Landslide Hazard Assessment

Proposed Residential Development

2983, 3053 and 3079 Navan Road
Ottawa, Ontario

Prepared for EXP Services Inc. (c/o 12714001 Canada Inc.)

Report PG6142-1 Revision 2 dated January 30, 2025

Table of Contents

Appendices

1.0 Introduction

1.1 Purpose of Study and Scope of Work

Paterson Group (Paterson) was commissioned by EXP Services Inc. to prepare a landslide hazard assessment study for the proposed residential development to be located at 2983, 3053 and 3079 Navan Road in the City of Ottawa, Ontario (reference should be made to Figure 1 - Key Plan in Appendix 2 of this report). The study has been prepared in response to the requirement by the Rideau Valley Conservation Authority (RVCA) as part of the Site Plan Approval process for the City of Ottawa for the subject site.

The objectives of the hazard assessment were to:

- Demonstrate that any landslide on the sloped areas, including a large “catastrophic landslide”, has an annual probability less than 1:10,000.

- If the landslide hazard cannot be demonstrated to have an annual probability of less than 1:10,000, it must be demonstrated that the individual risk is <1x10^{-5} per year and group risk falls within the “Acceptable” zone on a suitable group risk chart.

- If none of these criteria can be satisfied without mitigation measures, then the mitigation actions required must be demonstrated to reduce the risk below 10^{-5} per year and to “as low as reasonably practicable” (ALARP). If mitigation is required, further discussion with the RVCA will be required to determine what will be acceptable.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as they are understood at the time of writing this report.

1.2 Hazard Assessment Methodology

The methodology of this study was undertaken using a combination of the criteria and requirements set out by the following guidelines:

- ☐ Fraser Valley Regional District's Hazard Acceptability Thresholds for Development Applications dated October 2020
- ☐ The Association of Professional Engineers and Geoscientists of British Columbia's (APEGBC) Guidelines for Legislates Landslide Assessments for Proposed Residential Developments in BC, dated May 2010
- ☐ Geological Survey of Canada's Open File 7312 - Landslide Risk Evaluation Technical Guidelines and Best Practices, dated 2013

The scope of work used in this study included a review of published literature describing local landslides and their associated triggers, geotechnical hazards, inventoried regional landslides and the geological setting of the study area. Desktop review of published topographic mapping, LiDAR imaging, and other geological mapping was also used as part of this assessment.

Field reconnaissance was carried out over geotechnical field programs that have taken place throughout the subject site and undertaken by others, including field review and subsurface investigations. Review of publicly available well records and previous geotechnical investigations undertaken by Paterson for properties located near the subject site was also considered as part of our assessment.

1.3 Proposed Development

Based on the available drawings, it is understood that the proposed development will consist of a residential subdivision consisting of townhouse structures and low-rise apartment buildings with one basement level. It is also understood that commercial units will be part of the development.

Landscaped areas, roadways and access lanes are also anticipated as part of the proposed development. The proposed development will be integrated into the neighboring and existing residential communities and municipal infrastructure systems and will be municipally serviced.

1.4 Review of Previous Geotechnical Investigation

For this assessment, subsurface information was collected from site-specific investigations carried out by Paterson and others throughout the subject site. The results of the previous investigations are presented in the following reports:

- ☐ Report prepared by EXP Services Inc. for 12714004 Canada Inc. - *Updated Geotechnical Investigation - Proposed Residential Development - 2983, 3053 and 3079 Navan Road, Ottawa, Ontario - OTT-21004743-B0*, dated December 8, 2023.
- ☐ Report prepared by Paterson for Taggart Realty Management Inc. - *Geotechnical Investigation - Proposed Commercial Development - Brian Coburn Boulevard at Navan Road, Ottawa, Ontario - PG4415-1 Revision 1*, dated November 13, 2018.
- ☐ Report prepared by Paterson for Richcraft Homes Limited - *Geotechnical Investigation - Proposed Residential Development - Page Road at Renaud Road, Ottawa, Ontario - PG0861-1* dated February 26, 2007.
- ☐ Report prepared by Paterson for Claridge Homes (Carson) Inc. - *Geotechnical Investigation - Proposed Road Reconstruction - Renaud Road, Ottawa, Ontario - PG1745-1* dated January 19, 2009.
- ☐ Report prepared by Golder Associates for Stantec Consulting Limited – *Geotechnical Investigation – Pond 1 Ravine Crossing and Partial Ravine Filling West of Page Road; Cumberland Transitway: West of Innes Road to East of Tenth Line Road - Renaud Road, Ottawa, Ontario – Report Number: 09-1121-0049-4000-5* dated August 2013.

Further, boreholes catalogs made available by the Ministry of Energy, Northern Development and Mines of Ontario have also been incorporated as part of the assessment. Relevant test hole information and locations are presented on the Drawing PG6142-1 - Test Hole Location Plan in Appendix 2.

All reviewers of this report should understand that the geotechnical investigation undertaken in support of the proposed development has been undertaken in accordance with the City of Ottawa's *Geotechnical Investigation and Reporting Guidelines for Development Applications in the City of Ottawa*, that the slope stability fieldwork and analysis had been undertaken in accordance with the City of Ottawa's *Slope Stability Guidelines for Development Application in the City of Ottawa*, and that laboratory testing was undertaken in accordance with the above-noted guidelines and the *City of Ottawa's Tree Planting in Marine Clay Soils – 2017 Guidelines*.

2.0 Background of Study Area

2.1 Field Investigation

Geotechnical Investigations

An initial field investigation was completed at the subject site by Paterson on May 22 and 23, 2018. At that time, four (4) boreholes were advanced to a maximum depth of 9.8 m below existing ground surface. Supplemental investigations were completed by others on April 28 to 30, 2021 and September 11 to 14, 2023. At that time, a total of nineteen (19) boreholes and one (1) piezocone penetration testing were advanced to a maximum depth of 32.5 m below ground surface.

The test hole locations were placed in a manner to provide general coverage of the subject site taking into consideration site access, features and underground utilities. The locations of the boreholes are illustrated on Drawing PG6142-1 - Test Hole Location Plan included in Appendix 2. The subsurface profiles are presented in the Soil Profile and Test Data sheets and in the Borehole Logs by Others presented in Appendix 1.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using two different techniques, namely, sampled directly from the auger flights (AU) or collected using a 50 mm diameter split-spoon (SS) sampler. The depths at which the auger flights and split spoon samples were recovered from the boreholes are shown as AU and SS respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

A Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split spoon samples. The SPT results are recorded as "N" values on the Soil Profile and Test Data sheets. The "N" value is the number of blows required to drive the split spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

Undrained shear strength testing was carried out at regular depth intervals in cohesive soils using a field vane apparatus.

The overburden thickness was evaluated by dynamic cone penetration testing (DCPT) completed at BH 2 (2018) and BH-06. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at the tip, using a 63.5 kg hammer falling from a height of 760 mm. The number of blows required to drive the cone into the soil is recorded for each 300 mm increment.

A piezocone penetration testing was also completed in conjunction with seismic shear wave and pore pressure measurements.

Subsurface conditions observed in the test holes were recorded in detail in the field. The soil profiles are presented on the Soil Profile and Test Data sheets and in Borehole Logs by Others in Appendix 1.

Groundwater

Flexible polyethylene standpipes were installed in the boreholes at selected locations to allow groundwater level monitoring. The groundwater observations are noted on Borehole Logs by Others presented in Appendix 1.

Geotechnical Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging. Additionally, a total of thirteen (13) grain size distribution analysis, five (5) consolidation tests, and ten (10) Atterberg limits test were completed on selected soil samples. The results are presented in Section 2.5 and on the Borehole Logs and Testing Results by Others presented in Appendix 1.

2.5 Existing Conditions

Surface Conditions

The majority of the subject site is generally vacant and has recently been deforested for construction.

The subject site is bordered by Brian Coburn Drive followed by a City “Park and Ride” facility to the north, residential dwellings followed by Page Road to the east, and residential buildings followed by Navan Road to the south.

The ground surface across the site slopes downward gradually from north to south, from approximate geodetic elevation 85 to 81 m. The site is generally at grade with the surrounding roadways and properties.

A tributary of Mud Creek was observed to the northwest at a distance ranging between 80 and 200 m of the subject site, and beyond the City “Park and Ride” facility. The tributary meanders in a northeast to southwest direction. The creek water level was observed to be at a geodetic elevation of approximately 76 to 74 m.

At the time of preparing the original version of this report, a slope was observed to the south of the subject site and beyond Navan Road. The ground surface throughout the previous slope was observed to present a profile sloping in a north-south direction and ranging between 2.5H:1V and 9H:1V. The existing slope has been regraded to between 4H:1V and 2H:1V overlying a set of existing retaining walls constructed during the development of the associated residential development (bound by Navan Road and Renaud Road). The remainder of the slopes located southwest of the Brian Coburn Boulevard and Navan Road are between 5H:1V and 7.5H:1V and 10 m high.

It is also understood that the footprint of a historical landslide scar underlies the southern portion of the subject site. Municipal infrastructure, such as roads and service alignments, as well as a residential subdivision, are also located throughout this scar.

Existing Building Assessment

Paterson carried out a pre-construction survey of existing buildings nearby the subject site. Where carried out, as permitted by homeowners, the assessment consisted of documenting the exterior of the existing structures. The interiors of the buildings were not reviewed due to health and safety restrictions associated with COVID-19 and in place at the time of the assessment. Five of the homes reviewed as part of this assessment (2824 Pagé Road, 6027 Renaud Road, 6071 Renaud Road, 6079 Renaud Road, 6099 Renaud Road) were constructed throughout the footprint of the previous landslide scar, and as observed on Drawing PG6142-1 – Test Hole Location Plan in Appendix 2 of this report.

During our review of exterior conditions, the above-noted buildings appeared to be in good condition with some defects which are considered typical for residential structures founded over sensitive clay deposits throughout the Orleans area and Ottawa valley. Further details of the evaluation are discussed in Section 4.2.7 of this report.

Subsurface Conditions

Generally, the soil profile encountered at the test hole locations consisted of topsoil layer underlain by a deep deposit of silty clay. The silty clay deposit consisted of a stiff to very stiff brown silty clay crust followed by a deep, firm to stiff grey silty clay deposit. A thin layer of silty sand was encountered overlying the silty clay deposit discontinuously throughout the subject site. Refusal to DCPT was not encountered throughout the subject site.

Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for the details of the soil profile encountered at each test hole location.

Geotechnical Laboratory Testing

Atterberg Limit Tests

Atterberg limits testing, as well as associated moisture content testing, was completed by others on ten (10) select silty clay samples. The results of the Atterberg limits test are presented in Table 1 and on the Borehole Logs by Others in Appendix 1.

The tested silty clay sample classifies as inorganic clay of high plasticity (CH) and silty clay of medium plasticity (CL) in accordance with the Unified Soil Classification System.

Table 1 - Atterberg Limits Results

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)	Classification
BH 2 - SS7	6.1 - 6.7	50	25	25	76	CH
BH 3 - SS3	2.3 - 2.9	32	17	15	65	CL
BH 4 - SS6	4.7 - 5.3	58	27	31	62	CH
BH 6 - SS8	9.1 - 9.7	45	26	19	78	CL
BH 10 - SS4	3.2 - 3.8	50	22	28	71	CH
BH 11 - SS4	2.3 - 2.9	40	15	25	41	CL
BH 11 - SS5	3.8 - 4.4	59	26	33	77	CH
BH 12 - SS3	2.3 - 2.9	64	26	38	66	CH
BH 14 - SS2	0.8 - 1.4	52	20	32	28	CH
BH 17 - SS3	2.3 - 2.9	54	23	31	61	CH

Note: LL: Liquid Limit; PL: Plastic Limit; PI: Plastic Index; w: water content.
CH: Inorganic Clay of High Plasticity; CL: Silty Clay of Medium Plasticity

Grain Size Distribution and Hydrometer Testing

Grain size distribution analysis was completed by others on thirteen (13) select recovered soil samples. The results of the grain size distribution analysis are presented in Table 2 and on the Grain Size Distribution Testing Results by Others in Appendix 1.

Table 2 - Grain Size Distribution Results

Sample	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH 1 - SS1	0.8 - 1.4	0	84	13	3
BH 2 - SS7	6.1 - 6.7	0	3	28	72
BH 3 - SS3	2.3 -2.9	0	3	54	43
BH 4 - SS6	4.7 - 5.3	0	0	16	74
BH 6 - SS8	9.1 - 9.7	0	0	25	75
BH 10 - SS4	3.2 - 3.8	0	2	36	62
BH 11 - SS4	2.3 - 2.9	0	15	35	50
BH 11 - SS5	3.8 - 4.4	0	0	25	75
BH 12 - SS1	0.0 - 0.6	0	79	12	9
BH 12 - SS2	1.0 - 0.6	0	79	12	9
BH 12 - SS3	2.3 - 2.9	0	0	23	77
BH 14 - SS2	0.8 - 1.4	0	2	41	57
BH 17 - SS3	2.3 - 2.9	0	0	32	68

Bedrock

Based on available geological mapping, the bedrock throughout the majority of the subject site consists of interbedded limestone and shale of the Lindsay Formation. However, the bedrock at the south portion of the subject site consists of Paleozoic Shale of the Billings formation. Also, based on available geological mapping, the overburden thickness is expected to range from 25 to 50 m throughout the entire subject site.

Reference should be made to the Soil Profile and Test Data Sheets in Appendix 1 for details of the soil profile encountered at each borehole location.

Groundwater

Groundwater level readings were recorded by others and are presented in Borehole Logs by Others on Appendix 1. However, it should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater levels could vary at the time of construction.

3.0 Slope Stability Analysis

3.1 Slope Conditions

Paterson completed a total of two (2) cross-sections as the worst-case scenarios and analyzed as part of the slope stability analysis. The analysis was carried out in accordance with the City of Ottawa's standard guidelines prepared by Golder Associates titled Slope Stability Guidelines for Development Applications in the City of Ottawa, dated 2004.

The cross-section locations and topographic mapping information are presented on Drawing PG6142-1 - Test Hole Location Plan in Appendix 2.

3.2 Slope Stability Analysis

The analysis of the stability of the slope was carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including the Bishop's method, which is a widely used and accepted analysis method.

The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favoring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsoil and groundwater conditions, a factor of safety greater than one is usually required to ascertain that the risks of failure are acceptable.

Two (2) slope cross-sections were analysed utilizing the latest topographic mapping. The slope stability analysis was completed at each slope cross-section under worst-case-scenario by assigning cohesive soils under fully saturated conditions. The analysis was carried out in accordance with the City of Ottawa's standard guidelines prepared by Golder Associates titled Slope Stability Guidelines for Development Applications in the City of Ottawa, dated 2004.

The effective strength soil parameters used for static analysis were chosen based on the subsoil information recovered during the geotechnical investigation. The effective strength soil parameters used for static analysis are presented in Table 3 below.

Table 3 – Effective Stress Soil Parameters (Static Analysis)			
Soil Layer	**Unit Weight (kN/m^3)**	**Friction Angle (degrees)**	**Cohesion (kPa)**
Silty Sand	21	35	1
Brown Silty Clay (Crust)	17	33	5
Grey Silty Clay	16	33	10
Glacial Till	20	33	1
Bedrock	Impenetrable		

The total strength parameters for seismic analysis were chosen based on the in situ, undrained shear strengths recovered within the open boreholes completed at the time of our geotechnical investigation and based on our general knowledge of the geology of the area. The strength parameters used for seismic analysis at the slope cross-sections are presented in Table 4 below.

Table 5 – Total Stress Soil Parameters (Seismic Analysis)			
Soil Layer	**Unit Weight (kN/m^3)**	**Friction Angle (degrees)**	**Cohesion (kPa)**
Silty Sand	21	35	NA
Brown Silty Clay (Crust)	17	-	120
Grey Silty Clay	16	-	32 at top of layer. Increases by 2.5 kPa/m to maximum of 100 kPa.
Glacial Till	20	33	NA
Bedrock	Impenetrable		

The location of the three cross-sections analyzed are presented on Drawing PG6142-1 - Test Hole Location Plan enclosed.

Static Analysis

The results of the static analysis for the proposed slope under fully saturated conditions (worst-case-scenario) are shown in Figure 2A and 3A attached to the current report. The minimum analysed slope stability factor of safety under fully saturated conditions (worst case scenario) were calculated to be greater than 1.5.

As a result, the two slope cross-sections analyzed were all above the recommended Factor of Safety of 1.5 and are considered stable under static conditions.

Seismic Loading Analysis

An analysis considering seismic loading was also completed as part of our slope stability assessment. A horizontal seismic acceleration, K_h, of 0.18g was considered for the analyzed section and discussed further in Section 4.2 of this report.

This acceleration is considered as half of the peak (horizontal) ground acceleration (PGA) of 0.153g, specified in the National Building Code of Canada (NBCC 2015) Seismic Calculator as having a probability of exceedance of 2% in 50 years (1:2,475-year earthquake) for the subject site.

Since the PGA is considered for “firm ground” Site Class C values, the value was factored by 0.98 to an equivalent PGA for a Site Class E. Further, since the provided PGA values are representative of shaking forces at the surface of bedrock or dense soil, the analysis considers an increase of 20% to the design PGA, equivalent to 0.18g, to account for soil amplification of ground shaking experienced by the overburden.

A factor of safety of 1.1 is considered to be satisfactory for stability analysis including seismic loading (i.e. pseudo-static) as per the City of Ottawa’s *Slope Stability Guidelines for Development Applications*.

The results of the analysis including seismic loading fully saturated conditions (worst-case-scenario) are shown in Figure 2B and 3B attached to the current report.

The overall slope stability factor of safety at the three slope cross-sections when considering seismic loading was found to be greater than 1.1 which is considered to be stable under seismic loading.

3.3 Seismic Design Considerations

Based on the results of the geotechnical investigation, a seismic **Site Class E** is considered applicable for foundation design within the area of the subject site as per Table 4.1.8.4.A of the OBC 2012.

The soils underlying the proposed foundations are not susceptible to liquefaction. Reference should be made to the latest revision of the 2012 Ontario Building Code for a full discussion of the earthquake design requirements.

4.0 Landslide Hazard and Risk Assessment

4.1 General Methodology of Assessment

The methodology for the landside hazard assessment undertaken for this report may be considered as the following:

- ☐ Identify factors that are documented to contribute to the susceptibility for a landslide to occur throughout sloped terrain.
- ☐ Relate the aforementioned factors to the susceptibility for a landslide to occur throughout the subject site.
- ☐ Estimate the probability of a landslide to occur throughout the subject site based on historical regional landslide inventories. A baseline regional probability will be adjusted to a site-specific probability considering the site-specific factors that may promote landslide susceptibility using a Frequency Estimation Method.

If the hazard under consideration cannot be demonstrated to have an annual probability of less than 1:10,000, a group risk assessment estimating the annual probability of loss of lives would be carried out in accordance with the following equation:

$$\text{Risk} = P(H) \times P(S{:}H) \times P(T{:}S) \times V \times E$$

Where R represents the risk or annual probability of loss of life of an individual, P(H) stands for the annual probability that a landslide occurs, P(S:H) indicates the probability of impacting the elements taking into consideration the scale and location of the landslide events, P(T:S) is the temporal spatial probability of the elements being present at the time of a landslide (i.e.- the probability that a person is present at the location at risk), V represents the vulnerability, or likelihood of death or permanent injury of the individual given they are impacted and E represents the number of elements that would be impacted. The variable E can also be considered equal to the number of occupants for grouped areas.

Further, a hazard assessment of the potential for “creep” in the landslide scar to occur throughout the subject site has also been addressed in the following report sections.

4.2 Factors Affecting Landslide Susceptibility

The following sections discuss factors understood to affect the potential for a landslide to occur. The factors are described briefly and subsequently discussed on their impact to the susceptibility of a landslide throughout the subject site. The study area for the purpose of this discussion is considered as the area bound by the area considered by the Geological Survey of Canada under Open File 5311. The property discussed throughout this report is considered the subject site.

4.2.1 Clay Overburden

Based on the findings of the geotechnical investigation, the subsurface profile throughout the subject site consists primarily of a silty clay deposit inferred to be underlain by bedrock. Based on geological mapping undertaken by the Geological Survey of Canada under Open File 5311, the local deposit is considered to be formed by nearshore marine sediments, including deltaic and estuarian deposits.

The clay deposit encountered throughout the subject site was observed to consist of a stiff to very stiff, weathered, brown silty clay crust extending to depths between 1.5 to 3.7 m below the ground surface. The brown silty clay was underlain by a firm to stiff grey silty clay deposit. A thin layer of sand was encountered above the clay deposit discontinuously throughout the subject site.

Review of landslides inventoried under Geological Survey of Canada (GSC) Open Files 5311, 7432 and 8600 document approximately 132 large landslide footprints throughout the Ottawa region. Review of the surficial geology for land adjacent to the landslides inventoried by the above-noted sources indicated approximately 83% (i.e., 109 out of 114 landslides captured by the study area published in OF5311) of these landslides may have originated from marine deposits consisting of clay. The remaining five landslides were considered to have consisted of alluvial sediments and/or organic deposits.

It has also been documented that the retrogression of landslides might be predicted by the undrained shear strength values measured in the silty clay unit. Mitchell & Markell (1974) studied the characteristics of landslides in silty clay soils associated with river valleys. Their study, based on 41 documented landslides located within Eastern and Northern Ontario, indicated that Taylor’s stability number can be used as an indicator to evaluate the susceptibility of landslides to occur. Taylor’s stability number (Ns) is defined as

$$N_s = yH/S_u,$$

where y represents the bulk unit weight of soil (kN/m^3), H is the slope height (m), and S_u depicts the peak undrained shear strength of the silty clay (kPa). Mitchell & Markell (1974) determined that N_s should be greater or equal to 6 for the potential of retrogression to occur.

However, measurements reviewed further by Demers and others (L'Heureux; Demers, 2014) determined that large retrogressions had been measured where N_s values were less than 5, and as low as 3.3. Shear strength at the subject site ranges between 14 to 180 kPa. The maximum difference in elevation for the subject site is approximately 10 m, between the lands to the southwest (beyond the former paleo-channel bank, and the northwestern Mud Creek tributary). Based on this, the worst-case scenario **Ns values range generally between 0.9 and 6.6**. However, it should be noted that at BH 17, a higher N_s value of 11.4 was calculated at a depth of 1.65 m below the existing ground surface, however, this is considered an anomaly reading relative to the remainder of the deposit. It will be nonetheless considered in our assessment of the sensitivity of the deposit (adjust baseline factor by factor of 2.0).

Mitchell and Markell have also explored the sensitivity of clays as a factor in retrogression, where sensitivity is defined as the ratio of undisturbed to remolded shear strength. In their studies, Mitchell and Markell concluded that the sensitivity of retrogressive clays ranges between 10 to 1,000. Based on our review of clay sensitivity (ratio of in-situ undisturbed to remolded shear strength), the clay presented a sensitivity ranging between 2.0 and 22.0, which is slightly higher than 10. However, the results would suggest that the clay is considered sensitive (adjust baseline factor by factor of 2.0).

Further, larger landslides are understood to be associated with clay deposits with remolded shear strength measurements equal to or less than 1 kPa (Quinn et al., 2011). It is expected that clay deposits with such low values of remolded strength to be conducive to propagating planes of weakness and unable to resist high earthquake loads. Review of our test hole coverage indicated remolded shear strength values as low as 1.2 kPa and an average of 7 kPa throughout the subject site (adjust baseline factor by factor of 1.15).

Lastly, the in-situ moisture content for select samples considered for laboratory testing exceeded or are close to their liquid limit. While Paterson does not believe the soil is in a state of behaving as a liquid based on our experience with studying sensitive marine clays throughout the Ottawa region, it is an indicator that the material has a notably high-water content and given the sensitivity of the deposit, is a significant factor in resisting seismic and anthropogenic loading. Based on this, the baseline probability will be adjusted by a factor of 2.0 to consider this observation.

Based on these results, sensitive clay is considered to be present in the overburden profile throughout the subject site. Therefore, the baseline probability discussed in Section 4.3 – Hazard Assessment will be multiplied by a factor of 9.2.

4.2.2 Slope Inclination, Bedrock Depth and Surface Relief

Overburden thickness, surface relief and slope inclination are understood to be significant factors contributing to the potential for a landslide. Landslide susceptibility mapping carried out throughout National Topographic System (NTS) area 31H correlated higher values of drift thickness and surface relief to a higher rate of landslide incidence in Champlain Sea clays (Quinn, 2014). The study considered a weight of evidence approach which assigns a positive or negative weight for the ranges in these parameters with respect to the frequency of landslide occurrence.

A similar review was carried out to understand the relationship between overburden thickness, topographic relief, and angle of slope for landslides that have occurred throughout the study area (area comprised by OF5311). The results of our interpretation of the available information are summarized in Table 6, Table 7, and Table 8 below.

Topographic relief was interpreted using DEM provided by Google Earth. Relief was considered as the difference between the lowest and highest elevations and considering distances extending beyond a landslide footprint. Greater distances were considered where a landslide formed into a slope profile. Significantly large landslides could not be reasonably evaluated due to the highly variable topography beyond their footprint. The measure is considered subjective, however, appropriate based on the available topographic information for each of the landslides identified by OF5311, OF7432 and OF8600 and the purpose of this assessment.

In summary, incidences of landslides occur more frequently in areas with intermediate overburden thickness ranging between 15 to 40 m, and greater than 10 m of topographic relief throughout the study area. Further, landslides were observed throughout the study area only where slopes ranged between 5 and 30 degrees. In a previous study, Goodings & Schofield (1985) assessed that for slopes with angles up to 30 degrees, slope failures would occur only for slopes with more than 10 m of topographic relief.

Based on the available geological mapping, it is anticipated that the overburden ranges between 25 to 50 m throughout the subject site. However, it should be noted that the topographic relief observed throughout the site is less than 4 m, and slopes are less than 10 degrees.

Based on the above, the potential for a landslide as based on the above-noted factors is low to moderate throughout the subject site. This is discussed in further detail in *Section 4.3 – Hazard Assessment* of this report.

Table 6 – Summary of Drift Thickness Throughout Historic Landslide Footprints

Drift Thickness (m)	Number of Incidences	%*
0 to 1	0	0.0
1 to 2	0	0.0
2 to 3	0	0.0
3 to 5	0	0.0
5 to 10	8	7.0
10 to 15	7	6.1
15 to 25	34	29.8
25 to 50	49	43.0
50 to 100	16	14.0
Total Landslides Within Study Area	114	94.2
Total Landslides Documented by Open Files	121	

Note: Drift thickness interpreted using Google Earth and is considered subjective, however, appropriate based on the available information for each of the landslides identified by OF5311, OF7432 and OF8600 and the purpose of this assessment.
* Percentage is calculated over the total number of incidences observed

Slope inclination and shape are also factors associated with assessing landslide susceptibility and overall slope stability. Based on our review of LiDAR and topographic mapping, slopes located to the southwest of the subject site (a high slope that may be offering support for the subject site) are generally rectilinear and range in inclination between approximately 5H:1V (11 degrees) and nearly 7.5H:1V (13 degrees). However, it should also be mentioned that the slopes over the newly constructed retaining wall range between 4H:1V and 2H:1V.

Based on the above, the potential for a landslide as based on the above-noted factors is discussed further in detail in Section 4.3 - Hazard Assessment of this report. The baseline probability will be modified for each applicable combination of overburden thickness, topographic relief, and slope inclination understood to be located throughout the subject site in that portion of the report.

Table 7 – Summary of Topographic Relief in Historic Landslide Footprints

Topographic Relief (m)	Number of Incidences	%*
<1	0	0.0
1-2	0	0.0
2-3	1	0.9
3-4	2	1.8
4-5	0	0.0
5-6	2	1.8
6-7	0	0.0
7-8	2	1.8
8-9	3	2.7
9-10	3	2.7
10-12	8	7.1
12-14	11	9.7
14-16	16	14.2
16-18	8	7.1
18-20	5	4.4
20-25	21	18.6
25-30	12	10.6
30-40	13	11.5
>40	6	5.3
Total Landslides Within Study Area Capable of Being Measured	113	93.4
Total Landslides Documented by Open Files	121	

* Percentage is calculated over the total number of incidences observed

Table 8 – Summary of Angle of Slope Throughout Historic Landslide Footprints

Angle of Slope (Degree)	Number of Incidences	%
0-5	0	0.0
5-10	6	5.3
10-15	16	14.0
15-20	20	17.5
20-25	13	11.4
25-30	4	3.5
Total Landslides Within Study Area Capable of Being Measured	59	48.8

4.2.3 Groundwater, Surface Drainage and Toe Erosion

Groundwater

Groundwater is understood to be a factor contributing to landslide susceptibility. Landslides throughout the Ottawa Valley have been understood to generally occur most frequently during the spring thaw, which results in seasonal increases in the depth of the groundwater table and porewater pressure. It has been documented that larger slopes typically fail by a combination of a downward gradient throughout the table lands and an upward gradient (artesian) throughout the bottom of the slope profile and along the channel (Hugenholtz and Lacelle, 2004).

Groundwater regimes with primarily downward gradients from the table lands to the watercourse typically have stronger stability attributes in resisting the potential for a slope failure. Groundwater regimes may be influenced by other factors, such as rising bedrock surfaces (Quinn et al., 2010). The combination of a temporary (seasonal) artesian groundwater table gradient throughout the lower portion of the slope and rising bedrock surface may significantly impact the stability of a slope.

The adjacent Mud Creek tributary is located approximately 80 to 200 m from the subject site. Given the area is underlain by a deep deposit of relatively impermeable clay, groundwater fluctuations are not considered prevalent throughout the area of the subject site despite the presence of the nearby tributary. Based on our review of available topography, the valley sidewall throughout the valley corridor for the subject portion of Mud Creek has been reviewed to be approximately 3 to 5 m in height. Given the ratio between the distance between the subject site and the creek footprint to the height of the slope, groundwater regimes are not considered relevant in potentially creating artesian conditions and impacting the subject site.

It is understood a long-term permanent dewatering by urbanization of the subject site has been considered as part of the geotechnical analysis undertaken by others. This considers an additional stress posed onto the underlying deposit due to reduction in groundwater table recharge by seasonal variations in precipitation.

Based on this, given that groundwater conditions in the post-development condition are anticipated to be lower than in the pre-development condition, and that either post- or pre-development groundwater conditions would not be meaningfully governing the stability of the subject site from a geotechnical perspective, <u>groundwater will not be considered as a factor in modifying the baseline probability discussed in Section 4.3 (i.e., factor of 1.0).</u>

Surface Drainage

Surface drainage, or sheet drainage from the table lands towards the watercourse, can impact the stability of the subject slopes. Currently, in the pre-development condition, surface water generated from rain and snowmelt is handled by either ingress into the subsoils, or sheet drainage following local topography, and likely handled by municipal drains such as manholes and catch basins located around the perimeter of the subject site.

Surface drainage is expected to be maintained once the subject site is developed and serviced by additional storm sewers connecting to the local nearby sewer system. Based on this, surface drainage is not expected to be a major factor contributing to landslide susceptibility throughout the subject site or nearby watercourses, such as the Mud Creek Tributary.

Surface drainage is expected to be maintained throughout the sloped area southwest of the subject site and the intersection of Navan Road and Brian Coburn Boulevard. There are several roadside ditches, including a portion lined with rip-rap stone at the crosswalk, which are graded to divert surface water down the slope. Since this slope is heavily vegetated and is not subject to erosional action presented by an active watercourse, erosion caused by occasional sheet drainage from rain events and snowmelt is not expected to significantly alter or impact the stability of this slope.

Based on this, <u>the baseline probability discussed in Section 4.3 – Hazard Assessment will not be adjusted (i.e., factor of 1.0) to account for continued surface drainage in the post-development condition.</u>

Toe Erosion

Landslides throughout the Ottawa Valley have been documented to occur most frequently adjacent to a watercourse. The formation of valley corridors by watercourses results in erosion along the toe of the slope and subsequent downcutting of the bank face by the erosional force of the flowing water. Sufficient downcutting, oversteepening and erosion of the slope can result in the instability of a slope and the potential for a landslide if a slope failure is triggered.

There is a relationship between stream flow (via flow accumulation) and landslide incidence such that larger landslides tend to be associated with larger watercourses (Quinn et al., 2010). In addition, the stream flow of a watercourse can be directly correlated to its stream order. Stream order is the degree of a tributary and branch streams with respect to an artery stream.

Larger stream order values indicate the degree of closeness a stream is linked to the principal stream, whereas smaller values indicate the streams are considered to be distant tributaries from an artery stream. In summary, higher values of stream flow are correlated to higher degrees of stream order which are further correlated to older and fully developed watercourses. Smaller values of stream order are correlated to younger and less developed watercourses.

Generally, landslide density throughout the study area undertaken throughout NTS 31H was very low for streams up to order 3 and greater than or equal to order 9 (Quinn, 2009). The findings are similar for flow accumulation such that streams with less flow or smaller stream orders have a negative correlation with landslide incidence (Quinn, 2013). There is some evidence presented by a study area in Norway that younger streams have not fully developed their watercourse morphology and may be more erodible than larger, mature streams. However, the methodology undertaken to assess this for the study area of NTS 31H could not confirm this relationship for local and regional conditions at that time (Quinn, 2013).

Stream sinuosity was also explored as a variable impacting slope stability. Stream sinuosity is defined as the ratio of the total length along a stream segment to the shortest length between its endpoints (Quinn, 2013). Based on the review for the area of NTS 31H, it has been observed that landslides tend to be infrequent along streams with sinuosity lower than 1.338. Furthermore, channels with wider and more tightly spaced meander belts experience higher rates of erosion and are therefore more susceptible to landslides. Preferential occurrence of landslides in slopes situated on the outside of meander belts rather than in streams with low levels of sinuosity was similarly observed by Hugenholtz (2004).

Paterson was not able to obtain reports documenting stream sinuosity or stream order for the purpose of this assessment and reviewing the applicable information for the adjacent Mud Creek tributary. Based on that, Paterson will assume the Mud Creek tributary is best characterized as being highly sinuous and a medium stream order (modify baseline probability by 1.25). However, recent class environmental assessments undertaken for the northwestern portion of Willow Creek, adjoining Mud Creek northwest of the subject site, has demonstrated that erosion is active throughout the area of this watercourse, and remedial measures are in place to improve erosional action. For this section of Willow Creek, it had been concluded that uncontrolled flows triggered erodible soils to lose their stability and result in localized slope failures reaching rear-yard property limits.

In this scenario, a localized failure in 2017 required emergency action by the City of Ottawa and triggered a larger-scale review and assessment of the area. This resulted in the design and implementation of erosion protection measures, naturalization and re-shaping of portions of the slopes to be able to maintain overall channel stability despite the on-going natural erosional processes underway throughout the watercourse.

Although this effort was not carried forward into the Mud Creek tributary nearby the subject site, it gives indication that slope failures triggered by erosion in this area are generally smaller and localized, likely due to their relatively low height (3 to 5 m) and channel geometry being relatively smaller. Further, the two sides of the Mud Creek tributary are fronted on one side by residentials homes, and the other by the City of Ottawa (Park and Ride facility).

It is expected that if erosion triggers small, localized slope failures along this portion of the creek, that it would be reported and handled in a similar manner as was undertaken for Willow Creek. In this scenario, it would be anticipated that at some point in the future either the Mud Creek tributary would be either assessed for geotechnical and geomorphological solutions to reduce erosion while maintaining existing flow conditions (including downstream), or, that flow conditions would not reach a magnitude to trigger localized slope failures requiring additional channel enhancement works.

Paterson has not completed field reconnaissance throughout the Mud Creek tributary, however, based on review of aerial images, LiDAR and publicly available documentation for the area of this and nearby watercourses, it is anticipated there is active erosion underway along the bank and channel sidewalls. Given the photographs documented in the Willow Creek slide-deck, it is also expected the erosion can result in small, localized slumps. However, given the height of the slopes based on review of available topographic information, it is not expected these localized slope failures would result in larger-scale retrogressive failures given the relatively low height of the slopes available to result in that type of failure.

Local practices defined by the City of Ottawa’s *Slope Stability Guidelines for Development Application in the City of Ottawa* indicate that the horizontal allowance in sensitive marine clays where there is evidence of past failures could be considered as the greater of 1.5 times the footprint of the previous earthflow, or a 5H:1V project from bank face.

Cursory review of images provided in the Wilton Creek documents indicate previous failures may have extended to up to the height of the slopes (appeared to be 2 to 5 m in height) and potentially extending horizontally between 5 to 10 m in length. This geometry is considered consistent with the topographic information available for the Mud Creek tributary, and could be correlated to assume that a potential horizontal setback for hazardous land from the bank face along the Mud Creek tributary could range between 7.5 to 50 m.

Although this review is very preliminary and coarse, it would suggest that although on-going active erosion throughout the area of the adjacent Mud Creek tributary could results in localized slumps and slip failures, the hazardous lands that could be extrapolated from those potential failures based on previous nearby failures would not be anticipated to reach the subject site. However, since toe erosion persists throughout the area of the subject site, the baseline factor will be adjusted by a factor of 1.5. This factor would be typically considered higher for slopes subject to instability by toe erosion, however, since the height of banks subject to erosion is less than 5 m and they are located over 80 m from the subject site, it is not considered a major influence on the susceptibility to landslides at the subject site.

Erosion is a critical factor in triggering local slope failures and landslides and there is an active watercourse assumed to be highly sinuous in proximity to the northwest portion of the subject site. Therefore, the baseline probability for the applicable area will be multiplied by a factor of 1.875 (1.5 x 1.25) to consider future toe erosion. However, as discussed, a slope failure that would be triggered in the Mud Creek tributary is not expected to have a negative impact on the subject site given the distance between the features and the relatively low slope height. This is discussed in further detail in *Section 4.3 – Hazard Assessment* of this report.

4.2.4 Proximity to Landslides

Regional Landslide Inventory and Geology

Landslide inventory mapping published by GSC indicates the presence of potentially up to 4 landslides in proximity to the subject site. The proximity of land to previous landslides has been documented as a significant factor in assessing the susceptibility of potential for future landslides. It had been assessed that the likelihood of the nearest adjacent landslides being within a specified distance ranging between less than 50 and 2,000 m being between 49.2 and 96.7% (Quinn et al., 2011).

This pattern explains that future landslides are more likely in areas that have experienced previous landslides than in areas where no past landslides exist. This was observed by Hugenholtz (2004) in their review of Green's Creek and the concentration of landslides to re-occur in concentrated areas along the creek alignment.

Local Landslide Inventory

Landslide Mbu2 is located throughout the footprint of the subject site and extending to the south and east covering the footprint of existing residential dwelling structures throughout the neighboring developments. The location of the subject site in relation to Mbu2 and a smaller landslide, Mbu4, located approximately 350 m from the subject site, is depicted in Figure 1, for reference.

In addition to Mbu2 and Mbu4, other landslides documented in the area include MBu1 and MBu9 within approximately 1.3 and 2.5 km from MBu2, respectively. Further, Mbu9 to Mbu12 are located between 3.0 to 5.0 km southeast from the subject site. MBu1 and MBu9 appear to be located throughout unoccupied land consisting of agricultural farmland and heavily forested areas, respectively. MBu10, MBu11 and MB12 also share that their ground surface is currently covered by heavily vegetated forests.

The presence of landslides indicates that a specific set of terrain conditions may exist to promote landslide susceptibility. However, it is worth noting that landslides MBu1, MBu4, MBu9 through MBu12 each have an identified footprint area smaller than MBu2. The morphology for each of these landslides beyond MBu2 indicates that their debris fields are truncated and have been completely eroded across the edge of the source area. It should be noted that the debris field throughout MBu2 has been completely altered by urbanization (GSC OF8600, 2019).

The only other landslide footprint that is similar in failure type to MBu2 is MBu13 which is located approximately 18 km from the subject site at the southeastern ridge of the Mer Bleue paleo-island. Samples from the debris field have been carbon-dated to have occurred 4,380 to 4,560 years BP and is one of 13 landslides interpreted to have been triggered by a significant paleo-earthquake approximately 5,200 years ago (GSC OF8600, 2019 and Aylsworth, 2000).

Given the above, there are several other landslide scars in relatively close proximity to the subject site which could indicate landslide susceptibility in the area of the subject site based on historical landslide inventory. Therefore, it is considered appropriate to increase the baseline probability for landslides to occur throughout the subject site by a factor of 2 in *Section 4.3 – Hazard Assessment* of this report.

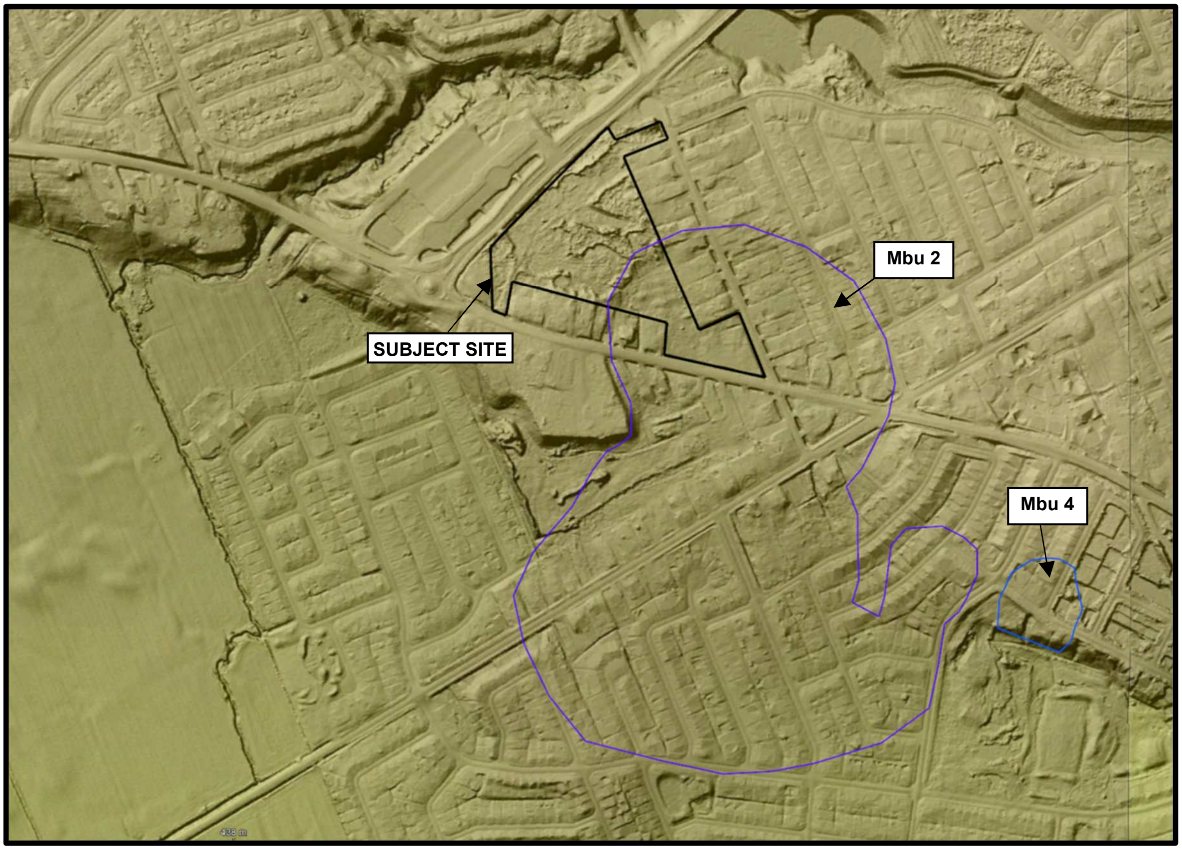


Figure 1 – LiDAR Image of Subject Site and closest documented landslides.

4.2.5 Earthquake or Ground-Motion Induced Landslide

Earthquakes are understood to be a major contributing factor in triggering some of the largest landslides inventoried throughout Champlain Sea clay deposits. Many large landslides have been estimated to have occurred approximately 4,550 years before present (BP) and another significant cluster approximately 7,060 years BP (GSC OF7432, 2021; Aylsworth and Lawrence, 2003). The lower bound of these paleo-earthquakes have been estimated to have consisted of M5.9 to M6.0 earthquakes. Several landslides were triggered by the 1663 M7 Charlevoix and 2010 Val-des-Bois M6.2 earthquakes.

The behavior of clay slopes during earthquakes is uncertain and is a topic of current research. Current research suggests that large earthquakes can propagate failures along pre-existing or partially developed planes of weakness along the slope footprint. The critical length of the propagation is understood to be influenced by the sensitivity and fracture toughness, or brittleness, of the clay deposit (Quinn et al. 2012).

The slopes and clay deposit throughout the subject site have been subject to large historic earthquakes that may have triggered significantly large historic landslides throughout the Ottawa Valley. Earthquake-induced landslides generally occur where the potential for slope failures already exists and has generally been assessed as part of our slope stability analysis.

As discussed in Section 3.0, the slopes present throughout the subject site are considered stable under drained static conditions and using a pseudo-static "seismic" analysis considering undrained strength parameters for the appropriate soil layers. Pseudo-static (seismic) loading of the slope profiles considered a PGA of 0.18g which is considered equivalent to a 1:1,250-year earthquake event.

The slope stability analysis results indicated all failure planes with factors of safety greater than the minimum of 1.5 and 1.1 for static and seismic loading, respectively. It should be further noted that the slope stability analysis was completed under the assumption that groundwater will be located at proposed finished grade across the subject site. However, it is expected that the long-term groundwater will be controlled at/or below the design underside of footing elevation of the proposed buildings, which would result in an increase to the overall slope stability for the subject site.

It is also expected that sources of subsurface vibrations such as those associated with building construction, compaction equipment and general earthworks equipment are not anticipated to exceed or be close to the magnitude of vibrations associated with the assessed earthquake load of 0.18g.

Further, local hazard peak-ground acceleration values for the subject site for a 2% exceedance is considered to be 0.306, which is marginally less than the regional of 0.32. This suggests that the area of the subject site has a marginally reduced seismicity than would be considered for the Ottawa region in general.

Given the above, earthquake loading is not anticipated to impact landslide susceptibility and will be considered a slightly notable factor in the calculation of the baseline probability (<u>i.e., multiplied by a factor of 1.1</u>).

4.2.6 "Creep" Movement in Existing Landslide Scar

It is understood that the subject site is located within the footprint of a landslide scar. Although it is not known when the landslide may have taken place, it is considered to be a pre-historic landslide which may have occurred within the past 8,000 years. In order to support servicing and infrastructure design for the subject site, the proposed ground surface throughout the majority of the site is expected to be raised to accommodate the proposed design details.

Due to this grade raise, there is a potential for some “creep” movement to develop throughout subsurface during the design-life of the proposed structures and infrastructure.

Existing Conditions Throughout the Landslide Scar

As noted, the existing landslide is understood to have occurred pre-historically. This would imply that it had occurred prior to the construction of the buildings that may be observed on historical aerial photographs throughout the landslide footprint.

Based on our review of these photographs, approximately 24 buildings occupied the landslide footprint in 1965. Comparing modern aerial photographs to historical aerial photographs, it appears approximately six of these older buildings were not modified extensively or entirely replaced from their original footprint. Of these unmodified buildings, Paterson has had the opportunity to review the exterior of 6027 and 6071 Renaud Road and 2824 Pagé Road as part of a pre-construction survey. Paterson has also reviewed the exterior of 6079 Renaud Road, 6099 Renaud Road, both of which are assumed to have been constructed in the 1990's.

