Public Works and Government Services Canada

Geotechnical Investigation, Joyceville Institution, Kingston, Ontario

Geotechnical Investigation Report

Date: June 2012
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Public Works and Government Services Canada

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INTRODUCTION

LVM inc was retained by Public Works and Government Services Canada (PWGSC) to carry out a geotechnical investigation for the construction of new buildings and a parking lot at the Joyceville Institution in Kingston, Ontario.

The purpose of the investigation was to determine the nature and properties of the soils and groundwater conditions at the site by means of six (6) geotechnical boreholes (BH-01-12 to BH-06-12) and soil sampling.

The information gathered allowed the formulation of geotechnical recommendations for the temporary excavation of the site, the structure of the foundations and temporary and permanent drainage solutions.

Some soil samples were taken in three (2) boreholes (BH-02-12, BH-03-12) for environmental purposes. The objective of the environmental characterisation was to obtain soil quality information on the subject sites for excavated soils management purposes during the eventual construction work.

The investigation was performed in accordance to our proposal dated March 27, 2012 (O/Ref.:12-0098-033).

This report contains a description of the sites and the methodology used during the site investigations as well as a detailed description of the soil's nature, their properties and the groundwater level at the locations. It also contains a section in which geotechnical recommendations are provided for the design of the project. The recommendations provided in this report are in accordance with the "National Building Code of Canada, 2005" (NBC 2005). The environmental characterization is presented in Section 6.

At the moment of the redaction of this report, the details of the design and construction for the intended structures are unknown. Once structures are design, it is recommended (if required) that LVM be mandated for the review of the geotechnical recommendations in relation with the final concept.

The specific limitations of the investigation, outlined in Appendix 1, should be read jointly with this report.

1 SITE AND PROJECT DESCRIPTION

1.1 PROJECT DESCRIPTION

Based on the information provided from PWGSC, geotechnical services were required to investigate one (1) site for the construction of a new building and a parking lot located in the Joyceville Institution.

The projected building is two (2) storeys in height and has an area of 2 500 square meters with the intended purpose for storage and program space. The structure will be mainly pre-fabricated steel frames and the foundation loads will be line loads from bearing walls.

1.2 SITE DESCRIPTION

Joyceville Institution is located on 3766 Highway 15, City of Kingston, Ontario. The study area is located near south-west gate.

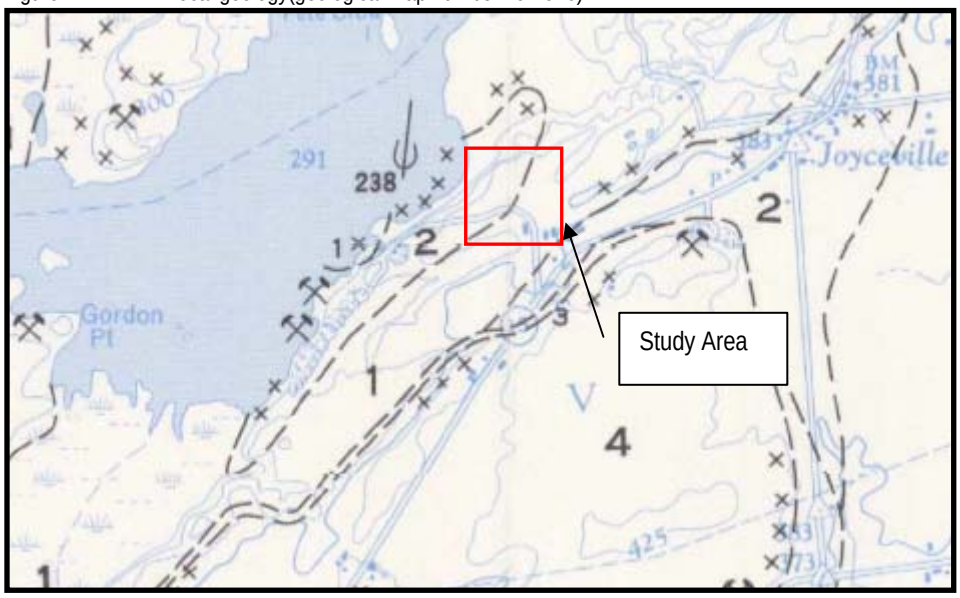
Figure 1 shows an aerial view of Joyceville Institution and the location of studied area.

Figure 1: Joyceville Institution (Source: Google Earth)

1.3 LOCAL GEOLOGY

The local geology is illustrated on the geological map number 19-1970, Bath area, by the Geological Survey of Canada. Within the area studied, the rock units consist mainly of sandstone.

Figure 2 : Local geology(geological map number 19-1970)



2	POTSDAM FORMATION: red, white, grey and yellow, evenly textured, fine-grained sandstone, and siltstone; in Knowlton Lake area this formation includes 81 feet of underlying dark grey shale as lower member (not included above)

2 INVESTIGATION PROCEDURES (FIELD WORK)

2.1 LOCATION OF THE BOREHOLES

A site survey, to determine the borehole locations, was carried out by LVM representatives. The elevations of the boreholes were taken from a plan transmitted by the Client at the beginning of the fieldwork. The locations of the boreholes are shown on the drawing 033-B-0001193-1-GE-D-0001 included in Appendix 4.

2.2 FIELD WORK

The fieldwork was performed May 24, 2012. A total of six (6) boreholes were carried out under the full-time supervision of a qualified technician from LVM. The boreholes were identified BH-01-12 to BH-06-12. Boreholes BH-01-12 to BH-0412 were performed at the proposed building location and boreholes BH-05-12 and BH-06-12 were performed at the proposed new parking lot.

The boreholes were carried out, using a CME-55 drill rig with hollow stem augers, down to a total depth ranging from 2.90 m to 8.23 m. Soil sampling and Standard Penetration Testing, in accordance with ASTM Standard D 1586, were performed with a standard split-spoon sampler of 51 mm outer diameter. The borehole BH-02-12 was continued by a dynamic cone penetration test until depths of 15.47 m; at which point, a refusal was reached on probable rock or very dense soil.

Borehole BH-03-12 was followed with core sampling to confirm the presence of rock and to determine its quality.

A perforated pipe was installed into borehole BH-01-12, in order to allow the measurement of the groundwater level.

Soil samples were collected for environmental purposes from boreholes BH-02-12 and BH-03-12. The results of the analyses are presented in section 6 of this report.

The subsoil details are presented in the individual borehole logs inserted in Appendix 2.

2.3 LABORATORY TESTING

All recovered samples were carefully preserved and transported to LVM's laboratory for identification, laboratory testing and classification. All soil samples were examined by a geotechnical engineer and were classified in accordance with the requirements specified in ASTM D2488. Representative soil samples from the geotechnical boreholes were submitted for two (2) measures of the consistency limits (liquid and plastic limits) and one (1) rock core sample was submitted to an unconfined compressive strength test. The complete laboratory test results are presented in Appendix 3 and are also included on the borehole logs in Appendix 2.

All geotechnical samples recovered from boreholes which were not consumed during laboratory analysis will be stored for a period of six (6) months from the date of completion of the fieldwork; after which, they will be destroyed unless written instructions on the sample storage and/or disposition are received from the Client by LVM.

Following the geotechnical fieldwork, a laboratory performed chemical analyses on some of the soil samples collected for environmental purposes from boreholes BH-02-12 and BH-03-12. The analyses were carried out by *Exova* of Ottawa (Ontario), an independent laboratory accredited by Ontario's Ministry of the Environment (MOE). Section 6 presents a detailed description of the analytical program and the chemical analysis results.

3 NATURE AND PROPERTIES OF SUBSOIL

The following paragraphs present a summary of the different soil layers encountered in the borehole. The locations of the six (6) boreholes completed at the Joyceville Institution are presented on the plan n° 033-B-0001193-1-GE-D-0001 in Appendix 4. The detailed borehole logs are presented in Appendix 2.

