Preliminary Geotechnical Investigation

Forever Homes Inc.

Project Name:
Proposed Residential Development
168 Meadowlily Road South
London, Ontario

Project Number:
LON-22019965-A0

Prepared By:
EXP Services Inc.
15701 Robin's Hill Road
London, Ontario, N5V 0A5
t: +1.519.963.3000
f: +1.519.963.1152

Date Submitted:
June 6, 2024

Preliminary Geotechnical Investigation

Forever Homes Inc.

Type of Document:

Preliminary Geotechnical Report

Project Name:
Proposed Residential Development
168 Meadowlily Road South
London, Ontario

Project Number:

LON-22019965-A0

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

____
Eric Buchanan, P. Eng.
Geotechnical Services

____
Ralph Billings, P.Eng.
Geotechnical Services

Date Submitted:

June 6, 2024

Table of Contents

Appendices

1. Introduction and Background

1.1 Introduction

EXP Services Inc. (EXP) was retained by **Forever Homes Inc.** (Client) to carry out a preliminary geotechnical investigation and prepare a preliminary geotechnical report relating to the proposed residential development located at 168 Meadowlily Road South in London, Ontario, hereinafter referred to as the 'Site'.

According to the concept plan provided by the client, it is understood that the residential development is expected to have one (1) 6-storey apartment building with a total of one hundred and twenty (120) units, two (2) 8-storey apartment buildings with a total of three hundred and fourteen (341) units, two (2) 12-storey apartment buildings with a total of three hundred and forty-eight (348) units, and 3-storey stacked back-to-back town houses with ninety-six (96) units. One level of underground parking is assumed for the two (2) 12-storey apartment buildings. The residential development is expected to have complete municipal servicing and will be accessed with paved local interior roads.

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 preliminary geotechnical engineering guidelines to support the proposed Site development.

1.2 Terms of Reference

Authorization to proceed with this investigation was received from Mr. Yasser Yanni of **Forever Homes Inc.** in an email dated August 8, 2022.

The purpose of the investigation was to examine the subsoil and groundwater conditions at the site by advancing a series of boreholes at the locations chosen by EXP and illustrated on the attached Borehole Location Plan (**Drawing 1**).

Based on an interpretation of the factual borehole data, and a review of soil and groundwater information from test holes advanced at the site, EXP Services Inc. has provided engineering guidelines for the preliminary geotechnical design and construction of the proposed development. More specifically, this report provides comments on site preparation, excavations, dewatering, foundation design, slab-on-grade and underground parking construction, site servicing, seismic considerations, pavement recommendations, and curbs and sidewalks.

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.

Reference is made to **Appendix E** 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 September 1 and 8, 2022. In general, the preliminary geotechnical investigation consisted of the advancement of eleven (11) boreholes at the locations denoted on **Drawing 1** as BH1 to BH11, inclusive. MW was suffixed to the borehole symbol (BH) where monitoring wells were installed.

Prior to the drilling, buried service clearances were obtained for the test hole locations by EXP.

The boreholes and monitoring wells were completed by a specialist drilling subcontractor under the full-time supervision of EXP geotechnical staff. The boreholes were advanced utilizing a track-mounted drill rig equipped with continuous flight solid and hollow stem augers, soil sampling and soil testing equipment. In each borehole, disturbed soil samples were recovered at depth intervals of 0.75 m and 1.5 m using conventional split spoon sampling equipment and Standard Penetration Test (SPT) methods or auger samples.

During the drilling, the stratigraphy in the boreholes was examined and logged in the field by EXP geotechnical personnel.

Short-term groundwater levels within the open boreholes and stabilized groundwater levels at the monitoring well locations were observed. These observations pertaining to groundwater conditions at the test hole locations are recorded in the borehole logs found in **Appendix A**. Following the drilling, the boreholes were backfilled with the excavated materials and bentonite, 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 and grain size analysis on select samples, presented on the borehole logs found in **Appendix A**.

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

Borehole locations were established in the field by EXP personnel based on information provided by the Client. Ground surface elevations were interpolated using City of London Mapping and the concept plan provided by the client.

3. Site and Subsurface Conditions

3.1 Site Description

The subject area is currently generally occupied by an agricultural field with a small section of vacant grassland with occasional semi mature to mature trees. The Site is generally bounded by rural residential dwellings to the west and north, Commissioners Road East to the south and a parking lot (City Wide Sports Park) to the east. According to the concept plan provided by the client, it is understood that the residential development is expected to have two (2) 6-storey apartment buildings with a total of two hundred and forty (240) units, 3-storey stacked town houses with ninety (90) units, 3-storey town houses with seventy-one (71) units, 4-storey stacked back-to-back townhouses with three hundred and twelve (312) units, and a potential stormwater management area. One level of underground parking is assumed for the two (2) 6-storey apartment buildings. The residential development is expected to have complete municipal servicing and will be accessed with paved interior local roads. The following sections provide a summary of the soil and groundwater conditions. The Site is generally level with a minor gradient down towards the northwest. The elevations across the Site generally range from 276.6 m in the northwest to 284.4 m in the vacant grassland at the south-central portion of the property. The following sections provide a summary of the soil and groundwater conditions.

