



REPORT OF
GEOTECHNICAL INVESTIGATION
FOR
THUNDERBIRD GIFTS - DECK SETTLEMENT

MACKINAC ISLAND
MACKINAC COUNTY
MICHIGAN

FEBRUARY 22, 2023



*Shoreline Architecture & Design, Inc.
8 Pennsylvania Plaza
Petoskey, Michigan 49770*

Project No. 2022.2381



February 22, 2023

Shoreline Architecture & Design, Inc.
8 Pennsylvania Plaza
Petoskey, Michigan 49770

Attention: Mr. Michael Pattullo

Regarding: Thunderbird Gifts – Deck Settlement
Mackinac Island, Mackinac County, Michigan
Project No. 2022.2381

Dear Mr. Pattullo:

Soils & Structures is pleased to present this geotechnical investigation report for the Thunderbird Gifts – Deck Settlement project in Mackinac Island, Mackinac County, Michigan.

The investigation included one (1) test boring drilled to a depth of 60.0 feet in accordance with ASTM D 1586 procedures.

The report, test boring location plan, and test boring logs are enclosed. The report provides recommendations for site preparation, foundations, and fill.

We appreciate the opportunity to provide you with engineering services. If you have any questions regarding this report, please contact our office.

Sincerely,
Soils & Structures, Inc.

A handwritten signature in black ink that reads "Malcolm P. Thompson".

Malcolm P. Thompson, P.E.
MPT/mt

Reviewed by:

A handwritten signature in black ink that reads "David W. Hohmeyer".

David W. Hohmeyer, P.E.

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Location of Soil Investigation

The soil investigation was located at 7293 Main Street, Mackinac Island, Mackinac County, Michigan. The parcel number is 051-440-016-00.

Purpose of Investigation

The purpose of this investigation is to provide geotechnical engineering recommendations for the proposed foundation improvements.

Design Information

The project consists of new foundations intended to stabilize an existing building and deck. The building is a one-and-two-story structure. The columns and walls are assumed to be supported on shallow foundations. The deck extends to the southeast from the building. The deck appears to be supported on timber posts bearing on concrete shafts. Information pertaining to the design and construction of the existing foundations has not been provided at the time of this report. Settlement analysis of the existing structures was not included as a part of this investigation.

The column and wall loads associated with the existing structures should be determined by a registered structural engineer. The maximum column load is anticipated to be less than 80,000 pounds. The maximum wall loads are anticipated to be less than 4,000 pounds per foot. After foundation improvements, allowable future settlements of 0.6 inches for total settlement and 0.4 inches for differential settlement are assumed. If the actual loads are significantly greater than the anticipated loads listed in this report, then Soils & Structures should be contacted so that the recommendations included in this report may be reviewed and revised if necessary.

The greatest depth of excavation is anticipated to be approximately 5.0 feet which will be required for the construction of new foundations. Temporary bracing, earth retention, and dewatering may be necessary to construct new foundations. Fill for this project will include backfill over foundations. The thickness of backfill over foundations is anticipated to be less than 5.0 feet.

Tests Performed

The investigation included one test boring drilled to a depth of 60.0 feet. The test boring was extended below the planned depth of 50.0 feet because a suitable bearing layer was not encountered. The test boring was terminated at 60.0 feet because a greater depth could not be achieved using the available equipment. The test boring is designated as Test Boring One. The location was determined jointly by Shoreline Architecture & Design, Inc. and Soils & Structures, Inc. The test boring was conducted in accordance with ASTM D 1586 procedures. The ASTM D 1586 standard describes the procedure for sampling and testing soil using the Standard Penetration Test. An automatic hammer was used to obtain the soil samples.

The surface elevation at the test boring location and additional points of reference were obtained with a Global Navigation Satellite System (GNSS) Receiver. The receiver was connected to the local MDOT CORS base station. Through this system, vertical measurements are obtained and referenced to the North American Vertical Datum (NAVD88). Horizontal measurements are also obtained at the test boring locations which are referenced to the Michigan State Plane Coordinate System. Both the vertical and horizontal measurements typically have an accuracy of approximately 0.5 inches. The measured test boring locations and surface elevations are represented in Table 1.

Table 1: Measured Test Boring and Points of Reference
Locations and Surface Elevations

Test Boring / Location	Elevation (feet)	Northing (feet)	Easting (feet)	Surface Cover
Test Boring One	586.6	397878.7	26853691.4	Gravel
Water Level of Lake Huron	578.6	397851.2	26853727.0	-
Concrete Dock at the Northeast Corner of the Existing Deck	586.2	397875.4	26853703.8	-
Northwest Corner of the Existing Building	589.4	397922.9	26853623.7	-
Base Setup VRS1	582.8	397874.7	26853689.4	-

Soil samples were classified according to the Unified Soil Classification System. This method is a standardized system for classifying soil according to its engineering properties. Please refer to the appendix of this report for the Unified Classification System Chart. The classification is shown in the "Material Description" column of the test boring logs.

The soil strength and the allowable soil bearing value were evaluated using the "N" value. The "N" value is the number of blows required to drive a soil sampler one foot with a standard 140 pound drop hammer. The sampler is driven a distance of 18.0 inches. The number of blows for each 6.0 inch increment is recorded. The sum of the second and third intervals is the "N" value. The number of blows for each 6.0 inch interval is shown on the test boring logs under the column labeled "Penetration." The "N" value for each sample is shown in the adjacent column.

Laboratory testing consisted of natural moisture content (ASTM D 2216) and sieve analysis (ASTM D 6913). The tests were performed on representative soil samples. The tests were performed in accordance with the ASTM standards listed above. The water content documents the presence of groundwater in the soil. The sieve test determines the particle distribution which is used to classify the soil and estimate its properties.

