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Rideau Canal Walls – Herridge St to Mutchmor Rd

Geotechnical Study

Public Works and Government Services Canada – Ontario Region
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1 Introduction

SNC-Lavalin GEM Québec inc. (SNC-Lavalin) has been retained by Public Works and Government Services Canada (PWGSC) in order to perform a Geotechnical Study for the replacement of a section of the Rideau Canal Walls. This work has been conducted for PWGSC under the terms and conditions of the Standing Offer N° EP168-123367/004/FE.

The proposed replacement of the Rideau Canal Walls is located between Herridge Street and Mutchmor Road in Ottawa, Ontario.

The geotechnical investigation was undertaken to provide comments and/or recommendations on the following:

- General subsoil conditions existing on the site;
- Groundwater conditions;
- Safe bearing capacity value for the design of the retaining walls;
- Expected total settlements;
- Site classification for seismic design;
- Potential for soil liquefaction;
- Depth of frost penetration;
- Site preparation recommendations for construction;
- Excavation and backfilling considerations and earth pressures;
- Temporary slope stability;
- Global stability analysis of wall
- Promptly verify the potential presence of petroleum parameters (BTEX and F1-F-4 PHC) in fill materials; and
- Inspection and review during construction.

This report contains all the information gathered on site within the framework of this study. It also provides the structural engineers with geotechnical comments and recommendations regarding the proposed structure.

This report has been prepared solely and exclusively for PWGSC, as well as for Consulting Engineers retained by PWGSC for the above-mentioned purposes, and is subject to the scope of work joined in Appendix 1. Any modifications to the project shall be submitted to SNC-Lavalin in order to ensure the relevance of the recommendations.

Ongoing liaison with SNC-Lavalin during the final design and construction phase of the project is recommended to ensure that the recommendations in this report are applicable and/or correctly interpreted and implemented. Also, any queries concerning the geotechnical aspects of the proposed project should be directed to SNC-Lavalin for further elaboration and/or clarification.

2 Site Description

The portion of the Rideau Canal Walls to be replaced follows Colonel By Drive, and is located between Herridge Street and Mutchmor Road. The replacement portion is between stations STA 1+000.000 and STA 1+400.000 for a length of 400 m, as illustrated in Figure 1 below (a location plan of the study site).

Figure 1: Location Plan (PWGSC)

3 Investigation Procedures

3.1 Field Work

Fieldwork for the project was carried out March 4th, between April 12th and 22nd and between May 2nd and May 4th 2016. In total, 11 boreholes identified as BH-16-01 to BH16-08, BH-16-14, BH-16-15 and BH-16-15A as well as 3 coring of the existing concrete retaining wall identified as CC-16-01 to CC-16-03 were drilled, under the constant supervision of an experienced SNC-Lavalin technician. Buried utility clearances were also obtained at all borehole locations prior to the start of fieldwork.

The locations of the soundings are presented in Table 1.

Table 1 : Sounding Locations

Location	Borehole / Coring
Rideau Canal Pathway	BH-16-01 to BH-16-08
Rideau Canal (on ice)	BH-16-14, BH-16-15 and BH-16-15A
Retaining Wall	CC-16-01 to CC-16-03

It should be noted that boreholes BH-16-01, BH-16-03, BH-16-05 and BH-16-07 were used for environmental purposes, to verify the potential presence of petroleum parameters (BTEX and F1-F-4 PHC) in fill materials as described in our scope of work.

Boreholes BH-16-01 to BH-16-08 were advanced using a track-mounted CME-55LC hydraulic drill rig. In the overburden material, the boreholes were advanced by rotation of 'NW' sized casing.

Boreholes BH-16-14, BH-16-15 and BH-16-15A were advanced using a motorized tripod on the ice of the Rideau Canal. In the overburden material, the boreholes were advanced by manual percussion of 'NW' casing.

In all boreholes, sampling of the overburden was performed with a standard 51 mm O.D. split spoon sampler. The sampling procedure was conducted according to standard ASTM D 1586 for the Standard Penetration Test (SPT), which also provides the penetration resistance "N" values of granular soils. Furthermore, intact clay samples were recovered in boreholes BH-16-01 and BH-16-04 using thin wall tubes.

The undrained shear strength (s_u) of the clay was measured by means of a Nilcon vane tester.

The concrete coring of the existing retaining wall, CC-16-01 to CC-16-03, were advance using a manual drill with a Hilti™ thin wall coring bit.

In order to allow for subsequent groundwater level observations, 2 Casagrande type hydraulic piezometers were installed in boreholes BH-16-05 and BH-16-07. Flush mounted casings were used to complete the installation of the piezometers.

The individual borehole and coring logs are presented in Appendix 2.

3.2 Survey Work

All boreholes and their geodetic elevations were surveyed in the field by a professional surveying firm. Precision of x, y and z coordinated is approximately 15 mm. The locations of the boreholes are shown on the drawing presented in Appendix 6 of this report.

3.3 Laboratory Work

3.3.1 Geotechnical

All recovered samples were transported to SNC-Lavalin's geotechnical laboratory for identification and classification purposes. Subsequently, the following laboratory tests were carried out on representative samples for soil classification and physical properties identification.

Table 2 : Geotechnical Laboratory Testing

Tests	Number
Sieve Analysis	18
Hydrometer	3
Water Content	23
Atterberg Limits	12
Consolidation	3

Results of testing are presented in Appendix 3 of this report.

All samples for geotechnical purposes recovered during the site work that have not been used for laboratory tests will be kept for a period of 6 months from the date of filing this report. Thereafter, they will be disposed of, unless a written notice from PWGSC is provided.

3.3.2 Environmental

Environmental fill soil samples from boreholes BH-16-01, BH-16-03, BH-16-05 and BH-16-07 were immediately split into two portions for field logging/screening and for possible laboratory analysis. The field logging/screening portion was placed in a sealable plastic bag and logged in the field for geotechnical purposes and visual evidence of impacts (i.e., staining, presence of ash or debris, etc.). Maximum headspace vapour readings in the sample bags were measured in the field using an RKI Eagle 2 organic vapour meter (OVM). The OVM was calibrated daily in

the field in methane-elimination mode to one hexane gas standard. Field screening with the OVM was used to qualitatively direct selection of samples for volatile parameters. The portion of each soil sample collected for potential laboratory analysis was placed directly into laboratory supplied sample jars and placed in a cooler with ice.

Selected soil samples were submitted for laboratory analyses following parameters presented in Table 3.

Table 3 : Environmental Laboratory Testing

Parameter	Number
Benzene	12
Toluene	12
Ethylbenzene	12
Xylene Mixture	12
F1 (C6 to C10)	12
F1 (C6 to C10) minus BTEX	12
F2 (C10 to C16)	12
F3 (C16 to C34)	12
F4 (C34 to C50)	12

Results of testing are presented in Appendix 4 of this report. Analytical methods used are identified on the certificate of analysis included in Appendix 4.

All soil samples were collected in laboratory prepared sampling containers and stored in a cooler with ice until delivery to the analytical laboratory. Laboratory analyses of soil were completed by AGAT Laboratories (AGAT) of Ottawa, Ontario. AGAT is accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA).

4 Results of the Investigation

4.1 Soil Conditions behind retaining wall

A detailed description of soil strata encountered at the boreholes is given on the individual borehole logs presented in Appendix 2 and is summarized in the following sections. The following table presents a strata summary for boreholes BH-16-01 to BH-16-08 which were advanced behind the retaining wall.

Table 4 : Stratification at boreholes behind retaining wall

Borehole ID	Fill		Sand		Silty Clay		Sand and Silt	
	Top of Layer Elev. (m)	Thickness (m)	Top of Layer Elev. (m)	Thickness (m)	Top of Layer Elev. (m)	Thickness (m)	Top of Layer Elev. (m)	Thickness (m)
BH-16-01	64.83	1.83	63.00	2.08	60.92	10.39	50.53	>9.63
BH-16-02	64.78	2.60	62.18	1.20	60.98	9.40	51.58	>2.65
BH-16-03	64.83	2.30	62.53	1.36	61.17	6.54	54.63	>5.65
BH-16-04	64.87	2.61	---	---	62.26	3.84	58.42	>18.24
BH-16-05	---	---	64.85	2.44	62.41	4.42	57.99	>8.99
BH-16-06	64.93	0.61	64.32	2.44	61.88	2.55	59.33	>10.25
BH-16-07	64.86	1.70	---	---	63.16	2.26	60.90	>11.89
BH-16-08	64.59	4.50	---	---	---	---	60.09	>14.40

4.1.1 Fill

Boreholes BH-16-01 to BH-16-07 were executed on the grass strip between the pathway and Colonel By Dr, where an organic soil layer was observed on top of the fill. BH-16-08 was executed directly on the pathway, where a layer of asphalt followed by granular A foundation were observed on top of the fill.

Under the organic soil layer and the pathway, a heterogeneous fill was encountered. The fill was observed to be mostly sand with traces to some silt to silty sand with various proportions of gravel. Presence of silty clay clumps and organic debris were observed at boreholes BH-16-03 and BH-16-08. The thickness of the fill varies from 0.61 to 4.50 m at borehole locations, except at borehole BH-16-05 where the organic soil was based on the natural soil.

Based on the SPT "N" values recorded in the boreholes, the compactness can be described as very loose to loose with a compact horizon at borehole BH-16-08.

4.1.2 Sand

A sand deposit, varying from sand with traces of silt to sand and silt, with occasional presence of gravel and silty clay interbeds was observed under the fill at boreholes BH-16-01 to BH-16-03, BH-16-05 and BH-16-06. Based on the SPT "N" values recorded in the boreholes, the compactness can be generally described as very loose to loose. The thickness of the sand deposit varies from 1.20 to 2.44 m.

4.1.1 Silty Clay

Below the sand deposit or directly below the fill, a silty clay deposit is observed at boreholes BH-16-01 to BH-16-07. The thickness of the silty clay deposit decreases from North, 10.39 m at BH-16-01, to South, 2.26 m at BH-16-07, and is absent at borehole BH-16-08.

Twelve Atterberg Limits were realized on remoulded samples from split spoon sampling and on intact samples from thin wall tubes. Also, 23 water content determinations were conducted throughout the deposit. The clay deposit is generally of medium plasticity with portions of low plasticity.

The deposit shows a plastic limit (w_P) ranging from 12 to 19%, a liquid limit (w_L) ranging from 28 to 43% and a water content (w) ranging from 31 to 46%. It results in a plasticity index (I_P) ranging from 15 to 24% and a liquidity index (I_L) ranging from 0.7 to 1.5. It can be classified as "CL", according to the Unified Soil Classification System (USCS).

The undrained shear strength resistance (s_u) measured in the field indicates that the clay deposit has a firm to very stiff consistency with values varying from 34 to 194 kPa.

Finally, three one-dimensional consolidation tests were carried out on samples TW-10 and TW-14 from borehole BH-16-01 and sample TW-6 from borehole BH-16-04. The preconsolidation pressure values (σ'_p) obtained were 180 kPa (BH-16-01 - TW-10), 270 kPa (BH-16-01 - TW-14) and 120 kPa (BH-16-04 - TW-6). The preconsolidation gap at those points shows that the deposit is overconsolidated. Furthermore, a unit weight (γ) ranging from 16.9 to 18.0 kN/m³ was measured.

4.1.1 Sand and Silt

Below the silty clay deposit or directly below the fill at borehole BH-16-08, a sand and silt deposit is observed throughout the site. The thickness was observed to be greater than 18.2 m at borehole BH-16-04.

The deposit consists generally of a uniform fine grained sand with various proportions of silt, varying from sand with traces of silt to sand and silt with occasional traces of gravel. The proportion of silt can also be greater than sand at some portions of the deposit, resulting in a silt with some sand to silt and sand. Based on the SPT "N" values recorded in the boreholes, the compactness can be generally described as loose to dense.

4.2 Soil Conditions in front of retaining wall

A detailed description of soil strata encountered at the boreholes is given on the individual borehole logs presented in Appendix 2 and is summarized in the following sections. The following table presents a strata summary for boreholes BH-16-14, BH-16-15 and BH-16-15A which were advanced in front of the retaining wall, on the ice of the Rideau Canal.

Table 5 : Stratification at boreholes in front of retaining wall

Borehole ID	Ice / Water		Sand		Silty Clay		Sand and silt	
	Top of Layer Elev. (m)	Thickness (m)	Top of Layer Elev. (m)	Thickness (m)	Top of Layer Elev. (m)	Thickness (m)	Top of Layer Elev. (m)	Thickness (m)
BH-16-14	62.87	0.39	62.48	0.61	61.87	>1.83	---	---
BH-16-15	62.83	1.10	---	---	61.73	>1.83		
BH-16-15A	62.83	1.10	---	---	61.73	1.47	60.26	>0.97

4.2.1 Sand

Underneath the ice and water at borehole BH-16-14, a thin sand deposit with traces of silt and clay, and presence of organic matters, was observed.

4.2.1 Silty Clay

Underneath the sand deposit at borehole BH-16-14 and underneath the ice and water at borehole BH-16-15A, a silty clay deposit was observed. Its thickness was 1.47 m at borehole BH-16-15A and greater than 1.83 at borehole BH-16-14.

Borehole BH-16-15 showed mostly various proportions of clay, silt and sand with presence of organic debris.

4.2.2 Sand and Silt

A sand and silt deposit was observed under the silty clay deposit at borehole BH-16-15A. Its composition varies from silt and sand to sand with traces of silt. Based on the SPT "N" values recorded in the borehole, the compactness is described as loose to compact.

4.3 Retaining Wall Conditions

Three coring of the concrete retaining wall were executed in the vicinity of boreholes BH-16-01, BH-16-04 and BH-16-08 and are identified as CC-16-01 to CC-16-03. The results showed that the existing wall has a height varying from 3.93 to 4.13 m at coring locations.

4.4 Environmental Conditions and Results

4.4.1 Soil Field Screening

Field observations and the results of field screening of soil samples from borehole BH-16-01, BH-16-03, BH-16-05 and BH-16-07 are summarized on the individual borehole logs presented in Appendix 2. OVM readings measured during borehole drilling ranged from below the instrument detection limit to 100 parts per million by volume (ppmv).

4.4.2 Soil Quality

The concentrations for petroleum parameters analyzed (BTEX and F1-F-4 PHC) in soil are presented on the certificate of analysis at Appendix 4. The concentrations were compared to MOECC Table 9 *Generic Site Condition Standards for Use within 30 m of a Water Body in a Non-Potable Ground Water Condition*.

The environmental results are all below detection limit, thus satisfying Table 9.

4.5 Groundwater Conditions

In order to allow for subsequent groundwater level observations, hydraulic piezometers (Casagrande type), were installed at select borehole locations. The results of the observations are summarized in the following Table 6.

Table 6 : Groundwater Observations

Borehole No.	Instrument	2016-07-28	2016-08-08	2016-08-17	2016-11-01
		Depth (m) / Elevation (m)			
BH-16-05	Hydraulic Piezometer (sand and silt deposit)	4,96 / 59,89	4,96 / 59,89	4,86 / 59,99	5,31 / 59,54
BH-16-07	Hydraulic Piezometer (sand and silt deposit)	4,71 / 60,15	4,69 / 60,17	4,61 / 60,25	5,13 / 59,73

It should be noted that the level of water of the Rideau Canal was approximately 0.5 to 0.6 m below the surface of the boreholes when the readings in July and August were taken. This showed that there is no correlation between the level of water of the Rideau Canal and the groundwater level behind the wall.

It is important to note that seasonal and climatic changes, along with environmental factors, may cause fluctuations of the water table, and that the groundwater level could be different at other periods of the year, or throughout different years.

5 Comments and Recommendations

5.1 General

5.1.1 The Project

The project consists of the replacement of a section of the Rideau Canal Walls.

The portion of the Rideau Canal Walls to be replaced follows Colonel By Drive, and is located between Herridge Street and Mutchmor Road. The replacement portion is between stations STA 1+000.000 and STA 1+400.000 for a length of 400 m, as illustrated in Figure 1 above.

5.1.2 Stratigraphic Profile and Groundwater

The summary of the stratigraphic profile behind the retaining wall is as follows:

- Under the organic soil layer and the pathway, a heterogeneous fill was encountered. The fill was observed to be mostly sand with traces to some silt to silty sand with various proportions of gravel. The thickness of the fill varies from 0.61 to 4.50 m at borehole locations;
- A sand deposit, varying from sand with traces of silt to sand and silt, with occasional presence of gravel and silty clay interbeds was observed under the fill at boreholes BH-16-01 to BH-16-03, BH-16-05 and BH-16-06. The compactness can be generally described as very loose to loose. The thickness of the sand deposit varies from 1.20 to 2.44 m;
- Below the sand deposit or directly below the fill, a silty clay deposit is observed at boreholes BH-16-01 to BH-16-07. The thickness of the silty clay deposit decreases from North, 10.39 m at BH-16-01, to South, 2.26 m at BH-16-07, and is absent at borehole BH-16-08. The undrained shear strength resistance (s_u) measured in the field indicates that the clay deposit has a firm to very stiff consistency with values varying from 34 to 194 kPa;
- Below the silty clay deposit or directly below the fill at borehole BH-16-08, a sand and silt deposit is observed throughout the site. The thickness was observed to be greater than 18.2 m at borehole BH-16-04. The compactness can be generally described as loose to dense.

