SUBSURFACE SOIL EXPLORATION
ANALYSIS AND RECOMMENDATIONS
CITY OF NAPLES UTILITIES BUILDING
NAPLES, COLLIER COUNTY, FLORIDA

Ardaman & Associates, Inc.

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Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

September 26, 2008
Ardaman Project No. 08-4560

CITY OF NAPLES
City of Naples Public Works
380 Riverside Circle
Naples, FL 34102

Attention: Mr. David A. Graff

SUBJECT: Subsurface Soil Exploration
Analysis and Recommendations
City of Naples Utilities Bldg.
Naples, Collier County, Florida

Gentlemen:

As requested and authorized by the **City of Naples**, Ardaman & Associates has completed the subsurface soil exploration program for the subject project. The purposes of this program were to evaluate the general subsurface conditions at the site and provide recommendations for site preparation and foundation design.

This report documents our findings and conclusions. It has been prepared for the exclusive use of the **City of Naples** and their consultants for specific application to the subject project in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

SCOPE

The scope of our services was limited to the following items:

1. Conducting three (3) Standard Penetration Test borings to determine the nature and condition of the subsurface soils.

2. Reviewing each soil sample obtained in our field testing program by a geotechnical engineer in our laboratory for further identification and assignment of laboratory tests, if required.

3. Analyzing the existing soil conditions with respect to the proposed construction as it relates to foundation design.

4. Preparing this report to document the results of our field exploration, engineering analysis and foundation design recommendations.

SITE LOCATION

The proposed structure will be developed on the current parking area on the eastern part of the property located at 280 Riverside Circle, in Naples, Collier County, Florida. The site was open and accessible to our truck-mounted drilling equipment.

FIELD EXPLORATION PROGRAM

Our field exploration consisted of performing three Standard Penetration Test (SPT) borings. The SPT borings were drilled to maximum depths of about 20 feet below the existing ground surface. The SPT borings were conducted using methods consistent with ASTM D-1586. The equipment and procedures used in the SPT borings are described in detail in the **Appendix**.

The locations of the borings are shown on the attached **Boring Location Plan**. The test locations were located in the field by reference to an aerial photo obtained from the flashearth.com website. Therefore, the locations indicated should be considered accurate only to the degree implied by the method of measurement used. If a more precise location of the borings is desired, then we recommend that a registered land surveyor be employed to locate the borings on site.

GENERAL SUBSURFACE CONDITIONS

The general subsurface conditions encountered during the field exploration are shown on the attached soil boring logs. Soil stratification is based on examination of recovered soil samples and interpretation of the field boring logs. The stratification lines represent the approximate boundaries between the soil types; the actual transitions may be gradual.

In general, the test borings encountered loose sandy peat (PT) layered with fine sands (SP/PT), slightly silty fine sand and slightly silty fine sand with organic fines (SP-SM), clayey sand (SC), silty sand with organic fines and organic silty sand (SM) and sandy lean clay (CL) to depths of about 7.5 to 14 feet below the existing ground surface. Underlying these surficial strata with organic fines, the test borings encountered medium dense to dense slightly silty sand and slightly silty sand with gravel (SP-SM), silty sand and silty sand with gravel (limestone and shell) (SM), clayey sand with gravel (limestone) (SC) and silty clayey sand with gravel (limestone and shell) (SC-SM) to the terminal depths of the exploration, or about 20 feet. Hard bedded limestone was encountered in two borings at depths ranging from 14 to 18 feet below ground surface.

The depth at which groundwater was encountered in the boreholes was measured at 3 to 3.5 feet below the existing ground surface at the time of our field exploration (09/26/07). The groundwater depth shown on the boring log represents the groundwater surface encountered on the date shown. Fluctuations in groundwater level should be anticipated throughout the year due to seasonal variations in rainfall, and other factors.

LABORATORY TESTING PROGRAM

Representative soil samples obtained during our field sampling operation were packaged and transferred to our office and, thereafter, examined by a geotechnical engineer to obtain more accurate descriptions of the existing soil strata. Laboratory testing was performed on selected samples as deemed necessary to aid in soil classification and to further define the engineering properties of the soils. The laboratory tests consisted of Natural Moisture Content and Organic Content tests. The test results are presented on the attached soil boring logs at the depths from which the samples were recovered. The soil descriptions shown on the logs are based upon visual-manual procedures in accordance with local practice. Soil classification is in general accordance with the Unified Soil Classification System (ASTM D-2487) and is also based on visual-manual procedures.