The U.S. Geological Survey Topographic map and the Quaternary Geology map of Michigan were reviewed. These maps provide general geological information about the region. Publicly available well logs were reviewed to determine the depth of bedrock.

Description of Soil

The general soil profile consists of a layer of gravel which extends to a depth of 8.5 feet over a layer of sand which extends to a depth of 17.5 feet. Below the sand layer, a layer of silt extends to a depth of 33.5 feet. A second layer of sand is present between depths of 33.5 and 43.5 feet. Below the second sand layer, a layer of clay extends to a depth of 55.5 feet. A third layer of sand is present between depths of 55.5 and at least 56.5 feet. The natural soil is part of a deposit of glacial till over bedrock. The till is deposited as a glacier melts and recedes. The depth to bedrock is anticipated to be in the range of 70.0 to 100.0 feet.

The upper 8.5 feet of the soil profile consists of brown to gray sandy gravel with lenses of cobble. The "N" values of the gravel layer range from 3 to 25, indicating the gravel is in a loose to very compact state. The "N" values correspond to an internal friction angle of 30 to 38 degrees.

The first sand layer is present between depths of 8.5 and 17.5 feet. The upper portion of the sand layer consists of gray gravelly sand. The "N" value of the upper portion of the sand layer is 22, indicating the sand is in a very compact state. The "N" value corresponds to an internal friction angle of 34 degrees. The lower portion of the sand layer consists of gray fine to medium sand. The "N" value of the lower portion of the sand layer is 2, indicating the sand is in a loose state. The "N" value corresponds to an internal friction angle of 26 degrees.

The portion of the soil profile between depths of 17.5 and 33.5 feet consists of gray silt with sand. The "N" value of the silt layer is 0, indicating the silt is in a loose state. The "N" value corresponds to an internal friction angle of less than 20 degrees. The silt layer will not provide suitable end bearing for deep foundations.

The second sand layer is present between depths of 33.5 and 43.5 feet. The "N" values of the second sand layer range from 13 to 14, indicating the sand is in a compact state. The "N" values correspond to an internal friction angle of 30 to 32 degrees. The second sand layer will not provide suitable end bearing for deep foundations due to the underlying layer of soft clay.

The portion of the soil profile between depths of 43.5 and 55.5 feet consist of brown clay. The "N" value of the clay layer is 0, indicating the clay is in a soft state. The clay layer will not provide suitable end bearing for deep foundations.

Below the clay layer, a third layer of sand extends to a depth of at least 56.5 feet. The "N" value of the third sand layer is 12, indicating the sand is in a compact state. The "N" value corresponds to an internal friction angle of 30 to 32 degrees.

Description of Groundwater Conditions

The water table is present at a depth of approximately 6.5 feet. This depth corresponds to an elevation of 580.1 feet which was near the water level of Lake Huron at the time the test boring was performed. The elevation of the water table is expected to change based on seasonal precipitation and will correspond to the water level of Lake Huron.

Description of Site

The site is located at 7293 Main Street in Mackinac Island, Mackinac County, Michigan. The site is a commercial building with a deck which extends to the southeast toward Lake Huron. The northeast portion of the site is bordered by a concrete dock and commercial buildings. The southeast portion of the site is bordered by Lake Huron. The southwest portion of the site is bordered by commercial buildings. The northwest portion of the site is bordered by Main Street. Photographs #1 and #2 show the site at the time the test borings were performed.



Photograph #1: View of the existing building and concrete dock. The view is to the southeast. [Project No. 2022.2381, Thunderbird Gifts – Deck Settlement, Mackinac Island, January, 2023]



Photograph #2: View of the existing deck foundation. (Project No. 2022.2381, Thunderbird Gifts – Deck Settlement, Mackinac Island, January, 2023)

Settlement

The maximum future settlement of the building and deck will be less than 0.5 inches if they are supported on new deep foundations. Differential settlement will be approximately one half of the maximum value. These levels of settlement are within the recommended acceptable limits of 0.6 inches of total settlement and 0.4 inches of differential settlement.

Discussion

The owner has indicated that the existing building and deck have experienced detrimental settlement. The original construction plans for the existing building and deck were not available at the time of this report. Settlement analysis of the existing structures was not performed as a part of this investigation. Based on the information obtained from the test boring, the observed settlement is probably caused by shallow foundation failure, the consolidation of deeper layers of soft soil, or both.

The upper 17.5 feet of the soil profile consists primarily of a gravel layer over a sand layer. The observed settlement may be caused by shallow foundation failure in this layer. Potential shallow failures include soil bearing failure caused by under designed footings, damage caused by frost action, and loss of soil due to drainage issues. If the observed settlement was caused entirely by a shallow foundation failure, then supporting the existing structures with new foundations bearing in the upper layers of gravel and sand should mitigate future settlement.

The portion of the soil profile between depths of 17.5 and 33.5 feet consists of soft silt. If the observed settlement was caused by the consolidation of the layer of soft silt, then new foundations bearing in the overlying sand and gravel layers will not mitigate future settlement. The overlying sand and gravel layers, and all foundations bearing in those layers, will continue to settle at the rate the layer of soft silt is consolidating. To mitigate future settlement, new deep foundations should bypass layers of compressible soil.

The portion of the soil profile between depths of 33.5 and 43.5 feet consists of compact sand. Consolidation of this layer is not anticipated to significantly contribute to the settlement of foundations in the overlying soil. However, this layer of sand is not suitable to support deep foundations due to the thickness of the sand layer and the underlying layer of soft clay.

The portion of the soil profile between depths of 43.5 and 55.5 feet consists of soft clay. The soft clay layer is compressible and consolidation of this layer may be contributing to the settlement of foundations in the overlying soil. The clay layer will not provide suitable support for deep foundations.

