Slope Stability and Geotechnical Investigation

Brock Development Group Inc.

Project Name:
Proposed Development
2624 Woodhull Road
London, Ontario

Project Number:
LON-21002656-AO

Prepared By:

EXP
15701 Robin’s Hill Road
London, Ontario, N2V 0A5
t: +1.519.963.3000
f: +1.519.963.1152

Date Submitted:
April 2021

Slope Stability and Geotechnical Investigation

Brock Development Group Inc.

Type of Document:

Final Report

Project Name:
Proposed Development
45 Hampton Crescent
London, Ontario

Project Number:

LON-21002656-AO

Prepared and Reviewed By:

EXP Services Inc.
15701 Robins Hill Road
London, ON, N5V 0A5
Canada
t: +1.519.963.3000
f: +1.519.963.1152

C. D. SWINSON
100120791

Craig Swinson, P. Eng.
Geotechnical Services

Eric Buchanan, P. Eng.
Geotechnical Services

Date Submitted:

April 2021

Table of Contents

1. Introduction and Background 1
1.1 Introduction 1
1.2 Terms of Reference 1
2. Methodology 2
2.1 Site Reconnaissance 2
2.2 Field Work 2
2.3 Review of Topographic Data 3
3. Site and Subsurface Conditions 3
3.1 Site Description 3
3.2 Soil Stratigraphy 4
3.3 Groundwater Conditions 5
4. Slope Stability 6
4.1 General 6
4.2 Erosion Hazard Limit 6
4.2.1 Toe Erosion Allowance 8
4.2.2 Stable Slope Geometry 9
4.2.3 Erosion Access Allowance 11
4.2.4 Erosion Hazard Limit – Development Setback 11
4.3 UTRCA Generic Regulation 11
4.4 General Comments for Site Works 12
5. Geotechnical Discussion and Recommendations 13
5.1 General 13
5.2 Site Preparation 13
5.3 Excavation and Dewatering 14
5.3.1 General 14
5.3.2 Excess Soil Management 14
5.3.3 Excavation Support 14
5.3.4 Construction Dewatering 16

5.4 Building Foundations 16
5.4.1 Conventional Strip and Spread Footing 16
5.4.2 Foundations General 17
5.5 Basement 18
5.6 Slab-on-Grade Construction 18
5.7 Foundation Backfill 19
5.8 Inspection and Testing Requirements 20
6. General Comments 21
Drawings 22
Appendix A – Borehole Logs 27
Appendix B – Slope Stability Rating Chart 31
Appendix C – Slope Stability Analyses 33
Appendix D – Site Photos 36
Appendix E – Limitations and Use of Report 39
Legal Notification 42

1. Introduction and Background

1.1 Introduction

EXP Services Inc. (EXP) was retained by **Brock Development Group Inc.** to carry out a Slope Stability and Geotechnical Investigation and prepare a report relating to the proposed development to be located at municipal number 2624 Woodhull Road in London, Ontario, hereinafter referred to as the 'Site'.

It is understood that the Client is proposing to construct a new residential house. As illustrated on **Drawing 1**, attached, the proposed development area is located at the top of a slope located east of the proposed building footprint.

Based on an interpretation of the factual test hole data and a review of soil and groundwater information from test holes advanced at the site, EXP has provided geotechnical engineering guidelines to support the construction of the proposed residence, and an assessment of the stability of the slope, once construction is complete.

The proposed development is within an area regulated by the Upper Thames River Conservation Authority (UTRCA). As a result, consent from the Conservation Authority is required prior to construction of the proposed development.

1.2 Terms of Reference

The geotechnical investigation was generally completed in accordance with the scope of work outlined in EXP's emailed proposal dated January 22, 2021. Authorization to proceed with this investigation was received from Ms. Michelle Doornbosch through email correspondence on February 8, 2021.

The purpose of the assessment was to examine the subsoil and groundwater conditions at the Site, assess the slope stability along the onsite slope and determine the recommended development setback limit, in accordance with the Ontario Ministry of Natural Resources (MNR) Technical Guide – River & Streams Systems: Erosion Hazard Limit and the Upper Thames River Conservation Authority guidelines.

Based on a site reconnaissance site visit, an interpretation of the factual borehole data, and a review of soil and groundwater information from test holes excavated at the site, EXP has provided geotechnical comments and recommendations on slope stability and Development Setback.

This report is provided on the basis of the terms of reference presented above, and on the assumption that the design will be in accordance with applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning geotechnical aspects of the codes and standards, this office should be contacted to review the design.

The information in this report in no way reflects on the environmental aspects of the soil. Should specific information in this regard be needed, additional testing may be required.

2. Methodology

2.1 Site Reconnaissance

A site reconnaissance survey was carried out on March 5, 2021. The purpose of the site visit was to examine the existing conditions of the site slopes which run along the east side of the property. The survey included detailed observations such as slope vegetation, old slump scars and seepage.

During the site reconnaissance, the 'Slope Stability Rating Chart', which was developed by MNR, was utilized to score a number of site characteristics, to determine the potential for slope instability. Site conditions which were reviewed include: slope height and inclination, soil stratigraphy, the presence and location of seepage zones, vegetative cover, overland drainage, and evidence of previous instability or landslide activity. A rating chart was completed (indicated as Cross Section A-A' on **Drawing 1**) throughout the existing slope profile at the site. The rating chart for the cross section examined is provided in **Appendix B** for review and consideration. Based on the values recorded on the Slope Stability Rating Chart, the existing site slope is considered to have a moderate potential for instability indicated by a Slope Instability Rating of 39.

At the time of the investigation, the slope surface was typically well vegetated with heavy shrubs and mature trees. No previous surficial sliding failures or drainage over the slope were observed. Selected photos of the slope are presented in **Appendix D**.

2.2 Field Work

In addition to the site reconnaissance, two (2) boreholes were advanced by EXP on March 5, 2021 to provide information on the soil stratigraphy.

In the boreholes, disturbed soil samples were recovered using conventional split spoon sampling equipment and Standard Penetration Test (SPT) methods. The boreholes were advanced depths of up to 20.3 m below existing grade.

During the sampling, the stratigraphy in the test holes was examined and logged in the field by EXP geotechnical personnel.

Short-term groundwater level observations within the open boreholes and observations pertaining to groundwater conditions at the test hole locations are recorded in the borehole logs found in **Appendix A**. Following the drilling, the water level was measured in the open boreholes.

Representative samples of the various soil strata encountered at the test locations were taken to our laboratory in London for further examination by a Geotechnical Engineer and laboratory classification testing. Laboratory testing for this investigation comprised of moisture content determinations with moisture content results presented on the borehole logs found in **Appendix A**.

Borehole samples remaining after the classification testing will be stored for a period of three months following the date of this report. After this time, they will be discarded unless prior arrangements have been made for longer storage.

The borehole elevations were interpreted from the topographical plan provided by Brock Development Group Inc.

2.3 Review of Topographic Data

Topographic mapping provided by Brock Development Group Inc. combined with a site elevation survey carried out by EXP was utilized to create the cross section for use in establishing the location of the Development Setback. Using engineering judgement and technical experience, the cross section (which is considered to be representative of typical site conditions) has been reviewed.

3. Site and Subsurface Conditions

3.1 Site Description

The site for the proposed development (see **Drawing 1**) is located on the east side of Woodhull Road within the property of MN2624 in London, Ontario. The site is bounded by a slope on the east side, neighbouring residential properties on the north and south sides, and an agricultural field on the west side of Woodhull Road. A narrow side channel (~1.7 m width) of Dingman Creek is located beyond the base of the slope on the east side of the site. A map of the site location (taken from MNRF Maps March 2021) is provided below.

The site currently contains some trees and bushes. Elevations range from 260.0 m near the front of the lot to 255.0 m along the crest of the slope. The slope crest generally follows the tree line along the east edge of the table land. The slope has an overall inclination ranging between about 1.7 horizontal to 1 vertical (1.7H:1V) and 2.6 horizontal to 1 vertical (2.6H:1V).

The slope has a height of approximately 16.0 m, is well vegetated throughout, and the mature trees do not show any signs of rotational movement or failure. There were also no signs of water seepage along the slope face.

The proximity of narrow side channel of Dingman Creek relative to the toe of slope was measured to be about 8.0 m as it traverses the site.

The following sections provide a summary of the soil conditions and groundwater conditions.

3.2 Soil Stratigraphy

The detailed stratigraphy encountered in each borehole is shown on the borehole logs found in **Appendix A** and summarized in the following paragraphs. It must be noted that the boundaries of the soil indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for geotechnical design and should not be interpreted as exact planes of geological change.

Topsoil

Topsoil was penetrated at the ground surface at the location of each borehole, measuring about 300 mm in thickness.

It should be noted that topsoil quantities should not be established from the information provided at the borehole locations only. If required, a more detailed analysis (involving additional shallow test pits) is recommended to accurately quantify the amount of topsoil to be removed for construction purposes.

Silty Sand

Underlying the topsoil, in borehole BH1 was a stratum of silty sand extending to a depth of about 4.6 m below ground surface (bgs). The silty sand was generally described as brown, dilatant, contained trace stiff clay layering, was compact in relative density (SPT N Values of 17 to 19) and wet (typical *in situ* moisture contents of 17 to 38 percent).

Silty sand layering was also encountered within the clayey silt till (described below) in each borehole. In general, the silty sand layering was noted to be grey, fine-grained and has a compact to dense relative density (tactile observations and SPT N Values ranging from 11 to 40). The *in situ* moisture content of the silty sand ranges from 18 to 20 percent indicating wet conditions.

Clayey Silt Till

Underlying the silty sand in BH1 and the topsoil in BH2, a glacial till was encountered. The till predominantly comprised of clayey silt was brown to grey and contained trace to some sand. The clayey silt till was typically in a stiff to very stiff state based on SPT N Values of 9 to 21 blows per 300 mm split spoon sampler penetration. Laboratory testing of the clayey silt till yielded *in situ* moisture contents of 12 to 20 percent, indicative of moist conditions.

3.3 Groundwater Conditions

Details of the groundwater conditions observed within the boreholes are provided on the attached borehole logs. Moisture contents of selected samples are also recorded on the attached borehole logs. Upon completion of drilling, the open borehole excavations were examined for the presence of groundwater and groundwater seepage.

The boreholes were each unstable within the upper silty sand upon completion of drilling. Based on the observations during drilling the shallow groundwater at the site is generally expected to be within the upper silty sand and perched above the less permeable clayey silt till.

