"BUILT ON THE ROCK"

PRELIMINARY GEOTECHINCAL INVESTIGATION REPORT

PROPOSED RESIDENTIAL DEVELOPMENT, HAWKRIDGE HEIGHTS, SEVERN, ON;

PROJECT NUMBER: 23-117-01

CLIENT: LIV Communities

ATTENTION: Ben Jones

DATE: September 19, 2024

PREPARED BY: Green Geotechnical Ltd.

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1.0 SITE AND PROJECT BACKGROUND

Green Geotechnical Ltd. (Green Geotechnical) was retained by LIV Communities to conduct a preliminary subsurface investigation and prepare a preliminary geotechnical design report for the proposed Hawkridge Heights residential development at the Hawkridge Golf Course, in the township of Severn, Ontario. The site is in a predominately rural and residential area off of Hurlwood Lane between Uhthoff Line and Burnside Drive, to the north of Highway 11. A site location plan is provided as Figure 1. Currently the site is an approximately 374-acre active golf course with a clubhouse located at 1151 Hurlwood Lane and a maintenance facility located off the Uhthoff Line.

Based on email and phone communication, it is understood that the site will be developed to include the construction of a residential subdivision with golf villa areas, roads connecting to existing municipal right of ways, full municipal services, and stormwater management facilities. It is assumed that the development is to be fully municipally serviced to an urban standard.

At the time of this investigation, no conceptual grading or servicing plans were available. It is presumed that site grades will generally be at or above their current elevations. Any regrading within the influence zones of buildings or settlement sensitive areas is anticipated to be done with the use of Engineered Fill.

This report encompasses the geotechnical investigation conducted for the Property to assess its geotechnical suitability for the proposed development. The field investigation consisted of advancing a total of four (24) exploratory boreholes (Boreholes 1 to 24) at the Property. The objective of the geotechnical investigation was to determine the prevailing subsurface soil and groundwater conditions, in order to provide preliminary geotechnical engineering recommendations for the design of the proposed building foundations, slab-on-grade or basement floor slabs, lateral earth pressure and seismic design parameters, pavement design, pipe bedding, and stormwater management facilities. In addition, comments are also included on the pertinent project construction aspects including excavation, backfill and groundwater control.

2.0 INVESTIGATION PROCEDURES AND METHODOLOGY

The field investigation was conducted on January 3rd to 12th, 2024, and consisted of drilling and sampling a total of twenty-four (24) exploratory boreholes (Boreholes 1 to 24) extending to termination depths ranging from approximately 4.5m to 6.6m below existing ground surface.

The boreholes were staked out in the field by Green Geotechnical based on the proposed development and existing site features. The approximate borehole locations are shown on the enclosed Borehole Location Plans as Figure 2 – Existing Conditions.

Various utility locates agencies (including a private locate company) were contacted by Green Geotechnical to clear the borehole locations prior to the commencement of the field investigation.

The ground surface elevations at the borehole locations were surveyed by Green Geotechnical. Borehole elevations are provided relative to Geodetic Datum (NAD). The horizontal coordinates are reported relative to the Universal Transverse Mercator geographic coordinate system (UTM Zone 17T). It should be noted that the elevations provided on the Borehole Logs are approximate and provided only for the purpose of relating borehole soil stratigraphy and should not be used or relied on for other purposes.

The borings were drilled by a specialist drilling contractor using a track mounted drill rig power auger and sampled at regular intervals with a conventional 50mm diameter split barrel sampler when the Standard Penetration Test (SPT) was conducted (ASTM D 1586). The field work (drilling, sampling, and testing) was observed full time and recorded by Green Geotechnical field staff, who logged the boring and examined the samples as they were obtained.

All samples obtained during the investigation were sealed into plastic jars and transported to our geotechnical laboratory for detailed inspection and testing. The borehole samples were examined (tactile) in detail by a geotechnical engineer and classified according to visual and index properties. Geotechnical laboratory testing consisted of water content determination on all samples, and grain size analysis on four (4) selected soil samples. The measured natural water contents of individual samples and the results of the grain size analysis test are plotted on the enclosed borehole logs at respective sampling depths. The results of the grain size analyses are also summarized in Section 3.9 of this report and are appended in Appendix B.

Groundwater levels were observed in the open boreholes upon the completion of drilling. Monitoring wells were installed in twenty-three (23) boreholes to facilitate one (1) stabilized groundwater level reading, which was taken between January 31st and February 1st, 2024. The results of the groundwater level readings are enclosed on the borehole logs and summarized in Section 3.8 of this report.

3.0 SUBSURFACE CONDITIONS

The specific soil conditions encountered at each borehole location are described in greater detail on the Borehole Logs, with a summary of the general subsurface soil conditions outlined below. This summary is intended to correlate this data to assist in the interpretation of the subsurface conditions at the site. The borehole logs are enclosed in Appendix A.

It should be noted that the subsurface conditions are confirmed at the borehole locations only and may vary between and beyond the borehole locations. The boundaries between the various strata as shown on the logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of geologic change.

3.1 Topsoil

Surficial topsoil with a thickness of approximately 0.1m to 0.5m was encountered at the ground surface of all Boreholes. The topsoil was dark brown in colour.

Topsoil thicknesses provided in this report were obtained at the individual borehole locations, as measured through the collar of the open borehole. Thicknesses may vary between and beyond borehole locations and should not be used/relied upon for costing purposes.

3.2 Earth Fill

Earth fill, primarily comprised of a silt, with sand content ranging from some sand to sandy, trace to some clay content, and organic inclusions was encountered in all boreholes underlying the surficial topsoil, with thicknesses ranging from approximately 0.1m to 2.2m. The earth fill zone was underlain by the native silty sand to sandy silt, glacial till, and silt layers.

The Standard Penetration Test result (N-Values) obtained from the earth fill zone ranged from 2 to 18 blows per 300mm of penetration, indicating a generally very loose to compact relative density.

The in-situ moisture contents of the earth fill samples ranged from 17 to 46 percent by weight, indicating a generally moist to wet condition.

3.3 Silty Sand to Sandy Silt

Native deposits of a silty sand to sandy silt, with trace to some clay and trace gravel was encountered in all boreholes except for boreholes 3, 4, 5, and 6 underlying the earth fill with thicknesses ranging from approximately 0.9m to 5.4m. The silty sand to sandy silt was underlain by the silty clay to clayey silt, silt, and glacial till layers.

The Standard Penetration Test result (N-Values) obtained ranged from 0 to 13 blows per 300mm of penetration, indicating a generally very loose to compact relative density.

The in-situ moisture contents of the silty sand to sandy silt samples ranged from 8 to 41 percent by weight, indicating a generally moist to wet condition.

3.4 Silt

Native deposits of a silt, with sand content ranging from some sand to sandy, clay content ranging from some clay to clayey, and trace gravel was encountered in boreholes 5, 8, and 17 below the earth fill or silty sand to sandy silt, with thicknesses ranging from approximately 1.5m to 2.4m.

The Standard Penetration Test result (N-Values) obtained ranged from 0 to 8 blows per 300mm of penetration, indicating a generally very loose to loose relative density.

The in-situ moisture contents of the silt samples ranged from 14 to 46 percent by weight, indicating a generally moist to wet condition.

3.5 Silty Clay to Clayey Silt

Native deposits of a silty clay to clayey silt with trace to some gravel, and trace to some sand was encountered in Boreholes 1, 2, 7-10, 12-19, and 22-24 below the silty sand to sandy silt and silt layers, with thicknesses ranging from approximately 0.6m to 4.4m. In boreholes 1, 2, 9, 13, 14, 16, 18, 19, and 22 to 24 the silty clay to clayey silt layer extended to the termination depth at approximately 6.6m.

The shear strength of the silty clay to clayey silt layer based on field vane tests ranged from 24kPa to 48kPa, indicating a generally soft to firm consistency. The sensitivity based on the remoulded vane shear tests of the silty clay to clayey silt layer ranged from 1.6 to 4.0, indicating a generally low sensitivity.

The in-situ moisture contents of the samples ranged from 19 to 75 percent by weight, indicating a generally moist to wet condition.

3.6 Sandy Silt to Silty Sand Glacial Till

Native deposits of a sandy silt to silty sand glacial till with gravel content ranging from some gravel to gravelly with cobbles and occasional boulders, and some clay was encountered in Boreholes 3-8, 10-12, and 15 below the earth fill zone, silt, silty sand to sandy silt, and silty clay to clayey silt layers, extending to the borehole termination depths of approximately 4.5m to 6.6m.

The Standard Penetration Test result (N-Values) obtained from this layer ranged from 0 to over 50 blows per 300 mm of penetration, indicating a generally very loose to very dense relative density.

The in-situ moisture contents of the silt soil samples ranged from 5 to 26 percent by weight, indicating a generally moist to wet condition.

3.7 Sand and Gravel

A native deposit of a sand and gravel with trace to some silt was encountered in Borehole 17 underlying the native sandy silt to silty sand layer, extending from 6.0m to the termination depth at 6.6m. This sand and gravel deposit contained an inferred artesian aquifer based on the flowing conditions out of the open borehole during drilling.

The Standard Penetration Test result (N-Values) obtained was 11 blows per 300mm of penetration, indicating a compact relative density.

The in-situ moisture content of the sample was 11 percent by weight, indicating a generally wet condition.

3.8 Groundwater

The depth of ground water and caving was measured in each of the boreholes immediately following the drilling. Water level measurements were made in the monitoring wells installed in all Boreholes exceptt Borehole 17 on January 31st and February 1st, 2024. The ground water observations of all the boreholes are summarized as follows:

Borehole No.	Depth of Auguring (m)	Depth to Cave (m)	Unstabilized Water Level (Depth/Elevation) (m)	Stabilized Water Level in well on January 31st and February 1st, 2023 (Depth/Elevation) (m)
1	6.1	Open	5.2 / 235.1	0.1 / 240.2
2	6.1	Open	3.2 / 234.8	0.0 / 238.0
3	6.1	Open	3.3 / 236.0	0.1 / 239.2
4	6.1	5.5	0.9 / 237.6	0.0 / 238.5
5	6.1	Open	0.9 / 237.9	0.5 / 238.3
6	4.5	Open	0.6 / 239.9	1.5 / 239.0
7	6.1	Open	1.7 / 227.1	0.0 / 228.7
8	6.1	Open	1.7 / 227.3	1.3 / 227.7
9	6.1	Open	1.8 / 230.5	0.2 / 232.1
10	6.1	Open	4.1 / 232.2	0.0 / 236.3
11	6.1	Open	4.4 / 234.1	0.3 / 238.2
12	6.1	4.9	0.6 / 234.4	0.5 / 234.5
13	6.1	Open	Dry	0.4 / 238.4
14	6.1	4.8	1.6 / 239.7	0.1 / 241.2

Borehole No.	Depth of Auguring (m)	Depth to Cave (m)	Unstabilized Water Level (Depth/Elevation) (m)	Stabilized Water Level in well on January 31st and February 1st, 2023 (Depth/Elevation) (m)
15	6.1	4.6	4.3 / 233.5	0.3 / 237.5
16	6.1	3.7	0.9 / 239.3	3.2 / 237.0
17	6.1	Open	0.0 / 236.0 Flowing artesian conditions encountered	No well installed due to inferred artesian aquifer.
18	6.1	Open	Dry	1.0 / 229.0
19	6.1	Open	1.5 / 228.5	0.0 / 230.0
20	6.1	5.2	4.4 / 224.1	0.0 / 228.5
21	6.1	5.9	1.0 / 230.0	1.7 / 229.3
22	6.1	5.8	5.2 / 224.6	0.0 / 229.8
23	6.1	Open	4.3 / 224.7	0.6 / 228.4
24	6.1	3.4	1.8 / 229.0	0.2 / 230.6

Groundwater levels will fluctuate seasonally and depending on the amount of surface runoff and precipitation.

3.9 Geotechnical Laboratory Test Results

The geotechnical laboratory testing consisted of natural moisture content determination for all samples, while grain size analysis was conducted on four selected soil samples (Borehole 1, Sample 5; Borehole 6, Sample 5; Borehole 11, Sample 4; and Borehole 17, Sample 2). The test results are listed on the enclosed Borehole Logs at the respective sampling depth.

