



Geotechnical Investigation

211 Centrum Boulevard
Ottawa, Ontario

Le Groupe Maurice

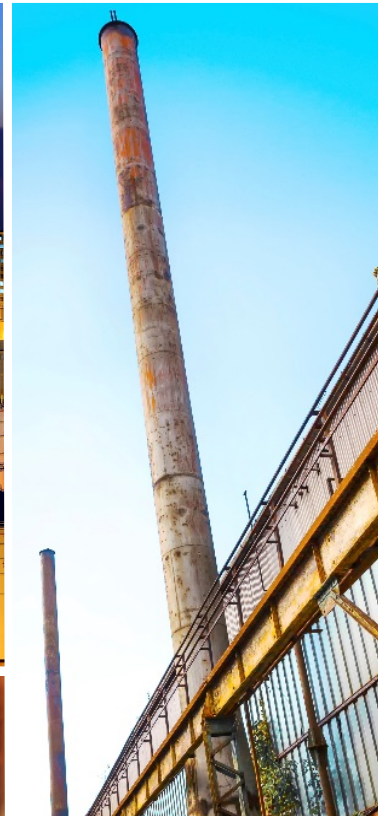




Table of Contents

1.	Introduction.....	1
2.	Site and Project Description.....	1
3.	Field Investigation	2
3.1	Laboratory Testing	3
4.	Subsurface Conditions	4
4.1	Surface Materials	4
4.2	FILL	4
4.3	Native Silty CLAY	5
4.4	Native Clayey SILT	5
4.5	Native Silty / Clayey SAND	5
4.6	Glacial TILL	5
4.7	Bedrock	6
5.	Groundwater.....	6
6.	Discussion and Recommendations.....	7
6.1	Site Preparation	8
6.2	Excavation and Dewatering	8
6.3	Foundations	10
6.3.1	Shallow Foundation on Bedrock – Southern Portion of the Site	10
6.3.2	Deep foundations – Northern Portion of the Site.....	11
6.4	Floor Slabs	12
6.5	Frost Protection.....	13
6.6	Seismic Site Classification	13
6.7	Lateral Earth Pressure	13
6.7.1	Static Conditions.....	14
6.7.2	Dynamic Condition.....	14
6.7.3	Basement Walls against Bedrock.....	15
6.8	Permanent Drainage	15
6.8.1	Underfloor Drainage	15
6.8.2	Perimeter drainage	15
6.9	Corrosion Potential of Soils.....	15
6.10	Building Backfill.....	16
6.10.1	Engineered Fill.....	16
6.10.2	Exterior Foundation Wall Backfill.....	17
6.11	Underground Services	18
6.11.1	Bedding and Cover	18



6.11.2	Service Trench Backfill	18
6.12	Pavement Sections	18
6.13	Construction Field Review	19
7.	Limitation of the Investigation.....	20

Table Index

Table 3-1	Groundwater Observations.....	3
Table 5-1	Groundwater measurements	6
Table 6-1	Preliminary bearing capacities.....	11
Table 6-2	Soil Parameters and Earth Pressure Coefficients	14
Table 6-3	Corrosivity test results	16
Table 6-4	Classes of Exposure.....	16
Table 6-5	Recommended Pavement Structure	19

Figure Index

Figure 1	Site Location Map
Figure 2	Test Location Plan

Appendix Index

Appendix A	Geotechnical Logs, Explanatory Notes and Rock Core Photos
Appendix B	MASW Investigation Seismic Site Classification Report
Appendix C	Laboratory Results and Summary Table
Appendix D	Concept Design Drawings

1. Introduction

GHD was retained by Le Groupe Maurice (Client), represented by Mr. Nabil Jurdak, to undertake a Geotechnical Investigation for a proposed new retirement home complex. The development is located at 211 Centrum Boulevard in Orleans (Ottawa), Ontario, hereafter referred to as the Site.

The purpose of this investigation was to evaluate and summarize the subsurface stratigraphy at the proposed development and provide recommendations for the foundation types and associated design bearing pressures, floor slab support, drainage requirements, as well as comment on excavation, backfill, pavement design and construction field review.

An initial test pitting program was undertaken by GHD at the site and summarized in a memorandum (Reference number 11206675 Memo-02 dated December 17, 2019). Subsequently, an intrusive geotechnical and environmental drilling investigation was undertaken. Results from both the initial and subsequent geotechnical investigations are presented in this report and the environmental results are presented under a separate cover.

The scope of work for the geotechnical assessment comprised:

- Underground Service Clearances | Confirmed location of private and public locations prior to fieldwork.
- Fieldwork | The advancement of a total of 12 boreholes, excavation of 10 test pits and a Multichannel Analysis of Surface Waves (MASW) assessment (MASW results presented under a separate cover). Eight of the boreholes were out-fitted with monitoring wells to measure the groundwater level across the site and for environmental sampling / testing (environmental results presented under a separate cover).
- Lab Testing | Five sieve analysis tests, four Atterberg Limits tests, one hydrometer test and 18 moisture contents on selected soil samples. Chemical testing of two soil samples to assess potential corrosive conditions to buried concrete and steel elements. Ten Unconfined Compressive Strength (UCS) test on rock cores.
- Reporting | Preparation of a Geotechnical Report (this document) which summarizes the findings of the drilling fieldwork program and presents preliminary comments and recommendations for design and construction of the development.

This report has been prepared with the understanding that the design will be as described in Section 2 and will be carried out in accordance with all applicable codes and standards. Any changes to the project described herein will require that GHD be retained to assess the impact of the changes on the recommendations provided.

2. Site and Project Description

At the time of investigation, the Site was primarily vacant with trees and overgrown vegetation. A disused parking garage and a commercial building are present at the southwestern corner of the Site.



Surrounding development comprises commercial structures, a gas station, a hotel and the Shenkman Arts Centre. The Site is bounded by an on ramp for the OR174 to the north, Place d'Orleans Drive to the west, Centrum Boulevard to the south, and Brisebois Crescent to the east.

An approximately 30 m long 5.0 m high concrete block retaining wall runs along the north eastern site boundary in the vicinity of BH11 and adjacent to the neighboring hotel.

The site topography generally slopes down from south to north. The southern half of the Site is estimated to slope at 0-2, the middle quarter of the site at 5-10 and the northern quarter at 0-2. The Site topography is noted to have been significantly altered by cutting and / or filling. Results of level survey of borehole locations indicates an elevation change in the order of 6.0 m from BH/MW2 to BH/MW11.

Piles of large (up to 2.0 m) bedrock blocks were noted on the surface and / or slightly buried in the vicinity of BH7, BH8 and BH11. Bedrock had also been used in landscaping in the vicinity of BH/MW1, BH/MW2 and BH/MW12

A rock cutting surrounds the northern and eastern edge of the existing two-storey parking garage. Cutting faces were noted to be at / near a vertical grade with no signs of instability noted. Exposed bedrock comprises horizontally bedded competent Limestone with relatively large (1.0 – 2.0 m) joint / defect spacing. Though not visible at the time of investigation due to snow cover, a review of aerial imagery indicates bedrock exposures at ground level between BH2 and BH4.

GHD understands that the proposed development will consist of the demolition of the existing two-storey parking garage structure, retention of the existing commercial structure, and construction of a new retirement home complex. Based on the concept drawings (provided in Appendix D) and information provided by the Client, it is understood that the proposed structure comprises of a residential, service and leisure complex with two structures up to 16 stories, two structures up to four stories high and one level of underground parking all interconnected. Additional associated development comprises surface parking, an undercover drop off area, internal access roads, service connections and landscaped areas.

The location of the Site is shown on the Site Location Plan attached as Figure 1 at the end of this report.

3. Field Investigation

The fieldwork program consisted of the advancement of twelve boreholes labelled as BH1 to BH12 and 10 test pits labelled as TP1 to TP10. The boreholes were advanced to depths ranging from 2.7 to 7.5 meters below ground surface (mbgs). The test pits were advanced to refusal encountered at depths ranging from 0.6 to 3.4 mbgs.

Eight boreholes were outfitted with monitoring wells (labelled as BH/MW1, BH/MW2, BH/MW4, BH/MW5, BH/MW8, BH/MW9, BH/MW11 and BH/MW12) to measure groundwater levels and for groundwater sampling. Monitoring wells MW1, MW2, MW9 and MW12 were sealed into bedrock. MW4, MW5, MW8 and MW11 were sealed into overburden soil materials. Groundwater sampling fieldwork and results are presented under a separate cover.



The location of the boreholes and test pits are shown in the Test Location Plan attached as Figure 2 at the end of this report.

The initial test pitting program was undertaken on December 13, 2019. Test pits were excavated to refusal using a 13.8 ton excavator with a standard bucket attachment.

Upon completion test pits were backfilled by returning excavated materials in lifts and compacting with the excavator bucket. Excess spoil was mounded over test pits to allow for settlement of backfilled test pits.

The borehole drilling fieldwork program was undertaken from January 9 to 15, 2020 with a track mounted drill rig, under the supervision of GHD field staff.

Boreholes were advanced into the overburden using hollow stem augers with Standard Penetration Tests (SPTs) at regular intervals using a 50 mm diameter split-spoon sampler and a 63.5 kg hammer, free falling from a distance of 760 mm, to collect soil samples. The number of drops required to drive the sampler 0.3 m recorded on the borehole logs as "N" value. To confirm bedrock and rock quality (ASTM D2113) rock coring at nine boreholes was undertaken using HQ or NQ diamond coring equipment.

All boreholes without groundwater wells were backfilled with bentonite hole plug and silica sand upon drilling completion. Auger cuttings were placed in drums and left on site for testing and future disposal.

The elevations of the boreholes were determined by GHD field staff using a laser level and related to the top of spindle of a fire hydrant on Centrum Boulevard to the south of the site (assigned benchmark). This benchmark was assumed to have an arbitrary elevation of 100 m. The elevations of the boreholes are not geodetic and are for use within the context of this report only.

The MASW assessment was undertaken on the January 28, 2020 by GHD field staff. A discussion on the procedure and findings from the MASW assessment are provided in the report titled; *MASW Investigation Seismic Site Classification*, attached in Appendix B.

3.1 Laboratory Testing

Collected soil and bedrock samples were submitted to our GHD Laboratory for geotechnical testing. Soil samples were submitted to a specialized environmental laboratory for corrosivity testing. The laboratory tests undertaken are shown in Table 3-1.

Table 3-1 Groundwater Observations

Laboratory test	Quantity of tests undertaken
Water content testing	18
Atterberg limits tests	4
Sieve analysis	5
Hydrometer testing	1
Corrosivity testing	2 ⁽¹⁾
UCS testing of rock core	10

Note: UCS = Unconfined compressive strength (1) 1 additional redox test undertaken



Laboratory results and a summary table of pertinent results are presented in Appendix C.

Results of the laboratory testing were used to confirm site soil logging and are discussed in the proceeding relevant subsurface material section.

4. Subsurface Conditions

In general, soils encountered at the test pit and borehole locations consisted of a surface layer of topsoil, overlying a fill material, overlying native silty clay to clayey sand transitioning to a silty sand (glacial till) deposit overlying Limestone bedrock. Bedrock was encountered at or near the surface towards the southern site extremity and gradually increased to depths of up to 4.5 mbgs at the northern Site boundary.

General descriptions of the subsurface conditions are summarized in the following sections, with a graphical representation of each test pit and borehole on the Geotechnical Logs. Notes on test pit and borehole logs are provided in Appendix A. Results from the laboratory testing and a summary table of pertinent laboratory results are presented in Appendix C.

4.1 Surface Materials

Topsoil was encountered in eight of the boreholes and nine of the test pits drilled / excavated at the Site to depths ranging from 0.025 m to 0.25 m and generally comprised sandy silt/ silty sand.

Surface materials at other bore locations comprised:

- 100 mm of Asphalt at the surface at BH/MW2
- Fill at BH6, BH7, BH/MW11 and TP04

The topsoil descriptions, and thicknesses within this report are for planning purposes only and should not be used for quality assessments or quantity take-offs.

4.2 FILL

Fill / possible FILL was encountered at the majority of borehole and test pit locations either at the surface or beneath topsoil layers in layer thicknesses ranging from 0.05 m to 2.9 m. Fill materials were highly variable and generally comprised clayey sandy SILT or gravelly / silty / clayey SAND or silty sandy GRAVEL. Fill materials were noted to have inclusions of organics, bricks, glass and rubber at some locations. Fill materials were also noted to contain varying proportions of cobbles and boulders up to 1.5 m diameter in TP01 to TP04, TP07, TP10, BH/MW5, BH6 and BH7.

SPT testing in the boreholes indicated that fill material was generally compact to dense and was recovered in moist condition. However, SPT testing at BH6 and BH/MW8 indicated fill was loose to compact. It is noted that fill materials at the site are considered to be uncontrolled fill, accordingly levels of in-situ compaction and material types may vary significantly over short distances.

Water content testing on fill materials returned results ranging from 19.7 percent to 37.4 percent. Sieve Analysis tests on a sample of fill from BH3 returned results of 33.7 percent gravel, 44.3 percent sand and 22 percent fines.



4.3 Native Silty CLAY

An approximately 3.0 m thick layer of grey silty clay overlying bedrock was encountered in TP06 and BH/MW11. SPT, pocket penetrometer and Shear Vane testing at BH/MW11 indicated the clay was stiff to very stiff in consistency. The clay samples were recovered in moist to wet condition.

Laboratory testing on silty clay materials from BH/MW11 returned water contents of 33.9 percent and 65.9 percent. Atterberg Limits tests returned a liquid limit of 81 percent and a plasticity index of 49 percent indicating that the clay is of high plasticity. Sieve Analysis with Hydrometer testing on a clay sample from BH/MW11 returned results of 0 percent gravel, 1 percent sand, 12 percent silt and 77 percent clay.

4.4 Native Clayey SILT

Thin layers of brown to grey clayey silt in a moist condition and of firm to stiff consistency were encountered in BH/MW4, BH/MW8 and BH/MW9 overlying granular till.

Laboratory testing on the clayey silt materials indicated water contents ranging from 24.1 percent to 31.8 percent. Atterberg limits testing on samples returned liquid limits of 41 percent and 36 percent and plasticity index results of 13 percent and 10 percent indicating these materials are of low plasticity.

4.5 Native Silty / Clayey SAND

Thin layers of brown silty / clayey sand was encountered underlying fill/ silty clay materials in TP04, TP05, TP08, TP09, BH/MW4, BH/MW5, BH/MW8 and BH/MW10. These materials were noted to generally be found overlying till / bedrock, be loose to compact condition and was recovered in moist condition.

Laboratory testing on one sample of the clayey sand returned a water content of 27.3 percent.

4.6 Glacial TILL

A glacial till deposit was encountered overlying bedrock in BH/MW4, BH/MW5, BH6, BH7, BH/MW8, BH/MW9 and BH10. Till materials generally comprised grey SILT & SAND with varying proportions of gravel, clay, cobbles and boulders up to 0.45 m in size. Till materials were generally compact to dense and was recovered in moist to wet condition.

Laboratory testing on till materials returned water contents ranging from 10 percent to 16.3 percent. Sieve Analysis testing returned results of 8.2 percent to 14.5 percent gravel, 25.3 percent to 44.7 percent sand and 40.8 percent to 66.5 percent fines. It is noted that split spoon refusal was encountered during multiple SPT tests. Spoon refusal may indicate the presence of boulders, cobbles abundant gravel or very dense layers. Accordingly, sieve analysis of till materials collected from split spoons will not be representative of all till materials present at the Site



4.7 Bedrock

All of the test pits were excavated to refusal on presumed bedrock. Excluding BH7 boreholes were drilled to practical refusal to auger advancement on inferred bedrock, fill or till. Where auger refusal was encountered in fill / till boreholes were advanced using diamond coring methods.

All boreholes excluding BH6, BH7 and BH10 were advanced into bedrock using NQ or HQ diamond coring methods to confirm the presence, type, and quality of bedrock. Bedrock (including presumed) was encountered at depths ranging from 0.15 m to 5.97 m.

Based on retrieved rock core and rock exposures, bedrock at the site comprises banded grey and dark grey Paleozoic Limestone of the Rockcliff Formation.

In BH/MW2 and BH3 assessed RQD values of 20 percent and 0 percent respectively indicate very poor rock quality designations for the top 0.16 to 0.5 m of bedrock. Following this zone and at all other borehole locations excluding BH/MW5, RQD values ranged from 78 to 100 percent indicating bedrock is of good to excellent quality. Bedrock at BH/MW5 was noted to be excellent quality (RQD of 97 percent) for the top 1.55 m overlying fair quality (RQD of 60 percent) bedrock for the remaining 1.5 m of the borehole.

UCS testing of 10 samples of the limestone bedrock returned UCS values ranging from 41.7 MPa to 95.8 MPa and an average value of 69.1 MPa. In accordance with The Canadian Foundation Engineering Manual – 2006 (CFEM) bedrock is classified as medium strong to strong. It is noted that excluding the one UCS test result of 41.7 MPa all UCS test results ranged from 50 MPa to 100 MPa indicating that in accordance with CFEM the majority of bedrock at the site is classified as strong.

Notes on rock quality designation based on RQD and core photographs are presented in Appendix A.

5. Groundwater

Monitoring wells were installed in eight boreholes as part of the scope of work. Groundwater levels in the wells were measured on January 22-23, 2020 and are presented in Table 5-1.

Table 5-1 Groundwater measurements

Borehole	Depth of water below existing ground surface (m)	Surface elevation ⁽¹⁾ (m)	Groundwater elevation ⁽¹⁾ (m)	Materials at well intake
BH/MW1	3.55	95.39	91.84	Bedrock
BH/MW2	3.06	97.99	94.93	Bedrock
BH/MW4	2.78	96.54	93.77	Soil
BH/MW5	2.51	95.66	93.16	Soil
BH/MW8	1.70	94.40	92.70	Soil
BH/MW9	1.38	92.74	91.36	Bedrock
BH/MW11	1.20	91.86	90.65	Soil
BH/MW12	1.00	95.66	94.66	Bedrock

Notes: (1) Elevations based on locally assigned benchmark and are not geodetic



The recorded groundwater levels indicate that likely one aquifer is present at the Site interconnected between bedrock and soil materials. Variation in groundwater head is likely due to the sloping nature of the Site. At the time of authoring this report the presumed locally assigned elevation for foundations was 95 m (not geodetic). All groundwater levels measured at the site were below presumed foundation levels.

It should be noted that the groundwater table is subject to seasonal fluctuations and in response to precipitation and snowmelt events. Also, it would be expected that water may be perched within the fill materials or the very poor bedrock, especially during and following periods of precipitation and in the spring and fall or other wet seasonal periods.

6. Discussion and Recommendations

The recommendations in this report are based on GHD's understanding of the proposed development, which is outlined as follows:

- The proposed structures are interconnected and include two low (four-storey) and two high-rise (>10 storey) buildings with one level of underground parking (see Section 2 of this report for more details).
- A founding elevation (locally assigned benchmark) of 95 m for the foundations which is approximately 3.0 m below current ground surface on the south of the Site and at approximately 2.0 – 3.0 m above the ground surface at the north of the Site. It is anticipated the foundations will comprise a combination of conventional shallow foundations and deep foundations founded on bedrock.
- The slab-on-grade is assumed to be lightly loaded (less than 24 kPa).
- It is our assumption that significant grade raise, in a range of 3.0 to 4.0 m will need to be carried out on the north portion of the Site, to elevate the Site to ground elevation at Brisebois Crescent.

Based on the subsurface conditions encountered in the boreholes, and assuming them to be representative of the subsurface conditions across the Site, the following recommendations are provided. Significant geotechnical considerations for design and construction of the proposed structure are:

- Variable subsurface conditions | Subsurface conditions were noted to vary significantly at the site with bedrock being encountered at an elevation 10 m lower towards the northern portion of the Site compared to the south. Variable depths and types of fill including fill containing large boulders (up to 1.5 m) are present at the site. High plasticity silty clay soils were encountered in the north eastern corner of the site.
- Bedrock Excavation | Based on the proposed founding depth of foundations for the structures, bedrock excavation will be required. Bedrock was noted to be generally good to excellent quality and medium strong to strong with thin layers of very poor and fair quality rock at some locations.
- Adjacent Structures - Construction Activity Induced Vibrations | The excavation operations of bedrock will impart vibrations affecting the nearby below grade and above grade structures including the adjacent buildings, roadways and retaining wall. The client, designers and contractors should implement measures to reduce risk and severity of vibrations and damage to



adjacent structures. The excavation methods must follow the City of Ottawa guidelines. Pre-Construction surveys should be carried out and contractors should incorporate excavation methods to minimize damage due to vibration to the adjacent structures.

