Geotechnical Investigation and Design Report

The Wicker Image Inc.

Type of Document:
Report

Project Name:
Proposed Residential Development
CKSO Road, Sudbury, Ontario

Project Number:
SUD-23015629-A0

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Further to our original Proposal No. 23/179/GP, dated November 27, 2023, EXP Services Inc. (EXP) has completed the geotechnical engineering evaluation for the proposed Residential Subdivision. Our comments and recommendations, based on the results of the field investigation and our understanding of the project scope, are provided in this report.

1. Introduction

It is understood by EXP that seven (7) residential lots are proposed for development along CKSO Road in Sudbury, Ontario. The lots will be located on the east side of CKSO Road, extending south from the intersection of Goodview Road. It is understood that the lots will be serviced with individual septic systems.

To assist with the design and development of the proposed residential lots, EXP has completed a geotechnical investigation at the site, with the results of the investigation and associated recommendations included within this report.

2. Field Investigation

The field investigation for this project consisted of the advancement of seven (7) sampled boreholes at accessible locations within the general footprint of each proposed lot. The borehole locations were determined in the field by EXP's geotechnical representative and are shown on Dwg. No. A-1, included in Appendix A.

The sampled boreholes were advanced on January 22 and 23, 2024 using a power auger drill rig equipped with 200 mm diameter Hollow Stem Augers (HSA) to depths shown on the attached borehole logs, Figures B-2 to B-8, in Appendix B. Soil samples were obtained using a 51 mm (2 inch) outside diameter split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586), at depths noted on the attached borehole logs in Appendix B. The Standard Penetration Test (SPT) "N" values were recorded and used to provide an assessment of the in-situ compactness condition of the encountered soils. A Dynamic Cone Penetration Test (DCPT) was completed adjacent to four (4) of the sampled boreholes in order to further assess the compactness condition of the encountered soils.

Groundwater level measurements were attempted within the open boreholes upon completion. Groundwater monitoring wells were installed in four (4) of the boreholes to observe long-term groundwater levels. The remaining boreholes were backfilled with auger cuttings and sealed with bentonite.

The retained soil samples were logged in the field and then carefully packaged and transported to our laboratory for detailed examination and testing.

The locations and elevations of the wells were provided to EXP by Dorland Surveying. The remaining elevations of the boreholes were extrapolated from the survey data. The locations and elevations should be considered accurate only to the degree implied by the methods used for reference purposes of this report. They should not be used for detailed design purposes.

3. Laboratory Testing

A laboratory testing program was performed on representative soil samples and consisted of particle size analyses and moisture content determinations. The geotechnical laboratory test results are summarized on the attached borehole logs in Appendix B, with detailed results included in Appendix C.

4. Subsurface Conditions

Details of the soils encountered during the field investigation are summarized on the attached logs in Appendix B. The logs include textural descriptions of the subsoil and indicate the soil boundaries inferred from non-continuous sampling and observations during the field investigation. These boundaries reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. When reading this report, the explanatory notes and definitions provided in Figures B-1A and B-1B in Appendix B should be referenced.

In general, the boreholes encountered topsoil overlying native cohesionless silt to clayey silt.

Topsoil was encountered at the surface of each borehole and ranged in thickness from 150 to 200 mm. Topsoil thicknesses may further vary beyond the borehole location.

Underlying the topsoil was native silt that extended to the borehole termination depths of 5.2 m at each borehole except BH-4, where the silt extended to 3.1 m depth. The silt was grey to brown in colour, moist to wet, and contained some clay and trace to some sand. Uncorrected SPT “N” values within the silt ranged from 6 to 18 blows per 300 mm, classifying the silt as loose to compact in compactness condition. Measured moisture contents within the silt ranged from 19.2 to 28.6%.

Underlying the silt at Borehole BH-4 and extending to the borehole termination depth of 5.2 m was native clayey silt. The clayey silt was brown to grey in colour, wet, and contained trace sand. Uncorrected SPT “N” values within the clayey silt ranged from 8 to 9 blows per 300 mm, classifying the clayey silt as loose in compactness condition. Measured moisture contents within the clayey silt ranged from 24.9 to 26.6%.

A Dynamic Cone Penetration Test (DCPT) was advanced adjacent to Boreholes BH-1, BH-3, BH-5, and BH-7. The DCPT values were generally higher than the SPT “N” values within the boreholes, suggesting the compactness condition of the encountered soils is higher than noted by the SPT results.

4.1 Groundwater

Each borehole was dry during the short term the boreholes were left open upon completion. Groundwater monitoring wells were installed at Boreholes BH-1, BH-3, BH-5, and BH-7 to observe long-term groundwater levels. EXP returned to the site on March 6, 2024 to measure the groundwater levels, with the results as follows:

Borehole No.	Surface Elev. (m, hand-held GPS)	Groundwater Depth (m) – March 6, 2024	Groundwater Elev. (m)
BH-1	242	0.36	241.64
BH-3	234	0.20	233.80
BH-5	242	0.00	242.00
BH-7	239	0.21	238.79

Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (such as spring thaw and late fall) and lower levels occurring during dry weather conditions.

5. Foundation Recommendations

Based on the soil conditions encountered, the proposed residential structures can be founded on conventional strip or spread footings bearing on the loose to compact native silt soils, or on a thickened edge slab-on-grade foundation bearing on an engineered fill pad overlying the loose to compact native silt soils.

It is cautioned that encountered groundwater levels were quite high. As such, excavations approaching, or below, the groundwater elevation will require significant dewatering and should be avoided if possible. Construction is also recommended to be completed in typically drier months (late summer, early fall). Groundwater levels should be monitored within the installed wells to understand long-term groundwater levels prior to construction.

Foundations and floors should be established a minimum of 0.6 m above the groundwater elevation. As such, raising of the existing site grades is anticipated to allow for the construction of the residential buildings.

5.1 Site Preparation

Grade raises are anticipated for construction of the residential buildings. Prior to placing fill materials for the grade raises, all in-situ topsoil and/or other deleterious materials are to be removed down to competent native soils. The exposed subgrade below the zone of influence of any foundations or floor slab-on-grade is to be proof-rolled and visually inspected by a qualified geotechnical engineer from this office to verify the founding soil conditions and construction procedures. Any soft areas encountered during proof rolling should be excavated and replaced with a Granular “A” or Granular “B” Type II in accordance with Ontario Provincial Standards and Specifications (OPSS) 1010.

Groundwater is anticipated at surface to a depth of 0.36 m based on observations within the installed wells on March 6, 2024.

Any fill materials to be placed below the zone of influence of any foundation, or below any floor slab-on-grade, is to consist of Granular “B” Type I or II, or Granular “A”, in accordance with OPSS 1010. A final 300 mm thick layer of Granular “A” (OPSS 1010) should be placed directly below the foundations. All engineered fill is to be placed in maximum 150 mm thick lifts and is to be compacted to 100% Standard Proctor Maximum Dry Density (SPMDD), within 1.5% of optimum moisture content. Engineered fill placement and compaction is to be continuously monitored on a full-time basis by a qualified geotechnical representative from EXP. If wet soil conditions are present, a non-woven geotextile separator (Terrafix 270R or equivalent) is to be used between the subgrade soils and the up-fill material to stabilize the native soils.

Where engineered fill is placed below the foundations, it is to extend horizontally a minimum of 0.3 m beyond the edges of the foundation and slope down at 1H:1V to the underlying native soils to ensure the foundation loads are properly transferred to the underlying subgrade.

The location of any foundation on an engineered soil pad is critical and certification by a qualified surveyor that the foundations are within the stipulated boundaries is mandatory. Since layout stakes are often damaged or removed during fill placement, offset stakes must be installed and maintained by the surveyors during the course of fill placement so that the contractor and engineering staff are continually aware of where the engineered fill limits lie.

Foundations, which are to be placed at different elevations in soils or near service trenches, should be located such that the footings are set below a line drawn up at 10 horizontal to 7 vertical from the near edge of a lower foundation or bottom of a service trench, as indicated on Figure 5-1 below.

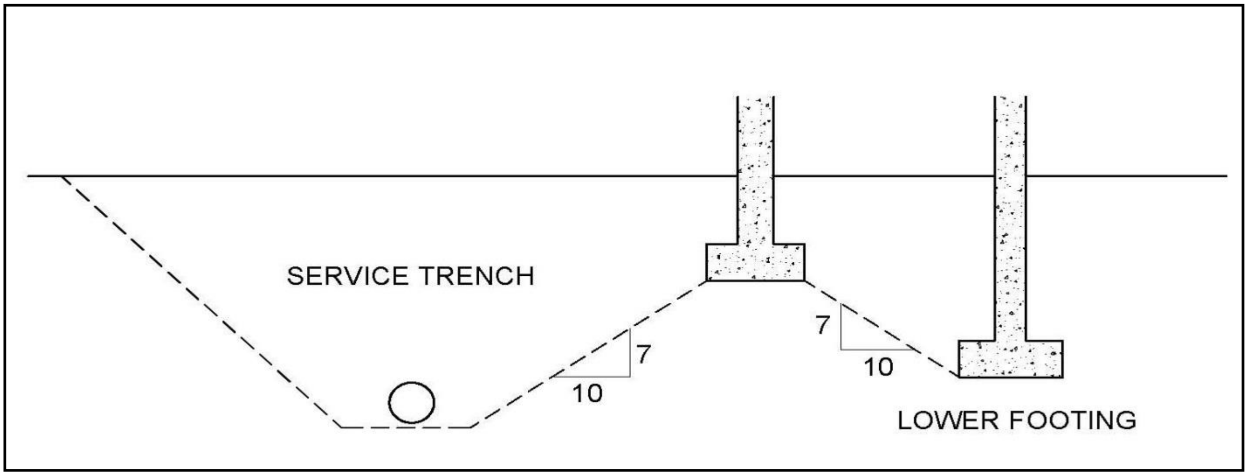

Figure 5-1: Footings near Service Trenches or at Different Elevations

It is recommended and of best practice, that all grade raises and site infill must be completed prior to building construction in order to ensure that any potential settlements, from the additional soil weight, dissipate before the building foundations and are constructed. In the cohesionless silts soils encountered, settlements should occur relatively quickly.