The portion of the soil profile between depths of 55.5 and at least 56.5 feet consists of compact sand. This layer is anticipated to extend to bedrock. This sand layer and bedrock will provide suitable support for deep foundations.

To reach bedrock, deep foundations must advance through a layer of gravel with cobble, compact sand layers, and layers of loose or soft soil. Also, the types of deep foundations which will be feasible to construct will be limited by accessibility. Helical piers and micropiles were considered because the equipment is relatively light allowing for installation in confined spaces.

Helical piers are round or square steel shafts with one or more steel helices. The helical piers are drilled into the subsurface and shaft extensions are added until a suitable bearing stratum has been reached. Helical piers are not recommended because the gravel and cobbles may damage the helices or the equipment may not achieve the torque required to advance the helices through the layers of compact soil. The helices may auger, turn without advancing in loose or soft soils so that the lead section can not develop enough thrust to force the tip into the bearing stratum.

Micropiles are a recommended deep foundation option. Micropiles are constructed using rock drilling equipment capable of penetrating soil layers with cobbles. Pressurized grout is pumped through the drilled shaft creating a slender column, typically less than 12.0 inches in diameter, and the column is internally reinforced.

Recommendations

Site & Subgrade Preparation

The existing foundations should be exposed and inspected as part of subgrade preparation. A registered structural engineer should design grade beams, pile caps or foundation brackets to transfer loads to the new deep foundations. Temporary supports and bracing should be installed as necessary.

Soil brought to the site for fill should be clean sand meeting MDOT Class II specifications. Fill should be placed in accordance with the "Fill" section of this report. The fill should be compacted to 95.0 percent of its maximum density. The soil which will be used for fill should be kept free of topsoil and other organic materials. Compaction tests are recommended to check the compaction of the new fill.

Foundations

Micropiles are recommended to support the existing building and deck. Micropiles should extend into bedrock which is anticipated to be present between depths of 70.0 and 100.0 feet. The micropiles should be installed with rock drilling equipment capable of advancing through compact soil layers containing cobble. A test micropile is recommended to determine the depth to bedrock. The grout strength should be 4000 pounds per square inch at twenty-eight days. Steel pipe or reinforcement should be included at every section of the micropile. Steel pipe should have a minimum wall thickness of 3/16" inch and a minimum yield strength of 45.0 kips per square inch. The micropiles should be installed with the generally accepted practices of micropile installation. Casing will probably be required.

The axial capacity of the micropiles will be developed by a bond zone in a combination of soil and bedrock. Bond zones present above layers of compressible soil will not contribute to the axial capacity of the micropile, and the design axial capacity should account for down drag. The construction technique used to build the micropiles will affect the grout-to-ground bond strength. The grout-to-ground nominal resistance in the compact sand layer is anticipated to be in the range of 1.5 to 5.0 kips per square foot. The grout-to-ground nominal resistance in bedrock is anticipated to be in the range of 5.0 to 20.0 kips per square foot. An appropriate factor of safety should be applied to the calculated nominal resistance. A load test is recommended to verify the micropile capacity.

If the micropiles are grouted inside temporary or permanent casing or a hole drilled into bedrock, the steel reinforcing should be designed to carry at least 40.0 percent of the design axial load. The steel reinforcing should be designed to carry the entire load for portions grouted in an open hole without suitable means of verifying the hole diameter during grouting.

Battered micropiles should be used to resist lateral loads.

The recommended minimum cover over the bottom of grade beams and pile caps is 42.0 inches for protection against frost heave.

Grade beams and pile caps should not be constructed on frozen soil. Grade beams and pile caps should be protected from freezing with insulated blankets. The blankets should be left in place under the backfill on both sides of the wall until the wall is placed. Grade beams and pile caps exposed to extended periods of freezing temperatures will heave which may damage the foundation and any overlying structures. Damaged grade beams or pile caps should be removed and replaced.

The site classification for seismic design is "E" based on the Michigan Building Code. The site has a peak ground acceleration of 0.053g with a 2.0 percent probability of exceedance in 50 years. The mapped spectral accelerations are 0.048 for the short-term response (S_s) and 0.025 for the one second response (S_1). The corresponding numeric seismic design values for the spectral response acceleration parameters above are 0.079g ($S_{0.5}$) and 0.059g ($S_{0.1}$) respectively.

Excavations

The in-situ sand is an OSHA type "C" soil. Excavations that will be entered by personnel should be based on OSHA requirements for a type "C" soil. Based on OSHA requirements, a maximum allowable side slope of 34 degrees (1.5H:1V) is recommended for excavations 4.0 to 20.0 feet deep. Excavations less than 4.0 feet deep may have vertical side slopes. For excavations adjacent to property lines, structures such as buildings or roads, or excavations over 10.0 feet deep retaining systems are recommended. The existing foundations must not be undermined. Temporary supports and bracing may be required for the installation of new foundations.

Fill

Fill should be compacted to a density of 95.0 percent of its maximum density to its full depth. The maximum density should be determined in accordance with the ASTM D 1557 standard. A maximum thickness per layer of 6.0 inches is recommended.

Soil brought to the site for structural fill should be sand meeting MDOT Class II requirements or ASTM requirements for a SP or SW which are the designations for clean sand.

Compaction tests are recommended to confirm that the fill is compacted to the required density.

Fill should not be placed over frozen ground, snow or ice. Soil which contains frozen material should not be used as fill. During winter construction, removal of frozen ground may be necessary prior to placing fill.