The results (graphs) of the grain size analyses are appended and a summary of the results are as follows:

Borehole No. Sample No.	Sampling Depth below Grade (m)	Percentage (by mass)				Descriptions (MIT System)
		Gravel	Sand	Silt	Clay	
Borehole 1, Sample 5	3.0 – 3.5	0	2	64	34	CLAYEY SILT, trace sand
Borehole 6, Sample 5	3.0 – 3.5	24	31	33	12	SANDY, GRAVELLY SILT, some clay
Borehole 11, Sample 4	2.3 – 2.7	15	39	31	15	SILTY SAND, some gravel, some clay
Borehole 17, Sample 2	0.6 – 1.2	0	18	74	8	SILT, some sand, trace clay

4.0 GEOTECHNICAL ENGINEERING DESIGN

The following discussion and recommendations are based on the factual data obtained from this investigation and are intended for use by the owner and the design engineer. Contractor's bidding or providing services on this project should review the factual data and determine their own conclusions regarding construction methods and scheduling.

This report is provided on the assumption that the design features relevant to the geotechnical analyses will be in accordance with applicable codes, standards, and guidelines of practice. If there are any changes to the site development features or any additional information relevant to the interpretations made of the subsurface information with respect to the geotechnical analyses or other recommendations, then Green Geotechnical should be retained to review the implications of these changes with respect to the contents of this report.

Based on email and phone communication, it is understood that the site will be developed to include the construction of a residential subdivision and golf villa areas, roads connecting to existing municipal right of ways, full municipal services, and stormwater management facilities. It is assumed that the development is to be fully municipally serviced to an urban standard.

At the time of this investigation, no conceptual grading or servicing plans were available. It is presumed that site grades will generally be at or above their current elevations. Any regrading within the influence zones of buildings or settlement sensitive areas is anticipated to be done with the use of Engineered Fill.

4.1 Foundation Design Parameters

Based on the field investigation at this site, at Boreholes 1 to 24, below the surficial topsoil and earth fill, the subsurface conditions predominantly consist of very loose to compact silty sand to sandy silt underlain by a soft to firm silty clay to clayey silt and/or a compact to dense sandy silt to silty sand glacial till. **Groundwater levels at this site are high, including expected artesian aquifer areas, and will have to be managed during any earthworks, including foundation construction.**

Any foundations placed on native soils are strongly recommended to be constructed during the driest summer months to minimize costly and time consuming constant sub-excavation and dewatering.

The undisturbed native site soils are suitable for the support of conventional spread footings, provided adequate dewatering is in place, as necessary during construction. The surficial topsoil, earth fill zones, weathered/disturbed native soils or high organic soil areas and/or any other deleterious materials are not suitable to support building foundations.

The native soil conditions encountered will allow structure foundations to be designed with varying maximum net geotechnical reactions (SLS) and factored geotechnical resistances (ULS) as outlined in the table below, subject to foundation inspection confirmation by Green Geotechnical. Greater capacity may be available at greater depths if required for specific components and can be assessed by Green Geotechnical on a case-by-case basis. Certain areas of the site indicate loose/soft soils at various depths which will support a lower bearing pressure as tabulated below:

Borehole Number	Approximate Existing Grade (m)	Design SLS/ULS (kPa)	Approximate Founding Level		
			Depth (m)	Elevation (m)	Bearing Stratum
1	240.3	75 / 115 50 / 75	0.9 – 1.2 > 0.9	239.4 – 239.1 < 239.1	Silty Sand to Sandy Silt Silty Sand to Sandy Silt
2	238.0	75 / 115 50 / 75	0.9 – 2.0 > 2.0	237.1 – 236.0 < 236.0	Silty Sand to Sandy Silt Silty Sand to Sandy Silt
3	239.3	100 / 150 150 / 225	0.9 – 4.6 > 4.6	238.4 – 234.7 < 234.7	Glacial Till Glacial Till

Borehole Number	Approximate Existing Grade (m)	Design SLS/ULS (kPa)	Approximate Founding Level		
			Depth (m)	Elevation (m)	Bearing Stratum
4	238.5	100 / 150	2.6 – 3.0	235.9 – 235.5	Glacial Till
		150 / 225	> 3.0	< 235.5	Glacial Till
5	238.8	50 / 75	0.9 – 3.0	237.9 – 235.8	Silt
		150 / 225	> 3.0	< 235.8	Glacial Till
6	240.5	100 / 150	0.9 – 1.5	239.6 – 239.0	Glacial Till
		150 / 225	> 1.5	< 239.0	Glacial Till
7	228.8	75 / 115	0.9 – 1.3	227.9 – 227.5	Silty Sand to Sandy Silt
		50 / 75	1.3 – 4.9	227.5 – 223.9	Silty Sand to Sandy Silt
		150 / 225	> 4.9	< 223.9	Glacial Till
8	229.0	50 / 75	> 0.9	< 228.1	Silty Sand to Sandy Silt
9	232.3	75 / 115	0.9 – 1.5	231.4 – 230.8	Silty Sand to Sandy Silt
		100 / 150	1.5 – 2.0	230.8 – 230.2	Silty Sand to Sandy Silt
		50 / 75	> 2.0	< 230.2	Silty Sand to Sandy Silt
10	236.3	100 / 115	0.9 – 1.3	235.4 – 235.0	Silty Sand to Sandy Silt
		50 / 75	> 1.3	235.5 – 231.8	Silty Sand to Sandy Silt
11	236.5	100 / 115	0.9 – 3.0	235.6 – 233.5	Silty Sand to Sandy Silt
		150 / 225	3.0 – 5.0	233.5 – 231.5	Glacial Till
		75 / 115	> 5.0	< 231.5	Glacial Till
12	235.0	50 / 75	0.9 – 1.5	234.1 – 233.5	Silty Sand to Sandy Silt
		100 / 150	1.5 – 3.5	233.5 – 231.5	Silty Sand to Sandy Silt
		50 / 75	> 3.5	< 231.5	Silty Clay to Clayey Silt

Borehole Number	Approximate Existing Grade (m)	Design SLS/ULS (kPa)	Approximate Founding Level		
			Depth (m)	Elevation (m)	Bearing Stratum
13	238.8	75 / 115 50 / 75	0.9 – 1.3 > 1.3	237.9 – 237.5 < 237.5	Silty Sand to Sandy Silt Silty Sand to Sandy Silt
14	241.3	75 / 115 50 / 75	0.9 – 1.3 > 1.3	240.4 – 240.4 < 240.4	Silty Sand to Sandy Silt Silty Sand to Sandy Silt
15	237.8	100 / 150 50 / 75	0.9 – 1.3 > 1.3	236.9 – 236.5 < 236.5	Silty Sand to Sandy Silt Silty Sand to Sandy Silt
16	240.3	50 / 75 100 / 150 50 / 75	0.9 – 2.3 2.3 – 3.5 > 3.5	239.4 – 238.0 238.0 – 236.8 < 236.8	Silty Sand to Sandy Silt Silty Sand to Sandy Silt Silty Sand to Sandy Silt
17	236.0	50 / 75 100 / 150	0.9 – 4.5 > 4.5	235.1 – 231.5 < 231.5	Silt Silty Sand to Sandy Silt
18	230.0	50 / 75	> 0.9	< 229.1	Silty Sand to Sandy Silt
19	230.0	50 / 75	> 0.9	< 229.1	Silty Sand to Sandy Silt
20	228.5	50 / 75	> 0.9	< 227.6	Silty Sand to Sandy Silt
21	231.0	50 / 75	> 0.9	< 230.3	Silty Sand to Sandy Silt
22	229.8	50 / 75	> 0.9	< 228.9	Silty Sand to Sandy Silt
23	229.0	50 / 75	> 0.9	< 228.1	Silty Sand to Sandy Silt
24	230.8	50 / 75	> 0.9	< 229.9	Silty Sand to Sandy Silt

A minimum soil cover of 1.6m or equivalent insulation is recommended for frost protection to footings in exterior or unheated areas. Construction during cold weather should also ensure temporary frost protection of footing bases.

Native soils tend to weather rapidly and deteriorate on exposure to the atmosphere and surface water. The time between foundation excavation and concrete placement should be minimized as much as possible.

The footing widths to be used in conjunction with the above recommended soil bearing pressures should be at least 0.6m for continuous footings and 1.0m for individual footings placed on native soils. **If individual footings are designed to be larger than 1.0m in width, then the SLS/ULS soil bearing pressures must be reduced to that of the looser/softer layer below, if the footing is within a distance equal to the width of the footing from that looser/softer layer.** Where there is a more compact/stiff layer below, this rule does not apply. Green Geotechnical should be consulted on any design considerations regarding the zone of influence of foundations.

The above recommended bearing capacities are based on estimated maximum total settlement of 25mm and differential settlement of 19mm.

It should also be noted that due to the variable conditions in the upper approximately 1 to 2m of the site, some downward stepping of footings should be anticipated in order to extend to competent soils. Footings stepped from one level to another must be at a slope not exceeding 7 vertical to 10 horizontal, and with a grade change not exceeding 600mm.

Prior to placing foundation concrete, all excavated foundation subgrade soils should be cleaned of all deleterious materials such as topsoil, fill, softened or disturbed materials as well as any standing water. It is recommended that the foundations be inspected by Green Geotechnical in order to confirm the exposed soil conditions and recommended bearing capacities.

Once a detailed site plan is available, it is recommended that Green Geotechnical extend additional boreholes and test pits to determine the subsurface conditions at the various foundation locations within the proposed development. This will allow for greater delineation of poor soil areas, allowing for proactive measures to be taken and the amount of budget uncertainty to be minimized.

4.1.1 Foundations on Engineered Fill

At the time of this investigation, no conceptual grading or servicing plans were available. It is presumed that site grades will generally be raised above their current elevations. Any regrading within the influence zones of buildings or settlement sensitive areas is anticipated to be done with the use of Engineered Fill.

The undisturbed native soils beneath the topsoil, weathered/disturbed zones, and earth fill are considered suitable for the support of Engineered Fill pads for supporting the building foundations. The Engineered Fill pads should extend at least 1m beyond any building footprint at underside of footing elevation and extend out at a 1:1 (horizontal to vertical) slope down to the native soils. Unless the foundations are constructed immediately on the Engineered Fill pad, the Engineered Fill should be built up at least an additional 1m in elevation to serve as a protective cap of the Engineered Fill at underside of footing level from the effects of weathering and freeze-thaw.

All deleterious or otherwise unsuitable materials such as topsoil, fill, softened or disturbed materials, as well as any standing water must be removed prior to the placement of Engineered Fill. These materials do not constitute an adequate subgrade for support of Engineered Fill. After any unsuitable materials are removed, the exposed competent native soil subgrade must be inspected and approved by Green Geotechnical prior to placement of Engineered Fill. Engineered Fill placed to raise grades must consist of clean earth, free from any organic/topsoil or deleterious matter and must be placed in maximum 150mm thick lifts and compacted to at least 98 percent Standard Proctor Maximum Dry Density (SPMDD). **Given the high groundwater levels at this site and susceptibility of the upper site soils to disturbance from vibrations, it is recommended that in at least the first one to two lifts of the Engineered Fill, that coarse granular-type soils such as Granular B 'Type II' or 50mm Crusher Run Limestone be used.** Any Engineered Fill construction must be completed under full time supervision by Green Geotechnical to monitor extent, lift thickness, compaction, material quality and the like.

Any excavation and compaction completed for the purpose of Engineered Fill is strongly recommended to be constructed during the driest summer months to minimize costly and time consuming constant sub-excavation and dewatering.

For Engineered Fill with a thickness of at least the width of the individual spread footings (minimum of 1m), constructed on a native subgrade approved by Green Geotechnical, the recommended maximum net geotechnical reaction may be equal to 1.5 times the value of the soil bearing pressure at the corresponding subgrade elevation from the table in Section 4.1 up to a maximum of 150kPa at SLS and 225kPa at ULS. Where structures are placed on at least 0.5m of Engineered Fill constructed on a subgrade approved by Green Geotechnical, the recommended maximum net geotechnical reaction may be equal to the value of the soil bearing pressure at the corresponding native subgrade elevation from the table in Section 4.1.

