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A REPORT TO
AMA INVESTMENTS INC.

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

84 NANCY STREET
TOWN OF CALEDON (BOLTON)

REFERENCE NO. 1805-S060

OCTOBER 2018

DISTRIBUTION

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1.0 INTRODUCTION

In accordance with the written authorization from Mr. Sandy Acchione of AMA Investments Inc. dated May 7, 2018, a geotechnical investigation was carried out at the property located at 84 Nancy Street in the Town of Caledon (Bolton).

The purpose of the investigation was to reveal the subsurface conditions and determine the engineering properties of the disclosed soils for the design and construction of a proposed residential development. In addition, slope stability assessment was conducted to delineate the natural hazards as related to the proposed development at the site.

The geotechnical findings and resulting recommendations are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

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

The subject property is irregular in shape. It is a sloping ground located at the east end of Nancy Street, in the south sector of Caledon. At the time of investigation, the majority of the site was vacant, with vegetation cover. At the north portion, there was an existing dwelling and a detached garage, which will be demolished.

We understand that the site will be graded for the construction of a 5-storey residential building, with 2 levels underground parking and an on-grade parking lot. The main floor of the proposed building will be at El. 247.0 m and there will be separate driveway entrances into the underground parking of the building.

3.0 **FIELD WORK**

The field work, consisting of nine (9) boreholes extending to depths of 6.6 to 17.2 m below the prevailing ground surface, was performed between June 18 and 21, 2018, at the locations shown on the Borehole Location Plan, Drawing No. 1.

The boreholes 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.

The field work was supervised and the findings were recorded by a Geotechnical Technician.

The ground elevation at each borehole location was interpolated from the topographic survey plan prepared by ERTL Surveyors, dated August 16, 2018.

4.0 SUBSURFACE CONDITIONS

The investigation revealed that beneath a topsoil veneer and a layer of earth fill in places, the site is underlain by strata of silty clay and silty clay till. Detailed descriptions of the subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 9, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing No. 2. The engineering properties of the disclosed soils are discussed herein.

4.1 **Topsoil** (All Boreholes)

Topsoil, approximately 10 to 23 cm in thickness, was encountered at the ground surface at the borehole locations. It is dark brown in colour, indicating appreciable amounts of roots and humus. After removal for the proposed development, the topsoil can be reused in landscaping purpose only. It must not be buried below any structure or deeper than 1.2 m below the exterior finished grade so it will not have an adverse impact on the environmental well-being of the developed area.

4.2 **Earth Fill** (Boreholes 1, 3 and 5)

The earth fill extends to a depth of 0.9 to 3.1 m below the prevailing ground surface in some borehole locations. It consists of silty clay and topsoil, with root inclusions.

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

4.3 **Silty Clay** (Borehole 4, 6, 8, 9) and **Silty Clay Till** (All Boreholes)

The native silty clay till deposit was encountered below the topsoil or earth fill, with laminated silty clay layers at shallow depths in some of the borehole locations.

The clay till extends to the maximum investigated depths. It consists of a random mixture of soils; the particle sizes range from clay to gravel, with the clay fraction exerting the dominant influence on its soil properties. Sample examinations show that the upper zone is permeated with fissures by the weathering process.

Grain size analyses were performed on three (3) representative samples of silty clay till; the results are plotted on Figure 10.

The consistency of the silty clay and silty clay till deposits, as inferred by the obtained 'N' values, are summarized in the following:

	'N' values	Consistency
Silty Clay	11 to 45 (median 21)	Stiff to hard, generally very stiff
Silty Clay Till	17 to over 100 (median 34)	Very Stiff to hard, generally hard

The natural water content of the clay and clay till samples range from 11% to 28%. The Atterberg Limits of two (2) representative samples of the silty clay till were determined and the results show that the clay till is medium plasticity:

Liquid Limit	33% and 37%
Plastic Limit	18% and 19%

Based on the above findings, the engineering properties of the silty clay and clay till are deduced:

- High frost susceptibility and high soil-adfreezing potential.
- Low water erodibility.
- Virtually impervious, with an estimated coefficient of permeability of less than 10^{-7} cm/sec, a percolation rate of over 80 min/cm, and runoff coefficients of:

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

- Cohesive-frictional soils, the shear strength is derived from the consistency and augmented by the internal friction of the sand and silt.
- The clay and clay till will generally be stable in a relatively steep cut; however, prolonged exposure will allow the sand and silt seams to become saturated which may lead to localized sloughing.
- Poor material to support pavement structure, with an estimated California Bearing Ratio (CBR) value of 3% to 5%.
- Moderately high corrosivity to buried metal, with an estimated electrical resistivity of 3500 ohm·cm.

4.4 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	17 to 21	17	12 to 21
Silty Clay	14 to 22	18	14 to 22
Silty Clay Till	11 to 28	17	13 to 21

Based on the above findings, the on-site material is mostly suitable for 95% + Standard Proctor compaction. Wet soils will require aeration or mixing with the drier soils before compaction. Aeration should be carried out by spreading the soils thinly on the ground during the dry, warm weather.

The on-site material should be compacted using a kneading-type roller. Granular fill can be compacted using a smooth roller, with or without vibration.

When compacting the till or clay on the dry side of the optimum, the compactive energy will frequently bridge over the chunks in the soil and be transmitted laterally into the soil mantle. Therefore, the lifts of this soil must be limited to 20 cm or a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction. Any oversized boulder must be removed from the fill material before compaction.

5.0 GROUNDWATER CONDITIONS

The boreholes were checked for the presence of groundwater and the occurrence of cave-in upon completion of the field work. In addition, one groundwater monitoring round of the wells was completed on July 13, 2018. The results are summarized in Table 2.

Table 2 - Groundwater Levels

Borehole No.	Borehole Depth (m)	Ground El. (m)	Groundwater Level Upon Completion of Drilling		Groundwater Level on July 13, 2018	
			Depth (m)	**El. (m)**	**Depth (m)**	**El. (m)**
1	6.6	240.1	Dry	-	No Well	
2	8.1	245.3	Dry	-	3.0	242.3
3	11.1	243.2	Dry	-	No Well	
4	11.1	246.3	Dry	-	No Well	
5	15.7	250.4	Dry	-	14.0	236.4
6	17.2	252.3	Dry	-	No Well	
7	15.7	249.8	Dry	-	No Well	
8	14.2	247.8	13.1	234.7	9.7	238.1
9	14.2	249.4	Dry	-	No Well	

Upon completion of borehole drilling, groundwater was recorded in Borehole 8 at a depth of 13.1 m or El. 234.7 m. The remaining boreholes remained dry and open throughout the drilling process.

On July 13, 2018, three weeks after well installation, the stabilized groundwater level in the monitoring wells was recorded between El. 236.4 m and 242.3 m, representing the perched water in the sand layers within the till deposit. The perched water is subject to seasonal fluctuation.

6.0 SLOPE STABILITY STUDY

The site is a sloping ground descending from east to west. The ground drops at an average gradient of 8º, or 7 Horizontal (H) : 1 Vertical (V) in the vicinity of the proposed building.

Beyond the south and southwest boundaries of the property, there is a valley land dropping almost 25 m to the vicintiy of Ted Houston Memorial Park, at a gradient of 2.5H to 3.0H:1V. The valley slope is covered with shrubs and mature trees. Groundwater seepage, surface erosion, or other signs of instability were not evident along the slope at the time of investigation.

A slope stability study has been conducted to establish the Long Term Stable Top of Slope (LTSTS) of the valley land for the development. The safety of excavation for the building foundation at the site is also addressed in the stability study.

6.1 Toe Erosion Allowance

There is no watercourse within 15 m from the bottom of slope. Hence, active erosion at the toe of slope is unlikely and no toe erosion allowance is required.

6.2 Stability Analysis

Two slope sections are selected on the valley land for analysis. The locations of these sections are presented on Drawing No. 3.

The slope profile of each section was interpolated from the elevation contours shown on the Topographic Survey prepared by ERTL Surveyors dated August 16, 2018.

The subsurface information was derived from Boreholes 4 and 6, located in close proximity of the valley slope. The groundwater recorded in the monitoring wells was also incorporated into the analysis as a phreatic surface.

Details of the slope sections are shown on Drawing Nos. 4 and 5. The soil strength parameters are shown in Table 3.

Table 3 - Shear Strength Parameters

Soil Type	**γ (kN/m^3)**	**Effective Shear Strength Parameters**	
		Cohesion c' (kPa)	**Angle of Internal Friction, ϕ'**
Native Silty Clay Till	22.0	5	28°
Silty Clay	21.5	5	18°

The analysis was carried out by "SLIDE", developed by Rocscience Inc., using force-moment-equilibrium criteria. The resulting minimum factors of safety (FOS) for the selected slope sections are 1.507 and 1.595. They are above the Ontario Ministry of Natural Resources and Forestry (OMNRF) requirements of 1.5 for 'Active' land use.

The LTSTS can be established at the top of the existing slope as shown on Drawing No. 3.

6.3 <u>Erosion Access Allowance of New Development</u>

A development setback buffer of 6 m for man-made and environmental degradation will be required. This is subject to the discretion of Toronto Region Conservation Authority (TRCA).

6.4 Excavation in Sloping Ground

Based on the proposed development plan, the area of the proposed building will be excavated for the construction of the foundation and the outdoor parking lot will be graded for the driveway and accessibility.

A stability analysis is conducted across the development at the stage the excavation is completed. Details of the slope section at the proposed building location is shown on Drawing No. 6.

According to the analytical results as shown on Drawing No. 6, the excavation will have no adverse effect on the global stability in the vicinity.

During construction, the walls of excavation will be shored to maintain local stability. After completion, the building walls will be a retaining structure and the building load is anticipated to transfer into the subsoil at a lower depth, without affecting the global stability in the vicinity.

6.5 Slope Maintenance

After development, any alteration on the sloping ground should either be restored to its original or better conditions for long term stability considerations.

In order to prevent disturbance of the stable slope and to enhance the stability of the bank for the proposed project, the following geotechnical constraints should be stipulated:

1. The prevailing vegetation cover must be maintained near the top of slope, since its extraction would deprive the bank of the rooting system that is reinforcement against soil erosion.
2. Site grading adjacent to the bank must be such that concentrated runoff is not allowed to drain onto the bank. Landscaping features which may cause runoff or ponding at the top of the bank must not be permitted.
3. Where construction is carried out near the top of the bank, dumping of loose fill over the bank must be prohibited.

In case of any removal of vegetation during the course of construction, restoration with selective native plantings, including deep rooting systems which would penetrate the original topsoil, shall be carried out after the development to ensure slope stability.

Provided that all the above recommendations are followed, the proposed development at the tableland should not have any adverse effect on the stability of the slope.

7.0 DISCUSSION AND RECOMMENDATIONS

The investigation has disclosed that beneath a topsoil veneer and a layer of earth fill in places, the site is underlain by strata of silty clay and silty clay till, generally very stiff to hard in consistency.

Groundwater was recorded in Borehole 8 at a depth of 13.1 m or El. 234.7 m upon completion of drilling. The stabilized groundwater level in the monitoring wells was recorded between El. 236.4 m and 242.3 m, representing the perched water in the wet sand layers within the till deposit.

The site will be graded for the construction of a 5-storey residential building with 2-levels underground parking, an on-grade parking lot and separate driveway entrances at El. 241.0 m for P2 and El. 244.0 m for P1 of the building. According to the development plan, the excavation at each borehole location is estimated as shown in Table 4:

Table 4 - Estimated Depth of Excavation and Site Grading

Borehole No.	**Area of Construction**	**Existing Ground Elevation (m)**	**Final Grade (m)**	**Excavation (m)**
1	Outdoor lower parking lot	240.1	240.0	0.1
2	Outdoor upper parking lot	245.3	242.5	2.8
3	P2/ Driveway entrance	243.2	241.0/ 241.0	2.2/ 2.2
4	P2/ Side grading	246.3	241.0/ 246.0	5.3/ 0.3
5	P2 lobby	250.4	241.0	9.4
6	P2/ Side grading	252.3	241.0/ 251.0	11.3/ 1.3
7	P2	249.8	241.0	8.8
8	P2/ P1 driveway entrance	247.8	241.0/ 244.0	6.8/ 3.8
9	P2/ Side grading	249.4	241.0/ 251.0	8.4/ -1.6

“-ve” denotes filling

The geotechnical findings warranting special consideration for the proposed building design and construction are presented below:

1. The existing topsoil will be removed for building construction. After removal, the topsoil can be reused in landscaping purpose only. It must not be buried below any structure or deeper than 1.2 m below the exterior finished grade so it will not have an adverse impact on the environmental well-being of the developed area.
2. For site grading, the existing earth fill should be removed, sorted free of organics, topsoil or deleterious fill, before re-use on-site for structural backfill.
3. Excavations must be completed in accordance to O. Reg. 213/91. If proper backing slope cannot be achieved, temporary shoring support will be required.
4. Upon completion of bulk excavation for building construction, the subgrade below the foundation level is anticipated to consist of very stiff to hard silty clay till, capable of supporting the proposed structure on conventional footings.
5. Perimeter subdrains and dampproofing of the foundation walls will be required for the substructure. All the subdrains must be encased in a fabric filter to protect them against blockage by silting.
6. Retaining walls will be required between the outdoor parking lots due to the difference in final grading. The walls should be designed properly for stability considerations.

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 Foundations

Upon completion of excavation for building construction, the foundation subgrade, below the estimated El. 240.0 to 240.5 m, is anticipated to consist of very stiff to hard silty clay till, capable of supporting the proposed building on conventional footings. The recommended bearing pressures for the design of footings are provided:

- Maximum Bearing Pressure at Serviceability Limit State (SLS) = 300 kPa
- Factored Ultimate Bearing Pressure at Ultimate Limit State (ULS) = 500 kPa

The total and differential settlements of footings, designing for the recommended bearing pressures, are estimated to be within 25 mm and 15 mm, respectively.

The footing subgrade should be inspected 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 design requirements.

Conventional footings exposed to weathering, or in unheated areas, should have at least 1.2 m of earth cover for protection against frost action. For an unheated underground parking garage, with limited open access and the overhead doors at the entrances are kept close at most of the time, a minimum soil cover of 0.9 m for the interior footings and 0.6 m for the perimeter footings is necessary for frost protection. Footings adjacent to the fresh air ducts, the entrance of the garage and other areas which may be exposed to freezing temperature from the exterior should be provided with a minimum frost cover of 1.2 m.

It should be noted that if groundwater seepage is encountered in the footing excavations, the subgrade should be protected by a concrete mud-slab immediately after exposure and removal of groundwater. This will prevent construction disturbance and costly rectification.

The building foundation must meet the requirements specified in the latest Ontario Building Code. As a guide, the structure should be designed to resist an earthquake force using Site Classification ‘D’ (stiff soil).

7.2 **Retaining Walls**

Retaining walls will be constructed between the parking lots and driveway. According to Boreholes 1 and 2, the proposed wall subgrade, at the assumed elevations of 240 m and 243 m, respectively, is anticipated to consist of native clay till or earth fill.

