Geotechnical Engineering Investigation

Travis Field WWTF
Savannah, Georgia

March 15, 2018
Terracon Project No. ES185011

Prepared for:

Thomas & Hutton
Savannah, Georgia

Prepared by:

Terracon Consultants, Inc.
Savannah, Georgia

March 15, 2018

Thomas & Hutton
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Attn: Mr. Fred Sororian, P.E.
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Re: Geotechnical Engineering Investigation
Travis Field WWTF
Savannah, Georgia
Terracon Project No. ES185011

Dear Mr. Sororian:

Terracon Consultants, Inc. (Terracon) has completed our Geotechnical Engineering Investigation for the above-referenced project. The services were performed in general accordance with the signed subcontract for services dated January 24, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations for the proposed construction.

We appreciate the opportunity to be of service to you. Should you have any questions concerning this report or if we may be of further service, please contact us at your convenience.

Sincerely,
Terracon Consultants, Inc.

GEORGIA Registered PROFESSIONAL Engineer GUOMING LIN

Yan Jiang, Ph.D., P.E.	Guoming Lin, Ph.D., P.E., D.GE.
Senior Staff Engineer	Senior Principal

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1 – File

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Terracon

EXECUTIVE SUMMARY

This report presents the results of our Geotechnical Engineering Investigation for the proposed improvements at the Travis Field Waste Water Treatment Facility (WWTF) with associated driveways and parking area within the Georgia Air National Guard at the southeast corner of the Savannah/Hilton Head International Airport in Savannah, Georgia. The investigation included a field exploration program and engineering evaluation of the subsurface conditions and foundation recommendations.

Based on the results of the subsurface exploration and analyses, we identified the following geotechnical considerations:

- In general, the subsurface soils consist of sandy clays in the upper 11 feet below ground surface (BGS), followed by a layer of variable soils including clayey sands or sands with clays and sandy clays to elevations of -12 to -14 feet. Below this layer of variable soils are sands with clays or silts or silty sands to elevations of -26 to -38 feet followed by sandy silts (Marl) to the termination of SPT boring at an elevation of about -51 feet. A detailed discussion about the subsurface conditions is provided in **Section 3.1**.
- Groundwater depth was measured at approximately depths of 3 to 12.5 feet BGS (corresponding to elevations of 8 to 6.5) within the SPT borings at the time of our field exploration and 24 hours after the field exploration. The groundwater level should be checked prior to construction in order to assess its effects on site work and other construction activities.
- We performed settlement analyses using the provided structural loads as discussed in Section 2.0, and soil profiles and parameters obtained from the field exploration. Based on the settlement analyses, we conclude that the effluent pump station can be supported on a shallow foundation. The proposed new treatment tank and building for new sludge dewatering system should be supported on a deep foundation system.
- Three commonly used pile foundations: prestressed concrete (PSC) piles, steel H-piles and augered cast-in-place (ACIP) piles were evaluated for the deep foundation system. See calculated pile capacities in Section 4.6 of this report.
- A net allowable bearing capacity of 2,500 pounds per square foot (psf) is recommended for the shallow foundation design. The allowable bearing capacity may be increased by 1/3 for transient wind load and seismic load conditions.
- For the seismic design, Terracon classifies the subject site as Site Class D in accordance with the International Building Code IBC (2012) and ASCE 7-10 Section 11.4.2.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and **the report must be read in its entirety** for a comprehensive understanding of the items and recommendations contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report's limitations.

GEOTECHNICAL ENGINEERING INVESTIGATION

Travis Field WWTF
Savannah, Georgia

Terracon Project No. ES185011
March 15, 2018

1.0 INTRODUCTION

Terracon has completed our Geotechnical Engineering Investigation for the proposed new construction at the existing Travis Field Waste Water Treatment Facility (WWTF) with associated driveways and parking area within the Georgia Air National Guard at the southeast corner of the Savannah/Hilton Head International Airport in Savannah, Georgia. The general location of the project site and its vicinity are shown on the Site Location Map in **Exhibit A-1**, **Appendix A**.

The investigation included a field exploration program and engineering evaluation of the subsurface conditions and foundation recommendations. The subsurface conditions within the proposed site were explored with seven Standard Penetration Testing (SPT) borings. The SPT borings were drilled to depths of approximately 35 to 70 feet below ground surface (BGS). The boring locations are shown in **Exhibit A-2, Appendix A**. Detailed boring logs are also included in **Appendix A**.

The purpose of our investigation was to evaluate the existing subsurface conditions at the project site and develop conclusions and geotechnical recommendations for the proposed construction. The following study was conducted in accordance with our scope of services outlined in the signed subcontract for services dated January 24, 2018:

- subsurface soil conditions
- site preparation
- seismic considerations
- groundwater conditions
- foundation design and construction
- pavement recommendation

2.0 PROJECT INFORMATION

Item	Description
Site location	The site is located within the Georgia Air National Guard at the southeast corner of the Savannah/Hilton Head International Airport in Savannah, Georgia. Latitude: 32.1131°, Longitude: -81.1863°

Item	Description
Existing improvements	Travis Field Water Reclamation Facility.
Current ground cover	The site has a waste water pond, two tanks, pipelines, other facility buildings.
Existing topography	The dike top around the waste water pond is at an elevation of 19 feet which is about 6 to 7 feet higher than other area of the project site.
Proposed improvements	The proposed project will include the construction of new waste water treatment facility with associate driveways and parking area.
Finished floor elevation	The bottom of the tank is at an elevation of 12 feet based on the document of "Hydraulic Profile" provided by Thomas & Hutton.
Maximum loads	Based on an email communication with Mr. Fred Sororian of Thomas & Hutton on February 27, 2018, we understand that a concrete treatment tank will be constructed in Phase I to hold about 1.5 million gallon water. The tank is 200 feet long, 80 feet wide, and 22 feet high. The tank wall is about 24 inches thick and the tank bottom is about 32 to 36 inches thick. The total weight of the tank with 1.5 million gallon water is about 23,400 kips and the corresponding slab load is about 1,460 psf. Based on the oral communication with Mr. Fred Sororian of Thomas & Hutton on March 6, 2018, we understand that the bottom of the slab of the pump station will be constructed at an elevation of about -7 feet. The wall of the pump station will be 20 feet high and the slab of the pump station will be 25 feet long and 25 feet wide. The thickness of the wall and the slab is about 12 and 20 inches, respectively. Assuming the pump station can hold the 9,062 ft^3 water (based on the water level in the pump station is at an elevation of 8.5 feet as shown in Hydraulic Profile provided) and the total weight of the pump station with the water is about 1,022 kips. Since the effluent pump station is constructed underground, the estimated buoyancy force due to groundwater will be about 780 kips. Based on an email communication with Mr. Fred Sororian of Thomas & Hutton on March 6, 2018, we understand that the new sludge dewatering system will be construction on the final grade with a prefabrication metal building. This building has an 18 inch thick slab with 1500 psf slab load. **We assume that no additional fill will be added on site for the settlement analyses.** If heavier structural loads are required or if more stringent settlement criteria are required, Terracon should be retained to perform an additional evaluation.
Maximum allowable settlement	The following settlement criteria were assumed for the settlement analyses. Total settlement: 1 inch (assumed). Differential settlement: ½ inch over 40 feet (assumed).

Item	Description
Grading	The existing Water Reclamation Facility including the pond, two tanks, roads, other buildings will be demolished. It is anticipated the site will be graded with a minimal amount of cut and fill.

Should any of the above information or assumptions be inconsistent with the planned construction, Terracon should be informed so that modifications to this report can be made as necessary.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of our field exploration program, we developed generalized soil profiles to represent the soil conditions of the project site, and they can be generalized as follows:

Description	Approximate Elevation to Bottom of Stratum (BGS)	Soil Classification based on SPT borings	Blow Counts
Stratum 1	8 feet	Sandy clays	13 to37
Stratum 2 (variable soils)	-12 to -14 feet	Clayey sands or sands with clay	0 to 14
		Sandy clays	
Stratum 3	-26 to -38	Sands with clays or silt or silty sands	14 to 50+
Stratum 4	-51 feet (SPT termination)	Sandy silts (Marl)	40 to 50+

Note: The existing grades range from EL. 19.0 to 11.8, but mostly at EL 19.0.

Details of subsurface conditions encountered at each boring location are presented in the individual SPT boring logs in **Appendix A** of this report. Stratification boundaries on the logs represent the approximate depth of changes in soil types; the transition between materials may be gradual.

3.2 Groundwater

Groundwater depth was measured at approximately depths of 3 to 12.5 feet BGS (corresponding to elevations of 8 to 6.5 feet) within the SPT borings at the time of our field exploration and 24 hours after the field exploration. Please refer to the individual boring for groundwater depth encountered in each test location. It should be noted that groundwater levels tend to fluctuate with tidal, seasonal and climatic variations, as well as with construction activities. As such, the possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. The groundwater table should be checked prior to construction to assess its effect on site work and other construction activities.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

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 and these recommendations must be re-evaluated to make appropriate revisions.

4.1 Geotechnical Considerations

The generalized soil profile is presented in **Section 3.1**. We performed settlement analyses using the structural loads and soil profiles and parameters derived from the SPT borings. The structural loads were discussed in Section 2.0. Based on the results of our settlement analyses, the total settlement of the effluent pump station was estimated to be less than 1.0 inch. As such the effluent pump station can be supported by a shallow foundation system. If heavier structural loads are required or if more stringent settlement criteria are required, Terracon should be retained to perform an additional evaluation.

For the new treatment tank and building for the sludge dewatering system, the total settlements were estimated to be greater than 1.0 inch. As such, a deep foundation system is required to mitigate the risk of settlement.

Three commonly used piles, augered cast-in-place (ACIP) piles, prestressed concrete (PSC) piles, and steel H-Piles were evaluated to support the new treatment tank and building for the sludge dewatering system. We performed pile capacity analyses for these three types of piles. In general, the piles shall be installed at least 5 feet into the Marl formation which appeared at an elevation of -33 feet. The estimated pile capacities and pile installation recommendations are presented in Section 4.6 of this report.

In addition, since the effluent pump station will be constructed underground, the buoyancy force due to the ground water will be about 780 kips. As such, the lowest water level in the pump station should be sustained in order to overcome an uplift due to this buoyancy force.

We understand that the existing pond, two tanks, roads, and other buildings will be demolished and sludge, waste or unsuitable materials encountered during the demolition need to be excavated and removed. Any undercuts should be backfilled with well compacted fills which should be a non-plastic granular material containing less than 25 percent fines passing the No. 200 sieve.

Based on the hydraulic profile dated Mach 7, 2018 provided by Thomas & Hutton, several pipelines will be buried in the ground to connect the new tank and pump stations and other equipment. The differential settlement will increase the risk of the damage of the pipeline system. We recommend the connection between pipelines and equipment be able to accommodate the differential settlements in order to reduce the risk of the damage of the pipeline system.

4.2 Subgrade Preparation

The site clearing should strip topsoil, rootmat and organics after the demolition of the existing pond, two tanks, roads, and other buildings. Roots larger than one inch in diameter should be cut off two feet beneath the top of the subgrade. During the subgrade preparation, sludge, waste and unsuitable materials within ponds and two tanks, and the near-surface soils with organics / soft soils (muck) should be removed. Furthermore, to minimize the disturbance of the natural soils during the site work, we recommend track mounted lightweight equipment should be used as opposed to a rubber tired machine.

The SPT boring of B7 shows that the location of the effluent pump station has soft / weak soils underneath the slab of the effluent pump station which requires deeper undercut and backfill to achieve a stable subgrade. As such, the contractor should be prepared to stabilize the ground by undercutting and backfilling of these soft areas. The actual depth of undercut should be determined in the field by Terracon based on the subgrade conditions encountered in the field.

The subgrade soils may lose some of their strengths when rain and surface water infiltrates into them. We recommend an effective drainage system be installed in the proposed construction area to intercept rain and surface water.

We recommend a thorough field quality control program of proofrolling of the subgrade. The bottom of the excavation should be observed for potential unsuitable material. Hand auger boring and dynamic cone penetration (DCP) testing should be performed to evaluate and confirm the subgrade conditions. It is anticipated that some deeper subgrade soil undercutting and backfilling may be required in some isolated areas under the buildings and the parking lots during the subgrade preparation.

During the site preparation, no topsoil, organic matter, stumps, undocumented fill or other unsuitable materials should be left in place below any footings, slab and/or pavement. All foundation should bear on suitable natural soil, or on properly compacted structural fill. Compacted fill below any foundation should be placed directly on suitable natural soils.

We recommend Terracon be retained to test the footing, slab and/or pavement subgrade during construction so that Terracon can provide additional recommendations to prepare the subgrade based on the conditions uncovered during the subgrade preparation.

The following sections will present the details of earthwork and the recommendations for shallow foundations.

4.3 Earthwork

Site preparation should include the installation of a site drainage system, the demolition of the existing pond, two tanks, roads and other buildings, topsoil stripping and grubbing, subgrade preparation, densification, and proofrolling. Due to the uneven ground surface of the site, the volume of topsoils may be significantly greater than the area times the topsoil thickness indicated in the boring logs. Deeper undercut may be needed in some localized areas to remove unsuitable materials.

4.3.1 Site Drainage

An effective drainage system 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 if the above ditch system cannot effectively drain water away from the site, especially during the rainy season. The site should be graded to shed water and avoid ponding over the subgrade.

4.3.2 Densification and Proofrolling

Prior to fill placement on the subgrade, the entire plant areas should be densified with a heavy-duty vibratory roller to achieve a uniform subgrade. The subgrade should be thoroughly proofrolled after the completion of densification. Proofrolling will help detect any isolated soft or loose areas that "pump", deflect or rut excessively, and also densify the near-surface soils for floor slab support.

A loaded tandem axle dump truck, capable of transferring a load in excess of 20 tons, should be utilized for this operation. Proofrolling should be performed under the Geotechnical Engineer's observation. Areas where pumping, excessive deflection or rutting is observed after successive passes of the proofrolling equipment should be undercut, backfilled and then properly compacted. It is anticipated that some amount of subgrade undercutting may be required under the footing during subgrade preparation.

4.3.3 Fill Material Consideration

Structural fill should be placed over a stable or stabilized subgrade. The properties of the fill will affect the performance of the footings and the floor slabs. The soils to be used as structural fill should be free of organics, roots, or other deleterious materials. It should be a non-plastic granular material containing less than 25 percent fines passing the No. 200 sieve.

Based on SPT borings, the project site mainly consists of sandy clays at an elevation of 12 feet where the bottom of new treatment tank is. The sandy clays are not suitable for structural fill. As such, it is anticipated that an offsite borrow source is required for the structural fill material.

