GEOTECHNICAL INVESTIGATION

PROPOSED DEVELOPMENT
181 ECO PARKWAY
DUNDALK, ONTARIO

CMT Project 23-174.R01

Prepared for:

Wilson Developments

July 19, 2023

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July 19, 2023 23-174.R01

Wilson Developments
569 Perth Street
Mount Forest, Ontario
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Attention: Mr. Josh Martino

Dear Sir:

Re: Geotechnical Investigation
Proposed Development
181 Eco Parkway
Dundalk, Ontario

As requested, CMT Engineering Inc. conducted a geotechnical investigation at the above-referenced site, and we are pleased to present the enclosed report.

We trust that this information meets your present requirements, and we thank you for allowing us to undertake this project. Should you have any questions, please do not hesitate to contact our office.

Yours truly,

Brandon Figg

Brandon R Figg, C.Tech.
Senior Soil Technician

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TABLE OF CONTENTS

1.0 INTRODUCTION

The services of CMT Engineering Inc. (CMT Inc.) were retained by Mr. Josh Martino to conduct a geotechnical investigation for the proposed development to be constructed at 181 Eco Parkway, in Dundalk, Ontario. The location of the subject site is shown on Drawing 1.

It is understood that the project will comprise the construction of a new warehouse with a total ground floor footprint of approximately 9,300 m^2 (100,104 ft^2) and two (2) rental units, associated parking areas, driveways, and a stormwater management pond.

The purpose of the geotechnical investigation was to assess the existing soil and groundwater conditions encountered in the boreholes. Included in the assessment are the soil classification and groundwater observations, as well as comments and recommendations regarding geotechnical resistance (bearing capacity); serviceability limit states (anticipated settlement); recommended founding elevations; site classification for seismic site response; dewatering considerations; recommendations for site grading, site servicing, excavations and backfilling; recommendations for slab-on-grade construction; pavement design/drainage; soil design properties; infiltration and a summary of the laboratory test results.

2.0 EXISTING SITE CONDITIONS

The site currently comprises of vacant land with some mature trees. It should be noted that stockpiles of concrete and topsoil/fill are present on the subject property.

The site is bounded by existing industrial land to the east, a vacant industrial lot to the west, a forest area to the north, and Eco Parkway to the south.

3.0 FIELD AND LABORATORY PROCEDURES

The field investigation was conducted on May 31 and June 5, 2023 and comprised the advancement of eight (8) boreholes (referenced as Boreholes 1 to 8, inclusive), utilizing a Geoprobe 7822DT drillrig operated by employees of CMT Drilling Inc. The boreholes were advanced in the area of the proposed warehouse, rental units and stormwater management pond to depths ranging from approximately 4.57 m (15.0 ft) to 6.10 m (20.0 ft) below ground surface.

Standard penetration testing and sampling was carried out in the boreholes using 38 mm inside diameter split spoon sampling equipment and an automatic hammer, in accordance with ASTM D 1586 "Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils". In the boreholes, SPT soil sampling was generally conducted at 0.76 m (2.5 ft) intervals to 3.05 m (10.0 ft), and every 1.52 m (5.0 ft) thereafter, to borehole termination. Macro core (MC5) direct push sampling was typically conducted between the SPT soil samples obtained below 3.05 m (10.0 ft) depth.

Technical staff from CMT Inc. observed the drilling operation and collected and logged the recovered soil samples. A small portion of each sample was placed in a sealed, marked jar for moisture content determinations.

Boreholes 1, 2 and 4 were equipped with 50 mm (2.0 inch) diameter PVC monitoring wells comprised of 1.5 m to 3.0 m long screens backfilled with filter sand and then riser pipe, backfilled with bentonite. The monitoring wells were installed according with the Ontario Water Resources Act, Regulation 903 (O.Reg. 903) by well technicians licensed by the Ministry of the Environment, Conservation and Parks (MECP), working for a contractor also licensed by the MECP. Boreholes not instrumented with monitoring wells were backfilled with bentonite in accordance with O.Reg. 903. The monitoring wells are registered with the MECP and must be decommissioned in accordance with O.Reg. 903 prior to future construction. The well log records are provided in Appendix C.

Representative samples from the boreholes at the following depths were submitted to our laboratory for grain size analyses:

- Borehole 3 – approximate depth 2.29 m to 2.90 m (7.5 ft to 9.5 ft); and
- Borehole 4 – approximate depth 0.76 m to 1.37 m (2.5 ft to 4.5 ft).

The borehole logs are provided in Appendix A and the grain size analyses are provided in Appendix B.

CMT Inc. personnel surveyed the ground surface elevations at the borehole locations (using laser survey equipment) on June 5, 2023. Benchmark 1 (top of standard iron bar located at northeast corner of subject property) was utilized as a temporary benchmark with a reported geodetic elevation of 509.20 m and the top of the existing sanitary manhole #2 was utilized as a temporary benchmark with a reported geodetic elevation of 510.50 m. As such, the ground surface elevations at the borehole locations ranged from approximately 510.24 m to 511.97 m. The locations of the boreholes and the temporary benchmark are shown on Drawing 2.

4.0 SUBSOIL CONDITIONS

The soils encountered in the boreholes are described briefly below with a more detailed stratigraphic description provided on the borehole logs in Appendix A. The following paragraphs have been simplified into terms of major soil strata. The soil boundaries indicated have been inferred from non-continuous samples and observations of sampling and drilling resistance and typically represent transitions from one soil type to another rather than exact planes of geological change. Further, the subsurface conditions are anticipated to vary between and beyond the borehole locations.

4.1. Topsoil

Dark brown, very loose to loose, moist, silty, organic topsoil was encountered at the surface in all the boreholes. The thickness of the topsoil at the borehole locations ranged between approximately 175 mm and 500 mm (average 338 mm). It should be expected that topsoil thickness will vary throughout the site. Materials noted as topsoil in this report were classified based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out.

4.2. Silty Sand Fill

Dark brown silty sand fill was encountered underlying the topsoil at Borehole 2. The fill material had a thickness of approximately 260 mm and was considered to be very loose, with a SPT N-value of 3 blows per 0.30 m. The fill material was considered to be visually moist at the time of the investigation.

4.3. Sand

Dark brown sand was encountered underlying the topsoil in Boreholes 4 and 5. The sand was considered to be very loose to loose, with SPT N-values ranging from 2 to 4 blows per 0.30 m (average 3 blows per 0.30 m). The sand was considered to be moist to wet, with a moisture content of about 18.0%.

4.4. Silt and Sand

Light brown and/or dark brown and/or grey/brown silt and sand, some clay, trace gravel was encountered underlying the fill in Borehole 2, underlying the topsoil in Boreholes 1, 3, 6, 7 and 8 and underlying the sand in Boreholes 4 and 5. The silt and sand was considered to be very loose to dense, with SPT N-values ranging from 2 to 32 blows per 0.30 m (average 17 blows per 0.30 m). The silt and sand was considered to be moist to wet with moisture contents ranging from about 9.0% to 21.5% (average 15.3%).

4.5. Silty Sand Till

Light brown to brown and/or grey and/or grey/brown silty sand till, with some clay and gravel was encountered underlying the silt and sand in all the boreholes. The silty sand till soils were considered to be compact to very dense, with SPT N-values ranging from 24 to greater than 100 blows per 0.30 m (average 62 blows per 0.30 m). The silty sand till soils were considered to be moist to very moist, with moisture contents ranging from about 6.2% to 12.7% (average 9.5%).

4.6. Groundwater

Monitoring wells were installed in Boreholes 1, 2 and 4 to measure the static groundwater level. The water levels in Boreholes 1, 2 and 4 were measured by CMT Inc. personnel on June 5, 2023.

The recorded groundwater elevation from the monitoring well installed in Boreholes 1, 2 and 4, the approximate zone of saturation observed in all of the boreholes, as well as the ground surface and bottom of borehole elevations, are provided in the following table:

Borehole No.	Ground Surface Elevation (m)	Approximate Elevation of Water in Monitoring Well (m) June 5, 2023 (Depth to Water) (m)	Estimated Zone of Saturation at the Time of Investigation Elevation (m) (Depth) (m)	Bottom of Borehole Elevation (m)
BH 1	510.91	507.34 (3.57)	507.86 to 506.34 (3.05 to 4.57)	505.73
BH 2	510.24	506.62 (3.62)	509.48 to 507.95 (0.76 to 2.29)	504.14
BH 3	510.74	--	509.22 to 508.45 (1.52 to 2.29)	504.64
BH 4	510.61	509.28 (1.33)	509.85 to 508.32 (0.76 to 2.29)	506.04
BH 5	511.08	--	510.32 to 508.79 (0.76 to 2.29)	506.51
BH 6	511.78	--	510.87 to 509.49 (0.91 to 2.29)	507.21
BH 7	511.90	--	511.14 to 509.61 (0.76 to 2.29)	507.33
BH 8	511.97	--	511.21 to 508.92 (0.76 to 3.05) 508.31 to 507.40 (3.66 to 4.57) (termination)	507.40

It should be noted that the dense to very dense silty sand till soils encountered in the boreholes have the potential to create perched water conditions in any overlying soils. Groundwater levels (particularly perched water) are generally dependent on the amount of precipitation, control of surface water, as well as the time of year, and can fluctuate significantly in elevation and volume. The groundwater levels and wet soil conditions encountered in some of the boreholes could make some excavations difficult. It should be expected that caving or sloughing of the excavation walls will occur.

The monitoring wells must be decommissioned in accordance with O.Reg. 903, prior to the start of construction.

5.0 DISCUSSION AND RECOMMENDATIONS

The following sections of the report provide our interpretation of the factual geotechnical data obtained during the investigation and is intended for the guidance of the design engineer. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Contractors bidding on or undertaking the work should make their own independent interpretation of the factual subsurface information provided as it affects their proposed construction means and methods, equipment selection, scheduling, pricing, and the like.

Utilizing the information gathered during the geotechnical investigation and assuming that the borehole information is representative of the subsoil conditions throughout the site, the following comments and recommendations are provided.

