GEOTECHNICAL INVESTIGATION REPORT FOR THE PROPOSED MULTI-UNIT RESIDENTIAL (STUDENT HOUSING) DEVELOPMENT

79 COLUMBIA STREET WEST, WATERLOO, ONTARIO

Client

Tuan Hoang

107 Meadowbank Rd
Etobicoke, Ont.
M9B-5E1

Prepared by:

PLANET ENGINEERING Inc.
Consulting Engineers

2179 Dunwin Drive, Unit 4
Mississauga, ON L5L 1X2

Project No. 2501194AG

August 18, 2025

PLANET ENGINEERING Inc.
Consulting Engineers

August 18, 2025 Reference No.: 2501194AG

Tuan Hoang
107 Meadowbank Rd
Etobicoke, Ont.
M9B-5E1
Email: hoanganhtuan17@gmail.com

Dear Mr. Hoang,

RE: Geotechnical Investigation Report for proposed Multi-Unit Residential Development (Student Housing), 79 Columbia Street West, Waterloo, Ontario

Enclosed is a copy of geotechnical investigation report related to the above noted site.

For and on behalf of PLANET Engineering Inc

Irfan Ahmad Khokhar, Ph.D., P.Eng., Consulting Engineer
Vice President and Principal

Executive Summary

A geotechnical investigation based on three boreholes (BH1 to BH3) was carried out for the proposed multi-unit residential development (student housing) located at 79 Columbia Street West in Waterloo, Ontario (the Site).

Based on the information provided by the client, we understand that the site is currently occupied by a single-storey residential dwelling. The proposed multi-residential development will be a five-storey building with one level of basement, intended for student housing.

PLANET does not have any structural information regarding the proposed development.

A top layer of topsoil, 150 mm to 200 mm thick, was encountered in boreholes BH1 and BH3, while a top layer of asphalt, 50 mm thick, was encountered in borehole BH2. Topsoil and asphalt quantities should not be calculated based on borehole data alone, as significant variations in depth may exist around the boreholes.

A layer of granular fill was encountered at the BH2 location, below the asphalt, and generally extended to a depth of approximately 250 mm below the existing ground surface. The granular fill consisted of sand and gravel with trace amounts of silt, clay, and rootlets, and was typically loose.

A layer of fill/disturbed native was encountered at all boreholes (BH1 to BH3) locations below topsoil/granular fill and extended in general to a depth approximately from 0.4m to 0.5m below the existing ground surface. The fill/disturbed native consisted of sandy silty clay, trace gravel, trace rootlets was typically firm to stiff.

Native materials were encountered underlying the fill/disturbed native material in all the boreholes. The native materials were generally cohesive to non-cohesive in nature (i.e., firm to hard sandy clayey silt, trace gravel & loose to very dense sandy silt, trace clay & gravel) to maximum explored depth ranging from 7.3m to 9.8m below existing ground surface.

Based on the borehole information, the fill/disturbed native materials are unsuitable to support foundations and slab on grade due to gross and differential settlements that could damage the structures. The proposed structures can be supported by conventional spread and strip footings founded on undisturbed native deposits predominantly sandy clayey silt & sandy silt for a geotechnical reaction of 100kPa to 200kPa at the Serviceability Limit States (SLS), and for a factored geotechnical resistance of 150kPa to 300kPa at the Ultimate Limit States (ULS). The geotechnical reactions and factored geotechnical resistances including the corresponding highest founding elevations at the borehole locations are summarized on Table 4.1. The recommended founding levels and geotechnical reactions for the proposed structures would need to be confirmed by PLANET at the time of construction.

The floor slab can be supported on grade, provided all topsoil, existing weathered/disturbed and surficially softened or loose materials are removed, and the subgrade thoroughly proof rolled. Any loose spots or areas revealed from proof rolling must be sub-excavated, backfilled and compacted.

During and upon completion of drilling, short-term groundwater was observed in all boreholes. At the completion of drilling, an unstable water table was recorded at approximate depths ranging from 3.5 m to 5.5 m below the existing ground surface.

Groundwater problems are anticipated during excavation and the installation of foundations below the existing ground surface. A positive dewatering system will be required to deal with water problems during the construction. It is strongly recommended that a hydrogeological assessment be carried out to evaluate the site-specific groundwater conditions in detail.

Note that the groundwater level can vary and is subjected to seasonal fluctuations and in response to major weather events. The depth of groundwater table can also be influenced by the presence of underground features such as utility trenches.

Perched water may be encountered in excavated areas during wet seasons. A perched water condition can occur due to the accumulation of surface water in the more pervious fill overlying less pervious deposit, or at the interface of fill and native soils, especially during wet periods. Note that the groundwater level can vary and is subject to seasonal fluctuations and in response to major weather events. The depth of groundwater table can also be influenced by the presence of underground features such as utility trenches and this may affect the construction procedures, costs and schedules.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the on-site fill material and loose to dense or very stiff to hard native soils can be classified as Type 3 soil. The dense to very dense native soils can be classified as Type 1 to Type 2 soil above the water level and Type 4 below the groundwater table. Wet sandy silt to silty sand seams can also be classified as Type 4 soils. As a general rule, the excavations in Type 1 and 2 soils can be carried out without support using side slopes 1H:1V, while the bottom 1.2m of the excavation can be cut vertically and could retain the wall for a short period of time. The excavation in Type 3 soil can be carried out maintaining the side slopes not steeper than 1H:1V. The excavations in Type 4 soils will require minimum flatter side slopes of 3H to 1V. These slopes should be visually monitored for any movement especially if workers are present within the excavation. These temporary slopes should only be utilized for a short duration. If an excavation contains more than one type of soil, the soil shall be classified as the type with the highest number among the types present.

The existing topsoil present on the site is not suitable for supporting the slab-on-grade. In order to have maintenance free floor slab, we recommend that all topsoil, fill, and surficial softened native soils are removed and the base thoroughly proof rolled. The fill required to raise the grade can consist of inorganic soil, placed in shallow lifts and compacted to 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

The select inorganic fill and native soils free from topsoil and organics can be used as general construction backfill where it can be compacted with sheep's foot type compactors. Loose lifts of soil, which are to be compacted, should not exceed 200 mm. Majority of the on-site inorganic fill is not considered suitable for backfilling, imported fill materials (preferably granular) with suitable moisture must be used to replace the existing fill under the slab-on-grade and in trenches.

Based on the borehole information, the subject site for the proposed addition can be classified as Class ‘D’ for seismic site response according to Table 4.1.8.4.A of OBC 2024 provided the footings will be supported on undisturbed native deposits. Consideration could be given to conduct an earthquake site assessment with the use of in-situ testing of the seismic characteristics (i.e. Geophysical testing – Multi-channel Analysis of Surface Waves-MASW) which can lead to an improved site classification (i.e. from Class D to Class C).

The multi-channel analysis of surface waves (MASW) method was used to obtain shear wave velocity profile. The VS30 values obtained from the MASW sounding varied from 410 m/s to 456 m/s with an average of 433m/s. Based on Sentence 4.1.8.4.(2b) of the National Building Code of Canada 2020 (NBC 2020), the applicable Site Designation is X433 and the investigated area is in Site Class C ($360 < VS30 \leq 760$m/s).

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1 INTRODUCTION

PLANET Engineering Inc (PLANET) was retained by Tuan Hoang (the Client) to carry out a geotechnical investigation for the proposed multi-unit residential development at 79 Columbia Street West in Waterloo, Ontario (the Site). The approximate location of the proposed building addition is shown in Drawings 1 and 1A.

This work was conducted in accordance with the scope of work outlined in PLANET's proposal number 2501194AG, dated June 19, 2025, which was approved on June 25, 2025.

Based on the information provided by the client, we understand that the site is currently occupied by a single-storey residential dwelling. The proposed multi-residential development will be a five-storey building with one level of basement, intended for student housing.

PLANET does not have any structural information regarding the proposed development. The purpose of this investigation was to assess the subsurface conditions at three borehole locations (BH1 to BH3), from the findings in the boreholes make geotechnical engineering recommendations for the following:

- Soil characteristics and drainage recommendations
- Location of investigation on site and servicing plans
- comments related to earth pressures
- frost susceptibility of all soils in the upper 1.2 metres
- special precautions specific to this site
- the use of the excavated soil
- temporary excavation shoring and dewatering recommendations
- Seismic site classification
- Recommendations for Asphalt pavement structure designs for roads and parking lots
- Recommendations for pipe bedding and backfill, trench slope stability

This report contains preliminary geotechnical findings. However, once conceptual drawings are finalized, a detailed geotechnical report is recommended.

This report is provided on the basis of the terms of reference presented above and, in the text, and on the assumption that the design will be in accordance with the applicable codes and standards. If there is any change in the design features relevant to the geotechnical analyses, or if any question arises concerning the geotechnical aspects of the codes and standards, PLANET should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of PLANET can be relied upon.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics and do not conform to generalized standards for services. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for Tuan Hoang (the Client), and its architects, consultants, contractors and designers. Third party use of this report without PLANET's consent is prohibited. The limitations presented in Appendix A form an integral part of the report and they must be considered in conjunction with this report.

2 FIELD AND LABORATORY WORK

Borehole locations for this investigation were established in and marked on the ground by PLANET personnel in accordance with the client requirements. Prior to drilling operations, underground utilities were cleared at borehole locations by the public utility's companies.

For this geotechnical investigation, three boreholes (BH1 to BH3) were drilled to depths varying from 7.3 to 9.8 m on July 22, 2025. The boreholes were advanced by a drilling sub-contractor, under the observations of PLANET personnel. The boreholes were advanced by utilizing continuous flight solid stem augers. Samples were retrieved at regular intervals with a 50 mm O.D. split-barrel sampler driven with a hammer weighing 624 N (63.5 kg) and dropping 760 mm in accordance with the Standard Penetration Test (SPT) method (ASTM D1586). The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 300 mm (12 inches) was recorded as SPT 'N' value of the soil which indicated the consistency of cohesive soils or compactness of non-cohesive soils. The results of SPT are shown in the Record of Boreholes. The samples were logged in the field and returned to the PLANET laboratory for detailed examination by the project engineer and for laboratory testing. The approximate borehole locations are shown on Drawing 1A.

Water level observations were made during drilling and at the completion of the drilling operations. Upon completion of drilling, each borehole was backfilled in accordance with current regulations.

The locations of the boreholes were established in the field by PLANET in consultation with the client. The borehole elevations and locations were surveyed and established by the PLANET staff. Note, these elevations are approximate only, for relating borehole soil stratigraphy and should not be used or relied on for other purposes.

Boreholes BH1 to BH3 were drilled and sampled within the approximate footprints of the proposed. multi-residential development.

As well as visual examinations in the laboratory, soil samples were tested for water content determinations. Grain size analyses were carried out on selected soil samples as presented in Table 2.1. The results of the laboratory tests are presented on the borehole logs.

Table 2.1: Sample Details for Grain Size Analyses

Sample No.	Approximate Depth Below the Existing Ground Surface (m)	Approximate Local Elevation (m)	Type of Test
BH1- SS2	0.8 – 1.2	218.5 – 217.9	MH
BH1- SS4	2.3 – 2.9	217.0 – 216.4	MH
BH2- SS3	3.1 – 3.7	216.2 – 215.6	MH

Notes: • MH stands for sieve and hydrometer grain size analyses
The result of grain size analyses is presented on referenced borehole log.

3 RESULTS OF THE INVESTIGATION

The site is located at 79 Columbia Street West, Waterloo, Ontario. The site key plan and the borehole locations are presented on Drawings 1 and 1A. Notes on sample descriptions and the general features of fill material and native soils are presented on Drawing 1B. Detailed subsurface conditions are presented on borehole log sheets, attached as Appendix B.

Details of the subsurface conditions encountered at the borehole locations are provided on the borehole logs following the text of this report. The borehole logs indicate the subsurface conditions only at the borehole locations. Note the material boundaries indicated on the attached sheets are approximate and based on visual observations. These boundaries typically represent a transition from one material type to another and should not be regarded as an exact plane of geological change. It should be pointed out that the subsurface conditions will vary across this site. The subsurface soil and groundwater conditions are summarized as follows.

3.1 Subsurface Conditions

The subsurface conditions encountered in the boreholes are summarized as follows.

3.1.1 Asphalt

A top layer of asphalt, 50 mm thick, was encountered in borehole BH2. Asphalt quantities should not be calculated based on borehole data alone, as significant variations in depth may exist around the borehole.

3.1.2 Topsoil

A top layer of topsoil, 150 mm to 200 mm thick, was encountered in boreholes BH1 and BH3. Topsoil quantities should not be calculated based on borehole data alone, as significant variations in depth may exist around boreholes.

3.1.3 Granular Fill

A layer of granular fill was encountered at the BH2 location, below the asphalt, and generally extended to a depth of approximately 250 mm below the existing ground surface. The granular fill consisted of sand and gravel with trace amounts of silt, clay, and rootlets, and was typically loose.

