Geotechnical Investigation

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Executive Summary

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed light industrial building with warehouse and office space to be located at 100 Bill Leathem Drive, Ottawa, Ontario. Terms and conditions of this assignment were outlined in EXP Services Inc. (EXP) proposal OTT-24002636-A0 dated February 27, 2024, with authorization to proceed with this work provided by Structura Construction by email on the same day.

This report supersedes the final report submitted on May 29, 2024.

It is understood that the site is to be developed with a light industrial slab-on-grade building with no basement. The building will serve as warehouse and office space with an approximate footprint of 1,130 m^2. The Finished Floor Elevation was provided by Novatech Engineers, Planners & Landscape Architects (Novatech) as Elevation 90.05 m. Design details such as the underside of footing (USF) elevations and underground service inverts elevations were not available at the time of this report.

The Ottawa Official Plan Schedule K – Environmental constraints, indicates that the slope to the south of the site is considered unstable and the City of Ottawa (the City) has requested a slope stability analysis of the south slope. The slope stability analysis was requested after the borehole investigation program was complete and as such no boreholes were drilled near the existing slope. The analysis has been carried out on the assumption that similar subsurface conditions are present at the borehole locations and at the existing slope.

A topographical survey was carried out by Annis, O'Sullivan, Vollebekk Ltd. (AOV) on January 25, 2024, and was provided to EXP as reference material for this report.

The fieldwork for this investigation was undertaken during the period between March 21 and 22, 2024 and consists of the drilling of six (6) boreholes (Borehole Nos. 1, 1A and 2 to 5) advanced to termination and Dynamic Cone Penetration Test refusal depths ranging from 5.2 m to 22.8 m (Elevation 84.8 m to Elevation 67.3 m). Borehole No. 1A was drilled to supplement the information for Borehole No. 1 and the two boreholes have been combined into one borehole log, presented as Borehole NO. 1. The fieldwork was supervised on a full-time basis by a representative from EXP. Nineteen (19) mm piezometers with screened sections, were installed in selected the boreholes. The fieldwork was supervised on a full-time basis by a representative from EXP.

The borehole information indicates that the subsurface conditions within the site consist of surficial topsoil and fill underlain by silty clay. A weathered stiff to very stiff silty clay crust was present underlying the topsoil or fill to 4.6 m to 4.7 m depth and in turn was underlain by a firm to stiff unweathered silty clay. Where fully penetrated the silty clay extended to 11.0 m depth and was in turn underlain by silt and then glacial till. DCPT refusal was encountered at 22.8 m depth below the existing ground surface which may indicate cobbles or boulders within the glacial till or the bedrock surface.

Provided that the footings are placed on the weathered silty clay crust then Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC) as amended May 2,2019, indicates that the site classification for seismic response is estimated to be **Class D**.

Based on the assumption that the FFE will be approximately 0.35 m above the surrounding grade, a cut of up to 0.5 m and a grade raise of up to 0.4 m are estimated based on the borehole elevations. For design purposes, the maximum grade raise at the site should be limited to 0.4 m due to the presence of the compressible silly clay. This office should be contacted if any additional grade raise is proposed at the site.

The design finished floor elevation (FFE) of the proposed building is Elevation 90.05 m. Based on a review of the borehole information, it is considered feasible to support the proposed building by spread and strip footings. The design building loading (foundations and floor slab) is not known. The building loading should be undertaken such that the unweathered firm to stiff silty clay underlying the desiccated brown silty clay crust is not overstressed to reduce settlements. It is therefore recommended that footings should be placed at Elevation 89.2 m. A review of the borehole logs for Borehole Nos. 1 to 3, drilled within the proposed building footprint, indicate that at Elevation 89.2 m, native stiff to very stiff silty clay is present.

Square spread footings having a maximum width and length of 3.0 m and strip footings having a maximum width of 1.5 m, founded at Elevation 89.2 m on approved native desiccated brown silty clay may be designed for a bearing capacity at serviceability limit state (SLS) of 125 kPa and factored geotechnical resistance at ultimate limit state (ULS) of 300 kPa. The factored geotechnical resistance value at ULS includes a resistance factor of 0.5. The floor slab loading has been assumed to be 12.5 kPa. The total and differential settlements of well designed and constructed footings placed in accordance with the above recommendations are expected to be less than 25 mm and 19 mm respectively. The SLS and factored ULS values are valid provided the site grade raise in Section 7 is respected. The actual floor building loading should be provided when available and this report updated as required.

The proposed buildings will require a perimeter drainage system. Underfloor drainage is not required.

A visual inspection of the existing slopes was carried out as per the Ontario Ministry of Natural Resources (MRN) Slope Inspection Record form and the form indicated that slope stability analysis is required. The AOV survey provided the topography along two sections of the slope and this information was used to establish the geometry for Sections A-A’ and B-B’ as shown in Figure 2.

The stability of the existing slopes at the site under consideration were analyzed with GeoStudio/Geo-slope office, Version 24.1.0.1406 using the Morgenstern-Price Method. A total of two cross-sections were analyzed, Sections A-A’ and Section B-B’, first under the existing conditions and then the analysis repeated applied a distributed loading of 12.5 kPa to represent the applied building loading.

Current practice in the industry and the City of Ottawa requires a Factor of Safety (FOS) of 1.5 for static loading conditions, both effective stress and total stress analyses, and a Factor of Safety (FOS) of 1.1 for seismic loading conditions (Mitchell 1983). A review of the slope stability analysis indicates that the sections meet the requirements listed above. The analysis was carried out based on the proposed building location, set back approximately 19 m from the existing slope, and the analyzed slope stability sections met the acceptable factor of safety for static and seismic loadings. If the location of the building is to be moved closer to the existing slopes, this office should be contacted, and further analysis would be required. It is understood that section 4.9.3 of the City of Ottawa Official Plan requires a minimum setback of 15 m from the edge of a stable slope and this setback distance should be considered the minimum deign setback for the development

Excavations for the construction of the proposed building foundations and installation of the underground services are anticipated to extend to depths of approximately 3.0 m below the final grade, within the desiccated brown silty clay, and are expected to extend below the groundwater level. The excavations may be undertaken by conventional heavy equipment and all excavations must be undertaken in accordance with the current Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91.

Seepage of the surface and subsurface water into excavations is anticipated and it should be possible to collect water entering the excavations at low points and to remove it by conventional pumping techniques. In areas of high infiltration and below the groundwater level, a higher seepage rate should be anticipated and may require high-capacity pumps to keep the excavation dry.

The results of the resistivity tests indicate that silty clay is moderately corrosive to bare steel as per the National Association of Corrosion Engineers (NACE). Appropriate measures should be taken to protect the buried bare steel from corrosion.

Based on the results of the Atterberg limits of the clayey soils and comparison of the results with the City of Ottawa 2005 Clay Soils Policy and 2017 Tree Planting in Sensitive Marine Clay Soils Guidelines (2017 Tree Planting Guidelines), the clayey soils at this site are considered to have a low/medium potential for soil volume change. Therefore, the tree planting should be carried out in accordance with the 2017 City of Ottawa Tree Planting Guidelines.

The above and other related considerations are discussed in greater detail in the main body of this report.

1. Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed light industrial building with warehouse and office space to be located at 100 Bill Leathem Drive, Ottawa, Ontario. Terms and conditions of this assignment were outlined in EXP Services Inc. (EXP) proposal OTT-24002636-A0 dated February 27, 2024, with authorization to proceed with this work provided by Structura Construction by email on the same day.

This report supersedes the report submitted on May 29, 2024.

It is understood that the site is to be developed with a light industrial slab-on-grade building with no basement. The building will serve as warehouse and office space with an approximate footprint of 1,130 m^2. The Finished Floor Elevation was provided by Novatech Engineers, Planners & Landscape Architects (Novatech) as Elevation 90.05 m. Design details such as the underside of footing (USF) elevations and underground service inverts elevations were not available at the time of this report.

The Ottawa Official Plan Schedule K – Environmental constraints, indicates that the slope to the south of the site is considered unstable and the City of Ottawa (the City) has requested a slope stability analysis of the south slope. The slope stability analysis was requested after the borehole investigation program was complete and as such no boreholes were drilled near the existing slope. The analysis has been carried out on the assumption that similar subsurface conditions are present at the borehole locations and at the existing slope.

A topographical survey was carried out by Annis, O'Sullivan, Vollebekk Ltd. (AOV) on January 25, 2024, and was provided to EXP as reference material for this report.

The geotechnical investigation was undertaken to:

a) Establish the subsurface soil and groundwater conditions at five (5) borehole locations;

b) Classify the site for seismic site response in accordance with the requirements of the 2012 Ontario Building Code (as amended January 1, 2022) and assess the potential for liquefaction of the subsurface soils during a seismic event;

c) Comment on grade-raise restrictions;

d) Make recommendations regarding the most suitable type of foundations, founding depth and bearing pressure at serviceability limit state (SLS) and factored geotechnical resistance at ultimate limit state (ULS) of the founding strata and comment on the anticipated total and differential settlements of the recommended foundation type;

e) Discuss slab on grade construction;

f) Provide pipe bedding requirements for underground services

g) Comment on excavation conditions and de-watering requirements during construction;

h) Discuss backfilling requirements and assessment of the suitability of on-site soils for backfilling purposes;

i) Recommend pavement structure thicknesses for access road and parking lots,

j) Undertake slope stability analysis; and

k) Comment on subsurface concrete and steel requirements.

The comments and recommendations given in this report are based on the assumption that the above-described design concepts 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 located south of Bill Leathem Drive with the municipal address of 100 Bill Leathem Drive, Ottawa, as shown on Figure 1. The site is roughly rectangular in shape with an area of 4,524 m^2 (0.45 ha). The site is bound to the west by undeveloped land and to the east by a church/community centre. To the south of the site is the Clarke Bellinger Environmental (Stormwater) Facility which includes two stormwater management ponds separated by Lekin Drive. The pond to the south of the site has a surface area of approximately 22,435 m^2 (2.24 ha). Based on historic ariel photographs the retention pond appears to be man-made.

The ground surface slopes to the south with borehole locations ranging from Elevation 90.3 m to Elevation 89.6 m.

3. Geology of the Site

3.1 Surficial Geology

The surficial geology was reviewed via the Google Earth applications published by the Ontario Ministry of Energy, Northern Development and Mines available via www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth/surficial-geology and was last modified on May 23, 2017. The map indicates that beneath any fill the site is underlain by fine-textured glaciomarine deposits consisting of silt and clay and minor sand and gravel. The surficial deposits are shown in Image 1 below.

🟦 Fine-textured glaciomarine deposits:
silt and silty clay, minor sand and gravel

Image 1 – Surficial Geology

3.2 Bedrock Geology

The bedrock geology was reviewed via the Google Earth applications published by the Ontario Ministry of Energy, Northern Development and Mines available via http://www.geologyontario.mndm.gov.on.ca/mines/data/google/MRD219/geology/doc.kml and publish in 2007. The map indicates sandstone, dolomitic sandstone and dolostone of the March formation.

🟦 March Formation: Sandstone, dolomitic
sandstone, dolostone

Image 2 – Bedrock Geology

4. Procedure

The fieldwork for this investigation was undertaken during the period between March 21 and 22, 2024 and consisted of the drilling of six (6) boreholes (Borehole Nos. 1, 1A and 2 to 5) advanced to termination and Dynamic Cone Penetration Test (DCPT) advanced to refusal depths ranging from 5.2 m to 22.8 m (Elevation 84.8 m to Elevation 67.3 m). The fieldwork was supervised on a full-time basis by a representative from EXP.

The borehole locations and geodetic elevations were established by a surveyor from EXP and are shown on the Borehole Location Plan, Figure 2.

The borehole locations were cleared of any private and public underground services, prior to the start of drilling operations by USL-1 cable Locators acting as subcontractor to EXP.

The boreholes were drilled using a CME-75 track mounted drill rig equipped with continuous flight hollow stem augers and the capability to sample soil. Standard penetration tests (SPTs) were performed in the boreholes at 0.75 m to 3.0 m depth intervals with soil samples retrieved by the split-barrel sampler. Auger samples were also taken from below the existing ground surface. Two (2) relatively undisturbed thin walled (Shelby) tube samples were retrieved from two (2) of the boreholes. The undrained shear strengths of the cohesive soils were measured by conducting penetrometer and in-situ vane tests. Dynamic Cone Penetration Tests (DCPT) were conducted in two (2) boreholes.

Borehole No. 1 was initially drilled and sampled to a depth of 12.8 m with the borehole continued with a DCPT, extending the borehole to the depth of DCPT refusal, 22.8 m below the existing grade. In order to confirm the transition between the subsurface layers and to account for sample disturbance below the groundwater table, Borehole No. 1A was drilled approximately 3 m from the location of Borehole No. 1. Borehole No. 1A was drilled without sampling to a depth of 9.1 m below the existing ground surface using N size casing and was advanced under a column of water. Additional SPT testing was taken from 9.1 m to 19.8 m depth. An additional DCPT test was also carried out just adjacent to Borehole No. 1A, advanced from 1.5 m to the depth of DCPT refusal, 17.5 m depth. The subsurface information from the two boreholes has been combined into one borehole log and are present as Borehole No. 1.

Piezometers (19 mm diameter) with slotted section were installed in selected boreholes for long-term monitoring of the groundwater levels. The piezometers were installed in accordance with EXP standard practice, and the installation configuration is documented on the respective borehole log. The boreholes were backfilled upon completion of drilling and the installation of the piezometers.

Upon completion of the borehole fieldwork, the soil samples were transported to the EXP Ottawa laboratory. The soil samples were visually examined in the laboratory by a geotechnical engineer. The soil samples were classified in accordance with the Unified Soil Classification System (USCS) and the modified Burmister System (as per the 2006 Fourth Edition Canadian Foundation Engineering Manual (CFEM)).

A summary of the soil sample laboratory testing program is shown in Table I.

Table I: Summary of Laboratory Testing Program

Type of Test	Number of Tests Completed
Moisture Content Determination	46
Grain Size Analysis	6
Atterberg Limit Determination	5
Corrosion Analysis (pH, sulphate, chloride and resistivity)	1

5. Subsurface Conditions and Groundwater Levels

A detailed description of the subsurface conditions and groundwater levels from this geotechnical investigation are given on the attached Borehole Logs, Figure Nos. 3 to 7 inclusive. 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 also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted.

Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling operations. These boundaries 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 “Note on Sample Descriptions” preceding the borehole logs form 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 levels.

5.1 Topsoil

A 100 mm thick surficial topsoil layer was encountered in Borehole Nos. 3 and 5.

5.2 Fill

The surficial soil in Borehole Nos. 1, 2 and 4 is fill which ranges from sand and gravel to silty clay and extends from 0.7 m to 1.1 m depths (Elevation 89.4 m to Elevation 89.2 m). The standard penetration test (SPT) N-values of the fill range from 4 to 9 indicating the fill is in a loose state. The moisture content of the fill is 2 percent to 59 percent.

The results from the grain-size analysis conducted on one (1) selected sample of the fill is summarized in Table II. The grain-size distribution curve is shown in Figure 8.

Table II: Summary of Results from Grain-Size Analysis -Fill Samples

Borehole No. (BH) – Grad Sample No. (GS)	Depth (m)	Grain-Size Analysis (%)			
		Gravel	Sand	Fines (Silt and Clay)	Soil Classification (USCS)
BH2 GS1	0 – 0.2	41	49	10	Poorly Graded Sand with Silt and Gravel (SP-SM)

Based on a review of the results from the grain size analysis, the fill may be classified as Poorly Graded Sand with Silt and Gravel (SP-SM) accordance with the Unified Soil Classification System (USCS).

5.3 Silty Clay

The topsoil and the fill are underlain by native undisturbed silty clay in all of the boreholes. The silty clay extends to the depth of sampling, 5.2 m to 7.2 m below the existing grade (Elevation 84.8 m to Elevation 83.1 m) in Borehole Nos. 2 to 5. In Borehole No. 1 the silty clay was fully penetrated and extended to 11.0 m depth (Elevation 79.1 m).

The silty clay consists of an upper weathered desiccated brown silty clay crust underlain by a weaker unweathered grey silty clay. The upper crust extends from 4.6 m to 4.7 m depth (Elevation 85.6 m to Elevation 85.0 m). The undrained shear strength of the upper crust ranges from 96 kPa to 160 kPa indicating a stiff to very stiff consistency The natural moisture content of the weathered crust ranges from 31 percent to 69 percent.

The lower unweathered grey silty clay’s undrained shear strength ranged from 29 kPa to 67 kPa indicating a firm to stiff consistency. The natural moisture contents of the unweathered grey silty clay ranges from 48 percent to 63 percent.

The results from the grain-size analysis and Atterberg limit determination conducted on three (3) selected samples of the silty clay are summarized in Table III. The grain-size distribution curves are shown in Figures 9 to 11.

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

Borehole No. (BH) – Sample No. (SS)	Depth (m)	Grain-Size Analysis (%)				Atterberg Limits (%)			
		Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification (USCS)
BH1-SS3	1.5-2.1	0	12	53	35	39	16	23	Silty Clay of Low Plasticity (CL), some sand
BH1-SS5	4.6-5.2	0	1	49	50	43	20	23	Silty Clay of Low Plasticity (CL), trace sand
BH1-SS7	9.1-9.8	0	1	54	45	45	21	23	Silty Clay of Low Plasticity (CL), trace sand

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

5.4 Silt

A non-plastic silt was encountered beneath the silty clay in Borehole No. 1 and extends to 14.2 m depth (Elevation 75.9 m). The standard penetration test (SPT) N-values of the silt ranged from 5 to 8 indicating the silt was in a loose state. The moisture content of the silt ranged from 31 percent to 38 percent.

The results of the grain-size analysis and Atterberg limit determination conducted on one (1) sample of the silt are summarized in Table IV. The grain-size distribution curve is shown in Figure 12.

Table IV: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination
Silt Sample

Borehole (BH) No. – Sample (SS) No.	Depth (m)	Grain-Size Analysis (%) and Atterberg Limits					
		Gravel	Sand	Silt	Clay	Plasticity Index	Soil Classification (USCS)
BH1-SS9	12.2-12.8	0	1	88	11	Non-plastic	Silt (ML), some clay, trace sand

Based on a review of the results of the grain-size analysis and Atterberg limits, the tested soil samples may be classified as silt (ML) in accordance with the USCS.

