Geotechnical Investigation

Warehouse and Offices
Intersection of Rideau Street
and Somme Street
Ottawa, Ontario

Consolidated Fastrate (Ottawa)
Holdings Inc.

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1. Introduction

GHD was retained by Consolidated Fastfrate (Ottawa) Holdings Inc. representative Mr. Pierre Courteau of CBRE Limited to undertake a geotechnical investigation for a new warehouse and office building located southeast of the intersection of Rideau Street and Somme Street in Ottawa, Ontario (Site).

GHD (formerly Inspec Sol/CRA) completed a Geotechnical Investigation and Phase II Environmental Site Assessment for the Site in 2008 and 2009 respectively.

GHD has reviewed the following documents provided by the client as part of the investigation:

- Phase II Environmental Site Assessment and Hydrogeological Assessment, Report Ref. No. 045804 (12), by Conestoga-Rovers & Associates, dated September 2008.
- Hydrogeological Investigation, Terrain Analysis and Impact Assessment, Proposed Industrial Subdivision, Report Ref. No. 08-1122-0215, by Golder Associates, dated December 2008.
- Geotechnical Study Subdivision Plan, Hawthorne Industrial Park, Report Ref. No. T020556-A1, by Inspec-Sol, dated May 4, 2009.
- Stormwater Management Report. Hawthorne Industrial Park, Report Ref. No. JLR 20983, by J.L. Richards & Associates Limited, dated February 2009 (Revised May 2009).

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

The purpose of the geotechnical investigation was to complete an evaluation of the subsurface stratigraphy on the Site and based upon the data, provide recommendations concerning foundation type and associated design bearing pressures, groundwater conditions as well as provide comments on excavation, backfill, pavement design and other geotechnical aspects of the development.

The scope of work for GHD consisted of the following activities:

- **Underground Service Clearances**.
- **Fieldwork |** The scope included the advancement of a total of four boreholes and one Dynamic Cone Penetration Test (DCPT). One of the boreholes was equipped with a monitoring well to measure ground water level along with the three existing wells on site.
- **Lab Testing |** Four hydrometer grain size analysis, two Atterberg limit tests, moisture contents on all collected samples, and corrosion testing on one collected sample. One collected rock core sample were selected for Unconfined Compressive Strength (UCS) testing.
- **Reporting |** Preparation of this Geotechnical Report which summarizes the findings of the fieldwork programs and presents recommendations for the design and construction of the structure and pavement areas.

2. Site and Project Description

At the time of the investigation, the Site was vacant and overgrown with vegetation. Evidence of fill (gravel, concrete, asphalt) could be observed on the ground surface. The surrounding blocks in the area were in a similar condition. There was also tree line along the north perimeter of the Site where a steep slope was also observed leading from the site down to the ditch directly to the south of Rideau Street.

GHD observed three existing groundwater monitoring wells and one hydrogeological testing well on the Site. One of these wells was confirmed as MW7-08 installed by CRA in 2008. Based on the position of the hydrogeological testing well adjacent to MW7-08, GHD believes this is TW-2 installed by Capital Water Supply Ltd. in 1993 as discussed in Golder's Hydrogeological report for the Site. It appeared that minimal to no fill placement has occurred around these well locations since 2008. The details of the remaining two existing wells on Site could not be confirmed.

The Site topography is relatively flat with various small mounds of fill material, sloping down to the surrounding streets. The surrounding topography slopes up from south to north by approximately 3.5 meters from Rideau Street to the section of Somme Street south of the Site. The Site elevation is higher compared to the surrounding streets varying from approximately 0.2 metres (m) higher on the south side (Somme Street) to 4.0 m higher on the north side (Rideau Street). There was also a ditch along the south, west, and north perimeters of the Site.

The historic fill placement at the Site has created sloping of approximately 2:1 (H:V) around the south, west, and north perimeters of the Site.

GHD's understanding of the proposed building is based on a sketch provided by the client shown on the Borehole Location Plan provided in Figure 2.

It is our understanding that the proposed new building will consist of an approximately 50,000 square feet (sf) warehouse on the eastern portion of the Site, connected to an approximately 20,000 sf cross dock on the western portion with approximately 1,500 sf of associated office space.

The location of the Site is shown on the Site Location Plan attached as Figure 1

3. Field Investigation

3.1 Borehole Drilling

The drilling component of this Geotechnical Investigation consisted of the advancement of four boreholes and one Dynamic Cone Penetration Test (DCPT), denoted as BH1 to BH4 and DCPT5. Boreholes were advanced to depths ranging from 11.1 to 14.9 meters below ground surface (mbgs). The DCPT test was advanced to refusal encountered at 5.9 mbgs. Borehole BH1 was outfitted with a monitoring well to monitor the groundwater level. The location of the boreholes are shown in the Borehole Location Plan attached as Figure 2 at the end of this report.

The borehole drilling fieldwork program was undertaken on August 6 and August 7, 2020, with a track mounted drill rig, under the supervision of GHD field staff. Boreholes were advanced into the overburden using Standard Penetration Tests (SPTs) at regular intervals using a 50 millimetres (mm) diameter split-spoon sampler and a 63.5 kilogram (kg) hammer, free falling from a distance of 760 mm, to collect soil samples. The number of drops required to drive the sampler 0.3 m is corrected for a hammer weight of 63.5 kg and recorded on the borehole logs as "N" value. Boreholes were backfilled with combination of sand, bentonite and auger cuttings.

Dynamic Cone Penetration Test was completed in one location to record continues penetration test within the fill layer.

General descriptions of the subsurface conditions are summarized in the following sections, with a graphical representation of each borehole on the Borehole Logs. Notes on Boreholes are provided in Appendix A, at the end of this Report.

3.2 Surveying

Geodetic ground surface elevations were collected by GHD field staff with a Leica 1200+ Real-Time-Kinematic (RTK) GPS survey system. The elevations of the boreholes are for use within the context of this report only.

3.3 Laboratory testing

Laboratory testing on recovered soil samples included four hydrometer grain size analysis, two Atterberg limit tests, and moisture contents on all collected samples. One collected rock core sample were selected for Unconfined Compressive Strength (UCS) testing. The results from the testing assisted in the subsoil descriptions provided below in Section 4 and on the borehole logs. The laboratory test results are also provided in Appendix B, at the end of this report.

Analytical testing was also carried out on a soil sample collected to determine corrosion potential of the subsurface soils at each site. The results of the corrosion testing are provided in Section 6.8.

4. Subsurface Conditions

In general, soils encountered at the borehole locations consisted of thick layer of fill material overlying a native silty sand to sandy silt deposit followed by a glacial till. Limestone bedrock with interbedded sandstone was encountered at depths ranging from 8.2 (BH1) to 11.9 mbgs (BH3).

General descriptions of the subsurface conditions are summarized in the following sections, with a graphical representation of each borehole on the Borehole Logs. Notes on Boreholes are provided in Appendix A, at the end of this Report.

4.1 Fill

The fill material encountered at the site consisted of a mixture of sand, silt, clay, and gravel. The composition of the fill material varied with depth and borehole location. The upper 3.0 m of the fill material ranged from a silty sand to gravel to silty clay. Cobbles and possible boulders were encountered in the boreholes at varying depths. Buried asphalt was also noted at the BH3 and BH4 locations.

The thickness of the fill at the borehole locations was approximately 6.0 m. the fill material was found to be loose to compact in compactness state and was recovered in a damp condition becoming moist to saturated with depth. Blow counts within the fill material ranged from weight of hammer within the clay material encountered at the BH2 location to greater than 50 in sand and gravel granular material.

One shear vane test was performed within the clay fill material at the BH2 location with a recorded shear strength of 50 kilopascal (kPa).

The results of the grain size analysis and Atterberg Limits completed on selected fill samples are summarized in Tables 4.1 and 4.2, respectively.

Table 4.1 Grain Size Analysis Results - Native

Borehole/Sample Identification	Depth (mbgs)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH1/SS3	1.5 – 2.1	51	43	5	1
BH2/SS4	2.3 – 3.0	1	2	36	61
BH2/SS7	4.6 – 6.1	25	38	29	8

Table 4.2 Atterberg Limit Test Results - Native

Borehole/Sample Identification	Depth (mbgs)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Water Content (%)	Liquidity Index
BH2/SS4	2.3 – 3.0	69	21	48	56	0.73

The laboratory test results are also provided in Appendix B, at the end of this report.

4.2 Sandy Silt / Silty Sand

Below the fill material a native deposit of sandy silt to silty sand with varying amounts of clay and gravel was encountered. Cobbles and possible boulders are expected within this deposit becoming more frequent with depth. The deposit was found in a compact state and recovered in a moist condition becoming saturated below the groundwater table. The deposit extended to depths ranging from 8.2 (BH1) to 11.9 mbgs (BH3). Recorded N values within this deposit ranged from 12 to greater than 50.

The result of the grain size analysis completed on one selected sample from the native deposit is provided in the Table 4.3. The laboratory test results are also provided in Appendix B, at the end of this report.

Table 4.3 Grain Size Analysis Results - Native

Borehole/Sample Identification	Depth (mbgs)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH3/SS10	6.9 – 7.5	8	47	37	8

4.3 Sandy Clay

A deposit of sandy clay was encountered below the native sandy silt at the historical B5-1 location. The material was very soft and in a moist condition. This material was not encountered within the new borehole locations as part of this investigation.

4.4 Silty Clay

Below the fill material and the native sandy clay (B5-1) was a native silty clay deposit. The deposit was encountered at depths ranging from 4.6 (B5-2) to 7.3 (B5-1) mbgs (2009). The deposit was firm becoming very stiff with depth and was recovered in a moist to wet condition. This material was not encountered within the new borehole locations as part of this investigation. Refusal was encountered within this deposit in the previous studies.

4.5 Bedrock

Limestone bedrock with interbedded sandstone was encountered at depths of 8.2 m (BH1), 9.3 m (BH2), and 11.9 m (BH3). Borehole BH4 was terminated upon refusal at a depth of 11.1 m on inferred bedrock. The bedrock quality varied with depth and location, the recorded Rock Quality Designation (RQD) ranged between 37 percent to 90 percent. The unconfined Compressive Strength (UCS) test results completed on a selected rock core sample (BH2-RC1) shows a compressive strength of 125.2 megapascal (MPa). The lab test results are provided in Appendix B of this report.

4.6 DCPT Results

The results of the DCPT test show the upper 5.9 m of the material is in loos to compact condition based on blow counts of less than 10 up to 20.

5. Groundwater

Three existing groundwater monitoring wells were present on site. One well was confirmed as MW7-08. The details of the other two wells are unknown.

One additional monitoring well was installed as part of the scope of work for this investigation. Groundwater levels were measured on August 18, 2020, at the monitoring wells. The following Table 5.1 shows the measured water levels.

Table 5.1 Groundwater Observations

Borehole ID (Year of Install)	Depth of Water (mbgs)	Groundwater Elevation (m)
BH1 (GHD 2020)	4.0	86.9
MW7 (CRA 2008)	3.3	87.5
Northwest well (Unknown)	3.3	87.6
Northeast well (Unknown)	3.5	86.8

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

6. Discussion and Recommendations

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

- A new approximately 50,000 sf warehouse on the west portion of the Site.
- An approximately 20,000 sf cross dock connected to the east face of the warehouse.
- Approximately 1,500 sf of office space connected to the south face of the cross dock.
- No underground levels are planned for the proposed structure.
- Structure will be slab-on grade construction.
- No information is available regarding the proposed finish grade for the new building.

Based on our understanding of the proposed development, the subsurface conditions encountered in the boreholes, and assuming them to be representative of the subsurface conditions across the Site, the following recommendations are provided. The most important geotechnical considerations for the design of the proposed building are the following:

- **Fill Material |** An approximately 6.0 m thick layer of fill is present throughout the Site. The composition of the fill material varies with depth borehole location. Buried asphalt was also noted in the fill material at various locations. The fill material in its current state is not suitable to support shallow foundations for the proposed structure. Soil improvement techniques may be an option; however, consultation with specially soil improvement contractors will be required. Refer to Section 6.3.1 of the Report for preliminary comments for soil improvement.
- **Presence of Cobbles and Boulders |** obstructions to SPT was encountered within the fill material as well as within the native deposit overlying the bedrock. The obstructions are assumed to be possible cobbles or boulders. The presence of cobbles and boulder could make driving piles difficult; contractors should account for this if a deep foundation option is preferred. It is recommended that during the detailed design additional investigation by means of test pit excavation be carried out to further determine the nature of the obstructions.

