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A REPORT TO
WYLDEWOOD CREEK INC.
(BRANDY LANE CORPORATION)

A GEOTECHNICAL INVESTIGATION FOR PROPOSED SIX 3-TO 4-STOREY BUILDINGS

10 VACATION INN DRIVE

TOWN OF COLLINGWOOD

REFERENCE NO. 1807-S088

SEPTEMBER 2018

DISTRIBUTION

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1.0 **INTRODUCTION**

In accordance with written authorization dated July 10, 2018, from Mr. David Hirsh, President of Wyldewood Creek Inc., a geotechnical investigation was carried out at a parcel of land at 10 Vacation Inn Drive, in the Town of Collingwood, for proposed Six 3- to 4-Storey Buildings.

The purpose of the investigation was to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the design and construction of the proposed project.

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

2.0 SITE AND PROJECT DESCRIPTION

The Town of Collingwood is situated in the Simcoe Lowlands bordering the Niagara Escarpment where lacustrine deposits, outwash sands and glacial tills bedded onto undulated Black River and Trenton Group of bedrock.

The investigated site is situated at the south end of Vacation Inn Drive and Trafalgar Road, in the Town of Collingwood. The site is occupied by several buildings and the area is generally grass- or weed-covered, with some trees. The ground surface is relatively flat and level, with some undulations.

The proposed project will consist of the demolition of existing buildings and the construction of six 3- to 4-storey slab-on-grade buildings. The new development will be provided with municipal services and paved roadways meeting municipal standards.

3.0 **FIELD WORK**

The field work, consisting of 13 boreholes to depths ranging from 0.7 to 2.4 m, was performed on August 13 and 14, 2018, at the locations shown on the Borehole Location Plan, Drawing No. 1. Refusal to augering was encountered at all boreholes at depths ranging from 0.7 to 2.2 m below the prevailing ground surface. It is inferred that shallow bedrock occurs at these levels. A total of 4 monitoring wells were installed at Boreholes 3, 5, 9 and 13 for future groundwater monitoring.

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 Engineer.

The elevation at each of the borehole locations was determined with reference to the site bench mark shown on Drawing No. 1. It has been given an assumed elevation of 100.00 m.

4.0 **SUBSURFACE CONDITIONS**

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 13, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing Nos. 2 and 3, and the engineering properties of the disclosed soils are discussed herein.

This investigation has disclosed that beneath a veneer of topsoil, a layer of granular fill, and a layer of earth fill in the majority of the boreholes, the site is underlain by strata of silty sand till and fine sand. Refusal to augering was encountered at all boreholes at depths ranging from 0.7 to 2.2 m below the prevailing ground surface. It is inferred that shallow bedrock occurs at these levels.

4.1 **Topsoil** (Boreholes 1 and 3) and **Granular Fill** (Borehole 8)

The revealed topsoil is 5 cm and 8 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.

A layer of granular fill, 360 mm thick, was found at the ground surface. It consists of a mixture of crushed gravel and silty sand, with rock fragments.

4.2 **Earth Fill** (Boreholes 4 to 13, inclusive)

The earth fill occurs in the majority of the boreholes; and it extends to depths ranging from 1.0 m to the maximum investigated depth. Sample examination shows that the earth fill consists of silty clay, silty sand and sand, with rock fragments and cobbles, and with topsoil inclusions.

The obtained 'N' values range from 4 blows per 30 cm to 30 blows with no penetration, with a median of 29 blows per 30 of penetration, indicating that the fill was loosely placed with nominal compaction. Its density is non-uniform and it is considered unsuitable to support structures sensitive to settlement. The high 'N' values are due to the presence of rock fragments and cobbles in the fill.

The natural water content values range from 3% to 45%, with a median of 7%, indicating that the fill is in a moist to wet condition. The high water content for some of the fill samples is due to the presence of topsoil in the fill.

Grain size analyses were performed on 2 representative samples of the earth fill; the results are plotted on Figure 14.

For structural use, the fill must be sorted free of topsoil and any other deleterious materials and must be properly compacted.

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 Sand Till** (Boreholes 1, 3 and 13)

The silty sand till was encountered below either a veneer of topsoil or a layer of fine sand and extends to the maximum investigated depth at all above boreholes. The till consists of a random mixture of soil particle sizes ranging from clay to gravel, with the sand being the dominant fraction. It is heterogeneous in structure, showing that it is a glacial deposit.

Frequent hard resistance to augering was encountered, showing that appreciable amounts of cobbles and boulders are embedded in the sand till.

The natural water content value of the samples was determined, and the results are plotted on the Borehole Logs; the values range from 5% to 12%, with a median of 9%, showing the sand till is in a moist to wet condition.

The obtained 'N' values range from 12 blows per 30 cm to 30 blows with no penetration, with a median of 50 blows per 15 cm, showing that its relative density is compact to very dense, being generally very dense.

Grain size analyses were performed on 2 of the samples and the results are plotted on Figure 15.

The deduced engineering properties pertaining to the project are given below:

- High frost susceptibility and moderate water erodibility.
- Moderately impervious, depending on the clay content, with an estimated coefficient of permeability of 10^{-5} cm/sec, an estimated percolation rate of about 50 min/cm, and runoff coefficients of:

Slope	
0% - 2%	0.11
2% - 6%	0.16
6% +	0.23

- A frictional soil, its shear strength is primarily derived from internal friction and is augmented by cementation. Therefore, its strength is density dependent.
- It will be stable in steep cuts; however, under prolonged exposure, immediate sloughing and sheet collapse will likely occur, particularly where seepage occurs.
- A fair pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 8%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.4 **<u>Fine Sand</u>** (Boreholes 2 and 13)

The sand deposit was encountered below a layer of earth fill at Borehole 13, and it extends to the maximum investigated depth at Borehole 2. It contains some silt and a trace of medium sand, with occasional silt seams and layers, showing that it is a glaciofluvial deposit. The sand layers are weathered.

A sample examination showed that the sand is non-cohesive; it is in a moist to wet condition. The wet sand samples are water bearing. This is confirmed by the determined water content values which are 8%, 19% and 26%.

The obtained 'N' values are 6, 8 and 9 blows per 30 cm of penetration, showing that the relative density of the sand is loose.

A grain size analysis was performed on 1 of the samples and the result is plotted on Figure 16.

Based on the above findings, the following engineering properties of the sand are deduced:

- Low frost susceptibility and high water erodibility.
- Low soil-adfreezing potential.
- Susceptible to migration through small openings under seepage pressure.
- Pervious, with an estimated coefficient of permeability of 10^{-3} cm/sec, an estimated percolation rate of 15 min/cm, and runoff coefficients of:

Slope	
0% - 2%	0.04
2% - 6%	0.09
6% +	0.13

- A frictional soil, its shear strength is derived from internal friction and is soil density dependent. Due to its dilatancy, its shear strength is susceptible to impact disturbance; i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and reduction of shear strength.

