SUBSURFACE SOIL EXPLORATION
AND
GEOTECHNICAL ENGINEERING EVALUATION
GRAVITY SEWER,
BRADENTON BEACH,
MANATEE COUNTY, FLORIDA

Ardaman & Associates, Inc.

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Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

October 14, 2020
File No. 19-7257

TO: Kimley-Horn & Associates, Inc.
100 Second Ave. South, Suite 105N
St. Petersburg, FL 33701

Attention: Mike Semago
Email: mike.semago@kimley-horn.com

SUBJECT: Subsurface Soil Exploration and Geotechnical Engineering Evaluation
Gravity Sewer, Bradenton Beach, Manatee County, Florida

Dear Mr. Semago:

As requested, we have completed a subsurface soil exploration and geotechnical engineering evaluation for the subject project. We understand that the project will include construction of approximately 3,000 lineal feet gravity sewer. The proposed method of installation is not known at this time.

SITE LOCATION

The proposed gravity sewer is located on Bradenton Beach, Manatee County, Florida. We understand that the alignment is to be located along 7th Street South, 8th Street South, 9th Street South, 10th Street South, 11th Street South, 12th Street South, 13th Street South and Gulf Drive South.

REVIEW OF SOIL SURVEY MAPS

Based on the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) "Web Soil Survey," (https://websoilsurvey.nrcs.usda.gov/app/) the soils along the gravity sewer are mapped primarily as the "8 – Canaveral fine sand, 0 to 5 percent slopes" soil series, but with the "2 – Beaches" soil series to the west. The soils map for the general area of the proposed gravity sewer is included in Appendix I of this report.

The mapped locations of the individual soil units and selected characteristics of each, according to the NRCS, are summarized in Appendix I of this report. The characteristics listed are the general ratings for corrosion of concrete, corrosion of steel and for shallow excavations, as reported by the NRCS. These ratings represent the "dominant condition" for the soil map unit and are not site specific.

FIELD EXPLORATION PROGRAM

Standard Penetration Test Borings

Our scope of work included performing thirteen (13) Standard Penetration Test (SPT) borings to a depth of 20 feet below the existing ground surface. The number of test borings, boring depths and approximate locations were determined by Kimley-Horn & Associates. The approximate boring locations are shown on the attached Figure 1.

The SPT borings were performed using the methodology outlined in ASTM D1586. A summary of the boring procedures is included in Appendix II. Split-spoon soil samples recovered during performance of the borings were visually classified in the field and representative portions of the soil samples were transported to our laboratory for further visual classification and laboratory testing.

Where encountered, the groundwater level at each of the boring locations was measured during drilling. The SPT borings were then plugged with cement grout (placed by tremie method, from bottom to top).

Test Boring Locations

The depths and approximate locations of the borings were requested by Kimley-Horn & Associates (KHA). Locations were adjusted in the field as necessary to avoid existing utilities or other obstructions, and to maintain a safe working distance from overhead power lines.

The approximate locations of the borings are schematically illustrated on Figure 1. The locations were determined in the field by visual reference to available site features and should be considered accurate only to the degree implied by the method used.

LABORATORY TESTING PROGRAM

The field soil boring logs and recovered soil samples were transported to our Sarasota office following the completion of the field exploration activities. Each representative sample was examined by a geotechnical engineer in our laboratory for visual classification and assignment of laboratory tests.

The soil descriptions shown on the soil profiles are based on a visual classification procedure in general accordance with the Unified Soil Classification System (ASTM D-2487 or D-2488).

Corrosivity Tests

The laboratory testing program also included corrosivity series testing. This series of tests includes determining electrical resistivity, soil pH, sulfates content and chlorides content (FM 5-550, 5-551, 5-552 and 5-553).

The tests were performed on three (3) composite samples. Each composite sample was formed by thoroughly mixing individual samples from selected borings and depths. The test results are summarized in the table below:

Sample	Borings	Depth (feet)	Soil Classification	pH	Chloride (ppm)	Sulfate (ppm)	Resistivity (ohm-cm)
C-1	BB-03	7½ - 20	SM	8.33	600	153	780
C-2	BB-05	4½ - 10½	SP/SP-SM	8.77	45	117	2670
C-3	BB-10	2 - 7½	SM/SP-SM	8.29	30	105	3730

Based upon Table 1.3.2-1 of the FDOT “Structures Design Guidelines” (Vol I, Sec. 1.3), sample C-1 would be classified as an “extremely aggressive” environment to steel and a “moderately aggressive” environment to concrete. Sample C-2 would be classified as a “moderately aggressive” environment to concrete and steel. Sample C-3 would be classified as a “slightly aggressive” environment to concrete and a “moderately aggressive” environment to steel. This assumes that the structure (pipeline) is not considered a “marine structure” (see Sec. 1.3.2.B).

GENERAL SUBSURFACE CONDITIONS

General Soil Profile

The results of the field exploration program are graphically summarized on the soil boring profiles presented on Figure 2. The stratification of the boring profiles represents our interpretation of the field boring logs and the results of laboratory examinations of the recovered samples. The stratification lines represent the approximate boundary between soil types. The actual transitions may be more gradual than implied.

The soils encountered from the ground surface to a depth of approximately 20 feet (end of boring) consisted primarily of very loose to very dense fine sand (SP), fine sand with silt (SP-SM), and silty fine sand (SM) with varying amounts of shell. Some exceptions to this included:

- A layer of hard sandy silt & rock encountered at a depth of approximately 13 to 15 feet at boring BB-01.
- Sandy soils mixed with concrete or brick debris at a depth of approximately 2 to 6 feet at boring BB-03 and 3 to 3½ feet at boring BB-04.
- Organic silty fine sand (mucky sand) at a depth of approximately 2 to 3½ feet at boring BB-05.
- Sandy soils mixed with large stones at a depth of approximately 4½ to 6 feet at boring BB-06.
- Hard limerock at a depth of approximately 3 to 4½ feet at borings BB-09 and BB-10.

The occurrences of hard silt, rock, large stones, concrete and brick were all at borings located along the west side of Gulf Drive. This may indicate the presence of a coastal revetment that has been buried beneath the current ground surface. Due to the relatively small diameter of SPT samples (approximately 1¾ inch), similar materials may also be present at locations and depths beyond what was detected in the SPT borings.

The above soil profile description is in general terms only. Please refer to Figure 2 for soil profile details.

Groundwater Level

The groundwater level in the boreholes was measured during drilling. As shown on Figure 2, the groundwater level was encountered at depths of approximately 1.5 to 4.6 feet below the ground surface. Fluctuations in groundwater levels should be anticipated throughout the year, primarily due to seasonal variations in rainfall and other factors that may vary from the time the borings were conducted. Groundwater levels may also be influenced by tidal fluctuations.

