Exit 42 Elevated Storage Tank

Geotechnical Engineering Report

July 18, 2023 | Terracon Project No. ES235113

Prepared for:

Brunswick-Glynn County Joint
Water and Sewer Commission
1703 Gloucester Str.
Brunswick, GA 31520

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July 18, 2023

Brunswick-Glynn County Joint Water and Sewer Commission
1703 Gloucester Str.
Brunswick, GA 31520

Attn: Ms. Pamela Drury-Crosby
P: (912) 261-7127
E: pcrosby@bgjwsc.org

Re: Geotechnical Engineering Report
Exit 42 Elevated Storage Tank
Brunswick, GA
Terracon Project No. ES235113

Dear Ms. Drury-Crosby:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PES235113 dated April 25, 2023. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon

Nurudeen Abidoye

Nurudeen Abidoye, M.S.
Staff Geotechnical Engineer

GEORGIA Registered No. 21979 PROFESSIONAL Engineer GUOMING LIN

Guoming Lin, Ph.D., P.E., D.GE
Senior Consultant

Table of Contents

Attachments

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Report Summary

Topic [1]	Overview Statement [2]
Project Description	The project includes the construction of an elevated water storage tank and connection to the existing 12-inch waterline adjacent to the property. The elevated water storage tank will have a capacity of 750,000 gallon. The tank height is approximately 150 feet and will be supported on a cylindrical pedestal structure which will have a diameter of approximately 35 feet.
Geotechnical Characterization	▪ Approximately 6 to 12 inches of topsoil (including organics/ roots/ wood chips). ▪ Below the topsoil, the site consists of loose to very dense sand mixtures (SM, SP-SM, and SP) in the upper 10 to 67 feet below the existing ground surface (BGS), followed by 10 feet of stiff sandy clays. The sandy clays are underlain by medium dense silty sands to the termination of the SPT boring at 90 feet below the existing ground surface (BGS). A detailed soil stratification is discussed in **Geotechnical Characterization** section. ▪ Groundwater was encountered at approximately 3 to 4.5 feet during our field exploration.
Earthwork	The open-cut excavations for the proposed utility connections may require protective measures unless the area has space for a sloped excavation. Dewatering of the pipeline trench and the bore pit excavation should be expected. The site soils are predominantly sandy and are highly susceptible to erosion. Site drainage and erosion protection should be considered during construction and for the long-term performance of the facilities.
Deep Foundations	**Elevated Water Tank**: Deep foundations auger-cast-in-place (**ACIP**)piles are considered the most suitable for this project in terms of reliability, cost, and constructability. Prestressed concrete (PSC) piles are also suitable but will require predrilling to overcome the shallow dense sand layer. A detailed discussion about the pile foundation recommendations is provided in the **Deep Foundation** section.
Seismic Considerations	For seismic design purposes, the subject site is classified as **Site Class D** in accordance with the International Building Code (IBC) 2018 and ASCE 7-16 Section 11.4.2.

General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed elevated water storage tank to be located at 118 Cherokee Trail in Brunswick, GA. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Foundation design and construction
- Lateral earth pressure
- Seismic site classification per IBC

The geotechnical engineering Scope of Services for this project included the advancement of 2 cone penetrometer test (CPT) soundings to depths ranging from approximately 10 to 50 feet below existing site grades (BGS, refusal/ termination depths), 1 standard penetration test (SPT) boring to depths of 90 feet (BGS, refusal depths), and 2 hand auger (HA) borings to depths of 5 feet below existing site grades (BGS, termination depths).

Drawings showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	An email request for proposal was provided by Ms. Pamela Drury-Crosby on April 18th, 2023. The request included geotechnical and environmental site assessment requirements and a topographic plan of the planned elevated tank.

Item	Description
Project Description	The project includes the construction of an elevated water storage tank on parcel number 03-28132. The elevated water storage tank will have a capacity of 750,000 gallon. The tank height is approximately 150 feet and will be supported on a cylindrical pedestal structure which will have a diameter of approximately 35 feet. The elevated storage tank will connect to the existing 12-inch waterline adjacent to the property.
Proposed Structure	Elevated water storage tank
Maximum Loads	Based on information provided, we understand the elevated storage tank will have a capacity of 750,000 gallon, with a height of 150 feet and supported on a cylindrical pedestal structure with a diameter of 35 feet. At full capacity, the weight of the water in the tower is expected to be approximately 6.26 million pounds.
Grading/Slopes	Proposed finished grade elevation for the tank is expected to be close to existing grade.

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at the 118 Cherokee Trail in Brunswick, GA. Latitude: 31.2969°, Longitude: -81.4837° See **Site Location**
Existing Improvements	None
Current Ground Cover	Heavily wooded
Existing Topography	Based on the topographic map provided, the existing elevation at the site varies from 28' to 29' (unspecified datum).

Geotechnical Characterization

Subsurface Profile

We have developed a general characterization of the subsurface soil and groundwater conditions based upon our review of the data and our understanding of the planned construction. The geotechnical characterization forms the basis of our geotechnical calculations and evaluation of the site preparation options. The following tables provide our geotechnical characterization.

Stratum	Approximate Depth to Bottom of Stratum (feet)	Elevation of Bottom of Stratum (feet)	Material Description	Consistency/ Relative Density
1	0.5 to 1		Topsoil: silty sands with roots and wood chips[1]	N/A
2	10 to 67	18 to -39	Sand mixtures[2] interbedded with sandy silt	Loose to very dense Stiff to very stiff
3	77	-49	Sandy clay	Stiff
4	90, termination of CPT sounding	-62	Poorly graded sand	Medium dense

1. Topsoil depth will vary throughout the site. The contractor should be prepared to strip/remove organics and unsuitable material prior to construction.
2. The sand mixtures consist of silty sands, poorly graded sand, and poorly graded sand with silt.

Conditions observed at each exploration points across the site are indicated on the individual logs shown in **Exploration Results** attached to this report. Stratification boundaries on the CPT soundings/ SPT/ HA boring logs represent the approximate location of changes in native soil types; in situ, **the transition between materials may be gradual**.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was observed at the CPT soundings and SPT/ hand auger boring locations. The groundwater was measured at depths of **3 to 4.5 feet (elevation of +25 to 23.5)** during field exploration. The water levels can be found on individual logs in the **Exploration Results** section attached to this report and are summarized below.

Exploration Location	Measured Groundwater below ground (ft.)	Approximate Groundwater Elevation (NAVD 88)
B1	4.5	+23.5
C2	3	+25
C2A	3	+25
C3	4	+24
HA1	4.5	+23.5

It is important to note: Groundwater conditions may change because of seasonal variations in rainfall, runoff, and other conditions not apparent at the time the borings were performed. Mottling, which is an indicator of seasonal high groundwater table, was not encountered during our field exploration. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. A positive site drainage plan is critical to site stability. The groundwater table should be checked prior to construction to assess its effect on sitework and other construction activities.

Laboratory Testing

Laboratory testing procedures were performed on soil samples collected at various points around the project area. Bag samples were obtained at multiple locations ranging from depths of 2 to 4 feet below the existing grade surface and shipped to Terracon's laboratory for the following testing procedures:

- **Moisture Content:** Standard Test Methods for Laboratory Determination of Water Content of Soil and Rock by Mass (ASTM D2216)
- **Grain Size Analysis:** Standard Test Method for Particle-Size Analysis of Soils (ASTM D422)
- **Corrosion Series**: Standard Test Method for Corrosion Test Series of Soils (ASTM D516-16 and G51-18)

Our laboratory testing results are represented in individual graphs and tables in more detail in **Exploration and Laboratory Results** attached to this report.

Natural Moisture Content: The natural moisture contents of the samples ranged from 15.1 % to 28.6%. Based on our experience, the subgrade soils with moisture content above 20 percent may not be stable judged by proofrolling. Therefore, the soils may need to be dried by scarifying, discing, or cement treatment.

Fine Content: The soil samples have a percentage of fine passing the No.200 sieve between 1.6% and 5.5%. It is recommended to place fill materials consisting of granular materials (sands with less than 25% fines passing the No. 200 sieve).

Corrosivity

A soil sample was sent to our analytical laboratory for testing of chemical properties that can influence the corrosion potential of the site. The test was performed to provide preliminary data for engineers and manufacturers of various products to evaluate the corrosion risk and the need for corrosion protection measures. The table below lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, redox and pH testing with more details in **Exploration Results** attached to this report.

Corrosivity Test Results Summary

Sample No	Sample Depth (feet)	pH	Soluble Sulfate mg/kg (ppm)	Soluble Chloride mg/kg (ppm)	Resistivity (Ω-cm)	Red-ox
HA1	1 - 3	4.76	32	20	34,000	+626

We evaluated the corrosion test results in accordance with the Georgia Department of Transportation (GDOT) Pipe Culvert Material Alternates and ACI 318-14. GDOT uses pH and electric resistivity to determine pipe materials allowed for corrosion consideration. Based on the above test results, **reinforced concrete AASHTO M-170, corrugated steel aluminum coated (TYPE 2) AASHTO M-36, polymer coated steel AASHTO M-245, corrugated aluminum (AASHTO M-196) and some thermoplastic pipes** are allowed under some conditions. Please refer to the results in the appendix for the complete list of pipe materials that are allowed for this site.

ACI 318 Table 19.3.1.1 lists five categories for concrete exposure to water-soluble sulfate (SO_4^{2-}) and dissolved sulfate (SO_4^{2-}) in water. The lab tests indicated sulfate and chloride content is minimal. As such, the site is in S0 exposure class, and no special cement is required for protection against sulfate or chloride.

Geotechnical Overview

The following evaluation and recommendations are based upon our understanding of the proposed construction and the results from our field exploration. **If the above-described project conditions are incorrect or changed after this report, or subsurface conditions encountered during construction are significantly different from those**

reported, Terracon should be notified so we can re-evaluate our recommendations and make appropriate revisions.

Geotechnical Considerations

The subsurface conditions are considered suitable for the proposed construction. The generalized soil profile is presented in the **Geotechnical Characterization** section.

Based on information provided, we understand the elevated water storage tank has a maximum capacity of 750,000 gallon, a height of 150 feet and will be supported on a cylindrical pedestal structure with a diameter of approximately 35 feet. We recommend the elevated storage tank should be supported on deep foundations consisting of prestressed concrete (PSC) piles or auger-cast-in place (ACIP) piles. In general, the pile shall be installed at least five feet into the medium dense sand layer which is at an elevation of -20’ (48 feet BGS). The estimated pile capacities and pile installation recommendations are presented in the **Deep Foundations** section of this report.

For the pipe connections to the existing 12-inch waterline adjacent to the property, we recommend the bottom of the excavation be observed for potentially unsuitable material. Disturbed or unstable materials should be removed before placing any granular bedding material. Where groundwater, lower strength soils, and unstable conditions are encountered, a greater thickness of bedding material should be provided. The material for the water main pipe bedding can consist of improved subgrade select fill material, or No. 57 stone. The minimum thickness of the bedding material should be 24 inches of improved subgrade or select fill material in accordance with the specification in the **Utility Trench Backfill** section of this report. If soft/weak clayey soils are encountered at the pipe installation depth, a 12-inch layer consisting of No. 57 stone is recommended for support.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include subgrade preparation and installation of site drainage. Deeper undercuts may be needed in some localized areas to remove unsuitable materials. The site work conditions will be dependent on the weather conditions and the contractor’s means and methods in controlling surface drainage and protecting the subgrade.

The following sections provide recommendations for use in the preparation of specifications for the work.

Site Drainage

An effective drainage system should be installed prior to site preparation and grading activities to intercept surface water and to improve overall shallow drainage. The drainage system may consist of perimeter ditches supplemented with parallel ditches and swales. Pumping equipment should be prepared to remove groundwater from the boring pits. The site should be graded to shed water and avoid ponding over the subgrade.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill. Structural fill is material used below the buildings and pavements.

Reuse of On-Site Soil: Most of the on-site soil encountered sandy soils classified as poorly graded sand (SP), poorly graded sand with silt (SP-SM), and silty sands (SM) during our field exploration which are considered suitable for fill materials. If the onsite soils are used as structural fill material, a sufficient number of samples should be submitted by the contractor to the geotechnical engineer for testing to verify that the requirements of this section are met. Earthen materials used for the fill should meet the following material property requirements:

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Granular	GW, GP, GM, GC, SW, SP, SM, SC	Less than 25% passing No. 200 sieve

1. Structural fill should consist of approved materials free of organic matter and debris. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e., jumping jack or plate compactor) is used

Item	Structural Fill
Minimum Compaction Requirements [1]	95% of max. above foundations, below floor slabs, and more than 1 foot below finished pavement subgrade
Water Content Range [1]	Granular: -3% to +3% of optimum

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 1557).

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility to be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1:1 projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the gradation and expansion index requirements of engineered fill discussed in this report.

Earthwork Construction Considerations

Shallow excavations, for the proposed structure, are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to the construction of floor slabs. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over, or adjacent to, construction areas should be removed.

If the subgrade saturates or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted, prior to floor slab construction. The groundwater table could affect over-excavation efforts, especially for over-excavation and replacement of lower strength soils. A temporary dewatering system consisting of sumps with pumps could be necessary to achieve the recommended depth of over-excavation.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations. Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and topsoil, proofrolling, and mitigation of areas delineated by the proofroll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency provided by the project plan and specifications. In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Deep Foundations

Based on the provided information and existing subsurface conditions, the elevated water tank should be supported on a deep foundation system including pile foundations. We evaluated different foundation options based on reliability, cost, and constructability, and considered driven prestressed concrete (PSC) piles and auger-cast-in-place (ACIP) piles as the most suitable piles for this project. In general, PSC piles are more reliable than ACIP piles. We analyzed pile axial and lateral capacities for 12, 14, 16, and 18 inches square PSC piles and 14, 16, 18 and 20 inches round ACIP piles. This section describes the procedures for pile capacity evaluations and presents our recommendations for the pile axial and lateral capacities.

Pile Axial Capacities

The ACIP piles are generally more economical than PSC piles but less reliable than PSC piles. To improve the quality of ACIP piles, we recommend the ACIP piles be installed carefully to avoid the potential necking or mining during construction. All piles are required to penetrate through the clay layer and into the underlying medium dense sands. For PSC piles, the piles may have difficulties penetrating into the very dense sands that have blow counts up to 60 blows per foot in the upper 15 feet BGS. A relative larger hammer may be required, and predrilling would be required in the upper 20 feet BGS. The size of the predrill should be less than the dimension of the square piles. **Furthermore, to improve the driving conditions, we recommend the PSC piles be manufactured using concrete with a 28-day compression strength of 7,000 psi. The piles should have an effective prestressing of at least 1,000 psi after relaxation.**

Based on the above pile configuration and soil parameters from the subsurface exploration, we calculated the allowable axial compression and tension capacities of individual PSC and ACIP piles, and are presented in the table below.

The medium dense sand layer below the very loose sand and below the stiff sandy clay is considered a pile bearing layer. We recommend all piles penetrate through the very loose sands/ stiff clay layer and tip into the underlying medium dense sand with a target tip elevation of -20' to -35' or elevation tip -50 to -55' EL. As shown in the soil profiles in the appendix, we recommend an average tip elevation of -20 feet EL for budgeting and planning purposes. The pile capacities presented in the following tables do not include down-drag loads.

Recommended Allowable Axial Capacities for PSC piles

Approx. Depth below grade[1] (feet, BGS)	Pile Tip Elevation (feet)	12-inch	14-inch	16-inch	18-inch
Allowable Compression Capacities (kips)					
48	**-20**	100	135	170	200
53	**-25**	115	150	185	220
58	**-30**	130	175	200	235
63	**-35**	135	180	215	250
78	**-50**	155	200	230	270
83	**-55**	185	250	270	300
Allowable Tension Capacities (kips)					
48	**-20**	40	50	60	70
53	**-25**	50	60	70	80
58	**-30**	55	70	80	95
63	**-35**	65	80	95	110

78	**-50**	85	100	105	115
83	**-55**	95	110	120	125

1. **The depth is measured from the existing ground surface.**

Recommended Allowable Axial Capacities for ACIP piles

Approx. Depth below grade[1] (feet, BGS)	Pile Tip Elevation (feet)	14-inch	16-inch	18-inch	20-inch
Allowable Compression Capacities (kips)					
48	**-20**	90	110	140	165
53	**-25**	100	120	155	185
58	**-30**	110	140	170	200
63	**-35**	120	150	180	215
78	**-50**	130	170	200	240
83	**-55**	160	200	250	290
Allowable Tension Capacities (kips)					
48	**-20**	35	45	55	65
53	**-25**	40	50	65	75
58	**-30**	50	60	75	90
63	**-35**	55	70	85	100
78	**-50**	75	90	110	130
83	**-55**	80	100	125	145

1. **The depth is measured from the existing ground surface.**

Pile Lateral Capacities

The behavior of the vertical piles under lateral loads was analyzed using the computer program *LPILE v.2019.* The LPILE program employs the *p-y* method based on the user-specified soil and pile properties. The deflections, rotations, and bending moments in a pile were calculated by solving the beam bending equation using finite difference numerical analysis. The allowable lateral pile capacities will be a function of the allowable lateral deflection at the pile top. The pile head deflections will be largely determined by the type of connections between pile head and pile cap. The actual connection may fall somewhere between a fixed head and free head conditions.

The following LPile analyses were performed based on the pile top at the existing ground elevation. The calculated lateral responses of PSC piles are profiled in the **Supporting Information** of this report. The following tables summarize the lateral capacities of piles.

Recommended Lateral Capacities (kips) for PSC piles

	12-inch Pile	14-inch Pile	16-inch Piles	18-inch Piles
Free Head Connection	5.4	7.1	9.2	11.8
Fixed Head Connection	15.0	19.6	24.9	31.0

Note: Based on an allowable lateral deflection of 0.25 inches. A higher lateral capacity is available if the allowable deflection is higher than 0.25 inch. No reduction of lateral pile capacity was considered for the group effect.

Recommended Lateral Capacities (kips) for ACIP piles

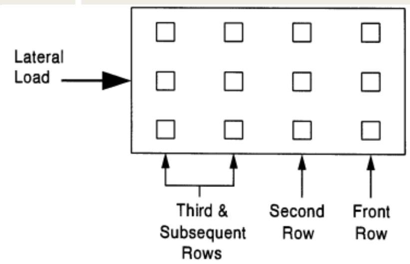
	14-inch Pile	16-inch Piles	18-inch Piles	20-inch Piles
Free Head Connection	5.6	7.3	9.3	12.0
Fixed Head Connection	15.5	19.8	24.7	30.

Note: Based on an allowable lateral deflection of 0.25 inches. A higher lateral capacity is available if the allowable deflection is higher than 0.25 inch. No reduction of lateral pile capacity was considered for the group effect.