5.5 Glacial Till

A deposit of glacial till was contacted below the silt at 14.2 m depth (Elevation 75.9 m) in Borehole No. 1. The glacial till contains varying amounts of gravel, sand, silt and clay within the soil matrix as well as cobbles and boulders. The standard penetration test (SPT) N-values of the glacial till ranged from 20 to 39 indicating the glacial till was in a compact to dense state. The moisture content of the glacial till is 2 percent to 14 percent.

Borehole No. 1A encountered DCPT refusal at 17.5 m depth (Elevation 72.6 m). As sampling in Borehole No. 1A extended deeper than the DCPT refusal depth, the DCPT refusal indicates the presence of cobbles or boulders within the glacial till layer.

The results from the grain-size analysis conducted on one (1) sample of the glacial till is summarized in Table V. The grain-size distribution curve is shown in Figure 13.

Table V: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination
Glacial Till Sample

Borehole (BH) No. – Sample (SS) No.	Depth (m)	Grain-Size Analysis (%) and Atterberg Limits					
		Gravel	Sand	Silt	Clay	Plasticity Index	Soil Classification (USCS)
BH1-SS11	15.2 - 15.8	14	44	31	11	Non-plastic	Silty Sand with Gravel (SM), trace clay

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

5.6 Inferred Boulders or Bedrock

Auger refusal was not encountered in any of the boreholes within the depth of sampling which ranged from 5.2 m to 19.8 m (Elevation 84.8 m to Elevation 70.3 m).

DCPT was conducted in Borehole Nos. 1 to refusal at 22.8 m depth (Elevation 67.3 m). The DCPT refusal may indicate the presence of cobbles or boulders within the glacial till or the bedrock surface.

5.7 Groundwater Level Measurements

A summary of the groundwater level measurements taken in the monitoring wells are shown in Table VI.

Table VI: Summary of Groundwater level Measurements

Borehole (BH)	Ground Surface Elevation (m)	Screened Material	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m
BH-2	90.30	Silty Clay	April 4, 2024 (19)	1.0 (89.3)
BH-3	89.60	Silty Clay	April 4, 2024 (19)	0.3 (89.3)
BH-4	90.00	Silty Clay	April 4, 2024 (19)	0.7 (89.3)

The groundwater level was found to be 0.3 m to 1.0 m (Elevation 89.3 m) below the existing ground surface at the piezometer locations.

It is suspected that the recorded groundwater readings are likely a perched water level. Based on the moisture content results of the retrieved samples, the stabilized groundwater table at the site is expected to be near the interface between the brown weathered silty clay and the unweathered grey clay, approximately 4.6 m depth (Elevation 85.6 m).

Water levels were determined in the boreholes and monitoring wells at the times and under the conditions noted above. 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. Site Classification for Seismic Site Response and Liquefaction Potential of Soils

6.1 Site Classification for Seismic Site Response

The borehole information indicates that the subsurface conditions within the site consist of surficial topsoil and fill underlain by silty clay. Weathered stiff to very stiff silty clay crust was present to 4.6 m to 4.7 m depth and underlain by a firm to stiff unweathered silty clay. Where fully penetrated the silty clay extended to 11.0 m depth and was in turn was underlain by silt and then glacial till. DCPT refusal was encountered at 22.8 m depth below the existing ground surface which may indicate cobbles or boulders within the glacial till or the bedrock surface.

Provided that the footings are placed on the weathered silty clay crust, Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC) as amended May 2,2019, indicates that the site classification for seismic response is **Class D**.

6.2 Liquefaction Potential of Soils

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

7. Grade Raise Restrictions

The design FFE elevation of the proposed building is Elevation 90.05. Based on the assumption that the FFE will be approximately up to 0.35 m above the surrounding grade based on the borehole elevations it is estimated that this will result in a cut of up to 0.5 m and a grade raise of up to 0.4 m.

For design purposes, the maximum grade raise at the site should be limited to 0.4 m due to the presence of compressible silly clay. This office should be contacted if an additional grade raise is proposed at the site.

8. Foundation Considerations

8.1 Building Supported on Foundations

The design Finished Floor Elevation (FFE) of the proposed building is Elevation 90.05 m. Based on a review of the borehole information, it is considered feasible to support the proposed building by spread and strip footings. The design building loading (foundations and floor slab) is not known. The building loading should be undertaken such that the unweathered firm to stiff silty clay underlying the desiccated brown silty clay crust is not overstressed to reduce settlements. It is recommended that footings should be placed at Elevation 89.2 m. A review of the borehole logs for Borehole Nos. 1 to 3, drilled within the proposed building footprint, indicate that at Elevation 89.2 m, native stiff to very stiff silty clay is present.

Square spread footings having a maximum width and length of 3.0 m and strip footings having a maximum width of 1.5 m, founded at Elevation 89.2 m on approved native desiccated brown silty clay may be designed for a bearing capacity at serviceability limit state (SLS) of 125 kPa and factored geotechnical resistance at ultimate limit state (ULS) of 300 kPa. The factored geotechnical resistance value at ULS includes a resistance factor of 0.5. The floor slab loading has been assumed to be 12.5 kPa. The total and differential settlements of well designed and constructed footings placed in accordance with the above recommendations are expected to be less than 25 mm and 19 mm respectively. The SLS and factored ULS values are valid provided the site grade raise in Section 7 is respected. The actual floor slab loading should be provided when available and this report updated as required.

The native silty clay is susceptible to disturbance and should be protected from the effects of weather. A 50 mm concrete mud slab may be required after the silty clay subgrade has been inspected and approved.

A minimum of 1.5 m of earth cover should be provided to the footings 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. If snow will be removed from the vicinity of the unheated structures, the frost cover should be increased to 2.4 m. Rigid insulation thermally equivalent to the required soil cover may be used instead of the soil cover. Where earth cover is less than the minimum required, an equivalent combination of earth fill and rigid polystyrene insulation (e.g. styrofoam HI-60 or equivalent) should be provided (Table VII). The Styrofoam should be placed along the exterior foundation wall from the finished exterior grade to top of footing, on top and sides of the footing and should extend laterally for a sufficient distance from the edge of the footings. The insulation details should be reviewed by EXP.

Table VII: Insulated Foundation Design Summary of Heated Structures

Thermal Condition	Soil Cover Provided D, mm	Insulation Dimensions (mm)	
		T (Thickness)	L (Extension)
Heated Structure (Appendix B)	Less than 600	Not Recommended	
	600 to 900	40	900
	900 to 1200	25	600
	1200 to 1500	25	300

The recommended factored geotechnical resistance at ULS has 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.

8.2 Ground Improvement

If the allowable design SLS bearing capacity is insufficient for the design building loading, consideration can be given to ground improvement. One method which can be considered is the preloading of the site with a load equal to the proposed building loading and the installation of prefabricated vertical (wick) drains. This will result in the consolidation settlement of the proposed building loading to take place prior to the construction of the building with the vertical drains significantly accelerating the consolidation process by alleviating the pore water pressure caused by the pre-loading. The surcharge would be continued until the bearing capacity of the silty clay meets the design bearing capacity requirements so that the total and differential settlements of well designed and constructed footings would be less than 25 mm and 19 mm, respectively.

Further discussion can be provided if this option is being considered once the proposed building loading is known.

9. Floor Slab and Drainage Requirements

The floor slab for the proposed buildings may be designed and constructed as a slab-on-grade placed on a 200 mm thick, 19 mm sized clear stone bed placed on a minimum 300 mm thick engineered fill pad set on the approved native subgrade. The clear stone will minimize the capillary rise of moisture from the sub-soil to the floor slab. Alternatively, the clear stone layer may be replaced with a 200 mm thick bed of OPSS Granular A overlain by a vapour barrier. Adequate saw cuts should be provided in the floor slabs to control cracking.

Based on the recorded water levels a perimeter drainage system must be provided for the proposed building. Underfloor drainage is not required.

Perimeter drains may consist of 100 mm diameter perforated pipe set on the footings and surrounded with 150 mm thick 19 mm sized clear stone that is fully wrapped or covered with an approved porous geotextile membrane, such as Terrafix 270R or equivalent. The perimeter drains should be connected to separate sumps equipped with backup pumps and generators in case of mechanical failure and/or power outage, so that at least one system would be operational should the other fail.

The floor slab should be set at a minimum of 150 mm higher than the final exterior grade surrounding the buildings.

The final exterior grade surrounding the proposed buildings should be sloped away from the proposed buildings to prevent ponding of surface water close to the exterior walls of the proposed buildings.

10. Slope Stability Analysis

10.1 Visual Assessment

A visual inspection of the existing slopes was carried out as per the Ontario Ministry of Natural Resources (MRN) Slope Inspection Record form.

The existing slope was noted to be grass covered with some trees. No erosion features (scour, undercutting etc.) or evidence of slope instability (tension cracks, bulges, leaning trees etc.) were noted.

The MRN inspection form was used to assign a score to the slope from 0 to 57 in order to determine the potential for slope instability. The recorded observations, along with the subsurface information, resulted in a score of 36 which indicates a moderate potential for slope instability which requires borehole information, a survey of the slope and a detailed report. A slope stability analysis was carried out as per the MNR requirements using the AOV topographical survey dated January 25, 2024.

10.2 Slope Stability Analysis

The AOV survey provided the topography along two sections of the slope and this information was used to establish the geometry for Sections A-A’ and B-B’ as shown in Figure 2.

10.2.1 Assumption of the analysis

The following assumptions were made:

(1) The subsurface conditions at the slope are similar to the subsurface conditions encountered in the boreholes.

(2) The depth of the retention pond was assumed to be 3 m below the water level of the pond at the time of the AOV survey.

(3) The slope inclination of the pond was assumed to be similar to the slope above the water level.

(4) The groundwater level was assumed to be at the interface between the desiccated clay and the underlying unweathered grey clay.

Table VIII presents the natural slope inclinations at the cross section analyzed based on the AOV topographical survey.

Table VIII: Material Properties for Slope Stability Analysis

Section	Crest of Slope Elevation (m)	Toe of Slope Elevation (m)	Height of Slope (m)	Overall Slope Inclination
A-A’	89.4	83.6	5.8	4.5H:1V
B-B’	89.5	83.6	5.9	3.9H:1V

The unit weight and the effective shear strength parameters were selected based on literature research and EXP’s experience in the area. Table IX presents the engineering properties of the various soils used in global slope stability analyses.

Table IX: Material Properties for Slope Stability Analysis

Soil Type	Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Angle of Internal Friction (Degrees)	Cohesion (kPa)
Fill	20	0	25	--
Desiccated Silty Clay	18	10	32	150
Desiccated Silty Clay – Lower Cohesion	18	--	--	110
Desiccated Silty Clay – Lowest Cohesion	18	--	--	75
Unweathered Silty Clay – Layer 1	16	0.5	28	50
Unweathered Silty Clay – Layer 2	16.5	0.5	28	30
Unweathered Silty Clay – Layer 3	16.5	0.5	28	65
Unweathered Silty Clay – Layer 4	16.5	0.5	28	45
Silt	18	0	28	--
Glacial Till	22	High Strength		

The designation of high strength for the glacial till allows the computer model to only consider slope stability failures which appear within the silty clay or the underlying silt which will reflect real world conditions.

10.2.2 Modelling of the Existing Slopes

The stability of the existing slopes at the site under consideration were analyzed with GeoStudio/Geo-slope office, Version 24.1.0.1406 using the Morgenstern-Price Method. A total of two cross-sections were analyzed, Sections A-A’ and Section B-B’, first under the existing conditions and then the analysis was repeated applying a distributed loading of 12.5 kPa to represent the building loading.

For each section, the analysis of static conditions was carried out for both effective stress and total stress parameters for the soil layers. The analyses of stability of the slopes due to a seismic event were undertaken using pseudo-static analyses using total stress parameters. The design ground acceleration for the subject site was determined by site classification and peak ground acceleration. Based on the soil conditions, the site classification of Class D was used for this site. Design ground acceleration for the project site was determined from the Earthquake Hazards Program Website by interpolating 2020 National Building Code of Canada Seismic hazard values, see Appendix A. The earthquake design ground motion was determined with an earthquake having 2 percent probability of exceedance in a 50-year period (0.000404 per annum probability or 2,475 return year). The map indicates a peak ground acceleration (PGA) of approximately 0.368 g[1] at the subject site.

For sustained earthquake loading, horizontal seismic coefficient of 0.245 g (~2/3 PGA) was applied for the analyses. It was assumed that horizontal and vertical acceleration will not occur simultaneously. Therefore, the applied vertical seismic coefficient is equal to 0.

---

[1] g = the acceleration of gravity, ~9.81 m/sec^2

10.3 Results and Discussion

The following are the results of the slope stability investigation for existing conditions, summarized in Table X.

Table X: Results of Slope Stability Analysis – Existing Conditions

Section	Loading Condition	Factor of Safety	Figure No.
Section A-A'	Static Analysis (Effective Stress)	1.7	A-1
	Static Analysis (Total Stress)	3.0	A-2
	Pseudo-static (Seismic) Analyses (Total Stress)	1.1	A-3
Section B-B'	Static Analysis (Effective Stress)	1.6	A-4
	Static Analysis (Total Stress)	2.6	A-5
	Pseudo-static (Seismic) Analyses (Total Stress)	1.1	A-6

Current practice in the industry and the City of Ottawa require a Factor of Safety (FOS) of 1.5 for static loading conditions (i.e., for effective stress and total stress analyses). The minimum acceptable factor of safety for seismic loading conditions is 1.1 (Mitchell 1983). A review of Table X indicates that the slope stability sections meet the acceptable factor of safety for static and seismic loading.

The analysis was repeated for the building loading, removing the existing fill within the building footprint and using a distributed load of 12.5 kPa to represent the floor slab loading.

The following were the results of the slope stability investigation, summarized in Table XI.

Table XI: Results of Slope Stability Analysis With Building Loading

Section	Loading Condition	Factor of Safety	Figure No.
Section A-A'	Static Analysis (Effective Stress)	1.7	A-7
	Static Analysis (Total Stress)	3.0	A-8
	Pseudo-static (Seismic) Analyses (Total Stress)	1.1	A-9
Section B-B'	Static Analysis (Effective Stress)	1.5	A-10
	Static Analysis (Total Stress)	2.6	A-11
	Pseudo-static (Seismic) Analyses (Total Stress)	1.1	A-12

A review of Table XI indicates that the slope stability sections meet the acceptable factor of safety for static and seismic loading.

10.4 Recommendations

The above analysis was carried out using a presumed building floor loading and using a presumed geometry of the retention pond. The analysis should be confirmed using the actual building loading, when available, and should as-built records exist for the retention pond then the geometry below the groundwater surface should be confirmed. Further recommendations may be provided based on the additional information.

It is important that the stability of the existing slope is not adversely impacted during construction. For this purpose, the following precautions should be taken:

1) Fill should not be stockpiled close to the crest of the slope, and
2) The existing slope should not be disturbed in any way.

10.5 Set Back Requirements

The above analysis was carried out based on the proposed building location, set back approximately 19 m from the existing slope, and the analyzed slope stability sections met the acceptable factor of safety for static and seismic loadings. If the location of the building is to be moved closer to the existing slopes, this office should be contacted, and further analysis would be required.

It is understood that section 4.9.3 of the City of Ottawa Official Plan requires a minimum setback of 15 m from the edge of a stable slope and this setback distance should be considered the minimum deign setback for the development.

11. Excavations and De-Watering Requirements

11.1 Excess Soil Management

Ontario Regulation 406/19 specifies protocols that are 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 and the requirements of the receiving site. 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

Excavations for the construction of the proposed building foundations and installation of the underground services are anticipated to extend to depths of approximately 3.0 m below the final grade within the desiccated brown silty clay. Excavations are expected to be above the groundwater level. However, some perched water may be present within the desiccated clay. The excavation depths are to be confirmed once the inverts of the proposed underground services are known.

The excavations may be undertaken by conventional heavy equipment and all excavations must be undertaken in accordance with the current 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. Within zones of seepage, the excavation side slopes are expected to slough and eventually stabilize at 2H:1V to 3H:1V from the bottom of the excavation. Where sufficient space is not present for the required slopes the installation of the municipal underground services may be undertaken within the confines of a prefabricated support system (trench box) designed and installed in accordance with OHSA.

A base heave type of failure for excavations that extend to 3.0 m below the final grade is not anticipated.

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 and Impact of Groundwater Lowering on Adjacent Structures

Seepage of the surface and subsurface water into excavations is anticipated and it should be possible to collect water entering the excavations at low points and to remove it by conventional pumping techniques. In areas of high infiltration and below the groundwater level, a higher seepage rate should be anticipated and may require high-capacity pumps to keep the excavation dry.

If less than 50 m^3 of water are to be pumped per day, no permits are required. If between 50 m^3 and 400 m^3 of water is to be pumped per day, then the activity should be registered on the Environmental Activity and Sector Registry (EASR), an online registry maintained by the Ministry of the Environment, Conservation and Parks (MECP). If more than 400 m^3 of water is to be pumped per day, then a Category 3 Permit to Take Water (PTTW) is required.

Since water taking can be groundwater, storm water, or a combination of both, the most likely potential for significant volumes of water requiring removal from an excavation at the site is storm water. If a major rain event occurs while a large excavation is open, then it is possible that the total accumulation of water within the excavation will exceed 50 m^3. If that occurs, then it may be removed without a permit by pumping over several days during which no single-day water-taking is more than 50 m^3. Alternatively, a maximum of 400 m^3 of water may be pumped per day once the online EASR application form is filled out and the fee is paid. The EASR application may be completed by the property owner or their delegate. EXP would be pleased to assist with the EASR, should it be deemed necessary. Per the terms of the EASR, the total quantities of water actually removed from the excavation must be reported to the MECP.

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

For site servicing, it is anticipated that the subgrade for the proposed underground services will consist of silty clay.

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

For paved surfaces that will be located over service trenches, it is recommended that the trench backfill material within the 1.8 m frost zone, should match the existing material exposed along the trench walls to minimize differential frost heaving of the subgrade. The trench backfill should be placed in 300 mm thick lifts and each lift should be compacted to 95 percent SPMDD. Alternatively, frost tapers may be used.

If the backfill for the service trenches will consist of granular fill, clay seals should be installed in the service trenches at select intervals (spacing) as per City of Ottawa Drawing No. S8. The seals should be 1.0 m wide, extend over the entire trench width and from the bottom of the trench to the underside of the pavement structure. The clay should be compacted to 95 percent SPMDD. The purpose of the clay seals is to prevent the permanent lowering of the groundwater level.

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

13. Access Roads and Parking Lots

Pavement structures for the proposed parking lots, access roads and loading areas are given on Table XII below for the anticipated silty clay subgrade. The pavement structures are based upon the assumption that the subgrade will be properly prepared and assumes a functional design life of 15 to 18 years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out.

