Geotechnical Investigation

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Geotechnical Investigation – Proposed Marginal Wharf Replacement, Machons Point, Kings County, PEI

Job No. 121618169 – File No. 3675

Stantec

Prepared for:

Public Works and Government Services Canada
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March 30, 2015

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Attention: Mr. Gordon MacPhee, P.Eng.
Public Works and Government Services Canada
3 Queen Street (Cambridge Building)
PO Box 1268
Charlottetown PE C1A 8R4

Dear Mr. MacPhee,

Reference: Geotechnical Investigation – Proposed Marginal Wharf Replacement, Machons Point, Kings County, PE

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 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 14, 2015, and consisted of drilling two (2) boreholes at the site, designated BH 201 and BH 202, with an auger drill rig equipped with a cantilevered platform to permit drilling over the edge of the existing wharf. An attempt to drill through the existing ice was unsuccessful as the drill rig was not able to safely access the ice sheet by way of the existing slipway. The boreholes were advanced to an average depth of 7.2 m below harbour bottom 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 location by rotary core drilling in NQ-size (45 mm core diameter).

All soil samples recovered were placed in moisture-proof containers and were delivered, with the rock core, to our Charlottetown laboratory for classification and testing. All soil and rock core samples remaining after testing will be stored for a period of three months 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.

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 site structures. The harbour

bottom elevations at the boreholes were determined with respect to Low Normal Tide (LNT) Datum based on the temporary benchmark provided (refer to Drawing No. 1, appended).

The subsurface information obtained at previous BH-01 (Stantec Report No. 2989, issued January 18, 2010) has been incorporated into this report.

SUBSURFACE CONDITIONS

The subsurface conditions encountered at the present boreholes and at previous BH-01, are shown in detail on the appended Borehole Records, are summarized on Table 1 (also appended) and are described below. The conditions encountered at the site are also depicted on the Stratigraphic Section (Drawing No. 2, appended).

Marine Deposit

Marine deposited soils were encountered at the surface of each borehole and found to extend to depths ranging from 0.6 to 1.4 m below harbour bottom. The marine soil was found to vary in composition from a dark grey sand to a silt and sand and to contain varying amounts of gravel, clay, organics, and shell fragments, as noted the Borehole Records.

Standard Penetration Test N-values obtained within the marine soil generally range from of 0 (i.e., weight of drill rods) to 7 indicating a very loose to loose relative density.

A grain size test (curve appended) performed on a split spoon sample of the marine soil recovered from BH 202 shows it to contain 20 percent gravel, 67 percent sand and 13 percent fines (i.e., silt and clay sizes). An Atterberg Limit determination showed this soil to be non-plastic. A grain size test (curve appended) performed on a split spoon sample of the marine soil recovered from previous BH-01 shows a similar gradation with 9 percent gravel, 72 percent sand and 19 percent fines. Three sample of the marine soil were each found to have a moisture content of 18 percent.

The following parameters may be assigned to the marine soil for design purposes:

Total Unit Weight	20 kN/m^3
Submerged Unit Weight	10 kN/m^3
Effective Friction Angle	30 degrees

Reference: Geotechnical Investigation – Proposed Marginal Wharf Replacement, Machons Point, Kings County, PE

Glacial Till

A reddish brown glacial till stratum, ranging in thickness from 0.9 to 3.4 m, was encountered directly below the marine deposit at the boreholes. The till was found to vary in composition from a silty sand, to a clayey silt and sand, to a sand, some silt. The till was found to contain trace to some gravel and sandstone cobbles.

N-values obtained within the till range from 15 to in excess of 50 indicating a compact relative density. The N-values greater than 50 may be attributed to the presence of sandstone cobbles within the till.

Grain size analyses (curves appended) performed on representative split spoon samples of the till show it to contain 5 to 17 percent gravel, 42 to 78 percent sand, and 18 to 41 percent fines. An Atterberg Limit determination performed on a clayey till sample recovered from BH 201 shows it to contain fines of low to medium plasticity based on liquid and plastic limits of 33 percent and 13 percent, respectively. A sample of silty sand till recovered from BH 201 was found to contain non-plastic fines. The natural moisture content of selected till samples was found to range from 16 to 18 percent.

The following parameters may be assigned to the till stratum for design purposes:

Total Unit Weight	21 kN/m^3
Submerged Unit Weight	11 kN/m^3
Effective Friction Angle	32 degrees

Bedrock

Sedimentary bedrock was encountered directly below the till stratum at the boreholes. The rock core recovered consists predominantly of reddish brown, fine to coarse grained sandstone with occasional stiff to hard reddish brown clayey/mudstone seams.

The bedrock surface was encountered 1.8 to 4.0 m below harbour bottom at the boreholes. The bedrock surface elevation was found to range from a low of el. -5.11 m at BH 201 to a high of el. -2.78 m at BH 202.