5.1. Serviceability and Ultimate Limit Pressure

Based on the information obtained from the boreholes, the following table provides a summary of the estimated geotechnical reaction at the Serviceability Limit State (SLS) and the factored geotechnical resistance at the Ultimate Limit State (ULS) at the various elevations, including soil types:

Borehole No.	Ground Surface Elevation (m)	SLS kPa (psf)	ULS kPa (psf)	Estimated Highest Founding Elevation (m)	Depth to Highest Founding Elevation (m)	Depth Below Proposed F.F. Elevation (El. 512.65 m) of Warehouse (m)	Soil Type
BH 1	510.91	150 (3,000)	225 (4,500)	509.39 to 507.86	1.52	--	Silt and Sand
		250 (5,000)	375 (7,500)	507.86 to 505.73 (termination)	3.05	--	Silty Sand Till

Borehole No.	Ground Surface Elevation (m)	SLS kPa (psf)	ULS kPa (psf)	Estimated Highest Founding Elevation (m)	Depth to Highest Founding Elevation (m)	Depth Below Proposed F.F. Elevation (El. 512.65 m) of Warehouse (m)	Soil Type
BH 2	510.24	150 (3,000)	225 (4,500)	508.72 to 507.95	1.52	--	Silt and Sand
		250 (5,000)	375 (7,500)	507.95 to 504.14 (termination)	2.29	--	Silty Sand Till
BH 3	510.74	250 (5,000)	375 (7,500)	508.45 to 504.64 (termination)	2.29	4.20	Silty Sand Till
BH 4	510.61	150 (3,000)	225 (4,500)	509.09 to 508.32	1.52	3.56	Silt and Sand
		250 (5,000)	375 (7,500)	508.32 to 506.04 (termination)	2.29	4.33	Silty Sand Till
BH 5	511.08	250 (5,000)	375 (7,500)	508.79 to 506.51 (termination)	2.29	3.86	Silty Sand Till
BH 6	511.78	250 (5,000)	375 (7,500)	509.49 to 507.21 (termination)	2.29	3.16	Silty Sand Till
BH 7	511.90	150 (3,000)	225 (4,500)	510.38 to 509.61	1.52	--	Silt and Sand
		250 (5,000)	375 (7,500)	509.61 to 507.33 (termination)	2.29	--	Silty Sand Till
BH 8	511.97	150 (3,000)	225 (4,500)	511.21 to 508.92	0.76	--	Silt and Sand
		250 (5,000)	375 (7,500)	508.92 to 507.40 (termination)	3.05	--	Silty Sand Till

Based on the bearing capacities and elevations provided in the table above, suitable founding elevations for conventional foundations designed with a minimum bearing capacity of 150 kPa (3,000 psf) at SLS and 225 kPa (4,500 psf) at the Ultimate Limit State (ULS) generally range below elevations 511.21 m to 508.45 m for Boreholes 1 to 8, inclusive, which corresponds with depths ranging between approximately 0.76 m and 2.29 m below the existing ground surface and approximately 3.16 m to 4.33 m below the proposed finished floor elevation of the proposed warehouse at the borehole locations.

Due to the varying depth of loose fill, native soils and very moist to wet soils, the founding soils must be assessed at the time of construction by qualified geotechnical personnel in order to confirm their founding suitability, and to determine whether or not mud mats and/or widening the footings may be required.

Should footings be designed to be constructed at elevations higher than the elevations indicated in the table above, then structural fill will be required in order to achieve the design grades for the proposed foundations. The serviceability limit pressure for good quality granular structural fill placed and compacted in accordance with Section 5.5.4 of this report and constructed on approved competent native soil is estimated to be at least 150 kPa (3,000 psf) at SLS and 225 kPa (4,500 psf) at ULS. Lean mix concrete fill could also be utilized for this application. Alternatively, footings could be stepped down to bear on approved undisturbed founding soil.

Footings may be placed at a higher elevation relative to another footing provided that the slope between the outside face of the footings is separated by a minimum slope of 10 horizontal to 7 vertical (10H:7V) with an imaginary line projected from the underside of the footings. This must be taken into account for any deep structures such as elevator pits, sump pits and/or pump chambers.

It is recommended that structural foundation drawings be cross-referenced with site servicing drawings to ensure that service pipes do not conflict with building foundations (including the zone of influence down and away from the footings).

With respect to the Serviceability Limit State (SLS), the total and differential footing settlements are not expected to exceed the generally acceptable limits of 25 mm (1") and 19 mm (3/4") respectively, assuming a minimum footing width of 0.6 m.

All exterior footings must be provided with a minimum of 1.2 m of soil cover or equivalent thermal insulation in order to provide protection against frost action.

It should be noted that the native soils that exist at or below founding elevations may be in a wet state and may be too wet to provide suitable bearing for foundations without drainage or construction of a mud mat or granular drainage layer. It is imperative that the subgrade soil be inspected and approved by competent geotechnical personnel to ensure that the founding soils are suitable for bearing. Dewatering during construction may be required (see Section 5.8 of this report).

5.2. Foundation Alternatives

Due to the material encountered during the investigation, it is possible that shallow foundations may be considered less feasible on the subject site and a deep foundation system such as helical piles, driven piles, or caissons, may be a more cost-effective option. If a deep foundation system is required, it would be recommended to contact a deep foundation supplier/installer to develop a site-specific foundation plan. Estimated soil design parameters for use in the design of deep foundations can be found in Section 5.4 of this report. The following are provided as general recommendations should deep foundations be required for this site.

5.2.1. Helical Piles

The soils encountered at the site are considered feasible for the support of helical pile foundations. The helical piles will need to be advanced through the upper very loose to loose, topsoil, fill and native soils and into the underlying compact to very dense native soils. Soils suitable to support helical piles were typically encountered in the boreholes at depths of between 0.76 m and 2.29 m below the existing ground elevation (approximately 3.16 m to 4.33 m below the proposed finished floor elevation of the proposed warehouse). The majority of the resistance of the helical piles will come from end bearing resistance, and it would be recommended to ignore skin friction within any saturated zones (if encountered). It should also be noted that any significant buried organic layers, if encountered, may not provide much lateral support and helical piles should be designed accordingly. It may be required to penetrate a substantial distance into the suitable founding soils in order to achieve the required pile capacity. No cobbles, boulders or fill materials which may hinder the installation of helical piles were encountered in the boreholes advanced on the subject site.

It should be noted that helical piles can be installed with many different configurations based on the intended application. It would be prudent to contact a specialized helical pile designer/installer for project specific helical pile designs.

When installing helical piles, the required load value is typically converted to a torque value based on the specific equipment used for installation. The conversion factors and equipment specifications are typically provided by the contractor/installer.

A qualified structural engineer should be retained to design the grade beams, pile cap foundations and structural slab for the helical pile system, using the estimated soil design parameters outlined in Section 5.4 of this report.

It is recommended that regular inspections by qualified personnel be conducted during helical pile installation in order to confirm the founding strata and installation torque values.

5.2.2. Driven Piles

The soils encountered at the site are considered feasible for the support of driven steel (H-pile, Pipe pile, etc.) foundations. The piles will need to be driven through the very loose to loose topsoil, fill and native soils and into the underlying compact to dense native soils. Soils suitable to support helical piles were typically encountered in the boreholes at depths of between 0.76 m and 2.29 m below the existing ground elevation (approximately 3.16 m to 4.33 m below the proposed finished floor elevation of the proposed warehouse). It may be required to penetrate a substantial distance into the suitable founding soils in order to achieve the required pile capacity. No cobbles, boulders or fill materials which may hinder the installation of driven piles were encountered in the boreholes advanced on the subject site.

The majority of the resistance strength of the piles will likely come from end bearing resistance, and skin friction should be ignored within any saturated soil zones (if encountered). The bearing resistances and estimated soil parameters for the soils encountered on the subject site which can be used in the design are provided in Sections 5.1 and 5.4 of this report. The structural resistance of the pile must be confirmed by the project structural engineer.

Pile drive shoes should be installed on each pile in accordance with all current OPSD standards. Piles must be driven a suitable depth to achieve the required end bearing resistance and the pile capacity should be verified in the field by the use of the Hiley formula (Standard Structural Drawing SS-103-11) or Pile Driving Analyzer (PDA). It is recommended that a pile driving log be kept for the entire driving of the pile. Normal tolerances during pile driving of 2% plumbness and 75 mm in location should not be exceeded.

5.2.3. Caissons

The soils encountered at the site are generally considered feasible for the support of drilled caisson foundations.

Given the significant thickness of very loose to loose materials encountered in the boreholes, temporary lining is expected to be required throughout installation. This is to prevent collapse of the soft/loose/organic subsoils into the caisson excavation as well as to assist in sealing off inflow of groundwater. "Telescoping" of several liners may be required. Should workers have to enter the caisson for inspection or cleaning, a liner must be provided. A pump should be present on-site to remove any water which may accumulate at the base of the caisson prior to concrete placement. Final cleaning of the caisson base and installation of the reinforcing cage should not be carried out unless a concrete truck is present on-site ready to discharge concrete immediately. Concrete must be placed via the use of a tremie pipe from the bottom of the caisson up, to avoid segregation of the concrete mix.

For a caisson foundation, it is anticipated that the caissons could be founded within the compact to dense native soils at minimum depths ranging from 0.76 m to 2.29 m below the existing ground elevation (approximately 3.16 m to 4.33 m below the proposed finished floor elevation of the proposed warehouse). It is, however, expected that the caissons will likely need to extend to greater depths, in order to provide the required resistance.

Should wet to saturated soils be encountered, it is recommended that the caisson contractor be prepared to utilize installation methods involving the use of a bentonite slurry (likely combined with temporary lining through the upper subsoil), to balance the hydrostatic pressure, if required. Concrete placement for the caisson would then be carried out under water and must be undertaken using a tremie system or a concrete pump from the bottom up. It is therefore recommended that the deep foundation contractor be prepared for such an eventuality. An experienced deep foundations contractor should be employed for this installation.

5.3. Seismic Site Classification

The site classification for seismic response in Table 4.1.8.4 of the 2012 Ontario Building Code relates to the average properties of the upper 30.0 m of strata. The information obtained in the geotechnical field investigation was gathered from the upper 4.57 m to 6.10 m of strata. Based on the information gathered in the geotechnical field investigation, the site classification for seismic site response would be considered Site Class D (stiff soil) for structures founded on the native soils at the recommended founding elevations provided in Section 5.1 of this report. For foundations constructed on existing engineered fill or structural fill, placed in accordance with Section 5.5.4 of this report, the site classification for seismic site response would be considered Site Class D (stiff soil). The structural engineer responsible for the design of the structure should review the earthquake loads and effects.

5.4. Soil Design Parameters

The following table provides the estimated soil design parameters for imported granular fill, as well as the existing native soils encountered on-site. It should be noted that earth pressure coefficients (Ka, Kp, Ko) provided are for flat ground surface conditions and will differ for areas with slopes or embankments.

The estimated soil design parameters can be utilized for the design of perimeter shoring, foundations and retaining walls, as required:

Soil Type	Soil/Rock Density (kg/m^3)	Friction Angle (Degree)	Coefficient of Active Pressure (K_a)	Coefficient of Passive Pressure (K_p)	Coefficient of At-Rest Pressure (K_o)	Coefficient of Friction (μ)	Cohesion (kPa)
Imported Granular 'A' (OPSS 1010)	2,100	34°	0.28	3.54	0.44	0.45	0
Imported Granular 'B' (OPSS 1010)	2,050	32°	0.31	3.25	0.47	0.41	0
Sand	1,850	33°	0.29	3.39	0.46	0.43	0
Silt and Sand	1,800	32°	0.31	3.25	0.47	0.41	0
Silty Sand Till	1,800	32°	0.31	3.25	0.47	0.41	0

5.5. Site Preparation

The site preparation for the proposed new warehouse and rental units is anticipated to consist of topsoil stripping, vegetation grubbing, removal of fill and unsuitable soils, the removal or relocation of any existing services, the subexcavation of all unsuitable native soils deemed not capable of supporting the design bearing capacity, followed by the placement of structural fill (as required) and site grading to achieve proposed grades.

5.5.1. Topsoil Stripping and Vegetation Grubbing

All topsoil (including any buried topsoil encountered) must be removed from within the proposed building, driveway, and parking lot envelopes to expose approved competent subgrade soils. The topsoil may be used in landscaped areas where some settlement can be tolerated; otherwise, it should be properly disposed of off-site.

Any vegetation (including tree stumps and root structures, as well as any loose soils that are typically associated with root structures) must be removed from within any proposed building, driveway, and parking lot envelopes to expose approved competent subgrade soils.

