Geotechnical Engineering

Environmental Engineering

Hydrogeology

Geological Engineering

Materials Testing

Building Science

Noise and Vibration Studies

patersongroup

Landslide Risk Assessment

Proposed St. Faustina Parish
2835 Old Montreal Road
Ottawa, Ontario

Prepared For

Mr. Ned Lathrop

March 22, 2022

Report: PG4197-2

Paterson Group Inc.
Consulting Engineers
154 Colonnade Road South
Ottawa (Nepean), Ontario
Canada K2E 7S8

Tel: (613) 226-7381
Fax: (613) 226-6344
www.patersongroup.ca

Table of Contents

PAGE

1.0 Introduction 1
1.1 Purpose of Study and Scope of Work 1
1.2 Risk Assessment Methodology 1
1.3 Proposed Development 2
1.4 Review of Previous Geotechnical Investigation 2
2.0 Background of Study Area 3
2.1 Field Investigation and Observations 3
2.2 Existing Conditions 4
3.0 Slope Stability Analysis 6
3.1 Static Loading Analysis 8
3.2 Seismic Loading Analysis 8
3.3 Limit of Hazard Lands 9
4.0 Landslide Hazard and Risk Assessment 10
4.1 General Methodology of Assessment 10
4.2 Factors Affecting Landslide Susceptibility 10
4.2.1 Clay Overburden 11
4.2.2 Bedrock Depth and Surface Relief 13
4.2.3 Groundwater and Toe Erosion 15
4.2.4 Proximity to Landslides 16
4.2.5 Earthquakes 17
4.3 Hazard Assessment 18
5.0 Conclusion 22
6.0 Statement of Limitations 23
7.0 Literature References 24

Appendices

Appendix 1

Borehole Logs by Others
Laboratory Test Results by Others
Earthquakes Canada Seismic Hazard (NBCC 2015)
Table 1 – Summary of Reviewed Landslide Inventory Data

Appendix 2

Figure 1 - Key Plan
Figures 2 & 3 – Slope Stability Analysis Cross-Sections
Figure 4 – LiDAR Image of Area of Subject Site
Drawing PG4197-1 – Test Hole Location Plan

1.0 Introduction

1.1 Purpose of Study and Scope of Work

Paterson Group (Paterson) was commissioned by Mr. Ned Lathrop to conduct a landslide risk assessment for the proposed Saint Faustina Parish to be located at 2835 Old Montreal 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 risk 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 Risk Assessment Methodology

The methodology of this study was undertaken using a combination of the criteria and requirements set out by the following risk assessment 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 assessment 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.

Further, Paterson reviewed the exiting test hole information for geotechnical investigation carried out by others throughout the subject site as part of this assessment. Review of publicly available well records located in close proximity to the subject site were also reviewed and considered as part of our assessment.

1.3 Proposed Development

It is expected that the proposed development will consist of a one-storey church building with a basement level and a bell tower structure. Associated at-grade parking areas, access lanes and landscaped areas are also anticipated as part of the proposed development. It is further anticipated that the site will be privately serviced.

1.4 Review of Previous Geotechnical Investigation

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

- ❏ Report prepared for Michael Falardeau, Archdiocese of Ottawa - Geotechnical Report - Old Montreal Road, Cumberland (City of Ottawa) – Project No. OCP-17-0077, dated April 2017.

- ❏ Report prepared for Novatech Engineering Consultants - Geotechnical Investigation - Proposed St. Margaret Mary's Church - Old Montreal Road, Ottawa, Ontario – PG4197-1 dated August 2, 2017.

- ❏ Report prepared for Mr. Ned Lathrop - Geotechnical Investigation - Proposed St. Faustina Parish - 2835 Old Montreal Road, Ottawa, Ontario – PG4197-1 Revision 1 dated March 22, 2022.

Relevant test hole information and locations are presented on the Drawing PG4197-1 - Test Hole Location Plan in Appendix 2.

2.0 Background of Study Area

2.1 Field Investigation and Observations

Geotechnical Investigations

A field investigation program was completed at the subject site by others on March 13, 2017 and April 21, 2017. At that time, a total of five (5) boreholes and ten (10) test pits were completed across the subject site to a maximum depth of 10.1 m below the ground surface. It is understood that the boreholes were completed using a track mounted drill rig. The test hole locations are shown on Drawing PG4197-1 - Test Hole Location Plan included in Appendix 2.

Sampling and In Situ Testing

It is understood that soil samples were collected from the boreholes using a 51 mm open diameter split-spoon (SS) sampler. The depths at which the samples were recovered from the split-spoon are shown as SS on the Borehole Logs by Others in Appendix 1.

It is also understood that a Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split-spoon samples. The SPT results are recorded as “blows/0.3m” values on the Borehole Logs by Others. The overburden thickness was evaluated by a dynamic cone penetration test (DCPT) completed at BH 17-2, BH 17-3 and BH 17-5.

It is further understood that undrained shear strength testing was carried out in cohesive soils using a field vane apparatus.

Reference should be made to the Borehole Logs by Others presented in Appendix 1 for specific details of the soil profile encountered at the test hole locations.

Groundwater

Borehole BH 17-2 was fitted with a flexible standpipe piezometer to allow for groundwater level monitoring. Groundwater level observations are discussed in Section 4.3 and are presented in the Borehole Logs by Others in Appendix 1.

Field Survey

The test hole locations and ground surface elevations were surveyed by others. It is understood that a level was used to obtain relative borehole elevations. All reported elevations are referenced to the base of a hydro pole with an assumed elevation of 100.0 m. The location of the test holes and ground surface elevation at each test hole location are presented on Drawing PG4197-1 – Test Hole Location Plan in Appendix 2.

Geotechnical Laboratory Testing

It is understood that the soil samples recovered from the field investigation completed by others were examined in the laboratory. At that time, two (2) samples were submitted for grain size distribution analysis, two (2) samples were submitted for Atterberg limits testing and moisture content testing was completed on all recovered soil samples from all boreholes. The results of the testing are presented on Laboratory Test Results by Others presented in Appendix 1.

2.2 Existing Conditions

Surface Conditions

The subject site is currently undeveloped and generally vacant. The existing ground surface slopes down from southwest to northeast, towards the Ottawa River.

The site is bordered to the north by Regional Road 174 followed by the Ottawa River, to the east and west by residential properties and to the south by Old Montreal Road. The existing ground surface across the subject site is relatively flat and at grade with surrounding roadways and properties. The area following Regional Road 174 and along Ottawa River is composed of a sloped terrain and valley corridors.

Due to the presence of the slopes bordering the Ottawa River and their proximity to the subject site, a slope stability assessment was carried out considering the slope conditions present in the subject site and described above. The results of the slope stability assessment are discussed further in Subsection 6.7 of this report.

Subsurface Conditions

Generally, the subsurface profile encountered at the test hole locations consisted of a thin layer of topsoil overlying a silty clay deposit. The topsoil was underlain by a layer of silty sand at boreholes BH 17-1, BH 17-3, and BH 17-5.

The silty sand deposit generally consisted of loose brown sand. The deposit was observed to extend to approximate depths ranging from 1.2 m to 5.8 m below ground surface.

The silty clay deposit generally consisted of a stiff brown weathered crust and/or a firm grey silty clay. The weathered crust was observed at boreholes BH 17-2 and BH 17-4 extending to depths ranging between 1.8 and 2.1 m below ground surface. The firm grey silty clay deposit was observed at all boreholes.

Practical refusal to DCPT was encountered at an approximate depth of 16 m, 16.1 m and 17.4 m below existing ground surface at the location of boreholes BH 17-2, BH 17-3 and BH 17-5, respectively.

Reference should be made to the Borehole Logs by Others presented in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Bedrock

Based on available geological mapping, the bedrock in the subject site consists of Paleozoic Dolomite of the Oxford formation with an overburden drift thickness of 10 to 50 m depth. Public well records in close proximity to the subject site indicate bedrock present at a depth of 19.3 m below ground surface.

Groundwater

Groundwater levels were measured by others in the installed piezometer at borehole BH 17-2 approximately 3 weeks after completion of the drilling program. Observations are presented in the Borehole Logs by Others in Appendix 1 and in Table 1 below.

Table 1 - Summary of Groundwater Level Readings

Borehole Number	Ground Elevation (m)	Groundwater Levels (m)	
		Depth	Elevation
BH 17-2	101.30	2.00	99.30

It should be noted that surface water can become trapped within a backfilled borehole that can lead to higher than typical groundwater level observations.

Long-term groundwater levels can also be estimated based on the observed color, moisture levels and consistency of the recovered samples. Based on our interpretation of the observations by other, the long-term groundwater level is expected between 3.0 and 5.0 m depth. However, it should be noted that groundwater levels are subject to seasonal fluctuations and, therefore, the groundwater level could vary at the time of construction.

3.0 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 than the risks of failure are acceptable. A minimum factor of safety of 1.5 is generally recommended for conditions where the failure of the slope would endanger permanent structures.

The cross-sections for existing conditions were analyzed utilizing the latest topographic mapping and assuming the worst-case-scenario by assigning cohesive soils under fully saturated conditions. Subsoil conditions at the sections were determined based on the findings at borehole locations along the top of slope and general knowledge of the geology of the area. The soil parameters were determined for the slope soils based on subsoil conditions at the boreholes along the top of slope. 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 2 below.

Table 2 - Effective Soil and Material Parameters (Static Analysis)			
Soil Layer	**Unit Weight (kN/m^3)**	**Friction Angle (degrees)**	**Cohesion (kPa)**
Topsoil	16	33	5
Silty Sand	20	35	0
Brown Silty Clay Crust	17	33	5
Grey Silty Clay	16	33	10
Glacial Till	20	33	2
Bedrock	22	Infinite Strength	

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 area's geology. The strength parameters used for seismic analysis at the slope cross-sections are presented in Table 3 below.

Table 3 - Total Stress Soil and Material Parameters (Seismic Analysis)			
Soil Layer	**Unit Weight (kN/m^3)**	**Friction Angle (degrees)**	**Undrained Shear Strength (kPa)**
Topsoil	16	33	5
Silty Sand	20	35	0
Brown Silty Clay Crust	17	-	120
Grey Silty Clay	16	-	70
Glacial Till	20	33	N/A
Bedrock	22	Infinite Strength	

The location of the cross-sections analyzed are presented on Drawing PG4197-1 - Test Hole Location Plan enclosed.

3.1 Static Loading Analysis

The results for the static analysis at the subject site are presented in Figures 2A and 3A in Appendix 2. The slope stability factors of safety were found to be greater than 1.5 at all sections analyzed. As a result, the slope is considered stable under static conditions.

3.2 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 0.21g was considered for the analyzed section and discussed further in Section 4.2.6 of this report.

This acceleration is considered to be higher than half of the peak (horizontal) ground acceleration (PGA) of 0.312g, specified in the National Building Code of Canada (NBCC 2015) Seismic calculator for the subject site. The above-noted specified PGA is considered to have a probability of exceedance of 2% in 50 years (i.e.,1:2,475 years) for the subject site. Based on a trendline considering the PGA values assigned for different probabilities of exceedance, a PGA equal to 0.21g may be approximately estimated to be equivalent to a probability of exceedance of 4% in 50 years (i.e., 1:1,250 years).

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 Figures 2B and 3B in Appendix 2. The overall slope stability factor of safety at all slope cross-sections when considering seismic loading was found to be greater than 1.1 which is considered to be stable under seismic loading.

Stable Slope Allowance

The stable slope limit is usually defined by the extent of the lowest slip circle (failure slip plains) analyzed behind the top of slope where the minimum factor of safety calculated is less than 1.5. The minimum factor of safety was calculated for the two sections analyzed to be above the recommended 1.5 under static conditions and above the recommended factor of safety of 1.1 under seismic loading. Therefore, the slope is defined as stable, and a stable slope allowance is not required from a geotechnical perspective.