Table 1 : Borehole summary

Site	Borehole n°	Organic Matter (m)	Asphalt (m)	Granular Fill (m)	Natural Deposit (m)	Rock Depth (m)	End of borehole (m)
Projected Building	BH-01-12	(2)	0.00–0.08	0.08–1.52	1.52 ≥ 6.71	(2)	6.71
	BH-02-12	(2)	0.00–0.08	0.08–0.76	0,76 ≥ 8.22	15.47(1)	15.47
	BH-03-12	(2)	0.00–0.08	0.08–0.76	0.76 – 4.67	4.67 ≥ 6.20	6.20
	BH-04-12	(2)	0.00–0.08	0.08–0.76	0.76 ≥ 3.45	(2)	3.45
Projected Parking Lot	BH-05-12	0.00–0.07	(2)	0.07–0.76	0.76 ≥ 2.90	(2)	2.90
	BH-06-12	0.00–0.07	(2)	0.07–1.52	1.52 ≥ 2.90	(2)	2.90

(1) Probable rock depth

(2) Stratigraphic unit not encountered

3.1 ORGANIC SOIL

Directly on the surface of boreholes BH-05-12 and BH-06-12, a layer of organic soil was intercepted on a thickness of 0.07 m.

3.2 ASPHALT

Directly on the surface of boreholes BH-01-12 to BH-04-12, asphalt was intercepted on a thickness of 0.08 m.

3.3 GRANULAR FILL

A granular fill of sand and gravel with various proportions of silt was intercepted in boreholes BH-01-12, BH-05-12 and BH-06-12 immediately beneath the topsoil or the asphalt. This deposit was intercepted on a thickness varying between 0.70 m and 1.45 m.

3.4 NATURAL DEPOSIT – SILTY CLAY

A natural deposit of silty clay with traces of sand was intercepted in all the boreholes. Traces of oxidation have been observed at BH-03-12.

Two (2) consistency limits (liquid and plastic limits) were done based on a representative samples. Table 2 shows the results of the analysis.

Table 2 : Results of Consistency Limits and Water Content

Borehole #	Samples #	Depth (m)	W (%)	W_L (%)	W_P (%)	I_P (%)	I_L	Classification
BH-02-12	SS-4	3.05 – 3.66	32	52	22	30	0.3	CH
BH-06-12	SS-3	1.52 – 2.13	31	56	26	30	0.2	CH

According to the unified classification (USCS), this soil type is classified as "CH" with a high degree of plasticity.

The undrain shear strength was between 109 and 166 kPa qualifying this clay as "very stiff".

3.5 BEDROCK

Underlying the natural deposit described above, bedrock was intercepted and cored in borehole BH-03-12 at a depth of 4.67 m. This bedrock was drilled with a core barrel on a length of about 1.5 m to confirm its presence and to determine its quality.

The rock was identified as sandstone. The Rock Quality Designation (RQD) is an indirect appreciation of the number of fractures and of the degree of rock alteration. An RQD of 90% was calculated on the rock recovered from the borehole and can be generally be qualified as «excellent».

An unconfined compressive strength of rock core analysis was performed on one (1) representative rock sample. Table 3 shows the results of the analysis which is also presented in Appendix 3.

Table 3 : Compressive Strength results

Borehole #	Sample #	Depth (m)	Uniaxial compressive strength (U) MPa
BH-03-12	RC-6	4.88 – 5.13	130

4 GROUNDWATER

One (1) perforated plastic tube was installed into borehole BH-01-12 in order to allow further readings of the groundwater level. Groundwater levels were recorded June 12th, 2012. The result is shown in Table 4.

Table 4 : Groundwater levels

Borehole n°	Type	Date Recorded	Depth of Water Level (m)
BH-01-12	Perforated pipe	2012-06-12	2.28

It is important to note that the groundwater level can be influenced by several factors including rainfalls, snow melts and modifications made to the immediate and surrounding physical environment and, thus, it can vary along seasons and over time.

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL REMARKS

Based on the information provided from PWGSC, geotechnical services were required to investigate various sites for the construction of a new building and a parking lot at the Joyceville Institution in Kingston, Ontario.

The projected building is two (2) storeys in height and has an area of 2 500 square meters with the intended purpose for storage and program space. The structure will be mainly pre-fabricated steel frames and the foundation loads will be line loads from bearing walls.

On the basis of the information gathered from the boreholes completed on the site, the subsurface stratigraphy is mainly characterized by the presence of a granular fill, followed by a natural clay deposit. Under this deposit, the rock was intercepted at a depth from 4.67 m to 15.47 m. The rock is composed of sandstone. The joints observed in the rock masses are generally sub-horizontal. The unconfined compressive strength performed on the rock sample has given a value of 130 MPa.

On June 12, 2012, groundwater level was recorded at a depth of 2.28 m from the surface.

According to the available data and the information obtained from the boreholes, our geotechnical commentaries and recommendations for the conception of the project are presented in the following sections.

5.2 FROST PROTECTION

According to the Environment Canada database, the average frost index is 725°C-day in the project region. Based on that information, the anticipated frost penetration depth in the soil is assessed at 1.50 m in the region.

5.3 EXCAVATION

In order to reach the foundation implementation level of 1.5 m, excavation will be required in the granular fill and into the natural clay deposit.

5.3.1 Temporary excavation in granular fill and natural deposit

If there is sufficient space, the required excavation to reach the footings can be done by doing open trenches. Because the slopes are only temporary, the contractor will be responsible for their stability.

The excavations must be done in accordance to the specifications of “Ontario Ministry of Labour”. If excavations without any support system stay open for a long duration, it is recommended that frequent inspections be done by specialized geotechnical personnel, in order to detect any risk of soil slip and to determine the measures to be taken to correct any anomalies.

It is recommended to avoid parking any vehicles at the top of the excavation at a distance lower than the depth of the excavation. It is also suggested to avoid any vehicle circulation at the top of the excavation at a distance lower than the depth of the excavation, in order to minimize the vibrations.

It will be important to keep a distance of at least equal to the depth of the excavation between the top of the slope and the base of the excavated material pile on site. This condition must be respected at all times, unless studies are carried out for any specific case.

5.3.2 Temporary drainage

It is recommended that an adequate pumping system be available in order to evacuate surface run-off and infiltration water that could accumulate at the bottom of the excavations, depending on the weather conditions, to allow a dry working environment.

5.4 FOUNDATION

The support foundation surface will be a very stiff silt and clay deposit.

The following recommendations are based on the directives of the NBC-2005 which recommends the use of the limits states method for calculation of the foundations.

The limits states represent the conditions of a structure beyond of which it ceases to fulfill the function for which it was designed. In the NBC-2005, the limits states are divided into two (2) groups:

- The ultimate limit states which correspond to the mechanisms of collapse and rupture of the structures; they are notions of safety of the works. As an example, the ultimate limit state for the foundation could be a shearing failure of the soil.
- The serviceability limit states correspond to the mechanisms which limit the proposed use of the structure. These mechanisms are usually associated with movements which stop or limit a structure to fulfill its purpose. As an example, the serviceability limit states for a foundation can be some excessive movements and settlements.

A secure foundation design has to satisfy these two (2) requirements. The ultimate limit states and serviceability limit states are presented in the next paragraphs.

5.4.1 Ultimate limit states (ULS)

According to the site stratigraphy, previously described, we recommend transferring the loads of the footing to the stiff clay and silt deposit (loose to compact soil) encountered at up to a depth of 8.23 m.

$$q_{ult} = c\, N_c\, S_c\, I_c + q'\, N_q\, S_q\, I_q + 0.5\, \gamma'\, B\, N_\gamma\, S_\gamma\, I_\gamma$$

The following geotechnical parameters can be used for the ultimate limit states (ULS) calculation.

Table 5 : Geotechnical parameters – Granular deposit

Parameters	Silty clay deposit
Effective soil cohesion (c')	5 kPa
Wet unit weight of soil (γ)	17 kN/m³
Submerged unit weight of soil (γ')	7 kN/m³
Effective angle of internal friction ((φ')	28
Bearing capacity factor (N_c)	21
Bearing capacity factor (N_q)	11
Bearing capacity factor (N_γ)	7
Footing width (B)	To be defined by designer
Footing depth	To be defined by designer

According to the NBC-2005, a resistance factor of 0.5 must be applied to the value of the ultimate bearing capacity in order to obtain a factored resistance.

