APPENDIX A

Geotechnical Report

GEOTECHNICAL INVESTIGATION
PROPOSED WHARF RECONSTRUCTION
SAVAGE HARBOUR SMALL CRAFT HARBOUR
QUEENS COUNTY, PEI

JOOSE ENVIRONMENTAL PROJECT NO. JE0300

GEO SERVICES
GEOTECHNICAL DIVISION OF
JOOSE ENVIRONMENTAL

Joose Environmental Consulting Inc.
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April 26, 2018

Joose Environmental Project No. JE0300

Ms. Katie McCarthy, P. Eng.
Small Craft Harbours, Fisheries and Oceans Canada
165 John Yeo Drive
Charlottetown, PE C1E 3J3

Dear Ms. McCarthy:

Reference: Geotechnical Investigation - Proposed Wharf Reconstruction
Savage Harbour Small Craft Harbour, Queens County, PEI

This report presents the results of the geotechnical investigation carried out for the above noted project, in accordance with your request. The purpose of the investigation was to establish the subsurface conditions within the area of the proposed wharf reconstruction and, based on the conditions encountered, to provide geotechnical engineering recommendations pertaining to wharf design and construction.

PROCEDURE

The field work for the present investigation was carried out on March 13, 2018 and consisted of drilling three (3) boreholes at the site, designated BH 1-18 to BH 3-18, with a CME 55 auger drill rig mounted on a tracked carrier. The boreholes were advanced to depths ranging from 15.3 to 18.3 m below the wharf deck (i.e., pavement surface) at the locations shown on the appended Drawing No. 1.

Samples of the overburden soils encountered were taken at regular intervals by means of a conventional split spoon sampler during the performance of Standard Penetration Tests. Bedrock was proven at each borehole by rotary core drilling in NQ-size (i.e., 48 mm core diameter).

All soil samples recovered were placed in moisture-proof containers and were delivered, with the rock core, to our office for classification and testing. All soil and rock core samples remaining after testing will be stored for a period of 60 days from the date of issue of this report after which they will be discarded unless directions to the contrary are received.

Detailed logs of the strata encountered at the site and of the sampling and testing carried out are shown on the appended Borehole Records.

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The locations and elevations of the boreholes were established in the field by our personnel. The borehole locations were established relative to the existing wharf and with a handheld GPS unit set to NAD 83 UTM Zone 20 as follows:

Location	Northing, m	Easting, m
BH 1-18	5141442	512333
BH 2-18	5141470	512314
BH 3-18	5141499	512293

The ground surface elevations at the boreholes were determined with respect to Low Normal Tide (Chart) Datum based on the existing site benchmark (CHS BM 76-P-116) shown on appended Drawing No. 1.

SUBSURFACE CONDITIONS

The subsurface conditions encountered at the boreholes are shown in detail on the appended Borehole Records, are summarized on Table 1 (also appended), and are described below. The results of all laboratory testing carried out for soil classification purposes are presented on Table 2 (appended).

Fill Materials

Fill materials were encountered at the surface of the boreholes and found to extend to depths ranging from 3.0 to 3.4 m. The fill was generally found to consist of a gravelly silty sand with some wood and occasional cobbles. The upper 75 to 90 mm of the fill at the boreholes is comprised of an asphalt pavement layer.

Standard Penetration Test N-values of 6, 10,13,17 and 45 were obtained within the fill indicating a highly variable, loose to compact, relative density. The N-value of 45 may be attributed to the presence of some wood (possibly cribbing) within the fill.

Grain size testing (curves appended) performed on representative samples of the fill shows it to contain 26 to 39 percent gravel, 45 to 53 percent sand, and 16 to 21 percent fines (i.e., silt and clay sizes). The moisture content of the fill (2 samples) was found to range from 12 to 13 percent.

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Marine Deposit

A marine deposited layer comprised of a reddish brown silty sand with trace to some gravel was encountered directly below the fill at the borehole locations. The thickness of the marine deposit was found to range from 1.5 m at BH 3-18 to 2.9 m at BH 1-18.

N-values obtained with the marine deposit were found to range from 1 to 6 with an average of 4 indicating a very loose to loose relative density.

A grain size test (curve appended) shows the silty sand to contain 20 percent gravel, 49 percent sand, and 31 percent fines. The silty sand sample was found to have a moisture content of 17 percent.

Glacial Till

A glacially derived till stratum, ranging in thickness from 6.4 to 8.8 m, was encountered directly below the marine deposit at the borehole locations. The till generally consists of a reddish brown silt and sand with trace clay, trace to some gravel, and occasional sandstone cobbles. The elevation of the till surface was found to range from a low of el. -4.56 m at BH 1-18 to a high of el. -2.87 m at BH 3-18.

N-values obtained within the till were found to range from 10 to 24 with an average of 15 indicating a compact relative density.

Grain size analyses (curves appended) performed on selected split spoon samples of the till show it to contain 8 to 36 percent gravel, 33 to 48 percent sand, and 31 to 44 percent fines. Two Atterberg Limit determinations performed on the till show it to contain fines of low plasticity based on average liquid and plastic limits of 18 percent and 15 percent, respectively. The natural moisture content of the till (4 samples) was found to range from 13 to 15 percent.

Bedrock

Sedimentary bedrock was encountered directly below the till stratum at the borehole locations, at depths ranging from 11.9 m at BH 3-18 to 14.9 m at BH 1-18. The elevation of the bedrock surface was found to range from a low of el. -13.40 m at BH 1-18 to a high of el. -10.19 m at BH 3-18.

The rock core recovered consisted predominantly of very weak to weak, medium-grained, reddish brown sandstone with occasional layers of very stiff to hard mudstone. A layer of very weak to weak, fine-grained sandstone was encountered at BH 3-18, as depicted on the Borehole Record.

The bedrock is horizontally bedded with extremely close (<20 mm) to moderately close (200 to 600 mm) joints which typically occur along the bedding planes. Average recovery and RQD (Rock Quality Designation) values of 96 percent and 59, respectively, indicate fair quality, fractured bedrock.

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Groundwater

It may be assumed that the groundwater table at the site is directly governed by tidal variations within Savage Harbour.

DISCUSSION AND RECOMMENDATIONS

It is understood that the existing wharf (i.e., Structures 404, 402 and 403) is be replaced with either a new Berlin Wall type structure (similar to the existing wharf construction) or a timber pile wharf, with a rock slope below. The effects of the subsurface conditions encountered on the design and construction of the proposed wharf are considered in the following sections.

Berlin Wall

For a wharf design incorporating steel H-piles, it is expected that the piles would be driven into bedrock. Steel piles should be driven to refusal using a hammer with a rated energy of at least 350 J/cm^2 of net steel cross sectional area. Refusal may be taken as 10 blows for the last 25 mm of pile penetration. Re-tapping of some piles (e.g., 20 percent) within a 48-hour period is recommended to assess relaxation effects, and the requirement to re-tap additional piles.

Actual penetration depths of steel H-piles into the sandstone bedrock will depend on the driving energy delivered and the bedrock condition/strength at the pile locations. Previous experience has shown that penetration depths can vary significantly from site to site or within the same site (depending on the rock quality and strength) and can range from less than 1 m to 2 m or more. For the conditions encountered at the boreholes, it is expected that penetration depths of more than 0.5 to 1 m would likely be difficult to achieve.

The vertical capacity of steel H-piles driven to refusal, as defined above, may be determined using an allowable contact stress of 50 MPa (based on net steel area). The settlement of piles installed as outlined above and proportioned for foundation loads would be negligible.

For the analysis of lateral resistance, an effective pile width of 2.5 times the pile diameter may be used. Additional geotechnical parameters required for the design of a Berlin Wall are provided in the Design Parameters section of the report.

Timber Piles

The capacity of timber piles driven to refusal on the bedrock surface would be governed by the allowable fiber stress of the pile. For timber piles driven to bedrock, refusal is typically taken as 4 blows per 25 mm of pile penetration using a hammer energy in the order of 750 joules times the pile tip diameter in centimeters. The use of a protective shoe is recommended to prevent damage to the pile tip during driving. Penetration of timber piles into the sandstone bedrock, of any significant amount, is not expected.