- In steep cuts, the sand will be stable in a damp to moist condition, but will slough if it is in a dry or wet condition, run with seepage and boil with a piezometric head of about 0.4 m.
- A fair pavement-supportive material, with an estimated CBR value of 10%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 6000 ohm·cm.

4.5 Interpretation of Refusal to Augering

Refusal to augering was encountered in all boreholes at depths ranging from 0.7 to 2.4 m. It is inferred that shallow bedrock occurs at these levels.

4.6 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	3 to 45 (median 7)	10 to 18	6 to 23
Silty Sand Till	5 to 12 (median 9)	10	6 to 15
Fine Sand	8, 19 and 26	11	5 to 16

According to the above findings, the majority of the earth fill, silty sand till and portion of the fine sand are generally suitable for a 95% or + Standard Proctor compaction. However, portions of the earth fill and fine sand are too wet and will require aeration, or mixing with drier soil prior to structural compaction. The earth fill must be sorted free of topsoil and any other deleterious materials, prior to its use as structural backfill.

The inorganic silty sand till should be compacted using a heavy-weight, kneading-type roller. The granular fill, silty sand fill and fine sand can be compacted by a smooth roller with or without vibration, depending on the water content of the soil being compacted. 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 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 road 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.

One should be aware that with considerable effort a 90%± Standard Proctor compaction of the wet sand is achievable. Further densification is prevented by the pore pressure induced by the compactive effort; however, large random voids will

have been expelled, and with time the pore pressure will dissipate and the percentage of compaction will increase. There are many cases on record where after a few months of rest, the density of the compacted mantle has increased to over 95% of its maximum Standard Proctor dry density.

If the compaction of the soils is carried out with the water content within the range for 95% Standard Proctor dry density but on the wet side of the optimum, the surface of the compacted soil mantle will roll under the dynamic compactive load. This is unsuitable for road 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 sewer and slab-on-grade, on the other hand, 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 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**

Groundwater was detected at depths of 0.8 m, 1.5 m and 1.0 m below the prevailing ground surface at Boreholes 2, 4 and 13, respectively. The measured groundwater levels generally represent the groundwater regime of the site at the time of the investigation. The groundwater level will be subject to seasonal fluctuation and the water level in the lake.

The yield of groundwater from the silty sand till and earth fill will be moderate, if encountered. The yield from the sand will likely be appreciable and persistent, if it occurs. Where groundwater is found in the bedrock, the yield will be appreciable initially, but will decrease and become spent with time if pumped continuously.

6.0 **DISCUSSION AND RECOMMENDATIONS**

This investigation has disclosed that beneath a veneer of topsoil, a layer of granular fill, and a layer of earth fill, the site is underlain by strata of silty sand till and fine sand. Refusal to augering was encountered at all boreholes at depths ranging from 0.7 to 2.4 m below the prevailing ground surface. It is inferred that shallow bedrock occurs at these levels.

Groundwater was detected at depths of 0.8 to 1.5± m below the prevailing ground surface depending on locations. The measured groundwater levels generally represent the groundwater regime of the site at the time of the investigation. The groundwater level will be subject to seasonal fluctuation and the water level in the lake.

The yield of groundwater from the silty sand till and earth fill, if it occurs, is expected to be moderate. The yield from the sand will likely be appreciable and persistent. Where groundwater is found in the bedrock, the yield will be appreciable initially, but will decrease and become spent with time if pumped continuously.

The geotechnical findings which warrant special consideration are presented below:

1. The topsoil is highly compressible and must be removed as they are unsuitable for engineering applications. Due to the high humus content, the topsoil will generate volatile gases under anaerobic conditions. For the environmental as well as the geotechnical well-being of the future development, the topsoil should not be buried within the building envelope, or deeper than a depth of 1.2 m below the exterior finished grade.

2. The earth fill in its present condition is not capable of sustaining foundation loads or any structure sensitive to settlement. It can be upgraded to structural status by sorting it free of topsoil and any other deleterious material prior to proper compaction.
3. Due to the shallow groundwater level encountered, subexcavating the existing earth fill to construct engineered fill will require the site to be predrained by an appropriate dewatering system.
4. The sound natural soils and the underlying bedrock are suitable for normal spread and strip footing construction. All of the footing subgrade must 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 requirements. Test pits will be required at the building locations to confirm the natural soil and bedrock subgrade at the time of construction.
5. Expansion joints will be required in the buildings to allow differential settlement of footings that are founded partially on soil and bedrock.
6. For slab-on-grade construction, any weathered, soft or loose soils and earth fill should be subexcavated, aerated and properly recompacted in layers prior to the placement of the slab. Any new material for raising the grade should consist of organic-free soil compacted to at least 98% of its maximum Standard Proctor dry density. 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.
7. A Class ‘B’ bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. The sewer joints should be leak-proof, or should be wrapped with an appropriate waterproof membrane to prevent subgrade migration. If subgrade stabilization is required, lean concrete or non-shrinkable fill may

be applied. In areas where more extensive dewatering is required for sewer construction, a Class 'A' bedding should be considered.

8. Excavation into the till containing boulders and cobbles may require extra effort and the use of a heavy-duty backhoe. Boulders larger than 15 cm in size are not suitable for structural backfill.
9. Excavation into the bedrock will require the use of a pneumatic hammer. Due to the proximity of the adjacent residences and other structures, any rock blasting must be conducted in a controlled manner by specialized personnel.

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**

It is understood that the proposed buildings will consist of 3- to 4-storey, slab-on-grade structures. According to the borehole findings, the footings should be placed below the topsoil, granular fill, earth fill and weathered soil onto the sound natural soils or bedrock. The recommended soil pressures and corresponding suitable founding levels are presented in Table 2.

Table 2 - Founding Levels

BH No.	Recommended Maximum Allowable Soil/Rock Pressure (SLS)/ Factored Ultimate Soil/Rock Bearing Pressure (ULS) and Corresponding Founding Level					
	150 kPa (SLS) 250 kPa (ULS)		300 kPa (SLS) 500 kPa (ULS)		500 kPa (SLS) 800 kPa (ULS)	
	Depth (m)	El. (m)	Depth (m)	El. (m)	Depth (m)	El. (m)
1	-	-	-	-	0.8 or +	101.1 or -
2	-	-	-	-	1.6 or +	98.4 or -
3	-	-	1.0 or +	98.4 or -	1.8 or +	97.6 or -
4	-	-	-	-	1.9 or +	99.2 or -
5	-	-	-	-	1.6 or +	98.8 or -
6	-	-	-	-	1.3 or +	99.0 or -
7	-	-	-	-	1.3 or +	98.9 or -
8	-	-	-	-	1.8 or +	97.8 or -
9	-	-	-	-	1.6 or +	99.1 or -
10	-	-	-	-	2.2 or +	98.8 or -
11	-	-	-	-	2.3 or +	98.3 or -
12	-	-	-	-	1.6 or +	99.3 or -
13	1.6 or +	98.5 or -	2.2 or +	97.9 or -	2.5 or +	97.6 or -

The bedrock at the site lies at shallow depths and a review of the proposed founding levels indicates that, in places, the footings will be founded on the bedrock. Test pits will be required at the time of construction to confirm the depth of the bedrock. For footings founded partly on the bedrock and partly on the native soil, construction joints must be provided in the structure at the transition from the bedrock to the native soil subgrade.