- **Dewatering |** GHD has not been provided the proposed final grade of the new warehouse structure. If excavations will extend below the measured groundwater level of approximately 3.5 mbgs, groundwater infiltration into the excavations is expected. The water quantities expected to enter open excavations during construction will depend on seasonal conditions, depth of excavations, and the duration that excavations are left open. Hydrogeological assessment to estimate the extent of dewatering activities and determine whether a Permit to take water (PTTW) or submission on the Ontario Environmental Activity and Site Registry (EASR) may be required.
- **Slope Stability |** The historic fill placement at the Site has created sloping of approximately 2:1 (H:V) around the south, west, and north perimeters of the Site. Based on the preliminary slope stability analysis, depending on the composition and compactness state of the fill material, the factor of safety for the slope may be equal or slightly below (i.e., 1.4 under static condition and 1.0 under pseudo-static condition) the recommend values of 1.5 for static condition and 1.1 for pseudo-static. GHD must be provided a topographic survey plan for the existing slope and the proposed finish grade at the detailed design stage to determine the design setback allowance for the building. It is noted that the condition of the slope must be monitored during site preparation and building construction.

6.1 Site Preparation

6.1.1 Building Footprints

Site preparation within the building footprint will depend on design finish grade and preferred foundation option. If shallow foundations are preferred, the existing fill within the building footprint will need to be improved using site specific ground improvement techniques. Refer to Section 6.3.1 of this Report for preliminary comments regarding ground improvement of the existing fill material.

If deep foundations are selected, excavations for the pile caps will need to extend below frost depth below finish grade of 1.5 m if the building is heated and 1.8 m for unheated or isolated structures. A suitable compact soil subgrade is required for pile cap construction. Pile caps should not be constructed on disturbed or loose subgrade. The exposed subgrade should be examined by Geotechnical personnel prior to pile cap installation. Any loose or disturbed material should be removed and replaced with suitable fill material meeting the requirements of Engineered Fill as per Section 6.10 of this report.

6.1.2 Heavy Duty Road

GHD anticipates the Site will require heavy duty roads for the heavy truck traffic to and from the warehouse. Due to the presence of the uncontrolled fill material, improvement of the road subgrade may be required. Improvement methods may include:

- Additional compaction of the subgrade soils.
- Soil improvement methods such as Dynamic Compaction discussed in Section 6.3.1
- Placement of a thicker road base and/or subbase.

- Strengthening the subgrade using geosynthetic materials like TriAx or Biaxial geogrides.
- Or a combination of these options may be implemented depending on the design requirements for the access roads.

6.1.3 Underground Services

Depending on the final site grades subgrade improvement may also be required for underground services. Improvement methods may be similar to the options provided for the heavy-duty roads above.

6.2 Excavation and Dewatering

The following are general comments regarding the excavations and dewatering requirements, as the depth of the excavations and dewatering requirements are dependent on final grades and foundation option selected.

Roadway construction debris including concrete and asphalt is expected within the fill material. This debris was also observed on the surface at the time of GHD's Site visit. The walls of the excavations must also be sloped at a minimum of 1H:1V as per the Occupational Health and Safety Act (OHSA) requirements for Type 3 soils (fill) or supported by temporary shoring.

Unsupported side slopes should be adjusted depending on the true subsoil and groundwater conditions encountered during excavation work and flatter side slopes than those mentioned above may be required locally.

During the excavation, no excavated material should be piled, nor machinery or equipment placed, closer than the distance equivalent to the depth of the excavations. Furthermore, no vertical un-braced excavations should be performed in the soil. In addition, the exposed subsoils should be protected against erosion from water run-off or rain.

The stability and safety of unsupported excavation slopes remain the responsibility of the contractor at all times.

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

A hydrogeological assessment of this Site was not part of the scope of work for this investigation. If excavations will extend below the measured groundwater level of approximately 3.5 mbgs, groundwater infiltration into the excavations is expected. The water quantities expected to enter open excavations during construction will depend on seasonal conditions, depth of excavations, and the duration that excavations are left open. Hydrogeological assessment to estimate the extent of dewatering activities and determine whether a Permit to take water (PTTW) or submission on the Ontario Environmental Activity and Site Registry (EASR) may be required.

6.3 Foundations

The foundation options for the proposed building depend upon proposed final grade elevations for the structure and design loadings. The suggested options and preliminary recommendation for the foundations for the warehouse are provided in the following sections.

6.3.1 Shallow Foundation- Soil Improvement

Deep fill layers were encountered in all boreholes drilled on site. Fill thickness, composition and compactness/consistency varies with depth and location; therefore, soil improvement is required to allow for the use of shallow foundations for this project.

The recommended soil improvement method at this time is Dynamic Compaction performed by specialty contractors. This method of soil improvement and use of shallow foundations may be a cost-effective alternative to deep foundation. It is however noted that the suitability of this method for the site condition should be evaluated by the specialty contractors.

This method will compact the existing fill material using a crane that repeatedly drops a 15 to 20 ton weight in a closely spaced grid pattern across the site, creating a uniformly compacted subgrade. In the areas with softer cohesive soils, the addition and compaction of imported granular material may be required to further strengthen the soil.

Following completion of the compaction, the contractor will perform on site pressure meter tests in the compacted areas to confirm that the design bearing capacity has been achieved or whether additional compaction is required.

Further discussion and field investigations with the specialty contractors will be required to evaluate this improvement option for this Site and to provide the estimated cost to complete the work and provide the achievable design bearing capacity.

GHD also recommends the structural engineer for the project be consulted to provide the design loadings for the structure.

6.3.2 Deep Foundations

Drilled piles (Micro piles) or drilled cast-in-place concrete piles (caissons) are feasible options to support the proposed warehouse. In both cases, the piles should be designed relying on shaft friction only due to presence of groundwater and inability to provide a clean base end bearing piles are not recommended.

Due to presence of obstructions identified as possible cobbles and boulders within the fill material and within the native soils driven piles such as H-Piles are not considered suitable for this site. The nature of the obstructions can be further investigated by excavating test pits at the time of detailed design to decide whether driven piles can be an option.

6.3.2.1 Drilled Deep Foundation

Depending on the required bearing capacities drilled piles supported within the native soils or bedrock can be an option to support the proposed structure; it is noted that to evaluate the suitability of the piles supported on or within the native soils, discussion with structural engineer will be require. Therefore, this option can be further reviewed once the design loads are provided.

Caissons supported on bedrock surface can be designed using a recommended bearing capacity of 1,000 kPa under Ultimate Limit State (ULS). Due to the presence of groundwater and cohesionless soils, a permanent steel casing set into the bedrock will be required for the cast-in-place piles. The total loads for the caissons must have the Resistance Factor of 0.4 applied to the value to provide the factored ULS value as per Table 8.1 of CFEM.

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

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

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

where:

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

And

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

where:

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

The unconfined compressive strength of the bedrock from the UCS test performed on the core sample from BH2/RC1 location was 125.2 MPa.

For this Site, values of shaft adhesion will be limited by concrete compressive strength. Therefore, the formula q_a=0.05f'_c must be used in the above equation. As an example, a design concrete strength of 30 megapascal (MPa) would result in a design shaft resistance of 550 kPa.

Designers can select economical socket length for the caisson based upon the formulas. The total loads for the caissons must have the Resistance Factor of 0.4 applied to the value to provide the factored ULS value as per Table 8.1 of CFEM.

Frictional forces derived from the existing fill and native soils are likely to be minimal, accordingly these have been neglected.

6.4 Seismic Site Classification

GHD understands that the proposed building will be governed by Part 4 of the Ontario Building Code (OBC-2012), and therefore will require a site classification for seismic site response.

Based upon the borehole information for the Site, a Site Classification 'D', with respect to Table 4.1.8.4.A of the National Building Code of Canada 2015 is recommended if deep foundations are used with pile caps placed on the existing unimproved fill.

A higher Site Classification 'C' may be achievable if the existing fill material is improved.

6.5 Floor Slabs

As discussed in Section 4 of this letter, approximately 6 m of fill material was encountered in boreholes drilled as part of this investigation.

The uncontrolled fill material may not be suitable to support a slab-on-grade construction and therefore following options are suggested regarding the floor slab design and construction:

- The use of a structural slab can be considered.
- Soil improvement methods may allow construction of slab on grade however this would require detailed discussion with soil improvement contractors.

6.6 Frost Protection

All exterior footings associated with the heated buildings must be provided with at least 1.5 m of soil cover or its equivalent in insulation, in order to provide adequate protection against detrimental frost action. This cover depth requirement must be increased to 1.8 m for footings for unheated or isolated structures such as signs, entrance canopy, or piers.

Should construction take place during winter, the exposed surfaces to support foundations must be protected by Contractors against freezing.

6.7 Permanent Drainage

6.7.1 Underfloor Drainage-Slab-on-Grade – No Basement

Under floor drains are not considered necessary for a structure without basement and a floor slab set above the surrounding grades. However, the drainage requirements must be re-evaluated once final design grades and proximity to the water table are determined.

6.7.2 Perimeter drainage

For the proposed building with no basement or underground level and based on the Site subsurface condition, perimeter drainage around the exterior of the walls of the proposed building is not considered necessary. However, the drainage requirements must be re-evaluated once final design grades and proximity to the water table are determined.

6.8 Corrosion Potential of Soils

Analytical testing was carried out on a soil sample collected to determine corrosion potential of the subsurface soils at each site. The selected soil sample was tested for pH, resistivity, chlorides, and sulphides, sulphates, and redox potential. The test results are summarized in the following table.

Table 6.1 Corrosion Parameter Results

Sample ID	MW4
pH	8.66
Resistivity (ohm-cm)	1920
Sulphate (%)	0.08
Chloride (%)	0.008
REDOX Potential (mV)	205
Sulphide (µg/g)	<0.20

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

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

Table 6.2 Classes of Exposure

Degree (Class) of Exposure	Water Soluble (SO_4) in Soil Sample (%)
Very Severe (S-1)	>2.0
Severe (S-2)	0.20 - 2.0
Moderate (S-3)	0.10 - 0.20

A review of the analytical test results shows the sulphate content in the tested samples was found to be less than 0.08 percent. Based upon the test results, the degree of exposure of the subsurface concrete structures to sulphate attack is low. Therefore, normal General Use (GU) hydraulic cement can be used for the below grade concrete structures.

6.9 Slope Stability

The historic fill placement at the Site has created sloping of approximately 2:1 (H:V) around the south, west, and north perimeters of the Site.

A slope stability assessment was performed for the existing slope along the north perimeter of the Site. GHD's understanding of the existing slope conditions is based on Site observations and field measurement. Analysis was performed on the existing slope under static condition and pseudo-static (i.e., seismic) conditions considering drained soil conditions.

The slope stability analysis was carried out using the SLOPE/W 2019 software package produced by GEO-SLOPE International Ltd. Each trial was modeled using the Morgenstern-Price method, and the optimized critical slip-surface was selected. In general, this approach calculates a factor of safety that represents the ratio of forces resisting a failure (i.e., shear strength, friction, etc.) to those favouring failure (weight, external loading, etc.). Theoretically, a factor of safety of 1.0 would represent a stable slope. However, the City of Ottawa recommends a minimum factor of safety of 1.5 under static condition and 1.1 under pseudo-static conditions.

The selected geotechnical parameters for the Site soils used in the analysis is summarized in Table 6.3 below.

Table 6.3 Geotechnical Parameters – Existing Slope

Material	Unit Weight (kN/m^3)	Cohesion (kPa)	Internal Friction Angle (°)
Existing Fill – Clayey Silty Sand	19	3	30
Existing Fill- Sand	19	0	30
Existing Fill- Clay	17	3	25
Native Silty Sand/Sandy Silt	20	0	30
Bedrock	N/A (Considered Impenetrable)		

A summary of the analyses is shown in Table 6.4 below, with the analysis for each condition provided in Appendix C at the end of this report.

Table 6.4 Summary of Analyses

Borehole Location	Condition (Drained)	Factor of Safety
BH1	Static	1.3
	Pseudo Static	0.9
BH2	Static	1.6
	Pseudo Static	1.1

Based on the preliminary slope stability analysis, depending on the composition and compactness state of the fill material, the factor of safety for the slope may be equal or slightly below (i.e., 1.3 under static condition and 0.9 under pseudo-static condition) the recommend values of 1.5 for static condition and 1.1 for pseudo-static condition. If the existing slopes are to remain on the Site, some slope remediation or adjustment may be required depending on the proposed structure location and distance from the slope. GHD must be provided a topographic survey plan for the existing slope and the proposed finish grade at the detailed design stage to determine the design setback allowance for the building and revise or confirm analysis. It is noted that the condition of the slope must be monitored during site preparation and building construction.