Re-tapping of some piles (e.g., 20 percent) within a 48-hour period is recommended to assess relaxation effects, and the requirement to re-tap additional piles.

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The settlement of piles installed as outlined above and proportioned for the expected loads would be negligible. For the analysis of lateral resistance, an effective pile width of 2.5 times the pile diameter may be used.

It should be noted that, in view of the very loose/loose marine soils encountered at the site, the design of a timber pile supported wharf would have to take into consideration the stability of the rock slope below. Depending on the expected design configuration/geometry of the proposed wharf, a slope stability analysis may be warranted to ensure long-term stable conditions are achieved. Additional comments/recommendations can be provided, if requested, when more design details are available.

Design Parameters

The geotechnical design parameters provided in the table below may be assigned to the various strata encountered for Berlin Wall wharf design purposes.

Design Parameters	Existing Fill	Marine Deposit (Silty Sand)	Glacial Till	Sandstone Bedrock
Total Unit Weight, kN/m^3	22	21	22	23
Submerged Unit Weight, kN/m^3	12	11	12	13
Effective Friction Angle (Φ), degrees	30	28	30	36[3]
Active Earth Pressure Coefficient, K_a[4]	0.33	0.36	0.33	0.26
Passive Earth Pressure Coefficient, K_p[1,4]	3.00	2.77	3.00	3.86
Passive Earth Pressure Coefficient, K_p[2,4]	5.13	4.59	5.13	7.46

Notes:

[1] - neglecting the effects of wall friction

[2] - including the effects of wall friction for a Berlin Wall with concrete panels (based on δ ultimate = 17 degrees)

[3] - based on sandstone bedrock zone fragmented by pile penetration

[4] - earth pressure coefficients provided are for a vertical wall and a horizontal backfill

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Other Considerations

For driven steel and timber piles, some uplift resistance will be obtained through shaft friction (typically 50 percent of the shaft friction available in compression is assumed for uplift). The actual magnitude of the uplift resistance would depend on the type/size of the pile selected for use and the depth driven. More details can be provided if requested.

For the Berlin Wall option, some settlement of the wharf deck could occur as a result of the compression of the loose existing fill and the underlying very loose/loose marine deposit, particularly if the wharf deck grade at the site is to be raised. Since the existing fill and the marine soil encountered at the boreholes are essentially coarse-grained soils with non-plastic fines, the majority of the expected settlement should occur as the load is being applied (i.e., during fill placement). Further comments pertaining to settlement can be provided, if requested, as more design details become available.

CLOSING COMMENTS

A subsurface investigation is a limited sampling of a site. In the event that any conditions are encountered that differ from those encountered at the test locations, we request that we be notified immediately to permit a reassessment of our design assumptions. We trust this report contains all of the information required at this time, and we are available at your convenience should you have any questions.

Sincerely,

JOOSE ENVIRONMENTAL CONSULTING INC.

George Zafiris

George W. Zafiris, P. Eng.
Geotechnical Engineer
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GWZ/gz

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APPENDIX

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Table 1 - Borehole Summary - Savage Harbour Small Craft Harbour

	Borehole Number		
	BH 1-18	BH 2-18	BH 3-18
Wharf Deck el., m	1.54	1.71	1.70
Fill Thickness, m	3.20	3.35	3.05
Marine Deposit Thickness, m	2.90	2.74	1.52
Depth to Till Surface, m	6.10	6.09	4.57
Till Surface el., m	-4.56	-4.38	-2.87
Till Thickness, m	8.84	6.41	7.32
Depth to Bedrock, m	14.94	12.50	11.89
Bedrock Surface el., m	-13.40	-10.79	-10.19
Depth of Borehole, m	18.29	17.07	15.32

NOTES:

- the boreholes was drilled at the site on March 13, 2018 using a track-mounted CME 55 auger drill rig
- elevations are referenced to Low Normal Tide (Chart) Datum based on CHS BM No. 76-P-116
- bedrock was proven at the boreholes by rotary core drilling in NQ-size

Table 2 - Laboratory Testing Summary - Savage Harbour

			Grain Size Distribution, %			Atterberg Limits, %			Moisture Content, %	Soil Description
Borehole No.	Sample No.	Depth, m	Gravel	Sand	Silt/ Clay	LL	PL	PI		
BH 1-18	SS 1	0.3 to 0.9	39	45	16	-	-	-	12	Gravelly silty sand: Fill
BH 1-18	SS 5	3.8 to 4.4	20	49	31	-	-	-	17	Silty sand, some gravel: Marine Deposit
BH 1-18	SS 7	6.0 to 6.6	8	48	44	19	16	3	14	Silt and sand, trace clay, gravel: Till
BH 3-18	SS 1	0.3 to 0.9	26	53	21	-	-	-	13	Gravelly silty sand: Fill
BH 3-18	SS 4	4.6 to 5.2	36	33	31	17	15	2	13	Gravelly silt and sand, trace clay: Till
BH 3-18	SS 6	7.6 to 8.2	-	-	-	-	-	-	13	Silt and sand, trace clay, gravel: Till
BH 3-18	SS 8	10.7 to 11.3	-	-	-	-	-	-	15	Silt and sand, trace clay, gravel: Till

Notes:

- LL denotes liquid limit
- PL denotes liquid limit
- PI denotes plasticity index

The following information is intended to assist in the interpretation of terms and symbols used on the borehole logs, test pit logs and reports.

Soils Description

Terminology describing common soil genesis:

Topsoil	-	mixture of soil and humus capable of supporting vegetative growth
Peat	-	mixture of visible and invisible fragments of decayed organic matter
Till	-	unstratified glacial deposit which may range from clay to boulders
Fill	-	material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	-	having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure
Varved	-	composed of regular alternating layers of silt and clay
Stratified	-	composed of alternating successions of different soil types, e.g. silt and sand
Layer	-	> 75 mm in thickness
Seam	-	2 mm to 75 mm in thickness
Parting	-	< 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Modified Unified Soil Classification System (MUSCS) and in accordance with the Canadian Foundation Engineering Manual Fourth Edition (Canadian Geotechnical Society, 2006). The classification excludes particles larger than 75 mm (3 inches). The MUSCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Consistency of Cohesive Soils: May be estimated using simple field tests, or described in terms of a strength scale. In the field, the undrained shear strength (s_u) can be assessed using a simple field tool appropriate for cohesive soils, in conjunction with the relevant calibration. Refer to AS 1726-1993, Table A4.

Consistency - Essentially Cohesive Soils					
Term	**Field Guide**	**Symbol**	**SPT "N" Value**	**Undrained Shear Strength su (kPa)**	**Unconfined Compressive Strength qu (kPa)**
Very soft	Oozes between fingers when	VS	0-2	<12	<25
Soft	Easily moulded with fingers.	S	2-4	12-25	25-50
Firm	Can be moulded by strong pressure of fingers.	F	4-8	25-50	50-100
Stiff	Not possible to mould with fingers.	St	8-15	50-100	100-200
Very stiff		VSt	15-30	100-200	200-400
Hard	Can be indented with difficulty by thumb nail.	H	>30	>200	>400

Note: SPT - N to q_u correlation from Terzaghi and Peck, 1967. (General guide only).

Soil Particle Sizes	
Term	**Size Range**
BOULDERS	>200 mm
COBBLES	63-200 mm
Coarse GRAVEL	20-63 mm
Medium GRAVEL	6-20 mm
Fine GRAVEL	2.36-6 mm
Coarse SAND	0.6-2.36 mm
Medium SAND	0.2-0.6 mm
Fine SAND	0.075-0.2 mm
SILT	0.002-0.075 mm
CLAY	<0.002 mm

Consistency of Non-Cohesive Soils: Is described in terms of the density index, as defined in AS 1289.0-2000. This can be assessed using a field tool appropriate for non-cohesive soils, in conjunction with the relevant calibration. Refer to AS 1726-1993, Table A5; BS5930-1999, p117.

