Geotechnical Investigation
Proposed Residential Development
1568 Meadowbrook Road
Ottawa, Ontario

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Executive Summary

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed residential development to be located on the parcel of land with the civic address of 1568 Meadowbrook Road, Ottawa, Ontario (Figure 1). Terms and conditions of this assignment were outlined in EXP's proposal number: OTT-21019403-A0 dated September 30,2021 and authorization to proceed with the geotechnical investigation was provided by Nemorin Group Limited.

In addition to providing geotechnical services for this project, EXP is also providing civil engineering design and environmental assessment services. The findings from the Phase One and Two Environmental Site Assessments and the civil engineering design are reported under separate covers.

It is our understanding that the residential development will consist of four (4) two-story long semi residential buildings. Each building will have one (1) basement level. The development will be serviced by underground services and will include paved right-of-ways and driveways. Information regarding the design elevation of the basement floor of the proposed buildings, final site grades and invert elevations of the underground services were not available at the time of this geotechnical investigation.

The fieldwork for the geotechnical investigation was completed on October 27, 2021 and consists of three (3) boreholes (Borehole Nos. 1 to 3) drilled to termination and auger refusal depths of 3.6 m and 5.1 m below the existing ground surface. Standpipes were installed in each borehole for long-term monitoring of the groundwater level. The fieldwork was supervised on a full-time basis by a representative from EXP.

The borehole information indicates the subsurface conditions consist of a surficial 100 mm and 150 mm thick topsoil layer underlain by fill to 0.9 m to 1.7 m depths (Elevation 70.6 m to Elevation 69.7 m) followed by compact to very dense glacial till to a 3.4 m depth (Elevation 68.0 m) which is underlain by shale bedrock of the Billings formation. The groundwater level ranges from 1.0 m to 2.8 m below ground surface (Elevation 70.5 m to Elevation 68.6 m).

Based on the borehole information and Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC) as amended May 2, 2019, the site classification for seismic site response is estimated to be **Class C.** The subsurface soils are not susceptible to liquefaction during a seismic event.

From a geotechnical perspective, based on a review of the subsurface soil and bedrock conditions, there is no restriction to raising the grades at the site for the proposed development.

Based on a review of the borehole information, it is considered feasible to support the proposed buildings on strip and spread footings founded on the native compact to very dense glacial till contacted at 0.9 m to 1.7 m depths (Elevation 70.6 m to Elevation 69.7 m) Spread and strip footings founded on the native glacial till may be designed for a bearing pressure at serviceability limit state (SLS) of 150 kPa and factored geotechnical resistance at ultimate limit state (ULS) of 225 kPa. The factored geotechnical resistance at ULS includes a resistance factor of 0.5.

If the footings for the proposed buildings and the lowest floor slab (basement floor slab) will be founded on the shale bedrock, EXP should be contacted to provide updated SLS and factored ULS values for the footings and to provide details regarding the special treatment of the Billings shale bedrock that will need to be incorporated into the design and construction of the foundations and basement floor slab of the proposed buildings.

A minimum of 1.5 m of earth cover should be provided to the exterior foundations of heated structures to protect them from damage due to frost penetration. The frost cover should be increased to 2.1 m for unheated structures if snow will not be removed from their vicinity and to 2.4 m if snow will be removed from the vicinity of the structure. When earth cover is less than the required cover, an equivalent thermal combination of earth cover and rigid insulation or rigid insulation alone should be provided. EXP can provide additional comments in this regard, if required.

The lowest floor slabs of the proposed buildings may be designed as a slab-on-grade founded on a bed of 200 mm of 19 mm clear stone placed on top of a minimum 300 mm thick compacted Granular B Type II pad placed on the native soils and constructed in accordance with Section 9 of this report. The clear stone would prevent the capillary rise of moisture from the sub-soil to the floor slab. Adequate saw cuts should be provided in the floor slabs to control cracking.

Perimeter and underfloor drainage systems should be provided for the proposed buildings. The basement walls should be backfilled with free draining material such as Ontario Provincial Standard Specification (OPSS) Granular B Type II material. The basement walls will need to be designed to resist lateral static and dynamic (seismic) earth forces.

The excavations may be undertaken by conventional heavy equipment capable of removing cobbles and boulders within the glacial till. All excavations must be undertaken in accordance with the Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91. Based on the definitions provided in OHSA, the subsurface soils on site are considered to be Type 3 and as such must be cut back at 1H:1V from the bottom of the excavation. Below the groundwater level, the excavation side slopes are expected to slough and eventually stabilize at a slope of 3H:1V to 2H:1V. If side slopes cannot be achieved due to space restrictions on site such as the proximity of open cut excavations to the property limits, existing infrastructure or to foundations of adjacent existing buildings the new building construction would have to be undertaken within the confines of an engineered support system (shoring system). The underground services may be installed within the confines of a prefabricated support system (trench box) in accordance with OHSA.

Seepage of the surface and subsurface water into the excavations above the groundwater level is anticipated and it should be possible to collect water entering the excavations at low points and to remove it by conventional pumping techniques. High-capacity pumps may be required in zones of persistent seepage where more permeable soil may exist along the side walls of the excavation.

It is anticipated that the majority of the material required for engineered fill and for backfilling purposes for this project would have to be imported and should preferably conform to the specifications provided in the attached report.

The above and other related considerations are discussed in greater detail in the attached report.

1. Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed residential development to be located on the parcel of land with the civic address of 1568 Meadowbrook Road, Ottawa, Ontario (Figure 1). Terms and conditions of this assignment were outlined in EXP's proposal number: OTT-21019403-A0 dated September 30, 2021 and authorization to proceed with the geotechnical investigation was provided by Nemorin Group Limited.

In addition to providing geotechnical services for this project, EXP is also providing civil engineering design and environmental assessment services. The findings from the Phase One and Two Environmental Site Assessments and the civil engineering design are reported under separate covers.

It is our understanding that the residential development will consist of four (4) two-story long semi residential buildings. Each building will have one (1) basement level. The development will be serviced by underground services and will include paved right-of-ways and driveways. Information regarding the design elevation of the basement floor of the proposed buildings, final site grades and invert elevations of the underground services were not available at the time of this geotechnical investigation.

This geotechnical investigation was undertaken to:

a) Establish the subsurface conditions and groundwater levels at three (3) boreholes located on the site,

b) Provide classification of the site for seismic design in accordance with requirements of the 2012 Ontario Building Code (OBC) as amended May 2, 2019 and assess the liquefication potential of the subsurface soils during a seismic event,

c) Discuss grade raise restrictions,

d) Provide the bearing pressure at Serviceability Limit State (SLS) and factored geotechnical resistance at Ultimate Limit State (ULS) of the most suitable type of foundation for the proposed buildings, as well as anticipated total and differential settlements,

e) Comment on slab-on-grade construction and permanent drainage system requirements,

f) Discuss excavation conditions and dewatering requirements during construction of the foundations for the proposed buildings and the installation of the underground services,

g) Provide pipe bedding requirements for the new underground services,

h) Comment on backfilling requirements and suitability of the on-site soils for backfilling purposes,

i) Discuss the subsurface concrete requirements and the corrosion potential of subsurface soils to buried metal structures/members; and

j) Provide the pavement structure for the paved right-of-ways and driveways.

The comments and recommendations given in this report assume that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

2. Site Description

The site is a rectangular-shaped property bounded along the north side by Meadowbrook Road, residential units to the east and west including a townhouse condominium complex on the east side. Maxime Park is located on the south side of the property. The site is currently occupied by a single family detached residential dwelling and detached garage.

Based on the ground surface elevations of the boreholes, the topography across the site is flat with ground surface elevations ranging between Elevation 71.38 m and Elevation 71.49 m at the locations of the boreholes.

3. Site Geology

3.1 Surficial Geology

The surficial geology map (Map 1506A – Surficial Geology, Ontario-Quebec, Geological Survey of Canada, printed by the Surveys and Mapping Branch, 1982) indicates that beneath any fill material, the site is underlain by a till plain of less than 5 m thick.

3.2 Bedrock Geology

The bedrock geology map (Map 1508A – Generalized Bedrock Geology, Ottawa-Hull, Ontario and Quebec, Geological Survey of Canada, printed by the Surveys and Mapping Branch, 1979) indicates the site is underlain by shale bedrock of the Billings formation.

