GEOTECHNICAL INVESTIGATION

PROPOSED 4-STOREY COMMERCIAL/RESIDENTIAL BUILDING
343 WATERLOO AVENUE
GUELPH, ONTARIO

CMT Project 24-901.R01

Prepared for:

Morgan Adams

January 30, 2025

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

January 30, 2025 24-901.R01

Morgan Adams
343 Waterloo Avenue
Guelph, Ontario,
N1H 3K1

Dear Morgan:

Re: Geotechnical Investigation
Proposed 4-Storey Commercial/Residential Building
343 Waterloo Avenue
Guelph, 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 R Figg, C. Tech.
Senior Soil Technician

cd

TABLE OF CONTENTS

1.0 INTRODUCTION

The services of CMT Engineering Inc. (CMT Inc.) were retained by Morgan Adams to conduct a geotechnical investigation for the new 4-storey commercial/residential development proposed to be constructed at 343 Waterloo Avenue in Guelph, Ontario. The location of the subject site is shown on Drawing 1.

It is understood that the proposed 4-storey building is to comprise ground floor commercial space and then three (3) levels of residential space. The proposed structure will comprise slab-on-grade construction (no basement) and will have a ground floor footprint of approximately 325 m^2. The proposed building will be serviced by municipal services (water and sewers).

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; and a summary of the laboratory test results.

2.0 EXISTING SITE CONDITIONS

The subject site is located at the corner of Waterloo Avenue and Beechwood Avenue in Guelph, Ontario. There is an existing one (1) storey building located along the Northeast side of the property. The existing driveway/parking lot appears to comprise concrete in the Southwest portion of the site and paving stone in the Southeast portion of the site. In general, the topography of the subject site is relatively flat in elevation.

The subject site is bounded by existing residential properties to the northwest and northeast, Waterloo Avenue to the southeast and Beechwood Avenue to the southwest.

3.0 FIELD AND LABORATORY PROCEDURES

The field investigation was conducted on December 16, 2024 and comprised the advancement of six (6) boreholes (referenced as Boreholes 1 to 6, inclusive), utilizing a drillrig operated by employees of Arrow Drilling Inc. The boreholes were advanced to depths ranging between approximately 2.13 m (7.0 ft) and 6.71 m (22.0 ft) below the existing ground surface elevation. Boreholes 1 to 4, inclusive were advanced into the existing bedrock by means of an air powered Down The Hole Hammer (DTH Hammer) to depths ranging from approximately 5.79 m (19.0 ft) to 6.71 m (22.0 ft) below the existing ground surface.

The table below outlines the approximate depths the boreholes were advanced below the existing ground surface, the approximate ground surface elevation, and the approximate termination elevation of the boreholes.

Borehole No.	Approximate Depth of Borehole (m below ground surface)	Approximate Ground Surface Elevation (m)	Approximate Borehole Termination Elevation (m)
1	6.40 m (21.0 ft)	312.15	305.75
2	6.40 m (21.0 ft)	312.01	305.61
3	5.79 m (19.0 ft)	312.88	307.09
4	6.71 m (22.0 ft)	312.91	306.20
5	2.13 m (7.0 ft)	312.65	310.52
6	2.13 m (7.0 ft)	312.52	310.39

All boreholes encountered refusal on presumed dolostone bedrock at the termination elevation. The dolostone bedrock was proven by utilizing a DTH Hammer to advance the boreholes into the rock as part of this geotechnical investigation in Boreholes 1 to 4, inclusive. The dolostone bedrock was not proven by coring/DTH Hammer as part of this geotechnical investigation in Boreholes 5 and 6.

Standard penetration testing and sampling was carried out throughout the soil 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". SPT soil sampling was generally conducted at 0.76 m (2.5 ft) intervals to refusal on presumed bedrock. As discussed above, a Down The Hole Hammer (DTH Hammer) was utilized to advance the boreholes in Boreholes 1 to 4, inclusive, into the bedrock below depths ranging from approximately 2.13 m (7.0 ft) and 2.44 m (8.0 ft) below ground surface.

Technical staff from Bluewater Geoscience Consultants 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 determination.

Boreholes 1 to 4, inclusive were equipped with a 38 mm (1.5 inch) diameter PVC monitoring well comprised of 3.05 m (10.0 ft) long screen backfilled with filter sand and then riser pipe, backfilled with bentonite The monitoring wells were installed in accordance 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 were registered with the MECP and must be decommissioned in accordance with O. Reg. 903 prior to future construction.

Representative samples from the boreholes at the following depths were submitted to the CMT Inc. laboratory in St. Clements, ON for grain size analyses:

- Borehole 3 – approximate depth 0.15 m to 0.30 m (0.5 ft to 1.0 ft), and
- Borehole 6 – approximate depth 1.52 m to 2.13 m (5.0 ft to 7.0 ft).

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

Bluewater Geoscience Consultants Inc. personnel surveyed the ground surface elevations at the borehole locations and reported the geodetic elevations to CMT Inc. As such, the ground surface elevations at the borehole locations ranged from approximately 312.01 m to 312.91 m. The locations of the boreholes are shown in Drawing 2.

4.0 SUBSOIL CONDITIONS

The soils encountered in the boreholes are described briefly below with more detailed stratigraphic descriptions 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, loose, moist, silty, organic topsoil was encountered at the surface in Boreholes 1, 2, 4 and 5. The thickness of the topsoil at the borehole locations ranged from approximately 75 mm and 300 mm (average 188 mm). It should be expected that the 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. Concrete Slab

An existing concrete slab was encountered at the surface and cored prior to advancement of the boreholes at Boreholes 3 and 6. The thickness of the concrete slab at the borehole locations was observed to be approximately 150 mm.

4.3. Gravelly Sand Fill

Brown gravelly sand fill, with some silt, trace clay was encountered underlying the concrete slab in Boreholes 3 and 6. The fill material was considered to be loose, with SPT N-values ranging from 5 to 6 blows per 0.30 m (average 6 blows per 0.30 m). The fill material was considered to be moist at the time of the investigation.

4.4. Sandy Silt

Brown, sandy silt, with some clay, trace gravel was encountered underlying the surficial topsoil at Boreholes 1, 2, 4 and 5 and underlying the gravelly sand fill material in Boreholes 3 and 6. The sandy silt was considered to be loose to compact, with SPT N-values ranging from 4 to 26 blows per 0.30 m (average 15 blows per 0.30 m). The sandy silt was considered to be moist, with moisture contents ranging between approximately 2.5% to 33.4% (average 18.0%).