When piles are used in groups, the lateral capacities of the piles in the second, third, and subsequent rows of the group should be reduced as compared to the capacity of a single, independent pile. Guidance for applying p-multiplier factors to the p values in the p-y curves for each row of pile foundations within a pile group are as follows:

Center to Center Pile Spacing [1,2]	P-Multiplier, P_m [3]		
	Front Row	Second Row	Third and Subsequent Rows
3B	0.8	0.4	0.3
4B	0.9	0.65	0.5
5B	1.0	0.85	0.7
6B	1.0	1.0	1.0

1. Spacing in the direction of loading. B = pile diameter
2. For the case of a single row of piles supporting a laterally loaded grade beam, group action for lateral resistance of piles would need be considered when spacing is less than three pile diameters (measured center-to-center).
3. See adjacent figure for definition of front, second and third rows.



Pile Testing and Monitoring for Driven PSC Piles

Due to the critical nature of the project, a pile monitoring and testing program is very important during production pile installation. The testing program will be required for the confirmation of pile lengths and capacities and the determination of pile driving criteria. Terracon should be retained for the monitoring and testing of the pile installation. Pile testing using pile driving analyzer (PDA) testing is recommended to measure driving stresses, evaluate hammer performance and verify pile capacities. PDA testing should be performed on at least two piles during the initial driving and restrike. Additional PDA tests should be performed if a different size or length of pile is used. The test piles can be as production piles.

Proper selection of a driving system is very important to install the recommended piles to the required depth and capacities. The hammer should have adequate energy to allow the piles to penetrate into the dense sand layer without introducing damaging driving stresses. The hammer should not generate excessive driving stresses to result in pile damage. Terracon requests an opportunity to evaluate the driving equipment and procedures after the pile hammer, pile cushion and driving procedures have been selected. We will perform a wave equation analysis of the proposed driving system. The driving system and procedures can be accepted only after a pile testing program.

During production pile installation, a Terracon geotechnical engineer should observe the initial pile installation. The purpose of the observation is to determine if the recommendations have been implemented.

The geotechnical engineer or an engineering technician working under the direction of the geotechnical engineer should monitor the entire driving process. Complete driving and installation records should be maintained.

For each pile driven, driving records should at least include pile type and dimensions, pile tip and cut-off elevations, butt deviation, batter angle, time to set up, time of driving, plumbness, penetration resistance values for each foot and any incidents relevant to the pile foundation installation such as pile damage or break-down of driving equipment. The geotechnical engineer should review the driving records and recommend necessary adjustments to achieve the design objectives.

Pile Installation, Load Testing and Quality Control for ACIP Piles

Pile Testing Program A pile test program is recommended for this project. The purpose of the pile test program is to verify the contractor's installation procedures and the estimated pile capacities. Installation procedures, refusal criteria if encountered, and pile capacities may be adjusted based on the results of the pile test program. We recommend that at least two probe piles be installed within the tank area and one probe pile be selected for load test. Additional test piles should be installed if more than one pile size is considered, or significantly different conditions are encountered among the test piles. The geotechnical engineer should help select locations for the test piles based on the soil conditions. The test program should be performed under the direct supervision of the geotechnical engineer.

We recommend static load testing be performed on at least one pile using strain gages along the center bar. Additional test piles with varying length may be performed to provide information for a potentially more economical foundation design. The strain gages should be placed based on the soil stratigraphy at the test pile location. The test piles should be loaded to at least three times of the design load. The test program should also include inspection/calibration of grout pump equipment and observation of augering/installation of indicator piles. The production piles should be installed using the procedures and criteria established from the test program.

ACIP Pile Monitoring Program There are inherent uncertainties with pile integrity in pile installation. The uncertainties or risks are considered relatively high for this site due to the soil profiles and the site development history. A quality control and testing program is essential to ensure the integrity of the piles. The recommended pile capacities are based on the conditions that all piles will be monitored by a qualified engineering firm retained by the owner and directly supervised by the geotechnical engineer. This monitoring provision is required by the International Building Code (IBC) 2018 and Georgia Special Inspection Guidelines in accordance with IBC2018.

Pile Integrity Testing. The risk of bulging and necking increases with the presence of a very soft/ very loose soil deposit. Terracon recommends the integrity for the piles be tested using thermal integrity profiling (TIP) in accordance with ASTM D7949.

TIP is a relatively new technology for assessing the quality of cast-in-place concrete foundations using the temperature field generated by curing cement. Fundamentally, a shortage of competent concrete such as necking is registered by relatively cool regions while the presence of extra concrete such as bulging is registered by warm regions. TIP measures the concrete temperatures either by a thermal probe or by embedded thermal sensors in the concrete. The thermal probe requires an access tube filled with water be prepared for probing; the measured temperature can be profiled continuously along the pile; however, the testing time is not continuous and should be selected at peak temperature. The testing by embedded thermal sensors typically gets temperatures through deploying thermal sensors at different depths, measures the temperature continuously, and automatically detects the peak temperature. However, it sacrifices the sensors embedded in the concrete.

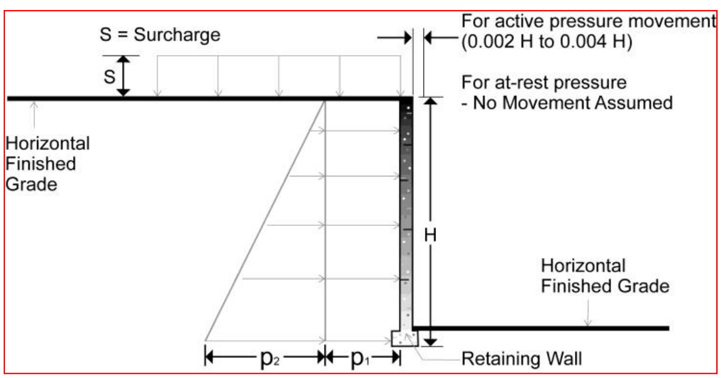
We recommend TIP testing be performed on all test piles and approximately 10 percent of the production piles. Terracon should select piles to be tested based on the conditions observed during installations as well as other considerations. The contractor shall prepare access tubes and install tubes along the center based on Terracon's selection of test piles.

Pile Spacing and Sequencing. We recommend that center-center spacing between adjacent piles be maintained at least three times the pile diameter. No reduction of axial pile capacity was considered for the group effect. Piles should not be installed less than 10 feet away from the nearest pile within 12 hours from its installation. The contractor should develop a sequencing plan to allow adequate grout setup before installing adjacent piles. The test program, should verify the recommended spacing and effect of sequencing.

Lateral Earth Pressures

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction, and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Earth Pressure Coefficients (from the structural fill)

Earth Pressure Conditions	Coefficient for Backfill Type	Equivalent Fluid Density **(pcf)**	Surcharge Pressure, p_1 **(psf)**	Earth Pressure, p_2 **(psf)**
Active (K_a)	Sand/ Silty Sand - 0.33	40	(0.33)S	(40)H
At-Rest (K_o)	Sand/ Silty Sand - 0.5	50	(0.46)S	(55)H
Passive (K_p)	Sand/ Silty Sand – 3.00	360	---	---

Applicable conditions to the above include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 **H** to 0.004 **H**, where **H** is wall height
- For passive earth pressure to develop, wall must move horizontally against the fill to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- In situ soil backfill weight a maximum of 115 pcf
- Horizontal backfill, compacted between 95 percent of modified Proctor maximum dry density
- Loading from heavy compaction equipment or dynamic loading not included
- No hydrostatic pressures acting on wall
- No safety factor included in soil parameters. We recommend a factor of safety be used for the passive resistance.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 degrees from vertical for the active case.

The lateral earth pressure recommendations given in this section are applicable to the design of rigid retaining walls subject to slight rotation, such as cantilever, or gravity type concrete walls. These recommendations are not applicable to the design of modular block - geogrid reinforced backfill walls (also termed MSE walls). Recommendations covering these types of wall systems are beyond the scope of services for this assignment. However, we would be pleased to develop a proposal for evaluation and design of such wall systems upon request.

Seismic Site Class

According to the International Building Code (IBC) 2018 and ASCE 7-16, structures should be designed and constructed to withstand the effects of earthquakes and avoid failure during a maximum considered earthquake. The maximum considered earthquake (MCE) is a seismic event that has a 50-year exposure period with a 2% probability of exceedance. The 2,500-year earthquake has a Moment Magnitude (Mw) of 7.3 and a Site Class Adjusted Peak Ground Acceleration (PGAM) of **0.139g**, as determined by data provided by the IBC-2018 and ASCE 7-16 Standards.

Based on our findings from the field exploration and our knowledge of the local geological formation in the project area, the site can be classified as **Site Class D** in accordance with International Building Code (IBC) 2018 and ASCE 7-16. The seismic design parameters obtained based on IBC 2018 and ASCE 7-16 are summarized in the table below.

The design response spectrum curve, as presented in the **Supporting Information** attachment of this report, was developed based on the S_{DS} and S_{D1} values according to IBC 2018 and ASCE 7-16.

Site Location (Latitude, Longitude)	Site Classification	S_s	S_1	F_a	F_v	S_{DS}	S_{D1}
31.2969°, -81.4837°	D	0.171g	0.077g	1.6	2.4	0.182g	0.123g

- In accordance with the 2018 International Building Code and ASCE 7-16.
- The 2018 IBC and ASCE 7-16 require a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope does not include 100-foot soil profile determination. Explorations for this project extended to a maximum depth of 90 feet BGS and this seismic site class definition was provided in consideration of the overall soil conditions as well as the general geology of the area.

Liquefaction

Liquefaction is a phenomenon in which the strength and stiffness of soil are reduced by earthquake shaking or other rapid cyclic loading. The effects of soil liquefaction on the built environment can be extremely damaging. A liquefaction analysis was performed by IBC 2018 by using shear stress ratio method with an earthquake magnitude of 7.3, and geometric mean peak ground acceleration (PGAm) of 0.139g for site class D. The geometric mean peak ground acceleration was obtained from the **Site Specific Response Analysis** study in this report. The earthquake magnitude of 7.3 was obtained from the seismic hazard deaggregation study for the project site.

In quantitative analysis, a liquefaction analysis was performed using the computer software Cliq 3.0, which computes soil liquefaction potential and post-liquefaction settlements. The liquefaction analysis results are graphically presented in the **Supporting Information** attached to this report. Based on the liquefaction analysis, the total settlement induced by liquefaction was estimated to be less than 1 inch. Soil liquefaction should not be a concern for this site.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction.

Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials, or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended.

Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly affect excavation cost.

Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development.

If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Attachments

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Exploration and Testing Procedures

Field Exploration

Number of Borings	Type of Exploration	Maximum Boring Depth (feet)	Location
2	Cone Penetrometer Test (CPT) Sounding	50	Tank Location
1	Standard Penetration Test (SPT) Boring	90	
2	Hand Auger (HA) Boring	5	

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±5 feet) and referencing existing site features. Elevation reading was interpolated from topographic map produced by TR Long Engineering dated 11/29/2022.

Subsurface Exploration Procedures: We advanced the CPT soundings with a track-mounted drill rig. CPT sounding is a technology in which an electronically instrumented cone penetrometer is hydraulically pushed through the soil while nearly continuous readings are recorded to a portable computer. The cone is equipped with electronic load cells to measure tip resistance and sleeve resistance and a pressure transducer to measure the generated ambient pore pressure. The face of the cone has an apex angle of 60° and an area of 10 cm^2. Digital data representing the tip resistance, friction resistance, pore water pressure, and probe inclination angle are recorded about every 2 centimeters while advancing through the ground at a rate between 1½ and 2½ centimeters per second. These measurements are correlated to various soil properties used for geotechnical design. No soil samples are gathered through this subsurface investigation technique. CPT soundings were performed in accordance with ASTM D-5778. The CPT data can be used to determine soil stratigraphy and to estimate soil parameters such as undrained shear strength and modulus of compression.

Sounding C2 initially encountered shallow refusal at approximately 10 feet BGS. Auger drilling was used to advance the hole through the very dense sand layer to an approximate depth of 19 feet BGS. The hole was backfilled with the disturbed soil cuttings and the CPT was resumed as sounding C2A. Soil conditions reported in the upper 19 feet of Sounding C2A should be neglected, as they are not appropriately representative of the site soil conditions.

The soil test borings were performed in accordance with ASTM D1586 with a track-mounted drilling rig using mud rotary drilling techniques. The SPT sampling were taken at 2 feet intervals in the upper ten (10) feet and at 5 feet intervals thereafter using the split-barrel sampling procedures. In the split barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in situ relative density of cohesionless soils and consistency of cohesive soils. The SPT boring at the site was drilled to a depth of 90 feet below the existing ground surface (BGS).

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. The groundwater levels are shown on the attached boring logs.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture)
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D516-16 and G51-18 – Standard Test Method for Corrosion Test Series of Soils

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Image Courtesy of
Google Earth™

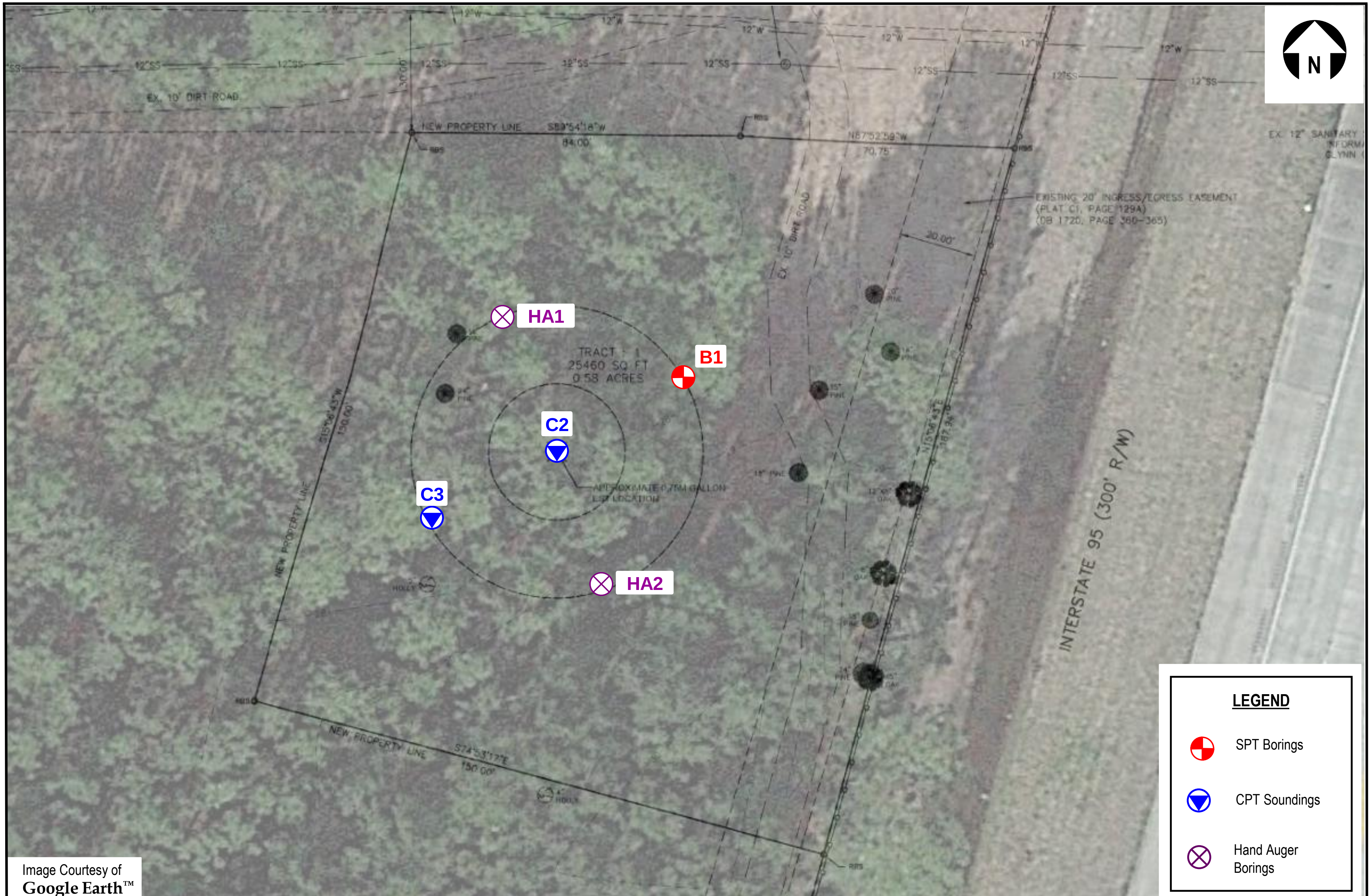
Project Manager: NAA	Project No. ES235113		
Drawn by: NAA	Scale: N.T.S.		
Checked by: CB	File Name:		
Approved by: GL	Date: 06-28-23		

Terracon

2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

SITE LOCATION PLAN

Exit 42 Elevated Storage Tank, JWSC Project No 2213
Brunswick
Glynn County, Georgia



NOTES:

CONCEPTUAL PLAN PROVIDED TO TERRACON BY BRUNSWICK-GLYNN COUNTY GA JWSC VIA EMAIL ON 04-18-23.

ALL EXPLORATION LOCATIONS ARE LOCATED IN THE FIELD USING A GPS UNIT AND / OR SITE LANDMARKS. EXPLORATION LOCATIONS SHOULD BE CONSIDERED APPROXIMATE. DIAGRAM IS FOR GENERAL LOCATION ONLY; NOT INTENDED FOR CONSTRUCTION PURPOSES.