3.2 Soil Stratigraphy

The detailed stratigraphy encountered in each test hole 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.

3.2.1 Topsoil

Each borehole was surfaced with a layer of topsoil. The topsoil thickness ranged between 180 mm and 350 mm.

It should be noted that topsoil quantities should not be established from the information provided at the test hole 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.

3.2.2 Fill

Beneath the topsoil and extending to 1.4 m below ground surface (bgs) in Borehole BH10 was a layer of fill. The composition of the fill was sandy silt, trace clay and was typically brown in colour. The sandy silt fill contained trace organics, was loose (based on Standard Penetration Test (SPT) N Values of 9 blow per 300 mm split spoon sampler penetration) and moist to wet (based on tactile examination and in situ moisture content of 18 percent).

3.2.3 Sandy Silt

Underlying the topsoil and extending to a maximum of 2.1 m below ground surface (bgs) in Boreholes BH1/MW, BH2, BH3, BH4/MW, BH8 and BH11/MW was a layer of sandy silt. The brown sandy silt, trace clay, trace to some gravel was typically described as compact (based on Standard Penetration Test (SPT) N Values of 18 and 26 blows per 300 mm split spoon sampler penetration). Laboratory testing of the sandy silt yielded *in situ* moisture contents of 5 and 7 percent, indicative of damp conditions.

3.2.4 Clayey Silt Till

Each borehole except BH1/MW terminated in a stratum of clayey silt till. The clayey silt till was brown becoming grey in colour with depth. The clayey silt till contained trace to some sand, trace gravel, was stiff to hard in consistency (SPT N Values of 10 to 39) and damp to moist (tactile examination and *in situ* moisture contents of 10 to 20 percent).

Three grain size analyses were done on samples of the clayey silt till from BH2, BH4/MW and BH9/MW near depths of 1.5 m and 4.6 m bgs. The findings are summarized in **Appendix B – Grain Size Distribution Analyses** as Figure 1, Figure 2 and Figure 3.

3.2.5 Silt

Borehole BH1/MW terminated in a stratum of silt. The silt was grey and contained trace clay, some sand and was dense in consistency (SPT N Values of 38 to 45) and moist to wet (tactile examination and in situ moisture contents of 18 and 19 percent).

3.3 Groundwater Conditions

Details of the groundwater conditions observed within the test holes are provided on the attached borehole logs. Upon completion of drilling, the open boreholes were examined for the presence of groundwater and groundwater seepage.

Four (4) monitoring wells were installed during the drilling on September 1st and 8th, 2022 at the Site. The wells were installed to depths of approximately 5.5 m to 6.3 m bgs. The summary of well construction details and stabilized groundwater levels are presented in the tables below.

Table 1 – Monitoring Well Construction Details

Well ID	Inferred Ground Surface Elevation (m)	Completion Depth (m bgs)	Screen Length (m)	Screened Strata
BH1/MW	276.6	5.5	1.5	Clayey Silt Till
BH4/MW	281.5	6.1	1.5	Clayey Silt Till
BH9/MW	282.5	6.1	1.5	Clayey Silt Till
BH11/MW	283.9	6.3	1.5	Clayey Silt Till

Manual water levels in the monitoring wells have been collected regularly between September 2022 and June 2023. Additional water level monitoring was completed in February 2024. Details of the water levels are summarized in **Appendix C**.

Overall, groundwater levels ranged from dry conditions noted in all four (4) wells to 1.32 m bgs at monitoring well BH/MW9 screened to a depth of 6.1 m bgs. Groundwater elevations ranged from dry conditions at all four (4) wells to 281.42 m amsl at BH/MW11. The highest groundwater elevations were observed at monitoring well BH/MW11 which is situated at the highest ground surface elevation. All four (4) monitoring wells are screened in clayey silt till and therefore recovery to static groundwater levels took several months, from installation in fall 2022 to spring 2023.

Further interpretation in this regard is provided under the hydrogeological cover

The monitoring wells have been registered with the Ministry of the Environment, Conservation and Parks (MECP), in accordance with Ontario Regulation 903, and remain intact for the purposes of ongoing monitoring of stabilized groundwater conditions, as required.

It is noted that insufficient time was available for the measurement of the depth to the stabilized groundwater table prior to backfilling the boreholes.

It is also noted that 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 higher levels in wet seasons. Capillary rise effects should also be anticipated in fine-grained soil deposits.

3.4 Methane Gas

No methane gas producing materials or significant organic matter was encountered at the borehole locations, except a thin veneer of topsoil.

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

According to the concept plan provided by the client, it is understood that the residential development is expected to have two (2) 6-storey apartment buildings with a total of two hundred and forty (240) units, 3-storey stacked town houses with ninety (90) units, 3-storey town houses with seventy-one (71) units, 4-storey stacked back-to-back townhouses with three hundred and twelve (312) units, and a potential stormwater management area. One level of underground parking is assumed for the two (2) 6-storey apartment buildings. The residential development is expected to have complete municipal servicing and will be accessed with paved interior local roads.

