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Soil and Materials Engineering
Environmental Engineering
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# 2115881 Ontario Limited

# Proposed Residential Development
# 560-576 Conservation Drive
# Waterloo, Ontario

## Geotechnical Engineering Report

Date: March 23, 2015
Ref. N°: 160-P-0008077-0-01-100-GE-R-0001-00

LVM, a division of EnGlobe Corp.



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# 560-576 Conservation Drive
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Test results mentioned herein are only valid for the sample(s) stated in this report.

LVM's subcontractors who may have accomplished work either on site or in laboratory are duly qualified as stated in our Quality Manual's procurement procedure. Should you require any further information, please contact your Project Manager."

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# 1 INTRODUCTION

LVM, a division of EnGlobe Corp. (LVM) was retained by 2115881 Ontario Limited, c/o Ian Cook Construction Limited, to carry out a geotechnical investigation at the site of a proposed residential development in Waterloo, Ontario. This work was authorized by Ms. Nicole Simas of Ian Cook Construction Limited on February 12, 2015 following submission of a detailed proposal.

The project involves the proposed construction of a new 21.8 hectare residential development to be situated on a parcel of land located north of Conservation Drive in Waterloo, Ontario at the location shown on Drawing 1, in Appendix 1. It is understood the lands are designated for residential streets and houses. The lots will be serviced with municipal water and sewer. A preliminary site plan was unavailable at the time of this report. No details were available regarding placement of proposed stormwater management structures.

The purpose of the investigation was to determine the subsurface soil and groundwater conditions at the site and, based on that information, prepare this engineering report with geotechnical recommendations pertaining to the development including site grading, site servicing, pavement construction, house construction, excavations and dewatering, and stormwater infiltration.

# 2 PREVIOUS WORK

In 2003, LVM (formerly Naylor Engineering Associates Ltd. prior to 2009) carried out a geotechnical investigation for the land on the east side of the site. The fieldwork for this investigation comprised of drilling of twenty-one boreholes (Boreholes 1 to 21) and excavation of thirty-four test pits (Test Pits 1 through 34). The results of this investigation were provided in our Geotechnical Engineering Report No. 4500G1.R01.

In 2005, LVM carried out a geotechnical investigation on Roy Schmidt Road adjacent to the site. The fieldwork for this investigation comprised the drilling of six boreholes (Boreholes 1 through 6). The results of this investigation were provided in our Geotechnical Engineering Report No. 4500G4.R01.

The relevant geotechnical information from the above noted reports have been incorporated into this report.

# 3 INVESTIGATION PROCEDURE

## 3.1 FIELD PROGRAM

The fieldwork for this investigation was carried out between February 26 and 27, 2015 and involved the drilling of ten boreholes (Boreholes BH-01-15 to BH-10-15) to depths of 5.0 to 8.1 m. The locations of the boreholes are shown on the Site Plan, Drawing 2 in Appendix 1.

Local utility companies were contacted prior to the start of drilling activities in order to demarcate underground utilities near the boring locations.

The boreholes were advanced with a CME-75 track mounted drillrig equipped with continuous flight hollow stem augers supplied and operated by a specialist drilling contractor.

In the boreholes, representative samples of the overburden were recovered at regular intervals throughout the depths explored. Standard Penetration Tests (SPT) were carried out during sampling operations in the boreholes using conventional split spoon equipment. The SPT N-values recorded are plotted on the borehole logs in Appendix 2.

Samples of the cohesive soils were tested using a hand-held pocket penetrometer to determine approximate shear strengths. The pocket penetrometer test results are plotted on the borehole logs in Appendix 2.

Standpipes were installed in Boreholes BH-01-15, BH 04-15, BH 05-15 and BH 07-15, to allow measurement of groundwater levels and the collection of groundwater samples. The standpipes installation comprises 19 mm diameter pipes with slotted screens, as well as bentonite seals near the ground surface. Details of the installations and groundwater observations and measurements are provided on the borehole logs in Appendix 2.

The standpipes were installed in accordance with Ontario Regulation 468/10 which provides requirements for wells in the Province of Ontario. The regulation encompasses test holes, and provides detailed requirements for monitoring well construction, test hole sealing, well record submission, drilling contractor licensing, well tagging, protective covers, and decommissioning.

A completed well record was submitted to the property owner and the Ministry of Environment for Ontario as per Ontario Regulation 468/10. A licensed well technician must properly decommission all standpipes before construction according to Regulation 903 of the Ontario Water Resources Act.

Upon completion of drilling, the remaining boreholes were backfilled with bentonite in accordance with the Ontario Regulation 468/10 (formerly Ontario Regulation 903) under the province's Water Resources Act.

The fieldwork was monitored throughout by a member of our geotechnical engineering staff, who documented the drilling procedures; recorded the results of the SPT and pocket penetrometer tests; documented the soil stratigraphies; monitored the groundwater conditions; documented the installation of the standpipes and, cared for the recovered soil samples.

The borehole locations and ground surface elevations were surveyed by LVM using Sokkia Model GXR 1 Global Navigation Satellite System (GNSS) rover. The borehole locations were referenced to Universal Trans Mercator North American Datum of 1983 (UTM NAD83) coordinates; the zone referenced (17T) has been excluded for presentation purposes. The ground surface elevations are geodetic, based on GNSS and local base station telemetry with a vertical root mean square error of less than 20 mm.

### 3.2 LABORATORY TESTING

All soil samples secured during this investigation were returned to our laboratory for visual examination, as well as moisture content tests. The moisture content test results are plotted on the borehole logs in Appendix 2. The geotechnical laboratory tests carried out on selected samples of the major subsurface soils from the investigation comprised the following:

- five particle size distribution analyses with results plotted on Figure 1 in Appendix 3; and,
- two standard Proctor moisture-density tests with results plotted on Figures 2 and 3 in Appendix 3.

The soil samples will be stored for a period of three months from the date of sampling. After this time, they will be discarded unless prior arrangements have been made for longer storage.

## 4 SUMMARIZED CONDITIONS

### 4.1 SITE DESCRIPTION

The subject property is located on the north side of Conservation Drive at the northwest corner of Waterloo, Ontario. The property is bordered on the east by an existing residential development and Roy Schmidt Road; on the south by Conservation Drive; on the west by a natural area and Beaver Creek; and on the north by agricultural land. There are two houses at 570 and 576 Conservation Drive.

The property currently comprises mostly agricultural land. The ground surface at the site slopes down from east to west (Elevation 363.1 m to Elevation 354.8 m) and from north to south (Elevation 357.6 m to Elevation 351.9 m).

## 4.2 SUBSOIL CONDITIONS

We refer to the appended borehole logs for detailed soil descriptions and stratigraphies; results of SPT and pocket penetrometer testing; moisture content profiles; and, groundwater observations and measurements.

In general, the subsurface stratigraphy contacted at the site comprise topsoil, overlying sand, silt and glacial till. Descriptions of the various soil deposits encountered are provided in the following subsections.

### 4.2.1 Topsoil

Topsoil was encountered surficially at all of the boreholes and is 150 to 1070 mm thick (average 475 mm). The topsoil comprises dark brown silt with trace sand and was frozen at the time of the fieldwork.

### 4.2.2 Sand

Sand was encountered beneath the topsoil in all boreholes. The sand is 2.7 and 5.0 m thick and extends below the termination depth of Boreholes BH 01-15, BH 03-15, BH 05-15, BH 07-15, BH 09-15 and BH 10-15. The sand ranges in composition from brown sand and silt with trace gravel to sand with some silt and trace gravel. The results of three grain size distribution analyses conducted on samples of sand are plotted on Figure 1 in Appendix 3 and are summarized on the following table:

Table 1: Sand Particle Size Distribution Analyses

| BOREHOLE NUMBER | SAMPLE DEPTH (m) | GRAVEL (%) | SAND (%) | FINES (%) |
|---|---|---|---|---|
| BH-04-15 | 2.29 – 2.74 | 6 | 85 | 9 |
| BH-05-15 | 1.52 – 1.98 | 21 | 65 | 14 |
| BH-07-15 | 2.29 – 2.74 | 1 | 95 | 4 |

SPT N-values measured in the sand deposits typically range from 6 to 33 blows per 300 mm penetration of the split spoon sampler indicating a loose to dense relative density. Insitu moisture contents in the sand range from 4 to 29% indicating moist to saturated conditions.

The results of a standard Procter moisture-density test conducted on a sample of sand are provided on Figure 2 in Appendix 3 and indicates a maximum dry density of 1.771 t/m$^3$ at an optimum moisture content 13.4%

### 4.2.3 Silt

Silt was encountered beneath the sand in Boreholes BH-01-15, BH-02-15 and BH-08-15; and beneath the till at Borehole BH-04-15. The silt is 4.6 m thick in Borehole BH-01-15, and extends below the termination depths of the remaining boreholes. The silt ranges in composition from silt and sand with trace gravel and clay to clay and silt with trace sand. The results of two particle size distribution analyses conducted on samples of silt are plotted on Figure 1 in Appendix 3 and summarized in the following table:

Table 2: Silt Particle Size Distribution Analyses Results

| BOREHOLE NUMBER | SAMPLE DEPTH (m) | GRAVEL (%) | SAND (%) | SILT (%) | CLAY (%) |
|---|---|---|---|---|---|
| BH-01-15 | 3.05 – 3.51 | 0 | 9 | 44 | 47 |
| BH-08-15 | 4.57 – 5.03 | 0 | 22 | 57 | 21 |

SPT N-values measured in the silt generally increase with depth and range from 14 to above 50 blows per 300 mm penetration of the split spoon sampler indicating a compact to very dense relative density. In-situ moisture contents of the silt range from 12 to 23% indicating very moist to wet conditions.

The results of a standard Proctor moisture-density test conducted on a sample of silt are provided on Figure 3 in Appendix 3 and indicate a maximum dry density of 1.968 t/m$^3$ at an optimum moisture content 11.8%.

### 4.2.4 Glacial Till

Glacial till was encountered at a depth of 3.0 m in Borehole BH-04-15 and at a depth of 4.6 in Borehole BH-06-15. The till is 2.1 m thick in Borehole BH-04-15 and extends below the termination depth of Borehole BH-06-15. The till ranges in composition from brown silt with some sand and trace clay and gravel to clayey silt with some sand and trace gravel.
SPT N-values measured in the till range from 14 to 30 blows per 300 mm penetration of the split spoon sampler indicating a compact to dense relative density. The till was moist or about the plastic limit at the time of fieldwork.

## 4.3 GROUNDWATER

Groundwater observations and measurements carried out in the open boreholes are provided on the appended borehole logs. Standpipes were installed in four boreholes drilled in various locations on the property. The groundwater level measurements are summarized in the following table:

Table 3: Groundwater Level Measurements

| BOREHOLE NUMBER | GROUND SURFACE ELEVATION (m) | MEASURED MARCH 9, 2015 | |
|---|---|---|---|
| | | GROUNDWATER DEPTH (m) | GROUNDWATER ELEVATION (m) |
| BH-01-15 | 361.21 | 6.99 | 354.22 |
| BH-04-15 | 351.86 | 0.95 | 350.91 |
| BH-05-15 | 353.74 | 1.53 | 352.21 |
| BH-07-15 | 354.85 | 2.78 | 352.07 |

Free groundwater was also encountered at a depth of 0.8 to 1.5 m in Boreholes BH-04-15 and BH-05-15; and at depths ranging from 3.0 to 6.1 m Boreholes BH-01-15, BH-02-15, BH-03-15, BH-07-15 and BH-08-15. No free groundwater was encountered in Boreholes BH-06-15, BH-09-15, and BH-10-15. The groundwater occurs in unconfined water table conditions.

Local variations and seasonal fluctuations in the groundwater levels would be expected.

