TIERRA

July 6, 2016

Kisinger Campo & Associates
201 N. Franklin Street, Suite 400
Tampa, Florida 33602

Attn: Mr. David Thompson, P.E.

RE: Report of Geotechnical Engineering Services
Sand Key Fender System
Pinellas County Public Works – Engineering Consulting Services
Pinellas County ID: 002582A
Tierra Project No.: 6511-16-081

Mr. Thompson:

Tierra, Inc. (Tierra) has completed services for the geotechnical engineering study for the above referenced project. The results of our field exploration and subsequent geotechnical recommendations are presented in this report.

Tierra appreciates the opportunity to be of service to Kisinger Campo & Associates on this project. If you have any questions or comments regarding this report, please contact our office at your earliest convenience.

Respectfully Submitted,

TIERRA, INC.

Kaitie C. Waterman, for
Engineering Assistant

Erick M. Frederick, P.E.
Senior Geotechnical Engineer
Florida License No. 63920

7/20/2016

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APPENDIX

1.0 PROJECT INFORMATION

1.1 Project Authorization

Authorization to proceed with this project was issued by Kisinger Campo & Associates in accordance with P.C. Contract No. 145-0342-CN TWO #1.

1.2 Project Description

The project consists of preparing design plans for a bulkhead barge protection fender system, which is intended to protect the existing bulkhead from barge impacts. The project also consists of performing an evaluation of the existing seawall adjacent to the proposed fender system and preparing design plans for the resurfacing of the neighboring reef material storage site. The project site is located on the northern portion of Sand Key, Florida.

It is our understanding that the proposed fender system will be constructed adjacent to an existing seawall. The proposed fender system is approximately 190 feet in length and will be supported by seventy-two 16-inch diameter polymeric piles. A 1-inch wale gap occurs along the proposed fender system approximately 30 feet northwest of the southeast end of the fender, creating a dividing line between the property owned by Pinellas County and the property owned by the City of Clearwater. In addition, the existing bollards will be removed to below the asphalt and new prefabricated bollards installed according to manufacturer's recommendations.

It is our understanding that asphalt reconstruction is proposed for the parking lot adjacent to the seawall.

2.0 PURPOSE AND SCOPE OF SERVICES

The purpose of this study is to provide geotechnical input for the design of the proposed fender system structure, an evaluation of the existing seawall and assistance with pavement resurfacing, including the following:

1. Provide geotechnical design parameters required for the improvement/replacement of the sea wall design for use by the structural engineer.

2. Provide FB-Multipier design parameters required for the proposed fender system lateral analysis for use by the structural engineer.

3. General location and description of potentially deleterious materials or conditions discovered in the borings which may interfere with construction progress and structure performance, including existing fills or surficial organics.

4. Provide pavement section and general construction considerations.

5. Identification of groundwater levels.

In order to achieve the preceding objective, the following services were provided:

1. Reviewed soil information from the "Soil Survey of Pinellas County, Florida" published by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). Reviewed topographic and potentiometric information obtained from the "Clearwater, Florida" Quadrangle map and the "Potentiometric Surface of the Upper Floridan Aquifer, West Central Florida" maps published by the United States Geological Survey (USGS).

2. Conducted a visual reconnaissance of the project site and located and coordinated utility clearance.

3. Executed a program of subsurface exploration consisting of Standard Penetration Test (SPT) borings, auger borings, pavement cores, subsurface sampling and field testing. Additionally collected bulk samples for laboratory Limerock Bearing Ratio testing.

4. Visually classified and stratified the samples in the laboratory using the Unified Soil Classification System (USCS). Conducted laboratory tests on selected soil samples to confirm visual classification and provide further characterization of the subsurface conditions.

5. Developed recommended soil parameters for use in the design of the proposed fender system as well as soil parameters for evaluation of the existing seawall.

6. Prepared this engineering report, which summarizes the course of study pursued, the field and laboratory data generated, the subsurface conditions encountered and the geotechnical recommendations for the project.

3.0 REVIEW OF AVAILABLE DATA

3.1 USDA Soil Survey

Based on a review of the Pinellas County Soil Survey published by the USDA NRCS, Candler Fine Sand (Map Unit 8) is the only soil-mapping unit identified within the project limits. A general description of this soil-mapping unit is presented in the subsection below:

Candler Fine Sand (Map Unit 8) - The Candler component makes up 90 percent of the map unit. Slopes are 5 to 12 percent. This component is on ridges on marine terraces on coastal plains, hill slopes on marine terraces on coastal plains. The parent material consists of eolian deposits and/or sandy and loamy marine deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is excessively drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent.

3.2 USGS Quadrangle Map

Based on a review of the "Clearwater, Florida" USGS Quadrangle Map, the natural ground surface elevations in the project vicinity are on the order of approximately +0 feet to +5 feet, National Geodetic Vertical Datum of 1929 (NGVD 29). This is relatively consistent with survey information provided for the project.

3.3 Review of Potentiometric Surface Information

Based on a rewview of the "Potentiometric surface of the upper Floridian Aquifer, West Central Florida" maps published by the USGS, the potentiometric surface elevation of the upper Floridian Aquifer at the proposed fender wall and sheet pile wall location is on the order of approximately +5 feet, NGVD. The Contractor's tools and construction methods should address and handle a potentiometric level up to +5 feet, NGVD, at no additional cost to the owner.

4.0 SUBSURFACE EXPLORATION

4.1 Boring Location Plan

Prior to commencing our subsurface exploration, a boring location plan for the project was developed. This boring location plan was generated based on the proposed limits for the fender system, seawall evaluation and pavement resurfacing, the project scope, and our engineering judgment. Upon finalizing the boring location plan, the borings were located and staked in the field using hand-held Garmin eTrex® Global Positioning System (GPS) equipment with a reported accuracy of 10 feet. Generally, the borings were performed at the proposed boring locations. When not possible due to access or utility constraints, the boring locations were altered and the relocated GPS coordinates were recorded on the field boring logs. The boring locations are illustrated on the **Boring Location Plan** sheet in the **Appendix**. Utility clearances were coordinated by Tierra and updated as required prior to performing the soil borings in order to reduce the potential for damage to the utilities during drilling.