6.10 Backfill

The placement and compaction of the materials that will support pavement, floor slab, or footings must be treated as Engineered Fill.

6.10.1 Engineered Fill

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

- Engineered Fill must be placed under the continuous supervision of the Geotechnical Engineer.
- Prior to placing any Engineered Fill, all unsuitable fill materials must be removed, and the subgrade proof rolled, and approved. Any deficient areas should be repaired.
- Prior to the placement of Engineered Fill, the source or borrow areas for the Engineered Fill must be evaluated for its suitability. Samples of proposed fill material must be provided to the Geotechnical Engineer and tested in the geotechnical laboratory for Standard Proctor Maximum Dry Density (SPMDD) and grain size, prior to approval of the material for use as Engineered Fill. The Engineered Fill must consist of environmentally suitable soils (as per industry standard procedures of federal or provincial guidelines/regulations), free of organics and other deleterious material (building debris such as wood, bricks, metal, and the like), compactable, and of suitable moisture content so that it is within -2 percent to +0.5 percent of the Optimum Moisture as determined by the Standard Proctor test. Imported granular soils meeting the requirements of Granular 'A', or Type II OPSS 1010 criteria would be suitable.
- The Engineered Fill must be placed in maximum loose lift thicknesses of 0.2 m. Each lift of Engineered Fill must be compacted with a heavy roller to 100 percent SPMDD.
- Field density tests must be taken by the Geotechnical Engineer, on each lift of Engineered Fill. Any Engineered Fill, which is tested and found to not meet the specifications, shall be either removed or re-compacted and retested.

6.10.2 Exterior Foundation Wall Backfill

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

- Free-draining granular backfill should be used for the foundation wall.
- Backfill should not be placed in a frozen condition or placed on a frozen subgrade.
- Backfill should be placed and compacted in uniform lift thickness compatible with the selected construction equipment, but not thicker than 0.2 m. Backfill should be placed uniformly on both sides of the foundation walls to avoid build-up of unbalanced lateral pressures.
- At exterior flush door openings, the underside of sidewalks should be insulated, or the sidewalk should be placed on frost walls to prevent heaving. Granular backfill should be used and extended laterally beneath the entire area of the entrance slab. The entrance slab should slope away from the building.
- For backfill that would underlie paved areas, sidewalks or exterior slabs-on-grade, each lift should be uniformly compacted to at least 98 percent of its SPMDD.

- For backfill on the building exterior that would underlie landscaped areas, each lift should be uniformly compacted to at least 95 percent of its SPMDD.
- In areas on the building exterior where an asphalt or concrete pavement will not be present adjacent to the foundation wall, the upper 0.3 m of the exterior foundation wall backfill should be a low permeable soil to reduce surface water infiltration.
- Exterior grades should be sloped away from the foundation wall, and roof drainage downspouts should be placed so that water flows away from the foundation wall.

6.11 Construction Field Review

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

- Prior to construction of footings, the exposed foundation subgrade should be examined by a Geotechnical Engineer (GE) or a qualified Technologist acting under the supervision of a GE, to assess whether the subgrade conditions correspond to those encountered in the boreholes and test pits, and the recommendations provided in this report have been implemented.
- A qualified Technologist acting under the supervision of a GE should monitor placement of Engineered Fill underlying floor slabs.
- Backfilling operations should be conducted in the presence of a qualified Technologist on a part-time basis, to ensure that proper material is employed, and specified compaction is achieved.
- Placement of concrete should be periodically tested to ensure that job specifications are being achieved.
- Piling operations should be monitored on a full-time basis by a qualified Technologist to verify pile installation and socket into bedrock and verticality.

7. Limitation of the Investigation

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

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

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

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

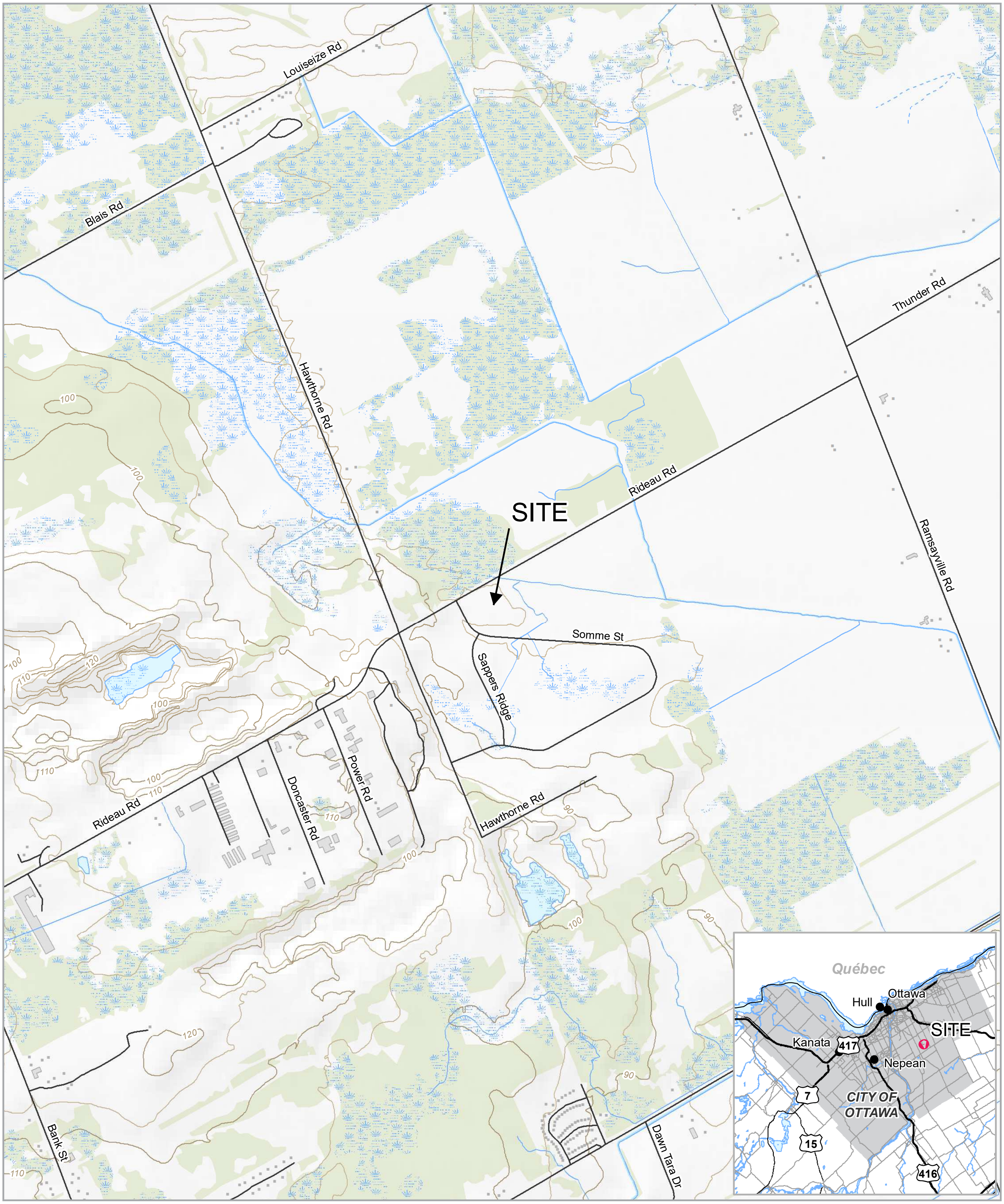
It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the test hole locations only. The subsurface conditions confirmed at these test locations may vary at other locations. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction, which could not be detected or anticipated at the time of our investigation. Should any conditions at the Site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD is completed.

All of Which is Respectfully Submitted,

GHD

Ryan Vanden Tillaart, P.Eng.

Bahareh Vazhbakht, M.A.Sc., P. Eng.



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0 140 280 420 560

Metres

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

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GHD

CONSOLIDATED FASTRATE HOLDINGS INC.
NEW WAREHOUSE
INTERSECTION OF RIDEAU STREET AND SOMME STREET
GEOTECHNICAL INVESTIGATION

SITE LOCATION MAP

Project No. **11215612**
Revision No. **-**
Date **Aug 21, 2020**

FIGURE 1

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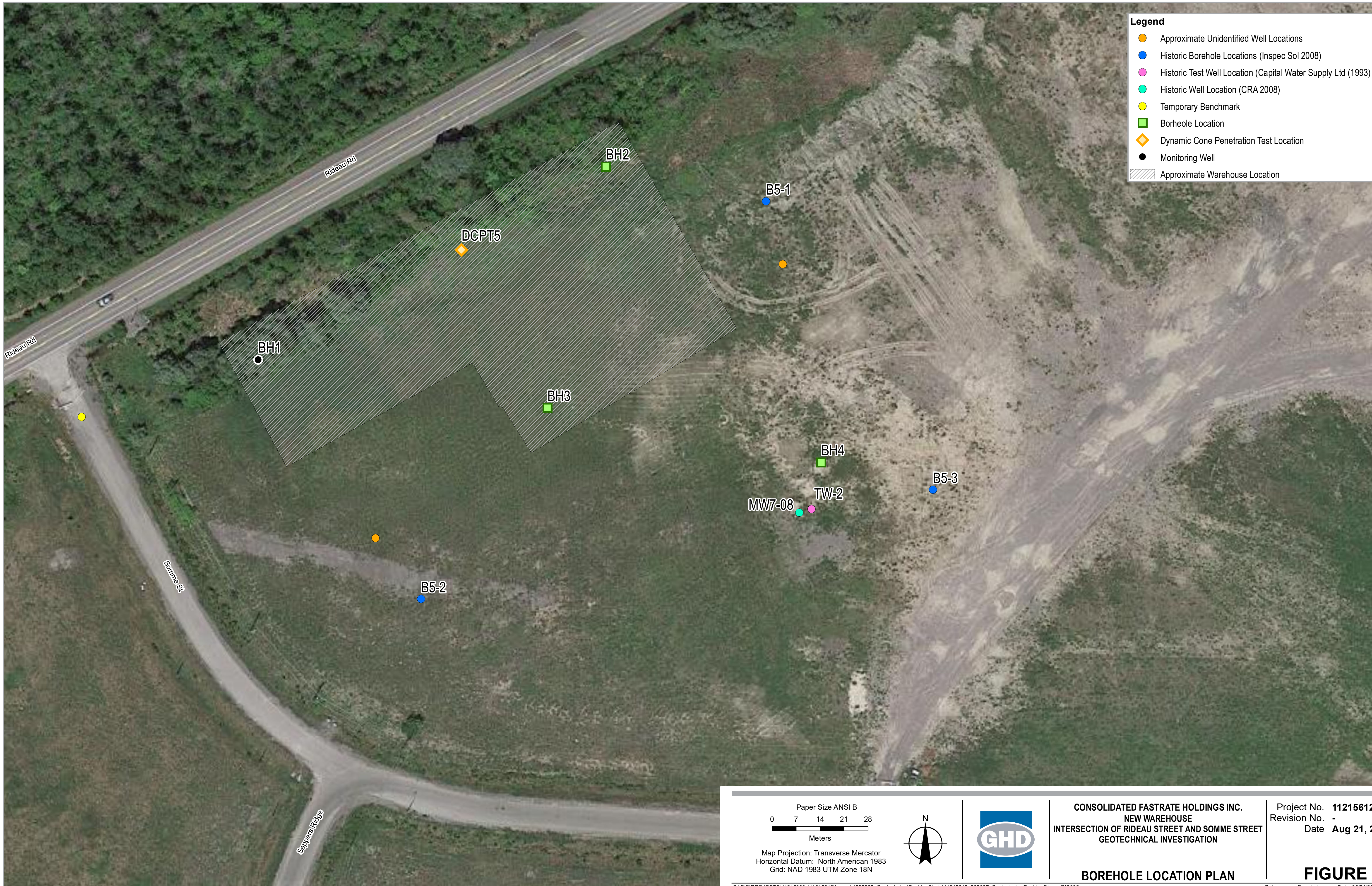
Print date: 21 Aug 2020 - 09:16



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

GHD

CONSOLIDATED FASTRATE HOLDINGS INC.
NEW WAREHOUSE
INTERSECTION OF RIDEAU STREET AND SOMME STREET
GEOTECHNICAL INVESTIGATION

Project No. 11215612
Revision No. -
Date Aug 21, 2020

BOREHOLE LOCATION PLAN

FIGURE 2

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Print date: 21 Aug 2020 - 10:14

Data source: Google Imagery Date, 06/01/2018 .