4. Procedure

The fieldwork for the geotechnical investigation was completed on October 27, 2021 and consists of three (3) boreholes (Borehole Nos. 1 to 3) drilled to termination and auger refusal depths of 3.6 m and 5.1 m below the existing ground surface. The fieldwork was supervised on a full-time basis by a representative from EXP.

The borehole locations and geodetic elevations were established by a survey crew from EXP and are shown on Figure 2.

Prior to the fieldwork, the locations of the boreholes were cleared of any public and private underground services. The boreholes were drilled using a truck mounted drill rig equipped with hollow stem augers and conventional rock coring equipment and operated by a drilling specialist subcontracted to EXP. Standard penetration tests (SPTs) were performed in all the boreholes at a 0.75 m depth interval and the soil samples were retrieved by the split-spoon sampler. The presence of the bedrock was confirmed in Borehole No. 1 by conventional rock coring techniques using the NQ-size core barrel. A record of wash water return, colour of wash water and any sudden drops of the core barrel was kept during the coring operation.

A 19 mm diameter standpipe (with slotted section) was installed in each borehole for long-term monitoring of the groundwater level. The standpipes were installed in accordance with EXP standard practice and the installation configuration is documented on the respective borehole logs. The boreholes were backfilled upon completion of drilling and the installation of the standpipes.

All soil samples were visually examined in the field for textural classification, logged, preserved in plastic bags and identified accordingly. Similarly, all rock cores were placed in core boxes, identified, visually examined and logged. On completion of the fieldwork, all the soil samples and rock cores were transported to the EXP laboratory located in the City of Ottawa.

The soil samples were classified in accordance with the Unified Soil Classification System (USCS). The rock cores were visually examined and logged in accordance with Section 3.2 of the 2006 Canadian Foundation Engineering Manual (Fourth Edition, CFEM) and a photograph taken of the rock core.

A summary of the soil and bedrock laboratory testing program is as follows:

Soil Samples:

Natural Moisture Content Determination .....15 tests
Natural Unit Weight Determination.....4 tests
Grain Size Analysis.....3 tests
Atterberg Limits.....3 tests
Chemical Analysis (pH, sulphate, chloride and resistivity) .....1 test

Rock Core Sample:

Uniaxial Compressive Strength Test and Unit Weight Determination.....1 test

5. Subsurface Soil and Groundwater Conditions

A detailed description of the geotechnical conditions encountered in the boreholes is given on the borehole logs, Figures 3 to 5.

The borehole logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time may also result in changes in the conditions interpreted to exist at the locations where sampling was conducted.

The boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of environmental conditions.

It should be noted that the soil boundaries indicated on the borehole logs are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Notes on Sample Descriptions" preceding the borehole logs forms an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following subsurface conditions with depth and groundwater level measurements.

5.1 Topsoil

A surficial 100 mm and 150 mm thick topsoil layer was contacted in all three (3) boreholes.

5.2 Fill

Fill was encountered beneath the topsoil in all three (3) boreholes and extends to depths of 0.9 m to 1.7 m below existing grade (Elevation 70.6 m and Elevation 69.7 m). The fill consists of a sandy clay with topsoil inclusions. The N values from the standard penetration test (SPT) range between 6 and 15 indicating the fill is in a loose to compact state. The moisture content of the fill ranges from 15 percent to 53 percent. The unit weight of the fill is 20.8 kN/m^3.

The results from the grain-size analysis and Atterberg limit determination conducted on one (1) selected sample of the fill is summarized in Table I. The grain-size distribution curve is shown in Figure 6.

Table I: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination - Fill Sample

Borehole (BH) No. – Sample (SS) No.	Depth (m)	Grain-Size Analysis (%)			Atterberg Limits (%)				
		Gravel	Sand	Fines (Silt and Clay)	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification (USCS)
BH 2 – SS2	0.8 – 1.4	3	32	65	24	36	18	18	Sandy Clay of Low to Medium Plasticity (CL)

Based on a review of the results of the grain-size analysis and Atterberg limits, the fill may be classified as a sandy clay of low to medium plasticity (CL) in accordance with the Unified Soil Classification System (USCS).

5.3 Glacial Till

The fill in the three (3) boreholes is underlain by glacial till that extends to a 3.4 m depth (Elevation 68.0 m) in Borehole No. 1. The glacial till contains gravel, shale fragments, cobbles and boulders. The SPT N values range from 16 to 70 indicating the glacial till is in a compact to very dense state. The natural moisture content of the glacial till is 5 percent to 20 percent. The natural unit weight of the glacial till is 20.7 kN/m^3 to 22.2 kN/m^3.

The results from the grain-size analysis conducted on one (1) sample of the glacial till from Borehole No. 1 are summarized in Table II. The grain-size distribution curve is shown in Figure 7.

Table II: Summary of Results from Grain-Size Analysis – Glacial Till Sample

Borehole (BH) No. – Sample (SS) No.	Depth (m)	Grain-Size Analysis (%)			Soil Classification (USCS)
		Gravel	Sand	Fines (Silt and Clay)	
BH 1 – SS3	1.5 – 2.1	9	57	34	Silty Sand (SM)

Based on a review of the results from the grain size analysis, the glacial till sample may be classified as a silty sand (SM) in accordance with the USCS. The glacial till contains gravel, shale fragments, cobbles and boulders.

5.4 Clay Layer

A 300 mm thick clay layer was contacted within the glacial till of Borehole No. 3 at a 2.7 m depth (Elevation 68.8 m). The SPT N value of 44 indicates the clay layer has a hard consistency. The natural moisture content of the clay is 16 percent.

The results from the grain-size analysis and Atterberg limit determination conducted on one (1) selected sample of the clay is summarized in Table III. The grain-size distribution curve is shown in Figure 8.

Table III: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination - Clay Sample

Borehole (BH) No. – Sample (SS) No.	Depth (m)	Grain-Size Analysis (%)			Atterberg Limits (%)				
		Gravel	Sand	Fines (Silt and Clay)	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification (USCS)
BH 3 – SS4	2.3 – 2.9	3	23	74	16	29	15	14	Clay with Sand of Low to Medium Plasticity (CL)

Based on a review of the results of the grain-size analysis and Atterberg limits, the soil may be classified as a clay with sand of low to medium plasticity (CL) in accordance with the USCS.

5.5 Shale Bedrock

Auger refusal was met on inferred cobbles, boulders or bedrock at 3.4 m and 3.6 m depths below existing grade (Elevation 68.0 m to elevation 67.8 m). The presence of the bedrock at a 3.4 m depth (Elevation 68.0 m) in Borehole No. 1 was confirmed by coring the bedrock from 3.4 m to the termination depth of 5.1 m (Elevation 66.3 m). The bedrock is shale bedrock of the Billings formation. A photograph of the bedrock core is shown in Figure 9.

A review of the recovered rock core indicates the total core recovery (TCR) is 100 percent. The rock quality designation (RQD) value is 67 percent indicating the bedrock is of fair quality.

One uniaxial compressive strength test was completed on the rock core indicating a compressive strength of 23.1 MPa. The unit weight was also determined to be 25.4 kN/m^3. Based on the uniaxial compressive strength test result, the bedrock may be classified as being weak in accordance with the 2006 Fourth Edition of the Canadian Foundation Engineering Manual (CFEM).

As previously mentioned, the site is underlain by shale bedrock of the Billings formation. This type of shale is prone to deterioration when exposed to the elements. It also heaves due to a complex mechanism caused in part from the bio-oxidation of the sulfides in the rock, which react with calcite seams to form expanding gypsum. This occurs when oxygen is permitted to enter the rock, usually by lowering of the water table and this process is accelerated by the presence of heat. Therefore, special treatment of the Billings shale bedrock will need to be incorporated into the design and construction of the proposed buildings should the foundations and basement slab of the proposed buildings and proposed new underground services extend into the shale bedrock.

5.6 Groundwater Levels

Groundwater level measurements were taken on November 10, 2021 in the standpipes installed in all three (3) boreholes. The groundwater level measurements are summarized in Table IV.

Table IV: Summary of Groundwater Level Measurements

Borehole No. (BH)	Ground Surface Elevation (m)	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m
BH 1	71.43	November 10, 2021 (14 days)	2.8 (68.6)
BH 2	71.38	November 10, 2021 (14 days)	2.2 (69.2)
BH 3	71.49	November 10, 2021 (14 days)	1.0 (70.5)

Based on a review of the groundwater level measurements, the groundwater level ranges from 1.0 m to 2.8 m (Elevation 70.5 m to Elevation 68.6 m).