3.3 Limit of Hazard Lands

Slope Condition Field Review

The slope stability analysis was completed using topographical mapping. Two slope cross-sections were studied along the slopes bordering the subject site. The cross-section locations are presented on Drawings PG4197-1 - Test Hole Location Plan in Appendix 2.

The toe erosion allowance for the slope is based on the cohesive nature of the top layers of the subsoils, the observed current erosional activities, and the width and location of the current watercourse. Since the toe of slope located along the Ottawa River is protected from erosion by shoreline protection measures, it is our opinion that no toe erosion allowance setback is required form a geotechnical perspective.

Based on the City of Ottawa guidelines for slope stability, where the development precludes an access for construction equipment such as a parking lot, access lanes, etc., a 6 m erosion access allowance should be provided. Therefore, an erosion access allowance of 6 m has been recommended from the top of slope.

Based on the above-note observations, a 6 m setback from the top of the current slope has been provided at the subject site. The limit of hazard lands is presented on Drawing PG4197-1 - Test Hole Location Plan in Appendix 2.

The existing vegetation on the slope faces and shoreline protection along the bank of the Ottawa River should not be removed as it contributes to the stability of the slope and mitigates the potential for impacts to the slope stability by the means of toe erosion.

Seismic Design Considerations

Based on the results of the geotechnical investigation, a seismic **Site Class D** 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.

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:

- ❑ Identification of factors that are documented to contribute to the susceptibility for a landslide to occur throughout sloped terrain.
- ❑ Explore the factor to relate how it would affect 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:

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

Where R = the risk or annual probability of loss of life of an individual, P(H) = the annual probability that a landslide occurs, P(S:H) = the probability of impacting the elements taking into consideration the scale and location of the landslide events, P(T:S) = 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 = the vulnerability, or likelihood of death or permanent injury of the individual given they are impacted and E = the number of elements that would be impacted. E will also be considered the number of occupants for the grouped areas.

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 slope profiles throughout the subject site consist primarily of a silty clay deposit underlain by an inferred relatively thin layer of glacial till and further by bedrock. Based on geological mapping undertaken by the Geological Survey of Canada under Open File 5311, the local deposit is considered as offshore marine sediments consisting of erosional terraces.

The clay deposit encountered throughout the northern portion of the subject site was observed to consist of a stiff, weathered, brown clay crust extending to depths between 1.8 and 2.1 m below the ground surface. Boreholes located at the south portion of the subject site, further from the slope face (BH 17-1, BH 17-3 and BH17-5) were typically observed to consist of a layer of silty sand underlain by grey silty clay. The encountered sand deposit above the clay deposit could potentially form a “sand cap” layer as has been documented throughout the Ottawa Valley.

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. There is some overlap between these three inventories given the background for each document. Open File (OF) 5311 identifies these footprints as “*Landslide Area – Reworked Marine Sediments*”. OF8600 identifies these landslide footprints with greater precision, as it is understood to have been carried using digital elevation models (DEM) and LiDAR imaging for the boundary occupied by the City of Ottawa. OF7432 is a compilation of radiocarbon dates for approximately 45 landslides throughout the Ottawa Valley.

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 been documented that approximately 10 very large (i.e., surface area greater than 1 km^2) landslides in the Ottawa Valley have occurred throughout subsurface profiles containing a surficial sand cap layer (Fransham and Gadd, 1977). This study provided a surficial geology map for the Ottawa Valley identifying areas of sand and gravel overlying clay and areas consisting solely of silt and clay.

The study concluded there is a higher incidence for very large landslides to occur throughout clay deposits with an overlying sand cap. Nearly a hundred additional landslides have been identified by GSC throughout the area of the mapping prepared by Fransham and Gadd. The majority of the more recently documented smaller-sized landslides have occurred throughout the "clay" unit.

The presence of a weathered, clay crust had been considered favorable in resisting the potential for a landslide to occur. However, review of 37 landslides throughout the Ottawa Valley and downstream of the Ottawa River and throughout Champlain Sea marine clay deposits indicate that clay crust and sand-capped clay deposits behave similarly during large retrogressive landslides (Perret, 2019). Based on this, it is inconclusive if the presence of a clay crust may or may not improve the resistance for clay soils to be susceptible to a landslide. Given the subject site considers both scenarios, the effect on landslide susceptibility is considered neutral for the subject site.

Further, studies have related the retrogression of landslides to the undrained shear strength using Taylor's stability number (N_s) as indicated below:

$$N_s = yH/S_u$$

Where y = unit weight of clay (kN/m^3), H = bank height (m) and S_u = peak undrained shear strength (kPa). Analysis of forty landslides determined that N_s should be greater than or equal to 6 for the potential of retrogression to occur (Mitchell & Markell, 1974). Shear strength at the subject site ranges between 40 to 85 kPa for areas where the bank height is observed to be approximately 12 m. Based on this, the worse-case scenario N_s values range between 2.2 and 4.8 and are less than 6, **which would not suggest the potential for retrogression**.

Mitchell and Markell have also explored the sensitivity of clays as a factor in retrogression. They concluded sensitivity for retrogressive clays ranges between 10 to 1,000. The majority of the sensitivity of the clay deposit throughout the subject site has been observed to be less than 10. Although one sampling interval yielded a sensitivity ratio of 11, the sensitivity of the clay deposit throughout the subject site is considered to be on the lower end for Champlain Sea clay deposits.

Therefore, the potential for a very large retrogressive landslide is not considered to be very likely throughout the subject site given the presence of the subsurface profile encountered during the geotechnical investigation.

4.2.2 Bedrock Depth and Surface Relief

Overburden thickness and surface relief 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 generally correlated higher values of drift thickness and surface relief to a higher rate of landslide incidence in Champlain Sea clays (Quinn, 2013). 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 and topographic relief 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 4 and Table 5 below.

Table 4 – Summary of Drift Thickness Throughout Historic Landslide Footprints

Drift Thickness	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	

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.

Table 5 – Summary of Topographic Relief Throughout Historic Landslide Footprints		
Topographic Relief	**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	

Topographic relief was interpreted using DEM provided by Google Earth. Relief was considered as the difference between the lowest and highest elevations between distances extending beyond a landslide footprint. Greater distances were considered where a landslide formed into a slope profile. Significantly large landslides could not be evaluated reasonably 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 more than 15 m of overburden and 10 m of topographic relief throughout the study area. Based on the current test hole coverage and slope stability sections, it is anticipated that the drift thickness at the subject site is about 16 to 19 m. Further, up to 23 m of relief may be observed between the Ottawa River and approximately 150 m south of the southern property boundary of the subject site.

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 accordingly in *Section 4.3 – Hazard Assessment* of this report.

4.2.3 Groundwater and Toe Erosion

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.

Given the relatively deep depth to bedrock and downward gradient of the bedrock profile throughout the subject site, this is not considered to have an impact on the landslide susceptibility. Further, the groundwater regime throughout the subject site is expected to follow general surficial topography such that drainage would be expected to occur from south to north and towards the Ottawa River. Surface drainage features consisting of ditches along the northern and southern boundaries of the subject site divert excessive surface and meltwater from entering and ponding throughout the subject site. Post-development conditions indicate over half of the subject site will be paved with relatively impermeable asphalt. This condition will result in a reduction of subsurface groundwater recharge during spring-melt and a reduction in the risk associated with temporary rises in the groundwater table impacting overall slope stability.

The Ottawa River experiences seasonal variations of flow with higher periods of flow being a result of springtime snowmelt, and periods of low flow during dry summer periods or winter. Periods of heavy springtime flow may also be coupled by temporary rises in the river surface that may extend beyond the confinement of the shoreline. Based on currently published 100-year floodplain mapping prepared by the RVCA, the current 100-year flood plain does not extend into the subject site. Saturation of the toe of slope is expected during temporary periods of flooding by the Ottawa River. However, given the presence of shoreline protection measures undertaken along the Ottawa River and in proximity to the subject site, it is expected there is negligible risk that significant toe erosion will occur that would impact the subject site. Therefore, the presence of the Ottawa River is not believed to significantly impact slope stability or landslide susceptibility throughout the subject site.

Fully saturated slope conditions have been considered as part of our slope stability assessment in Section 3.1 of this report. The slope stability factors of safety were found to be greater than 1.5 and 1.1 at all sections analyzed for static and seismic loading conditions, respectively. Therefore, a stable slope allowance is not considered applicable to the Limit of Hazard Lands line depicted on Drawing PG4197-1 – Test Hole Location plan in Appendix 2 of this report. Further, seasonal fluctuations in the groundwater table and the Ottawa River flow rates and/or current floodplain limits would not impact landslide susceptibility.

4.2.4 Proximity to Landslides

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 there is between 49.2 and 96.7% likelihood of a landslide in areas located less than 50 to 2,000 m from a previous landslide event (Quinn et al., 2011). It is further documented that areas that have previously been affected by landslide events are more vulnerable to experiencing new landslides. 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.

Landslide inventory mapping published by GSC indicates the presence of potentially up to two landslides within a proximity of 2 km to the subject site and are depicted on Figure 4 in Appendix 2 of this report. Landslide "Cbl3" is located 350 m east of the subject stie and Cbl2 is located 750 m southwest of the subject site. The area of Cbl2 and Cbl3 experience approximately 10 to 20 m of topographic relief, respectively and a relatively steep (i.e., over 20 degrees) slope along their flank. Drift thickness throughout the area of Cbl2 and Cbl3 range between 15 to 25 m and 50 to 100 m, respectively.

According to GSC files OF8600, Cbl2 retrogressed along the south side of the Ottawa River. However, the landslide's source area and debris lobe are heavily modified by the presence of a residential subdivision development. Review of topographic mapping indicate Cbl2 occurred along the bank of the former paleo-island formed by the proto-Ottawa River. Cbl3 retrogressed into the scarp slope formed along the margin of the proto-Ottawa River terrace. Cbl3's debris field forms a lobe into the Ottawa River and has a scarp distinctly one-step lower in height than Cbl2. Cbl3 is anticipated to be relatively young (i.e., less than 2,000 years) (OF8600, 2019).

Based on our review, Cbl2 does not share parameters of susceptibility with Cbl3, nor with the subject site. As such, it is not considered indicative of a higher probability for a landslide to occur throughout the subject site.

Further, given Cbl3 splayed into the Ottawa River and retrogressed into the terrace of the paleo-island, it is speculated that this landslide may have been triggered by extensive toe erosion by the proto-Ottawa River. This trigger factor was discussed in Section 4.2.3 of this report and was not considered to currently affect landslide susceptibility given the improved shoreline protection against toe erosion with respect to the currently established Ottawa River watercourse alignment. Therefore, it is not considered that the presence of Cbl3 indicates a higher likelihood of a landslide to occur to throughout the subject site.

Although the subject site does not share many of the attributes that may have contributed to the formation of the nearby landslides, its proximity to historical landslides is significant. Based on this review, it is considered appropriate and conservative to increase the baseline probability for a landslide to occur throughout the subject by one order of magnitude to account for this frequency of local incidences.

4.2.5 Earthquakes

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 exist and has generally been assessed as part of our slope stability analysis. Pseudo-static (seismic) loading of the slope profiles considered a PGA of 0.21g and resulted in factors of safety exceeding 1.1 as discussed in Section 3.0 of this report. This PGA is considered equivalent to a 1:1,250-year earthquake event. This value is considered suitable for assessing the stability of the subject slopes when subject to loading that may be associated with earthquakes experienced locally.

Further, larger landslides are understood to be associated with clay deposits with remolded shear strength is equal to or less than 1 kPa (Quinn et al., 2011). It would be expected clay deposits with such low values of remolded strength to be conductive to propagating planes of weakness and unable to resist high earthquake loads. Review of our test hole coverage, remolded shear strength values typically range between 5 and 14 kPa and exceed the 1 kPa threshold associated with landslides. Based on this, it is not expected a significant shear band would propagate throughout the slopes located throughout the subject site that would increase landslide susceptibility due to earthquake loading.

