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A REPORT TO
BROOKVALLEY PROJECT MANAGEMENT INC.

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

CHICKADEE LANE AND GLASGOW ROAD

TOWN OF CALEDON

REFERENCE NO. 1801-S032

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1.0 INTRODUCTION

In accordance with the written authorization dated November 13, 2017, from Mr. Frank Filippo of Brookvalley Project Management Inc., a geotechnical investigation was conducted at a parcel of property located in the area of Chickadee Lane and Glasgow Road in the Town of Caledon.

The purpose of the investigation was to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the design and construction of a residential development project. Since the property is located in close proximity of the Humber River, a slope stability study was also completed for the development. The findings and resulting recommendations are presented in this Report.

2.0 **SITE AND PROJECT DESCRIPTION**

The site is located at the south sector of the Town of Caledon, which is situated on Peel-Markham till plain where the drift dominates the soil stratigraphy. In places, lacustrine sand, silt, clay and drift which has been reworked by the water action of Peel Ponding (glacial lake) have modified the drift stratigraphy.

The subject property, approximately 10.91 hectares in area, is located beside the intersection of Chickadee Lane and Glasgow Road in the Town of Caledon. The existing site gradient is relatively flat, with sloping ground to the north and east of the property towards the vicinity of Humber River. The valley land is well vegetated with trees and bushes.

At the time of investigation, part of the property was an open field, with dwellings on the southeast and northwest of the road intersection.

The proposed development will consist of a residential subdivision on the south portion of the property, with municipal services and access roadways meeting the municipal standards.

3.0 **FIELD WORK**

The field work, consisting of twelve (12) sampled boreholes, was performed between January 23 and 29, 2018, at the locations shown on the Borehole Location Plan of Drawing No. 1. Boreholes 2 and 12, located close to the top of slope, extended to a depth of 19.8 m and 32.0 m from the prevailing ground surface. The remaining boreholes were terminated at a depth of 6.5 m or 8.1 m from the prevailing ground level.

The holes were advanced at intervals to the sampling depths by a track-mounted, continuous-flight power-auger machine equipped for soil sampling. Standard Penetration Tests, using the procedures described on the enclosed “List of Abbreviations and Terms”, were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or ‘N’ values) of the subsoil. The relative density of the granular strata and the consistency of the cohesive strata are inferred from the ‘N’ values. Split-spoon samples were recovered for soil classification and laboratory testing.

Upon completion of borehole drilling and sampling, monitoring wells were completed at the location of Boreholes 2, 5, 6 and 12 for hydrogeological study. The wells at Boreholes 5 and 6 were installed at a depth of 6.0 m. At the locations of Boreholes 2 and 12, nested wells were installed at a depth of 7.6 m and at the deeper levels of 19.8 m and 32.0 m, respectively. The locations and depths of the monitoring wells were specified by Palmer Environmental Consulting Group Inc., who will also be monitoring the wells.

The ground elevation at each borehole and monitoring well location was interpolated from the spot elevations shown on the Plan of Survey prepared by KRCMAR Surveyors Ltd. dated March 2017.

4.0 **SUBSURFACE CONDITIONS**

The boreholes revealed that beneath a veneer of topsoil and a layer of earth fill in places, the site is underlain by silty clay till with sandy silt till deposit at the deeper level. Detailed descriptions of the subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 12, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile in Drawing Nos. 2 and 3. The engineering properties of the disclosed soils are discussed herein.

4.1 **Topsoil** (All Boreholes)

The revealed topsoil is 16 cm to 46 cm in thickness. Thicker topsoil layers are expected to occur in places, especially in the treed area and the low-lying drainage area.

The topsoil is dark brown in colour, indicating appreciable amounts of roots and humus. These materials are unstable and compressible under loads; therefore, the topsoil can only be used for general landscaping purposes. Its suitability for planting and sodding purposes must be further assessed by fertility testing.

Due to the humus content, the topsoil may produce volatile gases and generate an offensive odour under anaerobic conditions. Therefore, the topsoil must not be buried below any structures or deeper than 1.2 m below the finished grade, so that it will not have an adverse impact on the environmental well-being of the developed areas.

4.2 **Earth Fill** (Boreholes 4, 5, 7, 9 and 11)

A layer of earth fill, consisting of brown and grey silty clay, with sand and gravel, occasional rootlets, topsoils inclusions wood and brick fragments, was contacted in some of the boreholes. The fill extends to a depth of 0.6 m to 2.4 m from the prevailing ground surface. It may be placed for site grading when the road and the existing houses were constructed in the past.

The water content of the earth fill samples was determined, ranging from 19% to 34%, indicating moist to wet conditions.

The obtained ‘N’ values range from 3 to 30, with a median of 6 blows per 30 cm of penetration, showing the fill is non-uniform in compaction and is unsuitable to support any structures sensitive to movement. For structural uses, the existing earth fill must be subexcavated, sorted free of topsoil and any deleterious material, aerated and properly compacted in layers.

One must be aware that the samples retrieved from boreholes 10 cm in diameter may not be truly representative of the geotechnical quality of the fill, and do not indicate whether the topsoil beneath the earth fill was completely stripped. This should be further assessed by test pits.

4.3 **Silty Clay Till** (All Boreholes)

The native silty clay till deposit is heterogeneous in structure and amorphous in places. Some of the clay till samples were found to contain sand seams and clay layers. Grain size analyses were performed on 3 representative samples and the results are plotted on Figure 13.

Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the stratum.

The silty clay till deposit was found to be weathered at the upper layer in some of the boreholes, up to a depth of 0.6 m to 0.8 m from grade. The obtained ‘N’ values range from 2 to 69 blows, with a median of 27 blows per 30 cm of penetration. This indicates that the consistency of the clay till is soft to hard, having the soft till in the weathered zone near the ground surface only. The consistency of the clay till is generally very stiff.

The Atterberg Limits of 4 representative samples and the water content values for all the clay till samples were determined. The results are plotted on the Borehole Logs and summarized below:

Liquid Limit	42, 38, 37, 36
Plastic Limit	21, 21, 19, 20
Natural Water Content	12% to 32% (median 17%)

The above results show that the clay till is cohesive, with medium plasticity. The natural water content values are mostly below the plastic limit, confirming the generally very stiff consistency of the clay as determined from the ‘N’ values. The higher water content samples were obtained near the ground surface which could have been disturbed by weathering.

Based on the above findings, the engineering properties of the clay till pertaining to the project design are given below:

- Highly frost susceptible and soil adfreezing potential.
- Low water erodibility.

- Very low in permeability, with an estimated coefficient of permeability of 10^{-7} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- A cohesive-frictional soil, its shear strength is derived from consistency and is augmented by internal friction, thus being inversely moisture dependent and, to a lesser extent, dependent on soil density.
- In excavation, the clay till will be stable in relatively steep slopes; however, prolonged exposure will allow infiltrating precipitation to saturate the fissures and sand layers in the till, causing localized sloughing.
- A poor pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 5%.
- Moderate corrosivity to buried metal, with an estimated electrical resistivity of 3500 ohm·cm.

4.4 **Sandy Silt Till** (Boreholes 2 and 12)

The sandy silt till was contacted below 16.5 m and 22.5 m at Boreholes 2 and 12, respectively. It is heterogeneous in structure with occasional sand seams, cobbles and boulders.

The obtained ‘N’ values range from 28 to 78, with a median of 39 blows per 30 cm of penetration. This indicates that the relative density of the silt till is compact to very dense, generally in the dense range.

The water content values for the silt till samples were determined; the results are plotted on the Borehole Logs, ranging from 12% to 15%.

Based on the above findings, the properties of the silt till pertaining to the project are given below:

- Moderately frost susceptibility, with high soil adfreezing potential.
- Low water erodibility.
- Relatively low in permeability, with an estimated coefficient of permeability of 10^{-6} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- A cohesive-frictional soil, its shear strength is derived from consistency and is augmented by internal friction, thus being inversely moisture dependent and, to a lesser extent, dependent on soil density.
- In excavation, the silt till will be stable in relatively steep slopes; however, prolonged exposure will allow infiltrating precipitation to saturate the sand layers causing localized sloughing.
- A poor pavement-supportive material, with an estimated CBR value of 8%.
- Moderate corrosivity to buried metal, with an estimated electrical resistivity of 4000 ohm·cm.

4.5 Compaction Characteristics of the Revealed Soils

The obtainable degree of compaction is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied. As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 1.

Table 1 - Estimated Water Content for Compaction

Soil Type	Determined Natural Water Content (%)	Water Content (%) for Standard Proctor Compaction	
		100% (optimum)	Range for 95% or +
Earth Fill	19 to 34	19	15 to 22
Silty Clay Till	12 to 32 (median 17)	18	14 to 22
Sandy Silt Till	12 to 15 (median 13)	14	10 to 17

Based on the above findings, the on-site materials are mostly suitable for 95% or + Standard Proctor compaction. However, some of the earth fill and the weathered soils are relatively too wet, which will require mixing with dry soils or aeration during dry and warm weather before compaction.

Any use of the existing earth fill should be reviewed, sorted free of organics and deleterious material, aerated, before reuse for structural backfill.

The on-site material should be compacted using a heavy-weight, kneading-type roller. The lifts for compaction should be limited to 20 cm, or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

When compacting the onsite material with cementation, the compactive energy will frequently bridge over the chunks in the soil and be transmitted laterally in the soil mantle. Therefore, the lifts of this soil must be limited to 20 cm or less (before compaction). It is difficult to monitor the lifts of backfill placed in deep trenches; therefore, it is preferable that the compaction of backfill at depths over 1.0 m below the pavement subgrade be carried out on the wet side of the optimum. This would allow a wider latitude of lift thickness.

If the compaction of the soils is carried out with the water content within the range for 95% Standard Proctor dry density but on the wet side of the optimum, the surface of the compacted soil mantle will roll under the dynamic compactive load. This is unsuitable for pavement construction since each component of the pavement structure is to be placed under dynamic conditions which will induce the rolling action of the subgrade surface and cause structural failure of the new pavement.

The foundation or bedding of the sewer and slab-on-grade will be placed on a subgrade which will not be subjected to impact loads. Therefore, the structurally compacted soil mantle with the water content on the wet side or dry side of the optimum will provide an adequate subgrade for the construction.

5.0 GROUNDWATER CONDITIONS

Groundwater seepage encountered during augering of boreholes was recorded on the field logs. Upon completion, the level of groundwater and cave-in were measured in the boreholes; the data are plotted on the Borehole Logs and listed in Table 2.

Table 2 - Groundwater Levels

Borehole/ Monitoring Well No.	Ground Elevation (m)	Borehole Depth (m)	Soil Colour Changes Brown to Grey		Measured Groundwater/ Cave-In* Level On Completion	
			Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
1	256.5	8.1	5.6	250.9	dry	-
2**	255.7	19.8/7.6	6.3	249.4	3.0	252.7
3	255.8	6.5	6.3	249.5	dry	-
4	258.9	6.5	5.4	253.5	dry	-
5	259.5	6.5	> 6.5	-	3.8	255.7
6	259.9	6.5	5.3	254.6	4.0	255.9
7	260.0	6.5	4.6	255.4	0.3	259.7
8	259.5	6.5	5.8	253.7	dry	-
9	260.0	6.5	4.3	255.7	1.5/4.0*	258.5/256.0*
10	257.8	6.5	3.4	254.4	dry	-
11	259.3	6.5	2.9	256.4	dry	-
12**	258.3	32.0/7.6	7.6	250.7	6.1	252.2

* Cave-in level upon completion of drilling

** With nested Monitoring Wells at shallow and deep level

Groundwater was recorded in six boreholes, at a depth of 0.3 m to 6.1 m from the ground surface, or El. 252.2 m to 259.7 m. The other six boreholes were dry throughout the investigation process.

The recorded water level in the open boreholes may represent perched groundwater in the earth fill or sand seams within the till stratum. It will fluctuate with the seasons.

In excavation, any groundwater yield is anticipated to be slow in rate and limited in quantity. It can be collected into a sump and remove by conventional pumping.

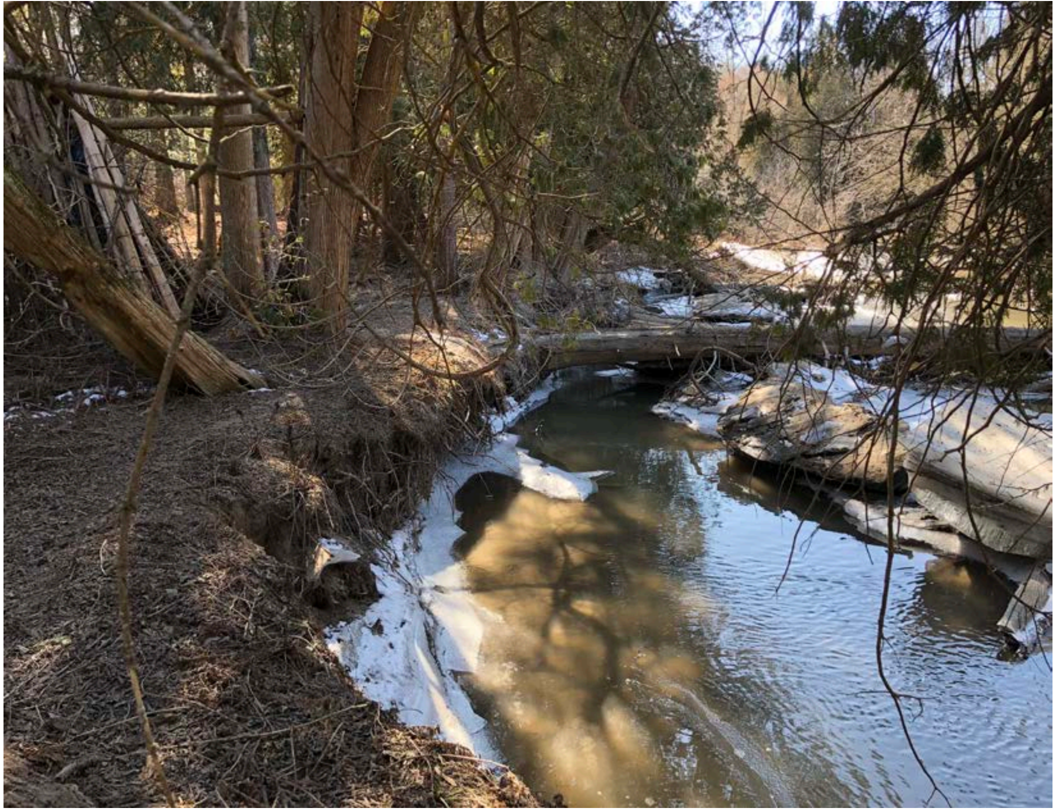
Palmer Environmental Consulting Group Inc., retained by Brookvalley Project Management Inc., will be monitoring the wells.

6.0 SLOPE STABILITY STUDY

A slope stability study was conducted for the valley land to the north and east of the subject property. It includes a visual inspection of the slope and stability analysis using force-moment-equilibrium criteria of the Bishop’s method.

A visual inspection of the slope was performed on March 20, 2018. The inspection revealed that the sloping ground is generally covered with mature trees or vegetation, with isolated bare spots covered with fallen leaves and wood branches. Most of the trees appeared in the upright position. There were no signs of water seepage or surface erosion along the slope surface, except multiple gullies and surface erosion were present to the north and west of the property. Toe erosion scars were also evident along Humber River, as seen in Diagram 1.

Diagram 1 - Evidence of toe erosion scars along Humber River



Towards the east of the property, the bottom of slope is a park vicinity with no erosion hazard.

Three slope sections were selected for stability analysis, based on the field observation and the contours of slope inclination. The locations of these sections are shown on Drawing No. 1. Each slope section has a height of 20 to 30 m, with an inclination between 1 vertical (V) : 2 horizontal (H) and 1V : 3H.

The slope profiles are interpreted from the contours on the topographic plan obtained from First Base Solutions. The subsurface profiles of the slope sections were interpreted from the findings of the nearby Boreholes 2 and 12 (Enclosure Nos. 2 and 12). The groundwater level recorded in these boreholes, at a depth of 3.0 m and 6.1 m, was used as the phreatic groundwater along the slope, although it was discontinuous and was considered as the perched water in the boreholes. The soil strength parameters of each soil layer are presented in Table 3.

Table 3 - Soil Strength Parameters

Soil Type	**Unit Weight γ (kN/m^3)**	**Shear Strength Parameters**	
		c' (kPa)	**ϕ' (degree)**
Silty Clay Till, very stiff	22.0	5	28
Silty Clay Till, stiff	21.5	5	25
Sandy Silt Till, dense	22.0	5	30

The stability analysis was completed using “SLIDE”, developed by Rocscience Inc. The results are illustrated on Drawing Nos. 4 to 6 and summarized in Table 4. The Technical Guide “River and Stream Systems: Erosion Hazard Limit” of Ministry of Natural Resources and Forestry (MNRF Guideline) was used for the management of erosion hazards along the bank.

Table 4 - Factors of Safety of Slope Sections

Slope Section	Minimum Factor of Safety of Existing Slope
A-A	1.393
B-B	1.496
C-C	1.509

The minimum Factors of Safety (FOS) in Table 4 meets the Design Minimum Factor of Safety (Table 4.3 in the guideline) of 1.3 to 1.5 for Active Landuse (habitable or occupied structures near slope; residential, commercial and industrial buildings, retaining walls, storage warehousing of non-hazardous substances).

Due to the low permeability of subsoil, the water penetration into the subsoil during regional flooding is local. Any instability due to saturation of subsoil during rapid drawdown is considered insignificant.

To establish the long-term stable slope line (LTSSL), a 5 m toe erosion allowance is recommended along the gullies and river bank where there are signs of erosion, according to Table 3 of MNRF Guideline. The LTSSL is shown on Drawing No. 7.

