Geotechnical Investigation

Elite Bradley Developments Inc.

Type of Document:
Final Report

Project Name:
Proposed Residential Development
1944 Bradley Avenue, London, Ontario

Project Number:
LON-22008344-A0

Prepared By:
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Date Submitted:
May 25, 2022

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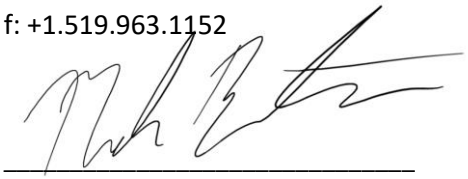

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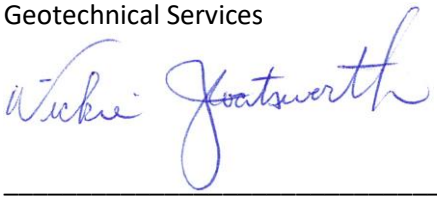

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Date Submitted:

May 25, 2022

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1. Introduction and Background

1.1 Introduction

EXP Services Inc. (EXP) was retained by Elite Bradley Developments Inc. to conduct a Geotechnical Investigation relating to a proposed residential development at 1944 Bradley Avenue, London, Ontario, hereinafter referred to as the 'Site'. The overall Site size is approximately 42.3 hectares. It is understood that the current development plans consist of single residential lots, townhouses and condominium back-to-back townhouses. It is understood that only the portion of the Site north of the hydro-corridor will be developed currently and the lands south of the corridor will be developed in the future.

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 proposed Site development.

1.2 Terms of Reference

The geotechnical investigation was done in general accordance with terms outlined in EXP's proposal emailed to the Client. Client authorization was received from Rachita Gupta in an email along with PO Number Bradley - 002.

The purpose of the investigation was to examine the subsoil and groundwater conditions at the Site by advancing eight (8) boreholes at the Site at the locations illustrated on the attached Borehole Location Plan, **Drawing 1**.

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 engineering guidelines to assist with the geotechnical design and construction of the proposed development. More specifically, this report provides comments on excavations, dewatering, backfill, foundation design, basement construction, site servicing, earthquake design considerations, pavement design and curbs and sidewalks.

This report is provided based on 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.

Reference is made to **Appendix C** of this report, which contains further information necessary for the proper interpretation and use of this report.

2. Methodology

The fieldwork was carried out on April 28, 2022. In general, the geotechnical investigation consisted of the advancement of eight (8) boreholes at the locations denoted on **Drawing 1** as BH1 to BH8 inclusive.

Prior to the investigation, buried service clearances were obtained for the boreholes.

The boreholes were advanced to depths of 5.0 m below ground surface (bgs) using a locally contracted track mounted drilling unit equipped with solid stem, soil sampling and soil testing equipment. Within each borehole, disturbed samples were recovered using conventional split spoon sampling equipment. Standard Penetration Tests (SPT's) were also performed throughout selected boreholes to assess the compactness or consistency of the underlying soils, and to obtain representative samples. The boreholes are described on the Borehole Logs (see **Appendix A**).

During the drilling, the stratigraphy within each borehole was examined and logged in the field by EXP geotechnical personnel. Observations of the groundwater level were also noted in the open test holes and were recorded on the attached Logs. Following the drilling, the boreholes were backfilled with bentonite hole plug and excavated material, to satisfy the requirements of O. Reg. 903.

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 routine moisture content determinations (results presented on the borehole logs).

Samples remaining after the classification testing will be stored for a period of three months following the date of reporting. After this time, they will be discarded unless prior arrangements are made for longer storage.

Borehole locations were established in the field by EXP personnel based on a proposed development plan provided by the client. The elevations were interpolated off City of London topographical mapping.

3. Site and Subsurface Conditions

3.1 Site Description

The Site is located at 1944 Bradley Avenue in London and is primarily used for agricultural fields and occupied by a single residence and agricultural buildings. A hydro corridor cuts through the Site near the middle. The Site is bounded by a woodlot to the north, agricultural fields to the east, Bradley Avenue to the south and a residential development currently under construction to the west. The site gently slopes from the north down to the south with an elevation change of 5.8 m based on the elevations of the boreholes.

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

3.2 Soil Stratigraphy

The detailed stratigraphy encountered in each borehole and the results of routine laboratory testing carried out on representative samples of the subsoil are given on the borehole logs presented 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.

3.2.1 Topsoil

Topsoil was found at surface at all Boreholes. The topsoil ranged in thickness from 250 mm to 300 mm.

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 shallow test pits) is recommended to accurately quantify the amount of topsoil to be removed for construction purposes.

3.2.2 Sandy Silt

Beneath the topsoil in boreholes BH1 and BH8, sandy silt was encountered. The sandy silt was generally brown to grey in colour with trace clay to some clayey layering. The sandy silt was generally loose to compact with SPT N values of 5 to 13 blows per 300 mm sample spoon penetration. The sandy silt was generally moist to wet with in-situ moisture contents of 18 to 29 percent. The sandy silt extended to depths of 1.4 m bgs at Borehole BH1 and 3.8 m bgs at Borehole BH8.

Borehole BH7 encountered a sandy silt layer near 3.8 m bgs and was terminated in this layer.

3.2.3 Clayey Silt Till

Clayey silt till was encountered below the topsoil and sandy silt at all boreholes. All boreholes were terminated in the till with the exception of BH7. The till was generally brown, becoming grey with depth and contained trace to some sand and trace gravel. The till displayed a consistency of stiff to hard based on SPT N Values of 8 to 30 for 300 mm penetration of the split spoon sampler. In situ moisture contents varied from 10 to 22 percent, indicating moist conditions.

3.3 Groundwater Conditions

Details of the groundwater conditions observed within the boreholes are provided on the Borehole Logs. Moisture contents of selected samples are provided on the logs in **Appendix A**.

At completion of drilling, water was measured in Boreholes BH6, BH7 and BH8 at depths of 3.0m, 4.0m and 4.0m bgs, respectively. All other boreholes were open and dry upon the completion of drilling.

It is believed that the observed groundwater is perched groundwater within sand seams of the clayey silt till or in the sandy silt layers between till layers.

Insufficient time was available to establish the stabilized groundwater condition at each borehole. The depth to the groundwater table may vary in response to climatic or seasonal conditions, and, as such, may differ at the time of construction, with high levels in wet seasons. Capillary rise effects should also be anticipated in fine-grained soil deposits.

3.4 Methane Gas

An RKI Gx-2003 Gas Detector was used in the upper levels of the open boreholes. The unit measures LEL combustibles, methane gas, oxygen content, carbon monoxide and hydrogen sulfide in standard confined space gases. No significant methane gas concentration was detected in the boreholes.

4. Discussion and Recommendations

4.1 General

It is understood that the current development plans consist of single residential lots, townhouses and condominium back-to-back townhouses. It is understood that only the portion north of the hydro-corridor on the Site will be developed currently and the lands south of the corridor are to be developed in the future. It is assumed that the residences will be homes constructed with basements.

The following sections of this report provide geotechnical comments regarding site preparation, excavations, dewatering, foundations, basement and slab-on-grade construction, site servicing, pavement design, seismic considerations and pavement design.

4.2 Site Preparation

Prior to placement of foundations and/or engineered fill, all surficial topsoil, vegetation and/or otherwise deleterious materials should be stripped. Thicker areas of topsoil may be anticipated in areas with trees and/or heavy vegetative cover. It is anticipated that the surficial topsoil may be stockpiled on site for possible reuse as landscaping fill.