Groundwater Management

Groundwater controls and dewatering may be necessary to construct the new foundations. Groundwater is present at a depth of approximately 3.0 feet below the current grade in the area of the test boring. If excavations encounter groundwater, the excavation bottom may be stabilized by placing a 6.0-to-8.0-inch layer of porous stone over the bottom of the excavation. The stone will stabilize the bottom of the excavation.

Quality Control Testing

The subgrade should be examined and tested before fill is placed. A density gauge and probe rod should be used to verify that the subgrade possesses the required compaction.

Inspection of the micropile installation is recommended. For each micropile the following information should be recorded; surface elevation, depth drilled, casing type and depth, drilling time, grouting time, grout volume, grout ratio, reinforcing, obstructions and offsets. To verify the strength of the grout, one set of four 4.0 inch diameter cylinders is recommended for each half day of production.

Compaction tests, in accordance with ASTM D 6938 procedures, are recommended to confirm that fill in the construction area is compacted to the specified density. While fill is being placed, compaction tests should be performed at the rate of one test per 400 cubic yards of fill and throughout the depth of the fill with a minimum of five tests at each 1.0-foot elevation interval. Tests should also be performed in the backfill over foundations and utilities. The maximum density should be determined in accordance with ASTM D 1557 or ASTM D 4253 procedures.

A smooth 0.5-to-0.75-inch diameter rod should be used in conjunction with compaction tests to probe for loose areas in fill.

A dynamic cone should not be substituted for compaction tests for evaluating backfill.

Compaction Testing should be performed by technicians supervised by a registered geotechnical engineer.

General Conditions & Reliance

The report was prepared in accordance with generally accepted practices of the geotechnical engineering profession. The scope of work consisted of performing one test boring and providing soil related recommendations for the design and construction of the proposed foundation improvements. The scope of work did not include an environmental study or wetland determination.

The report and the associated test boring were prepared specifically for the previously described project and site. Soils & Structures should be consulted if a significant change in the scope of the project is made.

The test boring represents point information and may not have encountered all of the soil types and materials present on this site. This report does not constitute a guarantee of the soil or groundwater conditions or that the test boring is an exact representation of the soil or groundwater conditions at all points on this site.



The descriptions and recommendations contained in this report are based on an interpretation of the test boring and laboratory tests. The test boring should not be used independently of the report. If soil conditions are encountered which are significantly different from the test boring, Soils & Structures should be consulted for additional recommendations.

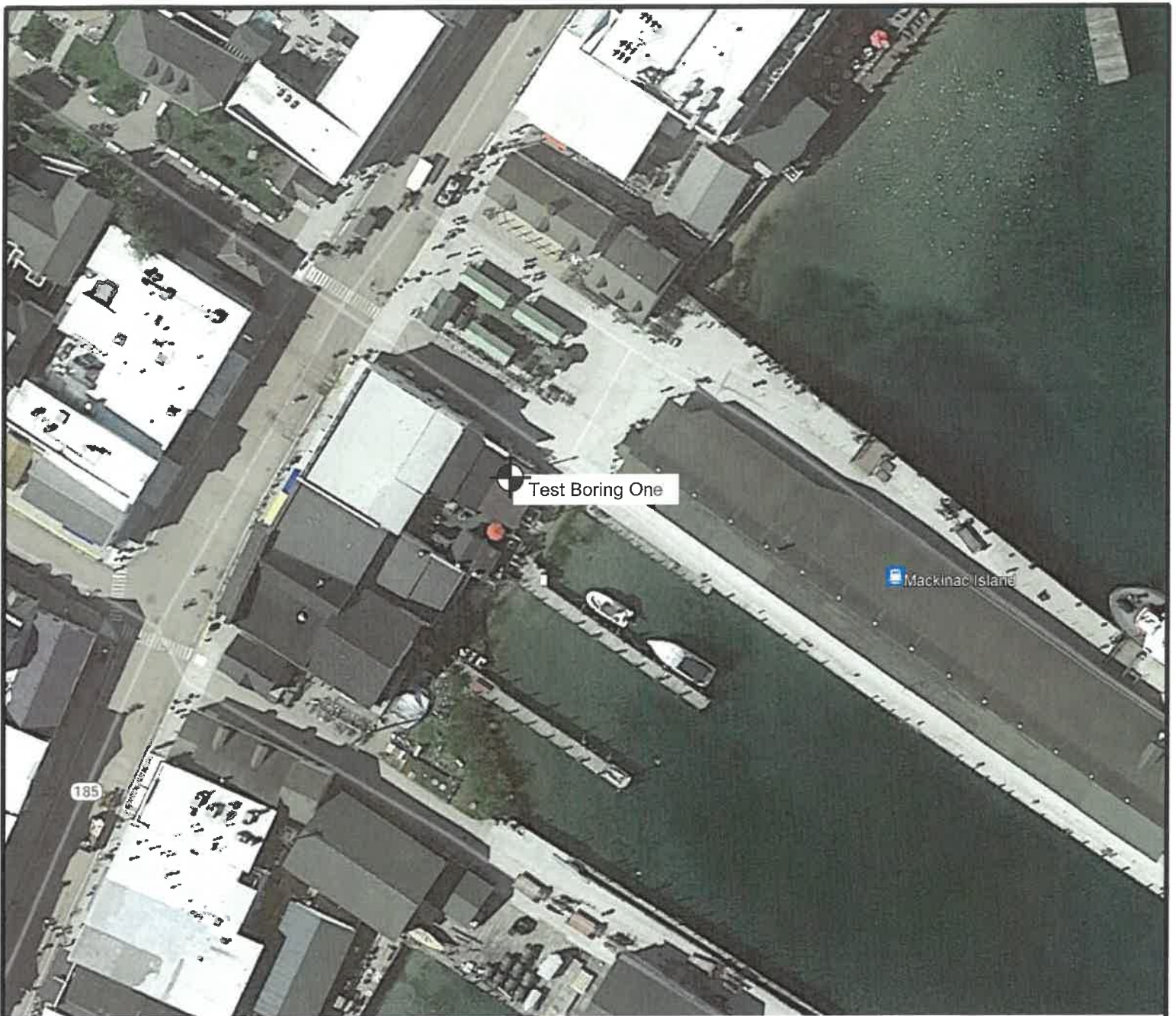
The report and test boring may be relied upon by Shoreline Architecture & Design, Inc. for the design, construction, permitting and financing associated with the construction of the Thunderbird Gifts – Deck Settlement project in Mackinac Island, Mackinac County, Michigan. The use of the report and test boring by third parties not associated with this project or for other sites has not been agreed upon by Soils & Structures. Soils & Structures does not recommend or consent to third party use or reliance of the report or test boring unless allowed to review the proposed use of these materials. Unless obtained in writing, consent to third party use should not be assumed. Third parties using the report or test boring logs do so at their own risk and are offered no guarantee or promise of indemnity.



