Final Geotechnical Investigation

Parks Canada
Point Pelee National Park
Marsh Area Renewal Project
Project No.: 1503

Prepared for:
Parks Canada Agency

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Project No. 160622453

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1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained to complete a Geotechnical Investigation for the proposed Marsh Area Renewal located south of the Municipality of Leamington, Ontario. The proposed redevelopment is located within a triangular shaped marshy area. (hereinafter referred as the "Site").

This report has been prepared specifically and solely for the project described herein. It contains the factual results of the Geotechnical Investigation, and provides comments and recommendations for the design and construction of the proposed redevelopment.

Limitations associated with this report and its contents are provided in the statement included in Appendix A.

2.0 SITE DESCRIPTION

The Site is bounded by Point Pelee Drive to the west, the marsh area to the east, north and south and Lake Erie located west of Point Pelee Drive.

The redevelopment includes the construction of washroom facilities, storage shed, extension of the parking lot, and replacement of the northern boardwalk along the marsh area.

Currently, the site is occupied by a gift shop, picnic shelter, washroom building, observation tower, boardwalk, and parking lot.

3.0 PROPOSED DEVELOPMENT

Three options are proposed for the redevelopment based on a Site Plan drawings prepared by Stantec, titled Landscape Plan Option 1,2, and 3, dated November 18 2016.

It is understood that the redevelopment will include the following:

- Expansion of the existing at-grade paved parking and driveway;
- Reconstruction of the northern stationary boardwalk;
- Consideration of structural improvements to the existing observation tower as identified in structural conditions assessment;
- Building a new washroom and demolishing the existing one;
- Construction of a storage shed and shade structure.

4.0 REGIONAL GEOLOGY

The Physiography of Southern Ontario, by Chapman and Putman (1984), indicates that the site is situated in the physiographic regions known as the Sand Plains and Clay Plains, which consist of a series of shoreline deposits along the west and north shores of Lake Erie. The Quaternary Geology of Southern Ontario Map 2556, produced by the Ministry of Northern Development and Mines (1991), indicates that the site is an area of Lacustrine and Glaciolacustrine deposits.

5.0 SCOPE OF WORK

The scope of work for the Geotechnical Investigation at this site was as follows:

- Advance one (1) borehole in the vicinity of the proposed dock/boat launch to a depth of 6 m below existing grade;
- Advance three (3) boreholes in the vicinity of the proposed parking area expansion to a depth of 3 m below existing grade;
- Advance one (1) borehole in the vicinity of the proposed storage shed to a depth of 6 m below existing grade;
- Advance one (1) borehole in the vicinity of the observation tower to a depth of 6 m below existing grade;
- Advance one (1) borehole in the vicinity of the potential bridge crossing of the existing marsh/waterway to a depth of 6 m below existing grade;
- Advance one (1) borehole in the vicinity of the proposed washroom building to a depth of 6 m below existing grade;
- Advance one (1) borehole in the vicinity of the proposed shade structure to a depth of 6 m below existing grade;
- Advance five (5) boreholes along the existing boardwalk to a depth of 6 m below the existing boardwalk;
- Record the soil conditions encountered in the boreholes;
- Record the groundwater level (where present) in the open borehole;
- Complete a laboratory testing program to characterize the soils encountered in the investigation. The laboratory testing program will include a series of moisture content tests, grain size distribution tests and Atterberg Limits tests; and,
- Prepare a report that includes the following:
  - Site plan showing the borehole locations;
  - Factual results of the investigation;
  - Borehole Records;
  - Results of the geotechnical laboratory testing program;
  - Geotechnical information, constraints, comments, and recommendations for the proposed scope of development;
  - Site preparation requirements;
  - General groundwater control requirements (construction and permanent);
  - Anticipated foundation type, foundation depths/elevations and bearing resistances and reactions for ULS and SLS for the proposed bridge and boardwalk;

- Site Classification for Seismic Site Response based upon the overburden conditions encountered to the termination depth of the boreholes; and,
- Typical asphalt pavement structure.

6.0 METHOD OF INVESTIGATION

6.1 PREPARATORY SERVICES

Prior to commencing the field investigation, the various public utility companies were consulted to identify where public utilities crossed the property boundaries. In addition, a private locator was contracted to clear the boreholes of any on-site services.

6.2 DRILLING PROGRAM

The locations of the fourteen (14) boreholes (BH1 to BH14) are shown on the borehole location plan inclusive in Appendix B.

The fieldwork for the geotechnical investigation was carried out between October 24 and 27, 2016.

The boreholes were advanced using Comacchio Geo 205 track mounted drill rig equipped with 200 mm solid-stem augers. Stantec field personnel recorded the conditions encountered in the boreholes. Due to access restrictions boreholes BH 10 to BH 14 were advanced using mini equipment (Ramsounder).

Soil samples from the drilled boreholes were obtained using a 50 mm O.D. split-spoon sampler by conducting penetration tests with a 70 lbs hammer, at a drop height of approximately 0.76 m, and in general conformance with the procedures outlined in the ASTM Specification D3550. The penetration resistances in number of blows were recorded for every 150 mm of driven depth. For the purpose of providing a general indication of the compactness or consistency of the soils encountered at the site, the penetration resistances reported herein and the Borehole Records are the average of the number of blows required to drive the sampler over the depth interval of 150 mm to 450 mm. Dynamic cone penetration tests were performed at some locations to evaluate the subsurface conditions.

All soil samples recovered from the boreholes were placed in moisture-proof bags and returned to Stantec's laboratory for detailed geotechnical classification and testing as required.

A groundwater monitoring program was not included as part of this assignment.

All boreholes were backfilled with a mixture of granular bentonite and auger spoils in accordance with the requirements of the MOECC Regulation 903.

6.3 SURVEY

The borehole locations were surveyed in the field by Stantec using the base co-ordinate system. The ground surface elevation at the borehole is referenced to a Geodetic Datum. The ground surface elevation at the borehole location is shown on the Borehole Records Sheets provided in Appendix C.

6.4 LABORATORY TESTING

All soil samples returned to the laboratory were subjected to detailed visual examination and classification.

Grain size distribution, Atterberg limit, and moisture content tests, were conducted on representative samples of the soils obtained from the investigation. Samples were selected for analysis that included the following:

- Grain size distribution with hydrometer 4
- Atterberg Limits 4
- Natural Moisture Content 39

The results of the laboratory tests are discussed in the text of this report and are provided on the Borehole Records in Appendix C. Figures illustrating the results of the grain size distribution tests and the Atterberg limit tests are included in Appendix D.

Unless specific instructions are received to the contrary, the samples will be discarded two months after issue of this report.

7.0 RESULTS OF THE INVESTIGATION

7.1 SUBSURFACE CONDITIONS

The subsurface conditions encountered in the boreholes are provided on the Borehole Records in Appendix C. An explanation of the symbols and terms used in the Borehole Records is included in Appendix C for reference.

It should be noted that the stratigraphic boundaries shown on the borehole logs are inferred from non-continuous sampling and should be considered approximate only.

The subsurface stratigraphy in the boreholes generally consists of gravel or topsoil underlain by fill material, overlying a native sand layer, overlying silty clay till.

Bedrock was not encountered in the boreholes advanced to the maximum investigated depth of 8.2 m below existing grade.

A summary of the soil and groundwater conditions encountered in the boreholes is provided below.

7.1.1 Ground Surface Cover

The ground surface cover consisted of gravel at boreholes BH 6 and 7 and landscaped grass with underlying topsoil at boreholes BH1 to 5 and BH 8 and 9 on the landside and about 3.0 m of water overlying marsh sediments overlying silty clay till along the boardwalk in the remaining boreholes BH 10 to 14. The thickness of the topsoil ranged from approximately 25mm to 250 mm.

Marsh Deposit

Marsh sediments were encountered below the surface water along the boardwalk within the marshy area. The thickness of this layer ranged between 2 m and 2.2 m. The sediments contained rootlets, alluvial deposits, organic material and peat inclusions.