Project Manager:	NAA
Drawn by:	NAA
Checked by:	CB
Approved by:	GL

Project No.	ES235113
Scale:	N.T.S.
File Name:	
Date:	06-28-23

Terracon
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

EXPLORATION PLAN

Exit 42 Elevated Storage Tank, JWSC Project No 2213

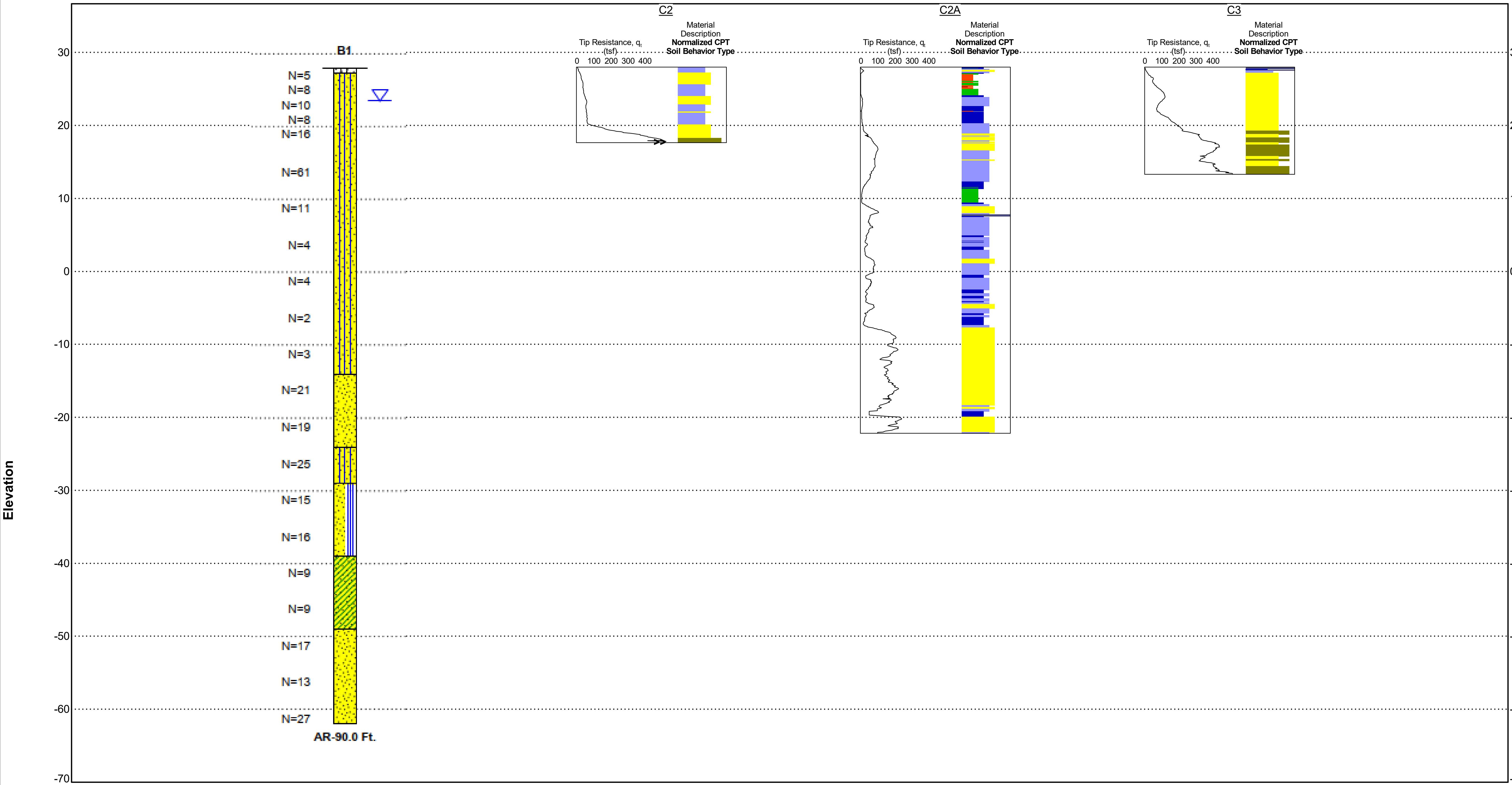
Brunswick

Glynn County, Georgia

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.



Explanation

C2 — Borehole Number
Moisture Content — %w
LL PL — Liquid and Plastic Limits
Sampling
Borehole Lithology
AR
BT — Borehole Termination Type

Water Level Reading at time of drilling.
Water Level Reading after drilling.

Topsoil
Silty Sand
Poorly-graded Sand
Poorly-graded Sand with Silt
Sandy Lean Clay

NOTES:
See Exhibit for orientation of soil profile.
See General Notes in Appendix for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ.
AR - Auger Refusal
BT - Boring Termination

Project Manager: NAA	Project No.: ES235113	
Drawn by: NAA	Scale: As Shown	
Approved by: GL	File Name: ES235113	
Date: 6/27/2023		

Terracon
2201 Rowland Ave
Savannah, GA
PH. 912-629-4000 FAX. 912-629-4001

SUBSURFACE PROFILE

JWSC EXIT 42 ELEVATED STORAGE TANK
118 CHEROKEE TRAIL
BRUNSWICK, GA

EXHIBIT

JWSC Exit 42 Elevated Storage Tank
118 Cherokee Trail | Brunswick, GA
Terracon Project No. ES235113

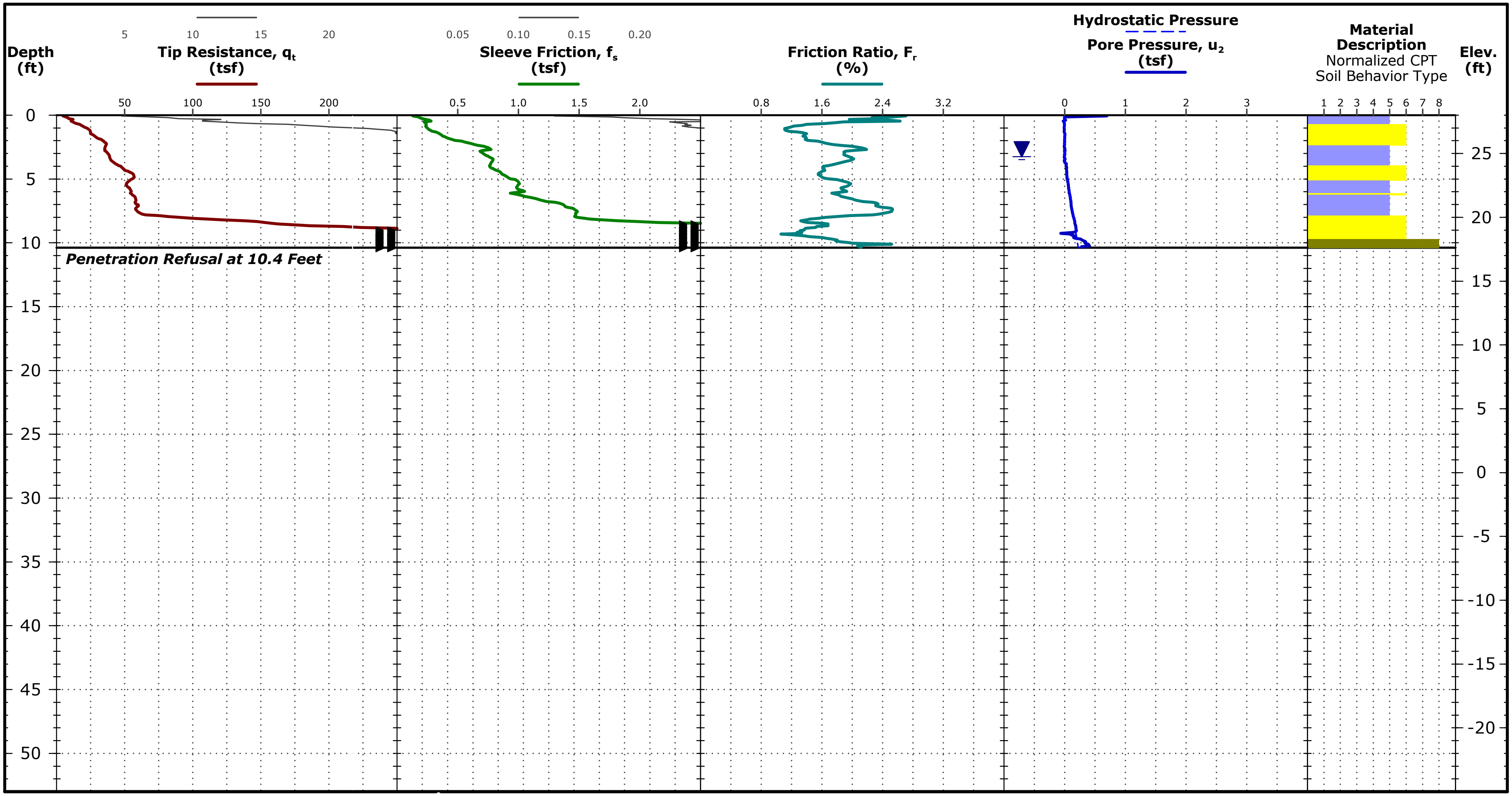
CPT Sounding ID C2

2201 Rowland Ave
Savannah, GA

Latitude: 31.2969° Longitude: -81.4837°

Elevation: 28 (ft)
Elevation Reference: Elevation readings was interpolated from topographic survey map produced by TR Long Engineering date 11/29/2022.

CPT Started: 6/21/2023
CPT Completed: 6/21/2023



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan

CPT Equipment

CPT Rig: Geoprobe
Operator: RM/MC
CPT sensor calibration reports available upon request
Probe No. 5759 with net area ratio of 0.852
U_2 pore pressure transducer location
Manufactured by Geotech A.B.- Calibrated 11/17/2021
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 2 in

Water Level Observation

3.25 ft measured water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

JWSC Exit 42 Elevated Storage Tank
118 Cherokee Trail | Brunswick, GA
Terracon Project No. ES235113

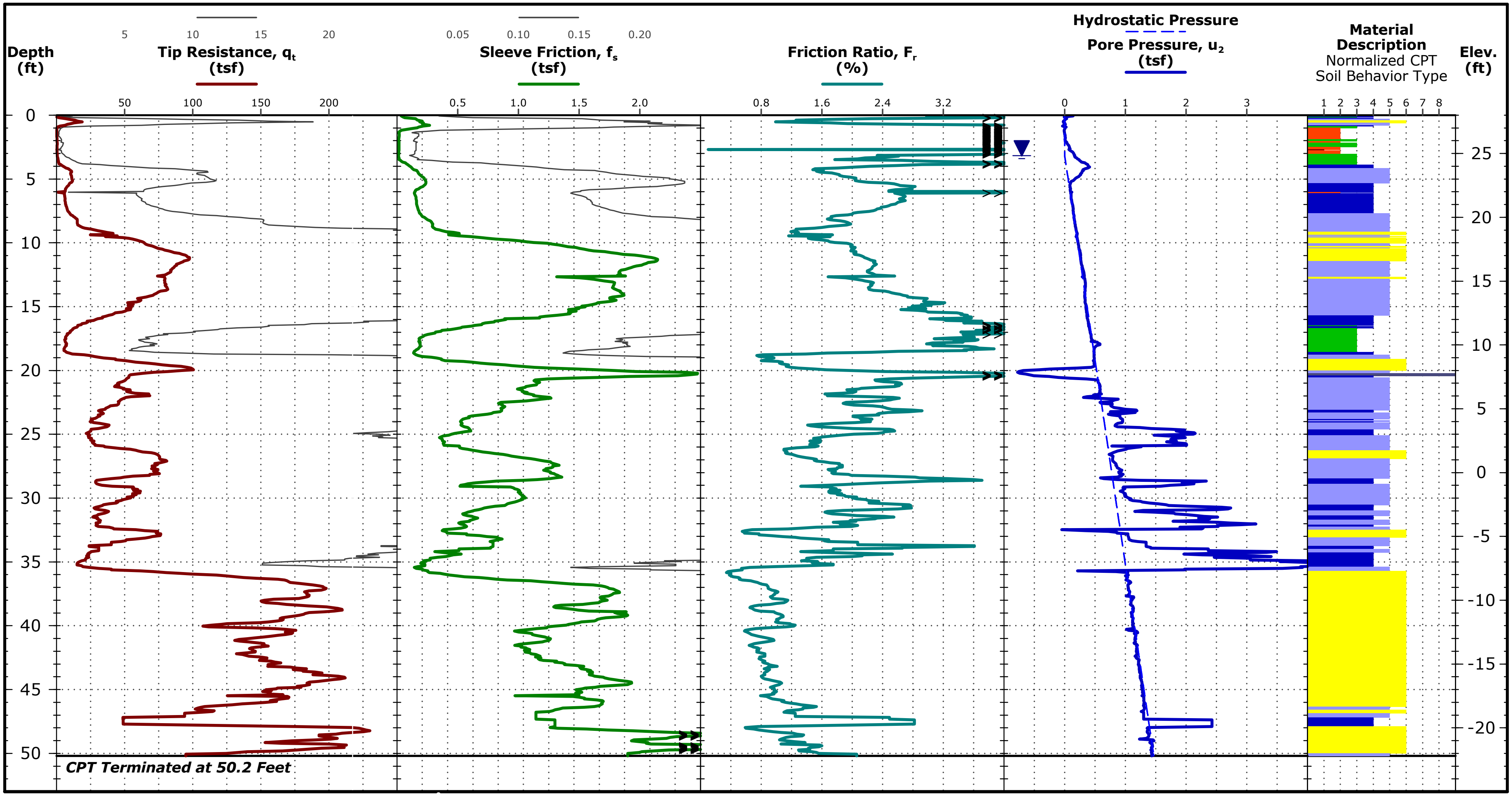
CPT Sounding ID C2A

Terracon
2201 Rowland Ave
Savannah, GA

Latitude: 31.2969° Longitude: -81.4837°

Elevation: 28 (ft)
Elevation Reference: Elevation readings was interpolated from topographic survey map produced by TR Long Engineering date 11/29/2022.

CPT Started: 6/21/2023
CPT Completed: 6/21/2023



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan

CPT location C2A was predrilled to 18.75'. Refer to C2 for soil detils of upper 10'

CPT Equipment

CPT Rig: Geoprobe

Operator: RM/MC

CPT sensor calibration reports available upon request

Probe No. 5759 with net area ratio of 0.852

U_2 pore pressure transducer location

Manufactured by Geotech A.B.- Calibrated 11/17/2021

Tip and sleeve areas of 10 cm^2 and 150 cm^2

Ring friction reducer with O.D. of 2 in

Water Level Observation

3.17 ft measured water depth

(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

JWSC Exit 42 Elevated Storage Tank
118 Cherokee Trail | Brunswick, GA
Terracon Project No. ES235113

CPT Sounding ID C3

Terracon
2201 Rowland Ave
Savannah, GA

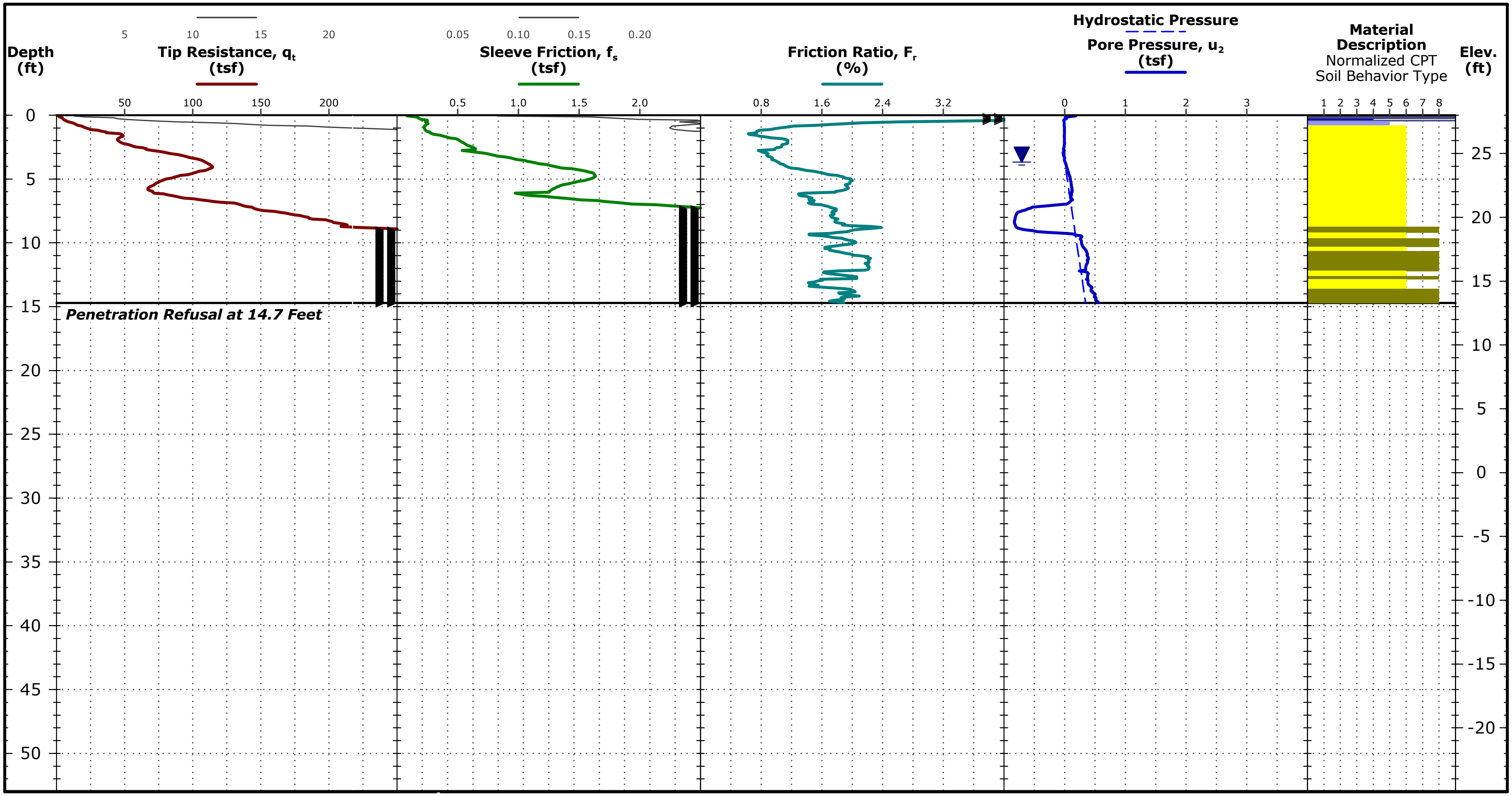
Latitude: 31.2969° Longitude: -81.4838°

Elevation: 28 (ft)

CPT Started: 6/21/2023

Elevation Reference: Elevation readings was interpolated from topographic survey map produced by TR Long Engineering date 11/29/2022.

CPT Completed: 6/21/2023



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan

CPT Equipment

CPT Rig: Geoprobe

Operator: RM/MC

CPT sensor calibration reports available upon request

Probe No. 5759 with net area ratio of 0.852

U_2 pore pressure transducer location

Manufactured by Geotech A.B.- Calibrated 11/17/2021

Tip and sleeve areas of 10 cm^2 and 150 cm^2

Ring friction reducer with O.D. of 2 in

Water Level Observation

3.67 ft measured water depth

(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

JWSC Exit 42 Elevated Storage Tank
118 Cherokee Trail | Brunswick, GA
Terracon Project No. ES235113

Terracon
2201 Rowland Ave
Savannah, GA

Boring Log No. B1

Location: See Exploration Plan

Latitude: 31.2970° Longitude: -81.4836°

Depth (Ft.)	Description	Elevation.: 28 (Ft.)
0.6	**TOPSOIL**, dark brown, Silty sand with roots and wood chips	27.4
	SILTY SAND (SM), fine grained, dark brown, loose	
	medium dense	
	brown, loose	
	medium dense	
	dark brown, very dense	
	brown, medium dense	
	loose	
	light brown, very loose	
	gray	
42.0		-14
	POORLY GRADED SAND (SP), medium grained, light gray, medium dense	

Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results
0–2		X	1-2-3-3 N=5
2–4		X	2-3-5-4 N=8
4–6	▽ (4.5)	X	3-5-5-5 N=10
6–8		X	3-3-5-6 N=8
8–10		X	3-6-10-10 N=16
13.5–15		X	19-30-31 N=61
18.5–20		X	2-5-6 N=11
23.5–25		X	2-2-2 N=4
28.5–30		X	1-2-2 N=4
33.5–35		X	0-1-1 N=2
38.5–40		X	1-1-2 N=3
43.5–45		X	8-10-11 N=21
48.5–50		X	7-9-10 N=19

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
▽ Groundwater encountered @ 4.5 ft BGS

Notes
Elevation Reference: Elevation readings was interpolated from topographic survey map produced by TR Long Engineering date 11/29/2022.