4.5. Presumed Dolostone Bedrock

Presumed dolostone bedrock was encountered underlying the sandy silt in Boreholes 1 to 6, inclusive. The bedrock appeared to be weathered/fractured in the upper zone, making it difficult to discern the soil/bedrock interface. Bedrock was proven by utilizing a DTH Hammer to advance the boreholes into the rock as part of the geotechnical investigation in Boreholes 1 to 4, inclusive. Bedrock was not proven by coring/DTH Hammer at Boreholes 5 and 6 as part of the geotechnical investigation.

The approximate depths below the existing ground surface that dolostone bedrock/presumed dolostone bedrock was encountered in the boreholes are summarized in the following table.

Borehole No.	Approximate Elevation Bedrock Was Encountered (m)	Approximate Depth Bedrock Was Encountered (m)	Quality
1	312.15	2.13	Weathered
2	312.01	2.13	Weathered
3	312.88	2.44	Weathered
4	312.91	2.13	Weathered

Borehole No.	Approximate Elevation Presumed Bedrock Was Encountered (m)	Approximate Depth Presumed Bedrock Was Encountered (m)	Quality
5	312.65	2.13	Presumed Weathered
6	312.52	2.13	Presumed Weathered

Note: The approximate elevations that bedrock was encountered, as noted above, reflect the presumed bedrock surface. Bedrock was proven by utilizing a DTH Hammer to advance the boreholes into the rock in Boreholes 1 to 4, inclusive and not proven by coring/DTH Hammer in Boreholes 5 and 6.

The Dolostone bedrock surface is typically undulating in nature and, therefore, the elevation can vary significantly. The degree of weathering and/or fracturing of the bedrock should also be expected to vary across the site. The bedrock elevation throughout the site should also be expected to be influenced by previous excavations for existing services and/or structures.

It should be noted that the boreholes were advanced into the dolostone bedrock using a Down the Hole Hammer (DTH Hammer) which does not produce a core sample of the rock. As such, the condition of the bedrock was difficult to determine.

4.6. Groundwater

Moist soil conditions were encountered in the majority of the boreholes. 38 mm (1.5 inch) diameter monitoring wells were installed in Boreholes 1 to 4, inclusive to measure the static groundwater level. The water level in the monitoring wells were measured by Bluewater Geoscience Consulting Inc. staff on December 18, 2024. It should be noted that the compact, typically fine-grained soils and the bedrock observed in the boreholes have the potential to create perched water conditions. These conditions would be expected to occur near the interface of the looser upper soils and the compact to very dense lower soils. Groundwater conditions (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. Groundwater levels and/or wet to saturated soil conditions (if encountered) during construction could make excavations difficult, and it should be expected that caving or sloughing of the excavation walls will occur when excavating into wet to saturated zones. Dewatering considerations are discussed in Section 5.10 of this report.

The recorded groundwater elevation in the monitoring wells installed in Boreholes 1 to 4, inclusive, the approximate zone of wet to saturated soils 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 the Monitoring Well (m) December 18, 2024 (Depth to Water)	Estimated Zone of Wet to Saturated Soil at the Time of Investigation Elevation (m)	Approximate Depth Below Ground Surface of Estimated Zone of Wet to Saturated Soil at the Time of Investigation (m)	Bottom of Borehole Elevation (m)
BH 1	312.15	307.22 (4.93)	--	--	305.75
BH 2	312.01	307.39 (4.62)	--	--	305.61
BH 3	312.88	309.79 (3.09)	--	--	307.09
BH 4	312.91	307.67 (5.24)	--	--	306.20
BH 5	312.65	--	--	--	310.52
BH 6	312.52	--	--	--	310.39

If required, dewatering works should be designed and constructed in accordance with the requirements of regulatory agencies such as the Ministry of Transportation, Ministry of Natural Resources and Fisheries, and the Ministry of the Environment. Dewatering must be 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 an environmental consultant be consulted prior to any on-site water being discharged to municipal outlets to ensure proper procedures are followed.

5.0 DISCUSSION AND RECOMMENDATIONS

The following sections of the report provide an 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)	Soil Type
BH 1	312.15	150 (3,000)	225 (4,500)	310.63 to 310.02	1.52	Sandy Silt
		250 (5,000)	375 (7,500)	310.02 to 305.75 (termination)	2.13	Bedrock
BH 2	312.01	150 (3,000)	225 (4,500)	311.25 to 309.88	0.76	Sandy Silt
		250 (5,000)	375 (7,500)	309.88 to 305.61 (termination)	2.13	Bedrock
BH 3	312.88	150 (3,000)	225 (4,500)	312.12 to 310.44	0.76	Sandy Silt
		250 (5,000)	375 (7,500)	310.44 to 307.09 (termination)	2.44	Bedrock
BH 4	312.91	150 (3,000)	225 (4,500)	312.15 to 310.78	0.76	Sandy Silt
		250 (5,000)	375 (7,500)	310.78 to 306.20 (termination)	2.13	Bedrock
BH 5	312.65	150 (3,000)	225 (4,500)	311.89 to 310.52	0.76	Sandy Silt
		250 (5,000)	375 (7,500)	310.52 (termination)	2.13	Presumed Bedrock
BH 6	312.52	150 (3,000)	225 (4,500)	311.76 to 310.39	0.76	Sandy Silt
		250 (5,000)	375 (7,500)	310.39 (termination)	2.13	Presumed Bedrock

Based on the information obtained during the geotechnical investigation and provided in the table above, soils suitable to support conventional foundations designed with a minimum bearing capacity of 150 kPa (3,000 psf) at SLS and 225 kPa (4,500 psf) at ULS were encountered at elevations ranging from 310.63 m to 312.15 m for Boreholes 1 to 6, inclusive, which corresponds with depths ranging from approximately 0.76 m and 1.52 m below the existing ground surface at the borehole locations.

Due to the presence of loose fill, native soils and weathered bedrock, it is imperative that the founding material be assessed at the time of construction by qualified geotechnical personnel in order to confirm their founding suitability. It is anticipated that sub-excavation of soft soils will be required during foundation excavations.

Should foundations (conventional shallow foundations or slab-on-grade) 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 on suitable subgrade soils and compacted in accordance with Section 5.4.5 of this report is estimated to be at least 150 kPa (3,000 psf) at SLS and 225 kPa (4,500 psf) at ULS.

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.

Footings founded on soil 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.