5.5.2. Fill/Unsuitable Soil Removal

Any existing fill containing organic material or unsuitable deleterious materials such as ash or bricks, as well as any fill or native soils that are deemed unsuitable to support foundations or slab-on-grades, must be subexcavated from within the proposed building envelopes to expose approved competent subgrade soil. It would also be sound construction practice to subexcavate all existing very loose to loose fill from the parking lot and driveway areas (if constructed); however, this may not be cost-effective. At a minimum, any fill with intermixed organic material should be subexcavated to prevent issues associated with frost heaving such as loss of structural integrity and frost boils. Thorough inspection will be required at the time of construction to assess any existing fill to ensure there is no buried topsoil or other deleterious materials within the subgrade. Remedial action may also be required to further consolidate any existing fill if it is decided to leave it in place under the driveway and parking lot areas. It would be expected that some air-drying may be required in order to achieve the design compaction. If any existing fill is left in place in the driveway/parking lot, provisions for alterations to the design of the pavement structure should be included in the tender documents. Review of the subgrade including proof-roll and potential changes to the design of the pavement structure, as required, will have to be addressed at the time of construction.

Any subexcavated fill that may be intermixed with organics could be used in non-structural landscaped areas where some settlement can be tolerated; otherwise, it should be disposed of accordingly off-site.

5.5.3. Removal/Relocation of Existing Services

Any existing/abandoned underground services including field tiles and subdrains (if present) that may be located within any proposed building envelope, parking lot and driveway areas should be removed/relocated. If left in place, the location of existing services must be reviewed to ensure that they do not conflict with the proposed foundation locations. Any terminated piping that is left in place must be completely sealed with watertight mechanical covers, concrete or grout at termination points to prevent the migration of soils into pipe voids which can result in potential settlement. All existing trench backfill material associated with underground services must be subexcavated and the subsequent excavation should be backfilled with approved soils placed in accordance with Section 5.5.4 of this report.

5.5.4. Site Grading

Following the subexcavation of any soils deemed unsuitable of supporting foundations, slab-on-grade and/or driveway and parking lot pavement structure (if constructed), the exposed subgrade must be proof-rolled and any loose/soft or unstable areas must be subexcavated and replaced with approved fill materials.

Any fill materials required to achieve the design site grades should be placed according to the following procedures:

- Should the native subgrade soils at the design founding elevation in the proposed building envelope(s) be comprised of wet or saturated soils, then a granular drainage layer constructed in accordance with Section 9.14.4 of the current Ontario Building Code (OBC) may be required. Alternatively, a lean mix concrete mud mat may be placed overlying the subgrade soils to provide a stable base;

- Prior to placement of any structural fill, the subgrade for the proposed new building(s), as well as any parking lots and driveways (if constructed), must be prepared large enough to accommodate a 1:1 slope commencing a distance of 1.0 m beyond the outside edge of the proposed foundation and pavement/concrete edge (where feasible) down to the approved competent founding soils;

- Soils approved for use as structural fill must be placed in loose lifts not exceeding 0.3 m (12") in depth for granular soils (recommended fill materials) and 0.2 m (8") in depth for silts and clays, or the capacity of the compactor (whichever is less);

- Imported granular fill materials (OPSS 1010 Type I or Type III Granular 'B' recommended for this application) can be compacted utilizing adequate heavy vibratory smooth drum compaction equipment;

- Fine-grained silt and clay soils (not recommended) must be compacted utilizing adequate heavy padfoot vibratory compaction equipment;

- Approved fill materials must be at suitable moisture contents to achieve the specified compaction. The wet soils encountered in the boreholes would generally be considered difficult for use as structural fill as they would require extensive air-drying in order to achieve the specified density. Soil moisture will also be dependent on weather conditions at the time of construction. Granular soils may require the addition of water in order to achieve the specified compaction;

- Approved structural fill materials that will support structures (including foundations, interior slab-on-grades, sidewalks, and large expansive exterior slabs) must be compacted to 100% standard Proctor maximum dry density (SPMDD);

- Approved bulk fill (foundation wall backfill, bulk fill under slab-on-grades that will not support footings or heavy point loading, bulk fill for driveways and parking lots) must be compacted to a minimum 95% SPMDD;

- Granular 'B' subbase and Granular 'A' base materials for the roadway and driveways must be compacted to 100% SPMDD.

Based on the subsurface conditions observed in the boreholes, wet soils may be encountered, depending on the depth of excavation. As such, for soils excavated from the zone of saturation, significant air-drying along with working of the soils may be required in order to achieve the specified compaction of 100% SPMDD for structural fill and 95% SPMDD for bulk fill for the parking lot and driveways. Utilizing the existing soils during site grading may be more achievable if work is completed during the generally drier summer months. Reuse of excavated soils on-site will be subject to approval from qualified geotechnical personnel.

5.6. Foundation Subgrade Preparation

The native soils encountered in the boreholes are sensitive to changes in moisture content and can become loose/soft if subjected to additional water or precipitation as well as severe drying conditions. The native subgrade soils could also be easily disturbed if traveled on during construction. Once they become disturbed, they are no longer considered adequate for the support of shallow foundations. To ensure and protect the integrity of the founding soils during construction operations, the following is recommended:

- During construction, the subgrade should be sloped/ditched to a sump (as required) located outside the building footprint (if feasible) in the excavation to promote surface drainage of rainwater or seepage, and the collected water should be pumped out of the excavation. It is critical that all water be controlled (not allowed to pond) and that the subgrade and foundation preparation commence in dry conditions;

- Should the native subgrade soils at the design founding elevations in the proposed building envelope(s) comprise of wet/saturated soils, then a granular drainage layer, constructed in accordance with Section 9.14.4 of the current Ontario Building Code (OBC), may be required;

- Construction equipment travel and foot traffic on the founding soils should be minimized;

- If construction is to be undertaken during subzero weather conditions, the founding native soils and any potential fill materials must be maintained above freezing;

- Prior to placing concrete for the foundation, the area must be cleaned of all disturbed or caved materials;

- The foundation formwork and concrete should be installed as soon as practical following the excavation, inspection, and approval of the founding soils. The longer that the excavated soils remains open to weather conditions and groundwater seepage, the greater the potential for construction problems to occur;

- If it is expected that the founding soils will be left open to exposure for an extended period of time, it is recommended that a 75 mm concrete mud slab be placed in order to protect the structural integrity of the founding soils.

5.6.1. Shoring/Underpinning (if required)

It is imperative that excavations do not extend into the zone of influence of any existing/neighbouring footings/structures or bottom of the foundation walls of any adjacent structures or services without providing support through shoring or underpinning.

If required, it is anticipated that an H-pile (soldier pile) and timber lagging system or an overlapping concrete caisson wall may be utilized as a shoring system. Alternatively, cast-in-place underpinning could be utilized depending on the application.

If required, the shoring system design must be completed by a qualified engineer and must include appropriate factors of safety, and any possible surcharge loading (such as but not limited to construction equipment, delivery vehicles, etc.) must be taken into account. The support system must comply with the current Occupational Health and Safety Act and Regulations for Construction Projects (O.Reg. 213/91). Soil design parameters for shoring design can be found in Section 5.4 of this report.

Underpinning may be required to ensure that any adjacent foundations bear on suitable soils as outlined in Section 5.1. Any adjacent footings could be undermined while subexcavating the unsuitable fill/native soils at the subject site. Any underpinning work required should be completed in sections not exceeding 1.2 m in width in a piano key style, or as directed by a structural engineer.

5.7. Slab-on-Grade/Modulus of Subgrade Reaction

Prior to the placement of the granular base for the slab-on-grade construction, the subgrade should be proof-rolled. Any soft or weak zones, as well as any potential unsuitable fill in the subgrade, should be subexcavated and backfilled with approved fill materials (see Sections 5.5.4 and 5.10 of this report).

The following table provides the estimated modulus of subgrade reaction (k) for the native soils encountered on-site:

Soil Type	Estimated Modulus of Subgrade Reaction (k)
Imported Granular 'A'/Granular 'B' (OPSS 1010)	81,000 kN/m^3 (300 lb/in^3)
Sand	41,000 kN/m^3 (150 lb/in^3)
Silt and Sand	54,000 kN/m^3 (200 lb/in^3)
Silty Sand Till	61,000 kN/m^3 (225 lb/in^3)

In dry conditions, slab-on-grades can be founded on a minimum thickness of 150 mm (6") of an OPSS 1010 granular material containing less than 10% fines and compacted to 100% SPMDD. Alternatively (particularly in wet conditions), 150 mm (6") of 19 mm clear crushed stone (OPSS 1004) should be used. Utilizing clear crushed stone for the slab-on-grade base can assist in providing a moisture barrier by reducing the potential for capillary rise of moisture from the subgrade soils. Compactive effort is required to consolidate the clear stone. The 19 mm clear crushed stone should meet the physical property and gradation requirements of OPSS 1004.

It is recommended that areas of extensive exterior slab-on-grade (sidewalks, accessibility ramps and exterior stairs) be constructed with a Granular 'B' subbase (450 mm) and a Granular 'A' base (150 mm), as well as incorporating subdrains, to provide rapid drainage and reduce the effects of frost heaving. This is particularly critical at all barrier-free access points. Alternatively, structural frost slabs could be designed and constructed, or sufficient thermal insulation could be provided, at all door entrances and areas of barrier-free access.

5.8. Excavations

All excavations must be carried out in accordance with Ontario Regulation 213/91 (Reg 213/91) of the Occupational Health and Safety Act and Regulations for Construction Projects.

Type 3 Soils - In general, the fill and native soils encountered in the boreholes in a drained state (not wet or saturated), would be classified as Type 3 soils under Reg 213/91. The Type 3 soils must be sloped from the bottom of the excavation at a minimum gradient of 1 horizontal to 1 vertical. All saturated soils encountered must be treated as Type 4 soils, as described below.

Type 4 Soils - In general, any wet to saturated soils would be classified as Type 4 soils under Reg 213/91. Type 4 soils must be sloped from the bottom of the excavation at a minimum gradient of 3 horizontal to 1 vertical.

If it is not practical to excavate according to the above requirements, then a trench support system (designed in accordance with the Ontario Health and Safety Act Regulations) may be utilized. When using a temporary trench support system consisting of trench boxes to reduce the lateral extent of the excavations, it should be noted that the support system is intended primarily for the protection of workers as opposed to controlling lateral soil movement. Any voids between the excavation walls and the support system should be immediately filled to reduce the potential for loss of ground and to provide support to existing adjacent utilities and structures, and it is recommended that the excavation be carried out in short sections, with the support system installed immediately upon excavation completion.

Any excavations that extend into a very dense/hard strata (soils with N-values in excess of 50 blows per 0.30 m) may prove difficult to remove with conventional excavating equipment, impacting the production schedule. It is imperative that when these very dense strata are utilized for backfilling of service trenches, the material must be broken down (pulverized) to minimize voids and reduce the potential for settlement. It is not recommended that these blocky excavated soils be utilized as structural fill.

5.9. Construction Dewatering Considerations

Monitoring wells were installed in Boreholes 1, 2 and 4 as part of the geotechnical field investigation to measure the static groundwater level. It should be noted that the groundwater levels were observed to range between approximately 1.33 m to 3.62 m below the existing ground surface and groundwater levels (particularly perched water) are generally dependent on the amount of precipitation, control of surface water, as well as the time of year, and can fluctuate significantly in elevation and volume. As such, provisions for site dewatering should be part of the site development and construction process.