Once the site grading plan is completed, it should be made available to Green Geotechnical. There may be settlement considerations which require monitoring and/or engineering design considerations from surcharge loading applied to the soft to firm silty clay to clayey silt native soils at the site depending on the amount of Engineered Fill placement.

Prior to placing foundation concrete, all Engineered Fill should be cleaned of all deleterious materials such as softened or disturbed materials as well as any standing water. It is required that the foundations placed on Engineered Fill be inspected by Green Geotechnical in order to confirm the exposed soil conditions and recommended bearing capacities.

The minimum footing widths to be used in conjunction with the above recommended soil bearing pressures should be 0.6m for continuous footings and 1.0m for individual footings placed on Engineered Fill. The above recommended bearing capacities are based on estimated maximum total settlement of 25mm and differential settlement of 19mm.

It should be noted that for structures placed on Engineered Fill, nominal reinforcing steel (rebar) at a minimum be placed in the foundations comprising two (2) continuous 15M bars in the strip footings, and two (2) continuous 15M bars at the top and bottom of the foundation walls be provided. Any column footing will require 15M bars spaced at 0.3m on centre, in each direction of the column. The reinforcing steel requirements of the structure are to be reviewed by a structural engineer.

A copy of "Engineered Fill Earthworks Specifications" is enclosed in Appendix E of this report for reference purposes. These specifications should be included in the earthworks contract.

4.2 Slab-on-Grade or Basement Floor Design Parameters

Groundwater levels recorded at this site were typically recorded at less than 1m below existing grades in January and February of 2024. **All finished floor surfaces are recommended to be at least 0.5m above the prevailing seasonally high groundwater level.**

All non-structural earth fill and any other deleterious or unsuitable materials must be removed prior to placement of new fill for grade raise. These materials do not constitute an adequate subgrade for support of Engineered Fill. After any unsuitable materials are removed, the exposed soil subgrade must be inspected and approved by Green Geotechnical at the time of construction. Any structural fill placed to raise grades, must be placed in maximum 150mm thick lifts, and compacted to at least 98 percent Standard Proctor Maximum Dry Density (SPMDD). Conventional lightly loaded concrete slab-on-grade floors can be placed on the Engineered Fill. The vertical moduli of subgrade reaction for compacted fill soils at the site is 18,000 kPa/m.

It is necessary that building floor slabs be provided with a capillary moisture barrier and drainage layer. This is accomplished by placing the slab on a minimum 200mm layer of 19mm clear stone (OPSS.MUNI 1004) compacted by vibration to a dense state. The upper 50mm of the 200mm drainage layer may be replaced with 50mm of Granular A (OPSS.MUNI 1010) to provide a trafficable surface. The 19mm clear stone can be replaced in its entirety with Granular 'A' so long as a minimum 10mil poly-vapour barrier is used below the slab base. However, these do not replace the floor manufacturers' specific requirement(s) for a moisture and vapour barrier. A suitable non-woven geotextile filter (Terrafix 360R or equivalent approved by Green Geotechnical) must be installed (with a minimum 900mm overlap) below the capillary moisture break to properly filter the slab base from the subgrade. Otherwise, this could result in the loss of ground supporting the slab and clogging of the slab base.

All basement floors should be constructed at least 0.5m above the seasonally high-water level. Perimeter weeping drains (filtered) are recommended to be installed leading to positive outlets such as a sump pump in the basement. Normal basement damp proofing with Miradrain is recommended. Basement walls must be backfilled either with imported Granular “B” type backfill or drainage mediums as per the Ontario Building Code. The insitu soils are not considered to be suitable for reuse as backfill against basement walls unless damp proofing measures as specified in the Ontario Building Code are taken on foundation walls. A typical Basement Drainage Detail is provided in the attached Appendix C.

Where a basement level is within 1.0m of the water table, under-floor drains should be considered. Under floor drainage tiles should consist of placing rows of 100mm diameter perforated drainage pipe leading to a positive sump or outlet. It is recommended that the under-floor drain invert be placed at least 300mm below the underside of the floor slab. Drainage tiles should be placed in parallel rows 3m on centre in each direction. The drainage tile must be surrounded with 100mm of rounded clear stone, completely wrapped in filter fabric. It is essential that the clear stone is separated from the subgrade by using an approved geotextile fabric material (effective opening size of less than 130 microns). Typical Basement Drainage Details are provided in the attached Appendix C.

The basement drainage system is a critical structural element since it keeps water pressure from acting on the basement floor slab or on the foundation walls, in addition to keeping moisture out of the basement. The size and arrangement of the pump system and battery backup system should be designed to be adequate to accommodate the anticipated groundwater and storm event flows. The subdrain system should be outlet to a suitable discharge point under gravity flow or connected to a sump located in the lowest level of the basement. The water from the sump must be pumped out to a suitable discharge point/positive outlet. The installation of the drains as well as the outlet must conform to the applicable plumbing code requirements.

Regardless of the approach to slab-on-grade floor construction, the floor slabs that are to have bonded floor finishes (such as tiles with adhesives) should be provided with a capillary moisture and vapour barrier and drainage layer. The floor manufacturers have specific requirements for moisture and vapour barrier; therefore, the floor designer/architect must ensure that a provision of appropriate moisture and vapour barrier conforming to specific floor finish product requirements is incorporated in the project specifications. Adequate testing must be carried out to ensure acceptable levels of moisture and relative humidity in the concrete slab prior to the installation of floor finish(es).

The under-slab vapour retarder specifications, selection and installation shall conform to ASTM E1745 and ASTM E1643. The moisture vapour measurement tests shall conform to RH: ASTM F2170, RH: ASTM F2420 and Calcium Chloride: ASTM F1869. The Surface Applied Moisture Vapour Barrier system shall meet the guidelines established in ASTM F3010-13.

4.3 Earthquake Design Parameters

The Ontario Building Code stipulates the methodology for earthquake design analysis. The determination of the type of analysis is predicated on the importance of the structure, the spectral response acceleration, and the site classification.

Under Ontario Regulation 88/19, the ministry amended Ontario's Building Code (O. Reg 332/12) to further harmonize Ontario's Building Code with the 2015 National Codes. These changes will help reduce red tape for businesses and remove barriers to interprovincial trade throughout the country. The amendments are based on code change proposals the ministry consulted in 2016 and 2017. The majority of the amendments came into effect on January 1, 2020, which includes structural sufficiency of buildings to withstand external forces and improve resilience.

Seismic hazard is defined in the Ontario Building Code (OBC) by uniform hazard spectra (UHS) at spectral coordinates of 0.2s, 0.5s, 1.0s and 2.0s and a probability of exceedance of 2% in 50 years. The OBC method uses a site classification system defined by the average soil/bedrock properties (e.g., shear wave velocity (vs), Standard Penetration Test (SPT) resistance, and undrained shear strength (s_u) in the top 30 meters of the site stratigraphy below the foundation level, as set out in the Ontario Building Code. There are 6 site classes from A to F, decreasing in ground stiffness from A, hard rock, to E, soft soil; with site class F used to denote problematic soils (e.g., sites underlain by thick peat deposits and/or liquefiable soils). The site class is then used to obtain peak ground acceleration (PGA), peak ground velocity (PGV) site coefficients Fa and Fv, respectively, used to modify the UHS to account for the effects of site-specific soil conditions.

Based on the above, it is recommended that the site designation for seismic analysis be **Site Class E**, as per the Ontario Building Code. It should be noted that the above site seismic designation is estimated on the basis of rational analysis of the undrained shear strength information obtained from the boreholes advanced at the site only up to about 6.6m depth below grade. **Consideration may be given to conducting a site-specific Multichannel Analysis of Surface Waves (MASW) at this site to confirm the average shear wave velocity in the top 30m of the site stratigraphy. MASW testing often determines higher seismic site class ratings than those able to be determined from SPT testing, resulting in potential project cost savings.**

The values of the site coefficient for design spectral acceleration at period T, F(T), and of similar coefficients F(PGA) and F(PGV) shall conform to Tables 4.1.8.4.B. to 4.1.8.4.I. using linear interpolation for intermediate values of PGA.

4.4 Lateral Earth Pressure Design Parameters

The appropriate values for use in the design of structures subject to unbalanced earth pressures at this site are tabulated as follows:

Stratum/Parameter	γ	ϕ	K_a	K_o	K_p
Compact Granular Fill Granular ‘B’ (OPSS.MUNI 1010)	21	32	0.31	0.47	3.25
Earth Fill	18	28	0.36	0.53	2.76
Silty Sand to Sandy Silt	18	28	0.36	0.53	2.76
Sandy Silt to Silty Sand Glacial Till	19	30	0.33	0.50	3.00

where: γ = bulk unit weight of soil (kN/m^3)

φ = internal angle of friction (degrees)

K_a = Rankine active earth pressure coefficient (dimensionless)

K_o = Rankine at-rest earth pressure coefficient (dimensionless)

K_p = Rankine passive earth pressure coefficient (dimensionless)

The above earth pressure parameters pertain to a horizontal grade condition behind a retaining structure. Values of earth pressure parameters for an inclined retained grade condition will vary.

Walls subject to unbalanced earth pressures must be designed to resist a pressure that can be calculated based on the following equation:

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

where, **P** = the horizontal pressure at depth, **h** (m)

K = the earth pressure coefficient

h_w = the depth below the groundwater level (m)

γ = the bulk unit weight of soil, (kN/m^3)

γ' = the submerged unit weight of the exterior soil, (γ - 9.8 kN/m^3)

q = the surcharge loading (kPa)

The above equation pertains to a horizontal grade condition behind a retaining structure. Values of earth pressure against retaining structures for an inclined retained grade condition will vary.

Where the wall backfill can be drained effectively to eliminate hydrostatic pressures on the wall that would otherwise act in conjunction with the earth pressure, this equation can be simplified to:

$$P = K[\gamma h + q]$$

Resistance to sliding of retaining structures is developed by friction between the base of the footing and the soil. This friction **(R)** depends on the normal load on the soil contact **(N)** and the frictional resistance of the soil **(tan ϕ)** expressed as: **R = N tan ϕ**. This is an unfactored resistance. The factored resistance at ULS is **R_f = 0.8 N tan ϕ**.

4.5 Pavement Design

The pavement subgrade is expected to comprise of native undisturbed silty sand to sandy silt, glacial till, or clean earth fill compacted to a minimum of 98% of SPMDD. The exposed subgrade should be shaped and graded with a typical 3% cross-fall, directed towards continuous subdrains with inverts at least 0.3m below subgrade level.

All topsoil, organic-rich, and otherwise deleterious material should be sub-excavated. The pavement subgrade should be assessed (proof rolled with a heavy rubber-tired vehicle, if deemed feasible by Green Geotechnical) and approved (no rutting or major deflections) by Green Geotechnical to ensure stability prior to the placement of the pavement granular courses. All unstable areas will require sub-excavation and re-compaction or increased thickness of granular subbase. It should be noted that the majority of the upper site soils are considered moderately to highly frost susceptible. Therefore, adequate subgrade drainage is recommended.

Based on the soil conditions encountered during our investigation, we recommend the following pavement structure for light duty (vehicle parking) and heavy-duty (fire route) traffic areas:

Pavement Structural Layers	Min. Thickness (mm)		Compaction Requirements
	Light Duty (Vehicle Parking) Traffic	Heavy Duty (Fire Route) Traffic	
Hot Mix Asphalt Surface Course, OPSS 1150 HL 3	40	50	as per OPSS 310
Hot Mix Asphalt Binder Course, OPSS 1150 HL 8	60	80	
Base Course, OPSS.MUNI 1010, Granular A or 19mm CRLS	150	150	100 percent of Standard Proctor Maximum Dry Density (SPMDD) (ASTM D698)
Subbase Course, OPSS.MUNI 1010, Granular B “Type II” or 50mm CRLS	300	450	98 percent of Standard Proctor Maximum Dry Density (SPMDD) (ASTM D698)

The above design assumes that sub-drainage of the granular fill will be provided. This should consist of continuous subdrains leading to catch basins.

It should be reiterated that the subgrade soils are moderately to highly frost susceptible. The subdrains are considered a valuable protection against frost heave damage and subgrade softening particularly impacting the long-term performance of the pavement.