Any new development will have to set back a minimum of 6 m from the LTSSL. The Erosion Hazard Limit, including the 6 m setback from the LTSSL is also shown on Drawing No. 7.

In order to maintain the safety of slope from erosion, the following geotechnical constraints should be stipulated for any development next to the slope:

1. The prevailing vegetative cover must be maintained, since its extraction would deprive the slope of the rooting system that acts as reinforcement against soil erosion by weathering. If for any reason the vegetation cover is

stripped, it must be reinstated to its original, or better than its original, protective condition.

2. The leafy topsoil cover on the slope face should not be disturbed, since this provides insulation and screen against frost wedging and rainwash erosion.
3. Grading of the land adjacent to the slope must be such that concentrated runoff is not allowed to drain onto the slope face. Landscaping features, which may cause runoff to pond at the top of the slope, such as infiltration trenches, as well as soil saturation at the tableland must not be permitted.
4. Where development is carried out near the top of the slope, there are other factors to be considered related to possible human environmental abuse. These include soil saturation from frequent watering to maintain of landscaping features, stripping of topsoil or vegetation, and dumping of loose fill and material storage close to the top of slope; none of these should be permitted.

7.0 DISCUSSION AND RECOMMENDATIONS

The investigation revealed that beneath a veneer of topsoil and a layer of earth fill in places, the site is underlain by soft to hard, generally very stiff silty clay till stratum and compact to very dense, generally dense sandy silt till deposit at the deeper level. Groundwater was recorded in six boreholes, at a depth of 0.3 m to 6.1 m from the ground surface. It represents a perched groundwater in the earth fill or sand seams within the till stratum.

The existing slope inclination has the minimum Factors of Safety (FOS) above 1.3 to 1.5, meeting the Design Minimum Factor of Safety (Table 4.3 in the MNRF guideline) for Active Landuse. A 5 m Toe Erosion Allowance is recommended along the gullies and river bank where there are signs of erosion. Any new development will have to set back a minimum of 6 m for the Erosion Access Allowance. The Erosion Hazard Limit, including the 5 m setback for the Toe Erosion Allowance and 6 m setback for the Erosion Access Allowance is shown on Drawing No. 7.

The geotechnical findings which warrant special consideration are presented below:

1. The existing topsoil must be removed for the development. The revealed thickness of topsoil at the borehole locations is between 16 cm and 46 cm. Thicker topsoil layer can occur, especially in depressed areas.
2. After demolition of existing area, the foundation and debris should be removed and disposal off-site. The cavity should be backfilled with an engineered fill for development.
3. The topsoil is void of engineering value and should be stripped and removed for the project construction. It must not be buried within the building envelope or deeper than 1.2 m below the exterior finished grade of the

development.

4. Engineered fill and sound natural soils are suitable for normal spread and strip footing construction for the proposed development. The footings must be designed in accordance with the recommended bearing pressures in Section 7.2 and the footing subgrade must be inspected by a geotechnical engineer to ensure that its condition is compatible with the design of the foundations.
5. For slab-on-grade construction, the slab should be constructed on a granular base, 20 cm thick, consisting of 20-mm Crusher-Run Limestone, or equivalent, compacted to its maximum Standard Proctor dry density.
6. A Class 'B' bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. Where water-bearing soil is present, a Class 'A' concrete bedding should be used.
7. Excavation should be carried out in accordance with Ontario Regulation 213/91.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

7.1 <u>Site Preparation</u>

The property is an open field, with existing dwellings on the southeast and northwest of the road intersection. For site preparation of development, the existing topsoil must be removed and the site can be regraded with an engineered fill for normal footing, sewer and pavement construction. After demolition of the existing dwellings, the foundation cavity should be subexcavated to undisturbed soil stratum, followed by backfilling with engineered fill, compacted in layers. The requirements for engineered fill construction are discussed in Section 7.3.

The existing earth fill should also be sub-excavated. Test pits may be excavated to evaluate the depth and the extent of earth fill for removal. The fill should be sorted free of topsoil, organic inclusion, debris, wood and other deleterious material, prior to reuse for engineered fill or structural backfill.

7.2 **Foundations**

The development will consist of residential houses with a normal depth basement. Based on the borehole findings, the houses can be built on conventional footings founded on sound natural silty clay till or engineered fill.

The recommended soil bearing pressures of 150 kPa (SLS) and 250 kPa (ULS) should be used for the design of normal spread and strip footings, founded on sound native soils or engineered fill. The total and differential settlements of the footings are estimated to be 25 and 15 mm, respectively.

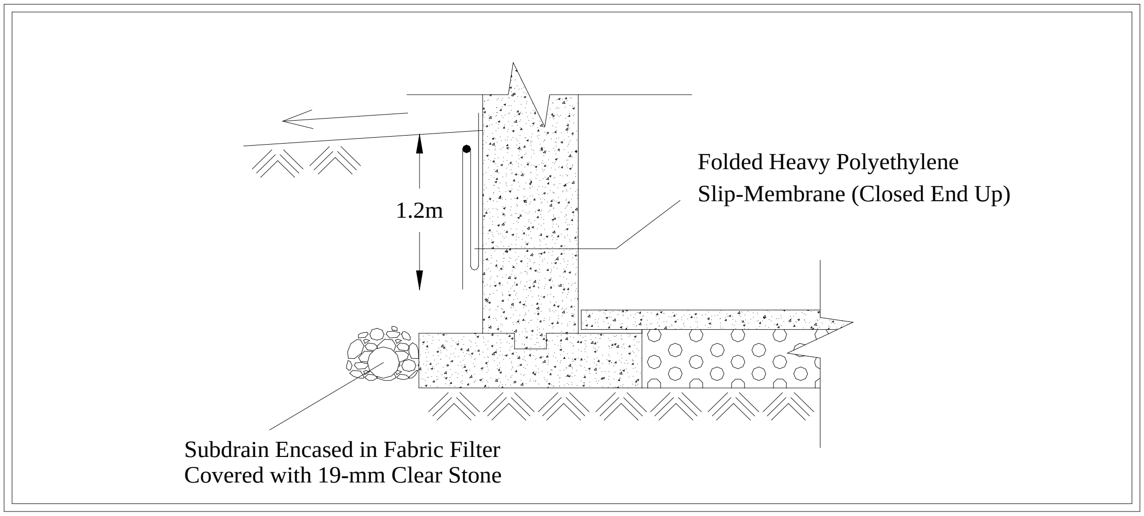
Higher design bearing pressures may be available for individual buildings at designated area. The building foundations can be reviewed by the geotechnical engineer after the site grading plan and the details of the proposed development is finalized.

The footing subgrade must be confirmed by inspection performed by a geotechnical engineer or a geotechnical technician under the supervision of a geotechnical engineer, to ensure that the revealed conditions are compatible with the foundation requirements.

Footings exposed to weathering, or in unheated areas, should have at least 1.2 m of earth cover for protection against frost action.

Some of the in situ soils have high soil-adfreezing potential. In order to alleviate the risk of frost damage, the foundation walls must be constructed of concrete and either the backfill must consist of non-frost-susceptible granular material, or the foundation walls must be shielded with a polyethylene slip-membrane between the concrete wall and the backfill. The recommended measures are schematically illustrated in Diagram 2.

Diagram 2 - Frost Protection Measures (Foundations)



Perimeter subdrains and dampproofing of the foundation walls will be required. All subdrains must be encased in a fabric filter to protect them against blockage by silting.

The building foundation must meet the requirements specified in the latest Ontario Building Code. As a guide, the structures founded on the sound native soils or engineered fill can be designed to resist an earthquake force using Site Classification ‘D’ (stiff soil).

7.3 **Engineered Fill**

Where earth fill is required to raise the site, it is generally more economical to place engineered fill for normal footing, underground service pipes and road construction. The engineering requirements for a certifiable fill for road construction, municipal services, and footings designed with a Maximum Allowable Soil Pressure (SLS) of 150 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 250 kPa are presented below:

1. All the topsoil must be removed, and the subgrade must be inspected and proof-rolled prior to any fill placement. The weathered soils and earth fill must be subexcavated, inspected, sorted free of organics and topsoil, aerated and properly compacted in layers.
2. The in situ organic-free soils can be used, and they must be uniformly compacted in 20 cm thick lifts to 98% or + of their maximum Standard Proctor dry density, up to the proposed lot grade and/or road subgrade. The soil moisture must be properly controlled near the optimum.
3. If the foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% of the maximum Standard Proctor compaction.
4. If imported fill is to be used, it should be inorganic soils, free of deleterious material with environmental issue (contamination). Any potential imported earth fill from off site must be reviewed for geotechnical and environmental quality by the appropriate personnel as authorized by the developer or agency, before it is hauled to the site.
5. If the engineered fill is to be left over the winter months, adequate earth cover, or equivalent, must be provided for protection against frost action.
6. The engineered fill must extend over the entire graded area; the engineered fill envelope and the finished elevations must be clearly and accurately defined in

the field, and they must be precisely documented by qualified surveyors.

7. Foundations partially on engineered fill must be reinforced by two 15-mm steel reinforcing bars, depending on the thickness of the fill, in the footings and upper section of the foundation walls, or be designed by a structural engineer to properly distribute the stress induced by the abrupt differential settlement (estimated to be 15± mm) between the natural soils and engineered fill.
8. The engineered fill must not be placed during the period from late November to early April, when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
9. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
10. Where the fill is to be placed on a bank steeper than 1 vertical:3 horizontal, the face of the bank must be flattened to 3 + so that it is suitable for safe operation of the compactor and the required compaction can be obtained.
11. Where the ground is wet due to subsurface water seepage, an appropriate subdrain scheme must be implemented prior to the fill placement, particularly if it is to be carried out on sloping ground.
12. The fill operation must be fully supervised and monitored by a technician under the direction of a geotechnical engineer.
13. The footings and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.
14. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who inspected the fill placement in order to document

the locations of excavation and/or to inspect reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.

15. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the foundations must be properly reinforced and designed by structural engineer for the project. The total and differential settlements of 25 mm and 15 mm, respectively, should be considered in the design of the foundations founded on engineered fill. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

7.4 **Underground Services**

The subgrade for the underground services should consist of natural soils or engineered fill. In areas where the subgrade consists of earth fill and/or weathered soil or loose soils, these soils should be subexcavated and replaced with properly compacted inorganic soil and/or bedding material compacted to at least 95% or + of their Standard Proctor compaction.

Where the sewers are to be constructed using the open-cut method, the construction must be carried out in accordance with Ontario Regulation 213/91. In areas where a vertical cut is necessary, the use of a trench box is appropriate.

A Class ‘B’ bedding is recommended for construction of the underground services. The bedding material should consist of compacted 20-mm Crusher-Run Limestone, or equivalent, as approved by a geotechnical engineer. Where water bearing soil is present, a Class ‘A’ bearing should be used. This can be determined at the time of construction.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover with a thickness equal to the diameter of the pipe should be in place at all times after completion of the pipe installation.

Openings to subdrains and catch basins should be shielded with a fabric filter to prevent blockage by silting.

The subgrade of the underground services will generally consist of silty clay till of moderate corrosivity. The underground services should be protected against soil corrosion. For estimation of anode weight requirements, the estimated electrical resistivity of 3500 ohm·cm can be used. This, however, should be confirmed by testing the soil along the water main alignment at the time of sewer construction.

7.5 **Backfilling in Trenches and Excavated Areas**

The backfill in service trenches should be compacted to at least 95% of its maximum Standard Proctor dry density and increased to 98% below the floor-slab.

In the zone within 1.0 m below the road subgrade, the material should be compacted with the water content 2% to 3% drier than the optimum; and the compaction should be increased to 98% of the respective maximum Standard Proctor dry density to provide the required stiffness for pavement construction.

Most of the in situ inorganic soils are generally suitable for use as trench backfill; however, where the soil is too wet for a 95% or + Standard Proctor compaction, it can be aerated by spreading it thinly on the ground for drying prior to structural compaction. In cases where the material is too dry to compact, it may require the addition of water or mixing with a wet material.

In normal construction practice, the problem areas of settlement largely occur adjacent to foundation walls, columns, manholes, catch basins and services crossings. In areas which are inaccessible to a heavy compactor, sand backfill should be used. Unless compaction of the backfill is carefully performed, settlement will occur. Often, the interface of the native soils and sand backfill will have to be flooded for a period of several days.

Narrow trenches for services crossings should be cut at 1V:2H, so that the backfill in the trenches can be effectively compacted. Otherwise, soil arching in the trenches will prevent the achievement of proper compaction. The lift of each backfill layer should either be limited to a thickness of 20 cm, or the thickness should be determined by test strips.

One must be aware of possible consequences during trench backfilling and exercise caution as described below:

- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soil have a water content on the dry side of the optimum, it would be impossible to wet the soil due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction. Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as when the trench box is removed. The above will invariably cause backfill settlement that may become evident within 1 to several years, depending on the depth of the trench which has been backfilled.
- In areas where the underground services construction is carried out during winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement

as the frost recedes, and repair costs will be incurred prior to final surfacing of the new pavement.

- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 1V:1.5+H, and the lifts of the fill and its moisture content are stringently controlled; i.e., lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 95% of the maximum Standard Proctor dry density, with the moisture content on the wet side of the optimum.
- It is often difficult to achieve uniform compaction of the backfill in the lower vertical section of a trench which is an open cut or is stabilized by a trench box, particularly in the sector close to the trench walls or the sides of the box. These sectors must be backfilled with sand. In a trench stabilized by a trench box, the void left after the removal of the box will be filled by the backfill. It is necessary to backfill this sector with sand, and the compacted backfill must be flooded for 1 day, prior to the placement of the backfill above this sector, i.e., in the upper sloped trench section. This measure is necessary in order to prevent consolidation of inadvertent voids and loose backfill which will compromise the compaction of the backfill in the upper section. In areas where groundwater movement is expected in the sand fill mantle, anti-seepage collars should be provided.

7.6 Garages, Driveways and Landscaping

Due to moderately high frost susceptibility of the underlying soil, heaving of the pavement is expected to occur during the cold weather. The driveways at the entrances to the garages must be backfilled with non-frost-susceptible granular material, with a frost taper at a slope of 1V:1H.

The slab-on-grade in open areas should be designed to tolerate frost heave, and the grading around the slab-on-grade must be such that it directs runoff away from the surface.

Interlocking stone pavement and slab-on-grade to be constructed in areas susceptible to ground movement must be constructed on a free-draining granular base at least 1.0 m thick, with proper drainage, which will prevent water from ponding in the granular base.

7.7 Pavement Design

In preparation of the pavement subgrade, topsoil and earth fill must be removed and the entire area should be proofrolled. Any soft spots should be subexcavated, and replaced by properly compacted inorganic earth fill. New fill should consist of organic free material, compacted to 95% or + of its maximum Standard Proctor dry density. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to 98% or + of its maximum Standard Proctor dry density, with the water content 2% to 3% drier than the optimum. The pavement design for local residential roadway and collectors is presented in Table 5.

Table 5 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	60	HL-8
Granular Base	150	OPSS Granular ‘A’
Granular Sub-Base	350	OPSS Granular ‘B’

All the granular bases should be compacted to their maximum Standard Proctor dry density.

The pavement subgrade will suffer a strength regression if water is allowed to infiltrate prior to paving. The following measures should therefore be incorporated into the construction and pavement design:

- If the pavement construction does not immediately follow the trench backfilling, the subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- Lot areas adjacent to the roads should be properly graded to prevent the ponding of large amounts of water during the interim construction period.
- If the roads are to be constructed during the wet seasons and extremely soft subgrade occurs, the granular sub-base may require thickening. This can be further assessed during construction.
- Fabric filter-encased curb subdrains are required to meet the Town requirements. These subdrains should be collected to catch basins or positive outlets where water can be removed by gravity.

7.8 Soil Parameters

The recommended soil parameters for the project design are given in Table 6.

Table 6 - Soil Parameters

Unit Weight and Bulk Factor	**Unit Weight (kN/m^3)**	**Estimated Bulk Factor**	
	Bulk	**Loose**	**Compacted**
Earth Fill	21.0	1.25	1.00
Silty Clay Till / Sandy Silt Till	22.0	1.33	1.05
Lateral Earth Pressure Coefficients	**Active K_a**	**At Rest K_o**	**Passive K_p**
Compacted Earth Fill	0.43	0.60	2.30
Silty Clay Till / Sandy Silt Till	0.36	0.53	2.70

Table 6 - Soil Parameters (cont'd)

Coefficients of Friction	
Between Concrete and Granular Base	0.50
Between Concrete and Sound Natural Soils	0.40

7.9 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. For excavation purposes, the types of soils are classified in Table 7.

Table 7 - Classification of Soils for Excavation

Material	Type
Silty Clay Till / Sandy Silt Till	2
Earth Fill	3

Excavation into the till containing cobbles and boulders will require extra effort and the use of heavy-duty equipment.

In excavation, any groundwater yield is anticipated to be slow in rate and limited in quantity. It can be collected into a sump and remove by conventional pumping.

Prospective contractors must be asked to assess the in situ subsurface conditions for soil cuts by digging test pits to at least 0.5 m below the sewer subgrade. These test pits should be allowed to remain open for a period of at least 4 hours to assess the trenching conditions.

8.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Brookvalley Project Management Inc., for review by the designated consultants, financial institutions, and government agencies. Use of this report is subject to the conditions and limitations of the contractual agreement. The material in the report reflects the judgment of Adrian Lo, B.Sc. and Bennett Sun, P.Eng., in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

SOIL ENGINEERS LTD.

Adrian Lo

Adrian Lo, B.Sc.