The normal seasonal high groundwater level each year typically occurs in August to September, which is the period near the end of the rainy season during a year of normal (average) rainfall patterns. The seasonal high groundwater level is affected by a number of factors, such as the drainage characteristics of the soils, the land surface elevation, relief points (such as lakes, rivers, swamp areas, etc.) and distance to relief points.

We estimate that the normal seasonal high groundwater level probably occurs within a depth of approximately 1 to 2 feet below the ground surface along most of the proposed pipeline alignment. The water table elevations associated with a flood may be higher than the normal seasonal high groundwater levels, however.

ENGINEERING EVALUATION AND RECOMMENDATIONS - CUT AND COVER

General

The results of this exploration indicate that most of the existing soils encountered are generally suitable for supporting the proposed pipelines and associated structures. One exception to this is the layer of “mucky sand” that was encountered at boring BB-05 at a depth of 2 to 3½ feet. This soil should be excavated and removed where it underlies the gravity sewer and associated structures. In addition, the hard sandy silt, limerock, and soils containing a significant amount of rock, large stones, concrete or brick would not for a suitable pipe bedding material or trench backfill, and may need to be undercut and replaced with suitable bedding material.

The following are our recommendations for overall site preparation and foundation support which we feel are best suited for the proposed pipelines and associated structures relative to the soil conditions encountered in the borings performed to-date. The recommendations are made as a guide for the design engineer, parts of which should be incorporated into the project's specifications.

Pipelines and Associated Structures

<u>Excavation</u>

Based on the conditions encountered during the field exploration, we anticipate that most of the soils encountered from the ground surface to a depth of 20 feet can generally be excavated with standard earth moving equipment (i.e., front-end loaders, backhoes and excavators). Exceptions to this may include:

- Hard sandy silt & rock (such as encountered at boring BB-01).
- Sandy soils mixed with concrete, brick or large stones (such as encountered at borings BB-03, BB-04 and BB-06).

- Hard limerock (such as encountered at borings BB-09 and BB-10).
- Sandy soils that are in a dense to very dense state (SPT N-value greater than approximately 30). Note that the N-values are listed adjacent to the boring logs on Figures 2 to 4.

The above exceptions may be more difficult to excavate than typical loose to medium dense soils (SPT N-values less than approximately 30). Please also refer to the “General Soil Profile” section on page 3 of this report and the individual soil profiles (boring logs) on Figure 2 for additional information.

The soils below the bottom of the excavations should not be disturbed by the excavation process. If soils become disturbed and difficult to compact, they should be over-excavated below the pipeline and other structures to a depth necessary to remove all disturbed soils. Over-excavated areas should be replaced with compacted backfill meeting the "Backfill Requirements" presented in a subsequent section of this report.

The excavations should be safely braced or sloped to prevent injury to personnel or damage to equipment. Temporary safe slopes in dewatered soils should be cut no steeper than 1.5 horizontal (H) to 1 vertical (V), in accordance with OSHA, 29 CFR Part 1926 Subpart P. Flatter slopes should be used if deemed necessary based on actual conditions encountered. Surcharge loads should be kept at least 5 feet from excavations. Spoil banks adjacent to excavations should be sloped no steeper than 2.0H to 1.0V. Provisions for maintaining workers' safety within and adjacent to excavations is the sole responsibility of the Contractor.

Dewatering

The control of the groundwater may be required to achieve the necessary depths of excavation and subsequent construction, backfilling and compaction requirements presented in the following sections. The actual method(s) of dewatering should be determined by the Contractor. However, regardless of the method(s) used, we suggest drawing down the groundwater table sufficiently (i.e., 2 to 3 feet) below the bottom of the excavation(s) to preclude "pumping" and/or compaction-related problems with the foundation soils. We recommend that the dewatering be accomplished in advance of the excavation.

Pipeline Bedding

Pipe bedding material should be compacted to achieve a density equivalent to 95 percent of the maximum dry density, as determined by the Modified Proctor (ASTM D-1557), to a minimum depth of 6 inches below the bottom of the pipe. Compact deeper if recommended by the pipe manufacturer.

To provide proper bedding, we recommend that the following soils be over-excavated to a depth of at least 6 inches below the bottom of the pipe and replaced with a suitable backfill.

- Hard sandy silt & rock (such as encountered at boring BB-01).
- Sandy soils mixed with concrete, brick or large stones (such as encountered at borings BB-03, BB-04 and BB-06).
- Hard limerock (such as encountered at borings BB-09 and BB-10).

The organic silty fine sand (mucky sand), such as was encountered at a depth of approximately 2 to 3½ feet at boring BB-05, should be fully removed where it occurs within the pipeline trench area. This should include an area equal to the width of the pipe plus at least 1 foot to each side of the pipe. It should be disposed of off-site and not used as backfill.

We recommend that the bedding for the pipe be preshaped by means of a template prior to placement of the pipe to ensure that the upward reaction on the bottom of the pipe will be well distributed over the width of the bedding contact. Based on the cost involved with preshaping the bedding material and the construction time requirements, an alternative procedure may be to utilize a level bed for the pipe and require a higher pipe strength class that will adequately carry the load on a lower class of bedding. It would be prudent to perform an economic analysis of the two alternatives, or specify both design conditions within the contract documents and allow the Contractor to decide the most efficient method.

If level bedding is utilized, it will be necessary to place and compact the haunching backfill (backfill between the bedding and the springline of the pipe) to the springline of the pipe. This material should be placed in simultaneous layers on each side of the pipe and must be compacted in such a manner as to ensure an intimate contact with the sides of the pipe. Do not use blocking under the pipe to raise the pipe to grade.

The final backfill above the haunching or springline of the pipe must extend all the way to the trench walls and should be placed in level lifts not exceeding 12 inches. Each lift should be compacted to at least 95 percent of the maximum dry density, as determined by the Modified Proctor (ASTM D-1557). Care should be taken not to damage the pipe or deflect it by compacting directly above the pipe where there is insufficient cover material present. Minimum cover criteria should be in accordance with the pipe manufacturer's recommendations.

Where the utility line will traverse roadways and/or other permanent structures such as sidewalks, all backfill should be compacted to 95 percent of maximum dry density, as determined by the Modified Proctor (ASTM D-1557), from the top of the pipe to the ground surface. The design engineer may wish to specify greater compaction for the pavement subgrade, to be consistent with the pavement design requirements.