4.2 Auger and SPT Borings

To evaluate the soil conditions in the vicinity of the proposed pavement resurfacing, three (3) pavement cores with associated hand auger borings were performed. The auger borings were performed by manually twisting a bucket auger into the ground, typically in 6 inch increments. The auger borings were advanced to a depth on the order of 6 feet below the existing pavement surface.

To evaluate the soil conditions along the existing seawall, two (2) SPT borings were performed to a depth of 50 feet below existing grades. In addition, to evaluate the soil conditions in the footprint of the proposed fender system, two (2) SPT borings were performed to depths ranging from 40 to 50 feet below the mudline. The SPT borings were performed with the use of a drill rig using Bentonite Mud drilling procedures. For the borings performed in the footprint of the proposed fender system, casing was set from the barge mounted equipment to approximately 9 feet below the mudline to facilitate drilling processes. The soil sampling was performed in general accordance with ASTM D-1586 "Penetration Test and Split-Barrel Sampling of Soils".

The initial 4 feet to 6 feet of the land based borings were manually augered to verify utility clearance and avoid contact with utilities and/or potential tie-rods associated with the seawall. SPT resistance N-values were then taken continuously to a depth of 10 feet and on intervals of 5 feet thereafter to the boring termination depth. For the barge mounted borings, SPT resistance N-Values were taken continuously in the initial 10 feet below the mudline and on 5 foot intervals thereafter to the boring termination depth.

As each soil type was encountered within the borings, representative samples were collected and returned to Tierra for laboratory classification and analysis. The results of the borings are presented on the **Soil Profiles** sheet in the **Appendix**.

5.0 LABORATORY TESTING

5.1 General

Representative soil samples collected from the borings were classified and stratified in general accordance with the Unified Soil Classification System (USCS). Our classification was based on visual observations, using the results from the laboratory testing as confirmation. Laboratory index property testing comprised of fines content analysis (passing #200 sieve), Atterberg Limits, natural moisture content determination, and organic content determination were performed on representative materials encountered in the borings. The results of the laboratory tests are presented on the **Soil Profiles** sheet in the **Appendix**.

5.2 Test Designation

The following list summarizes the laboratory tests performed and respective test methods utilized.

- <u>Fines Content Test</u> - The fines content tests were conducted in general accordance with the AASHTO test designation T-088 (ASTM test designation D-1140).

- <u>Atterberg Limits</u> – The liquid limit and plastic limit tests ("Atterberg Limits") were conducted in general accordance with the AASHTO test designations T-089 and T-090 respectively (ASTM test designation D-4318).

- <u>Natural Moisture Content</u> – The moisture content tests were conducted in general accordance with the AASHTO test designation T-265 (ASTM test designation D-2216).

- <u>Organic Content</u> - The organic content tests were conducted in general accordance with the AASHTO test designation T-267.

- <u>Limerock Bearing Ratio</u> – The Limerock Bearing Ratio (LBR) tests were conducted in general with Florida State Testing Method designation: FM 5-515.

6.0 RESULTS OF SUBSURFACE EXPLORATION

6.1 General Soil Conditions

The SPT borings performed within the footprint of the proposed fender system encountered sandy soils from the ground surface to a depth of 8 feet below the mudline, underlain by silt to clay to calcareous clay with weathered limestone to depths ranging from approximately 38 to 48 below the mudline, underlain by weathered limestone to the boring termination depths.

The SPT borings performed near the existing seawall generally encountered sandy soils from the ground surface to a depth of approximately 23 feet below existing grades, underlain by clayey sand to silt to clay to calcareous clay with weathered limestone to depths ranging from approximately 48 to 50 feet below existing grades. Boring B-1 encountered weathered limestone at a depth of approximately 48 below existing grades.

The auger borings performed in the vicinity of the proposed pavement resurfacing generally encountered sandy soils with occasional shells from the ground surface to the boring termination depths. Additionally, borings C-1 and C-2 encountered silty sand to silty clayey sand with trace organics from 2½ to 3 feet below existing grades and 3¾ to 4½ feet below existing grades, respectively.

The soil descriptions and classifications associated with the project are listed below.

Stratum Designation	Typical Soil Description	Unified Soil Classification System (USCS)
P	Asphalt Pavement and Base Material	--[1]
1	Pale Brown to Gray Sand to Sand with Silt, Occasionally with Shell	SP/SP-SM
2	Brown to Gray Silty Sand to Silty Clayey Sand	SM/SM-SC
3	Gray Clayey Sand	SC
4	Gray Silt to Clay	MH/CH
5	Calcareous Clay with Weathered Limestone	CH
6	Weathered Limestone	--[2]
7	Dark Gray to Black Silty Sand with Trace Organics	SM/PT

--[1] USCS nomenclature does include a classification for pavement and base material
--[2] USCS nomenclature does include a classification for weathered limestone

Soil stratification was determined based on a review of recovered samples, laboratory test results, and interpretation of field boring logs. Stratification lines represent approximate boundaries between soil layers of different engineering properties; however actual transitions between layers may be gradual. In some cases, small variations in properties that were not considered pertinent to our engineering evaluation may have been abbreviated or omitted for clarity. The soil profiles represent the conditions at the particular boring location and variations do occur among the borings. Specific details about subsurface conditions and materials encountered at each test location can be obtained from the soil profiles presented on the **Soil Profiles** sheet in the **Appendix**.

6.2 Groundwater

The groundwater table was encountered within the borings at depths ranging from 3¼ to 4 feet below existing grades. The encountered groundwater is shown adjacent to the soil profiles on the **Soil Profiles** sheet in the **Appendix**.

Groundwater conditions will vary with environmental variations and seasonal conditions, such as the frequency and magnitude of rainfall patterns, tidal conditions, as well as man-made influences (i.e. existing water management canals, swales, drainage ponds, underdrains and impervious areas). Groundwater levels are anticipated to generally follow the rise and fall of the tides of the bay adjacent to the proposed fender system structure and existing seawall.

6.3 Pavement Cores

Tierra performed pavement cores at the locations of the auger borings in order to evaluate the subgrade soils below the pavement. Based on the information obtained from the pavement cores, the asphalt pavement thicknesses ranged from approximately 0.7 inch to 1.0 inch at the locations tested. The asphalt pavement was underlain by a limerock base. The detailed results of the pavement coring operations are included on the **Pavement Section Data** sheet in the **Appendix**. The data provided is for design support only.