Seepage control requirements during construction will depend upon the area of work on the site, the depth of the excavations, the time of year, the amount of precipitation and the control of surface water. As required, seepage should generally be adequately controlled using conventional construction dewatering techniques such as pumping from sump pits. However, if heavy seepage occurs, it may be necessary to increase the number of pumps or install a dewatering system during construction.

Dewatering should be performed in accordance with OPSS 517 and the control of water must be in accordance with OPSS 518. It is the responsibility of the contractor to propose a suitable dewatering system based on the groundwater elevation at the time of construction. Collected water should discharge a sufficient distance away from the excavation to prevent re-entry. Sediment control measures must be installed at the discharge point of the dewatering system to avoid any potential adverse impacts on the environment. It is recommended that the environmental consultant for this project be consulted prior to any on-site water being discharged to municipal outlets to ensure proper procedures are followed.

5.10. Service Pipe Bedding

The existing fill (free of organics) and native soils encountered in the geotechnical investigation are generally considered suitable for indirect support of the site service pipes. Should instability due to saturated soil conditions be encountered, it may be necessary to increase the thickness of the granular base and utilize 19 mm clear stone to create an adequate supporting base for the service pipes and/or manholes. Pipe embedment, cover and backfill for both flexible and rigid pipes should be in accordance with all current and applicable OPSD, OPSS and OBC standards and guidelines and as follows:

Flexible Pipes - The pipe bedding should be shaped to receive the bottom of the pipe. If necessary, pipe culvert frost treatment should be undertaken in accordance with OPSD-803.031. The trench excavations should be symmetrical with respect to the centreline of the pipe. The granular material placed under the haunches of the pipe must be compacted to 100% SPMDD prior to the continued placement and compaction of the embedment material. The homogeneous granular material used for embedment should be placed and compacted uniformly around the pipe. Should wet conditions be encountered at the base of the trench, then the pipe bedding should consist of 19 mm clear stone (meeting OPS Specifications) wrapped completely in a geotextile fabric such as Terrafix 270 or equivalent.

Rigid Pipes - In general, the pipe installation recommendations for rigid pipes are the same as those for flexible pipes, except that the minimum bedding depth below a rigid pipe should be 0.15*D* (where *D* is the pipe diameter). In no case should this dimension be less than 150 mm or greater than 300 mm.

Any service pipes that are not provided with sufficient frost coverage must be protected with the necessary equivalent thermal insulation. The general contractor is responsible for protecting existing and new service piping from damage by heavy equipment.

5.11. Perimeter Building Drainage, Foundation Wall Backfill and Trench Backfill

In order to assist in maintaining dry buildings with respect to surface water seepage, it is recommended that exterior grades around the building(s) be sloped down and away at a 2% gradient or more, for a distance of at least 1.5 m. Any surface discharge rainwater leaders must be constructed with solid piping that discharges with positive drainage at least 1.5 m away from the building foundations and/or beyond external slab-on-grades to a drainage swale or appropriate storm drainage system.

Depending on the design founding elevations, and groundwater levels at the time of construction, it may be necessary to install a granular drainage layer to provide a suitable base for the foundations. The granular drainage layer must conform to the general requirements listed in Section 9.14.4 of the OBC 2012.

Should any proposed structures have a basement, an exterior perimeter drainage system comprising perforated drainage pipe with a factory installed filter sock, bedded in 19 mm clear crushed stone, and wrapped in a geotextile filter fabric such as Terrafix 270R (or equivalent), is recommended to improve drainage around the buildings. The drainage pipe should be installed at the founding elevation and be constructed with positive drainage into a sump pit or other suitable outlet that provides positive drainage away from the structure. The portion of the piping that connects any exterior drainage tile system into an interior sump pit must comprise solid piping to prevent exterior water from being introduced into the interior subslab stone. It may be prudent to install perforated drainage pipe in the interior area as well as to provide an outlet for any water that may collect in the subslab stone. It is also recommended that a capped cleanout port(s) be extended up to the ground surface elevation to provide future access (if required). Rainwater leaders must not be connected to the perimeter drainage system. Any foundation walls that are constructed below the water table must be waterproofed, not dampproofed. A waterproofing system should be installed in accordance with the OBC (2012). It is recommended that a waterproofing specialist be consulted for a waterproofing system to suit the site conditions.

In order to reduce the effects of surficial frost heave in areas that will be hard surfaced, it is recommended that the exterior foundation backfill consist of free-draining granular material such as imported sand or Granular 'B' Type I or Type III (OPSS 1010), with a maximum aggregate size not exceeding 100 mm, and that it extend a minimum lateral distance of 600 mm out from the foundation walls and/or beyond perimeter sidewalks and entranceway slabs. It is critical that particles greater than 100 mm in diameter are not in contact with the foundation wall to prevent point loading and overstressing. The backfill material used against the foundation walls must be placed so that the allowable lateral capacities of the foundation walls are not exceeded. Where only one side of a foundation wall will be backfilled, and the height of the wall is such that lateral support is required, or where the concrete strength has not been achieved, the wall must be braced or laterally supported prior to backfilling. In situations where both sides of the

wall are backfilled, the backfill should be placed in equal lifts, not exceeding 200 mm differential on each side during backfill operations and the backfill should be compacted to a minimum of 98% SPMDD.

It is recommended that frost tapers be constructed (refer to OPSD 3101.150 for typical details) in order to minimize differential frost action between the foundation wall backfill and any paved areas. The frost taper must be constructed utilizing the OPSS 1010 granular material that is used for the foundation wall backfill.

The native soils, free of any organics or deleterious materials are generally considered suitable for reuse as trench backfill and bulk fill; however, wet soils encountered may require air-drying in order to achieve the specified compaction. Air-drying cannot typically be achieved during winter construction; therefore, depending on the time of year that construction takes place, it may be more feasible to utilize an imported granular fill for this project (keeping in mind that frost tapers, as noted above, would be recommended to minimize differential frost heave).

Backfilling operations should be carried out with the following minimum requirements:

- Adequate heavy smooth drum or padfoot vibratory compaction equipment should be used for the compaction and to break down any large blocky pieces of soil;

- Loose lift thicknesses should not exceed 0.3 m (12") for granular soils or 0.2 m (8") for silt soils or the capacity of the compactor (whichever is less);

- The soils must be at suitable moisture contents to achieve compaction to a minimum 95% SPMDD in non-structural bulk fill areas. Service trenches excavated within the zone of influence of footings for structures must be compacted to a minimum of 100% SPMDD;

- It is recommended that inspection and testing be carried out during construction to confirm backfill quality, thickness and to ensure that compaction requirements are achieved;

- Service trench backfill materials may consist of approved excavated soils with no particles greater than 100 mm and no topsoil or other deleterious materials;

- If construction operations are undertaken in the winter, strict consideration should be given to the condition of the backfill material to make certain that frozen material is not used.

5.12. Pavement Design/Drainage

All loose/soft native soils must be stripped and subexcavated from within the proposed sidewalks, driveways, and surface parking lot areas; however, this may not be cost-effective. At a minimum, any existing fill with intermixed organic material, or other deleterious material should be subexcavated from the driveways and parking lot areas to prevent problems associated with frost heaving such as loss of structural integrity and frost boils. Thorough inspection and proof-rolling will be required at the time of construction to assess the existing fill to ensure there is no deleterious material within the subgrade. Remedial action will also be required to further consolidate any existing fill and/or loose/soft native soils if it is decided to leave them in place. It would be expected that significant air-drying may be required in order to achieve the design compaction. If any existing fill is left in place in the parking lot, provisions for the alterations to the design of the pavement structure such as increasing the thickness of the Granular 'B' base, installing a reinforcing geotextile and/or installing biaxial geogrids, should be included in the tender documents. Review of the subgrade and potential changes to the design of the pavement structure, as required, will have to be addressed at the time of construction.

Prior to placement of the granular base, the subgrade must be proof-rolled and any soft or unstable areas should be subexcavated and replaced with suitable drier materials. The subgrade should be graded smooth (free of depressions) and properly crowned to ensure positive drainage, with a minimum grade of 3% toward catch basins or to the parking lot/driveway edge (provided collection and proper gravity drainage to a suitable outlet is provided). When service pipes are installed, pipe bedding and backfilling should be undertaken as indicated in Sections 5.10 and 5.11 of this report.

Rapid drainage of the pavement structure is critical to ensure long-term performance. The requirement for subdrains will be dependent on the composition of the prepared pavement subgrade soils. The existing silt and sand and/or silty sand soils encountered in the boreholes are frost-susceptible soils and, as such, it is recommended to install subdrains (provided gravity drainage to a suitable outlet can be provided). It is recommended to install minimum 100 mm diameter perforated subdrains to collect and redirect water beneath the pavement surface. Subdrains should be designed and installed in accordance with OPSS 405 and OPSD 216.021. If Granular 'A' bedding (OPSS 1010) is utilized, the subdrains should be equipped with a factory installed filter sock. If 19 mm clear stone (OPSS 1004) is utilized as bedding for the subdrain, then the bedding must be wrapped completely with geotextile filter fabric such as Terrafix 270R (or equivalent) and a factory installed filter sock is not required. Installation of rigid subdrains allows for better grade control and less potential for damage during installation; however, it would be expected that there would be higher cost implications associated with the installation of rigid subdrains over flexible subdrains. Positive drainage through grade control of subdrains is critical, as improperly installed subdrains can turn drainage systems into reservoirs, which can fuel frost action. The subdrains will hasten the removal of water, thereby reducing the risk and effects of frost heaving and load transfer in saturated

conditions. It is suggested that, at a minimum, subdrains be installed through all low areas in the parking areas and driveways, and ideally along the curb lines as well to prevent water from entering the granular subbase. The subdrains should be installed in a 0.3 m (1.0 ft) by 0.3 m (1.0 ft) trench in the subgrade and bedded approximately 50 mm (2") above the bottom of the trench. The subgrade must be prepared with positive drainage to the subdrains and the subdrains must be installed with positive drainage into a catch basin structure or other suitable outlet.

Should the subgrade soils comprise free-draining granular soils (minimum 1.0 m thick with positive drainage at the interface with any relatively impermeable soils), then the installation of subdrains may not be required.

The native subgrade soils are sensitive to changes in moisture content and can become loose or soft if the soils are subject to inclement weather and seepage or severe drying. Furthermore, the subgrade soils could be easily disturbed if traveled on during construction. As such, where this material will be exposed, it is recommended that the granular subbase be placed immediately upon completion of the subgrade preparation to protect the integrity of the subgrade soils.

It is expected that the driveways and parking lots will experience some light traffic (personal vehicles) and mostly heavy traffic (delivery trucks, heavy equipment, maintenance, and emergency vehicles).

