Geotechnical Investigation

Proposed Four (4) Storey Long Term Care
Old Montreal Rd. and Famille-Laporte Ave.
Orleans, Ontario
Revision 4

Prepared for:

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LRL File No.: 210587

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1 INTRODUCTION

LRL Associates Ltd. (LRL) was retained by Arch Corporation to perform a geotechnical investigation for a parcel of land, located at the intersection of Old Montreal Road and Famille-Laporte Avenue, in Orleans, Ontario, for a proposed four (4) storey long term care home.

The purpose of the investigation was to identify the subsurface conditions across the site by the completion of a limited borehole drilling program. Based on the visual and factual information obtained, this report will provide guidelines on the geotechnical engineering aspects of the design of the project, including construction considerations. In addition, a section of the report will also include a section pertaining to the stability of the proposed slope, located east portion of the site, near the property limit.

This report has been prepared in consideration of the terms and conditions noted above. Should there be any changes in the design features, which may relate to the geotechnical recommendations provided in the report, LRL should be advised in order to review the report recommendations.

It shall be noted, a “Preliminary Geotechnical Investigation” was previously completed for this site, under the LRL File number 180485. Borehole data and laboratory analysis results can be found attached to this report in the Appendix, “Supporting Documentation”.

2 SITE AND PROJECT DESCRIPTION

The site under investigation is currently vacant land, located near the intersection of Old Montreal Road and Famille-Laporte Avenue. The location is presented in Figure 1 included in **Appendix A**. The lot is irregular in shape, fronts Famille-Laporte Avenue, and has a total surface area of approximately 5 acres. The site can be considered relatively flat, except for an approximately 1.0 m high mound, located at the south portion of the site. At the time of the investigation, the site was covered with wild grasses and the occasional shrub. Access to the site comes by way of Famille-Laporte Avenue.

It is understood the proposed construction for this site will consist of a four (4) storey long term care home, with a partial basement. Parking and access lanes will be present to the north, east, and south of the proposed building.

3 PROCEDURE

The fieldwork for this investigation was carried out on September 13, 14 and 15, 2021. Prior to the fieldwork, the site was cleared for the presence of any underground services and utilities. A total of twelve (12) boreholes, labelled BH21-1 through BH21-12, were drilled at predetermined locations, agreed upon by the engineering team and client. The approximate locations of the boreholes are shown in Figure 2 included in **Appendix A**.

The boreholes were advanced using a track mount CME 75 drill rig equipped with 200 mm diameter continuous flight hollow stem auger supplied and operated by CCC Geotechnical and Environmental Ltd.. A “two man” crew experienced with geotechnical drilling operated the drill rig and equipment.

Sampling of the overburden materials encountered in the boreholes was carried out at regular depth intervals using a 50.8 mm diameter drive open conventional spoon sampler in conjunction with standard penetration testing (SPT) “N” values. The SPT were

conducted following the method **ASTM D1586** and the results of SPT, in terms of the number of blows per 0.3 m of split-spoon sampler penetration after first 0.15 m designated as “N” value.

In-situ field vane shear test using a 125 x 40 mm tapered vane was carried-out in the cohesive soil deposits once the material became very soft based on the “N” values from the blow counts. The undrained shear strength values were calculated following the procedure **ASTM D 2573.**

The boreholes were advanced to depths ranging from 8.84 to 14.00 m below ground surface (bgs). Upon completion, the boreholes were backfilled and compacted using a combination of silica sand, bentonite and overburden cuttings.

19 mm diameter PVC pipe was installed in three (3) of the boreholes to measure the long-term static groundwater table. The piezometers were constructed using screened PVC pipe, silica sand, and sealed with bentonite.

The fieldwork was supervised throughout by a member of our engineering staff who oversaw the drilling activities, cared for the samples obtained and logged the subsurface conditions encountered within each of the boreholes. All soil samples collected from the boreholes were placed and sealed in plastic bags to prevent moisture loss. The recovered soil samples collected from the boreholes were classified based on visual examination of the materials recovered and the results of the in-situ testing. All soil samples were transported to our office for further examination by our geotechnical engineer.

Furthermore, all boreholes were surveyed and located using a Garmin Etrex Legend GPS (Global Positioning System) receiver using NAD 83 datum (North American Datum). LRL’s field personnel determined the existing grade elevations at the borehole locations through a topographic survey carried out using the “Site Benchmark ‘B’ (67.83 m)”. Respective ground surface elevations of boring locations are shown on their respective boreholes logs.

4 SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

4.1 General

A review of local surficial geology maps provided by the Department of Energy, Mines and Resources Canada suggest that the surficial geology for this area consist of silt and silty clay; commonly including lenses of sand and generally underlain at variable depth by blue-grey clay.

The subsurface conditions encountered in the boreholes were classified based on visual and tactile examination of the materials recovered from the boreholes and the results of in-situ laboratory testing. The soil descriptions presented in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil were conducted according to the procedure **ASTM D2487** and judgement, and LRL does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The subsurface soil conditions encountered at boreholes are given in their respective logs presented in **Appendix B**. A greater explanation of the information presented in the borehole logs can be found in **Appendix C** of this report. These logs indicate the subsurface conditions encountered at a specific test location only. Boundaries between zones on the logs are often not distinct, but are rather transitional and have been interpreted as such.

4.2 Topsoil

Topsoil of thickness 600 mm was found at all boring locations, the topsoil was clayey, with black organic material.

This material was classified as topsoil based on colour and the presence of organic material and is intended as identification for geotechnical purposes only. It does not constitute a statement as to the suitability of this layer for cultivation and sustaining plant growth.

4.3 Silty Clay

Underlying the topsoil, a deposit of brownish grey silty clay was encountered at all boring locations, it extended to depths ranging from 5.64 and 12.20 m bgs. Standard penetration tests were carried out in the silty clay material and the STP "N" value was found ranging from 20 to Weight of Hammer (WH), indicating the deposit is very stiff, and becoming very soft with increased depths. The natural moisture content was found varying between 30 and 70%.

The undrained shear strength values were found ranging from 38 to 100 kPa.

4.4 Silt and Clay

Underlying the silty clay in BH8, a layer of grey silt and clay was encountered, and extended to a depth of 8.84 m bgs. The "N" value was found to be WH. The natural moisture was determined to be 54%

The undrained shear strength values were found ranging from 80 to 96 kPa.

4.5 Glacial Till

Underneath the silty clay in BH3, BH9, BH10, and BH12 a deposit of glacial till was encountered and extended to depths ranging between 8.84 and 14.00 m bgs. The till material can generally be described as a heterogenous mixture of silt-sand, some clay, some gravel sized stone, and grey in colour. The recorded SPT "N" values of this deposit varied from 16 to 100+, indicating the deposit is compact to very dense in relative density. The natural moisture content was found to be 8 and 54%.

4.6 Laboratory Analysis

Three (3) soil samples were collected for laboratory gradation analyses. The gradation analyses comprised of sieve and hydrometer were conducted following the procedure **ASTM D422.** Details of laboratory analyses are reflected in **Table 1**

Table 1: Gradation Analysis Summary

Sample Location	Depth (m)	Percent for Each Soil Gradation					Estimated Hydraulic Conductivity K (m/s)
		Sand			Silt (%)	Clay (%)	
		Coarse (%)	Medium (%)	Fine (%)			
BH21-1	1.5 – 2.1	0.0	0.0	0.3	22.4	77.3	5×10^{-8}
BH21-4	3.1 – 3.7	0.0	0.0	0.4	23.3	76.3	5×10^{-8}
BH21-8	7.6 – 8.2	0.0	0.0	0.1	47.2	52.7	5×10^{-6}

Atterberg limits and moisture contents were conducted on two (2) spoon soil samples collected. A summary of these values are provided below in **Table 2**.

Table 2: Summary of Atterberg Limits and Water Contents

Sample Location	Parameter					
	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Water Content (%)	USCS Group Symbol
BH21-3	1.5 – 2.1	78	30	48	41	CH
BH21-7	6.1 – 6.7	64	27	37	62	CH

The laboratory reports can be found in **Appendix D** of this report.

4.7 Groundwater Conditions

For long-term static groundwater monitoring, piezometers were installed in three (3) boreholes. The water level measurements are shown on the borehole logs presented in **Appendix B,** and summarized in the below **Table 3.**

Table 3: Groundwater Monitoring Data

Boring Location	Existing Grade Elevation (m)	Date of Observation	Water Level Data	
			Depth Below Existing Grade (m)	Elevation (m)
BH21-4	68.66	October 13, 2021	1.8	66.86
BH21-5	67.25	October 13, 2021	2.3	64.95
BH21-11	68.00	October 13, 2021	1.75	66.25

It should be noted that groundwater levels could fluctuate with seasonal weather conditions, (i.e.: rainfall, droughts, spring thawing) and due to construction activities at or in the vicinity of the site.

5 GEOTECHNICAL CONSIDERATIONS

This section of the report provides general geotechnical recommendations for any design aspect of the project based on our interpretation of the information gathered from the boreholes performed at this site and from the project requirements.

This section will detail the specific requirements and limitations with regard to allowable foundation bearing pressure and depth, grade raise and size of the footings.

5.1 Foundations

Based on the subsurface soil conditions established at this site, it is recommended that the footings for the proposed building be founded over the undisturbed native silty clay, below the frost penetration depth. Therefore, all material including incompetent native soil should be removed from the proposed building's footprint down to the relatively stable native soil.

Alternatively, if a greater bearing capacity is required than what is indicated below in Section 5.1.1, consideration should be given to support the building on pile foundations.

5.1.1 Shallow Foundation

Conventional strip and column footings founded over the undisturbed native silty clay may be designed using a maximum allowable bearing pressure of **125 kPa** for serviceability limit state **(SLS)** and **185 kPa** for ultimate limit state **(ULS)** factored bearing resistance. The factored ULS value includes the geotechnical resistance factor of 0.5. This bearing capacity limits the allowable grade raise to 2.0 m; this grade raise shall be respected across the entirety of the site. This bearing capacity also allows for a strip footing of width minimum 0.6 to maximum 1.5 m, and a pad footing of width minimum 1.0 to maximum 3.0 m on any side. The bearing capacity includes the weight of the footing and soil above the footings.

In-situ field tests may be required to check the strength and stability of the footings subgrade. Any incompetent subgrade areas as identified from in-situ testing must be sub-excavated and backfilled with approved structural fill. Similarly, any soft or wet areas should also be sub-excavated and backfilled with approved structural fill only. Prior to placing the approved structural fill, the subgrade comprised of the silty clay deposit should be inspected and approved by geotechnical engineer or a qualified geotechnical personnel. The bearing pressure is contingent on the water level being 0.3 m below the underside footing elevation in order to have stable and dry footings subgrade during construction.

If the strip footings need to be founded at different level, it is recommended to use the step footings specification as recommended in **Clause 9.15.3.9 of OBC 2012** or any updated version.

Prior to pouring footings concrete, the subgrade comprised of the undisturbed silty clay should be inspected and approved by a geotechnical engineer or a representative of geotechnical engineer.

5.1.2 Deep Foundation (Steel Driven Piles)

If a greater bearing capacity is required than what is specified above in Section 5.1.1, consideration shall be given for supporting the building on deep foundations. The most common and typically cost-effective deep foundations used in this region are driven steel piles.

The proposed building could be supported on end bearing steel piles driven to refusal within the glacial till and/or bedrock. As most of the overburden soil found on this site is silty clay, it is unlikely that the piles will encounter any significant obstructions during pile installation until refusal is encountered.

Typically, two (2) types of driven steel piles are used within this region. These are as follows:

i. Steel H piles; and

ii. Closed ended, concrete filled, steel pipe piles.

The depth to practical refusal was established to range between 9.14 and 14.00 m bgs at this site. To minimize the potential for damage to the pile tips during driving, the piles should be provided with a driving shoe as per OPSD standards 3000.100 and 3001.100, for H-pile and steel tube piles, respectively.

Piles driven to refusal generate high ultimate geotechnical capacity, typically equal to the structural capacity of the steel section of the pile. For design example, an HP 310 x 79 with area 9980 mm^2 and yield strength 350 MPa has an un-factored ultimate structural capacity of 3140 kN (assuming structural capacity reduced to 90 percent due to bulking, and lateral loads). The maximum pile capacity for HP 310 x 79 driven to refusal can therefore be considered for **Service Limit State (SLS) 1040 kN** and **Ultimate Limit State (ULS) 1250 kN**. A geotechnical resistance factor 0.4 should be used to the ultimate structural value to obtain the factored ultimate resistance.

Closed ended, concrete filled steel pipe pile of 245 mm diameter can be considered to resist the geotechnical axial resistances as summarized in **Table 4.**

Table 4: Geotechnical Axial Resistance of Steel Pipe Piles

Pile Outside Diameter (mm)	Pipe Wall Thickness (mm)	Geotechnical Axial Resistance	
		Service Limit State (SLS), kN	Ultimate Limit State (ULS), kN
245	9	950	1140
	10	1050	1260
	11	1150	1380

This assumes that the steel has a minimum yield strength of 350 MPa and that the pipe pile is filled with 30 MPa concrete. Pipe piles should be equipped with a base plate having a thickness of at least 20 mm to limit damage to the pile tip during driving.

The piles should be driven no closer than three pile widths/diameters centre to centre.

All of the piles should be driven to refusal. The driving resistance criteria will be highly dependent on the required allowable load and the contractor's pile driving equipment. Typically, for drop hammer type piling rigs available in Ottawa and surrounding area, a refusal criteria of 20 blows for the last 25 millimetres of penetration would be sufficient to achieve the above allowable loads, assuming that about 35 kilojoules of energy is transferred to the pile per blow.

An allowance should be made in the specifications for this project for re-striking of all the piles at least once to confirm the design set and/or the permanence of refusal and to check for upward displacement due to driving adjacent piles. Piles that do not meet the design set criteria on the first re-strike should receive additional re-striking until the design set criteria is met. All re-striking should be performed after 48 hours of the previous set. Furthermore, provisions should be made for dynamic load tests on test piles and for dynamic testing and analysis on selected production piles to verify the driving resistance criteria and pile capacities.

The post construction settlement of elements of the structure, other than the elastic shortening of the piles, should be negligible for end bearing piles driven to refusal over bedrock. For pile foundations, there is no restriction on grade raise in this site

5.1.3 Ground Improvement

As an alternative to deep foundations, this site could also be suitable for ground improvement methods; such as:

- Controlled Modulus Columns (CMC), or;
- Rapid Impact Compaction.

If it is determined ground improvement methods would be suitable for this site, it allows for typical shallow foundations to be constructed onsite with an increased maximum allowable bearing pressure.

For more information about this method, it is recommended to contact a “design-build” contractor for consultation. If required, LRL can provide contact information of a contractor.

5.2 Structural Fill

For foundations set over undisturbed native soil and where excavation below the underside of the footings is performed in order to reach a suitable founding stratum, consideration should also be given to support the footings on structural fill. The structural fill should be placed over undisturbed native soils in layers not exceeding 300 mm and compacted to 98% of its Standard Proctor Maximum Dry Density (SPMDD) within ±2% of its optimum moisture content. In order to allow the spread of load beneath the footings and to prevent undermining during construction, the structural fill should extend minimum 1.0 m beyond the outside edges of the footings and then outward and downward at 1 horizontal to 1 vertical profile (or flatter) over a distance equal to the depth of the structural fill below the footing. Furthermore, the structural fill must be tested to ensure that the specified compaction level is achieved.

5.3 Sliding Resistance

Table 5 below outlines the unfactored friction coefficients that can be used when calculating the sliding resistance between two (2) different materials.

Table 5: Unfactored Friction Coefficients

Material #1	Material #2	Unfactored Friction Coefficient
Concrete	Silty Clay	0.30
Concrete	Structural Fill	0.55

5.4 Settlement

The estimated total settlement of the shallow foundations, designed using the recommended serviceability limit state capacity value, as well as other recommendations given above, will be less than 25 mm. The differential settlement between adjacent column footings is anticipated to be 15 mm or less.

5.5 Seismic

Frontwave Geophysics was retained by the client to carry-out shear wave velocity testing for the purposes of Seismic Site Classification.

In summary, the report concludes the site can be classified as Seismic Site Class “C”.

For your reference, the report is attached in **Appendix E.**

5.6 Liquefaction Potential

Referring to Canadian Foundation Engineering Manual, 2006, the following criteria can be used to determine liquefaction susceptibility of fine grained soils.