# 5 DISCUSSIONS AND RECOMMENDATIONS

## 5.1 GENERAL

The project involves the proposed construction of a residential subdivision on a 21.8 hectare parcel of land located north of Conservation Drive in Waterloo, Ontario at the location shown on Drawing 1, in Appendix 1. The lands are designated for residential streets and houses. The house lots will be serviced with municipal water and sewer.

Based on the results of the geotechnical investigation, the subsurface stratigraphy comprises topsoil overlying sand, silt and glacial till. The stabilized groundwater level generally occurs between Elevation 350.9 m and 354.2 m.

Based on the results of this geotechnical investigation, there are shallow groundwater levels at the south and east portions of the property; however, the site is suitable for the proposed residential development. The following subsections of this report contain geotechnical recommendations pertaining to development of the property including site grading, site servicing, pavements, residential buildings, and stormwater infiltration.

## 5.2 SITE GRADING

Area grading of the property will likely be required to prepare the land for the construction of the proposed residential subdivision. A proposed grading plan was unavailable at the time this report was issued.

Prior to carrying out any cutting and engineered fill placement, the surficial topsoil and loose native deposits should be removed from cuts and critical fill areas. In calculating the approximate quantity of soil to be removed, we recommend that the thicknesses on the individual borehole logs be increased by 50 mm to account for variations and some stripping of the mineral soil below. The topsoil material could be used for landscaping fill to raise grades in the rear yards of the house lots or in park areas. The topsoil ranges in thickness from 0.2 to 1.1 m at the borehole locations (average 475 mm).

The existing houses located off Conservation Drive will likely be demolished. The floor slabs, foundations, and foundation wall backfill should be removed prior to grading of this area.

Within the low-lying areas of the site where the groundwater table is quite close to the existing ground surface (west side of site) it will likely be necessary to remove the organic deposits with a tracked hydraulic excavator.

Following removal of the topsoil, the exposed subgrade should be inspected by LVM. Any fill required at the site should be placed in maximum 300 mm thick lifts and compacted to the following minimum percentages of standard Proctor maximum dry density (SPMDD):

Table 4: Compaction Specifications

| FILL USE | MINIMUM COMPACTION REQUIRED |
|---|---|
| Structural fill to support houses. | 98% SPMDD |
| Subgrade fill beneath streets or beneath services. | 95% SPMDD |
| Bulk fill in landscaped areas. | 90% SPMDD |

The silty nature of the subgrade soils, as well as shallow perched groundwater table, renders the subgrade material highly susceptible to pumping/disturbance from heavy construction equipment. It is recommended that construction traffic (particularly earth scrapers) be minimized on the finished subgrade, and the subgrade be sloped to promote rainwater drainage.

The major soils likely to be generated from cut areas at the site are silt and sand. Based on the results of insitu moisture content and standard Proctor moisture-density tests, the majority of the on-site excavated soils from above the groundwater table will be suited for reuse as road subgrade fill and structural fill if the grading work is carried out during relatively dry weather. The silt is generally very moist and will require drying or blending with dry sand prior to use as structural fill. If time is not available for drying, then this material should be used as pavement subgrade fill and in landscaped area.

Also, if structural fill operations are carried out in the fall, winter or spring, imported granular material is recommended. If imported fill is required onsite, we recommend structural fill used below buildings consisting of clean granular material such as OPSS Granular 'B'. Any imported fill material should be tested and approved by a geotechnical engineer prior to use.

Where structural fill is placed on a wet subgrade, we suggest that only a coarse sand and gravel material be used for the bottom few lifts. Also, the initial lift may be up to 750 mm thick in order to ensure trafficability and minimize compaction problems associated with instability of the subgrade caused by vibratory equipment.

The structural fill pads should extend at least 1.0 m beyond the footing edge of any building and down to the subgrade level at a slope of 45° to the horizontal. A typical detail for structural fill placement beneath house foundations is shown on Drawing 3, in Appendix 1.

Full-time testing by experienced geotechnical personnel should be carried out during fill placement and compaction to examine and approve potential sources of fill material, and to carefully monitor the placement and verify the compaction by in-situ density testing (ASTM D2167 or ASTM 2922).

## 5.3 SITE SERVICING

### 5.3.1 Excavations and Dewatering

Following site grading operations, the subdivision will be serviced to provide the individual lots with water and sewer services. It is anticipated that the invert levels for the watermain and sewers will be at conventional depths, some 2 to 4 m below finished grade through most of the site. We recommend that LVM be allowed to check the final site grading and servicing plans for the subdivision to ensure that the exploratory boreholes extend below the design invert elevations. It is noted additional boreholes may be required.

Temporary excavations to conventional depths for installation of underground pipes at this site must comply with the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The predominant soils encountered in the boreholes would be classified as Type 3 soils (O. Reg. 213/91, s. 226(4)). Temporary side slopes must be cut at an inclination of 1.0 horizontal to 1.0 vertical or less above the base of excavation as per O. Reg. 213/91, s. 234(2) (exclusive of groundwater effects).

Significant seepage was noted at a depth of 0.8 to 1.5 m at Boreholes BH-04-15 and BH-05-15. A positive dewatering system installed by a specialist dewatering contractor may be required if excavations extend below Elevation 354 m in the east portion of the site and below Elevation 352 m in the west portion of the site. It will be necessary to flatten the excavation side slopes where groundwater seepage is occurring to ensure stability. Every excavation that a worker may be required to enter shall be kept reasonably free of water (O. Reg. 213/91, s. 230).

A Permit to Take Water (PTTW) is required by the Ministry of Environment in the event that the daily taking of groundwater exceeds 50,000 L per day. If the contractor carefully plans and stages his work so that only short sections of trench are open at a given time, it may be possible to complete this project without the need for a PTTW.

The contractor should evaluate this latter recommendation to ensure that he is in agreement, and he should notify the prime consultant in the event that he feels that a PTTW will be needed on the basis of his excavation and pipe laying schedule.

The design of the dewatering system should be left to the contractor's discretion, and the system should meet a performance specification to maintain and control the groundwater at least 0.30 m below the invert level in order to provide a stable excavation base. Successful dewatering operations will depend on the contractor's own experience, construction techniques, sequencing, and efficiency of work force and plant. Also the dewatering must be in compliance with the Ontario Water Resources Act (OWRA) and the Water Taking and Transfer Regulation (O.Reg. 451/07).

It is recommended that several test pits be dug during the tendering stage of the project in order that prospective contractors may familiarize themselves with the soil and groundwater conditions to be contacted.

### 5.3.2 Pipe Bedding

The subgrade soils beneath the watermain and sewers will comprise native mineral soils or compacted fill placed during the site grading operations. No support problems are anticipated for flexible or rigid pipes founded in the native deposits or compacted on-site soils.

Pipe bedding for water and sewer services should be conventional Class 'B' pipe bedding comprising a minimum 150 mm thick layer of OPSS Granular 'A' aggregate below the pipe invert. The bedding course may be thickened if portions of the subgrade become unduly wet during excavation. Granular 'A' type aggregate should be provided around the pipe to at least 300 mm above the pipe. The bedding aggregate should be compacted to a minimum 95% standard Proctor maximum dry density (SPMDD). Water and sewer lines installed outside of heated areas should be provided with a minimum 1.2 m of soil cover or equivalent insulation for frost protection.

A well-graded clear stone such as Coarse Aggregate for HL4 Asphaltic Concrete (OPSS 1003) could be used in the sewer trenches as bedding below the spring line of the pipe to facilitate sump pump dewatering, if necessary. The clear stone should be compacted with a plate tamper.

The proposed sewers could create hydraulic connections between groundwater regimes that are not presently connected. To stop the movement of groundwater along the pipe bedding, it is recommended that concrete or clay collars be installed around the pipe. The collars should be at least 1.0 m long and in place of the standard bedding material. Clay seals shall be compacted to 95% standard Proctor maximum dry density (SPMDD) as per OPSS 410.07.18. (Also OPSD 802.095 and OPSS 1205).

Thrust blocks for the watermain should be designed using current OPSS Standards and shall conform to OPSD 1103.010 and 1103.020. The following soil parameters may be used for thrust restraint design:

- Angle of internal friction ($\phi$) = 30°
- Soil cohesion (c) = 0 kPa
- Soil unit weight ($\gamma$) = 20 kN/m$^3$

The interface friction coefficient for granular bedding and smooth ductile iron pipe or PVC pipe would be 0.60. An appropriate factor of safety should be employed.

### 5.3.3 Trench Backfilling

The trenches above the specified pipe bedding should be backfilled with inorganic on-site soils placed in 300 mm thick lifts and compacted to at least 95% SPMDD.

Based on the results of insitu moisture content and standard Proctor moisture-density tests carried out on the native overburden deposits, the majority of the on-site excavated materials will be compactable to the required density. If imported fill is required we recommend OPSS Granular ‘B’ be used.

If necessary, compensation for wet trench backfill conditions can be made with additional Granular 'B' in the pavement structure.

To minimize potential problems, backfilling operations should follow closely after excavation so that only a minimal length of trench is exposed. Care should be taken to protect side slopes of excavations by diverting surface run-off away from the excavations.

If construction extends into the winter, then the backfilling operations should be planned so that exposure of the backfill material to frost is kept to a minimum and to ensure that frozen material is not used as backfill.

Frequent compaction testing by experienced geotechnical personnel should be carried out to examine and approve backfill materials, and to verify that the specified degree of compaction has been achieved.

## 5.4 PAVEMENTS

### 5.4.1 Pavement Design

Following site grading and servicing operations, the pavement subgrade will comprise native and recompacted sand and silt soils or imported granular fill.

The following pavement component thicknesses are recommended based on the City of Waterloo Development Manual 2013, the proposed pavement usage, and the frost-susceptibility and strength of the subgrade soils:

Table 5: Pavement Designs

| PAVEMENT COMPONENT | COLLECTOR STREETS | LOCAL STREETS |
|---|---|---|
| Asphalt Hot Mix | 90 mm | 90 mm |
| OPSS 1010 Granular 'A' Base | 150 mm | 150 mm |
| OPSS 1010 Granular 'B' Type 1 Subbase | 500 mm | 300 mm |

The pavement designs meet City of Waterloo Standard Drawings Numbers W-201 and W-203 requirements.

The pavement design is based on the assumption that construction will be carried out during the drier time of the year and that the subgrade soil is stable as determined by proof-rolling inspected by a Geotechnical Engineer. If the subgrade is wet and unstable, additional granular subbase will be required.

Samples of both the Granular 'A' and Granular 'B' aggregates should be checked for conformance to OPSS 1010 prior to utilization on site and during construction. The Granular 'B' subbase and Granular 'A' base courses must be compacted to 100% SPMDD, as verified by insitu density testing.

The asphaltic concrete should comprise a binder layer of HL8 and a surface layer of HL3. It is recommended that the compacted thicknesses be 50 mm of HL8 binder and 40 mm of HL3 surface for both collector and local streets.

The asphaltic concrete paving materials should conform to the requirements of OPSS 1150. The asphalt should be placed and compacted in accordance with OPSS 310. The Performance Graded Asphalt Cement designation for the asphaltic concrete is 58-28.

The need for continuous paving supervision by a qualified pavement technician, and quality control testing during pavement construction cannot be over emphasized.

All materials and construction services required for the work should be in accordance with the applicable sections of the Ontario Provincial Standard Specifications.

### 5.4.2 Subdrains

Portions of he native subgrade soils have poor natural drainage therefore we recommend that where silt is encountered at the subgrade, subdrains be installed continuously along both sides of the street and connected to the catch basins. Where sand deposits are encountered at the subgrade level it is recommended that subdrain stubs be installed at the catchbasins. This should be confirmed by a geotechnical engineer at the time of subgrade preparation.

The purpose of the subdrains is to remove excess subsurface water in order to improve pavement serviceability and increase the pavement life. A detail for a typical pavement subdrain is provided on Drawing 4, in Appendix 1.