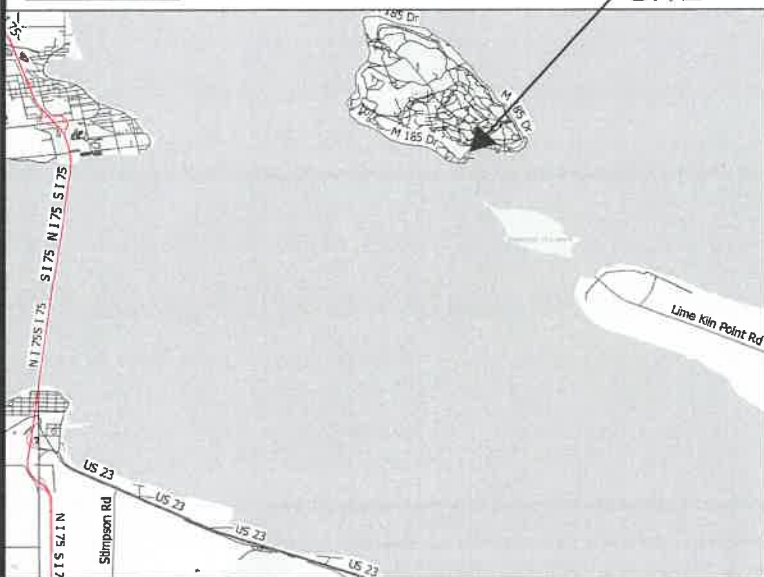
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Appendix

Test Boring Location Plan
Test Boring Log
Laboratory Tests
General Soil Information



VICINITY MAP



SITE

TEST BORING LOCATION PLAN NTS



Note: The background of the test boring plan is a portion of an aerial photograph from Google Earth dated 5/31/2015

Thunderbird Gifts - Deck Settlement

Mackinac Island, Mackinac County, Michigan

Soils & Structures, Inc.
6480 Grand Haven Road
Muskegon, Michigan 49441

JOB NO.: 2022.2381

DATE: 2-14-2023



SOILS & STRUCTURES

Borehole ID: TB-01

Sheet 1 of 2

Project Name:		Thunderbird Gifts - Deck Settlement		Project Number:		2022.2381													
Project Location:		Mackinac Island, Michigan		Logged By:		R.Roda		Reviewed By:		H.Barton									
Client:		Shoreline Architecture & Design, Inc.		Survey Datum:		NAD 1983 StatePlane Michigan North		Hole Depth:		60.00									
Date Started:		Jan 04 2023		Completed:		Jan 04 2023		Northing:		397878.7		Easting:		26853691.4		Elevation:		586.60	
Drilling Method:		3.25" Hollow Stem Auger		Ground Water Levels															
Equipment:						At Time of Drilling		8.00 on Jan 04 2023 - Groundwater Encountered											
Hammer Type:		Automatic Hammer																	
Notes:		Boring Began 3.5' Below Deck Level				After Drilling		6.50 on Jan 04 2023 - Static Water Level											

Depth	Graphic	Material Description	Sample Type	Number	Recovery % RQD	Blow Counts	N-Value	Pocket Pen (tsf)	Shear Strength (tsf)	Moisture Content (%)	Atterberg Limits			USCS
											Liquid Limit	Plastic Limit	Plasticity Index	
1		DECK												
2														
3														
4		GRAVEL - loose to compact dark brown to light brown fine to coarse sandy with a trace of silt with lenses of cobbles	SPT-A	33	1-2-1	3				14.5				GP
5														
6			SPT-B	67	3-4-6	10				11.1				GP
7														
8		GRAVEL - very compact light brown to gray fine to coarse sandy with lenses of silt	SPT-C	67	10-10-15	25				9.6				GW-GM
9														
10														
11														
12		SAND - very compact gray fine to medium gravelly												
13			SPT-D	0	13-13-9	22								SP
14														
15														
16														
17														
18		SAND - loose gray fine to medium	SPT-E	13	3-1-1	2								SP
19														
20														
21		SILT - soft gray with sand with a trace of clay												
22														
23														
24			SPT-F	100	0-0-0	0				36.0				ML
25														
26														
27														
28														
29			SPT-G	100	0-0-0	0				32.4				ML
30														