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AL/BS

LICENSED PROFESSIONAL ENGINEER
CHUN C. B. SUN
July 6, 2018
PROVINCE OF ONTARIO

LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

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

SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open (split spoon)
DS	Denison type sample
FS	Foil sample
RC	Rock core (with size and percentage recovery)
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—•—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

SOIL DESCRIPTION

Cohesionless Soils:

'N' (blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (blows/ft)	Consistency
less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0 Field vane test in borehole; the number denotes the sensitivity to remoulding

△ Laboratory vane test

☐ Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

METRIC CONVERSION FACTORS

1 ft = 0.3048 metres

1lb = 0.454 kg

1 inch = 25.4 mm

1ksf = 47.88 kPa

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GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE

JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

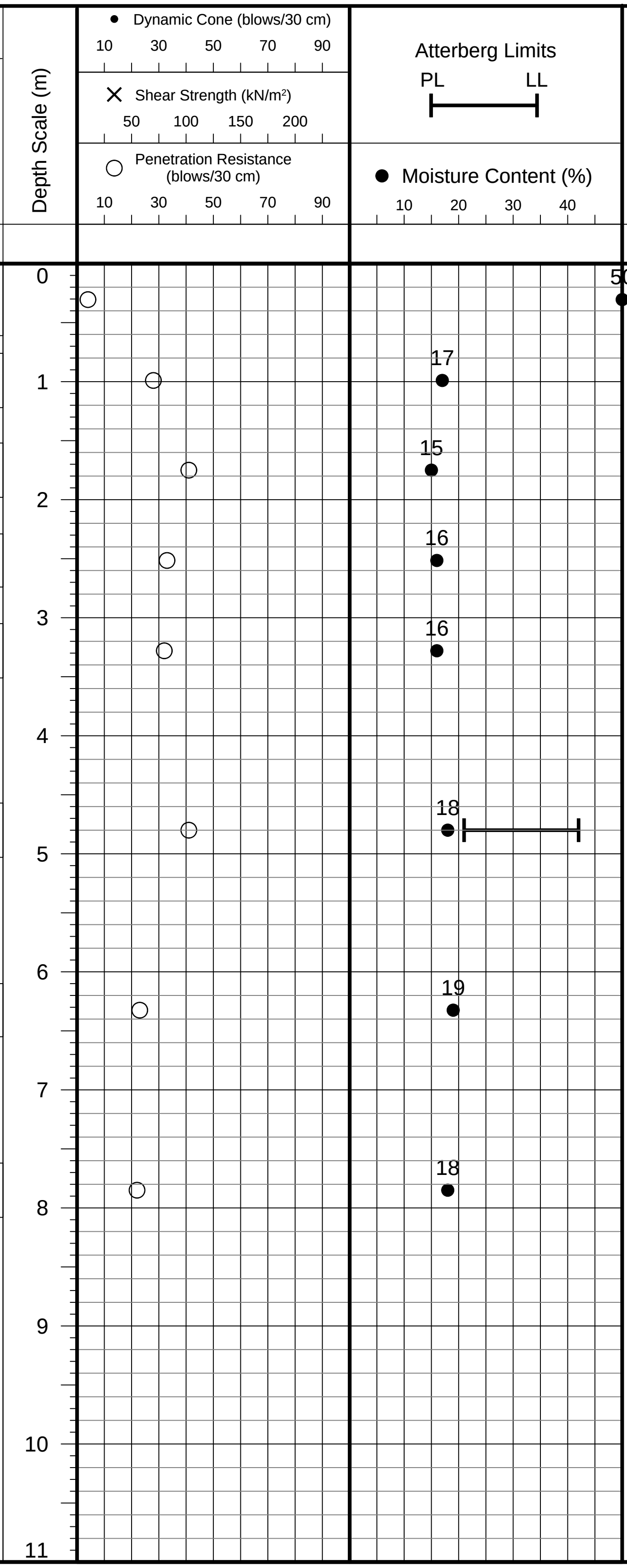
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 26, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
256.5	Ground Surface				
256.3 0.2	**160 mm TOPSOIL**				Dry on completion
	Brown, hard weathered	1	DO	4	
	SILTY CLAY TILL trace of gravel occ. sand seams, cobbles and boulders	2	DO	28	
		3	DO	41	
		4	DO	33	
		5	DO	32	
		6	DO	41	
	brown grey				
		7	DO	23	
		8	DO	22	
248.4 8.1	**END OF BOREHOLE**				



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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

PROJECT DESCRIPTION: Proposed Residential Development

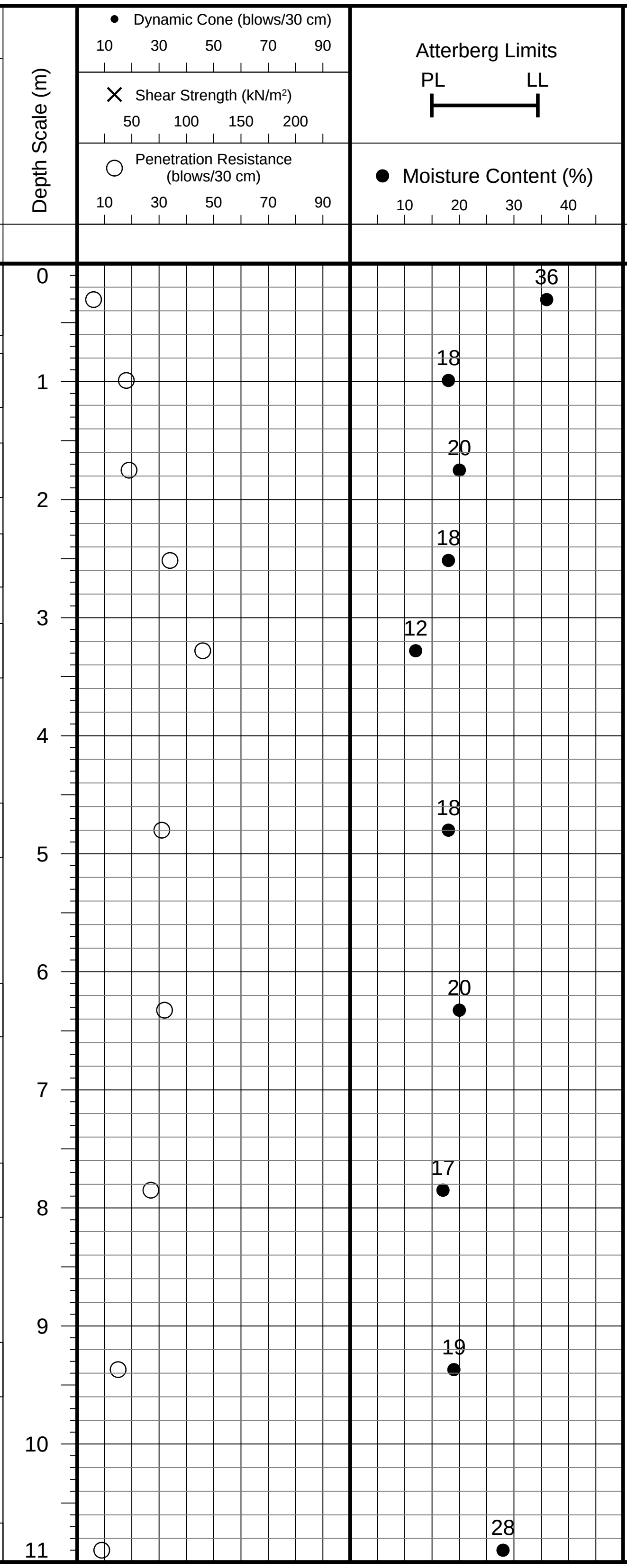
METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 26, 2018

El. (m) Depth (m)	SOIL DESCRIPTION
255.7	Ground Surface
255.5 0.2	**160 mm TOPSOIL**
	Brown, stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders
	weathered
	sandy
	brown grey

SAMPLES		
Number	Type	N-Value
1	DO	6
2	DO	18
3	DO	19
4	DO	34
5	DO	46
6	DO	31
7	DO	32
8	DO	27
9	DO	15
10	DO	9



WATER LEVEL

W.L @ Ele. 252.7 m upon completion.

Soil Engineers Ltd.

JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

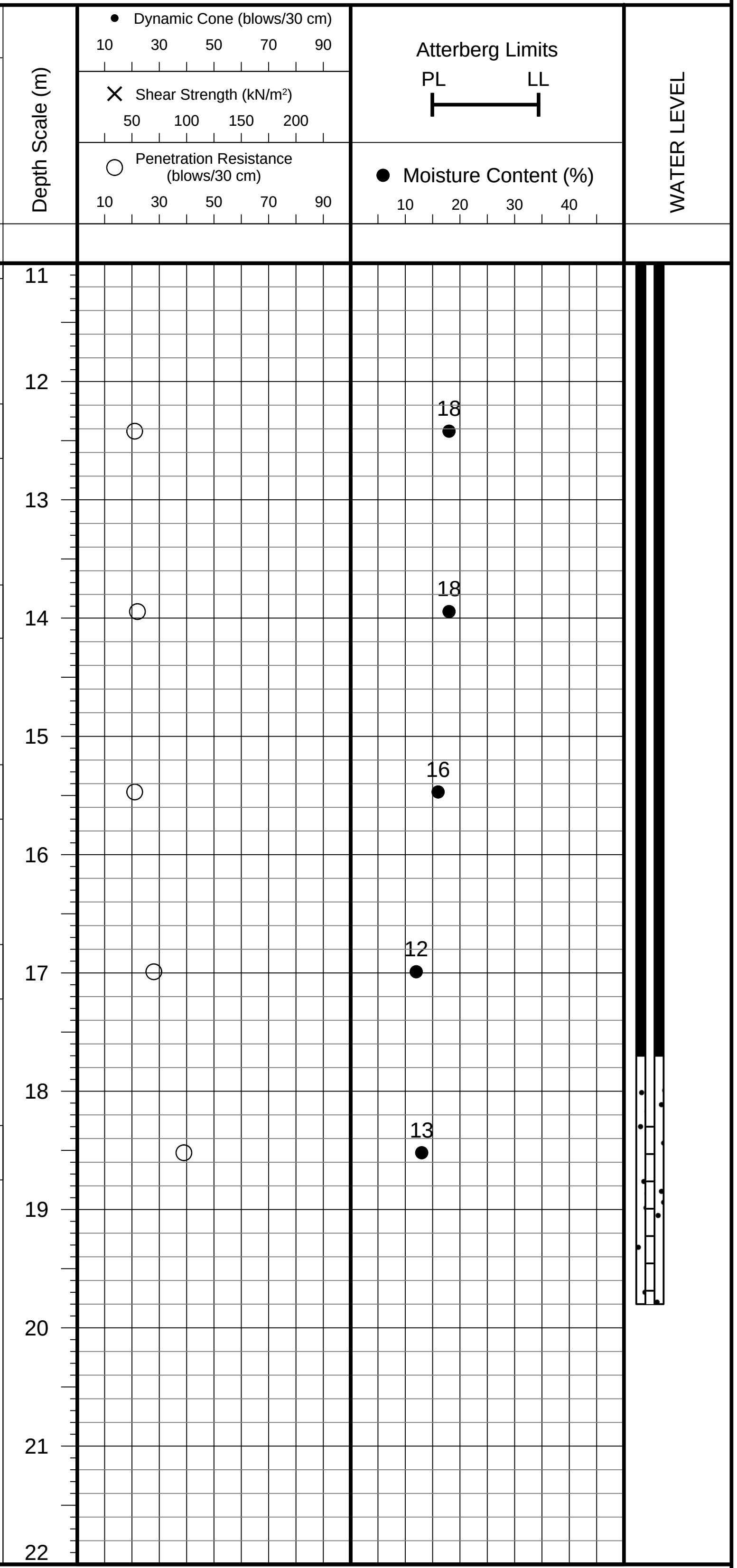
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 26, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
	SILTY CLAY TILL (Cont'd)			
		11	DO	21
		12	DO	22
		13	DO	21
239.3 16.4	Grey, compact to dense **SANDY SILT TILL** some clay and sand trace of gravel occ. sand seams, cobbles and boulders			
		14	DO	28
		15	DO	39
235.9 19.8	**END OF BOREHOLE** **Installed 50 mm Ø monitoring well to 19.8 m completed with 1.5 m screen.** **Sand backfill from 17.7 m to 19.8 m.** **Bentonite seal from 0 m to 17.7 m.** **Provided with protective monument casing.**			



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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 2N

FIGURE NO.: 2

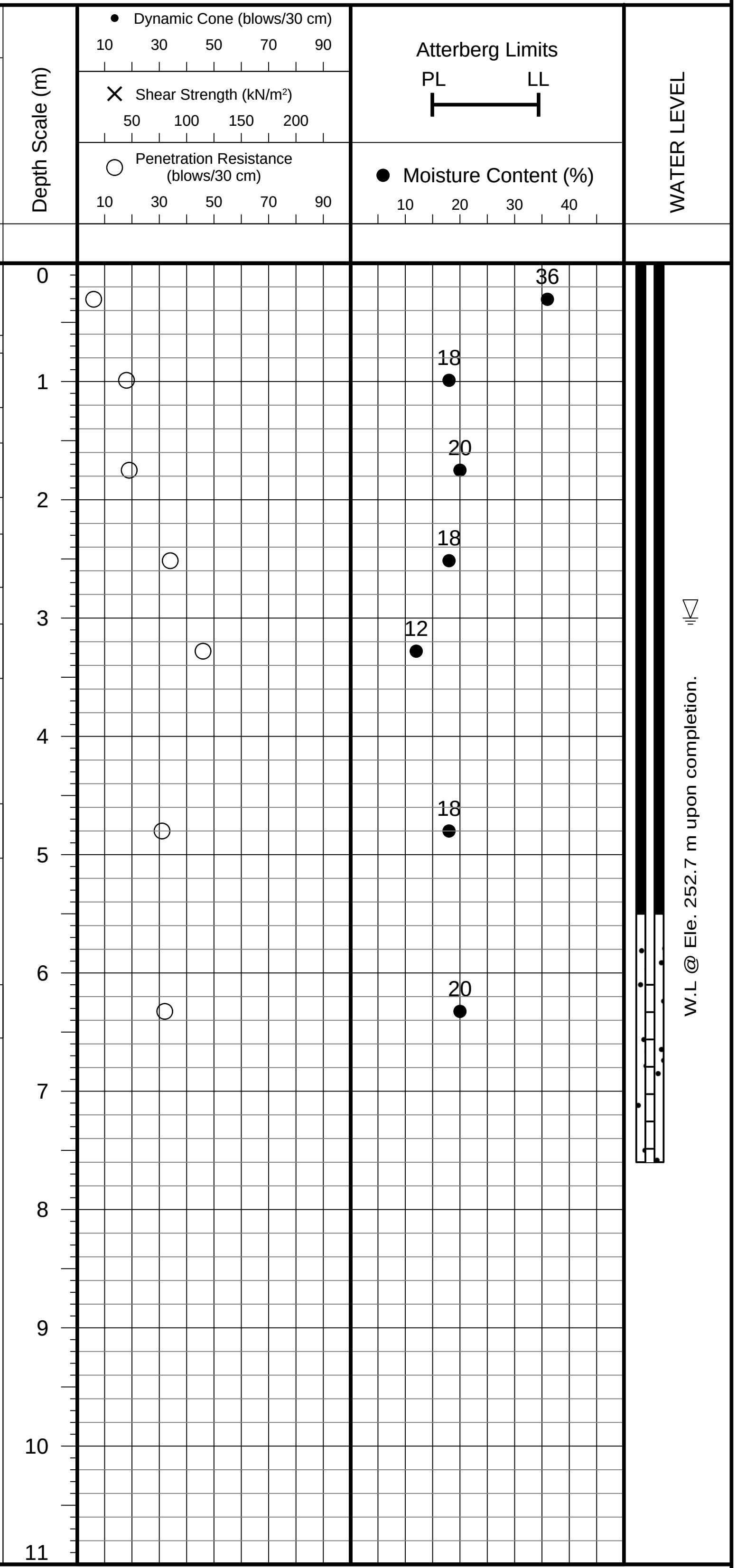
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 26, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
255.7 0.0	Ground Surface			
	Brown, firm to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	1	DO	6
		2	DO	18
		3	DO	19
		4	DO	34
		5	DO	46
		6	DO	31
		7	DO	32
248.1 7.6	**END OF BOREHOLE** **Installed 50 mm Ø monitoring well to 7.6 m completed with 1.5 m screen.** **Sand backfill from 5.5 m to 7.6 m.** **Bentonite seal from 0 m to 5.5 m.** **Provided with protective monument casing.**			



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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

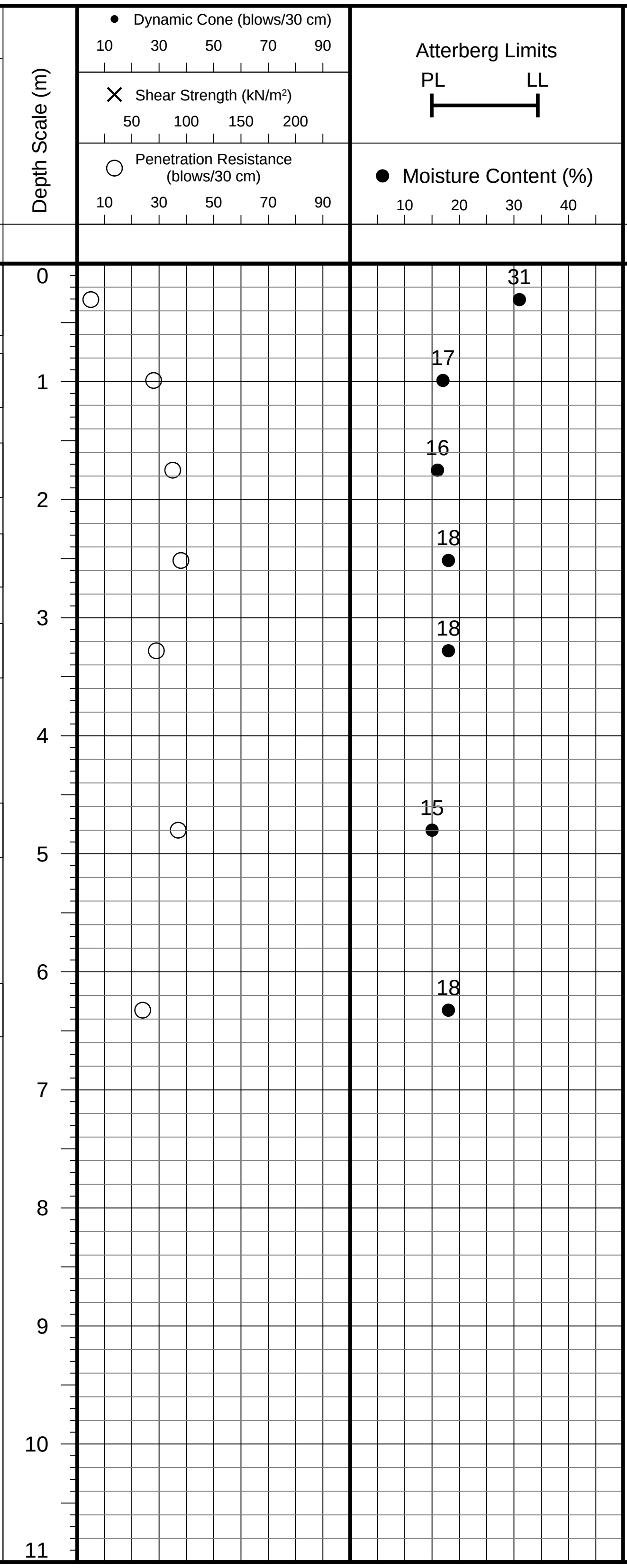
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 26, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
255.8	Ground Surface			
0.0	**260 mm TOPSOIL**			
255.5 0.3	Brown, very stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	1	DO	5
	weathered	2	DO	28
		3	DO	35
		4	DO	38
		5	DO	29
		6	DO	37
	brown grey	7	DO	24
249.3 6.5	**END OF BOREHOLE**			



WATER LEVEL

Dry on completion

Soil Engineers Ltd.

JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

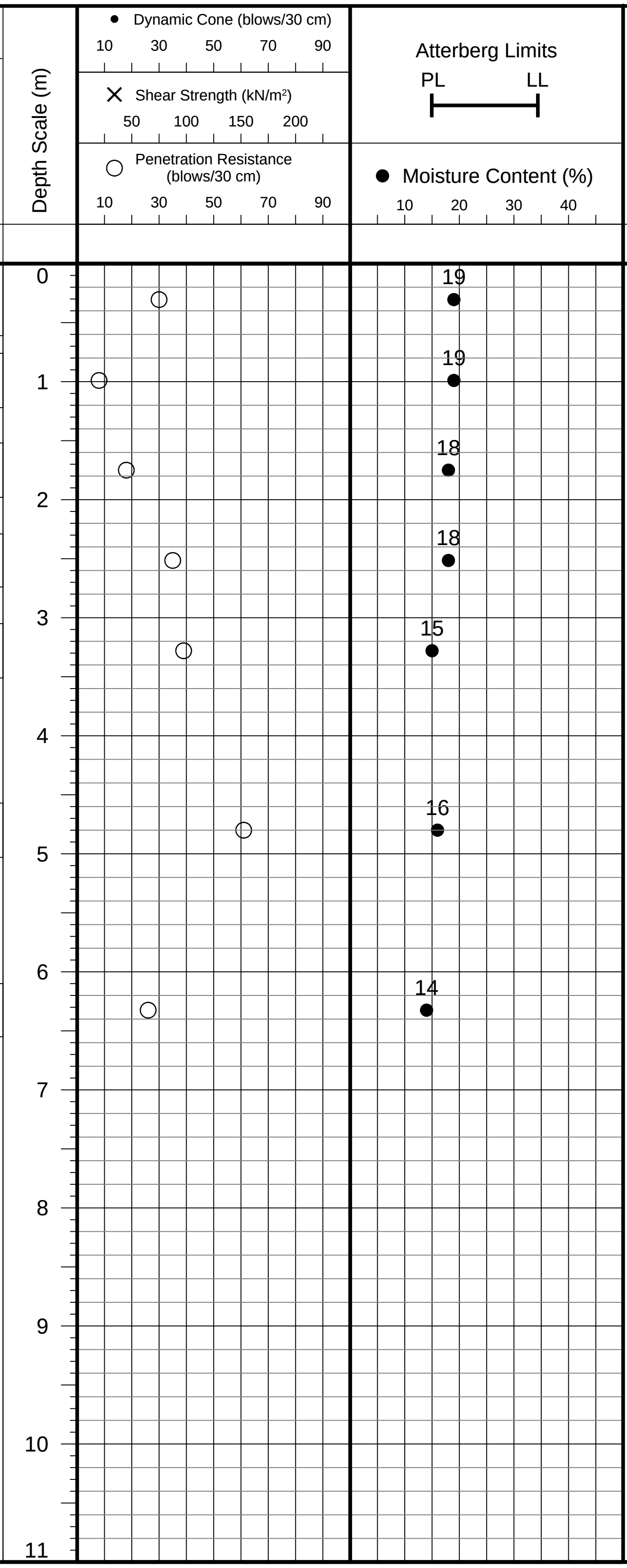
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 29, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
258.9	Ground Surface				
	210 mm TOPSOIL				
258.7 0.2	**EARTH FILL** brown and grey silty clay pockets of sand and gravel some topsoil and rootlets	1	DO	30	Dry on completion
		2	DO	8	
257.3 1.6	Brown, very stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	3	DO	18	
		4	DO	35	
		5	DO	39	
		6	DO	61	
	brown grey				
		7	DO	26	
252.4 6.5	**END OF BOREHOLE**				



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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

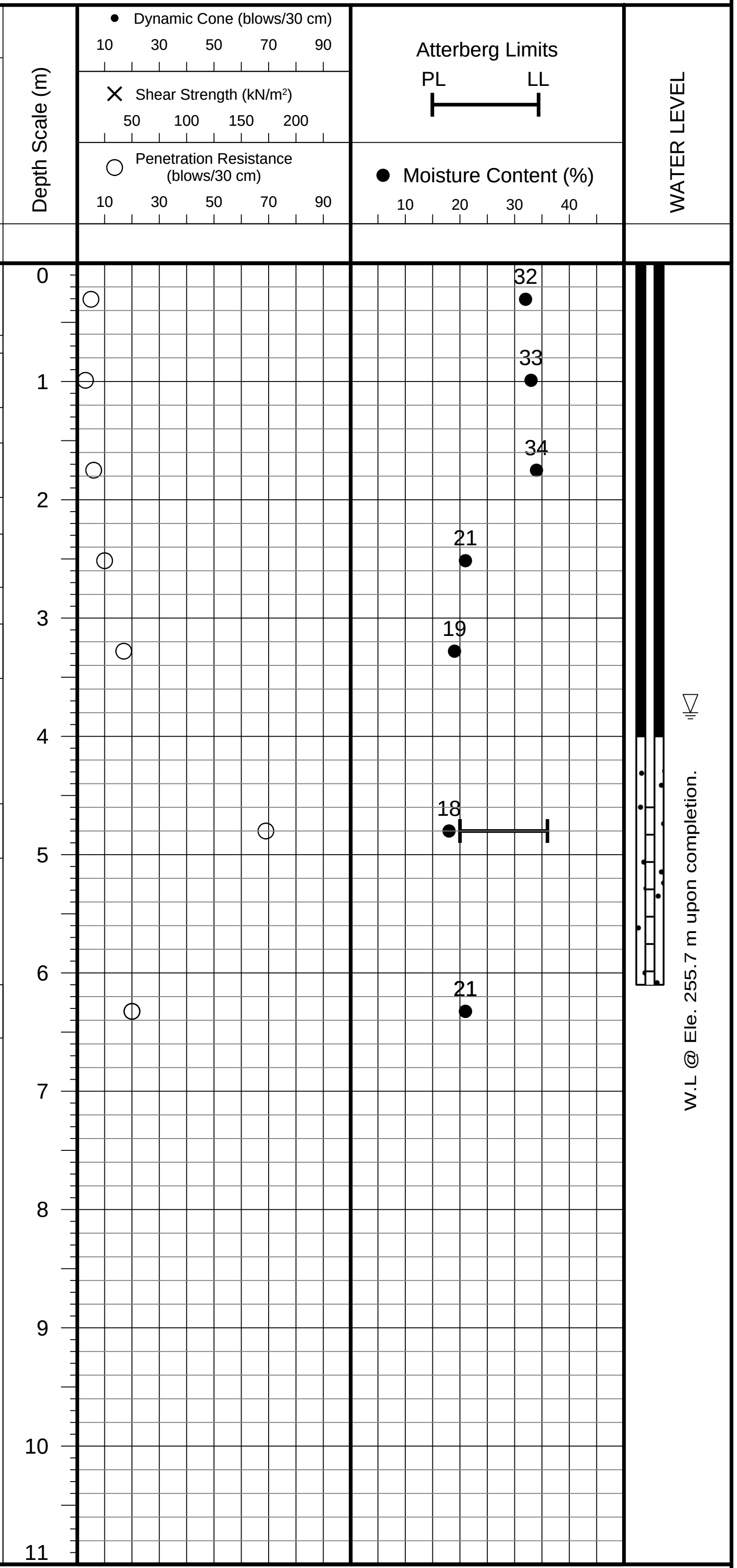
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 29, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
259.5	Ground Surface			
0.0	**440 mm TOPSOIL**	1	DO	5
259.1 0.4	**EARTH FILL** brown and grey silty clay pockets of topsoil some rootlets occ. wood pieces	2	DO	3
		3	DO	6
257.1 2.4	Grey and brown, stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	4	DO	10
		5	DO	17
		6	DO	69
		7	DO	20
253.0 6.5	**END OF BOREHOLE** **Installed 50 mm Ø monitoring well to 6.1 m completed with 1.5 m screen.** **Sand backfill from 4 m to 6.1 m.** **Bentonite seal from 0 m to 4 m.** **Provided with protective monument casing.**			



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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

PROJECT DESCRIPTION: Proposed Residential Development

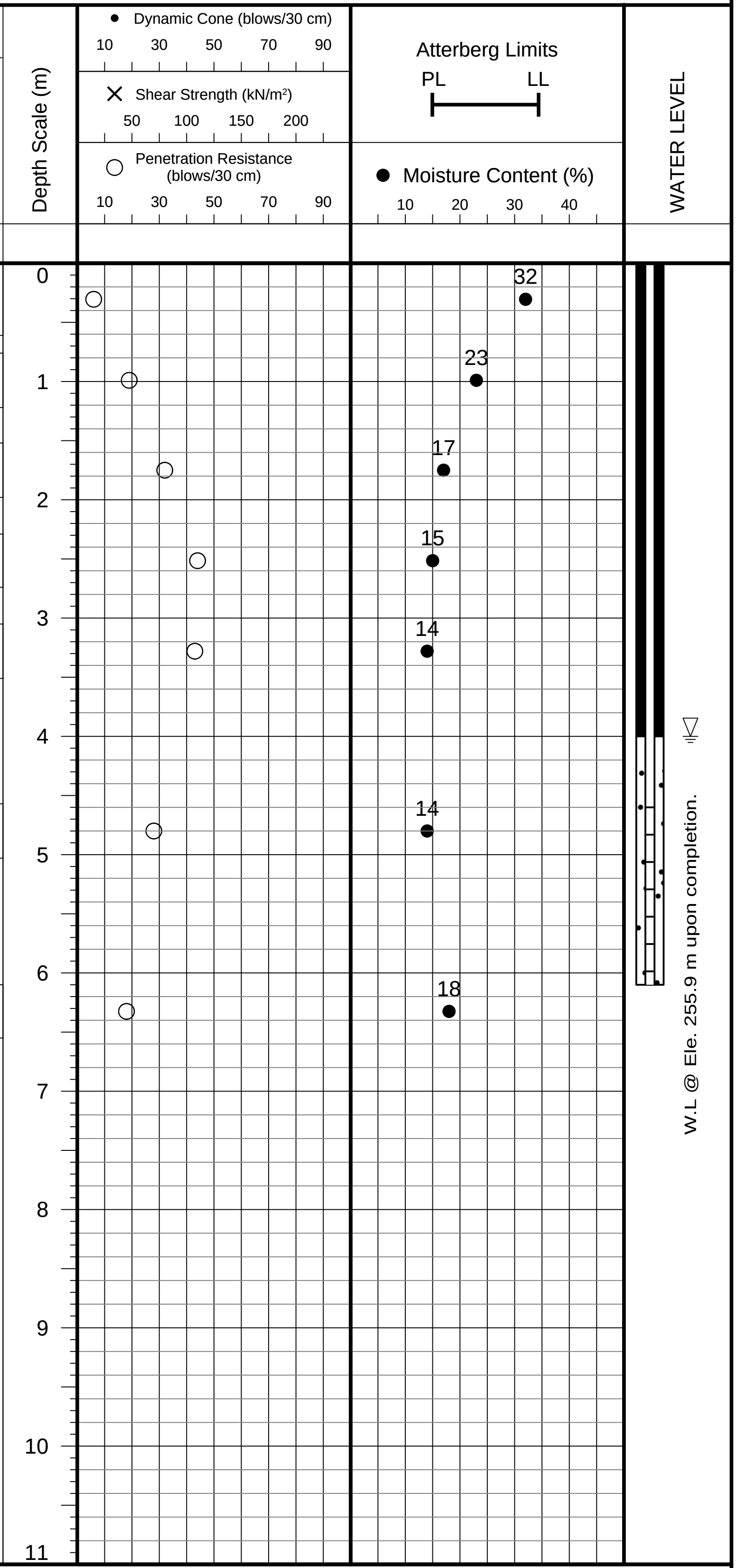
METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 25, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
259.9	Ground Surface			
259.7 0.2	**230 mm TOPSOIL**			
	Very stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders weathered	1	DO	6
		2	DO	19
		3	DO	32
		4	DO	44
		5	DO	43
		6	DO	28
	brown grey			
253.3 6.5		7	DO	18

END OF BOREHOLE
Installed 50 mm Ø monitoring well to 6.1 m completed with 1.5 m screen.
Sand backfill from 4 m to 6.1 m.
Bentonite seal from 0 m to 4 m.
Provided with protective monument casing.



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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

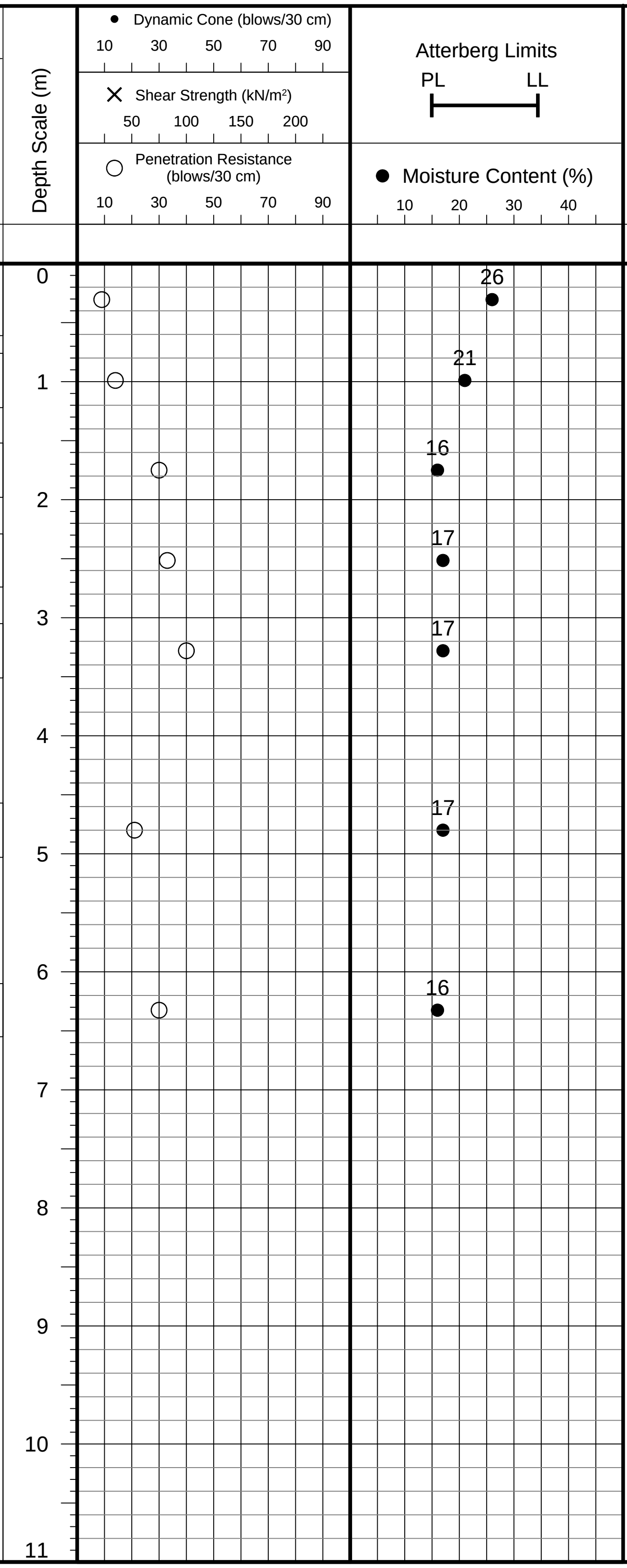
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 23, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
260.0 0.0	Ground Surface **280 mm TOPSOIL**			
259.7 0.3	**EARTH FILL** brown silty clay mixed with topsoil some brick fragments	1	DO	9
259.1 0.9	Stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	2	DO	14
		3	DO	30
		4	DO	33
		5	DO	40
	brown grey	6	DO	21
		7	DO	30
253.5 6.5	**END OF BOREHOLE**			



WATER LEVEL

∇

W.L @ Ele. 259.7 m upon completion.