Advancement Method
Mud Rotary

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
CME 45

Hammer Type
Automatic

Driller
CP/SP

Logged by
LV

Boring Started
06-23-2023

Boring Completed
06-23-2023

Terracon
2201 Rowland Ave
Savannah, GA

Boring Log No. B1

Location: See Exploration Plan

Latitude: 31.2970° Longitude: -81.4836°

Depth (Ft.)	Material Description	Elevation.: 28 (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results
	POORLY GRADED SAND (SP), medium grained, light gray, medium dense *(continued)*					
52.0		-24				
	SILTY SAND (SM), fine grained, light gray, medium dense		55		X	3-9-16 N=25
57.0		-29				
	POORLY GRADED SAND WITH SILT (SP-SM), fine to medium grained, light gray, medium dense		60		X	8-5-10 N=15
	medium grained, gray/light gray		65		X	5-7-9 N=16
67.0		-39				
	SANDY LEAN CLAY (CL), gray, stiff		70		X	1-4-5 N=9
			75		X	2-1-8 N=9
77.0		-49				
	POORLY GRADED SAND (SP), medium grained, gray, medium dense		80		X	6-7-10 N=17
	medium to coarse grained		85		X	6-7-6 N=13
90.0		-62	90		X	7-12-15 N=27
	Auger Refusal at 90 Feet					

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater encountered @ 4.5 ft BGS

Drill Rig
CME 45

Hammer Type
Automatic

Driller
CP/SP

Logged by
LV

Boring Started
06-23-2023

Boring Completed
06-23-2023

Notes
Elevation Reference: Elevation readings was interpolated from topographic survey map produced by TR Long Engineering date 11/29/2022.

Advancement Method
Mud Rotary

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
2201 Rowland Ave
Savannah, GA

Boring Log No. HA1

Location: See Exploration Plan

Latitude: 31.2970° Longitude: -81.4838°

Depth (Ft.)	Material Description	Elevation.: 28 (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Percent Fines	Water Content (%)
0.7	**TOPSOIL**, with roots and wood chips, fine to medium grained, very dark gray, silty sand	27.3					
2.0	**SILTY SAND (SM)**, fine to medium grained, gray/dark gray brown/gray	26	1				
3.5	**POORLY GRADED SAND WITH SILT (SP-SM)**, fine to medium grained, brown	24.5	2–3		Auger	6	28.6
5.0	**SILTY SAND (SM)**, fine to medium grained, brown	23	4–5	▽ (4.5 ft)			
	Boring Terminated at 5 Feet						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
▽ Groundwater encountered @ 4.5 ft BGS
Mottling not encountered

Drill Rig
Hand Auger

Notes
Elevation Reference: Elevation readings was interpolated from topographic survey map produced by Trent Long date 11/29/2022.

Advancement Method
Manual- Hand Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Driller
SF

Logged by
SF

Boring Started
06-13-2023

Boring Completed
06-13-2023

Terracon
2201 Rowland Ave
Savannah, GA

Boring Log No. HA2

Location: See Exploration Plan

Latitude: 31.2969° Longitude: -81.4836°

Depth (Ft.)	Material Description (Elevation.: 29 (Ft.))	Elevation (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Percent Fines	Water Content (%)
	TOPSOIL, with roots and wood chips, fine to medium grained, very dark gray, silty sand						
0.7		28.3					
	SILTY SAND (SM), fine to medium grained, gray/dark gray		1				
	brown/dark gray		2				
2.5		26.5					
	POORLY GRADED SAND (SP), medium to coarse grained, brown		3		Auger	2	15.1
4.0		25	4				
	SILTY SAND (SM), fine to medium grained, brown						
5.0		24	5				
	Boring Terminated at 5 Feet						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered
Mottling not encountered

Drill Rig
Hand Auger

Notes
Elevation Reference: Elevation readings was interpolated from topographic survey map produced by Trent Long date 11/29/2022.

Advancement Method
Manual- Hand Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Driller
SF

Logged by
SF

Boring Started
06-13-2023

Boring Completed
06-13-2023

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth (Ft.)	Soil Classification USCS	Water Content (%)	% Gravel	% Gravel	% Sand	% Fines	Cc	Cu
HA1	2-3	POORLY GRADED SAND W/ SILT(SP-SM)	28.6	0.0	0.0	94.5	5.5	0.91	1.55
HA2	3-4	POORLY GRADED SAND(SP)	15.1	0.0	0.0	98.4	1.6	0.89	1.73

PROJECT: JWSC Exit 42 Elevated Storage Tank

SITE: 118 Cherokee Trail
Brunswick, GA

Terracon
2201 Rowland Ave
Savannah, GA
PH. 912-629-4000 FAX. 912-629-4001

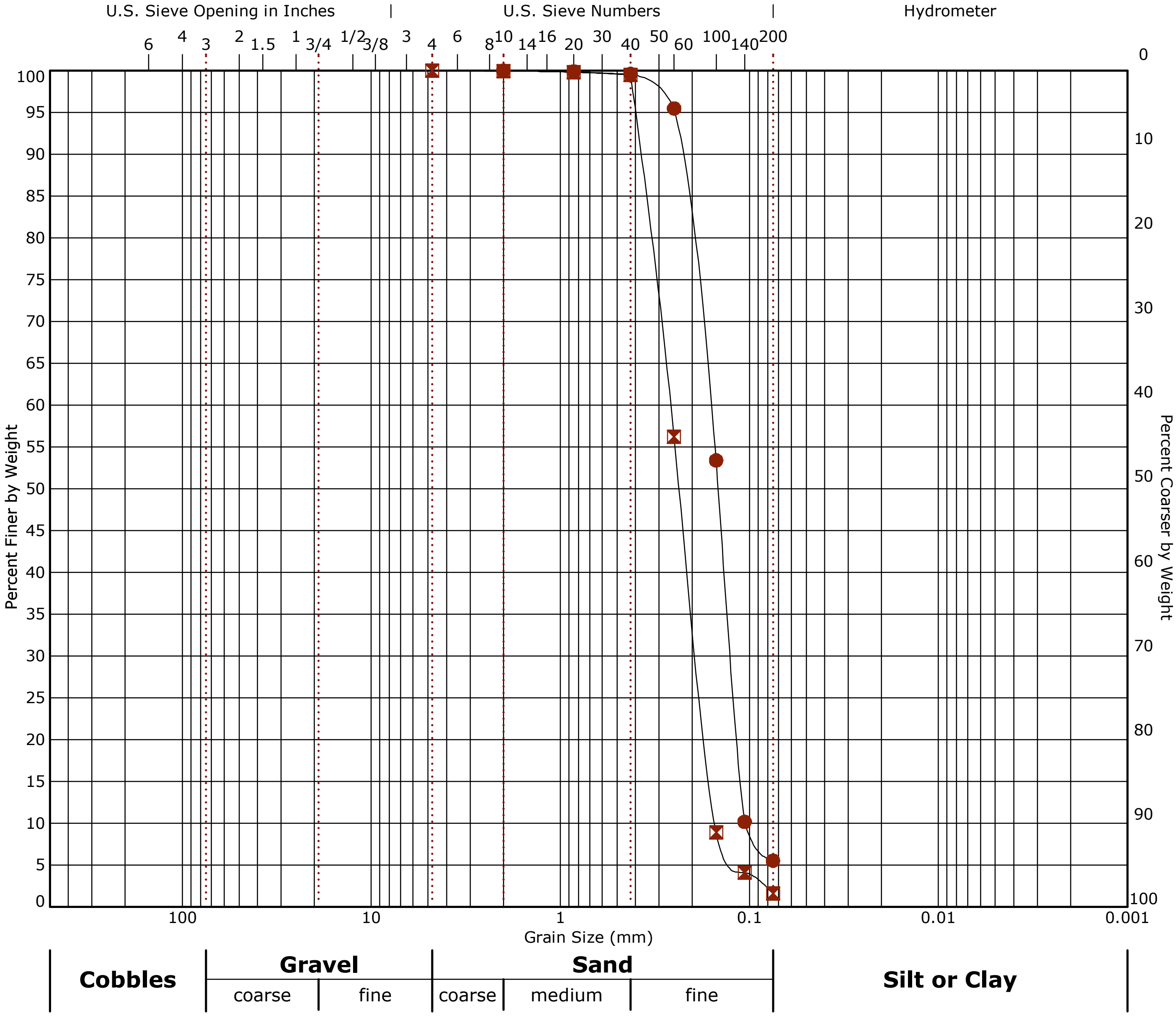
PROJECT NUMBER: ES235113

CLIENT: Brunswick & Glynn County Development Authority
Brunswick, GA

Terracon
2201 Rowland Ave
Savannah, GA

Grain Size Distribution

ASTM D422 / ASTM C136



	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	**HA1**	2 - 3	0.0	0.0	94.5	5.5			SP-SM
⊠	**HA2**	3 - 4	0.0	0.0	98.4	1.6			SP

	Description
●	POORLY GRADED SAND WIH SILT
⊠	POORLY GRADED SAND

	Remarks
●	
⊠	

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	Sieve	% Finer
#10	100.0	#4	100.0		
#20	99.89	#10	99.95		
#40	99.61	#20	99.81		
#60	95.48	#40	99.51		
#100	53.39	#60	56.19		
#140	10.17	#100	8.93		
#200	5.52	#140	4.1		
		#200	1.58		

Grain Size

	●	⊠	
D_{60}	0.163	0.262	
D_{30}	0.124	0.188	
D_{10}	0.105	0.152	

Coefficients

	●	⊠	
C_c	0.91	0.89	
C_u	1.55	1.73	

Client

Brunswick & Glynn County Development Authority
Brunswick, GA

Project

JWSC Exit 42 Elevated Storage Tank
ES235113

Date Received: 6/21/2023

Results from Corrosion Testing

Sample Location	HA-1
Sample Depth (ft.)	1.0'-3.0'
pH Analysis, ASTM G 51	4.76
Sulfates (SO4), ASTM D516-07, (mg/kg)	32
Sulfides, AWWA 4500-S D, (mg/kg)	Nil
Chlorides, APHA 4500-Cl$^-$ E, (mg/kg)	20
Red-Ox, ASTM G 200, (mV)	+626
Total Salts, AWWA 2520 B, (mg/kg)	68
Resistivity (Saturated), ASTM G 57, (ohm-cm)	34000

Analyzed By: ChrisAnne Ross
Field Geologist

The tests were performed in general accordance with applicable ASTM and AWWA test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

pH	4.76
Resistivity	34000

Boring Number: HA1
Sample Depth: 1' - 3'

Project Name: **Exit 42 Elevated Storage Tank**
Project Number: ES235113

County: **Glynn**
Location: Brunswick, GA

Pipe Culvert Material Alternates

TYPE OF INSTALLATION				PIPE TYPE									
				CONCRETE	STEEL			ALUMINUM	THERMOPLASTIC				
				REINFORCED CONCRETE AASHTO M-170	CORRUGATED STEEL ALUMINUM COATED (TYPE 2) AASHTO M-36	CORRUGATED STEEL PLAIN ZINC COATED AASHTO M-36	POLYMER COATED STEEL AASHTO M-245	CORRUGATED ALUMINUM AASHTO M-196	CORRUGATED HDPE AASHTO M-252	CORRUGATED SMOOTHED LINED HDPE TYPE "S" AASHTO M-294	CORRUGATED SMOOTH LINED POLYPROPYLENE AASHTO M 330	PVC CORRUGATED SMOOTH INTERIOR ASTM F-949	PVC Profile Wall Drain Pipe AASHTO M-304
STORM DRAIN	NON-TRAVEL BEARING (OUTSIDE ROADBED)		INTERSTATE	X									
			NON INTERSTATE	X	X		X	X		X	X	X	X
	TRAVEL BEARING (INSIDE ROADBED)	GRADE ≤ 10%	ADT < 1,500	X	X		X	X		X	X	X	X
			1,500 < ADT < 5,000	X	X		X	X		X	X	X	X
			5,000 < ADT < 15,000	X						X	X	X	X
			ADT > 15,000 & INTERSTATES	X									
		GRADE > 10%					X			X	X	X	X
SIDE DRAIN				X	X		X	X		X	X	X	X
PERMANENT SLOPE DRAIN					X	X	X	X		X	X	X	X
PERFORATED UNDERDRAIN					X	X		X	X	X	X	X	X

NOTES:

1 Allowable materials are indicated by an "X".

2 Structural, installation, fill height and backfill requirements of storm drain pipe will be in accordance with Georgia Standard 1030-D or 1030-P and the Standard Specifications

3 The Contractor shall provide additional storm sewer capacity calculations if a pipe material other than concrete is selected.

4 Pipe used under mechanically stabilized earth (MSE) walls, within MSE wall backfill, or within five feet of an MSE wall face shall be Class V Concrete Pipe.

Rev. 1-12-16

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Seismic Design Parameters Based on IBC2018 Code and ASCE 7-16 Standard