The work of subdrain installation shall be in accordance with OPSS 405 and OPSD 216.021. The subdrain shall be 100 or 150 mm diameter perforated pipe conforming to OPSS 1801 or 1840, and wrapped with geotextile conforming to OPSS 1860.

### 5.4.3 Curbs and Sidewalks

The concrete for curb and gutter should be proportioned, mixed, placed, and cured in accordance with the requirements of OPSS 353 and OPSS.MUNI 1350, and shall meet the following specific requirements (OPSS 353.05.01):

- minimum 28-day compressive strength = 30 MPa
- coarse aggregate = 19.0 mm nominal max. size
- maximum slump = 60 mm
- air entrainment = 7.0 ± 1.5%

During cold weather (when the air temperature is at or is likely to fall below 5°C within 96 hours of concrete placement) the freshly placed concrete must be covered with insulating blankets to protect against freezing, as per OPSS 904. Ice and snow must be removed from

the area where concrete is to be placed and the concrete must not be placed against frozen ground. All cold weather protection material shall be on site prior to each concrete placement.

The subgrade for the concrete sidewalks should comprise undisturbed native mineral soil or well-compacted fill. A minimum 150 mm thick layer of compacted Granular 'A' type aggregate should be placed beneath the sidewalk slabs. The subgrade and granular base should be prepared in accordance with the requirements of OPSS 315.

## 5.5 RESIDENTIAL BUILDINGS

### 5.5.1 Foundations

In general, the undisturbed native mineral soils are considered suitable to support residential house foundations. Where the footing levels will be above the existing native mineral soil grade, structural fill will probably be used. House footings constructed on the compact native mineral soil or approved structural fill may be designed using the minimum footing sizes provided in the Ontario Building Code.

All founding surfaces for residential dwellings on structural fill or native soils should be inspected by LVM personnel prior to placing concrete. The purpose of the inspection is to ensure that the founding conditions are consistent with the design bearing intended by the geotechnical engineer. The on-site review of the condition of the foundation soil as foundations are constructed is an integral part of the geotechnical design function and cannot be over emphasized. These reviews are required by Section 4.2.2.2 of the Ontario Building Code.

Further geotechnical investigation will be necessary for large structures such as schools, plazas or apartment buildings to provide specific recommendations for design of these structures. The preliminary Site Classification for Seismic Site Response is 'D'.

The subgrade soils are considered to be frost susceptible and must be protected from freezing at all times including during construction. The exterior footings or footings in unheated areas should be provided with a minimum 1.20 m of earth cover upon final grading for frost protection.

### 5.5.2 Basements

It is recommended basement floor slabs be installed above the groundwater levels and LVM review grading plans once complete.

House basements at this site must be provided with perimeter weeping tile systems as per the Ontario Building Code (Section 9.14). The drain tile or pipe should be laid on undisturbed or well-compacted soil so that the top of the tile or pipe (minimum 100 mm diameter) is below the bottom of the basement floor slab.

The top and sides of the drain tile or pipe shall be surrounded with not less than 150 mm of crushed stone or other clean coarse granular material containing no more than 10% of material that will pass the 4 mm sieve. The pipe bedding should be wrapped with geotextile filter fabric. The weeping tile must drain to a suitable frost-free outlet or sump.

The portion of the exterior basement wall below finished ground level must be damp-proofed as per Section 9.13.2 of the Ontario Building Code (2012). The basement wall backfill should be graded to prevent drainage towards the foundation after settling as per OBC 9.12.3.

The basement walls should be designed to resist the lateral earth pressure. For calculating the lateral earth pressure, the coefficient of earth pressure (K) may be assumed as 0.5 for cohesionless sand soils and 1.0 for silt and clay. The bulk unit weight of the retained backfill may be taken as 21 kN/m$^3$ for well-compacted soil. An appropriate factor of safety should be employed.

The subgrade for the basement floor slabs should comprise undisturbed native soil or well-compacted fill. A minimum 100 mm thick layer of coarse clean granular material containing not more than 10% material that will pass a 4 mm sieve shall be placed beneath slabs in houses as per Section 9.16.2 of the Ontario Building Code. If the subgrade soil is wet, we recommend that LVM be notified and subfloor weeping tiles be placed and connected to the sump pit.

To prevent the migration of moisture vapour into the houses from beneath basement floor slabs, particularly where moisture sensitive floor coverings are placed, a vapour retarder shall be placed directly beneath the floor slab that meets the requirements of the designer and flooring manufacturer. Prior to installing moisture sensitive floor coverings, the moisture content of the concrete slab must be determined at operational conditions by internal relative humidity testing to ensure an acceptable slab moisture level. It should be noted that it typically takes more than ninety days at operational conditions to lower the slabs internal relative humidity to 85%. Different flooring systems have different responses to slab moisture (i.e. some systems can tolerate more moisture than others), and the flooring contractor must assess the floor moisture levels with respect to their flooring components.

## 5.6 AT SOURCE STORMWATER INFILTRATION

At source infiltration of water from house roof leaders into dry wells may be feasible in areas where the natural groundwater level is below the bottom of the dry well and the native soils are relatively free-draining.

Based on the results of this investigation, the general soil profile existing at the site comprises surficial topsoil overlying major native deposits of sand with interbeds of silt. The hydraulic conductivity of the sand is in the order of $10^{-3}$ to $10^{-5}$ cm/sec, indicating that water infiltration would be feasible in this soil. The silt deposit has a hydraulic conductivity of $10^{--6}$ cm/sec or less, and therefore is not suitable for infiltration. The inferred groundwater table within most of the proposed residential lots is at least 3 m below existing grade.

The soak-away pits should be more than 5 m from the building foundations and located so that drainage is away from the buildings as per the Ontario Building Code.

Although the sand is prevalent across the site, it is anticipated that much of the sand will be stripped from the higher areas during site grading. For this reason, it will be necessary to identify potential infiltration lots during area grading. We would be pleased to provide preliminary information on which lots would be suitable for infiltration after reviewing the Site Grading Plan.

# 6 STATEMENT OF LIMITATIONS

The geotechnical recommendations provided in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known at the time of report preparation, we recommend that we be retained during the final design stage to verify that the geotechnical recommendations have been correctly interpreted in the design. We also recommend that we be retained during construction to confirm that the subsurface conditions do not deviate materially from those encountered in the boreholes and to ensure that our recommendations are properly understood.

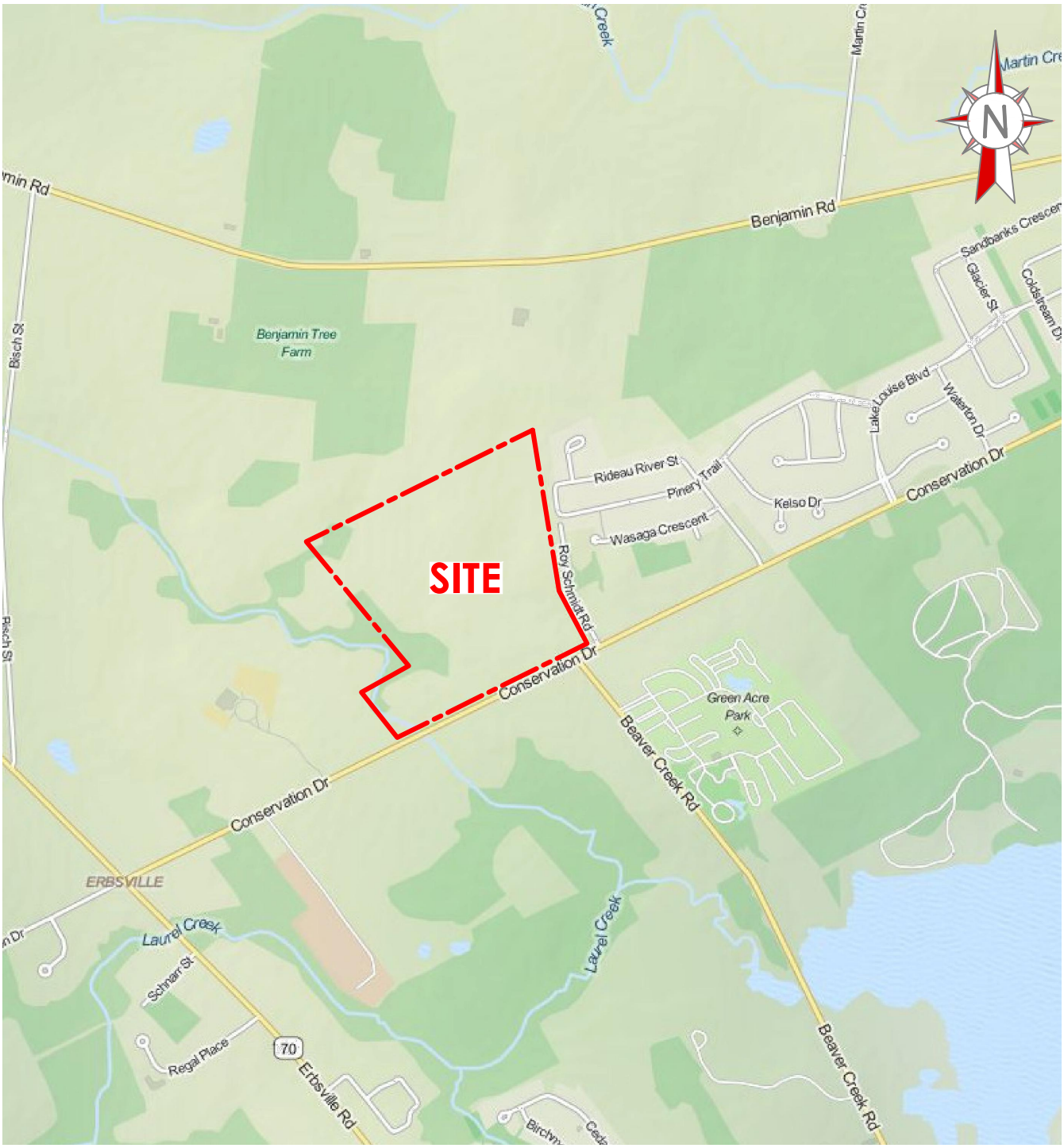
The geotechnical recommendations provided in this report are applicable only to the project described in the text and are intended for the use of the project designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions made based on it, are the responsibility of the contractor. The contractor must also accept the responsibility for means and methods of construction, seek additional information if required, and draw their own conclusions as to how the subsurface conditions may affect their work.

It is important to note that the geotechnical investigation involves a limited sampling of the site gathered at specific test hole locations and the conclusions in this report are based on this information gathered. The subsurface conditions between and beyond the boreholes will differ from those encountered at the test holes. Should subsurface conditions be encountered which differ materially from those indicated at the test holes, we request that we be notified in order to assess the additional information and determine whether or not changes should be made as a result of the conditions.

It must be recognized that the passage of time, natural occurrences and direct or indirect human intervention at or near the site have potential to alter the subsurface conditions. If during construction the soil or groundwater is found not to be of the type or in the condition used in design and as indicated on the drawings, the design shall be reassessed by the designer. If during construction, climatic (i.e. rain, frost etc.) or any other conditions (i.e. seepage, excavations etc.) have changed the properties of the soil or groundwater, the design shall be reassessed by the designer as per Section 4.2.2.3 of the Ontario Building Code.

# Appendix 1 Drawings

Drawing 1: Location Plan
Drawing 2: Site Plan
Drawing 3: Typical Structural Fill Detail
Drawing 4: Typical Pavement Subdrain Detail




NOTES :
1-REFERENCES : © OpenStreetMap contributors (2013).

