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Geotechnical Report

New Monopole Tower

Report Prepared for
Vertical Bridge LLC

Site Name: Hungry Howie
Site ID: US-FL-7140

Off Spirit Lake Road, Winter Haven, FL 33880
Lat: 27.998103
Lon: -81.784558

FDH Infrastructure Services Project Number PR-008353

Prepared by:

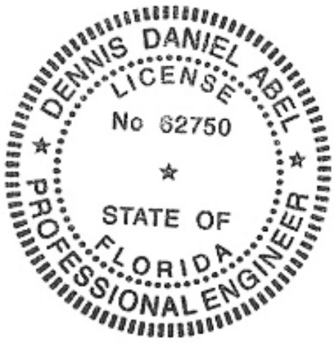
Pramila Adhikari, Ph.D., P.E.
Geotechnical Engineer

Reviewed and signed by:

Dennis D. Abel, PE
Florida License No. 62750
This item has been digitally signed and sealed by Dennis D. Abel, PE, on the date indicated herein. Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

Digitally signed by Dennis Abel
Date: 2022.09.22 08:00:39 -04'00'

Dennis Abel, P.E.
Chief Engineer



FDH Infrastructure Services
6521 Meridien Drive
Raleigh, NC 27616
(919) 755-1012
geotech@fdh-is.com

09/21/2022

FDH Infrastructure Services, LLC
COA 28282

FDH Infrastructure Services, 6521 Meridien Drive, Raleigh, NC 27616, Ph: 919.755.1012, Fax: 919.755.1031

INTRODUCTION

FDH Infrastructure Services is pleased to present this geotechnical report for a new monopole telecommunication tower. The design foundation loads at the base of the tower were not provided to us. The purpose of this study was to determine the general subsurface conditions in the vicinity of the proposed tower site and provide foundation recommendations. The results of the boring and laboratory testing are included, in addition to recommendations for designing and constructing the new tower's foundation.

This report should not be considered as a construction document.

SITE CONDITIONS

The subject site is located off Spirit Lake Road in Winter Haven, Florida, which is in Polk County. The proposed tower and equipment compound will be located in a land between Spirit Lake Road and Spirit Lake Drive towards the south. There is a Spirit Lake approximately 405.0 ft towards south-east from the proposed tower. The area around the proposed tower consists of residential properties and forests. A Satellite Map and a Topographic Map are presented in Figures 1 and 2 in this report.

FIELD EXPLORATION

Subsurface conditions were evaluated by obtaining one (1) test boring (B-1) at the proposed tower location as shown on Figure 3. The test boring was initiated and completed on 08/26/2022. The drilling was performed with a truck-mounted drill rig. A photograph of the drill rig and drill site is presented in Figure 4. The soil test boring was advanced using hollow stem auger up to a depth of 10.0 ft and followed by mud rotary drilling procedures. The subsurface soils were generally sampled at 2.0 ft intervals for the first 10.0 ft and at 5.0 ft intervals thereafter. The boring was sampled by driving a 1 ⅜ in. I.D. split spoon sampler in accordance with the standard penetration test procedures designated in ASTM D-1586. The sampler was first seated 6 in. to penetrate any loose cuttings and then driven an additional 12 in. with an automatic 140-pound hammer free falling 30 in. The number of hammer blows required to drive the sampler the final 12 in. is designated the standard penetration test N-value. A boring log is attached in Appendix I.

LABORATORY CLASSIFICATION AND TESTING

The soil samples were transported to our soil laboratory and examined by a geotechnical engineer. The soil samples were classified according to ASTM D-2487. Moisture content tests in accordance with ASTM D-2216 were conducted on all soil samples. Additionally, particle size analysis tests (ASTM D-422) and percent finer than No. 200 sieve tests (ASTM D-1140) were conducted on selected soil samples. The laboratory test results are presented on the boring log and in Appendix II. The soil samples will be retained in our laboratory for a period of six months (180 days), after which, they will be discarded unless other instructions are received as to their disposition.

SITE GEOLOGY

The site is located within the Coastal Plain physiographic province of the contiguous United States. The Coastal Plain is typically characterized by marine, alluvial, and aeolian sediments that were deposited during periods of fluctuating sea levels and moving shorelines. Basal formations are typical of those laid down in a shallow sloping sea bottom; dense sand, consolidated clay, limestone, chalk, marl, claystone, and sandstone. Shallow limestone deposits in Florida include underwater caves and sinkholes. Overburden

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soils include marine interbedded gravel, sand, silt, and clay. Many of the clays have been preconsolidated by dessication from frequent rising and lowering of the sea level and groundwater table. Alluvial gravel, sand, silt, and clay are typically present near rivers and creeks. Deposits of peat, organic silt, and organic clay are also typically present in or near current or former tidal marsh areas in the portion of the Coastal Plain nearest to the coastline.

According to the geologic map of Florida, the site is underlain by the Reworked Cypresshead sediments formation of Pliocene/Pleistocene age. This formation consists of sand, gravel, and clay.

According to the Polk County sinkholes map produced by the Florida Center for Instructional Technology (FCIT) in 2008, there are five sinkholes located within 1.0 mile radius towards east from the proposed tower. Due to the local karst conditions of the area, the site may be prone to the development of sinkholes. The use of precaution and adequate site monitoring which is in line with the proper assessment of the development of sinkholes due to local conditions should be implemented in the future.