Terracon Project Name: Exit 42 Elevated Storage Tank

Terracon Project No: ES235113

Site Location: Brunswick, Georgia

Latitude : 31.2969°

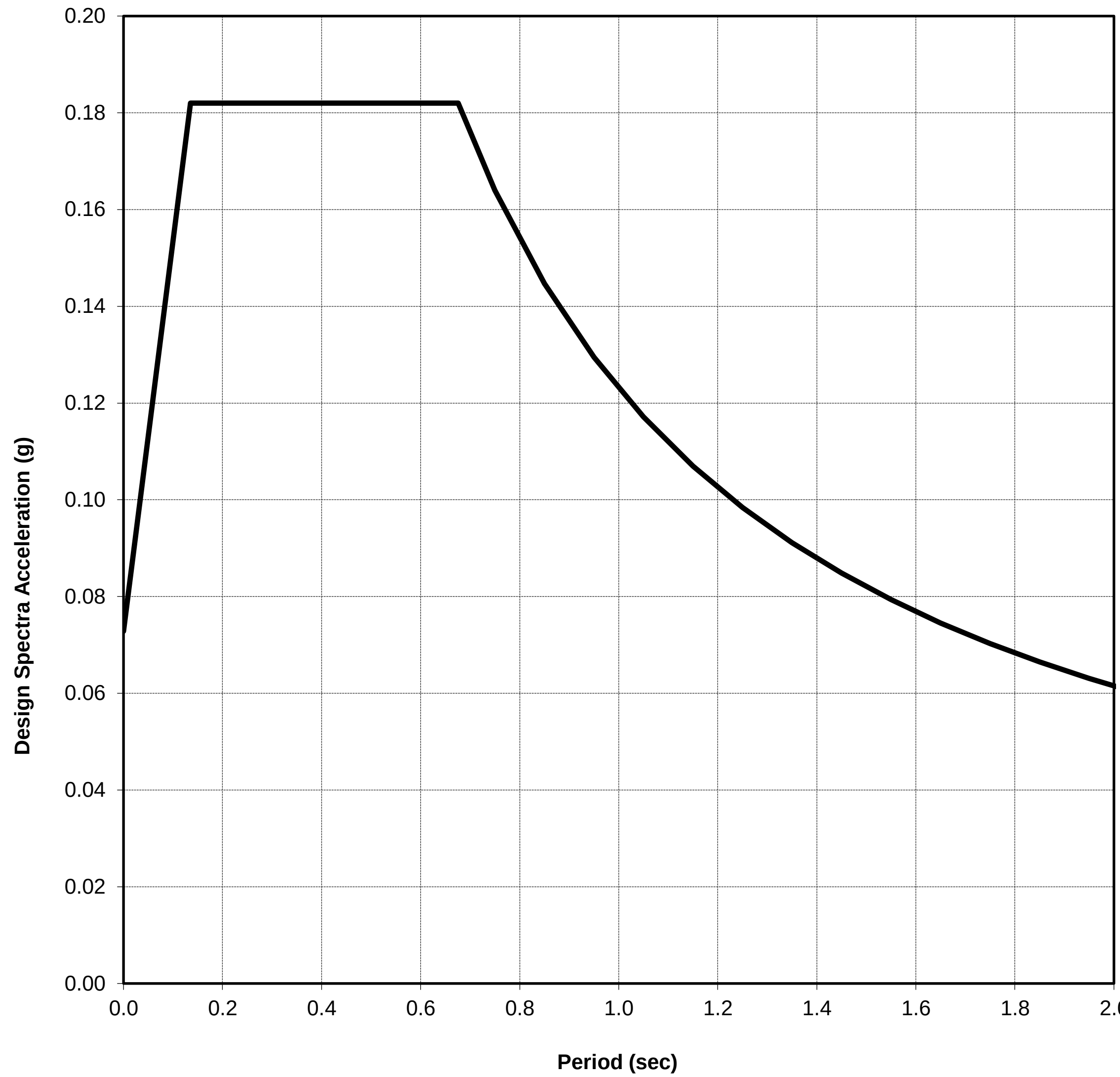
Longitude : -81.4837°

Site Class: **D**

Design Response Spectrum for the Site Class

S_s = 0.171	S_1 = 0.077
F_a = 1.600	F_v = 2.400
S_{MS} = 0.274	S_{M1} = 0.184
S_{DS} = 0.182	S_{D1} = 0.123

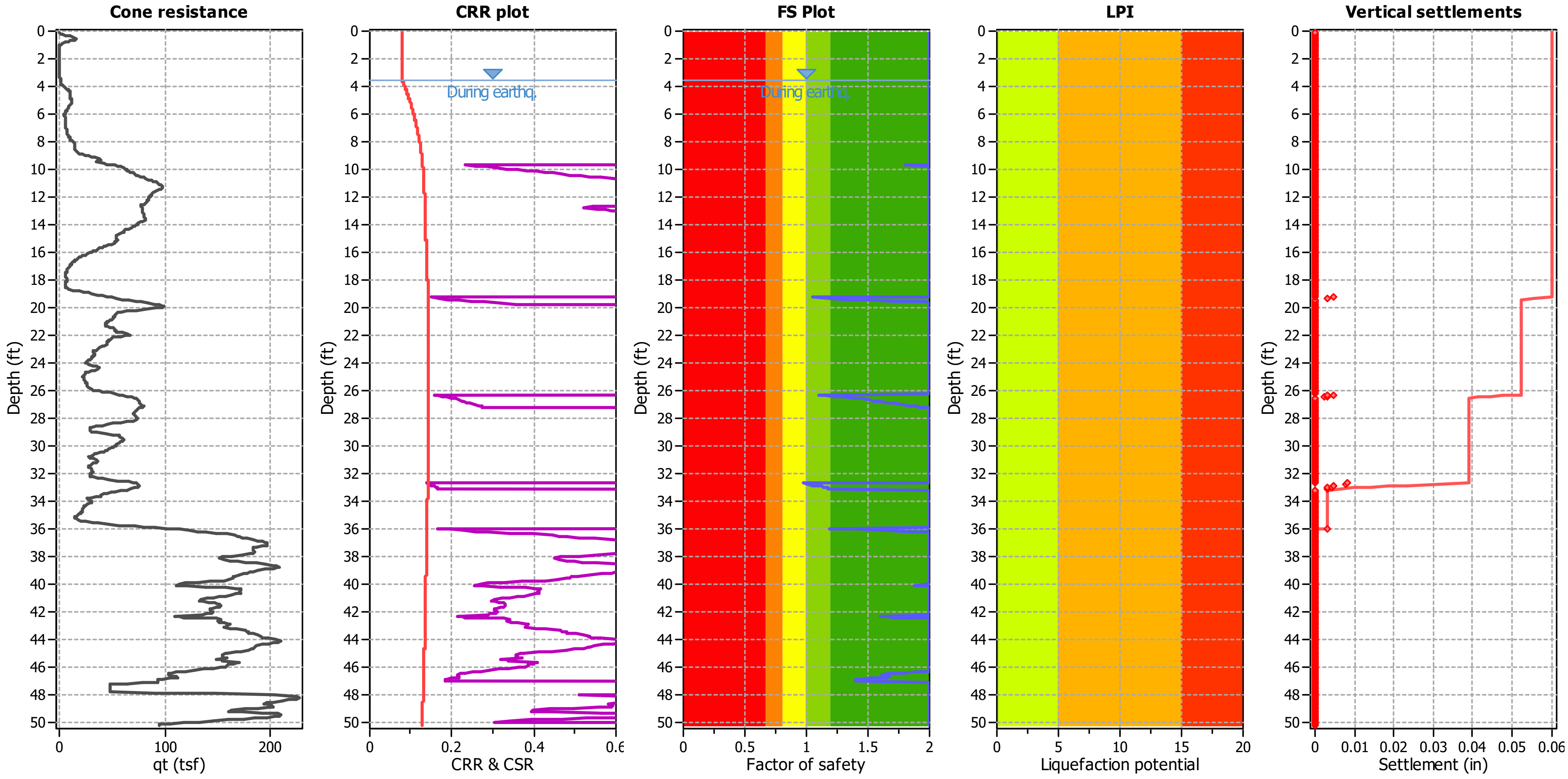
	Period (sec)	Sa (g)
	0.000	0.073
T_0 =	0.135	0.182
	0.200	0.182
T_S =	0.676	0.182
T =	0.750	0.164
	0.850	0.145
	0.950	0.129
	1.050	0.117
	1.150	0.107
	1.250	0.098
	1.350	0.091
	1.450	0.085
	1.550	0.079
	1.650	0.075
	1.750	0.070
	1.850	0.066
	1.950	0.063
	2.050	0.060
	2.150	0.057



Terracon Consultants Inc.
2201 Rowland Ave
Savannah, GA
http://www.terracon.com

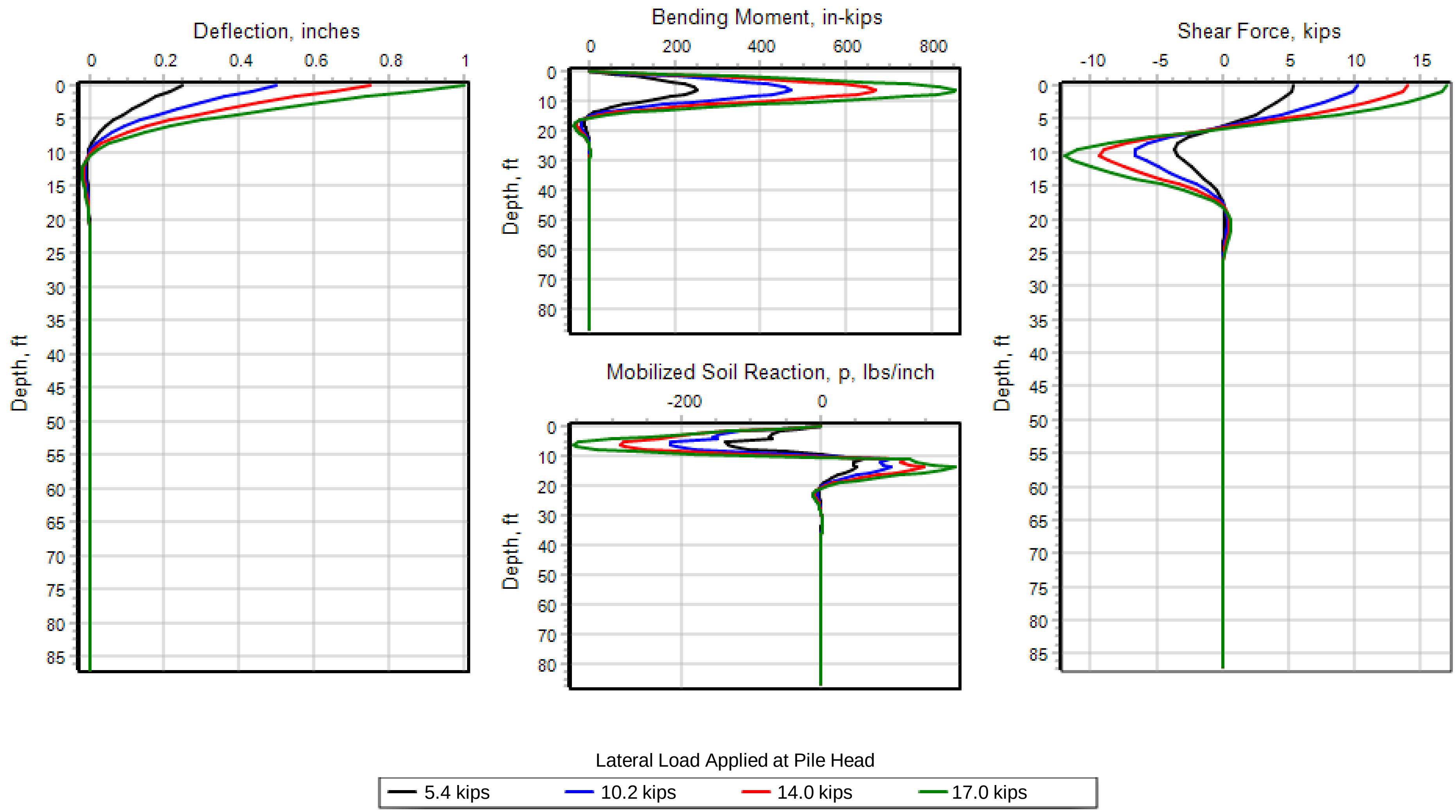
Project: Exit 42 Elevated Storage Tank
Location: Brunswick, GA

CPT: C2A
Total depth: 50.20 ft



Analysis method:	NCEER (1998)	G.W.T. (in-situ):	3.50 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	3.50 ft	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.10	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

12” PSC Piles, Static Loading, Free Head



Note:
- Depth in vertical axis means the distance below pile head.
- Pile head is at the existing ground surface
- Boring Location: B1

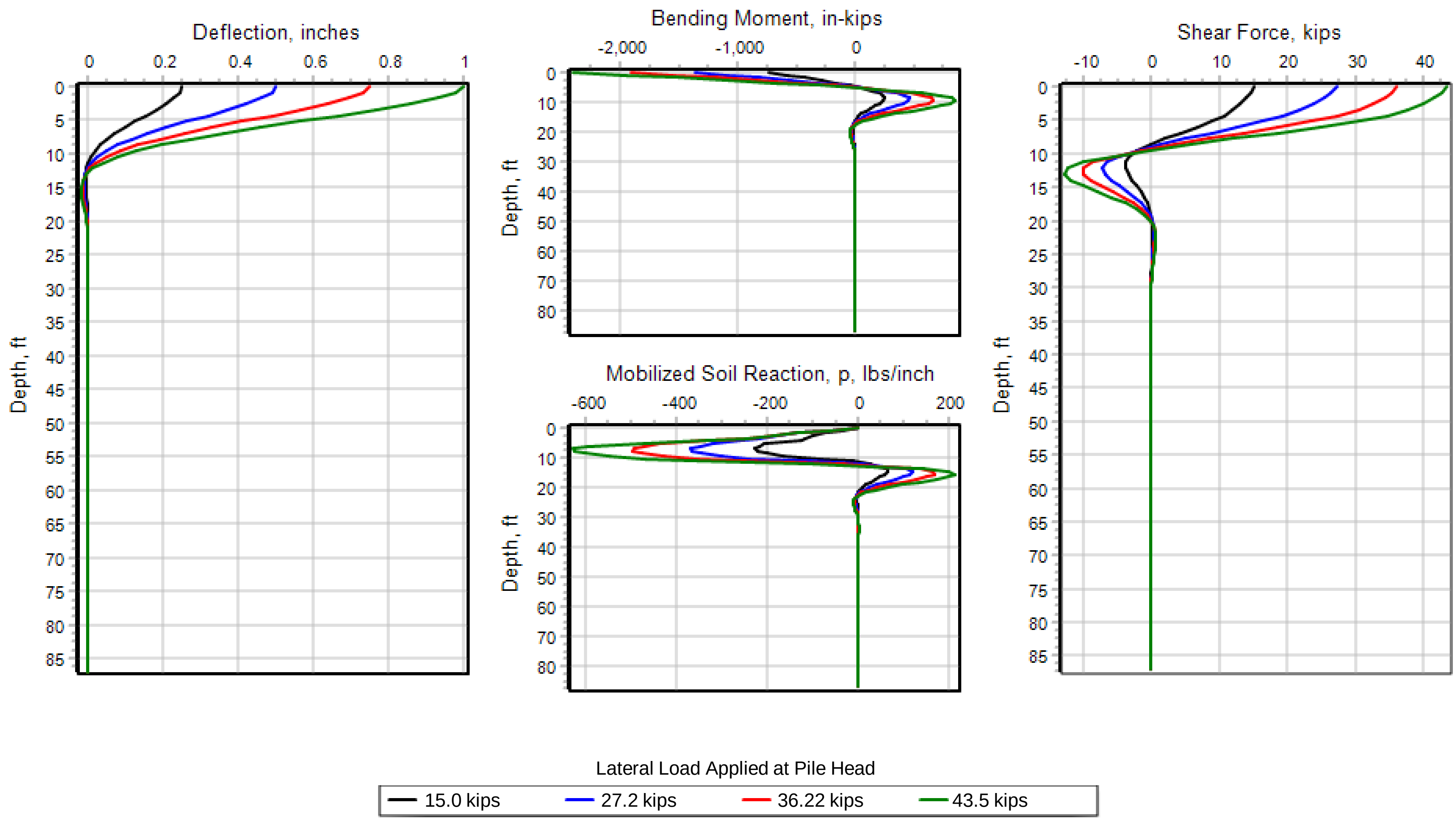
Project Manager: NA	Project No. ES235113
Drawn by: NA	Scale: N.T.S.
Checked by: CB	File Name:
Approved by: GL	Date: 06-29-2023

Terracon
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

12” PSC Piles, Static Loading, Fixed Head



Note:

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- Boring Location: B1

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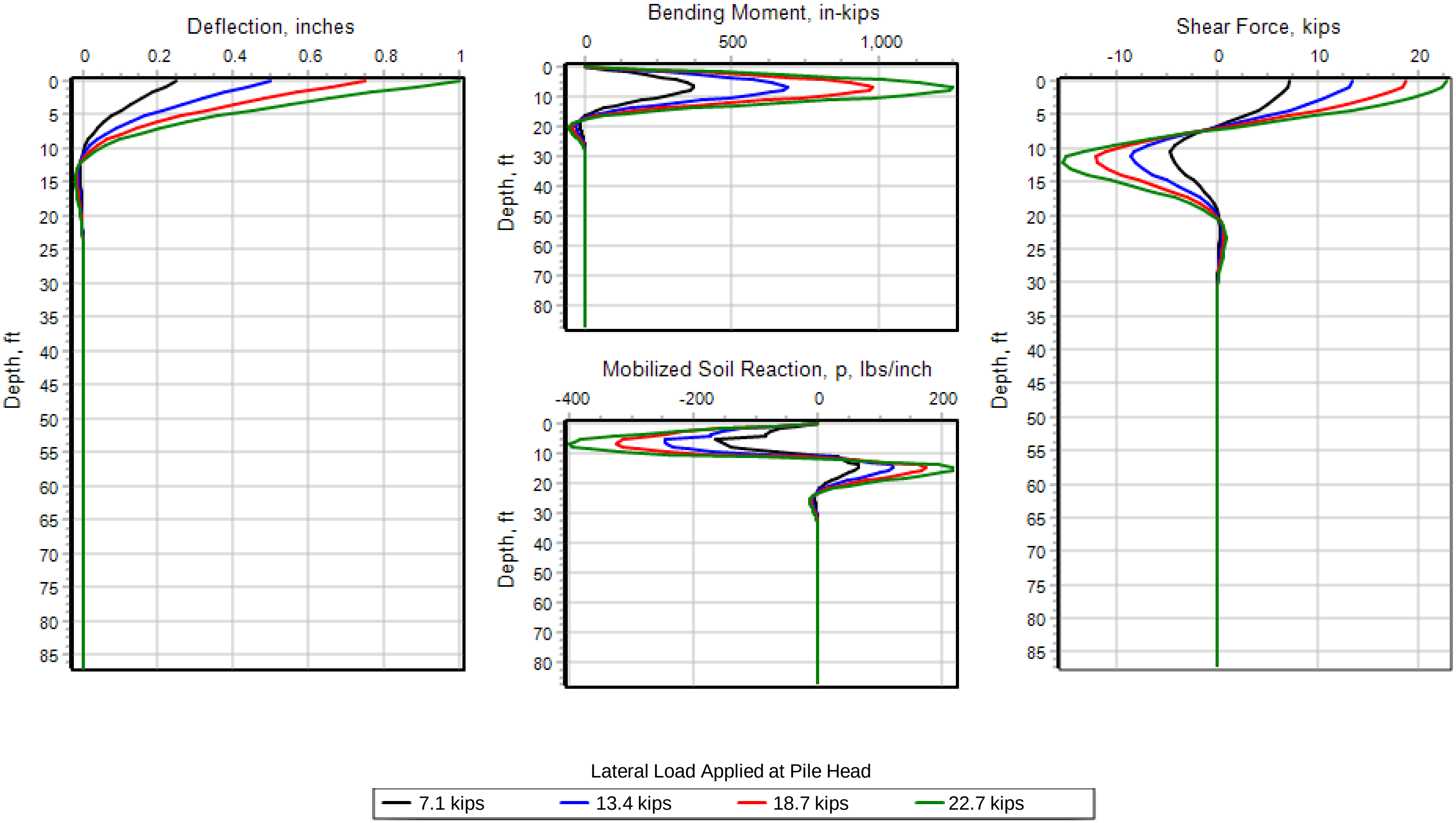
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

14” PSC Piles, Static Loading, Free Head



Note:
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- Boring Location: B1

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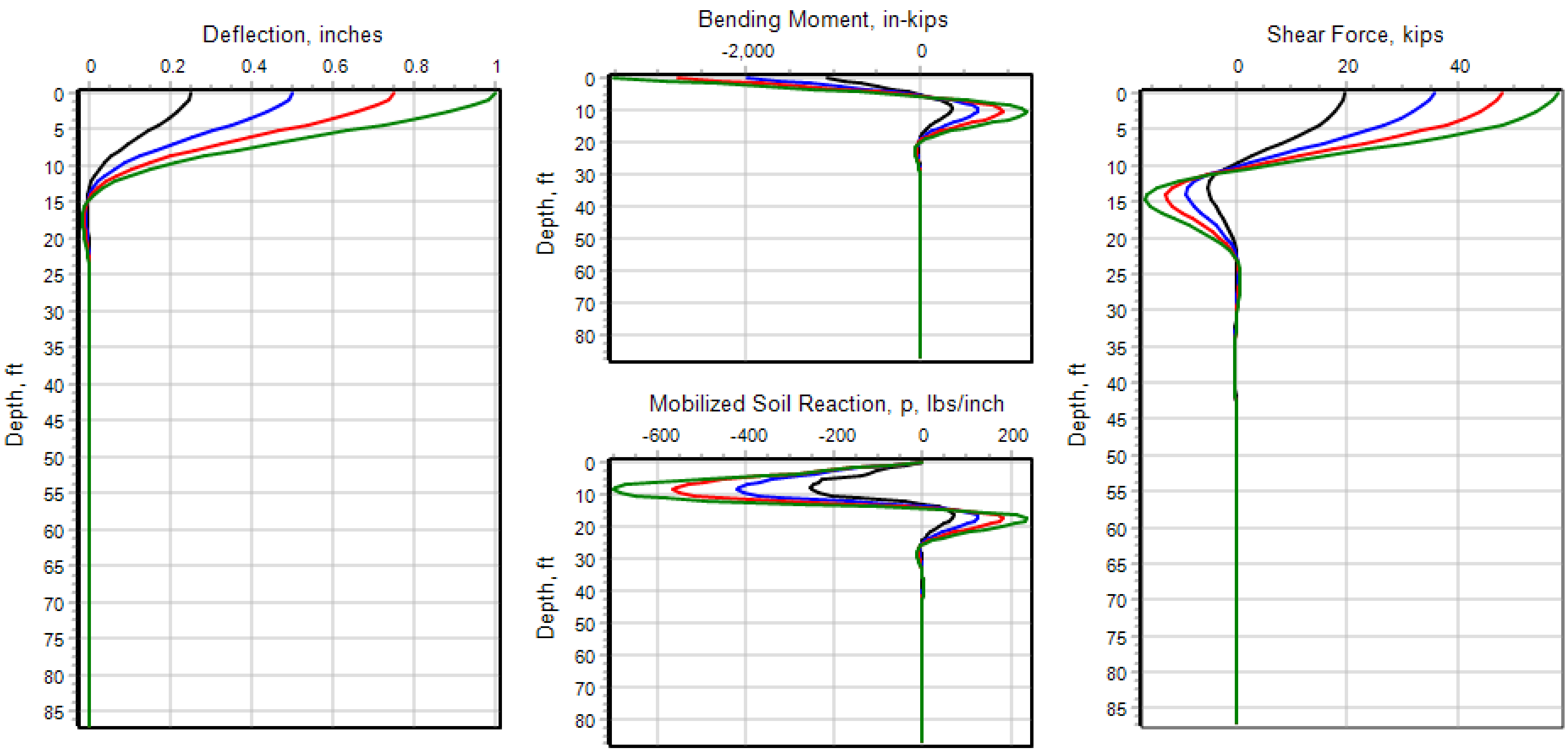
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