PROPOSED CONSTRUCTION

We understand the proposed construction will include metal framed structure approximately 111 by 60 feet in plan area with exterior walls of Structural Masonry block. Anticipated wall and column loads are 3 klf and 75 kips, respectively. Limited fill soils are anticipated beneath the building footprint. The recommendations contained in this report will not necessarily apply if loading conditions are in excess of the loading conditions provided.

ANALYSIS AND RECOMMENDATIONS

Due to the presence of weak, organic, compressible strata within the top 7.5 to 14 feet below ground surface, a shallow foundation system with only surface compaction is not recommended for this site. The material as encountered in the borings will not adequately support structural elements, or significant soil supported improvements without intolerable differential settlement. Therefore, our analysis considered a deep foundation system as the most appropriate foundation solution. A deep pile foundation system is necessary to transfer foundation loads to the layer of rock or to denser soils encountered from depths of about 15 feet below ground surface.

Driven prestressed, precast concrete piles and Augercast piles are appropriate for the proposed construction and site conditions. We have evaluated 12-inch square precast concrete piles driven to a depth of about 15 feet below ground surface, and 14-inch diameter pressure-grouted augered (Augercast) piles embedded to a depth of about 17 feet, as encountered at the time of our exploration.

Please note that typically grade supported elements such as the floor slab need to be pile supported to reduce the risk of intolerable differential settlement. Also, fill soils will cause consolidation of the organic stratum. Consider using paver bricks or similar materials that are more tolerant of settlement for use in sidewalks, driveways and other grade supported elements where it may be cost prohibitive to pile support. Isolate grade supported elements from pile supported structures.

The following are our recommendations for overall site preparation which we feel are best suited for the proposed structure and existing soil conditions. These recommendations are made as a guide for the design engineer and/or architect, parts of which should be incorporated into the project's general specifications.

OVERALL SITE PREPARATION:

1. The structure area "footprint" and paved parking and drive areas, plus a minimum margin of 5 feet, should be stripped and grubbed of all surface vegetation, debris or other deleterious material, including asphalt pavement, as encountered. These materials should be disposed of in areas designated by the Owner.

2. The cleared surfaces in construction areas should be proofrolled using the appropriate compaction equipment for site and soil conditions. Adjust the moisture content of the soil, as necessary, to aid compaction. Sufficient passes should be made to develop a minimum dry density of 95 percent of the Modified Proctor Maximum Dry Density (ASTM D-1557) to a depth of 12 inches below the compacted surface. Replace all material, if determined to be deleterious, in areas that "yield" during the proofrolling operation and replace with suitable fill material conforming to that stated in Item 4.

3. After satisfactory proofrolling of the cleared surface in accordance with the above, filling with suitable material may proceed, if necessary. Fill material should conform to that stated in Item 4 below. The fill should be placed in level lifts not exceeding 12 inches in uncompacted thickness. Each lift should be compacted by repeated passes with appropriate compaction equipment to achieve at least 95 percent of the Modified Proctor Maximum Dry Density (ASTM D-1557). The filling and compaction operations should continue until the desired elevation(s) is achieved.

4. Fill material should preferably consist of clean to slightly silty or slightly clayey fine sands, free of organic or other deleterious materials, with less than 12 percent passing the U.S. Sieve No. 200. The fill soils should be placed and compacted within +2% to -4% of the optimum moisture as defined by ASTM D-1557.

5. Ardaman & Associates, Inc. should be employed by the Owner to observe and test all prepared and compacted areas to document that all unsuitable soils are removed and that the natural foundation and fill soils are prepared and compacted in accordance with the above recommendations.

Driven Prestressed, Precast Concrete Piles Recommendations:

We recommend using a pile foundation to support the proposed structure, including the floor slabs. Our evaluation considered a 12-inch square driven prestressed, precast concrete pile installed to a depth of 15 feet below the existing ground surface or refusal on rock. This pile would have allowable pile capacities of 15 tons in compression and 4 tons in uplift. The lateral load of the pile would be 4 tons.

