GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL SUBDIVISION DEVELOPMENT
PART OF LOT 12, CONCESSION 6
WITHIN THE GEOGRAPHIC TOWNSHIP OF CAMBRIDGE
NOW IN THE VILLAGE OF CASSELMAN
UNITED COUNTIES OF PRESCOTT-RUSSELL

Prepared for:
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1 INTRODUCTION

Cassel Homelands Development Inc. retained the services of Lascelles Engineering & Associates Ltd. (Lascelles) to conduct a geotechnical investigation for a proposed residential subdivision development located in the Village of Casselman, Ontario.

The purpose of the investigation was to identify the subsurface soil conditions within the project by means of a limited number of test pits and boreholes, and based on the factual information obtained, provide preliminary guidelines on the geotechnical engineering aspects of the design of the proposed dwellings’ foundations and roadways, including construction considerations which may influence the design of the subdivision development in effort of obtaining “Draft Plan” approval.

Should there be any changes in the design features, which may relate to the guidelines provided in the report, Lascelles Engineering & Associates Ltd. should be advised in order to review the report recommendations.

2 PROJECT AND SITE

The proposed subdivision is located northwest boundary limits of the Village of Casselman community area. The development is located to the southwest of the intersection of Principale Street and Sarah Street; refer to Figure 1 location. The property has no civic address and is described as Part of Lot 12, Concession 6, within the Geographic Township of Cambridge, now in the Village of Casselman and within the United Counties of Prescott-Russell.

The site is bordered to the north by Principale Street, by Sarah Street to the east, Lafontaine Street to the west and by a railway to the south. The property has an irregular shape being approximately 292m wide (east-west) and approximately 383m deep (north-south) for an approximate total surface area of 8.11 ha (20.04 acres). Currently, the site is used as agricultural fields and with some overgrown wild grasses and shrubs along its perimeter.
The site is generally flat and appears to lack drainage. The road side ditches are very shallow and provide only limited drainage to the property. The ground surface elevation of the site would vary from Elev. 65.65 to 65.25m.

It is our understanding that the project will consist in the development of approximately sixty-four (64) residential lots that will house single and semi-detached family dwellings as well as townhouses and small apartment complexes. The number of units that the project will create is one-hundred and twenty-two (122) along with one park. The subdivision will be serviced with municipal water and sanitary sewers, which will connect with those on Principale and Sarah Street. The stormwater will be directed towards a stormwater management pond located in the northwest portion of the property, that will outlet to the north of the subdivision. However, at the time of completing this report, the final outlet to the stormwater was not known. A copy of the Draft Plan of Subdivision prepared by Arpentages Schultz Barrette Surveying, dated September 24, 2018, is presented in Appendix A.

Figure 1: Site Location

Site Location - Highlighted in Yellow - (Ref: UCPR- A La Carte)
3 PROCEDURE

The fieldwork for this investigation was carried out on November 9, 2017 and February 16, 2018. The fieldwork consisted of digging seven (7) test pits across the proposed subdivision and drilling two (2) deep boreholes. The approximate locations of the test pits and boreholes are shown below as part of Figure 2 as well as part of Appendix B. Prior to any fieldwork, the test hole locations were cleared for the presence of any underground services and utilities.

The test pits were completed on November 9th, 2017 using an excavator supplied and operated by Gagne Excavation. The test pits were taken down to depths ranging from 3.00m to 4.20m below ground surface (bgs). Sampling of the overburden materials encountered in the test pits was carried out by means of grab samples taken either directly from the excavation or from the bucket of the excavator. The recovered soil samples collected from the test pits were classified based on visual and tactile examination and the results of the in-situ testing. Upon completion, the test pits were backfilled with the excavated overburden materials and lightly compacted.

Standpipes were installed in three (3) of the test pits prior to backfilling them to measure the static groundwater level in the area. The standpipes consisted of 25mm diameter PVC piping that were slotted and placed within the overburden prior to backfilling them. The standpipes were used strictly to establish the static water level of the overburden water table.

The boreholes were advanced using a track mounted drill rig equipped with continuous flight hollow stem augers supplied and operated by Downing Drilling Inc. A “two-man” crew experienced with geotechnical drilling operated the drill rig and equipment. The boreholes were drilled down through the overburden material and to a depth of 12.95m (BH-1) and 6.13m (BH-2) below ground surface (bgs). BH-1 was further advanced using a dynamic cone penetrometer to establish the depth of the clay deposit and the start of the glacial deposit. The borehole was completed at a depth of 16.15m bgs.
Sampling of the overburden materials encountered in the borehole was carried out at regular depth intervals using a 50mm diameter drive open conventional split spoon sampler in conjunction with standard penetration testing ("N" value). The undrained shear strength (Cu) of the cohesive soils was determined using a field vane according to ASTM D-2573 at various depths. Finally, thin-walled Shelby tubes and a piston sampler were used to collect undisturbed clay samples for potential subsequent consolidation analysis on the clay deposit. All soil samples were visually examined, described, logged and stored before being transported to our office for further examination by our geotechnical engineer.

The fieldwork was supervised throughout by a member of our engineering staff who supervised the drilling of the boreholes, coordinated the testing of the materials, cared for the samples collected and logged the subsurface conditions encountered at each location. All samples collected during this project will be kept in storage for a period of six (6) months at which time, they will be disposed of, unless a written or verbal notice is received, requesting otherwise.
Finally, all test pits and borehole were surveyed and located using a GPS (Global Positioning System) receiver using NAD 83 datum (North American Datum). The topographic survey was conducted using a laser level. The test pits and boreholes elevations were referenced to a benchmark given to the top of the flange on the east side of the fire hydrant located on Sarah Street near its south end; Elev. 65.80m (considered geodetic).

4 SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

4.1 General

A review of the surficial geology maps for this area suggests that most of the site would be underlain by Champlain Sea Sediments consisting of Deltaic and Estuarine Deposits in the form of medium to fine grained sand overlying marine deposits (clay and silt). The drift thickness would vary between 15m to 25m deep. The bedrock would belong to the Lindsay formation, which is generally described as limestone with shale interbeds.

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

The subsurface soil conditions encountered at each test pit location are given in the Test Pit and Borehole Logs presented in Appendix C. These logs indicate the subsurface conditions encountered at specific test locations only. Boundaries between zones on the logs are often not distinct, but are rather transitional and have been interpreted.

4.2 Topsoil

A thin (200mm to 300mm) layer of topsoil was encountered at the surface in every test pits and borehole completed at this site. The topsoil is described as being a dark brown sandy loam.
The material was classified as topsoil based on colour and the presence of organic materials and is intended as identification for geotechnical purposes only. This does not constitute a statement as to the suitability of this layer for cultivation and sustaining plant growth.

### 4.3 Sand

A sand deposit was encountered in all of the test pits and boreholes completed at this site. The sand is described as uniform, sand-silt mixture near the surface becoming silty with depth, brownish grey in colour with oxidation stains near the surface become grey in colour with depth. The sand is loose to compact and moist. The sand deposit would extend 1.70 to 3.2m bgs and rest over a clay deposit.

A gradation analysis was carried out on sand samples collected from TP-1, TP-3 and TP-7. A summary of the results are presented in Table 1 below, while the laboratory reports are presented in Appendix D.