Within general landscaped areas, outside of the zone of influence of any foundations, floor slabs-on-grade, or roadways, fill materials may consist of Select Subgrade Material (SSM) in accordance with OPSS 1010, or an alternative well graded granular fill, free of organics or other deleterious materials, and approved by EXP. In these areas, fill materials should be placed in maximum 200 mm thick lifts and compact to 98% SPMDD within 2% of optimum moisture content.

5.2 Conventional Shallow Foundations and Thickened Edge Slab-on-Grade Foundations

Foundations founded on the native subsoils or on engineered fill overlying the native subsoils, can be designed with a factored geotechnical resistance at Ultimate Limit States (ULS) of 150 kPa. This value was calculated using a geotechnical resistance factor of 0.5. A bearing pressure at Serviceability Limit States (SLS) of 100 kPa may be used. Footings designed with the recommendations contained herein are expected to settle less than 25 mm total and 20 mm differential. Additional upfill, across the lots for grading purposes, of up to 3.0 m has been accounted for, in providing the above noted bearing capacity.

Based on the Canadian Foundation Engineering Manual (CFEM) 4th Edition, 2006, and in conjunction with engineering experience and analysis of the results of our soil investigation program, a vertical modulus of subgrade reaction (Kv) of the native soils can be taken as 10 MPa/m. Corrections for the modulus of subgrade reaction for size and shape shall be in accordance with the CFEM 4th Edition, 2006, Section 7.7.1.

Site preparation as noted in Section 5.1 is to be completed prior to construction of any foundations.

For a thickened edge slab-on-grade foundation, sufficient earth cover frost protection will not be available and as such, insulation will be required as outlined in Section 5.5 of this report. If proposed site grades will not provide sufficient earth cover frost protection for conventional strip or spread footings, insulation will also be required.

These foundation recommendations assume the structures are lightly loaded. Strip and spread footing widths must comply with minimum Code requirements.

5.3 Floor Slab-on-Grade

For a floor slab-on-grade where strip or spread foundations are used, construction will be possible at this site provided that site preparation is completed in accordance with Section 5.1 of this report. A final 300 mm thick layer of 19 mm minus clearstone (OPSS 1004) or Granular "A" (OPSS 1010) should be placed directly below the floor slab-on-grade combined with an appropriate moisture barrier such as a polyethylene membrane. All fill material below the floor slab-on-grade should be placed in maximum 150 mm thick lifts and be compacted to 100% of the SPMDD within 1.5% of the optimum moisture content.

Due to the anticipated high groundwater conditions noted at the site, the finish floor elevation of the lowest floor slab-on-grade should be designed to be a minimum of 600 mm above the groundwater elevation. As such based on current date the finish floor elevations for Lots 1 and 2 should be established a minimum of 0.24 above current grades. Those for Lots 3 and 4 should be established a minimum of 0.40 above current grades. Those for Lots 5 and 6 should be established a minimum of 0.60 above current grades. And those for Lots 7 should be established a minimum of 0.40 above current grades.

5.4 Backfill Recommendations

All imported backfill material used to backfill foundations should consist of Granular "B" Type I or Granular "B" Type II (OPSS 1010) material. Any Granular "B" used against or below foundations should have a maximum aggregate size of 120 mm and must be placed in lifts no greater than 150 mm in thickness and must be compacted to 100% SPMDD. Care must be taken to ensure over compaction and damage to the foundation does not occur.

5.5 Frost Considerations

The freezing index in the Greater Sudbury area is approximately 1,330 C degree-days. There is potential for up to 2.1 m of frost penetration to occur over the winter months in unprotected, unheated areas and 1.7 m for heated structures. A structure is considered heated if the temperature within the structure is maintained no lower than 18° C.

As such, foundations for unheated structures should be provided with the equivalent of a minimum of 2.1 m of earth cover frost protection and foundations for heated structures should be provided with a minimum of 1.7 m of earth cover frost protection.

Where sufficient earth cover is not available, or if a thickened edge slab-on-grade foundation is utilized, insulation will be required. Insulation should consist of rigid extruded polystyrene, have a minimum compressive strength of 275 kPa, and an R-Value of 5 for every 25.4 mm of thickness, (i.e. Styrofoam High Load 40). Any exposed insulation is to be protected against sunlight and physical damage. A rough estimate for cost evaluation purposes can be made by assuming that 25.4 mm of rigid insulation designed for below grade installation is equivalent to 300 mm of soil cover. Note that insulation for unheated structures must extend below the entire foundation. Higher compressive strength insulation (i.e. Styrofoam High Load 60 or 100, etc.) may be required if insulation extends below foundations, depending on foundation loading conditions.

Detailed insulation recommendations can be provided by EXP, if necessary, once the final foundation designs have been determined.

5.6 Lateral Earth Pressure

Any foundations or retaining structures should be designed to resist lateral earth pressure. The expression for calculating lateral earth pressure "p" at any depth "h" is given by the following:

$$\mathbf{p = K(\gamma h + q) + \gamma_w h_w}$$

where

p = Lateral earth pressure (kPa)
K = Coefficient of earth pressure
γ = Unit weight of backfill (kN/m^3)
γ_w = Unit weight of water (kN/m^3)
h = Depth to point of interest (m)
h_w = Depth of water above point of interest (m)
q = Surcharge load acting adjacent to the wall at the ground surface (kPa)

The below tables list various earth pressure properties for given materials.

Material	Friction Angle ø´ (unfactored)	Coefficient of Active Earth Pressure (k_a)	Coefficient of Passive Earth Pressure (k_p)	Coefficient of Earth Pressure at Rest (k_o)	Unit Weight γ (kN/m^3)
Granular "A"	38°	0.24	4.2	0.38	22
Granular "B" Type I	35°	0.27	3.7	0.43	21
Granular "B" Type II	38°	0.24	4.2	0.38	21

Note: Values given for horizontal earth pressures are for horizontal backfill. For sloping backfill, the design requirements outlined in the Canadian Foundation Engineering Manual should be used.

The mobilization of full active or passive resistance requires a measurable and perhaps significant wall movement or rotation. Therefore, unless the structural element can tolerate these deflections, the at-rest earth pressure should be used in design.

The effects of compaction surcharge should be taken into account in the calculations of active and at rest earth pressures. The lateral pressure due to compaction should be taken as at least 12 kPa at the surface, and its magnitude should be assumed to diminish linearly with depth to zero at the depth where the active (or at rest) pressure is equal to 12 kPa. This pressure distribution should be added to the calculated active (or at rest) pressure. Notwithstanding, lighter compaction equipment and smaller lifts should be used adjacent to walls to prevent overstressing.

5.7 Drainage

The exterior grade around the buildings should be sloped away from the walls to prevent surface runoff from entering the building. Permanent perimeter weeping tile should be installed where any floor is less than 150 mm above final grade and is required to be dry. The drainage tile should have a minimum diameter of 100 mm and be surrounded by well-draining filter material (i.e. 20 mm clearstone gravel). The filter material should be surrounded with a non-woven geotextile. The perforated drainage tile should drain to a suitable drainage area or interior sump. Any subsurface walls should be adequately damp-proofed above the water table and waterproofed below the water table. The roof drains should discharge away from the building to appropriate drainage areas.

5.8 Site Classification for Seismic Response

The Ontario Building Code (OBC) has adopted the National Building Code of Canada requirements for seismic design considerations. The Site Classification for Seismic Response has been estimated based on the boreholes advanced at the site. As the Site Classification for Seismic Response is based on soil conditions in the upper 30 m, assumptions were made by EXP for the soil conditions below the borehole termination depths.

Based on EXP's assumptions, the site is classified as Site Class E as per the OBC clause 4.1.8.4, Site Properties and Table 4.1.8.4 A, Site Classification for Seismic Response.

These earthquake/seismic design parameters should be reviewed in detail by the structural engineer and incorporated into the design as required. As this site class is based on an assumption of the soil conditions, the site class may not be sufficient, and it may result in an overdesign of the structure.

If a precise Site Classification is required, EXP can provide a quote to perform the necessary testing.

6. Preliminary Septic Design Consideration

It is understood that the proposed residential lots will be serviced by individual septic systems. It is unknown at this stage where the septic system will be located and what final grades would be. As such, to provide preliminary septic design information, two tested samples obtained near the surface of the site were analyzed to provide an estimated percolation time (T), as an indication of the suitability of the soil for use within a Class 4 Sewage System.