Based on the borehole findings, extended footings will be required at some areas for normal footings founded on natural soils or bedrock. It may be more efficient to subexcavate to a size 30% larger than the designed footing width and fill with structural concrete up to the proposed footing elevation immediately after the suitable founding soil or rock is exposed and inspected.

Alternatively, engineered earth fill can be used to replace the existing fill at the site for normal footing construction. A Maximum Allowable Soil Pressure (SLS) of 150 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 250 kPa can be used for the design of the structure founded on engineered fill.

The recommended soil pressures (SLS) for foundations incorporate a safety factor of 3. The total and differential settlements of the footings founded on soil are estimated to be 25 mm and 15 mm, respectively. The settlement of footings founded on bedrock will be negligible.

Foundations exposed to weathering, or in unheated areas, should have at least 1.5 m of earth cover for protection against frost action. For footings founded on sound bedrock, the minimum depth of soil cover for frost protection can be eliminated.

The footings 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 ‘C’ (very dense soil).

Due to the variation of the founding subgrade, the footing subgrade must be inspected by either a geotechnical engineer, or a geotechnical consultant under the

supervision of a geotechnical engineer, to ensure that the subgrade conditions are compatible with the foundation design requirements.

6.2 **Engineered Fill**

The existing earth fill can be upgraded to and/or replaced with engineered fill, and where earth fill is required to raise the site, it is generally economical to place engineered fill for normal footing, slab-on-grade, sewer and road 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 with a Factored Ultimate Soil Bearing Pressure (ULS) of 250 kPa are presented below:

1. The existing earth fill must be subexcavated, sorted free of topsoil and any other deleterious materials, aerated, if necessary, and properly compacted to at least 98% of their maximum Standard Proctor dry density. The subgrade surface must be inspected and proof-rolled prior to any fill placement.
2. Inorganic soils must be used, and they 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 and/or slab-on-grade subgrade. The soil moisture must be properly controlled on the wet side of the optimum. If the building 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.
3. If imported fill is to be used, it should be inorganic soils, free of any deleterious material with environmental issue (contamination). Any

potential imported earth fill from off-site must be reviewed for geotechnical and environmental quality by the appropriate personnel as authorized by the developer or agency, before it is hauled to the site.

4. 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.
5. The engineered fill must extend over the entire graded area; the 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 and designed by a structural engineer to properly distribute the stress induced by the abrupt differential settlement (estimated to be 15± mm) between the natural soils and engineered fill.
6. 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.
7. 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.
8. Where the fill is to be placed on sloping ground steeper than 1 vertical: 3 horizontal, the face of the sloping ground must be flattened to 3 + so that it is suitable for safe operation of the compactor and the required compaction can be obtained.
9. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
10. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement.

This is to ensure that the foundations are placed within the engineered fill envelope and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.

11. Any excavation carried out in the certified engineered fill must be reported to the geotechnical consultant who inspected the fill placement in order to document the locations of the excavation and/or to inspect reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.

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

6.3 **Slab-On-Grade**

In preparation of the subgrade, the topsoil and earth fill must be completely removed. The subgrade for slab-on-grade construction should consist of sound natural soils or properly-compacted inorganic earth fill. The subgrade should be inspected and proof-rolled. Any soft or loose soil detected must be subexcavated and replaced with inorganic earth fill or granular fill, compacted to at least 98% or + of its maximum Standard Proctor dry density.

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 25 MPa/m is recommended in the design of the floor slab.

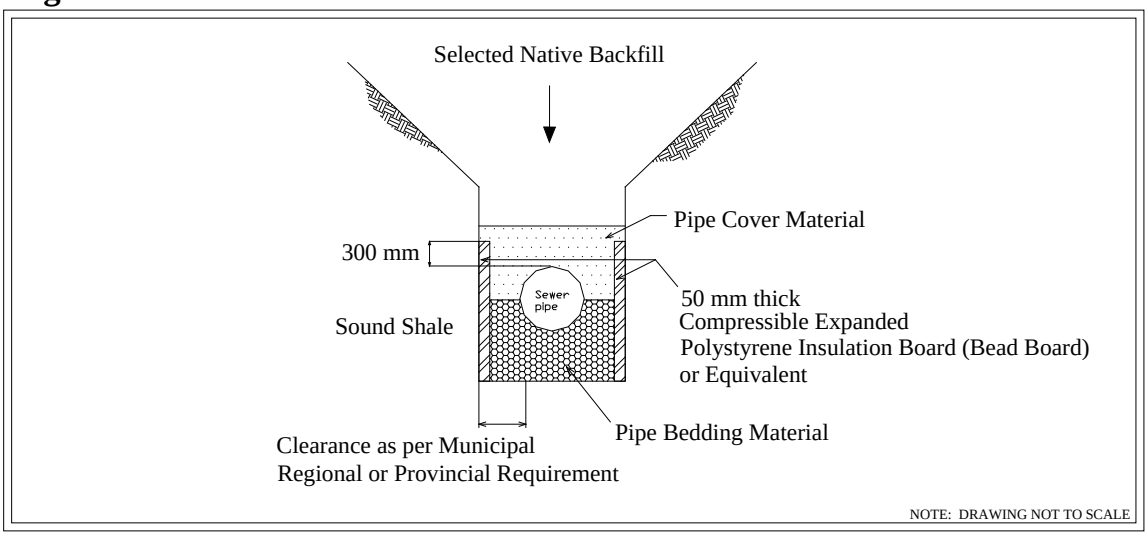
The exterior grading must be such that water is directed away from the building envelope.

6.4 **Underground Services**

A Class 'B' bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. The sewer joints should be leak-proof, or wrapped with an appropriate waterproof membrane, to prevent subgrade migration. If subgrade stabilization is required, lean concrete or non-shrinkable fill may be applied. In areas where more extensive dewatering is required for sewer construction, a Class 'A' bedding should be considered.