It should be noted that insufficient time was available for the measurement of the depth to the stabilized groundwater table prior to backfilling the borehole. The depth to the groundwater table may vary in response to climatic or seasonal conditions, and, as such, may differ with high levels occurring in wet seasons. Capillary rise effects should also be anticipated in fine-grained soil deposits.

4. Slope Stability

4.1 General

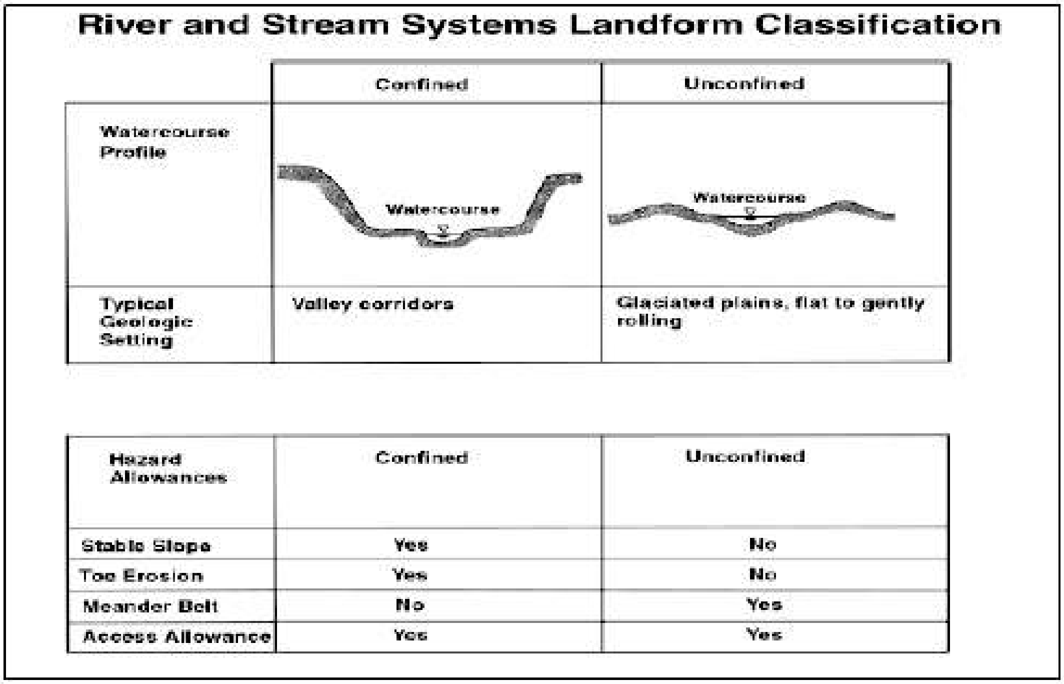
The purpose of this investigation was to determine a safe setback distance from the existing slope profile along the south edge of the site using the information which is currently available. It is important to mention that specific details regarding the proposed development, layout and site grading have not been examined as part of the current scope of work.

The slope was evaluated using the method prescribed by Ministry of Natural Resources in the Technical Guide for Assessing the Erosion Hazard Limit for River and Stream Systems. The overall Erosion Hazard Limit (Development Setback) for the site slope is determined by evaluating the slope stability, considering surficial seepage and shallow failures, allowance for potential flooding hazards, and an erosion allowance.

A Slope Stability Rating Chart has been completed for the referenced cross section and is attached, see **Appendix B**. Based on the values recorded on the Slope Stability Rating Chart, the rating suggest that a moderate potential of slope instability exists.

4.2 Erosion Hazard Limit

As defined by the MNR Technical Guide, based on the type of river and stream system landform (confined or unconfined) the following figure provides guidance on which factors (hazard allowances) should be used in defining the erosion hazard limits.



River and Stream Systems Landform Classification

	Confined	Unconfined
Watercourse Profile	Watercourse	Watercourse
Typical Geologic Setting	Valley corridors	Glaciated plains, flat to gently rolling

Hazard Allowances	Confined	Unconfined
Stable Slope	Yes	No
Toe Erosion	Yes	No
Meander Belt	No	Yes
Access Allowance	Yes	Yes

Figure obtained from page 35 of MNR Technical Guide – River and Stream Systems: Erosion Hazard Limit

As defined by the MNR Technical Guide, confined river and stream systems are ones in which the physical presence of a valley corridor containing a river or stream channel, which may or may not contain flowing water, is visibly discernable from the surrounding landscape by either field investigations, aerial photography and or map interpretation. The Erosion Hazard Limit for a confined system consists of the following hazard allowances:

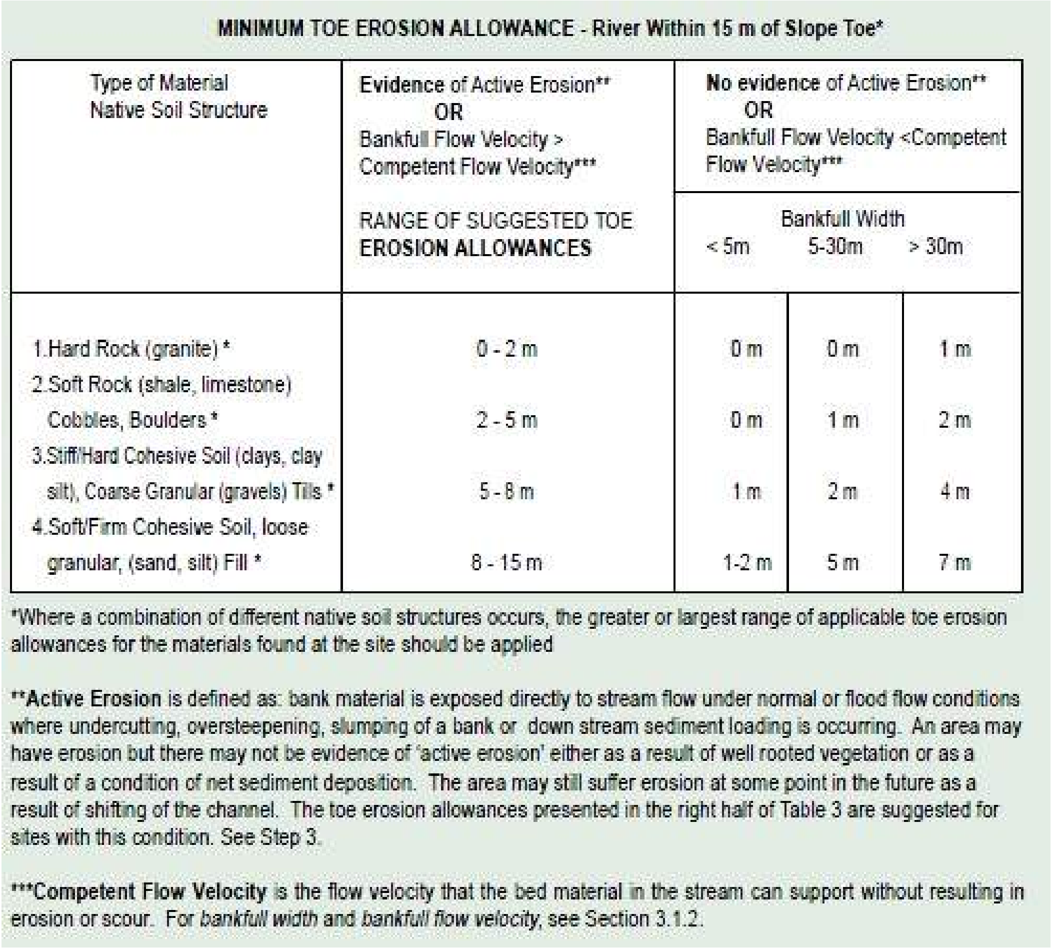
- Toe Erosion Allowance
- Stable Slope Allowance
- Access Allowance

Ultimately, the Erosion Hazard Limit also defines the development limit for the site. Additional setbacks may also be required based on local Municipal and Conservation Authority requirements.

The setback distance from the slope crest varies slightly along the slope, based on the overall slope height and inclination, and the type and amount of toe erosion at the base of the slopes. A cross section (Cross Section A-A') has been shown on **Drawing 1** along the existing slope profile and was used for establishing the location of the Erosion Hazard Limit. Additionally, the inferred location of the Erosion Hazard Limit, top of slope line, top of stable slope line, toe of slope and toe erosion allowance are also provided on **Drawing 1** and on cross sectional **Drawing 2.**

4.2.1 Toe Erosion Allowance

The extent of potential erosion damage is a function of the competence of the natural subgrade soils, the type and quality of vegetative cover, and the frequency with which the slope is subject to erosive forces. Active erosion of the soil on the face of the riverbank slope is most likely caused by normal or increased flow volumes and velocities moving through the creek. The figure below provides guidance on how to determine a minimum toe erosion allowance for a confined system.



MINIMUM TOE EROSION ALLOWANCE - River Within 15 m of Slope Toe*

Type of Material Native Soil Structure	Evidence of Active Erosion** OR Bankfull Flow Velocity > Competent Flow Velocity***	No evidence of Active Erosion** OR Bankfull Flow Velocity <Competent Flow Velocity***		
	RANGE OF SUGGESTED TOE EROSION ALLOWANCES	Bankfull Width < 5m	5-30m	> 30m
1.Hard Rock (granite) *	0 - 2 m	0 m	0 m	1 m
2.Soft Rock (shale, limestone) Cobbles, Boulders *	2 - 5 m	0 m	1 m	2 m
3.Stiff/Hard Cohesive Soil (clays, clay silt), Coarse Granular (gravels) Tills *	5 - 8 m	1 m	2 m	4 m
4.Soft/Firm Cohesive Soil, loose granular, (sand, silt) Fill *	8 - 15 m	1-2 m	5 m	7 m

*Where a combination of different native soil structures occurs, the greater or largest range of applicable toe erosion allowances for the materials found at the site should be applied

**Active Erosion is defined as: bank material is exposed directly to stream flow under normal or flood flow conditions where undercutting, oversteepening, slumping of a bank or down stream sediment loading is occurring. An area may have erosion but there may not be evidence of 'active erosion' either as a result of well rooted vegetation or as a result of a condition of net sediment deposition. The area may still suffer erosion at some point in the future as a result of shifting of the channel. The toe erosion allowances presented in the right half of Table 3 are suggested for sites with this condition. See Step 3.

***Competent Flow Velocity is the flow velocity that the bed material in the stream can support without resulting in erosion or scour. For *bankfull width* and *bankfull flow velocity*, see Section 3.1.2.