Note that these recommendations are preliminary and additional sampling and testing should be completed once the final septic locations and grades are determined.

Borehole BH-1, Sample AS1, 0.25 to 0.8 m depth

- D_{10} = 0.00046
- D_{60} = 0.042
- C_u = 91.3
- Estimated Hyd. Cond. (K) = 2.1 x 10^{-7} cm/sec
- Estimated Perc. Time (T) = > 50 min/cm
- Recommended Perc. Time (T) = > 50 min/cm

Based on the particle size analysis, the sample tested is a silt, some sand, some clay with an estimated percolation "T" time of >50 min/cm. As such, these soils are not suitable for a septic system and a raised bed would be required at this location with imported material.

Borehole BH-6, Sample SS2, 0.8 to 1.4 m depth

- D_{10} = 0.0017 mm
- D_{60} = 0.016 mm
- C_u = 9.4
- Estimated Hyd. Cond. (K) = 2.9 x 10^{-6} cm/sec
- Estimated Perc. Time (T) = 35 - 50 min/cm
- Recommended Perc. Time (T) = 50 min/cm

Based on the particle size analysis, the sample tested is a silt, some clay, trace sand with an estimated percolation "T" time of 35 to 50 min/cm. As such, 50 min/cm should be used for design.

It must be noted that the permeability and percolation rates have been estimated based on an approximate relationship of soil types as determined by the grain size distribution test conducted. Variability of soil types and actual performance of in-situ soils may vary across the site.

7. Excavations

The in-situ native soils may be classified as Type 3 soils for excavations terminating above the groundwater level and Type 4 soils for excavations terminating below the groundwater level in conformance with the Ontario Occupational Health and Safety Act (OHSA). Excavation side slopes in Type 3 soils should remain stable at a slope of 1H:1V. Excavation side slopes in Type 4 soils should remain stable at a slope of 3H:1V. The need to excavate flatter side slopes if excessively wet or soft/loose materials, or concentrated seepage zone are encountered, should not be overlooked.

Water (i.e. surface water runoff) should not be permitted to enter and/or pond within the construction area.

All excavations must be completed in accordance with the most recent regulations in the Ontario Occupational Health and Safety Act. The contractor should be aware that slope height, slope inclination, or excavation depths, should in no case, exceed those specified in local, provincial or federal safety regulations. Such regulations are strictly enforced and, if not followed, the owner, the contractor or earthwork or utility subcontractor could be liable for substantial penalties.

It is important to note that soils encountered in the construction excavations may vary significantly across the site. Our preliminary soil classifications are based solely on the materials encountered in widely spaced explorations. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, we recommend that EXP be contacted immediately to evaluate the conditions encountered.

7.1 Re-Use of Excavated Material

The encountered native soils cannot be re-used as free draining engineered fill, however, can be used for general landscaping purposes provided it is environmentally safe to do so. Excavated soils to be removed off site are considered to be Excess Soils and disposal of such soils should follow O.Reg. 406/19. Once the final site plan has been determined, and the known volume of soils to be excavated and removed off site is known, additional excess soil field studies can be completed. EXP would be pleased to complete the additional studies and provide all recommendations required.

8. Dewatering

As noted previously, groundwater was encountered at surface to a depth 0.36 m below existing grades on March 6, 2024. With the anticipated shallow groundwater, excavations approaching or extending below the groundwater level should be avoided if possible. Below the groundwater level, significant dewatering will be required during excavation, and possibly temporary shoring. Above the groundwater table, any perched water should be possible to remove using conventional construction pumps.

The estimated hydraulic conductivity, “K” of the native silt to clayey silt, based on empirical information, is 10^{-6} cm/s or slower.

Dewatering requirements will be governed by the time of the year the construction is performed. It is the responsibility of the Contractor to propose a suitable dewatering system based on the time of construction and groundwater levels. The method used should not undermine any adjacent structures or buried services. The dewatering method is the responsibility of the Contractor and the Contractor should submit his proposal to the Prime Consultant for review and approval prior to construction.

9. Construction Constraints Under Cold Weather Conditions

For all construction activities at this site, the following applies:

- During excavations, all subgrade soils must be maintained at a minimum temperature of 5° C.
- No granular material may be placed under frozen conditions, with all fill material maintained at a minimum temperature of 5° C prior to and during installation. If granular fill is to be placed in freezing conditions, the granular fill must be restricted to Granular “B” Type II material. Since Granular “B” Type II has a larger aggregate size, care should be taken to prevent point loading on the underside of the concrete.
- Soils and granular fill material that are in direct contact with fresh concrete must be at a minimum temperature of 5° C prior to pouring the concrete and must be free of snow and ice fragments.
- All granular fill, prior to placement of concrete, must be reviewed by this office to ensure that it is free of frost, buried ice and snow.
- All reinforcing steel in the concrete forms must be free of ice and snow, and must be maintained at a minimum temperature of 5° C.
- During the placement of concrete in cold weather conditions, a field cured cylinder should be placed beside the heated form for a period of 6 days. The field cured cylinder should be returned to a designated laboratory on the sixth day for 7-day compressive strength testing.
- All heated and tarped areas should be monitored for temperature using a max/min thermometer.
- All concrete is to have a minimum of 6% to 8% air entrainment to prevent cracking and shall be maintained at a minimum temperature of 10° C for a period of 4 to 7 days.

The 6% to 8% air entrained concrete during cold weather placement is to prevent significant strength loss of concrete as a result of freezing and thawing. The air entrainment will provide the capacity to absorb stresses during freeze/thaw action.

10. Construction Quality Control

Construction quality control of the “earthworks” should be provided throughout the project by a representative of EXP to verify all design assumptions, recommendations and confirmation of the subsurface soil conditions. This includes inspection of the excavation and subgrade prior to the placement of any structural fill and foundations, to ensure that any and all deleterious materials have been removed and to ensure that the actual conditions are not markedly different than those on which the recommendations made herein are based. Compaction control of structural fill is also recommended as standard practice, as is sampling and testing of aggregates and concrete.

11. Design Review

The recommendations made in this report are considered preliminary and in accordance with our present understanding of the project and are provided solely for the design team responsible for the project. If there are any changes, such as relocation of any structures or other features which may affect our analysis, the information obtained during this investigation may be inadequate and additional field work and reporting may be required.

EXP Services Inc. should be retained to review the final design and specifications to confirm that we are in general agreement with the assumptions on which our recommendations are based. If not accorded the privilege of making this review, EXP will assume no responsibility for interpretation of the recommendations in this report.

12. Limitations

A subsurface investigation is a limited sampling of a site. Should any conditions at the site be encountered that differ from those reported at the test locations, we require that we be notified immediately in order to allow reassessment of our recommendations.

Whereas this investigation has estimated the groundwater level at the time of the fieldwork, and commented on general construction problems, the presence of conditions, which would be difficult to establish from our test holes, may affect the type and nature of dewatering procedures which should be used in practice. These conditions include local and seasonal fluctuations in the groundwater table, erratic changes in the soil profile between the tests, and thin layers of soil with large or small permeabilities compared with the general soil mass, etc.

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

The investigation and comments are necessarily ongoing as new information of underground conditions becomes available. For example, more specific information is available with respect to in-situ subsurface conditions between test locations once construction is underway. Subsurface soil interpretation between test holes, as well as the recommendations of this report, should be verified through field inspections provided by EXP to validate the current information for use during the construction stage.

Virtually no scope of work, no matter how exhaustive, can identify all contaminants or all conditions above or below ground. For example, conditions elsewhere on the property may differ from those encountered, and conditions may change with time. Therefore, no warranty is provided that the entire site condition is represented by those identified at specific borehole locations.

This report in no way reflects any on-site environmental considerations.

13. Closure

We trust that these comments provide you with sufficient information to proceed with design. Should you have any questions, please do not hesitate to contact this office.

Yours truly,

EXP Services Inc.