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Page: 1 of 1

JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

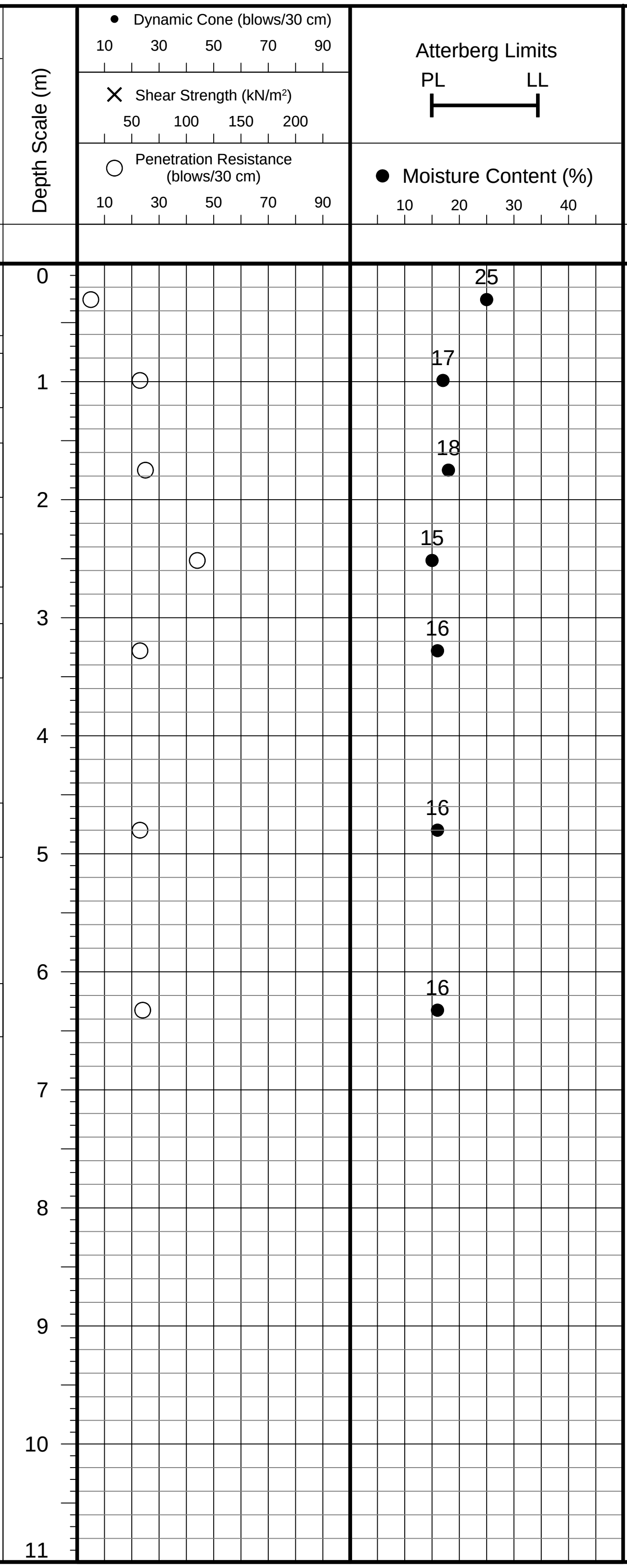
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 23, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
259.5	Ground Surface			
259.3 0.2	**210 mm TOPSOIL**			
	Very stiff to hard **SILTY CLAY TILL** weathered trace of gravel occ. sand seams, cobbles and boulders	1	DO	5
		2	DO	23
		3	DO	25
		4	DO	44
		5	DO	23
		6	DO	23
	brown grey			
		7	DO	24
253.0 6.5	**END OF BOREHOLE**			



WATER LEVEL

Dry on completion

Soil Engineers Ltd.

JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

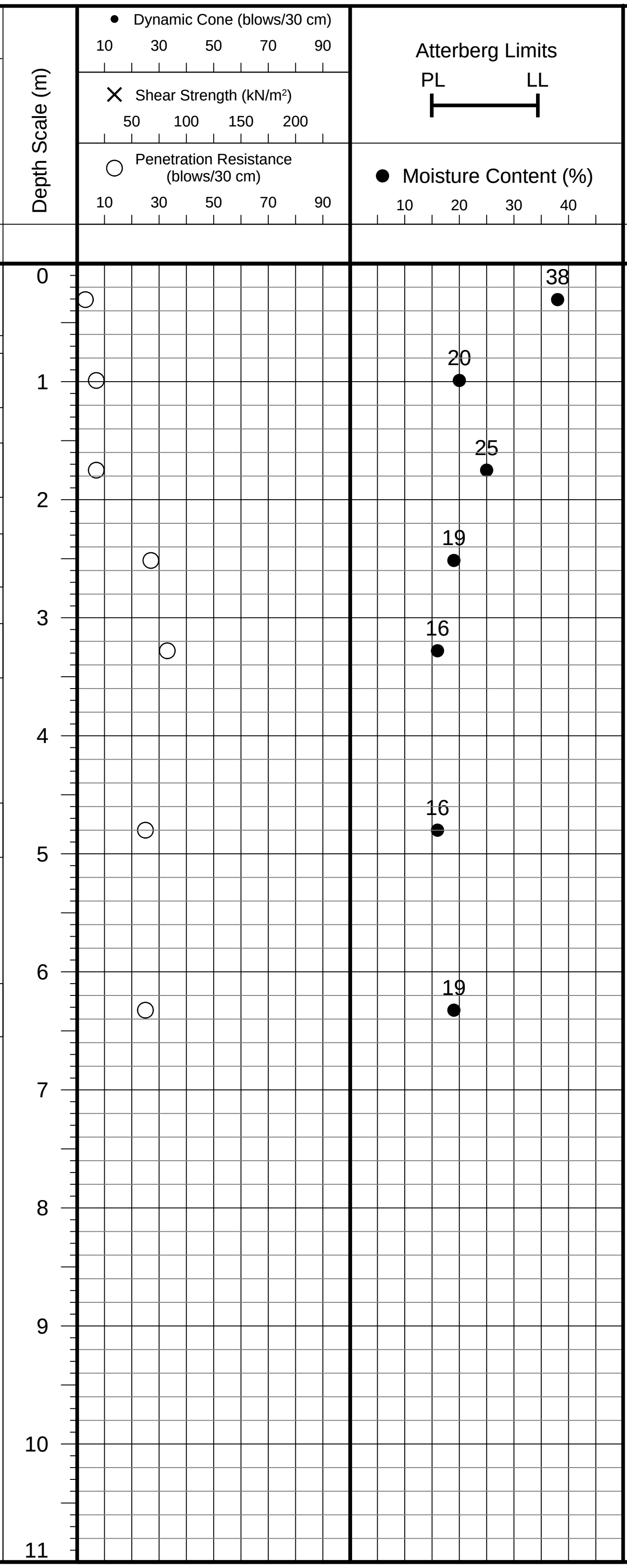
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 23, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
260.0	Ground Surface			
0.0	**280 mm TOPSOIL**			
259.7 0.3	**EARTH FILL** brown silty clay pockets of topsoil occ. rootlets	1	DO	3
259.2 0.8	Very stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	2	DO	7
		3	DO	7
		4	DO	27
		5	DO	33
	brown grey			
		6	DO	25
		7	DO	25
253.5 6.5	**END OF BOREHOLE**			



WATER LEVEL

W.L @ Ele. 258.5 m upon completion.

Cave-In @ Ele. 256 m upon completion.

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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 10

FIGURE NO.: 10

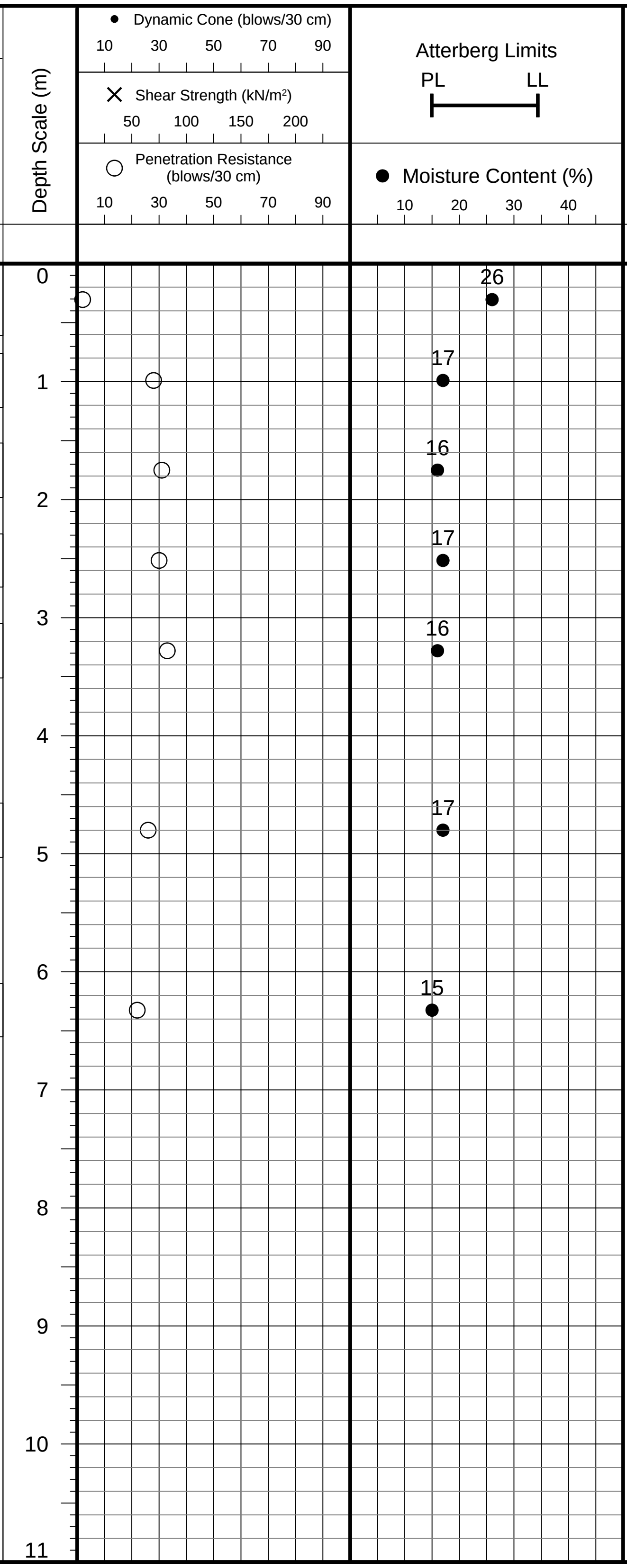
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 23, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
257.8	Ground Surface			
0.0	**280 mm TOPSOIL**			
257.5 0.3	Very stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	1	DO	2
	weathered	2	DO	28
		3	DO	31
		4	DO	30
	brown grey	5	DO	33
		6	DO	26
		7	DO	22
251.3 6.5	**END OF BOREHOLE**			



WATER LEVEL: Dry on completion

Soil Engineers Ltd.

JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 11

FIGURE NO.: 11

PROJECT DESCRIPTION: Proposed Residential Development

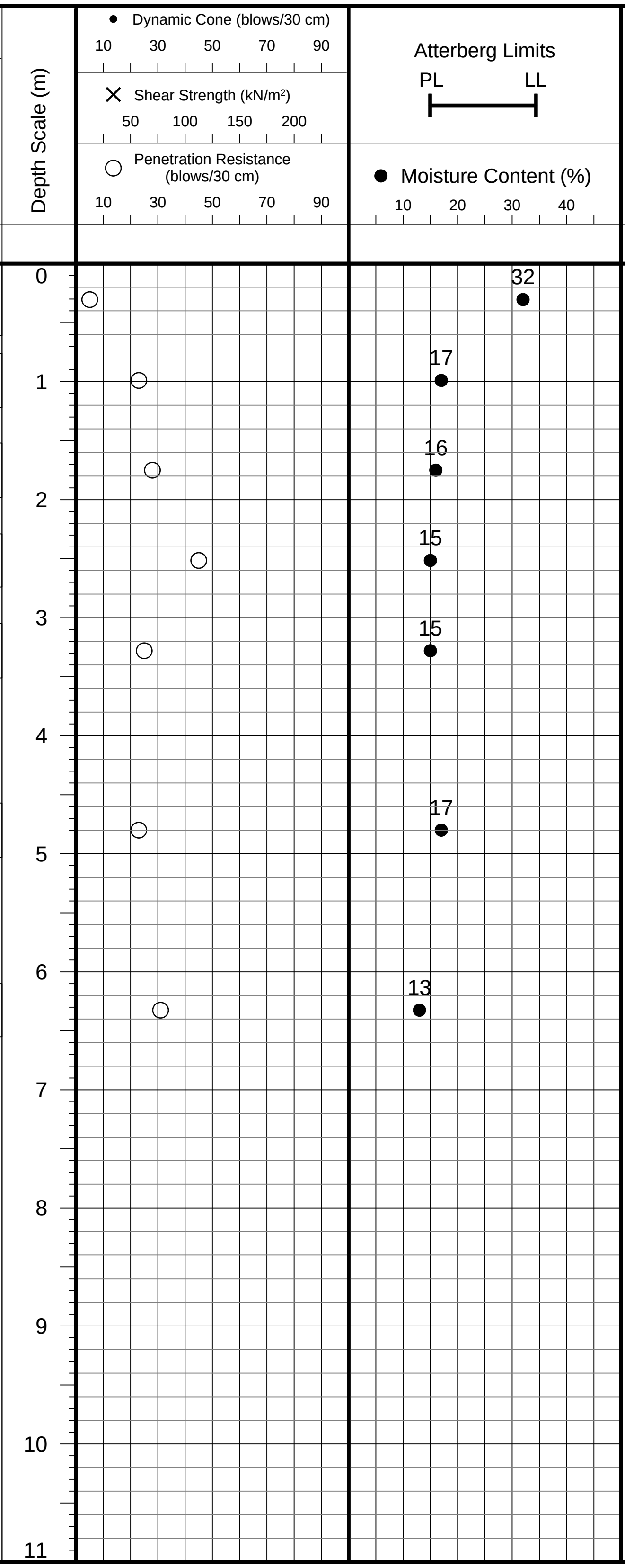
METHOD OF BORING: Flight-Auger
(Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 23, 2018

El. (m) Depth (m)	SOIL DESCRIPTION
259.3	Ground Surface
259.1 0.2	**210 mm TOPSOIL**
258.7 0.6	**EARTH FILL** dark brown silty clay mixed with topsoil some gravel
	Very stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders brown grey
252.8 6.5	**END OF BOREHOLE**

SAMPLES Number	Type	N-Value
1	DO	5
2	DO	23
3	DO	28
4	DO	45
5	DO	25
6	DO	23
7	DO	31



WATER LEVEL

Dry on completion

Soil Engineers Ltd.

JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 12

FIGURE NO.: 12

PROJECT DESCRIPTION: Proposed Residential Development

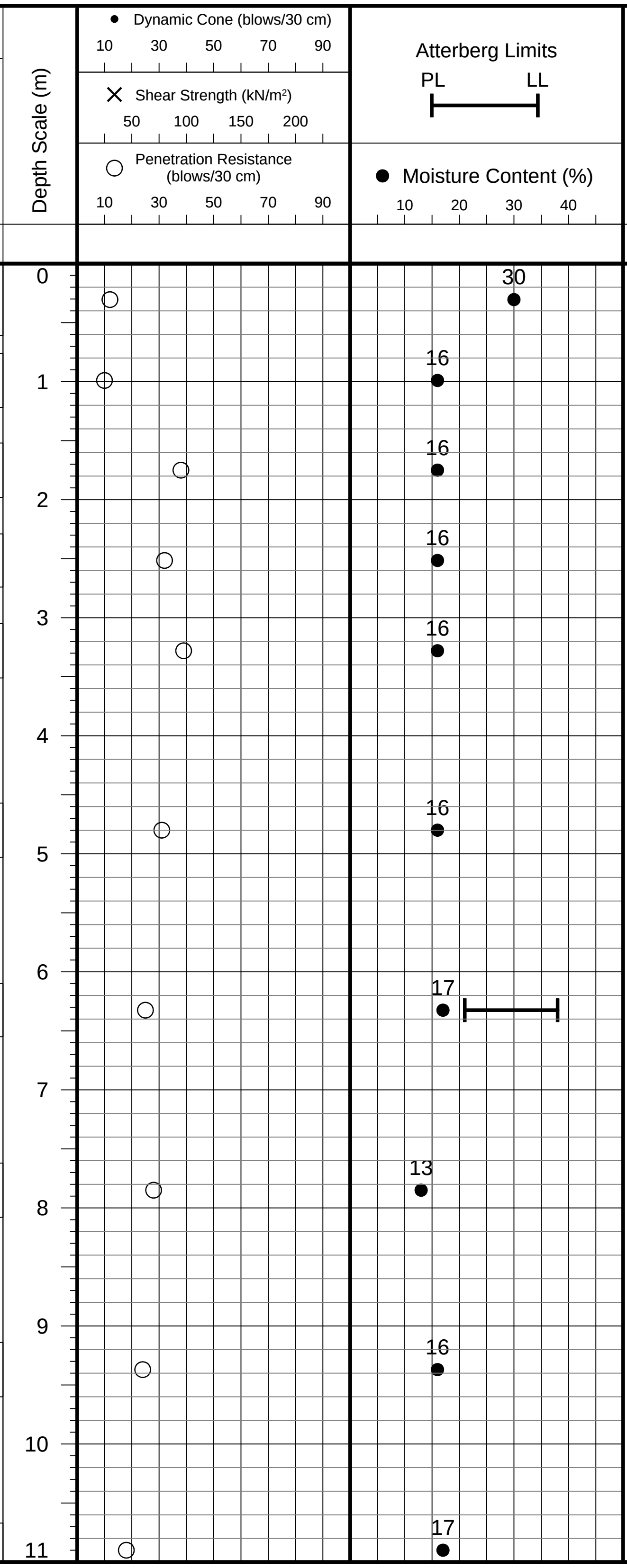
METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 24, 2018

El. (m) Depth (m)	SOIL DESCRIPTION
258.3	Ground Surface
0.0	**460 mm TOPSOIL**
257.8 0.5	Stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders weathered brown / grey

SAMPLES		
Number	Type	N-Value
1	DO	12
2	DO	10
3	DO	38
4	DO	32
5	DO	39
6	DO	31
7	DO	25
8	DO	28
9	DO	24
10	DO	18



WATER LEVEL

W.L @ Ele. 252.2 m upon completion.