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. An average RQD (Rock Quality Designation) value of 58 indicates poor quality, severely fractured bedrock.

The results of point load tests carried out on selected bedrock core samples are presented on Table 2, appended. The point load index (Is_{50}) was determined from both diametral and axial

tests. The unconfined compressive strength (Qu) was estimated from the point load data using the relationship Qu = 24 x Is_{50} (axial). The point load test data indicate that the sandstone core samples tested generally fall within the weak (i.e., Qu = 5 to 25 MPa) to strong (50 to 100 MPa) strength classifications. It should be noted that the weakest rock is often not recovered during coring operations and that intact core samples are required for testing. Consequently, a very weak to strong classification would be more representative of the overall rock mass at the site and is used on the Borehole Records.

The following parameters may be assigned to the bedrock stratum for design purposes:

Total Unit Weight	23 kN/m^3
Submerged Unit Weight	13 kN/m^3
Effective Friction Angle (for fractured, non-intact bedrock)	36 degrees

DISCUSSION AND RECOMMENDATIONS

It is understood that the proposed replacement for the existing marginal wharf is to be located immediately southeast of the existing wharf and could either consist of a pile-supported structure or a bulkhead type structure. A bulkhead structure could consist of a Berlin Wall system (utilizing steel H-piles and precast concrete panels or timber lagging) or a steel sheet pile wall. The effects of the subsurface conditions encountered on the design and construction of pile-supported and bulkhead wharves are considered in the following sections.

Pile-Supported Structure

It is understood that concrete filled steel pipe piles or H-piles with a protective jacket have been used for similar applications. It is expected that steel piles would be driven to bedrock to develop the required capacity. 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. Previous experience has shown that an actual delivered energy in the order of 200 J/cm^2 is required to attain the allowable contact stress/bearing pressure given below. 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 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. The stronger rock layers encountered at the boreholes will likely impede pile penetration.

The capacity of steel piles driven to refusal may be determined using an allowable contact stress of 50 MPa for steel H and open end pipe piles (based on net steel area). An allowable bearing pressure of 7 MPa may be used for design of closed end pipe piles (based on gross end 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 (i.e., 2.5D) may be used.

For driven steel 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. Additional uplift resistance, if required, could be obtained through the use of socketed piles and/or rock anchors.

Bulkhead Structure

It is recommended that the very loose to loose marine soil, which represents the upper 600 mm (+/-) of the marine deposit, be removed from with the footprint of any type of bulkhead structure. If left in place, the compression of this soil under the weight of new fills will result in high lateral loads that must be accounted for. Other potential concerns associated with leaving this compressive soil in place would include settlement of the new infill/wharf deck and over-stressing of the tie-rods.

For a bulkhead design incorporating steel piles, the pile design/installation recommendations provided in the previous section would be applicable. The following parameters may be assigned to the various strata encountered for bulkhead design purposes:

Parameter/Soil Type	Marine Soil	Glacial Till	Bedrock (Sandstone)	Select Borrow (Compacted Infill)
Total Unit Weight, kN/m^3	20	21	23	21
Submerged Unit Weight, kN/m^3	10	11	13	11
Effective Friction Angle, degrees	30	32	36[2]	33
Active Earth Pressure Coefficient, Ka	0.33	0.31	0.26	0.29
Passive Earth Pressure Coefficient, Kp[1]	3.00	3.25	3.86	3.39

Notes:
1. neglecting the effects of wall friction
2. based on bedrock zone fragmented by pile penetration

Reference: Geotechnical Investigation – Proposed Marginal Wharf Replacement, Machons Point, Kings County, PE

We would be pleased to provide further geotechnical input for this project on an as required, as requested basis.

CLOSING COMMENTS

Use of this report is subject to the Statement of General Conditions provided in the Appendix. It is the responsibility of Public Works and Government Services Canada, which is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec Consulting Ltd. should any of these not be satisfied. The Statement of General Conditions addresses the following:

- Use of the report
- Basis of the report
- Standard of care
- Interpretation of site conditions
- Varying or unexpected site conditions
- Planning, design or construction

We trust that this factual report it contains all of the information required at this time. Should you have any questions or if we can be of further service, please contact us at your convenience.

Regards,

STANTEC CONSULTING LTD.

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March 30, 2015
Mr. Gordon MacPhee, P.Eng.