5.4.2 Serviceability limit states (SLS)

A geotechnical resistance at the serviceability limit state (SLS) for footings, of 1.5 m width or less, placed on the stiff silt and clay deposit encountered, of 100 kPa can be used to design the foundations.

Total settlements are expected to be less than 25 mm for the above-mentioned load while differential settlements are expected to be less than 20 mm. This value supposes that the bottom of the excavation is horizontal, undisturbed and without very loose area.

5.5 REUSE OF THE EXCAVATED MATERIAL

The excavated material would be mainly composed of a silty clay material, having high frost susceptibility. For that reason, it is recommended to not reuse this material for the backfilling of the excavation.

5.6 BACKFILLING ALONG THE WALL

The backfill of the excavations inside and outside the foundation walls of the building must be done using compactable granular material of type “Granular B”, as defined by the Ontario Provincial Standards for Roads and Public Works “OPSS”.

This material must be set up in layers of a maximum thickness of 300 mm and must be compacted to at least 95 percent of the maximum dry density. Backfill must be brought up evenly on both sides of the walls, because these walls are not designed to resist lateral pressures.

5.7 SLAB-ON-GRADE

It is recommended that any organic soil or granular material, which would be present at the level of the proposed slab, be excavated completely under the occupied surface by the building slab of the projected building.

In addition, directly under the slab of the building, the NBC 2005 recommends the installation of a cushion of at least 100 mm in thickness, composed of clear stone materials.

The slab of the building must be placed on a mat of at least 300 mm thickness, composed of granular materials satisfying the grain size distribution requirements of crushed stone of type “Granular A“, as defined by the Ministry of Transportation of Ontario (M.T.O). This material must be compacted to at least 98 percent of the Standard Proctor. If the excavation is higher than 400 mm, the cushion could be preceded by a granular material of type “Granular B” compacted to at least 95 percent of the Standard Proctor.

Moreover, it is very important that all the new granular materials used not contain any clayed materials potentially expansive materials, such as shale limestone, which may cause important heaving of the slab. The material should be non susceptible to pyrite reaction.

5.8 SEISMIC DATA

5.8.1 Site class

The parameters used for the calculation of earthquake load and effects have been determined using the general stratigraphy of the site. Based on the information obtained from the borehole, the site class “D“ must be used for the study.

5.8.2 Spectral response acceleration

The values of spectral response acceleration for different periods and the values of Peak Ground Acceleration (PGA) for different municipalities (for a site class C) are indicated in the NBC 2005. The data’s for the region of Kingston are presented in Table 6.

Table 6 : Spectral Acceleration and PGA (for seismic site class C)

Area of Investigated Site	Seismic Data (g)				
	$S_a(0,2)$	$S_a(0,5)$	$S_a(1,0)$	$S_a(2,0)$	PGA
Kingston	0.30	0.16	0.084	0.024	0.16

5.9 PARKING LOTS DESIGN

5.9.1 Pavement design criteria

The comments and recommendations presented below are based on the fieldwork and laboratory tests as well as the information provided by the Client.

At the moment of the redaction of this report, there was no traffic data available and, for that reason, a 15 year pavement design life and 500 Annual Average Daily Traffic (AADT) were assumed for the pavement design of the parking lot. The pavement design was based on the American Association of State Highway and Transportation Officials (A.A.S.H.T.O.) (1993 Edition) design method.

5.9.2 Proposed pavement structure

The pavement construction should be carried out as follows:

- Subexcavate to the depth required for pavement installation (780 mm);
- The subgrade should be carefully proof-rolled and any soft or wet spots properly repaired with approved material (Granular B type I);
- Construct the pavement subbase with 500 mm of granular subbase meeting OPSS 1010 Granular B type I specifications, placed in lifts not exceeding 300 mm loose thickness. Compact to 100 percent Standard Proctor Maximum Dry Density (SPMDD);

- Construct the pavement base with 250 mm of granular base meeting OPSS 1010 Granular A gradation. Compact to 100 percent Standard Proctor Maximum Dry Density (SPMDD); and
- Place a lift of 70 mm of OPSS 1150 HL 3 hot-mix asphalt, placed and compacted in conformance with OPSS 310 requirements.

The material placed in the frost zone should match the existing soil at the same level for frost heave compatibility; otherwise transition will have to be done.

Table 7 shows the proposed pavement structure based on subsoil analysis and conception traffic hypothesis.

Table 7 : Proposed pavement structure

Structure Item	Type Of Material	Thickness (mm)	Compaction (%)
Asphalt mix			
▪ Asphalt material	HL-3	70 mm	Compacted to at least 92 % of Rice specific gravity (OPSS 310)
Base course	Granular Type A (1)	250 mm	Compacted to at least 100 % maximum dry density (OPSS 501)
Sub-base course	Granular Type B (1)(2)	500 mm	Compacted to at least 100 % maximum dry density (OPSS 501)
	Total :	820	

(1) : Excavated material could not be reused for the road structure

(2) : A geotextile membrane has to be installed on the subgrade surface prior to the installation of the subbase.

6 PRELIMINARY ENVIRONMENTAL SOIL CHARACTERIZATION

6.1.1 Methodology

Six (6) boreholes (BH-1-12 to BH-6-12) were completed under the supervision of LVM. The boreholes were positioned in order to respect the geotechnical requirements of the project and, whenever possible, to obtain supplementary information on the environmental quality of the soil on the subject property. No groundwater samples were collected during this study.

The LVM technician collected representative soil samples during the fieldwork. The presence of visual and/or olfactory indications of substances or materials that could affect the environmental quality of the soil was also verified during sampling. These observations were taken into account when selecting the samples for chemical analyses. Organoleptic observations are included in the borehole and test pit logs appended. Two (2) of the collected soil samples were selected for chemical analyses.

Sampling, transportation and preservation procedures for samples were carried out based on the methodologies suggested by the *Guidance on Sampling and Analytical Methods for Use at Contaminated Site in Ontario, 1996*.

6.1.2 Analytical program

Chemical analyses were performed by *Exova* of Ottawa. This laboratory is accredited by the Canadian Association for Laboratory Accrediation (CALA) with regards to the analytical parameters requested in this project. Selected soil samples were analyzed for one or more of the following parameters:

- PCB
- Total Organic Carbon
- Total Phosphorus
- Metals
- TCLP – Inorganics and metals

The analytical results and analytical methods are presented in the certificate of analysis appended.

The laboratory will keep samples according to current environmental standards and for duration of thirty (30) days from the date of the certificate. The samples will be disposed-of unless instructions to the contrary are received from the client.

6.1.3 Analytical results for the soil samples

The results and comments presented in this section are based on the Fill Quality Guide and Good Management Practices for Shore Infilling in Ontario and on the O.Reg 558/00 Waste Management.

The soil samples were collected in the field and transported to the analytical laboratory while adhering to the procedures prescribed by the MOE's guideline "Guidance on Sampling and Analytical Methods for Use at Contaminated Sites in Ontario" (MOE, 1996).

Chemical analysis results for the soil samples are presented in the certificates appended in appendix 5.

The chemical analysis results on the selected soil samples indicated the following:

- The soil samples show concentrations in total phosphorus, in chromium, in copper, in iron, in manganese and in nickel exceeding the applicable criteria for unconfined shore infilling.
- The soil sample analysed for the Toxicity Characteristic Leaching Procedure (TCLP) shows concentrations indicating that the soil is not leaching toxic substances.

