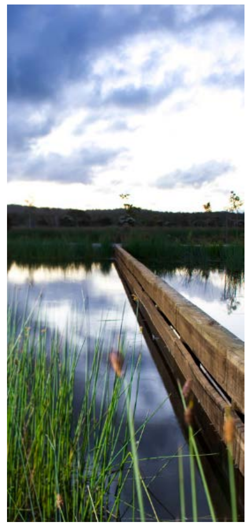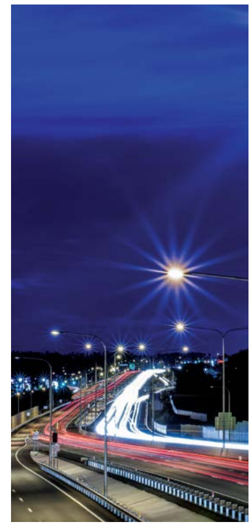

Geotechnical Investigation

2262 Braeside Avenue
Ottawa, Ontario

Ottawa Community Housing Corporation

GHD | 179 Colonnade Road Suite 400 South Ottawa Ontario K2E 7J4 Canada

11155186| A1 | Report No 1 | March 16, 2018

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1. Introduction

GHD was retained by Mr. Meyerhoffer of Ottawa Community Housing Corporation (OCHC or Client) to undertake a geotechnical investigation for a proposed new four-storey residential development hereafter referred to as the Site, located at 2262 Braeside Avenue, in Ottawa, Ontario.

The purpose of the investigation was to complete an evaluation of the subsurface stratigraphy on the proposed redevelopment site in order to summarize the subsurface conditions found at borehole locations, and based upon the data, provide recommendations concerning foundation type and associated bearing capacity, drainage requirements, as well as comment on excavation, backfill, pavement design and construction field review.

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

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

- Underground Service Clearances
- Fieldwork **|** The proposed scope included advancement of a total of five geotechnical boreholes and installation of two monitoring wells to measure ground water level.
- Lab Testing **|** One chemical testing of soil for corrosion assessment for ductile iron and concrete.
- 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.

2. Site and Project Description

The site is currently developed with a single, low-rise residential building and associated access driveway and parking area. The site is bounded by Braeside Avenue to the east, a single family residence to the north, a social service residence to the west, and a senior's apartment building to the south. The site topography slopes down approximately 1.0 m toward Braeside Avenue to the east of the site.

It is our understanding that the proposed new development will consist of demolition and removal of the existing residential building and construction of a four storey residential building with associated surface parking areas and access driveway. It is our understanding that at this time no underground levels (basement or underground parking) are planned for the proposed building.

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

3. Field Investigation

The fieldwork component of this Geotechnical Investigation consisted of the advancement of five boreholes BH1-17 to BH5-17. Boreholes were advanced to depths varying between 2.2 m to 5.1 m below the existing surface grade. Two of the boreholes (BH3-17 and BH5-17) were equipped with monitoring wells for further groundwater level measurement. Monitoring well, BH3-17, was installed in the bedrock and monitoring well BH5-17 was installed in the overburden. 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 December 20, 2017 with a truck 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 mm diameter split-spoon sampler and a 63.5 kg hammer, free falling from a distance of 760 mm, to collect soil samples. The number of drops required to drive the sampler 0.3 m is recorded on the borehole logs as "N" value. Boreholes BH2-17, BH3-17, and BH5-17 were advanced into bedrock using NQ diamond coring equipment, in order to confirm the existence of bedrock and comment on rock quality (ASTM D2113). Boreholes without monitoring wells were backfilled with bentonite to the top of bedrock and then with silica sand and auger cuttings to the surface upon drilling completion.

The elevations of the boreholes were determined by GHD field staff using a laser level; and related to a temporary benchmark (TBM) which was the top of a fire hydrant located on the Southwest corner of the parking lot of the social service residence. This benchmark was assumed to have an arbitrary elevation of 100.00 m. The elevations of the boreholes are for use within the context of this report only.

3.1 Laboratory testing

Analytical testing was carried out on one soil sample collected to determine corrosion potential, within the subsurface, to new ductile iron and buried concrete at the site. The results of the chemical analyses are discussed in Section 6.10.

4. Subsurface Conditions

In general, soils encountered at the borehole locations consisted of a grassed landscape or asphalt paved surface over a fill layer underlain by shale bedrock with laminations of limestone. A thin layer of gravelly sandy silt glacial till overlaid the bedrock in BH4-17, located at the north end of the site.

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

4.1 Surficial Fill

Boreholes BH1-17, BH2-17 and BH3-17 were drilled in a paved area which had an asphaltic concrete surface approximately 90 mm thick at the borehole locations and was followed by a fill material consisting of crushed limestone acting as the pavement structure overlying a gravelly sandy silt.