SOILS & STRUCTURES

Borehole ID: TB-01

Sheet 2 of 2

Project Name:	Thunderbird Gifts - Deck Settlement	Project Number:	2022.2381
Project Location:	Mackinac Island, Michigan	Logged By:	R.Roda
Client:	Shoreline Architecture & Design, Inc.	Reviewed By:	H.Barton
Date Started:	Jan 04 2023	Survey Datum:	NAD 1983 StatePlane Michigan North
Completed:	Jan 04 2023	Hole Depth:	60.00
Drilling Method:	3.25" Hollow Stem Auger	Northing:	397878.7
Equipment:		Easting:	26853691.4
Hammer Type:	Automatic Hammer	Elevation:	586.60
Notes:	Boring Began 3.5' Below Deck Level	Ground Water Levels	
		At Time of Drilling 8.00 on Jan 04 2023 - Groundwater Encountered	
		After Drilling 6.50 on Jan 04 2023 - Static Water Level	

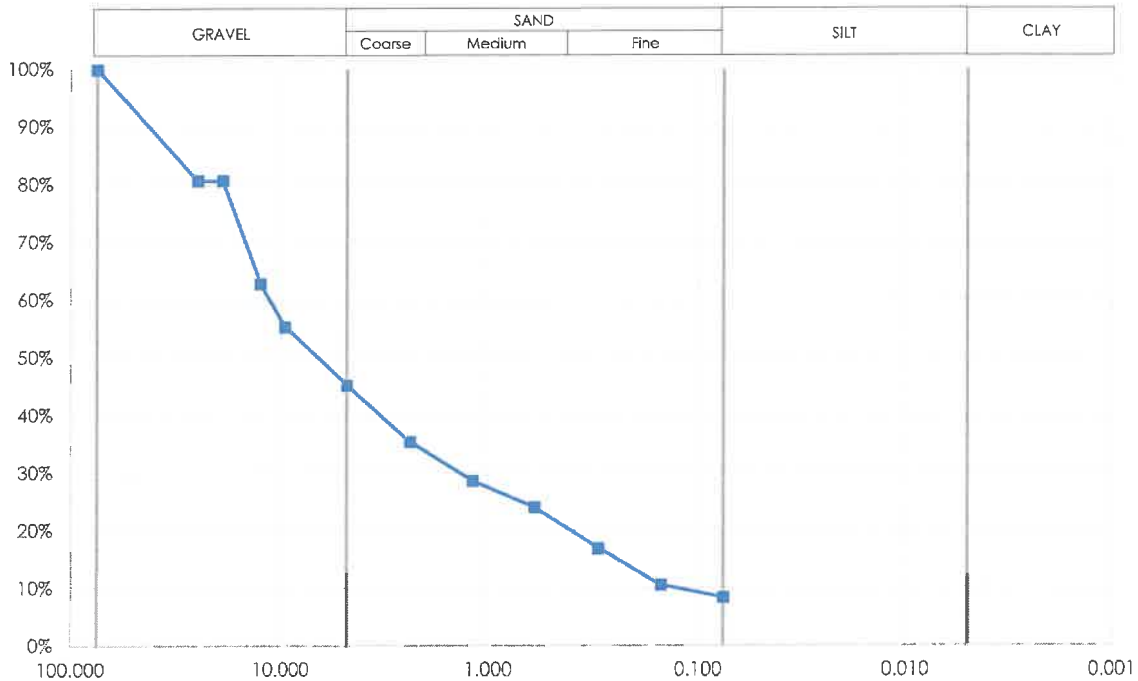
Depth	Graphic	Material Description	Sample Type	Number	Recovery % RQD	Blow Counts	N-Value	Pocket Pen (tsf)	Shear Strength (tsf)	Moisture Content (%)	Atterberg Limits			USCS
											Liquid Limit	Plastic Limit	Plasticity Index	
31		SILT - soft gray with sand with a trace of clay		SPT-H	100	0-0-0	0			18.3				ML
32														
33														
34														
35		SAND - compact gray fine to medium with silt		SPT-I	27	4-5-8	13			22.5				SP-SM
36														
37														
38														
39		SAND - compact gray fine to medium with a trace of silt		SPT-J	87	6-5-9	14			22.4				SP
40														
41														
42														
43		CLAY - soft brown with a trace of sand		SPT-K	100	0-0-0	0	0.00		24.5				CL
44														
45														
46														
47				SPT-L	100	0-0-0	0			33.3				CL
48														
49														
50														
51				SPT-M	100	0-6-6	12			16.1				SM
52														
53														
54														
55														
56														
57														
58														
59		SAND - compact brown fine to medium silty with a trace of clay												
60														



SOILS & STRUCTURES

Particle Size Distribution Report

Project Name Thunderbird Gifts - Deck Settlement
 Project Number 2022.2381
 Client Shoreline Architecture & Design, Inc.
 Date 1/31/2023
 Sample Location TB-01 Sample ID C Depth (ft) 8.5



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0%	19.3%	35.5%	11.9%	13.6%	11.5%	0.0%	0.0%
D85	D60	D50	D30	D15	D10	Loss By Wash	
36.0923	11.3803	7.0132	1.4242	0.2578	0.1346	8.3%	

Particle Size		Hydrometer		Material Description
Sieve	% Passing	Particle Size (mm)	% Passing	
3 in.	100%			GRAVEL - very compact light brown to gray fine to coarse sandy and lenses of silt (GW-GM)
1 in.	81%			
3/4 in.	81%			
1/2 in.	63%			
3/8 in.	55%			
No. 4	45%			
No. 8	35%			
No. 16	29%			
No. 30	24%			
No. 50	17%			
No. 100	10%			
No. 200	8.3%			
Remarks				

