Twenty Road West, Hamilton, ON

Corbett Land Strategies

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Proposed Upper West Side Secondary Plan
Twenty Road West
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1. Introduction and Background

This report presents the results of the preliminary geotechnical investigation carried out at the site of the proposed subdivision located between Twenty Road West and Dickenson Road West in Hamilton, Ontario. The proposed upper west side secondary plan is understood to comprise low to high density residential properties, institutional buildings, industrial and commercial space, and mixed-use buildings. The development will also include new roadways, site servicing, stormwater management ponds (SWPs), parkland, and designated natural heritage space. The investigation was authorized by Corbett Land Strategies Inc., on behalf of the Client, the Upper West Side Landowners Group (UWSLG).

Previous preliminary geotechnical and hydrogeological investigations were carried out at the site by EXP. The results of the previous geotechnical investigation were presented in our preliminary geotechnical report dated March 4, 2019 under Project No. HAM-00801363-A0 Rev. 1 and is superseded by this report. The initial geotechnical investigation included thirty-three (33) boreholes. Parcels were added to the original proposed community lands and as such, sixteen (16) additional boreholes were advanced for the current 2023 investigation. This preliminary geotechnical investigation includes all previous geotechnical data as well as the additional geotechnical data. This report does not address the environmental considerations at the site. Additional fieldwork was carried out at the site by others as part of a hydrogeological study.

The purpose of this preliminary investigation was to determine the subsoil and groundwater conditions at the site, and based on an assessment of the factual subsurface data, provide an updated engineering report containing general geotechnical recommendations pertinent to the proposed construction. It is understood that additional investigations will be carried out once the development plan is finalized.

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

1.1 Site Description & Geological Setting

The subject property study area is bounded by Twenty Road West to the north, Upper James Street to the east, Dickenson Road to the south, and Glancaster Road to the west within the City of Hamilton, Ontario. The land use in the site vicinity is typically agricultural and residential. A former golf course is located on the west side of the site; the John C. Munro Hamilton International Airport is located to the south; and several institutional/commercial establishments front onto Upper James Street to the east.

The site is largely farmland with several densely vegetated areas and a number of dwellings and out-building structures. Several watercourses and small ponds are also present. The site topography is variable with undulations in the order of approximately 16 m across the site.

Based on the review of the Ontario Geological Survey (OGS), Map P993, *Quaternary Geology of the Grimsby Area*, the native soil at the site consists of glaciolacustrine silt with areas of stream deposits comprising clay and silt with some sand and gravel. Based on the OGS Map 2343, *Paleozoic Geology of the Grimsby Area*, the bedrock in the area is identified as brown or tan dolostone of the Guelph Formation. Based on previous drilling operations, the bedrock

depth in the site vicinity is estimated to be about 30 m below grade. As noted, in EXP's Memo No. HAM-00801363-B0 dated September 5, 2019, karst is not a concern at this site.

2. Field Investigation

2.1 General Fieldwork

A total of forty-nine (49) boreholes were advanced at the site. The approximate borehole locations are shown on Drawing No. 1 in Appendix A. The boreholes were advanced to depths ranging from approximately 5.2 to 12.7 m below existing grade. The geotechnical investigations at the site were carried out in two stages as indicated below:

- March 26 to May 11, 2018, thirty-three (33) boreholes (Boreholes BH-01 to BH-33)
- September 7 to 14, 2023, sixteen (16) boreholes (Boreholes MW23-1 to MW23-12 and BH23-1 to BH23-4)

Drilling and sampling operations were completed by a combination of auger and split-spoon techniques using track mounted drilling equipment owned and operated by specialist drilling subcontractors which were retained by another consultant on behalf of the owner. Prior to the commencement of the drilling, the public and private-owned underground services were located to minimize the risk of contacting any such services during the investigation.

Soil samples were obtained using a 51 mm (2 inch) outside diameter split-spoon sampler driven in conjunction with Standard Penetration Test procedure (ASTM D1586) at the depths noted graphically on the borehole logs. The soil samples were logged in the field and then the samples retained by EXP were carefully packaged and transported to our Hamilton laboratory for detailed visual, textural, and olfactory classification. The Standard Penetration Test (SPT) N values, pocket penetrometer and an in-situ shear vane measurements were recorded and used to provide an assessment of the compactness condition or consistency of the in-situ soils.

Groundwater levels within the boreholes were measured prior to backfilling. Twenty-nine (29) 50 mm diameter monitoring wells were installed to allow for stabilized groundwater level measurements as well as subsequent groundwater monitoring as part of the hydrogeological study. The remaining boreholes were backfilled upon completion of drilling in accordance with Regulation 903.

The boreholes were located in accessible areas on site by field personnel. The ground surface elevations at the initial borehole locations (drilled in 2018) were provided by A.J. Clarke and Associates Ltd. following the investigation. The ground surface elevations at the additional boreholes (drilled in 2023) were provided by Crozier Consulting Engineers.

3. Subsurface Conditions

Details of the subsurface conditions encountered during the drilling program are summarized on the borehole logs in Appendix A. The logs include textural descriptions of the subsoil and groundwater conditions and indicate the soil boundaries inferred from non-continuous sampling and observations during drilling. These boundaries reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Notes on Sample Description" preceding the borehole logs form an integral part of and should be read in conjunction with this report.

3.1 Soil Stratigraphy

Surficial topsoil was encountered at all boreholes which was underlain by disturbed or reworked native soil and/or native soil. The disturbed or reworked native soil extended to a depth of less than 1.0 m below grade. The native soil at the site consisted predominantly of silt with layers of silty clay, sandy silt, silty sand, and sand. Details of the encountered materials are provided in the following subsections.

3.1.1 Topsoil

Surficial topsoil was encountered at all boreholes and ranged in thickness from approximately 80 to 280 mm. It should be noted that the topsoil measurements were carried out at the borehole locations only and were found to be variable. A more detailed analysis (involving test pits) is recommended to accurately quantify the amount of topsoil to be removed for construction purposes. Consequently, topsoil quantities should not be established from the information provided at the borehole locations only.

3.1.2 Fill (Reworked or Disturbed Native Soil)

A layer of fill was encountered below the topsoil in twenty-nine (29) of the boreholes (Boreholes BH-01 to BH-03, BH-05, BH-07 to BH-10, BH-12 to BH-25, and BH-27 to BH-33), extending to a depth of less than 1.0 m below grade. The material classified as fill may be reworked native soil which was disturbed during the agricultural operations at the site. The fill comprised silty clay or silt with rootlets; was brown or dark brown; and in a moist to very moist state, with moisture contents ranging from 17 to 32%.

3.1.3 Silt

Undisturbed native silt was encountered in all boreholes, except Boreholes BH-08, BH-18, BH-32, and BH-33. In thirty-one (31) of the boreholes, the silt was encountered below the topsoil or fill (disturbed/reworked native) and below a layer of silty clay at Boreholes BH-01, BH-04, BH-06, BH-07, BH-14, BH-21, BH-24, BH-25, BH-29, BH-30, MW23-1, MW23-6 to MW23-11. In Borehole BH-26, the silt was encountered below a layer of silty sand. This soil unit formed the majority of the soil profile in most of these boreholes. The silt deposit extended to depths ranging between 3.0 and 9.1 m below grade, and to the maximum depth explored at Boreholes BH-01, BH-05 to BH-07, BH-09, BH-19, BH-20, BH-22 to BH-28, MW23-1 to MW23-8, MW23-10, MW23-12, BH23-1, BH23-2, BH23-3. The silt was interrupted by a silty clay deposit at Boreholes BH23-1 to BH23-3, MW23-5, and MW23-12, and silty sand deposit at Borehole MW23-11. The silt generally contained varying proportions of sand and clay, occasional gravel, sand seams, and trace rootlets (in the upper layer); was brown and becoming grey below depths of approximately 2.0 to 5.0 m; and was in a moist to wet state with moisture contents ranging from 9 to 30%. Based on SPT N values ranging from 5 to over 100 blows per 305 mm penetration, the silt is in a loose to very dense condition.

Thirteen (13) grain size analyses were conducted on selected samples of the stratum and the results are summarized in the table below.

Table 3-1: Summary of Grain Size Analyses (Silt)

Borehole and Sample No.	Sample Depth (m)	Soil Fractions (%)			
		Clay	Silt	Sand	Gravel
BH-02 SS2	1.0	7	89	4	0

Borehole and Sample No.	Sample Depth (m)	Soil Fractions (%)			
		Clay	Silt	Sand	Gravel
BH-04 SS2	1.0	20	73	7	0
BH-06 SS2	1.0	13	84	3	0
BH-15 SS2	1.0	8	88	4	0
BH-29 SS4	2.3	16	71	13	0
BH-30 SS9	9.0	12	83	5	0
BH-31 SS3	1.5	12	84	4	0
BH-31 SS6	4.5	10	85	5	0
MW23-1 SS6	4.5	15	77	6	2
MW23-4 SS3	4.5	8	84	6	2
MW23-6 SS9	9.1	13	77	10	0
MW23-8 SS6	4.5	13	77	10	0
MW23-9 SS4	2.3	13	77	10	0

3.1.4 Sandy Silt / Silty Sand / Sand

Native cohesionless soils including sandy silt, silty sand, and sand were encountered below the silt, fill, or topsoil at Boreholes BH-02 to BH-04, BH-08, BH-10 to BH-12, BH-18, BH-26, BH-29 to BH-31, BH-33, BH23-3, and MW23-11 at depths ranging from 0.2 to 9.1 m below the grade. These soils extended to depths ranging from 1.5 to 7.6 m below grade at Boreholes BH-08, BH-10, BH-18, BH-26, BH23-3, and to the maximum drill depth at the remainder of the boreholes. The cohesionless strata contained occasional gravel and clay seams; were brown and grey; and in a moist to wet state, with moisture contents ranging from 13 to 31%. Based on SPT N values ranging from 2 to 85 blows per 305 mm penetration, the strata were in a very loose to very dense condition, but more typically compact to dense.

Four (4) grain size analyses were conducted on selected samples of the strata and the results are summarized in the table below.

Table 3-2: Summary of Grain Size Analyses (Sandy Silt / Silty Sand / Sand)

Borehole and Sample No.	Sample Depth (m)	Soil Fractions (%)			
		Clay	Silt	Sand	Gravel
BH-29 SS7	6.1	2	47	51	0
BH-31 SS10	10.7	2	35	63	0
MW23-6 SS5	3.1	15	62	22	1
MW23-11 SS7	6.1	7	17	73	3

3.1.5 Silty Clay / Clayey Silt

Native silty clay and clayey silt strata were encountered at BH-01, BH-04, BH-06, BH-07, BH-08, BH-10, BH-11, BH-14, BH-15, BH-18, BH-21, BH-24, BH-25, BH-29 to BH-33, MW23-1, MW23-5 to MW23-12, and BH23-1 to BH23-4, at widely varying depths and with variable thicknesses. The silty clay/clayey silt was generally noted to contain trace to some sand and occasional gravel with pockets or layers of sand and silt materials noted at Borehole BH-32 and BH-33. The silty clay was brown or grey and in a damp to wet state with moisture contents ranging from 11 to 32%. SPT N values ranged from 3 to 54 blows per 305 mm penetration. Based on estimated undrained shear strengths from 25 to greater than 225 kPa as determined by pocket penetrometer and an in-situ shear vane measurements, the silty clay/clayey silt is classified as soft to hard in consistency but was more typically very stiff to hard.

Ten (10) grain size analyses were conducted on selected samples of the silty clay/clayey silt strata and the results are summarized in the table below.

Table 3-3: Summary of Laboratory Testing of Native Silty Clay/Clayey Silt

Sample No. and Depth	Grain Size Distribution (%)				Atterberg Limits Results			Soil Classification
	Clay	Silt	Sand	Gravel	Liquid Limit	Plastic Limit	Plasticity Index	
BH-30 SS6 @ 4.6 m	12	83	5	0	23	17	6	CL - ML
BH-31 SS4 @ 2.3 m	25	57	14	4	35	20	15	CL
BH-31 SS7 @ 6.1 m	27	68	5	0	27	16	11	CL
BH-32 SS5 @ 3.1 m	16	79	5	0	25	8	17	CL
BH-32 SS8 @ 7.6 m	12	81	7	0	27	8	19	CL
BH-32 SS10 @ 10.7 m	33	64	3	0	32	19	13	CL
BH-33 SS7 @ 6.1 m	20	74	6	0	25	14	11	CI
MW23-4 SS6 @ 3.8 m	27	69	4	0	24	16	8	CL
MW23-6 SS3 @ 1.5 m	27	61	8	4	26	17	9	CL
MW23-9 SS6 @ 4.6 m	27	71	2	0	26	17	9	CL

The material is classified as a clayey silt (CL-ML) and low plasticity clay (CL) with liquid limit values ranging from 23 to 35, plastic limit values ranging from 8 to 20, and plasticity indices ranging from 6 to 19. The complete set of laboratory results are presented in Appendix B.

3.2 Groundwater Conditions

Groundwater conditions were monitored in the open boreholes during and upon completion of the investigation. Monitoring wells (50 mm diameter) were installed at Boreholes BH-01, BH-05, BH-07, BH-08, BH-09, BH-11, BH-12, BH-13, BH-15, BH-17, BH-18, BH-25, BH-29, BH-30 to BH-33, and MW23-1 to MW23-12 to facilitate long-term groundwater level measurements and hydrogeological testing. Nested shallow and deep monitoring wells were installed at Boreholes BH-29 to BH-33 located in the areas of the proposed SWPs. Groundwater level measurements are summarized in the table below; readings prior to 2023 were obtained by EXP and the 2023 readings were provided by Crozier Consulting Engineers.

Table 3-4: Groundwater Level Measurements at Monitoring Well Locations

	Groundwater Depth/Elevation (m)					
Borehole No.	Upon Completion	June 4, 2018	June 5, 2018	August 4, 2023	Oct. 13, 2023	Oct. 26, 2023
BH-01	5.22/232.71	-	0.78/237.15	0.56/237.37	2.35/235.58	-
BH-05	4.91/223.85	-	0.73/228.03	0.86/227.89	-	0.77/227.98
BH-07	9.21/212.89	0.27/221.83	-	0.64/221.46	-	0.49/221.61
BH-08	7.61/224.54	0.53/231.62	-	0.58/231.57	-	0.76/231.39
BH-09	4.64/228.39	0.74/232.29	-	0.90/232.13	-	1.11/231.92
BH-11	**above grade**	-	**-1.20/232.77**	-	-	-
BH-12	**above grade**	-	0.04/232.14	**-0.16/232.34**	-	-
BH-13	dry	-	**-0.19/230.59**	0.22/230.18	dry	-
BH-15	dry	0.65/231.54	-	0.45/231.74	2.35/229.84	-
BH-17	dry	-	0.50/230.53	0.52/230.51	-	0.80/230.23
BH-18	5.30/228.51	0.85/222.96	-	damaged	damaged	damaged
BH-25	5.81/229.49	-	0.34/234.96	0.52/234.78	dry	-
BH-29 (shallow)	0.84/231.13	-	**-2.90/234.87**	0.89/231.08	0.96/231.01	-
BH-29 (deep)	0.84/231.13	-	**-1.37/233.34**	**-0.94/232.91**	**-0.94/232.91**	-
BH-30 (shallow)	**above grade**	-	1.18/232.35	dry	dry	-
BH-30 (deep)	**above grade**	-	**-0.70/234.23**	**-0.62/234.15**	0.91/232.62	-
BH-31 (shallow)	3.10/228.84	-	0.20/231.74	dry	dry	dry
BH-31 (deep)	3.10/228.84	-	**-1.12/233.06**	**-1.40/233.34**	**-1.40/233.34**	-
BH-32 (shallow)	dry	-	0.46/221.53	0.75/221.24	-	dry
BH-32 (deep)	dry	-	0.56/221.43	0.62/221.37	-	3.19/218.80
BH-33 (shallow)	11.62/217.69	0.66/228.65	-	0.92/228.39	-	dry

	Groundwater Depth/Elevation (m)					
Borehole No.	Upon Completion	June 4, 2018	June 5, 2018	August 4, 2023	Oct. 13, 2023	Oct. 26, 2023
BH-33 (deep)	11.62/217.69	0.71/228.60	-	0.79/228.52	-	dry
MW23-1	-	-	-	-	1.31/238.59	-
MW23-2	-	-	-	-	3.40/239.40	-
MW23-3	-	-	-	-	3.17/246.93	-
MW23-4	-	-	-	-	2.04/238.04	-
MW23-5	-	-	-	-	-	2.17/230.96
MW23-6	-	-	-	-	2.70/233.23	-
MW23-7	-	-	-	-	-	2.27/227.06
MW23-8	-	-	-	-	-	2.15/224.09
MW23-9	-	-	-	-	-	4.40/220.60
MW23-10	-	-	-	-	2.41/231.42	-
MW23-11	-	-	-	-	1.48/235.55	-
MW23-12	-	-	-	-	4.34/228.35	-

Note that artesian groundwater conditions were encountered at Boreholes BH-11, BH-12, BH-13, BH-29, BH-30, and BH-31 as indicated by the negative groundwater depths.

Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions. Reference should be made to the hydrogeological studies for additional groundwater information.

4. Preliminary Discussion and Recommendations

It is understood that the proposed secondary plan area will include low to high density residential properties, institutional buildings, industrial and commercial space, and mixed-use buildings. The development will also include new roadways, site servicing, stormwater management ponds (SWPs), parkland, and designated natural heritage space. However, the details of the proposed site servicing, SWPs, and building configurations were not available at the time of the investigation. The recommendations provided are based on the general design information for the development and additional investigation should be anticipated once the development plan is finalized. We offer the following preliminary comments and recommendations for the proposed construction.

4.1 Site Grading

The grading plan showed areas of significant grade increases of as much as about 4 to 6 m. The majority of the soils are silt, so settlements resulting from the increased loading due to grade raise will mainly occur during the short-term period of construction. However, strata of silty clay which may undergo long-term consolidation settlements were present at the site. As part of the required supplemental geotechnical investigation(s), EXP should be contacted to review the final grading plan and assess the need for more detailed settlement analysis. The following procedures are recommended for the construction of building and pavement areas at the site:

- All fill materials, disturbed soils, and organic materials should be removed from the proposed building and pavement areas. Fill materials in pavement areas may remain in place, subject to being proof-rolled and replaced as directed by a geotechnical representative, but pavements constructed over fill may require more frequent maintenance and experience a reduced service life.

- The exposed subgrade surface should be proof-rolled with a heavy roller or partially loaded truck and reviewed by a geotechnical representative. Any soft areas detected during the proof-rolling process should be sub-excavated and replaced with approved material compacted to 100% Standard Proctor Maximum Dry Density (SPMDD).

- Low areas can then be brought up to final subgrade level with approved on-site or imported material placed in lifts not exceeding 200 mm. Fill placed in building areas must be compacted to 100% of SPMDD (i.e. constructed as *engineered fill* as given in Drawing No. 52 in Appendix A). Fill placed in pavement areas should be compacted to at least 95% SPMDD, with the upper 600 mm compacted to at least 98% SPMDD. The moisture content of the fill should be at or near its optimum moisture content to ensure the specified densities can be achieved with reasonable compactive effort.

- Given the elevated moisture content at some locations/depths, moisture content adjustment (e.g. spreading and drying) should be anticipated to facilitate compaction of re-used materials. The majority of the excavated soils will be silty materials which require strict moisture content control and heavy compaction equipment and so may not be practical for re-use. Furthermore, even after these soils have been compacted to a high density, the pore water pressure in the soils could remain high for a long time, making the soils “spongy” and not suitable for support of foundations or pavement. In any case, re-use of the on-site fill should be at the discretion of the geotechnical consultant during construction. Any re-used materials must also be free from organics and deleterious materials.

- All imported borrow fill material from local sources should be free from organic material and foreign objects (trees, roots, debris, etc.) and should be approved by EXP prior to transport to the site. In addition, the chemical quality of the borrowed fill material should be assessed by EXP in accordance with the current applicable MECP regulations and guidelines.

- All excavation, backfilling and compaction operations should be monitored on a full-time basis by EXP’s geotechnical staff to approve materials and to ensure the specified degrees of compaction have been obtained.

4.2 Site Servicing

Details of the proposed utility installations were not available at the time of the investigation. However, it is understood that the sewer mains may be installed as deep as approximately 12 m below grade. Once additional

details of the site servicing are available, EXP should be contacted to review the proposed layout and depths to assess the need for additional investigation.

Due to the presence of artesian groundwater conditions at the site, the deep excavations for site servicing may require significant dewatering and/or a shoring technique which limits groundwater infiltration as outlined in the following sections. Basal heave resulting from the artesian conditions may also be encountered and reference to the hydrogeological studies for the site should be made for the safe excavation depths. It is recommended that a test pit program be completed once additional project details are known to better assess the feasibility of open cut excavations and groundwater conditions in an open excavation.

4.2.1 Open-Cut Excavations

Open-cut excavations for site servicing can be carried out using heavy hydraulic excavators. All excavations must be completed in accordance with the most recent regulations of the Ontario Occupation Health and Safety Act (OHSA). The dense to very dense silts and sands and the very stiff to hard silty clay may be classified as Type 2 Soil. In general, the fill or disturbed native materials and loose to compact silts and sands may be classified as Type 3 Soil above the groundwater level. The soft clays and soils below the groundwater level are generally classified as Type 4 Soil.

Temporary excavations can be carried out with side slopes not steeper than 1H:1V in Type 2 or Type 3 soil (with Type 2 able to be sloped from 1.2 m above the base of the excavation) and 3H:1V in Type 4 soil. However, even at this relatively flat slope, seepage pressures may result in sloughing and unstable ground conditions. As such, dewatering (see Section 4.2.3) to temporarily draw down the groundwater level may be required.

4.2.2 Temporary Shoring

Where the construction is carried out close to the property limits, shoring will be required to support the excavation, to limit the horizontal and vertical movements of adjacent properties, roads and utilities. The preferred shoring system would be a contiguous caisson wall with tiebacks. Soldier piles with timber lagging may be considered, but extensive dewatering outside the perimeter of the excavation will be required. The dewatering could cause large ground settlements, possibly resulting in damage to existing nearby structures, roads, and/or utilities.

The shoring systems should be designed in accordance with the latest edition of the Canadian Foundation Engineering Manual (CFEM). The shoring should be designed for the lateral earth pressure given in Section 4.3.6 of this report. The coefficient of earth pressure (K) should be taken as:

0.25 Where minor ground movements can be tolerated.

0.35 Where utilities, roads, sidewalks must be protected from significant movement or where vibration from traffic is a factor.

0.45 Where movements are to be minimized such as near adjacent building footings or movement sensitive services (i.e. gas and watermains).

A natural unit weight of 22.0 kN/m^3 of the soil on site may be used.

Lateral restraints can be obtained by installing anchors in the native silt and clay. For preliminary design purposes, anchors may be installed in the native silt and clay utilizing an equivalent bond stress of 30 kPa. Where re-groutable anchors are used, the available bond may be higher. Clayey soil will tend to get smeared during installation leaving a

thin disturbed soil around the drill hole, thus resulting in lower bond values. Design tests should be carried out to confirm the available bond resistance of the soil and bedrock anchors.

The shoring system should be designed by a specialist shoring designer. All drilled vertical holes and tieback holes should be temporary cased to minimize the risk of caving. During winter months, the shoring should be covered with thermal blankets to prevent frost penetration behind the shoring system which may result in unacceptable movements.

The actual bond stress of soil anchors should be confirmed by load testing a number of anchors to 200% design load in accordance with the latest edition of the CFEM. The design for the production anchors should then be modified based on the test results, where necessary. All remaining anchors must be installed using similar procedures and proof tested to 1.33 times the design load.

EXP should be retained to review the shoring design, to monitor installation and testing of the system, and to monitor the shoring movements during all phases of the excavation. Inclinometers should be installed at locations where buildings or sensitive services lie close to the excavation. Careful monitoring is needed in any shored excavation, especially when buildings are located in close proximity. This is necessary not only to anticipate when and if additional support is needed, but also to provide data to meet claims from adjacent property owners. In this regard, it is essential that detailed precondition surveys be made on adjacent structures.

4.2.3 Groundwater Control

Stabilized groundwater level measurements obtained at the monitoring well locations ranged from 4.40 m below grade (Elev. 220.60 m) to 2.90 m above grade (Elev. 234.87 m), i.e. artesian conditions.

Any perched water within the fill or water bearing seams should generally be possible to remove using conventional construction sump pumping techniques for shallow utility excavations. More significant dewatering may be required in some water bearing layers. Basal heave resulting from the artesian conditions may also be encountered and require dewatering below the excavation depth; reference to the hydrogeological studies for the site should be made for the safe excavation depths.

To maintain stability of open-cut excavations in deeper excavations, the groundwater level will have to be temporarily drawn down, e.g. by using deep sumps, wells, or well points. Filtered sumps must be designed properly so that construction drainage water containing eroded soils does not flow into the nearby waterways. The design of dewatering systems for the open-cut and shored excavations is the responsibility of the contractor and it is expected that dewatering specialists will be retained for this task.

Reference to the hydrogeological studies for the subject site should be made for additional dewatering comments and recommendations. Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions.

4.2.4 Pipe Bedding

The native soils on site are expected to provide adequate support for the pipes, provided adequate dewatering is carried out. Pipe bedding and cover requirements should be in accordance with the Ontario Provincial Standard Drawing (OPSD) relevant to encountered ground conditions and the type of pipe installed. The pipe bedding should consist of Granular A material (OPSS 1010). The cover material should consist of Granular A or a compacted sand material with grain sizes not exceeding 25 mm.

The granular bedding and cover material should be placed in lifts not exceeding 150 mm and compacted to 95% of the SPMDD. In order to minimize the risk of damage to the pipe, the first lift above the pipe should be increased to at least 300 mm in thickness. Particular care should be taken when compacting beneath the pipe haunches. The degree of compaction achieved in the field should be checked by in-situ nuclear density tests.

In areas where wet or loose subgrade conditions are encountered, the bedding thickness can be increased, or a 300 mm thick layer of 19 mm clear stone wrapped in geotextile (e.g. Terrafix 360R or equivalent) may be used.

4.2.5 Thrust Blocks

It is recommended that all thrust blocks for the proposed watermains be poured neat against the native soils without the use of forms in order to achieve the maximum restraint with minimum deflection. Horizontal restraint for the thrust block is provided by the passive earth pressure developed in the soil behind the block and the friction along the base. The passive earth pressure may be estimated using the following equation and geotechnical parameters:

$$p = K(\gamma h)$$

where p = lateral earth pressure intensity at depth h (kPa)

K = earth pressure coefficient

γ = unit weight of soil (kN/m^3)

h = depth to point of interest (m)

In general, an earth pressure coefficient, K, of 2.2 may be used. An assumed coefficient of sliding friction of 0.35 may be used on the sandy silt, silt or silty clay soils and 0.45 on the silty sand to sand.

4.2.6 Trench Backfilling Operations

Given the elevated moisture content at some locations/depths, moisture content adjustment (e.g. spreading and drying) should be anticipated to facilitate compaction of re-used materials. The majority of the excavated soils will be silty materials which require strict moisture content control and heavy compaction equipment and so may not be practical for re-use as trench backfill. Furthermore, even after these soils have been compacted to a high density, the pore water pressure in the soils could remain high for a long time, making the soils “spongy” and not suitable for support of pavements. In any case, re-use of the on-site fill should be at the discretion of the geotechnical consultant during construction. Any re-used materials must also be free from organics and deleterious materials. Any shortfall of suitable on-site excavated material can be made-up with imported and approved fill or granular material (e.g. Granular B Type I or Type II, or equivalent).

All backfilling and compaction operations should be closely examined by a representative of this office to ensure uniform compaction to specification requirements, especially in the vicinity of manholes and in all areas that are not readily accessible to compaction equipment. All backfill should be placed in maximum 200 mm loose lifts and uniformly compacted to at least 95% SPMDD. For trenches below pavement areas, the upper 600 mm of backfill below subgrade level should be compacted to at least 98% SPMDD.

To mitigate the potential for differential settlement, the fill around catch basins and manholes should consist of free draining Granular B Type I or Type II material. To minimize potential problems, backfilling operations should follow closely after excavation and pipe installation so only a minimal length of trench is exposed. This will minimize wetting

of the subgrade and backfill materials. Should construction extend to the winter season, frozen material must not be used as backfill.

4.3 Building Construction

In general, the site is considered suitable for founding low-rise buildings on conventional shallow spread and strip footing foundations, with some areas also suitable for mid-rise buildings. It is understood that the proposed structures will typically not include more than one level of basement. EXP should be contacted to review the final site grades, proposed foundation elevations, and building configurations once available to ensure the geotechnical resistances provided are applicable. Additional boreholes will be required to confirm the foundation recommendations given once the final building locations and configurations are determined.

4.3.1 Conventional Foundations on Native Soil

The proposed buildings can be founded below any organics, fill, disturbed or loose materials, on the undisturbed native soil and, for preliminary guidance, designed using geotechnical resistances of between 100 kPa and 400 kPa at Serviceability Limit State (SLS) and between 150 kPa and 600 kPa at Ultimate Limit State (ULS) as detailed in the table below.

Table 4-1: Preliminary Available Geotechnical Resistance

Borehole No.	Available Geotechnical Resistance (kPa)	Founding Soils	Recommended Minimum Founding Depth / Elevation (m)
BH-01	150 SLS / 225 ULS	Native Silt	1.5 / 236.4
BH-02	200 SLS / 300 ULS	Native Silt	1.0 / 234.3
BH-03	200 SLS / 300 ULS	Native Silt	1.0 / 233.2
	400 SLS / 600 ULS	Native Sandy Silt/Silty Sand	3.1 / 231.1
BH-04	200 SLS / 300 ULS	Native Silt	1.0 / 229.7
	400 SLS / 600 ULS	Native Silt	2.3 / 228.4
BH-05	200 SLS / 300 ULS	Native Silt	1.0 / 227.8
	400 SLS / 600 ULS		2.3 / 226.5
BH-06	150 SLS / 225 ULS	Native Silt	1.0 / 229.9
	300 SLS / 450 ULS		1.5 / 222.4
BH-07	150 SLS / 225 ULS	Native Silty Clay/Silt	1.0 / 221.1
BH-08	150 SLS / 225 ULS	Native Silt	1.0 / 231.2
	300 SLS / 450 ULS		2.3 / 229.9
BH-09	100 SLS / 150 ULS	Native Silt	1.0 / 232.0
	400 SLS / 600 ULS		3.1 / 229.9
BH-10	400 SLS / 600 ULS	Native Silt/Silty Sand	1.5 / 232.0

Borehole No.	Available Geotechnical Resistance (kPa)	Founding Soils	Recommended Minimum Founding Depth / Elevation (m)
BH-11	200 SLS / 300 ULS	Native Silt	1.0 / 230.6
	300 SLS / 450 ULS	Native Silt/Silty Clay	2.3 / 229.3
BH-12	150 SLS / 225 ULS	Native Silt	1.0 / 231.2
	400 SLS / 600 ULS		2.3 / 229.9
BH-13	200 SLS / 300 ULS	Native Silt	1.0 / 229.4
	400 SLS / 600 ULS		2.3 / 228.1
BH-14	100 SLS / 150 ULS	Native Silt Clay/Silt	1.5 / 228.3
	400 SLS / 600 ULS	Native Silt	4.6 / 225.2
BH-15	150 SLS / 225 ULS	Native Silt	1.0 / 231.2
	300 SLS / 450 ULS		2.3 / 229.9
BH-16	150 SLS / 225 ULS	Native Silt	1.0 / 227.9
	300 SLS / 450 ULS		1.5 / 227.4
BH-17	150 SLS / 225 ULS	Native Silt	1.0 230.0
BH-18	100 SLS / 150 ULS	Native Silty Clay/Silty Sand	1.0 / 232.8
	400 SLS / 600 ULS	Native Silty Sand/Sandy Silt	2.3 / 231.5
BH-19	150 SLS / 225 ULS	Native Silt	1.0 / 234.0
	400 SLS / 600 ULS		2.3 / 232.7
BH-20	150 SLS / 225 ULS	Native Silt	1.0 / 233.8
	400 SLS / 600 ULS		4.6 / 230.2
BH-21	100 SLS / 150 ULS	Native Silty Clay/Silt	1.0 / 227.5
	400 SLS / 600 ULS	Native Silt	2.3 / 226.2
BH-22	150 SLS / 225 ULS	Native Silt	1.0 / 225.3
	300 SLS / 450 ULS		1.5 / 224.8
BH-23	150 SLS / 225 ULS	Native Silt	1.0 / 222.8
	300 SLS / 450 ULS		2.3 / 221.5
BH-24	150 SLS / 225 ULS	Native Silt	1.0 / 235.2
BH-25	200 SLS / 300 ULS	Native Silty Clay	1.0 / 234.3
	300 SLS / 450 ULS	Native Silt	2.3 / 233.0

Borehole No.	Available Geotechnical Resistance (kPa)	Founding Soils	Recommended Minimum Founding Depth / Elevation (m)
BH-26	200 SLS / 300 ULS	Native Silt	1.5 / 235.2
BH-27	200 SLS / 300 ULS	Native Silt	1.0 / 231.4
BH-28	150 SLS / 225 ULS	Native Silt	1.0 / 224.1
	400 SLS / 600 ULS		3.1 / 222.0
BH-29	100 SLS / 150 ULS	Native Silty Clay/Silt	1.0 / 231.0
	300 SLS / 450 ULS	Native Silt/Silty Sand	2.3 / 229.7
BH-30	200 SLS / 300 ULS	Native Silty Clay/Silt	1.0 / 232.5
BH-31	150 SLS / 225 ULS	Native Silt	1.0 / 230.9
	300 SLS / 450 ULS	Native Silty Clay	2.3 / 229.6
BH-32	200 SLS / 300 ULS	Native Silty Clay	1.0 / 221.0
MW23-1	200 SLS / 300 ULS	Native Silty Clay/Silt	1.1 / 238.8
	400 SLS / 600 ULS	Native Silt	3.1 / 236.8
BH23-1	200 SLS / 300 ULS	Native Silt/Silty Clay	1.1 / 240.9
MW23-2	150 SLS / 225 ULS	Native Silt	1.0 / 241.8
	300 SLS / 450 ULS		4.6 / 238.2
BH23-2	300 SLS / 450 ULS	Native Silty Clay/Silt	1.0 / 242.1
MW23-3	300 SLS / 375 ULS	Native Silt	1.5 / 248.6
BH23-3	200 SLS / 225 ULS	Silty Sand/Silt/Silty Clay	1.5 / 242.4
MW23-4	150 SLS / 225 ULS	Native Silt	1.1 / 239.0
BH23-4	150 SLS / 225 ULS	Native Silt	1.1
	250 SLS / 375 ULS	Native Silt	1.5
MW23-5	150 SLS / 225 ULS	Native Silt/Silty Clay	1.1 / 232.0
	400 SLS / 600 ULS	Native Silt	4.5 / 228.6
MW23-6	150 SLS / 225 ULS	Native Silty Clay/Silt	1.5 / 234.4
	400 SLS / 600 ULS	Native Silt	3.1 / 232.8

Borehole No.	Available Geotechnical Resistance (kPa)	Founding Soils	Recommended Minimum Founding Depth / Elevation (m)
MW23-7	250 SLS / 375 ULS	Native Silt	1.5 / 227.8
	400 SLS / 600 ULS		3.1 / 226.2
MW23-8	150 SLS / 225 ULS	Native Silty Clay/Silt	1.0 / 225.2
MW23-9	100 SLS / 150 ULS	Native Silt	1.5 / 223.5
MW23-10	100 SLS / 150 ULS	Native Silty Clay	1.5 / 232.3
	400 SLS / 600 ULS	Native Silt	4.6 / 229.2
MW23-11	200 SLS / 300 ULS	Native Silt	1.5 / 235.5
	300 SLS / 450 ULS	Native Silty Sand/Silt	2.6 / 234.4
MW23-12	150 SLS / 225 ULS	Native Silty Clay/Silt	1.0 / 231.7

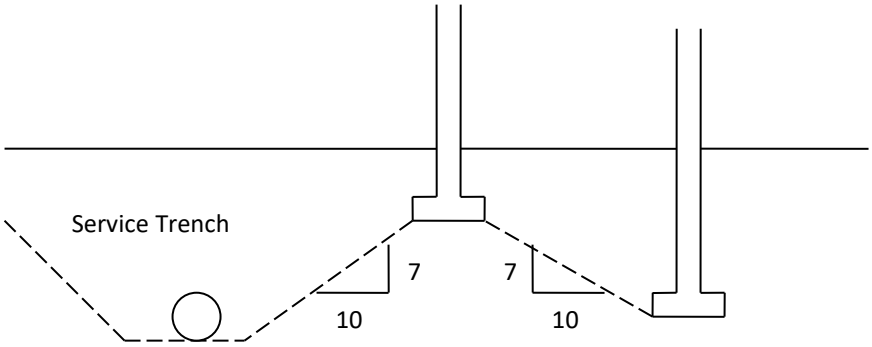
The footing base must be evaluated by geotechnical personnel from EXP prior to engineered fill or concrete placement to confirm the availability of the geotechnical resistance values provided and the foundation elevation.