6.4 Bulk Sampling and LBR Testing

Bulk samples were retrieved for Limerock Bearing Ratio (LBR) testing at two (2) locations. In general, these samples were collected from the top 1 to 2 feet of the near-surface soils encountered. The results of the LBR testing are presented in the **Results of Limerock Bearing Ratio Tests** in the **Appendix**. Tierra utilized the "±2 of Optimum Method" described in the FDOT Soils and Foundation to calculate a design LBR value for the project. The resulting design LBR value is 70 and is presented in the **Design LBR Calculation** in the **Appendix**. The data provided is for design support only.

7.0 RECOMMENDATIONS AND EVALUATIONS

7.1 General

The Contractor shall anticipate that difficult installation of sheet piles and piles for the fender system may be encountered due to the presence of compacted/dense soils and limestone at the project site. Variations in the depth and consistency of such materials shall be anticipated. Specialized equipment and/or installation methods, including the use of preformed pile holes, punching, and/or other methods may be required to install the sheet piles and fender support piles to the required minimum tip elevation. Jetting is not allowed.

Silty sand with trace organics (Stratum 7) was encountered within the auger borings performed with thicknesses ranging from approximately ½ to 1 foot thick. Through laboratory testing, the organic content was determined to range from 4 to 7 percent for an average of 5½ percent. The general thickness and organic content of the soils encountered do not appear to pose limitations on construction. However, due to the limited geotechnical investigation, variation in organic content and thickness should be anticipated. If organic soils are exposed during pavement reconstruction, these soils should be removed and replaced with clean sand.

Scour information was not available at the time of this report. The design team should consider the potential for scour when evaluating the seawall and fender system. Once scour information becomes available, Tierra should be given the opportunity to review the information and amend the recommendations in this report, if necessary.

7.2 Seawall

It is our understanding that an evaluation of the existing seawall is being performed by others. Tierra performed two (2) SPT borings to assist in this evaluation. The soil and groundwater conditions encountered in the borings performed near the seawall are presented on the **Soil Profiles** sheet in the **Appendix**.

In addition, Tierra developed the below recommended soil parameters based on the results of the SPT borings. The geotechnical soil parameters are being provided for informational purposes only. Should seawall sheet pile design become necessary, Tierra should be given the opportunity to perform a geotechnical review of the seawall sheet pile design to verify that the below geotechnical parameters were incorporated correctly.

Recommended Soil Parameters for Seawall Evaluation

Boring Name	Soil Classification	Depth (ft)		Unit Weight (pcf)		Cohesion/ Ultimate Shear Strength* (psf)	Internal Friction Angle	Wall Friction Angle(1) (Concrete)	Wall Friction Angle(2) (Steel)	Coefficient of Earth Pressure(3)	
		From	To	Saturated/ Total	Effective					Active	Passive
B-1	Medium Dense Sand	0	18	105	42.6	0	29°	17°	17°	0.347	2.88
	Very Loose Silty Sand	18	23	100	37.6	0	26°	17°	14°	0.391	2.56
	Stiff Clay	23	28	115	52.6	800	0°	--	--	1.000	1.00
	Hard Clayey Sand to Clay	28	48	125	62.6	7600	0°	--	--	1.000	1.00
	Limestone	48	50	135	72.6	15000*	0°	--	--	1.000	1.00
B-2	Medium Dense Sand	0	18	105	42.6	0	29°	17°	17°	0.347	2.88
	Very Loose Silty Sand	18	23	100	37.6	0	26°	17°	14°	0.391	2.56
	Firm Clay	23	28	110	47.6	500	0°	--	--	1.000	1.00
	Hard Clayey Sand to Clay	28	50	125	62.6	11650*	0°	--	--	1.000	1.00

(1) – Wall friction angle is based on concrete sheet piling and the sandy soils encountered within the borings.
(2) – Wall friction angle is based on steel sheet piling and the sandy soils encountered within the borings.
(3) – Coefficient of Earth Pressure is based on flat/non-sloping ground.

Note: The environmental classification for the project should be considered extremely aggressive as a result of the saltwater environment

7.3 Fender System

Based on our review of the plans, the proposed fender system is approximately 190 feet in length and will be supported by thirty-six 16-inch diameter polymeric piles. Geotechnical Soil Strength Parameters for the proposed fender system analysis for use by the structural engineer are included in the **Appendix** for design support purposes only. These parameters are based on the soil conditions encountered within the borings performed within the vicinity of the proposed fender system structure.

7.4 Pavement Considerations

Actual pavement section thickness should be provided by the design civil engineer based on traffic loads, volume, and the owners design life requirements. The following sections represent minimum thicknesses representative of typical load and construction practices and as such periodic maintenance should be anticipated. All pavement materials and construction procedures should conform to the appropriate County requirements.

In general, following the completion of the recommended clearing and grading operations and fill placement, the compacted fill and natural shallow sandy soils should be acceptable for construction and support of a flexible (limerock, crushed concrete, or shell base) type pavement section, or rigid (concrete) pavement section.

The results of the LBR testing are presented in the **Results of Limerock Bearing Ratio Tests** in the **Appendix**. Tierra utilized the "±2 of Optimum Method" described in the FDOT Soils and Foundation to calculate a design LBR value for the project. The resulting design LBR value is 70 and is presented in the **Design LBR Calculation** in the **Appendix**. The data provided is for design support only.

Following initial clearing and grading, the exposed subgrade shall be compacted to a minimum depth of 12 inches to a minimum density of 95% of the Modified Proctor maximum dry density. Any fill utilized to elevate the cleared pavement areas to subgrade elevation should consist of reasonably clean (maximum 12% passing the #200 sieve sizes) sands uniformly compacted to a minimum depth of 12 inches to a minimum density of 95% of the Modified Proctor maximum dry density. Traffic should not be allowed on the subgrade as the base is placed to avoid rutting. The subgrade should be checked for soundness and be true to line and grade prior to the placement of the base course.