Table XII: Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Computed Pavement Structure	
		Light Duty Traffic (Parking Lots - Cars Only)	Heavy Duty (Parking Lots and Access Roads)
Asphaltic Concrete (PG 58-34)	92-97% MRD	65 mm HL3/SP12.5 mm/ Cat. B	50 mm HL3/SP12.5 Cat. B 60 mm HL8/SP 19 Cat. B
OPSS 1010 Granular A Base (crushed limestone)	100% SPMDD	150 mm	150 mm
OPSS 1010 Granular B Type II Sub-base	100% SPMDD	450 mm	600 mm

Notes:

1. SPMDD denotes standard Proctor maximum dry density, ASTM, D-698-12e2.
2. MRD denotes Maximum Relative Density, ASTM D2041.

The upper 300 mm of the subgrade fill must be compacted to 98% SPMDD.

Additional comments on the construction of the parking lots, access roads and loading areas are as follows:

1. As part of the subgrade preparation, the proposed parking lots, access roads and loading areas should be stripped of topsoil and other obviously unsuitable material. The subgrade should be properly shaped, crowned, then proofrolled with a heavy vibratory 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 (ASTM D698-12e2). The subgrade should be covered with geotextile prior to placing granular materials.

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. Subdrains should be installed on both sides of the access road(s). Subdrains must be installed in the proposed parking area at low points and should be continuous between catchbasins or open drainage ditches 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 subdrains 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. Weep holes should be provided in the catchbasins/manholes to facilitate drainage of any water that may accumulate in the granular fill.

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. Relatively weaker subgrade may develop over service trenches at subgrade level. These areas may require the use of thicker/coarser sub-base material and the use of a geotextile at the subgrade level. If this is the case, it is recommended that additional 150 mm of granular sub-base, OPSS Granular B Type II, should be provided in these areas, in addition to the use of a geotextile at the subgrade level.

6. The granular materials used for pavement construction should conform to Ontario Provincial Standard Specifications (OPSS 1010) for Granular A and Granular B Type II and should be compacted to 100 percent of the SPMDD.

The asphaltic concrete use and placement should meet OPSS 1150 or 1151 requirements. It should be compacted from 92 percent to 97 percent of the MRD (ASTM D2041). Asphalt placement should be in accordance with OPSS 310 and OPSS 313.

It is recommended that EXP be retained to review the final pavement structure design and drainage plans prior to construction to ensure they are consistent with the recommendations of this report.

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

The material to be excavated during construction will consist of the topsoil, fill and the native silty clay. The topsoil is not considered suitable for reuse. The existing fill and silty clay are not considered suitable for reuse as backfill material in the interior of the building but may be used for backfilling service trenches (above the bedding and cover) in the exterior of the building, for general grading purposes and in landscaped areas.

Imported material should preferably conform to the following specification:

- Engineered fill under the footings and the slab-on-grade - OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 100 percent SPMDD under footings and to 98 percent SPMDD under floor slabs.
- 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 (above the bedding and cover) – On site desiccated silty clay, if compactable, placed in 300 mm thick lifts and each lift compacted to 95 percent of the SPMDD. The compactability of the clay should be determined prior to its use. It the clay is not suitable for compaction purposes, exterior service trenches should be backfilled with OPSS 1010 Select Subgrade Material (SSM) placed in 300 mm thick lifts and each lift compacted to 95 percent of the SPMDD.

15. Corrosion Potential

Chemical tests limited to pH, sulphate, chloride and resistivity were undertaken on one (1) soil sample. A summary of the results is shown in Table XIII. The laboratory certificate of analysis is shown in Appendix C.

Table XIII: Corrosion Test Results on Soil Samples

Borehole – Sample No.	Depth (m)	Soil Type	pH	Sulphate (%)	Chloride (%)	Resistivity (ohm-cm)
BH1 - SS4	3.0 m - 3.6 m	Desiccated Silty Clay	8.26	0.006	0.0178	3,820

The results indicate the silty clay has a negligible potential for sulphate attack on subsurface concrete. The concrete should be designed in accordance with CSA A.23.1-14.

The results of the resistivity tests indicate that silty clay is moderately corrosive to bare steel as per the National Association of Corrosion Engineers (NACE). Appropriate measures should be taken to protect the buried bare steel from corrosion.

16. Tree Planting Restrictions

Based on the results of the Atterberg limits of the clayey soils and comparison of the results with the City of Ottawa 2005 Clay Soils Policy and 2017 Tree Planting in Sensitive Marine Clay Soils Guidelines (2017 Tree Planting Guidelines), the clayey soils at this site are considered to have a low/medium potential for soil volume change. Therefore, the tree planting should be carried out in accordance with the 2017 City of Ottawa Tree Planting Guidelines.

A landscape architect should be consulted to ensure the tree planting restrictions and setbacks for the proposed development are in accordance with the applicable City of Ottawa guidelines.

17. Earthworks Quality Control During Construction

All earthworks activities from construction of footing foundations to subgrade preparation to the placement and compaction of fill soils should be inspected by geotechnical personnel to ensure that construction proceeds in accordance with the project specifications.

18. General Comments

The comments and recommendations given in this report are based on the assumption that the above-described design concepts 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. This geotechnical report should be updated once final design for the proposed development is available.

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

Daniel Wall

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Earth and Environment

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LICENSED PROFESSIONAL ENGINEER
August 15, 2024
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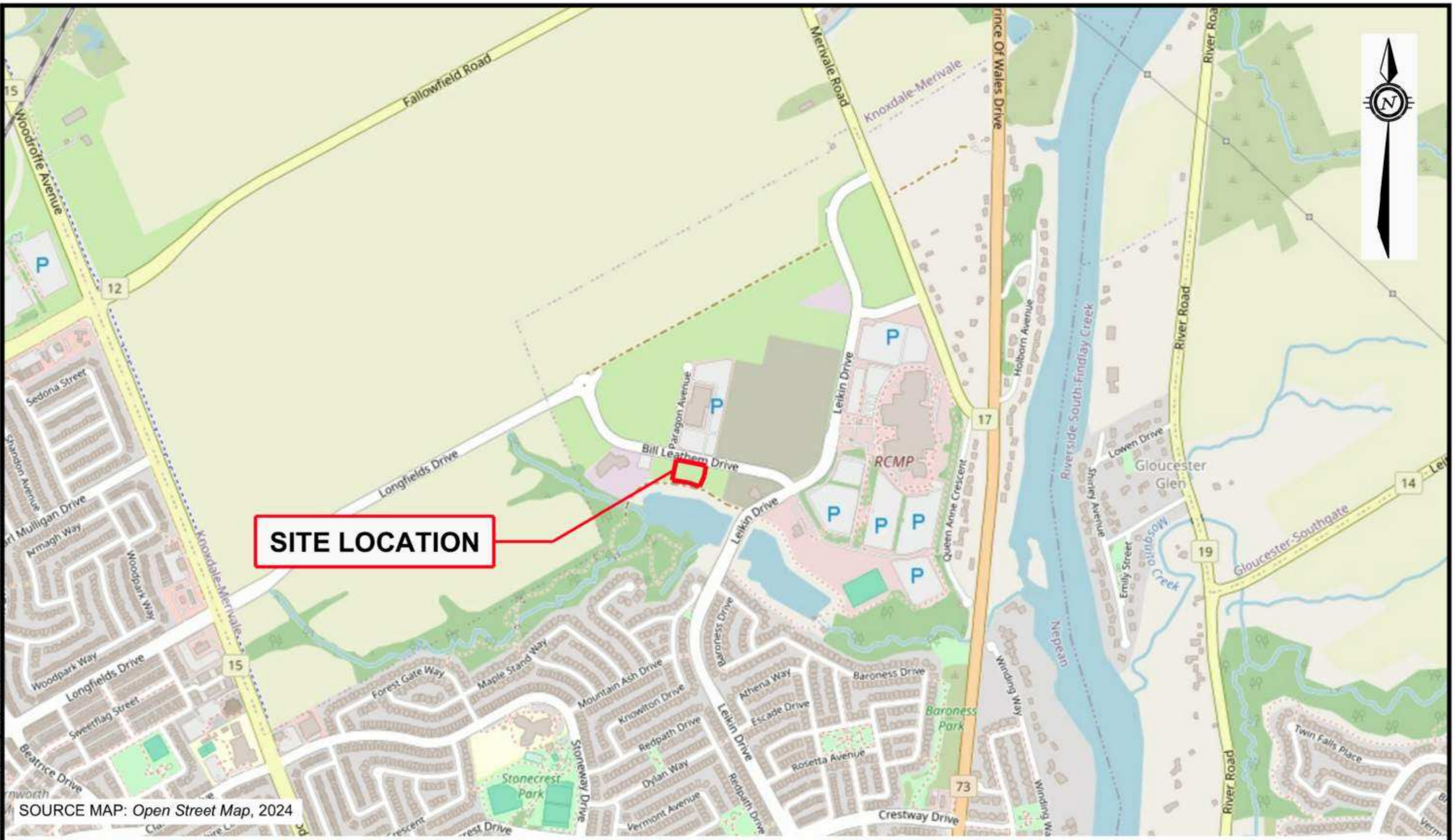
PROVINCE OF ONTARIO

Figures



SOURCE MAP: *Open Street Map*, 2024

ORIGINAL SHEET SIZE = 11" x 8.5"

0 150m 300m 600m

HORIZONTAL 1:15,000

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Ottawa, ON K2B 8H6, Canada

DATE APRIL 2024		CLIENT: STRUCTURA CONSTRUCTION	project no. OTT-24002636-A0
DESIGN MZ / DW	CHECKED IT	PROJECT: GEOTECHNICAL INVESTIGATION TITLE: SITE LOCATION PLAN	scale 1:15,000
DRAWN BY AS		ADDRESS: 100 BILL LEATHEM DRIVE, OTTAWA, ONTARIO	FIG 1

Filename: \\exp\data\OTT\OTT-24002636-A0\60 Execution\65 Drawings\OTT-24002636-A0_Geo.dwg
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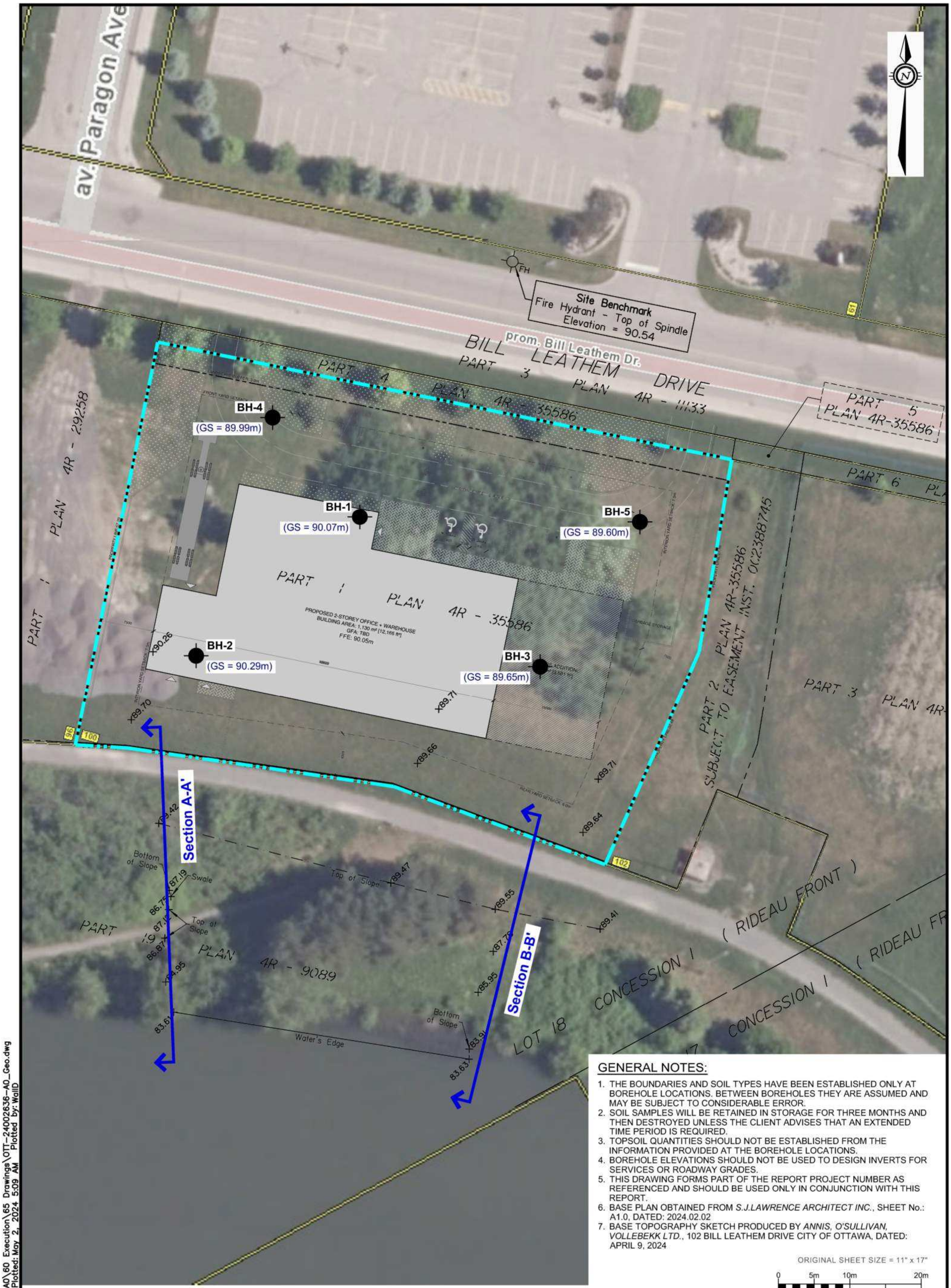

GENERAL NOTES:

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 INVERTS FOR SERVICES OR ROADWAY 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 OBTAINED FROM *S.J.LAWRENCE ARCHITECT INC.*, SHEET No.: A1.0, DATED: 2024.02.02
7. BASE TOPOGRAPHY SKETCH PRODUCED BY *ANNIS, O'SULLIVAN, VOLLEBEKK LTD.*, 102 BILL LEATHEM DRIVE CITY OF OTTAWA, DATED: APRIL 9, 2024

ORIGINAL SHEET SIZE = 11" x 17"

0 5m 10m 20m
HORIZONTAL 1:500

AERIAL PHOTO SOURCE: *geoOttawa*, 2022

LEGEND

━ · · ━	PROPERTY BOUNDARY
BH-1 ●	BOREHOLE NO. AND LOCATION
(GS = 90.07m)	GROUND SURFACE ELEVATION (masl)
↑ Sect.	SLOPE STABILITY SECTION MARK

exp.

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DATE: APRIL 2024
DESIGN: MZ / DW
CHECKED: IT
DRAWN BY: AS

CLIENT: STRUCTURA CONSTRUCTION
PROJECT: GEOTECHNICAL INVESTIGATION
TITLE: BOREHOLE LOCATION PLAN
ADDRESS: 100 BILL LEATHEM DRIVE, OTTAWA, ONTARIO

project no.: OTT-24002636-A0
scale: 1:500
FIG 2

Filename: \\exp\data\OTT\OTT-24002636-A0\60 Execution\65 Drawings\OTT-24002636-A0_Geo.dwg
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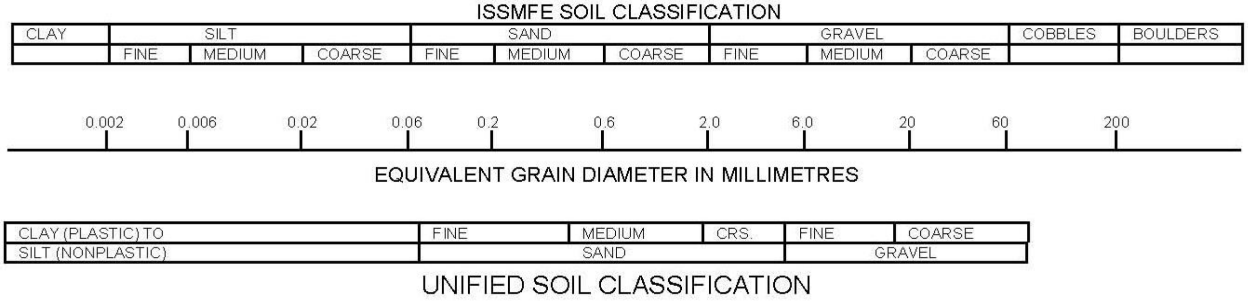
Notes On Sample Descriptions

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.



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 BH-1

Project No: OTT-24002636-A0

Project: Proposed Commercial Development

Location: 100 Bill Leathem Drive, Ottawa, Ontario

Figure No. 3

Page. 1 of 3

Date Drilled: 3/21/24

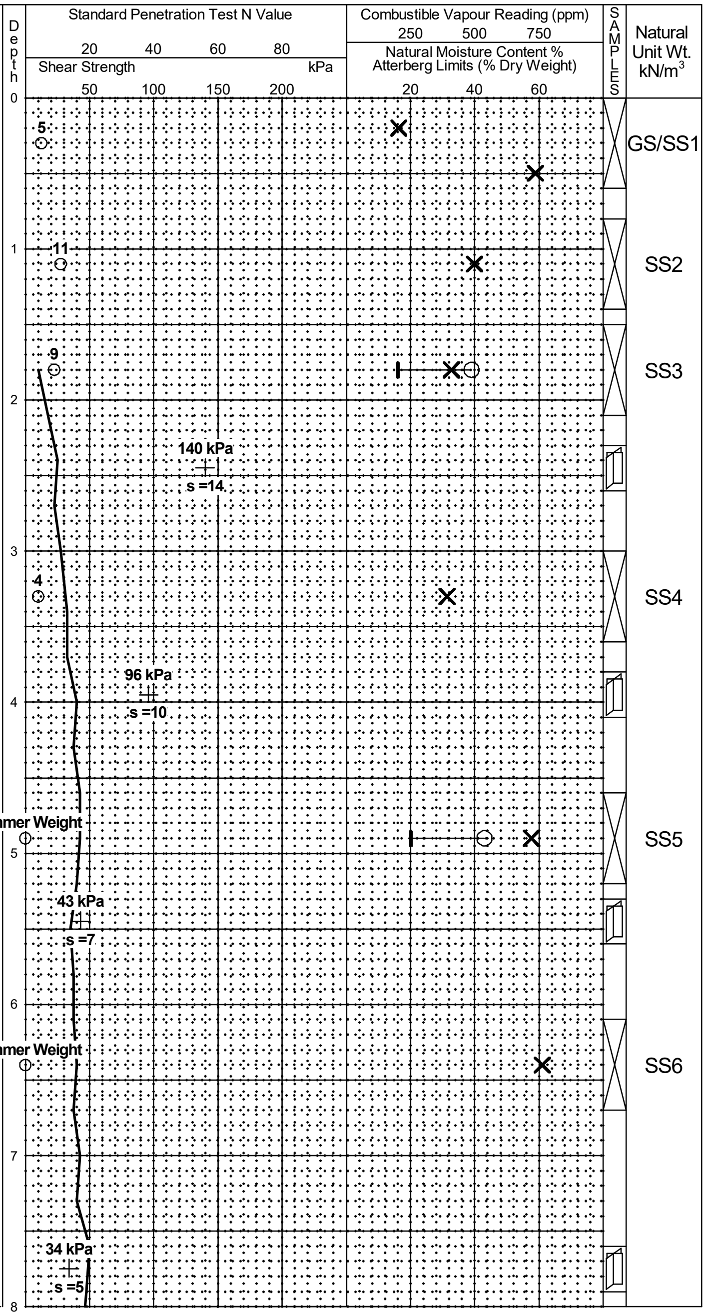
Drill Type: CME-75 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: D.W.