0 100 200 300 400 500 m
SCALE 1:15000

10 cm 0 1 2 3 4 5

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Project

# Geotechnical Investigation
# Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

**LOCATION PLAN**


LVM
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422


| | | | | | |
|---|---|---|---|---|---|
| Prepared | E.Ciochon | Discipline | GEOTECHNICAL | Project manager | M.Wilson |
| Drawn | E.Ciochon | Scale | 1 : 15000 | Sequence no. | 01 of 04 |
| Checked | M.Wilson | Date | 2015-03-03 | | |

| M. dept. | Project | Disc. | Dwg no. | Rev. |
|---|---|---|---|---|
| 160 | P-0008077-0-01-100 | GE | 001 | 00 |




LEGEND :

- SITE BOUNDARY LINE
- BOREHOLE LOCATION
- BOREHOLE/TEST PIT LOCATION (Previous NEA Investigation Project 4500G1. Feb 2003)
- BOREHOLE (Previous NEA Investigation Project 4500G4. July 2005)
- EL. 351.86 — GROUND SURFACE ELEVATION (m)
- 252.30 — GROUND WATER ELEVATION (m)

0 20 40 60 80 100 m

SCALE 1:3000

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, 2015.

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

3-Groundwater measured on March 9, 2015.

Project

**Geotechnical Investigation**
**Proposed Residential Development**

560/576 Conservation Drive, Waterloo, Ontario

Title

**SITE PLAN**


LVM

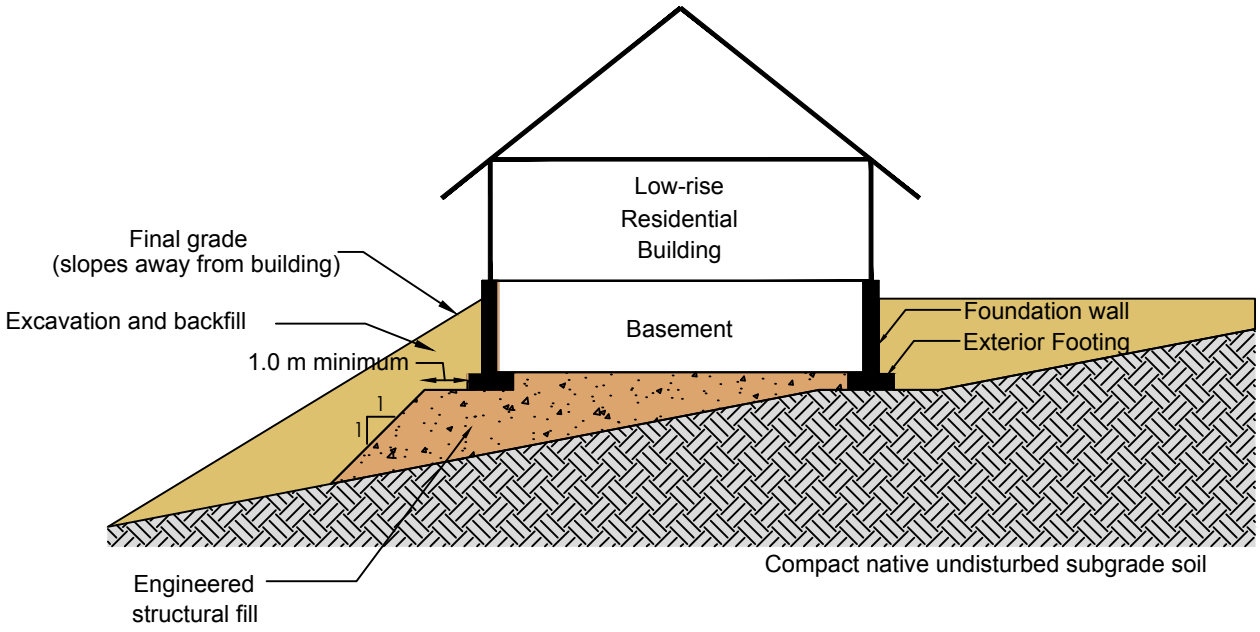
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422


| | | | |
|---|---|---|---|
| Prepared | S.Meteer | Discipline | GEOTECHNICAL |
| Drawn | S.Meteer | Scale | 1:3000 |
| Checked | D.Gonser | Date | 2015-02-17 |
| Project manager | D.Gonser | Sequence no. | 02 of 04 |

| M. dept. | Project | Disc. | Dwg no. | Rev. |
|---|---|---|---|---|
| 160 | P-0008077-0-01-100 | GE | 02 | 00 |

10 cm 0 1 2 3 4 5

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## GENERAL REQUIREMENTS FOR ENGINEERED STRUCTURAL FILL

1. The area must be excavated of all pre-existing, topsoil and/or organic soil until compact native undisturbed soil is reached.

2. The excavation should allow for the structural fill to extend 1.0 m beyond the outside edge of the building footings and down to the approved subgrade soil at a slope of 1 horizontal to 1 vertical (45 ° ).

3. The subgrade below the engineered fill should be inspected and approved by a geotechnical engineer prior to fill construction. Fill placement and compaction operations to be carried out under full-time geotechnical supervision.

4. The structural fill should comprise sand and gravel aggregate placed in 300 mm thick lifts and compacted to at least 98 % Standard Proctor Maximum Dry Density (SPMDD). The exterior backfill should consist of approved inorganic soil also placed in 300 mm thick lifts and compacted to minimum 95 % SPMDD.

5. Exterior footings should be provided with minimum 1.2 m of soil cover for frost protection.

6. All excavations must be carried out in conformance with the current Ontario Occupational Health and Safety Act and Regulations 213/91 for construction projects.

7. This is not a design drawing or contract specification.

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Project

**Geotechnical Investigation**
**Proposed Residential Development**

560/576 Conservation Drive, Waterloo, Ontario

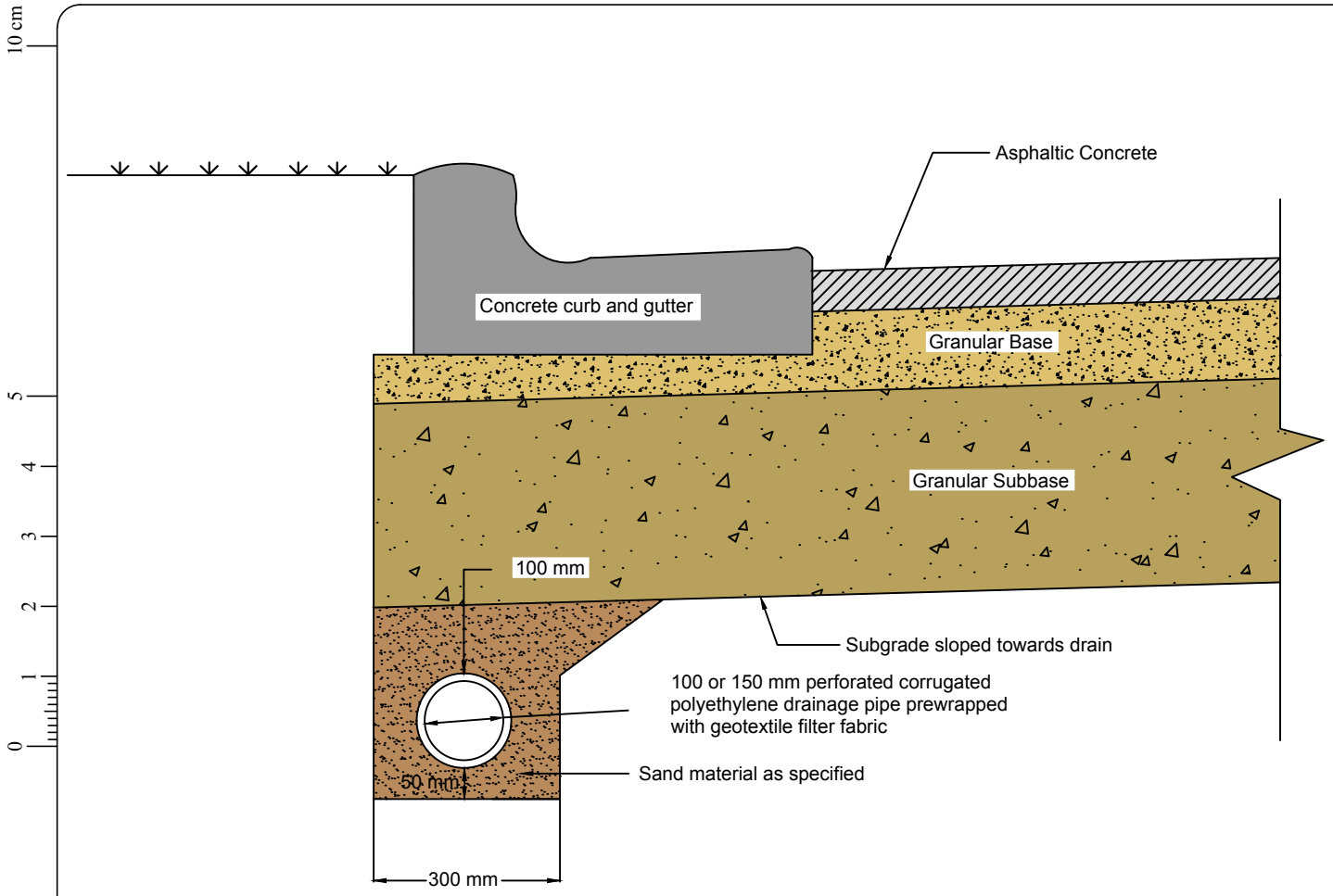
Title

**TYPICAL STRUCTURAL FILL DETAIL**

LVM
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

| | | | | | |
|---|---|---|---|---|---|
| Prepared | E.Ciochon | Discipline | GEOTECHNICAL | Project manager | M.Wilson |
| Drawn | E.Ciochon | Scale | NTS | Sequence no. | 03 of 04 |
| Checked | M.Wilson | Date | 2015-03-03 | | |

| M. dept. | Project | Disc. | Dwg no. | Rev. |
|---|---|---|---|---|
| 160 | P-0008077-0-01-100 | GE | 003 | 00 |




## GENERAL REQUIREMENTS FOR PAVEMENT SUBDRAINS

1. Perforated corrugated polyethylene drainage pipe shall meet the requirements of OPSS 1840.
2. Pipe filter fabric conforming to OPSS 1860 for geotextile Class 1 with a filtration opening size of 150 to 450 microns shall be supplied on all sections of perforated pipe.
3. The open upstream ends of pipes should be capped.
4. Subdrain pipes to be set on at least 1% grade draining to a positive frost-free outlet. If the subdrains are outletted to a ditch then the last 1.5 m of the outlet pipe should consist of a corrugated galvanized steel pipe equipped with a rodent gate.
5. Bedding and backfill material shall be concrete sand meeting the gradation requirements of OPSS 1002 (Fine Aggregate for Concrete).
6. This is not a design drawing or contract specification.