Areas to receive structural fills should be placed in thin (8 to 10 inches loose) lifts and compacted to a minimum of 95 percent of the soil's Modified Proctor maximum dry density (ASTM D-1557). The fill brought to the site should be within 3 percent (wet or dry) of the optimum moisture content and should meet the properties as described above.

Some manipulation of the moisture content (such as wetting, drying) will be required during the filling operation to obtain the required degree of compaction. The manipulation of the moisture content is highly dependent on weather conditions and site drainage conditions. Therefore, the contractor should prepare both dry and wet fill materials to obtain the specified compaction during grading.

4.4 Slab Foundation

The effluent pump station can be supported by a shallow foundation system, provided that the proposed structure will not exceed the structural loads as provided in Section 2.0 and the structure has a criterion of the allowable settlement of 1 inch or greater. The following sections present design recommendations and construction considerations for the shallow foundations for the proposed structures and related structural elements

4.4.1 Slab Design Recommendations

Item	Description
Floor slab support	Compacted structural fill / inspected and tested natural ground[1].
Modulus of subgrade reaction	120 pounds per square inch per in (psi / in) for point loading conditions.
Net allowable bearing pressure[2]	2,500 psf
Approximate total settlement [3]	<1 inch
Base course/capillary break[4]	4 inches of free draining granular material.
Vapor barrier	Project Specific[4].
Ultimate Coefficient of sliding friction [5]	0.32

1. The slab design should include a base course comprised of free-draining, compacted, granular material, at least 4 inches thick. The granular subbase may be graded aggregate base (GAB) or sands containing less than 5 percent fines (material passing the #200 sieve). GAB subbase can also help improve the workability of the subgrade, especially during rain periods.
2. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the base elevation. It assumes any unsuitable fill or soft soils, if encountered, will be replaced with compacted structural fill.
3. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the foundation, the thickness of compacted fill, and the quality of the earthwork operations.
4. The use of a vapor retarder should be considered beneath concrete slabs on the grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder. Water proofing should be performed for below ground structures.
5. Sliding friction along the base of the slab will not develop where net uplift conditions exist.

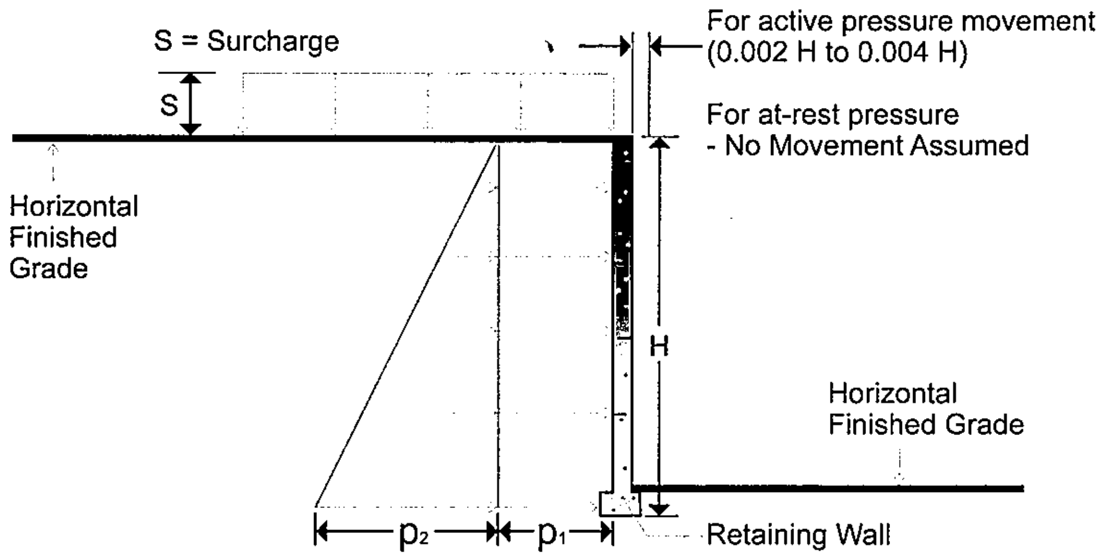
4.4.2 Floor Slab Construction Considerations

Prior to construction of grade supported slabs, varying levels of remediation may be required to reestablish stable subgrades within slab areas due to construction traffic, rainfall, disturbance, desiccation, etc. As a minimum, the following measures are recommended:

- The interior trench backfills placed beneath slabs should be compacted in accordance with recommendations outlined in **Section 4.3** of this report.
- All floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the stone base and concrete.

4.5 Lateral Earth Pressure Considerations

This project does not include independent retaining walls. However, the effluent pump station constructed underground with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. The earth pressure parameters are recommended based on the structural fills specified in the Structural Fill section of our report. 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. 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. The recommended design lateral earth pressures do not include a factor of safety or possible hydrostatic pressure on the walls.



Earth Pressure Coefficients

Earth Pressure Conditions	Coefficient for Backfill Type	Equivalent Fluid Density (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (K_a)	Granular - 0.31	38	(0.31)S	(38)H
At-Rest (K_o)	Granular - 0.47	57	(0.47)S	(57)H
Passive (K_p)	Granular - 3.3	400	---	---

<u>Applicable conditions to the above include:</u>

- 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 120 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

Backfill placed against structures should consist of granular soils. The granular backfill must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, a value of 0.35 should be used as the ultimate coefficient of friction between the footing and the underlying soil.

Depending on the depth of excavation and long term groundwater conditions, the unbalanced hydrostatic pressure may be considered in the design of the retaining wall. To control hydrostatic pressure behind the wall, we recommend that a drain be installed at the foundation wall with a collection pipe leading to a reliable discharge such as a stormwater drain. If this is not possible, hydrostatic pressure should be added to the lateral earth pressures recommended above. These pressures do not include the influence of surcharge, equipment or floor loading, which should be added. Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent lateral pressures more than those provided.

4.6 Pile Foundation Recommendation

We evaluated three types of piles to support the new treatment tank and building for the sludge dewatering system. We analyzed pile axial and lateral capacities for 12 and 14-inch Prestressed Concrete (PSC) piles, 12 and 14-inch steel H-piles, and 14 and 16-inch diameter auger cast piles. This section describes the procedures for pile capacity evaluations and presents our recommendations for the pile axial and lateral capacities.

4.6.1 Axial Pile Capacity

4.6.1.1 Driven Piles

The pile allowable axial compression and tension capacities were analyzed using the α and β methods and based on our experience with pile capacities in this area. A factor of safety of 2.0 was used for side resistance and a factor of safety of 3.0 was used for tip resistance in the allowable pile capacities. The allowable axial capacities for the 12 and 14-inch PSC piles and 12 and 14-inch steel H-piles are listed in the table below. To improve the driving conditions, we recommend the PSC piles be manufactured using concrete with a 28-day compression strength of 7,000 psi and an effective prestressing of 1,000 psi

We understand the site will be prepared and graded prior to the construction of the foundation. Hence, the downdrag forces were not considered in the pile compressive capacities analysis, otherwise a downdrag force of 30 to 50 tons should be considered.

Recommended Allowable Axial Load Capacities for PSC Piles and steel H-Piles

Embedment Depth* (feet)	Pile Tip Elevation (feet)	12-inch PSC	14-inch PSC	HP12X53	HP14x73
Allowable Compression Capacities (tons)					
45	-33	55	65	40	50
50	-38	65	75	45	54
55	-43	75	85	50	60
Allowable Tension Capacities (tons)					

45	-33	35	40	20	25
50	-38	40	45	25	30
55	-43	45	50	30	35

Note: assuming pile top at an elevation of 12 feet.

We recommend that center-center spacing between adjacent piles be maintained at least three times the pile side dimension. Piles installed less than the recommended spacing may result in driving difficulty or pile heave. Close attention should be directed during construction to observe potential pile heave. If pile heave is observed, the driving procedures or sequence may be adjusted to reduce or eliminate pile heave and heaved piles should be re-taped before cutoff.

4.6.1.2 Augered Cast-In-Place Pile

Continuous flight auger (CFA) piles or conventionally called auger cast piles (or augered cast-in-place) can also be used for the support of the new treatment tank and building for the sludge dewatering system. Augered cast-in-place (ACIP) piles can be installed more quickly than driven piles and generate less noise and vibration. We analyzed pile axial and lateral capacities for 16-inch and 18-inch diameter ACIP Piles. We recommend the ACIP pile should have concrete with a minimum compression strength of 5,000 psi at 28-days.

Analyzed pile axial capacities for the ACIP piles are listed in the table below. Based on the pile configuration and soil parameters from the subsurface exploration, we calculated the allowable axial compression and the tension capacities using the α and β methods and based on our experience with pile capacities in this area. A factor of safety of 2.0 was used for side resistance and a factor of safety of 3.0 was used for tip resistance in the allowable pile capacities.

Embedment Depth (feet)	Pile Tip Elevation (feet)	14-inch ACIP	16-inch ACIP
Allowable Compression Capacities (tons)			
45	-33	40	45
50	-38	50	55
55	-43	60	65
Allowable Tension Capacities (tons)			
45	-33	20	25
50	-38	30	30
55	-43	35	40

Note: assuming pile top at an elevation of 12 feet.

4.6.2 Lateral Pile Capacity

Behavior of the piles under lateral loads was analyzed using the computer program LPILE. The LPILE program employs the *p-y* method based on the user-specified soil and pile properties. The deflections, rotations, and bending moments in the pile were calculated by solving the beam bending equation using finite difference numerical techniques. 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 fixed head and free head conditions. The upper portion of the piles should have adequate reinforcement designed for the required lateral loads.

4.6.2.1 Driven Pile

The recommended lateral design capacities of driven piles are listed in the table below and the results of our analyses are presented in **Appendix B**.

Recommended Pile Lateral Design Capacities (kips)

	12inch PSC	14inch PSC	HP12x53	HP14x73
Free Head Connection	10	14	9	13
Fixed Head Connection	24	31	21	29

Note: Based on an allowable lateral deflection of 0.25 inches.

4.6.2.2 Augered Cast-In-Place Pile

The recommended lateral design capacities of ACIP piles are listed in the table below and the results of our analyses are presented in **Appendix B**.

Recommended Pile Lateral Design Capacities (kips)

	14 inch ACIP	16 inch ACIP
Free Head Connection	11	14
Fixed Head Connection	26	33

Note: Based on an allowable lateral deflection of 0.25 inches.

4.6.3 Pile Testing and Monitoring

4.6.3.1 Driven Pile

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 one pile. The test pile can be a production pile.

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 Marl formation 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, 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.

4.6.3.2 Augered Cast-In-Place Pile

The purpose of the ACIP 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 one (1) test (probe) piles were selected for load testing. The probe piles should be grouted as production piles but located outside the foundations. 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 supervision of the geotechnical engineer.

We recommend static load testing be performed on at least one (1) pile. Additional test piles with varying length may be performed to provide information for a potentially more economical foundation design. The test piles should be loaded to at least three (3) 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.

ACP Pile Monitoring Program There are inherent uncertainties with pile integrity in ACIP pile installation. 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) 2012 and Georgia Special Inspection Guidelines in accordance with IBC2012.

Pile Integrity Testing: The risk of bulging and necking increases with the presence of very soft soil deposit. Terracon recommends the integrity for the auger cast 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 relative 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 (3) 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.

4.7 Pavements

We understand the proposed development will include driveways and parking area. This section presents thickness recommendations for asphalt concrete and Portland cement concrete pavements and general considerations for the pavement construction. Pavement thickness design is dependent upon:

- The traffic loads including traffic pattern and the service life of the pavement;
- Subgrade conditions including soil strength and drainage characteristics;
- Paving material characteristics;
- Climatic conditions of the region.

Traffic patterns and anticipated loading conditions are not available at this time. We anticipate traffic loads will be produced primarily by automobile traffic and a limited number of delivery and trash removal trucks.

We have provided two pavement section alternatives: light and heavy duty sections. The light duty section is constructed for the areas that receive only car traffic. The heavy duty section assumed 2 trash removal trucks per week. If heavier traffic loading is expected, the commercial building should be provided with the anticipated traffic loading information and allowed to review these pavement sections. A design life of 20 years was assumed to develop the total traffic used in thickness design. However, as typical for pavement, some maintenance repairs are typically required for a period of 7 to 10 years.

For the pavement support, the subgrade conditions can often be the overriding factor in pavement performance. The subgrade conditions will depend on the in-situ soils at the subgrade level, characteristics of fill material for the subgrade as well as the site preparation procedures.

The subgrade conditions will depend on the in-situ soils at the subgrade level, characteristics of fill material for the subgrade as well as site preparation procedures. Assuming that the site will receive more than two feet of fill to reach the finished subgrade elevations. The subgrade will be fill material. We recommend the fill material for the subgrade be relatively clean sands with percent fines less than 15 percent. A California Bearing Ratio (CBR) value of 8 has been estimated based on the in-situ soils at the site and typical imported fills available in this area.

Climatic conditions are considered in the design subgrade support value listed above and in the paving material characteristics. The recommended paving material characteristics, taken from the Georgia Department of Transportation's (GDOT) 2001 edition of *Standard Specifications for Construction of Transportation Systems,* are included for the asphalt concrete sections.

4.7.1 Flexible (Asphalt) Pavement Design Recommendations

Material	**Minimum Section Thickness** (inch)		
	Light Duty Section	**Heavy Duty Section**	
	Auto Parking	**Access Road for Delivery / Trash Collection Vehicles**	**Concentrated and Repetitive Loading Areas (e.g. Dumpster pad, truck delivery docks and ingress/egress aprons)**
Asphalt Surface Course[1]	2	1 ½	We recommend concrete pavement sections for concentrated and repetitive loading areas, as concrete pavement, in general, performs better in these areas. Please refer to **Section 4.7.2** for the pavement section.
Asphalt Intermediate Course[1]	0	2	
Graded Aggregate Base Course[1]	7	8	
Total Pavement Section	**9**	**11 ½**	
Select fill[2] / improved subgrade[3]	24	24	

1. Asphalt concrete and base course materials should conform to the following GDOT material specifications.
   - Section 815 for Graded Aggregate
   - Section 828 for Hot Mix Asphalt Concrete Mixture. Surface course may use 9.5 mm Superpave for a smooth surface in the light-duty section or 12.5 mm Superpave for the heavy-duty section. 19 mm and/or 25 mm Superpave is recommended for the intermediate course.
2. The select fill should be relatively clean sands with percent fines less than 15% and should be compacted to a minimum of 95% of the soil's Modified Proctor maximum dry density (ASTM D-1557).
3. If SP or SP-SM or SM soils exist at the proposed subgrade elevation extending to a depth at least 24 inches below the proposed subgrade level, the in-situ soils can replace the select fill and the subgrade should be improved using densification as discussed in **Section 4.3.**

Notes:

- Proper surface and subgrade drainage system should be installed to avoid the saturation of subgrade soils underneath the asphalt pavements and should be designed to maintain the groundwater at least 2 feet below the top of the subgrade.
- We anticipate some subgrade soil undercutting and backfilling with suitable structural fill will be required if unstable subgrade soils are encountered during the subgrade preparation. The use of geogrid (Tensar BX1100 or equivalent) may be necessary to help reduce the depth of undercut to achieve stability if the unstable subgrade soils extend to greater depths. The need for geogrid and/or the need for undercutting and backfilling should be determined in the field during subgrade preparation.