The summary of the stratigraphic profile in front of the retaining wall is as follow:

- Underneath the ice and water at borehole BH-16-14, a thin sand deposit with traces of silt and clay, and presence of organic matters, was observed.
- Underneath the sand deposit at borehole BH-16-14 and underneath the ice and water at borehole BH-16-15A, a silty clay deposit was observed. Its thickness was 1.47 m at borehole BH-16-15A and greater than 1.83 at borehole BH-16-14. Borehole BH-16-15 showed mostly various proportions of clay, silt and sand with presence of organic debris.
- A sand and silt deposit was observed under the silty clay deposit at borehole BH-16-15A. Its composition varies from silt and sand to sand with traces of silt. The compactness is described as loose to compact.

A summary of the groundwater conditions is as follows:

› Readings taken during the months of July, August and November showed groundwater levels at depths varying from 4.6 to 5.3 m behind the retaining wall;
› It should be noted that the level of water of the Rideau Canal was approximately 0.5 to 0.6 m below the surface of the boreholes when the readings were taken. This showed that there is no correlation between the level of water of the Rideau Canal and the groundwater level behind the wall.

Three coring of the concrete retaining wall, identified as CC-16-01 to CC-16-03, showed that the existing wall has a height varying from 3.93 to 4.13 m at coring locations.

5.2 Liquefaction Potential of On-Site Soils

The liquefaction potential of the sand and silt deposit encountered on-site has been verified following the method proposed by Youd et al[1]. The analysis was carried out using magnitude earthquake (Mw) of 6.8; an earthquake with an annual probability hazard of 2% in 50 years (0.0004).

The information about the seismicity of the region of the site was obtained from a representative of the Canadian Hazards Information Service, Natural Resources Canada, Government of Canada.

The results of the analysis indicate that portions of the sand and silt deposit encountered at the boreholes present a liquefaction potential.

Furthermore, based on the Canadian Foundation Engineering Manual (4th edition, 2006), the silty clay deposit is moderately susceptible to liquefaction or cyclic mobility. It is important to note that this classification may be revised on a site-specific basis using data from laboratory cyclic shear testing.

Nevertheless, based on discussions with the client, the designers do not consider earthquake impacts on the proposed wall. Therefore, no mitigation solutions will be discussed in this report.

5.3 Seismic Site Classification

The Canadian Highway Bridge Design Code (S6-14) presents the Site Classification for seismic site response at Table 4.1 of section 4.4.3.2.

For a site that presents liquefaction potential, a Class “F” must be taken.

On the other hand, because the designers do not consider earthquake impacts on the proposed wall, a Class “D”, based on the geotechnical investigations results, can be retained. Nevertheless, the structural engineer must confirm that the fundamental period of vibration of the wall is equal or less than 0.5 seconds.

[1] Youd, T. L. et al. « Liquefaction Resistance of Soils : Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils », *Journal of Geotechnical and Geoenvironmental Engineering*, vol. 127, n° 10, October 2001, p. 817-833.

5.4 Frost Protection

For the design of foundations, the traditional approach consists of placing footings at a depth greater than the depth of frost penetration. In order to provide an adequate protection against the negative effects of frost, the retaining wall foundation should be placed at a depth of 1.8 m below final grade, on both sides of the wall.

If foundations are placed at a depth shallower than 1.8 m below the final grade, they must be protected against the negative effect of frost action by an adequate insulation material like «Styrofoam». The design for the minimum required insulation of the foundations should be done accordingly to the recommendations of section 13.5.2 of the Canadian Foundation Engineering Manual (4th edition, 2006), using a mean freezing index value of 1012° C-days.

5.5 Site Preparation

All fill materials should be entirely removed from beneath the proposed foundations. It is important to note that boreholes BH-16-01 to BH-16-07 were executed on the grass strip between the pathway and Colonel By Dr due to the presence of a high-voltage electrical cable. Therefore, the fill observed in those boreholes may not be representative of the fill directly behind the wall.

Considering that the thickness of the silty clay deposit decreases from the North end to the South end of the wall and that the wall foundation sits at a depth of approximately 4.5 m, the wall subgrade will consist of either silty clay or sand and silt.

From borehole BH-16-01 to BH-16-06 approximately, the excavation will reveal a silty clay deposit with a liquidity index (I_L) of the order of 1, which results in a very sensitive material. It can easily be disturbed, losing its consistency and bearing capacity. The silty clay subgrade should not be proof-rolled. The contractor is responsible to put in place all precautions needed to avoid disturbance of the native soil. We recommend the use of a bucket equipped with a blade for the excavation and avoid any equipment circulation on exposed clay surfaces.

From borehole BH-16-06 to BH-16-08 approximately, the excavation will reveal a sand and silt deposit, in a very loose to compact dense state. If disturbed, this deposit will lose its compactness and bearing resistance. The sand and silt subgrade should be proof-rolled using adequate compaction equipment and should be to the satisfaction of geotechnical personnel. The contractor is responsible to put in place all precautions needed to avoid disturbance of the native soil.

The implementation of lean concrete at the bottom of excavation, as has been used in the past during the replacement of other wall sections, is recommended for this project. Furthermore, it will help to make a transition between silty clay and sand and silt subgrades, avoiding unwanted differential settlements.

5.6 Foundations

The proposed retaining wall is planned to be built on a 3 m wide foundation.

Both silty clay and sand and silt deposits present very similar ULS and SLS bearing capacities. Therefore, only the sand and silt deposit parameters will be presented for calculation and will be applicable for both subgrades.

5.6.1 Bearing Capacity at ULS

The bearing capacity at the Ultimate Limit State (ULS), for a foundation placed directly on the undisturbed native deposit, can be calculated using the following formula:

$$q_{ULS} = s_u N_c s_c i_c + q' N_q s_q i_q + 0{,}5\gamma' B N_\gamma s_\gamma i_\gamma$$

where :

q_{ULS} : ultimate geotechnical resistance pressure (kPa);

s_u : undrained shear strength (kPa);

N_c, N_q, N_γ : bearing coefficients, function of the value of the effective internal friction angle (ϕ');

s_c, s_q, s_γ : shape factors that account for the width-to-length ratio of footings;

i_c, i_q, i_γ : inclination factors that account for the effects of load inclination;

q' : vertical effective stress acting at the elevation of the base of the foundation which is obtained by the product of the depth "D" of the foundation by the effective unit weight of the soil in place (kPa);

γ' : unit weight of the soil under the foundation (kN/m³);

B : width of the foundation (m).

Table 7 summarizes the geotechnical parameters to use for calculating the ultimate bearing capacity at the limit states. The first term of the equation equals zero.

Table 7: Geotechnical Parameters (ULS)

Parameters	Value
Undrained shear strength (s_u)	0 kPa
Bearing coefficients (N_q) – above foundation (ϕ'=30,0°)	18
Bearing coefficients (N_γ) – below foundation (ϕ'=29,0°)	14
Unit weight of the soil under the foundation (γ')	6 kN/m³
Vertical effective stress acting at the elevation of the base of the foundation for foundation at a depth of 1.8 m on Canal side (q')	11 kPa

The ultimate geotechnical resistance pressure must be multiplied by a consequence factor (ψ) and by an ultimate geotechnical resistance factor (ϕ_{gu}) to provide the factored geotechnical resistance pressure for foundation design. Those factors are presented at Tables 6.1 and 6.2 of the S6-14. We recommend an ultimate geotechnical resistance factor (ϕ_{gu}) of 0.5.

5.6.2 Bearing Capacity at SLS

All foundations shall be designed so as not to exceed the allowable stress in the soil. The recommended bearing capacity at Serviceability Limit States (SLS) is estimated at 110 kPa for 3 m width foundations on undisturbed native deposits. For footings designed and constructed in accordance with this SLS value, total settlements should be less than 25 mm.

5.6.3 Sliding Resistance

The retaining wall foundation has to be designed to resist against sliding.

The interface friction angle (δ) between the foundation and the sand and silt deposit to be used in the calculation is 19°. Therefore, the friction factor (tanδ) is 0.34.

For silty clay subgrade, an adhesion of 40 kPa is recommended.

5.6.4 Dewatering

As mentioned in section 4.5, the static water level was measured to be varying from 4.6 to 5.3 mbgs in the piezometers installed in boreholes BH-16-05 and BH-16-07. It is assumed that excavations of 4.5 to 5.0 m will be necessary for the replacement of the section of retaining wall at this site. The water table elevation will need to be lowered to a minimum of 0.5 m below the base of the excavation, for sand and silt subgrade, in order to provide a long term stable working conditions and to assure an adequate bearing capacity. It should be noted that the fill material and the sand and silt deposit present at the site are relatively high permeability materials.

Considering the relatively high permeability of the sand and silt deposit, lowering of the water table would be of crucial importance. As mentioned above, the contractor shall provide a proper dewatering system to lower the groundwater level at least 0.5 m below the bottom of the excavation, for sand and silt subgrade. This may involve the use of active dewatering techniques (i.e. wellpoint systems). A specialist dewatering contractor should be consulted in order to determine the most appropriate methodology for dewatering the site. However, for the guidance of designers, it is recommended that dewatering systems be designed to fulfill the following requirements:

- The stability of the sides and bottom of the excavation must be maintained at all times during construction. Fluctuations in the groundwater table which may cause excavation instability must be avoided;
- Effective filters must be provided to prevent migration of soil fines and subsequent loss of ground;
- Adequate pumping and standby pumping must be provided;
- Pumped water must be discharged such that it will not interfere with the excavation;

- The groundwater table must be maintained at least 0.5 m below the base of the excavation, including the progressively rising backfill during its placement to prevent pumping of the base due to the construction traffic/compaction effort;
- Adequate monitoring of groundwater levels must be carried out; and
- On completion of construction activities, dewatering systems should be gradually shut down to prevent the creation of transient critical exit gradient conditions, which may result in the migration of fines.

For silty clay subgrade, the run-off water from the surface, the canal and the fill material must be controlled at all time.

5.7 Temporary Slopes and Excavation Work

5.7.1 Inclination of the Temporary Slopes

Excavations will be carried out within fill materials and the native sand, silty clay and sand and silt deposits to a depth of 4.5 to 5.0 m, as assumed in Section 5.6.4 of this report.

The excavation should be carried out in accordance with the latest edition of the Ontario Occupational Health & Safety Act (OHSA) and Regulations for Construction Projects. The OHSA regulations require that if workmen must enter an excavation deeper than 1.2 m, the excavation must be suitably sloped and/or braced in accordance with the OHSA requirements. OHSA specifies maximum slope of the excavation for four broad soil types.

Above the groundwater table, the fill materials and the native sand, silty clay and sand and silt deposits at the site can be classified as Type 3 soils. The inclination of the temporary slope should then be of 1V:1H for the soil above the groundwater table. The slope is considered from the bottom of the excavation. However, it should be noted that any soils which are affected by seepage or below the groundwater table shall be considered as Type 4 soils with respect to the OHSA.

Excavations into the fill and native overburden soils should be relatively easy using conventional excavating equipment, however it is a possibility that deleterious materials such as construction debris, large logs and branches, or cobbles and boulders could be encountered.

Stockpiles of excavated materials must be kept from the edge of any excavation to avoid slope instability. It is therefore important to make sure to keep a distance from the edge at least equal to the depth of the excavation. This distance is also applicable for the passage of heavy machinery near excavations. This condition must be respected at all times unless specific studies are conducted for each case. Care must also be taken to avoid overloading of any underground services/structures by stockpile of materials.

5.7.2 Temporary Shoring

Because of the proximity of Colonel By Drive, temporary shoring would possibly be required. The following parameters may be utilized in its design:

Table 8: Geotechnical Parameters (temporary shoring)

Soil	Bulk Unit weight	Angle of internal friction	Effective cohesion	Coefficient of Lateral Earth Pressure		
	γ (kN/m³)	ϕ' (°)	c' (kPa)	K_a	K_o	K_p
Fil	18	30	0	0.33	0.50	3.00
Sand	16	30	0	0.33	0.50	3.00
Silty clay	18	30	7,5	0.33	0.50	3.00
Sand and silt	16	30	0	0.33	0.50	3.00

Furthermore, a short-term conditions analysis, i.e. total stress conditions, should also be carried on for the silty clay deposit. An undrained shear strength resistance (s_u) of 60 kPa may be utilized.

5.8 Backfilling Considerations and Earth Pressures

It is recommended that OPSS Granular B Type II, or of better quality, should be placed as backfilling material behind the wall. Each lift, not exceeding 300 mm, must be compacted separately. Compaction should be at least 95% of the material's Standard Proctor Maximum Dry Density (SPMDD). However, the last lift before the OPSS Granular A pathway base should be compacted to 100% of the material's SPMDD.

Table 9 presents geotechnical parameters to calculate earth pressures.

Table 9: Geotechnical Parameters (earth pressures)

Parameter	Value
Angle of Internal Friction (ϕ)	30°(1)
Bulk Unit Weight (γ)	22 kN/m³
Active earth pressure coefficient (K_a)	0,33
At rest pressure coefficient (K_o)	0,50
Note 1: Value in absence of a direct shear test on retained material.	

5.9 Global Stability Analysis

A global stability assessment was carried out for two representative cross sections of the proposed retaining wall. A first analysis was carried with a foundation based on silty clay deposit, while a second analysis was carried with a foundation based on sand and silt deposit.

Limit equilibrium slope stability analysis was carried out using the computer program SLOPE/W (GeoStudio). Factor of Safety was calculated using Morgenstern-Price method.

For a specific slip surface, the Factor of Safety is defined as the ratio of the available shear strength resisting movement, divided by the gravitational forces tending to cause movement. The Factor of Safety of 1.0 represents a "limiting equilibrium" condition where the slip surface is a point of pending failure since the soil resistance is equal to forces tending to cause movement. It is usual to require a Factor of Safety greater than one to ensure the stability of the proposed infrastructure. The typical Factor of Safety for engineering design is 1.5.

The results of field surveying and subsurface investigations were input for the slope stability analysis. The following soil properties were utilized for the soil strata in the stability analysis:

Table 10: Geotechnical Parameters (stability analysis)

Soil Strata	Unit weight	Cohesion	Angle of internal friction
	γ (kN/m³)	c (kPa)	ϕ'(°)
Fill	18	0	30
Engineered Fill	21	0	35
Silty Clay	18	7.5(1)	30
Sand, traces of silt	16	0	30
Sand and silt	16	0	30

(1) Cohesion of 1.5 kPa was assigned for the silty clay strata in front of the retaining wall over the sand and silt deposit.

The global stability analyses of the proposed retaining wall are presented at Appendix 5. Based on material strength parameters shown on Table 10, Factors of Safety of 2.53 (foundation based on silty clay deposit) and 2.04 (foundation based on sand and silt deposit) were obtained against a slope failure, which are considered satisfactory.

5.10 Inspection and Review During Construction

All constructions should be carried out under the continuous supervision of a qualified engineering staff. All the stages of the construction should be monitored by suitable laboratory tests for the construction materials used, and by an appropriate amount of field inspections.

The construction of the Engineered Fill should be performed under the supervision of a geotechnical engineer or his designate. All subgrade surfaces and temporary excavation slopes should be inspected and approved by a geotechnical engineer.

Dewatering at this site will be required. As mentioned in this report, the groundwater table should be lowered at least 0.5 m under below the bottom of any planned excavation for sand and silt subgrade. Monitoring wells should be installed on the site in order to verify the progression of groundwater level during pumping operation.

All works should be carried out with respect to an approved quality plan and in compliance with applicable federal, provincial and municipal specifications.

5.11 General Comments

This report has been prepared for and intended for the exclusive use of the PWGSC. The contents of this report should not be relied upon by any other party without the express written consent of SNC-Lavalin. This document is meant to be read as a whole, and sections or parts thereof should thus not read or relied upon out of context.

The findings are relevant for the dates and the precise locations of our investigating boreholes. They should not be relied upon to represent conditions at later dates or other locations.

This document contains the professional opinion of SNC-Lavalin as to the matters set out herein, based on professional judgment and reasonable care, and is thus of the opinion that there is a high probability that actual site geotechnical conditions will fall within the predicted range. However, no warranty should be implied as to the accuracy of estimates.

A subsoil investigation is performed with a limited number of soundings and samples on the site. Should any site condition encountered differ from those at the tested locations, SNC-Lavalin shall be notified immediately in order to be able to reassess the recommendations.