Based on the anticipated loading, the following pavement designs are provided:

Material	**Recommended Thickness For New Pavement**	
	Light Traffic	**Heavy Traffic**
Asphaltic Concrete	HL3 - 40 mm (1.5") HL4 or HL8 - 50 mm (2.0")	HL3 - 50 mm (2.0") HL4 or HL8 - 75 mm (3.0")
Granular 'A' Base	150 mm (6.0")	150 mm (6.0")
Granular 'B' Subbase	400 mm (16.0")	450 mm (18.0")

Should wet to saturated conditions be encountered during construction, site assessments may be required at the time of construction to determine what options can be undertaken to construct a stable driveway and parking lot base. These options may include subexcavation and increasing the thickness of the Granular 'B' subbase, the use of reinforcing geotextile and/or geogrid, or a combination of all. As such, it is recommended that provisions for subexcavation and disposal of wet soils, importing and placing additional Granular 'B' (OPSS 1010), as well as supply and placement of a reinforcing geotextile (Terrafix 270R or equivalent) and geogrid (Tensar BX1200 or equivalent) should be included in the tender documents.

The granular base and subbase materials must conform to the physical property and gradation requirements of OPSS 1010 and must be compacted to 100% SPMDD. Asphaltic concrete should be supplied, placed, and compacted to a minimum 92.0% Marshall maximum relative density, in accordance with OPSS 1150 and OPSS 310.

Construction joints in the surface asphalt must be offset a minimum of 150 mm to 300 mm (6" to 12") from construction joints in the binder asphalt so that longitudinal joints do not coincide.

Frost tapers must be constructed at any changes from light traffic to heavy traffic areas. If heavy traffic routes are not delineated by barriers or if it is anticipated that heavy equipment (such as loaders and dump trucks) will be utilized for snow removal and/or everyday use, it would be recommended that the heavy traffic pavement structure be utilized throughout.

Where new asphalt is joined into existing asphalt, it is recommended that the existing asphalt be sawcut in a straight line prior to being milled to a depth of 80 mm and a width of 300 mm as per OPSD 509.010. It is recommended that a tack coat in conformance with OPSS 308 be applied to the edge and surface of all milled asphalt prior to placement of new asphalt.

The pavement should be designed to ensure that water will not pond on the pavement surface. If the surface asphalt is not placed within a reasonable time following placement of the binder asphalt, it is recommended that the catch basin lids are set at a lower elevation or apertures provided to allow surface water to drain into the catch basins and not accumulate around the catch basins. The strength of the pavement structure relies on all of the components to be in place in order to provide the design strength; therefore, it is strongly recommended that the surface asphalt be placed shortly after placement of the binder asphalt so as to avoid undue stress on the binder asphalt by not having the complete pavement structure in place.

It would be expected that the grade will slope towards the proposed building in any loading dock areas. Therefore, it will be necessary to install a catch basin or drainage trench in the lower loading dock areas to collect and remove water, thereby limiting the potential for water to accumulate in this low-lying area. The catch basins/drainage trench must be provided with positive drainage to a suitable outlet. Alternatively, a pump system may be required. It is imperative that the granular base be effectively drained throughout the loading dock areas in order to avoid potential issues with frost heave and/or rutting. It is recommended that concrete dolly pads be constructed in the loading dock area if trailers will be unhitched and left on the ramps. Furthermore, if trucks and/or trailers are expected to sit for long periods of time on the loading dock ramps, it would be recommended to consider utilizing rigid concrete pavement throughout the loading dock areas as well as any long-term truck/trailer storage areas.

It should be noted that, currently, asphalt mixes tend to be more flexible and, as such, there is a tendency for damage to occur from vehicles turning their steering wheels or applying excessive brake pressure. The damage can occur from both passenger vehicles as well as large vehicles. The condition is further intensified during hot weather. In high traffic/tight turning areas, it is recommended that rigid Portland cement pavement be considered, especially in any high traffic areas.

5.13. Infiltration

As part of the geotechnical investigation completed at this site, gradation analyses were performed on representative samples of the native soils. The following table provides the sample location (borehole number), sample depth, corresponding estimated coefficient of permeability (k) as well as soil type:

Borehole No.	Depth (m)	Estimated Coefficient of Permeability (k) cm/s	Soil Type
3	2.29 – 2.90	1.80×10^{-7}	Silty sand till, some clay and gravel (ML)
4	0.76 – 1.37	4.1×10^{-7}	Silt and sand, some clay, trace gravel (ML)

Based on the grain size distribution curves and the estimated coefficient of permeability, the native silt and sand and silty sand till soils encountered in the boreholes are generally not considered conducive to storm water infiltration.

5.14. Chemical Analyses/Excess Soil Management

As per Ontario Regulation 406/19, if surplus/excess soils are to be exported off-site, it is typically necessary to undertake some environmental reporting and chemical analyses of the soils. Chemical analysis was **NOT** undertaken as part of this geotechnical investigation. Should chemical analysis tests be required, the required tests vary and will be dependent on the disposal site utilized by the general contractor.

At this time there are no estimates available for the volume of excess soil that may be removed from this site (if any). O. Reg. 406/19 indicates that the minimum amount of testing required based on a volume of excess soil of less than 600 m^3 would be three (3) soil samples plus one (1) duplicate (total of four (4) soil samples required) and that one (1) additional sample be tested for every additional 200 m^3 (for volumes of excess soils between the range of 600 m^3 and 10,000 m^3). This testing can be undertaken at the time of construction; however please keep in mind that the testing is currently

taking in excess of ten (10) business days to complete which could lead to contractor delays at the time of construction).

It should be noted that additional samples and testing parameters may be required based on the disposal site chosen by the contractor; as well, if any of the soils sampled are found to be impacted then additional parameters and leachate testing (TCLP/SPLP) may be required.

5.14.1. Leachate Testing Requirement

If soils are transported to a landfill facility, additional chemical testing in accordance with Ontario Regulation 347, Schedule 4, as amended to Ontario Regulation 558/00, dated March 2001, leaching testing will be required. When transporting soils off-site, the following is recommended:

- All chemical analyses and environmental assessment reports must be fully disclosed to the receiving site owners/authorities, whom must agree to receive the material;
- An environmental consultant must confirm the land use at the receiving site is compatible to receive the material;
- An environmental consultant must monitor the transportation and placement of the materials to ensure that the material is placed appropriately at the preapproved site;
- The excess materials may not be transported to a site that has previously had a Record of Site Condition (RSC) filed, unless the material meets the criteria outlined in the RSC.

It should be noted that landfill sites will generally only accept laboratory test results that have been completed within 30 days of exporting. Therefore, it is recommended that provisions for chemical analysis be included in the tender documents.

5.15. Radon

According to information provided by Health Canada, radon is a radioactive gas that is naturally formed through the breakdown of uranium in soil, rock, and water. When radon escapes the earth in the outdoors, it mixes with fresh air, resulting in concentrations that are too low to be of concern. However, when radon enters an enclosed space, such as a building, high concentration of radon can accumulate and become a health concern. Health Canada indicates that most buildings and homes have some level of radon in them. Unfortunately, it is not possible to predict before construction whether or not a new building will have high radon levels as radon can only be detected by radon measurement devices, which would be installed in a building, post construction. Section 9.13.4.1 Soil Gas Control of the current 2012 Ontario Building Code (OBC) states that *"Where methane or radon gases are known to be a problem, construction shall comply with the requirements for soil gas control in MMAH Supplementary Standard SB-9, Requirements for Soil Gas Control".*

6.0 SITE INSPECTIONS

Qualified geotechnical personnel should supervise excavation inspections as well as compaction testing for structural filling, site grading and site servicing. This will ensure that footings are founded in the proper strata and that proper material and techniques are used and the specified compaction is achieved. CMT Engineering Inc. would be pleased to review the design drawings and provide an inspection and testing program for the construction of the proposed development.

7.0 LIMITATIONS OF THE INVESTIGATION

This report is intended for the Client named herein and for their Client. The report should be read in its entirety, and no portion of this report may be used as a separate entity. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete, or if the proposed construction should differ from that mentioned in this report.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments are based on the results obtained at the test locations only. It is therefore assumed that these results are representative of the subsoil conditions across the site. Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations.

It should be noted that this report specifically addresses geotechnical aspects of the project and does not include any investigations or assessments relating to potential subsurface contamination. As such, there should be no assumptions or conclusions derived from this report with respect to potential soil or water contamination. Soil or water contamination is generally caused by the presence of xenobiotic (human-made) chemicals or other alteration processes in the natural soil and groundwater environment. If necessary, the investigation, assessment and rehabilitation of soil and water contaminants should be undertaken by qualified environmental specialists.

The samples obtained during the geotechnical investigation will be stored for a period of three months, after which time they will be disposed of unless alternative arrangements are made.

We trust that this report meets with your present requirements. Should you have any questions, please do not hesitate to contact our office.

Prepared by:

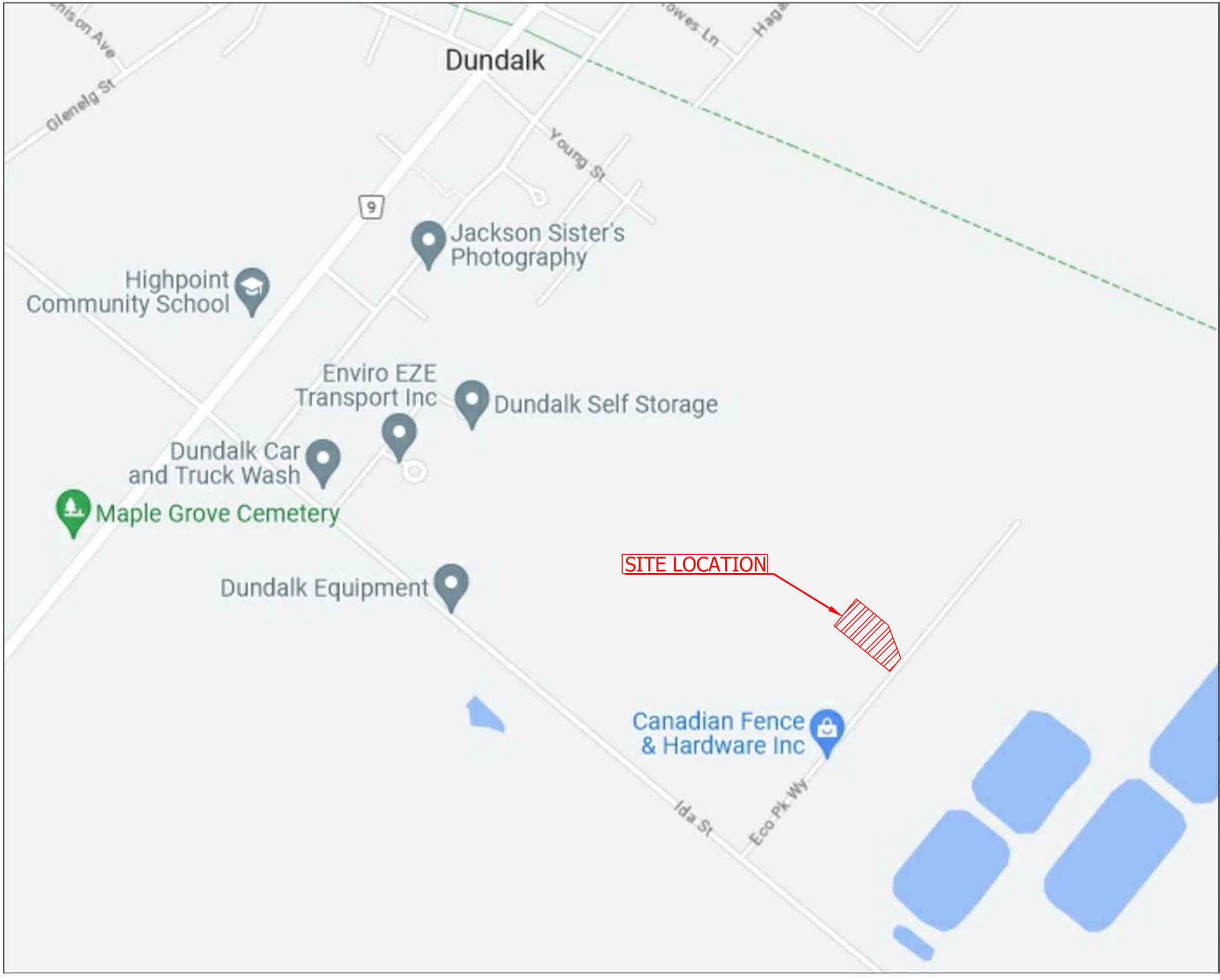
Brandon Figg

Brandon R Figg, C.Tech.
Senior Soil Technician

Reviewed by:

Nathan Chortos, P.Eng.
Senior Engineer

ht



NOTES:

1. BASE MAP PROVIDED BY GOOGLE MAPS

N

NO.	DESCRIPTION	DATE

REVISIONS

CMT ENGINEERING INC.
1011 Industrial Crescent, Unit 1
St. Clements, Ontario N0B 2M0
Tel.: 519-699-5775
Fax: 519-699-4664
www.cmtinc.net

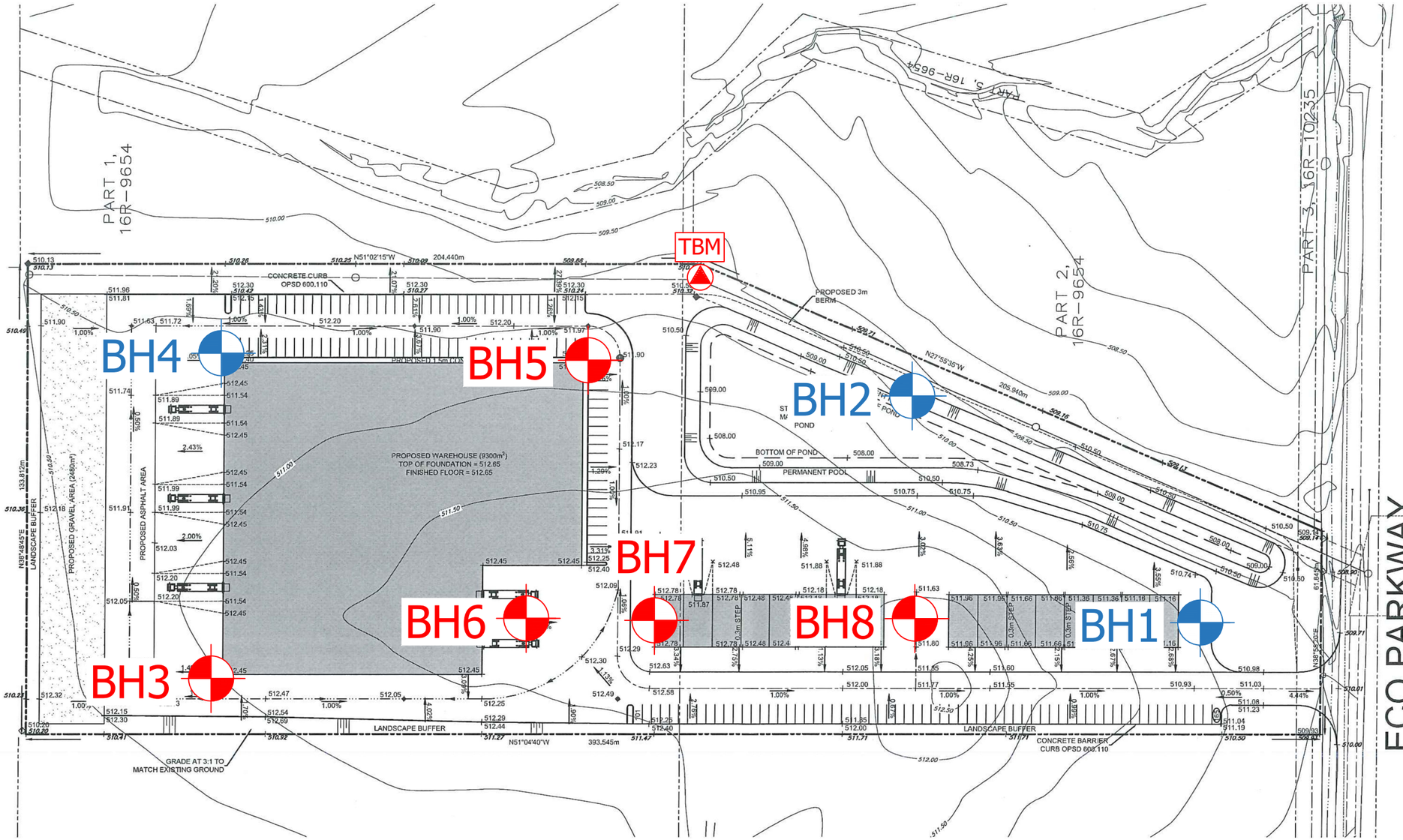
PROJECT:

Geotechnical Investigation
Proposed Development
181 Eco Parkway,
Dundalk, Ontario

DRAWING TITLE:

SITE LOCATION MAP

PROJECT NO.:	DATE:
23-174	June 8, 2023
SCALE:	DRAWING NO.
N.T.S.	1



NOTES:

1. DRAWING PROVIDED BY CLIENT

Legend

- CMT Borehole - 2023
- CMT Borehole with Monitoring Well - 2023
- Temporary Benchmark (TBM)

N

NO.	DESCRIPTION	DATE

REVISIONS

CMT ENGINEERING INC.
1011 Industrial Crescent, Unit 1
St. Clements, Ontario N0B 2M0
Tel.: 519–699–5775
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PROJECT:

Geotechnical Investigation
Proposed Development
181 Eco Parkway,
Dundalk, Ontario

DRAWING TITLE:

SITE PLAN SHOWING
BOREHOLE LOCATIONS

PROJECT NO.:	DATE:
23-174	June 8, 2023
SCALE:	DRAWING NO.
N.T.S.	2

APPENDIX A

BOREHOLE LOGS

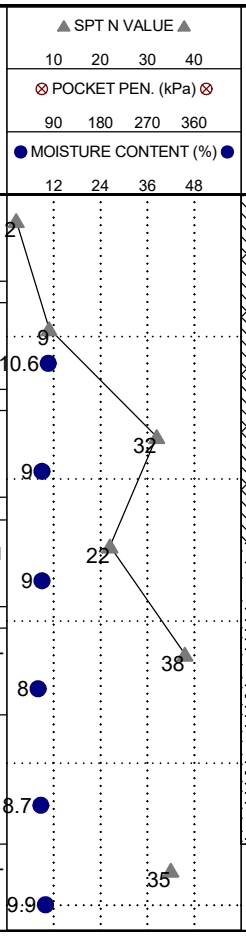
CMT ENGINEERING INC.
1011 Industrial Crescent, Unit 1
St. Clements, Ontario N0B 2M0
Telephone: 519-699-5775
Fax: 519-699-4664

BOREHOLE NUMBER BH1

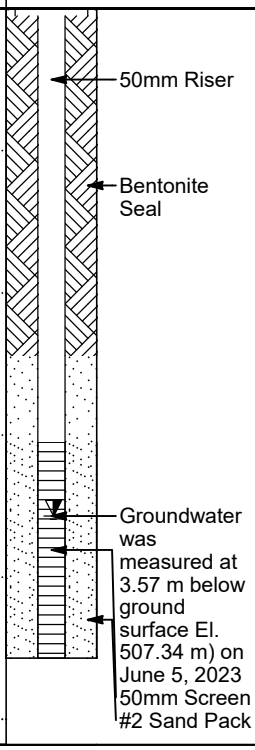
PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 5-31-23
GROUND ELEVATION: 510.91 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
0	**TOPSOIL:** Loose, dark brown, silty organic topsoil, moist (300 mm)	0.00, 510.91	SPT 1	49	1-1-1-1 (2)
	SILT AND SAND: Very loose, light brown, silt and sand, some clay, trace gravel, moist	0.30, 510.61			
1	becoming loose	0.76, 510.15	SPT 2	41	3-4-5-6 (9)
2	becoming dense	1.52, 509.39	SPT 3	67	6-15-17-11 (32)
3	becoming compact	2.29, 508.62	SPT 4	84	7-8-14-21 (22)
4	**SILTY SAND TILL:** Dense, light brown, silty sand till, some clay and gravel, moist with very moist seams	3.05, 507.86	SPT 5	100	19-20-18-20 (38)
			MC5 6	100	
5	becoming dense, grey	4.57, 506.34	SPT 7	100	18-17-18-19 (35)

Bottom of borehole at 5.18 m, Elevation 505.73 m.



WELL DIAGRAM



CMT ENGINEERING INC.
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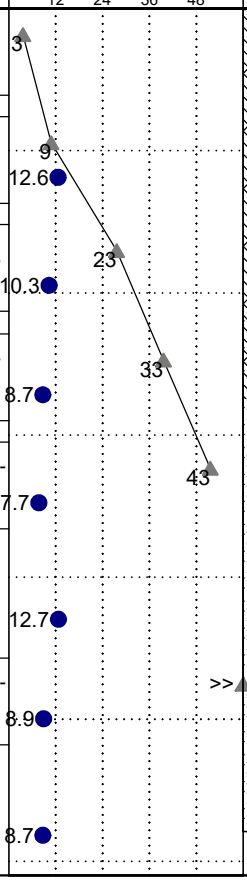
Fax: 519-699-4664

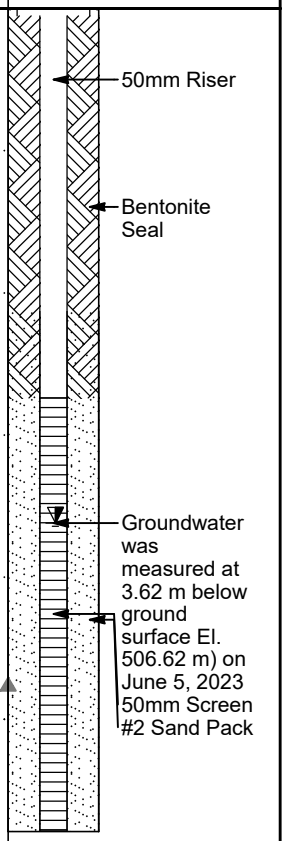
BOREHOLE NUMBER BH2

PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 5-31-23
GROUND ELEVATION: 510.24 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
0	**TOPSOIL:** Very loose, dark brown, silty organic topsoil, moist (500 mm)	0.00, 510.24	SPT 1	92	1-1-2-1 (3)
	SILTY SAND FILL: Very loose, dark brown, silty sand fill, moist	0.50, 509.74			
1	**SILT AND SAND:** Loose, light brown, silt and sand, some clay, trace gravel, very moist	0.76, 509.48	SPT 2	62	4-4-5-1 (9)
	becoming compact, wet	1.52, 508.72	SPT 3	46	4-15-8-8 (23)
2					
	SILTY SAND TILL: Dense, light brown, silty sand till, some clay and gravel, moist	2.29, 507.95	SPT 4	67	8-17-16-20 (33)
3			SPT 5	92	16-23-20-25 (43)
	becoming brown	3.66, 506.58	MC5 6	100	
4					
	becoming very dense, grey	4.57, 505.67	SPT 7	100	37-32-28-28 (60)
5	becoming grey/brown	5.08, 505.16	MC5 8	100	
6					

Bottom of borehole at 6.10 m, Elevation 504.14 m.