4.7.2 Rigid (Concrete) Pavement Design Recommendations

Material	**Minimum Section Thickness** (inch)		
	Light Duty Section	**Heavy Duty Section**	
	Auto Parking	**Access Road for Delivery / Trash Collection Vehicles**	**Concentrated and Repetitive Loading Areas (e.g. Dumpster pad, truck delivery docks and ingress/egress aprons)**
Concrete[1]	5	7	7
Graded aggregate base[2]	0	0	0
Select fill[3] / improved subgrade[4]	24	24	24

1. The concrete should be air entrained and have a minimum compressive strength of 4,000 psi after 28 days of lab curing per ASTM C-31.
2. The graded aggregate base should conform to the GDOT material specification Section 815.
3. The select fill should be relatively clean sands with percent fines less than 15%. The fill material should be compacted to a minimum of 95% of the soil's Modified Proctor maximum dry density (ASTM D-1557).
4. If SP or SP-SM or SM soils exist at the proposed subgrade elevation extending to a depth at least 24 inches below the proposed subgrade level, the in-situ soils can replace the select fill and the subgrade should be improved using densification as discussed in **Section 4.3.**

Notes:

- Concrete joints should be sealed properly to avoid the ingress of surface water into the subgrade soils. Proper surface and subgrade drainage system should be installed to avoid the saturation of subgrade soils underneath the concrete pavements. The site drainage should be designed to maintain the groundwater at least 2 feet below the top of the subgrade.
- Some subgrade soil undercutting and backfilling with suitable structural fill will be required if unstable subgrade soils are encountered during subgrade preparation. The use of geogrid (Tensar BX1100 or equivalent) may be necessary to help reduce the depth of undercut to achieve stability if the unstable subgrade soils extend to greater depths. The need for geogrid and/or the need for undercutting and backfilling should be determined in the field during subgrade preparation.

The above rigid and flexible pavement sections represent the minimum design thicknesses and, as such, periodic maintenance should be anticipated. Prior to the placement of the subbase (compacted structural fill), the pavement areas should be thoroughly proofrolled.

4.7.3 Pavement Construction Considerations

Pavement subgrades prepared early in the project should be carefully evaluated as the time for pavement construction approaches. We recommend the pavement areas be rough graded and then thoroughly proofrolled with a loaded tandem-axle dump truck.

Particular attention should be paid to the high traffic areas that were rutted and disturbed and to the areas where backfilled trenches are located. Areas, where unsuitable conditions are located, should be repaired by removing and replacing the materials with properly compacted fill. After proofrolling and repairing subgrade deficiencies, the entire subgrade should be scarified to a depth of 12 inches, and uniformly compacted to at least 95% of the materials' modified Proctor maximum dry density.

4.7.4 Pavement and Subgrade Drainage

Poor subgrade drainage is the most common cause of pavement failure. Pavement should be sloped to provide a rapid drainage of surface water. Water should not be allowed to pond on the pavement surface or adjacent to the pavement which would saturate the subgrade soils and weaken the subgrade support. We recommend the site drainage be designed to maintain the groundwater at least two (2) feet below the top of the subgrade.

Pavement subgrade drainage should be installed surrounding the areas anticipated for frequent wetting or having poor natural drainage, such as landscaped islands, along curbs and gutters and around drainage structures.

All landscaped areas in or adjacent to pavements should be sealed to reduce the moisture migration to subgrade soils. Subgrade drains should be installed with the pipe bottom at least two (2) feet below the top of the select fill. The civil engineer should decide the placement of the subgrade drains to avoid the saturation of pavement subgrade.

4.7.5 Pavement Maintenance

The performance of pavements will require regular maintenance. One key component of the maintenance is to minimize the infiltration of water into the pavement base and subgrade. Preventive maintenance should include crack and joint sealing and patching, as well as overall surface sealing and overlay. Additional engineering observation and evaluation is recommended prior to any major maintenance.

4.8 Seismic Considerations

4.8.1 Seismic Design Parameters

According to the International Building Code (IBC) 2012 and ASCE 7-10, 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 2500-year earthquake has a Moment Magnitude (Mw) of 7.3 and a Site Class Adjusted Peak Ground Acceleration (PGA_M) of 0.24g, as determined by data provided by the IBC 2012 and ASCE 7-10 Standards.

Based on the findings in 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) 2012 and ASCE 7-10. The seismic design parameters obtained based on IBC2012 and ASCE 7-10 are summarized in table below. The design response spectrum curve, as presented in the appendix, was developed based on the S_{DS} and S_{D1} values according to IBC2012 and ASCE 7-10.

Table 4.8.1.1 Summary of Seismic Design Parameters

Site Location (Latitude. Longitude.)	Site Classification	S_s	S_1	F_a	F_v	S_{DS}	S_{D1}
32.1131° -81.1963°	D	0.302g	0.118g	1.558	2.329	0.314g	0.183g

- The IBC 2012 and ASCE 7-10 require a seismic Site Class determination based on the soils in the upper 100 feet. The current scope of work for this project included a field exploration to a maximum depth of 70 feet BGS. The seismic Site Class was determined based on the results of the field exploration and our knowledge of the geologic conditions of the site area.

5.0 GENERAL COMMENTS

Terracon should be consulted to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the project design and specifications. Terracon should also be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analyses and recommendations presented in this report are based upon the data obtained from the explorations performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between exploration locations, across the site, or may be caused due to the modifying effects of construction or weather. Bear in mind that the nature and extent of such variations may not become evident until construction has started or until construction activities have ceased.

If variations do appear, Terracon should be notified immediately so that further evaluation and supplemental recommendations can be provided. The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or hazardous conditions. If the owner is concerned about the potential for such contamination or pollution, please advise so that additional studies may be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project and site discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes, and then either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

Image Courtesy of
Google Earth™

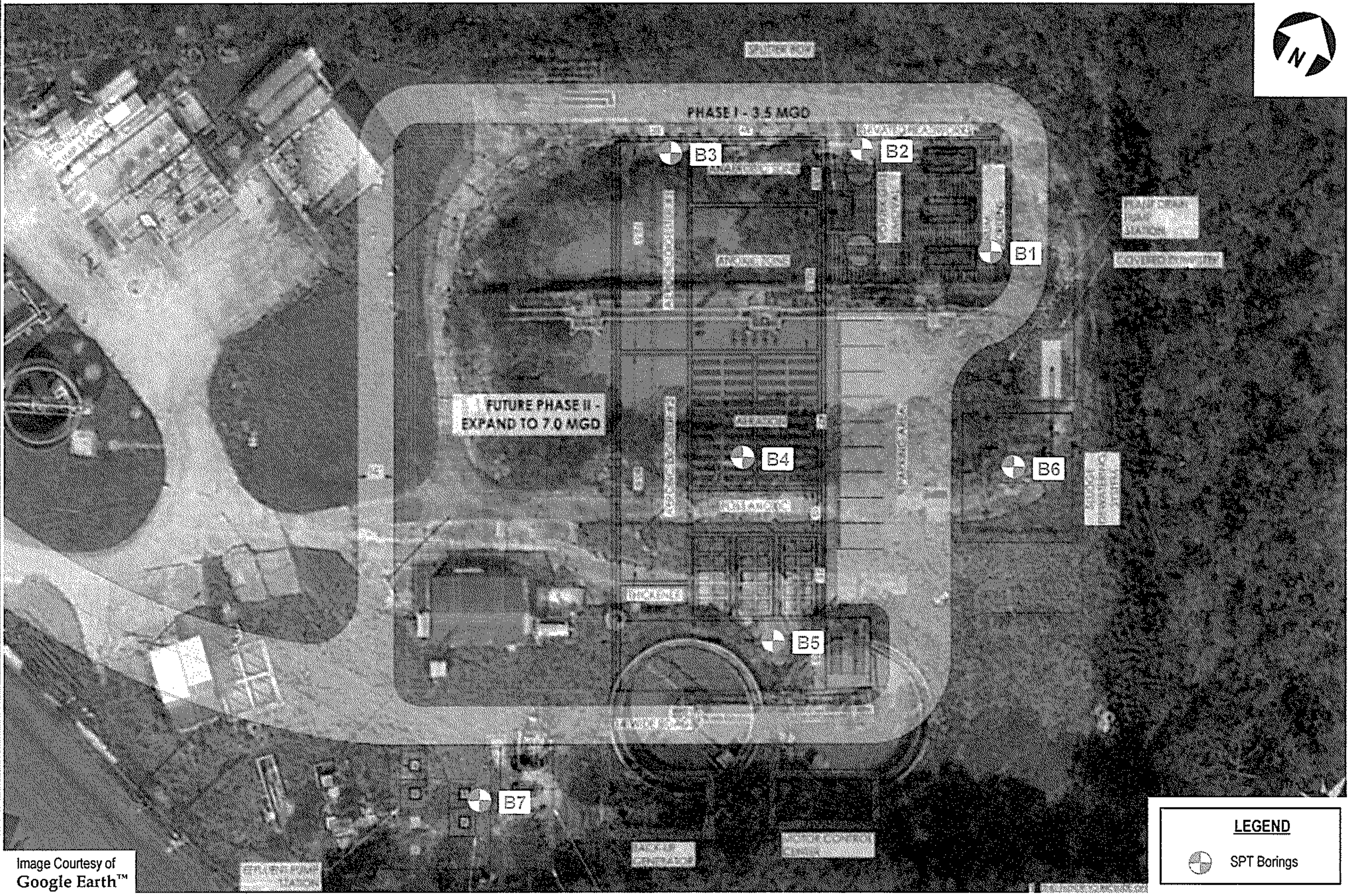
Project Manager: YJ	Project No. ES185011
Drawn by: YJ	Scale: N.T.S.
Checked by: GL	File Name:
Approved by: GL	Date: 2/16/18

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

SITE LOCATION MAP

Travis Field WWTF
Savannah
Chatham County, Georgia

Exhibit:
A-1



NOTES:

ALL EXPLORATION LOCATIONS WERE 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:	YJ	Project No.	ES185011
Drawn by:	YJ	Scale:	N.T.S.
Checked by:	GL	File Name:	
Approved by:	GL	Date:	2/16/18

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

EXPLORATION LOCATION PLAN

Travis Field WWTF
Savannah
Chatham County, Georgia

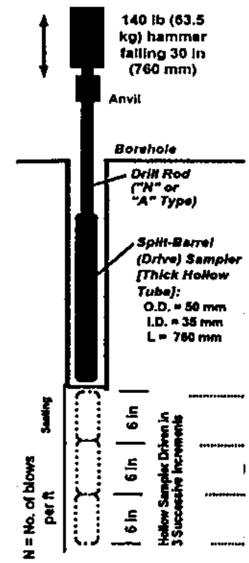
Exhibit:
A-2

Field Exploration Description

The locations of Standard Penetration Test (SPT) and hand auger borings are determined by Terracon based on the proposed plan and were located in the field using a hand-held GPS unit and in reference to the existing features. These locations are shown in the Exploration Location Plan in **Exhibit A-2** and should be considered approximate.

Standard Penetration Testing

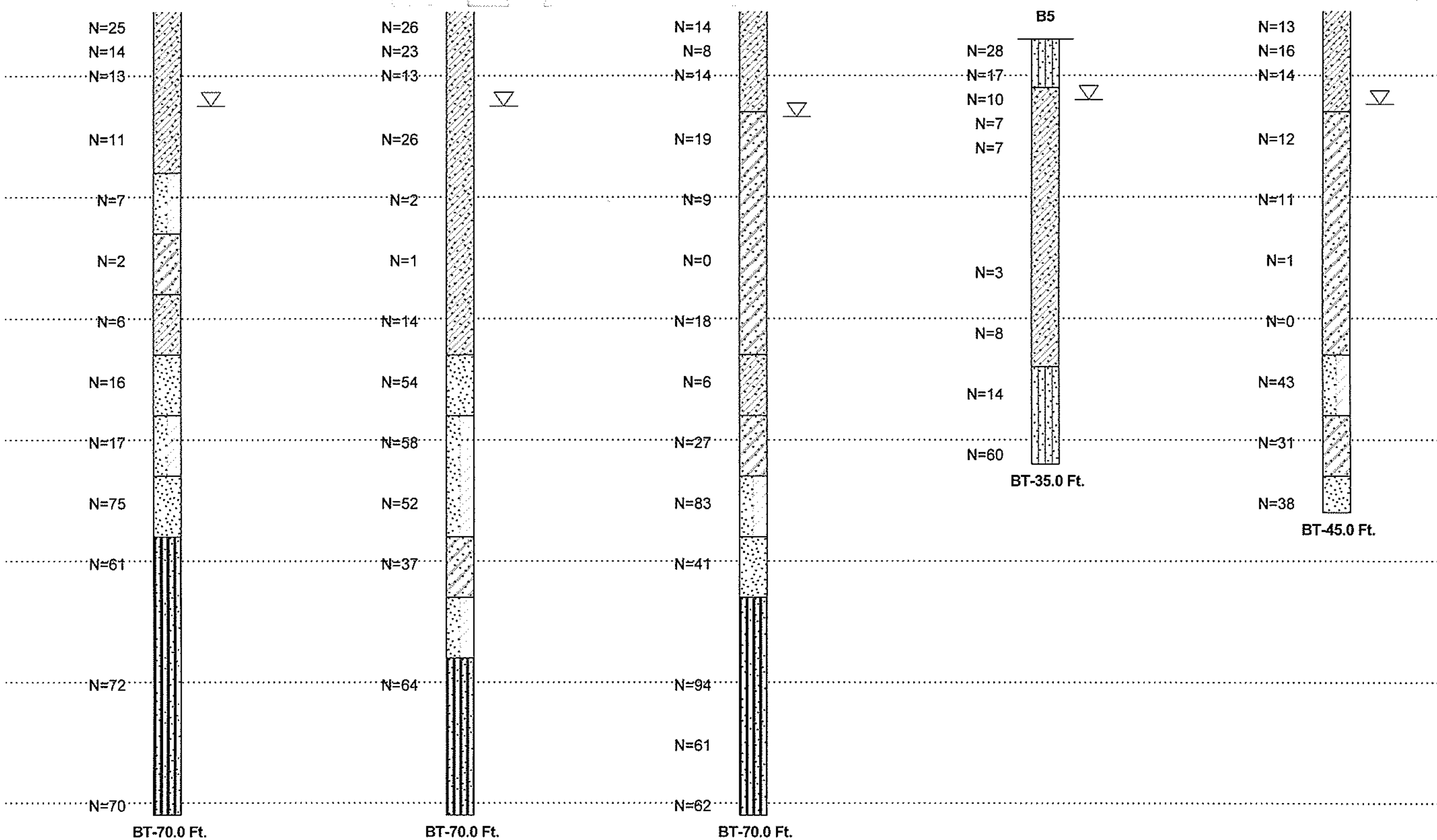
The SPT borings were performed in accordance with ASTM D1586 with a trailer-mounted CME drilling rig using mud rotatory drilling techniques. Samples of the soil encountered in the borings were obtained using split-barrel sampling procedures. In the split barrel sampling procedure, the number of blows 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. A rope and cathead hammer was used to advance the split-barrel sampler in the borings performed on this site.