Appendix 1

Scope of Work

SCOPE OF REPORT

1. Use of report

a. Use of report

This report has been prepared, and the work mentioned herein was carried out by SNC-Lavalin GEM Québec Inc. (SNC-Lavalin) exclusively for the client (the Client), to whom the report is addressed, and who took part in developing the scope of work and understands the limitations. The methodology, findings, recommendations and results cited in this report are based solely on the scope of work and are subject to the requirements of time and budget, as described in the offer of services and/or the contract under which this report was issued. Use of this report or any decision based on its content by third parties is the sole responsibility of the third parties. SNC-Lavalin is not responsible for any damage incurred by third parties due to the use of this report or of any decision based on its content. The findings, recommendations and results cited in this report (i) have been prepared in accordance with the skill level normally demonstrated by professionals operating in similar conditions in the sector, and (ii) are determined according to the best judgment of SNC-Lavalin, taking into account the information available at the time the report was prepared. The professional services provided to the Client and the findings, recommendations and results cited in this report are not subject to any guarantee, express or implied. The findings and results cited in this report are only valid on the date of the report and may be based in part on information provided by third parties. This report may require modifications in case of inaccurate information, discovery of new information or changes in project parameters. The results of this study are in no way a guarantee that the site in the study is free of contamination. This report must be considered as a whole and its parts or sections must not be taken out of context. If discrepancies were to appear between the draft and the final version of this report, the final version shall prevail. Nothing in this report is mentioned with the intention to provide or constitute legal advice. The content of this report is confidential and proprietary. It is prohibited for any person other than the Client to reproduce or distribute this report, to use or take a decision based on its content, in whole or in part, without the express written permission of the Client and SNC-Lavalin.

b. Modifications to project

The evidence, interpretations and recommendations contained in this report relate to the specific project as described in the report and do not apply to any other project or any other site. If the project is modified from a perspective of design, dimensioning, location or level, SNC-Lavalin must be consulted to confirm that the recommendations already given remain valid and enforceable.

c. Number of soundings

The recommendations in this report are intended only as a guide for the design engineer. The number of soundings to determine all subsurface conditions that may affect construction (costs, techniques, equipment, schedule) should normally be greater than that for the purpose of design. The number of sample sites and chemical analyzes as well as the sampling frequency and choice of parameters can influence the nature and extent of corrective actions as well as treatment or disposal technology and cost. Contractors bidding or subcontracting the work should rely on their own research and their own interpretations of the surveys' factual results to assess how underground conditions can affect their work and the cost of work.

d. Interpretation of data, comments and recommendations

Unless otherwise noted, data and results interpretation, comments and recommendations contained in this report are based, to the best of our knowledge, on environmental policies, criteria and regulations in force at the location of the project and on the production date of the report. If these policies, criteria and regulations are subject to change after submission of the report, SNC-Lavalin must be consulted to review the recommendations in the light of these changes. When no policy, criteria or regulation is available to allow for the interpretation of data and analytical results, comments or recommendations expressed by SNC-Lavalin are based on the best knowledge of the rules accepted in professional practice. The analyzes, comments and recommendations contained in this report are based on data and observations collected on the site, which come from sample work on the site. It is understood that only the data collected directly at the survey sites, sample sites and on the sample date are accurate and that any interpolation or extrapolation of these results to all or part of the site carries the risk of errors, which may themselves influence the nature and extent of the actions required on the site.

2. Sounding reports and interpretation of subsurface conditions

a. Soil and rock descriptions

The soil and rock descriptions given in this report are from classification and identification methods commonly accepted and used in the practice of geotechnical engineering. The classification and identification of soil and rock involves judgment. SNC-Lavalin does not guarantee that the descriptions will be identical in all respects to those made by another geotechnician possessing the same knowledge of geotechnical rules, but ensures accuracy only to what is commonly used in geotechnical practice.

b. Condition of soil and rock at sounding sites

The sounding reports only provide subsurface conditions and only at sounding sites. The boundaries between different layers on sounding reports are often approximate, rather corresponding to the transition zones and therefore subject to interpretation. The precision of subsurface conditions depends on the sounding method, frequency and method of sampling and consistency of the terrain encountered. The spacing between surveys, the sampling frequency and the type of sounding also reflect budgetary considerations and timelines that are outside the control of SNC-Lavalin.

c. Condition of soil and rock between sounding sites

The soil and rock formations are variable over a considerably large area. Subsurface conditions between sounding sites are interpolated and may vary significantly from the conditions encountered at sounding sites. SNC-Lavalin can guarantee the results at the site where sounding are conducted. Any interpretation of the conditions presented between sounding sites carries risks. These interpretations can lead to the discovery of conditions that are different from those that were expected. SNC-Lavalin cannot be held responsible for the discovery of different soil and rock conditions from those described elsewhere than at the site where soundings are conducted.

d. Groundwater levels

The groundwater levels provided in this report only correspond to those observed at the site and on the date indicated in the report and depends on the type of piezometric installation used. These conditions may vary based on the season or due to construction work on the site or on adjacent sites. These variations are beyond the control of SNC-Lavalin.

3. Contamination levels

The contamination levels described in this report (if within the scope) correspond to those detected at the site and on the date indicated in the report. These levels can vary based on the season or due to activities on the study site or on adjacent sites. These variations are beyond our control. Contamination levels are determined from the results of chemical analyzes of a limited number of soil, surface water or groundwater samples. The nature and degree of contamination between sample site may vary greatly. The chemical composition of groundwater at each sample site is likely to change due to groundwater flow, surface recharge conditions, stress of the formation investigated (i.e. pump or injection wells near the site) and natural seasonal variability. The accuracy of groundwater contamination levels depends on the frequency and the number of analyzes. The list of parameters analyzed is based on our best knowledge of the history of the site and the contaminants likely to be found on the site and is also a reflection of budgetary considerations and timelines. The fact that a parameter has not been analyzed does not exclude its presence at a concentration above the background noise or the detection limit of this parameter.

4. Study and work monitoring

a. Final phase verification

All design and construction details are not known at the time of issue of the report. It is therefore recommended that SNC-Lavalin's services be retained to provide light on the possible consequences of construction on the final work.

b. Inspection during execution

It is recommended that SNC-Lavalin's services be retained during construction to verify and confirm that groundwater conditions throughout the site do not differ from those given in the report and that the construction work will not have an adverse effect on the conditions of the site.

5. Changing conditions

The soil conditions described in this report are those observed during the study. Unless otherwise stated, these conditions are the basis for recommendations in the report. Soil conditions can be significantly affected by construction work (traffic, excavation, etc.) on the site or on adjacent sites. Excavation may expose the soil to changes due to humidity, drying or freezing. Unless otherwise indicated, the soil must be protected from these changes or rearrangements during construction. When conditions encountered at the site differ significantly from those provided in this report, due to the heterogeneous nature of the subsurface or due to construction work, it is the responsibility of the Client and the user of this report to notify SNC-Lavalin of changes and give SNC-Lavalin the opportunity to review the report's recommendations. Recognizing a change in ground conditions requires experience. It is therefore recommended that an experienced geotechnical engineer be dispatched to the site to see if conditions have changed significantly.

6. Drainage

Groundwater drainage is often required for both temporary and permanent project facilities. An incorrect drainage design or execution can have serious consequences. SNC-Lavalin cannot under any circumstance take responsibility for the effects of drainage unless SNC-Lavalin is specifically involved in the detailed design and monitoring of the drainage system's construction.

7. Environmental characterization – Phase I

This report was written after diligent research and evaluation of point data sources or information obtained from third parties that may present uncertainties, gaps or omissions. These sources of information are subject to change over time, for example, according to the progress of activities on the site and surrounding area. Phase I includes no testing, sampling or characterization analysis by a laboratory. Subject to exceptions, Phase I is based on the observation of visible and accessible components on the property and those nearby and could bring environmental harm to the quality of the land in the study. The property titles mentioned in this report are used to identify the former owners of the study site and cannot under any circumstance be considered as an official document for reproduction or other uses. Finally, any sketch, plan view or diagram appearing in the report or any statement specifying dimensions, capacities, quantities or distances are approximate and are included to help the reader visualize the property.

Appendix 2

Sounding Logs

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SUBSURFACE EXPLORATION LOG EXPLANATION SHEET

The object of the Subsurface Exploration Log is to present all the field and laboratory data regarding the soil, bedrock and groundwater conditions collected during the investigation. The purpose of this sheet is to explain the terminology, symbols and abbreviations used on the log.

STRATIGRAPHY

1. DEPTH - ELEVATION

The depth and the elevation of the boundaries between the various geological strata are given according the ground surface at the borehole location. The elevation refers to a datum as specified in the general heading of the subsurface log.

2. SOILS DESCRIPTION

Each geological stratum is described according to its physical and mechanical properties.

Each constituent of the soil as defined by the particle size range is indicated by the terms given below :

IDENTIFICATION	PARTICLE SIZE (mm)		
Clay		<	0.002
Silt	0.002	-	0.08
Sand	0.08	-	5
Gravel	5	-	80
Cobble	80	-	300
Boulder		>	300

The proportion of each constituent of the soil as defined by the particle size range is defined by the following descriptive terms :

DESCRIPTION	PARTICLE SIZE FRACTION (%)		
Trace	1	-	10
Some	10	-	20
Adjective (ex.: sandy silt, silty)	20	-	35
And (ex.: sand and gravel)		>	35

2.1 COMPACTNESS CONDITION OF COHESIONLESS SOIL

The compactness condition of cohesionless soil is defined in a borehole according to the “N” value of the Standard Penetration Test.

COMPACTNESS	SPT "N" (blows / 300 mm)		
Very loose		<	4
Loose	4	-	10
Compact	10	-	30
Dense	30	-	50
Very dense		>	50

2.2 CONSISTENCY AND PLASTICITY OF COHESIVE SOIL

The consistency of cohesive soils is defined by the undrained shear strength. The undrained shear strength of the intact clay (s_u) and remoulded clay (s_r) is measured in situ or in the laboratory.

CONSISTENCY	UNDRAINED SHEAR STRENGTH, s_u (kPa)		
Very soft		<	12
Soft	12	-	25
Firm	25	-	50
Stiff	50	-	100
Very stiff	100	-	200
Hard		>	200

DEGREE OF PLASTICITY	LIQUID LIMIT, W_L (%)		
Low		<	30
Medium	30	-	50
High		>	50

3. ROCK DESCRIPTION

The rock is described according to its geological origin, composition, structural characteristics and mechanical properties.

The Rock Quality Designation (RQD) is defined as the ratio of the total length of core pieces which are 100 mm or more in length divided by the total core length (core run). The RQD value is expressed as a percentage and is applicable to “N” size cores.

CLASSIFICATION	RQD VALUE (%)		
Very poor quality		<	25
Poor quality	25	-	50
Fair quality	50	-	75
Good quality	75	-	90
Excellent quality	90	-	100

JOINT SPACING CLASSIFICATION	SPACING WIDTH (mm)		
Extremely close	0	-	60
Close	60	-	200
Moderately close	200	-	600
Wide	600	-	2000
Very wide		>	2000

STRENGTH	UNCONFINED COMPRESSIVE STRENGTH, q_u (MPa)		
Extremely weak		<	1
Very weak	1	-	5
Weak	5	-	25
Medium strong	25	-	50
Strong	50	-	100
Very strong	100	-	250
Extremely strong		>	250

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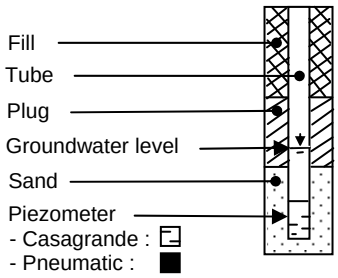
SUBSURFACE EXPLORATION LOG EXPLANATION SHEET

GROUNDWATER LEVEL

The column "Groundwater Level" gives the groundwater level measured in a stand pipe, in a piezometer, monitoring well or directly in the borehole as indicated. The date of observation is also indicated.



SAMPLES

1. TYPE AND NUMBER

The column "Type and Number" corresponds to the sample number. It includes 2 letters indicating the sample type followed by a sequence number. The sample types are the following :

CF :	Split Spoon	EL :	Wash sample
CG :	Large diameter sampler	ET :	Auger sample
TM :	Thin wall tube	VR :	Bulk sample (test pit)
CR :	Rock core		

2. CONDITION

The depth, the strength and the condition of each sample is given in this column. The following symbol indicates the condition of the sample :

3. RECOVERY

Soil sample and rock core recoveries are given in percentage of the penetration of the sampler. The sample length is equal to the distance from the top of the sampler to the cutting edge whether or not the lower part of the sample is lost.

IN SITU and LABORATORY TESTS

In situ and laboratory test results are indicated in the column "In Situ and Laboratory Tests" at the corresponding depth.

ABBREVIATIONS

A	Absorption, L/min-m (Packer Test in rock)
AC	Chemical Analyses
C	Consolidation Test
C_c	Curvature coefficient
C_u	Uniformity coefficient
s_u	Intact undrained shear strength measured with the field vane, kPa
s_r	Remoulded undrained shear strength measured, with the field vane, kPa
s_{us}	Intact undrained shear strength measured with the Swedish fall cone, kPa
s_{rs}	Remoulded undrained shear strength measured with the Swedish fall cone, kPa
s_{up}	Intact undrained shear strength measured with the portable vane apparatus, kPa
s_{rp}	Remoulded undrained shear strength measured with the portable vane apparatus, kPa
D_r	Relative density
E_M	Pressuremeter modulus, kPa or MPa
G	Particle size distribution by sieve and washing
I_L	Liquidity index
I_p	Plasticity index, %
k_c	Coefficient of permeability (hydraulic conductivity) measured in situ, m/s
k_L	Coefficient of permeability (hydraulic conductivity) measured in the laboratory, m/s
N_{dc}	Dynamic cone penetrometer blow count (DCPT)
N	Standard penetration test (SPT) index
P_{80}	Sieve analysis by washing on the 80 μm sieve
P_L	Pressuremeter limit pressure, kPa
P_r	Proctor Test
PV	Unit weight, kN/m^3
PV'	Effective unit weight, kN/m^3
q_c	Cone point-resistance (CPT), kPa
q_u	Unconfined compressive strength of rock, MPa
S	Particle size distribution by hygrometer testing
S_t	Sensitivity (c_u/c_r)
w	Water content, %
w_L	Liquid limit, %
w_p	Plastic limit, %

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BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-01

DATE : 2016-04-12

COORDINATES : SCoPQ NAD 83

E: 368 914,0 **N:** 5 029 911,9

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	64,83							W_P — W — W_L; 20 40 60 80		40 80 120 160
0,25	64,58	**ORGANIC SOIL** (sand, traces of gravel).		SS-1		90	3		**OVM = 55 ppm**	
1		**FILL:** sand, traces to some silt.		SS-2			5		**OVM = 50 ppm**	
		- Compactness: loose.		SS-3		75	5		**OVM = 85 ppm**	
1,83	63,00	**SAND**, traces to some silt (SP-SM to SM) with layers of silt and sand, traces of clay (ML).		SS-4		75	4		**OVM = 45 ppm**	
2				SS-5		82	4		**OVM = 100 ppm**	
3		- Compactness: loose.		SS-6		87	6			
3,51	61,32	Coarse **SAND**, some gravel, traces of silt (SP-SM).		SS-7		100	1	19 43 41		▲87
3,91	60,92	**SILTY CLAY**, traces of sand.		SS-8		100	0	26		
4		- Medium plasticity (CL).		SS-9		100	0	33		▲86
5		- Consistency: stiff.		TW-10		100	---	18 35 39		▲74
6				SS-11		100	0			
7				SS-12		100	0	17 37 38		▲79
8				SS-13		100	0			▲75
9				TW-14		100	---	19 37 46		▲79
10				SS-15		100	0	47		▲89
11				SS-16		100	3		N = 0-0-3-16	▲98
12				SS-17		70	9		G	
13				SS-18		54	39			▲98
14										
14,30	50,53	**SAND AND SILT**, traces of gravel (SM).								
15		- Compactness: loose to dense.								
16										
17										

REMARKS :

DRILLING METHOD : Hollow stem auger and NW casing using a track mounted CME-55LC drill.

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BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-01

DATE : 2016-04-12

COORDINATES : SCoPQ NAD 83

E: 368 914,0 **N:** 5 029 911,9

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: ▲S_u (kPa) ▼S_{us} (kPa) △S_r (kPa) ▽S_{rs} (kPa) / ●N_{dc} (blows/300 mm)
	47,83	... (cont.) sand and silt.						W_P W W_L; 20 40 60 80		40 80 120 160
18				SS-19		20	21			
19										
20										
21				SS-20		70	25		G	
22										
23										
24	23,93			SS-21		59	19			
	40,90	**END OF BOREHOLE**. No refusal.								
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

REMARKS :

DRILLING METHOD : Hollow stem auger and NW casing using a track mounted CME-55LC drill.