Consistency - Essentially Non-Cohesive Soils				
Term	**Symbol**	**SPT N Value**	**Field Guide**	**Density Index (%)**
Very loose	VL	0-4	Foot imprints readily	0-15
Loose	L	4-10	Shovels Easily	15-35
Medium dense	MD	10-30	Shovelling difficult	35-65
Dense	D	30-50	Pick required	65-85
Very dense	VD	>50	Picking difficult	85-100

Standard Penetration Test (SPT): Refer to. AS 1289.6.3.1-2004. Example report formats for SPT results are shown below:

Test Report	Penetration Resistance (N)	Explanation / Comment
4, 7, 11	N=18	Full penetration; N is reported on engineering borehole log
18, 27, 32	N=59	Full penetration; N is reported on engineering borehole log
4, 18, 30/15 mm	N is not reported	30 blows causes less than 100 mm penetration (3rd interval) - test discontinued
30/80 mm	N is not reported	30 blows causes less than 100 mm penetration (1st interval) - test discontinued
rw	N<1	Rod weight only causes full penetration
hw	N<1	Hammer and rod weight only causes full penetration
hb	N is not reported	Hammer bouncing for 5 consecutive blows with no measurable penetration - test discontinued

Rock Description

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology Describing Rock Quality:

RQD	Rock Mass Quality
0 - 25	*Very Poor Quality*
25 - 50	*Poor Quality*
50 - 75	*Fair Quality*
75 - 90	*Good Quality*
90 - 100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 inches) long are summed up and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved forma borehole of any orientation. All pieces of the solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of the natural occurring fractures.

Refer to AS 1726-1993 (Appendix A3.3) for the description and classification of rock material composition, including:

(a) Rock type (Table A6, (a) and (b))
(b) Grain size
(c) Texture and fabric
(d) Colour (describe as per soil).

The condition of a rock material refers to its weathering characteristics, strength characteristics and rock mass properties. Refer to AS 1726-1993 (Appendix A3 Tables A8, A9 and A10).

Weathering Condition (Degree of Weathering):

The degree of weathering is a continuum from fresh rock to soil. Boundaries between weathering grades may be abrupt or gradational.

Rock Material Weathering		
Weathering Grade	**Symbol**	**Definitio**
Residual Soil	RS	Soil-like material developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the material has not been significantly transported.
Extremely Weathered Rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded in water, but substance fabric and rock structure still recognizable.
Highly Weathered Rock	HW	Strong discolouration is evident throughout the rock mass, often with significant change in the constituent minerals. The intact rock strength is generally much weaker than that of the fresh rock.
Moderately Weathered Rock	MW	Modest discolouration is evident throughout the rock fabric, often with some change in the constituent minerals. The intact rock strength is usually noticeably weaker than that of the fresh rock.
Slightly Weathered	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh Rock	FR	Rock shows no sign of decomposition or staining.

Notes:

1. Minor variations within broader weathering grade zones will be noted on the engineering borehole logs.
2. Extremely weathered rock is described in terms of soil engineering properties.
3. Weathering may be pervasive throughout the rock mass, or may penetrate inwards from discontinuities to some extent.
4. The 'Distinctly Weathered (DW)' class as defined in AS 1726-1993 is divided to incorporate HW and MW in the above table. The symbol DW should not be used.

Strength Condition (Intact Rock Strength):

Terminology Describing Rock Strength

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	< 1
Very Weak	R1	1 - 5
Weak	R2	5 - 25
Medium Strong	R3	25 - 50
Strong Very	R4	50 - 100
Strong Extremely	R5	100 - 250
Strong	R6	> 250

Discontinuity Spacing: On the geotechnical borehole log, a graphical representation of defect spacing vs depth is shown. This representation takes into account all the natural rock defects occurring within a given depth interval, excluding breaks induced by the drilling / handling of core. Refer to AS 1726-1993, BS5930-1999.

Defect Spacing			Bedding Thickness (Sedimentary Rock Stratification)	
Spacing/Width (mm)	**Descriptor**	**Symbol**	**Descriptor**	**Spacing /Width (mm)**
			Thinly Laminated	<6
<20	Extremely Close	EC	Thickly Laminated	6 - 20
20 - 60	Very Close	VC	Very Thinly Bedded	20 - 60
60 - 200	Close	C	Thinly Bedded	60 -200
200 - 600	Medium	M	Medium Bedded	200 - 600
600 - 2000	Wide	W	Thickly Bedded	600 - 2000
2000 - 6000	Very Wide	VW	Very Thickly Bedded	>2000
>6000	Extremely Wide	EW		

Defect Spacing in 3D	
Term	**Description**
Blocky	Equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greater than cross section

Direct Persistence (areal extent)
Trace length of defect given in metres

The list on the following table provides an explanation of terms and symbols used on the geotechnical borehole, test pit and penetrometer logs.

Test Results					Test Symbols	
PI	Plasticity Index	c'	Effective Cohesion		DCP	Dynamic Cone Penetrometer
LL	Liquid Limit	c_u	Undrained Cohesion		SPT	Standard Penetration Test
LI	Liquidity Index	c'_R	Residual Cohesion		CPTu	Cone Penetrometer (Piezocone) Test
DD	Dry Density	φ'	Effective Angle of Internal Friction		PANDA	Variable Energy DCP
WD	Wet Density	φ_u	Undrained Angle of Internal Friction		PP	Pocket Penetrometer Test
LS	Linear Shrinkage	φ'_R	Residual Angle of Internal Friction		U50	Undisturbed Sample 50 mm (nominal diameter)
MC	Moisture Content	c_v	Coefficient of Consolidation		U100	Undisturbed Sample 100mm (nominal diameter)
OC	Organic Content	m_v	Coefficient of Volume Compressibility		UCS	Uniaxial Compressive Strength
WPI	Weighted Plasticity Index	$c_{\alpha\varepsilon}$	Coefficient of Secondary Compression		Pm	Pressuremeter

Test Results					Test Symbols	
WLS	Weighted Linear Shrinkage	e	Voids Ratio		FSV	Field Shear Vane
DoS	Degree of Saturation	φ'_{cv}	Constant Volume Friction Angle		DST	Direct Shear Test
APD	Apparent Particle Density	q_t / q_c	Piezocone Tip Resistance (corrected / uncorrected)		PR	Penetration Rate
s_u	Undrained Shear Strength	q_d	PANDA Cone Resistance		A	Point Load Test (axial)
q_u	Unconfined Compressive Strength	$I_{s(50)}$	Point Load Strength Index		D	Point Load Test (diametral)
R	Total Core Recovery	*RQD*	Rock Quality Designation		L	Point Load Test (irregular lump)

Sample Type

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameters tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ,NQ, BQ, etc	Rock core samples obtained with the use of standard size diamond coring bits.