When constructing new footings adjacent to existing footings, such as those from neighbouring buildings, all existing disturbed backfill material from the existing foundations must be sub-excavated to ensure that new footings are founded on approved undisturbed soil. Any areas sub-excavated to remove disturbed soils could be backfilled with mass concrete. It is imperative that excavations do not extend below any existing footings or the bottom of foundation walls without providing support to both the footing/underside of the foundation wall through shoring or underpinning, as well as support the foundation wall structure itself (as designed by the structural engineer).

All exterior slab-on-grades must be constructed on a minimum of 1.2 m of free draining sand and gravel (OPSS 1010 Type III Granular B) in a drained state, otherwise equivalent thermal insulation must be provided to provide protection against frost action.

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 5.10 of this report).

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

5.2. 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 2.13 m to 6.71 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 C (very dense soil and soft rock) for structures founded on the native soils and/or bedrock at the recommended founding elevations provided in Section 5.1 of this report. For foundations constructed on structural fill, placed in accordance with Section 5.4.5 of this report, the site classification for seismic site response would also be considered Site Class D (stiff soil).

5.3. Soil Design Parameters

The following table provides the estimated soil design parameters for imported granular fill and 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, slab-on-grade structures and retaining walls etc., 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

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)
Existing Fill	1,800	28°	0.36	2.77	0.53	0.35	0
Sandy Silt	1,800	32°	0.31	3.25	0.47	0.41	0

5.4. Site Preparation

The site preparation for the proposed 4-storey building is anticipated to consist of demolition of the existing structure(s), topsoil stripping and/or vegetation grubbing, removal of fill (if encountered) and unsuitable soils, the removal or relocation of any existing services (if present), the sub-excavation 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 the proposed grades.

5.4.1. Topsoil Stripping and Vegetation Grubbing

All topsoil (including buried topsoil if encountered) must be removed from within all proposed structures, driveways, 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 the proposed buildings and/or structures, driveway, and parking lot envelopes to expose approved competent subgrade soils.

5.4.2. 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 sub-excavated from within the proposed structure envelopes to expose approved competent subgrade soil. It would also be sound construction practice to subexcavate all existing loose fill from any parking lot and driveway areas; however, this may not be cost-effective. At a minimum, any fill with intermixed organic material should be sub-excavated 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 storage, 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 sub-excavated 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.

5.4.3. Removal/Relocation of Existing Services

Any existing/abandoned underground services, including field tiles, (if present) that may be located within the proposed structure envelope(s), as well as 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 sub-excavated and the subsequent excavation should be backfilled with approved soils placed in accordance with Section 5.4.5 of this report.

5.4.4. Building Demolition

It is understood that the existing structure(s) are to be demolished. All existing foundation walls, footings, slab-on-grades and other construction materials (concrete slab, pavement stone etc.), as well as all associated backfill material, must be removed from areas of the demolished structure(s). The excavations must be inspected and backfilled according to the procedures outlined in Section 5.4.5 of this report. It is recommended that imported sand and gravel (OPSS 1010 Granular 'B' Type I or an approved alternative) be placed as structural fill to backfill the building demolition areas.

5.4.5. Site Grading

Following the sub-excavation of any soils deemed unsuitable of supporting foundations, slab-on-grades, driveway and parking lot pavement structure, the exposed subgrade must be proof-rolled, and any loose/soft or unstable areas must be sub-excavated and replaced with approved fill materials.

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

- It is imperative that excavations do not extend below any existing (neighbouring) footings or bottom of foundation walls without providing support to both the footings or underside of the foundation wall through shoring or underpinning, as well as support the foundation wall structure itself (as directed by the structural engineer),

- Prior to placement of any structural fill, the subgrade 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 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. Any wet soils encountered 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, and

- Granular 'B' subbase and Granular 'A' base materials for any roadway, driveways and/or parking lot areas must be compacted to 100% SPMDD.

Based on the subsurface conditions observed in the boreholes, wet to saturated soils may be encountered depending on the depth of excavation. As such, for soils excavated from any 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 any parking lot and driveways (if constructed). 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.

5.5. 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 and/or structure 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 and/or structure 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, and

- 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. Shoring/Underpinning

It is imperative that excavations do not extend into the zone of influence of any existing/neighbouring footings/structures or the 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 could 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 suitable soil 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, 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 any 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 sub-excavated and backfilled with approved fill materials (see Sections 5.4.5 and 5.9 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)
Sandy Silt	34,000 kN/m^3 (150 lb/in^3)
Dolostone Bedrock	150,000 kN/m^3 (550 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 any 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, any 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.

Bedrock – With respect to Reg 213/91, excavations undertaken in the dolostone bedrock do not typically require a support system provided the bedrock is sound and stable and that the walls of the excavation are not influenced by surcharge loading from adjacent structures or traffic (including construction vehicles and road traffic). However, depending on the size of the excavation and quality of the rock encountered in the excavation walls, shoring or stabilization of the excavation may be necessary to ensure worker safety from potentially loose and/or falling rock.

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 to protect 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.

The surface of the bedrock generally exhibits chemical and physical weathering (fractures); however, the amount of weathering is expected to vary throughout the construction area. The extent of physical weathering will determine the methodology for excavating. It is anticipated that the upper zone of the bedrock should be able to be excavated utilizing large excavators designed for rock excavation. A pneumatic rock hammer may be required to break down massive bedrock that may be encountered within the fractured zone. There is also the potential that massive bedrock that may require line drilling to enable excavating to the design excavation or trench elevation could also be encountered. The structure of dolostone bedrock generally results in large pieces or blocks of bedrock being excavated. Therefore, over-excavation should be anticipated and a provision for additional foundation concrete and/or lean concrete backfill (as required), as well as bedding material (for services) should be included in the tender documents. Blasting is not recommended for this site due to the close proximity and age of adjacent buildings.

As previously mentioned, the dolostone bedrock surface is typically undulating in nature, and therefore, the elevation can vary significantly. The bedrock elevations may also be influenced by previous excavations.

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.

5.9. Backfilling

Approved fill/native gravel and sand material (non-organic) are generally considered to be suitable for reuse as backfill for any service trenches from the top of the pipe cover to the subgrade elevation. Any soils not considered suitable for reuse as backfill for the service trenches or for the driveway subgrade preparation should be disposed of properly off-site and replaced with a suitable approved alternative. Based on the in-situ moisture contents of the existing soil of the geotechnical investigation, and on past experience with similar soil types, it should be anticipated that the existing material encountered in the boreholes should generally be at suitable moisture contents to achieve the specified field compaction, however the fill soils encountered in the boreholes may require air drying prior to achieving the specified field compaction.