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Project

**Geotechnical Investigation**
**Proposed Residential Development**

560/576 Conservation Drive, Waterloo, Ontario

Title

**TYPICAL PAVEMENT SUBDRAIN DETAIL**

LVM
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

| | | | | | |
|---|---|---|---|---|---|
| Prepared | E.Ciochon | Discipline | GEOTECHNICAL | Project manager | M.Wilson |
| Drawn | E.Ciochon | Scale | NTS | Sequence no. | 04 of 04 |
| Checked | M.Wilson | Date | 2015-03-03 | | |

| M. dept. | Project | Disc. | Dwg no. | Rev. |
|---|---|---|---|---|
| 160 | P-0008077-0-01-100 | GE | 004 | 00 |

# Appendix 2 Borehole and Test Pit Logs

List of Abbreviations

Current Investigation: Boreholes BH-01-15 to BH-10-15

Previous Investigation: Boreholes BH1 and BH2, Test Pits TP29 and TP31 (LVM Report No.4500G1)

Previous Investigation Boreholes BH1 to BH5 (LVM Report No.4500G4)

# LIST OF ABBREVIATIONS

The abbreviations commonly employed on the borehole logs, on the figures, and in the text of the report, are as follows:

| Sample Types | | Soil Tests and Properties | |
|---|---|---|---|
| AS | Auger Sample | SPT | Standard Penetration Test |
| CS | Core Sample | UC | Unconfined Compression |
| RC | Rock Core | FV | Field Vane Test |
| SS | Split Spoon | ø | Angle of internal friction |
| TW | Thinwall, Open | $\gamma$ | Unit weight |
| WS | Wash Sample | $w_p$ | Plastic limit |
| BS | Bulk Sample | w | Water content |
| GS | Grab Sample | $w_L$ | Liquid limit |
| WC | Water Content Sample | $I_L$ | Liquidity index |
| TP | Thinwall, Piston | $I_p$ | Plasticity index |
| | | PP | Pocket penetrometer |

| Penetration Resistances | |
|---|---|
| Dynamic Penetration Resistance | The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) diameter 60º cone a distance 300 mm (12 in.).<br>The cone is attached to 'A' size drill rods and casing is not used. |
| Standard Penetration Resistance, N (ASTM D1586) | The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a standard split spoon sampler 300 mm (12 in.) |
| WH | sampler advanced by static weight of hammer |
| PH | sampler advanced by hydraulic pressure |
| PM | sampler advanced by manual pressure |

| Soil Description | | | |
|---|---|---|---|
| **Cohesionless Soils** | | **SPT N-Value** | **Relative Density ($D_r$)** |
| **Compactness Condition** | | (blows per 0.3 m) | (%) |
| Very Loose | | 0 to 4 | 0 to 20 |
| Loose | | 4 to 10 | 20 to 40 |
| Compact | | 10 to 30 | 40 to 60 |
| Dense | | 30 to 50 | 60 to 80 |
| Very Dense | | over 50 | 80 to 100 |
| **Cohesive Soils** | | **Undrained Shear Strength ($C_u$)** | |
| **Consistency** | | **kPa** | **psf** |
| Very Soft | | less than 12 | less than 250 |
| Soft | | 12 to 25 | 250 to 500 |
| Firm | | 25 to 50 | 500 to 1000 |
| Stiff | | 50 to 100 | 1000 to 2000 |
| Very Stiff | | 100 to 200 | 2000 to 4000 |
| Hard | | over 200 | over 4000 |
| DTPL | Drier than plastic limit | Low Plasticity, $W_L$ <30 | |
| APL | About plastic limit | Medium Plasticity, 30 < $W_L$ < 50 | |
| WTPL | Wetter than plastic limit | High Plasticity, $W_L$ > 50 | |

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| | | | |
|---|---|---|---|
| **Ground Elevation:** | *361.21 m* | **Borehole Number:** | **BH-01-15** |
| **Northing:** | *4815267 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532899 m* | **Drill Date:** | *2015-02-27* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| SOIL PROFILE | | | SAMPLE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value | Dynamic Cone / Std Penetration | Shear Strength (PP) kPa / Shear Strength (FV) kPa | Water Content (%) | Groundwater Observations and Standpipe Details |
| | Ground Elevation | | 361.21 | | | | | | | |
| | ***TOPSOIL:*** dark brown silt, trace sand, frozen | | 0.00 / 360.90 | | | | | | | |
| | ***SAND:*** compact brown silty sand, trace gravel, frozen to moist | | 0.30 / 360.45 | | | | | | | |
| 1 | very moist | | 0.76 / 359.69 | SS-1 | 6-8 10 | 18 | | | | |
| | ***SILT:*** compact brown silt, some sand, trace clay and gravel, moist | | 1.52 / 358.92 | SS-2 | 6-8 14 | 22 | | | | |
| 2 | some sand and clay, moist to very moist | | 2.29 / 358.16 | SS-3 | 6-9 10 | 19 | | | | |
| 3 | hard grey/brown clay and silt, trace sand and gravel, DTPL | | 3.05 | SS-4 | 10-13 15 | 28 | | > ▲. | | bentonite seal |
| 4 | | | | | | | | | | |
| | | | | SS-5 | 11-15 18 | 33 | | | | |
| 5 | | | | | | | | | | |
| 6 | | | 355.11 | | | | | | | |
| | ***SAND:*** very dense brown silty sand, wet | | 6.10 | SS-6 | 7-24 27 | 51 | | | | sand pack |
| 7 | | | | | | | | | | 19 mm pipe 1.52 m slotted screen |
| | dense, saturated | | 7.62 / 353.59 | SS-7 | 8-14 17 | 31 | | | | native cave |
| 8 | Borehole terminated at 8.08 m | | 353.13 / 8.08 | | | | | | | |

Dynamic Cone: 20 40 60 80 — Std Penetration: 20 40 60 80

Shear Strength (PP) kPa: 50 100 150 200 — ■ Initial, □ Remold — Shear Strength (FV) kPa: 50 100 150 200

WP WL — Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details: ▽ el. 354.22 m 2015-03-15

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:** *Bulk sample AS-1A taken from 0.61 to 1.52 m and AS-5A from 3.05 to 4.57 m.*

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| | | | |
|---|---|---|---|
| **Ground Elevation:** | *358.14 m* | **Borehole Number:** | **BH-02-15** |
| **Northing:** | *4815128 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532872 m* | **Drill Date:** | *2015-02-26* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| SOIL PROFILE | | | SAMPLE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value | Dynamic Cone / Std Penetration | Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa | WP WL / Water Content (%) | Groundwater Observations and Standpipe Details |
| | Ground Elevation | | 358.14 | | | | 20 40 60 80 | 50 100 150 200 | 10 20 30 | |
| | ***TOPSOIL:*** dark brown silt, trace sand, frozen | | 0.00 | | | | | | | |
| | | | 357.38 | | | | | | | |
| 1 | loose, moist | | 0.76 | SS-1 | 3-3 3 | 6 | | | | |
| | ***SAND:*** loose brown sand, some silt, trace topsoil, moist | | 357.07 1.07 | | | | | | | |
| | | | | SS-2 | 2-3 3 | 6 | | | | |
| 2 | | | 355.85 | | | | | | | bentonite seal |
| | silty sand, very moist | | 2.29 | SS-3 | 3-3 3 | 6 | | | | |
| 3 | | | | SS-4 | 1-3 7 | 10 | | | | |
| | | | 354.33 | | | | | | | |
| | wet | | 3.81 | SS-5 | 3-5 6 | 11 | | | | |
| 4 | | | 353.57 | | | | | | | |
| | saturated | | 4.57 | SS-6 | 1-3 4 | 7 | | | | |
| 5 | | | | | | | | | | |
| 6 | | | 352.04 | | | | | | | native cave |
| | ***SILT:*** compact grey/brown silt, some clay, sand and gravel, very moist, some wet sand seams | | 6.10 | SS-7 | 6-12 15 | 27 | | | | |
| 7 | | | | | | | | | | |
| | | | 350.52 | | | | | | | |
| | hard, trace sand and gravel, DTPL | | 7.62 | SS-8 | 10-13 17 | 30 | | >▲. | | |
| 8 | | | 350.06 | | | | | | | |
| | Borehole terminated at 8.08 m | | 8.08 | | | | | | | At drilling completion, wet cave at 4.27 m. |

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:** *Bulk sample taken from 2.13 to 3.05 m.*

| | | | |
|---|---|---|---|
| **Ground Elevation:** | *356.21 m* | **Borehole Number:** | **BH-03-15** |
| **Northing:** | *4815019 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532995 m* | **Drill Date:** | *2015-02-26* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| SOIL PROFILE | | | SAMPLE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value | Dynamic Cone / Std Penetration (20 40 60 80) | Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200) | Water Content (%) WP WL (10 20 30) | Groundwater Observations and Standpipe Details |
| | Ground Elevation | | 356.21 | | | | | | | |
| | ***TOPSOIL:*** dark brown sandy silt, frozen | | 0.00 / 356.06 | | | | | | | |
| | | | 0.15 | | | | | | | |
| | ***SAND:*** compact brown sand, some silt, trace gravel, frozen | | | SS-1 | 5-6 7 | 13 | | | | |
| | | | 354.69 | | | | | | | |
| | trace silt and gravel, moist | | 1.52 | SS-2 | 7-9 10 | 19 | | | | bentonite seal |
| | | | | SS-3 | 6-11 13 | 24 | | | | |
| | | | | SS-4 | 4-6 8 | 14 | | | | |
| | | | 351.64 | | | | | | | |
| | wet to saturated | | 4.57 | SS-5 | 6-6 8 | 14 | | | | native cave |
| | | | | SS-6 | 10-8 11 | 19 | | | | |
| | | | 349.66 | | | | | | | |
| | Borehole terminated at 6.55 m | | 6.55 | | | | | | | At drilling completion, wet cave at 3.96 m. |

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:**

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**Ground Elevation:** *351.86 m* | **Borehole Number:** **BH-04-15**

**Northing:** *4814862 m* | **Job N°:** *P-0008077-0-01-100*

**Easting:** *532751 m* | **Drill Date:** *2015-02-26*

**Project:** *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** *D.Souter*

**Location:** *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** *Hollow Stem Auger*

| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value |
|---|---|---|---|---|---|---|
| | Ground Elevation | | 351.86 | | | |
| | ***TOPSOIL:*** dark brown silt, some sand, frozen | | 0.00 / 351.50 | | | |
| | ***SAND:*** loose brown silty sand, trace gravel, wet | | 0.36 / 350.34 | SS-1 | 2-3 3 | 6 |
| | compact brown sand, trace gravel and silt, saturated | | 1.52 / 348.81 | SS-2 | 5-5 6 | 11 |
| | | | | SS-3 | 7-8 6 | 14 |
| | ***SILT TILL:*** hard grey clayey silt, some sand, trace gravel, APL | | 3.05 / 347.29 | SS-4 | 4-6 10 | 16 |
| | very stiff, trace sand and gravel, APL to WTPL | | 4.57 / 346.68 | SS-5 | 3-6 7 | 13 |
| | ***SILT:*** compact grey silt, some clay and fine sand, saturated | | 5.18 / 343.78 | SS-6 | 6-7 9 | 16 |
| | | | | SS-7 | 5-7 7 | 14 |
| | Borehole terminated at 8.08 m | | 8.08 | | | |

Dynamic Cone: 20 40 60 80 | Std Penetration: 20 40 60 80

Shear Strength (PP) kPa: 50 100 150 200 | Initial | Remold | Shear Strength (FV) kPa: 50 100 150 200

WP WL | Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

el. 350.91 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
3.05 m slotted screen

native cave

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* | **Drafted by:** *E.Ciochon* | **Sheet:** *1 of 1*

**Notes:**

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| | | | |
|---|---|---|---|
| **Ground Elevation:** | *353.74 m* | **Borehole Number:** | **BH-05-15** |
| **Northing:** | *4814992 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532711 m* | **Drill Date:** | *2015-02-26* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| SOIL PROFILE | | | SAMPLE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value | Dynamic Cone / Std Penetration (20 40 60 80) | Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200) | Water Content (%) WP WL (10 20 30) | Groundwater Observations and Standpipe Details |
| | Ground Elevation | | 353.74 | | | | | | | |
| | ***TOPSOIL:*** dark brown silt, trace sand, frozen | | 0.00 | | | | | | | |
| | | | 352.90 | | | | | | | |
| 1 | ***SAND:*** compact brown sand, some silt, trace gravel, frozen to moist | | 0.84 | SS-1 | 7-7 7 | 14 | | | | |
| | | | 352.22 | | | | | | | |
| | compact brown gravelly sand, some silt, trace gravel, saturated | | 1.52 | SS-2 | 7-7 6 | 13 | | | | |
| 2 | | | | | | | | | | |
| | | | | SS-3 | 5-7 10 | 17 | | | | |
| | | | 350.69 | | | | | | | |
| 3 | some gravel | | 3.05 | SS-4 | 3-7 12 | 19 | | | | |
| 4 | | | | | | | | | | |
| | | | 349.17 | | | | | | | |
| | trace gravel | | 4.57 | SS-5 | 7-10 10 | 20 | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| | | | | SS-6 | 15-9 8 | 17 | | | | |
| | | | 347.19 | | | | | | | |
| | Borehole terminated at 6.55 m | | 6.55 | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |

el. 352.21 m 2015-03-15

bentonite seal

19 mm pipe
1.52 m slotted screen

native cave

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:**

| | | | |
|---|---|---|---|
| **Ground Elevation:** | *356.92 m* | **Borehole Number:** | **BH-06-15** |
| **Northing:** | *4815119 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532711 m* | **Drill Date:** | *2015-02-26* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value |
|---|---|---|---|---|---|---|
| | Ground Elevation | | 356.92 | | | |
| | ***TOPSOIL:*** dark brown silt, trace sand and gravel, frozen | | 0.00 / 356.51 | | | |
| | ***SAND:*** loose to compact brown sand, some silt, trace gravel, frozen | | 0.41 / 356.01 | | | |
| 1 | moist | | 0.91 / 355.40 | SS-1 | 3-4 5 | 9 |
| | loose silty sand, very moist to wet | | 1.52 / 354.63 | SS-2 | 3-3 4 | 7 |
| 2 | | | | | | |
| | compact, trace gravel, moist | | 2.29 / 352.35 | SS-3 | 6-10 11 | 21 |
| 3 | | | | SS-4 | 5-12 16 | 28 |
| 4 | | | | | | |
| | ***SILT TILL:*** dense grey/brown silt, some sand, trace clay and gravel, moist | | 4.57 / 351.89 | SS-5 | 10-12 18 | 30 |
| 5 | Borehole terminated at 5.03 m | | 5.03 | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

**Groundwater Observations and Standpipe Details**

bentonite seal

At drilling completion, borehole open and dry.