Appendices

Appendix A
Borehole and Test Pit Logs and Notes on Boreholes

REFERENCE No.: 11215612-A2 ENCLOSURE No.: 1

BOREHOLE LOG

Page: 1 of 2

BOREHOLE No.: BH1

ELEVATION: 90.21 m

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.

PROJECT: New Warehouse

LOCATION: Somme Street, Ottawa, ON

DESCRIBED BY: RVT CHECKED BY: BV

DATE (START): 6 August 2020 DATE (FINISH): 6 August 2020

LEGEND

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

STRATIGRAPHY

Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK
90.21	GROUND SURFACE
90.1	TOPSOIL (75 mm thickness)
	FILL - Silty sand, trace gravel, loose, brown, damp
89.4	FILL - Gravel, trace sand, possible cobble/boulder, compact to dense, grey, damp
88.7	FILL - Silty sand, some clay, trace gravel, compact, brown and grey, damp
87.2	FILL - Silty clay, some sand, trace gravel, very stiff, brown and grey, damp becoming sandy at 3.8 mbgs
86.3	FILL - Clayey silty sand, compact, grey and brown, moist
84.3	SILTY SAND- some clay, trace to some gravel, compact, brown and grey, moist

Depth BGS (meters): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5

MONITOR WELL

- 1.01
- Riser
- Cuttings
- WL 3.99
- 4.57
- Bentonite
- 5.18
- 5.49
- Sand
- Screen

SAMPLE DATA

Type and Number	Recovery (%)	OVC (ppm)	Penetration Index / RQD (N)
SS1	50		5
SS2	50		47
SS3	42		20
SS4	58		19
SS5	33		10
SS6	58		14
SS7	21		14
SS8	46		12
SS9	54		12

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

NOTES:
mbgs: meters below ground surface
RQD: Rock Quality Designation

REFERENCE No.: 11215612-A2 ENCLOSURE No.: 1

BOREHOLE No.: BH1
ELEVATION: 90.21 m

BOREHOLE LOG

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.
PROJECT: New Warehouse
LOCATION: Somme Street, Ottawa, ON
DESCRIBED BY: RVT CHECKED BY: BV
DATE (START): 6 August 2020 DATE (FINISH): 6 August 2020

LEGEND

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

Depth BGS (meters)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	MONITOR WELL	Type and Number	Recovery (%)	OVC (ppm)	Penetration Index / RQD (N)
	90.21	GROUND SURFACE					
7.01		Refusal encountered at 7.2 mbgs Cobbles and boulders encountered from 7.3 to 8.2 mbgs	7.01	SS10	71		50+
				RC1	49		
8.2	82.0	LIMESTONE- interbedded sandstone, grey, fair becoming good quality with depth based on RQD		RC2	94		73
				RC3	100		82
				RC4	100		90
11.3	78.9	Borehole terminated at 11.3 mbgs					

Depth scale: 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5

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

NOTES:
mbgs: meters below ground surface
RQD: Rock Quality Designation

BOREHOLE LOG 11215612-A2-BH LOGS.GPJ INSPEC_SOL.GDT 4/9/20

REFERENCE No.: 11215612-A2 ENCLOSURE No.: 2

BOREHOLE No.: BH2
ELEVATION: 89.80 m

BOREHOLE LOG

Page: 1 of 2

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.
PROJECT: New Warehouse
LOCATION: Somme Street, Ottawa, ON
DESCRIBED BY: RVT CHECKED BY: BV
DATE (START): 6 August 2020 DATE (FINISH): 6 August 2020

LEGEND

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

Depth BGS (meters)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery (%)	OVC (ppm)	Penetration Index / RQD (N)
	89.80	GROUND SURFACE				
	89.7	TOPSOIL (75 mm thickness)				
		FILL - Silty clay, firm to stiff, grey, moist	SS1	58		2
0.5						
1.0			SS2	100		2
1.5						
2.0			SS3	100		1
2.5			SS4	100		WH
3.0						
3.5			FV5			
	86.0	FILL - Clayey sand, some gravel, organics, loose, grey and brown, moist				
4.0			SS6	75		5
4.5	85.2	FILL - Gravelly sandy silt, compact to very dense, brown and grey, saturated				
5.0			SS7	83		33
5.5			SS8	63		70
6.0	83.7	SILTY SAND- some gravel, compact to very dense, grey, moist to saturated				
6.5			SS9	100		27

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

NOTES:
mbgs: meters below ground surface
RQD: Rock Quality Designation

BOREHOLE No.: BH2

ELEVATION: 89.80 m

BOREHOLE LOG

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.

PROJECT: New Warehouse

LOCATION: Somme Street, Ottawa, ON

DESCRIBED BY: RVT CHECKED BY: BV

DATE (START): 6 August 2020 DATE (FINISH): 6 August 2020

LEGEND

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

Depth BGS (meters)	Elevation (m)	Description of Soil and Bedrock	Type and Number	Recovery (%)	OVC (ppm)	Penetration Index / RQD (N)
	89.80	GROUND SURFACE				
			SS10	83		57
			SS11	91		70
		Cobbles and boulders encountered from 8.4 to 9.3 mbgs	SS12	100		50+
		Refusal encountered at 9.3 mbgs	SS13	100		50+
	80.5	LIMESTONE- interbedded sandstone, grey, fair to good quality based on RQD	RC1	100		85
			RC2	100		83
			RC3	100		52
	77.6	Borehole terminated at 12.2 mbgs				

Depth scale: 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5

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

NOTES:
mbgs: meters below ground surface
RQD: Rock Quality Designation

REFERENCE No.: 11215612-A2 ENCLOSURE No.: 3

BOREHOLE No.: BH3

ELEVATION: 90.88 m

BOREHOLE LOG

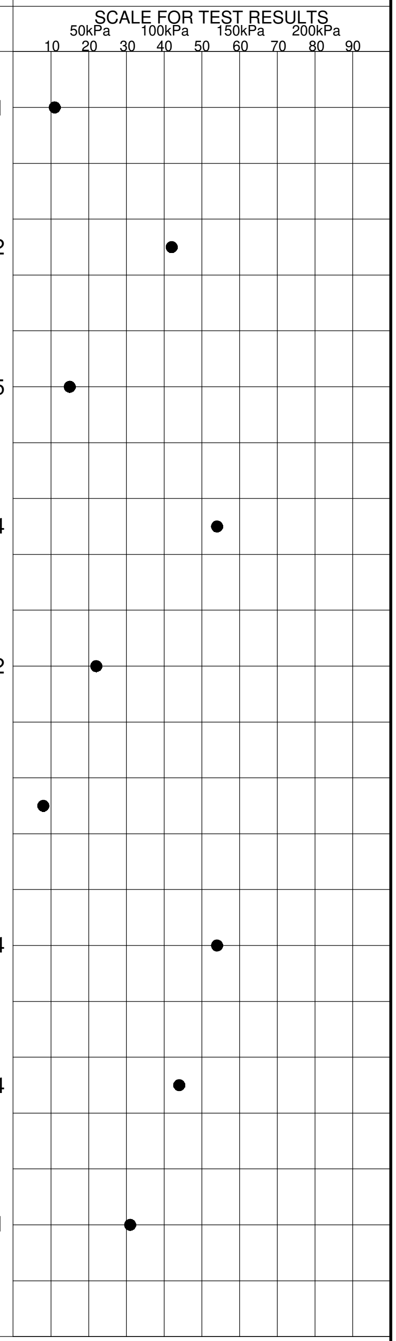
CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.
PROJECT: New Warehouse
LOCATION: Somme Street, Ottawa, ON
DESCRIBED BY: RVT CHECKED BY: BV
DATE (START): 7 August 2020 DATE (FINISH): 7 August 2020

LEGEND

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

Depth BGS (meters)	Elevation (m)	Description of Soil and Bedrock	Type and Number	Recovery (%)	OVC (ppm)	Penetration Index / RQD (N)
	90.88	GROUND SURFACE				
	90.8	TOPSOIL (125 mm thickness)				
0.5		FILL - Clayey silty sand, trace to some gravel, compact, brown and grey, damp	SS1	63		11
1.0	90.0	FILL - Crushed limestone, asphalt, compact, grey and black, damp	SS2	58		42
1.5	89.4	FILL - Sand, trace gravel, clay pockets, asphalt, compact, grey and black, damp to moist	SS3	38		15
2.0	88.6	FILL - Silty sand, some gravel, trace clay, possible cobbles/boulders, compact , grey, moist	SS4	33		54
3.0	87.8	FILL - Clayey sand, asphalt, loose to compact, grey and brown, moist	SS5	33		22
4.0			SS6	4		8
4.5	86.3	FILL - Silty sand, trace gravel, trace to some clay, dense to very dense, brown and grey, damp to moist, possible cobbles/boulders	SS7	50		54
5.5			SS8	33		44
6.0	84.8	SANDY SILT- some gravel, compact to very dense, grey, damp	SS9	83		31

SCALE FOR TEST RESULTS



NOTES:
mbgs: meters below ground surface
RQD: Rock Quality Designation

BOREHOLE No.: BH3

ELEVATION: 90.88 m

BOREHOLE LOG

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.

PROJECT: New Warehouse

LOCATION: Somme Street, Ottawa, ON

DESCRIBED BY: RVT CHECKED BY: BV

DATE (START): 7 August 2020 DATE (FINISH): 7 August 2020

LEGEND

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

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

Depth BGS (meters)	Elevation (m)	Description of Soil and Bedrock	Type and Number	Recovery (%)	OVC (ppm)	Penetration Index / RQD (N)
	90.88	GROUND SURFACE				
			SS10	83		28
7.5		Possible cobbles/boulders encountered from 7.6 to 9.1 mbgs				
8.0			SS11	83		24
8.5			SS12	25		80
9.0						
9.5			SS13	100		42
10.0		Refusal encountered at 10 mbgs Cobbles and boulders encountered from 10.0 to 11.9 mbgs				
10.5						
11.0			RC1	32		
11.5						
12.0	79.0	LIMESTONE- interbedded sandstone, grey, poor to fair quality based on RQD				
12.5			RC2	100		57
13.0						
13.5		Rock core mechanical breaks during coring from 13.4 to 14.9 mbgs				

NOTES:
mbgs: meters below ground surface
RQD: Rock Quality Designation

BOREHOLE No.: BH3

ELEVATION: 90.88 m

BOREHOLE LOG

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.

PROJECT: New Warehouse

LOCATION: Somme Street, Ottawa, ON

DESCRIBED BY: RVT CHECKED BY: BV

DATE (START): 7 August 2020 DATE (FINISH): 7 August 2020

LEGEND

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

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	90.88		GROUND SURFACE			%	ppm	N
					RC3	92		37
14.5								
15.0	75.9		Borehole terminated at 14.9 mbgs					
15.5								
16.0								
16.5								
17.0								
17.5								
18.0								
18.5								
19.0								
19.5								
20.0								
20.5								

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

NOTES:
mbgs: meters below ground surface
RQD: Rock Quality Designation

REFERENCE No.: 11215612-A2 ENCLOSURE No.: 4

BOREHOLE No.: BH4

ELEVATION: 90.44 m

BOREHOLE LOG

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.