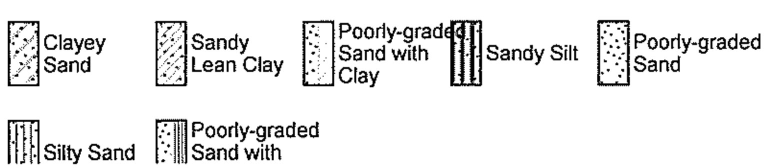
Source: FHWA NHI-06-088

Hand Auger Borings

Hand auger borings were conducted in general accordance with ASTM D 1452-80, Standard Practice for Soil Investigation and Sampling by Auger Borings. In this test, hand auger borings are drilled by rotating and advancing a bucket auger to the desired depths while periodically removing the auger from the hole to clear and examine the auger cuttings. The soils were classified in accordance with ASTM D2488.



Distance Along Baseline - Feet



BORING LOG NO. B1

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton
Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1135° Longitude: -81.1861°

Approximate Surface Elev: 19 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	CLAYEY SAND (SC), fine grained, dark gray and brown and orange, dense				X	13-18-19-13 N=37
2.0		17+/-				
	SANDY LEAN CLAY (CL), with mulch, gray and orange, very stiff				X	8-16-13-13 N=29
	with some shell fragments and mulch, dark bluish gray, very stiff		5		X	8-8-11-11 N=19
	dark bluish gray and brown, very stiff				X	13-12-7-9 N=19
	gray and orange, stiff				X	15-9-7-9 N=16
			10	▽		
12.0		7+/-				
	CLAYEY SAND (SC), fine to medium grained, brown and dark gray, medium dense				X	12-5-5 N=10
			15			
	with shell fragments, fine to coarse grained, dark gray, loose		20		X	15-6-1 N=7
	fine grained, gray, very loose		25		X	0-0-0 N=0
27.0		-8+/-				
	SANDY LEAN CLAY (CL), dark gray, soft		30		X	0-0-2 N=2
32.0		-13+/-				
	POORLY GRADED SAND WITH CLAY (SP-SC), fine to medium grained, dark gray, dense		35		X	16-15-21 N=36
	dark gray, very dense		40		X	18-28-24 N=52

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-10-2018	Boring Completed: 02-10-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-1

BORING LOG NO. B1

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton
Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1135° Longitude: -81.1861°

Approximate Surface Elev: 19 (Ft.) +/-

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
		POORLY GRADED SAND WITH CLAY (SP-SC), fine to medium grained, dark gray, dense *(continued)*					
		dark gray, very dense		45		X	34-36-50/4"
	47.0		-28+/-				
		SANDY SILT (ML), fine grained, dark gray and olive green, hard		50		X	21-23-28 N=51
		fine grained, dark gray and olive green, hard		55		X	35-43-50/5"
		fine grained, dark gray and olive green, hard		60		X	30-35-44 N=79
		fine grained, dark gray and olive green, hard		65		X	50/5"
	70.0	fine grained, dark gray and olive green, hard	-51+/-	70		X	21-26-38 N=64
		Boring Terminated at 70 Feet					

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-10-2018	Boring Completed: 02-10-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-1

BORING LOG NO. B2

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton, Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1134° Longitude: -81.1864°

Approximate Surface Elev: 19 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	SANDY LEAN CLAY (CL), gray and orange, stiff				X	12-8-8-13 N=16
	dark gray and orange, very stiff				X	9-11-9-9 N=20
	dark gray and orange, very stiff		5		X	9-12-13-10 N=25
	dark gray and orange, stiff				X	9-7-7-7 N=14
	dark gray and orange, stiff		10	▽	X	6-7-6-6 N=13
	dark gray and orange, stiff		15		X	10-5-6 N=11
17.0	**POORLY GRADED SAND WITH CLAY (SP-SC)**, fine grained, gray, loose	2+/-	20		X	5-4-3 N=7
22.0	**CLAYEY SAND (SC)**, fine grained, dark gray, very loose	-3+/-	25		X	0-0-2 N=2
27.0	**SANDY LEAN CLAY (CL)**, dark gray, medium stiff	-8+/-	30		X	6-3-3 N=6
32.0	**POORLY GRADED SAND (SP)**, fine to medium grained, dark gray, medium dense	-13+/-	35		X	23-6-10 N=16
37.0	**POORLY GRADED SAND WITH CLAY (SP-SC)**, fine to coarse grained, dark gray, medium dense	-18+/-	40		X	14-7-10 N=17

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-09-2018	Boring Completed: 02-09-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-2

BORING LOG NO. B2

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton, Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1134° Longitude: -81.1864°

Approximate Surface Elev: 19 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
42.0	POORLY GRADED SAND WITH CLAY (SP-SC), fine to coarse grained, dark gray, medium dense *(continued)*	-23+/-				
47.0	POORLY GRADED SAND (SP), fine to medium grained, dark gray, very dense	-28+/-	45		X	41-38-37 N=75
	SANDY SILT (ML), dark gray and olive green, hard		50		X	22-31-30 N=61
	dark gray and olive green, hard		55		X	50/5"
	No Recovery		60		X	41-49-23 N=72
	dark gray and olive green, hard		65		X	40-45-50/5"
70.0	dark gray and olive green, hard	-51+/-	70		X	30-36-34 N=70

Boring Terminated at 70 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method: Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

After 24 hours

Terracon

2201 Rowland Ave
Savannah, GA

Boring Started: 02-09-2018	Boring Completed: 02-09-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-2

BORING LOG NO. B3

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton, Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1134° Longitude: -81.1866°

Approximate Surface Elev: 19 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	SANDY LEAN CLAY (CL), gray and orange, stiff				X	8-7-8-8 N=15
	No Recovery				X	11-11-11-10 N=22
	brown and gray, very stiff		5		X	14-15-11-13 N=26
	gray and orange, very stiff				X	11-11-12-8 N=23
	gray and orange, stiff				X	8-6-7-11 N=13
			10	▽		
	gray, very stiff		15		X	8-12-14 N=26
	gray, very soft to soft		20		X	5-1-1 N=2
	gray, very soft		25		X	0-0-1 N=1
	gray, stiff		30		X	8-8-6 N=14
32.0	POORLY GRADED SAND (SP), fine to coarse grained, gray, very dense	-13+/-	35		X	21-26-28 N=54
37.0	POORLY GRADED SAND WITH CLAY (SP-SC), fine to coarse grained, gray, very dense	-18+/-	40		X	21-28-30 N=58

Stratification lines are approximate. In-situ, the transition may be gradual.

Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-09-2018	Boring Completed: 02-09-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-3

BORING LOG NO. B3

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1134° Longitude: -81.1866°

Approximate Surface Elev: 19 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	POORLY GRADED SAND WITH CLAY (SP-SC), fine to coarse grained, gray, very dense *(continued)*					
	fine to coarse grained, gray, very dense		45		X	8-26-26 N=52
47.0		-28+/-				
	CLAYEY SAND (SC), fine grained, gray, hard		50		X	12-13-24 N=37
52.0		-33+/-				
	POORLY GRADED SAND WITH CLAY (SP-SC), fine grained, gray, very dense		55		X	50/5"
57.0		-38+/-				
	SANDY SILT (ML), dark gray and olive green, hard		60		X	25-28-36 N=64
	dark gray and olive green, hard		65		X	31-37-50/4"
	dark gray and olive green, hard				X	22-50/5"
70.0		-51+/-	70			
	Boring Terminated at 70 Feet					

Stratification lines are approximate. In-situ, the transition may be gradual.

Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-09-2018	Boring Completed: 02-09-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-3

BORING LOG NO. B4

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1131° Longitude: -81.1863°

Approximate Surface Elev: 19 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	SANDY LEAN CLAY (CL), dark gray and brown, stiff				X	13-8-6-6 N=14
	gray and orange, very stiff				X	7-11-13-11 N=24
	dark gray and brown, stiff		5		X	6-8-6-6 N=14
	dark gray and brown, medium stiff				X	6-4-4-7 N=8
	gray and orange, stiff		10		X	14-7-7-10 N=14
12.0		7+/-		▽		
	CLAYEY SAND (SC), fine grained, gray and orange, medium dense		15		X	12-11-8 N=19
	fine grained, gray and orange, loose		20		X	6-5-4 N=9
	with some mulch, fine grained, gray, very loose		25		X	0-0-0 N=0
	fine grained, dark gray, medium dense		30		X	0-10-8 N=18
32.0		-13+/-				
	SANDY LEAN CLAY (CL), dark gray, medium stiff		35		X	1-3-3 N=6
37.0		-18+/-				
	CLAYEY SAND (SC), fine to medium grained, dark gray, medium dense		40		X	9-16-11 N=27

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-10-2018	Boring Completed: 02-10-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-4

BORING LOG NO. B4

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton, Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1131° Longitude: -81.1863°

Approximate Surface Elev: 19 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	CLAYEY SAND (SC), fine to medium grained, dark gray, medium dense *(continued)*					
42.0		-23+/-				
	POORLY GRADED SAND WITH CLAY (SP-SC), fine to coarse grained, dark gray, very dense		45		X	36-48-35 N=83
47.0		-28+/-				
	POORLY GRADED SAND (SP), fine to coarse grained, dark gray, very dense		50		X	38-21-20 N=41
52.0		-33+/-				
	SANDY SILT (ML), fine grained, dark gray and olive green, hard		55		X	38-50/4"
	dark gray and olive green, hard		60		X	40-44-50 N=94
	dark gray and olive green, hard		65		X	23-28-33 N=61
	dark gray and olive green, hard				X	25-24-38 N=62
70.0		-51+/-	70			
	Boring Terminated at 70 Feet					

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method: Mud Rotary	See Exhibit A-3 for description of field procedures. See Appendix B for description of laboratory procedures and additional data (if any). See Appendix C for explanation of symbols and abbreviations.	Notes:
Abandonment Method:		

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-10-2018	Boring Completed: 02-10-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-4

BORING LOG NO. B5

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.113° Longitude: -81.1862°

Approximate Surface Elev: 13 (Ft.) +/-

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	SILTY SAND (SM), fine grained, brown, dense				X	10-14-14-18 N=28
	trace shell fragments, brown, medium dense			∇ (after 24 hours)	X	11-10-7-6 N=17
4.0		9+/-				
	SANDY LEAN CLAY (CL), gray and brown, stiff		5	∇ (while drilling)	X	5-4-6-6 N=10
	gray and brown, medium stiff				X	4-3-4-3 N=7
	gray and brown, medium stiff				X	3-3-4-3 N=7
			10			
	wood stump, No Recovery					50/1"
			15			
	light gray, soft				X	3-1-2 N=3
			20			
	with nodules quartz pebbles, gray, medium stiff				X	5-5-3 N=8
			25			
27.0		-14+/-				
	SILTY SAND (SM), fine to coarse grained, light gray, medium dense				X	10-6-8 N=14
			30			
	very dense				X	32-28-32 N=60
35.0		-22+/-	35			
	Boring Terminated at 35 Feet					

Stratification lines are approximate. In-situ, the transition may be gradual.

Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

∇ *While drilling*

∇ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-11-2018	Boring Completed: 02-11-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-5

BORING LOG NO. B6

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton
Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1132° Longitude: -81.186°

Approximate Surface Elev: 19 (Ft.) +/-

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
		SANDY LEAN CLAY (CL), gray and brown, very stiff				X	17-11-12-16 N=23
		with shell fragments, gray and orange, very stiff				X	11-10-11-15 N=21
		gray and orange and green, stiff		5		X	11-8-5-6 N=13
		gray and orange, stiff				X	14-5-11-10 N=16
		gray and orange, stiff				X	11-8-6-6 N=14
				10	▽		
	12.0		7+/-				
		CLAYEY SAND (SC), fine grained, gray and orange, medium dense				X	17-8-4 N=12
				15			
		fine grained, gray and orange, medium dense		20		X	8-7-4 N=11
		fine grained, dark gray, very loose		25		X	0-0-1 N=1
		fine grained, dark gray, very loose		30		X	0-0-0 N=0
	32.0		-13+/-				
		POORLY GRADED SAND WITH CLAY (SP-SC), fine to medium grained, dark gray, dense		35		X	45-21-22 N=43
	37.0		-18+/-				
		CLAYEY SAND (SC), fine to medium grained, dark gray, dense		40		X	15-15-16 N=31

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-10-2018	Boring Completed: 02-10-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-6

BORING LOG NO. B6

PROJECT: Travis Field WWTF

CLIENT: Thomas & Hutton
Savannah, GA

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1132° Longitude: -81.186°

Approximate Surface Elev: 19 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	CLAYEY SAND (SC), fine to medium grained, dark gray, dense *(continued)*					
	42.0	-23+/-				
	POORLY GRADED SAND (SP), fine to medium grained, dark gray, dense				X	20-16-22 N=38
	45.0	-26+/-	45			
	Boring Terminated at 45 Feet					

Stratification lines are approximate. In-situ, the transition may be gradual.

Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-10-2018	Boring Completed: 02-10-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-6

BORING LOG NO. B7

PROJECT: Travis Field WWTF | **CLIENT: Thomas & Hutton, Savannah, GA**

SITE: Savannah, Georgia

LOCATION See Exhibit A-2

Latitude: 32.1128° Longitude: -81.1863°

Approximate Surface Elev: 11.8 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	SILTY SAND (SM), brown				X	13-11-8-11 N=19
	with broken brick fragments, brown				X	8-10-12-8 N=22
4.0		8+/-				
	SANDY LEAN CLAY (CL), brown		5	▽	X	15-14-14-10 N=28
	brown				X	12-8-8-8 N=16
	gray and brown				X	10-7-7-7 N=14
			10			
	gray and brown and orange				X	6-2-2 N=4
			15			
17.0		-5+/-				
	CLAYEY SAND (SC), light gray					
					X	1-2-1 N=3
			20			
	light gray				X	4-2-3 N=5
			25			
27.0		-15+/-				
	POORLY GRADED SAND WITH SILT (SP-SM), fine to medium grained, light gray					
					X	20-22-21 N=43
			30			
	fine to medium grained, light gray				X	26-27-19 N=46
			35			
37.0		-25+/-				
	SANDY SILT (ML), fine grained, dark gray and olive green, hard					
					X	15-19-21 N=40
			40			

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *While drilling*
- ▽ *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-11-2018	Boring Completed: 02-11-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-7

BORING LOG NO. B7

PROJECT: Travis Field WWTF	**CLIENT: Thomas & Hutton** **Savannah, GA**
SITE: Savannah, Georgia	

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 32.1128° Longitude: -81.1863° Approximate Surface Elev: 11.8 (Ft.) +/- DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	SANDY SILT (ML), fine grained, dark gray and olive green, hard *(continued)*				
	dark gray and olive green, hard			X	30-36-25 N=61
	45.0 / -33+/-	45			
	Boring Terminated at 45 Feet				

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation was estimated based on Site Plan dated March 6, 2018 provided by Thomas & Hutton

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
- *While drilling*
- *After 24 hours*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 02-11-2018	Boring Completed: 02-11-2018
Drill Rig: BR-2500	Driller: Josh & Matt
Project No.: ES185011	Exhibit: A-7

APPENDIX B
SUPPORTING INFORMATION

Seismic Design Parameters Based on IBC2012 Code and ASCE 7-10 Standard
Terracon Project Name: Travis Field WWTF
Terracon Project Number: ES185011

Terracon

Site Location: Savannah, Georgia
Latitude : 32.1131
Longitude : -81.1963

Site Class: D
Design Response Spectrum for the Site Class

S_s 0.302	S_1 0.118
F_a 1.558	F_v 2.329
S_{MS} 0.471	S_{M1} 0.275
S_{DS} 0.314	S_{D1} 0.183

	Period (sec)	Sa (g)
	0.000	0.125
T_0	0.117	0.314
	0.200	0.314
T_S	0.584	0.314
T	0.700	0.262
	0.800	0.229
	0.900	0.204
	1.000	0.183
	1.100	0.167
	1.200	0.153
	1.300	0.141
	1.400	0.131
	1.500	0.122
	1.600	0.115
	1.700	0.108
	1.800	0.102
	1.900	0.096
	2.000	0.092

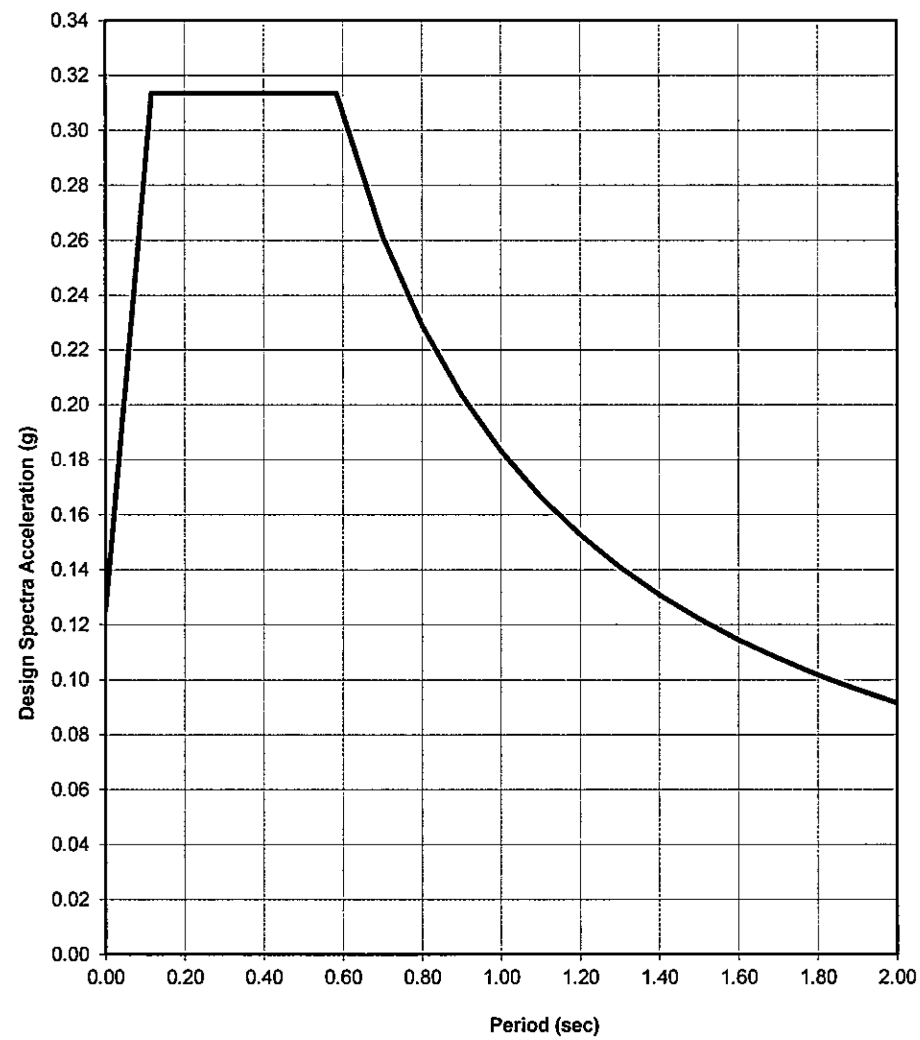
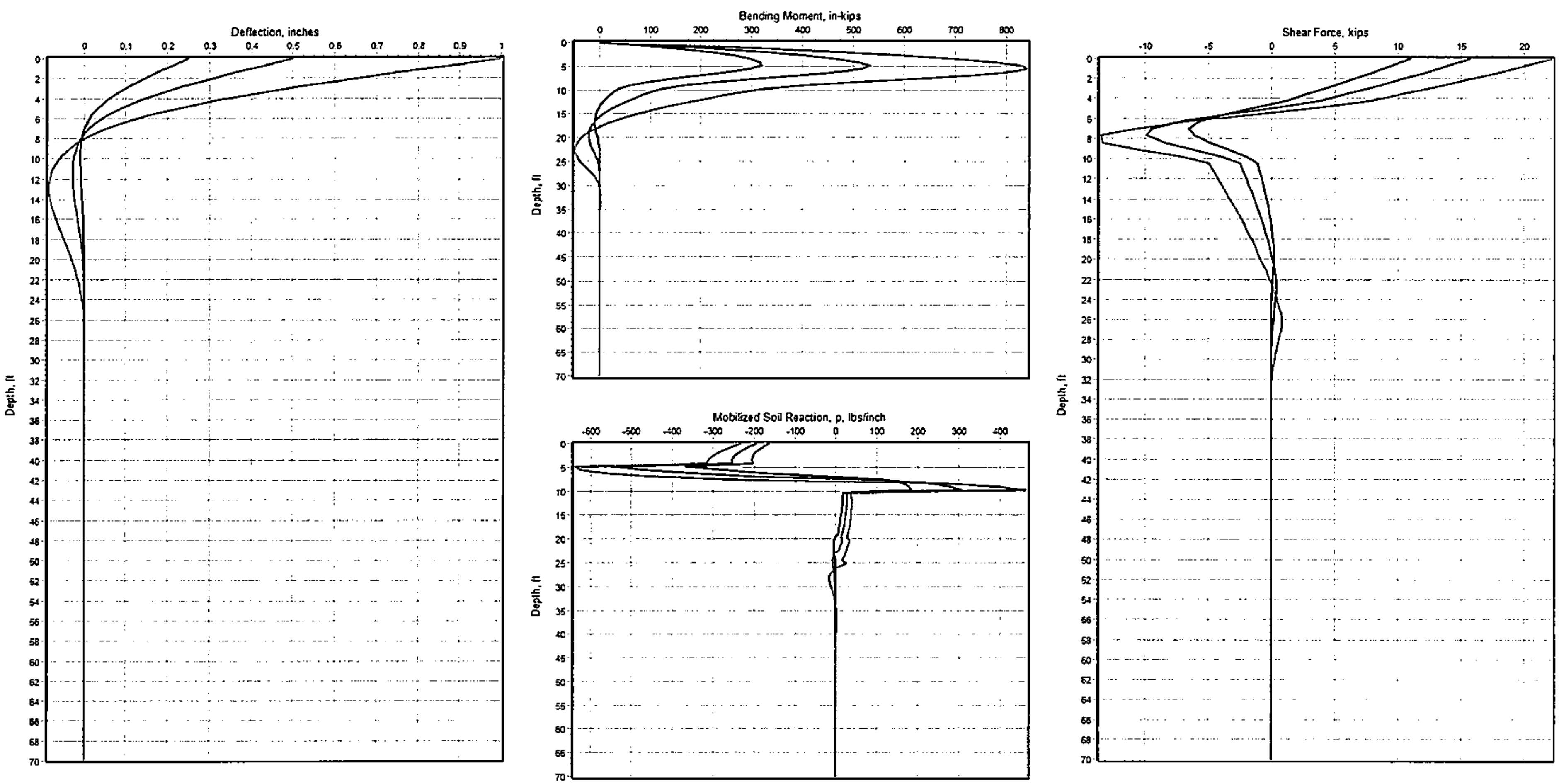


Exhibit B-1

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

Project Manager: YJ	Project No. ES185011
Drawn by: YJ	Scale: N.T.S.
Checked by: GL	File Name:
Approved by: GL	Date: 3/7/2018

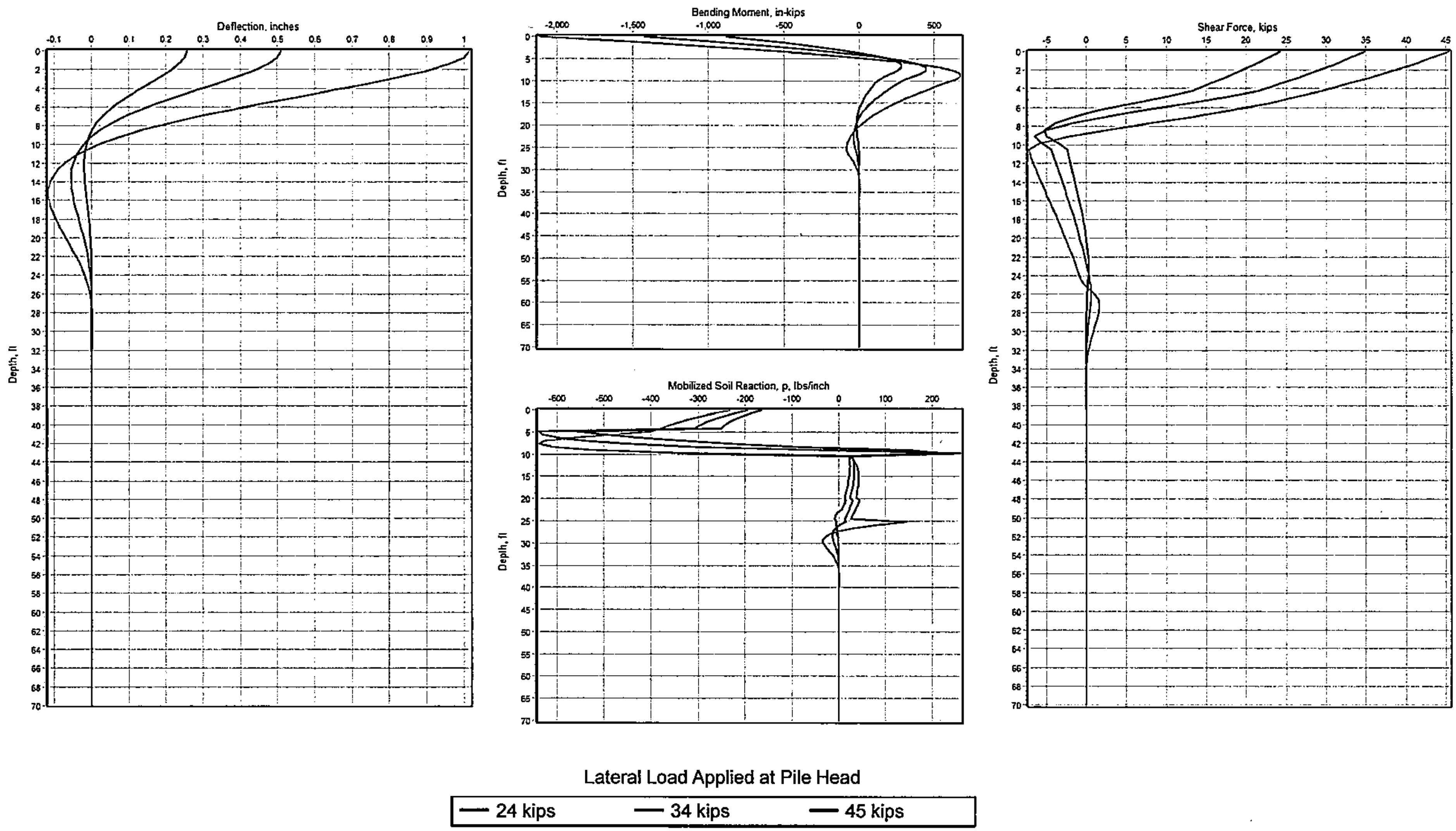
Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure
B-2-1