- $w/w_L \geq 0.85$ and $I_p \leq 12$: Susceptible to liquefaction or cyclic mobility
- $w/w_L \geq 0.8$ and $12 \leq I_p \leq 20$: Moderately susceptible to liquefaction or cyclic mobility
- $w/w_L < 0.8$ and $I_p \geq 20$: No liquefaction or cyclic mobility, but may undergo significant deformations if cyclic shear stress > static undrained shear strength.

Based on the laboratory results, the silty clay deposit is not susceptible to liquefaction.

5.7 Frost Protection

All exterior footings for any heated structure exposed to frost conditions should have a minimum of 1.5 m of earth cover. Footings for any unheated structures, signage, lighting etc. and where snow will be cleared, 1.8 m of earth cover is required. Alternatively, the required frost protection could be provided using a combination of earth cover and extruded polystyrene insulation. Detailed guidelines for footing insulation frost protection can be provided upon request.

In the event that foundations are to be constructed during winter months, the foundation soils are required to be protected from freezing temperatures using suitable construction techniques. The base of all excavations should be insulated from freezing temperatures immediately upon exposure, until heat can be supplied to the building interior and the footings have sufficient soil cover to prevent freezing of the subgrade soils.

5.8 Foundation Drainage

Permanent perimeter drainage is only required for buildings where basements or whenever any open spaces are located below the finish ground. It is our understanding that a partial basement is being considered as part of the proposed development and hence perimeter drainage is required.

In order to minimize ponding of water adjacent to the foundation walls, roof water should be controlled by a roof drainage system that directs water away from the building to prevent ponding of water adjacent to the foundation wall.

5.9 Foundation Walls Backfill (Shallow Foundations)

To prevent possible foundation frost jacking and lateral loading, the backfill material against any foundation walls, grade beams, isolated walls, or piers should consist of free draining, non-frost susceptible material such as sand or sand and gravel meeting OPSS Granular B Type II or equivalent grading requirements.

The foundation wall backfill should be compacted to minimum 95% of its SPMDD using light compaction equipment, where no loads will be set over top. The compaction shall be increased to 98% of its SPMDD under walkways, slabs or paved areas close to the foundation or retaining walls. Backfilling against foundation walls should be carried out on both sides of the wall at the same time where applicable.

5.10 Slab-on-grade Construction

Concrete slab-on-grade should rest directly over a minimum 150 mm thick layer of OPSS Granular A, compacted to 98% of its SPMDD. Prior to the placement of Granular A, all organic or otherwise deleterious material shall be removed from the proposed building's footprint down to the native subgrade surface. The subgrade should then be inspected and approved by qualified geotechnical personnel prior to placement of Granular A.

It is also recommended that the area of extensive exterior slab-on-grade (sidewalks, ramp etc.) shall be constructed using Granular A base of thickness 150 mm. The modulus of subgrade reaction (ks) for the design of the slabs is **18 MPa/m.**

In order to further minimize and control cracking, the floor slab shall be provided with wire or fibre mesh reinforcement and construction or control joints. The construction or control joints should be spaced equal distance in both directions and should not exceed 4.5 m. The wire or fibre mesh reinforcement shall be carried out through the joints.

5.11 Retaining Walls and Shoring

The following **Table 6** below provides the suggested soil parameters for the design of retaining wall and/or shoring systems. For excavations near existing services and structures, the coefficient of earth pressure at rest (K_o) should be used. Material properties for shoring and permanent wall design (static) are shown in details in **Table 6**.

Table 6: Material Properties for Shoring and Permanent Wall Design (Static)

Type of Material	Bulk Density (kN/m^3)	Friction Angle (Φ)	Pressure Coefficient			
			At Rest (K_0)	Active (K_A)	Passive (K_P)	Combined Static and Seismic Active Earth Pressure Coefficient (K_{AE})
Granular A	23.0	34	0.44	0.28	3.54	0.40
Granular B Type I	20.0	31	0.49	0.32	3.12	0.44
Granular B Type II	23.0	32	0.47	0.31	3.25	0.43
Silty Clay	18.0	28	0.48	0.36	2.76	0.48
Glacial Till	21.0	34	0.44	0.28	3.54	0.40

The above values are for a flat surface behind the wall, a straight wall and a wall friction angle of 0 ^{o}. The designer should consider any difference between these coefficients, and make appropriate corrections for a sloped surface behind the wall, angled wall or wall friction as required. The bearing capacity for the design of a retaining wall are the same as provided for the building structure provided it is founded over the same soil stratum.

Retaining walls should also be designed to resist the earth pressures produces under seismic conditions. The total active thrust (P_{AE}) in seismic condition includes both a static component (P_A) and a dynamic component (ΔP_{AE}), and can be calculated as follows:

The active thrust, $P_{AE} = P_A + \Delta P_{AE}$

Where

$P_A = ½ K_A \gamma H^2$

(K_A = 0.31 for Granular B Type II. For other material, use relevant value for K_A from the above Table 4)

H = Total height of the wall (m)

γ = Unit weight of the backfill material (kN/m^3)

These dynamic thrust (ΔP_{AE}) can be calculated from

$$\Delta P_{AE}, = 0.375\ (a_c \gamma H^2/g)$$

Where

$$a_c = (1.45 - a_{max}/g)a_{max}$$

The peak ground acceleration (PGA) or a_{max}, for this area is 0.32g according to 2015 National Building Code Seismic Hazard Calculation and acceleration of gravity, g = 9.81 m/s^2. The seismic coefficient in the vertical direction is assumed to be negligible. The total active thrust P_{AE} may be considered to act at a height, h (m), from the base of the wall,

$$h = [P\ (H/3) + \Delta P_{AE}\ (0.6H)]/\ P_{AE}$$

Internal force acting on the reinforced zone, $P_{IR} = a_c \gamma_r HL/g$

Where

γ_r is the unit weight of reinforced zone.

Add P_{AE} and 0.5 P_{IR} to check the stability. Factor of safety (Seismic) ≥ 0.75 Factor of safety (Static).

5.12 Basement Slab Construction

Basement floor slabs shall be founded on a minimum of 200 mm thick layer of 19 mm clear stone meeting the **OPSS 1004** gradation requirements should be placed.

An under-floor drainage system with an invert located a minimum of 300 mm below the underside of basement slab is recommended to be installed. This shall be comprised of 100 mm diameter weeping tile pre-wrapped with geotextile knitted sock, embedded in a 150 mm layer of 19 mm clear stone. It should installed in one direction below the slab and connected to a sump/frost-free outlet of the exterior weeping tile from which water is pumped to the nearby ditches or storm sewer line, if available.

Proper moisture barrier with vapour retarder should be used for any slab on grade where the floor will be covered by moisture sensitive flooring materials/equipment or environment will exist.

5.13 Corrosion Potential and Cement Type

Two (2) soil samples were submitted to Paracel Laboratories Ltd. for chemical testing. The following **Table 7** below summarizes the results.

Table 7: Results of Chemical Analysis

Sample Location	Depth (m)	pH	Sulphate (µg/g)	Chloride (µg/g)	Resistivity (Ohm.cm)
BH21-6	7.6 – 8.2	7.76	279	9	2,250
BH21-12	1.5 – 2.1	7.07	102	132	2,690

Based on the CAN/CSA-A23.1 standards (Concrete Materials and Methods of Concrete Construction), a sulphate concentration of less than 1000 µg/g falls within the negligible category for sulphate attack on buried concrete. The test results from soil samples were below the noted threshold. As such, buried concrete for footings and foundations walls

will not require any special additive to resist sulphate attack and the use of normal Portland cement is acceptable.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. Based on the above results, the soil resistivity falls within the highly corrosive range.

5.14 Tree Planting Guidelines

As indicated above in Section 4.6, the Plasticity Index (PI) of the cohesive soils below the underside of footing onsite are less than 40% (BH21-7, PI=37%) . This confirms the site is considered a low-medium sensitive area for tree planting; as outlined in the "Tree Planting in Sensitive Marine Clay Soils – 2017 Guidelines" document.

Large trees (mature height greater than 14 m) may be planted onsite if the setback distance to the foundation is at least equal to the mature tree height.

Small (7.5 m mature tree height) to medium (7.5 – 14 m mature tree height) trees may be planted onsite provided they are set back a minimum of 4.5 m from the foundation if the following conditions are met:

- The USF is 2.1 m or greater below the lowest finished grade.
- A small tree must have a minimum of 25 m^3 of available soil volume, and a medium tree must be provided with a minimum of 30 m^3 of available soil volume as determined by a landscape architect.
- Foundation walls are reinforced with two (2) upper and two (2) lower 15M rebar.
- Grading surrounding the tree must promote draining to the tree root zone.

6 EXCAVATION AND BACKFILLING REQUIREMENTS

6.1 Excavation

Excavations being carried out will be through silty clay. Excavation must be carried out in accordance with Occupational Health and Safety Act and Regulations for Construction Projects.

According to the Ontario's Occupational Health and Safety Act (OHSA), O. Reg. 213/91 and its amendments, the surficial overburden expected to be excavated into at this site can be classified as Type 3. Therefore, shallow temporary excavations in overburden soil classified as Type 3 can be cut at 1 horizontal to 1 vertical (1H: 1V), for a fully drained excavation starting at the base of the excavation and as per requirements of the OHSA regulations.

In the event that the aforementioned slopes are not possible to achieve due to space restrictions, the excavation shall be shored according to OHSA O. Reg. 213/91 and its amendments. A shoring design team shall design and approve the shoring and establish the shoring depth under the excavation profile. Refer to the parameters provided in **Table 6** in **Section 5.11** for use in the design of any shoring structures.

Any excavated material stockpiled near an excavation or trench should be stored at a distance equal to or greater than the depth of the excavation/trench and construction equipment, traffic should be limited near open excavation.

6.2 Groundwater Control

Based on the subsurface conditions encountered at this site, some groundwater seepage or infiltration from the native soils into the shallow temporary excavations during construction is expected. However, it is anticipated that pumping from open sumps should be sufficient to control groundwater inflow. Any groundwater seepage or infiltration entering the excavation should be removed from the excavation by pumping from sumps within the excavations. Surface water runoff into the excavation should be minimized and diverted away from the excavation if possible.

A permit to take water (PTTW) is required from Ministry of Environment and Climate Change (MOECC), Ontario Reg. 387/04, if more than 400,000 litres per day of groundwater will be pumped during a construction period less than 30 days. Registration in the Environmental Activity and Sector Registry (EASR) is required when the takings of ground water and storm water for the purpose of dewatering construction projects range between 50,000 and 400,000 litres per day.

Based on the field investigation through localized borings, it is anticipated that pumping of groundwater should not exceed 50,000 litres per day. As such, EASR registration would not be required for this site. However, this can be confirmed by undertaking a hydrogeological study to determine the maximum volume of groundwater inflow requiring dewatering.

6.3 Pipe Bedding Requirements

It is anticipated that the subgrade material for any underground services required as part of this project will be founded over the native silty clay material. Any sub-excavation of disturbed soil should be removed and replaced with a Granular A, Granular B Type II or I or approved equivalent, laid in loose lifts of thickness not exceeding 300 mm and compacted to 95% of its SPMDD. Bedding, thickness of cover material and compaction requirements for any pipes should conform to the manufacturers design requirements and to the detailed installations outlined in the Ontario Provincial Standard Specifications (OPSS) and any applicable standards or requirements. At minimum, a 150 mm thick layer of Granular A shall be used as pipe bedding, at the springline of the pipe, and a 300 mm thick layer above the obvert of the pipe.

If sewers are required to be founded below the groundwater table the native materials may be sensitive to disturbances. Therefore, special precautions should be taken in these areas to stabilize and confine the base of the excavation such as using recompression (thicker bedding) and/or dewatering methods (pumping). In order to properly compact the bedding, the water table should be kept at least 300 mm below the base of the excavation at all time during the installation of any sewers and structures.

As an alternative to Granular A bedding and only where wet conditions are encountered, the use of “clear stone” bedding, such as 19 mm clear stone, **OPSS 1004**, may be considered only in conjunction with a suitable geotextile filter (such as terrafix 270R or approved equivalent). Without proper filtering, there may be entry of fines from native soils and trench backfill into the bedding, which could result in loss of support to the pipes and possible surface settlements. The sub-bedding, bedding and cover materials should be compacted in maximum 300 mm thick lifts to at least 95% of its SPMDD within ±2% of its optimum moisture content using suitable vibratory compaction equipment.

6.4 Trench Backfill

All service trenches should be backfilled using compactable material, free of organics, debris and large cobbles or boulders. Acceptable native materials (if encountered and where possible) should be used as backfill between the roadway subgrade level and the depth of seasonal frost penetrations (i.e. 1.8 m below finished grade) in order to reduce the potential for differential frost heaving between the new excavated trench and the adjacent section of roadway. Where native backfill is used, it should match the native materials exposed on the trench walls. Backfill below the zone of seasonal frost penetration could consist of either acceptable native material or imported granular material conforming to OPSS Granular B Type II. Any boulders larger than 150 mm in size should not be used as trench backfill.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the roadway, the trench should be compacted in maximum 300 mm thick lifts to at least 95% of its SPMDD. The specified density may be reduced where the trench backfill is not located within or in close proximity to existing roadways or any other structures.

For trenches carried out in existing paved areas, transitions should be constructed to ensure that proper compaction is achieved between any new pavement structure and the existing pavement structure to minimize potential future differential settlement between the existing and new pavement structure. The transition should start at the subgrade level and extend to the underside of the asphaltic concrete level (if any) at a 1 horizontal to 1 vertical slope. This is especially important where trench boxes are used and where no side slopes are provided to the excavation. Where asphaltic concrete is present, it should be cut back to a minimum of 150 mm from the edge of the excavation to allow for proper compaction between the new and existing pavement structures.

7 SLOPE STABILITY ANALYSIS

The slope under investigation is located at the eastern portion of the site, adjacent to the property limit. The top of the slope will tie into existing grades at the property limits. The slope will slope downwards towards a parking area. Slope protection is proposed to be installed on the slope to help provide stability. The slope protection is recommended to consist of a non-woven geotextile fabric, overlaid with a 100 – 150 mm thick layer of Granular A, overlaid by a minimum 600 mm thick layer of 200 – 400 mm diameter rip rap.

The maximum allowable slope of the rip rap protection should match the proposed grades of the slope indicated on the Grading Plan, generated by Dillon Consulting, dated 20/01/2023, steeper grades would result in LRL needing to re-run modelling results to ensure the below results are still deemed satisfactory.

The slope profile used in the modelling was obtained from the project's Grading Plan.

7.1 Slope Stability Results

The slope modelling program, Slide 5.0 (Rocscience), was used to implement the Bishop simplified method of slices. A slope profile, considered to be the steepest onsite (worst case scenario) was selected and modeled to check the conditions of the slope. The slope was analyzed under both the undrained (short term failure) and drained (long term failure) conditions.

The seismic analysis was performed by incorporating the seismic coefficient (k_h) into the modelling. The peak ground acceleration (PGA) for this area is equal to 0.32 for the 2% in 50 year probability of exceedance as per the NBC 2015. The value for k_h was taken as

50% of the PGA, which equates to 0.16. The minimum factor of safety (FoS) with regards to seismic condition is 1.10.

The field measurements from the boreholes in conjunction with known published data of the materials encountered onsite were used for selection of appropriate soil modelling parameters in the slope stability analyses.

The results of the analyses are potentially dependent on the assumption of groundwater condition. During the development of this report, no information on the groundwater level was available throughout the year. However, as a conservative approach the analysis was completed assuming full saturation throughout the slope profile.

Table 8: Soil Parameters used in Slope Stability Analysis

Soil Type	Effective cohesion (c') - KPa	Angle of internal friction (ϕ') - degrees	Bulk unit weight (γ_B) – KN/m^3
Drained Parameters (Long Term)			
Rip-Rap	-	-	22.0
Pavement Structure	-	-	22.0
Silty Clay	8	36	18.5
Till	1	38	21.0
Undrained Parameters (Short Term)			
Rip-Rap	-	-	22.0
Pavement Structure	-	-	22.0
Silty Clay	75	-	18.5
Till	1	38	21.0

The below **Table 9** is a summary of the factor of safety (FoS).

Table 9: FOS Values for Slope Stability Modelling

	Drained Condition	Undrained Condition	Seismic
Factor of Safety	2.21	9.95	4.43
Min. Required	**1.50**	**1.50**	**1.10**

These results indicate that the slope will remain stable in both the short and long term, and in the event of seismic activity.