- **Excavation** | The excavation faces through the overburden depth will need to be adequately shored or sloped. Upper levels of fractured bedrock should be planned to be sloped at 1:1. The underlying more sound bedrock should be able to be cut at / near vertical.
- **Dewatering** | The recorded groundwater levels at the borehole locations show likely one aquifer with groundwater levels generally below the proposed depth of founding or earthworks. GHD did not complete a hydrogeological assessment of this site as part of the scope of work. A variation in the proposed scope may require a hydrogeological assessment to estimate the extent of dewatering activities and whether a Permit to take water (PTTW) or submission on the Ontario Environmental Activity and Site Registry (EASR) will be required.
- **Earthworks** | Based on concept design sketches, project appreciation and site topography filling and/or cutting will be required to bring the ground surface to a suitable founding and / or finished grade. The surficial fill encountered in boreholes and test pits and observed on the ground surface contains large size bedrock blocks or boulders that are not suitable to support foundations, floor slab, access roads or underground services and is recommended to be removed and replaced with suitable fill. Significant grade raises in order of 3.0 to 4.0 m is expected in the north portion of the site.

6.1 Site Preparation

Site preparation for filling within the structures footprint, beneath roads / pavements and at locations requiring filling will involve the removal of existing vegetation, topsoil, asphalt, fill and deleterious materials to expose native soils / bedrock. It is noted that the proposed development also comprises removal of the existing two-storey parking structure.

The exposed subgrade surface should be compacted and proof rolled under examination by geotechnical personnel. This would be part of a program to assess the competency and any identified local anomalies (over size materials) or soft spots should be subsequently excavated, replaced with suitable fill, and compacted. Field verification should be carried out by qualified geotechnical personnel during construction. Detailed recommendations regarding the pavement subgrade preparation is provided in Section 6.12 of this report.

Bedrock removal is expected to achieve founding levels, for underground services and underground parking level. Recommendations for excavation of bedrock are provided in Section 6.2.

It is noted that environmental requirements for removal of existing materials is provided under a separate cover and not addressed in the above recommendations

6.2 Excavation and Dewatering

All excavations should be completed and maintained in accordance with the Occupational Health and Safety Act (OHSA) requirements. The following recommendations for excavations should be considered to be a supplement to, not a replacement of, the OHSA requirements.



Based on the results of the investigation and in accordance with the OSHA requirements the subsurface soil materials are classified as *Type 3*.

In accordance with O.Reg. 213/91 *Type 3* soils should be battered at 1:1 or supported by a shoring system where excavations greater than 1.2 m depth are required.

Fractured bedrock encountered in BH/MW2 and BH3 should be treated as *Type 3* soil materials and shored / battered accordingly. Bedrock of fair or better quality may be considered as sound and excavated at / near vertical. During construction, excavations of bedrock may encounter areas requiring treatment of issues such as local fractures, shear zones or weathered areas. Anticipated treatments may include (but not limited to) scaling, over excavation, rock bolting and rock bolting with mesh and shotcrete. It is recommended to include a provisional allowance for such treatments within the construction contract.

The above recommendations of excavation stability should be assessed by a suitably qualified engineer during construction to confirm their suitability and ensure conformance with O.Reg 213/91.

It is anticipated that excavation of most site soils may be undertaken using conventional excavation equipment (i.e. excavators). However, the presence of large boulders in fill and till materials indicate that large excavation equipment may be required.

Bedrock at the site was noted to generally be fair or better quality and medium strong to strong. Accordingly, bedrock will likely not be excavatable using conventional methods (i.e. excavators). Unconventional bedrock excavation methods may include:

- A combination of line drilling and pneumatic or hydraulic breakers such as hoe rams or heavy excavation equipment equipped for rock excavation such as rock grinders.
- A combination of controlled blasting techniques and line drilling. Local by-laws should be consulted to confirm that blasting will be allowed in this area. Line drilling on a closely spaced pattern may also be an option to assist excavation methods and prevent over breakage issues, especially around the perimeter or to create local excavations for elevator pits, footings, etc.

If waterproofing is required, the excavation method and degree of roughness may dictate the excavation method. For example, the use of cutter heads/grinders would assist to have a smooth rock face.

Temporary support may be required where excavations are proposed adjacent to existing structures / roadways or within influence zones of adjacent foundations. Advance planning to ensure minimal impacts on adjacent structures / roadways is recommended. Any excavation methodology is subject to the laws and blasting restrictions that are in effect for the area. Parameters for the design of temporary support of excavations are provided in Table 6-2 and should include loads imparted by adjacent structures.

The excavation operations of bedrock will impart vibrations affecting the surrounding buildings. Contractors must use techniques and methods to prevent settlement of adjacent ground, structural damage to adjacent buildings and minimize aesthetic impacts (e.g., paint/drywall cracks, pavement cracking). It is recommended that the specifications require pre-construction condition surveys as well as submittal of plans for excavations, blasting, vibration monitoring, and soil and groundwater management plans.



It is recommended that the client's design team include in the specification package, requirements for the successful contractor to submit written Plans for Excavation, blasting, vibration monitoring as well as Soil and Groundwater Management for review by the client design team.

Surface water seepage is expected in the excavation. Based on a founding elevation of 95 m (not geodetic) groundwater seepage is not expected in the excavated areas. However, groundwater levels depend on seasonal conditions and dewatering may need to be reassess especially where any variation in depth of excavations is proposed or where excavations are left open. Where required conventional construction dewatering techniques should be taken during construction, such as pumping from sumps and or ditches. Contractors will need to use techniques and methods to minimize disturbance to soils.

GHD did not complete a hydrogeological assessment of this site as part of the scope of work. If excavation / founding depths vary from this report a hydrogeological assessment may be required to estimate the extent of dewatering activities and whether a Permit to take water (PTTW) or submission on the Ontario Environmental Activity and Site Registry (EASR) will be required.

Method of disposal of the groundwater in the excavations (if encountered) will depend on the environmental quality of the Site groundwater. The results of the groundwater analysis and recommendations are discussed in a separate report.

6.3 Foundations

As discussed in Section 2, the proposed structures comprise two low (four-storey) and two high-rise (>10-storey) buildings with one level of underground parking all interconnected (see Section 2 of this report for more details).

Based on the geotechnical investigation, it is understood that foundations for structures located on the southern half of the site will likely comprise conventional strip and pad footings founded on bedrock.

Foundations for structures located on the northern portion of the site is recommended to consist of deep foundations supported on bedrock.

The Ontario Building Code (OBC 2012) requires buildings to be designed using Limit States Design values (LSD) of Serviceability Limit States (SLS) and Ultimate Limit States (ULS).

6.3.1 Shallow Foundation on Bedrock – Southern Portion of the Site

At the time of writing this report it is understood that one level of underground parking is being considered. Based on this and surface elevations at the south of the site a foundation elevation of 95 m has been assumed for shallow foundations. Note that the aforementioned elevations are not geodetic and are based on a locally assigned benchmark.

Conventional strip and pad footings supported on bedrock for the structures on the southern portion of the site are considered suitable for the proposed development.

It is noted that as foundation loads from the structures are anticipated to be relatively high and due to variable subsurface condition shallow foundation supported on native soil deposit is not



recommended for the structures located in the northern portion of the site as significant differential displacements (i.e. settlements) can be anticipated.

Table 6-1 Preliminary bearing capacities

Subsurface material	Unfactored ULS bearing capacity(q_b) (kPa)	Factored ULS bearing capacity(q_a) (kPa)
Limestone – very poor quality	2000	1000
Limestone – Good quality or better	4000	2000

The calculated ULS values provided in Table 6.1 are based on a minimum foundation size of 0.75 m for pad footings and 0.5 m for strip footings. The factored ULS values include the geotechnical resistance factor (Φ) of 0.5 for shallow foundations. For all footings set on bedrock, there is no corresponding SLS value, as settlement is considered to be nil for the footings founded on bedrock.

It is noted that at the time of writing this report the proposed development is in the process of design. Accordingly varying the proposed depth of the basement level, final site grading or additional basement levels could be considered to allow for founding of all structures on rock using shallow foundations.

Excavations for footings and other adjacent structures (sump pits, storm water tank, sewer trenches, etc.) set within bedrock at various levels, including step footings, should be positioned such that they do not encroach within the 1V:1H zone of influence of an adjacent footing. Step footings should be designed in a manner that the average slope of the benching is no steeper than 1V:2H along the length and the height of the bench is less than 0.3 m

6.3.2 Deep foundations – Northern Portion of the Site

Deep foundations are recommended on the northern portion of the site where bedrock was encountered at a significantly lower elevation. Based on the presence of large boulders in the native till materials, the use of driven or screw piles is not recommended due to the likelihood of early refusal and / or intolerable lateral displacements during installation. Based on the site conditions, short bored cast in-situ reinforced concrete piles (i.e. Caissons) or micropiles founded on bedrock or socketed in bedrock are recommended from a geotechnical standpoint.

The method for calculation of bearing capacities are presented in Section 9 and 18 of the CFEM of this report. The bearing capacities for shallow foundations on bedrock presented in Table 6-1 are suitable for the design of bored piles founded in rock surface. The total loads for the caissons must have the Resistance Factor of 0.4 applied to the value to provide the factored ULS value as per Table 8.1 of CFEM.

Bored piles socketed into bedrock will provide some increased bearing capacity, however due to anticipated groundwater infiltration and the inability to provide a 'clean' pile base, the recommended design approach is to rely on shaft friction only using methods outlined in CFEM Section 18.6.4.



For bored piles designed as friction piles deriving frictional forces from bedrock the method outlined in Section 18.6.4.2 and formula 18.44 of CFEM is recommended which is:

- $Q_s = \pi B_s L_s q_s$ Equation 18.4.3 (CFEM)

Where:

- B_s = diameter of the socket
- L_s = length of socket

And

- $q_s/P_a = b(q_u / P_a)^{0.5}$ Equation 18.44 (CFEM)

where:

- q_s = socket shear, kPa
- q_u –unconfined compressive strength of bedrock where UCS is less than f'_c or $q_a = 0.05f'_c$, where UCS is higher than f'_c in kPa
- f'_c = concrete compressive strength, kPa
- b = empirical factor, assume as 1.41 for Limit State design approach
- P_a = atmospheric pressure, assume 101.5 kPa

Values of shaft adhesion may be limited by concrete compressive strength. Accordingly they have not been presented and should be calculated at the time of design.

Where piles are proposed within close proximity to each other, pile group effects should be considered.

It is noted that due to relatively thin layers of soil materials frictional forces derived from soil are likely to be minimal, accordingly these have been neglected.

6.4 Floor Slabs

Conventional slab-on-grade construction is considered suitable for the proposed buildings. We understand that the building will have light floor loadings only, i.e., considered to be less than 24 kPa. Higher loading requirements will require additional consultation and analysis.

Preparation of the subgrade for floor slab as discussed in Section 6.1 and 6.2 includes removal of any unsuitable overburden (topsoil, vegetation, asphalt and surficial fill) or bedrock materials to expose suitable subgrade and/or the design subgrade level. Any local weakened areas should be excavated and replaced with suitable fill and compacted. Field verification should be carried out by geotechnical personnel during construction.

A layer consisting of Granular 'A' at least 200 mm thick should be placed immediately below the floor slabs to support the slab-on-grade. This layer should be compacted to 100 percent of its SPMDD and placed on approved subgrade surfaces.



If floor coverings are to be used on slab-on-grades then, a vapour barrier is recommended to be incorporated beneath the slab and should be specified by the architect. Floor toppings may also be impacted by curing and moisture conditions of the concrete. Floor finish manufacturer's specifications and requirements should be consulted and procedures outlined in the specifications should be followed.

The slabs should not be tied into the foundation walls. Construction and control joints in the concrete should be designed by a suitably qualified and experienced engineer.

6.5 Frost Protection

It is anticipated that foundations for the structure shall comprise piles and / or shallow foundations on bedrock. Where adequate drainage is provided or the depth of cover over the foundation is greater than 1.8 m detrimental frost action effects will be negligible.

Where foundations do not comply with the above, all exterior footings associated with either heated or unheated / isolated structures must be provided with a minimum of 1.5 m or 1.8 m of soil cover respectively (or its equivalent in insulation).

Common examples of unheated and isolated structures include signs, entrance canopies and piers.

6.6 Seismic Site Classification

In accordance with OBC-2012, the building and its structural elements must be designed to resist a minimum earthquake force. Based upon the results of the borehole drilling program, the assumption that all foundations will be on rock and the MASW assessment, the site is considered to be 'Class B' with respect to Table 4.1.8.4.A of the National Building Code of Canada 2010. It is noted that Site Class B or A can be used only if there is less than 3.0 m of soil between the bottom of the foundation (i.e. footings or pile caps) and top of bedrock. Where there will be more than 3.0 m of soil between the foundation and top of bedrock Site Class C must be used. Therefore seismic site classification for this site should be reviewed once final foundation elevation is known.

It is also noted that the results of the MASW analysis shows shear wave velocities close to "Site Class A" however this would need further analysis and confirmation. This can be reviewed in detailed design stage and once foundation depth/elevation is known.

Further discussion of the MASW assessment are provided in the report; *MASW Investigation Seismic Site Classification*, attached in Appendix B.

6.7 Lateral Earth Pressure

Permanent basement walls and retaining walls at grade changes with adjacent properties should be designed for lateral pressures resulting from the following sources:

- Unit weight of the backfilled soil
- Temporary and permanent vertical loads on the completed ground surface



6.7.1 Static Conditions

The following soil parameters can be used for designing of the retaining walls for lateral earth pressures.

Table 6-2 Soil Parameters and Earth Pressure Coefficients

Soil	Unit weight ' γ ' (kN/m ³)	Angle of internal Friction	Rankin Earth Pressure Coefficients ^{(1) (2)}		
		ϕ	K_a	K_0	K_p
Compacted granular backfill such as an OPSS "Granular BI or BII" type product	21	32	0.31	0.47	3.25
Existing fill	17	27	0.38	0.55	2.66
Native silty/clayey sands	17	28	0.36	0.53	2.77
Native clay soils	16	25	0.41	0.58	2.46
Native Till (silt and sand)	18	30	0.33	0.50	3.00

Notes:

(1) Assumes level/flat backfill surface

(2) For Temporary soils support shoring is required, designers should refer to the CFEM for design assistance

For yielding walls the active earth pressure coefficients K_a is recommended to be used.

For non-yielding wall the at-rest K_0 should be used.

The resultant of the applicable static or at-rest force is assumed to act at 1/3H above the base of the wall where H is the height of the wall for the permanent wall with free drain backfill material.

It is noted that for the temporary shoring system that will support the existing site soil materials and upper fractured bedrock Section 26.10.3 of CFEM 2006 should be used by designers regarding the distribution of the forces. The soils encountered in the boreholes and likely to be excavated during construction consist mainly of granular soils. If the shoring must support existing structures then the stiffness of the shoring system must be addressed by the designers and K_0 is recommended. The contractor must also ensure installation procedures minimize risk of lateral movements especially where structures are being supported by the shoring system. Hydrostatic pressures should be considered in the design of the shoring systems

These statements are based on the assumption that there is a perimeter drainage system installed at the base of the retaining walls draining under gravity to a frost free outlet, to prevent the build-up of hydrostatic pressure behind the wall; hydrostatic pressures may not be included in the design.

6.7.2 Dynamic Condition

For a seismic event, the Mononobe-Okabe (M-O) equations, shown in Section 24.9 of CFEM-2006 are recommended for design implications for permanent earth retaining walls. In these formulas, there are both geotechnical and geometric components. The geotechnical parameters of imported granular backfill are provided in the above table.



Assuming:

$k_h = (PGA)$ – Corrected PGA is 0.274 for Site Class B for this area.

k_v = typically a range of $2/3 \times k_h$ to $1/3 \times k_h$ is considered but a value closer to $2/3 \times k_h$ is recommended.

The total active thrust under seismic loading (P_{ae}) is recommended to be expressed as follows:

$$P_{ae} = \frac{1}{2} K_{ae} \gamma H^2 \times (1 - k_v)$$

This includes both the active pressures under static (P_a) as well as the increased force due to seismic or simply as follows:

$$P_a = \frac{1}{2} K_a \gamma H^2$$

Therefore, the seismic force (P_e) is simply the difference between the P_{ae} and P_a , or:

$$P_e = P_{ae} - P_a$$

The active force under static conditions is assumed to act at a point of $(0.3 \times H)$ above the base and the seismic force is assumed to act near $(0.6 \times H)$ above the base, where H is the height of the wall. Therefore the point of applying P_{ae} may be calculated from the following:

$$h = [(0.33H \times P_a) + (0.6H \times P_e)] / P_{ae}$$

In reducing the above formula for this site, we recommend values of $K_{ae} \times (1 - k_v) = 0.46$ and $K_a = 0.31$. This condition applies for open cut excavations and granular backfill behind the walls, assuming there is permanent drainage system in place.

6.7.3 Basement Walls against Bedrock

If the bedrock is cut vertical in the sound bedrock at depth, the rock pressures may be less. This will be discussed once the foundation depth is known.

6.8 Permanent Drainage

6.8.1 Underfloor Drainage

Under floor drains are recommended for structures with underground levels.

6.8.2 Perimeter drainage

Perimeter drainage around the exterior of the walls of the proposed buildings is recommended. The drain should be connected to a frost-free outlet for year round drainage.

6.9 Corrosion Potential of Soils

Analytical testing on two collected soil samples was undertaken to assess the corrosion potential of the soil materials to buried concrete and steel structural elements. The test results are summarized in Table 6-3.

Table 6-3 Corrosivity test results

Sample ID	PH	Resistivity (ohm-cm)	Sulphate (percent)	Chloride (percent)	Redox (mV)
BH8, SS6	-	-	-	-	187
BH8, SS7	8.08	14 300	0.02	0.003	230
BH9, SS4	8.07	16 700	0.03	<0.002	225

The American Water Works Association (AWWA) publication 'Polyethylene Encasement for Ductile-Iron Pipe Systems' ANSI/AWWA C105/A21.5-10 dated October 1, 2010 assigns points based on the results of the above tests. Soil that has a total point score of 10 or more is considered to be potentially corrosive to ductile iron pipe. Based on the results obtained for the sample submitted, the Site soils are considered to be not corrosive to cast iron pipe.

Table 3 of the Canadian Standards Association (CSA) document A23.1-04/A23.2-04 'Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete' divides the degree of exposure into the following three classes:

Table 6-4 Classes of Exposure

Degree (Class) of Exposure	Sulphate (SO ₄) in Groundwater Sample (percent)
Very Severe (S-1)	>2.0
Severe (S-2)	0.2 – 2.0
Moderate (S-3)	0.1 – 0.2

A review of the analytical test results shows the sulphate content in the tested sample was found to be less than 0.1 percent. Based upon the test results, the degree of exposure of the subsurface concrete structures to sulphate attack is low. Therefore, normal General Use (GU) hydraulic cement can be used for the below grade concrete structures.

6.10 Building Backfill

Where it is required to have the placement and compaction of the granular materials and these will support the floor slabs, foundations, pavement or any interior backfill then these materials must be treated as Engineered Fill.

6.10.1 Engineered Fill

The fill operations for Engineered Fill must satisfy the following criteria:

- Engineered Fill must be placed under the continuous supervision of the Geotechnical Engineer.
- Prior to placing any Engineered Fill, all unsuitable existing fill, topsoil and deleterious materials must be removed. Following this the subgrade should be proof rolled with any weak / soft areas being over excavated and replaced with engineered fill.
- Prior to the placement of Engineered Fill, the source or borrow areas for the Engineered Fill must be evaluated for its suitability. Samples of proposed fill material must be provided to the Geotechnical Engineer and tested in the geotechnical laboratory for Standard Proctor Maximum Dry Density (SPMDD) and grain size, prior to approval of the material for use as Engineered Fill.



The Engineered Fill must consist of environmentally suitable soils (as per industry standard procedures of federal or provincial guidelines/regulations), free of organics and other deleterious material (building debris such as wood, bricks, metal, and the like), compactable, and of suitable moisture content so that it is within -2 percent to +0.5 percent of the Optimum Moisture as determined by the Standard Proctor test. Imported granular soils meeting the requirements of Granular 'A', or 'B' Type II OPSS 1010 criteria would be suitable.