An adequate granular working surface would likely be required in order to minimize subgrade disturbance and protect its integrity in wet periods. The fill material may consist of granular type material with a moisture content within ±2 percent of optimum moisture content. Fill materials should be placed and compacted in accordance with OPSS.MUNI 501 and the subgrade should be compacted to 98 percent of SPMDD.

The granular subbase and base fill materials should be compacted to a minimum of 98% and 100% of Standard Proctor Maximum Dry Density (SPMDD), respectively, placed in lifts of 150mm or less. Asphaltic concrete materials should be rolled and compacted as per OPSS 310 based on density testing. **Due to the high groundwater levels and susceptibility of the site soils to disturbance, care should be taken that construction occurs in the driest summer periods. If this is not possible, the granular subbase may require additional thickness.**

Control of surface water is a principal factor in achieving a good pavement life. The need for adequate subgrade drainage cannot be over-emphasized. The subgrade must be free of depressions and sloped (preferably at a minimum grade of 3 percent) to provide effective drainage toward subgrade drains. Grading adjacent to pavement areas should be designed to ensure that water is not allowed to pond adjacent to the outside edges of the pavement. Continuous pavement subdrains should be provided along both sides of the driveway and drained into respective catch basins to facilitate drainage of the subgrade and the granular materials. The subdrain inverts should be maintained at least 0.3m below subgrade level. Continuous subdrains should also be provided for pavement areas along any curb-lines/sidewalks. Two lengths of subdrain stubs (each minimum 3m long) should be installed at each catch basin (refer to Appendix D - Pavement Drainage Details).

The granular base beneath the sidewalks and concrete walkways should be extended to provide continuous drainage paths outletting to the pavement curb-line or ditch subdrains to facilitate subgrade drainage and help minimize concrete slab heaving. The concrete surface sidewalk must be supported on a minimum of 1.6m thick non-frost susceptible material provided with a provision of a subdrain with a positive outlet to help minimize slab heave due to freezing weather conditions, or consideration should be given to install a frost slab in these areas.

The above pavement design thicknesses are considered adequate for design traffic. However, if the pavement construction occurs in wet or inclement weather, it may be necessary to provide additional subgrade support for heavy construction traffic by increasing the thickness of the granular sub-base, base, or both. Further, traffic areas for construction equipment may experience unstable subgrade conditions. These areas may be stabilized utilizing additional thickness of granular materials.

The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures must be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as possible when fill is placed, and the natural subgrade is not disturbed or weakened after it is exposed.

It should be noted that in addition to adherence of the above pavement design recommendations, a close control on the pavement construction process will also be required in order to obtain the desired pavement life. Therefore, it is required that regular inspection and testing by Green Geotechnical be conducted during the pavement construction to confirm material quality, stability, thickness, and to ensure adequate compaction.

4.6 Pipe Bedding

Trench bases are expected to consist primarily of native, undisturbed silty sand to sandy silt or glacial till soils, or clean earth fill compacted to a minimum of 98% of SPMDD. The native, undisturbed site soils as well as Engineered Fill will generally be suitable for support of underground services with conventional Class ‘B’ granular bedding. Additional granular bedding may be necessary for stabilization of wet trench bases or particularly soft areas. The granular bedding should consist of a well graded material such as Granular ‘A.’ Excavation bases should be free of standing water prior to and during bedding and service placement. A servicing plan is not yet available, however based on the site’s groundwater levels it is expected that dewatering will be required during servicing.

Any soft, loose, or disturbed soils encountered as a result of groundwater seepage or construction traffic should be sub excavated and replaced with suitably compacted granular fill. Additionally, any loose or deleterious fill or organics encountered below proposed pipe inverts should be sub excavated and replaced with suitable compacted bedding material. Granular ‘A’ bedding material should be placed in thin lifts and compacted to a minimum of 95% of SPMDD. If HL8 coarse aggregate or 19mm clear stone is used this will require light tamping only. However, it should be cautioned that this HL8 aggregate or clear stone should not be used directly against native deposits unless a geotextile fabric is also considered as a complete wrap to prevent migration of fines into the bedding from the surrounding fine soil. Without proper filtering, this loss of ground could result in loss of support to the pipes and in potential future.

In areas where the soils become wet, unstable and dilatant (easily disturbed) such as saturated silts, clays and water bearing granular soils, careful construction techniques and dewatering should be followed. If the pipes are laid on disturbed, dilatant soil, significant post-construction settlements could occur after the trenches are backfilled. In such cases, disturbed soil must be removed. The bottom of wet trenches will have to be stabilized by dewatering. The placement of a thin layer of lean mix concrete or a 'mud slab' may be considered to prevent heaving of sensitive or easily disturbed sub-soils and prevent disturbance of sensitive sub-soils due to construction activity. If a 'mud slab' option is not used, then increasing the Class 'B' type bedding thickness in order to stabilize the subgrade soil is recommended.

4.7 Stormwater Management Facilities

Proposed Stormwater Management Pond (SWMP) structures (such as concrete headwalls) placed on undisturbed native soils are recommended to be designed for maximum net allowable bearing pressures as per Section 4.1.

Proposed side slopes associated with the SWMP should be finalized at slopes which are at least 3:1 (horizontal to vertical) or flatter, and 5:1 or flatter within 3m of the permanent pool, and are to be in accordance with the Ministry of Environment, Conservation and Parks Stormwater Management Planning and Design Manual. All bare surfaces should be covered with topsoil and seeded upon completion in order to minimize long term surface erosion.

Depending on the groundwater levels at the time of SWMP construction, some difficulty may be encountered with the movement of construction equipment on the site, especially when excavation approaches the base elevations. For this reason, construction is recommended to be carried out during dry weather (summer) months.

The SWMP's cell and forebay base and walls should be comprised of soils containing at least 10% clay sizes, at least 35% silt sizes, and at most 40% sand sizes (by weight) and must be free of organics, topsoil inclusions, cobbles, and boulders. The native silty clay to clayey silt deposits at the site meet this specification based on the laboratory testing done on the sample obtained at Borehole 1, Sample 5, the results of which are available in Appendix B – Geotechnical Laboratory Analysis. Additional grain size testing prior to or during construction is required on the site's silty clay to clayey silt soils to confirm these preliminary findings.

The site's more readily available upper silty sand to sandy silt and glacial till soils appear to marginally fail these requirements based on the laboratory testing done on the samples obtained at Borehole 6, Sample 5, and Borehole 11, Sample 14, the results of which are available in Appendix B – Geotechnical Laboratory Analysis. Additional testing prior to or during construction can confirm or overrule these results.

To ensure the SWMP's cell and forebay base and walls are not in a disturbed state following construction traffic, they should be surface compacted to ensure they are compacted to at least 95% of SPMDD. This is to be confirmed by field density testing by Green Geotechnical.

Given the high groundwater levels at the site, it is anticipated that groundwater seepage and sloughing of soils will likely occur during sub-excavation works. Contractors should be prepared to meet the possibility of groundwater constraints and disturbed subgrade soils. Depending on design elevations, dewatering will likely be required during construction.

The upper native soils identified at the site are suitable for re-use as general fill for berm construction. Native soils may have moisture constraints with regard to re-use and moisture conditioning may be required to achieve the recommended compactive effort. General berm fills should be placed in lifts not exceeding 150mm in thickness, compacted to 98% of SPMDD at ±2% optimum moisture content.

Where groundwater enters the proposed pond through walls, additional slope protection/support may be required in the form of rip-rap placed on filter fabric. The pond designers should assess uplift/unbalanced hydrostatic forces created on any proposed liner under various groundwater and pond level conditions.

Granular materials and crusher run limestone materials scheduled for use on maintenance access roads are recommended to be compacted to 100% of SPMDD.

Proposed clay trench plug/anti-seepage collars should be at least 1.0m thick, measured along the pipe, and should completely replace the granular bedding and relatively permeable (sand, granular) backfill. The clay plug must be compacted to a minimum of 95% of SPMDD. The clay plug material should have a coefficient of permeability less than 10^{-6}cm/s and must include a minimum of 15 percent clay (finer than 0.002 mm) and 30 percent silt sized (finer than 0.06 mm) particles. The backfill material must not include particles greater than 100mm in diameter, greater than 15 percent of the material larger than 4.8mm size (No. 4 sieve), and greater than 5 percent organic content by weight, as well as visible roots or topsoil.

Alternatively, seepage cut off collars can be installed around the pipe barrel to achieve the same effect. Collars should not be placed closer than 1.0m to a pipe joint and precautions should be taken to ensure that a minimum of 95% of SPMDD is achieved around the collars. Watertight connections are required between the collar and pipe wall.

Some maintenance of slopes may be required in the first years until a strong vegetative growth of ground cover is established.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Excavation and Backfill

Excavations must be conducted in accordance with the Occupational Health and Safety Act, Ontario Regulation 213/91 (as amended), Construction Projects, Part III – Excavations, Sections 222 through 242. These regulations designate four (4) broad classifications of soils to stipulate appropriate measures for excavation safety. For practical purposes, the site soils are classified as Type 3 soil above and Type 4 soil below the groundwater table.

Where workers must enter excavations advanced deeper than 1.2m, the trench walls should be suitably sloped and/or braced in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. The regulation stipulates safe slopes of excavation by soil type as follows:

Soil Type	Base of Slope	Steepest Slope Inclination
1	within 1.2 metres of bottom of trench	1 horizontal to 1 vertical
2	within 1.2 metres of bottom of trench	1 horizontal to 1 vertical
3	from bottom of trench	1 horizontal to 1 vertical
4	from bottom of trench	3 horizontal to 1 vertical

Minimum support system requirements for steeper excavations are stipulated in the Occupational Health and Safety Act and Regulations for Construction Projects, and include provisions for timbering, shoring and moveable trench boxes.

The subsurface soils can be removed by conventional excavation equipment. Larger size particles (cobbles and boulders) that are not specifically identified in the boreholes may be present in the native soils. The size and distribution of cobbles/boulders/obstructions cannot be predicted with boreholes, as the sampler size is insufficient to secure representative particles of this size. The risk and responsibility for the removal and disposal of cobbles/boulders/obstructions and appropriate use of equipment must be addressed in the contract documents for foundations, excavations, and shoring contractors.

Structures such as existing buried foundations, previously backfilled excavations, existing old wells/cisterns, drainage tiles, boulders, rubble, etc. may also be present at the site. The presence of these structures if encountered, will likely affect construction methods and cost if they exist within proposed structure areas.

The surficial topsoil, earth fill, and native soil layers with amounts of organics should not be reused as backfill in settlement sensitive areas (beneath floor slabs, trench backfill and pavement areas). However, these materials may be stockpiled and reused for landscaping purposes.

Unsaturated native cohesionless soils which are free of organics, boulders, and deleterious inclusions, encountered above the groundwater table, are considered to be suitable for reuse as backfill, so long as moisture content levels are within 2 percent of the optimum moisture content level. Otherwise, consideration should be given to importing granular type fill to achieve adequate compaction in Engineered Fill and trench backfill activities, where use of the site’s coarser grained soils is not feasible. The site’s wet cohesive silty clay to clayey silt should not be used as trench/excavation backfill material, but can be used in landscaping areas.

It should be noted that native soils excavated from below the prevailing groundwater level (if encountered) will likely be too wet to compact to required compaction specification.

The moisture content of the backfill soils should be within 2 percent of their optimum moisture content. Any soil material with in-situ moisture content higher than 2 percent of its optimum moisture content could be put aside to dry or be tilled to reduce the moisture content so that it can be effectively compacted. Alternatively, materials of higher moisture content could be wasted and replaced with imported material which can be readily compacted.

In settlement sensitive areas, the backfill should consist of clean earth and should be placed in lifts of 150mm thicknesses or less, and heavily compacted to a minimum of 95 percent SPMDD at a water content close to optimum. The non-cohesive soils encountered on the site and imported granular type fill soils will be best compacted with a heavy smooth drum type roller.