Reference: Geotechnical Investigation – Proposed Marginal Wharf Replacement, Machons Point, Kings County, PE

APPENDIX

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd. , sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

Table 1 - Borehole Summary - Machons Point

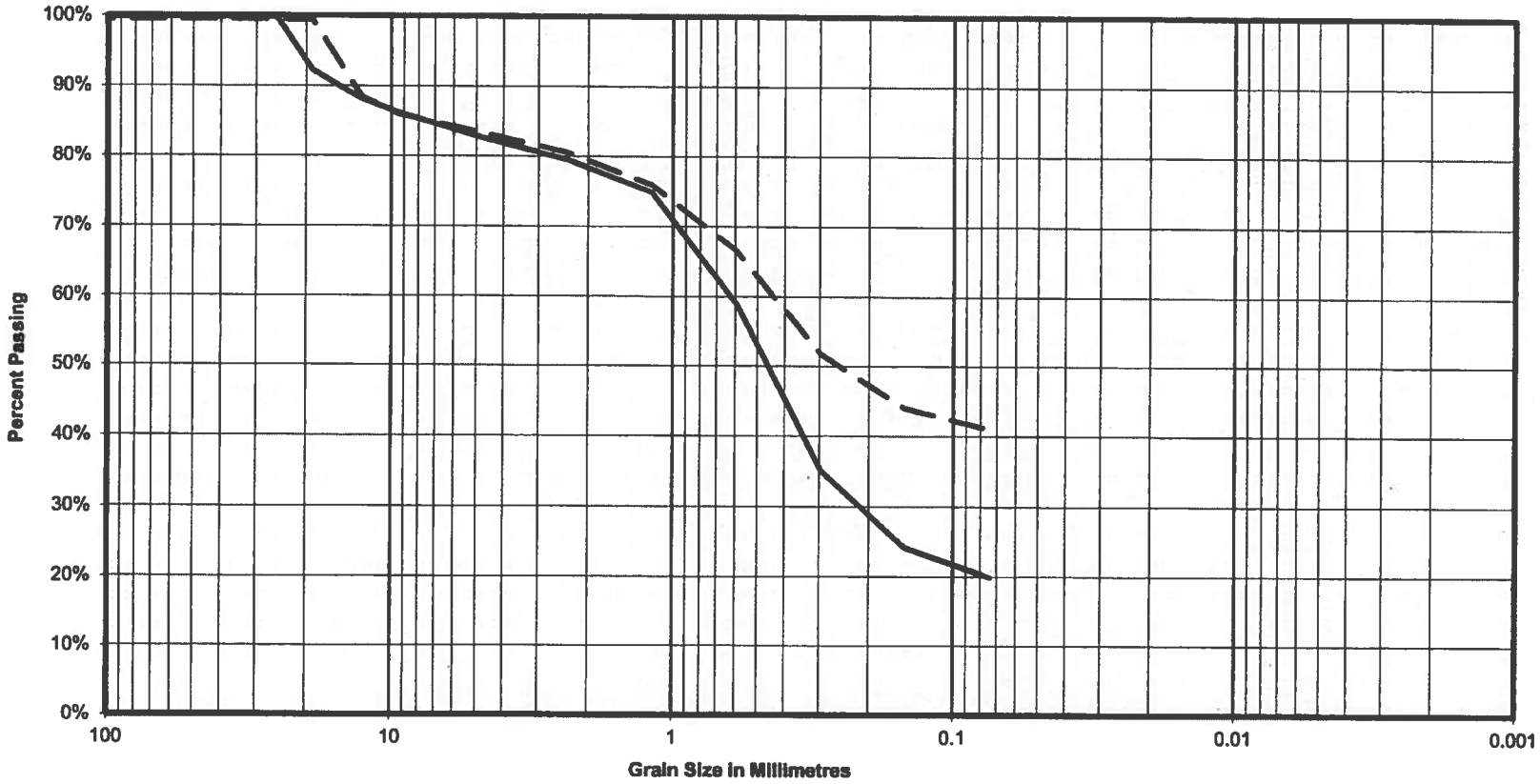
	Borehole Number		
	Present Investigation		Previous
	BH 201	BH 202	BH-01
Harbour Bottom el., m	-1.07	-0.95	-0.10
Marine Soil Thickness, m	0.61	0.89	1.37
Till Surface el., m	-1.68	-1.84	-1.47
Till Thickness, m	3.43	0.94	2.14
Depth to Bedrock, m	4.04	1.83	3.51
Bedrock Surface el., m	-5.11	-2.78	-3.61
Depth of Borehole, m	8.61	5.79	5.82

NOTES:

- BH 201 and BH 202 were drilled at the site on March 14, 2015; BH-01 was drilled December 14, 2009
- harbour bottom elevations are referenced to Low Normal Tide (LNT) datum based on the benchmark provided
- sandstone bedrock was proven at each borehole by rotary core drilling

Approved:

Project Name: Machons Point



	Gravel		Sand			Silt and Clay
	Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System ASTM D 2487/2488

Curve	BOREHOLE/TESTPIT	SAMPLE	DEPTH (m)	Soil Fractions			Soil Description
				Gravel	Sand	Silt/Clay	
———	BH 201	2	0.9	17%	63%	20%	Silty sand, some gravel: Till
— — ·	BH 201	3	1.5	17%	42%	41%	Clayey silt and sand, some gravel: Till