Figure obtained from page 38 of MNR Technical Guide – River and Stream Systems: Erosion Hazard Limit

Where detailed slope stability analyses have not been carried out, the Natural Hazards Manual by Ministry of Natural Resources indicates that a minimum toe erosion allowance of 5 to 8 m is recommended where the bank materials are comprised of stiff clayey soils are exposed directly to stream flow under normal flow or flood conditions. Signs of active erosion along the watercourse are not present. It should be noted that the watercourse, a narrow side channel of Dingman Creek with a bankfull width of less than 5 m, is located approximately 8.0 m beyond the toe of the slope. As a conservative measure, a toe erosion allowance of 2 m was applied. As detailed in the cross section, the application of the stable slope line to the 2 m toe erosion allowance does not govern the erosion hazard setback.

4.2.2 Stable Slope Geometry

The stability of the slope was investigated for a number of conditions. The examinations involve an assessment of the section of slope with and without the influence of perched groundwater and the effects of possible construction in proximity to the site slopes. The various types of failures analyzed include shallow slumping failures, medium depth rotational failures, and deep rotational failures through the entire height of the slope. The analyses were undertaken by computer methods utilizing the Slope/W computer program.

The soil parameters used were conservative to build in an added safety factor for the analyses. The following table summarizes the parameters for the predominant soils which were used in EXP's evaluation of the stable slope configuration:

Table 1 – Soil Parameters

Soil Type	Density	Cohesion	Angle of Internal Friction
Clayey Silt Till	22.0 kN/m^3	18 kPa	32 °

Minimum factors of safety are provided in the report "Geotechnical Principles for Stable Slopes" prepared for the Ministry of Natural Resources, for infrastructure and public use (Section 4.3.3.1 in the MNR Technical Guide).

In order to determine a stable slope, a minimum factor of safety of 1.40 was used during the computerized for long term stable slope analyses. The following table from the MNR Technical Guide provides guidance on how to select a minimum factor of safety based on the intended land use above or below the slope.

Table 2 – Design Minimum Factor of Safety

	LAND-USES	FACTOR OF SAFETY
A	**PASSIVE**; no buildings near slope; farm field, bush, forest, timberland, woods, wasteland, badlands, tundra	1.10
B	**LIGHT**; no habitable structures near slope; recreational parks, golf courses, buried small utilities, tile beds, barns, garages, swimming pools, sheds, satellite dishes, dog houses	1.20 to 1.30
C	**ACTIVE**; habitable or occupied structures near slope; residential, commercial, and industrial buildings, retaining walls, storage/warehousing of non-hazardous substances	1.30 to 1.50
D	**INFRASTRUCTURE and PUBLIC USE**; public use structures or buildings (i.e., hospitals, schools, stadiums), cemeteries, bridges, high voltage power transmission lines, towers, storage/warehousing of hazardous materials, waste management areas	1.40 to 1.50

Table obtained from page 60 of MNR Technical Guide – River and Stream Systems: Erosion Hazard Limit

One cross section was assessed to provide adequate coverage of the slope at the site. The section evaluated was selected to represent the worst-case-scenario of the slope. The cross section location is shown on **Drawing 1** and the profile is provided on **Drawing 2**. The information plotted in the cross section was based on EXP's detailed slope survey and Callon Dietz Inc.'s topographic mapping with elevations assumed based on the topographic mapping. The toe and top of slope at the cross section are defined as the points of transition to an inclination of 4H:1V or shallower.

The failures at the cross section consisted of shallow depth failures and deep rotational failures throughout the depth of the slope. After completing the computerized stable slope analysis on the cross section, the minimum calculated factor of safety (FOS) under the existing conditions at Cross Section A-A' was 1.46. These FOS are an indication of long-term safe slope conditions.

Both failure modes for the profile were above the recommended minimum FOS value of 1.40. Summarized results are provided in the following table:

Table 2 - Summary of Pertinent Slope Stability Analyses

Cross Section Condition	Description of Failure Mode	Computed Factor of Safety
Slope Section, A-A'	Shallow Depth Failure (< 2 m deep)	1.46
Slope Section, A-A'	Deep Rotational Failure (> 4 m deep)	1.68

The findings were in general agreement with observations of the local slope (vegetated and treed slope which is beneficial for protection against shallow slides). The soil conditions encountered in the boreholes were generally found to comprise stiff to very stiff clayey silt till deposits with compact silty sand layering throughout. In determining suitable input soil and groundwater parameters, consideration has been given to incorporating the presence of groundwater within the subsurface soil strata. Local changes and variations in the groundwater level were also considered when carrying out the analyses, to examine possible post-development effects. Changes in the groundwater level may result from a number of causes, included (but not limited to) possible site grading activities, changes to site drainage, use of at-source infiltration, or types of surface cover.

The average inclinations along the existing slope profile at the investigated cross section range between about 1.7H:1V to 2.6H:1V. Based on the soil conditions encountered during the field investigation and based on the results of the computerized slope stability analysis a stable slope line of 2.0H:1V has been applied and should be considered suitable based on the results of the current geotechnical study.

It should be noted that the theoretical calculations for FOS are conservative. Based on the site reconnaissance conducted by EXP, it was observed that the slope face is covered by vegetation (mature trees and heavy shrubs). The trees were generally in an upright state. The deep roots of mature trees assist to reinforce and to enhance the stabilization of slopes.

In addition to the stable slope geometry, an emergency access allowance should also be applied. This is described in the following section.

4.2.3 Erosion Access Allowance

The Ontario Government provides planning guidelines for development adjacent to slopes. The 2005 Provincial Policy Statement (PPS Section 3.1.3) requires that an access allowance be included as part of the Erosion Hazard Limit. In accordance with PPS, 6 to 15 m setback is required in addition to the erosion and stability setbacks, which are discussed in the following sections. It is understood that this access allowance is required to ensure that there is a large enough safety zone for people and vehicles to enter and exit an area during an emergency, such as slope failure and flooding.

Since the subsurface conditions within the study area are generally considered to be geologically stable, we recommend that at a minimum, a planning setback of 6 m be applied to existing slopes.

4.2.4 Erosion Hazard Limit – Development Setback

The Erosion Hazard Limit is defined by the sum of the Stable Safe Slope Line plus the Toe Erosion Component plus the Erosion Access Allowance. The table below summarizes the 3 components to the Recommended Development Limit Setback.

Table 3 – Erosion Hazard Limit Components

Cross Section	Toe Erosion Allowance (m)	Stable Slope Allowance (From Top of Slope, m)	Emergency Access Allowance (m)	Erosion Hazard Limit (From Top of Slope)
A-A'	2 (Does not govern. Refer to Section 4.2.1)	3.4	6.0	9.4

The Stable Slope Setback and Erosion Hazard Limit are shown on **Drawing 1**. Any proposed development should not encroach on the Erosion Hazard Limit.

4.3 UTRCA Generic Regulation

In May 2006, Ontario Regulation 157/06 came into effect in the Upper Thames River Conservation Authority (UTRCACA) watershed, which locally implements the Generic Regulation (Development, Interference with Wetlands and Alterations to Shoreline and Watercourses). This regulation replaces the former Fill, Construction and Alteration to Waterways regulations, and is intended to ensure public safety, prevent property damage and social disruption, due to natural hazards such as flooding and erosion. Ontario Regulation 157/06 is implemented by the local Conservation Authority, by means of permit issuance for works in or near watercourses, valleys, wetlands, or shorelines, when required.

Property owners must obtain permission from the UTRCA before beginning any development, site alteration, construction, or placement of fill within the regulated area. Permits are also required for any wetland interference, or for altering, straightening, diverting or interfering in any way with the existing channel of a creek, stream or river. Proposed development within the study area will be subject to the above referenced Regulation. Consultation with the local Conservation Authority for review of site-specific development plans is recommended in this regard.

4.4 General Comments for Site Works

It is imperative that future development generally not occur within the Erosion Hazard Limit identified at the site. To this end, the following comments are provided and measures are recommended.

1. The surficial soils on the face of the slope experience minor long-term erosion due to weathering (wetting/drying and freezing/thawing cycles). The extent of potential erosion damage is a function of the competence of the natural subgrade soils, the type and quality of vegetative cover, and the frequency with which the slope is subject to erosive forces. Surficial erosion of the soil on the face of the slope could be caused by run-off water washing over the face of the slope, such as tile drains or redirected surface water which is directed onto existing slopes. Where possible, uncontrolled surface water flows over the face of the slope should be minimized, to reduce the risk of surface erosion. Erosion control measures may be required during construction, to reduce the risk of surface water flows from washing out non-vegetated surfaces.

2. Indiscriminate stockpiling of fill or construction materials should be avoided. In the event that stockpiling of material is proposed in the vicinity of the slope crest, a review by the Geotechnical consultant is required.

3. Any buildings and permanent structures associated with the proposed site development must be located outside of the Erosion Hazard Limit, which is identified on the Site Plan. The Cross Section drawing helps identify the location of this line.

4. Water from downspouts and perimeter weeping tile etc. must also be collected in a controlled manner and re-directed away from the slope.

5. Existing vegetation on the slope should be maintained.

6. Building foundations should be founded on the competent soil, set below a line drawn from the erosion setback at the toe of the slope at 2.2H:1V. Review by the Geotechnical consultant is recommended to confirm that the geotechnical requirements for foundation design are satisfied.

Final design drawings including building locations, services etc. should be reviewed by a geotechnical consultant to ensure that the Erosion Hazard Limit is properly interpreted. Geotechnical inspection and testing is recommended during construction to confirm that all recommendations set out will be followed.

5. Geotechnical Discussion and Recommendations

5.1 General

It is understood that the proposed development will consist of a residential structure with a basement and/or slab-on-grade floors. The following sections of this report provide geotechnical recommendations regarding site preparation, excavations, dewatering, foundations, bedding and backfill.

5.2 Site Preparation

Prior to placement of foundations and/or engineered fill, any surficial topsoil, vegetation and/or otherwise deleterious materials should be stripped. The surficial topsoil may be stockpiled on site for possible reuse for landscaping.

Following the removal of the topsoil and building debris and prior to fill placement, the exposed subgrade should be inspected by a Geotechnical Engineer. Any loose or soft zones noted in the inspection should be over-excavated and replaced with approved fill.

It is recommended that construction traffic be minimized on the finished subgrade, and that the subgrade be sloped to promote surface drainage and runoff.