The following sections of this report provide preliminary geotechnical comments and recommendations regarding site preparation, excess soil management, excavations, dewatering, foundations, slab-on-grade and underground parking construction, bedding and backfill, elevator pits, earthquake design considerations, pavement recommendations, and curbs and sidewalks.

4.1 Site Preparation

Prior to placement 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 a structure was demolished in the vacant grassland/treed area at the south-central portion of the Site. The removal of the existing foundations should include all building debris, foundation walls, footings and concrete floor slabs. The removal and disposal of the previously occupied buildings must satisfy the local building standards, Ontario Building Code (OBC), Ministry of Labour (MOL) and the Ministry of Environment, Conservation and Parks (MECP) requirements. Removal of the associated septic tank and field tile, if present, will also be required. Any potable wells on site must be properly decommissioned by a licensed well contractor to protect the aquifer from surface contamination, prevent vertical movement of water between aquifers, or between an aquifer and the ground surface, and eliminate a potential safety hazard. The well decommissioning requirements and standards from Ontario Regulation 903 must be adhered to.

Following the removal of the topsoil and unsuitable materials described above 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 loose 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, depending on depth, 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.

4.2 Excavation and Groundwater Control

4.2.1 Excess Soil Management

It should be noted that the Geotechnical Investigation does not include any testing for off-site disposal according to the new Regulation O. Reg. 406/19.

Ontario Regulation 406/19 made under the Environmental Protection Act (November 28th, 2019) was implemented on January 1st, 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 soil is 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.

Soil sampling requirements for Areas of Potential Environmental Concern (APEC) related to the new standard effective January 1st, 2022 are provided below.

Table 2 – Recommended Ex-Situ (e.g., Stockpiles)

Soil Volume	Sampling Frequency
< 130 m^3	Minimum of 3
> 130 - 220 m^3	4
> 220 – 5,000 m^3	5-32*
> 5,000 m^3	N = 32 + (Volume – 5,000) / 300

*refer to stockpile sampling frequency in O.Reg. 153/04 for specifics. Essentially, one sample for every 150 m^3 after 800 m^3

Table 3 – Recommended In Situ

Soil Volume	Sampling Frequency
< 600 m^3	Minimum of 3
> 600 m^3 - 10,000 m^3	1 sample per every additional 200 m^3
> 10,000 m^3 – 40,000 m^3	1 sample per every additional 450 m^3
> 40,000 m^3	1 sample per every additional 2,000 m^3

In areas where no APECs have been identified, the sampling frequency in the tables noted above do not need to be followed and can be determined at the discretion of the QP.

In addition to the above tables, one field duplicate should be submitted for approximately every 10 samples taken for quality control/quality assurance purposes.

Soil Analytical Testing Requirements:

- Samples to be tested for a minimum of Petroleum Hydrocarbons (PHCs) – Fractions F1-F4, Benzene, Toluene, Ethylbenzene & Xylenes (BTEX), Metals & Inorganics, including Electrical Conductivity (EC) and Sodium Absorption Ration (SAR);

- Any additional potential Contaminant of Concern identified in past uses report (comes into effect January 1st, 2022); and,

- mSPLP Leachate testing (metals and VOCs) (not required for volumes under 350 m^3: between 350 m^3 and 600 m^3 (minimum of 3); greater than 600 m^3 (10 % of samples).

Other components of the new regulation include:

- The Sampling and Analysis Plan (SAP) which follows the APU;
- The Soil Characterization Report (SCR) which follows the sampling program;
- The Excess Soil Destination Assessment Report (ESDAR) which follows the SCR;
- Notice of Project on the Resouce Productivity and Recovery Authority (RPRA) which is usually the responsibility of the Contractor during the construction phase; and,
- Tracking Requirements on the RPRA, again, usually the responsibility of the Contractor during the construction phase.

In general, it is most economical to provide a site grading plan that keeps all excess soils on site so that O. Reg 406/19 is not invoked.

4.2.2 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 preliminary geotechnical investigation and in accordance with Section 226 of Ontario Regulation 213/91, very stiff to hard clayey silt till soils are classified as Type 2 soils, while the sandy silt, silt and stiff clayey silt till soils encountered at the site are classified as Type 3 soils.

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.

When excavations extend through Type 2 and Type 3 soils, the excavation should be cut as a Type 3 soil. Geotechnical inspection at the time of excavation can confirm the soil type present.

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

Although not encountered, it should be noted that the presence of cobbles and boulders in natural glacial deposits may influence the progress of excavation and construction.

4.2.3 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 or to minimize disturbance to surrounding lands, shoring such as sheeting or soldier piles and lagging can be considered. Alternatively, the option of a prefabricated trench box system may be available depending on the required depths. The prefabricated trench box system, if utilized, must be designed by a professional engineer to withstand the soil and hydrostatic loading. 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 (K_o) 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.