3.1.4 Fill/Disturbed Native Soil

A layer of fill/disturbed native was encountered at all boreholes (BH1 to BH3) locations below topsoil/granular fill and extended in general to a depth approximately from 0.4m to 0.5m below the existing ground surface. The fill/disturbed native consisted of sandy silty clay, trace gravel, trace rootlets was typically firm to stiff.

Based on the visual observation in the field and our experience in the area, it appears that these SPT N values are not representative to determine the compactness. It also indicates that the fill did not receive systematic compaction. It should be noted that the thickness of fill could vary between and beyond boreholes and this should be considered when estimating.

3.1.5 Native Soils:

Native materials were encountered underlying the fill/disturbed native material in all the boreholes. The native materials were generally cohesive to non-cohesive in nature (i.e., firm to hard sandy clayey silt, trace gravel & loose to very dense sandy silt, trace clay & gravel) to maximum explored depth ranging from 7.3m to 9.8m below existing ground surface.

The grain-size distribution of four selected soil samples from the silty clay was carried out and results are summarized in Table 3.1.

Table 3.1: Summary of Grain-Size Distribution

Sample No.	Depth Below the Existing Ground Surface (m)	Sieve and Hydrometer Test Results			
		Gravel %	Sand %	Silt %	Clay %
BH1- SS2	0.8 – 1.2	1	24	39	36
BH1- SS4	2.3 – 2.9	1	29	36	34
BH2- SS5	3.1 – 3.7	1	13	84	2

3.2 Groundwater Conditions

During and upon completion of drilling, short-term groundwater was observed in all boreholes. At the completion of drilling, an unstable water table was recorded at approximate depths ranging from 3.5 m to 5.5 m below the existing ground surface.

Groundwater problems are anticipated during excavation and the installation of foundations below the existing ground surface. A positive dewatering system will be required to deal with water problems during the construction. It is strongly recommended that a hydrogeological assessment be carried out to evaluate the site-specific groundwater conditions in detail.

Note that the groundwater level can vary and is subjected to seasonal fluctuations and in response to major weather events. The depth of groundwater table can also be influenced by the presence of underground features such as utility trenches.

Perched water may be encountered in excavated areas during wet seasons. A perched water condition can occur due to the accumulation of infiltrated water in the more pervious fill overlying less pervious deposit, or at the interface of fill and native soils, especially during wet periods.

It must be noted that that the ground water levels may fluctuate seasonally based on the amount of precipitation and surface runoff, and wet soils may be encountered to about 0.6 m higher than the water levels noted due to capillary rise in fine cohesionless soils. It should be noted that excavations carried through and below the water bearing cohesionless soils (sand, silt), will experience loosening and sloughing of the sides and unstable excavation base thus requiring relatively flatter excavation slopes.

4 DISCUSSION AND RECOMMENDATIONS

Based on the information provided by the client, we understand that the site is currently occupied by a single-storey residential dwelling. The proposed multi-residential development will be a five-storey building with one level of basement, intended for student housing.

PLANET does not have any structural information regarding the proposed development.

The following sections of the report provide our interpretation of the factual geotechnical data obtained during our field evaluation and are intended for the guidance of the design engineer only. Where comments are made on aspects of 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 interpretation of the subsurface information provided as it affects their proposed construction methods, equipment selection, scheduling, safety, and the like.

Boreholes BH1 to BH3 were drilled and sampled within the approximate footprints of the proposed. multi-residential development

4.1 Foundations

Based on the borehole information, the fill/disturbed native materials are unsuitable to support foundations and slab on grade due to gross and differential settlements that could damage the structures

4.1.1 Footings founded on Native Soils

Based on the borehole information, the fill/disturbed native materials are unsuitable to support foundations and slab on grade due to gross and differential settlements that could damage the structures. The proposed structures can be supported by conventional spread and strip footings founded on undisturbed native deposits predominantly sandy clayey silt & sandy silt for a geotechnical reaction of 100kPa to 200kPa at the Serviceability Limit States (SLS), and for a factored geotechnical resistance of 150kPa to 300kPa at the Ultimate Limit States (ULS). The geotechnical reactions and factored geotechnical resistances including the corresponding highest founding elevations at the borehole locations are summarized on Table 4.1. The recommended founding levels and geotechnical reactions for the proposed structures would need to be confirmed by PLANET at the time of construction.

The recommended founding levels and geotechnical reactions for the proposed structures would need to be confirmed by PLANET at the time of construction.

Table 4.1: Bearing Values & Founding Levels of Footings on Native Soils

BH No.	Material	Ground Elevation	Geotechnical Reaction at SLS (kPa)	Factored Geotechnical Resistance at ULS (kPa)	Minimum Depth below Existing Grade (m)	Elevation Corresponding to Proposed Footing Base (m)
BH1	Sandy Clayey Silt	344.1	100	150	1.2	342.9
	Sandy Silt		200	300	3.3	340.8
BH2	Sandy Clayey Silt	343.7	75	110	1.2	342.5
	Sandy Silt		200	300	3.3	340.4
BH3	Sandy Clayey Silt	344.2	100	150	1.2	343.0
			200	300	3.3	340.9

4.1.2 Other Comments on Foundations

Variations in the soil conditions are expected in between the borehole locations, and during construction, the soil bearing pressures should be confirmed by the Geotechnical Engineer.

The base of all footings must be inspected by this office to ensure their placement on the competent native soil.

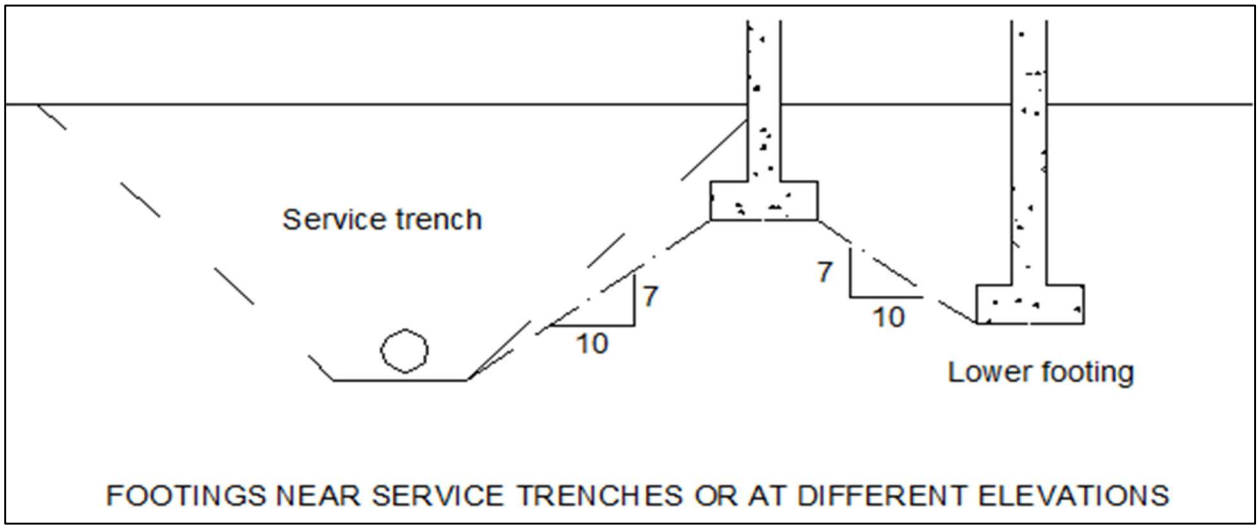
Footings designed to the specified bearing capacity at the serviceability limit states (SLS) are expected to settle less than 25 mm total and 19 mm differential.

In the vicinity of the existing buried utilities, footings must be lowered to undisturbed native soils, or alternatively the services must be structurally bridged.

During winter construction, foundations and slab (if applicable) on grade must not be poured on frozen soil. Foundations must be adequately protected at all times from cold weather and freezing conditions.

Design frost protection depth for the general area is 1.2m. Therefore, for frost protection, new footings should have a permanent earth cover of at least 1.2m or be provided with an equivalent thickness of extruded rigid exterior-grade polystyrene insulation. In case of rip-rap (rock fill), only one-half of the rock fill thickness should be assumed to be effective in providing frost protection.

Where it is necessary to place footings at different levels, the upper footing must be founded below an imaginary 10 horizontal to 7 vertical line drawn up from the base of the lower footing. The lower footing must be installed first to help minimize the risk of undermining the upper footing. Footings close to underground services should also be set back from the services based on this slope limitation as shown in the following Figure.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

The recommended bearing capacities and the corresponding founding elevations would need to be confirmed by the representative of PLANET during construction. It should be noted that the recommended bearing capacities have been calculated by PLANET from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information on the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and

the recommendations of this report must therefore be checked through field inspections provided by PLANET to validate the information for use during the construction stage. In this regard, PLANET should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, PLANET will assume no responsibility for interpretation of the recommendations in the report.

4.2 Floor Slab and Permanent Drainage

Based on the anticipated lowest basement level (3.2m below existing grade), the basement slab subgrade is expected to consist of generally compact to very dense non cohesive soils. The slab subgrade should be assessed by a geotechnical engineer and disturbed/soft/wet subgrade areas should be sub excavated and replaced with imported Granular A and/or Granular B Type 2. The imported granular material must meet the specifications defined in OPSS-1010-13. The existing fill free from topsoil and organics may be used to raise the grade, provided it is confirmed by a qualified geotechnical professional from PLANET Engineering Inc. at the time construction. The fill required to raise the grade must be placed in shallow lifts (each lift not more than 200 mm) and compacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

It is necessary that the basement floor slab be provided with a capillary moisture barrier and drainage layer. This is provided by placing the slab on a minimum layer of 19 mm clear stone (OPSS 1004) compacted by vibration to a compact state. Regardless of the approach to slab construction, the floor slabs that are to have bonded floor finishes (such as tiles with adhesives) should be provided with a capillary moisture and vapour barrier. The floor manufacturers have specific requirements for vapor barrier; therefore, the floor designer/architect must ensure that a provision of appropriate vapour barrier conforming to specific floor finish requirements is incorporated in the project specifications. Adequate testing must be carried out to ensure acceptable levels of moisture/relative humidity in the concrete slab prior to the installation of floor finish(es). Studies indicate that a provision of 200 mm thick 19 mm clear stone base (OPSS 1004) under the slab helps provide a good capillary moisture break provided the granular base is positively drained. However, this provision does not replace the floor manufacturers' specific requirement(s) for a vapour barrier.

The estimated modulus of subgrade reaction (ks) equal to 20 MN/m^3 may be used for the design of slab-on-grade supported on native or structural fill soils, provided that the construction is in accordance with the recommendations provided herein. If structural fill (Granular A or B Type II) having minimum thickness of 300 mm, this value can be increased to 30 MN/m^3. The estimated value provided above may need to be adjusted based on the structure size and location of detailed design.

Such slab are expected to settle less than 25 mm total and $L/\Delta \leq 1/500$ differential. Where

Δ = difference in settlement between two points

L = distance between those points

The floor slabs should not be tied to any load-bearing walls or columns unless they have been designed accordingly. Contraction/expansion joints should be provided for the slabs as required by the structural engineer.

To assist in maintaining a dry basement from seepage, it is recommended that exterior grades around the building be sloped away at a 2 percent gradient or more, for a distance of at least 1.2 m. A perimeter drainage system is provided by forming a drained cavity with prefabricated drain core material such as Miredrain 2000 (Mirafi) or Terradrain 20 (Terrafix). The composite drainage board then discharges to the drainage layer beneath the lowest floor slab through ports made in the foundation wall above the footing level. The subfloor drainage system directs the discharge of water to the building stormwater sump. A conceptual underfloor drainage is shown on Drawing 3. It should be noted that upon completion of the detailed design of the below grade structure, the underfloor drainage system design shall be reviewed and finalized.

In addition to the perimeter drainage, the provision of a sub-floor drainage system installed beneath the basement floor slab is also recommended. The sub-floor drainage system should consist of perforated pipes surrounded by granular filter consisting of a free draining material consisting of 19 mm clear stone (OPSS 1004) wrapped in filter fabric (Terrafix 270R or equivalent or OPSS HL 8 Coarse Aggregate) located at a maximum spacing of 3.0 m on centers (refer to attached Drawing 4 – Basement floor Subdrains).

The exposed subgrade is expected to consist of sandy silt below the water table, and all openings including the subgrade must be covered or wrapped with filter fabric, typically a Class II non-woven textile with a filtration opening size (F.O.S.) of 50 to 100 µm.

The perimeter and sub-floor drains should outlet to a suitable discharge point under gravity flow or connected to a sump pit(s) located in the lowest level of the basement, and the water be pumped up to a suitable discharge point. The size of the sump should be adequate to accommodate anticipated water seepage. A duplex pumping arrangement (main pump with a provision of a backup pump) on emergency backup power is recommended. The pumps should have sufficient capacity to accommodate the anticipated maximum peak water flow. The sub-drain installation and outlet must conform to the plumbing code requirements.