In the building areas where the grade will be raised, the fill material should comprise imported granular or approved onsite (excavated) material. The fill material should be inspected and approved by a Geotechnical Engineer, be placed in maximum 300 mm (12 inch) thick lifts and uniformly compacted to 100 percent Standard Proctor Maximum Dry Density (SPMDD) within 3 percent of optimum moisture content. The geometric requirements for engineered fill are provided on **Drawing 3**.

The natural and inorganic fill materials on site would be suitable for reuse as engineered fill. The material should be examined and approved by a Geotechnical Engineer prior to reuse.

In situ compaction testing should be carried out during the fill placement to ensure that the specified compaction is being achieved.

If imported fill material is utilized at the site, verification of the suitability of the fill may be required from an environmental standpoint. Conventional geotechnical testing will not determine the suitability of the material in this regard. Analytical testing and environmental site assessment may be required at the source. This will best be assessed prior to the selection of the material source. A quality assurance program should be implemented to ensure that the fill material will comply with the current Ministry of Environment, Conservation and Parks (MECP) standards for placement and transportation. The disposal of excavated materials must also conform to the MECP guidelines and requirements. EXP can be of assistance if an assessment of the materials is required. property.

5.3 Excavation and Dewatering

5.3.1 General

All work associated with design and construction relative to excavations must be carried out in accordance with Part III of Ontario Regulation 213/91 under the Occupational Health and Safety Act. Based on the results of the geotechnical investigation and in accordance with Section 226 of Ontario Regulation 213/91, the soils encountered at the site are classified as Type 3 soils. It is anticipated that all excavations will extend through Type 3 soils.

For reference, temporary excavation sidewalls which extend through and terminate within Type 2 soil may be cut vertical in the bottom 1.2 m (4 ft.), and cut back at an inclination of 1 horizontal to 1 vertical above that level. Where excavations extend into or through Type 3 soil, excavation side slopes must be cut back at a maximum inclination of about 1H:1V from the base of the excavation. Should groundwater egress loosen the side slopes of Type 2 or Type 3 soils, slopes of 3H:1V or flatter will be required.

Geotechnical inspection at the time of excavation can confirm the soil type present.

It should be noted that the presence of cobbles and boulders in natural glacial deposits may influence the progress of excavation and construction.

5.3.2 Excess Soil Management

Ontario Regulation 406/19 made under the Environmental Protection Act (November 28, 2019) was implemented on January 1, 2021. The new regulation dictates the testing protocol that will be required for the management and disposal of Excess Soils. As set forth in the Regulation, specific analytical testing protocols will need to be implemented and followed based on the volume of soil to be managed. The testing protocols are specific as to whether the soils are stockpiled or in-situ. In either scenario, the testing protocols are far more onerous than have been historically carried out as part of standard industry practices. These decisions should be factored in and accounted for prior to the initiation of the project-defined scope of work. EXP would be pleased to assist with the implementation of a soil management and testing program that would satisfy the requirements of Ontario Regulation 406/19.

5.3.3 Excavation Support

The recommendations for side slopes given in the above section would apply to most of the conventional excavations expected for the proposed development. However, in areas adjacent to buried services that are located above the base of the excavations, side slopes may require support to prevent possible disturbance or distress to these structures. This concept also applies to connections to existing services. In granular soils above the groundwater and in cohesive natural soils, bracing will not normally be required if the structures are behind a 45-degree line drawn up from the toe of the excavation. In wet sandy or silty soils, the setback should be about 3H to 1V if bracing is to be avoided.

For support of excavations such as for any deep manholes, shoring such as sheeting or soldier piles and lagging can be considered. The design and use of the support system should conform to the requirements set out in the most recent version of the Occupational Health and Safety Act for Construction Projects and approved by the Ministry of Labour. Excavations should conform to the guidelines set out in the proceeding section and the Safety Act.

The shoring should also be designed in accordance with the guidelines set out in the Canadian Foundation Engineering Manual, 4th Edition. Soil-related parameters considered appropriate for a soldier pile and lagging system are shown below.

Where applicable, the lateral earth pressure acting on the excavation shoring walls may be calculated from the following equation:

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

where, P = lateral earth pressure in kPa acting at depth h;

γ = natural unit weight, a value of 20.4 kN/m3 may be assumed;

h = depth of point of interest in m;

q = equivalent value of any surcharge on the ground surface in kPa.

The earth pressure coefficient (K) may be taken as 0.25 where small movements are acceptable and adjacent footing or movement sensitive services are not above a line extending at 45 degrees from the bottom edge of the excavation; 0.35 where utilities, roads, sidewalks must be protected from significant movement; and 0.45 where adjacent building footings or movement sensitive services (gas and water mains) are above a line of 60 degrees from the horizontal extending from the bottom edge of the excavation.

For long term design, a K at rest (Ko) of a minimum of 0.5 should be considered.

The above expression assumes that no hydrostatic pressure will be applied against the shoring system. It should be recognized that the final shoring design will be prepared by the shoring contractor. It is not possible to comment further on specific design details until this design is completed.

If the shoring is exposed to freezing temperatures, appropriate insulation may be provided to prevent outward movement.

The performance of the shoring must be checked through monitoring for lateral movement of the walls of the excavation to ensure that the shoring movements remain within design limits. The most effective method for monitoring the shoring movements can best be devised by this office when the shoring plans become available. The shoring designer should however assess the specific site requirements and submit the shoring plans to the engineer for review and comment.

5.3.4 Construction Dewatering

As stated in Section 3.3, the shallow groundwater at the site is generally expected to be within the upper silty sand and perched above the less permeable clayey silt till. Based on the soil texture encountered during the investigation, groundwater infiltration may be anticipated within the building excavations depending on the depth of excavation.

Any minor groundwater infiltration can likely be accommodated using conventional sump pumping techniques; however, if groundwater infiltration persists, more extensive dewatering measures may be required. EXP would be pleased to provide further information in this regard, upon request.

The collected water should be discharged a sufficient distance away from the excavated area to prevent the discharge water from returning to the excavation. Sediment control measures should be provided at the discharge point of the dewatering system. Caution should also be taken to avoid any adverse impacts to the environment.

It is important to mention that for any projects requiring positive groundwater control with a removal rate of 50,000 liters to less than 400,000 liters per day, an Environmental Activity and Sector Registry (EASR) will be required. Permit to Take Water (PTTW) applications are required for removal rates more than 400,000 L per day and will need to be approved by the MECP per Sections 34 and 98 of the Ontario Water Resources Act R.S.O. 1990 and the Water Taking and Transfer Regulation O. Reg. 387/04. It is noted that a standard geotechnical investigation will not determine all the groundwater parameters which may be required to support the application. Accordingly, a detailed hydrogeological assessment from a quantitative point of view may be required to estimate the quantity of water to be removed. EXP can assist if the need arises.

5.4 Building Foundations

5.4.1 Conventional Strip and Spread Footing

The proposed structure can be constructed on conventional strip and spread footings with a basement or slab-on-grade floor, in accordance with the general comments provided in the following paragraphs.

Foundations for the proposed addition can be set on the natural, competent soils at a depth of approximately 1.2 m below existing grade. Founding levels may be affected by existing structures and services including abandoned ones.

The following allowable bearing pressures (net stress increase) can be used on the natural, undisturbed soils in the area of the proposed addition:

Bearing Resistance at Serviceability Limit States (SLS)	145 kPa (3,000 psf)
Factored Bearing Resistance at Ultimate Limit States (ULS)	215 kPa (4,500 psf)

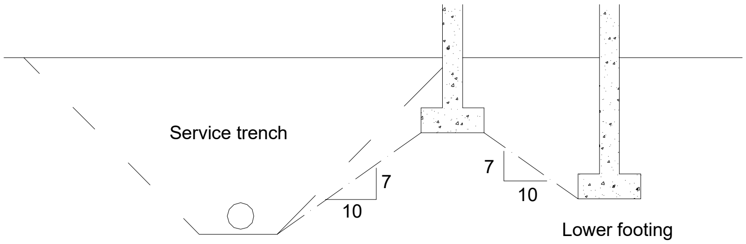
If the grades are to be raised or restored, engineered fill can be used for foundation support.

The geometric requirements for the fill placement are shown on **Drawing 3**, appended. The available SLS and ULS bearing capacities for the engineered fill is 145 kPa (3,000 psf) and 215 kPa (4,500 psf) respectively. For footings placed on engineered fill, it is recommended that the strip footings be widened to 500 mm (20 inches) and contain nominal concrete reinforcing steel. The engineered fill construction should be monitored on a full-time basis by qualified geotechnical personnel to examine and approve fill materials, to evaluate placement operations, and to verify that the specified degree of compaction is being achieved uniformly throughout the fill.

In areas where wet silty sand is exposed following removal of the topsoil and/or otherwise deleterious material, the exposed subgrade will likely be susceptible to disturbance by construction traffic. It is recommended that, in these areas, construction traffic be minimized on the finished subgrade, and the subgrade be sloped to promote surface water drainage. Where sensitive subgrade soils are exposed, tracked hydraulic excavators may be required to move some of the fill material.

5.4.2 Foundations General

Footings at different elevations should be located such that the higher footings are set below a line drawn up at 10 horizontal to 7 vertical from the near edge of the lower footing. This concept should also be applied to service excavation, etc. to ensure that undermining is not a problem.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

Provided that the footing bases are not disturbed due to construction activity, precipitation, freezing and thawing action, etc., and the aforementioned bearing pressures are not exceeded, the total and differential settlements of footings designed in accordance with the recommendations of this report and with careful attention to construction detail are expected to be less than 25 mm and 20 mm (1 and ¾ inch) respectively.

All footings exposed to seasonal freezing conditions should be protected from frost action by at least 1.2 m (4 ft) of soil cover or equivalent insulation.

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

5.5 Basement

All basement walls should be damp-proofed and must be designed to resist a horizontal earth pressure ‘p’ at any depth ‘h’ below the surface as given by the following expression:

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

where:

P = lateral earth pressure in kPa acting at a depth h:

K = earth pressure coefficient, assumed to be 0.4;

γ = unit weight of backfill, a value of 20.4 kN/m3 may be assumed;

h = depth to point of interest in m and,

q = equivalent value of any surcharge on the ground surface.

If basements are planned, installation of perimeter drains is required. The above expression assumes that the perimeter drainage system prevents the build-up of any hydrostatic pressure behind the wall. Suggestions for permanent perimeter drainage are given on **Drawing 4**.