Generally, the above-noted buildings appeared to be in relatively good condition with some defects that are considered typical for residential structures founded over sensitive clay deposits throughout the Orleans area and Ottawa valley. This damage typically consists of small gaps between garage door and window frames from the building frame, diagonal or vertical cracking within mortar joints in brick facades, small cracks in weak points throughout the foundation such as window-wells and basement door openings, and small cracks where roof soffits meet the exterior wall facade. The majority of these defects form over a 10- to 30- year timespan and are generally associated with long-term and tolerable movement of the foundation.

Generally, and in our experience, this movement may be attributed to subsurface condition factors such as fluctuations in the groundwater table, additional settlement from excessive grade raises or post-construction additions and moisture depletion of clay from high-water demanding trees, among other factors associated with older construction techniques. In our experience, it is very likely that the non-structural defects noted at the time of our review are associated with some of the common issues with buildings founded over Champlain clay.

Further, Paterson had been involved with the residential development located within the northern portion of the landslide-bowl shape (south of Nevan Road and north of Renaud Road, as well as south of Navan Road). The methodology applied in carrying out the geotechnical design for the buildings located within this existing subdivision is the same implemented for the subject site. This includes assessing the geotechnical strength and in-situ conditions of the subsurface profile and providing design details that would mitigate excessive settlement and movement of the buildings to support the proposed development.

Should excessive movements have been observed by the current homeowners, whether noted in interior or exterior of these buildings, the original builder would have been made aware of these issues. Since these homes were constructed, Paterson has not been made aware of any claims of damage that may be associated with movement of the ground by the builder. The finished grade throughout the portion of this subdivision within the landslide scar has also been raised above the original pre-development ground surface elevation.

Compared to the subject site, there is an existing and similarly dense residential subdivision located throughout the southern portion of MBu2. Paterson was not involved in the phases of the development located throughout the landslide scar. Based on review of public well records, the subsurface profile throughout this subdivision is considered to be very similar to the subject site.

Based on aerial photographs, this subdivision was constructed throughout the early 2010's. Based on the previously noted observations and understanding of this general area, Paterson considers it unlikely for the portion of the subdivision located throughout the footprint of MBu2 to have undergone intolerable ground movements. If intolerable movements or damage associated with ground movements in a new residential subdivision happened, it would have likely become a well-known local issue amongst builders and land developers. Further, municipal infrastructure would have been undergoing equally damaging movement such that it is unlikely the City of Ottawa would not be aware of potentially damaged subsurface linear infrastructure.

Further, cursory review of the existing roadways and properties located throughout the area of the landslide scar do not show signs of observable damage associated with ground movement. This is expected to consist of cracks in landscaped and hardscaped ground surfaces, similar to slope failures or tension cracks, and tearing or excessive cracking of pavement surfaces.

Further, although grade raises might be required to accommodate the proposed residential development, it is expected that the grades proposed throughout the landslide scar will not exceed permissible grade raise restrictions provided for the subject site.

Boreholes undertaken throughout the landslide scar do not appear to demonstrate in-situ characteristics that differ from boreholes undertaken beyond it, which suggest the previously disturbed state of the subsoils is not a factor in assessing geotechnical design factors such as bearing capacity and grade raise restrictions.

Based on our review, there is a possibility for movement throughout the subsurface profile associated with "creep" in the landslide scar. However, it is not considered to be of relevant magnitude and is considered negligible and would not likely be of a sufficient magnitude to exceed the conventional post-construction settlements noted in the aforementioned geotechnical report. Further, considering the majority of the MBu2 footprint has been altered significantly without negatively impacting the structures within its footprint, the failure plane is considered to be stable and/or unaffected by the existing ground conditions and structures/infrastructure.

It is generally expected that the proposed buildings will experience "creep" movement, if present, in a manner that is very similar to and within the tolerances of conventional post-construction settlements.

Based on the above, the potential for a landslide as based on the above-noted factors is low to moderate throughout the subject site. This is discussed in further detail in *Section 4.3 – Hazard Assessment* of this report. Based on this, it is suggested that the baseline probability discussed in Section 4.3 – Hazard Assessment will be multiplied by a factor of 3.0 to account for soil creep movement along the landslide scar. While this is only considered relevant for the southeastern portion of the subject site, it will be applied to the entire site.

4.2.7 Sources of Anthropogenic/Construction Vibrations

It is anticipated that the underlying clay deposit will experience vibrations from several sources during the construction phase of the proposed development. It is anticipated the proposed structures will consist of one underground basement or slab-on-grade constructions and be serviced by relatively (i.e., by services with inverts being within 4 m of finished grade throughout the subject site) shallow site services.

Based on the above, earthworks undertaken throughout the subject site are not anticipated to result in vibrations that would be of sufficient magnitude to affect the stability of the subsoils and nearby slope supporting the subject site.

This is reinforced given that the recent construction of the subdivision located to the south of the subject site, which included excavations into a nearly 8 m high 1H:1V slope for a retaining wall, and associated excavations for site services, did not trigger any slope instabilities throughout that or the subject site.

Paterson was involved during the construction review and inspection portion of the adjacent subdivision and did not observe any issues associated with slope stability during that time.

Based on this, the construction phase is generally considered negligible from a landslide hazard perspective given the above-noted discussion. Then, the baseline probability will be adjusted by a factor of 2.0 to consider unknown potential effects the construction programs for sites located beyond the subject site could stress onto the subsoils.

4.3 Hazard Assessment

Frequency Estimation Method

Approximately 132 individual landslides have been identified between GSC files OF8600, OF7432 and OF5311. The study area between these files considers an approximate surface area of approximately 11,800 km^2. This surface area may be decreased to approximately 6,845 km^2 when neglecting the area comprised of bedrock. A summary of the information available for the aforementioned landslides is presented in Table 1 - Summary of Reviewed Landslide Inventory Data, included in Appendix 1 of this report.

The study area was reduced accordingly to consider the absence of Champlain Sea marine deposits throughout areas of bedrock outcrops and where overburden is not present. An average landslide density of 1.9x10^{-2} per km^2 may be extrapolated from this information.

Based on the information provided in OF5311, landslides have not been recorded to have originated from areas comprised of till or glaciofluvial deposits. The study area may be therefore reduced further to approximately 5,354 km^2 and consisting of nearshore and offshore marine deposits, alluvial sediments, organic deposits, and sand dunes. The surficial deposits are considered susceptible to a landslide given their vulnerability to failure by the factors discussed in the preceding sections of this report. Based on this, the baseline landslide frequency, and probability, may be considered as 2.5x10^{-2} per km^2 throughout the study area.

The estimated density may vary notably across the study area given that many landslides generally occurred in localized clusters. The distinct clusters of landslides are likely indicative of conditions that are more conducive to landslide hazards in localized zones rather than the entire study area. However, this is considered appropriate as an average density for the purpose of this assessment.

The temporal frequency of landslide occurrence may vary substantially across the study area. OF7432 sought to carbon date 45 separate landslide features throughout the study area. The landslides interpreted by that study documented landslides having occurred potentially between approximately 90 to 7,140 years before present.

The results from the study and approximations provided by OF8600, neglecting the potential deviation and range of uncertainty, are summarized in Figure 2 below.

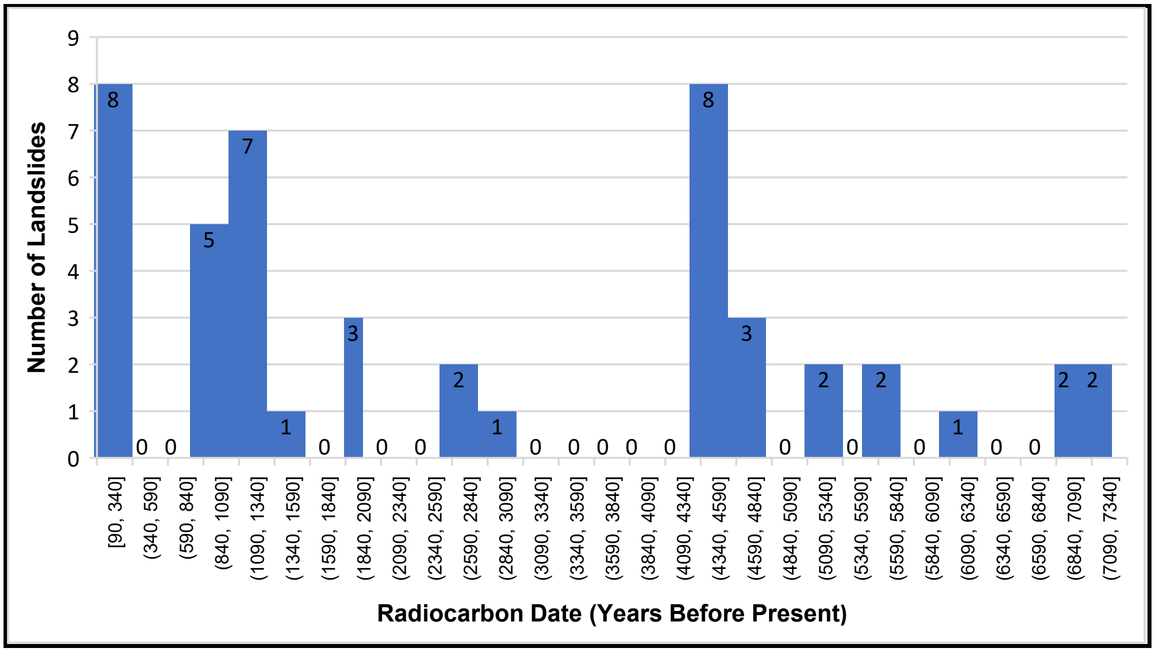


Figure 2 - Summary of Carbon-dated Landslides (GSC OF7432)

Temporal factors such as periods of increased earthquakes and climatic factors affecting these frequencies have been explored by others. Based on the above, more than half of the carbon dated landslides have occurred within the past 3,090 years, and over a quarter within the past 1,090 years.

Quinn et al. (2011) proposed a conservative lower bound of 500 years as a return period for the study area of NTS 31H. This value could be considered appropriate throughout the subject site based on the information presented above. However, the study area of NTS 31H considers a much higher density of landslides (i.e., 1,248 landslides over 75-80,000 km^2) than the study area considered for the subject site.

Based on this, a return period equivalent to the average frequency of landslides (i.e., 132 landslides over 7,140 years) provides a smaller lower bound return period of approximately one large landslide every 54.1 years. With a return period of 54.1 years, a baseline landslide probability of 4.6x10^{-4} landslides per km^2 and annum is calculated over the study area defined by the GSC files.

Considering the area of the subject site (approximately 52,500 m^2), this baseline probability may be reduced to <u>a site-specific baseline probability of 2.4x10^{-5} landslide per year</u>. The baseline estimate would be then adjusted based on our assessment of site-specific factors that are known to have resulted in large, catastrophic landslides.

Based on our review of site-specific factors identified throughout this report, additional factors have been considered for adjusting the baseline probability to provide a site-specific landslide probability. Table 9 presents a summary of the above-noted Ottawa-wide probability being reduced to a site-specific probability, omitting the factors associated with drift thickness and topographic relief (which are summarized in the preceding paragraphs).

Table 9 – Summary of Site-Specific Baseline Probability Modification Factors

Baseline Probability for Landslide to Occur Throughout Subject Site	2.4x10^{-5}
Section 4.2.1. Factor – Clay Overburden Sensitivity	9.2
Stability Number Exceeding 3.3 and 5.0	2.0
Sensitive Clay Deposit Characterized by Shear Strength Ratio	2.0
Remould Strength Exceeds 1.0 kPa	1.15
Moisture Content Exceeding Liquid Limit	2.0
Section 4.2.2. Factor – Slope Inclination, Overburden Thickness and Topographic Relied	
Slope Inclination	Estimated in Subsequent Tables
Overburden Thickness	
Topographic Relief	
Section 4.2.3 Factor – Groundwater, Surface Drainage and Toe Erosion	1.0
Section 4.2.4 Factor – Proximity to Landslides and Slope Failures	2.0
Section 4.2.5 Factor – Earthquakes and Seismic Hazard	1.1
Section 4.2.6 Factor – Creep Movement along Fault Surface	3.0
Section 4.2.7 Factor – Anthropogenic Factors	2.0
Modified Site-Specific Baseline Probability (Not Considering Drift Thickness, Surface Relief and Inclination Factors), $P_{Modified}$	**2.9x10^{-3}**

The weight factors for drift thickness, surface relief, and inclination considered for the subject site are included in Table 10 to Table 12 included below.

Table 10 – Summary of Drift Thickness Weight Factors Applicable to the Subject Site

Drift Thickness (m)	Weight Factor
0 to 10	0.01
10 to 15	0.10
15 to 25	0.50
25 to 50	1.00
50 to 100	2.00

Table 11 – Summary of Surface Relief Weight Factors Applicable to the Subject Site

Surface Relief (m)	Weight Factor
0 to 8	0.01
8 to 12	0.10
12 to 15	0.50
15 to 20	1.00
20 to 30	2.00
> 30	5.00

Table 12 – Summary of Inclination Weight Factors Applicable to the Subject Site

Inclination (Degrees)	Weight Factor
0 to 10	0.01
10 to 20	0.10
20 to 25	0.50
25 to 30	1.00
30 to 35	1.50

Based on the above analysis, the subject site may be divided into two major areas. The northwest portion of the subject, characterized by its proximity to the tributary to Mud Creek, and the remaining of the subject site characterized by the site proximity to the slope encountered across Navan Road, which is partially being retained by a newly constructed retaining wall.

Considering these factors, the subject site may be divided into two areas with distinct attributes as depicted in Figure 3 included in the following page.

Based on this, the probability for a landslide to occur throughout the subject site would be the cumulative site-specific probability which has been adjusted for the drift thickness, topographic relief and slope angle weight factors applicable throughout each portion of the subject site. Since these attributes vary along the property, the associated weight would be modified for each considered portion of the site, and as discussed in Section 4.2.2 of this report.

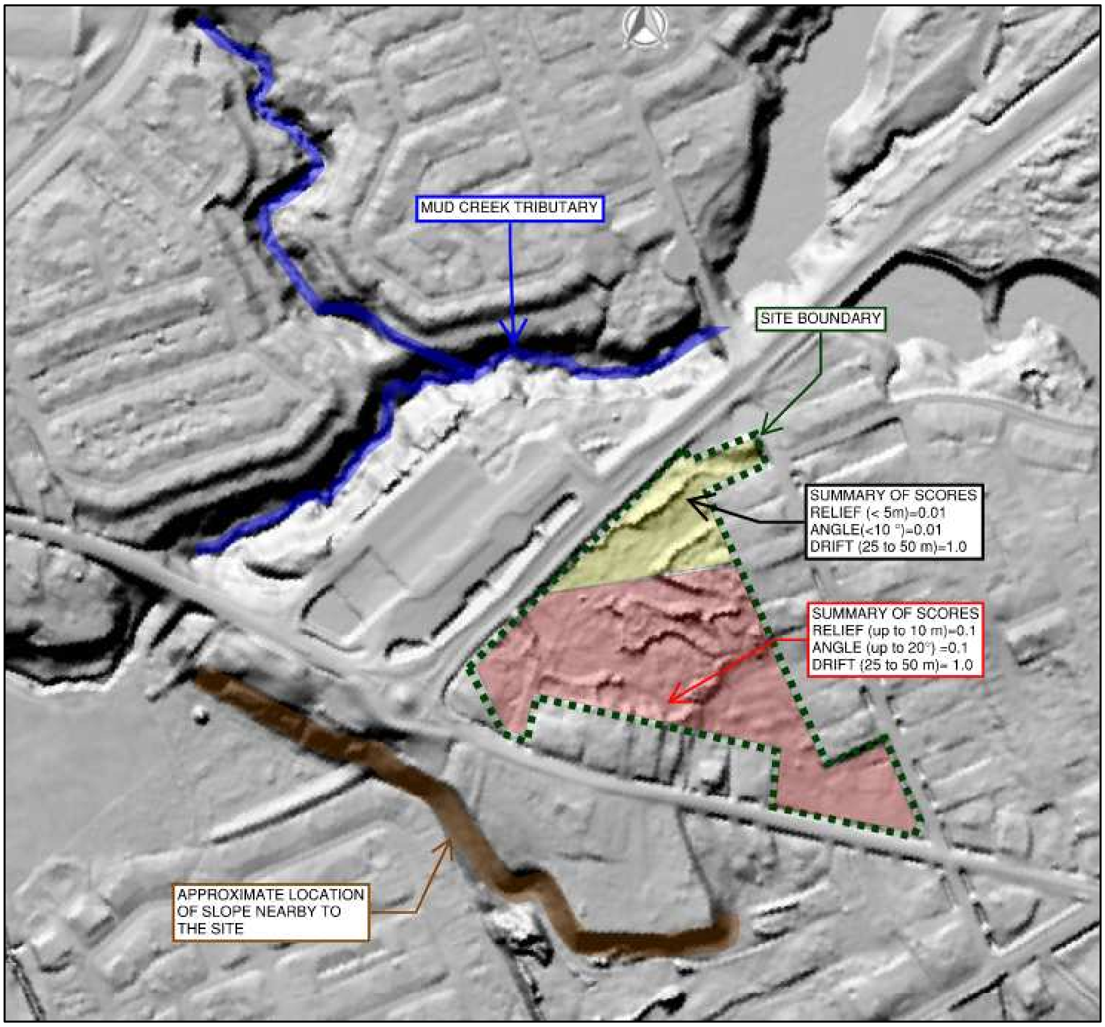


Figure 3 - Summary of Drift Thickness, Surface Relief, and Slope Angle Weight Factors

Based on the above, the probability of a landslide occurring throughout the subject site may be considered as follows:

$$P_{\text{Landslide}} = (P_{\text{Modified for Toe Erosion}})\text{x}(\text{Factors for Yellow Area}) + (P_{\text{Modified}})\text{x}(\text{Factors for Red Area})$$

P_{Modified}, which is $2.9\text{x}10^{-3}$, or 1 in 344 and provided at the end of Table 9, is a modified site-specific probability which has not been further modified to consider the weights associated with drift thickness, topographic relief and slope angle. These attributes, as discussed in Section 4.2.2 of this report, are notable in evaluating the potential for a landslide to occur.

It should be noted that since the portion of the subject site identified in yellow on Figure 3 may be subject to active toe erosion, a modified probability has been considered including a toe erosion factor of 1.85, rather than 1 as discussed in Section 4.2.3. This would result in a $P_{\text{Modified for Toe Erosion}} = 5.5\text{x}10^{-3}$ or 1 in 184.

Based on this, the probability of a landslide occurring throughout the subject site has been estimated to be **1 in 33,784 per year**. Therefore, the annual probability of a large landslide occurring at or directly impacting the subject site is estimated to be less than 1:10,000 per year.

Based on our analysis, the hazard threshold criteria for the subject site is not exceeded, therefore a risk assessment is not considered required.

5.0 Conclusion

In summary, a residential development is currently being proposed to occupy the subject site. A pre-historic landslide event is understood to have taken place throughout the south portion of the subject site and several others within 2 to 3 kilometers of the subject site. These landslide events took place along the banks of the proto-Ottawa River throughout the now-abandoned Mer Bleue paleo-channel.

Field investigations and reconnaissance carried out by Paterson and others throughout the subject site and study area did not indicate any signs of movement, activity or cause of concern with respect to landslide susceptibility. The area was also reviewed by means of available published literature of the surrounding inventory, research and studies carried out by others specializing in the field of earthquakes, landslides and geology.

Using a combination of the above and our experience with sites of similar geology throughout the Ottawa region, the annual probability of a large catastrophic landslide occurring at or directly impacting the subject site, including individual risk, is less than 1:10,000 per year.

Based on our interpretation of the information available to carry out this assessment, the subject site is considered safe and suitable for consideration of the purpose of the proposed development.

6.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project and the applicable guidelines.

A geotechnical investigation of this nature is a limited sampling of a site. The recommendations are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around the test locations.

The extent of the limited area depends on the soil, bedrock, and groundwater conditions, as well the history of the site reflecting nature, construction, and other activities. Should any conditions at the site be encountered which differ from those at the test locations, we request notification immediately in order to permit reassessment of our recommendations.

The assessments provided in this report are intended for the use of design professionals associated with this project. The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than EXP Services Inc. or their agent(s) is not authorized without review by Paterson Group for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
January 30, 2025
D. J. PETAHTEGOOSE
100568013
PROVINCE OF ONTARIO

Fernanda Carozzi, PhD. Geoph.

Drew Petahtegoose, P. Eng.

Report Distribution:

☐ EXP Services Inc.
☐ Paterson Group Inc.

7.0 Literature References

[1] APEGBC, 2010, Guidelines for legislated landslide assessments for proposed residential developments in BC: Technical report, Association of Professional Engineers and Geoscientists of British Columbia.

[2] Aylsworth, J., and D. Lawrence, 2002, Earthquake-induced land sliding east of Ottawa; a contribution to the Ottawa Valley landslide project: Presented at the Geohazards 2003, 3rd Canadian Conference on Geohazards and natural Hazards; Edmonton, Alberta; June 9-10, 2003, Canadian Geotechnical Society.

[3] Bélanger, R., 2008, Urban geology of the National Capital area: Geological Survey of Canada, Open File 5311.

[4] Bobrowsky, P., and R. Couture, 2012, Canadian technical guidelines and best practices related to landslides: a national initiative for loss reduction: Geological Survey of Canada, Open File 7312.

[5] Brooks, G., B. Medioli, J. Aylsworth, and D. Lawrence, 2021, A compilation of radiocarbon dates relating to the age of sensitive clay landslide is in the Ottawa valley, Ontario-Quebec: Geological Survey of Canada, Open File 7432.

[6] Fransham, P., and N. Gadd, 1977, Geological and geomorphological controls of landslides in Ottawa valley, Ontario: Canadian Geotechnical Journal, 14, 531–539.

[7] Hugenholtz, Chris., and Lacelle, Denis, 2004, Geomorphic Controls on Landslide Activity in Champlain Sea Clays along Green’s Creek, Eastern Ontario, Canada: Géographie physique at Quartenaire, 58(1), 9-23.

[8] Mitchell, R., and Markell, A., 1974, Flowsliding in Sensitive Soils: Canadian Geotechnical Journal, 11, 11-31.

[9] Perret, Didier, 2019, Influence of surficial crusts on the development of spreads and flows in Eastern Canadian sensitive clays: Presented at the 72nd Canadian Geotechnical Conference in St-John’s, Newfoundland and Labrador, Canada, Natural Resources Canada, Geological Survey of Canada.

[10] Quinn, Peter Eugene, 2009, Large Landslides in Sensitive Clay in Eastern Canada and the Associated Hazard and Risk to Liner Infrastructure, Queen’s University.

[11] Quinn, P.E., Hutchinson, D.J., Diederichs, M.S., Rowe, R.K., 2010, Regional-scale landslide susceptibility mapping using the weights of evidence method: an example applied to linear infrastructure: Canadian Geotechnical Journal,47, 905-927.

[12] Quinn, P.E., Hutchinson, D.J., Diederichs, M.S., Rowe, R.K., 2011, Characteristics of large landslides in sensitive clay in relation to susceptibility, hazard, and risk: BGC Engineering in Ottawa Ontario and Canadian Geotechnical Journal, 48, 1212-1232.

[13] Quinn, Peter E., 2014, Landslide susceptibility in sensitive clay in eastern Canada: some practical considerations and results in development of an improved model: International Journal of Image and Data Fusion, Volume 5, No 1, 70-96.

[14] L'Heureux, J.-S., Demers, D. 2014, Landslides in Sensitive Clays: From Geosciences to Risk Management, Advances in Natural and technological Hazards Research 36, 77-88.

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

BOREHOLE LOGS BY OTHERS

GRAIN-SIZE DISTRIBUTION TESTING RESULTS BY OTHERS

CONSOLIDATION TESTING RESULTS BY OTHERS

EARTHQUAKES CANADA SEISMIC HAZARD (NBCC 2015)

TABLE 1 - SUMMARY OF REVIEWED LANDSLIDE INVENTORY DATA

WILLOW CREEK SLIDE-DECK

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Commercial Development - Navan Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

BORINGS BY CME 18 Power Auger

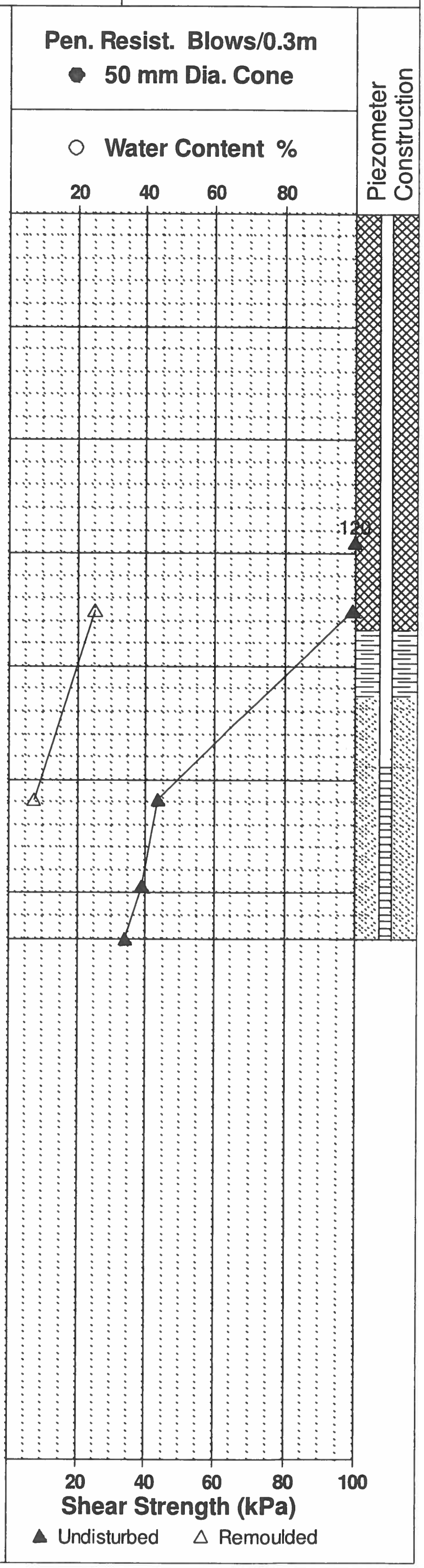
DATE 22 May 2018

FILE NO. PG4415

HOLE NO. BH 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
TOPSOIL 0.20		AU	1		
Compact, brown **SILTY SAND,** trace gravel, organics 1.45		SS	2	83	15
Very stiff to stiff, brown **SILTY CLAY** - stiff to firm and grey by 3.7m depth 6.40		SS	3	96	5
		SS	4	100	W
End of Borehole					

DEPTH (m)	ELEV. (m)
0	85.34
1	84.34
2	83.34
3	82.34
4	81.34
5	80.34
6	79.34



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Commercial Development - Navan Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

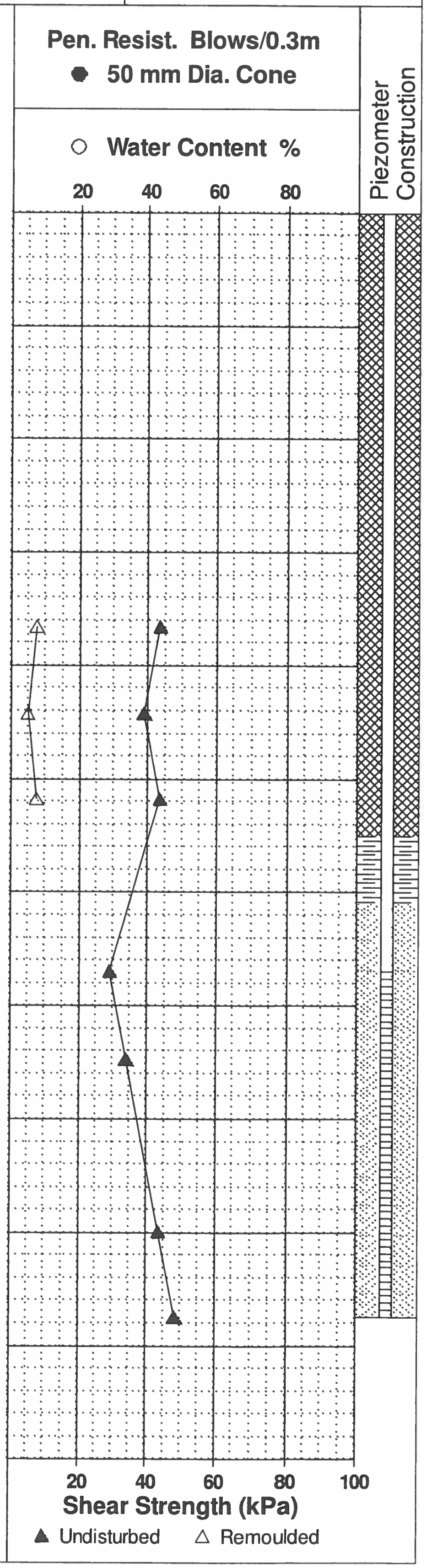
BORINGS BY CME 18 Power Auger

DATE 22 May 2018

FILE NO. PG4415

HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	84.32
TOPSOIL 0.30		AU	1				
Firm, grey **SILTY CLAY**		SS	2	96	4	1	83.32
		SS	3	100	4	2	82.32
		SS	4		W	3	81.32
						4	80.32
						5	79.32
		SS	5	100	W	6	78.32
						7	77.32
		SS	6	83	W	8	76.32
9.75						9	75.32
Dynamic Cone Penetration Test commenced at 9.75m depth. Cone pushed to 24.7m depth.						10	74.32
						11	73.32



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Commercial Development - Navan Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

FILE NO. PG4415

REMARKS

HOLE NO. BH 2

BORINGS BY CME 18 Power Auger

DATE 22 May 2018

SOIL DESCRIPTION GROUND SURFACE	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
						11	73.32
						12	72.32
						13	71.32
						14	70.32
Inferred **SILTY CLAY**						15	69.32
						16	68.32
						17	67.32
						18	66.32
						19	65.32
						20	64.32
						21	63.32
						22	62.32

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Commercial Development - Navan Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

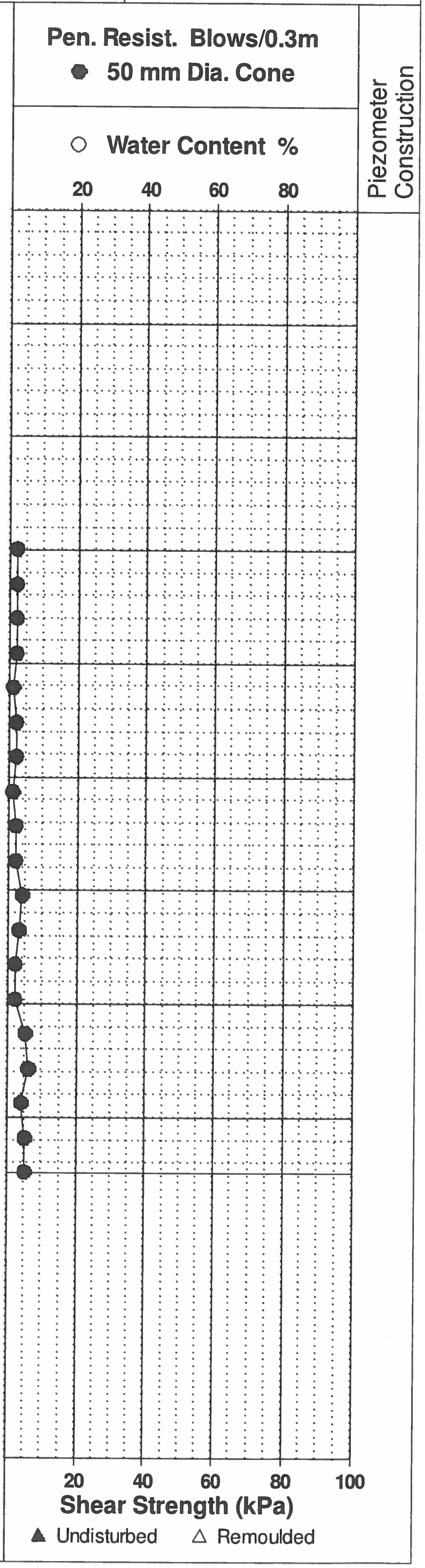
BORINGS BY CME 18 Power Auger

DATE 22 May 2018

FILE NO. PG4415

HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
	▨					22	62.32
	▨					23	61.32
	▨					24	60.32
	▨					25	59.32
Inferred **SILTY CLAY**	▨						
	▨					26	58.32
	▨					27	57.32
	▨					28	56.32
	▨					29	55.32
	▨					30	54.32
30.48							
End of Borehole							



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Commercial Development - Navan Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

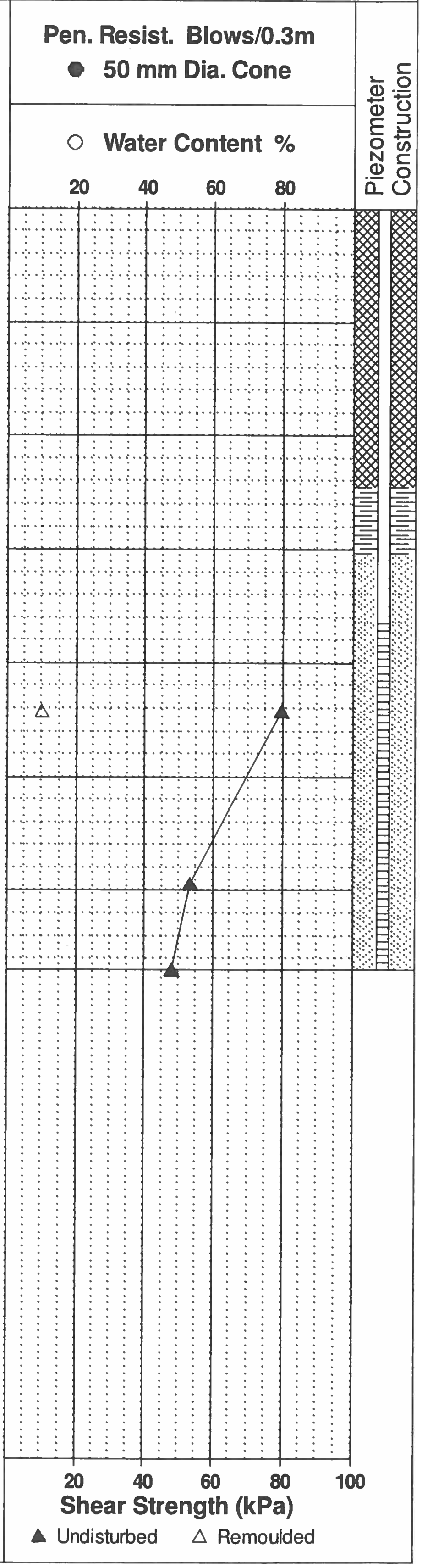
BORINGS BY CME 18 Power Auger

DATE 22 May 2018

FILE NO. PG4415

HOLE NO. BH 3

SOIL DESCRIPTION	SAMPLE				DEPTH (m)	ELEV. (m)
	TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE					0	84.27
TOPSOIL 0.30	AU	1				
Loose, brown **SILTY SAND,** some clay 1.45	SS	2	83	8	1	83.27
Stiff to firm, brown **SILTY CLAY**	SS	3	100	4	2	82.27
	SS	4	96	4		
	SS	5	100	2	3	81.27
- grey by 3.7m depth					4	80.27
	SS	6	25	W	5	79.27
					6	78.27
6.70						
End of Borehole						



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Commercial Development - Navan Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

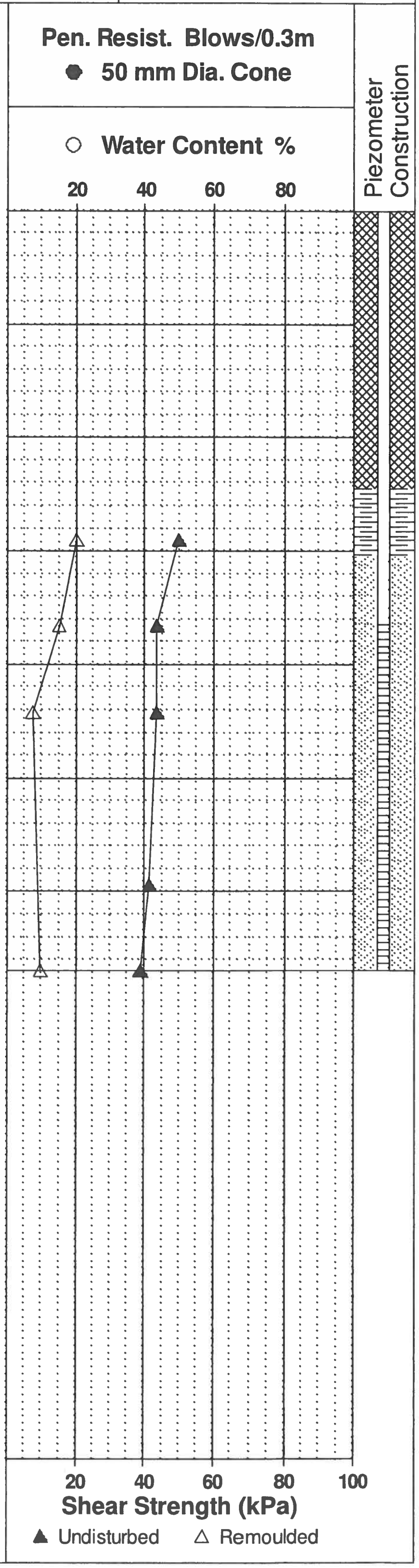
BORINGS BY CME 18 Power Auger

DATE 23 May 2018

FILE NO. PG4415

HOLE NO. BH 4

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	85.01
TOPSOIL 0.20	AU	1				
Compact, brown **SILTY SAND**	SS	2	54	23	1	84.01
1.45						
Stiff to firm, brown **SILTY CLAY,** trace sand	SS	3	92	4	2	83.01
- grey by 3.0m depth					3	82.01
					4	81.01
	SS	4	46	W	5	80.01
					6	79.01
6.70						
End of Borehole						



SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation 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 layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) ‘N’ value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	‘N’ Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	‘N’ Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	ROCK QUALITY
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC% - Natural moisture content or water content of sample, %
LL - Liquid Limit, % (water content above which soil behaves as a liquid)
PL - Plastic limit, % (water content above which soil behaves plastically)
PI - Plasticity index, % (difference between LL and PL)

Dxx - Grain size which xx% of the soil, by weight, is of finer grain sizes
These grain size descriptions are not used below 0.075 mm grain size
D10 - Grain size at which 10% of the soil is finer (effective grain size)
D60 - Grain size at which 60% of the soil is finer

Cc - Concavity coefficient = $(D30)^2$ / (D10 x D60)
Cu - Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

p'_o - Present effective overburden pressure at sample depth
p'_c - Preconsolidation pressure of (maximum past pressure on) sample
Ccr - Recompression index (in effect at pressures below p'_c)
Cc - Compression index (in effect at pressures above p'_c)

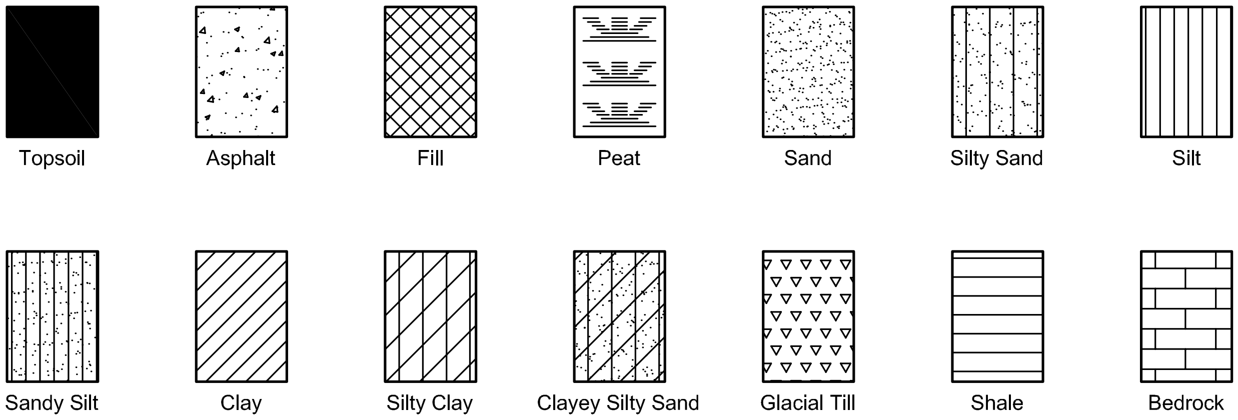
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

k - Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

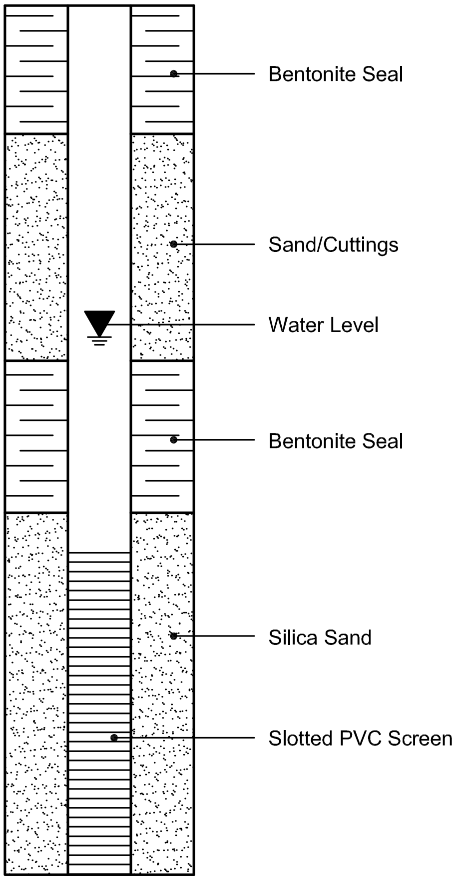
SYMBOLS AND TERMS (continued)

STRATA PLOT

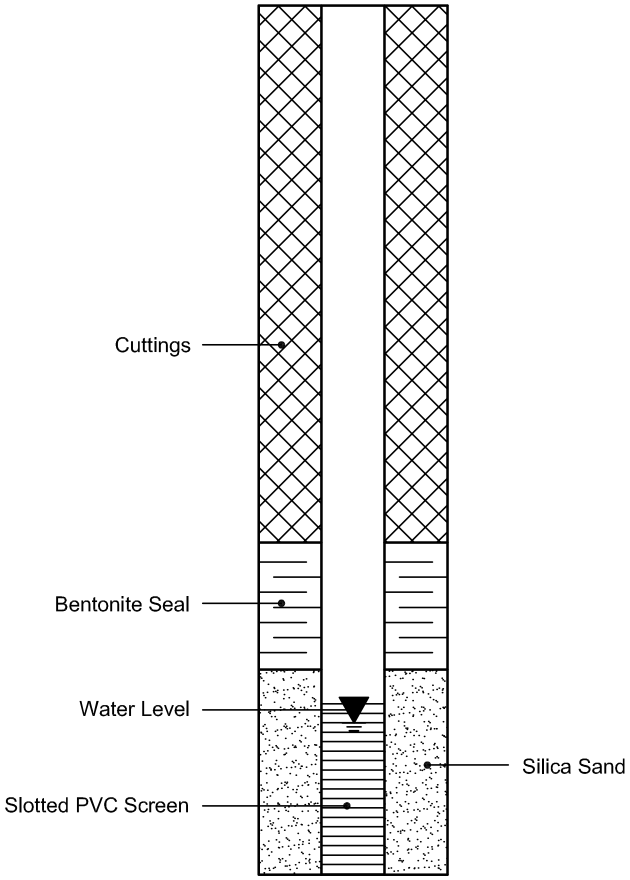


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Log of Borehole BH-01

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 3

Page. 1 of 1

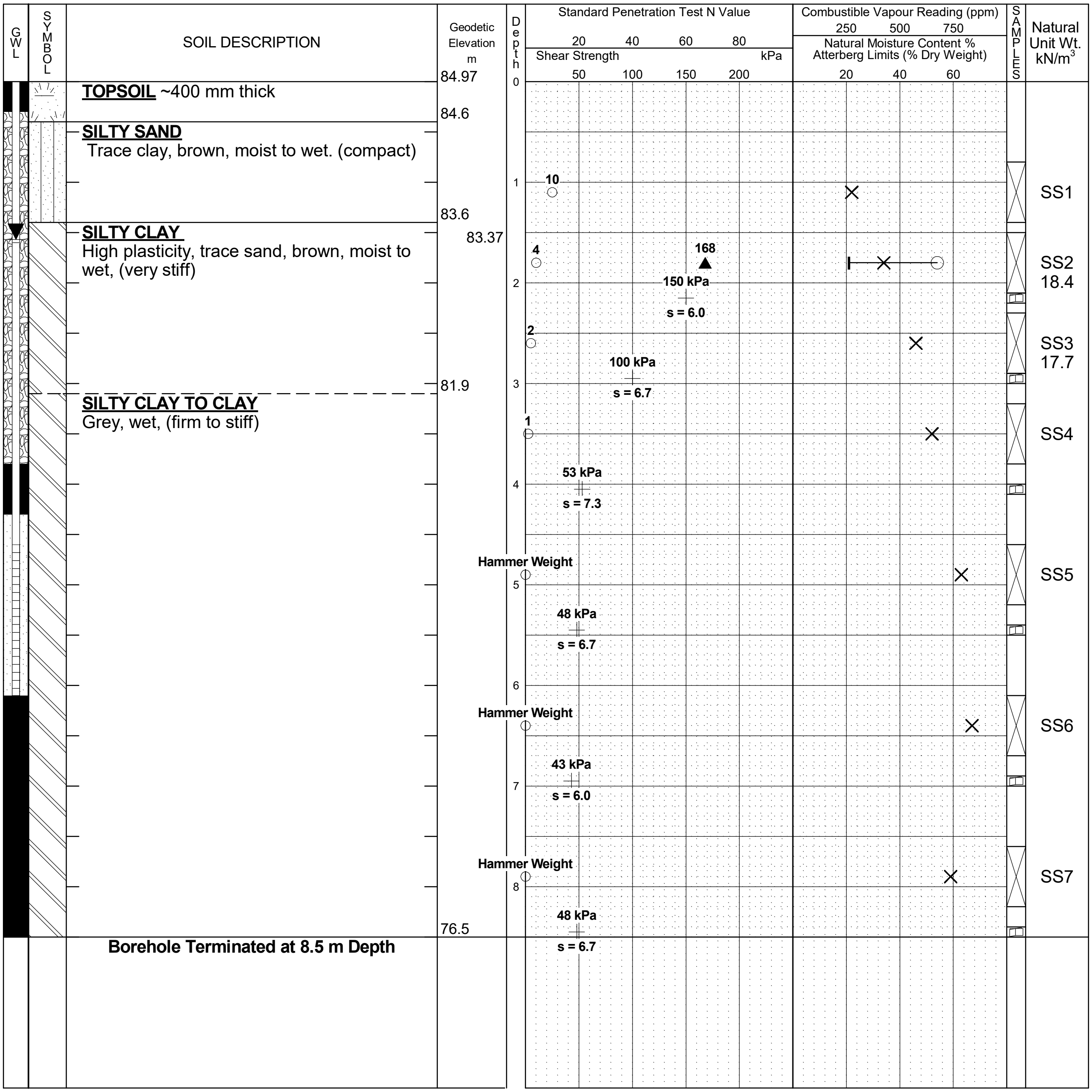
Date Drilled: 'April 29, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