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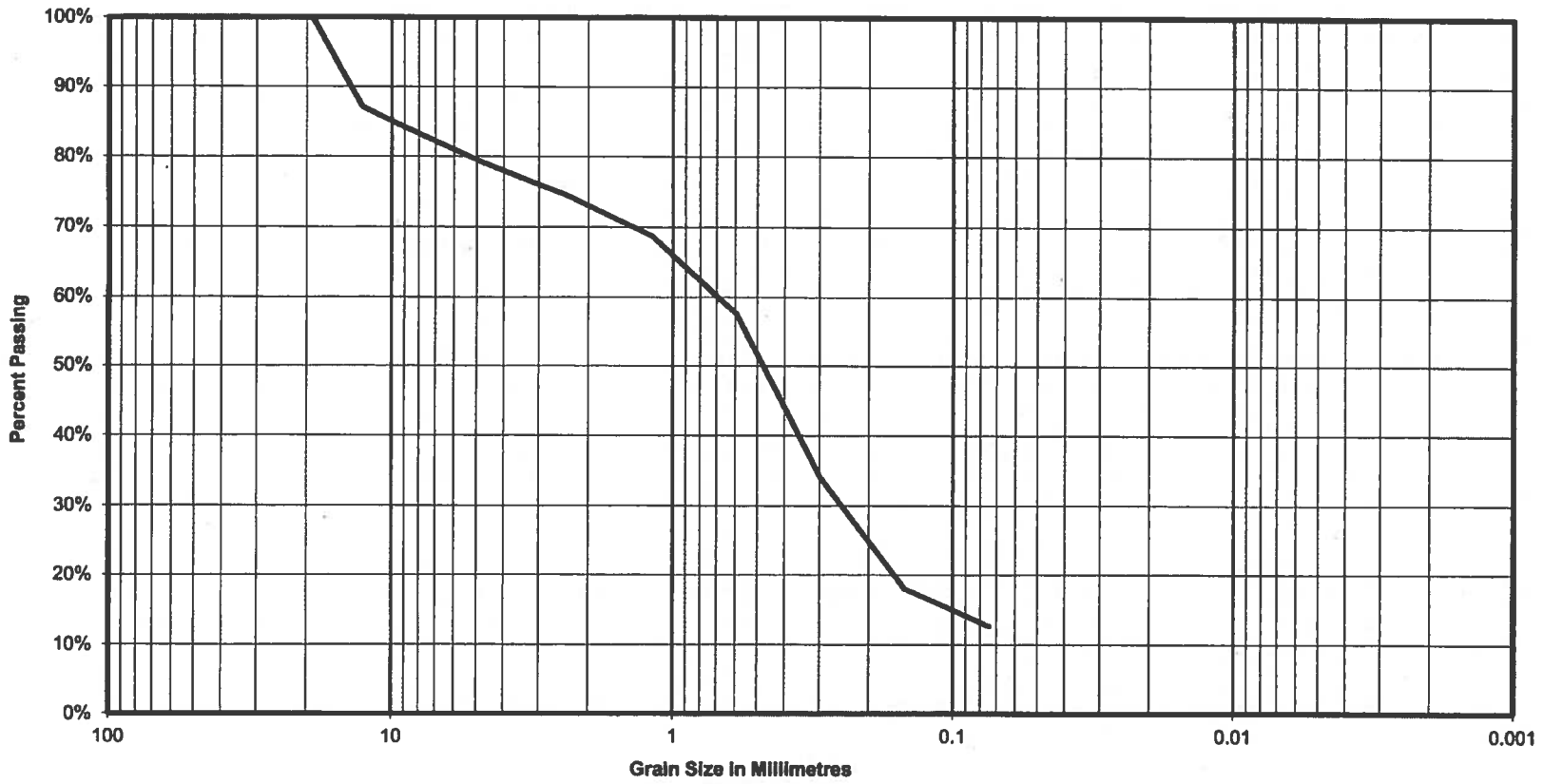
Approved:

Project Name: Machons Point



	Gravel		Sand			Silt and Clay
	Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System ASTM D 2487/2488

Curve	BOREHOLE/TESTPIT	SAMPLE	DEPTH (m)	Soil Fractions			Soil Description
				Gravel	Sand	Silt/Clay	
———	BH 202	1	0.4	21%	67%	13%	Sand, trace silt, gravel: Marine Deposit