4.3.2 Conventional Foundations on Engineered Fill

Alternatively, if required due to the site grades, the buildings can be supported on conventional footings founded on engineered fill overlying native soil. Footings supported on at least 500 mm of engineered fill constructed in accordance with Drawing No. 52 in Appendix A may be designed on a preliminary basis utilizing a geotechnical resistance of 150 kPa at SLS and 225 kPa at ULS.

4.3.3 General Foundation Recommendations

Conventional foundations in soil at different elevations should be located such that higher footings are set below a line drawn up at 10:7, horizontal to vertical from the near edge of the lower footing. This concept should also be applied to excavations for new foundations in relation to existing foundations or underground services.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

All foundations exposed to freezing conditions must be provided with a minimum of 1.2 m of earth cover or equivalent insulation for frost protection, depending on the final grade requirements.

Provided that the soil is not disturbed due to groundwater, precipitation, traffic, etc., and the aforementioned bearing pressure is not exceeded, then total and differential settlements should be small and within the normally tolerated limits of 25 mm and 19 mm, respectively.

The recommended geotechnical resistances have been calculated by EXP from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of underground conditions becomes available. For example, it should be appreciated that modifications to bearing levels may be required if unforeseen subsoil conditions are revealed after the excavation is exposed to full view or if final design decisions differ from those assumed in this report. For this reason, this office should be retained to review final foundation drawings and to provide field inspections during the construction stage.

4.3.4 Building Excavations

Excavations for the proposed buildings are anticipated to extend to depths in the order of 1.5 to 3.0 m below the final site grades. Excavations within the encountered overburden may be undertaken with a sufficiently sized hydraulic excavator.

All excavations must be completed in accordance with the most recent regulations of the Ontario Occupation Health and Safety Act (OHSA). The dense to very dense silts and sands and the very stiff to hard silty clay may be classified as Type 2 Soil above the groundwater level. In general, the fill or disturbed native materials and loose to compact silts and sands may be classified as Type 3 Soil above the groundwater level. The soft clays and soils below the groundwater level are generally classified as Type 4 Soil. Temporary excavations can be carried out with side slopes not steeper than 1H:1V in Type 2 or Type 3 soil (with Type 2 able to be sloped from 1.2 m above the base of the excavation) and 3H:1V in Type 4 soil. However, even at this relatively flat slope, seepage pressures may result in sloughing and unstable ground conditions. As such, dewatering (see Section 4.2.3) to temporarily draw down the groundwater level may be required, particularly for any buildings with more than one level of basement.

4.3.5 Groundwater Control

The relatively shallow excavations are typically not expected to encounter significant groundwater. Any perched water within the fill or water bearing seams should be possible to remove using conventional construction sump

pumping techniques combined with oversized excavations and ditching, as required. Basal heave resulting from the artesian conditions may also be encountered and require dewatering below the excavation depth; reference to the hydrogeological studies for the site should be made for the safe excavation depths. Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions.

4.3.6 Lateral Earth Pressure

The lateral earth pressure acting on the foundation walls may be calculated using the following equation:

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

where
- p = lateral earth pressure intensity at depth h (kPa)
- K = earth pressure coefficient (assume 0.40)
- γ = unit weight of retained soil (assume 21.0 kN/m^3 for granular backfill)
- h = depth to point of interest (m)
- q = surcharge load acting adjacent to the wall at the ground surface (kPa)

The above expression assumes that the perimeter drainage system prevents the build-up of hydrostatic pressure behind the wall and free-draining granular material will be used for backfilling adjacent to the wall. The City of Hamilton does not allow discharge of groundwater to sewer systems and so it may be required to construct basements to be waterproofed and designed to resist hydrostatic pressure. In this case the following expression would instead be applicable:

$$p = K[(\gamma h_w) + \gamma'(h - h_w) + q] + \gamma_w (h - h_w)$$

where
- p = lateral earth pressure and hydrostatic pressure acting at depth h (kPa)
- K = active earth pressure coefficient, assume 0.40
- γ_w = unit weight of water, 10 kN/m^3
- γ = unit weight of soil surrounding the structure, assume 22.0 kN/m^3
- γ' = effective unit weight of retained soil, assume 12 kN/m^3
- h = depth to point of interest (m)
- q = equivalent value of surcharge on the ground surface (kPa)

4.3.7 Building Floor Slab-on-Grade and Permanent Drainage

No concerns are anticipated for the floor slab-on-grade for the buildings, provided the subgrade is prepared as detailed in Section 4.1 (Site Grading). The floor slab should be cast on a moisture barrier consisting of 19 mm clear stone with a thickness of at least 200 mm. The clear stone layer will minimize the capillary rise of moisture from the subgrade to the floor slab (moisture barrier). Adequate saw cuts should be provided in the floor slab as directed by the structural engineer to help control cracking.

Around the perimeter of the proposed buildings, the ground surface should be sloped away from the structure to promote surface water run-off and reduce groundwater infiltration adjacent to the foundations. Perimeter drains can be eliminated if the floor slab is at least 300 mm above the exterior grade. Underfloor drains are not required for

proposed buildings with no basements. Underfloor drains (or waterproofing and "tanking" of the foundation) may be required depending on the proposed founding level and groundwater conditions at the proposed building location; this should be further assessed once the site grades and founding levels have been determined. If underfloor drainage is installed, the perimeter and underfloor systems should not be connected to the same collector pipe.

4.3.8 Backfill

Backfill used to satisfy under slab requirements and against foundation walls, etc. should be compactible fill, i.e. inorganic soil with its moisture content close to its optimum moisture content as determined in the standard Proctor test. Fill placed below concrete slab areas should be compacted to 100% Standard Proctor Maximum Dry Density (SPMDD) in lifts not exceeding 200 mm.

In general, the overburden soils are not free draining and therefore should not be used where this characteristic is required, or in confined areas. Imported granular material conforming to OPSS Granular B Type I or II would be suitable for these purposes.

All backfilling and compaction operations must be closely examined by a qualified geotechnical consultant to ensure uniform compaction to specification requirements, especially in the vicinity of manholes and catch basins, and in all areas that are not readily accessible to compaction equipment. Should construction extend to the winter season, particular attention should be given to ensure that frozen material is not used as backfill.

4.3.9 Earthquake Considerations

The subsoil and groundwater information at this site have been examined in relation to Section 4.1.8.4 of the OBC 2012. The subsoil typically consisted of compact to very dense silts and sands and very stiff to hard silty clay with zones of loose/soft soils. Foundations are anticipated to be founded on the compact to dense or very stiff to hard native soils or on engineered fill overlying native soil. The reported N values for the native soil below the anticipated founding level ranged from 2 to greater than 100 blows per 305 mm penetration. Undrained shear strengths from pocket penetrometer readings ranged from 25 to greater than 225 kPa. There have been no shear wave velocity measurements carried out at this site and therefore, N values and EXP's knowledge of the soil and bedrock conditions in the area have been used to determine the site classification.

Based on the known soil conditions and anticipated founding conditions, the preliminary recommended Site Class for this site is typically expected to be "D" as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2012. However, given the widely variable conditions across the site, the seismic site classification is to be re-evaluated for each building area following additional investigation. The acceleration and velocity-based site coefficients, F_a and F_v, should be determined from Tables 4.1.8.4.B. and 4.1.8.4.C. respectively of the OBC for the above recommended Site Class.

It may be possible to achieve an improved site class through the evaluation of the subsurface conditions using shear wave velocities at some building locations. EXP can be contacted to provide this service, if required.

4.4 Stormwater Management Ponds

It is understood that the project will include the construction of multiple stormwater management ponds (SWP). Details of the proposed SWP's (depths, sizes, slopes, etc.) were not available at the time of the investigation and the

locations have changed since the 2018 investigation. Boreholes BH-31, MW23-4, and MW23-9 were advanced within the general areas of the proposed SWP's. These boreholes generally encountered silt and silty clay, with silty sand encountered at greater depths at BH-31. The groundwater levels, as reported above, ranged from approximately 2.0 to 4.4 m below grade in MW23-4 and MW23-9, with artesian conditions encountered in Borehole BH-31.

The hydrostatic uplift pressure, base stability, and drainage requirements should be evaluated by EXP once the pond base elevation is determined and following seasonal groundwater level measurements. Preliminary comments on the pond construction are provided in the following sections.

4.4.1 Pond Excavation and Construction

The proposed pond excavation depths were not available at the time of this report and are required to provide specific recommendations. Excavations above the groundwater level are not expected to encounter significant issues and can be carried out with a heavy hydraulic excavator. Some groundwater infiltration from surface run-off and perched water within the reworked soil may be encountered but should be possible to control using conventional construction pumping techniques. More significant dewatering methods may be required in some water bearing layers, e.g. silty or sandy layers within silty clay soils at depth, and below the groundwater level. Basal heave resulting from the artesian conditions may also be encountered and require dewatering below the excavation depth; reference to the hydrogeological studies for the site should be made for the safe excavation depths.

Based on the near surface to artesian groundwater conditions encountered at the sites of the proposed SWP's, a drainage system in combination with a synthetic or compacted clay liner should be anticipated. It should be noted that drawing down the groundwater level can result in settlements of structures within the zone of influence. Depending on the pond base elevation, dewatering restrictions, and available drainage courses, more elaborate groundwater control methods may be required, e.g. continuous pumping of groundwater, structural concrete slab and tie-downs.

4.4.2 Compacted Clay Liner

4.4.2.1 Material Specifications

All materials to be used in the construction of a clay liner shall be analyzed for particle size distribution and Atterberg Limits. If the distribution of the particle sizes and the Atterberg Limits fall within the ranges given below, the material is considered acceptable for compacted clay liner construction without the need for additional laboratory testing, provided it is installed using the recommended equipment and procedures. The use of materials as defined herein are expected to produce a clay liner with a hydraulic conductivity of $1x10^{-8}$ m/sec or less.

Acceptable particle size ranges (by weight):

- Percent fines ≥ 50%
- Clay Content ≥ 20%
- Sand Content ≤ 45%

Where the fines are defined as the soil fraction which passes through a No. 200 (75 µm) US Standard sieve, and clay and sand are defined in the ASTM D2487 standard.

Acceptable Atterberg Limits:

- Plasticity Index (PI) ≥ 0.73(LL - 20)
- Liquid Limit (LL) ≥ 40

Poorly graded materials with high silt content may not be acceptable. Such materials do not compact well and are highly erodible. Based on the results of the grain sizes and Atterberg Limits tests and the above requirements, the encountered materials at the site are generally not considered suitable for use in the clay liner.

When the material to be used for the construction of a compacted clay liner does not meet all the criteria above, additional testing is required to demonstrate that the "as-constructed" clay liner will have a field hydraulic conductivity of $1x10^{-8}$ m/sec or less. Laboratory hydraulic conductivity shall be determined following ASTM 5084 on no less than three samples after compaction to at least 95% SPMDD.

Alternatively, material for the clay liner may be made from 1 part bentonite powder and 3.5 parts Granular A (OPSS 1010) by volume. Mixing of the material shall be carried out in an approved mechanical mixer.

4.4.2.2 Liner Placement and Compaction

The following comments regarding liner placement and compaction should be adhered to:

- *Compaction Specification* - The clay liner shall be compacted to at least 95% SPMDD at a moisture content between 90 and 120% of optimum.
- *Moisture Management* – If additional moisture is required for compaction, water shall be applied by sprinkling directly on the liner material. The quality of the water shall be subject to the approval of the Engineer and shall be free from undesirable quantities of organic matter and mineral salts. Water application pressure shall be controlled to prevent erosion of the liner and to prevent freestanding water on the surface.
- *Liner Lift Placement* – Liner materials shall be spread by a motor grader or other means approved by Engineer to obtain a uniform lift thickness prior compaction. In the bottom of the excavation, the liner material shall be first placed in the lowest elevations.
- *Lift Thickness* – The foot length of the compaction equipment will govern the thickness of the loose lift that can be compacted. The thickness of each uncompacted lift shall be at least 25 mm less than the foot length of the compaction equipment. This is to ensure full penetration through the uncompacted lift and into the previous compacted liner layer or subgrade on the first pass of the compaction roller feet.
- *Bonding Between Lifts* – If the surface prior to placing the next lift is too hard for the feet on the sheepsfoot roller to penetrate, the surface shall be scarified.
- *Foreign Materials* – All rocks greater than 75 mm in diameter, roots and organic debris shall be removed from the liner material prior to compaction.
- *Construction Below Freezing* – Excavation and compaction shall be completed only when soil temperatures are above freezing.
- *Overlap of Equipment Passes* – The overlap between equipment passes shall not be less than 10% of width of the equipment being used to ensure lateral bonding between placed materials.

- *Liner Desiccation* – Each compacted lift shall be protected from drying out to prevent cracking due to shrinkage.

4.4.2.3 Synthetic Clay Liner

A synthetic liner (e.g. Bentofix SRNWL or equivalent) can be considered. The liner should be installed on a properly prepared subgrade in accordance with the liner manufacturer's specifications. If the pond slopes are to be vegetated, it will be necessary to specify a liner that will exhibit sufficient friction to ensure topsoil will not slide off the liner when the pond is in service. The liner should be installed in accordance with the following procedures:

- After stripping, the exposed subgrade should be inspected and approved by a geotechnical representative from this office. The groundwater table should be lowered to at least 0.5 m below the pond base level.

- A 150 mm diameter perforated drain should be installed in a drainage blanket and discharged to a sump or the nearest suitable creek. The water in the sump should not exceed elevation of the base of the pond to prevent uplift.

- A minimum 150 mm levelling sand layer should be placed over the drainage blanket prior to installing the synthetic liner.

- A minimum 200 mm of top dressing should be placed over the synthetic liner, which will act as a "reminder layer". The rock layer is to mark the location of the liner for future maintenance operations. As an alternative to rip-rap, 300 mm of native compacted soil may be used if orange plastic "safety fencing" or another highly-visible, continuous marker is embedded 150 mm above the membrane. This will ensure that during maintenance operations machinery operators know when they have reached the bottom of the pond and do not over-excavate and damage the liner.

- Alternatively, a geo-cell confinement system could be installed over the liner and infilled with topsoil above the permanent water elevation. As penetrations through the liner would not be allowed, the geo-cell system would need to be anchored at the top of the pond in a keyway and supported by tendons that extend through the geo-cell webbing. Geo-Web cellular confinement or a similar system could be considered for this purpose.

4.4.3 Pond Grading and Surface Treatment

Loose and unsuitable materials should be removed from pond slope areas. Provided an adequate drainage system is implemented, the sides of the ponds may be sloped at 3H:1V or flatter. The slopes should be surface compacted with a heavy roller and should be grassed to prevent surface erosion. Armour stone or rip-rap with filter cloth backing should be placed on the slope face where extensive wet/saturated layers are encountered to prevent side sloughing.

4.5 Pavement Considerations

It is understood that new roadways will be constructed at the site. The proposed subdivision includes commercial and industrial properties. The recommended pavement structures are provided in the table below and are based on the City of Hamilton standards and an estimate of the subgrade soil properties determined from visual examination and textural classification of the soil samples and assumed traffic requirements. Consequently, the recommended pavement structures should be considered for preliminary design purposes only.

Table 4-2: Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Hamilton Standard (Collector Roads - Commercial/ Industrial)	Hamilton Standard (Collector Roads - Residential)	Hamilton Standard (Local Roads - Commercial/ Industrial)	Private Medium-Duty Parking/ Driveways	Private Industrial Roads & Heavy-Duty Parking
Superpave Asphalt (OPSS 1151)	Min. 92% Maximum Relative Density (MRD)	50 mm SP 12.5 FC1/2	40 mm SP 9.5	40 mm SP 9.5	-	-
		110 mm SP 19.0	100 mm SP 19.0	80 mm SP 19.0		
Asphaltic Concrete (OPSS 1150)	Min. 92% MRD	-	-	-	40 mm HL3	40 mm HL3
					50 mm HL8	100 mm HL8
Granular A (OPSS 1010)	100% SPMDD	150 mm	150 mm	150 mm	150 mm	150 mm
Granular B Type II (OPSS 1010)	100% SPMDD	450 mm	300 mm	300 mm	200 mm	450 mm

The subgrade should be properly shaped, crowned, and thoroughly proof-rolled under the guidance of the geotechnical consultant and any soft spots or unsuitable material revealed during proof-rolling should be sub-excavated and replaced with suitable approved fill or imported granular fill compacted to 98% Standard Proctor Maximum Dry Density (SPMDD). If required, the area can then be brought up to final subgrade level with approved on site or imported material placed in lifts not exceeding 200 mm and compacted to 95% of SPMDD (with the upper 600 mm compacted to 98% of SPMDD).

The granular base must be placed in maximum 200 mm lifts and compacted to 100% of the Standard Proctor Maximum Dry Density (SPMDD) at a moisture content within 2% of the optimum moisture content.

The foregoing design assumes adequate provision for drainage, construction is carried out during dry periods and the subgrade is stable under the load of construction equipment. If construction is carried out during wet weather, and heaving or rolling of the subgrade is experienced, additional thickness of granular material may be required.

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 uniform subgrade moisture and density conditions are achieved. In addition, the need for adequate drainage cannot be over emphasized. The finished pavement surface and underlying subgrade should be free of depressions and should be sloped to provide effective surface drainage toward catch basins or drainage areas. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. Subdrains should be installed to intercept excess subsurface moisture and prevent subgrade softening.

Additional comments on the construction of the pavement areas are as follows:

- To minimize problems of differential movement between the pavement and catch basins/manholes due to frost action, the backfill around the structures should consist of free draining granular.

- The most severe loading conditions on pavement areas and the subgrade may occur during construction. Consequently, special provisions such as restricted lanes, half loads during paving, etc. may be required, especially if construction is carried out during unfavourable weather.

- To minimize settlement and cracking of the pavement structures above services, it is recommended that paving of the roadways be delayed as long as is practically possible to allow for the trench backfill to settle over time. Further, placement of the surface course should be delayed for as long as is practically possible.

- When the subgrade is totally or partially saturated the application of dynamic loadings cause increased pore pressures and therefore reduce the internal friction and lower resistance to shear. For prevention, an adequate surface and subsurface drainage system implementation is an imperative. Subsurface drainage should drain water, which has permeated the pavement structure and surrounding soil. Such water may enter through open joints and cracks, porous pavement surfaces etc.

A tack coat between the binder and surface course is to be placed in accordance with OPSS 308.

A frost penetration depth of 1.2 m may be used for roadways in the Hamilton area. Frost tapers should be constructed where required in accordance with the applicable Ontario Provincial Standards Drawing OPSD803.030 or OPSD803.031.

5. General Comments

The information presented in this report is based on a limited investigation designed to provide information to support an overall assessment of the current geotechnical conditions of the subject property. The conclusions presented in this report reflect site conditions existing at the time of the investigation.

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

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

More specific information, with respect to the conditions between samples, or the lateral and vertical extent of materials, may become apparent during excavation operations. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent; should this occur, EXP Services Inc. should be contacted to assess the situation and additional testing and reporting may be required. EXP Services Inc. has qualified personnel to provide assistance in regard to future geotechnical and environmental issues related to this property.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Isaac Asonya, P.Eng.
Geotechnical Engineer

Jeffrey Golder, P.Eng.
Manager, Hamilton Geotechnical Services

Appendix A

Drawings & Borehole Logs

EXP Services Inc.

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1595 Clark Boulevard
Brampton, ON L6T 4V1
Canada
www.exp.com

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N

0 50 100 150 200 250 m

- Borehole (EXP, 2018)
- Borehole (EXP / Crozier, 2023)
- Borehole / Monitoring Well (EXP, 2018)
- Borehole / Monitoring Well (EXP / Crozier, 2023)
- Approximate Site Boundary

TITLE AND LOCATION:

BOREHOLE / MONITORING WELL LOCATION PLAN
Geotechnical Investigation
Proposed Subdivision
Twenty Road West
Hamilton, Ontario

PROJECT No.: HAM-00801363-D0	DWN: AC
SCALE: AS NOTED	CHKD: IA
DATE: OCTOBER 2023	DWG. No.: 1

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	

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-01

Project No. HAM-00801363-A0 Drawing No. 3

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

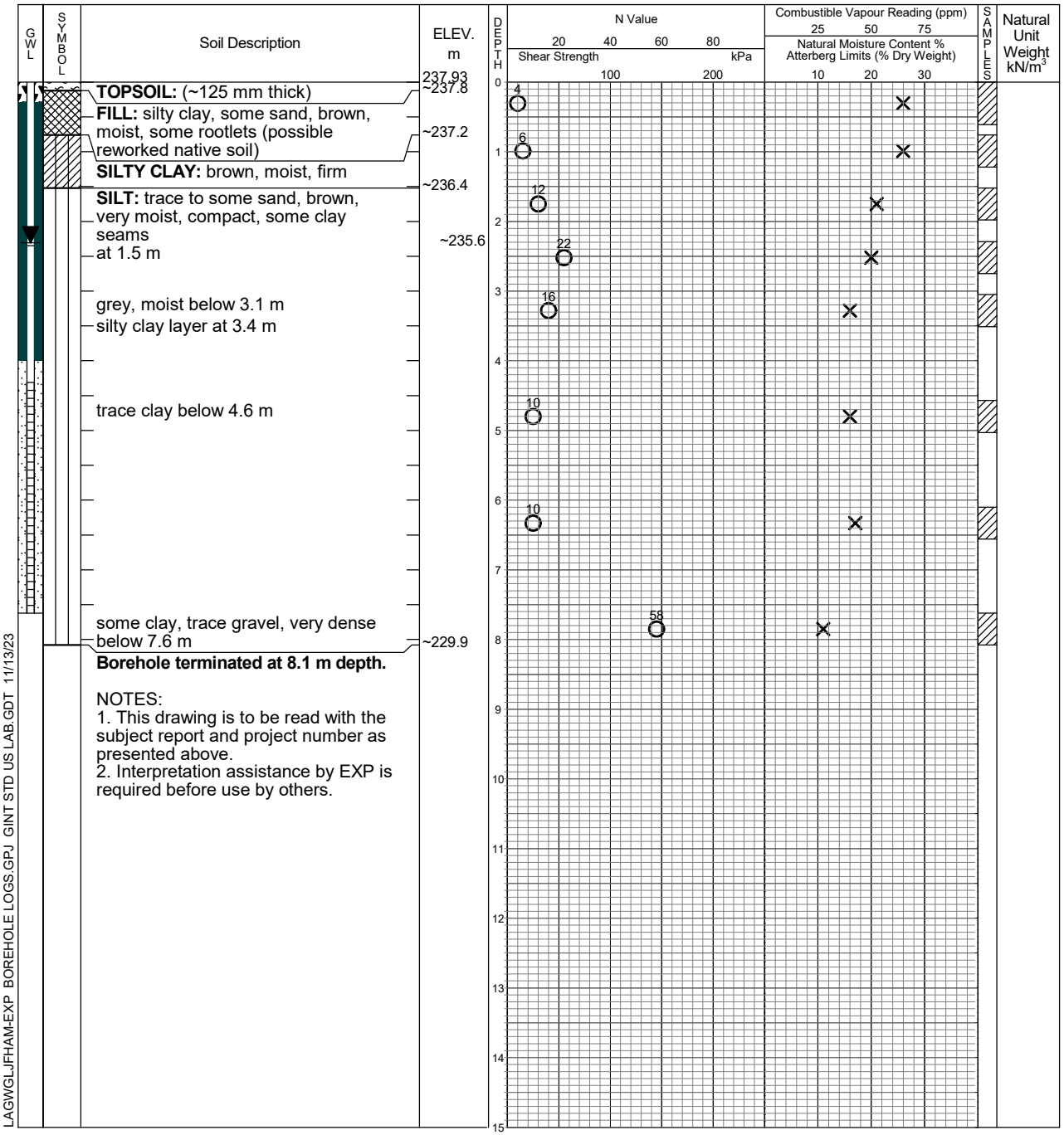
Date Drilled: March 27, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	5.22 bgs	no cave
June 5, 2018	0.78 bgs	--
August 4, 2023	0.56 bgs	
October 13, 2023	2.35 bgs	

EXP Services Inc.
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Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-02

Project No. HAM-00801363-A0 Drawing No. 4

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

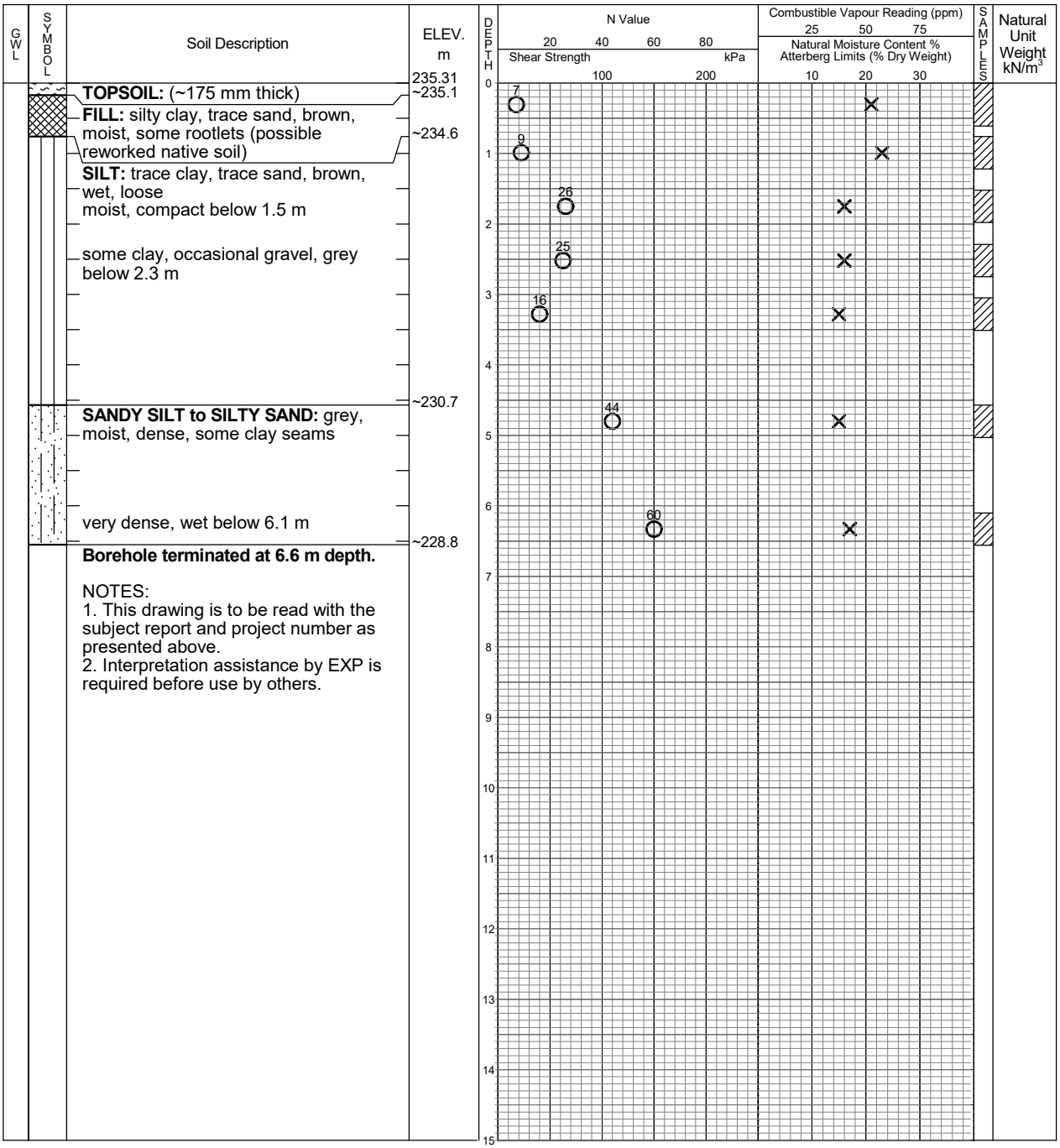
Date Drilled: March 27, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



TOPSOIL: (~175 mm thick)

FILL: silty clay, trace sand, brown, moist, some rootlets (possible reworked native soil)

SILT: trace clay, trace sand, brown, wet, loose
moist, compact below 1.5 m

some clay, occasional gravel, grey below 2.3 m

SANDY SILT to SILTY SAND: grey, moist, dense, some clay seams

very dense, wet below 6.1 m

Borehole terminated at 6.6 m depth.