This conclusion may be extrapolated further to the potential for sources of subsurface vibrations such as those associated with building construction, compaction equipment and general earthworks equipment. These sources of vibrations are not anticipated to exceed or be close to the magnitude of vibrations associated with the assessed earthquake load of 0.21g.

Given the above, earthquake loading is not anticipated to impact landslide susceptibility. This would also be considered unlikely given the relatively shallow relief throughout the majority of the tributary. However, a return period of 1,250 years may be considered the upper bound of the baseline probability for landslides to occur throughout the subject site.

4.3 Hazard Assessment

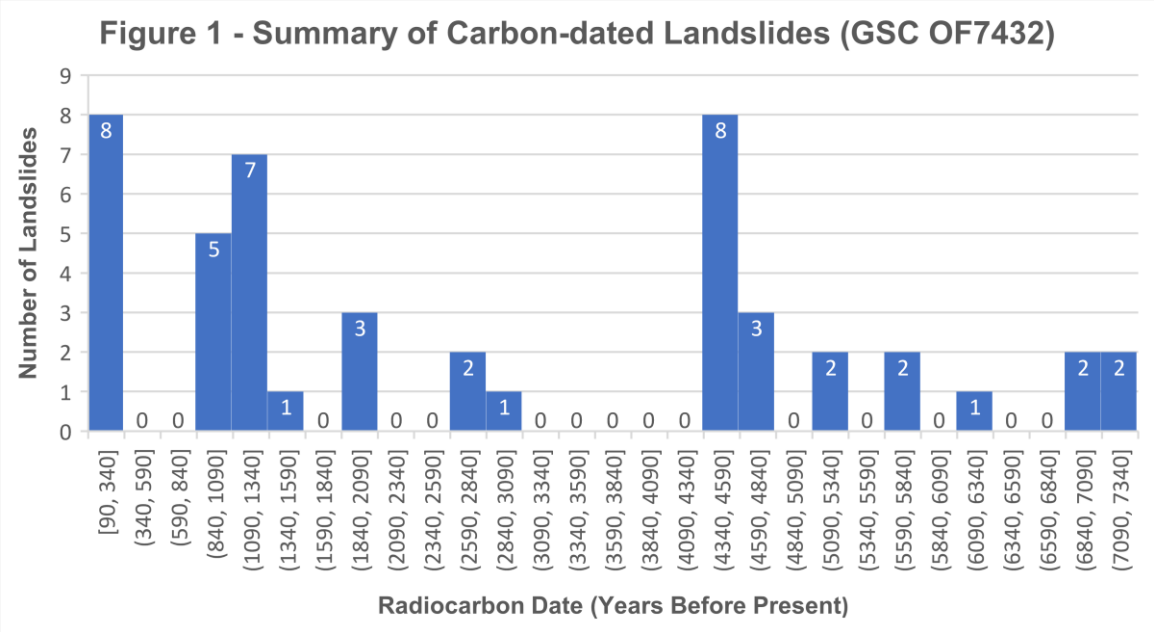
Frequency Estimation Method

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. 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. 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 1 below.



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 75-80,000km^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. The upper bound would be considered approximately 1,250 years as indicated in Subsection 4.2.5. of this report. This would consider a baseline landslide probability of $4.6x10^{-4}$ landslides per km^2 per annum over the study area.

The current baseline probability ($4.6x10^{-4}$ per km^2 per annum) assumes uniform susceptibility across the study area. The baseline estimate may be adjusted based on our judgement of a combination of regional landslide inventories, local site attributes and our experience assessing the performance of slopes comprised of Champlain Sea marine deposits throughout the study area. Based on our review, it had been assessed that the proximity of historic landslides to the subject site was of sufficient significance to increase the estimate by one order of magnitude. Therefore, the baseline probability may be considered as $4.6x10^{-3}$ per km^2 per annum.

Surface relief and drift thickness were also considered notable factors affecting landslide susceptibility, as discussed in Subsection 4.2.2 of this report. The cumulative percentages for each range of these variables were considered as having their own rate of landslide incidence throughout the study area. To consider a percentage as a probability of occurrence, the cumulative percentages were divided by an appropriate return period. The landslide frequency was increased by one order of magnitude accordingly for this purpose (i.e., 5.4 years per landslide).

This was considered appropriate to reflect the potential for smaller localized landslides, or slope failures, to occur on a smaller scale than a large, retrogressive landslide. This return period was not considered as the lower boundary for the occurrence of large landslides (i.e., the baseline probability) as this frequency has not occurred within recent history throughout the study area. However, there is evidence to support smaller localized failures may occur on as little as a summer to winter seasonal basis in some areas.

This was observed by Hugenholtz (2004) in their review of Green's Creek and the concentration of landslides to re-occur throughout concentrated areas along the creek alignment. They had observed as many as 52 landslides of varying sizes and classes over the period of 1928 and 2001 (73 years) using digital photogrammetric techniques. The conditions observed throughout Green's Creek are not considered comparable to the subject site, however, is an example of the potential for more frequent smaller-scale landslides beyond the larger-scale retrogressive slides that are more readily identified. Given this, a return period of one tenth of the large landslide return-period is considered appropriate for the relief and drift thickness variables throughout the subject site.

The probabilities for landslides to occur throughout considering drift thickness and surface relief are estimated accordingly in Table 8 and Table 9, respectively, below:

Table 8 – Summary of Drift Thickness Throughout Historic Landslide Footprints

Drift Thickness (m)	Number of Incidences	%	Probability (5.4-year return period, cumulative)
0 to 1	0	0.0	0.0
1 to 2	0	0.0	0.0
2 to 3	0	0.0	0.0
3 to 5	0	0.0	0.0
5 to 10	8	7.0	0.013
10 to 15	7	6.1	0.024
15 to 25	34	29.8	0.080
25 to 50	49	43.0	0.159
50 to 100	16	14.0	0.185

Table 9 – Summary of Surface Relief Throughout Historic Landslide Footprints

Surface Relief (m)	Number of Incidences	%	Probability (5.4-year return period, cumulative)
0 to 4	0	0.0	0.005
4 to 6	0	0.0	0.008
6 to 8	1	0.9	0.011
8 to 10	2	1.8	0.021
10 to 12	0	0.0	0.034
12 to 14	2	1.8	0.053
14 to 16	0	0.0	0.079
16 to 18	2	1.8	0.092
18 to 20	3	2.7	0.100
20 to 25	3	2.7	0.135
25 to 30	8	7.1	0.154
30 to 40	11	9.7	0.175
>40	16	14.2	0.185

Based on our assessment, the probability for a landslide to occur throughout the subject site has been estimated as **1:20,408 per annum** for a 1:54.1-year return period (product of baseline probability, probability based on cumulative surface relief between 0 and 25 m and probability of landslide occurrence based on cumulative drift thickness between 0 and 25 m).

Based on the above, 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 annum.

5.0 Conclusion

In summary, the St. Faustina Parish development is currently being proposed at the subject site. Several pre-historic landslide events are understood to have taken place in close proximity to the subject site. Based on our review, these landslides have occurred throughout sections of the paleo-island banks and proto-Ottawa River terraces that may have been more susceptible to these hazards than the subject site.

The area was 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 very similar geology throughout the Ottawa region, the annual probability of a large catastrophic landslide occurring at or directly impacting the subject site is estimated to be less than 1:10,000. 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 natural, 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 assessment 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 Mr. Ned Lathrop 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.



Drew Petahtegoose, B. Eng.

David J. Gilbert, P. Eng.

Report Distribution:

- ❑ Mr. Ned Lathrop (email copy)
- ❑ Paterson Group (1 copy)

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 landsliding 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.

[11] 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.

[12] 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.

APPENDIX 1

BOREHOLE LOGS BY OTHERS

LABORATORY TEST RESULTS BY OTHERS

EARTHQUAKES CANADA SEISMIC HAZARD (NBCC 2015)

TABLE 1 – SUMMARY OF REVIEWED LANDSLIDE INVENTORY DATA

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSION AND STRUCUTRAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINT AND BEDDING:

SPACING	50mm	50 300mm	0.3m 1m	1m 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
Φ'	$^{-o}$	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
Φ_u	$^{-o}$	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = ($W_L - W_L$)	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = ($W - W_P$)/ I_P	i	1	HYDAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = ($W_L - W$) / 1_P	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERED SOIL	$e_{,max}$	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-1

1 OF 1

METRIC

DATE 13/03/2017 | LOCATION Old Montreal Rd, Cummberland | ORIGINATED BY MG

ID CP-17-0077 | COORDINATE lat: 45.518563 , lon: -75.395127 | COMPILED BY MG

CLIENT Archdiocese Ottawa | DATUM Assumed | CHECKED BY NT

ELEVATION 103.68

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES (REC)	* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.7	**SNOW**										
103.7 / 0.0											
			1	SS	7		103				
	SAND, loose, wet, brown		2	SS	9		102				
			3	SS	5		101				
100.8 / 2.9			4	SS	2				o		
	CLAY, firm, wet, grey		5	SS	1		100		o		
99.6 / 4.1	**END OF BOREHOLE** *water in sand layer										

$+^{3}$, $\times^{3}$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-2

1 OF 2

METRIC

DATE 10/03/2017
ID CP-17-0077
CLIENT Archdiocese Ottawa
ELEVATION 101.33

LOCATION Old Montreal Rd, Cummberland
COORDINATE lat: 45.519338 , lon: -75.395526
DATUM Assumed

ORIGINATED BY GR
COMPILED BY MG
CHECKED BY NT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES (REC)	* GROUND WATER CONDITIONS
101.3	**SNOW**					
101.1 0.0	**TOPSOIL**					
0.2	**CLAY,** trace sand, trace silt, stiff, desiccated, moist, brown		1	SS	4	
99.5 1.8			2	SS	2	▼
	CLAY, firm, wet, grey		3	TW		
			4	SS	0	
95.7 5.6	Probable **CLAY**					

ELEVATION SCALE: 101, 100, 99, 98, 97, 96, 95, 94, 93, 92

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
25 50 75

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

+ 5
+ 6
+ 10
+ 8

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity
○ $^{3\%}$ STRAIN AT FAILURE

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-2

2 OF 2

METRIC

DATE 10/03/2017
ID CP-17-0077
CLIENT Archdiocese Ottawa
ELEVATION 101.33
LOCATION Old Montreal Rd, Cummberland
COORDINATE lat: 45.519338 , lon: -75.395526
DATUM Assumed
ORIGINATED BY GR
COMPILED BY MG
CHECKED BY NT

SOIL PROFILE			SAMPLES								
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES (REC)	* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Probable **CLAY** *(continued)*						91 / 90 / 89 / 88 / 87 / 86				
86.4 / 14.9	Probable **TILL**										
85.4 / 16.0	**END OF BOREHOLE** Refusal at probable bedrock										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-3

1 OF 2

METRIC

DATE 10/03/2017
ID CP-17-0077
CLIENT Archdiocese Ottawa
ELEVATION 102.68
LOCATION Old Montreal Rd, Cummberland
COORDINATE lat: 45.518973 , lon: -75.394639
DATUM Assumed
ORIGINATED BY GR
COMPILED BY MG
CHECKED BY NT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES (REC)	* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
102.7	**SNOW**										
102.5 0.2	**TOPSOIL**										
			1	SS	9	▼	102				
			2	SS	5		101				
			3	SS	6						0 95 (5)
	SAND, loose, wet, brown		4	SS	2		100				0 98 (2)
			5	SS	4		99				
			6	SS	2		98				
			7	SS	2						
96.9 5.8			8	SS	1		97		○		
							96				Vane Refusal - sand in augers
			9	SS	0		95		○		
	CLAY, firm, wet, grey										Vane Refusal - sand in augers
			10	SS	3		94		○		
							93				Vane Refusal - sand in augers