- The Engineered Fill must be placed in maximum loose lift thicknesses appropriate to the compaction equipment utilized. Typical loose thicknesses range from 0.2 m to 0.3 m. Each lift of Engineered Fill must be compacted to 100 percent SPMDD using an appropriately sized roller, suitable for the fill material.
- Field density tests must be taken by the Geotechnical Engineer, on each lift of Engineered Fill. Any Engineered Fill, not meeting compaction specifications, shall be removed or re-compacted and retested.

6.10.2 Exterior Foundation Wall Backfill

Where applicable and/or if necessary, any backfill placed against the foundation walls should be free draining granular materials meeting the grading requirements of OPSS 1010 for Granular 'B' Type I specifications up to within 0.3 m of the ground surface. The upper 0.3 m should be a low permeable soil to reduce surface water infiltration. Foundation backfill should be placed and compacted as outlined below.

- Free-draining granular backfill should be used for the foundation wall.
- Backfill should not be placed in a frozen condition, or placed on a frozen subgrade.
- Backfill should be placed and compacted in uniform lift thickness compatible with the selected construction equipment, but not thicker than 0.2 m. Backfill should be placed uniformly on both sides of the foundation walls to avoid build-up of unbalanced lateral pressures.
- At exterior flush door openings the underside of sidewalks should be insulated, or the sidewalk should be placed on frost walls to prevent heaving. Granular backfill should be used and extended laterally beneath the entire area of the entrance slab. The entrance slab should slope away from the building.
- For backfill that would underlie paved areas, sidewalks or exterior slabs-on-grade, each lift should be uniformly compacted to at least 98 percent of its SPMDD.
- For backfill on the building exterior that would underlie landscaped areas, each lift should be uniformly compacted to at least 95 percent of its SPMDD.
- In areas on the building exterior where an asphalt or concrete pavement will not be present adjacent to the foundation wall, the upper 0.3 m of the exterior foundation wall backfill should be a low permeable soil to reduce surface water infiltration.
- Exterior grades should be sloped away from the foundation wall, and roof drainage downspouts should be placed so that water flows away from the foundation wall.



6.11 Underground Services

6.11.1 Bedding and Cover

The following are recommendations for service trench bedding and cover materials that may be associated with the development.

- Bedding for buried utilities should be OPSS Granular 'A', and placed in accordance with City of Ottawa specifications.
- The cover material should be a sand material or Granular 'A' and the dimensions should comply with City of Ottawa standards.
- The bedding material and cover materials should be compacted as per City of Ottawa standards and to at least 95 percent of its SPMDD.
- Compaction equipment should be used in such a way that the utility pipes are not damaged during construction.

6.11.2 Service Trench Backfill

Backfill above the cover for buried utilities should be in accordance with the following recommendations:

- For service trenches under pavement areas, the backfill should be placed and compacted in uniform thickness compatible with the selected compaction equipment and not thicker than 200 mm. Each lift should be compacted to a minimum of 95 percent SPMDD.
- To reduce the potential for differential settlement and frost heave the excavation sides should have frost tapers as per OPSD 800 series which essentially indicates that there should be a back slope of 10:1 (H:V) within the frost zone below finished grade.

6.12 Pavement Sections

Access driveways and parking areas are expected to be constructed over engineered fill or bedrock. In order to prepare the site for the pavement area, it is necessary that the area be stripped of any existing cover materials such as surficial topsoil or any other deleterious materials deemed unsuitable by geotechnical personnel to expose a suitable subgrade. The exposed subgrade should be proof rolled in the presence of a Geotechnical Engineer. Any areas where "soft spots", rutting, local anomalies, or appreciable deflection are noted should be excavated and replaced with suitable fill. IN problematic areas the use of geotextiles may be warranted for strength improvement. The fill should be compacted to at least 95 percent of its SPMDD.

The pavement sections described in the table below are recommended for areas subjected to parking lot and access road. Pavement materials and workmanship should conform to the appropriate Ontario Provincial Standard Specifications (OPSS).



Table 6-5 Recommended Pavement Structure

Pavement Layer	Minimum Thickness	Heavy Duty (Access Roads)
HL3 Asphalt	50 mm	40 mm
HL8 Asphalt	n/r	50 mm
Granular 'A' Base Course	150 mm	150 mm
Granular 'B', Type II Sub-Base Course	300 mm	450 mm

In order to accommodate the recommended thicknesses, designers will need to review grades and determine where stripping or filling is necessary. Pavement materials and workmanship should conform to the appropriate OPSS.

Minimum Performance Grade (PG) at 58 – 34 should be used at this Site.

Drainage of the pavement layers is important. The subgrade surface and each layer of the pavement section should be provided with a suitable cross fall (approximately 2 percent) to prevent water from ponding on the pavement surface and beneath the pavement layers. Surface runoff should be directed to storm sewers, or allowed to flow into ditches.

Where the new pavement abuts existing and the subgrade levels vary between the two areas, then a frost transition should be integrated into the subgrade with a 10:1 slope in the subgrade. Sufficient field-testing should be carried out during construction to assess compaction of each lift of the pavement layers. This should be accompanied by laboratory testing of the granular and asphalt materials. All granular base course materials should be compacted to 100 percent of its SPMDD.

Annual or regular maintenance will be required to achieve maximum life expectancy. Generally, the asphalt pavement maintenance will involve crack sealing and repair of local distress.

It should be noted that the pavement sections described within this report represent end-use conditions only, which includes light vehicular traffic and occasional garbage or service trucks. It may be necessary that these sections be temporarily over-built during the construction phase to withstand larger construction loadings such as loaded dump trucks or concrete trucks.

6.13 Construction Field Review

The recommendations provided in this report are based on an adequate level of construction monitoring being conducted during construction phase of the proposed building. GHD requests to be retained to review the drawings and specifications, once complete, to verify that the recommendations within this report have been adhered to, and to look for other geotechnical problems. Due to the nature of the proposed development, an adequate level of construction monitoring is considered to be as follows:

- Prior to construction of footings, the exposed foundation subgrade should be examined by a Geotechnical Engineer or a qualified Technologist acting under the supervision of a Geotechnical Engineer, to assess whether the subgrade conditions correspond to those



encountered in the boreholes, and the recommendations provided in this report have been implemented.

- A qualified Technologist acting under the supervision of a Geotechnical Engineer should monitor placement of Engineered Fill underlying floor slabs.
- Backfilling operations should be conducted in the presence of a qualified Technologist on a part time basis, to ensure that proper material is employed and specified compaction is achieved.
- Placement of concrete should be periodically tested to ensure that job specifications are being achieved.

7. Limitation of the Investigation

This report is intended solely for Le Groupe Maurice and is prohibited for use by others without GHD's prior written consent. This report is considered GHD's professional work product and shall remain the sole property of GHD. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient's sole risk, without liability to GHD. Client shall defend, indemnify and hold GHD harmless from any liability arising from or related to Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The recommendations made in this report are in accordance with our present understanding of the project, the current site use, ground surface elevations and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of Geotechnical Engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in the study report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. We should be retained to review our recommendations when the drawings and specifications are complete. Without this review, GHD will not be liable for any misunderstanding of our recommendations or their application and adaptation into the final design.

By issuing this report, GHD is the Geotechnical Engineer of record. It is recommended that GHD be retained during construction of all foundations and during earthwork operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the test hole locations only. The subsurface conditions confirmed at these test locations may vary at other locations. Soil and



groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction, which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD is completed.



All of which is Respectfully Submitted,

GHD

A handwritten signature in blue ink, reading 'Bahareh Vazhbakht'.

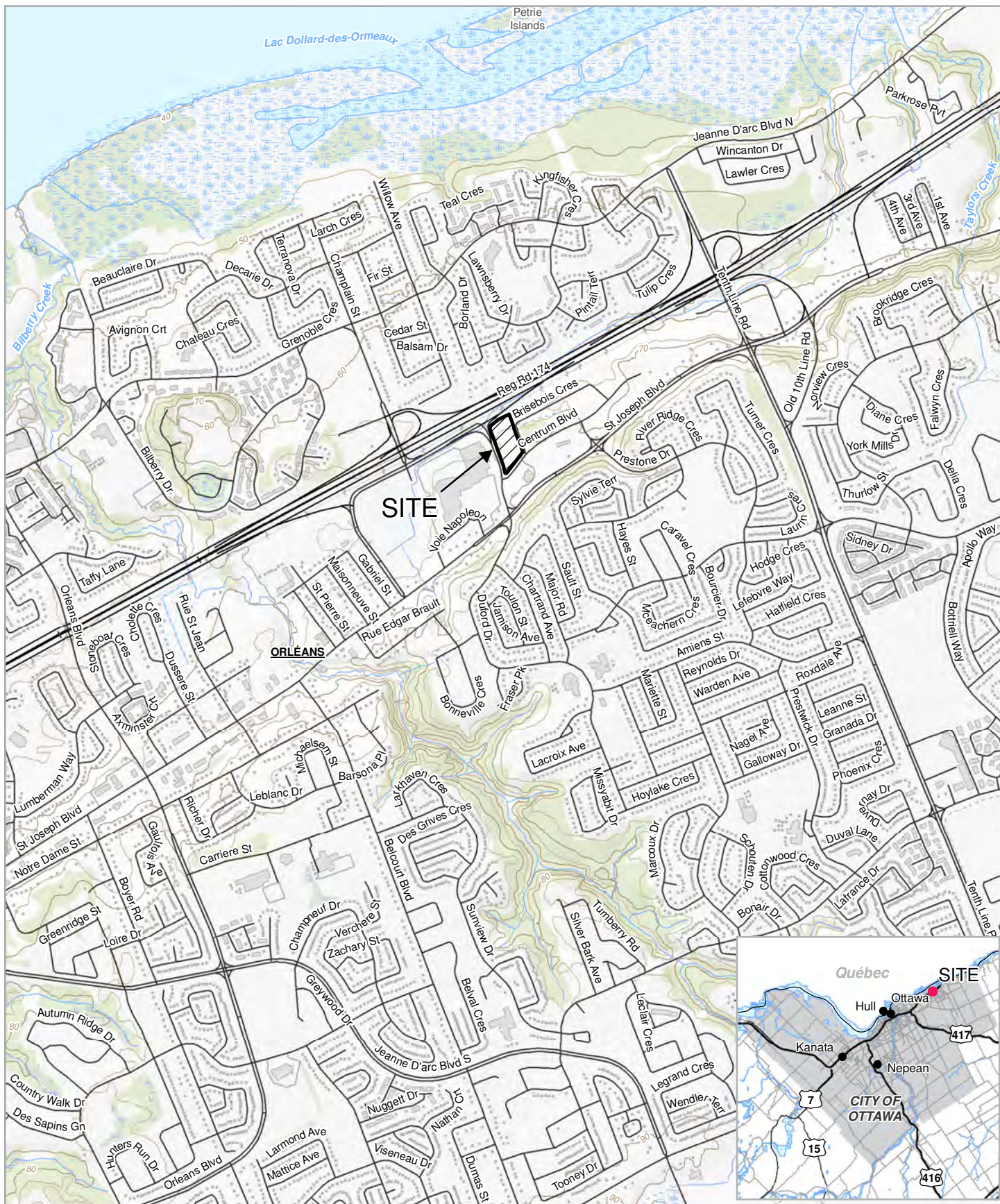
Bahareh Vazhbakht, M.ASc., P.Eng



A handwritten signature in blue ink, reading 'J. Bennett'.

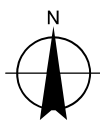
Joseph Bennett, P. Eng.

Figures



Paper Size ANSI A
0 140 280 420 560
Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 18N



LE GROUPE MAURICE
211 CENTRUM BOULEVARD, OTTAWA, ONTARIO
GEOTECHNICAL INVESTIGATION

Project No. 11206675
Revision No. -
Date Jan 29, 2020

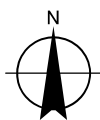
SITE LOCATION MAP

FIGURE 1



Paper Size ANSI A
0 5 10 15 20
Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 18N



LE GROUPE MAURICE
211 CENTRUM BOULEVARD, OTTAWA, ONTARIO
GEOTECHNICAL INVESTIGATION

Project No. 11206675
Revision No. -
Date Feb 7, 2020

TEST LOCATION PLAN

FIGURE 2

Appendix A

Geotechnical Logs, Rock Core Photos and Explanatory Notes



Notes on Borehole and Test Pit Reports

Soil description :

Each subsurface stratum is described using the following terminology. The relative density of granular soils is determined by the Standard Penetration Index ("N" value), while the consistency of clayey soils is measured by the value of undrained shear strength (Cu).

Classification (Unified system)			
Clay	< 0.002 mm		
Silt	0.002 to 0.075 mm		
Sand	0.075 to 4.75 mm	fine	0.075 to 4.25 mm
		medium	0.425 to 2.0 mm
		coarse	2.0 to 4.75 mm
Gravel	4.75 to 75 mm	fine	4.75 to 19 mm
		coarse	19 to 75 mm
Cobbles	75 to 300 mm		
Boulders	>300 mm		

Terminology	
"trace"	1-10%
"some"	10-20%
adjective (silty, sandy)	20-35%
"and"	35-50%

Relative density of granular soils	Standard penetration index "N" value (BLOWS/ft – 300 mm)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Consistency of cohesive soils	Undrained shear strength (Cu)	
	(P.S.F)	(kPa)
Very soft	<250	<12
Soft	250-500	12-25
Firm	500-1000	25-50
Stiff	1000-2000	50-100
Very stiff	2000-4000	100-200
Hard	>4000	>200

Rock quality designation	
"RQD" (%) Value	Quality
<25	Very poor
25-50	Poor
50-75	Fair
75-90	Good
>90	Excellent

STRATIGRAPHIC LEGEND			
Sand	Gravel	Cobbles & boulders	Bedrock
Silt	Clay	Organic soil	Fill

Samples:

Type and Number

The type of sample recovered is shown on the log by the abbreviation listed hereafter. The numbering of samples is sequential for each type of sample.

SS: Split spoon

ST: Shelby tube

AG: Auger

SSE, GSE, AGE: Environmental sampling

PS: Piston sample (Osterberg)

RC: Rock core

GS: Grab sample

Recovery

The recovery, shown as a percentage, is the ratio of length of the sample obtained to the distance the sampler was driven/pushed into the soil

RQD

The "Rock Quality Designation" or "RQD" value, expressed as percentage, is the ratio of the total length of all core fragments of 4 inches (10 cm) or more to the total length of the run.

IN-SITU TESTS:

N: Standard penetration index

N_c: Dynamic cone penetration index

k: Permeability

R: Refusal to penetration

Cu: Undrained shear strength

ABS: Absorption (Packer test)

Pr: Pressure meter

LABORATORY TESTS:

I_p: Plasticity index

H: Hydrometer analysis

A: Atterberg limits

C: Consolidation

O.V.: Organic vapor

W_l: Liquid limit

GSA: Grain size analysis

w: Water content

CS: Swedish fall cone

W_p: Plastic limit

γ: Unit weight

CHEM: Chemical analysis

BOREHOLE No.: BH1

ELEVATION: 95.39 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 15, 2020

DATE (FINISH): January 15, 2020

LEGEND

- | | | |
|---|----|--|
|  | SS | Split Spoon |
|  | GS | Auger Sample |
|  | ST | Shelby Tube |
|  | | Water Level |
|  | | Water content (%) |
|  | | Atterberg limits (%) |
|  | N | Penetration Index based on Split Spoon sample |
|  | N | Penetration Index based on Dynamic Cone sample |
|  | Cu | Shear Strength based on Field Vane |
|  | Cu | Shear Strength based on Lab Vane |
|  | S | Sensitivity Value of Soil |
|  | | Shear Strength based on Pocket Penetrometer |

SCALE		STRATIGRAPHY		MONITOR WELL	SAMPLE DATA																
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK			State	Type and Number	Recovery	OVC	Penetration Index / RQD											
meters	95.39		GROUND SURFACE					%	ppm	N	SCALE FOR TEST RESULTS										
				1.05 —	1.01 —						50kPa	100kPa	150kPa	200kPa	30	40	50	60	70	80	90
0.5	95.1 94.9		TOPSOIL, Silty SAND trace of clay, brown, presence rootlets, frozen 0.1m, becoming unfrozen, moist, loose to compact	0.30 —	Bentonite		SS1	56	0.1	10	●										
1.0			FILL, Gravelly SAND with some silt, grey, moist, loose to compact	0.50 —			RC2	100		94											
1.5			LIMESTONE, grey with dark grey bands, fresh, excellent quality																		
2.0				Sand	2" non slotted PVC pipe		RC3	100		100											
2.5																					
3.0				3.00 —	Bentonite		RC4	99		97											
3.5				WL 3.55	1/23/20 8:00am																
4.0			4.19 m, becoming good quality	3.60	3.80																
4.5																					
5.0				2" slotted PVC pipe			RC5	99		86											
5.5				Sand																	
6.0							RC6	100		83											
6.5																					
7.0	88.6			6.80 —																	
7.5																					

● N Penetration Index based on Split Spoon sample

• N Penetration Index based on Dynamic Cone sample

△ Cu Shear Strength based on Field Vane

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on Pocket Penetrometer

NOTES:

NOTES:
Elevations are based on an assigned benchmark, Auger refusal at 0.55 m

BOREHOLE LOG 11206675 BORE LOGS.GPJ INSPEC SOL.GDT 2/10/20



BOREHOLE No.: BH2
ELEVATION: 97.99 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 9, 2020

DATE (FINISH): January 9, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- Penetration Index based on Split Spoon sample
- Penetration Index based on Dynamic Cone sample
- Shear Strength based on Field Vane
- Shear Strength based on Lab Vane
- Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		MONITOR WELL	SAMPLE DATA			
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK		Type and Number	Recovery	OVC	Penetration Index / RQD
meters	97.99		GROUND SURFACE			%	ppm	N
97.9	97.8		ASPHALT	1.00 — 0.96 —	SS1	100	0.0	R
0.5			FILL, Silty SAND with some gravel, grey, moist, very dense	0.30 — Bentonite 0.50 —	RC1	88		20
1.0			LIMESTONE, grey with dark grey bands, fresh, fractured in zones, very poor quality		RC2	100		100
1.5			0.72m, becoming excellent quality, without fractured zones	2" non slotted PVC pipe Sand				
2.0				2.00 —	RC3	100		99
2.5			2.3m, 2 cm zone of crushed rock with clay infill	Bentonite				
3.0				3.00 — WL 3.06 1/23/20 9:50 3.30 —	RC4	100		100
3.5								
4.0								
4.5			4.22m, becoming good quality	2" slotted PVC pipe Sand	RC5	95		83
5.0								
5.5								
6.0			5.69m, becoming excellent quality		RC6	100		100
6.5	91.7			6.30 —				
7.0								
7.5								

NOTES:

Elevations are based on an assigned benchmark



BOREHOLE No.: BH3
ELEVATION: 93.66 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 15, 2020

DATE (FINISH): January 15, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- △ Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- ▲ Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY			SAMPLE DATA			
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	93.66		GROUND SURFACE			%	ppm	N
0.5	93.6		TOPSOIL, Silty SAND, brown, presence organics, frozen FILL, Gravelly Silty SAND, grey, moist compact		SS1	77	0.1	26
1.0	92.7		LIMESTONE, grey with dark grey bands, fresh, abundantly fractured, very poor quality		SS2	60	0	R
1.5			1.16m, becoming good quality		RC3	100		0
2.0			1.35m, bedrock no longer abundantly fractured					
2.5			1.45m, joint at approx 45° to core axis, planar, rough and no infill		RC4	100		81
3.0								
3.5					RC5	100		88
4.0								
4.5			4.16m, becoming excellent quality					
5.0					RC6	97		97
5.5								
6.0								
6.5					RC7	100		92
7.0								
7.5	86.4							

NOTES:

Elev ations are based on an assigned benchmark, Auger refusal at 0.96 m



BOREHOLE No.: BH4

ELEVATION: 96.54 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 9, 2020

DATE (FINISH): January 9, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- Penetration Index based on Split Spoon sample
- Penetration Index based on Dynamic Cone sample
- Shear Strength based on Field Vane
- Shear Strength based on Lab Vane
- Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		MONITOR WELL	SAMPLE DATA				SCALE FOR TEST RESULTS									
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK		Type and Number	Recovery	OVC	Penetration Index / RQD										
meters	96.54		GROUND SURFACE			%	ppm	N										
0.5	96.5		TOPSOIL, sandy silt, presence abundant organics and rootlets, brown, frozen	Bentonite 0.30	SS1	40	0.1	R										
1.0	95.5		FILL, Gravelly Silty SAND, brown, presence brick and glass fragments, moist, compact	2" non slotted PVC pipe Sand 1.00	SS2	84	0	16										
1.5	95.2		Clayey SILT, traces of sand, brown, low plasticity, grey, moist, stiff	Bentonite	SS3	46	0	R										
2.0	94.9		Clayey SAND, brown, moist compact	1.60 1.70														
2.5			Cobbles and Boulders (TILL) with some gravel, sand, silt and clay, boulders up to a minimum 0.45 m diameter	2" slotted PVC pipe Sand	RC4	62												
3.0				WL 2.78 1/22/20 9:30														
3.5	93.3		LIMESTONE, grey with dark grey bands, fresh, excellent quality	3.20	RC5	100		100										
4.0					RC6	100		94										
4.5					RC7	100		100										
5.0																		
5.5																		
6.0	90.5																	
6.5																		
7.0																		
7.5																		

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 1.7 m



BOREHOLE No.: BH5
ELEVATION: 95.66 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 10, 2020

DATE (FINISH): January 10, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- ▼ Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- △ Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- ▲ Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		MONITOR WELL	SAMPLE DATA																	
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK		State	Type and Number	Recovery	OVC	Penetration Index / RQD													
meters	95.66		GROUND SURFACE				%	ppm	N	SCALE FOR TEST RESULTS												
										50kPa	100kPa	150kPa	200kPa	30	40	50	60	70	80	90		
0.5	95.6		TOPSOIL, Silty SAND with some gravel, trace of clay, brown, presence rootlets, frozen	1.05 — 1.01 —																		
			FILL, Clayey sand, presence cobbles boulders, brown, presence organics, moist, compact, presence organic/septic odour	0.30 — Bentonite 2" non slotted PVC pipe 1.00 — 1.20 —		SS1	36	0.1	32													
1.0						SS2	28	0.1	R													
1.5	94.1		Silty SAND, dark brown, presence organics and rootlets, moist, loose to compact																			
2.0	93.7		Clayey SILT with some sand, grey to brown, low plasticity, moist to wet, compact			SS3	92	0	10													
2.5	93.3		2.29m, becoming sandy clay																			
			Silty SAND (TILL), trace of clay and gravel, grey, moist to wet, dense	WL 2.51 — 1/22/20 9:40 Sand 2" slotted PVC pipe		SS4	64	0	39													
3.0			2.8m, becoming with a presence cobbles / boulders																			
4.0						SS5	20		R													
4.5	91.5		LIMESTONE, grey with dark grey bands, fresh, excellent quality	4.20 —																		
5.0						RC6	100		97													
5.5			5.66m, becoming fair quality																			
6.0																						
6.5			6.30 - 6.90m, multiple bedding partings perpendicular to core axis, generally tight, thin clay veneer on defect faces.			RC7	100		60													
7.0																						
7.5	88.5																					

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 1.1 m



BOREHOLE No.: BH6

ELEVATION: 96.04 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 10, 2020

DATE (FINISH): January 10, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- △ Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- ▲ Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY			SAMPLE DATA																
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD													
meters	96.04		GROUND SURFACE			%	ppm	N	SCALE FOR TEST RESULTS												
									50kPa	100kPa	150kPa	200kPa	10	20	30	40	50	60	70	80	90
0.5			FILL, Sandy SILT, brown, presence organics, rootlets rubber, boulders and cobbles, moist, loose to compact		SS1	63	0.2	R													
1.0			0.76m becoming, SAND with some clay		SS2	21	0	23													
1.5			1.5m, presence rubber		SS3	41	0.1	7													
2.0																					
2.5	93.8		SILT & SAND (TILL), with some gravel, grey with brown mottles, moist, very dense		SS4	94		R													
2.5	93.4																				
3.0																					
3.5																					
4.0																					
4.5																					
5.0																					
5.5																					
6.0																					
6.5																					
7.0																					
7.5																					

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 2.64 m



BOREHOLE No.: BH7

ELEVATION: 94.93 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 14, 2020

DATE (FINISH): January 14, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- Penetration Index based on Split Spoon sample
- Penetration Index based on Dynamic Cone sample
- Shear Strength based on Field Vane
- Shear Strength based on Lab Vane
- Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY			SAMPLE DATA																	
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD														
meters	94.93		GROUND SURFACE			%	ppm	N	SCALE FOR TEST RESULTS													
									50kPa	100kPa	150kPa	200kPa	10	20	30	40	50	60	70	80	90	
0.5			FILL, Silty SAND, with some gravel, presence organics, brown to grey, frozen 0.1m, becoming not frozen, moist to wet, dense 0.51m, presence boulders/cobbles		SS1	65	0.2	42														
1.0			1.22m to 2.9m, one large continuous limestone boulder																			
1.5																						
2.0																						
2.5																						
3.0	92.0		Sandy SILT (TILL), with some gravel, trace of clay, brown, presence cobbles up to 0.36m diameter, wet compact,		SS2	91	0	13														
3.5																						
4.0																						
4.5				4.34m, becoming very dense		SS3	50	0	70													
4.5			4.6m, becoming grey																			
5.0																						
5.5																						
6.0	89.1																					
6.5																						
7.0																						
7.5																						

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 1.22 m



BOREHOLE No.: BH8
ELEVATION: 94.40 m

BOREHOLE LOG

Page: 1 of 1CLIENT: Le Groupe MauricePROJECT: 211 Centrum Boulevard, OrleansLOCATION: 211 Centrum Boulevard, OrleansDESCRIBED BY: D.Cooper

CHECKED BY: _____

DATE (START): January 13, 2020DATE (FINISH): January 13, 2020

LEGEND

- SS Split Spoon
- GS Auger Sample
- ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- Penetration Index based on Split Spoon sample
- Penetration Index based on Dynamic Cone sample
- Shear Strength based on Field Vane
- Shear Strength based on Lab Vane
- Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		MONITOR WELL	SAMPLE DATA				SCALE FOR TEST RESULTS									
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK		Type and Number	Recovery	OVC	Penetration Index / RQD										
meters	94.40		GROUND SURFACE			%	ppm	N										
0.5	94.4		TOPSOIL, silty sand, presence rootlets and organics, brown, frozen	Bentonite 0.30	SS1	66	0.0	13	●									
1.0	93.5		FILL, Silty SAND with some gravel, trace of clay, presence organics, brown, frozen 0.1m, becoming unfrozen, moist, loose to compact	2" non slotted PVC pipe Sand Bentonite	SS2	60	0.1	7	●									
1.5	92.9		Clayey SAND, possible fill, brown, moist, loose	1.30														
2.0	92.5		Silty CLAY, grey, moist, stiff	1.50	SS3	98	0.0	12	●									>>4
2.5			SILT & SAND (TILL), with some gravel, grey, moist to wet, compact	WL 1.70 11:30														
3.0					SS4	66	0.0	29	●									
3.5			3.05-3.60, presence cobbles/boulders. trace of clay, grey	Sand 2" slotted PVC pipe	SS5	34	0.0	R										
4.0					SS6	33	0.0	23	●									
4.5				4.50	SS7	16	0.0	29	●									
5.0																		
5.5			5.28m, becoming loose		SS8	30	0.0	5	●									
6.0	88.4		LIMESTONE, grey with dark grey bands, fresh, excellent quality															
6.5																		
7.0					RC9	100		100										
7.5	86.9																	

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 5.97 m



BOREHOLE No.: BH9
ELEVATION: 92.74 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

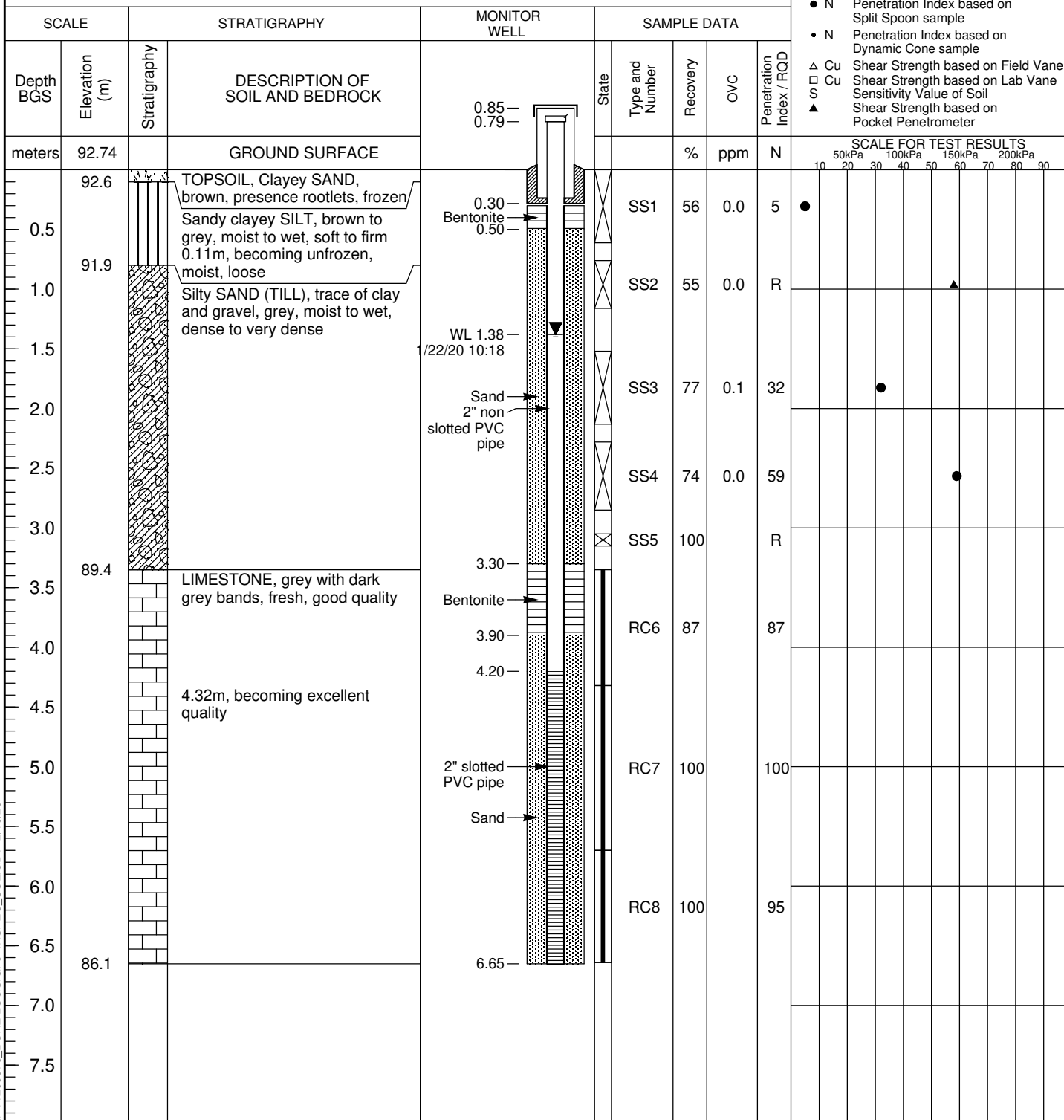
CHECKED BY:

DATE (START): January 14, 2020

DATE (FINISH): January 14, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- ▼ Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- △ Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- ▲ Shear Strength based on Pocket Penetrometer



NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 3.15 m



BOREHOLE No.: BH10

ELEVATION: 92.39 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 14, 2020

DATE (FINISH): January 14, 2020

LEGEND

- ☒ SS Split Spoon
- ☒ GS Auger Sample
- ☒ ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- Penetration Index based on Split Spoon sample
- Penetration Index based on Dynamic Cone sample
- Shear Strength based on Field Vane
- Shear Strength based on Lab Vane
- Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY			SAMPLE DATA			
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	92.39		GROUND SURFACE			%	ppm	N
0.5	92.3		TOPSOIL, Silty SAND, brown, presence, organics and rootlets, frozen		SS1	61	0.1	20
	91.8		FILL, Silty SAND, with some gravel, trace of clay, presence organics, moist and compact					
1.0	91.4		Silty SAND, brown, moist, compact					
1.5			Sandy SILT (TILL), trace of gravel and clay, moist and compact		SS2	95	0.1	10
2.0			1.25m, becoming wet		SS3	33	0.0	25
2.5					SS4	45	0.1	R
2.7	89.7							
3.0								
3.5								
4.0								
4.5								
5.0								
5.5								
6.0								
6.5								
7.0								
7.5								

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 2.7 m



BOREHOLE No.: BH11

ELEVATION: 91.86 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 13, 2020

DATE (FINISH): January 13, 2020

LEGEND

- SS Split Spoon
- GS Auger Sample
- ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- Penetration Index based on Split Spoon sample
- Penetration Index based on Dynamic Cone sample
- Shear Strength based on Field Vane
- Shear Strength based on Lab Vane
- Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		MONITOR WELL	SAMPLE DATA			
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK		Type and Number	Recovery	OVC	Penetration Index / RQD
meters	91.86		GROUND SURFACE			%	ppm	N
0.5			FILL, Clayey sandy SILT, trace of gravel, grey, frozen 0.1m, becoming moist to wet, loose to compact	0.90 — 0.82 — Bentonite 2" non slotted PVC pipe 0.30 — 1.00 — WL 1.20 — 1/22/20 12:20	SS1	74	0.0	10
1.0					SS2	57	0.0	10
1.5					SS3	43	0.0	10
2.0	90.2		Silty CLAY trace of sand, high plasticity, grey, moist, stiff to very stiff		VA1			
2.5					SS4	100	0.0	2
3.0					VA2			
3.5								
4.0								
4.5	87.3		LIMESTONE, grey with dark grey bands, fresh, excellent quality					
5.0								
5.5					RC5	100		98
6.0	85.8							
6.5								
7.0								
7.5								

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 4.6 m



BOREHOLE No.: BH12
ELEVATION: 95.66 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Le Groupe Maurice

PROJECT: 211 Centrum Boulevard, Orleans

LOCATION: 211 Centrum Boulevard, Orleans

DESCRIBED BY: D.Cooper

CHECKED BY:

DATE (START): January 15, 2020

DATE (FINISH): January 15, 2020

LEGEND

- ☒ SS Split Spoon
- GS Auger Sample
- ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- Penetration Index based on Split Spoon sample
- Penetration Index based on Dynamic Cone sample
- Shear Strength based on Field Vane
- Shear Strength based on Lab Vane
- Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		MONITOR WELL	SAMPLE DATA				SCALE FOR TEST RESULTS									
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK		Type and Number	Recovery	OVC	Penetration Index / RQD										
meters	95.66		GROUND SURFACE			%	ppm	N										
0.5	95.5		TOPSOIL, Silty SAND, brown, presence rootlets & organics, frozen	0.36	SS1	59	0.4	29										
1.0	95.1		FILL, Silty SAND with some gravel, grey, dry to moist, compact, faint odour (hydrocarbon?)	2" non slotted PVC Bentonite 1.00 WL 1.00 1/22/20 8:45	RC2	87		78										
1.5			LIMESTONE, grey with dark grey bands, fresh, good quality		RC3	100		93										
2.0			1.45m, becoming excellent quality		RC4	100		97										
2.5																		
3.0																		
3.5																		
4.0																		
4.5	91.2																	
5.0																		
5.5																		
6.0																		
6.5																		
7.0																		
7.5																		

NOTES:

Elevations are based on an assigned benchmark, Auger refusal at 0.51 m

BH/MW01 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW01 – Core Photographs

Scale | NA

Date | 7 Feb 20202

Job No.	11206675
File ref.	-
Rev. No.	Rev 0

BH/MW02 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW02 – Core Photographs

Scale | NA Date | 7 Feb 2020

Job No.	11206675
File ref.	-
Rev. No.	Rev 0

BH03 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW03 – Core Photographs

Scale | NA

Date | 7 Feb 2020

Job No. | 11206675

File ref. | -

Rev. No. | Rev 0

BH/MW04 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW04 – Core Photographs

Scale | NA

Date | 7 Feb 2020

Job No.	11206675
File ref.	-
Rev. No.	Rev 0

BH/MW05 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW05 – Core Photographs

Scale | NA

Date | 7 Feb 2020

Job No. | 11206675

File ref. | -

Rev. No. | Rev 0

BH/MW08 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW08 – Core Photographs

Scale | NA

Date | 7 Feb 2020

Job No.	11206675
File ref.	-
Rev. No.	Rev 0

BH/MW09 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW09 – Core Photographs

Scale | NA

Date | 7 Feb 2020

Job No. | 11206675

File ref. | -

Rev. No. | Rev 0

BH/MW11 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW11 – Core Photographs

Scale | NA Date | 7 Feb 2020

Job No.	11206675
File ref.	-
Rev. No.	Rev 0

BH/MW12 Core Photographs



CLIENTS | PEOPLE | PERFORMANCE
GHD

Le Groupe Maurice
211 Centrum Boulevard
BH/MW12 – Core Photographs

Scale | NA

Date | 7 Feb 2020

Job No. | 11206675

File ref. | -

Rev. No. | Rev 0



TEST PIT No.: TP-01
ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

← Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL(150 mm)			
0.5			CLAYEY SILTY SAND possible fill, cobbles, organics, brown, damp			
1.0			Test pit terminated at 0.7 mbgs on bedrock / boulders			
1.5						
2.0						
2.5						
3.0						
3.5						
4.0						
4.5						

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-02

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

┌─┐ Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL(125 mm)			
			CLAYEY SILTY SAND possible fill, cobbles, organics, brown, damp			
0.5						
			Test pit terminated at 0.6 mbgs on bedrock / boulders			
1.0						
1.5						
2.0						
2.5						
3.0						
3.5						
4.0						
4.5						

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-03

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

├─┤ Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL(125 mm)			
			FILL, CLAYEY SILTY SAND possible fill, organics, cobbles, brown, damp			
0.5			FILL, CLAYEY SAND cobbles/boulders, organics, brown, damp to moist			
1.0						
1.5						
2.0						
2.5			CLAYEY SAND (TILL) cobbles/boulders, organics, grey, damp to moist			
3.0			Test pit terminated at 3.0 mbgs on bedrock / boulders			
3.5						
4.0						
4.5						

SCALE FOR TEST RESULTS
50kPa 100kPa 150kPa 200kPa
10 20 30 40 50 60 70 80 90

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-04

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

├─┤ Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
0.5			FILL (BEDROCK BLOCKS)			
1.0			FILL - Clayey sand, cobbles/boulders, organics, brown, damp			
1.5						
2.0						
2.5			CLAYEY SAND (TILL) cobbles/boulders, organics, brown and grey, damp to moist			
3.0						
3.5			Test pit terminated at 3.4 mbgs on bedrock / boulders			
4.0						
4.5						

NOTES:
mbgs: meters below ground surface



TEST PIT No.: TP-05

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample (environmental)

GS Grab Sample (Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

├─┤ Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL (125 mm)			
			FILL / REWORKED CLAYEY SAND Organics, cobbles/boulders, brown, damp to moist			
0.5						
1.0						
1.5			CLAYEY SAND (TILL) cobbles/boulders, grey, damp to moist			
2.0						
2.5						
3.0						
3.5			Test pit terminated at 3.4 mbgs on bedrock / boulders			
4.0						
4.5						

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-06

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

← Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL(150 mm)			
			SILTY CLAY- brown and grey, damp to moist			
0.5						
1.0						
1.5						
2.0						
2.5						
3.0						
3.5						
4.0						
4.5						
			Test pit terminated at 3.0 mbgs on bedrock / boulders			

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-07

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

← Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL(125 mm)			
			FILL, CLAYEY SAND possible fill, organics, brown, damp			
0.5						
			TILL, CLAYEY SAND presence cobbles/boulders, grey, damp, moist,			
1.0						
			becoming brown			
1.5						
2.0			Test pit terminated at 2.1 mbgs on bedrock / boulders			
2.5						
3.0						
3.5						
4.0						
4.5						

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-08

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

┌─┐ Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL (220 mm)			
0.5			CLAYEY SAND (TILL) } organics, cobbles/boulders, brown, damp to moist			
1.0						
1.5						
2.0						
2.5						
3.0			Test pit terminated at 3.0 mbgs on bedrock / boulders			
3.5						
4.0						
4.5						

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-09

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

┌─┐ Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL (125 mm)			
0.5			CLAYEY SAND (TILL) organics, cobbles/boulders, brown, damp to moist			
1.0						
1.5						
2.0						
2.5			becoming grey			
3.0						
3.5			Test pit terminated at 3.2 mbgs on bedrock / boulders			
4.0						
4.5						

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

NOTES:

mbgs: meters below ground surface



TEST PIT No.: TP-10

ELEVATION: _____

TEST PIT LOG

Page: 1 of 1

CLIENT: Groupe Maurice

PROJECT: Geotechnical Investigation

LOCATION: 211 Centrum Boulevard

DESCRIBED BY: RVT

CHECKED BY: _____

DATE (START): December 15, 2019

DATE (FINISH): December 15, 2019

LEGEND

GSE Grab Sample
(environmental)GS Grab Sample
(Geotechnical)

CHEM Chemical Analysis

▼ Water Level

○ Water content (%)

← Atterberg limits (%)

□ Cu Shear Strength based on Lab Vane

S Sensitivity Value of Soil

▲ Shear Strength based on
Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA		
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Test Type	OVC
meters			GROUND SURFACE			ppm
			TOPSOIL (100 mm)			
			CLAYEY SAND- possible fill, organics, cobbles, brown, damp to moist			
0.5						
1.0						
			Test pit terminated at 1.0 mbgs on bedrock / boulders			
1.5						
2.0						
2.5						
3.0						
3.5						
4.0						
4.5						

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

NOTES:

mbgs: meters below ground surface

Appendix B

MASW Investigation Seismic Site Classification Report



MASW Investigation Seismic Site Classification

Residential, Service and Leisure Complex
211 Centrum Boulevard, Orleans,
Ottawa, Ontario

Le Groupe Maurice

Draft for Review

This document is in draft form. A final version of this document may differ from this draft. As such, the contents of this draft document shall not be relied upon. GHD disclaims any responsibility or liability arising from decisions made based on this draft document.