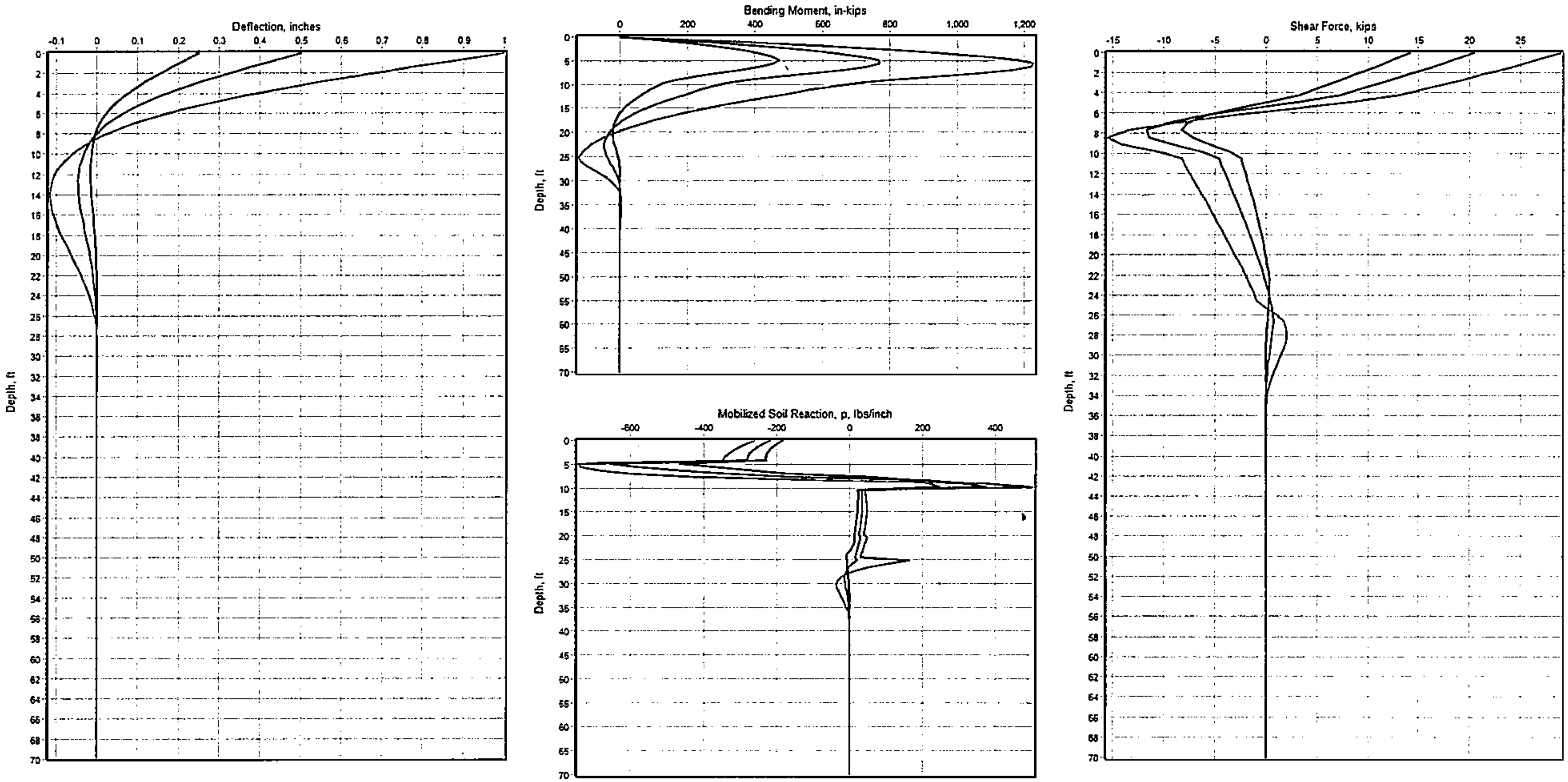
12" PSC Piles, Static Loading, Fixed Head



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

Project Manager: YJ	Project No. ES185011	Terracon Consulting Engineers & Scientists	LPILE Analyses
Drawn by: YJ	Scale: N.T.S.	2201 Rowland Avenue Savannah, Georgia 31404	Travis Field WWTF Savannah, Georgia
Checked by: GL	File Name:	Phone (912) 629 4000 Fax (912) 629 4001	Figure B-2-2
Approved by: GL	Date: 3/7/2018		

14" PSC Piles, Static Loading, Free Head



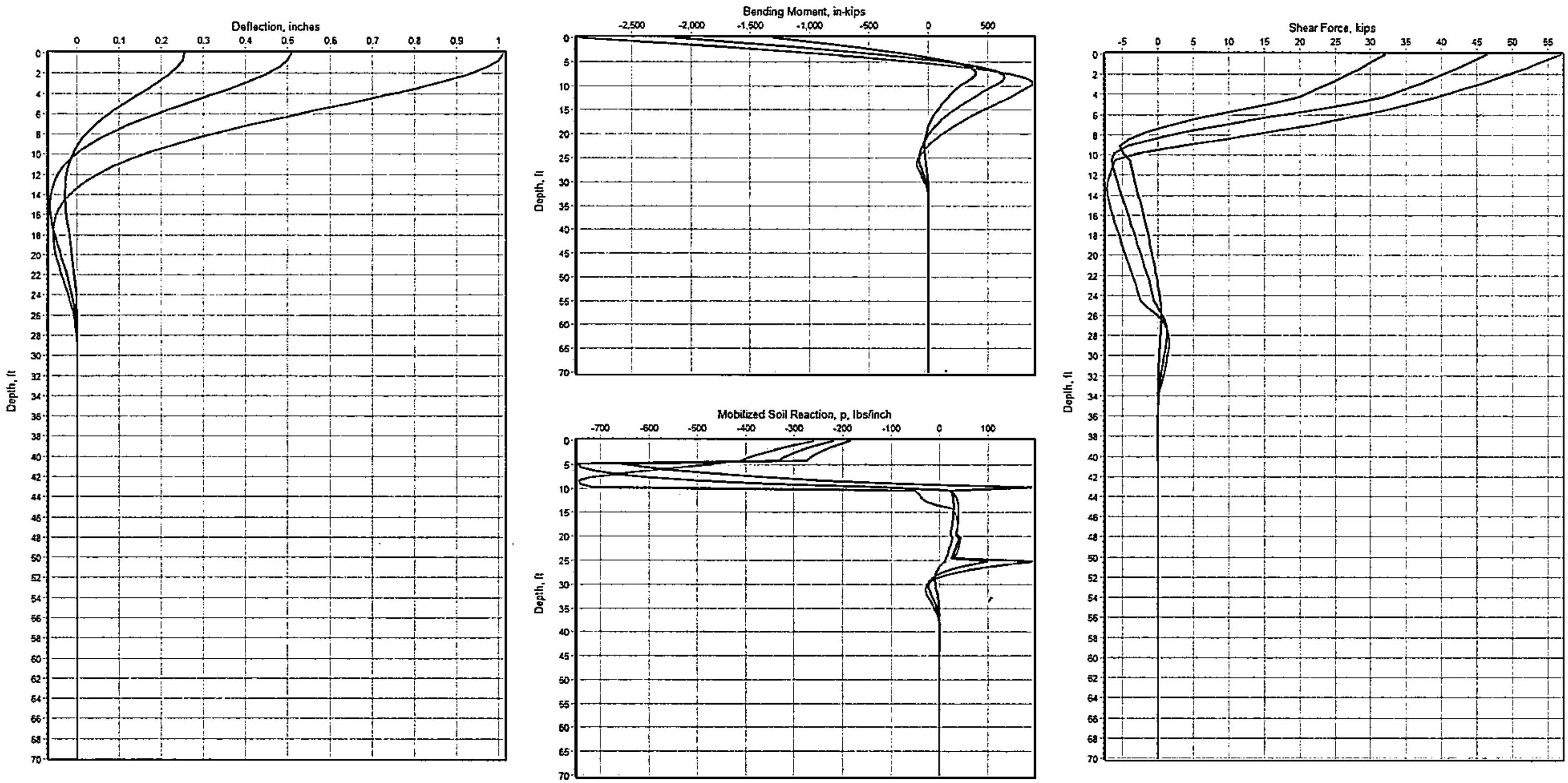
Lateral Load Applied at Pile Head

— 14 kips — 20 kips — 28 kips

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

Project Manager: YJ	Project No. ES185011	Terracon Consulting Engineers & Scientists	LPILE Analyses
Drawn by: YJ	Scale: N.T.S.	2201 Rowland Avenue Savannah, Georgia 31404	Travis Field WWTF Savannah, Georgia
Checked by: GL	File Name:	Phone (912) 629 4000 Fax (912) 629 4001	Figure B-2-3
Approved by: GL	Date: 3/7/2018		

14” PSC Piles, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

— 31 kips — 46 kips — 56 kips

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

Project Manager: YJ	Project No. ES185011		
Drawn by: YJ	Scale: N.T.S.		
Checked by: GL	File Name:		
Approved by: GL	Date: 3/7/2018		

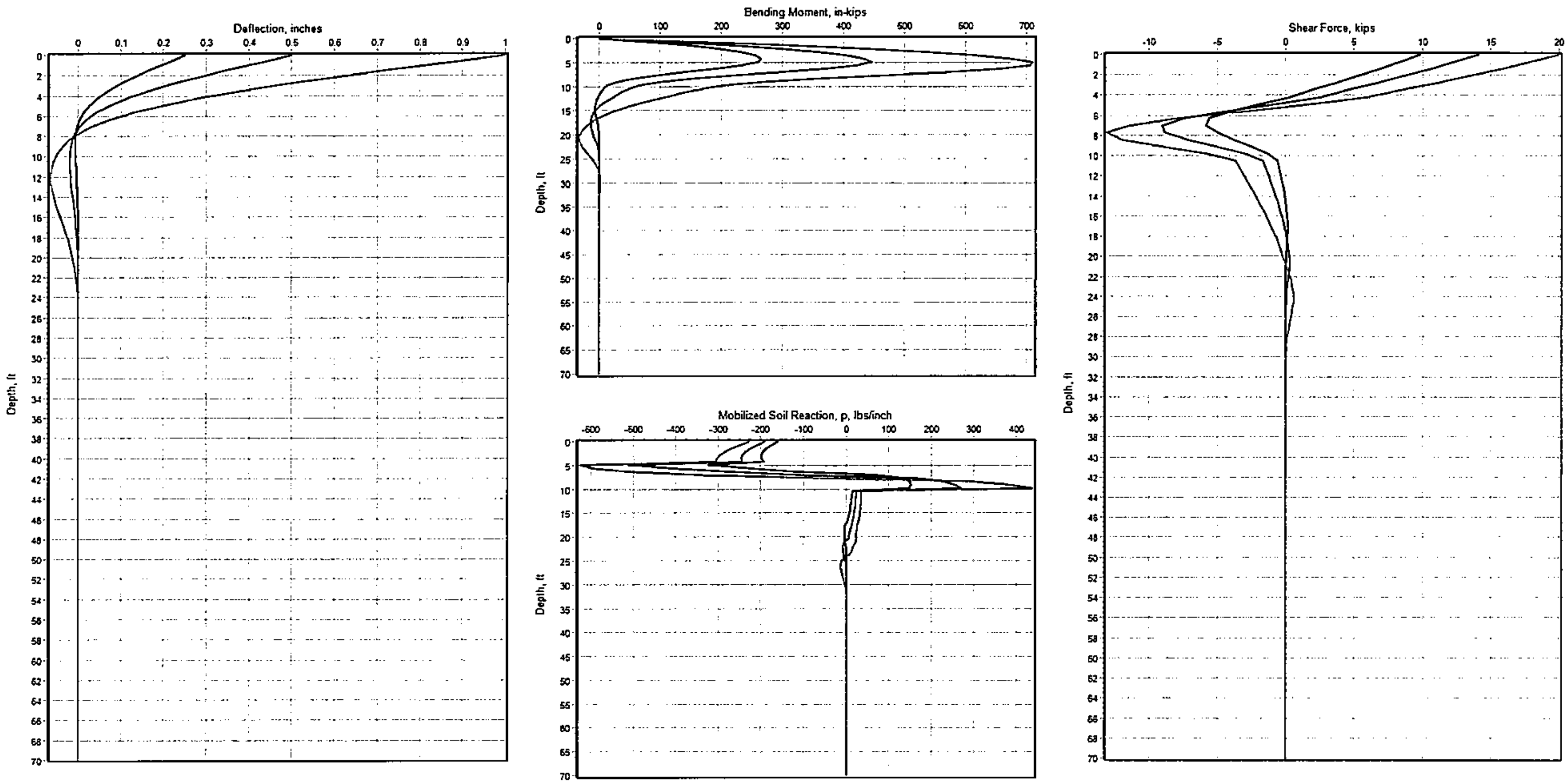
Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure
B-2-4

12” HP12x53, Static Loading, Free Head



Lateral Load Applied at Pile Head

— 9 kips — 14 kips — 19 kips

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

Project Manager: YJ	Project No. ES185011
Drawn by: YJ	Scale: N.T.S.
Checked by: GL	File Name:
Approved by: GL	Date: 3/7/2018

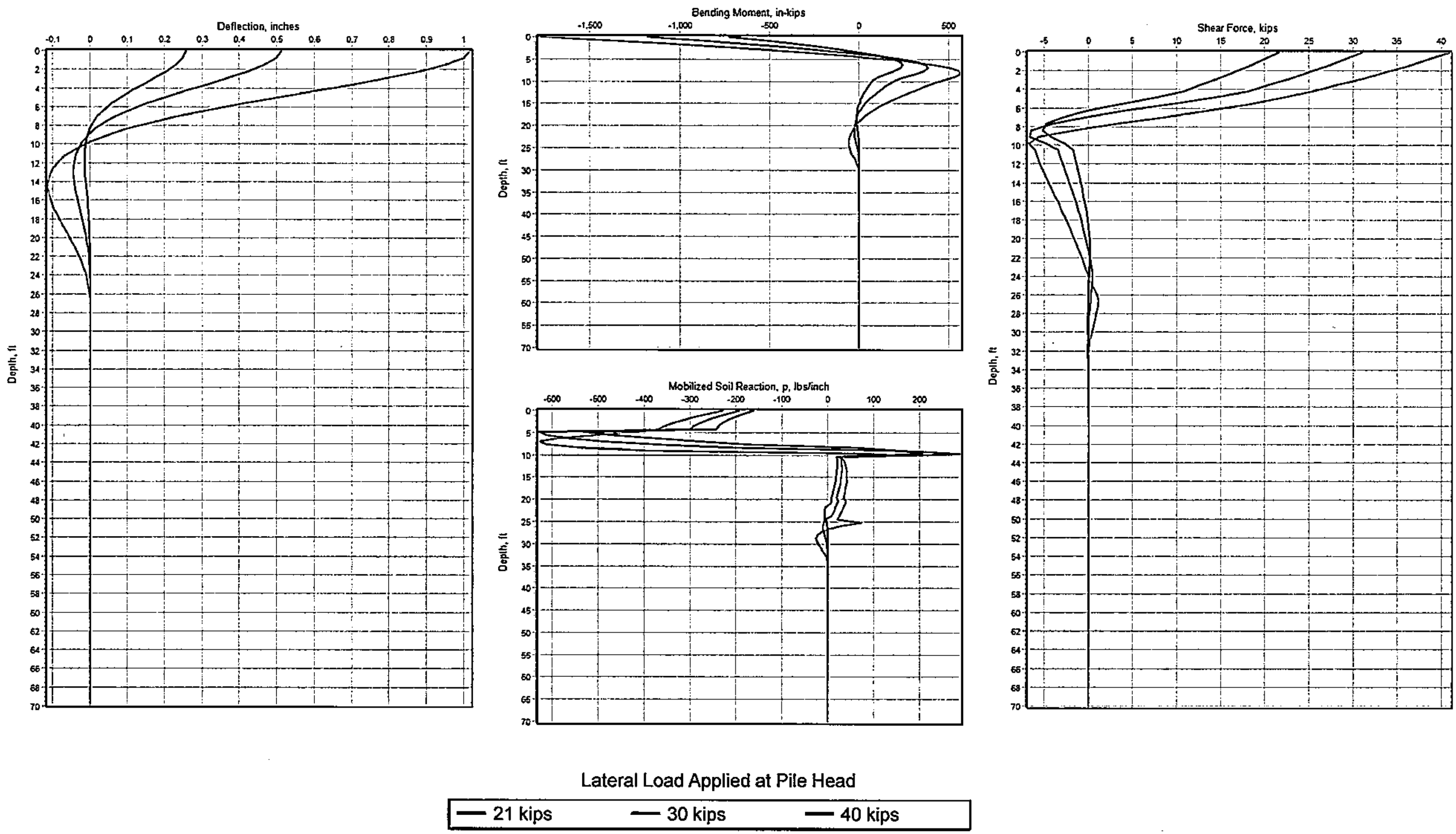
Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure B-2-5