Subgrade preparation for the retaining wall should consist of complete excavation of the existing earth fill. Any new fill beneath the wall structure should consist of organic free material, compacted to 98% + of the Standard Proctor maximum dry density. The recommended soil bearing pressures of 100 kPa (SLS) and 150 kPa (ULS) are recommended for the design of retaining walls bearing on well compacted earth fill or native till deposit.

The wall structure must be designed by qualified personnel, in terms of the respective internal and global stabilities. In calculating the lateral earth pressure to be imposed on the retaining wall, the recommended soil parameters are presented in Section 7.8. Any applicable surcharge loads adjacent to the proposed structure must also be considered in the design.

The retaining walls may consist of precast concrete blocks or reinforced concrete. They are sensitive to frost-induced ground movement and must be constructed below the frost penetration depth of 1.2 m. If ground movement induced by frost action is tolerable, the wall can be constructed on a free-draining, non-frost-susceptible granular material such as Granular ‘A’, or equivalent, at least 15 cm thick and compacted to 98%+ of its maximum Standard Proctor dry density.

A drainage layer should be provided behind the retaining wall and a filter-socked weeper subdrain connected to a positive outlet should be provided behind the wall at the foundation level for drainage purposes. This is to prevent freezing of ponded water resulting in severe ice pressure that would cause the wall to bulge or lean.

Backfill behind the wall should be free draining. A fabric filter is required between the retained soils and the granular backfill.

Where the embedment depth of the wall foundation is less than the frost depth, slight frost heave is expected in cold weather. To prevent damage caused by frost heave, structures which are sensitive to movement must not be constructed at or near the top of the retaining wall.

7.3 Underground Garage and Slab-On-Grade

The perimeter walls of the underground structure should be designed to sustain a lateral earth pressure, calculated using the soil parameters given in Section 7.8. Any applicable surcharge loads adjacent to the underground structure must also be considered in the foundation wall design.

The perimeter underground garage walls should be dampproofed and provided with a perimeter subdrain at the wall base. Backfill of open excavation should be free-draining granular material unless the prefabricated drainage board is installed over the entire wall below grade. At the shoring location, prefabricated drainage board, such as Miradrain 6000 or equivalent, must be provided on the perimeter walls, between the shoring wall and the cast-in-place foundation wall. The perimeter drains should be installed on a positive gradient, connecting into the frost-free sump-well and discharge into the storm sewers.

The slab-on-grade should be constructed on a granular base of 20-mm Crusher-Run Limestone, not less than 20 cm thick and compacted to its maximum Standard Proctor dry density. A Modulus of Subgrade Reaction of 25 MPa/m can be used for the design of the floor slab.

No underfloor drain is required below the slab-on-grade. The ground around the buildings must be graded to direct water away from the structures to minimize the frost heave phenomenon generally associated with the disclosed soils.

To prevent frost action induced by cold wintry drafts in areas where vertical ground movement cannot be tolerated, the floor at the entrances and in areas of close proximity to air shafts should be insulated, or the subgrade material should be replaced with 1.2 m of non-frost-susceptible granular material and provided with subdrains. The insulation should extend 5.0 m internally.

7.4 **Underground Services**

The subgrade for underground services should consist of properly compacted inorganic earth fill or sound natural soils. A Class ‘B’ bedding is recommended for the design of the underground services construction. The bedding material should consist of compacted 20-mm Crusher-Run Limestone, or equivalent.

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 by a fabric filter to prevent blockage by silting.

All metal fittings for the underground services should be protected against soil corrosion. The in situ soils have moderate to moderately high corrosivity to buried metal. In determining the mode of protection, an electrical resistivity of 3500 ohm·cm should be used. This, however, should be confirmed by testing the soil along the water main alignment at the time of services construction.

7.5 Trench Backfilling

The backfill in service trenches or beside foundation walls should be compacted to at least 95% of its maximum Standard Proctor dry density and increased to 98% below the concrete sidewalk. In the zone within 1.0 m below the pavement subgrade, the material should be compacted with the water content 2% to 3% drier than the optimum; compacted to 98% of the respective maximum Standard Proctor dry density.

The on site inorganic soils are suitable for use as trench backfill; where the in situ soils are too wet, they must be aerated by spreading them thinly on the ground during the dry, warm weather before compaction.

In normal construction practice, the problem areas of pavement settlement largely occur adjacent to foundation walls, columns, manholes, catch basins and services crossings. In areas which are inaccessible to a heavy compactor, granular 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.

7.6 Sidewalks, Interlocking Stone Pavement and Landscaping

Interlocking stone pavement, slab-on-grade, sidewalks and landscaping structures in areas which are sensitive to frost-induced ground movement, such as in front of building entrances, must be constructed on a free-draining, non-frost-susceptible granular material such as Granular ‘B’. This material must extend to at least 0.3 to 1.2 m below the sidewalk, slab or pavement surface, depending on the degree of tolerance of ground movement, and be provided with positive drainage, such as weeper subdrains connected to manholes or catch basins. Alternatively, the landscaping structures, sidewalks, slab-on-grade and interlocking stone pavement should be properly insulated with 50-mm Styrofoam, or equivalent.

The grading around structures must be such that it directs runoff away from the structures.

7.7 Pavement Design

For the on-grade driveway and outdoor parking, the subgrade is anticipated to consist of frost susceptible silt and clay. The recommended pavement design is presented in Table 5:

Table 5 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	35	HL-3
Asphalt Binder		HL-8
Light Duty Parking	40	
Driveway and Fire Route	65	
Granular Base	150	OPSS Granular ‘A’ or equivalent
Granular Sub-base		OPSS Granular ‘B’ or equivalent
Light Duty Parking	250	
Driveway and Fire Route	350	

The granular base and sub-base should be compacted to 100% of the maximum Standard Proctor dry density.

Prior to placement of the granular bases, the subgrade should be proof-rolled and any soft spots should be rectified. In order to provide a stable subgrade for pavement construction, it is imperative that the subgrade within the 1.0 m zone below the underside of the granular base be compacted to at least 98% of its maximum Standard Proctor dry density with the moisture content 2% to 3% drier than the optimum. This is to provide adequate stability for the pavement construction.

The following measures should be incorporated in the construction procedures and road design:

- Areas adjacent to the pavement structure should be properly graded to prevent ponding of large amounts of water. Otherwise, the water will seep into the subgrade mantle and induce a regression of the subgrade strength with costly consequences for the pavement construction.
- If the pavement is to be constructed during wet seasons, thickening of the granular sub-base may be required. The requirement for this can be determined

at the time of the pavement construction.

- Fabric filter-encased curb subdrains and stub drains in all catch basins will be required. They should be installed at a minimum depth of 0.3 m below the underside of the granular sub-base.

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**
Existing Earth Fill	20.5	1.25	1.00
Silty Clay	21.5	1.30	1.03
Silty Clay Till	22.0	1.30	1.03
Lateral Earth Pressure Coefficients	**Active K_a**	**At Rest K_o**	**Passive K_p**
Compacted Earth Fill	0.40	0.55	2.50
Silty Clay/ Clay Till	0.35	0.50	3.00
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
Sound native soils	2
Earth Fill and weathered soils	3

Groundwater yield from the clay and clay till is expected to be slow in rate and limited in quantity. Water from sand or silt layers within the clay and clay till deposits maybe appreciable, but with limited quantity. Where water seepage is encountered, it can be removed by pumping from sumps.

Where sloped excavation is not feasible, a braced shoring will be required. The overburden load and the surcharge from any adjacent structures should also be considered in the design of shoring. The design parameters for shoring and our recommendations are provided in the Appendix of this report.

It is recommended that close monitoring of vertical and lateral movement of the shoring wall should be carried out and frequent site inspections be conducted to ensure that the excavation does not adversely affect the structural stability of the adjacent buildings and the existing underground utilities. A pre-construction survey of the adjacent properties should be carried out prior to the commencement of the excavation.

8.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of AMA Investments Inc., for review by the designated consultants, contractors, 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 judgement of Kin Fung Li, P.Eng., 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.

Kin Fung Li, P.Eng.

Bennett Sun, P.Eng.
KFL/BS

LICENSED PROFESSIONAL ENGINEER
K. F LI
100169280
Oct 16, 2018
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
CHUN C. B. SUN
Oct 16, 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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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

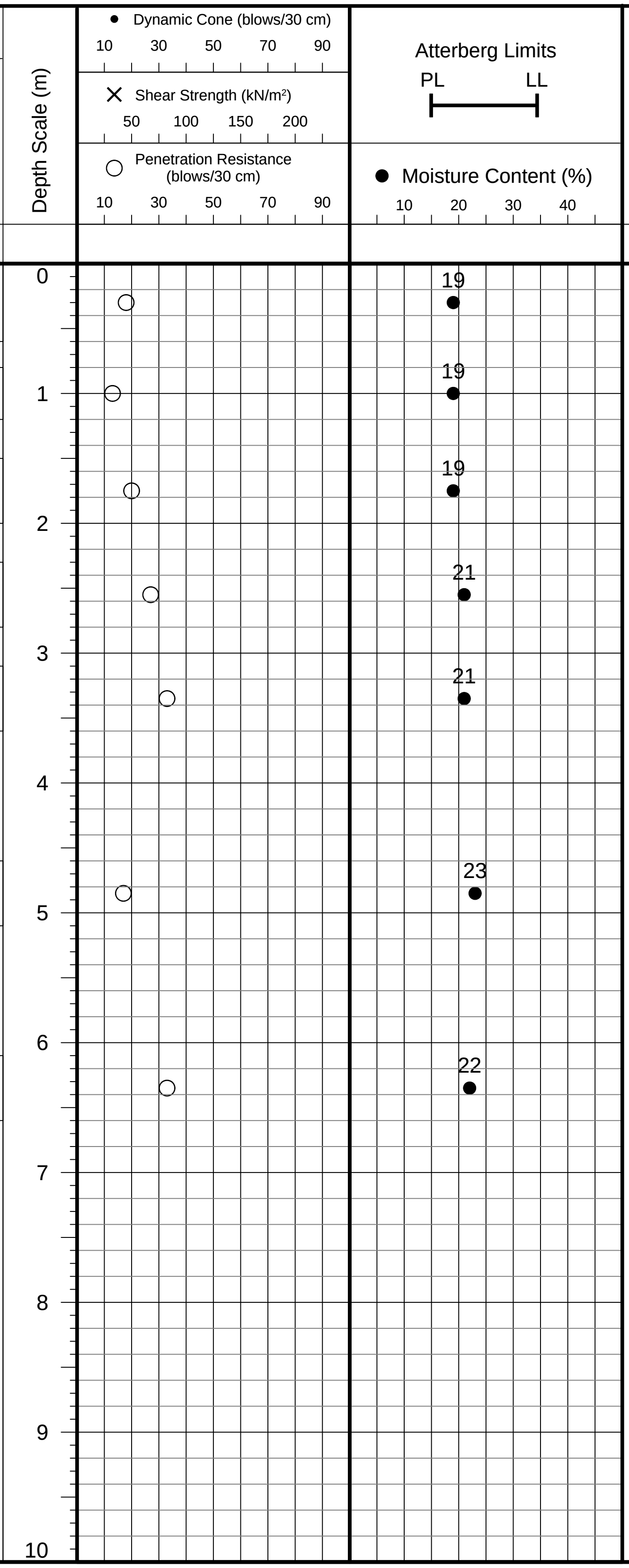
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 21, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
240.1	Ground Surface			
0.0	**20 cm TOPSOIL**			
	Dark brown **EARTH FILL** silty clay with some sand and gravel occ. topsoil inclusions	1	DO	18
239.2 0.9	Stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	2	DO	13
		3	DO	20
		4	DO	27
		5	DO	33
	brown grey	6	DO	17
	sand layer	7	DO	33
233.5 6.6	**END OF BOREHOLE**			



WATER LEVEL: Dry upon completion

Soil Engineers Ltd.

JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

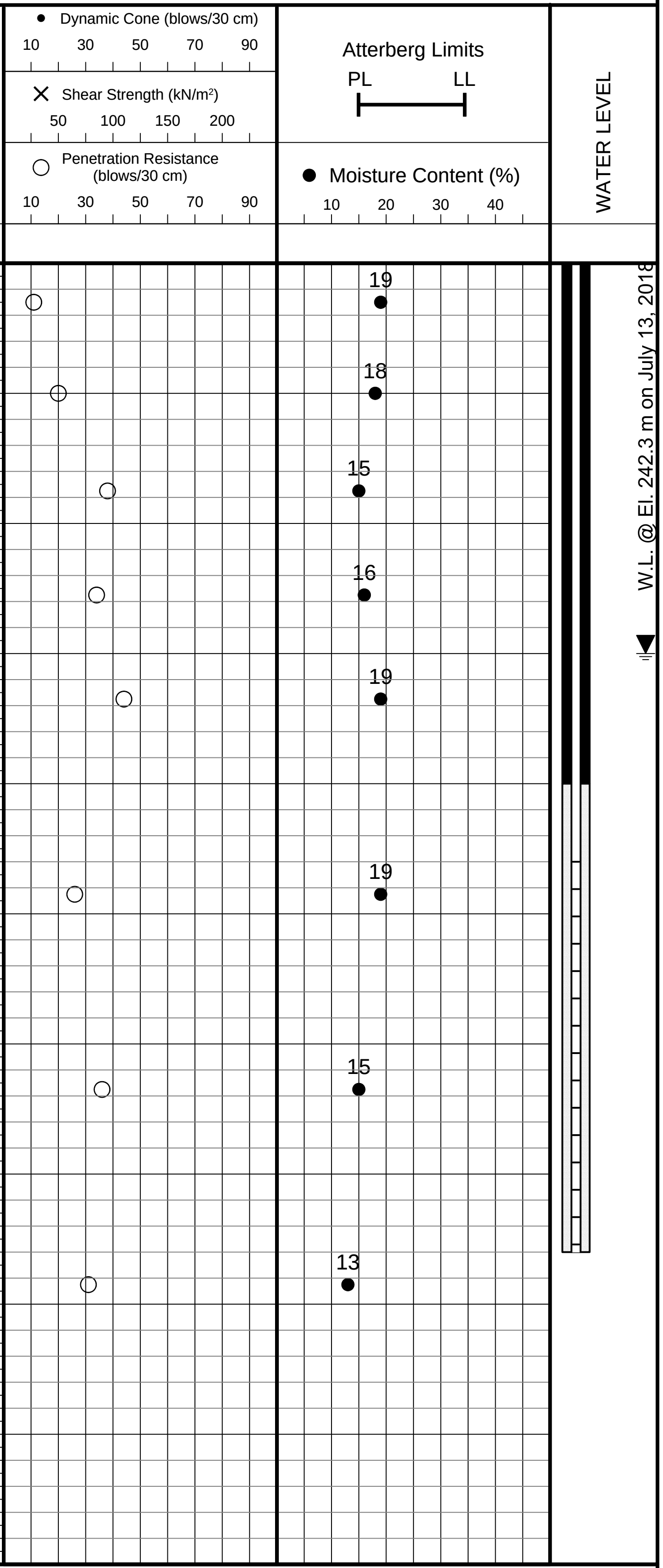
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 21, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	Depth Scale (m)
245.3	Ground Surface				
0.0	**13 cm TOPSOIL**				0
	Stiff to hard **SILTY CLAY TILL** weathered traces of sand and gravel occ. sand and silt seams, cobbles and boulders	1	DO	11	
		2	DO	20	1
		3	DO	38	2
		4	DO	34	
		5	DO	44	3
	brown grey	6	DO	26	4 5
		7	DO	36	6
		8	DO	31	7
237.2 8.1	**END OF BOREHOLE**				8 9 10