FROST DEPTH

Based on the TIA Standard (TIA-222-H), the recommended design frost penetration depth to be used for Polk County, Florida is 0 inch (0.0 ft).

SUBSURFACE CONDITIONS

The boring encountered the general strata given in the following table.

Strata #	Approx. Depth (ft)	General Description
I	0.0 – 6.0	Very loose to loose poorly graded sand (SP)
II	6.0 – 13.5	Very loose to loose poorly graded sand with silt (SP-SM)
III	13.5 – 33.5	Medium dense silty sand (SM)
IV	33.5 – 48.5	Loose poorly graded sand with silt (SP-SM)
V	48.5 – 50.0	Very loose clayey sand (SC)

Additional details for each stratum are given on the attached boring log.

Groundwater was encountered in soil boring B-1 at a depth of 7.9 ft below grade at the time of drilling. Groundwater levels will fluctuate with seasonal and climatic changes and may be different at other times. According to the USDA Web Soil Survey, the seasonal high water table is at depths of 0.5 ft to 1.5 ft below the ground surface for the soil series mapped at this site.

SOIL RESISTIVITY

Laboratory soil resistivity tests were conducted according to procedures designated in ASTM G-187 and test results are presented in the following table. Soil resistivity values will vary with temperature and moisture content changes and may be different at other times.

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Boring	Sample Depth (ft)	Resistivity (Ohm-cm)
B-1	2.0 – 4.0	920,000

RECOMMENDATIONS

Foundations

The following recommendations are made based on our review of the test boring data and laboratory results and our past experience with similar projects and subsurface conditions. Ultimate soil strength parameters, along with recommended groundwater depth for analysis, are presented on Table 1 (attached). Based on the subsurface conditions and typical design foundation loads for similar monopoles, we recommend that either a caisson (drilled shaft) or pad/pier be used to support the new tower.

Caisson (Drilled Shaft)

Should a caisson (drilled shaft) foundation be used, the caisson (drilled shaft) will achieve compressive (downward) resistance through skin friction along the side of the shaft. In addition to skin friction, bearing resistance at the caisson's tip will contribute to compressive capacity. We recommend the values given in the Table 2 (attached) be used for this project. Please note the tip bearing capacity and skin frictions are ultimate values. Appropriate factors of safety or resistance factors should be used. Lateral loads and overturning moment can be resisted by the lateral stiffness of the soil. Parameters for analysis of the laterally loaded caisson are also given in Table 2.

Based on the subsurface conditions, excavation for the caisson (drilled shaft) should be possible using a large, truck-mounted, hydraulic-advanced drill rig. All debris, loose or disturbed soil should be removed from the excavation prior to placing reinforced steel and/or concrete. Reinforcing steel and/or concrete should be placed immediately upon completion of the excavation.

The excavation may be susceptible to caving. Drilling fluid or casing could be used to assist in keeping the drilled hole open. If casing is used, we recommend it be removed from the excavation as concrete is being placed. Continuous vibration or other approved methods should be used during casing withdrawal to reduce the potential for void-space formation within the concrete. If water is present during concrete placement and/or drilling fluids are used to maintain hole stability, concrete should be pumped or otherwise discharged to the bottom of the hole via a hose or tremie pipe. The end of the hose or tremie pipe must remain below the top surface of any water, drilling fluid and the in-place concrete at all times. Additionally, concrete should be consolidated using vibration methods over the entire length and width of the caisson and the consolidation should be performed only after these fluids are removed and to the extent possible.

Pad & Pier

Should a pad & pier foundation be used, we recommend the pad & pier be reinforced with steel to resist and transfer lateral and axial loads, as well as prevent cracking and shrinkage due to temperature and moisture variations. Based on the subgrade conditions and frost penetration depth of the project site, we recommend the bottom of the pad foundation bears at a depth deeper than 4.0 ft. The tower's foundation capacity can be determined using the soil's bearing capacity, passive pressure resistance, and a sliding friction factor.

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- **Net Ultimate Bearing Capacity and Ultimate Sliding Friction Factor**: Shown in Table 3 (attached). This table contains ultimate values and an appropriate factor of safety or resistance factor should be used.

- **Ultimate Passive Pressure vs. Depth**: Shown in Table 4 (attached). This table contains ultimate values and an appropriate factor of safety or resistance factor should be used. These values have been reduced for frost penetration to a depth of 0.0 ft.

The pad should bear on natural soils or on controlled structural fill placed on satisfactory, firm, and stable natural soils. The site should be stripped to suitable depths to remove any existing grass, topsoil, rootmat, or other deleterious material. Structural fill used to elevate the grade and/or backfill any excavations should consist of clean granular soils without deleterious inclusions and with maximum 3.0-inch particle size. The structural granular fill may need to be imported from an offsite location. The structural granular fill material should be placed in maximum of 8.0 inches loose lifts and compacted to a minimum of 95 percent of the maximum dry density as per ASTM D-698. The moisture content should be within -3 to +3 % of optimum moisture.

The pad should be protected from freezing if built during the winter or subject to freezing temperatures during construction. Groundwater was encountered at a depth of 7.9 ft in boring B-1. The water level at the tower site should be closely monitored during construction. If necessary, a proper dewatering method should be used to lower down the water level to a depth at least 2.0 ft below the bearing depth of the foundation.

Additionally, positive surface drainage should be provided to prevent rainwater water collection in foundation excavations or on subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward a corner to facilitate removal of any collected rainwater or surface runoff with a sump pump.