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-3

2 OF 2

METRIC

DATE 10/03/2017
ID CP-17-0077
CLIENT Archdiocese Ottawa
ELEVATION 102.68
LOCATION Old Montreal Rd, Cummberland
COORDINATE lat: 45.518973 , lon: -75.394639
DATUM Assumed
ORIGINATED BY GR
COMPILED BY MG
CHECKED BY NT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES (REC)	* GROUND WATER CONDITIONS	ELEVATION SCALE
92.6 / 10.1	Probable **CLAY**						92
							91
							90
							89
88.0 / 14.6	Probable **TILL**						88
							87
86.6 / 16.1	**END OF BOREHOLE** Refusal at probable bedrock						

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
25 50 75

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity
$\circ^{3\%}$ STRAIN AT FAILURE

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-4

1 OF 1

METRIC

DATE 13/03/2017
ID CP-17-0077
CLIENT Archdiocese Ottawa
ELEVATION 100.78
LOCATION Old Montreal Rd, Cummberland
COORDINATE lat: 45.519466 , lon: -75.394129
DATUM Assumed
ORIGINATED BY MG
COMPILED BY MG
CHECKED BY NT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES (REC)	* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.8	**SNOW**										
100.6 / 0.2	**TOPSOIL**										
	CLAY, stiff, desiccated, moist, brown		1	SS	7		100				
			2	SS	8		99				
98.6 / 2.1			3	SS	0		98	8, 7			
	CLAY, firm, wet, grey										
97.6 / 3.2	**END OF BOREHOLE**										
	*no water observed in open borehole										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: 20 40 60 80 100
WATER CONTENT (%): 25 50 75

+ ³, × ³: Numbers refer to Sensitivity
○ ³% STRAIN AT FAILURE

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-5

1 OF 2

METRIC

DATE 13/03/2017
ID CP-17-0077
CLIENT Archdiocese Ottawa
ELEVATION 103.3
LOCATION Old Montreal Rd, Cummberland
COORDINATE lat: 45.518673 , lon: -75.393816
DATUM Assumed
ORIGINATED BY MG
COMPILED BY MG
CHECKED BY NT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES (REC)	* GROUND WATER CONDITIONS
103.3 / 0.0	**SNOW**					
103.1 / 0.2	**TOPSOIL**					
	SAND, compact, wet, brown		1	SS	10	
102.1 / 1.2			2	SS	0	
	CLAY, firm, wet, grey		3	SS	0	
			4	SS	0	
98.1 / 5.2	Probable **CLAY**					

ELEVATION SCALE: 103, 102, 101, 100, 99, 98, 97, 96, 95, 94

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
25 50 75

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

McIntosh Perry Consulting Engineers Ltd
1-1329 Gardiners Rd
Kingston, Ontario K7P 0L8

RECORD OF BOREHOLE No 17-5

2 OF 2

METRIC

DATE 13/03/2017
ID CP-17-0077
CLIENT Archdiocese Ottawa
ELEVATION 103.3
LOCATION Old Montreal Rd, Cummberland
COORDINATE lat: 45.518673 , lon: -75.393816
DATUM Assumed
ORIGINATED BY MG
COMPILED BY MG
CHECKED BY NT

SOIL PROFILE			SAMPLES								
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES (REC)	* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Probable **CLAY** *(continued)*						93 92 91 90 89 88 87 86				
87.8 / 15.5	Probable **TILL**										
85.9 / 17.4	**END OF BOREHOLE** *no water observed in open borehole										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Borehole Records

Site Investigation: April 21st, 2017

Logged By: Mary-Ellen Gleeson

TP1:

0 – 255	Sandy Topsoil, trace organics
255 – 560	Sand, brown
560	Clay, stiff, desiccated, wet

Water infiltrating test pit

TP2:

0 – 255	Sandy Topsoil, trace organics
255 – 1000	Sand, brown

Water infiltrating test pit

TP3:

0 – 455	Sandy Topsoil, trace organics
455 – 585	Sand, brown
585	Clay, stiff, desiccated, wet

Water infiltrating test pit

TP4:

0 – 380	Sandy Topsoil, trace organics
380 – 610	Sand, brown
610	Clay, stiff, desiccated, wet

Water infiltrating test pit

TP5:

0 – 305	Sandy Topsoil, trace organics
305 – 990	Sand, brown
990	Clay, firm, wet, grey blue

Water infiltrating test pit

TP6:

0 – 75	Topsoil, trace organics
75	Clay, stiff, desiccated

TP7:

0 – 75	Topsoil, trace organics
75	Clay, stiff, desiccated

TP8:

0 – 75	Topsoil, trace organics
75	Clay, stiff, desiccated

TP9:

0 – 240	Topsoil, trace organics
240 – 430	Sand, brown
430	Clay, stiff, desiccated

Water infiltrating test pit

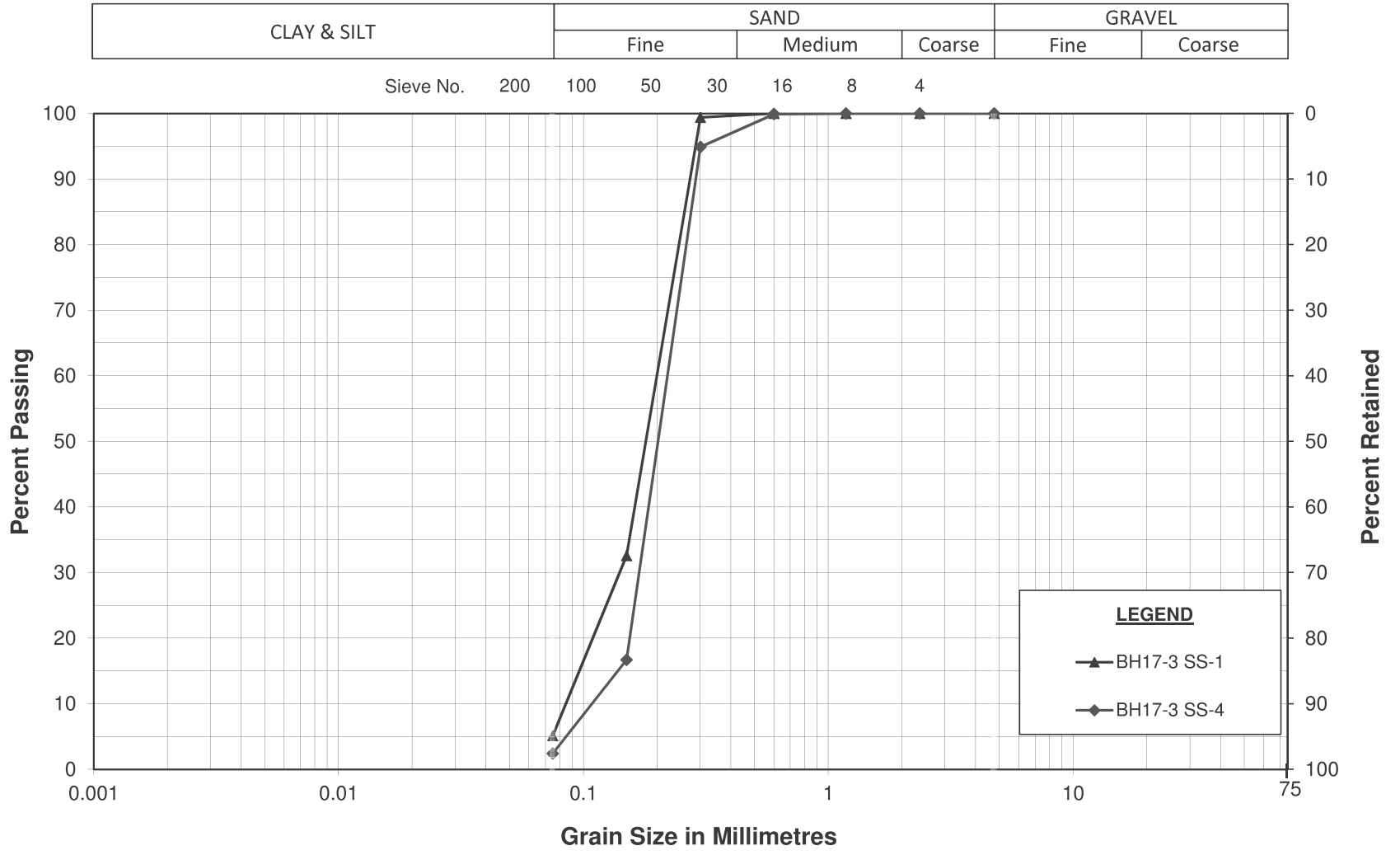
TP2:

0 – 230	Sandy Topsoil, trace organics
230 – 1000	Sand, brown

Water infiltrating test pit

Note:
All measurements are in millimeter indicating the depth below existing ground surface.