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BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-02

DATE : 2016-04-13

COORDINATES : SCoPQ NAD 83

E: 368 933,0 **N:** 5 029 856,0

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: ▲s_u (kPa) ▼s_{us} (kPa) △s_r (kPa) ▽s_{rs} (kPa) / ●N_{dc} (blows/300 mm)
	64,78							W_P — W — W_L; 20 40 60 80		40 80 120 160
0,13	64,65	**ORGANIC SOIL** (sand, traces of gravel).		SS-1		82	3			
1		**FILL:** sand, some silt.		SS-2		90	5			
		- Compactness: loose.		SS-3		72	9			
2				SS-4		100	5			
2,60	62,18	**SAND**, some silt, traces of gravel (SM). Presence of silty clay interbeds.		SS-5		100	3			
3				SS-6		66	3			
3,80	60,98	- Compactness: very loose.		SS-7		41	3			
		SILTY CLAY, traces of sand and gravel.								▲62
5				SS-8		87	3	18 33 — W — 34		
		- Medium plasticity (CL). - Consistency: stiff to very stiff.		SS-9		20	2			▲62
6				SS-10		100	3	W — 39		▲73
7				SS-11		100	2			▲62
8				SS-12		100	0	17 36 — W — 39		▲64
9										
		Presence of millimeter sand interbeds from 9.5 m in depth.		SS-13		100	1			▲62
10										▲101
11				SS-14		100	4			▲101
12										
				SS-15		100	3	W — 53		
13										
13,20	51,58	**SILT AND SAND** (ML).								
14		- Compactness: compact to dense.		SS-16		75	12			
15										
				SS-17		70	38		G	
15,85	48,93	**END OF BOREHOLE**. No refusal.								
16										
17										

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-03

DATE : 2016-04-14

COORDINATES : SCoPQ NAD 83

E: 368 952,9 **N:** 5 029 780,7

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	64,83							W_P — W — W_L; 20 40 60 80		40 80 120 160
0,13	64,70	**ORGANIC SOIL** (sand, traces of gravel).		SS-1		75	6		OVM = 0 ppm	
1		**FILL:** sand, some silt to silty sand. Presence of silty clay clumps and organic debries (wood pieces).		SS-2		79	8		OVM = 0 ppm	
				SS-3		87	4		OVM = 0 ppm	
2				SS-4 A		95	2		OVM = 0 ppm	
2,30	62,53	- Compactness: very loose to loose.		SS-4 B						
		Silty **SAND** to gravely silty sand (SM). Presence of silty clay interbeds.		SS-5		77	3		OVM = 0 ppm	
3				SS-6		49	9			
3,66	61,17	- Compactness: very loose to loose.		SS-7		56	0			
4		**SILTY CLAY**, traces of sand.		SS-8		100	0	16 38 37		▲69
		- Medium to low plasticity (CL). - Consistency: stiff to very stiff.		SS-9		100	0			▲82
6				SS-10		52	0	37		▲96
7				SS-11		95	4			▲121
8				SS-12		90	4	12 29 31		
9										
				SS-13		100	3	49		
10										
10,20	54,63	Silty **GRAVEL AND SAND** (GM).								
11		- Compactness: dense.		SS-14		25	33			
11,70	53,13	**SILT AND SAND**, traces of gravel (ML).								
12				SS-15		25	16			
13		- Compactness: loose to compact.								
14				SS-16		25	7		G	
15										
				SS-17		26	24			
15,85	48,98	**END OF BOREHOLE**. No refusal.								
16										
17										

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-04

DATE : 2016-04-15

COORDINATES : SCoPQ NAD 83

E: 368 967,5 **N:** 5 029 721,2

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: ▲s_u (kPa) ▼s_{us} (kPa) △s_r (kPa) ▽s_{rs} (kPa) / ●N_{dc} (blows/300 mm)
	64,87							W_P W_L W; 20 40 60 80		40 80 120 160
0,12	64,75	**ORGANIC SOIL** (sand, some silt, traces of gravel).		SS-1		87	6			
1		**FILL:** sand, some silt to silty sand, traces of gravel.		SS-2		100	5			
				SS-3		100	8			
2		- Compactness: loose.		SS-4		87	7			
2,61	62,26	**SILTY CLAY**, traces of sand and gravel.		SS-5		100	2			
3				TW-6		100	---	16 33 36		▲64
		- Medium to low plasticity (CL).								
4		- Consistency: stiff.		SS-7		46	0	36		
				SS-8		100	1	35		▲62
5										
		Silty sand interbeds from 5.3 m in depth.		SS-9		100	2	13 28 32		▲87
6										
6,45	58,42	**SAND,** some silt (SM).		SS-10		100	19			
7				SS-11		44	16		G	
		- Compactness: compact.								
8				SS-12		48	20			
8,70	56,17	**SAND AND SILT,** traces of clay (SM).								
9				SS-13		79	27		G S	
		- Compactness: compact.								
10										
11		Layer of silt, traces of sand and gravel (ML) was observed at SS-14.		SS-14		61	25		G	
12										
				SS-15		48	21			
13										
14				SS-16		100	---		G	
15										
				SS-17		46	14			
16										
16,80	48,07									
17										

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-04

DATE : 2016-04-15

COORDINATES : SCoPQ NAD 83

E: 368 967,5 **N:** 5 029 721,2

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: ▲S_u (kPa) ▼S_{us} (kPa) △S_r (kPa) ▽S_{rs} (kPa) / ●N_{dc} (blows/300 mm)
	47,87							W_P — W — W_L; 20 40 60 80		40 80 120 160
18		**SAND,** some silt, traces of gravel (SM). - Compactness: dense to very dense.								
19				SS-18	☒	100	36			
20										
21										
22				SS-19	☒	75	41		G	
23										
24										
24,69	40,18			SS-20	☒	100	66			
25		**END OF BOREHOLE**. No refusal.								
26										
27										
28										
29										
30										
31										
32										
33										
34										

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-05

DATE : 2016-04-20

COORDINATES : SCoPQ NAD 83

E: 368 973,2 **N:** 5 029 703,4

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL 2016-08-17	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	64,85							20 40 60 80		40 80 120 160
0,08	64,77	**ORGANIC SOIL** (silty sand).		SS-1		100	8		OVM = 0 ppm	
		SAND AND SILT to silty sand (SM). Presence of thin silty clay interbeds.		SS-2		100	10		OVM = 0 ppm	
		- Compactness: loose.		SS-3		100	6		OVM = 0 ppm	
				SS-4		100	8		OVM = 70 ppm	
2,44	62,41	**SILTY CLAY**, traces of sand.		SS-5		100	0		OVM = 0 ppm	▲ 34
		- Medium plasticity (CL). - Consistency: firm to very stiff.		TW-6		100	0	W 35		
				SS-7		100	2	W_P 15 38 W_L 35		▲ 57
4,86	*59,99*		▼	SS-8		100	1			▲ 87
		Silty sand interbeds from 5.3 m in depth.		SS-9		100	4			▲ 103
				SS-10		100	2			
6,86	57,99	Silty **SAND** to sand and silt (SM).		SS-11		80	14			
		- Compactness: compact to dense.		SS-12		56	11			
				SS-13		67	23			
				SS-14		100	25			
				SS-15		49	20			
				SS-16		100	13			
				SS-17		75	33			
15,85	49,00	**END OF BOREHOLE**. No refusal.								

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-06

DATE : 2016-04-18

COORDINATES : SCoPQ NAD 83

E: 368 989,6 **N:** 5 029 662,3

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: ▲s_u (kPa) ▼s_{us} (kPa) △s_r (kPa) ▽s_{rs} (kPa) / ●N_{dc} (blows/300 mm)
	64,93							W_P W_L W; 20 40 60 80		40 80 120 160
0,10	64,83	**ORGANIC SOIL** (sand some silt).		SS-1		61	10			
0,61	64,32	**FILL:** sand some silt.		SS-2		100	9			
		SAND AND SILT to silty sand (SM). Presence of thin silty clay interbeds from 1,8 m in depth.		SS-3		100	9			
				SS-4		100	4			
		- Compactness: loose.		SS-5		100	4			
3,05	61,88	**SILTY CLAY**, traces of sand with silty sand interbeds.		SS-6		100	2			
				SS-7		100	1	14 38 31		▲98
		- Medium plasticity (CL). - Consistency: stiff to very stiff.		SS-8		100	4	32		▲103
5,60	59,33	**SILTY SAND** (SM).		SS-9		85	1			
				SS-10		46	10			
		- Compactness: loose.		SS-11		57	7			
				SS-12		100	7			
8,70	56,23	**SAND,** some silt (SM).								
				SS-13		100	24			
		- Compactness: compact to dense.								
				SS-14		66	24		G	
				SS-15		95	23			
				SS-16		100	28			
				SS-17		75	32			
15,85	49,08	**END OF BOREHOLE**. No refusal.								

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-07

DATE : 2016-04-20

COORDINATES : SCoPQ NAD 83

E: 369 005,1 **N:** 5 029 631,2

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL 2016-08-17	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	64,86							W_P — W — W_L ; 20 40 60 80		40 80 120 160
0,12	64,74	**ORGANIC SOIL** (silty sand).		SS-1		72	6		OVM = 0 ppm	
		FILL: silty sand to sand some silt and gravel.		SS-2		26	10		OVM = 0 ppm	
		- Compactness: loose.		SS-3		66	8		OVM = 0 ppm	
1,70	63,16	**SILTY CLAY**, traces of sand.		SS-4		67	6		OVM = 45 ppm	
		- Consistency: very stiff to stiff.								
				SS-5		87	6			▲194
3,96	60,90	**SAND AND SILT**, traces of clay (SM) to **SILT**, some sand (ML).		SS-6		100	4			▲66
4,61	*60,25*			SS-7		51	11		G	
		- Compactness: very loose to compact.		SS-8		89	3		G S	
				SS-9		90	1		G	
				SS-10		21	6			
		* Layers of sand, traces of silt (SP) were observed at SS-11, SS-13 and SS-16.		SS-11		39	3		G	
				SS-12		84	6			
		*		SS-13		46	25			
				SS-14		57	25			
				SS-15		62	30			
		*		SS-16		28	18			
15,85	49,01	**END OF BOREHOLE**. No refusal.								

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-08

DATE : 2016-04-22

COORDINATES : SCoPQ NAD 83

E: 369 036,6 **N:** 5 029 565,1

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: ▲s_u (kPa) ▼s_{us} (kPa) △s_r (kPa) ▽s_{rs} (kPa) / ●N_{dc} (blows/300 mm)
	64,59							W_P — W — W_L; 20 40 60 80		40 80 120 160
0,06	64,53	**ASPHALT**.								
0,26	64,33	**GRANULAR A**.								
		FILL: sand to sand and silt, traces of gravel, presence of silty clay clumps and organic debries.		SS-1		66	16			
				SS-2		30	11			
				SS-3		26	9			
		- Compactness: loose to compact.		SS-4		0	3			
				SS-5		79	2			
				SS-6		48	33			
				SS-7		8	7			
4,50	60,09	Silty **SAND** (SM) to sandy **SILT** (ML), traces of gravel and clay.		SS-8		92	2			
		- Compactness: very loose to loose.		SS-9		100	4		G	
				SS-10		64	8			
				SS-11		69	1		G S	
				SS-12		80	5		G	
8,70	55,89	**SAND**, traces of gravel and silt (SP).								
		- Compactness: compact to dense.		SS-13		48	21			
				SS-14		61	18		G	
				SS-15		61	25			
				SS-16		46	10			
				SS-17		38	32			

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-08

DATE : 2016-04-22

COORDINATES : SCoPQ NAD 83

E: 369 036,6 **N:** 5 029 565,1

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	47,59							W_P — W — W_L; 20 40 60 80		40 80 120 160
17,10	47,49	**SILT AND SAND** (ML). - Compactness: compact.		SS-18		69	14			
18,90	45,69	**END OF BOREHOLE**. No refusal.								

REMARKS :

DRILLING METHOD : NW casing using a track mounted CME-55LC drill.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-14

DATE : 2016-03-04

COORDINATES : SCoPQ NAD 83

E: 368 914,2 **N:** 5 029 869,6

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	62,87							W_P W W_L — 20 40 60 80		40 80 120 160
		ICE.								
0,39	62,48	**SAND**, traces of silt and clay. Presence of organic matters.		SS-1		42	1			
1,00	61,87	**SILTY CLAY**.		SS-2		100	2			
				SS-3		100	3			
				SS-4		100	5			
2,83	60,04	**END OF BOREHOLE**. No refusal.								

REMARKS :

DRILLING METHOD : Manual percussion drilling using a motorized tripod.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-15

DATE : 2016-03-04

COORDINATES : SCoPQ NAD 83

E: 368 996,2 **N:** 5 029 623,5

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: ▲s_u (kPa) ▼s_{us} (kPa) △s_r (kPa) ▽s_{rs} (kPa) / ●N_{dc} (blows/300 mm)
	62,83	**ICE.**						W_P W W_L		
0,43	62,40	**WATER.**								
1,10	61,73	**CLAY, SILT AND SAND** in various proportions. Presence of organic debries (wood pieces).		SS-1		46	2			
				SS-2		29	15			
				SS-3		4	14			
2,93	59,90	**END OF BOREHOLE**. No refusal.								

20 40 60 80

40 80 120 160

REMARKS :

DRILLING METHOD : Manual percussion drilling using a motorized tripod.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : BH-16-15A

DATE : 2016-03-04

COORDINATES : SCoPQ NAD 83

E: 368 995,4 **N:** 5 029 624,8

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	62,83							W_P — W — W_L; 20 40 60 80		40 80 120 160
0,43	62,40	**ICE.**								
		WATER.								
1,10	61,73	**SILTY CLAY,** some sand. Presence of organic matters.		SS-1		100	4			
1,63	61,20	**SILTY CLAY**.		SS-2		75	2			
2,57	60,26	**SILT AND SAND.** - Compactness: loose.		SS-3		100	7			
2,93	59,90	**SAND**, traces of silt. - Compactness: compact.		SS-4		42	12			
3,54	59,29	**END OF BOREHOLE**. No refusal.								

REMARKS :

DRILLING METHOD : Manual percussion drilling using a motorized tripod.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : CC-16-01

DATE : 2016-05-03

COORDINATES : SCoPQ NAD 83

E: 368 909,3 **N:** 5 029 910,7

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	64,59	**CONCRETE**. Rideau Canal retaining wall.		CR-1		94	---			
1				CR-2		97	---			
2				CR-3		96	---			
3				CR-4		100	---			
4	3,95 60,64	**END OF CORING**. Silty clay at the end of the coring bit.								
5										
6										

WATER CONTENT AND ATTERBERG'S LIMITS (%): W_P, W, W_L; 20 40 60 80

S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm): 40 80 120 160

REMARKS :

DRILLING METHOD : Hilti thin wall concrete coring bit.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : CC-16-02

DATE : 2016-05-04

COORDINATES : SCoPQ NAD 83

E: 368 963,5 **N:** 5 029 720,0

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	64,69	**CONCRETE**. Rideau Canal retaining wall.		CR-1		100	---			
				CR-2		100	---			
				CR-3		100	---			
				CR-4		100	---			
				CR-5		100	---			
3,93	60,76	**END OF CORING**. Silty clay at the end of the coring bit.								

WATER CONTENT AND ATTERBERG'S LIMITS (%): W_P, W, W_L; 20 40 60 80

S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm): 40 80 120 160

REMARKS :

DRILLING METHOD : Hilti thin wall concrete coring bit.

SNC·LAVALIN

BOREHOLE LOG

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464

BOREHOLE : CC-16-03

DATE : 2016-05-02

COORDINATES : SCoPQ NAD 83

E: 369 035,4 **N:** 5 029 564,7

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY (%)	IN SITU AND LABORATORY TESTS: N or RQD (%)	IN SITU AND LABORATORY TESTS: WATER CONTENT AND ATTERBERG'S LIMITS (%)	IN SITU AND LABORATORY TESTS: OTHER TESTS	IN SITU AND LABORATORY TESTS: S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm)
	64,59	**CONCRETE**. Rideau Canal retaining wall.		CR-1		67	---			
				CR-2		100	---			
				CR-3		100	---			
1				CR-4		100	---			
2				CR-5		99	---			
3				CR-6		90	---			
4				CR-7		54	---			
4,13	60,46	**END OF CORING**. Sandy soil and wood pieces at the end of the coring bit.								
5										
6										

WATER CONTENT AND ATTERBERG'S LIMITS (%): W_P, W, W_L; 20 40 60 80

S_u (kPa), S_{us} (kPa), S_r (kPa), S_{rs} (kPa), N_{dc} (blows/300 mm): 40 80 120 160

REMARKS :

DRILLING METHOD : Hilti thin wall concrete coring bit.