Boreholes BH4-17 and BH5-17 were located in landscaped areas of the Site consisting of a surficial layer of topsoil overlying a silty fill material.

4.2 Glacial Till

In borehole BH4-17, a layer of native gravelly sandy silt glacial till overlaid the bedrock. The layer was observed to have a thickness of approximately 0.8 m where borehole BH4-17 was stopped at auger refusal. The native material was compact to very dense and was recovered in a moist condition.

4.3 Bedrock

Practical refusal to auger advancement was encountered in all boreholes, at depths ranging from 2.2 to 3.5 m below the existing ground surface in borehole BH1-17 and BH2-17respictively. The type of bedrock and its quality was confirmed by retrieving samples from three borehole locations by diamond coring techniques. Highly weathered and fractured black Shale bedrock with laminations of Limestone was encountered at the borehole locations. The quality of this rock was very poor to poor with RQDs of 15 to 44 within the upper portion of the bedrock. Mud seams were encountered within the bedrock at depths ranging from 2.4 to 3.8 m below ground surface.

5. Groundwater

Two monitoring wells were installed as part of the scope of work. Groundwater levels were measured on January 11, 2018, at the monitoring wells. Monitoring well, BH3-17, was installed in the bedrock and monitoring well BH5-17 was installed in the overburden/upper weathered bedrock. The following Table 5.1 shows the measured water levels.

Table 5.1 Groundwater Observations

Borehole Location	Depth of Water Below Existing Grade (m)	Elevation (m)
BH3-17	3.32	95.96
BH5-17	2.24	96.72

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

6. Discussion and Recommendations

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

- The proposed development will consist of demolition and removal of the existing low-rise residential dwelling.
- The proposed structure will consist of a four-storey residential building with no underground levels (basement or underground parking).
- The floor slab is of a lightly loaded residential type (i.e., assumed to be approximately 24 kPa).
- No information is available regarding the foundation depth/elevation of the existing building or of the off-site adjacent structures.

Based on our understanding of the proposed structure, 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 geotechnical considerations for the design of the proposed buildings are the following:

- Existing and Buried Structures | It is important to note that no information was provided regarding the founding depth of the existing building. It is our understanding that the existing structure will be demolished. Following demolition of the existing structure, all foundations and buried structures must be removed from the footprint of the proposed building.
- Fill Material | Surficial fill material was observed across the site. Boreholes show between 1.7 to 3.5 m of fill material on site. Unknown fill material with various thickness may be present at site.
- Frost Susceptibility of the Bedrock | Upper layers of the bedrock were found to be highly fractured and with the recorded groundwater levels near the proposed underside of footing, the bedrock may be susceptible to frost action (frost heaving). Should construction take place during winter, the exposed surfaces to support foundations must be protected by Contractors against freezing and foundations on bedrock should have adequate soil cover.
- Rock Disturbance | Bedrock consists of shale of Billing Formation; this rock is subject to expansion if exposed to air. If bedrock is exposed during excavation, it is required that a lean concrete mud slab be placed on the rock surfaces (horizontal and vertical) and the exposed rock within the excavation/trench side walls be covered by shotcrete or other available material within 24 hrs of excavation.

6.1 Site Preparation

Site preparation within the new building footprint will involve the demolition and removal of the existing structure, removal of existing vegetation, topsoil and any existing fill materials to expose the bedrock. The exposed surfaces should be examined by geotechnical personnel to assess the competency.

The surficial fill material was found in loose condition; loose soil layers may not be suitable to support the slab-on-grade. Unsuitable fill material must be removed and replaced with Engineered Fill

Site preparation for landscaped or pavement areas will involve removal of the existing structure, existing topsoil and asphaltic concrete. Following the required removals, if soils (fills or native) remain, then these should be reviewed by the geotechnical Engineer to determine if they are suitable to remain in place for re-use. Field verifications should be carried out by qualified geotechnical personnel during construction.

6.2 Excavation and Dewatering

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

Based on the results of the investigation, overburden soil material within excavation would be considered as 'Type 4 Soils', as defined by the OHSA Regulations for Construction.

Bedrock excavation may be required for the footing excavations to reach competent rock, based on geotechnical personnel's assessment of exposed bedrock surface. The weathered rock should be planned to be cut back at a 30 degree from vertical. Based on the existence of mud seam layers in bedrock, it is our recommendation that rock probing be completed at the time of construction to evaluate the bedrock beneath footing subgrade for mud seams. This "probing" may consist of contractors being required to drill a 50 mm diameter hole, 1.5 m below the base of the exposed footing subgrade. These probe holes should then be assessed by the Geotechnical Engineer to confirm the absence/presence of mud seams and then recommend whether additional deeper excavation to remove the rock down to the underside of the mud seam is required, if the mud seam is deemed significant by the Geotechnical Engineer. Structural engineers should determine the remedial approach for foundation support if this over excavation is required. Remedial approach options may be bulk concrete backfill, extending the foundation walls or other. Designers/Owners should account for this work and unit rates for over excavation and remedial approach in the Tender and Specification documents. If the mud seam are greater than 1 m below footing level and/or thin enough then the Geotechnical assessment during construction may allow the mud seam to be left in-place.