Unified Soil Classification System

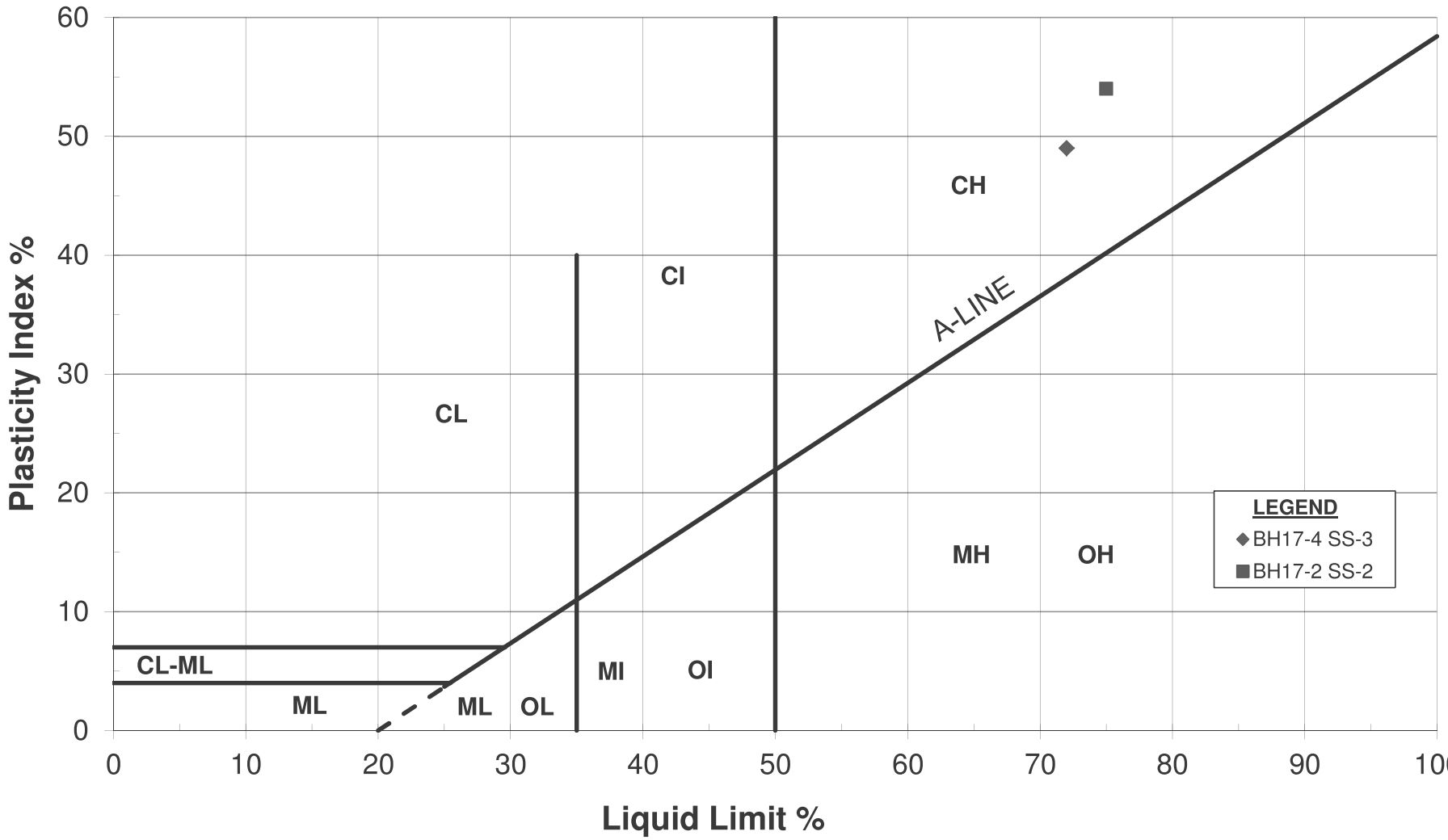


McINTOSH PERRY

Grain Size Distribution
Sand
Archdiocese - Old Montreal Rd

Figure No. 3

CP-17-0077



McINTOSH PERRY

PLASTICITY CHART

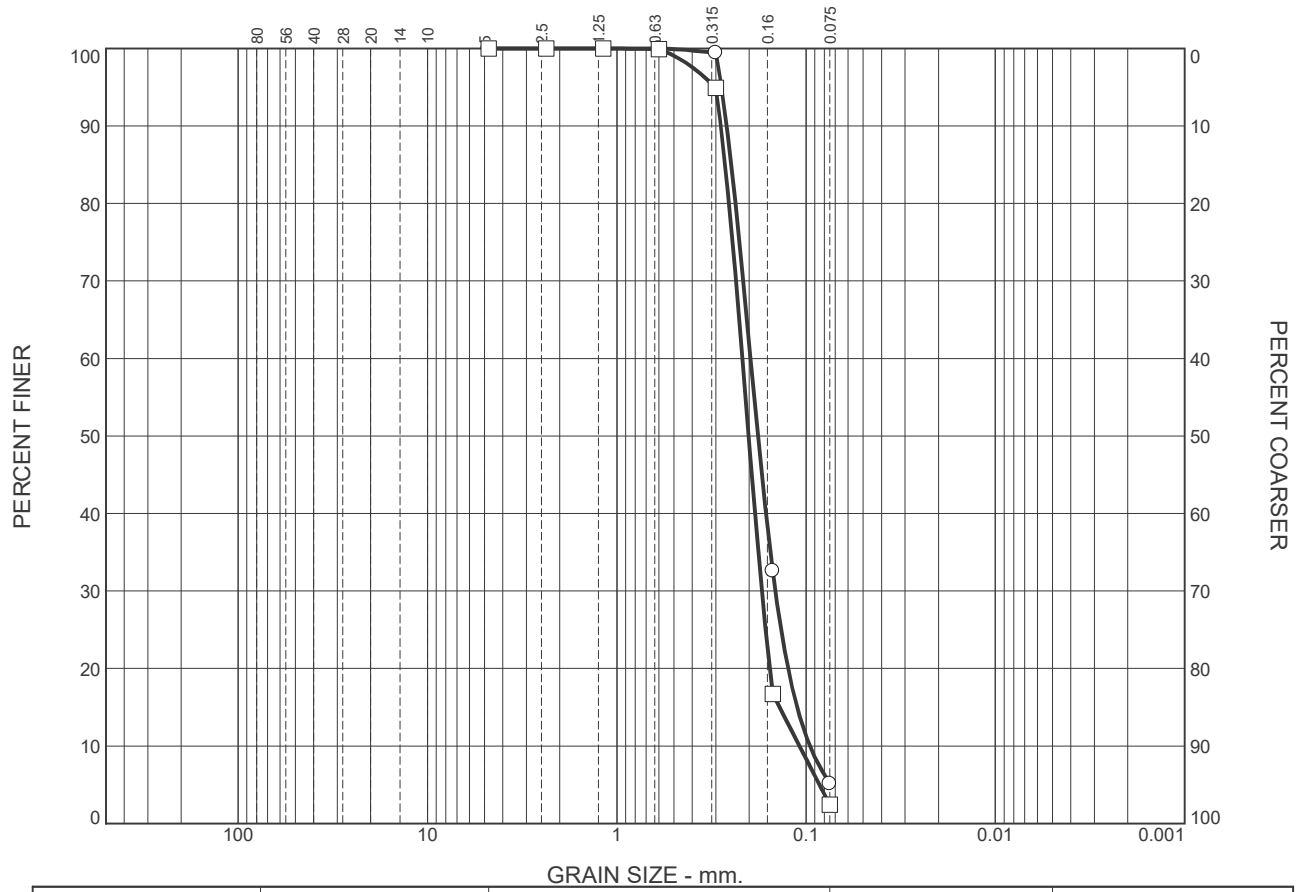
CLAY

Archdiocese - Old Montreal Rd

Figure No. 4

CP-17-0077

Particle Size Distribution Report



	% +3"	% Gravel	% Sand	% Silt	% Clay
○	0.0	0.0	94.9	5.1	
□	0.0	0.0	97.6	2.4	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (m.)	Material Description	USCS
○		BH17-3SS1		Sand trace Silt	
□		BH17-3SS4		Sand trace Silt	SP

AME Materials Engineering

Client: McIntosh Perry

Project: Archdioceses - Old Montreal Rd.

Project No.: 60182.005 (CP-17-0077) **Figure**

Checked By: H.Smith

GRAIN SIZE DISTRIBUTION TEST DATA

03/28/2017

Client: McIntosh Perry
Project: Archdioceses - Old Montreal Rd.
Project Number: 60182.005 (CP-17-0077)
Sample Number: BH17-3SS1
Material Description: Sand trace Silt
Checked by: H.Smith

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
177.10	0.00	0.00	4.75 mm	0.00	100.0	0.0
			2.36 mm	0.00	100.0	0.0
			1.18 mm	0.00	100.0	0.0
			.600 mm	0.00	100.0	0.0
			.300 mm	1.00	99.4	0.6
			.150 mm	119.40	32.6	67.4
			.075 mm	168.00	5.1	94.9

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.0	94.9		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0954	0.1117	0.1245	0.1453	0.1628	0.1794	0.1965	0.2365	0.2488	0.2629	0.2800

Fineness Modulus	C_u	C_c
0.68	2.06	1.13

GRAIN SIZE DISTRIBUTION TEST DATA

03/28/2017

Client: McIntosh Perry
Project: Archdioceses - Old Montreal Rd.
Project Number: 60182.005 (CP-17-0077)
Sample Number: BH17-3SS4
Material Description: Sand trace Silt
USCS: SP
Checked by: H.Smith

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
223.70	0.00	0.00	4.75 mm	0.00	100.0	0.0
			2.36 mm	0.00	100.0	0.0
			1.18 mm	0.00	100.0	0.0
			.600 mm	0.20	99.9	0.1
			.300 mm	11.40	94.9	5.1
			.150 mm	186.30	16.7	83.3
			.075 mm	218.30	2.4	97.6

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.0	97.6		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0850	0.1083	0.1380	0.1556	0.1711	0.1860	0.2011	0.2172	0.2558	0.2681	0.2824	0.3027

Fineness Modulus	C_u	C_c
0.88	2.01	1.24

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: 45.519N 75.394W **User File Reference:** Saint Faustina Parish 2022-03-18 20:43 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)	0.527	0.291	0.173	0.050
Sa (0.1)	0.609	0.347	0.214	0.068
Sa (0.2)	0.500	0.290	0.182	0.060
Sa (0.3)	0.375	0.219	0.138	0.047
Sa (0.5)	0.262	0.153	0.096	0.033
Sa (1.0)	0.127	0.075	0.047	0.016
Sa (2.0)	0.060	0.034	0.022	0.006
Sa (5.0)	0.016	0.009	0.005	0.001
Sa (10.0)	0.006	0.003	0.002	0.001
PGA (g)	0.322	0.187	0.116	0.036
PGV (m/s)	0.218	0.122	0.074	0.023

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

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	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	65.80	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	66.46	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	65.72	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss4	45.40073	-76.25147	Landslide	Truncated source area	0.01	Unknown	14.00	66.25	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	65.82	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	66.40	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss7	45.39121	-76.25506	Landslide	Truncated source area	0.01	Unknown	15.00	66.74	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	66.71	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	67.07	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	67.09	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	68.04	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	68.32	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	68.77	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	69.22	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	68.99	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	68.57	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	68.50	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	68.85	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Mississippi River	OF8600	Mss19	45.36122	-76.27561	Landslide	Source area with debris field	0.04	Unknown	10.00	69.15	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss20	45.36267	-76.28135	Landslide	Source area with debris field	0.02	Unknown	10.00	69.57	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	68.55	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	69.25	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	69.73	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	69.90	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	70.04	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	68.40	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	***	68.32	***	***	***
Cody Creek	OF8600	Cdy3	45.34522	-76.26452	Landslide	Truncated source area	0.01	Unknown	21.00	68.73	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	69.04	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	68.42	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	67.74	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	***	67.30	***	***	***
Cody Creek	OF8600	Cdy8	45.33762	-76.24262	Landslide	Source area with truncated debris field	0.03	Unknown	23.00	67.23	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	66.73	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	66.50	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	**	66.69	**	**	**

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Cody Creek	OF8600	Cdy12	45.32989	-76.22645	Landslide, probably	Source area with truncated debris field	0.04	Unknown	**	66.22	**	**	**
Cody Creek	OF8600	Cdy13	45.32654	-76.22004	Landslide, probably	Source area with truncated debris field	0.03	Unknown	**	65.83	**	**	**
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	65.56	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		66.38			
Madawaska Lake reservoir	OF8600	Mdw1	45.40855	-76.35190	Landslide, former site of	Inundated beneath lake waters	**	Unknown	7.00	74.28	Marine Deposits	10 to 15	Marble
Fitzroy	OF8600	Ftz1	45.50319	-76.22097	Landslide	Truncated source area	0.03	Unknown	10.00	62.72	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	62.14	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	57.68	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	56.03	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	53.20	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	52.90	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	52.44	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	51.18	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	23.86	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	27.86	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		31.72			
Rockcliffe	OF8600	Rkf1	45.45147	-75.67312	Landslide, probably	Truncated source area	0.02	Unknown		18.39			
Gloucester	OF8600	Glt1	45.44963	-75.59729	Landslide	Source area with debris field	0.12	About 1000 cal yr BP	30.00	12.63	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Orleans	OF8600	Oln1	45.45962	-75.55209	Landslide, possibly	Truncated source area?	0.02	Unknown		8.78			
Orleans	OF8600	Oln2	45.45719	-75.54766	Landslide	Debris field within a narrow stream valley	0.11	Unknown	17.00	8.62	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	7.97	Marine Deposits	50 to 100	Shale
Orleans	OF8600	Oln4	45.45726	-75.54049	Landslide	Debris field within a narrow stream valley	0.02	Unknown	5.00	8.12	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	8.18	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	7.89	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	7.82	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	7.66	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	7.45	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln10	45.46378	-75.53684	Landslide	Truncated source area	0.07	Unknown	20.00	7.45	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln11	45.46497	-75.53146	Landslide	Truncated source area	0.06	Unknown	18.00	7.00	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln12	45.46706	-75.52809	Landslide	Truncated source area	0.05	Unknown	18.00	6.64	Nearshore Marine	25 to 50	Shale
Orleans	OF8600	Oln13	45.47042	-75.52019	Landslide, probably	Truncated source area	0.07	Unknown		5.87			
Orleans	OF8600	Oln14	45.48981	-75.50782	Landslide	Source area with debris field	0.08	Late Holocene?	18.00	4.07	Alluvial Sediments	15 to 25	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln15	45.48871	-75.47487	Landslide, probably	Truncated source area	0.08	Unknown		1.57			
Orleans	OF8600	Oln16	45.48586	-75.47170	Landslide	Debris field within a narrow stream valley	0.07	Unknown	29.00	1.61	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	1.10	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	0.88	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Cumberland	OF8600	Cmb1	45.51313	-75.43362	Landslide	Truncated source area	0.14	Unknown	35.00	2.88	Erosional Terraces	15 to 25	Shale
Cumberland	OF8600	Cmb2	45.51302	-75.40335	Landslide	Source area with debris field	0.04	Unknown	24.00	5.00	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	6.87	Erosional Terraces	50 to 100	Dolomite
Cumberland	OF8600	Cmb4	45.51651	-75.33631	Landslide	Source area with debris field	0.02	Unknown	49.00	10.40	Nearshore Marine	25 to 50	Interbedded Limestone and Dolomite
Mer Bleue paleochannel	OF8600	MBu1	45.43409	-75.53765	Landslide	Truncated source area	0.02	Unknown	13.00	9.77	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	9.11	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	9.22	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu4	45.42782	-75.51290	Landslide	Truncated source area	0.01	Unknown	**	9.20	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu5	45.42639	-75.50741	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.14	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu6	45.42500	-75.50289	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.14	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu7	45.42364	-75.49702	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.11	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu8	45.42335	-75.49197	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.01	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu9	45.42158	-75.48102	Landslide	Truncated source area	0.03	Unknown	15.00	8.98	Erosional Terraces	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu10	45.42089	-75.47444	Landslide	Truncated source area	0.03	Unknown	15.00	8.97	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu11	45.41891	-75.46077	Landslide	Truncated source area	0.03	Unknown	14.00	9.12	Nearshore Marine	15 to 25	Shale
Mer Bleue paleochannel	OF8600	MBu12	45.41829	-75.45649	Landslide	Truncated source area	0.01	Unknown	15.00	9.20	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	18.46	Nearshore Marine	25 to 50	Interbedded Limestone and Shale
Beta-90881	OF7432	1	45.46110	-75.26110	Landslide	*	*	3050±70	20.00	16.85	Nearshore Marine	15 to 25	Interbedded Limestone and Shale