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:** *Bulk sample taken from 2.44 to 3.66 m.*

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| | | | |
|---|---|---|---|
| **Ground Elevation:** | *354.85 m* | **Borehole Number:** | **BH-07-15** |
| **Northing:** | *4815131 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532578 m* | **Drill Date:** | *2015-02-27* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| SOIL PROFILE | | SAMPLE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value | Dynamic Cone / Std Penetration (20 40 60 80) | Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200) | Water Content (%) WP WL (10 20 30) | Groundwater Observations and Standpipe Details |
| | Ground Elevation | | 354.85 | | | | | | | |
| | ***TOPSOIL:*** dark brown silt, trace sand, frozen | | 0.00 / 354.44 | | | | | | | |
| | ***SAND:*** loose brown sand, some silt, frozen to moist | | 0.41 / 354.09 | | | | | | | |
| 1 | moist | | 0.76 / 353.33 | SS-1 | 2-3 3 | 6 | | | | |
| | trace silt and gravel | | 1.52 | SS-2 | 1-1 3 | 4 | | | | |
| 2 | | | | SS-3 | 2-3 3 | 6 | | | | |
| 3 | | | 351.80 | | | | | | | |
| | some silt and gravel, saturated | | 3.05 | SS-4 | 8-10 12 | 22 | | | | |
| 4 | | | | | | | | | | |
| | dense | | 350.28 / 4.57 | SS-5 | 8-14 19 | 33 | | | | |
| 5 | Borehole terminated at 5.03 m | | 349.82 / 5.03 | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |

el. 352.07 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
1.52 m slotted screen

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:**

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| | | | |
|---|---|---|---|
| **Ground Elevation:** | *357.56 m* | **Borehole Number:** | **BH-08-15** |
| **Northing:** | *4815292 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532630 m* | **Drill Date:** | *2015-02-27* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| SOIL PROFILE | | | SAMPLE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value | Dynamic Cone / Std Penetration | Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa | WP WL / Water Content (%) | Groundwater Observations and Standpipe Details |
| | Ground Elevation | | 357.56 | | | | 20 40 60 80 | 50 100 150 200 | 10 20 30 | |
| | ***TOPSOIL:*** dark brown silt, some sand, frozen | | 0.00<br>357.41<br>0.15 | | | | | | | |
| | ***SAND:*** brown sand, some silt and topsoil, frozen | | 356.80<br>0.76 | | | | | | | |
| 1 | compact, some silt, trace gravel, moist | | | SS-1 | 4-6<br>5 | 11 | | | | |
| | | | 356.04 | | | | | | | |
| | compact brown silty sand, trace gravel, wet | | 1.52 | SS-2 | 5-5<br>8 | 13 | | | | |
| 2 | | | | | | | | | | |
| | | | | SS-3 | 4-6<br>7 | 13 | | | | bentonite seal |
| 3 | | | | | | | | | | |
| | | | | SS-4 | 7-18<br>20 | 38 | | | | |
| 4 | | | | | | | | | | |
| | | | 352.99 | | | | | | | |
| | ***SILT:*** dense grey/brown sandy clayey silt, trace gravel, very moist | | 4.57 | SS-5 | 8-19<br>16 | 35 | | | | |
| 5 | | | | | | | | | | |
| 6 | | | 351.46 | | | | | | | native cave |
| | compact | | 6.10 | SS-6 | 9-10<br>16 | 26 | | | | |
| | | | 351.01 | | | | | | | At drilling completion, wet cave at 5.79 m. |
| | Borehole terminated at 6.55 m | | 6.55 | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:**

Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

| | | | |
|---|---|---|---|
| **Ground Elevation:** | *361.96 m* | **Borehole Number:** | **BH-09-15** |
| **Northing:** | *4815237 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532778 m* | **Drill Date:** | *2015-02-26* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| SOIL PROFILE | | | SAMPLE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value | Dynamic Cone / Std Penetration | Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa | WP WL / Water Content (%) | Groundwater Observations and Standpipe Details |
| | Ground Elevation | | 361.96 | | | | | | | |
| | ***TOPSOIL:*** dark brown silt, trace sand, frozen | | 0.00 | | | | | | | |
| | | | 361.05 | | | | | | | |
| 1 | ***SAND:*** loose brown fine sand, some silt, moist | | 0.91 | SS-1 | 2-3 3 | 6 | | | | |
| | | | 360.44 | | | | | | | |
| | compact | | 1.52 | SS-2 | 4-6 9 | 15 | | | | |
| 2 | | | | | | | | | | |
| | | | | SS-3 | 5-10 10 | 20 | | | | bentonite seal |
| 3 | | | 358.91 | | | | | | | |
| | dense | | 3.05 | SS-4 | 10-16 17 | 33 | | | | |
| 4 | | | | | | | | | | |
| | | | 357.24 | | | | | | | |
| | sand, trace silt | | 4.72 | SS-5 | 15-18 25 | 43 | | | | |
| 5 | | | 356.93 | | | | | | | |
| | Borehole terminated at 5.03 m | | 5.03 | | | | | | | At drilling completion, borehole open and dry. |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial, Remold

WP WL / Water Content (%): 10 20 30

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:** *Bulk sample taken from 1.52 to 3.05 m.*

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| | | | |
|---|---|---|---|
| **Ground Elevation:** | *363.11 m* | **Borehole Number:** | **BH-10-15** |
| **Northing:** | *4815398 m* | **Job N°:** | *P-0008077-0-01-100* |
| **Easting:** | *532842 m* | **Drill Date:** | *2015-02-27* |
| **Project:** | *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** | *D.Souter* |
| **Location:** | *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** | *Hollow Stem Auger* |

| Depth (m) | Description | Symbol | Elevation (m) / Depth (m) | Type and Number | "Blows" /150 mm | SPT 'N' Value |
|---|---|---|---|---|---|---|
| | Ground Elevation | | 363.11 | | | |
| | ***TOPSOIL:*** dark brown silt, trace sand, frozen | | 0.00<br>362.96<br>0.15 | | | |
| | ***SAND:*** compact brown silty fine sand, frozen | | 362.50<br>0.61 | | | |
| 1 | moist | | | SS-1 | 3-5<br>6 | 11 |
| | some silt | | 361.59<br>1.52 | SS-2 | 3-5<br>7 | 12 |
| 2 | | | | SS-3 | 3-7<br>7 | 14 |
| 3 | some silty sand seams | | 360.06<br>3.05 | SS-4 | 7-12<br>14 | 26 |
| 4 | | | | | | |
| 5 | | | | SS-5 | 7-7<br>10 | 17 |
| 6 | | | | SS-6 | 7-9<br>13 | 22 |
| | Borehole terminated at 6.55 m | | 356.56<br>6.55 | | | |
| 7 | | | | | | |
| 8 | | | | | | |

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

**Groundwater Observations and Standpipe Details**

benonite seal

native cave

At drillig completion, borehole open and dry.

Vertical Scale = 1 : 50.0

**Reviewed by:** *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

**Notes:** *Bulksample AS-4A taken from 3.05 to 4.57 m.*

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

BOREHOLE: 1
Sheet 1 of 1

PROJECT Proposed Residential Subdivision
DATE 6 December 2002
JOB NO. 4500G01
LOCATION Activa Conservation Lands, Waterloo, Ontario
FIELD ENG/TECH RM

| DEPTH (m) | DESCRIPTION | LEGEND | ELEV. | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES N-VALUE |
|---|---|---|---|---|---|---|
| | GROUND ELEVATION: 364.23 | | | | | |
| 0 | 0.20 TOPSOIL: dark brown silt, moist | | 364 | | | |
| | SILT: compact brown silt, some sand, trace clay, wet | | | 1 | SS | 16 |
| 1 | 1.50 compact to dense | | 363 | | | |
| | | | | 2 | SS | 43 |
| 2 | | | 362 | 3 | SS | 20 |
| 3 | | | 361 | 4 | SS | 29 |
| 4 | 3.95 SILT TILL: very stiff grey clayey silt, trace sand, APL | | 360 | | | |
| | | | | 5 | SS | 17 |
| 5 | 5.05 Borehole terminated at 5.05 m. | | | | | |

SHEAR STRENGTH. kPa(ksf)
FV. NAT. ■ REM. □
UC ✕ PP ▲
50(1)100(2)150(3)200(4)
PENETRATION RESISTANCE
DYNAMIC CONE ✕
STANDARD PENETRATION ●
20 40 60 80

150 mm

WATER CONTENT (%)
Wp W Wl
10 20 30

GROUNDWATER OBSERVATIONS & PIEZOMETER DETAILS

bentonite seal

13 mm pipe

native backfill

1.2 m slotted filter

At drilling completion, dry cave at 4.6 m.

December 12, 2002
Water level at 4.28 m
(Elev. 359.95)

NOTES:

DRILLING METHOD: Solid Stem Augers

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

BOREHOLE: 2
Sheet 1 of 1

PROJECT Proposed Residential Subdivision
DATE 6 December 2002
JOB NO. 4500G01
LOCATION Activa Conservation Lands, Waterloo, Ontario
FIELD ENG/TECH RM

| DEPTH (m) | DESCRIPTION | ELEV. | NUMBER | TYPE | N-VALUE |
|---|---|---|---|---|---|
| | GROUND ELEVATION: 362.60 | | | | |
| 0 | TOPSOIL: dark brown silt, moist | | | | |
| 0.30 | SILT: compact to dense brown silt, trace sand and clay, wet | 362 | 1 | SS | 12 |
| 1 | | 361 | 2 | SS | 32 |
| 2 | | | | | |
| 2.45 | | | | | |
| 2.60 | SILT TILL: dense brown silt, some clay, wet | 360 | 3 | SS | 44 |
| 3 | hard grey clayey silt, trace sand, APL | 359 | 4 | SS | 22 |
| 3.95 | brown; some silt layers, wet | 358 | 5 | SS | 45 |
| 4 | | | | | |
| 5.05 | Borehole terminated at 5.05 m. | | | | |
| 5 | | | | | |

SHEAR STRENGTH, kPa(ksf)
FV. NAT. ■ REM. □
UC ✜ PP ▲
50(1)100(2)150(3)200(4)
PENETRATION RESISTANCE
DYNAMIC CONE ×
STANDARD PENETRATION ●
20 40 60 80

WATER CONTENT (%)
Wp W Wl
10 20 30

GROUNDWATER OBSERVATIONS & PIEZOMETER DETAILS

bentonite seal

13 mm pipe

native backfill

1.2 m slotted filter

At drilling completion, dry cave at 4.6 m.

