APPENDIX B:

GEOTECHNICAL REPORT
Report of Geotechnical Exploration

Marco Shores Water and Sewer System Improvements
Collier Boulevard (SR 951)
Marco Island/ Isle of Capri, Collier County, Florida

May 25, 2017
GFA Project No.: 15-2559

For: AECOM
May 25, 2017

Mr. Ronald R. Cavalieri, P.E., BCEE
AECOM
4415 Metro Parkway, Suite 404
Fort Myers, FL 33916
Phone: (239) 278-7996
Cell: (239) 278-0913
Email: Ronald.Cavalieri@AECOM.com

Site: Geotechnical Engineering Services Report
Marco Shores Water & Sewer System Improvements
Collier Boulevard (SR 951)
Marco Island/ Isle of Capri, Collier County, Florida
GFA Project # 15-2559.00

Dear Mr. Cavalieri:

GFA International, Inc. (GFA) has completed the subsurface exploration and geotechnical engineering evaluation for the above-referenced project in accordance with the geotechnical and engineering service agreement for this project. The scope of services was completed in accordance with our Geotechnical Engineering Proposal (15-2559.00), planned in conjunction with and authorized by you.

EXECUTIVE SUMMARY

The purpose of our subsurface exploration was to classify the nature of the subsurface soils and general geomorphic conditions and evaluate their impact upon the proposed construction. This report contains the results of our subsurface exploration at the site and our engineering interpretations of these, with respect to the project characteristics described to us including providing recommendations for site preparation.

GFA understands the project will consist of the new construction of a potable water main and wastewater force main alignment as well as the new construction of a master pump station. The goal of the Marco Shores Alternative Water and Sewer Improvement is to install the infrastructure needed to service residents in the Marco Shores community and residents in the Isles of Capri. The work includes the following major items:

- Construction of a new 16 inch (inside diameter) potable water main from Collier Boulevard at North Barfield Drive to the north landing of the S.S. Jolley Bridge and connected to the existing 16-inch water main (dry-line) that is currently not in use. The new potable water main will be installed via open cut, jack and bore and horizontal directional drilling. The new potable water main will cross Marco Pass via Horizontal Directional Drill at a maximum depth of +/- 80 ft. below sea level. The existing 16-inch water main (dry-line) extends from the north landing of the Jolley Bridge to Mainsail Drive and would be placed into service as part of this project after pressure testing, pigging, and leakage testing. New sampling point locations and fire hydrants will be installed on the new and existing water mains in the project area to serve Marco Shores.
Marco Shores Water & Sewer System Improvements
Geotechnical Report
Collier Blvd (SR 951), Marco Island/Isle of Capri, Collier County, Florida
May 25, 2017
GFA Project No. 15-2559
Page 2 of 15

- Construction of a new wastewater MPS at the site of the City’s old raw water booster station (located approximately 700 feet to the north of the existing Isles of Capri MPS). Improvements will include:
  - New paving, grading, drainage, pump station utilities and landscaping improvements, including all ancillary improvements.
  - Three new electric pumps in concrete wet well, discharge piping with valves, pipe supports, including all electrical, control, and other appurtenances.

- Construction of a new 12 inch (inside diameter) wastewater force main from the new MPS to a point of connection to the Marco Island wastewater conveyance system located at the intersection of East Elkcam Circle and Collier Boulevard. The new force main will be installed along Collier Boulevard, Fairlawn Court, Waikiki Court, Sixth Avenue and East Elkcam Circle via open cut, jack and bore, and horizontal directional drilling. The wastewater force main will cross Marco Pass via Horizontal Directional Drill at a maximum depth of +/- 60 ft. below sea level.

- Demolition and decommissioning of the existing Irrigation Quality (IQ) ground storage tank/high service pump station and Marco Shores WWTP, including removal of underground pipe and structures. The facilities are located on two adjacent parcels owned by the City of Marco Island.

- Construction of a new 10 inch (inside diameter) wastewater force main between the existing Isles of Capri MPS and the new MPS via horizontal directional drilling and open cut.

- Demolition and decommissioning of the existing Isles of Capri MPS.

Design documents provided were a 30% Design Submittal (47 pages, dated February 2017). Boring locations were provided and based on current design plans. The recommendations provided herein are based upon the above considerations. If the project description has been revised, please inform GFA International so that we may review our recommendations with respect to any modifications.

The following was completed by GFA for this study:

- Four (4) Standard Penetration Test (SPT) borings to a depth of approximately 25 feet below ground surface (BGS) were completed for the general utility alignment.