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
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LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

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Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	5.83 bgs	no cave

Log of Borehole BH-03

Project No. HAM-00801363-A0 Drawing No. 5

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

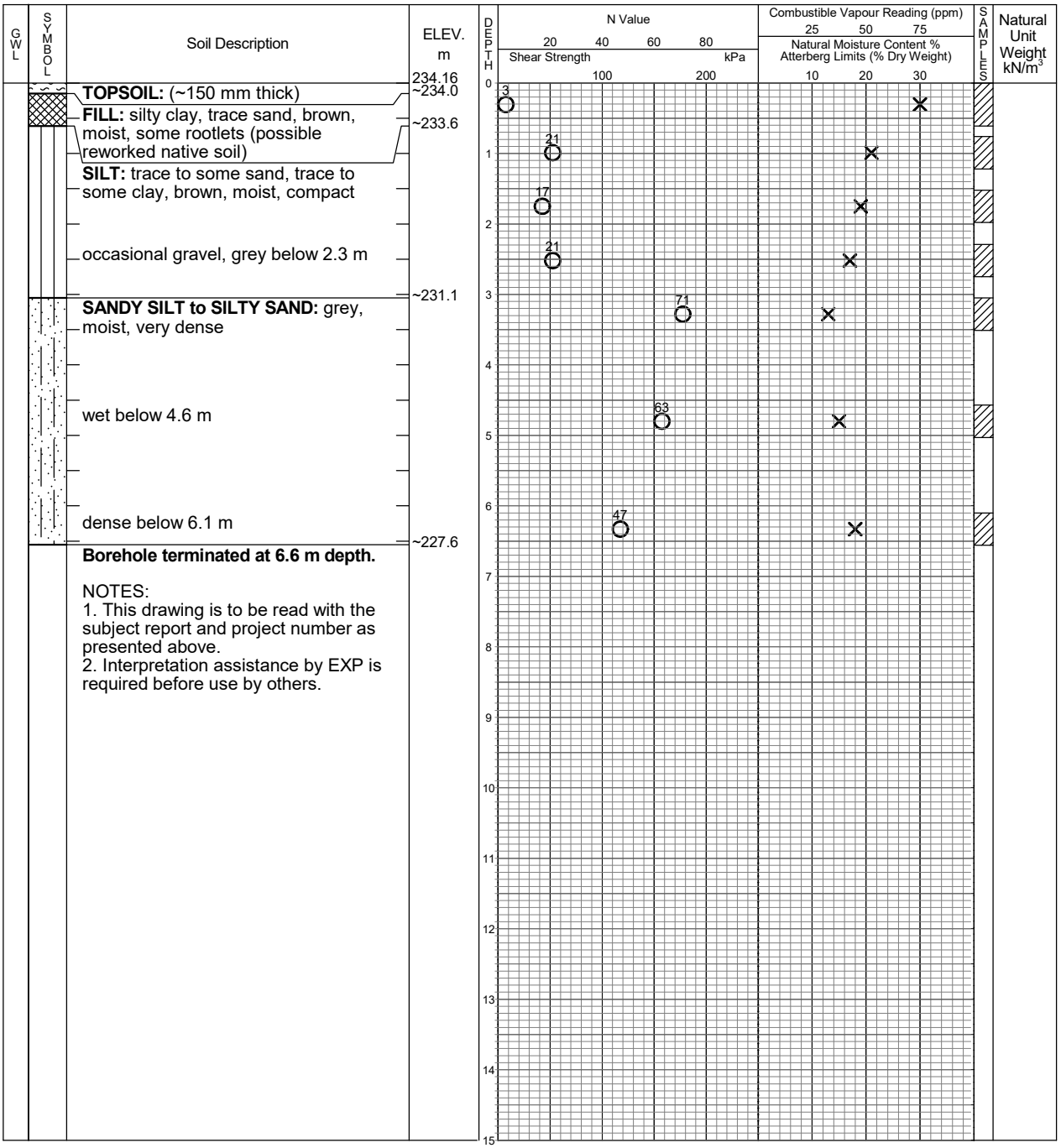
Date Drilled: March 28, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
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Time	Water Level (m)	Depth to Cave (m)
on completion	6.05 bgs	no cave

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Log of Borehole BH-04

Project No. HAM-00801363-A0 Drawing No. 6

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

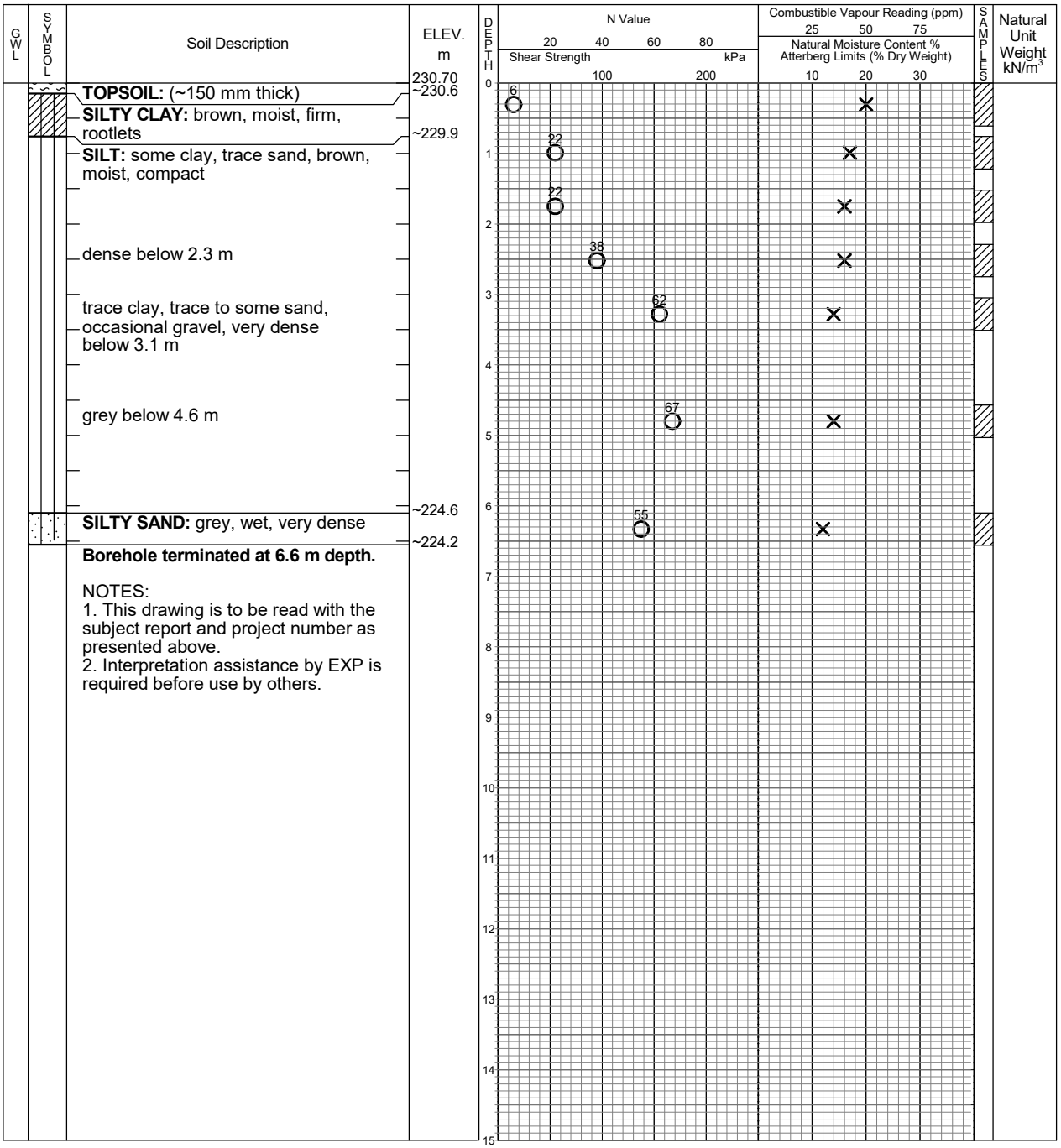
Date Drilled: April 3, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	5.79 bgs	no cave

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Telephone: 905.573.4000
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Log of Borehole BH-05

Project No. HAM-00801363-A0 Drawing No. 7

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

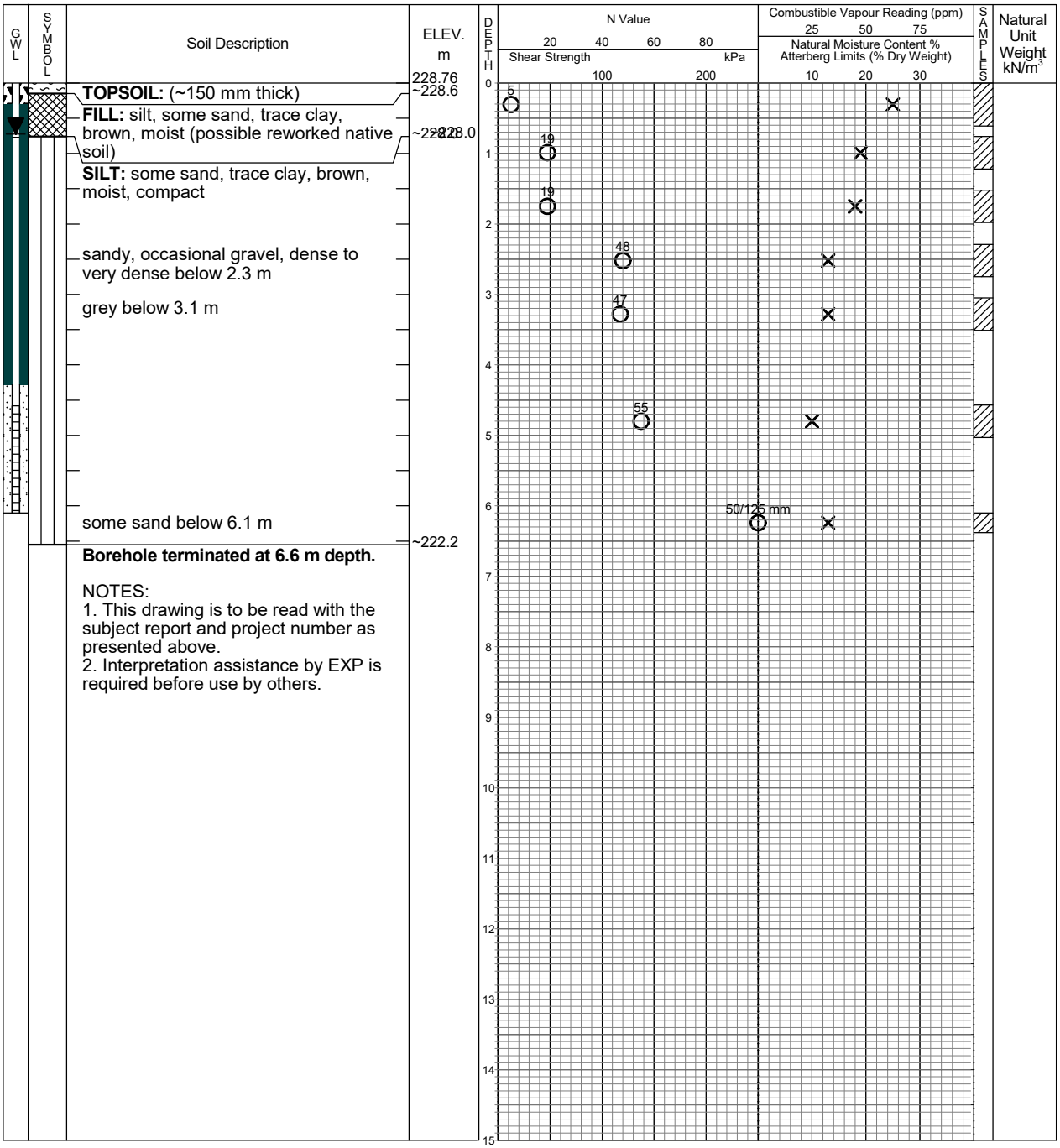
Date Drilled: April 18, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
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Time	Water Level (m)	Depth to Cave (m)
on completion	4.91 bgs	no cave
June 5, 2018	0.73 bgs	--
August 4, 2023	0.86 bgs	
October 26, 2023	0.77 bgs	

Log of Borehole BH-06

Project No. HAM-00801363-A0 Drawing No. 8

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

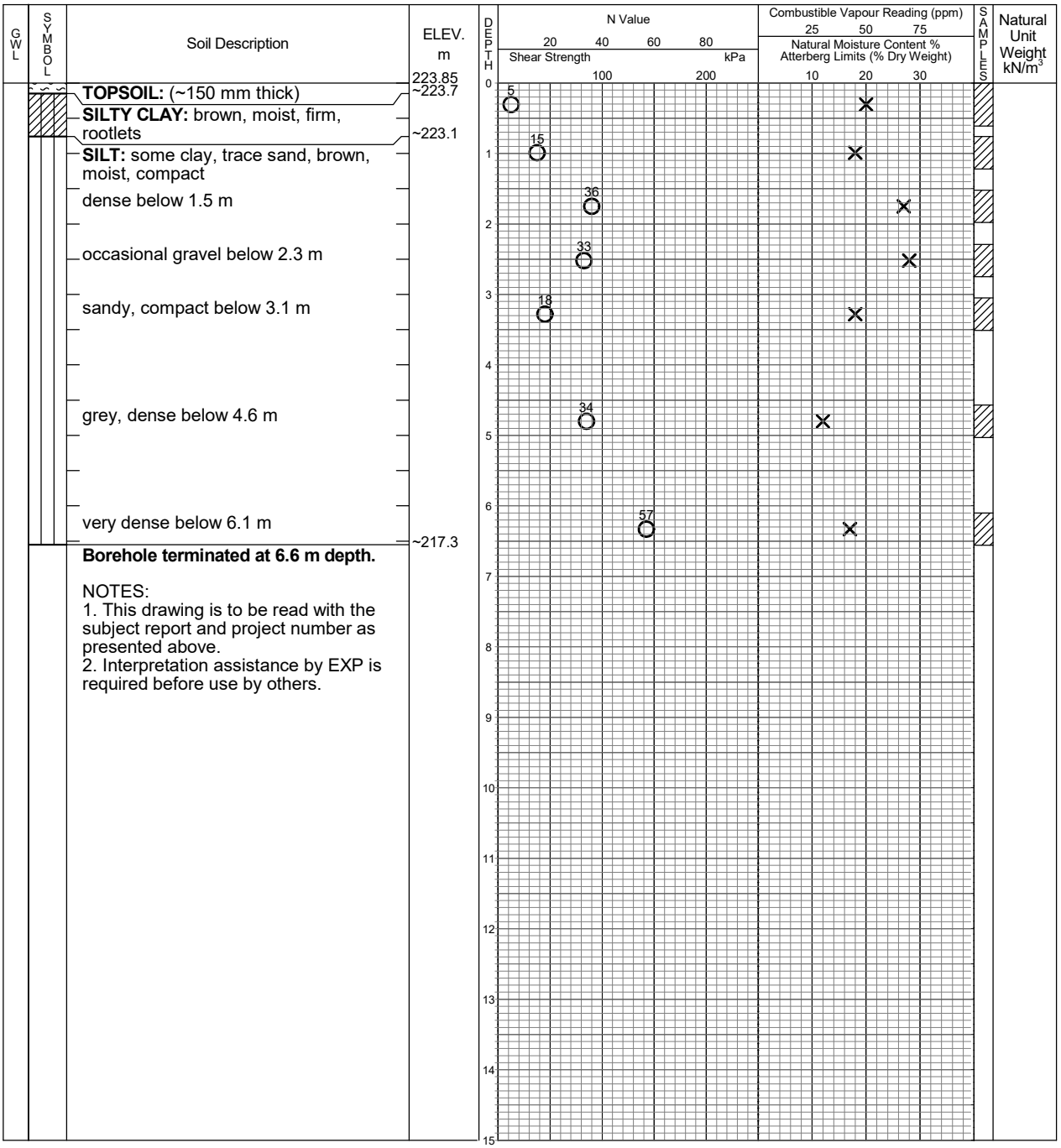
Date Drilled: April 3, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	5.84 bgs	no cave

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Log of Borehole BH-07

Project No. HAM-00801363-A0 Drawing No. 9

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

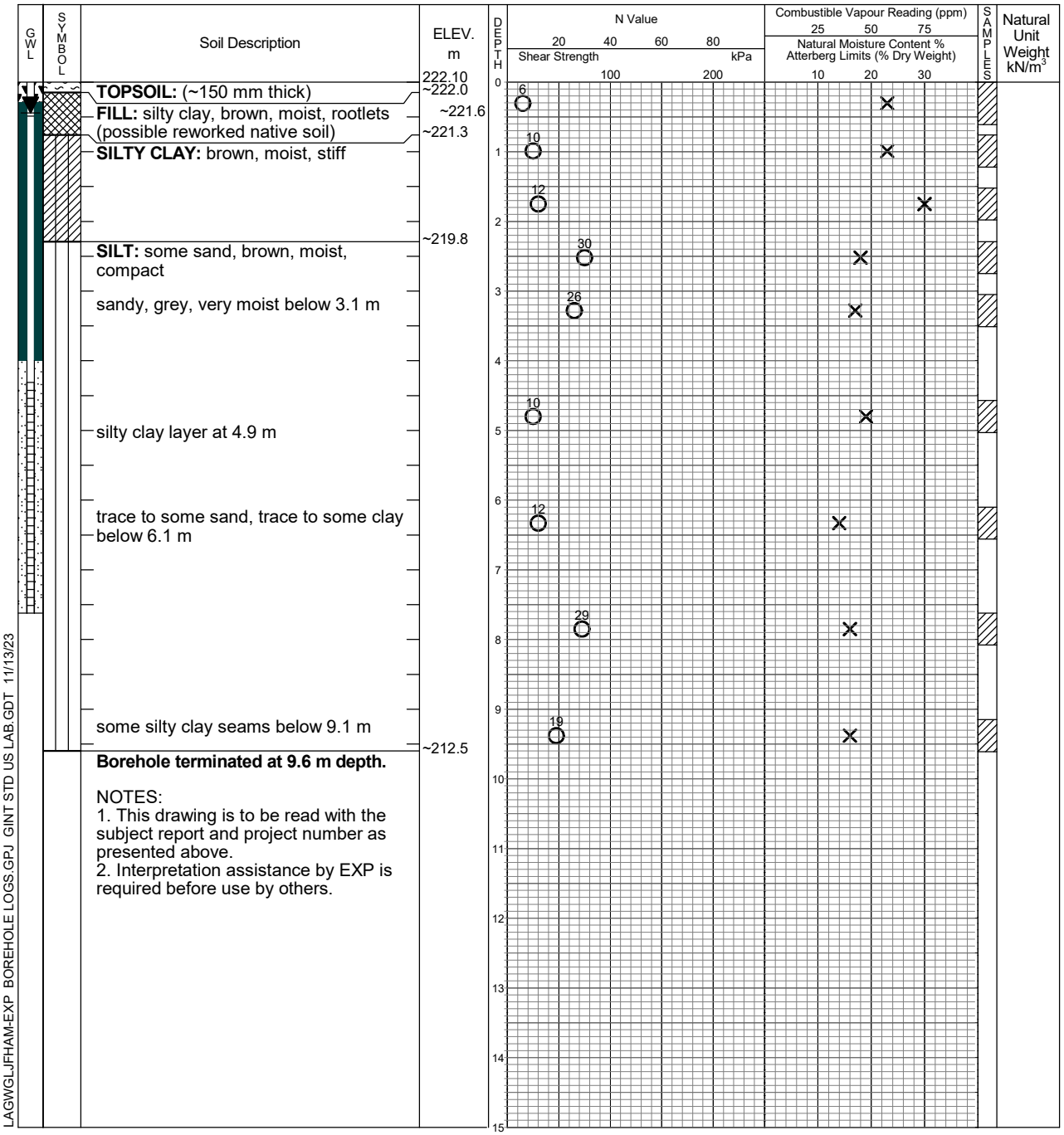
Date Drilled: May 9, 2018

Drill Type: CME-55 Track Mount. Hollow Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
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Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	9.21 bgs	no cave
June 4, 2018	0.27 bgs	--
August 4, 2023	0.64 bgs	
October 26, 2023	0.49 bgs	

Log of Borehole BH-08

Project No. HAM-00801363-A0 Drawing No. 10

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

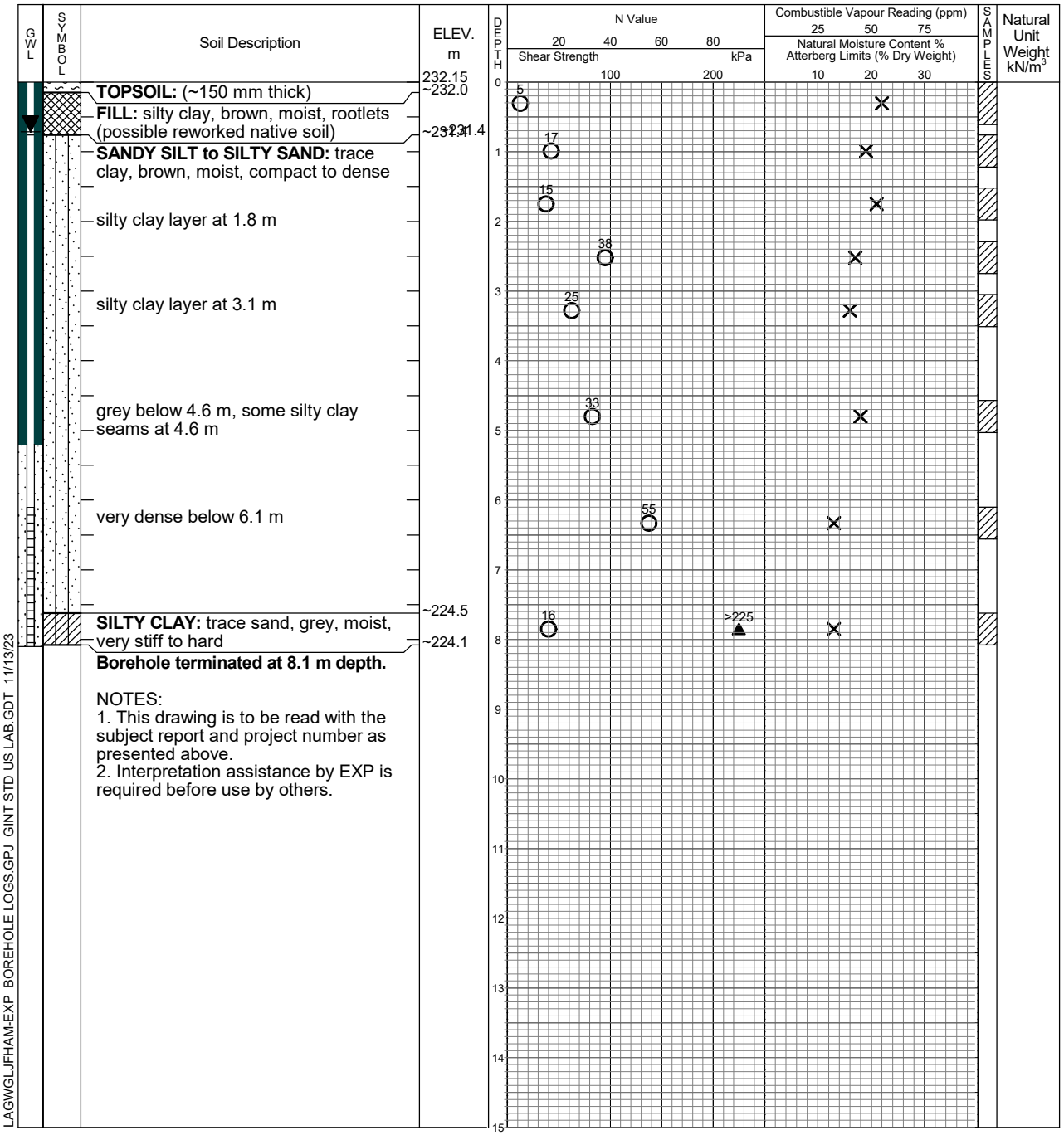
Date Drilled: May 11, 2018

Drill Type: CME-55 Track Mount. Hollow Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

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Time	Water Level (m)	Depth to Cave (m)
on completion	7.61 bgs	no cave
June 4, 2018	0.53 bgs	--
August 4, 2023	0.58 bgs	
October 26, 2023	0.76 bgs	

Log of Borehole BH-09

Project No. HAM-00801363-A0 Drawing No. 11

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

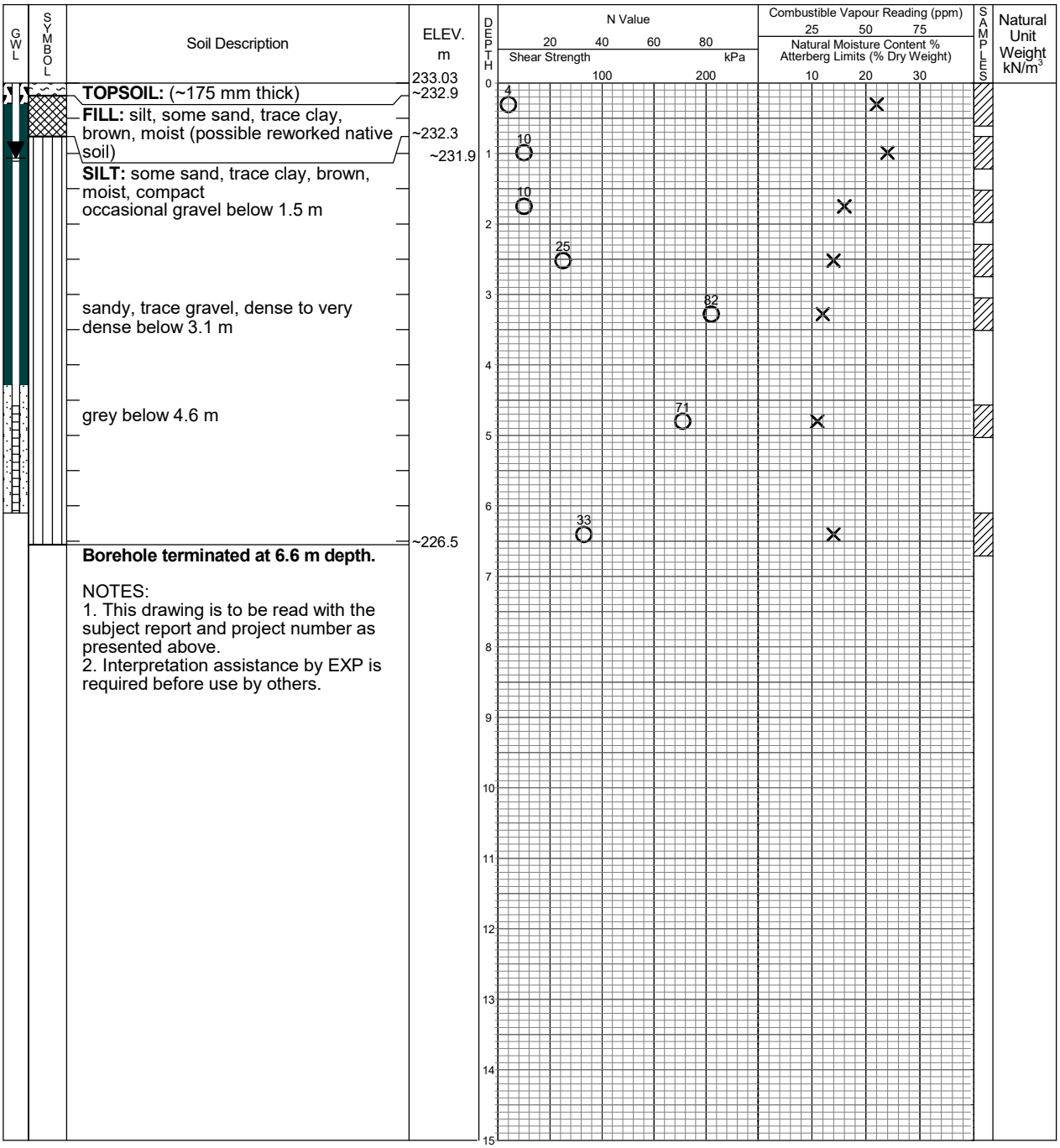
Date Drilled: April 18, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
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Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	4.63 bgs	no cave
June 4, 2018	0.74 bgs	--
August 4, 2023	0.90 bgs	
October 26, 2023	1.11 bgs	

Log of Borehole BH-10

Project No. HAM-00801363-A0 Drawing No. 12

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

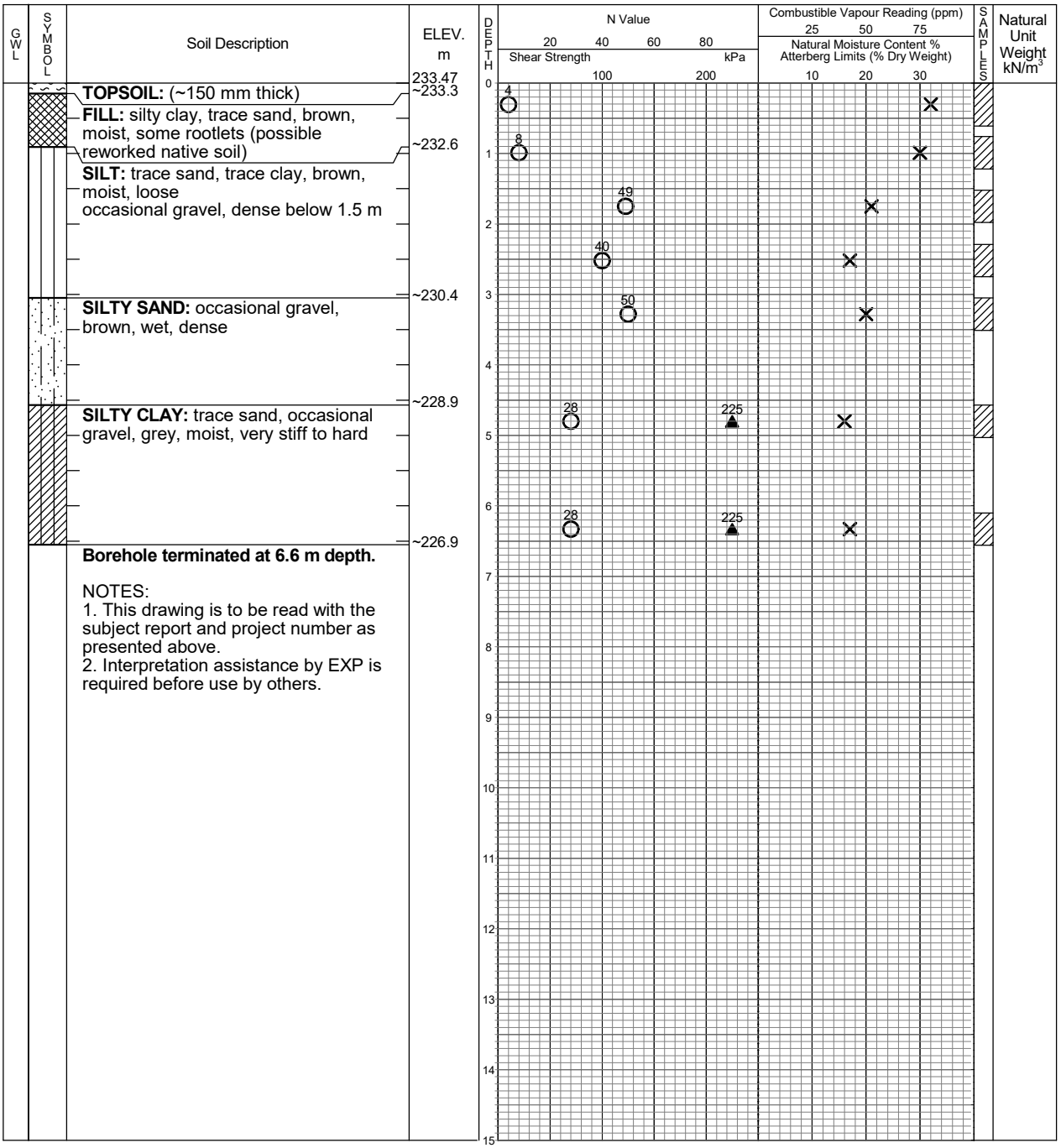
Date Drilled: March 29, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

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Facsimile: 905.573.9693

Log of Borehole BH-11

Project No. HAM-00801363-A0 Drawing No. 13

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: March 29, 2018

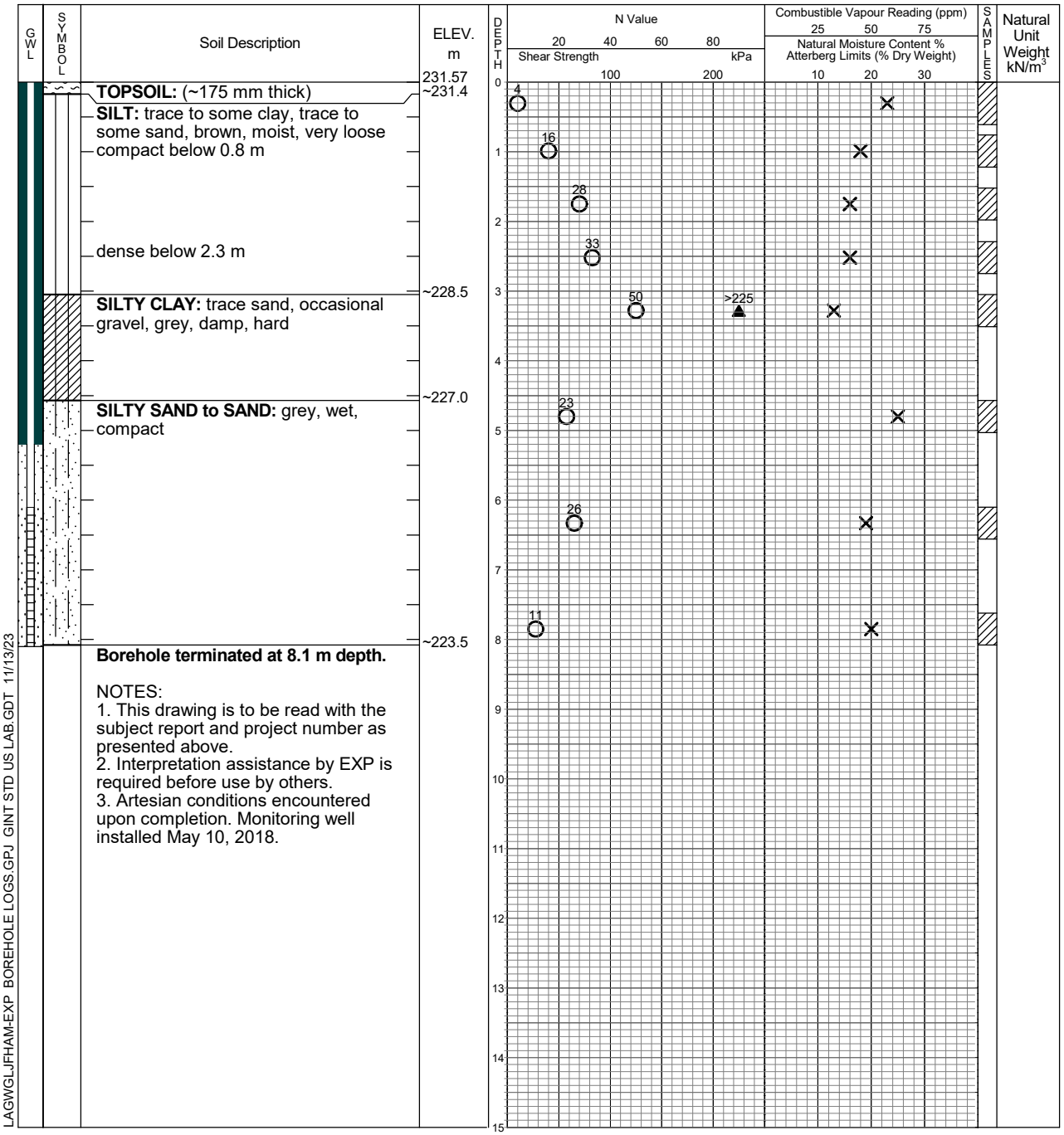
Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

