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A REPORT TO
TYROLEAN VILLAGE RESORTS LIMITED

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

138 KANDAHAR LANE

TOWN OF THE BLUE MOUNTAINS

REFERENCE NO. 2011-S017

FEBRUARY 2021

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1.0 INTRODUCTION

In accordance with written authorization dated November 2, 2020, from Mr. Denis Martinek, President, of Tyrolean Village Resorts Ltd., a geotechnical investigation was carried out at a parcel of land located at 138 Kandahar Lane, Town of The Blue Mountains, for a proposed Residential Development.

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 the proposed project.

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

2.0 SITE AND PROJECT DESCRIPTION

The site is situated on a bluff of the Nottawasaga basin where glacial Lake Nipissing previously extended. The stratigraphy consists of glacial till and sand derived from outwash of the Edenvale Moraine, fluvial deposit of Lake Nipissing and the present Nottawasaga River, overlying limestone bedrock at shallow to moderate depths.

The investigated site is situated at the southwest sector of Tyrolean Lane and Kandahar Lane, in Town of The Blue Mountains. The investigated area is a grass- or weed-covered open field and the ground surface is relatively level with some undulations and is in a gentle descend towards the east.

The proposed project will consist of the construction of a new residential development, with municipal services and roadways meeting the municipal standards.

3.0 FIELD WORK

The field work, consisting of 10 boreholes to depths of 6.3 m, 6.5 m and 6.6 m, was performed on November 23 and 24, 2020, at the locations shown on the Borehole Location Plan, Drawing No. 1.

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.

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

The geodetic elevation at each of the borehole locations was obtained by Soil Engineers Ltd. using the Global Navigation Satellite System (GNSS).

4.0 **SUBSURFACE CONDITIONS**

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 10, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile on Drawing Nos. 2 and 3, and the engineering properties of the disclosed soils are discussed herein.

The investigation has disclosed that beneath a veneer of topsoil and in some location, a layer of earth fill, the site is underlain by a stratum of silty clay till.

4.1 **Topsoil** (All Boreholes)

The revealed topsoil ranges from 15 to 30 cm thick. It is dark brown in colour, indicating that it contains appreciable amounts of roots and humus. These materials are unstable and compressible under loads; therefore, the topsoil is considered to be void of engineering value. Due to its humus content, it 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.

Since the topsoil is considered void of engineering value, it can only be used for general landscaping and landscape contouring purposes. A fertility analysis can determine the suitability of the topsoil as a planting material.

4.2 **Earth Fill** (Boreholes 1, 2, 6, 7 and 8)

The earth fill was found extending to depths of 0.6 m and 1.0 m below the prevailing ground surface. The fill consists of silty clay material, with occasional topsoil layers.

The obtained 'N' values of the fill range from 6 to 10, with a median of 8 blows per 30 cm of penetration showing that the earth fill was loosely placed without proper compaction.

The natural water content values range from 13% to 47%, with a median of 23%, indicating that the fill is in a moist to wet condition, which was confirmed by the sample examinations.

Due to its loose, non-uniform density and unknown history, the earth fill is considered unsuitable for supporting structures. For structural use, the fill must be subexcavated, sorted free of topsoil any other deleterious material, and properly compacted. If it is impractical to sort the fill, then it must be wasted.

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

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

The silty clay till 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. Occasional sand and silt seams and layers were also detected in the clay till mantle. The till is heterogeneous in structure, indicating that it is a glacial deposit. The clay till layer is weathered to depths of 0.7 m and 1.4 m, at some borehole locations.

The obtained ‘N’ values range from 6 blows per 30 cm to 50 blows with no penetration, with a median of 56 blows per 30 cm of penetration, indicating that the consistency of the silty clay till is firm to hard, being generally hard. The firm soil is generally restricted to the weathered zone.

Hard resistance was encountered during augering, showing that the till is embedded with cobbles and boulders.

The Atterberg Limits of 1 representative sample and the natural water content values of all the samples were determined; the results are plotted on the Borehole Logs and summarized below:

Liquid Limit	22%
Plastic Limit	16%
Natural Water Content	6% to 21% (median 9%)

The results show that the clay till is a cohesive material with low plasticity. The natural water content values generally lie below its plastic limit, confirming the generally hard consistency of the till as determined by the ‘N’ values.

Grain size analyses were performed 2 representative samples of the silty clay till. The results are plotted on Figure 11.

Based on the findings, the engineering properties related to the project are as follows:

- High frost susceptibility, with low water erodibility.
- Low permeability, with an estimated coefficient of permeability of 10^{-7} cm/sec, an estimated percolation rate of over 80 min/cm, and runoff coefficients of:

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

- A cohesive soil, its shear strength is primarily derived from consistency which is inversely related to its moisture content. It contains sand; therefore, its shear strength is augmented by internal friction.
- It will generally be stable in a relatively steep cut; however, prolonged exposure will allow the fissures in the weathered zone and the wet sand and silt seams and layers to become saturated, which may lead to localized sloughing.
- A very poor pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 3% or less.
- Moderate high corrosivity to buried metal, with an estimated electrical resistivity of 3000 ohm·cm.

4.4 Compaction Characteristics of the Revealed Soils

The obtainable degree of compaction of the on-site material 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	13 to 47 (median 23)	18	12 to 23
Silty Clay Till	6 to 21 (median 9)	16	12 to 21

Based on the above findings, a portion of the earth fill is generally suitable for a 95% or + Standard Proctor compaction; whereas, the silty clay till is generally too dry and will require addition of water prior to structural compaction. The earth fill must be sorted free of topsoil and any deleterious materials prior to use as structural fill, otherwise it must be wasted.

The silty clay till and fill 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 very stiff to hard silty clay till 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 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. Wetting of the till will be necessary to achieve this requirement.

If the compaction of the soil 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 foundations or bedding of the underground services 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.

The presence of boulders in the till will prevent transmission of the compactive energy into the underlying material to be compacted. If an appreciable amount of boulders or shale fragments over 15 cm in size is mixed with the material, it must either be sorted or must not be used for structural backfill.

5.0 GROUNDWATER CONDITIONS

No groundwater was detected and all boreholes remained dry upon completion of field work. The groundwater level is subject to seasonal fluctuations.

The groundwater yield from the silty clay till, if any, due to its low permeability, will be small and limited.

6.0 DISCUSSION AND RECOMMENDATIONS

The findings from the boreholes have revealed that beneath a veneer of topsoil and a layer of earth fill in places, the site is underlain by a stratum of firm to hard, generally hard silty clay till. The surficial soil layer is generally weathered to depths of 0.7 m and 1.4 m below the prevailing ground surface, at some borehole locations.

No groundwater was detected and all boreholes remained dry upon completion of field work. The groundwater level is subject to seasonal fluctuations.

The geotechnical findings which warrant special consideration are presented below:

1. The topsoil must be stripped for the project construction. This material will generate volatile gases under anaerobic conditions and is unsuitable for engineering applications.
2. The existing earth fill is unsuitable for supporting structures in its current state. In using the fill for structural backfill, it should be subexcavated, inspected, sorted free of topsoil and any deleterious materials, proof-rolled and properly compacted. Otherwise. It must be wasted.
3. The sound natural soil below the topsoil, earth fill and weathered soil is suitable for normal spread and strip footing construction.
4. Due to the presence of topsoil, earth fill and weathered soil, the footing subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to ensure that its condition is compatible with the design of the foundation.

5. For basement construction, perimeter subdrains and dampproofing of the foundation walls will be required. All the subdrains must be encased in a fabric filter to protect them against blockage by silting and must be connected to a positive outlet. This can be assessed at the time of construction.
6. For slab-on-grade construction, the slab should be placed on the sound natural soil or properly compacted earth fill. Prior to the slab construction, the subgrade must be proof-rolled and inspected. Any weathered or soft soils detected must be subexcavated and replaced with inorganic material compacted to 98% or + Standard Proctor dry density.
7. A Class 'B' bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. Where water-bearing silt occurs, the sewer joints should be leak-proof, or wrapped with an appropriate waterproof membrane, to prevent subgrade migration.
8. The till contains occasional boulders and cobbles. Boulders over 15 cm in size must not be used for structural backfill. Excavation into the till containing boulders will require extra effort and the use of a heavy-duty backhoe.

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.