It should be noted that the site soils vary greatly in their drainage properties and will be difficult to manage and compact should they become wetter as a result of inclement weather or seepage from the high groundwater table without dewatering efforts. **Hence, it can be expected that earthworks will be difficult during the wet periods (i.e., spring and fall) of the year and may result in increased earthwork costs.**

5.2 Groundwater Control

Groundwater levels recorded at this site were typically recorded at less than 1m below existing grades in January and February of 2024. Long term monitoring was beyond the scope of this investigation and the seasonal water table may fluctuate. Seepage near or above the groundwater levels should be managed adequately using filtered sump pumps placed at the base of the excavations for most of the site. More significant dewatering efforts will be required below the groundwater levels, and particularly in sandy/gravelly soil pockets.

Soils with varying permeabilities were encountered in the boreholes. These soils may yield varying amounts of groundwater seepage into the excavation depending upon the type of soil and the depth of excavation. The amount of water seepage is expected to increase with the depth of excavation. Groundwater control will be required for excavations extending within 1.0m of and into/or below the prevailing groundwater level, prior to and during the subsurface construction. Without positive groundwater control, the subgrade in wet permeable soils will become weak/disturbed and lose its integrity to support. Consideration should be given to install a skim coat of lean concrete (mud-slab) to preserve the subgrade integrity in these areas, and to provide a working platform, as deemed appropriate by the project geotechnical engineer during construction.

All finished floor surfaces are recommended to be at least 0.5m above the prevailing seasonally high groundwater level.

It should be noted that excavations carried through and below the water bearing soils will likely experience loosening and sloughing of the base and sides unless the groundwater level is lowered first to at least 1.0m below the bottom of the excavation.

5.3 Quality Control

The foundation installations must be reviewed in the field by Green Geotechnical, the geotechnical engineer, as they are constructed. The on-site review of the condition of the foundation subgrade as the foundations are constructed is an integral part of the geotechnical design function. If Green Geotechnical is not retained to conduct foundation evaluations during construction, then Green Geotechnical accepts no responsibility for the performance or non-performance of the foundations, even if they are ostensibly constructed in accordance with the conceptual design advice contained in this report.

The long-term performance of the pavement is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as practically possible. The design advice in this report is based on an assessment of the subgrade support capabilities as indicated by the boreholes. These conditions may vary across the site depending on the final design grades and therefore, the preparation of the subgrade and the compaction of all fills should be monitored by Green Geotechnical at the time of construction to confirm material quality, thickness, and to ensure adequate compaction.

The requirements for fill placement on this project have been stipulated relative to Standard Proctor Maximum Dry Density (SPMDD). In situ determinations of density during fill placement on site are required to demonstrate that the specified placement density is achieved. Green Geotechnical can provide sampling and testing services for the project as necessary, with our qualified technical staff.

Concrete will be specified in accordance with the requirements of CAN3 - CSA A23.1. Green Geotechnical maintains a concrete laboratory and can provide concrete sampling and testing services for the project, as necessary.

6.0 LIMITATIONS AND REPORT USE

6.1 Procedures

This subsurface investigation has been conducted using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Green Geotechnical and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained by Green Geotechnical.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Green Geotechnical has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Green Geotechnical has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment, and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities so that they may draw their own conclusions as to how the subsurface conditions may affect them.

6.2 Changes in Site and Scope

It must also be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

The discussion and recommendations are based on the factual data obtained from this investigation made at the site by Green Geotechnical and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructability issues and quality control may not be relevant or complete for the revised project. Green Geotechnical should be retained to review the implications of such changes with respect to the contents of this report.

This report was prepared for the express use of LIV Communities and their retained design consultants and is not for use by others. This report is copyright of Green Geotechnical Inc., and no part of this report may be reproduced by any means, in any form, without the prior written permission of Green Geotechnical and LIV Communities, who are the authorized users.

It is recognized that the regulatory agencies in their capacities as the planning and building authorities under Provincial statues, will make use of and rely upon this report, cognizant of the limitations thereof, both expressed and implied.

We trust this report meets your requirements. Should you have any questions regarding the information presented, please do not hesitate to contact our office.

Sincerely,

Green Geotechnical Ltd.

Luke Kim, E.I.T.
Project Coordinator

T A Kuchar

Steven Green

LICENSED PROFESSIONAL ENGINEER
S. C. GREEN
100175284
Sept. 19, 2024
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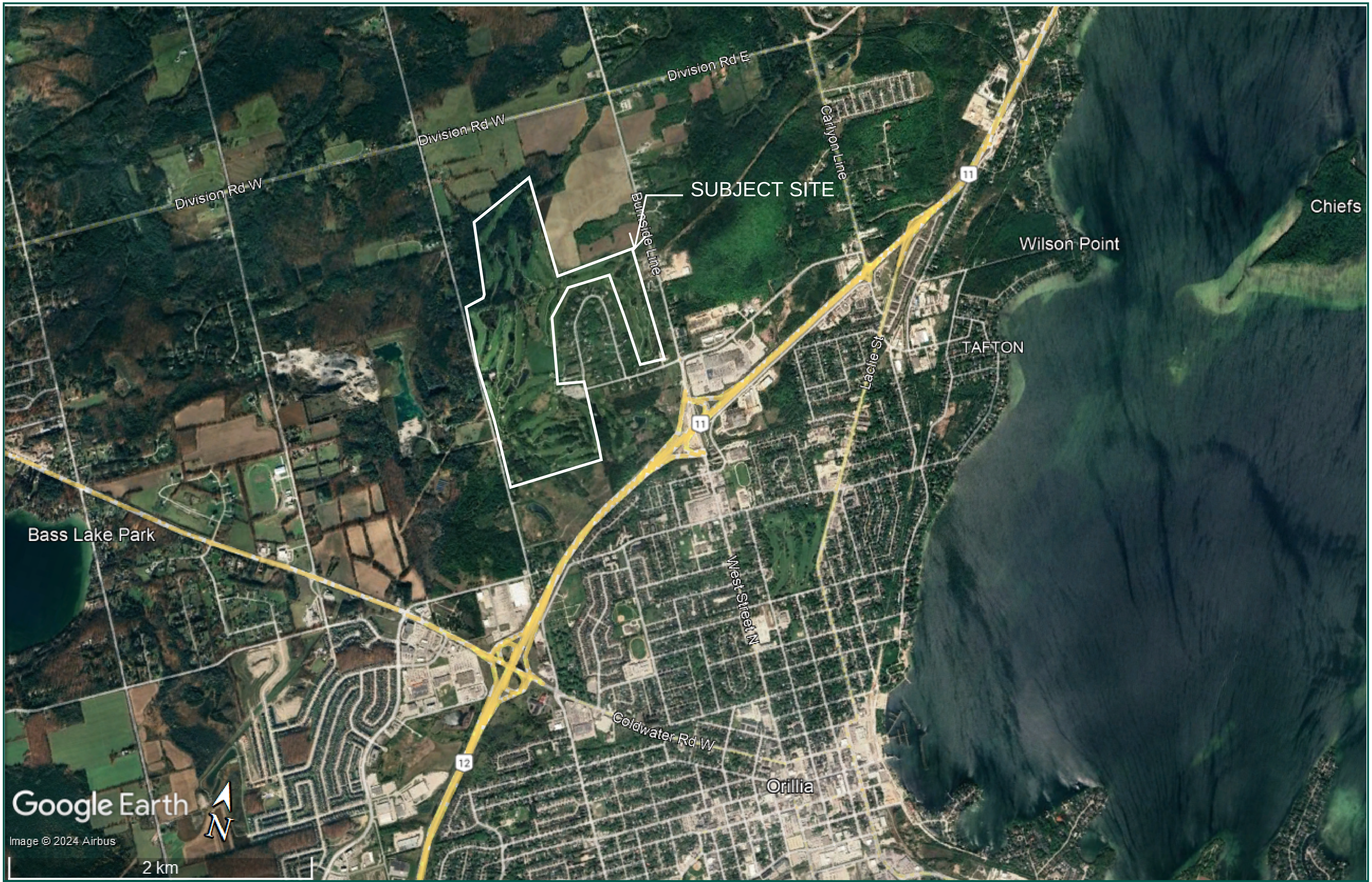
Tristan Kuchar, B.A.Sc., E.I.T.
Project Manager

Steven Green, P.Eng.
President

Enclosures: Figures and Appendices

ENCLOSURES

FIGURES



Title:
Figure 1: SITE LOCATION PLAN

Project:
HAWKRIDGE HEIGHTS RESIDENTIAL DEVELOPMENT, SEVERN, ON

Client:
LIV COMMUNITIES

Reference:
Map Data © 2023 Google Maps

Drawn By:
NC

Reviewed By:
TK

Project Number:
23-117-02

Date:
MAR. 2024

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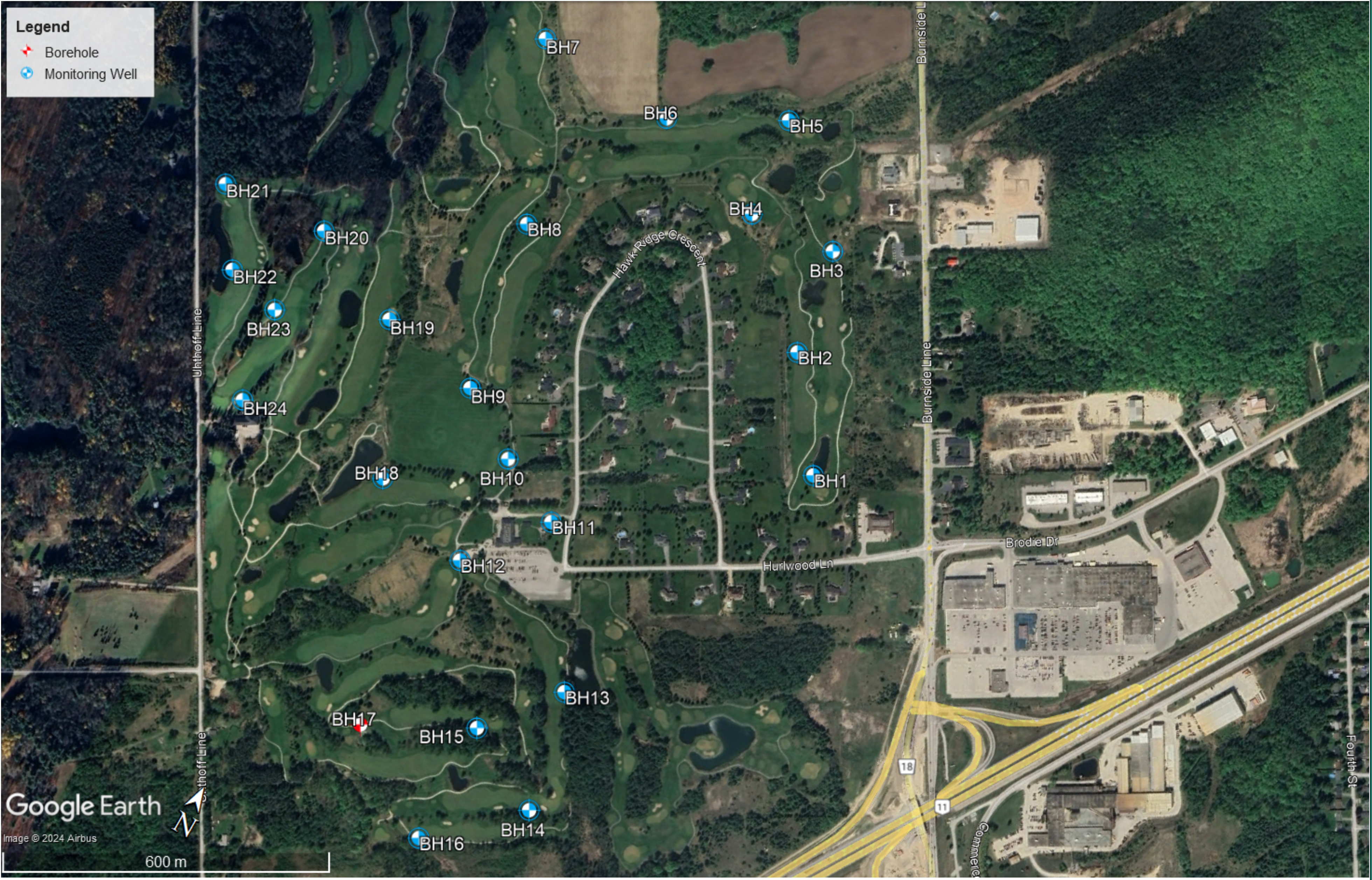