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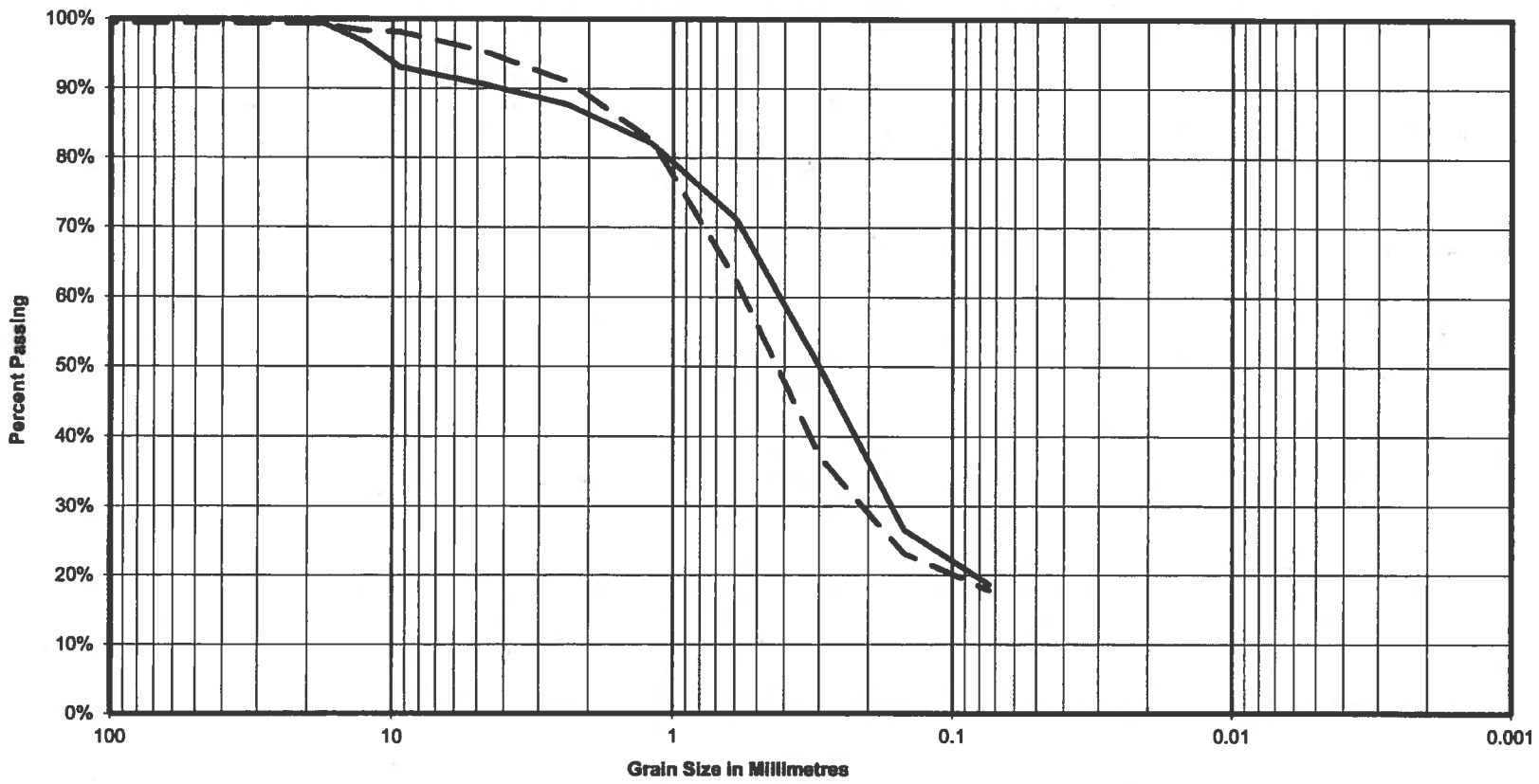
Job No.: 3675

Approved:

Project Name: Machons Point



	Gravel		Sand			Silt and Clay
	Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System ASTM D 2487/2488

Curve	BOREHOLE/TESTPIT	SAMPLE	DEPTH (m)	Soil Fractions			Soil Description
				Gravel	Sand	Silt/Clay	
———	BH-01	2	0.9	9%	72%	19%	Sand, some silt, trace gravel: Marine Deposit
— — ·	BH-01	3	1.5	5%	78%	18%	Sand, some silt, trace gravel: Till