The allowable loads were determined by utilizing a factor of safety equal to at least 3 for compression, and a factor of safety of 3 for uplift and lateral. The allowable lateral load assumes a fixed headed condition with the lateral load resultant at the existing ground surface. Lateral deflection was limited to 0.25 inches.

An indicator pile program is recommended prior to ordering and installing the production piles. This program should consist of about 5 percent of the total number of piles for the project. We suggest that the indicator pile lengths be at least 5 feet longer than the estimated pile length listed above. The blow count criterion determined from the wave equation analysis will be used during this program for driven piles. The purposes of the indicator piles are to confirm the driving criteria, and to determine the production pile length.

The prestressed precast concrete piles should be driven with a pile driving hammer compatible with the type of pile being driven and the subsurface soil conditions. We recommend a minimum rated pile hammer energy of 8,000 ft.-lbs. A pile driving formula should be used to establish the pile driving criterion for the allowable pile load based on the pile driving hammer used. We recommended the wave equation analysis since this takes into account energy losses that occur during driving.

We estimate settlement of a single pile to be 0.5 inches of less, most of it due to elastic shortening of the pile. Piles should be spaced a minimum of three feet center to center.

A geotechnical engineer, or his representative, from Ardaman & Associates, Inc. should be present during the entire pile installation program to monitor the pile installation operation.

Pressure Grouted Augered Pile Recommendations:

We have evaluated a 14-inch diameter, pressure-grouted augered (Augercast) pile foundation system to support the foundation loads. Grout strength is required to be equal to or greater than 4,000 psi. Our evaluation considered a 14-inch diameter augured pile installed to a depth of 17 feet below the existing ground surface. This pile would have allowable pile capacities of 15 tons in compression and 1.5 tons in uplift. The lateral load of the pile would be 5.5 tons. The allowable loads were determined by utilizing a factor of safety equal to at least 2 for compression, and a factor of safety of 3 for uplift and lateral. The allowable lateral load assumes a fixed headed condition with the lateral load resultant at the existing ground surface. Lateral deflection was limited to 0.25 inches.

For the pressure-grouted augered piles, steel reinforcing will be necessary to transfer uplift and lateral loads to the pile. We recommend reinforcing with a single bar the full length of the pile. Reinforcing steel to resist bending is typically required in the top 15 to 20 feet of the pile.

We estimate settlement of a single pile to be 0.75 inches or less, most of it due to elastic shortening of the pile. Piles should be spaced a minimum of three pile diameters center to center.

The allowable pile compression loads should be confirmed by a test pile program for the design load condition. A verification pile should be tested in accordance with ASTM D-1143, "Piles Under Static Compression Load". The load test will be performed to twice the allowable load. The need for an uplift test (ASTM D-3689, "Individual Piles Under Static Axial Tension Load" will be dependent on whether a higher allowable uplift load (with a factor of safety of 2) is necessary.

While subsurface conditions are adequate to allow construction of pressure grouted auger piles, the test borings encountered compressible soil strata in the top 7.5 to 14 feet below ground surface. These conditions can be compensated for during installation; however, the risk of soil consolidation due to the weight of the grout column may cause a reduced pile cross-sectional area above the bulge. Therefore, pile integrity testing using a Pile Integrity Tester (P.I.T.) should be performed on a minimum of 25 percent of the production piles. Integrity testing with a P.I.T. is a simple operation performed by affixing an accelerometer to the pile top and then striking the pile top with a hand held hammer. The

hammer. The resulting reflected stress waves are measured and then investigated for pile discontinuities.

A geotechnical engineer, or his representative, from Ardaman & Associates, Inc. should be present during the entire pile test and installation program to monitor the pile installation operation.

GENERAL COMMENTS

The analysis and recommendations in this report are based on the data obtained from the three soil borings performed at the approximate location shown on the attached **Boring Location Plan**.