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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

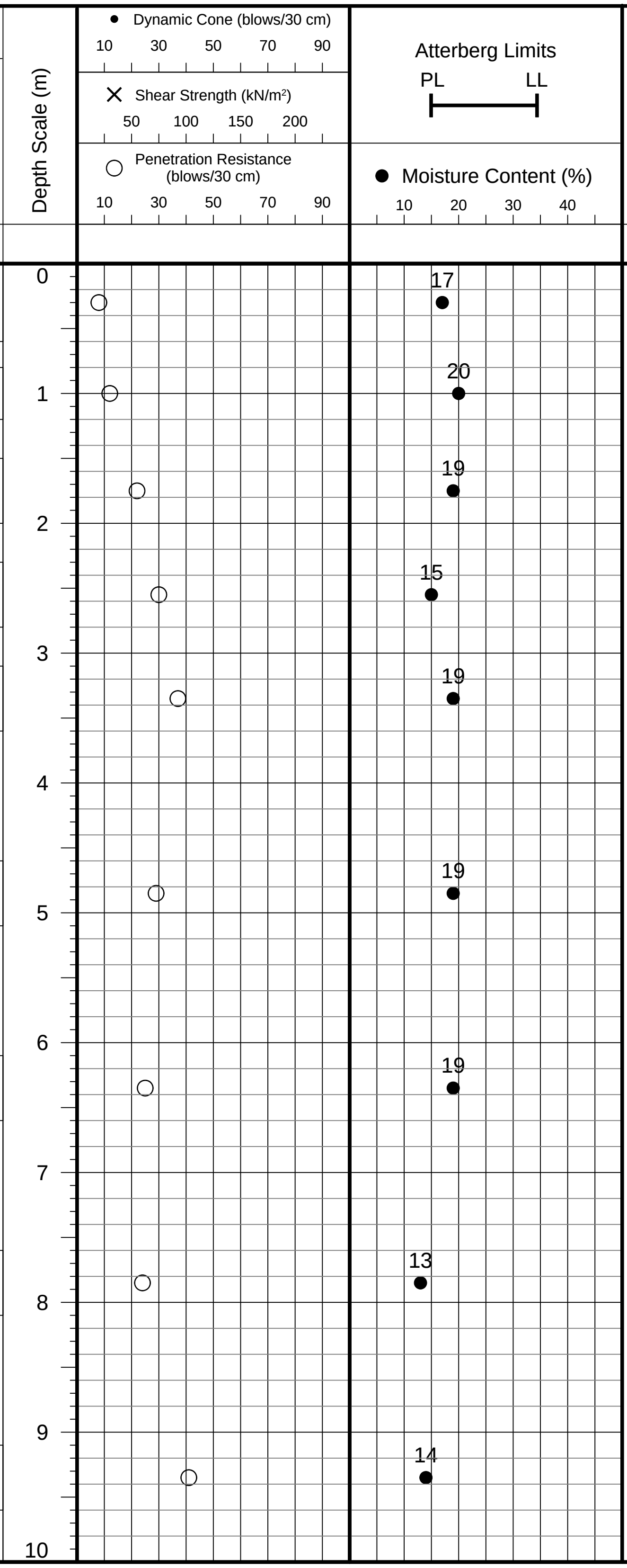
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	WATER LEVEL
243.2	Ground Surface				
0.0	**23 cm TOPSOIL**				
	Dark brown **EARTH FILL** silty clay mixed with some rootlets occ. topsoil inclusions	1	DO	8	
		2	DO	12	
242.1 1.1	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	3	DO	22	
		4	DO	30	
		5	DO	37	
	brown grey	6	DO	29	Dry upon completion
		7	DO	25	
		8	DO	24	
		9	DO	41	
233.2					



Soil Engineers Ltd.

JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

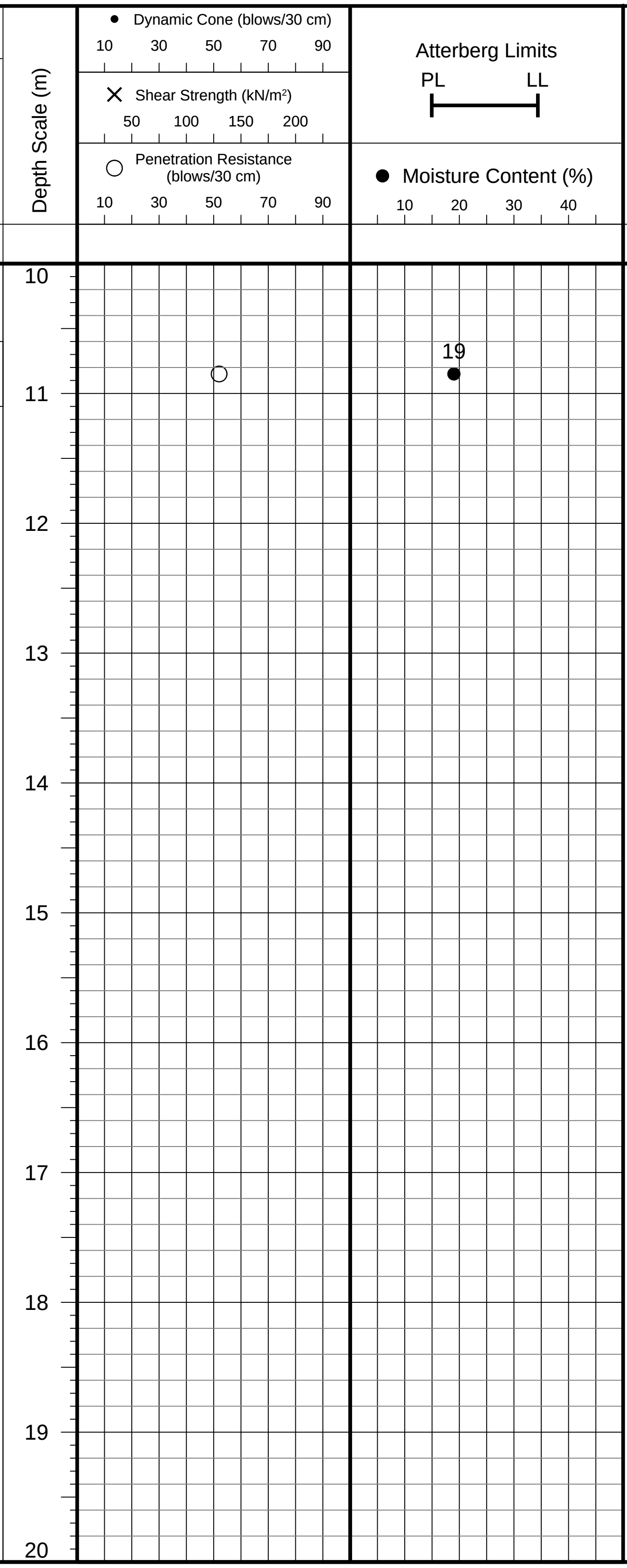
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	WATER LEVEL
10.0	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	10	DO	52	
232.1 11.1	**END OF BOREHOLE**				



JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

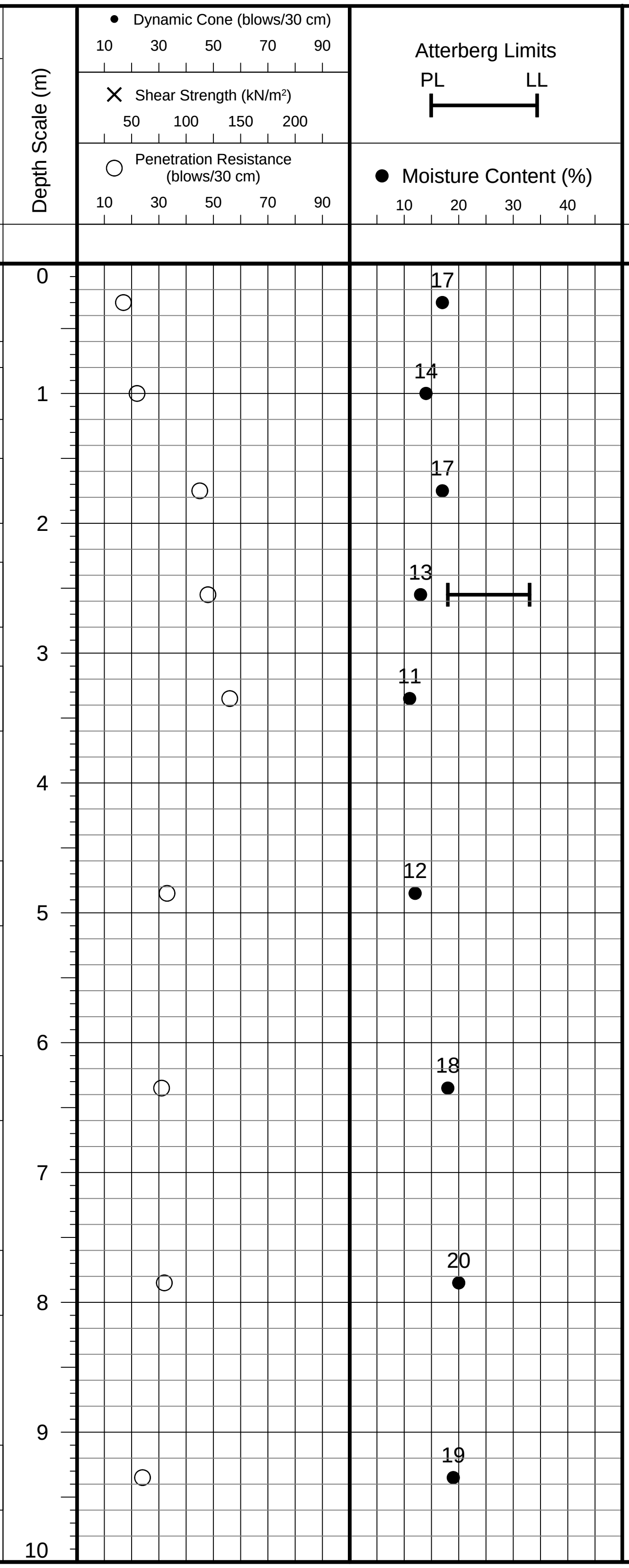
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 21, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
246.3	Ground Surface			
0.0	**10 cm TOPSOIL** Brown, very stiff to hard **SILTY CLAY** occ. silt and sand seams weathered	1	DO	17
		2	DO	22
		3	DO	45
244.0 2.3	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	4	DO	48
		5	DO	56
	brown grey	6	DO	33
		7	DO	31
		8	DO	32
		9	DO	24
236.3				



WATER LEVEL

Dry upon completion

Soil Engineers Ltd.

JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

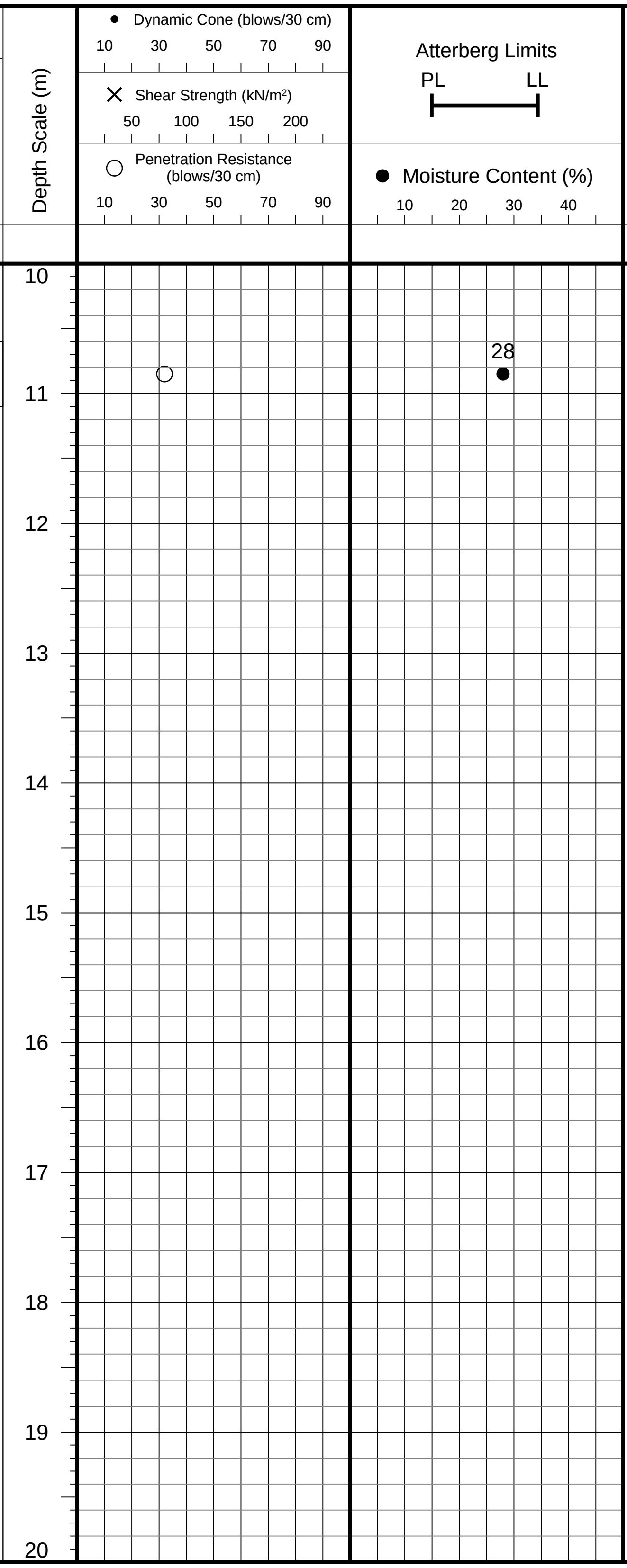
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 21, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	WATER LEVEL
10.0	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	10	DO	32	
235.2 11.1	**END OF BOREHOLE**				



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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