Construction Inspection

We recommend that the foundation excavation and fill placement process be monitored by a geotechnical engineer or representative thereof. Subsurface condition variances may occur at project site. Therefore, the excavations should be inspected to confirm that the bearing materials are similar to those encountered by the boring and that the subgrade has been properly prepared. The geotechnical engineer should be immediately notified should any subsurface conditions be discovered that will alter the conclusions and recommendations contained in this report. Further investigation and supplemental recommendations may be required if such a condition is encountered.

Samples of the proposed structural fill material should be obtained prior to fill placement operations for laboratory moisture/density testing (Proctor tests). The tests will then provide a basis for evaluating the in-place density requirements during compaction operations. A qualified soil technician should perform sufficient in-place density tests during the filling operations to verify that proper levels of compaction are being attained.

Prior to placement of concrete, the foundation excavation should be inspected to verify that the excavation is to the proper depth and reinforcing steel is placed as recommended. Concrete cylinders should be made for compressive strength testing at curing times of 7 days and 28 days, at a minimum.

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LIMITATIONS

All opinions and conclusions are considered accurate to a reasonable degree of engineering certainty based upon the evidence available at the time of this report. All opinions and conclusions are subject to revision based upon receipt of new or additional/updated information. All services are provided exercising a level of care and diligence equivalent to the standard and care of our profession. No other warranty or guarantee, expressed or implied, is offered. Our services are confidential in nature and we will not release this report to any other party without the client's consent. The use of this engineering work is limited to the express purpose for which it was commissioned and it may not be reused, copied, or distributed for any other purpose without the written consent of FDH Infrastructure Services.

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TABLES

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Table 1 – Ultimate Strength Parameters

Boring #	Depth (ft)	Unified Soil Classification	*Total Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
B-1	0.0 – 4.0	SP	105	26	0
	4.0 – 8.0	SP / SP-SM	108	28	0
	8.0 – 13.5	SP-SM	105	27	0
	13.5 – 18.5	SM	120	32	0
	18.5 – 33.5	SM	116	30	0
	33.5 – 43.5	SP-SM	108	29	0
	43.5 – 48.5	SP-SM	115	30	0
	48.5 – 50.0	SC	105	27	0

**Recommended groundwater depth for analysis is 0.5 ft. Utilize buoyant unit weight below this depth.*

Table 2 – Caisson (Drilled Shaft) Parameters

Depth (ft)	Net Ultimate Tip Bearing Capacity (ksf)	*Ultimate Skin Friction (ksf)	Lateral Modulus (pci)	ε_{50} (in/in)
0.0 – 3.0	--	--	20.0	--
3.0 – 4.0	--	0.1	20.0	--
4.0 – 13.0	--	0.3	20.0	--
13.0 – 18.0	10.5	0.9	60.0	--
18.0 – 23.0	11.0	0.8	60.0	--
23.0 – 28.0	13.0	0.9	60.0	--
28.0 – 33.0	6.0	1.0	60.0	--
33.0 – 43.0	5.5	0.8	20.0	--
43.0 – 48.0	3.0	1.0	20.0	--
48.0 – 50.0	2.5	0.7	20.0	--

**We recommend the skin friction be ignored for the top 3.0 ft of the caisson.*

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Table 3 – Net Ultimate Bearing Capacity

Pad Bearing Depth (ft)	Net Ultimate Bearing Capacity (psf)	Sliding Friction Factor
4.0 – 6.0	1,600	0.30
6.0 – 8.0	2,200	0.30

Table 4 – Ultimate Passive Pressure

Boring #	Depth (ft)	*Ultimate Passive Pressure (psf)
B-1	0.0 – 0.5	0 – 135
	0.5 – 4.0	135 – 515
	4.0 – 8.0	560 – 1,065
	8.0 – 10.0	1,025 – 1,250