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◫	Natural Moisture Content	✕
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m
		FILL Silty clay with gravel and cobbles, occasionaly rootlets, grey, moist, (loose)	90.1
		SILTY CLAY Brown, moist to wet, (stiff to very stiff)	89.4
		Firm and grey below 4.6 m depth	



Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. The borehole was backfilled upon completion.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24002636-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Completion	Dry to 11.6 m	11.6

CORE DRILLING RECORD

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

Log of Borehole BH-1

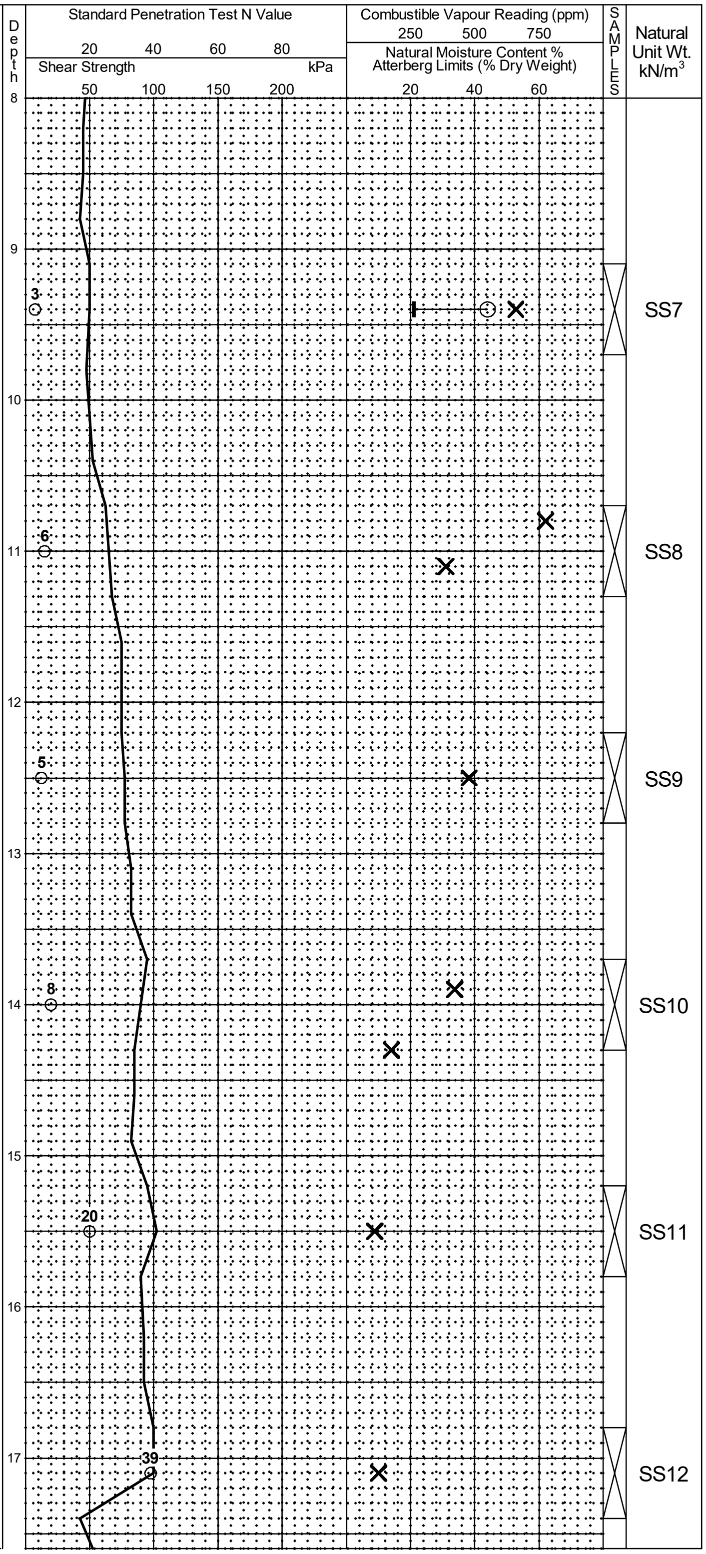
Project No: OTT-24002636-A0

Project: Proposed Commercial Development

Figure No. 3

Page. 2 of 3

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m
	▨	**SILTY CLAY** Brown, moist to wet, (stiff to very stiff) *(continued)*	82.1
		CLAYEY SILT Grey, wet, (loose)	79.1
		GLACIAL TILL Silty sand with clay and gravel, grey, moist, (compact to dense)	75.9



Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. The borehole was backfilled upon completion.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24002636-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Completion	Dry to 11.6 m	11.6

CORE DRILLING RECORD

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

Log of Borehole BH-1

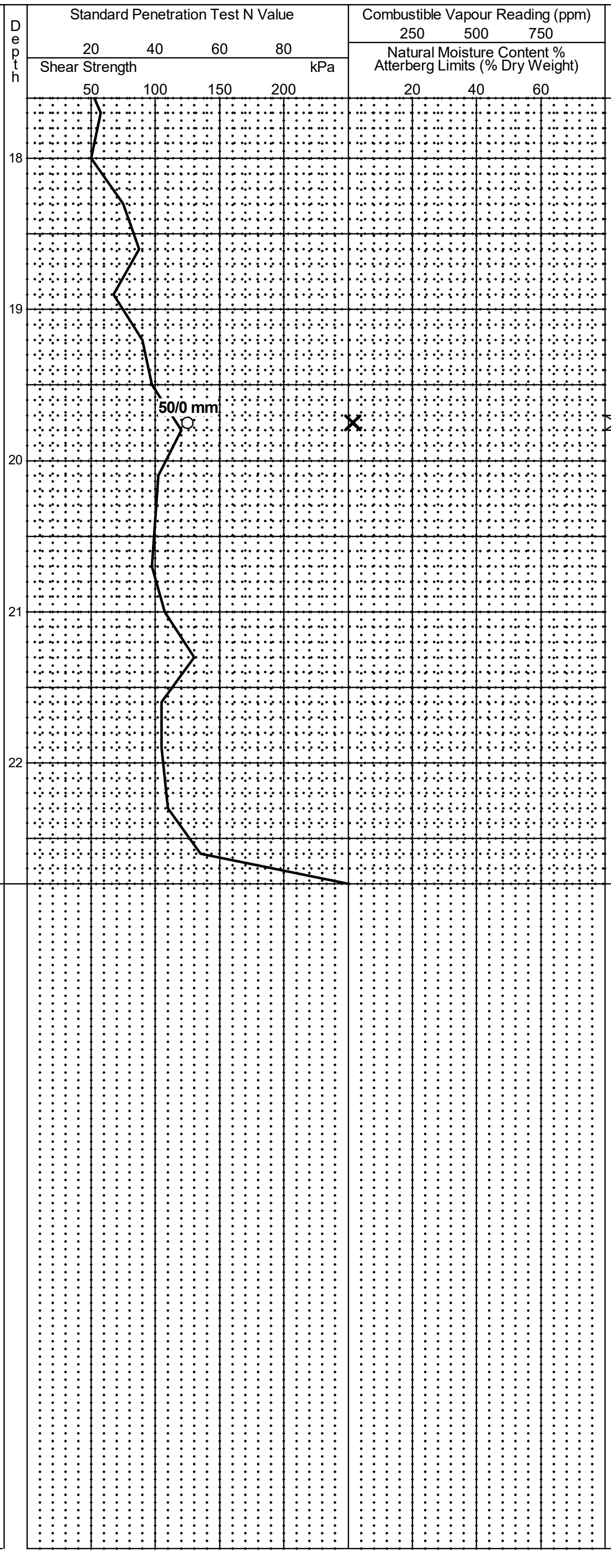
Project No: OTT-24002636-A0

Project: Proposed Commercial Development

Figure No. 3

Page. 3 of 3

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	SAMPLES	Natural Unit Wt. kN/m³
		GLACIAL TILL Silty sand with clay and gravel, grey, moist, (compact to dense) *(continued)*	72.5		
		DCPT from 19.8 m to 22.8 m	70.3	☒ SS13	
		Dynamic Cone Penitration Test Refusal at 22.8 m Depth	67.3		



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. The borehole was backfilled upon completion.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24002636-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Completion	Dry to 11.6 m	11.6

CORE DRILLING RECORD

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

Log of Borehole BH-2

Project No: OTT-24002636-A0

Project: Proposed Commercial Development

Location: 100 Bill Leathem Drive, Ottawa, Ontario

Figure No. 4

Page. 1 of 1

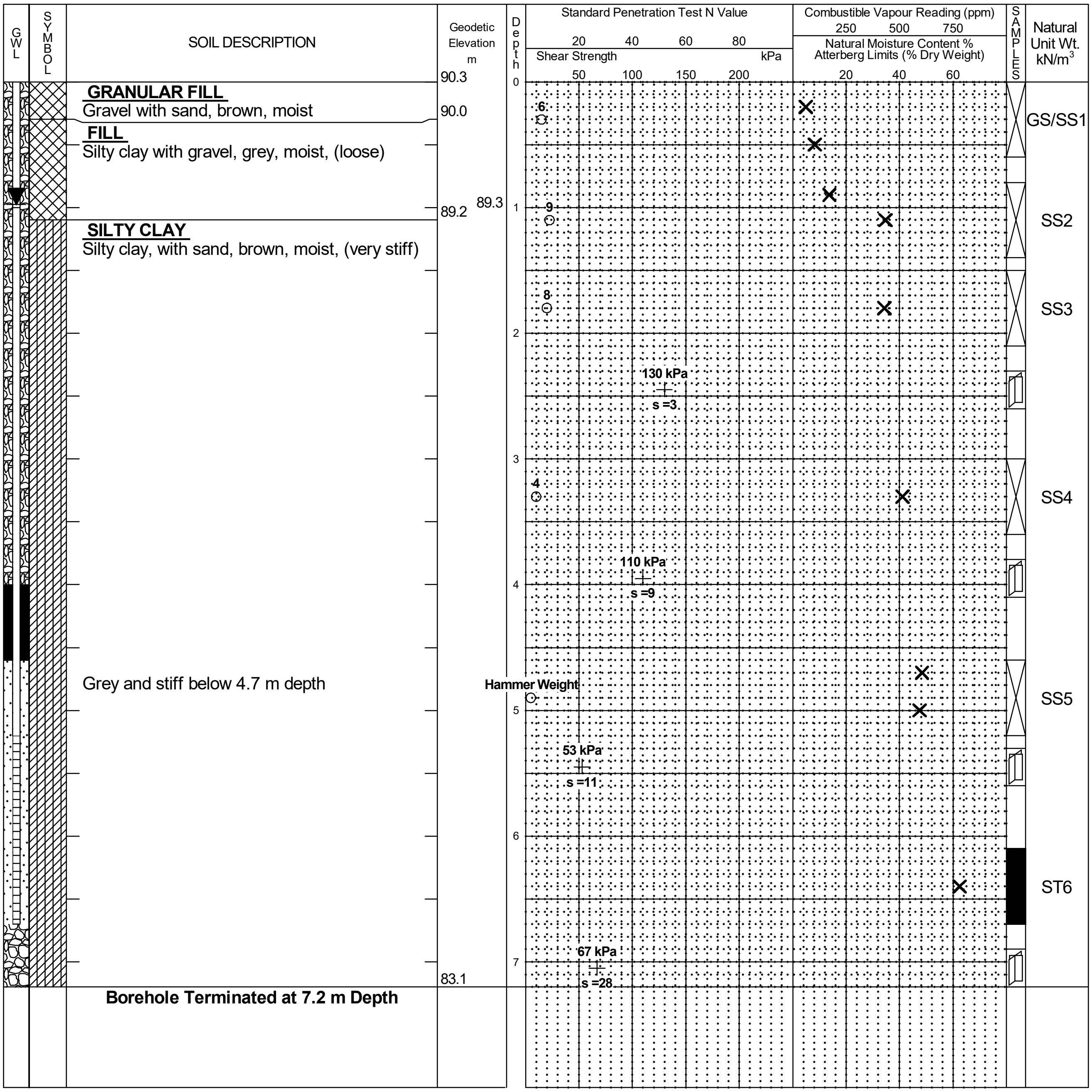
Date Drilled: 3/21/24

Drill Type: CME-75 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: D.W.

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◫	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter peizometer was installed upon completion.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24002636-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Completion	Dry to 6.7 m	6.7
4/9/2024	1.0	

CORE DRILLING RECORD

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

Log of Borehole **BH-3**

Project No: OTT-24002636-A0

Project: Proposed Commercial Development

Location: 100 Bill Leathem Drive, Ottawa, Ontario

Figure No. 5

Page. 1 of 1

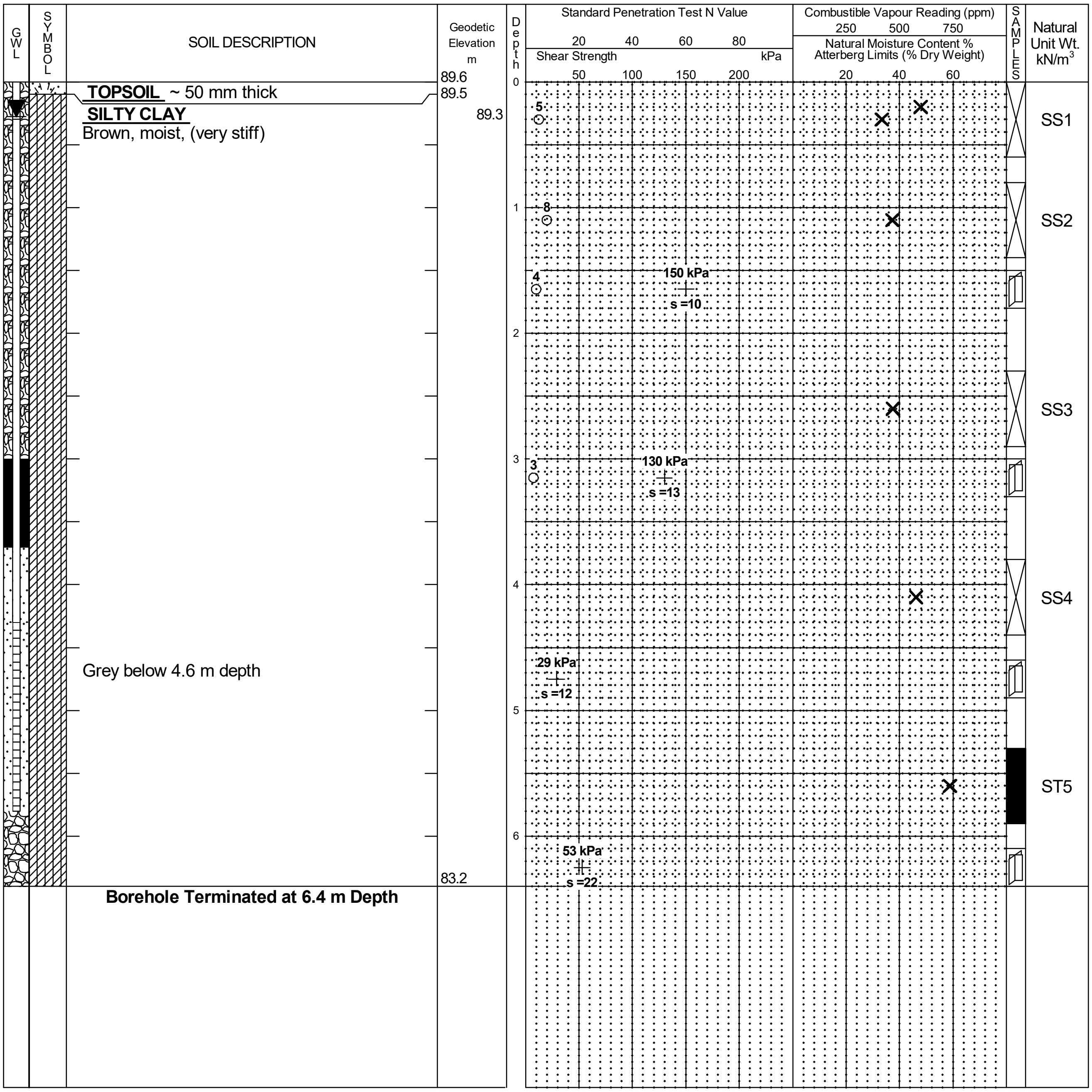
Date Drilled: 3/21/24

Drill Type: CME-75 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: D.W.