6.1 **Foundations**

Based on the borehole findings, it is recommended that the normal spread and strip footings for the proposed project must be placed below the topsoil, earth fill and weathered soils onto the sound natural soil. The recommended soil pressures and corresponding suitable founding levels are presented in Table 2.

Table 2 - Founding Levels

BH No.	**Recommended Maximum Allowable Soil Pressure (SLS)/ Factored Ultimate Soil Bearing Pressure (ULS) and Corresponding Founding Level**			
	200 kPa (SLS) 320 kPa (ULS)		**300 kPa (SLS) 480 kPa (ULS)**	
	Depth (m)	**El. (m)**	**Depth (m)**	**El. (m)**
1	-	-	1.2 or +	218.1 or -
2	1.2 or +	216.5 or -	1.6 or +	216.1 or -
3	1.4 or +	215.7 or -	1.6 or +	215.5 or -
4	-	-	1.2 or +	214.4 or -
5	-	-	1.2 or +	212.5 or -
6	1.2 or +	218.5 or -	1.6 or +	218.1 or -
7	1.2 or +	216.5 or -	1.6 or +	216.0 or -
8	-	-	1.2 or +	215.5 or -
9	-	-	1.2 or +	214.3 or -
10	1.4 or +	215.0 or -	1.6 or +	214.8 or -

The recommended soil pressures (SLS) for normal foundations incorporate a safety factor of 3. The total and differential settlements of the foundations are estimated to be 25 mm and 15 mm, respectively.

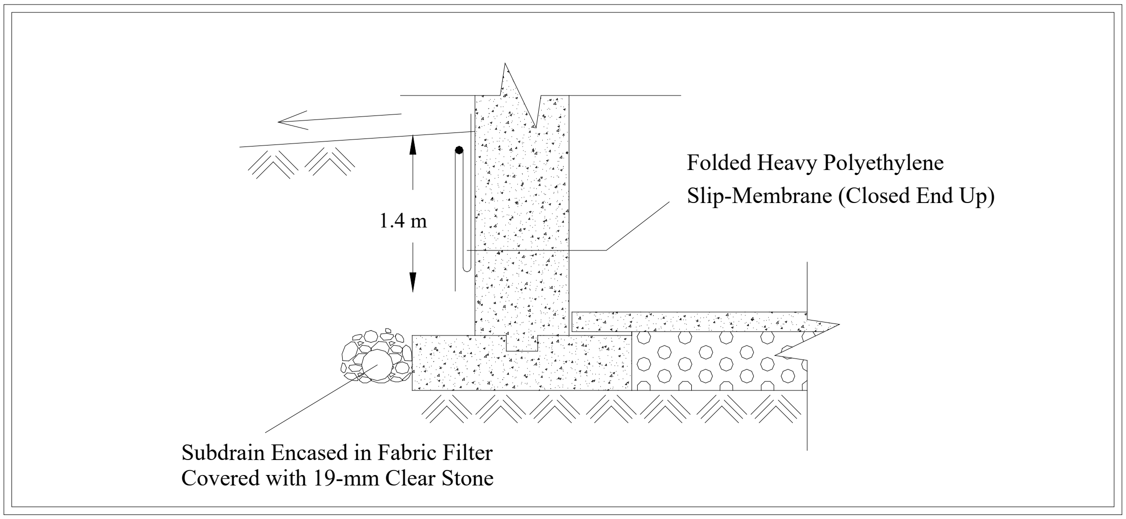
The foundations exposed to weathering and in unheated areas should have at least 1.4 m of earth cover for protection against frost action, or must be properly insulated.

To ensure that the condition of the subgrade is compatible with the foundation design requirements, the footing subgrade of the normal foundations must be inspected by a geotechnical engineer, or a technician under the supervision of a geotechnical engineer.

If the proposed buildings contain basements, perimeter subdrains and Dampproofing of the basement walls will be required. All the subdrains must be encased in a fabric filter t protect them against blockage by silting.

The occurring soil is high in frost heave and soil-adfreezing potential. If this soil is to be used for the foundation backfill, the foundation walls should be shielded by a polyethylene slip-membrane for protection against soil adfreezing. The membrane will allow vertical movement of the heaving soil (due to frost) without imposing structural distress on the foundations. The recommended measures are schematically illustrated in Diagram 1.

Diagram 1 - Frost Protection Measures (Foundations)



The necessity to implement the above recommendations should be further assessed by a geotechnical engineer at the time of construction.

The footings should meet the requirements specified in the latest Building Code. The structure should be designed to resist a minimum earthquake force using Site Classification ‘D’ (stiff soil).

6.2 **Engineered Fill**

Where earth fill is required to raise the site or where extended footings are necessary for foundation construction, the engineering requirements for a certifiable fill for road construction, municipal services, slab-on-grade, and footings designed with a Maximum Allowable Soil Pressure (SLS) of 150 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 240 kPa for normal footings are presented below:

1. The topsoil must be removed.
2. The earth fill, weathered and loose or firm soils must be subexcavated, and sorted prior to reuse. The subgrade must be inspected and proof-rolled prior to any fill placement.
3. Inorganic soils must be used for filling. The fill should be free of topsoil inclusions or other deleterious materials. It must be uniformly compacted in lifts 20 cm thick to 98% or + of their maximum Standard Proctor dry density up to the proposed finished

grade. The soil moisture must be properly controlled on the wet side of the optimum.

4. If imported fill is to be used, the hauler is responsible for its environmental quality and must provide a document to certify that the material is free of hazardous contaminants.
5. If the house 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.
6. 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.
7. The engineered fill must extend over the entire graded area; the engineered fill envelope and finished elevations must be clearly and accurately defined in the field, and they must be precisely documented by qualified surveyors.

   Foundations partially on engineered fill must be reinforced by two 15-mm steel reinforcing bars 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 (about 15 mm) between the natural soil 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. 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.
10. 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.
11. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
12. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that supervised 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.
13. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who supervised the fill placement in order to document the locations of excavation and/or to supervise 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.

14. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the strip footings and the upper section of the foundation walls constructed on the engineered fill may require continuous reinforcement with steel bars, depending on the uniformity of the soils in the engineered fill and the thickness of the engineered fill underlying the foundations. Should the footings and/or walls require reinforcement, the required number and size of reinforcing bars must be assessed by considering the uniformity as well as the thickness of the engineered fill beneath the foundations. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

6.3 Slab-On-Grade

For slab-on-grade construction, the subgrade must consist of sound natural soils, or properly compacted inorganic earth fill. The surface of the subgrade must be inspected and proof-rolled. Any soft or loose areas detected must be subexcavated and replaced with inorganic fill, compacted to at least 98% of its maximum Standard Proctor dry density prior to placement to the granular base. 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.

A Modulus of Subgrade Reaction of 35 MPa/m is recommended for the design of the floor slab.

The ground around the buildings must be graded to direct water away from the structure to minimize the frost heave phenomenon generally associated with the disclosed soils.

6.4 Underground Services

The subgrade for the underground services should consist of natural soils or compacted organic-free earth fill. Where topsoil, earth fill, loose and badly weathered soils are encountered, these materials must be subexcavated and replaced with properly compacted bedding material.

A Class ‘B’ bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. Where the services are constructed in water-bearing silt, the pipe joints should be leak-proof or wrapped with an appropriate waterproof membrane to prevent subgrade migration.

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.

Since the silty clay till has moderately high corrosivity to buried metal, the water main should be protected against corrosion. In determining the mode of protection, an electrical resistivity of 4000 ohm·cm should be used. This, however, should be confirmed by testing the soil along the water main alignment at the time of sewer construction.

6.5 **Trench Backfilling**

The on-site inorganic soil is suitable for trench backfill. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% of its maximum Standard Proctor dry density with the moisture content 2% to 3% drier than the optimum. In the lower zone, a 95% or + Standard Proctor compaction is considered to be adequate; however, the material must be compacted on the wet side of the optimum.

In normal underground services construction practice, the problem areas of road settlement largely occur adjacent to manholes, catch basins, services crossings, foundation walls and columns, and it is recommended that a sand backfill be used. The interface of the native soils and the sand backfill will have to be flooded for a period of several days.