LICENSED PROFESSIONAL ENGINEER
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100060114
PROVINCE OF ONTARIO

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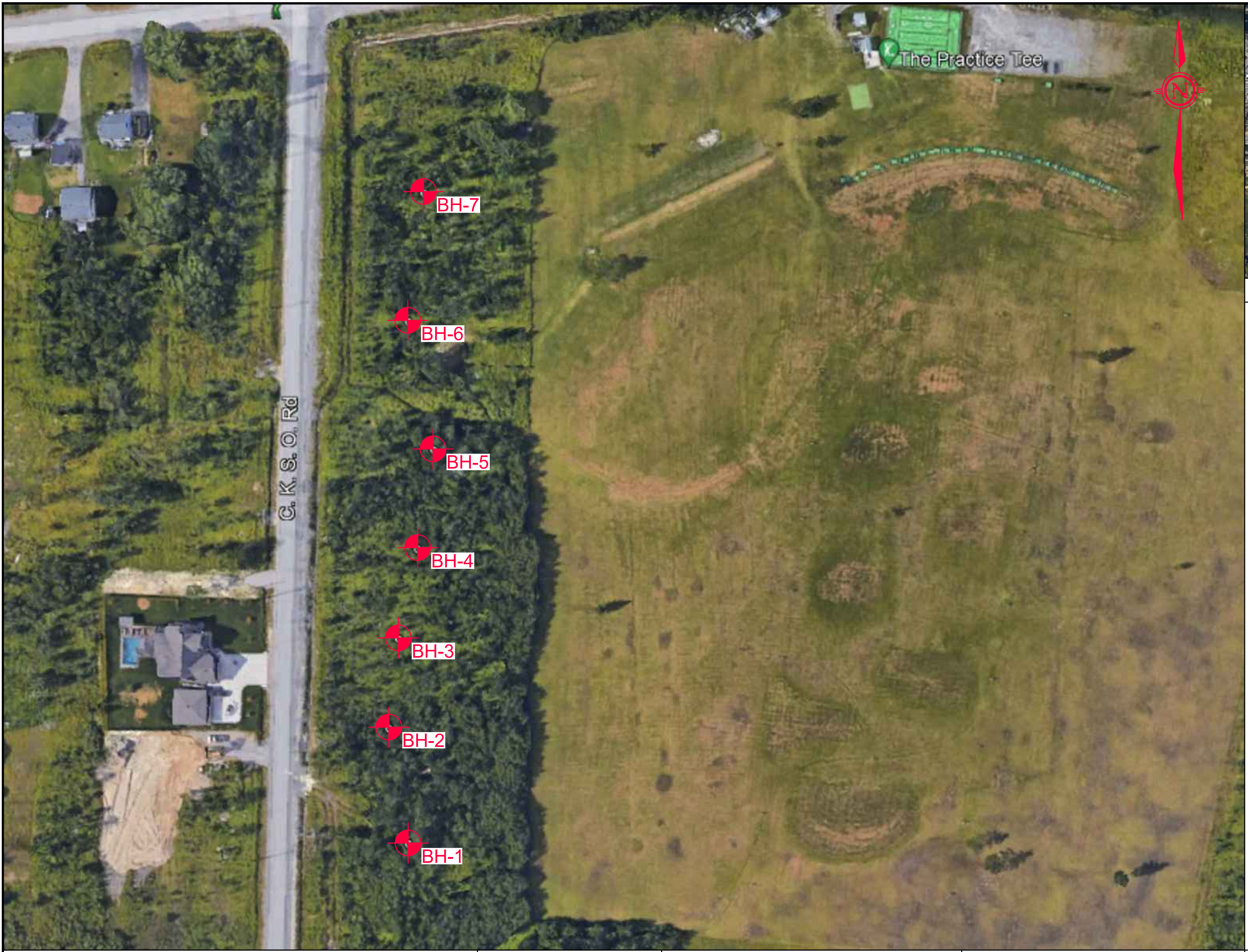
Appendix A - Drawing



KEYPLAN - N.T.S.

LEGEND

⊕ EXP BOREHOLE

— NOTES —

1) The boundaries and soil types have been established only at Test Hole locations. Between Test Holes, they are assumed and may be subject to considerable error.

2) Do not use Test Hole elevations for design purposes.

3) Soil samples will be retained in storage for 3 month and then destroyed unless client advises that an extended time period is required.

4) Quantities should not be established from the information provided at the Test Hole locations.

5) This drawing forms part of the report, project number as referenced, and should be used only in conjunction with this report.

Mar 06, 2024 – 10:18am E:\SUD\SUD-23015629-A0\60 Execution\65 Drawings\SUD-23015629-A0- BOREHOLE LOCATION PLAN.dwg

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REVISIONS

No.	DESCRIPTION	DATE

CLIENT
THE WICKER IMAGE INC.

PROJECT
PROPOSED RESIDENTIAL DEVELOPMENT
CKSO ROAD, SUDBURY, ONTARIO

PROJECT NO.
SUD-23015629-A0

TITLE:
BOREHOLE LOCATION PLAN

DATE
MARCH 2024

SCALE:
NTS

DWG NO.
A-1

Appendix B – Borehole Logs

Notes on Sample Descriptions

1. All sample descriptions included in this report follow the International Society for Soil Mechanics and Foundation Engineering (ISSMFE), as outlined in the Canadian Foundation Engineering Manual. Note, however, that behavioral properties (i.e. plasticity, permeability) take precedence over particle gradation when classifying soil. 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.

UNIFIED SOIL CLASSIFICATION

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

0.002	0.006	0.02	0.06	0.2	0.6	2.0	6.0	20	60	200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

ISSMFE SOIL CLASSIFICATION

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

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 (75 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.

Notes On Soil Descriptions

4. The following table gives a description of the soil based on particle sizes. With the exception of those samples where grain size analyses have been performed, all samples are classified visually. The accuracy of visual examination is not sufficient to differentiate between this classification system or exact grain size.

Soil Classification		Terminology	Proportion
Clay and Silt	<0.060 mm	“trace” (e.g. Trace sand)	1% to 10%
Sand	0.060 to 2.0 mm	“some” (e.g. Some sand)	10% to 20%
Gravel	2.0 to 75 mm	adjective (e.g. sandy, silty)	20% to 35%
Cobbles	75 to 200 mm	“and” (e.g. and sand)	35% to 50%
Boulders	>200 mm		

The compactness of Cohesionless soils and the consistency of the cohesive soils are defined by the following:

Cohesionless Soil		Cohesive Soil		
Compactness	Standard Penetration Resistance “N” Blows / 0.3 m	Consistency	Undrained Shear Strength (kPa)	Standard Penetration Resistance “N” Blows / 0.3 m
Very Loose	0 to 4	Very soft	<12	<2
Loose	4 to 10	Soft	12 to 25	2 to 4
Compact	10 to 30	Firm	25 to 50	4 to 8
Dense	30 to 50	Stiff	50 to 100	8 to 15
Very Dense	Over 50	Very Stiff	100 to 200	15 to 30
		Hard	>200	>30

5. **ROCK CORING**

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundless of the rock mass. It is obtained from the rock cores by summing the length of the core covered, counting only those pieces of sound core that are 100 mm or more length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

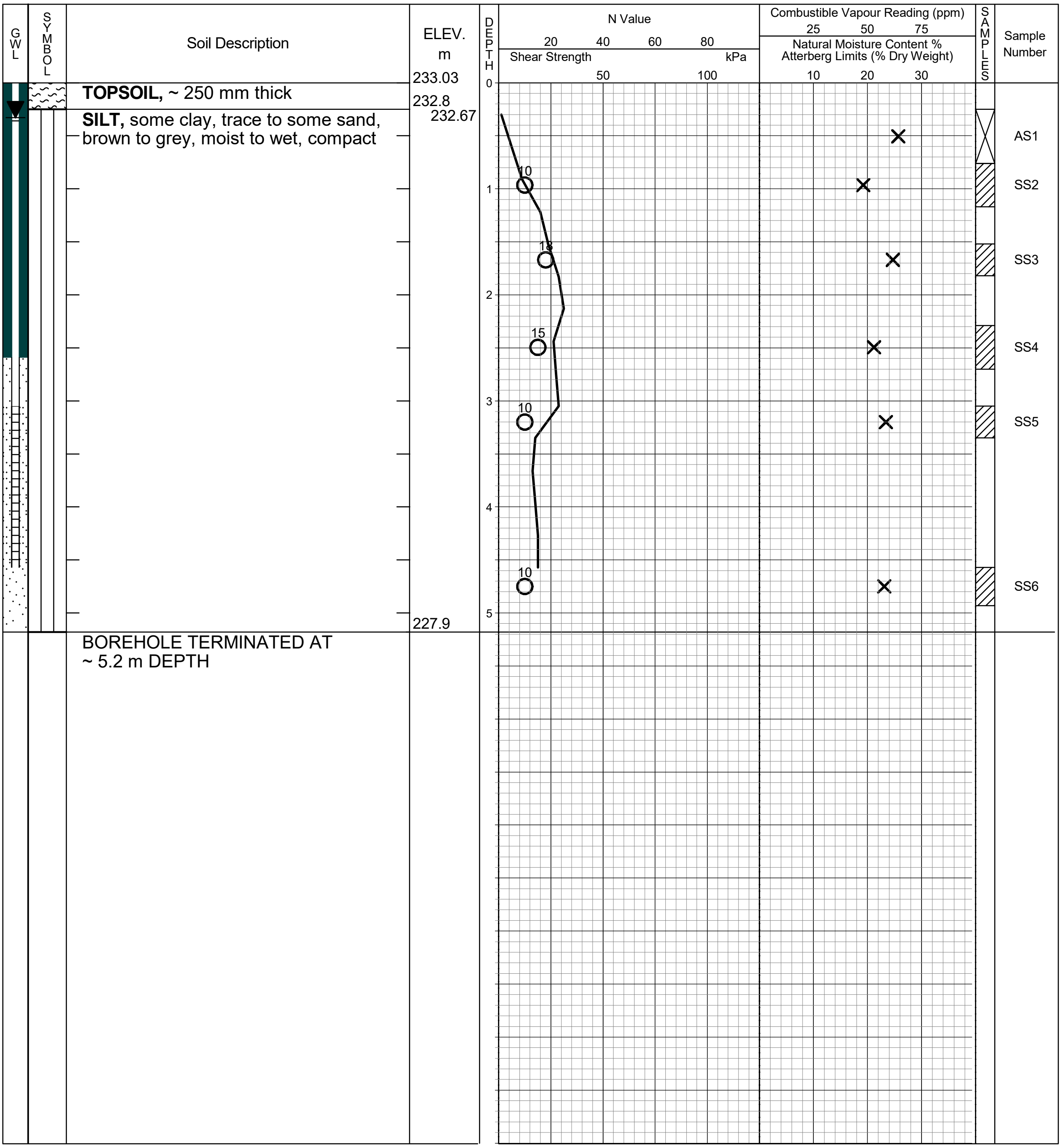
RQD Classification	RQD (%)
Very Poor Quality	<25
Poor Quality	25 to 50
Fair Quality	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100

$$\text{Recovery Designation \% Recovery} = \frac{\text{Length of Core Per Run}}{\text{Total Length of Run}} \times 100$$