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◫	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



TOPSOIL ~ 50 mm thick

SILTY CLAY
Brown, moist, (very stiff)

Grey below 4.6 m depth

Borehole Terminated at 6.4 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter peizometer was installed upon completion.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24002636-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
4/9/2024	0.3	

CORE DRILLING RECORD

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

LOG OF BOREHOLE GINT LOGS 04.17.2024.GPJ TROW OTTAWA.GDT 5/29/24

Log of Borehole BH-4

Project No: OTT-24002636-A0

Project: Proposed Commercial Development

Location: 100 Bill Leathem Drive, Ottawa, Ontario

Figure No. 6

Page. 1 of 1

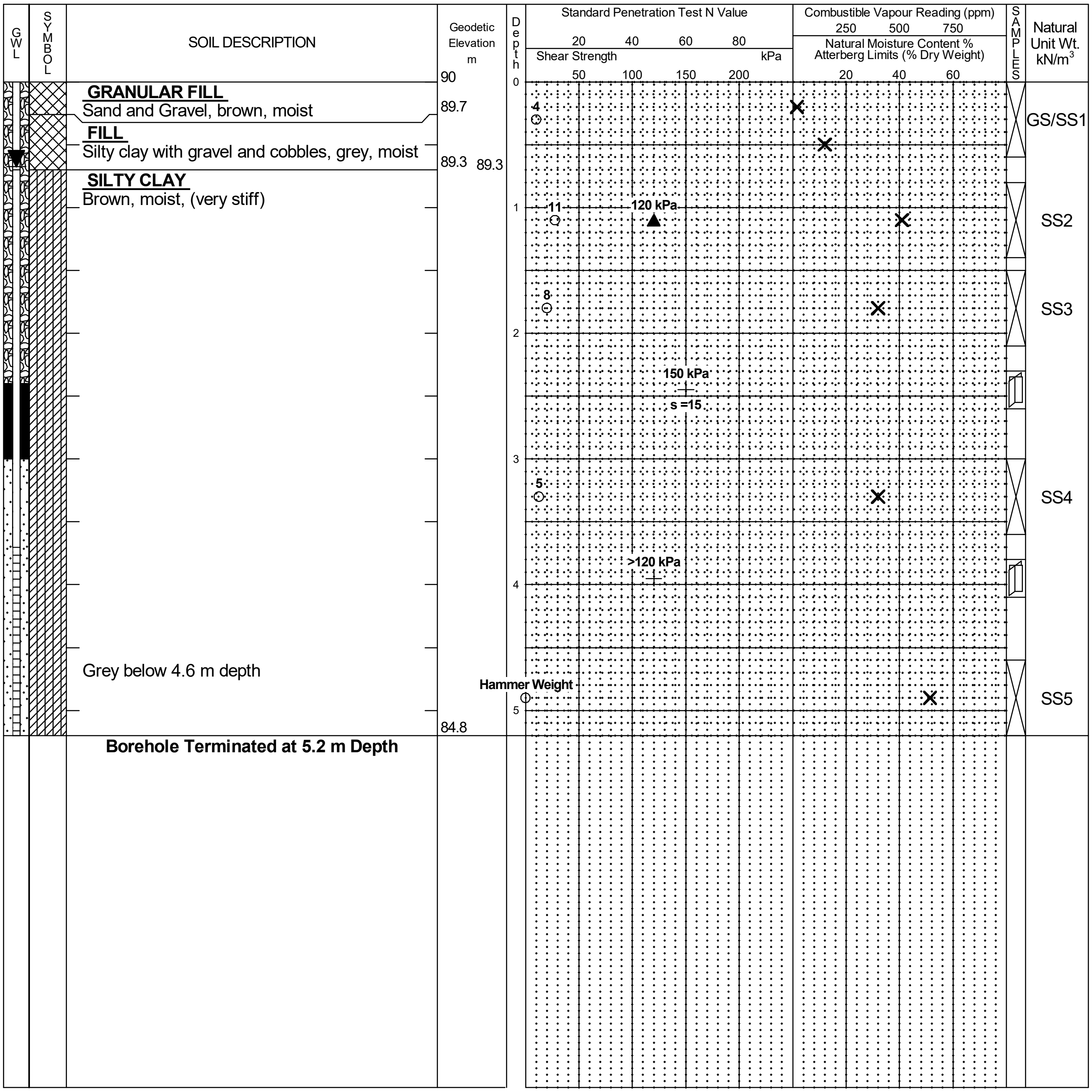
Date Drilled: 3/21/24

Drill Type: CME-75 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: D.W.

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



SOIL DESCRIPTION	Geodetic Elevation m
	90
GRANULAR FILL Sand and Gravel, brown, moist	89.7
FILL Silty clay with gravel and cobbles, grey, moist	89.3 89.3
SILTY CLAY Brown, moist, (very stiff) Grey below 4.6 m depth	84.8
Borehole Terminated at 5.2 m Depth	

SAMPLES	Natural Unit Wt. kN/m³
GS/SS1	
SS2	
SS3	
SS4	
SS5	

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter peizometer was installed upon completion.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24002636-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
4/9/2024	0.7	

CORE DRILLING RECORD

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

Log of Borehole **BH-5**

Project No: OTT-24002636-A0

Project: Proposed Commercial Development

Location: 100 Bill Leathem Drive, Ottawa, Ontario

Figure No. 7

Page. 1 of 1

Date Drilled: 3/22/24

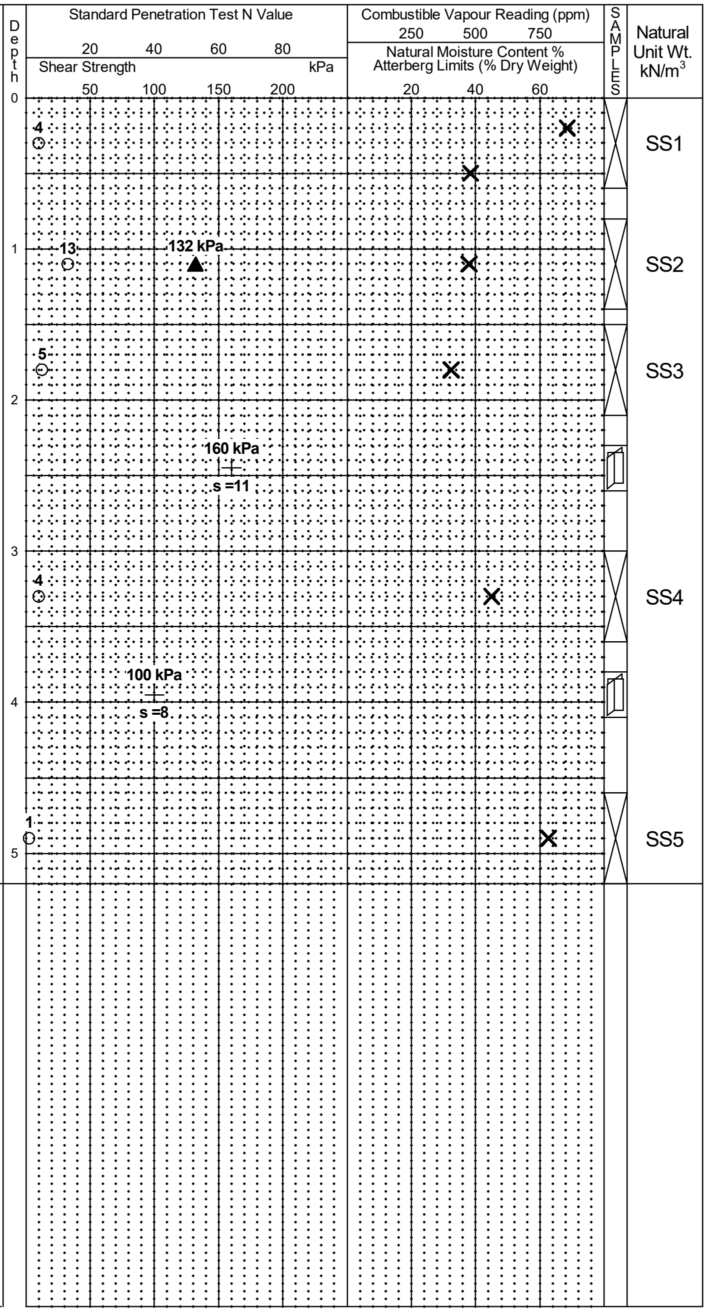
Drill Type: CME-75 Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: D.W.

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	▥	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢⊖
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m
			89.6
		TOPSOIL ~ 50 mm thick	89.5
		SILTY CLAY Brown, moist, (very stiff)	
		Grey below 4.6 m depth	
			84.4
		Borehole Terminated at 5.2 m Depth	



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. The borehole was backfilled upon completion.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24002636-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Completion	4.0	4.3

CORE DRILLING RECORD

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

LOG OF BOREHOLE GINT LOGS 04.17.2024.GPJ TROW OTTAWA.GDT 5/29/24

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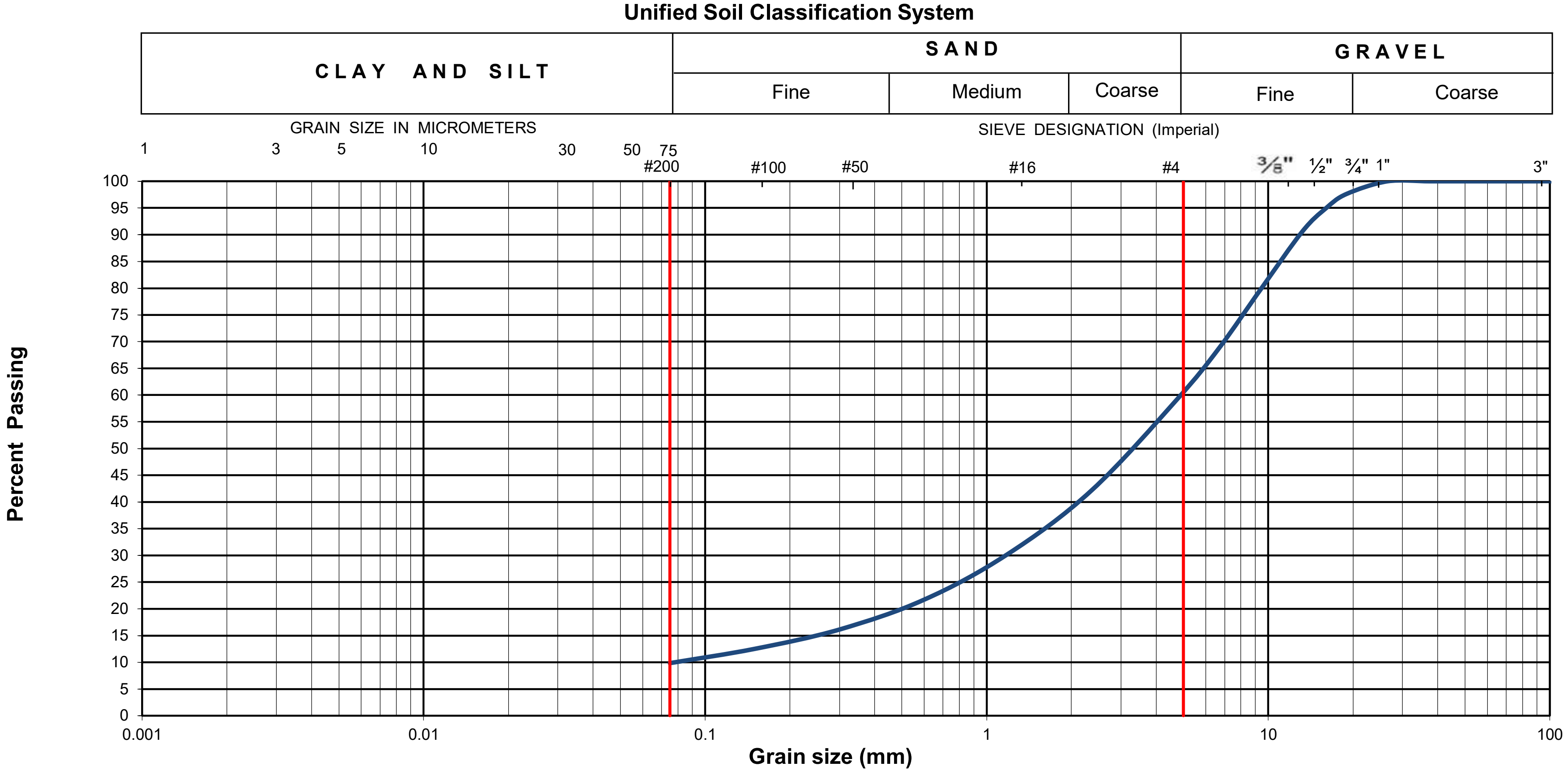
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136



EXP Project No.:	**OTT-24002636-A0**	**Project Name :**	**Geotechnical Investigation - Proposed Commercial Development**					
Client :	**Structura Construction**	**Project Location :**	**100 Bill Leathem Drive, Ottawa**					
Date Sampled :	**March 21, 2024**	**Borehole No:**	**BH2**	**Sample:**	**GS1**		**Depth (m) :**	**0-0.2**
Sample Composition :		**Gravel (%)**	**41**	**Sand (%)**	**49**	**Silt & Clay (%)** **10**	**Figure :**	**8**
Sample Description :	**Fill: Poorly Graded Sand with Silt and Gravel (SP-SM)**							

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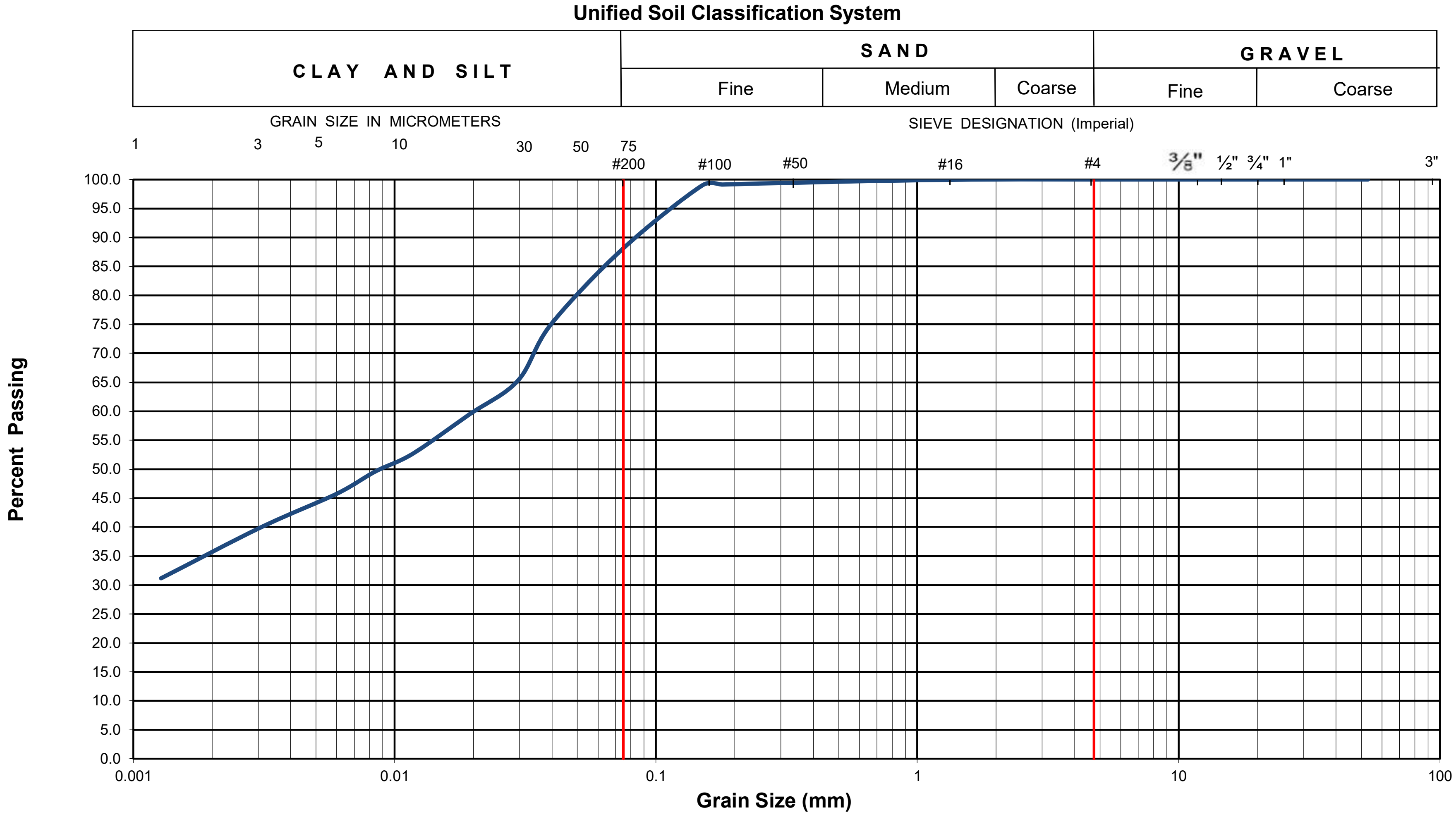
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-24002636-A0**	**Project Name :**	**Geotechnical Investigation - Proposed Commercial Development**						
Client :	**Structura Construction**	**Project Location :**	**100 Bill Leatham Drive, Ottawa**						
Date Sampled :	**March 21, 2024**	**Borehole No:**	**BH 1**	**Sample No.:**	**SS3**	**Depth (m) :**	**1.5-2.1**		
Sample Description :		**% Silt and Clay**	**88**	**% Sand**	**12**	**% Gravel**	**0**	**Figure :**	**9**
Sample Description :	**Silty Clay of Low Plasticity (CL), some sand**								