Appendix 3

Geotechnical Laboratory Test Results

SNC·LAVALIN

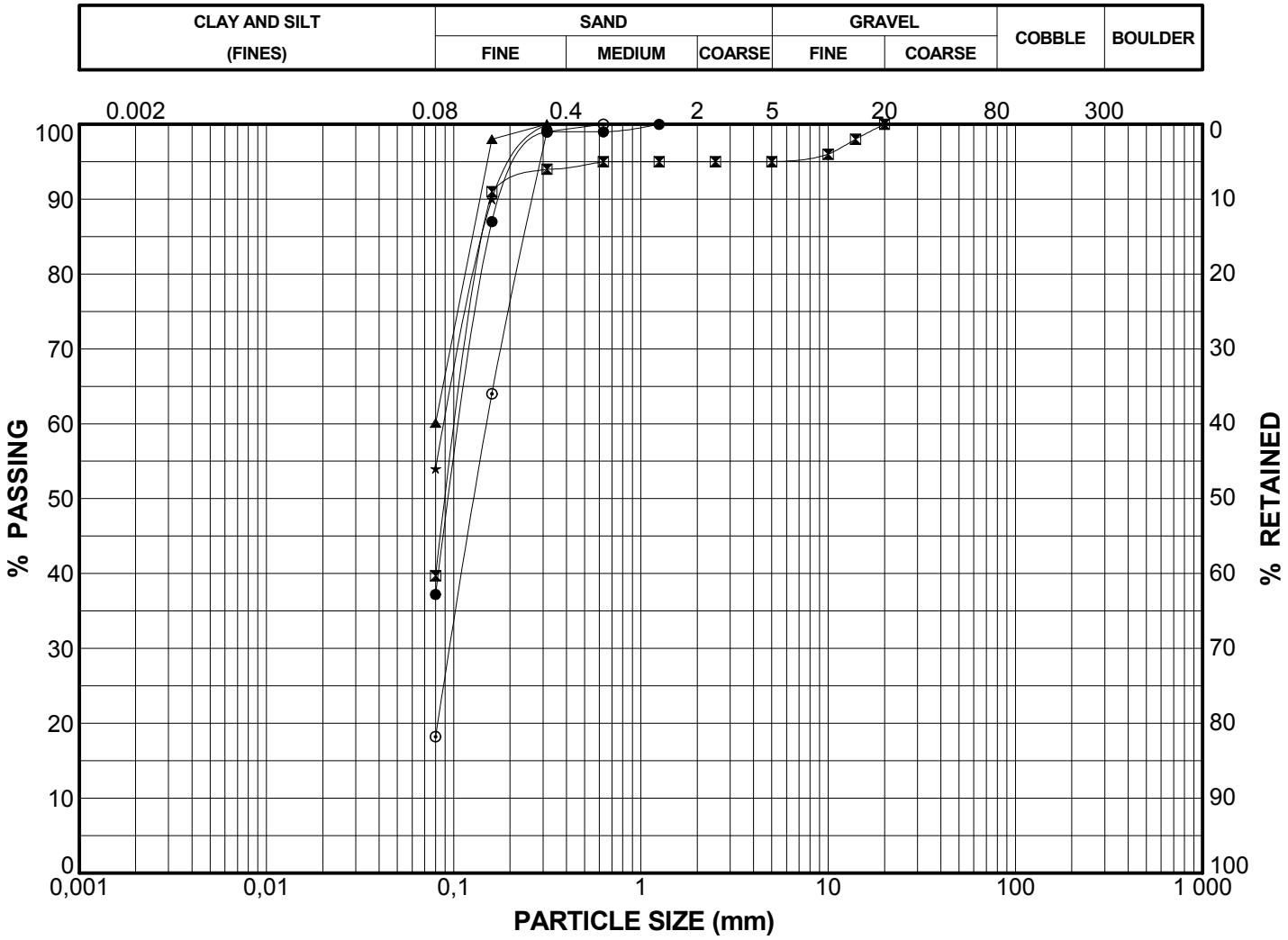
PARTICLE SIZE DISTRIBUTION

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464



	Boring and / or Test Pit	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	BH-16-01	SS-17	14,48	15,09	0	63	37,2	Sand and silt. (SM)
⊠	BH-16-01	SS-20	20,73	21,34	5	55	39,7	Sand and silt, traces of gravel. (SM)
▲	BH-16-02	SS-17	15,24	15,85	0	40	60,1	Silt and sand. (ML)
★	BH-16-03	SS-16	13,72	14,33	0	46	54,0	Silt and sand. (ML)
⊙	BH-16-04	SS-11	6,86	7,47	0	82	18,2	Sand some silt. (SM)

REMARKS :

SNC·LAVALIN

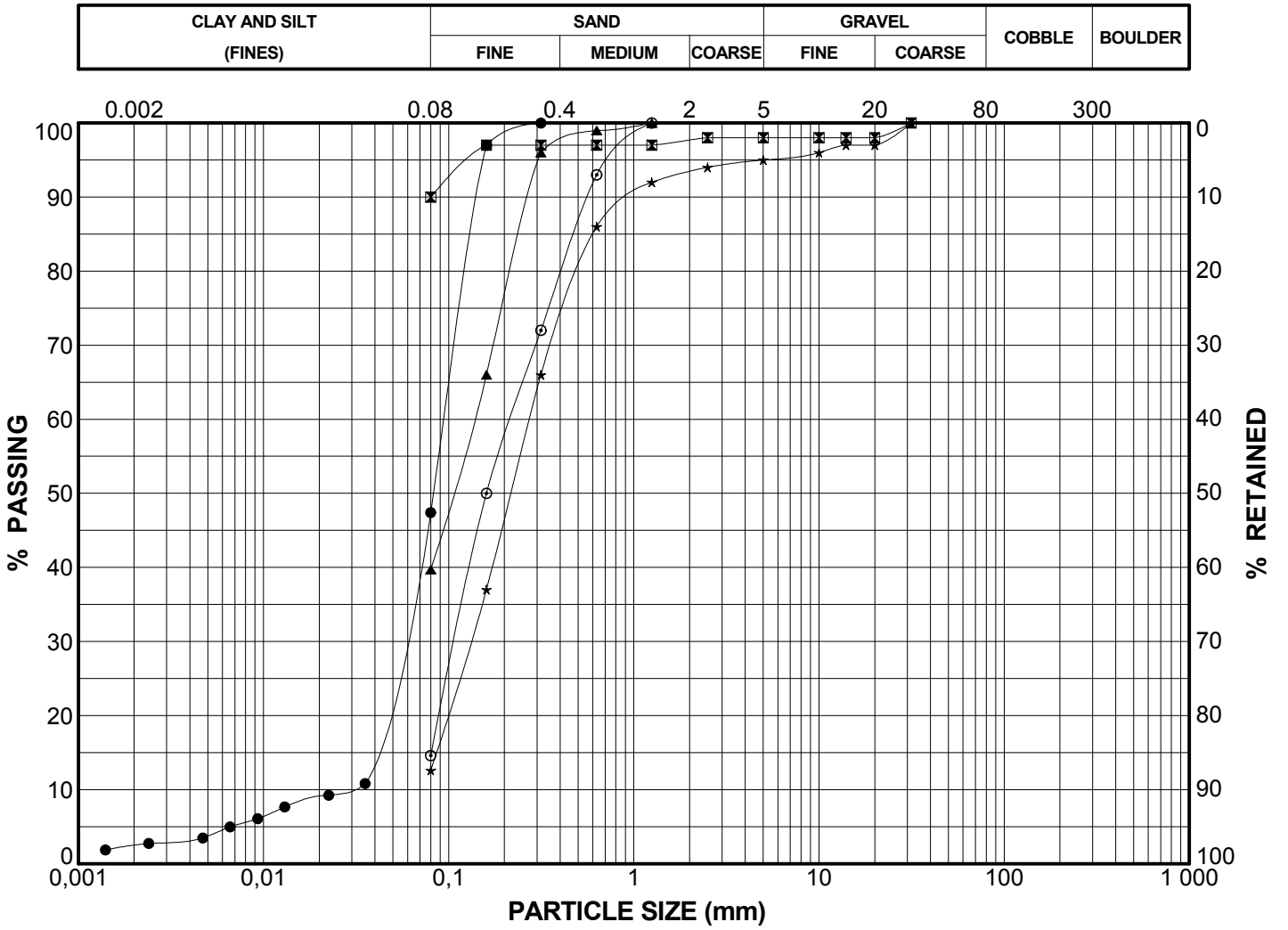
PARTICLE SIZE DISTRIBUTION

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464



	Boring and / or Test Pit	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	BH-16-04	SS-13	9,14	9,75	0	53	45,0 2,4	Sand and silt, traces of clay. (SM)
⊠	BH-16-04	SS-14	10,67	11,28	2	8	90,0	Silt, traces of sand and gravel. (ML)
▲	BH-16-04	SS-16	13,72	14,33	0	60	39,7	Sand and silt. (SM)
★	BH-16-04	SS-19	21,03	21,64	5	82	12,6	Sand some silt, traces of gravel. (SM)
⊙	BH-16-06	SS-14	10,67	11,28	0	85	14,6	Sand some silt. (SM)

REMARKS :

SNC·LAVALIN

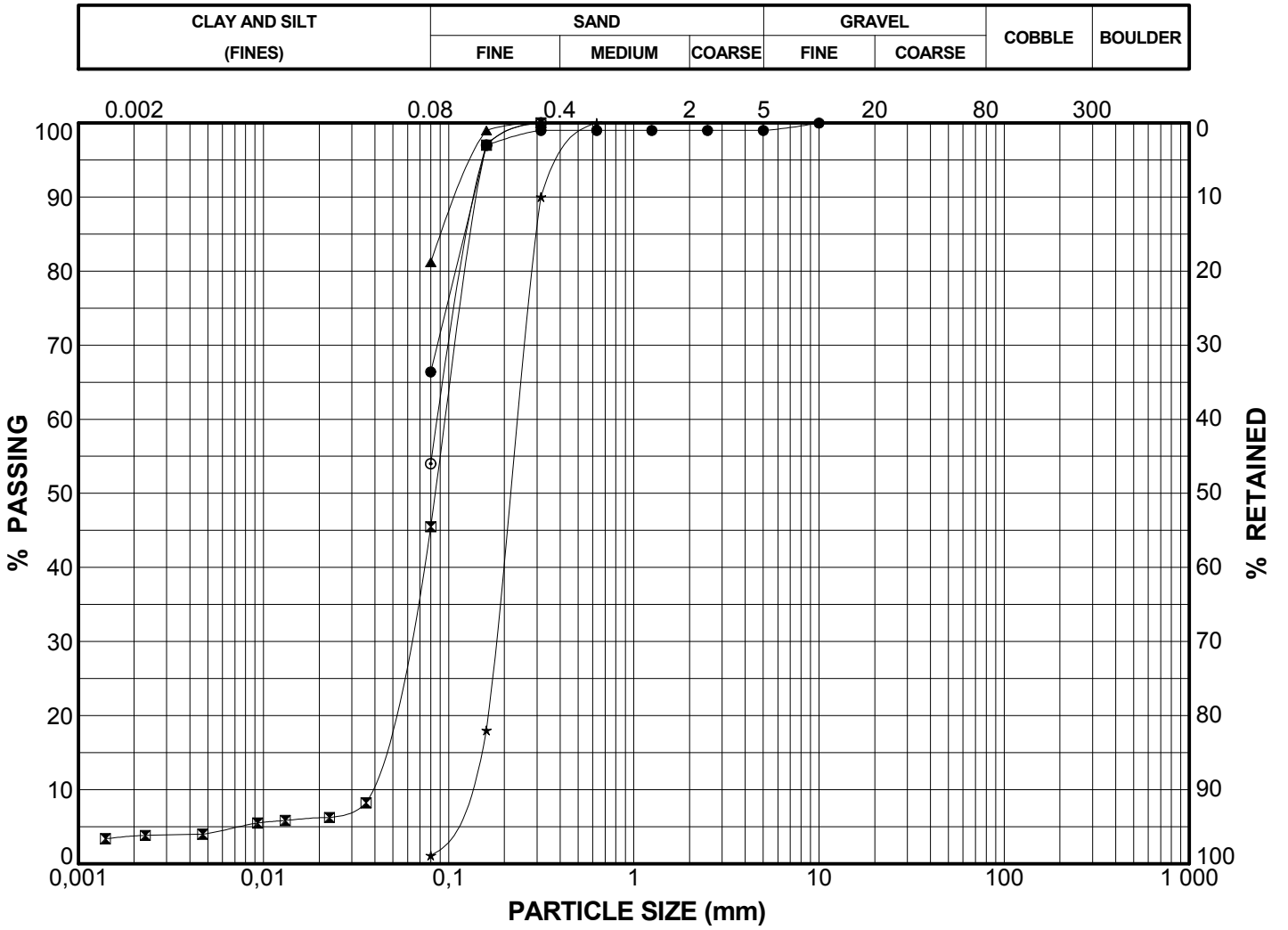
PARTICLE SIZE DISTRIBUTION

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464



	Boring and / or Test Pit	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	BH-16-07	SS-7	4,57	5,18	1	33	66,4	Sandy silt, traces of gravel. (ML)
⊠	BH-16-07	SS-8	5,33	5,94	0	55	41,8 3,7	Sand and silt, traces of clay. (SM)
▲	BH-16-07	SS-9	6,10	6,71	0	19	81,2	Silt some sand. (ML)
★	BH-16-07	SS-11	7,62	8,23	0	99	1,1	Sand, traces of silt. (SP)
⊙	BH-16-08	SS-9	5,33	5,94	0	46	54,0	Silt and sand. (ML)

REMARKS :

SNC·LAVALIN

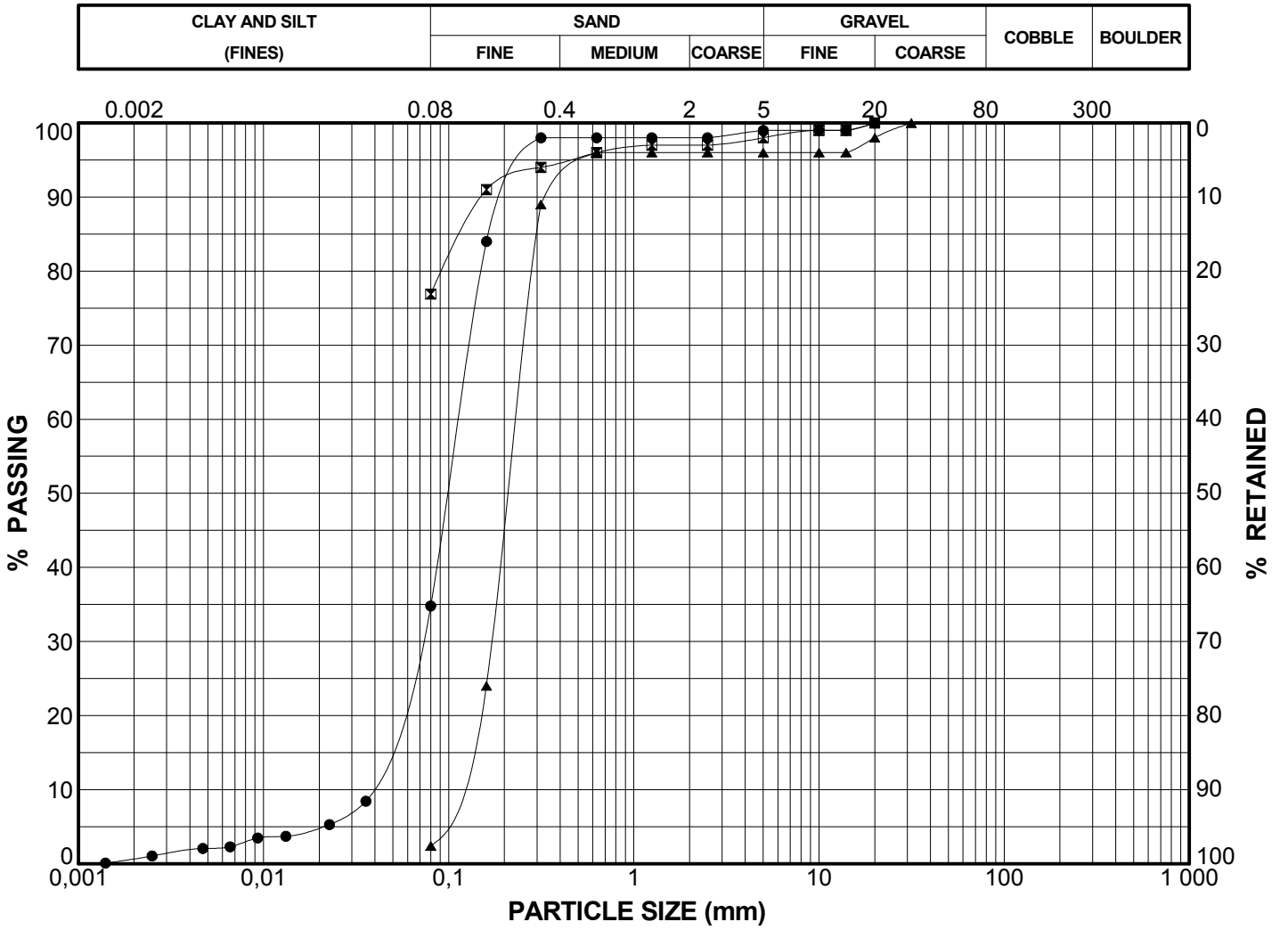
PARTICLE SIZE DISTRIBUTION

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464



	Boring and / or Test Pit	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	BH-16-08	SS-11	6,86	7,47	1	64	34,1 0,7	Silty sand, traces of gravel and clay. (SM)
⊠	BH-16-08	SS-12	7,62	8,23	2	21	76,9	Sandy silt, traces of gravel. (ML)
▲	BH-16-08	SS-14	10,67	11,28	4	94	2,4	Sand, traces of gravel and silt. (SP)

REMARKS :