The model results are included in **Appendix F.**

7.2 Conclusions/Recommendations

The following recommendations should be adhered to during the construction and post construction to ensure the long-term stability of the slopes.

- Any existing vegetation cover near and within the existing slope should not be disturbed any more than is absolutely necessary for any proposed construction, as it promotes stability and erosion control to the slope.
- If grades are altered from what is proposed in the above-mentioned Grading Plan, LRL shall be retained to review that these changes do not affect stability of the slope.

- Any site drainage should be diverted away from the slope. Drainage outlets, if any, shall be protected with riprap over approved geotextile to eliminate erosion in the slope.

8 REUSE OF ON-SITE SOILS

The existing surficial overburden soils consist mostly of silty clay. The overburden silty clay is considered to be frost susceptible and should not be used as backfill material directly against foundation walls or underneath unheated concrete slabs. However, these could be reused as general backfill material (service trenches, general landscaping/backfilling) if it can be compacted according to the specifications outlined herein at the time of construction and found free from any waste, organics and debris. Typically, cohesive material similar to what was encountered onsite will require a "sheep's foot" steel drum roller in order to properly consolidate. Any imported material shall conform to OPSS Granular B – Type II or approved equivalent.

It should be noted that the adequacy of any material for reuse as backfill will depend on its water content at the time of its use and on the weather conditions prevailing prior to and during that time. Therefore, all excavated materials to be reused shall be stockpiled in a manner that will prevent any significant changes in their moisture content, especially during wet conditions. Any excavated materials proposed for reuse should be stockpiled in a manner to promote drying and should be inspected and approved for reuse by a geotechnical engineer.

9 RECOMMENDED PAVEMENT STRUCTURE

It is anticipated that the subgrade soil for the new parking and access lanes will consist of silty clay. The construction of access lanes and parking areas will be acceptable over the undisturbed silty clay once all debris, organic material, or otherwise deleterious material are removed from the subgrade area. Furthermore, the silty clay must be compacted using a suitable heavy duty compacting equipment and approved by a geotechnical engineer prior to placing any granular base material.

The calculated minimum Granular Base Equivalency (GBE) is 450 and 630 for light and heavy duty pavement respectively. The following **Table 10** presents the recommended pavement structures to be constructed over a stable subgrade along the proposed parking areas and access lane or driveway as part of this project.

Table 10: Recommended Pavement Structure

Course	Material	Thickness (mm)	
		Light Duty Parking Area (mm)	Heavy Duty Parking Area (Access Roads, Fire Routes and Trucks) (mm)
GBE		450	630
Surface	HL3 A/C	50	40
Binder	HL8 A/C	-	50
Base course	Granular A	150	150
Sub base	Granular B Type II	300	450
Total:		500	690

Performance Graded Asphaltic Cement (PGAC) **58-34** is recommended for this project.

The base and subbase granular materials shall conform to **OPSS 1010** material specifications. Any proposed materials shall be tested and approved by a geotechnical engineer prior to delivery to the site and shall be compacted to 95% of its SPMDD. Asphaltic concrete shall conform to **OPSS 1150** and be placed and compacted to at least 95% of the Marshall Density. The mix and its constituents shall be reviewed, tested and approved by a geotechnical engineer prior to delivery to the site.

9.1 Paved Areas & Subgrade Preparation

The access lanes and parking areas shall be stripped of vegetation, debris and other obvious objectionable material. Following the backfilling and satisfactory compaction of any underground service trenches up to the subgrade level, the subgrade shall be shaped, crowned and proof-rolled. A loaded Tandem axle, dual wheel dump truck or approved equivalent heavy duty smooth drum roller shall be used for proof-rolling. Any resulting loose/soft areas should be sub-excavated down to an adequate bearing layer and replaced with approved backfill.

The preparation of subgrade shall be scheduled and carried out in manner so that a protective cover of overlying granular material (if required) is placed as quickly as possible in order to avoid unnecessary circulation by heavy equipment, except on unexcavated or protected surfaces. Frost protection of the surface shall be implemented if works are carried out during the winter season.

The performance of the pavement structure is highly dependent on the subsurface groundwater conditions and maintaining the subgrade and pavement structure in a dry condition. To intercept excess subsurface water within the pavement structure granular materials, sub-drains with suitable outlets should be installed below the pavement area's subgrade if adequate overland flow drainage is not provided (i.e. ditches). The surface of the pavement should be properly graded to direct runoff water towards suitable drainage features. It is recommended that the lateral extent of the subbase and base layers not be terminated vertically immediately behind the curb/edge of pavement line but be extended beyond the curb.

10 INSPECTION SERVICES

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed site do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design.

All footing areas and any structural fill areas for the proposed structures should be inspected by LRL to ensure that a suitable subgrade has been reached and properly prepared. The placing and compaction of any granular materials beneath the foundations and slab-on-grade should be inspected to ensure that the materials used conform to the grading and compaction specifications.

The subgrade for the pavement areas and underground services should be inspected and approved by geotechnical personnel. In-situ density testing should be carried out on the pavement granular materials, pipe bedding and backfill to ensure the materials meet the specifications for required compaction.

If footings are to be constructed during winter season, the footing subgrade should be protected from freezing temperatures using suitable construction techniques.

11 REPORT CONDITIONS AND LIMITATIONS

It is stressed that the information presented in this report is provided for the guidance of the designers and is intended for this project only. The use of this report is intended for the client only. However, it may be shared with a third party provided LRL receives a written notice of the distribution of the report. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

The professional services for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible contamination resulting from previous uses or activities at this site or adjacent properties, and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report.

The recommendations provided in this report are based on subsurface data obtained at the specific boring locations only. Boundaries between zones presented on the borehole are often not distinct but transitional and were interpreted. Experience indicates that the subsurface soil and groundwater conditions can vary significantly between and beyond the test locations. For this reason, the recommendations given in this report are subject to a field verification of the subsurface soil conditions at the time of construction.

The recommendations are applicable only to the project described in this report. Any changes to the project will require a review by LRL Associates Ltd., to insure compatibility with the recommendations contained in this project.

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we may be of further services to you, please do not hesitate to contact the undersigned.

Yours truly,
LRL Associates Ltd.

Brad Johnson, P. Eng.
Geotechnical Engineer

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APPENDIX A

Site and Borehole Location Plan

LRJ
ENGINEERING | INGÉNIERIE
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www.lrl.ca | (613) 842-3434

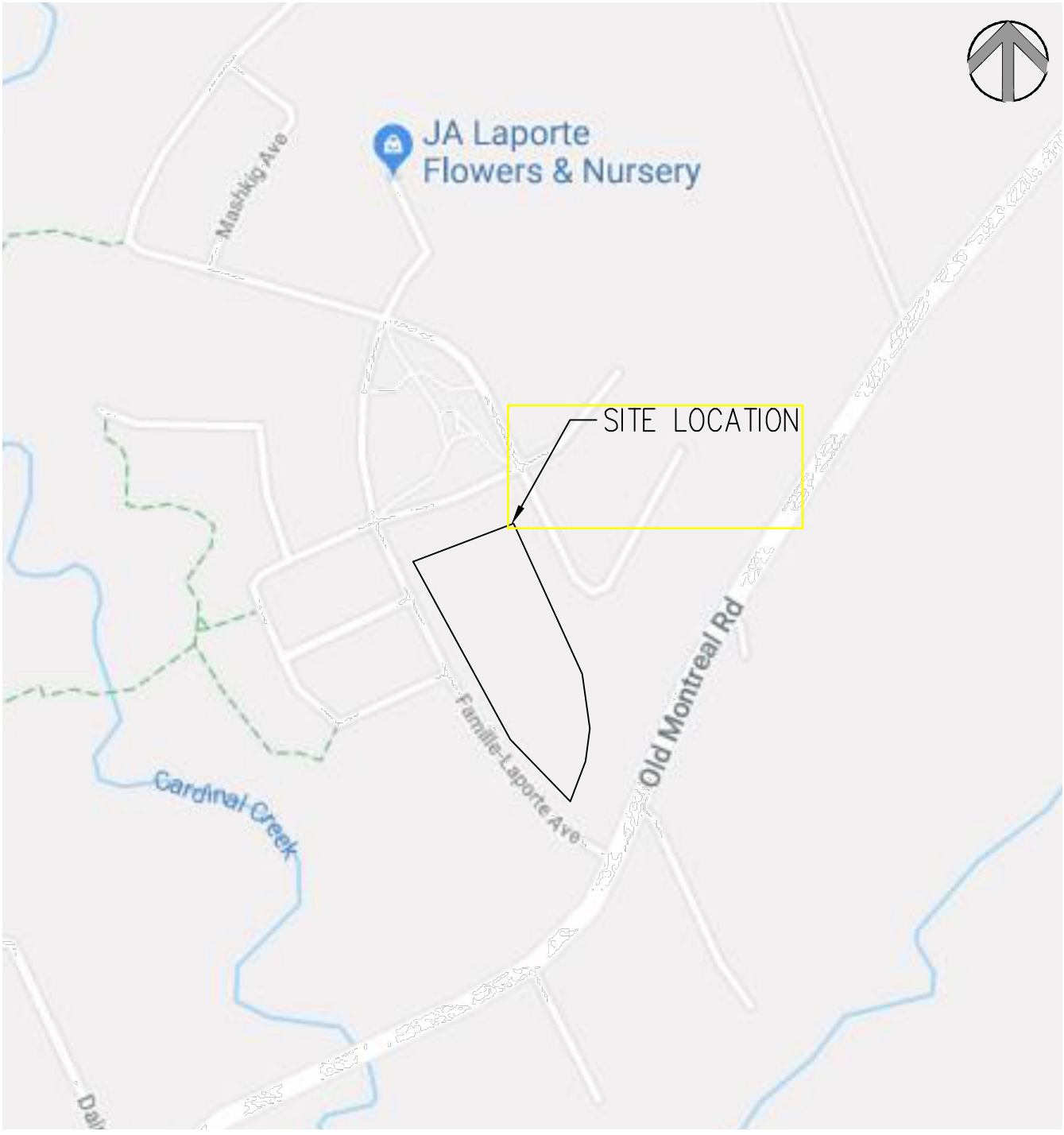
PROJECT

GEOTECHNICAL INVESTIGATION
ORLEANS LTC
FAMILLE-LAPORTE AVE.
ORLEANS, ONTARIO

DRAWING TITLE

SITE LOCATION
SOURCE: GOOGLE MAPS 2021

CLIENT	DATE	PROJECT	
ARCH CORPORATION	SEPTEMBER 2021	210587	FIGURE 1



LRJ
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www.lrl.ca | (613) 842-3434

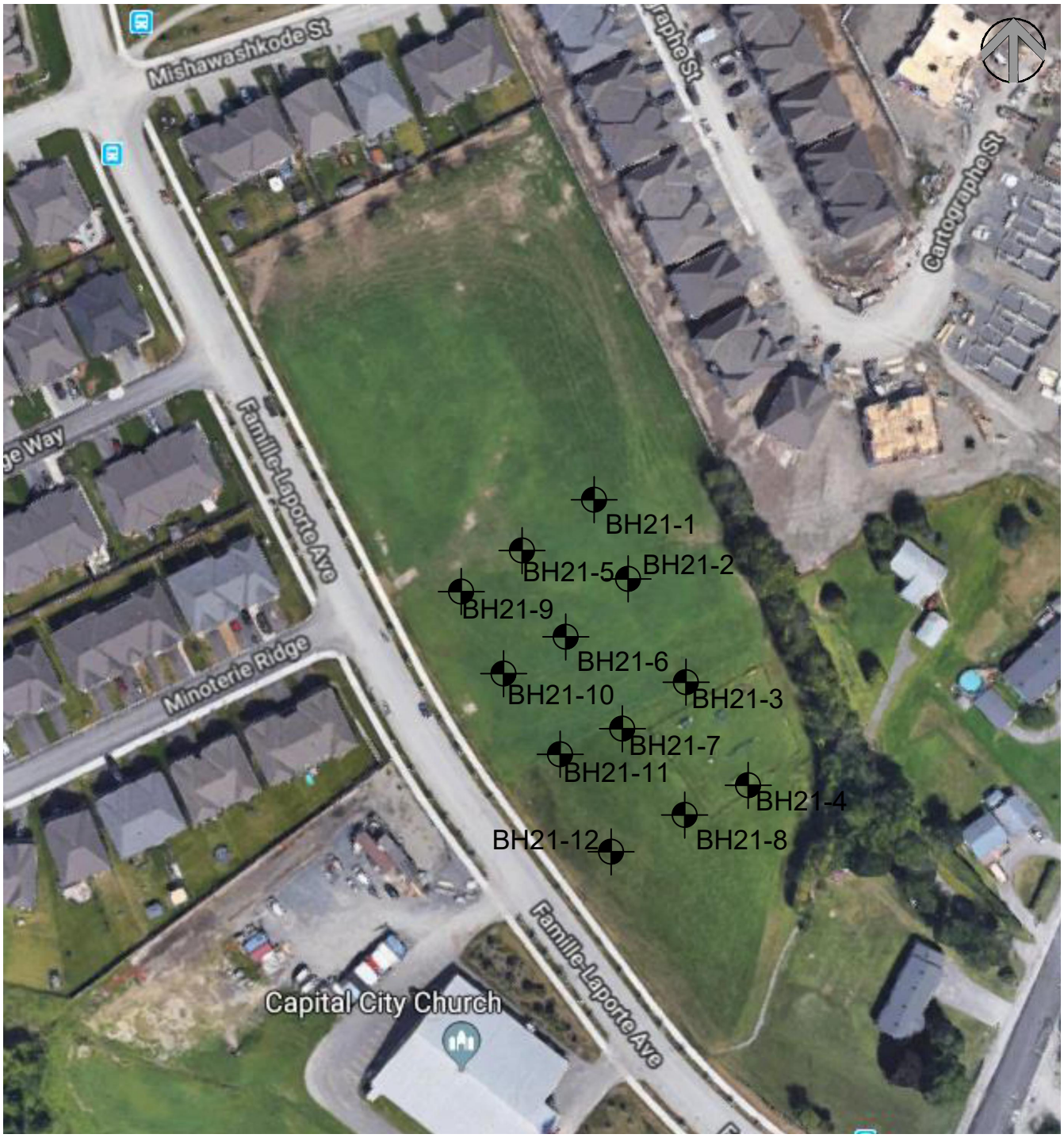
PROJECT

GEOTECHNICAL INVESTIGATION
ORLEANS LTC
FAMILLE-LAPORTE AVE.
ORLEANS, ONTARIO

DRAWING TITLE

BOREHOLE LOCATION
SOURCE: Imagery 2021 Google, DigitalGlobe Map Data

CLIENT	DATE	PROJECT	
ARCH CORPORATION	SEPTEMBER 2021	210587	FIGURE 2



APPENDIX B
Borehole Logs

Borehole Log: BH21-1

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
ft / m	Ground Surface	67.38							
0 / 0	**TOPSOIL** clayey, about 600 mm thick.	0.00							
1		66.78		SS1	10	42	10	33	
2	**SILTY CLAY** brownish grey, moist, stiff, becoming very soft with increased depth.	0.60							
3 / 1				SS2	13	92	13		
5				SS3	10	100	10	44	
6 / 2									
7				SS4	5	100	5		
8									
9									
10 / 3				SS5	2	100	2	64	
11									
12									
13 / 4							96		
14							92		
15									
16 / 5				SS6	WH	100	0		
17									
18							78		
19							72		

Easting: 463364 m **Northing:** 5038167 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 67.38 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-1

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21				SS7	1	100	1	61	
22									
23 — 7							76		
24							80		
25									
26 — 8				SS8	1	100	1		
27									
28							74		
29		58.54					80		
9	End of Borehole	8.84							
30									
31									
32									
33 — 10									
34									
35									
36 — 11									
37									
38									
39									

NOTES

Borehole Log: BH21-2

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA								
Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	Shear Strength (kPa) 50–150 / SPT N Value (Blows/0.3 m) 20–80	Water Content (%) 25–75 / Liquid Limit (%) 25–75	Monitoring Well Details
Ground Surface		67.40							
TOPSOIL clayey, about 600 mm thick.		0.00		SS1	15	58	15		
		66.80							
SILTY CLAY brownish grey, moist, stiff, becoming very soft with increased depth.		0.60		SS2	15	92	15	38	
				SS3	8	100	8		
				SS4	4	100	4	52	
				SS5	2	100	2		
				SS6	1	100	1	65	
							86		
							92		