- One (1) Standard Penetration Test (SPT) borings to a depth of approximately 20 feet below ground surface (BGS) were completed for the general utility alignment.

- Five (5) Standard Penetration Test (SPT) borings to a depth of approximately 15 feet below ground surface (BGS) were completed for the general utility alignment.

- One (1) Standard Penetration Test (SPT) borings to a depth of approximately 28 feet below ground surface (BGS) were completed for the proposed master pump station.

- One (1) Standard Penetration Test (SPT) boring to a depth of approximately 85 feet below ground surface (BGS) was completed at the base of the north side of the Jolly Bridge for the general utility alignment.
The subsurface soil conditions encountered at this site generally consists of very loose to very dense sand (SP; A-3), well graded sand (SW; A-1-b), sand with silt (SP-SM; A-3/ A-2-4), silty sand (SM; A-2-4), peat (PT; A-8), weathered limestone (WLS), and very soft to medium hard limestone (LS) to the boring termination depths. Please refer to "Appendix B – Record of Soil Borings" for a detailed account of each boring.

The following report presents an overview of the project, our observation of the existing site conditions, the subsurface geotechnical information obtained during this exploration and our recommendations on the suitability of the soils encountered for the water and sewer system improvements project. Also included with this report are the results of our field and laboratory testing. The assessment of site environmental conditions for the presence of pollutants in the soil, rock, and groundwater at this site was not included as a part of our services.

We appreciate the opportunity to be of service to you on this project and look forward to a continued association. Please do not hesitate to contact us if you have any questions or comments, or if we may further assist you as your plans proceed.

Respectfully Submitted,
GFA International, Inc.
Florida Certificate of Authorization Number 4930

[Signature]
Lee S. Khan, E.I.
Staff Engineer

Copies: 3, Addressee
1, CD-R
# TABLE OF CONTENTS

1.0 INTRODUCTION.................................................................................................................. 5  
  1.1 Scope of Services .............................................................................................................. 5  
  1.2 Project Description ......................................................................................................... 5  

2.0 OBSERVATIONS............................................................................................................... 6  
  2.1 Site Inspection ................................................................................................................. 6  
  2.2 Field Exploration ............................................................................................................. 7  
  2.3 Laboratory Analysis ....................................................................................................... 7  
    2.3.1 Organic Content ...................................................................................................... 8  
    2.3.2 Gradation Tests ...................................................................................................... 8  
  2.4 Geomorphic Conditions ................................................................................................. 9  
  2.5 Hydrogeological Conditions .......................................................................................... 9  

3.0 ENGINEERING EVALUATION AND RECOMMENDATIONS...................................... 10  
  3.1 General .......................................................................................................................... 10  
  3.2 General Utility Alignment .............................................................................................. 10  
    3.2.1 Site Preparation Procedures .................................................................................. 10  
    3.2.2 Pipe Bedding and Initial Backfill ......................................................................... 11  
    3.2.3 Open Cut (Trench Excavation) ........................................................................... 11  
    3.2.4 Horizontal Directional Drill ................................................................................. 12  
    3.2.5 Trench Backfill ...................................................................................................... 12  
    3.2.6 Jack and Bore Recommendations ....................................................................... 13  
  3.3 Master Pump Station ...................................................................................................... 14  

4.0 DEWATERING OF EXCAVATIONS.............................................................................. 15  

5.0 REPORT LIMITATIONS................................................................................................. 15  

6.0 BASIS FOR RECOMMENDATIONS............................................................................... 15  

Appendix A - Vicinity Map & Test Location Plans  
Appendix B - Record of Soil Borings  
Appendix C - Notes Related to Borings  
Appendix D - Discussion of Soil Groups  
Appendix E - Hydrologic Soils Map  
Appendix F - Roadway Soil Survey  
Appendix G - Gradation Test Results  
Appendix H - Organic Content Results  
Appendix I - Soil Parameters
1.0 INTRODUCTION

1.1 Scope of Services

The objective of our geotechnical services was to collect subsurface data for the subject project, summarize the test results, and discuss any apparent site conditions that may have geotechnical significance for construction. The following scope of service is provided within this report:

1. Prepare records of the soil boring logs depicting the subsurface soil conditions encountered during our field exploration.

2. Conduct a review of each soil sample obtained during our field exploration for classification and additional testing if necessary.

3. Analyze the existing soil conditions found during our exploration for the suitability of the soils encountered for the potable water main and wastewater force main alignment.

4. Provide recommendations with respect to backfill material for the potable water main and wastewater force main alignment.

5. Provide criteria and site preparation procedures to prepare the site for the proposed construction.

6. Provide recommendations for subaqueous crossings, jack and bore, and horizontal directional drill design based on project documents.