The narrow trenches should be cut at 1 vertical:2 or + horizontal so that the backfill can be effectively compacted. Otherwise, soil arching 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 the 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 the following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soils have a water content on the dry side of the optimum, it would be impossible to wet the soils 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 in a narrow vertical trench section, or 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 and the slab-on-grade construction.
- 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 1 vertical:1.5 + horizontal, 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.

6.6 **Pavement Design**

Based on the borehole findings, the recommended pavement for local roads design is presented in
Table 3.

Table 3 - Pavement Design (Local Road)

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	50	HL-8
Granular Base	150	Granular ‘A’, or equivalent
Granular Sub-base	300	Granular ‘B’, or equivalent

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

In preparation of the subgrade, the surface should be properly graded and proof-rolled. Any topsoil fill, earth fill, weathered or soft subgrade and deleterious materials within 1.0 m below the underside of the granular sub-base should be subexcavated and replaced by properly compacted organic-free earth fill. The final subgrade should consist of a uniform material, and should be properly graded with a crossfall in order to prevent differential heaving during winter.

In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% of its maximum Standard Proctor dry density, with the water content 2% to 3% drier than the optimum. In the lower zone, a 95% or + Standard Proctor compaction is considered adequate.

Along the perimeter of the pavement and at edge of the roadway where surface runoff may drain onto the pavement, or water may seep into the granular base, a swale or a subdrain system should be installed. The swale should be graded so that the water can drain towards an outlet. Subdrains, consisting of filter-wrapped weepers, should be installed below the granular sub-base in the roadway and the parking lot. They should be connected to catch basins or storm manholes where water can be removed.

6.7 **Soil Parameters**

The recommended soil parameters for the project design are given in Table 4.

Table 4 - Soil Parameters

Unit Weight and Bulk Factor			
	Unit Weight (kN/m^3)	**Estimated Bulk Factor**	
	Bulk	**Loose**	**Compact**
Earth Fill and weathered Soil	21.0	1.20	1.00
Silty Clay Till	22.0	1.33	1.03
Lateral Earth Pressure Coefficients			
	Active K_a	**At Rest K_o**	**Passive K_p**
Earth Fill and weathered Soil	0.40	0.50	2.50
Silty Clay Till	0.35	0.45	2.86

6.8 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91.

Excavations in excess of 1.2 m should be sloped at 1 vertical:1 horizontal for stability.

Excavation into the till containing boulders will require extra effort and the use of a heavy-duty backhoe equipped with a rock-ripper.

For excavation purposes, the types of soils are classified in Table 5.

Table 5 - Classification of Soils for Excavation

Material	Type
Sound Till	1 and 2
Earth Fill and weathered Soil	3

The yield of groundwater from the silty clay till, due to its low permeability, is expected to be small and limited and can be controlled by pumping from sumps.

Prospective contractors must be asked to assess the in situ subsurface conditions for soil cuts by digging test pits to at least 1.0 m below the intended bottom of excavation. These test pits should be allowed to remain open for a period of at least 4 hours to assess the trenching conditions.

7.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Tyrolean Village Resorts Ltd., and for review by their designated agents, financial institutions, and government agencies. Use of the report is subject to the conditions and limitations of the contractual agreement. The material in it reflects the judgment of Frank Lee, P.Eng., and Bernard Lee, 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, and/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.

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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

JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

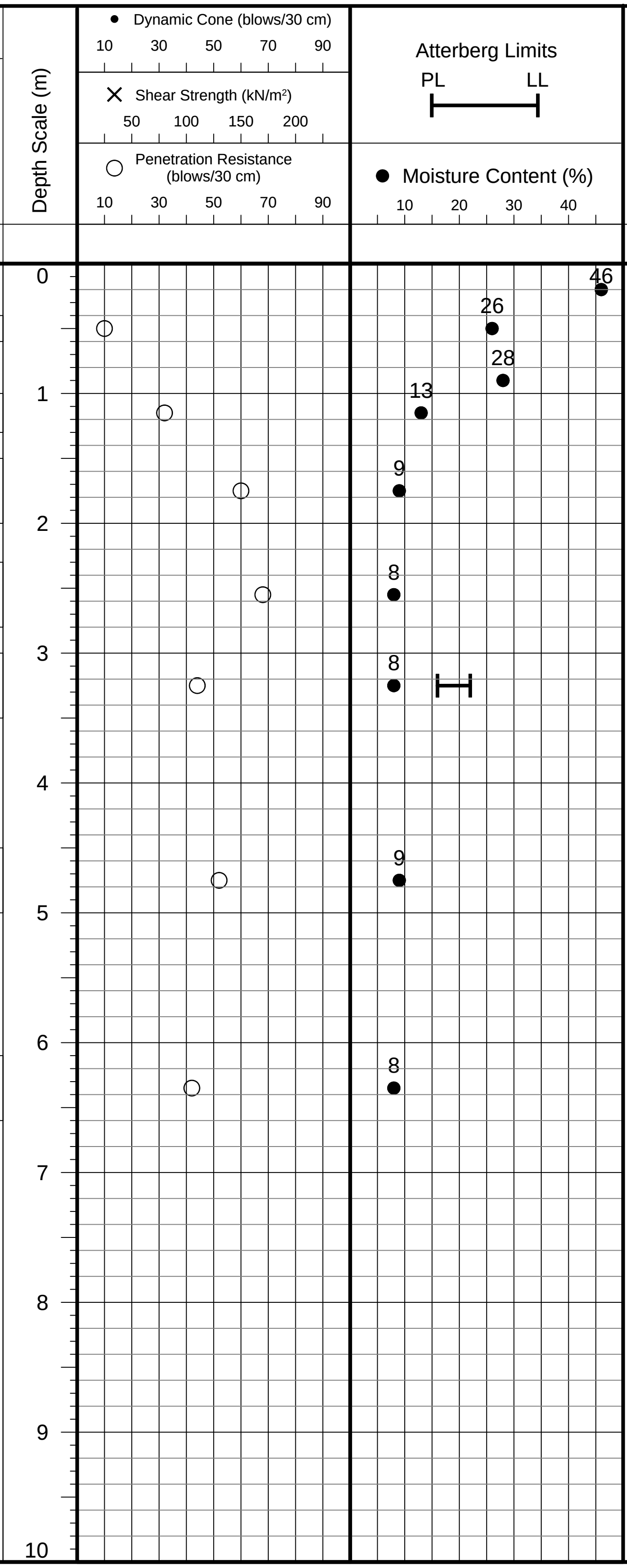
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 24, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
219.3 0.0	Ground Surface **25 cm TOPSOIL**				
	Brown **EARTH FILL** silty clay **TOPSOIL**	1A	DO		
		1B	DO	10	
		2A	DO		
218.3 1.0	Very stiff to hard **SILTY CLAY TILL** — brown / grey occ. wet sand and silt seams and layers cobbles and boulders	2B	DO	32	Dry on completion
		3	DO	60	
		4	DO	68	
		5	DO	44	
		6	DO	52	
		7	DO	42	
238.7 6.6	**END OF BOREHOLE**				



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JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