~232.9

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.
3. Artesian conditions encountered upon completion. Monitoring well installed May 10, 2018.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	ags	6.70
May 10, 2018	ags	--
June 5, 2018	1.20 ags	--

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Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-12

Project No. HAM-00801363-A0 Drawing No. 14

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

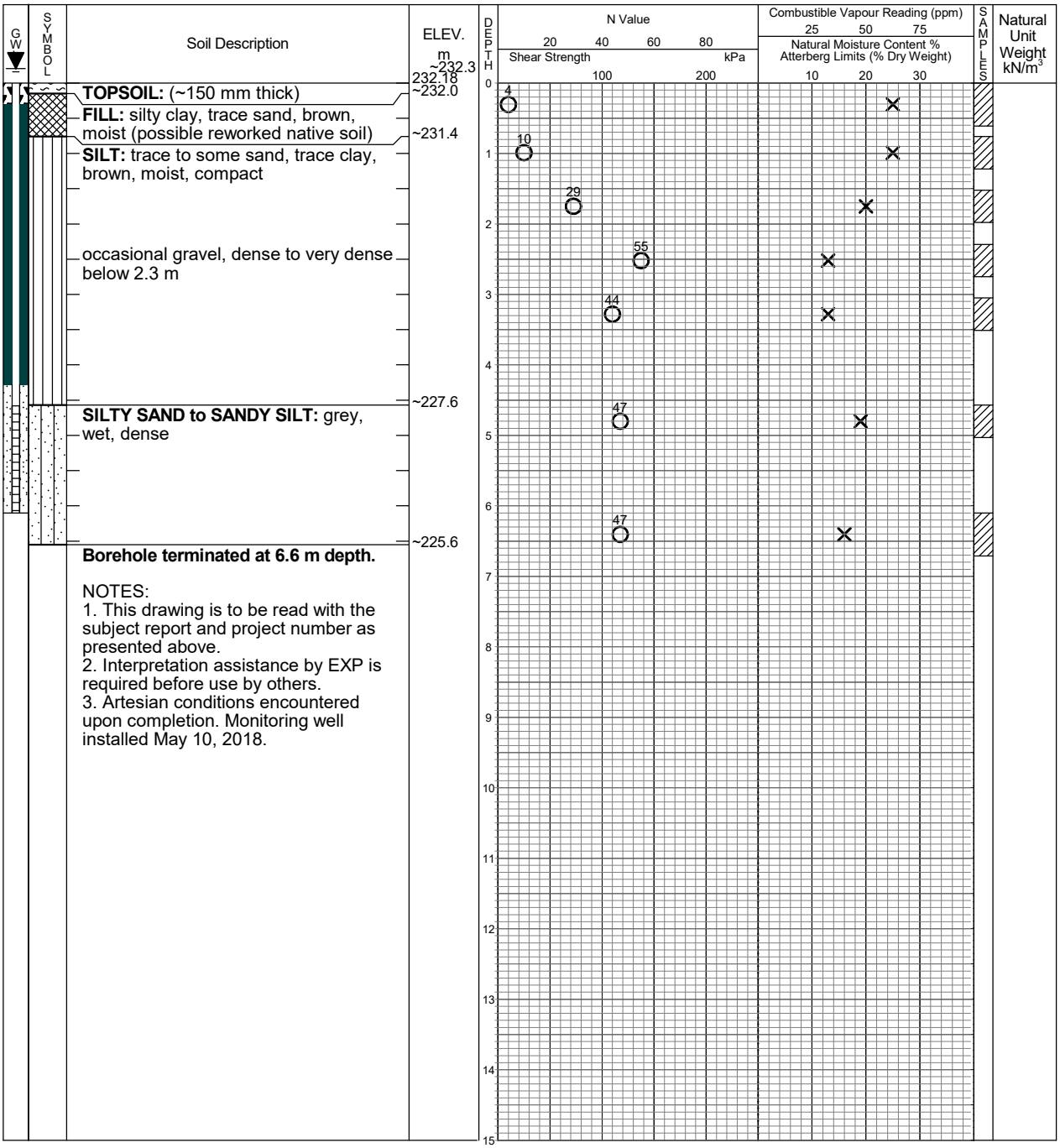
Date Drilled: April 17, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.
3. Artesian conditions encountered upon completion. Monitoring well installed May 10, 2018.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	ags	3.70
May 10, 2018	ags	--
June 5, 2018	0.04 bgs	--
August 4, 2023	0.16 ags	

EXP Services Inc.
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Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-13

Project No. HAM-00801363-A0 Drawing No. 15

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

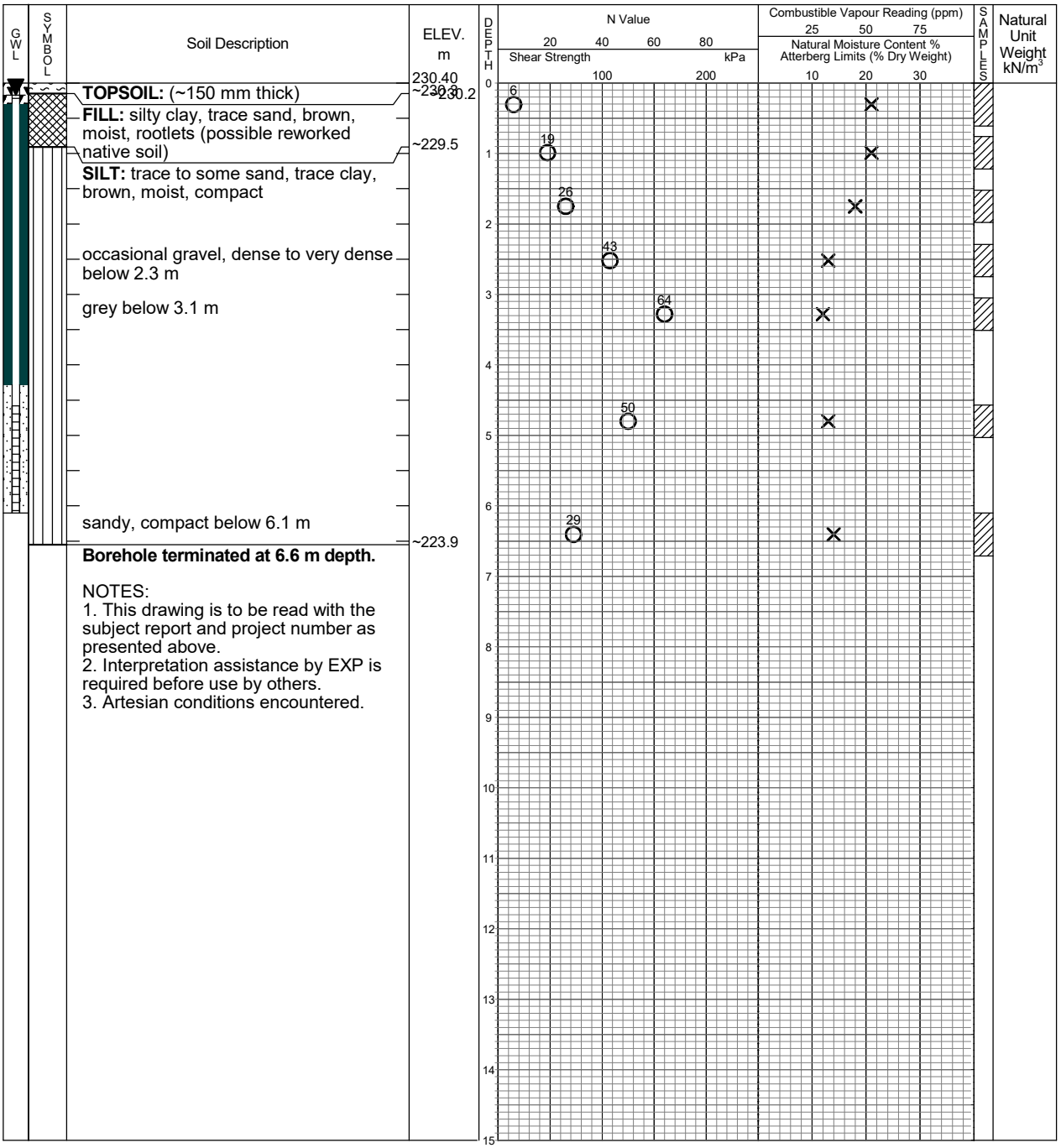
Date Drilled: April 17, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.
3. Artesian conditions encountered.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave
June 5, 2018	0.19 ags	
August 4, 2023	0.22 bgs	
October 13, 2023	dry	

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Facsimile: 905.573.9693

Log of Borehole BH-14

Project No. HAM-00801363-A0 Drawing No. 16

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

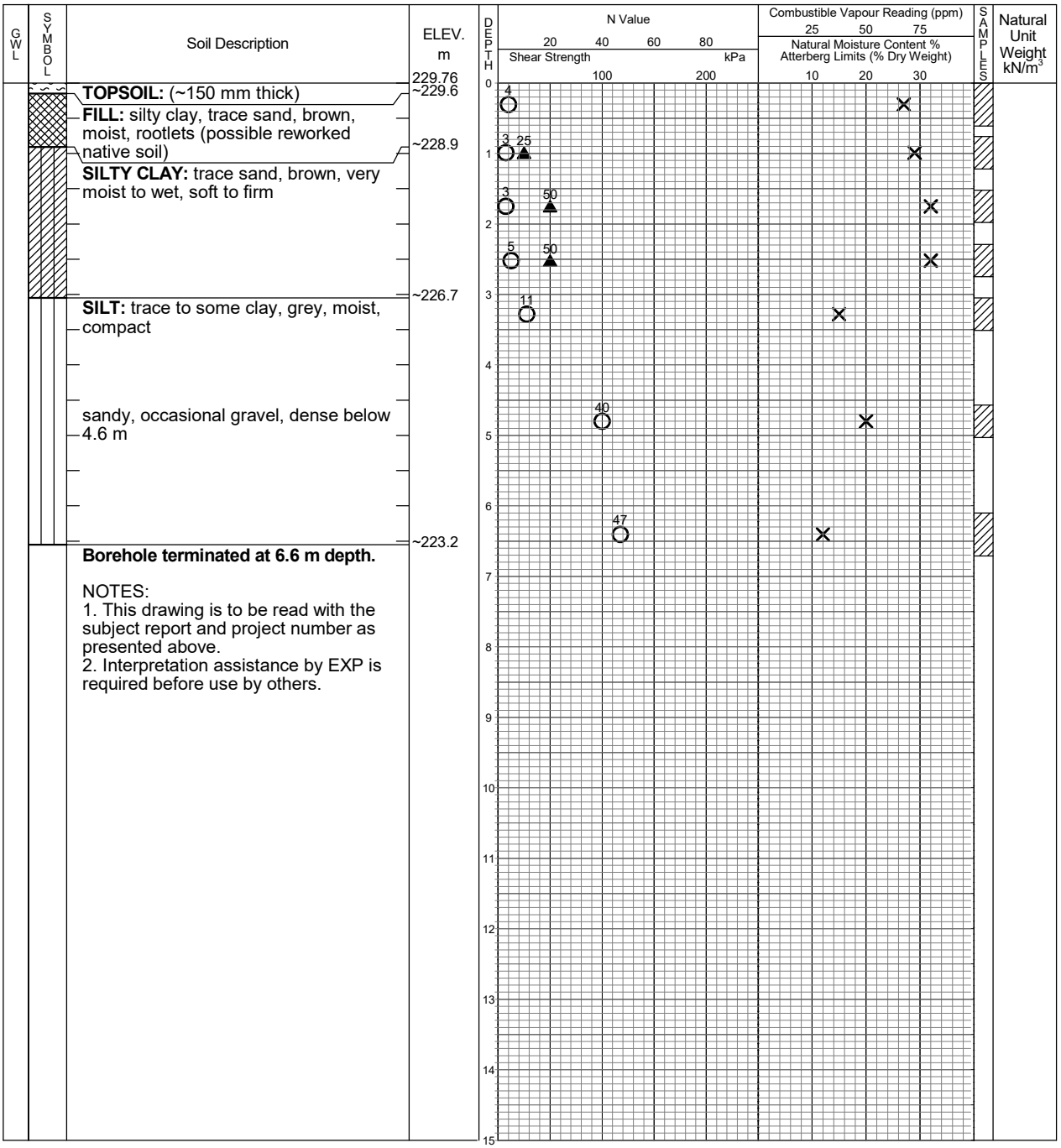
Date Drilled: April 17, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	N/A	0.9 (bridged)

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-15

Project No. HAM-00801363-A0 Drawing No. 17

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

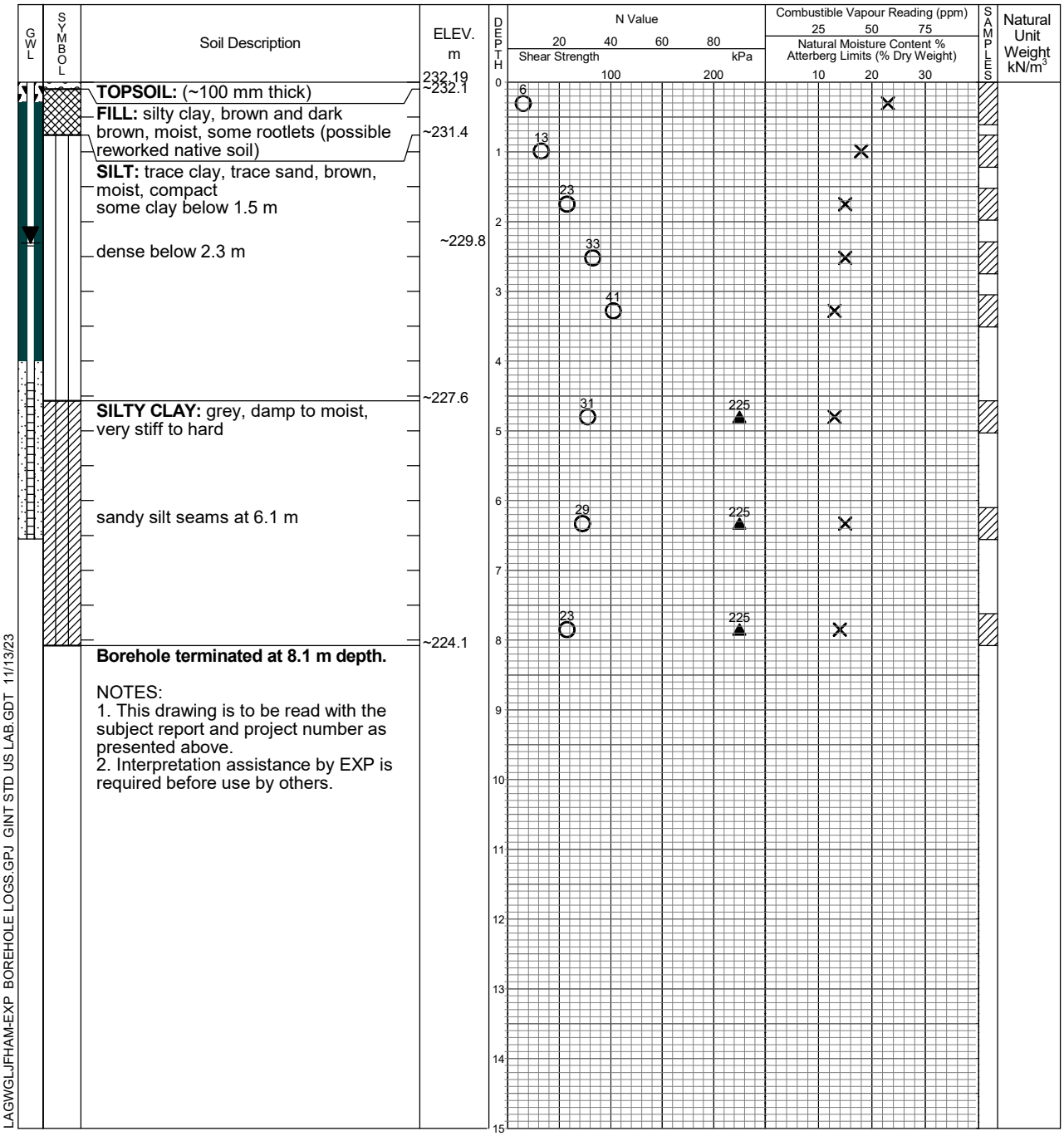
Date Drilled: March 26, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave
Mar. 27	1.59 bgs	--
June 4, 2018	0.65 bgs	--
August 4, 2023	0.45 bgs	
October 13, 2023	2.35 bgs	

Log of Borehole BH-16

Project No. HAM-00801363-A0 Drawing No. 18

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

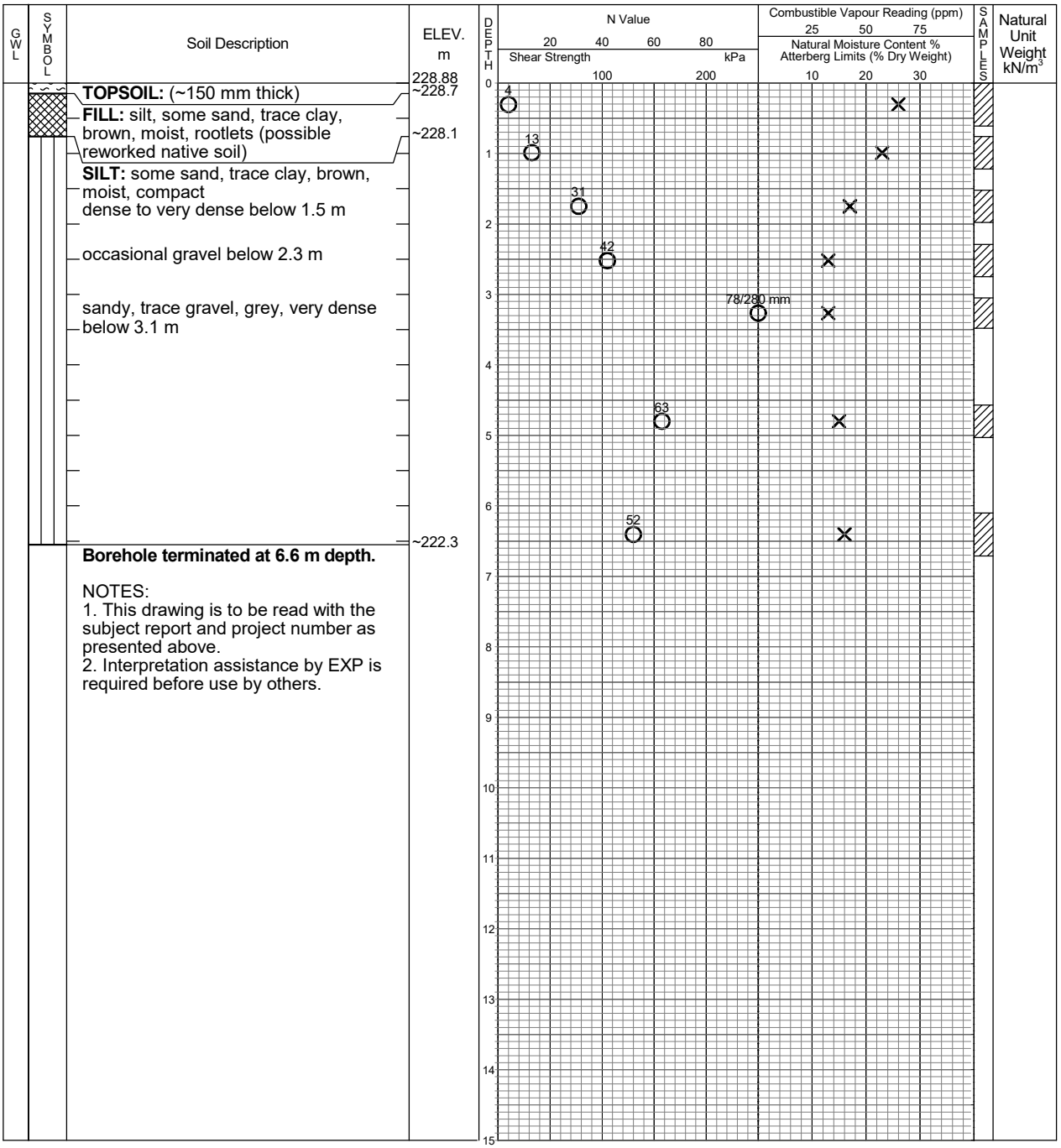
Date Drilled: April 17, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	5.80 bgs	no cave

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-17

Project No. HAM-00801363-A0 Drawing No. 19

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

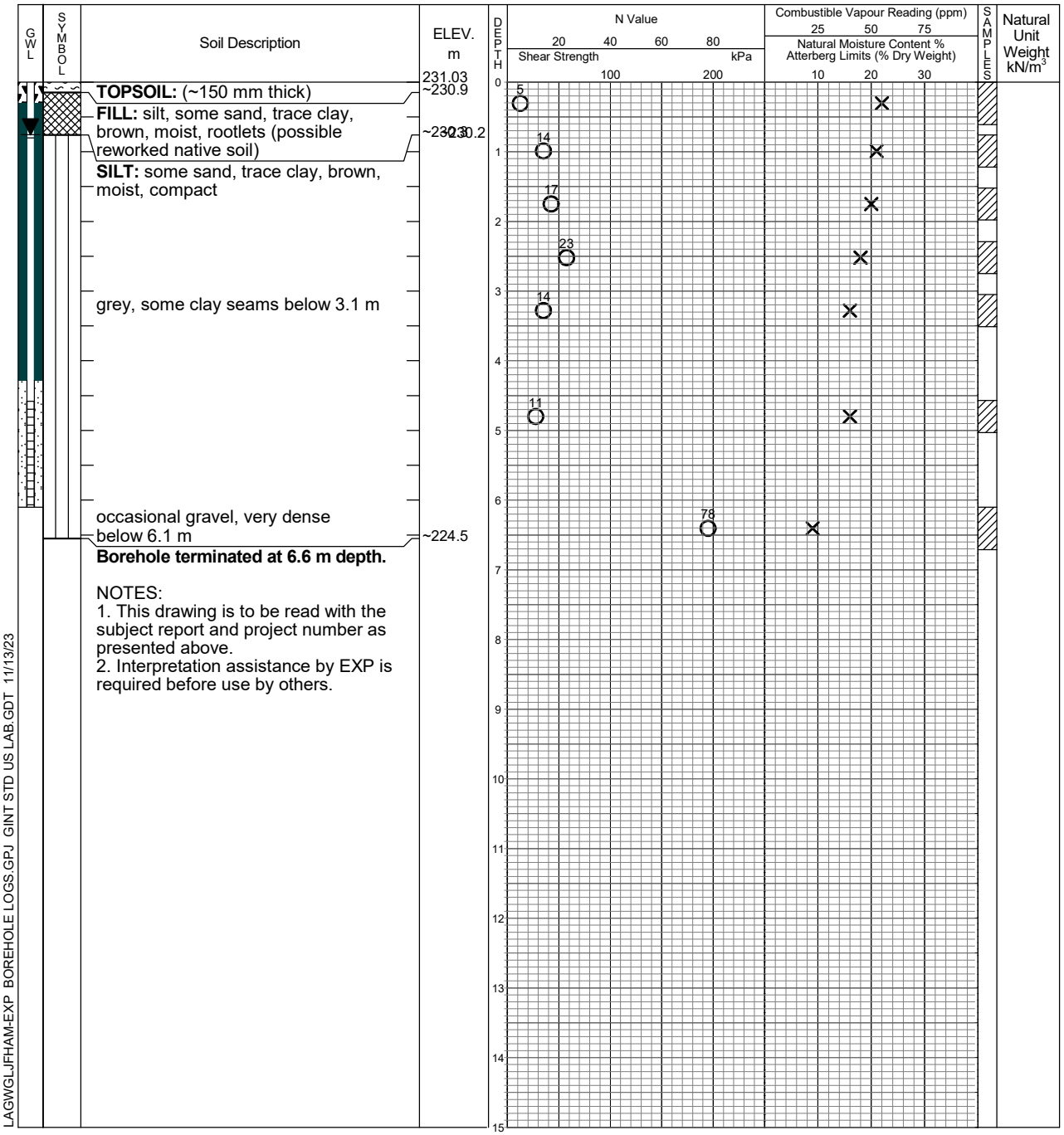
Date Drilled: April 17, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave
June 5, 2018	0.50 bgs	--
August 4, 2023	0.52 bgs	
October 26, 2023	0.80 bgs	

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-18

Project No. HAM-00801363-A0 Drawing No. 20

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

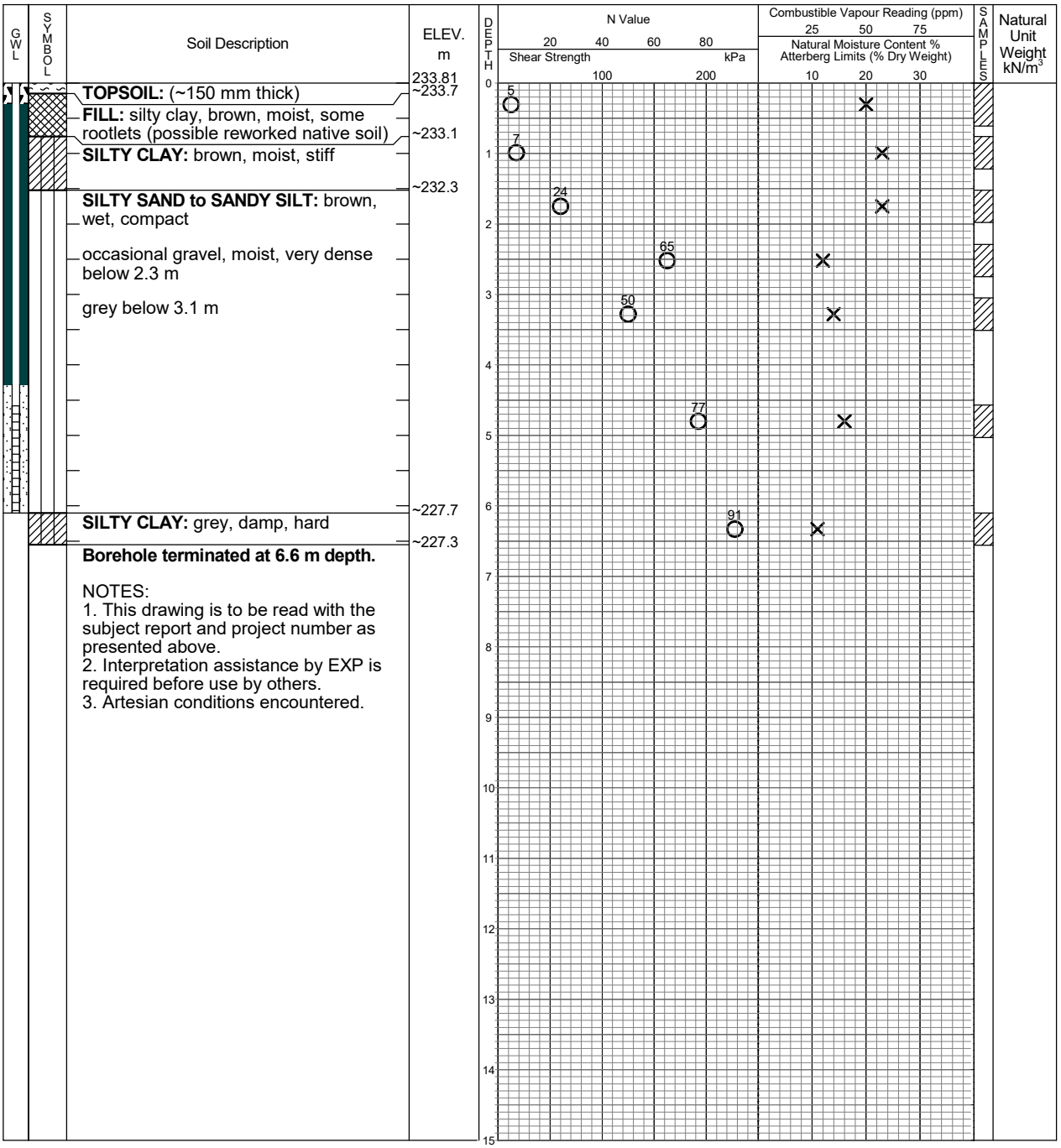
Date Drilled: March 28, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.
3. Artesian conditions encountered.

Time	Water Level (m)	Depth to Cave (m)
on completion	5.3 bgs	no cave
June 4, 2018	0.85 ags	--

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-19

Project No. HAM-00801363-A0 Drawing No. 21

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

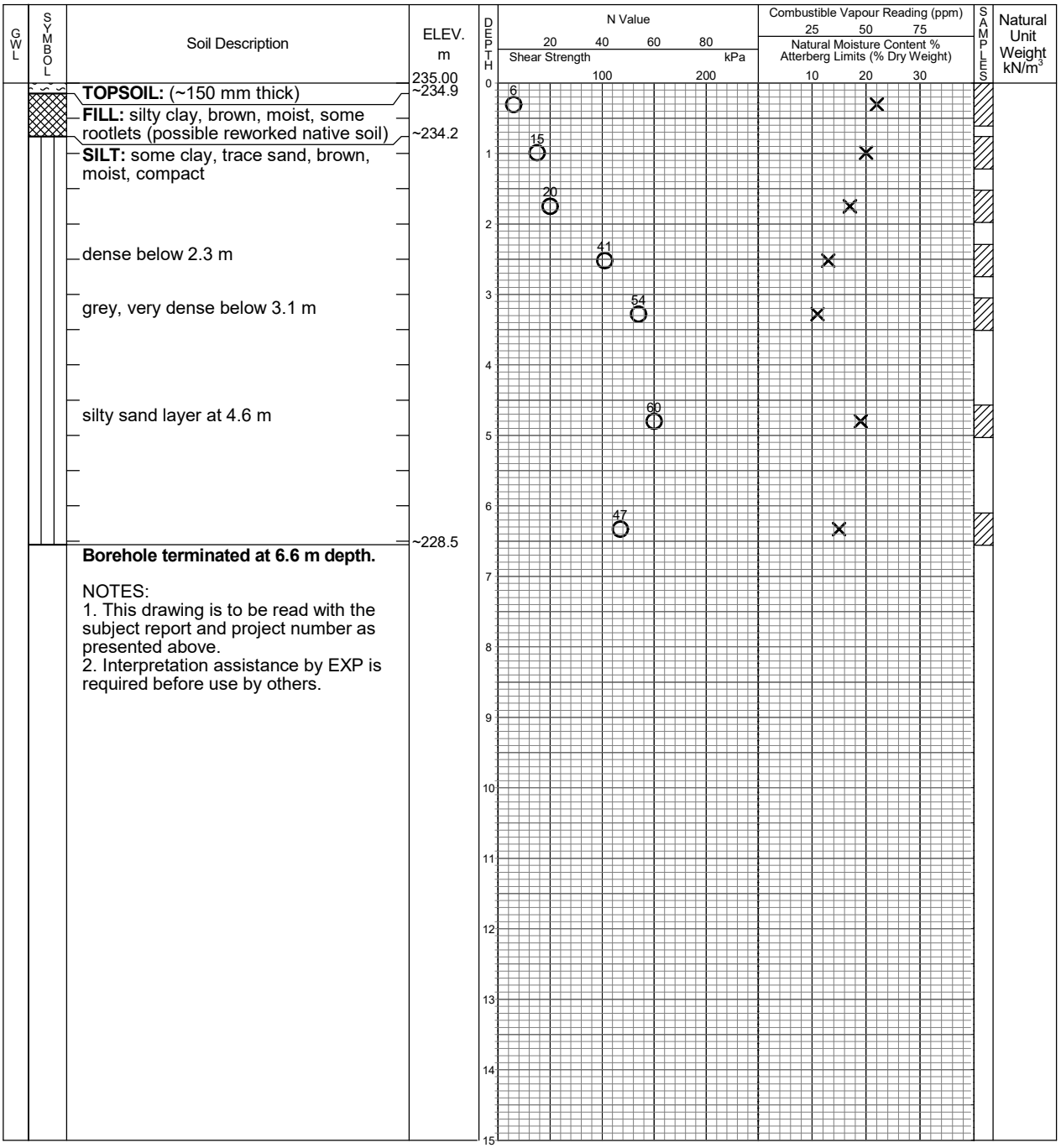
Date Drilled: March 28, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-20