PROJECT: New Warehouse

LOCATION: Somme Street, Ottawa, ON

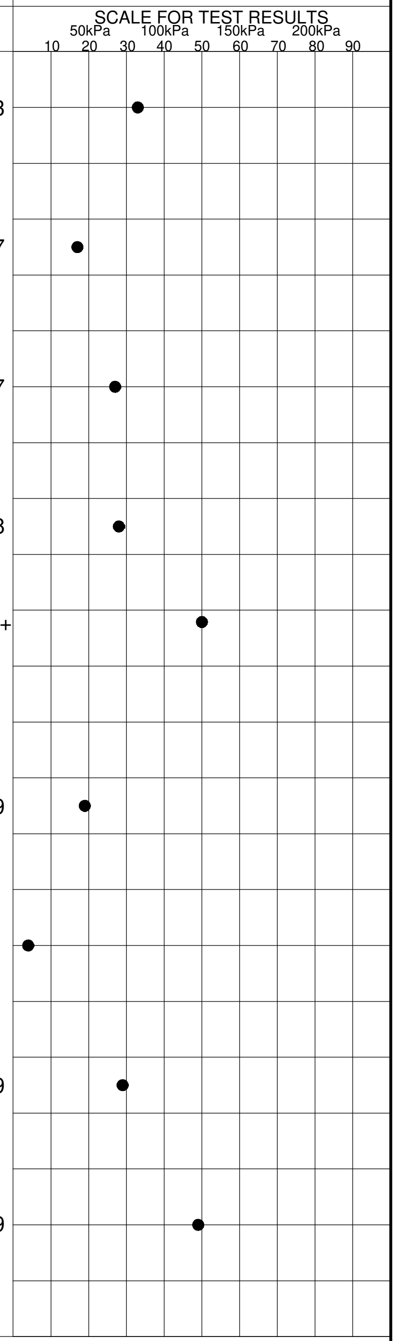
DESCRIBED BY: RVT CHECKED BY: BV

DATE (START): 7 August 2020 DATE (FINISH): 7 August 2020

LEGEND

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

Depth BGS (meters)	Elevation (m)	Description of Soil and Bedrock	State	Type and Number	Recovery (%)	OVC (ppm)	Penetration Index / RQD (N)
	90.44	GROUND SURFACE					
	90.3	TOPSOIL (125 mm thickness)					
		FILL - Gravelly sand, compact, grey, damp	☒	SS1	63		33
0.5	89.7	FILL - Sand and gravel, compact, grey, damp					
1.0			☒	SS2	50		17
1.5		Asphalt encountered at 1.5 mbgs					
2.0			☒	SS3	54		27
2.5			☒	SS4	58		28
3.0	87.4	FILL - Silty sand, trace clay, trace to some gravel, possible cobbles/boulders, brown and grey, damp to moist	☒	SS5	100		50+
3.5							
4.0		Wood encountered at 3.8 mbgs	☒	SS6	17		19
4.5							
5.0			☒	SS7	0		4
5.5			☒	SS8	75		29
6.0	84.3	SILTY SAND- trace to some gravel, trace clay, compact to dense, grey and brown, moist					
6.5			☒	SS9	79		49
			☒				



NOTES:
mbgs: meters below ground surface

BOREHOLE No.: BH4
ELEVATION: 90.44 m

BOREHOLE LOG

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.
PROJECT: New Warehouse
LOCATION: Somme Street, Ottawa, ON
DESCRIBED BY: RVT CHECKED BY: BV
DATE (START): 7 August 2020 DATE (FINISH): 7 August 2020

LEGEND

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

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa; 10 20 30 40 50 60 70 80 90
meters	90.44		GROUND SURFACE			%	ppm	N	
					SS10	4		32	
7.5									
8.0					SS11	58		18	
8.5					SS12	58		44	
9.0									
9.5					SS13	67		50	
10.0									
10.5									
11.0					SS14	88		50+	
	79.3		Borehole terminated at refusal at 11.1 mbgs						
11.5									
12.0									
12.5									
13.0									
13.5									

NOTES:
mbgs: meters below ground surface

REFERENCE No.: 11215612-A2 ENCLOSURE No.: 5

BOREHOLE No.: DCPT5

ELEVATION: 90.76 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Consolidated Fastrate (Ottawa) Holdings Ltd.

PROJECT: New Warehouse

LOCATION: Somme Street, Ottawa, ON

DESCRIBED BY: RVT CHECKED BY: BV

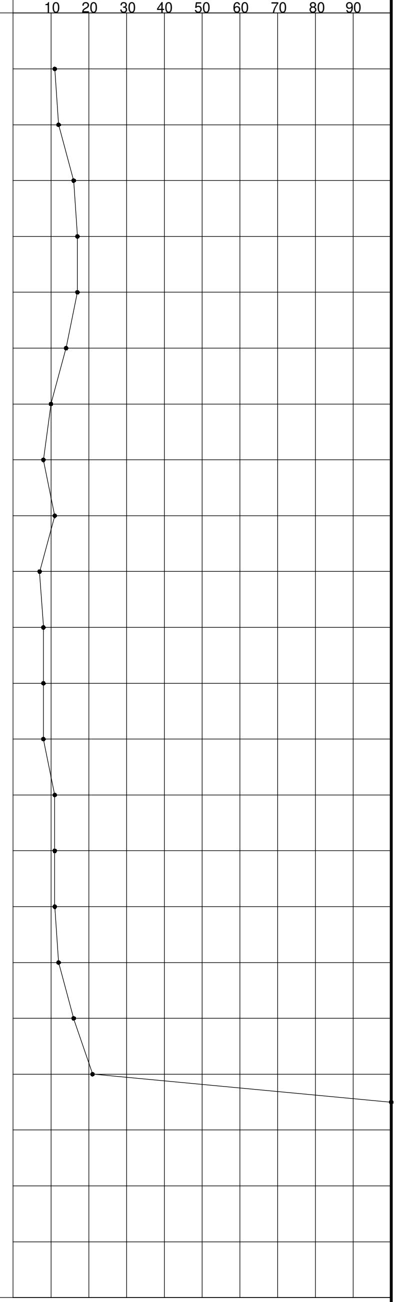
DATE (START): 7 August 2020 DATE (FINISH): 7 August 2020

LEGEND

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

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	90.76		GROUND SURFACE			%	ppm	N
			Dynamic Cone Penetration test from surface to refusal encountered at 5.9 mbgs					
0.5								
1.0								
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								
5.5								
6.0	84.8							
6.5								

SCALE FOR TEST RESULTS



NOTES:
mbgs: meters below ground surface

Notes on Borehole and Test Pit Reports

Soil description :

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

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

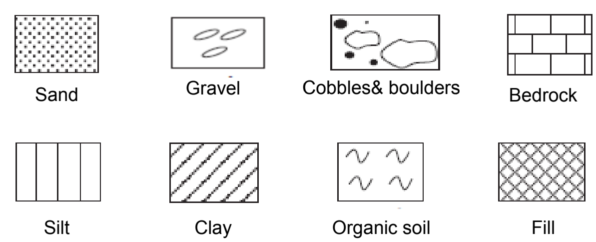
Terminology	
"trace"	1-10%
"some"	10-20%
adjective (silty, sandy)	20-35%
"and"	35-50%

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

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

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

STRATIGRAPHIC LEGEND



Samples:

Type and Number

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

SS: Split spoon
ST: Shelby tube
AG: Auger
SSE, GSE, AGE: Environmental sampling
PS: Piston sample (Osterberg)
RC: Rock core
GS: Grab sample

Recovery

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

RQD

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

IN-SITU TESTS:

N: Standard penetration index
N_c: Dynamic cone penetration index
k: Permeability
R: Refusal to penetration
Cu: Undrained shear strength
ABS: Absorption (Packer test)
Pr: Pressure meter

LABORATORY TESTS:

I_p: Plasticity index
H: Hydrometer analysis
A: Atterberg limits
C: Consolidation
O.V.: Organic vapor
W_l: Liquid limit
GSA: Grain size analysis
w: Water content
CS: Swedish fall cone
Wp: Plastic limit
γ: Unit weight
CHEM: Chemical analysis

Appendix B
Laboratory Testing Results

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

Client:	Consolidated Fastrate (Ottawa) Holdings ltd	**Lab no.:**	G-20-13
Project/Site:	New warehouse, Somme Street, Ottawa, On	**Project no.:**	11215612-A2

Borehole no.:	2	Sample no.:	4	Depth:	2.3 - 3.0m
Soil description:				Date sampled:	7-Aug-20

Apparatus:	Hand Crank/ Motor Driven	Balance no.:	1	Porcelain bowl no.:	1
Liquid limit device no.:	1	Oven no.:	1	Spatula no.:	1
Sieve no.:	1	Glass plate no.:	1		

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	30	27	20
Water Content:			
Tare no.	S15	S16	S29
Wet soil+tare, g	43.61	38.30	40.40
Dry soil+tare, g	34.97	31.57	32.70
Mass of water, g	8.64	6.73	7.70
Tare, g	22.02	21.72	21.82
Mass of soil, g	12.95	9.85	10.88
Water content %	66.7%	68.3%	70.8%

Plastic Limit (PL) - Water Content:

Tare no.	S14	S20
Wet soil+tare, g	27.14	27.75
Dry soil+tare, g	26.20	26.85
Mass of water, g	0.94	0.90
Tare, g	21.84	22.53
Mass of soil, g	4.36	4.32
Water content %	21.6%	20.8%
Average water content %	21.2%	

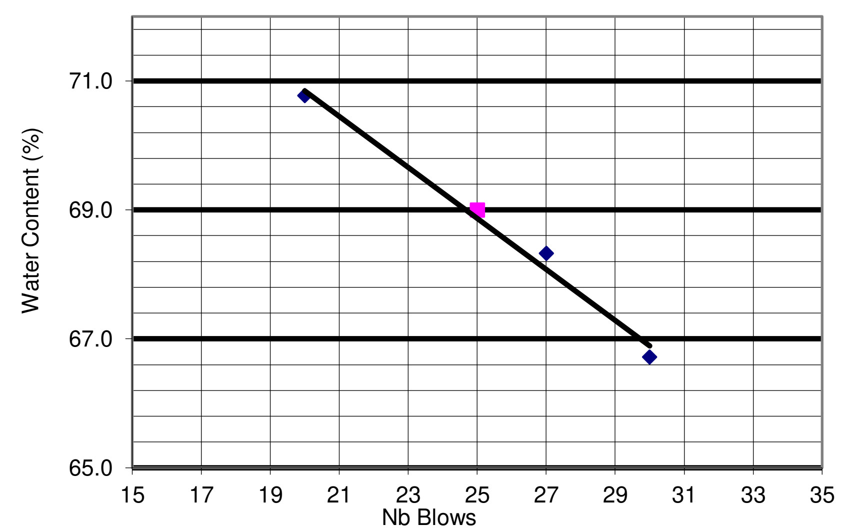
Natural Water Content (W^n):

Tare no.	S8	
Wet soil+tare, g	44.50	
Dry soil+tare, g	33.60	
Mass of water, g	10.90	
Tare, g	14.30	
Mass of soil, g	19.30	
Water content %	56.5%	

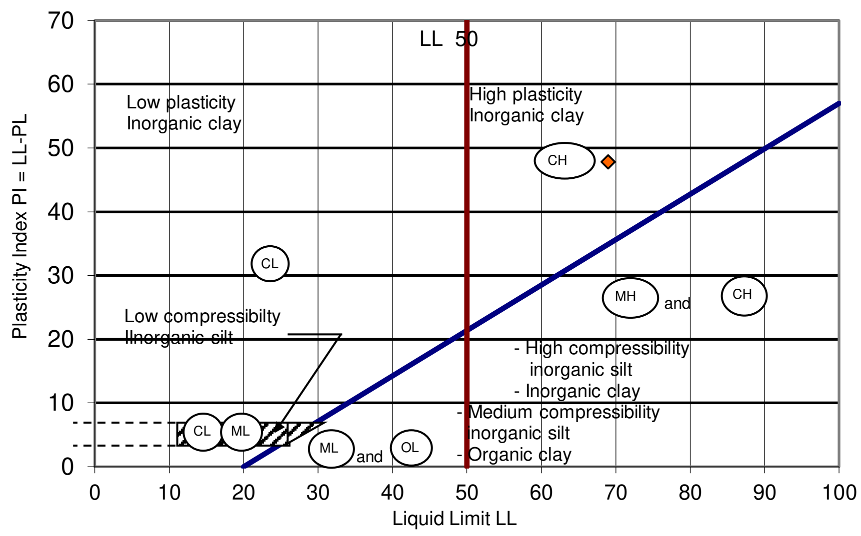
Soil Preparation:

- ☑ Cohesive <425 µm
- ☐ Cohesive >425 µm
- ☐ Non-cohesive
- ☐ Dry preparation
- ☑ Wet preparation

Results



Soil Plasticity Chart



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
69	21	48	56

Remarks:

Performed by:	Z. Mathurin	**Date:**	August 27, 2020
Verified by:		**Date:**	September 4, 2020

Moisture Content of Soils
(ASTM D2216)

Client: Consolidated Fastrate (Ottawa) Holdings Ltd
Project: New Warehouse, Somme Street, Ottawa, On
Location: Ottawa, On