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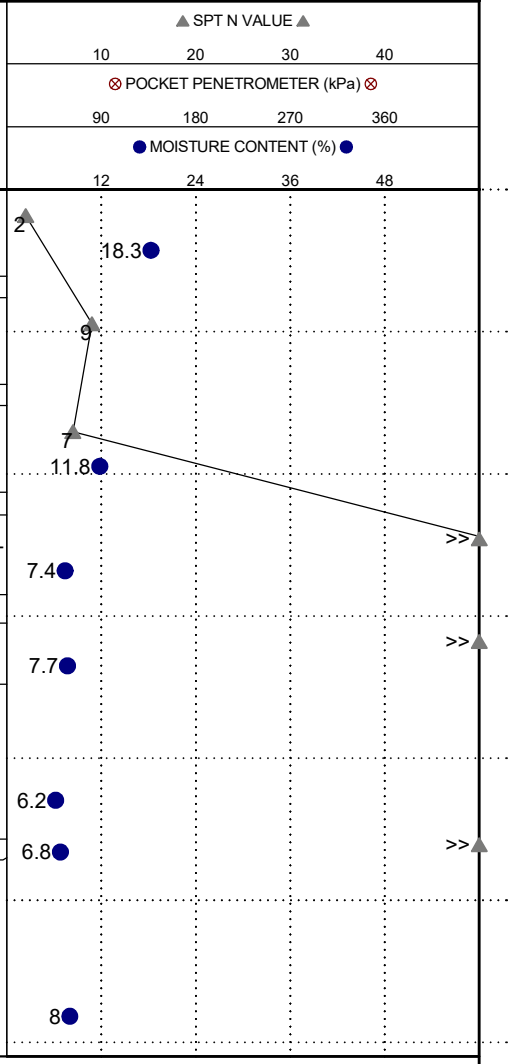
BOREHOLE NUMBER BH3

PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 5-31-23
GROUND ELEVATION: 510.74 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
0	**TOPSOIL:** Very loose, dark brown, silty organic topsoil, moist (175 mm)	0.00, 510.74	SPT 1	70	0-1-1-2 (2)
	SILT AND SAND: Very loose, dark brown, silt and sand, some clay, trace gravel, very moist	0.18, 510.57			
1	becoming loose, light brown, moist	0.76, 509.98	SPT 2	13	5-3-6-7 (9)
2	becoming very moist to wet	1.52, 509.22	SPT 3	21	3-3-4-7 (7)
3	**SILTY SAND TILL:** Very dense, light brown, silty sand till, some clay and gravel, moist	2.29, 508.45	SPT 4	104	16-21-28-50/0.11
			SPT 5	100	37-44-50/0.13
4	becoming brown	3.66, 507.08	MC5 6	100	
5			SPT 7	38	50/0.13
6			MC5 8	100	

Bottom of borehole at 6.10 m, Elevation 504.64 m.



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BOREHOLE NUMBER BH4

PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 5-31-23
GROUND ELEVATION: 510.61 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / POCKET PEN. (kPa) / MOISTURE CONTENT (%)	WELL DIAGRAM
	TOPSOIL: Very loose, dark brown, silty organic topsoil, moist (250 mm)	0.00, 510.61	SPT 1	100	0-0-2-4 (2)	2, 18	50mm Riser
	SAND: Very loose, dark brown, sand, trace organics, moist	0.25, 510.36					
1	**SILT AND SAND:** Loose, light brown, silt and sand, some clay, trace gravel, very moist	0.76, 509.85	SPT 2	54	2-2-2-2 (4)	4, 10.5	Bentonite Seal
	becoming compact, wet	1.52, 509.09	SPT 3	62	0-5-5-7 (10)	10, 10.3	Groundwater was measured at 1.33 m below ground surface El. 509.28 m) on June 5, 2023
2							
	SILTY SAND TILL: Very dense, light brown, silty sand till, some clay and gravel, moist	2.29, 508.32	SPT 4	66	23-40-50 (90)	>>, 7	50mm Screen #2 Sand Pack
3			SPT 5	0	50/0.08	>>	
4			MC5 6	100		6.7	

Bottom of borehole at 4.57 m, Elevation 506.04 m.

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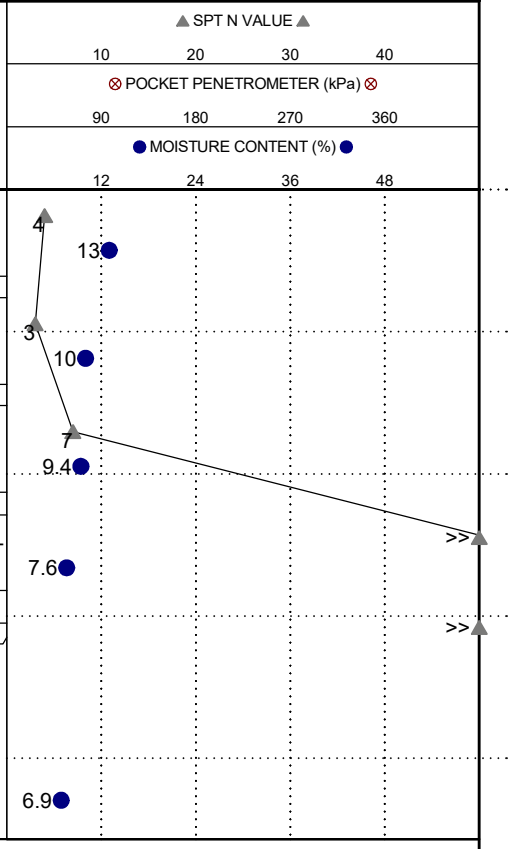
BOREHOLE NUMBER BH5

PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 6-5-23
GROUND ELEVATION: 511.08 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
	TOPSOIL: Loose, dark brown, silty organic topsoil, moist (225 mm)	0.00, 511.08	SPT 1	87	1-2-2-3 (4)
	SAND: Loose, dark brown, sand, moist	0.23, 510.86			
	SILT AND SAND: Loose, grey/brown, silt and sand, some clay, trace gravel, moist	0.30, 510.78			
1	becoming very loose, light brown, very moist	0.76, 510.32	SPT 2	30	1-1-2-2 (3)
	becoming loose, wet	1.52, 509.56	SPT 3	46	4-3-4-8 (7)
2					
	SILTY SAND TILL: Very dense, light brown, silty sand till, some clay and gravel, moist	2.29, 508.79	SPT 4	87	11-21-23-50/0.08
3			SPT 5	50	50/0.10
4			MC5 6	100	

Bottom of borehole at 4.57 m, Elevation 506.51 m.



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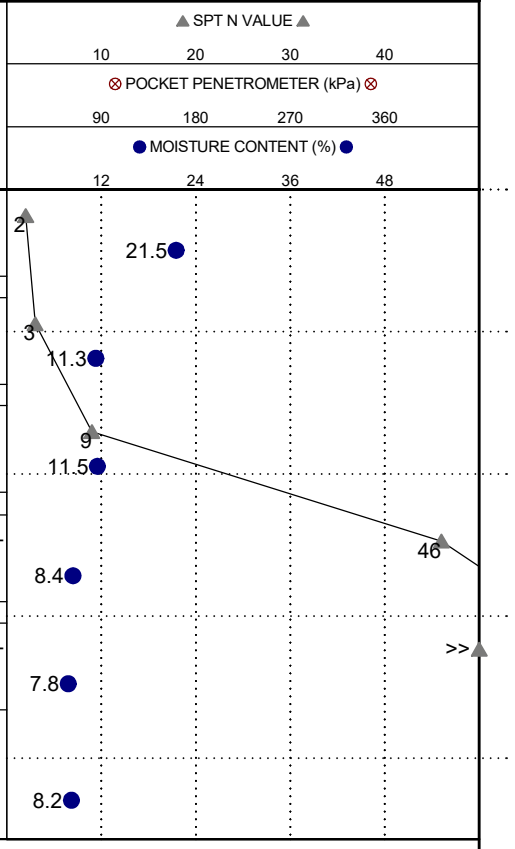
BOREHOLE NUMBER BH6

PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 6-5-23
GROUND ELEVATION: 511.78 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
	TOPSOIL: Very loose, dark brown, silty organic topsoil, moist (275 mm)	0.00, 511.78	SPT 1	87	1-1-1-1 (2)
	SILT AND SAND: Very loose, dark brown, silt and sand, some clay, trace gravel, moist	0.28, 511.51			
1	trace organics	0.76, 511.02	SPT 2	87	1-1-2-1 (3)
	no organics, becoming light brown, wet	0.91, 510.87			
	becoming loose	1.52, 510.26	SPT 3	30	1-5-4-10 (9)
2					
	SILTY SAND TILL: Dense, light brown, silty sand till, some clay and gravel, moist	2.29, 509.49	SPT 4	87	14-20-26-32 (46)
3					
	becoming very dense	3.05, 508.73	SPT 5	100	18-28-35-35 (63)
4			MC5 6	87	

Bottom of borehole at 4.57 m, Elevation 507.21 m.



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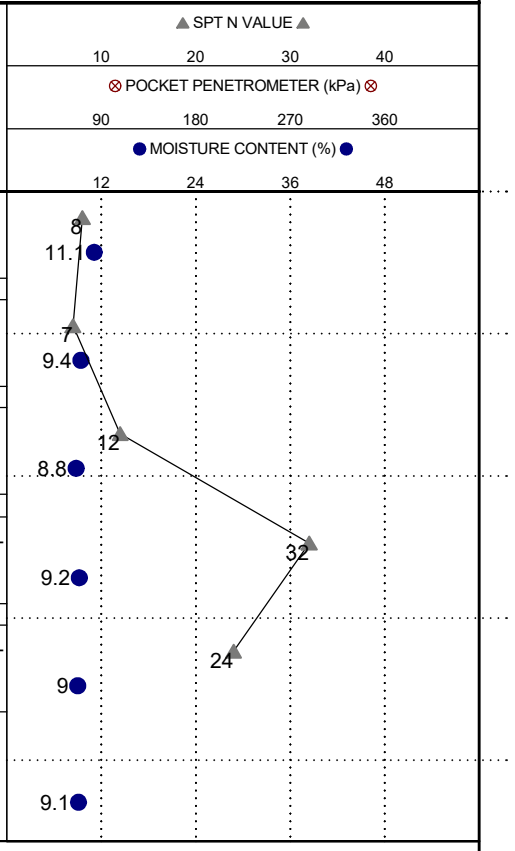
BOREHOLE NUMBER BH7

PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 6-5-23
GROUND ELEVATION: 511.90 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
	TOPSOIL: Loose, dark brown, silty organic topsoil, moist (250 mm)	0.00, 511.90	SPT 1	62	1-3-5-13 (8)
	SILT AND SAND: Loose, light brown, silt and sand, some clay, trace gravel, moist	0.25, 511.65			
1	becoming very moist	0.76, 511.14	SPT 2	59	2-4-3-7 (7)
2	becoming compact	1.52, 510.38	SPT 3	100	2-6-6-10 (12)
3	**SILTY SAND TILL:** Dense, light brown, silty sand till, some clay and gravel, moist	2.29, 509.61	SPT 4	75	12-14-18-15 (32)
	becoming compact	3.05, 508.85	SPT 5	100	11-12-12-14 (24)
4			MC5 6	100	

Bottom of borehole at 4.57 m, Elevation 507.33 m.