December 12, 2002
Water level at 4.74 m
(Elev. 357.86)

NOTES: Bulk sample taken at 2.4 to 3.4 m.

DRILLING METHOD: Solid Stem Augers

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

TEST PIT: 29

LOCATION Proposed Residential Subdivision  DATE 10 December 2002  JOB NO. 4500G01

PROJECT Activa Conservation Lands, Waterloo, Ontario  FIELD ENG/TECH RM

| SOIL PROFILE | | | | | WATER CONTENT (%) Wp W Wl | GROUNDWATER OBSERVATIONS AND HEADSPACE READINGS (ppm) |
|---|---|---|---|---|---|---|
| DEPTH m | DESCRIPTION | LEGEND | ELEV. | SAMPLE | 10 20 30 | |
| | GROUND ELEVATION: 363.73 | | | | | |
| 0 | TOPSOIL: dark brown silt, moist | | | | | |
| 0.55 | SILT: rusty brown silt, trace sand, wet | | 363 | | | |
| 0.80 | brown | | | | ⊙ | |
| 1.10 | Test pit terminated at 1.10 m. | | | | | Upon completion of excavation, test pit sidewalls stable.<br><br>No free groundwater encountered during excavation. |

NOTES:

ENGINEER:

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

TEST PIT: 31

LOCATION Proposed Residential Subdivision DATE 10 December 2002 JOB NO. 4500G01

PROJECT Activa Conservation Lands, Waterloo, Ontario FIELD ENG/TECH RM

| SOIL PROFILE | | | | | WATER CONTENT (%) Wp W Wl | GROUNDWATER OBSERVATIONS AND HEADSPACE READINGS (ppm) |
|---|---|---|---|---|---|---|
| DEPTH m | DESCRIPTION | LEGEND | ELEV. | SAMPLE | 10 20 30 | |
| | GROUND ELEVATION: 362.62 | | | | | |
| 0 | TOPSOIL: dark brown silt, moist | | | | | |
| 0.35 | SAND: rusty brown fine to medium sand, some silt, moist | | 362 | | | |
| 0.85 | brown, trace silt | | | | | |
| 1.00 | Test pit terminated at 1.00 m. | | | | | Test pit sidewalls caving below 0.4 m.<br><br>No free groundwater encountered during excavation. |

NOTES:

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

**Borehole Number: 1**

**Ground Elevation:** ***N/A***

**Project:** ***Emergency Access Road***

**Job No.:** ***4500G4***

**Location:** ***Roy Schmidt Road, Waterloo, Ontario***

**Drill Date:** ***July 18, 2005***

| Depth (m) | Description | Symbol | Elevation (m) | Sample Number | Sample Type | N-Value |
|---|---|---|---|---|---|---|
| | Ground Elevation | | 0.00 | | | |
| 0.00 | ***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 50 mm; Granular 'A': 150 mm | | | | | |
| | ***SAND:*** compact fine brown sand, trace silt, damp | | | 1 | SS | 14 |
| 1.00 | | | -1.00 | 2 | SS | 10 |
| | compact light brown fine sand, some silt, wet | | | 3 | SS | 17 |
| 2.00 | Borehole terminated at 1.98 m. | | -2.00 | | | |

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
WP WL
Water Content (%): 10 20 30

**Groundwater Observations and Standpipe Details**

dry-pack asphalt seal

native backfill

native cave

At drilling completion, dry cave at 1.52 m.

**Reviewed by:** ***D.M.***

**Field Tech.:** ***D.M.***

**Drill Method:** ***Solid Stem Auger***

**Sheet:** ***1 of 1***

**Notes:**

**Drafted by:** ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

**Borehole Number: 2**

**Ground Elevation:** ***N/A***

**Project:** ***Emergency Access Road***

**Job No.:** ***4500G4***

**Location:** ***Roy Schmidt Road, Waterloo, Ontario***

**Drill Date:** ***July 18, 2005***

| Depth (m) | Description | Elevation (m) | Number | Type | N-Value |
|---|---|---|---|---|---|
| | Ground Elevation | 0.00 | | | |
| 0.00 | ***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 40 mm; Granular 'A': 125 mm | | | | |
| | ***FILL:*** loose dark brown silt, some clay and gravel, trace sand, very moist | | 1 | SS | 7 |
| 1.00 | ***SAND:*** very loose brown sand, some silt, moist | -1.00 | 2 | SS | 4 |
| | ***SAND AND GRAVEL:*** compact brown medium to coarse sand and gravel, trace silt, moist | | 3 | SS | 13 |
| 2.00 | Borehole terminated at 1.98 m. | -2.00 | | | |

Dynamic Cone: 20 40 60 80
Standard Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

**Reviewed by:** ***D.M.***

**Field Tech.:** ***D.M.***

**Drill Method:** ***Solid Stem Auger***

**Sheet:** ***1 of 1***

**Notes:**

**Drafted by:** ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

**Borehole Number: 3**

**Ground Elevation:** ***N/A***

**Project:** ***Emergency Access Road***

**Job No.:** ***4500G4***

**Location:** ***Roy Schmidt Road, Waterloo, Ontario***

**Drill Date:** ***July 18, 2005***

| Depth (m) | Description | Elevation (m) | Number | Type | N-Value |
|---|---|---|---|---|---|
| | Ground Elevation | 0.00 | | | |
| 0.00 | ***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 40 mm; Granular 'A': 205 mm | | | | |
| | ***FILL:*** firm dark brown clayey silt, some gravel, trace sand, damp | | 1 | SS | 8 |
| | ***SILT:*** light brown silt, some sand, trace gravel, moist | | | | |
| | silt, trace sand, trace gravel, very moist | | 2 | SS | 10 |
| 1.00 | | -1.00 | | | |
| | ***SAND:*** dense light brown silty fine sand, very moist to wet | | 3 | SS | 39 |
| 2.00 | Borehole terminated at 1.98 m. | -2.00 | | | |

Dynamic Cone: 20 40 60 80
Standard Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

**Reviewed by:** ***D.M.***

**Field Tech.:** ***D.M.***

**Drill Method:** ***Solid Stem Auger***

**Sheet:** ***1 of 1***

**Notes:**

**Drafted by:** ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

**Borehole Number: 4**

**Ground Elevation:** ***N/A***

**Project:** ***Emergency Access Road***

**Job No.:** ***4500G4***

**Location:** ***Roy Schmidt Road, Waterloo, Ontario***

**Drill Date:** ***July 18, 2005***

| Depth (m) | Description | Elevation (m) | Sample Number | Sample Type | N-Value |
|---|---|---|---|---|---|
| | Ground Elevation | 0.00 | | | |
| 0.00 | ***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 50 mm; Granular 'A': 100 mm | | | | |
| | ***FILL:*** firm dark brown clayey silt, some gravel, trace sand, damp | | | | |
| | ***SAND:*** compact rusty brown sand, some silt, moist | | 1 | SS | 11 |
| | compact light brown fine sand, some silt, moist | | 2 | SS | 18 |
| 1.00 | | -1.00 | | | |
| | wet | | 3 | SS | 22 |
| 2.00 | Borehole terminated at 1.98 m. | -2.00 | | | |

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
Water Content (%): WP WL; 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

**Reviewed by:** ***D.M.***

**Field Tech.:** ***D.M.***

**Drill Method:** ***Solid Stem Auger***

**Sheet:** ***1 of 1***

**Notes:**

**Drafted by:** ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

**Borehole Number: 5**

**Ground Elevation:** ***N/A***

**Project:** ***Emergency Access Road***

**Job No.:** ***4500G4***

**Location:** ***Roy Schmidt Road, Waterloo, Ontario***

**Drill Date:** ***July 18, 2005***

| Depth (m) | Description | Elevation (m) | Sample Number | Sample Type | N-Value |
|---|---|---|---|---|---|
| 0.00 | Ground Elevation | 0.00 | | | |
| | ***FILL:*** Topsoil Fill: 50 mm; Granular 'A': 150 mm | | | | |
| | ***SAND:*** compact brown sand, trace silt, moist | | 1 | SS | 10 |
| 1.00 | ***SILT:*** very loose mottled brown/rusty silt, some sand, very moist | -1.00 | 2 | SS | 4 |
| | compact light brown silt, trace sand, very moist | | 3 | SS | 12 |
| 2.00 | Borehole terminated at 1.98 m. | -2.00 | | | |

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
Water Content (%): WP — WL; 10 20 30

Groundwater Observations and Standpipe Details:
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

**Reviewed by:** ***D.M.***

**Field Tech.:** ***D.M.***

**Drill Method:** ***Solid Stem Auger***

**Sheet:** ***1 of 1***

**Notes:**

**Drafted by:** ***A.G._01a***

# Appendix 3 Figures

Figures 1: Particle Size Distribution Analyses
Figures 2 and 3: Standard Proctor Moisture-Density Test Results

Z:\Style_LVM_Ontario\Lab Lab_Particle_Size_LVM_Ontario.STY - Printed: 2015-03-16T09:40:16

# PARTICLE SIZE ANALYSIS

Project: **Geotechnical Investigation, Proposed Residential Development**

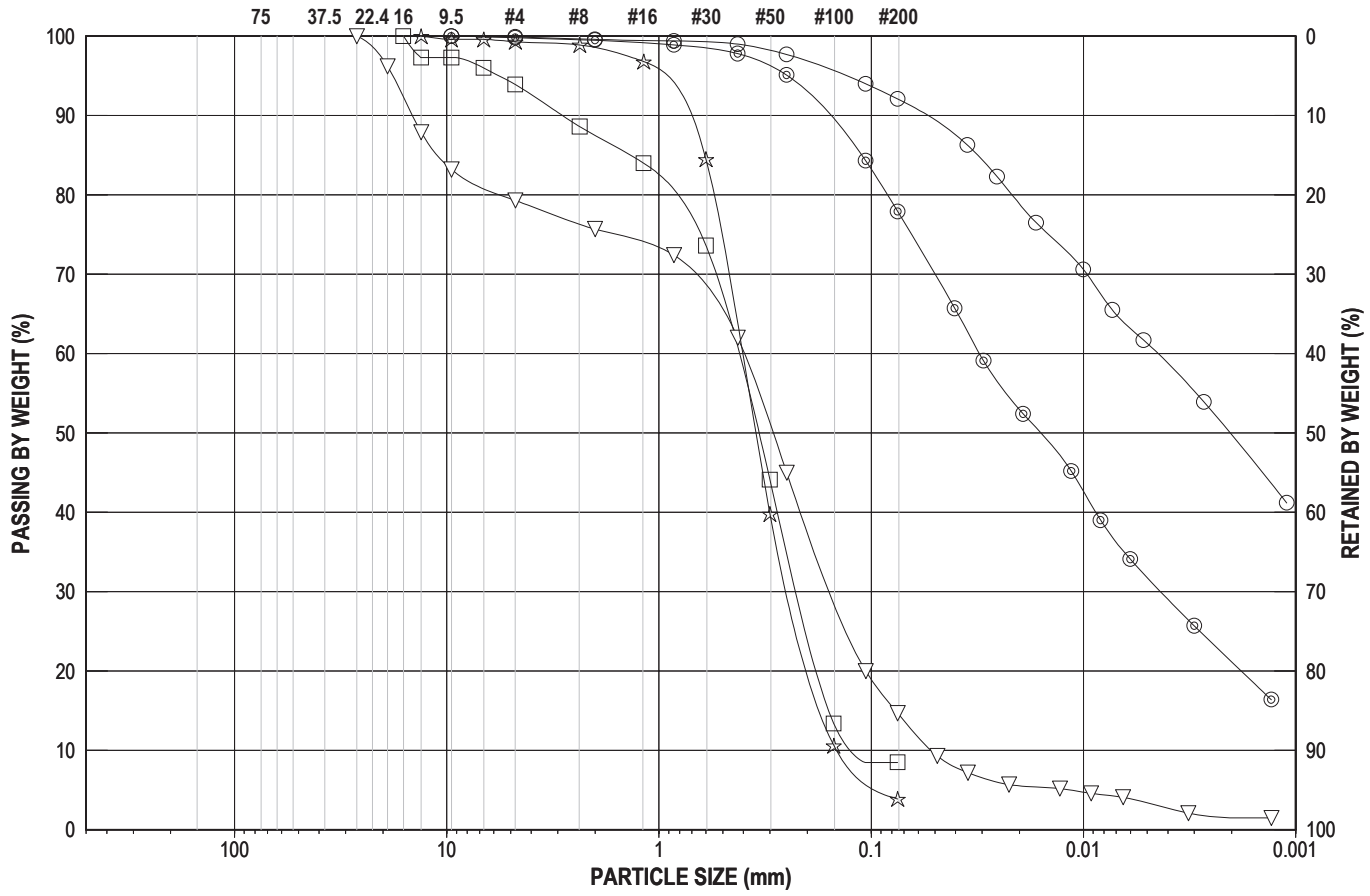
Figure No : **1**

Location: **560/576 Conservation Drive, Waterloo, Ontario**

File No : **P-0008077-0-01-100**

UNIFIED SOIL CLASSIFICATION

| *COBBLES* | *GRAVEL* | | *SAND* | | | *SILT OR CLAY* |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |
| *U.S. SIEVE SIZE IN MILLIMETRES* | | | *U.S. STANDARD SIEVE No.* | | | *HYDROMETER* |