A geotechnical engineer or a designated representative from Ardaman & Associates, Inc. should observe and test all prepared and compacted areas to verify that all bedding, haunching and final backfill are prepared and compacted in accordance with the aforementioned specifications

Backfill Requirements

As a general guide to aid the Contractor regarding materials to use for fill in the excavations, we recommend using fine sand (SP) to fine sand with silt (SP-SM) that contains less than 1 percent organic matter and no greater than 12 percent by dry weight of material passing the U.S. Standard No. 200 sieve size. Soils with more than 12 percent passing the No. 200 sieve will be more difficult to compact due to their inherent nature to retain soil moisture.

Based on the soil samples obtained during our subsurface investigation, the on-site fine sand (SP) and fine sand with silt (SP-SM) soils (those without roots, organic matter, rock, concrete/brick debris or large stones) appear suitable for use as structural backfill for the pipe. Material removed from below the groundwater table will be wet and will require time to dry sufficiently.

The silty fine sand (SM) could be used in some applications as structural backfill, but will be more difficult to moisture condition and compact due to its inherent nature to retain moisture.

Resistance to Horizontal Forces on Pipeline Structures

Horizontal forces which act on structures such as thrust blocks or anchor blocks can be resisted to some extent by the earth pressures that develop in contact with the buried vertical face (buried vertical face is perpendicular and in front of the applied horizontal load) of the block structures and by shearing resistance mobilized along the base of the block structures and soil subgrade interface.

Allowable earth pressure resistance may be determined using an equivalent fluid density of 110 pounds per cubic foot (pcf) for moist soil above the water table and 70 pcf for submerged soils below the water table[1]. The passive earth pressures are developed from ground surface[2] to the bottom of the block structure.

The values presented above presume that the block structures are surrounded by well compacted sand backfill extending at least 5 feet horizontally beyond the vertical buried face. In addition, it is presumed that the block structures can withstand horizontal movements on the order of one-quarter (1/4) to three-eighths (3/8) inch before mobilizing full passive resistance. The factors of safety assumed in the above recommendations are 2.5 for passive pressure with submerged conditions, and 3.0 for passive pressure without submerged conditions.

1 Equivalent fluid density (moist soil) = $K_p \gamma_m$/S.F. = 110 pcf
Equivalent fluid density (submerged soil) = $K_p (\gamma_s - \gamma_w)$/S.F. = 70 pcf

Where: K_p = effective coefficient of passive earth pressure = 3.0
S.F. = safety factor = (values given above)
γ_m = unit weight of moist soil = 110 pcf
γ_s = unit weight of saturated soils = 120 pcf
γ_w = unit weight of water = 62.4 pcf

2 Assuming there is no excavation in the vicinity of the block structure that would reduce the available passive pressure.

The sliding shearing resistance mobilized along the base of the block structure may be determined by the following formula:

Allowable Shearing Resisting Force, $P = V \tan(2/3\ \phi)/S.F$

Where: P = Shearing Resistance Force (pounds)
V = Net Vertical Force (total weight of block and soil overlying the structure minus uplift forces including buoyancy forces) (pounds)
ϕ = Angle of Internal Friction of Soil = 30 degrees
S.F. =Safety Factor = 1.5

The vertical earth pressures developed by the overburden weight of soil can be calculated using the following unit weights:

- Compacted moist soil = 110 pcf
- Saturated soil = 120 pcf (buoyant unit weight of saturated soil = 58 pcf)

Vertical pressure distributions in accordance with the above do not take into account vertical forces from construction equipment, wheel loads or other surcharge loads.

Foundation Support and Estimated Settlements

The permanent structures such as anchor blocks, thrust blocks, air release valves, blow offs, etc., bearing at least 18 inches below adjacent grade and at least 18 inches wide can be designed for the following maximum vertical bearing capacities:

- 1,500 psf on undisturbed natural granular soils.
- 2,000 psf on compacted natural or backfilled subgrade; this value assumes compaction of at least 95 percent of the Modified Proctor maximum density (ASTM D-1557, AASHTO T-180) to a depth of 1 foot below the structure.

Pipe settlement during and after construction should be negligible (less than 1/2 inch) provided the bedding and backfilling criteria in the above sections are satisfied. The volume of soil displaced by the pipe, compared to the weight of the pipe when full, will result in little if any net increase in bearing stress to the subsurface soils.

Uplift Resistance

Permanent structures submerged below the groundwater table will be subjected to uplift forces caused by buoyancy. The components resisting this buoyancy include: 1) the total weight of the pipe or structure divided by an appropriate factor of safety; 2) the buoyant weight of soil overlying the pipe or structure; and 3) the shearing forces that act on shear planes that radiate vertically upward from the perimeter of the pipe or the edges of the structure to the ground surface. The allowable unit shearing resistance may be determined by the following formula:

Allowable Shearing Resistance, $F=K_o\gamma_m h(2/3 \tan\phi)/S.F.$ (above water table)

Allowable Shearing Resistance, $F=K_o[\gamma_m h_w+\gamma_b(h-h_w)](2/3 \tan\phi)/S.F.$ (below water table)

where: F = unit shearing resistance (psf)
K_o = coefficient of earth pressure at rest = 0.5
γ_m = unit weight of moist soil = 110 pcf
γ_b = buoyant unit weight of soil = 58 pcf
h = vertical depth (feet) below grade at which shearing resistance is determined
h_w = vertical depth (feet) below grade to groundwater table
ϕ = angle of internal friction of the soil = 30 degrees
S.F. = safety factor = 2.0

The values given for the above parameters assume that the permanent structures are covered by clean, well-compacted, granular backfill that extends horizontally at least 2 feet beyond the structures.

Earth Pressure on Shoring and Bracing

If temporary shoring and bracing are required for any excavations, the system should be designed to resist lateral earth pressures. The design earth pressure will be a function of the flexibility of the shoring and bracing system. For a flexible system restrained laterally by braces placed as the excavation proceeds, the design earth pressure for shoring and bracing can be computed using a uniform earth pressure distribution with depth. It is recommended that soils be dewatered around the excavations. For such dewatered excavations, we recommended using the following uniform pressure distribution over the full braced height as follows:

Uniform Soil Pressure Distribution, $p = 0.65\ K_a \gamma_s H$

where: p = uniform pressure distribution for design of braced excavation
K_a = coefficient of active earth pressure = 0.33
γ_s = unit weight of saturated soils = 120 pcf
H = depth of excavation

An appropriate factor of safety should be applied for the design of the braced excavations.

Lateral pressure distributions determined in accordance with the above do not take hydrostatic pressures or surcharge loads into account. To the extent that such pressures and forces may act on the walls, they should be included in the design.

Construction equipment and excavated fill should be kept a minimum distance of 5 feet from the edge of the braced or shored excavation. Backfill material placed adjacent to (maintaining a minimum 5-foot horizontal clearance) the braced or shored excavation should have a minimum slope of 2.0H to 1.0V or flatter, if required by site specific conditions and/or to meet OSHA requirements.