**Ultimate passive pressure can be interpolated for foundation depths with the depth ranges given.*

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FIGURES

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FIGURE 1: Satellite Map

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FIGURE 2: Topographic Map

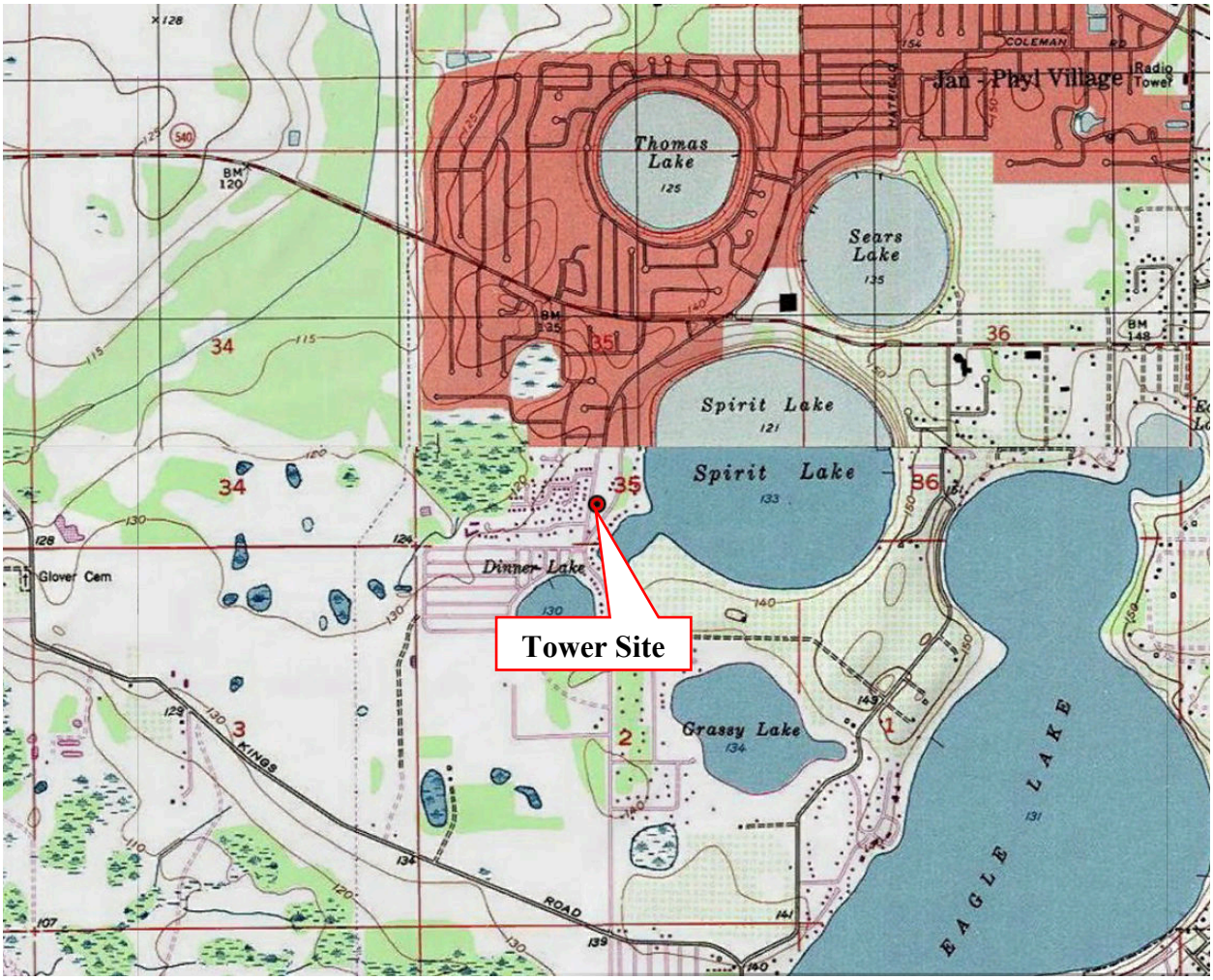

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FIGURE 3: Boring Location Plan