Title:

FIGURE 2: EXISTING BOREHOLE LAYOUT PLAN

Project:

HAWKRIDGE HEIGHTS RESIDENTIAL DEVELOPMENT, SEVERN, ON

Client:

LIV COMMUNITIES

Drawn By:

NC

Project Number:

23-117-02

Reference:

Map Data © 2023 Google Maps

Reviewed By:

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MAR. 2024

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APPENDICIES

APPENDIX A

SYMBOLS and ABBREVIATIONS USED ON BOREHOLE LOGS

PROPORTIONAL TERMS

Term	Proportion
trace	0 to 10%
some	10 to 20%
-y or -ey	20 to 35%
and	>35%

MOISTURE DESCRIPTION

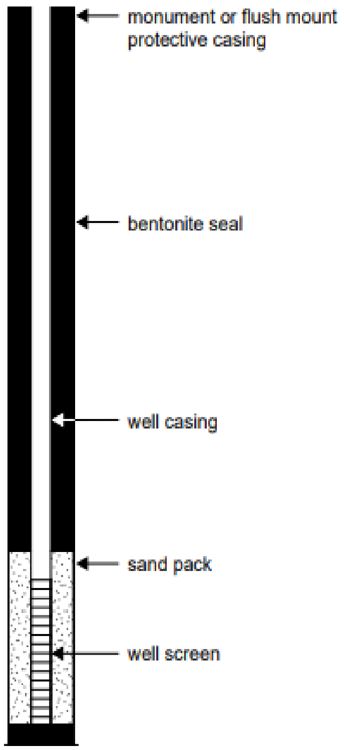
Term	Description
dry	No observable pore moisture
moist	Inferred pore moisture, no observable free water
wet	Weakened by moisture, free water on hands when handling

CONSISTENCY of COARSE-GRAINED SOILS

Consistency	Blow Count N
very loose	< 4
loose	4 to 10
compact	10 to 30
dense	30 to 50
very dense	> 50

Notes: SPT/DCPT 'N' values are 'raw' field blow counts, measured for 300 mm (12 inch) of penetration.

WELL LEGEND



CONSISTENCY of FINE-GRAINED SOILS

Consistency	Blow Count N	Undrained Shear Strength Su (kPa)	
very soft	< 2	< 12	Easily exudes between fingers when squeezed
soft	2 to 4	12 to 25	Easily intended by fingers
firm	4 to 8	25 to 50	Can be intended by strong finger or thumb pressure
stiff	8 to 16	50 to 100	Cannot be intended by thumb pressure
very stiff	16 to 30	100 to 200	Can be intended by thumb nail
hard	> 30	> 200	Difficult to intend by thumb nail

ASTM STANDARDS
ASTM D1568 Standard Penetration Test (SPT) - Driving a 51 mm O.D. split-barrel sampler ("split spoon") into soil with a 63.5 kg weight free falling 760mm. The blows required to drive the split spoon 300mm ("bpf") after an initial penetration of 150 mm is referred to as the N-Value.
ASTM D1568 Cone Penetration Test (CPT) - Pushing an internal still rod with a outer hollow rod ("sleeve") tipped with a cone with an apex angle of 60° and a cross-sectional area of 1000 mm^2 Into soil. The resistance is measured in the sleeve and at the tip to determine the skin friction and the tip resistance.
ASTM D2573 Field Vane Test (FVT) - Pushing a four blade vane into soil and rotating it from the surface to determine the torque required to shear a cylindrical surface with the vane. The torque is converted to the shear strength of the soil using a limit equilibrium analysis.
ASTM D1587 Shelby Tubes (ST) - Pushing a thin-walled metal tube into the in-situ soil at the bottom of a borehole, removing the tube and sealing the ends to prevent soil movement or changes in moisture content for the purposes of extracting a relatively undisturbed sample.

SYMBOL	Description
AS	Auger Sample
CC	Continuous Core Sample
DC	Drill Cuttings
GS	Grab Sample
SS	SPT Spoon Sample
TS	Thin-walled / Shelby Sample
WS	Water Sample

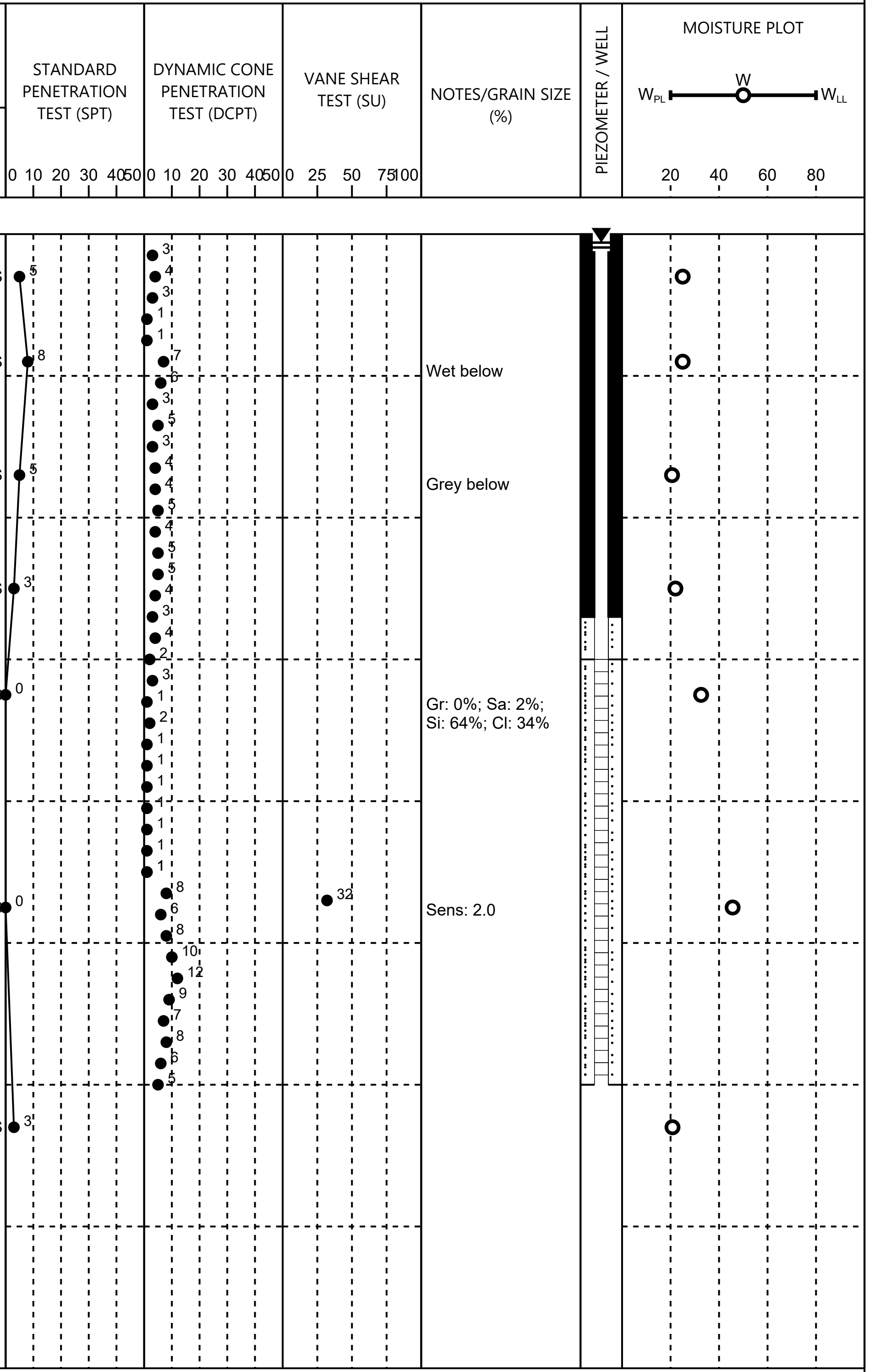
SYMBOL	Description
▼	Measured in a piezometer or well
▽	Inferred water level based on observations during investigation

BOREHOLE LOG: BH 1

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623594
Northing: 4943167
Elevation:240.3 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-08

DEPTH	SOIL STRATIGRAPHY	SAMPLES NO.	SAMPLES SYMBOLS	SPT	NOTES/GRAIN SIZE (%)
	GroundSurface EL 240.3 m				
0 – 0.4 m	**TOPSOIL** 0.4 m EL 239.9 m	1	SS	5	
0.4 – 0.6 m	**FILL** silt, some to sandy, trace organic inclusions, trace clay, loose, moist to wet, brownish grey 0.6 m EL 239.7 m	2	SS	8	Wet below
0.6 – 2.2 m	**SILTY SAND TO SANDY SILT** trace gravel, trace clay, loose, wet, brownish grey 2.2 m EL 238.1 m	3	SS	5	Grey below
2.2 – 6 m	**SILTY CLAY TO CLAYEY SILT** trace gravel, trace sand, firm, wet, grey 6 m EL 234.3 m	4 5 6	SS SS SS	3 0 0	Gr: 0%; Sa: 2%; Si: 64%; Cl: 34% Sens: 2.0
6 – 6.6 m	**GRAVELLY SILTY CLAY TO CLAYEY SILT** trace sand, soft, wet, grey 6.6 m EL 233.7 m	7	SS	3	
	BH 1 Terminated at 6.6 m				

08 Jan 2024

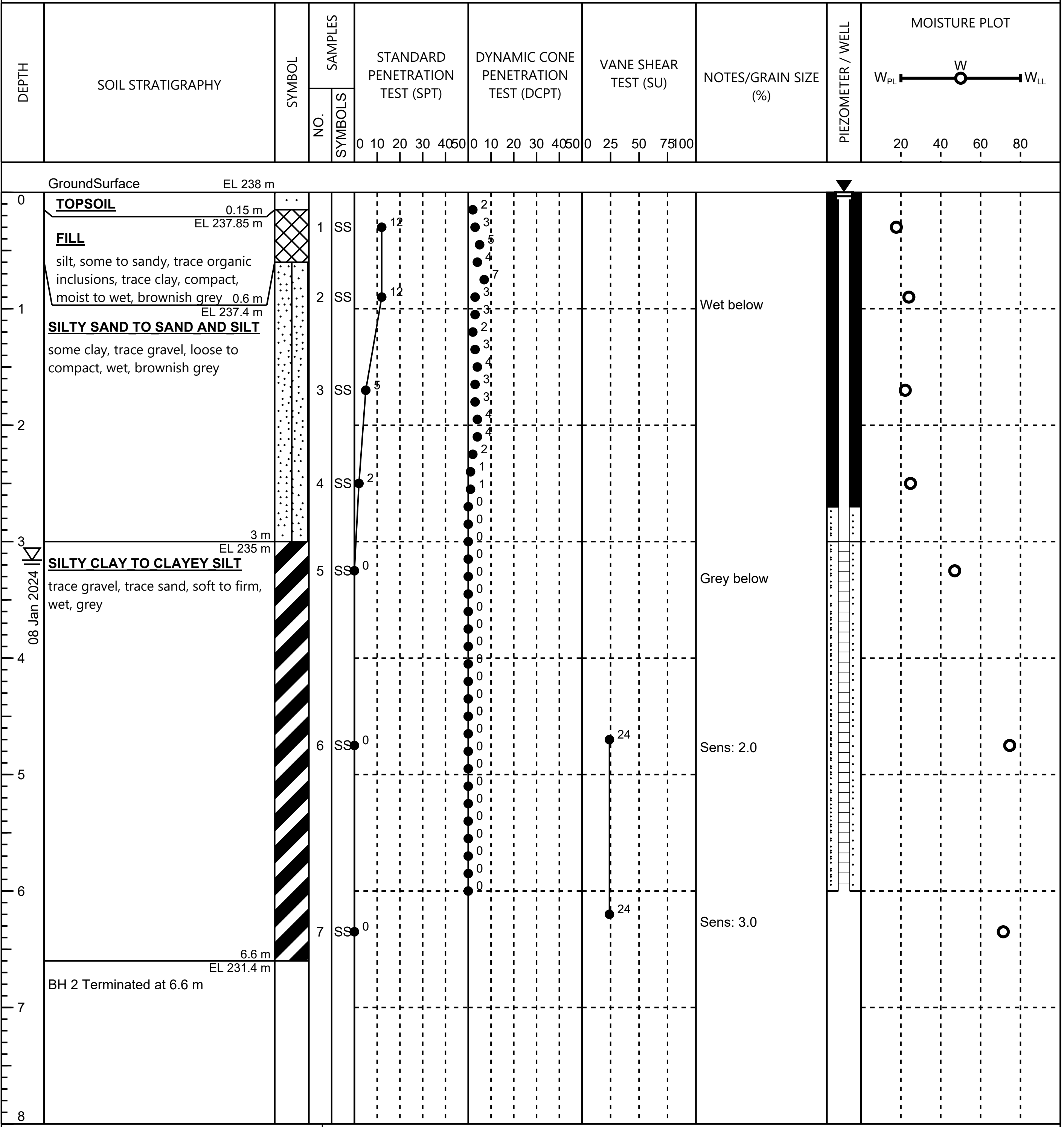


GREEN GEOTECHNICAL

Notes:
Borehole had water at 5.2 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.1 mbg (elev. 240.2m) on 01-31-24.