Means and methods of excavation and bracing should be the responsibility of the Contractor; however, excavation and/or bracing should, at a minimum, comply with the requirements of the Occupational Safety Health Administration (OSHA).

Lateral Earth Pressures

Lateral loads acting on the embedded structure will include at-rest earth pressures as well as hydrostatic pressures and surcharge loads. The lateral earth pressure will be a function of both the depth below ground surface and the soil unit weight (submerged or moist) plus hydrostatic pressure (if applicable). The following equations can be used to determine the lateral at-rest earth pressure:

$\sigma_h = K_o \gamma_m h$ (above water table)
$\sigma_h = K_o[\gamma_m h_w + \gamma_b(h-h_w)]$ (below water table)

where:
- σ_h = lateral earth pressure (psf)
- K_o = coefficient of at rest earth pressure (0.5) (this value assumes that the backfill is lightly compacted yet not overcompacted)
- γ_m = moist unit weight of soil = 110 pcf for compacted moist soil above the water table.
- γ_b = buoyant unit weight of soil = 58 pcf for compacted saturated soil below the water table.
- h= vertical depth (feet) below grade at which lateral earth pressure is determined.
- h_w = vertical depth (feet) below grade to groundwater table

For design, an appropriate factor of safety should be applied to the lateral earth pressure calculated using the above equation. Lateral pressure distributions determined in accordance with the above do not include hydrostatic pressures or surcharge loads. Where applicable, they should be incorporated in the design.

Pipeline Directional Drill Locations

We understand that the installation method(s) for the pipeline have not been determined, but that portions may be installed by directional drill. The SPT borings provide soil stratigraphy data that can be used for the directional drill design.

Classification in accordance with the Unified Soil Classification System and the SPT N-values were used to estimate unit weights, the angles of internal friction, cohesion and the shear modulus for the types of soils encountered in the borings. These are summarized in the following table:

Summary of Soil Parameters

Boring No	Depth Range (ft)	(see Note 1) Soil Classification	(see Note 4) Internal Friction Angle (degrees)	Saturated Soil Weight (pcf)	(see Note 2) Moist Soil Weight (pcf)	(see Note 3) Cohesion (psf)	Shear Modulus (ksf)
BB-01	0 - 5	SP/SM	33	128	114	---	400
	5 - 13	SP-SM/SM	36 - 38	132	---	---	700
	13 - 15	ML	---	135	---	18,000	280
	15 - 20	SM	35	130	---	---	520
BB-02	0 - 6	SP/ML/SP-SM	32	120	107	---	300
	6 - 17	SM	28	115	---	---	150
	17 - 20	SM	35	130	---	---	560
BB-03	0 - 2	SP	33	128	114	---	400
	2 - 6	SP	36 - 38	132	120	---	700
	6 - 20	SP-SM/SM	35	130	---	---	520
BB-04	0 - 3	SP	33	128	114	---	400
	3 - 6	SP-SM	36 - 41	133	---	---	800
	6 - 12	SM	35	130	---	---	540
	12 - 20	SM	36 - 39	133	---	---	730
BB-05	0 - 5	SP/SM	30	120	103	---	200
	5 - 17	SP/SP-SMSM	31	123	---	---	220
	17 - 20	SP-SM/SM	34	129	---	---	500
BB-06	0 - 4	SP	33	128	114	---	400
	4 - 20	SP-SM/SM	36 - 37	132	---	---	650
BB-07	0 - 9	SP	33	128	114	---	420
	9 - 12	SM	28	115	---	---	150
	12 - 20	SP-SM/SM	36 - 37	132	---	---	670
BB-08	0 - 5	SW/SP/SM/SP-SM	30	120	103	---	180
	5 - 12	SM	31	124	---	---	250
	12 - 20	SP-SM/SM	36 - 38	132	---	---	690
BB-09	0 - 4	SP	32	125	108	---	300
	4 - 5	Limerock	---	---	---	---	---
	5 - 13	SP/SM	35	130	---	---	540
	13 - 20	SP/SP-SM	36 - 40	135	---	---	800
BB-10	0 - 8	SP-SM/SM	28	115	92	---	150
	8 - 20	SP-SM/SM	32	125	---	---	320
BB-11	0 - 3	SP	32	125	108	---	300
	3 - 4	Limerock	---	---	---	---	---
	4 - 13	SP	36	131	---	---	630
	13 - 20	SM	29	118	---	---	160
BB-12	0 - 5	SP/SP-SM/ML/SM	32	120	107	---	300
	5 - 16	SP-SM	34	129	---	---	500
	16 - 20	SM	32	125	---	---	300
BB-13	0 - 3	SP/SP-SM	33	125	112	---	400
	3 - 8	SP	36 - 38	133	---	---	710
	8 - 20	SP/SP-SM	30	120	---	---	170

Notes: pcf = pounds per cubic foot psf = pounds per square foot ksf = kips per square foot

(1) Disregarding rock, concrete or brick within the soils, where these are present.

(2) Estimate for a drained soil above the groundwater table.

(3) No value indicates a soil that is generally considered cohesionless.

(4) If a range is listed, use the value which yields a more conservative result.

(5) The values listed above are based upon emperical correlations with the average soil conditions encountered. Appropriate safety factors should be used with these values.

(6) The soil layers presented above are generalized and should be used for design purposes only. The above values should not be used to assess constructability of the proposed pipeline.

The following should be noted when reviewing the data in the above table.

- Buoyant Soil Unit Weight = Saturated Soil Unit Weight – Water Unit Weight

- The groundwater table may, at times, be very near the ground surface. This should be considered in calculating minimum effective soil overburden weights.

- Values given in the table are based on empirical correlations with the soil conditions encountered in the referenced boring. Appropriate safety factors should be used with these values.

We caution that the soil layers shown in the table are very generalized and should be used for design purposes only. In particular, the soil parameters are not specifically representative of limerock, rock, concrete or brick where they occur within the soil profile (either as a specific layer or mixed with the soils). The soil stratigraphy on the boring profiles (Figure 2) is more detailed than presented in the above table. The information in the above table should not be used for assessing the constructability of the proposed pipeline. The success of the directional drill program will depend on the means and methods of the directional drill contractor.

QUALITY CONTROL

We recommend establishing a comprehensive quality control program to verify that all excavation, bedding, and backfilling is conducted in accordance with the appropriate plans and specifications. Materials testing and inspection services should be provided by Ardaman & Associates, Inc. In-situ density tests should be conducted during bedding and backfilling activities to verify that the required densities are achieved.