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Beta-122473	OF7432	1	45.44170	-75.22220	Landslide	*	*	4590±40	8.00	20.57	Nearshore Marine	25 to 50	Interbedded Limestone and Shale
Beta-122475	OF7432	1	45.44240	-75.19240	Landslide	*	*	2760±50	20.00	22.90	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Beta-127281	OF7432	1	45.54160	-75.24160	Landslide	*	*	5130±60	53.00	18.69	Nearshore Marine	10 to 15	Limestone
Beta-127284	OF7432	1	45.52080	-75.26670	Landslide	*	*	4440±80	21.00	16.12	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Beta-127244	OF7432	1	45.50000	-75.20280	Landslide	*	*	4570±70	30.00	21.13	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Beta-122472	OF7432	1	45.48330	-75.19170	Landslide	*	*	4520±50	30.00	22.10	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-127282	OF7432	1	45.47500	-75.12920	Landslide	*	*	4540±90	24.00	27.31	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-127283	OF7432	1	45.52500	-75.01110	Landslide	*	*	4530±60	12.00	37.06	Erosional Terraces	10 to 15	Interbedded Limestone and Shale
Beta-122478	OF7432	1	45.51390	-75.00280	Landslide	*	*	4700±50	15.00	37.65	Erosional Terraces	15 to 25	Interbedded Limestone and Shale
Beta-122471	OF7432	1	45.51850	-74.95570	Landslide	*	*	1870±40	26.00	41.55	**	**	**
Beta-127242	OF7432	1	45.51380	-74.93750	Landslide	*	*	4820±70	26.00	43.02	**	**	**
Beta-122474	OF7432	1	45.53610	-75.15830	Landslide	*	*	4470±50	**	25.22	Nearshore Marine	25 to 50	Limestone
GSC-1922	OF7432	2	45.54370	-75.40110	Landslide	*	*	4620±80	81.00	7.33	Marine Deposits	15 to 25	Felsic Intrusive Rocks
GSC-2068	OF7432	4	45.52080	-75.49170	Landslide	*	*	6240±70	59.00	3.90	Marine Deposits	25 to 50	Dolomite
UCIAMS-71217	OF7432	6	45.57980	-75.04260	Landslide	*	*	7105±20	35.00	35.66	Erosional Terraces	50 to 100	Shale
UCIAMS-71211	OF7432	7	45.57020	-75.11560	Landslide	*	*	7140±20	31.00	29.58	Marine Deposits	50 to 100	Interbedded Limestone and Dolomite
GSC-1741	OF7432	10	45.46500	-75.75130	Landslide	*	*	120±150	**	24.33	Marine Deposits	25 to 50	Dolomite
UCIAMS-88796	OF7432	11	45.48290	-75.93490	Landslide	*	*	1125±15	29.00	39.20	Marine Deposits	25 to 50	Felsic Intrusive Rocks

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
UCIAMS-88704	OF7432	11	45.48530	-75.93630	Landslide	*	*	2805±20	29.00	39.30	Marine Deposits	25 to 50	Felsic Intrusive Rocks
GSC-6233	OF7432	11	45.48310	-75.93320	Landslide	*	*	7050±80	25.00	39.05	Marine Deposits	25 to 50	Felsic Intrusive Rocks
UCIAMS-88816	OF7432	11	45.48020	-75.93090	Landslide	*	*	200±15	24.00	38.88	Marine Deposits	15 to 25	Felsic Intrusive Rocks
GSC-6449	OF7432	11	45.47180	-75.91290	Landslide	*	*	1080±70	15.00	37.47	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
UCIAMS-88703	OF7432	11	45.47990	-75.91740	Landslide	*	*	180±20	26.00	37.77	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6318	OF7432	11	45.47860	-75.91180	Landslide	*	*	1030±70	24.00	37.32	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
UCIAMS-88806	OF7432	11	45.47730	-75.90280	Landslide	*	*	1895±25	12.00	36.59	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6482	OF7432	11	45.48120	-75.90670	Landslide	*	*	1210±50	8.00	36.88	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6433	OF7432	11	45.48540	-75.89640	Landslide	*	*	1440±50	18.00	36.02	Marine Deposits	15 to 25	Felsic Intrusive Rocks
UCIAMS-88818	OF7432	11	45.48520	-75.90600	Landslide	*	*	2755±20	22.00	36.81	Marine Deposits	25 to 50	Felsic Intrusive Rocks
GSC-6355	OF7432	11	45.48250	-75.91180	Landslide	*	*	1170±50	27.00	37.30	Marine Deposits	25 to 50	Felsic Intrusive Rocks
Beta-139135	OF7432	11	45.49650	-75.92780	Landslide	*	*	310±40	10.00	38.57	Marine Deposits	50 to 100	Felsic Intrusive Rocks
UCIAMS-122468	OF7432	12	45.53530	-76.03060	Landslide	*	*	1095±20	21.00	47.24	Marine Deposits	15 to 25	Felsic Intrusive Rocks
UCIAMS-106656	OF7432	13	45.54090	-76.04890	Landslide	*	*	1150±15	22.00	48.81	Marine Deposits	25 to 50	Felsic Intrusive Rocks
UCIAMS-171460	OF7432	14	45.55390	-76.13020	Landslide	*	*	1305±20	9.00	55.62	Nearshore Marine	50 to 100	Felsic Intrusive Rocks
UCIAMS-171459	OF7432	15	45.55130	-76.14060	Landslide	*	*	185±20	9.00	56.44	Nearshore Marine	50 to 100	Felsic Intrusive Rocks
UCIAMS-106587	OF7432	16	45.55190	-76.28630	Landslide	*	*	1180±20	24.00	68.37	Erosional Terraces	15 to 25	Felsic Intrusive Rocks
UCIAMS-106575	OF7432	17	45.61920	-76.37190	Landslide	*	*	955±15	32.00	76.43	**	**	**

Table 1 - Proposed St. Faustina Parish - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
UCIAMS-106650	OF7432	18	45.50140	-76.28260	Landslide	*	*	1145±20	52.00	67.79	Nearshore Marine	15 to 25	Felsic Intrusive Rocks
UCIAMS-106581	OF7432	19	45.51700	-76.27470	Landslide	*	*	5830±20	34.00	67.17	Nearshore Marine	15 to 25	Felsic Intrusive Rocks
UCIAMS-122453	OF7432	20	45.54620	-76.52600	Landslide	*	*	5745±20	**	87.99	**	**	**
UCIAMS-137113	OF7432	21	45.72570	-75.89150	Landslide	*	*	4525±20	52.00	44.56	**	**	**
UCIAMS-137101	OF7432	22	45.69440	-75.89960	Landslide	*	*	90±20	23.00	43.01	**	**	**
UCIAMS-122455	OF7432	23	45.80960	-75.95980	Landslide	*	*	940±15	25.00	55.15	**	**	**