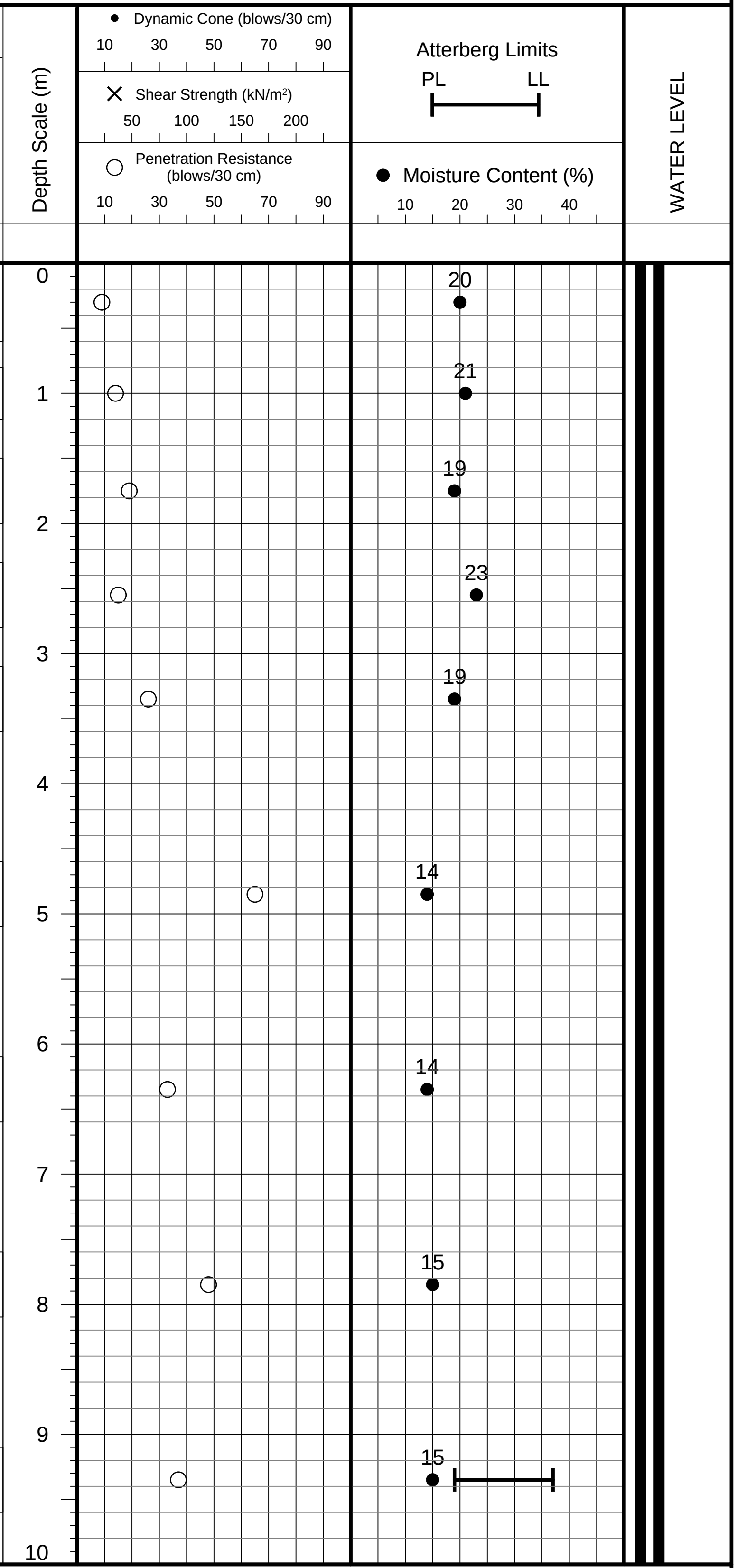
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
250.4	Ground Surface			
0.0	**15 cm TOPSOIL**			
	Dark brown **EARTH FILL** silty clay with some rootlet occ. topsoil inclusions	1	DO	9
		2	DO	14
		3	DO	19
248.3 2.1	Brown, stiff **SILTY CLAY** occ. fine sand seams	4	DO	15
247.3 3.1	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	5	DO	26
		6	DO	65
	brown grey	7	DO	33
		8	DO	48
		9	DO	37
240.4				



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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

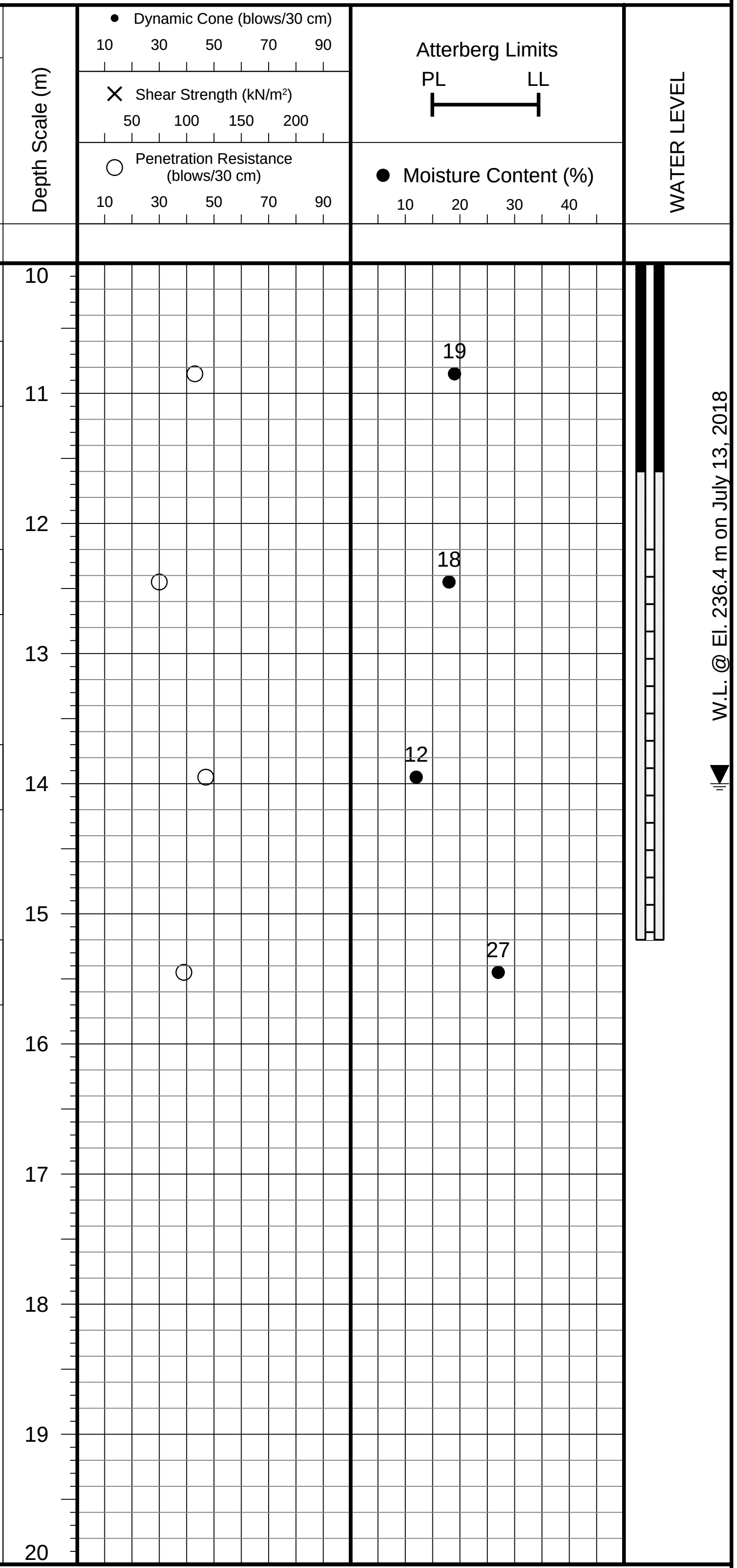
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES		
		Number	Type	N-Value
10.0	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders			
		10	DO	43
		11	DO	30
		12	DO	47
		13	DO	39
234.7 15.7	**END OF BOREHOLE**			



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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

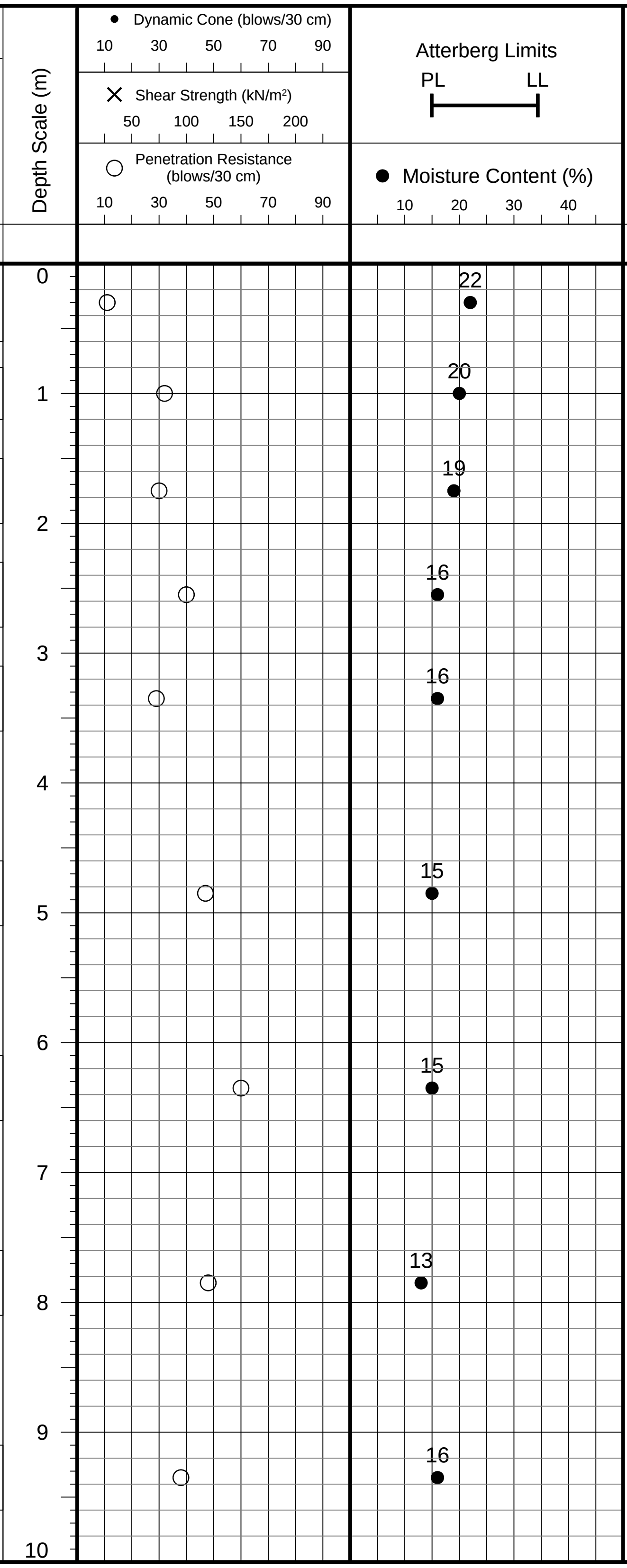
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 20, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Moisture Content (%)	WATER LEVEL
252.3	Ground Surface					
0.0	**13 cm TOPSOIL**					
	Brown, stiff to very stiff **SILTY CLAY** weathered occ. fine sand and silt seams	1	DO	11	22	Dry upon completion
		2	DO	32	20	
250.8 1.5	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	3	DO	30	19	
		4	DO	40	16	
		5	DO	29	16	
		6	DO	47	15	
		7	DO	60	15	
	brown grey	8	DO	48	13	
		9	DO	38	16	
242.3						



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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

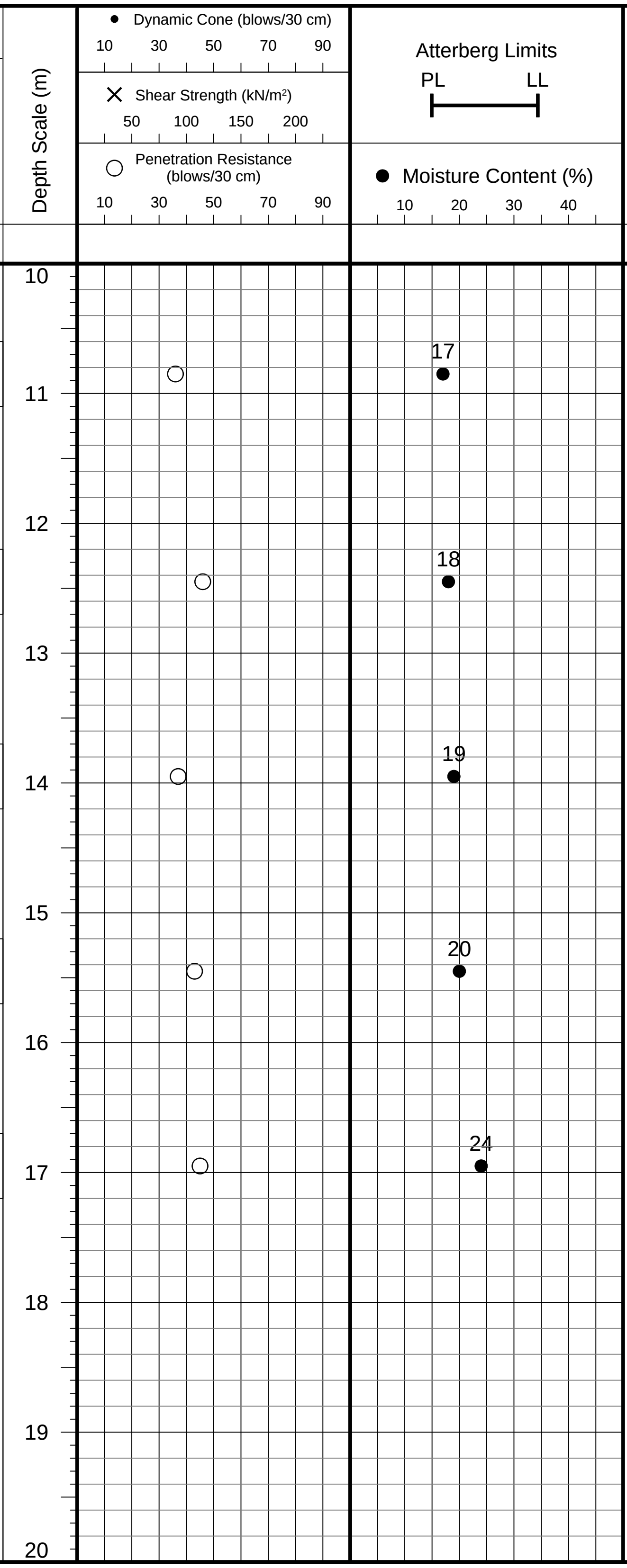
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 20, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES			WATER LEVEL
		Number	Type	N-Value	
10.0	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	10	DO	36	
		11	DO	46	
		12	DO	37	
		13	DO	43	
	sand layers	14	DO	45	
235.1 17.2	**END OF BOREHOLE**				



JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

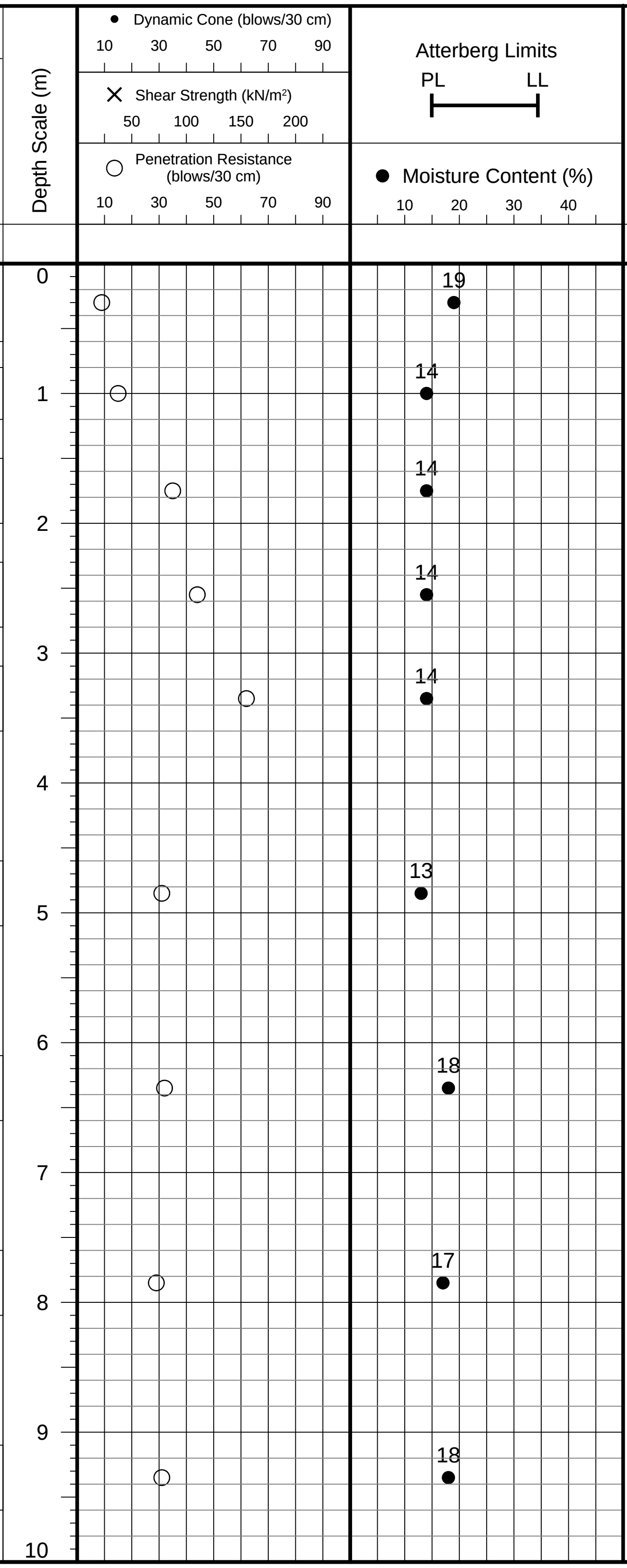
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 19, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
249.8	Ground Surface			
0.0	**15 cm TOPSOIL**			
	Stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	1	DO	9
	weathered	2	DO	15
	sandy silt till layer	3	DO	35
		4	DO	44
		5	DO	62
	brown grey	6	DO	31
		7	DO	32
		8	DO	29
		9	DO	31
239.8				



WATER LEVEL

Dry upon completion

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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

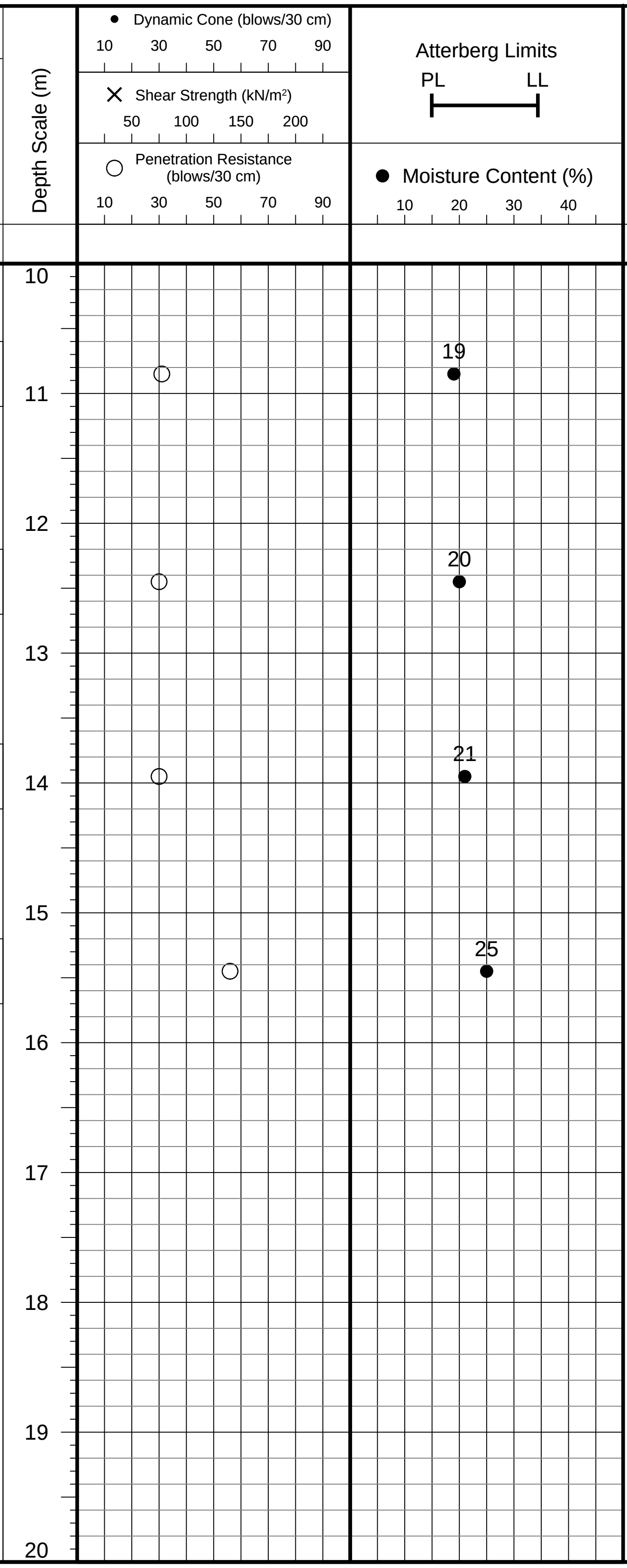
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 19, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
10.0	Stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders				
		10	DO	31	
		11	DO	30	
		12	DO	30	
	sand layers	13	DO	56	
234.1 15.7	**END OF BOREHOLE**				



JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

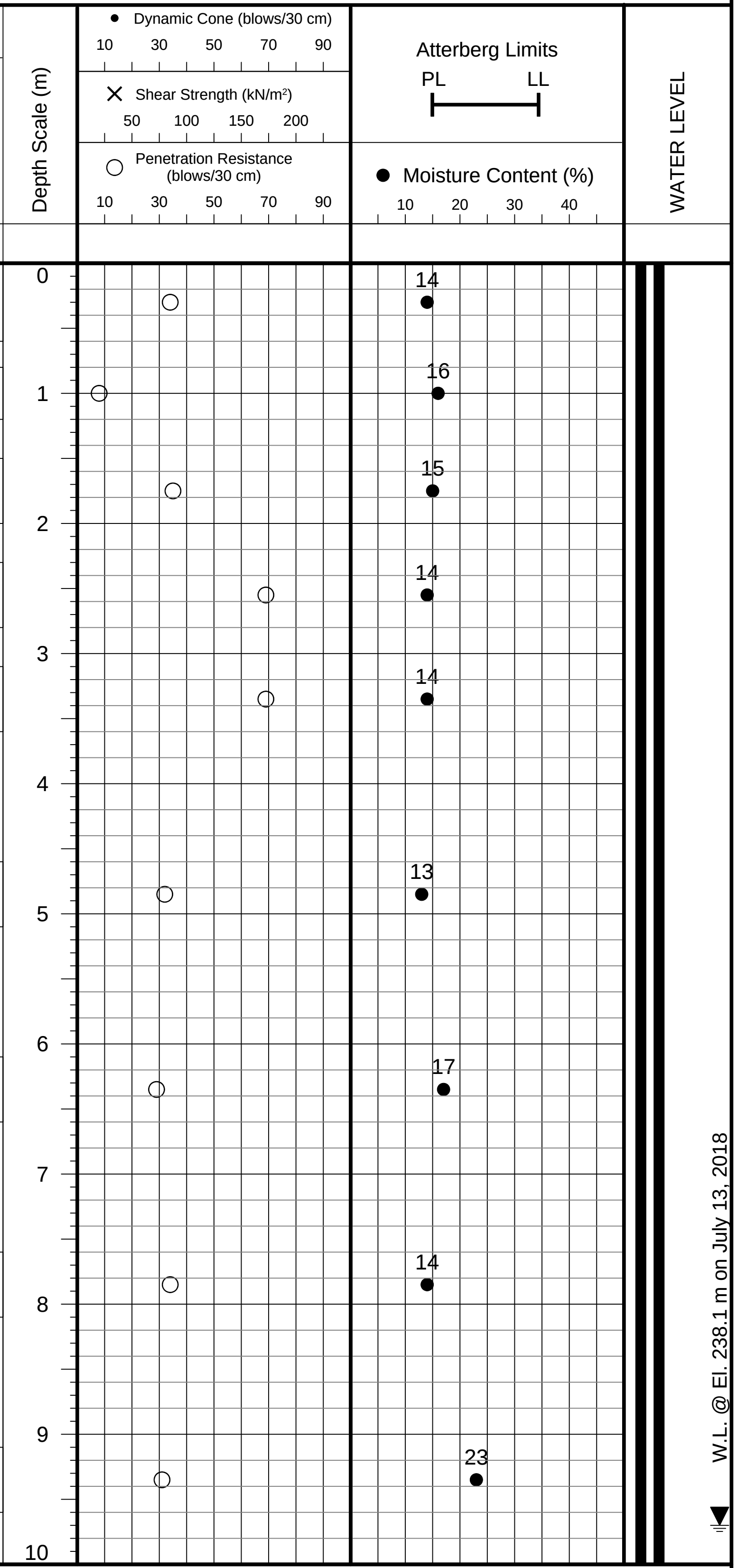
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 19, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
247.8	Ground Surface			
0.0	**15 cm TOPSOIL** Brown, stiff to hard **SILTY CLAY** occ. gravel	1	DO	34
	weathered	2	DO	8
		3	DO	35
245.5 2.3	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	4	DO	69
		5	DO	69
	brown grey	6	DO	32
		7	DO	29
	some sand to sandy	8	DO	34
	wet sand layer	9	DO	31
237.8				



W.L. @ El. 238.1 m on July 13, 2018

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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

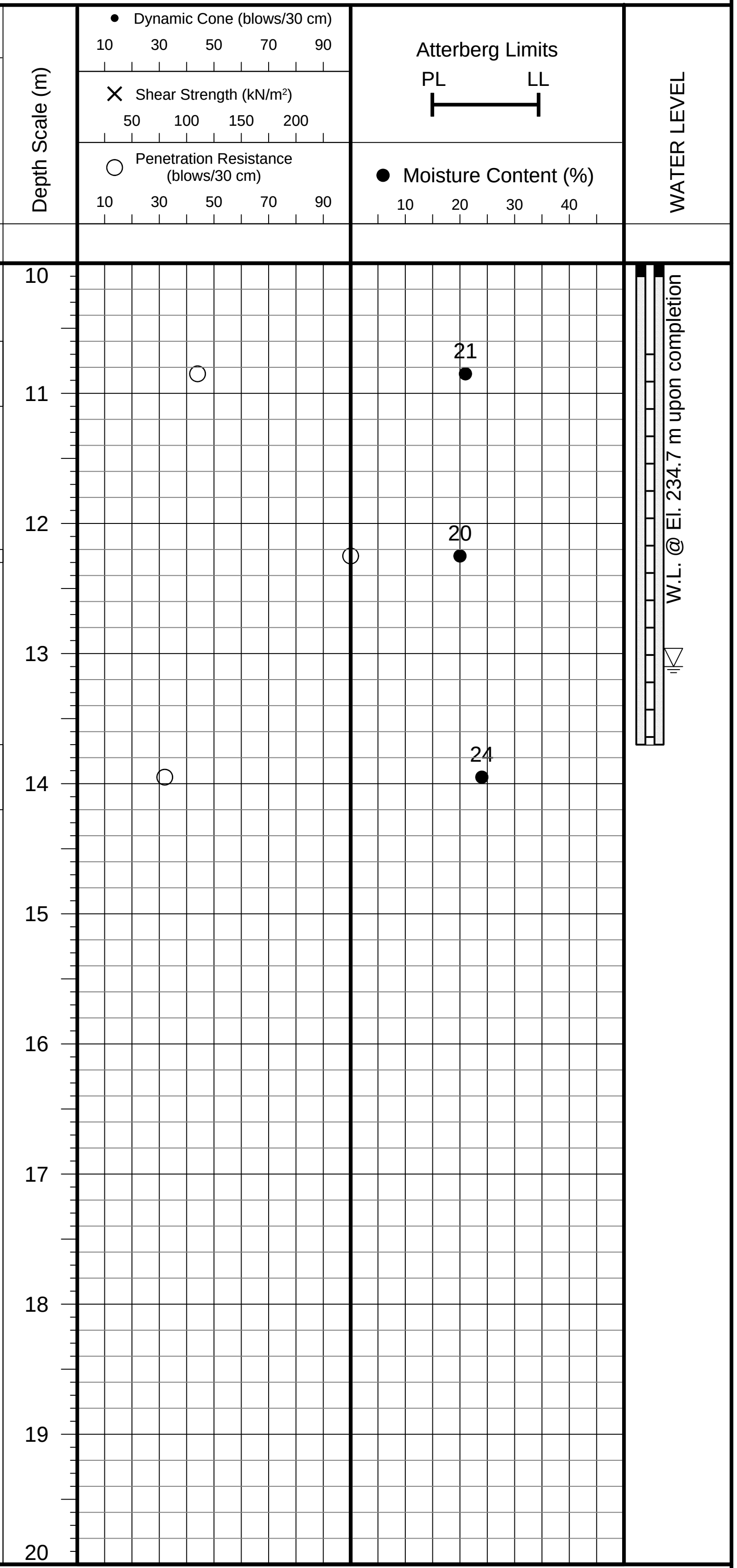
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 19, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
10.0	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders			
		10	DO	44
		11	DO	50/5
		12	DO	32
233.6 14.2	**END OF BOREHOLE**			



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JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