Easting: 463375 m **Northing:** 5038148 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 67.40 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-2

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21				SS7	1	100	1		
22									
23	7						84		
24							82		
25									
26	8			SS8	1	100	1	50	
27									
28							74		
29		58.56					78		
		8.84							
	End of Borehole								
30	9								
31									
32									
33	10								
34									
35									
36	11								
37									
38									
39									

NOTES

Borehole Log: BH21-3

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

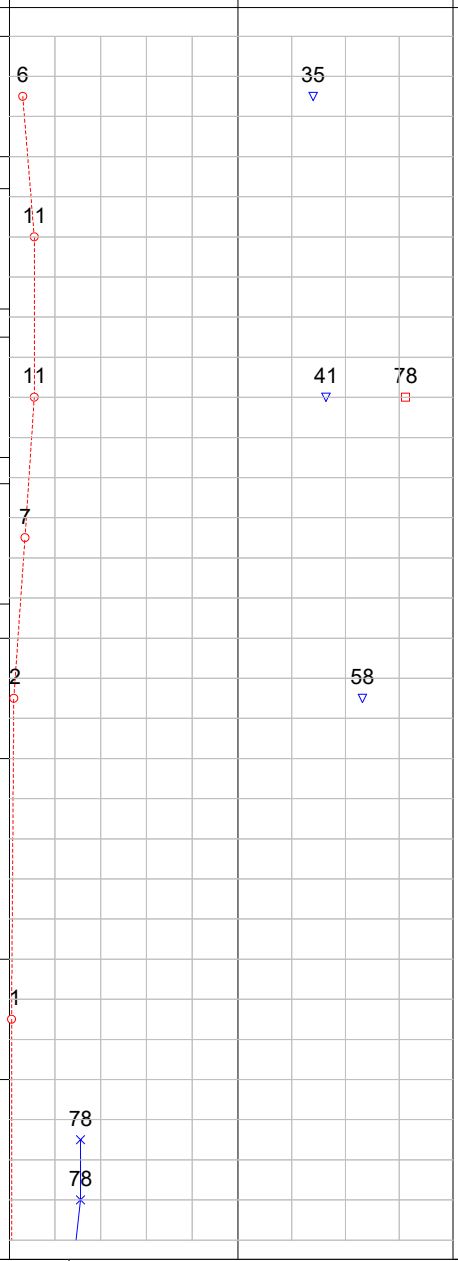
Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)
0 / 0	Ground Surface	67.95				
0 – 1	**TOPSOIL** clayey, about 600 mm thick.	0.00		SS1	6	42
2 – 4 / 1	**SILTY CLAY** brownish grey, moist, very stiff, becoming very soft with increased depths.	67.35 0.60		SS2	11	100
5 – 7 / 2				SS3	11	100
8 – 9				SS4	7	100
10 – 11 / 3				SS5	2	100
12 – 15 / 4 – 5				SS6	1	100
16 – 19						

Shear Strength (kPa) 50 150 — SPT N Value (Blows/0.3 m) 20 40 60 80

Water Content (%) 25 50 75 — Liquid Limit (%) 25 50 75

Monitoring Well Details



Easting: 463385 m **Northing:** 5038127 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 67.95 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-3

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA							
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
20									
21				SS7	1	100	1	70	
22									
23	7						48		
24							82		
25									
26	8			SS8	1	100	1		
27									
28							80		
29							38		
30	9						2		
31	Dynamic Cone Penetration (DCP) Test started at 9.1 m bgs.						3		
32							3		
33	10						3		
34							4		
35							5		
36	11						6		
37							7		
38							7		
39							7		

NOTES

Borehole Log (continued): BH21-3

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
40		55.75					10		
	INFERRED GLACIAL TILL	12.20							
41							35		
42							37		
43	13	54.84					50+		
	End of Borehole	13.11							
44									
45									
46	14								
47									
48									
49	15								
50									
51									
52	16								
53									
54									
55									
56	17								
57									
58									
59									

NOTES

Borehole Log: BH21-4

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)
0 / 0	Ground Surface	68.66				
0 / 0	**TOPSOIL** clayey, about 600 mm thick.	0.00				
		68.06		SS1	5	50
2 / 0.6	**SILTY CLAY** brownish grey, moist, stiff, becoming very soft with increased depth.	0.60				
3 / 1				SS2	10	50
6 / 2				SS3	9	100
8 / 2				SS4	5	100
11 / 3				SS5	3	100
16 / 5				SS6	1	100
19						

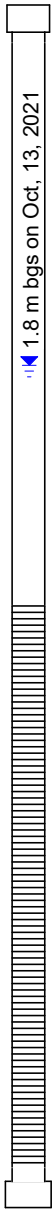
SPT N Value (Blows/0.3 m): 5, 10, 9, 5, 3, 92, 88, 1, 76, 82

Shear Strength (kPa): 50 – 150

Water Content (%): 25 – 50 – 75

Liquid Limit (%): 25 – 50 – 75

Monitoring Well Details



Easting: 463398 m **Northing:** 5038109 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 68.66 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-4

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21				SS7	1	100	1		
22									
23							84		
24							66		
25									
26				SS8	1	100	1	60	
27									
28							82		
29		59.82					83		
30	End of Borehole	8.84							
31									
32									
33									
34									
35									
36									
37									
38									
39									

7 8 9 10 11

NOTES

Borehole Log: BH21-5

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)
0 / 0	Ground Surface	67.25				
0 – 1 / 0	**TOPSOIL** clayey, about 600 mm thick.	0.00 – 66.65		SS1	16	42
2 – 6 / 1 – 2	**SILTY CLAY** brownish grey, moist, very stiff, becoming very soft with increased depth.	0.60		SS2	16	67
				SS3	15	100
				SS4	6	100
10 – 11 / 3				SS5	3	100
15 – 16 / 5				SS6	1	100
17 – 19						

Shear Strength (kPa) 50 150 — SPT N Value (Blows/0.3 m) 20 40 60 80

Water Content (%) 25 50 75 — Liquid Limit (%) 25 50 75

SPT N Value: 16, 16, 15, 6, 3, 1, 54, 68

Water Content: 9, 39, 58

Monitoring Well Details: 2.3 m bgs on Oct, 13, 2021

Easting: 463346 m **Northing:** 5038161 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 67.25 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-5

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21				SS7	1	100	1	54	
22									
23							84		
24							86		
25									
26				SS8	1	100	1		
27									
28							80		
29		58.41					78		
30	End of Borehole	8.84							
31									
32									
33									
34									
35									
36									
37									
38									
39									

7 8 9 10 11

NOTES

Borehole Log: BH21-6

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 15, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
0 / 0	Ground Surface	67.45							
0 – 1 / 0	**TOPSOIL** clayey, about 600 mm thick.	0.00		SS1	11	33	11		
		66.85							
2 – 4 / 1	**SILTY CLAY** brownish grey, moist, stiff, becoming very soft with increased depth.	0.60		SS2	10	83	10	39	
5 – 7 / 2				SS3	13	100	13		
8 – 9 / 2				SS4	8	100	8	45	
10 – 11 / 3				SS5	4	100	4		
12 – 15 / 4									
16 / 5				SS6	2	100	2	70	
17 – 19 / 5							46 56		

Easting: 463357 m **Northing:** 5038142 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 67.45 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-6

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 15, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21									
22				SS7	WH	100	0		
23	7						82		
24							76		
25									
26	8			SS8	1	100	1	59	
27									
28							74		
29		58.61					72		
	End of Borehole	8.84							
30	9								
31									
32									
33	10								
34									
35									
36	11								
37									
38									
39									

NOTES

Borehole Log: BH21-7

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 15, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)
0 / 0	Ground Surface	68.25				
0 – 2 / 0 – 0.6	**TOPSOIL** clayey, about 600 mm thick.	0.00		SS1	6	42
2 – 19 / 0.6 – 5.8	**SILTY CLAY** brownish grey, moist, very stiff, becoming very soft with increased depth.	0.60		SS2	20	54
				SS3	15	88
				SS4	9	100
				SS5	5	100
				SS6	WH	100
		67.65				

Shear Strength (kPa) 50 150 | SPT N Value (Blows/0.3 m) 20 40 60 80: 6, 20, 15, 9, 5, 0, 66, 76

Water Content (%) 25 50 75 | Liquid Limit (%) 25 50 75: 34, 40, 54

Monitoring Well Details

Easting: 463370 m **Northing:** 5038114 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 68.25 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-7

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 15, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21				SS7	WH	100	0	62 64	
22									
23 — 7							84		
24							78		
25									
26 — 8				SS8	1	100	1		
27									
28							82		
29 — 9	End of Borehole	59.41 8.84					92		
30									
31									
32									
33 — 10									
34									
35									
36 — 11									
37									
38									
39									

NOTES

Borehole Log: BH21-8

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 15, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
ft / m	Ground Surface	68.70							
0 / 0	**TOPSOIL** clayey, about 600 mm thick.	0.00							
		68.10							
2 /	**SILTY CLAY** brownish grey, moist, very stiff, becoming very soft with increased depth.	0.60							
3 / 1				SS2	10	25	10	30	
5 /				SS3	14	88	14		
6 / 2									
8 /				SS4	10	100	10	43	
9 /									
10 / 3				SS5	4	100	4		
12 /									
13 / 4									
15 /				SS6	2	100	2	65	
16 / 5									
17 /							100+		
18 /							100+		
19 /									

Easting: 463391 m **Northing:** 5038088 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 68.70 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-8

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 15, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21									
22				SS7	WH	100	0		
23	**SILT and CLAY** grey, moist, very soft.	61.85 6.85					96 84		
24									
25									
26				SS8	WH	100	0	54	
27									
28							82		
29	End of Borehole	59.86 8.84					80		
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									

7 8 9 10 11

NOTES

Borehole Log: BH21-9

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
ft / m	Ground Surface	67.08							
0 / 0	**TOPSOIL** clayey, about 600 mm thick.	0.00							
		66.48		SS1	15	50	15	25	
2	**SILTY CLAY** brownish grey, moist, very stiff, becoming very soft with increased depths.	0.60							
3 / 1				SS2	17	83	17		
5				SS3	11	100	11	38	
7 / 2				SS4	5	100	5		
9				SS5	2	100	2	57	
10 / 3									
12									
13 / 4									
15				SS6	1	100	1		
16 / 5									
18		61.44							
19		5.64							

Easting: 463329 m **Northing:** 5038154 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 67.08 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-9

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 14, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20	**GLACIAL TILL** silt-sand, some clay, some gravel sized stone, grey, dense.								
21				SS7	30	33	30	8	
22									
23 — 7									
24									
25				SS8	38	33			
26 — 8							38		
27									
28	Dynamic Cone Penetration (DCP) Test started at 8.5 m bgs.						54		
29							62		
30 — 9		57.94					100+		
	End of Borehole	9.14							
31									
32									
33 — 10									
34									
35									
36 — 11									
37									
38									
39									

NOTES

Borehole Log: BH21-10

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 13, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	Shear Strength (kPa) / SPT N Value (Blows/0.3 m)	Water Content (%) / Liquid Limit (%)	Monitoring Well Details
0 / 0	Ground Surface	67.50							
0 – 2 / 0 – 0.6	**TOPSOIL** clayey, about 600 mm thick.	0.00		SS1	8	50	8		
		66.90							
2 – 19 / 0.6 – 5.8	**SILTY CLAY** brownish grey, moist, very stiff, becoming very soft with increased depth.	0.60		SS2	18	75	18	34	
				SS3	12	100	12		
				SS4	6	100	6	44	
				SS5	2	100	2		
				SS6	WH	100	0	57	
							64		
							74		

Easting: 463344 m **Northing:** 50380128 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 67.50 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-10

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 13, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21									
22									
23 — 7				SS7	WH	100	0 / 76 / 84		
24									
25	**GLACIAL TILL** silt-sand, same clay, some gravel sized stone, wet, grey, compact.	60.04 / 7.46							
26 — 8				SS8	16	50	16	54	
27									
28									
29	End of Borehole	58.66 / 8.84							
30 — 9									
31									
32									
33 — 10									
34									
35									
36 — 11									
37									
38									
39									

NOTES

Borehole Log: BH21-11

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 13, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	Shear Strength (kPa) / SPT N Value (Blows/0.3 m)	Water Content (%) / Liquid Limit (%)	Monitoring Well Details
0 / 0	Ground Surface	68.00							
0 – 1	**TOPSOIL** clayey, about 600 mm thick.	0.00		SS1	8	50	8	20	
1 – 2		67.40							
2 – 3	**SILTY CLAY** brownish grey, moist, stiff, becoming very soft with increased depth.	0.60		SS2	10	58	10		
3 – 4									
4 – 5				SS3	12	100	12	33	
5 – 6									
6 – 7				SS4	12	100	12		
7 – 8									
8 – 9				SS5	6	100	6	47	
9 – 10									
10 – 11									
11 – 12				SS6	2	100	2		
12 – 13							76		
13 – 14							68		
14 – 15									
15 – 16									
16 – 17									
17 – 18									
18 – 19									

Monitoring Well Details: 1.75 m bgs on Oct 13, 2021

Easting: 463398 m **Northing:** 5038110 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 68.00 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-11

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 13, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
20									
21				SS7	WH	100	0	70	
22									
23 — 7							64		
24							72		
25									
26 — 8				SS8	1	100	1		
27									
28							76		
29 — 9	End of Borehole	59.16 8.84					80		
30									
31									
32									
33 — 10									
34									
35									
36 — 11									
37									
38									
39									

NOTES

Borehole Log: BH21-12

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 13, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
ft / m	Ground Surface	68.95							
0 / 0	**TOPSOIL** clayey, about 600 mm thick.	0.00							
		68.35		SS1	8	58	8		
2	**SILTY CLAY** brownish grey, moist, stiff, becoming very soft with increased depths.	0.60							
3 / 1				SS2	12	67	12	31	
5				SS3	13	100	13		
6 / 2									
7				SS4	10	100	10	40	
8									
9									
10 / 3				SS5	4	100	4		
11									
12									
13 / 4							100+		
14							100+		
15									
16 / 5				SS6	1	100	1	63	
17									
18							72		
19							82		

Easting: 463367 m **Northing:** 5038083 m

Site Datum: Site Benchmark 'B' (67.83 m).

Groundsurface Elevation: 68.95 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH21-12

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 13, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) / SPT N Value (Blows/0.3 m)	Water Content (%) / Liquid Limit (%)	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	50 150 / 20 40 60 80	25 50 75 / 25 50 75	
20									
21				SS7	WH	100	0		
22									
23	7						80		
24							68		
25									
26	8			SS8	WH	100	0	62	
27									
28							80		
29							82		
30	9 Dynamic Cone Penetration (DCP) Test started at 9.1 m bgs.						3		
31							3		
32							3		
33	10						4		
34							5		
35							7		
36	11						6		
37							6		
38	**INFERRED GLACIAL TILL**	57.37 / 11.58					12 / 8		
39									

NOTES

Borehole Log (continued): BH21-12

Project No.: 210587 **Project:** Orleans LTC

Client: Arch Corporation **Location:** Famille-Laporte Ave, Orleans ON

Date: September 13, 2021 **Field Personnel:** SV

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 55 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)			
40							18		
41							31		
42							20		
43 13							23		
44							25		
45							49		
46 14	End of Borehole	54.95 / 14.00					100+		
47									
48									
49 15									
50									
51									
52 16									
53									
54									
55									
56 17									
57									
58									
59									

NOTES

APPENDIX C

Symbols and Terms used in Borehole Logs

Symbols and Terms Used on Borehole and Test Pit Logs

1. Soil Description

The soil descriptions presented in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves some judgement and LRL Associates Ltd. does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice. Boundaries between zones on the logs are often not distinct but transitional and were interpreted.

a. Proportion

The proportion of each constituent part, as defined by the grain size distribution, is denoted by the following terms:

Term	Proportions
"trace"	1% to 10%
"some"	10% to 20%
prefix (i.e. "sandy" silt)	20% to 35%
"and" (i.e. sand "and" gravel)	35% to 50%

b. Compactness and Consistency

The state of compactness of granular soils is defined on the basis of the Standard Penetration Number (N) as per ASTM D-1586. It corresponds to the number of blows required to drive 300 mm of the split spoon sampler using a metal drop hammer that has a weight of 62.5 kg and free fall distance of 760 mm. For a 600 mm long split spoon, the blow counts are recorded for every 150 mm. The "N" value is obtained by adding the number of blows from the 2nd and 3rd count. Technical refusal indicates a number of blows greater than 50.