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Job No.: 2989

Table 2 - Point Load Test Summary - Machons Point

Borehole Number	Sample Depth, m	Test Type	Is(50), MPa	UCS (Qu), MPa	Rock Type
BH-01	4.0	D	0.1		MGSS
	4.0	A	0.0	1	MGSS
	4.6	D	0.1		MGSS
	4.6	A	0.6	15	MGSS
	5.2	D	1.0		MGSS
	5.2	A	1.0	25	MGSS
	5.6	D	1.7		MGSS
	5.6	A	2.2	53	MGSS
	5.9	D	2.1		MGSS
	5.9	A	1.9	46	MGSS
	7.0	D	1.3		MGSS
	7.0	A	1.9	45	MGSS
	7.3	D	1.7		MGSS
	7.3	A	2.8	67	MGSS
	7.9	D	1.0		MGSS
	7.9	A	2.6	63	MGSS
	8.4	D	0.8		MGSS
	8.4	A	1.2	29	MGSS
BH-02	2.3	D	3.0		MGSS
	2.3	A	2.8	67	MGSS
	2.5	D	1.0		MGSS
	2.5	A	1.5	35	MGSS
	2.9	D	0.1		CGSS
	2.9	A	0.1	4	CGSS
	3.6	D	0.3		CGSS
	3.6	A	1.0	24	CGSS
	4.3	D	0.2		MGSS
	4.3	A	1.2	28	MGSS
	5.1	D	0.8		MGSS
	5.1	A	1.0	24	MGSS
	5.4	D	0.8		MGSS
	5.4	A	1.0	24	MGSS

Legend:

A- axial test
D- diametral test
UCS- unconfined compressive strength
FGSS- fine grained sandstone
MGSS- medium grained sandstone
CGSS- coarse grained sandstone

Note: USC is estimated based on relationship Qu = 24 x Is50 (axial)

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
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 Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS 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 75 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%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

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 in.) long are summed 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 from a borehole of any orientation. All pieces of 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 natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

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	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

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

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 diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT


measured in standpipe, piezometer, or well


inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

Stantec

BOREHOLE RECORD

BH 201

CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA — PROJECT No. 3675

LOCATION Proposed Harbour Modifications, Machons Point, Kings County, PEI — BH SIZE 100 mm

DATES: BORING 2015/03/14 — WATER LEVEL Tidal — DATUM LNT

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N-VALUE OR-RQD %	OTHER TESTS
							mm		
0	-1.07	Very loose dark grey silty sand, trace clay, organics, shell fragments: MARINE DEPOSIT			SS	1	50	3	
	-1.68				SS	2	375	17	S/A
1		Compact reddish brown silty sand to clayey silt and sand, some gravel and sandstone cobbles: TILL			SS	3	400	15	S/A
					~~SS~~	~~4~~	~~75~~	~~90~~	
2					NQ	5	375	-	
3					NQ	6	425	-	
4	-5.11	Very weak to weak, reddish brown, fine to medium grained sandstone: BEDROCK; occasional clayey partings/seams; extremely close to moderately close joint spacing			NQ	7	100%	RQD 50	
5	-6.63								
6		Very weak to strong, reddish brown to whitish red, medium to coarse grained sandstone: BEDROCK; extremely close to moderately close joint spacing			NQ	8	97%	RQD 68	
7									
8					NQ	9	100%	RQD 78	
	-9.68	End of Borehole							
9									

UNDRAINED SHEAR STRENGTH - kPa
20 40 60 80
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50 60 70 80 90

MBH 3/30/15

App'd Mar 30 2015 10:2:6

Stantec

BOREHOLE RECORD

BH 202

CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA PROJECT No. 3675

LOCATION Proposed Harbour Modifications, Machons Point, Kings County, PEI BH SIZE 100 mm

DATES: BORING 2015/03/14 WATER LEVEL Tidal DATUM LNT

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N-VALUE OR-RQD %	OTHER TESTS
							mm		
0	-0.95	Loose to compact dark grey silty sand to sand, some silt, some gravel, trace clay, organics, shell fragments: MARINE DEPOSIT			SS	1	300	5	S/A
					SS	2	325	22	
1	-1.84	Compact reddish brown silty sand to silt and sand, some gravel and sandstone cobbles: TILL			NQ	3	0	-	
2	-2.78	Very weak to strong, reddish brown to whitish red, fine to medium grained sandstone: BEDROCK; extremely close to moderately close joint spacing			NQ	4	1175	-	
3	-3.69	Very weak to weak, reddish brown, medium to coarse grained sandstone: BEDROCK; occasional clayey partings; extremely close to moderately close joint spacing			NQ	5	98%	RQD 23	
4									
5					NQ	6	100%	RQD 73	
	-6.74								
6		End of Borehole							
7									
8									
9									

UNDRAINED SHEAR STRENGTH - kPa
20 40 60 80
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50 60 70 80 90

App'd Mar 30 2015 10:2:7

MBH 3/30/15

BOREHOLE RECORD

Stantec

BOREHOLE No.: BH-01

PROJECT No.: 2989

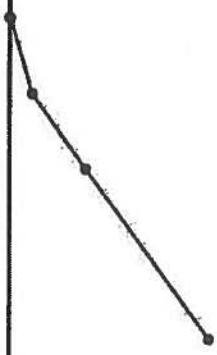
CLIENT: Public Works and Government Services Canada

LOCATION: Machons Point Harbour, Kings County, PEI

DATES: BORING: December 14, 2009 **WATER LEVEL:** Tidal **DATUM:** Low Normal Tide