Where the pipe is to be placed in bedrock, the trench sides should be sloped rather than vertical. The side slopes shall be no steeper than 2 vertical:1 horizontal. Alternatively, a larger trench can be excavated and the rock face can be lined with 50-mm Styrofoam, or equivalent. This will act as a cushioning layer to reduce the residual stress exerted on the buried structure. The bedding material should have a minimum thickness of 20 cm. Backfill between the pipes and the lined rock face should consist of fine sand with medium compaction. The recommended scheme is illustrated in Diagram 1.

Diagram 1 - Sewer Installation in Sound Bedrock



6.5 **Backfilling in Trenches and Excavated Areas**

The on-site inorganic soils are 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. Below the floor slab, the backfill must be compacted to 98% or + of its maximum Standard Proctor dry density.

The rock fragments, cobbles or boulders should either be pulverized to sizes less than 15 cm and thoroughly mixed with the overburden soils, or the trench can be backfilled by levelling the debris using a bulldozer with lifts no more than 20 cm (loose) in thickness. Compaction should be carried out by a vibratory sheepsfoot roller, with water consistently sprayed on each lift.

In normal project construction practice, the problem areas of settlement largely occur adjacent to foundation walls, columns, manholes, catch basins and services crossings. In areas which are inaccessible to a heavy compactor, the interface of the native soils and sand backfill will have to be flooded for a period of at least 1 day.

The narrow trenches for service crossings should be cut at 1 vertical:2 horizontal so that the backfill in the trenches can be effectively compacted. Otherwise, soil arching in the trenches will prevent achievement of the proper compaction. In this case, imported sand fill, which can be appropriately compacted by using a smaller vibratory compactor, must be used. The areas at the interface of the native soil and the sand backfill should preferably be flooded for at least 1 day.

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 these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soil have a water content on the dry side of the optimum, it would be impossible to wet the soil due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction. Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as when the trench box is removed, or when backfill consists of oversized rock fragments. 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 the 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 the final surfacing of the new pavement.
- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 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**

According to the borehole findings, the recommended structure of the pavement design is presented in Table 3.

Table 3 - Pavement Design

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 Parking Fire Route	 350 450	Granular 'B' or equivalent

In preparation of the subgrade, the subgrade surface should be proof-rolled and any soft subgrade, organics 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.

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

Earth fill to raise the grade for pavement construction should consist of organic-free soil uniformly compacted to 95% or + of its maximum Standard Proctor dry density.

The subgrade in the zone within 1.0 m below the underside of the granular sub-base should be compacted to at least 98% of its maximum Standard Proctor dry density,

with a moisture content 2% to 3% drier than its optimum. If the pavement is to be placed on the existing earth fill, the fill must be surface-compacted, and any serious topsoil inclusions and/or deleterious materials at the subgrade surface must be removed.

Along the perimeter where surface runoff may drain onto the pavement or water may seep into the granular bases, a swale or an intercept subdrain system should be installed. Subdrains, consisting of filter-wrapped weepers, should also be installed 0.3 m below the granular sub-base, and they should be connected to the catch basins and storm manholes in the paved areas and backfilled with free-draining granular material.

6.7 Sidewalks, Interlocking Stone Pavement and Landscaping

Interlocking stone pavement and the sidewalks in areas which are sensitive to frost-induced ground movement, such as entrances, must be constructed on a free-draining, non-frost-susceptible granular material such as Granular 'B'. It must extend to 1.4 m below the slab or pavement surface and be provided with positive drainage such as weeper subdrains connected to manholes or catch basins. Alternatively, the sidewalks and the interlocking stone pavement should be properly insulated with 70-mm Styrofoam, or equivalent.

6.8 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**	**Compacted**
Earth Fill and weathered Soil	21.0	1.20	1.00
Silty Sand Till	22.0	1.33	1.03
Fine Sand	20.5	1.25	1.00
Lateral Earth Pressure Coefficients			
	Active K_a	**At Rest K_o**	**Passive K_p**
Compacted Earth Fill and weathered Soil	0.40	0.50	2.50
Silty Sand Till and Fine Sand	0.30	0.40	3.33

6.9 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. Any excavation in excess of 1.2 m should be sloped at 1 vertical:1 horizontal for stability.

Excavation into the very dense till containing boulders and cobbles will require extra effort and a properly equipped backhoe. Boulders larger than 15 cm in size are not suitable for structural backfill.

Excavation into the sound bedrock will require the use of a pneumatic hammer and/or rock blasting. Due to the proximity of the adjacent residence and other structures, any rock blasting must be conducted in a controlled manner by specialized personnel.

Where rock blasting or construction with vibration is to be performed at the site, pre- and post-construction surveys are to be conducted to document the existing condition of the adjacent structures in order to settle any claims for damage that may be caused by the blasting/construction vibration.

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

Table 5 - Classification of Soils for Excavation

Material	Type
Sound Bedrock	1
Sound Till and weathered Bedrock	2
Earth Fill, weathered Soil and Sand above groundwater	3
Sand below groundwater	4

The yield of groundwater from the silty sand till and earth fill is expected to be moderate and can generally be controlled by pumping from sumps. If groundwater is encountered in the sand, the yield is expected to be appreciable and persistent and groundwater, if any, may be controllable by pumping from closely spaced sumps. The yield from the bedrock will be appreciable initially but will decrease and become spent with time if pumped continuously.

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

7.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Wyldewood Creek Inc., and for review by its 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 the report reflects the judgment of Frank Lee, P.Eng., and Daniel Man, 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.: 1807-S088

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
101.9	Ground Surface							
0.0	**5 cm TOPSOIL**				0			Dry on completion
	Brown, very dense							
	SILTY SAND TILL with rock fragments	1	DO	50/15			8	
101.2 / 0.7	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**				1			
					2			
					3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
100.0	Ground Surface							
0.0	Brown, loose, weathered				0			
		1	DO	6		○	8 ●	
	FINE SAND some silt							
		2	DO	9	1	○	19 ●	W.L. @ El. 99.2 m on completion
98.5 / 1.5	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**				2			
					3			

Soil Engineers Ltd.

JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
99.4	Ground Surface							
0.0	**8 cm TOPSOIL**				0			
	Brown, compact to very dense	1	DO	12			12	
	SILTY SAND TILL							Dry on completion
	occ. wet sand and silt seams and layers, cobbles and boulders — weathered	2	DO	50/NP	1		5	
		3	DO	50/2				
97.7 / 1.7	**END OF BOREHOLE**							
	Refusal to augering **Inferred bedrock**				2			
	Installed 50 mm Ø monitoring well to 1.7 m provided with a steel protective casing							
					3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 14, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
101.1	Ground Surface							
0.0	Brown				0			
	EARTH FILL silty sand and sand with rock fragment and topsoil inclusions	1	DO	38			6	W.L. @ El. 99.6 m on completion
		2	DO	56	1		9	
		3	DO	30/NP			18	
99.3 1.8	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**				2			
					3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 14, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
100.4	Ground Surface							
0.0	Brown	1	DO	50/15	0		3	Dry on completion
	EARTH FILL silty sand with rock fragments and cobbles	2	AS				5	
		3	DO	4	1		8	
98.9 1.5	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock** Installed 50 mm Ø monitoring well to 1.5 m provided with a steel protective casing				2 3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 14, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
100.3	Ground Surface							
0.0	Brown				0			Dry on completion
	EARTH FILL sand with rock fragments and topsoil inclusions	1	DO	36			4	
		2	DO	30/NP	1		16	
99.1 1.2	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**							
					2			
					3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 14, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
100.2	Ground Surface							
0.0	Brown **EARTH FILL** sand with rock fragments and topsoil inclusions	1	DO	20	0		7	Dry on completion
		2	DO	14	1		45	
99.0 1.2	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**				2 3			

Soil Engineers Ltd.

JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
99.6	Ground Surface							
0.0	**360 mm GRANULAR FILL with rock fragments**				0			Dry on completion
	Brown	1	DO	23			5	
	EARTH FILL silty clay and sity sand with rock fragments and topsoil inclusions				1			
		2	AS					
		3	DO	50/NP			13	
97.9 1.7	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**				2			
					3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
100.7	Ground Surface							
0.0	Brown **EARTH FILL** silty sand with topsoil inclusions	1	DO	18	0		4	Dry on completion
		2	DO	7	1		21	
99.2 1.5	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock** Installed 50 mm Ø monitoring well to 1.5 m provided with a steel protective casing				2 3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 10

FIGURE NO.: 10

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
101.0	Ground Surface							
0.0	Brown/black				0			Dry on completion
	EARTH FILL silty sand and sand with rock fragments wood debris and topsoil inclusions	1	DO	37			3	
		2	DO	21	1		10	
		3	DO	12			7	
					2			
98.9 2.1	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**							
					3			

Soil Engineers Ltd.

JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 11

FIGURE NO.: 11

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm)	Shear Strength (kN/m²)	Penetration Resistance (blows/30 cm)	Atterberg Limits PL LL / Moisture Content (%)	WATER LEVEL
100.6	Ground Surface									
0.0	Brown **EARTH FILL** silty clay, silty sand and sand with rock fragments and topsoil inclusions	1	DO	31	0				5	Dry on completion
		2	DO	28	1				7	
		3	DO	16					15	
		4	AS		2				17	
98.4 2.2	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**				3					

Dynamic Cone (blows/30 cm): 10 30 50 70 90
Shear Strength (kN/m²): 50 100 150 200
Penetration Resistance (blows/30 cm): 10 30 50 70 90
Moisture Content (%): 10 20 30 40

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 12

FIGURE NO.: 12

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 13, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
100.9	Ground Surface							
0.0	Brown				0			Dry on completion
	EARTH FILL silty sand and sand with rock fragments	1	DO	20			3	
		2	DO	33	1		6	
99.4 1.5	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock**				2			
					3			

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JOB NO.: 1807-S088

LOG OF BOREHOLE NO.: 13

FIGURE NO.: 13

PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings

METHOD OF BORING: Flight-Auger/HS

PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

DRILLING DATE: August 14, 2018

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
100.1	Ground Surface							
0.0	Brown **EARTH FILL** sand with topsoil layer	1	DO	29	0		9	
		2A	DO				33	
99.1					1			
1.0	Grey, loose, weathered **FINE SAND** some silt	2B	DO	8			26	
98.7								
1.4	Grey, compact to very dense **SILTY SAND TILL**	3	DO	18			12	W.L. @ EL.99.1 m on completion
					2			
		4	DO	30/NP			9	
97.7								
2.4	**END OF BOREHOLE** **Refusal to augering** **Inferred bedrock** Installed 50 mm Ø monitoring well to 2.4 m provided with a steel protective casing				3			

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GRAIN SIZE DISTRIBUTION

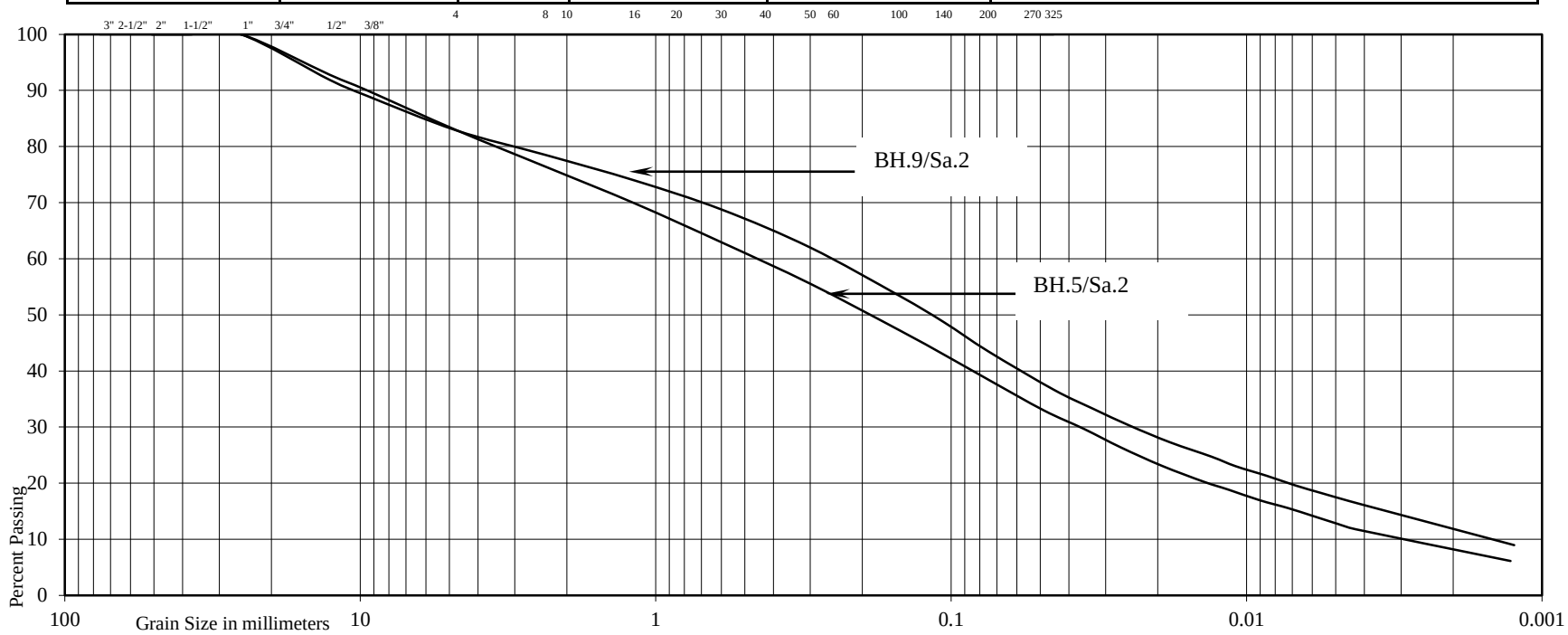
Reference No: 1807-S088

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project:	Proposed Six 3- to 4-Storey Buildings		BH./Sa.	5/2	9/2
Location:	10 Vacation Inn Drive, Town of Collingwood		Liquid Limit (%) =	-	-
			Plastic Limit (%) =	-	-
Borehole No:	5	9	Plasticity Index (%) =	-	-
Sample No:	2	2	Moisture Content (%) =	5	21
Depth (m):	0.5	1.0	Estimated Permeability		
Elevation (m):	99.9	99.7	(cm./sec.) =	10^{-5}	10^{-6}