Fill Material

A layer of fill was encountered underlying the topsoil in boreholes BH6 to BH9. In boreholes BH6 and BH7 where the ground cover consists of gravel the fill material consisted mainly of sand and gravel. In boreholes BH8 and BH9, the fill consisted mainly of silty clay. The fill layer extends to an approximate depth of 0.8 m below grade.

One SPT N-value of 2 was obtained from the silty clay in borehole BH9. Based on this value, the fill at this location was assessed as very soft.

Based on visual and textural examination, the fill was assessed as moist. The results of the moisture content tests indicated that the moisture content of this layer ranged from 3% to 38%.

7.1.2 Sand

A sand stratum was encountered in all boreholes completed at the landside (i.e. boreholes BH1 to BH9) underlying the topsoil and the fill material. The sand contained trace clay and gravel, occasional rootlets, silty clay seams and peat inclusions . In borehole BH7, the sand was silty near the bottom of the layer. In boreholes BH4 and BH8 this layer contained sand with gravel below a depth of 4.2 m below existing grade. The thickness of this stratum is variable, extends to the maximum investigated depth of 3.6 m below existing grade in the shallow boreholes (i.e. BH1 to BH3) and to the maximum investigated depth of 6.7 m below existing grade in borehole BH7.

The N-values obtained from the SPTs in the sand ranged from 1 to 52. Based on these values, the soil was assessed as very loose to very dense.

Based on visual and textural examination, the samples of the sand were assessed as moist to wet. The results of the moisture content tests indicated moisture contents ranging from 2.6% to 35.5%.

Two grain size distribution tests were completed on samples of the sand. The results of the tests were as follows:

Table 7.1: Grain Size Distribution – Sand

Borehole	Sample	Depth (m)	Description	% Gravel	% Sand	% Silt	% Clay
BH1	SS3	1.8	Poorly Graded Sand (SP)	3	94	3	
BH7	SS7	6.4	Silty Sand (SM)	3	70	27	

The results of the grain size distribution tests are shown on the Borehole Record sheet included in **Appendix C** and on Figure 1 in **Appendix D**.

In accordance with the Unified Soil Classification System, the sample tested can be classified as Poorly Graded Sand (SP) and Silty Sand (SM).

7.1.3 Silty Clay Till

A stratum of silty clay till was encountered in boreholes BH4 to BH6, BH9, BH10, and from boreholes BH12 to BH14 underlying the sand in the landside boreholes and underlying the water and marsh sediments in the marshy area. This stratum extended to the maximum investigated depth where encountered.

The N-values obtained from the SPTs in the silty clay till ranged from 4 to 66. Based on these values, the soil was assessed as soft to hard.

Based on visual and textural examination, the samples of the silty clay till were assessed as moist to wet. The results of the moisture content tests indicated moisture contents ranging from 10% to 26%.

Two grain size distribution tests were completed on samples of the silty clay till. The results of the tests were as follows:

Table 7.2: Grain Size Distribution – Silty clay Till

Borehole	Sample	Depth (m)	Description	% Gravel	% Sand	% Silt	% Clay
BH5	SS6	4.8	Silty Clay (CL-ML), TILL	1	11	36	52
BH9	SS7	6.4	Silty Clay (CL-ML), TILL	1	11	37	51

The results of the grain size distribution test are shown on the Borehole Record sheet included in **Appendix C** and on Figure 1 (**Appendix D**).

In accordance with the Unified Soil Classification System, the sample tested can be classified as Silty Clay (CL-ML), Till.

Atterberg Limits tests were conducted on the samples referenced above.

The results are shown in Table 7.3 below.

Table 7.3: Atterberg Limits Test Results for the Silty Clay Till

Borehole No.	Sample No.	Sample Median Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture Content (%)
BH9	SS7	6.4	38	20	18	18

The results of the Atterberg Limits Tests indicate that the bulk of the soil can be described as a clay of low plasticity. For purposes of this report, and to remain consistent with the methods described in the Canadian Foundation Engineering Manual (The Canadian Geotechnical Society 2006) and ASTM specification D2487, the soil in this stratum is described as silty clay till (CL-ML). The results are included in **Figure 2 (Appendix D)**.

7.1.4 Groundwater Conditions

The groundwater conditions and associated levels measured in the boreholes advanced by Stantec are shown in Table 7.4 below.

Table 7.4: Groundwater Conditions

Borehole No.	Borehole Elevation	Groundwater Depth Below Existing Grade (m)	Groundwater Elevation (m)
BH1	177.0	2.3	174.7
BH2	175.6	1.0	174.6
BH3	176.2	1.7	174.5
BH4	176.0	1.0	175.0
BH5	175.2	1.0	174.2
BH6	175.1	0.7	174.4
BH7	175.9	1.4	174.5
BH8	175.5	1.0	174.5
BH9	174.9	1.0	173.9
BH10	174.6	0.6	174.0
BH11	174.5	0.5	174.0
BH12	174.6	0.6	174.0
BH13	174.6	0.6	174.0
BH14	174.6	0.6	174.0

Boreholes BH 10 to 14 in the marshy area were drilled through 1.2 m of surface water. It should be noted that these observations reflect the conditions encountered in the boreholes at the time of the field investigation. The expected stabilized groundwater level is expected to lie at shallow depths below the existing grade and will be influenced by the water level of Lake Erie. During

the month of October at the time of the investigation the mean water elevation in Lake Erie was 174.33 m.

8.0 DISCUSSION AND RECOMMENDATIONS

8.1 SUMMARY AND EVALUATION OF EXISTING CONDITIONS

The following general development considerations and constraints are provided with respect to observations made during the investigation, the subsurface conditions encountered, and the intended scope of development:

- The overall soil and groundwater findings indicates the overall Site is suitable for the construction of the proposed redevelopment;
- Water was measured in all boreholes at a depth within the sand layer which ranged from 0.8 m to 2.4 m below the existing ground surface.
- Although deep excavations are not anticipated any shallow excavations extending to the permanent ground water level will require temporary dewatering measures. It should be noted that the groundwater level is subject to seasonal fluctuations and will be influenced by the water level of Lake Erie (EL 174.33)
- The existing fill material is not suitable for the support of the foundation. It is suggested the fill materials could be removed and replaced with engineered fill for normal footing construction with the foundation designed with a 100 kPa Maximum bearing Soil Pressure (SLS);
- The existing topsoil will need to be removed as a component of site preparation activities. The thickness of the topsoil observed at the borehole locations ranged from approximately 25 mm to 250 mm;
- The use of-slab-on-grade foundations and helical pile footing foundations founded on the native sand and silty clay till is a practical foundation option; and,
- The program for grading and earthworks should be designed in advance, and carefully executed in consideration of the time of year of execution, prevailing weather conditions, storm-water management control, and associated issues and concerns, and the intended end-use of the property as described.

Geotechnical comments, discussion, and recommendations are provided in the following sections with respect to the proposed development.

8.2 SITE PREPARATION

Prior to grading and/or cut and fill earthworks operations, the ground surface cover consisting of topsoil will require removal. The thickness of topsoil encountered in the boreholes ranged from approximately 25 mm to 250 mm, however, variations less than and greater than this range should be anticipated. The underlying sand may remain in place.

As mentioned above, sand was encountered underlying the topsoil and/or the fill material in all boreholes completed on the landside. The groundwater level was recorded at a depth ranging from 0.8 m to 2.4 m below the existing grade.

Subsequent to completing the stripping program, the exposed subgrade surface should be inspected to confirm the removal of any deleterious materials, organics, or loose/soft or wet zones. Where such materials are identified, they should be removed and the areas backfilled with engineered fill in accordance with the recommendations provided below.