A minimum separation distance of 1 m is recommended between the basement floor slab, and the local groundwater level. In the event that less than 1 m is provided (at least 0.5 m above the shallow water level), then the basement design and foundation construction should include water-proofing measures such as installation of a water-stop between the footings and foundation walls, and foundation wall backfill using low-permeability soils, perimeter weeping tiles and underfloor drains, dedicated pumps and sumps to a positive outlet. If less than 0.5 m of separation distance is available, full water-proofing on the slab and would also be required.

5.6 Slab-on-Grade Construction

Preparation of the subgrade should include the removal of all topsoil and/or deleterious material from the proposed building area. The entire floor slab area should then be thoroughly proof-rolled with a heavy roller and examined by a Geotechnical Engineer. Any excessively soft or loose areas should be sub-excavated and replaced with suitable compacted fill. Where the exposed subgrade requires reconstruction to achieve the design elevations, structural fill should be used. It is recommended that structural fill be comprised of granular material, such as OPSS Granular ‘B’, or approved alternative material. The fill should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD). For best compaction results, the *in situ* moisture content of the fill should be within about three percent of optimum, as determined by Standard Proctor density testing.

A moisture barrier, consisting of a 200 mm (8 in.) thick, compacted layer of 19 mm (3/4 in.) clear stone, should be then placed between the prepared granular sub-base and the floor slab.

The installation and requirement of a vapor barrier under a concrete slab should conform to the flooring manufacturer's and designer's requirements. Moisture emission testing will be required to determine the concrete condition prior to flooring installation. In order to minimize the potential for excess moisture in the floor slab at the time of the flooring installation, a concrete mixture with a low water-to-cement ratio (i.e., 0.45 to 0.55) should be used. Chemical additives may be required at the time of placement to make the concrete workable, and should be used in place of additional water at the point of placement. Ongoing liaison from this office will be required.

For slab on grade design, the modulus of subgrade reaction (k) can be taken as 25 MPa/m for the compacted stone layer over the compacted granular subbase.

The water-to-cement ratio and slump of concrete used in the floor slabs should be strictly controlled to minimize shrinkage of the slabs. Adequate joints should be provided in the floor slab to further control cracking. During placement of concrete at the construction site, testing should be performed on the concrete.

No special underfloor drains are required provided that the exterior grades are lower than the floor slabs, and positively sloped away from the slabs. It is recommended that an impermeable soil seal such as clay, asphalt or concrete be provided on the surface to minimize water infiltration. Drainage and backfill recommendations are provided in **Drawing 4**.

5.7 Foundation Backfill

In general, the existing natural soils excavated from the foundation area should be suitable for re-use as foundation wall backfill if the work is carried out during relatively dry weather. The materials to be re-used should be within three percent of optimum moisture for best compaction results. Materials should be stockpiled per their composition; i.e. sandy soils should not be mixed with clayey soils.

If the weather conditions are very wet during construction, then imported granular material such as OPSS Granular 'B' should be used. Site review by the geotechnical consultant may be advised.

The backfill must be brought up evenly on both sides of walls not designed to resist lateral earth pressures.

During construction, the fill surface around the perimeter of structures should be sloped in such a way that the surface runoff water does not accumulate around the structure.

5.8 Inspection and Testing Requirements

An effective inspection and testing program is an essential part of construction monitoring. The Inspection and Testing Program typically includes the following items:

- Subgrade examination prior to engineered fill placement, footing base evaluation;
- Inspection and Materials testing during engineered fill placement (full-time supervision is recommended), including soil sampling, laboratory testing (moisture contents and Standard Proctor density test on the engineered fill material), monitoring of fill placement, and *in situ* density testing;
- Materials testing for concrete foundations, walls and floor slabs.

EXP would be pleased to prepare an inspection and testing work program prior to construction, incorporating the above items.

6. General Comments

The information presented in this report is based on a limited investigation designed to provide information to support an assessment of the current geotechnical conditions within the subject property. The conclusions and recommendations presented in this report reflect site conditions existing at the time of the investigation. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent. Should this occur, EXP Services Inc. should be contacted to assess the situation, and the need for additional testing and reporting. EXP has qualified personnel to provide assistance in regards to any future geotechnical and environmental issues related to this property.

Our undertaking at EXP, therefore, is to perform our work within limits prescribed by our clients, with the usual thoroughness and competence of the engineering profession.

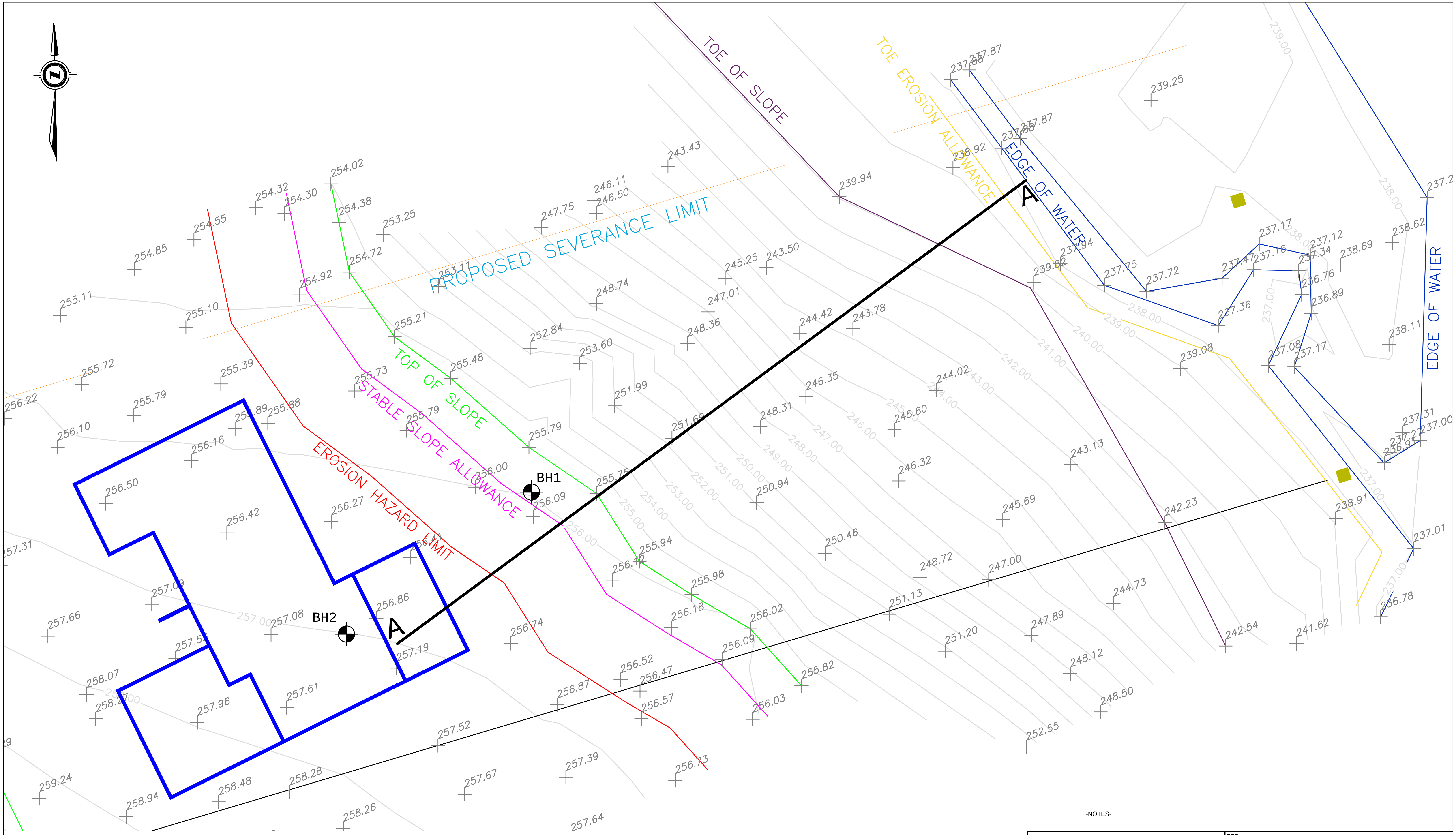
The comments given in this report are intended only for the guidance of design engineers. The number of test holes required to determine the localized underground conditions between test holes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. would be much greater than 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.

EXP Services Inc. 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 afforded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations in this report.

This report was prepared for the exclusive use of **Brock Development Group Inc.** and may not be reproduced in whole or in part, without the prior written consent of EXP, or used or relied upon in whole or in part by other parties for any purposes whatsoever. Any use which a third party makes of this report, or any part thereof, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. EXP Services 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 trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Drawings



LEGEND

⊕ BH1 Approximate Borehole Location

— Top of Slope

— Toe of Slope

— Approximate Stable Slope Allowance, 2.0H:1V

— Approximate Erosion Hazard Limit

— TOE EROSION ALLOWANCE

-NOTES-

1. The boundaries and soil types have been established only at test hole locations. Between test holes they are assumed and may be subject to considerable error.
2. Soil samples will be retained in storage for 3 months and then destroyed unless client advises that an extended time period is required.
3. Topsoil quantities should not be established from the information provided at the test hole locations.
4. The site plan should be read in conjunction with EXP Geotechnical Report LON-21002656-AO.
5. Topographical mapping provided by Callon-Dietz Inc.

CLIENT Brock Development Group Inc.