SNC·LAVALIN

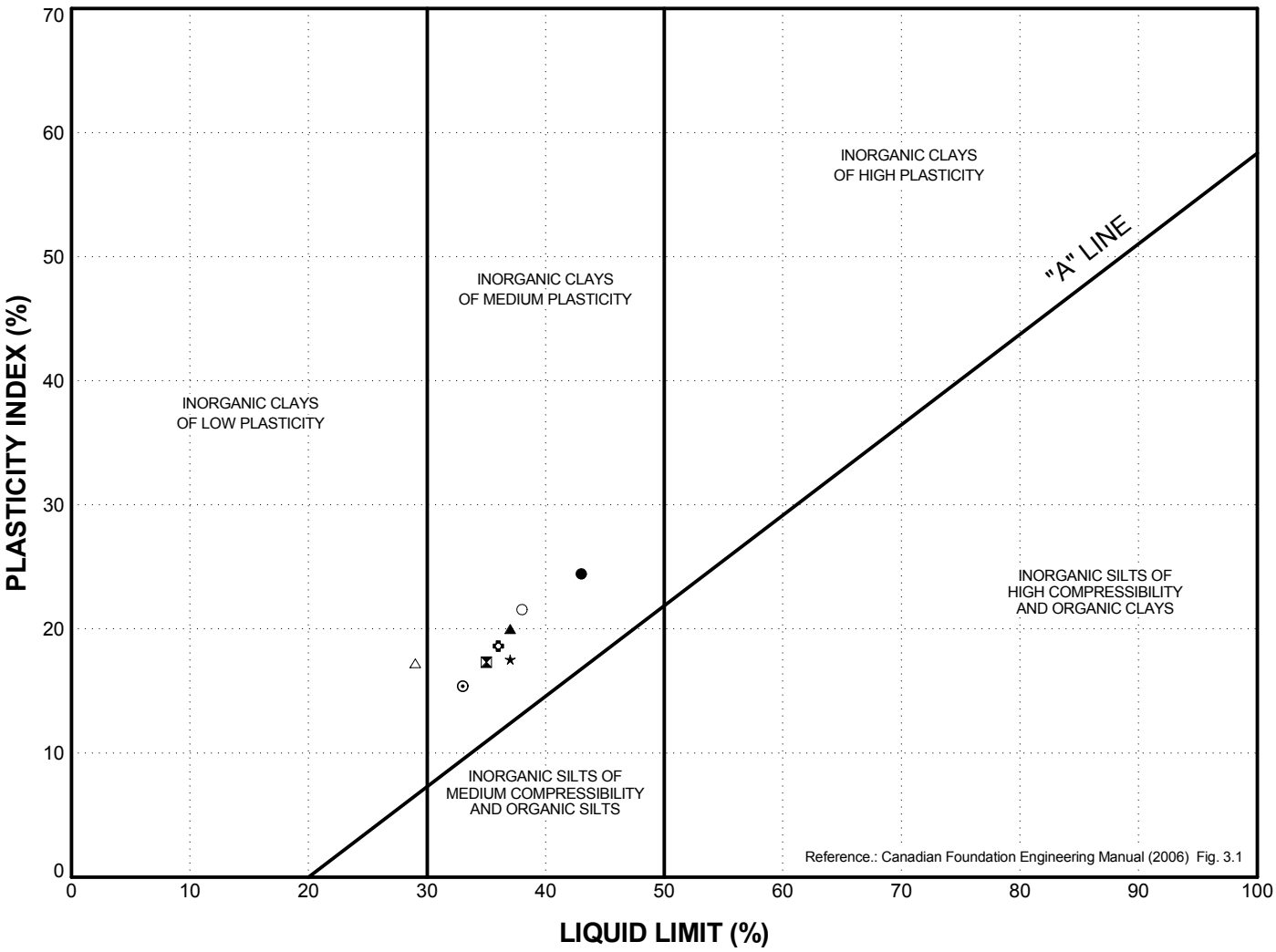
PLASTICITY CHART

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464



	Boring and/or Test Pit	Sample	Depth (m) from	Depth (m) to	w (%)	w_L (%)	w_P (%)	I_P (%)	I_L	DESCRIPTION
●	BH-16-01	SS-7	3,81	4,42	41	43	19	24	0,9	Silty clay of medium plasticity. (CL)
⊠	BH-16-01	TW-10	6,10	6,71	39	35	18	17	1,2	Silty clay of medium plasticity. (CL)
▲	BH-16-01	SS-12	7,62	8,23	38	37	17	20	1,1	Silty clay of medium plasticity. (CL)
★	BH-16-01	TW-14	10,52	11,33	46	37	19	18	1,5	Silty clay of medium plasticity. (CL)
⊙	BH-16-02	SS-8	4,57	5,18	34	33	18	15	1,1	Silty clay of medium plasticity. (CL)
✿	BH-16-02	SS-12	7,62	8,23	39	36	17	19	1,2	Silty clay of medium plasticity. (CL)
○	BH-16-03	SS-8	4,27	4,88	37	38	16	22	1,0	Silty clay of medium plasticity. (CL)
△	BH-16-03	SS-12	7,62	8,23	31	29	12	17	1,1	Silty clay of low plasticity. (CL)

REMARKS :

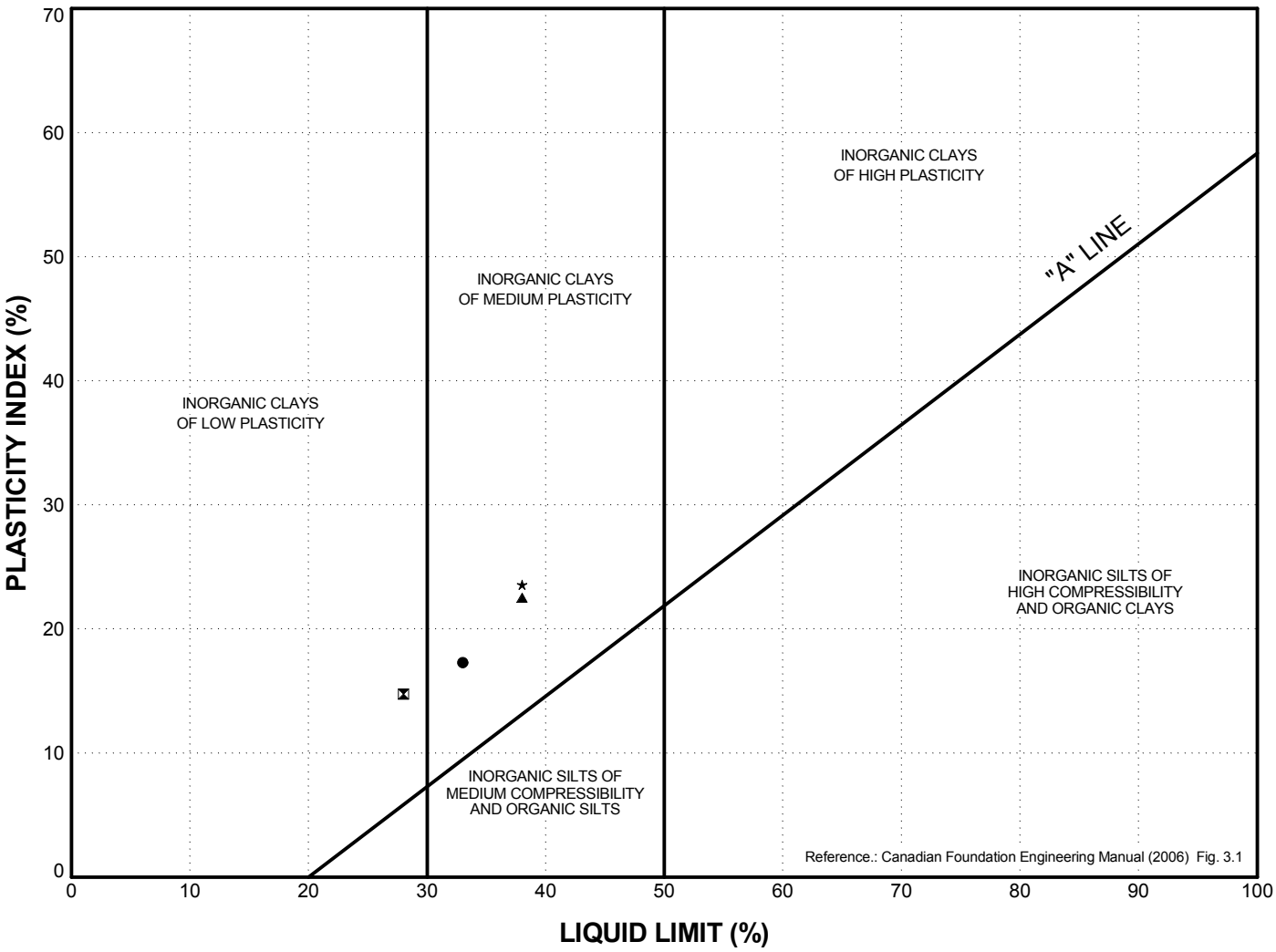
PLASTICITY CHART

CLIENT : PWGSC

PROJECT : Geotechnical Investigation - Rideau Canal Walls (Herridge St to Mutchmor Rd)

LOCATION : Rideau Canal Pathway, Ottawa, Ontario

FILE : 636464



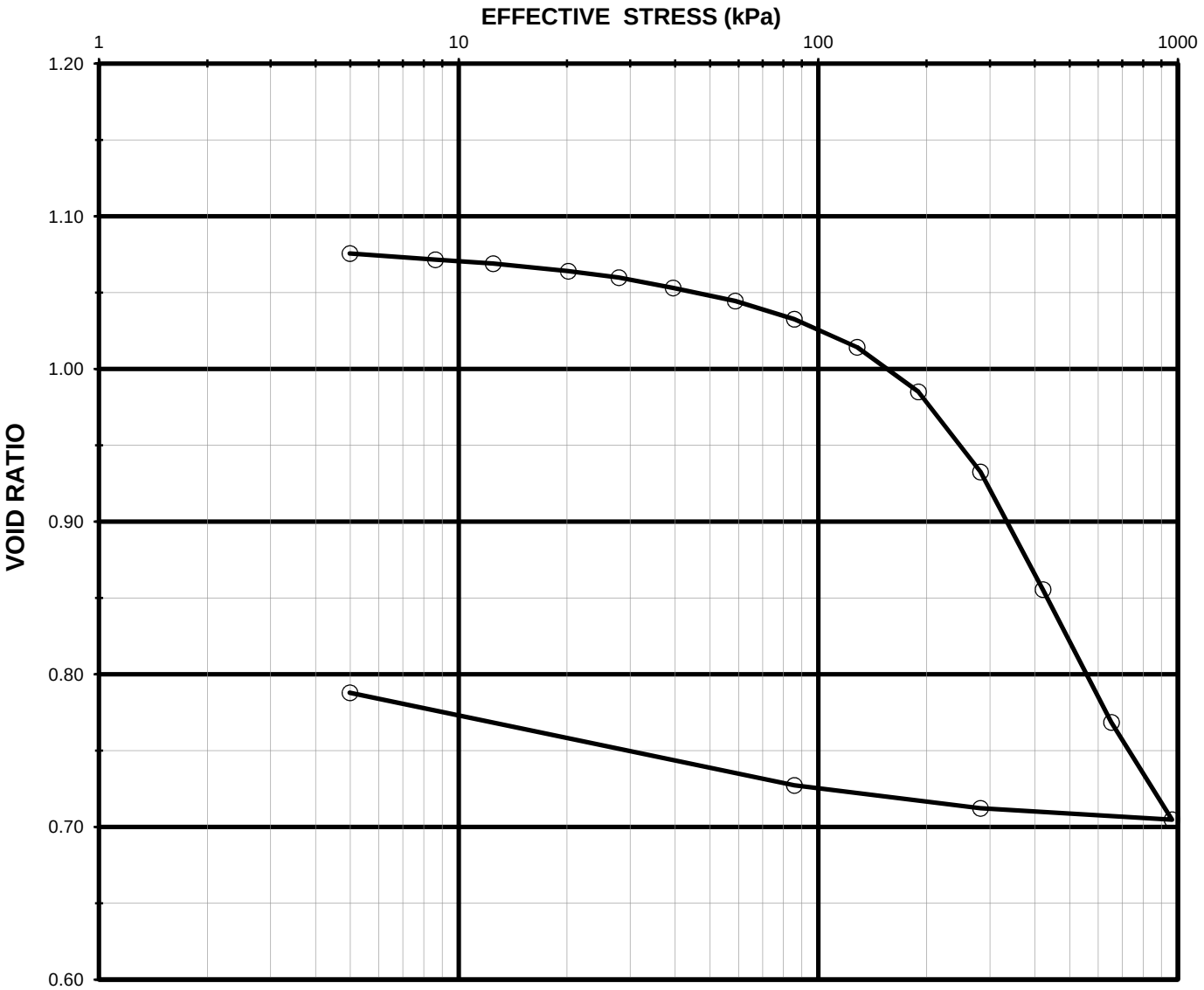
	Boring and/or Test Pit	Sample	Depth (m) from	Depth (m) to	w (%)	w_L (%)	w_P (%)	I_P (%)	I_L	DESCRIPTION
●	BH-16-04	TW-6	3,05	3,66	36	33	16	17	1,2	Silty clay of medium plasticity. (CL)
⊠	BH-16-04	SS-9	5,33	5,94	32	28	13	15	1,3	Silty clay of low plasticity. (CL)
▲	BH-16-05	SS-7	3,81	4,42	35	38	15	23	0,9	Silty clay of medium plasticity. (CL)
★	BH-16-06	SS-7	3,81	4,42	31	38	14	24	0,7	Silty clay of medium plasticity. (CL)

REMARKS :

SNC·LAVALIN

CONSOLIDATION TEST

CLIENT	: Public Works and Goverment Services Canada	**BOREHOLE**	: BH-16-01
PROJECT	: Geotechnical Investigations - Rideau Canal Walls (Herridge St to Mutchmor Rd)	**SAMPLE**	: TW-10
LOCATION	: Ottawa, Ontario	**DEPTH**	: 6.10 to 6.71 m
FILE	: 636464		



Test depth: 6.46 m **Test elevation : 58.37 m**

PARAMETERS			
γ : 18.0 kN/m³	w : 39 %	σ'_p : 180 kPa	
e_i : 1.08	w_L : 35 %		
c_{cr} : 0.02	w_P : 18 %		
c_c : 0.46			

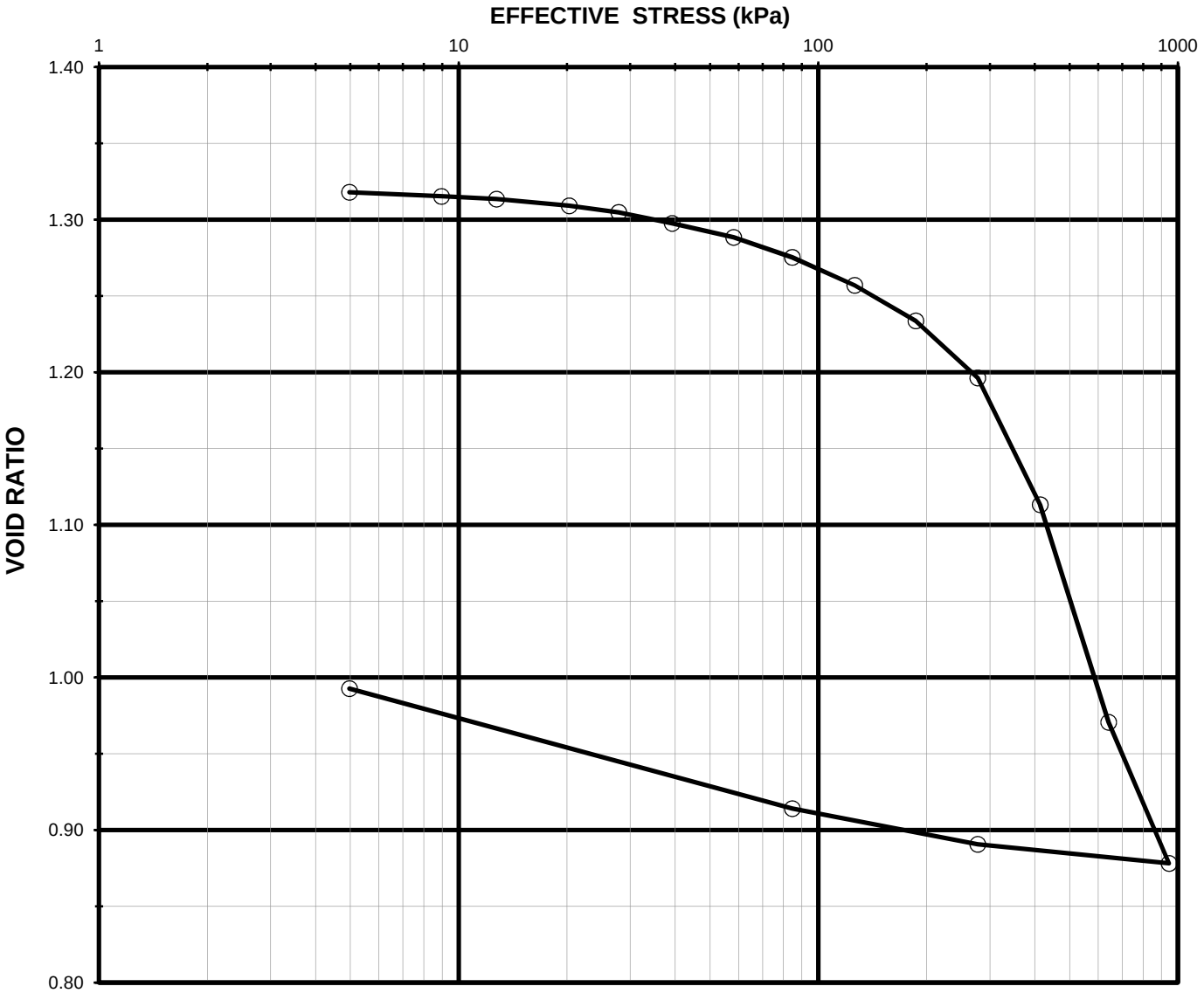
REMARKS:

Standard: Consolidation ASTM D2435-11 (method A)

SNC·LAVALIN

CONSOLIDATION TEST

CLIENT	: Public Works and Goverment Services Canada	**BOREHOLE**	: BH-16-01
PROJECT	: Geotechnical Investigations - Rideau Canal Walls (Herridge St to Mutchmor Rd)	**SAMPLE**	: TW-14
LOCATION	: Ottawa, Ontario	**DEPTH**	: 10.52 to 11.13 m
FILE	: 636464		