Following completion of the required stripping and removal as noted above, the exposed surface should be proof-rolled and compacted using large, vibratory compaction equipment with a minimum static weight of ten tonnes. This will provide a uniform, compact surface that will minimize the potential for infiltration of precipitation and ground surface runoff, and promote drainage at the ground surface. The proof rolling program should consist of a minimum of five passes per unit area to provide a uniform surface for construction and to confirm that the surficial soils have been compacted to achieve the required density consistent with the placement of engineered fill as discussed below.

8.3 GRADING AND EARTHWORKS

It is anticipated that a major engineering cut and fill program will not be required to facilitate the proposed redevelopment.

With respect to the required cut, it is anticipated that the cut materials will consist of fill materials and native sand.

The compactness/consistency of the existing fill material is variable and is not suitable for the support of shallow strip and spread footings.

The exposed subgrade surface will consist of sand. The exposed subgrade surface should be inspected to confirm the removal of any deleterious materials, organics, or loose/soft materials or wet zones. Where such materials are identified, they should be removed and the areas backfilled with engineered fill in accordance with the recommendations provided below.

Excavation in the native sandy soil should be straight forward using large tracked excavating equipment. Presuming that portions of the soil soils will be used as fill within the site, any cobbles (in excess of 150 mm on any dimension) and boulders should be removed prior to reuse. Further comments with respect to reuse of this soil are provided below.

It is not anticipated that imported fill materials will be required for general grading of the subject property. Additional details with respect to materials recommended for use during periods of poor weather conditions are discussed below. As a minimum, materials meeting the requirements of OPSS Granular B – Type I or Type II, or Select Sub-Grade Material (SSM) should be considered for use.

All fill materials imported to the site must meet all applicable municipal, provincial, and federal guidelines and requirements associated with environmental characterization of the materials.

All materials placed as engineered fill should be placed in 200 mm thick loose lifts. Each lift should be uniformly compacted to achieve a minimum of 98% of the material's Standard Proctor Maximum Dry Density (SPMDD).

The program for grading and earthworks should be designed in advance, and carefully executed in consideration of the time of year of execution, prevailing weather conditions, construction storm-water management control, and associated issues and concerns, and the intended end-use of the subject property as described herein.

8.4 SITE MATERIALS REUSE

Generally, the predominant soil, the sand soil encountered in the investigation may be considered suitable for reuse as general engineered fill to develop design grades and elevations. The predominantly fine wet sand is susceptible to softening and loss of strength in the presence of excess moisture originating from precipitation and/or ground surface runoff. As a result, some aerating and/or drying, or mixing with dryer soils, may be required to facilitate reuse.

In addition, prior to proceeding with backfilling of these materials, they should be inspected and tested to assure that they are free of topsoil and other deleterious materials.

8.5 PAVEMENT DESIGN

Asphalt pavement will be required for the driveway and parking area. Provided that the exposed sub-grade surface is prepared in accordance with the recommendations provided in the previous sections of this report, and all required earthworks are conducted as recommended herein, the asphalt pavement structures provided below can be considered for use at this site.

Table 8.1: Recommended Asphalt Pavement Structure Design

Material	Standard Duty	Heavy Duty	Compaction Requirements
HL3 (surface course asphalt)	60 mm	40 mm	92 % MTRD
HL8 (base course asphalt)	--	50 mm	92 % MTRD
OPSS Granular 'A' Base	150 mm	150 mm	100 % SPMDD
OPSS Granular 'B' Sub-base	200 mm	300 mm	100 % SPMDD

In preparation for construction of new pavements, the finished sub-grade surface should be proof-rolled and compacted to identify the presence of soft, wet, or deflecting areas; such areas should be removed and replaced with approved engineered fill compacted to a minimum of 98% SPMDD.

The base and sub-base materials should be compacted to a minimum of 100% SPMDD. The asphaltic concrete should be compacted to a minimum of 92% of Maximum Theoretical Relative Density (MTRD).

8.6 WASHROOM AND STORAGE SHED FLOOR SLAB

A conventional slab-on-grade can be used for the proposed light weight storage shed and washroom facility, provided that the subgrade is prepared in accordance with the recommendations provided herein. Boreholes BH1, 2, and 3 are representative for the subsurface conditions at the washroom and storage shed location.

It is recommended that a moisture break be installed prior to construction of the floor slab. The moisture break should consist of a 300 mm thick layer of OPSS Granular A compacted to a minimum of 100% of the materials SPMDD.

A modulus of subgrade reaction, ks, of 25 MN/m3 can be used for design of the floor slab at this site, provided that the construction is in accordance with the recommendations provided herein.

A perimeter drainage system will not be required, provided that the proposed finished floor is a minimum of 150 mm above the exterior grade and the ground surface around the perimeter of the washroom facility slopes down away from the facility.

Under floor drains will not be required for the planned structure.

8.7 BOARDWALK AND BRIDGE FOUNDATION - HELICAL PILES

Helical piles founded in the native silty clay till should be feasible to support the boardwalk and proposed bridge. Preliminary values available from the Helical pile's suppliers (such as POSTECH Screw Piles) for bearing resistance at Ultimate Limit State (ULS) and Serviceability Limit State (SLS) are provided in **Table 8.2** for different blade sizes. These values are based on 2 to 3 m penetration of single helical in the foundation soil. **Table 8.2** should be reviewed and refined during the detailed design stage for the selected product.

Based on the subsurface soil conditions encountered in the boreholes. Borehole BH10 to BH14 are representative of subsurface conditions along the boardwalk and BH 5 and BH6 represent the soil conditions underneath the observation tower and proposed bridge), the parameters provided could be considered for use in preliminary design of Helical piles.

Table 8.2: Parameters for Helical Piles Design

	Blade Diameter Size				
	255 mm	**300 mm**	**355 mm**	**405 mm**	**455 mm**
Foundation Material	Native Silty Clay Till				
Expected Termination Depth Below Existing Boardwalk (m)	8 m				
Average Undrained Shear Strength (kPa)	110				
Factored Pile Resistance at ULS (kPa)	16	22.4	31	40	50
Pile Bearing Resistance at SLS (kPa)	12	17	23	30	37
Coefficient of Horizontal Subgrade Reaction, K_s (kN/m³)					
From 0 m to 5 m below Existing boardwalk	0				
Below 5 m	15,000				

The ULS values include a resistance factor of 0.4. The SLS values have been estimated for a total settlement of approximately 25 mm.

The horizontal coefficient of subgrade reaction value provided in Table 8.2 can be used to evaluate the lateral capacity of the Helical piles. The top 5 m of the piles will be exposed to air/water/sedimentation; therefore, the piles should be protected from corrosion by providing sufficient thickness of pile material for corrosion or by applying a protective layer. The helical section of the pile should be installed in a competent foundation soil which is anticipated at 5 m depth below existing boardwalk.

It is recommended to avoid using the blades within the top portion of the piles (approximately top 2.5 m) to mitigate the adfreeze force on the piles.

8.8 EXCAVATIONS AND BACKFILL

8.8.1 Excavations

Temporary excavations for the proposed development must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA).

The existing sand and silty sand, soft to stiff clay should be considered a Type 4 soil. The maximum excavation side slope for a Type 4 soil is 3:1 (Horizontal: Vertical) in accordance with the OHSA regulation

The very stiff silty clay should be considered as Type 3 soils. In accordance with the OH&S Act, the maximum excavation side slope for a Type 3 soil is 1:1 (Horizontal: Vertical) extending from the base of the excavation.

The native hard silty clay should be classified as Type 2 soils. In accordance with the OH&S Act, the maximum excavation side slope for a Type 2 soil is 1:1 (Horizontal: Vertical) but a vertical cut of 1.2 m is permitted extending from the base of the excavation.

Groundwater was encountered in all of the boreholes at a depth of 0.8 m to 2.4 m below the existing ground surface. For shallow excavations to the groundwater level seepage if encountered from the sand soils should be handled by pumping from sumps using conventional submersible pumps provided the excavations remain open for a short period of time, less than 48 hours.

At such times or when deeper excavations are intended, additional and more extensive dewatering efforts may be required.