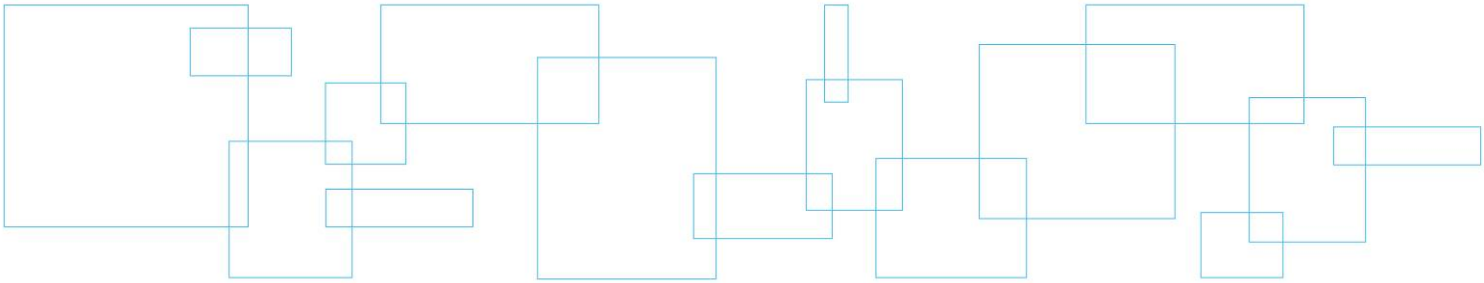
6.2 COMMENTS

The proposed work involves the excavation of soils. For that purpose, PWGSC requested that selected soil samples be tested to assess whether excavated material meets Ministry of Environment open water lakefill, or landfill disposal criteria.

On the basis of the laboratory results, the excavated soil cannot be used for open water lakefill as per the Fill Quality Guide and Good Management Practices for Shore Infilling in Ontario.

However the soil can be disposed of at any municipal landfill as they do not leach toxic substances as per Ontario Regulation 558/00.

Appendix 1 Scope and Limitations of the Study



SCOPE OF THE GEOTECHNICAL AND ENVIRONMENTAL STUDY

1.0 Soil and Rock Characteristics

The soil and rock characteristics described in this report originate from geotechnical investigations conducted within a given period and correspond to the nature of the terrain only at the specific locations where these investigations were carried out.

Soil and rock formations have natural variations. The limits between the different formations presented in the sounding logs must therefore be considered as transitions between the formations rather than set boundaries. The precision of these limits depends on the type and number of soundings, the sounding methods used, as well as sampling frequency and methods.

The descriptions of the samples taken are based on recognized identification and classification methods used in geotechnics. They can call into play the judgement and interpretation of the personnel who carried out the examination of materials and can be presumed to be accurate and correct in keeping with current best practices in the field of geotechnics. Finally, if tests were carried out, the results of these tests apply solely to the samples tested, as described in this report.

The properties of the soil and rock can undergo significant modifications in the wake of construction activities such as excavation, blasting, pile driving or drainage activities, carried out on the site under study or an adjacent site. They can also be indirectly modified by the exposure of the soil or rock to freezing or weather stresses.

2.0 Groundwater Conditions

The groundwater conditions presented in this report apply only to the site under study. The accuracy and representation of these conditions must be interpreted based on the type of instrumentation used, as well as the period, duration, and number of observations carried out. These conditions can vary depending on precipitation, the seasons and, ultimately, the tides. They can also vary as a result of construction activities or the modification of physical elements on the site under study or in its vicinity. The problematic of ferrous ochre and its effects is not covered in this report.

3.0 Use of the Report

The comments and recommendations contained in this report are intended primarily for the project's design team. The number of soundings required to identify all of the underground conditions that could impact construction costs, techniques, the choice of equipment and planning of operations could be greater than the number required for design purposes. All contractors bidding on or carrying out the work on the site under study must undertake their own interpretation of the results of the soundings and, if need be, carry out their own investigations to determine how site conditions could influence their operations or work methods.

Any modifications to the design, position and elevation of the works must be quickly communicated to LVM, allowing the validity of the recommendations presented to be verified. Complementary site or laboratory work could ultimately be required.

4.0 Project Follow-up

The interpretation of the on-site and laboratory results obtained, as well as the recommendations presented in this report, apply solely to the site under study and to the information available about the project at the time this report was drafted.

Information available concerning the site and groundwater conditions increases as construction work progresses. As site conditions were interpreted and correlated between sounding points, LVM should be allowed to verify these conditions, during site visits conducted as work progresses, in order to confirm the information provided by the drillings soundings. If it is not possible for us to conduct these verifications, LVM shall assume no responsibility for geotechnical interpretations by third parties concerning recommendations contained in this report, particularly if the design has been modified or if site conditions different from those described in this report are encountered. The identification of such changes requires experience and must be carried out by an experienced geotechnical engineer.

5.0 Environment

Information and comments relating to the environmental conditions of the site are to be considered as summary and limited. They relate solely to the environmental quality of the soil samples taken from the soundings, and not to the environmental quality of the groundwater.

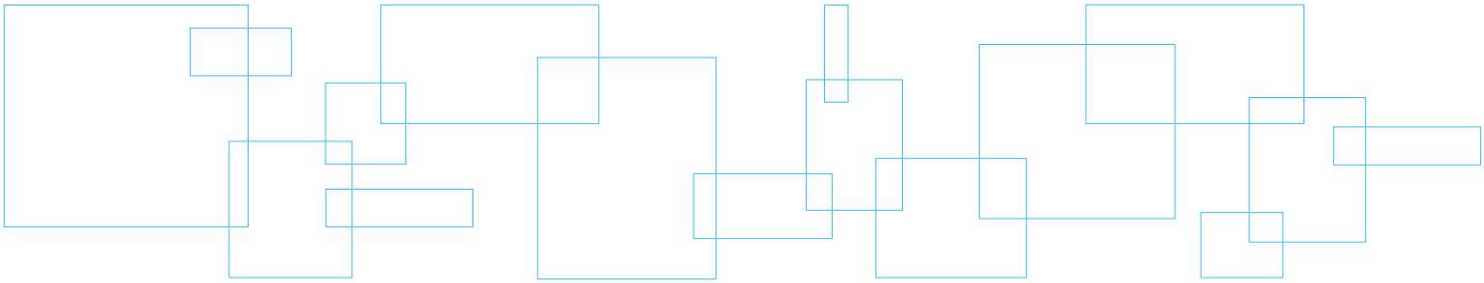
Unless otherwise noted, the interpretation of the data, the environmental comments and the recommendations contained in this report are based, to the best of our knowledge, on the policies, criteria and environmental regulations in effect at the time this project was carried out, within their applicable limits, according to the specific nature of the project and the intended use of the site under study. If these policies, criteria and regulations differ from those presumed to be in effect, or if they have undergone changes following the production of this report, LVM must be consulted in order to revise the recommendations according to these changes. In the event that no policies, criteria or regulations are available to permit the interpretation of data, the comments and recommendations expressed by LVM are based on our best possible knowledge of accepted best professional practices applicable to the project involved.

The conditions indicated in this report correspond to those detected at the locations and dates of the observations as indicated herein. They can vary over time, resulting from activities carried out on the site under study or on adjacent sites, or following natural events, natural reactions or other occurrences.

Concentrations identified in the soil samples are determined based on the results of chemical analyses carried out on a limited number of samples. Concentrations between sampling points can vary based on the conditions encountered at the locations where the analyzed samples were taken.

The fact that a certain parameter has not been analyzed does not exclude the possibility that it may be present in concentrations greater than the background noise or the detection limit for said parameter.

Appendix 2 Explanation Notes and Borehole Log Reports



EXPLANATION NOTE ON SOUNDING LOGS

The following sounding logs summarize soils and rock geotechnical properties as well as ground water conditions, as collected during field work and/or obtained from laboratory tests. This note explains the different symbols and abbreviations used in these logs.

STRATIGRAPHIC UNITS

Elevation/Depth: Reference to the geodesic elevation of the soil or to a bench mark of arbitrary elevation, at the location of the sounding. Depth of the different geological boundaries as measured from ground surface. On the left, the scale is in meters while on the right, it is in feet.

Description of the stratigraphic units: Every geological formation is detailed.

The proportion of the different elements of the soil, defined according to the size of the particles, is given following the classification hereafter. The relative compactness of cohesionless soils is defined by the "N" index of the Standard Penetration Test. The consistency of cohesive soils is defined by their shear resistance.