This report does not reflect any variations that may occur within the area of the proposed development. The nature and extent of variations may not become evident until during the course of construction. If variations then appear evident, it will be necessary for a reevaluation of the recommendations of this report to be made after performing on-site observations during the construction period and noting the characteristics of any variations.

When the final design and specifications are completed, we would like the opportunity to review them in order to determine whether changes in the original concept may have affected the validity of our recommendations and whether these recommendations have been implemented in the design and specifications.

If you have any questions about this report, please contact this office.

Very truly yours,

ARDAMAN & ASSOCIATES, INC.

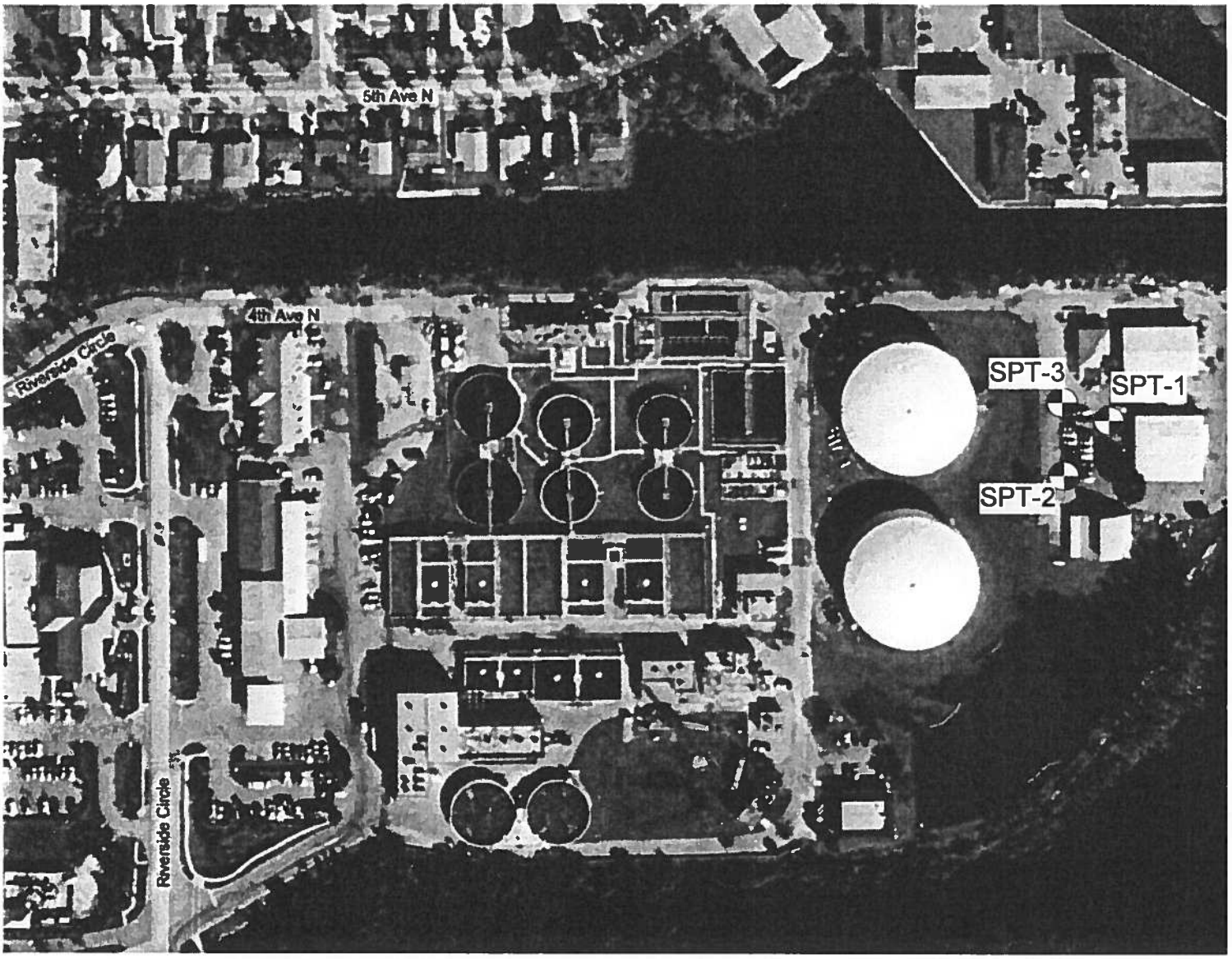
Jorge A. Rivas, E.I.
Project Engineer

Martin A. Call, P.E.
Senior Project Engineer

1 Copy – Astorino, Mr. Joseph Birdwell, Assoc. AIA

ATTACHMENTS

- **BORING LOCATION PLAN - FIGURE NO. 1**
- **BORING LOGS SPT-1, 2 & 3**



SOURCE: PARTIAL COPY OF AERIAL PHOTOGRAPH OBTAINED FROM FLASHEARTH.COM WEBSITE.
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BORING LOCATION PLAN

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

CITY OF NAPLES UTILITIES BLDG.
NAPLES, COLLIER COUNTY, FL

Drawn By: JAR	Checked By: MAC	Date: 09/08
File No. 08-4560	Approved By: Martin A. Call, P.E.	Figure No. 1

BORING LOCATION: See Boring Location Plan

STATION: **OFFSET:**

DATE DRILLED: 09-26-08 **START:** **FINISH:**

GROUND SURFACE ELEVATION:

WATER TABLE DEPTH (ft): 3.5 **TIME:** **DATE:** 09-26-08

CLIENT: CITY OF NAPLES PUBLIC WORKS

PROJECT: CITY OF NAPLES UTILITIES BUILDING

LOCATION: NAPLES, COLLIER COUNTY, FLORIDA