The design of any dewatering system should address the extent of dewatering required, the depth of intended excavation, and the soil and groundwater conditions that prevail at the intended excavation location. The design of a dewatering system is beyond the scope of this investigation and geotechnical report.

The preceding comments are intended for general reference and information only. The Contractor is solely responsible for the design and implementation of any required dewatering, including requirements for withdrawal, handling, treatment, and discharge.

Excavation side slopes should be protected from exposure to precipitation and associated ground surface runoff and should be inspected regularly for signs of instability. If localized instability is noted during excavation or if wet conditions are encountered, the side slopes should be flattened as required to maintain safe working conditions.

If space is restricted such that the side slopes cannot be safely cut back in accordance with the OHSA Regulation, or sloughing and cave-in are encountered in the excavation, the slopes should be flattened to achieve a stable configuration or temporary shoring provided.

The presence of the heterogeneous fill materials, possible deleterious and debris materials, and presence of perched and static groundwater, will influence the conditions encountered in open excavations on the site.

8.8.2 Backfill

The existing sand and silty sand or approved imported soil can be used as backfill materials with moisture contents within 2% of their optimum moisture content based on the Standard Proctor moisture-density relationship tests.

All backfill should be placed in 200 mm thick loose lifts and compacted to a minimum of 98% SPMDD.

All backfill and compaction operations should be monitored to verify that the specified degree of compaction is being achieved uniformly.

Where potential for adverse frost conditions exist, it is recommended that the implementation of supplementary drainage and frost protection be considered.

8.9 SEISMIC SITE CLASS

The seismic site class determination is based on the soil conditions in the upper 30 m of the stratigraphy as encountered in the boreholes for the geotechnical investigation. For the purposes of this report, the weighted average N-value method has been used to assess the Seismic Site Classification for this project location, consistent with the second of three methods stated in the National Building Code (2015).

The following stratigraphic profile and respective N-values were considered for purposes of assessing the Seismic Site Classification:

- Layer 1 – Thickness of 4 m
  Average Cu = 110 (Silty Clay Till)

Therefore, in accordance with the Ontario Building Code (2012), Seismic Site Class 'C' can be used for design.

A copy of the NBC Seismic Hazard Calculation Data sheet is provided in **Appendix E**.

9.0 CLOSURE

Use of this report is subject to the Statement of General Conditions provided in **Appendix A**. It is the responsibility of the Parks Canada who 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 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; and,
- Planning, design or construction.

Respectfully Submitted,

STANTEC CONSULTING LTD.

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APPENDICES

Appendix A

A.1 STATEMENT OF GENERAL CONDITIONS

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.

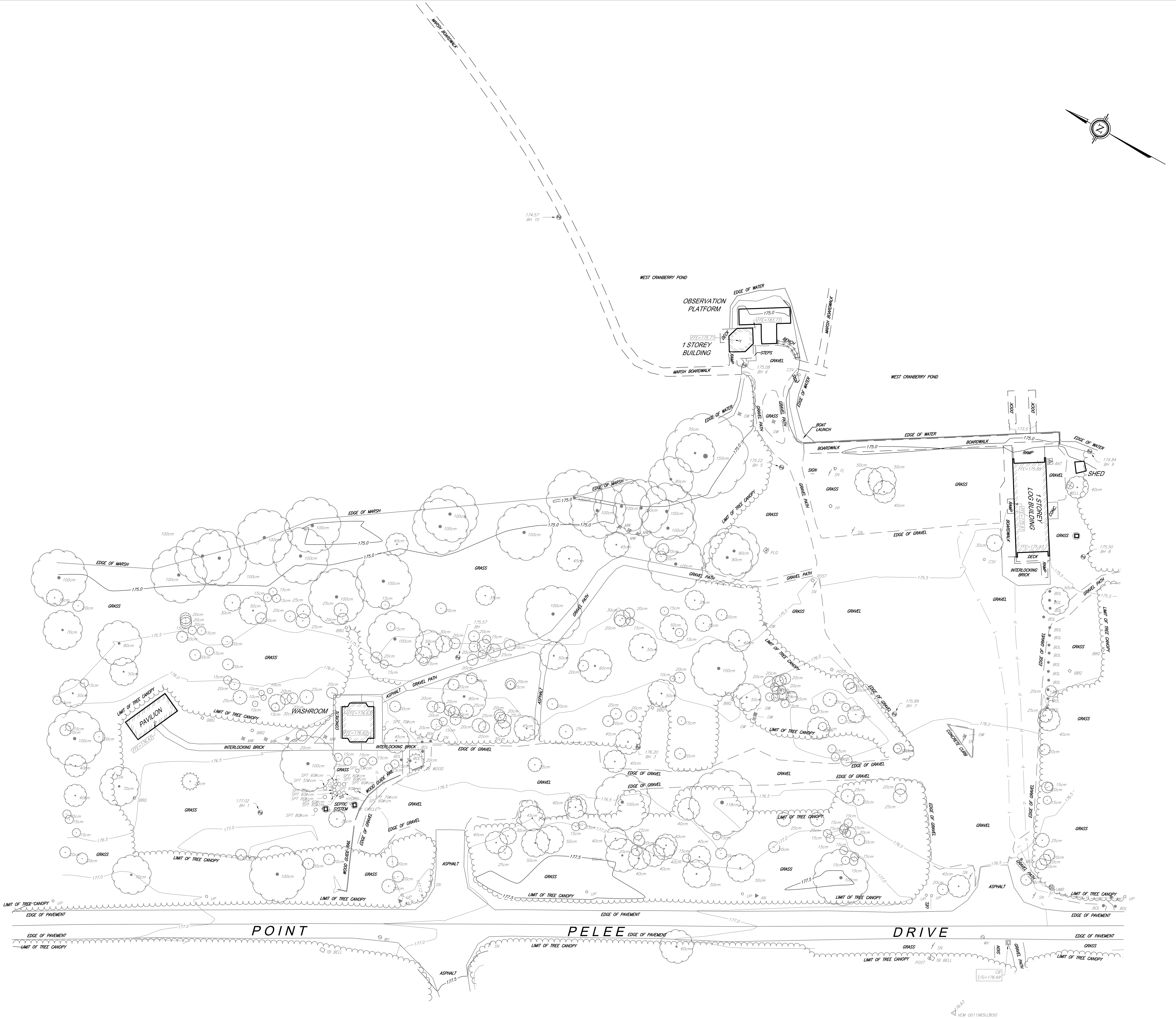
INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications 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.

Appendix B

B.1 DRAWINGS



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www.stantec.com

TOPOGRAPHIC SKETCH of

MARSH BOARDWALK

POINT PELEE NATIONAL PARK

Scale 1:400

3 0 10 20 30 METRES

Stantec Geomatics Ltd.
ONTARIO LAND SURVEYORS

METRIC CONVERSION

DISTANCES AND COORDINATES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048

VERTICAL DATUM NOTE

ELEVATIONS ARE REFERRED TO THE CANADIAN GEODETIC VERTICAL DATUM (CGVD-1928:1978) AND ARE DERIVED FROM BENCHMARK MONUMENT No. 0011965U3650, HAVING A PUBLISHED ELEVATION OF 176.627 METRES.

HORIZONTAL DATUM NOTE

PROJECTION: UNIVERSAL TRANSVERSE MERCATOR (UTM, ZONE 17, CM81°00'W)
DATUM: NAD 83 (CSRS)(2010.0)

THIS PLAN MAY BE CONVERTED TO GROUND BY DIVIDING BY A COMBINED SCALE FACTOR OF 0.99977645.