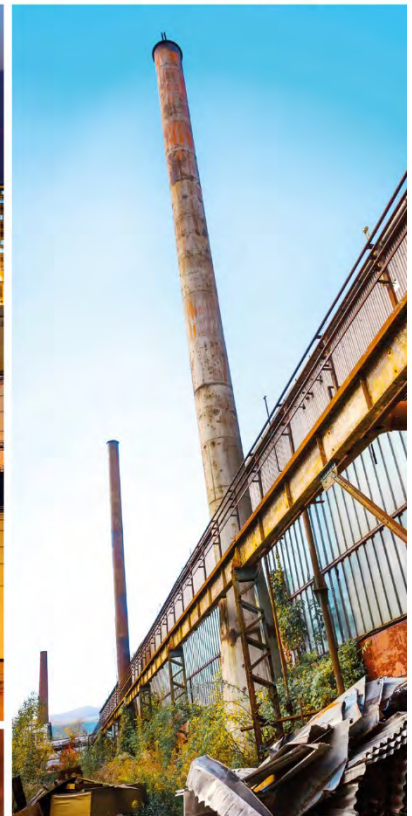




Table of Contents

1.	Introduction.....	1
2.	MASW Procedure.....	1
3.	Fieldwork	2
4.	Data Interpretation.....	3
5.	Closure	4

Figure Index

Figure 1	Site Location Map
Figure 2	MASW Survey Investigation Lines Layout
Figure 3	Shear wave velocity vs depth

Table Index

Table 1	Summary of Shear wave velocity measurements
Table 2	Site Classification for Seismic Site Response – Table 4.1.8.4 OBC 2012

Appendix Index

Appendix A	Seismic Hazard Values
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1. Introduction

GHD was retained by Le Groupe Maurice (Client) to conduct a Multichannel Analysis of Surface Waves (MASW) investigation for the proposed residential, service and leisure complex located at 211 Centrum Boulevard, Orleans, Ontario (Site). A site location map is provided on Figure 1.

Based on the information received, the project includes demolition of the existing two-story parking garage structure, retention of the existing commercial structure and construction of a new retirement home complex. Based on the concept drawings and information provided by the client, it is understood that the proposed structure comprises of an interconnected residential, service and leisure complex with two structures up to 16 stories (primarily residences) and two structures up to four stories high (leisure and service) and one level of underground parking. Additional associated development comprises surface parking, an undercover drop off area, internal access roads and landscaped areas.

It is our understanding that the proposed development is located centrally on the site and our scope is based upon the provided concept designs. The total area of the site including structures car parking, access roads and landscaped areas is approximately 1.7 hectares (ha).

The purpose of the MASW survey was to assist with the seismic site class determination by measuring the average shear wave velocity approximately within the upper 30 m of the soil/rock profile below the founding elevation of the proposed structures at the site. The shear wave velocity measurements were carried out along two MASW survey lines assumed to be representative of the Site. The investigation line locations are shown in the attached Figure 2.

Based on the available field borehole logs from ongoing geotechnical investigation by GHD (boreholes locations are shown in Figure 2), the Site in general consists of loose to compact fill material consisting of silty sand, sandy silt and clayey sand. The thickness of fill varies between 0.2 m to around 3.0 m. The fill is underlain by a silty sand with some gravel deposit which is underlain by bedrock. The thickness the silty sand layer was reported between almost 0 in boreholes located at south of the site (near the Line 1) to around 3 m in boreholes located at middle and north of the site (near to Line 2). The SPT 'N' values indicate the compact to dense consistency of the deposit. A soft to stiff silty clay was also reported in BHMW-11 at east north of the site. The maximum bedrock depth was reported less than 6 m in BH-7.

2. MASW Procedure

To carry out the MASW test, 24 transducers (geophones) are deployed along a line at certain distances from a seismic source. The length of the geophone array determines the deepest investigation depth that can be obtained from the measurements. The source should produce enough seismic energy over the desired test frequency range to allow for detection of Rayleigh waves above background noise (Park et al., 1999¹). A common seismic source is either a sledgehammer or a drop weight hitting a metallic or rubber base plate set at ground surface. The

¹ Park, C. B., Miller, R. D., & Xia, J. (1999). Multichannel analysis of surface waves. *Geophysics*, 64(3), 800-808.

existing traffic noise or the noise generated by heavy machinery travelling close to the survey line can also be utilized as a source for investigating deep soil layers. For this site, only active seismic source is used. Figure 2.1 shows a typical MASW setup.

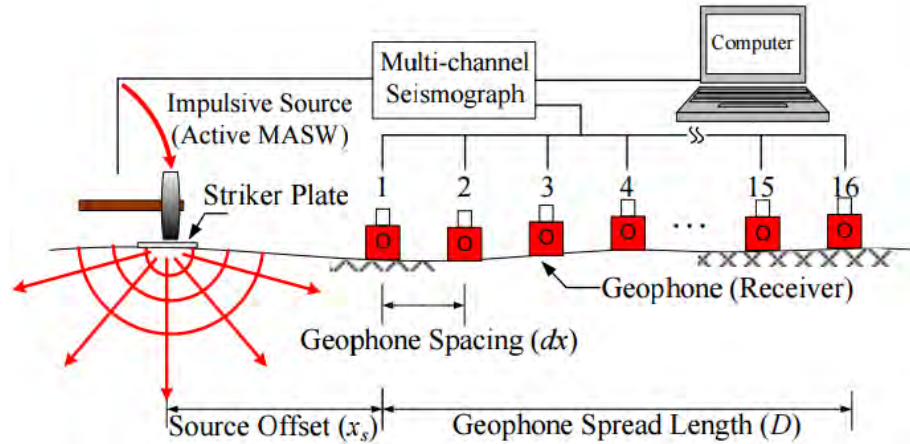


Figure 2.1: Schematic Layout of MASW Test Setup (Sahadewa et al., 2012²)

3. Fieldwork

The fieldwork for this MASW investigation program was carried out on January 28, 2020 by GHD professionals. The field data was collected using a 24 channel seismograph (Geometrics Geode 24 consol #3389), twenty-four 4.5 Hz geophones, and one 24 take-out cable with 5 m spacing. A Panasonic Toughbook® laptop was used in the field to record and collect the seismic data utilizing Geometrics single geode OS controller version 9.14.0.0.

The survey was carried out along two survey lines along the North-South and East-West directions in the vicinity of boreholes and monitoring wells as shown on Figure 2. For all line locations, the geophones were installed 75 mm into the ground by manually pushing them into position.

A multi geometry approach was utilized for data collection along both lines. The active data sets were collected using a 4.5 kg sledge hammer hitting the ground surface at three different offset distances (distance between the source and first geophone) along each survey line. The following table summarizes the geometry for each investigation line.

MASW Line Geometry

Line No.	Designation	Geophone Spacing (m)	Array Length (m)	Offset Distances (m)
Line 1	Long	2.0	46.0	30.0, 20.0, 10.0
Line 1	Short	1.0	23.0	15.0, 10.0, 5.0
Line 2	Long	2.0	46.0	30.0, 20.0, 10.0

² Sahadewa, A., Zekkos, D., & Woods, R. D. (2012). Observations from the implementation of a combined active and passive surface wave based methodology. In GeoCongress 2012: State of the Art and Practice in Geotechnical Engineering (pp. 2786-2795).

Four sets of data files (active) were collected for each array location/set up. For the active survey measurements, the ground vibrations were recorded for four seconds with one sample per 0.25 ms.

4. Data Interpretation

MASW method utilize the frequency-dependent properties of Rayleigh surface waves in order to develop the profile of shear wave velocity versus with depth. This method includes three stages as shown in Figure 4.1. In this project, generation of dispersion curves, inversion of the obtained dispersion curves and development of the 1D shear wave velocity profiles were carried out using SurfSeis© version 6.0. The dispersion curves were calculated at the middle stations along each line. At each investigation line, the dispersion images obtained from active data at different offsets were stacked to obtain a combined dispersion curve. The data inversion was carried out using a 10-layer soil velocity numerical model to obtain 1D shear wave velocity profiles at the location of each mid station. The calculated 1D velocity profile along the investigation lines are shown on the attached Shear Wave Velocity Profile. Figure 3 shows the obtained results at the proposed location for the construction of the building. As can be seen in this figure, lower values of shear wave velocity for Line 2 was obtained. This is mainly due to presence of around 5m thick compact to dense layer observed at north part of the site. At the south, bedrock was reported near the ground surface (see Section 1).

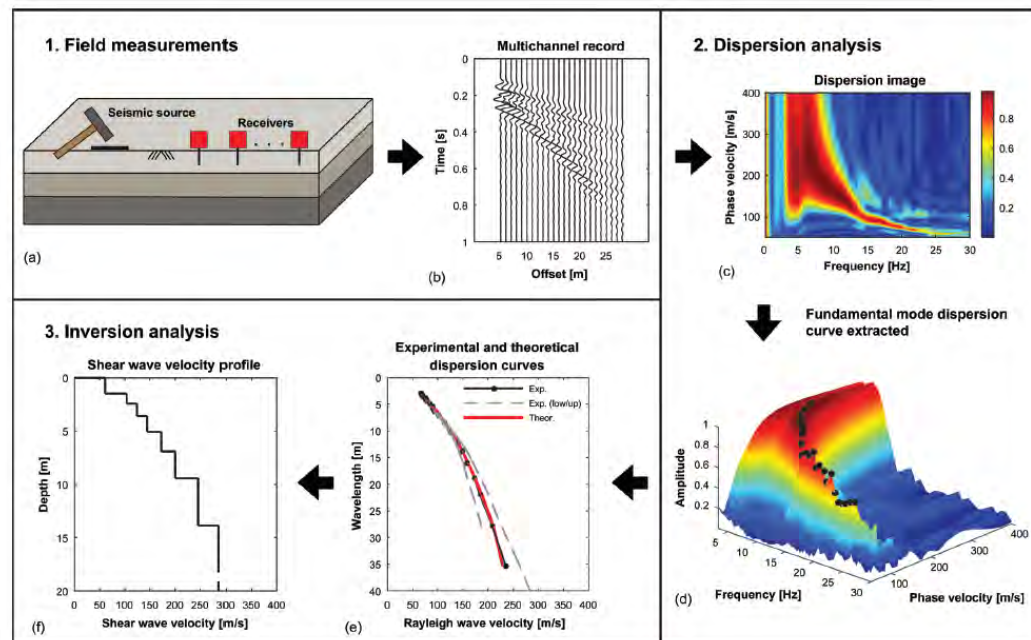


Figure 4.1: Overview of MASW method (Olafsdottir et al., 2018³)

³ Olafsdottir, E. A., Erlingsson, S., & Bessason, B. (2018). Tool for analysis of multichannel analysis of surface waves (MASW) field data and evaluation of shear wave velocity profiles of soils. *Canadian Geotechnical Journal*, 55(2), 217-233.



In accordance with the requirements of Ontario Building Code (OBC 2012) and National Building Code of Canada 2015 (NBC 2015), the variation of the measured shear wave velocity versus depth up to 30 m below the proposed founding level of the building (assumed to be 3.0 m bgs for this project) was obtained along each line and is shown on Tables 1-A and 1-B. The average shear wave velocity within the upper 30 m of the soil/rock profile (V_{s30}) immediately below the founding level of the building (at 3.0 m bgs) were obtained utilizing the averaging scheme introduced in Sentence 4.1.8.4 (2) of Commentary J of NBC (2010) User's Guide.

Based on the calculations presented in the Table 1, the lowest average shear wave velocity (from 3.0 m bgs to 33.0 m bgs) along the investigation line is 1004 m/s (along Line 2). Therefore, in accordance Table 4.1.8.4.A of OBC 2012 (Table 2) and based on the measured shear wave velocity, for seismic load calculations the Site can be classified as Class 'B'.

As per OBC 2012, Site Classes A and B are not to be used if there is more than 3 m of softer materials between the rock and the underside of footing. In this condition, the Site Class 'C' shall be considered for design purpose in this site.

It is noteworthy that based on interpretation results of collected data, Site Class 'A' may also be achievable subject to additional investigation.

The seismic site classification provided in this report is based solely on the shear wave velocity values derived from the MASW method and that it can be superseded by other geotechnical information as per requirement from NBC (2010).

The seismic hazards for the site as obtained from Natural Resources Canada (NRC) website are provided as Appendix A to this correspondence.

5. Closure

It is important to emphasize that the results and conclusions of the MASW analysis are based on the available geotechnical information and the survey conducted along two investigation lines. Should any conditions at the Site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations.

All of Which is Respectfully Submitted,

GHD

DRAFT

Ali Ghassemi, Ph.D.

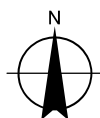
DRAFT

Farsheed Bagheri, P. Eng.



Paper Size ANSI A
0 70 140 210 280
Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 18N

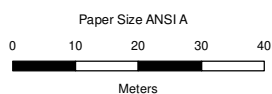
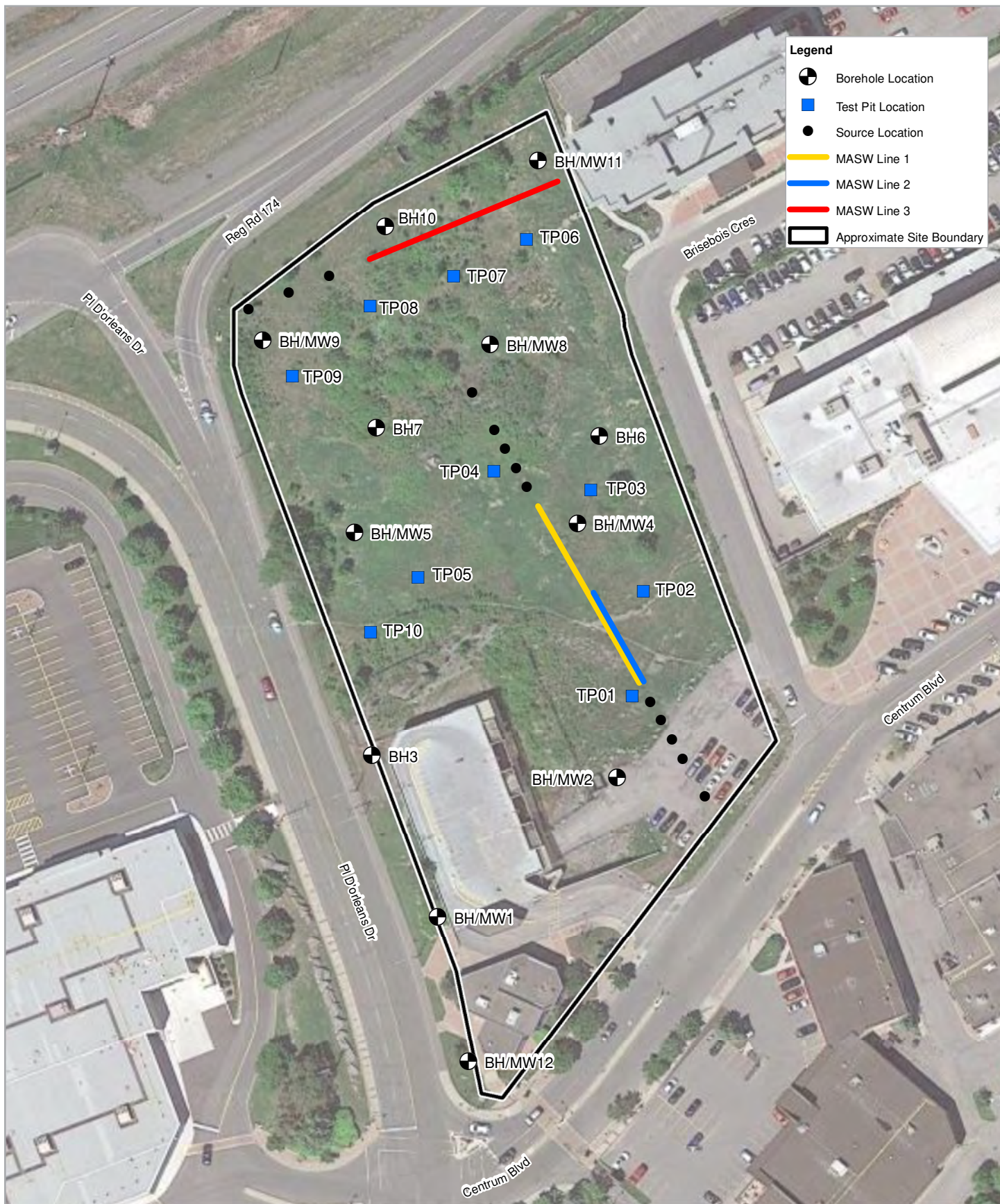


LE GROUPE MAURICE
211 CENTRUM BOULEVARD, OTTAWA, ONTARIO
GEOTECHNICAL INVESTIGATION

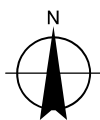
Project No. 11206675
Revision No. -
Date Dec 16, 2019