Backfilling operations should be carried out according with OPSS 401 along with the following minimum requirements:

- Adequate heavy smooth drum (granular soils) or sheepsfoot (cohesive soils) vibratory compaction equipment should be used to break up and compact the soils,

- Loose lift thicknesses should not exceed 0.3 m (12") for granular soils or 0.2 m (8") for silt and clay soils (if imported) 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 areas. Service trenches excavated within the zone of influence of the base of any structures (such as buildings, manholes, catch basins, culverts, hydro poles and retaining walls) must be compacted to a minimum of 100% SPMDD,

- Backfill materials may consist of approved excavated soils with no particles greater than 100 mm and no topsoil, organics, rootlets, or other deleterious materials, and

- 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.

5.10. Construction Dewatering Considerations

Moist soils were encountered in the majority of the boreholes. 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.

5.11. Service Pipe Bedding

The fill (free of organics/debris) 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 to protect existing and new service piping from damage by heavy equipment.

5.12. Perimeter Drainage, Foundation Wall Backfill and Trench Backfill

In order to assist in maintaining dry structures with respect to surface water seepage, it is recommended that the exterior grades around the structures 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 and/or structure 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 2024.

Should any of the proposed structures have a basement (not anticipated), 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 and/or structures. 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 sub-slab stone. Given the water conditions encountered in the boreholes, it would be prudent to include an interior underfloor drainage system within any structures which contain a basement. 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 such 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 mineral 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 (granular soils) or sheepsfoot (cohesive soils) vibratory compaction equipment should be used to break up and compact the soils,

- 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.

5.13. Pavement Design/Drainage

All loose and/or soft fill (if encountered), buried topsoil (if encountered) and native soils must be stripped and/or sub-excavated from within any 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 (topsoil/buried topsoil), or other deleterious material should be sub-excavated 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 sub-excavated 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 5.11 and 5.12 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 subgrade soils. The sandy silt soils encountered underlying the topsoil and fill soils would be considered frost susceptible. 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 heavy traffic (loading equipment, delivery trucks, maintenance, and emergency vehicles).

Based on the anticipated loading, the following pavement design is provided:

Material	**Recommended Thickness For New Pavement (if constructed)**	
	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	300 mm (12.0")	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

sub-excavation 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 sub-excavation 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, 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 and/or structure 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 or locations where trucks/trailers will be parked for significant periods of time, it is recommended that rigid Portland cement pavement be considered.

5.14. Excess Soil Management

5.14.1. Chemical Testing was NOT Undertaken by CMT Engineering Inc.

Generally, if surplus soils are to be exported off-site, it will be necessary to perform chemical analysis 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.

5.14.2. 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, Toxicity Characteristic Leaching Procedure (TCLP) 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, who 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 pre-approved 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. It should also be noted that the laboratory testing generally takes five (5) working days to process with a regular turnaround time.

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 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/subgrade inspections as well as compaction testing for structural filling, site grading, and site servicing. This will ensure that construction occurs 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.

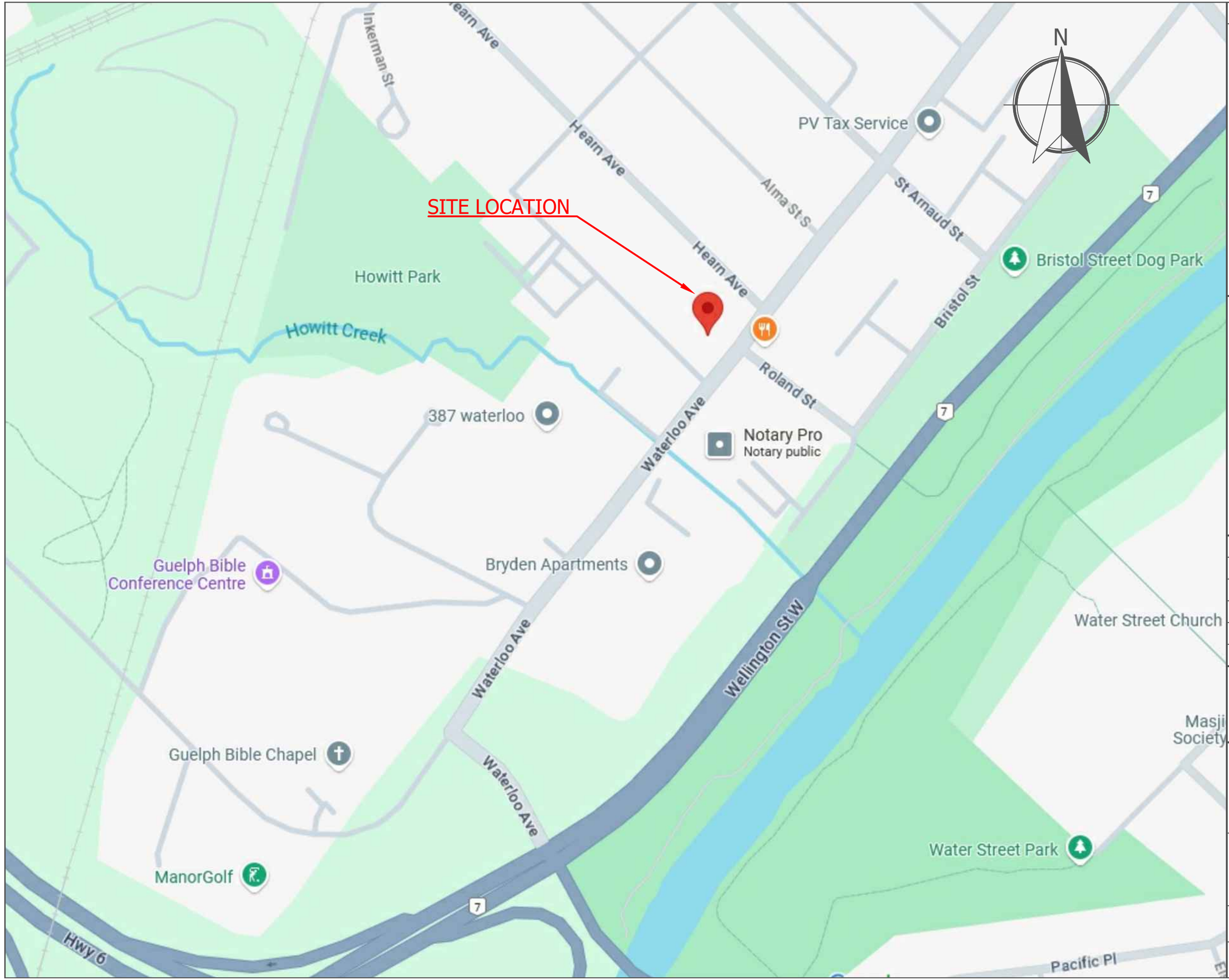
Prepared by:

Brandon R Figg, C.Tech.
Senior Soil Technician

Reviewed by:

Nathan Chortos, P.Eng.
Senior Engineer

cd



NOTES:

1. BASE MAP PROVIDED BY GOOGLE MAPS.

NO.	DESCRIPTION	DATE

REVISIONS

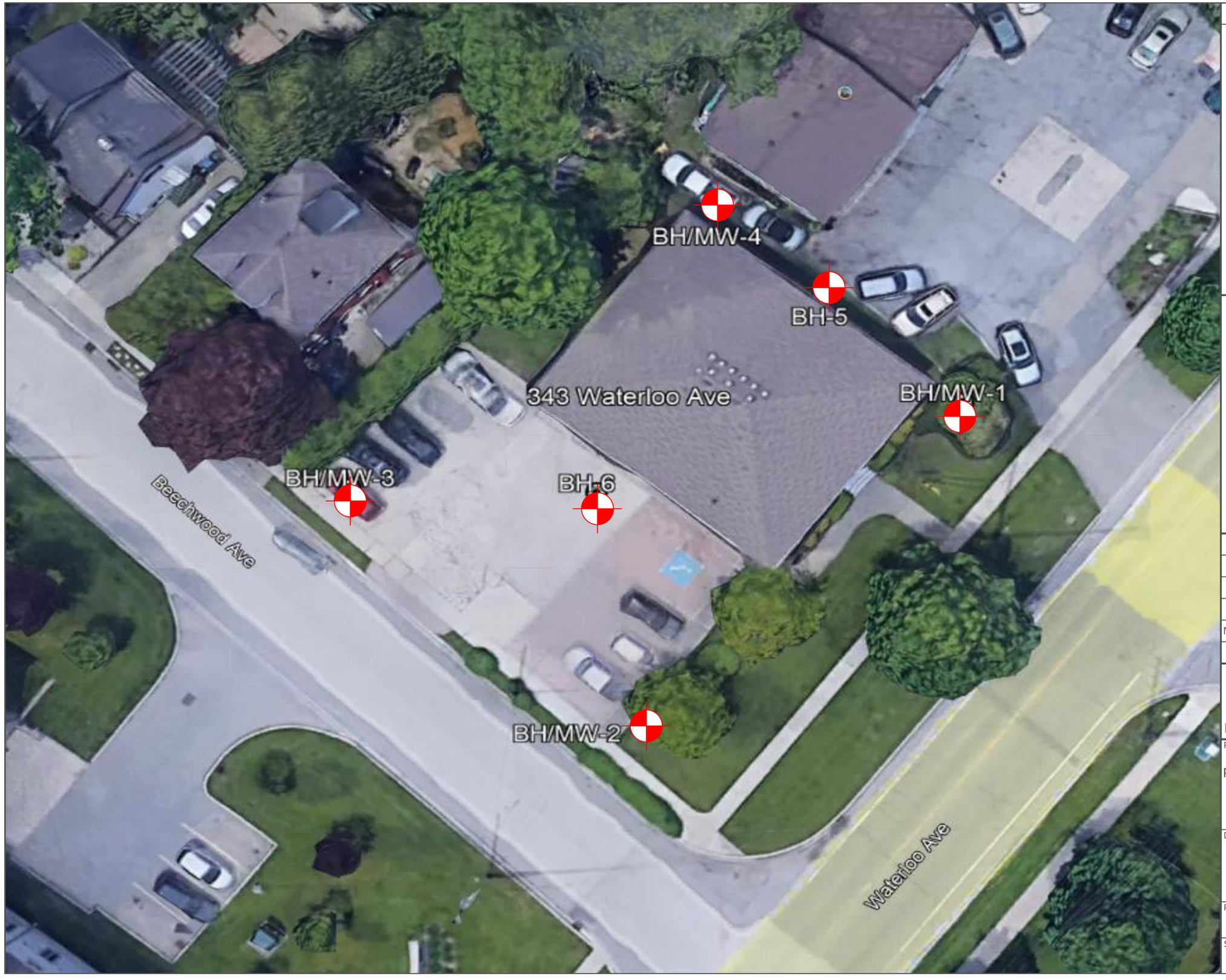
CMT ENGINEERING INC.
1011 Industrial Crescent, Unit 1
St. Clements, Ontario N0B 2M0
Tel.: 519-699-5775
Fax: 519-699-4664
www.cmtinc.net

PROJECT:
Geotechnical Investigation
Proposed 4-Storey Commercial/Residential Building
343 Waterloo Avenue,
Guelph, Ontario

DRAWING TITLE:

SITE LOCATION MAP

PROJECT NO.:	DATE:
24-901	January 16, 2025
SCALE:	DRAWING NO.
N.T.S.	1



NOTES:

1. DRAWING PROVIDED BY GOOGLE EARTH.

CMT Borehole - 2024

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 4-Storey Commerfial/Residential Building
343 Waterloo Avenue,
Guelph, Ontario

DRAWING TITLE:
AERIAL MAP SHOWING APPROXIMATE BOEHOLE LOCATIONS

PROJECT NO.:	DATE:
24-901	January 16, 2025
SCALE: N.T.S.	DRAWING NO. 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 BH/MW1

PROJECT: Proposed 4-Storey Commercial/Residential Building
PROJECT ADDRESS: 343 Waterloo Avenue
PROJECT NUMBER: 24-901
PROJECT LOCATION: Guelph, Ontario
DRILLING DATE: 12-16-24
GROUND ELEVATION: 312.15 m
DRILLING CONTRACTOR: Arrow Drilling Inc.
LOGGED BY: BL
DRILLING EQUIPMENT: Diedrich
SAMPLING METHOD: SPT

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, 312.15	SPT 1		2-1-3-4 (4)
	SANDY SILT: Loose, brown, sandy silt, some clay, trace gravel, moist	0.30, 311.85			
1			SPT 2		2-3-3-7 (6)
	becoming compact	1.52, 310.63	SPT 3		7-7-6-50 (13)
2	**BEDROCK:** Dolostone Bedrock	2.13, 310.02			
3					
4			NR 4		
5					
6					

SPT N VALUE: 10 20 30 40
POCKET PEN. (kPa): 90 180 270 360
MOISTURE CONTENT (%): 12 24 36 48

WELL DIAGRAM: Bentonite Seal; 38mm Riser; #2 Sand Pack; 38mm Screen; Groundwater was measured at a depth of 4.93 m (El. 307.22 m) on December 18, 2024

Bottom of borehole at 6.40 m, Elevation 305.75 m.