The subfloor drainage system is a critical structural element at this site, since it keeps water pressure from acting on the basement floor slab. As such the storm sump that ensures the performance of this system must have duplexed pump arrangement on emergency power, as noted above, for 100 percent pumping redundancy.

4.3 Excavations and Backfill

Excavations can be carried out with a heavy hydraulic backhoe. Considering topsoil and/or disturbed material removal, it is anticipated that the excavation will be extended to about 3.5 m below the existing grade. Based on the borehole information, groundwater problems are anticipated for the installation of foundations below the existing ground surface. Any seepage, which may occur during wet periods through fill, can be removed by conventional pumping from sumps for excavation.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the on-site fill material and compact to loose or firm native soils can be classified as Type 3 soil. The dense to very dense native soils can be classified as Type 1 to Type 2 soil above the water level and Type 4 below the groundwater table. Wet sandy silt to silty sand seams can also be classified as Type 4 soils. As a general rule, the excavations in Type 1 and 2 soils can be carried out without support using side slopes 1H:1V, while the bottom 1.2m of the excavation can be cut vertically and could retain the wall for a short period of time. The excavation in Type 3 soil can be carried out maintaining the side slopes not steeper than 1H:1V. The excavations in Type 4 soils will require minimum flatter side

slopes of 3H to 1V. These slopes should be visually monitored for any movement especially if workers are present within the excavation. These temporary slopes should only be utilized for a short duration. If an excavation contains more than one type of soil, the soil shall be classified as the type with the highest number among the types present.

Note that till is non-sorted sediment and therefore may contain boulders. Possible large obstructions such as buried concrete pieces may also be encountered in the fill material. Provisions must be made in the excavation contract for the removal of possible boulders in the till or obstructions in the fill material during construction.

The existing fill (free of topsoil) and native soils can be used as general construction backfill where it can be adequately compacted with suitable type compactors. Loose lifts of soil, which are to be compacted, should not exceed 200 mm. Noted that the excavated soils are subject to moisture content increase during wet weather which would make these materials too wet for adequate compaction. Stockpiles should therefore be compacted at the surface or be covered with tarpaulins to help minimize moisture intake.

Imported granular fill, which can be compacted with handheld equipment, should be used in confined areas. The excavated soils are considered to be free draining. Where free draining backfill is required, imported granular fill such as OPSS Granular B should be used.

Stockpiles should be placed well away from the edge of excavation and their height should be controlled so that they do not surcharge the sides of the excavation. Surface drainage should be controlled to prevent flow of surface water into the excavations. Excavation safety and stability of temporary construction slopes and lateral support systems are the contractor's responsibility.

During winter construction, concrete and/or fill must not be placed on frozen fill or soil. Subgrades and foundations must be placed adequately protected at all times from cold weather and freezing conditions.

4.4 Frost Susceptibility of Soils

The frost depth penetration in this area is considered to be 1.2m. Based on the grain size analysis and using the Ministry of Transportation (MTO) category for frost susceptibility soils, the on-site fill/disturbed native soils would be classified as moderate susceptible to frost heaving.

4.5 Earth Pressures

The lateral earth pressures acting on walls or underground structures may be calculated from the following expression:

$$p = K(\gamma h + q)$$

where p = Lateral earth pressure in kPa acting at depth h

K = Earth pressure coefficient equal to 0.4 for vertical walls and horizontal Granular B backfill used for permanent construction. Water pressure must be considered, if continuous wall drains are not used.

γ = Unit weight of backfill, a value of 20.5 kN/m^3 may be assumed

h = Depth to point of interest in meters

q = Equivalent value of surcharge on the ground surface in kPa

The above expression assumes that the perimeter drainage system prevents the build up of any hydrostatic pressure behind the wall.

Table 4.2: Lateral Earth Pressure Parameters

Static Lateral Earth Pressure Parameters	Sandy Clayey Silt	Sandy Silt
Active, K_a	0.33	0.27
At-rest, K_o	0.4	0.4
Passive, K_p	3.0	3.7

Table 4.3: Lateral Earth Pressure Parameters

Soil Strength Parameters	Sandy Clayey Silt	Sandy Silt
Angle of Friction φ′ (deg)	30	35
Cohesion c′ (kPa)	5	0

4.6 Earthquake Considerations

Geophysical investigation was carried out on August 12, 2025. The objective of the survey was to determine site class for seismic site response based on average shear wave velocity value measured in the upper 30 m (VS30). The multi-channel analysis of surface waves (MASW) method was used to obtain shear wave velocity profile. The VS30 values obtained from the MASW sounding varied from 410 m/s to 456 m/s with an average of 433m/s. Based on Sentence 4.1.8.4.(2b) of the National Building Code of Canada 2020 (NBC 2020), the applicable **Site Designation** is **X433** and the investigated area is in **Site Class C** (360 < VS30 ≤ 760m/s).

4.7 Underground Utility Trenches

As a part of the site development, a network of utility trenches needs to be constructed.

4.7.1 Trenching

It is expected that in most cases the trenches will be excavated through loose to compact fill/disturbed native and/or loose to very dense non-cohesive soils.

Groundwater is anticipated to be a major problem for excavating utility trenches. Any cut below the groundwater level (positive dewatering system such as well points or educators or deep wells will be required. Otherwise, it will result in an unstable excavation base and flowing sides. The groundwater table must be lowered one meter below the lowest excavation level. The test pit should be carried out in this area before the excavation to further explore the groundwater and seepage conditions. A specialized dewatering contractor should install the dewatering system. In accordance with OHSA, on-site fill above the groundwater table can be classified as Type 3 soil and the undisturbed native soils as Type 1 to Type 2 soils. Sandy seams or fill layers below the groundwater table can be classified as Type 4.

4.7.2 Bedding

The undisturbed native deposits or engineered fill will provide adequate support for the utility pipes and allow the use of normal Class B type bedding.

The recommended minimum thickness of granular bedding below the invert of the pipes is 150 mm. The thickness of the bedding may, however, have to be increased depending on the pipe diameter or in accordance with local standards or if wet or weak subgrade conditions such are encountered, especially when the soil at the trench base level consists of wet, dilatant silts, sand to silty sand The bedding material should consist of well-graded granular material such as Granular 'A' or equivalent. After installing the pipe on the bedding, a granular surround of approved bedding material, which extends at least 300 mm above the obvert of the pipe, or as set out by the local authority, should be placed.

To avoid the loss of soil fines from the subgrade, uniformly graded clear stone should not be used unless, below the granular bedding material, a suitable, approved filter fabric (geotextile) is placed. The geotextile should extend along the sides of the trench and should be wrapped all around the poorly graded bedding material.

4.7.3 Backfilling of Trenches

The existing fill (free of topsoil) and native soils can be used as general construction backfill where it can be adequately compacted with suitable type compactors.

The backfill should be placed in maximum 200 mm thick layers at or near (±2%) of the optimum water content and each layer should be compacted to at least 95% SPMDD to within 1.5 m to final subgrade. In the upper 1 m, the degree of compaction should be a minimum 98% SPMDD, except for landscape area. Unsuitable materials such as organic soils, boulders, cobbles, frozen soils, etc. should not be used for backfilling.

The on-site excavated soils should not be used in confined areas (e.g. around catch basins and laterals under roadways) where heavy compaction equipment cannot be operated. The use of imported granular fill together with an appropriate frost taper would be preferable in confined areas and around structures, such as catch basins.

4.8 Pavements

The pavement structures presented in Table 4.4 can be used for the design of proposed asphalt play areas Included in the design are areas of asphalt paving, accessible ramp associated play area, concrete and curbing

The explored fill/disturbed generally extended not more than 0.5m in boreholes. The subgrade is expected to consist of fill materials and/or native soils depending upon the proposed grades of pavement structure. The zone of influence of the pavement subgrade is generally estimated within 0.6m below the underside of the granular sub-base.

4.8.1 Ideal Conditions

Under ideal conditions, the zone of the pavement subgrade within 0.8m below the underside of the granular sub-base must be compacted to at least 95% of its Standard Proctor Maximum Dry Density (SPMDD) with moisture content 2 to 3% drier than its optimum and then the compaction should be increased to 98% of SPMDD in the upper 0.6 m of the subgrade.

4.8.2 Non-Ideal Conditions

If the proposed pathways are to be constructed during the wet seasons and if the subgrade is unsuitable then either the top 0.6m of the subgrade should be replaced with drier, compacted, select subgrade material meeting as OPSS 1010-13 or the top 0.6 m of the subgrade should be replaced with granular material

meeting the specifications defined in OPSS-1010-13. This will be assessed at the time of access roadways construction and parking area.

The existing fill/disturbed native within 0.6m from the underside of sub-base must be excavated and assessed its stability and suitability according to ideal/non-ideal conditions criteria stipulated by the local authority having jurisdiction over the project site. Depending upon evaluation either the excavated material will be re-used or if found to be unsuitable replaced with select subgrade/granular materials.

In preparation of the subgrade, prior to placement of the granular sub-base and base materials, the subgrade must be proof rolled to determine its stability and suitability for access road construction and parking area by a qualified geotechnical professional.

The recommended pavement structures provided in Table 4.4 are based upon an estimate of the subgrade soil properties determined from visual examination and textural classification of the soil samples. Consequently, the recommended pavement structures should be considered for preliminary design purposes only. A functional design life of eight to ten years has been used to establish the pavement recommendations. This represents the number of years to the first rehabilitation, assuming regular maintenance is carried out. If required, a more refined pavement structure design can be performed based on specific traffic data and design life requirements and will involve specific laboratory tests to determine frost susceptibility and strength characteristics of the subgrade soils, as well as specific data input from the client.

Table 4.4: Recommended Pavement Structure Thickness

Pavement Layer	Compaction Requirements	Light Duty Parking (Cars)	Medium Duty Parking (Occasional Service Vehicle)	Heavy Duty Parking (Delivery Trucks)
Asphaltic Concrete	92 to 96.5% Maximum Relative Density	40 mm OPSS HL 3 40 mm OPSS HL 8	40 mm OPSS HL 3 80 mm OPSS HL 8	50 mm OPSS HL 3 80 mm OPSS HL 8
OPSS Granular A Base** (or 20mm Crushed Limestone)	100% SPMDD*	150 mm	150 mm	150 mm
OPSS Granular B Type I or approved equivalent***	100% SPMDD	200 mm	250 mm	350 mm

* Denotes Standard Proctor Maximum Dry Density, ASTM-D698

** As per TS1010 recycled concrete materials are not acceptable for base material as replacement of granular A.

***An additional thickness of 50mm will be added for sub-base, if recycled concrete materials are used as granular B.

The subgrade must be compacted to 98% SPMDD for at least the upper 300 mm unless accepted by PLANET.

The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure uniform subgrade moisture and density conditions are achieved.

Alternatively, consideration should be given to the use of rigid Portland Cement Concrete pavement where there is intense truck use, parking and turning of vehicles. The following Table 4.5 provides the minimum recommended rigid pavement structure.

Table 4.5: Minimum Rigid Concrete Pavement Structure

Pavement Layer	Compaction Requirements	Heavy Duty Pavement	Light Duty Pavement
Portland Cement Concrete (CAN3-CSA A23.1) - Class C-2	CAN3-CSA A23.1	225 mm	150mm
Base Course: Granular A (OPSS 1010) or 19 mm Crusher Run Limestone	100% Standard Proctor Maximum Dry Density (ASTM-D698)	150 mm	150mm

It must be noted that this structure does not provide full protection of the subgrade from frost penetration; therefore, the pavement slabs must be separated from the building structure.

Control of surface water is an important factor in achieving a good pavement life. The need for adequate subgrade drainage cannot be over-emphasized. The subgrade must be free of depressions and sloped (preferably at a minimum grade of two percent) to provide effective drainage toward subgrade drains. Grading adjacent to the pavement areas should be designed to ensure that water is not allowed to pond adjacent to the outside edges of the pavement. Continuous pavement subdrains should be provided along both sides of the driveway/access routes and drained into respective catch basins to facilitate drainage of the subgrade and granular materials. The subdrain invert should be maintained at least 0.3 m below subgrade level. Subdrains should also be provided at all catch basins within the parking area.

Concrete should be proportioned, mixed, placed and cured in accordance with the requirements of CSA Standard CAN/CSA-A23.1-19 for class C-2 exposure, with the following key requirements:

minimum 28-day compressive strength: 32 MPa

air entrainment: 5 to 8 %

maximum water/cementing material ratio: 0.45

Concrete should be placed and spread in a manner which avoids segregation. It should be consolidated with a vibratory screed or internal vibrators. Consolidation close to form edges must be given special consideration.

Concrete should be finished with a thickness tolerance of 0 to plus 10 mm. Concrete must be cured adequately to provide durability and strength. Curing can be accomplished by wet blankets, sprinkling, plastic sheets and curing compounds. Curing should begin immediately after loss of bleed water.