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

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

APPENDIX 2

FIGURE 1 – KEY PLAN

FIGURES 2 & 3 – SLOPE STABLITY ANALYSIS CROSS-SECTIONS

FIGURE 4 – LIDAR IMAGE OF AREA OF SUBJECT SITE

DRAWING PG4197-1 – TEST HOLE LOCATION PLAN

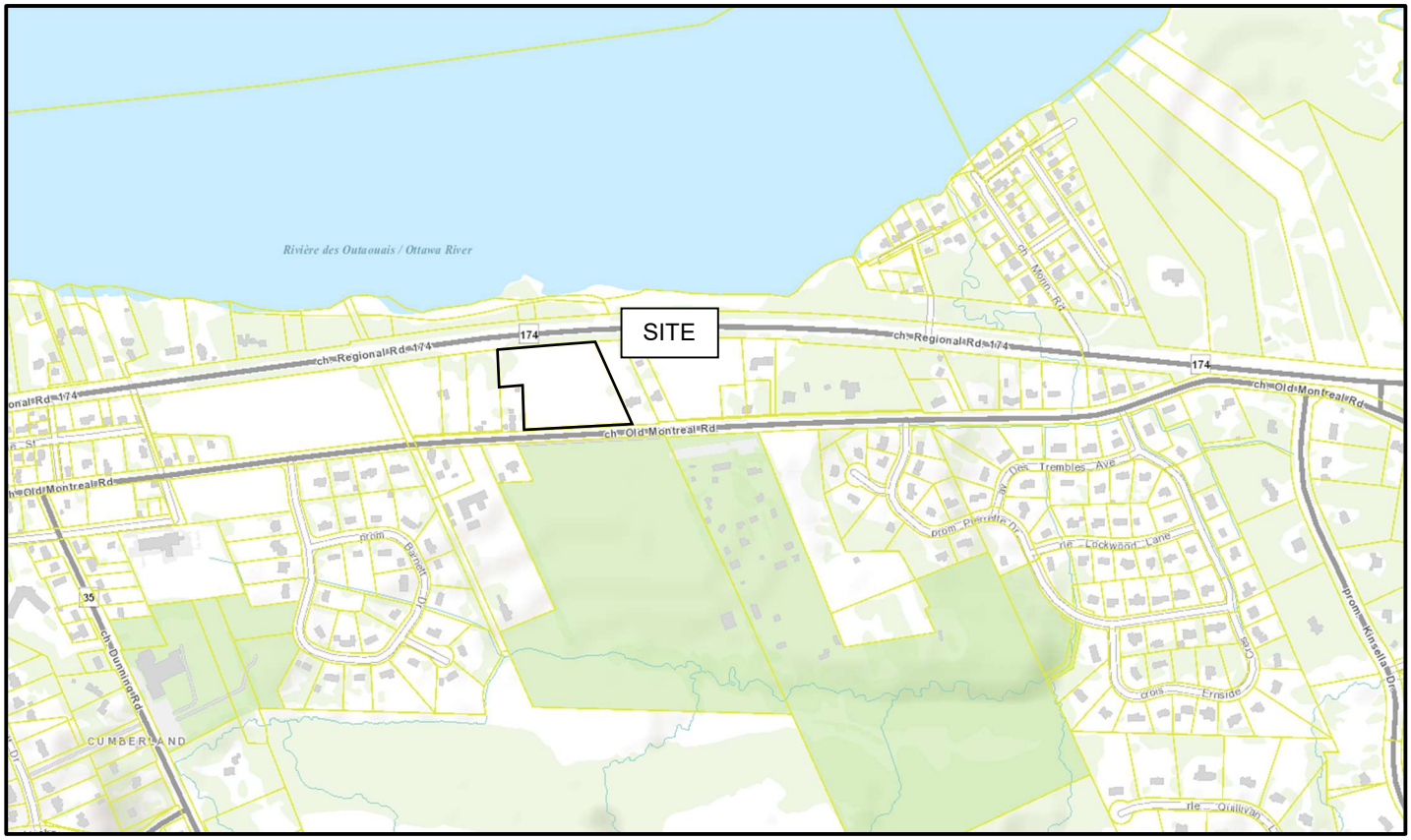
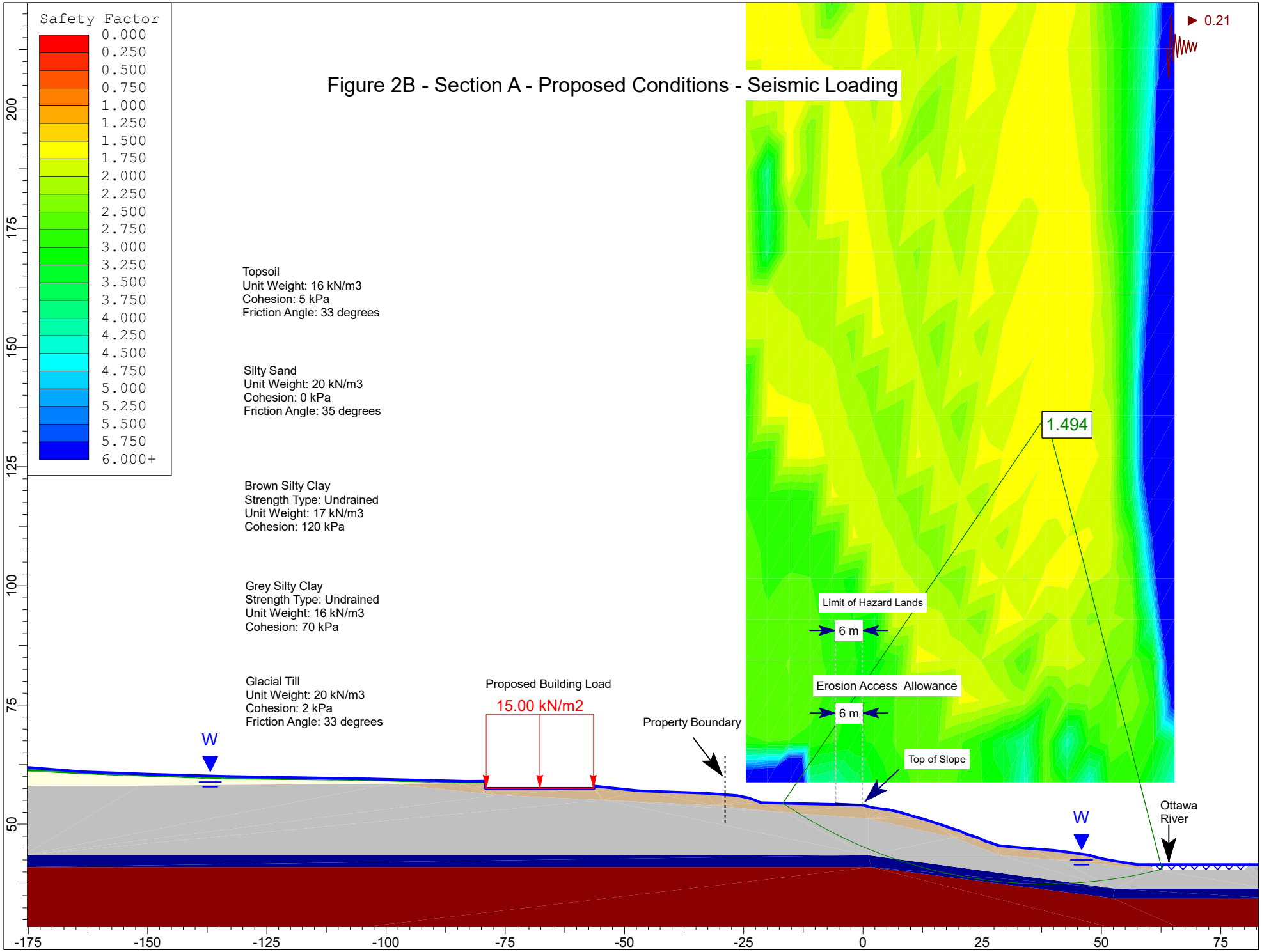
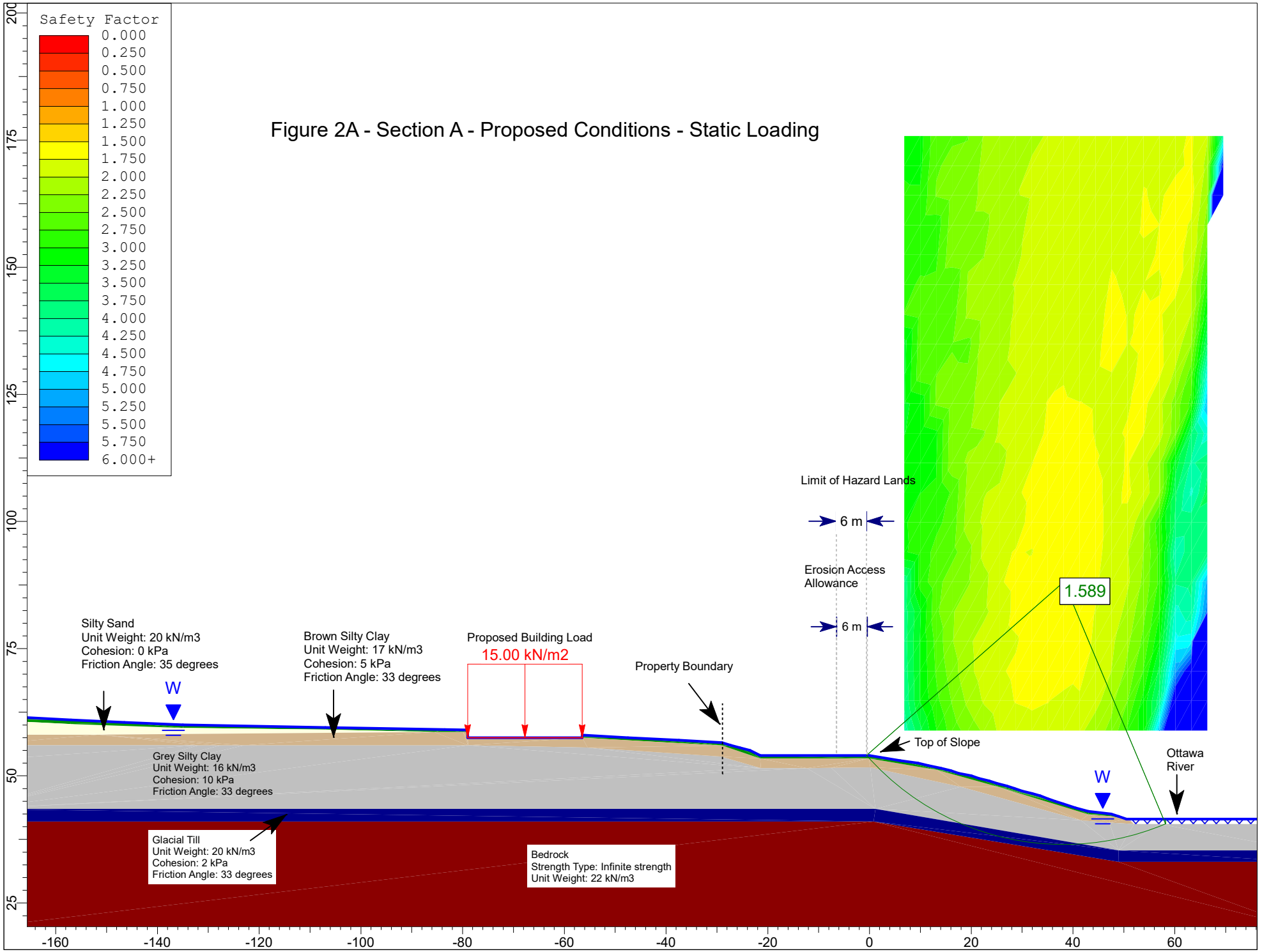
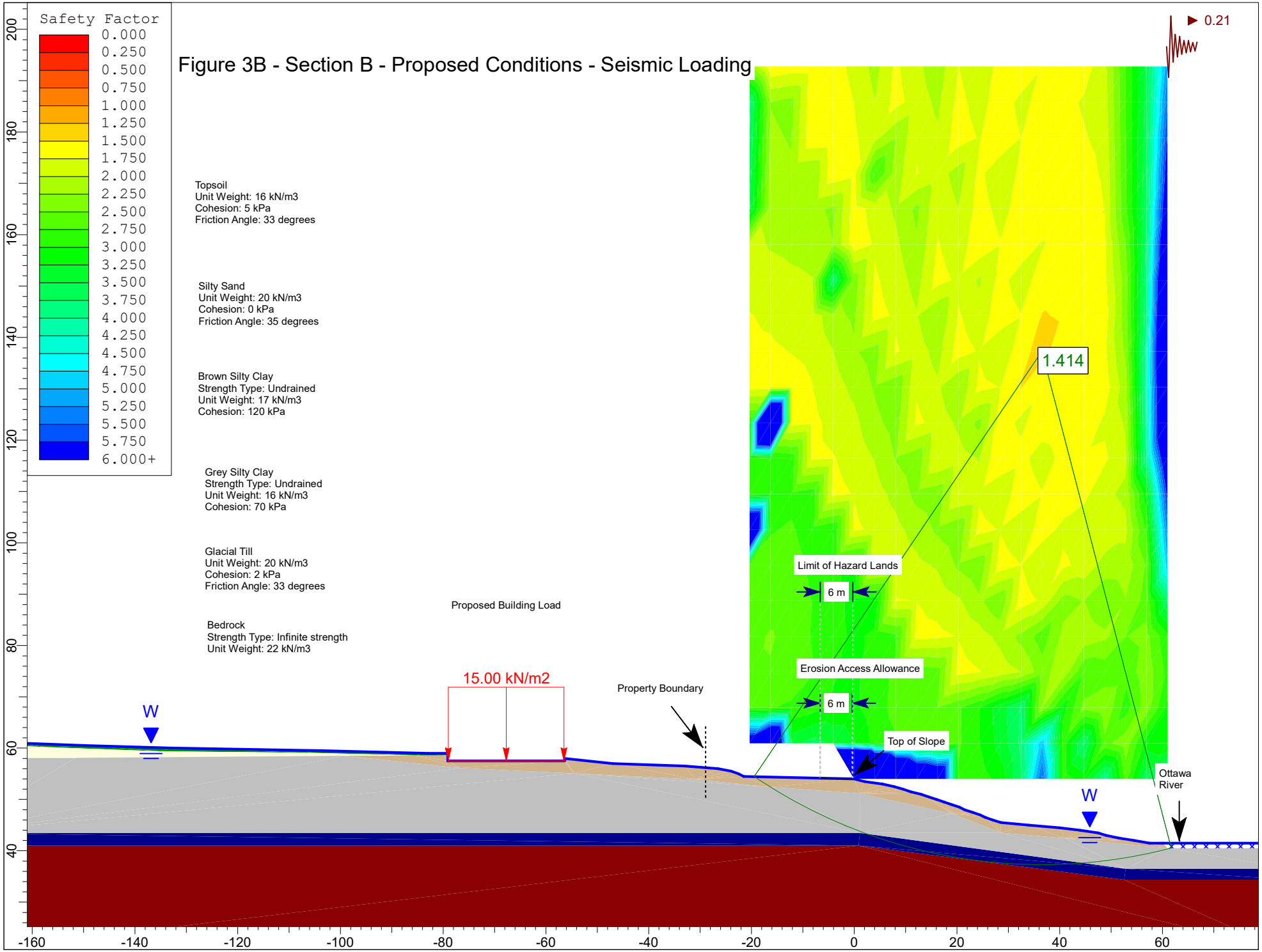