The consistency of clayey or cohesive soils is based on the shear strength of the soil, as determined by field vane tests and by a visual and tactile assessment of the soil strength.

The state of compactness of granular soils is defined by the following terms:

State of Compactness Granular Soils	Standard Penetration Number "N"	Relative Density (%)
Very loose	0 – 4	<15
Loose	4 – 10	15 – 35
Compact	10 - 30	35 – 65
Dense	30 - 50	65 - 85
Very dense	> 50	> 85

The consistency of cohesive soils is defined by the following terms:

Consistency Cohesive Soils	Undrained Shear Strength (C_u) (kPa)	Standard Penetration Number "N"
Very soft	<12.5	<2
Soft	12.5 - 25	2 - 4
Firm	25 - 50	4 - 8
Stiff	50 - 100	8 - 15
Very stiff	100 - 200	15 - 30
Hard	>200	>30

c. Field Moisture Condition

Description (ASTM D2488)	Criteria
Dry	Absence of moisture, dusty, dry to touch.
Moist	Dump, but not visible water.
Wet	Visible, free water, usually soil is below water table.

2. Sample Data

a. Elevation depth

This is a reference to the geodesic elevation of the soil or to a benchmark of an arbitrary elevation at the location of the borehole or test pit. The depth of geological boundaries is measured from ground surface.

b. Type

Symbol	Type	Letter Code
	Auger	AU
	Split Spoon	SS
	Shelby Tube	ST
	Rock Core	RC

c. Sample Number

Each sample taken from the borehole is numbered in the field as shown in this column.

LETTER CODE (as above) – Sample Number.

d. Recovery (%)

For soil samples this is the percentage of the recovered sample obtained versus the length sampled. In the case of rock, the percentage is the length of rock core recovered compared to the length of the drill run.

3. Rock Description

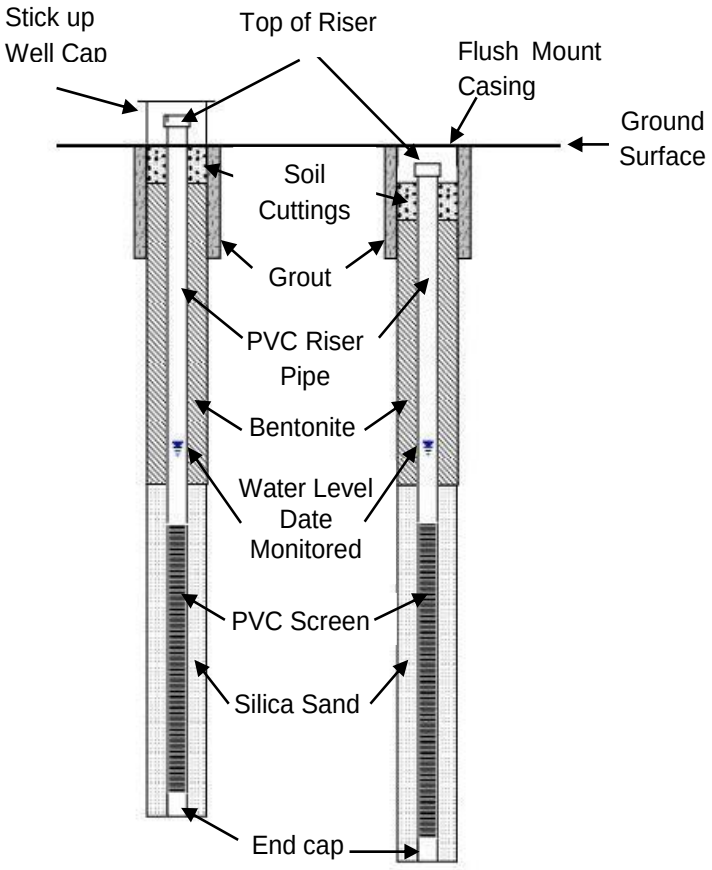
Rock Quality Designation (RQD) is a rough measure of the degree of jointing or fracture in a rock mas. The RQD is calculated as the cumulative length of rock pieces recovered having lengths of 100 mm or more divided by the length of coring. The qualitative description of the bedrock based on RQD is given below.

Rock Quality Designation (RQD) (%)	Description of Rock Quality
0 –25	Very poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

Strength classification of rock is presented below.

Strength Classification	Range of Unconfined Compressive Strength (MPa)
Extremely weak	< 1
Very weak	1 – 5
Weak	5 – 25
Medium strong	25 – 50
Strong	50 – 100
Very strong	100 – 250
Extremely strong	> 250

4. General Monitoring Well Data



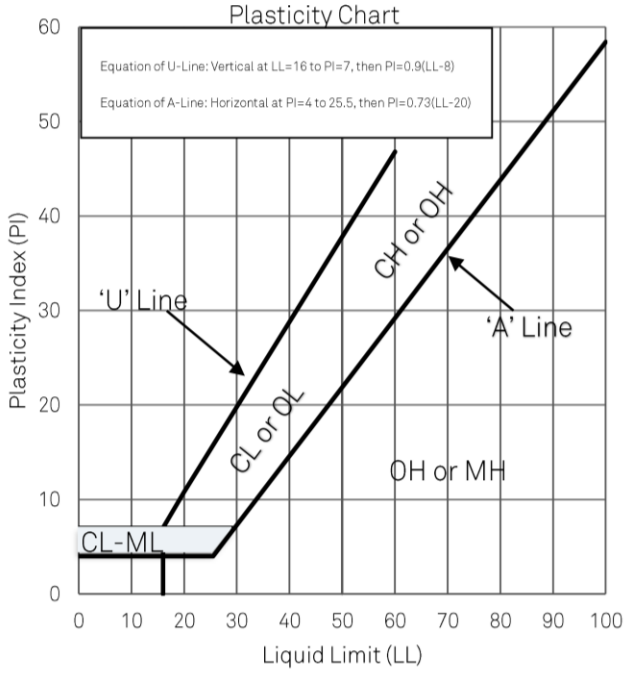
5. Classification of Soils for Engineering Purposes (ASTM D2487)

(United Soil Classification System)

Major divisions			Group Symbol	Typical Names	Classification Criteria
Coarse-grained soils More than 50% retained on No. 200 sieve* (>0.075 mm)	Gravels More than 50% of coarse fraction retained on No. 4 sieve(4.75 mm)	Clean gravels <5% fines	GW	Well-graded gravel	If 15% sand add "with sand" to group name.
			GP	Poorly graded gravel	
		Gravels with >12% fines	GM	Silty gravel	
			GC	Clayey gravel	
	Sands 50% or more of coarse fraction passes No. 4 sieve(<4.75 mm)	Clean sands <5% fines	SW	Well-graded sand	If 15% gravel add "with gravel to group name
			SP	Poorly graded sand	
		Sands with >12% fines	SM	Silty sand	
			SC	Clayey sand	
Fine-grained soils50% or more passes No. 200 sieve* (<0.075 mm)	Silts and Clays Liquid Limit <50%	Inorganic	ML	Silt	If 15 to 29% coarse-grained, add "with sand" or "with gravel" as appropriate. If > 30% coarse-grained, add "sandy" or "gravelly" as appropriate. Class as organic when oven dried liquid limit is < 75% of undried liquid limit.
			CL	Lean Clay -low plasticity	
		Organic	OL	Organic clay or silt (Clay plots above 'A' Line)	
	Silts and Clays Liquid Limit >50%	Inorganic	MH	Elastic silt	
			CH	Fat Clay -high plasticity	
		Organic	OH	Organic clay or silt (Clay plots above 'A' Line)	
	Highly Organic Soils		PT	Peat, muck and other highly organic soils	

Classification on basis of percentage of fines:
Less than 5% pass No. 200 sieve - GW, GP, SW, SP
More than 12% pass No. 200 sieve - GM, GC, SM, SC
5 to 12% pass No. 200 sieve - Borderline classifications, use of dual symbols

$C_u = \frac{D_{60}}{D_{10}} \geq 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3		
Not meeting either Cu or Cc criteria for GW		
Atterberg limits below "A" line or PI less than 4		Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
Atterberg limits on or above "A" line and PI > 7		If fines are organic add "with orgnic fines" to group name
$C_u = \frac{D_{60}}{D_{10}} \geq 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3		
Not meeting either Cu or C ccriteria for SW		
Atterberg limits below "A" line or PI less than 4		Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
Atterberg limits on or above "A" line and PI > 7		If fines are organic add "with orgnic fines" to group name



APPENDIX D
Laboratory Results

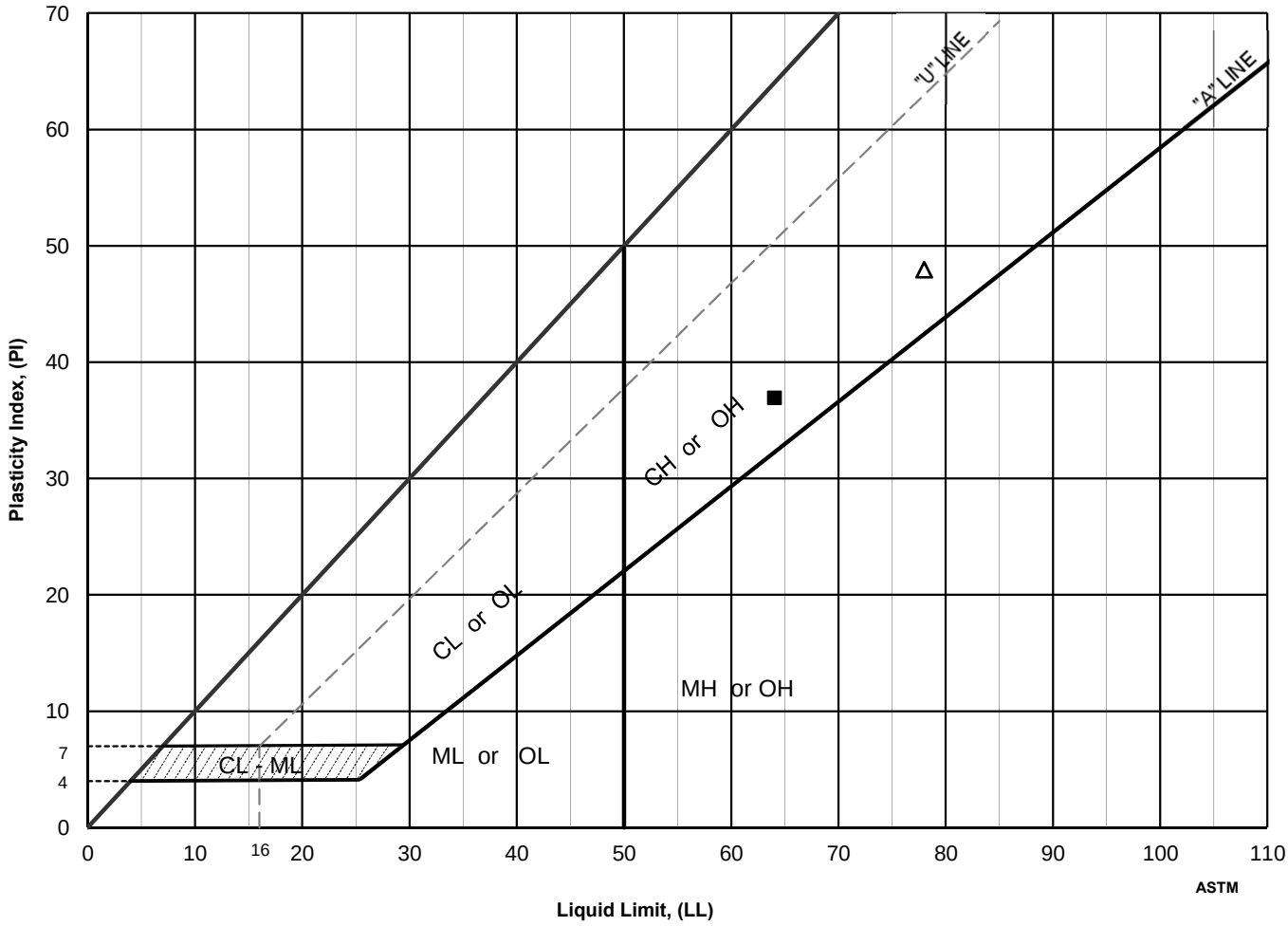
LRL Associates Ltd.

PLASTICITY INDEX

ASTM D 4318 / LS-703/704

Client:	Arch Corportation	**File No.:**	210587
Project:	Geotechnical Investigation	**Report No.:**	1
Location:	1161 Montreal Road, Ottawa, ON.	**Date:**	September 13, 2021

Plasticity Chart



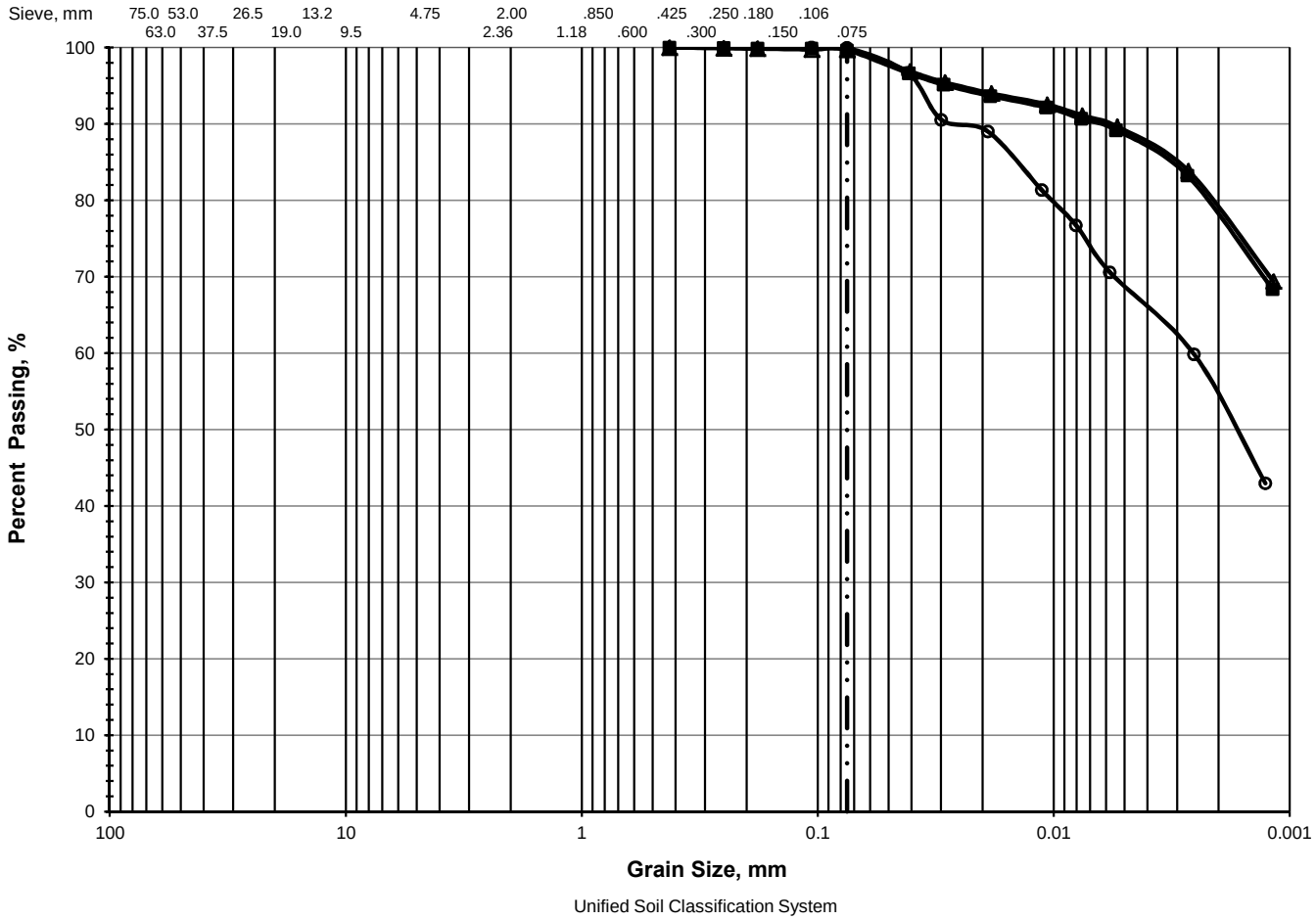
	Location	Sample	Depth, m	Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Activity Number	USCS
△	BH 3	SS3	1.52 - 2.13	41	78	30	48	0.24	n/d	CH
■	BH 7	SS7	6.10 - 6.71	62	64	27	37	0.94	n/d	CH

LRL Associates Ltd.