The excavation of the weathered bedrock may require pneumatic or hydraulic breakers such as hoe rams or heavy excavation equipment equipped for rock excavation. It is recommended that the client's design team request in the specification package that contractors submit Excavation Plans and Soil and Groundwater Management Plan for review by the client design team. The client's design team should provide vibration limits for the adjacent off-site buildings and underground structures. The contractors plan should include methodology for how they will control vibrations and adjust their excavation methodology in the event of vibration exceedances. Local municipal guidelines should act as a minimum standard but designers should determine if the standard's criteria is sufficient to protect the buildings.

Surface water and groundwater seepage is expected in the excavated areas. Water quantities will depend on seasonal conditions, depth of excavations, and the duration that excavations are left open. Conventional construction dewatering techniques should be taken during construction, such as pumping from sumps and or ditches.

6.3 Foundations

The Ontario Building Code (OBC 2012) requires buildings to be designed using Limit States Design values (LSD) of Serviceability Limit States (SLS) and Ultimate Limit States (ULS). It is expected that the foundation of the proposed residential building will be bearing on bedrock and will be supported by conventional spread footings.

Based on the recorded conditions within the boreholes, it is recommended that the shallow pad and strip footings be founded within the weathered shale bedrock. The recommended bearing pressures for strip and pad footings, founded on the shale bedrock is 350 kPa under SLS condition and 500 kPa under factored ULS conditions. The factored ULS value includes the geotechnical resistance factor (Φ) of 0.5. The minimum founding sizes should be 0.75 m for pad footings and 0.5 m widths for strip footings on bedrock using the bearing pressure.

Higher capacities for footings bearing on sound bedrock are available if designs assessed will result in a more economical design, but further investigation and rock probing would be required.

Based on the existence of mud seam recorded in the coring of the bedrock, it is our recommendation that rock probing be completed at the time of construction to evaluate the bedrock for mud seams. (Refer to further comments in Section 6.2).

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

6.4 Floor Slabs

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

Preparation of the subgrade as discussed in Section 6.1 and 6.2 would include removal of unsuitable overburden materials to expose the competent subgrade. Field verification should be carried out by geotechnical personnel during construction.

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

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

Designers should consider concrete slab crack control measures and whether the slabs should be tied into the foundation walls. The designers and contractors must carefully plan the placement of construction and control joints in the concrete and should be in accordance with generally accepted practice.

6.5 Frost Protection

The shale bedrock was found to be weathered and fractured, and the water table is close to the underside of footing elevation, therefore, the bedrock may be susceptible to frost action and frost heave. All exterior footings associated with the heated building 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 subgrade surfaces must receive adequate temperature protection by Contractors to protect against freezing for the duration of the construction period.

6.6 Seismic Site Classification

In accordance with OBC-2012, the building and its structural elements must be designed to resist a minimum earthquake force based upon the borehole drilling program that was undertaken as part of this Geotechnical Investigation, this Site is recommended to have a Site Classification 'C', with respect to Table 4.1.8.4.A of the National Building Code of Canada 2010.

Higher site class may be available, but would require confirmation by additional investigation using geophysical methods, in order to measure the shear wave velocity within the soil and rock mass.

6.7 Permanent Drainage

Under floor and perimeter drains are not considered necessary for a structure with no basement and a floor slab set at a minimum of 0.3 m above finished exterior grades. If the floor slab is set level with exterior grades then perimeter drainage around the proposed building is recommended for precautionary purposes. The drain should be connected to a frost-free outlet for year round drainage. If elevator pits are incorporated these should have drainage or waterproofing design measures.

6.8 Corrosion Potential of Soils

Analytical testing was carried out on a groundwater 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	6.35
Resistivity (ohm-cm)	9090
REDOX Potential (mV)	188

Table 6.1 Corrosion Parameter Results

Sample ID	MW4
Sulphate (%)	<0.01
Chloride (%)	<0.002

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 0.01 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 Building Backfill

The placement and compaction of the materials that will support the floor slabs, pavement or any interior backfill must be treated as Engineered Fill.

6.9.1 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 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.

6.9.2 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.