Log of Borehole BH-1

Project No. SUD-23015629-A0
Figure No. B-2
Project: CKSO Road Residential Development
Sheet No. 1 of 1
Location: Sudbury, Ontario
503323E; 5141981N
Date Drilled: January 22, 2024
Drill Type: CME 55 Track Mount
Datum: Geodetic

Auger Sample ☒
SPT (N) Value ○ ▨
Dynamic Cone Test —
Shelby Tube ■
Field Vane Test ✚ S
Combustible Vapour Reading ☐
Natural Moisture ✕
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at % Strain at Failure ⊕
Penetrometer ▲



TOPSOIL, ~ 250 mm thick

SILT, some clay, trace to some sand, brown to grey, moist to wet, compact

BOREHOLE TERMINATED AT ~ 5.2 m DEPTH

EXP Services Inc.
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f: +1.705.674.5583

Borehole data requires interpretation assistance from EXP before use by others.

See Figures B-1A and B-1B for Notes on Sample Description

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	Open
Mar. 6, 2024	0.36	

Log of Borehole BH-2

Project No. SUD-23015629-A0

Figure No. B-3

Project: CKSO Road Residential Development

Sheet No. 1 of 1

Location: Sudbury, Ontario

503317E; 5142017N

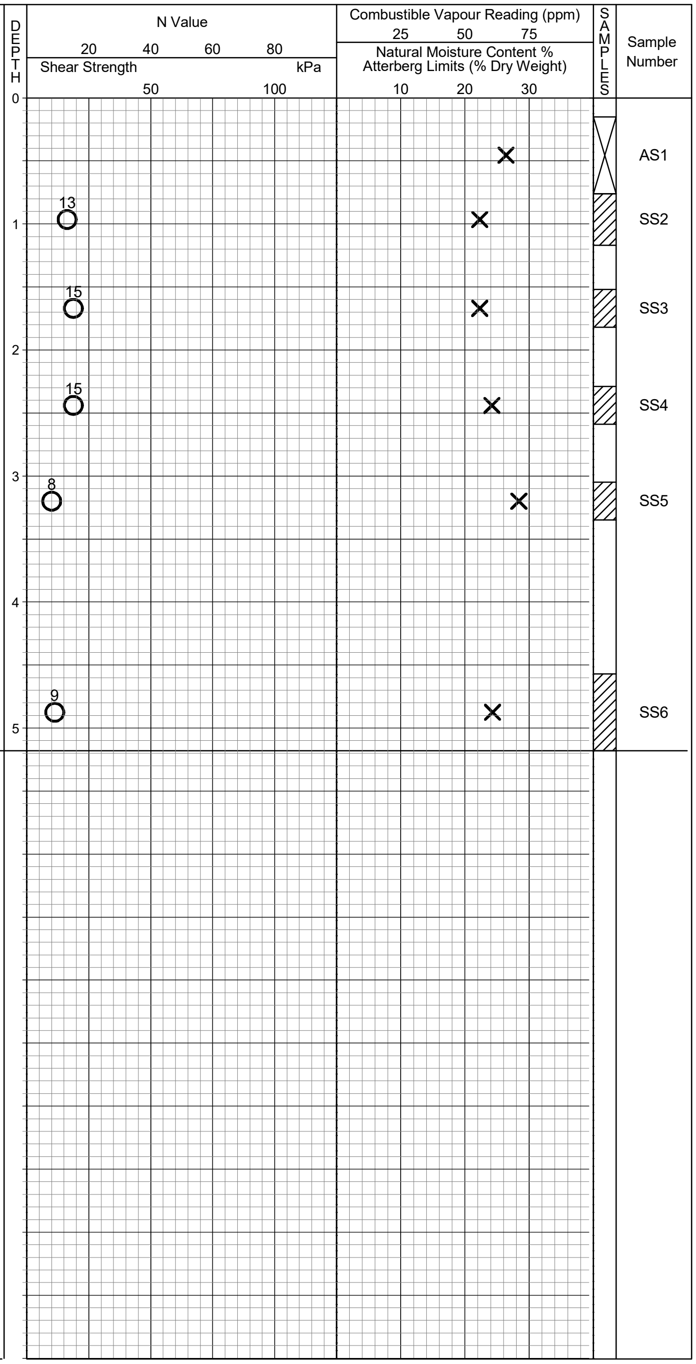
Date Drilled: January 22, 2024

Drill Type: CME 55 Track Mount

Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	□
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	⊢○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲

GWL	SYMBOL	Soil Description	ELEV. m
			233.04
		TOPSOIL, ~ 150 mm thick	232.9
		SILT, some clay, trace to some sand, brown to grey, moist to wet, compact to loose	
			227.9
		BOREHOLE TERMINATED AT ~ 5.2 m DEPTH	



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Borehole data requires interpretation assistance from EXP before use by others.

See Figures B-1A and B-1B for Notes on Sample Description

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	3.9

Log of Borehole BH-3

Project No. SUD-23015629-A0

Figure No. B-4

Project: CKSO Road Residential Development

Sheet No. 1 of 1

Location: Sudbury, Ontario

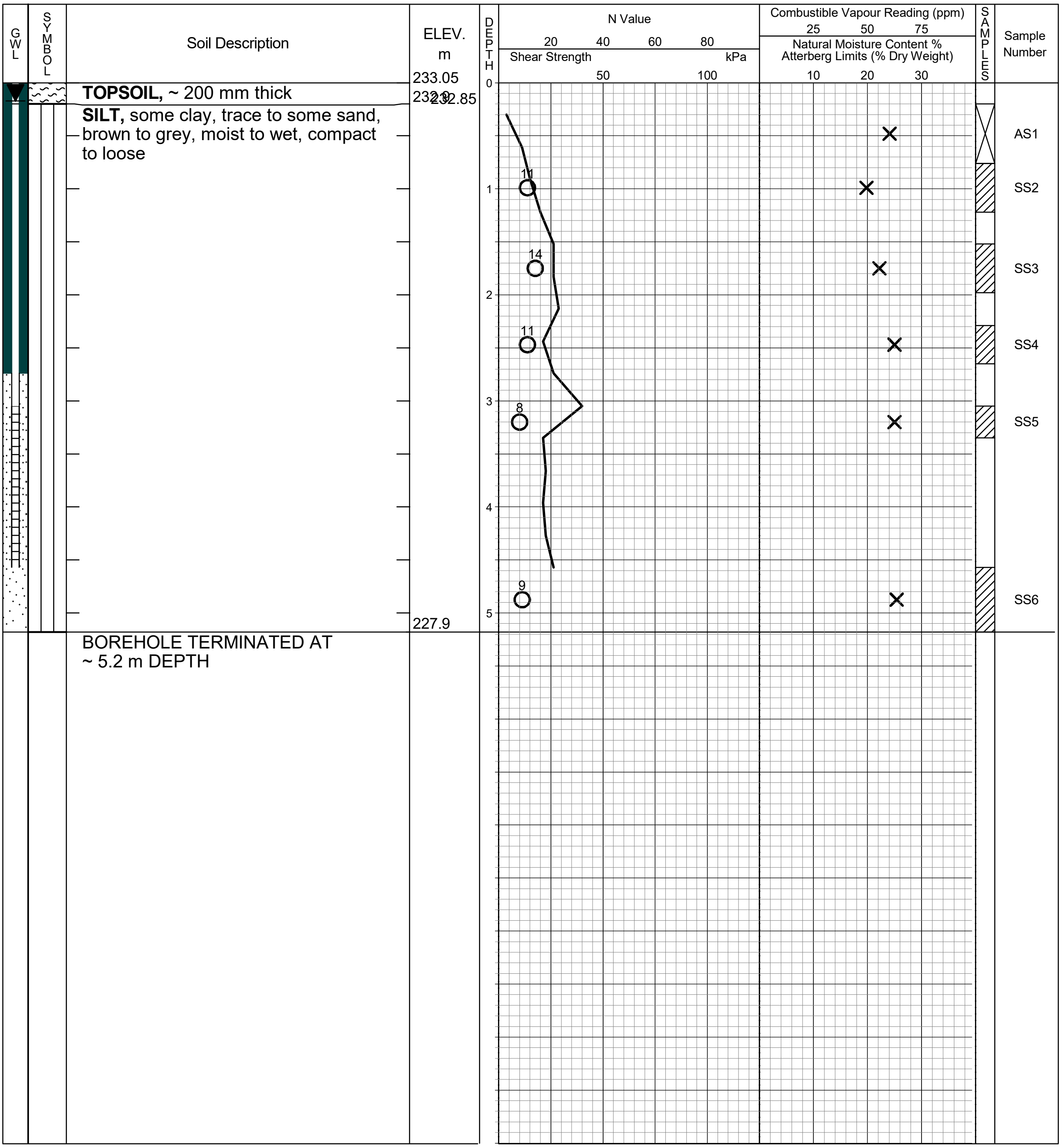
503320E; 5142045N

Date Drilled: January 22, 2024

Drill Type: CME 55 Track Mount

Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	✕
Dynamic Cone Test	—	Plastic and Liquid Limit	├──○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲



TOPSOIL, ~ 200 mm thick

SILT, some clay, trace to some sand, brown to grey, moist to wet, compact to loose

BOREHOLE TERMINATED AT
~ 5.2 m DEPTH

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Borehole data requires interpretation assistance from EXP before use by others.