Lab No.: G-20-13
Project No.: 11215612

Apparatus Used for Testing

Oven no.: 1 Scale no.: 1

Sample No.	BH1SS1	BH1SS2	BH1SS3	BH1SS4	BH1SS6	BH1SS7	BH1SS8	BH1SS9
Container no.	S18	S21	Bowl	S16	S15	S29	S43	S34
Mass of container + wet soil (g)	70.9	78.5	350.4	83.1	92.1	95.5	91.5	87.1
Mass of container + dry soil (g)	65.2	75.7	335.8	77.9	86.7	88.1	76.9	72.9
Mass of container (g)	22.7	21.8	0.0	21.8	22.1	21.8	22.1	14.6
Mass of dry soil (g)	42.5	53.9	335.8	56.1	64.6	66.3	54.8	58.3
Mass of water (g)	5.7	2.8	14.6	5.2	5.4	7.4	14.6	14.2
Moisture content (%)	13.4	5.2	4.3	9.3	8.4	11.2	26.6	24.4
Sample No.	BH1SS10	BH2SS1	BH2SS2	BH2SS2	BH2SS4	BH2SS4	BH2SS6	BH2SS6
Container no.	S5	S28	S41	S41	S8	S8	S9	S9
Mass of container + wet soil (g)	89.8	76.8	75.9	75.9	44.5	44.5	100.3	100.3
Mass of container + dry soil (g)	84.6	64.2	58.4	58.4	33.6	33.6	89.4	89.4
Mass of container (g)	22.2	21.9	22.9	22.9	14.3	14.3	21.7	21.7
Mass of dry soil (g)	62.4	42.3	35.5	35.5	19.3	19.3	67.7	67.7
Mass of water (g)	5.2	12.6	17.5	17.5	10.9	10.9	10.9	10.9
Moisture content (%)	8.3	29.8	49.3	49.3	56.5	56.5	16.1	16.1

Remarks:

Performed by: Z. Mathurin **Date:** August 27, 2020

Verified by : [signature] **Date:** September 4, 2020

Moisture Content of Soils
(ASTM D2216)

Client:	Consolidated Fastrate (Ottawa) Holdings Ltd	**Lab No.:**	G-20-13
Project:	New Warehouse, Somme Street, Ottawa, On	**Project No.:**	11215612-A2
Location:	Ottawa, On		

Apparatus Used for Testing

Oven no.: 1 Scale no.: 1

Sample No.	BH2SS7	BH2SS8	BH2SS9	BH2SS10	BH2SS11	BH2SS12	BH2SS13	BH2SS14
Container no.	S11	S31	S38	S26	S36	S39	S35	S10
Mass of container + wet soil (g)	90.6	75.1	79.5	99.9	83.8	101.3	55.7	73.1
Mass of container + dry soil (g)	84.1	66.7	74.3	93.7	79.0	92.5	55.6	55.5
Mass of container (g)	21.5	21.6	21.5	21.6	22.1	22.0	14.5	22.0
Mass of dry soil (g)	62.6	45.1	52.8	72.1	56.9	70.5	41.1	33.5
Mass of water (g)	6.5	8.4	5.2	6.2	4.8	8.8	0.1	17.6
Moisture content (%)	10.4	18.6	9.8	8.6	8.4	12.5	0.2	52.5

Sample No.	BH3SS1	BH3SS2	BH3SS3	BH3SS4	BH3SS5	BH3SS6	BH3SS7	BH3SS8
Container no.	S37	S25	S22	S20	S14	S7	S17	S2
Mass of container + wet soil (g)	87.3	73.4	76.6	102.3	66.7	57.8	89.6	102.2
Mass of container + dry soil (g)	78.7	71.6	72.4	97.8	64.3	56.4	83.5	96.5
Mass of container (g)	22.0	21.8	22.2	22.5	21.8	21.7	21.5	21.8
Mass of dry soil (g)	56.7	49.8	50.2	75.3	42.5	34.7	62.0	74.7
Mass of water (g)	8.6	1.8	4.2	4.5	2.4	1.4	6.1	5.7
Moisture content (%)	15.2	3.6	8.4	6.0	5.6	4.0	9.8	7.6

Remarks:

Performed by:	Z. Mathurin	**Date:**	August 27, 2020
Verified by :		**Date:**	September 4, 2020

Moisture Content of Soils
(ASTM D2216)

Client: Consolidated Fastrate (Ottawa) Holdings Ltd
Project: New Warehouse, Somme Street, Ottawa, On
Location: Ottawa, On
Lab No.: G-20-13
Project No.: 11215612-A2

Apparatus Used for Testing

Oven no.: 1 Scale no.: 1

Sample No.	BH3SS9	BH3SS10	BH3SS11	BH3SS12	BH3SS13	BH4SS1	BH4SS2	BH4SS3
Container no.	S12	S32	S13	S4	S120	S6	S23	S40
Mass of container + wet soil (g)	88.7	84.4	88.7	77.6	85.2	93.5	76.9	96.9
Mass of container + dry soil (g)	84.0	79.9	84.5	75.9	79.6	85.7	73.6	93.1
Mass of container (g)	21.6	21.7	24.1	21.8	21.9	21.9	22.3	22.3
Mass of dry soil (g)	62.4	58.2	60.4	54.1	57.7	63.8	51.3	70.8
Mass of water (g)	4.7	4.5	4.2	1.7	5.6	7.8	3.3	3.8
Moisture content (%)	7.5	7.7	7.0	3.1	9.7	12.2	6.4	5.4
Sample No.	BH4SS4	BH4SS5	BH4SS6	BH4SS8	BH4SS9	BH4SS11		
Container no.	S19	S1	S130	S42	S110	88		
Mass of container + wet soil (g)	105.4	92.9	44.1	101.8	98.5	73.0		
Mass of container + dry soil (g)	101.9	86.7	41.8	94.3	92.8	66.5		
Mass of container (g)	21.9	22.0	22.1	21.8	21.7	1.5		
Mass of dry soil (g)	80.0	64.7	19.7	72.5	71.1	65.0		
Mass of water (g)	3.5	6.2	2.3	7.5	5.7	6.5		
Moisture content (%)	4.4	9.6	11.7	10.3	8.0	10.0		

Remarks:

Performed by: Z. Mathurin **Date:** August 27, 2020

Verified by : **Date:** September 4, 2020

Moisture Content of Soils
(ASTM D2216)

Client: Consolidated Fastrate (Ottawa) Holdings Ltd
Project: New Warehouse, Somme Street, Ottawa, On
Location: Ottawa, On

Lab No.: G-20-13
Project No.: 11215612-A2

Apparatus Used for Testing

Oven no.: 1 Scale no.: 1

Sample No.	BH4SS12	BH4SS13	BH4SS14					
Container no.	70	42	44					
Mass of container + wet soil (g)	60.0	67.4	72.1					
Mass of container + dry soil (g)	54.0	61.2	64.6					
Mass of container (g)	1.5	1.4	1.4					
Mass of dry soil (g)	52.5	59.8	63.2					
Mass of water (g)	6.0	6.2	7.5					
Moisture content (%)	11.4	10.4	11.9					

Sample No.								
Container no.								
Mass of container + wet soil (g)								
Mass of container + dry soil (g)								
Mass of container (g)								
Mass of dry soil (g)								
Mass of water (g)								
Moisture content (%)								

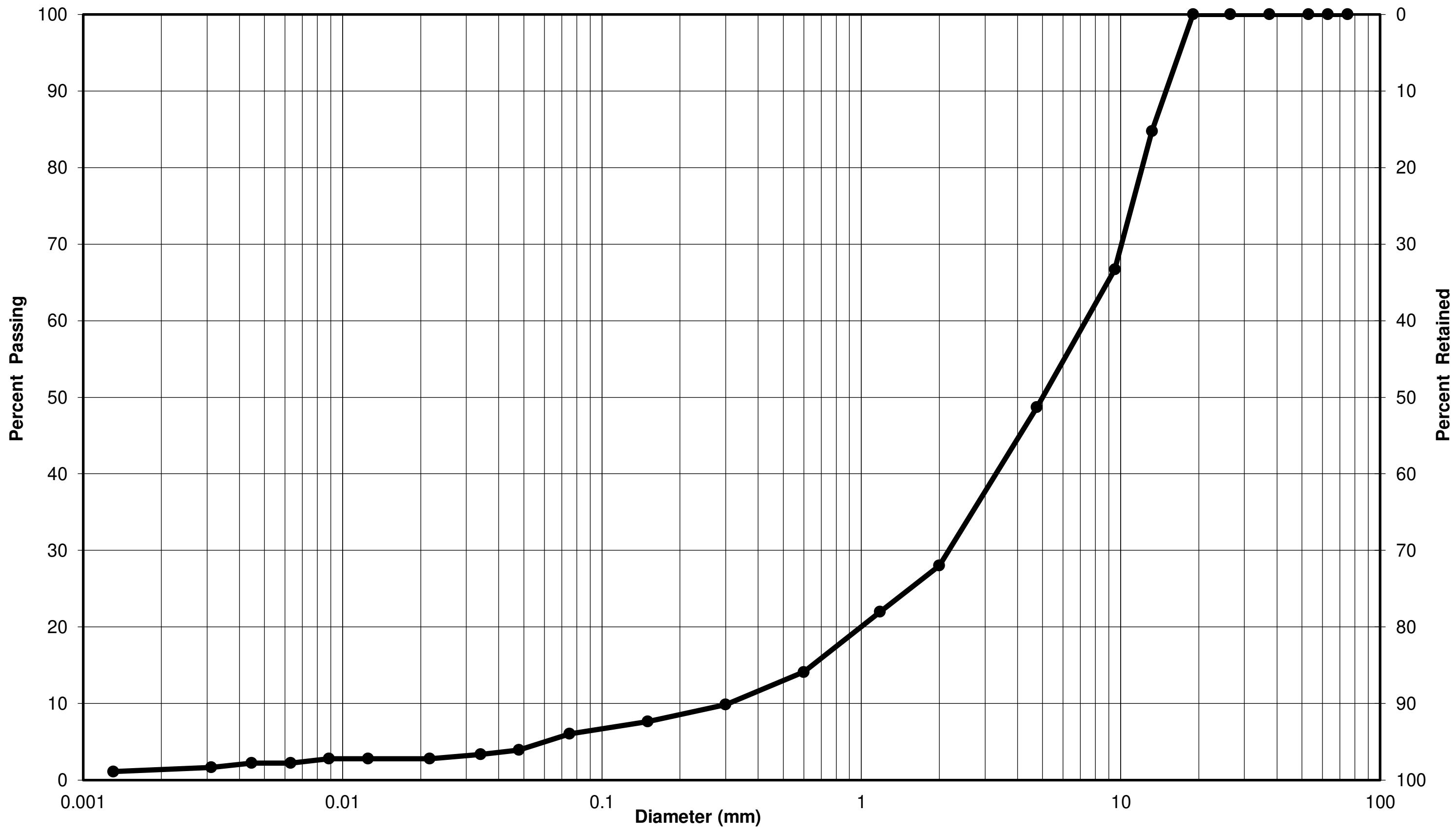
Remarks:

Performed by: Z. Mathurin **Date:** August 27, 2020

Verified by : EQ **Date:** September 4, 2020

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

Client:	Consolidated Fastrate (Ottawa) Holdings Ltd.	**Lab No.:**	G-20-13
Project, Site:	New Warehouse, Somme Street, Ottawa, ON	**Project No.:**	11215612
Borehole No.:	1	Sample No.:	3
Depth:	1.5 - 2.1m	Enclosure:	-