6.10 Underground Services

6.10.1 Bedding and Cover

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

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

6.10.2 Service Trench Backfill

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

- For service trenches under pavement areas, the backfill should be placed and compacted in uniform thickness compatible with the selected compaction equipment and not thicker than 200 mm. Each lift should be compacted to a minimum of 95 percent SPMDD.
- The backfill placed in the upper 300 mm below a pavement subgrade elevation should be compacted to a minimum of 100 percent SPMDD.
- To reduce the potential for differential settlement and frost heave the excavation sides should have frost tapers as per OPSD 800 series which essentially indicates that there should be a back slope of 10:1 (H:V) within the frost zone below finished grade.

6.11 Pavement Sections

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

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

Table 6.3 Recommended Pavement Structure

Pavement Layer	Minimum Thickness	Heavy Duty (Access Roads)
HL3 Asphalt	50 mm	40 mm
HL8 Asphalt	n/r	50 mm
Granular 'A' Base Course	150 mm	150 mm

Table 6.3 Recommended Pavement Structure

Pavement Layer	Minimum Thickness	Heavy Duty (Access Roads)
Granular 'B', Type II Sub-Base Course	300 mm	450 mm

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

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

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

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

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

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

6.12 Construction Field Review

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

- Prior to construction of footings, the exposed foundation subgrade should be examined by a Geotechnical Engineer or a qualified Technologist acting under the supervision of a Geotechnical Engineer, to assess whether the subgrade conditions correspond to those encountered in the boreholes, and the recommendations provided in this report have been implemented.
- A qualified Technologist acting under the supervision of a Geotechnical Engineer should monitor placement of Engineered Fill underlying floor slabs.

- Backfilling operations should be conducted in the presence of a qualified Technologist on a part time basis, to ensure that proper material is employed and specified compaction is achieved.
- Placement of concrete should be periodically tested to ensure that job specifications are being achieved.

7. Limitation of the Investigation

This report is intended solely for Ottawa Community Housing Corporation (OCHC) 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. Client shall defend, indemnify and hold GHD harmless from any liability arising from or related to Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