12” HP12x53, Static Loading, Fixed Head



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

Project Manager: YJ	Project No. ES185011		
Drawn by: YJ	Scale: N.T.S.		
Checked by: GL	File Name:		
Approved by: GL	Date: 3/7/2018		

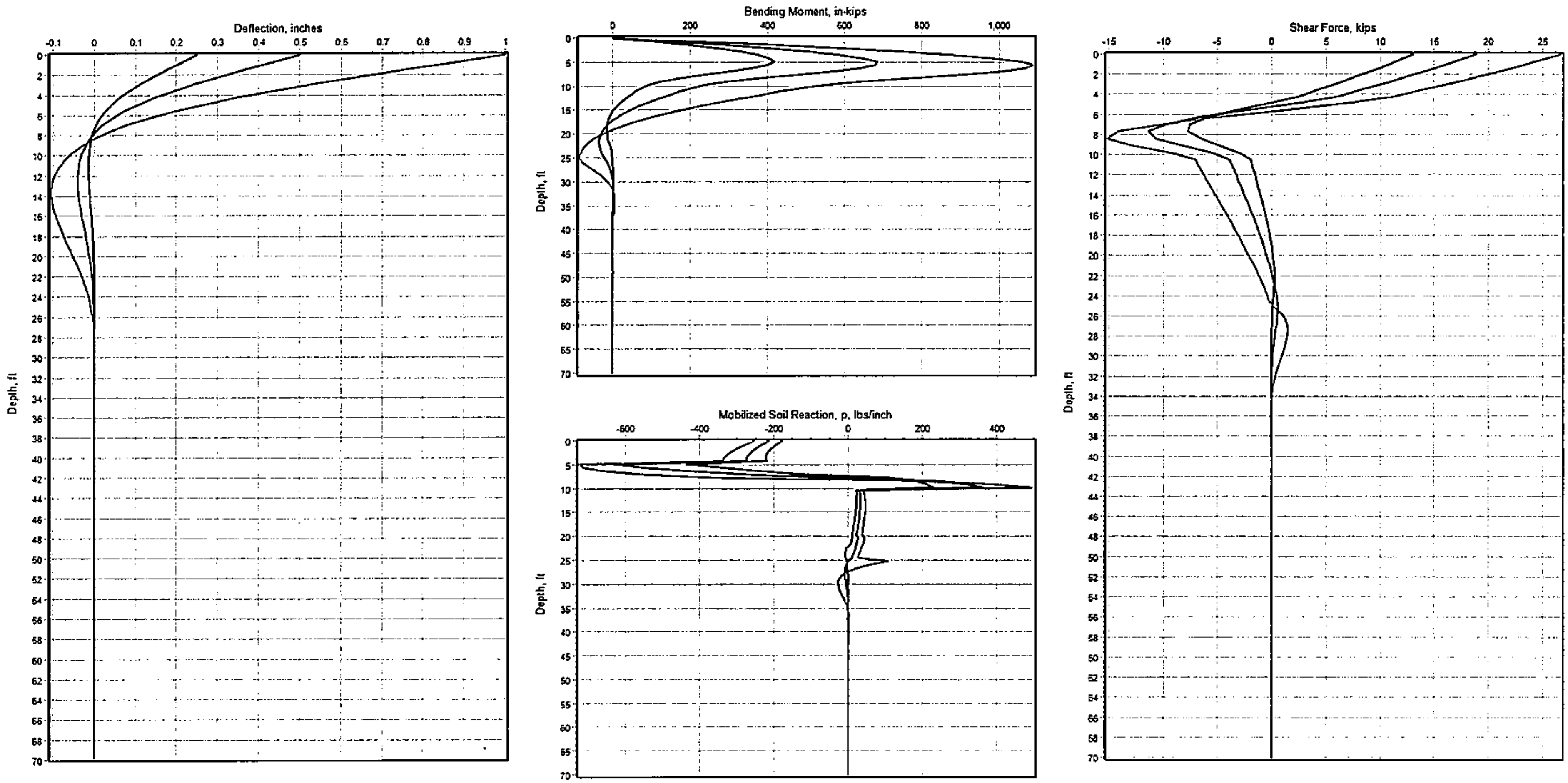
Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure
B-2-6

14" HP14x73, Static Loading, Free Head



Lateral Load Applied at Pile Head

— 13 kips — 18 kips — 26 kips

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

Project Manager: YJ	Project No. ES185011		
Drawn by: YJ	Scale: N.T.S.		
Checked by: GL	File Name:		
Approved by: GL	Date: 3/7/2018		

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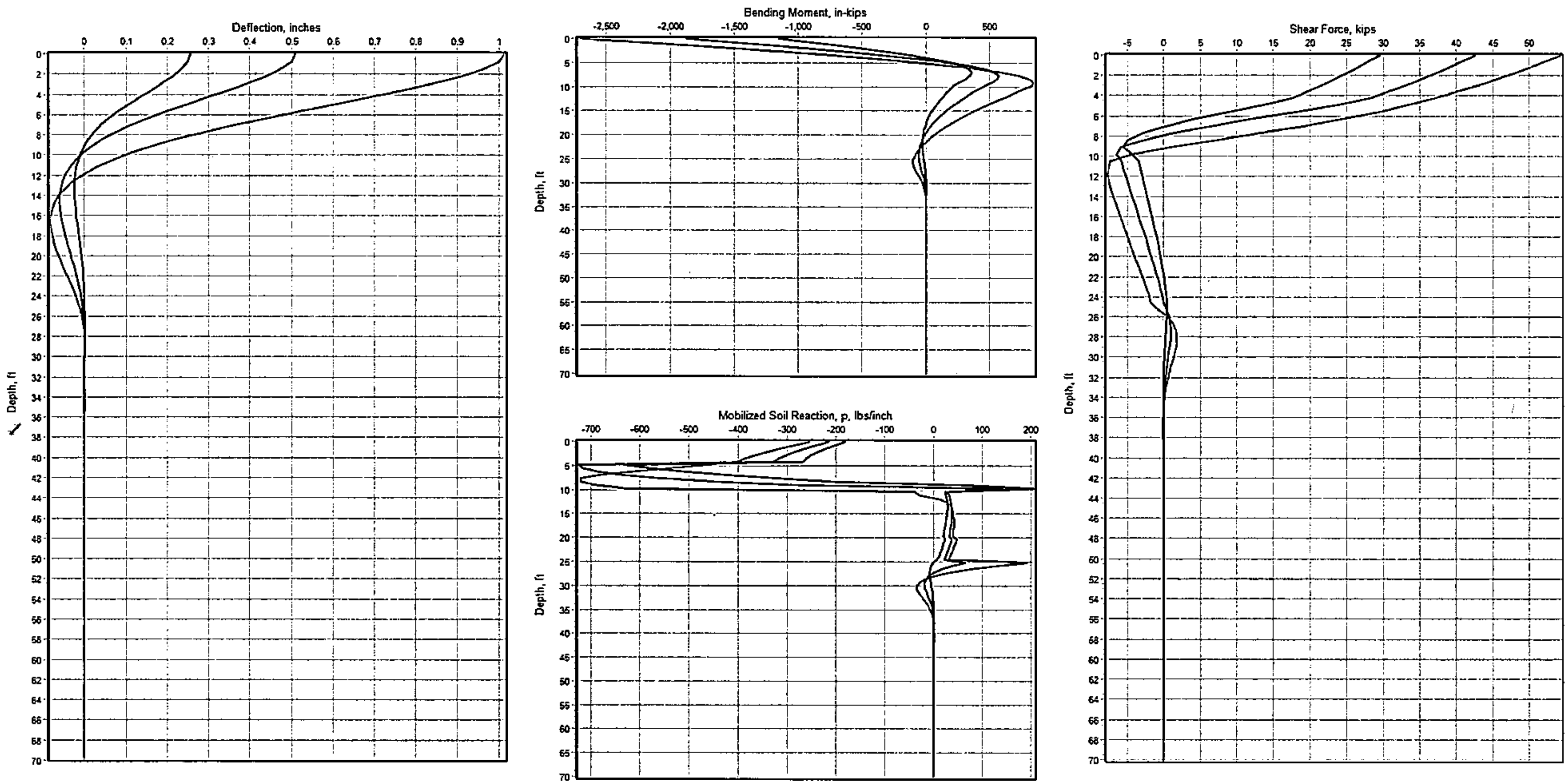
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure
B-2-7

14" HP14x73, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

— 29 kips — 42 kips — 52 kips

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

Project Manager: YJ	Project No. ES185011		
Drawn by: YJ	Scale: N.T.S.		
Checked by: GL	File Name:		
Approved by: GL	Date: 3/7/2018		

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

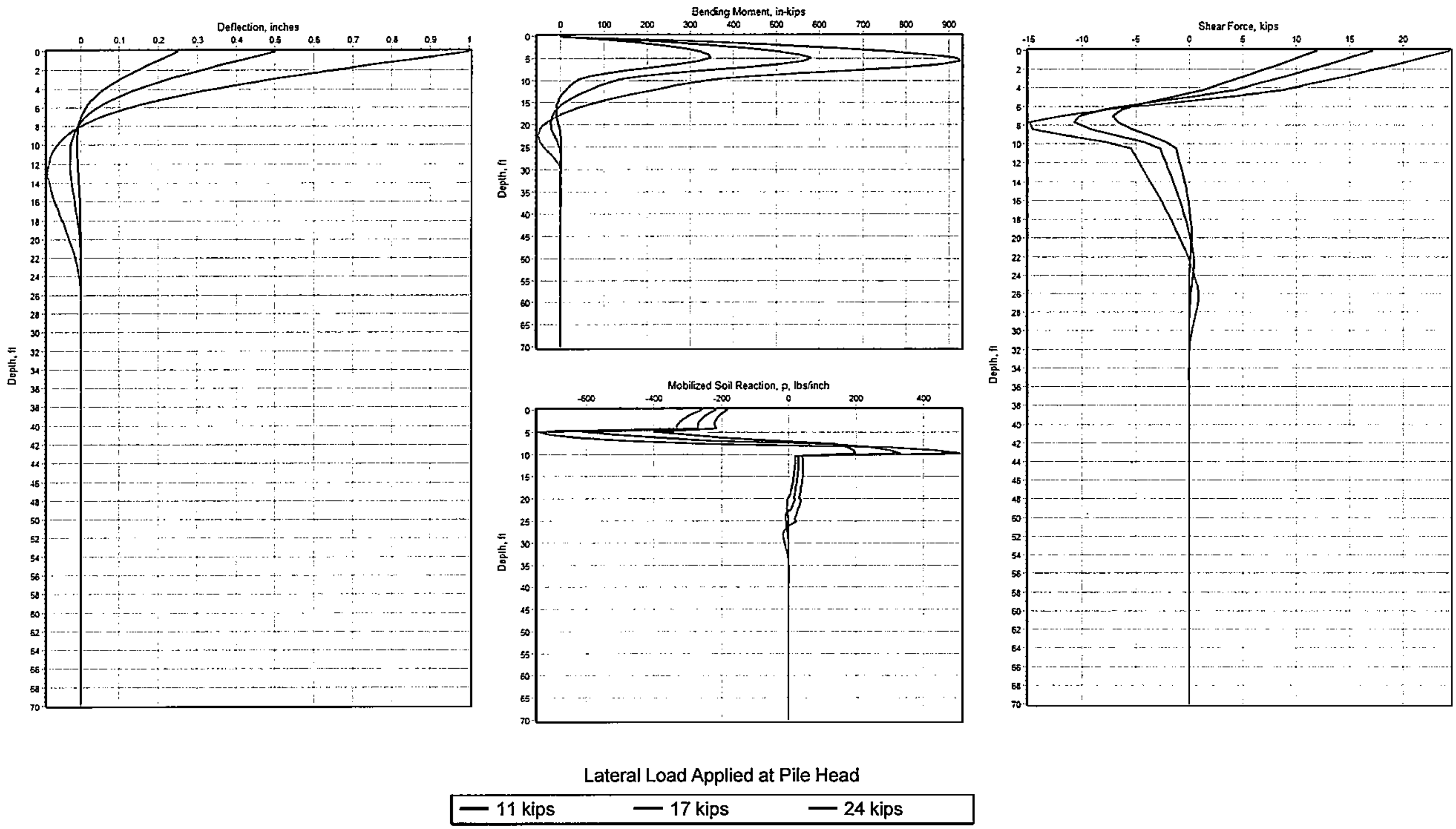
LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure

B-2-8

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

Project Manager: YJ	Project No. ES185011
Drawn by: YJ	Scale: N.T.S.
Checked by: GL	File Name:
Approved by: GL	Date: 3/7/2018