1.2 Project Description

GFA understands the project will consist of the new construction of a potable water main and wastewater force main alignment as well as the new construction of a master pump station. The goal of the Marco Shores Alternative Water and Sewer Improvement is to install the infrastructure needed to service residents in the Marco Shores community and residents in the Isles of Capri. The work includes the following major items:

- Construction of a new 16 inch (inside diameter) potable water main from Collier Boulevard at North Barfield Drive to the north landing of the S.S. Jolley Bridge and connected to the existing 16-inch water main (dry-line) that is currently not in use. The new potable water main will be installed via open cut, jack and bore and horizontal directional drilling. The new potable water main will cross Marco Pass via Horizontal Directional Drill at a maximum depth of +/- 80 ft. below sea level. The existing 16-inch water main (dry-line) extends from the north landing of the Jolley Bridge to Mainsail Drive and would be placed into service as part of this project after pressure testing, pigging, and leakage testing. New sampling point locations and fire hydrants will be installed on the new and existing water mains in the project area to serve Marco Shores.
Construction of a new wastewater MPS at the site of the City’s old raw water booster station (located approximately 700 feet to the north of the existing Isles of Capri MPS). Improvements will include:
  - New paving, grading, drainage, pump station utilities and landscaping improvements, including all ancillary improvements.
  - Three new electric pumps in concrete wet well, discharge piping with valves, pipe supports, including all electrical, control, and other appurtenances.

Construction of a new 12 inch (inside diameter) wastewater force main from the new MPS to a point of connection to the Marco Island wastewater conveyance system located at the intersection of East Elkcam Circle and Collier Boulevard. The new force main will be installed along Collier Boulevard, Fairlawn Court, Waikiki Court, Sixth Avenue and East Elkcam Circle via open cut, jack and bore, and horizontal directional drilling. The wastewater force main will cross Marco Pass via Horizontal Directional Drill at a maximum depth of +/- 60 ft. below sea level.

Demolition and decommissioning of the existing Irrigation Quality (IQ) ground storage tank/high service pump station and Marco Shores WWTP, including removal of underground pipe and structures. The facilities are located on two adjacent parcels owned by the City of Marco Island.

Construction of a new 10 inch (inside diameter) wastewater force main between the existing Isles of Capri MPS and the new MPS via horizontal directional drilling and open cut.

Demolition and decommissioning of the existing Isles of Capri MPS.

Design documents provided were a 30% Design Submittal (47 pages, dated February 2017). Boring locations were provided and based on current design plans. The recommendations provided herein are based upon the above considerations. If the project description has been revised, please inform GFA International so that we may review our recommendations with respect to any modifications.

2.0 OBSERVATIONS

2.1 Site Inspection

A site reconnaissance was conducted by members of our engineering staff prior to mobilization of drilling equipment and crews. The purpose of the site visit was to observe the existing site conditions in order to detect any factors that may impact our studies and recommendations.

Generally, the proposed construction site is located within the sloped grass southbound shoulder along Collier Boulevard as well as under the existing asphalt roadway. The original boring locations within the sloped grass shoulder were relocated due to accessibility with our drilling equipment and existing underground utility locates. No standing water on the surface was observed during the time of our drilling. The tested site consists of an urban area and is landscaped.
2.2 Field Exploration

The following was completed by GFA for this study:

- Four (4) Standard Penetration Test (SPT) borings to a depth of approximately 25 feet below ground surface (BGS) were completed for the general utility alignment.

- One (1) Standard Penetration Test (SPT) boring to a depth of approximately 20 feet below ground surface (BGS) were completed for the general utility alignment.

- Five (5) Standard Penetration Test (SPT) borings to a depth of approximately 15 feet below ground surface (BGS) were completed for the general utility alignment.

- One (1) Standard Penetration Test (SPT) boring to a depth of approximately 28 feet below ground surface (BGS) were completed for the proposed master pump station.

- One (1) Standard Penetration Test (SPT) boring to a depth of approximately 85 feet below ground surface (BGS) was completed at the base of the north side of the Jolly Bridge for the general utility alignment.

The locations of the borings performed are illustrated in “Appendix A: Vicinity Map and Test Location Plans”. The Standard Penetration Test (SPT) boring method was used as the investigative tool within the borings. SPT tests were performed in substantial accordance with ASTM Procedure D-1586, “Penetration Test and Split-Barrel Sampling of Soils”. This test procedure consists of driving a 1.4-inch I.D. split-tube sampler into the soil profile using a 140-pound hammer falling 30 inches. The number of blows per foot, for the second and third 6-inch increment, is an indication of soil strength.