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

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

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

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

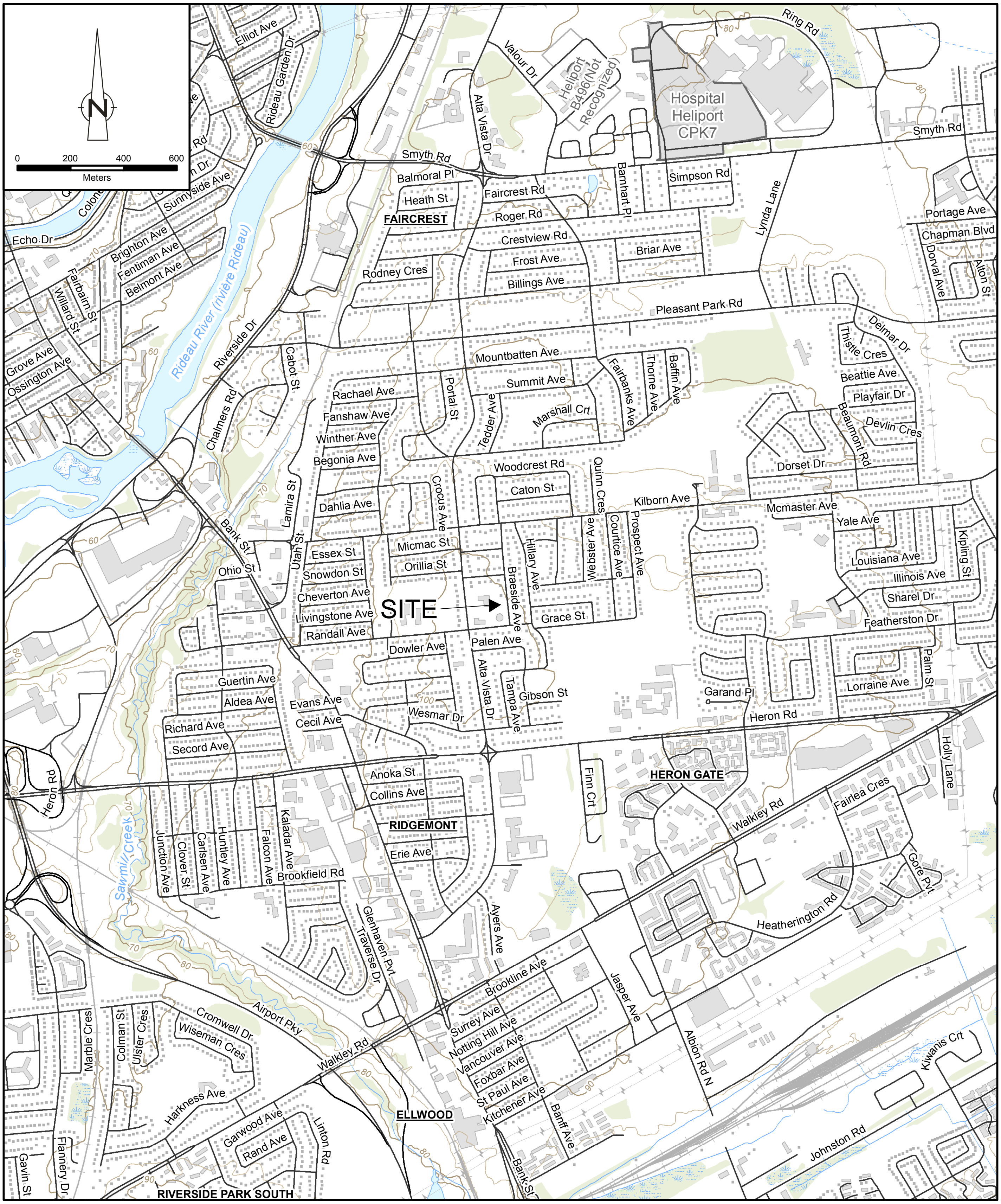
All of Which is Respectfully Submitted,

GHD

Ryan Vanden Tillaart, B.A.Sc

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

Gerardo Cardenast, M.A.Sc,. P. Eng.



Source: MNRF NRVIS, 2018. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2018.
Coordinate System: NAD 1983 UTM Zone 18N

OTTAWA COMMUNITY HOUSING
2262 BRAESIDE AVENUE, OTTAWA, ONTARIO
GEOTECHNICAL INVESTIGATION

11155186-A1
Jan 16, 2018

SITE LOCATION PLAN

FIGURE 1

GIS File: Q:\GIS\PROJECTS\11155000s\11155186\Layouts\001\11155186-A1(001)GIS-OT001.mxd

Source: Image ©2018 Google, Imagery date: 09/05/2016
Coordinate System: NAD 1983 UTM Zone 18N

OTTAWA COMMUNITY HOUSING
2262 BRAESIDE AVENUE, OTTAWA, ONTARIO
GEOTECHNICAL INVESTIGATION

11155186-A1
Mar 5, 2018

BOREHOLE LOCATION PLAN

FIGURE 2

GIS File: Q:\GIS\PROJECTS\11155000s\11155186\Layouts\001\11155186-A1(001)GIS-OT002.mxd

Appendices

Appendix A
Borehole Logs and Notes on Borehole Logs

REFERENCE No.: 11155186-A1

ENCLOSURE No.: 1

BOREHOLE REPORT

Page: 1 of 1

BOREHOLE No.: BH1-17

ELEVATION: 99.85 m

CLIENT: Ottawa Community Housing

PROJECT: Geotechnical Investigation

LOCATION: 2262 Braeside Avenue, Ottawa, Ontario

DESCRIBED BY: S. Wheeler

CHECKED BY: R. Vanden Tillaart

DATE (START): December 20, 2017

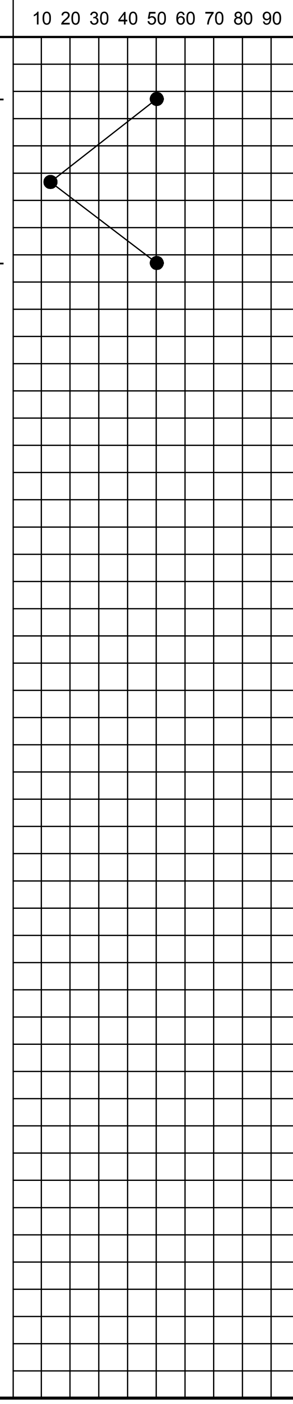
DATE (FINISH): December 20, 2017

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- AU - AUGER PROBE
- WATER LEVEL

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetraion Index (N)
	99.85	GROUND SURFACE					
0.08	99.77	ASPHALT - 80mm					
0.30	99.55	FILL-SAND AND GRAVEL, grey, damp					
		FILL-GRAVELLY SANDY SILT, grey to brown, damp, compact	SS1	17	--	50+	50+
			SS2	96	--	8-7-6-7	13
			SS3	33	--	25-50+	50+
1.68	98.17	WEATHERED SHALE BEDROCK, grey, very poor quality			--	--	--
2.18	97.67	AUGER REFUSAL Elevations were surveyed relative to a fire hydrant on site.					