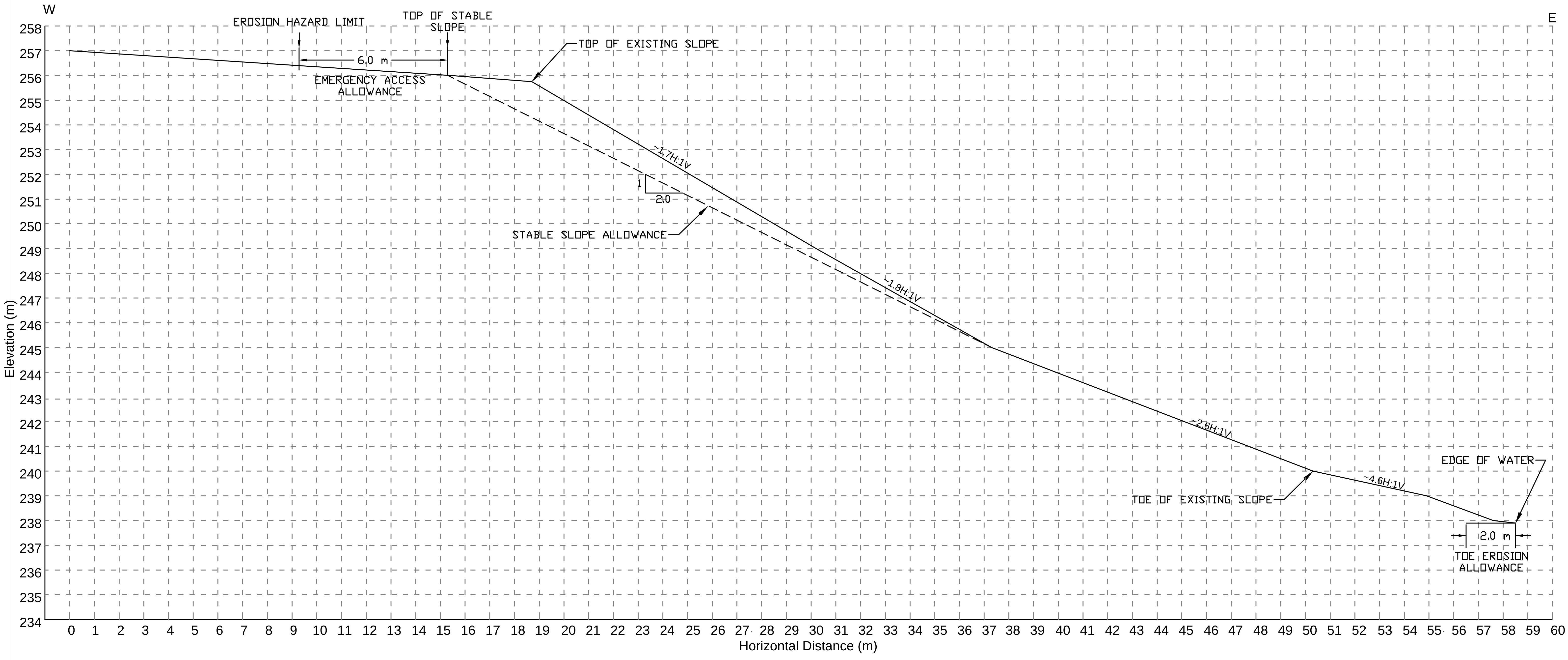
PROJECT 2624 Woodhull Road, LONDON, ON

TITLE ESTIM-TED SLOPE SETB-CKS

EXP Services Inc.
15701 Robin's Hill Road, London, Ontario N5V 0-5

D-TE	SC-LE	PROJECT NO.	DWG.
-pril 2021	1:250	LON-21002656-0	1

Cross Section A - A'



-NOTES-

1. The cross section should be read in conjunction with EXP Report LON-21002656-A0.

Slope Stability Assessment

2624 Woodhull Road
London, Ontario

CLIENT
Brock Development Group Inc.

TITLE
Cross Section A - A'

DRAWN BY:
C.S.

REVIEWED BY:
E.B.

DATE
April 2021

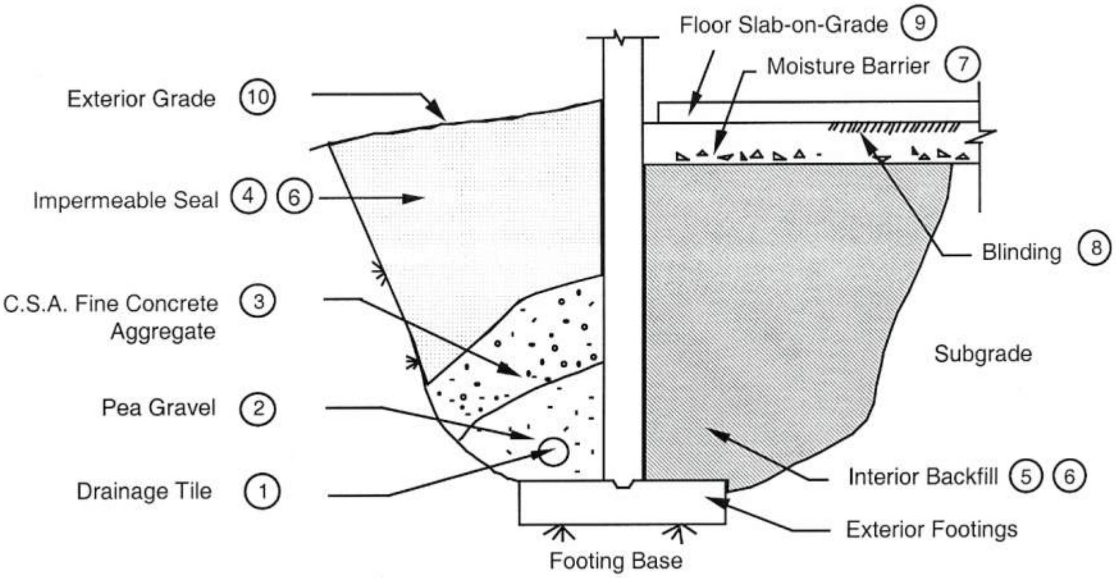
EXP Services Inc.
15701 Robin's Hill Road
London, ON, N5V 0A5

SCALE
1:150

PROJECT NO.
LON-21002656-A0

DWG.
2

DRAWING 3 – DRAINAGE AND BACKFILL RECOMMENDATIONS (NOT TO SCALE)

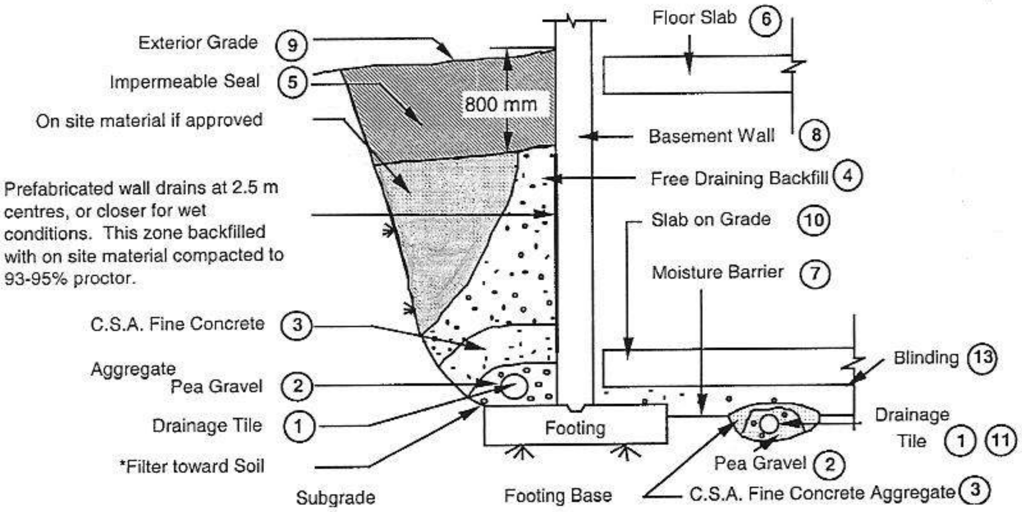


NOTES:

1. Drainage tile to consist of 100 mm (4 in.) diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet. Invert to be minimum of 150 mm (6 in.) below underside of interior floor slab.
2. Pea gravel 150 mm (6 in.) top and sides of drain. If drain is not on footing, place 100 mm (4 in.) of pea gravel below drain. 20 mm (3/4 in.) clear stone may be used provided if it is covered by an approved porous geotextile fabric membrane (Terrafix 270R or equivalent).
3. C.S.A. fine concrete aggregate to act as filter material. Minimum 300 mm (12 in.) top and side of drain. This may be replaced by an approved porous geotextile membrane (Terrafix 270R or equivalent).
4. Impermeable backfill seal of compacted clay, clayey silt or equivalent. If original soil is free-draining, seal may be omitted. Compact backfill to 95 percent Standard Proctor Maximum Dry Density.
5. The interior fill may be any clean, inorganic soil which may be compacted to at least 95 percent Standard Proctor density in this confined space.
6. Do not use heavy compaction equipment within 450 mm (18 in.) of the wall. Do not fill or compact within 1.8 m (6 ft) of wall unless fill is placed on both sides simultaneously.
7. Moisture barrier to be at least 200 mm (8 in.) of compacted 20 mm (3/4 in.) clear, crushed stone or equivalent free-draining material.
8. If the 20 mm (3/4 in.) clear stone requires surface binding, use 60 mm (1/4 in.) clear stone chips.
9. Slab on grade should not be structurally connected to wall or footing.
10. Exterior grade to slope away from building.

This system is not normally required if the floor is at least 300 mm (1 ft.) above exterior grade.

DRAWING 4 – BACKFILL AND BASEMENT DRAINAGE DETAIL, (NOT TO SCALE)



NOTES:

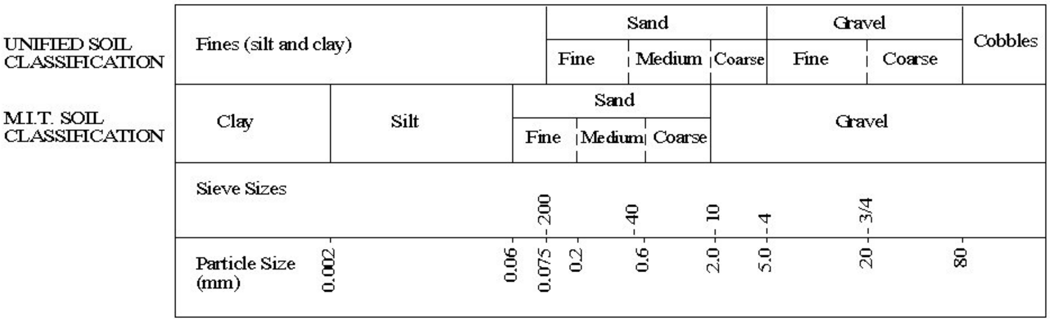
1. Drainage tile to consist of 100 mm (4 in.) diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet. Invert to be minimum of 150 mm (6 in.) below underside of floor slab.
2. Pea gravel 150 mm (6 in.) top and sides of drain. If drain is not on footing, place 100 mm (4 in.) of pea gravel below drain. 20 mm (3/4 in.) clear stone may be used provided if it is covered by an approved porous geotextile fabric membrane (Terrafix 270R or equivalent).
3. C.S.A. fine concrete aggregate to act as filter material. Minimum 300 mm (12 in.) top and side of drain. This may be replaced by an approved porous geotextile membrane (Terrafix 270R or equivalent).
4. Free-draining backfill - OPSS Granular B or equivalent compacted to 93 to 95 (maximum) percent Standard Proctor density. Do not compact closer than l.8 m (6 ft) from wall with heavy equipment. Use hand controlled light compaction equipment within 1.8 m (6 ft) of wall.
5. Impermeable backfill seal of compacted clay, clayey silt or equivalent. If original soil is free-draining, seal may be omitted.
6. Do not backfill until wall is supported by basement and floor slabs or adequate bracing.
7. Moisture barrier to consist of compacted 20 mm (3/4 in.) clear, crushed stone or equivalent free-draining material. Layer to be 200 mm (8 in.) minimum thickness.
8. Basement walls to be damp-proofed.
9. Exterior grade to slope away from wall.
10. Slab on grade should not be structurally connected to wall or footing.
11. Underfloor drain invert to be at least 300 mm (12 in.) below underside of floor slab. Drainage tile placed in parallel rows 6 to 8 m (20 to 25 ft.) centres one way. Place drain on 100 mm (4 in.) of pea gravel with 150 mm (6 in.) of pea gravel top and sides. CSA fine concrete aggregate to be provided as filter material or an approved porous geotextile membrane (as in 2 above) may be used.
12. Do not connect the underfloor drains to perimeter drains.
13. If the 20 mm (3/4 in.) clear stone requires surface binding, use 6 mm (1/4 in.) clear stone chips.