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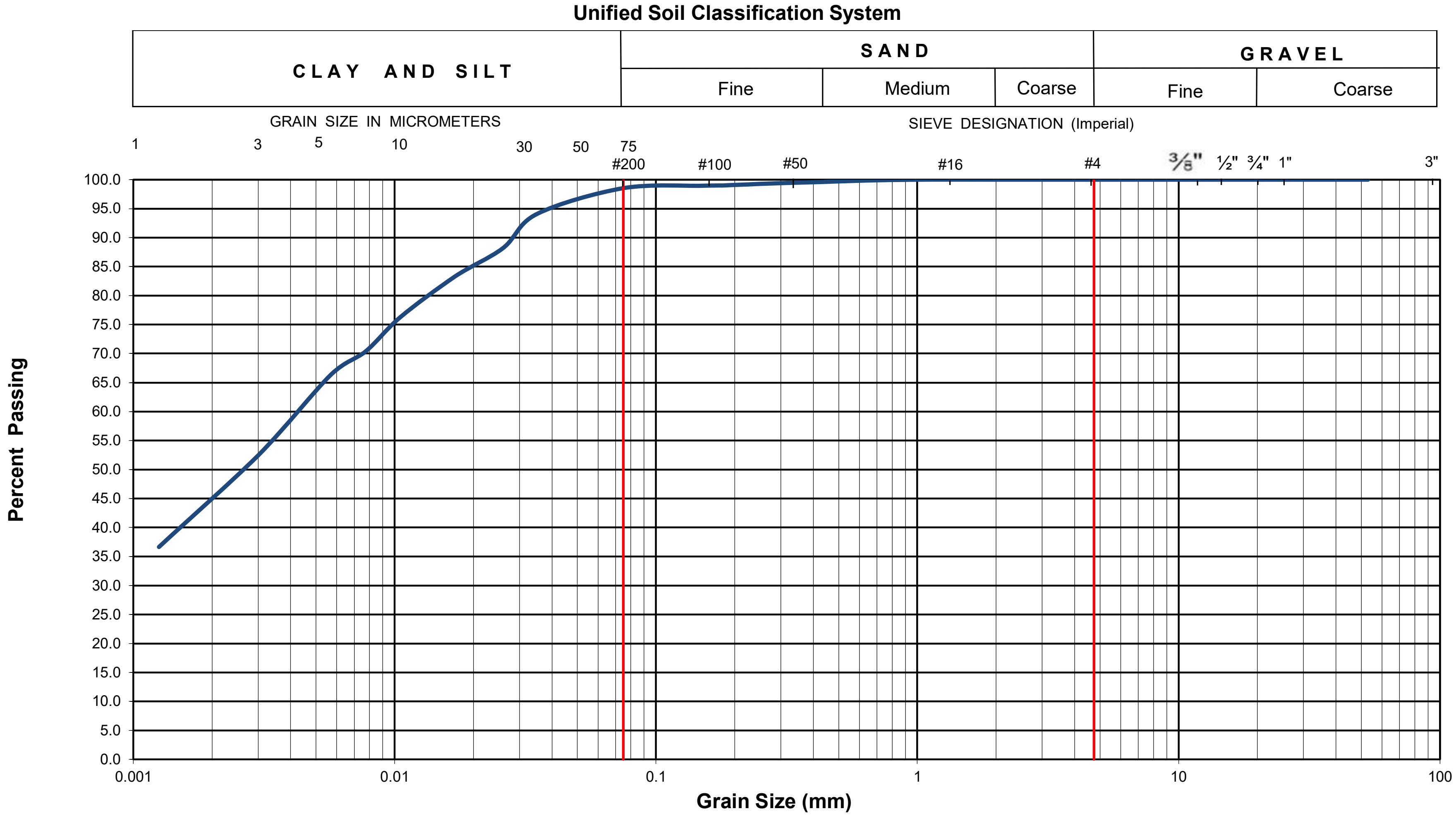
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	OTT-24002636-A0	**Project Name :**	Geotechnical Investigation - Proposed Commercial Development				
Client :	Structura Construction	**Project Location :**	100 Bill Leatham Drive, Ottawa				
Date Sampled :	March 21, 2024	**Borehole No:**	BH 1	**Sample No.:**	SS7	**Depth (m) :**	9.1-9.7
Sample Description :		**% Silt and Clay**	99	**% Sand**	1	**% Gravel**	0
Sample Description :	Silty Clay of Low Plasticity (CL), trace sand					**Figure :**	10

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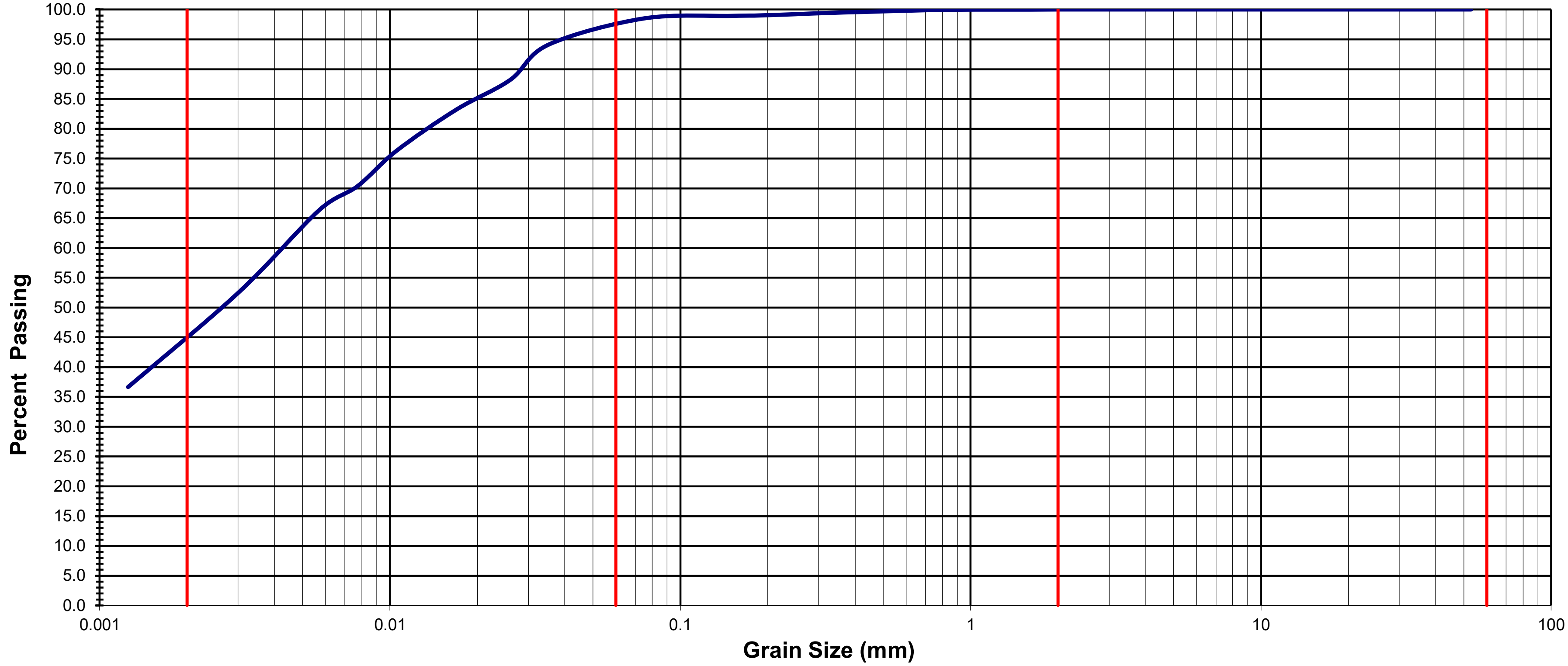
Grain-Size Distribution Curve
Method of Test for Particle Size Analysis of Soil
ASTM C-136/ASTM D-422

Modified M.I.T. Classification

CLAY	SILT			SAND			GRAVEL			
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	



EXP Project No.:	**OTT-24002636-A0**	**Project Name :**	**Geotechnical Investigation - Proposed Commercial Development**				
Client :	**Structura Construction**	**Project Location :**	**100 Bill Leatham Drive, Ottawa**				
Date Sampled :	**March 21, 2024**	**Borehole No:**	**BH 1**	**Sample No.:**	**SS7**	**Depth (m) :**	**9.1-9.7**
Sample Composition:	**% Clay: 63**	**% Silt: 31**	**% Sand: 6**	**% Gravel: 0**		**Figure :**	**11**
Sample Description :	**Silty Clay of Low Plasticity (CL), trace sand**						

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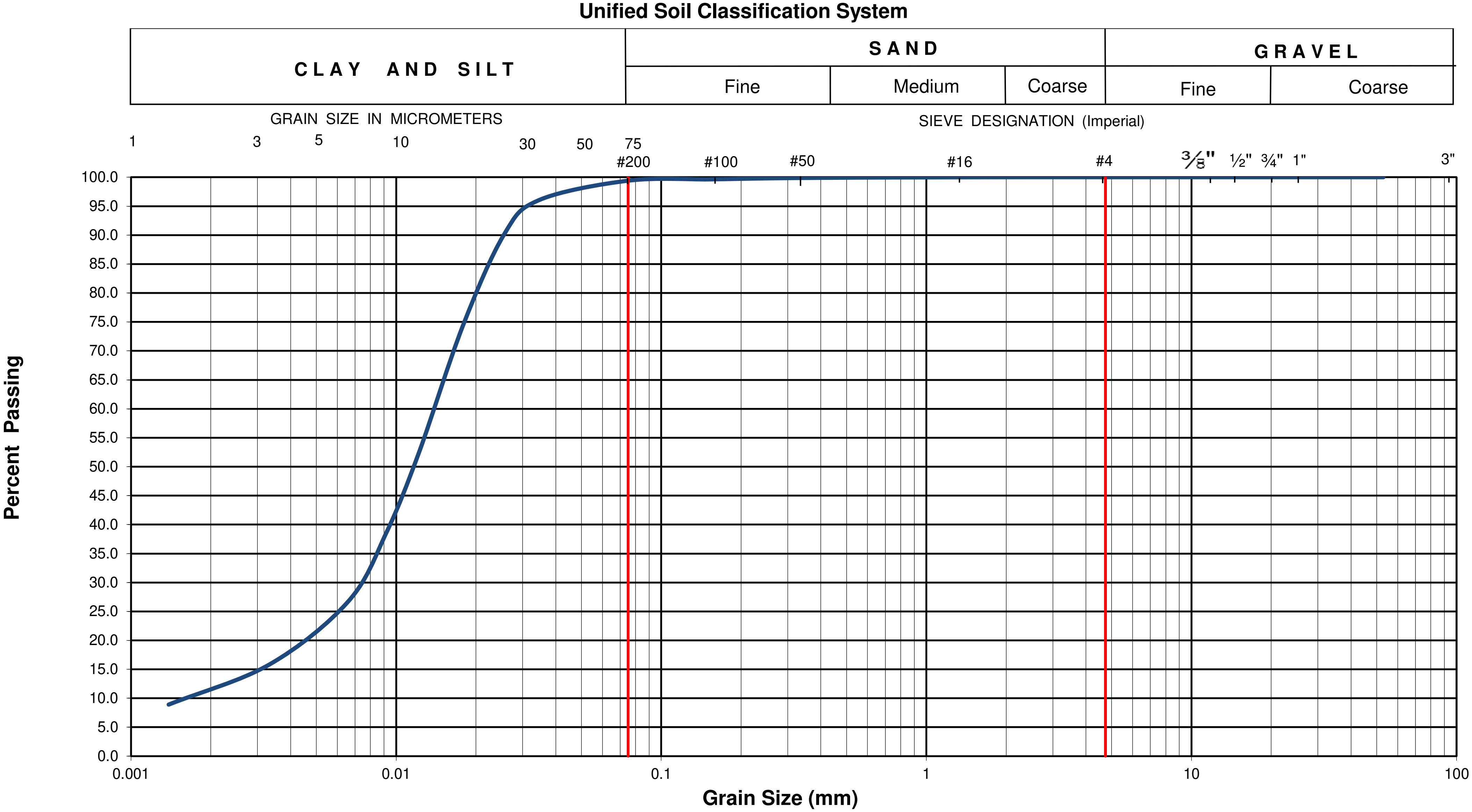
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-24002636-A0**	**Project Name :**	**Geotechnical Investigation - Proposed Commercial Development**				
Client :	**Structura Construction**	**Project Location :**	**100 Bill Leatham Drive, Ottawa**				
Date Sampled :	**March 22, 2024**	**Borehole No:**	**BH 1**	**Sample No.:**	**SS9**	**Depth (m) :**	**12.2-12.8**
Sample Description :		**% Silt and Clay**	**99**	**% Sand**	**1**	**% Gravel**	**0**
Sample Description :	**Silt (ML) - trace clay, trace sand**					**Figure :**	**12**

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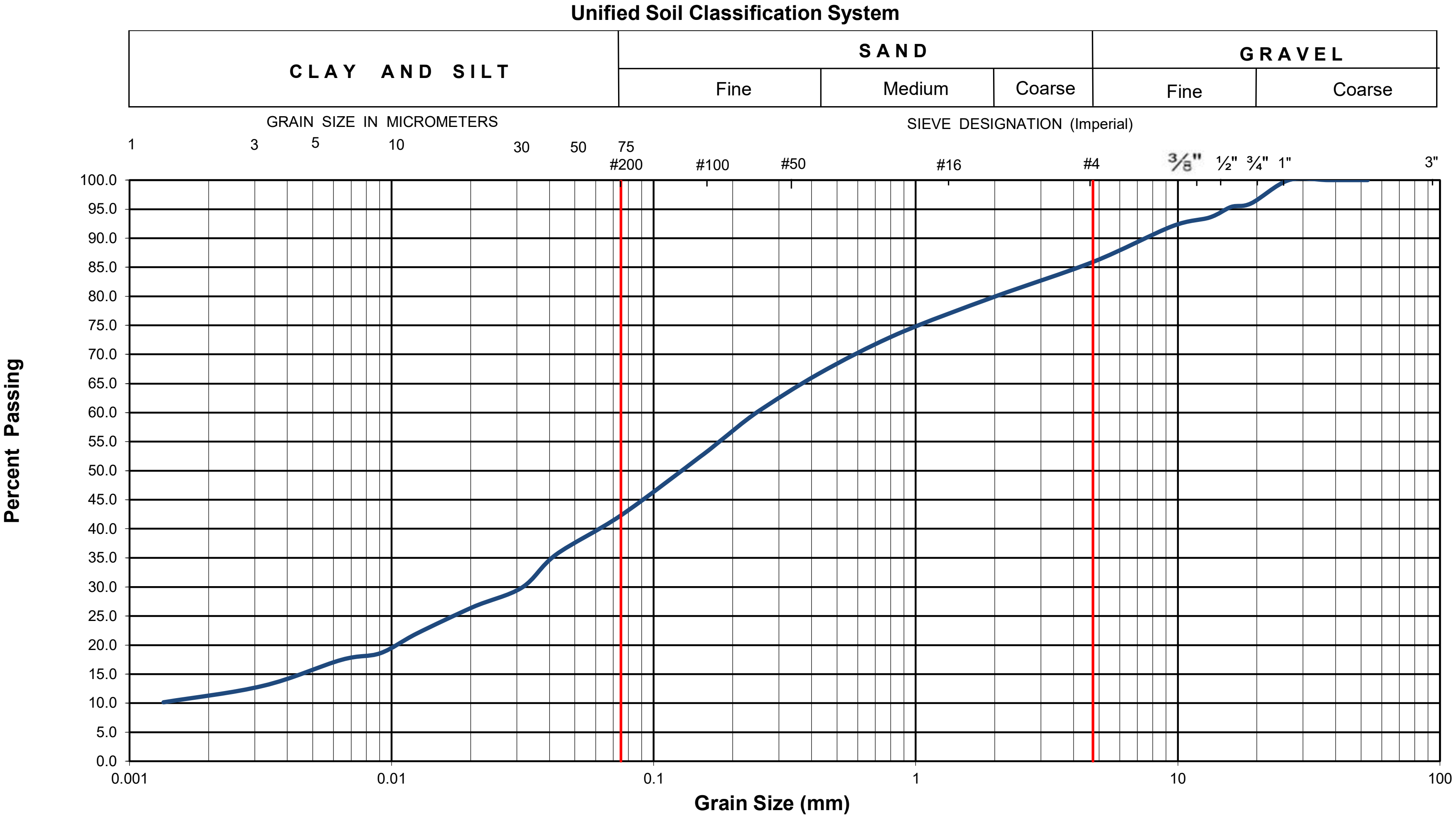
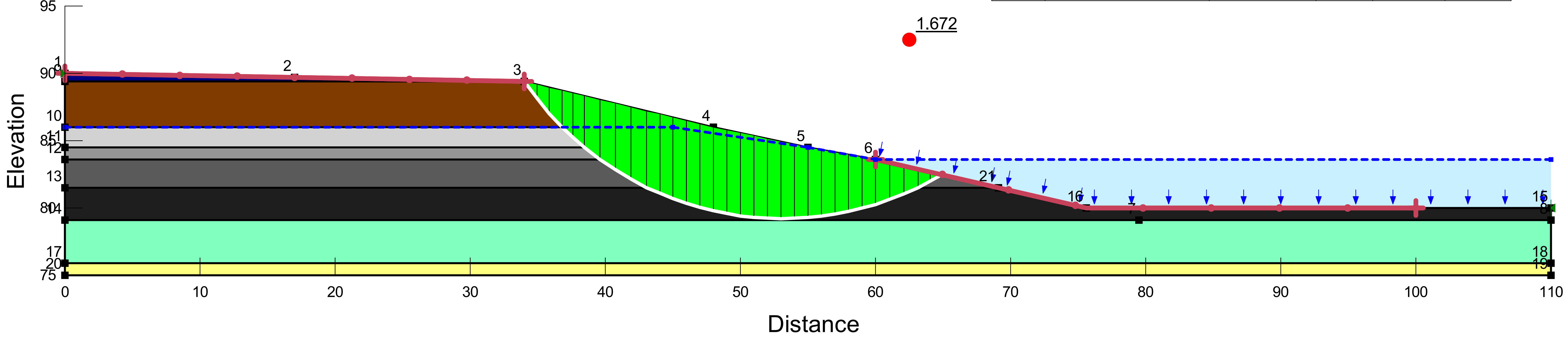
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-24002636-A0**	**Project Name :**	**Geotechnical Investigation - Proposed Commercial Development**				
Client :	**Structura Construction**	**Project Location :**	**100 Bill Leatham Drive, Ottawa**				
Date Sampled :	**March 22, 2024**	**Borehole No:**	**BH 1**	**Sample No.:**	**SS11**	**Depth (m) :**	**15.2-15.8**
Sample Description :		**% Silt and Clay**	**42**	**% Sand**	**44**	**% Gravel**	**14**
Sample Description :	**Glacial Till - Silty Sand with Gravel (SM), trace clay**					**Figure :**	**13**

Appendix A – Slope Stability Analysis Figures

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
🟫	Clay Crust (Effective)	Mohr-Coulomb	18	10	32
🟦	Fill	Mohr-Coulomb	20	0	25
🟨	Glacial Till	High Strength	22		
🟩	Silt	Mohr-Coulomb	18	0	28
⬜	Unweathered Clay Layer 1 (Effective Stress)	Mohr-Coulomb	16	0.5	28
▨	Unweathered Clay Layer 2 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28
▨	Unweathered Clay Layer 3 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28
⬛	Unweathered Clay Layer 4 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28



Section A-A'