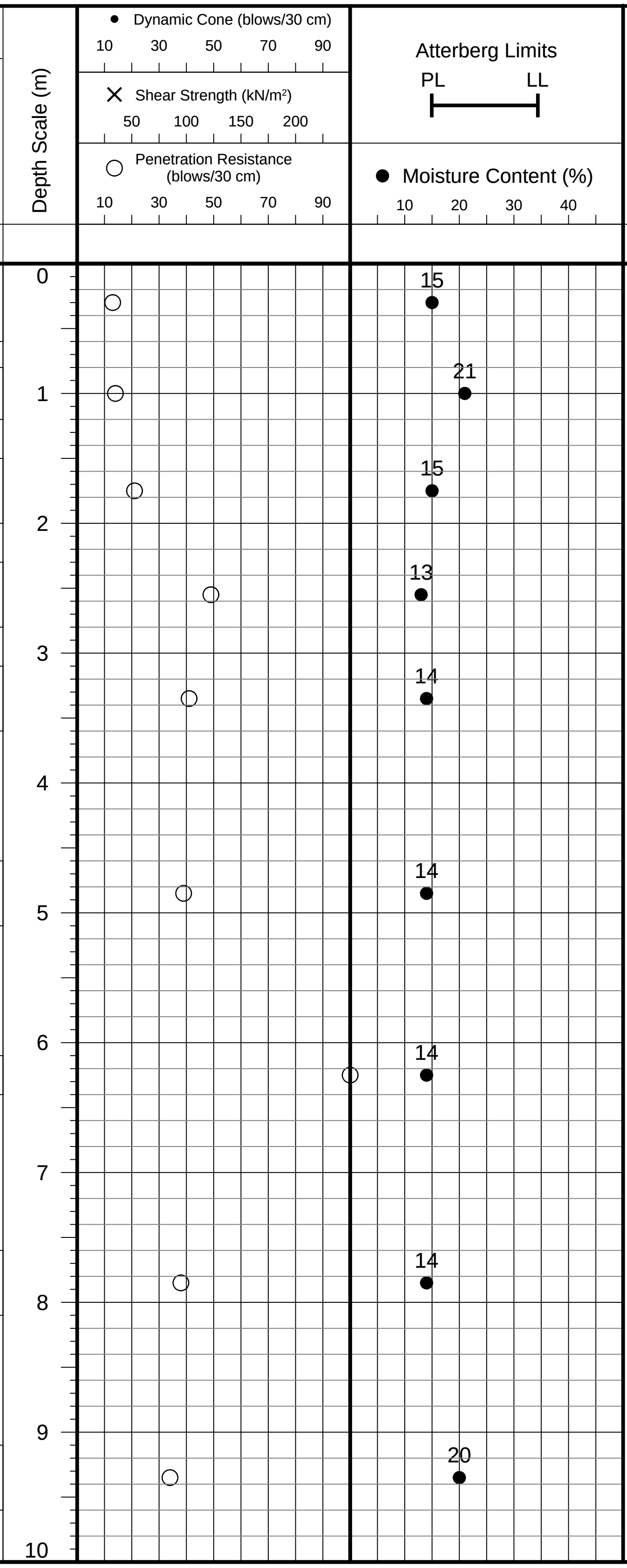
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 20, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES		
		Number	Type	N-Value
249.4	Ground Surface			
0.0	**13 cm TOPSOIL**			
	Brown, stiff to very stiff **SILTY CLAY** occ. topsoil and rootlet inclusions	1	DO	13
	weathered	2	DO	14
		3	DO	21
247.1 2.3	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders	4	DO	49
		5	DO	41
	brown grey	6	DO	39
		7	DO	50/13
		8	DO	38
		9	DO	34
239.4				



WATER LEVEL

Dry upon completion

Soil Engineers Ltd.

JOB NO.: 1805-S060

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

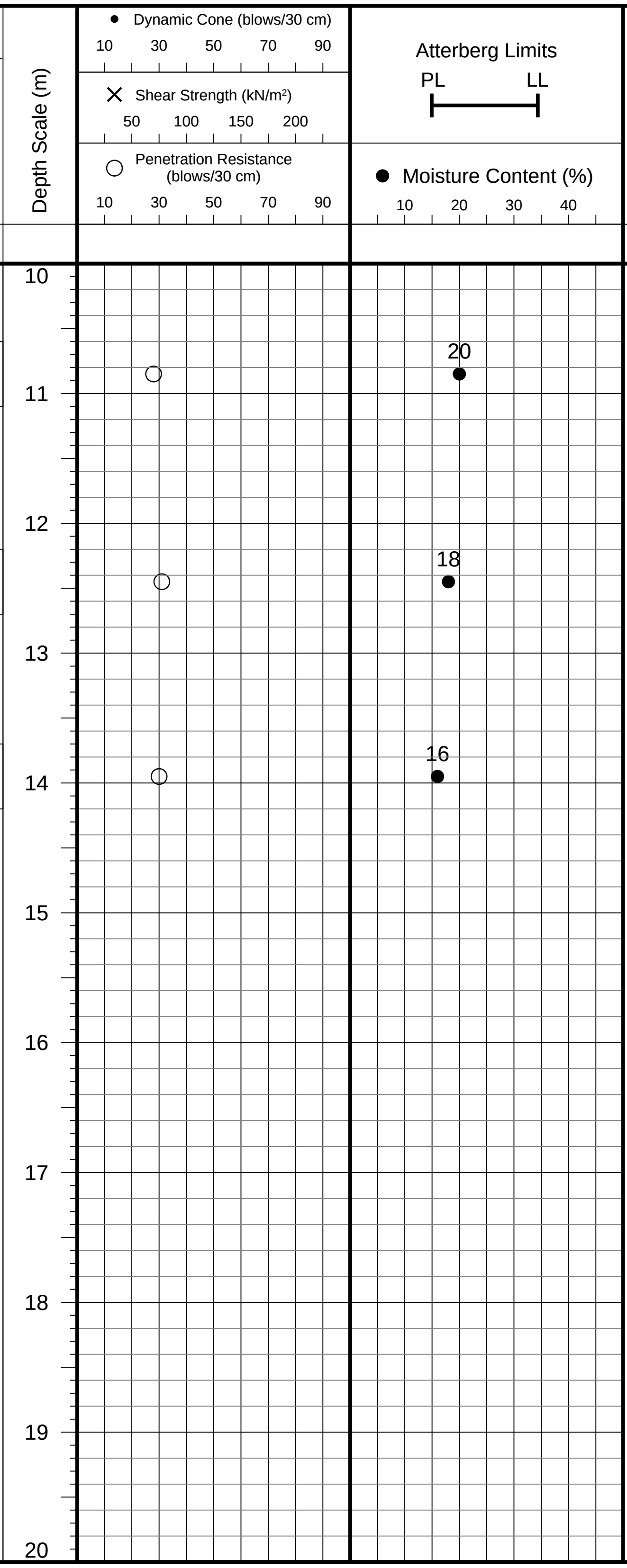
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

DRILLING DATE: June 20, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	WATER LEVEL
10.0	Very stiff to hard **SILTY CLAY TILL** traces of sand and gravel occ. sand and silt seams, cobbles and boulders				
		10	DO	28	
		11	DO	31	
		12	DO	30	
235.2 14.2	**END OF BOREHOLE**				



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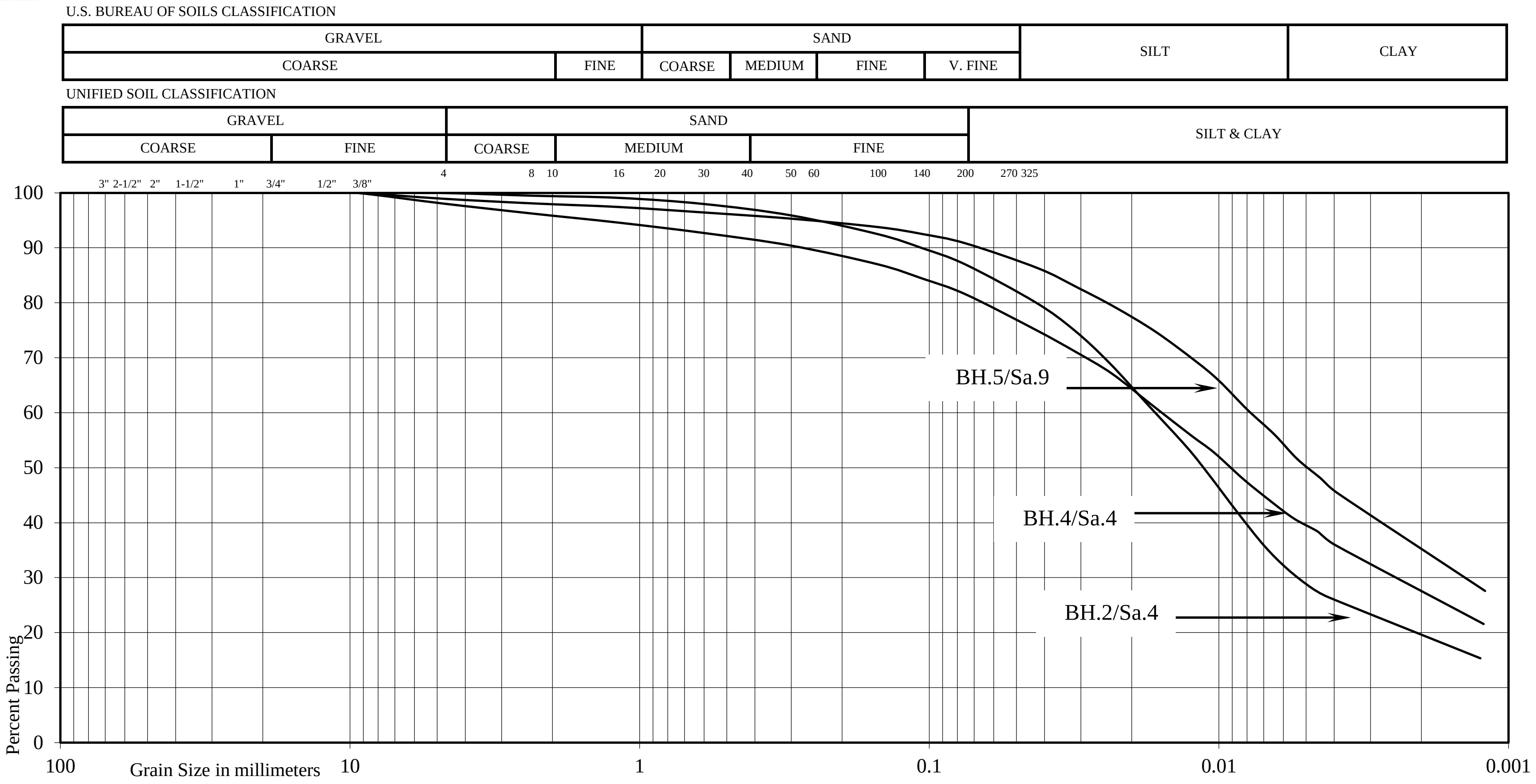
GRAIN SIZE DISTRIBUTION

Reference No: 1805-S060



Project: Proposed Residential Development

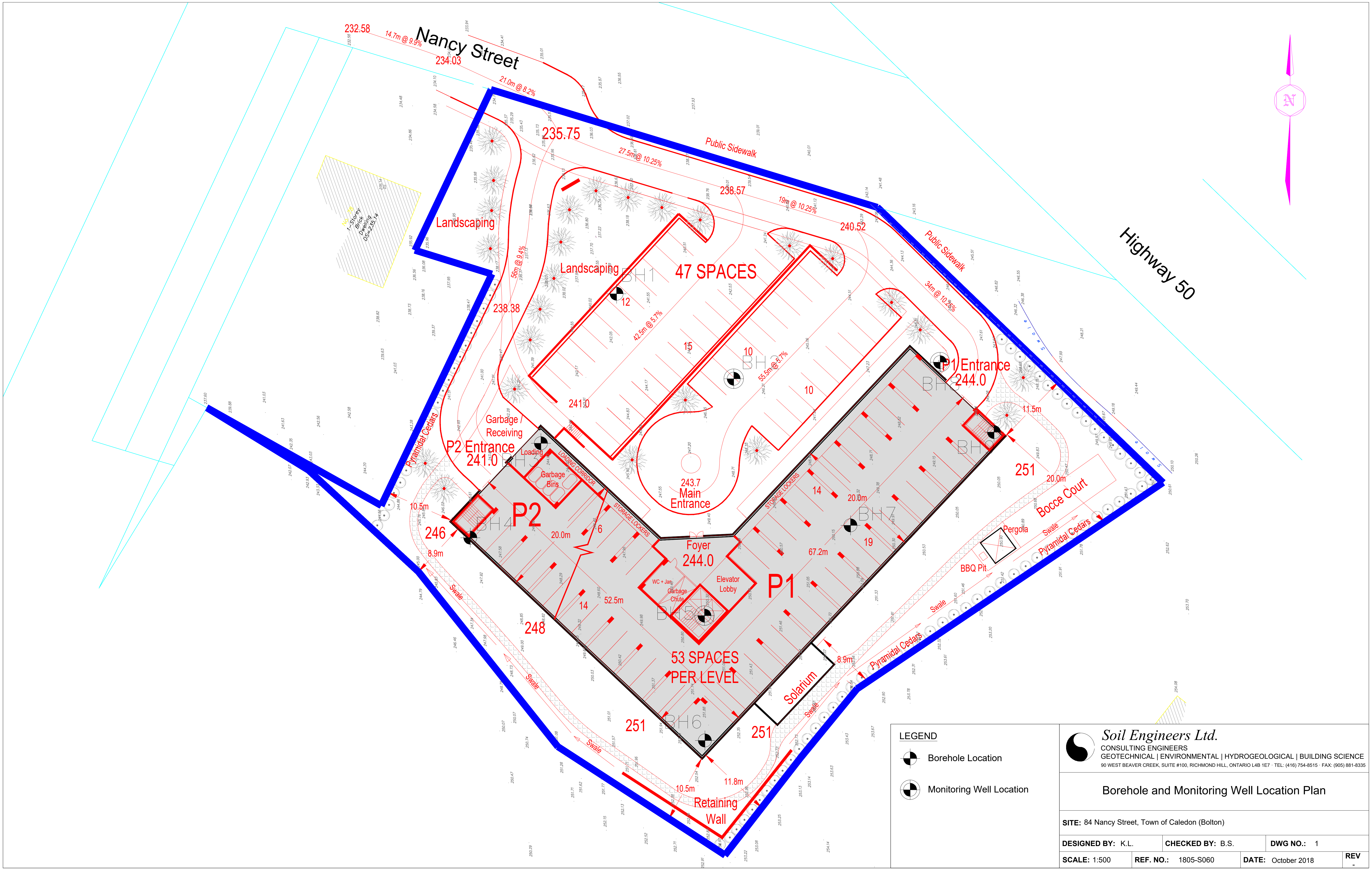
Location: 84 Nancy Street, Town of Caledon (Bolton)