<table>
<thead>
<tr>
<th>Borehole</th>
<th>Sample</th>
<th>Depth (m)</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gravel (%)</td>
</tr>
<tr>
<td>TP-1</td>
<td>SA-3</td>
<td>1.70</td>
<td>0.0</td>
</tr>
<tr>
<td>TP-3</td>
<td>SA-1</td>
<td>0.75</td>
<td>0.0</td>
</tr>
<tr>
<td>TP-7</td>
<td>SA-2</td>
<td>1.00</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The gradation analysis indicate that the sand contains no gravel and would be comprised of 60.4 to 81.5 percent of sand and 18.5 to 39.6 percent of silt and clay. According to the Unified Soil Classification System, the sand material would classified as SM (silty sand/sand-silt mixture).

### 4.4 Clay

A clay deposit was encountered underlying the sand layer in all test pits and boreholes. The clay is described as silty with traces of sand, grey in colour with some reddish bands, stiff consistency near the surface becoming firm with depth, but returning to stiff at around 11m bgs. It has a medium plasticity near the surface becoming high plasticity with depth and a high
moisture content. All test pits were terminated within the clay deposit as well as BH-2. Based on the blow counts from BH-1, it would appear that the clay deposit changes to a granular (probable sand deposit) near the depth of 14m.

Five (5) representative clay samples were sent to the laboratory for Atterberg Limit and water content analysis. A summary of the results is presented in Table 2 below, while the laboratory reports are presented in Appendix D.

The samples submitted included samples from TP-3 and TP 5, respectively from depths of 3.0m and 2.5m, as well as three (3) split spoon samples from BH-1 at depths of 6.10m, 11.43m and 12.19m.

Table 2: Clay analysis summary

<table>
<thead>
<tr>
<th>Test Hole</th>
<th>Location</th>
<th>Depth (m)</th>
<th>Moisture content (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Natural</td>
</tr>
<tr>
<td>TP-3</td>
<td>SA-4</td>
<td>3.0</td>
<td>63.1</td>
</tr>
<tr>
<td>TP-5</td>
<td>SA-3</td>
<td>2.5</td>
<td>39.7</td>
</tr>
<tr>
<td>BH-1</td>
<td>SS-7</td>
<td>6.10</td>
<td>65.9</td>
</tr>
<tr>
<td>BH-1</td>
<td>SS-10</td>
<td>11.43</td>
<td>58.1</td>
</tr>
<tr>
<td>BH-1</td>
<td>SS-11</td>
<td>12.19</td>
<td>54.1</td>
</tr>
</tbody>
</table>

NA: Not analysed

The analysis indicates that the clay samples have a liquid limit varying between 39.0 and 61.2 percent, a plastic limit varying between 18.0 and 22.1 percent and a plasticity index varying between 20.9 and 39.1 percent. The natural moisture content measured from the samples submitted varies between 39.7 and 65.9 percent. The moisture content of the clay generally appears to be at its highest between 3.0 to 6.0m bgs with a slight decrease with depth. For all samples, the clay is close or above its liquid limit. The clay is classified as low to medium plasticity (CL) near the surface becoming high plasticity clay (CH) as per the Unified Soil Classification System.

A one-dimensional consolidation analysis on soil using incremental loading was conducted on two (2) samples collected from the Shelby tube recovered form the boreholes. The samples were extracted from BH-1 - SH-1 (depth 4.80m to 4.90m) and BH-1 - SH-3 (depth 10.90m to 11.00m). The results of the consolidation analysis indicated the samples reflected an initial effective stress of 66 kPa and 113 kPa, respectively, as well as a preconsolidation pressure of
115kPa and 190 kPa. The over-consolidation deviation was calculated to be 49 kPa and 77 kPa respectively. The laboratory reports are presented in Appendix D.

4.5 Groundwater Conditions

The static water level was measured within the standpipes installed within TP-1, TP-3, and TP-6, using a water meter on January 15, 2018. The depth of the groundwater was found to be at the surface or very close to it; 0.0m to 0.1m bgs. The water level is considered very high as the site lacks drainage and water appears to pond throughout the site. The water table is considered a perched water table flowing within the sand deposit, whereby it flows over the imperious clay deposit found across the site. In addition, the water table would be seasonable in some areas considering that at the time of the digging the test pit, the sand was only moist. Once property drainage is provided to the site, the water table would be artificially lowered by the installation of underground services.

It should be noted that this groundwater table can easily fluctuate with seasonal weather conditions (i.e.: rainfall, droughts and spring thawing). In addition, it can be locally affected by the presence of existing ditches and underground services trenches at or in the vicinity of the site.

5 Geotechnical Considerations

5.1 General

It is our understanding that the project will consist in the development of approximately sixty-four (64) residential lots that will house single and semi-detached family dwellings as well as townhouses and small apartment complexes. The number of units that the project will create is one-hundred and twenty-two (122) along with one park. The subdivision will be serviced with municipal water and sanitary sewers, which will connect with those on Principale and Sarah Street. The stormwater will be directed towards a stormwater management pond located in the northwest portion of the project, that will outlet to the north of the subdivision. However, at the time of completing this report, the final outlet to the stormwater was not fully known. A copy of the draft plan of subdivision prepared by Arpentages Schultz Barrette Surveying, dated September 24, 2018, is presented in Appendix A.
5.2 Foundations

Based on the subsurface soil conditions encountered at this site, it is recommended that the foundations for the proposed dwellings be founded over the native undisturbed sand deposit. Consequently, all organics and fill material (if encountered) will need to be removed from dwellings’ footprints to expose undisturbed native sand.

Conventional strip and pad footings set over the native undisturbed sand or properly prepared and approved engineered fill, may be designed using a maximum allowable bearing pressure of **75kPa** for serviceability limit state (**SLS**) and **110kPa** for ultimate limit state (**ULS**) factored bearing resistance. The bearing capacity provided is conditional on a minimum footing width of 0.75m for strip footings and a minimum width of 1.5m for pad footings. The maximum allowable grade raise for this site should be taken to be 1.5m above the existing ground surface. The maximum founding depth should be 1.0m below the existing ground surface due to the presence of a seasonal high water table.

Should a greater bearing capacity be required, such as for the proposed apartment complexes a project/building specific investigation would need to be carried out. Should grade raises be needed beyond the limitations given in this report, consideration should be given to the use of light-weight fill for backfilling purposes. Information on light-weight fill can be provided upon request.

5.3 Settlement

Provided that any loose and/or disturbed soil is removed from the bearing surfaces prior to pouring concrete, the estimated total settlement of the foundations, designed using the recommended serviceability limit state capacity value given herein as well as other recommendations provided herein will be less than 25mm. The differential settlement between adjacent footings is anticipated to be 20mm or less.

5.4 Structural Fill

Where excavation below the underside of the footing is performed, consideration shall be given to support the footings on structural fill. The structural fill must extend 0.6m beyond the outside
edge of the footings and extend outward and down at a 1 Horizontal to 1 Vertical profile out from the edge equal to the depth of the structural fill set below the footing. The recommended material to be used as structural fill to support the footings shall consist of Granular B Type II crushed stone, or an approved equivalent material.

The structural fill shall be placed over undisturbed native soils in layers not exceeding 300mm and compacted to 98 percent of its Standard Proctor Maximum Dry Density (SPMDD) as per ASTM D-698. Prior to placing any structural fill or to pouring the footings, it is required that any disturbed soils along the base of the footing be removed and that the subgrade soils be inspected and approved by the geotechnical engineer. Furthermore, the structural fill must be tested to ensure that the specified compaction level was achieved.

5.5 Seismic Design

Based on the results of the geotechnical investigation, the subsurface at this property can be classified as a Class “E” as per the Site Classification for Seismic Site Response in accordance with the latest version of the Ontario Building Code. It is noted that a greater seismic site response class may be obtained by carrying out seismic velocity testing using a multichannel analysis of surface waves (MASW).