4.2.4 Construction Dewatering

Based on the soil texture encountered during the investigation, significant groundwater infiltration is not anticipated within service trench and foundation excavations at conventional depths and within the anticipated excavation depth of the apartment building's one (1) level underground parking garage (approximately 3 to 4 m below existing grade). Some temporary dewatering efforts will be necessary for water bearing silt layer that was encountered in the drilling program. 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. The requirement for an EASR or PTTW application will be discussed in greater detail in a hydrogeological report which will be issued supplementary to this report.

4.3 Building Foundations

4.3.1 Conventional Strip and Spread Footings

Proposed residential developments can be supported on conventional spread and strip footings founded below the topsoil or unsuitable soils on the natural competent subgrade soils or engineered fill.

It is assumed that the two (2) 12-storey apartment buildings may have one (1) level of underground parking. Boreholes BH10 and BH11/MW are located near the proposed footprint of the 12-storey apartment buildings while BH3 is located near the proposed footprint of the 8-storey apartment buildings, BH2 and BH3 are located near the proposed footprint of the 6-storey apartment building, and BH5, BH6, BH8 and BH9/MW are located near the proposed footprint of the 3-storey stacked back-to-back townhouses. Foundations for the proposed residential buildings at these borehole locations can be set on the natural, competent clayey silt till soils at the depths shown in **Table 4 and 5** below.

Table 4 – Foundation Depth and Bearing Capacity - Townhouses

Borehole ID	Ground Surface Elevation (m)	Minimum Depth to Achieve 145 kPa (SLS) and 215 kPa (ULS)	
		Depth (m bgs)	Elevation (m)
BH5	281.2	0.8	280.4
BH6	284.4	0.8	283.6
BH8	282.0	1.5	280.5
BH9/MW	282.5	0.8	281.7

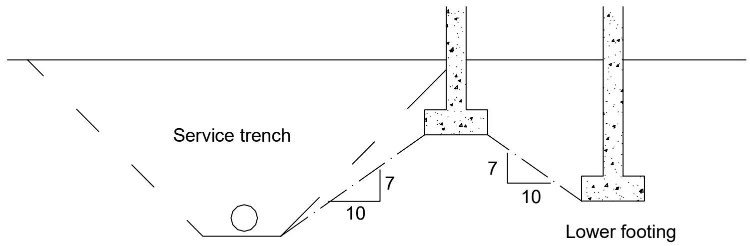
Table 5 – Foundation Depth and Bearing Capacity – Apartment Buildings

Borehole ID	Ground Surface Elevation (m)	Minimum Depth to Achieve 190 kPa (SLS) and 285 kPa (ULS)	
		Depth (m bgs)	Elevation (m)
BH2	281.0	0.8	280.0
BH3	282.2	0.8	281.0
BH10	283.9	1.5	282.2
BH11/MW	283.9	0.8	282.9

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 2**, 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. Verification of the soil conditions and the extent of reinforcement are best determined by the Geotechnical Engineer at the time of excavation.

4.3.2 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.

4.4 Underground Parking

It is understood that the proposed development may include one (1) level of underground parking. The parking garage footings are expected to be founded on the clayey silt till deposits. The perimeter garage walls should be designed to sustain lateral earth pressures calculated using the soil parameters stated in Section 4.2.3 and any applicable surcharge loads.

At the garage entrance, the subgrade should be properly insulated, or heated and the subgrade material should be replaced with 1.2 m of non-frost-susceptible material; the garage should be provided with subdrains. This will minimize frost action in this area where vertical ground movement cannot be tolerated. The floor at the entrances and in areas of close proximately to air shafts should be insulated.

Around the perimeter of the building the ground surface should be sloped on a positive grade away from the structure to promote surface water run-off and reduce groundwater infiltration adjacent to the foundations. Perimeter drains are recommended in areas of the building where there will be underground space. The purpose of the perimeter drains is to collect water that infiltrates down from ground surface and through the foundation wall backfill. The peak flow into these drains is expected to occur following heavy rainfalls or during periods of frequent precipitation. In areas where hard landscaping features are present next to the building, minimal surface water infiltration is anticipated. Suggestions for permanent perimeter drainage are given on **Drawing 3**.

Depending on the final depth of the basement floor, an under-floor drainage system may be required. EXP should be contacted when design information becomes available.

The perimeter drains should be installed at the footing level elevation. It is recommended that a core blanket be provided adjacent to the foundation walls, down to the perimeter drain elevation to facilitate drainage immediately adjacent to the building. The perimeter drains may be connected to an interior pump and connected to the storm sewer system.

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 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.

A modulus of subgrade reaction of 25 MPa/m can be used for the design of the floor slab on the compacted granular materials.

4.5 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 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 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 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 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 20 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.

4.6 Foundation Backfill

In general, the existing natural soils excavated from the foundation area should be suitable for re-use as foundation wall backfill beyond the free-draining zone subject that 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. The upper 0.8 m of the backfill should be sealed with clay soil. Any excavated soils proposed for re-use as backfill should be examined by a Geotechnical Engineer. The materials to be re-used should be within three percent of optimum moisture for best compaction results. If the weather conditions are very wet during construction, then consideration should be given to the use of imported granular material such as OPSS Granular 'B' as backfill material.