Borehole No:	2	4	5
Sample No:	4	4	9
Depth (m):	2.5	2.5	9.3
Elevation (m):	242.8	243.8	241.1

BH./Sa.	2/4	4/4	5/9
Liquid Limit (%) =	-	33	37
Plastic Limit (%) =	-	18	19
Plasticity Index (%) =	-	15	18
Moisture Content (%) =	16	13	15
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: 10



LEGEND

⊕ Borehole Location

⊕ Monitoring Well Location

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

Borehole and Monitoring Well Location Plan

SITE: 84 Nancy Street, Town of Caledon (Bolton)

DESIGNED BY: K.L.
CHECKED BY: B.S.
DWG NO.: 1
SCALE: 1:500
REF. NO.: 1805-S060
DATE: October 2018
REV -

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE

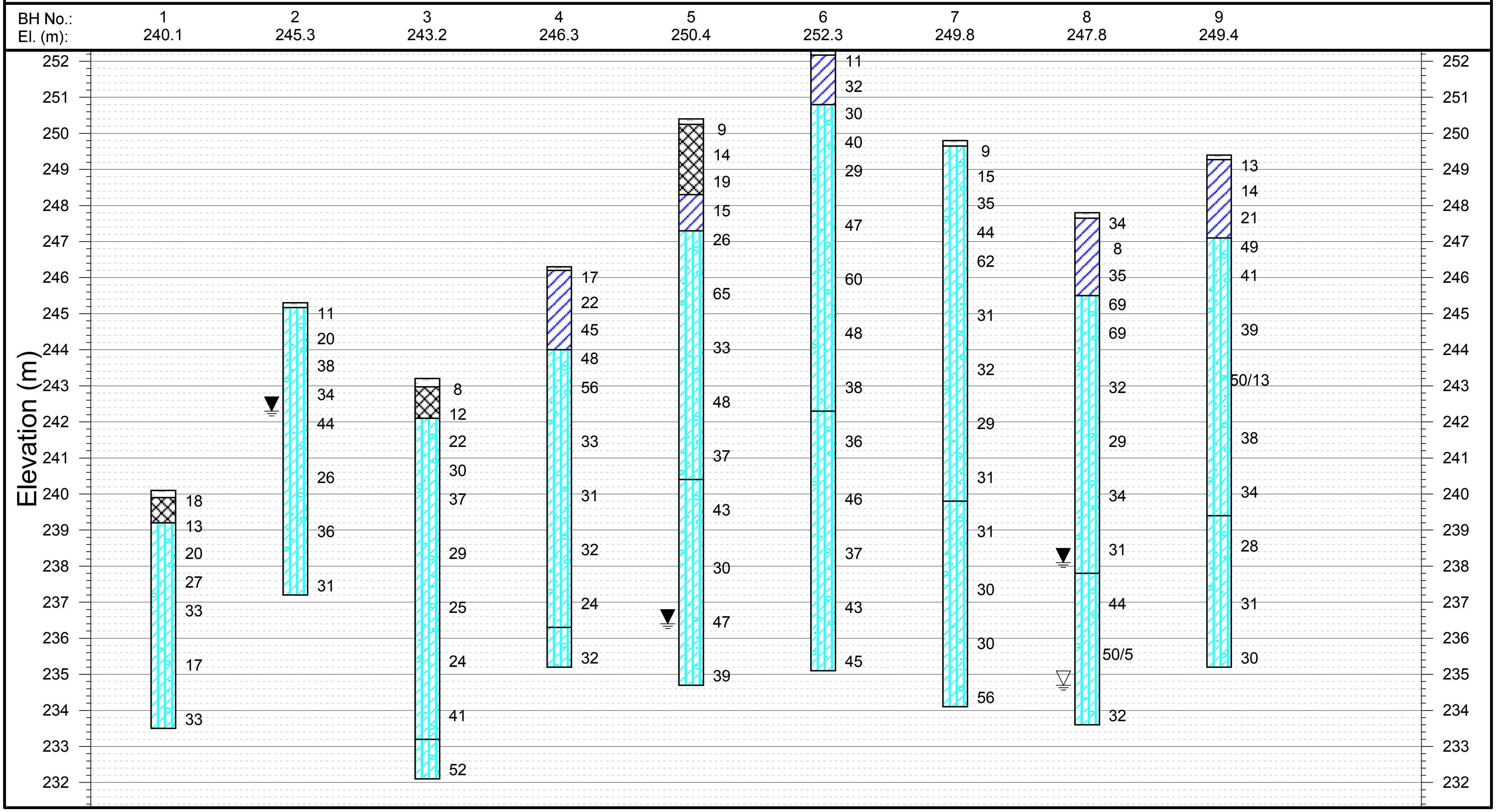
SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

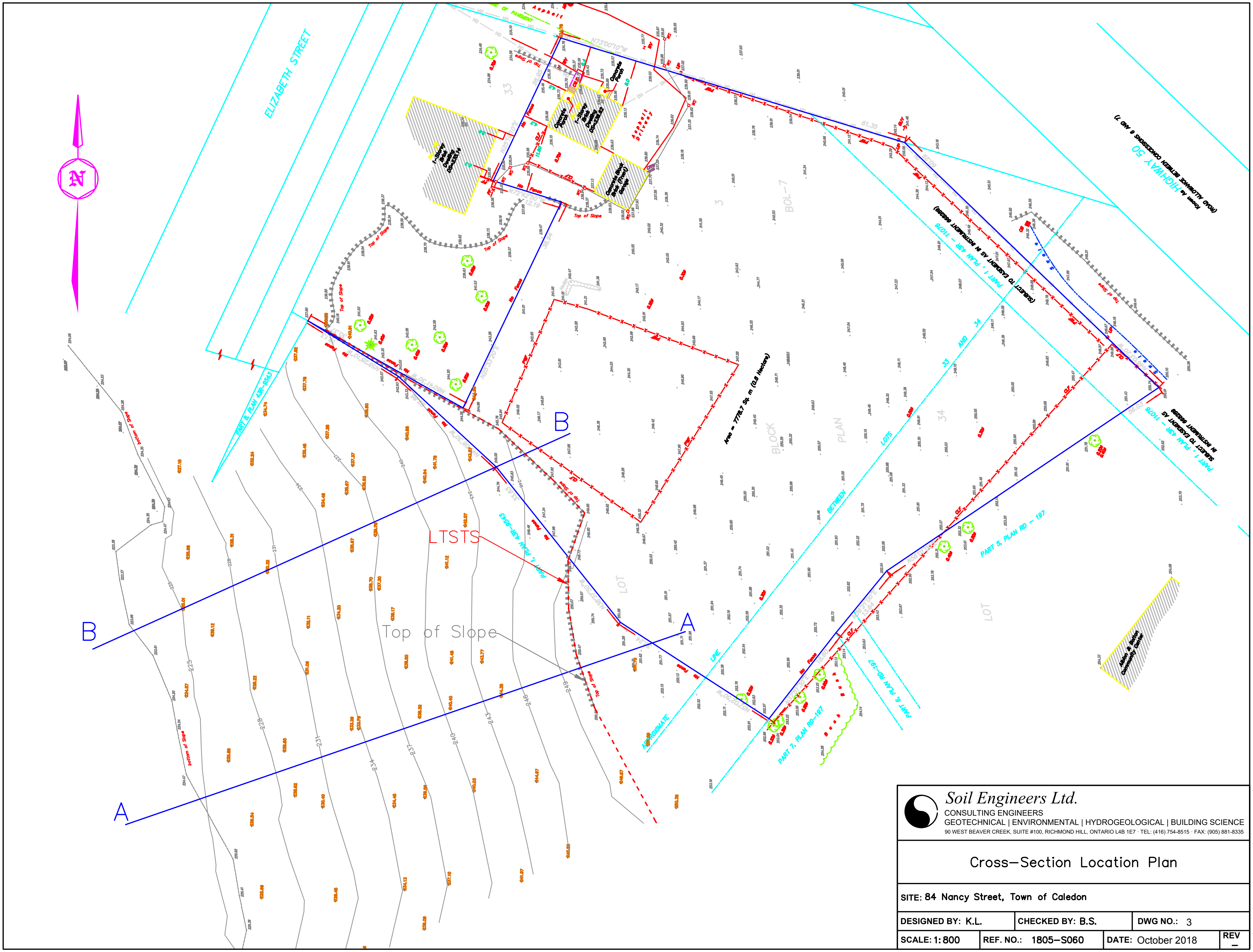
JOB NO.: 1805-S060
REPORT DATE: October 2018
PROJECT DESCRIPTION: Proposed Residential Development
PROJECT LOCATION: 84 Nancy Street, Town of Caledon (Bolton)

LEGEND

▨ TOPSOIL ▩ FILL ▧ SILTY CLAY ▥ SILTY CLAY TILL

▽ WATER LEVEL (END OF DRILLING) ▼ WATER LEVEL (STABILIZED)





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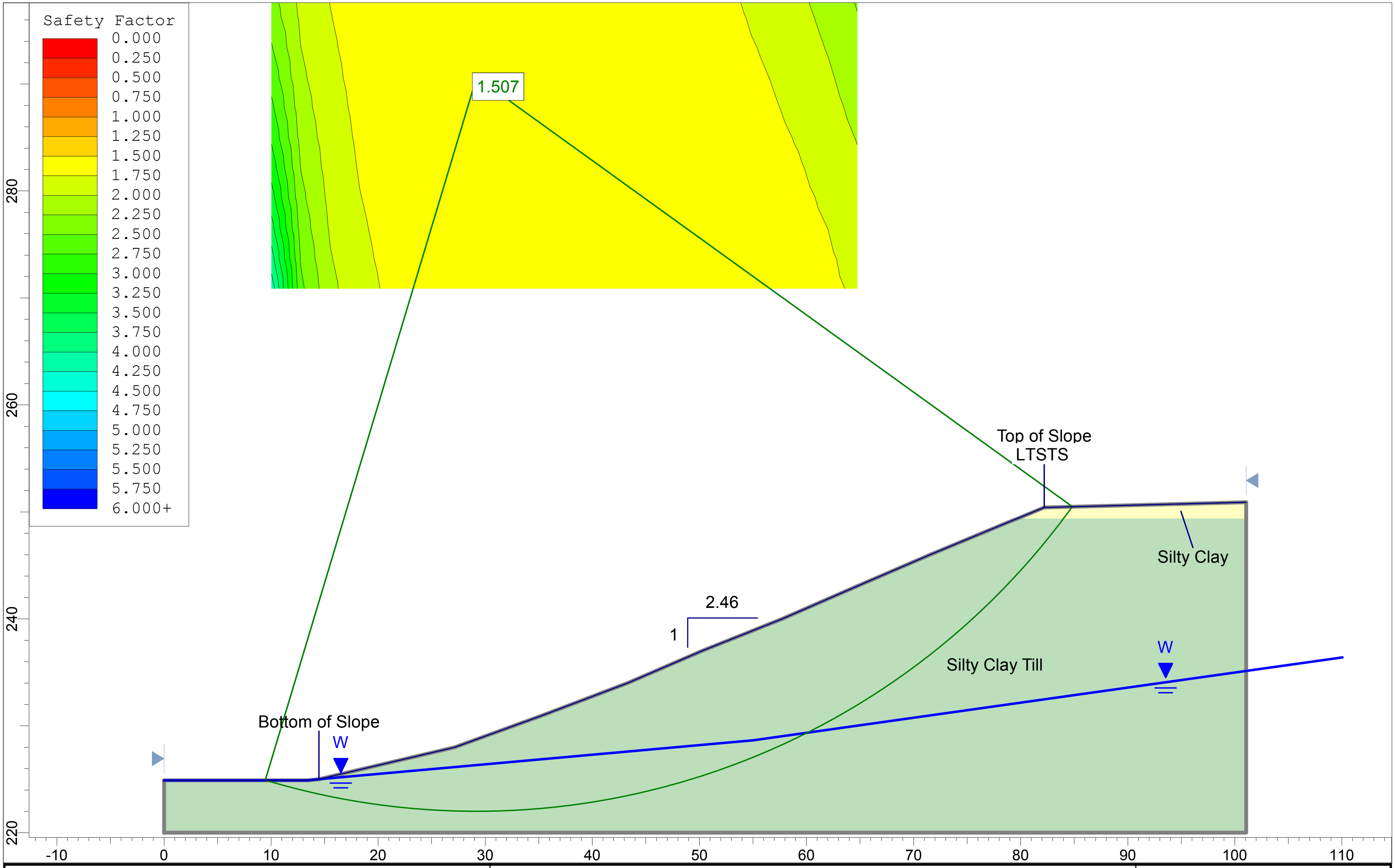
90 WEST BEAVER CREEK, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Cross—Section Location Plan

SITE: 84 Nancy Street, Town of Caledon

DESIGNED BY: K.L.
CHECKED BY: B.S.
DWG NO.: 3
SCALE: 1:800
REF. NO.: 1805—S060
DATE: October 2018
REV —



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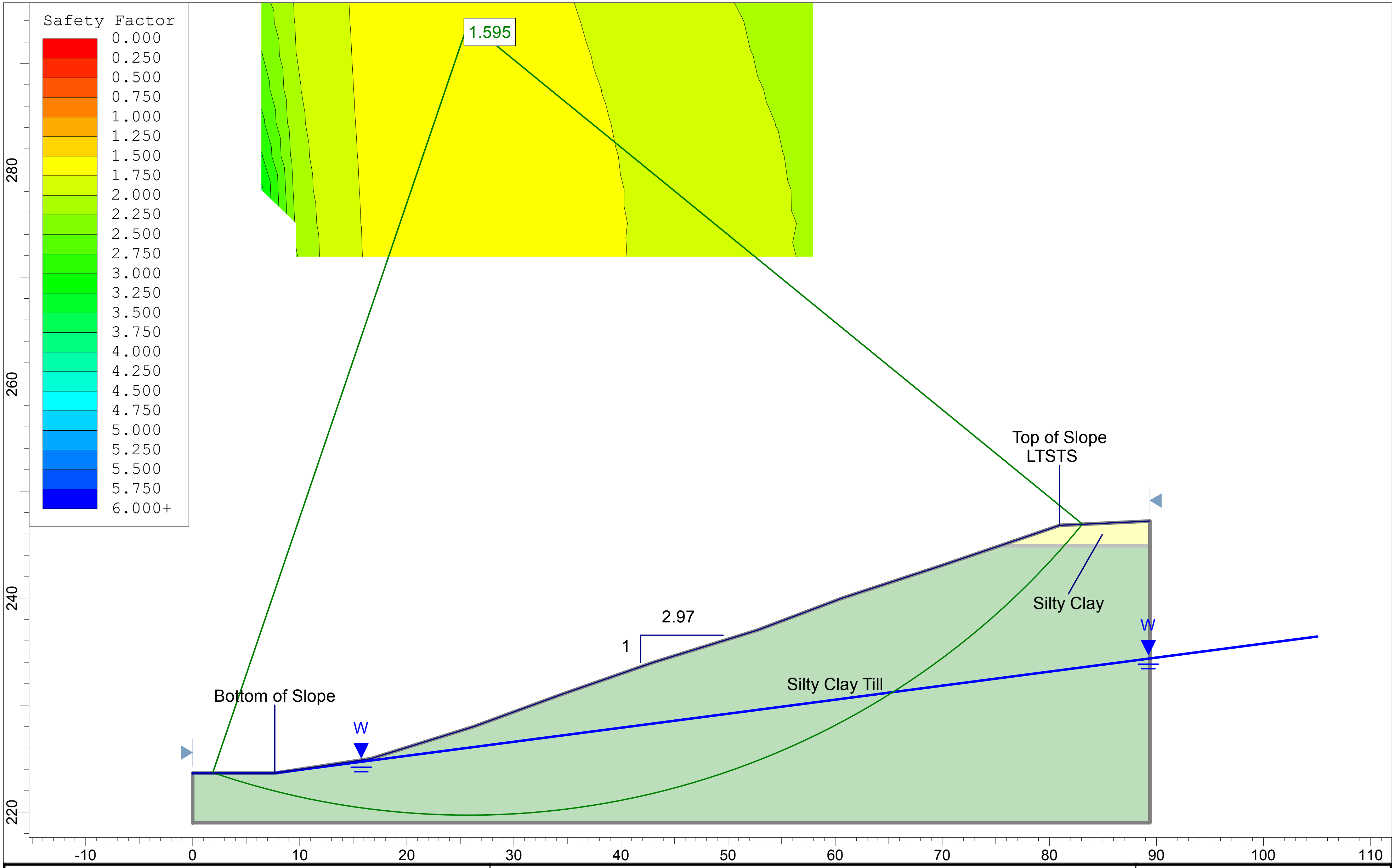
Project Title: Slope Stability Analysis - Cross Section A-A
Load Case: Existing Condition
Location: 84 Nancy Street, Town of Caledon
Drawn By: K.L.
Checked By: B.S.
Scale: 1:500
Revision: -
Date: October 2018
Reference No.: 1805-S060
Drawing No.: 4