PARTICLE SIZE ANALYSIS

ASTM D 422 / LS-702

Client:	Arch Corporation	**File No.:**	210587
Project:	Geotechnical Investigation	**Report No.:**	2
Location:	1161 Montreal Road, Ottawa, ON.	**Date:**	September 13, 2021



Unified Soil Classification System

	> 75 mm	% GRAVEL		% SAND			% FINES	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
△	0.0	0.0	0.0	0.0	0.0	0.3	22.4	77.3
■	0.0	0.0	0.0	0.0	0.0	0.4	23.3	76.3
○	0.0	0.0	0.0	0.0	0.0	0.1	47.2	52.7

	Location	Sample	Depth, m	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
△	BH 1	SS3	1.52 - 2.13							
■	BH 4	SS5	3.05 - 3.66							
○	BH 8	SS8	7.62 - 8.23	0.0026	0.0018					

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www.paracellabs.com

Certificate of Analysis

LRL Associates Ltd.

5430 Canotek Road
Ottawa, ON K1J 9G2
Attn: Brad Johnson

Client PO:
Project: 210587
Custody: 62252

Report Date: 13-Oct-2021
Order Date: 5-Oct-2021

Order #: 2141241

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
2141241-01	BH6 25-27'
2141241-02	BH12 5-7'

Approved By:

Dale Robertson, BSc
Laboratory Director

Any use of these results implies your agreement that our total liabilty in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.

Certificate of Analysis

Client: LRL Associates Ltd.

Client PO:

Report Date: 13-Oct-2021

Order Date: 5-Oct-2021

Project Description: 210587

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-Oct-21	13-Oct-21
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	6-Oct-21	7-Oct-21
Resistivity	EPA 120.1 - probe, water extraction	8-Oct-21	8-Oct-21
Solids, %	Gravimetric, calculation	6-Oct-21	6-Oct-21

Certificate of Analysis

Client: LRL Associates Ltd.

Client PO:

Report Date: 13-Oct-2021

Order Date: 5-Oct-2021

Project Description: 210587

	Client ID:	BH6 25-27'	BH12 5-7'	-	-
	Sample Date:	15-Sep-21 09:00	15-Sep-21 12:00	-	-
	Sample ID:	2141241-01	2141241-02	-	-
	MDL/Units	Soil	Soil	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	64.6	73.5	-	-
General Inorganics					
pH	0.05 pH Units	7.76	7.07	-	-
Resistivity	0.10 Ohm.m	22.5	26.9	-	-
Anions					
Chloride	5 ug/g dry	9	132	-	-
Sulphate	5 ug/g dry	279	102	-	-

Certificate of Analysis

Client: LRL Associates Ltd.

Client PO:

Report Date: 13-Oct-2021

Order Date: 5-Oct-2021

Project Description: 210587

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Client: LRL Associates Ltd.

Client PO:

Report Date: 13-Oct-2021

Order Date: 5-Oct-2021

Project Description: 210587

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	12.3	5	ug/g dry	11.1			10.2	20	
Sulphate	24.7	5	ug/g dry	23.3			6.0	20	
General Inorganics									
pH	7.52	0.05	pH Units	7.63			1.5	2.3	
Resistivity	78.7	0.10	Ohm.m	75.7			3.9	20	
Physical Characteristics									
% Solids	91.5	0.1	% by Wt.	92.8			1.4	25	

Certificate of Analysis

Client: LRL Associates Ltd.

Client PO:

Report Date: 13-Oct-2021

Order Date: 5-Oct-2021

Project Description: 210587

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	102	5	ug/g	11.1	91.1	82-118			
Sulphate	95.0	5	ug/g	ND	95.0	87-113			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.
NC: Not Calculated

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

APPENDIX E

MASW Survey

FRONTWAVE
GEOPHYSICS

August 4, 2021 File No. F-21027

Mr. Ben Villani, OAA
Vice President, Development
Arch Corporation
TD Canada Trust Tower
161 Bay Street, Suite 2100
Toronto, Ontario, M5J 2S1

Email: bvillani@archcorporation.com

Re: Shear wave velocity test for seismic site classification at the north corner of the intersection of Old Montréal Road and Famille-Laporte Avenue, Orléans, Ontario.

Dear Mr. Villani:

Frontwave Geophysics Inc. was retained by Arch Corporation to carry out a geophysical investigation at the proposed LTC facility site located at the north side of Old Montréal Road and to the east of Famille-Laporte Avenue in Orléans, Ontario. The location of the site is shown on Figure 1.

The objective of the survey was to determine site class for seismic site response based on average shear wave velocity value measured over the upper 30 m (V_S30). The multi-channel analysis of surface waves (MASW) and seismic refraction methods were used to obtain shear wave velocity profile.

The fieldwork was conducted on August 3rd, 2021.

This report describes basic principles of MASW, survey design, interpretation method, and presents the results of the investigation in chart and table format.

Figure 1: Site boundaries and location of the MASW geophone spread, Orléans, ON.

MASW Survey

Overview

The Multi-channel Analysis of Surface Waves (MASW) is a seismic method widely applied to produce shear wave velocity (V_S) profiles. It is based on the dispersive nature of Rayleigh surface waves in layered media. Surface waves with longer wavelengths propagate deeper in the subsurface, hence, their phase velocity is more influenced by the elastic properties of deeper layers. The velocity of Rayleigh waves depends mainly on the shear wave velocity of the medium. Distribution of Rayleigh waves phase velocities as a function of wavelength (or frequency) can be visualized as a dispersion curve. The inverse problem is then solved by modelling the experimental data with a theoretical dispersion curve; the model parameters are typically limited to layer thickness and shear wave velocity with an assumption of horizontally layered strata. As a result of the inversion, a shear wave velocity depth profile is obtained. Figure 2 illustrates the overall procedure of the MASW method.

Two approaches different in data acquisition and processing can be implemented. The active method involves using artificial sources (e.g., sledgehammer, drop weight) to generate seismic energy, whereas the passive method utilizes energy generated by natural sources (wind, waves, microseismicity) and human activities (mostly vehicle traffic). The energy that can be generated with easily accessible active sources such as sledgehammers is typically concentrated within a relatively high frequency range, and the maximum depth of penetration for active surveys is limited to approximately 15-30 m, depending on the mass of the source and geology of the site. Ambient vibrations registered with the passive acquisition are usually of lower frequency and provide better resolution at greater depths. When survey logistics allow, the active and passive source methods are combined for obtaining well-resolved dispersion images over a wide frequency range, thus increasing the depth of investigation while retaining high resolution at shallow depths.

Survey Design

The acquisition layout consisted of 24 receivers in a linear array (spread), connected with two 12-channel cables to P.A.S.I. Gea-24 seismograph. 4.5 Hz natural frequency vertical geophones were used for this survey. To optimize sampling of different wavelengths two sets of measurements were conducted with spread lengths of 23 m and 69 m (1 m and 3 m spacing between geophones respectively). Data collected with longer spreads provide greater depth of investigation, whereas data collected with shorter geophone spacings ensure better resolution in the uppermost few meters of the subsurface.

8-kg sledgehammer was used as an energy source for active acquisition. Shots were executed at five locations per spread: two shots close to the ends of the spread, one shot in the middle, and two shots with an offset of 25 m from the ends of the spread. A total of 10 shot records was collected. The record length was set to 1500 ms with a 0.1 ms sampling interval.

For passive acquisition, a linear 24-channel array with 3 m spacing between geophones was used. Ambient wavefield was recorded for approximately 10 minutes with a sampling interval of 2 ms.

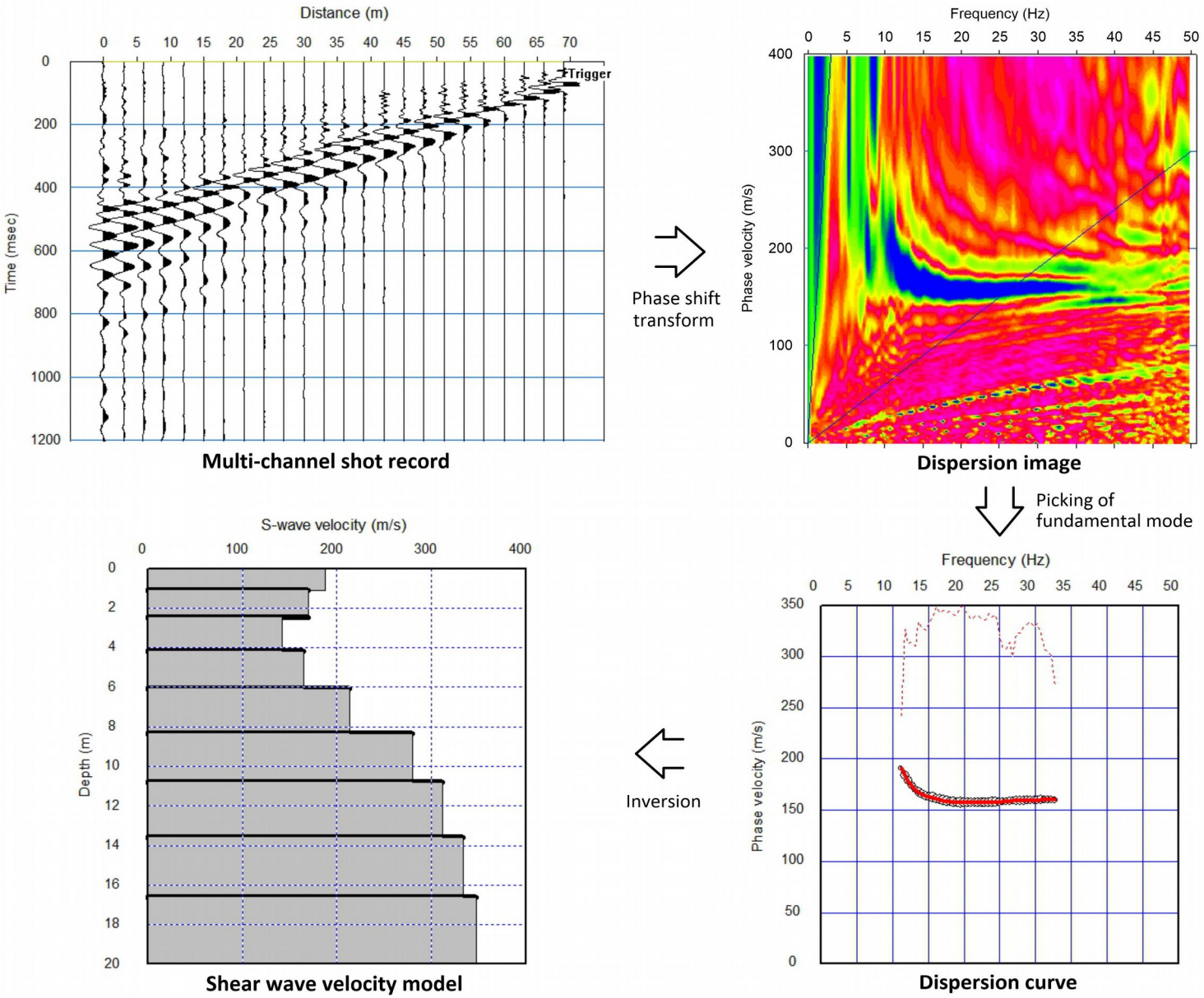


Figure 2. The procedure of MASW data processing using the SeisImager SW software package.

Interpretation

A dispersion curve is obtained from each field record by converting the shot gather into a dispersion image and then identifying and picking the fundamental mode. A shear wave velocity profile is obtained through inversion of the dispersion curve by modelling the subsurface as a horizontally layered medium with the model parameters limited to the number of layers, their thickness and shear-wave velocity.

SeisImager SW software package was used for processing, picking and inversion of the MASW data.

Some variability among the dispersion curves and resulting models obtained from different shot records is always observed due to lateral velocity variations, near and far field effects, different signal-to-noise ratio, etc. Combining independent inversion results from multiple shot records improves the estimation of the actual shear wave velocity and provides an assessment of uncertainty. The results of the interpretation are presented in the form of the average shear wave velocity profile; the observed variability of the MASW data is reported as upper and lower bound velocity profiles.

The solution of the inverse problem is non-unique (many different models can equally fit the experimental dispersion curve). To limit the non-uniqueness, P-wave refraction analysis of the collected dataset is implemented and the results are used to constrain the S-wave velocity model during the inversion process. The refraction technique allows to calculate the depth and give an estimate of S-wave velocity of high velocity contrast layers such as bedrock. Introducing the high-velocity layer into inherently smooth initial MASW models allows to produce higher resolution, higher confidence inversion results.

Accuracy of the results

The accuracy of MASW generally depends on the complexity of the subsurface and specific site conditions (noise levels, topography, etc.). Lateral velocity variations and steeper bedrock topography increase the dispersion uncertainty. The presence of high velocity contrast layers such as bedrock will require the use of a-priory information to optimize model parameters for more accurate results. Hence, if the a-priory information is not available (e.g., when the data are overly noisy to carry out refraction analysis), the accuracy decreases.

Conventional opinion based on decades of experience estimates the error margin of V_S30 value determined from MASW to be within +/-10%. In practice, it means that the MASW data can be used to provide reliable site classification if the calculated V_S30 value is not within 10% of a site class boundary.

RESULTS

The results of the MASW sounding are presented in Figure 3. The average shear wave velocity profile from the active shot records and passive data is plotted in the chart as a solid line. The dashed lines represent the upper and lower bound S-wave velocity profiles.

Seismic refraction analysis indicated that the depth to bedrock ranged approximately from 9.5 to 11 m. Compressional (P) wave velocity measured in the bedrock was 4700 m/s. Assuming suitable Poisson's ratio for rock, with values ranging between 0.2 and 0.25, expected S-wave velocities in the bedrock could be in the range of 2715 to 2880 m/s. These values were used for parameterization of the initial inversion model.

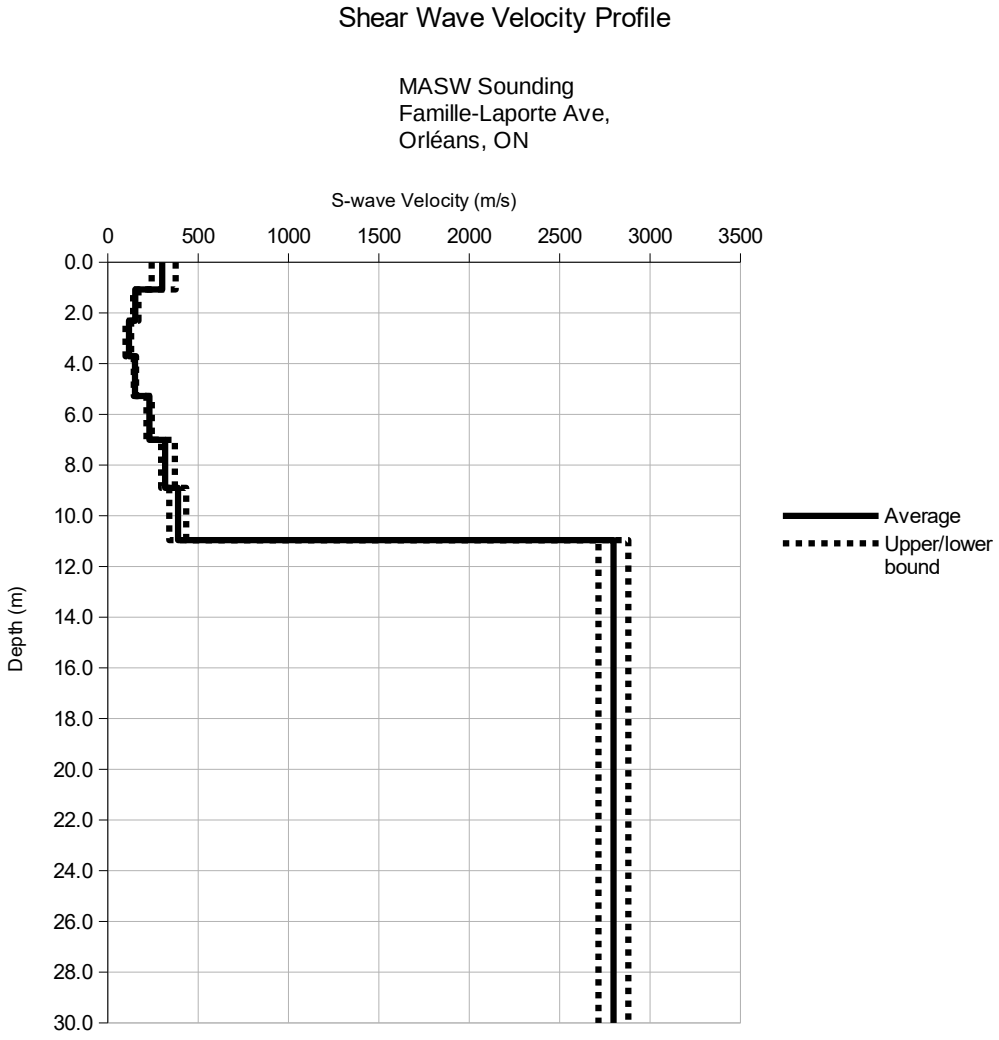


Figure 3. Shear wave velocity profile from MASW sounding.