Classification	Particle size (mm)
Clay	< 0.002
Clay and silt (undifferentiated)	< 0.08
Sand	0.08 to 5
Gravel	5 to 80
Cobble	80 to 300
Boulder	> 300

Descriptive terminology	Proportion (%)
"Traces" (tr.)	1 to 10
"Some" (s.)	10 to 20
Adjective (ex.: sandy, silty)	20 to 35
"And" (ex.: sand and gravel)	35 to 50

Compactness of cohesionless soils	Standard Penetration Test index ("N" value), ASTM D-1586 (blows for a 300mm penetration)
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

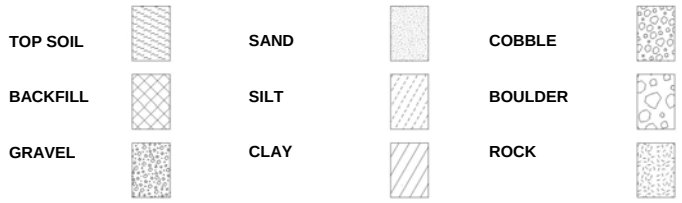
Consistency of cohesive soils	Undrained shear strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Plasticity of cohesive soils	Liquid limit (%)
Low	< 30
Medium	30 to 50
High	> 50

Sensitivity of cohesive soils	$S_t = (C_u/C_{ur})$
Low	$S_t < 2$
Medium	$2 < S_t < 4$
High	$4 < S_t < 8$
Extra-sensitive	$8 < S_t < 16$
Quick (sensitive) clay	$S_t > 16$

Classification of rock	RQD (%)
Very poor quality	< 25
Poor quality	25 to 50
Fair quality	50 to 75
Good quality	75 to 90
Excellent quality	90 to 100

SYMBOLS



WATER LEVEL

This column shows the ground water level, as measured at a given time during the geotechnical investigation. The details of the installation (type and depth) are also illustrated in this column.

SAMPLES

Type and number: Each sample is labelled in accordance with the number of this column and the given notation refers to samples types.

Sub-sample: When a sample contains two or more different stratigraphic units, it is sometimes necessary to separate it and create sub-samples. This column allows for the identification of the latter and the association to *in situ* or laboratory measurements to these sub-samples.

Condition: The position, length and condition of each sample are shown in this column. The symbol shows the condition of the sample, following the legend given on the sounding log.

Size: This column indicates the split spoon sampler size.

"N" index The standard penetration index shown in this column is expressed with the letter "N". This index is obtained with the Standard Penetration Test. It corresponds to the number of blows required to drive the last 300mm of the split spoon, using a 622 Newton hammer falling freely from a height of 762mm (ASTM D-1586). For a 610mm long split spoon, the "N" index is obtained by adding the number of blows required for the driving of the 2nd and 3rd 150mm of the split spoon. Refusal (R) indicates a number of blows greater than 100. A set of numbers such as 28-30-50/60mm indicates that the number of blows required to drive the 1st and 2nd 150mm of the split spoon are respectively 28 and 30. Moreover, it indicates that 50 blows were necessary to get a penetration of 60mm, whereupon the test was suspended.

RQD index: Rock Quality Designation index: This index is defined as the ratio between the total length of all rock cores of 100mm and more in length over the total length of the core run. The RQD index is an indirect measurement of the number of "natural" fractures and of the amount of the alteration in a rock mass.

TESTS

Results: This column shows, for the corresponding depth, the results of tests carried out in the field or in the laboratory (shear strength, dynamic penetration, Atterberg limits with the cone, etc.). For more information, please refer to the legend in the upper part of the sounding log. However, an abbreviation indicating the type of analysis performed is shown next to the sample tested.

Graph: This graph shows the undrained shear strength resistance of cohesive soils, as measured *in situ* or in the laboratory (NQ 2501-200). It is also used to present the Dynamic Cone Penetration Test (NQ 2501-145) results.

Moreover, this graph is used for the representation of the water content and Atterberg limits test results.

Client :

PUBLIC WORKS & GOVERNMENT SERVICES CANADA

BOREHOLE REPORT

File n°: **B-0001193-1**
Borehole n°: **BH-01-12**
Date: **2012-05-24**

Project: **Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)**

Location: **Joyceville Institution, Kingston, Ontario**

Coordinates (m): North 4912334,0 (Y); East 392442,0 (X); Elevation **110,95 (Z)**

Bedrock: m End depth: 6,71 m

Sample condition

Intact | Remoulded | Lost | Core

Organoleptic soil examination:

Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
AS	Auger
MA	Bulk sample
TU	Transparent tube
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm) ●
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	CA	Chemical Analysis		**Undrained shear strength** (Field ▲ / Laboratory ■)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa) ▲ ■
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa) △ □
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_O	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		110,95													
		0,00	Asphalt												
1		110,88	***Road fill:*** Grey sand with some silt, some gravel and traces of clay			SS-1				67	1-4 3-3	7			
2		0,07 110,19													
3	1	0,23	Gravelly sand with traces of silt and some grey clay			SS-2				12	3-2 4-5	6			
4		109,43													
5		1,52	***Clay deposit :*** Grey silty clay with traces of sand			SS-3				62	2-5 5-7	10			
6	2														
7															
8															
9															C_U> 146 kPa
10	3														
11						SS-4				100	4-5 6-9	11			
12															
13	4														
14															
15															
16	5					SS-5				100	4-5 6-7	11			
17															
18															
19															
20	6														
21						SS-6				100	3-3 3-4	6			
22		104,24													
23	7	6,71	End of borehole												
24															
25															
26	8														
27															
28															
29															

FIELD AND LABORATORY TESTS

NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120

UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 75

Remarks:

Borehole type: **Borehole**

Boring equipment: **CME-75**

Prepared by: **S. Séguin, tech.**

Approved by: **T. Lampron**

2012-06-14

Page: 1 of 1

Client :

PUBLIC WORKS & GOVERNMENT SERVICES CANADA

BOREHOLE REPORT

File n°: **B-0001193-1**
Borehole n°: **BH-02-12**
Date: **2012-05-24**

Project: **Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)**

Location: **Joyceville Institution, Kingston, Ontario**

Coordinates (m): North 4912343,0 (Y)
East 392427,0 (X)
Elevation **110,85 (Z)**
Bedrock: m End depth: 15,47 m

Sample condition

Intact | Remoulded | Lost | Core

Organoleptic soil examination:

Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
AS	Auger
MA	Bulk sample
TU	Transparent tube
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm) ●
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	CA	Chemical Analysis		Undrained shear strength (Field ▲ / Laboratory ■)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa) ▲ ■
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa) △ □
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_O	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	SAMPLES: TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		110,85													
1		0,00 / 110,77	Asphalt												
2		0,08 / 110,09													
3	1	0,76 / 109,33	***Clay deposit:*** Grey silty clay with traces of sand			SS-1				67	3-2 / 3-2	5			
4															
5		1,52 / 108,56	Grey silty clay with traces of sand, traces of gravel, very wet			SS-2				54	1-2 / 2-1	4			
6	2														
7		2,29 / 106,28	Black silt			SS-3				62	2-6 / 6-6	12			
8															
9															
10	3					SS-4				75	3-3 / 4-4	7			
11															
12															
13	4														
14															
15		4,57 / 104,75	Grey silty clay, wet			SS-5				29	6-8 / 11-13	19			
16															
17	5														
18															
19															
20	6	6,10 / 102,62	Grey silt and clay, a little wet			SS-6				100	3-3 / 4-6	7			
21															
22															
23	7														
24															
25															
26	8					SS-7				100	1-4 / 4-4	8			
27		8,23	End of sampling and the beginning of dynamic penetration test												N_C= 7
28															N_C= 12
29															

NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120

UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 75

Remarks:

Borehole type: **Borehole**

Boring equipment: **CME-75**

Prepared by: **S. Séguin, tech.**

Approved by: **T. Lampron**

2012-06-14

Client : **PUBLIC WORKS & GOVERNMENT SERVICES CANADA**

BOREHOLE REPORT

File n°: **B-0001193-1**
Borehole n°: **BH-02-12**
Date: **2012-05-24**

Project: **Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)**

Location: **Joyceville Institution, Kingston, Ontario**

Coordinates (m): North 4912343,0 (Y)
East 392427,0 (X)
Elevation **110,85 (Z)**
Bedrock: m End depth: 15,47 m