SITE LOCATION MAP

FIGURE 1



Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 18N

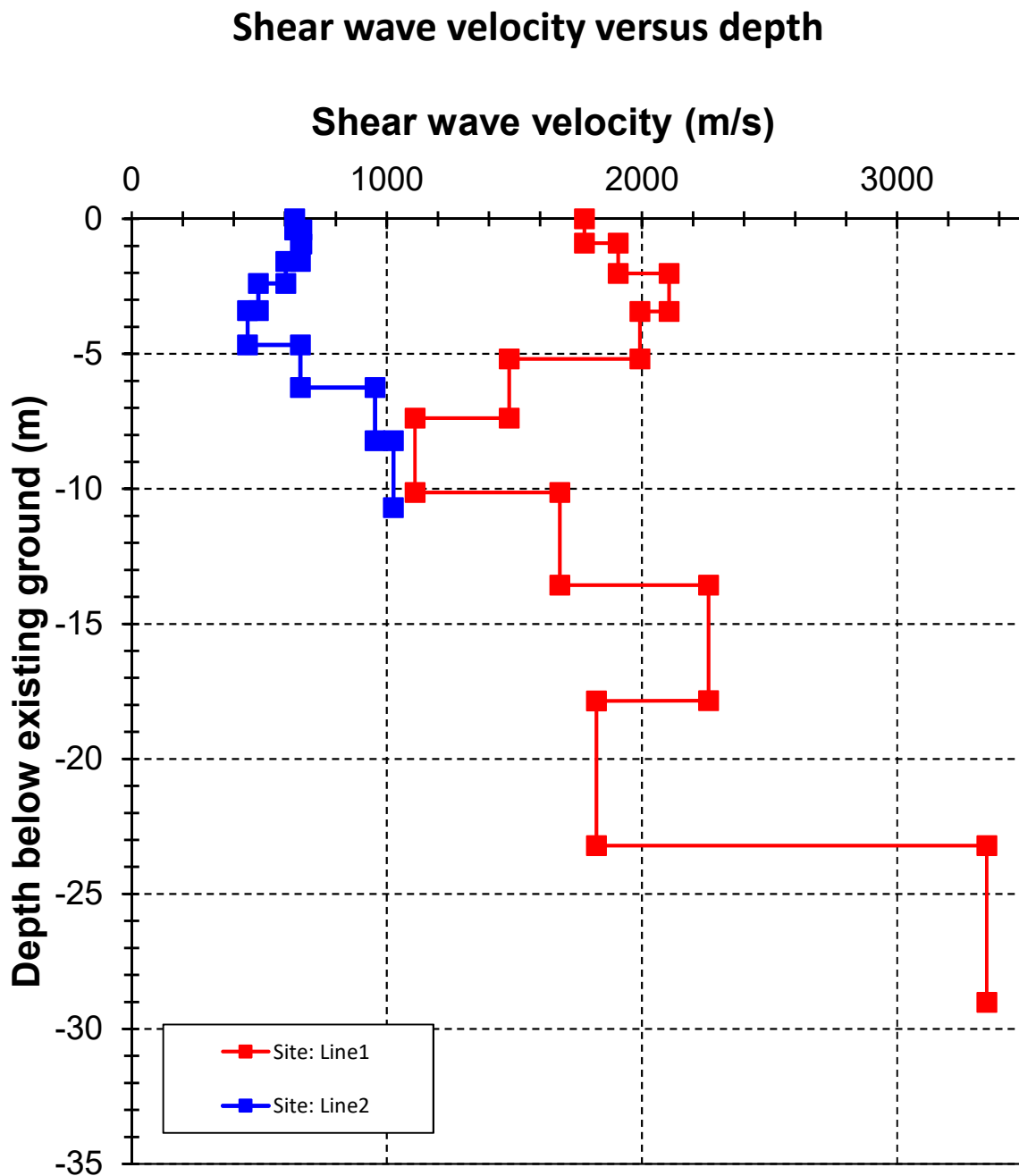


LE GROUPE MAURICE
211 CENTRUM BOULEVARD, OTTAWA, ONTARIO
GEOTECHNICAL INVESTIGATION

Project No. 11206675
Revision No. -
Date Feb 7, 2020

MASW TEST LOCATION PLAN

FIGURE 2



Le Groupe Maurice
Proposed residential, service and leisure complex
211 Centrum Boulevard, Orleans

PROJECT NO.
11206675
DATE
4-Feb-19

SHEAR WAVE VELOCITY VS DEPTH

FIGURE NO. 3



Table 1
Summary of Shear Wave Velocity Measurements
Seismic Site Class Determination
Proposed Development
Le Groupe Maurice
211 Centrum Boulevard, Orleans, ON

Table 1-A: Average Shear Wave Velocity (VS_{30}) (Assumed foundation at 3.0 m below existing ground surface)					
Line 1					
Layer No.	Depth (m bgs)		Thickness m	V_s m/s	d_i/V_{si}
	From	To			
1	3.0	3.4	0.4	2106	0.0002
2	3.4	5.2	1.8	1992	0.0009
3	5.2	7.4	2.2	1479	0.0015
4	7.4	10.1	2.7	1110	0.0025
5	10.1	13.6	3.4	1678	0.0020
6	13.6	17.8	4.3	2261	0.0019
7	17.8	23.2	5.4	1822	0.0029
8	23.2	33.0	9.8	3351	0.0029
Total			30.0		0.0148
Average Shear Wave Velocity Along the Line (m/s)					2020

Table 1-B: Average Shear Wave Velocity (VS_{30}) (Assumed foundation at 3.0 m below existing ground surface)					
Line 2					
Layer No.	Depth (m bgs)		Thickness m	V_s m/s	d_i/V_{si}
	From	To			
1	3.0	3.4	0.4	496	0.0008
2	3.4	4.7	1.3	454	0.0028
3	4.7	6.2	1.6	660	0.0024
4	6.2	8.2	2.0	954	0.0021
5	8.2	10.7	2.5	1026	0.0024
6	10.7	33.0	22.3	1149	0.0194
Total			30.0		0.0299
Average Shear Wave Velocity Along the Line (m/s)					1004

Average VS_{30} = **1512** m/s

Recommended Site Class: **B** Subjected to Code requirements

Notes:

- 1 - The Seismic Site class is recommended in accordance to Table 4.1.8.4.A of the National Building code of Canada 2010 and based on the lowest measured average shear wave velocity measured along the investigated lines.
- 2 - VS_{30} is calculated based on the average shear wave velocity below the proposed founding elevation.
- 3 - Site Classes A and B are only applicable if footings are founded on bedrock or there is no more than 3.0 m of soil between founding elevation and bedrock.
- 4 - The recommended site class is only applicable if site conditions for Site Class F (liquefiable soil/soft soil layers more than 3.0 m thick) are not applicable.



Table 2
Site Classification for Seismic Site Response
Forming Part of Sentences 4.1.8.4. (1) to (3)

	Ground Profile Name	Average Properties in Top 30 m		
		Average Shear Wave Velocity, $\bar{V}_s$ (m/s)	Average Standard Penetration Resistance, $\bar{N}_{60}$	Soil Undrained Shear Strength, s_u
A	Hard rock	$\bar{V}_s > 1500$	N/A	N/A
B	Rock	$760 < \bar{V}_s \leq 1500$	N/A	N/A
C	Very dense soil and soft rock	$360 < \bar{V}_s < 760$	$\bar{N}_{60} > 50$	$s_u > 100$ kPa
D	Stiff soil	$180 < \bar{V}_s < 360$	$15 \leq \bar{N}_{60} \leq 50$	$50 \text{ kPa} < s_u \leq 100$ kPa
E	Soft soil	$\bar{V}_s < 180$	$\bar{N}_{60} \leq 15$	$s_u < 50$ kPa
		Any profile with more than 3m of soil with the following characteristics: plasticity index: $PI > 20$ moisture content $w \geq 40\%$, and undrained shear strength: $s_u < 25$ kPa		
F	Other soils	Site-specific evaluation required		

Reference: 2012 Ontario Building Code Compendium, Division B – Part 4, Section 4.1.8.4.

Appendices

Appendix A

Seismic Hazard Values

2015 National Building Code Seismic Hazard Calculation

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

Site: 45.400N 75.653W

User File Reference: Children's Hospital of Eastern Ontario Campus 2020-01-06 20:17 UT

Requested by: GHD

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.453	0.251	0.150	0.044
Sa (0.1)	0.530	0.304	0.189	0.061
Sa (0.2)	0.444	0.258	0.162	0.055
Sa (0.3)	0.337	0.197	0.125	0.044
Sa (0.5)	0.239	0.140	0.089	0.031
Sa (1.0)	0.119	0.070	0.045	0.015
Sa (2.0)	0.056	0.033	0.021	0.006
Sa (5.0)	0.015	0.008	0.005	0.001
Sa (10.0)	0.005	0.003	0.002	0.001
PGA (g)	0.284	0.165	0.103	0.033
PGV (m/s)	0.198	0.112	0.068	0.021

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

References

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

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

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

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



Natural Resources
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Ressources naturelles
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about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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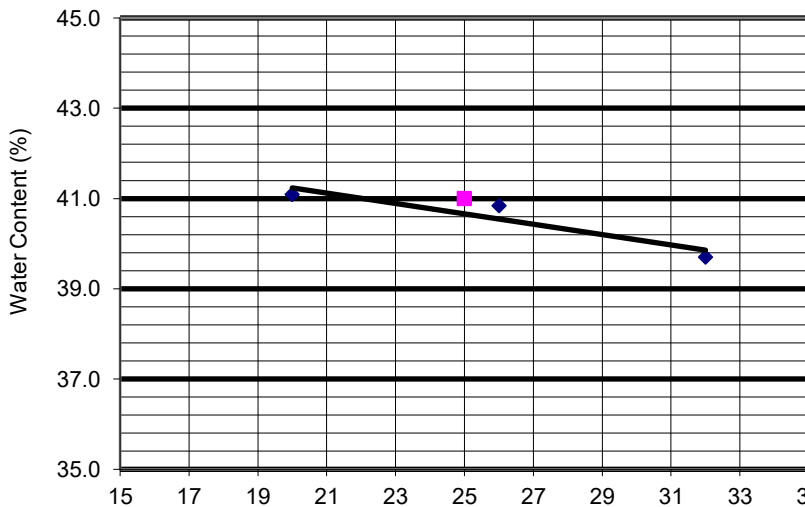
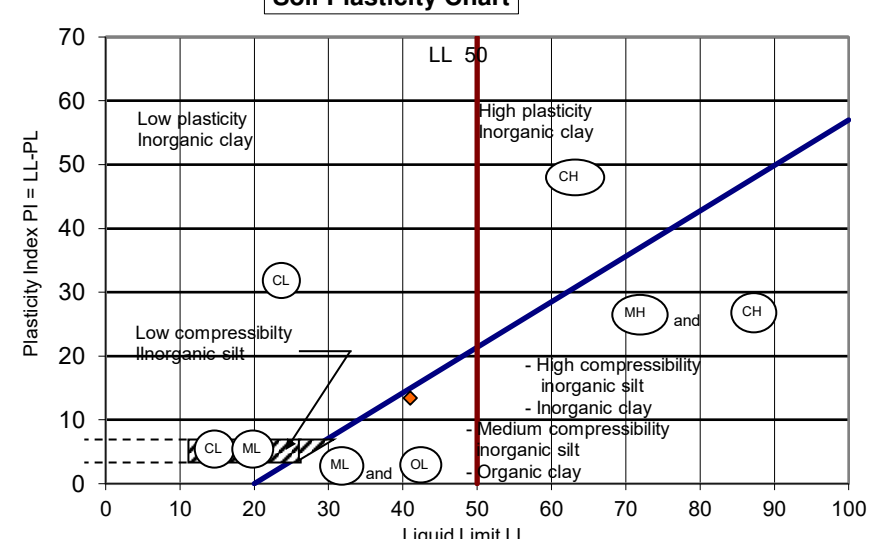
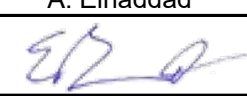
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Appendix C

Laboratory Results and Summary Table



Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client:	Le Groupe Maurice		Lab no.:	G-20-01	
Project/Site:	211 Centrum Boulevard, Orleans		Project no.:	11206675	
Borehole no.:	BH4	Sample no.:	SS2	Depth:	0.76-1.37
Soil description:			Date sampled:	9-Jan-20	
Apparatus:	Hand Crank/ Motor Driven	Balance no.:	1	Porcelain bowl no.:	1
Liquid limit device no.:	1	Oven no.:	1	Spatula no.:	1
Sieve no.:	1	Glass plate no.:	1		
Liquid Limit (LL):			Soil Preparation:		
	Test No. 1	Test No. 2	Test No. 3	☒ Cohesive <425 µm ☐ Dry preparation	
Number of blows	32	26	20	☐ Cohesive >425 µm ☒ Wet preparation	
Water Content:			☐ Non-cohesive		
Tare no.	S41	S13	S28	Results 	
Wet soil+tare, g	40.70	41.60	39.90		
Dry soil+tare, g	35.30	35.80	34.60		
Mass of water, g	5.40	5.80	5.30		
Tare, g	21.70	21.60	21.70		
Mass of soil, g	13.60	14.20	12.90		
Water content %	39.7%	40.8%	41.1%		
Plastic Limit (PL) - Water Content:					
Tare no.	S11	S39			
Wet soil+tare, g	29.10	28.70			
Dry soil+tare, g	27.40	27.20			
Mass of water, g	1.70	1.50			
Tare, g	21.50	21.50			
Mass of soil, g	5.90	5.70			
Water content %	28.8%	26.3%			
Average water content %	27.6%				
Natural Water Content (Wⁿ):					
Tare no.	S6				
Wet soil+tare, g	70.10				
Dry soil+tare, g	59.50				
Mass of water, g	10.60				
Tare, g	21.80				
Mass of soil, g	37.70				
Water content %	28.1%				
			Soil Plasticity Chart 		
			Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
			41	28	13
			Natural Water Content Wⁿ		
			28		
Remarks:					
Performed by:			Date:		
A. Elhaddad			January 28, 2020		
Verified by:			Date:		
			January 29, 2020		



Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D4318)

Client: Le Groupe Maurice		Lab no.: G-20-01	
Project/Site: 211 Centrum Boulevard, Orleans		Project no.: 11206675	
Borehole no.: BH5	Sample no.: SS3	Depth: 1.52 – 2.13	
Soil description:		Date sampled: 10-Jan-20	
Apparatus: Hand Crank/ Motor Driven	Balance no.: 1	Porcelain bowl no.: 1	
Liquid limit device no.: 1	Oven no.: 1	Spatula no.: 1	
Sieve no.: 1	Glass plate no.: 1		

Liquid Limit (LL):				Soil Preparation:	
	Test No. 1	Test No. 2	Test No. 3	☒ Cohesive <425 µm	☐ Dry preparation
Number of blows	28	23	17	☐ Cohesive >425 µm	☒ Wet preparation
Water Content:				☐ Non-cohesive	
Tare no.	S12	S26	S38		
Wet soil+tare, g	41.30	37.50	46.10		
Dry soil+tare, g	36.20	33.20	39.40		
Mass of water, g	5.10	4.30	6.70		
Tare, g	21.50	21.50	21.50		
Mass of soil, g	14.70	11.70	17.90		
Water content %	34.7%	36.8%	37.4%		
Plastic Limit (PL) - Water Content:					
Tare no.	S34	S31			
Wet soil+tare, g	28.90	28.70			
Dry soil+tare, g	27.50	27.30			
Mass of water, g	1.40	1.40			
Tare, g	22.10	21.80			
Mass of soil, g	5.40	5.50			
Water content %	25.9%	25.5%			
Average water content %	25.7%				
Natural Water Content (W ⁿ):					
Tare no.	S18				
Wet soil+tare, g	74.90				
Dry soil+tare, g	62.10				
Mass of water, g	12.80				
Tare, g	21.80				
Mass of soil, g	40.30				
Water content %	31.8%				

Results

Soil Plasticity Chart

Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W ⁿ
36	26	10	32

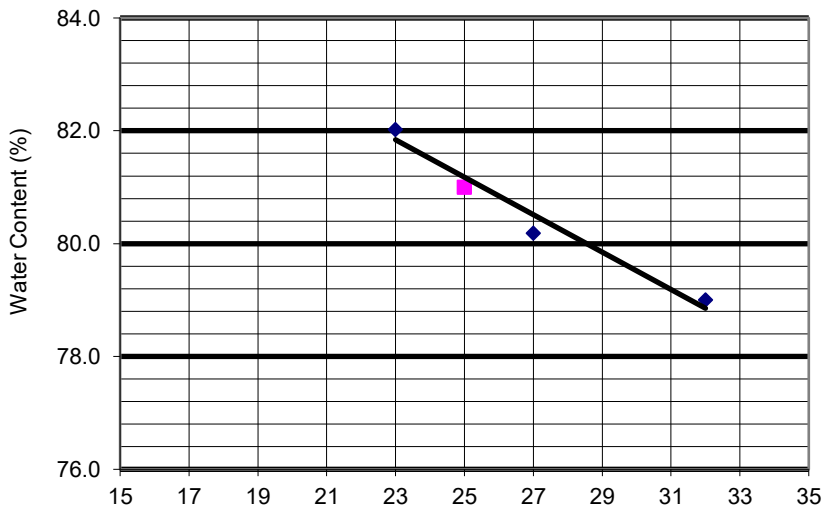
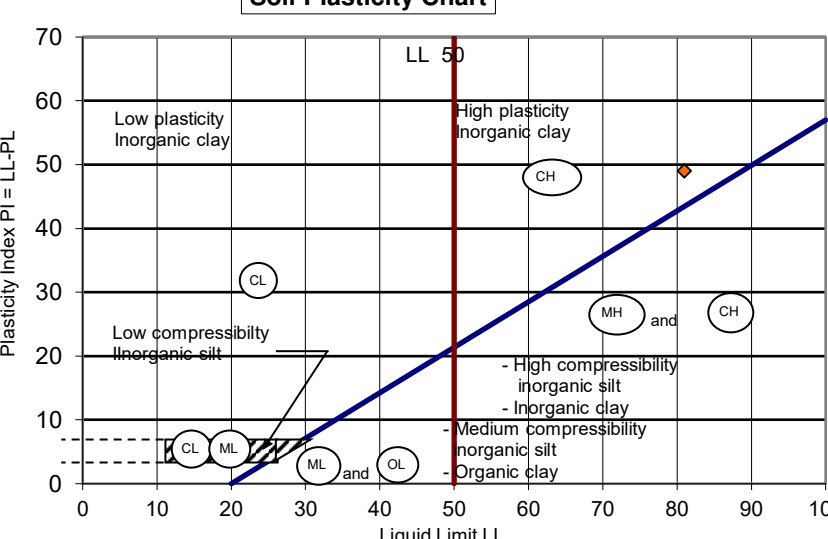
Remarks:

Performed by: A. Elhaddad **Date:** January 28, 2020

Verified by: **Date:** January 29, 2020



Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client:	Le Groupe Maurice		Lab no.:	G-20-01		
Project/Site:	211 Centrum Boulevard, Orleans		Project no.:	11206675		
Borehole no.:	BH11	Sample no.:	SS4	Depth:	3.05 - 3.66	
Soil description:			Date sampled:	13-Jan-20		
Apparatus:	Hand Crank/ Motor Driven	Balance no.:	1	Porcelain bowl no.:	1	
Liquid limit device no.:	1	Oven no.:	1	Spatula no.:	1	
Sieve no.:	1	Glass plate no.:	1			
Liquid Limit (LL):			Soil Preparation:			
	Test No. 1	Test No. 2	Test No. 3	☒ Cohesive <425 µm ☐ Dry preparation		
Number of blows	32	27	23	☐ Cohesive >425 µm ☒ Wet preparation		
Water Content:			☐ Non-cohesive			
Tare no.	S35	S10	S36	Results 		
Wet soil+tare, g	39.40	41.00	38.10			
Dry soil+tare, g	31.50	32.50	30.80			
Mass of water, g	7.90	8.50	7.30			
Tare, g	21.50	21.90	21.90			
Mass of soil, g	10.00	10.60	8.90			
Water content %	79.0%	80.2%	82.0%			
Plastic Limit (PL) - Water Content:			Soil Plasticity Chart 			
Tare no.	S16	S17				
Wet soil+tare, g	28.10	27.90				
Dry soil+tare, g	26.50	26.40				
Mass of water, g	1.60	1.50				
Tare, g	21.60	21.60				
Mass of soil, g	4.90	4.80				
Water content %	32.7%	31.3%				
Average water content %	32.0%					
Natural Water Content (Wⁿ):						
Tare no.	S15					
Wet soil+tare, g	79.70					
Dry soil+tare, g	56.70					
Mass of water, g	23.00					
Tare, g	21.80					
Mass of soil, g	34.90					
Water content %	65.9%					
			Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content Wⁿ
			81	32	49	66
Remarks:						
Performed by:			Date:			
A. Elhaddad			January 28, 2020			
Verified by:			Date:			
[Signature]			January 29, 2020			



Moisture Content of Soils (ASTM D2216)

Client:	Le Groupe Maurice	Lab No.:	G-20-01
Project:	211 Centrum Boulevard	Project No.:	11206675
Location:	Orleans, On		

Apparatus Used for Testing	
Oven no.: 1	Scale no.: 1

Sample No.	BH4-SS2	BH5-SS3	BH11-SS3	BH11-SS4	BH3-SS1	BH6-SS4	BH7-SS2	BH8-SS8
Container no.	S6	S18	S9	S15	S12	S40	S1	S11
Mass of container + wet soil (g)	70.1	74.9	60.0	79.7	77.4	86.3	96.0	119.2
Mass of container + dry soil (g)	59.5	62.1	50.3	56.7	66.7	78.8	85.6	109.0
Mass of container (g)	21.8	21.8	21.7	21.8	21.9	21.8	21.8	21.5
Mass of dry soil (g)	37.7	40.3	28.6	34.9	44.8	57.0	63.8	87.5
Mass of water (g)	10.6	12.8	9.7	23.0	10.7	7.5	10.4	10.2
Moisture content (%)	28.1	31.8	33.9	65.9	23.9	13.2	16.3	11.7