See Figures B-1A and B-1B for Notes on Sample Description

Time	Water Level (m)	Depth to Cave (m)
Upon Completion Mar. 6, 2024	Dry 0.20	Open

Log of Borehole BH-4

Project No. SUD-23015629-A0

Figure No. B-5

Project: CKSO Road Residential Development

Sheet No. 1 of 1

Location: Sudbury, Ontario

503326E; 5142073N

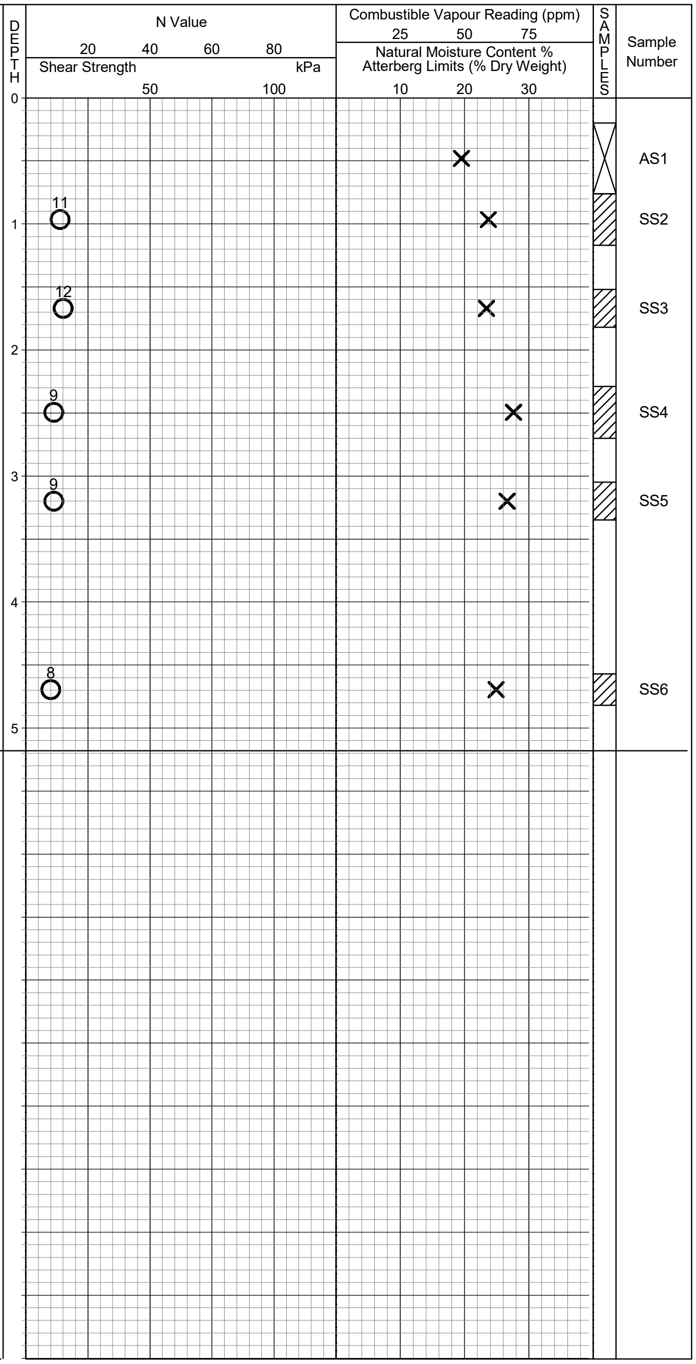
Date Drilled: January 22, 2024

Drill Type: CME 55 Track Mount

Datum: Geodetic

Auger Sample	☒
SPT (N) Value	○ ▨
Dynamic Cone Test	—
Shelby Tube	■
Field Vane Test	✚ S
Combustible Vapour Reading	☐
Natural Moisture	✕
Plastic and Liquid Limit	├──○
Undrained Triaxial at % Strain at Failure	⊕
Penetrometer	▲

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH
			233.00	0
		TOPSOIL, ~ 200 mm thick	232.8	
		SILT, some clay, trace to some sand, brown to grey, moist to wet, compact to loose		
		CLAYEY SILT, trace sand, brown to grey, wet, loose	230.0	3
		BOREHOLE TERMINATED AT ~ 5.2 m DEPTH	227.8	5



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Borehole data requires interpretation assistance from EXP before use by others.

See Figures B-1A and B-1B for Notes on Sample Description

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	3.7

Log of Borehole BH-5

Project No. SUD-23015629-A0

Figure No. B-6

Project: CKSO Road Residential Development

Sheet No. 1 of 1

Location: Sudbury, Ontario

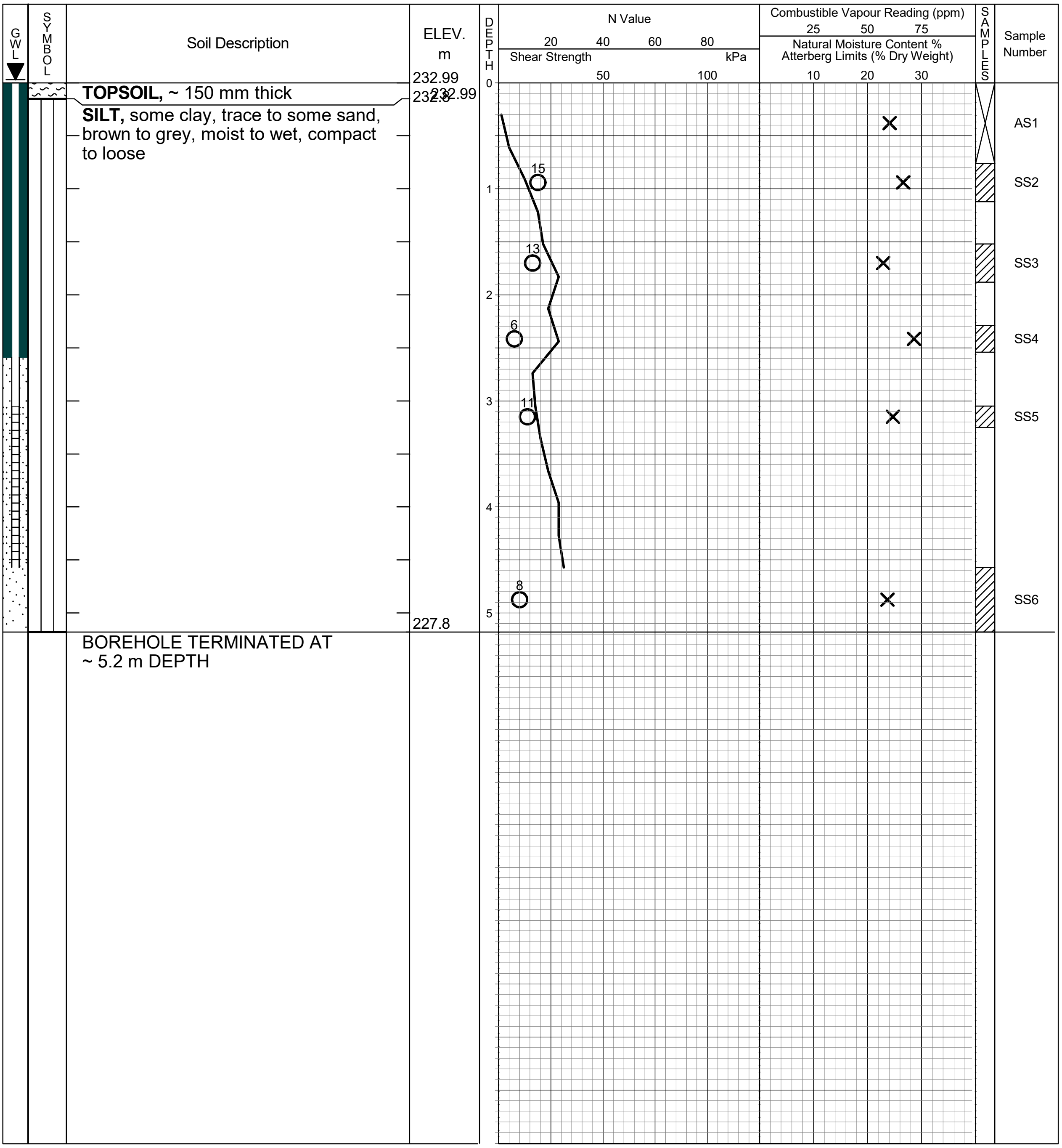
503331E; 5142104N

Date Drilled: January 22, 2024

Drill Type: CME 55 Track Mount

Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├──○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲



TOPSOIL, ~ 150 mm thick

SILT, some clay, trace to some sand, brown to grey, moist to wet, compact to loose

BOREHOLE TERMINATED AT ~ 5.2 m DEPTH

SUDBURY GEO SUD-23015629-A0 - CKSO ROAD DEVELOPMENT, SUDBURY, ON.GPJ NEW.GDT 3/20/24

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Borehole data requires interpretation assistance from EXP before use by others.