BOREHOLE LOG: BH 2

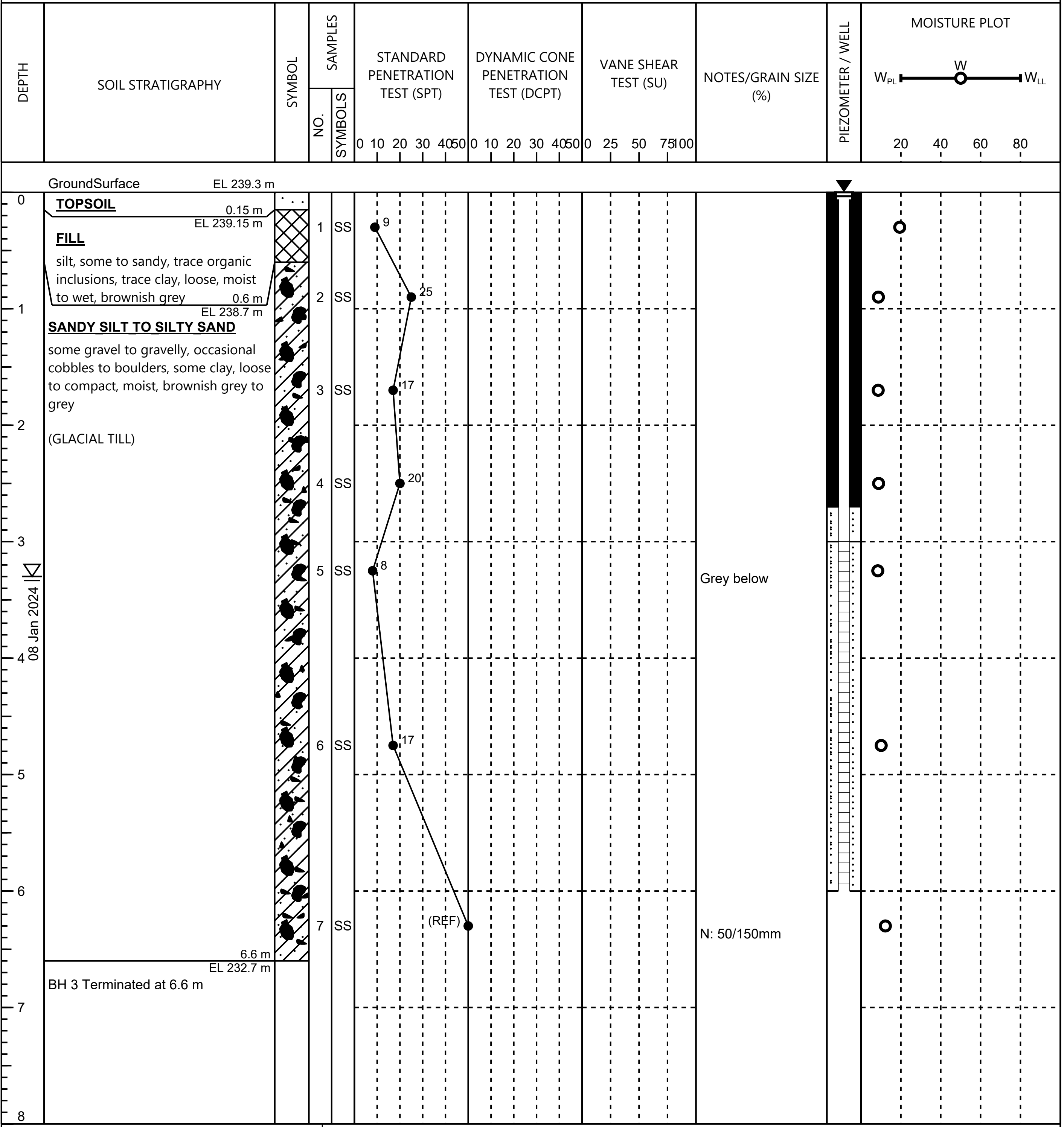
Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623452
Northing: 4943346
Elevation:238 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-08



Notes:
Borehole had water at 3.2 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.0 mbg (elev. 238.0m) on 01-31-24.

BOREHOLE LOG: BH 3

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623412
Northing: 4943539
Elevation:239.3 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-08



GroundSurface EL 239.3 m

TOPSOIL 0.15 m EL 239.15 m

FILL silt, some to sandy, trace organic inclusions, trace clay, loose, moist to wet, brownish grey 0.6 m EL 238.7 m

SANDY SILT TO SILTY SAND some gravel to gravelly, occasional cobbles to boulders, some clay, loose to compact, moist, brownish grey to grey

(GLACIAL TILL)

6.6 m EL 232.7 m

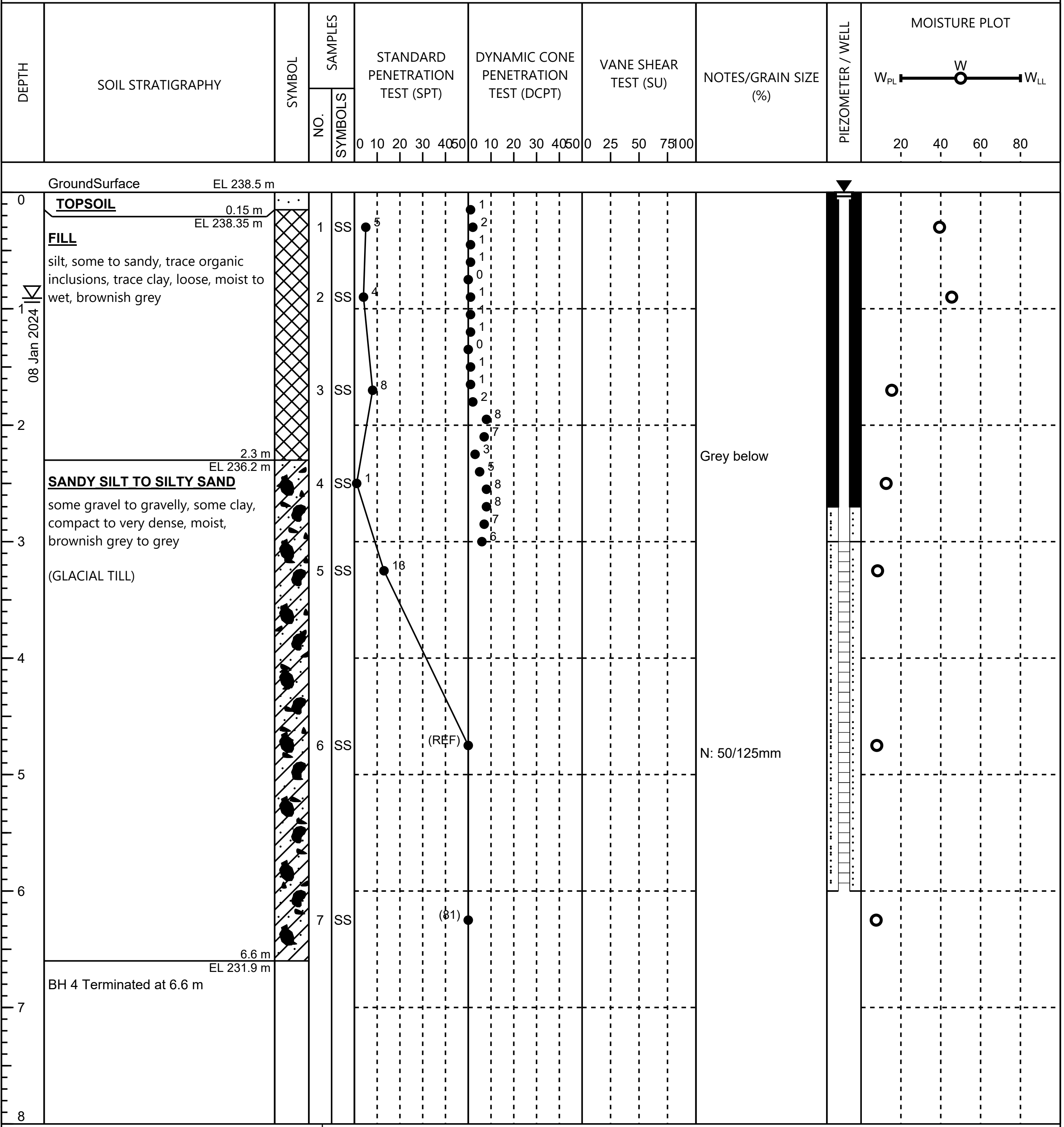
BH 3 Terminated at 6.6 m

NO.	SYMBOLS	SPT	NOTES/GRAIN SIZE (%)
1	SS	9	
2	SS	25	
3	SS	17	
4	SS	20	
5	SS	8	Grey below
6	SS	17	
7	SS	(REF)	N: 50/150mm

Notes:
Borehole had water at 3.3 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.1 mbg (elev. 239.2m) on 01-31-24.

BOREHOLE LOG: BH 4

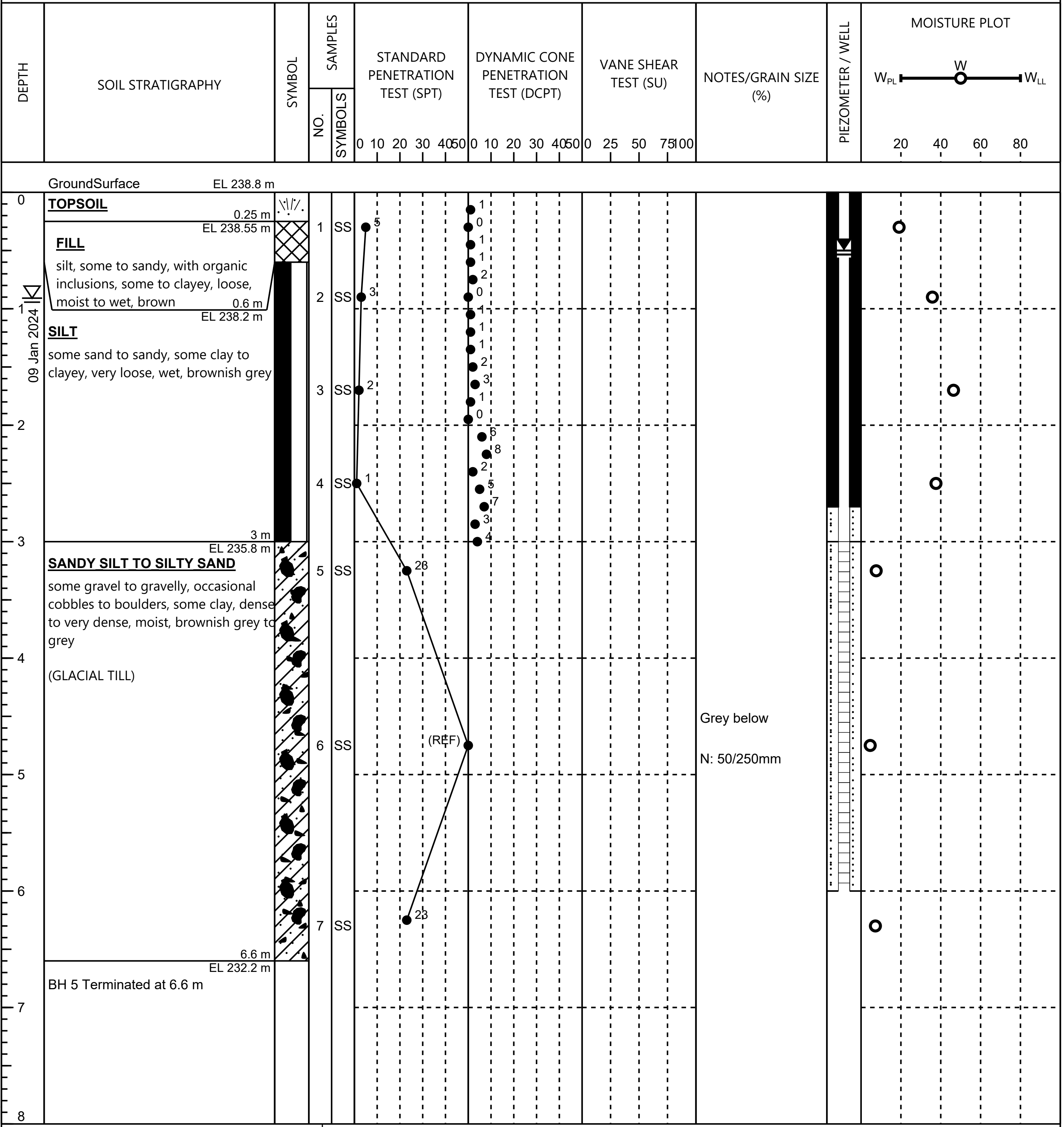
Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623247
Northing: 4943522
Elevation:238.5 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-08