DRILL CREW: Lockley **LOGGED BY:** J Rivas

DRILL MAKE & MODEL: Mobile B-57 **BIT:** 3-7/8" diam. tricone roller **DRILLING RODS:** NW

DRILLING METHOD: Rotary wash with drilling fluid **WEATHER CONDITIONS:** Sunny

DEPTH, FT.	BLOWS PER SIX INCHES	SPT N-VALUE	SAMPLE NO.	GRAPHIC LOG	USCS	SOIL DESCRIPTION	REMARKS	% WATER CONTENT	PERCENT FINES	% ORGANIC CONTENT	LIQUID LIMIT	PLAST. INDEX
0	32-27-11	38	1			Asphalt and base course						
	8-6-4	10	2		SP-SM	Poorly Graded Sand with Silt- Brown slightly silty fine sand, some roots and wood debris						
3	3-3-3	6	3		PT	Sandy Peat- Dark brown sandy peat with layers of fine sand		86		13		
	3-2-2	4	4		SM	Silty Sand- Brown slightly organic silty fine sand						
6	2-1-1	2	5		PT	Sandy Peat- Dark brown sandy peat with layers of fine sand						
	1-0-3	3	6									
9	2-2-2	4	7		SM	Silty Sand- Dark grayish brown silty fine sand						
	1-5-6	11	8									
12	5-5-5	10	9		SP-SM	Poorly Graded Sand with Silt- Light brownish gray slightly silty fine sand, trace gravel (limestone)						
	6-8-7	15	10		SP-SM	Poorly Graded Sand with Silt and Gravel- Pale gray gravelly (limestone and shells) slightly silty fine sand						
15	57-50/0"-	50/0"	11			Hard Bedded Limestone						
18	4-2-1	3	12		SM	Silty Sand with Gravel- Pale gray silty fine sand, some gravel (limestone and shells)						
21						Boring terminated at 20.5'						

BORING LOCATION: See Boring Location Plan

STATION: **OFFSET:**

DATE DRILLED: 09-26-08 **START:** **FINISH:**

GROUND SURFACE ELEVATION:

WATER TABLE DEPTH (ft): 3 **TIME:** **DATE:** 09-26-08

CLIENT: CITY OF NAPLES PUBLIC WORKS

PROJECT: CITY OF NAPLES UTILITIES BUILDING

LOCATION: NAPLES, COLLIER COUNTY, FLORIDA

DRILL CREW: Lockley **LOGGED BY:** J Rivas

DRILL MAKE & MODEL: Mobile B-57 **BIT:** 3-7/8" diam. tricone roller **DRILLING RODS:** NW