Concrete pavement should be provided with joints to control stresses and prevent the formation of irregular cracks. Recommended joint spacing is 24 to 30 times slab thickness to a maximum dimension of about 4.0m. We would also recommend that load transfer dowels be placed at 50 mm spacing at the joints.

Sawed joints should be cut before random cracking occurs in the slab, usually within 6 to18 hours after concrete placement. The maximum thickness (aperture) of control joints should 6 mm, while the depth of control joints should be about 1/4th of the slab thickness.

The pavement should be closed to traffic until a minimum flexural strength of 2 MPa is attained or an approximate compressive strength of 20 MPa. This minimum strength is generally reached when the concrete can be sawcut without ravelling.

Additional comments on the construction of parking areas and access roadways are as follows:

1. Removal of all fill for pavement is not necessary. As part of the subgrade preparation, proposed parking and play areas and access roadways should be stripped fill at least in the upper 0.8 m below grade and surficially softened native soils and the base then should be thoroughly proof rolled by using a loaded truck. Unstable areas or areas with excessive organic materials should be further sub-excavated. The fill required to raise the grade can consist of inorganic soil, placed in shallow lifts and compacted to minimum 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

2. The locations and extent of sub-drainage required within the paved areas should be reviewed by this office in conjunction with the proposed lot grading. Assuming that satisfactory crossfalls in the order of two percent have been provided, subdrains extending from and between catch basins may be satisfactory. In the event that shallower crossfalls are considered, a more extensive system of sub-drainage may be necessary and should be reviewed by PLANET.

3. The above pavement structure considers that construction will be carried out during the dry period of the year. If the subgrade becomes excessively wet or rutted during construction activities, additional sub-base material or placement of geogrids may be required. The need for additional sub-base material and/or placement of geogrids including filter fabric to stabilize the base is best determined during construction. It is recommended that the existing subgrade be heavily proof rolled prior to placement and any areas showing excessive deflection be replaced prior to placing the granular sub-base material.

4. It is recommended that PLANET be retained to review the final pavement structure designs and drainage plans prior to construction to ensure that they are consistent with the recommendations.

4.8.3 Stripping, Sub-excavation and Grading

The final subgrade should be cambered or otherwise shaped properly to facilitate rapid drainage and to prevent the formation of local depressions in which water could accumulate.

Owing to the clayey (i.e. impervious) nature of the subsoil at some locations of the site, proper cambering and allowing the water to escape towards the sides (where it can be removed by means of subdrains) is considered to be beneficial for this project. Otherwise, any water collected in the granular sub-base materials could be trapped thus causing problems due to softened subgrade, differential frost heave, etc. For the same reason damaging the subgrade during and after placement of the granular materials by heavy construction traffic should be avoided. If the moisture content of the local material cannot be maintained at ±2% of the optimum moisture content, imported granular material may need to be used.

Any fill required regarding the site or backfill should be select, clean material, free of topsoil, organic or other foreign and unsuitable matter. The fill should be placed in thin layers and compacted to at least 95% of its SPMDD. The degree of compaction should be increased to 98% within the top 1.0 m of the subgrade, or as per City Standards. The compaction of the new fill should be checked by frequent field density tests.

The native deposit may contain larger particles (cobbles and boulders) that are not specifically identified in the boreholes. The size and distribution of such obstructions cannot be predicted with borings, because the borehole sampler size is insufficient to secure representative samples of the particles of this size. Provision should be made in excavation contracts to allocate risks associated with time spent and equipment utilized to remove or penetrate such obstructions when encountered.

The undisturbed native soil deposit at the site predominantly consists of silty sand with trace to some clay. Based on the borehole and water level data as well as estimated underside of excavation is not expected

to extend below the prevailing ground water table, therefore, there is no significant water seepage expected in relatively shallow excavations, except for relatively limited amounts of perched ground water which may be present in wet silt/sand lenses within native soils. Any ground water seepage encountered should diminish slowly and can be controlled by continuous pumping from a conventional sump and pump arrangement at the base of the excavation.

It is noted that the native soils tend to weather rapidly and deteriorate when exposed to the atmosphere and water. Therefore, any excavation base that remains open for an extended period should be protected with a skim coat of lean concrete.

During and at the completion of drilling, no ground water was observed in any of the boreholes. Perched water may be encountered in excavated areas during wet seasons. A perched water condition can occur due to the accumulation of surface water in the more pervious fill overlying less pervious deposit, or at the interface of fill and native soils, especially during wet periods. Note that the groundwater level can vary and is subject to seasonal fluctuations and in response to major weather events. The depth of groundwater table can also be influenced by the presence of underground features such as utility trenches, and this may affect the construction procedures, costs and schedules. Wet soils may be encountered to about 0.6 m higher than the water levels noted due to capillary rise in fine cohesionless soils. It should be noted that excavations carried through and below the water bearing cohesionless soils (sand, silt), will experience loosening and sloughing of the sides and/or unstable base, thus requiring relatively flatter excavation slopes.

4.8.4 Construction

Once the subgrade has been inspected and approved, the granular base and sub-base course materials should be placed in layers not exceeding 200 mm (uncompacted thickness) and should be compacted to at least 100% of their respective SPMDD. The grading of the material should conform to current OPS Specifications.

The placing, spreading, and rolling of the asphalt should be in accordance with OPS Specifications or, as required by the local authorities.

Frequent field density tests should be carried out on both the asphalt and granular base and sub-base materials to ensure that the required degree of compaction is achieved.

4.8.5 Drainage

All paved surfaces should be sloped to provide satisfactory drainage towards catch basins. Installation of full-length subdrains on all roads is recommended. The subdrains should be properly filtered to prevent the loss of (and clogging by) soil fines.

4.9 Geotechnical Review

It is recommended that the project design drawings be submitted to PLANET for review for compatibility with site subsurface conditions and the recommendations contained in this report.

4.10 Percolation Test Memo

The percolation test memo, including recommendations regarding the long-term percolation capacity is presented in Appendix E

4.11 Engineered Fill and Sub-Excavation

Detailed site grading plans for the proposed development were not available to us at the time of preparation of this report. In the areas where earth fill is required for site grading purposes, engineered fill can be used and similarly, if the area under consideration need to be raised, engineered fill can be used.

Prior to the placement of the engineered fill, all of the existing fill, the loose possible fill/disturbed soil, and surficially softened native soils must be removed and the exposed surface proof rolled. Any soft spots revealed during proof rolling must be sub-excavated and re-engineered. The depths of sub-excavation required for the construction of engineered fill will be assessed by a geotechnical professional at the time of excavation.

General guidelines for the placement and preparation of engineered fill are presented on Appendix “C”. A geotechnical reaction of 100 to 150 kPa (2000 to 3000 psf) at the Serviceability Limit States (SLS) and factored geotechnical resistances of 150 to 225 kPa at the Ultimate Limit States (ULS) can be used on engineered fill, provided that all requirements on Appendix “C” are adhered to. To reduce the risk of improperly placed engineered compacted fill, full-time supervision of the contractor is essential. Despite full time supervision, it has been found that contractors frequently bulldoze loose fill into areas and compact only the surface. The inspector, either busy on other portions of the site or absent during “off hours” will be unaware of this condition. For this reason, we cannot guarantee the performance of the engineered fill, and this guarantee must be the responsibility of the contractor. The owner and his representatives must accept the risk involved in the use of engineered fill and offset this risk with the monetary savings of avoiding deep foundations/soil improvement. This potential problem must be recognized and discussed at a pre-construction meeting. Procedures can then be instigated to reduce the risk of settlement resulting from un-compacted fill.

The following is a recommended procedure for engineered fill:

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained, and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages (if applicable), etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and PLANET Engineering Inc. Without this confirmation no responsibility for the performance of the structure can be accepted by PLANET Engineering Inc. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by PLANET Engineering Inc engineer prior to placement of fill.

5. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur.

6. Full-time geotechnical inspection by PLANET Engineering Inc during placement of engineered fill is required. Work cannot commence or continue without the presence of the PLANET representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. A geotechnical reaction of 100 to 150 kPa (2000 to 3000 psf) may be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings should be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

10. After completion of the pad a second contractor may be selected to install footings. All excavations must be backfilled under full time supervision by PLANET to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of PLANET.

11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the PLANET`s geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

5 GENERAL COMMENTS

The recommended bearing capacities (Geotechnical Reaction) and the corresponding founding elevations would need to be confirmed by the representative of PLANET during construction. It should be noted that the recommended bearing capacities have been calculated by PLANET from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by PLANET to validate the information for use during the construction.

In this regard, PLANET should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, PLANET will assume no responsibility for interpretation of the recommendations in the report.

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information in this report in no way reflects any of the environmental aspects of the soil condition at the site and has not been specifically addressed in this report, since this aspect was beyond the scope and terms of reference.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

For and on behalf of PLANET Engineering Inc

For and on behalf of Planet Engineering Inc (HLV2K Engineering Ltd)