LEGEND

■	DENOTES	FOUND MONUMENTS
□	"	SET MONUMENTS
IB	"	IRON BAR
IBø	"	ROUND IRON BAR
SIB	"	STANDARD IRON BAR
SSIB	"	SHORT STANDARD IRON BAR
CC	"	CUT CROSS
CP	"	CONCRETE PIN
WIT	"	WITNESS
PIN	"	PROPERTY IDENTIFICATION NUMBER
MEAS	"	MEASURED
PROP	"	PROPORTIONED
UEL	"	UNDERGROUND HYDRO
STANTEC	"	STANTEC GEOMATICS LTD.
AN	"	ANCHOR
ANT	"	ANTENNA
BH	"	BOREHOLE
BOL	"	BOLLARD
CB	"	CATCH BASIN
CO	"	CLEAN OUT
CSV	"	CURB STOP VALVE
FP	"	FLAG POLE
FL	"	FLOOD LIGHT
HW	"	HAND WELL
MW	"	MONITORING WELL
OW	"	OBSERVATION WELL
SN	"	SIGN
TB BELL	"	TERMINAL BOX - BELL
TB CATV	"	TERMINAL BOX - CABLE
UP	"	UTILITY POLE
WV	"	WATER VALVE
	"	TREE CONIFEROUS (D.B.H. SHOWN)
	"	TREE DECIDUOUS (D.B.H. SHOWN)

UNDERGROUND TELEPHONE — T — T — T
UNDERGROUND HYDRO — P — P — P
WATERMAIN — WTM — WTM — WTM
GASMAIN — G — G — G

DRAWN: BL   DATE: October 25, 2016   PROJECT No.: 160622453

Appendix C

C.1 BOREHOLE RECORDS AND SYMBOLS AND TERMS USED ON THE BOREHOLE RECORDS

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

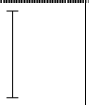
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals 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

BOREHOLE RECORD

Stantec

BH 1

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 24, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0	177.0	**Rough Grass**			0					
		TOPSOIL, 130 mm								
		Loose to compact, brown SAND (SP) - trace gravel - moist to wet		▽	1	SS	1	430/610	9	
1					2					
					3	SS	2	460/610	11	
					4					
					5					
2					6	SS	3	460/610	5	3 94 3
					7					
					8	SS	4	510/610	11	
					9					
3					10					
					11	SS	5	510/610	11	
	173.4				12					
4		END OF BOREHOLE at approximately 3.6 m below existing grade. Borehole open to approximately 2.6 m below grade on completion of drilling. Groundwater level measured in open borehole at approximately 2.4 m below grade.			13					
					14					
					15					
5					16					
					17					
					18					
					19					
6					20					
					21					
					22					
					23					
7					24					
					25					
					26					
8					27					
					28					
					29					
9					30					
					31					
					32					
10										

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90 100

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

Stantec

BH 2

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 24, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	**175.6**	**Rough Grass**			0				
	175.3	TOPSOIL, 250 mm							
		Loose to compact, brown SAND (SP) - moist		▽	1	SS	1	460/610	1
1					2				
					3	SS	2	460/610	8
					4				
					5				
2					6	SS	3	410/610	9
					7				
					8	SS	4	460/610	10
					9				
3					10				
					11	SS	5	510/610	14
	171.9	- wet			12				
		END OF BOREHOLE at approximately 3.6 m below existing grade. Borehole open to approximately 1.2 m below grade on completion of drilling. Groundwater level measured in open borehole at approximately 0.9 m below grade.			13				
4					14				
					15				
					16				
5					17				
					18				
					19				
6					20				
					21				
					22				
7					23				
					24				
					25				
8					26				
					27				
					28				
9					29				
					30				
					31				
10					32				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH 3

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 24, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	176.2	**Rough Grass**			0				
		TOPSOIL, 25 mm							
		Loose to compact, brown to dark brown SAND (SP)			1	SS	1	460/610	9
		- moist			2				
1					3	SS	2	510/610	6
					4				
				▽	5				
					6	SS	3	460/610	9
2					7				
					8	SS	4	460/610	14
		- wet			9				
3					10				
	172.7				11	SS	5	460/460	27
		END OF BOREHOLE at approximately 3.5 m below existing grade.			12				
4					13				
		Borehole open to approximately 1.8 m below grade on completion of drilling.			14				
					15				
		Groundwater level measured in open borehole at approximately 1.7 m below grade.			16				
5					17				
					18				
					19				
6					20				
					21				
					22				
7					23				
					24				
					25				
8					26				
					27				
					28				
9					29				
					30				
					31				
10					32				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

Stantec

BH 4

CLIENT Parks Canada Agency — PROJECT No. 160622453

LOCATION Point Pelee National Park — DATUM

DATES: BORING October 26, 2016 — WATER LEVEL — TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	176.0	**Rough Grass**	0				
	175.8	TOPSOIL, 205 mm					
		Loose to compact, brown, SAND (SP) - moist	1	SS	1	380/610	5
1			2				
			3	SS	2	460/610	9
			4				
			5				
2		- moist to wet	6	SS	3	610/610	6
			7				
			8	SS	4	510/610	23
3			9				
			10				
		- trace to some gravel - moist to wet	11	SS	5	460/610	22
			12				
4	171.7		13				
		Very dense, brown, SAND (SP) with gravel - moist	14				
			15				
			16	SS	6	460/610	52
5			17				
			18				
	170.1		19				
6		Hard, brown, , silty CLAY (CL-ML), TILL - moist	20				
	169.3		21	SS	7	250/610	34
		END OF BOREHOLE at approximately 6.7 m below existing grade. Borehole open to approximately 1.4 m below grade on completion of drilling. Groundwater level measured in open borehole at approximately 1.1 m below grade.	22				
7			23				
			24				
			25				
			26				
8			27				
			28				
			29				
9			30				
			31				
10			32				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

Stantec

BH 5

CLIENT Parks Canada Agency — PROJECT No. 160622453

LOCATION Point Pelee National Park — DATUM

DATES: BORING October 25, 2016 — WATER LEVEL — TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0	175.2	**Rough Grass**	0					
	175.1	TOPSOIL, 150 mm						
		Very loose to compact, dark brown, SAND (SP)	1	SS	1	410/610	16	
		- moist	2					
1		- grey	3	SS	2	380/610	1	
	173.8	- with occasional rootlets	4					
		Very loose, dark brown, silty SAND (SM)	5					
2		- occasional rootlets	6	SS	3	250/610	1	
		- moist to wet	7					
			8	SS	4	200/610	1	
	172.2		9					
3		Very loose, dark brown SAND (SP)	10					
		- occasional rootlets	11	SS	5	150/610	1	
		- wet	12					
			13					
4	171.1	- with occasional silty clay seams and layers	14					
		Stiff to hard, brown, silty CLAY (CL-ML)	15					
		- moist	16	SS	6	410/610	9	1 11 36 52
5			17					
			18					
			19					
6			20					
			21	SS	7	300/610	34	
	168.5		22					
7		END OF BOREHOLE at approximately 6.7 m below existing grade.	23					
			24					
		Borehole open to approximately 1.8 m below grade on completion of drilling.	25					
			26					
8			27					
		Groundwater level measured in open borehole at approximately 0.9 m below grade.	28					
			29					
9			30					
			31					
			32					
10								

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90 100

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

Stantec

BH 6

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 26, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	175.1	**Gravel**	0				
	174.9	FILL: brown, sand and gravel					
		FILL: brown sand	1	SS	1	410/610	8
	174.4	- moist	2				
1		Brown, SAND (SP)	3	AS	2		
		- some silt	4				
		- moist to wet	5				
			6	AS	3		
2		- wet	7				
		Peat	8	AS	4		
		- some rootlets	9				
	172.1		10				
3		- very loose	11	SS	5	300/610	1
			12				
4			13				
	170.7		14				
		Stiff, brown, silty CLAY (CL-ML), TILL	15				
		- moist	16	SS	6	200/610	9
5			17				
			18				
			19				
6			20				
		- very stiff	21	SS	7	380/610	25
			22				
7			23				
			24				
			25				
8			26	SS	8	250/610	9
	166.9		27				
		END OF BOREHOLE at approximately 8.2 m below existing grade.	28				
9			29				
		Borehole open to approximately 0.8 m below grade on completion of drilling.	30				
			31				
10			32				