For seismic site classification, the average shear wave velocity within the upper 30 meters (V_S30) is defined as the travel-time weighted average velocity from surface to a depth of 30 m and calculated using the following formula:

$$V_S30 = 30 / \Sigma (d/V_S),$$

where d is the thickness of any layer and V_S is the layer S-wave velocity. In other words, V_S30 is calculated as 30 m divided by the sum of the S-wave travel times for each layer within the topmost 30 m.

The calculated V_S30 values are presented in Table 1.

Table 1. V_S30 values from MASW sounding.

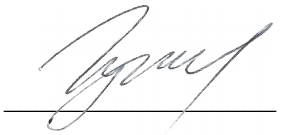
Depth Range (m)	Minimum V_S30 (m/s)	Average V_S30 (m/s)	Maximum V_S30 (m/s)	NBC 2015 Seismic Site Class
0 to 30	455	**503**	549	**C**

The V_S30 values obtained from the MASW sounding varied from 455 m/s to 549 m/s with an average of 503 m/s.

Based on the Site Classification for Seismic Site Response (Table 4.1.8.4.-A) of the National Building Code of Canada 2015 (NBC), the investigated area is in site class C ($360 < V_S30 \leq 760$ m/s).

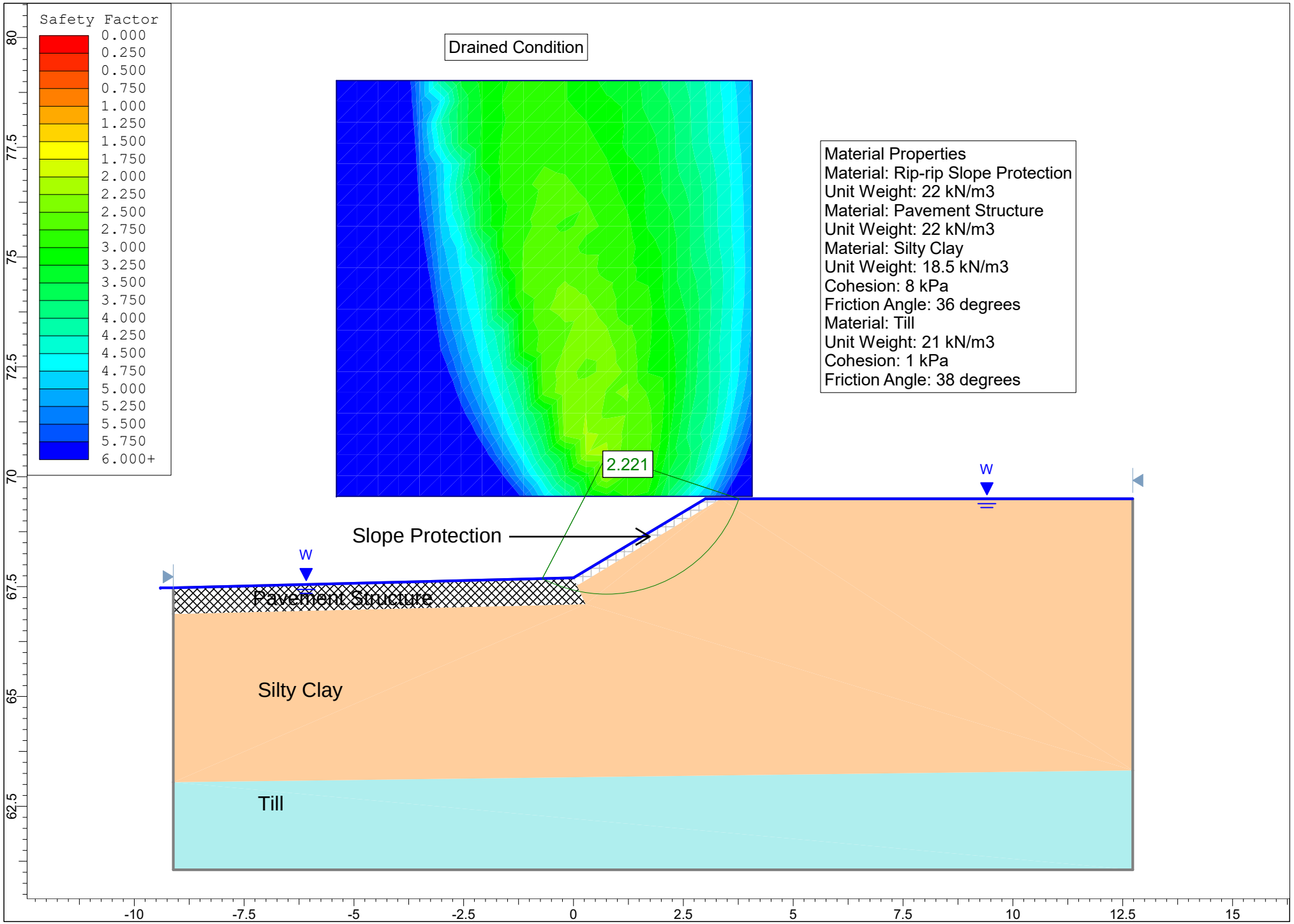
We hope you find this report satisfactory. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Frontwave Geophysics Inc.



Ilia Gusakov, P.Geo.
Geophysicist
(647) 514-4724
ilia.gusakov@frontwave.ca

APPENDIX F
Slope Stability Modelling Results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0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
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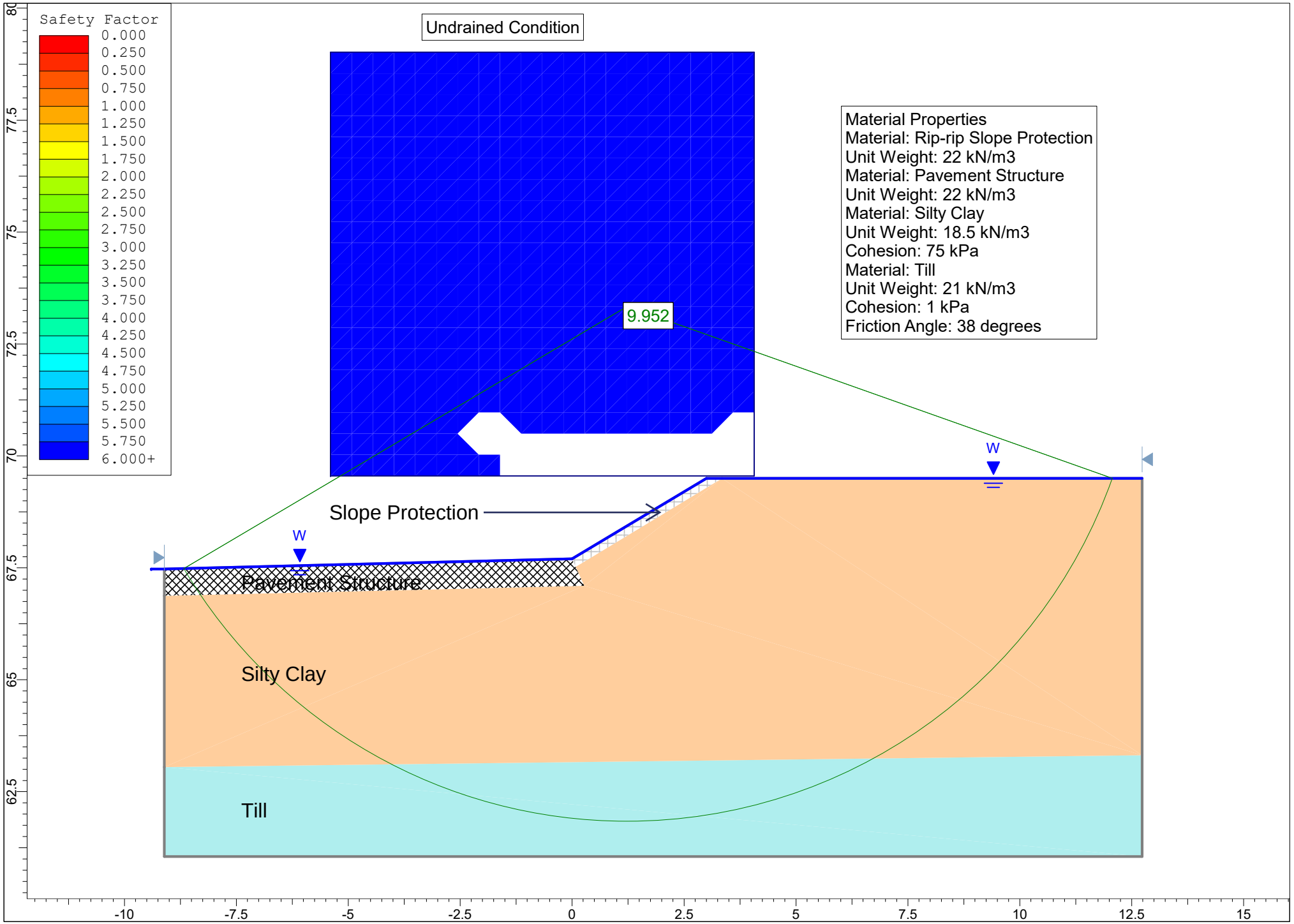
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Drained Condition
Material Properties
Material: Rip-rip Slope Protection
Unit Weight: 22 kN/m3
Material: Pavement Structure
Unit Weight: 22 kN/m3
Material: Silty Clay
Unit Weight: 18.5 kN/m3
Cohesion: 8 kPa
Friction Angle: 36 degrees
Material: Till
Unit Weight: 21 kN/m3
Cohesion: 1 kPa
Friction Angle: 38 degrees
2.221
W
W
Slope Protection
Pavement Structure
Silty Clay
Till
80
77.5
75
72.5
70
67.5
65
62.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15


Safety Factor
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0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
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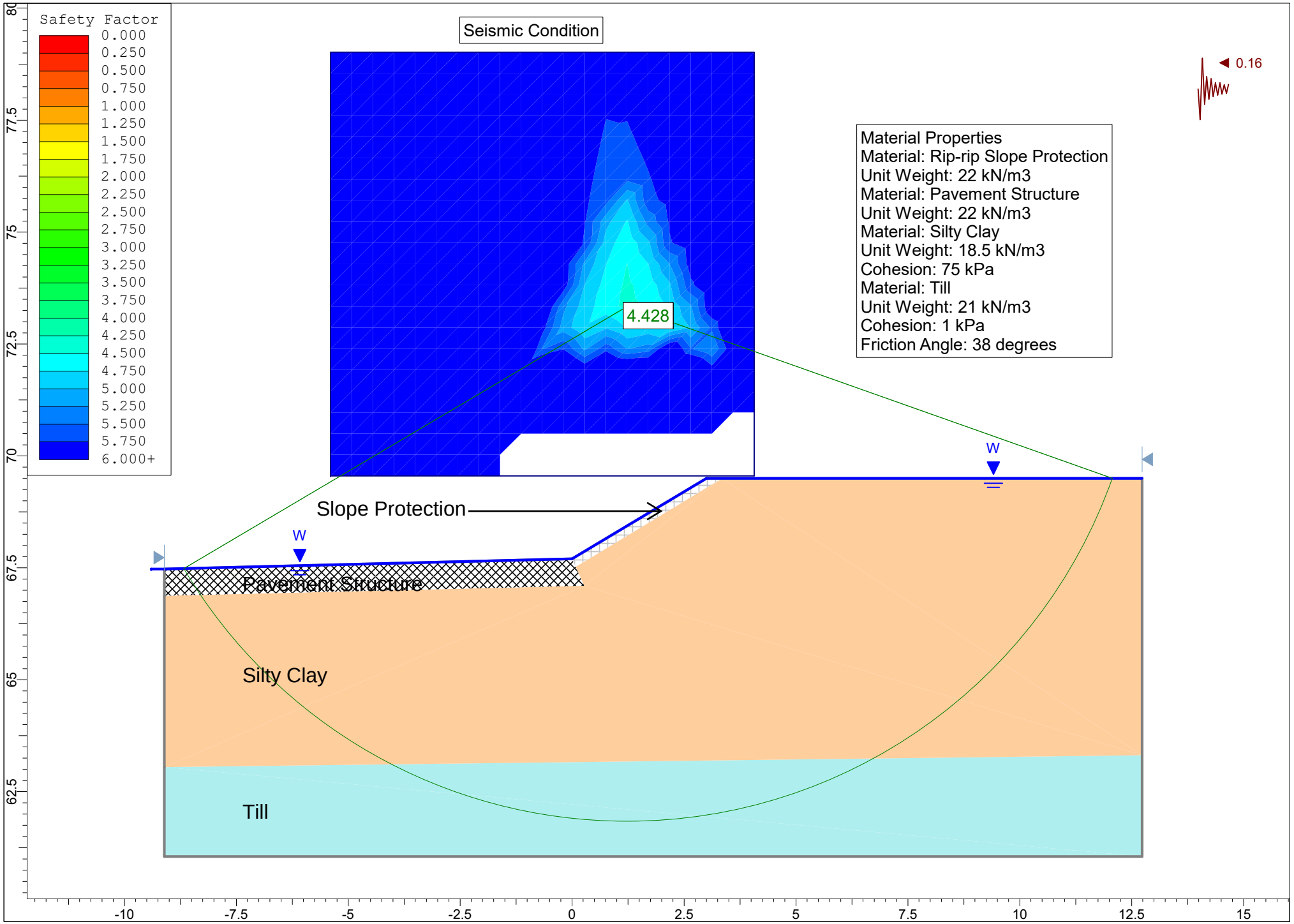
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Undrained Condition
9.952
Material Properties
Material: Rip-rip Slope Protection
Unit Weight: 22 kN/m3
Material: Pavement Structure
Unit Weight: 22 kN/m3
Material: Silty Clay
Unit Weight: 18.5 kN/m3
Cohesion: 75 kPa
Material: Till
Unit Weight: 21 kN/m3
Cohesion: 1 kPa
Friction Angle: 38 degrees
W
W
Slope Protection
Pavement Structure
Silty Clay
Till
80
77.5
75
72.5
70
67.5
65
62.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15


Safety Factor
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1.250
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1.750
2.000
2.250
2.500
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3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Seismic Condition
0.16
4.428
Material Properties
Material: Rip-rip Slope Protection
Unit Weight: 22 kN/m3
Material: Pavement Structure
Unit Weight: 22 kN/m3
Material: Silty Clay
Unit Weight: 18.5 kN/m3
Cohesion: 75 kPa
Material: Till
Unit Weight: 21 kN/m3
Cohesion: 1 kPa
Friction Angle: 38 degrees
W
W
Slope Protection
Pavement Structure
Silty Clay
Till
80
77.5
75
72.5
70
67.5
65
62.5
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15

APPENDIX G

Supporting Documentation

LRJ
ENGINEERING | INGÉNIERIE
5430 Canotek Road | Ottawa, ON, K1J 9G2
www.lrl.ca | (613) 842-3434

PROJECT

PRELIMINARY GEOTECHNICAL INVESTIGATION
OLD MONTREAL RD. AND FAMILLE-LAPORTE AVE.
ORLEANS, ONTARIO

DRAWING TITLE

BOREHOLE LOCATION
SOURCE: Imagery 2018 Google, DigitalGlobe Map Data

CLIENT	DATE	PROJECT
RISKCHECK INC.	SEPTEMBER 12, 2018	180485

FIGURE 2

Borehole Log: BH1

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskChek Inc **Location:** Old Montreal Rd and Famille-Laporte Ave, Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