The choice of pavement base type will depend on final pavement grades. If a minimum separation of 18 inches between the bottom of the base and the seasonal high groundwater level (anticipated to follow tidal levels) is obtained, then a limerock, shell, or crushed concrete base can be utilized. A crushed concrete base should be utilized if the separation between the bottom of the base and the seasonal high groundwater is a minimum of 12 inches and less than 18 inches. Base material elevations should not be designed for saturated conditions. If the designer wishes to have base material closer than 12 inches to the SHGWT, then an underdrain system should be utilized that will maintain the 12 inches of separation. The SHGWT should be re-established relative to a known elevation prior to setting final grades. Limerock, shell and crushed concrete base material should meet Florida Department of Transportation (FDOT) requirements including compaction to a minimum density of 98% of the Modified Proctor maximum dry density and a minimum Limerock Bearing Ratio (LBR) of 100%. Crushed concrete should be graded in accordance with FDOT Standard Specification Section 901-5. As a guideline for pavement design, we recommend that the base course be a minimum of 6 inches thick in parking areas and 8 inches thick in heavily traveled drives. Before paving, the base should be checked for soundness.

The asphaltic concrete structural course should consist of at least one and one-half (1½) inches of Type S or SP asphaltic concrete material. The asphaltic concrete should meet standard FDOT material requirements and placement procedures as outlined in the current FDOT Specifications.

8.0 REPORT LIMITATIONS

Our services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices at the time of this report. Tierra is not responsible for the conclusions, opinions or recommendations made by others based on this data.

The scope of the exploration was intended to evaluate soil conditions within the influence zone of the proposed fender system structure and pavement resurfacing and assist with an evaluation of the existing seawall. The analyses and recommendations submitted in this report are based upon the data obtained from the soil borings performed at the locations indicated. If any subsoil variations become evident during the course of this project, a re-evaluation of the recommendations contained in this report will be necessary after we have had an opportunity to observe the characteristics of the condition encountered. The applicability of the report should also be reviewed in the event significant changes occur in the design, nature or location of the proposed structure replacement.

The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater, or surface water within or beyond the site studied. Any statements in this report regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of Kisinger Campo & Associates and its consultants.

APPENDIX

Boring Location Plan

Soil Profiles

Pavement Section Data

Results of Limerock Bearing Ratio Tests

Design LBR Calculation

Geotechnical Soil Strength Parameters – Fender System

NOTES:

1. BASE MAP PROVIDED BY KISINGER CAMPO & ASSOCIATES.
2. THE BORINGS WERE LOCATED IN THE FIELD BY A REPRESENTATIVE OF TIERRA USING A GARMIN ETREX HANDHELD GPS UNIT WITH A REPORTED ACCURACY OF 10 FEET. THE BORING LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.

BORING LOCATION PLAN

0 50'

PLAN SCALE

N

LEGEND

- ⌖ APPROXIMATE LOCATION OF SPT BORING
- ● APPROXIMATE LOCATION OF PAVEMENT CORE AND HAND AUGER BORING
- ▲ APPROXIMATE LOCATION OF BULK SAMPLE FOR LBR TESTING

REV. NO.	DATE	DESCRIPTION	REV. BY

DESIGNED SW
DRAWN SW
CHECKED DRR

TIERRA
7351 Temple Terrace Highway
Tampa, Florida 33637
Phone: 813-989-1354 Fax: 813-989-1355
FL Cert. No.: 6486

PROJECT: SAND KEY FENDER SYSTEM

DESCRIPTION: BORING LOCATION PLAN

APPROVED BY:

ERICK M. FREDERICK, P.E. DATE
FLA. LIC. NO 63920

DATE: JUNE 2016
PROJECT NO. 6511-16-081
SHEET: 1 OF 2

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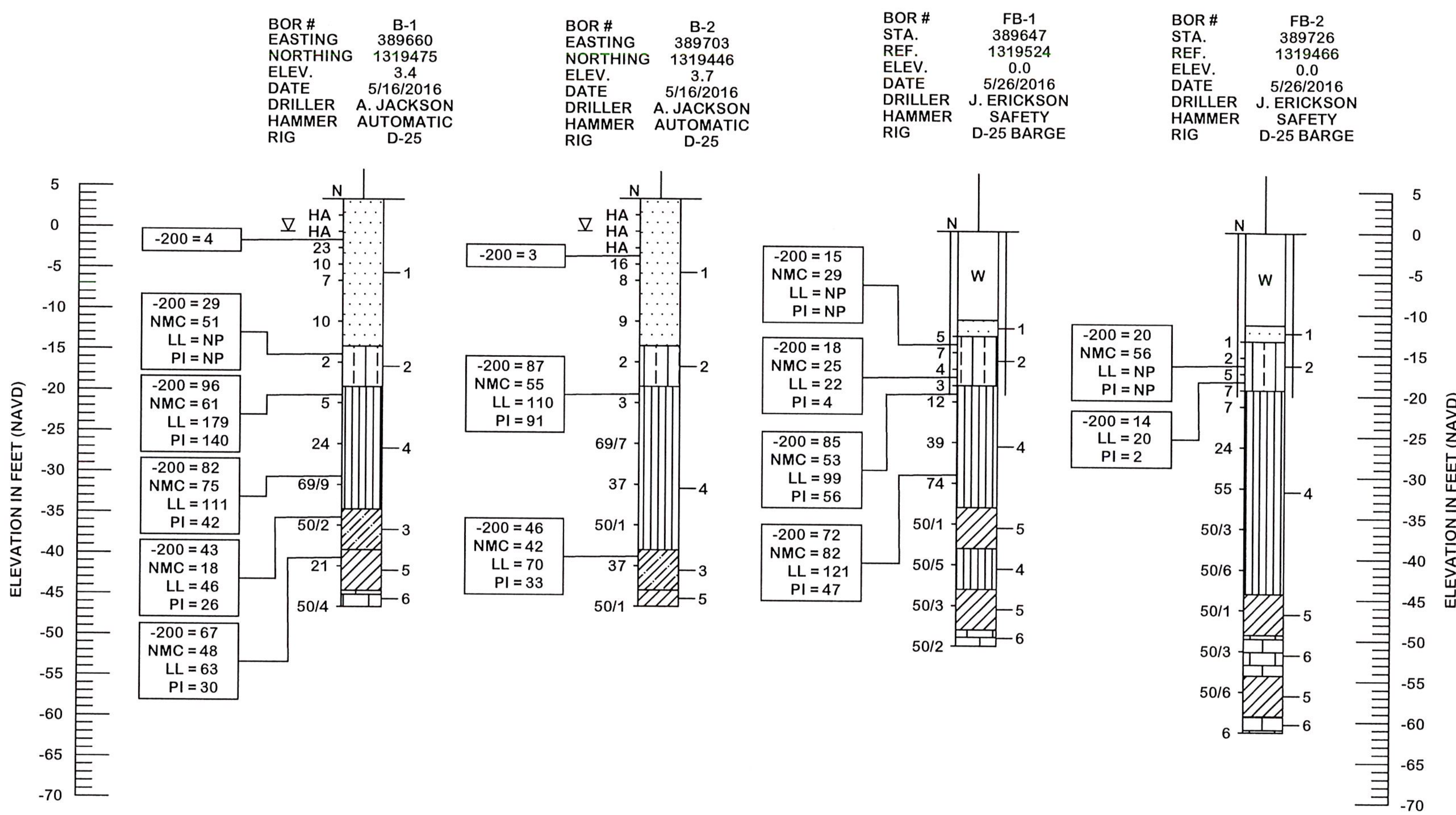
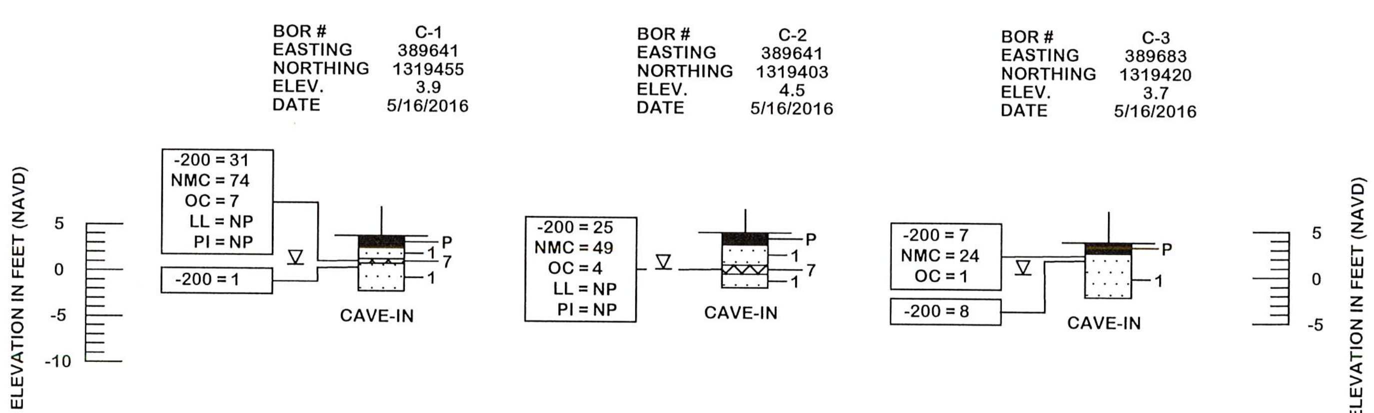
SOIL PROFILES