DEPTH - ft	DEPTH - m	STRATIGRAPHY: ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	SAMPLES: TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	FIELD AND LABORATORY TESTS: RESULTS
30															N_C= 12
31															N_C= 10
32	10														N_C= 10
33															N_C= 15
34															N_C= 16
35															N_C= 23
36	11														N_C= 19
37															N_C= 18
38															N_C= 22
39	12														N_C= 23
40															N_C= 31
41															N_C= 34
42	13														N_C= 34
43															N_C= 44
44															N_C= 43
45															N_C= 50
46	14														N_C= 45
47															N_C= 48
48															N_C= 70
49	15														N_C= 85
50		95,38													N_C= 96
51		15,47	End of borehole after obtaining a refusal on dense soil at 15.47 m												N_C= 100
52	16														
53															
54															
55															
56	17														
57															
58															
59	18														
60															
61															
62	19														
63															
64															
65															
66	20														
67															
68															
69	21														
70															
71															
72	22														

FIELD AND LABORATORY TESTS

NATURAL WATER CONTENT AND LIMITS (%)
Wp W WL
20 40 60 80 100 120

UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION
20 40 60 80 100 120

Vertical Scale = 1 : 75

Remarks:

Borehole type: **Borehole**

Boring equipment: **CME-75**

Prepared by: **S. Séguin, tech.**

Approved by: **T. Lampron**

2012-06-14

Client :

PUBLIC WORKS & GOVERNMENT SERVICES CANADA

BOREHOLE REPORT

File n°: **B-0001193-1**
Borehole n°: **BH-03-12**
Date: **2012-05-24**

Project: **Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)**

Location: **Joyceville Institution, Kingston, Ontario**

Coordinates (m): North 4912311,0 (Y)
East 392435,0 (X)
Elevation **111,09 (Z)**
Bedrock: 4,67 m End depth: 6,20 m

Sample condition

Intact | Remoulded | Lost | Core

Organoleptic soil examination:

Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
AS	Auger
MA	Bulk sample
TU	Transparent tube
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits
W_L	Liquid Limit (%)
W_P	Plastic Limit (%)
I_P	Plasticity Index (%)
I_L	Liquidity Index
W	Natural Water Content (%)
GS	Grain Size Analysis
S	Hydrometer analysis
R	Refusal
VBS	Methylene Blue Value
WR	Weight of Rods
O.M.	Organic Matter (%)
K	Permeability (cm/s)
UW	Unit Weight (kN/m³)
A	Absorption (l/min. m)
U	Uniaxial Compressive strength (MPa)
RQD	Rock Quality Designation (%)
CA	Chemical Analysis
P_L	Limit Pressure (kPa)
E_M	Pressuremeter Modulus (MPa)
E_r	Modulus of subgrade reaction (MPa)
SP_O	Segregation Potential (mm²/H °C)
	Water Level
N	Std Penetration test (blows/300mm)
N_C	Dyn. Penetration test (blows/300mm) ●
σ'_P	Preconsolidation Pressure (kPa)
SCI	Soil Corrosivity Index

Undrained shear strength (Field ▲ / Laboratory ■)

C_U	Undisturbed (kPa)
C_{UR}	Remoulded (kPa)

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		111,09													
1		0,00 / 111,01	Asphalt												
2		0,08 / 110,33													
3	1	0,76	***Clay deposit:*** Grey silty clay with traces of sand, traces of gravel and trace of oxydation			SS-1				46	2-3 / 5-6	8			
4		109,57													
5		1,52	Grey clayey silt with traces of sand and traces of oxydation												
6	2					SS-2				96	4-5 / 5-6	10			
7															
8						SS-3				100	2-4 / 6-6	10			
9		108,04													
10	3	3,05	Grey silt with some clay, traces of sand and traces of oxydation			SS-4				100	2-3 / 4-5	7			
11															
12															
13	4														
14															
15		106,42				SS-5				0	50 /10 cm	R			
16		4,67	***Rock :*** Sandstone												
17	5														
18						RC-6				100		90			U = 130 MPa
19															
20	6	104,89													
21		6,20	End of borehole												
22															
23	7														
24															
25															
26	8														
27															
28															
29															

NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120

UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 75

Remarks:

Borehole type: **Borehole**

Boring equipment: **CME-75**

Prepared by: **S. Séguin, tech.** | Approved by: **T. Lampron** | 2012-06-14 | Page: 1 of 1

Client :

PUBLIC WORKS & GOVERNMENT SERVICES CANADA

BOREHOLE REPORT

File n°: **B-0001193-1**
Borehole n°: **BH-04-12**
Date: **2012-05-24**

Project: **Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)**

Location: **Joyceville Institution, Kingston, Ontario**

Coordinates (m): North 4912323,0 (Y)
East 392416,0 (X)
Elevation **111,06 (Z)**
Bedrock: m End depth: 3,45 m

Sample condition
Intact | Remoulded | Lost | Core

Organoleptic soil examination:
Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
AS	Auger
MA	Bulk sample
TU	Transparent tube
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits
W_L	Liquid Limit (%)
W_P	Plastic Limit (%)
I_P	Plasticity Index (%)
I_L	Liquidity Index
W	Natural Water Content (%)
GS	Grain Size Analysis
S	Hydrometer analysis
R	Refusal
VBS	Methylene Blue Value
WR	Weight of Rods
O.M.	Organic Matter (%)
K	Permeability (cm/s)
UW	Unit Weight (kN/m³)
A	Absorption (l/min. m)
U	Uniaxial Compressive strength (MPa)
RQD	Rock Quality Designation (%)
CA	Chemical Analysis
P_L	Limit Pressure (kPa)
E_M	Pressuremeter Modulus (MPa)
E_r	Modulus of subgrade reaction (MPa)
SP_O	Segregation Potential (mm²/H °C)
	Water Level
N	Std Penetration test (blows/300mm)
N_C	Dyn. Penetration test (blows/300mm) ●
σ'_P	Preconsolidation Pressure (kPa)
SCI	Soil Corrosivity Index

Undrained shear strength (Field ▲ / Laboratory ■)
C_U Undisturbed (kPa)
C_{UR} Remoulded (kPa) △ □

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		111,06													
		0,00 / 110,98	Asphalt												
		0,08 / 110,30													
	1	0,76 / 109,69	***Clay deposit :*** Silty clay with traces of sand, traces of gravel			SS-1				50	2-3 / 2-2	5			
		1,37 / 109,23													
	2	1,83	Beginning of van test at 1.83 m												C_U= 109 kPa
		108,23													
	3	2,83	End of van test at 2.83 m												C_U> 166 kPa
		107,61													
	4	3,45	End of borehole												

FIELD AND LABORATORY TESTS

NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120

UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 75

Remarks:

Borehole type: **Borehole**

Boring equipment: **CME-75**

Prepared by: **S. Séguin, tech.**

Approved by: **T. Lampron**

2012-06-14

Page: 1 of 1

Client :

PUBLIC WORKS & GOVERNMENT SERVICES CANADA

BOREHOLE REPORT

File n°: **B-0001193-1**
Borehole n°: **BH-05-12**
Date: **2012-05-24**

Project: **Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)**

Location: **Joyceville Institution, Kingston, Ontario**

Coordinates (m): North 4912402,0 (Y)
East 392421,0 (X)
Elevation **110,45 (Z)**
Bedrock: m End depth: 2,90 m

Sample condition

Intact | Remoulded | Lost | Core

Organoleptic soil examination:

Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
AS	Auger
MA	Bulk sample
TU	Transparent tube
PW	LVM Mega-Sampler
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Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm) ●
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	CA	Chemical Analysis		Undrained shear strength (Field ▲ / Laboratory ■)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa)
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa)
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_O	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		110,45													
1		0,00 / 110,38	Topsoil and organic matter												
2		0,07 / 109,69	***Granular fill :*** Grey gravelly sand with some silt			SS-1				29	3-8 6-4	14			
3	1	0,76 / 108,93	***Natural deposit :*** Grey silt with some clay, traces of sand and traces of gravel			SS-2				25	2-3 3-6	6			
5		1,52 / 108,16	Grey clayey silt with traces of sand and traces of gravel			SS-3				29	2-3 2-2	5			
7	2	2,29 / 107,55	Grey clayey silt with traces of sand			SS-4				71	3-3 5-5	8			
10	3	2,90	End of borehole												
13	4														
16	5														
20	6														
23	7														
26	8														
29															