The soil samples recovered from the soil borings were visually classified and their stratification is illustrated in “Appendix B: Record of Soil Borings”. It should be noted that soil conditions might vary between the strata interfaces, which are shown. The soil boring data reflect information from a specific test location only. Site specific survey staking for the test locations was not provided for our field exploration. The indicated depth and location of each test was approximated based upon existing grade and estimated distances and relationships to obvious landmarks. The boring depths were selected based on our knowledge of vicinity soils and to include the zone of soil likely to be stressed by the proposed construction.

2.3 Laboratory Analysis

Soil samples recovered from GFA’s field explorations were visually examined in general accordance with ASTM D-2488. Samples were evaluated to obtain an accurate understanding of the soil properties and site geomorphic conditions. After a thorough visual examination of the recovered site soils, laboratory testing was conducted to determine organic content and particle size distribution on selected samples.

All laboratory tests were conducted in general accordance with ASTM or Florida Methods, as applicable. The test method method number for each test and the number of tests completed are presented in the following table.
Bag samples of the soil encountered during our field exploration will be held in our laboratory for your inspection for 90 days and then discarded unless we are notified otherwise in writing.

2.3.1 Organic Content

A total of three (3) organic content tests were performed on samples obtained during GFA’s field exploration program. The tested samples contained the most organic content based on the visual-manual procedure for description of soils. The table below shows the results:

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (Feet BGS)</th>
<th>Organic Content (%)</th>
<th>Soil Description</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-5</td>
<td>13 – 15</td>
<td>3.4</td>
<td>Black Silty Sand with Traces of Organics</td>
<td>SM (Organics)</td>
</tr>
<tr>
<td>B-6</td>
<td>6 – 8</td>
<td>5.9</td>
<td>Black Peat with Some Silty Sand</td>
<td>PT</td>
</tr>
<tr>
<td>B-8</td>
<td>8 – 10</td>
<td>21.9</td>
<td>Black Peat</td>
<td>PT</td>
</tr>
</tbody>
</table>

Refer to “Appendix H: Organic Content Results” for testing procedures and complete results. Where organic soils are encountered during construction, they shall be removed and replaced to a required level (the future project specification) with a compacted suitable fill. The suitable fill material shall contain less than 12 percent of fines passing the No. 200 sieve, not contain clay balls and rock fragments greater than 3 inches in diameter.

Based on the laboratory test results the majority of the near surface soils consist of poorly graded clean sands to slightly silty sands. Compressible peat, encountered in Borings B-6 (6-7 ft. & 9-14 ft.) and B-8 (7-13 ft.) does not meet the specification for the FDOT Design Indices 500/505 and cannot be used for pipe bedding and initial backfill or backfill.

2.3.2 Gradation Tests

A total of six (6) gradation tests were performed on samples obtained during GFA’s field exploration program. Material passing the No. 200 sieve is considered “fines” and will be either silt or clay. The percent passing the No. 200 sieve, for the tested samples, ranged from 2.6 to 32.9 percent and resulted in the sampled material to be considered poorly graded. A summary of the gradation test results are presented in “Appendix G: Gradation Test Results”.

Table 1: Marco Shores Water & Sewer System Improvements Laboratory Tests

<table>
<thead>
<tr>
<th>TEST DESCRIPTION</th>
<th>NUMBER OF TESTS</th>
<th>ASTM TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Classification</td>
<td>82</td>
<td>D-2488</td>
</tr>
<tr>
<td>Organic Content</td>
<td>3</td>
<td>D-2974</td>
</tr>
<tr>
<td>Gradation Analysis</td>
<td>6</td>
<td>D-6913</td>
</tr>
</tbody>
</table>
2.4 Geomorphic Conditions

Boring logs derived from our field exploration are presented in “Appendix B: Record of Soil Borings”. The boring logs depict the observed soils in graphic detail. The Standard Penetration Test borings indicate the penetration resistance, or N-values, logged during the drilling and sampling activities. The classifications and descriptions shown on the logs are generally based upon visual characterizations of the recovered soil samples. All soil samples reviewed have been depicted and classified in general accordance with the Unified Soil Classification System, modified as necessary to describe typical southwest Florida conditions. See “Appendix D: Discussion of Soil Groups”, for a detailed description of various soil groups.

The subsurface soils have been grouped into 7 strata. Refer to “Appendix B: Record of Soil Borings” for soil description and depths at which they are encountered.