It is understood that the existing structures on site will be demolished. The removal of the buildings should include all building debris, foundation walls, footings and concrete floor slabs. The removal and disposal of the previously occupied buildings and associated fill must satisfy the local building standards, Ontario Building Code (OBC), Ministry of Labour (MOL) and the Ministry of Environment, Conservation and Parks (MECP) requirements. If any potable wells are present on Site, they should be properly decommissioned by a licensed well contractor, in accordance with Ontario Regulation 903.

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 and should 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 2.

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 areas along the proposed roadways, fill material used to raise grades may comprise onsite excavated soils, or imported granular fill approved by an engineer. The fill should be placed in maximum 300 mm (12 inch) thick loose lifts and uniformly compacted to 95/98 percent SPMDD within 3 percent of optimum moisture content to provide adequate stability for the new pavements.

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.

4.3 Excavation and Groundwater Control

4.3.1 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 is 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 quality and quantity of soil to be managed. The quality of soils is assessed through an Assessment of Past Uses (APU) including the provision of an Ecolog ERIS data base report to determine if there are any Areas of Potential Environmental Concern (APEC). The parameters to be tested will be determined by the APU results.

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.

The most economical solution to avoid the additional costs related to O. Reg. 406/19 is to provide a site grading plan that keeps all excess soils on Site.

4.3.2 Excavations

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 sandy silt and stiff clayey silt till encountered within the boreholes are classified as Type 3 soil. The very stiff to hard clayey silt till soils are classified as Type 2 soils.

Where excavations extend into or through Type 3 soils, excavation side slopes must be cut back at a maximum inclination of about 1H:1V from the base of the excavation. Excavations in Type 2 soils may be vertical in the bottom 1.2 m and then sloped at an inclination of 1H:1V or flatter, above that level. Should groundwater egress loosen the side slopes, 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.

4.3.3 Excavation Support

The recommendations for side slopes given above would apply to most of the conventional excavations expected for the proposed development. However, in areas adjacent to existing structures and 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 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, a prefabricated trench box or shoring such as sheeting or soldier piles and lagging can be considered if it is designed by a professional engineer to withstand the soil and hydrostatic loading (if applicable). 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/m^3 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 them to the engineer for review and comment.

4.3.4 Construction Dewatering

All boreholes were dry upon completion of drilling with the exception of BH6, BH7 and BH8. Groundwater was observed near 3.0 to 4.0 m bgs in these boreholes. It should be noted that these boreholes are located in the south parcel which will be developed in the future. It is recommended that additional boreholes and monitoring wells be installed in this south parcel closer to the time of its development. Based on the results of the field drilling program for the north parcel, significant groundwater infiltration is not anticipated during excavation for buildings and services to conventional depths. In the event of minor groundwater seepage during excavation for foundations or site servicing, it can likely be accommodated using conventional sump pumping techniques. If groundwater infiltration persists, more extensive dewatering measures may be required.

Collected water from service trenches and temporary excavations 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.

Although not anticipated for this project, it should be noted that for projects requiring positive groundwater control with a removal rate more than 50,000 litres per day, an Environmental Activity and Sector Registry (EASR) or Permit to Take Water (PTTW) will be required. PTTW applications are required for removal rates more than 400,000 L per day and will need to be approved by the MECP according to 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 PTTW 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.

4.4 Foundation Construction

4.4.1 Shallow Strip and Spread Footings on Natural Competent Soils

Foundations for the proposed development can be set on the natural, competent compact sandy silt and stiff to hard clayey silt till soils encountered near 1.2 m bgs and below. The following allowable bearing pressures (net stress increase) can be used on the natural, undisturbed compact sandy silt and clayey silt till at a minimum depth of 1.2 m bgs for all of the boreholes except for Borehole BH8:

Bearing Resistance at Serviceability Limit States (SLS)	145 kPa (3,000 psf)
Factored Bearing Resistance at Ultimate Limit States (ULS)	220 kPa (4,500 psf)

At the location of Borehole BH8, competent soil for foundations was encountered at a depth of 3.0 m bgs.

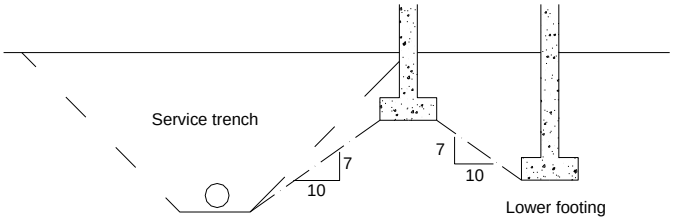
If grades are to be raised or restored, engineered fill can be used for foundation support. The available SLS bearing capacity for the engineered fill is 145 kPa (3,000 psf). **Drawing 2** provides requirements for engineered

fill placement. The subgrade level for footings set on engineered fill can be set higher than the 1.2 m bgs noted above.

All organic material and unsuitable soils should be removed from the footprint area of the buildings prior to engineered fill placement. A proof roll should be carried out over the subgrade in the presence of an EXP representative. Any soft spots detected by the proof roll should be dug out and replaced with competent material under the direction of an EXP representative.

4.4.2 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 excavations, 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 (i.e., where more specific information becomes available with respect to conditions between borehole locations 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.

4.5 Basement Construction

The basement floors can be constructed using cast slab-on-grade techniques provided the subgrade is stripped of all topsoil and other obviously objectionable material. The subgrade should then be proof rolled thoroughly. Any soft zones detected should be dug out and replaced with approved granular material placed in accordance with the requirements outlined in the previous Section 4.1.

A granular base, 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 subgrade and the floor slab. Alternatively, 300 mm of OPSS Granular 'A' material compacted to 100 percent SPMDD may be considered.

The installation and requirement of a vapour barrier under the floor slab, where applicable, should conform to the flooring manufacturers and designer's requirements. Moisture emission testing is recommended to determine the concrete condition prior to flooring installation.

The basement foundation walls should be damp-proofed and backfilled using a free draining granular material such as Granular 'B', Type I material. This material should be placed in maximum 250 mm thick loose lifts and uniformly compacted to at least 95 percent of SPMDD.

For foundation walls backfilled as outlined above, the lateral earth pressures acting on the walls maybe calculated as follows:

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

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/m^3 may be assumed

h = depth to point of interest in m

q = equivalent value of any surcharge on the ground surface

Where 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. The drains should be connected to a free discharge outlet or a sump pump system. Suggestions for permanent perimeter drainage are given on **Drawing 3**.

4.6 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 granular fill. Where the exposed subgrade requires reconstruction to achieve the design elevations, structural fill should be used. It is recommended that structural fill comprises 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.

No special underfloor drains are required provided that the exterior grades are lower than the floor slab, and positively sloped away from the slab. It is recommended that an impermeable soil seal such as clay, asphalt or concrete be provided on the surface to minimize water infiltration from the exterior of the building. See **Drawing 4** for Drainage and Backfill recommendations for slab-on-grade construction.

A granular base, consisting of a 200 mm (8 in.) thick, compacted layer of 19 mm (3/4 in.) clear stone, should then be placed between the prepared subgrade and the floor slab. Alternatively, 300 mm of OPSS Granular 'A' material compacted to 100 percent SPMDD may be considered.

The installation and requirement of a vapour barrier under a concrete slab should conform to the flooring manufacturers 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 15 MPa/m for the compacted stone layer over the compacted granular subbase.