5.6 Potential for Soil Liquefaction

Based on the preliminary characterisation of the subsurface soil conditions established at this site, the potential of soil liquefaction is not considered to be a concern.

5.7 Slab-on-Grade Construction

For predictable performance of the proposed concrete basement slab-on-grade, it shall rest over native soil or structural fill only. Therefore, all organic, deleterious or otherwise objectionable fill material encountered shall be removed from any building’s footprint.

The exposed native subgrade surface should then be inspected and approved by geotechnical personnel. Any soft areas evident should be sub-excavated and replaced with suitable engineered fill, however, disturbances should be minimized as much as possible.
Any underfloor fill needed to raise the general floor grade shall consist of OPSS Granular B Type I material or an approved equivalent, compacted to 95 percent of its SPMDD. The final lift shall be compacted to 98 percent of its SPMDD. A 200mm layer of OPSS Granular A material shall be placed under the slab and compacted to at least 98 percent of the SPMDD.

In order to minimize and control cracking, the floor slab should be provided with wire or fibre mesh reinforcement and crack control joints. The crack control joints should be spaced equal distance in both directions and where possible not exceeding a spacing of 4.5 metres. The mesh reinforcement should be carried through the joints.

5.8 Frost Protection

All exterior footings and those located in any unheated portion of the proposed building should be provided with at least 1.5m of earth cover for frost protection purposes. Exterior footings constructed in areas that are to be cleared of snow during the winter period should be provided with at least 1.7m of earth cover for frost protection purposes. Alternatively, the required frost protection could be provided using a combination of earth cover and extruded polystyrene insulation. Lascelles Engineering should review the detailed design of frost protection with the use of equivalent insulation prior to construction.

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

5.9 Foundation Drainage

It is anticipated that the dwellings will have basements and will therefore, require permanent perimeter drainage. The drainage pipe shall be embedded in a 300mm layer of 20mm diameter clear crushed stone wrapped in a geotextile and set adjacent to the perimeter footings. The drainage pipe should be connected positively to a suitable outlet such as a sump pit or storm sewer. In order to reduce the potential for ponding of water adjacent to the foundation walls, roof water should be controlled by a roof drainage system that directs water away from the
building and the exterior grade should be sloped to promote water away from the foundation walls.

5.10 Foundation Wall Backfill

To prevent possible foundation frost jacking, the backfill against foundation walls should consist of free draining, non-frost susceptible material meeting OPSS Granular B Type I gradation requirements.

The foundation fill should be compacted to 90 percent of its SPMDD using light compaction equipment, where no loads will be set over top. The compaction shall be increased to 95 percent under walkways, slabs or paved areas close to the foundation or retaining walls. Backfilling against foundation walls should be carried out on both sides of the wall at the same time.

5.11 Retaining Walls and Shoring

The following Table 3 below provides the suggested soil parameters for the design of retaining wall and/or shoring systems. For excavations near existing services and structures, the coefficient of earth pressure at rest (Ko) should be used.

<table>
<thead>
<tr>
<th>Type of Material</th>
<th>Bulk Density (kg/m³)</th>
<th>Pressure Coefficient</th>
<th>At Rest (Ko)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Active (Ka)</td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td>18</td>
<td>0.45</td>
<td>0.80</td>
</tr>
<tr>
<td>Sand</td>
<td>19</td>
<td>0.33</td>
<td>0.50</td>
</tr>
<tr>
<td>Till</td>
<td>22</td>
<td>0.27</td>
<td>0.50</td>
</tr>
<tr>
<td>Granular B Type I</td>
<td>20</td>
<td>0.33</td>
<td>0.50</td>
</tr>
<tr>
<td>Granular B Type II</td>
<td>23.1</td>
<td>0.31</td>
<td>0.47</td>
</tr>
<tr>
<td>Granular A</td>
<td>23.5</td>
<td>0.27</td>
<td>0.43</td>
</tr>
</tbody>
</table>

The above values are for a flat surface behind the wall, a straight wall and a wall friction angle of 0 degree. The designer should consider any difference between these coefficients, and make appropriate corrections for a sloped surface behind the wall, angled wall or wall friction as required. The bearing capacity for the design of a retaining wall are the same as provided for

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the building structures provided it is founded over native soil or properly prepared and approved structural fill.

Retaining walls should also be designed to resist the earth pressures produces under seismic conditions. Lascelles recommends the use of combined coefficients of static and seismic earth pressure, referred to as $K_{AE}$ for active conditions and $K_{PE}$ for passive conditions for routine design purposes.

The total active and passive loads under seismic conditions can be calculated using the following two equations;

$$P_{AE} = \frac{1}{2} K_{AE} \gamma H^2 (1-K_V)$$
$$P_{PE} = \frac{1}{2} K_{PE} \gamma H^2 (1-K_V)$$

Where;

$K_{AE}$ = Combined Static and Seismic Active Earth Pressure Coefficient
$K_{PE}$ = Combined Static and Seismic Passive Earth Pressure Coefficient
$H$ = Total Height of the Wall (m)
$K_h$ = Horizontal Acceleration Coefficient
$K_v$ = Vertical Acceleration Coefficient
$\gamma$ = bulk density (kg/m$^3$)

These equations are based on a horizontal slope behind the wall and a vertical back of the retaining wall and zero wall friction. For this site, the following design parameters were used to develop the recommended $K_{AE}$ and $K_{PE}$ values.

$$A = \text{Zonal acceleration ratio} = 0.2$$
$$K_h = \text{Horizontal acceleration coefficient} = 0.1$$
$$K_v = \text{Horizontal acceleration coefficient} = 0.067$$

The above value of $K_h$ corresponds to $\frac{1}{2}$ of the $A$ value and the value $K_v$ of corresponds to 0.67 of the $K_h$ value. The angle of friction between the soil and the wall has been set at $0^o$ to provide a conservative estimate. The following Table 4 provides the parameters for seismic design of retaining structures.
Table 4: Material Properties for Shoring and Permanent Wall Design (Seismic)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OPSS Granular B Type I</th>
<th>OPSS Granular A and Granular B Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Unit Weight, $\gamma$ (kN/m$^3$)</td>
<td>20</td>
<td>23.3</td>
</tr>
<tr>
<td>Effective Friction Angle (degrees)</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Angle of Internal Friction Between wall and Backfill (degrees)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Yielding Wall</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Seismic Earth Pressure Coefficient ($K_{AE}$)</td>
<td>0.37</td>
<td>0.33</td>
</tr>
<tr>
<td>Height of the Application of $P_{AE}$ from the base of the wall as a ratio of its height (H)</td>
<td>0.36</td>
<td>0.37</td>
</tr>
<tr>
<td>Passive Seismic Earth Pressure Coefficient ($K_{PE}$)</td>
<td>3.06</td>
<td>3.48</td>
</tr>
<tr>
<td>Height of the Application of $P_{PE}$ from the base of the wall as a ratio of its height (H)</td>
<td>0.30</td>
<td>0.30</td>
</tr>
</tbody>
</table>

5.12 Trees

It should be noted that the silty clay soils found at the site may be sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the clay, the clay undergoes shrinkage which can result in settlement of adjacent structures. Research carried out by the Institute for Research Construction, formerly the Division of Building Research, of the National Research Council of Canada, referenced as CBD-62. Trees and Buildings, published in February 1965, provides the following guideline:

“If trees are already growing on the building site, every effort should be made so to locate the structure such that it conforms to the suggestions in the next paragraph. If this cannot be done then, with natural reluctance trees that are going to be too close to the building must be cut down and their root systems removed. It is far better that this should be done and new trees planted appropriately than that aesthetic claims should over-rule sound judgment with the possibility of damage to the building and the eventual inevitable removal of the trees in any case. Care should be taken that the removed trees have not already desiccated the clay, which may then swell under the changed environment.”