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

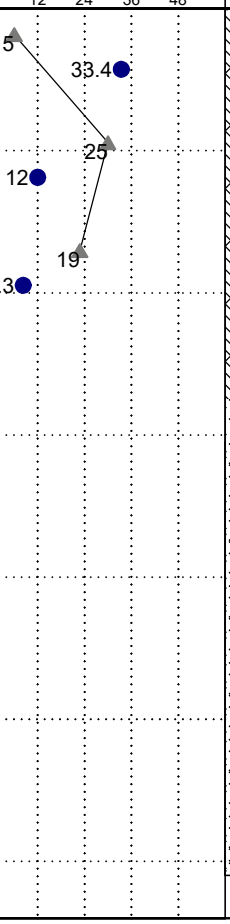
BOREHOLE NUMBER BH/MW2

PROJECT: Proposed 4-Storey Commercial/Residential Building
PROJECT ADDRESS: 343 Waterloo Avenue
PROJECT NUMBER: 24-901
PROJECT LOCATION: Guelph, Ontario
DRILLING DATE: 12-16-24
GROUND ELEVATION: 312.01 m
DRILLING CONTRACTOR: Arrow Drilling Inc.
LOGGED BY: BL
DRILLING EQUIPMENT: Diedrich
SAMPLING METHOD: SPT

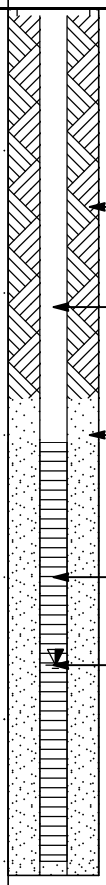
DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
0	**TOPSOIL:** Loose, dark brown, silty organic topsoil, moist (75 mm)	0.00, 312.01	SPT 1		1-2-3-3 (5)
		0.08, 311.93			
	SANDY SILT: Loose, brown, sandy silt, some clay, trace gravel, moist				
1	becoming compact	0.76, 311.25	SPT 2		2-11-14-16 (25)
2			SPT 3		10-11-8-61 (19)
	BEDROCK: Dolostone Bedrock	2.13, 309.88			
3					
4			NR 4		
5					
6					

Bottom of borehole at 6.40 m, Elevation 305.61 m.

SPT N VALUE
10 20 30 40
POCKET PEN. (kPa)
90 180 270 360
MOISTURE CONTENT (%)
12 24 36 48



WELL DIAGRAM



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

BOREHOLE NUMBER BH/MW3

PROJECT: Proposed 4-Storey Commercial/Residential Building
PROJECT ADDRESS: 343 Waterloo Avenue
PROJECT NUMBER: 24-901
PROJECT LOCATION: Guelph, Ontario
DRILLING DATE: 12-16-24
GROUND ELEVATION: 312.88 m
DRILLING CONTRACTOR: Arrow Drilling Inc.
LOGGED BY: BL
DRILLING EQUIPMENT: Diedrich
SAMPLING METHOD: SPT

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
0	**CONCRETE:** Concrete Slab (150 mm)	0.00, 312.88					
	GRAVELLY SAND FILL: Loose, brown, gravelly and fill, some silt, trace clay, moist	0.15, 312.73	SPT 1		1-2-3-3 (5)	5, 23.7	
		0.30, 312.58					
1	**SANDY SILT:** Compact, brown, sandy silt, some clay, trace gravel, moist becoming compact	0.76, 312.12	SPT 2		2-11-14-16 (25)	25, 2.5	Bentonite Seal
2			SPT 3		10-11-8-61 (19)	19, 9.7	38mm Riser
			SPT 4		12-50/0.00	>>, 9.1	
	BEDROCK: Dolostone Bedrock	2.44, 310.44					
3							Groundwater was measured at a depth of 3.09 m (El. 309.79 m) on December 18, 2024
4			NR 5				38mm Screen
5							#2 Sand Pack

Bottom of borehole at 5.79 m, Elevation 307.09 m.

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

BOREHOLE NUMBER BH/MW4

PROJECT: Proposed 4-Storey Commercial/Residential Building
PROJECT ADDRESS: 343 Waterloo Avenue
PROJECT NUMBER: 24-901
PROJECT LOCATION: Guelph, Ontario
DRILLING DATE: 12-16-24
GROUND ELEVATION: 312.91 m
DRILLING CONTRACTOR: Arrow Drilling Inc.
LOGGED BY: BL
DRILLING EQUIPMENT: Diedrich
SAMPLING METHOD: SPT

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
0	**TOPSOIL:** Loose, dark brown, silty organic topsoil, moist (150 mm)	0.00, 312.91	SPT 1		3-4-4-4 (8)
	SANDY SILT: Loose, brown, sandy silt, some clay, trace gravel, moist	0.15, 312.76			
1	becoming compact	0.76, 312.15	SPT 2		8-9-17-15 (26)
2			SPT 3		8-9-10-50/0.01
	BEDROCK: Dolostone Bedrock	2.13, 310.78			
3					
4			NR 4		
5					
6					

SPT N VALUE: 10 20 30 40
POCKET PEN. (kPa): 90 180 270 360
MOISTURE CONTENT (%): 12 24 36 48

8
16.1
26
8.5
>>
7.8

WELL DIAGRAM:
- Bentonite Seal
- 38mm Riser
- #2 Sand Pack
- 38mm Screen
- Groundwater was measured at a depth of 5.24 m (El. 307.67 m) on December 18, 2024

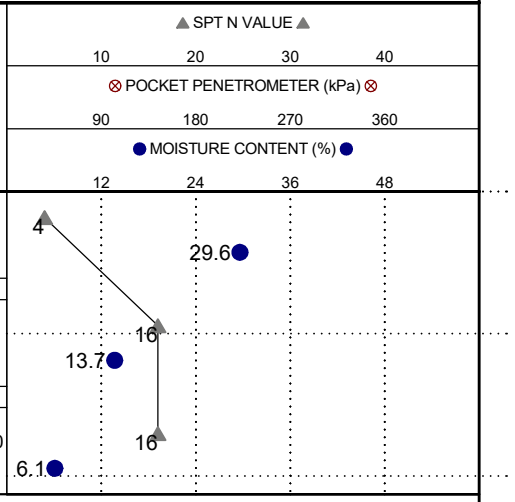
Bottom of borehole at 6.71 m, Elevation 306.20 m.