Groundwater levels were determined in the boreholes at the times and under the conditions stated in the scope of services. Note that fluctuations in the level of groundwater may occur due to a seasonal variation such as

precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.

6. Seismic Site Classification and Liquefaction Potential of Soils

6.1 Site Classification for Seismic Site Response

Based on the borehole information and Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC) as amended May 2, 2019, the site classification for seismic site response is estimated to be **Class C.**

6.2 Liquefaction Potential of Soils

The subsurface soils are not considered to be liquefiable during a seismic event.

7. Grade Raise Restrictions

From a geotechnical perspective, based on a review of the subsurface soil and bedrock conditions, there is no restriction to raising the grades at the site for the proposed development.

8. Foundation Considerations

Based on a review of the borehole information, the proposed residential buildings may be supported by strip and spread footings designed to bear on the native glacial till contacted at 0.9 m and 1.7 m depths (Elevation 70.6 m and Elevation 69.7 m). The existing fill is not considered suitable to support the foundations of the proposed residential buildings. Spread and strip footings founded on the native glacial till may be designed for a bearing pressure at serviceability limit state (SLS) of 150 kPa and factored geotechnical resistance at ultimate limit state (ULS) of 225 kPa. The factored geotechnical resistance at ULS includes a resistance factor of 0.5.

Settlement of footings designed for the above SLS bearing pressures are expected to be within the tolerable limits of 25 mm total and 19 mm differential movements.

It is possible that in areas of the existing structures that will be demolished as part of the proposed site development and in areas elsewhere on the site, loose /unsuitable soils may be encountered at the design founding level for the new footings. In this case, the loose/unsuitable soils should be excavated and removed to the competent glacial till and the excavation backfilled with Ontario Provincial Standard Specification (OPSS) Granular B Type II material placed in 300 mm thick lifts and each lift compacted to 100 percent of the standard Proctor maximum dry density (SPMDD). The surface of the glacial till should be examined by a geotechnical engineer prior to placement of the OPSS Granular B Type II material. The engineered fill should be placed under the full-time supervision of a geotechnician working under the direction of a geotechnical engineer. In-place density tests should be undertaken on each lift of the engineered fill to ensure that it is properly compacted prior to placement of the subsequent lift. Alternatively, lean mix concrete may be used to raise the grades to the underside of footing, which would eliminate the use of compaction equipment along the property boundaries.

Footings that are to be placed at different elevations should be located such that the higher footing is set below a line drawn up at 10H:7V from the near edge of the lower footing. This concept should also be applied to underground service excavations to ensure that foundations and underground services will not be undermined.

If the footings for the proposed buildings will be founded on the shale bedrock, EXP should be contacted to provide updated SLS and factored ULS values for the footings and to provide details regarding the special treatment of the Billings shale bedrock that will need to be incorporated into the design and construction of the foundations and basement floor slab of the proposed buildings.

All footing beds should be examined by a geotechnical engineer to ensure that the founding surfaces are capable of supporting the design bearing pressure at SLS and that the footing beds have been properly prepared.

The surface of the glacial till is below the prevailing groundwater table. It is recommended that the footing beds be covered with a 50 mm thick concrete mud slab within the same day of examination and approval by a geotechnical engineer to prevent disturbance to the glacial till subgrade.

A minimum of 1.5 m of earth cover should be provided to the exterior foundations of heated structures to protect them from damage due to frost penetration. The frost cover should be increased to 2.1 m for unheated structures if snow will not be removed from their vicinity and to 2.4 m if snow will be removed from the vicinity of the structure. When earth cover is less than the required cover, an equivalent thermal combination of earth cover and rigid insulation or rigid insulation alone should be provided. EXP can provide additional comments in this regard, if required.

The recommended bearing pressure at SLS and factored geotechnical resistances at ULS 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, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field monitoring provided by an experienced geotechnical engineer to validate the information for use during the construction stage.

9. Slab-on-Grade Construction and Permanent Drainage Systems

The lowest floor slabs (basement floor slabs) of the proposed buildings may be designed as a slab-on-grade founded on a bed of 200 mm of 19 mm clear stone placed on top of a minimum 300 mm thick compacted Ontario Provincial Standard Specification (OPSS) Granular B Type II pad placed on the native glacial till and compacted to 98 percent standard Proctor maximum dry density (SPMDD). The clear stone would prevent the capillary rise of moisture from the sub-soil to the floor slab. Alternatively, the floor slab may be cast on a 200 mm thick bed of OPSS Granular A material overlain by a vapour barrier. Adequate saw cuts should be provided in the floor slabs to control cracking.

A perimeter drainage system and underfloor drainage system should be provided for the proposed buildings.

The long-term lowering of the groundwater level by the perimeter and underfloor drainage systems is not expected to adversely impact adjacent existing structures and infrastructure.

If the lowest floor slab (basement slab) of the proposed buildings will be founded on the shale bedrock, EXP should be contacted to provide details regarding the special treatment of the Billings shale bedrock that will need to be incorporated into the design and construction of the foundations and basement floor slab of the proposed buildings.

The ground floor slab should be set at least 150 mm above the surrounding exterior grades and the exterior grades should be sloped away from the proposed buildings to prevent ponding of surface water close to the exterior walls of the proposed buildings.

10. Lateral Earth Pressure on Subsurface Walls

The subsurface basement walls of the building should be backfilled with free draining material, such as OPSS Granular B Type II compacted to 95 percent SPMDD and equipped with a perimeter drainage system to prevent the buildup of hydrostatic pressure behind the walls. The walls will be subjected to lateral static and dynamic (seismic) earth forces. The expressions below assume free draining backfill material, a perimeter drainage system, level backfill surface behind the wall and vertical face on the back side of the wall.

For design purposes, the lateral static earth thrust against the subsurface walls may be computed from the following equation:

$$P = K_0\, h\, (½\, \gamma h + q)$$

where P = lateral earth thrust acting on the subsurface wall, kN/m

K_0 = lateral earth pressure at rest coefficient, assumed to be 0.5 for Granular B Type II backfill material

γ = unit weight of free draining granular backfill; Granular B Type II = 22 kN/m^3

h = depth of point of interest below top of backfill, m

q = surcharge load stress, kPa

The lateral dynamic thrust may be computed from the equation given below:

$$\Delta_{Pe} = \gamma H^2 \frac{a_h}{g} F_b$$

where Δ_{Pe} = dynamic thrust in kN/m of wall

H = height of wall, m

γ = unit weight of backfill material = 22 kN/m^3

$\frac{a_h}{g}$ = earth pressure coefficient = 0.32 for Ottawa area

F_b = thrust factor = 1.0

The dynamic thrust does not take into account the surcharge load. The resultant force of the lateral dynamic thrust acts approximately at 0.63H above the base of the wall.

All subsurface walls should be properly waterproofed.

11. Excavation and De-Watering Requirements

11.1 Excess Soil Management

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

11.2 Excavations

Excavation for the construction of the proposed building foundations and installation of the underground municipal services are anticipated to extend into the glacial till to a 3.0 m depth and will likely be below the groundwater level.

The excavations may be undertaken by conventional heavy equipment capable of removing cobles and boulders within the glacial till.

All excavations must be undertaken in accordance with the Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91. Based on the definitions provided in OHSA, the subsurface soils on site are considered to be Type 3 and for open cut excavations, the side slopes of the excavation must be cut back at 1H:1V from the bottom of the excavation. Below the groundwater level, the excavation side slopes are expected to slough and eventually stabilize at a slope of 3H:1V to 2H:1V.

If side slopes noted above cannot be achieved due to space restrictions on site, such as the proximity of open cut excavations to the property limits, existing infrastructure or to foundations of adjacent existing buildings the excavation for the new building construction would have to be undertaken within the confines of an engineered support system (shoring system). Underground services may be installed within the confines of a prefabricated support system (trench box) in accordance with OHSA. The need for a shoring system, the most appropriate type of shoring system and the design and installation of the shoring system should be determined by the contractors bidding on this project. The design of the shoring system should be undertaken by a professional engineer experienced in shoring design and the installation of the shoring system should be undertaken by a contractor experienced in the installation of shoring systems. The shoring system should be designed and installed in accordance with latest edition of Ontario Regulation 213/91 under the OHSA and the 2006 Fourth Edition of the Canadian Foundation Engineering Manual (CFEM). The shoring system as well as adjacent settlement sensitive structures (buildings) and infrastructure should be monitored for movement (deflection) on a periodic basis during construction operations.