“If trees are to be planted as a part of the landscaping around the building, a good working rule has been found to be that trees should preferably be planted no nearer a building on shrinkable clay than the eventual height to which the tree may be expected to grow. This rule may require
modification if the topography around the building varies. Even in its application, attention must be given to the differing transpiration characteristics of trees"

6 EXCAVATION AND GROUNDWATER CONTROL

It is anticipated that shallow excavation in overburden soils would not exceed 3.0m bgs for the proposed dwellings and municipal services. Most of the shallow excavation will be through sand and clay deposits. According to the Ontario’s Occupational Health and Safety Act (OHSA), O. Reg. 213/91 and its amendments, the surficial overburden soil anticipated to be excavated into at this site can be classified as Type 3 for fully drained excavations. Therefore, shallow temporary excavation in the overburden soil classified as Type 3 can be cut at 1 horizontal to 1 vertical for a fully drained excavation starting at the base of the excavation and as per requirements of the OHSA regulations.

The listed slopes are for fully drained excavations. Gentler slopes could be required under undrained excavations or below the water table, where localised water infiltrations can occur and where the excavations are exposed for a prolonged period of time.

Any excavated material stockpiled near a trench or open excavation should be stored at a distance equal to or greater than the depth of the excavated soil within the trench or open excavation and equipment circulation should be restricted away from the top of the slope excavation.

In the event that the aforementioned slopes are not possible to achieve due to space restrictions, the excavation should be shored according to OHSA O. Reg. 213/91 and its amendments. A geotechnical engineer should design and approve the shoring and establish the shoring depth under the excavation profile. Refer to the parameters provided in Tables 3 and 4 in Section 5.11 for use in the design of any shoring structures. The excavation for the underground services could be carried out within tightly fitting, braced steel trench boxes, approved by a professional engineer.
6.1 Groundwater Control

Groundwater seepage and infiltration entering shallow and temporary excavations performed within the overburden consisting of sand and clay should be mitigated by pumping from sumps installed in the excavation. Surface water runoff into the excavation should be avoided and diverted away from the excavation.

It is anticipated that the invert of the municipal services will be founded below the water table. The sand is sensitive below the water table and may also be susceptible to piping and scouring from water pressure at the base of the excavation. The base of the excavation should not be exposed for prolonged periods of time and should be backfilled as soon as possible.

6.2 Pipe Bedding Requirements

Bedding, thickness of cover material and compaction requirements for the underground municipal services should conform to the manufacturers design requirements and to the requirements and detailed installations outlined in the Ontario Provincial Standard Specifications (OPSS) and any applicable standards or requirements from the Village of Casselman.

Where the invert of an underground service will be founded below the groundwater table and within sand, the sand may be sensitive to disturbances and may also be susceptible to piping and scouring from water pressure at the base of the excavation. Therefore, special precautions should be taken in these areas to stabilize and confine the base of the excavation such as using recompression (thicker bedding) and/or dewatering methods (pre-pumping). In order to properly compact the bedding, the water table should be kept at least 0.30m below the base of the excavation at all time during the installation of the underground services.

As an alternative to Granular A bedding and only where wet conditions are encountered, the use of “clear stone” bedding, such as 19mm clear stone, OPSS 1004, may be considered only in conjunction with a suitable geotextile filter placed between the native soil and the clear stone. Without proper filtering, there may be entry of fines from native soils and trench backfill into the bedding, which could result in loss of support to the pipes and possible surface settlements.
The sub-bedding, bedding and cover materials should be compacted in maximum 200mm thick lifts to at least 95 percent of the standard Proctor maximum dry density (SPMDD) using suitable vibratory compaction equipment.

6.3 Trench Backfill

Acceptable and compactable native materials should be used as trench backfill between the roadway subgrade level and the depth of seasonal frost penetrations (i.e. 1.8m below finished grade). In order to reduce the potential for differential frost heaving between the new excavated trench and the adjacent section of roadway, the selected trench backfill material should match, as best as possible, the existing soil exposed on the trench walls. Any boulders larger than 300mm in size should not be used as trench backfill. Where there is lack of backfill material and it would need to be imported, it should conform to OPSS Granular B Type I or approved equivalent.

Where two different frost susceptible soil types are used in the trench backfill, frost tapers should be provided. The minimum frost taper should consist of cutting back the side slope of the trench to 3 horizontal to 1 vertical profile starting at 1.2m below the finish grade.

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

Thrust blocks, where required, should be designed according to OPSD 1103.01 and 1103.020 using the allowable soil bearing capacities given hereafter. It is anticipated that thrust blocks would be located within 4.0m of the ground surface. An allowable bearing pressure of 75kPa may be used for the design of thrust blocks located in clay. The bearing pressure of the soil should be verified on-site at the time of construction.

6.4 Seepage Barriers

The permanent lowering of the groundwater level can be caused by drainage through the granular bedding and cover materials within the watermain trench. Groundwater lowering within clay type soils can cause them to consolidate, which in turn can cause ground settlement of the
roadway and to nearby building structures’ footings/foundations. Clay type soils were identified in the subdivision.

To minimize the potential for groundwater lowering at this site due to the presence of the proposed watermain and sewers, it is considered that clay dykes should be provided at about 150m spacing, where clay is encountered. The barriers shall be constructed as per OPSS 410 and OPSD 802.095.

7 REUSE OF ON-SITE SOILS

The existing overburden found at this site consist of silty sand, sand-silt and silty clay, which are all considered to be frost susceptible and should not be used as backfill material directly against foundation walls or underneath concrete slabs. It is however possible to use these soils for landscaping and general backfilling purposes, if the material can be compacted according to the specifications outlined herein at the time of construction. Any stones, cobbles or boulders larger than 300mm in size should not be used as service trench backfill.

Most of the existing overburden material found above the water table, except the organic deposits, could be reused for service trench backfill, if the material can be compacted according to the guidelines outlined herein at the time of construction. Any boulders larger than 300mm in size should not be used as service trench backfill. The reuse of the overburden found below the water table or the stiff to firm clay will depend on its water content at the time of construction, its ability to be properly compacted and if it can be dried sufficiently. It should generally be possible to reuse the upper portion of the silty clay deposit (clay crust) if the operations are carried out in dry weather. With depth, the water content of the clay is above the range of which it could properly be compacted. It is anticipated that efforts to reduce the moisture content of the clay to an acceptable level may be time consuming, if even possible. Any imported material should conform to OPSS Granular B- Type I.

It should be noted that the adequacy of a material for reuse as backfill will primarily depend on the water content of the material at the time of use and on weather conditions at that time. Any excavated materials proposed for reuse should be stockpiled in a manner to promote drying and should be inspected and approved for reuse by a geotechnical engineer.
8 PAVEMENT DESIGN

For predictable performance of the municipal roads, any organic, soft or deleterious materials should be removed from the proposed pavement areas to expose native undisturbed subgrade soil. The exposed subgrade should be inspected and approved by geotechnical personnel and any evidently loose and unstable areas should be sub-excavated and replaced with suitable earth borrow approved by the geotechnical engineer. The subgrade should be shaped and crowned to promote drainage of the roadway. Following approval of the preparation of the subgrade, the granular subbase may be placed.