Shear test (Cu) △ Field
Sensitivity (S) □ Lab
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)



REFERENCE No.: 11155186-A1 ENCLOSURE No.: 2

BOREHOLE No.: **BH2-17**

ELEVATION: 99.10 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Ottawa Community Housing

PROJECT: Geotechnical Investigation

LOCATION: 2262 Braeside Avenue, Ottawa, Ontario

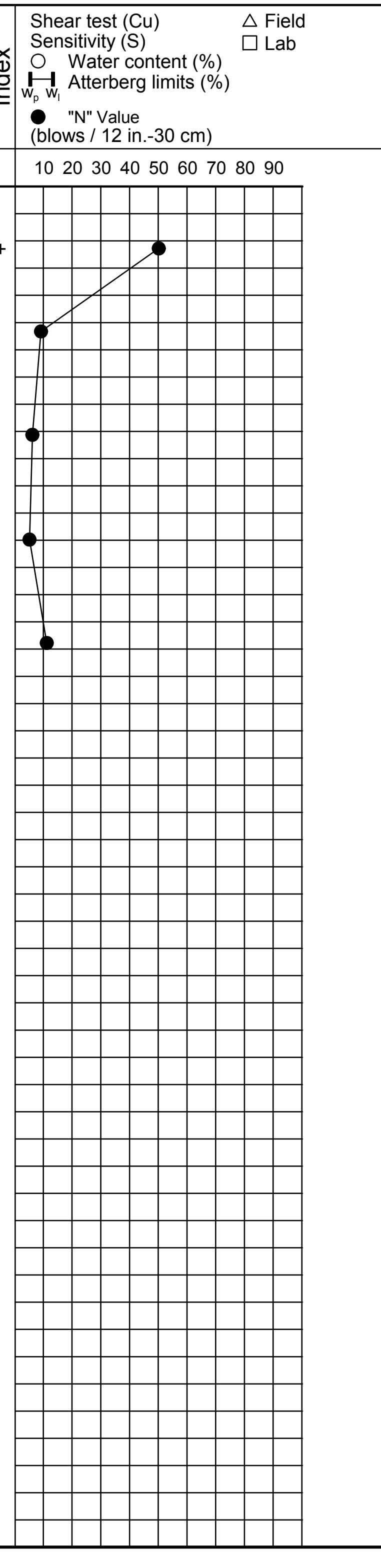
DESCRIBED BY: S. Wheeler CHECKED BY: R. Vanden Tillaart

DATE (START): December 20, 2017 DATE (FINISH): December 20, 2017

LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ AU - AUGER PROBE
- ▼ - WATER LEVEL

Depth (Metres)	Elevation (m) BGS	Description of Soil and Bedrock	Type and Number	Recovery %	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index N
	99.10	GROUND SURFACE					
0.08	99.02	ASPHALT - 80mm					
0.30	98.80	FILL-SAND AND GRAVEL, brown, damp, very dense	SS1	2	--	50+	50+
		FILL-GRAVELLY SANDY SILT, brown, damp, loose, possible cobbles	SS2	63	--	5-3-6-4	9
			SS3	13	--	1-3-3-4	6
		becoming moist	SS4	58	--	4-2-3-5	5
		becoming wet	SS5	33	--	6-5-6-50+	11
3.50	95.60	BEDROCK-SHALE with limestone laminations, poor quality based on RQD mud seam encountered at 3.8m BGS	RC1	100	--	26/59	--
5.10	94.00	End of Borehole					