PROJECT DESCRIPTION: Proposed Residential Development

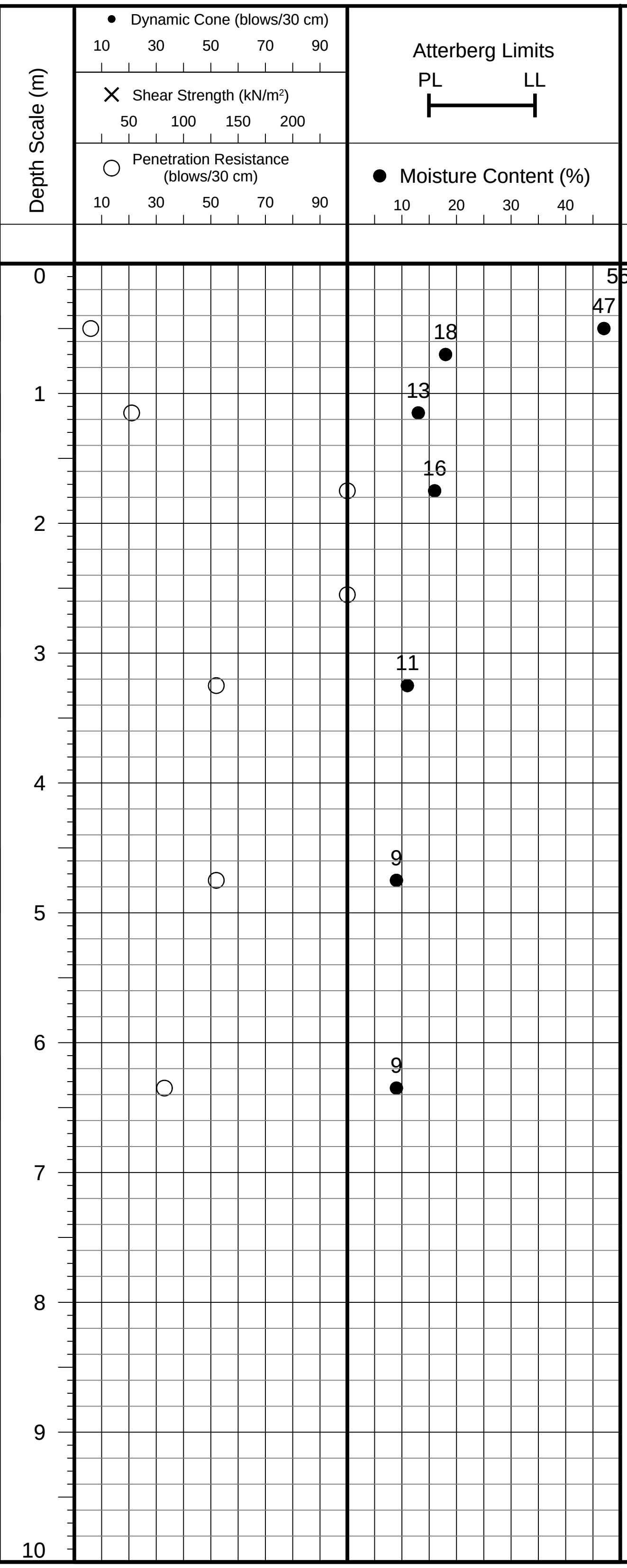
METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 23, 2020

El. (m) Depth (m)	SOIL DESCRIPTION
217.7	Ground Surface
0.0	**23 cm TOPSOIL**
	Red **EARTH FILL** silty clay
217.1 0.6	Very stiff to hard **SILTY CLAY TILL** occ. wet sand and silt seams and layers cobbles and boulders brown grey
211.1 6.6	**END OF BOREHOLE**

SAMPLES Number	Type	N-Value
1A	DO	
1B	DO	6
1C	DO	
2	DO	21
3	DO	50/15
4	DO	50/10
5	DO	52
6	DO	52
7	DO	33



WATER LEVEL: Dry on completion

JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

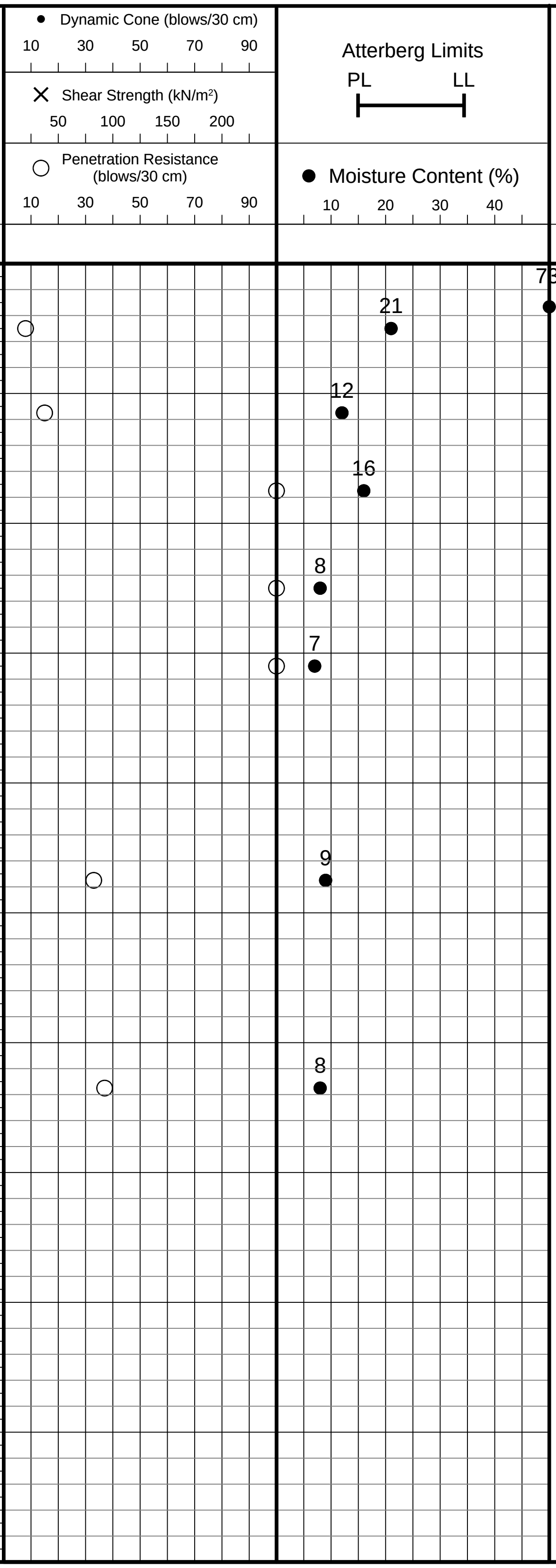
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 23, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)
217.1	Ground Surface				
0.0	**18 cm TOPSOIL**	1A	DO		0
	Firm to hard weathered	1B	DO	8	
		2	DO	15	1
		3	DO	50/15	
	SILTY CLAY TILL occ. wet sand and silt seams and layers cobbles and boulders	4	DO	50/8	2
	brown grey	5	DO	50/15	3
		6	DO	33	4
		7	DO	37	6
210.5 6.6	**END OF BOREHOLE**				



WATER LEVEL

Dry on completion

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JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

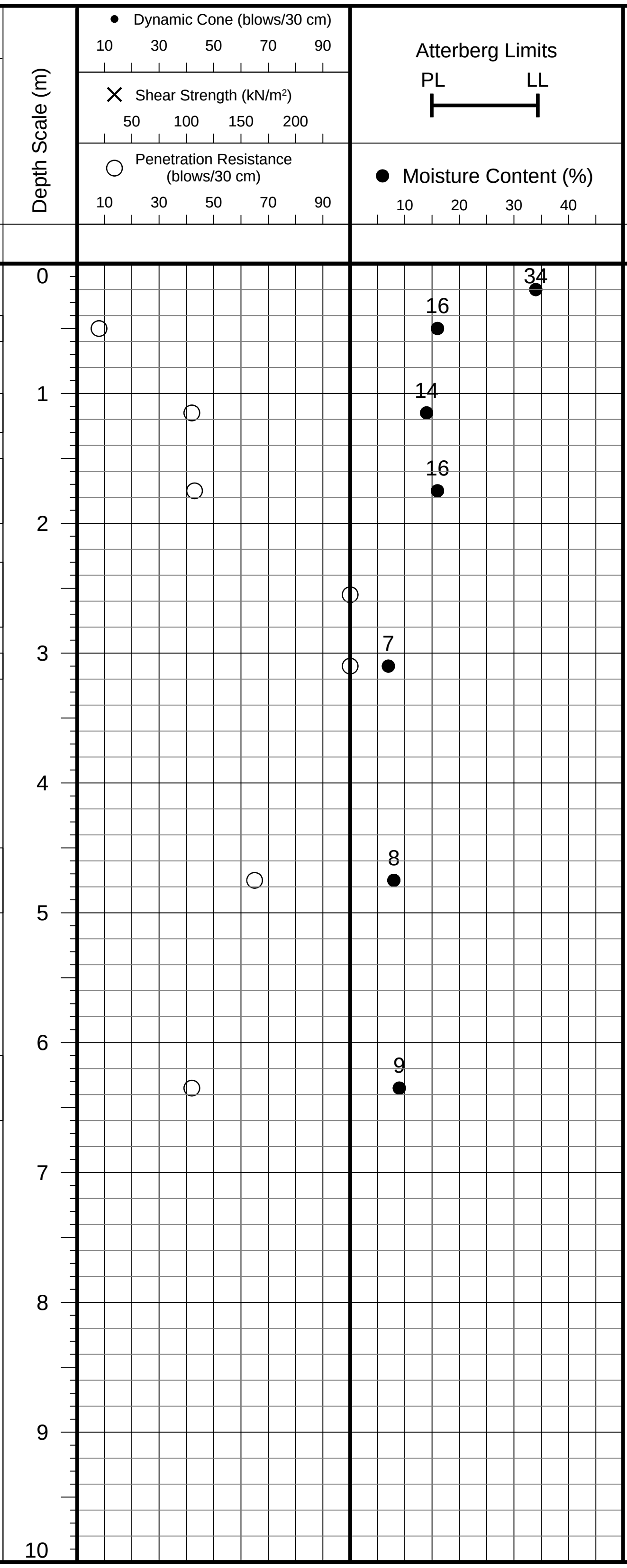
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 23, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
215.6	Ground Surface				
0.0	**30 cm TOPSOIL**	1A	DO		Dry on completion
	Firm to hard weathered	1B	DO	8	
		2	DO	42	
		3	DO	43	
	brown grey **SILTY CLAY TILL**	4	DO	50/15	
	occ. wet sand and silt seams and layers cobbles and boulders	5	DO	50/15	
		6	DO	65	
		7	DO	42	
209.0 6.6	**END OF BOREHOLE**				