Sample No.	BH10-SS2	BH1-SS1	BH4-SS3	BH5-SS2	BH6-SS3	BH8-SS4	BH9-SS1	BH9-SS5
Container no.	S13	S2	S23	S29	S37	S25	S42	S32
Mass of container + wet soil (g)	91.9	88.5	80.8	71.2	85.9	90.9	82.3	88.2
Mass of container + dry soil (g)	84.0	70.3	68.1	60.6	75.3	84.6	70.5	82.1
Mass of container (g)	22.1	21.7	21.6	21.9	21.6	21.8	21.5	21.5
Mass of dry soil (g)	61.9	48.6	46.5	38.7	53.7	62.8	49.0	60.6
Mass of water (g)	7.9	18.2	12.7	10.6	10.6	6.3	11.8	6.1
Moisture content (%)	12.8	37.4	27.3	27.4	19.7	10.0	24.1	10.1

Remarks:	
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Performed by:	A. Elhaddad	Date:	January 27, 2020
Verified by :		Date:	January 29, 2020



Moisture Content of Soils (ASTM D2216)

Client:	Le Groupe Maurice	Lab No.:	G-20-01
Project:	211 Centrum Boulevard	Project No.:	11206675
Location:	Orleans, On		

Apparatus Used for Testing	
Oven no.:	1
Scale no.:	1

Sample No.	BH10-SS1	BH12-SS1						
Container no.	S20	S22						
Mass of container + wet soil (g)	80.8	73.7						
Mass of container + dry soil (g)	66.2	59.9						
Mass of container (g)	22.5	21.7						
Mass of dry soil (g)	43.7	38.2						
Mass of water (g)	14.6	13.8						
Moisture content (%)	33.4	36.1						
Sample No.								
Container no.								
Mass of container + wet soil (g)								
Mass of container + dry soil (g)								
Mass of container (g)								
Mass of dry soil (g)								
Mass of water (g)								
Moisture content (%)								

Remarks:	
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Performed by:	A. Elhaddad	Date:	January 27, 2020
Verified by :		Date:	January 29, 2020



Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	<u>Le Groupe Maurice</u>	Lab No.:	<u>G-20-01</u>
Project, Site:	<u>211 Centrum Boulevard, Orleans</u>	Project No.:	<u>11206675</u>
Borehole No.: <u>BH11</u>		Sample No.: <u>SS4</u>	
Depth: <u>3.05 - 3.66 m</u>		Enclosure: <u>-</u>	

Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty, Clay, trace Sand	0	1	99
Clay-size particles (<0.002 mm):	77 %		

Remarks:

Performed by:	<u>A. Elhaddad</u>	Date:	<u>January 28, 2020</u>
Verified by:	<u></u>	Date:	<u>January 29, 2020</u>

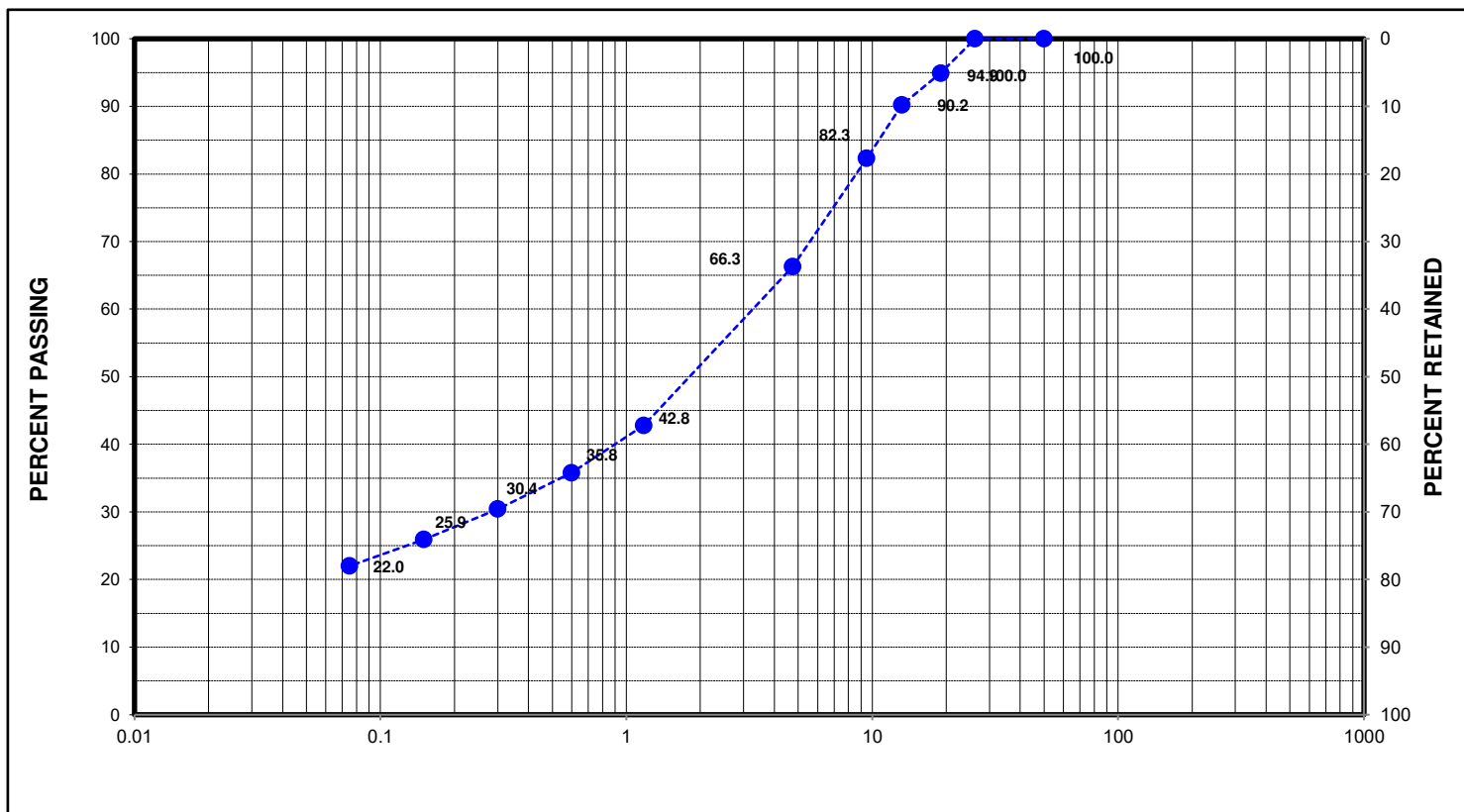


**SIEVE ANALYSIS
ASTM C136**

CLIENT: Le Groupe Maurice **LAB No.:** G-20-01
PROJECT/SITE: 211 Centrum, Orleans, On **PROJECT No.:** 11206675-02

SOURCE: BH3 - SS1 **DEPTH (m):** 0.0 - 0.61m

SIEVE SIZE (mm)	SAMPLE % PASSING	
50.0	100.0	
26.2	100.0	
19.0	94.9	
13.2	90.2	
9.5	82.3	
4.75	66.3	
1.18	42.8	
0.600	35.8	
0.300	30.4	
0.150	25.9	
0.075	22.0	



REMARKS: _____

PERFORMED BY: A. Elhaddad **DATE:** January 27, 2020
VERIFIED BY:  **DATE:** January 29, 2020

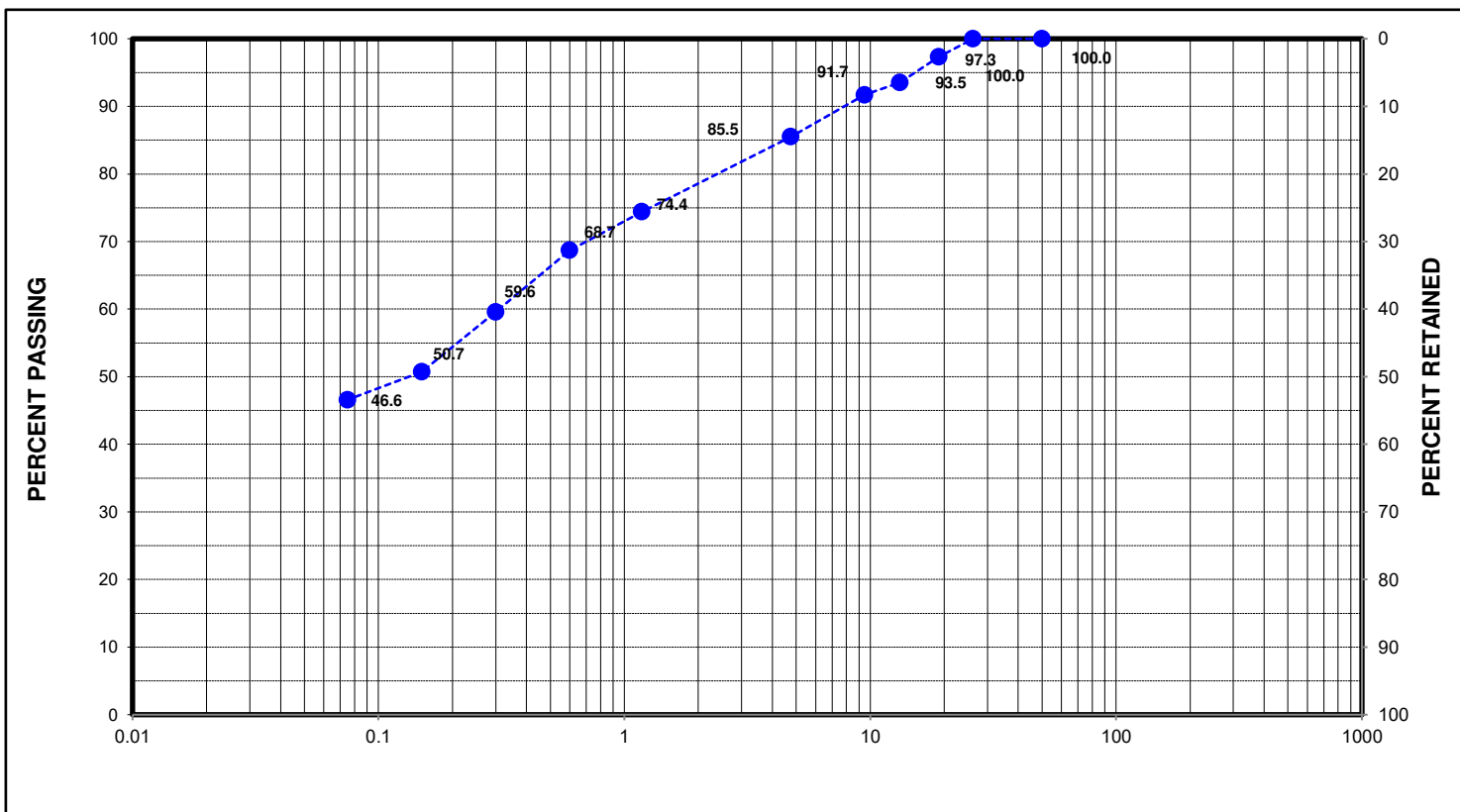


**SIEVE ANALYSIS
ASTM C136**

CLIENT: Le Groupe Maurice **LAB No.:** G-20-01
PROJECT/SITE: 211 Centrum, Orleans, On **PROJECT No.:** 11206675-02

SOURCE: BH6 - SS4 **DEPTH (m):** 2.27 - 2.64

SIEVE SIZE (mm)	SAMPLE % PASSING	
50.0	100.0	
26.2	100.0	
19.0	97.3	
13.2	93.5	
9.5	91.7	
4.75	85.5	
1.18	74.4	
0.600	68.7	
0.300	59.6	
0.150	50.7	
0.075	46.6	



REMARKS: _____

PERFORMED BY: A. Elhaddad **DATE:** January 27, 2020
VERIFIED BY:  **DATE:** January 29, 2020

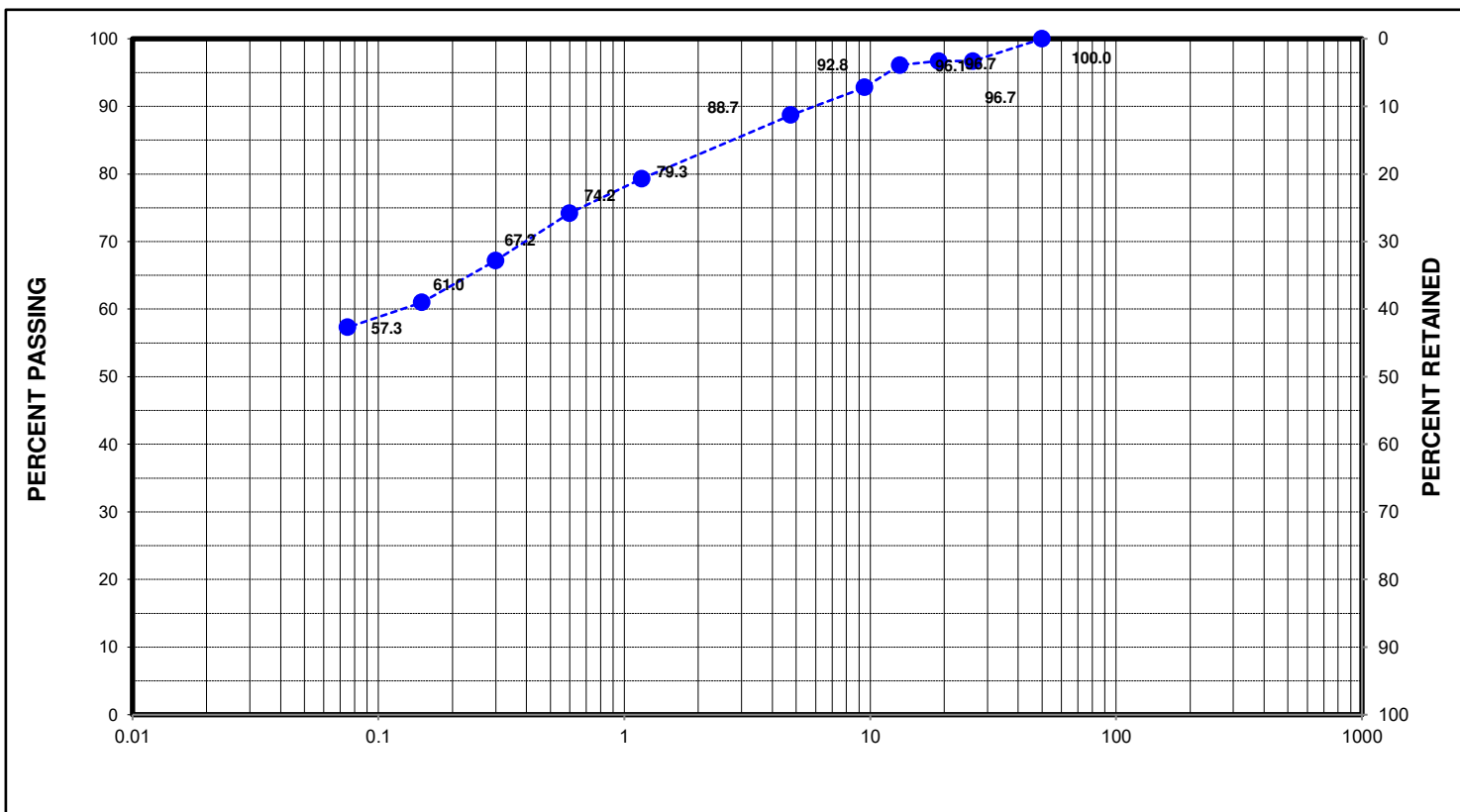


**SIEVE ANALYSIS
ASTM C136**

CLIENT: Le Groupe Maurice **LAB No.:** G-20-01
PROJECT/SITE: 211 Centrum, Orleans, On **PROJECT No.:** 11206675-02

SOURCE: BH7 - SS2 **DEPTH (m):** 3.05 - 3.52

SIEVE SIZE (mm)	SAMPLE % PASSING	
50.0	100.0	
26.2	96.7	
19.0	96.7	
13.2	96.1	
9.5	92.8	
4.75	88.7	
1.18	79.3	
0.600	74.2	
0.300	67.2	
0.150	61.0	
0.075	57.3	



REMARKS: _____

PERFORMED BY: A. Elhaddad **DATE:** January 27, 2020
VERIFIED BY: **DATE:** January 29, 2020

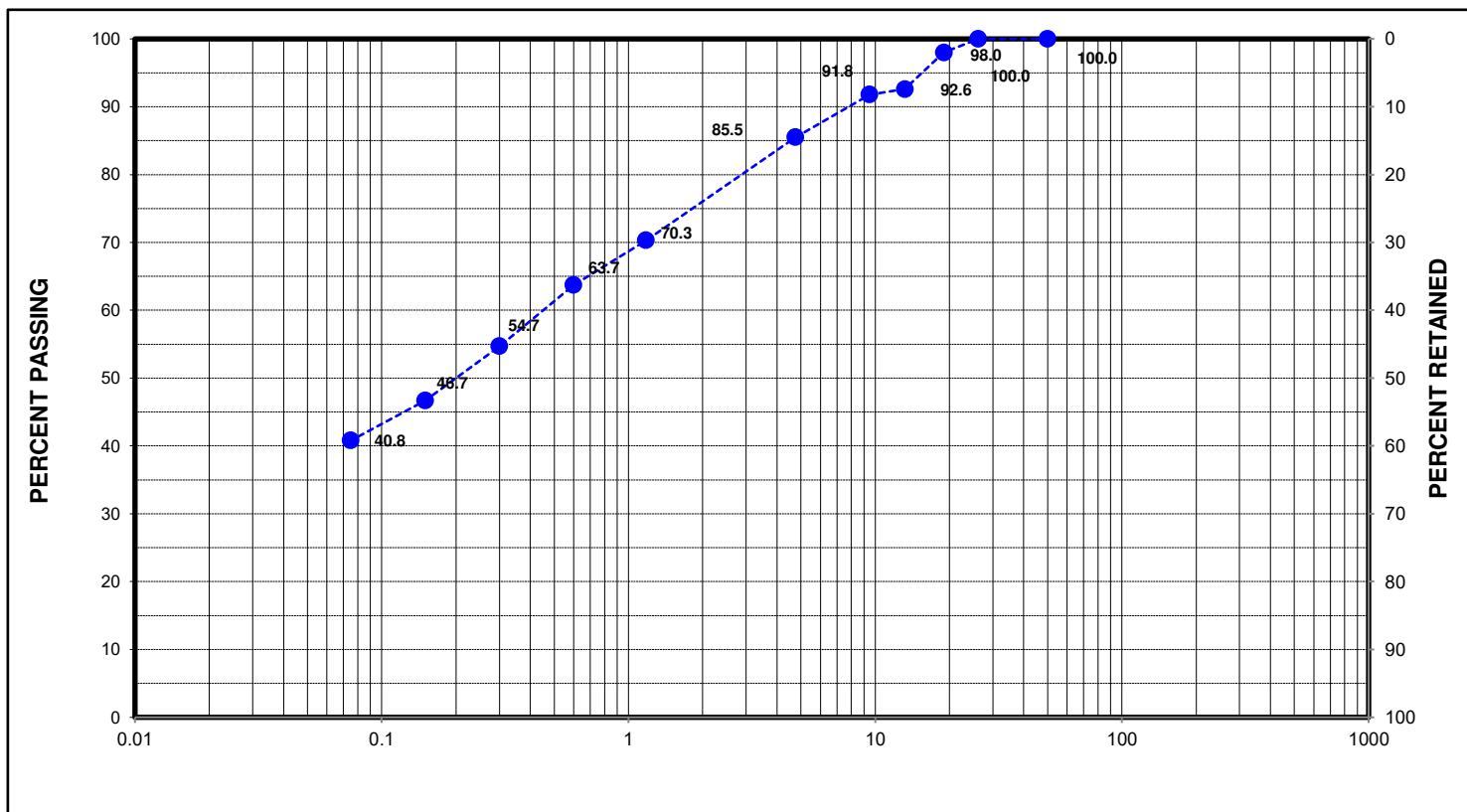


**SIEVE ANALYSIS
ASTM C136**

CLIENT: Le Groupe Maurice **LAB No.:** G-20-01
PROJECT/SITE: 211 Centrum, Orleans, On **PROJECT No.:** 11206675-02