LEGEND

1. PALE BROWN TO GRAY SAND TO SAND WITH SILT, OCCASIONALLY WITH SHELL (SP/SP-SM)
2. BROWN TO GRAY SILTY SAND TO SILTY CLAYEY SAND (SM/SM-SC)
3. GRAY CLAYEY SAND (SC)
4. GRAY SILT TO CLAY (MH/CH)
5. CALCAREOUS CLAY WITH WEATHERED LIMESTONE (CH)
6. WEATHERED LIMESTONE
7. DARK GRAY TO BLACK SILTY SAND WITH TRACE ORGANICS (SM/PT)

P — ASPHALT PAVEMENT AND BASE MATERIAL

EASTING — EASTING COORDINATE REFERENCED TO THE FLORIDA STATE PLANE COORDINATE SYSTEM, FLORIDA WEST ZONE, N.A.D. 83 DETERMINED USING HAND-HELD GARMIN ETREX EQUIPMENT WITH A REPORTED ACCURACY OF 10 FEET

NORTHING — NORTHING COORDINATE REFERENCED TO THE FLORIDA STATE PLANE COORDINATE SYSTEM, FLORIDA WEST ZONE, N.A.D. 83 DETERMINED USING HAND-HELD GARMIN ETREX EQUIPMENT WITH A REPORTED ACCURACY OF 10 FEET

W — WATER

∇ — GROUNDWATER LEVEL ENCOUNTERED DURING INVESTIGATION

N — SPT N-VALUE IN BLOWS/FOOT FOR 12 INCHES OF PENETRATION (UNLESS OTHERWISE NOTED)

SP — UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2488) GROUP SYMBOL AS DETERMINED BY VISUAL REVIEW AND LABORATORY TESTING ON SELECTED SAMPLES FOR CONFIRMATION OF VISUAL REVIEW

50/4 — NUMBER OF BLOWS FOR 4 INCHES OF PENETRATION

HA — HAND AUGERED TO VERIFY UTILITY CLEARANCES

| | — CASING

-200 — PERCENT PASSING #200 SIEVE

NMC — NATURAL MOISTURE CONTENT (%)

OC — ORGANIC CONTENT (%)

LL — LIQUID LIMIT (%)

PI — PLASTICITY INDEX (%)

NP — NON PLASTIC

CAVE-IN — BOREHOLE TERMINATED DUE TO CAVE-IN FROM SHALLOW GROUNDWATER INTRUSION

NGVD — NATIONAL GEODETIC VERTICAL DATUM OF 1929

NAVD — NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES:

1. BASED ON REVIEW OF THE "POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, WEST-CENTRAL FLORIDA" MAPS PUBLISHED BY THE USGS, THE POTENTIOMETRIC SURFACE ELEVATION OF THE UPPER FLORIDAN AQUIFER AT THE PROPOSED FENDER WALL AND SHEET PILE WALL LOCATION IS ON THE ORDER OF APPROXIMATELY +5 FEET, NGVD. THE CONTRACTOR'S TOOLS AND CONSTRUCTION METHODS SHOULD ADDRESS AND HANDLE A POTENTIOMETRIC LEVEL UP TO +5 FEET, NGVD, AT NO ADDITIONAL COST TO THE OWNER.
2. THE CONTRACTOR SHALL ANTICIPATE THAT DIFFICULT INSTALLATION OF SHEET PILES AND PILES FOR FENDER SYSTEM MAY BE ENCOUNTERED DUE TO THE PRESENCE OF COMPACTED/DENSE SOILS AND LIMESTONE AT THE PROJECT SITE. VARIATIONS IN THE DEPTH AND CONSISTENCY OF SUCH MATERIALS SHALL BE ANTICIPATED. SPECIALIZED EQUIPMENT AND/OR INSTALLATION METHODS, INCLUDING THE USE OF PREFORMED PILE HOLES, PUNCHING, AND/OR OTHER METHODS MAY BE REQUIRED TO INSTALL THE SHEET PILES AND FENDER SUPPORT PILES TO THE REQUIRED MINIMUM TIP ELEVATION. JETTING IS NOT ALLOWED.
3. THE ELEVATIONS PROVIDED WERE ESTIMATED USING SITE SURVEY INFORMATION AND AS A RESULT, THE ELEVATIONS SHOULD BE CONSIDERED APPROXIMATE.