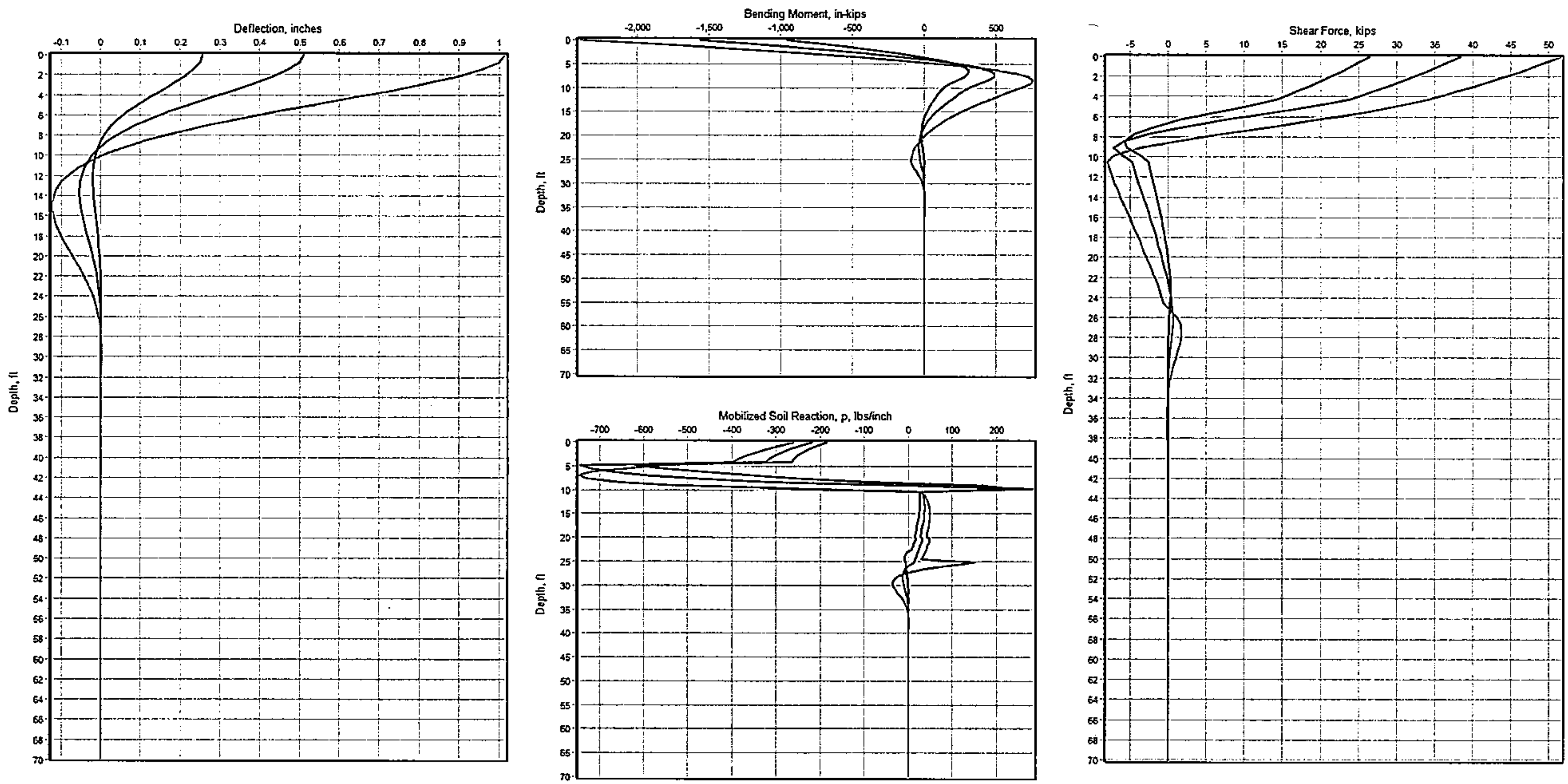
Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure B-2-9

14" ACIP Piles, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

— 26 kips — 38 kips — 51 kips

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

Project Manager: YJ	Project No. ES185011		
Drawn by: YJ	Scale: N.T.S.		
Checked by: GL	File Name:		
Approved by: GL	Date: 3/7/2018		

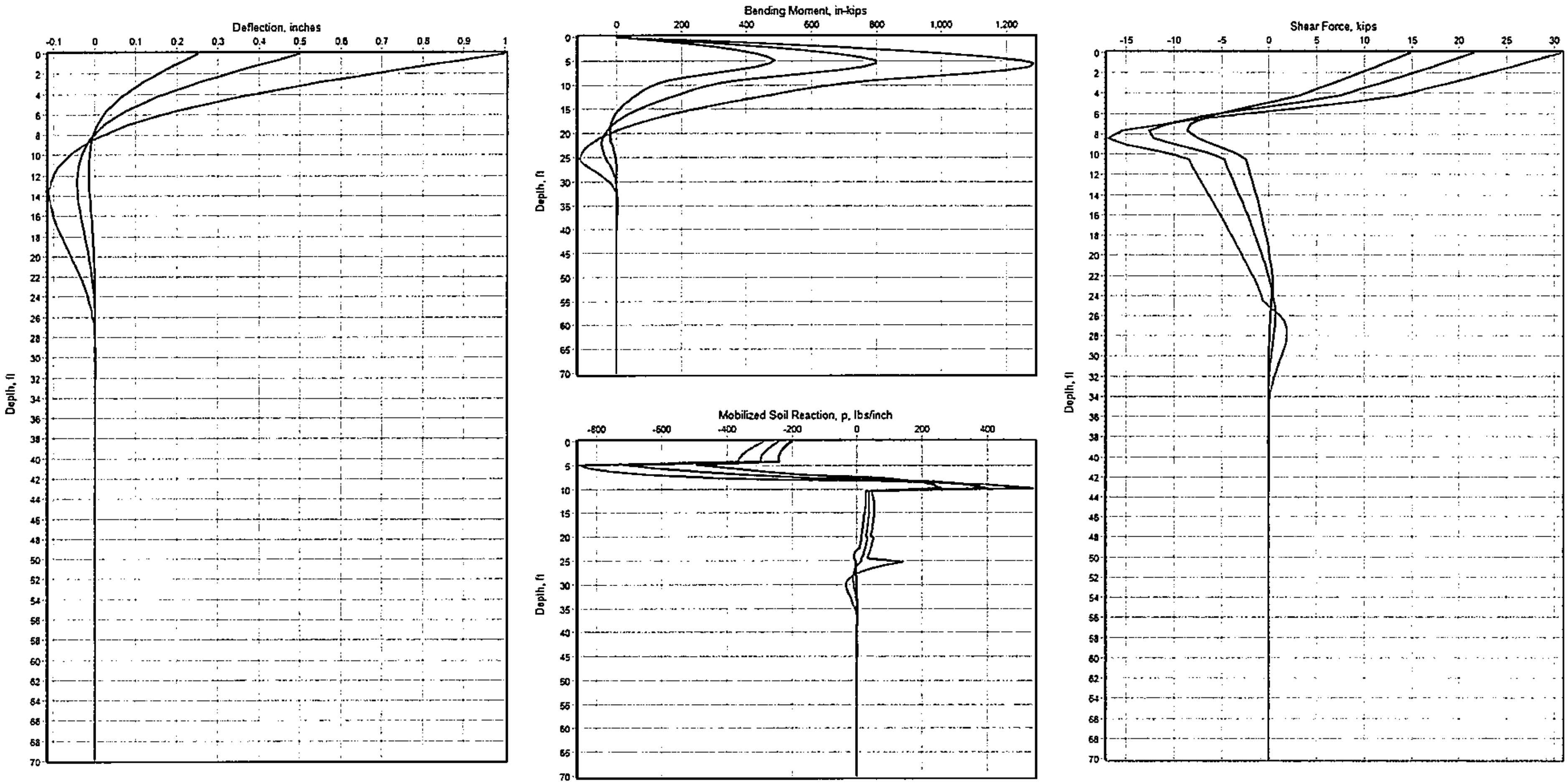
Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure
B-2-10

16” ACIP Piles, Static Loading, Free Head



Lateral Load Applied at Pile Head

— 14 kips — 21 kips — 30 kips

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

Project Manager: YJ	Project No. ES185011
Drawn by: YJ	Scale: N.T.S.
Checked by: GL	File Name:
Approved by: GL	Date: 3/7/2018

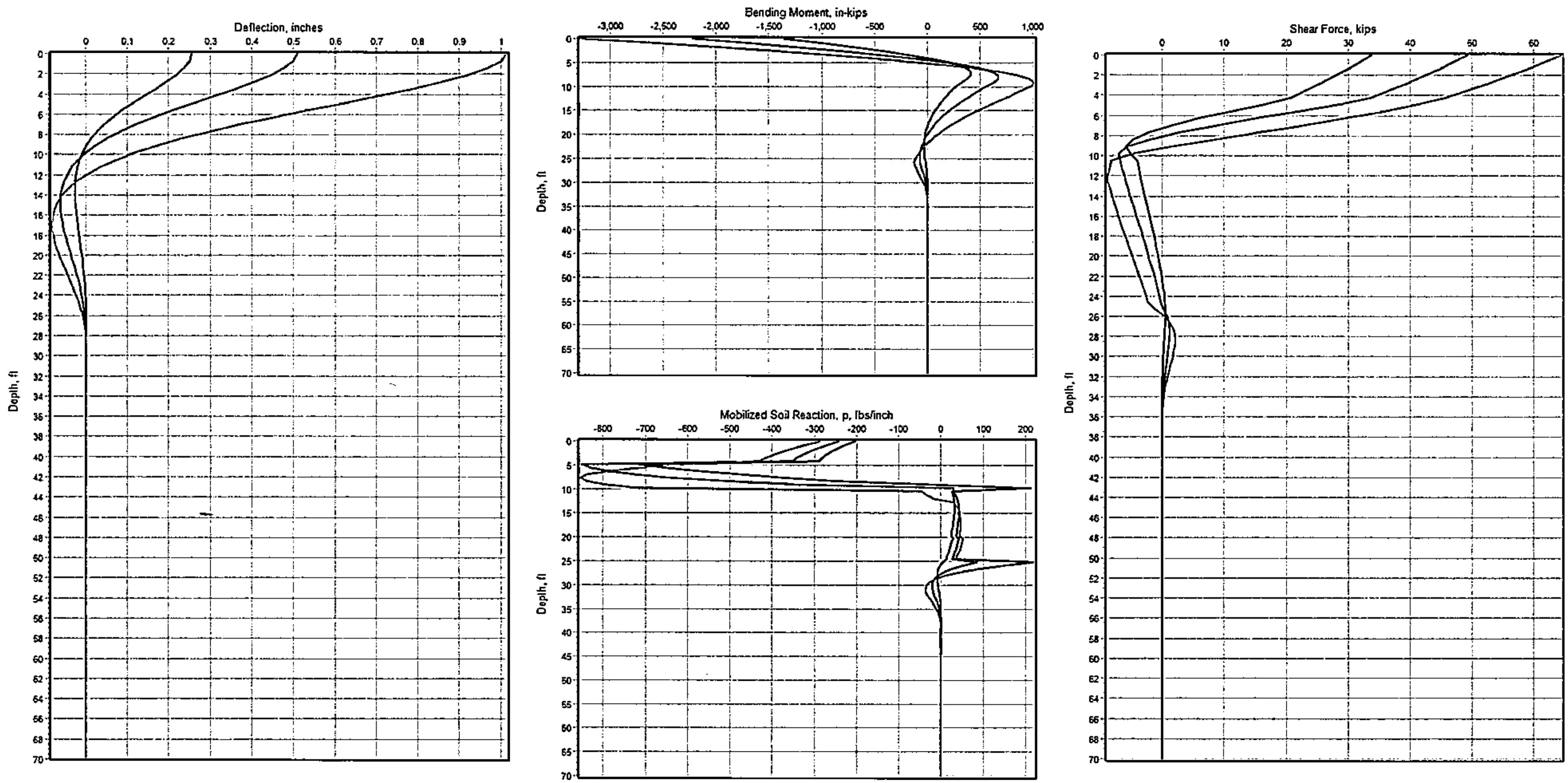
Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

LPILE Analyses

Travis Field WWTF
Savannah, Georgia

Figure
B-2-11

16" ACIP Piles, Static Loading, Fixed Head



Lateral Load Applied at Pile Head

— 33 kips — 48 kips — 63 kips

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

Project Manager: YJ	Project No. ES185011
Drawn by: YJ	Scale: N.T.S.
Checked by: GL	File Name:
Approved by: GL	Date: 3/7/2018

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LPILE Analyses

Travis Field WWTF
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Figure B-2-11

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING	GROUNDWATER	FIELD TESTS
Auger; Split Spoon; Shelby Tube; Macro Core; No Recovery; Rock Core; Ring Sampler	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.	(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.

STENGTH 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

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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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[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 on or above "A" line[J]	CL	Lean clay[K,L,M]
			$PI < 4$ or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - 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	Liquid limit - oven dried / Liquid limit - 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-in. (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] $PI \geq 4$ 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.

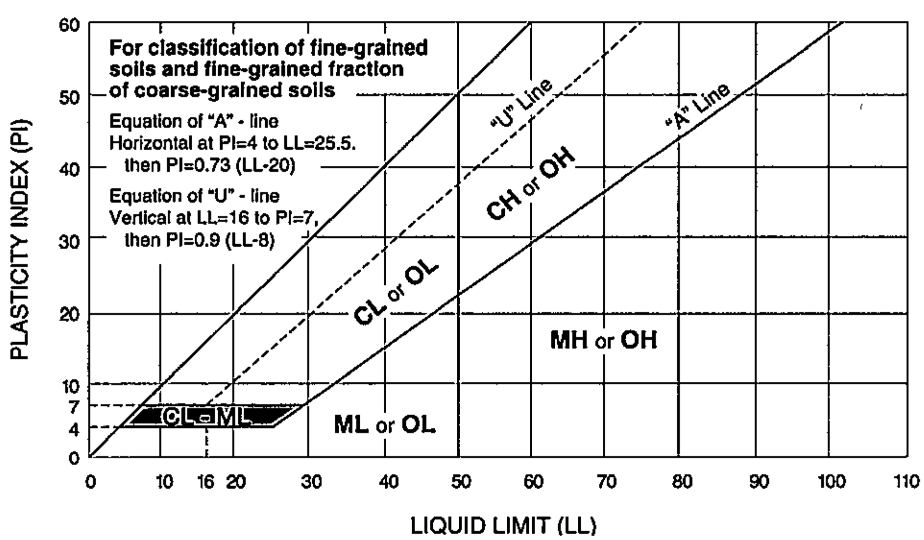

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Exhibit B-4

Form 111—6/98