Based on the subsurface soils profiles obtained from the soil borings, the near surface soils mostly consist of clean to slightly silty sands and silty sands (strata 1, 4, and 5) with scattered zones containing a trace to some shell fragments. These sands extend to the boring termination depths.

In borings B-1, B-3, and B-4, at intermediate depths ranging from 6 to 18 feet below existing grade (stratum 5), silty sands were encountered with 23.8% to 32.9% silt content.

Organic soils, peat (PT), was encountered in borings B-6 and B-8, at intermediate depths ranging from 6 to 13 feet below existing grade (stratum 6). The test sample, collected from the peat layer, contained a range from 5.9% to 21.9% of organic matter. Stratum 4 in boring B-5 consists of “muck” deposit with organic content of 3.4%.

The subsurface soil conditions encountered at this site generally consists of very loose to very dense sand (SP; A-3), well graded sand (SW; A-1-b), sand with silt (SP-SM; A-3/ A-2-4), silty sand (SM; A-2-4), peat (PT; A-8), weathered limestone (WLS), and very soft to medium hard limestone (LS) to the boring termination depths. Please refer to “Appendix B – Record of Soil Borings” for a detailed account of each boring.

2.5 Hydrogeological Conditions

On the dates of our field exploration, the groundwater table was encountered at depths approximately 3.75 to 9 feet below the existing ground surface. The groundwater table will fluctuate depending upon seasonal conditions.

Located in “Appendix E: Hydrologic Soils Map” is the following descriptive characteristics of the type of soils encountered during the drilling operations based on the soil survey of Collier County, Florida, published by the United States Department of Agriculture:

Urban Land-Aquents Complex, Organic Substratum (35): This map unit consists of Urban land and soil materials that have been dug from different areas in the county and have been spread over the muck soils for coastal urban development. The depth of fill material used in construction of urban areas ranges from 30 to 80 inches. The depth of the water table varies depending upon the amount of fill material and the extent of artificial drainage in mapped area.
Durbin and Wulfert Mucks, Frequently Flooded (40): These level, very poorly drained soils are in tidal mangrove swamps. The permeability in the Durbin soil is rapid and the available water capacity is high. The permeability in the Wulfert soil is rapid, and the available water capacity is moderate. The water table fluctuates with the tide. It is within a depth of 12 inches for most of the year. The soil is subject to tidal flooding.

3.0 ENGINEERING EVALUATION AND RECOMMENDATIONS

3.1 General

The geotechnical evaluations for the proposed construction site are based on the subsurface soil and groundwater conditions encountered during this study, the project information made available, our site observations, and our experience in the vicinity. The test data has been evaluated using established geotechnical parameters of the soils recorded at this site, laboratory test results, and the observed performance of similar soil types. Because of the large study area, only broad generalities may be stated about subsurface conditions.

3.2 General Utility Alignment

3.2.1 Site Preparation Procedures

Based on the soil conditions encountered in the performed borings, the near surface soils meet the below mentioned Florida Department of Transportation (FDOT) Standard Specifications for Road and Bridge Construction – Section 120 and 125 (January 2017). Due to the compressible peat encountered in borings B-6 (6-7 ft. and 9-14 ft.) and B-8 (7-13 ft.), material use should be completed with accordance with FDOT index Nos. 500 and 505 and cannot be used for pipe bedding, initial backfill, and fill. The project may be designed according to the recommendations and site preparations as discussed below with a fill material meeting the specifications. At borings B-6 and B-8, GFA recommends additional soil borings be performed on 25-foot centers, per FDOT standards, prior to construction to delineate the extent and overall impact the organic material may have on construction activities.

Site preparation procedures should begin with the removal of existing debris, vegetation, or other unsuitable materials within and beyond the excavation construction.

Where organic soils are encountered during construction, they shall be removed and replaced to a required level (the future project specification) with a compacted suitable fill. The suitable fill material shall contain less than 12 percent of fines passing the No. 200 sieve, not contain clay balls and rock fragments greater than 3 inches in diameter.

An adequate dewatering system shall be installed to maintain the water table 2 feet or more below the maximum depth of excavation. The continuous dewatering shall be provided until the pipeline is completed and backfill is above the water table. When a professional engineer approves the discontinuing of the dewatering, the rate of pumping shall slowly decrease, allowing the water level to rise slowly.
The soils that extend below the water table should be allowed to dry prior to placement as a backfill material and compaction. This can be accomplished by stockpiling the material and allowing it to drain, or by spreading it in relatively thin lifts on the surface and allowing it to dry prior to compaction. The silty or sands with clay may require moisture conditioning so that the soil moisture content at the time of compaction is at or near the optimum moisture content.