A pre-construction condition survey of buildings and infrastructure within the influence zone of the construction should be undertaken prior to start of construction activities.

It is recommended that vibration monitoring be conducted at the site and at adjacent existing buildings and infrastructure during the installation of the shoring system and during construction of the new building to ensure the existing structures and infrastructure are not damaged as a result of the construction activities.

Many geologic materials deteriorate rapidly upon exposure to meteorological elements. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from moisture, desiccation, and frost action throughout the course of construction.

11.3 De-Watering Requirements

Seepage of the surface and subsurface water into the excavations above the groundwater level is anticipated and it should be possible to collect water entering the excavations at low points and to remove it by conventional pumping techniques. High-capacity pumps may be required in zones of persistent seepage where more permeable soil may exist along the side walls of the excavation.

The dewatering of excavations on site during the short-term construction operations is not expected to adversely impact adjacent existing structures and infrastructure.

It is anticipated that groundwater will need to be removed from the excavations. It is noteworthy to mention that legislation came into force in Ontario on March 29, 2016 to regulate groundwater takings for construction dewatering purposes. Prior to March 29, 2016, a Category 2 Permit to Take Water (PTTW) was required from the Ontario Ministry of the Environment, Conservation and Parks (MECP) for groundwater takings related to construction dewatering, where taking volumes in excess of 50 m^3/day, but less than 400 m^3/day, and the taking duration was no more than 30 consecutive days. The 2016 legislation replaces the Category 2 PTTW for construction dewatering with a process under the Environmental Activity and Sector Registry (EASR). The EASR is an on-line registry, which allows persons engaged in prescribed activities, such as water takings, to register with the MECP instead of applying for a PTTW.

To be eligible for the new EASR process, the construction dewatering taking must be less than 400 m^3/day under normal conditions. The water taking can be groundwater, storm water, or a combination of both. It should be noted that the 30-consecutive day limit on the water taking under the old Category 2 PTTW process has been removed in the new EASR process. Also, it should be noted that the EASR process requires two technical studies be prepared by a Qualified Person, prior to any water taking. These studies include a Water Taking Report, which provides assurance that the taking will not cause any unacceptable impacts, and a Discharge Plan, which provides assurance that the discharge will not result in any adverse impacts to the environment. EXP has qualified persons who can prepare these types of reports, if required. A significant advantage of the new EASR process over the former Category 2 PTTW process, is that the groundwater taking may begin immediately after completing the on-line registration of the taking and paying the applicable fee, assuming the accompanying technical studies have been completed. The former PTTW process typically took more than 90 days, which had the potential to impact construction schedules.

Although this investigation has estimated the groundwater levels at the time of the fieldwork, and commented on dewatering and general construction problems, conditions may be present which are difficult to establish from standard boring and excavating techniques and which may affect the type and nature of dewatering procedures used by the contractor in practice. These conditions include local and seasonal fluctuations in the groundwater table, erratic changes in the soil profile, thin layers of soil with large or small permeabilities compared with the soil mass, etc. Only carefully controlled tests using pumped wells and observation wells will yield the quantitative data on groundwater volumes and pressures that are necessary to adequately engineer construction dewatering systems.

12. Pipe Bedding Requirements

It is anticipated that underground municipal services will be founded to a maximum depth of 3.0 m below existing grade and the subgrade will consist of glacial till and the clay layer located within the glacial till.

It is recommended that the bedding for the underground services including material specifications, thickness of cover material and compaction requirements conform to municipal requirements and/or Ontario Provincial Standard Specification and Drawings (OPSS and OPSD).

The pipe bedding should consist of 300 mm thick of OPSS Granular A bedding material. The bedding material should be compacted to at least 98 percent SPMDD.

The bedding thickness may be further increased in areas where the subgrade becomes disturbed. Trench base stabilization techniques, such as removal of loose/soft material, placement of crushed stone sub-bedding (Granular B Type II) that is completely wrapped in a non-woven geotextile, may also be used if trench base disturbance becomes a problem in wet or soft areas.

It is anticipated that paved surfaces will be located over service trenches. In this case, it is recommended that the trench backfill material within the frost zone up to 1.5 m below finished grade, should match the existing material exposed in the sidewalls of the trench, provided the material is determined to be suitable for re-use as backfill material. The matching of materials minimizes differential frost heave of the subgrade material. If the trench backfill material is different than the material in the sidewalls of the trench, a 3H:1V frost taper should be provided to minimize differential frost heave. The trench backfill should be placed in 300 mm thick lifts and each lift compacted to 95 percent SPMDD.

If the subgrade for the underground service pipes will be the shale bedrock, EXP should be contacted to provide details regarding the special treatment of the Billings shale bedrock that will need to be incorporated into the installation of the new underground services.

The underground services should be installed in short open trench sections that are excavated and backfilled the same day.

13. Backfilling Requirements and Suitability of On-Site Soils for Backfilling Purposes

The material to be excavated from the site will mainly comprise of topsoil, sandy clay fill, glacial till and the clay layer within the glacial till. These soils are not considered suitable for use under structural elements and for backfilling purposes. Portions of the glacial till (free of shale fragments, cobbles and boulders) and clay above the groundwater level may be used for general grading purposes in landscaped areas.

It is anticipated that the majority of the material required for engineered fill and for backfilling purposes for this project would have to be imported and should preferably conform to the following specification:

- Engineered fill under footings and slab-on-grade - OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 100 percent SPMDD beneath footings and to 98 percent SPMDD beneath the floor slab

- Backfill in footing trenches and against foundation walls – OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 98 percent of the SPMDD inside the building and 95 percent SPMDD outside the building respectively.

- Backfill in services trenches inside building – OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 98 percent of the SPMDD.

- Backfill in exterior services trenches – OPSS 1010 Select Subgrade Material (SSM) placed in 300 mm thick lifts and each lift compacted to 95 percent of the SPMDD.

14. Subsurface Concrete and Steel Requirements

Chemical tests limited to pH, chloride, sulphate and resistivity were performed on one (1) selected soil sample. The laboratory certificate of analysis is attached in Appendix A and the results are summarized in Table V below.

Table V: Results of pH, Chloride, Sulphate and Resistivity Tests on Soil Sample

Borehole No. (Sample No.)	Depth (m)	Soil Type	pH	Sulphate (%)	Chloride (%)	Resistivity (ohm-cm)
BH 2 – SS4	2.3 -2.9	Glacial Till	8.46	0.0151	0.0003	3640

The results indicate the glacial till has a sulphate content of less than 0.1 percent. This concentration of sulphate in the glacial till would have a negligible potential of sulphate attack on subsurface concrete. The concrete should be designed in accordance with Table Nos. 3 and 6 of CSA A.23.1-14. However, the concrete should be dense, well compacted and cured.

Based on a review of the resistivity test result, the glacial till sample is considered to be mildly corrosive to bare steel as per the National Association of Corrosion Engineers (NACE). Appropriate measures should be undertaken to protect buried steel elements from corrosion.

15. Pavement Structures

It is our understanding that the development will have paved right-of-ways between the residential buildings and driveways for parking. Therefore, it is anticipated that the pavement structures will be exposed to light and heavy-duty traffic.

The subgrade for the parking areas (driveways) and right-of ways (access roads) at the site is anticipated to consist of the existing fill, native glacial till, OPSS Granular B Type II material and/or OPSS select subgrade material (SSM). Pavement structure thicknesses required for light and heavy-duty traffic on the right-of-ways (access roads) and in parking areas (driveways) were computed and are shown in Table VI. The pavement structure thicknesses are based upon an estimate of the properties of the anticipated subgrade and functional design life of eight (8) to ten (10) years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out.