RECOMMENDED ENVIRONMENTAL CLASSIFICATION:
SUBSTRUCTURE CONCRETE: EXTREMELY AGGRESSIVE
SUBSTRUCTURE STEEL: EXTREMELY AGGRESSIVE

	SAFETY HAMMER	AUTOMATIC HAMMER
GRANULAR MATERIALS- RELATIVE DENSITY	SPT N-VALUE (BLOWS/FT.)	SPT N-VALUE (BLOWS/FT.)
VERY LOOSE LOOSE MEDIUM DENSE DENSE VERY DENSE	LESS THAN 4 4 to 10 10 to 30 30 to 50 GREATER THAN 50	LESS THAN 3 3 to 8 8 to 24 24 to 40 GREATER THAN 40
SILTS AND CLAYS CONSISTENCY	SPT N-VALUE (BLOWS/FT.)	SPT N-VALUE (BLOWS/FT.)
VERY SOFT SOFT FIRM STIFF VERY STIFF HARD	LESS THAN 2 2 to 4 4 to 8 8 to 15 15 to 30 GREATER THAN 30	LESS THAN 1 1 to 3 3 to 6 6 to 12 12 to 24 GREATER THAN 24

REV. NO.	DATE	DESCRIPTION	REV. BY

DESIGNED SW
DRAWN SW
CHECKED DRR

TIERRA
7351 Temple Terrace Highway
Tampa, Florida 33637
Phone: 813-989-1354 Fax: 813-989-1355
FL Cert. No.: 6486

PROJECT: SAND KEY FENDER SYSTEM

DESCRIPTION: SOIL PROFILES

APPROVED BY:
ERICK M. FREDERICK, P.E.
FLA. LIC. NO 63920
DATE

DATE: JUNE 2016
PROJECT NO. 6511-16-081
SHEET: 2 OF 2

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PAVEMENT SECTION DATA

Project Name: Proposed Sand Key Fender System

Tierra Project Number: 6511-16-081 **Cored by: Tierra**

Core No.	Asphalt Pavement	Base Material		Subgrade	
	Pavement Thickness (in)	Base Type	Base Thickness (in)	Type	Depth
C-1	1.0	Limerock	15.0	Sand to Sand with Silt	16.0" to 2.5'
				Silty Sand with Trace Organics	2.5' to 3.0'
				Sand to Sand with Silt	3.0' to 6.0'
C-2	0.7	Limerock	15.3	Sand to Sand with Silt	16.0" to 3.5'
				Silty Sand with Trace Organics	3.5' to 4.5'
				Sand to Sand with Silt	4.5' to 6.0'
C-3	0.8	Limerock	13.2	Sand to Sand with Silt	14.0" to 6.0'

Refer to Boring Location Plan sheet for core locations

TIERRA INC.

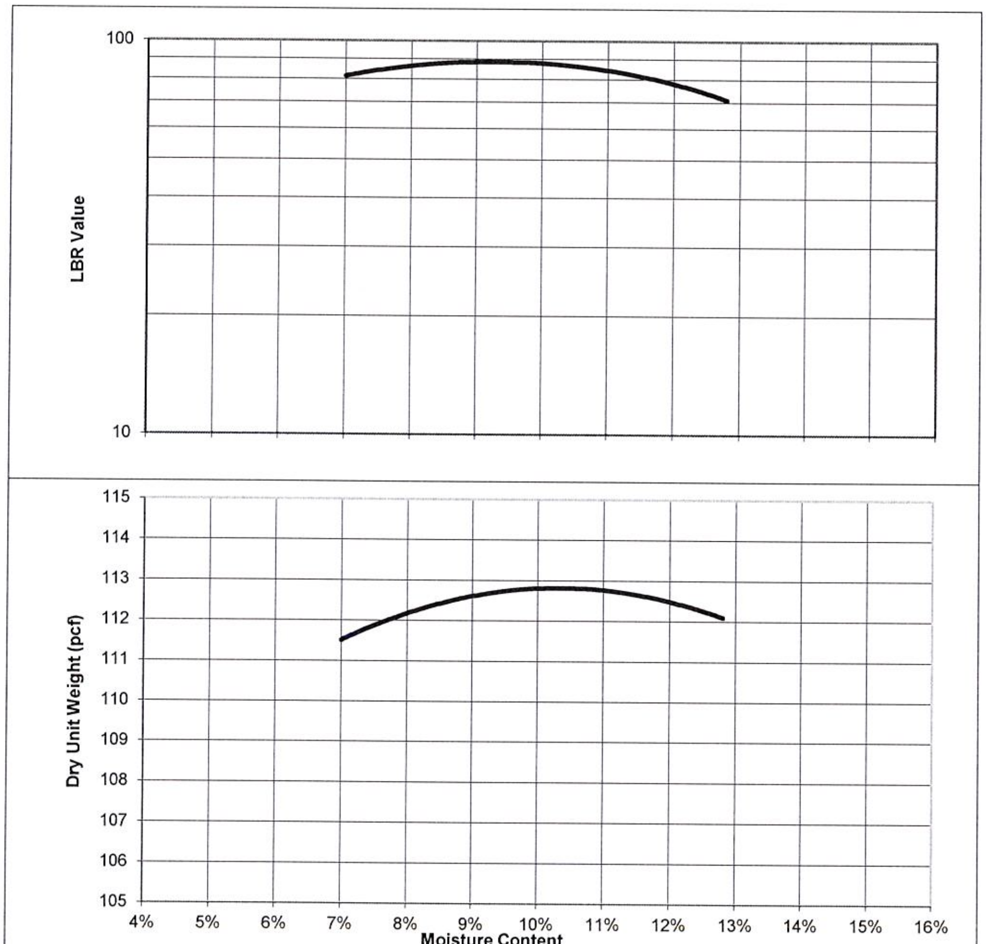
RESULTS OF LIMEROCK BEARING RATIO TEST

Project: Sand Key Fender

Date: 5/20/2016

Project No. 6511-16-081
Report No. LBR-01

LBR & MOISTURE-DENSITY RELATIONSHIP



LBR Value	89
Maximum Density	112.8 pcf
Optimum Moisture	10 %
Test Method:	FSTM FM 5-515
Sampled By:	J. Berg

Description: Light Brown Slighty Silty Fine Sand with Shell Fragments (SP/SP-SM)

Sample Location: GPS 3094253-320400

cc:

Respectfully Submitted,
TIERRA INC.