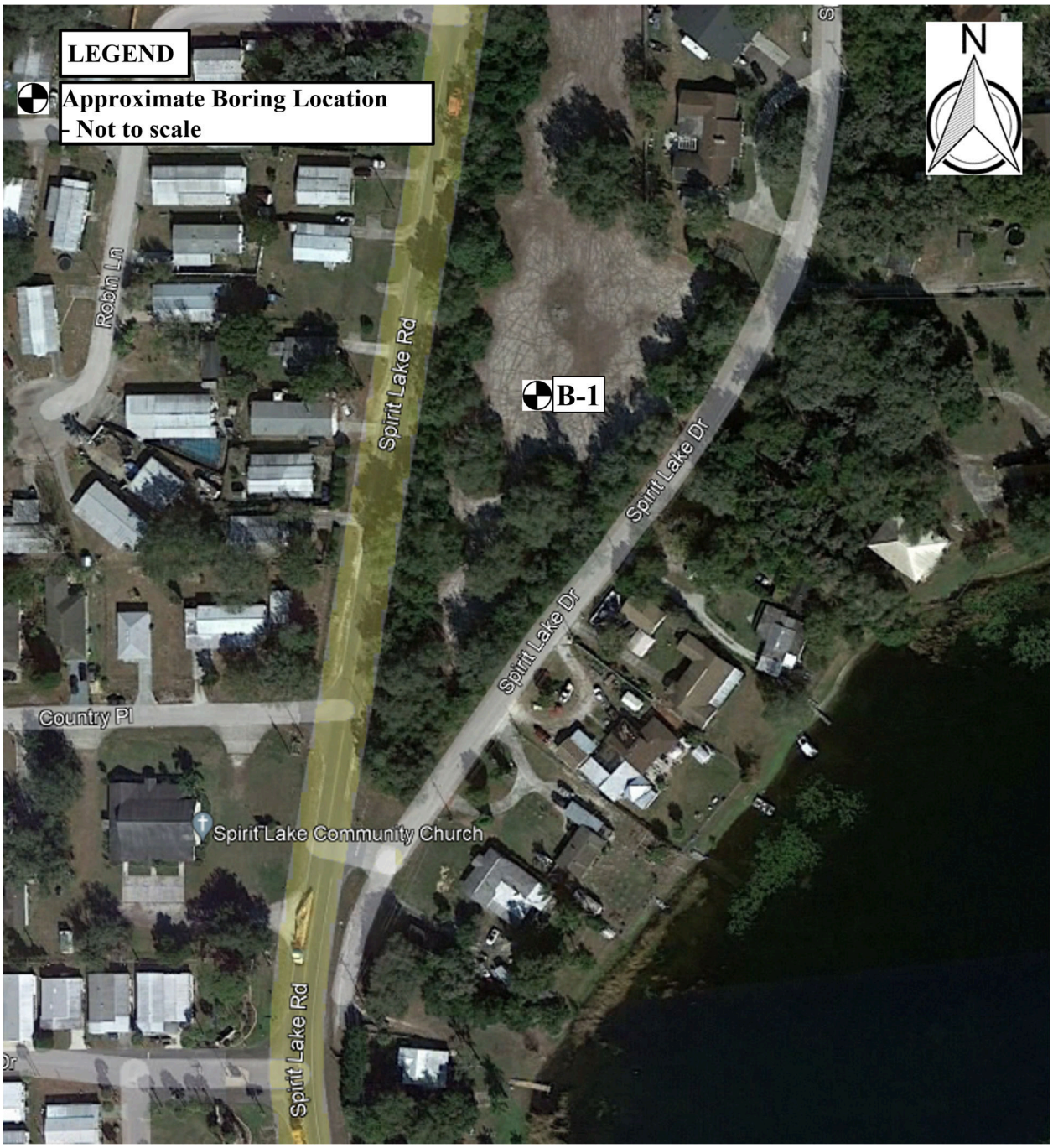

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FIGURE 4: Photograph of Drill Rig and Tower Site

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APPENDIX I – BORING LOG

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PROJECT NAME US-FL-7140 - Hungry Howie
PROJECT NUMBER PR-008353
CLIENT Vertical Bridge LLC
PROJECT LOCATION Off Spirit Lake Road, Winter Haven, FL 33880

Boring No.: B-1

LATITUDE:
LONGITUDE:
ELEVATION (ft):

DATE DRILLED : 8/26/2022
DRILLING METHOD : Hollow Stem Auger & Mud Rotary
HAMMER TYPE: Automatic
HAMMER EFFICIENCY:

GROUND WATER LEVELS:
AT TIME OF DRILLING : 7.90 ft
AFTER DRILLING : ---
BORING DEPTH (ft) : 50

DEPTH (ft)	SAMPLE TYPE	GRAPHIC LOG	MATERIAL CLASSIFICATION	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	TORVANE (tsf)	MOIST UNIT WT. (pcf)	MOISTURE CONTENT (%)	COMPRESSIVE STRENGTH (ksf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	MATERIAL DESCRIPTION
0			SP	1-1-1-1 (2)				7						POORLY GRADED SAND (SP), trace organics, fine grained, very loose, gray, moist
				1-1-1-2 (2)				5					2	- no organics, light brown
				2-3-3-5 (6)				4						- loose
			SP-SM	3-3-3-3 (6)				19					8	POORLY GRADED SAND WITH SILT (SP-SM), cemented, fine grained, loose, grayish-brown, moist
10				1-2-2-6 (4)				18						- trace clay pockets, very loose
			SM	12-11-11 (22)				19					15	SILTY SAND (SM), medium dense, fine grained, gray and brown, moist
20				4-6-7 (13)				21						
				4-5-8 (13)				19						- tan
30				5-5-8 (13)				17						
			SP-SM	2-3-3 (6)				25					14	POORLY GRADED SAND WITH SILT (SP-SM), fine grained, loose, tan, moist
40				3-3-4 (7)				24						
				4-4-5 (9)				27						
50			SC	1-2-2 (4)				38						CLAYEY SAND (SC), very loose, light gray, moist
														Bottom of borehole at 50.0 feet.

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APPENDIX II – LABORATORY TEST RESULTS

September 9, 2022

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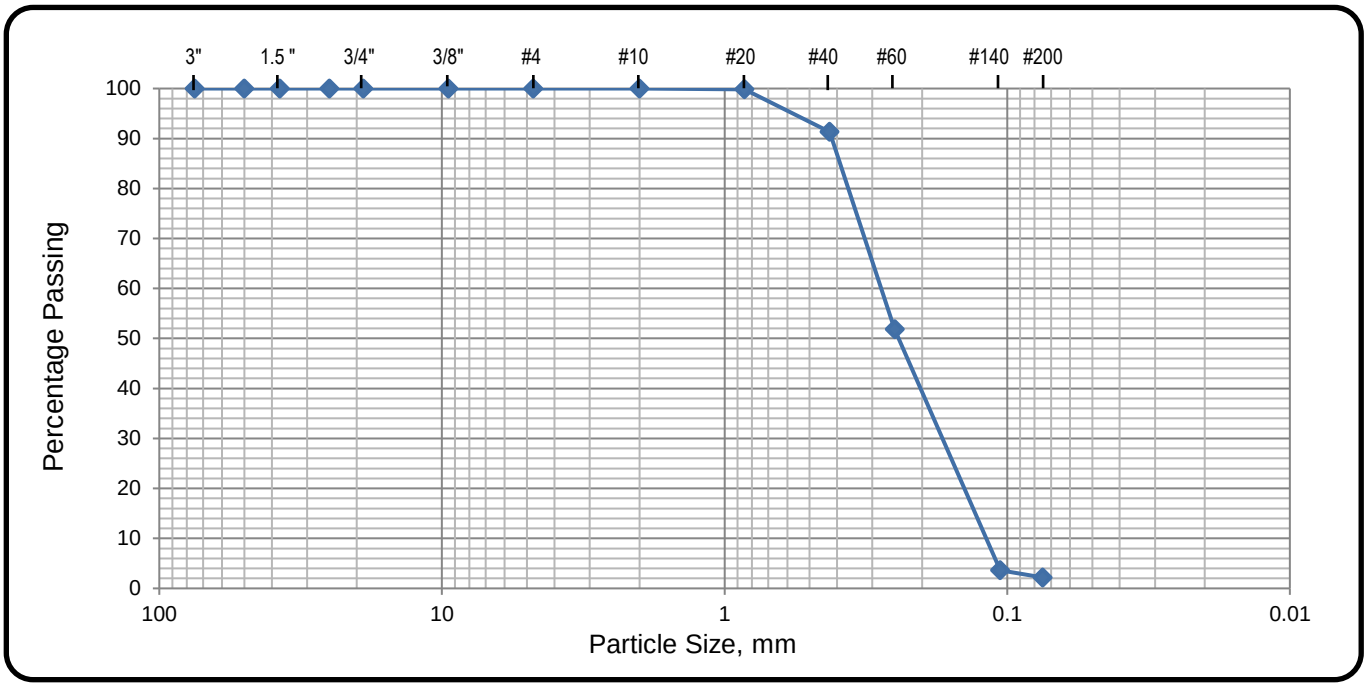
REPORT OF PARTICLE-SIZE ANALYSIS