Table VI: Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Light Duty Traffic (Cars)	Heavy Duty Parking Areas and Right-of Ways (such as Fire Trucks/Garbage Trucks)
Asphaltic Concrete (PG 58-34)	92 percent to 97 percent MRD	65 mm – SP12.5 Cat B or HL3	40 mm – 12.5 Cat B/HL3 50 mm – 19.0 Cat B/HL8
Granular A Base (OPSS 1010) (crushed limestone)	100 percent SPMDD	150 mm	150 mm
Granular B Sub-base, Type II (OPSS 1010)	100 percent SPMDD	300 mm	450 mm
SPMDD denotes Standard Proctor Maximum Dry Density, ASTM-D698-12e2 MRD denotes Maximum Relative Density, ASTM D2041			

The foregoing design assumes that construction is carried out during dry periods and that the subgrade is stable under the load of construction equipment. If construction is carried out during wet weather, and heaving or rolling of the subgrade is experienced, additional thickness of granular material and/or geotextile may be required. Additional comments on the construction of the right-of-ways (access roads) and parking lots are as follows:

(1) As part of the subgrade preparation, the proposed right-of-ways (access roads) and parking areas (driveways) should be stripped of unsuitable fill and other obviously unsuitable material. The subgrade should be proofrolled in the presence of a geotechnician and approved before placement of the granular materials for the pavement structure or material to raise the grades. Fill required to raise the grades to the design subgrade elevation should consist of OPSS select subgrade material (SSM) compacted to 95

percent SPMDD. After all the underground services have been installed and in areas with no service trenches, the subgrade should be properly shaped, crowned and proofrolled with a heavy roller in the full-time presence of a representative of this office. Any soft or spongy subgrade areas detected should be sub-excavated and properly replaced with suitable approved backfill compacted to 95 percent SPMDD.

(2) The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. The need for adequate drainage cannot be over-emphasized. Sub-drains must be installed on both sides of the proposed right-of-ways (access roads). In parking areas, they should be installed at low points and should be continuous between catch basins to intercept excess surface and subsurface moisture and to prevent subgrade softening. This will ensure no water collects in the granular course, which could result in pavement failure during the spring thaw. The location and extent of subdrainage required within the paved areas should be reviewed by this office in conjunction with the proposed site grading.

(3) To minimize the problems of differential movement between the pavement and catchbasins/ manhole due to frost action, the backfill around the structures should consist of free-draining granular preferably conforming to OPSS Granular B Type II material.

(4) The finished pavement surface should be free of depressions and should be sloped (preferably at a minimum cross fall of 2 percent) to provide effective surface drainage towards catch basins. Surface water should not be allowed to pond adjacent to the outside edges of paved areas.

(5) The granular materials used for pavement construction should conform to Ontario Provincial Standard Specifications (OPSS) for Granular A and Granular B Type II and should be compacted to 100 percent SPMDD. The asphaltic concrete and its placement should meet OPSS 1151 requirements. It should be placed and compacted to OPSS 311 and 313.

16. General Comments

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

The information contained in this report is not intended to reflect on environmental aspects of the soils. Should specific information be required, including for example, the presence of pollutants, contaminants or other hazards in the soil, refer to the environmental site assessment reports prepared by EXP for this project.

We trust that the information contained in this report is satisfactory for your purposes. Should you have any questions, please contact this office.

Sincerely,

Matthew Zammit, M.A.Sc., P.Eng.
Geotechnical Engineer
Earth and Environment

Susan M. Potyondy, P.Eng.
Senior Project Manager
Earth and Environment

Figures

0 50m 100m 200m

HORIZONTAL 1:5000

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100-2650 Queensview Drive
Ottawa, ON K2B 8H6

www.exp.com

DESIGN	IT
DRAWN	GC
DATE	NOV. 2021
FILE NO	OTT-21019403-A0

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
1568 MEADOWBROOK ROAD, OTTAWA, ON
NEMOURIN GROUP LTD.

BOREHOLE LOCATION PLAN

SCALE	1:5000
SKETCH NO	FIG 1

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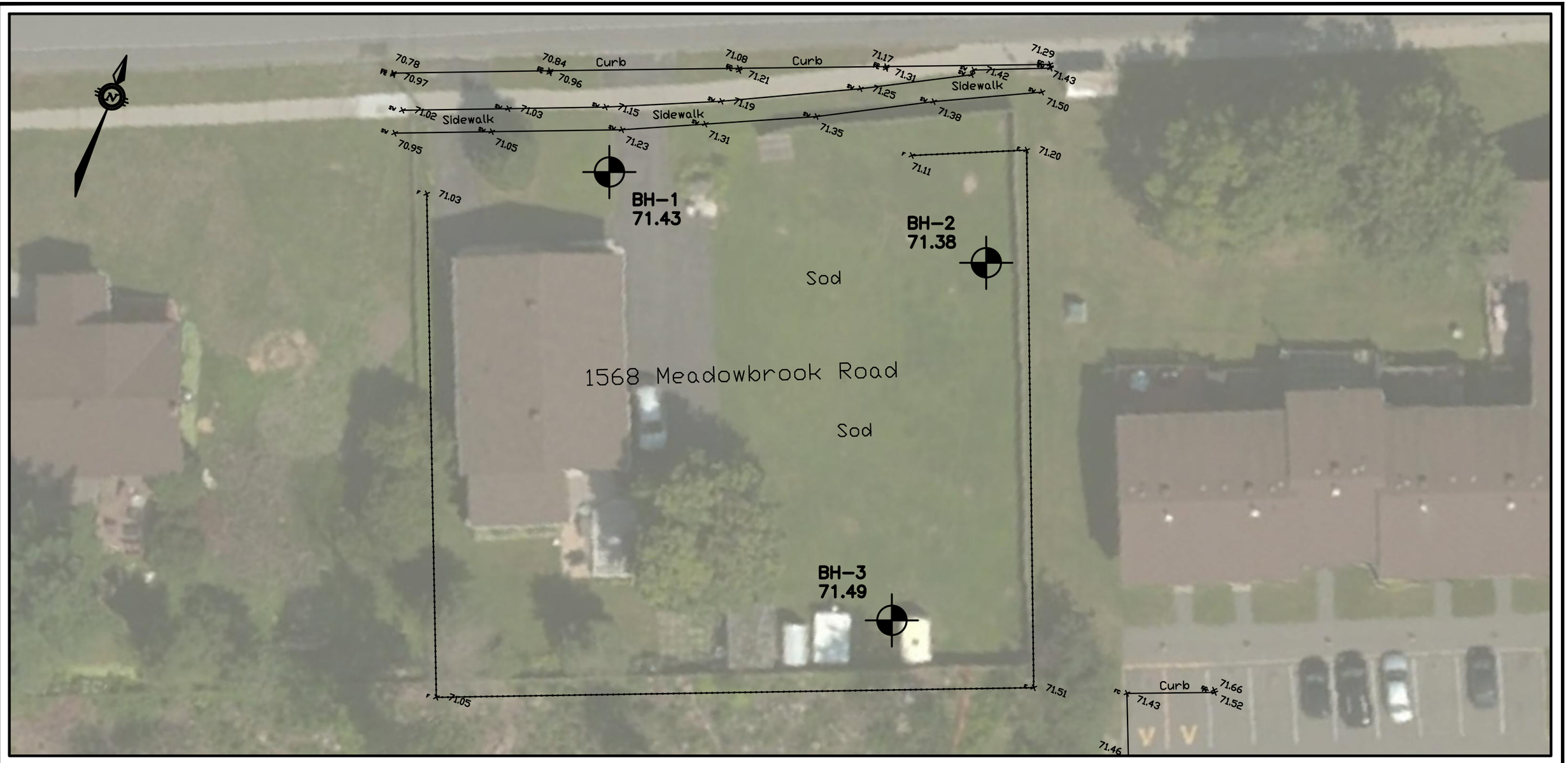

LEGEND

BH-1 71.43 — BOREHOLE NO & LOCATION, GROUND SURFACE ELEVATION

NOTES:

1. THE BOUNDARIES AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
5. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.
6. BASE PLAN INFORMATION OBTAINED FROM EXP SURVEY CONDUCTED NOVEMBER 15, 2021.

0 2m 4m 10m
HORIZONTAL 1:250

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DESIGN	IT
DRAWN	GC
DATE	NOV. 2021
FILE NO	OTT-21019403-A0

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
1568 MEADOWBROOK ROAD, OTTAWA, ON
NEMOURIN GROUP LTD.