Classification of Sample [& Group Symbol]: SILTY SAND FILL, traces to some clay and gravel

Figure: 14

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

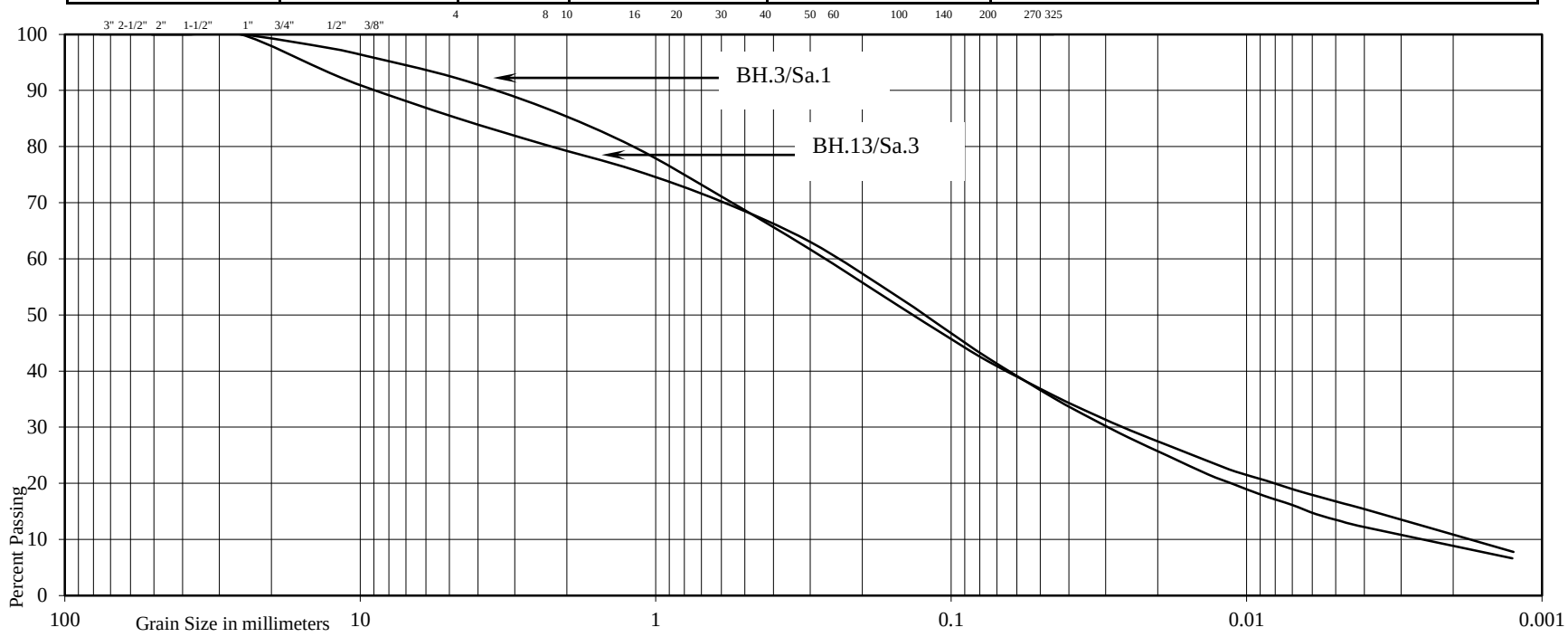
Reference No: 1807-S088

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project:	Proposed Six 3- to 4-Storey Buildings		BH./Sa.	3/1	13/3
Location:	10 Vacation Inn Drive, Town of Collingwood		Liquid Limit (%) =	-	-
			Plastic Limit (%) =	-	-
Borehole No:	3	13	Plasticity Index (%) =	-	-
Sample No:	1	3	Moisture Content (%) =	12	12
Depth (m):	0.4	1.7	Estimated Permeability		
Elevation (m):	99.0	98.4	(cm./sec.) =	10^{-6}	10^{-5}

Classification of Sample [& Group Symbol]: SILTY SAND TILL, traces to some clay and gravel