Fractional Component Percentages

Plus 3 "	Coarse Gravel	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines
0.0	0.0	0.0	0.0	8.7	89.1	2.2

Total Percentages:	Gravel:	0.0	Sand:	97.8	Fines:	2.2

Sieve Designation	Amounts Retained (grams)	Amounts Retained (percent)	Percent Passing
3"	0.00	0.0	100.0
2"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	0.00	0.0	100.0
#4	0.00	0.0	100.0
#10	0.00	0.0	100.0
#20	0.18	0.1	99.9
#40	10.48	8.7	91.3
#60	58.22	48.2	51.8
#140	116.51	96.4	3.6
#200	118.24	97.8	2.2

Project Name: Hungry Howie
Project Number: PR-008353
Site Identification: US-FL-7140
Sample Identification: B1 SS2 (2ft - 4ft)
Description: Poorly graded sand

As-received water content, %: 4.7
USCS Classification: SP
Liquid Limit: ND
Plastic Limit: ND
Plasticity Index: ND

D_{10} = 0.12
D_{30} = 0.17
D_{60} = 0.28

Total dry mass, g: 120.89

C_u: 2.35 ***C_c: 0.87***

Remarks: Entire sample was tested. ND=Not Determined.

Reviewed by: Sushmaben Patel

Document: Enter Sample IDB1 SS2 Particle-Size Analysis & Classification.xlsx

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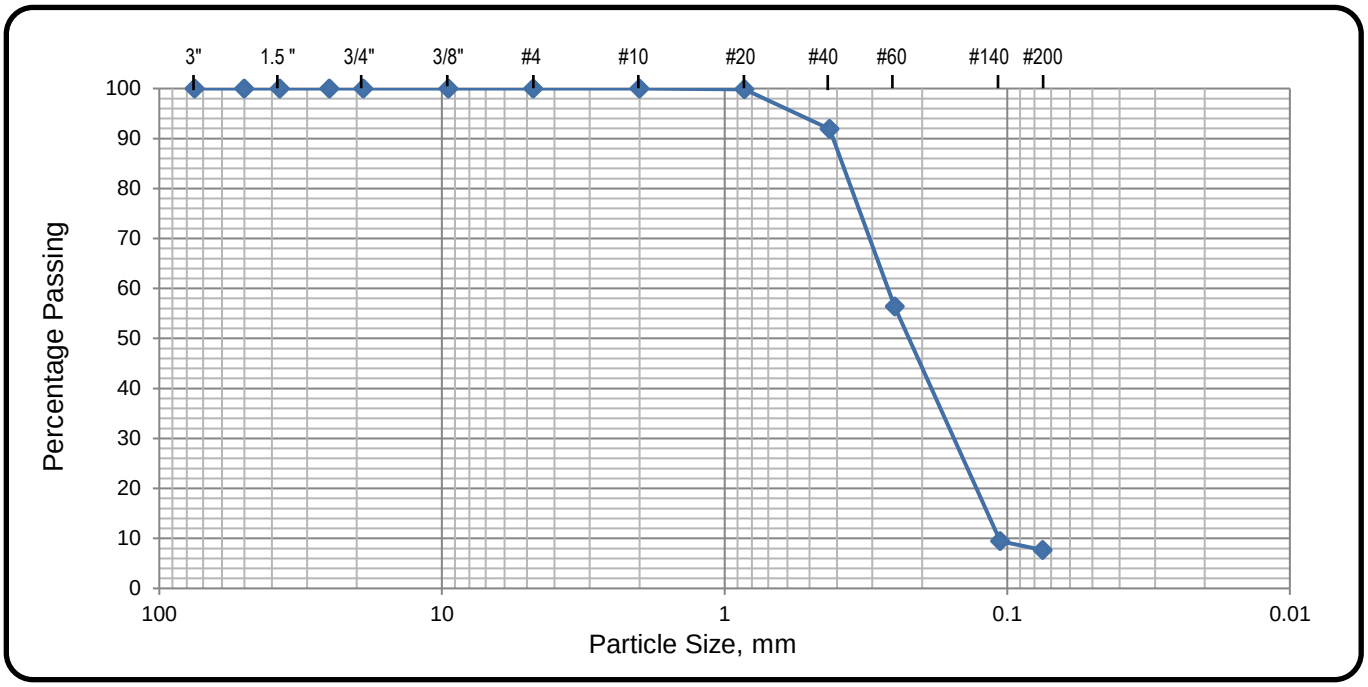
REPORT OF PARTICLE-SIZE ANALYSIS