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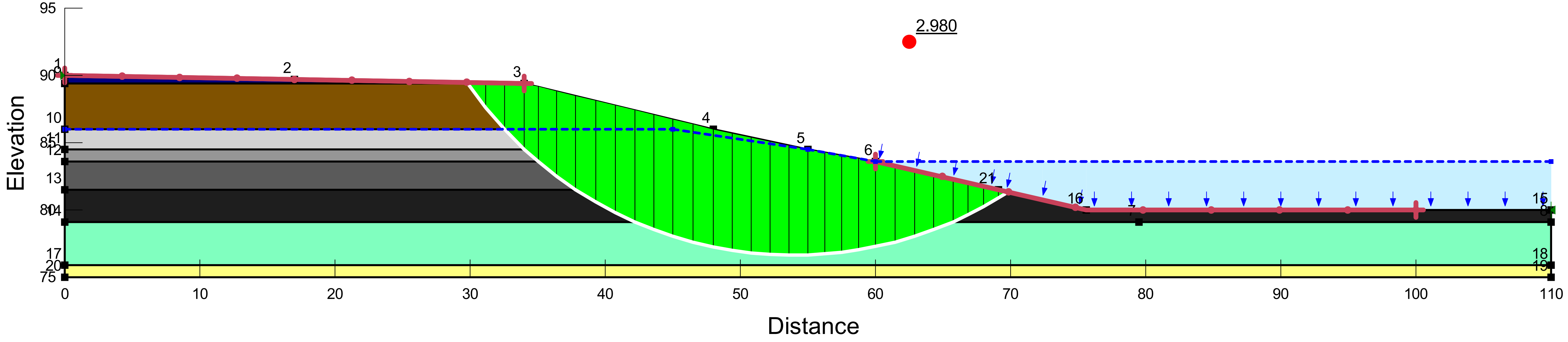
DATE May 9, 2024
CLIENT: Structura Construction
project no. OTT-24002636-A0
DESIGN DW
CHECKED SA
DRAWN BY DW
TITLE: STATIC SLOPE STABILITY ANALYSIS
Effective Stress Parameters - Existing Conditions
100 Bill Leathem Drive, Ottawa, ON
scale Not to scale
Figure A-1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Undrained Shear Strength (kPa)
🟫	Clay Crust (Total Stress)	Undrained (Phi=0)	18			110
🟦	Fill	Mohr-Coulomb	20	0	25	
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
⬜	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
▒	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
▓	Unweathered Clay Layer 3 (Total Stress)	Undrained (Phi=0)	16.5			65
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



Section A-A'

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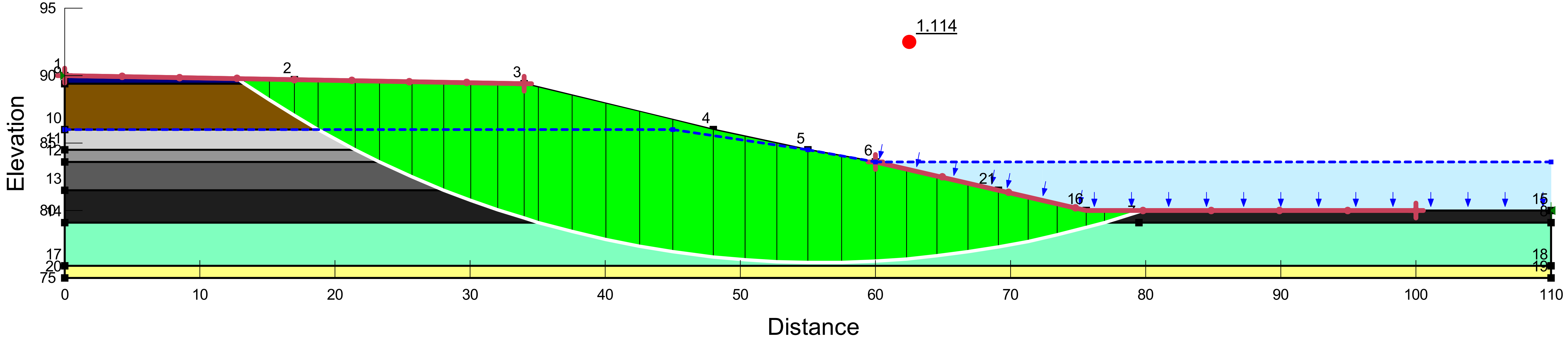
DATE May 9, 2024
CLIENT: Structura Construction
project no. OTT-24002636-A0
DESIGN DW
CHECKED SA
DRAWN BY DW
TITLE: STATIC SLOPE STABILITY ANALYSIS
Total Stress Parameters- Existing Conditions
100 Bill Leathem Drive, Ottawa, ON
scale Not to scale
Figure A-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Undrained Shear Strength (kPa)
🟫	Clay Crust (Total Stress)	Undrained (Phi=0)	18			110
🟦	Fill	Mohr-Coulomb	20	0	25	
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
⬜	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
▨	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
▩	Unweathered Clay Layer 3 (Total Stress)	Undrained (Phi=0)	16.5			65
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



Section A-A'

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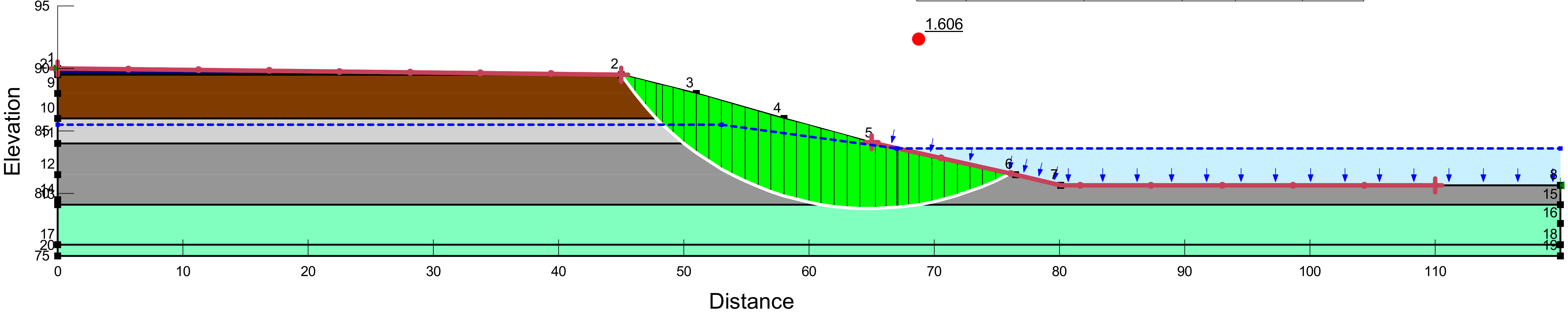
DATE May 9, 2024
CLIENT: Structura Construction
project no. OTT-24002636-A0
DESIGN DW
CHECKED SA
DRAWN BY DW
TITLE: PSEUDO-STATIC SLOPE STABILITY ANALYSIS
Total Stress Parameters - Existing Conditions
100 Bill Leathem Drive, Ottawa, ON
scale Not to scale
Figure A-3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
🟫	Clay Crust (Effective)	Mohr-Coulomb	18	10	32
🟦	Fill	Mohr-Coulomb	20	0	25
🟨	Glacial Till	High Strength	22		
🟩	Silt	Mohr-Coulomb	18	0	28
⬜	Unweathered Clay Layer 1 (Effective Stress)	Mohr-Coulomb	16	0.5	28
⬛	Unweathered Clay Layer 2 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28



Section B-B'

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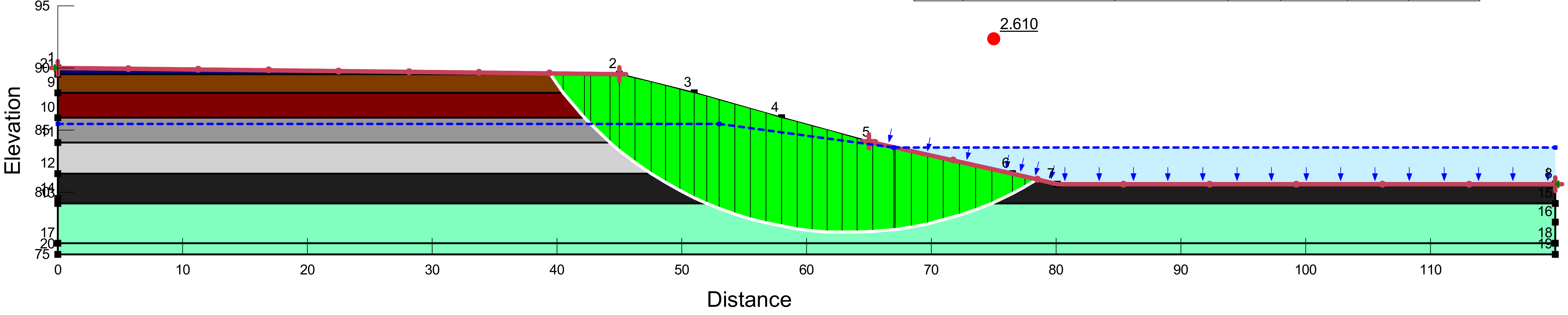
DATE May 9, 2024
DESIGN DW
CHECKED SA
DRAWN BY DW
CLIENT: Structura Construction
TITLE: STATIC SLOPE STABILITY ANALYSIS
Effective Stress Parameters - Existing Conditions
100 Bill Leathem Drive, Ottawa, ON
project no. OTT-24002636-A0
scale Not to scale
Figure A-4

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Undrained Shear Strength (kPa)
🟫	Clay Crust (Total Stress) Section B	Undrained (Phi=0)	18			150
🟥	Clay Crust Lower (Total Stress) Section B	Undrained (Phi=0)	18			75
🟦	Fill	Mohr-Coulomb	20	0	25	
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
⬜	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
▨	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



Section B-B'

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Canada
www.exp.com

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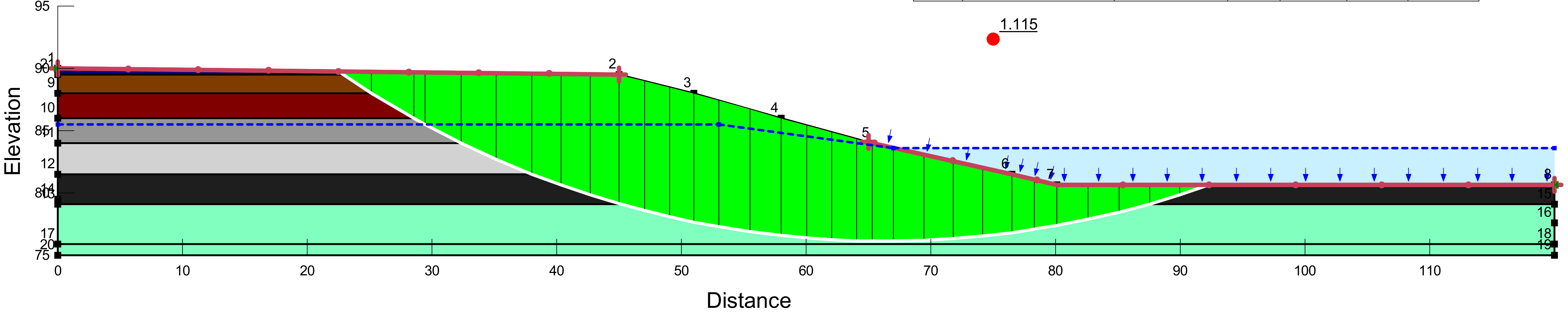
• INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

DATE May 9, 2024
CLIENT: Structura Construction
project no. OTT-24002636-A0
DESIGN DW
CHECKED SA
DRAWN BY DW
TITLE: STATIC SLOPE STABILITY ANALYSIS
Total Stress Parameters- Existing Conditions
100 Bill Leathem Drive, Ottawa, ON
scale Not to scale
Figure A-5

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Undrained Shear Strength (kPa)
🟫	Clay Crust (Total Stress) Section B	Undrained (Phi=0)	18			150
🟥	Clay Crust Lower (Total Stress) Section B	Undrained (Phi=0)	18			75
🟦	Fill	Mohr-Coulomb	20	0	25	
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
⬜	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
▨	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



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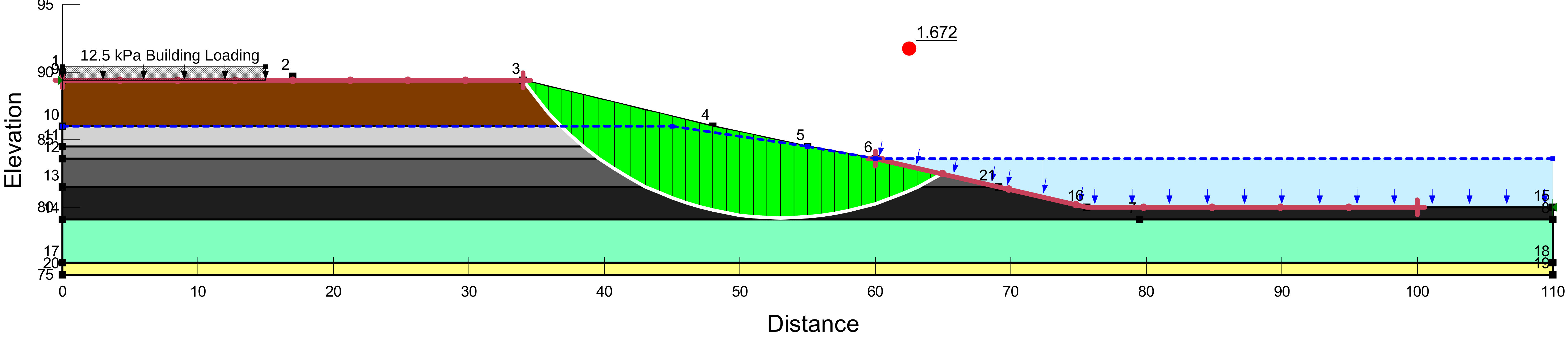
DATE Aug 26, 2022
CLIENT: Structura Construction
project no. OTT-24002636-A0
DESIGN DW
CHECKED SA
DRAWN BY DW
TITLE: PSEUDO-STATIC SLOPE STABILITY ANALYSIS
Total Stress Parameters - Existing Conditions
100 Bill Leathem Drive, Ottawa, ON
scale Not to scale
Figure A-6

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
🟫	Clay Crust (Effective)	Mohr-Coulomb	18	10	32
🟨	Glacial Till	High Strength	22		
🟩	Silt	Mohr-Coulomb	18	0	28
⬜	Unweathered Clay Layer 1 (Effective Stress)	Mohr-Coulomb	16	0.5	28
▨	Unweathered Clay Layer 2 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28
▨	Unweathered Clay Layer 3 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28
⬛	Unweathered Clay Layer 4 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28



Section A-A'

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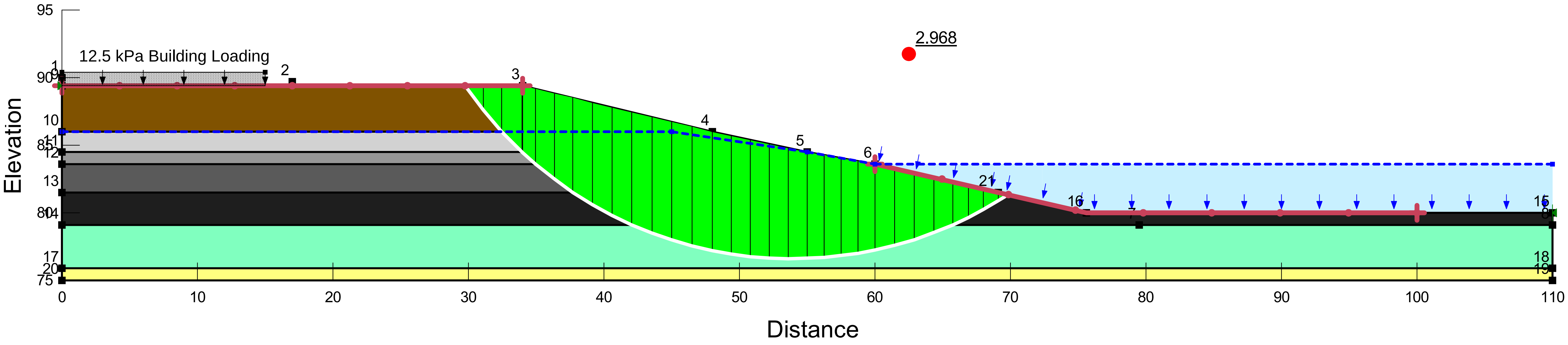
DATE May 9, 2024
CLIENT: Structura Construction
project no. OTT-24002636-A0
DESIGN DW
CHECKED SA
DRAWN BY DW
TITLE: STATIC SLOPE STABILITY ANALYSIS
Effective Stress Parameters - Building Loading
100 Bill Leathem Drive, Ottawa, ON
scale Not to scale
Figure A-7

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Undrained Shear Strength (kPa)
🟫	Clay Crust (Total Stress)	Undrained (Phi=0)	18			110
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
⬜	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
▒	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
▓	Unweathered Clay Layer 3 (Total Stress)	Undrained (Phi=0)	16.5			65
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



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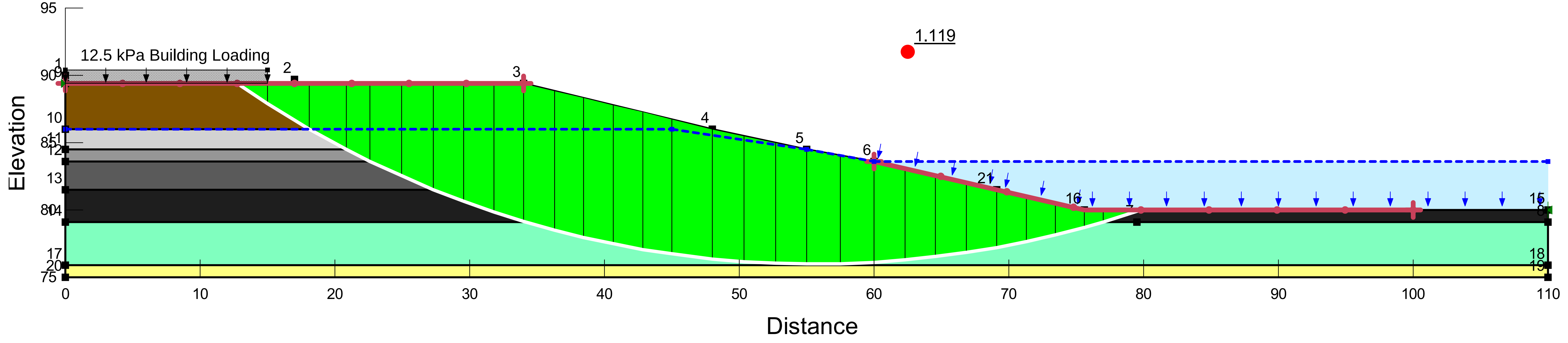
DATE May 9, 2024		CLIENT: Structura Construction	project no. OTT-24002636-A0
DESIGN DW	CHECKED SA	TITLE: STATIC SLOPE STABILITY ANALYSIS Total Stress Parameters- Building Loading 100 Bill Leathem Drive, Ottawa, ON	scale Not to scale
DRAWN BY DW			Figure A-8