DRILLING METHOD: Rotary wash with drilling fluid **WEATHER CONDITIONS:** Sunny

DEPTH, FT.	BLOWS PER SIX INCHES	SPT N-VALUE	SAMPLE NO.	GRAPHIC LOG	USCS	SOIL DESCRIPTION	REMARKS	% WATER CONTENT	PERCENT FINES	% ORGANIC CONTENT	LIQUID LIMIT	PLAST. INDEX
0	38-33-6	39	1			Asphalt and base course						
	5-6-6	12	2		SP-SM	Poorly Graded Sand with Silt and Organic Fines- Dark brown slightly organic, slightly silty fine sand						
3	2-3-3	6	3		PT	Sandy Peat- Dark brown sandy peat with layers of fine sand						
	3-4-3	7	4		SM	Silty Sand- Brown slightly organic silty fine sand						
6	1-3-2	5	5		SC	Clayey Sand- Brownish gray clayey fine sand						
	1-1-2	3	6		SM	Silty Sand with Organic Fines- Dark brown organic silty fine sand		50		10		
9	1-1-3	4	7									
	3-5-6	11	8		SP-SM	Poorly Graded Sand with Silt and Organic Fines- Brownish gray slightly organic, slightly silty fine sand						
12	3-4-5	9	9									
	8-35-36	71			SC	Clayey Sand with Gravel- Gray clayey sand, some gravel (limestone)						
15	12-16-10	26	10		SC-SM	Silty Clayey Sand with Gravel- Gray gravelly (limestone and shells) silty, clayey fine sand						
	11-15-16	31	11									
18	14-17-20	37										
	10-8-3	11	12		SM	Silty Sand with Gravel- Gray gravelly (limestone and shells) silty fine sand						
21						Boring terminated at 20.5'						

BORING LOCATION: See Boring Location Plan

STATION: **OFFSET:**

DATE DRILLED: 09-26-08 **START:** **FINISH:**

GROUND SURFACE ELEVATION:

WATER TABLE DEPTH (ft): 3.5 **TIME:** **DATE:** 09-26-08

CLIENT: CITY OF NAPLES PUBLIC WORKS

PROJECT: CITY OF NAPLES UTILITIES BUILDING

LOCATION: NAPLES, COLLIER COUNTY, FLORIDA

DRILL CREW: Lockley **LOGGED BY:** J Rivas

DRILL MAKE & MODEL: Mobile B-57 **BIT:** 3-7/8" diam. tricone roller **DRILLING RODS:** NW

DRILLING METHOD: Rotary wash with drilling fluid **WEATHER CONDITIONS:** Sunny

DEPTH, FT.	BLOWS PER SIX INCHES	SPT N-VALUE	SAMPLE NO.	GRAPHIC LOG	USCS	SOIL DESCRIPTION	REMARKS	% WATER CONTENT	PERCENT FINES	% ORGANIC CONTENT	LIQUID LIMIT	PLAST. INDEX
0	41-30-28	58	1			Asphalt and base course						
	12-7-4	11	2		SP-SM	Organic Slightly Silty Sand- Dark brown organic slightly silty sand						
3	5-9-9	18	3		SM	Silty Sand with Organic Fines- Dark brown organic silty fine sand, some roots and wood debris						
	6-6-5	11	4		CL	Sandy Lean Clay- Gray sandy lean clay						
6	4-2-4	6	5		SM	Silty Sand with Organic Fines- Brown organic silty fine sand						
	7-5-5	10	6		SM	Silty Sand- Light brownish gray silty fine sand, some wood debris						
9	10-7-5	12	7		SP-SM	Poorly Graded Sand with Silt- Gray slightly silty fine sand						
	8-8-7	15	8									
12	9-10-50/0"	50/0"	9			Hard Bedded Limestone						
15												
18					SM	Silty Sand with Gravel- Gray gravelly (limestone and shells) silty fine sand						
	0-0-10	10	12									
21						Boring terminated at 21.0'						