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JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

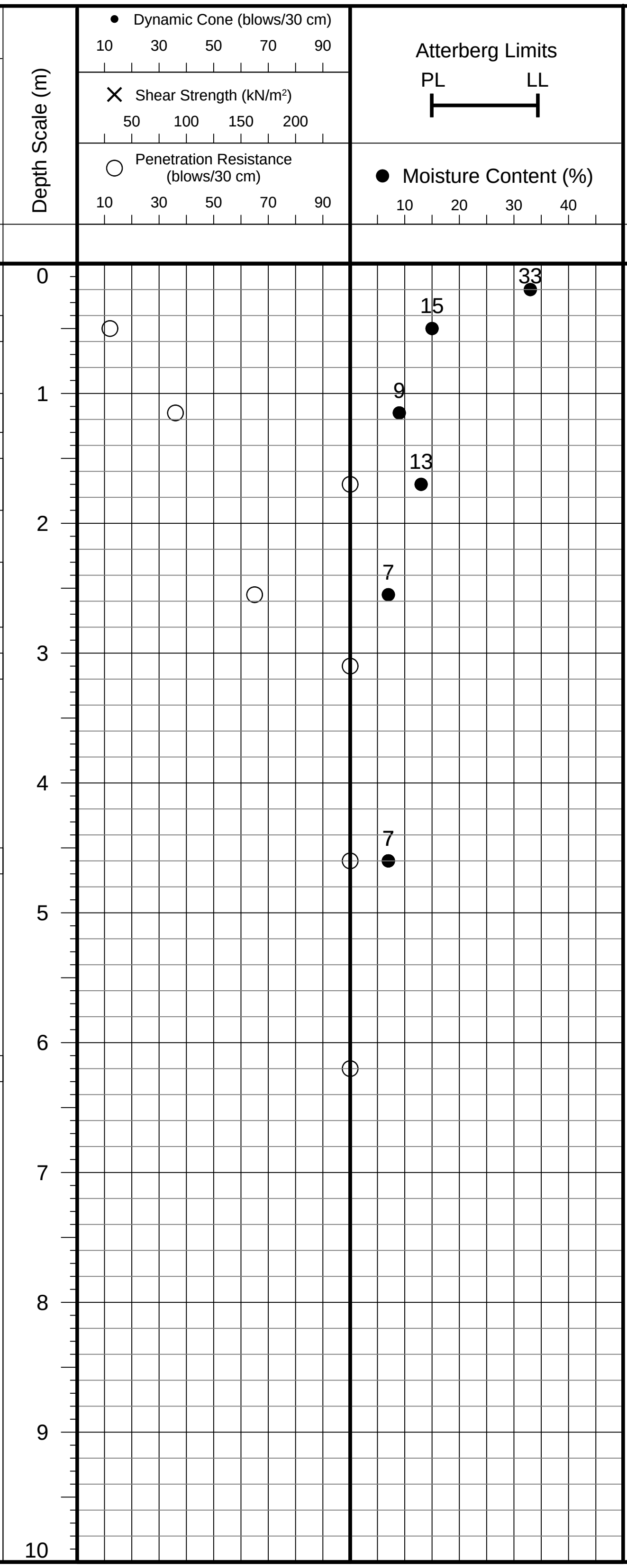
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 23, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
213.7 0.0	Ground Surface **15 cm TOPSOIL**			
	Stiff to hard	1A	DO	
	weathered	1B	DO	12
		2	DO	36
		3	DO	50/15
	brown grey **SILTY CLAY TILL** occ. wet sand and silt seams and layers cobbles and boulders	4	DO	65
		5	DO	50/0
		6	DO	30/0
		7	DO	50/10
207.4 6.3	**END OF BOREHOLE**			



WATER LEVEL

Dry on completion

Soil Engineers Ltd.

JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

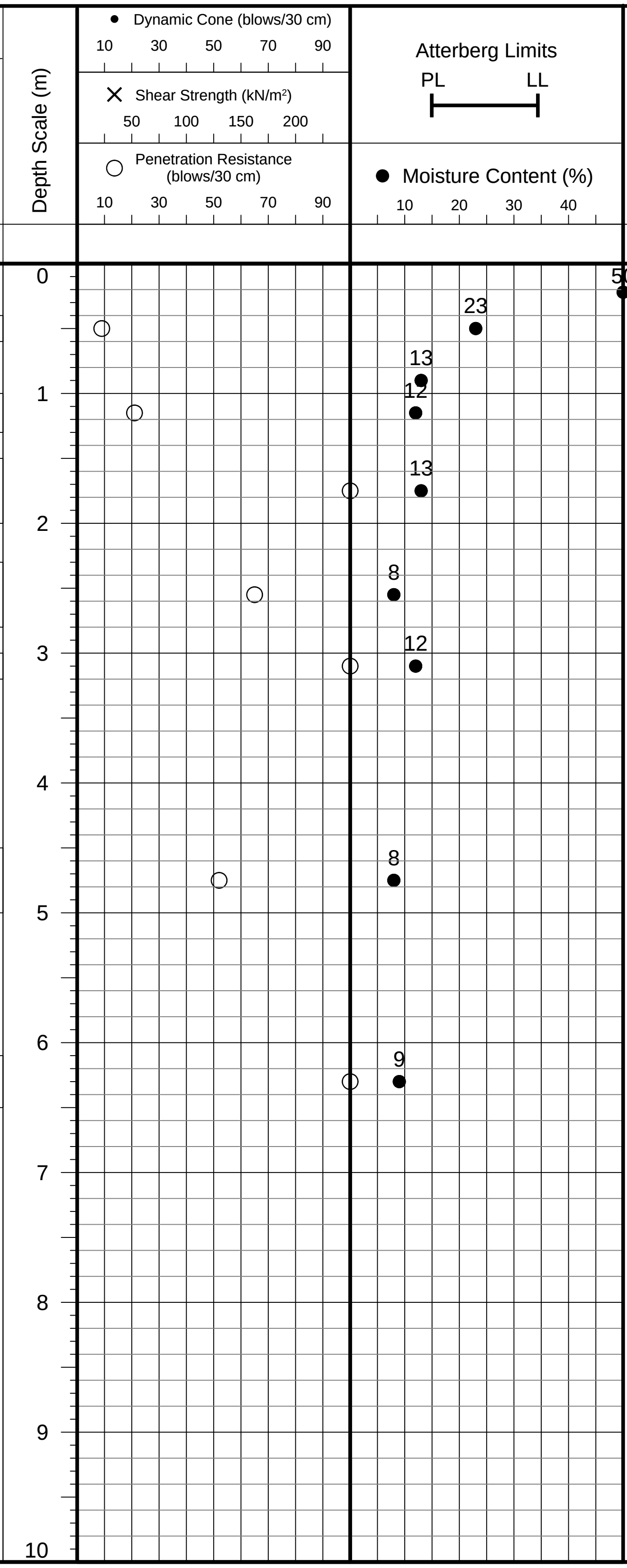
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 24, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
219.7	Ground Surface				
0.0	**20 cm TOPSOIL**	1A	DO		
	Brown **EARTH FILL** silty clay **TOPSOIL**	1B	DO	9	
		2A	DO		
218.7 1.0	Very sttiff to hard	2B	DO	21	
		3	DO	50/15	
		4	DO	65	
	SILTY CLAY TILL occ. wet sand and silt seams and layers cobbles and boulders	5	DO	50/15	Dry on completion
	brown grey	6	DO	52	
		7	DO	30/0	
213.2 6.5	**END OF BOREHOLE**				