BOREHOLE LOCATION PLAN

SCALE 1:250
SKETCH NO FIG 2

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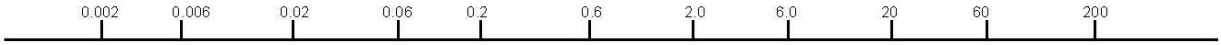
Notes On Sample Descriptions

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

ISSMFE SOIL CLASSIFICATION

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



EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

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

UNIFIED SOIL CLASSIFICATION

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

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

Log of Borehole BH1

Project No: OTT-21019403-A0

Project: Proposed Residential Development

Location: 1568 Meadowbrook Road, Ottawa, Ontario

Figure No. 3

Page. 1 of 1

Date Drilled: 'October 27, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: MZ Checked by: SMP

Split Spoon Sample ☒
Auger Sample ◧
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits |—○
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		TOPSOIL: ~150 mm thick	71.43	0				
		FILL: Sandy clay, some silt, trace gravel, brown, black, and grey, moist (compact)	71.3		10		SS1	
				1	15		SS2	
			69.7					
		GLACIAL TILL: Silty sand with gravel, shale fragments, cobbles and boulders, grey, wet (very dense)		2	56		SS3	
					60		SS4	
			68.63	3	50/138 mm sampler refusal		SS5	
		SHALE BEDROCK: Black, fair quality, (Billings formation)	68.0	4			Run 1 25.4	
				5				
		Borehole Terminated at 5.1 m Depth	66.3					

LOG OF BOREHOLE 1568 MEADOWBROOK ROAD.GPJ TROW OTTAWA.GDT 11/22/21

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Fieldwork was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21019403-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Nov 10, 2021	2.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	3.4 - 5.1	100	67

Log of Borehole BH2

Project No: OTT-21019403-A0

Project: Proposed Residential Development

Location: 1568 Meadowbrook Road, Ottawa, Ontario

Figure No. 4

Page. 1 of 1

Date Drilled: 'October 27, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: MZ Checked by: SMP

Split Spoon Sample ⊠
Auger Sample ◧
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits |—○
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		TOPSOIL: ~100 mm thick	71.38	0				
		FILL: Sandy clay of low to medium plasticity, topsoil inclusions, brown, moist (loose to compact)	71.3		7		SS1	
				1	12		SS2	20.8
			69.7					
		GLACIAL TILL: Silty sand with gravel, shale fragments, cobbles and boulders, grey, damp (dense to very dense)			40		SS3	22.0
			69.18	2				
					52		SS4	
				3	50 / 138 mm sampler refusal		SS5	
		Auger Refusal at 3.6 m Depth	67.8					

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Fieldwork was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21019403-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)
Nov 10, 2021	2.2	

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE 1568 MEADOWBROOK ROAD.GPJ TROW OTTAWA.GDT 11/22/21

Log of Borehole BH3

Project No: OTT-21019403-A0

Project: Proposed Residential Development

Location: 1568 Meadowbrook Road, Ottawa, Ontario

Figure No. 5

Page. 1 of 1

Date Drilled: 'October 27, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: MZ Checked by: SMP

Split Spoon Sample ⊠
Auger Sample ◧
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits ⊢○
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		TOPSOIL: ~150 mm thick	71.49 / 71.3	0
		FILL: Sandy clay, some silt, trace gravel, topsoil inclusions, brown, moist (loose)	70.6 / 70.49	
		GLACIAL TILL: Silty sand with gravel, shale fragments, cobbles and boulders, grey, damp (very dense)		1
				2
			68.8	
		CLAY With sand, low to medium plasticity, grey, damp, (hard)	68.5	3
		GLACIAL TILL: Silty sand with gravel, shale fragments, cobbles and boulders, grey, damp (very dense)	67.9	
		Auger Refusal at 3.6 m Depth		

Standard Penetration Test N Value: 20 40 60 80
Shear Strength kPa: 50 100 150 200
Combustible Vapour Reading (ppm): 250 500 750
Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES	Natural Unit Wt. kN/m³	Test Values
SS1		6
SS2	20.7	16
SS3	22.2	70
SS4		44
SS5		88 / 230 mm sampler refusal

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Fieldwork was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-21019403-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Nov 10, 2021	1.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE 1568 MEADOWBROOK ROAD.GPJ TROW OTTAWA.GDT 11/22/21

EXP Services Inc.
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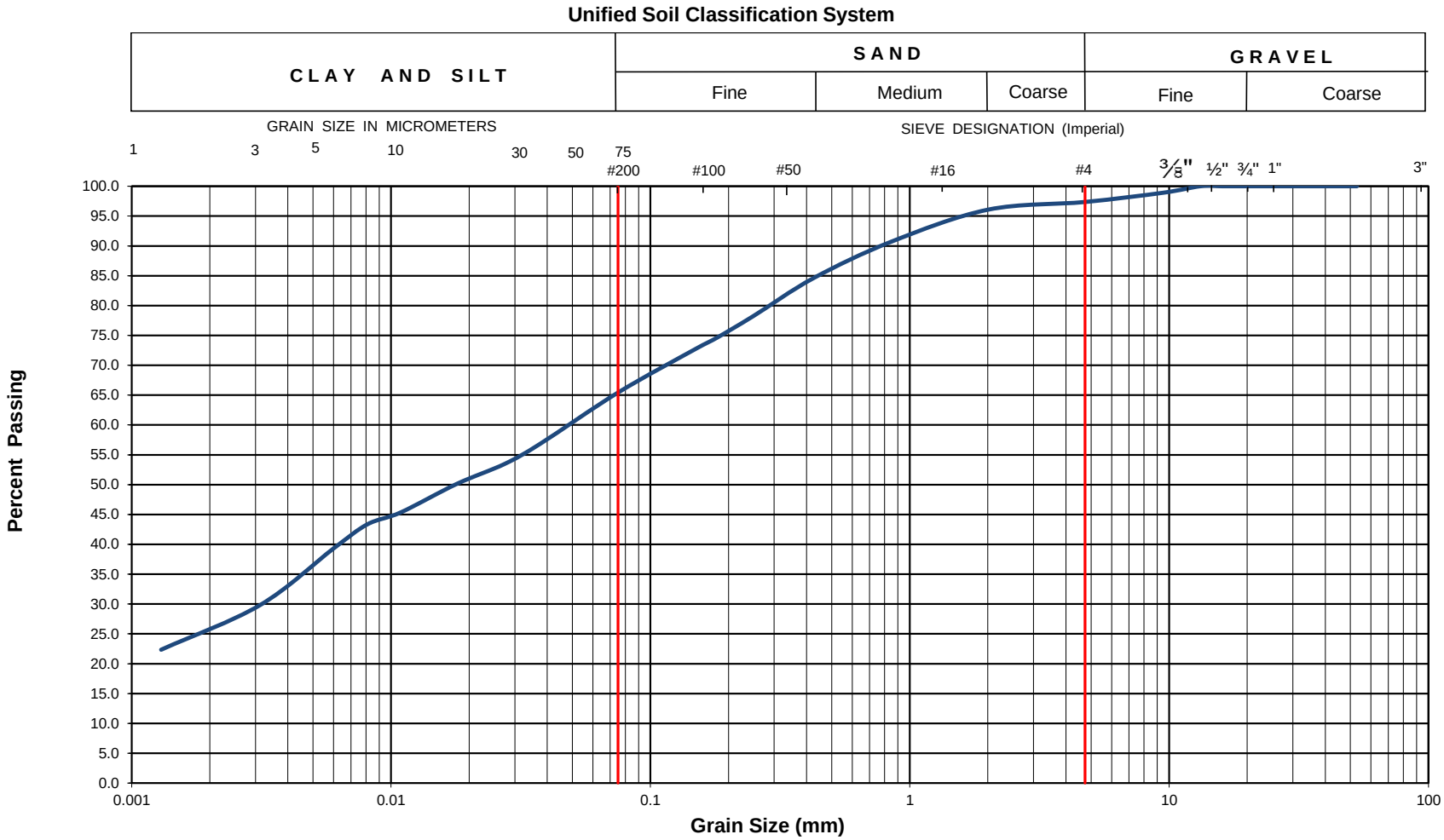
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-21019403-A0**	**Project Name :**	**Proposed Residential Development**						
Client :	**Nemorin Group Limited**	**Project Location :**	**1568 Meadowbrook Road, Ottawa, ON.**						
Date Sampled :	**October 27, 2021**	**Borehole No:**	**BH2**	**Sample No.:**	**SS2**	**Depth (m) :**	**0.8-1.4**		
Sample Description :		**% Silt and Clay**	**65**	**% Sand**	**32**	**% Gravel**	**3**	**Figure :**	**6**
Sample Description :	**FILL: Sandy Clay of Low to Medium Plasticity (CL)**								