The backfill must be brought up evenly on both sides of walls not designed to resist lateral earth pressures. The backfill materials should be compacted to 95 to 98 percent SPMDD. Drainage and backfill recommendations are given in **Drawing 3**.

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. It is recommended that an impermeable soil seal such as clay, asphalt or concrete be provided on the surface to minimize water infiltration.

4.7 Site Servicing

The subgrade soils beneath the water and sewer pipes which will service the site are generally expected to comprise clayey silt till. For services constructed on the natural soils or engineered fill, the bedding should conform to OPS and City of London 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 sewer 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 metre 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 OPS and City of London requirements. A summary of the general recommendations for trench backfill is presented on **Drawings 5** and **6**. A program of *in situ* density testing 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.

4.8 Seismic Considerations

The recommendations for the geotechnical aspects to determine the earthquake loading for design using the OBC 2012 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 2012. The subsoils at the Site generally consist of topsoil over sandy silt and glacial till deposits. It is anticipated that the proposed structures will be founded on the natural deposits, below any loose or soft zones.

Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 indicates that to determine the site classification, the average properties in the top 30 m (below the lowest basement level) are to be used. The boreholes advanced at this Site were excavated to a maximum depth of 11.1 m below existing grade. 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 2012. Additional depth drilling may be advised to determine if the soil conditions below the current depth of exploration can support a higher Site Classification.

4.9 Elevator Pits

Based on previous experience, it is assumed the elevators will be a traction-based system (cables and pulley's) and we are not anticipating a requirement for any hydraulic equipment below the level of the pit floor. Based on the available soils information, the following general comments are provided regarding the elevator pits:

- Depending on final location and the depth of elevator pits, the underside of the pits could potentially be below the water table, as measured during the investigation. As discussed in Section 4.2.4, groundwater ingress may be encountered depending on the depth of excavation;
- Consideration should be given to providing a permanent seal and waterproofing system at the elevator pits to minimize any potential water seepage into the bottom of the pits;
- A dedicated sump pump can be considered a precautionary measure to handle excessive water ingress.

If other alternatives are considered and our assumptions are not valid, EXP should be requested to review the proposed system for applicable geotechnical considerations.

4.10 Site Pavement Design

Areas to be paved should be stripped of all topsoil, organics and other obviously unsuitable material. The exposed subgrade must then be thoroughly proof-rolled. Any soft areas 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 the following table are recommended for the anticipated traffic loading and subgrade conditions.

Table 6 – Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Light Duty Pavement Structure (Cars Only)	Heavy Duty Pavement Structure (Cars and 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)	100% SPMDD[1]	150 mm	150 mm
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.

For the heavy duty pavement structure, it is recommended that the 50 mm wearing course consist of an HL-3 with a Performance Grade Asphalt Cement (PGAC) grade of 64-28 to improve longevity. The above pavement structure thicknesses were provided as a general guide for design engineers. Once a detailed development plan is available, this office should be contacted for review and comment.

The recommended pavement structure provided in the above table is 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 and City of London requirements 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 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, OPSS 1350 and City of London Standards.

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

No methane gas producing materials or significant organic matter was encountered at the borehole locations, except a thin veneer of topsoil.

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 prior to engineered fill placement, footing base evaluation;
- 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;
- Materials testing for concrete curbs and sidewalks.
- Inspection and Materials testing during paved area construction, including subgrade examination of the paved area subgrade soils following site servicing, laboratory testing (grain size analyses and Standard Proctor density tests on the Granular A and B material placed on site roadways), and *in situ* density testing;
- Inspection and Materials testing for base and surface asphalt, including laboratory testing on asphalt sampling to confirm conformance to project specifications and standards.

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

5. 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.