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JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

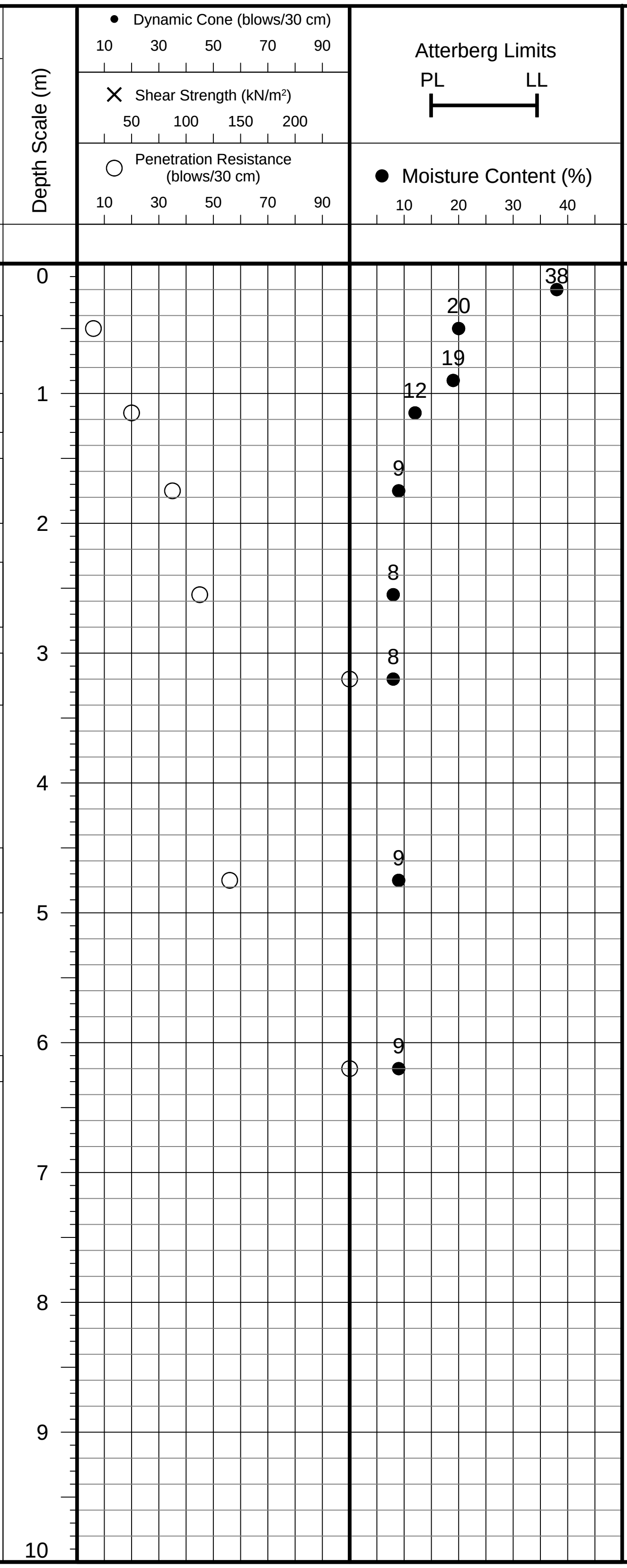
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 24, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
217.6	Ground Surface				
0.0	**20 cm TOPSOIL**	1A	DO		
	Brown **EARTH FILL** silty clay **TOPSOIL**	1B	DO	6	
		2A	DO		
216.6 1.0	Stiff to hard	2B	DO	20	
		3	DO	35	
		4	DO	45	
	SILTY CLAY TILL occ. wet sand and silt seams and layers cobbles and boulders	5	DO	50/10	Dry on completion
	brown grey	6	DO	56	
211.3 6.3		7	DO	30/0	
	END OF BOREHOLE				



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JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

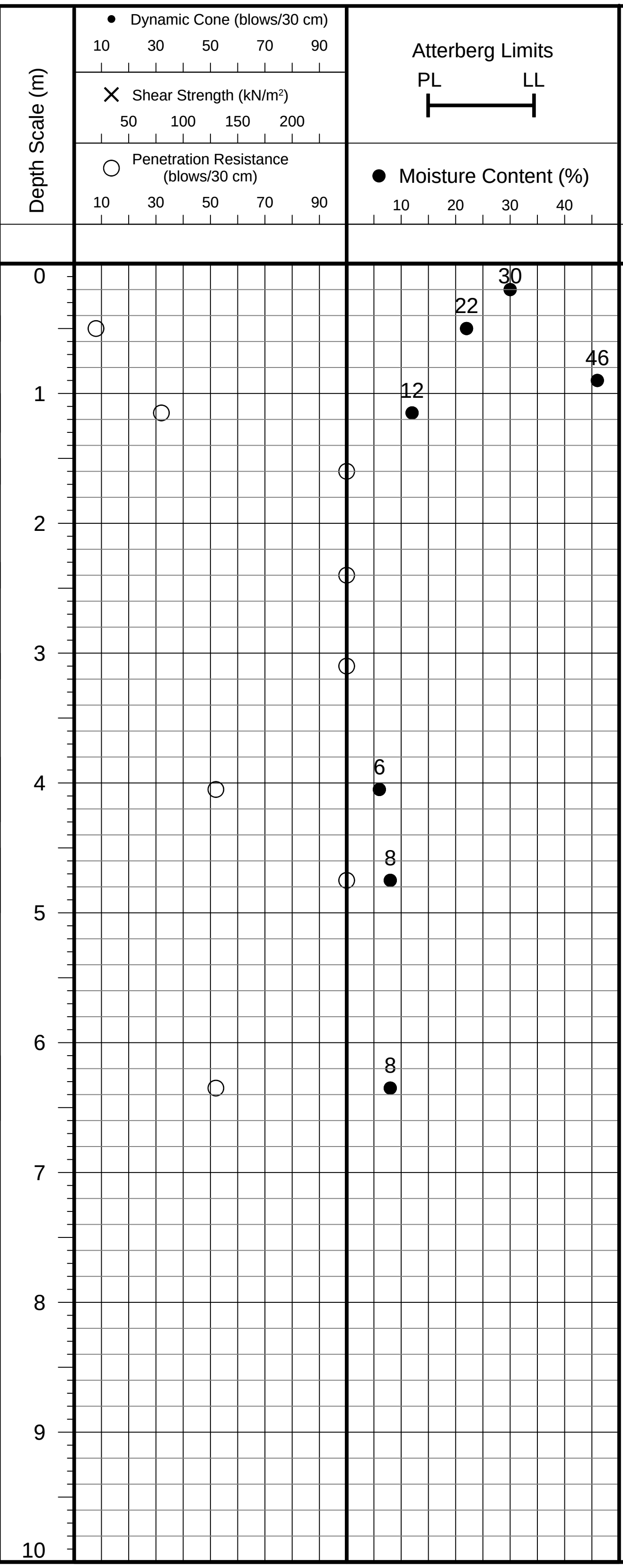
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 24, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
216.7	Ground Surface			
0.0	**20 cm TOPSOIL**	1A	DO	
	Brown **EARTH FILL** silty clay **TOPSOIL**	1B	DO	8
		2A	DO	
215.7 1.0	Very stiff to hard **SILTY CLAY TILL** occ. wet sand and silt seams and layers cobbles and boulders	2B	DO	32
		3	DO	50/2
		4	DO	50/5
		5	DO	50/2
	brown grey	6	DO	52
		7	DO	30/8
		8	DO	52
210.1 6.6	**END OF BOREHOLE**			



WATER LEVEL: Dry on completion

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JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