LOG OF BOREHOLE NO.: 12

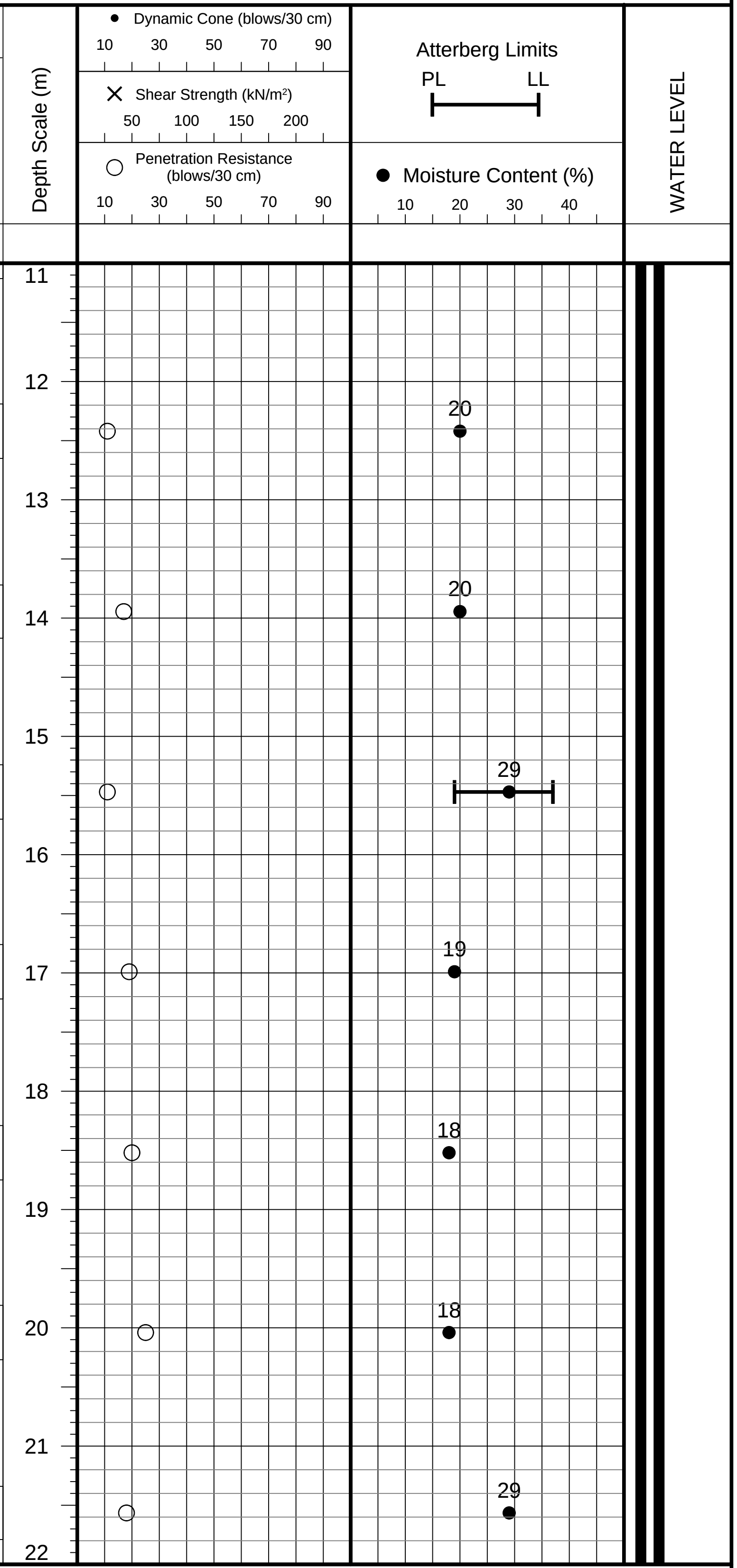
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger
(Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 24, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
	SILTY CLAY TILL (Cont'd)			
		11	DO	11
		12	DO	17
	silty clay layer	13	DO	11
		14	DO	19
		15	DO	20
		16	DO	25
		17	DO	18



JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 12

FIGURE NO.: 12

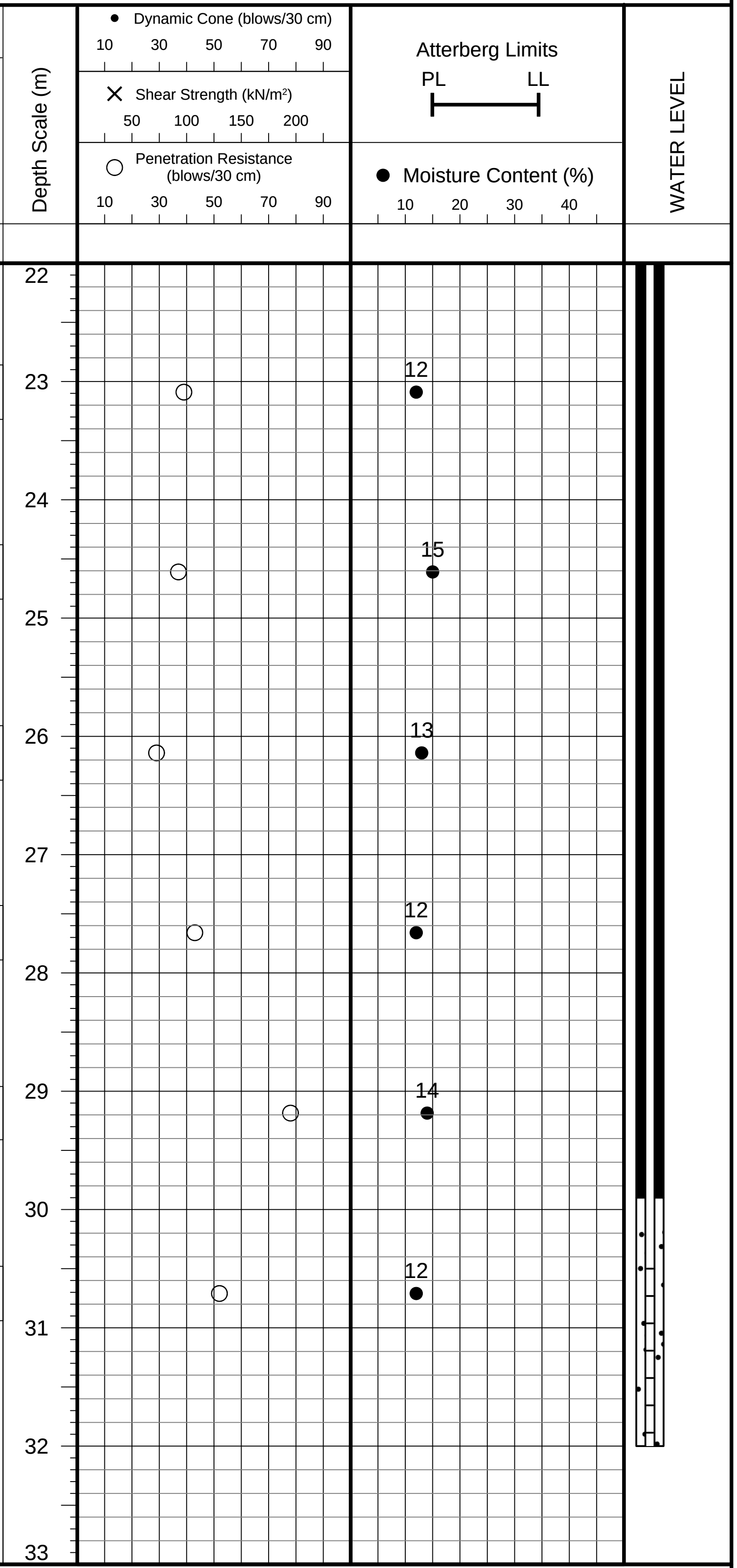
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 24, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
235.8 22.5	Grey, compact to very dense **SANDY SILT TILL** some clay and gravel occ. sand seams, cobbles and boulders	18	DO	39
		19	DO	37
		20	DO	29
		21	DO	43
		22	DO	78
		23	DO	52
226.3 32.0	**END OF BOREHOLE** **Installed 50 mm Ø monitoring well to 32 m completed with 1.5 m screen.Sand backfill from 29.9 m to 32 m. Bentonite seal from 0 m to 29.9 m. Provided with protective monument casing.**			



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JOB NO.: 1801-S032

LOG OF BOREHOLE NO.: 12N

FIGURE NO.: 12

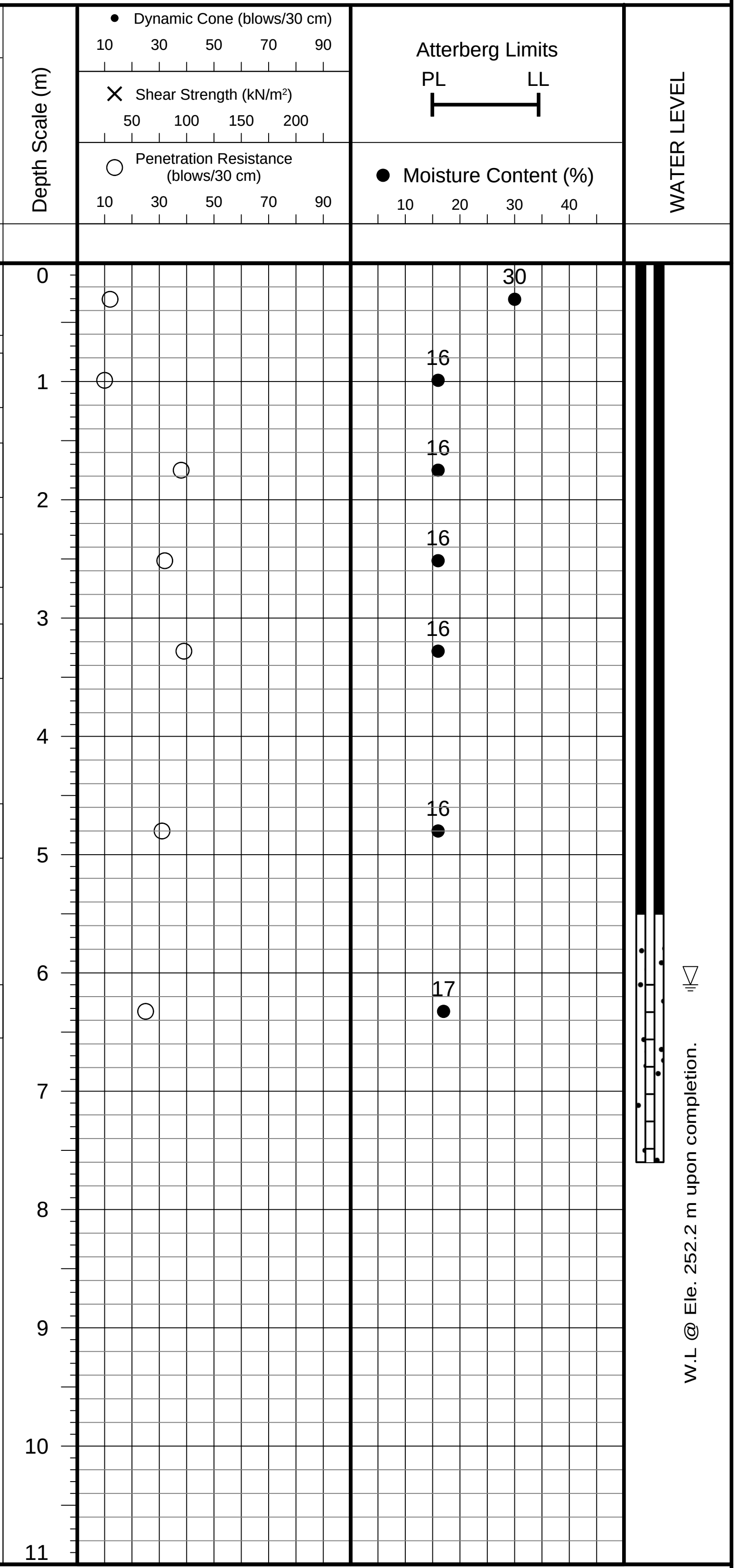
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger (Solid-Stem)

PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

DRILLING DATE: January 24, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
258.3	Ground Surface			
0.0	Brown, stiff to hard **SILTY CLAY TILL** trace of gravel occ. sand seams, cobbles and boulders	1	DO	12
		2	DO	10
		3	DO	38
		4	DO	32
		5	DO	39
		6	DO	31
		7	DO	25
250.7 7.6	**END OF BOREHOLE** **Installed 50 mm Ø monitoring well to 7.6 m completed with 1.5 m screen.** **Sand backfill from 5.5 m to 7.6 m.** **Bentonite seal from 0 m to 5.5 m.** **Provided with protective monument casing.**			



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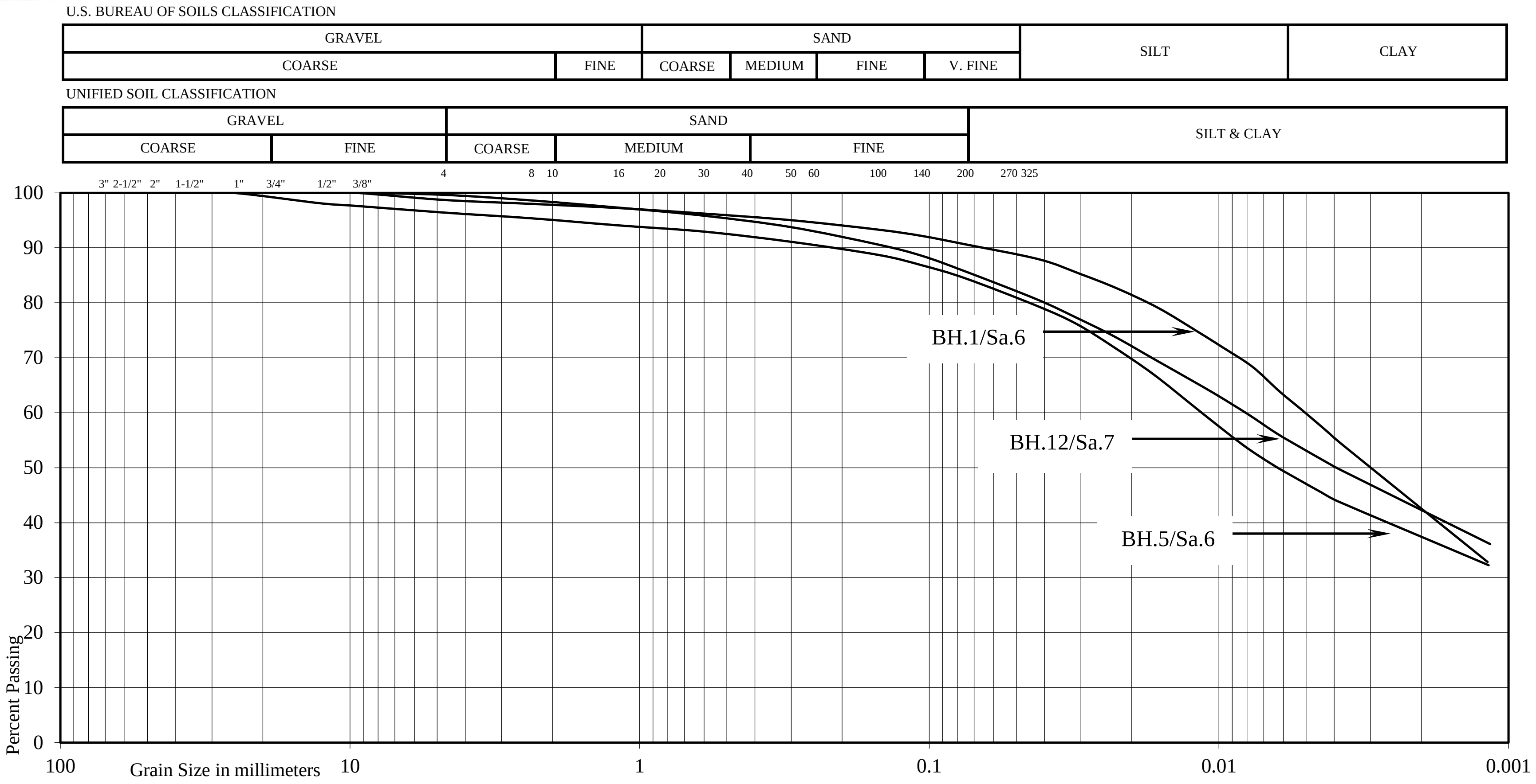
GRAIN SIZE DISTRIBUTION