Test depth: 10.82 m **Test elevation : 54.01 m**

PARAMETERS			
γ : 16.9 kN/m³	w : 46 %	σ'_p : 270 kPa	
e_i : 1.32	w_L : 37 %		
c_{cr} : 0.02	w_P : 19 %		
c_c : 0.75			

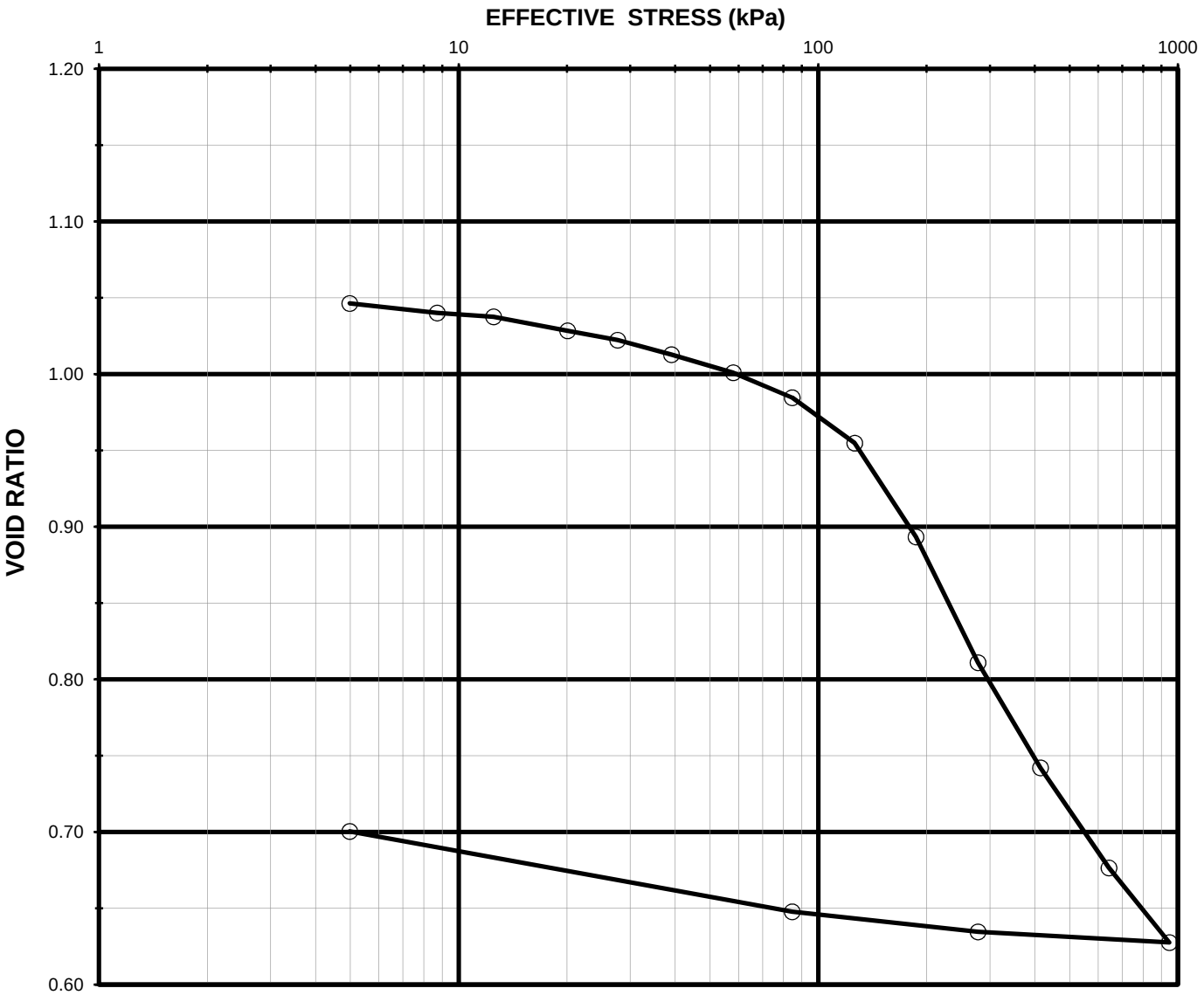
REMARKS:

Standard: Consolidation ASTM D2435-11 (method A)

SNC·LAVALIN

CONSOLIDATION TEST

CLIENT	: Public Works and Goverment Services Canada	**BOREHOLE**	: BH-16-04
PROJECT	: Geotechnical Investigations - Rideau Canal Walls (Herridge St to Mutchmor Rd)	**SAMPLE**	: TW-6
LOCATION	: Ottawa, Ontario	**DEPTH**	: 3.05 to 3.66 m
FILE	: 636464		



Test depth: 3.51 m **Test elevation : 61.36 m**

PARAMETERS			
γ : 17.9 kN/m³	w : 36 %	σ'_p : 120 kPa	
e_i : 1.05	w_L : 33 %		
c_{cr} : 0.02	w_P : 16 %		
c_c : 0.48			

REMARKS:

Standard: Consolidation ASTM D2435-11 (method A)

Appendix 4

Environmental Certificate of Analysis

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: SNC-LAVALIN GEM QUEBEC INC
420 BOULEVARD MALONEY EST BUREAU 6
GATINEAU, QC J8P1E7
(819) 669-1225

ATTENTION TO: Sebastien Bisson

PROJECT: 636464

AGAT WORK ORDER: 16T100529

TRACE ORGANICS REVIEWED BY: Neli Popnikolova, Senior Chemist

DATE REPORTED: Jun 08, 2016

PAGES (INCLUDING COVER): 9

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
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http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 16T100529

PROJECT: 636464

CLIENT NAME: SNC-LAVALIN GEM QUEBEC INC

ATTENTION TO: Sebastien Bisson

SAMPLING SITE:

SAMPLED BY:Stephane Royer

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

DATE RECEIVED: 2016-05-31 **DATE REPORTED: 2016-06-08**

		SAMPLE DESCRIPTION:		BH-16-01 SS-1	BH-16-01 SS-3	BH-16-01 SS-5	BH-16-03 SS-1	BH-16-03 SS-2	BH-16-03 SS-4B	DUP - 1	BH-16-05 SS-3
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		4/21/2016	4/21/2016	4/21/2016	4/21/2016	4/21/2016	4/21/2016	4/28/2016	4/21/2016
Parameter	**Unit**	**G / S**	**RDL**	**7600353**	**7600365**	**7600367**	**7600369**	**7600371**	**7600373**	**7600375**	**7600380**
Benzene	µg/g		0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Toluene	µg/g		0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Ethylbenzene	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Xylene Mixture	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
F1 (C6 to C10)	µg/g		5	<5	<5	<5	<5	<5	<5	<5	<5
F1 (C6 to C10) minus BTEX	µg/g		5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10 to C16)	µg/g		10	<10	<10	<10	<10	<10	<10	<10	<10
F3 (C16 to C34)	µg/g		50	<50	<50	<50	<50	<50	<50	<50	<50
F4 (C34 to C50)	µg/g		50	<50	<50	<50	<50	<50	<50	<50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	NA	NA	NA	NA	NA	NA
Moisture Content	%		0.1	13.0	23.1	20.3	24.2	15.8	18.1	9.1	19.8
Surrogate	**Unit**	**Acceptable Limits**									
Terphenyl	%	60-140		85	61	60	61	70	66	62	64

Certified By:

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 16T100529

PROJECT: 636464

CLIENT NAME: SNC-LAVALIN GEM QUEBEC INC

ATTENTION TO: Sebastien Bisson

SAMPLING SITE:

SAMPLED BY:Stephane Royer

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

DATE RECEIVED: 2016-05-31 **DATE REPORTED: 2016-06-08**

		SAMPLE DESCRIPTION:		BH-16-05 SS-4	BH-16-05 SS-5	BH-16-07 SS-3	BH-16-07 SS-4	BH-16-09 SS-1B	BH-16-09 SS-2	BH-16-09 SS-3	BH-16-09 SS-6
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		4/21/2016	4/21/2016	4/21/2016	4/21/2016	4/25/2016	4/25/2016	4/25/2016	4/25/2016
Parameter	**Unit**	**G / S**	**RDL**	**7600383**	**7600385**	**7600387**	**7600389**	**7600392**	**7600395**	**7600428**	**7600430**
Benzene	µg/g		0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Toluene	µg/g		0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Ethylbenzene	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Xylene Mixture	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
F1 (C6 to C10)	µg/g		5	<5	<5	<5	<5	<5	<5	<5	<5
F1 (C6 to C10) minus BTEX	µg/g		5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10 to C16)	µg/g		10	<10	<10	<10	<10	<10	<10	<10	<10
F3 (C16 to C34)	µg/g		50	<50	<50	<50	<50	<50	<50	<50	<50
F4 (C34 to C50)	µg/g		50	<50	<50	<50	<50	<50	<50	<50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	NA	NA	NA	NA	NA	NA
Moisture Content	%		0.1	16.6	24.9	4.4	28.4	18.7	19.5	16.7	24.3
Surrogate	**Unit**	**Acceptable Limits**									
Terphenyl	%	60-140		62	75	76	99	91	76	116	76

Certified By:

AGAT Laboratories
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TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 16T100529

PROJECT: 636464

CLIENT NAME: SNC-LAVALIN GEM QUEBEC INC

ATTENTION TO: Sebastien Bisson

SAMPLING SITE:

SAMPLED BY:Stephane Royer

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

DATE RECEIVED: 2016-05-31 **DATE REPORTED: 2016-06-08**

		SAMPLE DESCRIPTION:		BH-16-09 SS-8	BH-16-11 SS-1B	BH-16-11 SS-4	BH-16-11 SS-5	BH-16-11 SS-6	BH-16-13 SS-1B	BH-16-13 SS-2	BH-16-13 SS-4
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		4/25/2016	4/26/2016	4/26/2016	4/26/2016	4/26/2016	4/26/2016	4/28/2016	4/28/2016
Parameter	**Unit**	**G / S**	**RDL**	**7600432**	**7600434**	**7600436**	**7600438**	**7600440**	**7600442**	**7600444**	**7600446**
Benzene	µg/g		0.02	<0.02	0.49	<0.02	<0.02	<0.02	0.03	<0.02	<0.02
Toluene	µg/g		0.08	<0.08	0.95	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Ethylbenzene	µg/g		0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Xylene Mixture	µg/g		0.05	<0.05	0.66	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
F1 (C6 to C10)	µg/g		5	<5	6	<5	<5	<5	<5	<5	<5
F1 (C6 to C10) minus BTEX	µg/g		5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10 to C16)	µg/g		10	<10	<10	<10	<10	<10	<10	<10	<10
F3 (C16 to C34)	µg/g		50	<50	<50	<50	<50	<50	<50	<50	<50
F4 (C34 to C50)	µg/g		50	<50	<50	<50	<50	<50	<50	<50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	NA	NA	NA	NA	NA	NA
Moisture Content	%		0.1	6.6	12.6	7.0	23.9	18.7	18.7	19.6	15.0
Surrogate	**Unit**	**Acceptable Limits**									
Terphenyl	%	60-140		108	102	67	103	100	128	120	129

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

7600353-7600446 Results are based on sample dry weight.
The C6-C10 fraction is calculated using Toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.
The chromatogram has returned to baseline by the retention time of nC50.
Total C6 - C50 results are corrected for BTEX contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 + nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.
Fractions 1-4 are quantified with the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.
Quality Control Data is available upon request.

Certified By: NPopowkolof

AGAT Laboratories

5835 COOPERS AVENUE
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Quality Assurance

CLIENT NAME: SNC-LAVALIN GEM QUEBEC INC

AGAT WORK ORDER: 16T100529

PROJECT: 636464

ATTENTION TO: Sebastien Bisson

SAMPLING SITE:

SAMPLED BY:Stephane Royer

Trace Organics Analysis

RPT Date: Jun 08, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - PHCs F1 - F4 (Soil)															
Benzene	7600438	7600438	< 0.02	< 0.02	NA	< 0.02	107%	60%	130%	100%	60%	130%	119%	60%	130%
Toluene	7600438	7600438	< 0.08	< 0.08	NA	< 0.08	106%	60%	130%	94%	60%	130%	119%	60%	130%
Ethylbenzene	7600438	7600438	< 0.05	< 0.05	NA	< 0.05	110%	60%	130%	92%	60%	130%	113%	60%	130%
Xylene Mixture	7600438	7600438	< 0.05	< 0.05	NA	< 0.05	111%	60%	130%	97%	60%	130%	114%	60%	130%
F1 (C6 to C10)	7600438	7600438	< 5	< 5	NA	< 5	80%	60%	130%	94%	85%	115%	90%	70%	130%
F2 (C10 to C16)	7600438	7600438	< 10	< 10	NA	< 10	96%	60%	130%	92%	80%	120%	98%	70%	130%
F3 (C16 to C34)	7600438	7600438	< 50	< 50	NA	< 50	98%	60%	130%	98%	80%	120%	102%	70%	130%
F4 (C34 to C50)	7600438	7600438	< 50	< 50	NA	< 50	85%	60%	130%	102%	80%	120%	112%	70%	130%

Comments: When the average of the sample and duplicate results is less than 5x the RDL, the Relative Percent Difference (RPD) will be indicated as Not Applicable (NA).

Certified By: N Popnikolof

AGAT Laboratories

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Method Summary

CLIENT NAME: SNC-LAVALIN GEM QUEBEC INC

AGAT WORK ORDER: 16T100529

PROJECT: 636464

ATTENTION TO: Sebastien Bisson

SAMPLING SITE:

SAMPLED BY:Stephane Royer

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Trace Organics Analysis			
Benzene	VOL-91-5009	EPA SW-846 5035 & 8260	P & T GC/MS
Toluene	VOL-91-5009	EPA SW-846 5035 & 8260	P & T GC/MS
Ethylbenzene	VOL-91-5009	EPA SW-846 5035 & 8260	P & T GC/MS
Xylene Mixture	VOL-91-5009	EPA SW-846 5035 & 8260	P & T GC/MS
F1 (C6 to C10)	VOL-91-5009	CCME Tier 1 Method	P & T GC/FID
F1 (C6 to C10) minus BTEX	VOL-91-5009	CCME Tier 1 Method	P & T GC/FID
F2 (C10 to C16)	VOL-91-5009	CCME Tier 1 Method, EPA SW846 8015	GC / FID
F3 (C16 to C34)	VOL-91-5009	CCME Tier 1 Method, EPA SW846 8015	GC / FID
F4 (C34 to C50)	VOL-91-5009	CCME Tier 1 Method, EPA SW846 8015	GC / FID
Gravimetric Heavy Hydrocarbons	VOL-91-5009	CCME Tier 1 Method	BALANCE
Moisture Content	VOL-91-5009	CCME Tier 1 Method	BALANCE
Terphenyl	VOL-91-5009		GC/FID

Appendix 5

Stability Analysis

SNC·LAVALIN

File: 636464

Stability Analysis- effective stress
Herridge to Mutchmor Rideau Canal Wall

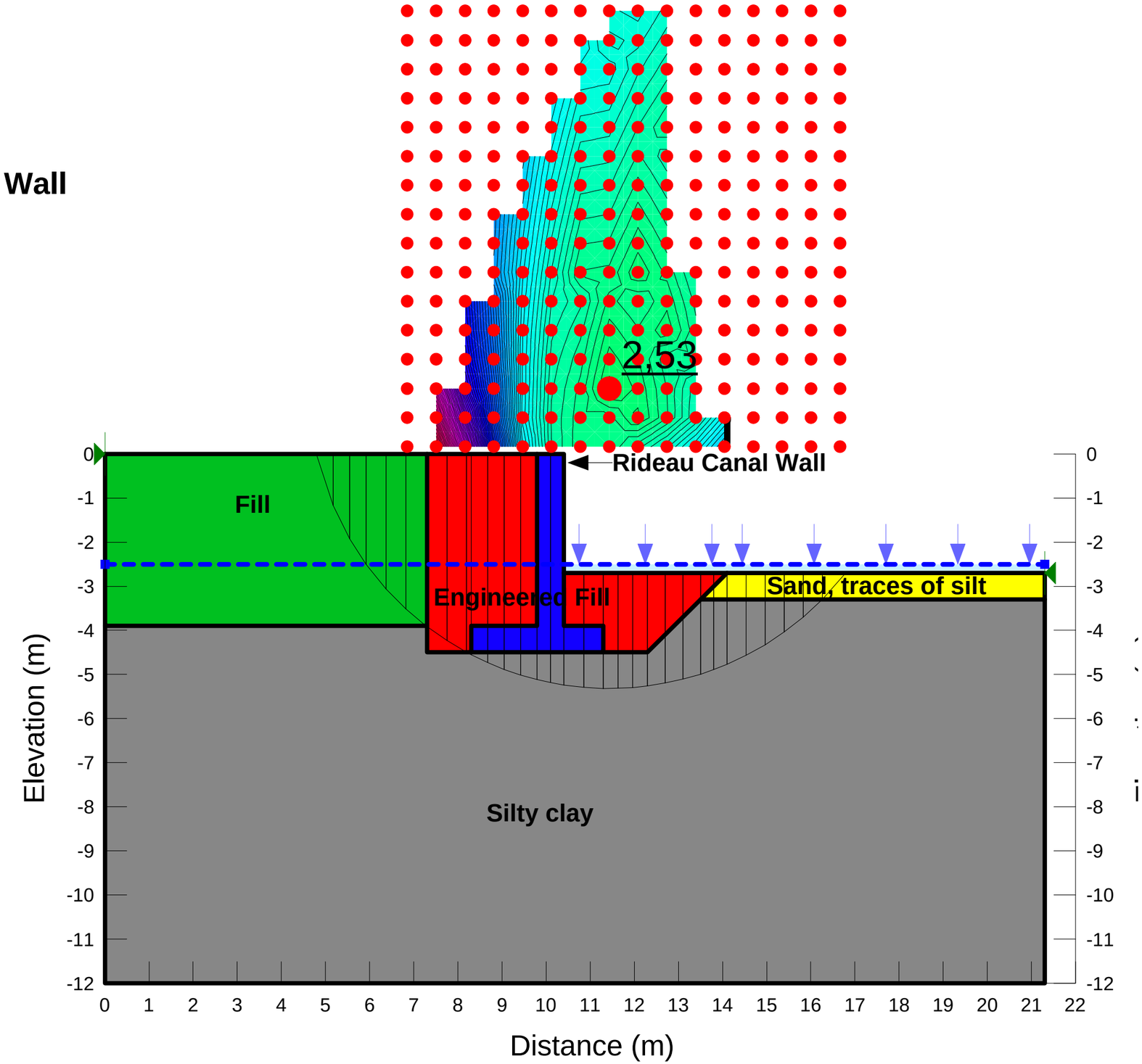
FIll
- Unit weight : 18.0 kN/m³
- Friction angle : 30°
- Cohesion : 0 kPa