The water-to-cement ratio and slump of concrete utilized 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.

4.7 Foundation Backfill

In general, the existing natural, non-organic soils excavated from the foundation area should be suitable for re-use as foundation wall backfill, behind the free-draining layer. The materials to be re-used should be within three percent of optimum moisture for best compaction results. Materials should be stockpiled according to their composition; i.e. sandy soils should not be mixed with till 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.

4.8 Site Servicing

Based on the results of the investigation, it is anticipated that services will be set into the natural clayey silt till or engineered soils. No bearing problems are anticipated for services set into these soils. The subgrade soil should be inspected by EXP during construction to verify/ensure a competent subgrade is present. For services constructed on the natural soils or engineered fill, the bedding should conform to OPS Standards. The bedding course may be thickened if portions of the subgrade become wet during excavation. Bedding aggregate should be placed around the pipe to at least 300 mm (12 inch) above the pipe and be compacted to a minimum 95 percent SPMDD.

Water and sewage lines installed outside of heated areas should be provided with a minimum 1.2 m (4 ft) of soil cover for frost protection.

The bases of excavations which cut into and terminate in competent natural soils are expected to remain stable for the short construction period. For bases terminated in wet silty layers, localized improvement will be

required. Base improvement may also be required if work is carried out in wet weather seasons. The extent of base improvement or stabilization is best determined in the field during construction, with consultation from a Geotechnical Engineer.

To minimize disturbance to the base, pipe laying should be carried out in short sections, with backfilling following closely after laying and no section of trench should be left open overnight.

The trenches above the specified pipe bedding should be backfilled with inorganic on-site soils placed in 300 mm thick lifts and uniformly compacted to at least 95% SPMDD. For trench backfill within 1 meter below the roadway subbase, the fill should be uniformly compacted to at least 98% SPMDD. A program of *in situ* density testing should be set up to ensure that satisfactory levels of compaction are achieved.

Requirements for backfill in service trenches, etc. should also have regard for OPSS requirements. A summary of the general recommendations for trench backfill is presented on **Drawings 5** and **6**. A program of *in situ* density testing (see **Appendix B**) should be set up to ensure that satisfactory levels of compaction are achieved.

Based on the results of this investigation, the majority of the excavated natural material may be used for construction backfill provided that reasonable care is exercised in handling. In this regard, the material should be within 3 percent of the optimum moisture as determined in the Standard Proctor density test and stockpiling of material for prolonged periods of time should be avoided. This is particularly important if construction is carried out in wet or otherwise adverse weather.

Soils excavated from below the stabilized groundwater table may be too wet for reuse as backfill unless adequate time is allowed for drying, or if the material is blended with approved dry fill; otherwise, it may be stockpiled onsite for reuse as landscape fill.

As noted previously, disposal of excavated materials off site should conform to current MECP guidelines.

4.9 Earthquake Design Considerations

The recommendations for the geotechnical aspects to determine the earthquake loading for design using the OBC 2020 are presented below.

The subsoil and groundwater information at this Site have been examined in relation to Section 4.1.8.4 of the OBC 2020. The subsoils on Site generally consist of stiff to very stiff clayey silt till deposits. It is anticipated that the proposed structures will be founded on the till or engineered fill.

Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2020 indicated that to determine the Site Classification, the average properties in the top 30 m (below the lowest founding level) are to be used. The boreholes advanced on Site were to a maximum of about 5.0 m depth. Therefore, the Site Classification recommendation would be based on the available information as well as our interpretation of conditions below the boreholes based on our knowledge of the soil conditions in the area.

Based on the above assumptions, interpretations in combination with the known local geological conditions, the Site Class for the proposed development is “D” as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2020.

4.10 Pavement Design

Areas to be paved should be stripped of all topsoil, organics, fill and other obviously unsuitable material. The exposed subgrade must then be thoroughly proof rolled. Any soft zones revealed by this or any other observations must be over-excavated and backfilled with approved material. All fill required to backfill service trenches or to raise the subgrade to design levels must conform to requirements outlined previously. Preferably, the natural inorganic excavated soils should be used to maintain uniform subgrade conditions, provided adequate compaction can be achieved.

Provided the preceding recommendations are followed, the pavement thickness design requirements given in Table 1 are recommended for the anticipated loading and subgrade conditions.

Table 1 – Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Light Duty Pavement (for Cars Only)	Heavy Duty Pavement (Cars & Trucks)
Asphaltic Concrete	92% MRD[1] or 97% BRD[1]	40 mm HL-3 50 mm HL-8	50 mm HL-3 60 mm HL-8
Granular 'A' (Base)			
Granular 'B' (Base)	100% SPMDD[1]	300 mm	450 mm

*Notes: 1) SPMDD denotes Standard Proctor Maximum Dry Density, MRD denotes Maximum Relative Density, BRD denotes Bulk Relative Density.
2) The subgrade must be compacted to 98% SPMDD.
3) The above recommendations are minimum requirements.
4) The City of London pavement design is based on allowable deflection as determined by Benkelman Beam Rebound testing.

The recommended pavement structures provided in the above table are based on the existing 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. Other granular configurations may also be possible provided the granular base equivalency (GBE) thickness is maintained. These recommendations on thickness design are not intended to support heavy and concentrated construction traffic, particularly where only a portion of the pavement section is installed.

If construction is undertaken under adverse weather conditions (i.e., wet or freezing conditions) subgrade preparation and granular sub-base requirements should be reviewed by the Geotechnical Engineer. If the sub-base is set on wet or dilatant silty soils, a geotextile will be required. A woven type geotextile such as Terrafix 200W or equivalent would be suitable for this application.

If only a portion of the pavement will be in place during construction, the granular subbase may have to be thickened. This is best determined in the field during the site servicing stage of construction, prior to road construction.

Samples of both the Granular 'A' and Granular 'B' aggregate should be checked for conformance to OPSS 1010 prior to utilization on Site, and during construction. The Granular 'B' subbase and the Granular 'A' base courses must be compacted to 100 percent SPMDD.

The asphaltic concrete paving materials should conform to the requirements of OPSS MUNI 1150. The asphalt should be placed in accordance with OPSS 310 and compacted to at least 97 percent of the Marshall mix design bulk relative density or 92% of maximum relative density. A tack coat should be applied between the surface and binder asphalt courses.

Good drainage provisions will optimize pavement performance. The finished pavement surface should be free of depressions and should be sloped (preferably at a minimum grade of two percent) to provide effective surface drainage toward catch basins. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. In low areas, sub-drains should be installed to intercept excess subsurface moisture and prevent subgrade softening, as shown on **Drawing 7**. This is particularly important in heavier traffic areas at the site entrances. The locations and extent of sub-drainage required within the paved areas should be reviewed by this office in conjunction with the proposed grading.

A program of in situ density testing must be carried out to verify that satisfactory levels of compaction are being achieved.

To minimize the effects of differential settlements of service trench fill, it is recommended that wherever practical, placement of binder asphalt be delayed for approximately six months after the granular sub-base is put down. The surface course asphalt should be delayed for a further one year. Prior to the surface asphalt being placed, it is recommended that a pavement evaluation be carried out on the base asphalt to identify repair areas or areas requiring remedial works prior to surface asphalt being placed.

4.11 Curbs and Sidewalks

It is recommended that the concrete for curb and gutter and sidewalks should be proportioned, mixed, placed, and cured in accordance with the requirements of OPSS 353 and OPSS 1350.