Reference No: 1801-S032



Project: Proposed Residential Development

Location: Chickadee Lane and Glasgow Road, Town of Caledon

Borehole No:	1	5	12
Sample No:	6	6	7
Depth (m):	4.7	4.7	6.3
Elevation (m):	251.8	254.8	252.0

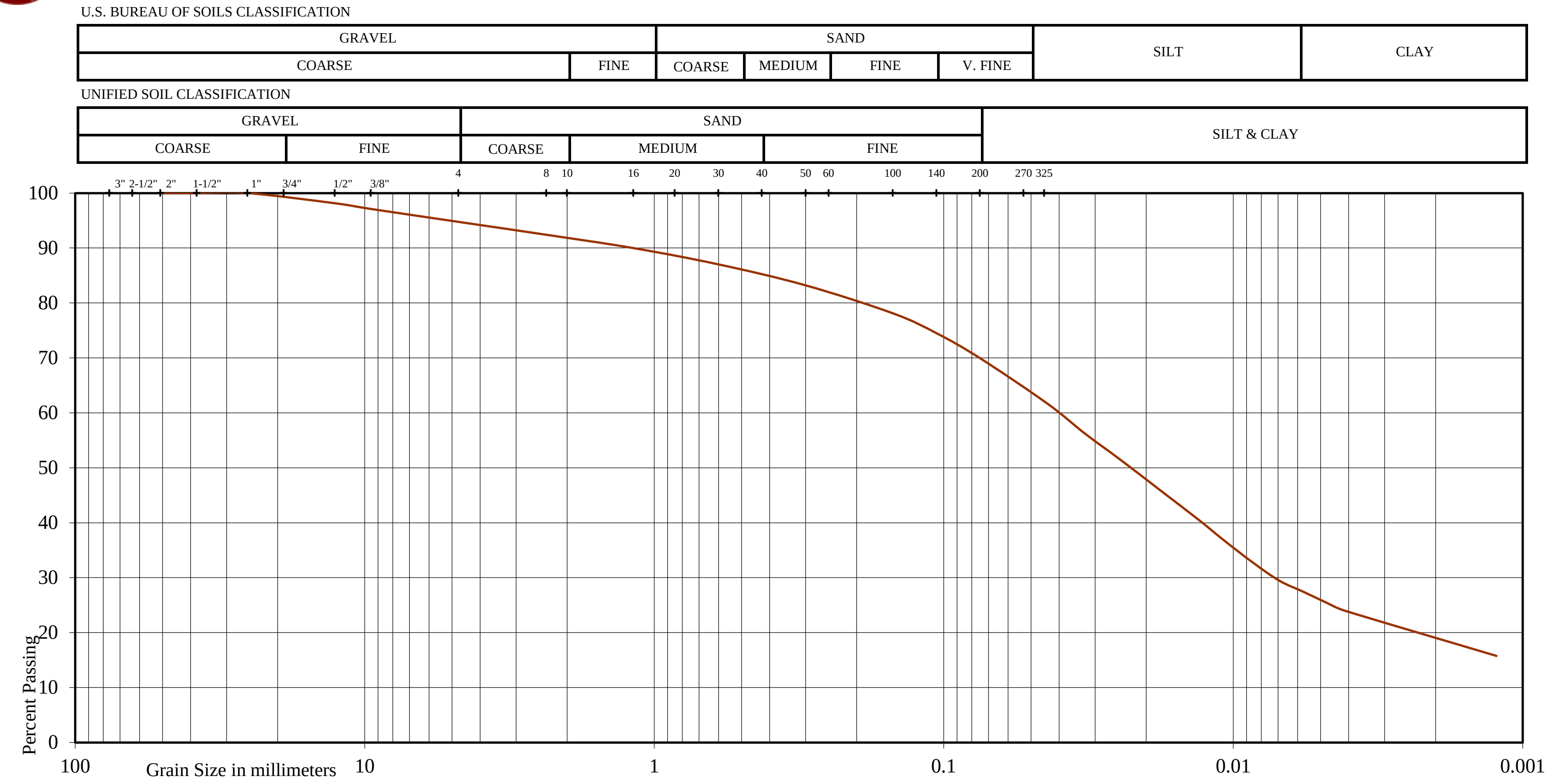
BH./Sa.	1/6	5/6	12/7
Liquid Limit (%) =	42	36	38
Plastic Limit (%) =	21	20	21
Plasticity Index (%) =	21	16	17
Moisture Content (%) =	18	18	17
Estimated Permeability (cm./sec.) =	10^{-7}	10^{-7}	10^{-7}

Classification of Sample [& Group Symbol]: SILTY CLAY TILL, a trace to some sand, a trace of gravel

Figure: 13

GRAIN SIZE DISTRIBUTION

Reference No: 1801-S032

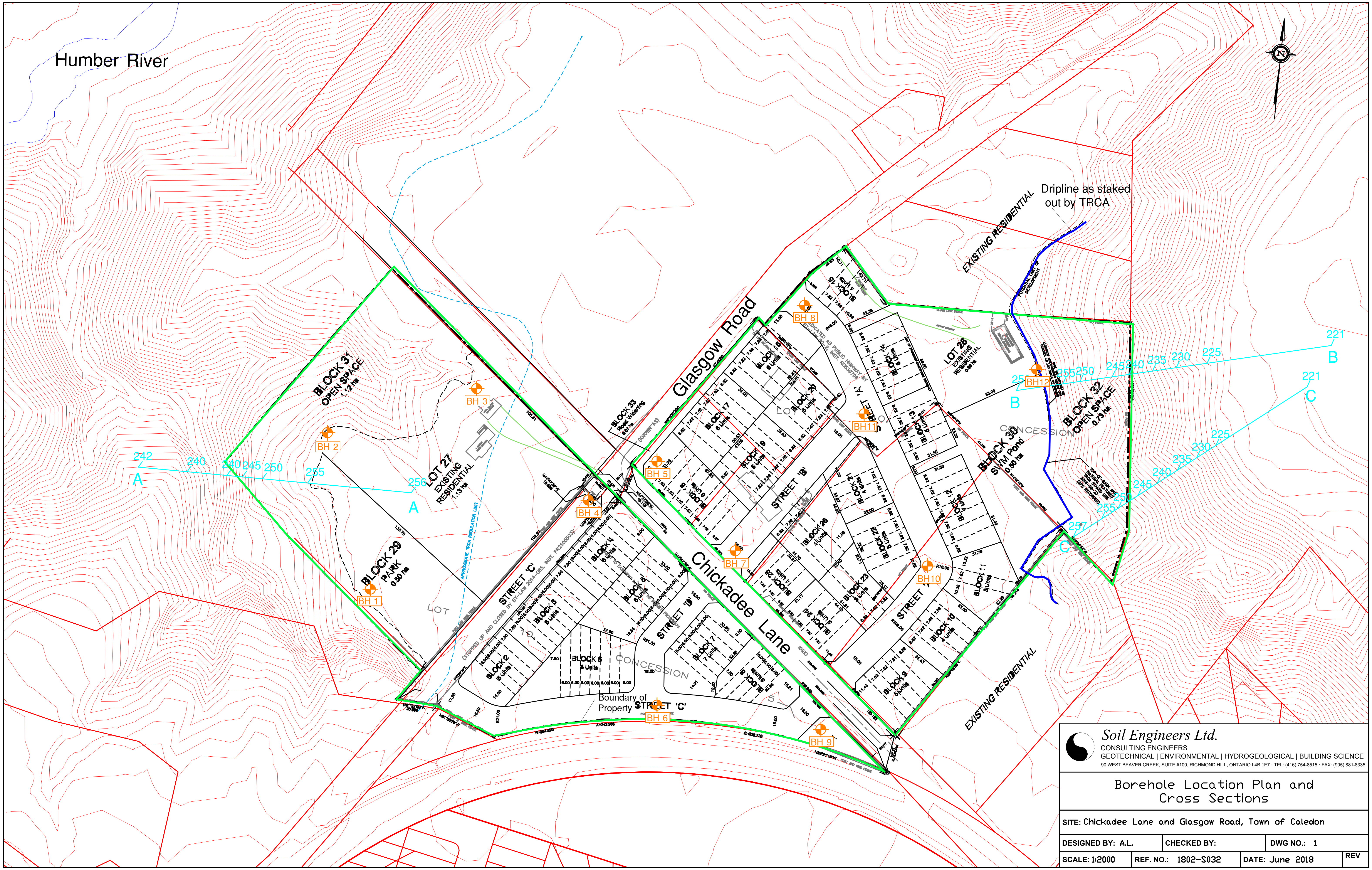


Project:	Proposed Residential Development
Location:	Chickadee Lane and Glasgow Road, Town of Caledon

Liquid Limit (%) =	25
Plastic Limit (%) =	16
Plasticity Index (%) =	9
Moisture Content (%) =	13
Estimated Permeability (cm./sec.) =	10^{-7}

Borehole No:	2
Sample No:	15
Depth (m):	18.5
Elevation (m):	237.2

Classification of Sample [& Group Symbol]: SANDY SILT TILL, some clay and sand, a trace of gravel



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CONSULTING ENGINEERS
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90 WEST BEAVER CREEK, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Borehole Location Plan and Cross Sections

SITE: Chickadee Lane and Glasgow Road, Town of Caledon

DESIGNED BY: A.L.	CHECKED BY:	DWG NO.: 1

SCALE: 1:2000	REF. NO.: 1802-S032	DATE: June 2018	REV

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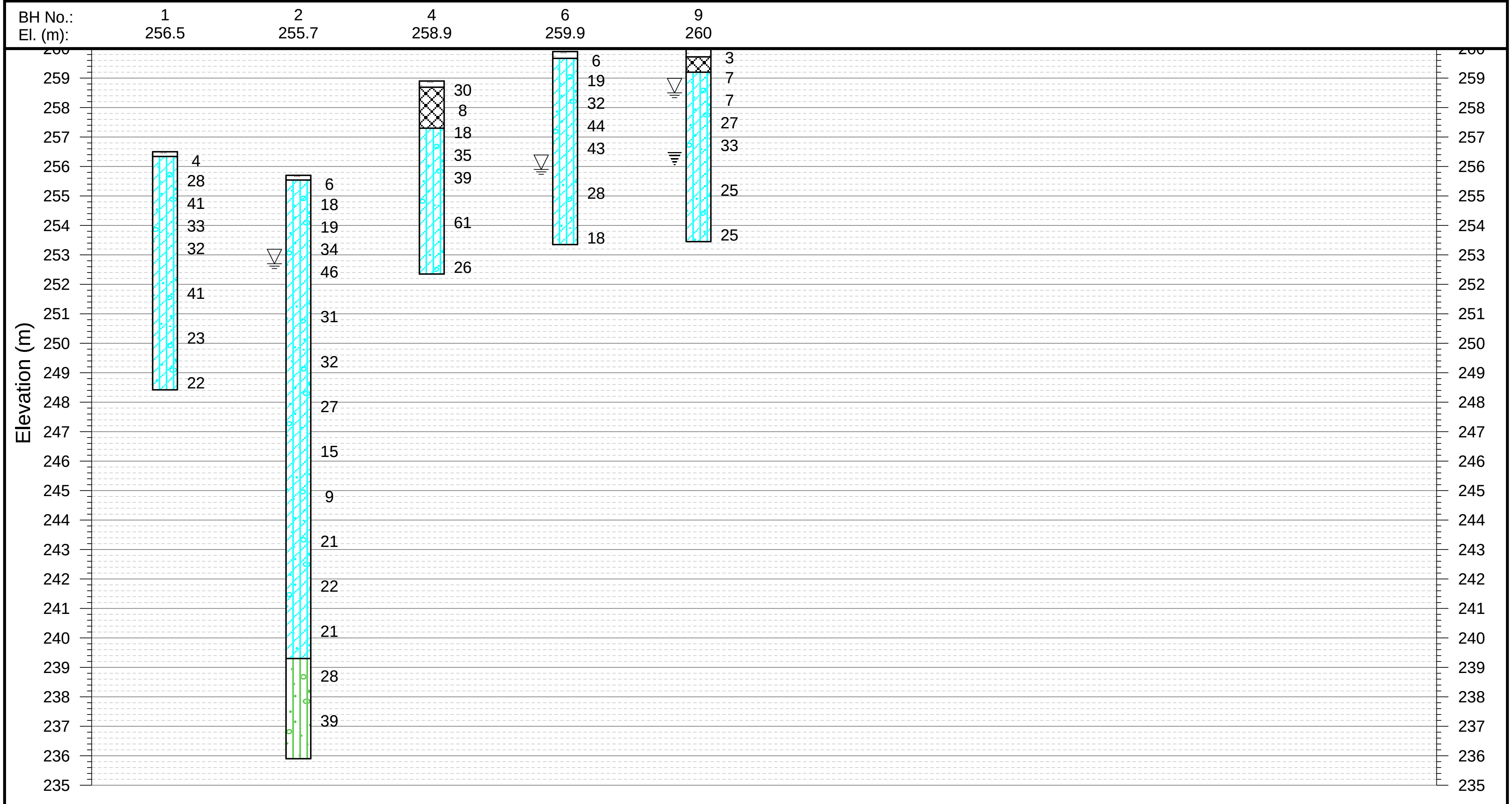
SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

JOB NO.: 1801-S032
REPORT DATE: June 2018
PROJECT DESCRIPTION: Proposed Residential Development
PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