See Figures B-1A and B-1B for Notes on Sample Description

Time	Water Level (m)	Depth to Cave (m)
Upon Completion Mar. 6, 2024	Dry 0.0	Open

Log of Borehole BH-6

Project No. SUD-23015629-A0

Figure No. B-7

Project: CKSO Road Residential Development

Sheet No. 1 of 1

Location: Sudbury, Ontario

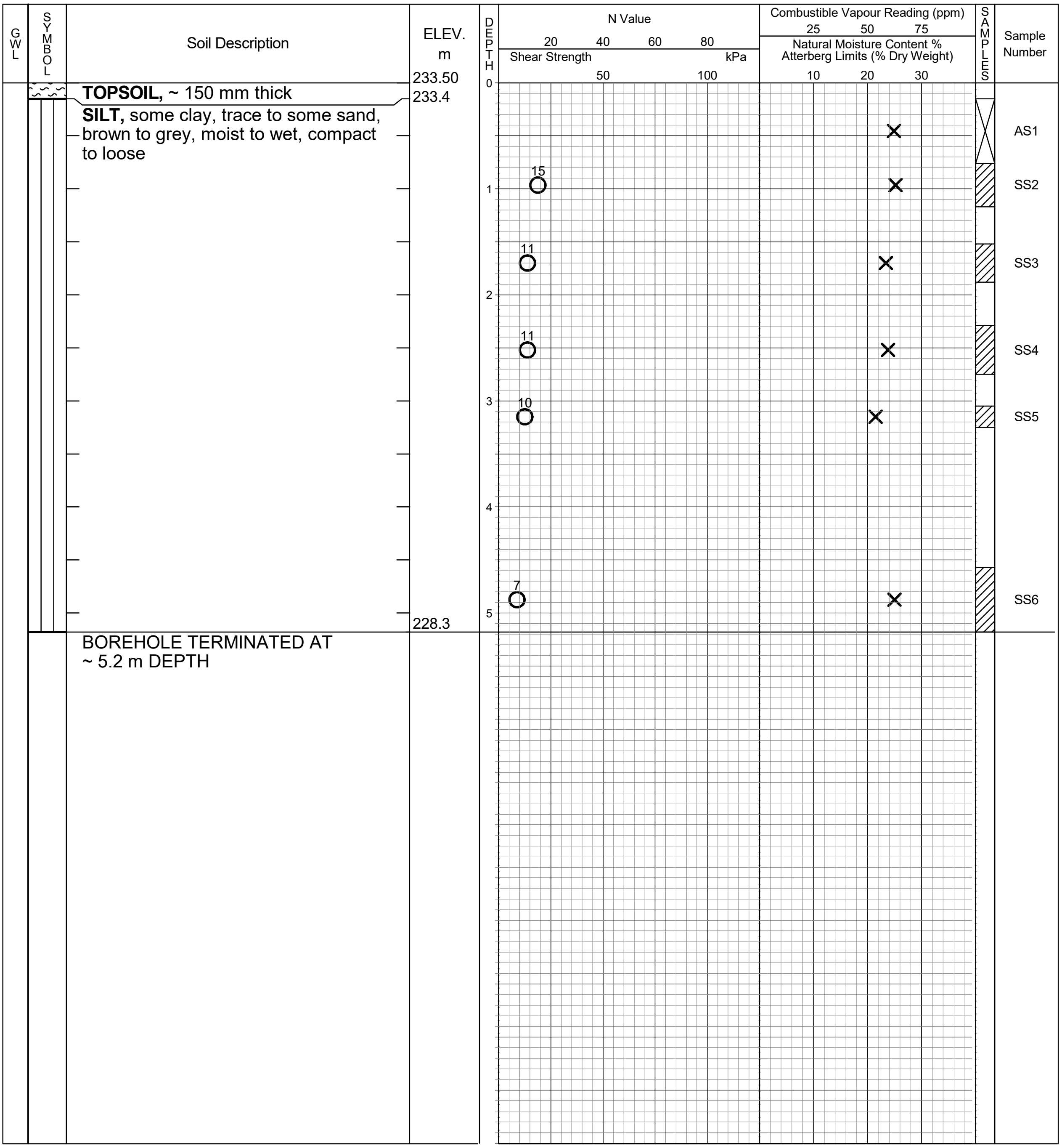
503323E; 5142144N

Date Drilled: January 22, 2024

Drill Type: CME 55 Track Mount

Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├──○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲



TOPSOIL, ~ 150 mm thick

SILT, some clay, trace to some sand, brown to grey, moist to wet, compact to loose

BOREHOLE TERMINATED AT ~ 5.2 m DEPTH

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Borehole data requires interpretation assistance from EXP before use by others.

See Figures B-1A and B-1B for Notes on Sample Description

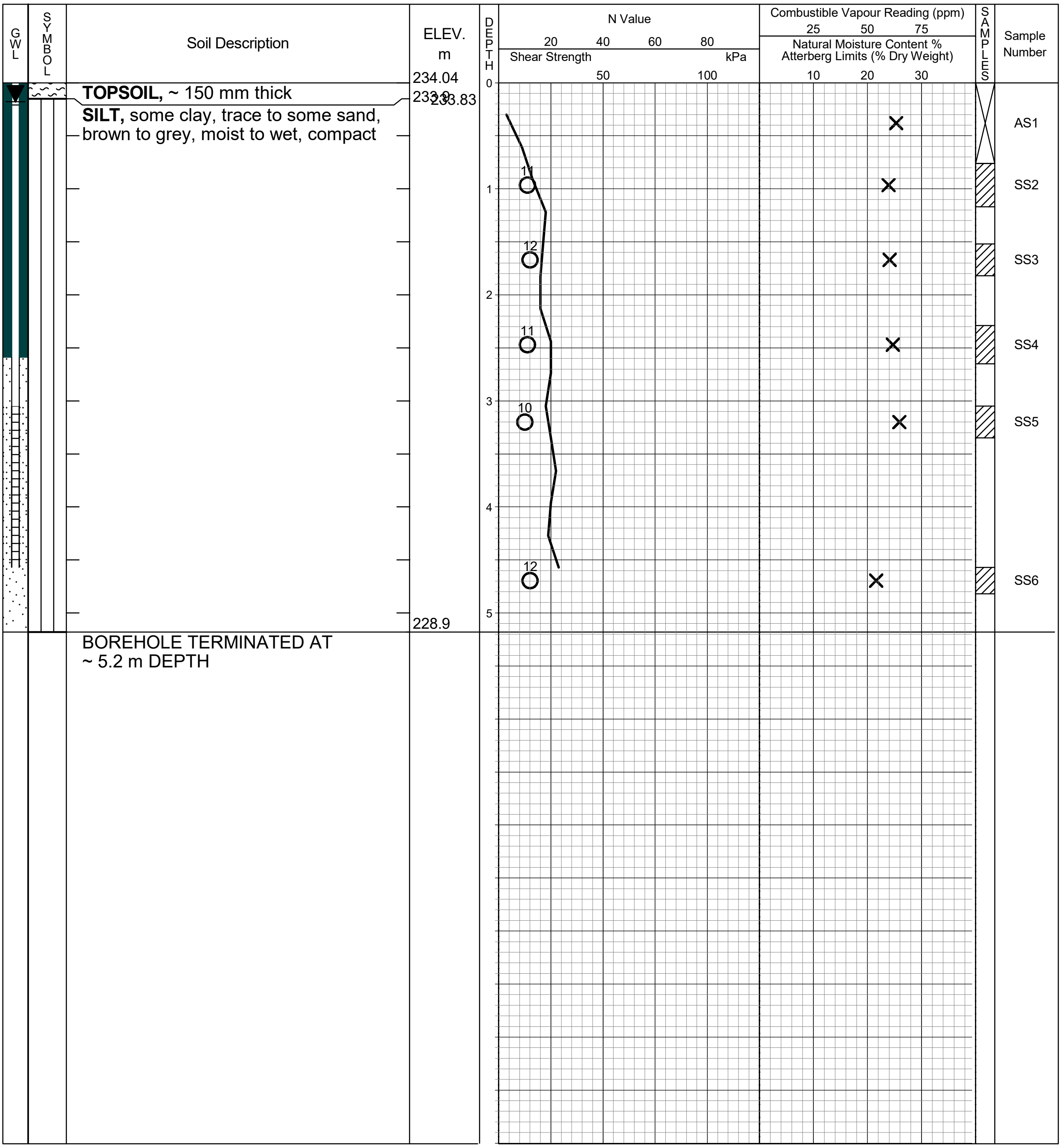
Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	4.6