Backfill for the proposed pipeline should be tested at a minimum frequency of one in-place density test for each lift for each 200 lineal feet of pipe. Additional tests should be performed beneath foundations and in backfill for other associated structures. In-situ density values should be compared to laboratory Proctor moisture-density results for each of the different natural and fill soils encountered.

CLOSURE

The analyses and recommendations submitted herein are based on the data obtained from the soil borings presented on Figure 1. This report does not reflect any variations which may occur adjacent to or between the borings. The nature and extent of the variations between the borings may not become evident until during construction. If variations then appear evident, it will be necessary to re-evaluate the recommendations presented in this report after performing on-site observations during the construction period and noting the characteristics of the variations.

This study is based on a relatively shallow exploration and is not intended to be an evaluation for sinkhole potential. This study does not include an evaluation of the environmental (ecological or hazardous/toxic material related) condition of the site and subsurface.

This report has been prepared for the exclusive use of Kimley-Horn & Associates in accordance with generally accepted geotechnical engineering practices. In the event any changes occur in the design, nature, or location of the proposed improvements, we should review the applicability of conclusions and recommendations in this report. We recommend a general review of final design and specifications by our office to verify that earthwork and foundation recommendations are properly interpreted and implemented in the design specifications. A representative of Ardaman & Associates should attend the pre-bid and preconstruction meetings to verify that the bidders/contractor understand the recommendations contained in this report.

We are pleased to be of assistance to you on this phase of the project. Please contact us when we may be of further service to you or should you have any questions.

Very truly yours,

ARDAMAN & ASSOCIATES, INC.
Fl. Registry No. 5950

JERRY H. KUEHN
LICENSE
No. 35557
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

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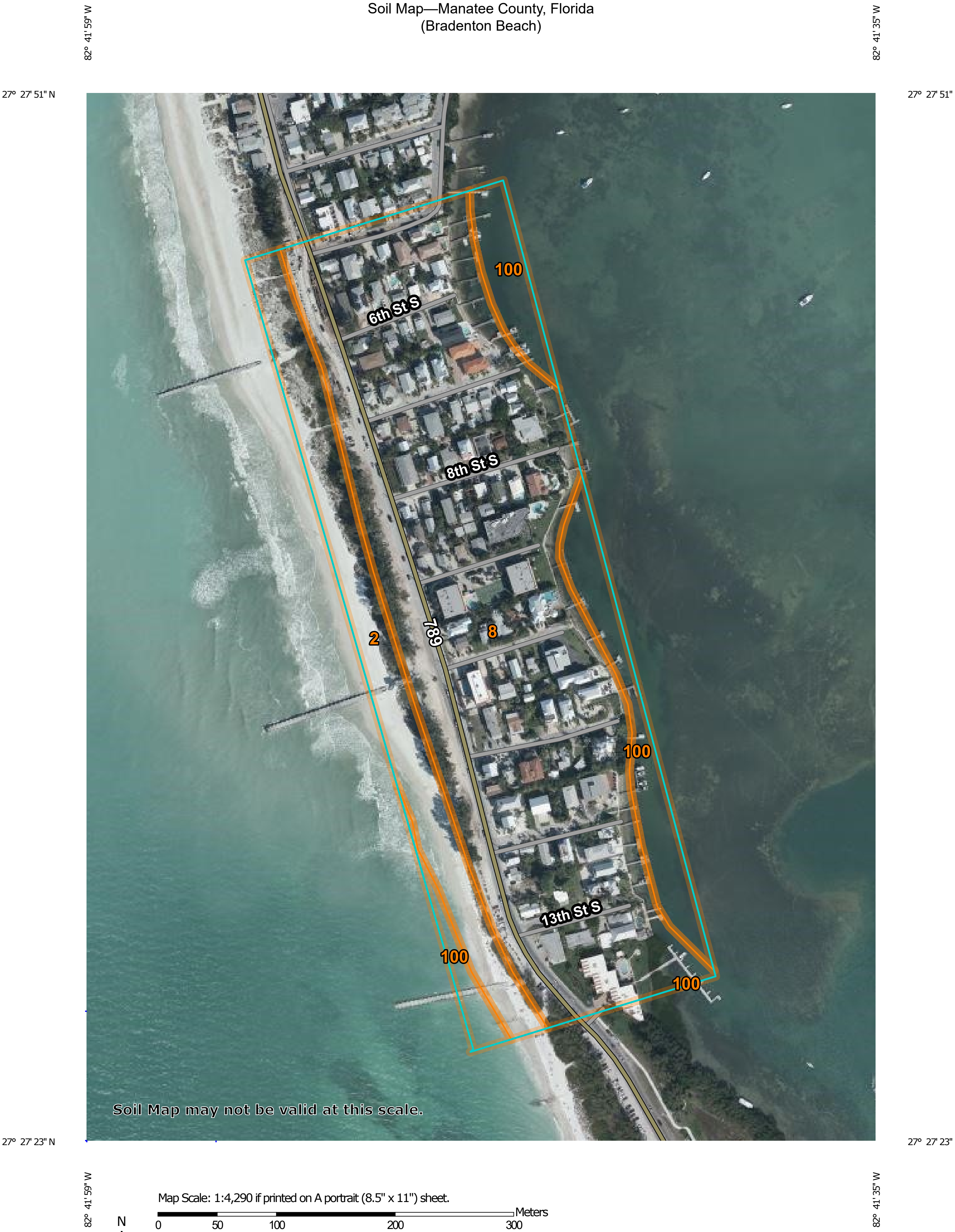
APPENDIX I

Soils Map and Selected Soil Characteristics From NRCS “Web Soil Survey”



Map Scale: 1:4,290 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

N

Map projection: Web Mercator Corner coordinates: WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Manatee County, Florida
Survey Area Data: Version 17, Jun 8, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 5, 2020—Mar 10, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
2	Beaches	5.6	14.9%
8	Canaveral fine sand, 0 to 5 percent slopes	27.5	73.0%
100	Waters of the Gulf of Mexico	4.6	12.2%
Totals for Area of Interest		**37.7**	**100.0%**

Corrosion of Concrete

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Beaches		5.6	14.9%
8	Canaveral fine sand, 0 to 5 percent slopes	Low	27.5	73.0%
100	Waters of the Gulf of Mexico		4.6	12.2%
Totals for Area of Interest			**37.7**	**100.0%**

Description

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens concrete. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the concrete in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Corrosion of Steel

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Beaches		5.6	14.9%
8	Canaveral fine sand, 0 to 5 percent slopes	High	27.5	73.0%
100	Waters of the Gulf of Mexico		4.6	12.2%
Totals for Area of Interest			**37.7**	**100.0%**