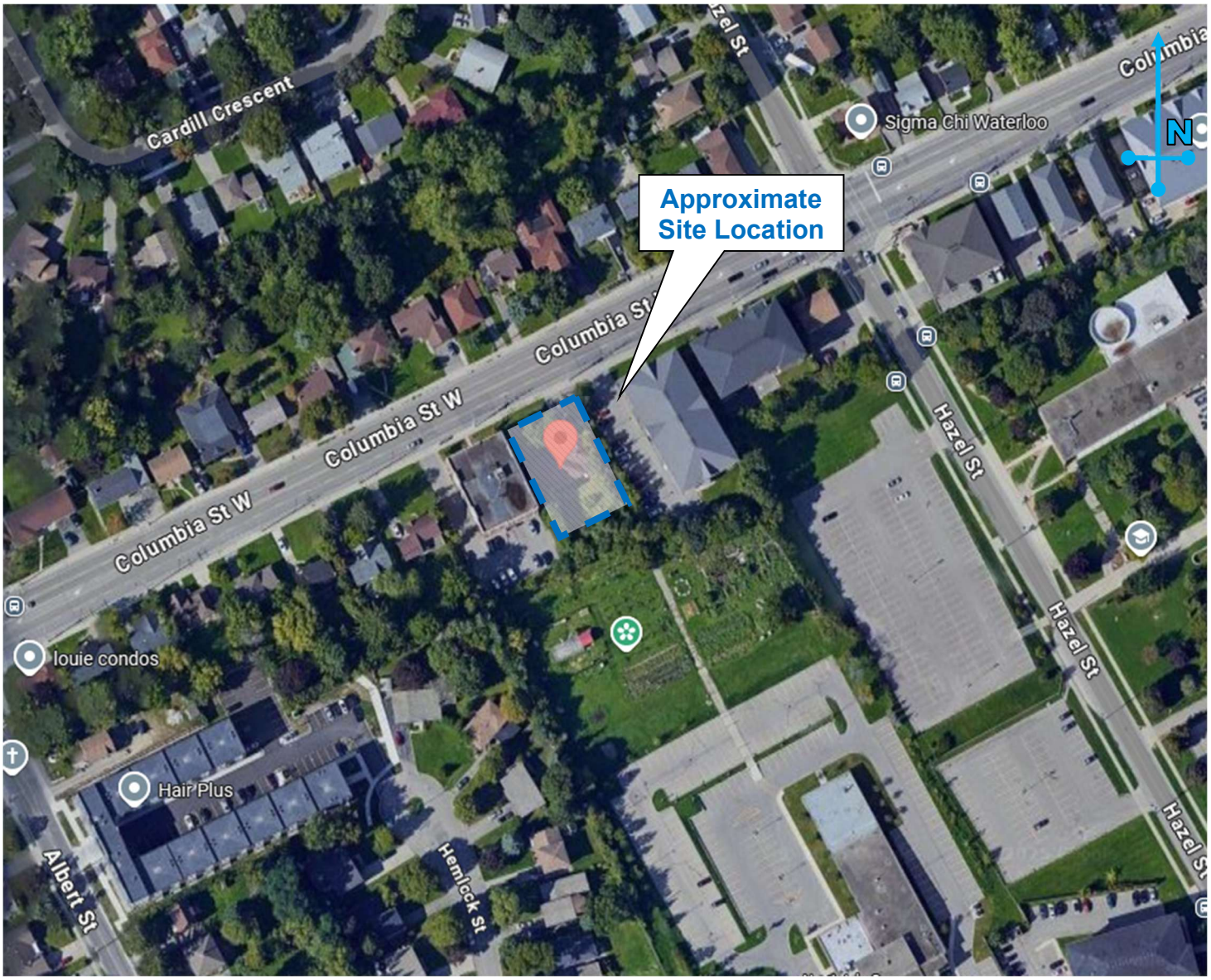
Haseeb Hasan, M.Eng.
Project Manager





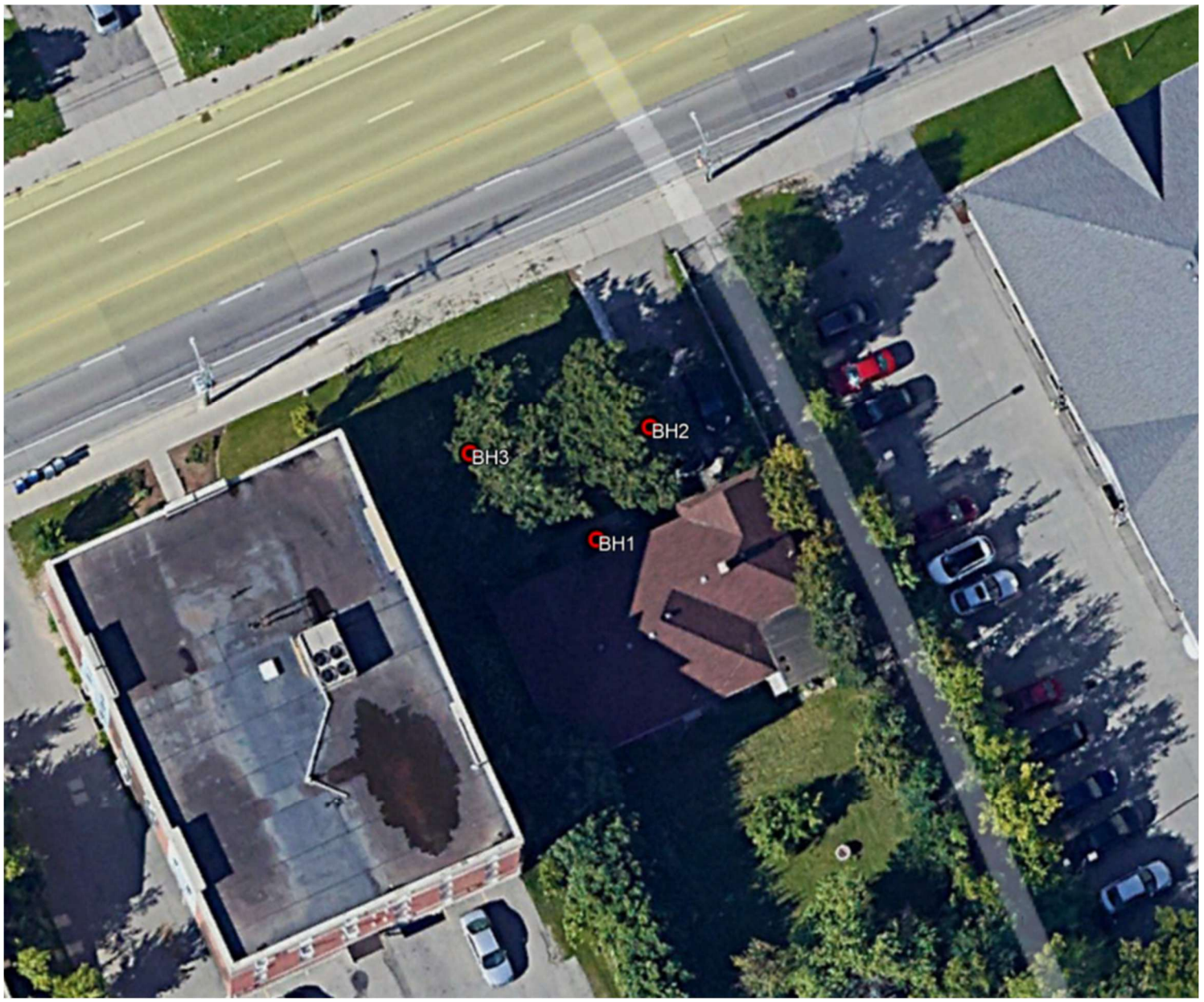
Irfan Khokhar, Ph.D., P.Eng.
Principal Geotechnical Engineer

DRAWINGS



SITE LOCATION PLAN

Drawn By: ZA	Project: **GEOTECHNICAL INVESTIGATION** **FOR THE PROPOSED MULTI-UNIT RESIDENTIAL (STUDENT HOUSING) DEVELOPMENT** **79 COLUMBIA STREET WEST, WATERLOO, ONTARIO**	Date: July 28, 2025
Approved By: IK		Project No: 2501194AG
PLANET ENGINEERING Inc. Consulting Engineers	Client: **Tuan Hoang**	Drawing No 1



BOREHOLE LOCATION PLAN

Drawn By: ZA	Project: **GEOTECHNICAL INVESTIGATION** **FOR THE PROPOSED MULTI-UNIT RESIDENTIAL (STUDENT HOUSING) DEVELOPMENT** **79 COLUMBIA STREET WEST, WATERLOO, ONTARIO**	Date: July 28, 2025
Approved By: IK		Project No: 2501194AG
PLANET ENGINEERING Inc. Consulting Engineers	Client: **Tuan Hoang**	Drawing No 1A

Drawing 1B: Notes on Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by PLANET Engineering Inc also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002 0.006 0.02 0.06 0.2 0.6 2.0 6.0 20 60 200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

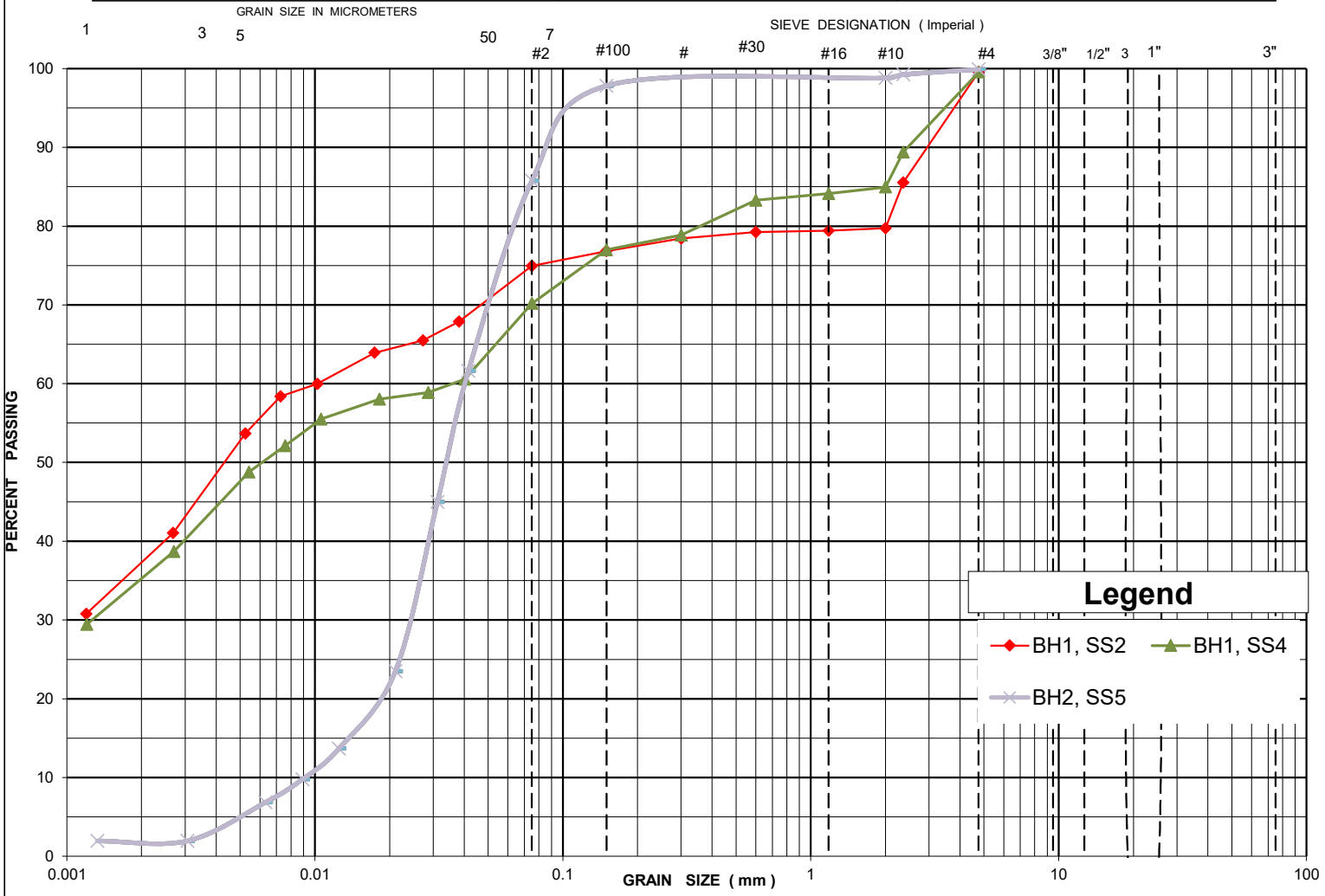
UNIFIED SOIL CLASSIFICATION

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advice of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