EXP Services Inc.
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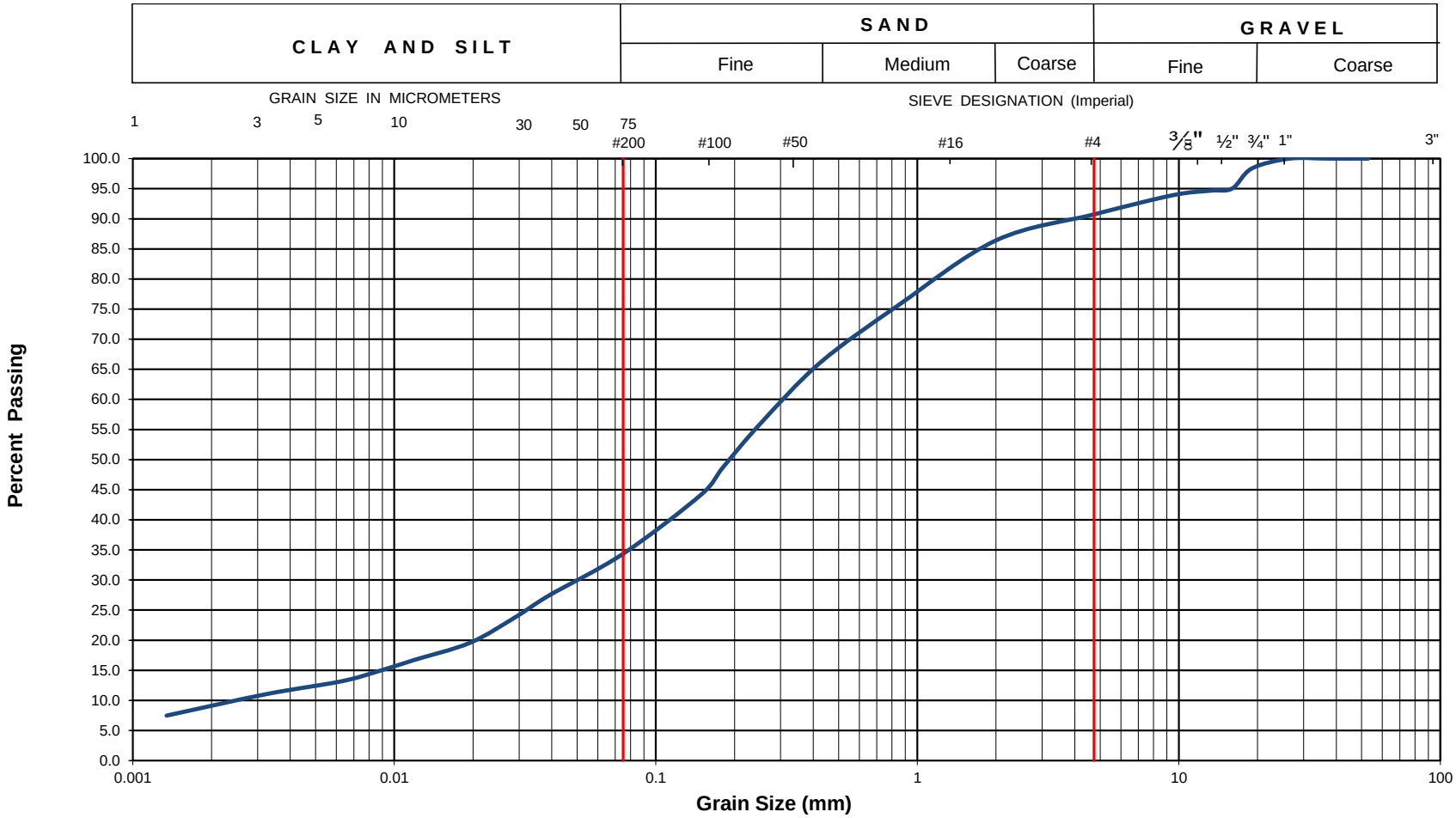
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

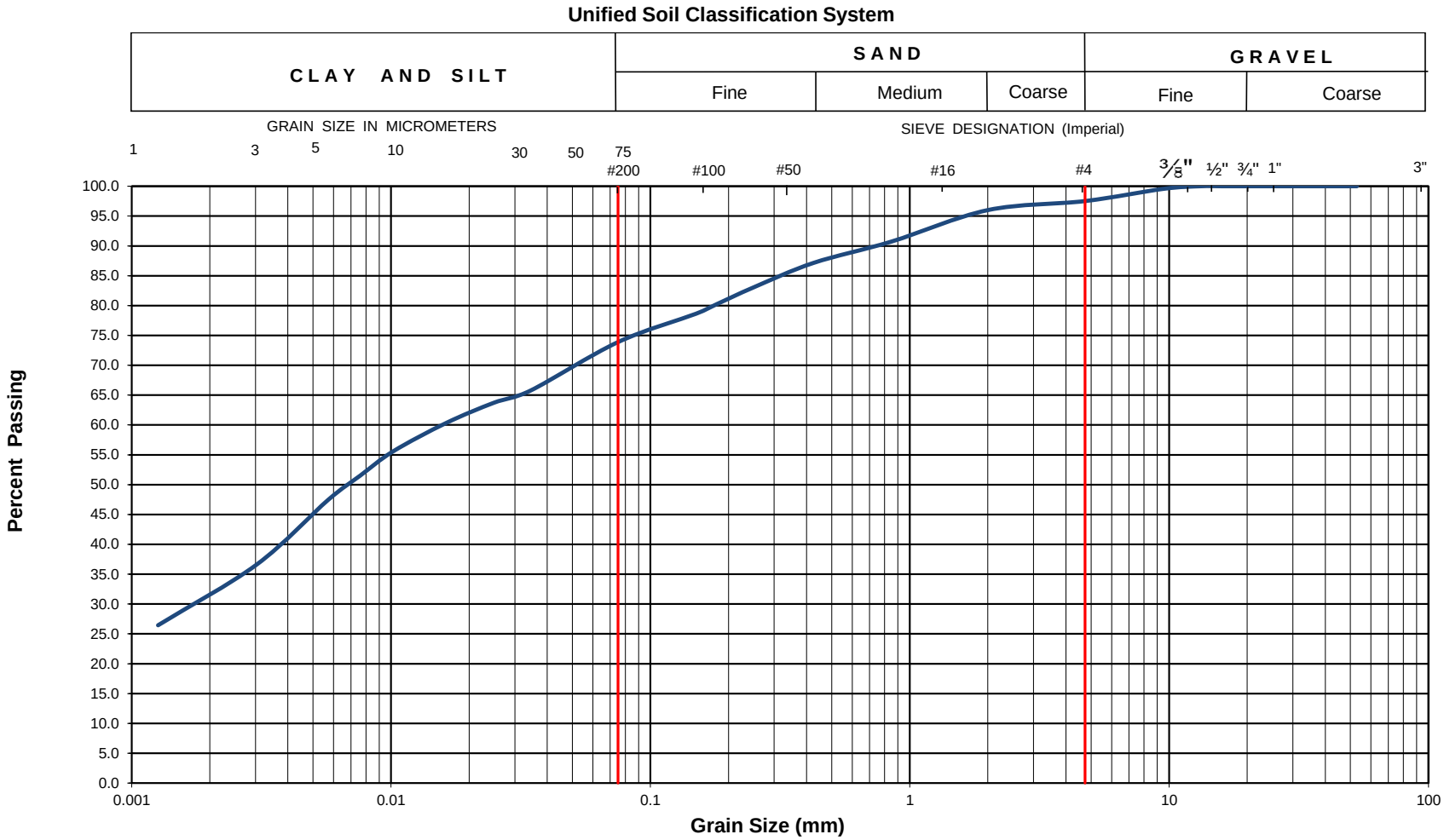
Unified Soil Classification System



EXP Project No.:	**OTT-21019403-A0**	**Project Name :**	**Proposed Residential Development**						
Client :	**Nemorin Group Limited**	**Project Location :**	**1568 Meadowbrook Road, Ottawa, ON.**						
Date Sampled :	**October 27, 2021**	**Borehole No:**	**BH1**	**Sample No.:**	**SS3**	**Depth (m) :**	**1.5-2.1**		
Sample Description :		**% Silt and Clay**	**34**	**% Sand**	**57**	**% Gravel**	**9**	**Figure :**	**7**
Sample Description :		**GLACIAL TILL: Silty Sand (SM)**							