14” PSC Piles, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

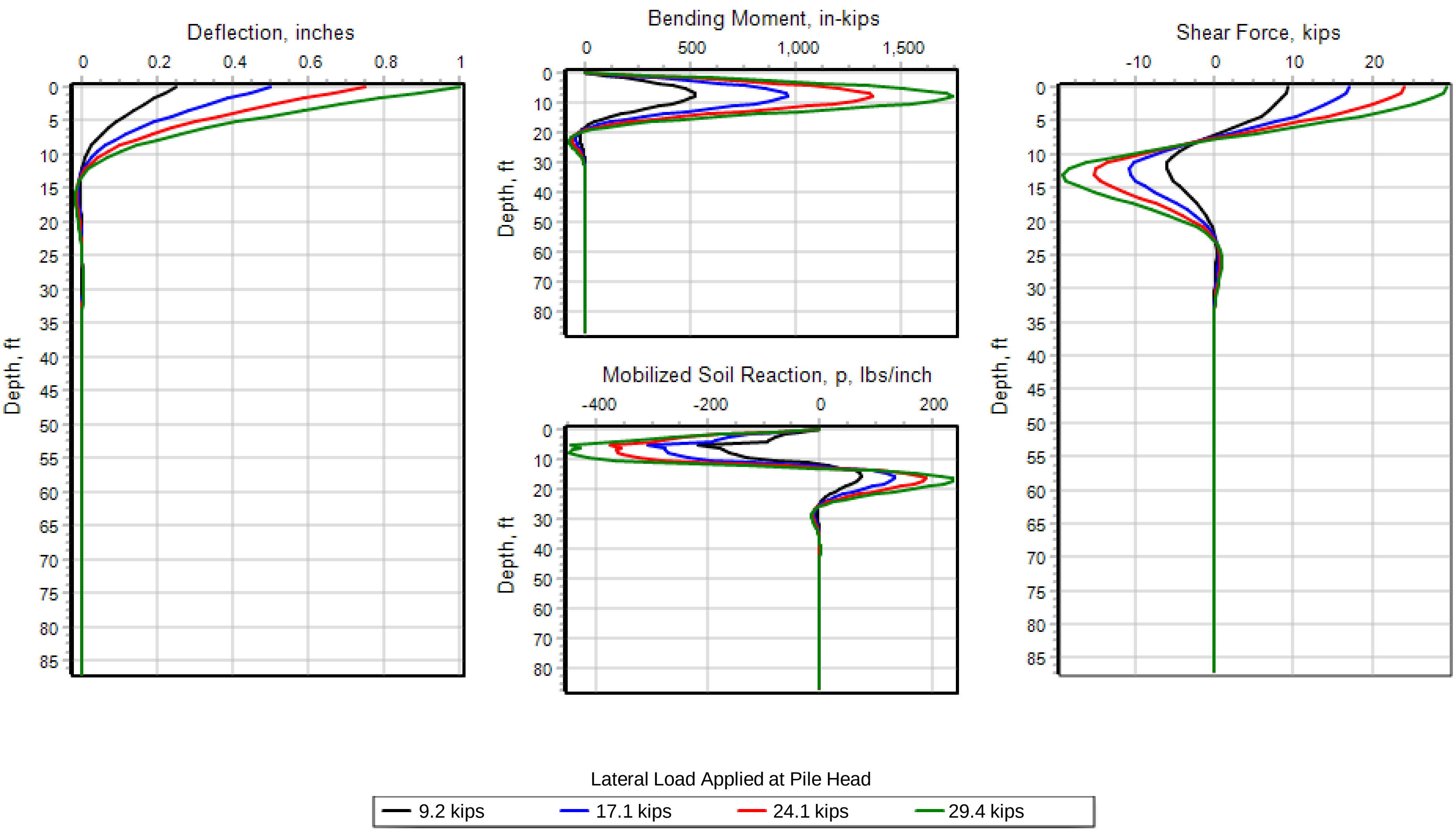
19.6 kips — 35.6 kips — 47.8 kips — 57.8 kips

Note:

- Depth in vertical axis means the distance below pile head.
- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113	Terracon	**LPILE Analyses**
Drawn by: NA	Scale: N.T.S.		**Exit 42 Elevated Storage Tank**
Checked by: CB	File Name:	2201 Rowland Avenue Savannah, Georgia 31404	Brunswick, Georgia
Approved by: GL	Date: 06-29-2023	Phone (912) 629 4000 Fax (912) 629 4001	

16” PSC Piles, Static Loading, Free Head



Note:

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- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113
Drawn by: NA	Scale: N.T.S.
Checked by: CB	File Name:
Approved by: GL	Date: 06-29-2023

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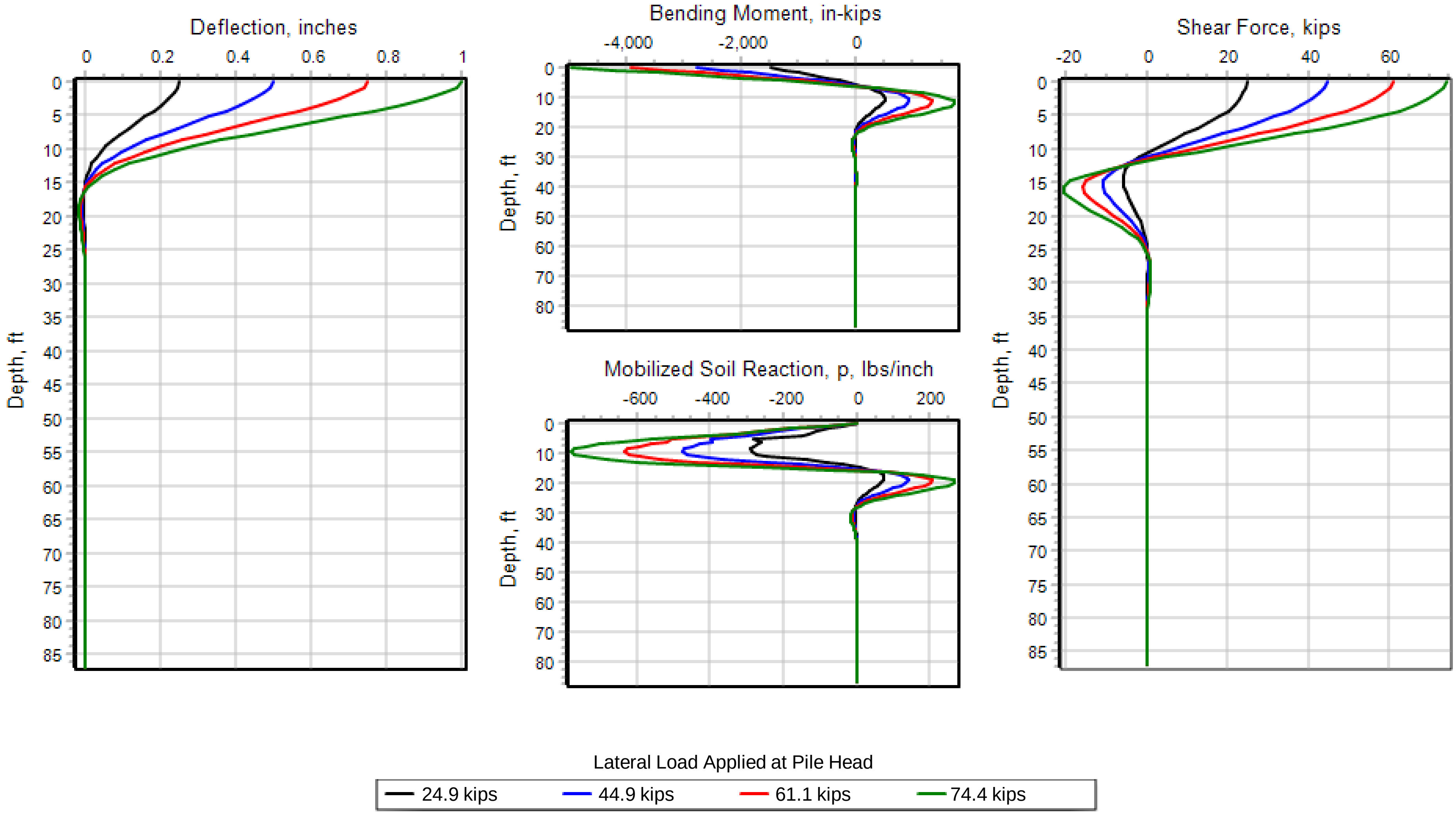
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

16” PSC Piles, Static Loading, Fixed Head



Note:

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- Boring Location: B1

Project Manager: NA	Project No. ES235113
Drawn by: NA	Scale: N.T.S.
Checked by: CB	File Name:
Approved by: GL	Date: 06-29-2023

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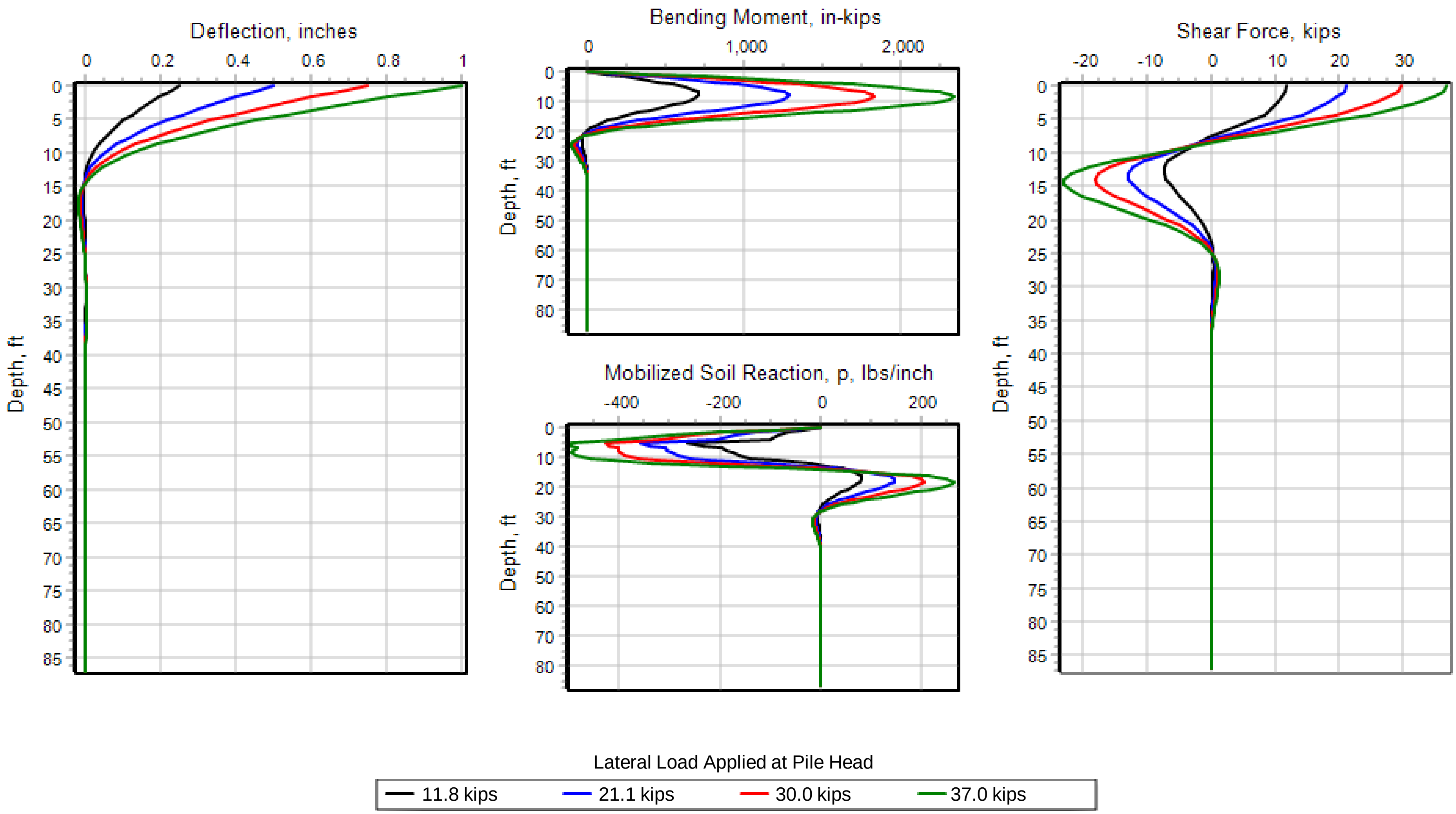
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

18” PSC Piles, Static Loading, Free Head



Note:
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- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager:	NA	**Project No.**	ES235113
Drawn by:	NA	**Scale:**	N.T.S.
Checked by:	CB	**File Name:**	
Approved by:	GL	**Date:**	06-29-2023

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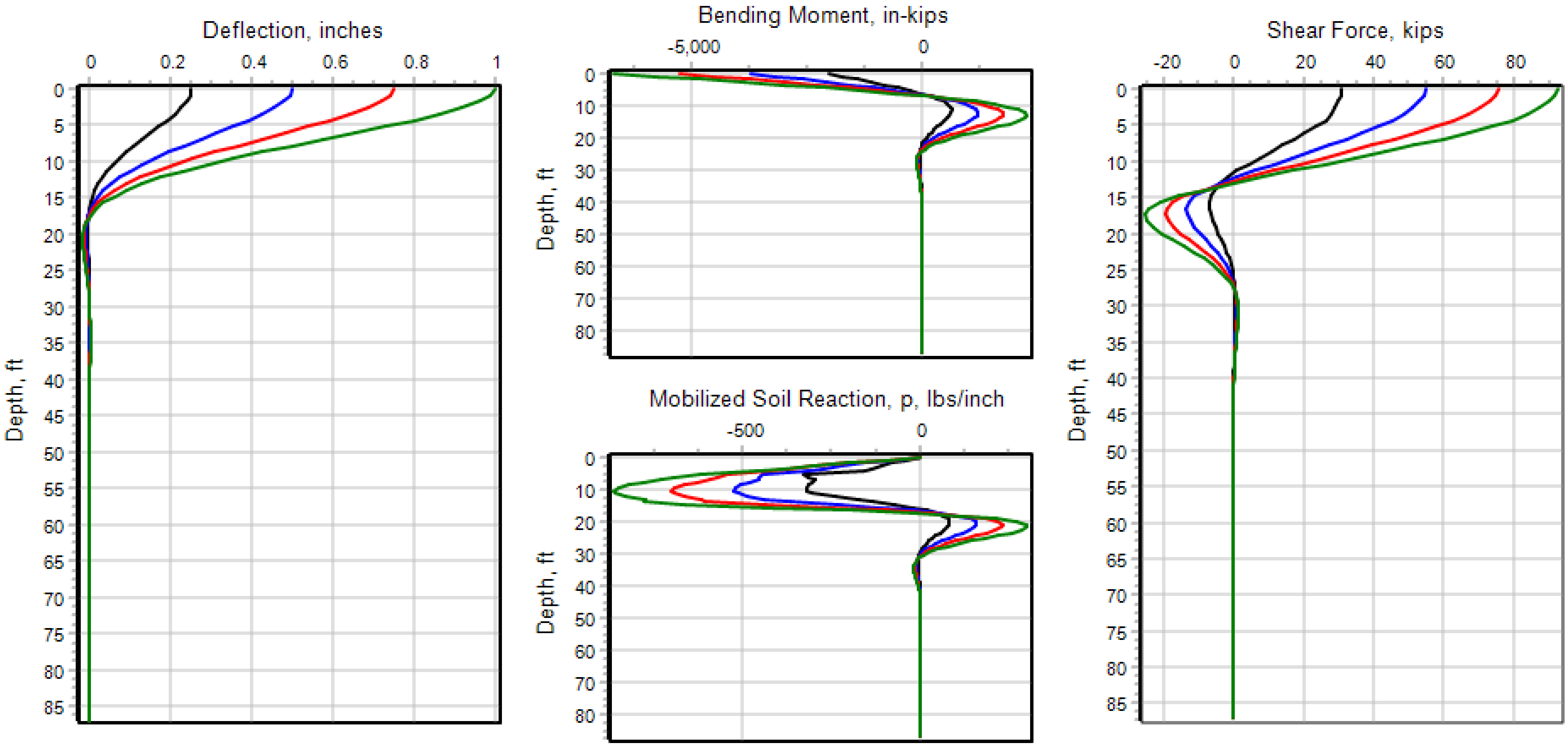
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

18” PSC Piles, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

31.0 kips | 55.1 kips | 75.9 kips | 92.8 kips

Note:
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- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113
Drawn by: NA	Scale: N.T.S.
Checked by: CB	File Name:
Approved by: GL	Date: 06-29-2023

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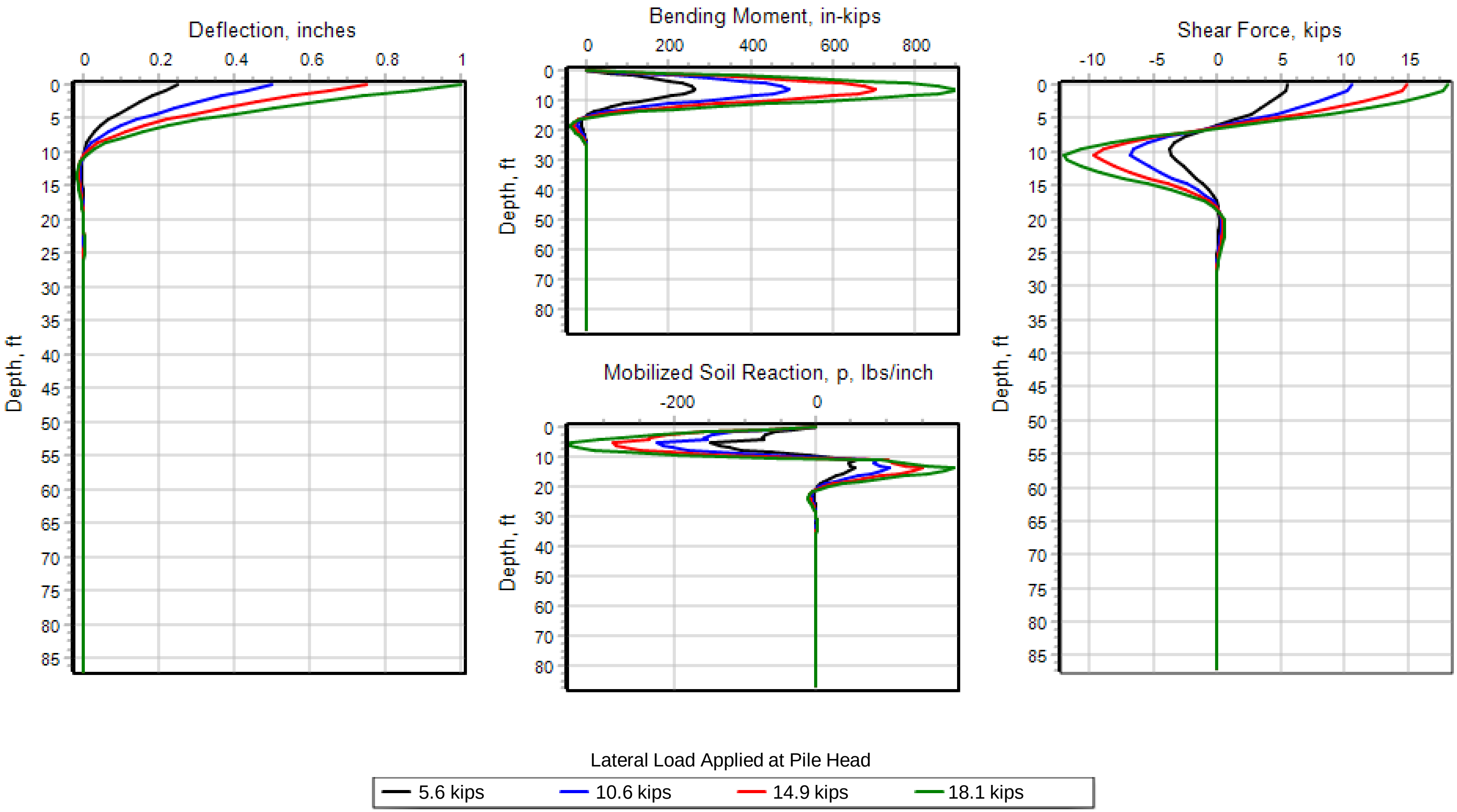
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