UNIFIED SOIL CLASSIFICATION SYSTEM LS 702/D 422

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



PLANET ENGINEERING Inc.
Consulting Engineers

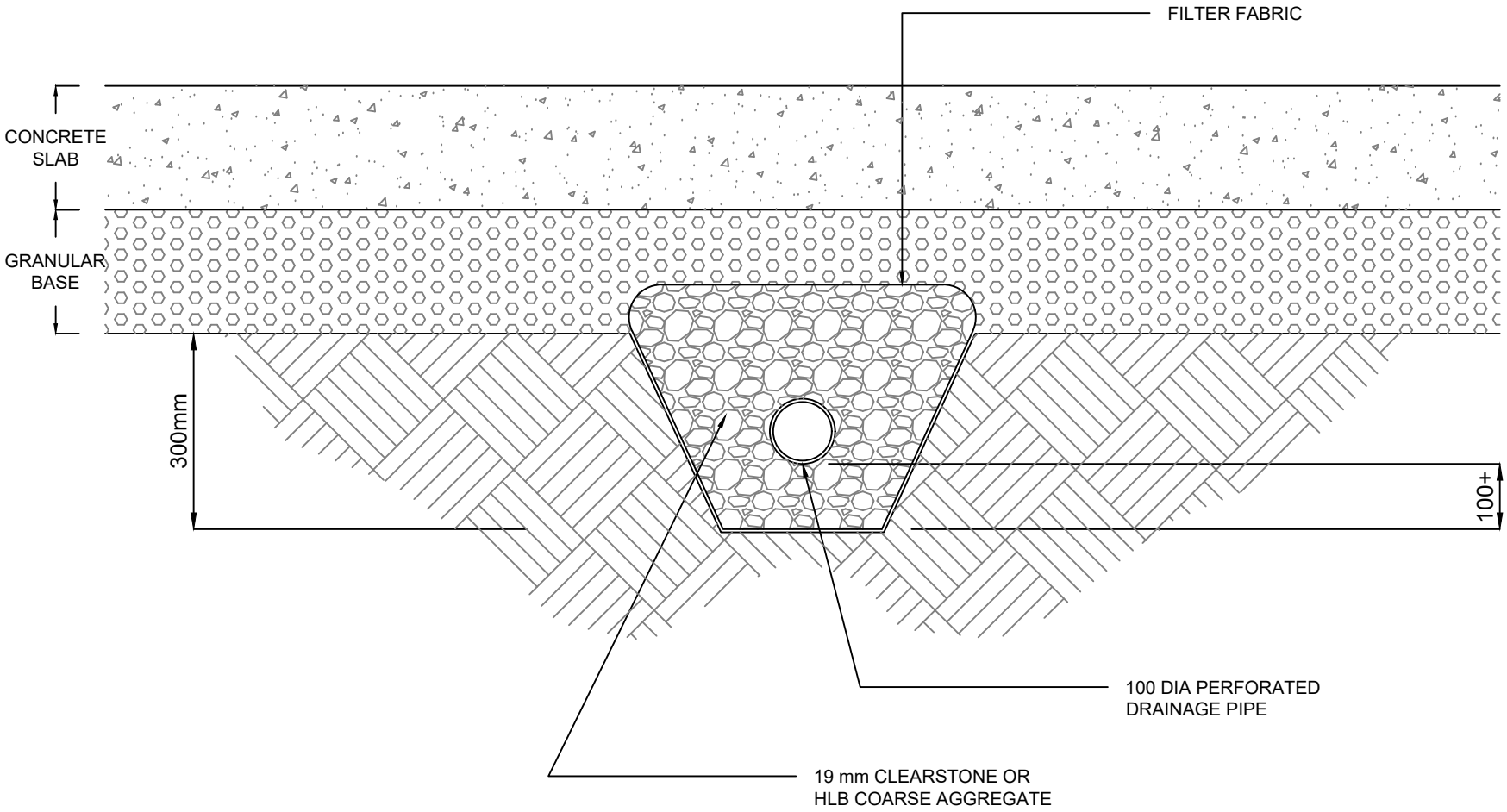
GRAIN SIZE DISTRIBUTION

Drawing No : 2

PROJECT # : 2501194AG

DATE : July 28, 2025

Drawing No. 3

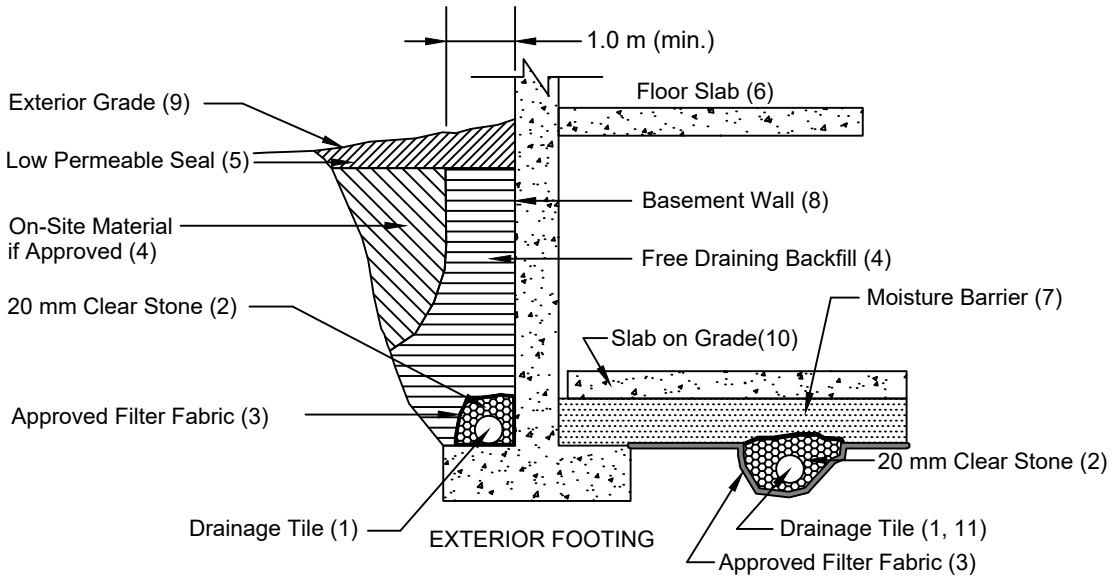


PLANET ENGINEERING Inc.
Consulting Engineers

Title:

UNDERFLOOR SUBDRAINS

Drawing No. 4



Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place100 mm (4 inches) of stone below drain .
3. Wrap the clear stone with an approved filter fabric (Terrafix 270R or equivalent).
4. Free Draining backfill - OPSS Granular B or equivalent compacted to the specified density. Do not use heavy compaction equipment within 450 mm (18") of the wall. Use hand controlled light compaction equipment within 1.8 m (6') of wall. The minimum width of the Granular 'B' backfill must be 1.0 m.
5. Low permeable backfill seal - compacted clay, clayey silt or paved with concrete/asphalt or equivalent. If original soil is free-draining, seal may be omitted. Maximum thickness of seal to be 0.5 m.
6. Do not backfill until wall is supported by basement and floor slabs or adequate bracing.
7. Moisture barrier to be at least 200 mm (8") of compacted clear 20 mm (3/4") stone or equivalent free draining material. A vapour barrier may be required for specialty floors.
8. Basement wall to be damp proofed for parking garage and water proofed for finished basement.
9. Exterior grade to slope away from building.
10. Typically slab on grade is not structurally connected to the wall or footing. However, if it is connected to the wall, it should be designed accordingly.
11. Underfloor drain invert to be at least 300 mm (12") below underside of floor slab.
12. Drainage tile placed in parallel rows 6 to 8 m (20 to 25') centers one way. Place drain on 100 mm (4") clear stone with 150 mm (6") of clear stone on top and sides. Enclose stone with filter fabric as noted in (3).
13. The entire subgrade to be sealed with approved filter fabric (Terrafix 270R or equivalent) if non-cohesive (sandy) soils below ground water table encountered.
14. Do not connect the underfloor drains to perimeter drains.
15. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE AND BACKFILL RECOMMENDATIONS
Basement with Underfloor Drainage
(not to scale)

PLANET ENGINEERING Inc.
Consulting Engineers

Title:

BACKFILL-BASEMENT-OPENCUT-WITHOUT GEOTEXTILE-MODEL DRAINAGE

APPENDICES

Appendix A:
Limitations of Report

Limitations of Report

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to PLANET Engineering Inc. at the time of preparation. Unless otherwise agreed in writing by PLANET Engineering Inc, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

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. PLANET Engineering Inc accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time. Any user of this report specifically denies any right to claims against the Consultant, Sub-Consultants, their officers, agents and employees in excess of the fee paid for professional services.

Appendix B:
Borehole Logs

PLANET ENGINEERING Inc. Consulting Engineers

LOG OF BOREHOLE BH1

PROJECT: Geotechnical Investigations

CLIENT: Tuan Hoang

PROJECT LOCATION: 79 Columbia Street West, Waterloo, Ontario

DATUM: Geodetic

BH LOCATION: N 4814142.103 E 537778.242

DRILLING DATA

Method: Solid Stem Auger

Diameter: 150mm

Date: Jul-22-2025

REF. NO.: 2501194AG

DRAWING NO.: 1

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
219.3						
219.1 0.0	**Topsoil:** 200mm					
0.2 218.8	**Fill/Disturbed Native:** sandy silty clay, trace gravel, rootlets, brown, very moist, stiff	1	SS	12	219	
0.5	**Sandy Clayey Silt:** trace gravel, trace rootlets, brown, wet, stiff to very stiff	2	SS	10		1 24 39 36
		3	SS	19	218	
216.3		4	SS	21	217	1 29 36 34
3.1	**Sandy Silt:** trace clay, trace gravel, brown, very moist, compact to dense	5	SS	32	216	
		6	SS	43	215	
		7	SS	19	214	
		8	SS	41	213	
		9	SS	29	212	
209.6					211	
9.8	**End of Borehole:** borehole terminated at 9.7 m Upon completion: 1) Cave-in: open 2) Water: 3.5mbgs				210	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ $^{\varepsilon}$=3% Strain at Failure

PLANET ENGINEERING Inc. Consulting Engineers

LOG OF BOREHOLE BH2

PROJECT: Geotechnical Investigations

CLIENT: Tuan Hoang

PROJECT LOCATION: 79 Columbia Street West, Waterloo, Ontario

DATUM: Geodetic

BH LOCATION: N 4814149 E 537781.558

DRILLING DATA

Method: Solid Stem Auger

Diameter: 150mm

Date: Jul-22-2025

REF. NO.: 2501194AG

DRAWING NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
219.3					
219.0 0.3	**Asphalt:** 50mm		GR		
218.8 0.5	**Fill:** sand and gravel, trace silt, brown, very moist, loose	1	SS	6	219
1	**Fill/Disturbed Native:** sandy silty clay, trace gravel, trace rootlets, brown, very moist, firm	2	SS	10	
	Sandy Clayey Silt: trace gravel, trace rootlets, brown, wet, firm to stiff	3	SS	6	218
2 217.0					
2.3	**Sandy Silt:** trace clay, trace gravel, brown, wet to very moist, loose to very dense	4	SS	7	217
3		5	SS	36	216
4					215
5		6	SS	61	
6					214
		7	SS	35	213
7 212.0		8	SS	50 / 100mm	212
7.3	**End of Borehole:** borehole terminated at 7.3 m Upon completion: 1) Cave-in: open 2) Water: 5.5mbgs				

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH (kPa) (20 40 60 80 100)
- ○ UNCONFINED
- ● QUICK TRIAXIAL
- + FIELD VANE & Sensitivity
- × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
1	13	84	2

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

PLANET ENGINEERING Inc. Consulting Engineers

LOG OF BOREHOLE BH3

PROJECT: Geotechnical Investigations

CLIENT: Tuan Hoang

PROJECT LOCATION: 79 Columbia Street West, Waterloo, Ontario

DATUM: Geodetic

BH LOCATION: N 4814147.23 E 537770.615

DRILLING DATA

Method: Solid Stem Auger

Diameter: 150mm

Date: Jul-22-2025

REF. NO.: 2501194AG

DRAWING NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS "N" 0.3 m	GROUND WATER CONDITIONS	ELEVATION
219.3							
219.0 / 0.2	**Topsoil:** 150mm						
218.9 / 0.4	**Fill/Disturbed Native:** sandy silty clay, trace gravel, trace rootlets, brown, very moist, stiff		1	SS	11		219
1	**Sandy Clayey Silt:** trace gravel, trace rootlets, brown, very moist to wet, stiff to hard		2	SS	14		218
2			3	SS	23		
3			4	SS	19		217
215.6			5	SS	46		216
3.7	**Sandy Silt:** trace clay, trace gravel, brown, wet, compact to very dense						
4							215
5			6	SS	26		
6							214
			7	SS	50 / 125mm		213
7							
8							212
211.1			8	SS	79		
8.2	**End of Borehole:** borehole terminated at 8.2 m Upon completion: 1) Cave-in: open 2) Water: 4.2mbgs						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH (kPa) (20 40 60 80 100)
- ○ UNCONFINED
- ● QUICK TRIAXIAL
- + FIELD VANE & Sensitivity
- × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

Appendix C:

General Requirements for Engineered Fill

GENERAL REQUIREMENTS FOR ENGINEERED FILL

Compacted imported soil that meets specific engineering requirements and is free of organics and debris and that has been continually monitored on a full-time basis by a qualified geotechnical representative is classified as engineered fill. Engineered fill that meets these requirements and is bearing on suitable native subsoil can be used for the support of foundations.

Imported soil used as engineered fill can be removed from other portions of a site or can be brought in from other sites if suitable. In general, most of Ontario soils are too wet to achieve the 100% Standard Proctor Maximum Dry Density (SPMDD) and will require drying and careful site management if they are to be considered for engineered fill. Imported non-cohesive granular soil is preferred for all engineered fill. For engineered fill, Planet Engineering Inc (PLANET) recommends use of OPSS Granular 'B' sand and gravel fill material only.

Adverse weather conditions such as rain make the placement of engineered fill to the required degree of density difficult or impossible; engineered fill should not be placed during freezing conditions, i.e. normally not between December 15 and April 1 of each year. If the project demands placement of engineered fill in winter (December 15- April1) it can be placed only under the following conditions:

- All frozen material and or snow must be removed before placement of engineered fill on a daily basis
- Only Granular B Type 2 or Granular A (including crushed concrete or crushed limestone)
- The fill placement must be supervised on a full time basis by a geotechnical consultant

The location of the foundations on the engineered soil pad is critical and certification by a qualified surveyor that the foundations are within the stipulated boundaries is mandatory. Since layout stakes are often damaged or removed during fill placement, offset stakes must be installed and maintained by the surveyors during the course of fill placement so that the contractor and engineering staff are continually aware of where the engineered fill limits lie. Foundations placed within the engineered soil pad must be backfilled with the same conditions and quality control as the original pad.

To perform satisfactorily, engineered fill requires the cooperation of the designers, engineers, contractors and all parties must be aware of the requirements. The minimum requirements are as follows, however, the geotechnical report must be reviewed for specific information and requirements.

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and Planet Engineering Inc. Without this confirmation no responsibility for the performance of the structure can be accepted by Planet Engineering Inc. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by an engineer from Planet Engineering Inc. prior to placement of fill.

5. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur and should be evaluated prior to placing the fill.

6. Full-time geotechnical inspection by Planet Engineering during placement of engineered fill is required. Work cannot commence or continue without the presence of Planet Engineering representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. The allowable bearing pressure provided in the accompanying report may be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings must be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

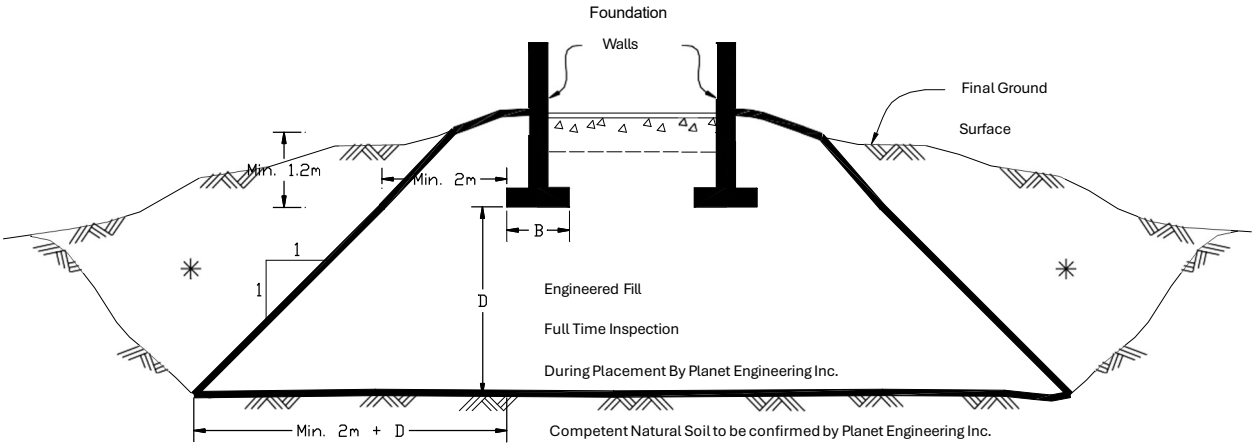
10. After completion of the pad a second contractor may be selected to install footings. The prepared footing bases must be evaluated by engineering staff from Planet Engineering Inc. prior to footing concrete placements. All excavations must be backfilled under full time supervision by Planet Engineering Inc. representative to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of Planet Engineering Inc.