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

BOREHOLE NUMBER BH5

PROJECT: Proposed 4-Storey Commercial/Residential Building
PROJECT ADDRESS: 343 Waterloo Avenue
PROJECT NUMBER: 24-901
PROJECT LOCATION: Guelph, Ontario
DRILLING DATE: 12-16-24
GROUND ELEVATION: 312.65 m
DRILLING CONTRACTOR: Arrow Drilling Inc.
LOGGED BY: BL
DRILLING EQUIPMENT: Diedrich
SAMPLING METHOD: SPT

DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
		TOPSOIL: Loose, dark brown, silty organic topsoil, moist (150 mm)	0.00, 312.65	SPT 1		4-3-1-1 (4)
			0.15, 312.50			
		SANDY SILT: Loose, brown, sandy silt, some clay, trace gravel, moist				
1		becoming compact	0.76, 311.89	SPT 2		1-8-8-10 (16)
				SPT 3		6-6-10-50 (16)
2		Refusal on probable bedrock was encountered at a depth of approximately 2.13 m (El. 310.52 m) below ground surface.	,			
		Bottom of borehole at 2.13 m, Elevation 310.52 m.				

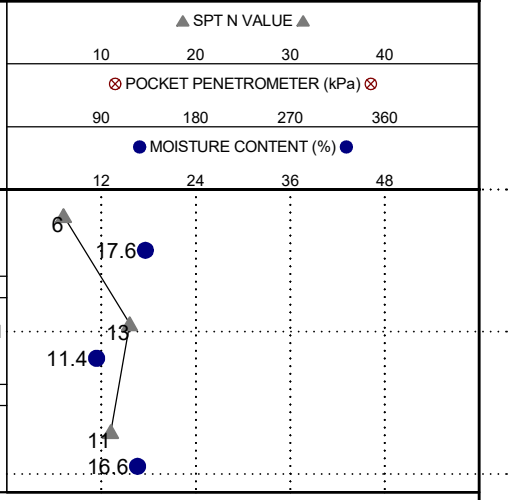


CMT ENGINEERING INC.
1011 Industrial Crescent, Unit 1
St. Clements, Ontario N0B 2M0
Telephone: 519-699-5775
Fax: 519-699-4664

BOREHOLE NUMBER BH6

PROJECT: Proposed 4-Storey Commercial/Residential Building
PROJECT ADDRESS: 343 Waterloo Avenue
PROJECT NUMBER: 24-901
PROJECT LOCATION: Guelph, Ontario
DRILLING DATE: 12-16-24
GROUND ELEVATION: 312.52 m
DRILLING CONTRACTOR: Arrow Drilling Inc.
LOGGED BY: BL
DRILLING EQUIPMENT: Diedrich
SAMPLING METHOD: SPT

DEPTH (m)	MATERIAL DESCRIPTION	Depth, Elevation (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)
	CONCRETE: Concrete Slab (150 mm)	0.00, 312.52			
	GRAVELLY SAND FILL: Loose, brown, gravelly sand fill, some silt, trace clay, moist	0.15, 312.37 0.30, 312.22	SPT 1		12-4-2-3 (6)
1	**SANDY SILT:** Loose, brown, sandy silt, some clay, trace gravel, moist becoming compact	0.76, 311.76	SPT 2		8-3-10-11 (13)
2			SPT 3		5-5-6-50 (11)



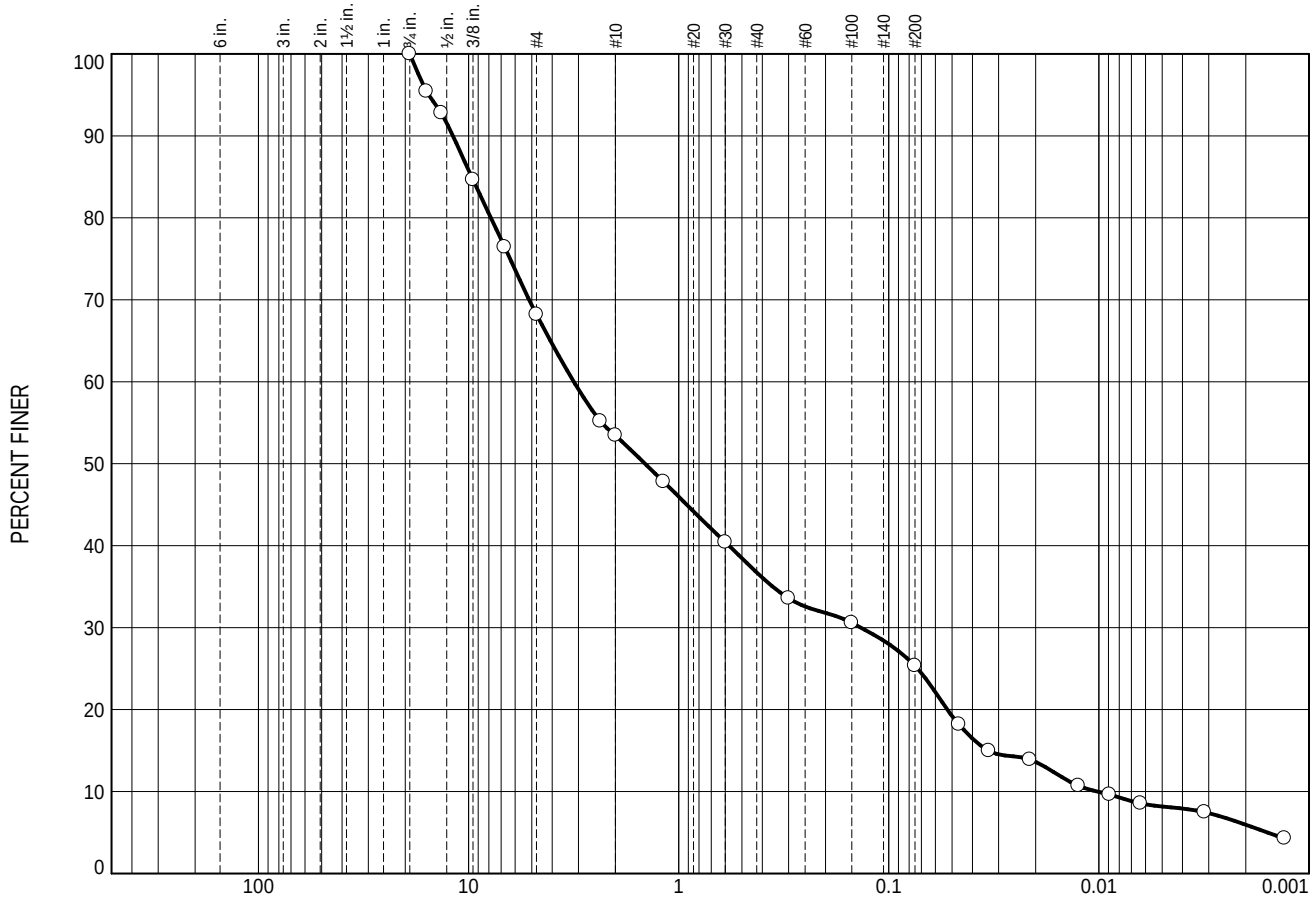
Refusal on probable bedrock was encountered at a depth of approximately 2.13 m (El. 310.39 m) below ground surface.