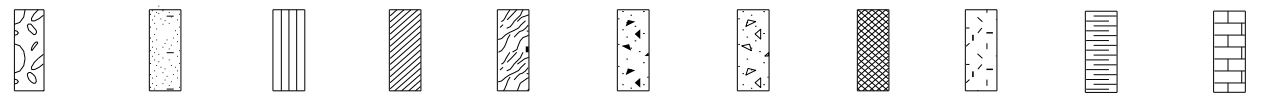
Water Level Measurement

Measurement in standpipe, piezometer, or well

Inferred

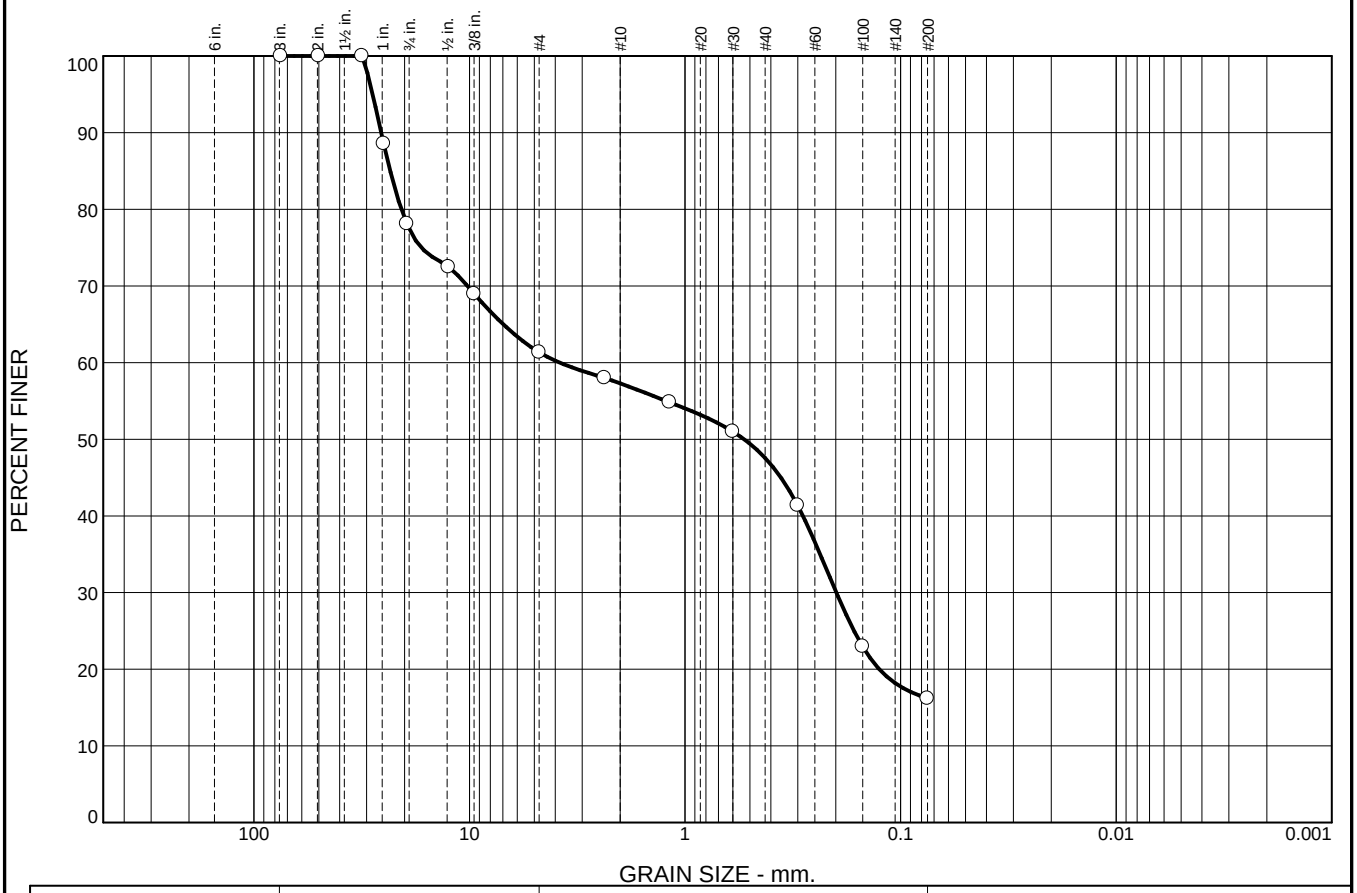
Strata Plot

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders Cobbles Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Igneous Bedrock | Meta-morphic Bedrock | Sedi-mentary Bedrock

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	23	16	4	9	32	16	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			23.3077	3.8182	0.5322	0.1986				

Material Description	USCS	AASHTO
○ Insitu, March 20, 2018		

Project No. 18-12994 **Client:** Joose Environmental

Project: QC Soils Analysis JE-300 Savage Harbour

○ **Location:** BH#1-18-SS#1 **Sample Number:** 1

Remarks:

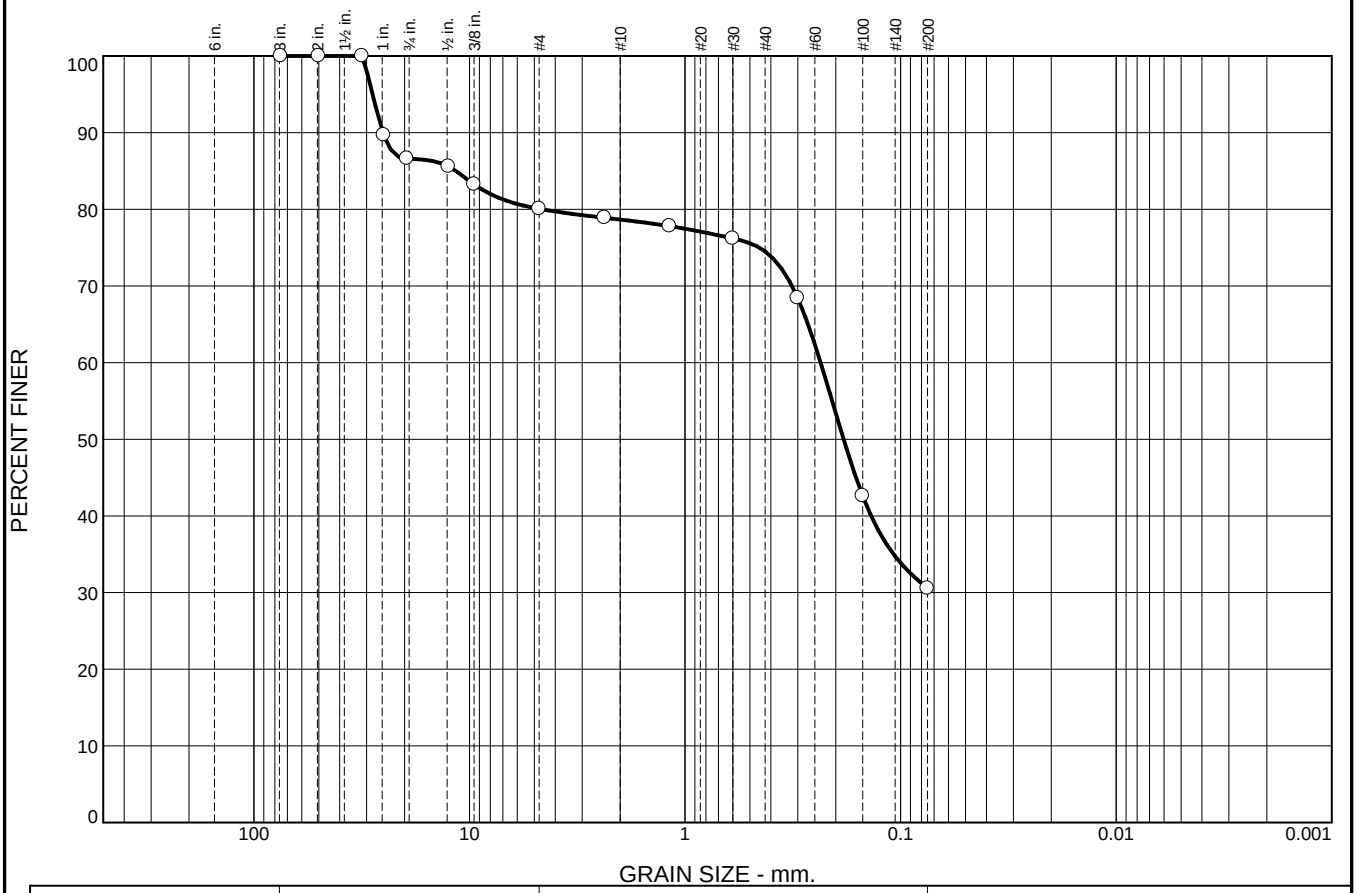
○Moisture content of the sample was 12.0%

FUNDY Engineering

Figure

Tested By: D. Taweel

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	13	7	1	5	43	31	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			11.5645	0.2351	0.1838					

Material Description	USCS	AASHTO
○ Insitu, March 20, 2018		

Project No. 18-12994 **Client:** Joose Environmental

Project: QC Soils Analysis JE-300 Savage Harbour

○ **Location:** BH#1 - SS#5 **Depth:** 12'6"-14'6" **Sample Number:** 2

Remarks:

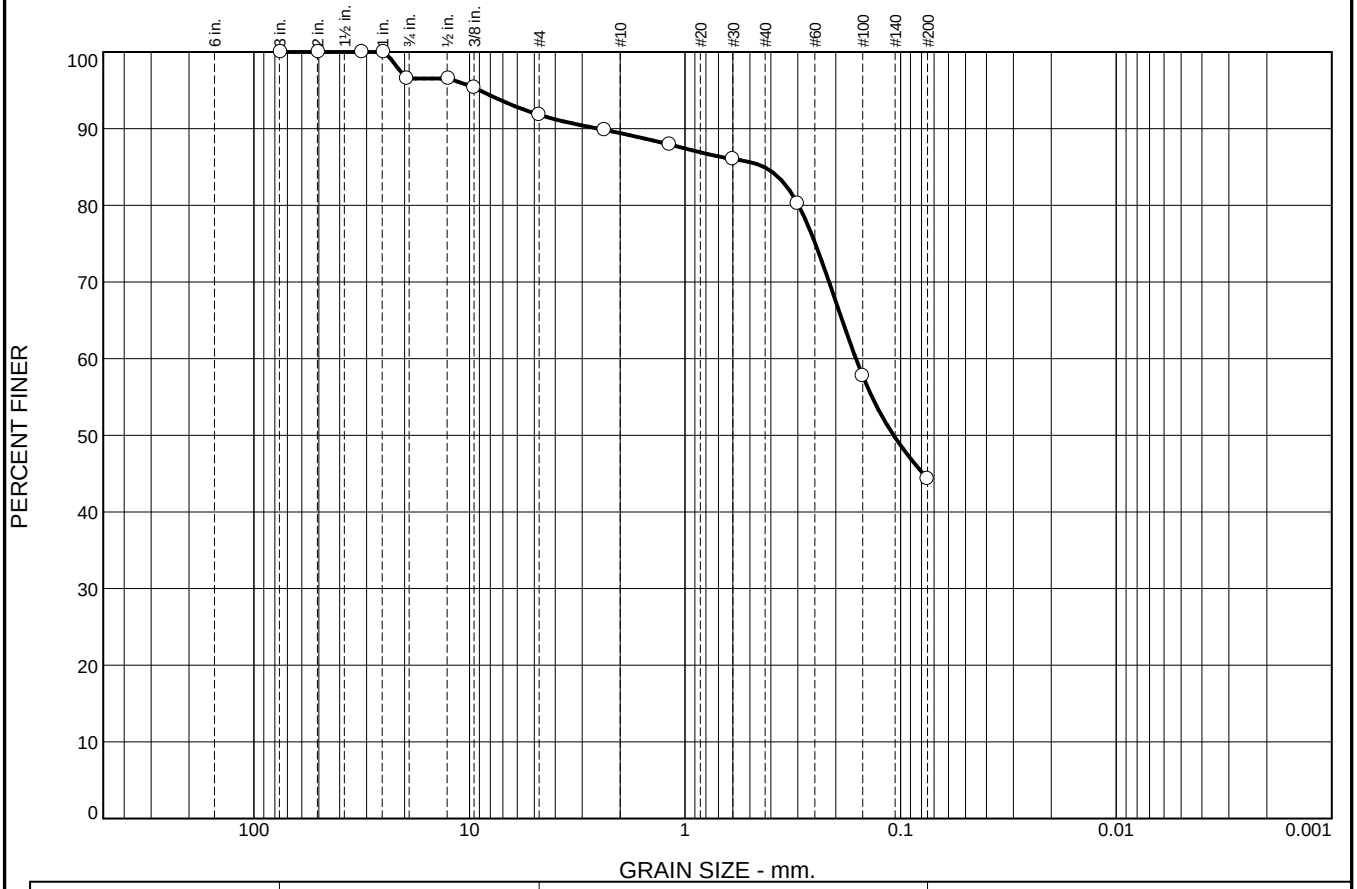
○Moisture content of the sample was 17.3%

FUNDY Engineering

Figure

Tested By: D. Taweel

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	3	5	3	4	41	44	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.4303	0.1613	0.1078					

Material Description	USCS	AASHTO
○ Insitu, March 20, 2018		

Project No. 18-12994 **Client:** Joose Environmental

Project: QC Soils Analysis JE-300 Savage Harbour

○ **Location:** BH#1 - SS#7 **Depth:** 20'- 22' **Sample Number:** 3

FUNDY Engineering

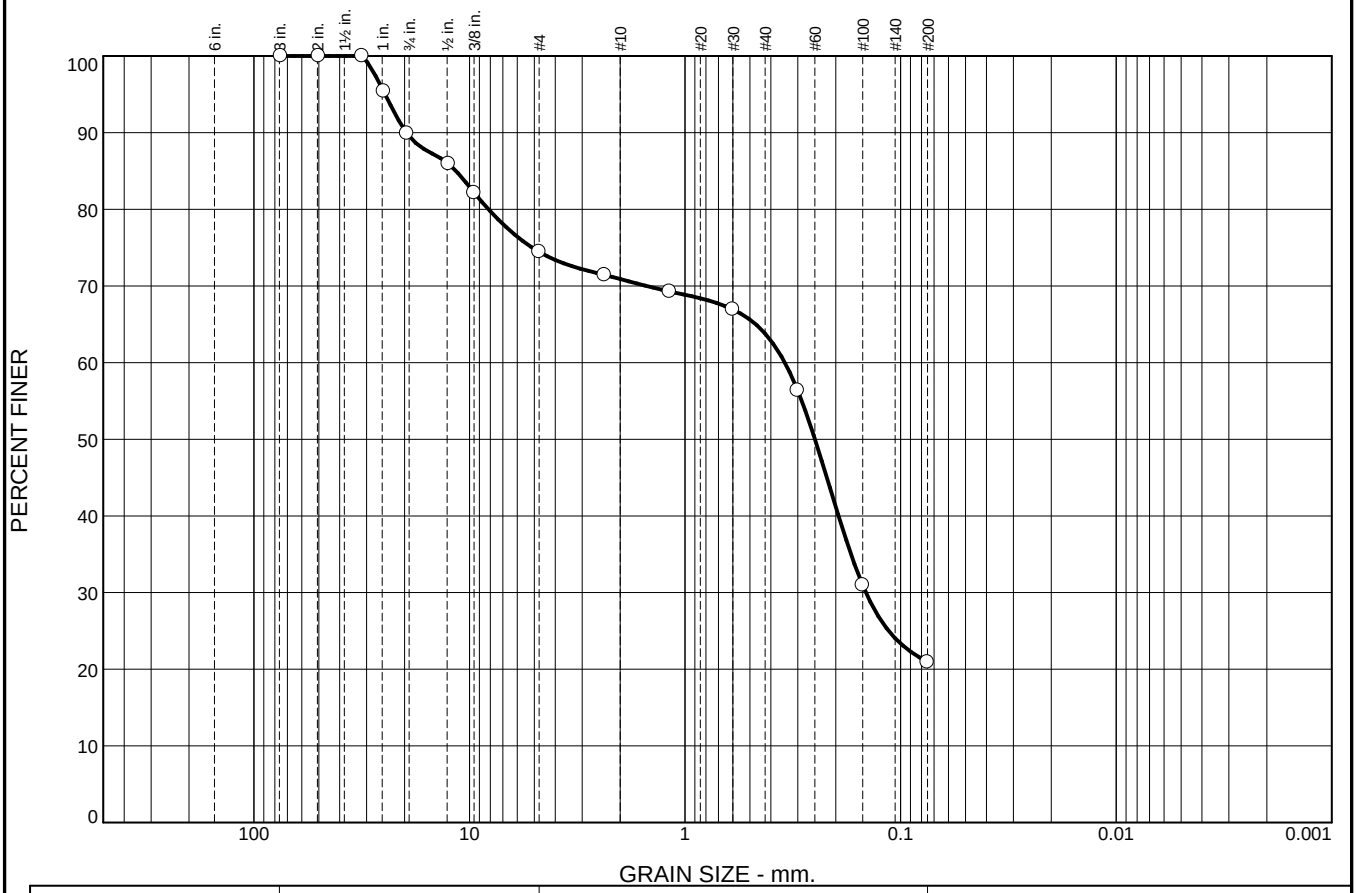
Remarks:

○Moisture content of the sample was 14.6%

Figure

Tested By: D. Taweel

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	10	16	3	7	43	21	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			11.5439	0.3444	0.2497	0.1449				

Material Description	USCS	AASHTO
○ Insitu, March 20, 2018		

Project No. 18-12994 **Client:** Joose Environmental

Project: QC Soils Analysis JE-300 Savage Harbour

○ **Location:** BH#3 - 18 SS#1 **Depth:** 1'-3' **Sample Number:** 4

Remarks:

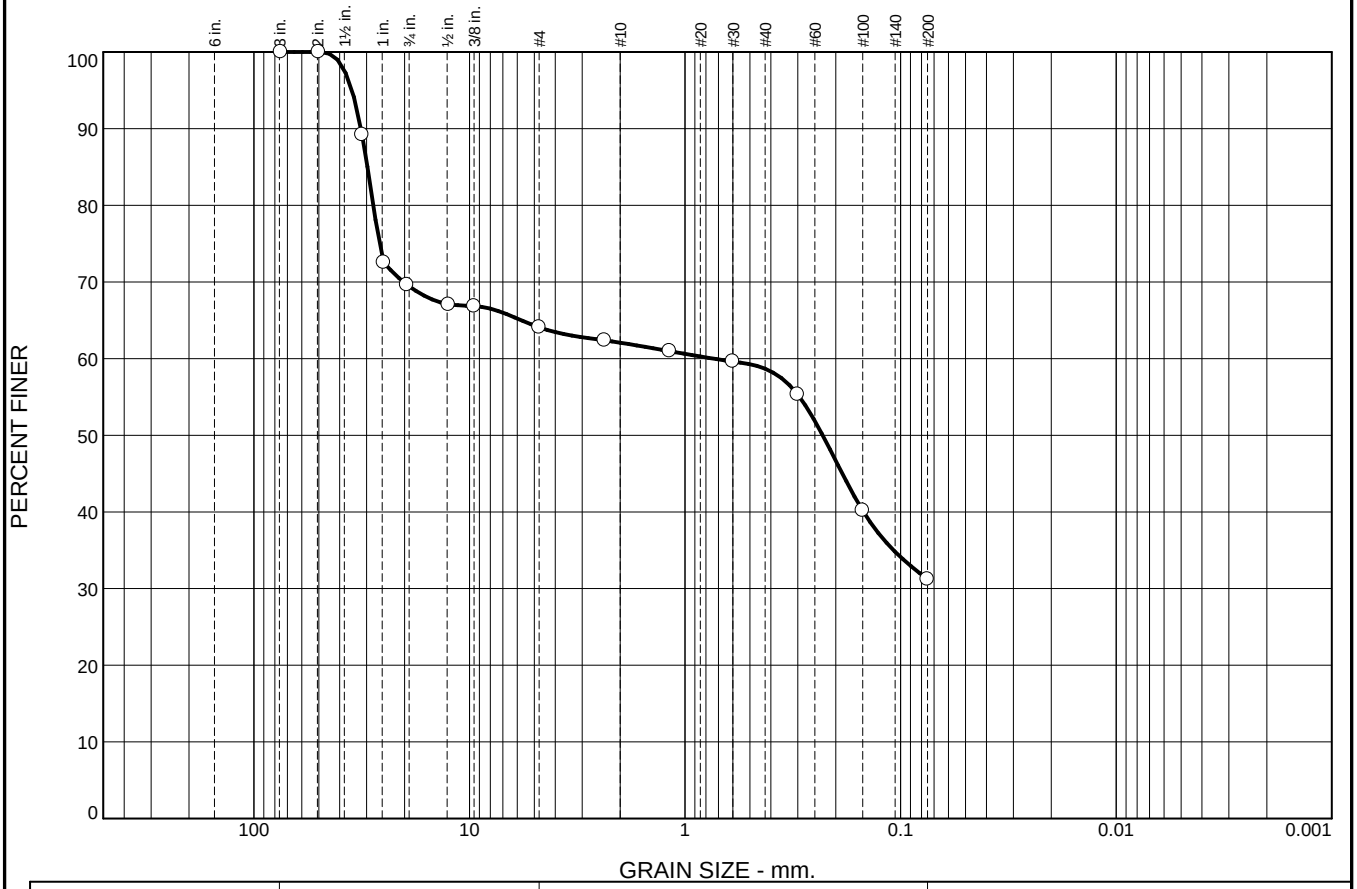
○Moisture content of thew sample was 13.0%

FUNDY Engineering

Figure

Tested By: D. Taweel

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	31	5	2	3	28	31	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			29.7649	0.7386	0.2300					

	Material Description	USCS	AASHTO
○	Insitu, March 20, 2018		

Project No. 18-12994 **Client:** Joose Environmental

Project: QC Soils Analysis JE-300 Savage Harbour

○ **Location:** BH#3 - 18 SS#4 **Depth:** 15'-17' **Sample Number:** 5

Remarks:

○Moisture content of the sample was 13.4%

FUNDY Engineering

Figure

Tested By: D. Taweel

BOREHOLE No. BH 1-18

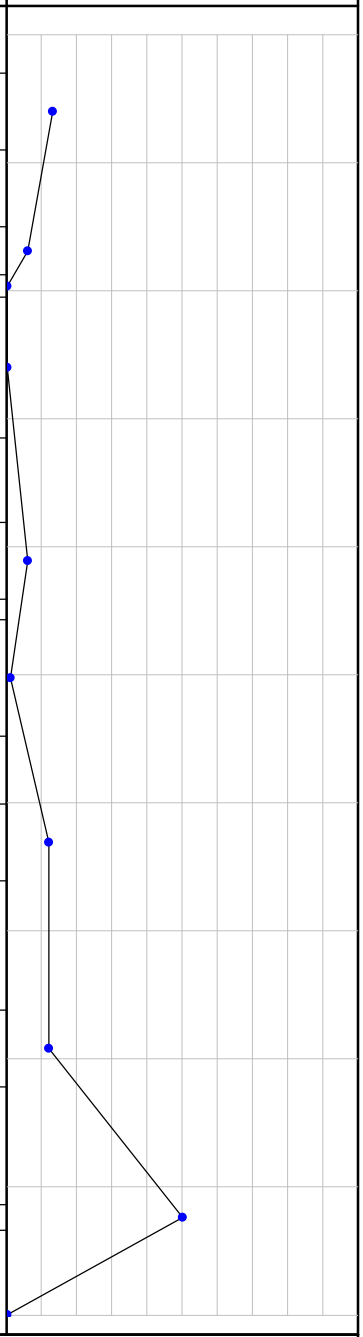
Date Drilled: March 13, 2018
Water Level: Tidal
Contractor/Equipment: Logan/CME 55

Project No.: JE0300
Elevation: 1.54 m
Datum: Low Normal Tide (Chart)

Location: Savage Harbour, Queens County, PEI
Project: Proposed Wharf Reconstruction
Client: Small Craft Harbours, Fisheries and Oceans Canada

Depth (ft / m)	Elevation, m	SOIL DESCRIPTION	Strata Plot	Water Level	Sample Type	Sample Number	Recovery, mm	SPT N-Value	RQD	Moisture Content, %	Other Tests
0 / 0	1.54	Wharf Deck									
	0.00										
2		Compact to loose reddish brown gravelly silty sand, some wood, and occasional cobbles (imported): **FILL**; upper 90 mm pavement			SS	1	450	13		12	S
6					SS	2	175	6			
					NQ	3	175				
10 / 3					NQ	4	100				
	-1.66										
	3.20										
13 / 4		Loose to very loose reddish brown silty sand, trace to some gravel: **MARINE DEPOSIT**			SS	5	450	6		17	S
16 / 5					SS	6	150	1			
19 / 6	-4.56										
20	6.10				SS	7	400	12		14	S/A
23 / 7		Compact reddish brown silt and sand, trace clay, trace to some gravel, occasional sandstone cobbles: **TILL**									
26 / 8					SS	8	450	12			
29 / 9					SS	9	75	50			
33					NQ	10	300				