Engineered Fill
- Unit weight : 21.0 kN/m³
- Friction angle : 35°
- Cohesion : 0 kPa

Sand, traces of silt
- Unit weight : 16.0 kN/m³
- Friction angle : 30°
- Cohesion : 0 kPa

Silty clay
- Unit weight : 18.0 kN/m³
- Friction angle : 30°
- Cohesion : 7.5 kPa

Rideau Canal Wall
- Unit weight : 24.0 kN/m³



SNC·LAVALIN

File: 636464

Stability Analysis- effective stress
Herridge to Mutchmor Rideau Canal Wall

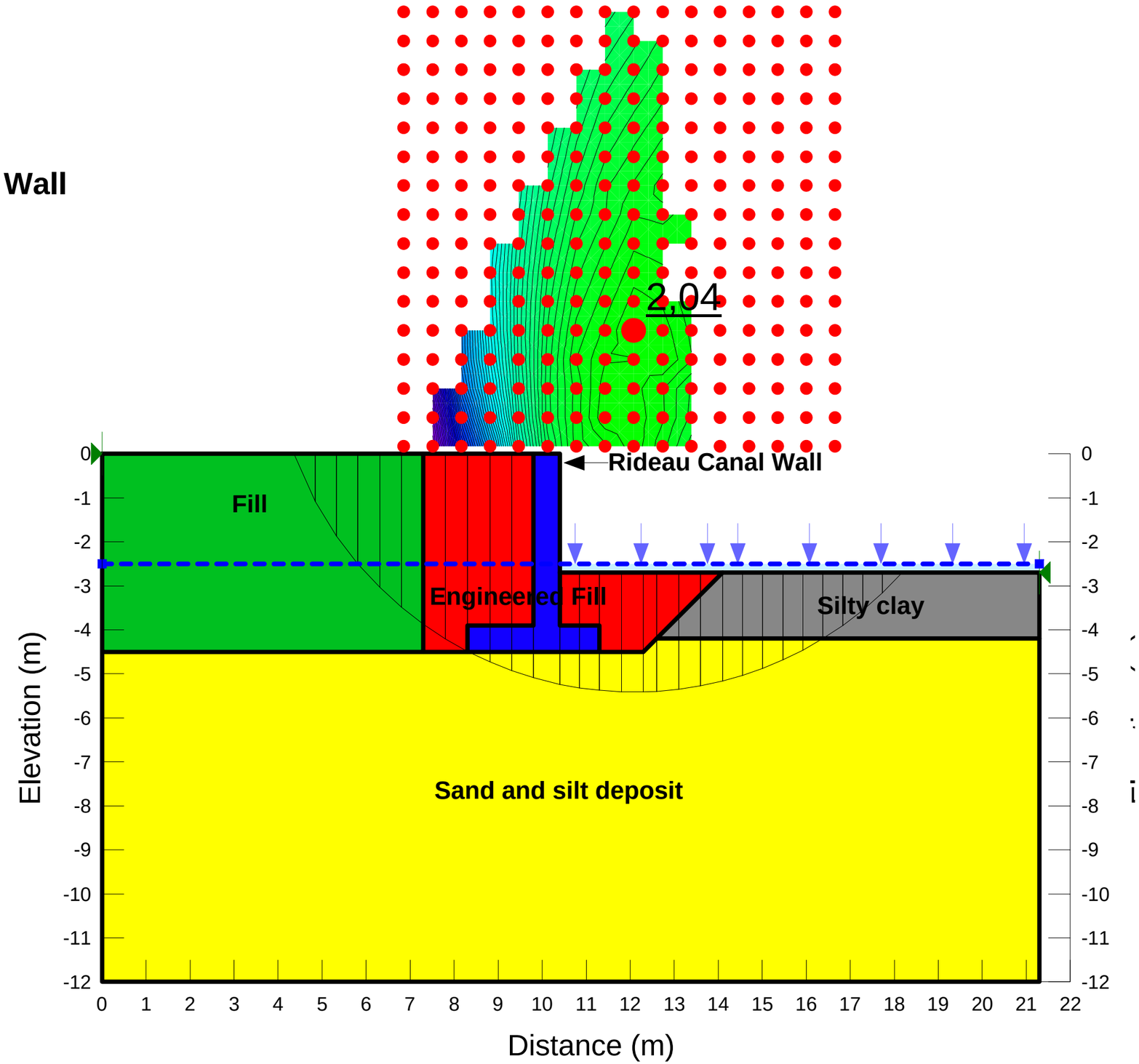
FIll
- Unit weight : 18.0 kN/m³
- Friction angle : 30°
- Cohesion : 0 kPa

Engineered Fill
- Unit weight : 21.0 kN/m³
- Friction angle : 35°
- Cohesion : 0 kPa

Sand and silt deposit
- Unit weight : 16.0 kN/m³
- Friction angle : 30°
- Cohesion : 0 kPa

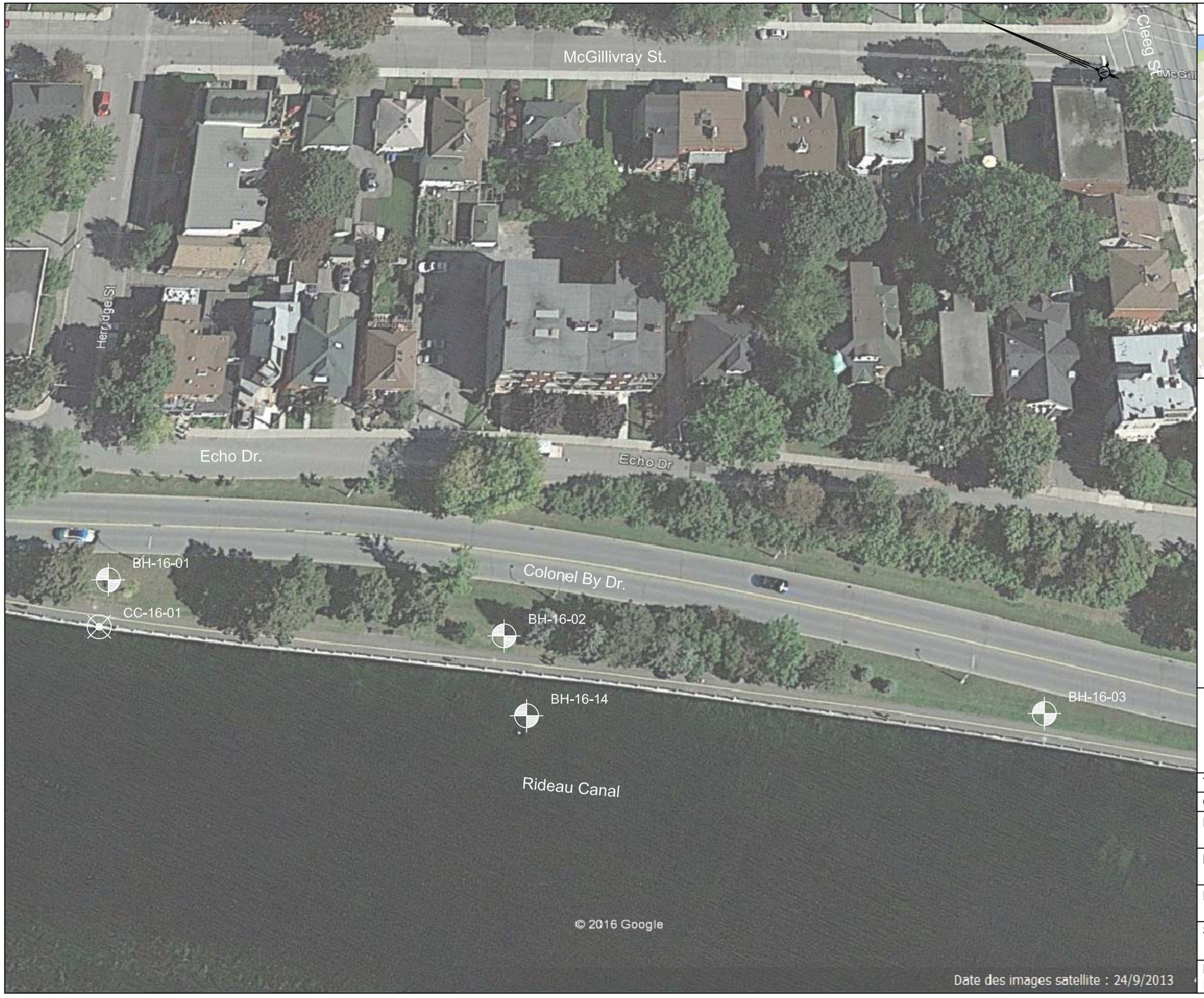
Silty clay
- Unit weight : 18.0 kN/m³
- Friction angle : 30°
- Cohesion : 1.5 kPa

Rideau Canal Wall
- Unit weight : 24.0 kN/m³

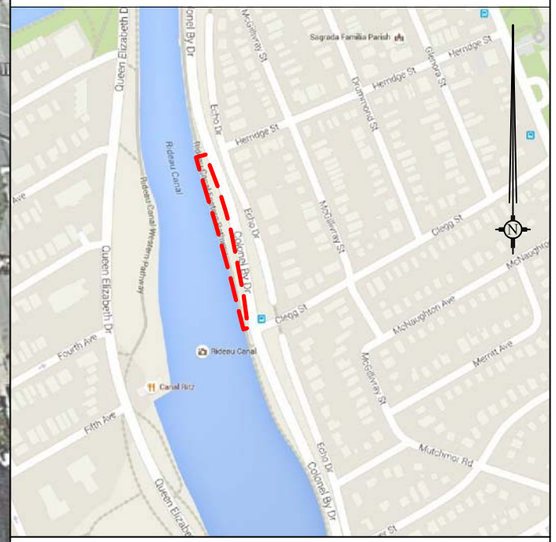


Appendix 6

Sounding Location Plan



SITE LOCATION



LEGEND :

BH-16-01 - Borehole #1

CC-16-01 - Concrete coring #1

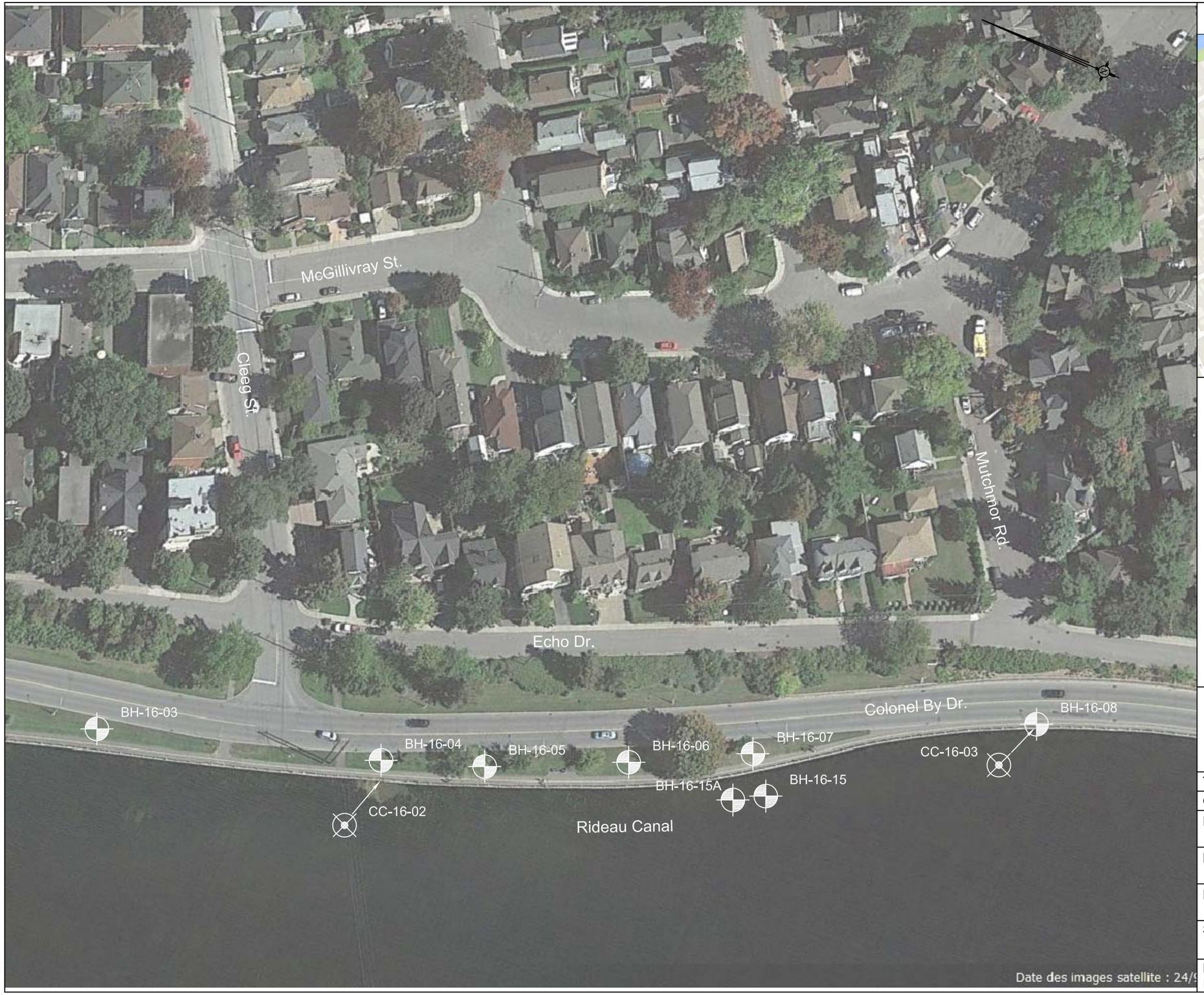
NOTES:

1- Base plan from Google Map.

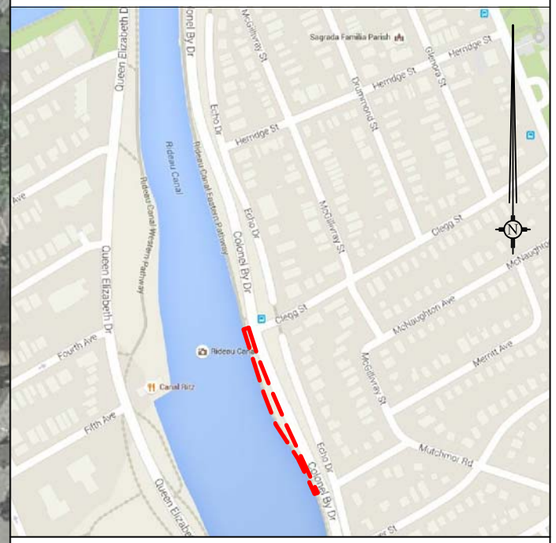
SNC·LAVALIN

TITLE	: Sounding location plan
CLIENT	: PWGSC
PROJECT	: Geotechnical Investigation Rideau Canal Walls (Herridge to Mutchmor)
LOCATION	: Rideau Canal Pathway - Colonel By Drive Ottawa, Ontario
ENGINEER:	Sébastien Bisson, P.Eng., M.Eng. *PEO# 100206436*
SCALE	: None

DATE :	FILE NO. :	DRAWING :
November 2016	636464	1 of 2



SITE LOCATION



LEGEND :

BH-16-04 - Borehole #4

CC-16-02 - Concrete coring #2

NOTES:

1- Base plan from Google Map.

SNC·LAVALIN

TITLE	: Sounding location plan
CLIENT	: PWGSC
PROJECT	: Geotechnical Investigation Rideau Canal Walls (Herridge to Mutchmor)
LOCATION	: Rideau Canal Pathway - Colonel By Drive Ottawa, Ontario
ENGINEER:	Sébastien Bisson, P.Eng., M.Eng. *PEO# 100206436*
SCALE	: None

DATE :	FILE NO. :	DRAWING :
November 2016	636464	2 of 2