Bottom of borehole at 2.13 m, Elevation 310.39 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	31.8	14.7	16.8	11.4	19.4	5.9

SOIL DATA					
	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	BH3	1	0.15-0.30m	gravelly sand, some silt, trace clay	SM
				Sampled by Bluewater, December 18, 2024	
				Tested by GS of CMT Engineering December 19, 2024	

CMT Engineering Inc.

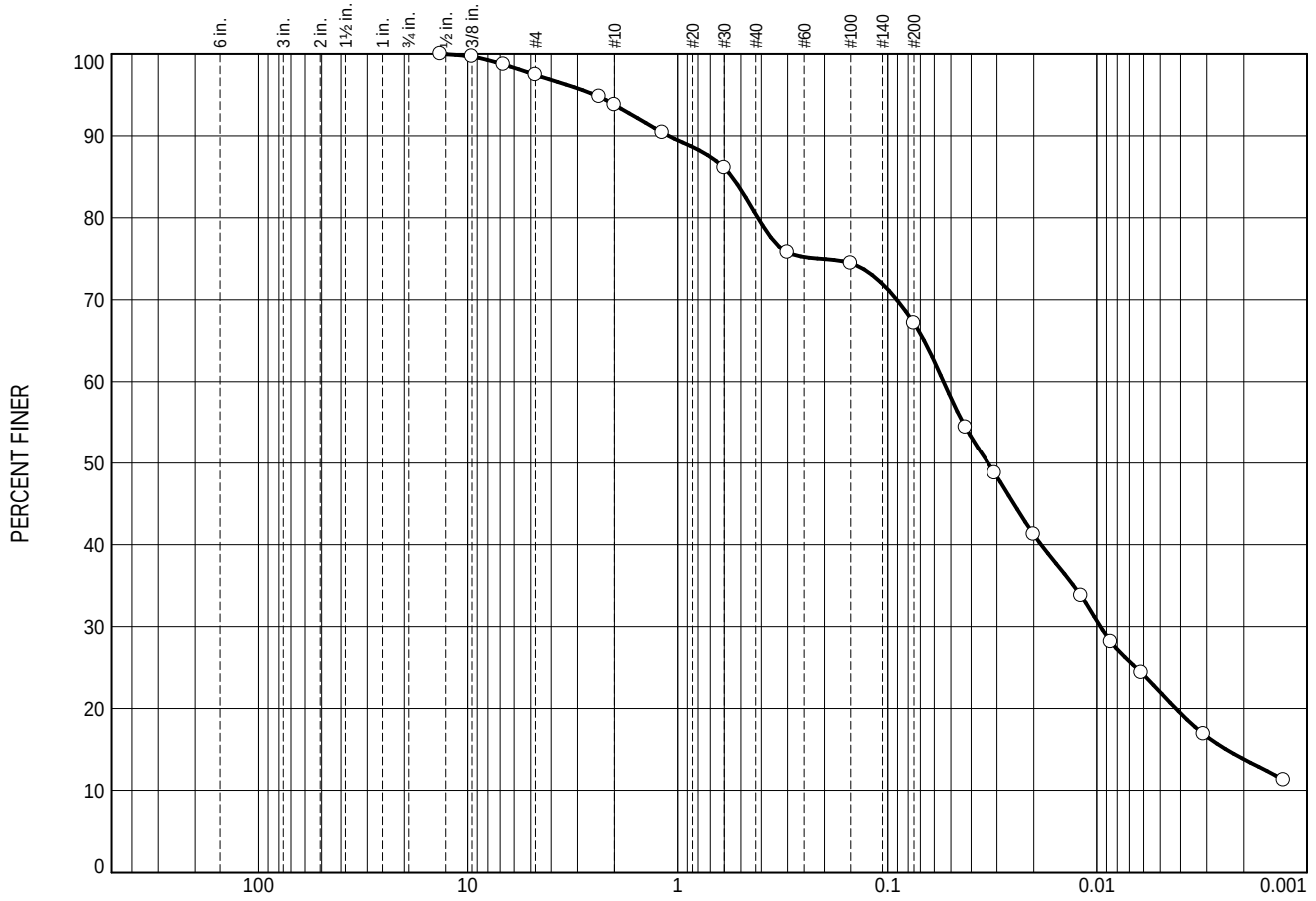
St. Clements, ON

Client: Morgan Adams

Project: Proposed 4-Storey Commercial / Residential Building
343 Waterloo Avenue, Guelph, Ontario

Project No.: 24-901 Figure 1

Particle Size Distribution Report



	% Cobbles	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.6	3.6	13.4	13.3	53.3	13.8

SOIL DATA

	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	BH6	3	1.52-2.13m	sandy silt, some clay, trace gravel	
				Sampled by Bluewater, December 18, 2024	
				Tested by GS of CMT Engineering December 19, 2024	

CMT Engineering Inc.

St. Clements, ON

Client: Morgan Adams

Project: Proposed 4-Storey Commercial / Residential Building
343 Waterloo Avenue, Guelph, Ontario

Project No.: 24-901 Figure 2