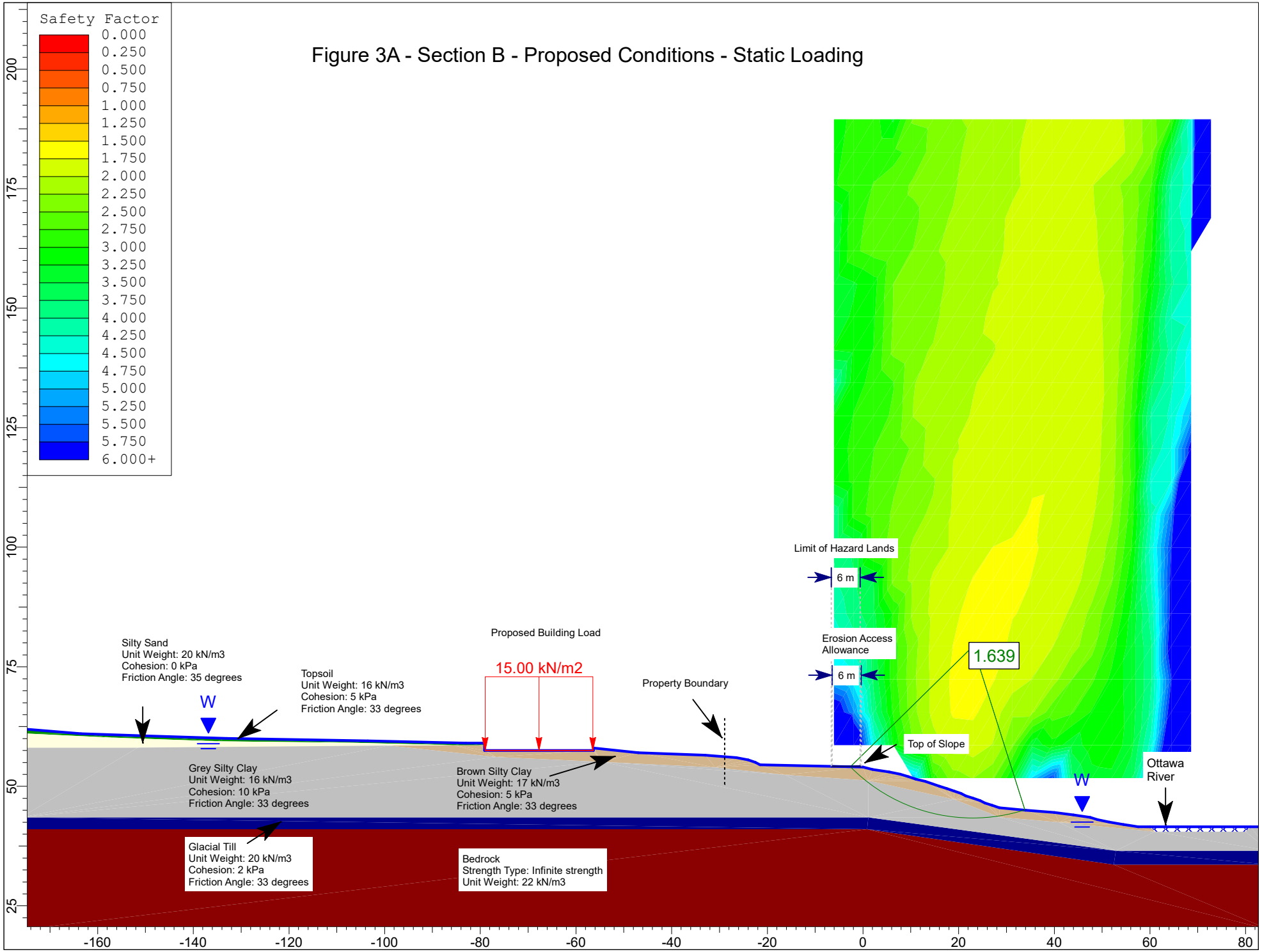
FIGURE 1

KEY PLAN


Figure 2B - Section A - Proposed Conditions - Seismic Loading
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.21
Topsoil
Unit Weight: 16 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Silty Sand
Unit Weight: 20 kN/m3
Cohesion: 0 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: 70 kPa
Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 2 kPa
Friction Angle: 33 degrees
1.494
Limit of Hazard Lands
6 m
Erosion Access Allowance
6 m
Top of Slope
Proposed Building Load
15.00 kN/m2
Property Boundary
W
W
Ottawa River
200
175
150
125
100
75
50
-175
-150
-125
-100
-75
-50
-25
0
25
50
75


Figure 2A - Section A - Proposed Conditions - Static Loading
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Limit of Hazard Lands
6 m
Erosion Access Allowance
6 m
1.589
Silty Sand
Unit Weight: 20 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
W
Brown Silty Clay
Unit Weight: 17 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Proposed Building Load
15.00 kN/m2
Property Boundary
Top of Slope
Ottawa River
W
Grey Silty Clay
Unit Weight: 16 kN/m3
Cohesion: 10 kPa
Friction Angle: 33 degrees
Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 2 kPa
Friction Angle: 33 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
200
175
150
125
100
75
50
25
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60


Figure 3B - Section B - Proposed Conditions - Seismic Loading
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.21
Topsoil
Unit Weight: 16 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Silty Sand
Unit Weight: 20 kN/m3
Cohesion: 0 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: 70 kPa
Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 2 kPa
Friction Angle: 33 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
1.414
Limit of Hazard Lands
6 m
Erosion Access Allowance
6 m
Top of Slope
Proposed Building Load
15.00 kN/m2
Property Boundary
W
W
Ottawa River
200
180
160
140
120
100
80
60
40
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60


Figure 3A - Section B - Proposed Conditions - Static Loading
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Limit of Hazard Lands
6 m
Erosion Access Allowance
6 m
Proposed Building Load
15.00 kN/m2
Property Boundary
1.639
Top of Slope
Ottawa River
W
W
Silty Sand
Unit Weight: 20 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
Topsoil
Unit Weight: 16 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Grey Silty Clay
Unit Weight: 16 kN/m3
Cohesion: 10 kPa
Friction Angle: 33 degrees
Brown Silty Clay
Unit Weight: 17 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 2 kPa
Friction Angle: 33 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
200
175
150
125
100
75
50
25
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80

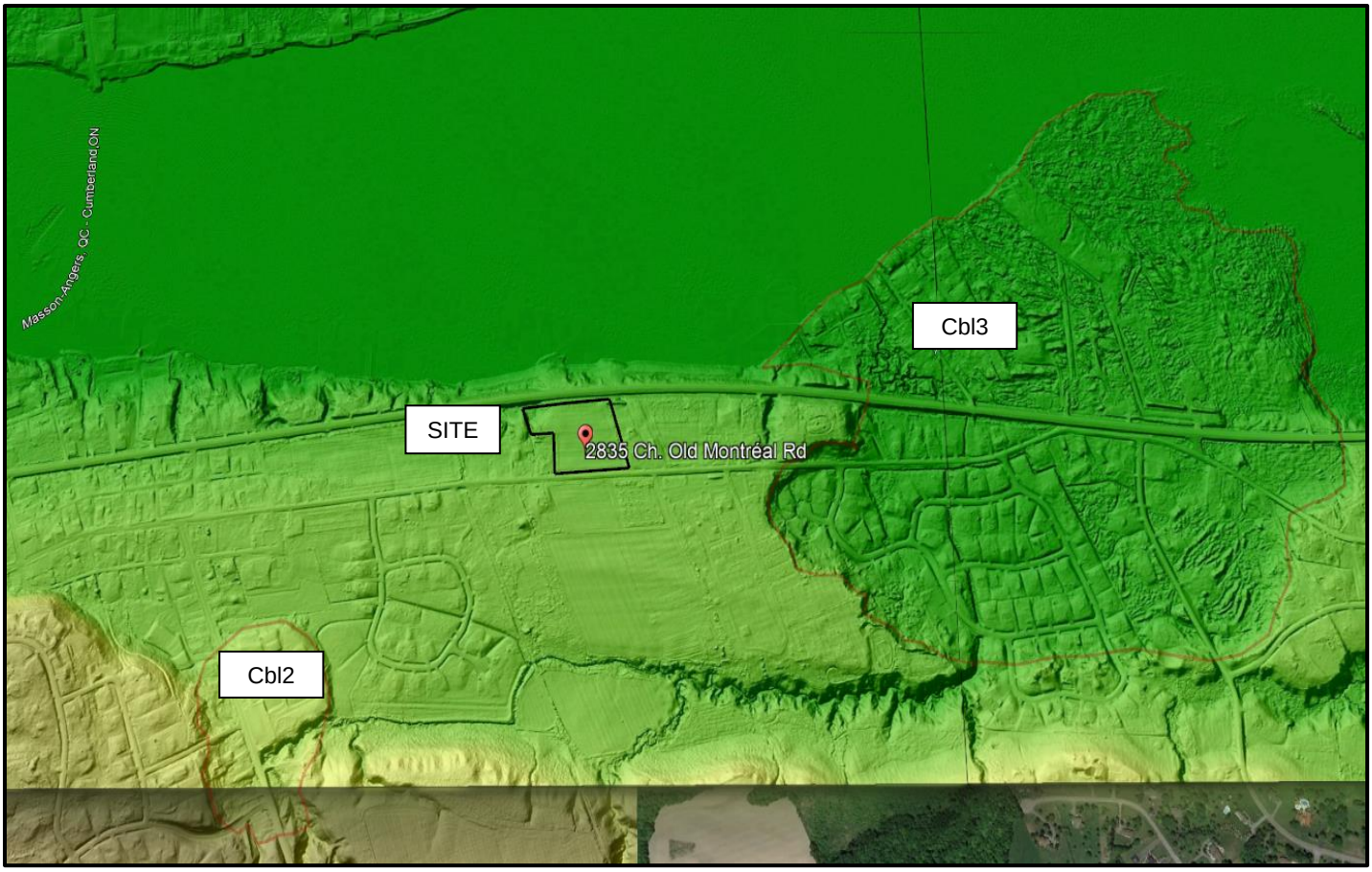


FIGURE 4

LIDAR IMAGE OF AREA OF SUBJECT SITE



LEGEND:

- BOREHOLE LOCATION BY OTHERS (MCINTOSH PERRY)
- TEST PIT LOCATION BY OTHERS (MCINTOSH PERRY)
- 102.70 GROUND SURFACE ELEVATION (m)
- (86.60) PRACTICAL REFUSAL TO AUGERING ELEVATION (m)
- SLOPE STABILITY CROSS SECTION LOCATION

TOPOGRAPHIC ELEVATIONS ARE PROVIDED BY CITY OF OTTAWA (CAD 2000 OPEN DATA)

TBM - HYDRO POLE LOCATED SOUTH OF REGIONAL ROAD 174. ASSUMED ELEVATION = 100.00 m

SCALE: 1:1500

0 25 50 75 100m

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL
2	TOP OF SLOPE & LIMIT OF HAZARD LANDS ADDED TO PLAN	01/26/2022	FC
1	CONCEPTUAL PLAN UPDATED TO DRAWING	01/18/2022	FC

MR. NED LATHROP

SLOPE STABILITY ANALYSIS AND LANDSLIDE HAZARD ASSESSMENT STUDY
2835 OLD MONTREAL ROAD

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:1500	Date: 11/2021
Drawn by: RCG	Report No.: PG4197-1
Checked by: FC	Dwg. No.: PG4197-1
Approved by: DJG	Revision No.: 2

p:\autocad drawings\geotechnical\pg41xx\pg4197\pg4197-1-thlp rev.02.dwg