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

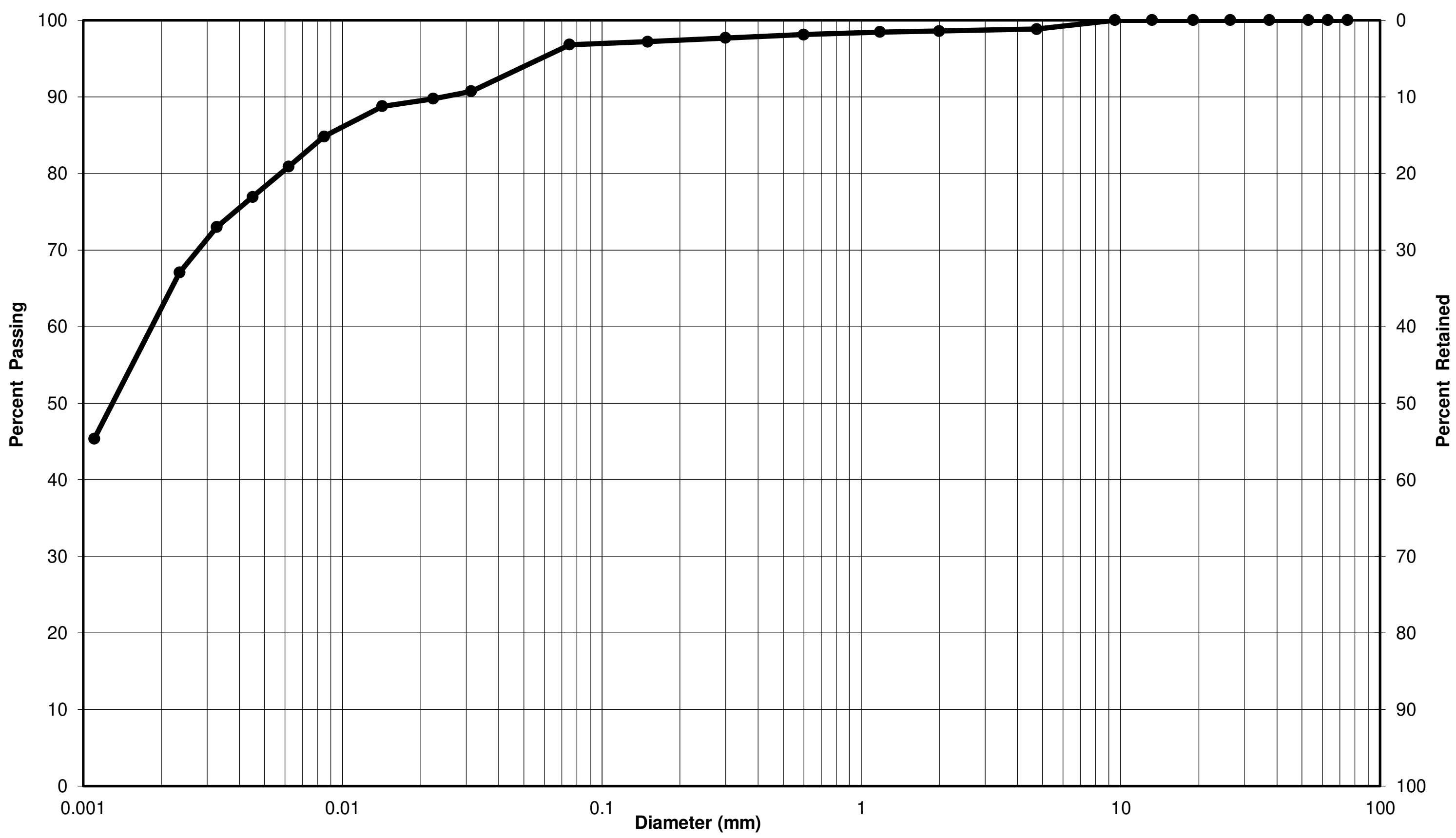
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Gravel and Sand, trace Silt, trace Clay	51	43	6
			1 %

Remarks:

Performed by:	Z. Mathurin	**Date:**	August 27, 2020
Verified by:		**Date:**	September 4, 2020

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

Client:	Consolidated Fastrate (Ottawa) Holdings Ltd.	**Lab No.:**	G-20-13
Project, Site:	New Warehouse, Somme Street, Ottawa, ON	**Project No.:**	11215612
Borehole No.:	2	Sample No.:	4
Depth:	2.3 - 3.0m	Enclosure:	-



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

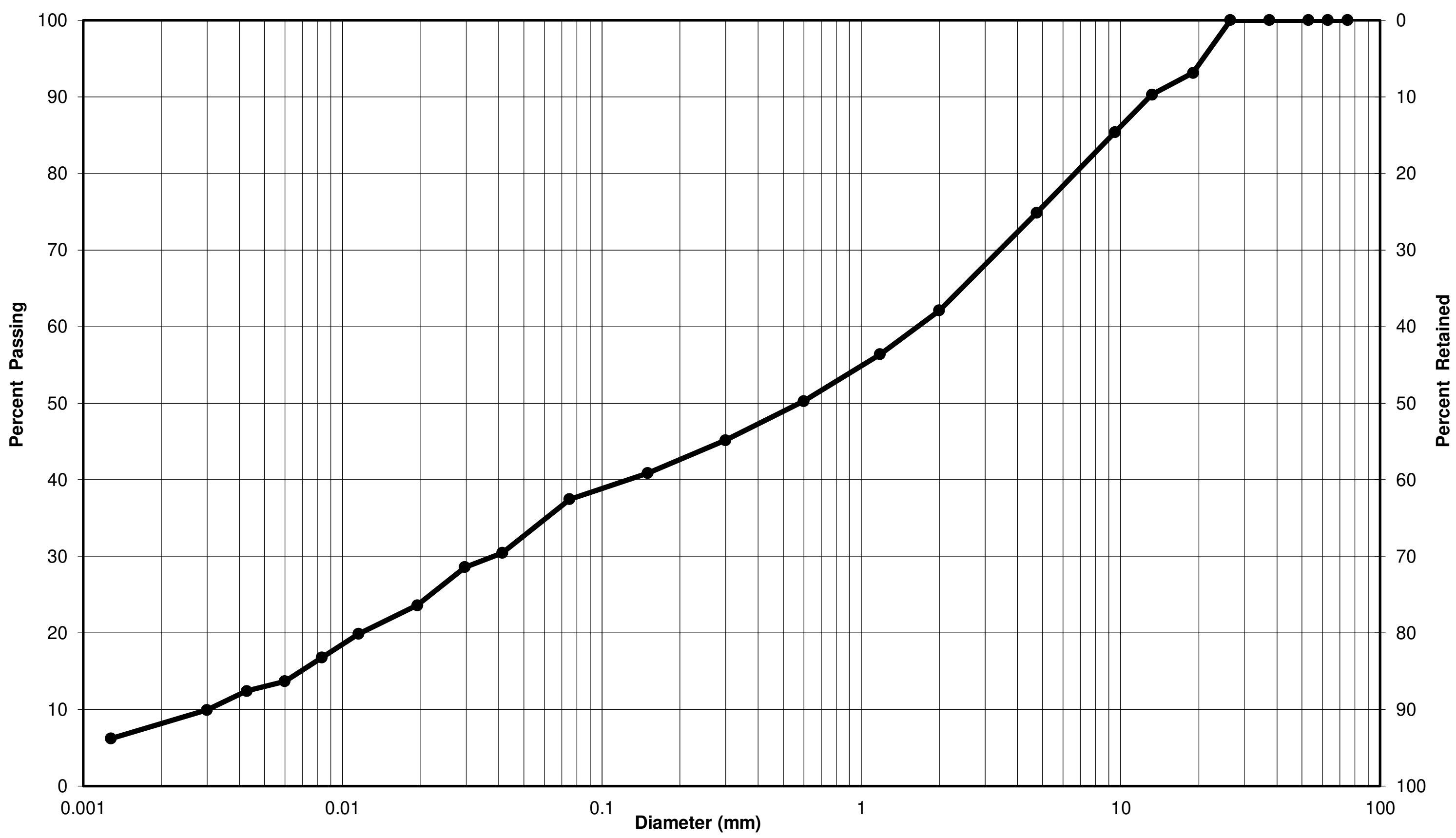
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Clay and Silt, trace Sand, trace Gravel	1	2	97
Clay-size particles (<0.002 mm):	61 %		

Remarks:

Performed by:	Z. Mathurin	**Date:**	August 27, 2020
Verified by:		**Date:**	September 4, 2020

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

Client:	Consolidated Fastrate (Ottawa) Holdings Ltd.	**Lab No.:**	G-20-13
Project, Site:	New Warehouse, Somme Street, Ottawa, ON	**Project No.:**	11215612
Borehole No.:	2	Sample No.:	7
Depth:	4.5 - 6.1m	Enclosure:	-



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

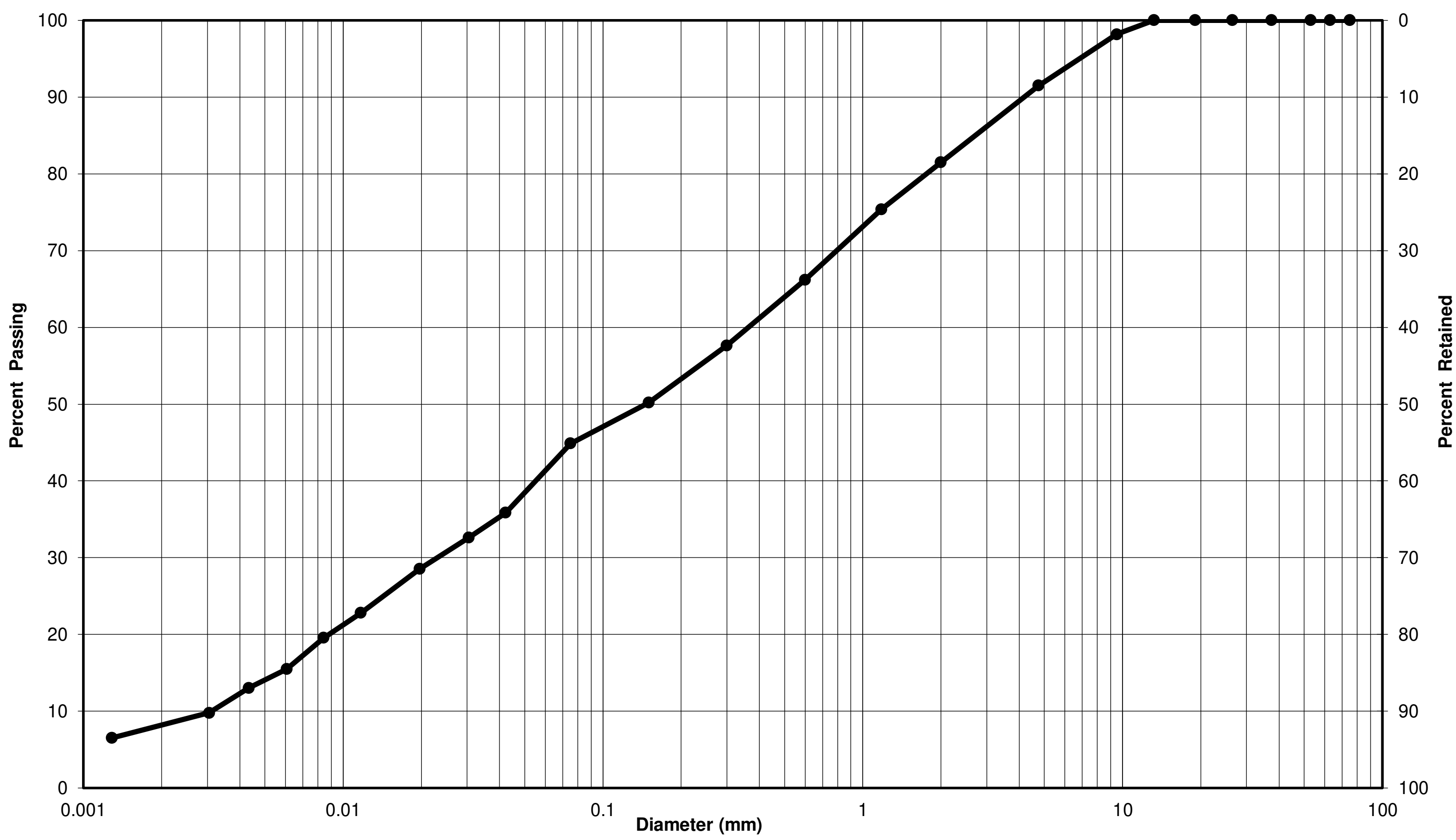
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Gravelly, Silty, Sand, trace Clay	25	38	37
Clay-size particles (<0.002 mm):			8 %

Remarks:

Performed by:	Z. Mathurin	**Date:**	August 27, 2020
Verified by:		**Date:**	September 4, 2020

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

Client:	Consolidated Fastrate (Ottawa) Holdings Ltd.	**Lab No.:**	G-20-13
Project, Site:	New Warehouse, Somme Street, Ottawa, ON	**Project No.:**	11215612
Borehole No.:	3	Sample No.:	10
Depth:	6.9 - 7.5m	Enclosure:	-



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

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Sand and Silt, trace Gravel, trace Clay	8	47	45
Clay-size particles (<0.002 mm):			8 %

Remarks:

Performed by:	Z. Mathurin	**Date:**	August 27, 2020
Verified by:	[signature]	**Date:**	September 4, 2020

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

Client :	Consolidated Fastrate (Ottawa) Holdings ltd	**Project N° :**	G-20-13
Project :	New Warehouse, Somme Street, Ottawa, O	**Sample N° :**	BH2-RC1
		Depth :	30'11"- 31'5"
		Sampling Date :	August 7, 2020