During cold weather, the freshly placed concrete must be covered with insulating blankets to protect against freezing. Three cylinders from each day's pour should be taken for compressive strength testing. Air entrainment, temperature, and slump tests should be made from the same batch of concrete from which test cylinders are made.

The subgrade for the sidewalks should comprise undisturbed natural competent soil of well-compacted fill. A minimum 150 mm thick layer of compacted Granular 'A' type aggregate should be placed beneath the sidewalk slabs. It is recommended that the Granular 'A' be compacted to a minimum 100 percent SPMDD, to provide adequate support for the concrete sidewalk. Construction traffic should be kept off the placed curbs and sidewalks as they are not designed to withstand heavy traffic load.

4.12 Methane Gas Testing

An RKI Gx-2003 Gas Detector was used in the upper levels of the open boreholes. The unit measures LEL combustibles, methane gas, oxygen content, carbon monoxide and hydrogen sulfide in standard confined space gases. No significant methane gas was detected in any of the boreholes.

Based on the present information, no special methane gas abatement measures are indicated at this site.

4.13 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 following removal of existing services (if any), fill and organics, prior to foundation installation and engineered fill placement (if required)
- Inspection and materials testing during engineered fill placement (full-time supervision is recommended) and site servicing works, including soil sampling, laboratory testing (moisture contents and Standard Proctor density test on the pipe bedding, trench backfill and engineered fill material), monitoring of fill placement, and in situ density testing
- Footing base examinations to confirm suitability to support the design bearing pressures; and visual examination of concrete reinforcing steel placement in footings set on engineered fill
- Inspection and testing for underfloor subgrade and granular placement
- Materials testing for concrete foundations, floor slab, curbs and sidewalks
- Inspection and materials testing during paving work including laboratory testing and in situ density testing

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

5. General Limitations

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 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. No other warranty or representation, either expressed or implied, is included or intended in this report.

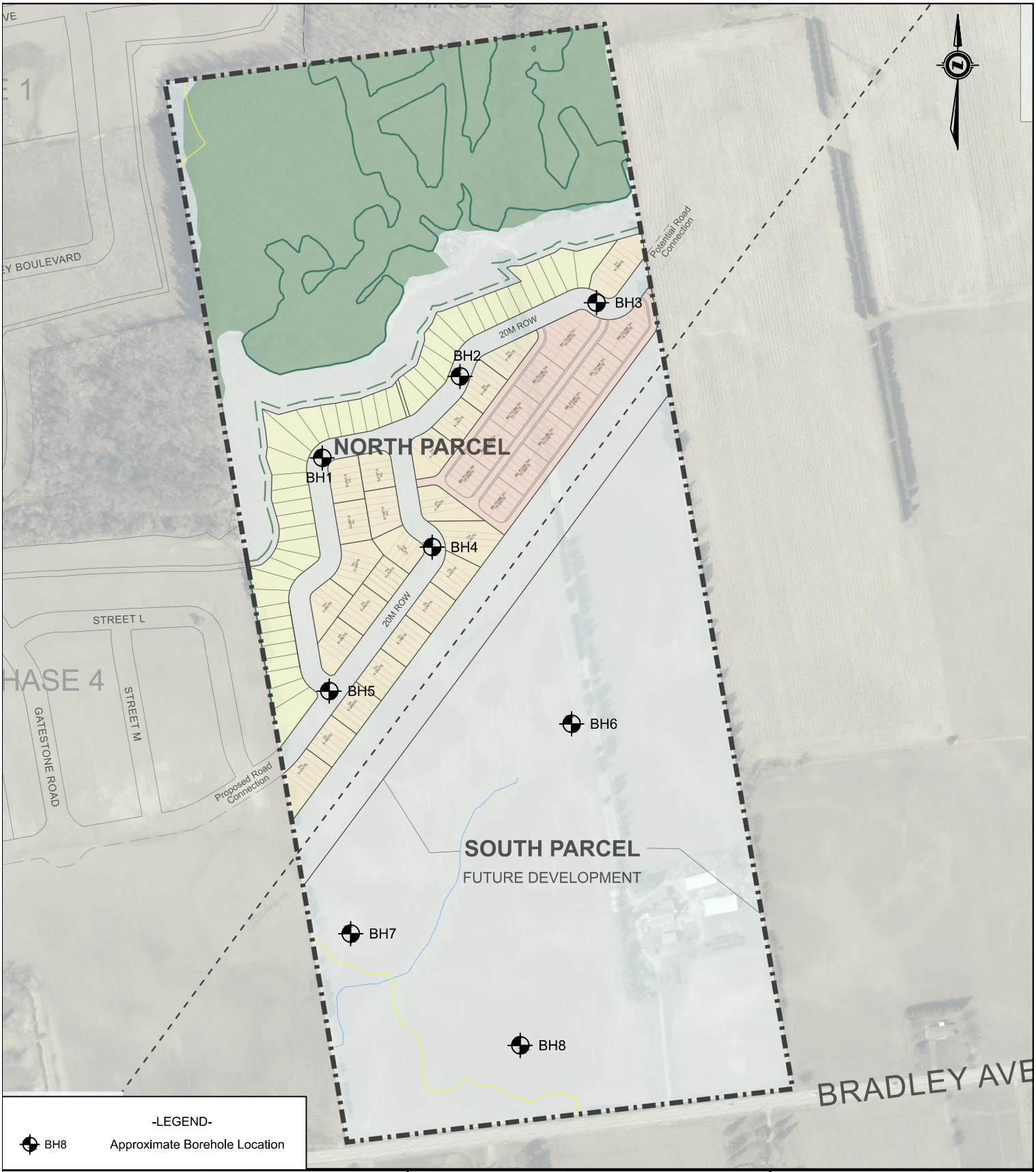
The comments given in this report are intended only for the guidance of design engineers. The number of test holes required to determine the localized underground conditions between test holes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. would be much greater than 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 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 will assume no responsibility for interpretation of the recommendations in this report

This report was prepared for the exclusive use of **Elite Bradley Developments 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 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-

BH8 Approximate Borehole Location

-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. The site plan has been reproduced from a drawing provided by the Client and should be read in conjunction with EXP Geotechnical Report LON-22008334-A0