TOPSOIL ~400 mm thick

SILTY SAND
Trace clay, brown, moist to wet. (compact)

SILTY CLAY
High plasticity, trace sand, brown, moist to wet, (very stiff)

SILTY CLAY TO CLAY
Grey, wet, (firm to stiff)

Borehole Terminated at 8.5 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.4	7.6
August 2, 2023	1.3	
September 21, 2023	1.4	
October 6, 2023	1.6	
October 19, 2023	1.6	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-02

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 4

Page. 1 of 1

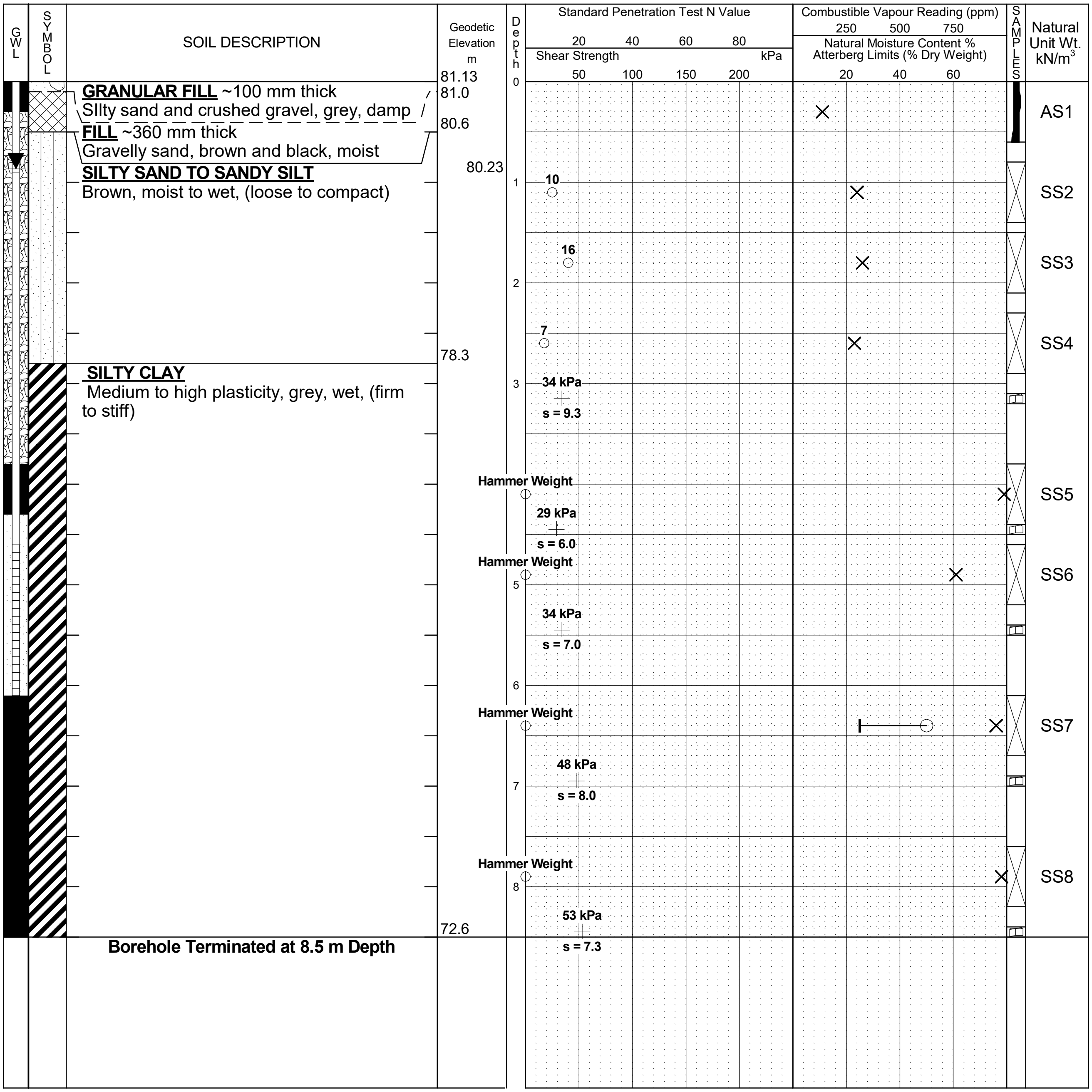
Date Drilled: 'April 28, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



Geodetic Elevation m	SOIL DESCRIPTION
81.13	
81.0	**GRANULAR FILL** ~100 mm thick SIlty sand and crushed gravel, grey, damp
80.6	**FILL** ~360 mm thick Gravelly sand, brown and black, moist
80.23	**SILTY SAND TO SANDY SILT** Brown, moist to wet, (loose to compact)
78.3	**SILTY CLAY** Medium to high plasticity, grey, wet, (firm to stiff)
72.6	

Borehole Terminated at 8.5 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	0.9	7.6
August 2, 2023	Damaged	
September 21, 2023	Not Found	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-03

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 5

Page. 1 of 1

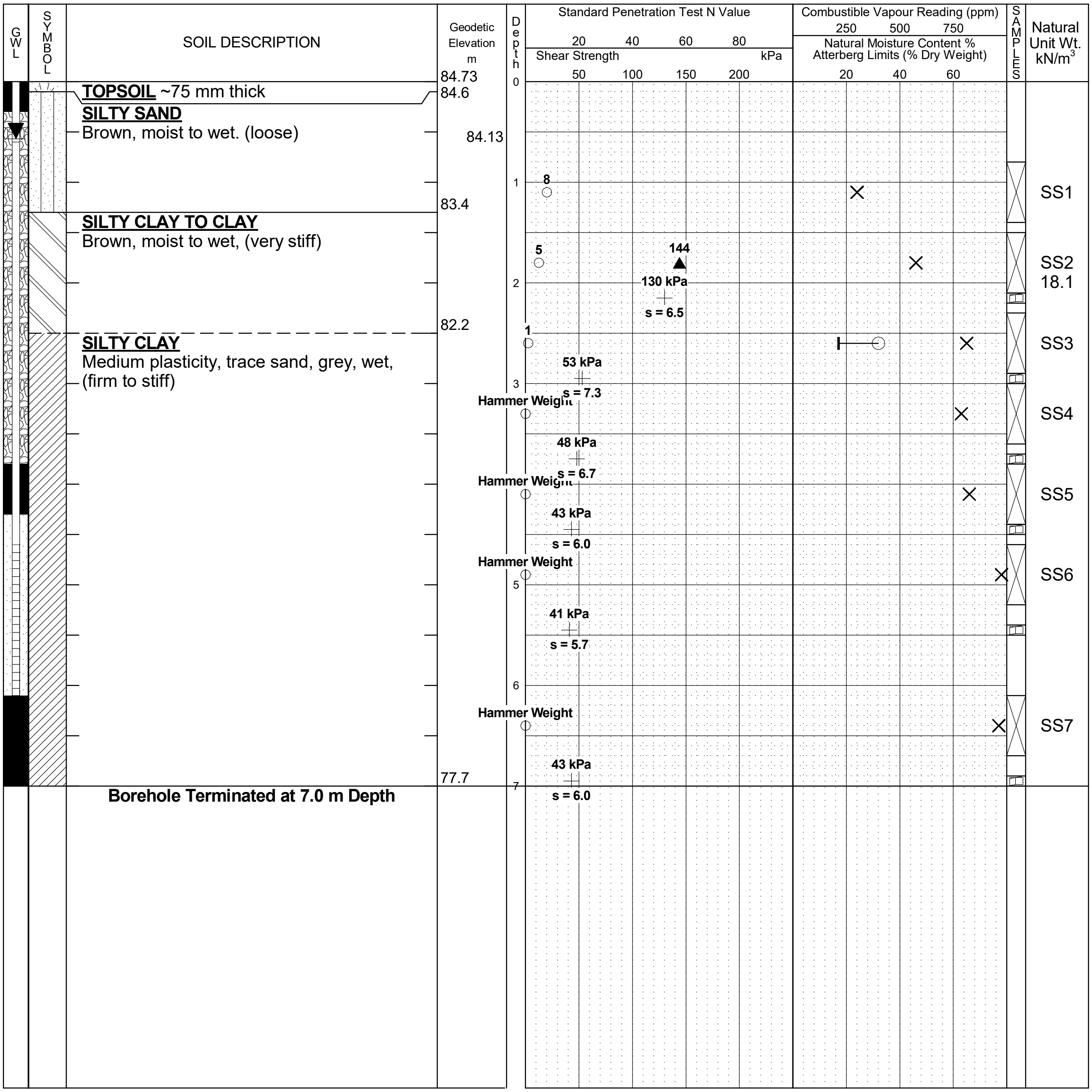
Date Drilled: 'April 29, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



Geodetic Elevation (m)	Soil Description
84.73	
84.6	**TOPSOIL** ~75 mm thick
	SILTY SAND Brown, moist to wet. (loose)
83.4	**SILTY CLAY TO CLAY** Brown, moist to wet, (very stiff)
82.2	**SILTY CLAY** Medium plasticity, trace sand, grey, wet, (firm to stiff)
77.7	**Borehole Terminated at 7.0 m Depth**

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	0.6	6.1
August 2, 2023	Not Found	
September 21, 2023	Not Found	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-04

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 6

Page. 1 of 1

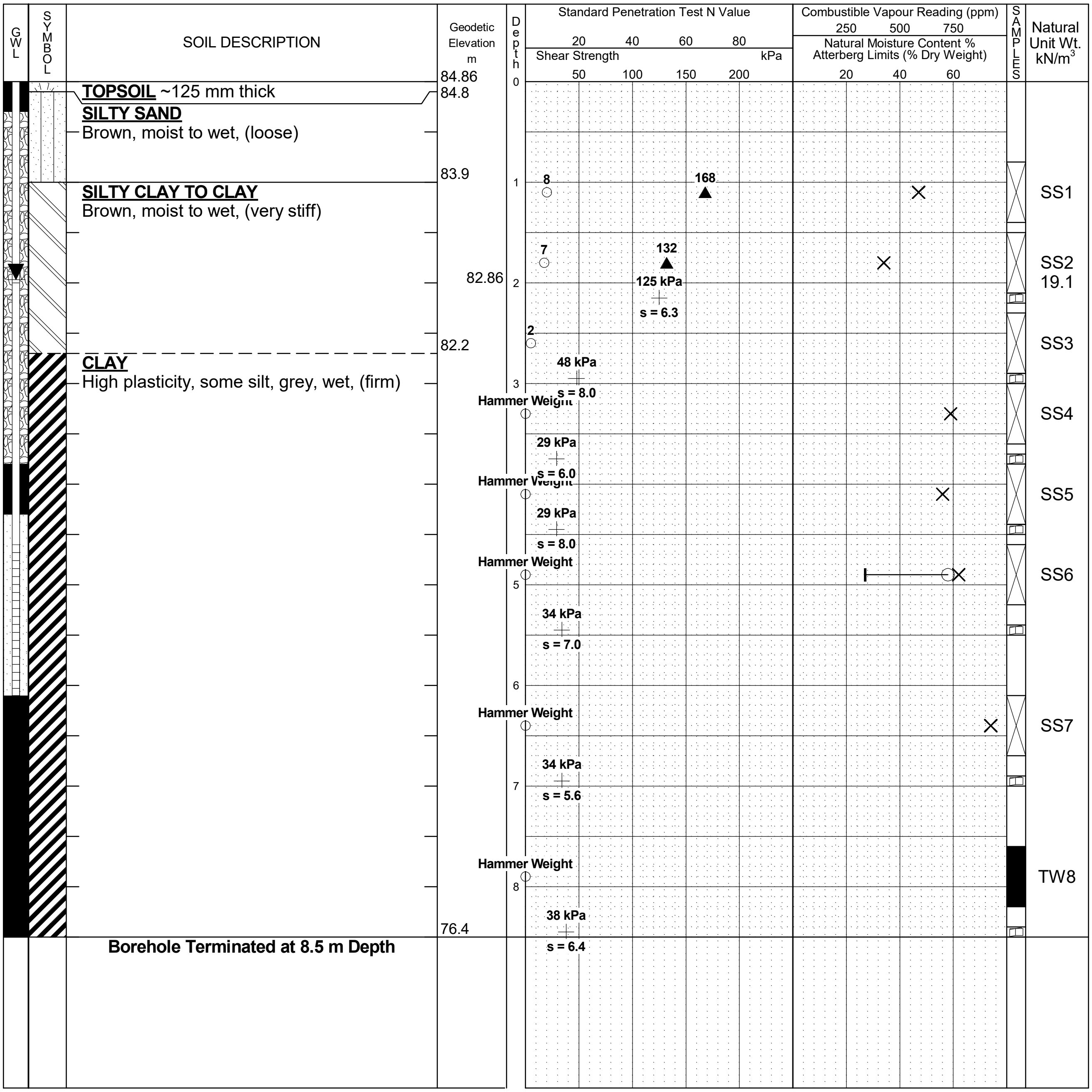
Date Drilled: 'April 30, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.7	7.6
August 2, 2023	1.4	
September 21, 2023	1.7	
October 6, 2023	1.8	
October 19, 2023	2.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-05

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 7

Page. 1 of 1

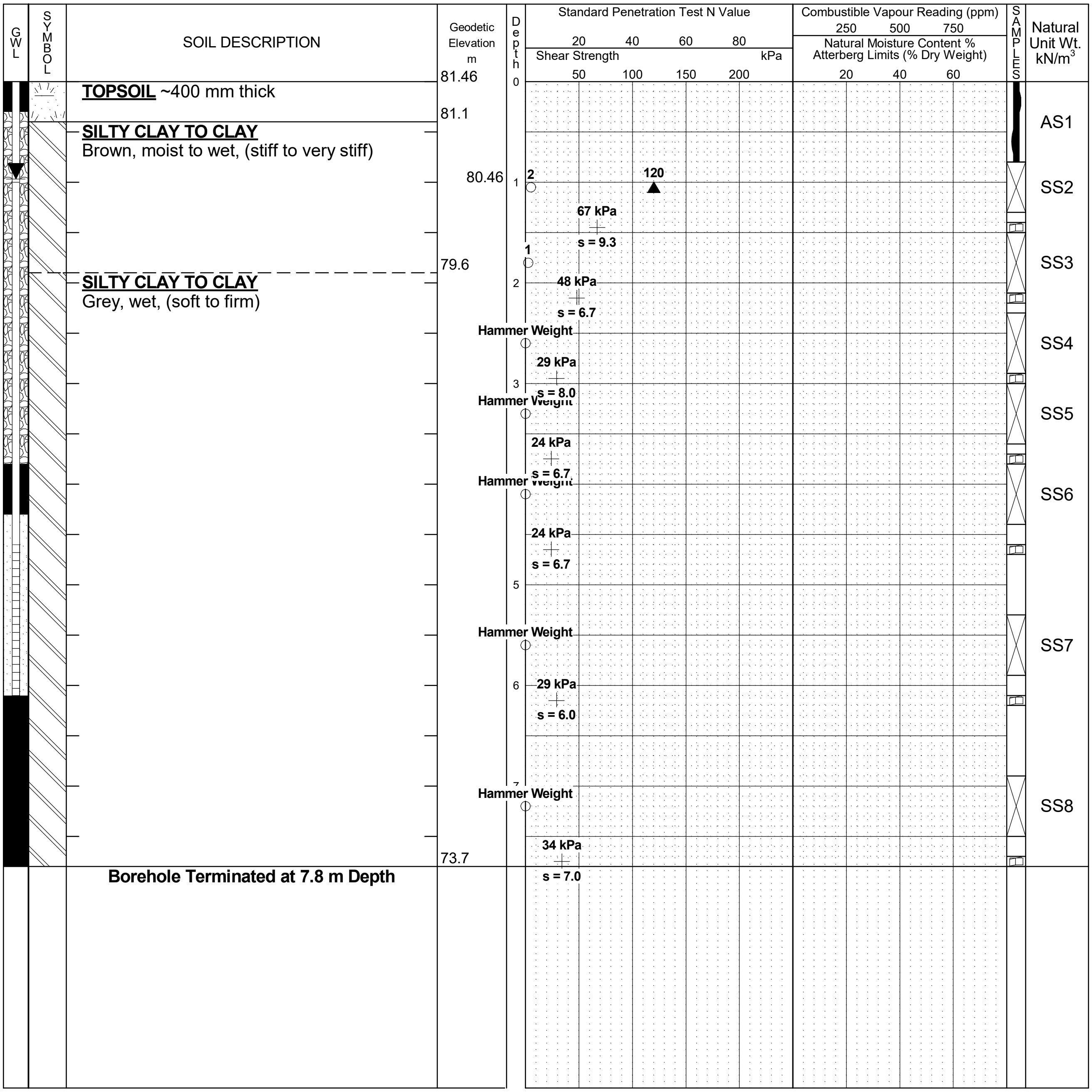
Date Drilled: 'April 28, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



TOPSOIL ~400 mm thick

SILTY CLAY TO CLAY
Brown, moist to wet, (stiff to very stiff)

SILTY CLAY TO CLAY
Grey, wet, (soft to firm)

Borehole Terminated at 7.8 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.0	6.7
August 2, 2023	0.9	
September 21, 2023	1.0	
October 6, 2023	1.0	
October 19, 2023	1.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-06

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 8

Page. 1 of 3

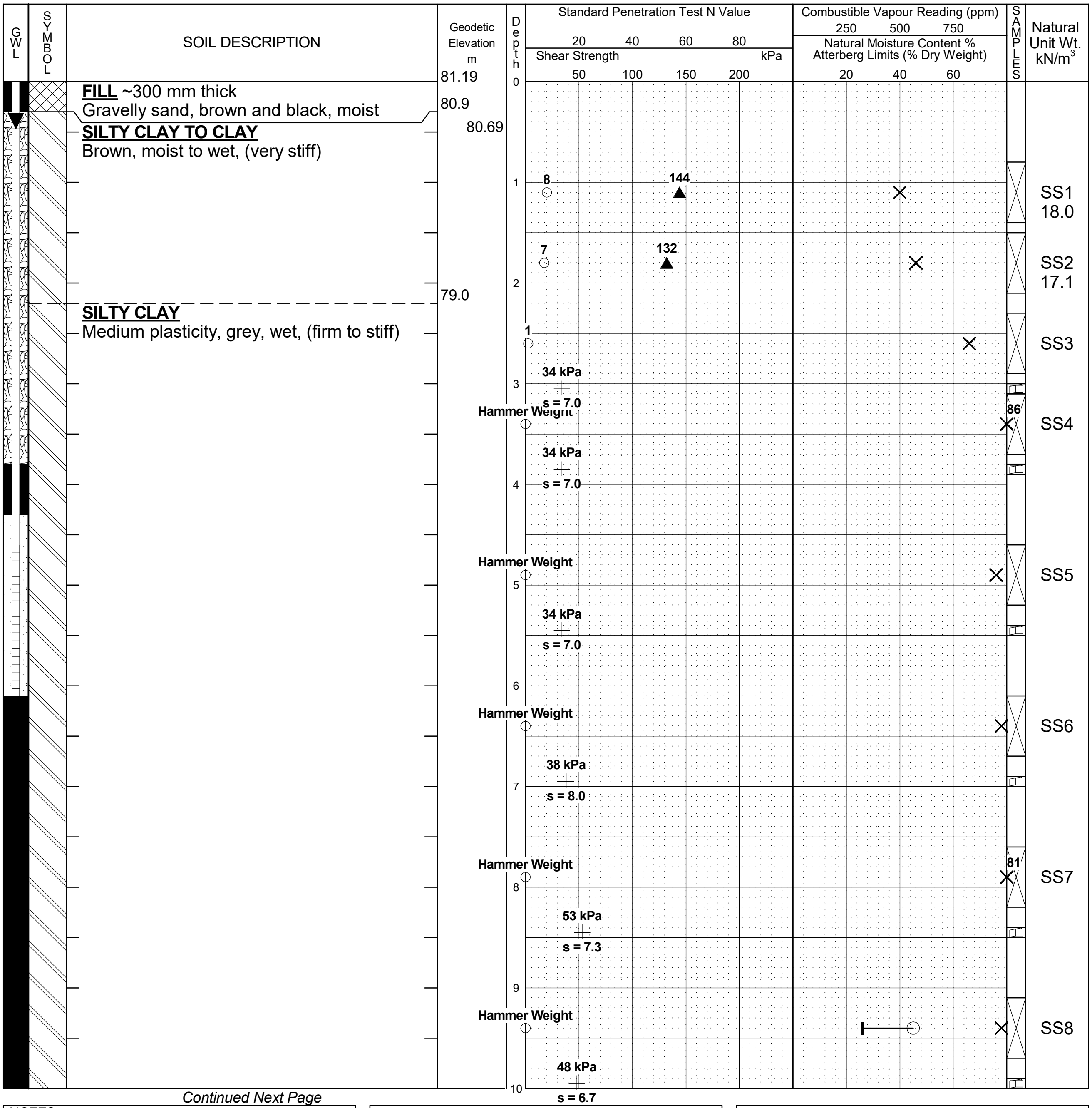
Date Drilled: 'April 28, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML   Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



FILL ~300 mm thick
Gravelly sand, brown and black, moist

SILTY CLAY TO CLAY
Brown, moist to wet, (very stiff)

SILTY CLAY
Medium plasticity, grey, wet, (firm to stiff)

Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.7	7.6
August 2, 2023	0.5	
September 21, 2023	Not Found	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-06

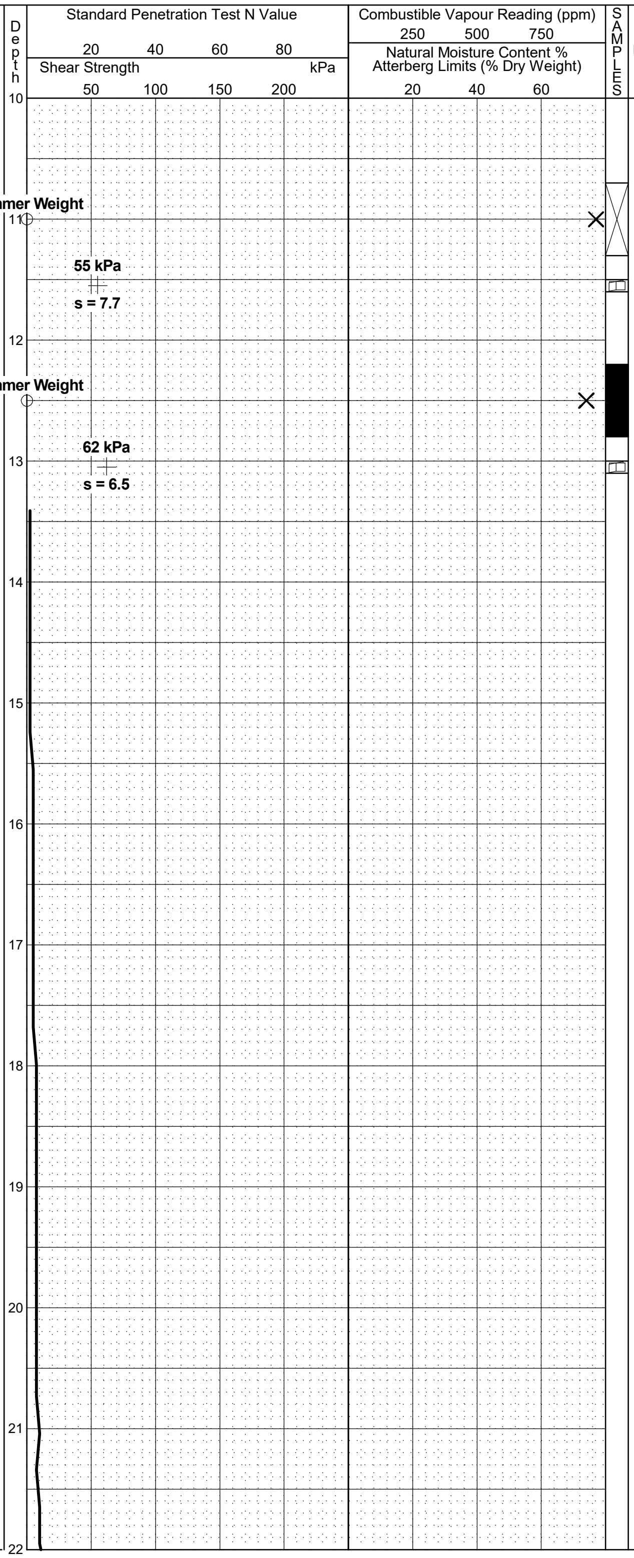
Project No: OTT-21004743-B0

Project: Proposed Residential Development

Figure No. 8

Page. 2 of 3

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	SAMPLES	Natural Unit Wt. kN/m³
		SILTY CLAY Medium plasticity, grey, wet, (firm to stiff) *(continued)*	71.19	10		
				11	SS9	
				12.5	TW10	15.0
		Dynamic cone penetration test (DCPT) conducted from 13.1 m to 30.5 m termination depth.	68.1	13.1		



Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.7	7.6
August 2, 2023	0.5	
September 21, 2023	Not Found	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-06

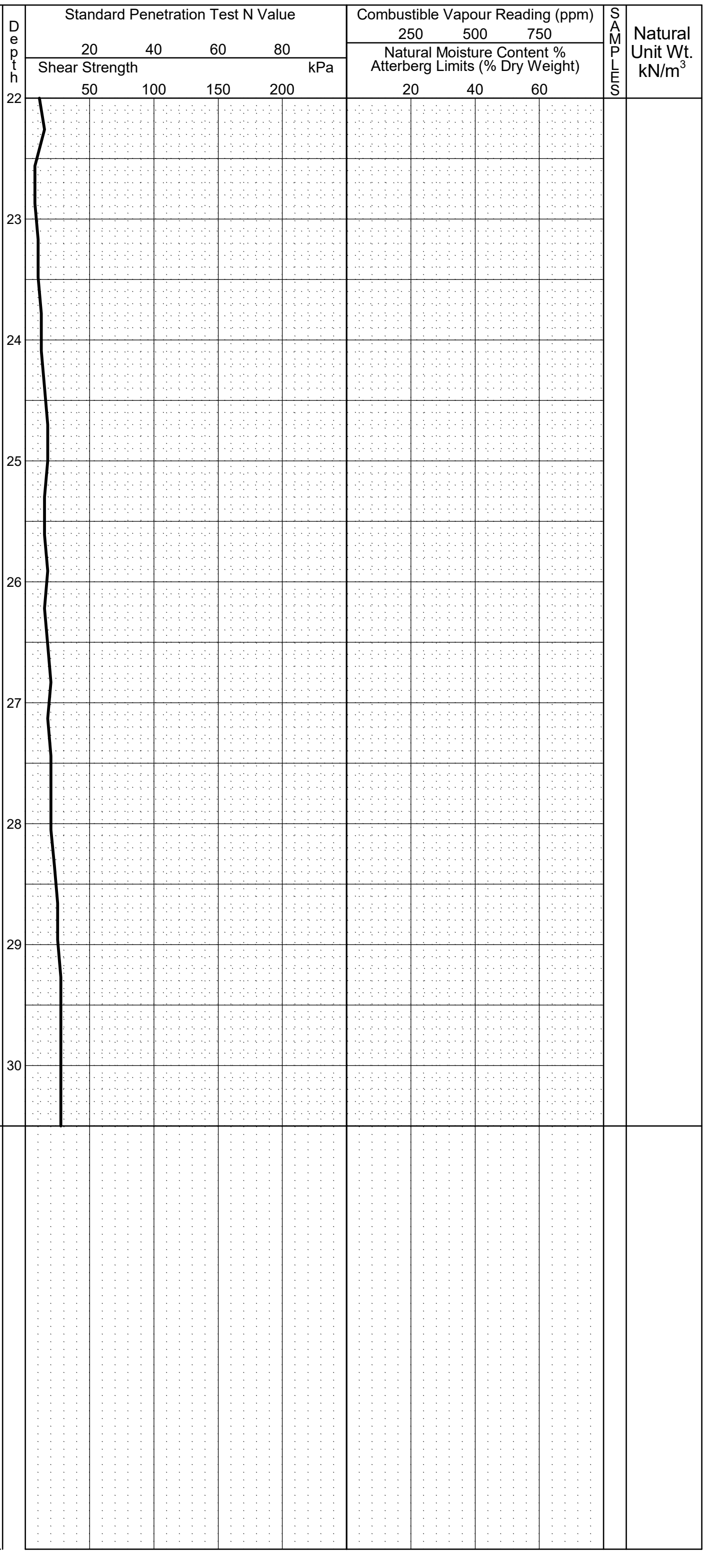
Project No: OTT-21004743-B0

Project: Proposed Residential Development

Figure No. 8

Page. 3 of 3

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m
		Dynamic cone penetration test (DCPT) conducted from 13.1 m to 30.5 m termination depth. *(continued)*	59.19
			50.7
		DCPT Terminated at 30.5 m Depth	



NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.7	7.6
August 2, 2023	0.5	
September 21, 2023	Not Found	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-07

Project No: OTT-21004743-B0

Figure No. 9

Page. 1 of 1

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

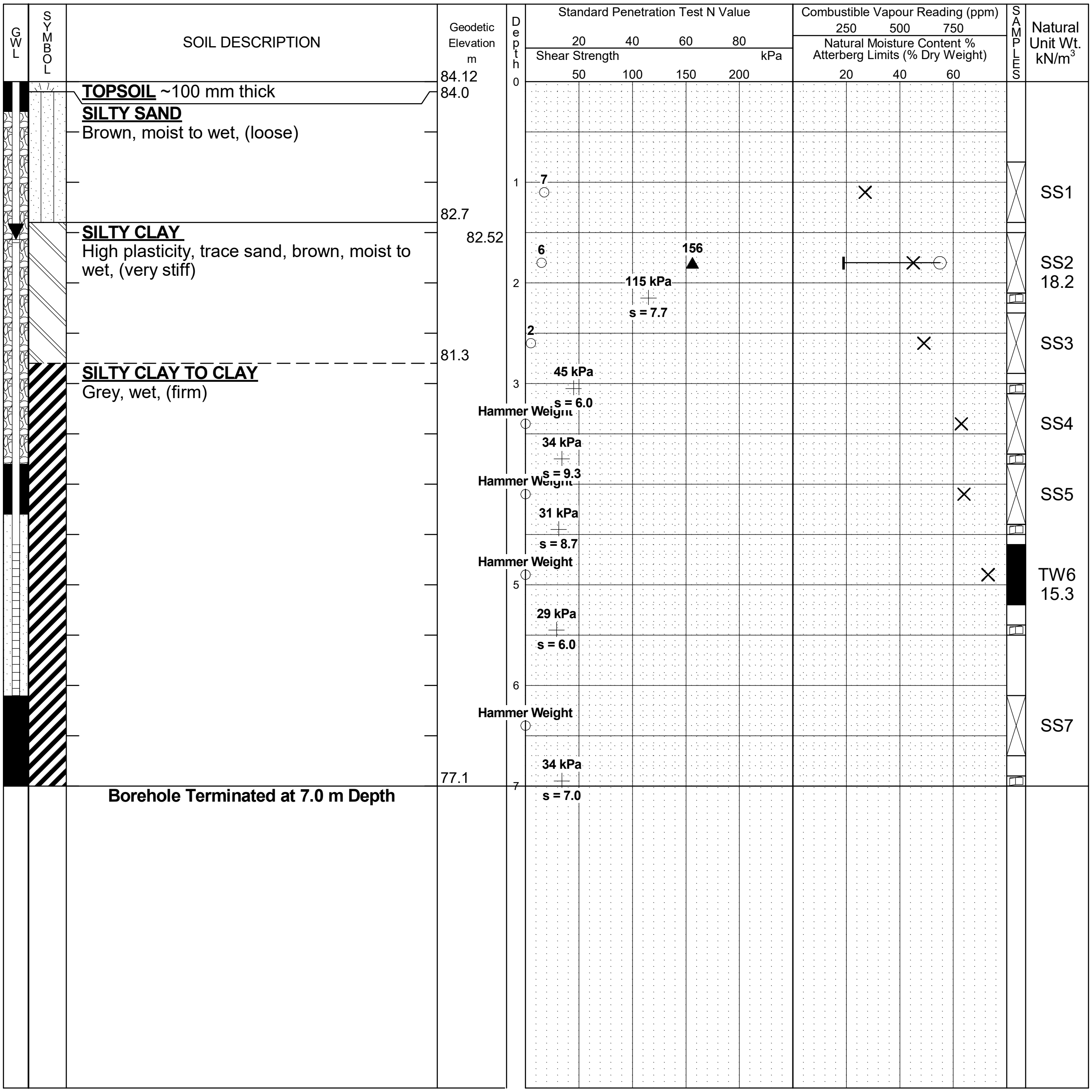
Date Drilled: 'April 30, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



TOPSOIL ~100 mm thick

SILTY SAND
Brown, moist to wet, (loose)

SILTY CLAY
High plasticity, trace sand, brown, moist to wet, (very stiff)

SILTY CLAY TO CLAY
Grey, wet, (firm)

Borehole Terminated at 7.0 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.4	6.1
August 2, 2023	1.1	
September 21, 2023	1.4	
October 6, 2023	1.7	
October 19, 2023	1.6	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-08

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 10

Page. 1 of 1

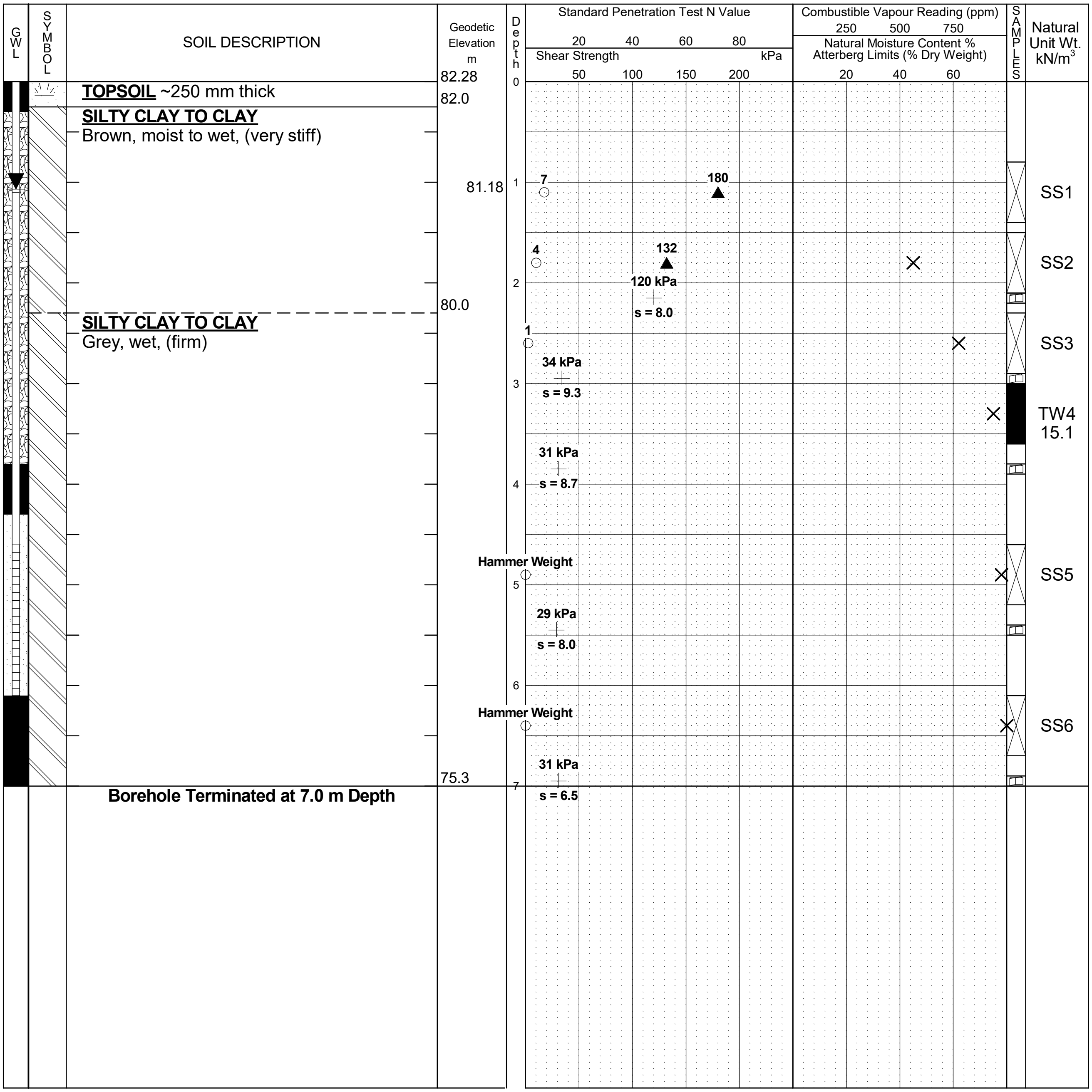
Date Drilled: 'April 29, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



TOPSOIL ~250 mm thick (82.28 – 82.0)

SILTY CLAY TO CLAY
Brown, moist to wet, (very stiff)

SILTY CLAY TO CLAY (80.0)
Grey, wet, (firm)

Borehole Terminated at 7.0 m Depth (75.3)

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.4	6.1
August 2, 2023	1.1	
September 21, 2023	Not Found	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-09

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 11

Page. 1 of 1

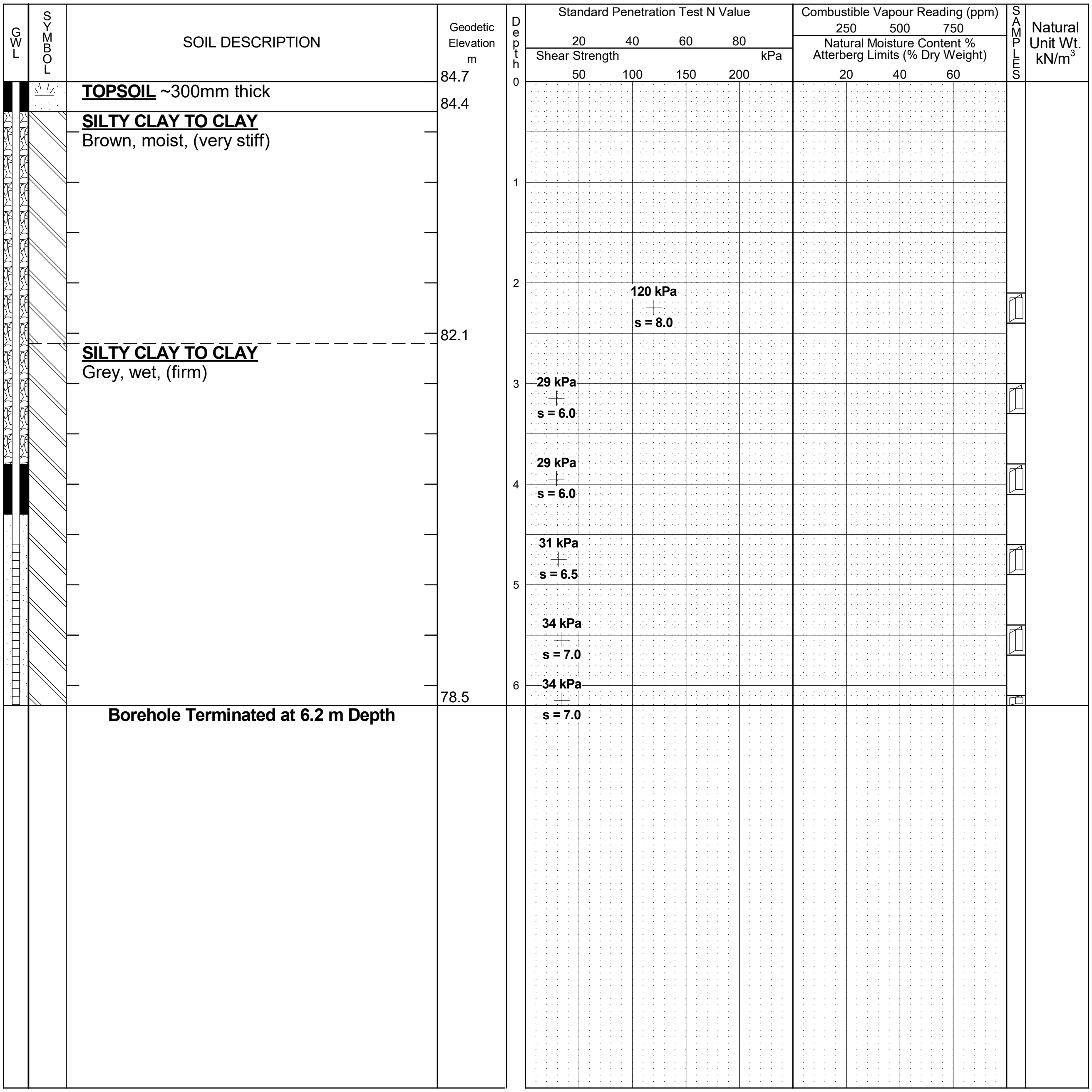
Date Drilled: 'April 30, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



Soil Description	Geodetic Elevation m
	84.7
TOPSOIL ~300mm thick	84.4
SILTY CLAY TO CLAY Brown, moist, (very stiff)	82.1
SILTY CLAY TO CLAY Grey, wet, (firm)	78.5
Borehole Terminated at 6.2 m Depth	

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	Damaged	6.1
August 2, 2023	Not Found	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-10

Project No: OTT-21004743-B0

Figure No. 12

Page. 1 of 1

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

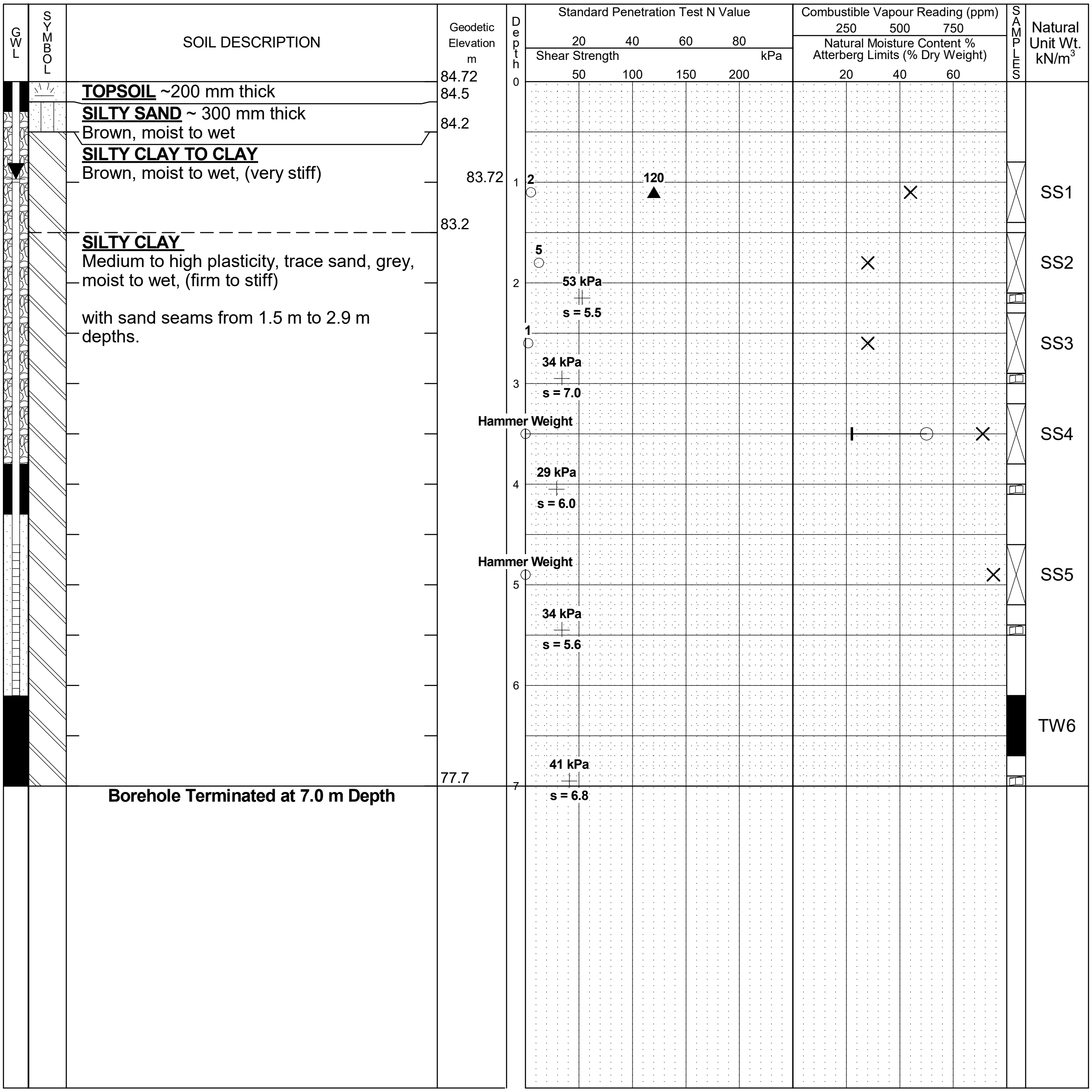
Date Drilled: 'April 29, 2021

Drill Type: CME-850 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



TOPSOIL ~200 mm thick

SILTY SAND ~ 300 mm thick
Brown, moist to wet

SILTY CLAY TO CLAY
Brown, moist to wet, (very stiff)

SILTY CLAY
Medium to high plasticity, trace sand, grey, moist to wet, (firm to stiff)

with sand seams from 1.5 m to 2.9 m depths.