REFERENCE No.: 11155186-A1

ENCLOSURE No.: 3

BOREHOLE No.: **BH3-17**

ELEVATION: 99.28 m

BOREHOLE REPORT

CLIENT: Ottawa Community Housing

PROJECT: Geotechnical Investigation

LOCATION: 2262 Braeside Avenue, Ottawa, Ontario

DESCRIBED BY: S. Wheeler   CHECKED BY: R. Vanden Tillaart

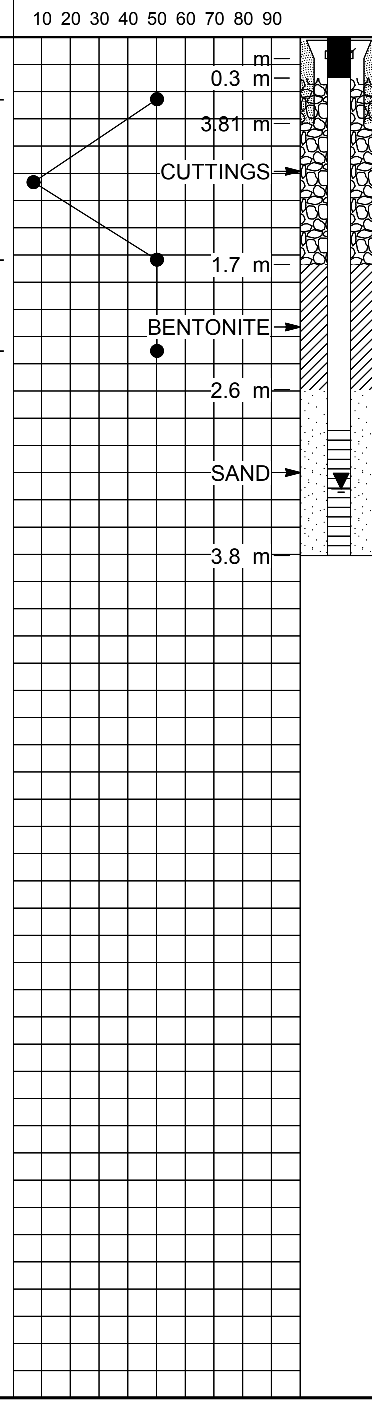
DATE (START): December 20, 2017   DATE (FINISH): December 20, 2017

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- AU - AUGER PROBE
- ▼ - WATER LEVEL

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index (N)
	99.28	GROUND SURFACE					
0.08	99.20	ASPHALT - 80mm					
0.30	98.98	FILL-SAND AND GRAVEL, brown, damp, very dense	SS1	33	--	33-50+	50+
		FILL-SANDY SILT, trace gravel, brown, damp, loose, organics, organic staining	SS2	92	--	4-4-3-4	7
			SS3	21	--	16-50+	50+
1.68	97.60	WEATHERED SHALE BEDROCK, grey, very poor quality	SS4	0	--	50+	50+
2.44	96.84	SHALE BEDROCK, thinly laminated with limestone, mud seams, very poor quality based on RQD	RC1	96	--	8/54	--
3.81	95.47	End of Borehole Groundwater encountered at 3.32m BGS / 95.96m					

Shear test (Cu) / Sensitivity (S): △ Field ☐ Lab; ○ Water content (%); W_p W_l Atterberg limits (%); ● "N" Value (blows / 12 in.-30 cm)



REFERENCE No.: 11155186-A1

ENCLOSURE No.: 4

BOREHOLE No.: BH4-17

ELEVATION: 98.48 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Ottawa Community Housing

PROJECT: Geotechnical Investigation

LOCATION: 2262 Braeside Avenue, Ottawa, Ontario

DESCRIBED BY: S. Wheeler CHECKED BY: R. Vanden Tillaart

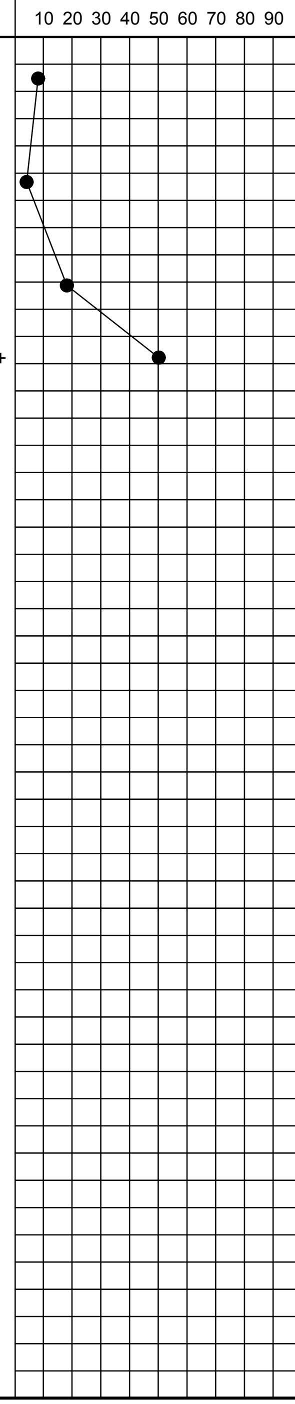
DATE (START): December 20, 2017 DATE (FINISH): December 20, 2017

LEGEND

☒ SS - SPLIT SPOON
▨ ST - SHELBY TUBE
◧ AU - AUGER PROBE
▼ - WATER LEVEL

Depth (Feet)	Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetraion Index (N)
		98.48		GROUND SURFACE						
0	0.08	98.40		TOPSOIL - 80mm						
				FILL-GRAVELLY SILT, some sand, brown, moist, very loose, organics	☒	SS1	33	--	4-3-5-4	8
					☒	SS2	83	--	2-1-3-2	4
6	1.83	96.65		GLACIAL TILL, gravelly sandy silt, brown, moist, very dense	☒	SS3	83	--	4-3-15-3-4	18
					☒	SS4	21	--	50+	50+
	2.62	95.86		AUGER REFUSAL						