Description

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Shallow Excavations

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Beaches	Not rated	5.6	14.9%
8	Canaveral fine sand, 0 to 5 percent slopes	Very limited	27.5	73.0%
100	Waters of the Gulf of Mexico	Not rated	4.6	12.2%
Totals for Area of Interest			**37.7**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Very limited	27.5	73.0%
Null or Not Rated	10.2	27.0%
Totals for Area of Interest	**37.7**	**100.0%**

Description

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

APPENDIX II

Soil Boring, Sampling and Test Methods

SOIL BORING, SAMPLING AND TESTING METHODS

Standard Penetration Test

The Standard Penetration Test (SPT) is a widely accepted method of in situ testing of foundation soils (ASTM D-1586). A 2-foot long, 2-inch O.D. split-barrel sampler attached to the end of a string of drilling rods is driven 18 inches into the ground by successive blows of a 140-pound hammer freely dropping 30 inches. The number of blows needed for each 6 inches of penetration is recorded. The sum of the blows required for penetration of the second and third 6-inch increments of penetration constitutes the test result or N-value. After the test, the sampler is extracted from the ground and opened to allow visual examination and classification of the retained soil sample. The N-value has been empirically correlated with various soil properties allowing a conservative estimate of the behavior of soils under load. The following tables relate N-values to a qualitative description of soil density and, for cohesive soils, an approximate unconfined compressive strength (Qu):

Cohesionless Soils:

N-Value	Description
0 to 4	Very loose
4 to 10	Loose
10 to 30	Medium dense
30 to 50	Dense
Above 50	Very dense

Cohesive Soils:

N-Value	Description	Qu (ton/ft^2)
0 to 2	Very soft	Below 1/4
2 to 4	Soft	1/4 to 1/2
4 to 8	Medium stiff	1/2 to 1
8 to 15	Stiff	1 to 2
15 to 30	Very stiff	2 to 4
Above 30	Hard	Above 4

The tests are usually performed at 5-foot intervals. However, more frequent or continuous testing is done by our firm through depths where a more accurate definition of the soils is required. The test holes are advanced to the test elevations by rotary drilling with a cutting bit, using circulating fluid to remove the cuttings and hold the fine grains in suspension. The circulating fluid, which is a bentonitic drilling mud, is also used to keep the hole open below the water table by maintaining an excess hydrostatic pressure inside the hole. In some soil deposits, particularly highly pervious ones, NX-size flush-coupled casing must be driven to just above the testing depth to keep the hole open and/or prevent the loss of circulating fluid.

Representative split-spoon samples from each sampling interval and from every different stratum are brought to our laboratory in air-tight jars for further evaluation and testing, if necessary. After thorough examination and testing of the samples, the samples are discarded unless prior arrangements have been made. After completion of a test boring, the hole is kept open until a steady state groundwater level is recorded. The hole is then sealed, if necessary, and backfilled.

A hammer with an automatic drop release (auto-hammer) is sometimes used. In this case, a correction factor is applied to the raw blow counts, since the energy efficiency of the auto-hammer is greater than that of the safety hammer. Based upon calibration of the auto-hammer (per ASTM D4633) and standard practice, we use a multiplier of 1.24 to correct the auto-hammer blow counts to equivalent safety hammer “N” values.

Hand Auger Borings

Hand auger borings are used, if soil conditions are favorable, when the soil strata are to be determined within a shallow (approximately 5 to 9 feet) depth or when access is not available to power drilling equipment. A 3-inch diameter, hand bucket auger with a cutting head is simultaneously turned and pressed into the ground. The bucket auger is retrieved to the surface at approximately 6-inch intervals and its contents emptied for inspection. The soil sample so obtained is classified and representative samples put in bags or jars and transported to the laboratory for further classification and testing.

Laboratory Test Methods

Soil samples returned to our laboratory are examined by a geotechnical engineer or geotechnician to obtain more accurate descriptions of the soil strata. Laboratory testing is performed on selected samples as deemed necessary to aid in soil classification and to further define engineering properties of the soils. The test results are presented on the soil boring logs at the depths at which the respective sample was recovered, except that grain size distributions or selected other test results may be presented on separate tables, figures or plates as described in this report. The soil descriptions shown on the logs are based upon a visual-manual classification procedure in general accordance with the Unified Soil Classification System (ASTM D-2488-84) and standard practice. Following is a list of abbreviations which may be used on the boring logs or elsewhere in this report.

-200	- Fines Content (percent passing the No. 200 sieve); ASTM D1140
DD	- Dry Density of Undisturbed Sample; ASTM D2937
Gs	- Specific Gravity of Soil; ASTM D854
k	- Hydraulic Conductivity (Coefficient of Permeability)
LBR	- Limerock Bearing Ratio, FM1-T180, FM5-515
LL	- Liquid Limit; ASTM D423
OC	- Organic Content; ASTM D2974
pH	- pH of Soil; ASTM D2976
PI	- Plasticity Index (LL-PL); ASTM D424
PL	- Plastic Limit; ASTM D424
Qp	- Unconfined Compressive Strength by Pocket Penetrometer;
Qu	- Unconfined Compressive Strength; ASTM D2166 (soil), D7012 (rock)
SL	- Shrinkage Limit; ASTM D427
ST	- Splitting Tensile Strength; ASTM D3967 (rock)
USCS	- Unified Soil Classification System; ASTM D2487, D2488
w	- Water (Moisture) Content; ASTM D2216

Soil Classifications

The soil descriptions presented on the soil boring logs are based upon the Unified Soil Classification System (USCS), which is the generally accepted method (ASTM D-2487 and D-2488) for classifying soils for engineering purposes. The following modifiers are the most commonly used in the descriptions.

For Sands:

Modifier	Fines, Sand or Gravel Content*
with silt or with clay	5% to 12% fines
silty or clayey	12% to 50% fines
with gravel or with shell	15% to 50% gravel or shell

For Silts or Clays:

Modifier	Fines, Sand or Gravel Content*
with sand	15% to 30% sand and gravel; and % sand > % gravel
sandy	30% to 50% sand and gravel; and % sand > % gravel
with gravel	15% to 30% sand and gravel; and % sand < % gravel
gravelly	30% to 50% sand and gravel; and % sand < % gravel