Geotechnical Investigation

Proposed Residential Development

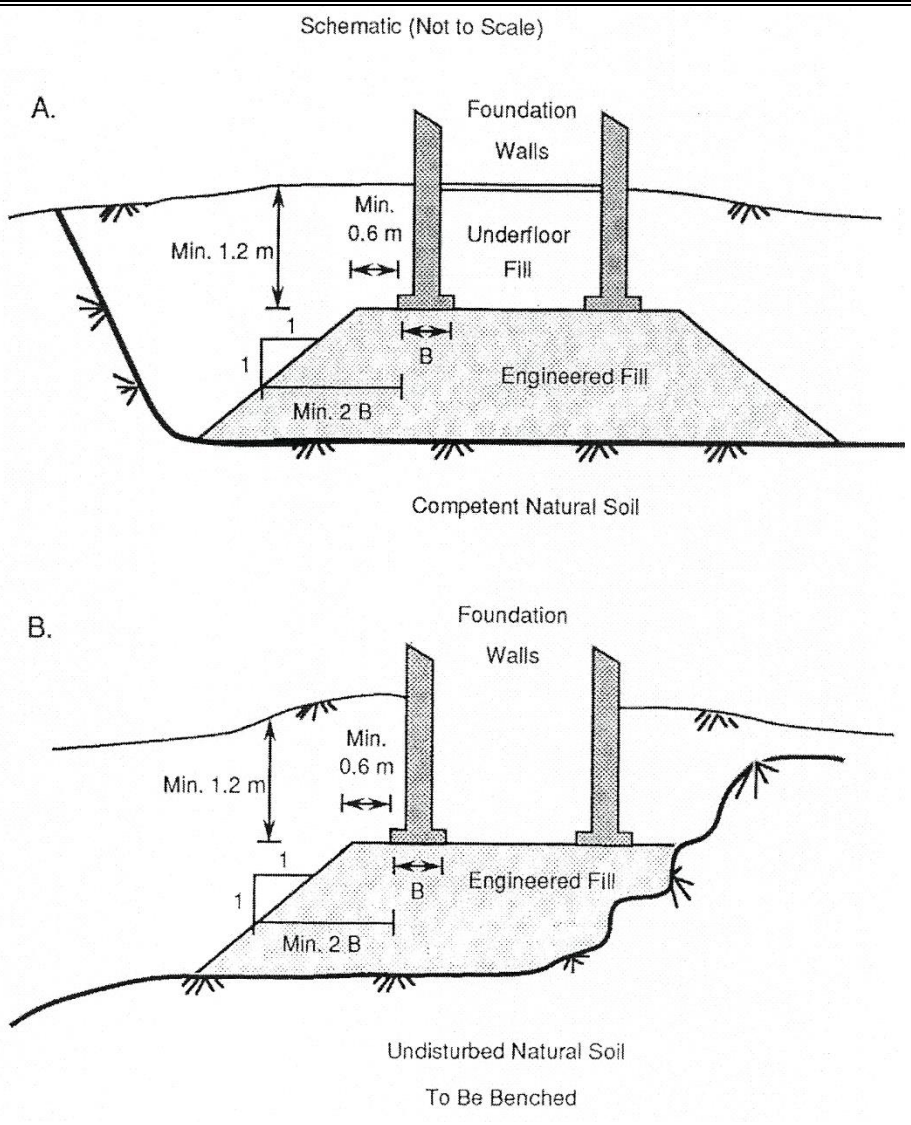
1944 Bradley Avenue,
London, Ontario

CLIENT	Elite Bradley Developments Inc.
TITLE	Borehole Location Plan
DR- BY:	M.B.
RE EWED BY:	V.C.
SC-LE	NTS

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

D-TE	PROJECT NO.	DWG.
MAY 2022	LON-22008334-A0	1

DRAWING 2 – GEOMETRIC REQUIREMENTS FOR FOUNDATIONS ON ENGINEERED FILL



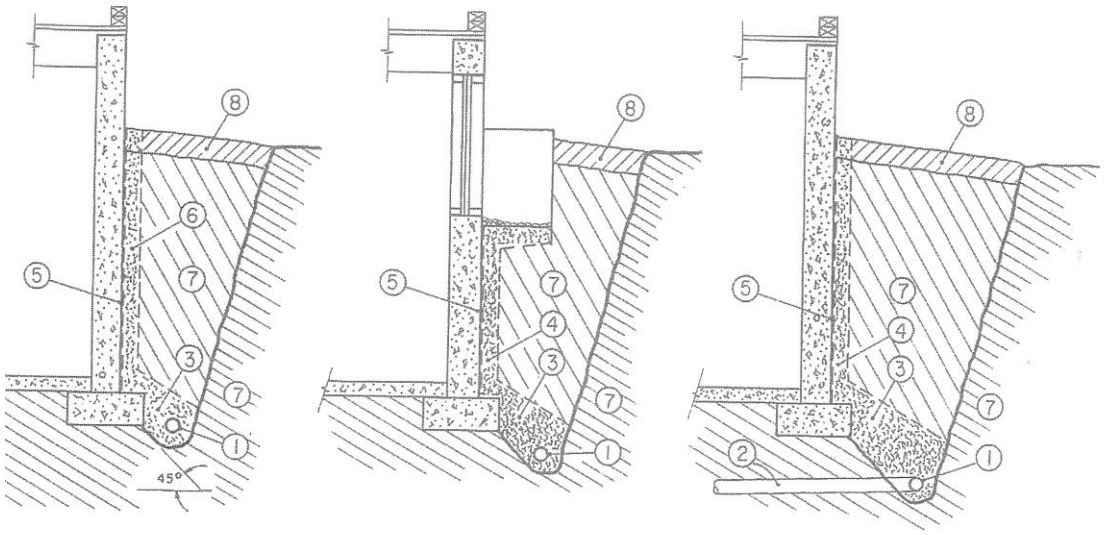
SECTION VIEW

Section A – Typical Section of Slab-on-Grade Building
Section B – Typical Section of Building with Basement
Refer to Detailed Notes on following page.

NOTES FOR ENGINEERED FILL PLACMENT:

1. The area must be stripped of all topsoil contaminated fill material, and other unsuitable soils, and proof rolled. Soft spots must be dug out. The stripped natural subgrade must be examined and approved by an EXP Engineer prior to placement of engineered fill.
2. In areas where engineered fill is placed on a slope, the fill should be benched into the approved subgrade soils. EXP would be pleased to provide additional comments and recommendations in this regard, if required.
3. All excavations must be carried out in accordance with the Occupational Health and Safety Regulation of Ontario (Construction Projects - O.Reg. 213.91)
4. Material used for engineered fill must be free of topsoil, organics, frost and frozen material, and otherwise unsuitable or compressible soils, as determined by a Geotechnical Engineer. Any material proposed for use as engineered fill must be examined and approved by EXP, prior to use onsite. Clean compactable granular fill is preferred.
5. Approved engineered fill should be placed in maximum 300 mm thick lifts, and uniformly compacted to 100% Standard Proctor dry density throughout. For best compaction results, engineered fill should be within 3 percent of its optimum moisture content, as determined by the Standard Proctor density test. Imported fill should satisfy the MECP regulations and requirements.
6. Full time geotechnical monitoring, inspection and insitu density (compaction) testing by EXP is required during placement of the engineered fill.
7. Site grades should be maintained during area grading activities to promote drainage, and to minimize ponding of surface water on the engineered fill mat. Rutting by construction equipment should be kept to a minimum, where possible. Additional work to ensure suitability of engineered fill may be required if fill is placed in extreme (hot/cold) weather.
8. The fill must be placed such that the specified geometry is achieved. Refer to sketches (previous page) for minimum requirements. Proper environmental protection will be required, such as providing frost penetration during construction, and after the completion of the engineered fill mat.
9. An allowable bearing pressure of 145 kPa (3000 psf) may be used provided that all conditions outlined above, and in the Geotechnical Report are adhered to.
10. These guidelines are to be read in conjunction with the attached Geotechnical Report. (EXP Project No. LON-22008334-A0)
11. For foundations set on engineered fill, footing enhancement and/or concrete reinforcing steel placement is recommended. The footing geometry and extent of concrete reinforcing steel will depend on site specific conditions. In general, consideration may be given to having a minimum strip footing width of 500 mm (20 inches), containing nominal steel reinforcement. Alternatively, concrete reinforcement may be recommended in the top and bottom of the foundation wall strip. The final footing geometry and extent of reinforcement is best determined in the field, by a Geotechnical Engineer.