14” ACIP Piles, Static Loading, Free Head



Note:
- Depth in vertical axis means the distance below pile head.
- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113
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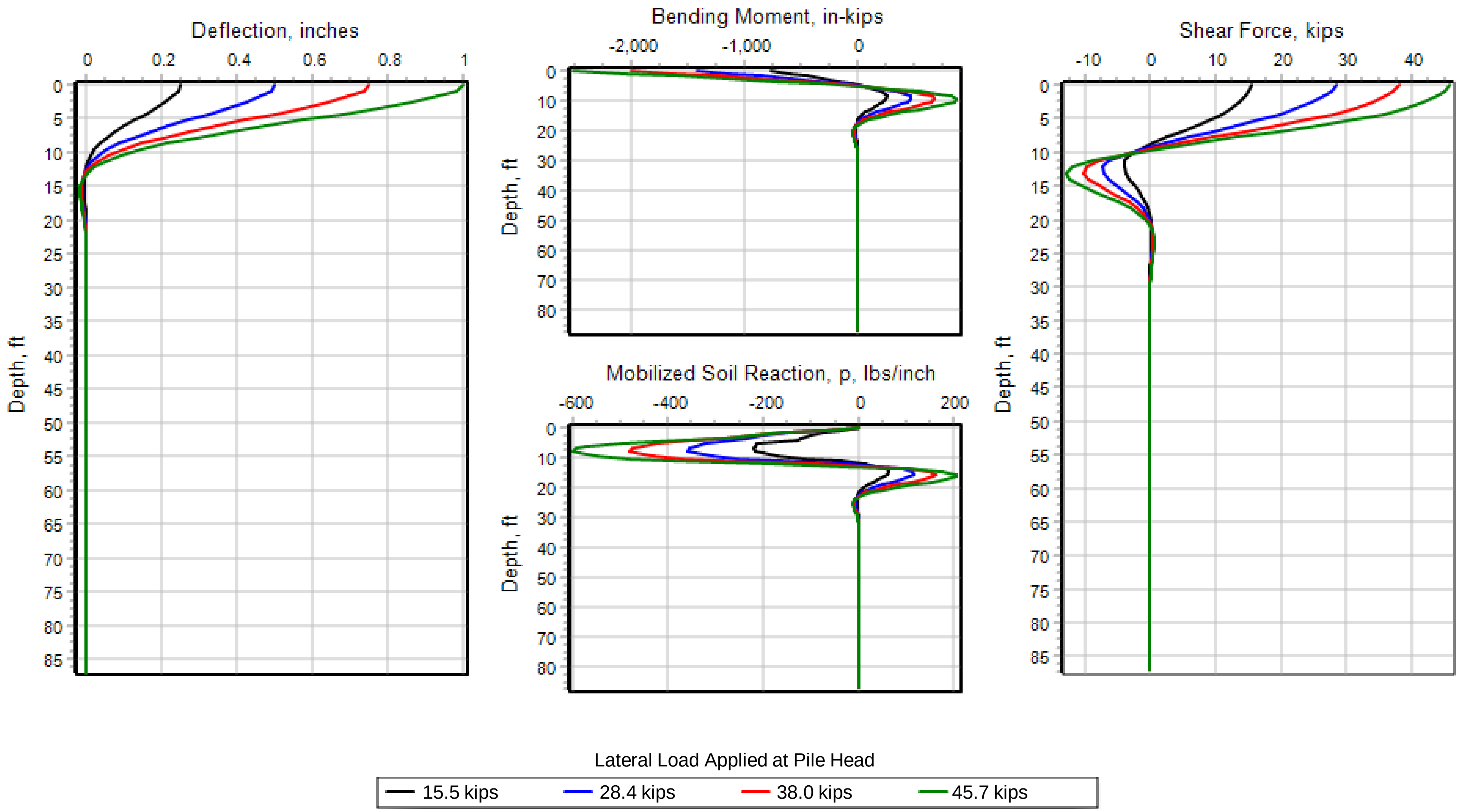
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

14” ACIP Piles, Static Loading, Fixed Head



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- Boring Location: B1

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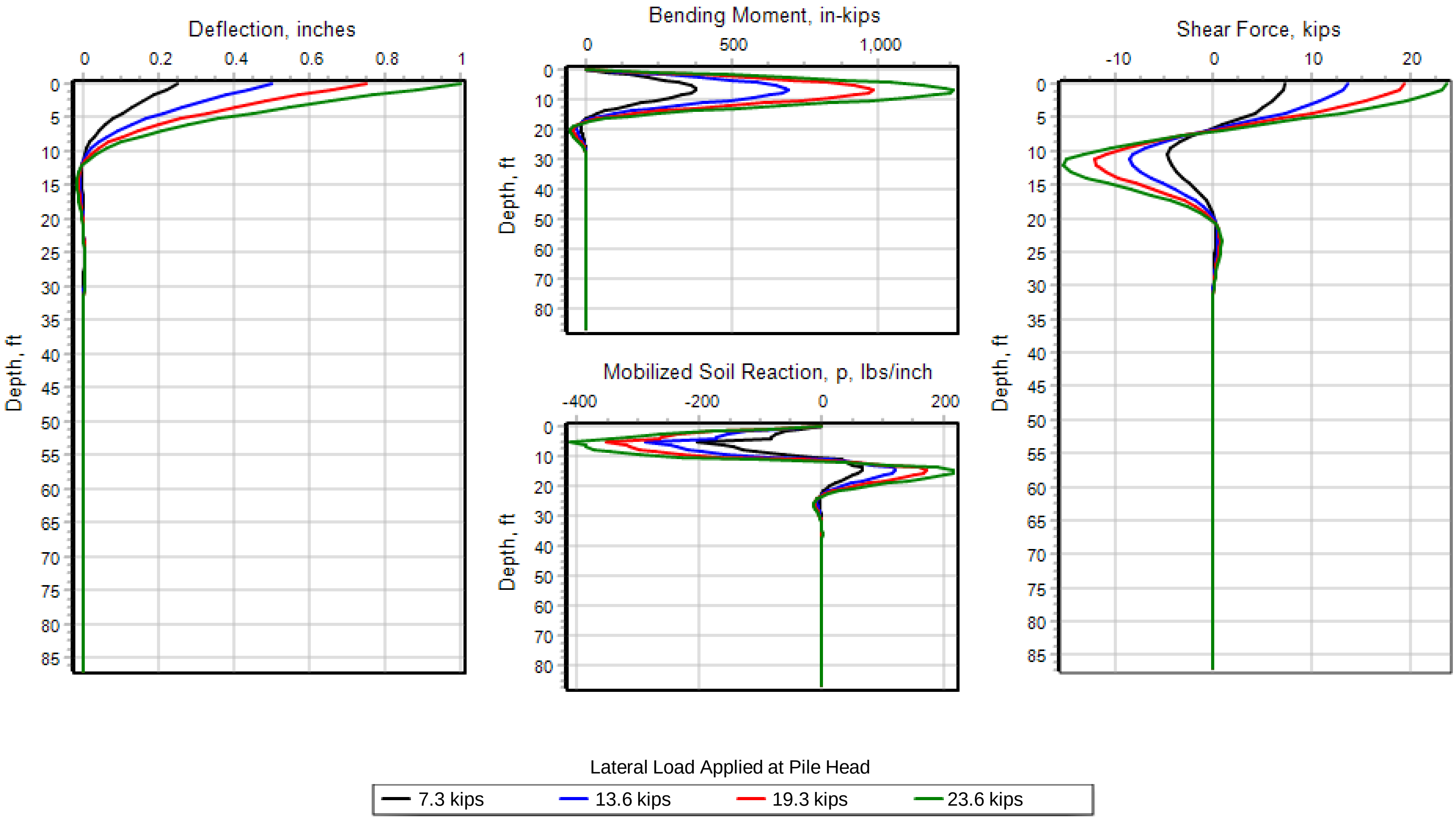
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

16” ACIP Piles, Static Loading, Free Head



Note:

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- Pile head is at the existing ground surface
- Boring Location: B1

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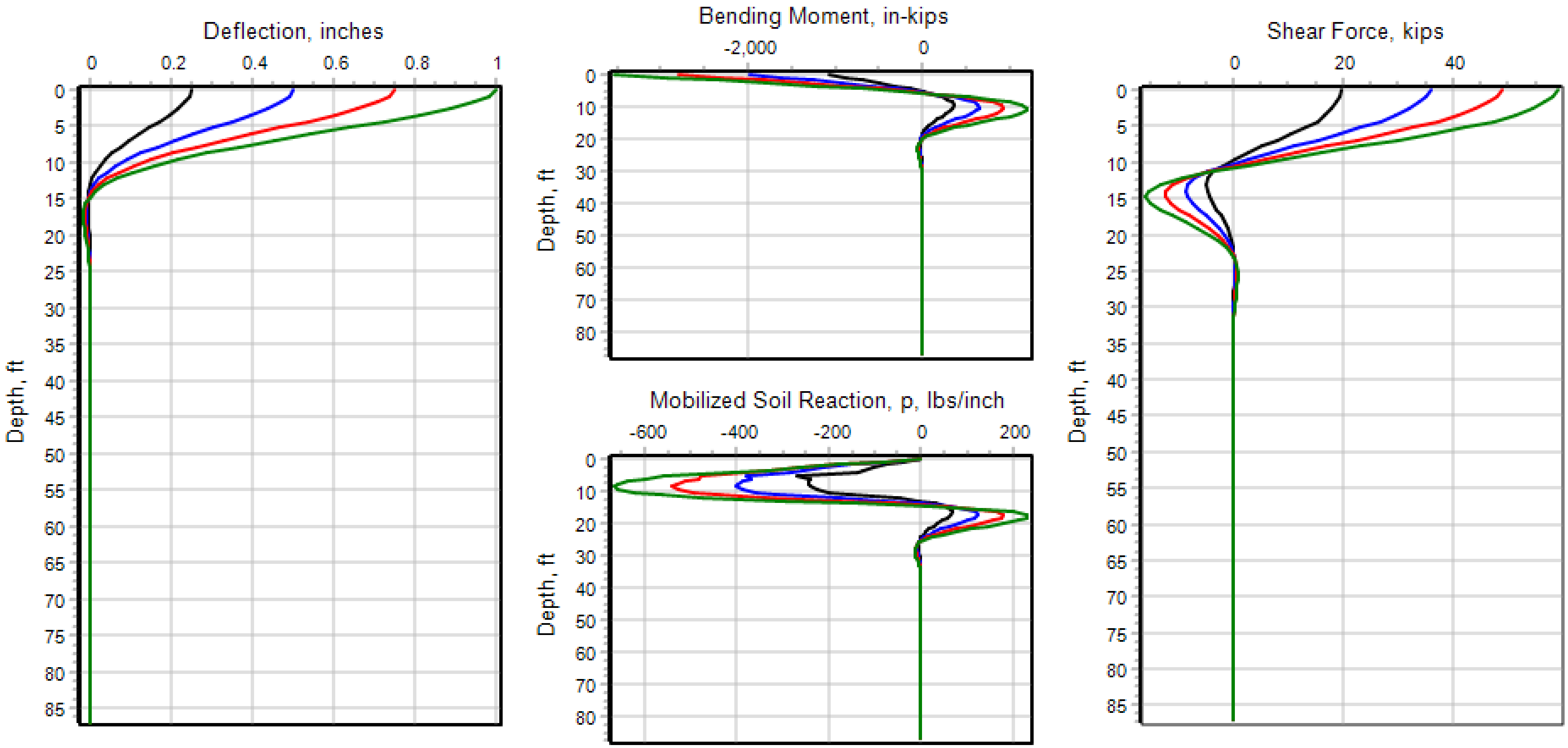
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

16” ACIP Piles, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

19.8 kips | 35.8 kips | 48.7 kips | 59.0 kips

Note:

- Depth in vertical axis means the distance below pile head.
- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113
Drawn by: NA	Scale: N.T.S.
Checked by: CB	File Name:
Approved by: GL	Date: 06-29-2023

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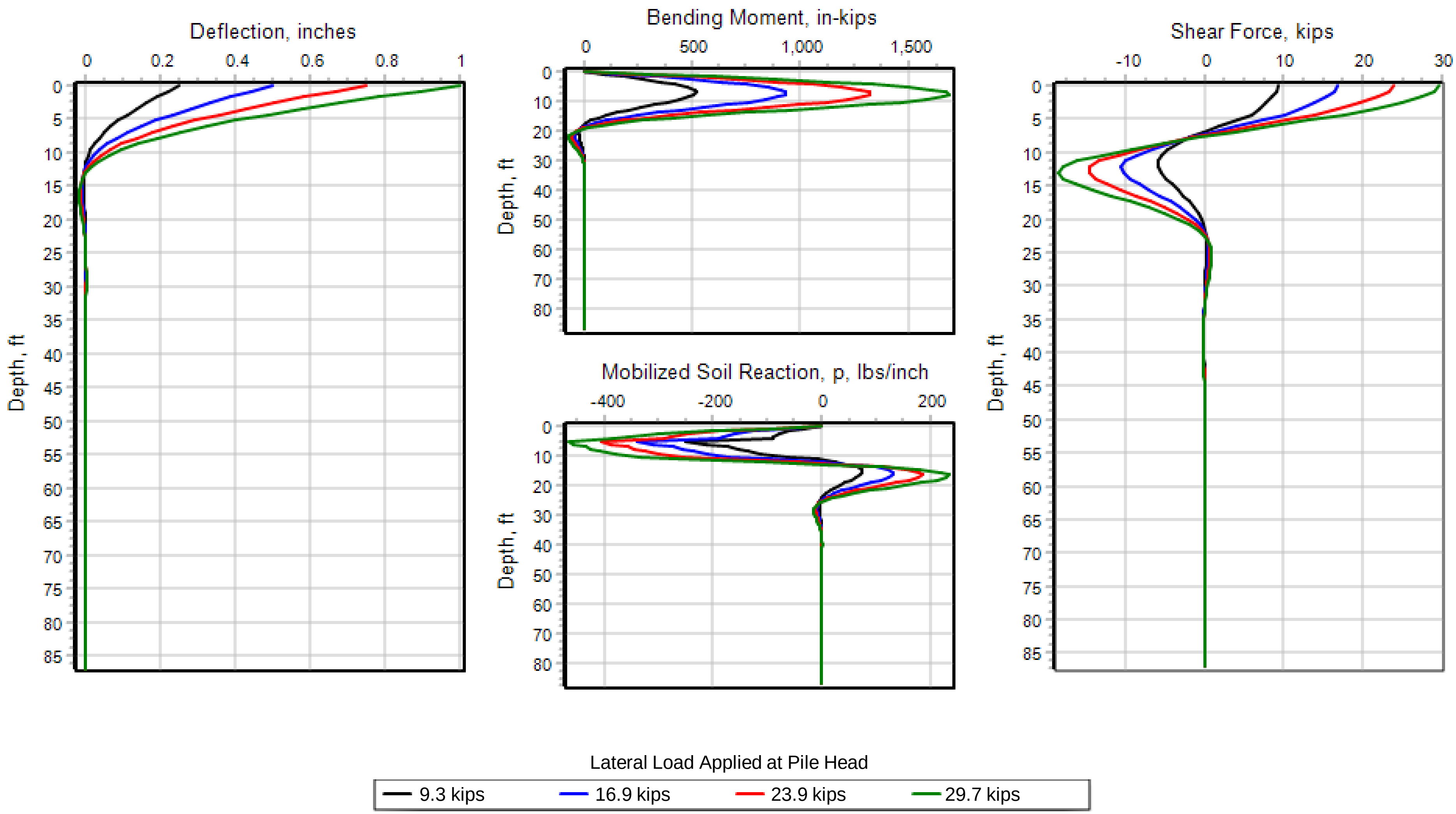
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

18” ACIP Piles, Static Loading, Free Head



Note:
- Depth in vertical axis means the distance below pile head.
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- Boring Location: B1