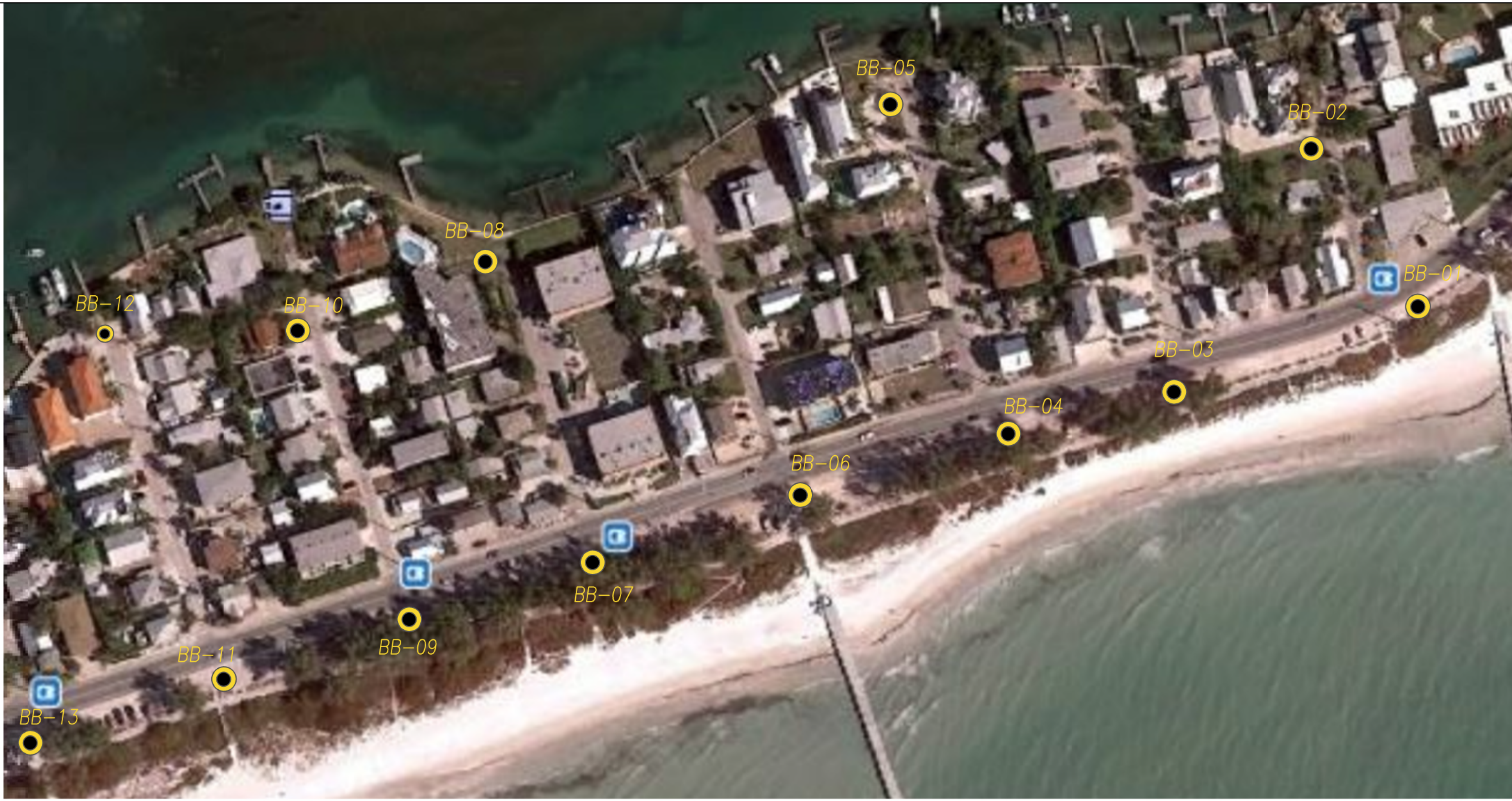
* may be determined by laboratory testing or estimated by visual/manual procedures. Fines content is the combined silt and clay content, or the percent passing the No. 200 sieve.

The USCS also uses a set of Group Symbols, which may also be listed on the soil boring logs. The following is a summary of these.

Group Symbol	General Group Name*	Group Symbol	General Group Name*
GW	Well-graded gravel	SW	Well-graded sand
GP	Poorly graded gravel	SP	Poorly graded sand
GW-GM	Well-graded gravel with silt	SW-SM	Well-graded sand with silt
GW-GC	Well-graded gravel with clay	SW-SC	Well-graded sand with clay
GP-GM	Poorly graded gravel with silt	SP-SM	Poorly graded sand with silt
GP-GC	Poorly graded gravel with clay	SP-SC	Poorly graded sand with clay
GM	Silty gravel	SM	Silty sand
GC	Clayey gravel	SC	Clayey sand
GC-GM	Silty, clayey gravel	SC-SM	Silty, clayey sand
CL	Lean clay	ML	Silt
CL-ML	Silty clay	MH	Elastic silt
CH	Fat clay	OL or OH	Organic silt or organic clay

* Group names may also include other modifiers, per standard or local practice.

Other soil classification standards may be used, depending on the project requirements. The AASHTO classification system is commonly used for highway design purposes and the USDA soil textural classifications are commonly used for septic (on-site sewage disposal) system design purposes.



REFERENCE: GOOGLE EARTH PRO 2019, IMAGERY DATED 1/2019

LEGEND

● APPROXIMATE LOCATION OF BORING LOCATIONS

N

0 50 100
APPROXIMATE SCALE: 1"=100'

TEST LOCATION PLAN		
Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants		
BRADENTON BEACH GRAVITY SEWER GULF DRIVE SOUTH MANATEE COUNTY, FLORIDA		
DRAWN BY: AUR	CHECKED BY: MEM	DATE: 10/1/20
FILE NO. 19-36-7257	APPROVED BY: MEM	FIGURE: 1