Technician
Hanna

Checked
Hanna

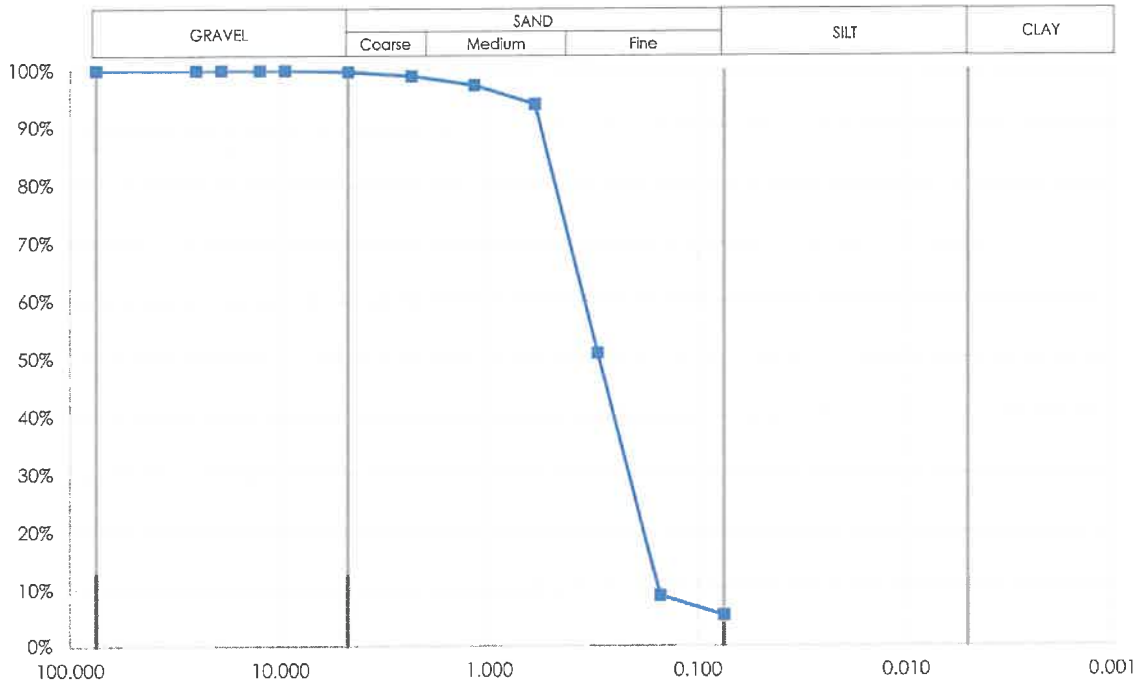
Approved
Hanna



SOILS & STRUCTURES

Particle Size Distribution Report

Project Name Thunderbird Gifts - Deck Settlement
 Project Number 2022.2381
 Client Shoreline Architecture & Design, Inc.
 Date 1/31/2023
 Sample Location TB-01 Sample ID J Depth (ft) 43.5

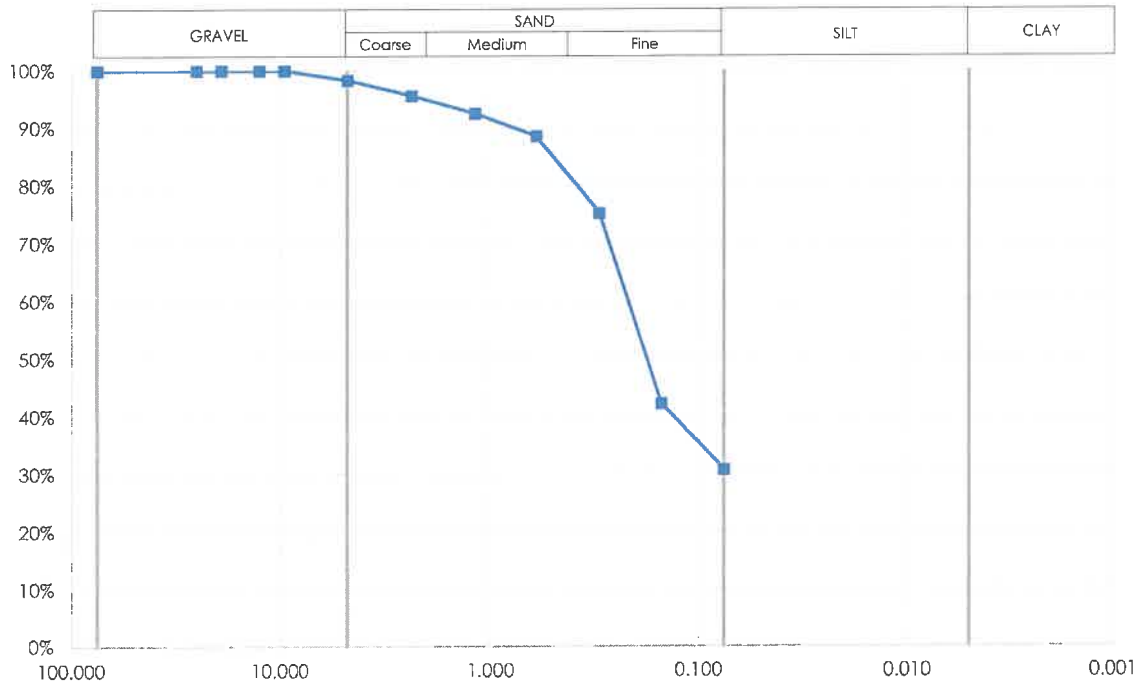




SOILS & STRUCTURES

Particle Size Distribution Report

Project Name Thunderbird Gifts - Deck Settlement
 Project Number 2022.2381
 Client Shoreline Architecture & Design, Inc.
 Date 1/31/2023
 Sample Location TB-01 Sample ID M Depth (ft) 58.5



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0%	0.0%	1.7%	3.6%	13.9%	50.1%	0.0%	0.0%
D85	D60	D50	D30	D15	D10	Loss By Wash	
0.5197	0.2311	0.1858	0.0733	0.0367	0.0244	30.7%	