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

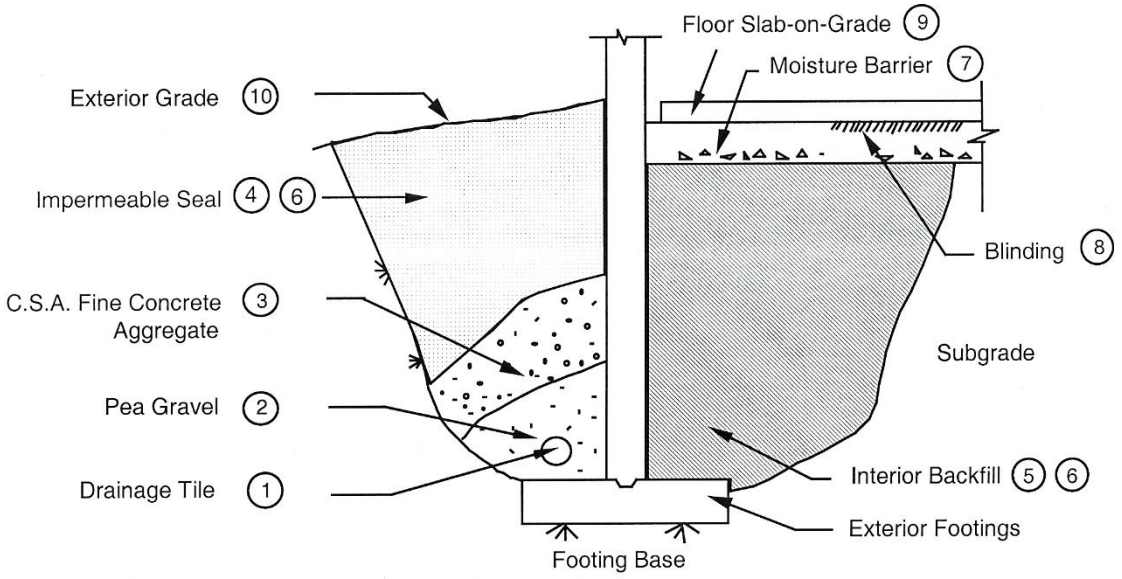


NOTES:

1. Perforated or slotted pipe placed about 300 mm below the upper level of the basement floor slab;
2. Unperforated drain pipe connected to a positive sump; connect to appropriate trap and backwater valve before connecting to sewer, where applicable. Provide appropriate access to the trap for inspection and cleaning;
3. Filter material that is compatible with the grain size characteristics of the foundation and backfill soils, as well as the perforations of the pipe;
4. Filter material continuously or intermittently placed next to the foundation wall to intercept water from window wells and low areas near building (see also 6);
5. Damp-proofing on wall;
6. Optional use of sheet drain or synthetic filter blanket next to foundation wall to replace the soil filter described in 4;
7. Foundation and backfill soils, which may contain fine grain and erodible materials; and,
8. "Topping-off" material, graded away from the building to redirect surface water from the foundations. Low permeability soils, or concrete or asphalt, are preferred.

Reference: Canadian Geotechnical Society 2006, *Canadian Foundation Engineering Manual, 4th Edition, (Figure 12.1, p184).*

DRAWING 4 – DRAINAGE AND BACKFILL RECOMMENDATIONS (NOT TO SCALE)



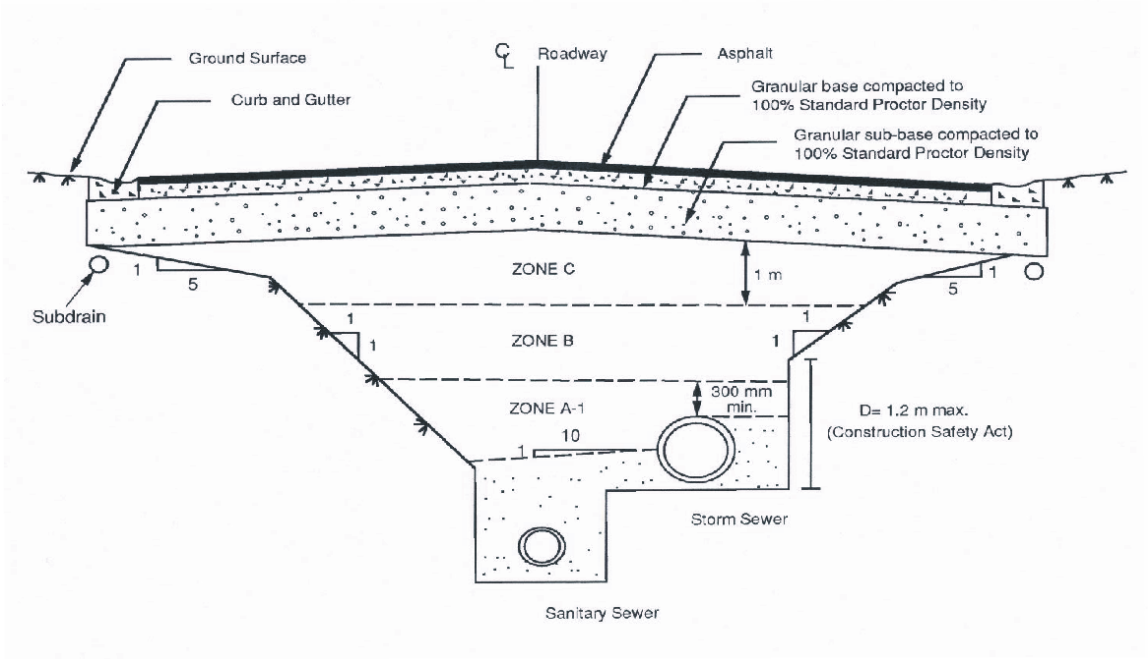
NOTES:

1 Drainage tile to consist of 100 mm (4 in) diameter weeping tile or equivalent perforated pipe leading to a positive sup 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 5 – TYPICAL BACKFILL DETAIL
STORM AND SANITARY SEWER (COMMON TRENCH)



SECTION VIEW

NOTES:

ZONE A

Granular bedding satisfying current OP Standards compacted to 95% Standard Proctor maximum dry density.

ZONE A-l

To be compacted to at least 95% Standard Proctor maximum dry density.

ZONE B

To be compacted to at least 95% Standard Proctor maximum dry density.

ZONE C

To be compacted to 98% Standard Proctor maximum dry density.

The excavations shown above are for Type 1 or 2 soils. Where excavations extend through Type 3 soils, the side walls should be sloped back at a maximum inclination of 1 horizontal to 1 vertical from the base (Reference O.Reg 213/91).