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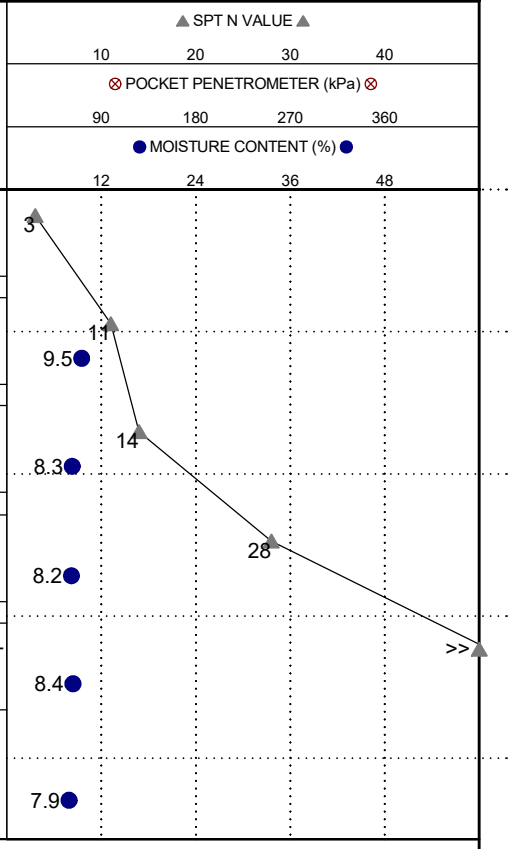
BOREHOLE NUMBER BH8

PROJECT: Proposed Development
PROJECT ADDRESS: 181 Eco Parkway
PROJECT NUMBER: 23-174
PROJECT LOCATION: Dundalk, ON
DRILLING DATE: 6-5-23
GROUND ELEVATION: 511.97 m
DRILLING CONTRACTOR: CMT Drilling Inc.
LOGGED BY: BRF
DRILLING EQUIPMENT: Geoprobe 7822DT
SAMPLING METHOD: SPT/MC5

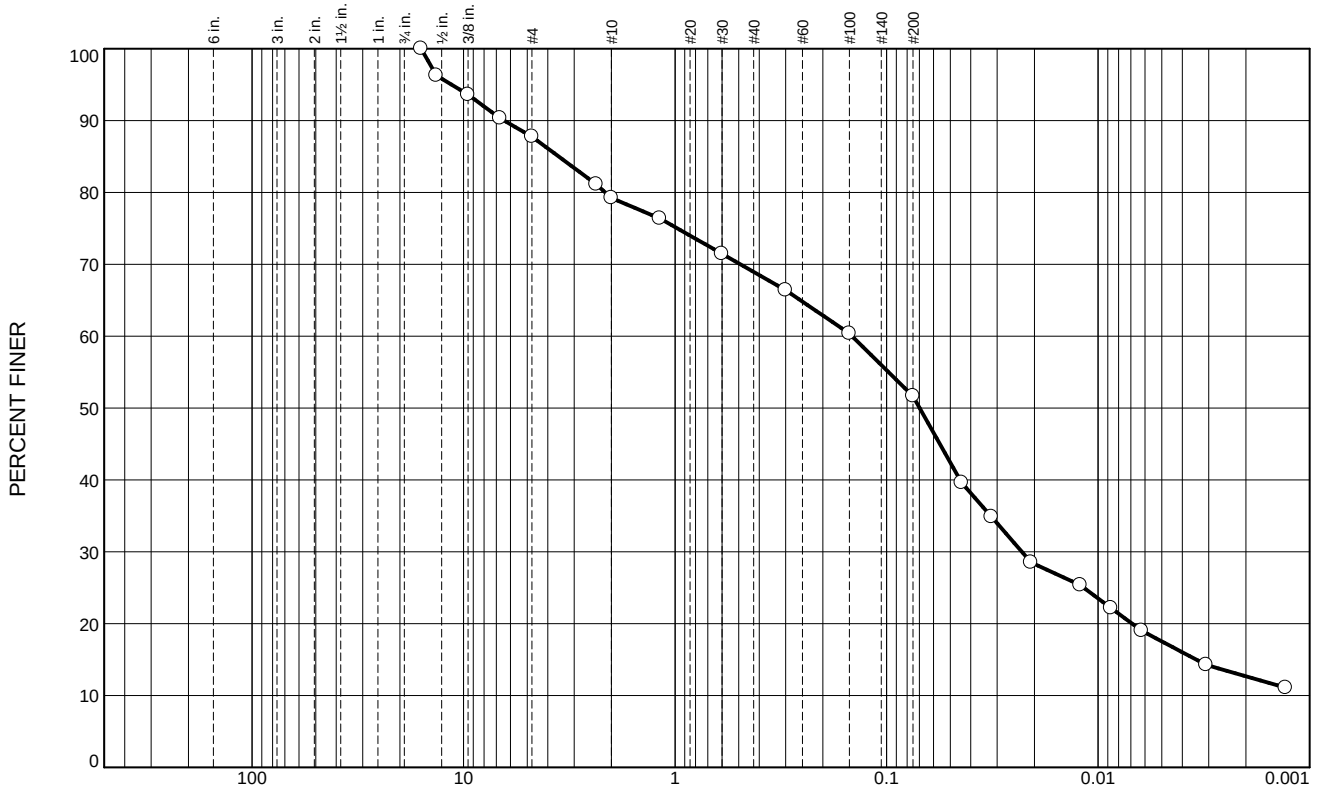
DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
	TOPSOIL: Very loose, dark brown, silty organic topsoil, moist (325 mm)	0.00, 511.97	SPT 1	87	1-2-1-2 (3)
	SILT AND SAND: Very loose, dark brown, silty sand, some clay, some organics, trace gravel, moist	0.33, 511.65			
1	no organics, becoming light brown, compact, very moist	0.76, 511.21	SPT 2	100	6-7-4-4 (11)
			SPT 3	95	4-7-7-10 (14)
2			SPT 4	100	9-16-12-21 (28)
3	**SILTY SAND TILL:** Very dense, light brown, silty sand till, some clay and gravel, moist	3.05, 508.92	SPT 5	95	28-29-22-27 (51)
	very moist seams encountered	3.66, 508.31	MC5 6	100	
4	Bottom of borehole at 4.57 m, Elevation 507.40 m.				



APPENDIX B

GRAIN SIZE ANALYSES

Particle Size Distribution Report



	% Cobbles	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	12.2	8.6	10.3	17.2	34.2	17.5

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	BH3	4	2.29-2.90m	silty sand, some clay and gravel	ML
				Sampled by BRF of CMT Engineering Inc. May 31, 2023	
				Tested by JM of CMT Engineering Inc. June 2, 2023	

CMT Engineering Inc.

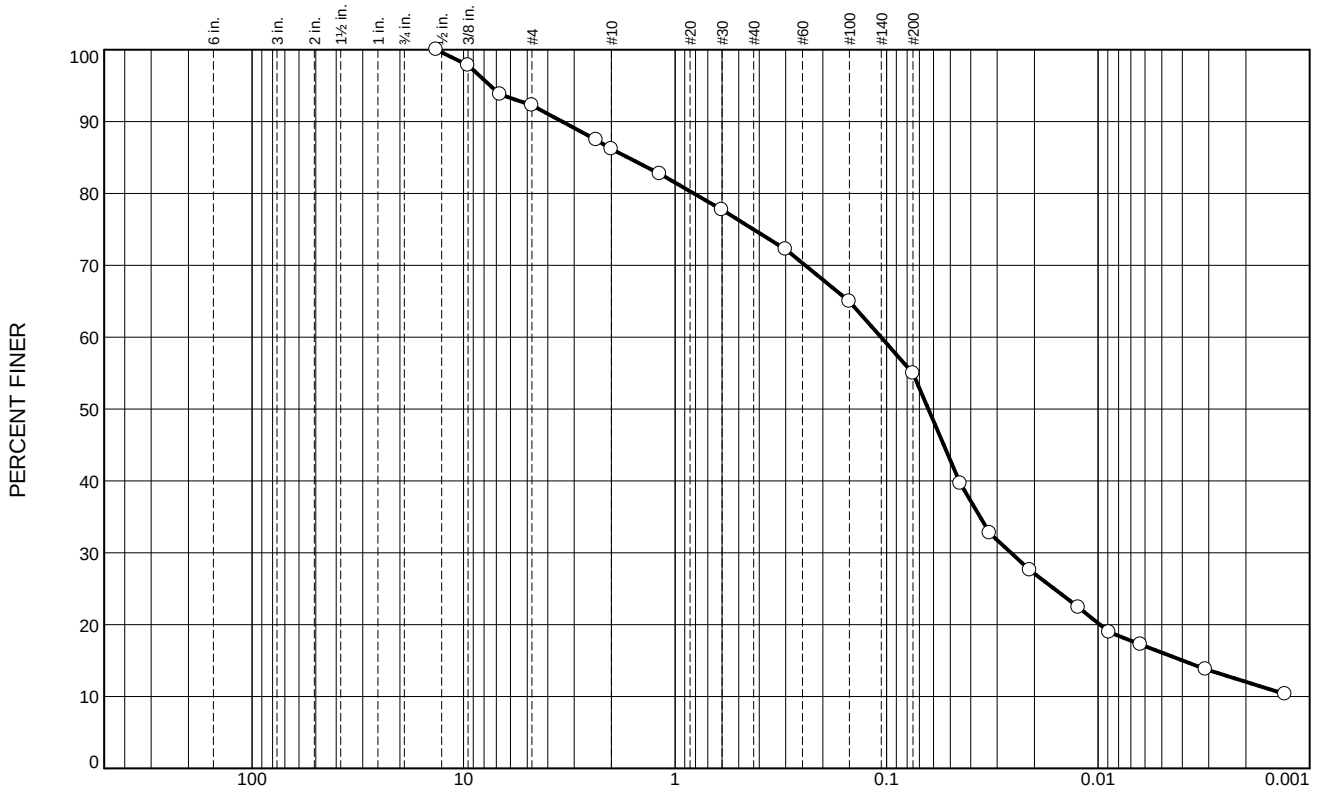
St. Clements, ON

Client: Wilson Developments

Project: Proposed Development
Eco Parkway, Dundalk, Ontario

Project No.: 23-174 **Figure** 1

Particle Size Distribution Report



	% Cobbles	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	7.7	6.1	11.2	20.0	38.9	16.1

SOIL DATA					
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	BH4	2	0.76-1.37m	silt and sand, some clay, trace gravel	ML
				Sampled by BRF of CMT Engineering Inc. May 31, 2023	
				Tested by JM of CMT Engineering Inc. June 2, 2023	

CMT Engineering Inc.

St. Clements, ON

Client: Wilson Developments

Project: Proposed Development
Eco Parkway, Dundalk, Ontario

Project No.: 23-174 **Figure** 2

APPENDIX C

WELL LOG RECORD