SPT N-Value
10 20 30 40 50 60 70 80 90



Joose Environmental

GEO SERVICES
GEOTECHNICAL DIVISION OF JOOSE ENVIRONMENTAL

BOREHOLE No. BH 1-18

Date Drilled: March 13, 2018
Water Level: Tidal
Contractor/Equipment: Logan/CME 55

Project No.: JE0300
Elevation: 1.54 m
Datum: Low Normal Tide (Chart)

Location: Savage Harbour, Queens County, PEI
Project: Proposed Wharf Reconstruction
Client: Small Craft Harbours, Fisheries and Oceans Canada

Depth	Elevation, m	SOIL DESCRIPTION	Strata Plot	Water Level	Sample Type	Sample Number	Recovery, mm	SPT N-Value	RQD	Moisture Content, %	Other Tests
11		**TILL**, as above			NQ	11	300				
12					SS	12	450	17			
13											
14											
	-13.40										
15	14.94										
16		Very weak to weak, medium grained, reddish brown sandstone, occasional very stiff to hard mudstone layers (up to 300 mm): **BEDROCK**; extremely close to moderately close joint spacing			NQ	13	92%		65		
17					NQ	14	98%		75		
18											
	-16.75										
	18.29	End of Borehole									
19											

SPT N-Value
10 20 30 40 50 60 70 80 90

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GEO SERVICES
GEOTECHNICAL DIVISION OF JOOSE ENVIRONMENTAL

BOREHOLE No. BH 2-18

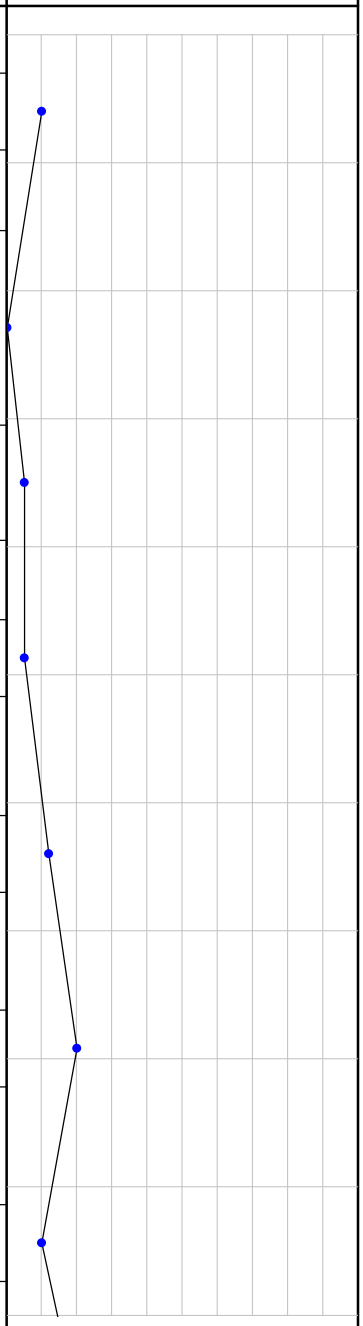
Date Drilled: March 13, 2018
Water Level: Tidal
Contractor/Equipment: Logan/CME 55

Project No.: JE0300
Elevation: 1.71 m
Datum: Low Normal Tide (Chart)

Location: Savage Harbour, Queens County, PEI
Project: Proposed Wharf Reconstruction
Client: Small Craft Harbours, Fisheries and Oceans Canada

Depth (ft / m)	Elevation, m	SOIL DESCRIPTION	Strata Plot	Water Level	Sample Type	Sample Number	Recovery, mm	SPT N-Value	RQD	Moisture Content, %	Other Tests
0 / 0	1.71	Wharf Deck									
	0.00	Compact to loose reddish brown gravelly silty sand, some wood, and occasional cobbles: **FILL**; upper 75 mm pavement			SS	1	450	10			
3 / 1											
6 / 2					NQ	2	100				
10 / 3	-1.64										
11	3.35	Loose reddish brown silty sand, trace to some gravel: **MARINE DEPOSIT**			SS	3	450	5			
13 / 4											
16 / 5					SS	4	450	5			
19 / 6	-4.38										
20	6.09	Compact reddish brown silt and sand, trace clay, trace to some gravel, occasional sandstone cobbles: **TILL**			SS	5	175	12			
23 / 7											
26 / 8					SS	6	150	20			
29 / 9											
31					SS	7	100	10			
33											

SPT N-Value
10 20 30 40 50 60 70 80 90



Joose Environmental

GEO SERVICES
GEOTECHNICAL DIVISION OF JOOSE ENVIRONMENTAL

BOREHOLE No. BH 2-18

Date Drilled: March 13, 2018
Water Level: Tidal
Contractor/Equipment: Logan/CME 55

Project No.: JE0300
Elevation: 1.71 m
Datum: Low Normal Tide (Chart)

Location: Savage Harbour, Queens County, PEI
Project: Proposed Wharf Reconstruction
Client: Small Craft Harbours, Fisheries and Oceans Canada

Depth	Elevation, m	SOIL DESCRIPTION	Strata Plot	Water Level	Sample Type	Sample Number	Recovery, mm	SPT N-Value	RQD	Moisture Content, %	Other Tests
11		**TILL**, as above			SS	8	100	22			
12					SS	9	150	32			
	-10.79										
	12.50				NQ	10	92%		33		
13		Very weak to weak, medium grained, reddish brown sandstone, occasional very stiff to hard mudstone layers (150 to 200 mm): **BEDROCK**; extremely close to moderately close joint spacing									
14					NQ	11	93%		42		
15											
16					NQ	12	97%		67		
	-15.36										
17	17.07	End of Borehole									
18											
19											

SPT N-Value
10 20 30 40 50 60 70 80 90

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GEO SERVICES
GEOTECHNICAL DIVISION OF JOOSE ENVIRONMENTAL

BOREHOLE No. BH 3-18

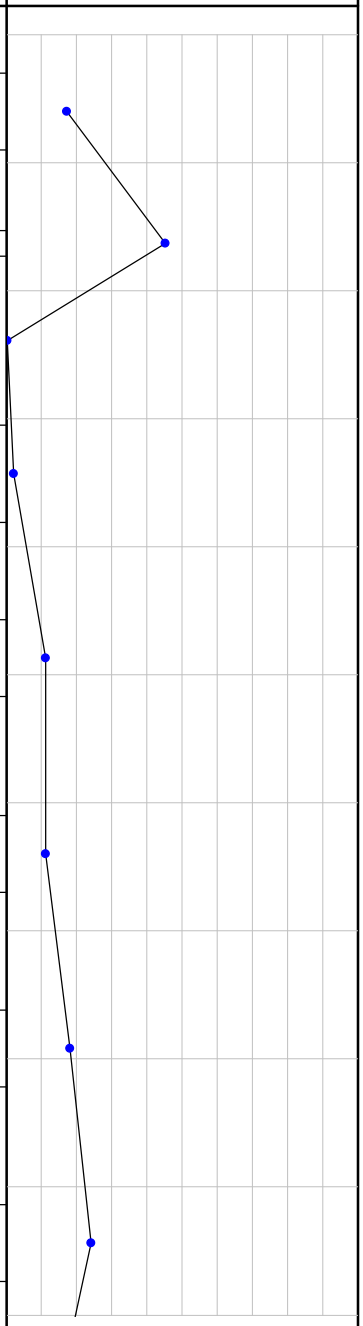
Date Drilled: March 13, 2018
Water Level: Tidal
Contractor/Equipment: Logan/CME 55

Project No.: JE0300
Elevation: 1.70 m
Datum: Low Normal Tide (Chart)

Location: Savage Harbour, Queens County, PEI
Project: Proposed Wharf Reconstruction
Client: Small Craft Harbours, Fisheries and Oceans Canada