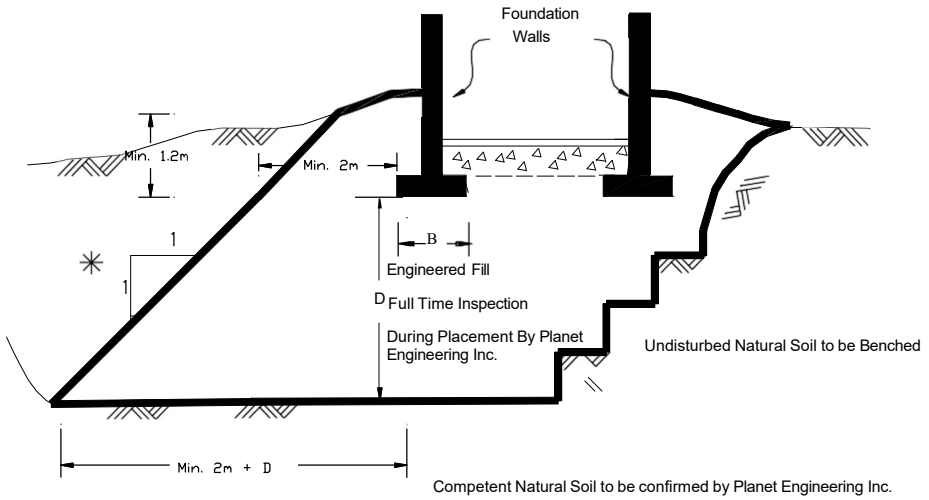
11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost. During the course of fill placement, the engineered fill must be smooth-graded, proof rolled and sloped/crowned at the end of each day, prior to weekends and any stoppage in work in order to promote rapid runoff of rainwater and to avoid any ponding surface water. Any stockpiles of fill intended for use as engineered fill must also be smooth-bladed to promote runoff and/or protected from excessive moisture take up.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

13. The geometry of the engineered fill as illustrated in these General Requirements is general in nature. Each project will have its own unique requirements. For example, if perimeter sidewalks are to be constructed around the building, then the projection of the engineered fill beyond the foundation wall may need to be greater.

14. These guidelines are to be read in conjunction with Planet Engineering Inc. report attached.

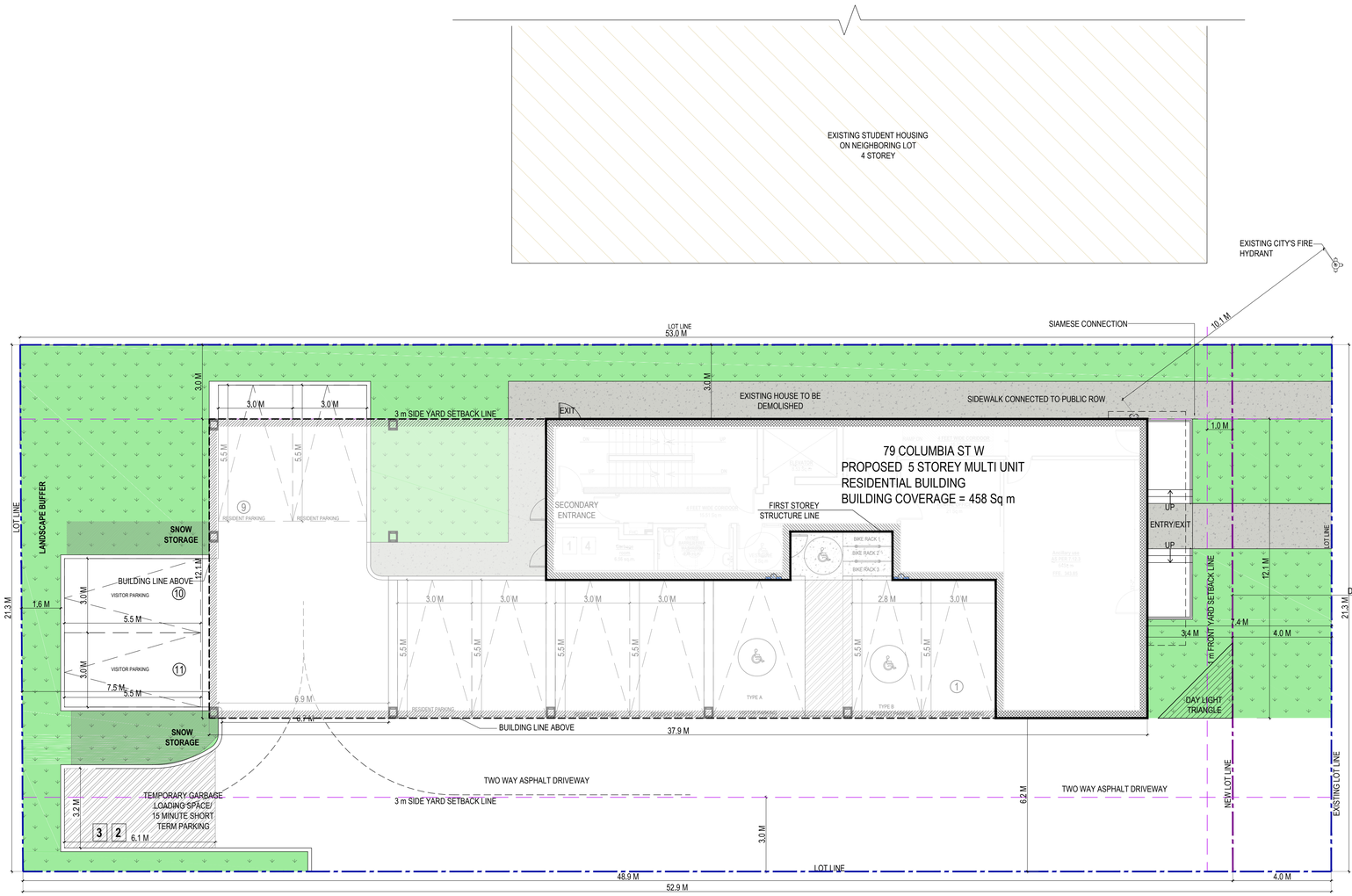




✳ Backfill in this area to be as per the Planet Engineering Inc. report

Appendix D:

Proposed Site Plan Provided by the Client



01 SITE PLAN

1:100

SITE SUMMARY / ZONING MATRIX:			
ZONING:	RESIDENTIAL NORTHDALE EIGHT (RN-8)		
REGULATIONS AS PER ZONING BYLAW 2018-050	**REQUIRED**	**PROVIDED**	**COMPLIES YES/NO**
LOT AREA (minimum)	1,000 Sq m	1041 Sq m	Yes
LOT FRONTAGE (Convertible)	1.0 metres(minimum) 75% FACADE (within 5 metres)		Yes
SETBACKS:			
FRONT (NORTH) SETBACK	MIN - 1 metres MAX - 3 metres	1.0 m	Yes
SIDE YARD (EAST SETBACK)	3.0 metres	6.0 m	Yes
SIDE YARD (WEST SETBACK)	3.0 metres	3.0 m	Yes
REAR YARD (SOUTH) SETBACK	7.5 metres	7.5 m	Yes
DENSITY (RES. UNITS / HA)	450 BEDROOMS PER HECTARE 51 bedrooms	51 bedrooms	Yes
HEIGHT	08 STOREYS 27.5 metres	05 STOREYS 20.54 m	Yes
NUMBER OF FIRST STOREY ENTRANCES (minimum)	1 PER 15 metres BUILDING FACADE	02	Yes
AMENITY AREA (MINIMUM AS PER TABLE 7R)	3 sq m for first bedroom and 2 sq m for each additional bedroom 117 sq.m	126 Sq. m INDOOR AMENITY	Yes
LANDSCAPED OPEN SPACES (minimum)	30% 312.3 Sq. m	29.42% 306.35 Sq. m	No
TOTAL CAR PARKING	No minimum required MTSA's	11 CAR SPACES	Yes
BICYCLE PARKING	Residential = .25 per Bedroom = 13 Non-Residential = 1 / 100 sq m= .62	14	Yes
NUMBER OF DRIVEWAYS	1 per lot	01	Yes
TOTAL NON RESIDENTIAL AREA	ancillary+ rental office	62 Sq. m + 21 Sq. m 83 Sq m	Yes
ANCILLARY USES	15% of building floor area = 343.2 Sq m	62 Sq. m	Yes
BUILDING FLOOR AREA DEVOTED TO USES DEFINED UNDER SECTION 7.12.9.2	30% MAX 55.2 Sq m	25.99% MAX 46.71 Sq m	Yes

BUILDING FLOOR AREAS		NO. OF 2 BEDROOMS UNIT	NO. OF 5 BEDROOMS UNIT	TOTAL BEDROOMS
BASEMENT FLOOR	231 Sq m	0	0	0
FIRST FLOOR	184 Sq m	0	0	0
SECOND FLOOR	453 Sq m	2	2	14
THIRD FLOOR	448 Sq m	2	2	14
FOURTH FLOOR	448 Sq m	2	2	14
FIFTH FLOOR	453 Sq m	2	1	09
		0	0	0
TOTAL BUILDING FLOOR	2217 Sq. m	8	7	TOTAL - 51

GARBAGE MANAGEMENT PLAN

1. TENANTS OF DEVELOPMENT WILL CARRY WASTE / RECYCLING TO GARBAGE ROOM ON GROUND FLOOR AND PLACE IN BINS.
2. THE GARBAGE CONTAINERS WILL BE TEMPORARILY RELOCATED BY FACILITY MANAGEMENT TO THE LOADING SPACE EACH WEEK FOR COLLECTION (OR AS NEEDED)
3. GARBAGE CONTAINERS WILL BE EMPTIED AND THEIR CONTENT COLLECTED AND REMOVED FROM PREMISES BY PRIVATE CONTRACTOR
4. AFTER PICKUP, GARBAGE CONTAINERS WILL BE IMMEDIATELY REMOVED FROM THE LOADING SPACE AND STORED IN THE GARBAGE ROOM

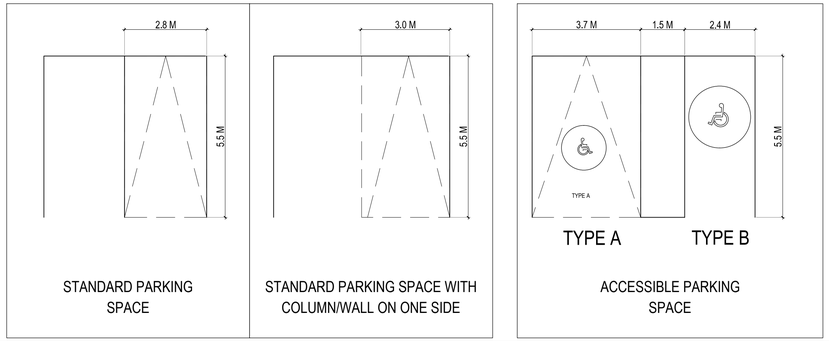
Note: All proposed signs shall be in accordance with the City's Sign By-law.

	Rb-93 ACCESSIBLE PARKING
	EXISTING WATER HYDRANT
	EXISTING LOT LINE
	NEW LOT LINE
	SETBACK LINE

TRUE NORTH

PROJECTED NORTH

TYPICAL PARKING DETAIL WITH DIMENSIONS



FILE # PC-24-07

R0	ZBA	2024-10-03

PROJECT NAME AND ADDRESS :

PROPOSED 5 STOREY MULTI-UNIT RESIDENTIAL AT 79 COLUMBIA ST W, WATERLOO, ON

LEAD CONSULTANT :

technoarch
architects + designers
Unit-214 - 2550 Matheson Blvd East,
Mississauga, Ontario, Canada L4W 4Z1
Tel : +1-905-792-0038
Email: hbhons@technoarch.ca
www.technoarch.ca

DRAWING TITLE :

SITE PLAN + ZONING MATRIX

DRAWN BY	SM
CHECKED BY	DT
APPROVED BY	HB
SCALE 1:100	SIZE 36" X 24"
SHEET NO A1.0	STAGE ZBA
PHASE 00	REV R0
ISSUED DATE	2024-10-03

Appendix E:
Percolation Memo

PLANET ENGINEERING Inc.
Consulting Engineers

MEMO

To:

Tuan Hoang
107 Meadowbank Rd
Etobicoke, Ontario M9B 5E1
hoanganhtuan17@gmail.com

Copies:

From:

Kourosh Mohammadi, Ph.D. P.Eng.