Trench bottoms should be compacted with a small roller or vibratory plate compactor prior to pipe placement. Any loose or soft yielding areas detected during compaction of the trench bottoms should either be further compacted to at least 95% of maximum dry density or removed and replaced with a select fill and compacted to 95% of maximum dry density. Bedding stone may be used.

During the compaction operation, a geotechnical engineer or a supervised engineering technician should observe the soils to verify that the exposed soils are suitable and that unsuitable soils have been removed. Samples of the backfill materials should be obtained to determine the grain size distribution, its maximum dry density and optimum moisture content in the laboratory in accordance with ASTM D-1557 (Modified Proctor Test).

3.2.2 Pipe Bedding and Initial Backfill

According to the FDOT Standard Specification for Road and Bridge Construction – Section 125 (January 2017) Backfilling, a fill material shall be used for pipe bedding and initial backfill from top of bedding to 1 foot over the top of pipes. The fill shall be compacted to not less than 95 percent of the maximum dry density as determined by ASTM D-1557.

The fill material placed for pipe bedding should be inorganic (classified as SP, SW, GP, GW, SP-SM, SW-SM, GW-GM, GP-GM) containing not more than 5 percent (by weight) organic materials. Fill materials with silt and clay soil fines in excess of 15% should follow FDOT Standard Specification for Road and Bridge Construction – Section 120 (January 2017). Fill should be placed in lifts with a maximum lift thickness not exceeding 12-inches. Each lift should be compacted and tested prior to the placement of the next lift. Density tests should be performed within the fill at a frequency of not less than one test per 500 linear feet or a single run of pipe connecting two successive structures, whichever is less.

Pipe bedding containing very fine sand, uniformly graded sands and gravel, silt, soft earth, or other material that have a tendency to flow under pressure when wet is unacceptable.

Based on the laboratory test results the majority of the near surface soils consist of poorly graded clean sands to slightly silty sands. Compressible peat, if encountered, does not meet the specification for the FDOT Design Indices 500/505 and cannot be used for pipe bedding and initial backfill or backfill.

3.2.3 Open Cut (Trench Excavation)

All excavations shall be made by open cut unless otherwise indicated in the specifications on the drawings. All trenches shall have bottoms below the organic soils (when encountered) and shall be sufficiently wide and deep to allow proper installation of pipes. If organics extend below the depth of the proposed excavations, the organic material shall be removed and replaced with clean fill. We recommend about 12 inches clear of the pipe on either side at any point. Boulders, rocks, or other hard unyielding material shall be excavated to a depth of 12 inches below the bottom of the pipe elevation.
All trench excavations with side walls greater than 5 feet in depth shall be sloped or shored to protect workers. Material suitable for backfilling, clean to silty sand, shall be stockpiled far enough from the trench edge to avoid overloading slides or cave-ins. We recommend that distance shall be greater or equal to a depth of the trench.

Sloping is accomplished by cutting the banks of the excavation back to the angle of repose. The angle of repose for “in-situ” fine sands and sands with silt will be about 26 to 30 degrees, respectively. Normally, this angle would be not less than 1.5 feet on the horizontal to each foot on the vertical. When the excavation will be performed in the area not large enough to slope to the angle of repose, shoring must be erected to prevent cave-in. Due to the depth of excavations and the depth of the water table, we anticipate the excavation will require shoring or a trench box. Trenching should be in general accordance with any FDOT trenching requirements and the Occupational Safety and Health Administration (OSHA) requirements, as applicable.

3.2.4 Horizontal Direction Drill

GFA understands that directional boring method shall be used beneath the Marco channel and other specified area to limit disturbance.

The directional boring method comprises a three stage process. In the first stage, a pilot hole is drilled on the designed path. The pilot hole is enlarged in the second stage by passing a cutting tool known as the back reamer. In the third stage the pipe or casing pipe is placed in the enlarged hole. A starting pit with a drilling fluid in the pit is required to start the pilot hole. The drilling fluid is continuously pumped to the cutting head to facilitate the drilling, cutting, and to stabilize the bore hole.

3.2.5 Trench Backfill

Trench backfill material shall be clean earth fill composed of sand, sand and stone, crushed stones or other soils approved by a professional engineer. The trench backfilling shall be accomplished from the top of the initial backfill to the ground surface. The backfill, unless otherwise specified, shall be compacted to 95% of maximum density, as determined by ASTM D-1557.

When trenches are cut in pavements or areas to be paved, compaction shall be equal to 98% of maximum density. In unpaved portions of the Right-of-Way areas, compaction shall be not less than 95% of maximum density.