Project No. HAM-00801363-A0 Drawing No. 22

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

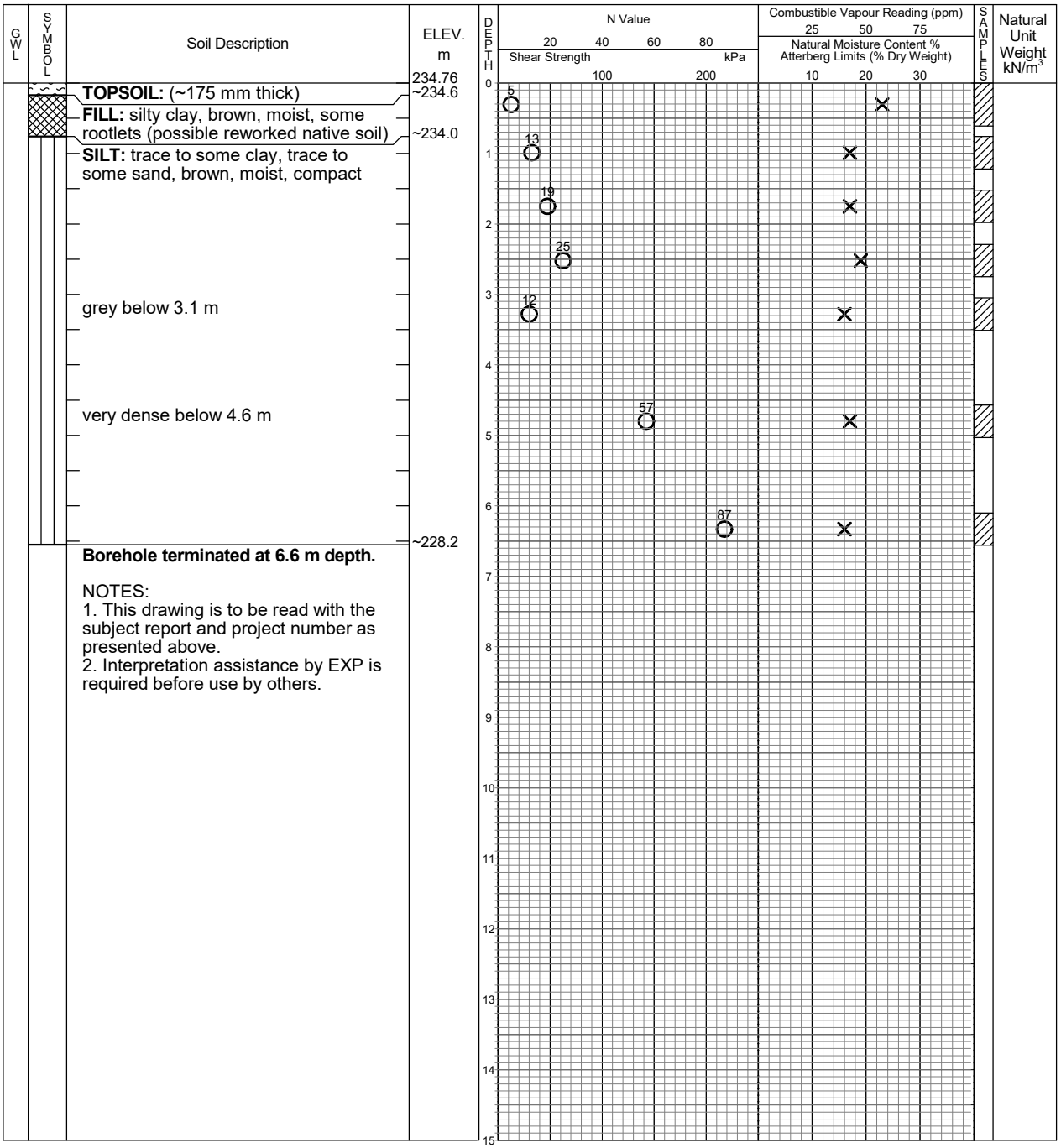
Date Drilled: March 28, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

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Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-21

Project No. HAM-00801363-A0 Drawing No. 23

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

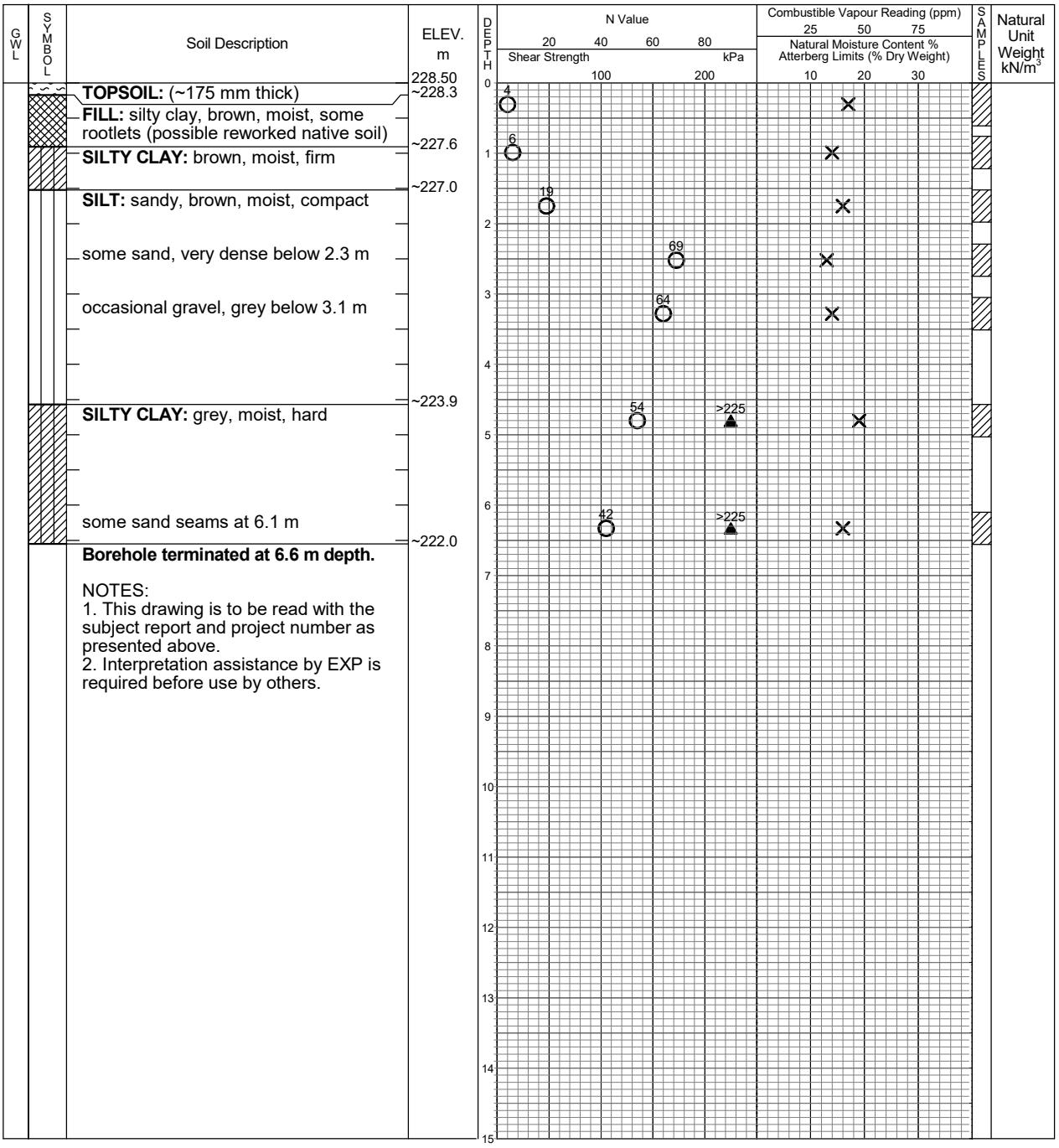
Date Drilled: April 3, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	5.51 bgs	no cave

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-22

Project No. HAM-00801363-A0 Drawing No. 24

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

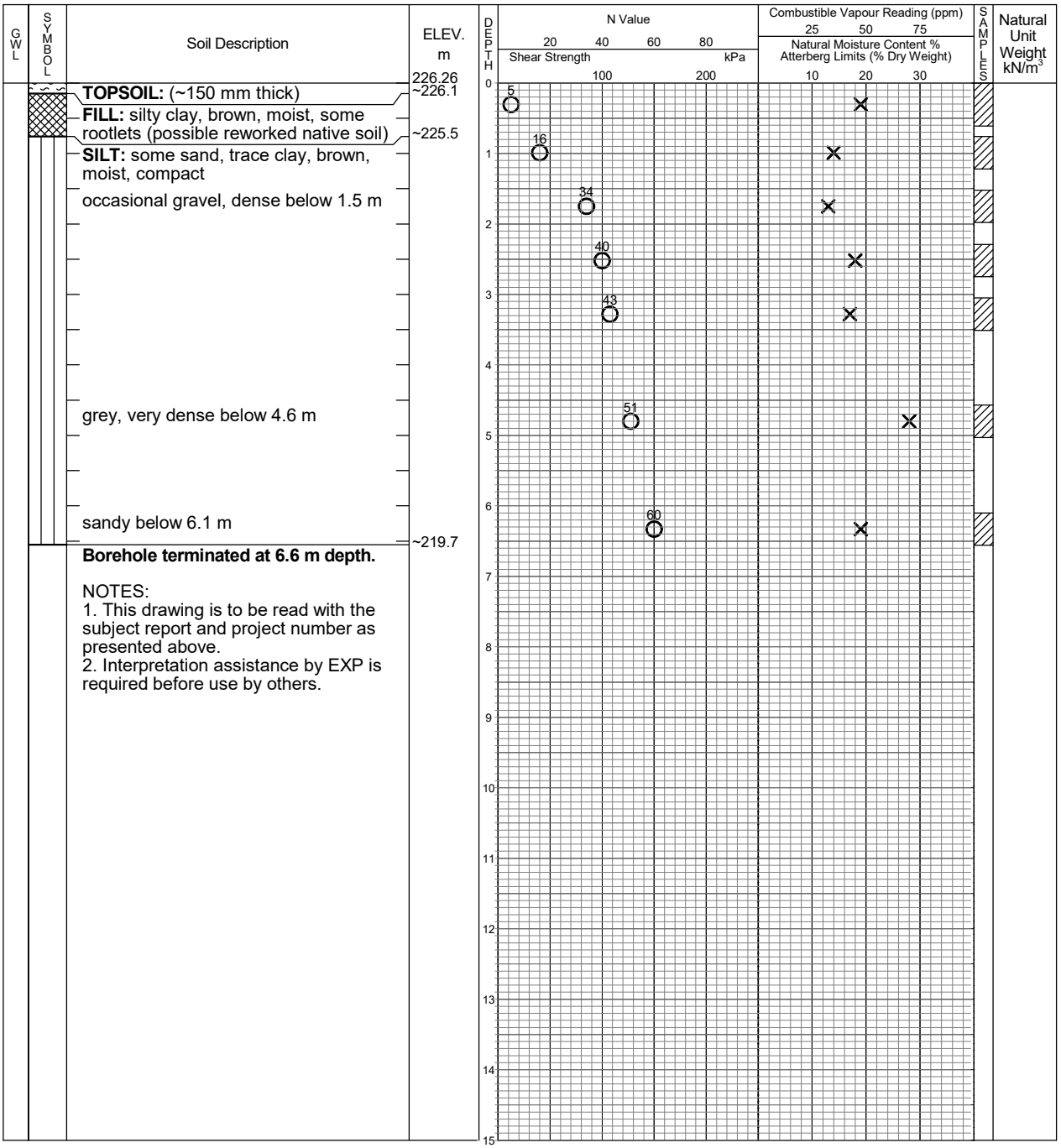
Date Drilled: April 3, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	5.90 bgs	no cave

EXP Services Inc.
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Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-23

Project No. HAM-00801363-A0 Drawing No. 25

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

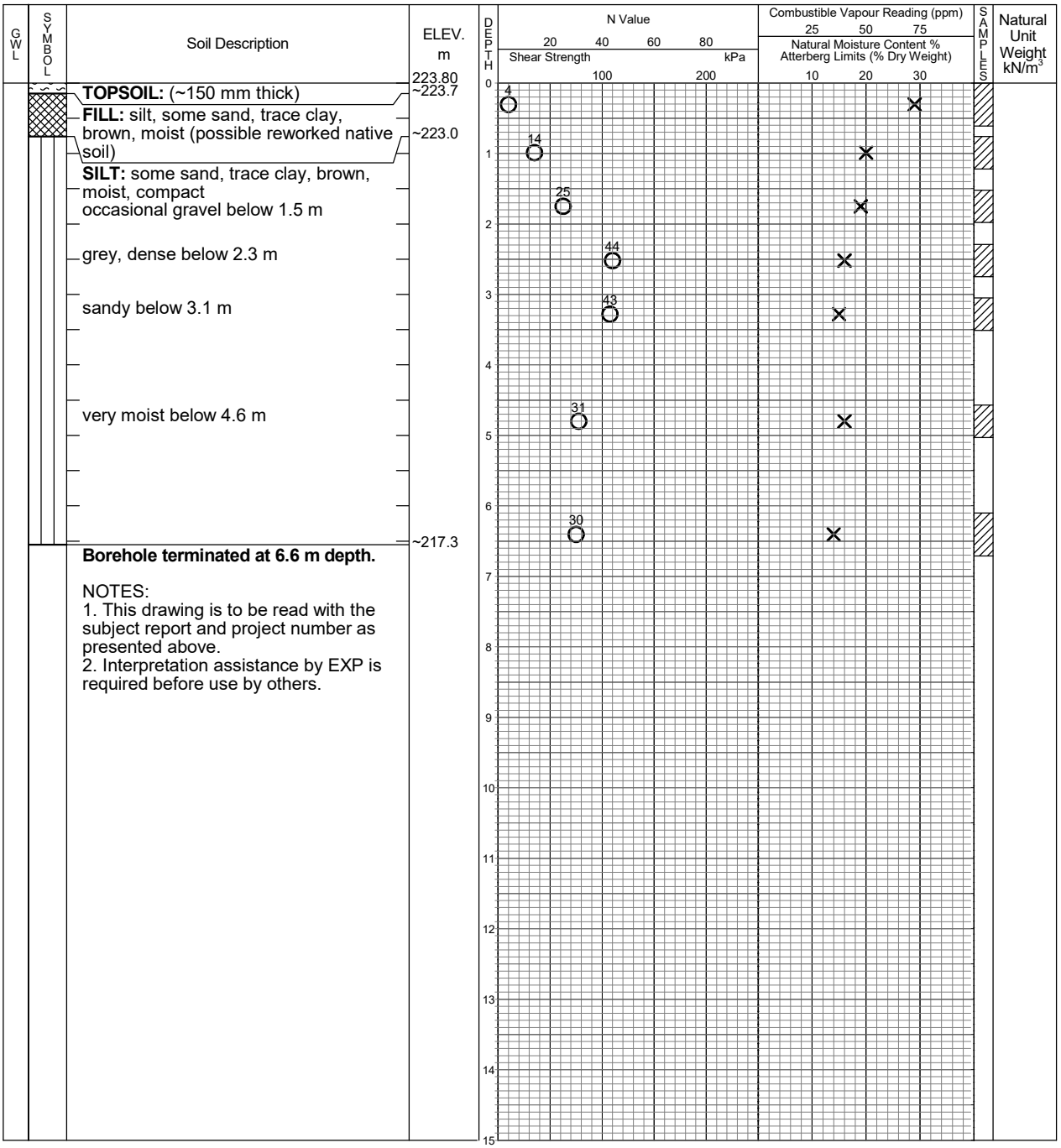
Date Drilled: April 18, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	5.21 bgs	no cave

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-24

Project No. HAM-00801363-A0 Drawing No. 26

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

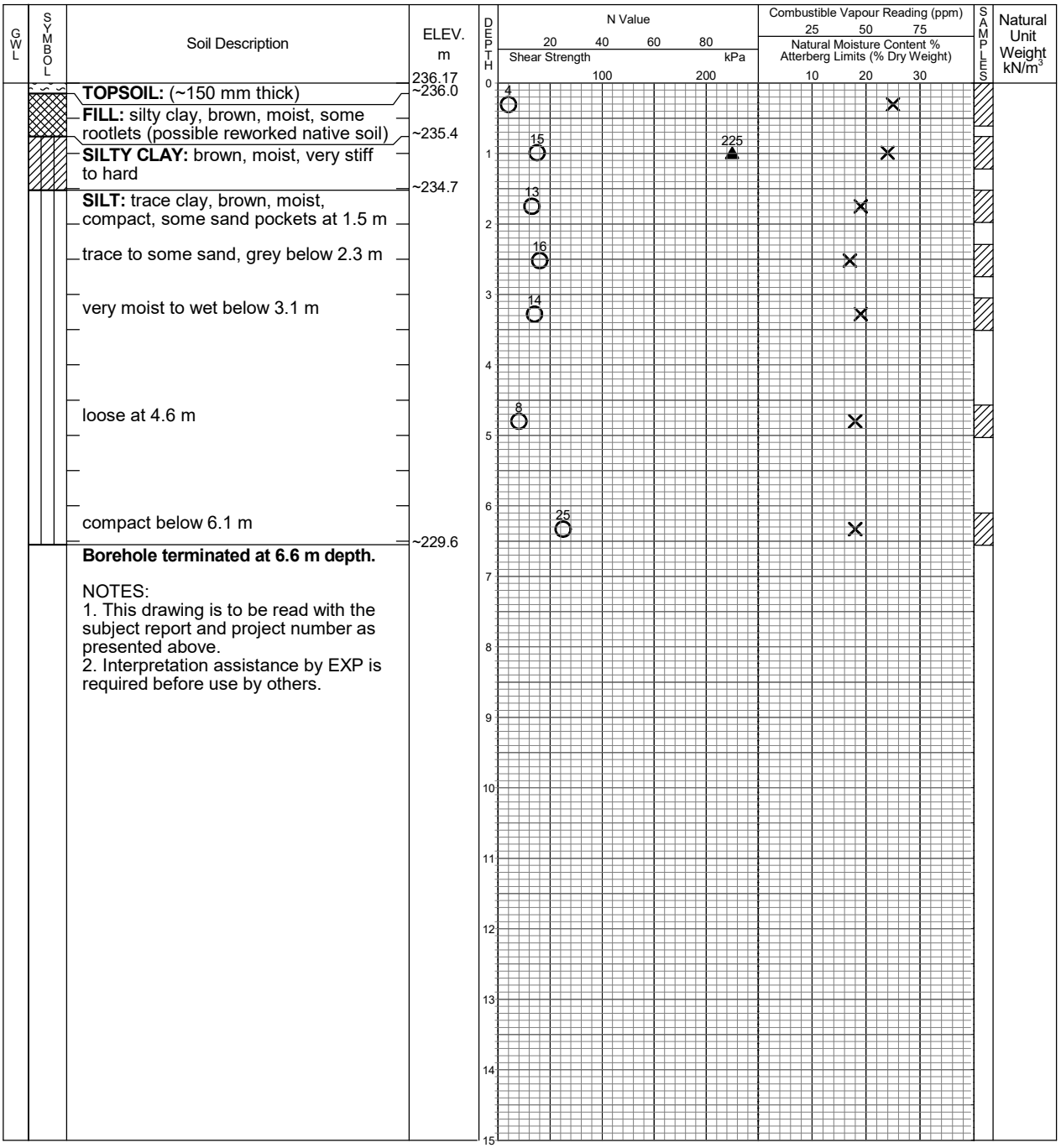
Date Drilled: March 26, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	5.52 bgs	no cave

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Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-25

Project No. HAM-00801363-A0 Drawing No. 27

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

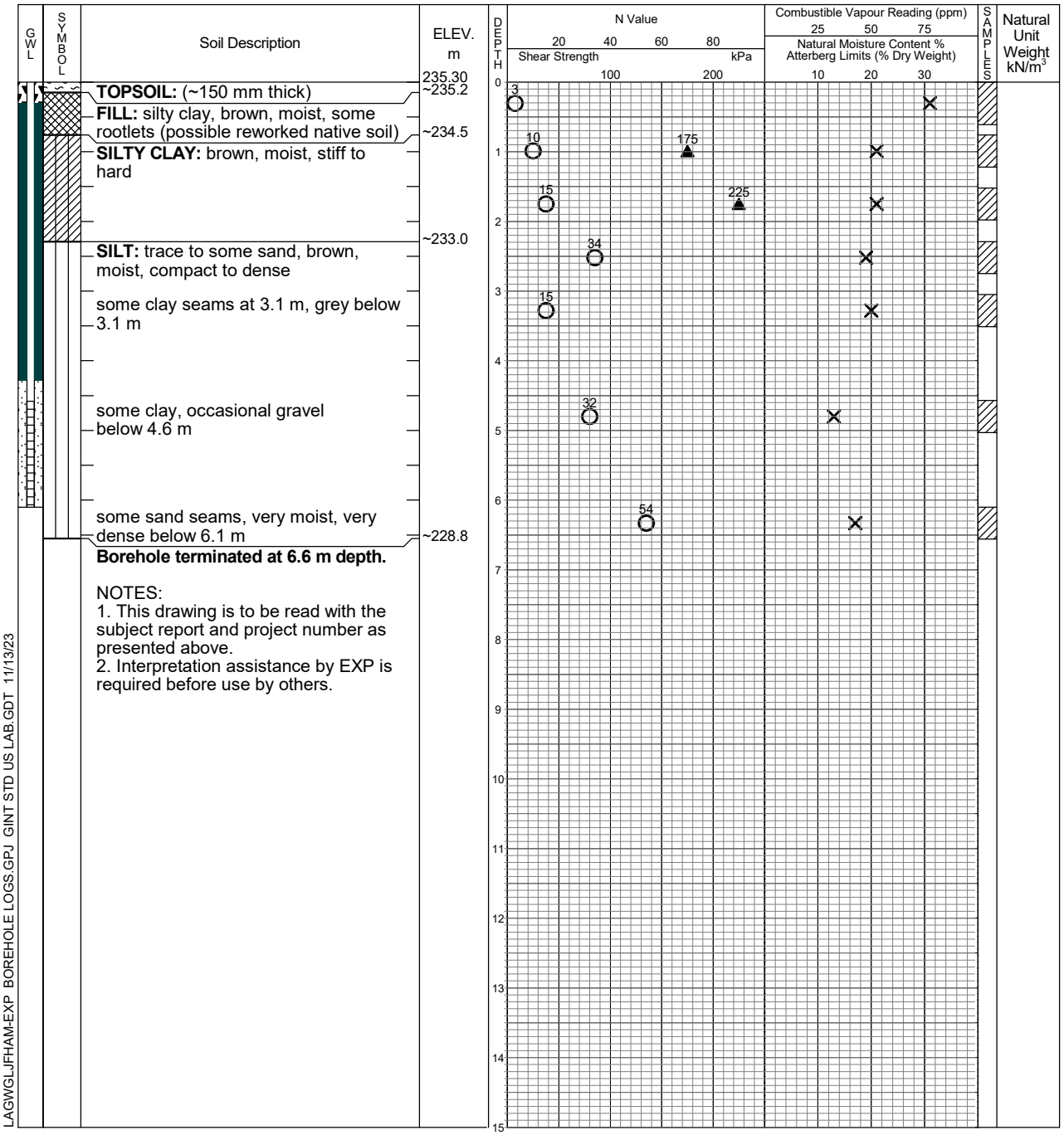
Date Drilled: March 27, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
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Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	5.81 bgs	no cave
June 5, 2018	0.34 bgs	--
August 4, 2023	0.52 bgs	
October 13, 2023	dry	

Log of Borehole BH-26

Project No. HAM-00801363-A0 Drawing No. 28

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

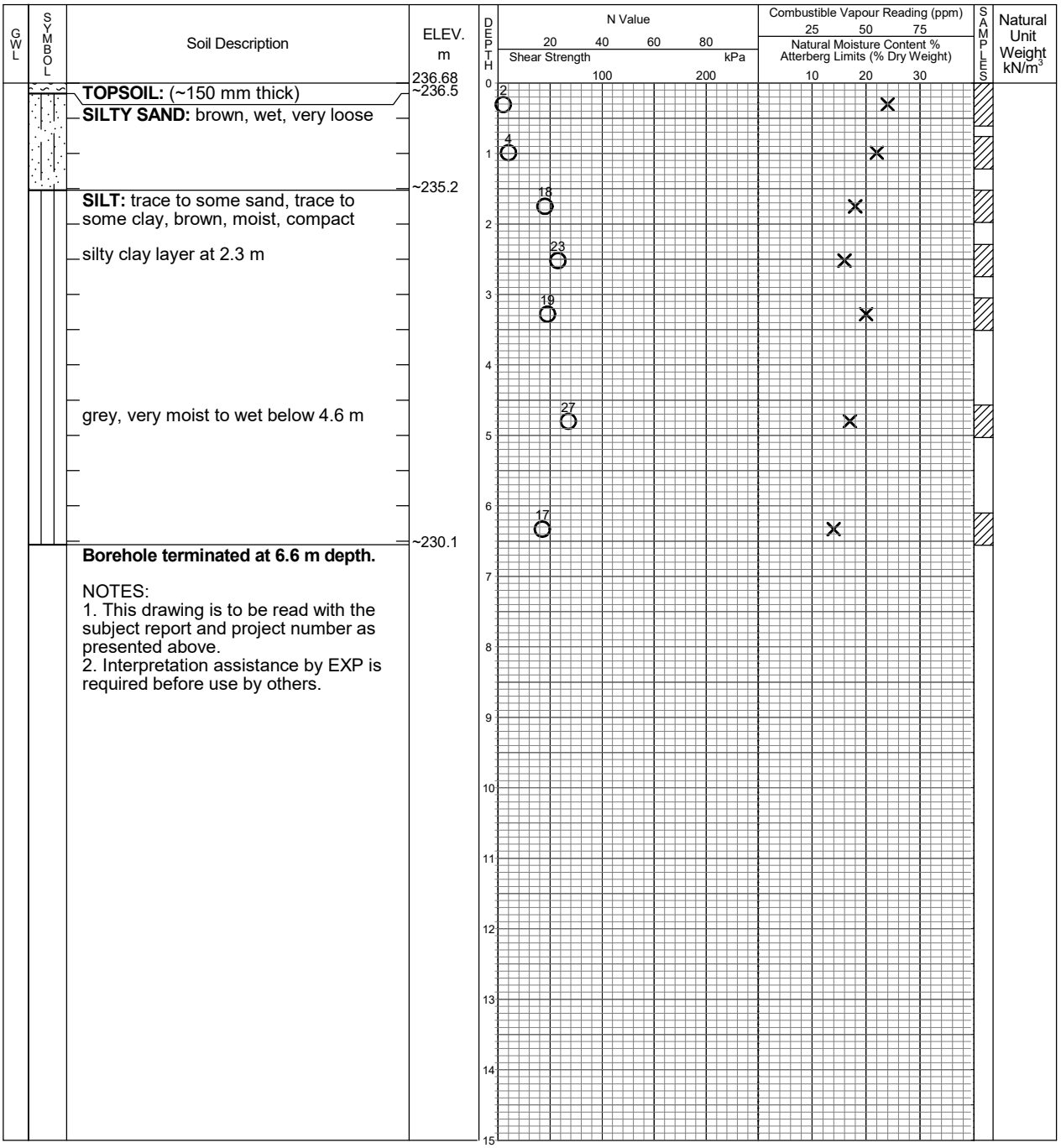
Date Drilled: March 26, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	4.32 bgs	no cave

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Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-27

Project No. HAM-00801363-A0 Drawing No. 29

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

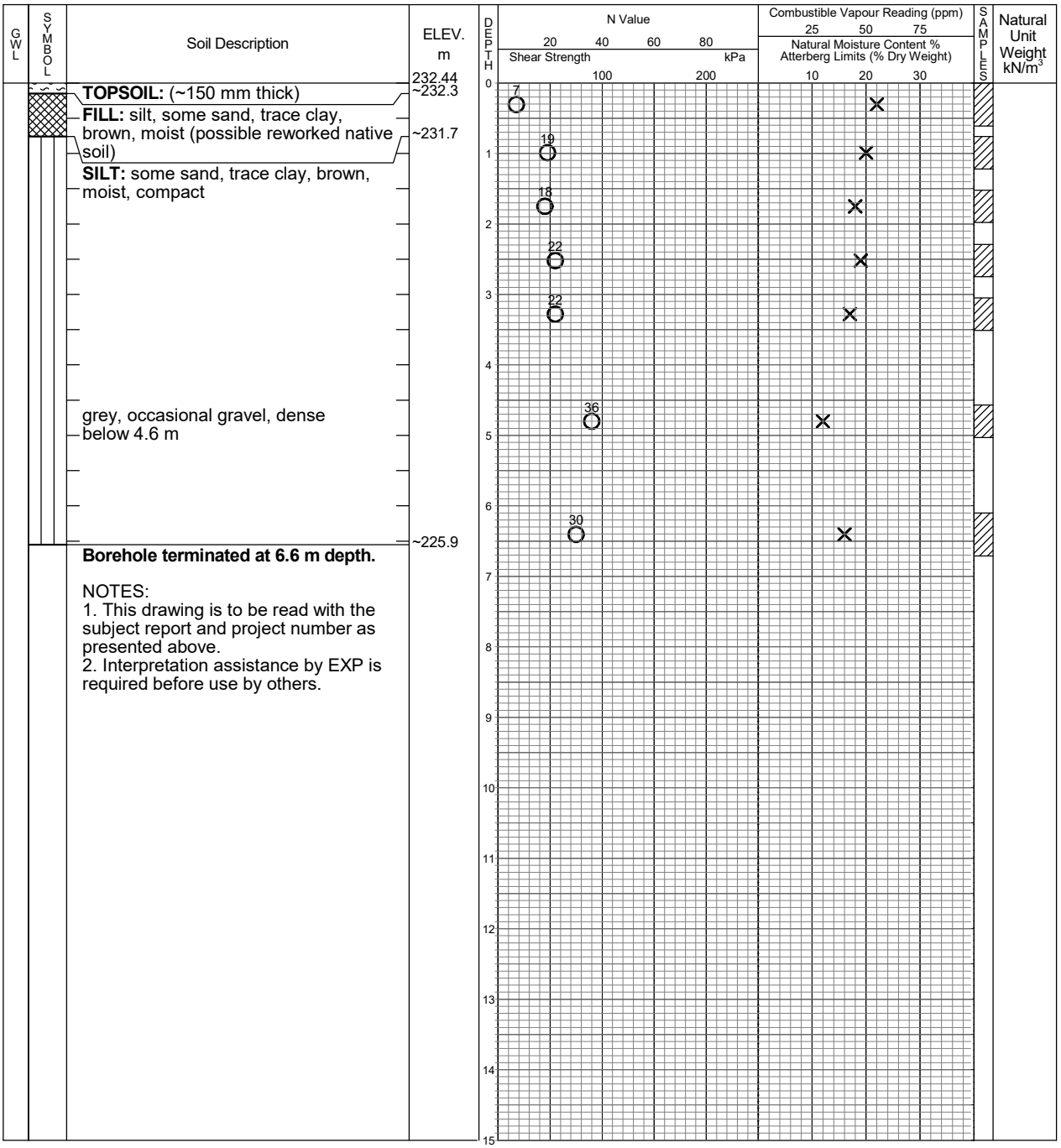
Date Drilled: April 18, 2018

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	5.83 bgs	no cave

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Log of Borehole BH-28

Project No. HAM-00801363-A0 Drawing No. 30

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

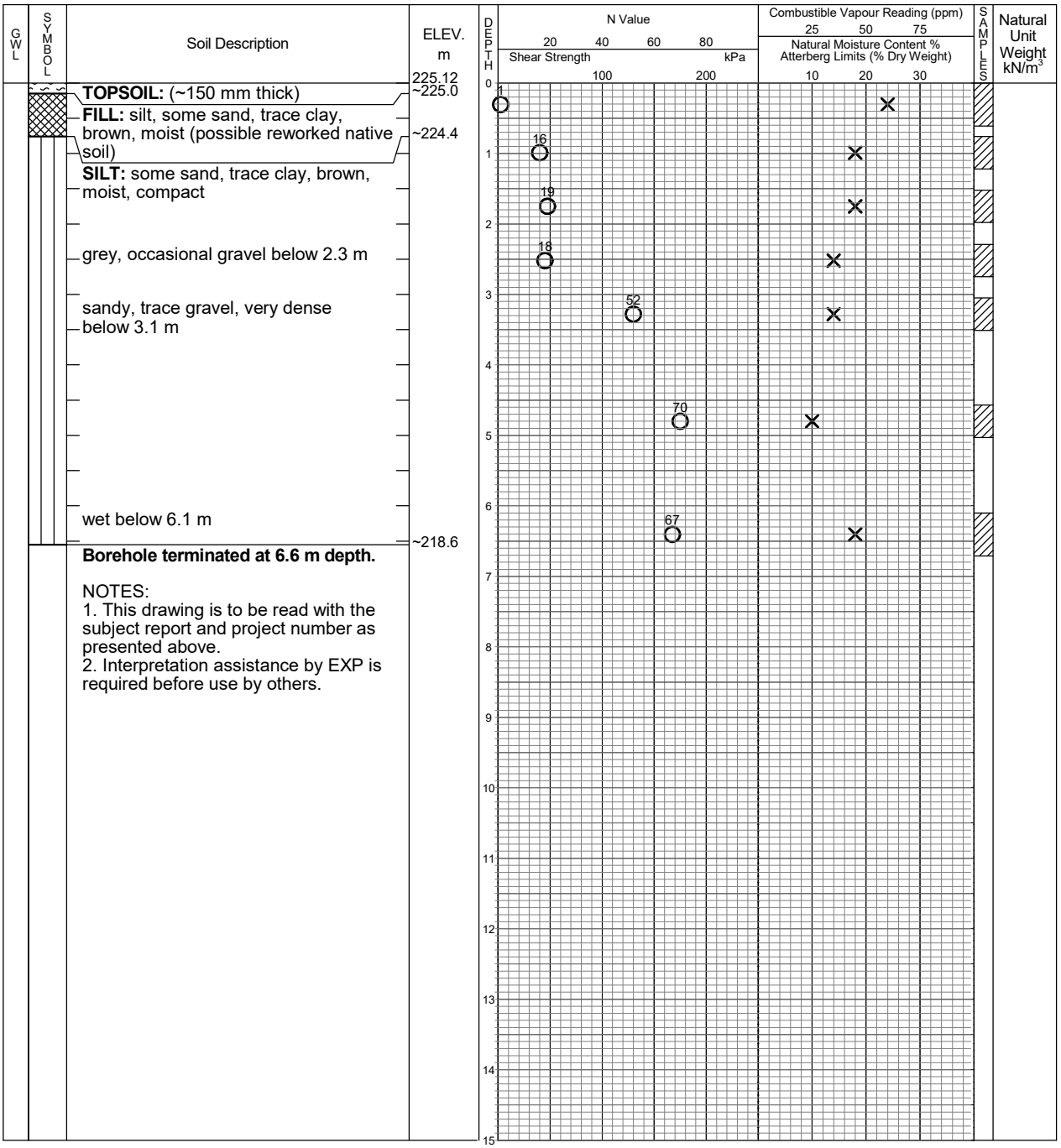
Date Drilled: April 18, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	5.94 bgs	no cave