Figure: 15

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GRAIN SIZE DISTRIBUTION

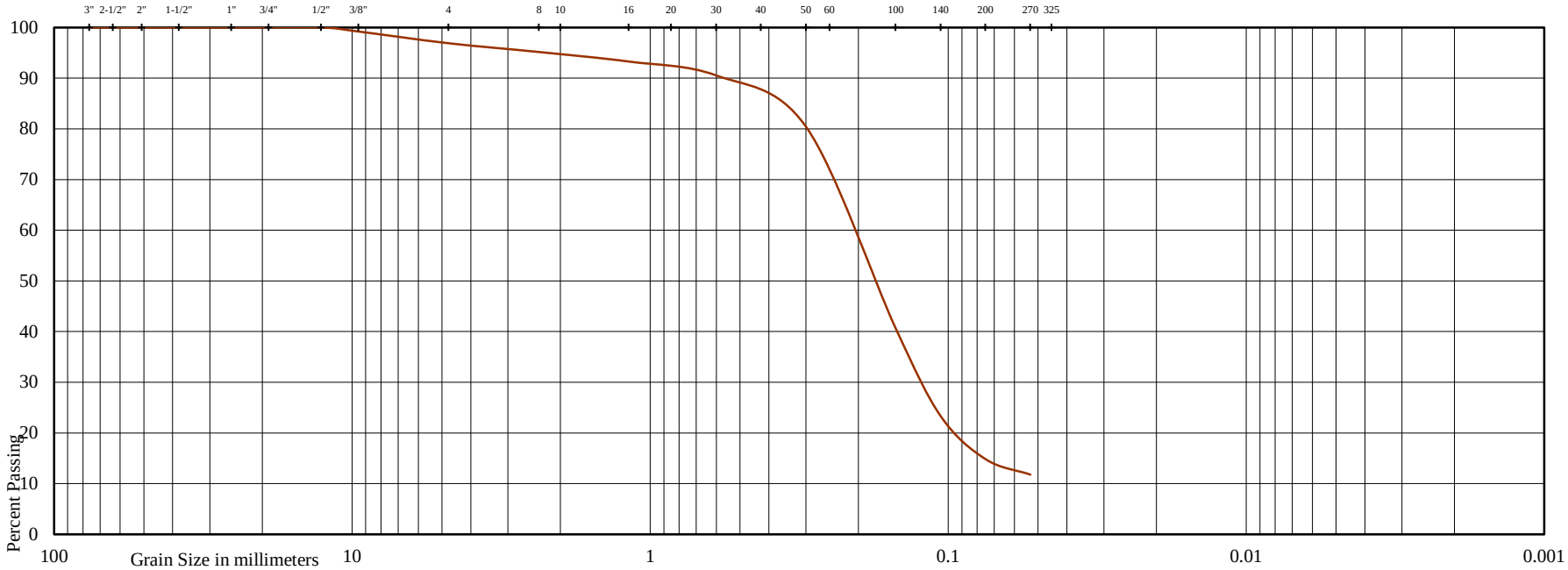
Reference No: 1807-S098

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Proposed Six 3- to 4-Storey Buildings

Location: 10 Vacation Inn Drive, Town of Collingwood

Borehole No: 2

Sample No: 2

Depth (m): 1.0

Elevation (m): 99.0

Liquid Limit (%) = -

Plastic Limit (%) = -

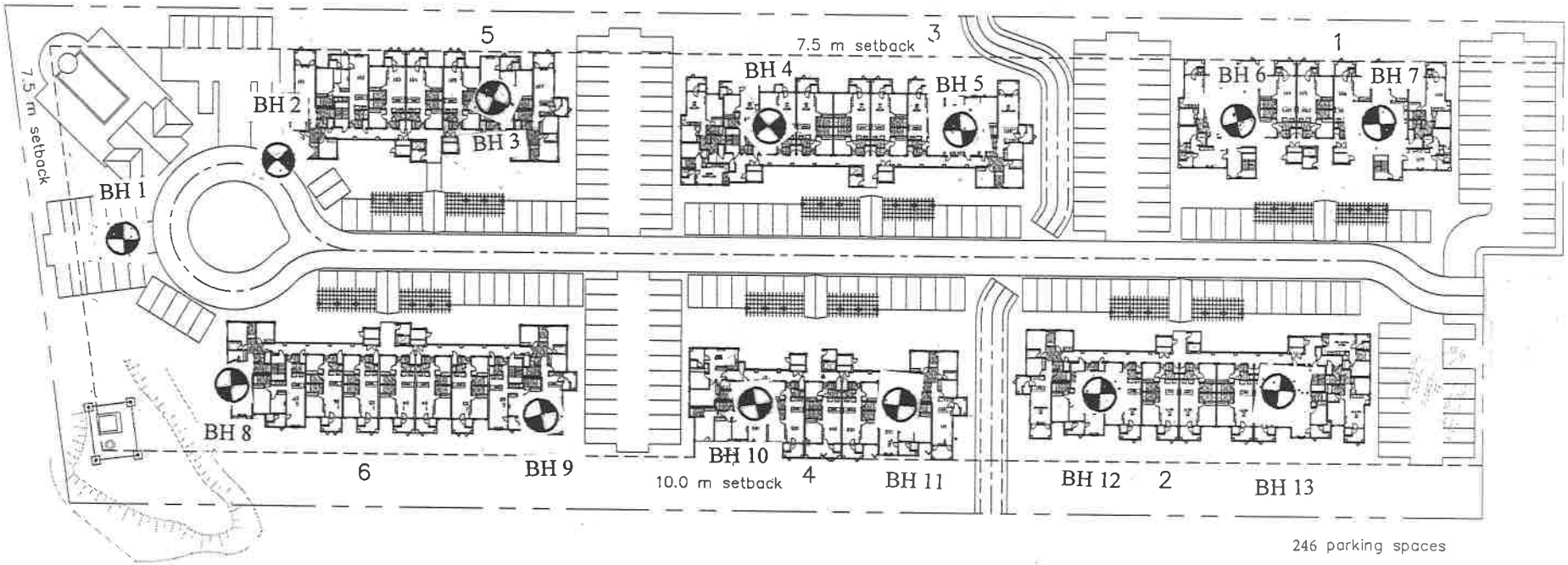
Plasticity Index (%) = -

Moisture Content (%) = 19

Estimated Permeability (cm./sec.) = 10^{-3}

Classification of Sample [& Group Symbol]: FINE SAND, some silt, traces of medium sand, coarse sand and gravel

Figure: 16



* BM (Top of fire hydrant assumed El. 100.0 m)

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GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE
90 West Beaver Creek Road, Richmond Hill, Ontario L4B 1E 7 Tel:(416) 754-8515 Fax: (905) 881-8335