It is anticipated that the subgrade for the proposed municipal street will consist of silty sand. The recommended pavement structure for the proposed municipal street should consist of:

- 40 millimetres of hot mix asphaltic concrete surface layer (HL3 – PG 58-34) over
- 40 millimetres of hot mix asphaltic concrete binder layer (HL8 – PG 58-34) over
- 150 millimetres of OPSS Granular A base over
- 350 millimetres of OPSS Granular B, Type II subbase

The base and subbase granular materials should conform to OPSS Form 1010 material specifications. Prior to importing any granular material onto the site, it should be tested and approved by a geotechnical engineer prior to delivery to the site and should be compacted to 100% SPMDD. Compaction of the granular pavement materials should be carried out in maximum 200 mm thick loose lifts to 100% of its SPMDD using suitable vibratory compaction equipment.

The Job Mix Formula (JMF) of the asphaltic concrete should be in accordance with OPSS 1150 for Material Specification for Hot Mix Asphalt. The asphaltic concrete should be placed in accordance to OPSS 310 for Construction Specification for Hot Mix Asphalt. The asphaltic concrete should compacted to a minimum of 92% of the Maximum Relative Density. The JMF and its constituents should be reviewed, tested and approved by a geotechnical engineer prior to delivery to the site.
8.1 Paved Areas and Subgrade Preparation

The footprint of the proposed municipal streets should be stripped of vegetation, topsoil, debris and other obvious objectionable material. Following the backfilling and satisfactory compaction of any underground service trenches up to the subgrade level, the subgrade should be shaped, crowned and proof-rolled using a heavy roller with any resulting soft areas sub-excavated down to an adequate bearing layer and replaced with approved backfill. Following approval of the preparation of the subgrade, the pavement structure may be placed.

Any materials used as select subgrade should be approved by the geotechnical engineer before placement within the roadway. These materials should be placed in maximum 300mm thick loose lifts and be compacted to at least 95 percent of its SPMDD using suitable compaction equipment. Any grade raise must respect the recommendations provided in the foundation section.

If the roadway subgrade is disturbed or wetted due to construction operations or precipitation, the granular thicknesses given above may not be adequate and it may be necessary to increase the thickness of the Granular B Type II subbase and/or incorporate a non-woven geotextile separator between the roadway subgrade surface and the granular subbase material.

The preparation of subgrade should be scheduled and carried out in such a manner that a protective cover of overlying granular material is placed as quickly as possible in order to avoid unnecessary circulation by heavy equipment over the subgrade. Frost protection of the surface should be implemented (i.e. insulated tarps, etc.), if works are carried out during the winter months.

Transitions should be constructed between new and existing pavement structures where the new street will meet with the existing street. In areas where the new pavement structure will abut existing pavement structure, the depths of granular materials should be tapered up or down at 5 horizontal to 1 vertical, or flatter, to match the depths of the granular material(s) exposed in the existing pavement.
The performance of the pavement structure is highly dependent on the subsurface groundwater conditions and maintaining the subgrade and pavement structure in a dry condition. To intercept excess subsurface water within the pavement structure granular materials, sub-drains with suitable outlets should be installed below the pavement structure subgrade if adequate overland flow drainage is not provided (i.e. ditches). The surface of the pavement should be properly graded to direct runoff water towards suitable drainage features. It is recommended that the lateral extent of the subbase and base layers not be terminated vertically immediately behind any proposed the curb/edge of pavement line but be extended beyond the curb.

9 CONSTRUCTION CONSIDERATION

It is suggested that the final design drawings for this project, including the proposed site grading plan, be reviewed by the geotechnical engineer to ensure that the guidelines provided in this report have been interpreted as intended.

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed development do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design. All footing areas and any engineered fill areas (if required) for the proposed project should be inspected by Lascelles Engineering and Associates Ltd. to ensure that a suitable subgrade has been reached and properly prepared. The placing and compaction of any granular materials beneath the foundations (if required) should be inspected to ensure that the materials used conform to the gradation and compaction specifications.

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

The subgrade for the pavement areas, watermain and sewers should be inspected and approved by geotechnical personnel. In-situ density testing should be carried out on the pavement granular materials and pipe bedding and backfill to ensure the materials meet the specifications from a compaction point of view.
10 REPORT CONDITIONS AND LIMITATIONS

It is stressed that the information presented in this report is provided for the guidance of the designers and is intended for this project only. The use of this report as a construction document is neither intended nor authorized by Lascelles Engineering & Associates Ltd. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

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

The recommendations provided in this report are based on subsurface data obtained at the specific test locations only. Experience indicates that the subsurface soil and groundwater conditions can vary significantly between and beyond the test locations. For this reason, the recommendations given in this report are subject to a field verification of the subsurface soil conditions at the time of construction.

The report recommendations are applicable only to the project described in the report. Any changes to the project will require a review by Lascelles Engineering & Associates Ltd., to ensure compatibility with the recommendations contained in this report.
We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we may be of further services to you, please do not hesitate to contact our office.

Yours truly,

Lascelles Engineering & Associates Ltd.

Mario Elie, Senior Technologist
Project Manager

Will Ball, P. Eng.
Geotechnical Engineer
Appendix A

Draft Plan of Subdivision
Appendix B

Test Pit & Borehole Location Plan
Appendix C

Test Pit and Borehole Logs
**SOIL PROFILE**

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
<th>ELEV.</th>
<th>SHEAR STRENGTH kPa</th>
<th>SAMPLE #</th>
<th>Water Level (Standpipe or Open Excavation)</th>
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**Easting:** 491394  
**Northing:** 5018523  
**Site Datum:** Geodetic  
**Groundsurface Elevation:** 65.41m  
**Width of Excavation:** 0.75m  
**Length of Excavation:** 1.5m  

**COMMENTS:**
# TEST PIT LOG: TP-2

**PROJECT No.:** 170043  
**LOGGED BY:** C.Y.  
**CLIENT:** Cassel Homelands Development Inc.  
**LOCATION:** Principal Street and Sarah Street, Casselman, Ontario  
**DATE:** November 9, 2017  
**CONTRACTOR:** Gagné Excavation  
**EXCAVATION METHOD:** Backhoe

## SOIL PROFILE

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<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
<th>ELEV.</th>
<th>SAMPLE #</th>
<th>SHEAR STRENGTH (kPa)</th>
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## Soil Profile Details

- **Easting:** 491438  
- **Northing:** 5018605  
- **Site Datum:** Geodetic  
- **Groundsurface Elevation:** 65.65mm  
- **Width of Excavation:** 0.75m  
- **Length of Excavation:** 1.5m  

**COMMENTS:**

- Water Level (Standpipe or Open Excavation)
### TEST PIT LOG: TP-3

**PROJECT No.:** 170043  
**LOGGED BY:** C.Y.  
**LOCATION:** Principal Street and Sarah Street, Casselman, Ontario  
**DATE:** November 9, 2017  
**CONTRACTOR:** Gagné Excavation  
**EXCAVATION METHOD:** Backhoe

### SOIL PROFILE

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<th>SHEAR STRENGTH kPa</th>
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**Site Datum:** Geodetic  
**Groundsurface Elevation:** 65.41m  
**Width of Excavation:** 0.75m  
**Length of Excavation:** 1.5m