STRATA PLOT

WATER LEVEL ▽

UNDRAINED SHEAR STRENGTH (kPa)
50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)
10 20 30 40 50 60 70 80 90 100
GR SA SI CL

Continued Next Page

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

BH 6

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 26, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)
	165.1								
10		Groundwater level measured in open borehole at approximately 0.8 m below grade.			33				
					34				
					35				
11					36				
					37				
					38				
12					39				
					40				
					41				
13					42				
					43				
					44				
14					45				
					46				
					47				
15					48				
					49				
					50				
16					51				
					52				
					53				
17					54				
					55				
					56				
18					57				
					58				
					59				
19					60				
					61				
					62				
20					63				
					64				
					65				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

Stantec

BH 7

CLIENT Parks Canada Agency — PROJECT No. 160622453

LOCATION Point Pelee National Park — DATUM

DATES: BORING October 26, 2016 — WATER LEVEL — TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
	175.9	**Gravel**					
0		FILL: sand and gravel	0				
		FILL: brown, sand	1	SS	1	510/610	11
	175.2		2				
1		Loose to compact, brown, SAND (SP)	3				
		- moist	4	SS	2	610/610	8
			5				
			6	SS	3	510/610	9
2			7				
			8	SS	4	510/610	26
		- wet	9				
3			10				
			11	SS	5	460/610	25
			12				
4			13				
			14				
			15				
			16	SS	6	510/610	27
5		- some gravel	17				
		- moist to wet	18				
			19				
6			20				
			21	SS	7	460/610	22
	169.2	- with silty clay seam at 6.4 m	22				
7		END OF BOREHOLE at approximately 6.7 m below existing grade.	23				
			24				
		Borehole open to approximately 1.5 m below grade on completion of drilling.	25				
			26				
8			27				
		Groundwater level measured in open borehole at approximately 1.4 m below grade.	28				
			29				
9			30				
			31				
10			32				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

3 70 27

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

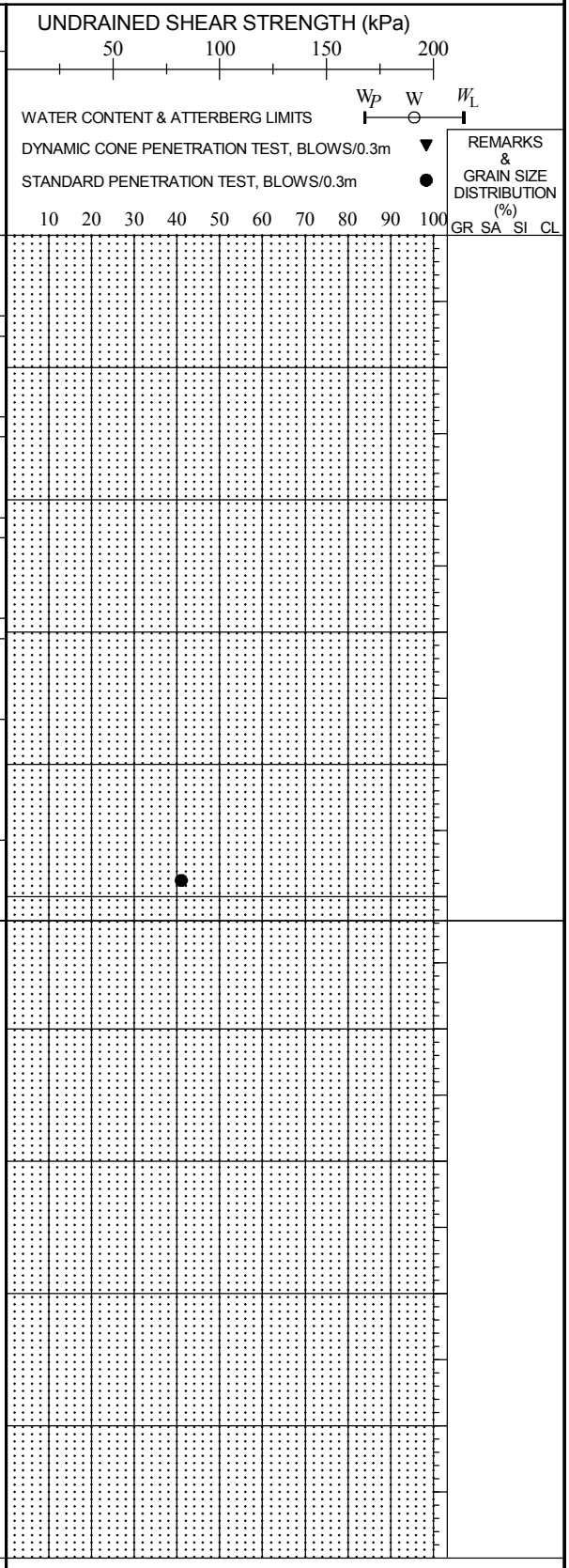
BH 8

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 26, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	175.5	**Rough Grass**	0				
	175.3	TOPSOIL, 150 mm					
		FILL: brown, silty clay - moist	1	AS	1		
	174.8		2				
1		Brown, SAND (SP) - wet	3	AS	2		
			4				
			5				
2			6	AS	3		
			7				
			8	AS	4		
			9				
3			10				
			11	AS	5		
			12				
			13				
4	171.2		14				
		Brown, SAND (SP) with gravel - wet	15				
			16	SS	6		41
5	170.3		17				
		END OF BOREHOLE at approximately 5.2 m below existing grade.	18				
			19				
6		Groundwater level measured in open borehole at approximately 0.9 m below grade.	20				
			21				
			22				
7			23				
			24				
			25				
8			26				
			27				
			28				
9			29				
			30				
			31				
10			32				



Stantec

BOREHOLE RECORD

BH 9

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 26, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0	174.8	**Rough Grass**			0					
	174.7	TOPSOIL, 150 mm								
		FILL: silty clay - moist			1	SS	1	150/610	2	
	174.2				2					
1		Very loose, dark grey SAND (SP) - wet		▽	3	SS	2	300/610	1	
					4					
					5					
2					6	SS	3	0.0/610	WH	
					7					
					8	SS	4	200/610	1	
					9					
3					10					
					11	SS	5	250/610	6	
					12					
4					13					
	170.6				14					
		Stiff, brown, silty CLAY (CL-ML), TILL - moist			15					
					16	SS	6	300/610	9	
5					17					
					18					
					19					
6					20					
					21	SS	7	360/610	14	1 11 37 51
	168.1				22					
7		END OF BOREHOLE at approximately 6.7 m below existing grade.			23					
					24					
		Borehole open to approximately 0.9 m below grade on completion of drilling.			25					
					26					
8					27					
					28					
		Groundwater level measured in open borehole at approximately 0.9 m below grade.			29					
					30					
9					31					
					32					
10										

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90 100

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

BH10

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 25, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)
0	**174.6**	**Top of Boardwalk**	0				
	174.0	Water	1				
1			2				
	172.7	Marsh Deposit - organics/peat - alluvial deposit	3				
2			4				
			5				
3	170.8		6				
		Stiff to hard, grey, silty CLAY (CL-ML), TILL - moist to wet	7				
4			8				
			9				
			10				
			11				
			12				
			13	SS	1	410/760	9
			14				
5			15				
			16	SS	2	200/760	22
			17				
			18				
			19	SS	3	250/760	60
6	168.5		20				
		END OF BOREHOLE at approximately 6.1 m below top of board Dynamic cone test recorded from approximately 5.5 m to 6.7 m below top of board	21				
			22				
7			23				
			24				
			25				
			26				
8			27				
			28				
			29				
			30				
9			31				
			32				
10							