LEGEND

TOPSOIL FILL SANDY SILT TILL SILTY CLAY TILL



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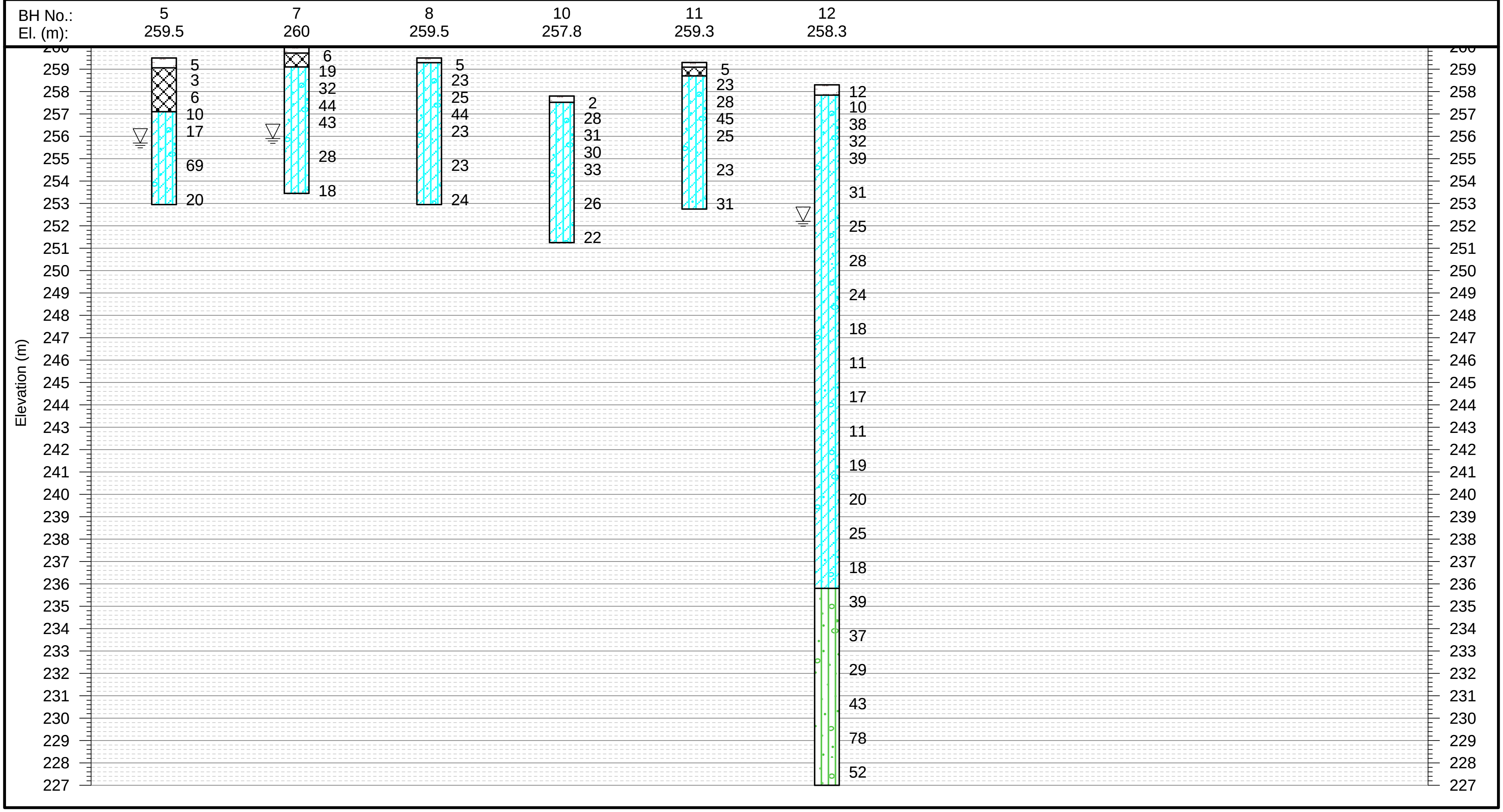
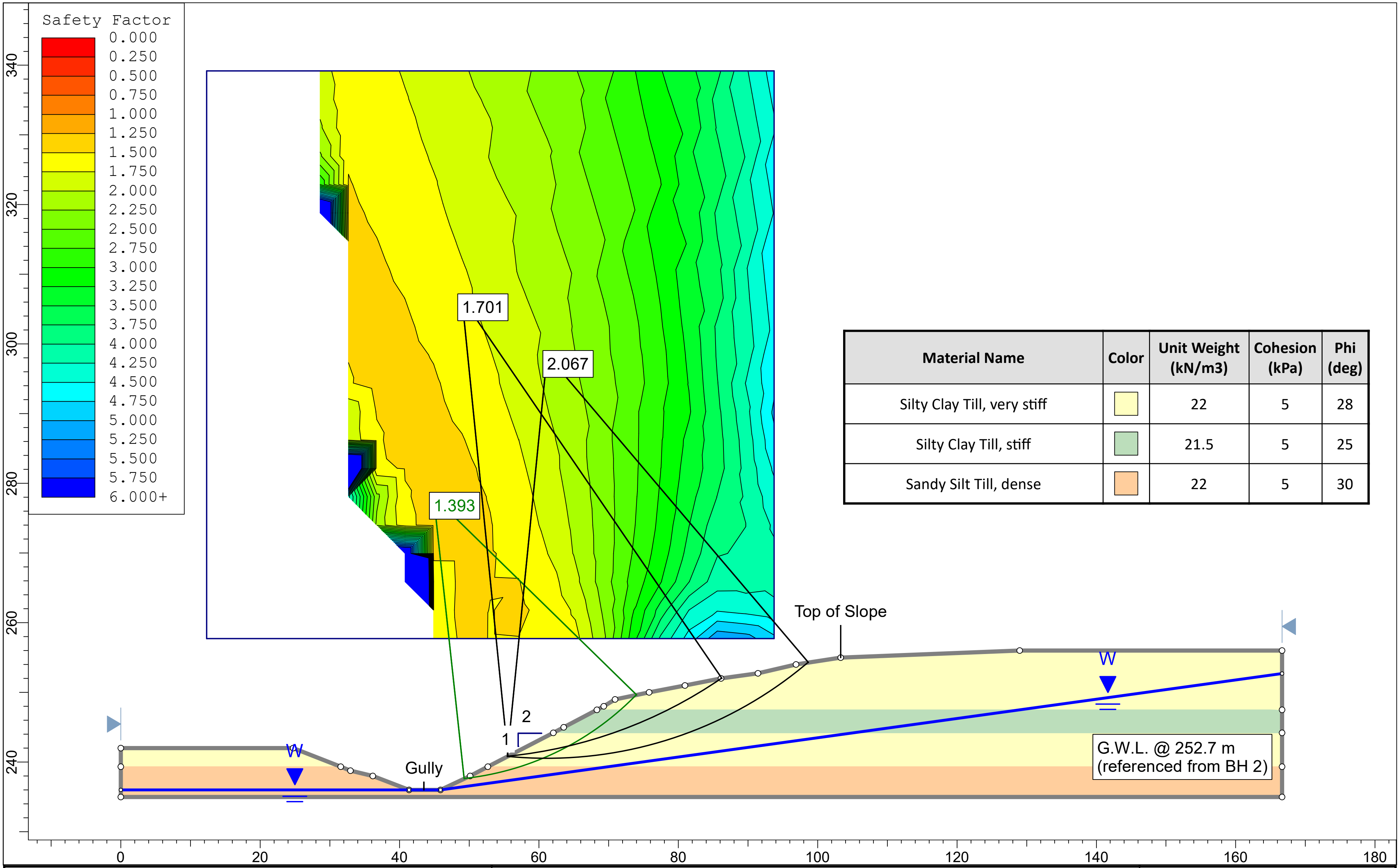
SUBSURFACE PROFILE
DRAWING NO. 3
SCALE: AS SHOWN

JOB NO.: 1801-S032
REPORT DATE: June 2018
PROJECT DESCRIPTION: Proposed Residential Development
PROJECT LOCATION: Chickadee Lane and Glasgow Road, Town of Caledon

LEGEND

- TOPSOIL
- FILL
- SANDY SILT TILL
- SILTY CLAY TILL





Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silty Clay Till, very stiff	🟨	22	5	28
Silty Clay Till, stiff	🟩	21.5	5	25
Sandy Silt Till, dense	🟧	22	5	30

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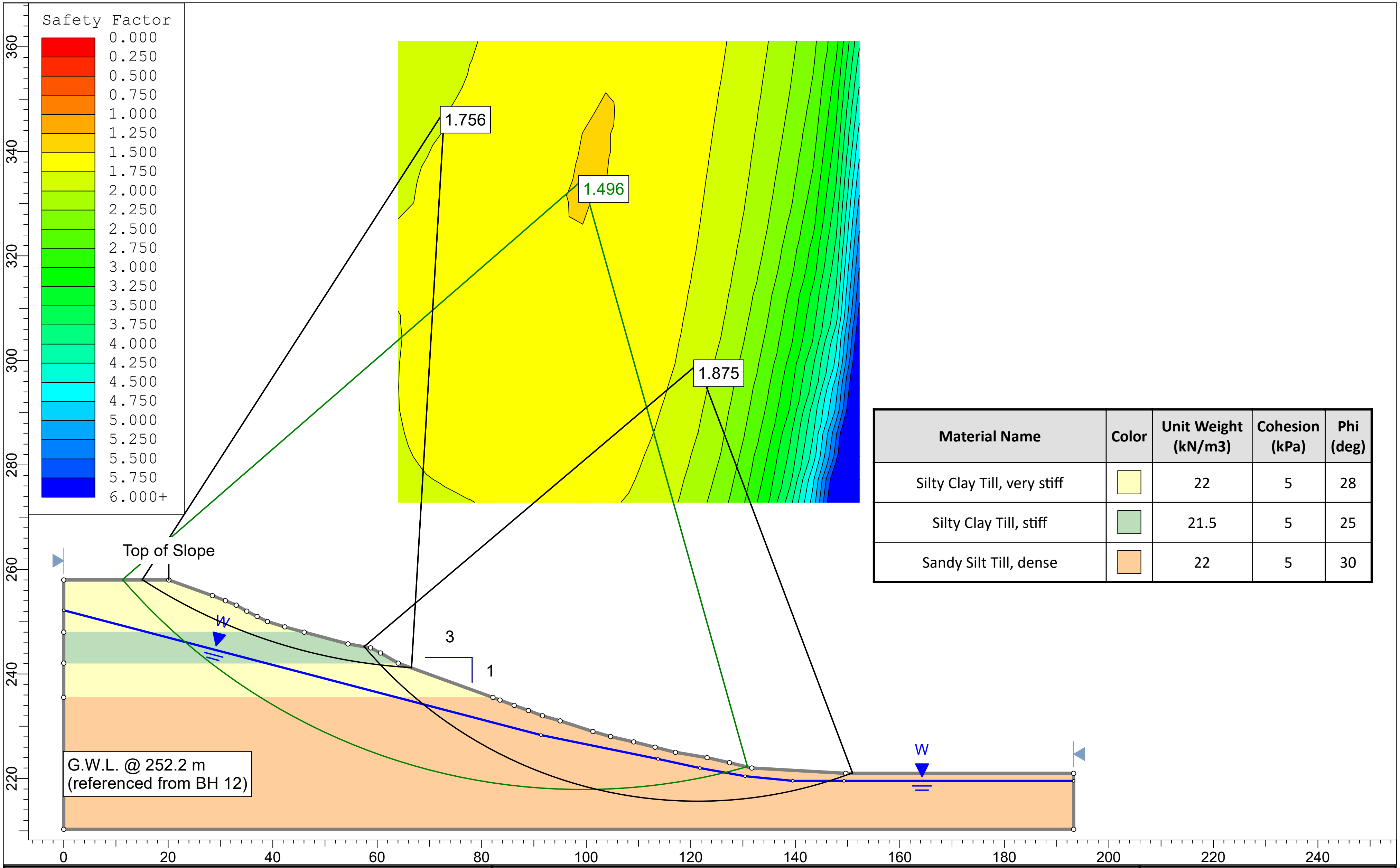
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Project Title: Slope Stability Analysis - Cross Section A-A
Load Case: Existing Condition
Location: Chickadee Lane and Glasgow Road, Town of Caledon
Drawn By: A.L.
Checked By:
Scale: 1:750
Revision:
Date: May 2018
Reference No.: 1801-S032
Drawing No.: 4



G.W.L. @ 252.2 m
(referenced from BH 12)

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silty Clay Till, very stiff	🟨	22	5	28
Silty Clay Till, stiff	🟩	21.5	5	25
Sandy Silt Till, dense	🟧	22	5	30

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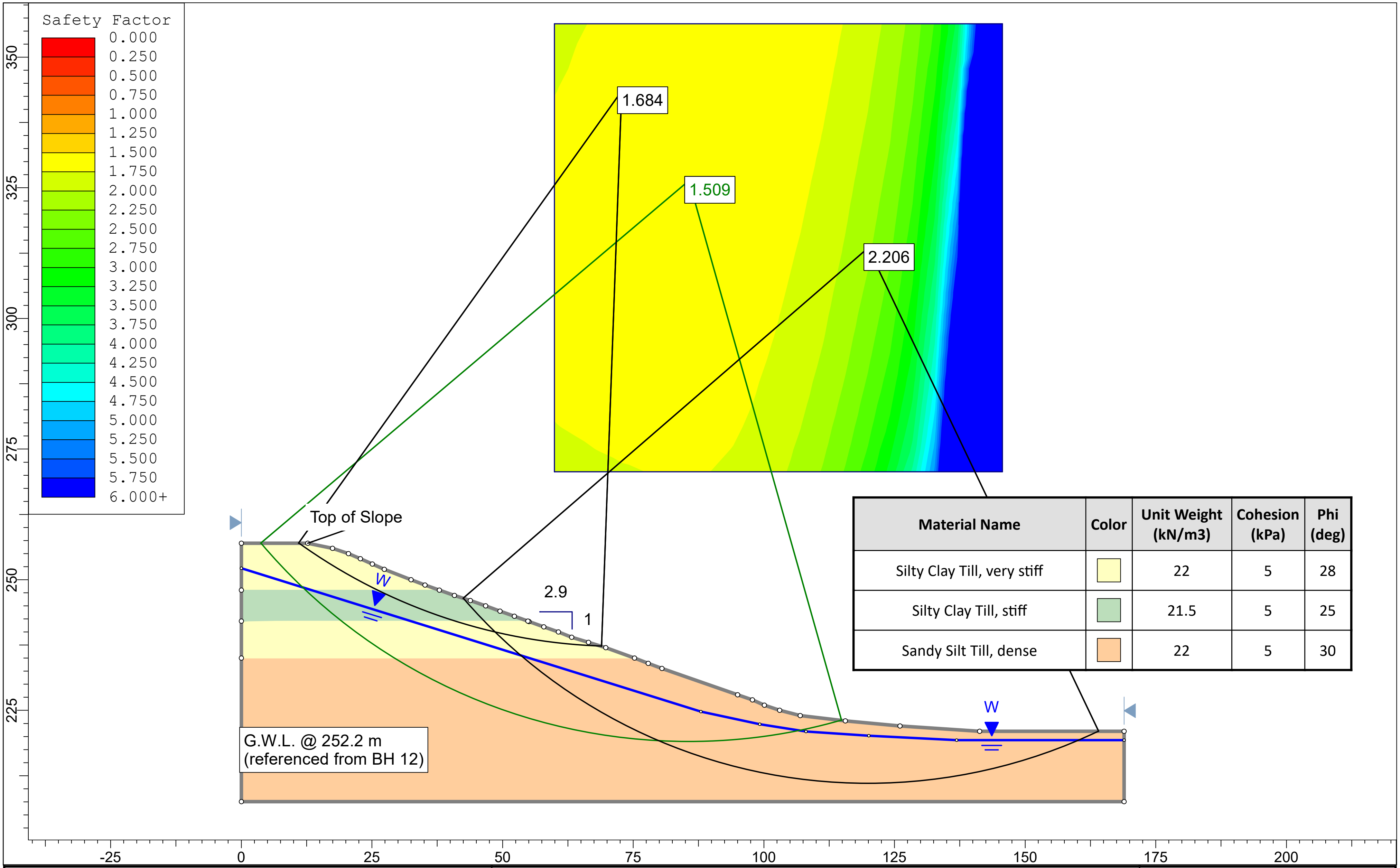
Project Title: Slope Stability Analysis - Cross Section B-B
Load Case: Existing Condition
Location: Chickadee Lane and Glasgow Road, Town of Caledon
Drawn By: A.L.
Checked By:
Scale: 1:1000
Revision:
Date: June 2018
Reference No.: 1801-S032
Drawing No.: 5



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silty Clay Till, very stiff	🟨	22	5	28
Silty Clay Till, stiff	🟩	21.5	5	25
Sandy Silt Till, dense	🟧	22	5	30

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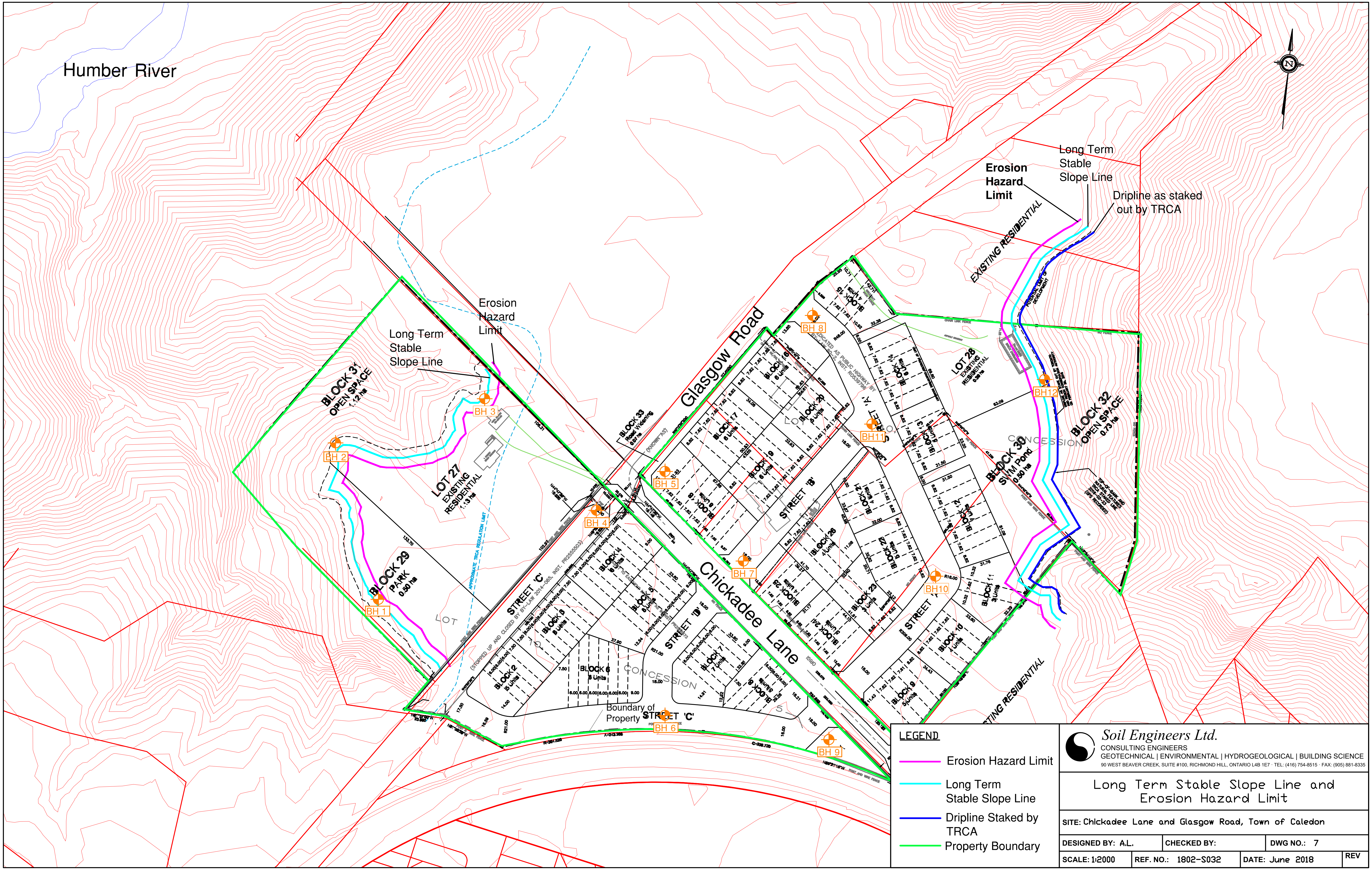
Project Title: Slope Stability Analysis - Cross Section C-C
Load Case: Existing Condition
Location: Chickadee Lane and Glasgow Road, Town of Caledon
Drawn By: A.L.
Checked By:
Scale: 1:1000
Revision:
Date: June 2018
Reference No.: 1801-S032
Drawing No.: 6



LEGEND

Erosion Hazard Limit

Long Term Stable Slope Line

Dripline Staked by TRCA

Property Boundary

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90 WEST BEAVER CREEK, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Long Term Stable Slope Line and Erosion Hazard Limit

SITE: Chickadee Lane and Glasgow Road, Town of Caledon

DESIGNED BY: A.L.	CHECKED BY:	DWG NO.: 7

SCALE: 1:2000	REF. NO.: 1802-S032	DATE: June 2018	REV