DRAWING 6 – TRENCH BACKFILL REQUIREMENTS

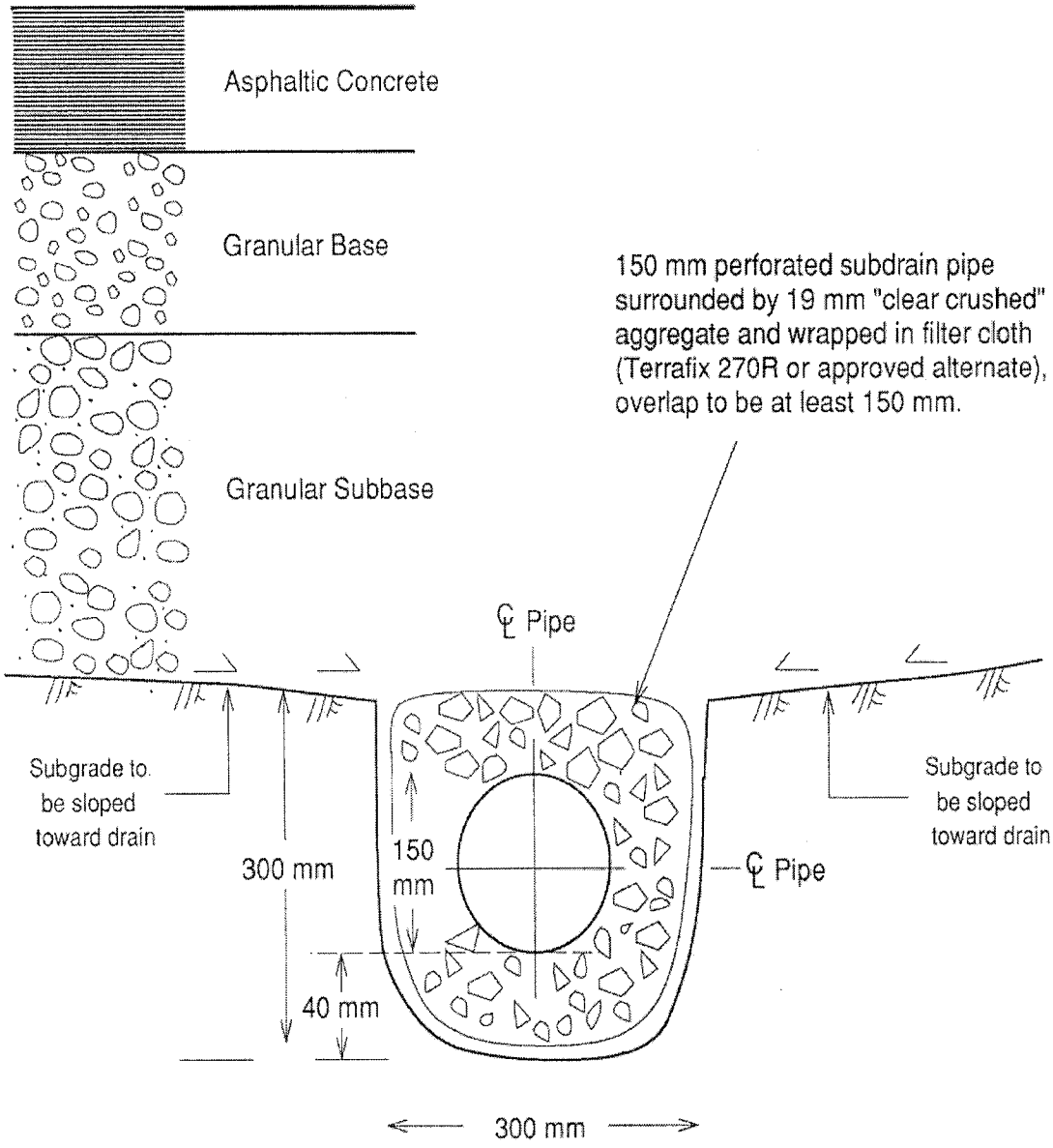
Requirements for backfill in service trenches, etc. should conform to current OPS requirements. A summary of the general recommendations for trench backfill is presented on Drawing 5.

The bedding materials for the services designated as Zone A on the attached drawings should consist of approved granular material satisfying the current OPS minimum standards and specifications. (Class B bedding should provide adequate support for the pipes). These materials should be uniformly compacted to 95 percent of standard Proctor dry density. Some problems may be encountered in maintaining alignment when bedding pipes in wet sandy soil. If Granular 'A' or other sandy material is used for bedding, they may become 'spongy' when saturated. If significant amounts of clear stone are used to stabilize the base, a geotextile should be incorporated to avoid problems with migration of fine grained materials and differential settlement under the pipes as the groundwater rises after backfilling. For minor local use of crushed stone without a geotextile filter, a graded HL3 stone is preferable.

The backfill in Zone B will consist of the native material. This material should be placed in loose lifts not exceeding 300 mm (12 inches) and be uniformly compacted to at least 95 percent of the standard Proctor maximum dry density. Material wetter than 5 percent above optimum must be allowed to dry sufficiently or should be discarded or used in landscaped areas.

The upper 1 meter of the general backfill (i.e. Zone C) should be placed in loose lifts not exceeding 300 mm (12 inches) and be uniformly compacted to at least 98 percent of the standard Proctor maximum dry density. To achieve satisfactory compaction, the fill material should be within 3 percent of standard Proctor optimum moisture content at placement.

DRAWING 7 – PAVEMENT SUBDRAIN DETAIL



NOTES:

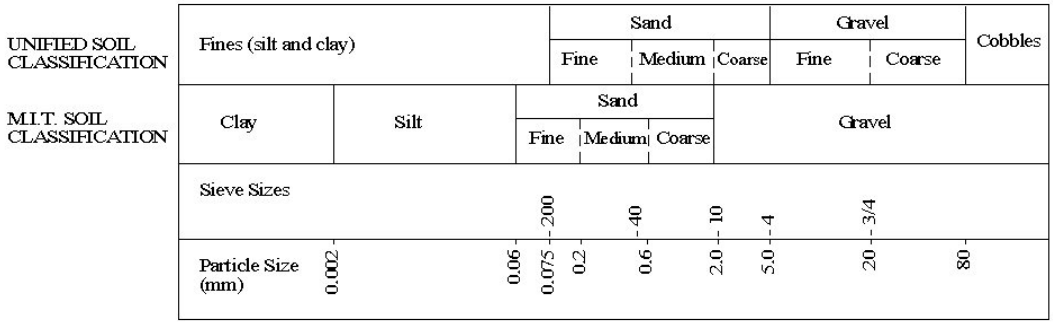
1. All dimensions in millimetres.
2. All sub drains to be set on at least 1% grade draining to a positive outlet.
3. Subgrade soil conditions should be verified onsite, during subgrade preparation works, following site servicing installations.

Scale: NTS

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 **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	276.0								
	275.7	**TOPSOIL** - 300mm							
		SANDY SILT - brown, trace clay, trace gravel, compact, very, moist							
1					SS	S1	400	13	18
	274.6								
		CLAYEY SILT TILL - brown, some sand, trace gravel, stiff to very stiff, moist			SS	S2	450	15	15
2									
					SS	S3	450	20	16
3		- becoming grey near 3.0 m bgs.			SS	S4	400	17	14
4									
					SS	S5	450	11	15
5	271.0								
		End of Borehole at 5.0 m bgs.							
6									
7									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L
SPT N Value Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open and dry upon completion of drilling.
3) bgs denotes below ground surface.
4) 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 **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	277.0								
	276.7	**TOPSOIL** - 300mm							
		CLAYEY SILT - brown, some sand, trace gravel, stiff, moist							
1					SS	S1	400	11	22
	275.6								
		CLAYEY SILT TILL - brown, some sand, trace gravel, stiff to very stiff, moist							
2					SS	S2	450	15	10
					SS	S3	450	13	13
3									
					SS	S4	450	12	20
4									
					SS	S5	450	12	17
5	272.0								
		End of Borehole at 5.0 m bgs.							
6									
7									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L
SPT N Value × Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open and dry upon completion of drilling.
3) bgs denotes below ground surface.
4) 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

BH3
Sheet 1 of 1

CLIENT **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	277.3	**TOPSOIL** - 300mm							
	277.0	**CLAYEY SILT TILL** - brown, some sand, trace gravel, stiff to very stiff, moist							
1					SS	S1	450	17	13
		- occasional sand layering near 1.5 m bgs			SS	S2	450	18	11
2									
		- becoming grey near 2.3 m bgs			SS	S3	450	20	15
3					SS	S4	400	15	15
4									
5	272.3				SS	S5	450	13	17
		End of Borehole at 5.0 m bgs.							
6									
7									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L