**East:** 491599  
**North:** 5018588

**COMMENTS:**

![Diagram](image-url)
## TEST PIT LOG: TP-4

**PROJECT No.:** 170043  
**LOGGED BY:** C.Y.  
**CLIENT:** Cassel Homelands Development Inc.  
**LOCATION:** Principal Street and Sarah Street, Casselman, Ontario  
**DATE:** November 9, 2017  
**CONTRACTOR:** Gagné Excavation  
**EXCAVATION METHOD:** Backhoe

### Soil Profile

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<th>Depth (m)</th>
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### Water Level (Standpipe or Open Excavation)

- [ ] 20
- [ ] 40
- [ ] 60
- [ ] 80
- [ ] 100

### Comments:

- Easting: 491556  
- Northing: 5018470  
- Site Datum: Geodetic  
- Groundsurface Elevation: 65.30m  
- Width of Excavation: 0.75m  
- Length of Excavation: 1.5m
### TEST PIT LOG: TP-5

**PROJECT No.:** 170043  
**LOGGED BY:** C.Y.  
**LOCATION:** Principal Street and Sarah Street, Casselman, Ontario  
**DATE:** November 9, 2017  
**CONTRACTOR:** Gagné Excavation  
**EXCAVATION METHOD:** Backhoe

#### SOIL PROFILE

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<th>SHEAR STRENGTH kPa</th>
<th>SAMPLE #</th>
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**End of Test Pit**

**COMMENTS:**

**Easting:** 491457  
**Northing:** 5018386  
**Site Datum:** Geodetic  
**Groundsurface Elevation:** 65.41m  
**Width of Excavation:** 0.75m  
**Length of Excavation:** 1.5m
## TEST PIT LOG: TP-6

**PROJECT No.:** 170043  
**LOGGED BY:** C.Y.  
**LOCATION:** Principal Street and Sarah Street, Casselman, Ontario  
**DATE:** November 9, 2017  
**CONTRACTOR:** Gagné Excavation  
**EXCAVATION METHOD:** Backhoe

### SOIL PROFILE

| DEPTH (m) | DESCRIPTION | ELEV. | SAMPLE # | SHEAR STRENGTH (kPa) | Water Level  
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**Easting:** 491503  
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**Site Datum:** Geodetic  
**Groundsurface Elevation:** 65.25m  
**Width of Excavation:** 0.75m  
**Length of Excavation:** 1.5m  
**COMMENTS:**

Water Level (Standpipe or Open Excavation): 0.1 m (01/15/2018)
**TEST PIT LOG: TP-7**

**PROJECT No.:** 170043  
**LOGGED BY:** C.Y.  
**CLIENT:** Cassel Homelands Development Inc.  
**LOCATION:** Principal Street and Sarah Street, Casselman, Ontario  
**DATE:** November 9, 2017  
**CONTRACTOR:** Gagné Excavation  
**EXCAVATION METHOD:** Backhoe

### SOIL PROFILE

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
<th>ELEV.</th>
<th>SHEAR STRENGTH kPa</th>
<th>WATER LEVEL (Standpipe or Open Excavation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Ground Surface</td>
<td>65.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td><strong>Topsoil:</strong> 300mm of dark brown sandy loam.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td><strong>Sand:</strong> Uniform, sand-silt mixture near the surface becoming silty with depth, brownish grey in colour with oxidation stains near the surface becoming grey in colour with depth, loose to compact and moist.</td>
<td>64.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td><strong>Clay:</strong> Silty with trace of sand, grey in colour with some reddish bands, stiff in consistency near the surface becoming firm with depth; low in plasticity near the surface becoming high plasticity with depth and a high moisture content.</td>
<td>62.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>End of Test Pit</td>
<td>62.26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Eastings:** 491607  
**Northings:** 5018336  
**Site Datum:** Geodetic  
**Groundsurface Elevation:** 65.26m  
**Width of Excavation:** 0.75m  
**Length of Excavation:** 1.5m  
**COMMENTS:**
SOIL PROFILE

DEPTH (m) | DESCRIPTION | ELEV. | NUMBER | TYPE | NVALUE / RQD | RECOVERY | SHEAR STRENGTH (kPa) | WATER CONTENT (%) | WATER LEVEL
---|---|---|---|---|---|---|---|---|---
0.0 | Ground Surface | 65.30 | | | | | | |
Topsoil: 200mm of dark brown sandy loam.

Sand: Uniform, sand-silt mixture near the surface becoming silty with depth, brownish grey in colour with oxidation stains near the surface becoming grey in colour with depth, loose to compact and moist.

Clay: Silty with trace of sand, grey in colour with some reddish bands, stiff in consistency near the surface becoming firm with depth, but returning to stiff at around 11m bgs; low in plasticity near the surface becoming high plasticity with depth and a high moisture content.

End of sampling; hammered cone below 12.95m bgs to 16.15m bgs.

End of Borehole | 16.15 | 3 | SS-11 | 3 | 70% |

COMMENTS:

Easting: 491620
Site Datum: N/A
Top of Casing Elev.: N/A
Borehole Diameter: 200mm

North: 5019351
Groundsurface Elev.: 65.30m
Top of Riser Elev.: N/A
Monitoring Well Diameter: N/A
### Soil Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Ground Surface</td>
</tr>
<tr>
<td>0.00</td>
<td>Topsoil: 200mm of dark brown sandy loam.</td>
</tr>
<tr>
<td>0.20</td>
<td>Sand: Uniform, sand-silt mixture near the surface becoming silty with depth, brownish grey in colour with oxidation stains near the surface becoming grey in colour with depth, loose to compact and moist.</td>
</tr>
<tr>
<td>1.20</td>
<td>Clay: Silty with trace of sand, grey in colour with some reddish bands, stiff in consistency near the surface becoming firm with depth; low in plasticity near the surface becoming high plasticity with depth and a high moisture content.</td>
</tr>
<tr>
<td>2.54</td>
<td>End of Borehole</td>
</tr>
</tbody>
</table>

### Samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number</th>
<th>Type</th>
<th>N-value / RQD</th>
<th>Recovery</th>
<th>Shear Strength (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS-1</td>
<td>10</td>
<td>66%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-2</td>
<td>11</td>
<td>58%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-3</td>
<td>8</td>
<td>58%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-4</td>
<td>-</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-5</td>
<td>1</td>
<td>88%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-6</td>
<td>-</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH-1</td>
<td>-</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Water Level

- **Ground Surface:** 0.00
- **Topsoil:** 0.20
- **End of Borehole:** 2.54
Appendix D

Laboratory Reports
One-Dimensional Consolidation Properties of Soils Using Incremental Loading
ASTM D 2435 - Taylor Method

Client: Lascelles
Project: Y/Project: 170043
Boring No.: Shelby1, BH-1
Sample No.: 5
Depth (m): 4.80 to 4.90m

Hydrostatic stress at the test (date):

Provided by □ the client □ Englobe

Geotechnical Characteristics of Soils:

- Initial void ratio \( (\varepsilon_0) \): 2.479
- Initial water content \( (w) \): 90.1%
- Initial humid unit weight \( (\gamma_h) \): 14.7 kN/m³
- Initial saturation degree \( (S_i) \): 100.0%
- Recompression index \( (C_r) \): 0.046
- Virgin compression index \( (C_v) \): 2.88
- Initial effective stress \( (\sigma_{\text{eff}}) \): 66 kPa
- Preconsolidation pressure \( (\sigma_{\text{pc}}) \): 115 kPa
- Overconsolidation deviation \( (\Delta\sigma) \): 49 kPa

Remarks:
The sampling and transportation of the sample were carried out by a client's representative.
The initial effective stress has been provided by the client.