Testing Apparatus Used : **Loading device N° 1** **Caliper N° 1**

Technical Data

				Average	
Diameter :	47	46.9	47	47.0	(mm)
Length :	95	94.9	95.2	95.0	(mm)
Straightness (0.5mm maximum) (S1) :	0.3	0.3	0.3	0.3	(mm)
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	Ok	
Parallelism (0.25 ° maximum) (FP2) :	0.15	0.2	0.2	0.15	(°)

Mass : 435.4 (g) Volume: 164644 (mm^3)

Density : 2644 (kg/m^3)

Moisture Conditions : Dry

Loading Rate (0.5 to 1.0 MPa / sec) : 0.8 (MPa/sec)

Type of Fracture : 3

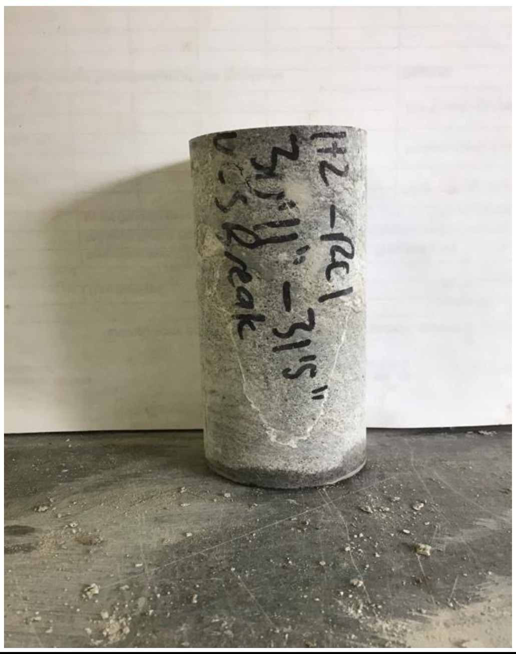
Test Duration (2-15 Minutes) : 3 (minutes)

Maximum Applied Load : 216.97 ☑ kN ☐ lbs

Compressive Strength : 125.2 (MPa)

View of Specimen

Before Test :



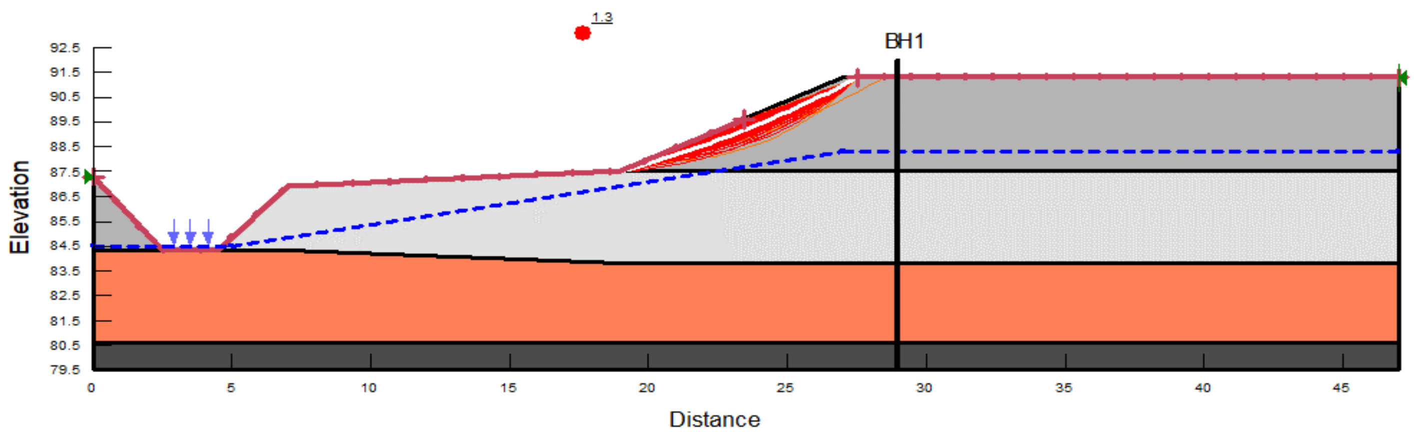
After Test :

Remarks :

Analysed by :	Z. Mathurin	**Date :**	September 4, 2020
Verified by :		**Date :**	September 4, 2020

Appendix C
Slope Stability Analysis Results

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Bedrock			
	Existing Fill - Clayey silty sand	19	3	30
	Existing Fill - Sand	19	0	30
	Native Silty Sand/Sandy Silty	20	0	30

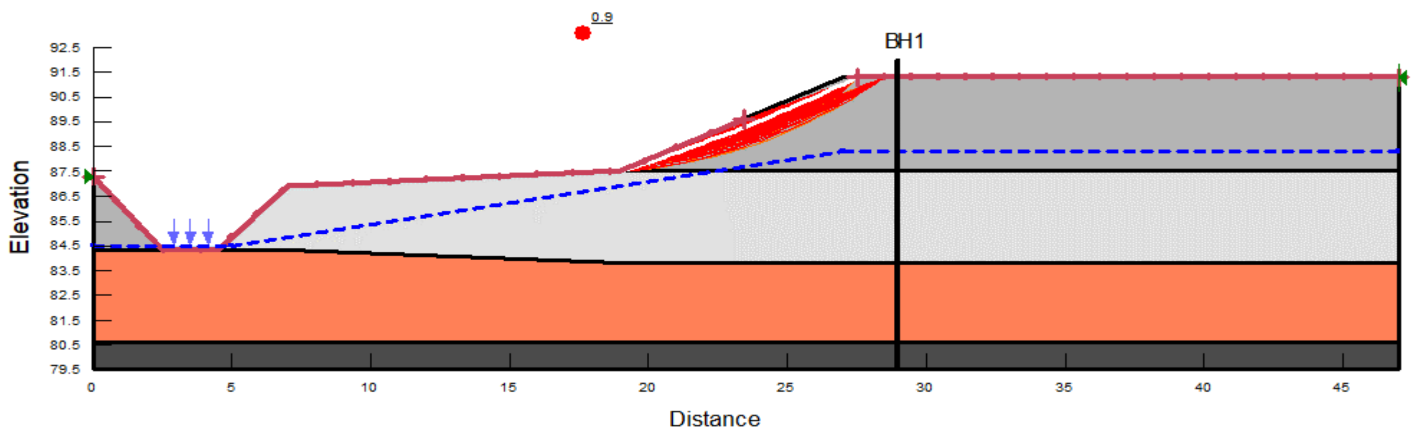


SLOPE STABILITY ANALYSIS - BH1
DRAINED CONDITION
STATIC ANALYSIS

COSTCO PEDESTRIAN BRIDGE REPLACEMENT

DRAWN BY: RVT	REFERENCE NO: 11215612-A2	
CHECKED BY: BV	DATE: 09/04/2020	SCENARIO NO. 1

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Bedrock			
	Existing Fill - Clayey silty sand	19	3	30
	Existing Fill - Sand	19	0	30
	Native Silty Sand/Sandy Silty	20	0	30

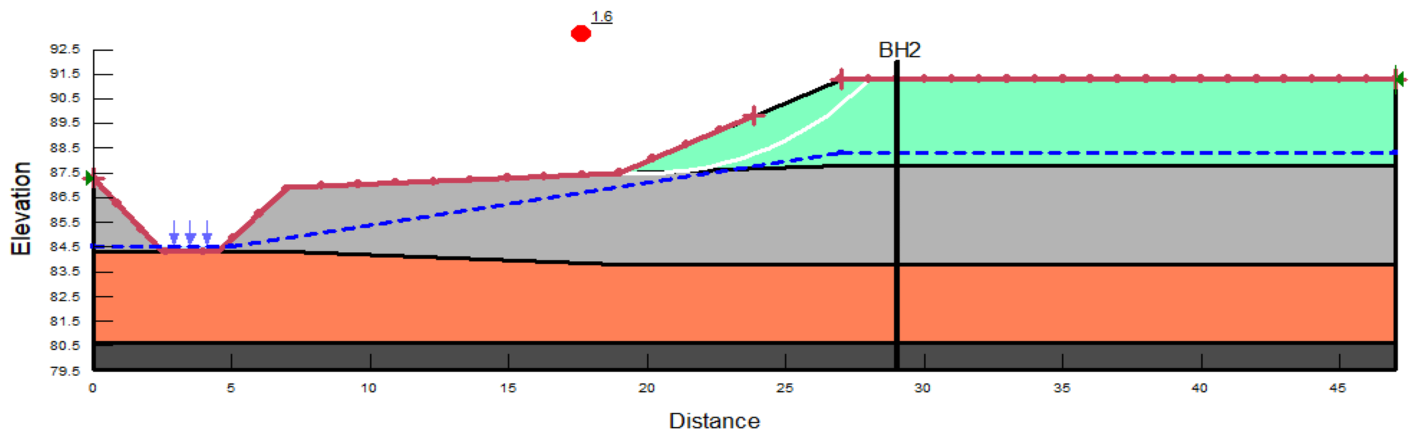


SLOPE STABILITY ANALYSIS - BH1
DRAINED CONDITION
PSEUDO-STATIC ANALYSIS

COSTCO PEDESTRIAN BRIDGE REPLACEMENT

DRAWN BY: RVT	REFERENCE NO: 11215612-A2	
CHECKED BY: BV	DATE: 09/04/2020	SCENARIO NO. 2

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Bedrock			
	Existing Clay Fill	17	3	25
	Existing Granular Fill	19	0	30
	Native Silty Sand/Sandy Silty	20	0	30

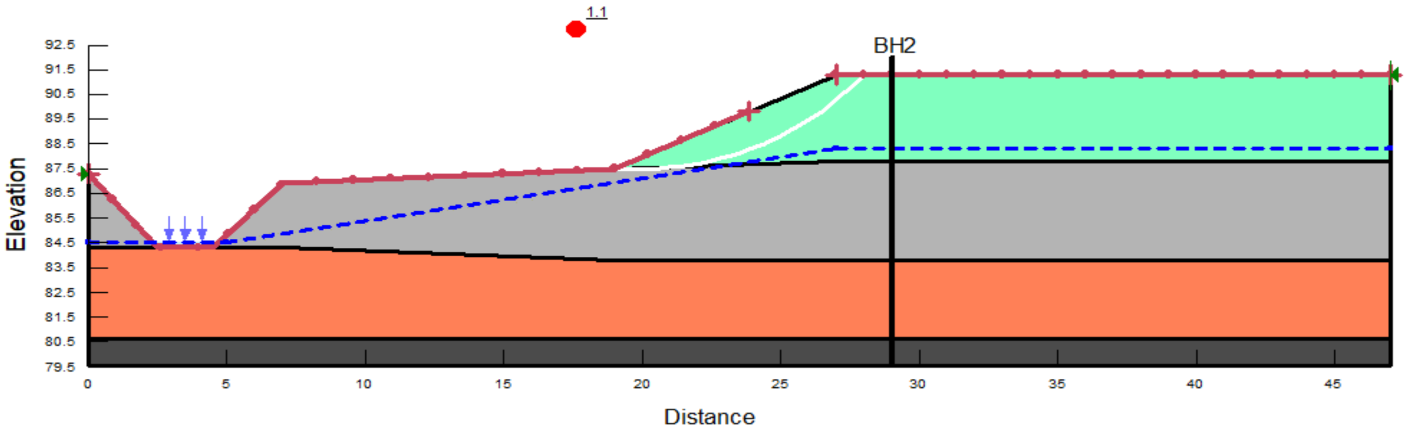


SLOPE STABILITY ANALYSIS - BH2
DRAINED CONDITION
STATIC ANALYSIS

COSTCO PEDESTRIAN BRIDGE REPLACEMENT

DRAWN BY: RVT	REFERENCE NO: 11215612-A2	
CHECKED BY: BV	DATE: 09/04/2020	SCENARIO NO. 3

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Bedrock			
	Existing Clay Fill	17	3	25
	Existing Granular Fill	19	0	30
	Native Silty Sand/Sandy Silty	20	0	30



SLOPE STABILITY ANALYSIS - BH2
DRAINED CONDITION
PSEUDO-STATIC ANALYSIS

COSTCO PEDESTRIAN BRIDGE REPLACEMENT

DRAWN BY: RVT	REFERENCE NO: 11215612-A2	
CHECKED BY: BV	DATE: 09/04/2020	SCENARIO NO. 4

about GHD

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

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