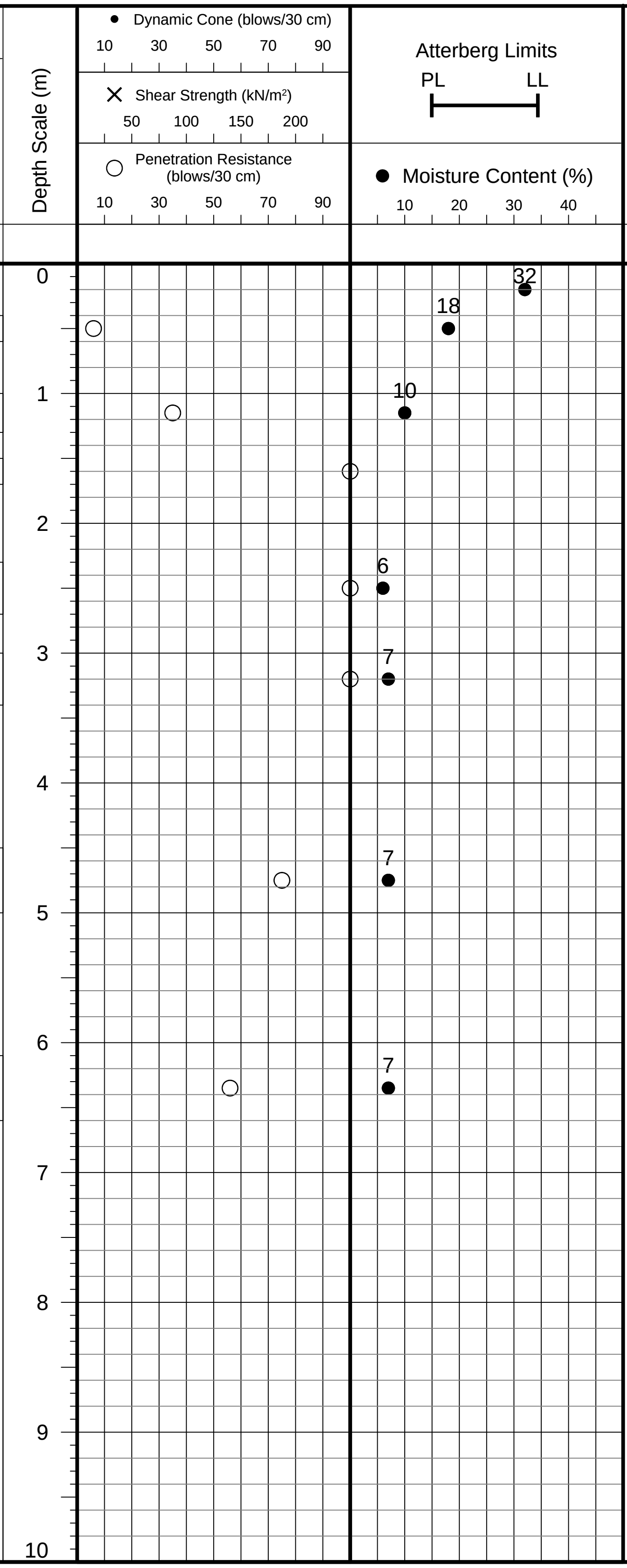
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 23, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
215.5 0.0	Ground Surface **25 cm TOPSOIL**	1A	DO		
	Firm to hard weathered	1B	DO	6	
		2	DO	35	
		3	DO	50/0	
	SILTY CLAY TILL brown grey occ. wet sand and silt seams and layers cobbles and boulders	4	DO	50/10	Dry on completion
		5	DO	50/15	
		6	DO	75	
		7	DO	56	
208.9 6.6	**END OF BOREHOLE**				



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JOB NO.: 2011-S017

LOG OF BOREHOLE NO.: 10

FIGURE NO.: 10

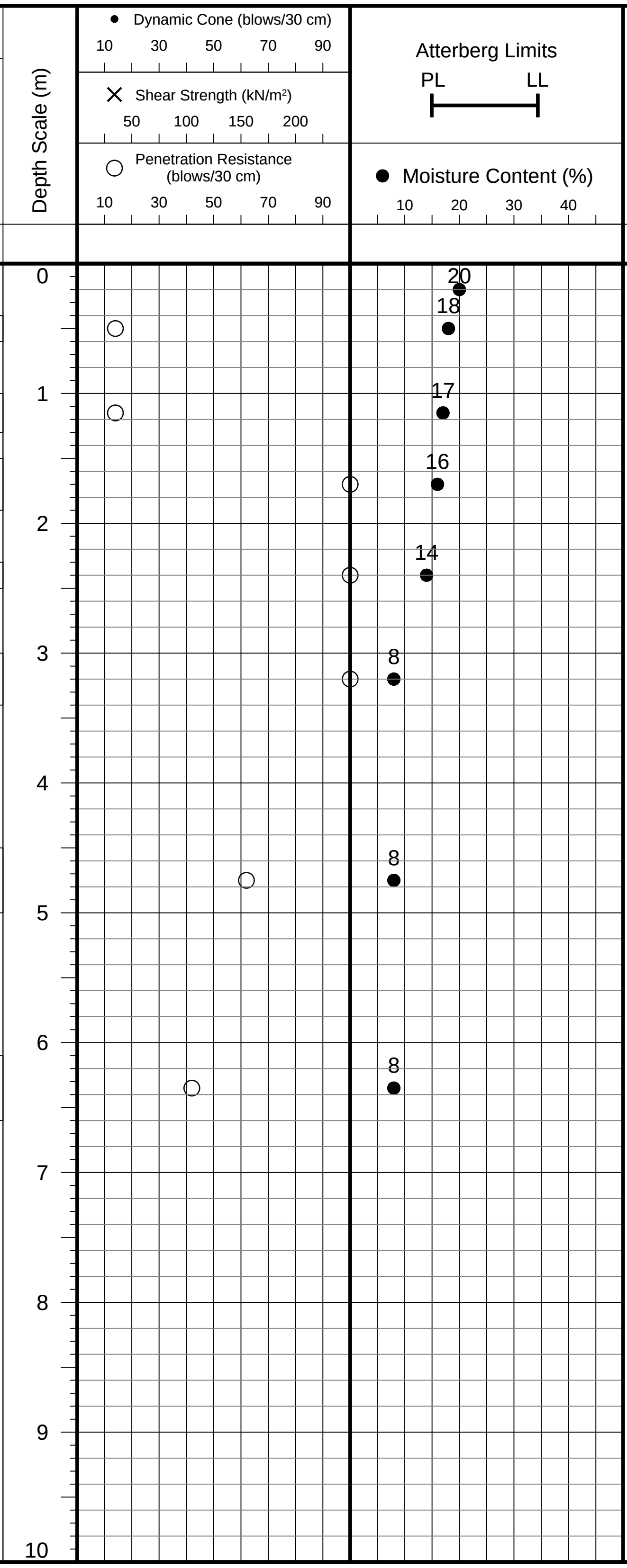
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 138 Kandahar Lane
Town of The Blue Mountains

DRILLING DATE: November 23, 2020

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
216.4 0.0	Ground Surface **15 cm TOPSOIL**	1A	DO		Dry on completion
	Stiff to hard	1B	DO	14	
		2	DO	14	
	weathered	3	DO	50/15	
	SILTY CLAY TILL occ. wet sand and silt seams and layers cobbles and boulders	4	DO	30/0	
	brown grey	5	DO	50/15	
		6	DO	62	
		7	DO	42	
209.8 6.6	**END OF BOREHOLE**				