Date:

August 15, 2025

Planet Project No.:

2501194AG

Subject:

Percolation Rate Estimates at 79 Columbia Street West, Waterloo, Ontario

1 INTRODUCTION

Planet Engineering Inc. (PLANET) was retained by Tuan Hoang (the Client) to estimate the percolation rate at 79 Columbia Street West, Waterloo, Ontario (the Site). PLANET conducted a geotechnical investigation for this Site (Planet, 2025). As part of the investigation, PLANET drilled three (3) boreholes to depths between 7.3 m and 9.8 m below ground surface (mbgs). A soil sample collected from BH1 at the approximate depth of 1.2 mbgs (BH1-SS2) was selected and the grain size distributions were analyzed in the PLANET laboratory. The grain size distributions are provided in **Attachment A**.

2 PERCOLATION RATE ESTIMATION

2.1 Ontario Building Code Graphs

The gradation graphs, provided in **Attachment A**, were used to estimate the percolation time. Using "Supplementary Standard SB-6 for Percolation Time and Soil Descriptions in Building Code (September 14, 2012)", the soil falls in the soil category of CL which is silty clay to sandy clay with a percolation time of over 50 min/cm. The estimated hydraulic conductivity of this soil is from 10^{-6} cm/sec or less.

2.2 Using Particle Size Data

2.2.1 Kozeny-Carmen Formula

An equation attributed to Kozeny and Carmen (Freeze and Cherry 1979; Rosas et al. 2014) may be used to estimate the saturated hydraulic conductivity of sediments and soils:

$$K = \left(\frac{\rho g}{\mu}\right)\left[\frac{n^3}{(1-n)^2}\right]\left(\frac{D_{10}^2}{180}\right)$$

Where K is hydraulic conductivity [m/s], C is an empirical coefficient equal to 1/180 [dimensionless], g is gravitational acceleration [m/s²], μ is viscosity of water [Pa-s] and n is total porosity [dimensionless]. D_{10} is measured in m.

The Kozeny-Carmen formula is assumed valid for sediments and soils composed of silt, sand and gravelly sand. Using the D_{10} = 0.0001 mm and soil porosity of 0.4, the estimate K is **9.7×10^{-7} cm/s**.

2.2.2 USBR Formula

The United States Bureau of Reclamation (1978, as reported in Vukovic and Soro, 1992) developed a relationship shown in Equation Box 4-11 for medium sands with a uniformity coefficient of less than 5.

$K = C\ (D_{20}^{2.3})$

where:

K = Estimated hydraulic conductivity in centimeters per second (cm/sec)

C = Empirical coefficient (ranges from 3.5 to 4.0 for sandy soils)

D_{20} = Grain size in centimeters (D_{20} finer-than) (cm)

Using USBR formula and C=3.8 and D20 = 0.0005 mm, the estimated saturated hydraulic conductivity is **9.7×10^{-7} cm/s**.

2.2.3 Estimating Percolation Rate

An estimate of the percolation rate for the Site was produced based on accepted literature values from the Ontario Ministry of Municipal Affairs and Housing (OMMAH) Supplementary Guidelines to the Ontario Building Code 2012 and provided in the Low Impact Development Stormwater Management Planning and Design Guide, Appendix C (TRCA/CVC, 2010) and Wet Weather Flow Management Guidelines (City of Toronto, 2006). The empirically derived relationship is as follows:

$K_{sat} = 6 \times 10^{-11} I^{3.7363}$

Where:

K_{sat} = hydraulic conductivity (cm/sec)

I = Percolation rate (mm/hr).

Based on the saturated hydraulic conductivity calculated using both Kozeny-Carmen formula and USBR formula yield an estimate of 4 mm/hour.

3 CONCLUSION

It is recommended to adopt the average infiltration rate of **4 mm/hour** for design purposes, which correspond to a percolation time of 150 min/cm.

4 LIMITATIONS

Planet Engineering Inc. has performed this site assessment in accordance with generally accepted professional practices and procedures at the time of the assessment. These services are not subject to any express or implied warranties and none should be inferred.

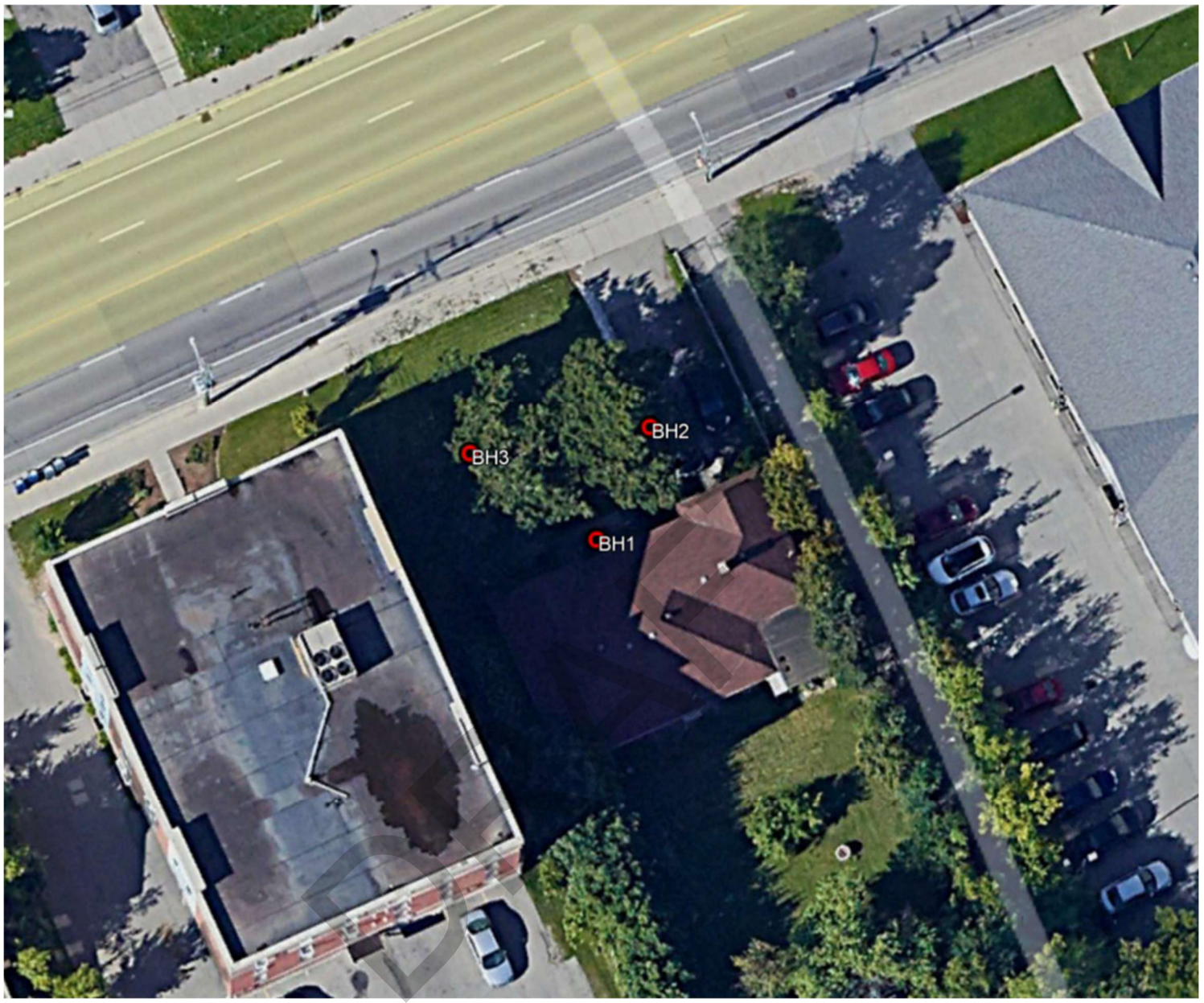
For and on behalf of Planet Engineering Inc.



Kourosh Mohammadi, Ph.D., P.Eng.

Principal Hydrogeological Engineer

FIGURES



BOREHOLE LOCATION PLAN

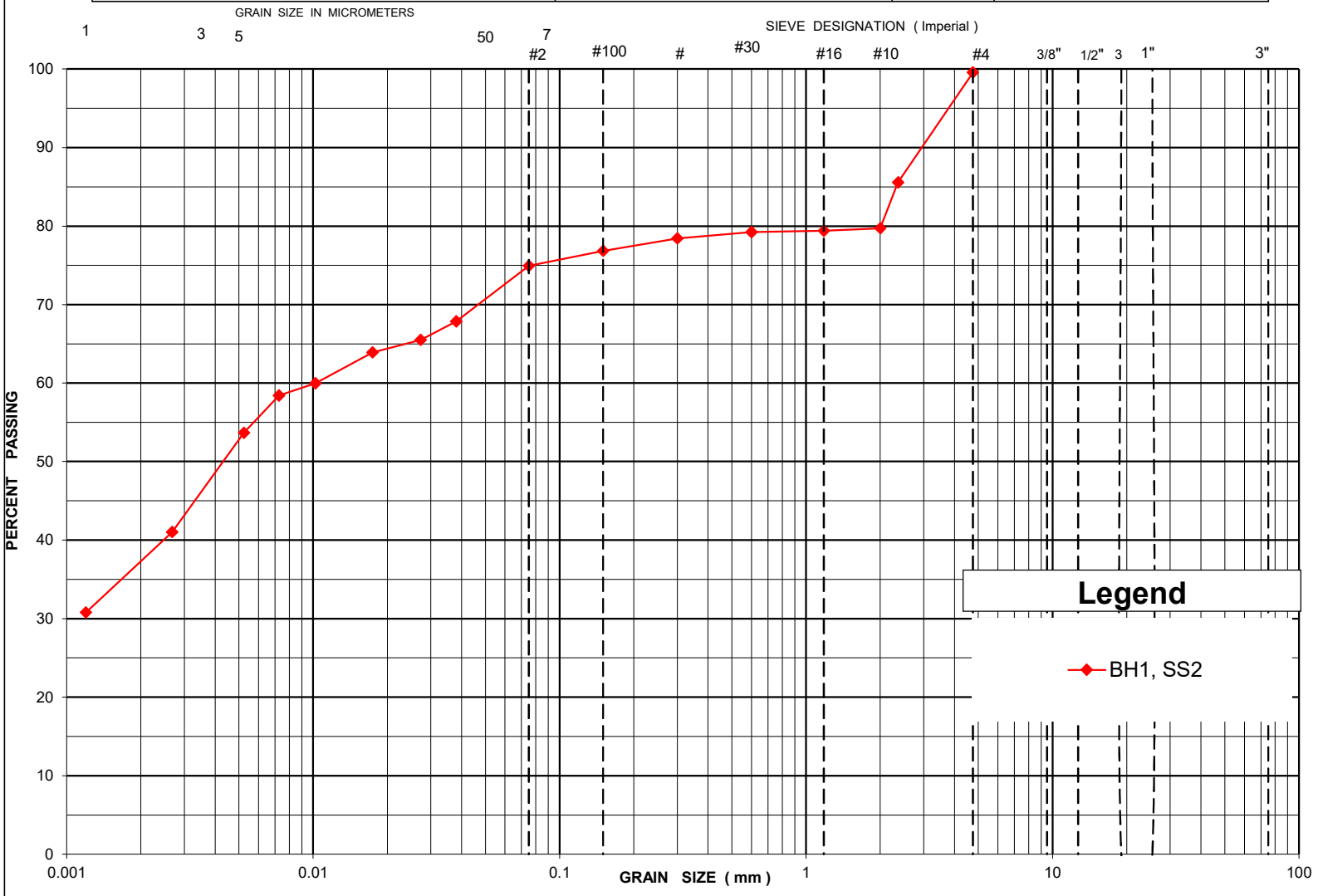
Drawn By: ZA	Project: **GEOTECHNICAL INVESTIGATION** **FOR THE PROPOSED MULTI-UNIT RESIDENTIAL (STUDENT HOUSING) DEVELOPMENT** **79 COLUMBIA STREET WEST, WATERLOO, ONTARIO**	Date: July 28, 2025
Approved By: IK		Project No: 2501194AG
PLANET ENGINEERING Inc. Consulting Engineers	Client: **Tuan Hoang**	Drawing No 1A

ATTACHMENT A

Grain Size Distribution

UNIFIED SOIL CLASSIFICATION SYSTEM LS 702/D 422

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



PLANET ENGINEERING Inc.
Consulting Engineers

GRAIN SIZE DISTRIBUTION

Drawing No : 2
PROJECT # : 2501194AG
DATE : July 28, 2025