Project Manager: NA	Project No. ES235113
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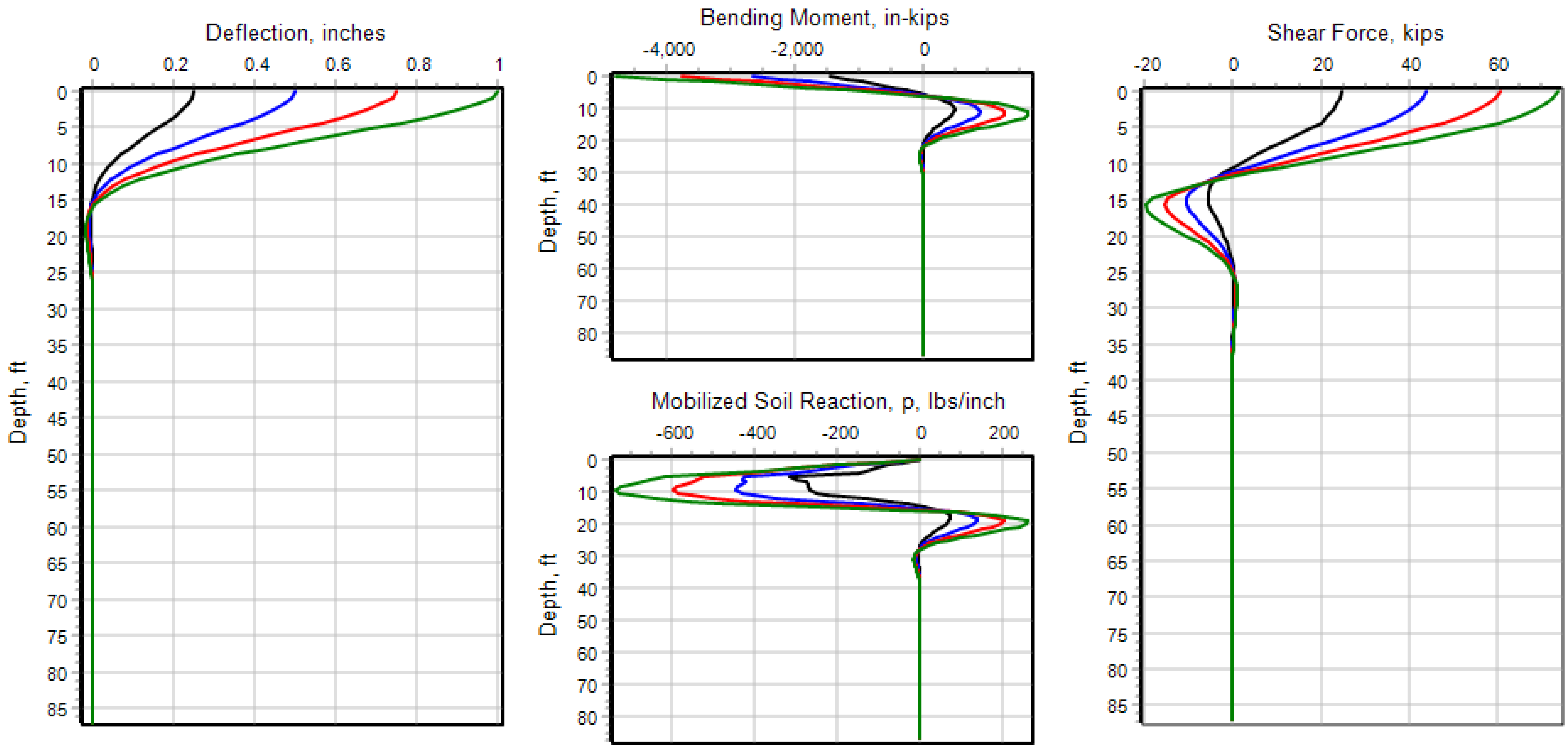
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

18” ACIP Piles, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

24.7 kips | 44.0 kips | 60.6 kips | 73.7 kips

Note:
- Depth in vertical axis means the distance below pile head.
- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113
Drawn by: NA	Scale: N.T.S.
Checked by: CB	File Name:
Approved by: GL	Date: 06-29-2023

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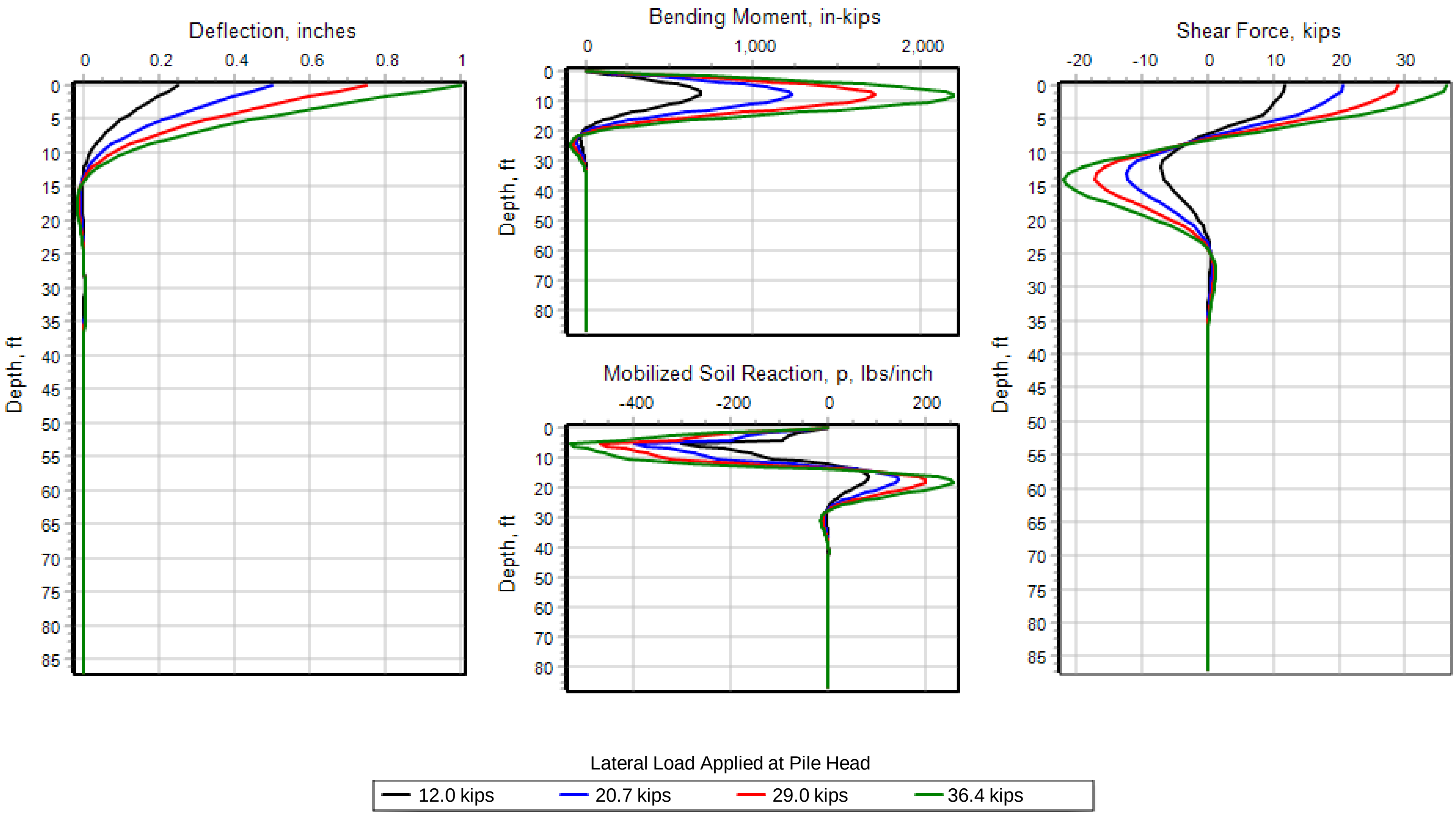
LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

20” ACIP Piles, Static Loading, Free Head



Note:

- Depth in vertical axis means the distance below pile head.
- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113	Terracon	**LPILE Analyses**
Drawn by: NA	Scale: N.T.S.		**Exit 42 Elevated Storage Tank**
Checked by: CB	File Name:		Brunswick, Georgia
Approved by: GL	Date: 06-29-2023		

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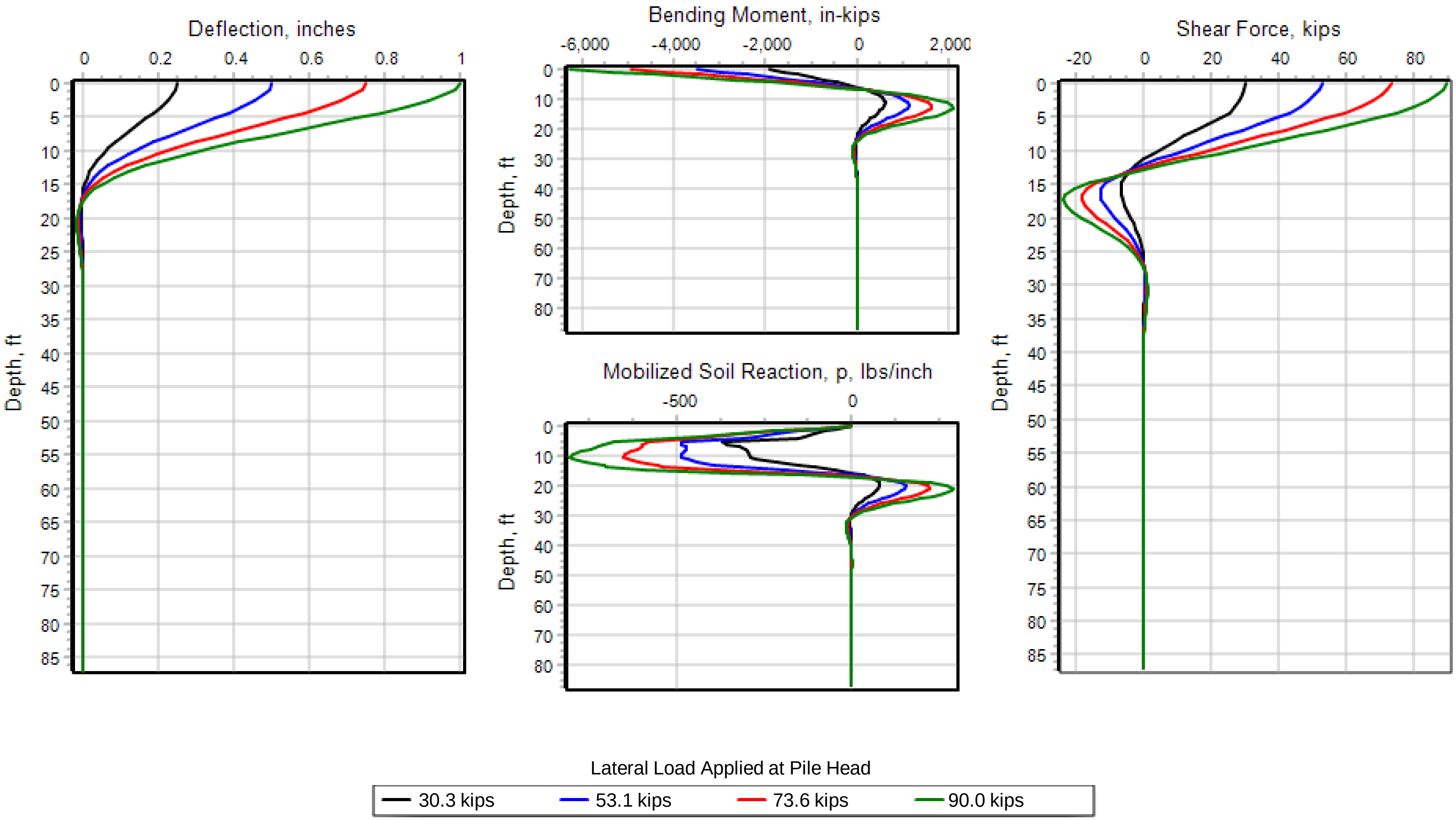
20” ACIP Piles, Static Loading, Fixed Head



Note:
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- Pile head is at the existing ground surface
- Boring Location: B1

Project Manager: NA	Project No. ES235113
Drawn by: NA	Scale: N.T.S.
Checked by: CB	File Name:
Approved by: GL	Date: 06-29-2023

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LPILE Analyses

Exit 42 Elevated Storage Tank
Brunswick, Georgia

CPT GENERAL NOTES

DESCRIPTION OF MEASUREMENTS AND CALIBRATIONS

To be reported per ASTM D5778:

Uncorrected Tip Resistance, q_c
Measured force acting on the cone divided by the cone's projected area

Corrected Tip Resistance, q_t
Cone resistance corrected for porewater and net area ratio effects
$q_t = q_c + U2(1 - a)$
Where a is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

Pore Pressure, U1/U2
Pore pressure generated during penetration
U1 - sensor on the face of the cone
U2 - sensor on the shoulder (more common)

Sleeve Friction, fs
Frictional force acting on the sleeve divided by its surface area

Normalized Friction Ratio, FR
The ratio as a percentage of fs to q_t, accounting for overburden pressure

To be reported per ASTM D7400, if collected:

Shear Wave Velocity, Vs
Measured in a Seismic CPT and provides direct measure of soil stiffness

DESCRIPTION OF GEOTECHNICAL CORRELATIONS

Normalized Tip Resistance, Q_t
$Q_t = (q_t - \sigma_{V0})/\sigma'_{V0}$

Over Consolidation Ratio, OCR
OCR (1) = $0.25(Q_t)^{1.25}$
OCR (2) = $0.33(Q_t)$

Undrained Shear Strength, Su
$Su = Q_t \times \sigma'_{V0}/N_{kt}$
N_{kt} is a geographical factor (shown on Su plot)

Sensitivy, St
$St = (q_t - \sigma_{V0}/N_{kt}) \times (1/fs)$

Effective Friction Angle, ϕ'
ϕ' (1) = $\tan^{-1}(0.373[\log(q_t/\sigma'_{V0}) + 0.29])$
ϕ' (2) = $17.6 + 11[\log(Q_t)]$

Unit Weight
$UW = (0.27[\log(FR)]+0.36[\log(q_t/atm)]+1.236) \times UW_{water}$
σ_{V0} is taken as the incremental sum of the unit weights

SPT N_{60}
$N_{60} = (q_t/atm) / 10^{(1.1268 - 0.2817Ic)}$

Soil Behavior Type Index, Ic
$Ic = [(3.47 - \log(Q_t))^2 + (\log(FR) + 1.22)^2]^{0.5}$

Small Strain Modulus, G_0
$G_0 = \rho Vs^2$

Elastic Modulus, Es (assumes $q/q_{ultimate}$ ~ 0.3, i.e. FS = 3)
Es (1) = $2.6\Psi G_0$
where $\Psi = 0.56 - 0.33\log Q_{t,clean\ sand}$
Es (2) = G_0
Es (3) = $0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{V0})$
Es (4) = $2.5q_t$

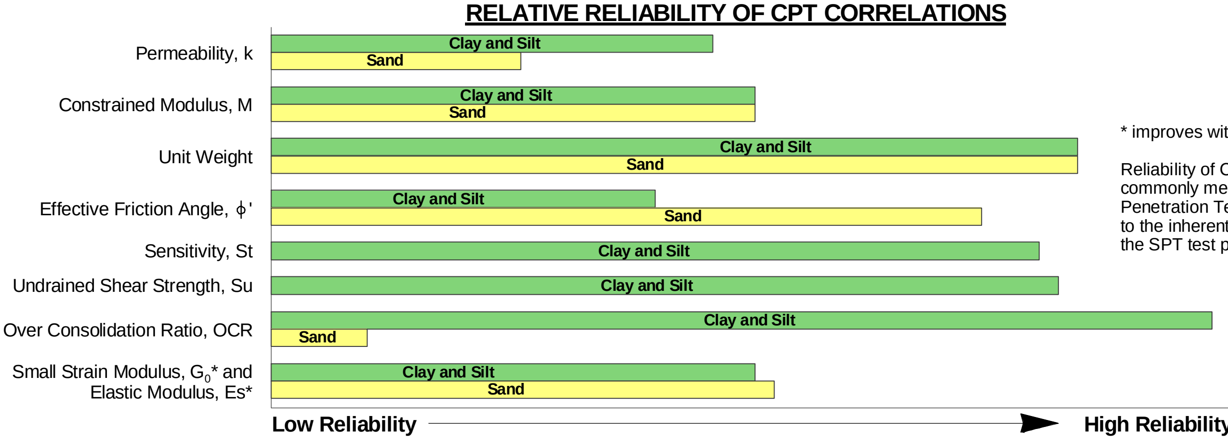
Constrained Modulus, M
$M = \alpha_M(q_t - \sigma_{V0})$
For Ic > 2.2 (fine-grained soils)
$\alpha_M = Q_t$ with maximum of 14
For Ic < 2.2 (coarse-grained soils)
$\alpha_M = 0.0188 \times 10^{(0.55Ic + 1.68)}$

Hydraulic Conductivity, k
For 1.0 < Ic < 3.27 $k = 10^{(0.952 - 3.04Ic)}$
For 3.27 < Ic < 4.0 $k = 10^{(-4.52 - 1.37Ic)}$

REPORTED PARAMETERS

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include tip resistance, sleeve resistance, and porewater pressure. Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters. The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

RELATIVE RELIABILITY OF CPT CORRELATIONS



* improves with seismic Vs measurements

Reliability of CPT-predicted N_{60} values as commonly measured by the Standard Penetration Test (SPT) is not provided due to the inherent inaccuracy associated with the SPT test procedure.

WATER LEVEL

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be "measured" or "estimated:"

Measured - Depth to water directly measured in the field

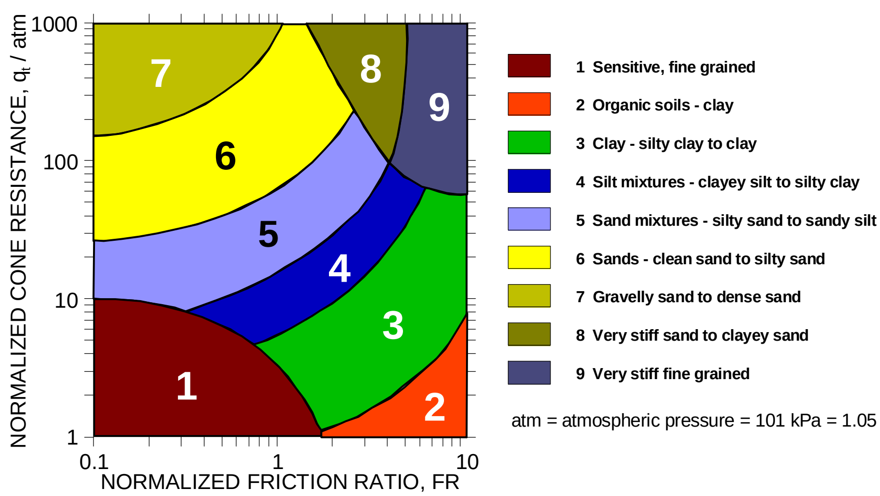
Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions

While groundwater levels displayed as "measured" more accurately represent site conditions at the time of testing than those "estimated," in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

CONE PENETRATION SOIL BEHAVIOR TYPE

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance (q_t), friction resistance (fs), and porewater pressure (U2). The normalized friction ratio (FR) is used to classify the soil behavior type.

Typically, silts and clays have high FR values and generate large excess penetration porewater pressures; sands have lower FRs and do not generate excess penetration porewater pressures. Negative pore pressure measurements are indicative of fissured fine-grained material. The adjacent graph (Robertson et al.) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability in onshore CPTs.



atm = atmospheric pressure = 101 kPa = 1.05 tsf

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Robertson, P.K., Cabal, K.L. (2012). "Guide to Cone Penetration Testing for Geotechnical Engineering," Signal Hill, CA.
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Terracon

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger
Split Spoon
Shelby Tube
Macro Core
No Recovery
Rock Core
Ring Sampler

GROUNDWATER

Groundwater Initially Encountered

Groundwater Level After a Specified Period of Time

Static Groundwater Level After a Specified Period of Time

No Groundwater Observed

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	Std. Penetration Resistance (blows per foot)	Descriptive Term (Consistency)	Undrained Shear Strength (kips per square foot)	Std. Penetration Resistance (blows per foot)
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium-Stiff	0.50 to 1.00	5 - 7
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 14
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	above 4.00	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Descriptive Term(s) of other constituents	Percent of Dry Weight
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	**Group Name** [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.