Note: a) Underfloor drainage can be deleted where not required (see report).
b) Free draining backfill, item 4 may be replaced by wall drains, as indicated, if more economical.

Appendix A – Borehole Logs

NOTES ON SAMPLE DESCRIPTIONS

1. All descriptions included in this report follow the 'modified' Massachusetts Institute of Technology (M.I.T.) soil classification system. The laboratory grain-size analysis also follows this classification system. Others may designate the Unified Classification System as their source; a comparison of the two is shown for your information. Please note that, with the exception of those samples where the grain size analysis has been carried out, all samples are classified visually and the accuracy of the visual examination is not sufficient to differentiate between the classification systems or exact grain sizing. The M.I.T. system has been modified and the EXP classification includes a designation for cobbles above the 75 mm size and boulders above the 200 mm size.



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 therefore, may not be applicable as a general description of the site fill material. All fills should be expected to contain obstructions such as large concrete pieces or subsurface basements, floors, tanks, even though none of these obstructions may have been encountered in the borehole. 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 and correct 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. The fill at this site has been monitored for the presence of methane gas and the results are recorded on the borehole logs. The monitoring process neither indicates the volume of gas that can be potentially generated or pinpoints the source of the gas. These readings are to advise of a potential or existing problem (if they exist) and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic waste that renders the material unacceptable for deposition in any but designated land fill sites; unless specifically stated, the fill on the site has not been tested for contaminants that may be considered hazardous. This testing and a potential hazard study can be carried out if you so request. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common, but not detectable using conventional geotechnical procedures.

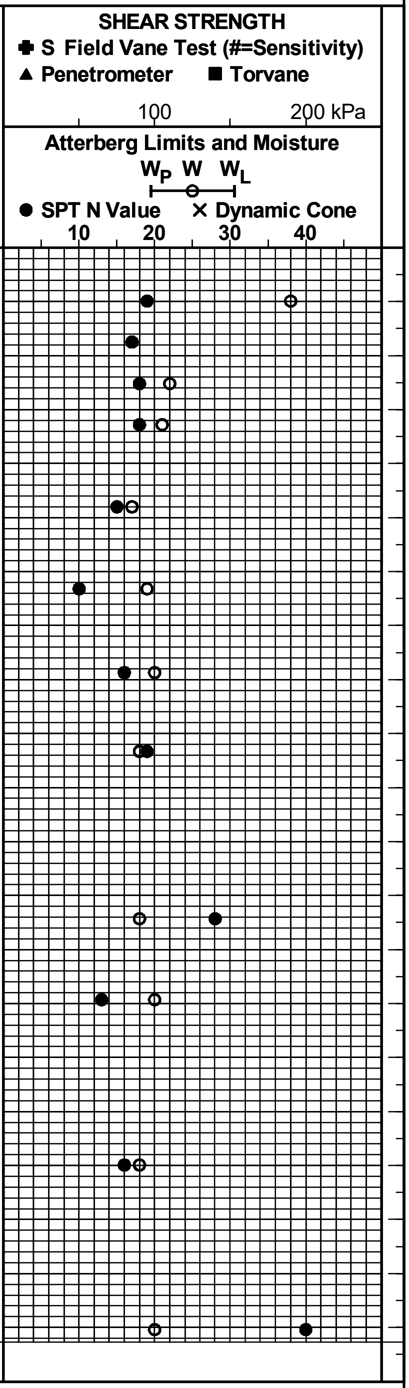
3. **Glacial Till**: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process, the till must be considered heterogeneous in composition and as such, may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm in diameter) or boulders (greater than 200 mm diameter) and therefore, contractors may encounter them during excavation, even if they are not indicated on the borehole logs. It should be appreciated that normal sampling equipment can not differentiate the size or type of obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited area; therefore, caution is essential when dealing with sensitive excavations or dewatering programs in till material.

BOREHOLE LOG

BH1
Sheet 1 of 1

CLIENT **Brock Development Group Inc.**
PROJECT NO. **LON-21002656-AO**
PROJECT **Slope Stability Assessment**
DATUM **Geodetic**
LOCATION **2624 Woodhull Road, London, Ontario**
DATES: Boring **Mar 5/2021**
Water Level

ELEVATION (~m)	STRATA DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N VALUE (blows)	MOISTURE CONTENT (%)
256.0 ~~255.7~~	**TOPSOIL** - 300 mm					
	SILTY SAND , brown, dilatant, trace stiff clay layering, compact, wet	SS	S1	300	19	38
		SS	S2	400	17	17
		SS	S3	450	18	22
		SS	S4	450	18	21
	-becoming grey with no clay layering at 3.8 m bgs					
251.4	**CLAYEY SILT TILL** , grey, trace sand, stiff, moist	SS	S5	400	15	17
		SS	S6	450	10	19
	-becoming very stiff at 7.6 m bgs	SS	S7	450	16	20
		SS	S8	450	19	18
243.8	**SILTY SAND** , grey, dilatant, compact, wet	SS	S9	410	28	18
		SS	S10	300	13	20
239.2	**CLAYEY SILT TILL** , grey, trace sand, very stiff, moist	SS	S11	400	16	18
236.2 235.7	**SILTY SAND** , grey, fine-grained, dense, wet	SS	S12	400	40	20
	End of Borehole at 20.27 m bgs.					



NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-21002656-AO.
2) Borehole open to 4.0 m bgs and dry upon completion of drilling.
3) bgs denotes below ground surface.
4) Ground surface elevation interrupted from topographic survey provided by Client.
5) No significant methane gas concentration was detected upon completion of drilling.

SAMPLE LEGEND
☒ AS Auger Sample
▨ SS Split Spoon
■ ST Shelby Tube
◫ Rock Core (eg. BQ, NQ, etc.)
◫ VN Vane Sample

OTHER TESTS

G Specific Gravity	C Consolidation
H Hydrometer	CD Consolidated Drained Triaxial
S Sieve Analysis	CU Consolidated Undrained Triaxial
γ Unit Weight	UU Unconsolidated Undrained Triaxial
P Field Permeability	UC Unconfined Compression
K Lab Permeability	DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)

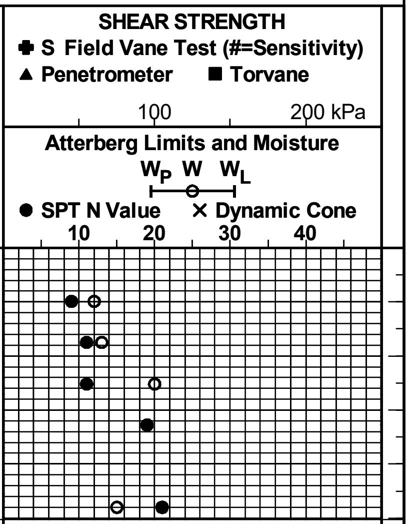
BOREHOLE LOG

BH2
Sheet 1 of 1

CLIENT **Brock Development Group Inc.**
PROJECT NO. **LON-21002656-AO**
PROJECT **Slope Stability Assessment**
DATUM **Geodetic**
LOCATION **2624 Woodhull Road, London, Ontario**
DATES: Boring **Mar 5/2021**
Water Level

Depth scale (m bgs): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21

ELEVATION (~m)	STRATA DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N VALUE (blows)	MOISTURE CONTENT (%)
257.0						
~~256.7~~	**TOPSOIL** - 300 mm					
	CLAYEY SILT TILL , brown, weathered, trace to some sand, stiff, moist	SS	S1	400	9	12
		SS	S2	450	11	13
254.7	**SILTY SAND** , grey, fine-grained, compact, wet	SS	S3	400	11	20
		SS	S4	450	19	19
252.4						
252.0	**CLAYEY SILT TILL** , grey, trace sand, very stiff, moist	SS	S5	400	21	15
	End of Borehole at 5.03 m bgs.					



NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-21002656-AO.
2) Borehole open to 2.4 m bgs and dry upon completion of drilling.
3) bgs denotes below ground surface.
4) Ground surface elevation interrupted from topographic survey provided by Client.
5) No significant methane gas concentration was detected upon completion of drilling.

SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
◫ Rock Core (eg. BQ, NQ, etc.) ◫ VN Vane Sample

OTHER TESTS

G Specific Gravity	C Consolidation
H Hydrometer	CD Consolidated Drained Triaxial
S Sieve Analysis	CU Consolidated Undrained Triaxial
γ Unit Weight	UU Unconsolidated Undrained Triaxial
P Field Permeability	UC Unconfined Compression
K Lab Permeability	DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)

Appendix B – Slope Stability Rating Chart

Slope Stability Rating Chart – A-A’

Geotechnical Principles for Stable Slopes
Ontario Ministry of Natural Resources

Site Location: 2624 Woodhull Road	**Project No.: LON-21002656-AO**
Town/City: London, Ontario	**Inspection Date: March 5, 2021**
	Weather: Sunny, 0 C

	Rating Value	**Slope Rating**
Slope Inclination		
degrees or less (3H:1V or flatter)	0	
to 28 degrees (2H:1V to 3H:1V)	6	
degrees or more (steeper than 2H:1V)	16	**16**
Soil Stratigraphy		
shale / limestone	0	
sand, gravel	6	
till	9	**9**
clay, silt	12	
fill	18	
leda clay	24	
Seepage from Slope Face		
none, or near bottom only	0	**0**
near mid-slope only	6	
near crest only, or from several levels	12	
Slope Height		
2 m or less	0	
2.1 to 5 m	2	
5.1 to 10 m	4	
more than 10 m	8	**8**
Vegetation Cover on Slope Face		
well vegetated: heavy shrubs or forested with mature trees	0	**0**
light vegetation: grass, weeds, occasional trees, shrubs	4	
no vegetation: bare	8	
Table Land Drainage		
table land flat, no apparent drainage over slope	0	**0**
minor drainage over slope, no active erosion	2	
drainage over slope, active erosion, gullies	4	
Proximity of Watercourse to Slope Toe		
15 m or more from slope toe	0	
Less than 15 m from slope toe	6	**6**
Previous Landslide Activity		
No	0	**0**
Yes	6	
Slope Instability Rating		**39**

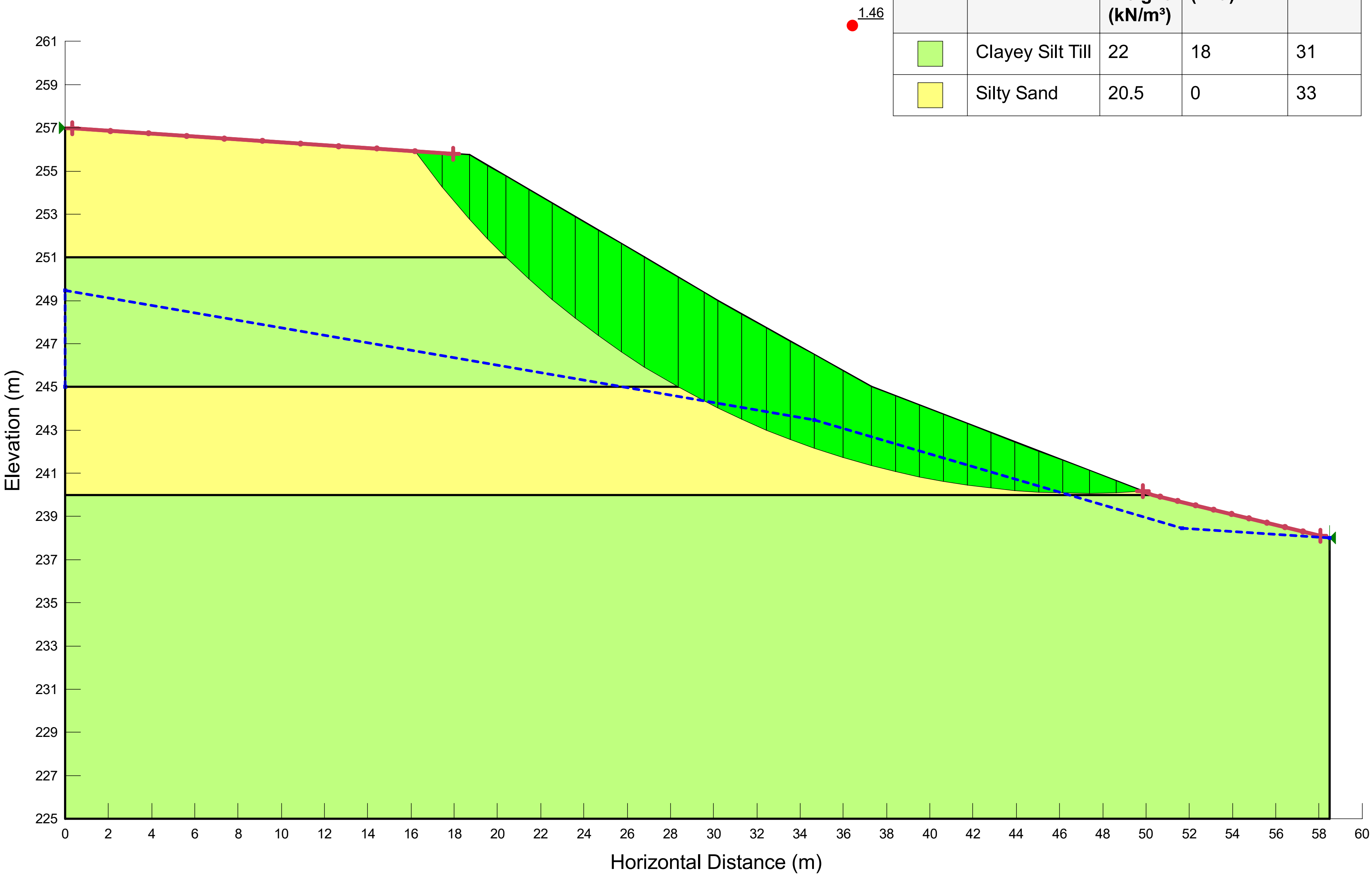
Low Potential	< 24	Site Inspection only, confirmation, report letter
Slight Potential	25-35	Site Inspection and surveying, preliminary study, detailed report
Moderate Potential	> 35	BH Investigation, piezometers, lab tests, surveying, detailed report

Notes:
Is there is a water body (stream, creek, river, pond, bay, lake) at the toe of slope? No
If YES - the potential for toe erosion and undercutting should be evaluated in detail.

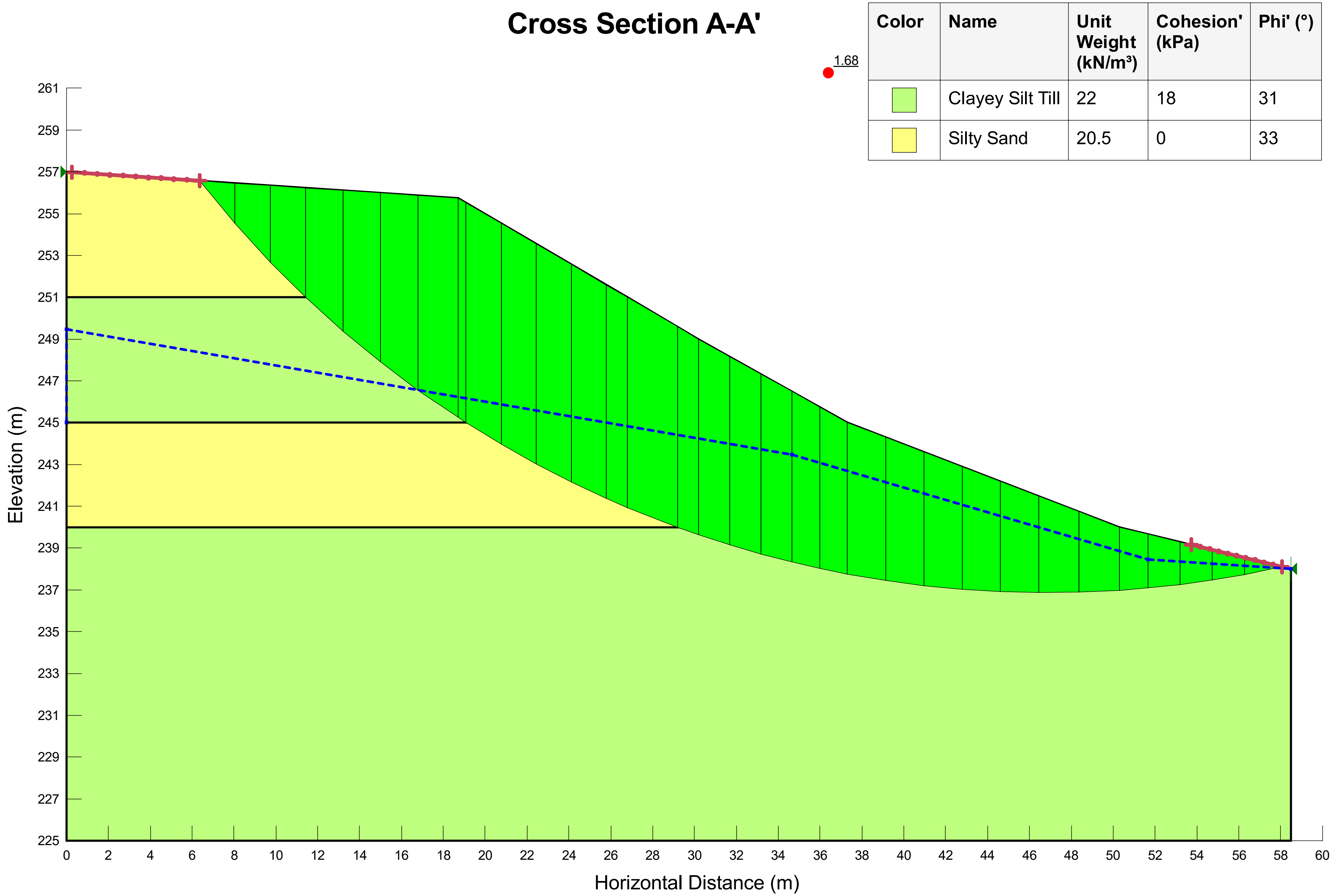
Appendix C – Slope Stability Analyses

Cross Section A-A'

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟩	Clayey Silt Till	22	18	31
🟨	Silty Sand	20.5	0	33



Cross Section A-A'



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟩	Clayey Silt Till	22	18	31
🟨	Silty Sand	20.5	0	33

Appendix D – Site Photos

Photo 1

Photo 2

Photo 3

Photo 4

Appendix E – Limitations and Use of Report

LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report (“Report”) is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of EXP may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by EXP. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and EXP’s recommendations. Any reduction in the level of services recommended will result in EXP providing qualified opinions regarding the adequacy of the work. EXP can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to EXP to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to EXP by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. EXP has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to EXP.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to EXP by its client (“Client”), communications between EXP and the Client, other reports, proposals or documents prepared by EXP for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. EXP is not responsible for use by any party of portions of the Report.

USE OF REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of EXP. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. EXP is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

REPORT FORMAT

Where EXP has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by EXP have utilize specific software and hardware systems. EXP makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems. Regardless of format, the documents described herein are EXP’s instruments of professional service and shall not be altered without the written consent of EXP.

Legal Notification

This report was prepared by EXP Services Inc. for the exclusive use of **Brock Development Group Inc.** and may not be reproduced in whole or in part, or used or relied upon in whole or in part by any party other than **Brock Development Group Inc.** for any purpose whatsoever without the express permission of **Brock Development Group Inc.**in writing.

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