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

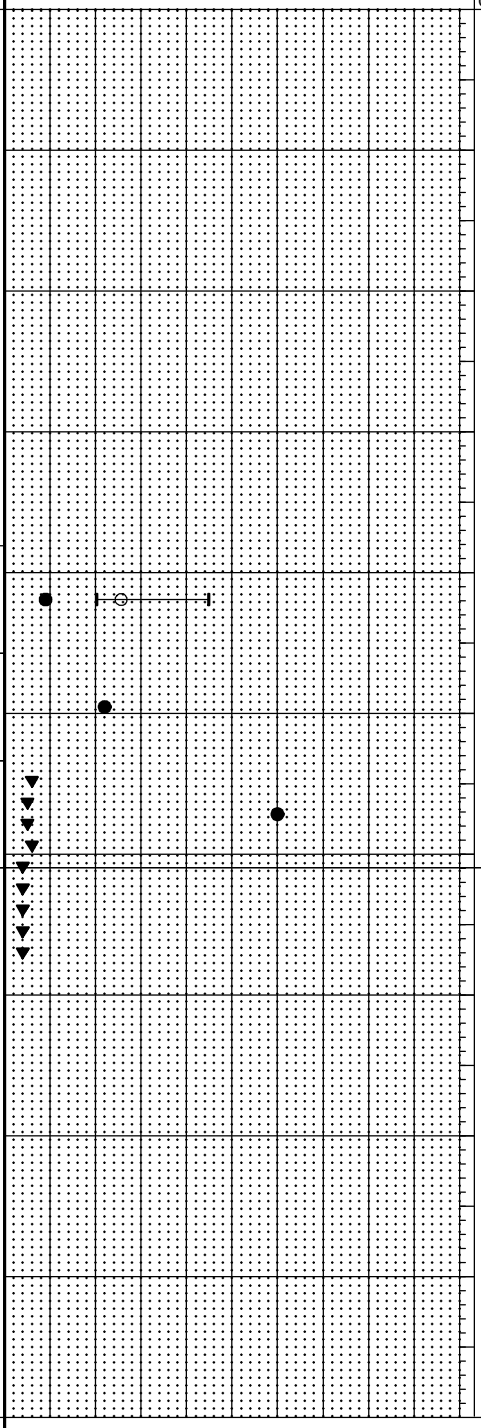
DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m

STANDARD PENETRATION TEST, BLOWS/0.3m

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL



□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

Stantec

BH11

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 25, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)
0	174.5	**Top of Boardwalk**			0
	173.9	Water		▽	1
1					2
	172.7	Marsh Deposit - organics/peat - alluvial deposit			3
2					4
					5
					6
3					7
					8
					9
	170.7				10
4					11
					12
					13
					14
5					15
					16
					17
					18
6					19
					20
					21
					22
7					23
					24
					25
					26
8					27
					28
					29
					30
9		Dynamic cone test recorded from approximately 6.1 m to 9.7 m below top of board			31
					32
10					

SAMPLES: TYPE | NUMBER | RECOVERY (mm) TCR(%) / SCR(%) | N-VALUE OR RQD(%)

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH12

CLIENT Parks Canada Agency — PROJECT No. 160622453

LOCATION Point Pelee National Park — DATUM

DATES: BORING October 25, 2016 — WATER LEVEL — TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)
0	**174.6**	**Top of Boardwalk**			0				
	174.0			▽	1				
1		Water			2				
	172.8				3				
2		Marsh Deposit - organics/peat - alluvial deposit			4				
	170.6				5				
4		Firm, grey, silty CLAY CL-ML), TILL - moist - very stiff			13				
					14	SS	1	360/610	7
5					15				
					16	SS	2	460/760	20
					17				
					18				
		- hard			19	SS	3	250/760	66
6	168.5	- moist			20				
		END OF BOREHOLE at approximately 6.1 m below top of board			21				
7					22				
					23				
					24				
					25				
8					26				
					27				
					28				
					29				
9					30				
					31				
10					32				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH13

CLIENT Parks Canada Agency PROJECT No. 160622453

LOCATION Point Pelee National Park DATUM

DATES: BORING October 25, 2016 WATER LEVEL TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)
0	**174.6**	**Top of Boardwalk**			0				
	174.0			▽	1				
1		Water			2				
	172.7				3				
2		Marsh Deposit - organics/peat - alluvial deposit			4				
	170.8				5				
4		Soft, grey, silty CLAY (CL-ML) - moist			6				
	170.2				7				
		Very stiff to hard, grey, silty CLAY (CL-ML) - moist			8				
5					9				
		- brown			10	SS	1	460/760	4
					11				
					12				
					13				
					14				
					15	SS	2	410/760	28
					16				
					17				
					18				
					19	SS	3	460/760	48
6	168.5				20				
		END OF BOREHOLE at approximately 6.1 m below top of board.			21				
					22				
7					23				
					24				
					25				
8					26				
					27				
					28				
					29				
9					30				
					31				
10					32				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

Stantec

BH14

CLIENT Parks Canada Agency — PROJECT No. 160622453

LOCATION Point Pelee National Park — DATUM

DATES: BORING October 25, 2016 — WATER LEVEL — TPC ELEVATION

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)
0	174.5	**Top of Boardwalk**			0				
	173.9	Water		▽	1				
1					2				
	172.7	Marsh Deposit - organics/peat - alluvial deposit			3				
2					4				
					5				
3					6				
	170.6	Peat			7				
4					8				
	169.8	Very stiff to hard, brown, silty CLAY (CL-ML), TILL - moist			9				
5					10				
					11				
					12				
					13				
					14	SS		0.0/760	7
					15				
					16				
					17	SS	1	760/760	29
					18				
6					19	SS	2	510/760	20
		- soft, unreliable SPT value at 6.7 m			20				
					21				
					22	SS	3	200/760	8
7					23				
	166.9				24	SS	4	300/760	39
		END OF BOREHOLE at approximately 7.5 m below top of board.			25				
8					26				
					27				
					28				
					29				
9					30				
					31				
10					32				

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)

10 20 30 40 50 60 70 80 90 100

GR SA SI CL

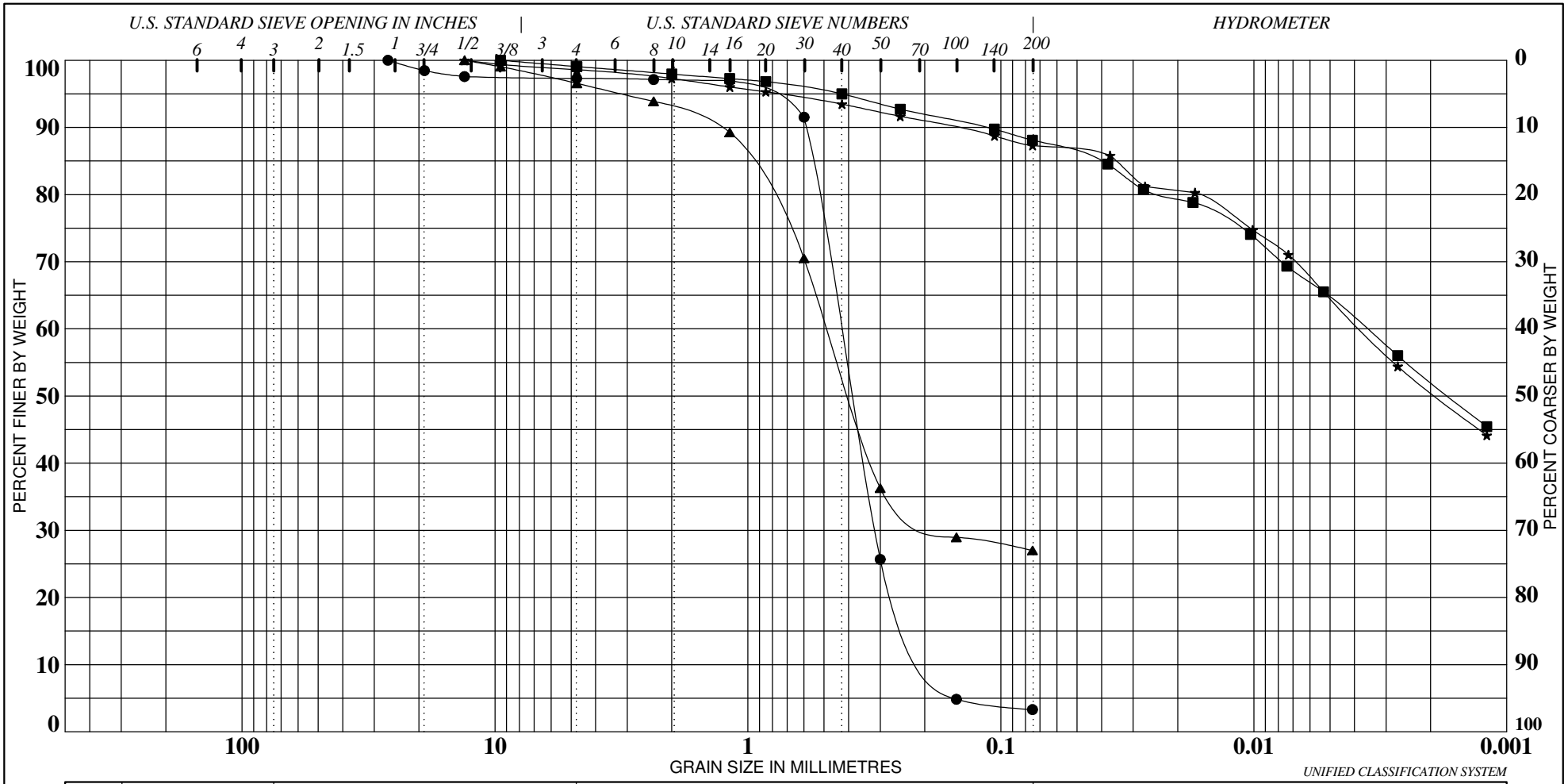
□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Appendix D