LBR-01_05-20-16

TIERRA INC.

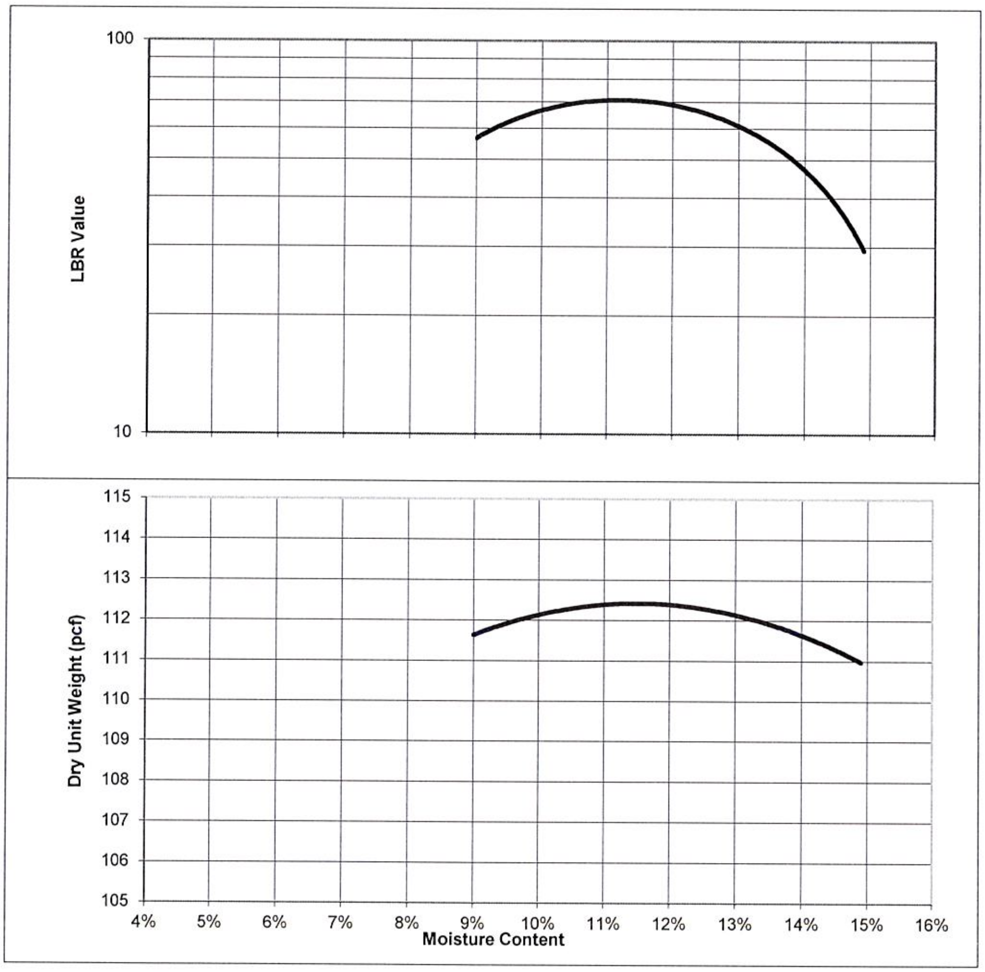
RESULTS OF LIMEROCK BEARING RATIO TEST

Project: Sand Key Fender

Date: 5/20/2016

Project No. 6511-16-081
Report No. LBR-02

LBR & MOISTURE-DENSITY RELATIONSHIP



LBR Value	70
Maximum Density	112.4 pcf
Optimum Moisture	11.5 %
Test Method:	FSTM FM 5-515
Sampled By:	J. Berg

Description: White-Brown Slighty Silty Fine Sand with Shell Fragments (SP/SP-SM)

Sample Location: GPS 30949190-320477

cc:

Respectfully Submitted,
TIERRA INC.

LBR-02_05-20-16

Design LBR Calculation

Sand Key Fender System

Tierra Project No. 6511-16-081

2% of Optimum Method

Test No.	Bulk Sample Boring Location	Maximum LBR	LBR at Moisture Contents: (Of Optimum LBR) - 2%	+ 2%
LBR # 1	LBR-1	89	86	78
LBR # 2	LBR-2	70	62	55
Mean LBR Value		80	74	66
Design LBR = 70				

Geotechnical Soil Strength Parameters - Fender System

Proposed Sand Key Fender System
Pinellas County, Florida
Tierra Project No.: 6511-16-081

	Reference Boring	FB-1
	Ground Surface Elevation/Mudline (ft)	-10.9
	Ground Water Table Elevation (ft)	0.0

Foundation Type	Polymeric Pile
Size (inch)	16.00
Base Area (ft²)	1.40

Notes:

1. Limestone with blow counts less than 10 modeled as sand

	Layer No.	1	2	3	4	5			
	Soil Description	Sand	Clay	Clay	Clay	Limestone			
	Soil Type	Cohesionless	Cohesive	Cohesive	Cohesive	Rock			
	Top Boundary Elevation (ft)	-10.90	-18.90	-23.90	-28.90	-48.90	-	-	-
	Bottom Boundary Elevation (ft)	-18.90	-23.90	-28.90	-48.90	-50.90			
	Average SPT N-Value (Blows/ft)	5	12	39	94	100			
LATERAL	Soil Model	Sand (Reese)	Clay (Stiff<Water)	Clay (Stiff<Water)	Clay (Stiff<Water)	Limestone (McVay)			
	Internal Friction Angle, ϕ	29	-	-	-	-	-	-	-
	Total Unit Weight (pcf), γ_t	105	115	125	125	135	-	-	-
	Subgrade Modulus (pci), k	14	430	1780	2000	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	1500	4875	6000	-	-	-	-
	Major Principal Strain @ ε_{50}	-	0.010	0.007	0.005	-	-	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	1500	4875	6000	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	80000	-	-	-
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile			
	Total Unit Weight (pcf), γ_t	105	115	125	125	135	-	-	-
	Shear Modulus (ksi), G	0.42	1.81	4.63	4.63	92.59	-	-	-
	Poisson's ratio, ν	0.25	0.50	0.50	0.50	0.50	-	-	-
	Ultimate Unit Skin Friction (psf) (Pile)	190	1174	2764	3020	1200	-	-	-
	Undrained Shear Strength (psf), c_u	-	1500	4875	6000	-	-	-	-
	Ultimate Unit Skin Friction (psf) (Shaft)	-	-	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic			
	Total Unit Weight (pcf), γ_t	105	115	125	125	135	-	-	-
	Internal Friction Angle, ϕ	29	-	-	-	35	-	-	-
	Undrained Shear Strength (psf), c_u	-	1500	4875	6000	-	-	-	-
	Shear Modulus (ksi), G	0.42	1.81	4.63	4.63	92.59	-	-	-
	Torsional Shear Stress (psf)	190	1174	2764	3020	1200	-	-	-
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile			
	Shear Modulus (ksi), G	0.42	1.81	4.63	4.63	92.59	-	-	-
	Poisson's ratio, ν	0.25	0.50	0.50	0.50	0.50	-	-	-
	Unit Bearing , ksf	32	17	55	84	432	-	-	-
	Axial Bearing Failure, kips	512.0	268.8	873.6	1344.0	6912.0	-	-	-
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-	-	-

Geotechnical Soil Strength Parameters - Fender System

Proposed Sand Key Fender System
Pinellas County, Florida
Tierra Project No.: 6511-16-081

	Reference Boring	FB-2
	Ground Surface Elevation/Mudline (ft)	-11.3
	Ground Water Table Elevation (ft)	0.0

Foundation Type	Polymeric Pile
Size (inch)	16.00
Base Area (ft^2)	1.40

Notes:

1. Limestone with blow counts less than 10 modeled as sand

	Layer No.	1	2	3	4	5	6	7	
	Soil Description	Sand	Clay	Clay	Clay	Limestone	Clay	Sand	
	Soil Type	Cohesionless	Cohesive	Cohesive	Cohesive	Rock	Cohesive	Cohesionless	
	Top Boundary Elevation (ft)	-11.30	-19.30	-24.30	-34.30	-49.30	-54.30	-59.30	
	Bottom Boundary Elevation (ft)	-19.30	-24.30	-34.30	-49.30	-54.30	-59.30	-61.30	-
	Average SPT N-Value (Blows/ft)	4	7	40	100	100	100	6	
LATERAL	Soil Model	Sand (Reese)	Clay (Stiff<Water)	Clay (Stiff<Water)	Clay (Stiff<Water)	Limestone (McVay)	Clay (Stiff<Water)	Sand (Reese)	
	Internal Friction Angle, ϕ	29	-	-	-	-	-	35	-
	Total Unit Weight (pcf), γ_t	100	110	125	125	135	125	105	-
	Subgrade Modulus (pci), k	11	180	1830	2000	-	2000	17	-
	Undrained Shear Strength (psf), c_u	-	875	5000	6000	-	6000	-	-
	Major Principal Strain @ ε_{50}	-	0.015	0.007	0.005	-	0.005	-	-
	Major Principal Strain @ ε_{100}	-	-	-	-	-	-	-	-
	Average Undrained Shear Strength (psf)	-	875	5000	6000	-	6000	-	-
	Unconfined Compressive Strength (psf)	-	-	-	-	80000	-	-	-
AXIAL	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	
	Total Unit Weight (pcf), γ_t	100	110	125	125	135	125	105	-
	Shear Modulus (ksi), G	0.33	1.10	4.63	4.63	92.59	4.63	0.50	-
	Poisson's ratio, ν	0.25	0.45	0.50	0.50	0.50	0.50	0.25	-
	Ultimate Unit Skin Friction (psf) (Pile)	152	720	2795	3020	1200	3020	228	-
	Undrained Shear Strength (psf), c_u	-	875	5000	6000	-	6000	-	-
	Ultimate Unit Skin Friction (psf) (Shaft)	-	-	-	-	-	-	-	-
	Mass Modulus (ksi)	-	-	-	-	-	-	-	-
	Modulus Ratio	-	-	-	-	-	-	-	-
	Surface (Rough/Smooth)	-	-	-	-	-	-	-	
	Unconfined Compressive Strength (psf)	-	-	-	-	-	-	-	-
	Split Tensile Strength (psf)	-	-	-	-	-	-	-	-
	Concrete Unit Weight (pcf)	-	-	-	-	-	-	-	-
	Slump (in)	-	-	-	-	-	-	-	-
TORSIONAL	Soil Model	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	Hyperbolic	-
	Total Unit Weight (pcf), γ_t	100	110	125	125	135	125	105	-
	Internal Friction Angle, ϕ	29	-	-	-	35	-	35	-
	Undrained Shear Strength (psf), c_u	-	875	5000	6000	-	6000	-	-
	Shear Modulus (ksi), G	0.33	1.10	4.63	4.63	92.59	4.63	0.50	-
	Torsional Shear Stress (psf)	152	720	2795	3020	1200	3020	228	-
TIP	Soil Model	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	Driven Pile	
	Shear Modulus (ksi), G	0.33	1.10	4.63	4.63	92.59	4.63	0.50	-
	Poisson's ratio, ν	0.25	0.45	0.50	0.50	0.50	0.50	0.25	-
	Unit Bearing , ksf	26	10	56	84	432	84	38	-
	Axial Bearing Failure, kips	409.6	156.8	896.0	1344.0	6912.0	1344.0	614.4	-
	Uncorrected SPT-N Value (blows/ft)	-	-	-	-	-	-	-	-
	Undrained Shear Strength (psf), c_u	-	-	-	-	-	-	-	-
	IGM Mass Modulus (ksi), E_m	-	-	-	-	-	-	-	-