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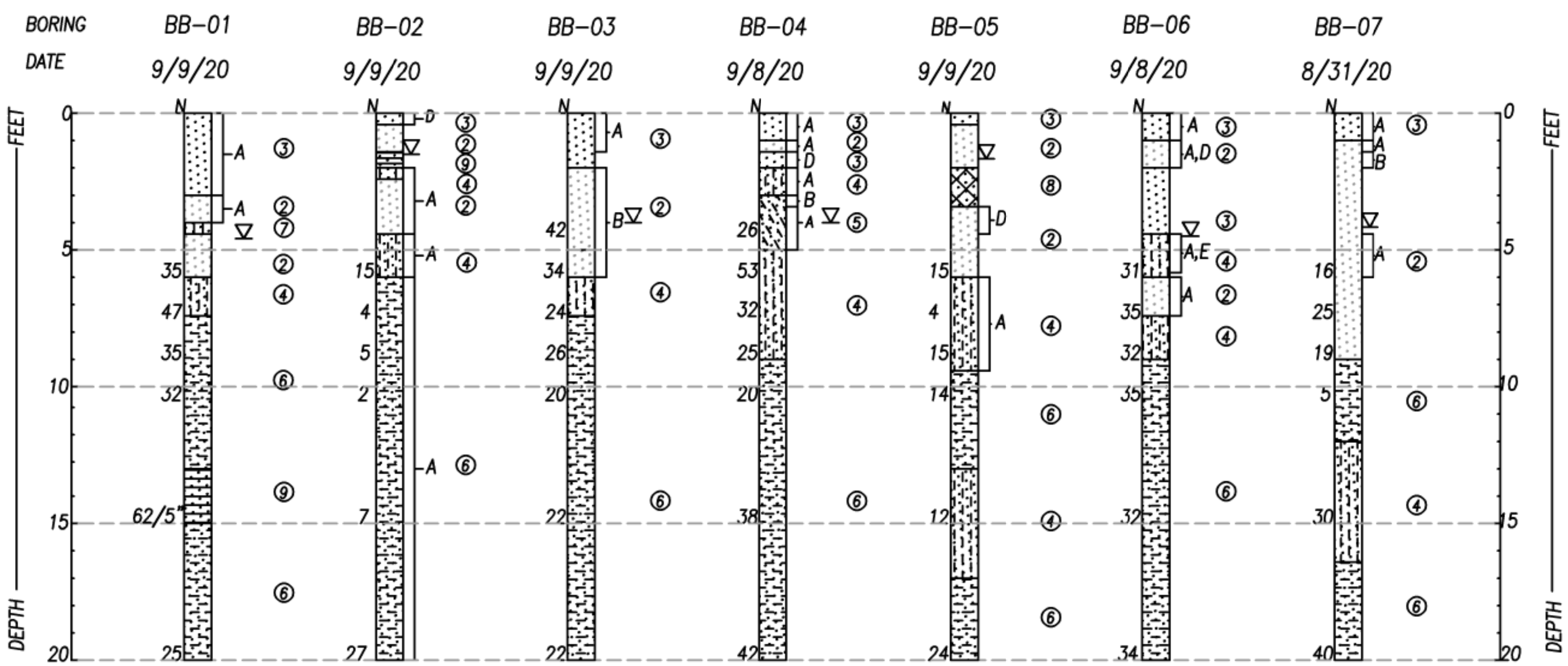

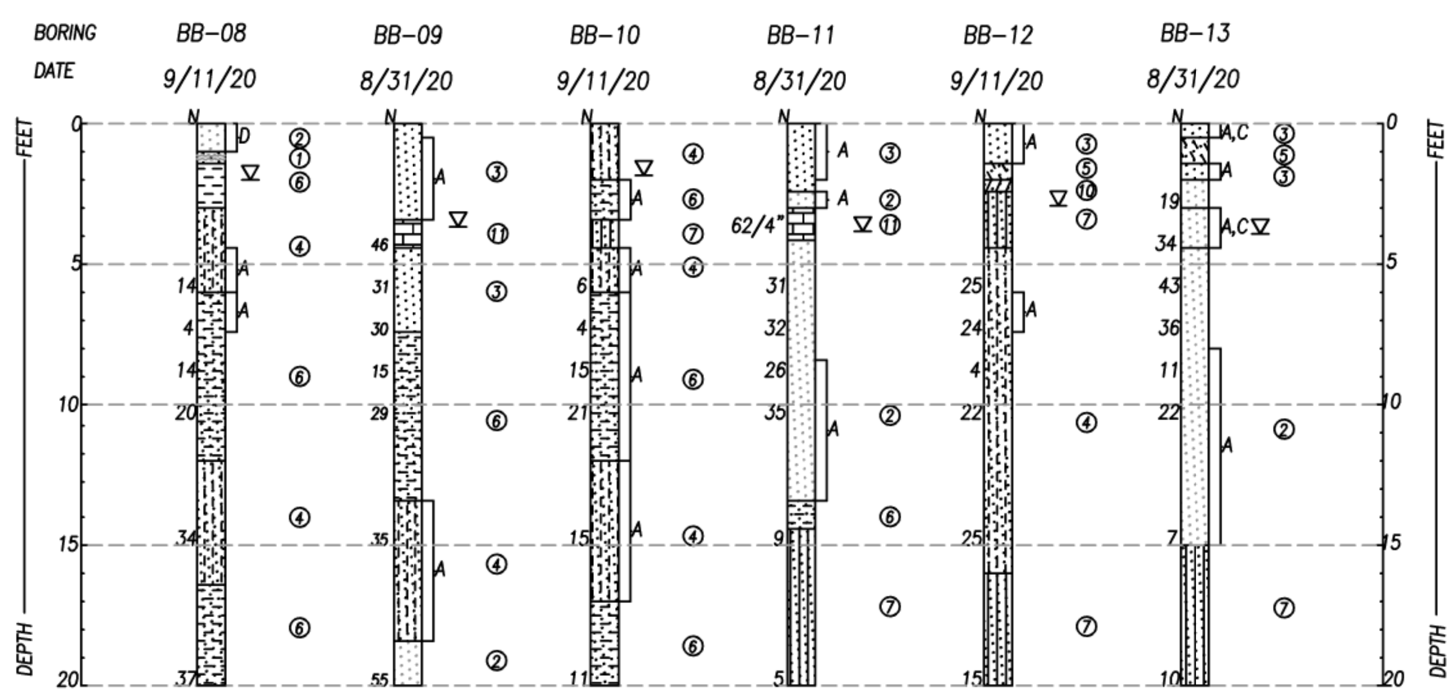

LEGEND

- ① Gray Shelly Sand (SW)
- ② Light Gray to Dark Brown Fine Sand (SP)
- ③ Pale Brown to Dark Brown Fine Sand (SP)
- ④ Light Gray to Dark Gray Fine Sand with Silt (SP-SM)
- ⑤ Brown to Dark Brown Fine Sand with Silt (SP-SM)
- ⑥ Light Gray to Gray Silty Fine Sand (SM)
- ⑦ Brown to Dark Brown Silty Fine Sand (SM)
- ⑧ Brown Organic Silty Fine Sand (Mucky Sand)
- ⑨ Gray Sandy Silt (ML) and Rock
- ⑩ Dark Brown Silt (ML)
- ⑪ Limerock

- A WITH SHELL
- B WITH CONCRETE DEBRIS/BRICK DEBRIS
- D WITH ROOTS
- E WITH LARGE STONES

- (SP) UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOL
- ∇ GROUNDWATER LEVEL MEASURED ON DATE DRILLED
- N SPT N-VALUE IN BLOWS PER FOOT

NOTE

AUTO HAMMER VALUES CONVERTED TO EQUIVALENT MANUAL HAMMER N-VALUES

SOIL BORING PROFILES

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BRADENTON BEACH GRAVITY SEWER
GULF DRIVE SOUTH
MANATEE COUNTY, FLORIDA

DRAWN BY: AUR	CHECKED BY: MEM	DATE: 10/1/20
FILE NO. 19-36-7257	APPROVED BY: MEM	FIGURE: 2