Based on the soil profiles, presented in “Appendix B: Record of Soil Borings”, the material from on-site excavation that will contain sands and silt or gravel size limestone fragments may be used for the trench backfill. If organic soils are encountered during construction, they are not suitable and shall not be used as a trench backfill material.
3.2.6 Jack and Bore Recommendations

A temporary wall may be utilized for the jack and bore construction at Station 56+75. If utilized, this wall may be designed as a cantilever sheet pile wall. The stability of the cantilever sheet pile wall is generally based on the simplification of the earth pressure acting on the wall. Since lateral displacement of the wall produces a state of minimum active earth pressure, the wall stability is subjected entirely to the active pressure behind the wall (that is lower than earth pressure at rest) and passive resistance developed at the bottom of the wall. For design purpose, the recommended values of geotechnical parameters for “in-situ” soils are provided in Table 3 below:

Table 3: Temporary Wall Soil Parameters (Sta. 56+75)

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Soil (AASHTO)</th>
<th>Depth (feet)</th>
<th>Unit Weight (moist) (pcf)</th>
<th>Angle of Internal Friction (°)</th>
<th>Cohesion Cu (psf)</th>
<th>Coefficient of Earth Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Active</td>
</tr>
<tr>
<td>B-3</td>
<td>A-3 (SP)</td>
<td>0 – 6</td>
<td>115</td>
<td>32</td>
<td>-</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>A-2-4 (SM)</td>
<td>6 – 13</td>
<td>110</td>
<td>30</td>
<td>-</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>A-3 (SP)</td>
<td>13 - 25</td>
<td>115</td>
<td>32</td>
<td>-</td>
<td>0.31</td>
</tr>
</tbody>
</table>

If the entry and receiving pit will be required, the vertical walls shall be supported to avoid lateral displacement of the surrounding soils. This requires some kind of retaining structure constructed as sheet piling. Sheet piling constructed as Z piles is commonly used for retaining excavations because it has the highest strength/weight ratio, is reusable, and can generally be easily installed either with sheet pile hammers or with vibratory driving devices. The sheet pile wall will be used for temporary support and it may be designed as a cantilever sheet pile wall.

The stability of a cantilever sheet pile wall is generally based on the simplification of earth pressure acting on the wall. Since a lateral displacement of the wall produces a state of minimum active earth pressure, the wall stability is subjected entirely to active pressure behind the wall (that is lower than earth pressure at rest) and passive resistance developed below the bottom. The sheet pile walls need to be driven to depths sufficient to resist the lateral earth pressure and water pressure imposed by the differential water depths.

The sheet pile walls should be driven deep enough to reduce the upward seepage forces. A bottom failure may occur because of piping or “quick” conditions if the hydraulic gradient acting on the bottom is higher than the vertical hydraulic gradient.

The earth coefficients presented in “Appendix I: Soil Parameters” may be used for sheet pile wall design and assume the sheet pile walls would be backfilled with clean granular soils. Where the potential exists for buildup of hydrostatic pressure due to the water table, hydrostatic pressure should be assumed and added to the earth pressure for design, unless drainage is provided behind the sheet pile wall.
### 3.3 Master Pump Station

The subsurface soil conditions at the project site are generally favorable for the support of the proposed wet well and valve vault structures with a net allowable bearing capacity of 2,000 psf and 2,500 psf, respectfully. GFA understands the floor of the wet well and valve vault for the master pump station is at el. -13.80 and 2.20 (NGVD 29), respectively.

Based on the encountered water table depth at the time of our exploration and the published Soil Survey of Collier County, GFA recommends using a seasonal high water table of 2.5 feet below existing grade for design of the master pump station. GFA also recommends that structures are designed as “floating” and therefore settlement would be negligible due to the structure likely weighing less than replaced soil.

Due to the depths associated with the proposed construction, dewatering may be required to complete the work in the dry. The high groundwater tables in the vicinity of excavations shall be reduced to prevent water inflow into excavations. Each excavation shall be kept dry during subgrade preparation and continually thereafter until installation of the pipe, wet well, or valve vault structures. The dewatering will be required to maintain groundwater elevation at least 24 inches below the bottom of the excavation at all times to prevent bottom disturbance or failure.

Excavation of the underlying soils and placement of #57 stone in lieu of soil densities may be required for stabilization of the bottom of the excavation. The over excavation should extend to a minimum of 12 inches below the bottom of bearing surface. The #57 stone should be placed in lifts with maximum lift thicknesses of 12 inches. Each lift of stone should be tamped using the bucket of a backhoe. Foundations can then be poured directly upon the stone surface. The installation of a geo-fabric will be required below the stone to prevent the stone from raveling down into the underlying soils.