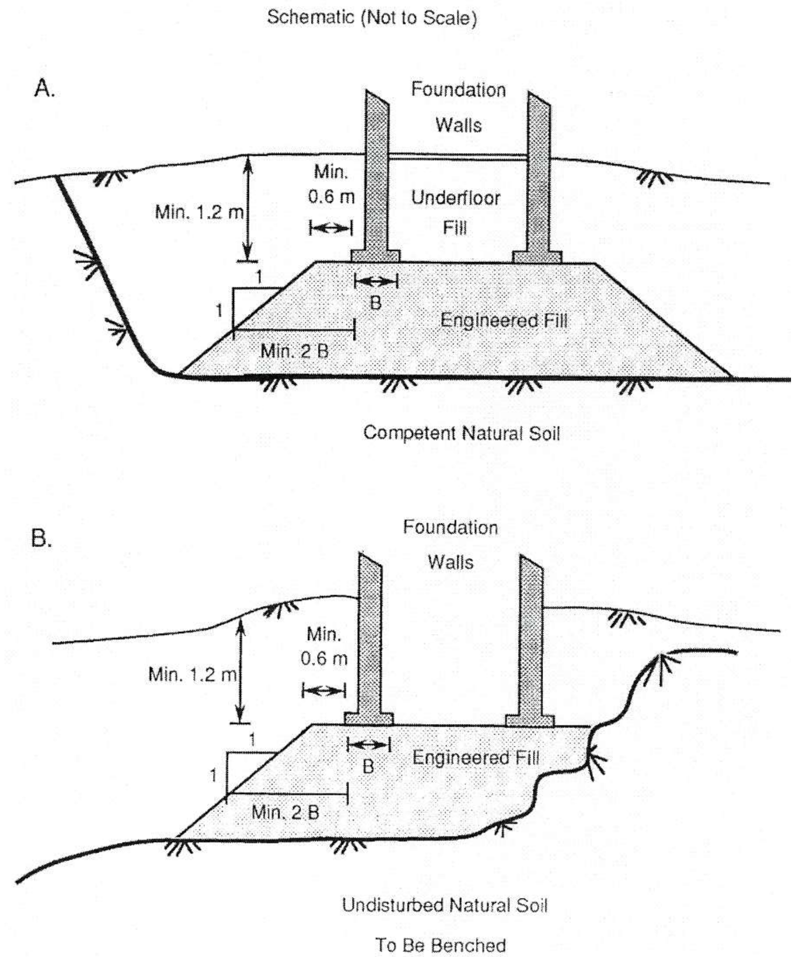
EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not afforded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations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

This report was prepared for the exclusive use of **Forever Homes 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

DRAWING 2 – GEOMETRIC REQUIREMENTS FOR FOUNDATIONS ON ENGINEERED FILL

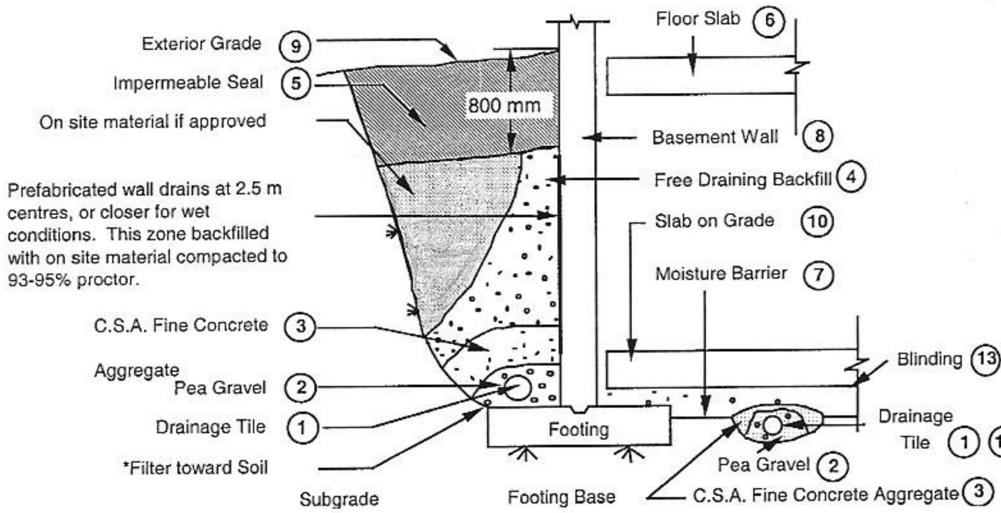


▪ SECTION VIEW

NOTES:

1. The area must be stripped of all topsoil contaminated fill material and proof rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by an EXP engineer prior to placement of fill.
2. The approved engineered fill must be compacted to 100% Standard Proctor dry density throughout. Granular fill is required.
3. Fulltime geotechnical inspection by EXP is required during placement of the engineered fill.
4. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements.
5. An allowable SLS bearing pressure of 145 kPa (3,000 psf) may be used provided that all conditions outlined above, are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and as a precautionary measure, footings should be provided with nominal steel reinforcement.
6. All excavations must be done in accordance with the Occupational Health and Safety Regulation of Ontario (Construction Projects - O.Reg. 213.91)
7. These guidelines are to be read in conjunction with the attached EXP Report for Project Number LON-22019965-A0.