Borehole Terminated at 7.0 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
June 19, 2021	1.3	6.1
August 2, 2023	1.0	
September 21, 2023	0.9	
October 6, 2023	1.0	
October 19, 2023	1.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-11

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 13

Page. 1 of 1

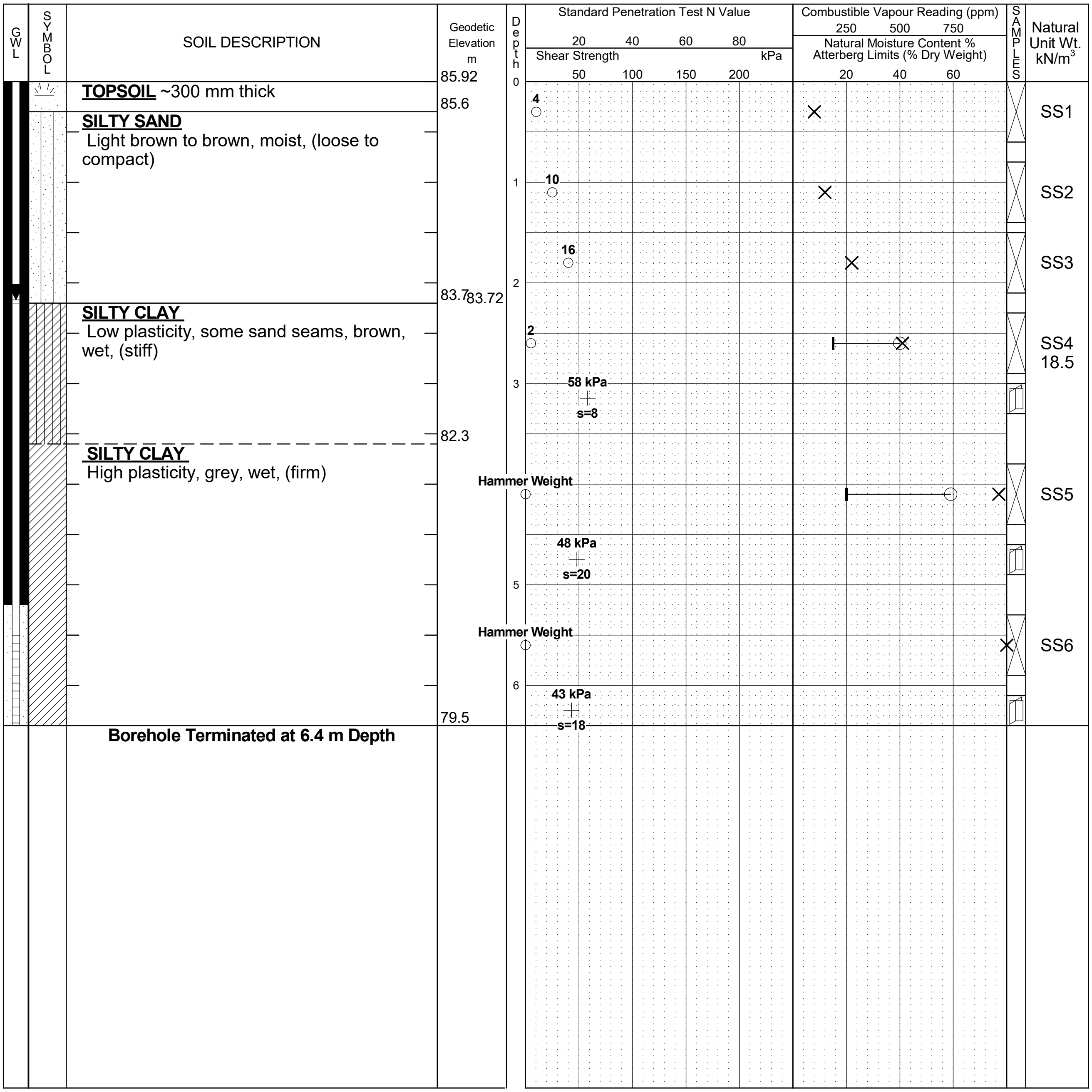
Date Drilled: 'September 12, 2023

Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



TOPSOIL ~300 mm thick

SILTY SAND
Light brown to brown, moist, (loose to compact)

SILTY CLAY
Low plasticity, some sand seams, brown, wet, (stiff)

SILTY CLAY
High plasticity, grey, wet, (firm)

Borehole Terminated at 6.4 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	2.3	
October 6, 2023	2.2	
October 19, 2023	2.2	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-12

Project No: OTT-21004743-B0

Figure No. 14

Page. 1 of 1

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

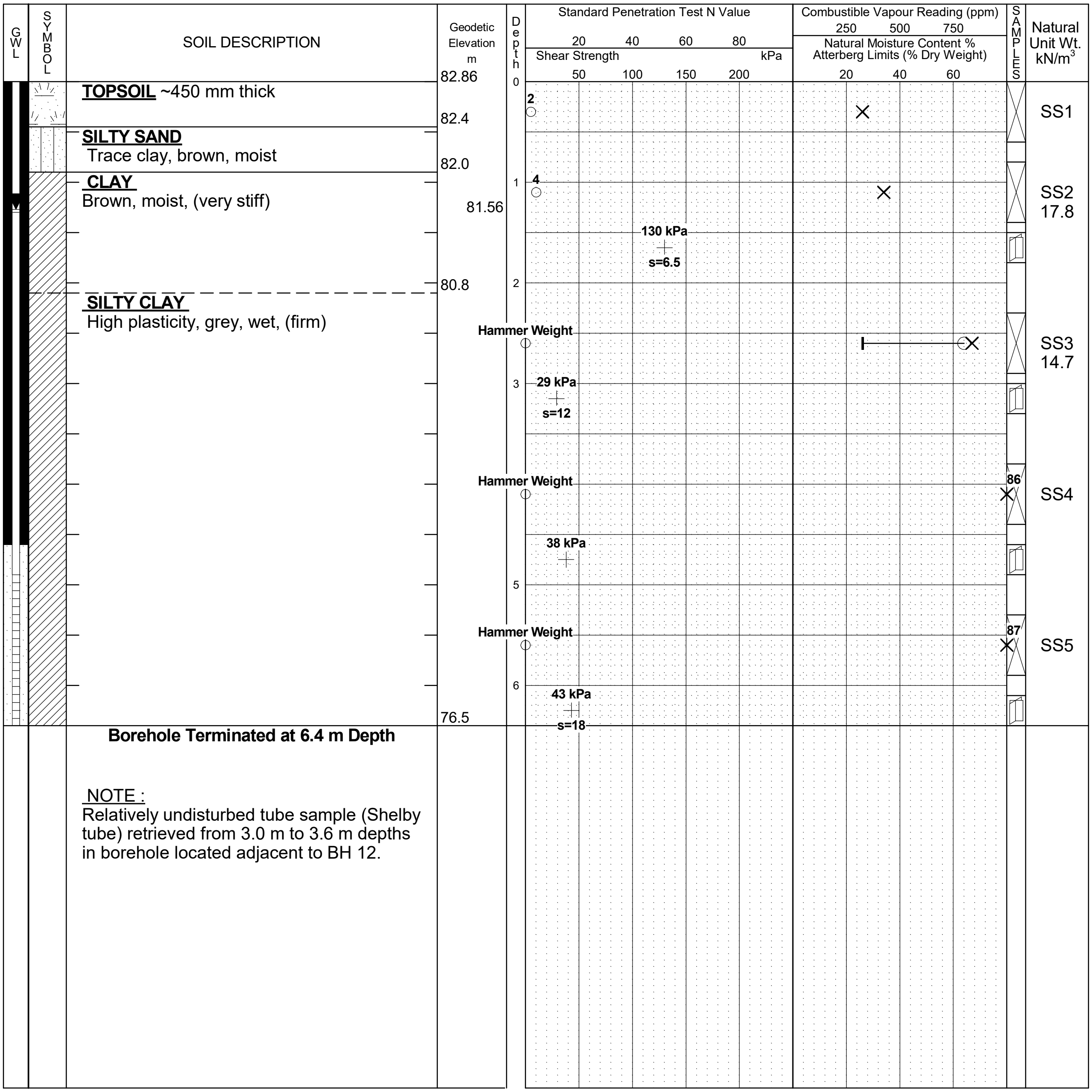
Date Drilled: 'September 12, 2023

Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



TOPSOIL ~450 mm thick

SILTY SAND
Trace clay, brown, moist

CLAY
Brown, moist, (very stiff)

SILTY CLAY
High plasticity, grey, wet, (firm)

Borehole Terminated at 6.4 m Depth

NOTE :
Relatively undisturbed tube sample (Shelby tube) retrieved from 3.0 m to 3.6 m depths in borehole located adjacent to BH 12.

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	3.3	
October 6, 2023	1.4	
October 19, 2023	1.3	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-13

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 15

Page. 1 of 1

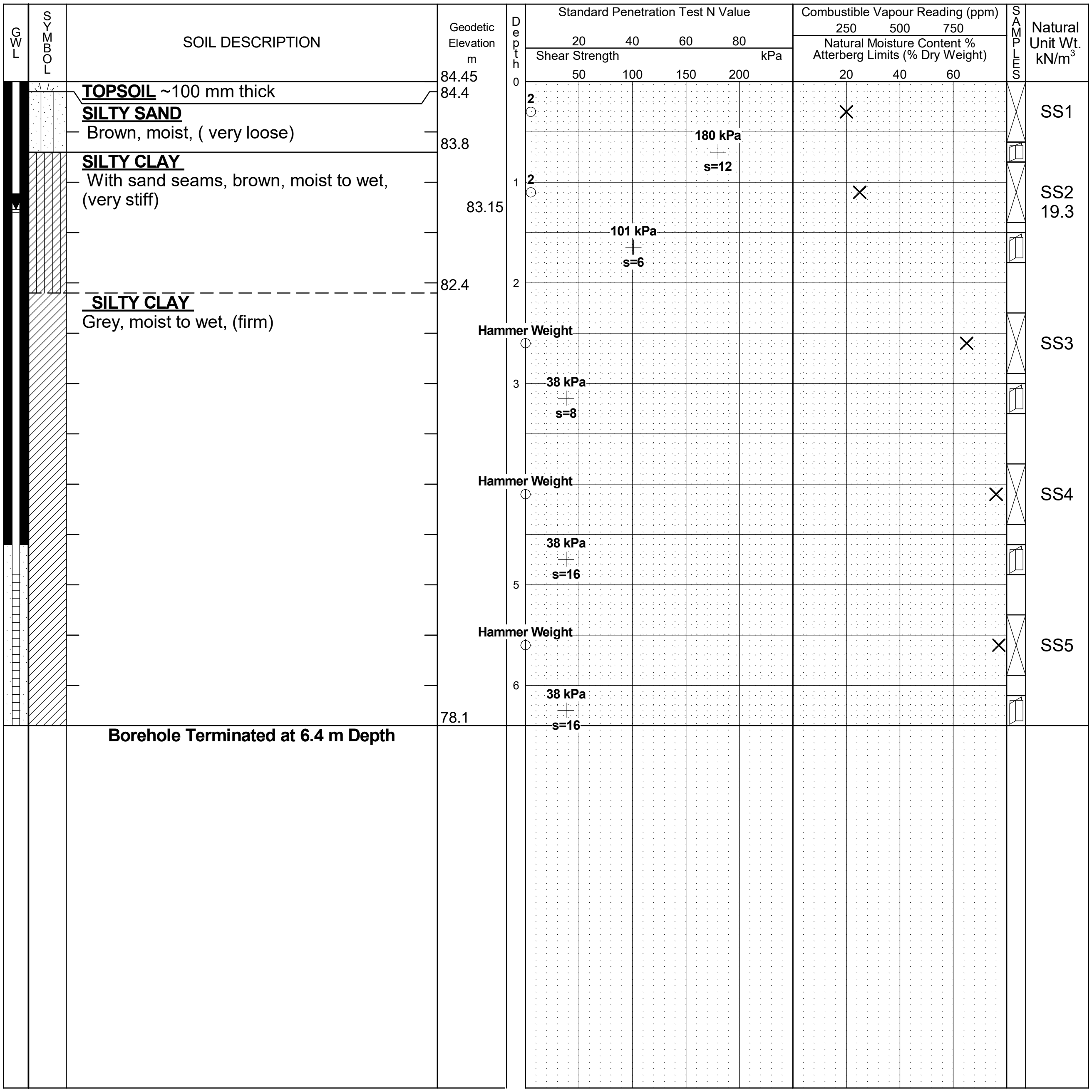
Date Drilled: 'September 12, 2023

Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z   Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



TOPSOIL ~100 mm thick

SILTY SAND
Brown, moist, (very loose)

SILTY CLAY
With sand seams, brown, moist to wet, (very stiff)

SILTY CLAY
Grey, moist to wet, (firm)

Borehole Terminated at 6.4 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	1.8	
October 13, 2023	1.4	
October 19, 2023	1.3	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-14

Project No: OTT-21004743-B0

Figure No. 16

Project: Proposed Residential Development

Page. 1 of 1

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Date Drilled: 'September 12, 2023

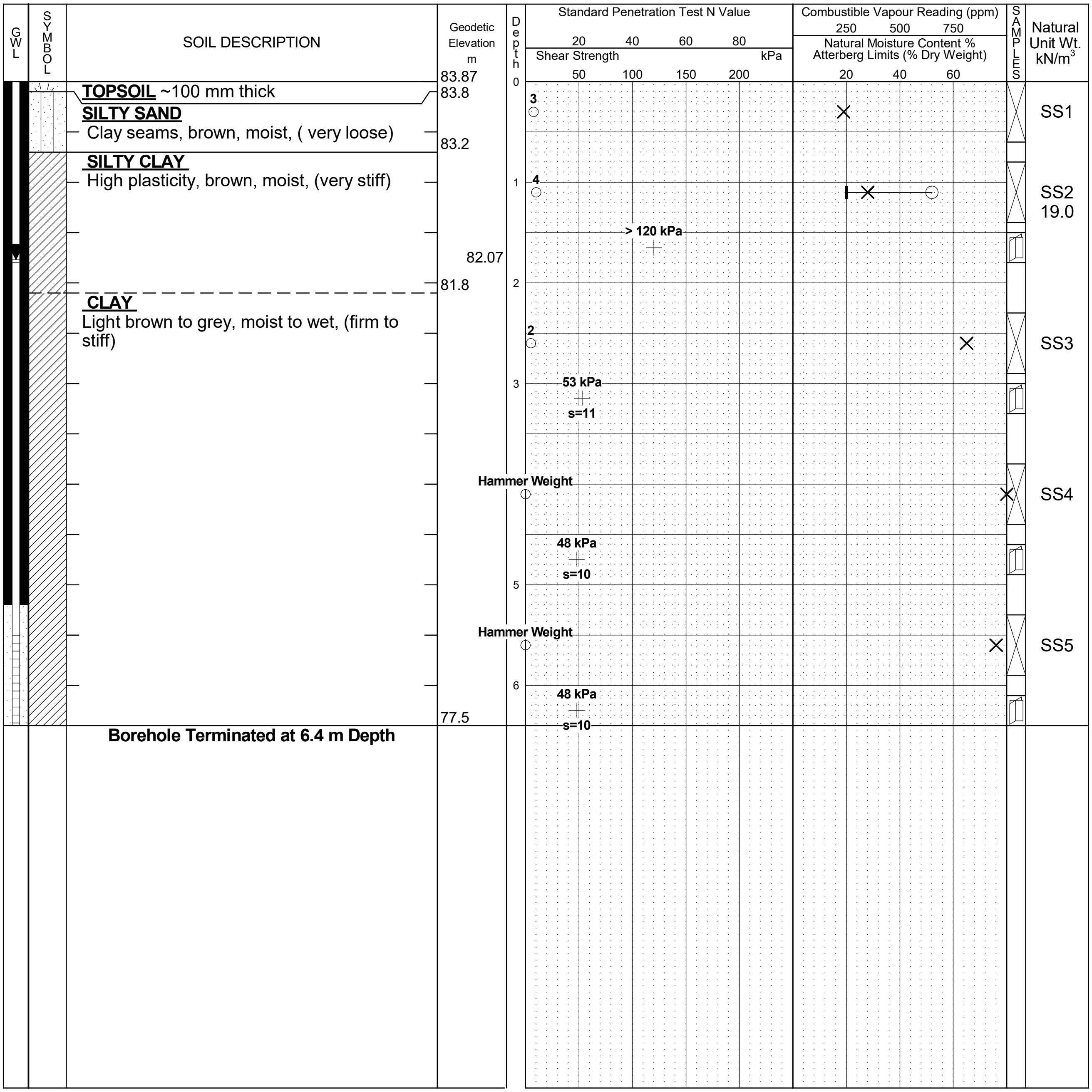
Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z

Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



GWL | SYMBOL | SOIL DESCRIPTION | Geodetic Elevation m | Depth | Standard Penetration Test N Value / Shear Strength kPa | Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) | SAMPLES | Natural Unit Wt. kN/m³

TOPSOIL ~100 mm thick

SILTY SAND
Clay seams, brown, moist, (very loose)

SILTY CLAY
High plasticity, brown, moist, (very stiff)

CLAY
Light brown to grey, moist to wet, (firm to stiff)

Borehole Terminated at 6.4 m Depth

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	1.7	
October 6, 2023	1.7	
October 19, 2023	1.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-15

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 17

Page. 1 of 1

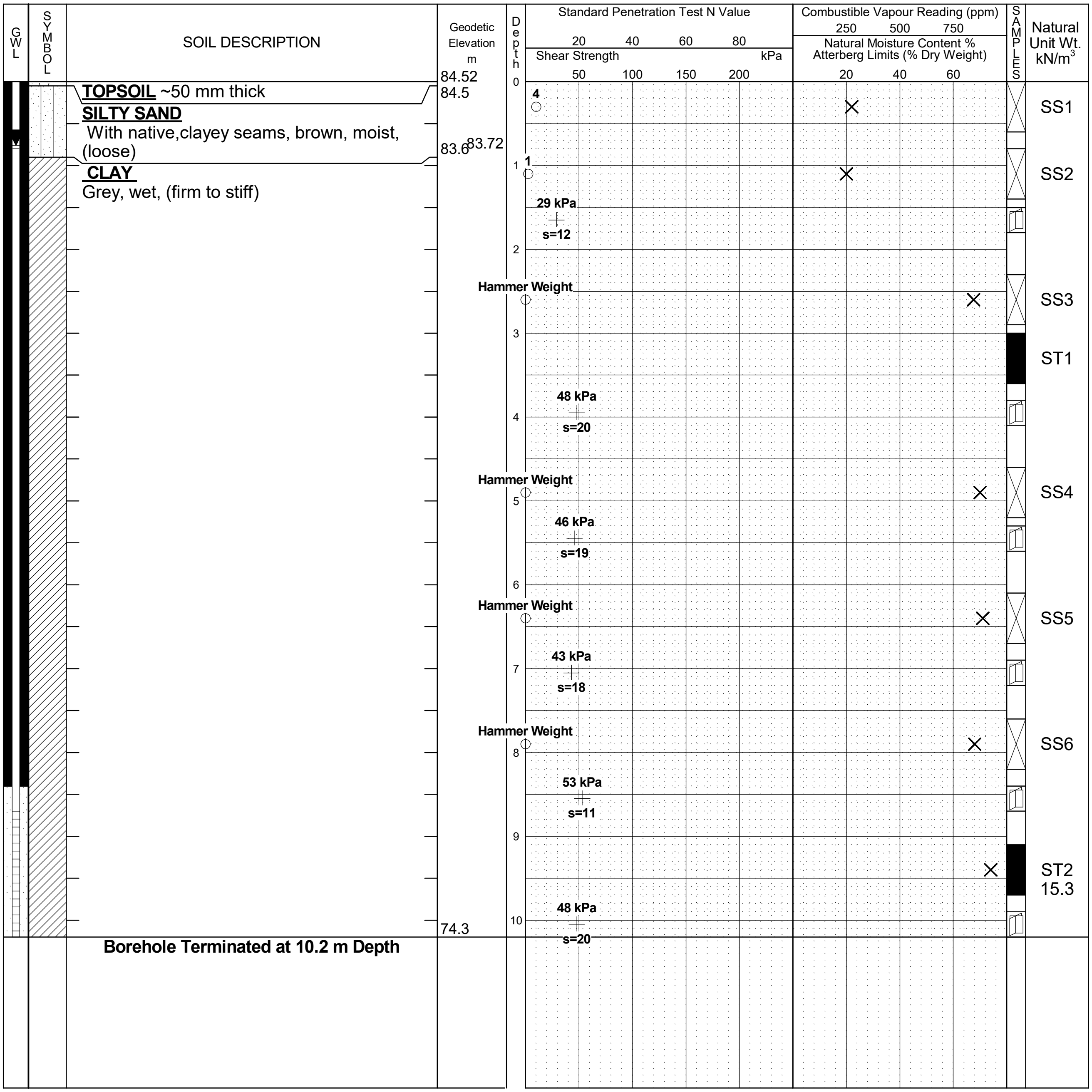
Date Drilled: 'September 13, 2023

Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



TOPSOIL ~50 mm thick

SILTY SAND
With native,clayey seams, brown, moist, (loose)

CLAY
Grey, wet, (firm to stiff)

Borehole Terminated at 10.2 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	0.8	
October 6, 2023	0.9	
October 19, 2023	0.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole **BH-16**

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 18

Page. 1 of 1

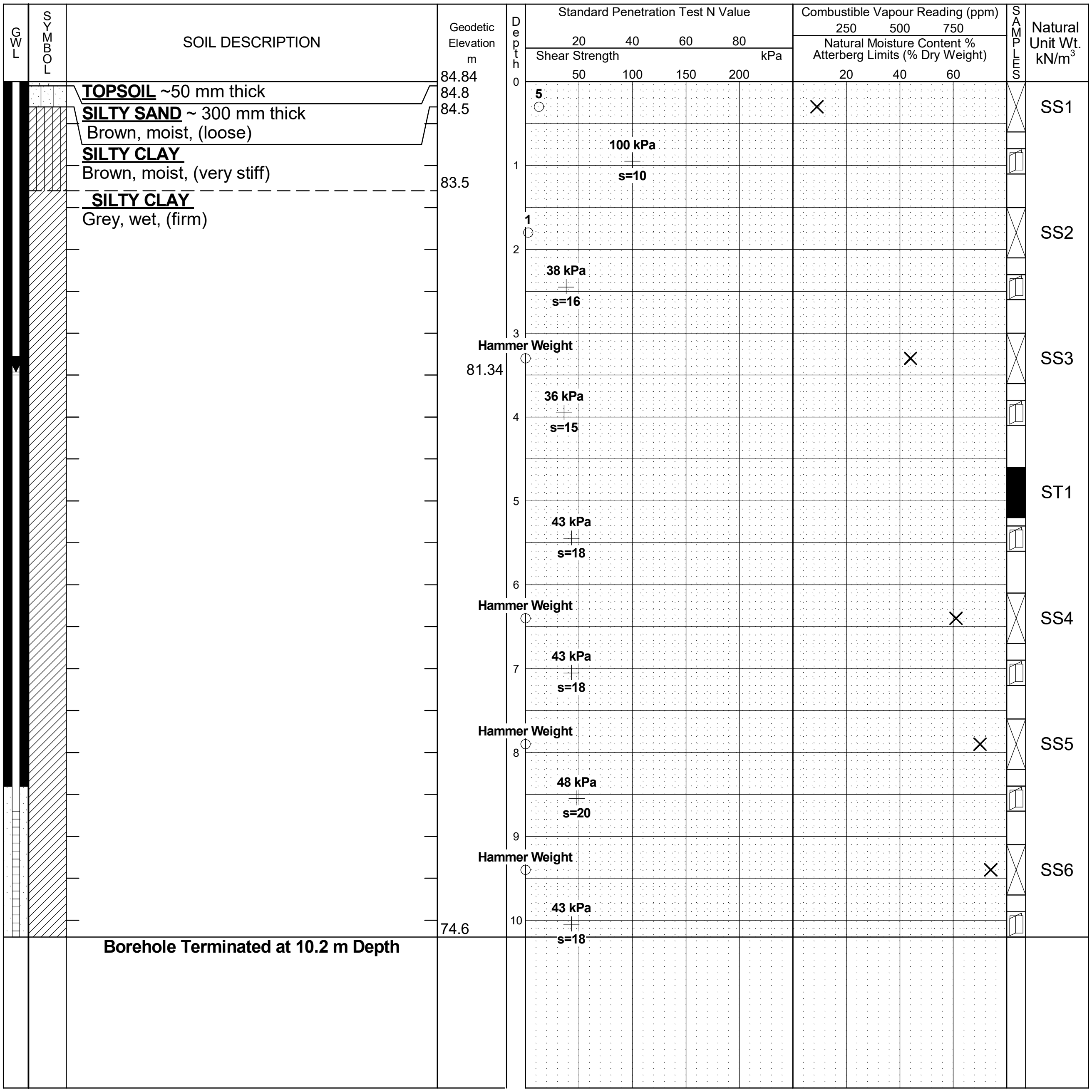
Date Drilled: 'September 13, 2023

Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	3.4	
October 6, 2023	3.5	
October 19, 2023	3.5	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-17

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 19

Page. 1 of 1

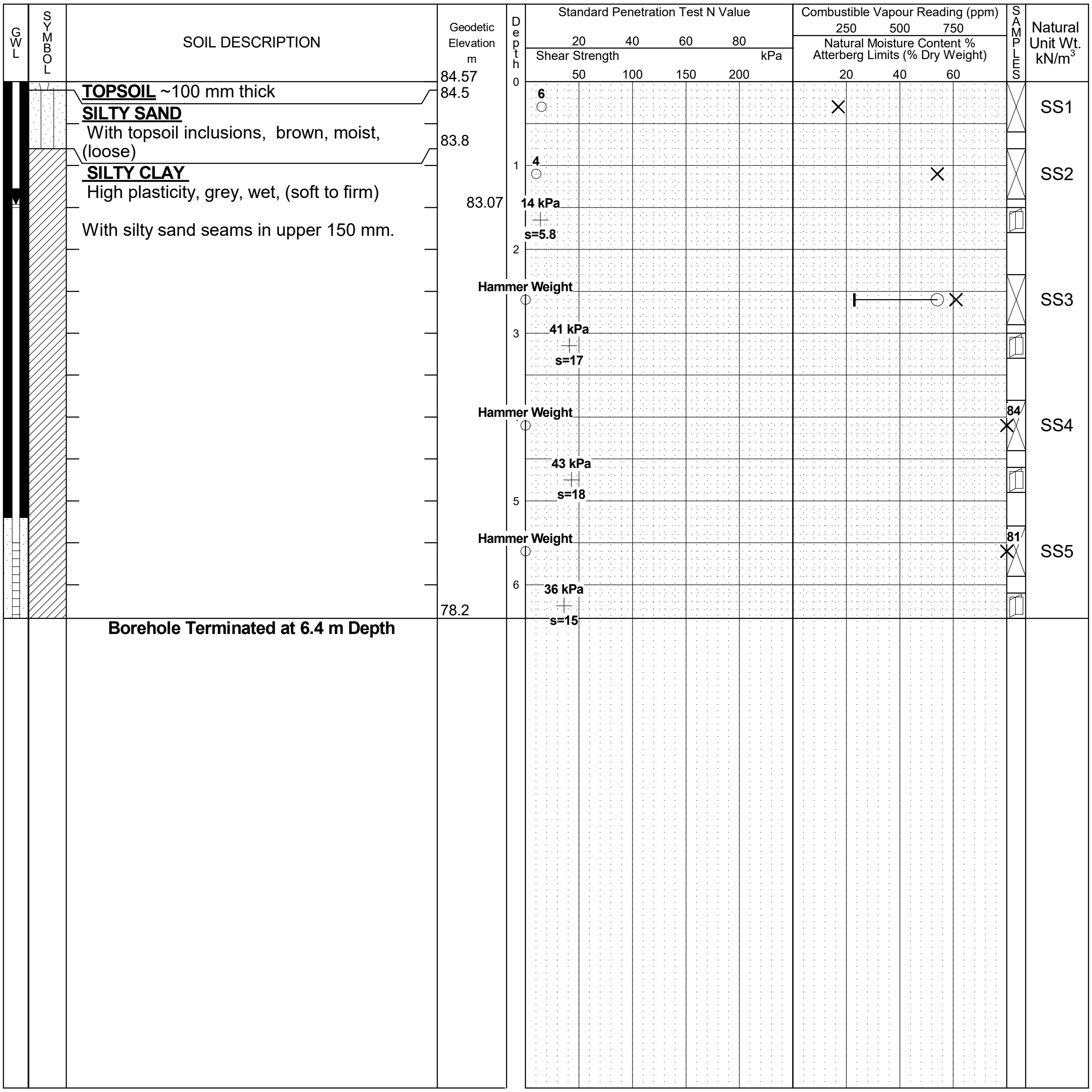
Date Drilled: 'September 11, 2023

Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



TOPSOIL ~100 mm thick

SILTY SAND
With topsoil inclusions, brown, moist, (loose)

SILTY CLAY
High plasticity, grey, wet, (soft to firm)

With silty sand seams in upper 150 mm.

Borehole Terminated at 6.4 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	1.6	
October 6, 2023	1.5	
October 19, 2023	1.5	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-18

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 20

Page. 1 of 1

Date Drilled: 'September 11, 2023

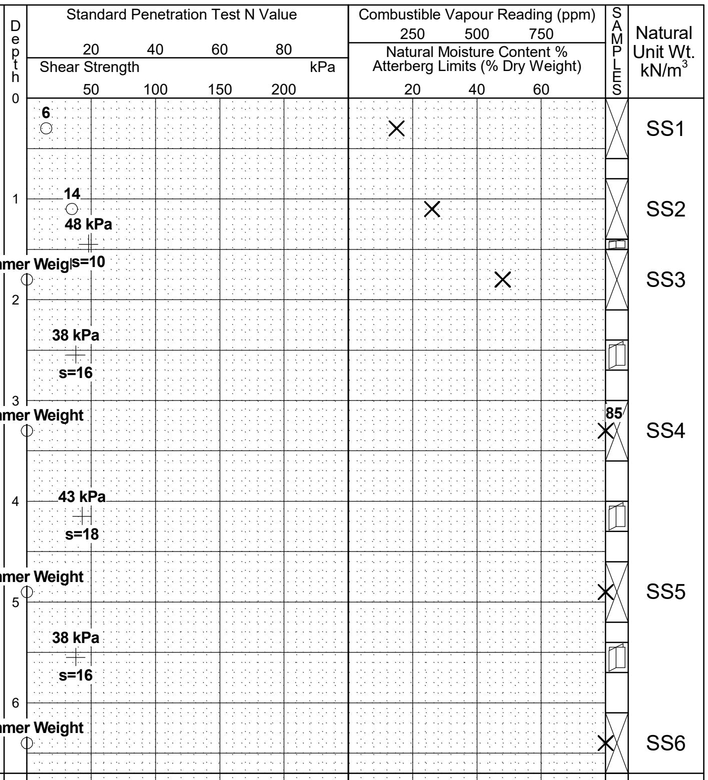
Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

SOIL DESCRIPTION	Geodetic Elevation m	Samples
	84.41	
TOPSOIL ~100 mm thick	84.3	SS1
SILTY SAND Clay seams and with topsoil inclusion, brown to grey, moist, (loose to compact)	83.0	SS2
SILTY CLAY Grey, wet, (firm) With reddish brown bands in upper 300 mm.	82.81 77.7	SS3 SS4 SS5 SS6
Borehole Terminated at 6.7 m Depth		



NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	1.8	
October 6, 2023	1.5	
October 19, 2023	1.6	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE BH LOGS - JULY 5 UPDATED BOREHOLE LOGS.GPJ TROW OTTAWA.GDT 11/13/23

Log of Borehole BH-20

Project No: OTT-21004743-B0

Project: Proposed Residential Development

Location: 2983, 3053 and 3079 Navan Road, Ottawa, Ontario

Figure No. 21

Page. 1 of 1

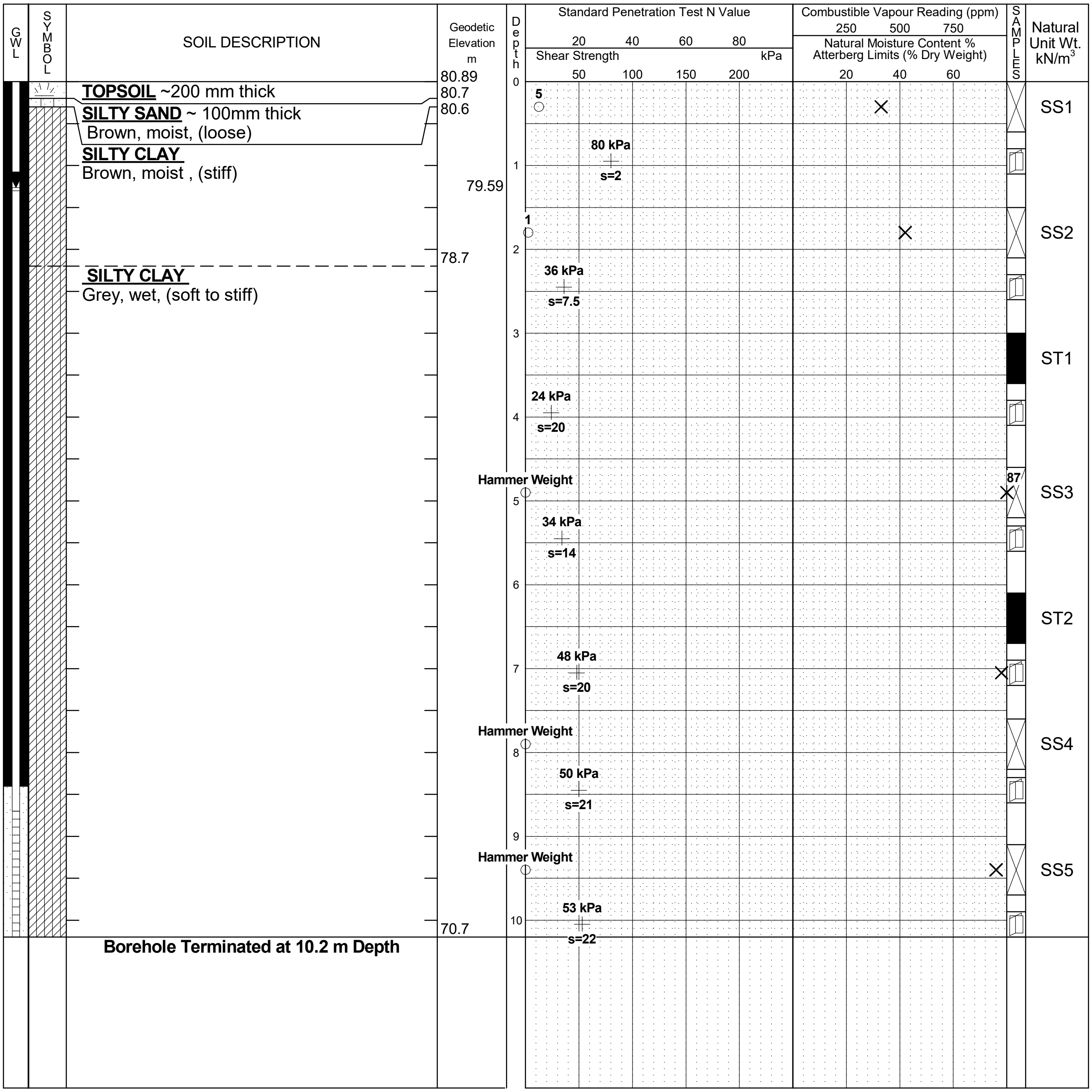
Date Drilled: 'September 14, 2023

Drill Type: CME-55 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z   Checked by: IT

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



TOPSOIL ~200 mm thick

SILTY SAND ~ 100mm thick
Brown, moist, (loose)

SILTY CLAY
Brown, moist , (stiff)

SILTY CLAY
Grey, wet, (soft to stiff)

Borehole Terminated at 10.2 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21004743-B0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
September 21, 2023	5.7	
October 6, 2023	1.5	
October 19, 2023	1.3	

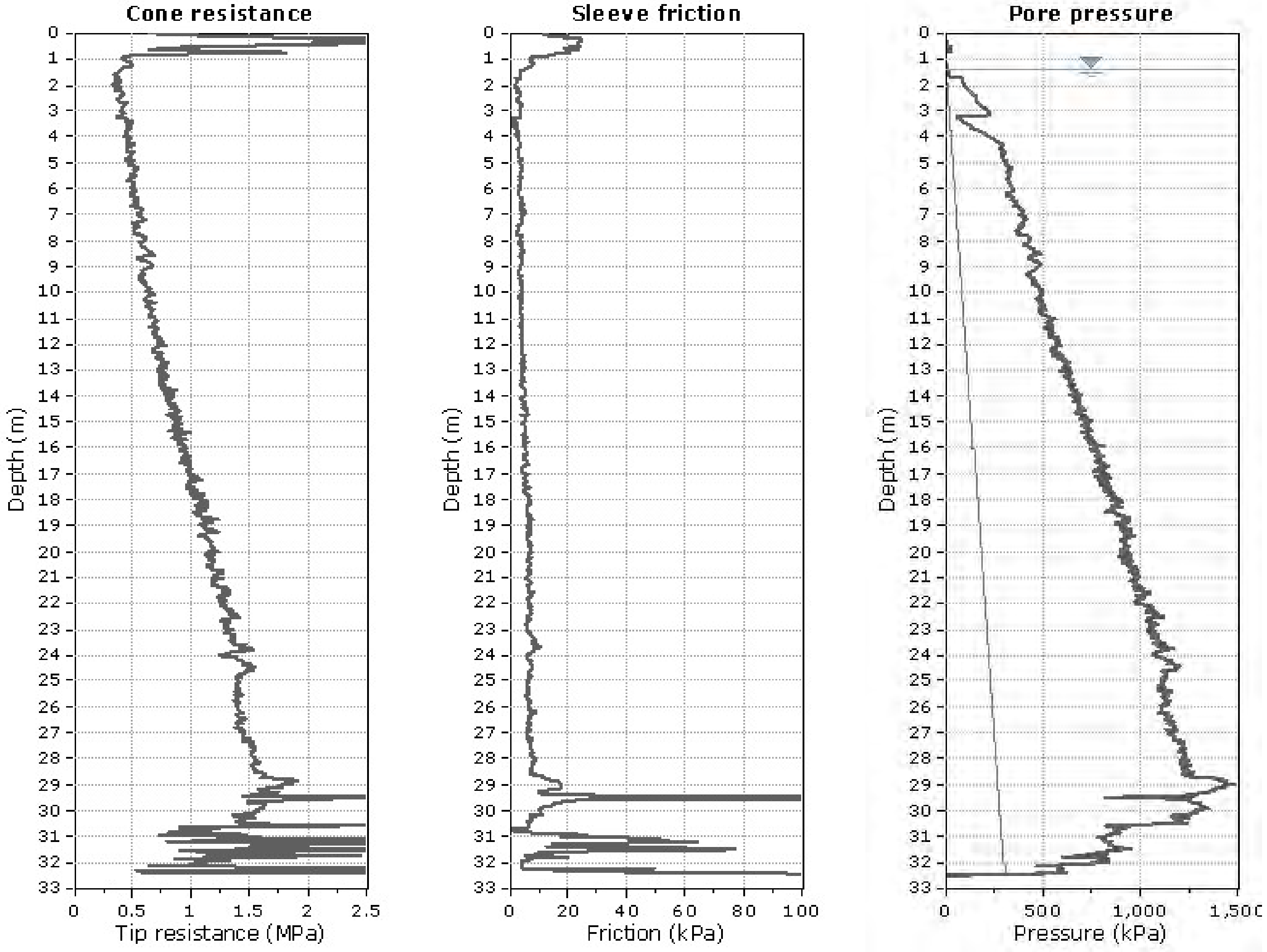
CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

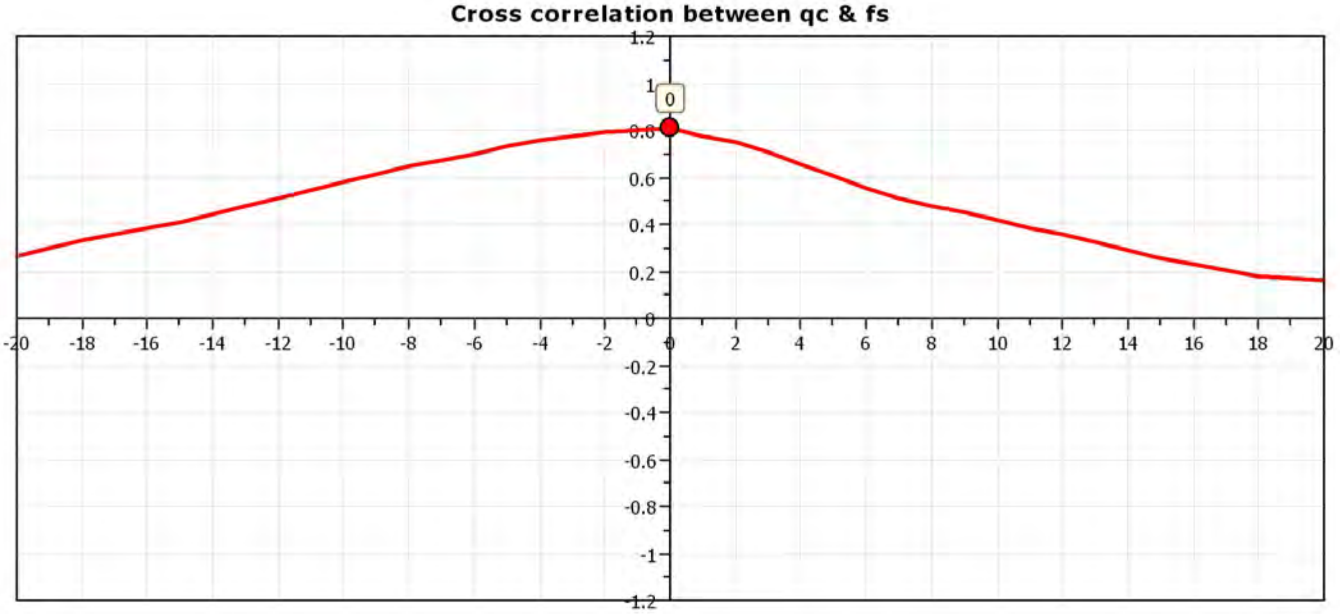
EXP
2650 Queensview Dr Suite 100
Ottawa, Ontario, K2B 8H6
https://ww.exp.com

CPT: SCPTu-9
Total depth: 32.51 m
Surface Elevation: 84.70 m
Cone Type: Vertek 4544 - 5t
Cone Operator: Kevin Simoneau, P.Eng, M.Sc.