An alternative to #57 stone placement at the bottom of the excavation is utilizing a concrete mud slab. If a mud slab is utilized we recommend a minimum 3000 psi concrete and a minimum 4 inch thick slab.

The soil parameters listed in the table below are for design purposes of the master pump station:

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth BGS (ft.)</th>
<th>Unit Weight (moist) (pcf)</th>
<th>Friction Coefficient ($f_o$)</th>
<th>Angle of Internal Friction ($\phi$)</th>
<th>Lateral Earth Pressure ($K_o$)</th>
<th>Active Lateral Pressure ($K_a$)</th>
<th>Passive Lateral Pressure ($K_p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B - 12</td>
<td>0 – 6</td>
<td>120</td>
<td>0.50</td>
<td>38</td>
<td>0.38</td>
<td>0.24</td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>6 – 13</td>
<td>110</td>
<td>0.45</td>
<td>32</td>
<td>0.47</td>
<td>0.31</td>
<td>3.25</td>
</tr>
<tr>
<td></td>
<td>13 – 18</td>
<td>90</td>
<td>0.40</td>
<td>29</td>
<td>0.52</td>
<td>0.35</td>
<td>2.88</td>
</tr>
<tr>
<td></td>
<td>18 – 28</td>
<td>110</td>
<td>0.45</td>
<td>32</td>
<td>0.47</td>
<td>0.31</td>
<td>3.25</td>
</tr>
<tr>
<td>Subgrade Modulus (Below Water Table)</td>
<td>6 – 13 ft. BGS:</td>
<td>25 pci</td>
<td>13 – 28 ft. BGS:</td>
<td>50 pci</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Master Pump Station Soil Parameters
4.0 DEWATERING OF EXCAVATIONS

The high groundwater tables in the vicinity of excavations shall be reduced to prevent water inflow into excavations. Each excavation shall be kept dry during subgrade preparation and continually thereafter until installation of the pipe. The dewatering will be required to maintain groundwater elevation at least 24 inches below the bottom at all times to prevent bottom disturbance or failure.

5.0 REPORT LIMITATIONS

This consulting report has been prepared for the exclusive use of the current project owners and other members of the design team for the Marco Shoes Water and Sewer System Improvements located in Marco Island/Isle of Capri, Collier County, Florida. This report has been prepared in accordance with generally accepted local geotechnical engineering practices; no other warranty is expressed or implied. The evaluation submitted in this report, is based in part upon the data collected during a field exploration, however, the nature and extent of variations throughout the subsurface profile may not become evident until the time of construction. If variations then appear evident, it may be necessary to reevaluate information and professional opinions as provided in this report.

In the event changes are made in the nature, design, or locations of the proposed structure, the evaluation and opinions contained in this report shall not be considered valid, unless the changes are reviewed and conclusions modified or verified in writing by GFA International. GFA is not responsible for damage caused by soil improvement and/or construction activity vibrations related to this project. GFA is also not responsible for damage concerning drainage or moisture related issues for the proposed or nearby structures.

6.0 BASIS FOR RECOMMENDATIONS

The analysis and recommendations submitted in this report are based on the data obtained from the tests performed at the locations indicated on the attached figure in “Appendix A: Vicinity Map and Test Location Plan”. This report does not reflect any variations, which may occur between borings. While the borings are representative of the subsurface conditions at their respective locations and for their vertical reaches, local variations characteristic of the subsurface soils of the region are anticipated and may be encountered. The delineation between soil types shown on the soil logs is approximate and the description represents our interpretation of the subsurface conditions at the designated boring locations on the particular date drilled.

Any third party reliance of our geotechnical report or parts thereof is strictly prohibited without the expressed written consent of GFA International. The methodology (ASTM D-1586) used in performing our borings and for determining penetration resistance is specific to the sampling tools utilized and does not reflect the ease or difficulty to advance other tools or materials.
Appendix A - Vicinity Map & Test Location Plans
VICINITY MAP
Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL

*Scale is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

*Scale is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

*Scale is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL

*Scale is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL

*Scale is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN
Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL

*Saw is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL

*Scale is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL

*Scale is an approximation and may not be accurate.

SPT Soil Boring
TEST LOCATION PLAN

Marco Shores Water & Sewer System Improvements - Phase 1
Collier Boulevard (SR-951)
Marco Island, Collier County, Florida
GFA International Project No.: 15-2559

Site Location
Marco Island, FL

Scale is an approximation and may not be accurate.

SPT Soil Boring