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

REVIEWED BY: Martin A. Call, P.E. **FILE NO:** 08-4560 **BORING NO.:** SPT-3

APPENDIX

- **SOIL BORING, SAMPLING AND TESTING METHODS**
  PROJECT SOIL DESCRIPTION PROCEDURE - UNIFIED

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 (0.6 m) long, 2-inch (50 mm) O.D. split-barrel sampler attached to the end of a string of drilling rods is driven 18 inches (0.45 m) into the ground by successive blows of a 140-pound (63.5 Kg) hammer freely dropping 30 inches (0.76 m). The number of blows needed for each 6 inches (0.15 m) of penetration is recorded. The sum of the blows required for penetration of the second and third 6-inch (0.15 m) increments penetration constitutes the test result or N-value. After the test, the sampler is extracted from the ground and opened to allow visual description 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
	0 to 2	Very soft	Below 0.25 tsf (25 kPa)
	2 to 4	Soft	0.25 to 0.50 tsf (25 to 50 kPa)
	4 to 8	Medium stiff	0.50 to 1.0 tsf (50 to 100 kPa)
	8 to 15	Stiff	1.0 to 2.0 tsf (100 to 200 kPa)
	15 to 30	Very stiff	2.0 to 4.0 tsf (200 to 400 kPa)
	Above 30	Hard	Above 4.0 tsf (400 kPa)

The tests are usually performed at 5-foot (1.5 m) 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 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, 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. After completion of a test boring, the hole is kept open until a steady state groundwater level is recorded. The hole is then sealed by backfilling with neat cement.

Representative split-spoon samples from each sampling interval and from different strata are brought to our laboratory in air-tight jars for classification and testing, if necessary. Afterwards, the samples are discarded unless prior arrangements have been made.

POWER AUGER BORINGS

Auger borings are used when a relatively large, continuous sampling of soil strata close to the ground surface is desired. A 4-inch (100 mm) diameter, continuous flight, helical auger with a cutting head at its end is screwed into the ground in 5-foot (1.5 m) sections. It is powered by the

rotary drill rig. The sample is recovered by withdrawing the auger out of the ground without rotating it. The soil sample so obtained, is described and representative samples put in bags or jars and returned to the laboratory for classification and testing, if necessary.

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-foot [1.5 m]) depth or when access is not available to power drilling equipment. A 3-inch (75 mm) diameter hand bucket auger with a cutting head is simultaneously turned and pressed into the ground. The bucket auger is retrieved at approximately 6-inch (0.15 m) intervals and its contents emptied for inspection. Sometimes post-hole diggers are used, especially in the upper 3 feet (1 m) or so. The soil sample obtained is described and representative samples put in bags or jars and transported to the laboratory for classification and testing, if necessary.

Undisturbed Sampling

Undisturbed sampling implies the recovery of soil samples in a state as close to their natural condition as possible. Complete preservation of in situ conditions cannot be realized; however, with careful handling and proper sampling techniques, disturbance during sampling can be minimized for most geotechnical engineering purposes. Testing of undisturbed samples gives a more accurate estimate of in situ behavior than is possible with disturbed samples.

Normally, we obtain undisturbed samples by pushing a 2.875-inch (73 mm) I.D., thin wall seamless steel tube 24 inches (0.6 m) into the soil with a single stroke of a hydraulic ram. The sampler, which is a Shelby tube, is 30 (0.8 m) inches long. After the sampler is retrieved, the ends are sealed in the field and it is transported to our laboratory for visual description and testing, as needed. Undisturbed sampling is noted on the boring logs as thus "U-".

Laboratory Test Methods

Soil samples returned to our laboratory are looked at again 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 help 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 discussed in this report. The soil descriptions shown on the logs are based upon visual-manual procedures in accordance with local practice. Soil classification is in general accordance with the Unified Soil Classification System (ASTM D-2487) and is also based on visual-manual procedures. Following is a list of abbreviations that may appear in the Remarks column on the boring logs indicating additional laboratory testing was performed.