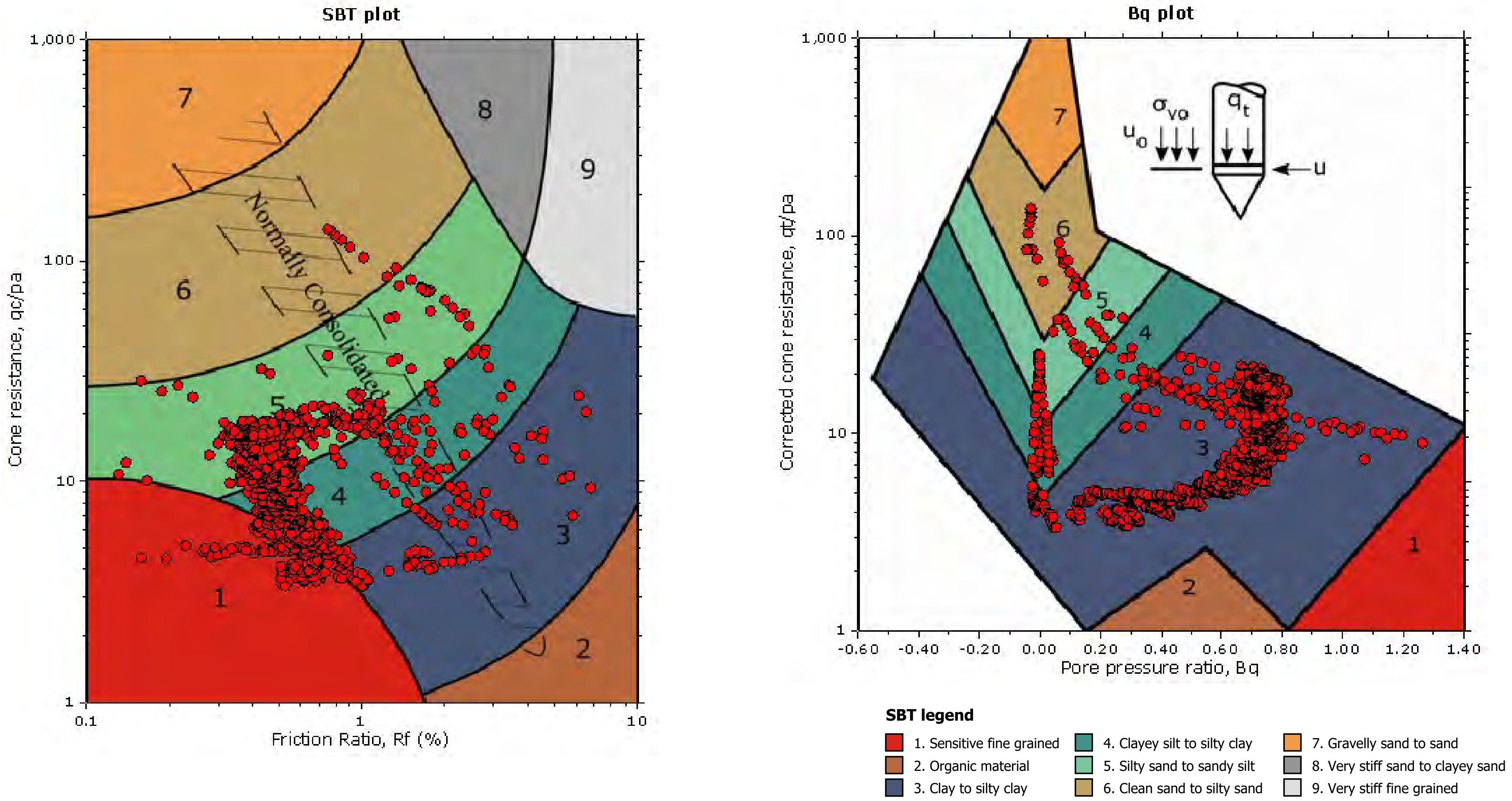
Project: **3053 & 3079 Navan Road**
Location: **Navan / Pagé Roads, Ottawa**



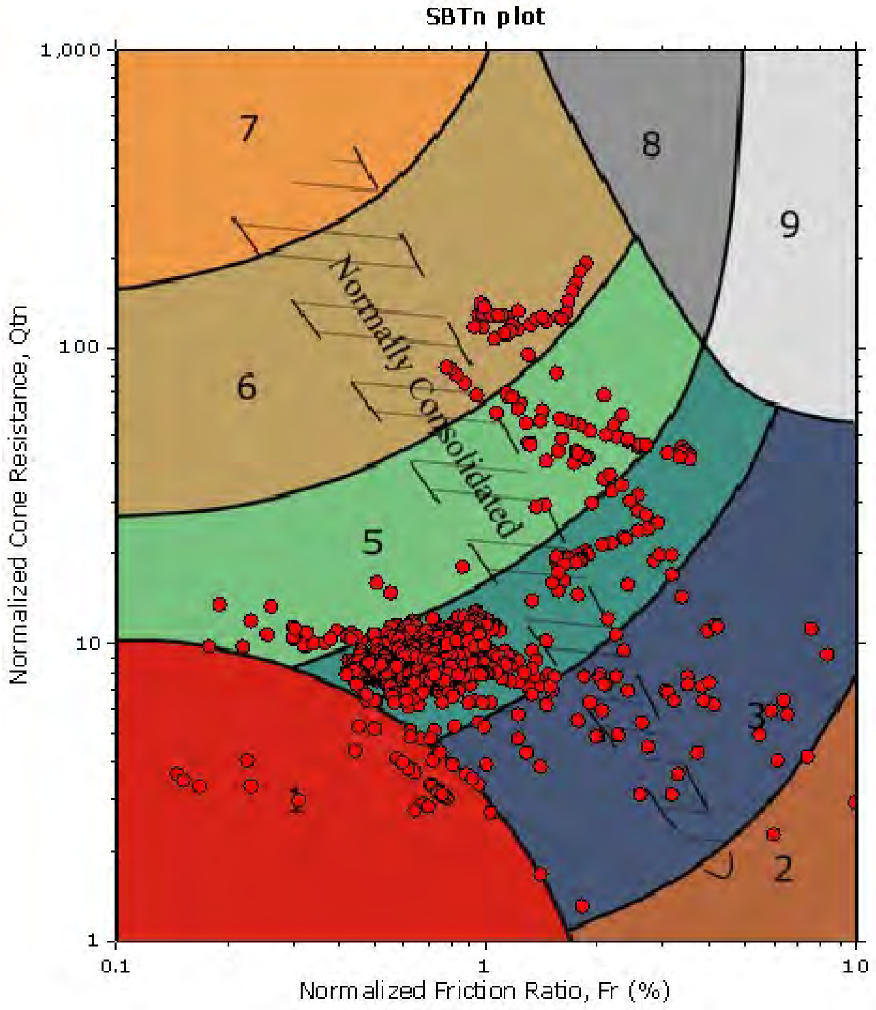
The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

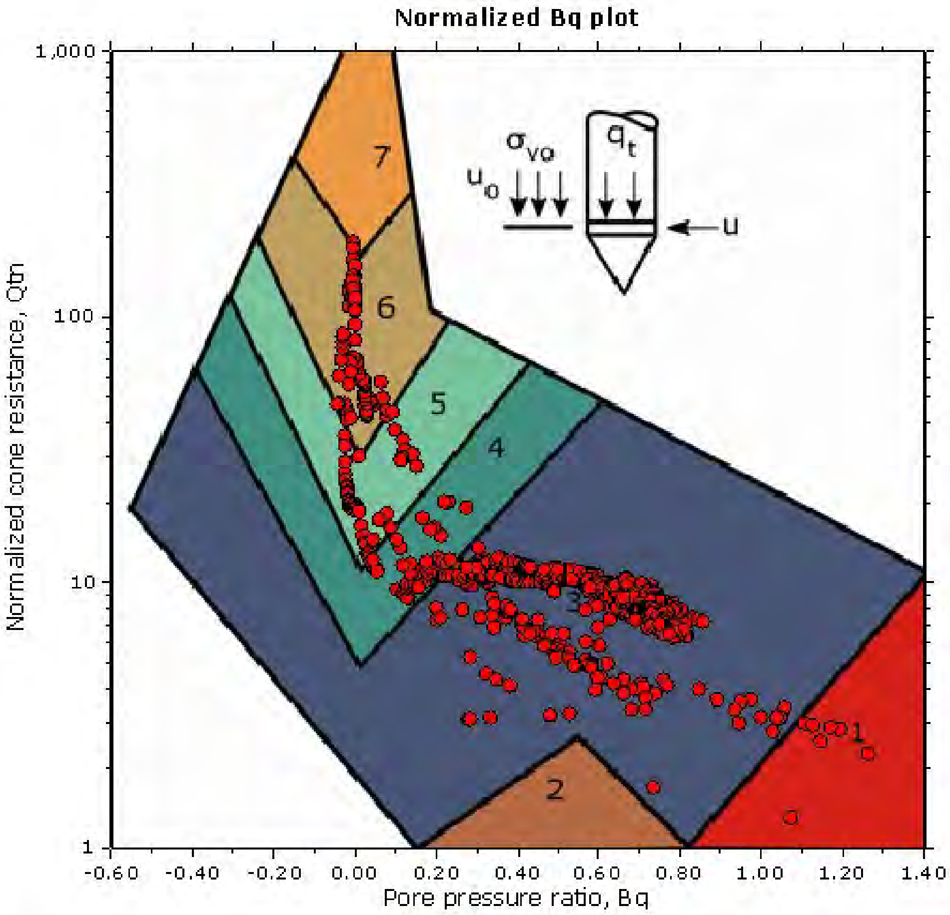


SBT - Bq plots


SBT plot
Cone resistance, qc/pa
1,000
100
10
1
0.1
1
10
Friction Ratio, Rf (%)
Normally Consolidated
1
2
3
4
5
6
7
8
9
Bq plot
Corrected cone resistance, qt/pa
1,000
100
10
1
-0.60
-0.40
-0.20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Pore pressure ratio, Bq
σ_{vo}
u_o
q_t
u
1
2
3
4
5
6
7
SBT legend
🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty clay
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravelly sand to sand
⬛ 8. Very stiff sand to clayey sand
⬜ 9. Very stiff fine grained

SBT - Bq plots (normalized)

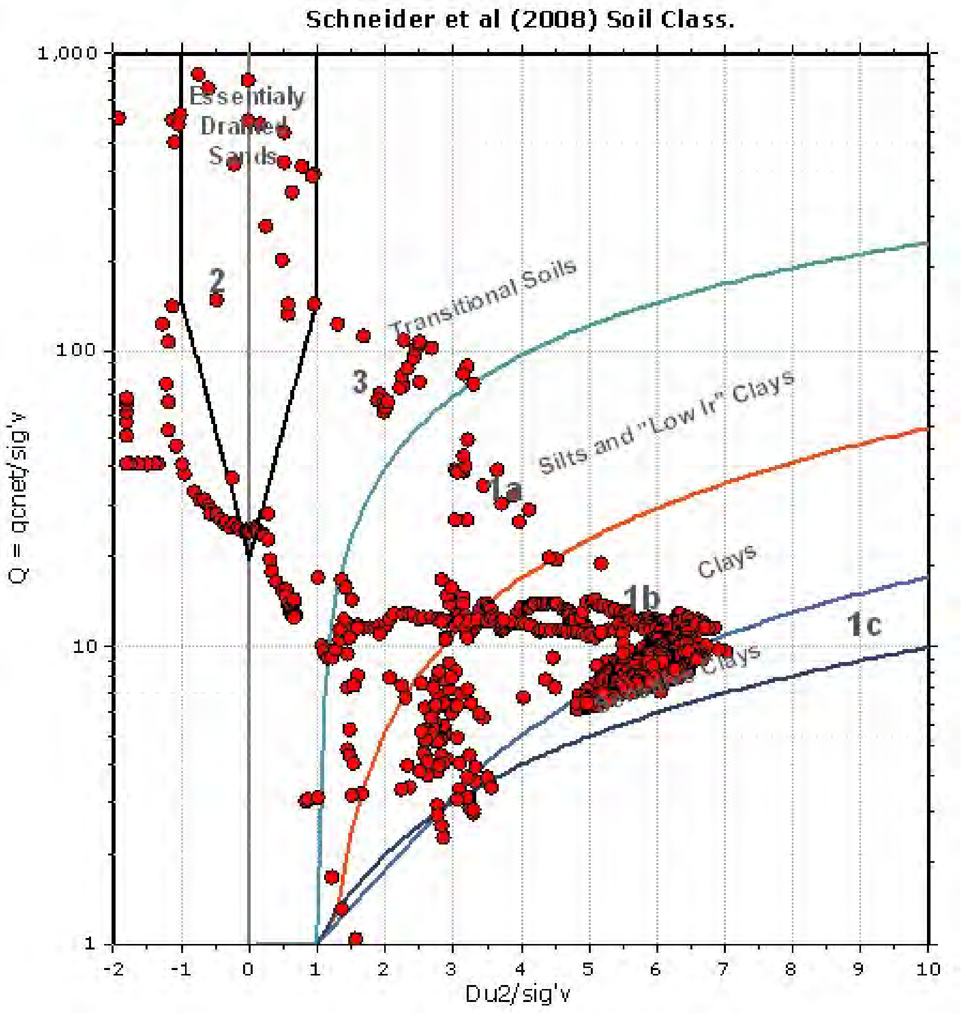


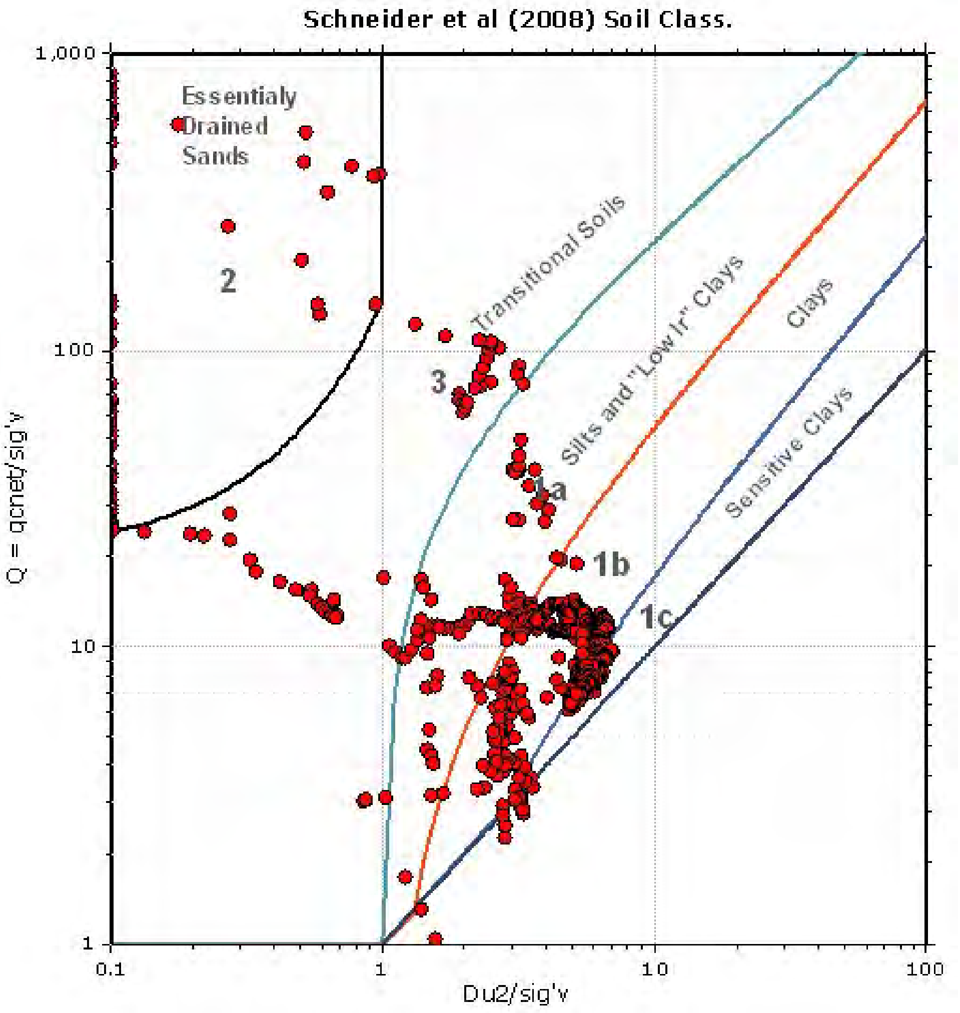


SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty clay
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravelly sand to sand
- ⬛ 8. Very stiff sand to clayey sand
- ⬜ 9. Very stiff fine grained

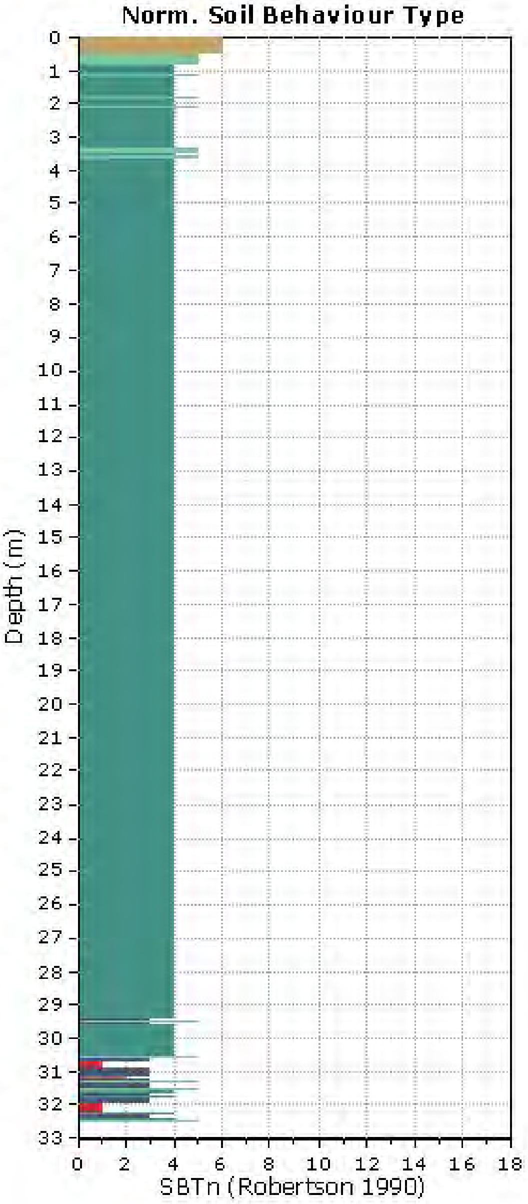
Bq plots (Schneider)

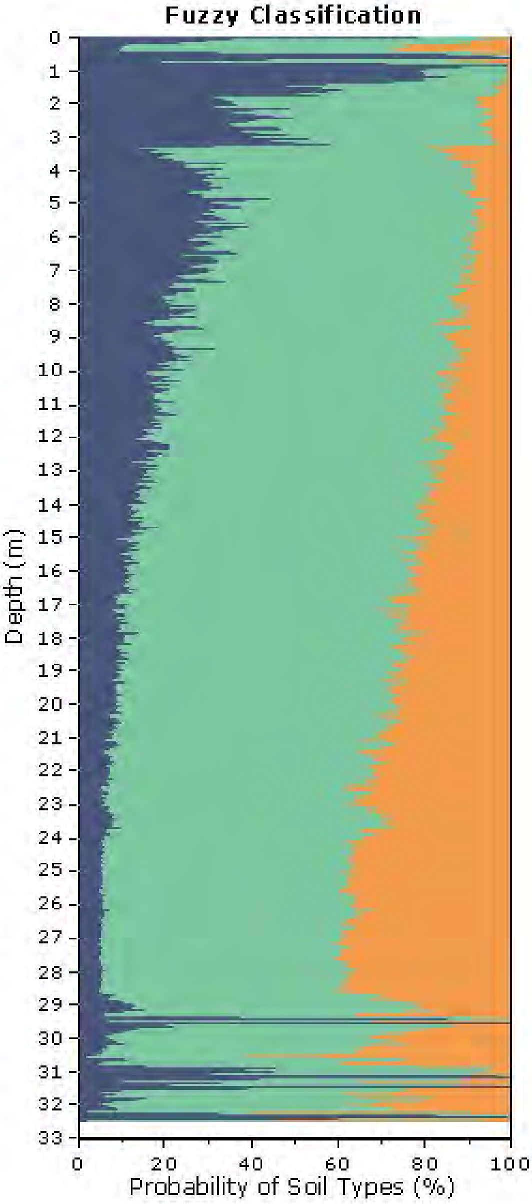




CPT: SCPTu-9
Total depth: 32.51 m
Surface Elevation: 84.70 m
Cone Type: Vertek 4544 - 5t
Cone Operator: Kevin Simoneau, P.Eng, M.Sc.

Project: **3053 & 3079 Navan Road**
Location: **Navan / Pagé Roads, Ottawa**

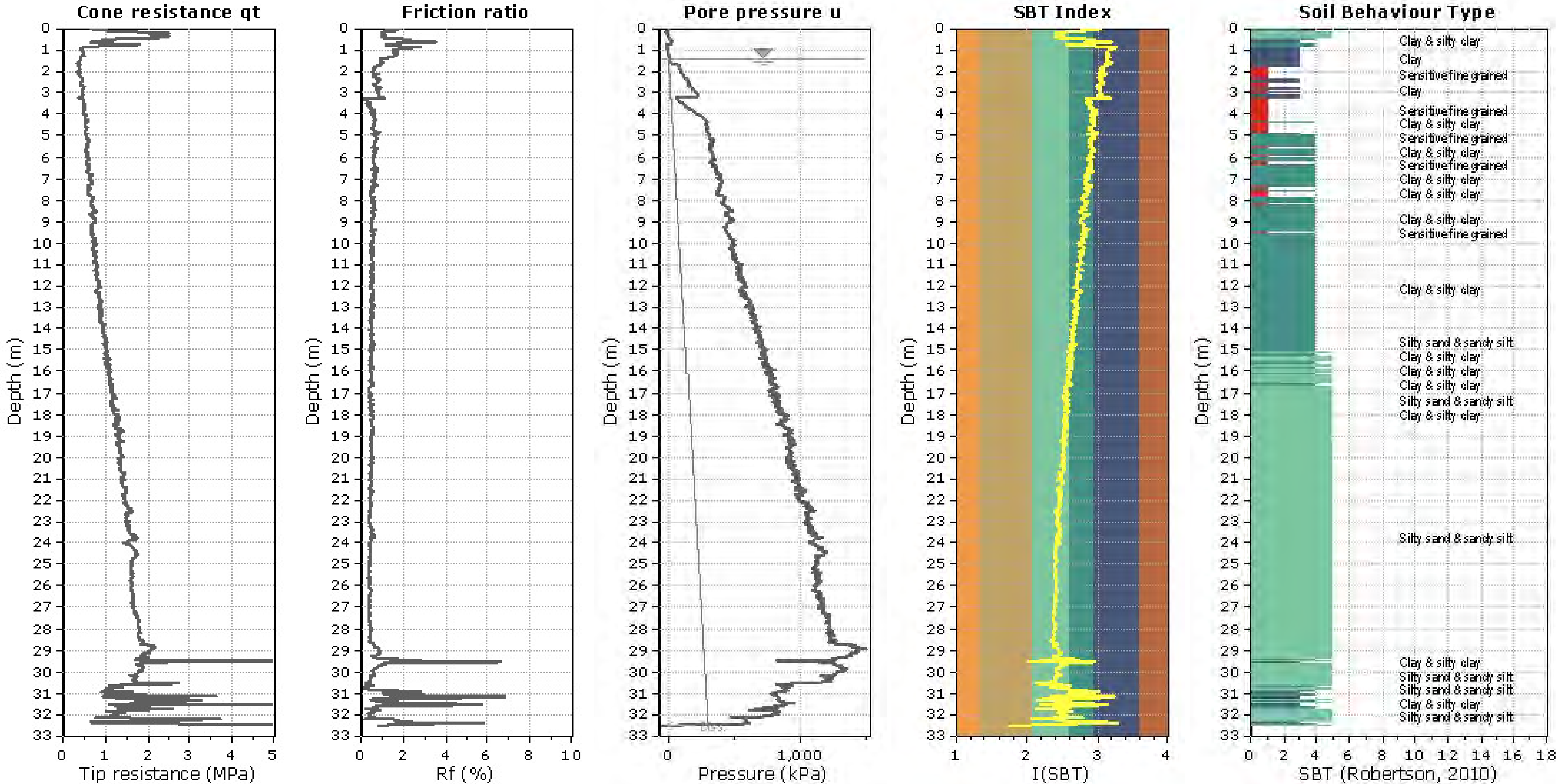




EXP
2650 Queensview Dr Suite 100
Ottawa, Ontario, K2B 8H6
https://ww.exp.com

Project: **3053 & 3079 Navan Road**
Location: **Navan / Pagé Roads, Ottawa**

CPT: SCPTu-9
Total depth: 32.51 m
Surface Elevation: 84.70 m
Cone Type: Vertek 4544 - 5t
Cone Operator: Kevin Simoneau, P.Eng, M.Sc.



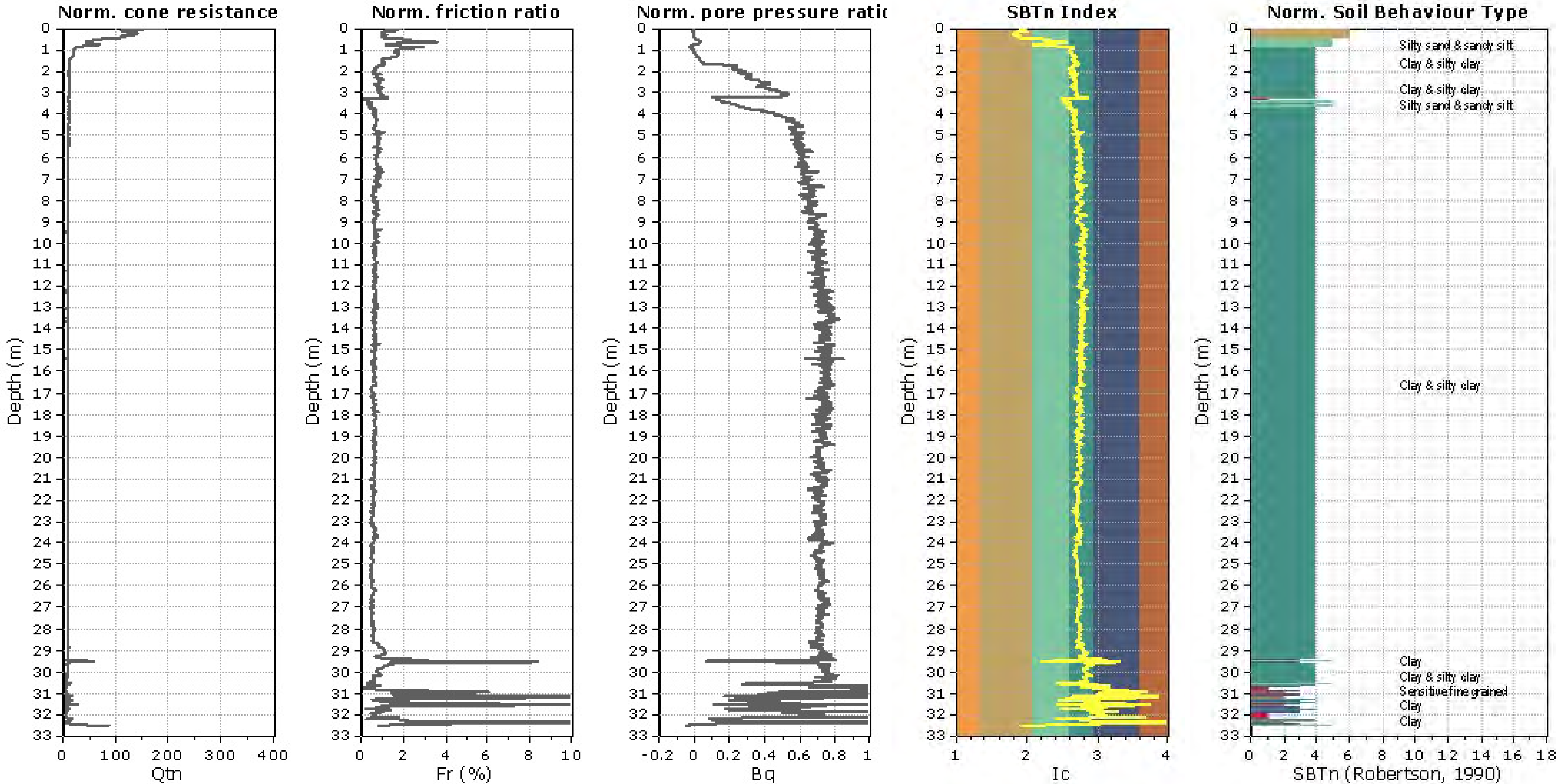
SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty clay	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to clayey sand
🟦 3. Clay to silty clay	🟫 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

EXP
2650 Queensview Dr Suite 100
Ottawa, Ontario, K2B 8H6
https://ww.exp.com

CPT: SCPTu-9
Total depth: 32.51 m
Surface Elevation: 84.70 m
Cone Type: Vertek 4544 - 5t
Cone Operator: Kevin Simoneau, P.Eng, M.Sc.

Project: **3053 & 3079 Navan Road**
Location: **Navan / Pagé Roads, Ottawa**



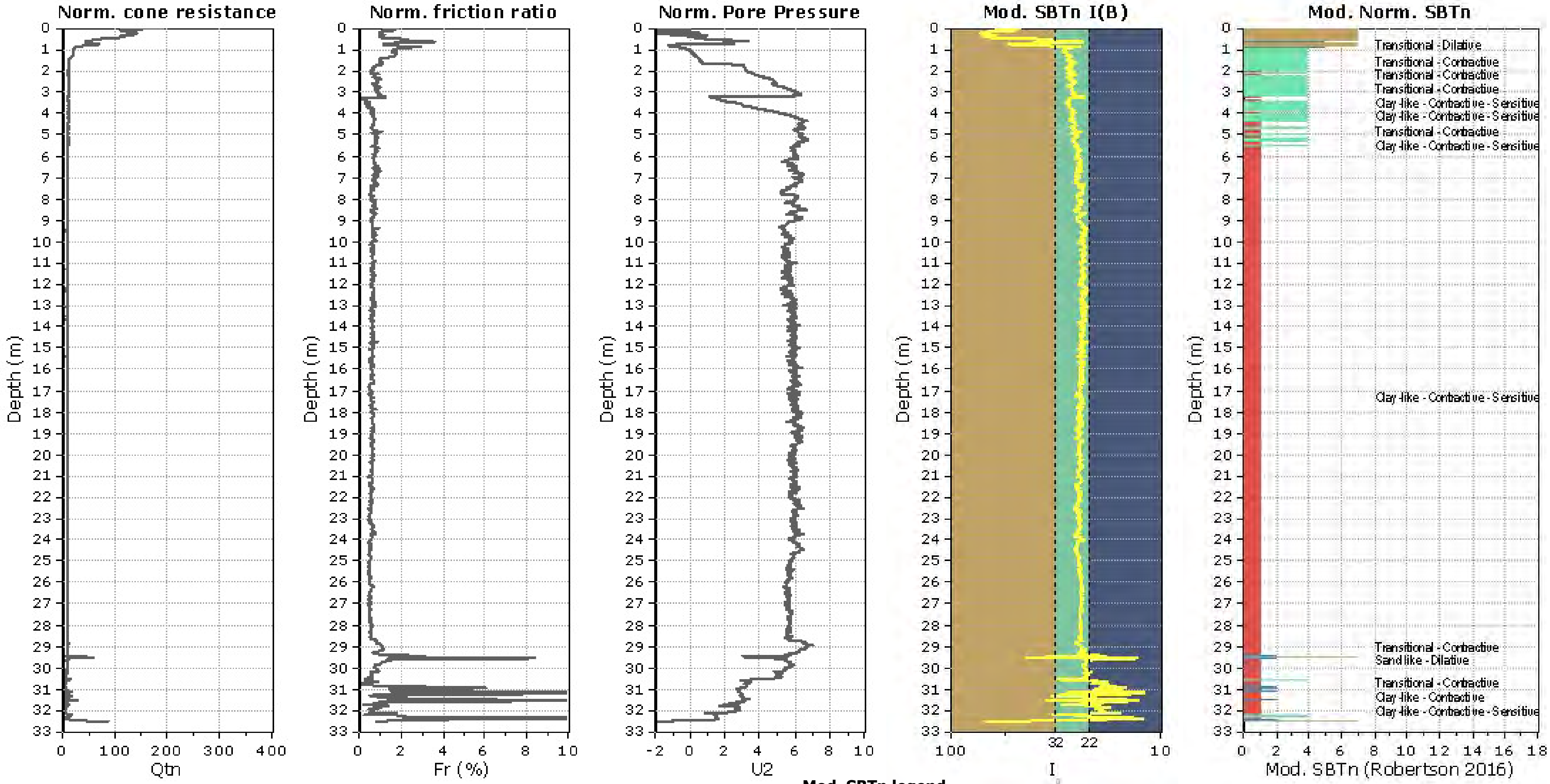
SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty clay
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬜ 8. Very stiff sand to clayey sand
- ⬜ 9. Very stiff fine grained

EXP
2650 Queensview Dr Suite 100
Ottawa, Ontario, K2B 8H6
https://ww.exp.com

CPT: SCPTu-9
Total depth: 32.51 m
Surface Elevation: 84.70 m
Cone Type: Vertek 4544 - 5t
Cone Operator: Kevin Simoneau, P.Eng, M.Sc.

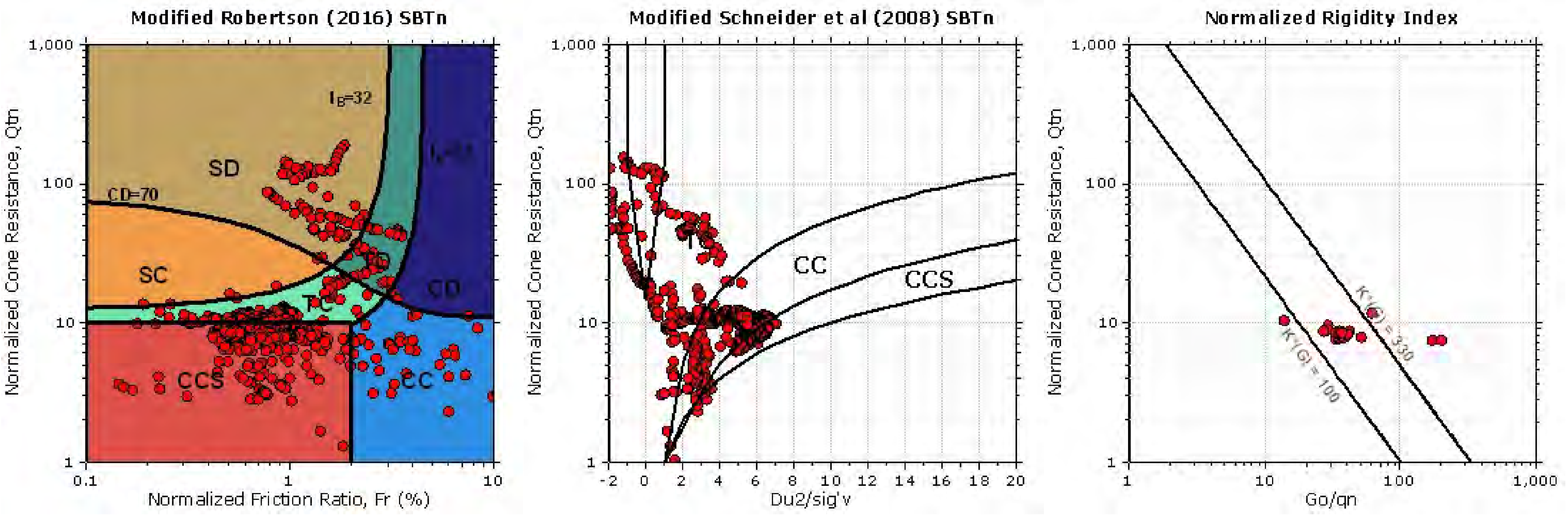
Project: **3053 & 3079 Navan Road**
Location: **Navan / Pagé Roads, Ottawa**



Mod. SBTn legend

- 🟥 1. CCS: ClayLike - Contractive, Sensitive
- 🟦 2. CC: Clay-like - Contractive
- ■ 3. CD: Clay-Like: Dilative
- 🟩 4. TC: Transitional - Contractive
- 🟩 5. TD: Transitional - Dilative
- 🟧 6. SC: Sand-like - Contractive
- 🟫 7. SD: Sand-like - Dilative

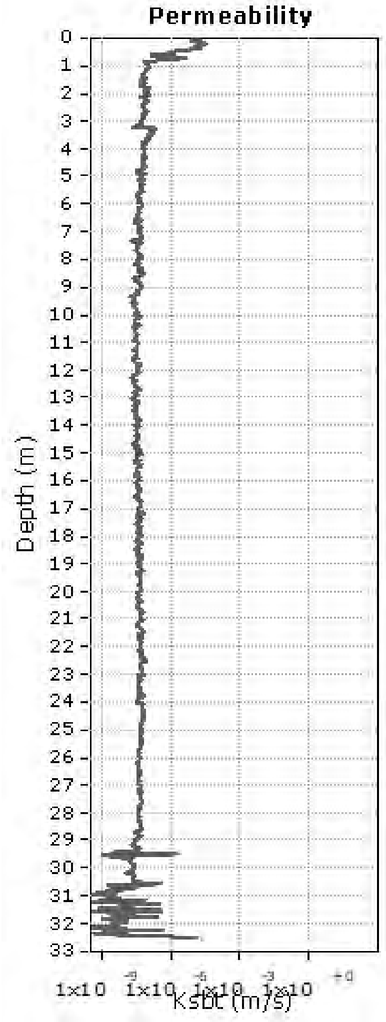
Updated SBTn plots

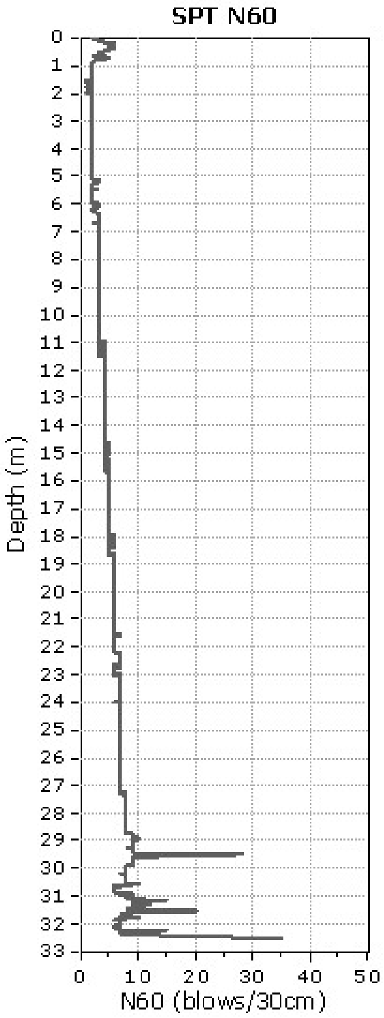


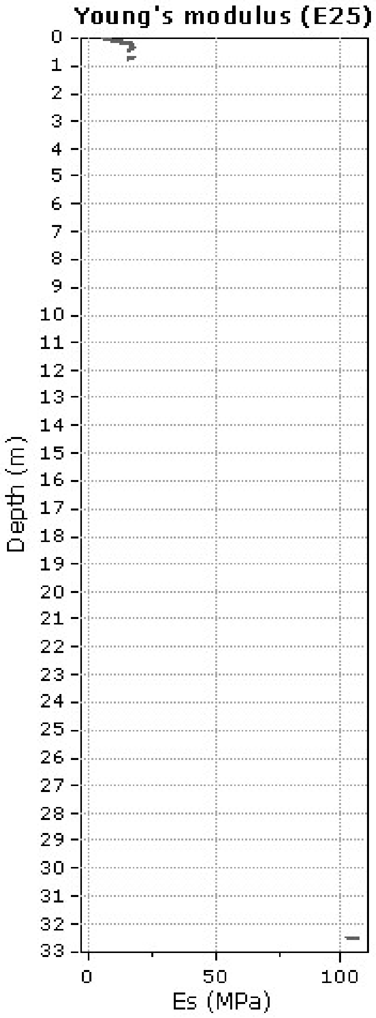
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

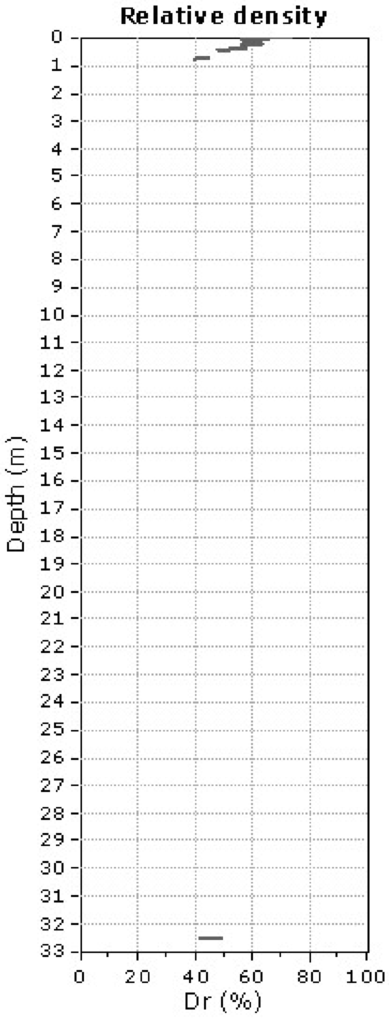
K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

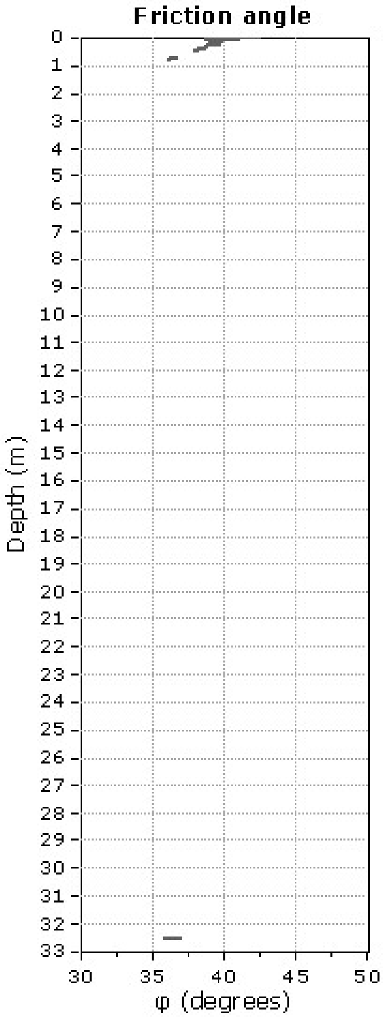
CPT: SCPTu-9
Total depth: 32.51 m
Surface Elevation: 84.70 m
Cone Type: Vertek 4544 - 5t
Cone Operator: Kevin Simoneau, P.Eng, M.Sc.



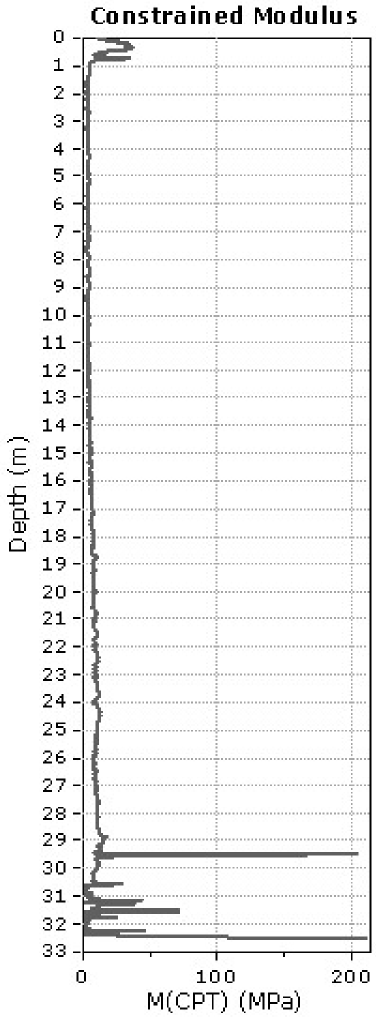


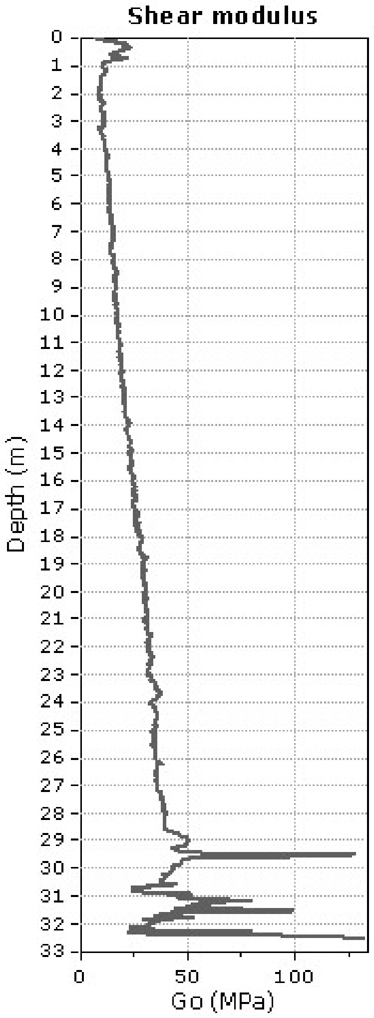


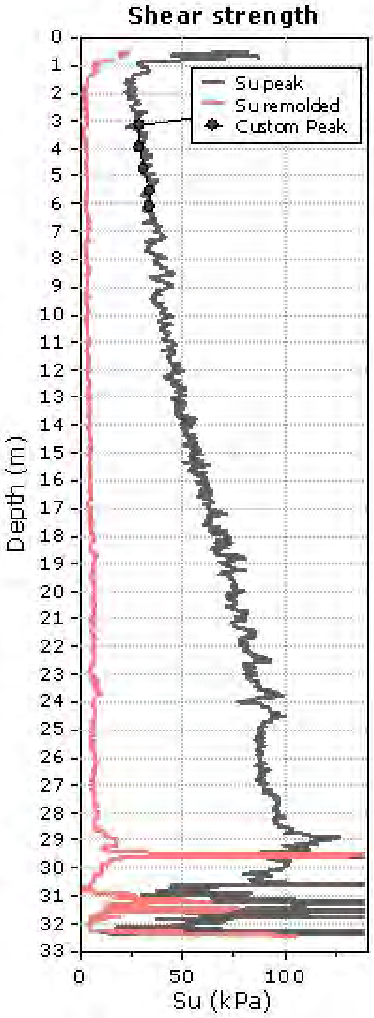


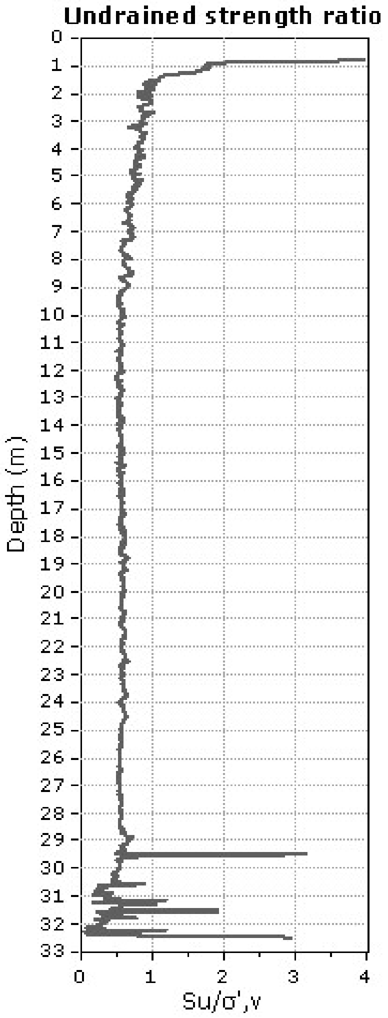


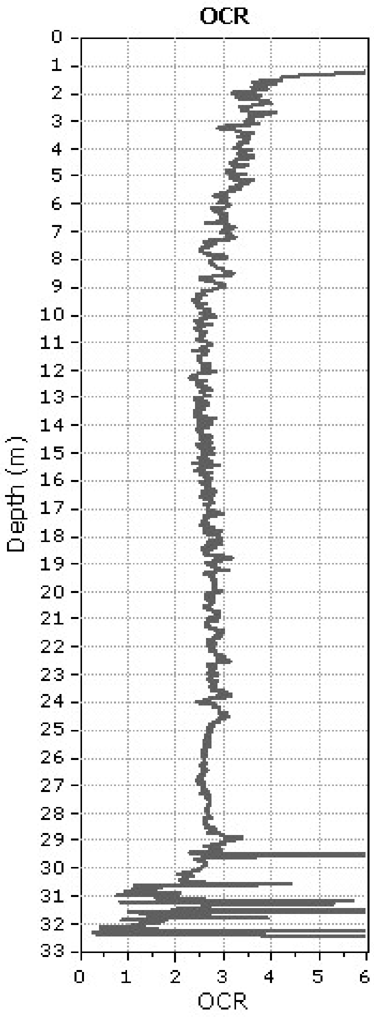
Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
—●— User defined estimation data











Calculation parameters

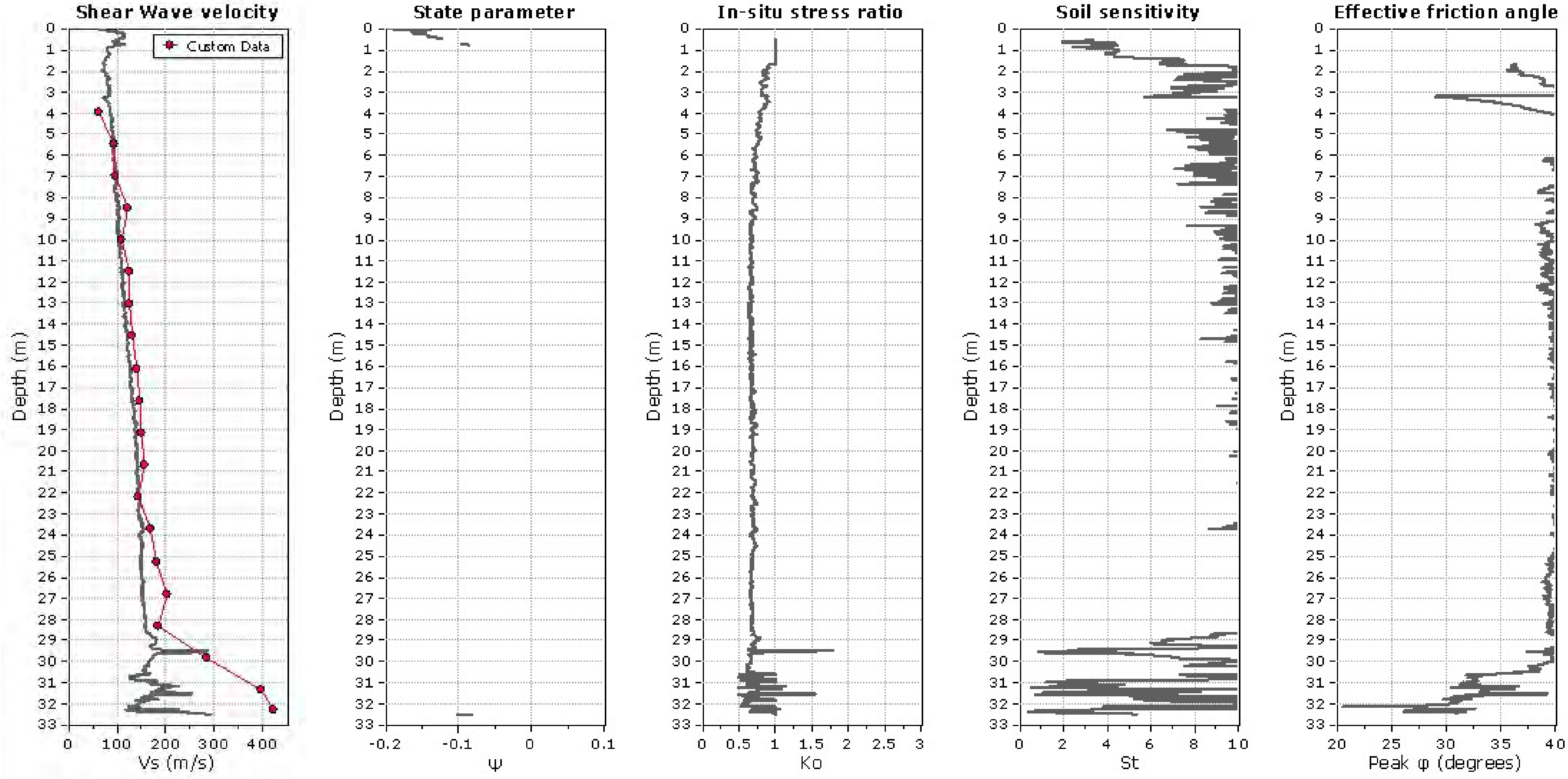
Constrained modulus: Based on variable alpha using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable alpha using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
—●— User defined estimation data
—●— Flat Dilatometer Test data

EXP
2650 Queensview Dr Suite 100
Ottawa, Ontario, K2B 8H6
https://ww.exp.com

CPT: SCPTu-9
Total depth: 32.51 m
Surface Elevation: 84.70 m
Cone Type: Vertek 4544 - 5t
Cone Operator: Kevin Simoneau, P.Eng, M.Sc.