SOURCE: BH8 - SS8 **DEPTH (m):** 5.28 - 5.89

SIEVE SIZE (mm)	SAMPLE % PASSING	
50.0	100.0	
26.2	100.0	
19.0	98.0	
13.2	92.6	
9.5	91.8	
4.75	85.5	
1.18	70.3	
0.600	63.7	
0.300	54.7	
0.150	46.7	
0.075	40.8	



REMARKS: _____

PERFORMED BY: A. Elhaddad **DATE:** January 27, 2020
VERIFIED BY: **DATE:** January 29, 2020

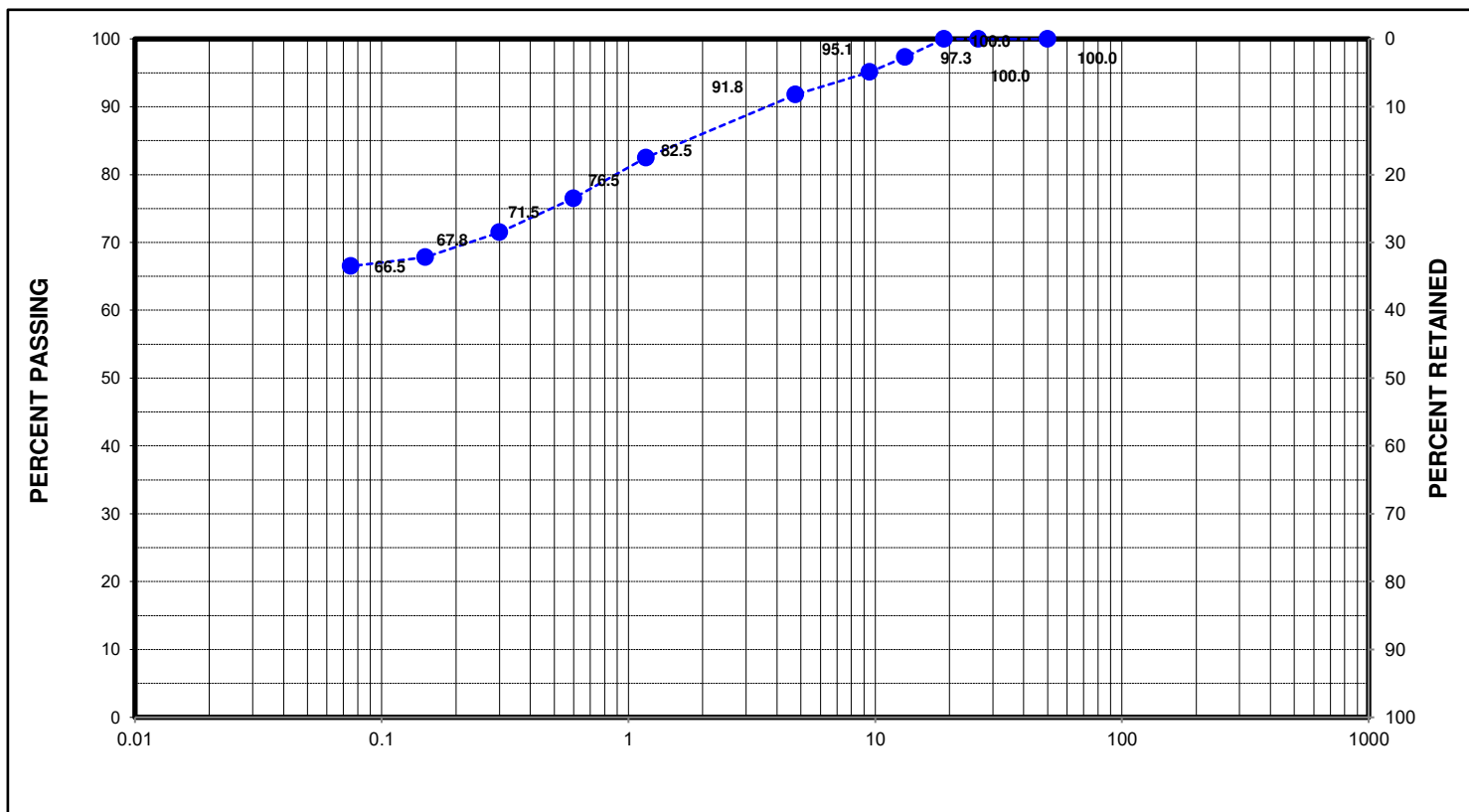


**SIEVE ANALYSIS
ASTM C136**

CLIENT: Le Groupe Maurice **LAB No.:** G-20-01
PROJECT/SITE: 211 Centrum, Orleans, On **PROJECT No.:** 11206675-02

SOURCE: BH10 - SS2 **DEPTH (m):** 0.76 - 1.37m

SIEVE SIZE (mm)	SAMPLE % PASSING	
50.0	100.0	
26.2	100.0	
19.0	100.0	
13.2	97.3	
9.5	95.1	
4.75	91.8	
1.18	82.5	
0.600	76.5	
0.300	71.5	
0.150	67.8	
0.075	66.5	



REMARKS: _____

PERFORMED BY: A. Elhaddad **DATE:** January 27, 2020
VERIFIED BY:  **DATE:** January 29, 2020



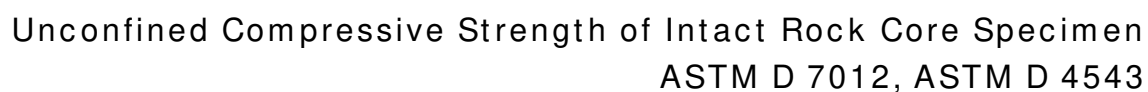
Unconfined Compressive Strength of Intact Rock Core Specimen
ASTM D 7012, ASTM D 4543

Client :	<u>Le Groupe Maurice</u>	Project No :	<u>11206675-02</u>
Project :	<u>211 Centrum Boulevard, Orleans, On</u>	Sample No :	<u>BH1 - RC2</u>
		Depth :	<u>0.50 - 0.70 m</u>
		Sampling Date :	<u>January 15, 2020</u>

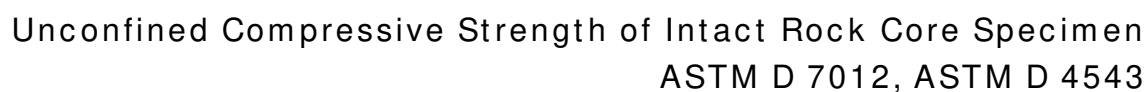
Testing Apparatus Used :	Loading device No <u>9130</u>	Caliper No <u>S103.1</u>
---------------------------------	--------------------------------------	---------------------------------

Technical Data					View of Specimen
					Before Test :
Diameter :	64	64	64	Average 64.0	
	(mm)				
Length :	128	128	128	128.0	
	(mm)				
Straightness (0.5mm maximum) (S1) :	0.2	0.2	0.3	0.2	
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	Ok	
Parallelism (0.25 ° maximum) (FP2) :	0.1	0.1	0.1	0.1	
	(°)				
Mass :	<u>1076</u> (g)		Volume:	<u>411775</u> (mm³)	
Density :			<u>2613</u> (kg/m³)		
Moisture Conditions :			<u>Dry</u>		
Loading Rate (0.5 to 1.0 MPa / sec) :			<u>0.75</u> (MPa/sec)		
Type of Fracture :			<u>1</u>		
Test Duration (2-15 Minutes) :			<u>3</u> (minutes)		
Maximum Applied Load :			<u>260.6</u> ☒ kN ☐ lbs		
Compressive Strength :			<u>81.0</u> (MPa)		

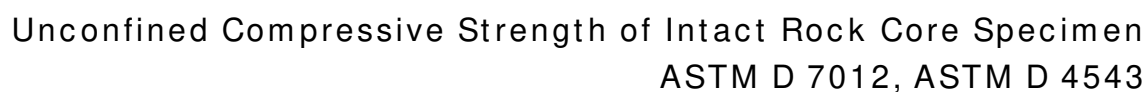
Remarks :	<u></u>		
Analysed by :	<u>A. Elhaddad</u>	Date :	<u>January 23, 2020</u>
Verified by :	<u></u>	Date :	<u>January 29, 2020</u>



GHD FO-930.112 - Unconfined Compressive Strength of Intact Rock Core Specimen - Rev.0 - 07/01/2015



GHD FO-930.112 - Unconfined Compressive Strength of Intact Rock Core Specimen - Rev.0 - 07/01/2015



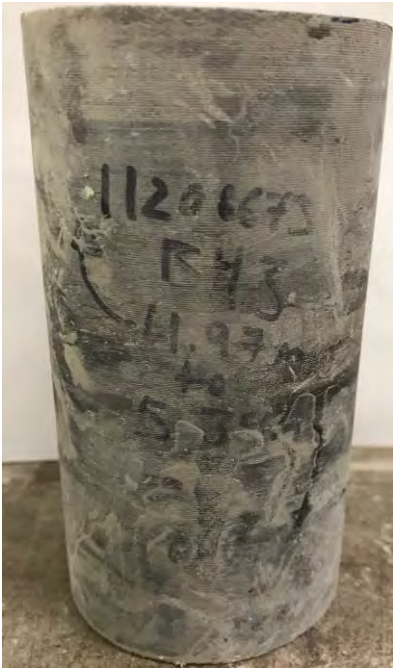
GHD FO-930.112 - Unconfined Compressive Strength of Intact Rock Core Specimen - Rev.0 - 07/01/2015



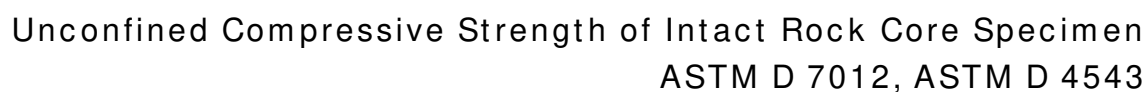
Unconfined Compressive Strength of Intact Rock Core Specimen
ASTM D 7012, ASTM D 4543

Client :	Le Groupe Maurice	Project No :	11206675-02
Project :	211 Centrum Boulevard, Orleans, On	Sample No :	BH3 - RC6
		Depth :	4.97 - 5.39 m
		Sampling Date :	January 15, 2020

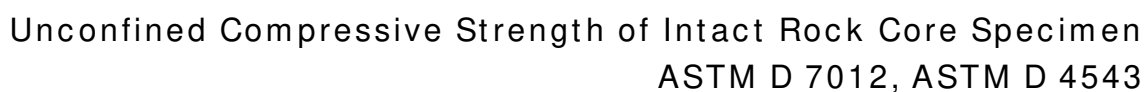
Testing Apparatus Used :	Loading device No 9130	Caliper No S103.1
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Technical Data					View of Specimen	
Diameter :	64	64	64	Average 64.0	(mm)	Before Test : 
Length :	127	127	127	127.0	(mm)	
Straightness (0.5mm maximum) (S1) :	0.3	0.3	0.2	0.3	(mm)	After Test : 
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	Ok		
Parallelism (0.25 ° maximum) (FP2) :	0.2	0.15	0.1	0.2	(°)	
Mass :	1054	(g)	Volume:	408558	(mm³)	
Density :			2580	(kg/m³)		
Moisture Conditions :			Dry			
Loading Rate (0.5 to 1.0 MPa / sec) :			0.75	(MPa/sec)		
Type of Fracture :			1			
Test Duration (2-15 Minutes) :			3.25	(minutes)		
Maximum Applied Load :			206.04	☒ kN ☐ lbs		
Compressive Strength :			64.0	(MPa)		

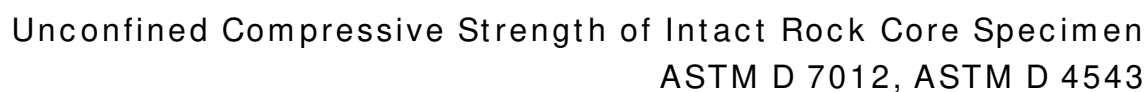
Remarks :			
Analysed by :	A. Elhaddad	Date :	January 23, 2020
Verified by :		Date :	January 29, 2020



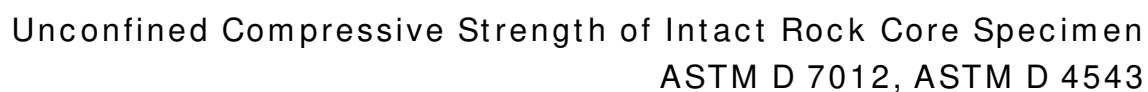
GHD FO-930.112 - Unconfined Compressive Strength of Intact Rock Core Specimen - Rev.0 - 07/01/2015



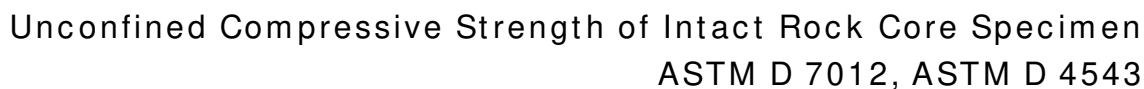
GHD FO-930.112 - Unconfined Compressive Strength of Intact Rock Core Specimen - Rev.0 - 07/01/2015



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Client: GHD Limited (Ottawa)
400-179 Colonnade Rd.
Ottawa, ON
K2E 7J4
Attention: Mr. Demetrius Cooper
PO#:
Invoice to: GHD Limited

Report Number: 1924365
Date Submitted: 2020-01-21
Date Reported: 2020-02-03
Project: 11206675
COC #: 99180

Page 1 of 4

Dear Demetrius Cooper:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Revised results for redox potential values

APPROVAL:

Rebecca Koshy, Project Manager

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: <http://www.cala.ca/scopes/2602.pdf>.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

Client: GHD Limited (Ottawa)
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					Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1476292 Soil 2020-01-13 BH8 SS7	1476293 Soil 2020-01-14 BH9 SS4	1477914 Soil 2020-01-14 BH8 SS6
Group	Analyte	MRL	Units	Guideline				
Anions	Cl	0.002	%			0.003	<0.002	
	SO4	0.01	%			0.02	0.03	
General Chemistry	Electrical Conductivity	0.05	mS/cm			0.07	0.06	
	pH	2.00				8.08	8.07	
	Resistivity	1	ohm-cm			14300	16700	
Redox Potential	REDOX Potential		mV			230	225	187
Subcontract	Moisture-Humidite	0.25	%			7.33	5.98	
	S2-	0.20	mg/kg			<0.20	0.42	

Guideline = * = Guideline Exceedence

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

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Project:
COC #: 99180

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 378908 Analysis/Extraction Date 2020-01-27 Analyst JM Method Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	98	90-110
Run No 379053 Analysis/Extraction Date 2020-01-29 Analyst R K Method C SM2580B			
REDOX Potential	0 mV		
Run No 379058 Analysis/Extraction Date 2020-01-30 Analyst AET Method C CSA A23.2-4B			
Chloride		100	90-110
Run No 379078 Analysis/Extraction Date 2020-01-30 Analyst JM Method Ag Soil			
pH	5.26	100	90-110
Resistivity	6580 ohm-cm		
Run No 379085 Analysis/Extraction Date 2020-01-30 Analyst SKH Method AG SOIL			
SO4	<0.01 %	91	70-130
Run No 379157 Analysis/Extraction Date 2020-01-31 Analyst R K Method C SM2580B			
REDOX Potential			

Guideline = * = **Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

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Date Reported: 2020-02-03
Project:
COC #: 99180

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 379181 Analysis/Extraction Date 2020-01-30 Analyst R K Method SUBCONTRACT-A			
Moisture-Humidite	<0.25 %	100	
S2-	<0.20 mg/kg	114	

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Copies: White - Laboratory, Yellow - Samples

Table C 1 Summary of Geotechnical Laboratory Test Results

Borehole	Sample No.	Depth (m)	Material	MC (per cent)	LL (per cent)	PL (per cent)	PI (per cent)	PSD				UCS (MPa)
								Gravel (percent)	Sand (percent)	Silt (per cent)	Clay (per cent)	
BH1	SS1	0.0 – 0.5	FILL	37.4	-	-	-	-	-	-	-	-
BH1	RC2	0.5 – 0.7	Limestone	-	-	-	-	-	-	-	-	81.0
BH1	RC6	5.7 – 6.2	Limestone	-	-	-	-	-	-	-	-	95.8
BH2	RC2	0.72 – 1.16	Limestone	-	-	-	-	-	-	-	-	79.6
BH2	RC5	5.22 – 5.61	Limestone	-	-	-	-	-	-	-	-	80.8
BH3	SS1	0.0 – 0.61	FILL	23.9	-	-	-	33.7	44.3	22		
BH3	RC6	4.97-5.39	Limestone	-	-	-	-	-	-	-	-	64.0
BH4	SS2	0.76 – 1.37	Clayey SILT	28.1	41	28	13	-	-	-	-	-
BH4	SS3	1.52 – 1.73	Clayey SAND	27.3	-	-	-	-	-	-	-	-
BH4	RC5	3.27 – 3.50	Limestone	-	-	-	-	-	-	-	-	65.7
BH5	SS2	0.76 – 0.92	FILL	27.4	-	-	-	-	-	-	-	-
BH5	SS3	1.52 – 2.13	Clayey SILT	31.8	36	26	10	-	-	-	-	-
BH5	RC7	6.86 – 7.15	Limestone	-	-	-	-	-	-	-	-	56.2
BH6	SS3	0.76 – 1.14	FILL	19.7	-	-	-	-	-	-	-	
BH6	SS4	2.27 – 2.64	SILT & SAND, with some gravel	13.2	-	-	-	14.5	38.9	46.6		-
BH7	SS2	3.05 – 3.52	Sandy SILT, with some gravel	16.3	-	-	-	11.3	31.4	57.3		-
BH8	SS4	2.28 – 2.89	SILT & SAND, with some gravel	10.0	-	-	-	-	-	-	-	-
BH8	SS8	5.28 – 5.89	SILT & SAND with some gravel	11.7	-	-	-	14.5	44.7	40.8	-	-
BH8	RC9	7.03 – 7.23	Limestone	-	-	-	-	-	-	-	-	66.7
BH9	SS1	0.0 – 0.61	Sandy Clayey SILT	24.1	-	-	-	-	-	-	-	-
BH9	SS5	3.05 – 3.15	SILT & SAND, with some gravel	10.1	-	-	-	-	-	-	-	-
BH9	RC7	5.14 – 5.51	Limestone	-	-	-	-	-	-	-	-	59.6
BH10	SS1	0.0 – 0.61	FILL / TOPSOIL	33.4	-	-	-	-	-	-	-	
BH10	SS2	0.76 – 1.37	Sandy SILT, trace gravel & clay	12.8	-	-	-	8.2	25.3	66.5	-	-
BH11	SS3	1.52 – 2.13	Silty CLAY	33.9	-	-	-	-	-	-	-	-
BH11	SS4	3.05 – 3.66	Silty CLAY, trace sand	65.9	81	32	49	0	1	12	77	
BH11	RC5	5.20 – 5.42	Limestone	-	-	-	-	-	-	-	-	41.7
BH12	SS1	0.0 – 0.61	TOPSOIL/FILL	36.1	-	-	-	-	-	-	-	-

Appendix D

Concept Design Drawings

BUILDING
OUTLINE FOR
CONCEPT LAYAL



LEGEND

- 1 MAIN STREET PLAZA COURTYARD
- 2 COVERED DROP OFF & SURFACE VISITOR PARKING
- 3 2 STOREY VOLUME - ENTRANCE HALL
- 4 DINING GALLERIA
- 5 HEALTH AND VITALITY
- 6 ACCESS TO UNDERGROUND PARKING
- 7 LOADING



HOBIN

2 1 1
CENTRUM BLVD

CONCEPT R1
AERIAL NE

NOVEMBER 5, 2019



HOBIN

2 1 1
CENTRUM BLVD

CONCEPT R1
AERIAL NW

NOVEMBER 5, 2019



HOBIN

2 1 1
CENTRUM BLVD

CONCEPT R1
AERIAL SE

NOVEMBER 5, 2019



HOBIN

2 1 1
CENTRUM BLVD

CONCEPT R1
AERIAL SW

NOVEMBER 5, 2019



about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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