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-29

Project No. HAM-00801363-A0 Drawing No. 31

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

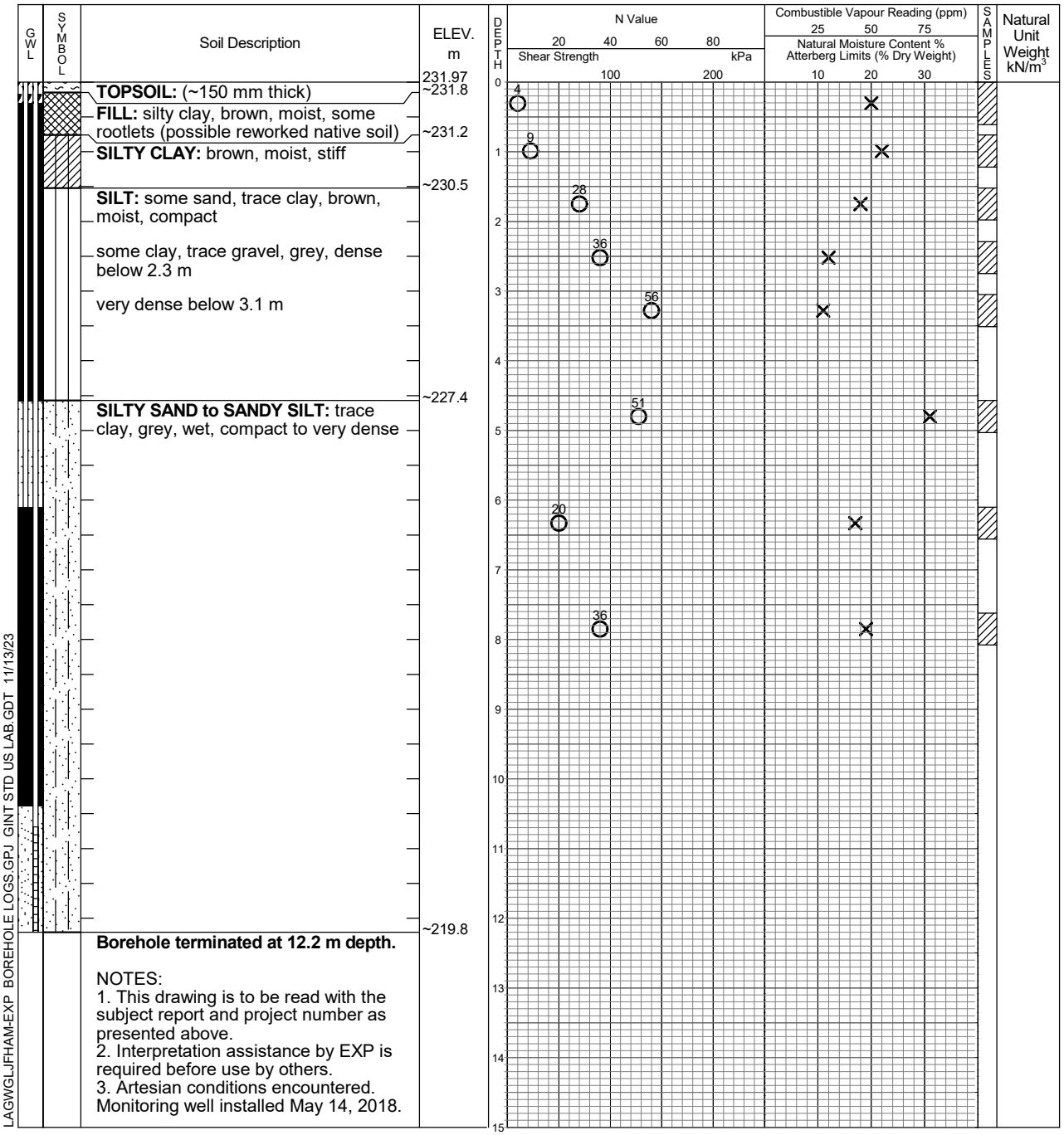
Date Drilled: March 28, 2018

Drill Type: CME-55 Track Mount. Hollow Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.
3. Artesian conditions encountered. Monitoring well installed May 14, 2018.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	0.84 bgs	6.1
June 14, 2018 (shallow)	ags	--
June 14, 2018 (deep)	ags	--
Oct. 13, 2023 (shallow)	0.96 bgs	--
Oct. 13, 2023 (deep)	0.94 ags	--

Log of Borehole BH-30

Project No. HAM-00801363-A0 Drawing No. 32

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

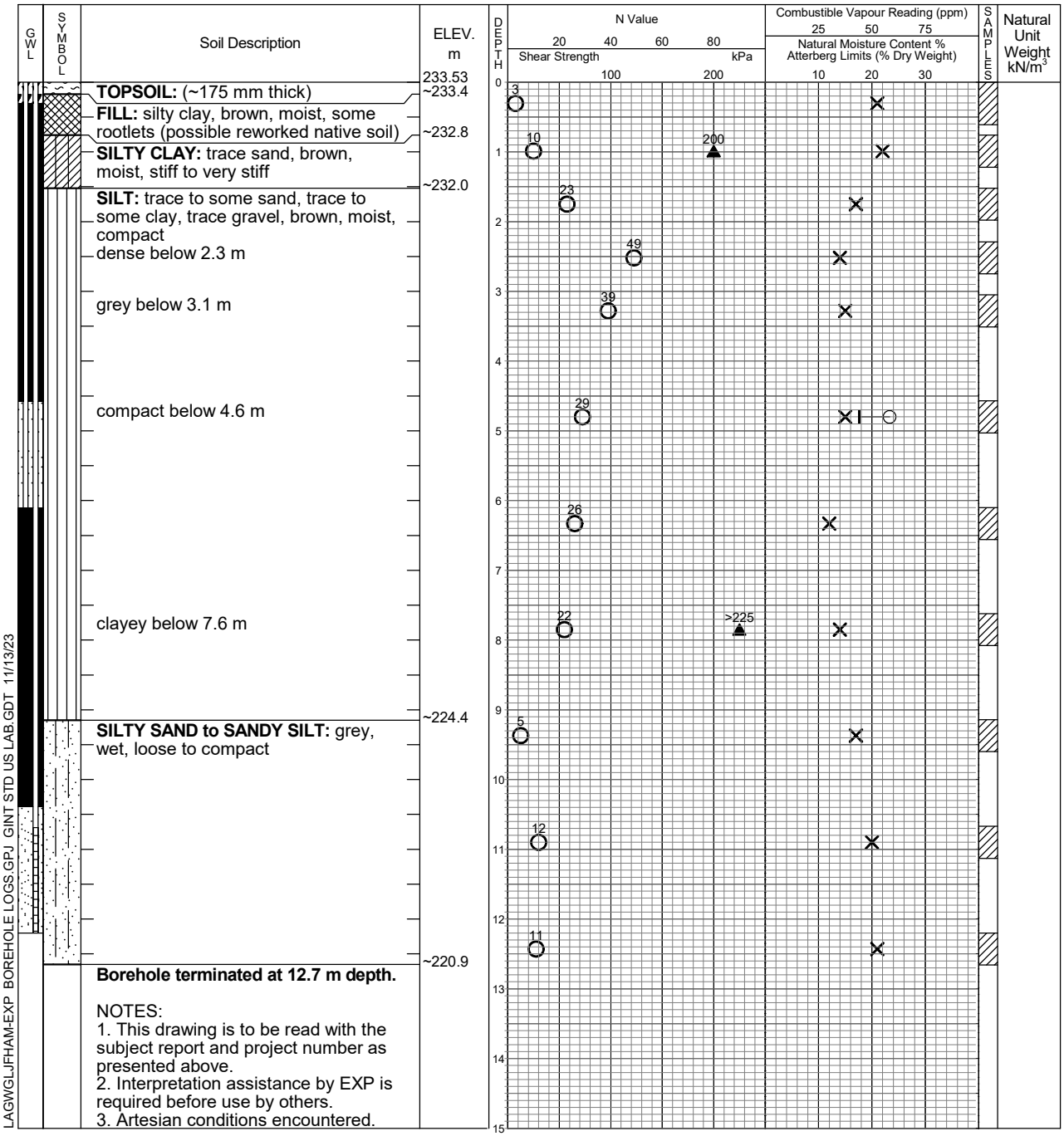
Date Drilled: May 10, 2018

Drill Type: CME-55 Track Mount. Hollow Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	ags	9.3
June 5, 2018 (shallow)	1.18 bgs	--
June 5, 2018 (deep)	0.70 ags	--
Oct. 13, 2023 (shallow)	dry	
Oct. 13, 2023 (deep)	0.91 bgs	

Log of Borehole BH-31

Project No. HAM-00801363-A0 Drawing No. 33

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

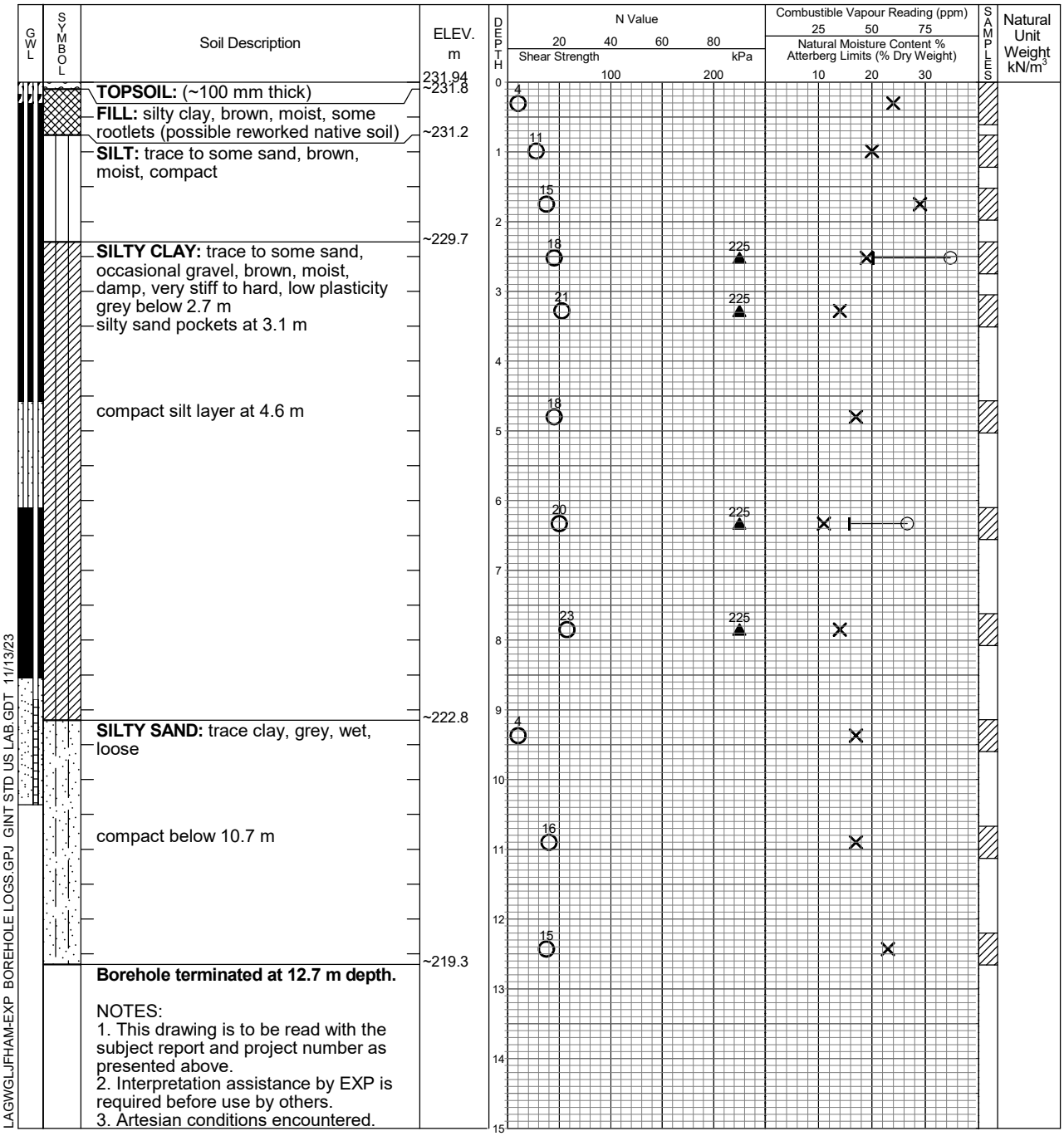
Date Drilled: March 26, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	3.10 bgs	10.41
June 5, 2018 (shallow)	0.20 bgs	--
June 5, 2018 (deep)	1.12 ags	--
Oct. 13, 2023 (shallow)	dry	--
Oct. 13, 2023 (deep)	1.40 ags	--

Log of Borehole BH-32

Project No. HAM-00801363-A0 Drawing No. 34

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

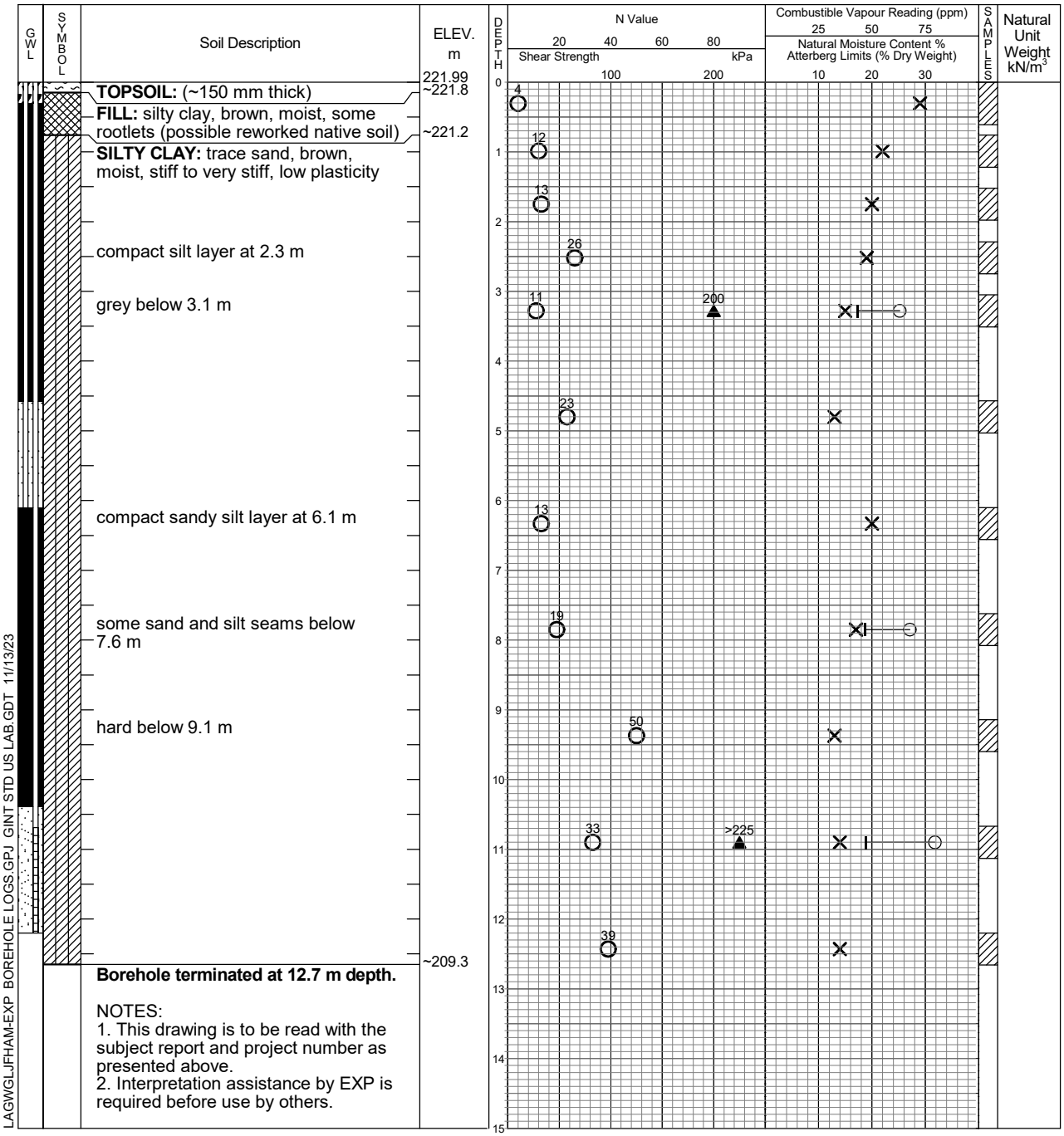
Date Drilled: May 9, 2018

Drill Type: CME-55 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave
June 5, 2018 (shallow)	0.46 bgs	--
June 5, 2018 (deep)	0.56 bgs	--
Oct. 26, 2023 (shallow)	dry	
Oct. 26, 2023 (deep)	3.19 bgs	

Log of Borehole BH-33

Project No. HAM-00801363-A0 Drawing No. 35

Project: Upper West Side Draft Plan of Industrial Subdivision Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

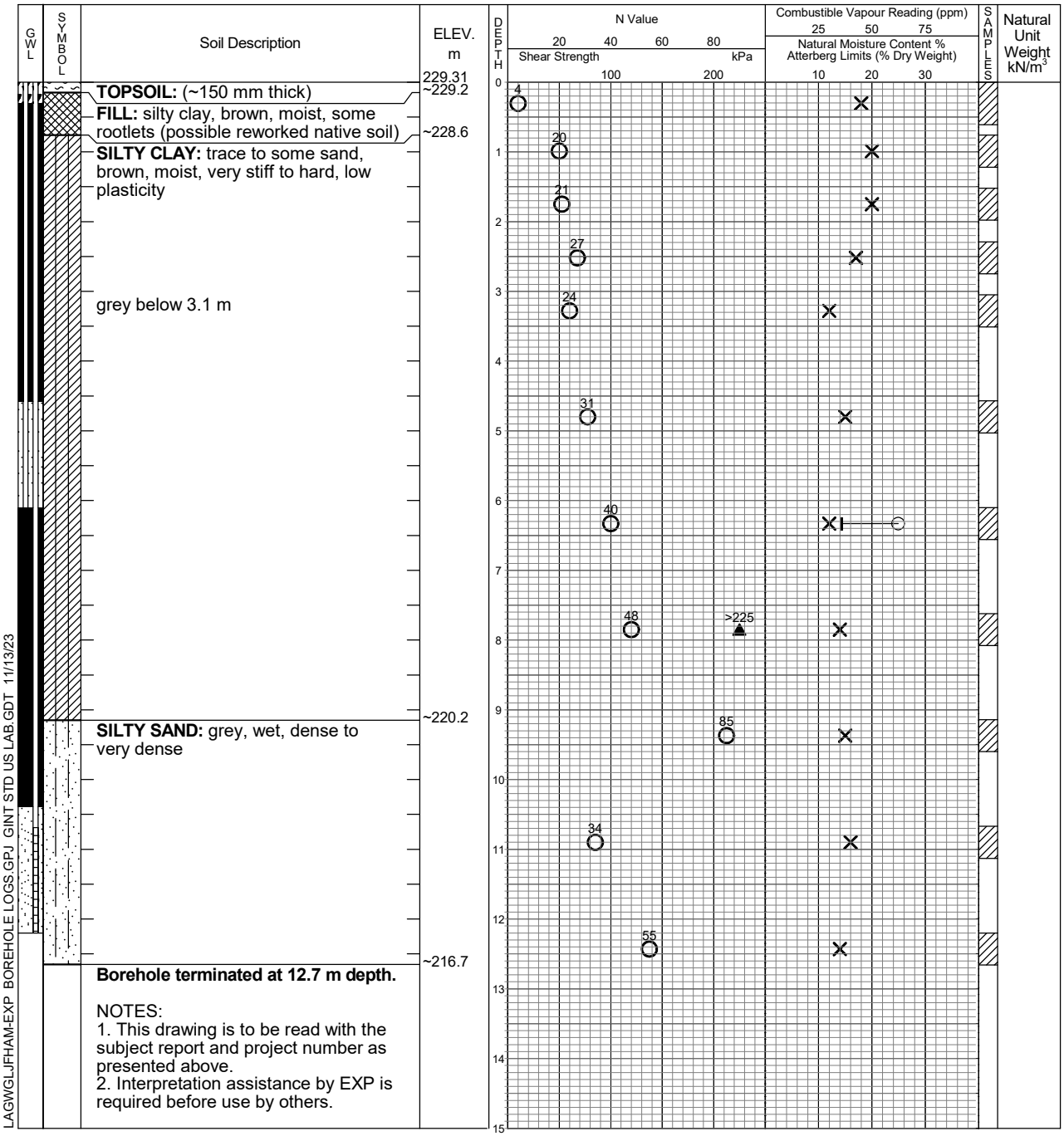
Date Drilled: May 9, 2018

Drill Type: CME-55 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BOREHOLE LOGS.GPJ GINT STD US LAB.GDT 11/13/23

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Time	Water Level (m)	Depth to Cave (m)
on completion	11.62 bgs	no cave
June 4, 2018 (shallow)	0.66 bgs	--
June 4, 2018 (deep)	0.71 bgs	--
Oct. 26, 2023 (shallow)	dry	
Oct. 26, 2023 (deep)	dry	

Log of Borehole MW23-1

Project No. HAM-00801363-D0 | Drawing No. 36

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: September 11, 2023

Drill Type: D-50 Track Mount. Hollow Stem.

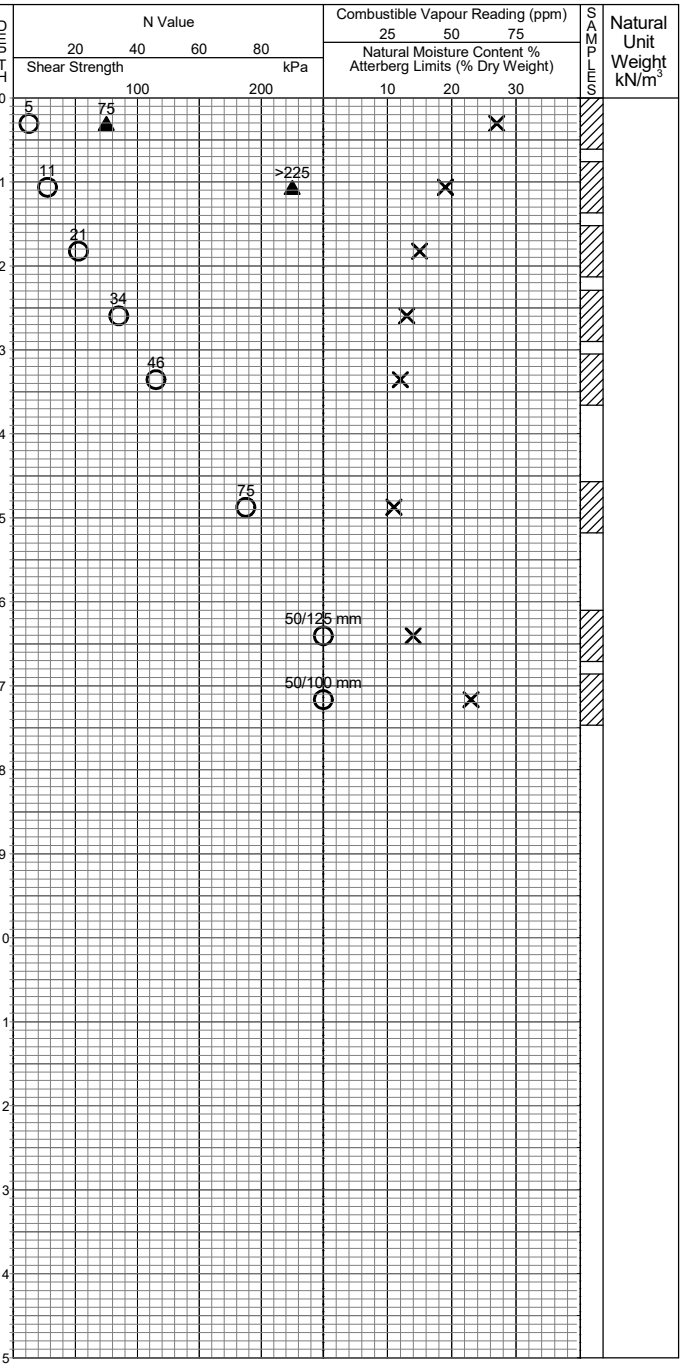
Datum: Geodetic

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
			239.90
		TOPSOIL: (~200 mm thick)	~239.7
		SILTY CLAY: trace gravel, trace sand, brown, moist, stiff trace rootlets, trace organics in upper 0.6 m	~238.6
		hard below 0.8 m	~238.4
		SILT: some clay, trace sand, trace gravel, brown, moist, compact 200 mm thick sand layer, wet at 2.3 m dense below 2.5 m grey below 2.7 m	
		very dense below 4.5 m	
		wet below 7.0 m	~232.4
		Borehole terminated at 7.5 m	

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



Time	Water Level (m)	Depth to Cave (m)
on completion	5.5	open
October 13, 2023	1.31	

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Log of Borehole BH23-1

Project No. HAM-00801363-D0 | Drawing No. 37

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

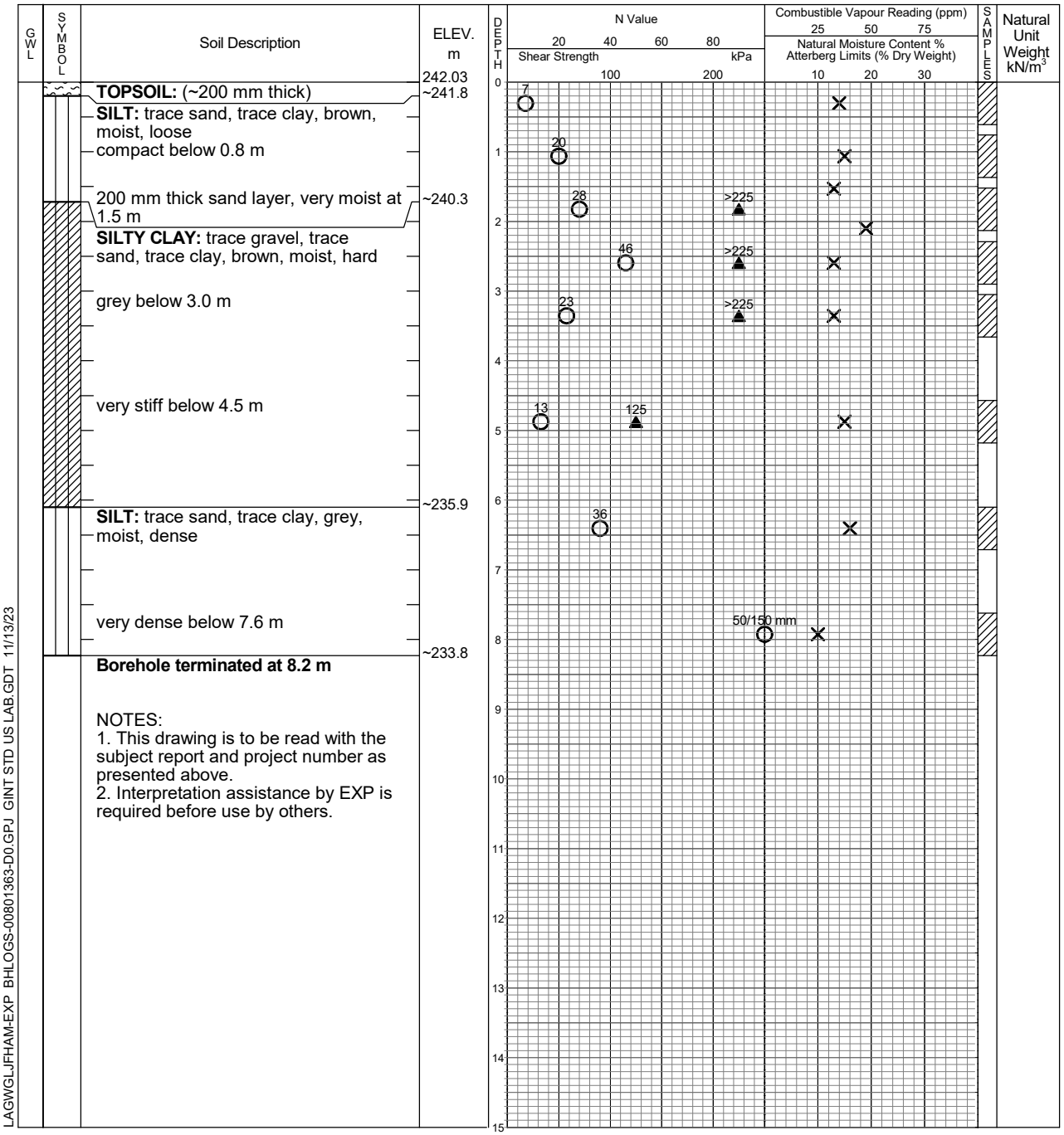
Date Drilled: September 11, 2023

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	open

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Log of Borehole MW23-2

Project No. HAM-00801363-D0 | Drawing No. 38

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

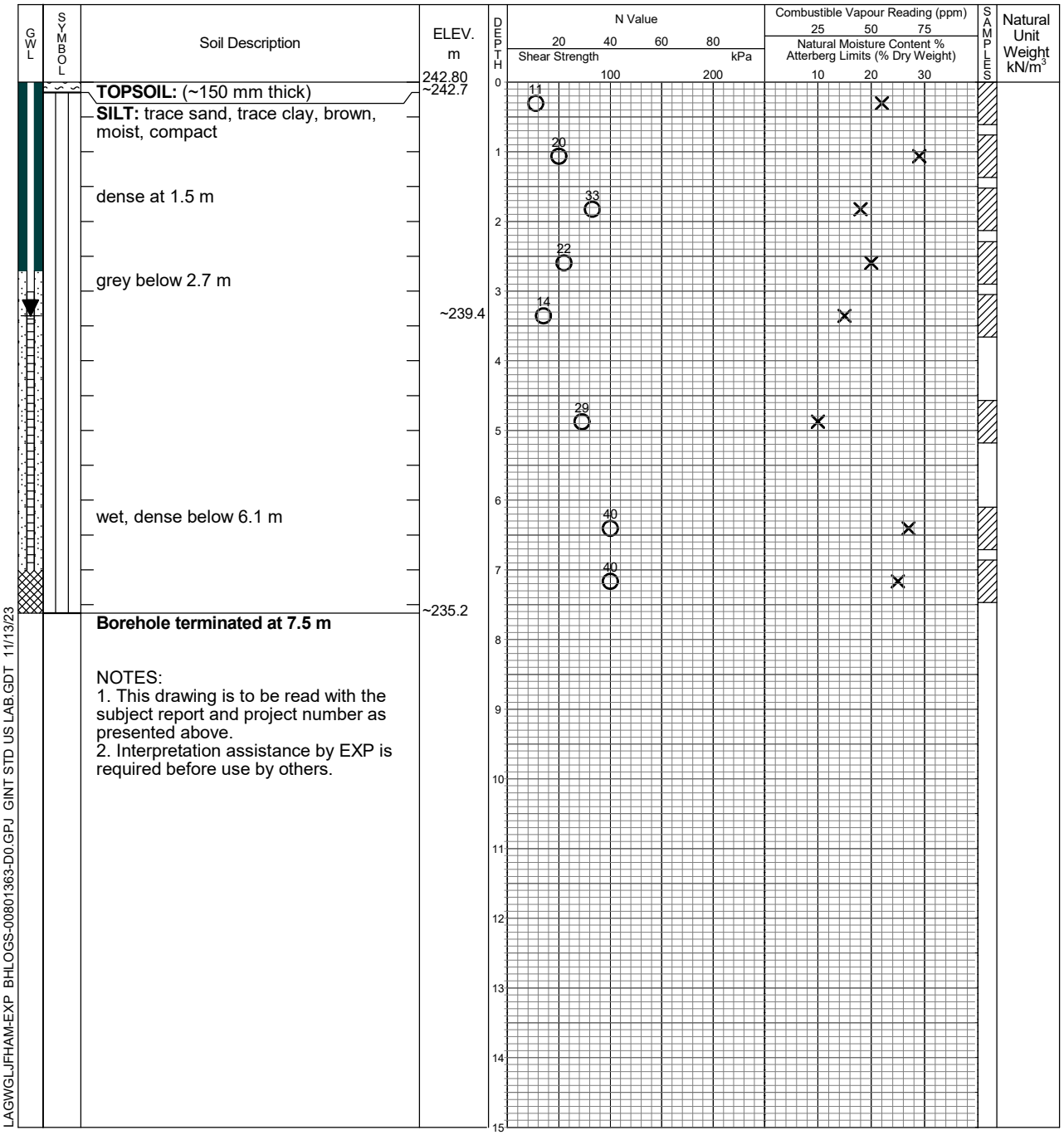
Date Drilled: September 7, 2023

Drill Type: D-70 Track Mount. Hollow Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	7.0
October 13, 2023	3.40	

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Log of Borehole BH23-2

Project No. HAM-00801363-D0 | Drawing No. 39

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: September 8, 2023

Drill Type: D-70 Track Mount. Hollow Stem.