Project: **3053 & 3079 Navan Road**
Location: **Navan / Pagé Roads, Ottawa**



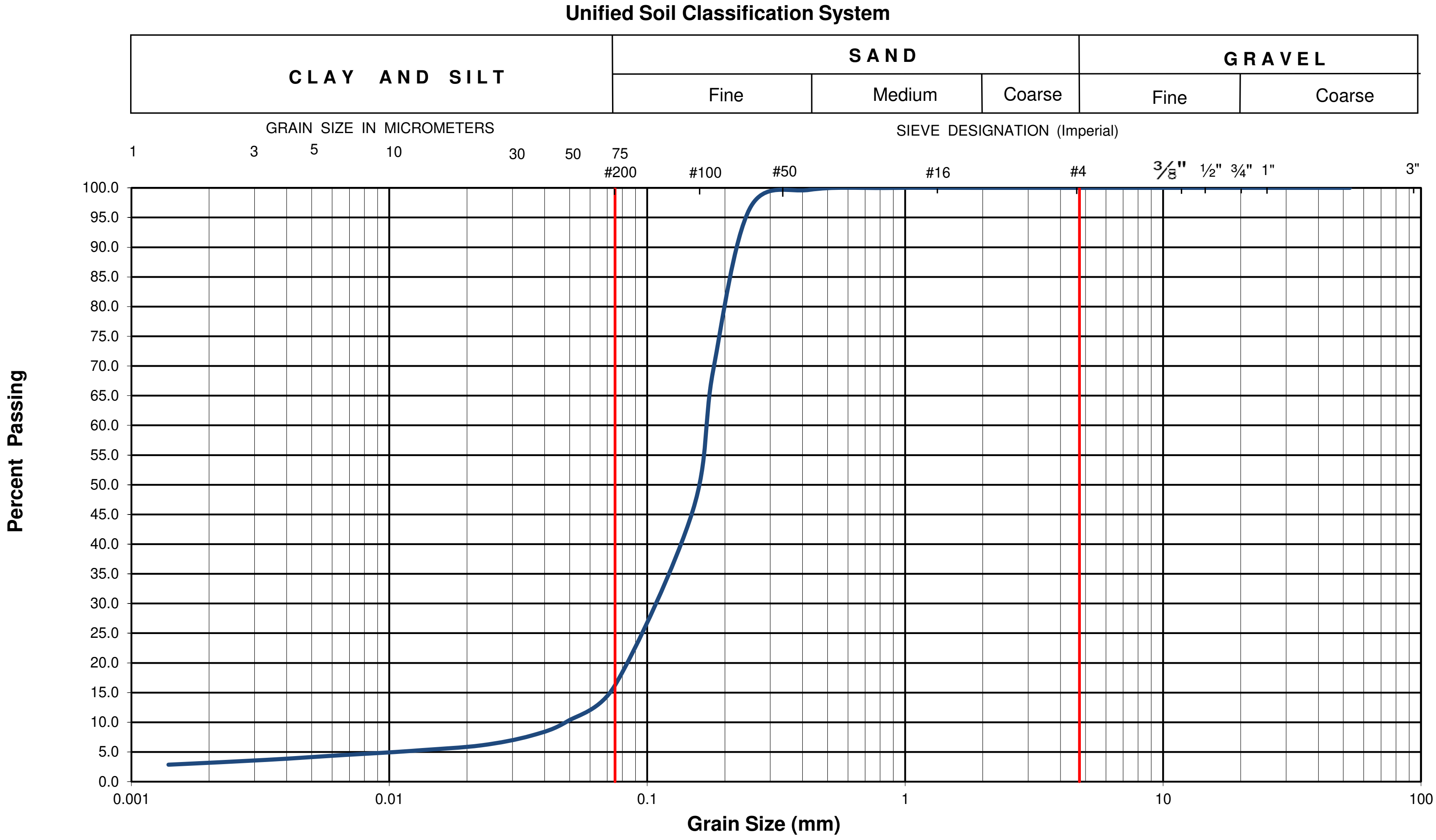
Calculation parameters

Soil Sensitivity factor, N_S: 7.00

● User defined estimation data

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

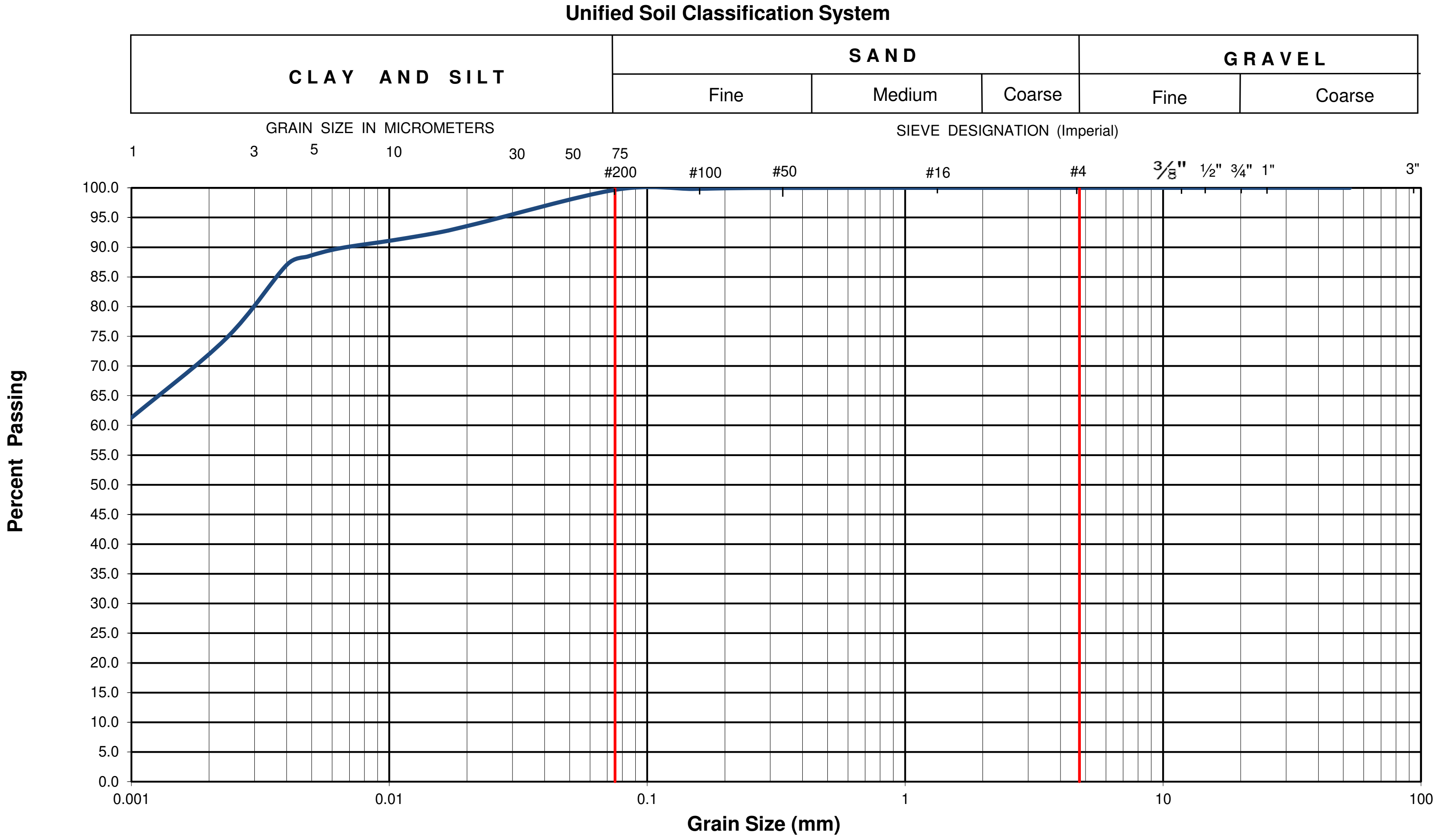
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	OTT-21004743-B0	**Project Name :**	Proposed Residential Development					
Client :	12714001 Canada Inc.	**Project Location :**	2983, 3053 & 3079 Navan Road, Ottawa, ON					
Date Sampled :	April 29, 2021	**Borehole No:**	BH 1		**Sample No.:** SS1		**Depth (m) :**	0.8-1.4
Sample Description :		**% Silt and Clay**	16	**% Sand**	84	**% Gravel** 0	**Figure :**	22
Sample Description :		Silty Sand (SM) - Trace Clay						

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 8H6

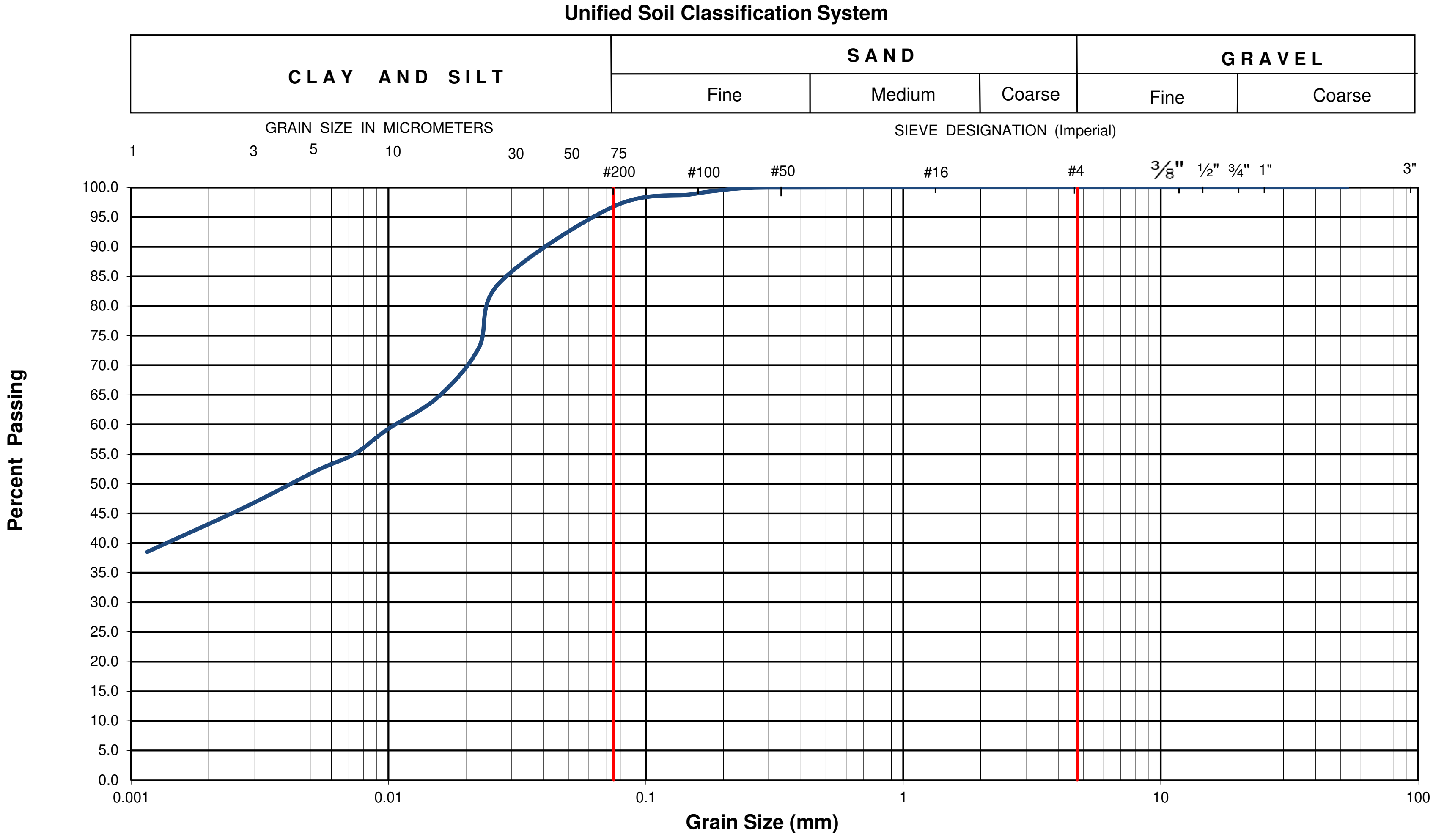
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-21004743-B0**	**Project Name :**	**Proposed Residential Development**						
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**						
Date Sampled :	**April 28, 2021**	**Borehole No:**		**BH 2**		**Sample No.:**	**SS7**	**Depth (m) :**	**6.1-6.7**
Sample Description :		**% Silt and Clay**	**100**	**% Sand**	**0**	**% Gravel**	**0**	**Figure :**	**26**
Sample Description :	**Grey Clay of Medium to High Plasticity (CI and CH)**								

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 8H6

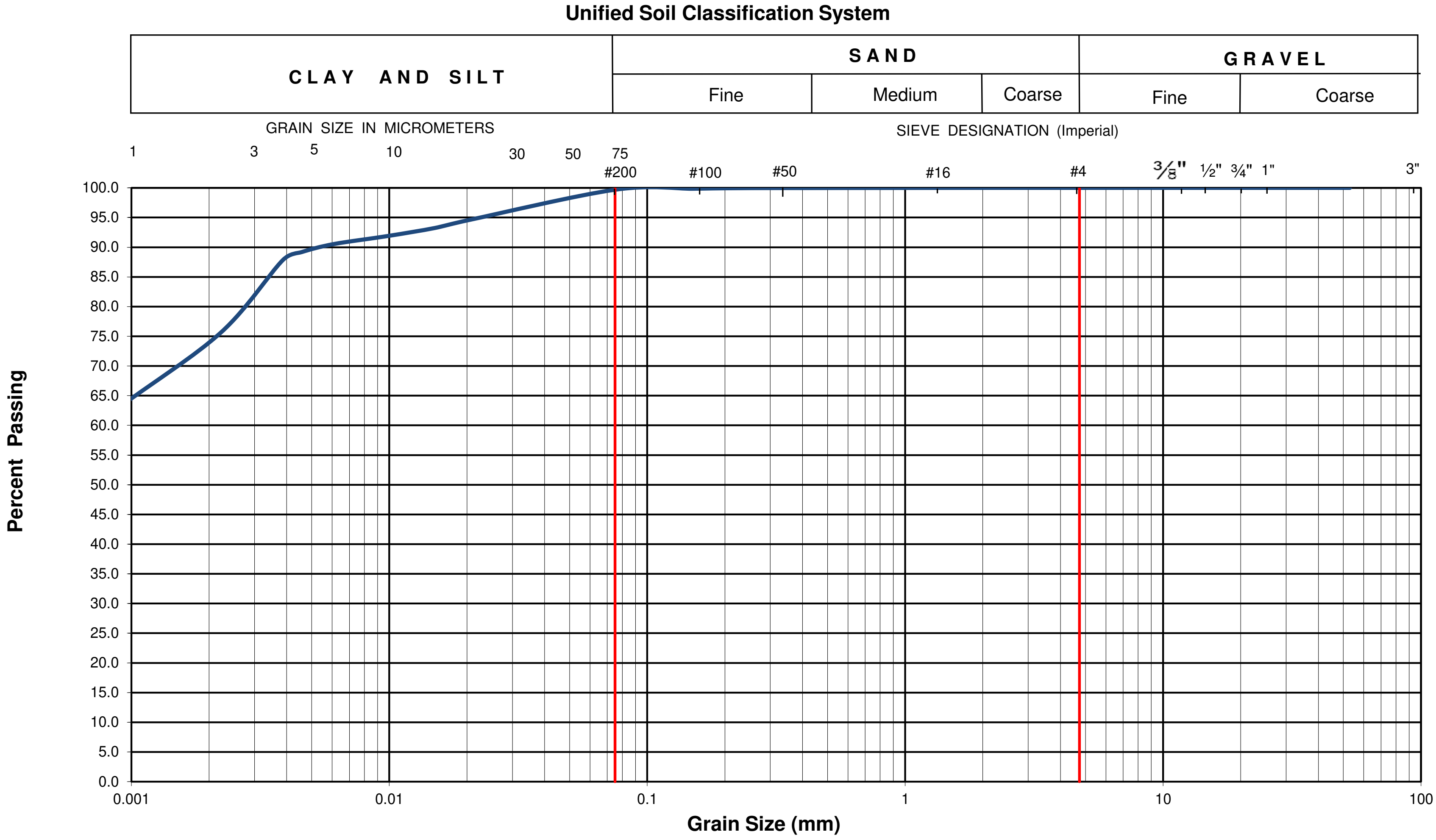
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-21004743-B0**	**Project Name :**	**Proposed Residential Development**						
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**						
Date Sampled :	**April 29, 2021**	**Borehole No:**	**BH 3**	**Sample No.:**	**SS3**			**Depth (m) :**	**2.3-2.9**
Sample Description :		**% Silt and Clay**	**97**	**% Sand**	**3**	**% Gravel**	**0**	**Figure :**	**27**
Sample Description :	**Silty Clay of Medium Plasticity (CI) -Trace Sand**								

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 8H6

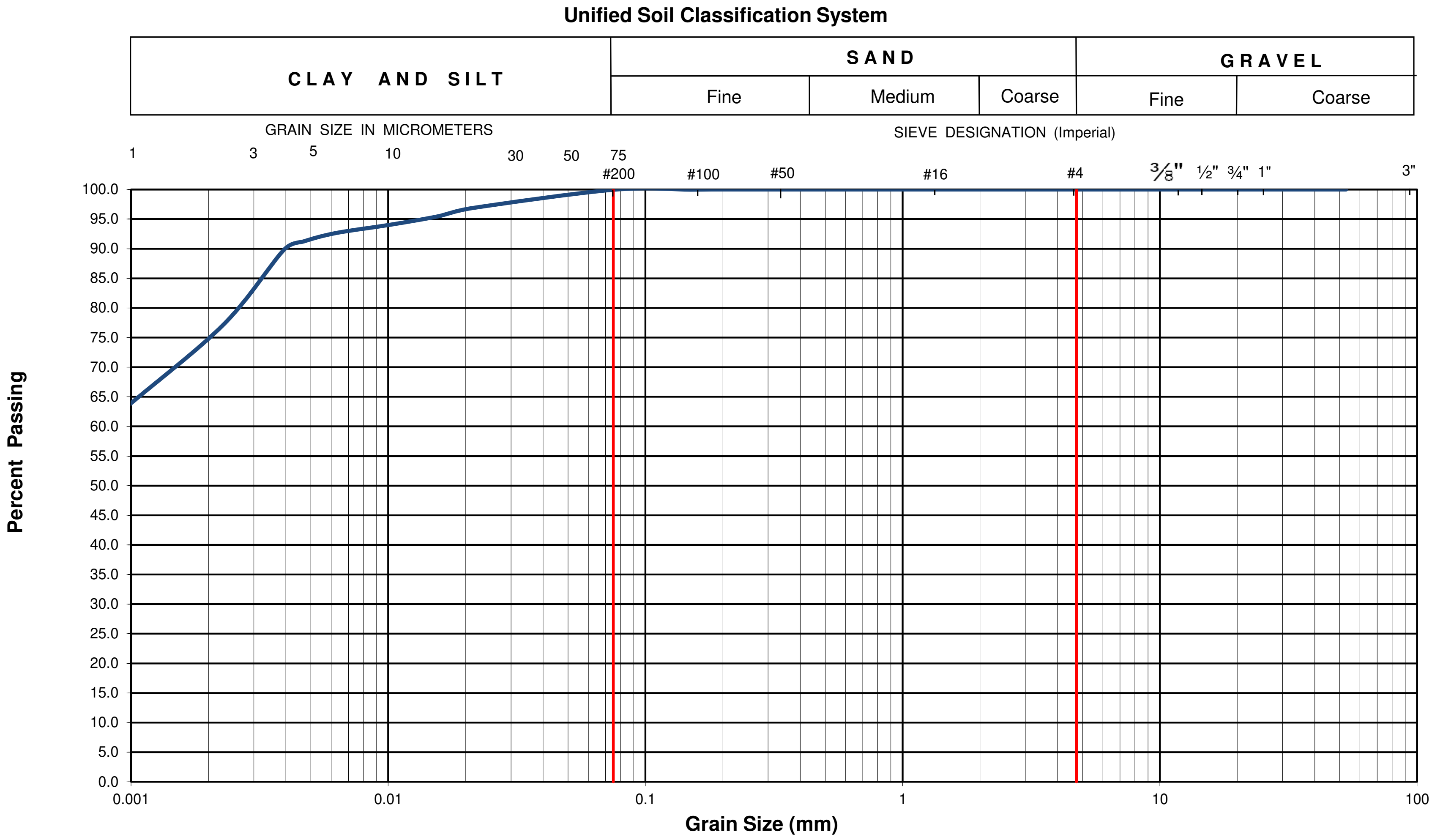
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	OTT-21004743-B0	**Project Name :**	Proposed Residential Development					
Client :	12714001 Canada Inc.	**Project Location :**	2983, 3053 & 3079 Navan Road, Ottawa, ON					
Date Sampled :	April 28, 2021	**Borehole No:**	BH 4	**Sample No.:**	SS6		**Depth (m) :**	4.7-5.3
Sample Description :		**% Silt and Clay**	100	**% Sand**	0	**% Gravel** 0	**Figure :**	28
Sample Description :		Clay of High Plasticity (CH) -Some Silt						

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

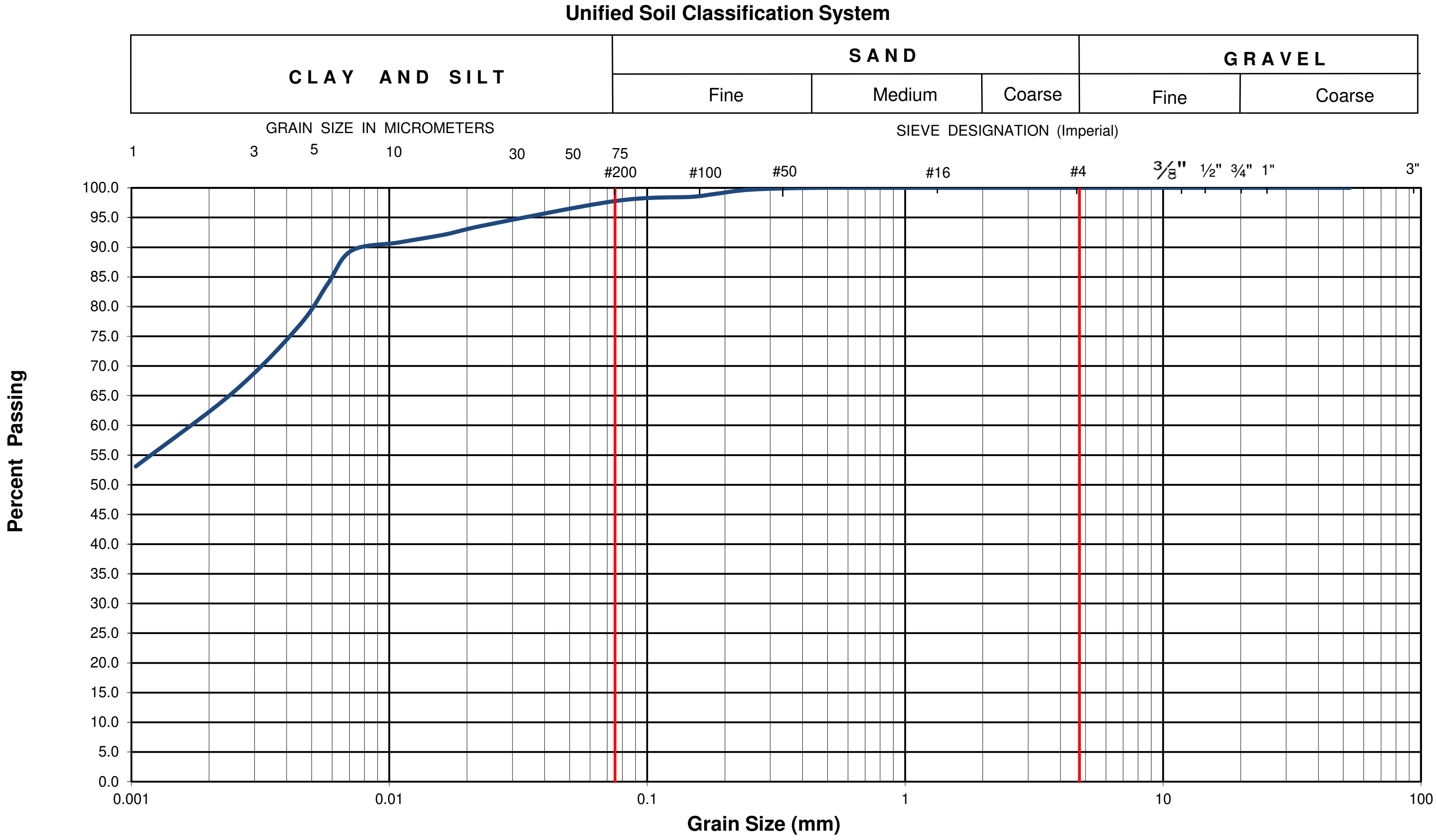
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-21004743-B0**	**Project Name :**	**Proposed Residential Development**						
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**						
Date Sampled :	**April 28, 2021**	**Borehole No:**		**BH 6**	**Sample No.:**	**SS8**		**Depth (m) :**	**9.1-9.7**
Sample Description :		**% Silt and Clay**	**100**	**% Sand**	**0**	**% Gravel**	**0**	**Figure :**	**29**
Sample Description :	**Silty Clay of Medium Plasticity (CI)**								

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

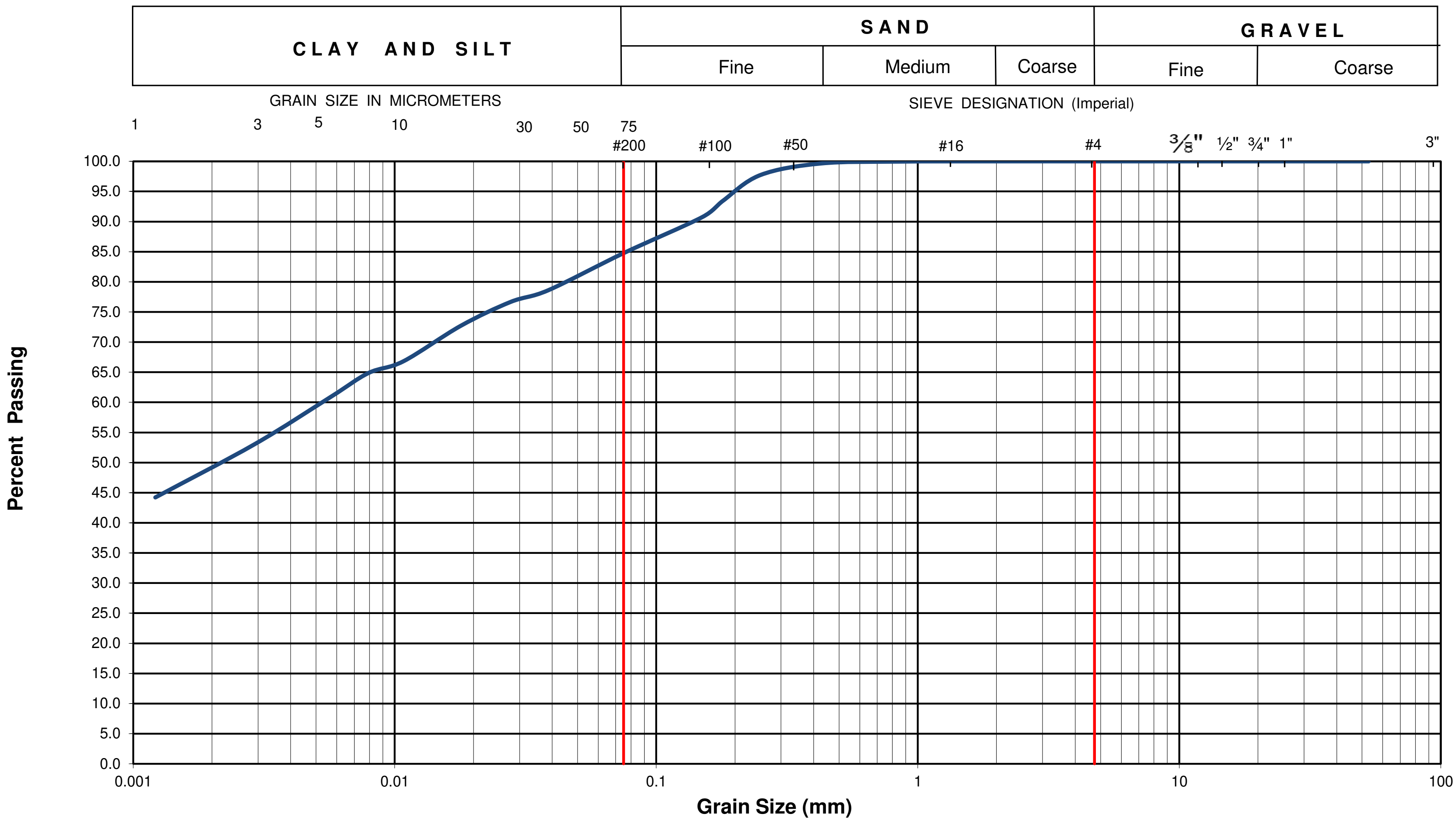


EXP Project No.:	OTT-21004743-B0	**Project Name :**	Proposed Residential Development				
Client :	12714001 Canada Inc.	**Project Location :**	2983, 3053 & 3079 Navan Road, Ottawa, ON				
Date Sampled :	April 29, 2021	**Borehole No:**	BH 10	**Sample No.:**	SS4	**Depth (m) :**	3.2-3.8
Sample Description :		**% Silt and Clay**	98	**% Sand**	2	**% Gravel**	0
Sample Description :	Silty Clay of Medium to High Plasticity (CI and CH) -Trace Sand					**Figure :**	30

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

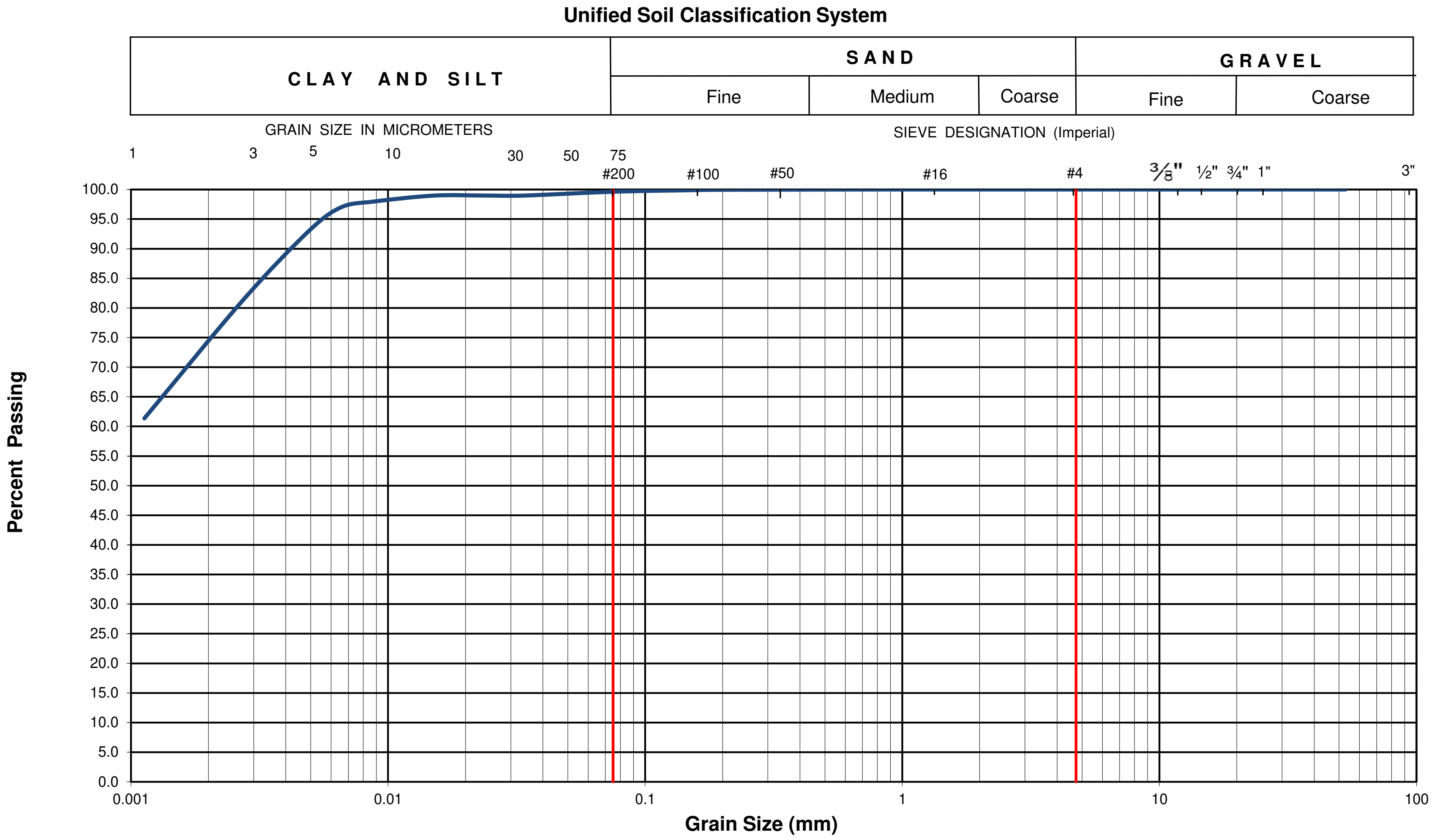
Unified Soil Classification System



EXP Project No.:	**OTT-21004743-A0**	**Project Name :**	**Proposed Residential Development**						
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**						
Date Sampled :	**September 12, 2023**	**Borehole No:**	**BH 11**	**Sample No.:**	**SS4**			**Depth (m) :**	**2.3-2.9**
Sample Description :		**% Silt and Clay**	**85**	**% Sand**	**15**	**% Gravel**	**0**	**Figure :**	**24**
Sample Description :	**Silty Clay of Low Plasticity (CL) - Some Sand**								

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 8H6

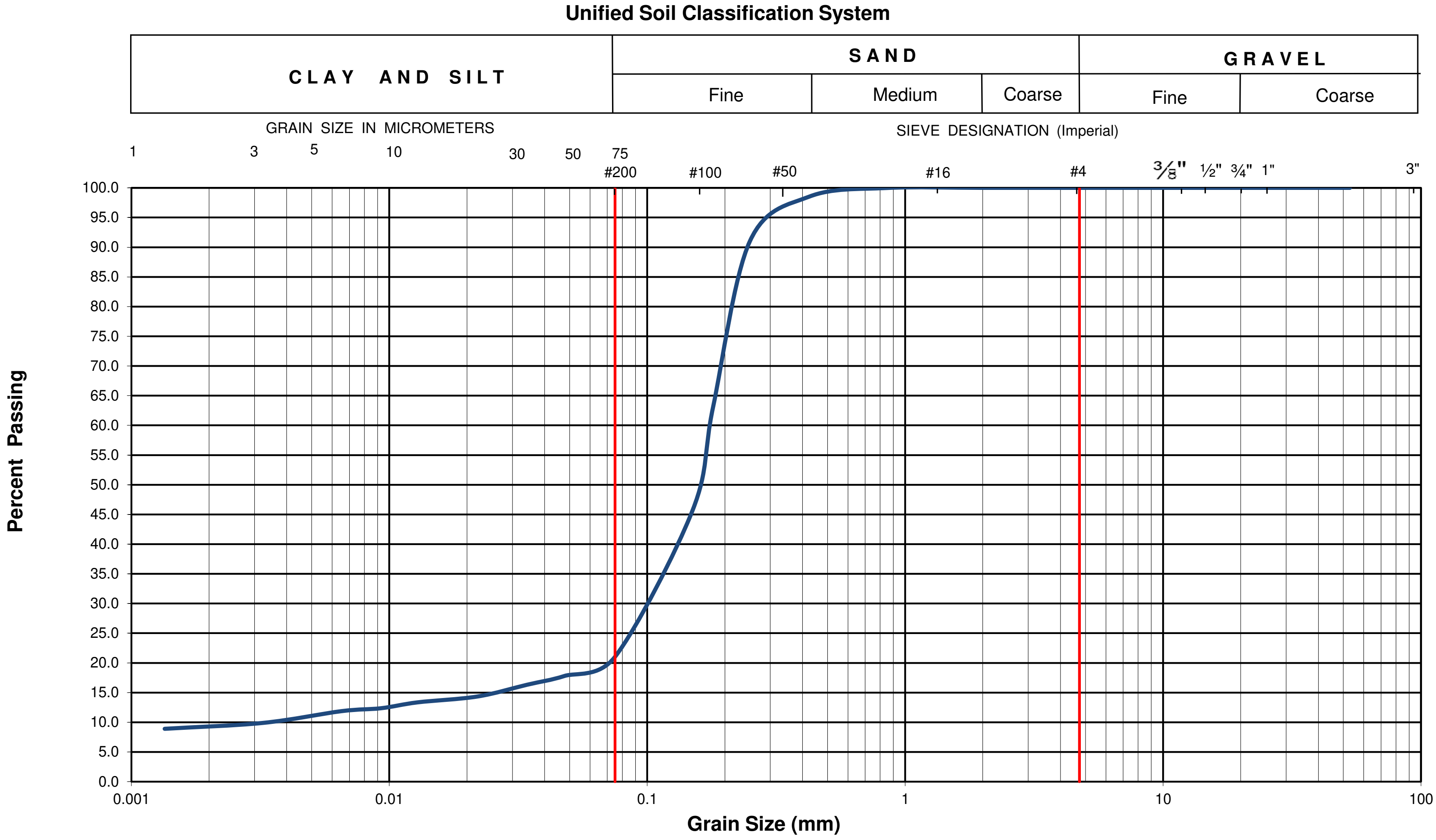
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-21004743-A0**	**Project Name :**	**Proposed Residential Development**						
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**						
Date Sampled :	**September 12, 2023**	**Borehole No:**	**BH 11**	**Sample No.:**	**SS5**			**Depth (m) :**	**3.8-4.4**
Sample Description :		**% Silt and Clay**	**100**	**% Sand**	**0**	**% Gravel**	**0**	**Figure :**	**31**
Sample Description :	**Silty Clay of High Plasticity (CH)**								

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

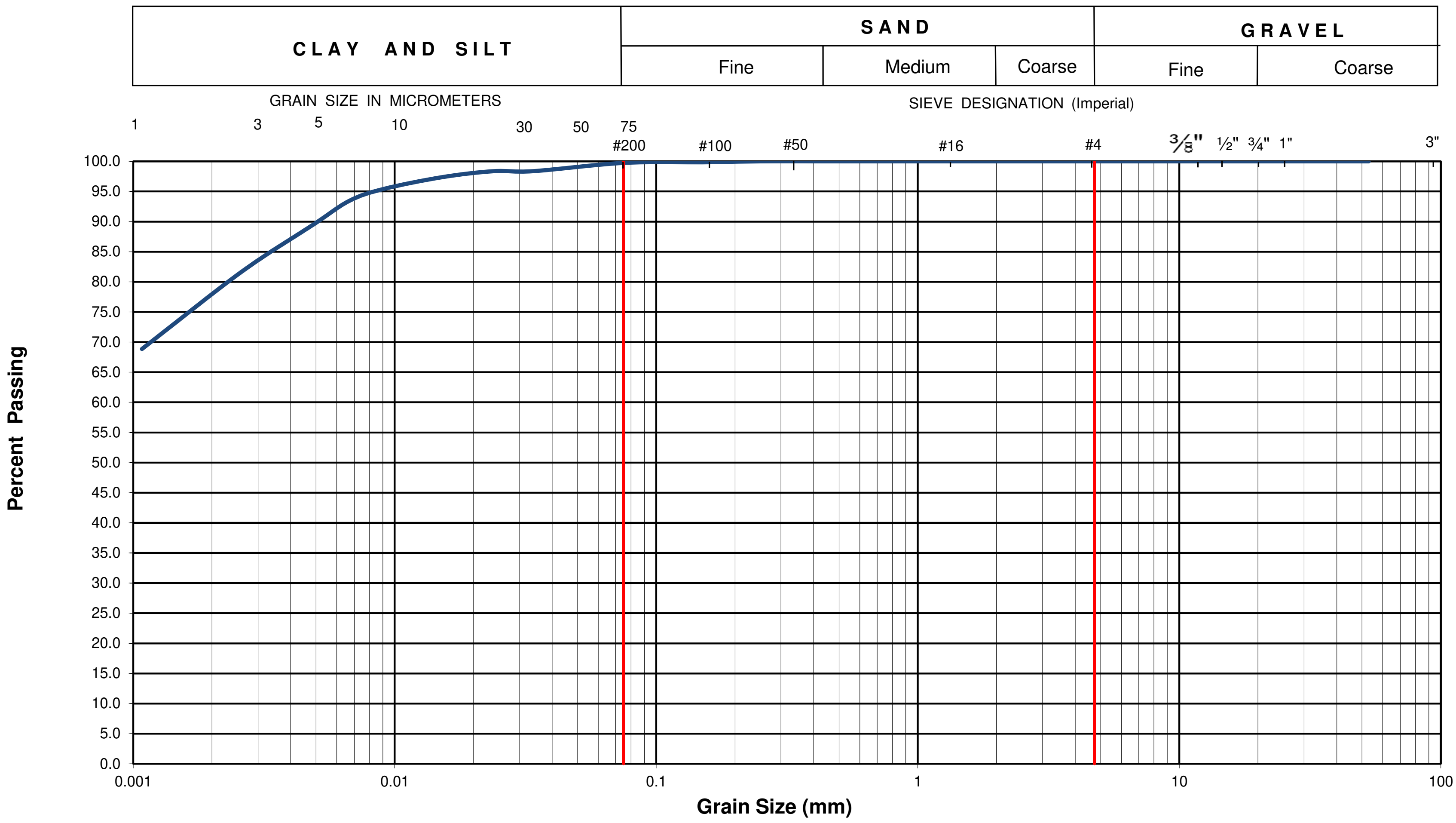


EXP Project No.:	**OTT-21004743-A0**	**Project Name :**	**Proposed Residential Development**				
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**				
Date Sampled :	**September 12, 2023**	**Borehole No:**	**BH 12**	**Sample No.:**	**SS1 & SS2**	**Depth (m) :**	**0-1.4**
Sample Description :		**% Silt and Clay**	**21**	**% Sand**	**79**	**% Gravel**	**0**
Sample Description :		**Silty Sand (SM) -Trace Clay**				**Figure :**	**23**

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

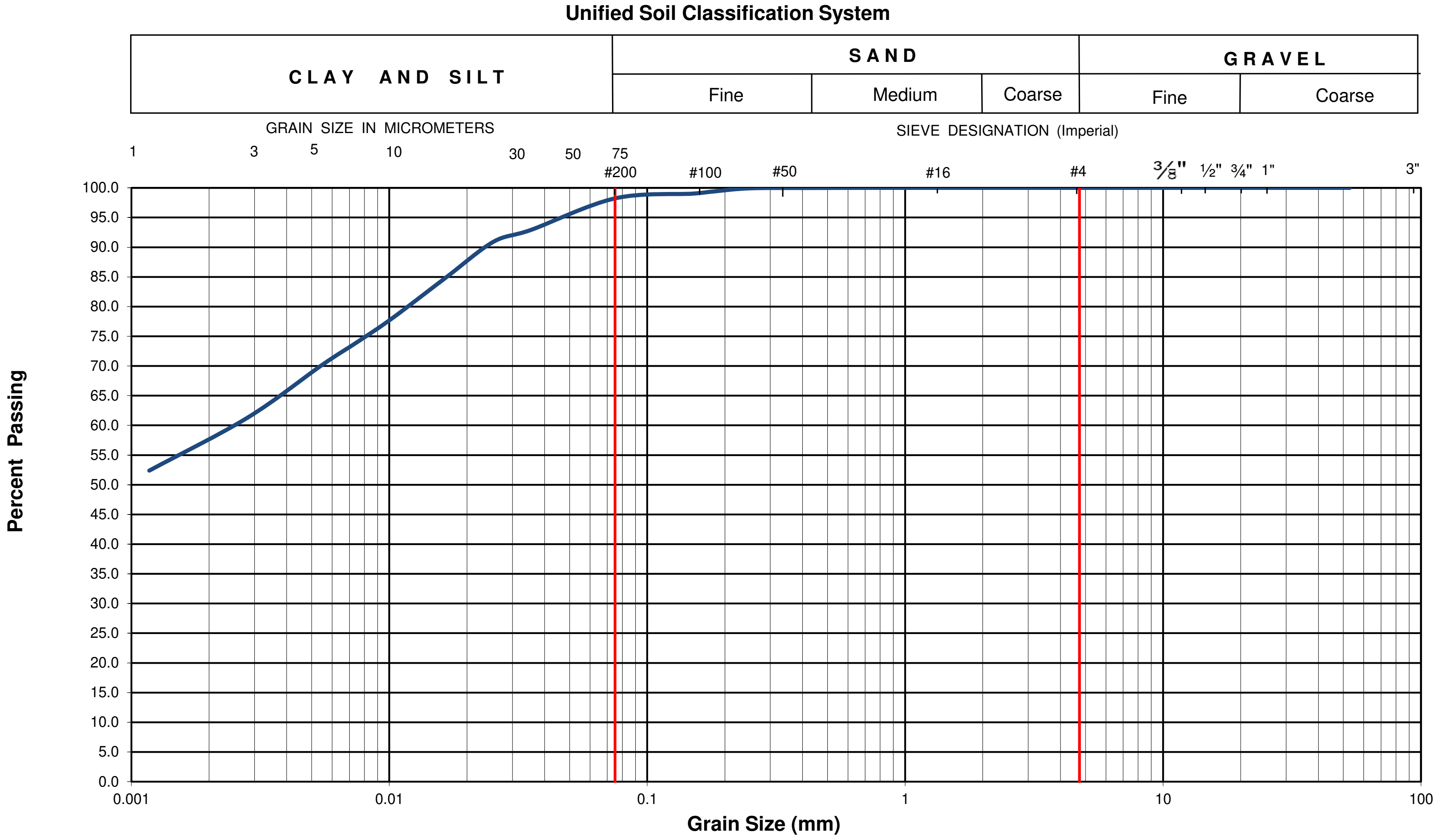
Unified Soil Classification System



EXP Project No.:	**OTT-21004743-A0**	**Project Name :**	**Proposed Residential Development**						
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**						
Date Sampled :	**September 12, 2023**	**Borehole No:**	**BH 12**	**Sample No.:**	**SS3**			**Depth (m) :**	**2.3-2.9**
Sample Description :		**% Silt and Clay**	**100**	**% Sand**	**0**	**% Gravel**	**0**	**Figure :**	**32**
Sample Description :		**Silty Clay of High Plasticity (CH)**							