Prepared by: Adlane Bouadma, Jr Eng
Verified by: Farnakhan Fainke, Eng

EQ-09-IM-274 Rev. 04 (13-10)
One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D 2435 - Taylor Method

Client: Lascelles
Project: Y/Project: 170043
Boring No.: Shelby3, BH-1
Sample No.: 7
Hydrostatic stress at the test (date):

Date: 2018-02-28
Our file No.: P-0011703-5-01
Depth (m): 10.90 to 11.00m

Stress vs Void Ratio Curve

<table>
<thead>
<tr>
<th>Stress (kPa)</th>
<th>Void Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,060</td>
<td>0.860</td>
</tr>
<tr>
<td>1,260</td>
<td>1.060</td>
</tr>
<tr>
<td>1,460</td>
<td>1.260</td>
</tr>
<tr>
<td>1,660</td>
<td>1.460</td>
</tr>
<tr>
<td>1,860</td>
<td>1.660</td>
</tr>
</tbody>
</table>

Geotechnical Characteristics of Soils:

Initial void ratio (e0): 1.732
Initial water content (w): 62.7%
Initial humid unit weight (γ): 16.1 kN/m³
Initial saturation degree (S): 99.6%
Recompression index (C): 0.029
Virgin compression index (Cv): 1.16
Initial effective stress (σ): 113 kPa
Preconsolidation stress (σc): 190 kPa
Overconsolidation deviation (Δσ): 77 kPa

Remarks:
The sampling and transportation of the sample were carried out by a client's representative.
The initial effective stress has been provided by the client.

Prepared by: Adiane Bouadma, Jr Eng
Verified by: Famakhari Fainke, Eng.
# Extraction and Visual Description

**Project No.**  P-0011703-5-01  
**Client**  Lascelles  
**Project**  Y/Project: 170043  
**Sample**  5  

<table>
<thead>
<tr>
<th>Date of sampling</th>
<th>2018-02-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of tube extraction</td>
<td>2018-02-21</td>
</tr>
<tr>
<td>Storage time</td>
<td>1 year</td>
</tr>
<tr>
<td>Tube in good condition</td>
<td>Yes</td>
</tr>
<tr>
<td>Depth of tube</td>
<td>4.57 to 5.33m</td>
</tr>
<tr>
<td>Borehole</td>
<td>Shelby-1, BH-1</td>
</tr>
<tr>
<td>Sample</td>
<td>-------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tube</th>
<th>Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>4.57m</td>
</tr>
<tr>
<td></td>
<td>4.70m</td>
</tr>
<tr>
<td></td>
<td>4.80m</td>
</tr>
<tr>
<td>Bottom</td>
<td>5.17m</td>
</tr>
<tr>
<td></td>
<td>4.90m</td>
</tr>
<tr>
<td></td>
<td>5.00m</td>
</tr>
<tr>
<td></td>
<td>5.10m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual description</th>
<th>Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silty clay with a gray brown color. Presence of a bed of organic matter with a thickness of 5 mm, presence of a layer of fine sand at 4.62m with a thickness of 3 cm.</td>
<td>4.70m</td>
</tr>
<tr>
<td>Silty clay with a brick red color. Color transition to gray between 4.75 to 4.79m.</td>
<td>4.80m</td>
</tr>
<tr>
<td>Silty clay with a gray brown color, slight crack at 4.92m. Possibly remolded sample between 4.90 and 4.95m.</td>
<td>4.90m</td>
</tr>
</tbody>
</table>
| Consistency: Medium  
Plasticity: Medium  
Sensibility: Medium | 5.10m |

---

**Prepared by**  Adlane Bouadma, Jr Eng  
**Date**  2018-02-21  
**Approved by**  Adlane Bouadma, Jr Eng  
**Date**  2018-02-22
## Extraction and Visual Description

**Project No.** P-0011703-5-01  
**Client** Lascelles  
**Project** Y/Project: 170043  
**Sample** 6  
**Specification**

| Date of sampling | 2018-02-16 | Tube in good condition | ✔ Yes  
|------------------|------------|------------------------|-------  
| Date of tube extraction | 2018-02-21 | Depth of tube | 6.86 to 7.62m  
| Storage time | 1 year | Borehole Shelby-2, BH-1 | Sample  

<table>
<thead>
<tr>
<th>Tube</th>
<th>Depth (mm)</th>
<th>Visual description</th>
<th>Depth (mm)</th>
<th>Laboratory analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>6.86m</td>
<td>6.86 to 6.90m</td>
<td>Preserved</td>
<td>Analysis</td>
</tr>
<tr>
<td></td>
<td>Remolded</td>
<td></td>
<td>6.90m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silty clay with a gray brown color.</td>
<td></td>
<td>7.00m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consistency: Medium</td>
<td></td>
<td>7.10m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plasticity: Medium</td>
<td></td>
<td>7.20m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sensibility: Medium</td>
<td></td>
<td>7.30m</td>
<td></td>
</tr>
<tr>
<td>Bottom</td>
<td>7.43m</td>
<td></td>
<td>7.40m</td>
<td></td>
</tr>
</tbody>
</table>

**Prepared by** Adlane Bouadma, Jr Eng  
**Date** 2018-02-21  
**Approved by** Adlane Bouadma, Jr Eng  
**Date** 2018-02-22
# Extraction and Visual Description

**Project No.:** P-0011703-5-01  
**Client:** Lascelles  
**Project:** Y/Project: 170043  
**Sample:** 7  

<table>
<thead>
<tr>
<th>Date of sampling</th>
<th>2018-02-16</th>
<th>Tube in good condition</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of tube extraction</td>
<td>2018-02-21</td>
<td>Depth of tube</td>
<td>10,67 to 11,43m</td>
<td></td>
</tr>
<tr>
<td>Storage time</td>
<td>1 year</td>
<td>Borehole</td>
<td>Shelby-3, BH-1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tube</th>
<th>Depth (mm)</th>
<th>Visual description</th>
<th>Depth (mm)</th>
<th>Laboratory analysis</th>
</tr>
</thead>
</table>
| Top  | 10,67m     | 10,67 to 10,70m  
Gray silty clay remolded.               | 10,70m     | Preserved |
|      | 10,70m     | 10,70 to 11,10m  
Gray silty clay, transition of color from gray to gray brown at 10,90m | 10,80m   | Analysis |
|      | Bottom     | 11,19m               | 10,90m     | Consoliation |
|      |            |                      | 11,00m     |                  |
|      |            |                      | 11,10m     |                  |

**Prepared by:** Adlane Bouadma, Jr Eng  
**Date:** 2018-02-21  
**Approved by:** Adlane Bouadma, Jr Eng  
**Date:** 2018-02-22  

EQ-09-IM-555a rév. 00 (13-04)
### Extraction and Visual Description

**Project No.** P-0011703-5-01  
**Client** Lascelles  
**Project** Y/Project: 170043  
**Sample** 8  

**Specification**

<table>
<thead>
<tr>
<th>Date of sampling</th>
<th>2018-02-16</th>
<th>Tube in good condition</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of tube extraction</td>
<td>2018-02-21</td>
<td>Depth of tube</td>
<td>5.33 to 6.10m</td>
<td></td>
</tr>
<tr>
<td>Storage time</td>
<td>1 year</td>
<td>Borehole</td>
<td>Shelby-1, BH-2</td>
<td>Sample</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tube</th>
<th>Depth (mm)</th>
<th>Visual description</th>
<th>Depth (mm)</th>
<th>Laboratory analysis</th>
</tr>
</thead>
</table>
| Top  | 5.33m      | 5.33 to 5.45m  
Remolded mix of clay and fine sand. | 5.45m | |
|      | 5.45m      | 5.45 to 5.73m  
Gray silty clay. | 5.50m | |
|      | 5.73m      | Consistency: Medium  
Plasticity: Medium  
Sensibility: Medium | 5.60m | |
|      | 5.70m      |                     | 5.70m | |

**Bottom**

---

**Prepared by** Adlane Bouadma, Jr Eng  
**Date** 2018-02-21  
**Approved by** Adlane Bouadma, Jr Eng  
**Date** 2018-02-22
Date: February 27, 2018
File: 122411086

Attention: Frank Elie, Lascelles Engineering Associates

Reference: Lascelles File #170043
ASTM D4318 Atterberg Limit & ASTM D2216 Moisture Content

The table below summarizes Atterberg Limit & Moisture Content results.