FIELD AND LABORATORY TESTS

NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120

UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 75

Remarks:

Borehole type: **Borehole**

Boring equipment: **CME-75**

Prepared by: **S. Séguin, tech.**

Approved by: **T. Lampron**

2012-06-14

Page: 1 of 1

Client :

PUBLIC WORKS & GOVERNMENT SERVICES CANADA

BOREHOLE REPORT

File n°: **B-0001193-1**
Borehole n°: **BH-06-12**
Date: **2012-05-24**

Project: **Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)**

Location: **Joyceville Institution, Kingston, Ontario**

Coordinates (m): North 4912403,0 (Y)
East 392439,0 (X)
Elevation **110,40 (Z)**
Bedrock: m End depth: 2,90 m

Sample condition
Intact | Remoulded | Lost | Core

Organoleptic soil examination:
Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
AS	Auger
MA	Bulk sample
TU	Transparent tube
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm) ●
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	CA	Chemical Analysis		Undrained shear strength (Field ▲ / Laboratory ■)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa) ▲ ■
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa) △ □
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_O	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		110,40													
1		0,00 / 110,33	Topsoil and organic matter												
2		0,07 / 109,64	***Granular fill:*** Grey sand with some silt and some gravel			SS-1				25	2-7 15-6	22			
3	1	0,76	Grey gravelly sand with some silt			SS-2				17	4-4 2-2	6			
4		108,88													
5		1,52	***Natural deposit :*** Grey silty clay with traces of sand and trace of gravel			SS-3				92	3-4 5-5	9			L W = 31.0
6	2														
7						SS-4				96	3-5 6-8	11			
8															
9		107,50													
10	3	2,90	End of borehole												
11															
12															
13	4														
14															
15															
16	5														
17															
18															
19															
20	6														
21															
22															
23	7														
24															
25															
26	8														
27															
28															
29															

FIELD AND LABORATORY TESTS

NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120

UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 75

Remarks:

Borehole type: **Borehole**

Boring equipment: **CME-75**

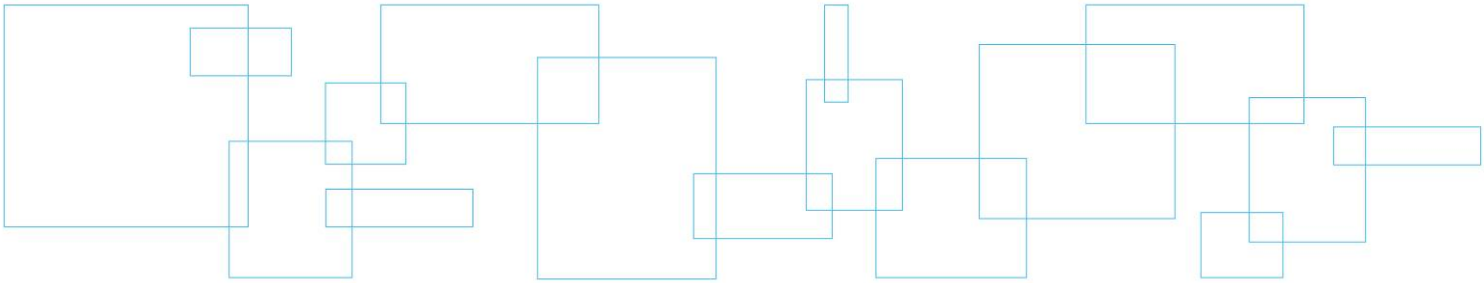
Prepared by: **S. Séguin, tech.**

Approved by: **T. Lampron**

2012-06-14

Page: 1 of 1

Appendix 3 Laboratory Test Results



UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORES

Client : **PWGSC**	Date : **2012-06-05** File : **B-0001193-1**
	Description of work: **Geotechnical Investigation**
Project : **Various Institutions in Kingston**	
(Joyceville)	Client Ref.:

SAMPLING OF ROCK CORES				
Laboratory number	:	**B-0001193-1-004**		
Borehole No	:	**BH-03-12**		
Core No.	:	**RC-6**		
Length of recovery (m)	:			
Location	:	**4.88 to 5.13 m**		
Sampled by	:	**Sylvain Séguin**		
Location of boreholes proposed by	:			

COMPRESSIVE STRENGTH TESTING					
Conditioning of samples		Date	**2012-05-24**		
Compressive strength testing		Date	**2012-06-05**		
Preparation of extremities		:			
Length after cut	(mm)	:	**176.5**		
Length after polishing	(mm)	:	**154.0**		
Diameter of core	(mm)	:	**63.0**		
Height/diameter ratio (H/d)		:	**2.444**		
Correction factor		:	**1.00**		
Compressive strength	(MPa)	:	**130.1**		
Results transmitted to :			Date:		