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

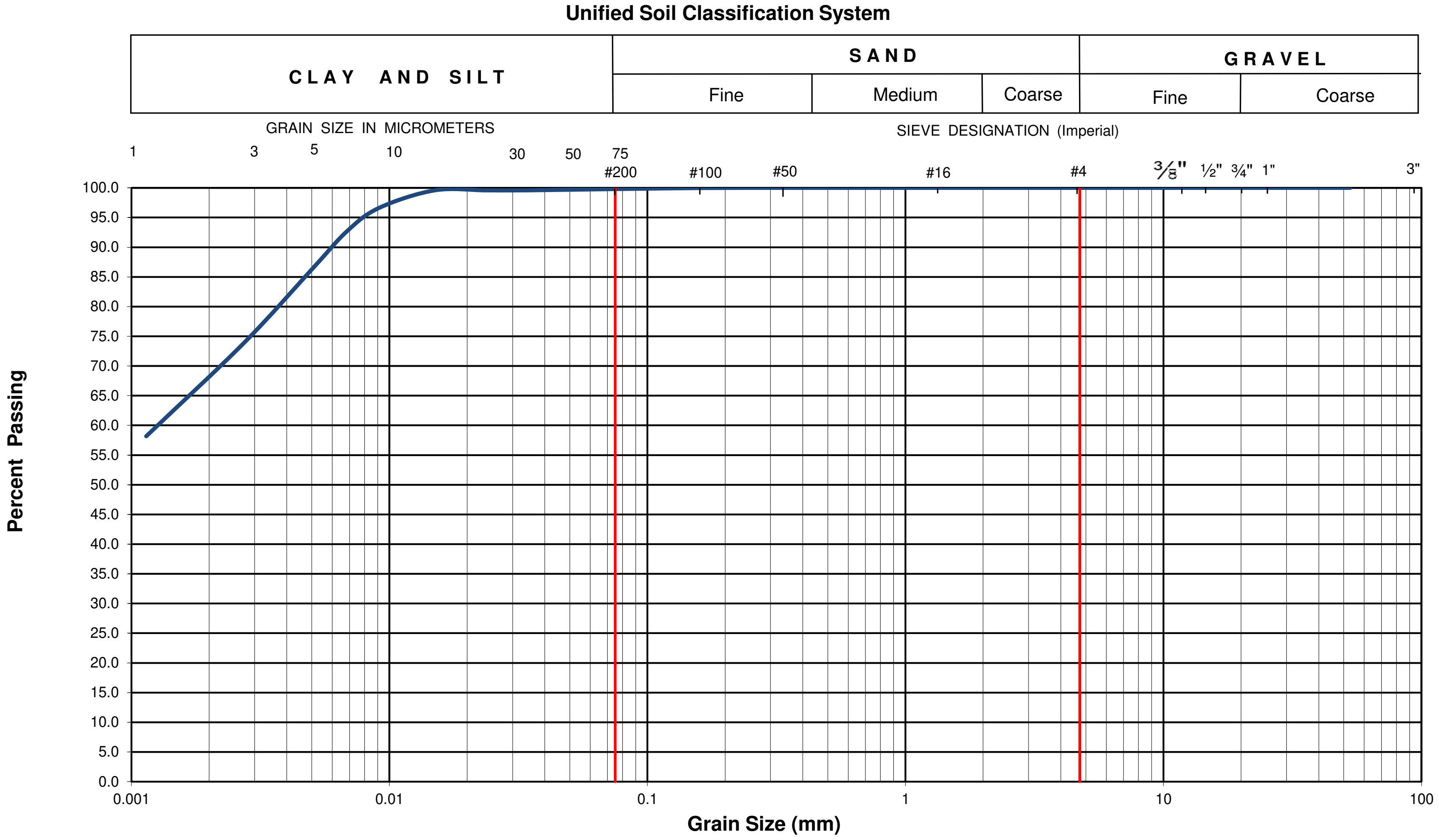
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	OTT-21004743-A0	**Project Name :**	Proposed Residential Development					
Client :	12714001 Canada Inc.	**Project Location :**	2983, 3053 & 3079 Navan Road, Ottawa, ON					
Date Sampled :	September 12, 2023	**Borehole No:**	BH 14	**Sample No.:**	SS2		**Depth (m) :**	0.8-1.4
Sample Description :		**% Silt and Clay**	98	**% Sand**	2	**% Gravel** 0	**Figure :**	25
Sample Description :	Silty Clay of High Plasticity (CH) - Trace Sand							

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

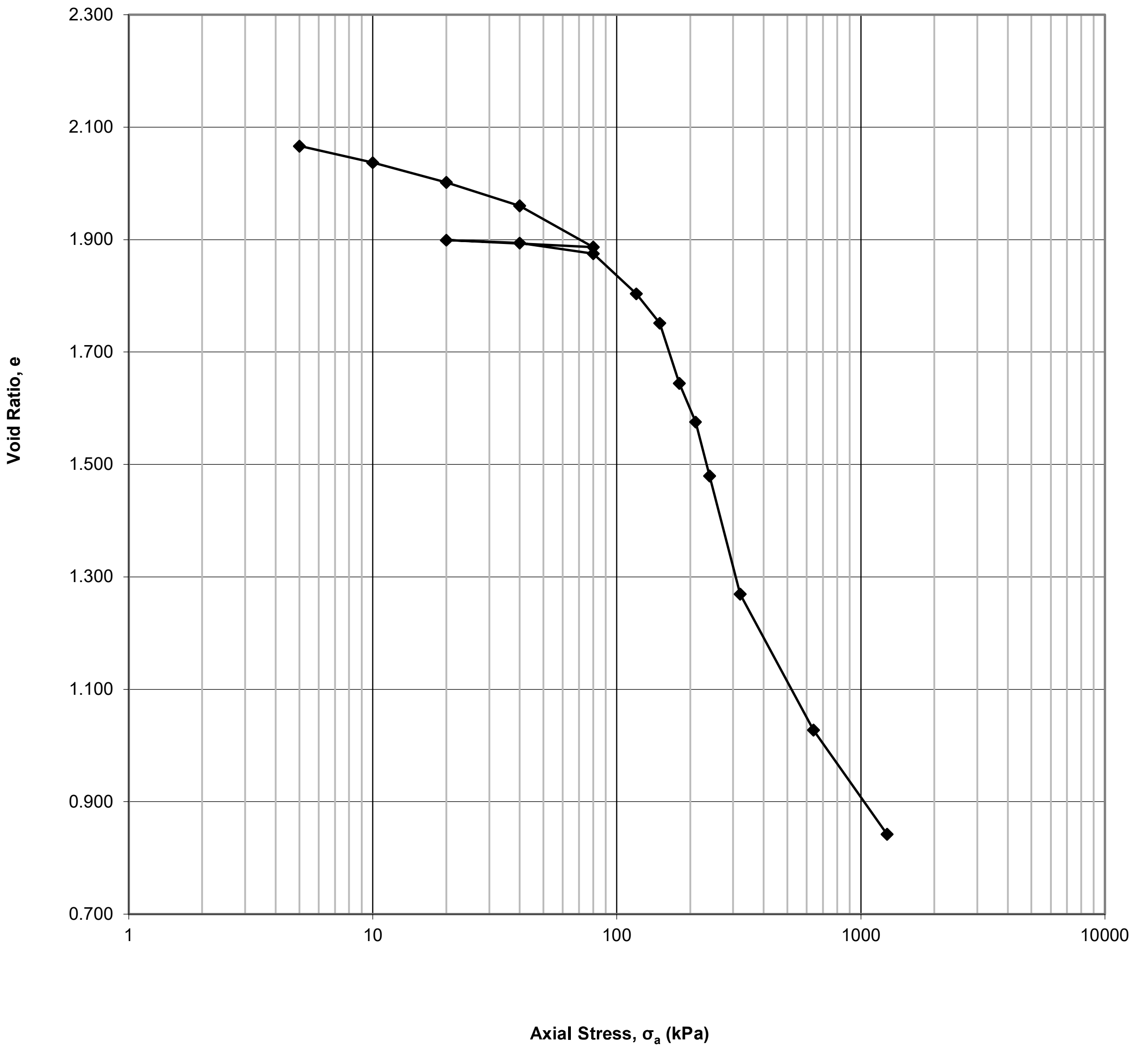


EXP Project No.:	**OTT-21004743-A0**	**Project Name :**	**Proposed Residential Development**				
Client :	**12714001 Canada Inc.**	**Project Location :**	**2983, 3053 & 3079 Navan Road, Ottawa, ON**				
Date Sampled :	**September 11, 2023**	**Borehole No:**	**BH 17**	**Sample No.:**	**SS3**	**Depth (m) :**	**2.3-2.9**
Sample Description :		**% Silt and Clay**	**100**	**% Sand**	**0**	**% Gravel**	**0**
Sample Description :	**Silty Clay of High Plasticity (CH)**					**Figure :**	**33**

One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11(2020)

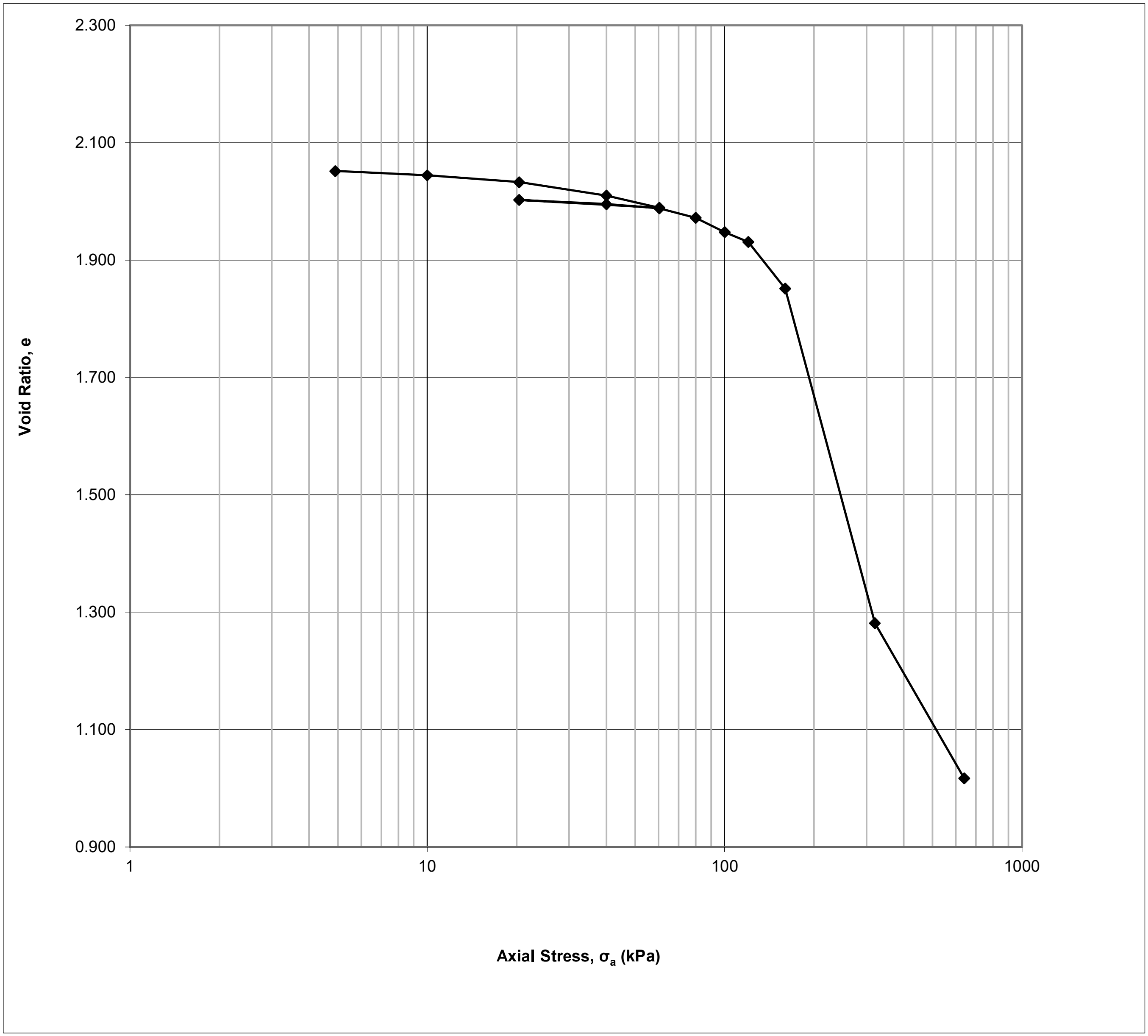
Project	**Exp, File# OTT21004743-B0**
Project No.	**121623683**
Borehole No.	**BH 6**
Sample No.	**TW10**
Sample Depth	**40-42 ft.**



One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11(2020)

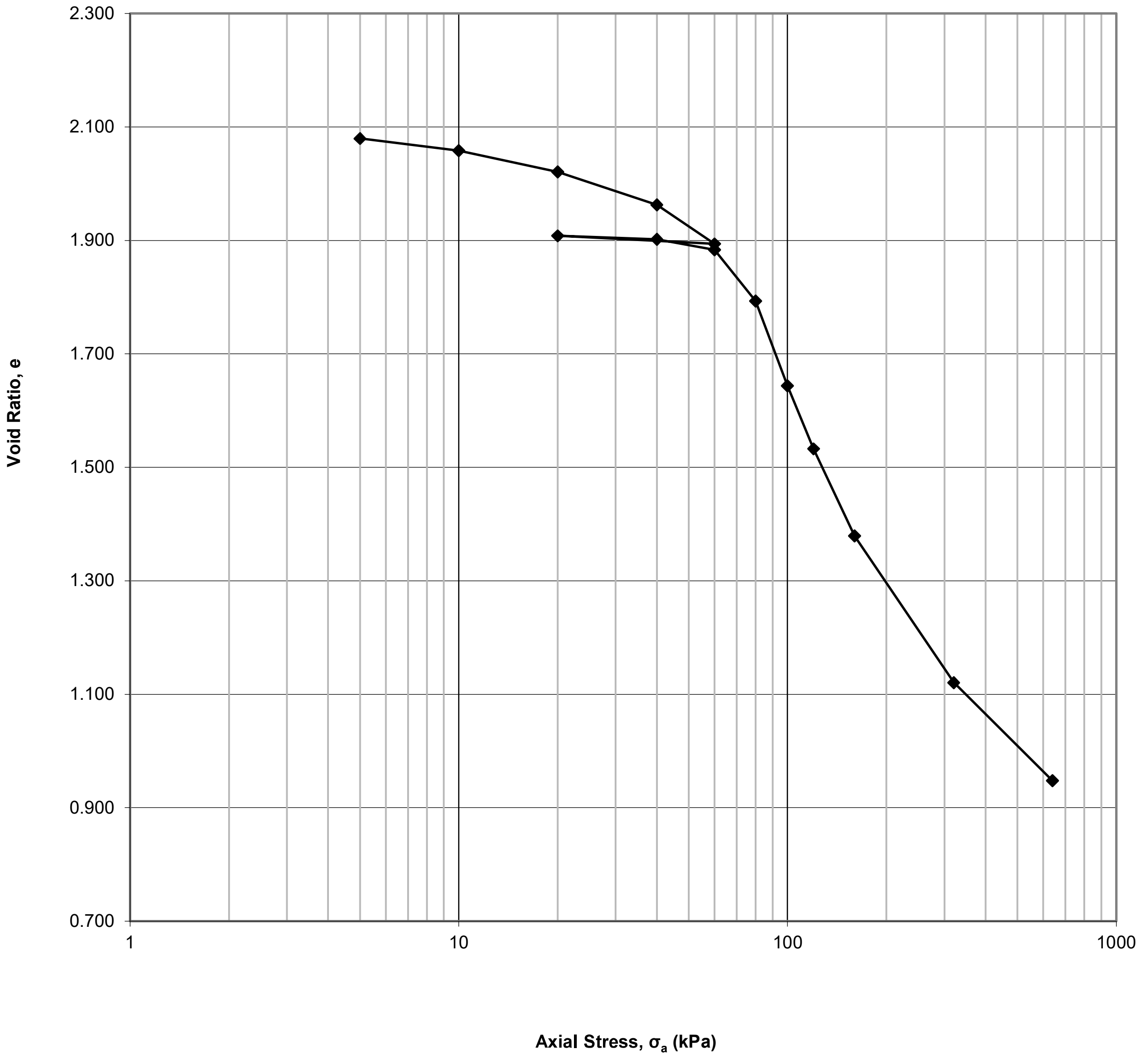
Project	**Exp, File# OTT21004743-B0**
Project No.	**121623683**
Borehole No.	**BH 7**
Sample No.	**TW6**
Sample Depth	**15-17 ft**



One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11(2020)

Project	**Exp, File# OTT21004743-B0**
Project No.	**121623683**
Borehole No.	**BH 8**
Sample No.	**TW4**
Sample Depth	**10-12 ft.**

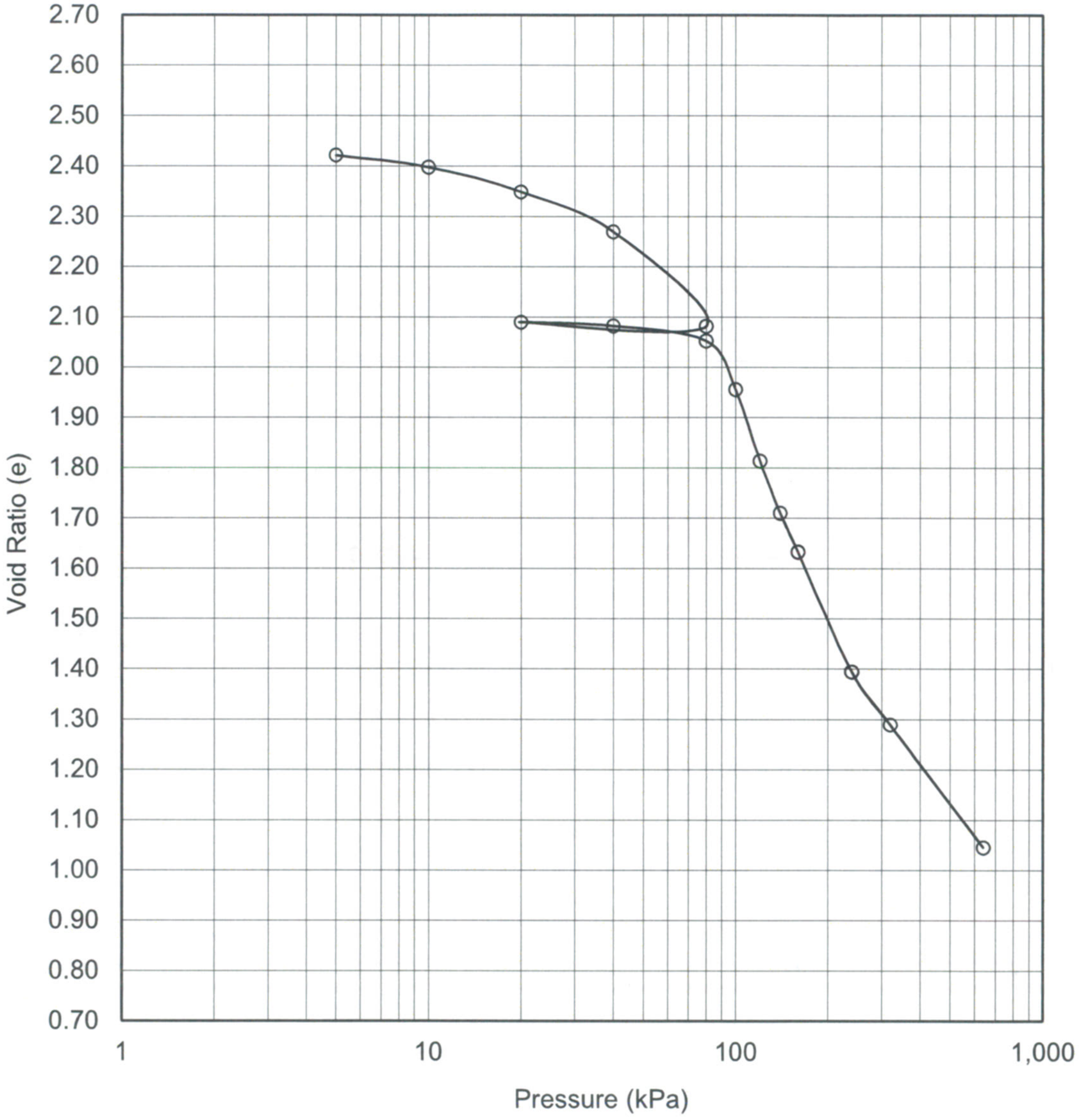


CONSOLIDATION TEST	FIGURE 1

Exp, File# OTT-21004743-B0

BH 12, ST1

Void Ratio vs Pressure



Soil Type : Silty clay, grey, fraible, very wet

e_o = 2.443

ω = 88.05 %

γ = 14.7 kN/m^3

Gs = 2.75

ω_L = N/A

ω_P = N/A

PI = N/A

σ_{v0}' = XX kPa

σ_P' = XX kPa

Project No. : 121624678

Date : 12-Oct-23

Stantec

Prepared By : DB

Checked By : RG

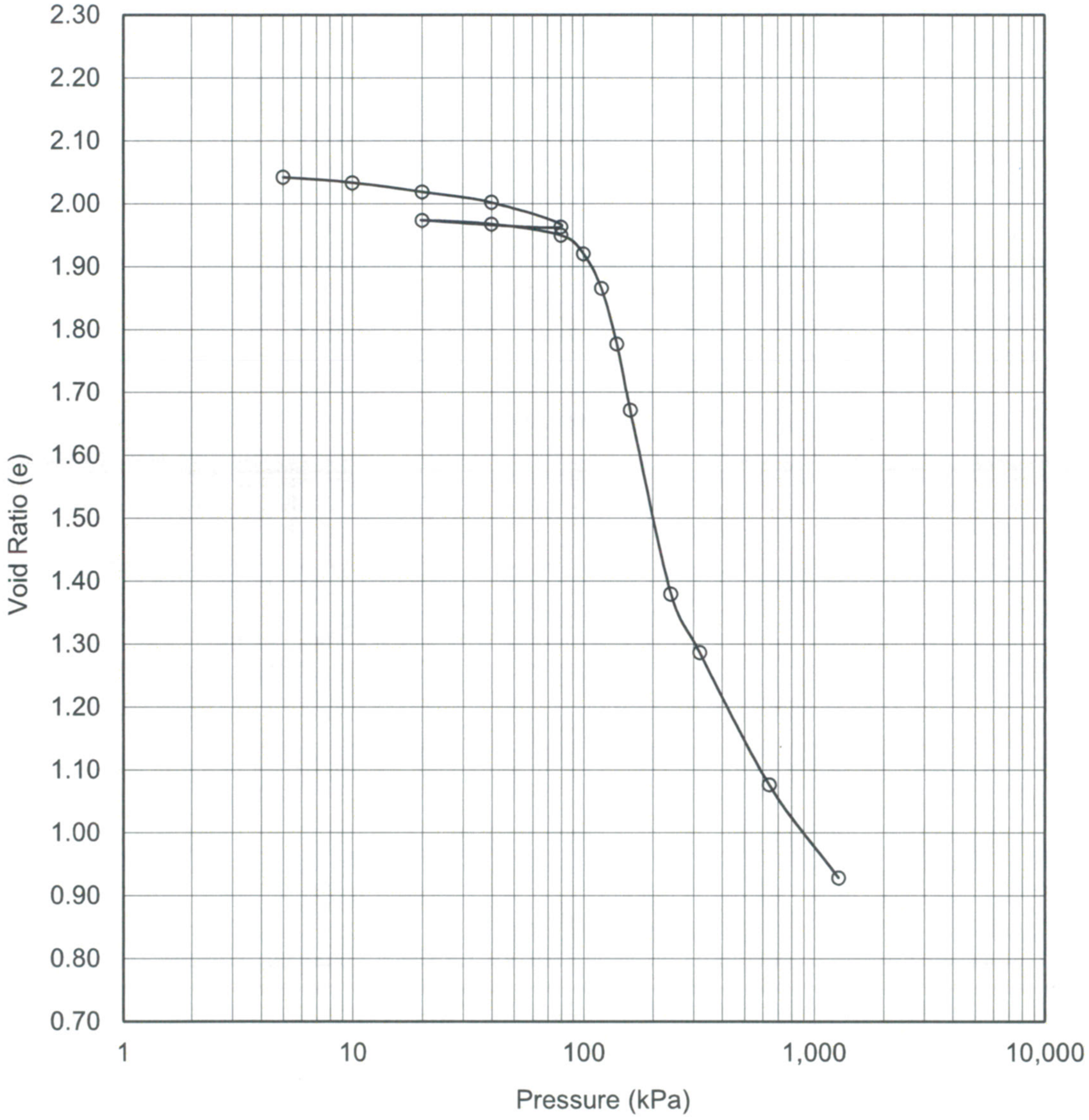
CONSOLIDATION TEST

FIGURE 1

Exp, File# OTT-21004743-B0

BH 15, ST2

Void Ratio vs Pressure



Soil Type : Silty clay, grey, fraible, very wet

e_o =	2.054	ω_L =	N/A	σ_{v0}' =	XX kPa
ω =	73.70 %	ω_P =	N/A	σ_P' =	XX kPa
γ =	15.3 kN/m^3	PI =	N/A		
Gs =	2.75				

Project No. : 121624678
Date : 12-Oct-23

Stantec

Prepared By : DB
Checked By : RG

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

Site: 45.430N 75.521W **User File Reference:** Renaud Road and Navan Road, Navan, Ontario 2021-02-17 12:59 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.494	0.273	0.162	0.047
Sa (0.1)	0.574	0.327	0.202	0.064
Sa (0.2)	0.477	0.275	0.173	0.058
Sa (0.3)	0.360	0.209	0.132	0.045
Sa (0.5)	0.253	0.147	0.093	0.032
Sa (1.0)	0.124	0.073	0.046	0.016
Sa (2.0)	0.058	0.034	0.021	0.006
Sa (5.0)	0.015	0.008	0.005	0.001
Sa (10.0)	0.006	0.003	0.002	0.001
PGA (g)	0.306	0.177	0.109	0.034
PGV (m/s)	0.210	0.117	0.071	0.022

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" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. 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.**

References

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

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
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

Natural Resources Canada Ressources naturelles Canada

Canada

Table 1 - 2983, 3053 & 3079 Navan Road - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG6142	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Mississippi River	OF8600	Mss1	45.41279	-76.24891	Landslide	Source area with truncated debris field	0.08	Unknown	15.00	60.08	Marine Deposits	15 to 25	Granite
Mississippi River	OF8600	Mss2	45.41224	-76.25685	Landslide	Source area with debris field	0.03	Unknown	11.00	60.74	Marine Deposits	15 to 25	Granite
Mississippi River	OF8600	Mss3	45.40384	-76.24579	Landslide	Source area with debris field	0.11	Unknown	23.00	59.88	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss4	45.40073	-76.25147	Landslide	Truncated source area	0.01	Unknown	14.00	60.37	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss5	45.39957	-76.24593	Landslide	Source area with truncated debris field	0.02	Unknown	20.00	59.92	Erosional Terraces	15 to 25	Marble
Mississippi River	OF8600	Mss6	45.39906	-76.25294	Landslide	Source area with truncated debris field	0.04	Unknown	15.00	60.50	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss7	45.39121	-76.25506	Landslide	Truncated source area	0.01	Unknown	15.00	60.75	Erosional Terraces	10 to 15	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss8	45.38970	-76.25421	Landslide	Source area with truncated debris field	0.03	Unknown	12.00	60.69	Erosional Terraces	5 to 10	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss9	45.38953	-76.25872	Landslide	Source area with truncated debris field	0.02	Unknown	15.00	61.07	Organic Deposits	5 to 10	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss10	45.38715	-76.25825	Landslide	Source area with truncated debris field	0.01	Unknown	15.00	61.05	Erosional Terraces	5 to 10	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss11	45.37849	-76.26739	Landslide	Truncated source area	0.03	Unknown	13.00	61.90	Erosional Terraces	50 to 100	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss12	45.37130	-76.26864	Landslide	Truncated source area	0.02	Unknown	11.00	62.10	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi Valley	OF8600	Mss13	45.36543	-76.27229	Landslide	Truncated source area	0.02	Unknown	12.00	62.49	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss14	45.36519	-76.27788	Landslide	Source area with truncated debris field	0.02	Unknown	12.00	62.95	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss15	45.36304	-76.27430	Landslide	Source area with truncated debris field	0.03	Unknown	15.00	62.69	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss16	45.36359	-76.26926	Landslide	Truncated source area	0.01	Unknown	17.00	62.27	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss17	45.36075	-76.26736	Landslide	Source area with debris field	0.06	Unknown	20.00	62.16	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss18	45.36124	-76.27193	Landslide	Truncated source area	0.01	Unknown	12.00	62.52	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss19	45.36122	-76.27561	Landslide	Source area with debris field	0.04	Unknown	10.00	62.82	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite

Table 1 - 2983, 3053 & 3079 Navan Road - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG6142	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Mississippi River	OF8600	Mss20	45.36267	-76.28135	Landslide	Source area with debris field	0.02	Unknown	10.00	63.27	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss21	45.35604	-76.26640	Landslide	Source area with debris field	0.11	Unknown	15.00	62.16	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss22	45.35416	-76.27441	Landslide	Truncated source area	0.01	Unknown	17.00	62.84	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss23	45.35244	-76.27982	Landslide	Truncated source area	0.01	Unknown	25.00	63.32	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss24	45.35168	-76.28166	Landslide	Truncated source area	0.01	Unknown	25.00	63.48	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss25	45.35103	-76.28318	Landslide	Truncated source area	0.02	Unknown	20.00	63.62	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy1	45.35143	-76.26277	Landslide	Source area with truncated debris field	0.01	Unknown	16.00	61.94	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy2	45.35023	-76.26130	Landslide, possibly	Source area with debris field	0.01	Unknown	***	61.85	***	***	***
Cody Creek	OF8600	Cdy3	45.34522	-76.26452	Landslide	Truncated source area	0.01	Unknown	21.00	62.21	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy4	45.34223	-76.26721	Landslide	Truncated source area	0.02	Unknown	17.00	62.48	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy5	45.33939	-76.25827	Landslide	Source area with truncated debris field	0.07	Unknown	17.00	61.82	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy6	45.33979	-76.24991	Landslide	Source area with truncated debris field	0.06	Unknown	13.00	61.13	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy7	45.34175	-76.24524	Landslide, possibly	Source area with truncated debris field	0.10	Unknown	***	60.71	***	***	***
Cody Creek	OF8600	Cdy8	45.33762	-76.24262	Landslide	Source area with truncated debris field	0.03	Unknown	23.00	60.58	Marine Deposits	10 to 15	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy9	45.33822	-76.23647	Landslide	Source area with truncated debris field	0.01	Unknown	17.00	60.07	Marine Deposits	5 to 10	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy10	45.33477	-76.23220	Landslide	Source area with truncated debris field	0.06	Unknown	12.00	59.81	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy11	45.33386	-76.23415	Landslide, probably	Source area with truncated debris field	0.04	Unknown	**	59.98	**	**	**
Cody Creek	OF8600	Cdy12	45.32989	-76.22645	Landslide, probably	Source area with truncated debris field	0.04	Unknown	**	59.46	**	**	**
Cody Creek	OF8600	Cdy13	45.32654	-76.22004	Landslide, probably	Source area with truncated debris field	0.03	Unknown	**	59.02	**	**	**

Table 1 - 2983, 3053 & 3079 Navan Road - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG6142	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Cody Creek	OF8600	Cdy14	45.32031	-76.21358	Landslide	Source area with truncated debris field; isolated areas of debris field	0.05	Unknown	24.00	58.66	Marine Deposits	10 to 15	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy15	45.34728	-76.23587	Landslide, probably	Debris field within a narrow stream valley	0.01	Unknown		59.83			
Madawaska Lake reservoir	OF8600	Mdw1	45.40855	-76.35190	Landslide, former site of	Inundated beneath lake waters	**	Unknown	7.00	68.59	Marine Deposits	10 to 15	Marble
Fitzroy	OF8600	Ftz1	45.50319	-76.22097	Landslide	Truncated source area	0.03	Unknown	10.00	58.29	Alluvial Sediments	5 to 10	Interbedded Limestone and Dolomite
Fitzroy	OF8600	Ftz2	45.50437	-76.21394	Landslide	Truncated source area	0.02	Unknown	16.00	57.74	Alluvial Sediments	5 to 10	Interbedded Limestone and Dolomite
Fitzroy	OF8600	Ftz3	45.49835	-76.15980	Landslide	Source area with truncated debris field	0.16	Unknown	27.00	53.22	Erosional Terraces	10 to 15	Interbedded Limestone and Dolomite
Fitzroy	OF8600	Ftz4	45.50664	-76.13974	Landslide	Truncated source area	0.23	Unknown	11.00	51.74	Erosional Terraces	5 to 10	Interbedded Limestone and Dolomite
Buckhams Bay	OF8600	BkB1	45.48572	-76.10521	Landslide	Source area with truncated debris field	0.49	Unknown	34.00	48.57	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Buckhams Bay	OF8600	BkB2	45.48122	-76.10138	Landslide	Source area with truncated debris field	0.13	Unknown	30.00	48.19	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Buckhams Bay	OF8600	BkB3	45.47977	-76.09564	Landslide	Source area with truncated debris field	0.10	Unknown	30.00	47.70	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Carp Creek	OF8600	Crp1	45.34812	-76.04299	Landslide	Source area with debris field	0.10	Unknown	20.00	44.20	Marine Deposits	25 to 50	Interbedded Limestone and Shale
Rideau River	OF8600	Rid1	45.38818	-75.70428	Landslide	Truncated source area	0.05	Unknown	15.00	15.99	Erosional Terraces	5 to 10	Limestone
Rideau River	OF8600	Rid2	45.32436	-75.69166	Landslide	Source area with debris field	0.06	Unknown	30.00	18.95	Alluvial Sediments	15 to 25	Interbedded Dolomite and Sandstone
Rideau River	OF8600	Rid3	45.28377	-75.69606	Landslide, possibly	Truncated source area?	0.01	Unknown		22.65			
Rockcliffe	OF8600	Rkf1	45.45147	-75.67312	Landslide, probably	Truncated source area	0.02	Unknown		12.76			
Gloucester	OF8600	Glt1	45.44963	-75.59729	Landslide	Source area with debris field	0.12	About 1000 cal yr BP	30.00	6.63	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln1	45.45962	-75.55209	Landslide, possibly	Truncated source area?	0.02	Unknown		4.14			
Orleans	OF8600	Oln2	45.45719	-75.54766	Landslide	Debris field within a narrow stream valley	0.11	Unknown	17.00	3.69	Marine Deposits	25 to 50	Shale
Orleans	OF8600	Oln3	45.46016	-75.54108	Landslide	Debris field within a narrow stream valley	0.05	Unknown	5.00	3.69	Marine Deposits	50 to 100	Shale

Table 1 - 2983, 3053 & 3079 Navan Road - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG6142	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Orleans	OF8600	Oln4	45.45726	-75.54049	Landslide	Debris field within a narrow stream valley	0.02	Unknown	5.00	3.37	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln5	45.45487	-75.53897	Landslide	Debris field within a narrow stream valley	0.02	Unknown	9.00	3.06	Marine Deposits	50 to 100	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln6	45.45863	-75.53838	Landslide	Debris field within a narrow stream valley	0.01	Unknown	3.00	3.44	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln7	45.45977	-75.53858	Landslide	Debris field within a narrow stream valley	0.00	Unknown	2.00	3.56	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln8	45.46051	-75.53690	Landslide	Debris field within a narrow stream valley	0.01	Unknown	7.00	3.59	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln9	45.46092	-75.53424	Landslide	Debris field within a narrow stream valley	0.02	Unknown	3.00	3.56	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln10	45.46378	-75.53684	Landslide	Truncated source area	0.07	Unknown	20.00	3.95	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln11	45.46497	-75.53146	Landslide	Truncated source area	0.06	Unknown	18.00	3.96	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln12	45.46706	-75.52809	Landslide	Truncated source area	0.05	Unknown	18.00	4.15	Nearshore Marine	25 to 50	Shale
Orleans	OF8600	Oln13	45.47042	-75.52019	Landslide, probably	Truncated source area	0.07	Unknown		4.50			
Orleans	OF8600	Oln14	45.48981	-75.50782	Landslide	Source area with debris field	0.08	Late Holocene?	18.00	6.86	Alluvial Sediments	15 to 25	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln15	45.48871	-75.47487	Landslide, probably	Truncated source area	0.08	Unknown		7.65			
Orleans	OF8600	Oln16	45.48586	-75.47170	Landslide	Debris field within a narrow stream valley	0.07	Unknown	29.00	7.50	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln17	45.48877	-75.46692	Landslide	Debris field within a narrow stream valley	0.04	Unknown	8.00	8.00	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln18	45.49016	-75.46497	Landslide	Debris field within a narrow stream valley	0.03	Unknown	10.00	8.22	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cumberland	OF8600	Cmb1	45.51313	-75.43362	Landslide	Truncated source area	0.14	Unknown	35.00	11.92	Erosional Terraces	15 to 25	Shale
Cumberland	OF8600	Cmb2	45.51302	-75.40335	Landslide	Source area with debris field	0.04	Unknown	24.00	13.56	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cumberland	OF8600	Cmb3	45.51737	-75.38140	Landslide	Source area with debris field	0.53	relatively young, less than 2000(?)	30.00	15.24	Erosional Terraces	50 to 100	Dolomite
Cumberland	OF8600	Cmb4	45.51651	-75.33631	Landslide	Source area with debris field	0.02	Unknown	49.00	18.14	Nearshore Marine	25 to 50	Interbedded Limestone and Dolomite

Table 1 - 2983, 3053 & 3079 Navan Road - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG6142	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Mer Bleue paleochannel	OF8600	MBu1	45.43409	-75.53765	Landslide	Truncated source area	0.02	Unknown	13.00	1.41	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Mer Bleue paleochannel	OF8600	MBu2	45.43092	-75.51828	Landslide	Source area with debris field	0.12	Unknown	15.00	0.25	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu3	45.42843	-75.51485	Landslide	Source area with debris field	0.01	Unknown	12.00	0.65	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu4	45.42782	-75.51290	Landslide	Truncated source area	0.01	Unknown	**	0.82	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu5	45.42639	-75.50741	Landslide, former site of	Completely altered	N.A.	Unknown	**	1.29	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu6	45.42500	-75.50289	Landslide, former site of	Completely altered	N.A.	Unknown	**	1.69	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu7	45.42364	-75.49702	Landslide, former site of	Completely altered	N.A.	Unknown	**	2.20	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu8	45.42335	-75.49197	Landslide, former site of	Completely altered	N.A.	Unknown	**	2.59	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu9	45.42158	-75.48102	Landslide	Truncated source area	0.03	Unknown	15.00	3.50	Erosional Terraces	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu10	45.42089	-75.47444	Landslide	Truncated source area	0.03	Unknown	15.00	4.04	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu11	45.41891	-75.46077	Landslide	Truncated source area	0.03	Unknown	14.00	5.18	Nearshore Marine	15 to 25	Shale
Mer Bleue paleochannel	OF8600	MBu12	45.41829	-75.45649	Landslide	Truncated source area	0.01	Unknown	15.00	5.54	Nearshore Marine	15 to 25	Shale
Mer Bleue paleochannel	OF8600	MBu13	45.41206	-75.27053	Landslide	Source area with debris field	1.42	about 5200 cal yrBP	19.00	20.77	Nearshore Marine	25 to 50	Interbedded Limestone and Shale
Beta-90881	OF7432	1	45.46110	-75.26110	Landslide	*	*	3050±70	20.00	21.67	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-122473	OF7432	1	45.44170	-75.22220	Landslide	*	*	4590±40	8.00	24.64	Nearshore Marine	25 to 50	Interbedded Limestone and Shale
Beta-122475	OF7432	1	45.44240	-75.19240	Landslide	*	*	2760±50	20.00	27.10	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Beta-127281	OF7432	1	45.54160	-75.24160	Landslide	*	*	5130±60	53.00	26.35	Nearshore Marine	10 to 15	Limestone
Beta-127284	OF7432	1	45.52080	-75.26670	Landslide	*	*	4440±80	21.00	23.38	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Beta-127244	OF7432	1	45.50000	-75.20280	Landslide	*	*	4570±70	30.00	27.38	Erosional Terraces	25 to 50	Interbedded Limestone and Shale

Table 1 - 2983, 3053 & 3079 Navan Road - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG6142	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Beta-122472	OF7432	1	45.48330	-75.19170	Landslide	*	*	4520±50	30.00	27.77	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-127282	OF7432	1	45.47500	-75.12920	Landslide	*	*	4540±90	24.00	32.66	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-127283	OF7432	1	45.52500	-75.01110	Landslide	*	*	4530±60	12.00	43.38	Erosional Terraces	10 to 15	Interbedded Limestone and Shale
Beta-122478	OF7432	1	45.51390	-75.00280	Landslide	*	*	4700±50	15.00	43.74	Erosional Terraces	15 to 25	Interbedded Limestone and Shale
Beta-122471	OF7432	1	45.51850	-74.95570	Landslide	*	*	1870±40	26.00	47.64	**	**	**
Beta-127242	OF7432	1	45.51380	-74.93750	Landslide	*	*	4820±70	26.00	49.00	**	**	**
Beta-122474	OF7432	1	45.53610	-75.15830	Landslide	*	*	4470±50	**	32.26	Nearshore Marine	25 to 50	Limestone
GSC-1922	OF7432	2	45.54370	-75.40110	Landslide	*	*	4620±80	81.00	16.40	Marine Deposits	15 to 25	Felsic Intrusive Rocks
GSC-2068	OF7432	4	45.52080	-75.49170	Landslide	*	*	6240±70	59.00	10.69	Marine Deposits	25 to 50	Dolomite
UCIAMS-71217	OF7432	6	45.57980	-75.04260	Landslide	*	*	7105±20	35.00	43.02	Erosional Terraces	50 to 100	Shale
UCIAMS-71211	OF7432	7	45.57020	-75.11560	Landslide	*	*	7140±20	31.00	37.10	Marine Deposits	50 to 100	Interbedded Limestone and Dolomite
GSC-1741	OF7432	10	45.46500	-75.75130	Landslide	*	*	120±150	**	19.39	Marine Deposits	25 to 50	Dolomite
UCIAMS-88796	OF7432	11	45.48290	-75.93490	Landslide	*	*	1125±15	29.00	34.64	Marine Deposits	25 to 50	Felsic Intrusive Rocks
UCIAMS-88704	OF7432	11	45.48530	-75.93630	Landslide	*	*	2805±20	29.00	34.81	Marine Deposits	25 to 50	Felsic Intrusive Rocks
GSC-6233	OF7432	11	45.48310	-75.93320	Landslide	*	*	7050±80	25.00	34.51	Marine Deposits	25 to 50	Felsic Intrusive Rocks
UCIAMS-88816	OF7432	11	45.48020	-75.93090	Landslide	*	*	200±15	24.00	34.27	Marine Deposits	15 to 25	Felsic Intrusive Rocks
GSC-6449	OF7432	11	45.47180	-75.91290	Landslide	*	*	1080±70	15.00	32.65	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
UCIAMS-88703	OF7432	11	45.47990	-75.91740	Landslide	*	*	180±20	26.00	33.16	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6318	OF7432	11	45.47860	-75.91180	Landslide	*	*	1030±70	24.00	32.68	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite

Table 1 - 2983, 3053 & 3079 Navan Road - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG6142	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
UCIAMS-88806	OF7432	11	45.47730	-75.90280	Landslide	*	*	1895±25	12.00	31.93	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6482	OF7432	11	45.48120	-75.90670	Landslide	*	*	1210±50	8.00	32.32	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6433	OF7432	11	45.48540	-75.89640	Landslide	*	*	1440±50	18.00	31.58	Marine Deposits	15 to 25	Felsic Intrusive Rocks
UCIAMS-88818	OF7432	11	45.48520	-75.90600	Landslide	*	*	2755±20	22.00	32.35	Marine Deposits	25 to 50	Felsic Intrusive Rocks
GSC-6355	OF7432	11	45.48250	-75.91180	Landslide	*	*	1170±50	27.00	32.76	Marine Deposits	25 to 50	Felsic Intrusive Rocks
Beta-139135	OF7432	11	45.49650	-75.92780	Landslide	*	*	310±40	10.00	34.38	Marine Deposits	50 to 100	Felsic Intrusive Rocks
UCIAMS-122468	OF7432	12	45.53530	-76.03060	Landslide	*	*	1095±20	21.00	43.71	Marine Deposits	15 to 25	Felsic Intrusive Rocks
UCIAMS-106656	OF7432	13	45.54090	-76.04890	Landslide	*	*	1150±15	22.00	45.34	Marine Deposits	25 to 50	Felsic Intrusive Rocks
UCIAMS-171460	OF7432	14	45.55390	-76.13020	Landslide	*	*	1305±20	9.00	52.19	Nearshore Marine	50 to 100	Felsic Intrusive Rocks
UCIAMS-171459	OF7432	15	45.55130	-76.14060	Landslide	*	*	185±20	9.00	52.93	Nearshore Marine	50 to 100	Felsic Intrusive Rocks
UCIAMS-106587	OF7432	16	45.55190	-76.28630	Landslide	*	*	1180±20	24.00	64.59	Erosional Terraces	15 to 25	Felsic Intrusive Rocks
UCIAMS-106575	OF7432	17	45.61920	-76.37190	Landslide	*	*	955±15	32.00	73.42	**	**	**
UCIAMS-106650	OF7432	18	45.50140	-76.28260	Landslide	*	*	1145±20	52.00	63.29	Nearshore Marine	15 to 25	Felsic Intrusive Rocks
UCIAMS-106581	OF7432	19	45.51700	-76.27470	Landslide	*	*	5830±20	34.00	62.90	Nearshore Marine	15 to 25	Felsic Intrusive Rocks
UCIAMS-122453	OF7432	20	45.54620	-76.52600	Landslide	*	*	5745±20	**	83.87	**	**	**
UCIAMS-137113	OF7432	21	45.72570	-75.89150	Landslide	*	*	4525±20	52.00	46.03	**	**	**
UCIAMS-137101	OF7432	22	45.69440	-75.89960	Landslide	*	*	90±20	23.00	43.82	**	**	**
UCIAMS-122455	OF7432	23	45.80960	-75.95980	Landslide	*	*	940±15	25.00	57.16	**	**	**