D.1 LABORATORY TEST RESULTS



BLDs	COBBLES	GRAVEL		SAND			SILT & CLAY	
		coarse	fine	coarse	medium	fine	SILT	CLAY

Sample		Depth (m)	Description	W%	W_L	W_P	I_P	%Gravel	%Sand	%Silt	%Clay
●	BH 1	1.8	POORLY GRADED SAND(SP)	7				3	94	3	
■	BH 5	4.9	CLAY (CL)	11				1	11	36	52
▲	BH 7	6.4	SILTY SAND (SM)	17				3	70	27	
★	BH 9	6.4	CLAY (CL)	18	38	20	18	1	11	37	51

Stantec

Project: PT Pelee NP Marsh Area Renewal

Location: Point Peel National Park

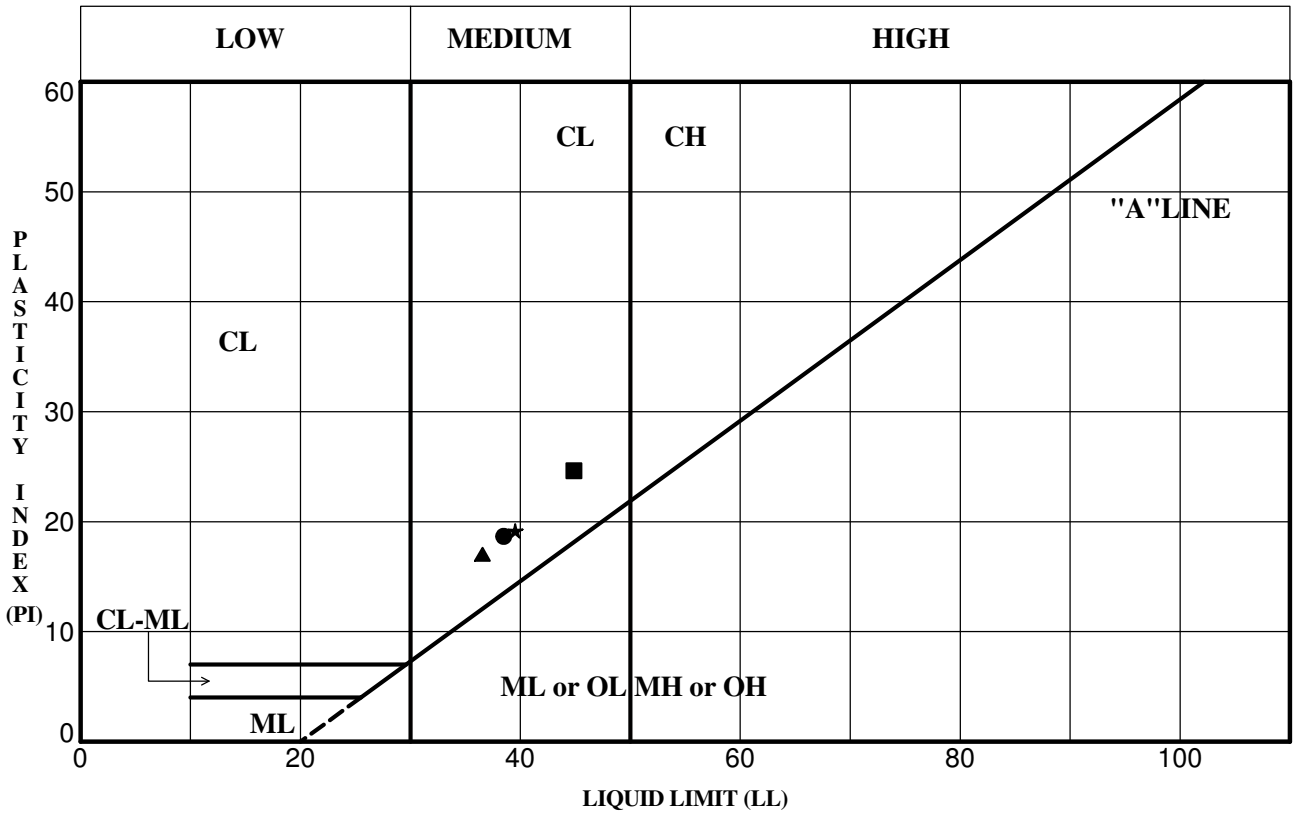
Project No.: 160622453

GRADATION CURVE (ASTM D422)

Figure: 1

Remarks:

PLASTICITY CHART



	Specimen	Depth (m)	LL	PL	PI	Fines	W%	Classification
●	BH 9	6.4	38	20	18	87	18	CLAY (CL)
■	BH10	4.2	45	20	25		26	CLAY (CL)
▲	BH12	4.3	37	20	17		21	CLAY (CL)
★	BH14	5.9	40	20	20		20	CLAY (CL)

Stantec

Project: PT Pelee NP Marsh Area Renewal

Location: Point Peel National Park

Project No.: 160622453

ATTERBERG LIMITS
(ASTM D4318)

Figure: 2

Remarks:

STN13-ATTERBERG 160622453.GPJ MM.GDT 11/15/16

Appendix E

E.1 SEISMIC HAZARD CALCULATION SHEET

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

December 07, 2016

Site: 41.9552 N, 82.5172 W User File Reference: Point Pelee National Park

Requested by: Zeyad Al-Hayazai, Stantec

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.101	0.133	**0.121**	0.097	**0.073**	**0.039**	**0.019**	**0.0044**	**0.0018**	**0.074**	**0.056**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.0088	0.034	0.056
Sa(0.1)	0.014	0.048	0.078
Sa(0.2)	0.014	0.046	0.073
Sa(0.3)	0.012	0.038	0.059
Sa(0.5)	0.0082	0.029	0.044
Sa(1.0)	0.0036	0.015	0.024
Sa(2.0)	0.0013	0.0061	0.011
Sa(5.0)	0.0004	0.0013	0.0024
Sa(10.0)	0.0003	0.0007	0.0011
PGA	0.0072	0.026	0.043
PGV	0.0047	0.019	0.032

References

National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français

Natural Resources Canada Ressources naturelles Canada

Canada