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

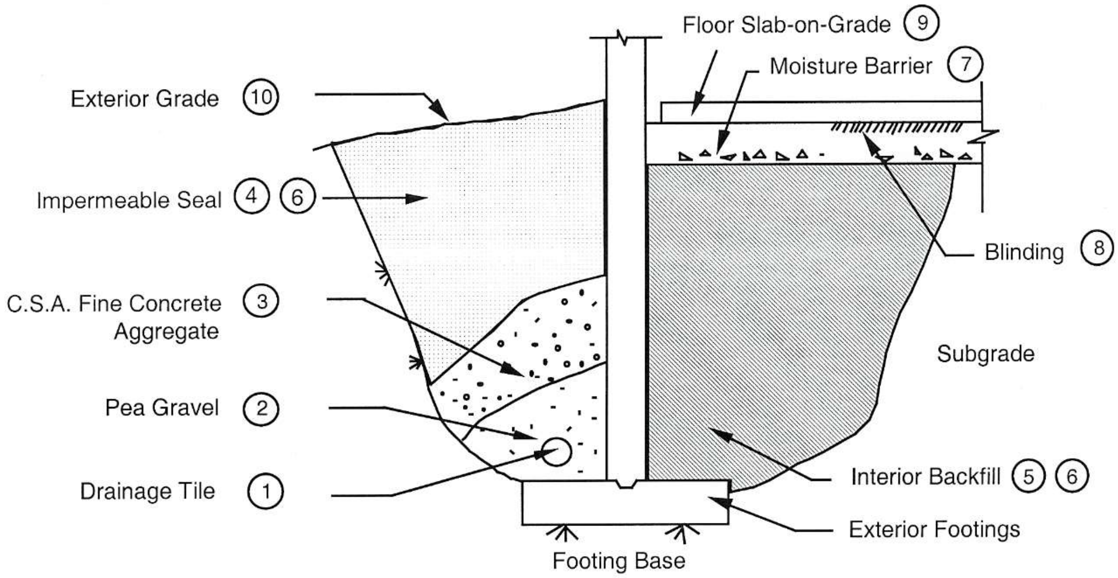


NOTES:

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.

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

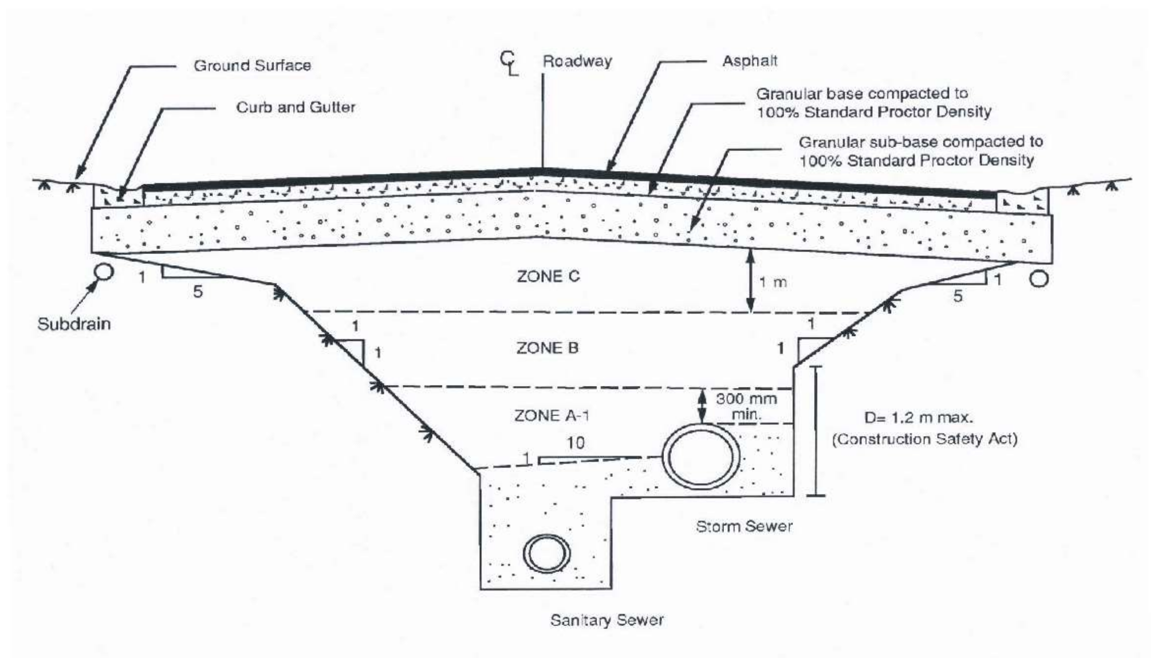


NOTES:

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



SECTION VIEW

NOTES:

ZONE A
Granular bedding satisfying current City of London Standards compacted to 95% Standard Proctor maximum dry density.

ZONE A-l
To be compacted to 95% Standard Proctor maximum dry density.

ZONE B
To be compacted to 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 219/31).