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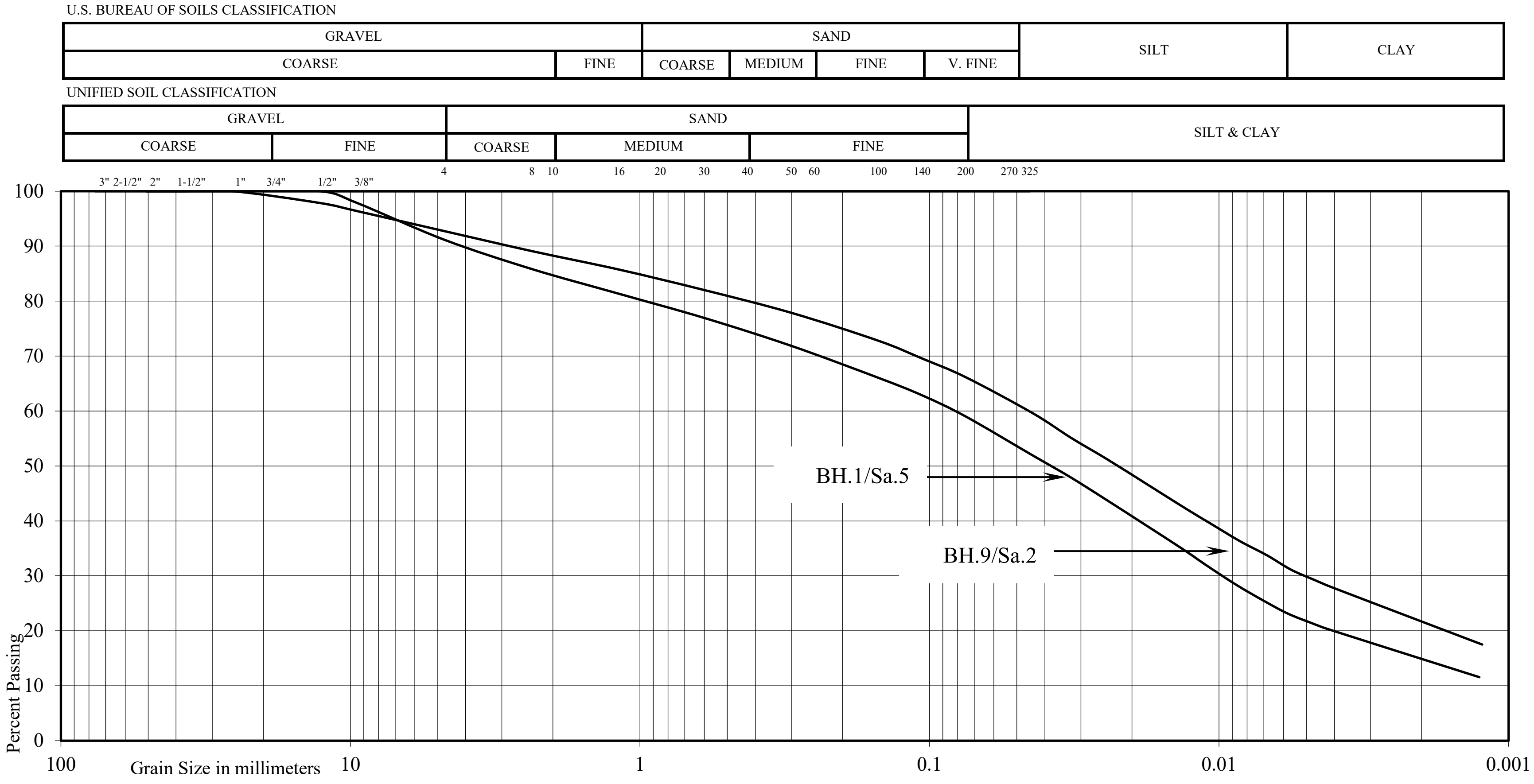
GRAIN SIZE DISTRIBUTION

Reference No: 2011-S017



Project: Proposed Residential Development

Location: 138 Kandahar lane, Town of The Blue Mountains

Borehole No:	1	9
Sample No:	5	2
Depth (m):	3.3	1.1
Elevation (m):	216.0	214.4

BH./Sa.	1/5	9/2
Liquid Limit (%) =	22	-
Plastic Limit (%) =	16	-
Plasticity Index (%) =	6	-
Moisture Content (%) =	8	10
Estimated Permeability (cm./sec.) =	10^{-6}	10^{-7}

Classification of Sample [& Group Symbol]: SILTY CLAY TILL, some clay to clayey, sandy and a trace of gravel

Figure: 11

BH Location Plan

SOIL ENGINEERS LTD.
Reference No. 2011-S017
Drawing No. 1

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SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

JOB NO.: 2011-S017

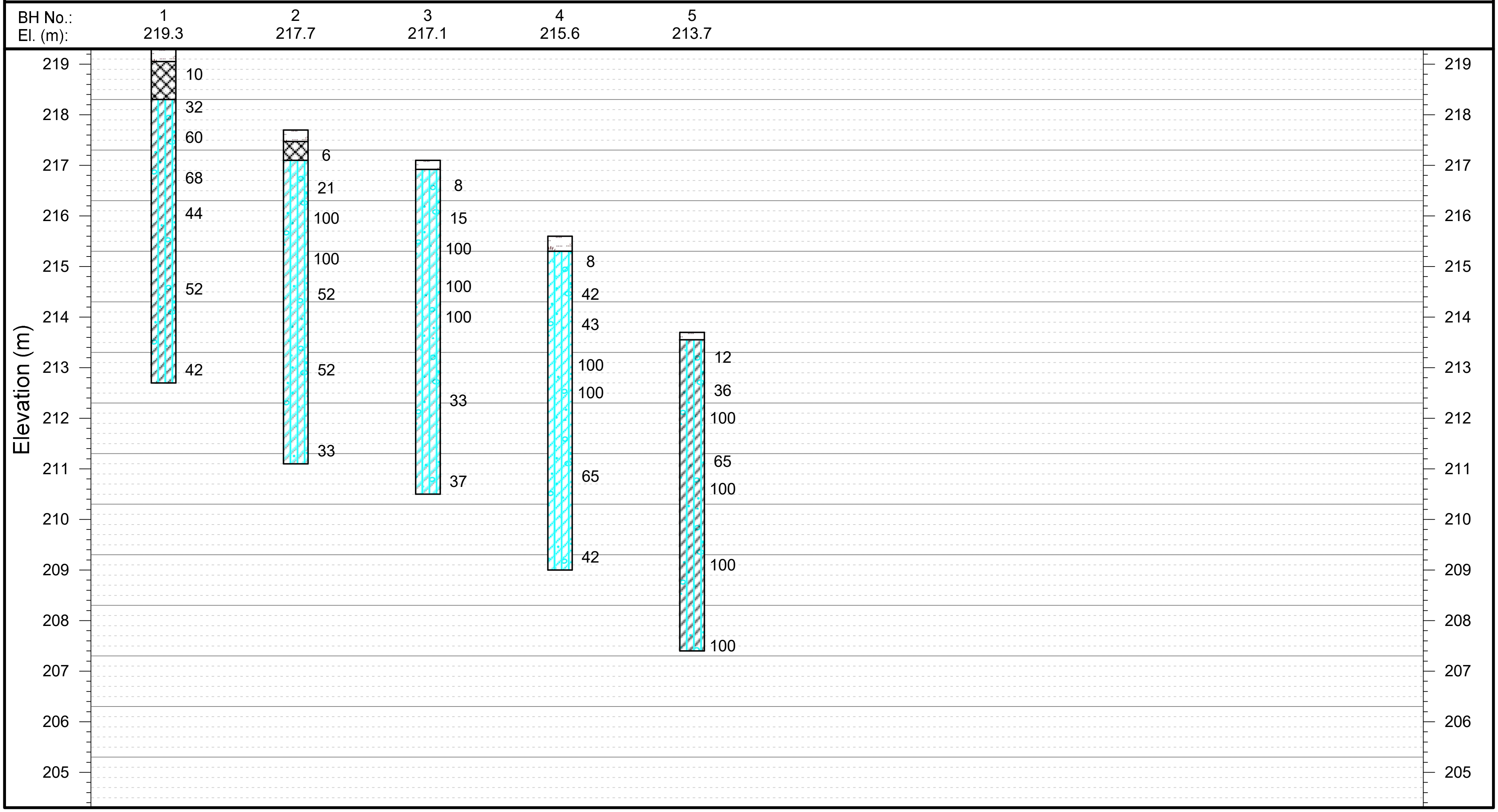
REPORT DATE: January 2021

PROJECT DESCRIPTION: Proposed Residential Development

PROJECT LOCATION:
138 Kandahar Lane
Town of The Blue Mountains

LEGEND

▤	TOPSOIL	▩	FILL	▨	SILTY CLAY TILL



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SUBSURFACE PROFILE
DRAWING NO. 3
SCALE: AS SHOWN

JOB NO.:	2011-S017
REPORT DATE:	January 2021
PROJECT DESCRIPTION:	Proposed Residential Development
PROJECT LOCATION:	138 Kandahar Lane Town of The Blue Mountains

LEGEND

▤ TOPSOIL ▩ FILL ▨ SILTY CLAY TILL