Depth (m)	Elevation (m)	Soil Description	Strata Plot	Water Level	Sample Type	Sample Number	Recovery (mm)	SPT N-Value	RQD (%)	Moisture (%)	Other Tests
0	-0.10	Harbour Bottom									
0.00	0.00	Very loose dark grey to reddish brown silt and sand, trace organics, shells: **Marine Deposit**			SS	1	500	0			
0.81	-0.71	Loose reddish brown sand, some silt, trace gravel: **Marine Deposit**			SS	2	375	7		18	S
1.37	-1.47	Compact reddish brown *sand, some silt to silt and sand*, trace to some gravel, occassional sandstone cobbles and clayey layers: **Till**			SS	3	600	24		16	S
					SS	4	425	63		47	
3.51	-3.61	Very weak to medium strong, medium to coarse grained, reddish brown to whitish red sandstone, occasional mudstone seams: **Bedrock**; extremely close to close joint spacing			NQ	5	44%		7		
					NQ	6	84%		57		
5.82	-5.92	End of Borehole									

SPT N-Value: 10 30 50 70 90



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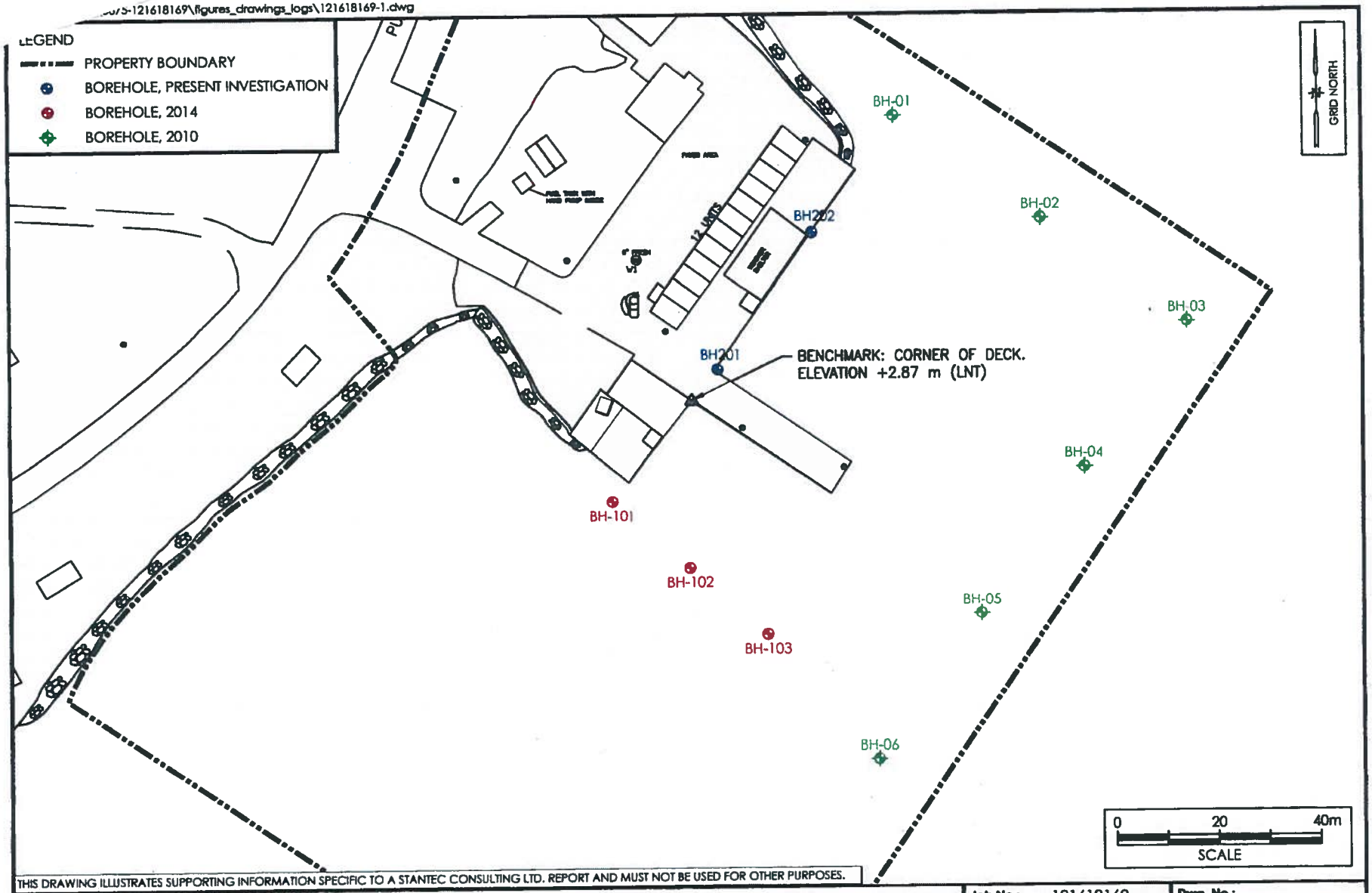