SPT N Value Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open and dry upon completion of drilling.
3) bgs denotes below ground surface.
4) 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

BH4
Sheet 1 of 1

CLIENT **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	276.0								
	275.8	**TOPSOIL** - 250mm							
		CLAYEY SILT TILL - brown, some sand, trace gravel, stiff to very stiff, moist			SS	S1	450	20	14
1									
					SS	S2	450	24	15
2									
		- becoming grey near 2.3 m bgs.			SS	S3	450	21	15
3									
					SS	S4	400	17	16
4									
					SS	S5	450	13	16
5	271.0								
		End of Borehole at 5.0 m bgs.							
6									
7									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L
SPT N Value Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open and dry upon completion of drilling.
3) bgs denotes below ground surface.
4) 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

BH5
Sheet 1 of 1

CLIENT **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

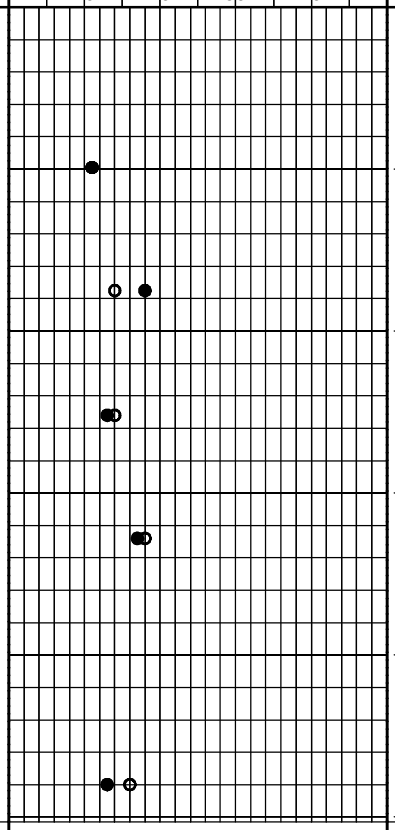
DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	276.0						
	275.8	**TOPSOIL** - 250mm					
		CLAYEY SILT TILL - brown, some sand, trace gravel, stiff to very stiff, moist					
1			SS	S1	400	11	11
			SS	S2	450	18	14
2							
		- becoming grey near 2.3 m bgs.	SS	S3	450	13	14
3							
			SS	S4	400	17	18
4							
			SS	S5	450	13	16
5	271.0						
		End of Borehole at 5.0 m bgs.					
6							
7							

STRATA PLOT

WELL LOG

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L
SPT N Value Dynamic Cone
10 20 30 40



NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open and dry upon completion of drilling.
3) bgs denotes below ground surface.
4) 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

BH6
Sheet 1 of 1

CLIENT **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	275.3	**TOPSOIL** - 300mm							
	275.0	**CLAYEY SILT TILL** - brown, some sand, trace gravel, stiff to hard, moist - wet sand layer near 0.6 m bgs							
1					SS	S1	400	12	11
		- becoming grey near 1.5 m bgs							
2					SS	S2	450	17	16
					SS	S3	450	18	15
3				▽					
					SS	S4	400	30	14
4									
5	270.3				SS	S5	450	21	16
		End of Borehole at 5.0 m bgs.							
6									
7									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L
SPT N Value Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open to 4.3 m and water was observed near 3.0 m bgs upon completion of drilling.
3) bgs denotes below ground surface.
4) 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

BH7
Sheet 1 of 1

CLIENT **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	272.4	**TOPSOIL** - 300mm							
	272.1	**CLAYEY SILT TILL** - brown, some sand, trace gravel, stiff to very stiff, moist			SS	S1	300	8	19
1					SS	S2	400	17	14
2		- becoming grey near 2.3 m bgs			SS	S3	400	26	15
3					SS	S4	450	27	15
	268.6								
4		**SANDY SILT** - grey, dilatant, dense, wet		▽					
	267.4				SS	S5	450	34	20
5		**End of Borehole at 5.0 m bgs.**							
6									
7									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L

SPT N Value × Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open to 4.0 m and water was observed near 4.0 m bgs upon completion of drilling.
3) bgs denotes below ground surface.
4) 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

BH8
Sheet 1 of 1

CLIENT **Elite Bradley Developments Inc.** PROJECT NO. **LON-22008334-A0**

PROJECT **Proposed Residential Development** DATUM **Geodetic**

LOCATION **1944 Bradley Avenue, London, Ontario** DATES: Boring **April 28, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	271.5								
	271.2	**TOPSOIL** - 300mm							
		SANDY SILT - grey, some clayey layering, loose to compact, very moist to wet							
1					SS	S1	400	5	29
					SS	S2	350	6	23
2									
		- becoming grey near 2.3 m bgs			SS	S3	400	9	19
3									
					SS	S4	400	10	20
	267.7								
4		**CLAYEY SILT TILL** - grey, trace sand, trace gravel, stiff, moist		▽					
					SS	S5	450	13	16
5	266.5								
		End of Borehole at 5.0 m bgs.							
6									
7									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L
SPT N Value Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22008334-A0. For definition of terms used on logs, see sheet prior to logs.
2) Borehole open to 4.0 m and water was observed near 4.0 m bgs upon completion of drilling.
3) bgs denotes below ground surface.
4) 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 – Inspection and Testing

INSPECTION & TESTING SCHEDULE

The following program outlines suggested minimum testing requirements during backfilling of service trenches and construction of pavements. In adverse weather conditions (wet/freezing), increased testing will be required. The testing frequencies are general requirements and may be adjusted at the discretion of the engineer based on test results and prevailing construction conditions.

I TRENCH BACKFILL

ZONE A	- one in situ density test per 100 cubic meters or 50 linear metres of trench whichever is less - one laboratory grain size and Proctor density test per 50 density tests or 4000 cubic metres or on change of material (source, visual)
ZONE A1	- one in situ density test per 75 cubic metres of material or 25 linear metres of each lift of fill - one laboratory grain size and Proctor density test per each 50 density tests or 4000 cubic metres of material placed or as directed by the engineer
ZONES B & C	- one in situ density test per 150 cubic metres of material or 50 linear metres or each lift whichever is less - one laboratory grain size and Proctor density test per 50 density tests or 4000 cubic metres of material placed or as directed by the engineer

II PAVEMENT MATERIALS

GRANULAR SUBBASE	- one in situ density test per 50 linear metres of road - one laboratory grain size and standard Proctor test per 50 density tests or 4000 cubic metres or each change of material (visual, source), as determined by the engineer
GRANULAR BASE	- one in situ density test per 50 linear metres of road - one laboratory grain size and Proctor per 50 density tests or 8000 cubic metres or change in material (visual, source), as determined by the engineer - Benkelman beam testing at 10 metre intervals per lane, after final grading and compaction. Asphaltic concrete should not be placed until rebound criteria have been satisfied.
ASPHALTIC CONCRETE	- one in situ density test per 25 linear metres of roadway - one complete Marshall Compliance test including stability flow, etc. for each mix type to check mix acceptability. One extraction and gradation test per each day of paving to be compared to job mix formula

NOTES: Where testing indicates inadequate compaction, additional fill should not be placed until the area is recompacted and retested at the discretion of the engineer.

Appendix C - 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 judgement. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigation s 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 the 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 unauthorized 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.

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