Depth (ft / m)	Elevation, m	SOIL DESCRIPTION	Strata Plot	Water Level	Sample Type	Sample Number	Recovery, mm	SPT N-Value	RQD	Moisture Content, %	Other Tests
0 / 0	1.70	Wharf Deck									
	0.00										
2		Compact to loose reddish brown gravelly silty sand, some wood, and occasional cobbles: **FILL**; upper 75 mm pavement			SS	1	600	17		13	S
5					SS	2	175	45			
7 / 2					NQ	2x	150				
10 / 3	-1.35										
	3.05	Very loose to loose reddish brown silty sand, trace to some gravel, trace wood: **MARINE DEPOSIT**			SS	3	150	2			
15 / 4	-2.87										
	4.57				SS	4	350	11		13	S/A
20 / 6		Compact reddish brown silt and sand, trace clay, trace to some gravel, occasional sandstone cobbles: **TILL**			SS	5	450	11			
26 / 8					SS	6	375	18		13	
31 / 9					SS	7	100	24			
33											

SPT N-Value
10 20 30 40 50 60 70 80 90



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GEO SERVICES
GEOTECHNICAL DIVISION OF JOOSE ENVIRONMENTAL

BOREHOLE No. BH 3-18

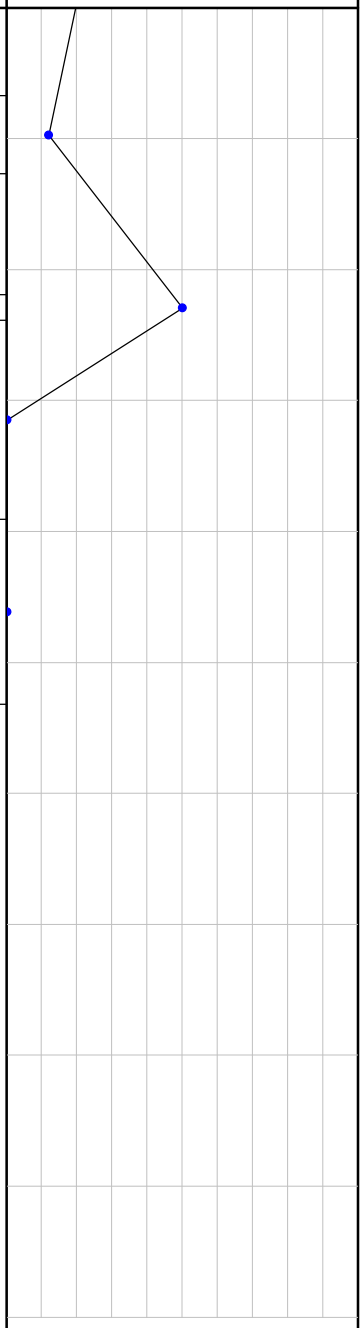
Date Drilled: March 13, 2018
Water Level: Tidal
Contractor/Equipment: Logan/CME 55

Project No.: JE0300
Elevation: 1.70 m
Datum: Low Normal Tide (Chart)

Location: Savage Harbour, Queens County, PEI
Project: Proposed Wharf Reconstruction
Client: Small Craft Harbours, Fisheries and Oceans Canada

Depth	Elevation, m	SOIL DESCRIPTION	Strata Plot	Water Level	Sample Type	Sample Number	Recovery, mm	SPT N-Value	RQD	Moisture Content, %	Other Tests
11		**TILL**, as above			SS	8	300	12		15	
	-10.19										
12	11.89	Very weak to weak, medium grained, reddish brown sandstone: **BEDROCK**; extremely close to moderately close joint spacing			SS	9	75	50			
13					NQ	10	100%		55		
	-12.00										
14	13.70	Hard reddish brown mudstone: **BEDROCK**									
	-13.00				NQ	11	100%		75		
15	14.70	Very weak to weak, fine grained, reddish brown sandstone: **BEDROCK**; extremely close to moderately close joint spacing									
	-13.62										
16	15.32	End of Borehole									
17											
18											
19											

SPT N-Value
10 20 30 40 50 60 70 80 90



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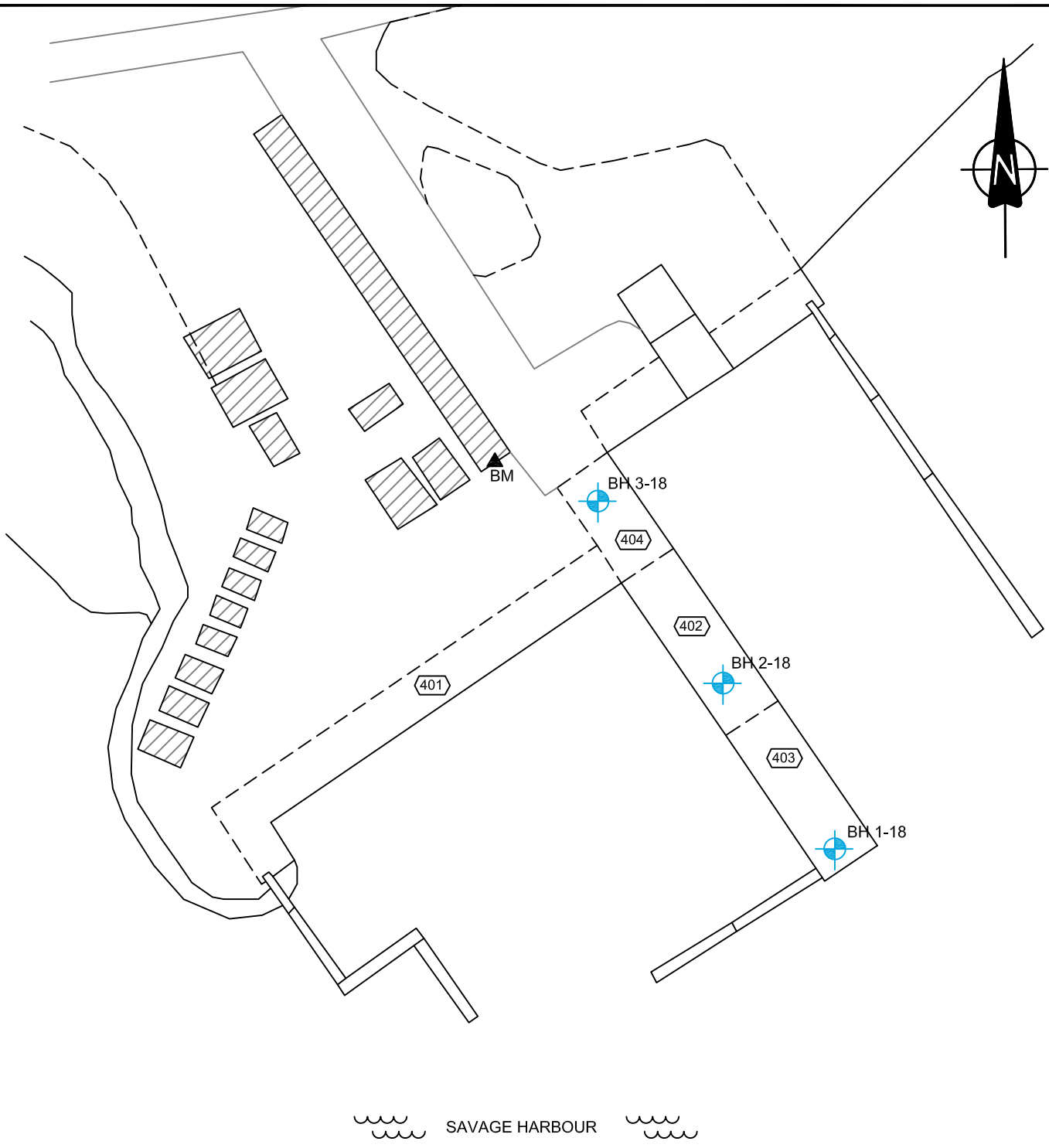

LEGEND

BOREHOLE LOCATION (BH)

BM BENCHMARK 76-P-116; EL. 2.537 M

GEO SERVICES
GEOTECHNICAL DIVISION OF JOOSE ENVIRONMENTAL

BOREHOLE LOCATION PLAN

PROPOSED WHARF RECONSTRUCTION

SAVAGE HARBOUR, QUEENS COUNTY, PEI

CLIENT: SMALL CRAFT HARBOURS, FISHERIES AND OCEANS CANADA

SCALE:		JOB NO.:	DWG NO.:
1 : 1000		JE0300	1
DATE	DWN BY:	APPD BY:	
2018/03/22	MLJ	GWZ	