Shear test (Cu) △ Field
Sensitivity (S) □ Lab
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)



Depth scale: Feet 0–32; Metres 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0

REFERENCE No.: 11155186-A1 ENCLOSURE No.: 5

BOREHOLE REPORT

Page: 1 of 1

BOREHOLE No.: BH5-17

ELEVATION: 98.96 m

CLIENT: Ottawa Community Housing

PROJECT: Geotechnical Investigation

LOCATION: 2262 Braeside Avenue, Ottawa, Ontario

DESCRIBED BY: S. Wheeler CHECKED BY: R. Vanden Tillaart

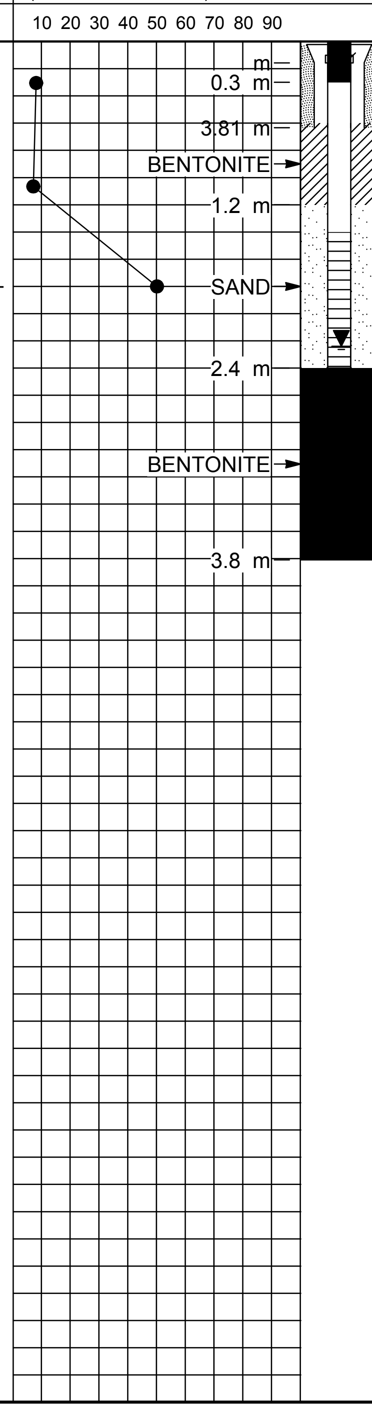
DATE (START): December 20, 2017 DATE (FINISH): December 20, 2017

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- AU - AUGER PROBE
- ▼ - WATER LEVEL

Shear test (Cu) △ Field; Sensitivity (S) □ Lab; ○ Water content (%); W_p W_l Atterberg limits (%); ● "N" Value (blows / 12 in.-30 cm)

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetraion Index (N)
	98.96	GROUND SURFACE					
0.18	98.78	TOPSOIL - 180mm					
		FILL-GRAVELLY SANDY SILT, brown, loose, moist	SS1	58	--	1-5-3-2	8
0.61	98.35	FILL-SILT AND SAND, some gravel, brown, moist, loose	SS2	92	--	3-4-3-4	7
			SS3	58	--	12-14-50+	50+
2.08	96.88	WEATHERED SHALE BEDROCK, grey, very poor quality					
2.41	96.55	SHALE BEDROCK, thinly laminated, with limestone, poor quality based on RQD, mud seam enountered at 2.41m BGS	RC1	98	--	18/57	--
3.81	95.15	End of Borehole Groundwater encountered at 2.24m BGS / 96.72m					



SOIL LOG WITH GRAPH+WELL 11155186-SC.GPJ GHD_Geotechnical 2/12/18

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%

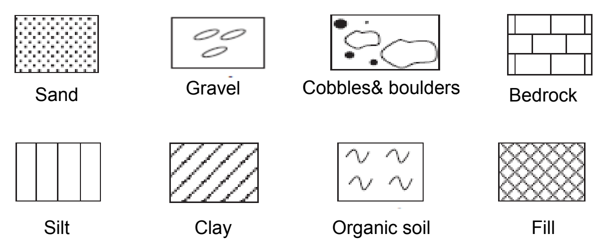
Relative density of granular soils	**Standard penetration index "N" value** (BLOWS/ft – 300 mm)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

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
SSE, GSE, AGE: Environmental sampling
ST: Shelby tube
PS: Piston sample (Osterberg)
AG: Auger
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
R: Refusal to penetration
N_c: Dynamic cone penetration index
Cu: Undrained shear strength
Pr: Pressure meter
k: Permeability
ABS: Absorption (Packer test)

LABORATORY TESTS:

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

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