Fractional Component Percentages

Plus 3 "	Coarse Gravel	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines
0.0	0.0	0.0	0.0	8.1	84.2	7.7

Total Percentages:	Gravel:	0.0	Sand:	92.3	Fines:	7.7

Sieve Designation	Amounts Retained (grams)	Amounts Retained (percent)	Percent Passing
3"	0.00	0.0	100.0
2"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	0.00	0.0	100.0
#4	0.00	0.0	100.0
#10	0.00	0.0	100.0
#20	0.16	0.1	99.9
#40	8.74	8.1	91.9
#60	47.14	43.6	56.4
#140	97.86	90.5	9.5
#200	99.80	92.3	7.7

Project Name: Hungry Howie
Project Number: PR-008353
Site Identification: US-FL-7140
Sample Identification: B1 SS4 (6ft - 8ft)
Description: Poorly graded sand with silt

As-received water content, %: 19.1
USCS Classification: SP-SM
Liquid Limit: ND
Plastic Limit: ND
Plasticity Index: ND

D_{10} = 0.11
D_{30} = 0.15
D_{60} = 0.26

Total dry mass, g: 108.10

C_u: 2.47 ***C_c: 0.84***

Remarks: Entire sample was tested. ND=Not Determined.

Reviewed by: Sushmaben Patel

Document: Enter Sample IDB1 SS4 Particle-Size Analysis & Classification.xlsx

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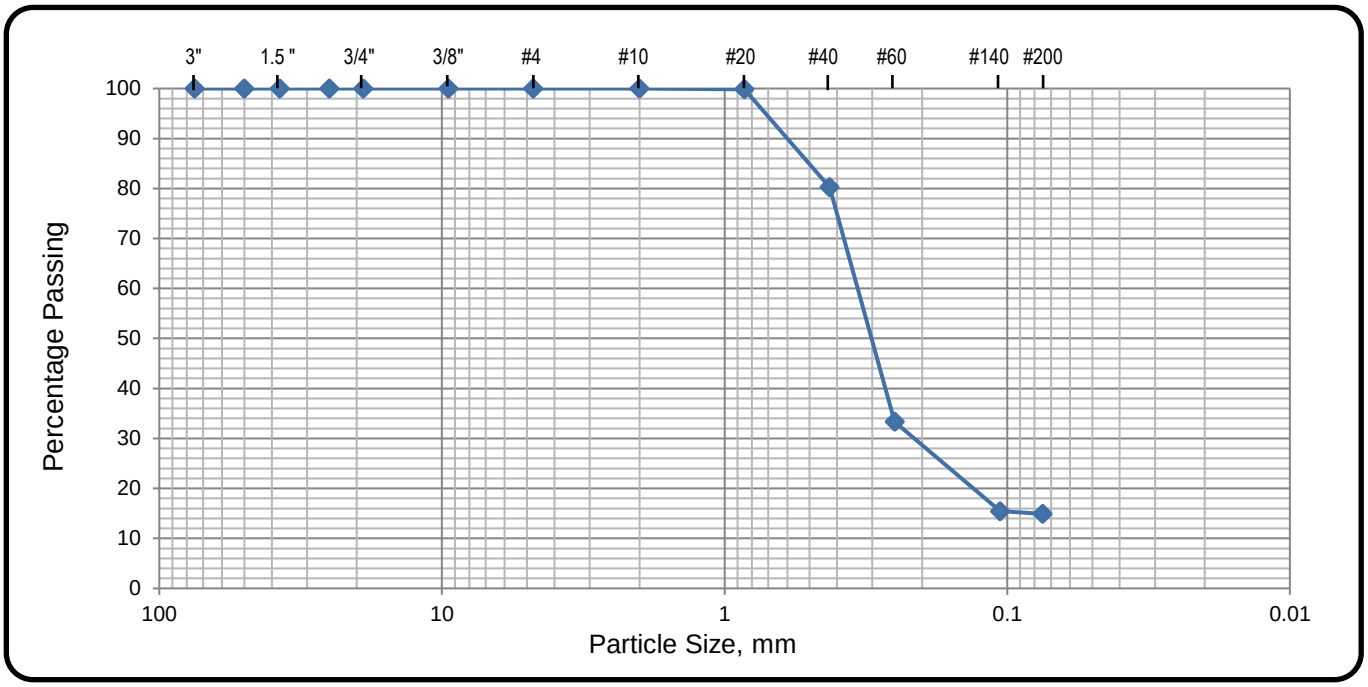
REPORT OF PARTICLE-SIZE ANALYSIS



Fractional Component Percentages

Plus 3 "	Coarse Gravel	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines
0.0	0.0	0.0	0.0	19.7	65.4	14.9

Total Percentages:	Gravel:	0.0	Sand:	85.1	Fines:	14.9

Sieve Designation	Amounts Retained (grams)	Amounts Retained (percent)	Percent Passing
3"	0.00	0.0	100.0
2"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	0.00	0.0	100.0
#4	0.00	0.0	100.0
#10	0.00	0.0	100.0
#20	0.21	0.2	99.8
#40	25.28	19.7	80.3
#60	85.42	66.7	33.3
#140	108.31	84.5	15.5
#200	109.00	85.1	14.9

Project Name: Hungry Howie
Project Number: PR-008353
Site Identification: US-FL-7140
Sample Identification: B1 SS6 (13.5ft - 15ft)
Description: Silty sand

As-received water content, %: 18.9
USCS Classification: SM
Liquid Limit: ND
Plastic Limit: ND
Plasticity Index: ND

D_{10} = ND
D_{30} = 0.21
D_{60} = 0.34

Total dry mass, g: 128.11

C_u: ND ***C_c: ND***

Remarks: Entire sample was tested. ND=Not Determined.