<table>
<thead>
<tr>
<th>Source</th>
<th>Depth</th>
<th>Natural Moisture Content</th>
<th>Liquid Limit</th>
<th>Plastic Limit</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-1 SS7</td>
<td>20'</td>
<td>65.9</td>
<td>61.2</td>
<td>22.1</td>
<td>39.1</td>
</tr>
<tr>
<td>BH-1 SS10</td>
<td>37'6&quot;</td>
<td>58.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BH-1 SS11</td>
<td>40'</td>
<td>54.1</td>
<td>50.8</td>
<td>21.8</td>
<td>29.0</td>
</tr>
</tbody>
</table>

Sincerely,

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com

Attachments: Atterberg Limit Plasticity Chart
December 29, 2017
File: 122411086

Attention: Frank Elie, Lascelles Engineering Associates

Reference: Lascelles File #170043
ASTM D4318 Atterberg Limit & ASTM D2216 Moisture Content

The table below summarizes Atterberg Limit & Moisture Content results.

<table>
<thead>
<tr>
<th>Source</th>
<th>Depth</th>
<th>Natural Moisture Content</th>
<th>Liquid Limit</th>
<th>Plastic Limit</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-3 SA-4</td>
<td>3.0m</td>
<td>63.1%</td>
<td>46.4</td>
<td>19.5</td>
<td>26.9</td>
</tr>
<tr>
<td>TP-5 SA-3</td>
<td>2.5m</td>
<td>39.7%</td>
<td>39.0</td>
<td>18.0</td>
<td>20.9</td>
</tr>
</tbody>
</table>

Sincerely,

Stantec Consulting Ltd

[Signature]

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com

Attachments: Atterberg Limit Plasticity Chart
Stantec
2781 Lancaster Road
Ottawa ON, K1B 1A7

Sieve Analysis
LS 602
ASTM C136

Client: Lascelles Engineering, File #170043
Project: Sarah @ Principale St., Casselman, ON
Material Type: Soils / Aggregates
Proposed Use: Fill/Granulars
Source: TP-1
Sample Number: SA-3
Sampled Depth: 1.7m
Sampled By: Lascelles Engineering Limited
Date Sampled: November 9, 2017

Tested By: Matt Carter
Date Tested: December 22, 2017

Sample Weight Before Sieve, (g): 495.2
Sample Weight After Sieve, (g): 494.5
Percent Loss In Sieve, (%): 0.14

Sample Weight Before Wash, (g): 250.9
Sample Weight After Wash, (g): 220.1
Percent Passing No. 200, (%): 12.3

### Sieve Test Data

<table>
<thead>
<tr>
<th>Sieve No.</th>
<th>Size of Opening</th>
<th>Weight Retained</th>
<th>Cumulative Weight Retained</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.060</td>
<td>0.060</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>0.075</td>
<td>0.075</td>
<td>4.75</td>
<td>4.75</td>
<td>494.5</td>
</tr>
<tr>
<td>0.150</td>
<td>0.150</td>
<td>16.0</td>
<td>16.0</td>
<td>100.0</td>
</tr>
<tr>
<td>0.125</td>
<td>0.125</td>
<td>13.2</td>
<td>13.2</td>
<td>100.0</td>
</tr>
<tr>
<td>0.080</td>
<td>0.080</td>
<td>9.5</td>
<td>9.5</td>
<td>100.0</td>
</tr>
<tr>
<td>0.060</td>
<td>0.060</td>
<td>4.75</td>
<td>4.75</td>
<td>100.0</td>
</tr>
<tr>
<td>0.040</td>
<td>0.040</td>
<td>2.36</td>
<td>2.36</td>
<td>100.0</td>
</tr>
<tr>
<td>0.020</td>
<td>0.020</td>
<td>1.18</td>
<td>1.18</td>
<td>100.0</td>
</tr>
<tr>
<td>0.015</td>
<td>0.015</td>
<td>0.60</td>
<td>0.60</td>
<td>100.0</td>
</tr>
<tr>
<td>0.010</td>
<td>0.010</td>
<td>0.30</td>
<td>0.30</td>
<td>100.0</td>
</tr>
<tr>
<td>0.005</td>
<td>0.005</td>
<td>0.15</td>
<td>0.15</td>
<td>100.0</td>
</tr>
<tr>
<td>0.002</td>
<td>0.002</td>
<td>0.075</td>
<td>0.075</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Wash Test Data

<table>
<thead>
<tr>
<th>corrected</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.3</td>
</tr>
</tbody>
</table>

### Sieve Analysis

Classification of Sample: % Gravel: 0.0 % Sand: 81.5 % Silt & Clay: 18.5

### Graph

- **Percent Passing** vs **Grain Size in Millimeters**

**Remarks:**

Reviewed By: [Signature]

Date: December 29, 2017
Sieve Analysis
LS 602
ASTM C136

Client: Lascelles Engineering, File #170043
Project: Sarah @ Principale St., Casselman, ON
Material Type: Soils / Aggregates:
Proposed Use: Fill/Granulars
Source: TP-3
Sample Number: SA-1
Sampled Depth: 0.75m
Sampled By: Lascelles Engineering Limited
Date Sampled: November 9, 2017

Project Number: 122411086
Tested By: Matt Carter
Date Tested: December 22, 2017

Sieve Test Data

<table>
<thead>
<tr>
<th>Sieve No.</th>
<th>Size of Opening</th>
<th>Weight Retained (g)</th>
<th>Cumulative Weight Retained (g)</th>
<th>Percent Passing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inches (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>150</td>
<td>575.3</td>
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<td>24.9</td>
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Classification of Sample:
% Gravel: 0.0 % Sand: 60.4 % Silt & Clay: 39.6

Remarks:

Reviewed By: Brian Peake
Date: December 29, 2017
Sieve Analysis
LS 602
ASTM C136

Client: Lascelles Engineering, File #170043
Project: Sarah @ Principale St., Casselman, ON
Material Type: Soils / Aggregates:
Proposed Use: Fill/Granulars
Source: TP-7
Sample Number: SA-2
Sample Depth: 1.0m
Sampled By: Lascelles Engineering Limited
Date Sampled: November 9, 2017

Tested By: Matt Carter
Date Tested: December 22, 2017

Sieve Test Data

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Wash Test Data

Sieve Analysis

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Classification of Sample: % Gravel: 0.0 % Sand: 65.0 % Silt & Clay: 35.0

Remarks:

Reviewed By: [Signature]
Date: December 29, 2017

V:\0124\Active\laboratory_standings offer\2017 Laboratory Standing Offers\122411086 Lascelles Engineering\December 20, 2017, Limits, Sieves & MCo, Lascelles #170043 Sieve Analysis.xlsx