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

BOREHOLE LOCATION PLAN

PROPOSED HARBOUR MODIFICATIONS

MACHONS POINT, KINGS COUNTY, PE

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Job No.:	121618169
Scale:	1 : 1000
Date:	03-MAR-2015
Dwn. By:	MO
App'd By:	GZ

Dwg. No.: 1

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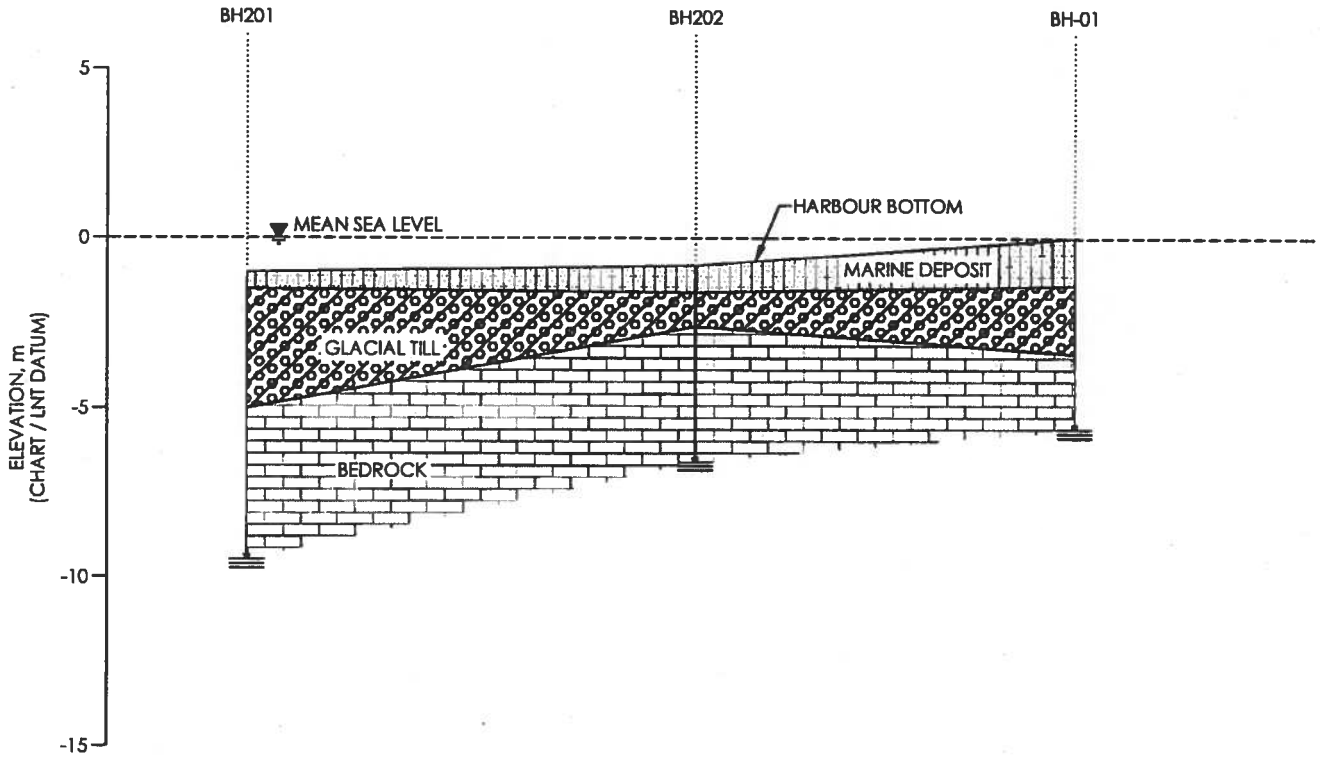

NOTES:

- SUBSURFACE CONDITIONS SHOWN BETWEEN BOREHOLES ARE EXTRAPOLATED FROM AVAILABLE INFORMATION; ACTUAL CONDITIONS BETWEEN BOREHOLE LOCATIONS MAY DIFFER FROM THOSE SHOWN.

SCALE 1:500 (HORIZONTAL)
1:200 (VERTICAL)

DENOTES END OF BOREHOLE

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

BOREHOLE STRATIGRAPHY

PROPOSED HARBOUR MODIFICATIONS
MACHONS POINT, KINGS COUNTY, PE

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Job No.:	1216118169
Scale:	AS SHOWN
Date:	03-MAR-2015
Dwn. By:	MO
App'd By:	GZ

Dwg. No.: 2

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