DRAWING 6 – TRENCH BACKFILL REQUIREMENTS

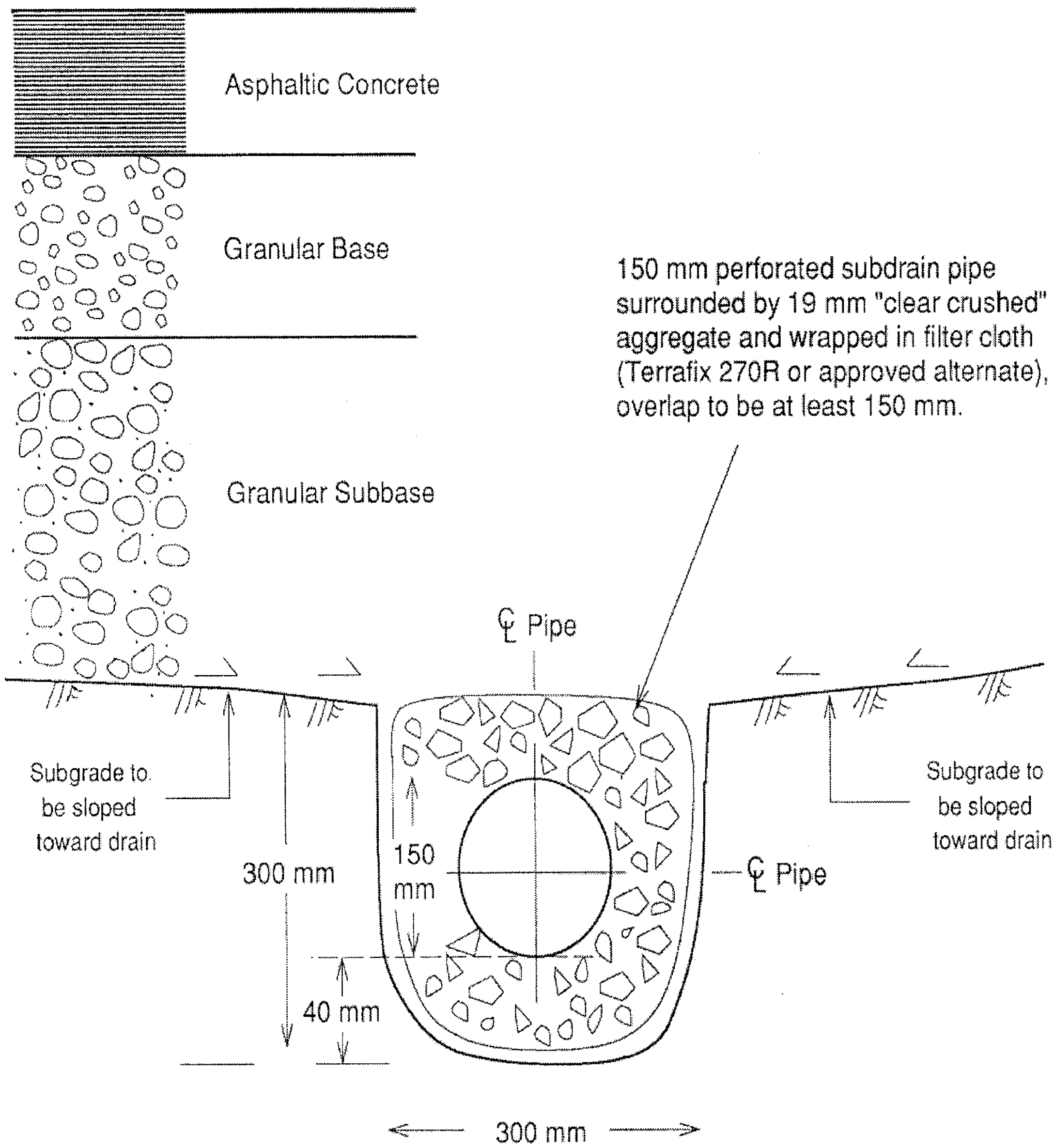
Requirements for backfill in service trenches, etc. should conform to current City of London and OPSS requirements. A summary of the general recommendations for trench backfill is presented on **Drawing 5**.

The bedding materials for the services designated as Zone A on the attached drawings should consist of approved granular material satisfying the current City of London 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 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:

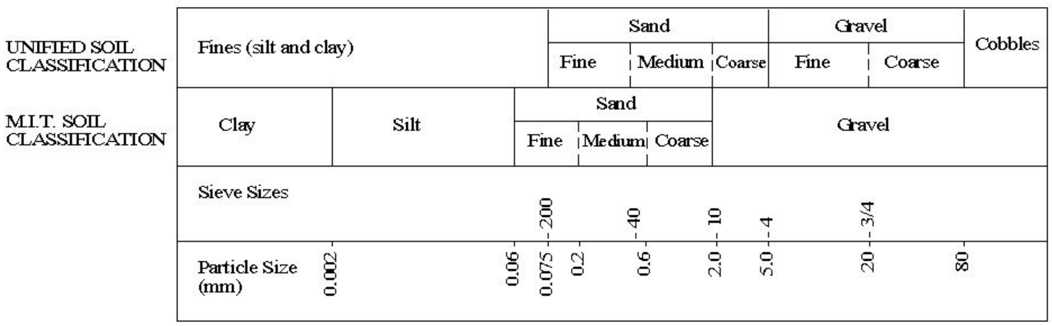
1. All dimensions in millimetres.
2. All sub drains to be set on at least 1% grade draining to a positive outlet.
3. Subgrade soil conditions should be verified onsite, during subgrade preparation works, following site servicing installations.

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. Despite the use of borehole, 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.

Appendix B – Grain Size Distribution Analyses

Appendix C – Water Levels

Appendix D – Inspection and Testing Schedule

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 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 test pit results contained in the Report. The number of test pits 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 the **Forever Homes 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 the **Forever Homes Inc.** for any purpose whatsoever without the express permission of the EXP 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.