DD - Dry Density of Undisturbed Sample
k - Hydraulic Conductivity (Coefficient of Permeability)
Qu - Unconfined Compression Strength; ASTM D-2166 (soil), D-2938 (rock)
Consol - One-Dimensional Consolidation test performed on subsample from undisturbed sample; ASTM D-2425 (report usually presented in Appendix)

THE PROJECT SOIL DESCRIPTION PROCEDURE FOR SOUTHWEST FLORIDA[1]
For use with the ASTM D 2487 Unified Soil Classification System

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ORGANIC SOILS (Continued):

Organic Content	Descriptive Adjectives	Classification
5 - 30%	organic	SM with organic fines Organic Silt (OL) Organic Clay (OL) Organic Silt (OH) Organic Clay (OH)

HIGHLY ORGANIC SOILS AND MATTER

	Description	
30-75%	sandy peat	Peat (PT)
	silty peat	Peat (PT)
>75%	amorphous peat	Peat (PT)
	fibrous peat	Peat (PT)

STRATIFICATION AND STRUCTURE

Descriptive Term		Thickness
with interbedded		
seam	--	less than 1/2-inch (13 mm) thick
layer	--	1/2 to 12-inches (13 to 300 mm) thick
stratum	--	more than 12-inches (300 mm) thick
pocket	--	small, erratic deposit, usually less than 1-foot
lens	--	lenticular deposits
occasional	--	one or less per foot of thickness
frequent	--	more than one per foot of thickness
calcareous	--	containing calcium carbonate (reaction to diluted HCL)
hardpan	--	spodic horizon usually medium dense
marl	--	mixture of carbonate clays, silts, shells and sands.

ROCK CLASSIFICATION (FLORIDA) CHART

Symbol	Typical Description
LS	Hard Bedded Limestone or Caprock
WLS	Fractured or Weathered Limestone
LR	Limerock (gravel, sand, silt and clay mixture)
SLS	Stratified Limestone and Soils

(1) This soil description procedure was developed specifically for projects in southwest Florida because it is believed that the terminology will be better understood as a result of local practice. It is not intended to supplant other visual-manual classification procedures for description and identification of soils such as ASTM D 2488.
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THE PROJECT SOIL DESCRIPTION PROCEDURE FOR SOUTHWEST FLORIDA[1]
For use with the ASTM D 2487 Unified Soil Classification System

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

BOULDERS (>12" [300 mm]) and COBBLES (3" [75 mm] TO 12" [300 mm]):

GRAVEL: Coarse Gravel: 3/4" (19 mm) to 3" (75 mm)
Fine Gravel: No. 4 (4.75 mm) Sieve to 3/4" (19 mm)

Descriptive adjectives:

0 - 5%	-- no mention of gravel in description
5 - 15%	-- trace
15 - 29%	-- some
30 - 49%	-- gravelly (shell, limerock, cemented sands)

SANDS

COARSE SAND: No. 10 (2 mm) Sieve to No. 4 (4.75 mm) Sieve
MEDIUM SAND: No. 40 (425 μm) Sieve to No. 10 (2 mm) Sieve
FINE SAND: No. 200 (75 μm) Sieve to No. 40 (425 μm) Sieve

Descriptive adjectives:

0 - 5%	--	no mention of sand in description
5 - 15%	--	trace
15 - 29%	--	some
30 - 49%	--	sandy

SILT/CLAY: < #200 (75 μm) sieve

SILTY OR SILT: PI < 4
SILTY CLAYEY OR SILTY CLAY: 4 ≤ PI ≤ 7
CLAYEY OR CLAY: PI > 7

Descriptive adjectives/adverbs:

< - 5%	--	clean (no mention of silt or clay in description).
5 -12% to 15%	--	slightly
16 - 35%	--	clayey, silty, or silty clayey
36 - 49%	--	very

ORGANIC SOILS

Organic Content	Descriptive Adjectives	Classification
0 - 2.5%	usually no mention of organics in description	See Above
2.6 - 5%	slightly organic	add "with organic fines" to group name

TABLE 1 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS More than 50 % retained on No. 200 sieve	Gravels More than 50 % of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5 % fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12 % fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50 % or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12 % fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
FINE-GRAINED SOILS 50 % or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit — oven dried}}{\text{Liquid limit — not dried}} < 0.75$	OL	Organic clay[K,L,M,N] / Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit — oven dried}}{\text{Liquid limit — not dried}} < 0.75$	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15 % sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15 % gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30 % plus No. 200, predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30 % plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.