Log of Borehole BH-7

Project No. SUD-23015629-A0
Figure No. B-8
Project: CKSO Road Residential Development
Sheet No. 1 of 1
Location: Sudbury, Ontario
503328E; 5142184N
Date Drilled: January 22, 2024
Drill Type: CME 55 Track Mount
Datum: Geodetic

Auger Sample ☒
SPT (N) Value ○ ▨
Dynamic Cone Test —
Shelby Tube ■
Field Vane Test ✚ S

Combustible Vapour Reading ☐
Natural Moisture ✕
Plastic and Liquid Limit ├──○
Undrained Triaxial at % Strain at Failure ⊕
Penetrometer ▲



TOPSOIL, ~ 150 mm thick

SILT, some clay, trace to some sand, brown to grey, moist to wet, compact

BOREHOLE TERMINATED AT
~ 5.2 m DEPTH

SUDBURY GEO SUD-23015629-A0 - CKSO ROAD DEVELOPMENT, SUDBURY, ON.GPJ NEW.GDT 3/20/24

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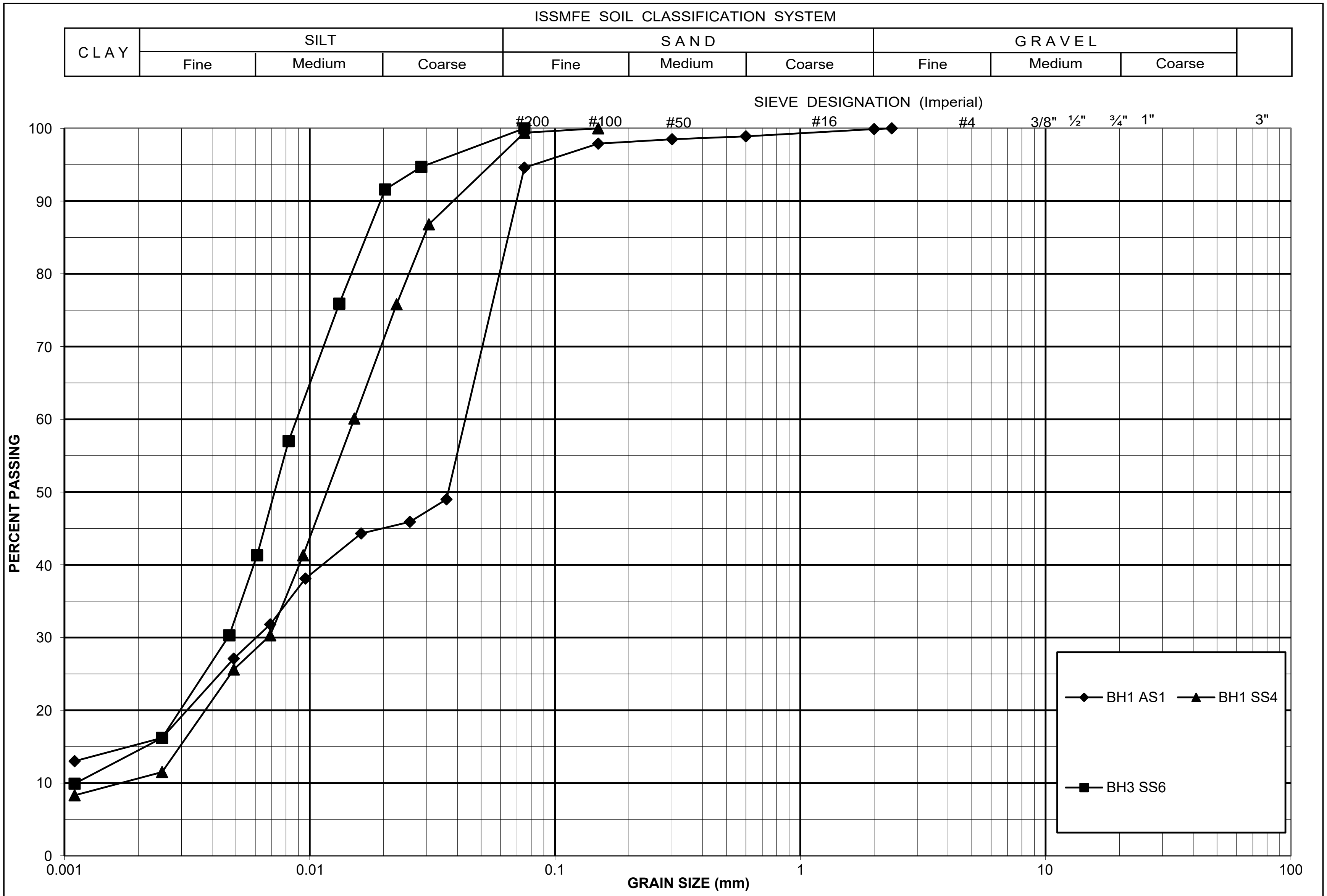
Borehole data requires interpretation assistance from EXP before use by others.

See Figures B-1A and B-1B for Notes on Sample Description

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	Open
Mar. 6, 2024	0.21	

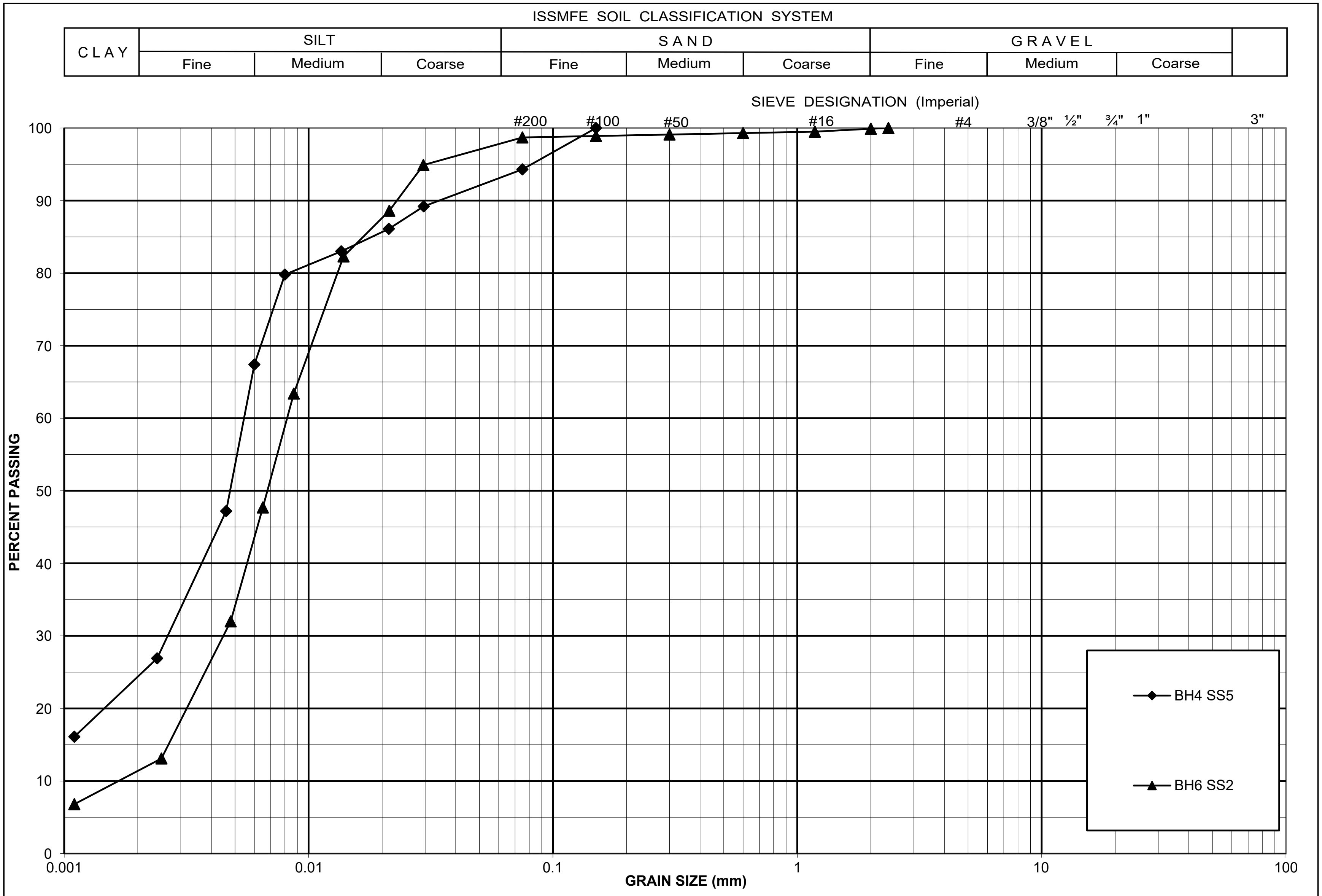
Appendix C – Laboratory Testing



GRAIN SIZE DISTRIBUTION

Proposed Residential Development
CKSO Road, Sudbury, Ontario

FIGURE: C-1
PROJECT No: SUD-23015629-AO
DATE: March 2024



GRAIN SIZE DISTRIBUTION

CKSO Road Residential Development
Sudbury, Ontario

FIGURE: C-2

PROJECT No: SUD-23015629-AO

DATE: February, 2024