Particle Size		Hydrometer		Material Description
Sieve	% Passing	Particle Size (mm)	% Passing	SAND - compact brown fine to medium silty with a trace of clay (SM)
3 in.	100%			
1 in.	100%			
3/4 in.	100%			
1/2 in.	100%			
3/8 in.	100%			
No. 4	98%			
No. 8	96%			
No. 16	93%			
No. 30	89%			
No. 50	75%			Remarks
No. 100	42%			
No. 200	30.7%			

Technician
Hanna

Checked
Hanna

Approved
Hanna

General Information for Method of Field Investigation

The soil investigation was performed in accordance with the American Society of Testing and Materials method ASTM D 1586, which is the "Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils". Samples of compressible clays or organic soils are obtained in accordance with ASTM D 1587, which is the "Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes." Rock may be cored in conjunction with the above methods as specified in ASTM D 2113 which is the "Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation."

Field Testing

Standard Penetration Tests (SPT) in accordance with ASTM D 1586 were generally performed at depths of 2.0', 4.5', 7.0', 9.5' and 5.0' intervals thereafter.

Laboratory Testing

Samples obtained from the Standard Penetration Test, ASTM D 1586 or thin walled tube method, ASTM D 1587, were tested in the laboratory for the moisture content and density and/or particle size, where applicable. When soils sampled possessed sufficient cohesive properties, it was tested for its compressive strength in the unconfined state.

Natural Percent Moisture content (N.P.M.) of the soil is the percentage by weight of water contained in the soil sample compared to the dry weight of the solids of which the soil is composed. The NPM of select samples is determined in accordance with ASTM D 2216.

Natural Density (N.D.) of soil as reported on the appended boring logs is the natural wet density of the soils expressed in pounds per cubic foot.

The unconfined compressive strength of cohesive soils is determined in the laboratory on "undisturbed" select samples in accordance with ASTM D 2166. This test determines the maximum load required at a specified rate to deform the cohesive soil specimen length twenty (20%) percent. The primary purpose of the unconfined compression test is to obtain approximate quantitative values of the compressive strength of soils possessing sufficient coherence to permit testing in the unconfined state. The shear strength of the cohesive soil can be calculated from the results of the unconfined compressive strength test.

Color

When the color of the soils is uniform throughout, the color recorded will be such as brown, gray, and black and may be modified by adjectives such as light and dark. If the soils predominant color is shaded by secondary color, the secondary color precedes the primary color, such as gray-brown, or yellow-brown. If two major and distinct colors are swirled throughout the soil, the colors will be modified by the term mottled; such as mottled brown and gray.

Water Observations

Depth of water recorded in the test boring is measured from the ground surface to the water surface. Initial depth indicates water level during boring, completing depth indicates water level immediately after boring, and depth after "X" number of hours indicates water level after allowing the groundwater rise or fall over a period of time. Water observations in pervious soils are considered reliable groundwater levels for accurate groundwater measurements at the time the test borings were performed unless records are made over several days' time. Factors such as weather, soils porosity, etc., will cause the groundwater level to fluctuate for both pervious and impervious soils.

Sample Type

If not otherwise indicated, the sample is a split-barrel liner sample ASTM D 1586.

"S.T." – Shelby tube sample, ASTM D 1587
"A" – disturbed augered sample
"C" – rock core sampled ASTM D 2113
N.P.M. – Natural Percent Moisture of in-situ soils sample
N.D. – Natural Density of in-situ soils sample in pcf.
S.S. – Shear Strength of cohesive soils samples as determined by the Unconfined Compression tests in ksf.

Classification Data – Laboratory data to assist in classification of soils and classification of soils characteristics; i.e., plastic limit or liquid limit

Test Boring Logs

Particle Size	Visual
Boulders	Larger than 12" (300 mm)
Cobbles	12" to 3" (300 to 75 mm)
Gravel - Coarse	3" to ¾" (75 to 19 mm)
Gravel - Fine	19.0 to 4.75 mm
Sand - Coarse	4.75 to 2.0 mm
Sand - Medium	2.0 to 0.425 mm
Sand - Fine	0.425 to 0.075 mm
Silt	0.075 to 0.002 mm
Clay	0.002 mm and smaller

Soils Components

Major Component	Minor Component
Gravel	Trace [1 - 10%]
Sand	Some [11 - 35%]
Silt/Clay	And [36 - 50%]

Condition of Soil Relative to Compactness

Granular Material	"N" Value
Loose	0 - 4
Slightly Compact	5 - 7
Compact	8 - 20
Very Compact	21 - 50
Extremely Compact	51 and above

Cohesive Material	"N" Value
Soft	0 - 4
Firm	5 - 7
Stiff	8 - 20
Very Stiff	21 - 50
Extremely Stiff	51 and above

"N" values in clay soils are not to be used as a measure of shear strength. However, they may be used as a general indication of strength.

Unified Soil Classification System Chart

Major Divisions			Letter Symbol	Typical Descriptions
Coarse Grained Soils	Gravel – Gravelly Soils	Clean gravels (little or no fines)	GW	Well-Graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly-Graded gravels, gravel-sand mixtures, little or no fines
		Gravel with Fines (appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sand and Sandy Soils	Clean Sand (little or no fines)	SW	Well-Graded sands, gravelly sands, little or no fines
			SP	Poorly-Graded sands, gravelly sands, little or no fines
		Sand with Fines (appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine Grained Soils	Silts and Clays Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays or low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays or low plasticity
	Silts and Clays Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sand or silty soils
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays or medium to high plasticity, organic silts
	Highly organic soils		PT	Peat, humus, swamp soils with high organic contents

For Laboratory Classification of Fine Grained Soil Plasticity Chart