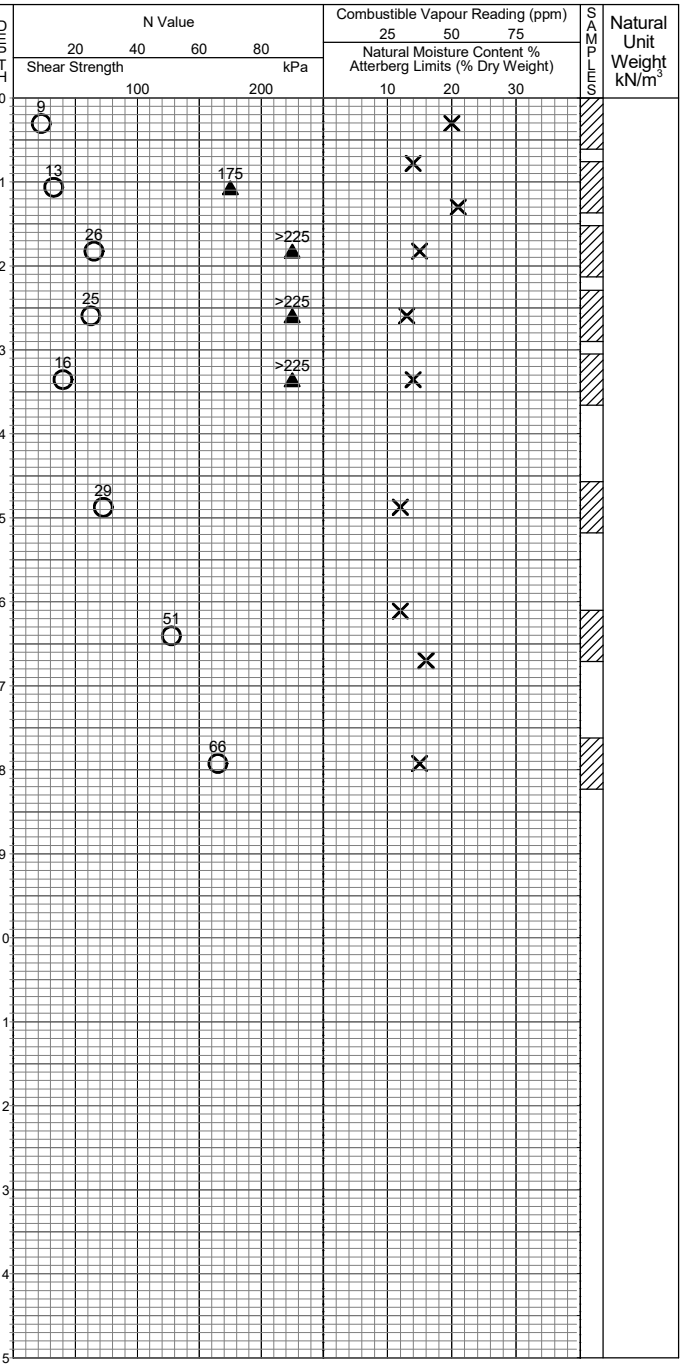
Datum: Geodetic

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
			243.08
		TOPSOIL: (~200 mm thick)	~242.9
		SILT: trace sand to sandy, trace clay, brown, moist, loose, trace rootlets	
			~242.0
		SILTY CLAY: trace sand, brown, moist, very stiff to hard	
		grey below 2.3 m	
			~238.5
		SILT: trace sand, trace clay, grey, moist, compact	
		some sand to sandy, wet, very dense below 6.1 m	
			~234.9
		Borehole terminated at 8.2 m	

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



LAGWGLJFHAM-EXP BHLOGS-00801363-D0.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	7.0	open

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Log of Borehole MW23-3

Project No. HAM-00801363-D0 | Drawing No. 40

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

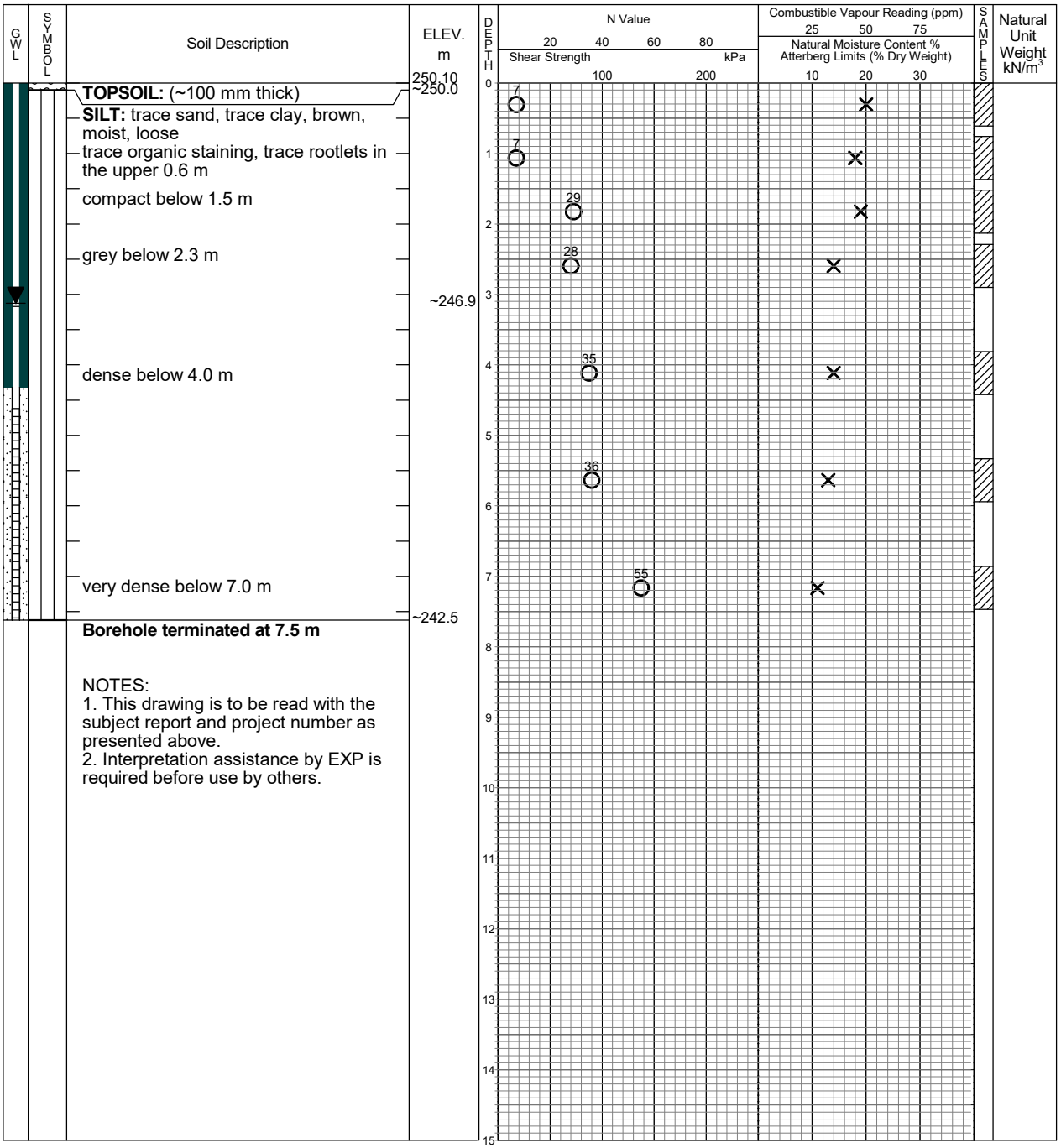
Date Drilled: September 6, 2023

Drill Type: D-70 Track Mount. Hollow Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	4.6	4.6
October 13, 2023	3.17	

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Log of Borehole BH23-3

Project No. HAM-00801363-D0 | Drawing No. 41

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

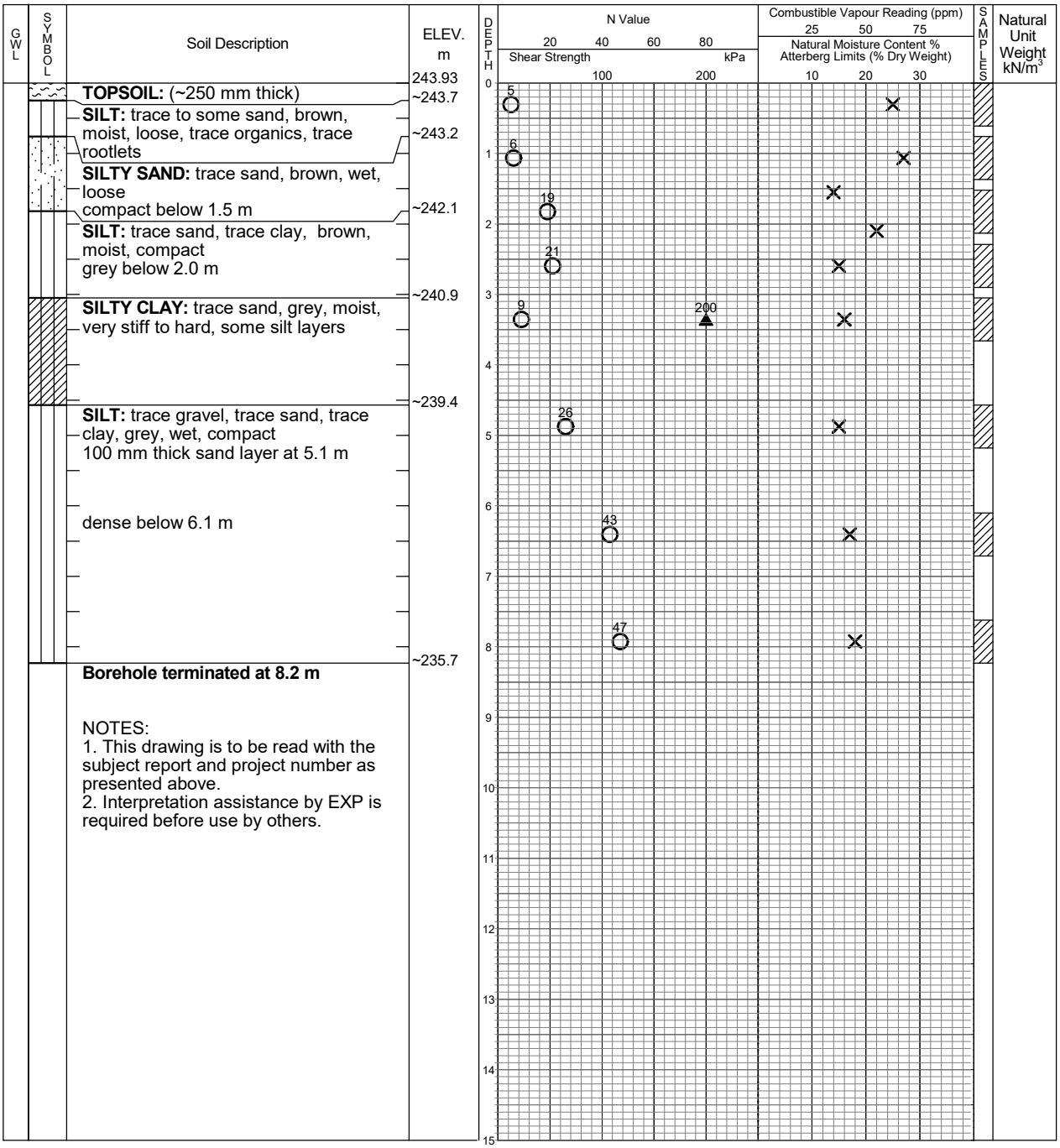
Date Drilled: September 8, 2023

Drill Type: D-70 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	6.7	open

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Log of Borehole MW23-4

Project No. HAM-00801363-D0 | Drawing No. 42

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

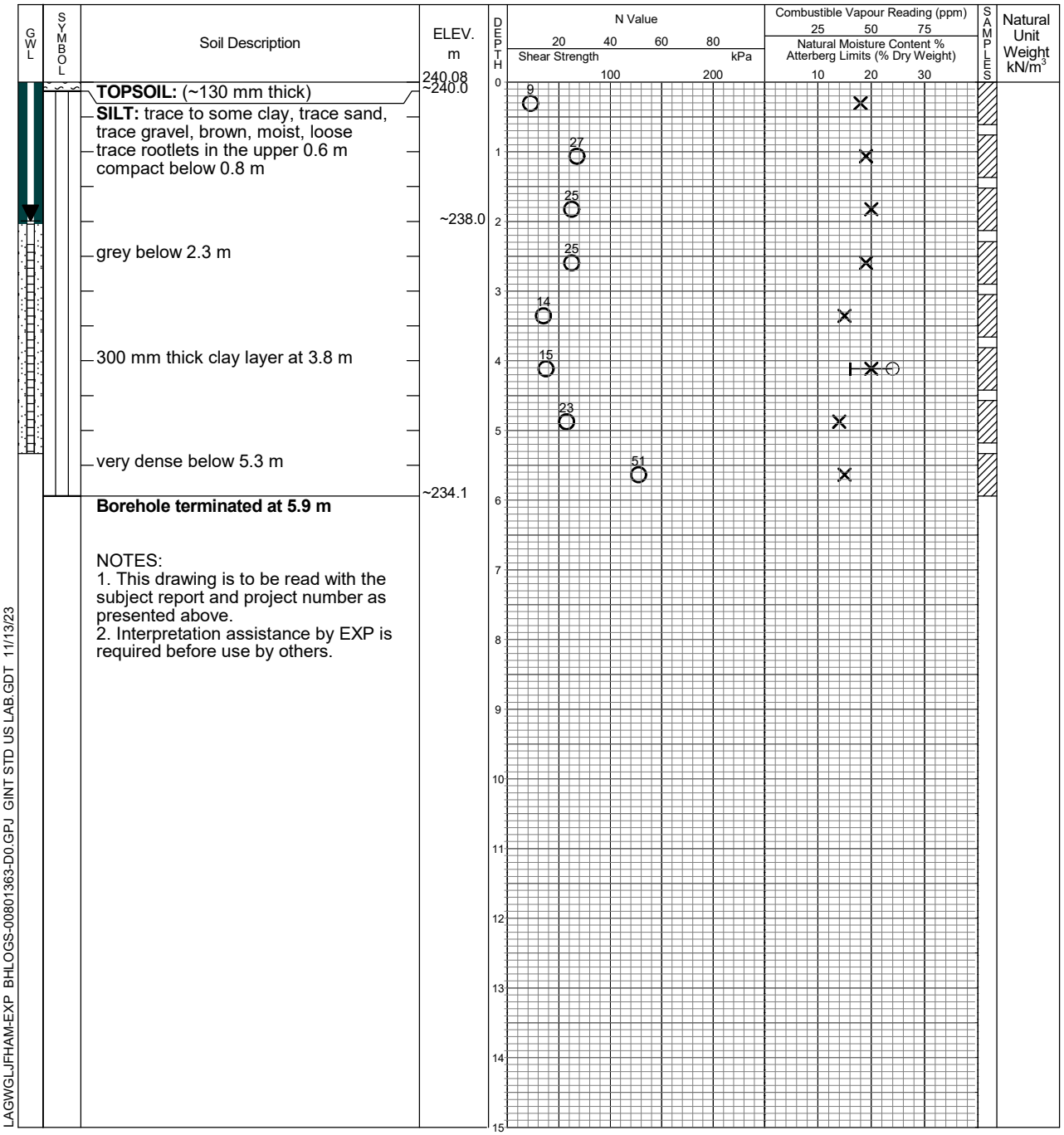
Date Drilled: September 6, 2023

Drill Type: D-70 Track Mount. Hollow Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	5.2	open
October 13, 2023	2.04	

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Log of Borehole BH23-4

Project No. HAM-00801363-D0 | Drawing No. 43

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: September 7, 2023

Drill Type: D-70 Track Mount. Hollow Stem.

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
		TOPSOIL: (~100 mm thick)		0
		SILT: trace to some clay, trace to some sand, brown, moist, loose		
		trace rootlets in the upper 0.6 m		
		compact below 0.8 m		1
				2
		grey below 2.6 m		
		dense below 3.0 m		3
				4
				5
		compact below 6.1 m		6
		SILTY CLAY: trace sand, grey, moist, very stiff to hard		7
		Borehole terminated at 6.7 m		8
				9
				10
				11
				12
				13
				14
				15

N Value (20 40 60 80)
Shear Strength kPa (100 200)
Combustible Vapour Reading (ppm) (25 50 75)
Natural Moisture Content % Atterberg Limits (% Dry Weight) (10 20 30)
SAMPLES
Natural Unit Weight kN/m³

N Value: 5, 16, 27, 27, 31, 43, 25
Shear Strength: 200

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	5.9	open

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Log of Borehole MW23-5

Project No. HAM-00801363-D0 | Drawing No. 44

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

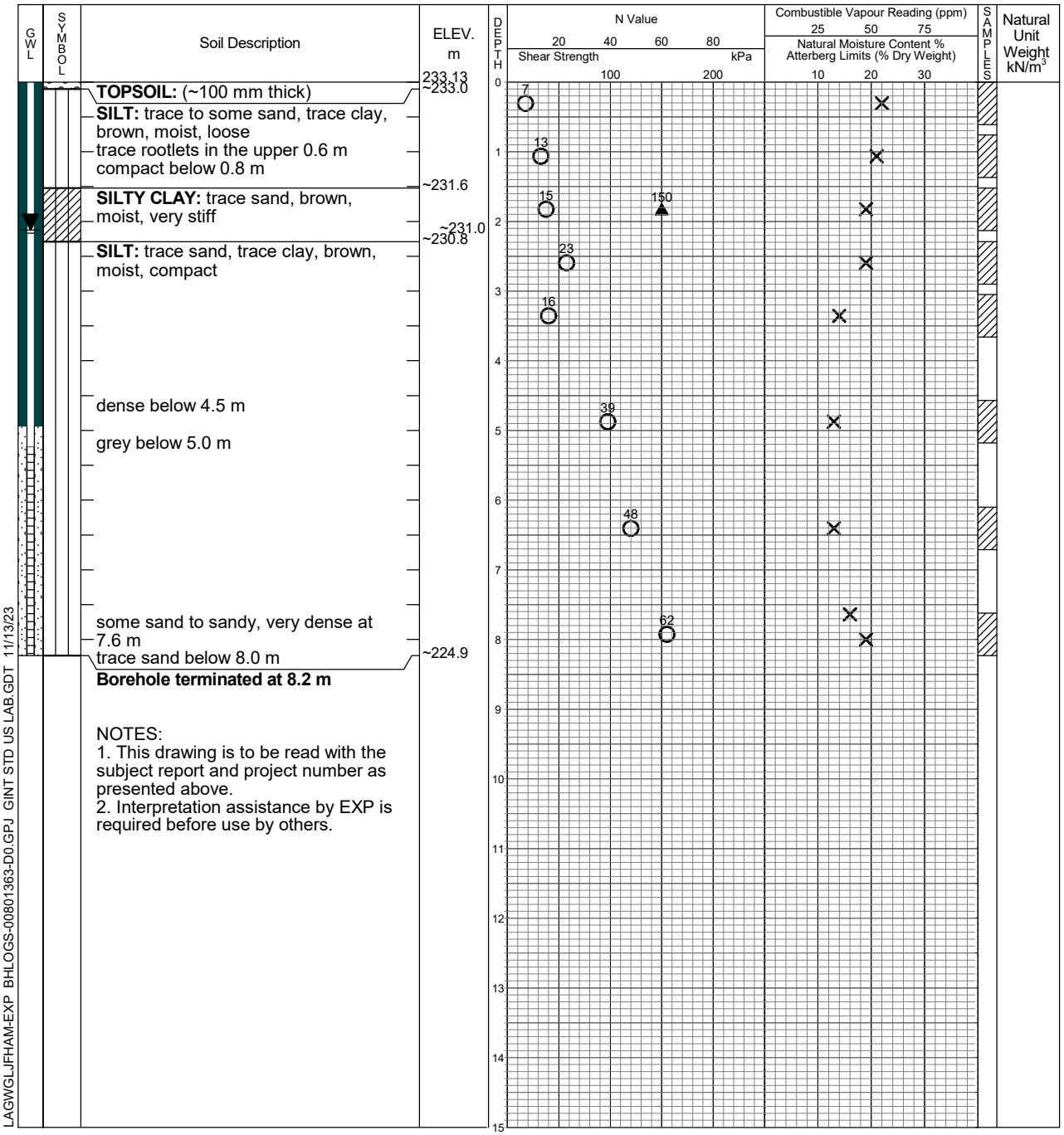
Date Drilled: September 13, 2023

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

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Time	Water Level (m)	Depth to Cave (m)
on completion	dry	open
October 26, 2023	2.17	

Log of Borehole MW23-6

Project No. HAM-00801363-D0 | Drawing No. 45

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

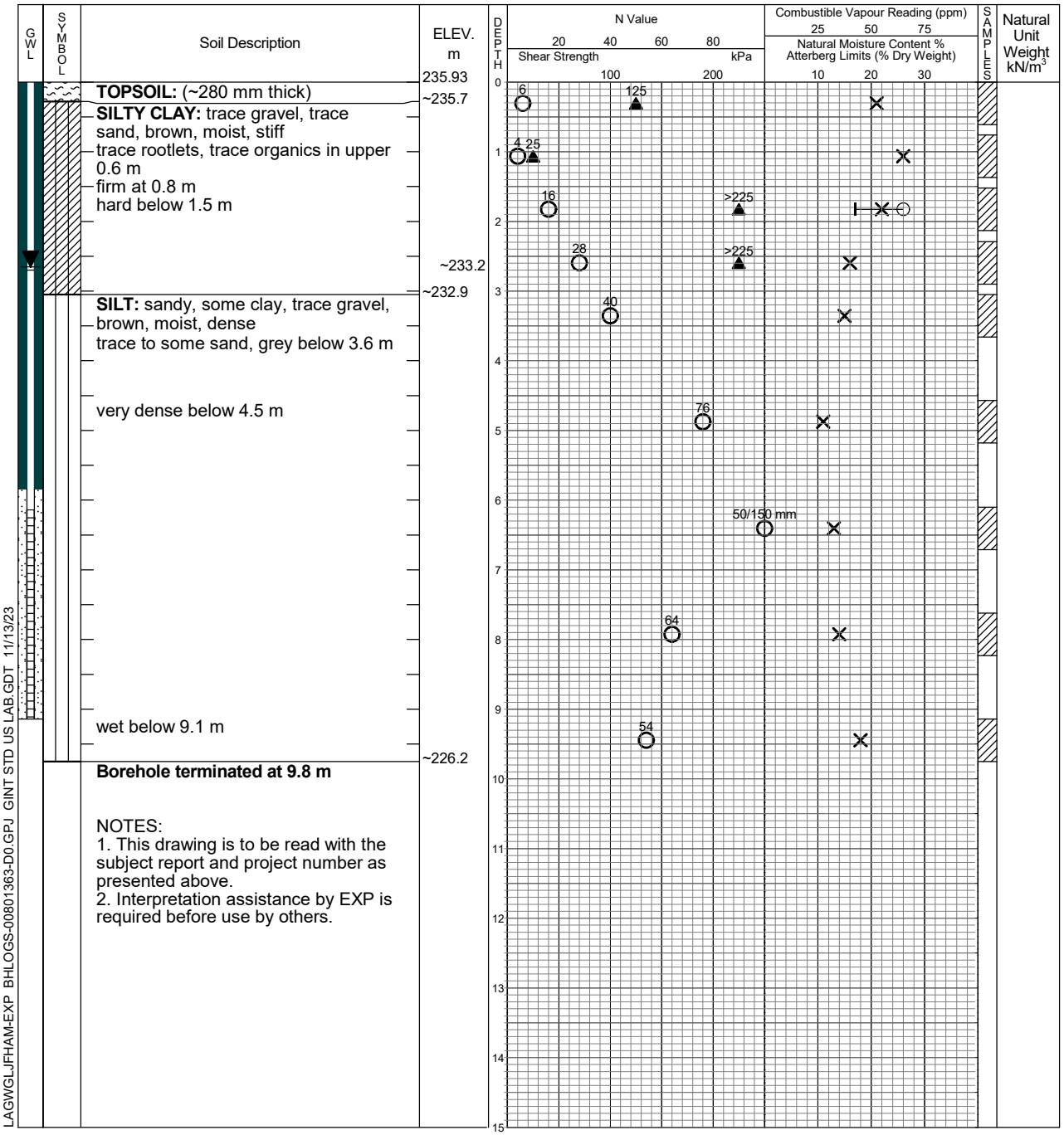
Date Drilled: September 12, 2023

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	9.1	open
October 13, 2023	2.70	

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Log of Borehole MW23-7

Project No. HAM-00801363-D0 | Drawing No. 46

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

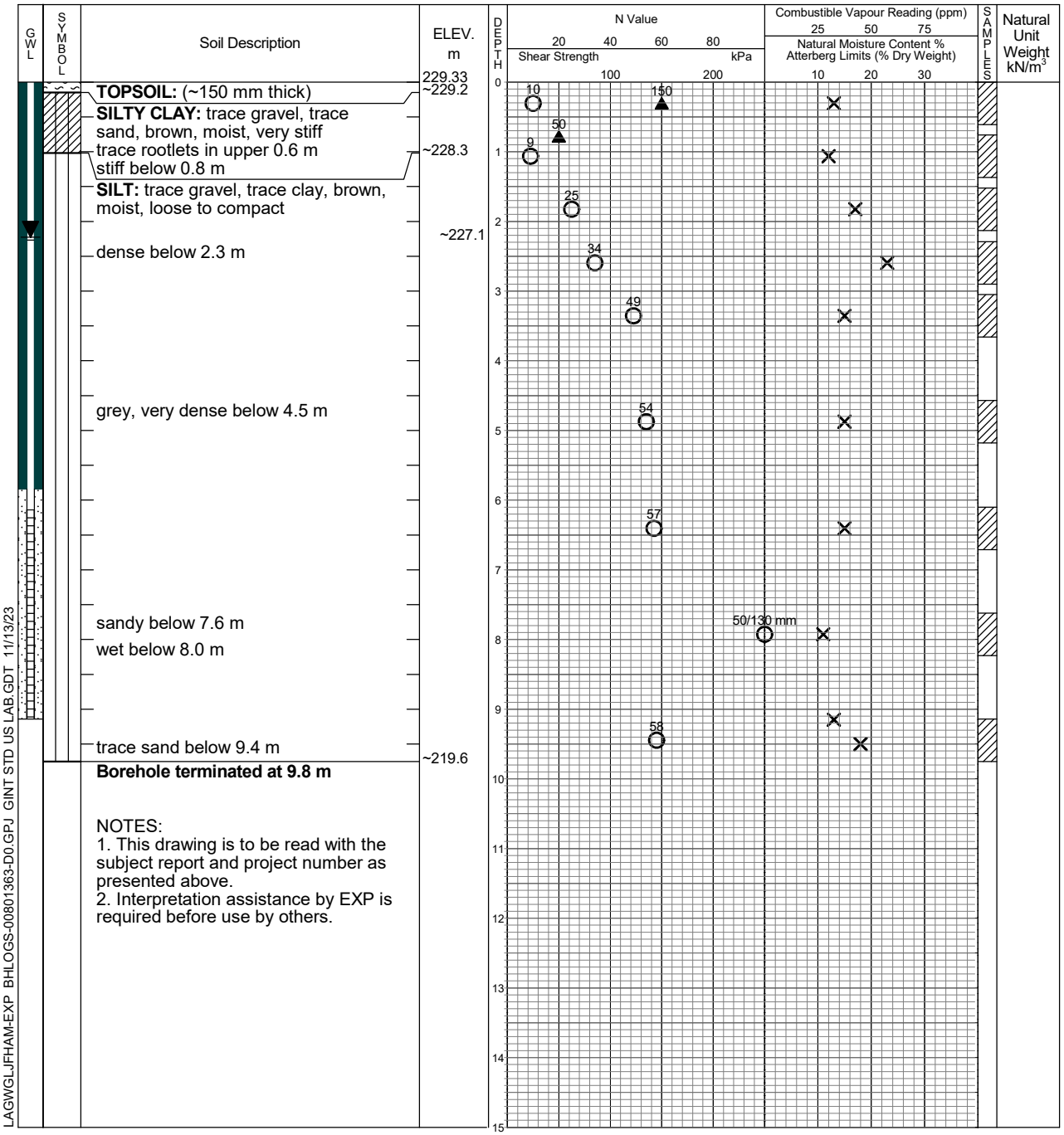
Date Drilled: September 12, 2023

Drill Type: D-50 Track Mount. Solid Stem.

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



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BHLOGS-00801363-D0.GPJ GINT STD US LAB.GDT 11/13/23

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	open
October 26, 2023	2.27	

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Log of Borehole MW23-8

Project No. HAM-00801363-D0 | Drawing No. 47

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: September 13, 2023

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

Soil Description	ELEV. m	DEPTH
	226.24	0
TOPSOIL: (~200 mm thick)	~226.0	
SILTY CLAY: trace sand, brown, moist, stiff to very stiff trace rootlets, trace organics in upper 0.6 m hard at 1.5 m	~224.1	1
SILT: some sand, some clay, brown, moist, compact to dense grey below 3.4 m very moist below 4.5 m	~223.7	2
Borehole terminated at 6.7 m	~219.5	7

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

N Value (Shear Strength kPa): 4, 50, 12, 175, 14, >225, 100, 16, 31, 27, 13

Combustible Vapour Reading (ppm) 25 50 75
Natural Moisture Content % Atterberg Limits (% Dry Weight) 10 20 30

Natural Unit Weight kN/m³

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	5.5
October 26, 2023	2.15	

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Log of Borehole MW23-9

Project No. HAM-00801363-D0 | Drawing No. 48

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: September 13, 2023

Drill Type: D-50 Track Mount. Solid Stem.

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
		TOPSOIL: (~250 mm thick)	225.00 ~224.8	0
		SILTY CLAY: trace sand, brown, moist, very stiff trace rootlets in upper 0.6 m		
			~223.5	
		SILT: some sand, some clay, brown, moist, compact grey below 2.3 m		2
			~220.6	4
		SILTY CLAY: trace sand, grey, wet, firm	~220.4	
			~219.8	5
		Borehole terminated at 5.2 m		

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

N Value (20, 40, 60, 80)
Shear Strength (100, 200 kPa)
Combustible Vapour Reading (ppm) (25, 50, 75)
Natural Moisture Content % / Atterberg Limits (% Dry Weight) (10, 20, 30)
SAMPLES
Natural Unit Weight kN/m³

N Value: 8, 125, 6, 100, 28, 15, 19, 5, 25

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Time	Water Level (m)	Depth to Cave (m)
on completion	dry	open
October 26, 2023	4.40	

Log of Borehole MW23-10

Project No. HAM-00801363-D0 | Drawing No. 49

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

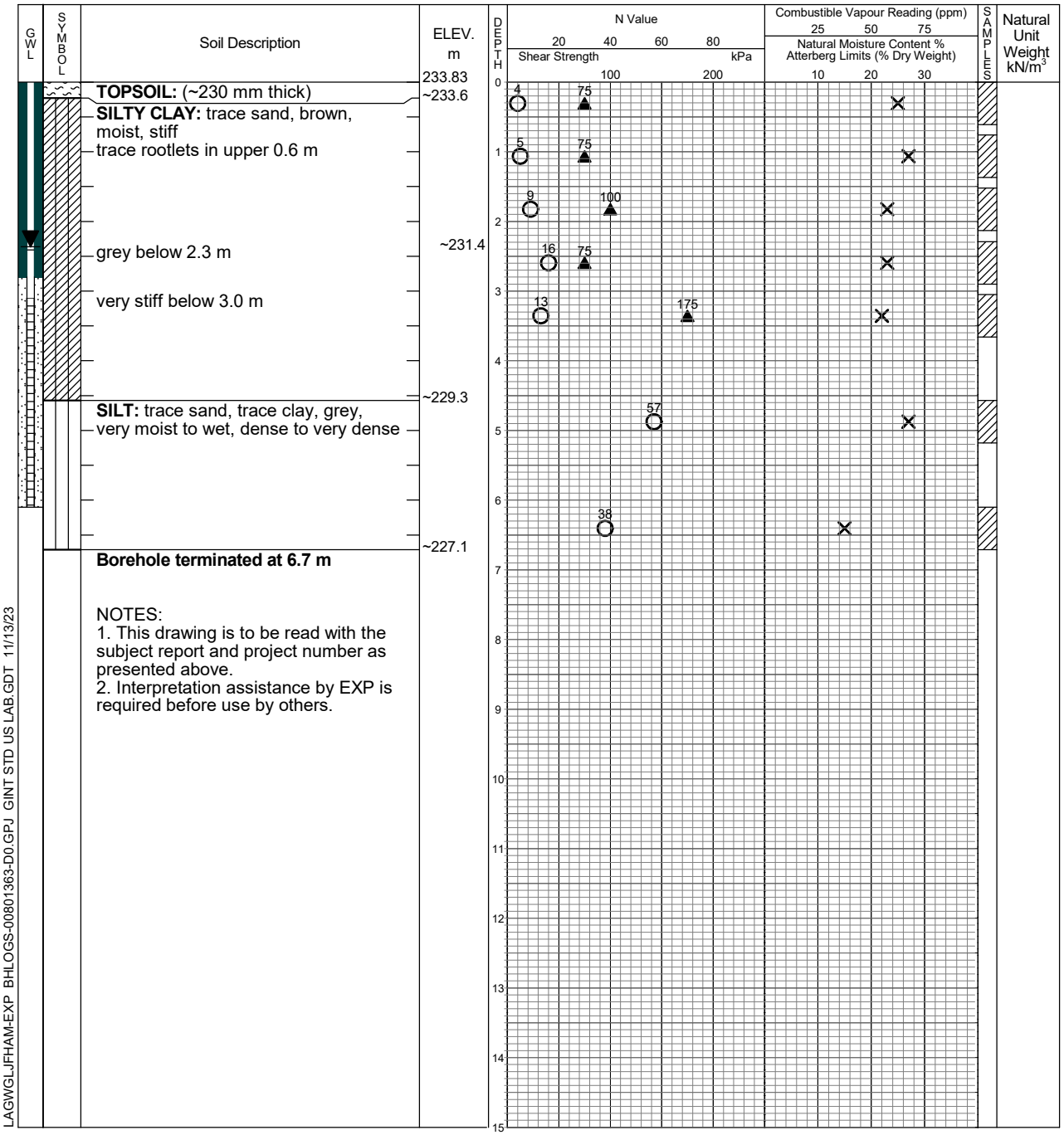
Date Drilled: September 12, 2023

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



Time	Water Level (m)	Depth to Cave (m)
on completion	3.4	open
October 13, 2023	2.41	

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Log of Borehole MW23-11

Project No. HAM-00801363-D0 | Drawing No. 50

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: September 7, 2023

Drill Type: D-70 Track Mount. Solid Stem.