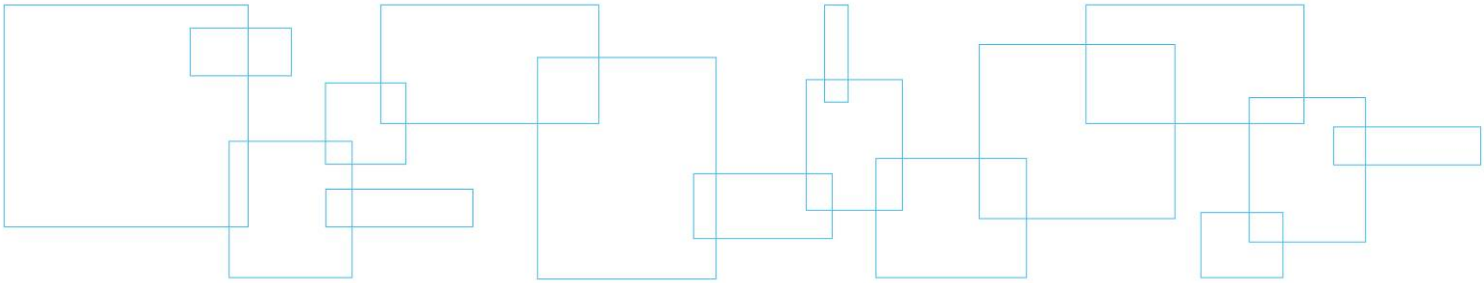
SAMPLING AND TESTING

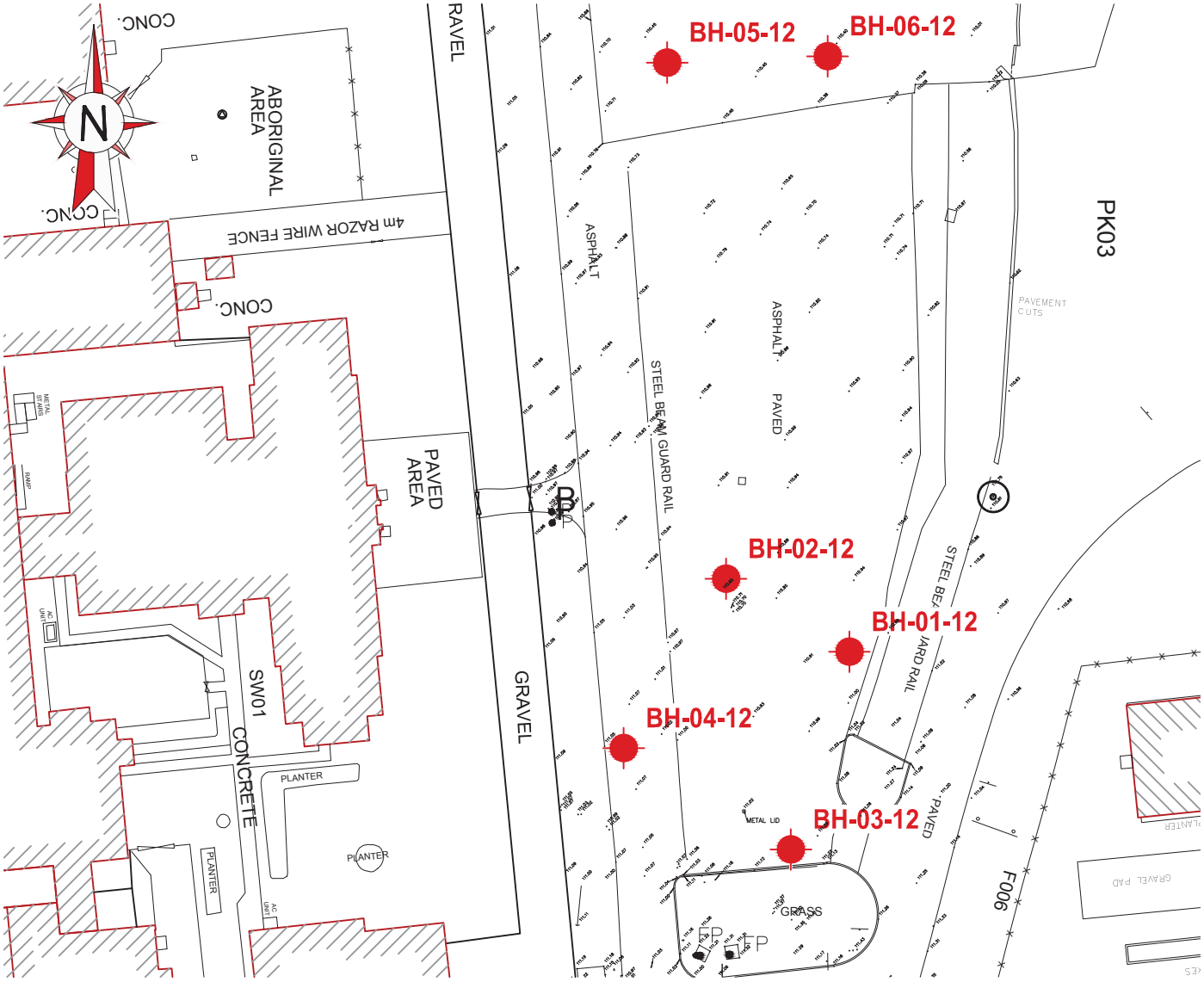
Conditioning : Humidity ☐ Dry ☒

Remarks:

Sanja Tokmacic	Jean-Pierre Lavoie	Jean-Pierre Lavoie.
Realized by	Verified by	Approved by

Appendix 4 Borehole Locations





This document must be used jointly with the recommendations formulated in the geotechnical study report

LEGEND :

BH-NN-YY BOREHOLE-NUMBER-YEAR

SURVEY COORDINATED

BOREHOLE	NORTH (Y)	EAST (X)	ELEVATION (m)
BH-01-12	4912334	392442	110,95
BH-02-12	4912343	392427	110,85
BH-03-12	4912311	392435	111,09
BH-04-12	4912323	392416	111,06
BH-05-12	4912402	392421	110,45
BH-06-12	4912403	392439	110,40

Project

PWGSC
Sub-surface Investigation, Various Institutions (Millhaven, Joyceville and Bath)

Title

Boreholes Location
Joyceville Institution

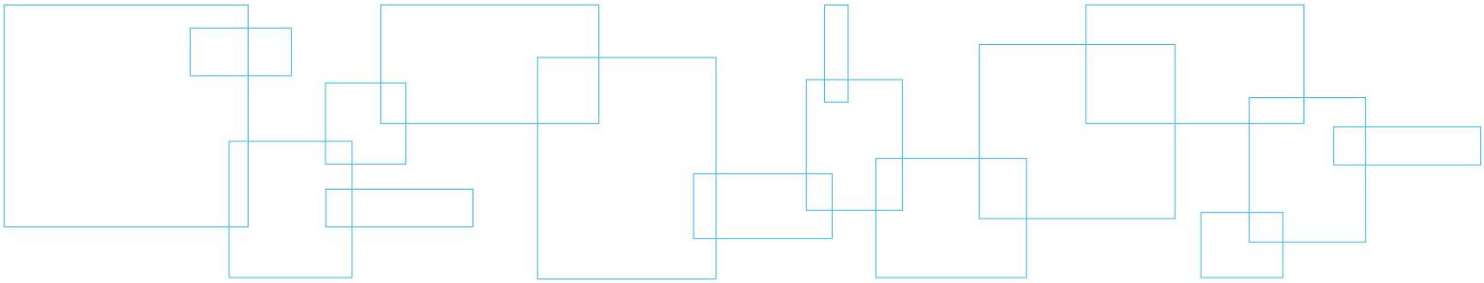
LVM inc.
556, O'Connor Drive, unit 127
Kingston (Ontario) K7P 1N3
Phone : 613.504.4306
Fax : 613.389.1563

Prepared **S. Séguin**	Discipline **GEOTECHNICAL**	Project Manager **C. Perez**
Drawn **R. FRENETTE**	Scale **1:750**	Extract from: Rev.:
Checked **T. LAMPRON**	Date **2012-06-07**	

Serv. char.	Project	Wbs	Disc.	Type	Drawing No.	Rev.
033	B-0001193	1	GE	D	0001	

G:\033\B-0001193\B-0001193-1IZ5_CAD_INF\033-B-0001193-1.DWG

Appendix 5 Chemical Analysis Certificate



LVM

Table 8 : Summary of soil samples results - Inorganics, Metals and PCB

Parametres	Units	FQG[1] Table C-2[2]	Analytical results	
Samples			BH-02-12 SS-2	BH-03-12 SS-4
Sampling Date			2012-05-22	2012-05-22
Depth (m)			1.52 - 2.13	3.05 - 3.66
Stratigraphic Unit			Clay	Clay
Electrical Conductivity	mS/cm		0,6	
pH			7,9	
Resistivity	ohm-cm		1,670	
Sulphate	%		0,02	
Total Organic Carbon	%	1	0,25	0,27
Total Phosphorus	%	0.06	0,12	0,13
Aluminum	ug/g		19,700	11,400
Barium	ug/g		263	168
Beryllium	ug/g		<1	<1
Cadmium	ug/g	0.6	<0.5	<0.5
Chromium	ug/g	26	46	28
Cobalt	ug/g		14	10
Copper	ug/g	16	32	20
Iron	ug/g	20,000	30,400	22,200
Lead	ug/g	31	9	6
Manganese	ug/g	460	709	520
Molybdenum	ug/g		<1	<1
Nickel	ug/g	16	26	17
Silver	ug/g		<0.2	<0.2
Strontium	ug/g		74	88
Thallium	ug/g		<1	<1
Vanadium	ug/g		69	47
Zinc	ug/g	120	79	50
Polychlorinated Biphenyls (PCBs)	ug/g	0.07	<0.02	<0.02

Notes:

(1) : Fill Quality Guide and Good Management Practices for Shore Infilling in Ontario

(2) : Table C-2: Unconfined fill Guide Parameter List - Lowest Effect Level

5,9 : Concentrations higher than the Lowest Effect Level for Unconfined fill

Table 9 : Summary of soil samples results - Toxicity Characteristic Leaching Procedure

Parametres	Units	Reg 347[1] Sched 4[2]	Analytical results
Samples			BH-02-12 SS-2
Sampling Date			2012-05-22
Depth (m)			1.52 - 2.13
Stratigraphic Unit			Clay
Cyanide (free)	mg/L	20	< 0.02
Flash Point	C		> 70
Fluoride	mg/L	150	0,4
NO2+NO3 as N	mg/L	1,000	0,81
Mercury	mg/L	0,1	< 0.001
Silver	mg/L	5	< 0.001
Arsenic	mg/L	2,5	< 0.01
Boron	mg/L	500	< 1
Barium	mg/L	100	0,8
Cadmium	mg/L	0,5	< 0.001
Chrome	mg/L	5	< 0.05
Lead	mg/L	5	< 0.01
Selenium	mg/L	1	< 0.01
Uranium	mg/L	10	< 0.01

Notes:

(1) : Ontario Regulation 558/00 - Waste Management

(2) : Schedule 4 - Leachate Quality Criteria

5,9 : Concentrations higher than the Lowest Effect Level for Unconfined fill