Depth (ft / m)	Soil Description	Elev./Depth (m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Water Level (Standpipe or Open Borehole)
0 / 0	Ground Surface	100.59									
	TOPSOIL- about 125 mm thick.	0.00									
	SILTY CLAY, trace sand, brownsih grey with red blend, stiff, becoming very soft with increased depth.	0.13			SS1-1	8	63	8		17	
3 / 1					SS1-2	15	100	15		36	
6 / 2					SS1-3	12	100	12		40	
8 /					SS1-4	5	100	5		51	
10 / 3					SS1-5	WH	100	0		61	
12 /									8 94		
13 / 4											
15 /	-becomes grey below about 4.6 m.				SS1-6	WH	100	0		56	
16 / 5									4 57		
17 /											
18 /											
19 /											

Easting: 463336 **Northing:** 5038246

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 100.59 m **Top of Riser Elev.:** N/A

Hole Diameter: 200 mm

Borehole Log: BH1

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskChek Inc **Location:** Old Montreal Rd and Famille-Laporte Ave, Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

SUBSURFACE PROFILE		SAMPLE DATA									
Depth	Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Water Level (Standpipe or Open Borehole)
20											
21					SS1-7	WH	100	0		57	
22									4 65		
23 7											
24											
25		92.97							14 98		
	End of Borehole	7.62									
26 8											
27											
28											
29 9											
30											
31											
32											
33 10											
34											
35											
36 11											
37											
38											
39											

Easting: 463336 **Northing:** 5038246

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 100.59 m **Top of Riser Elev.:** N/A

Hole Diameter: 200 mm

Borehole Log: BH2

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskCheck Inc. **Location:** Old Montreal Rd and Famille-Laporte Ave, Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

Depth (ft / m)	Soil Description	Elev./Depth (m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Water Level (Standpipe or Open Borehole)
0 ft / 0 m	Ground Surface	100.13									
	TOPSOIL- about 200 mm thick.	0.00									
1	**SILTY CLAY-** trace sand, brownish grey, moist, stiff, becoming very soft with increased depth.	0.20			SS2-1	18	75	18		35	
2											
3 / 1					SS2-2	14	83	14		35	
4											
5					SS2-3	13	100	13		39	
6 / 2											
7					SS2-4	9	100	9		42	
8											
9											
10 / 3					SS2-5	6	100	6		50	
11											
12											
13 / 4											
14											
15	-becomes dark grey below about 4.6 m.										
16					SS2-6	WH	100	0		53	
17 / 5											
18					ST1						
19		94.13									
		6.00									

Water Level: 5.10 m bgs on September 14, 2018

Easting: 463319 **Northing:** 5038183

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 100.13 m **Top of Riser Elev.:** 101.03 m

Hole Diameter: 200 mm

Borehole Log: BH2

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskCheck Inc. **Location:** Old Montreal Rd and Famille-Laporte Ave, Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

SUBSURFACE PROFILE		SAMPLE DATA									
Depth	Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa)	Water Content (%) 25 50 75 / Liquid Limit (%)	Water Level (Standpipe or Open Borehole)
20	**SILTY SAND TILL-** trace clay, some gravel, grey, wet, compact to dense.										
21					SS2-7	15	25	15		13	
22											
23 – 7											
24											
25											
26					SS2-8	28	50	28		12	
27 – 8		91.90									
28	End of Borehole	8.23									
29											
30 – 9											
31											
32											
33 – 10											
34											
35											
36 – 11											
37											
38											
39											

Easting: 463319 **Northing:** 5038183

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 100.13 m **Top of Riser Elev.:** 101.03 m

Hole Diameter: 200 mm

Borehole Log: BH3

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskCheck Inc. **Location:** Old Montreal Rd and Famille Laporte Ave. Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

Depth (ft / m)	Soil Description	Elev./Depth (m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa)	Water Content (%) 25 50 75 / Liquid Limit (%)	Water Level (Standpipe or Open Borehole)
0 / 0	Ground Surface	101.15									
	TOPSOIL- about 150 mm thick.	0.00									
	SILTY CLAY- trace sand, brownish grey, moist, stiff, becoming very soft with increased depth.	100.90 0.25			SS3-1	9	42	9		37	
3 / 1					SS3-2	11	100	11		39	
6 / 2					SS3-3	8	100	8		44 74	
8 / 2					SS3-4	4	100	4		61	
10 / 3					SS3-5	1	100	1	6 61	63	
15 / 5	-becomes dark grey below about 4.6 m.				SS3-6	WH	100	0	7 65	71	
19											

Easting: 463371 **Northing:** 5038155

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 101.145 m **Top of Riser Elev.:** N/A

Hole Diameter: 200 mm

Borehole Log: BH3

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskCheck Inc. **Location:** Old Montreal Rd and Famille Laporte Ave. Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

SUBSURFACE PROFILE		SAMPLE DATA									
Depth	Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Water Level (Standpipe or Open Borehole)
20											
21					SS3-7	WH	100	0		61	
22									4 69		
23	7										
24											
25										57	
26	8				SS3-8	WH	100	0			
27		92.77							5 81		
28	End of Borehole	8.38									
29											
30	9										
31											
32											
33	10										
34											
35											
36	11										
37											
38											
39											

Easting: 463371 **Northing:** 5038155

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 101.145 m **Top of Riser Elev.:** N/A

Hole Diameter: 200 mm

Borehole Log: BH4

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskCheck Inc. **Location:** Old Montreal Rd and Famille-Laporte Ave. Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

Depth (ft / m)	Soil Description	Elev./Depth (m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa)	Water Content (%) 25 50 75 / Liquid Limit (%)	Water Level (Standpipe or Open Borehole)
0 ft / 0 m	Ground Surface	101.85									
	TOPSOIL- about 1.2 m thick.	0.00			SS4-1	8	50	8		33	
3 ft / 1 m					SS4-2	12	58	12		19	
		100.65									
	SILTY CLAY- trace sand, brownish grey, moist, stiff, becoming very soft with increased depth.	1.20			SS4-3	9	100	9		44	
7 ft / 2 m					SS4-4	6	100	6		48	
10 ft / 3 m					SS4-5	5	100	5		51	
13 ft / 4 m	-becomes dark grey below about 4.6 m.				SS4-6	WH	100	0	2 57	66	
16 ft / 5 m											
19 ft / 6 m											

Easting: 463373 **Northing:** 5038090

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 101.584 m **Top of Riser Elev.:** N/A

Hole Diameter: 200 mm

Borehole Log: BH4

Project No.: 180485 **Project:** Preliminary Geotechnical Investigation

Client: RiskCheck Inc. **Location:** Old Montreal Rd and Famille-Laporte Ave. Orleans ON

Date: September 6, 2018 **Field Personnel:** BJ

Driller: George Downing Estate Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** HSA

SUBSURFACE PROFILE		SAMPLE DATA									
Depth	Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Values (Blows/0.3 m) 20 40 60 80	Vane Shear Strength (kPa) 20 40 60 80 / Vane Remold Shear Strength (kPa) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Water Level (Standpipe or Open Borehole)
20											
21											
22					SS4-7	WH	100	0	6 73	69	
23 – 7											
24											
25											
26					SS4-8	WH	100	0		64	
27 – 8											
		93.47							8 73		
28	End of Borehole	8.38									
29											
30 – 9											
31											
32											
33 – 10											
34											
35											
36 – 11											
37											
38											
39											

Easting: 463373 **Northing:** 5038090

Site Datum: Top of Flange of Fire Hydrant at Entrance of Church Across the Road (100.00 m)

Groundsurface Elevation: 101.584 m **Top of Riser Elev.:** N/A

Hole Diameter: 200 mm

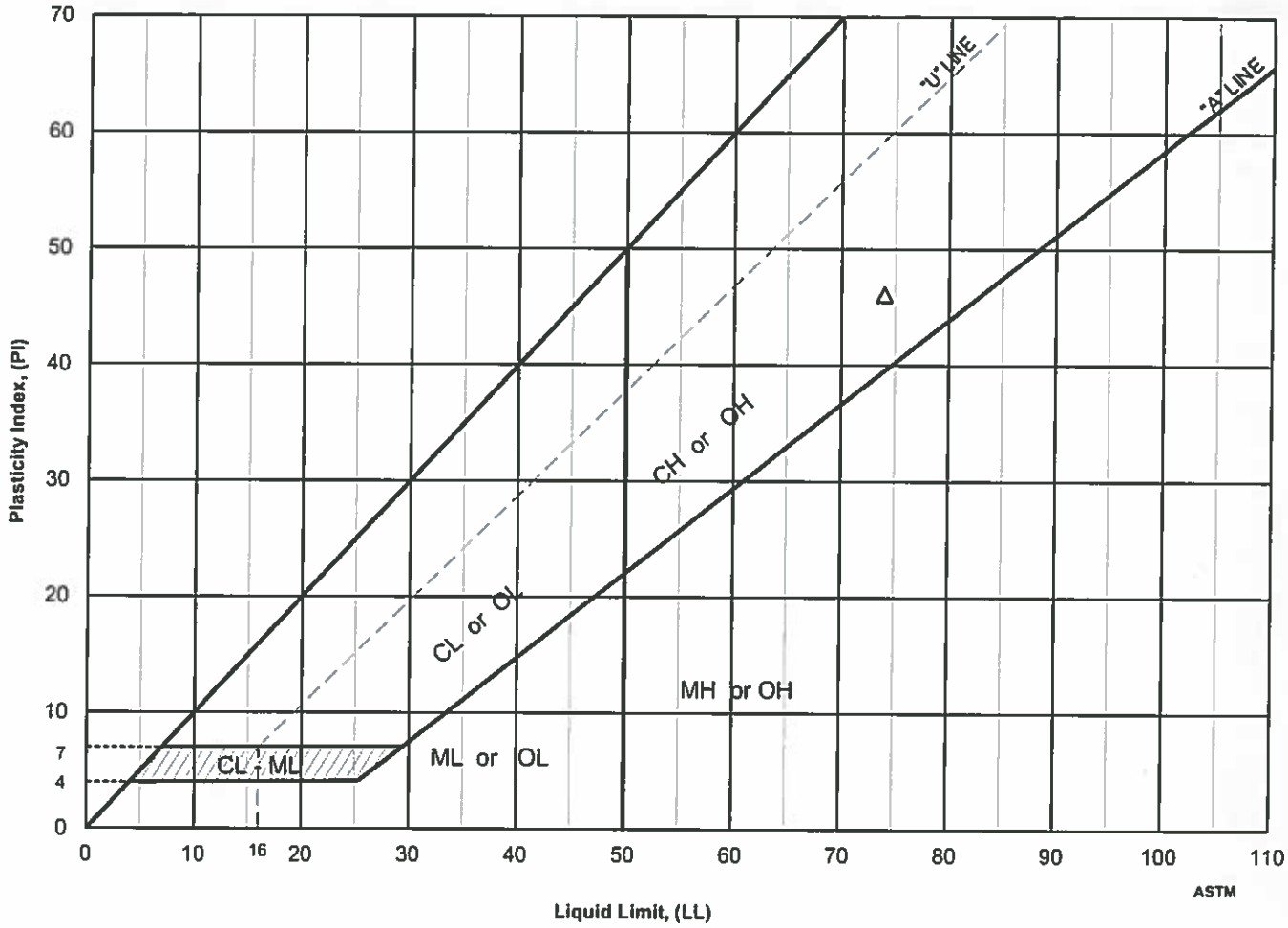
LRL Associates Ltd.

PLASTICITY INDEX

ASTM D 4318 / LS-703/704

Client:	RiskCheck Inc.	**File No.:**	180485
Project:	Geotechnical Investigation	**Report No.:**	1
Location:	Old Montreal Road & Famille-Laporte Avenue, Ottawa	**Date:**	September 6, 2018

Plasticity Chart



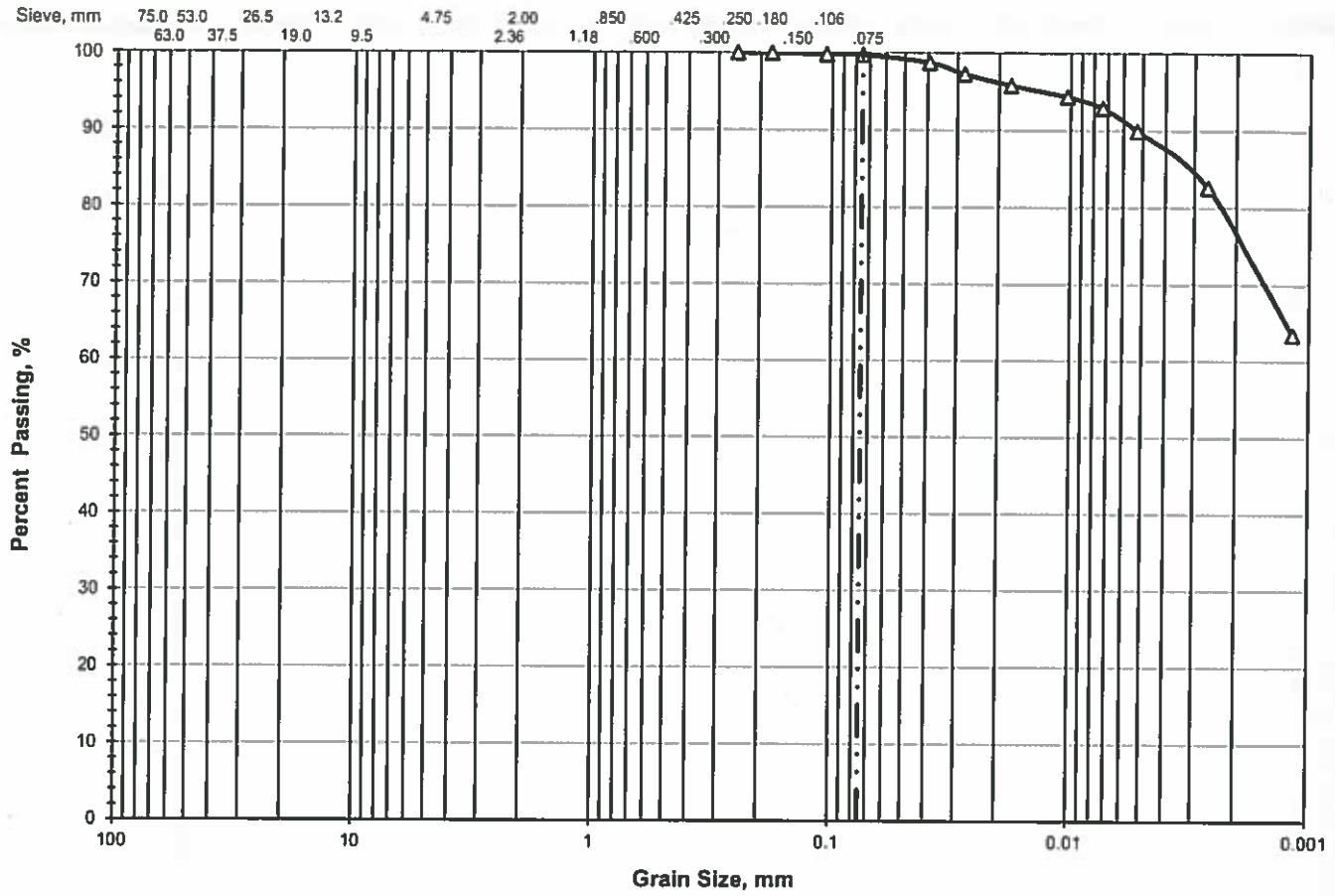
	Location	Sample	Depth, m	Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Activity Number	USCS
Δ	BH 3	SS-3	1.52 - 2.13	44	74	28	46	0.34	n/d	CH

LRL Associates Ltd.

PARTICLE SIZE ANALYSIS

ASTM D 422 / LS-702

Client:	RiskCheck Inc.	**File No.:**	180485
Project:	Geotechnical Investigation	**Report No.:**	2
Location:	Old Montreal Road & Famille-Laporte Avenue, Ottawa	**Date:**	September 6, 2018



Unified Soil Classification System

	> 75 mm	% GRAVEL		% SAND			% FINES	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
△	0.0	0.0	0.0	0.0	0.0	0.3	25.5	74.2

	Location	Sample	Depth, m	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
△	BH 2	SS-3	1.52 - 2.13							