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Undrained Shear Strength (kPa)
🟫	Clay Crust (Total Stress)	Undrained (Phi=0)	18			110
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
⬜	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
▒	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
▓	Unweathered Clay Layer 3 (Total Stress)	Undrained (Phi=0)	16.5			65
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



Section A-A'

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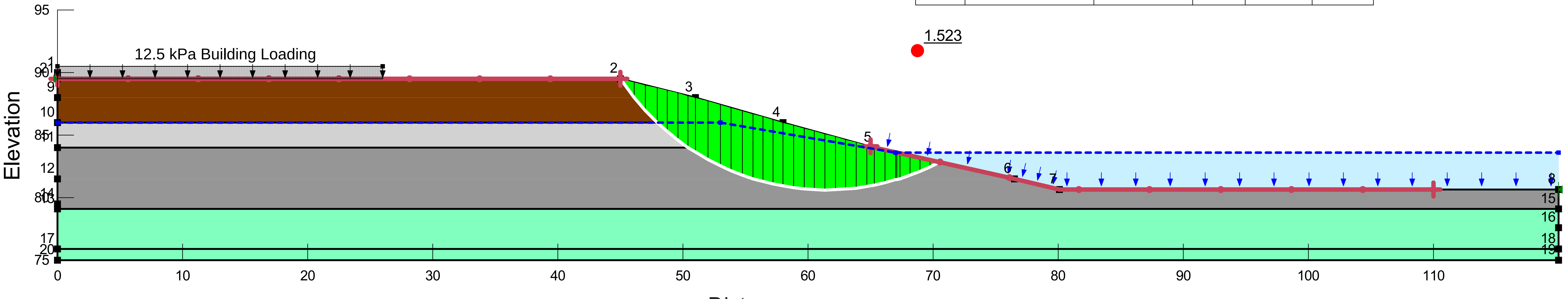
DATE May 9, 2024		CLIENT: Structura Construction	project no. OTT-24002636-A0
DESIGN DW	CHECKED SA	TITLE: PSEUDO-STATIC SLOPE STABILITY ANALYSIS Total Stress Parameters - Building Loading 100 Bill Leathem Drive, Ottawa, ON	scale Not to scale
DRAWN BY DW			Figure A-9

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
🟫	Clay Crust (Effective)	Mohr-Coulomb	18	10	32
🟨	Glacial Till	High Strength	22		
🟩	Silt	Mohr-Coulomb	18	0	28
⬜	Unweathered Clay Layer 1 (Effective Stress)	Mohr-Coulomb	16	0.5	28
⬛	Unweathered Clay Layer 2 (Effective Stress)	Mohr-Coulomb	16.5	0.5	28



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DATE May 9, 2024
DESIGN DW
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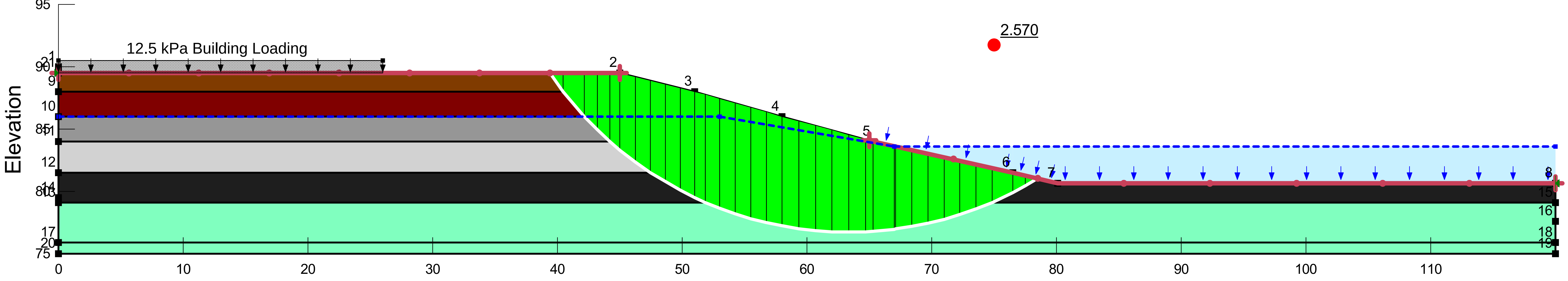
DRAWN BY DW
CLIENT: Structura Construction
TITLE: STATIC SLOPE STABILITY ANALYSIS
Effective Stress Parameters - Building Loading
100 Bill Leathem Drive, Ottawa, ON
project no. OTT-24002636-A0
scale Not to scale
Figure A-10

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Undrained Shear Strength (kPa)
🟫	Clay Crust (Total Stress) Section B	Undrained (Phi=0)	18			150
🟥	Clay Crust Lower (Total Stress) Section B	Undrained (Phi=0)	18			75
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
◻	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
◼	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



Section B-B'

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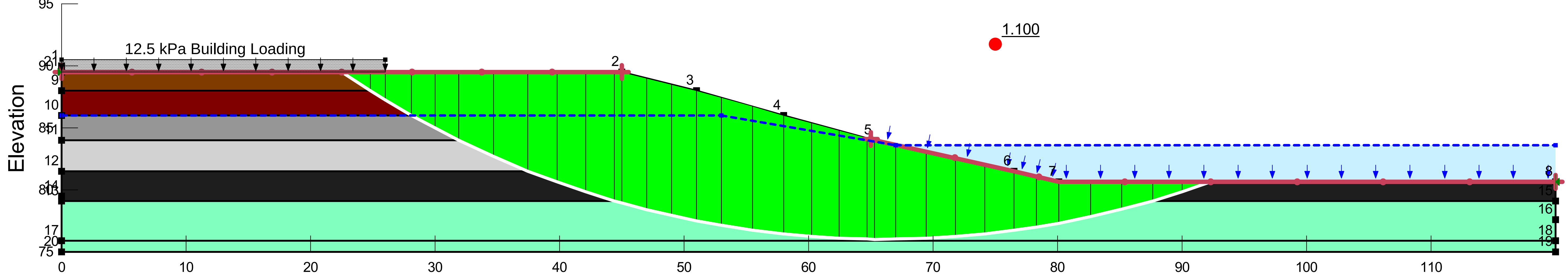
DATE May 9, 2024
CLIENT: Structura Construction
project no. OTT-24002636-A0
DESIGN DW
CHECKED SA
DRAWN BY DW
TITLE: STATIC SLOPE STABILITY ANALYSIS
Total Stress Parameters- Building Loading
100 Bill Leathem Drive, Ottawa, ON
scale Not to scale
Figure A-11

Color	**Name**	**Slope Stability Material Model**	**Unit Weight (kN/m³)**	**Effective Cohesion (kPa)**	**Effective Friction Angle (°)**	**Undrained Shear Strength (kPa)**
🟫	Clay Crust (Total Stress) Section B	Undrained (Phi=0)	18			150
🟥	Clay Crust Lower (Total Stress) Section B	Undrained (Phi=0)	18			75
🟨	Glacial Till	High Strength	22			
🟩	Silt	Mohr-Coulomb	18	0	28	
⬜	Unweathered Clay Layer 1 (Total Stress)	Undrained (Phi=0)	16			50
▨	Unweathered Clay Layer 2 (Total Stress)	Undrained (Phi=0)	16.5			30
⬛	Unweathered Clay Layer 4 (Total Stress)	Undrained (Phi=0)	16.5			45



Section B-B'

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DATE Aug 26, 2022		CLIENT: Structura Construction	project no. OTT-24002636-A0
DESIGN DW	CHECKED SA	TITLE: PSEUDO-STATIC SLOPE STABILITY ANALYSIS Total Stress Parameters - Building Loading 100 Bill Leathem Drive, Ottawa, ON	scale Not to scale
DRAWN BY DW			Figure A-12

Government of Canada
Gouvernement du Canada

Canada.ca > Natural Resources Canada > Earthquakes Canada

2020 National Building Code of Canada Seismic Hazard Tool

This application provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada (NBC) 2020 as prescribed in Article 1.1.3.1. of Division B of the NBC 2020.

Seismic Hazard Values

User requested values

Code edition	NBC 2020
Site designation X_S	X_D
Latitude (°)	45.294
Longitude (°)	-75.712

Please select one of the tabs below.

NBC 2020 | Additional Values | Plots | API | Background Information

The 5%-damped spectral acceleration ($S_a(T,X)$, where T is the period, in s, and X is the site designation) and peak ground acceleration (PGA(X)) values are given in units of acceleration due to gravity (g, 9.81 m/s^2). Peak ground velocity (PGV(X)) values are given in m/s. Probability is expressed in terms of percent exceedance in 50 years. Further information on the calculation of seismic hazard is provided under the *Background Information* tab.

The 2%-in-50-year seismic hazard values are provided in accordance with Article 4.1.8.4. of the NBC 2020. The 5%- and 10%-in-50-year values are provided for additional performance checks in accordance with Article 4.1.8.23. of the NBC 2020.

See the *Additional Values* tab for additional seismic hazard values, including values for other site designations, periods, and probabilities not defined in the NBC 2020.

NBC 2020 - 2%/50 years (0.000404 per annum) probability

$S_a(0.2, X_D)$	$S_a(0.5, X_D)$	$S_a(1.0, X_D)$	$S_a(2.0, X_D)$	$S_a(5.0, X_D)$	$S_a(10.0, X_D)$	$PGA(X_D)$	$PGV(X_D)$
0.63	0.513	0.306	0.146	0.0407	0.0127	0.368	0.359

The log-log interpolated 2%/50 year $S_a(4.0, X_D)$ value is : **0.0556**

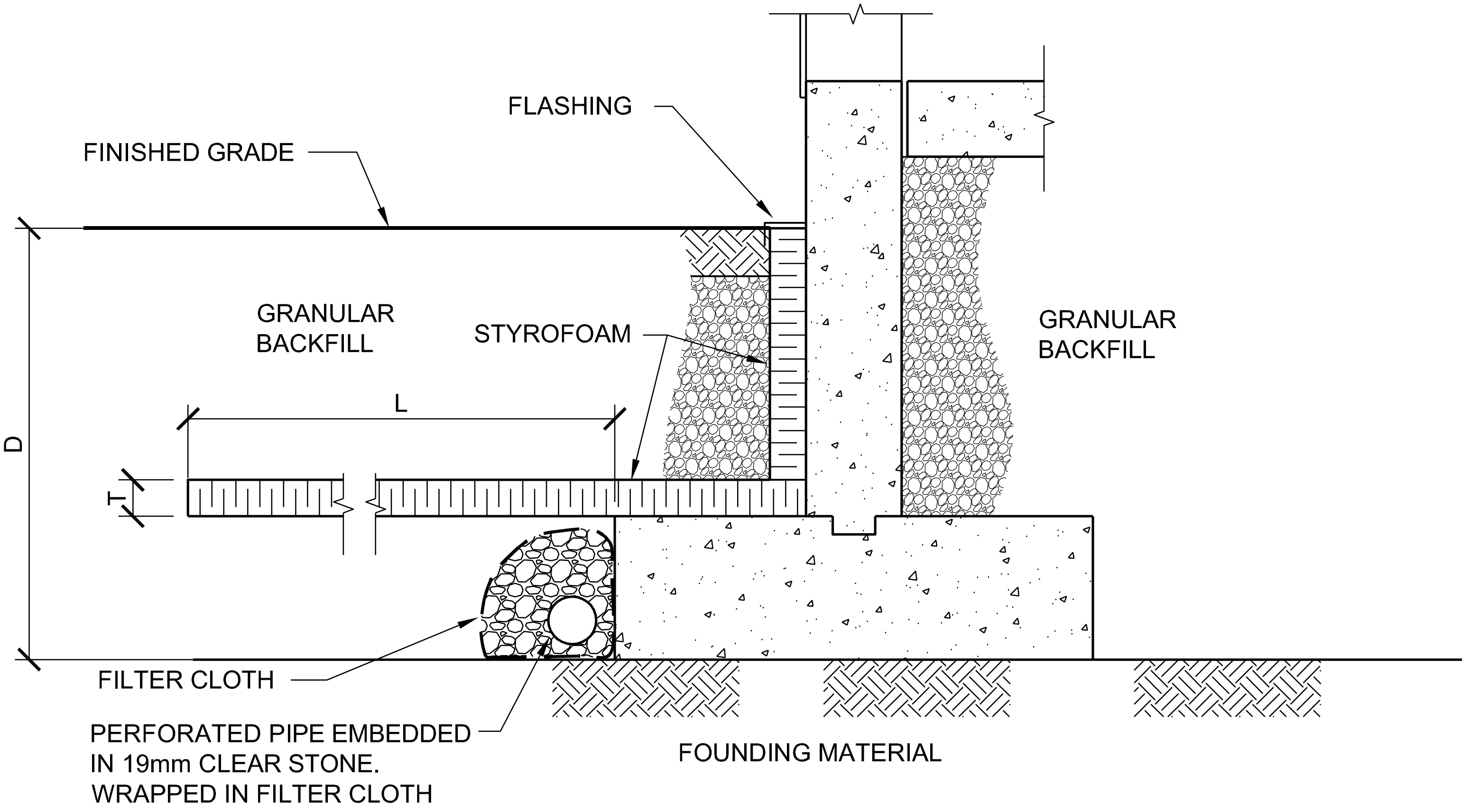
▶ Tables for 5% and 10% in 50 year values

Download CSV

⬅ Go back to the seismic hazard calculator form

Date modified: 2021-04-06

Appendix B – Foundation Insulation for a Heated Structure



NOTES:
REFER TO ATTACHED TABLE FOR DIMENSIONS FOR A GIVEN SOIL COVER "D"

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The new identity of Trow

SCALE NTS
DATE: May 2024
DRAWN: M.N.

PROJECT:
GEOTECHNICAL REPORT
100 BILL LEATHEM DRIVE, OTTAWA, ON

TITLE:
FOUNDATION INSULATION DETAILS
HEATED STRUCTURE

JOB NO. OTT-24002436-A0
FIGURE NO. B-1

Appendix C – Laboratory Certificate of Analysis

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-24002636-A0

AGAT WORK ORDER: 24Z136815

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Lab Operation Manager

DATE REPORTED: Apr 12, 2024

PAGES (INCLUDING COVER): 5

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.*
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- *All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.*
- *For environmental samples in the Province of Quebec: The analysis is performed on and results apply to samples as received. A temperature above 6°C upon receipt, as indicated in the Sample Reception Notification (SRN), could indicate the integrity of the samples has been compromised if the delay between sampling and submission to the laboratory could not be minimized.*

Member of: Association of Professional Engineers and Geoscientists of Alberta (APEGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

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Certificate of Analysis

AGAT WORK ORDER: 24Z136815
PROJECT: OTT-24002636-A0

CLIENT NAME: EXP SERVICES INC **ATTENTION TO: Matthew Zammit**
SAMPLING SITE:100 Bill Leathem Drive, Ottawa **SAMPLED BY:EXP**

(Soil) Inorganic Chemistry

DATE RECEIVED: 2024-04-05 **DATE REPORTED: 2024-04-12**

			SAMPLE DESCRIPTION:	BH1 SS4 10'-12'
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2024-03-21
Parameter	**Unit**	**G / S**	**RDL**	**5787130**
Chloride (2:1)	µg/g		2	178
Sulphate (2:1)	µg/g		2	62
pH (2:1)	pH Units		NA	8.26
Resistivity (2:1) (Calculated)	ohm.cm		1	3820

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
5787130 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: Amanjot Bhela

CHARTERED
AMANJOT BHELA
CHEMIST

Quality Assurance

CLIENT NAME: EXP SERVICES INC
PROJECT: OTT-24002636-A0
SAMPLING SITE:100 Bill Leathem Drive, Ottawa

AGAT WORK ORDER: 24Z136815
ATTENTION TO: Matthew Zammit
SAMPLED BY:EXP

Soil Analysis

RPT Date: Apr 12, 2024			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
(Soil) Inorganic Chemistry															
Chloride (2:1)	5787073		540	551	2.0%	< 2	101%	70%	130%	97%	80%	120%	NA	70%	130%
Sulphate (2:1)	5787073		90	88	2.2%	< 2	100%	70%	130%	96%	80%	120%	96%	70%	130%
pH (2:1)	5788446		8.58	8.55	0.4%	NA	107%	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.

Certified By: Amanjot Bhela

AMANJOT BHELA

Method Summary

CLIENT NAME: EXP SERVICES INC
PROJECT: OTT-24002636-A0
SAMPLING SITE:100 Bill Leathem Drive, Ottawa

AGAT WORK ORDER: 24Z136815
ATTENTION TO: Matthew Zammit
SAMPLED BY:EXP

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
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

Have feedback? Scan here for a quick survey!

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 #: 24Z1360815

Cooler Quantity: one-no ice/pack

Arrival Temperatures: 22.9 | 22.6 | 22.8
3.8 | 3.5 | 3.0

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes:

Report Information:

Company: EXP Services Inc
Contact: Matthew Zammit
Address: 2650 Queensview Drive Unit 100, Ottawa, ON, K2B 8H6
Phone: 613-688-1891 Fax:
Reports to be sent to:
1. Email: matthew.zammit@exp.com
2. Email: jeff.macmillan@exp.com

Regulatory Requirements:

(Please check all applicable boxes)

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

☐ Regulation 406
Table ____ *Indicate One*
☐ Regulation 558
☐ CCME

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

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

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

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-24002636-A0
Site Location: 100 Bill Leathem Drive, Ottawa
Sampled By: EXP
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

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	Metals - ☐CrVI, ☐Hg, ☐HWSB	BTEX, F1-F4 PHCs	VOC	PAHs	PCBs	PCBs: Aroclors ☐	O. Reg 558 Landfill Disposal Characterization TCLP: TCLP: ☐M&I ☐VOCs ☐ABNs ☐B(a)P ☐PCBs	O. Reg 406 Regulation 406 SPLP Rainwater Leach SPLP: ☐Metals ☐VOCs ☐SVOCs	Regulation 406 Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Corrosivity: ☐Moisture ☐ Sulphide	pH	Sulphate	Chloride	Resistivity			Potentially Hazardous or High Concentration (Y/N)
1. BH 1 SS4 10'-12'	March 21	AM PM	1	S														☑	☑	☑	☑			
2.		AM PM																						
3.		AM PM																						
4.		AM PM																						
5.		AM PM																						
6.		AM PM																						
7.		AM PM																						
8.		AM PM																						
9.		AM PM																						
10.		AM PM																						
11.		AM PM																						

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Jeff MacMillan	April 5, 2024		C. Griffith	04/05/24	16h25
Cc to [illegible]	04/08/24	15h00	M. GRASIC	Apr 9	8:50

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