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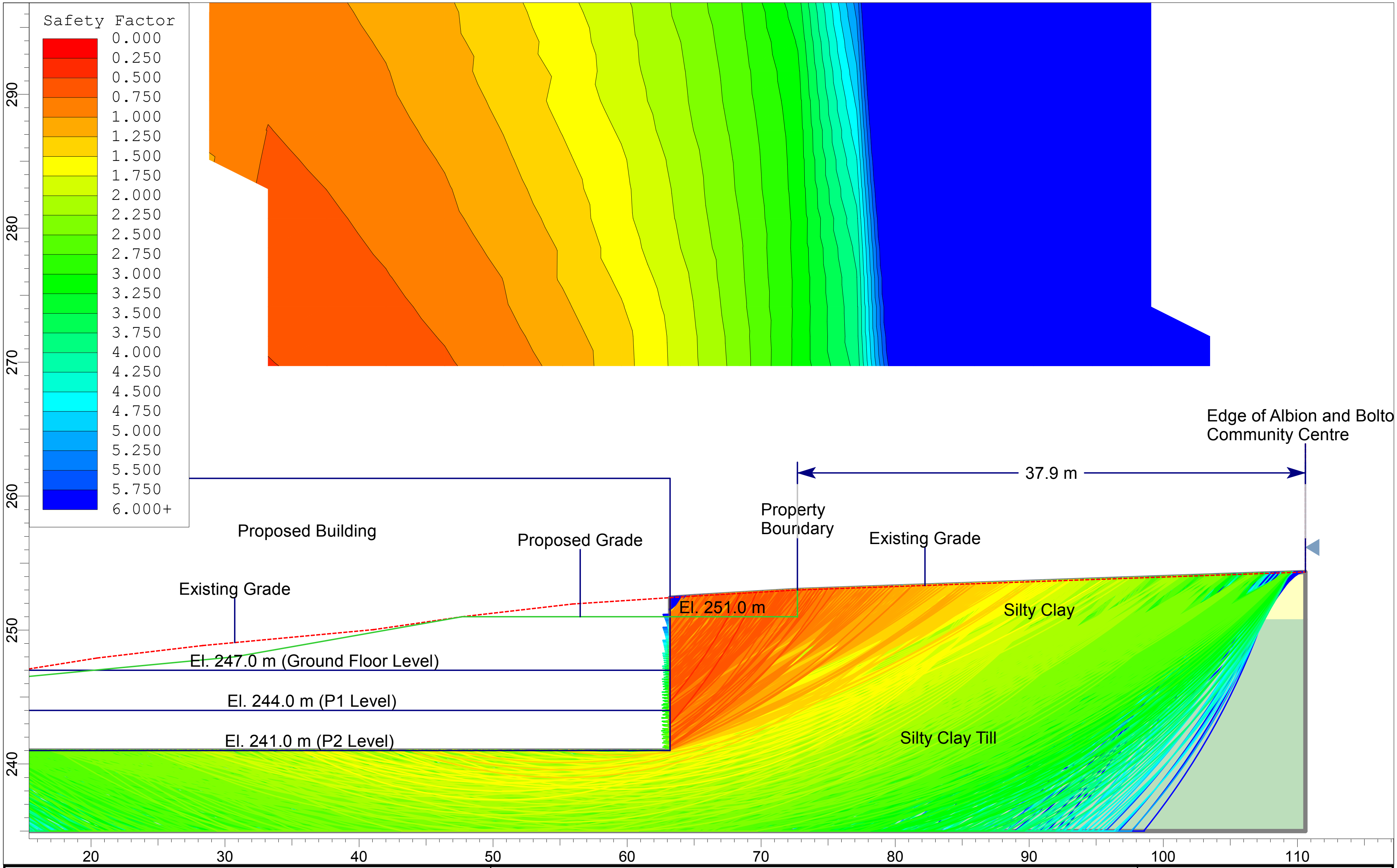
Project Title: Slope Stability Analysis - Cross Section B-B
Load Case: Existing Condition
Location: 84 Nancy Street, Town of Caledon
Drawn By: K.L.
Checked By: B.S.
Scale: 1:500
Revision: -
Date: October 2018
Reference No.: 1805-S060
Drawing No.: 5



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Project Title	Slope Stability Analysis - Cross Section C-C			Load Case	During Construction
Location	84 Nancy Street, Town of Caledon				
Drawn By K.L.	Checked By B.S.	Scale	1:400	Revision	-
Date	October 2018	Reference No.	1805-S060	Drawing No.	6

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APPENDIX

SHORING DESIGN

REFERENCE NO. 1805-S060

SHORING SYSTEM

Shoring will be required in an excavation to limit the horizontal and vertical movements of adjacent properties.

A shoring system consisting of soldier piles and lagging boards can be used in an excavation where slight movement in the adjacent properties is tolerable. In an area with close proximity of adjacent structure and the excavation will be extending below the foundation level where any movement in the adjacent properties is a concern, or in an excavation embedding into saturated sand or silt deposit, an interlocking caisson wall is more appropriate.

The design and construction of the shoring system should be carried out by a specialist designer and contractor experienced in this type of construction. All specifications for the design of the shoring system should be in accordance with the latest edition of the Canadian Foundation Engineering Manual (CFEM).

LATERAL EARTH PRESSURE

For single and multiple level supporting systems, the lateral earth pressure distributions on the shoring walls are shown on Drawing A1. The design soil parameters are provided in the geotechnical report.

The lateral earth pressure expressions do not include hydrostatic pressure buildup behind the shoring. If the wall is designed to be watertight or undrained, such as a caisson wall, the anticipated hydrostatic pressure must be included behind the structure.

PILE PENETRATION

The depth of pile support should be calculated from the following expressions:

$$R = 1.5\ D\ K_p\ L^2\ \gamma$$

where	R	= Ultimate load to be restrained	kN
	D	= Diameter of concrete filled hole	m
	K_p	= Passive resistance of soils below the level of excavation	
	L	= Embedment depth of the pile	m
	γ	= Unit weight of the soil	kN/m^3

The shoring system should be designed for a factor of safety of F = 2.

For anchor supported shoring system, the global factor of safety against sliding and overturning of the anchored block of soil must also be considered.

The steel soldier piles in the shoring system must be installed in pre-augured holes. The lower portion will have to be filled with 20 MPa (3000 psi) concrete to the excavation level. The upper portion of the pile within the excavation depth should be filled with lean mix concrete or non-shrinkable cementitious filler (U-fill).

LAGGING

The following thicknesses of lagging boards have been recommended in CFEM:

Thickness of Lagging	**Maximum Spacing of Soldier Piles**
50 mm (2 in)	1.5 m (5 ft)
75 mm (3 in)	2.5 m (8 ft)
100 mm (4 in)	3.0 m (10 ft)

Local experience has indicated that the lagging board thickness of 75 mm has been adequate for soldier pile spacing of 3 m for soil conditions similar to those encountered at the subject site. However, it is important to consider all local conditions, such as the duration of excavation, the weather likely to be encountered through the construction period, seasonal variations in the ground water and ice lensing causing frost heave and softening of soils in determining the lagging thickness. During winter months, the shoring should be covered with thermal blankets to prevent frost penetration behind the shoring system which may result in unacceptable movements.

During construction of shoring, all the spaces behind the lagging board must be filled with free-draining granular fill. If wet conditions are encountered, the space between the boards should be packed with a geotextile filter fabric or straw to prevent the loss of fine particles.

TIEBACK ANCHORS

The minimum spacing and the depths of the soil anchors should be as recommended in the CFEM.

All drilled holes for tieback anchors should be temporarily cased or lined to minimize the risk of caving. Systems involving high grout pressures should be avoided if working near other basements or buried services.

The tieback anchor lengths can be estimated using an adhesion values of 30 kPa. Full scale load tests should be carried out on the tieback anchors in each type of soils and at each level of anchor support at the site to confirm the design parameters and the adhesion values. The test anchors should be loaded in a pattern as described in CFEM, to 200% of the design load or until there is a significant increase in the pullout rate. In the latter case, the design load must be limited to 50% of the maximum load at which the pullout increases. Based on the results of the pullout test, it may be necessary to modify the anchor design of the production anchors.

Each tieback anchor must be proof-loaded to 133% of the design load, and the anchor must be capable of sustaining this load for a minimum of 10 minutes without creep. The load may then be relaxed to 100% of the design and locked in. The higher the lock-in loads, the less will be the outward movement on the shoring wall after excavation.

RAKERS

An alternative to tieback anchor support of the shoring is to use raker footings. Rakers inclining at an angle of 45º, founded in the native soil deposit below the bottom of excavation should be designed for the allowable bearing pressure of 200 kPa (4.0 k.s.f.).

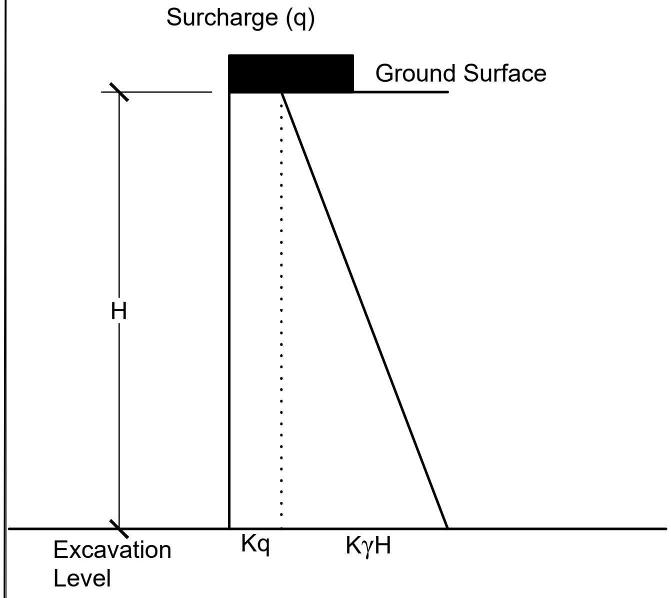
The raker footings should be located outside the zone of influence of the buried portion of the soldier piles at a distance of not less than 1.5 of the length of embedment of the soldier pile.

To prevent undermining of the raker footing, no excavation should be made within two times the width of raker footing on the opposite side of the raker.

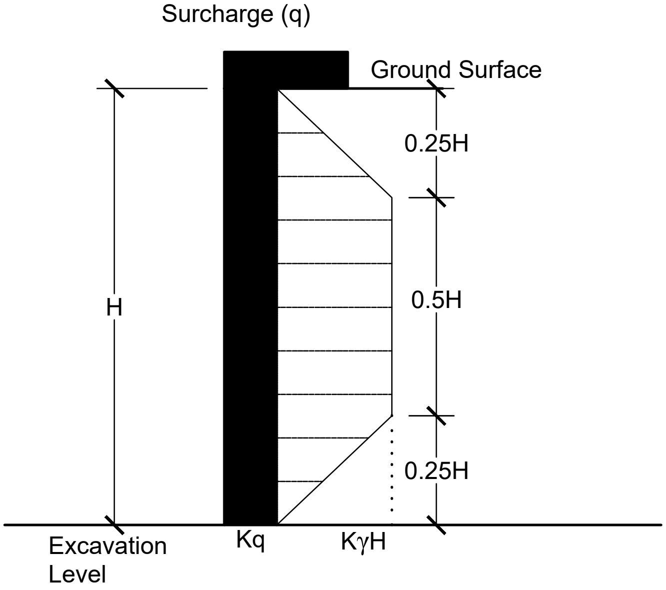
MONITORING OF PERFORMANCE

Close monitoring of the vertical and lateral movement of the shoring system, by inclinometers or by survey on targets, should be carried out at the site. Extra bracing or support may be required if any movement is found excessive. The contractor should maintain the shoring to ensure any movement is within the design limit.

TEMPORARY SHORING
Lateral Earth Pressures



Single Support System



Multiple Support System

Lateral Pressure $P = K(\gamma H + q)$

Where

H = Height of Shoring m

γ = Unit Weight of Retained Soil 21 kN/m^3

q = Surcharge kPa

K = Earth Pressure Coefficient

- If moderate ground and shoring movements are permissible then:
  $K = K_a$ = Active Earth Pressure Coefficient

- if there are building foundations within a distance of 0.5 H behind the shoring then:
  $K = K_o$ = Earth Pressure at rest

- If there are building foundations within a distance of between 0.5 H and H behind the shoring then:
  $K = 0.5\,(K_a + K_o)$

Note:

1. The lateral pressure expression assumes effective drainage from behind the temporary shoring.
2. The earth pressure coefficients are specified in the geotechnical report.

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Temporary Shoring

SITE: 84 Nancy Street, Town of Caledon (Bolton)

DESIGNED BY: K.L. **CHECKED BY:** B.S. **DWG NO.:** A1

SCALE: N.T.S. **REF. NO.:** 1805-S060 **DATE:** July 2018 **REV** -