| Symbol | Borehole n° | Sample n° | Depth (m) | Description |
|---|---|---|---|---|
| ○ | BH-01-15 | SS-4 | 3.05 - 3.51 | SILT and CLAY, trace Sand |
| □ | BH-04-15 | SS-3 | 2.29 - 2.74 | SAND, trace Gravel and Silt |
| ▽ | BH-05-15 | SS-2 | 1.52 - 1.98 | Gravelly SAND, some Silt, trace Clay |
| ☆ | BH-07-15 | SS-3 | 2.29 - 2.74 | SAND, trace Gravel and Silt |
| ◎ | BH-08-15 | SS-5 | 4.57 - 5.03 | Sandy, Clayey SILT |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

FIGURE NO. 2

# LABORATORY PROCTOR MOISTURE–DENSITY TEST

PROJECT Proposed Residential Development

LOCATION 560 / 576 Conservation Drive, Waterloo, Ontario JOB NO. P-0008077-0-01-100

BOREHOLE NO. BH-09-15 Bulk Sample DATE TESTED March, 2015

SAMPLE DEPTH 1.52 m - 3.05 m TESTED BY M.D

SOIL TYPE SAND MOISTURE CONTENT 9.5 %

REMARKS

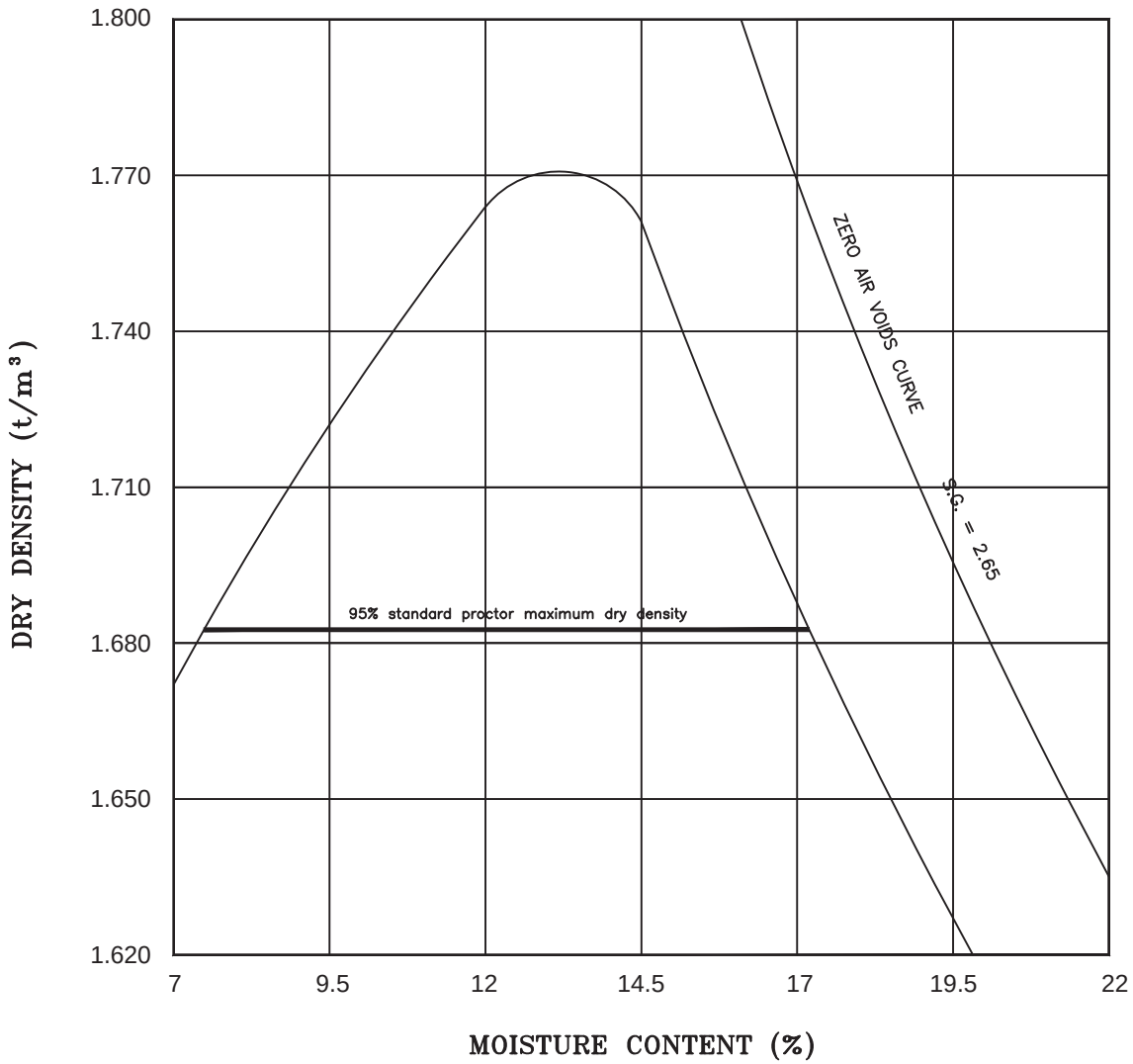
METHOD LS – 706

PROCEDURE: 1☒ 2☐ 3☐

Procedure 1 (Mold ø – 101.6 mm)
Procedure 2 (Mold ø – 101.6 mm)
Procedure 3 (Mold ø – 152.4 mm)

MAXIMUM DRY DENSITY 1.771 t/m³

OPTIMUM MOISTURE 13.4 %




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FIGURE NO. 3

# LABORATORY PROCTOR MOISTURE–DENSITY TEST

PROJECT Proposed Residential Development

LOCATION 560 / 576 Conservation Drive, Waterloo, Ontario JOB NO. P-0008077-0-01-100

BOREHOLE NO. BH-01-15 Auger Sample #6 DATE TESTED March 4, 2015

SAMPLE DEPTH 3.05 - 4.57 m TESTED BY M.Dalgliesh

SOIL TYPE SILT MOISTURE CONTENT 18.9 %

REMARKS

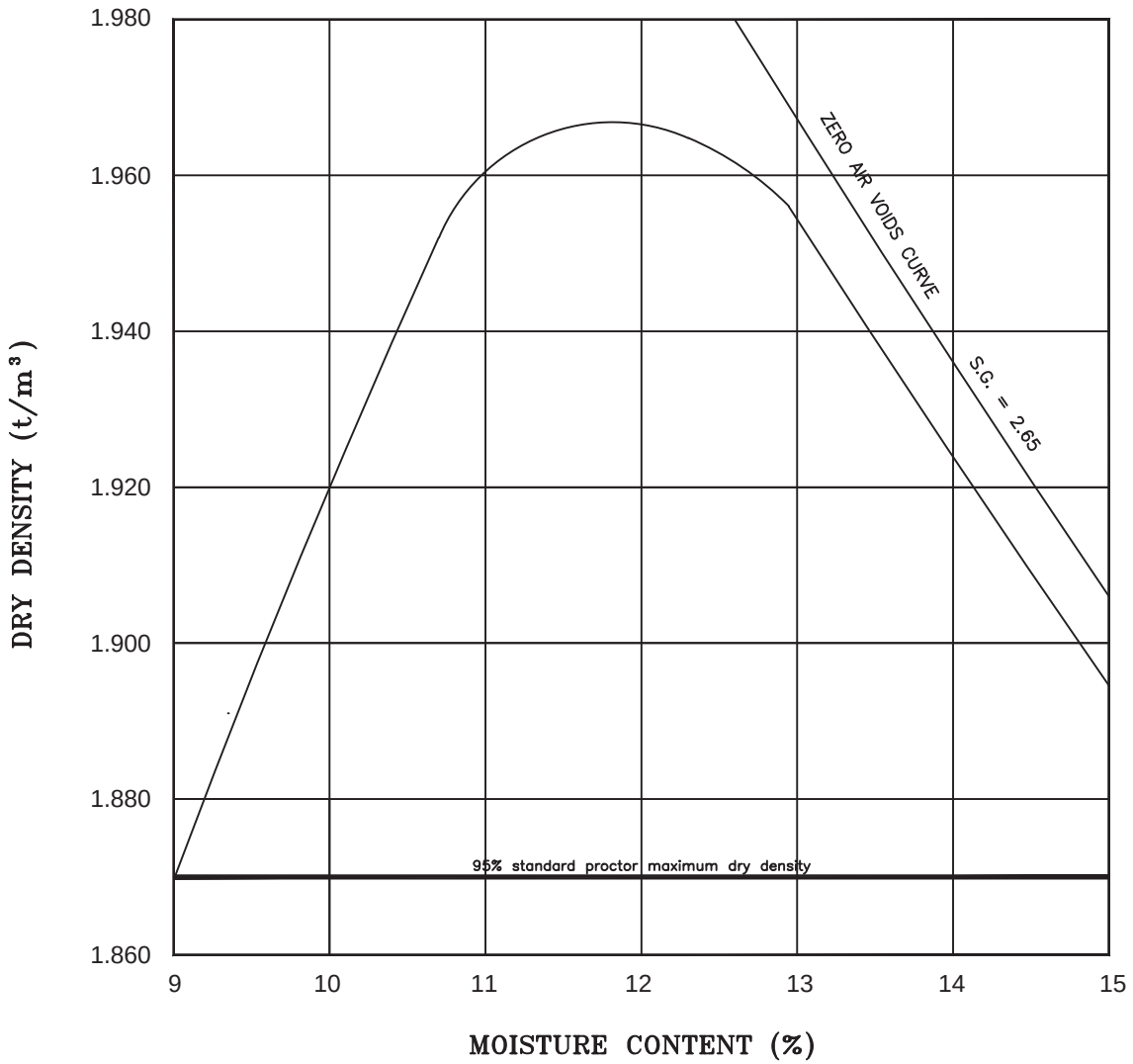
METHOD LS – 706

PROCEDURE: 1☒ 2☐ 3☐

Procedure 1 (Mold ø – 101.6 mm)
Procedure 2 (Mold ø – 101.6 mm)
Procedure 3 (Mold ø – 152.4 mm)

MAXIMUM DRY DENSITY 1.968 t/m³

OPTIMUM MOISTURE 11.8 %




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