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
			237.03	0
		TOPSOIL: (~180 mm thick)	~236.9	
		SILTY CLAY: trace sand, brown, moist, stiff to very stiff trace rootlets in upper 0.6 m		1
			~235.6	
		SILT: trace sand, trace clay, brown, moist, compact		2
			~234.4	
		SILTY SAND: brown, very moist, dense	~233.8	3
		SILT: trace gravel, trace to some sand, trace clay, grey, moist, dense		4
				5
			~230.9	6
		SAND: some silt, trace clay, trace gravel, grey, very moist, dense	~230.3	
		Borehole terminated at 6.7 m		7
				8
				9
				10
				11
				12
				13
				14
				15

N Value (20, 40, 60, 80)
Shear Strength kPa (100, 200)
Combustible Vapour Reading (ppm) (25, 50, 75)
Natural Moisture Content % / Atterberg Limits (% Dry Weight) (10, 20, 30)
SAMPLES
Natural Unit Weight kN/m³

N Value: 4, 50, 6, 125, 24, 54, 34, 46, 40

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

Time	Water Level (m)	Depth to Cave (m)
on completion	5.5	open
October 13, 2023	1.48	

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Log of Borehole MW23-12

Project No. HAM-00801363-D0 | Drawing No. 51

Project: Geotechnical Investigation | Sheet No. 1 of 1

Location: Twenty Road West, Hamilton, ON

Date Drilled: September 14, 2023

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH
			232.69	0
		TOPSOIL: (~80 mm thick)	~232.6	
		SILT: trace sand, trace clay, brown, moist, compact, trace rootlets	~232.2	
		SILTY CLAY: trace sand, brown, moist, very stiff to hard		1
				2
			~230.4	
		SILT: trace sand, trace clay, brown, very moist, compact		3
		grey below 2.7 m		4
			~228.4	
				5
			~226.6	6
		SILTY CLAY: trace sand, grey, very moist, firm		7
		very stiff at 7.3 m	~225.1	
		SILT: trace sand, trace clay, grey, moist, compact	~224.5	8
		Borehole terminated at 8.2 m		9
				10
				11
				12
				13
				14
				15

N Value (20 40 60 80)
Shear Strength (100 200 kPa)
Combustible Vapour Reading (ppm) (25 50 75)
Natural Moisture Content % Atterberg Limits (% Dry Weight) (10 20 30)
SAMPLES
Natural Unit Weight kN/m³

N Value: 13, 11, 11, 16, 13, 20, 9, 25, 23
Shear Strength: >225, 200, 150, >150

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BHLOGS-00801363-D0.GPJ GINT STD US LAB.GDT 11/13/23

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	7.0	open
October 13, 2023	4.34	

GENERAL REQUIREMENTS FOR ENGINEERED FILL

1. The area must be stripped of all topsoil, fill, organic stained or disturbed native material and proof-rolled. Soft and loose spots must be dug out. The stripped native subgrade must be examined and approved by an EXP Services Inc. (EXP) engineer prior to placement of engineered fill.

2. The structure/building footprint, including basements, garages, etc. must be defined by offset stakes that remain in place until the foundations and service connections are all constructed. Confirmation that the foundations are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and EXP. Without this confirmation, no responsibility for the performance of the structure can be accepted by EXP.

3. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular fill conforming to Granular B (OPSS 1010) is preferred.

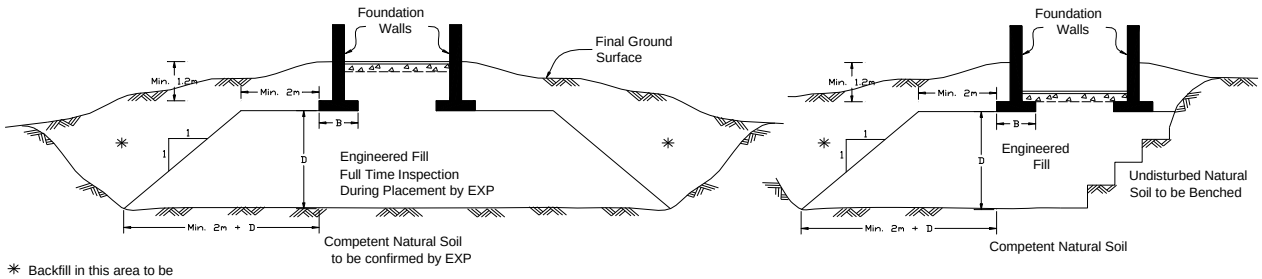
4. Full-time geotechnical inspection by EXP during placement of engineered fill is required.

5. The fill must be placed such that the specified geometry is achieved. Refer to sketches below for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

6. A minimum footing width of 500 mm (20 inches) is suggested and footings must be provided with nominal steel reinforcement.

7. All excavations must be done in accordance with the Ontario Occupational Health and Safety Act.

8. These guidelines are to be read in conjunction with the EXP report attached. Foundations on at least 500 mm of engineered fill constructed in accordance with the above requirements and the attached EXP report may support a geotechnical resistance of 150 kPa at Serviceability Limit States (SLS) and 225 kPa at Ultimate Limit States (ULS).

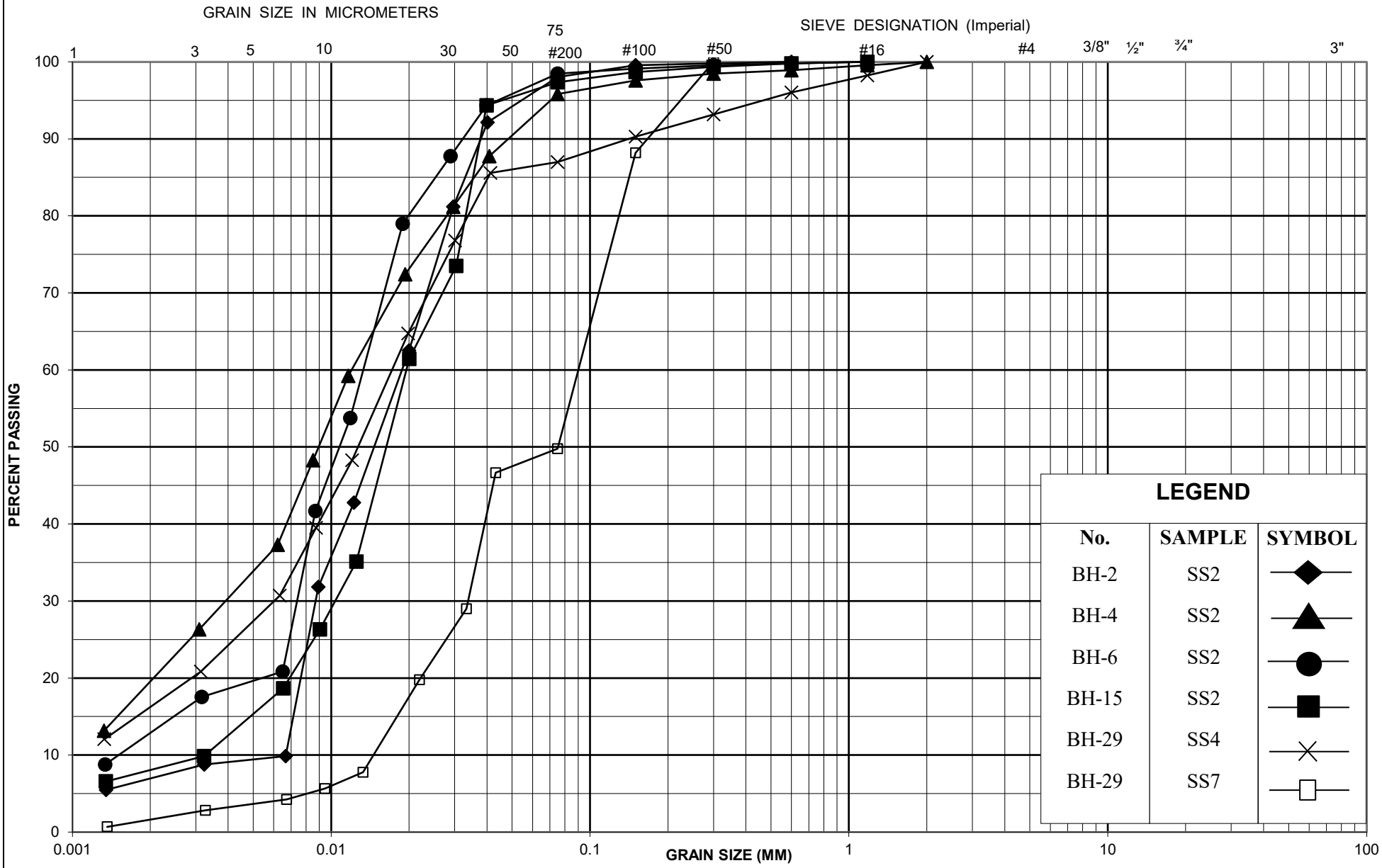


Appendix B

Laboratory Test Results

ISSMFE SOIL CLASSIFICATION SYSTEM

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



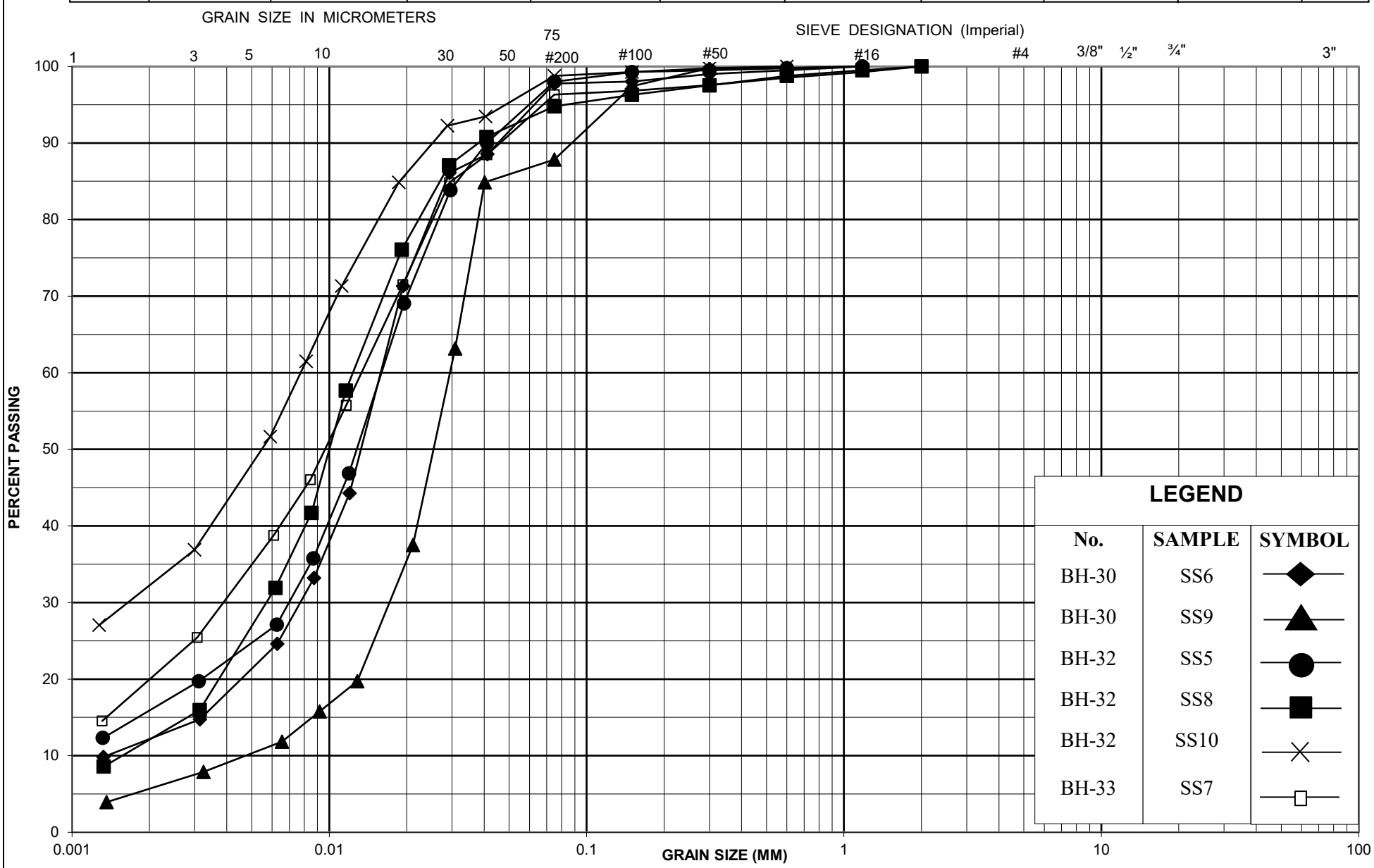
exp.

GRAIN SIZE DISTRIBUTION

DRAWING NO.:	B1
PROJECT NO.:	HAM-00801363-A0
DATE:	APRIL 2018

ISSMFE SOIL CLASSIFICATION SYSTEM

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



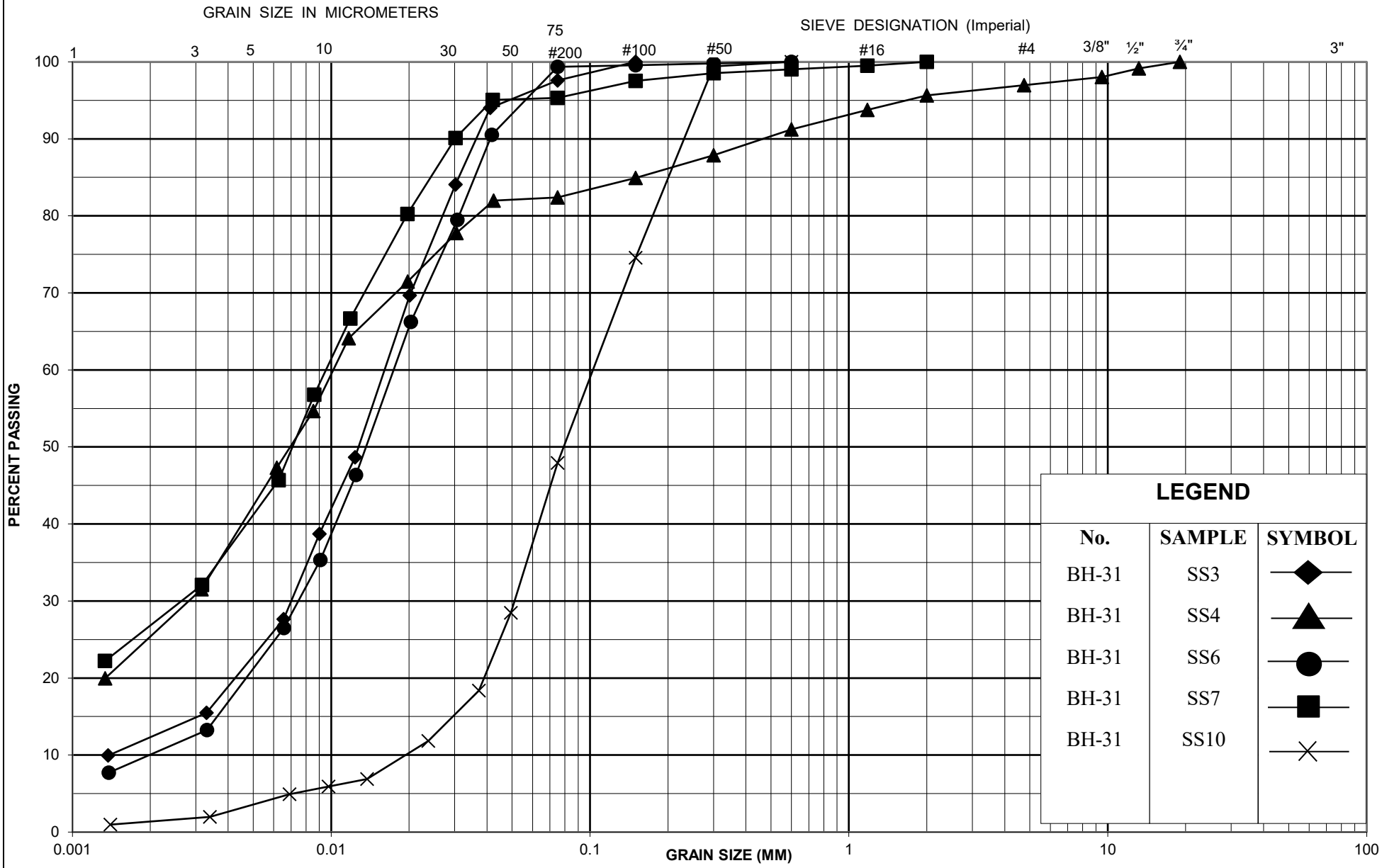
exp.

GRAIN SIZE DISTRIBUTION

DRAWING NO.:	B2
PROJECT NO.:	HAM-00801363-A0
DATE:	JUNE 2018

ISSMFE SOIL CLASSIFICATION SYSTEM

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



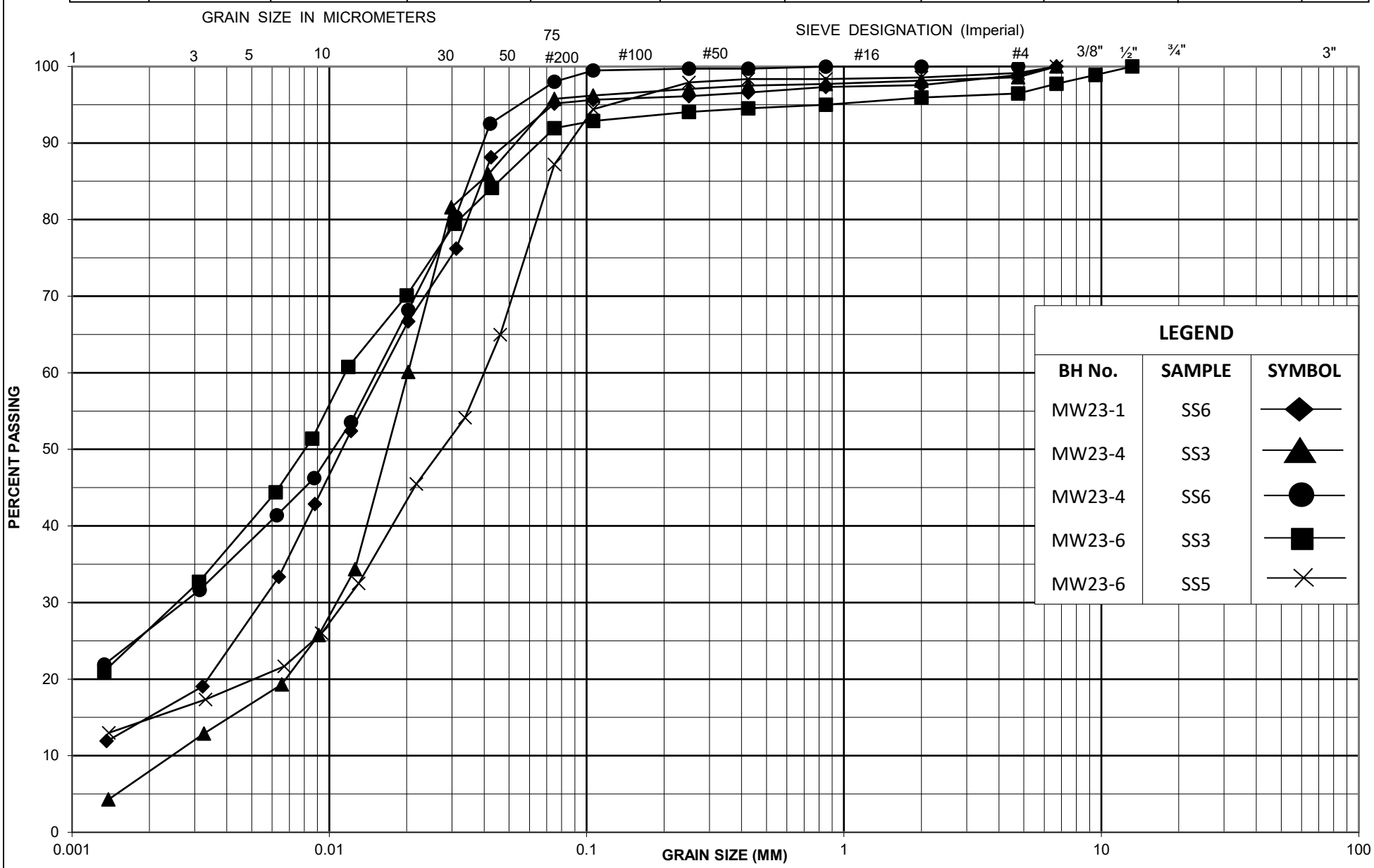
exp.

GRAIN SIZE DISTRIBUTION

DRAWING NO.:	B3
PROJECT NO.:	HAM-00801363-A0
DATE:	APRIL 2018

ISSMFE SOIL CLASSIFICATION SYSTEM

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

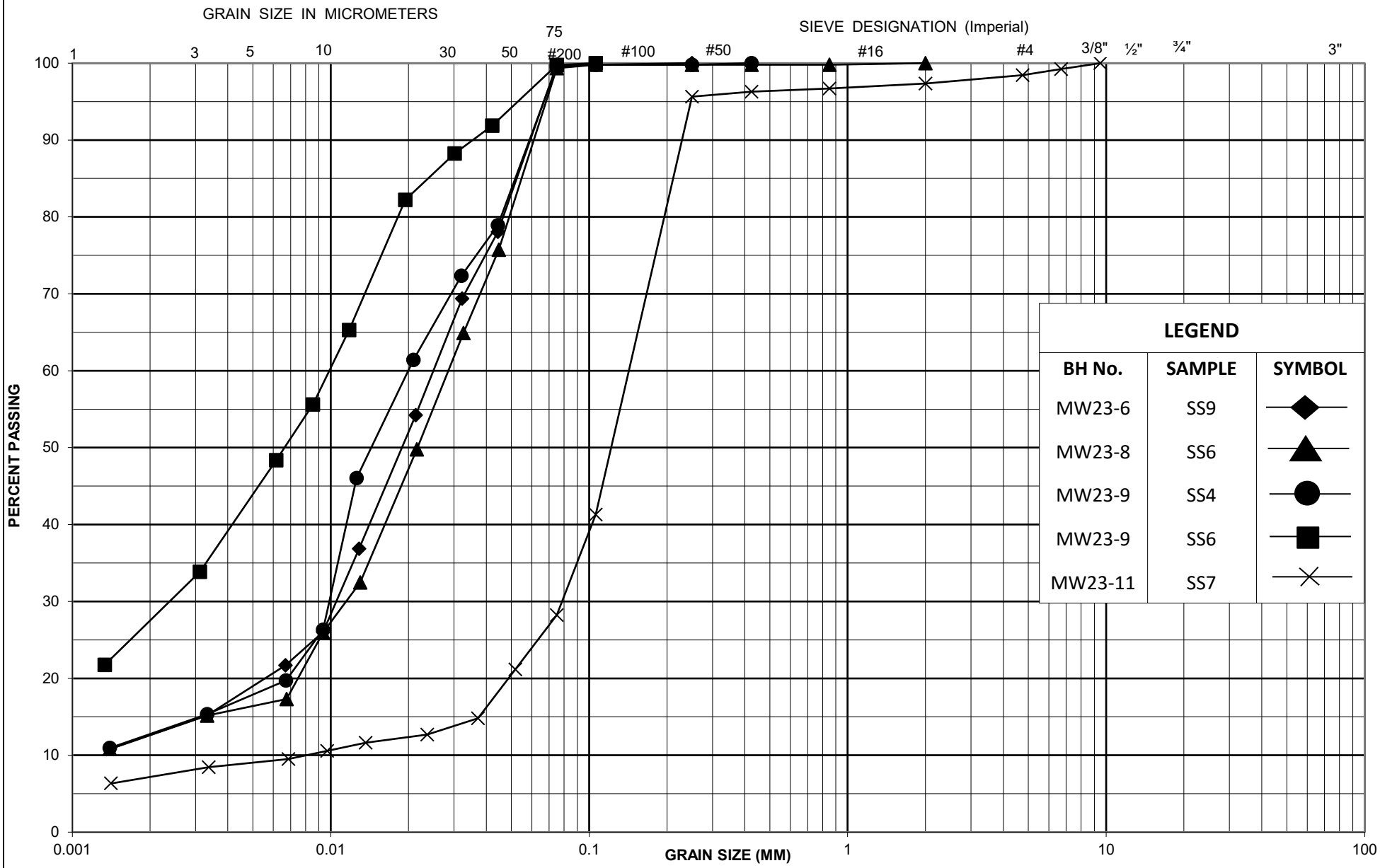


GRAIN SIZE DISTRIBUTION

DRAWING NO.:	B4
PROJECT NO.:	HAM-00801363-D0
DATE:	OCTOBER 2023

ISSMFE SOIL CLASSIFICATION SYSTEM

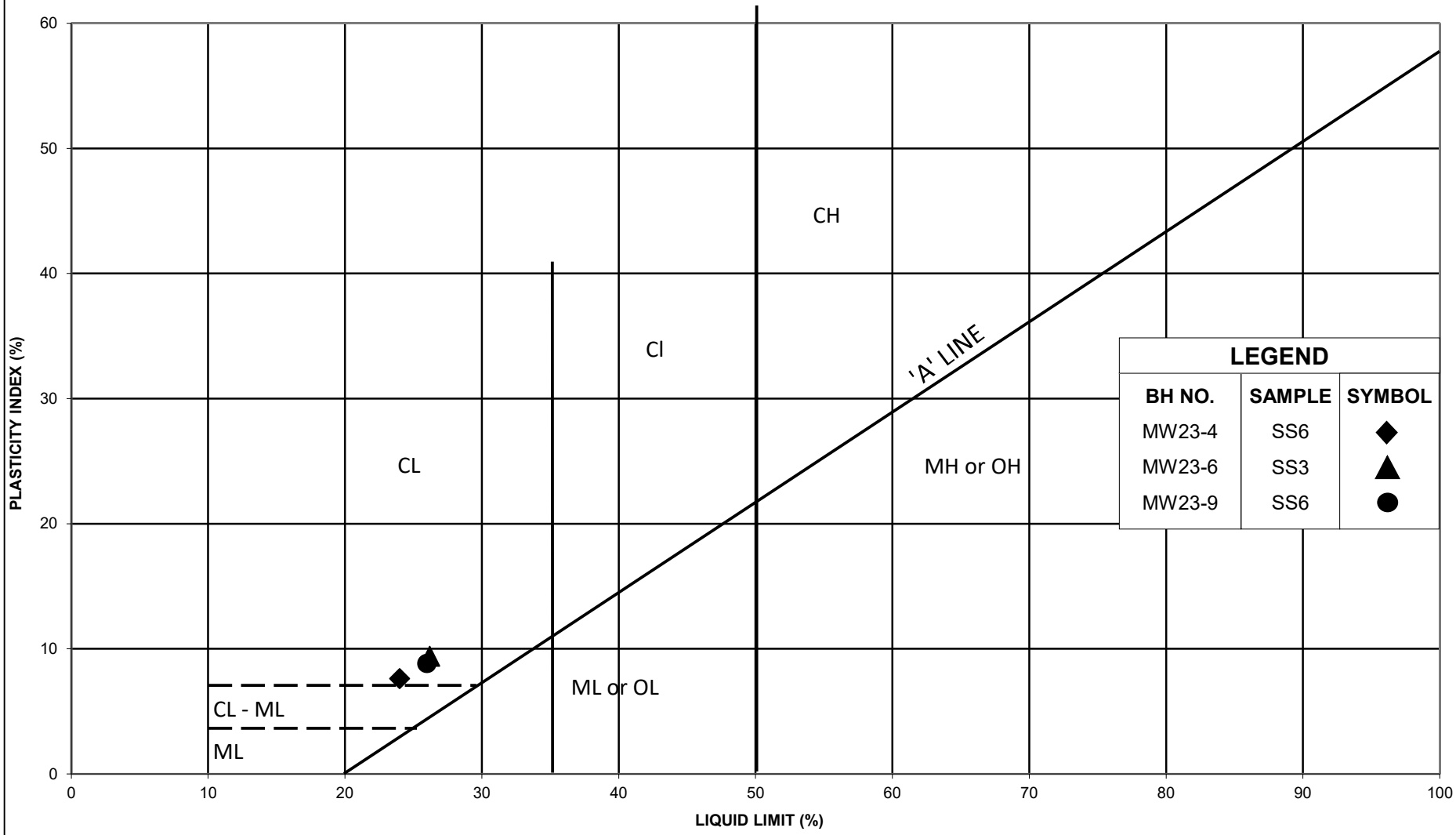
CLAY	SILT			SAND			GRAVEL			Cobbles
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	



GRAIN SIZE DISTRIBUTION

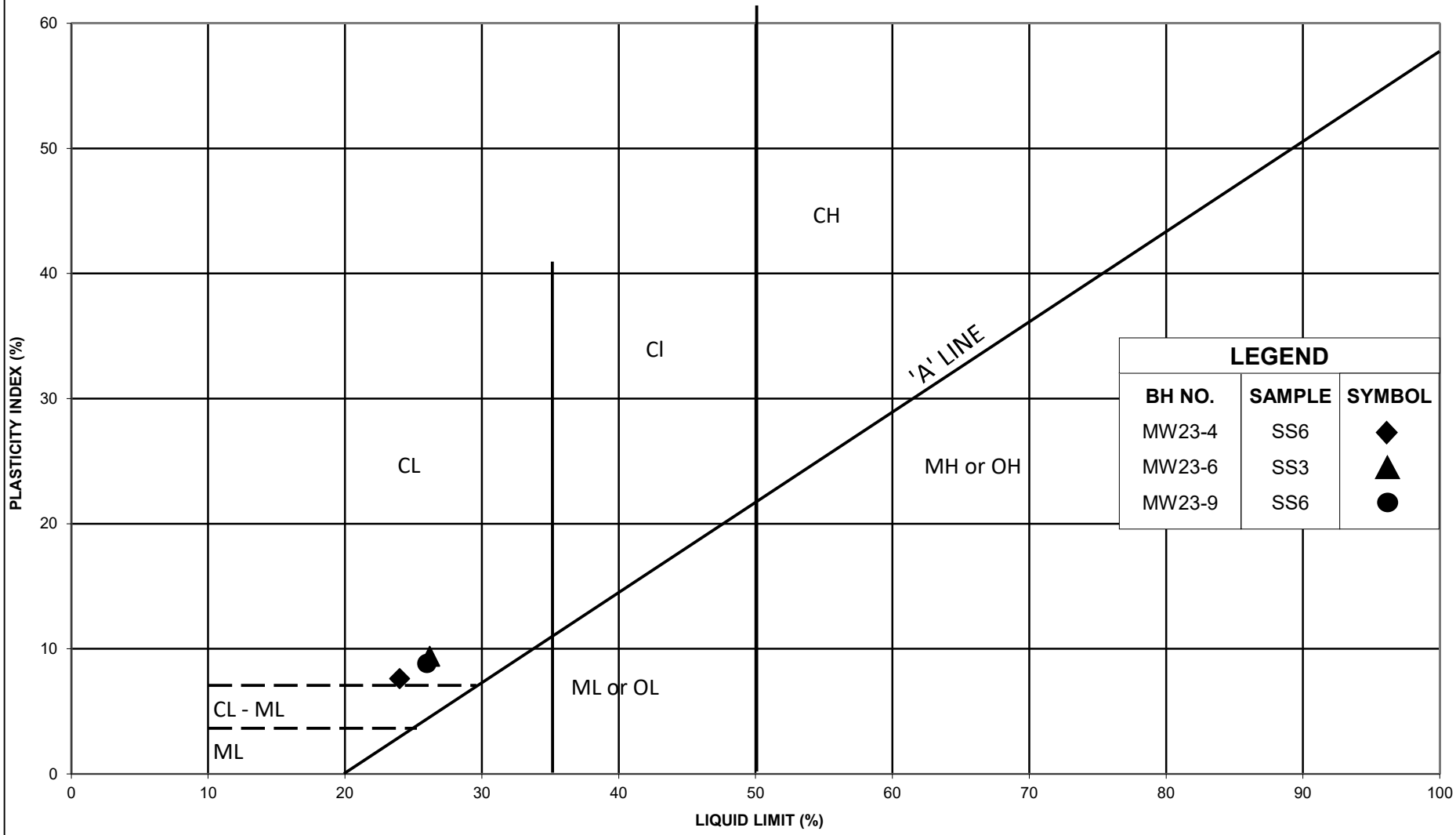
DRAWING NO.:	B5
PROJECT NO.:	HAM-00801363-D0
DATE:	OCTOBER 2023

PROPOSED SUBDIVISION
Twenty Road West, Hamilton, ON



exp.	PLASTICITY CHART ***SILTY CLAY (CL)***	DRAWING NO.: B6 PROJECT NO.: HAM-00801363-D0 DATE: OCTOBER 2023

PROPOSED SUBDIVISION
Twenty Road West, Hamilton, ON



exp.	PLASTICITY CHART ***SILTY CLAY (CL)***	DRAWING NO.: B7 PROJECT NO.: HAM-00801363-D0 DATE: OCTOBER 2023