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

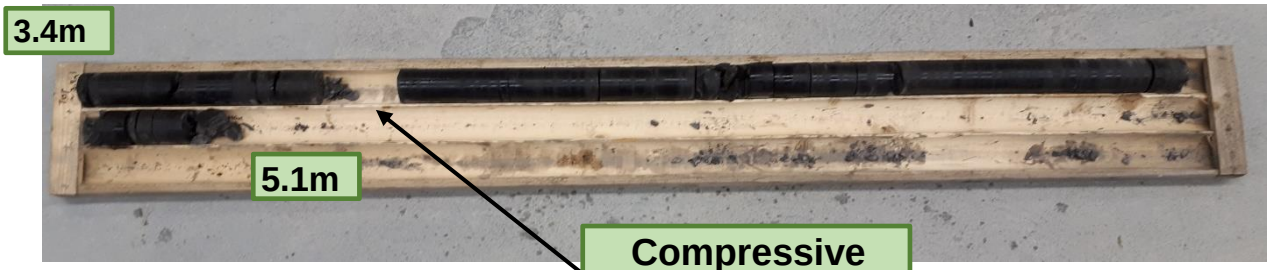
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-21019403-A0**	**Project Name :**	**Proposed Residential Development**						
Client :	**Nemorin Group Limited**	**Project Location :**	**1568 Meadowbrook Road, Ottawa, ON.**						
Date Sampled :	**October 27, 2021**	**Borehole No:**	**BH3**	**Sample No.:**	**SS4**	**Depth (m) :**	**2.3-2.9**		
Sample Description :		**% Silt and Clay**	**74**	**% Sand**	**23**	**% Gravel**	**3**	**Figure :**	**8**
Sample Description :	**CLAY with Sand of of Low to Medium Plasticity (CL)**								

DRY BEDROCK CORES

WET BEDROCK CORES



exp Services Inc.
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
Canada
www.exp.com

• BUILDINGS • EARTH & ENVIRONMENT • ENERGY •
• INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

borehole no.	core runs	PROJECT:	project no.
BH-1	Run 1: 3.4m - 5.1 m	Proposed Residential Development 1568 Meadowbrook Road, Ottawa, ON	OTT-21019403-A0
date cored Oct 27, 2021		ROCK CORE PHOTOGRAPHS	FIG. 9

Appendix A:
Laboratory Certificate of Analysis

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC
2650 QUEENSVIEW DRIVE, UNIT 100
OTTAWA, ON K2B8H6
(613) 688-1899
ATTENTION TO: matthew Zammit
PROJECT: OTT-21019403-AO
AGAT WORK ORDER: 21Z823524
SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Lab Manager
DATE REPORTED: Nov 04, 2021
PAGES (INCLUDING COVER): 6
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

Notes

Disclaimer:

- *All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.*
- *All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.*
- *AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.*
- *This Certificate shall not be reproduced except in full, without the written approval of the laboratory.*
- *The test results reported herewith relate only to the samples as received by the laboratory.*
- *Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.*
- *All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.*

AGAT Laboratories

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MISSISSAUGA, ONTARIO
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http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 21Z823524

PROJECT: OTT-21019403-AO

CLIENT NAME: EXP SERVICES INC

ATTENTION TO: matthew Zammit

SAMPLING SITE:1568 Meadowbrook Dr., Ottawa

SAMPLED BY:

Chloride and Sulphate in %

DATE RECEIVED: 2021-10-29 **DATE REPORTED: 2021-11-04**

			SAMPLE DESCRIPTION:	BH2 SS4 7. 5'-9.5'
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2021-10-27
Parameter	Unit	G / S	RDL	3148780
Chloride (2:1)	%		0.0002	0.0003
Sulphate (2:1)	%		0.0002	0.0151

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3148780 Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 21Z823524

PROJECT: OTT-21019403-AO

CLIENT NAME: EXP SERVICES INC

ATTENTION TO: matthew Zammit

SAMPLING SITE:1568 Meadowbrook Dr., Ottawa

SAMPLED BY:

Inorganic Chemistry (Soil)

DATE RECEIVED: 2021-10-29 **DATE REPORTED: 2021-11-04**

			SAMPLE DESCRIPTION:	BH2 SS4 7. 5'-9.5'
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2021-10-27
Parameter	Unit	G / S	RDL	3148780
Chloride (2:1)	µg/g		2	3
Sulphate (2:1)	µg/g		2	151
pH (2:1)	pH Units		NA	8.46
Electrical Conductivity (2:1)	mS/cm		0.005	0.275
Resistivity (2:1) (Calculated)	ohm.cm		1	3640

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3148780 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 21Z823524

PROJECT: OTT-21019403-AO

ATTENTION TO: matthew Zammit

SAMPLING SITE:1568 Meadowbrook Dr., Ottawa

SAMPLED BY:

Soil Analysis

RPT Date: Nov 04, 2021			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Inorganic Chemistry (Soil)															
Chloride (2:1)	3152963		10	11	9.5%	< 2	95%	70%	130%	102%	80%	120%	101%	70%	130%
Sulphate (2:1)	3152963		13	13	0.0%	< 2	97%	70%	130%	101%	80%	120%	100%	70%	130%
pH (2:1)	3152963	3152963	8.56	8.58	0.2%	NA	98%	80%	120%						
Electrical Conductivity (2:1)	3148780	3148780	0.275	0.285	3.6%	< 0.005	99%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.
Duplicate NA: results are under 5X the RDL and will not be calculated.

Chloride and Sulphate in %															
Chloride (2:1)	3152963		0.0010	0.0011	9.5%	< 0.0002	95%	70%	130%	102%	80%	120%	101%	70%	130%
Sulphate (2:1)	3152963		0.0013	0.0013	0.0%	< 0.0002	97%	70%	130%	101%	80%	120%	100%	70%	130%

Comments: NA signifies Not Applicable.
Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By:

Amanjot Bhela

CHARTERED CHEMIST AMANJOT BHELA — ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
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Method Summary

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 21Z823524

PROJECT: OTT-21019403-AO

ATTENTION TO: matthew Zammit

SAMPLING SITE:1568 Meadowbrook Dr., Ottawa

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	modified from MSA PART 3, CH 14 and SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

1 HTYC

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Laboratory Use Only

Work Order #: 21Z823524

Cooler Quantity: bag - no ice
Arrival Temperatures: 19.5 | 19.5 | 19.6
7.0 | 6.2 | 6.6

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes: ice in cooler

Report Information:

Company: EXP
Contact: Matthew Zammit
Address: 2650 Queensview drive Suite 100
Ottawa ON K2B 8H6
Phone: 613-688-1899 Fax:
Reports to be sent to:
1. Email: Matthew.Zammit@exp.com
2. Email:

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table ___ (Indicate One)
☐Ind/Com
☐Res/Park
☐Agriculture
Soil Texture (Check One)
☐Coarse
☐Fine

☐ Excess Soils R406
Table ___ (Indicate One)
☐ Regulation 558
☐ CCME

☐ Sewer Use
☐Sanitary ☐Storm
Region ___
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
___ (Indicate One)

Turnaround Time (TAT) Required:

Regular TAT ☒ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
*TAT is exclusive of weekends and statutory holidays

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: OTT-21019403-AO
Site Location: 1568 Meadowbrook Drive, Ottawa
Sampled By: EXP
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC (Y / N)	O. Reg 153: Metals & Inorganics	O. Reg 153: Metals - ☐CrVI, ☐Hg, ☐HWSB	O. Reg 153: BTEX, F1-F4 PHCs	O. Reg 153: Analyze F4G if required ☐Yes ☐No	PAHs	PCBs	VOC	O. Reg 558: Landfill Disposal Characterization TCLP: TCLP: ☐M&I ☐VOCs ☐ABNs ☐B(a)P ☐PCBs	O. Reg 406: Excess Soils SPLP Rainwater Leach SPLP: ☐Metals ☐VOCs ☐SVOCs	O. Reg 406: Excess Soils Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Salt - EC/SAR	pH	Sulphates	Chlorides	Electro Resistivity			Potentially Hazardous or High Concentration (Y/N)
BH 2 SS4 7.5'-9.5'	Oct 27/21	AM PM	1															✓	✓	✓	✓			
		AM PM																						
		AM PM																						
		AM PM																						
		AM PM																						
		AM PM																						
		AM PM																						
		AM PM																						
		AM PM																						
		AM PM																						
		AM PM																						

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Ryan DiGiuseppe	Oct 28/21	5:00pm	Uber Thelet	21/10/29	9h59
Uber Thelet	21/10/29	16h00	Dane Eastman	10/30/21	10:40 am

Page ___ of ___

Nº: 111866

Appendix B:
Legal Notification

Legal Notification

This report was prepared by EXP Services Inc. (EXP) for the account of Nemorin Group Limited.

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

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