'*' - Indicates information not provided by source (Geological Survey of Canada Open File 7432)

'' Indicates information could not be interpreted from available mapping.**

Ruisseau Park Ravine Rehabilitation Class Environmental Assessment

Réfection du ravin du parc du Ruisseau Évaluation environnementale municipale de portée générale

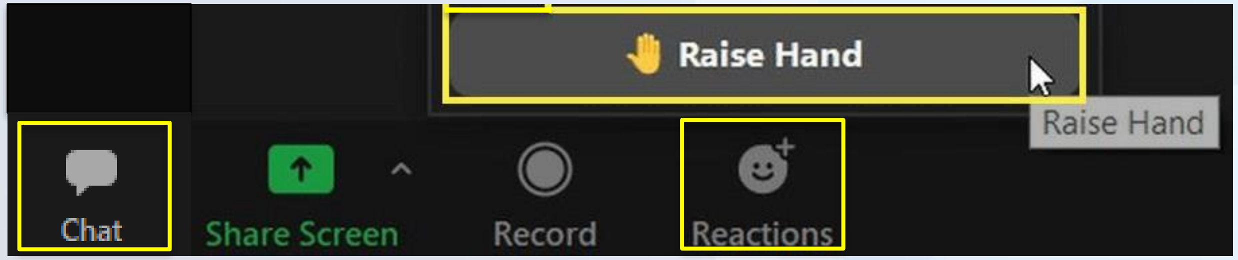
Public Meeting #1
Existing Conditions
March 31, 2021

Assemblée publique #1
Conditions existantes
March 31, 2021

Housekeeping Items / Questions administratives

- Discussion at end of presentation
- Keep your microphone on mute during the presentation
- Use the "Raise Your Hand" feature if you have a question, or
- Use the "Chat" option

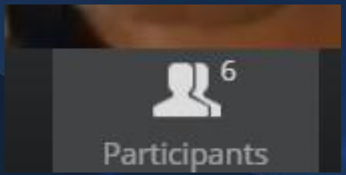
- Discussion à la fin de la présentation
- Gardez votre microphone en sourdine pendant la présentation
- Utilisez la fonction « Raise Hand » (Lever la main) si vous avez une question ou
- Utilisez le « Chat » (clavardage)

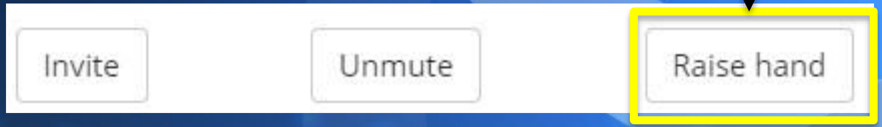


Alternate "Raise You Hand" procedure

Autre procédure pour « lever la main »

"Click on Participants"





Presentation Agenda / Ordre du jour

1. Project Team Members with us Tonight
2. Project Background
3. Project Objectives
4. Municipal Class Environment Assessment (Class EA) Requirements
5. Approach and Methodology
6. Existing Conditions
7. Key Findings
8. Next Steps
9. Contacts
10. Summary (in French)
11. Open Discussion

1. Membres de l'équipe du projet présents ce soir
2. Contexte du projet
3. Objectifs du projet
4. Exigences relatives à l'évaluation environnementale municipale de portée générale
5. Approche et méthodologie
6. État actuel
7. Principales conclusions
8. Prochaines étapes
9. Donnez votre avis!
10. Résumé (en français)
11. Discussion ouverte

1. With us Tonight… / Membres présents ce soir

City of Ottawa / Ville d’Ottawa
- Darlene Conway
- Karine Bertrand
- Laurent Jolliet 🎙

Wood
- Steve Chipps 🎙
- Patrick MacDonald 🎙
- Samantha Stokke

Coldwater Consulting - Stream Morphology / Morphologie des cours d’eau
- Neil MacDonald 🎙
- Mike Davies

2. Project Background / Contexte du projet

- Study Area:
  - Blue Willow Creek, tributary to Mud Creek
  - On-line Blue Willow SWM facility
- Uncontrolled runoff from 106 ha of existing residential development
- Excessive erosion, widening and movement of the channel and slope failures

- Zone à l'étude:
  - Ruisseau Blue Willow, affluent du ruisseau Mud;
  - Installation de gestion des eaux pluviales Blue Willow.
- Eaux de ruissellement non contrôlées provenant du lotissement résidentiel amont (106 ha)
- Érosion excessive, élargissement et déplacement du canal et instabilités de pente

2. Project Background / Contexte du projet

- 2017 slope failure
- Emergency repair: rock fill material
- Blue Willow Class Environmental Assessment initiated in 2020

- Rupture de pente en 2017
- Réparation d’urgence (enrochement)
- Évaluation environnementale municipale de portée générale du parc Blue Willow entreprise en 2020

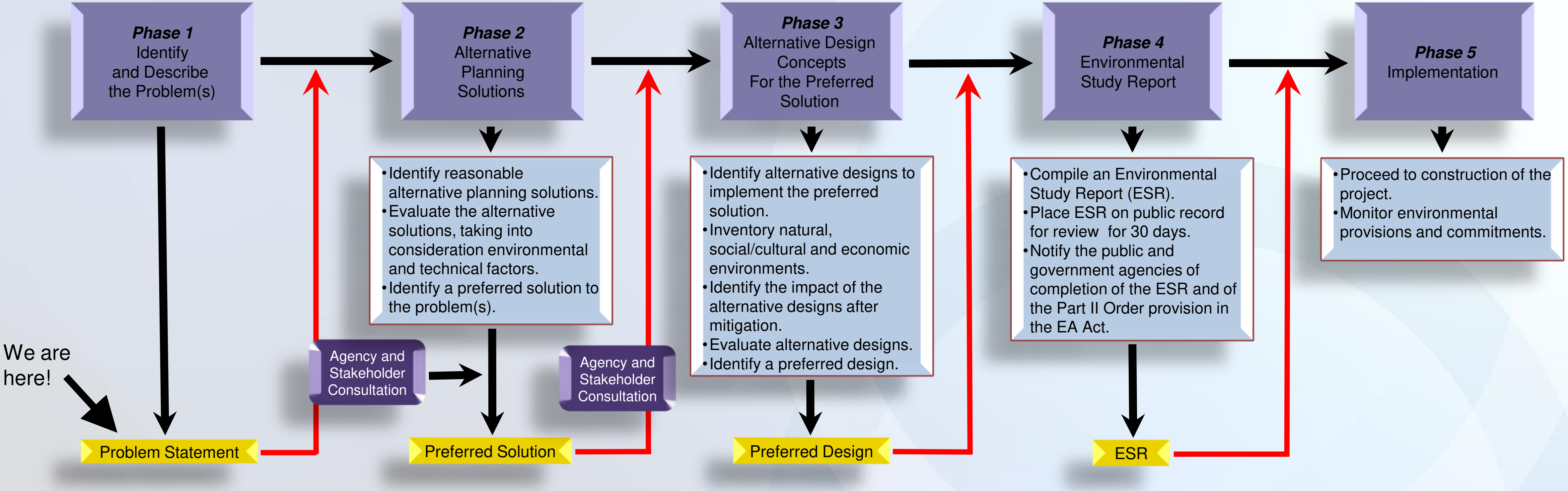
3. Project Objectives / Objectifs du projet

- Protect private and public property from slope instability concerns
- Minimize long-term maintenance requirements, and
- Minimize impacts to existing natural features within the ravine.

- Protéger le domaine privé et le domaine public contre l'instabilité des pentes;
- Réduire le plus possible les travaux d'entretien nécessaires à long terme;
- Réduire le plus possible les effets négatifs sur les fonctions naturelles du ravin existant.

4. Municipal Class EA Requirements

The Ruisseau Ravine Class EA is following the Municipal Class Environmental Assessment process (Phases 1-4 and Schedule B) which is outlined in the Municipal Engineers Association document titles "Municipal Class Environmental Assessment," (Oct 2000, as amended in 2007, 2011, and 2015)



Phase 1
Identify
and Describe
the Problem(s)

Phase 2
Alternative
Planning
Solutions

- Identify reasonable alternative planning solutions.
- Evaluate the alternative solutions, taking into consideration environmental and technical factors.
- Identify a preferred solution to the problem(s).

Phase 3
Alternative Design
Concepts
For the Preferred
Solution

- Identify alternative designs to implement the preferred solution.
- Inventory natural, social/cultural and economic environments.
- Identify the impact of the alternative designs after mitigation.
- Evaluate alternative designs.
- Identify a preferred design.

Phase 4
Environmental
Study Report

- Compile an Environmental Study Report (ESR).
- Place ESR on public record for review for 30 days.
- Notify the public and government agencies of completion of the ESR and of the Part II Order provision in the EA Act.

Phase 5
Implementation

- Proceed to construction of the project.
- Monitor environmental provisions and commitments.

Agency and Stakeholder Consultation

Agency and Stakeholder Consultation

We are here!

Problem Statement

Preferred Solution

Preferred Design

ESR

5. Approach / Approche

Approach

- Assess the drainage and flow rates to Blue Willow Creek.
- Identify sections of the creek susceptible to erosion.
- Assess the condition and stability of the existing ravine slopes.

Approche

- Évaluer le drainage et le débit du ruisseau Blue Willow.
- Recenser les sections du ruisseau sujettes à l’érosion.
- Évaluer l’état et la stabilité des pentes existantes du ravin.

5. Methodology / Méthodologie

Methodology

- Data collection and site reconnaissance.
- Site investigations identified areas for erosion and slope analysis.
- Determine flow rates and establish flow characteristics within the channel.
- Alternative assessment will provide recommendations to mitigate the areas of concern.

Méthodologie

- Procéder à la collecte de données et à la reconnaissance du site.
- Les études du site ont permis de repérer les zones d'érosion et d'effectuer une analyse des pentes.
- Déterminer le débit et établir les caractéristiques de l'écoulement dans le canal.
- Une évaluation de mesures alternatives permettra d'identifier des recommandations de mesures d'atténuation des zones préoccupantes.

SUBJECT: Ruisseau Park Ravine Rehabilitation, Class Environmental Assessment and Functional Design

File Number: ACS2022-PIE-IS-0003

Report to Standing Committee on Environmental Protection, Water and Waste Management **on 21 Jun 2022**

and Council 6 July 2022

Submitted on 21 Jun 2022 by Marilyn Journeaux, Director, Water Services, Infrastructure & Water Services Department

Contact Person: Laurent Jolliet, Project Specialist, Stormwater, Infrastructure and Water Services Department

613-580-2424, 17149, Laurent.jolliet@ottawa.ca

Ward: INNES (2)

OBJET : Réfection du ravin du parc Ruisseau, évaluation environnementale de portée générale (ÉÉ) et conception fonctionnelle

Dossier : ACS2022-PIE-IS-0003

Rapport au Comité permanent de la protection de l’environnement, de l’eau et de la gestion des déchets **le 21 juin 2022**

et au Conseil le 6 juillet 2022

Soumis le 21 Jun 2022 par Marilyn Journaux, Directrice, Services d’eau, Département des services d’infrastructure et d’eau

Personne ressource : Laurent Jolliet, Spécialiste de projet, gestion des eaux pluviales, Département des services d’infrastructure et d’eau

613-580-2424, 17149, Laurent.jolliet@ottawa.ca

Quartier : INNES (2)

REPORT RECOMMENDATION(S)

That the Standing Committee on Environmental Protection, Water and Waste Management Committee recommend Council approve the results of the Class Environmental Assessment Study for the Ruisseau Park Ravine Rehabilitation as detailed in Document 1 and direct staff to proceed with posting the Notice of Study Completion for a 30-day public review period in accordance with the *Ontario Municipal Class Environmental Assessment* Schedule "B" process.

RECOMMANDATION(S) DU RAPPORT

Que le Comité permanent de la protection de l'environnement, de l'eau et de la gestion des déchets recommande au Conseil d'approuver les résultats de l'évaluation environnementale de portée générale concernant le projet de réfection du ravin du parc Ruisseau, comme le précise le document 1, et de demander au personnel de déposer un avis d'achèvement de l'étude ouvrant une période d'examen public de 30 jours, conformément à la procédure prévue à l'annexe « B » de l'Évaluation environnementale municipale de portée générale de l'Ontario.

BACKGROUND

The Ruisseau Park ravine forms part of the Blue Willow stormwater management (SWM) facility, a stormwater quantity control facility built online to a small tributary of Mud Creek in the 1990's. Document 2 provides a location plan of the ravine and SWM facility.

Uncontrolled runoff from the SWM facility's 106-hectare catchment area discharges to the ravine at three locations. The absence of runoff quantity control has resulted in widening and movement of the channel, creating valley wall contacts. Continued erosion, if unchecked, is expected to threaten adjacent property.

In 2017, the ravine corridor at the back of 9 Sprucewood Place experienced a slope failure, which was addressed by Construction Services with the placement of rip rap material on the slope as a temporary emergency stabilization measure. A Class Environmental Assessment (Class EA) Study was then initiated to assess the existing conditions of the entire creek corridor, identify areas of concern, assess various alternative solutions and prepare a functional design for the preferred alternative to resolve erosion and slope stability problems within the ravine.

The objectives of this assignment are to:

- protect private and public property from slope instability concerns;
- minimize long-term maintenance requirements; and
- minimize impacts to existing natural features within the ravine.

DISCUSSION

This Class EA study has examined different alternatives to address erosion issues and protect private and public property from slope instability concerns. The following six alternatives have been assessed and compared:

- Do nothing (existing conditions);
- Implementation of stormwater management measures within the upstream existing development area;
- Creek realignment;
- Creek partial enclosure;
- Creek control structures;
- Channel hardening;

The evaluation of alternatives addressed four main criteria including: functional, natural, social and economic environment. The results from the assessment demonstrated that as standalone measures, the above alternatives do not provide an adequate solution to the existing creek erosion and slope stability issues. Therefore, three additional combined alternatives have been developed:

- Realignment, reshaping and hardening (hardening focus)
- Realignment, structures and hardening (structures focus)
- Realignment, structures and naturalization (adaptive management focus)

The “realignment, structures and hardening” alternative (structure focus) was identified as the preferred solution and includes:

- the construction of six weir-pool structures along the channel to dissipate the flow energy and reduce erosion;
- the realignment of the creek over a distance of 135 meters to move the channel away from the slopes of concerns;
- the filling and regrading of four slopes to provide stabilization; and
- the planting of new shrubs and trees to ensure the tree canopy that will be lost due to construction activities will be replaced with a diverse selection of native tree species.

The “structure focus” solution mitigates the risks to public and private property, while minimizing long-term maintenance requirements and limiting the impact to the natural environment.

The use of stormwater Low Impact Development (LID) measures within the upstream development area is also recommended in conjunction with the preferred solution to reduce the runoff conveyed to the Blue Willow SWM facility over the long term. LID retrofits can be considered when roads and services are replaced at the end of their life cycles.

Following the alternative assessment, a functional design was prepared (see Document 3). Detailed design of the recommended measures is expected to start by the end of 2022 with construction starting in late 2023.

FINANCIAL IMPLICATIONS

The total Class C capital cost estimate for the recommended alternative is $2.6 million (2022 dollars), which includes engineering, contingencies and related City costs.

Funding to complete the detailed design of the recommended measures is available from 909815 - 2020 ORAP WES Phase 2. Funding to complete construction will be sought through the 2023 capital budget process.

LEGAL IMPLICATIONS

There are no legal impediments to the adoption of the recommendation in this report.

COMMENTS BY THE WARD COUNCILLOR(S)

Councillor Dudas is aware of this project and does not have any comments on the study or the recommended measures.

CONSULTATION

Public consultation and communication efforts undertaken included the following:

The Technical Advisory Committee (TAC) was comprised of City staff from a variety of departments, and representatives from the Ministry of the Environment, the Ministry of Natural Resources, and Rideau Valley Conservation Authority. The TAC met twice during the study - on February 12, 2021, and December 10, 2021 and provided advice and guidance to the study team on a range of issues. Meeting minutes are provided in Document 1.

Public Consultation: The results of the existing condition assessment were presented at a virtual public meeting on March 31, 2021. A second virtual public meeting was held on March 30, 2022 to present the results of the alternative assessment and the functional design for the recommended solution. Comments received at the 2021 and 2022 virtual public meetings are summarized in Document 4. The bilingual and AODA accessible boards from the presentations as well as an FAQ document were also posted on the City's website.

Public Notification: For both public meetings, a Notice of Public Meeting was published in the local newspaper and advertised on the Councillor's webpage. A geotargeted ad was also posted on Facebook and Twitter for a two-week period and an invitation letter was hand delivered to every home backing onto the ravine (43 homes). Approximately 10-15 people registered for both events.

Communication with Local Councillor: From the very beginning of the study, direct communication was established with Councillor Dudas, who attended both public meetings.

ACCESSIBILITY IMPACTS

The existing pathway running from the playground structure to Auburn Ridge Drive will be closed during construction. There are no other accessibility implications associated with this report.

ASSET MANAGEMENT IMPLICATIONS

The recommendations documented in this report are consistent with the City's Comprehensive Asset Management (CAM) Program (City of Ottawa Comprehensive Asset Management Program) objectives.

The Class Environmental Assessment Study for the Ruisseau Park Ravine Rehabilitation supports a forward-looking approach to provide long term protection to existing private and public properties and infrastructure. Operation, maintenance and capital renewal works associated with the proposed recommendations are consistent with current practice. The anticipated ongoing operation, maintenance and future renewal costs will be captured as part of future budget updates, Long Range Financial Plans and Asset Management Plans.

CLIMATE IMPLICATIONS

There are no climate implications associated with the project.

ENVIRONMENTAL IMPLICATIONS

The Ruisseau Park Ravine Rehabilitation project was classified as a Schedule B project which involved the identification of potential adverse environmental impacts and mitigation measures associated with each alterative. The implementation of the recommended measures will require significant tree removal in locations that will undergo significant alteration. During detailed design, Forestry Services will be consulted to identify the trees to be removed and ensure the tree canopy will be replaced with a diverse selection of native tree species.

RISK MANAGEMENT IMPLICATIONS

There are risk implications until the recommended measures are implemented. Of particular concern is the creek bank at the rear of 13 Sprucewood Place, where active erosion is threatening the stability of an existing retaining wall. To mitigate this risk, the City has retained the services of a geotechnical expert to monitor the areas of concern and report on any significant change. Interim protection measures may be implemented if the conditions in this area were to rapidly change. Implementation of the measures recommended in this report will reduce the risk of slope instability within the ravine and protect existing property and infrastructure.

RURAL IMPLICATIONS

There are no rural implications. The entirety of the proposed recommendations will be implemented within the urban boundary and will not have any effect outside the limits of the project.

TERM OF COUNCIL PRIORITIES

The project is consistent with the long-term sustainability goals for stormwater management. Implementation of the recommended measures will ensure that erosion risks are properly managed.

SUPPORTING DOCUMENTATION

Document 1: Ruisseau Park Ravine Rehabilitation, Class Environmental Assessment

Document 2: Study Area

Document 3: Functional Design

Document 4: Comments from the Public

DISPOSITION

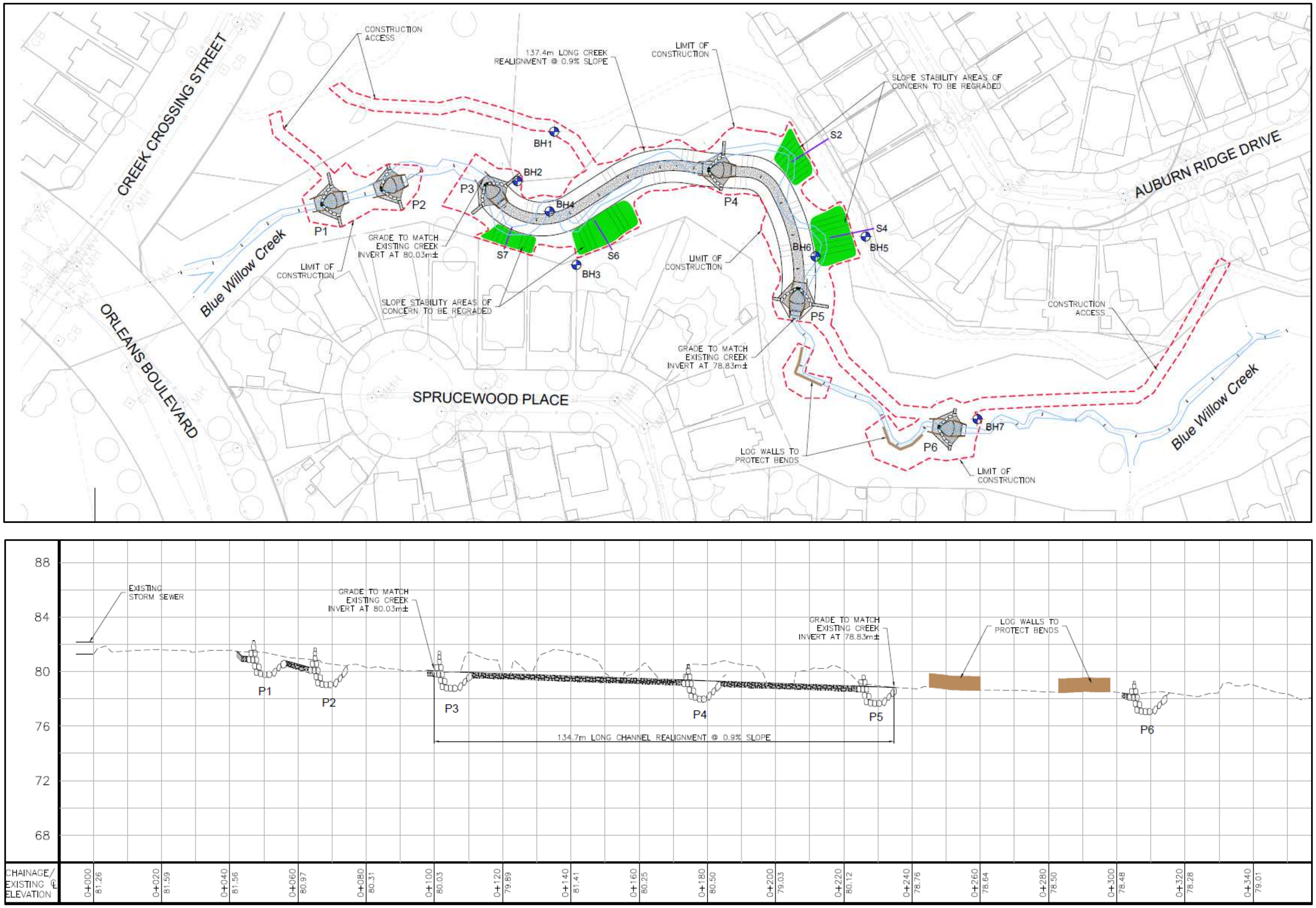
Should Committee and Council approve the Ruisseau Park Ravine Rehabilitation Class Environmental Assessment and Functional Design, the report will be made available to the public for a 30-day review period in accordance with the Ontario Municipal Class Environmental Assessment Schedule “B” process. If no request is received within the review period specified in the Notice, the City will proceed to detailed design and construction of the project.

City staff will ensure the recommendations to minimize the disturbance to the natural environment are incorporated in the detailed design of the measures. City staff will also continue monitoring the areas of concern within the channel until the recommended measures are implemented.

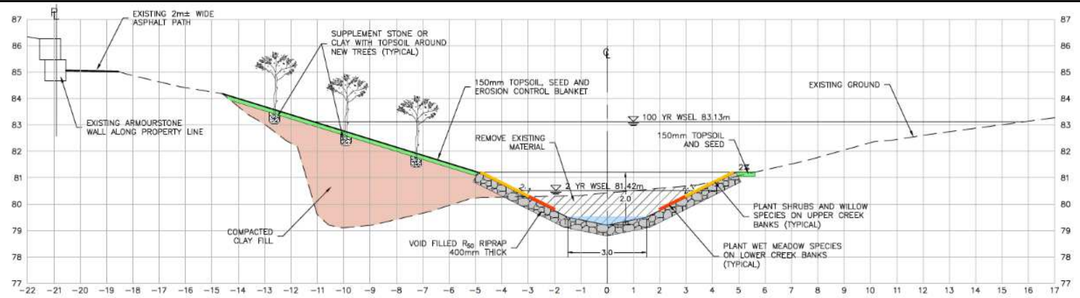
Document 2 – Study Area

Document 3 – Functional Design

Plan and Profile

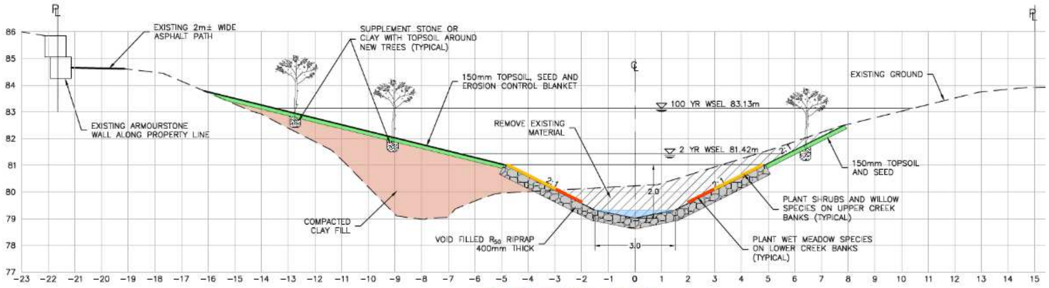


Sections



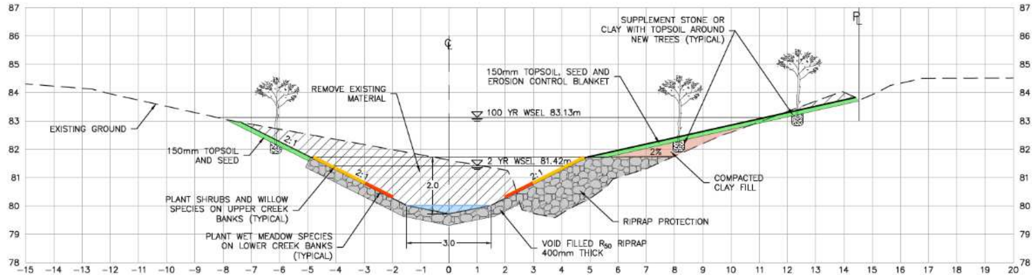
SLOPE S2 (0+092.6)

SCALE 1:100



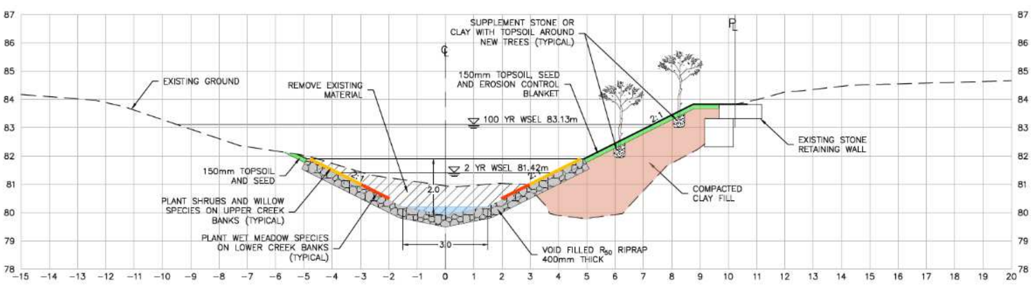
SLOPE S4 (0+113.2)

SCALE 1:100



SLOPE S6 (0+035)

SCALE 1:100



SLOPE S7 (0+015)

SCALE 1:100

Document 4 – Summary of Public Comments and Responses:

A total of 21 and 31 comments were received as part of the first and second public meetings that took place on March 31, 2021 and March 30, 2022 respectively. Major themes heard from the public included the loss of vegetation and replanting, the impact to the existing pathways, the construction schedule and future public consultation opportunities.

Responses to key concerns and questions raised by the public were provided and are summarized below:

- **Loss of vegetation and replanting:** Tree removal is required to stabilize existing slopes, realign the channel and construct erosion control measures. The project team recognizes the value of existing mature trees and has prioritized minimizing the extent of tree removal. The number of trees to be removed will be confirmed during detailed design through consultation with Forestry Services. The existing tree canopy will be replaced with a diverse selection of tree species. Naturalization of the creek corridor is expected within 3-5 years with fast growing shrubs and grasses.

- **Impact to the existing pathway:** The existing pathway running from the playground structure to Auburn Ridge Drive will be closed during construction, however the current pathway alignment will remain unchanged after construction. It is not anticipated that a detour will be required during the closure of the pathway. The playground structure will likely remain open during construction activities with proper construction fencing around the work area to ensure public safety at all times.

- **Construction schedule:** For City construction projects, it is common to assume one year for detailed design and one additional year for construction. The intent is to start construction as soon as possible and to minimize the duration of construction. Meanwhile, the City has retained the services of geotechnical experts to observe and monitor the slopes of concern through regular site visits. Interim protection measures can be implemented if warranted.

- **Future public consultation opportunities:** After Council approval of the study recommendations, the Class Environmental Assessment report and functional design will be available for consultation for a 30-day review period. Construction

Services will also be advised of the significant public interest in the project and resident requests to remain updated during the next phases of the project.

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURE 2 & 3 - SLOPE STABILITY SECTIONS

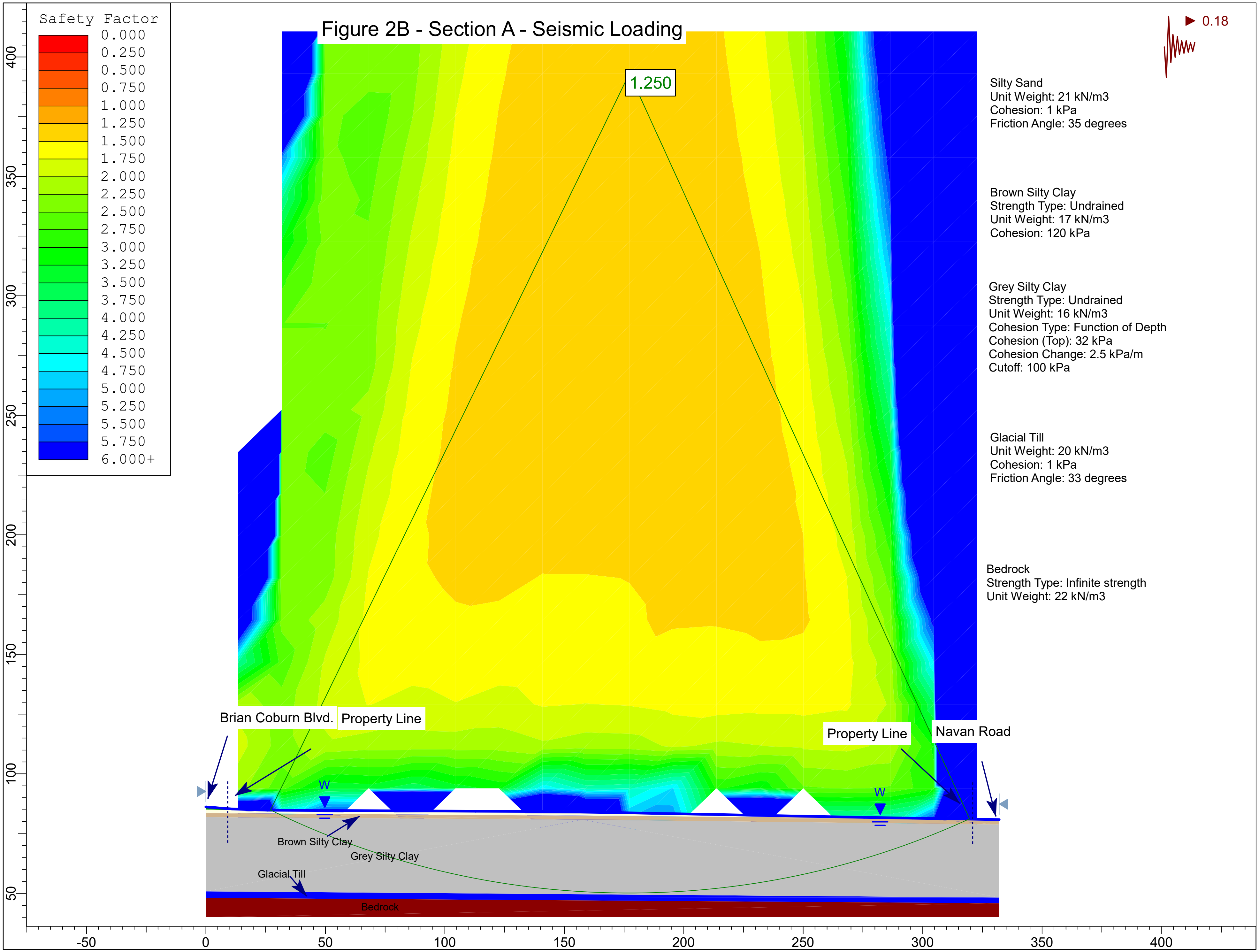
DRAWING PG6142-1 - TEST HOLE LOCATION PLAN

FIGURE 1

KEY PLAN

Figure 2A - Section A - Static Loading

Figure 2B - Section A - Seismic Loading



Silty Sand
Unit Weight: 21 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees

Brown Silty Clay
Strength Type: Undrained
Unit Weight: 17 kN/m3
Cohesion: 120 kPa

Grey Silty Clay
Strength Type: Undrained
Unit Weight: 16 kN/m3
Cohesion Type: Function of Depth
Cohesion (Top): 32 kPa
Cohesion Change: 2.5 kPa/m
Cutoff: 100 kPa

Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 33 degrees

Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3

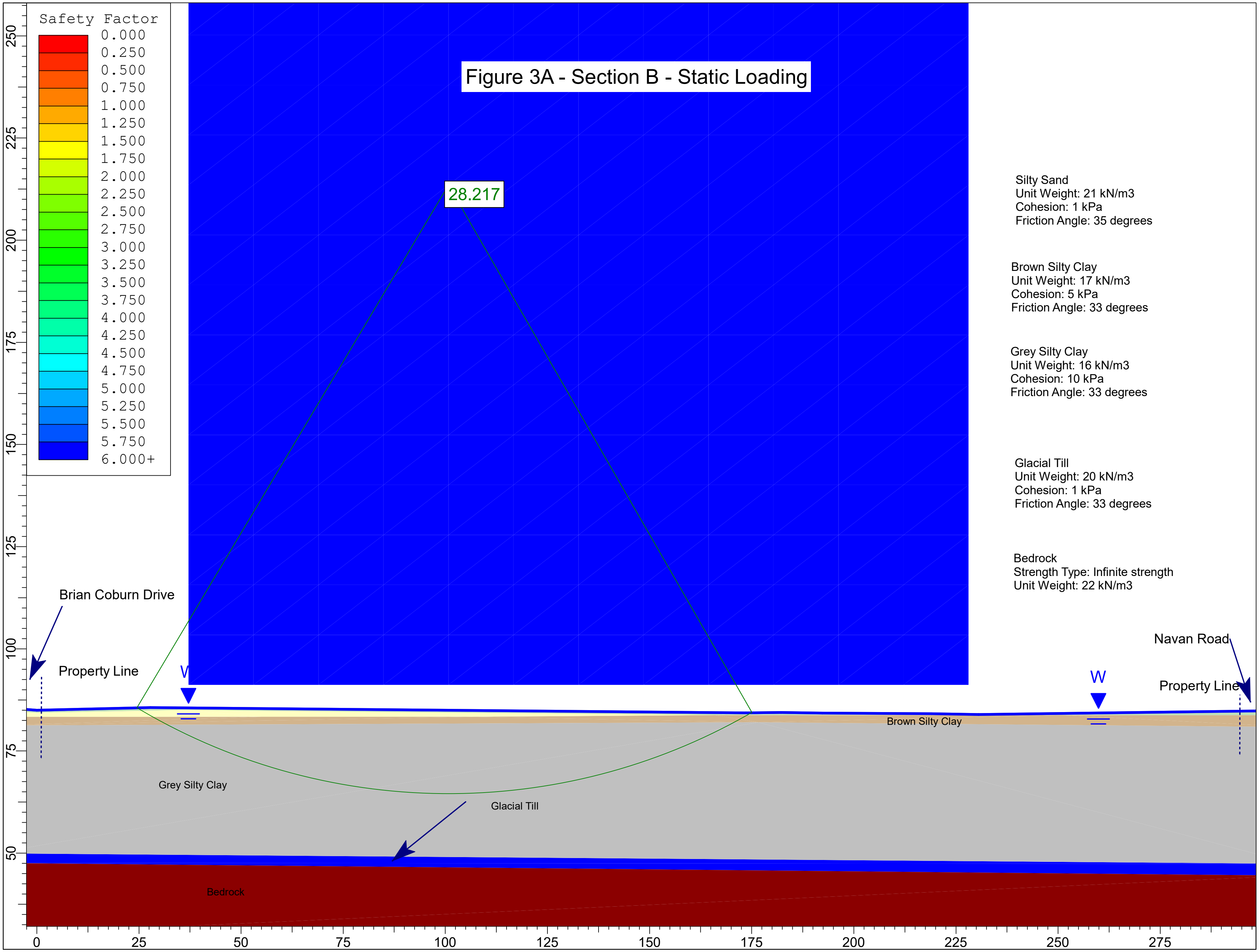


Figure 3A - Section B - Static Loading

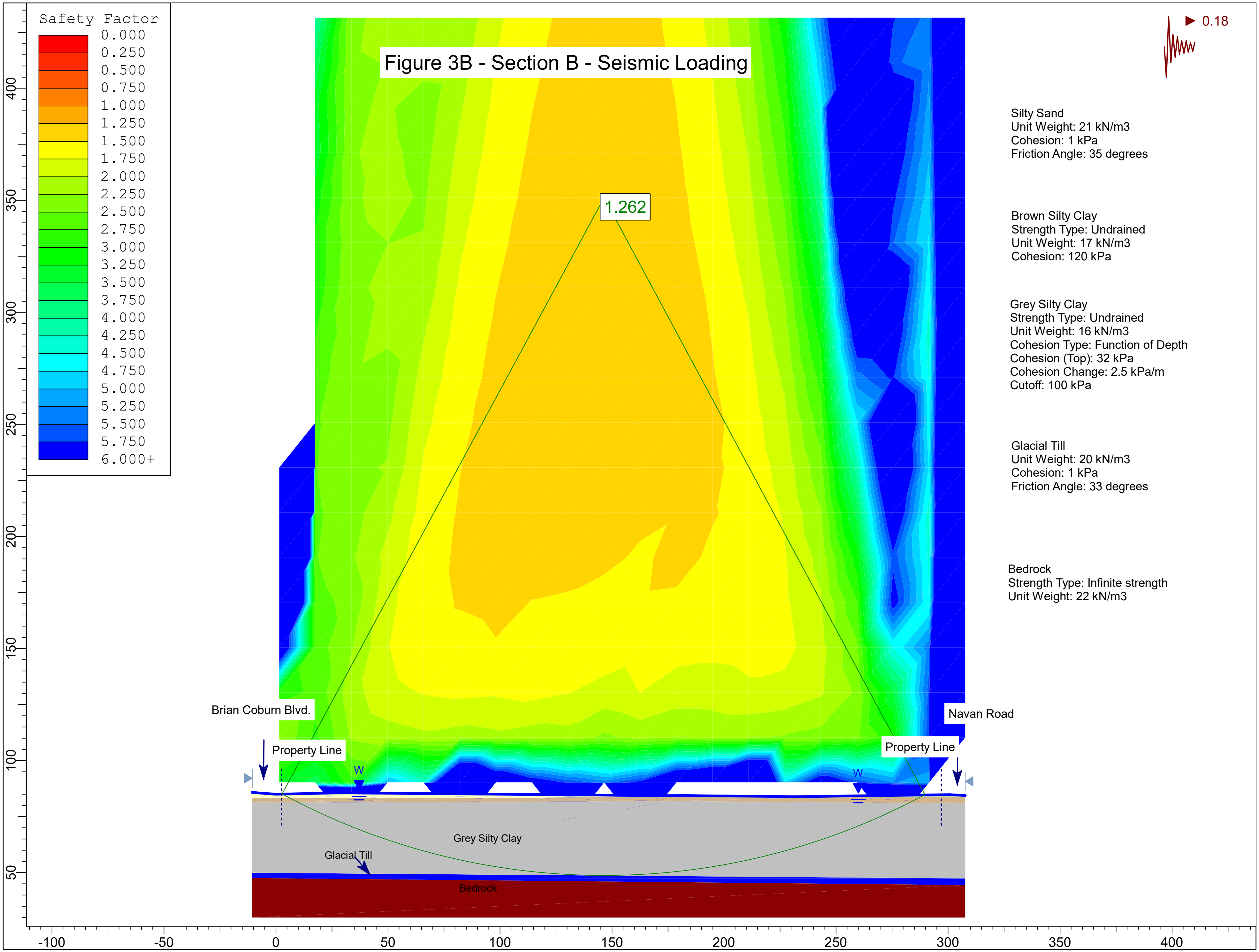


Figure 3B - Section B - Seismic Loading

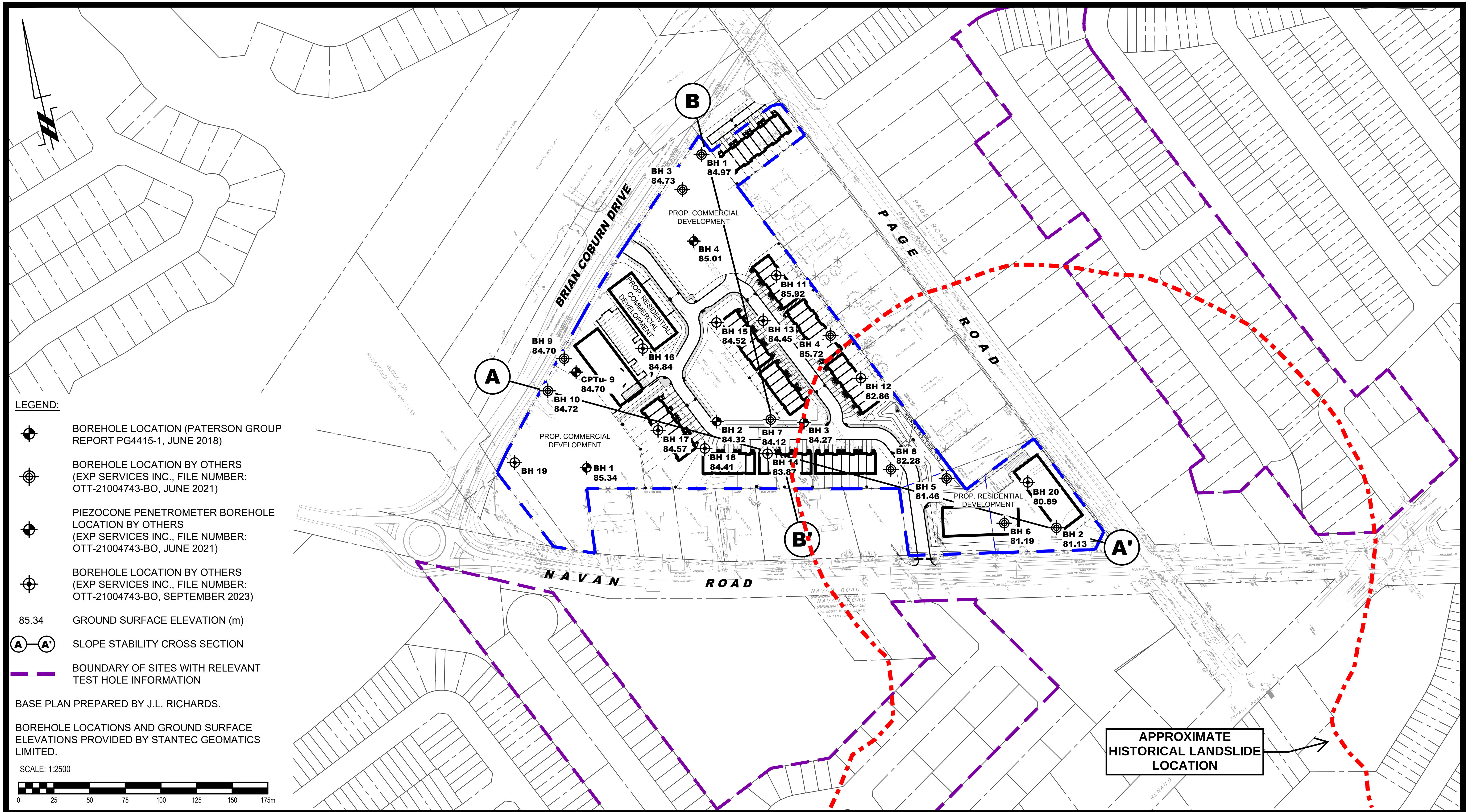
Silty Sand
Unit Weight: 21 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees

Brown Silty Clay
Strength Type: Undrained
Unit Weight: 17 kN/m3
Cohesion: 120 kPa

Grey Silty Clay
Strength Type: Undrained
Unit Weight: 16 kN/m3
Cohesion Type: Function of Depth
Cohesion (Top): 32 kPa
Cohesion Change: 2.5 kPa/m
Cutoff: 100 kPa

Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 33 degrees

Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3



LEGEND:

⌖ BOREHOLE LOCATION (PATERSON GROUP REPORT PG4415-1, JUNE 2018)

⌖ BOREHOLE LOCATION BY OTHERS (EXP SERVICES INC., FILE NUMBER: OTT-21004743-BO, JUNE 2021)

⌖ PIEZOCONE PENETROMETER BOREHOLE LOCATION BY OTHERS (EXP SERVICES INC., FILE NUMBER: OTT-21004743-BO, JUNE 2021)

⌖ BOREHOLE LOCATION BY OTHERS (EXP SERVICES INC., FILE NUMBER: OTT-21004743-BO, SEPTEMBER 2023)

85.34 GROUND SURFACE ELEVATION (m)

A—A' SLOPE STABILITY CROSS SECTION

— — BOUNDARY OF SITES WITH RELEVANT TEST HOLE INFORMATION

BASE PLAN PREPARED BY J.L. RICHARDS.

BOREHOLE LOCATIONS AND GROUND SURFACE ELEVATIONS PROVIDED BY STANTEC GEOMATICS LIMITED.

SCALE: 1:2500

0 25 50 75 100 125 150 175m

PATERSON GROUP
9 AURIGA DRIVE
OTTAWA, ON
K2E 7T9
TEL: (613) 226-7381

NO.	REVISIONS	DATE	INITIAL
1	UPDATED BASE PLAN & ADDED 2023 EXP BOREHOLE LOCATIONS	28/06/2024	FC

EXP SERVICES INC. c/o 12714001 CANADA INC.

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
2983, 3053 & 3079 NAVAN ROAD

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:2500
Date: 02/2022
Drawn by: YA
Report No.: PG6142-1
Checked by: FC
Dwg. No.: PG6142-1
Approved by: DJG
Revision No.: 1

11x17

p:\autocad drawings\geotechnical\pg61xx\pg6142\pg6142-1-test hole location plan (rev.01).dwg