BOREHOLE LOCATION PLAN

DESIGNED	CHECKED	DWG NO. 1	REV
SCALE 1:1235	REF. NO. 1807-S088	DATE September 2018	

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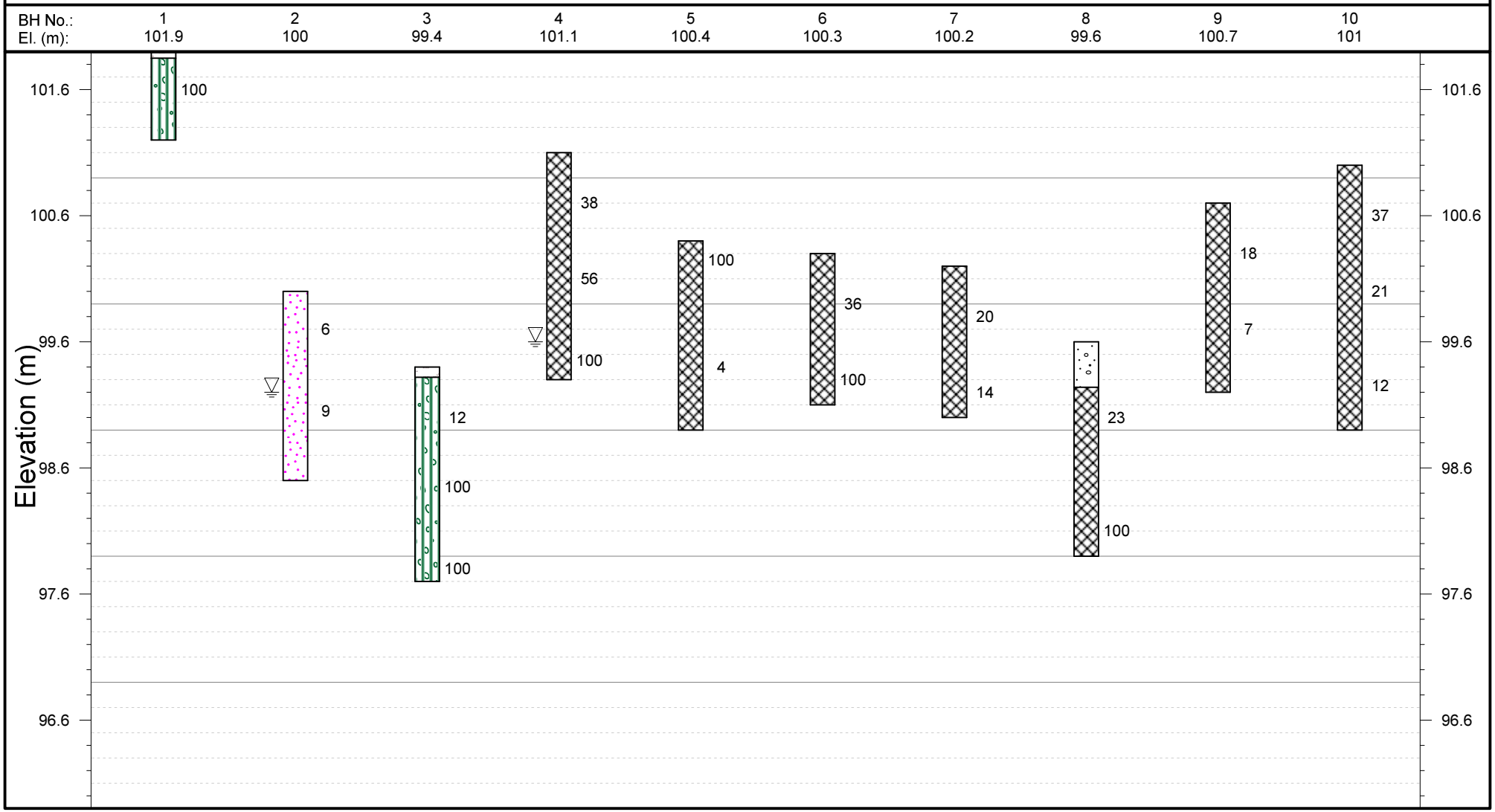
SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

JOB NO.: 1807-S088
REPORT DATE: September 2018
PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings
PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

LEGEND

TOPSOIL, FILL, SAND, SILTY SAND TILL, GRANULAR



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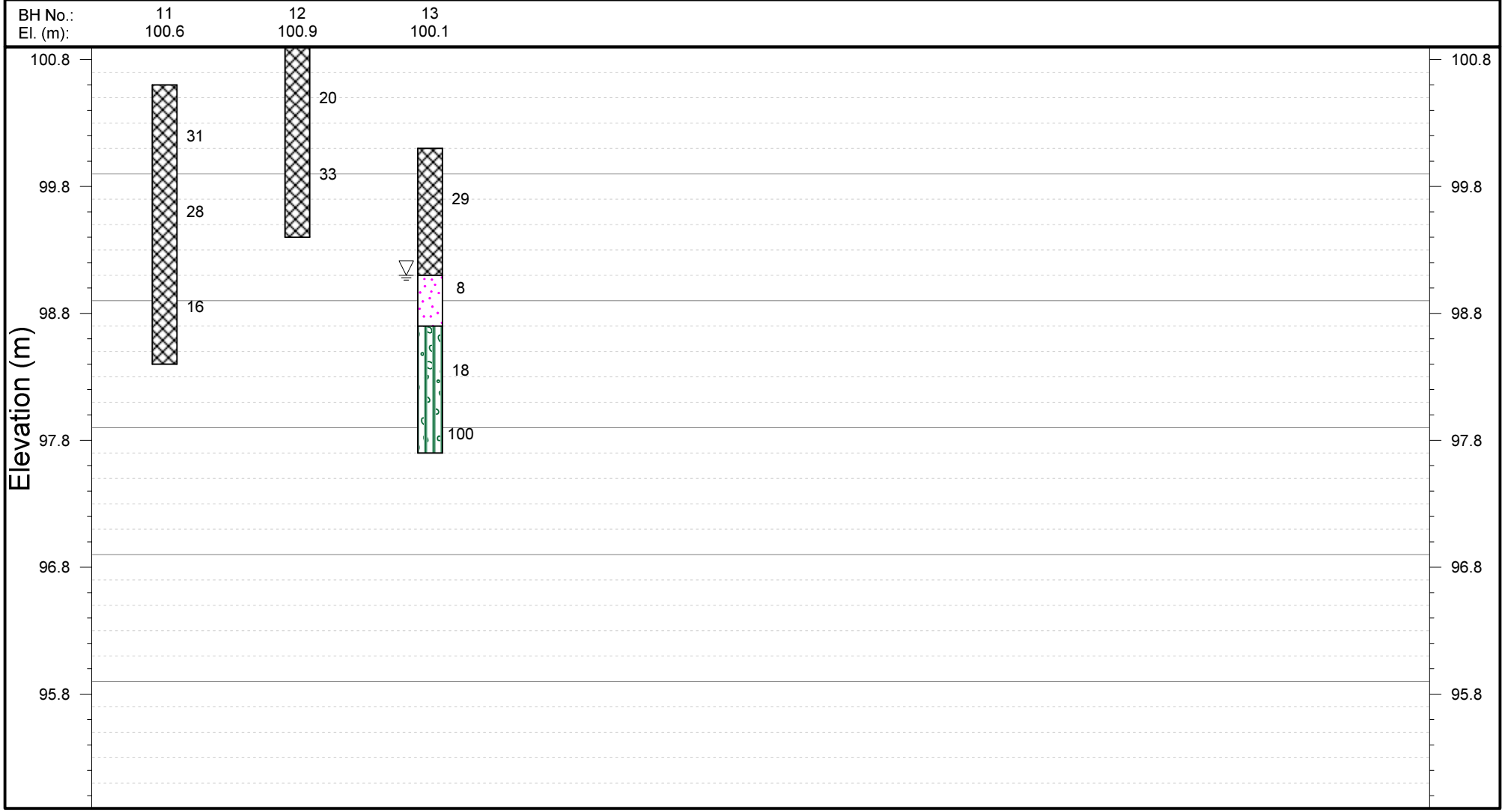
SUBSURFACE PROFILE
DRAWING NO. 3
SCALE: AS SHOWN

JOB NO.: 1807-S088
REPORT DATE: September 2018
PROJECT DESCRIPTION: Proposed Six 3- to 4- Storey Buildings
PROJECT LOCATION: 10 Vacation Inn Drive
Town of Collingwood

LEGEND

FILL | SAND | SILTY SAND TILL

WATER LEVEL (END OF DRILLING)