Reviewed by: Sushmaben Patel

Document: Enter Sample IDB1 SS6 Particle-Size Analysis & Classification.xlsx

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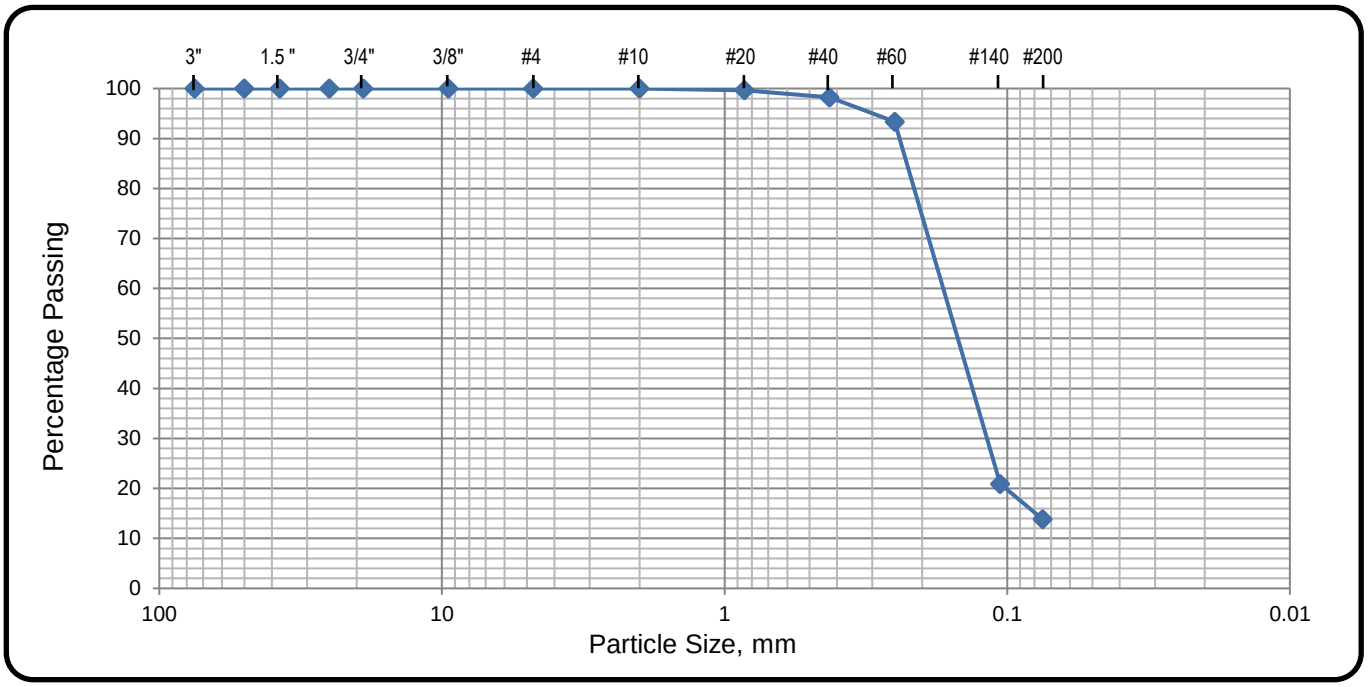

Fractional Component Percentages

Plus 3 "	Coarse Gravel	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines
0.0	0.0	0.0	0.0	1.8	84.3	13.9

Total Percentages:	Gravel:	0.0	Sand:	86.1	Fines:	13.9

Sieve Designation	Amounts Retained (grams)	Amounts Retained (percent)	Percent Passing
3"	0.00	0.0	100.0
2"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	0.00	0.0	100.0
#4	0.00	0.0	100.0
#10	0.00	0.0	100.0
#20	0.43	0.4	99.6
#40	2.20	1.8	98.2
#60	8.15	6.6	93.4
#140	97.17	79.1	20.9
#200	105.82	86.1	13.9

Project Name: Hungry Howie
Project Number: PR-008353
Site Identification: US-FL-7140
Sample Identification: B1 SS10 (33.5ft - 35ft)
Description: Poorly graded sand with silt

As-received water content, %: 24.7
USCS Classification: SP-SM
Liquid Limit: ND
Plastic Limit: ND
Plasticity Index: ND

D_{10} = ND
D_{30} = 0.12
D_{60} = 0.17

Total dry mass, g: 122.84

C_u: ND ***C_c: ND***

Remarks: Entire sample was tested. ND=Not Determined.

Reviewed by: Sushmaben Patel

Document: Enter Sample IDB1 SS10 Particle-Size Analysis & Classification.xlsx

FDH Infrastructure Services, LLC 6521 Meridien Drive Raleigh, NC 27616
Telephone: 919-755-1012 Fax: 919-755-1031 www.fdh-is.com