Notes:
Borehole had water at 0.9 mbg and caved to 5.5 mbg upon completion of drilling.
Stabilized water level measured at 0.0 mbg (elev. 238.5m) on 01-31-24.

BOREHOLE LOG: BH 5

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623216
Northing: 4943706
Elevation:238.8 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-09



GroundSurface EL 238.8 m

TOPSOIL

0.25 m
EL 238.55 m

FILL

silt, some to sandy, with organic inclusions, some to clayey, loose, moist to wet, brown

0.6 m
EL 238.2 m

SILT

some sand to sandy, some clay to clayey, very loose, wet, brownish grey

3 m
EL 235.8 m

SANDY SILT TO SILTY SAND

some gravel to gravelly, occasional cobbles to boulders, some clay, dense to very dense, moist, brownish grey to grey

(GLACIAL TILL)

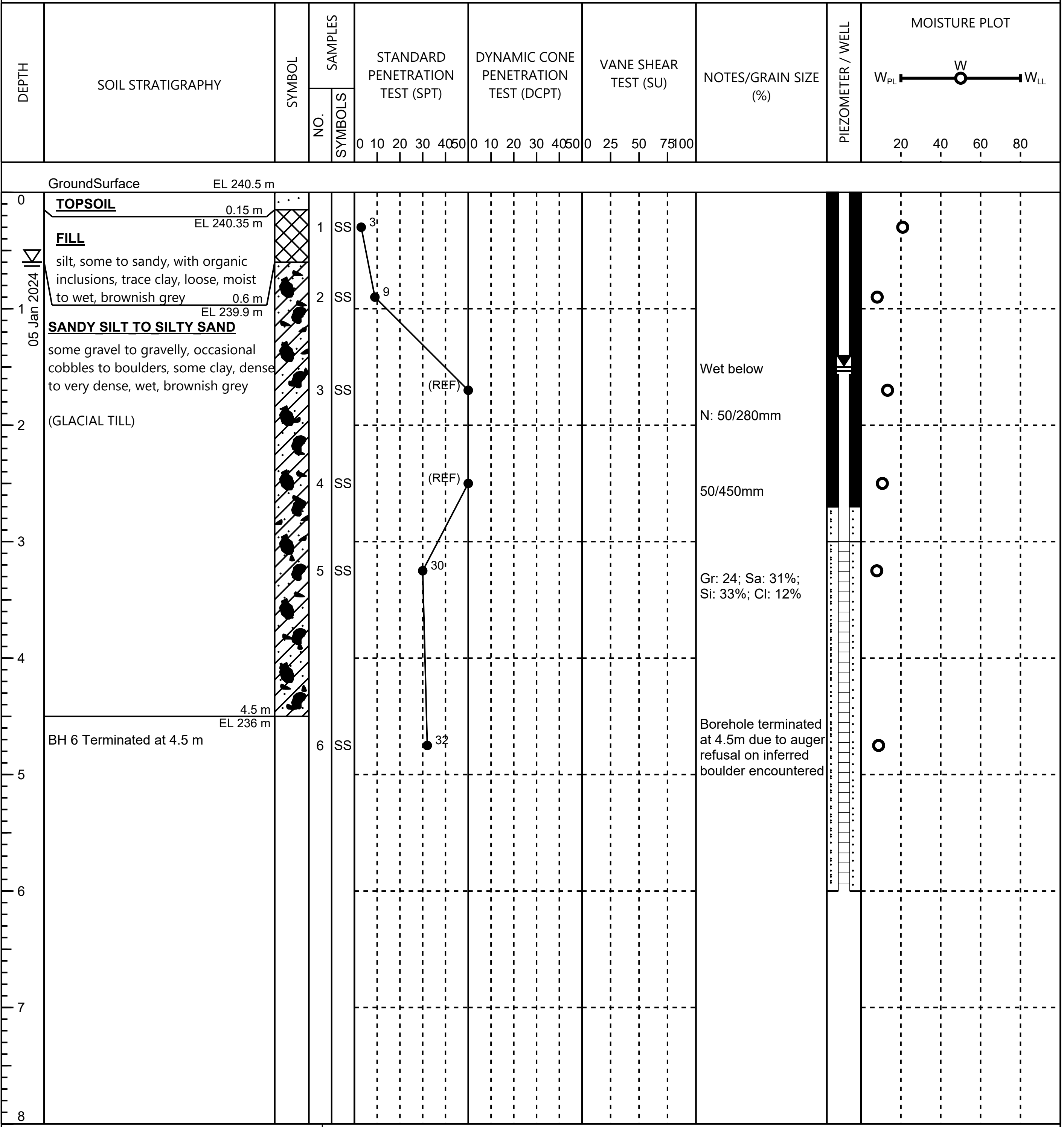
6.6 m
EL 232.2 m

BH 5 Terminated at 6.6 m

Notes:
Borehole had water at 0.9 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.5 mbg (elev. 238.3m) on 01-31-24.

BOREHOLE LOG: BH 6

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623019
Northing: 4943592
Elevation:240.5 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-05



GroundSurface EL 240.5 m

TOPSOIL 0.15 m EL 240.35 m

FILL
silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brownish grey 0.6 m EL 239.9 m

SANDY SILT TO SILTY SAND
some gravel to gravelly, occasional cobbles to boulders, some clay, dense to very dense, wet, brownish grey

(GLACIAL TILL)

4.5 m EL 236 m

BH 6 Terminated at 4.5 m

Wet below

N: 50/280mm

50/450mm

Gr: 24; Sa: 31%; Si: 33%; Cl: 12%

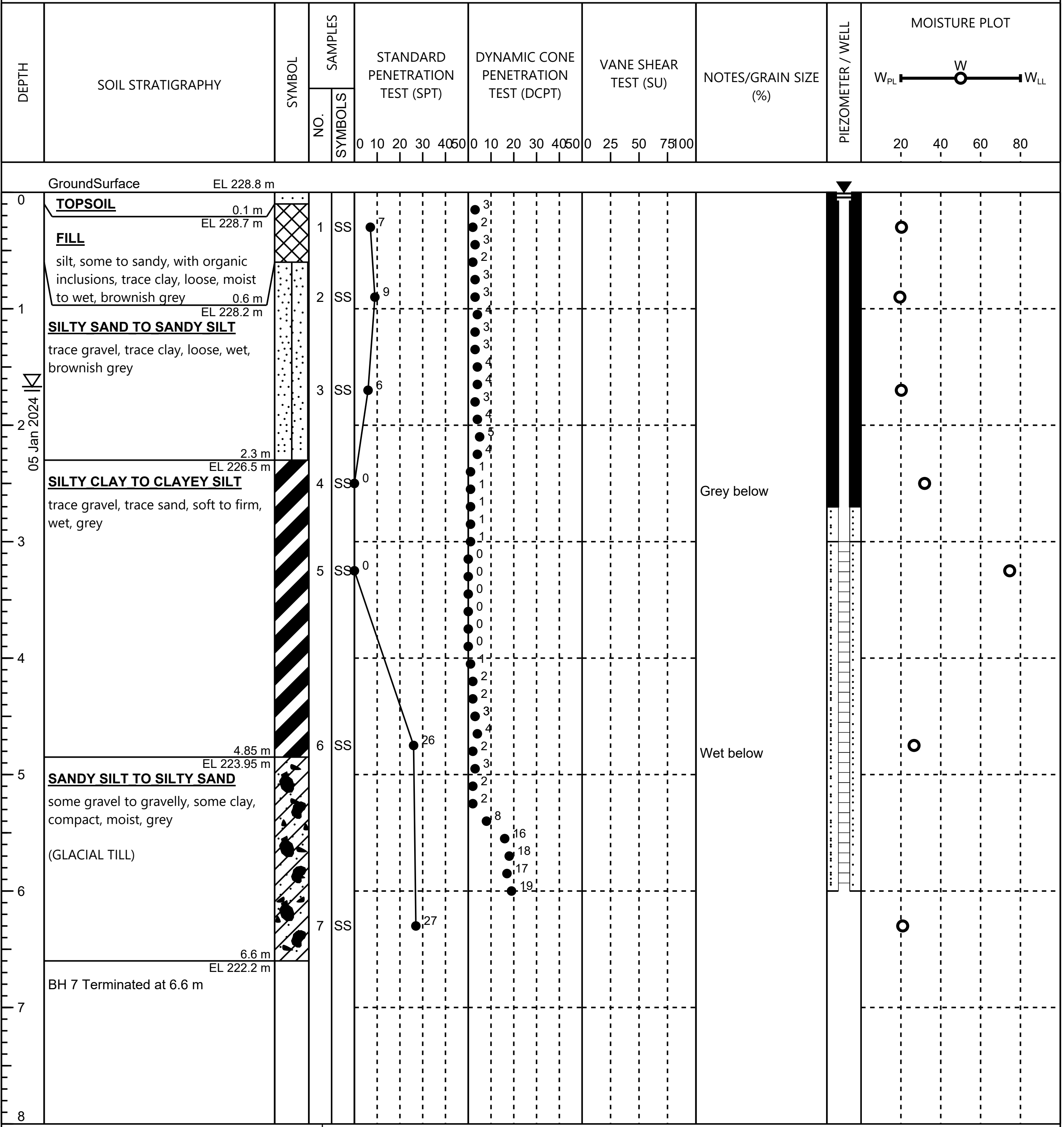
Borehole terminated at 4.5m due to auger refusal on inferred boulder encountered

GREEN GEOTECHNICAL

Notes:
Borehole had water at 0.6 mbg and was open upon completion of drilling.
Stabilized water level measured at 1.5 mbg (elev. 239.0m) on 01-31-24.

BOREHOLE LOG: BH 7

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622748
Northing: 4943603
Elevation:228.8 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-05



GroundSurface EL 228.8 m

TOPSOIL 0.1 m EL 228.7 m

FILL
silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brownish grey 0.6 m EL 228.2 m

SILTY SAND TO SANDY SILT
trace gravel, trace clay, loose, wet, brownish grey 2.3 m EL 226.5 m

SILTY CLAY TO CLAYEY SILT
trace gravel, trace sand, soft to firm, wet, grey 4.85 m EL 223.95 m

SANDY SILT TO SILTY SAND
some gravel to gravelly, some clay, compact, moist, grey

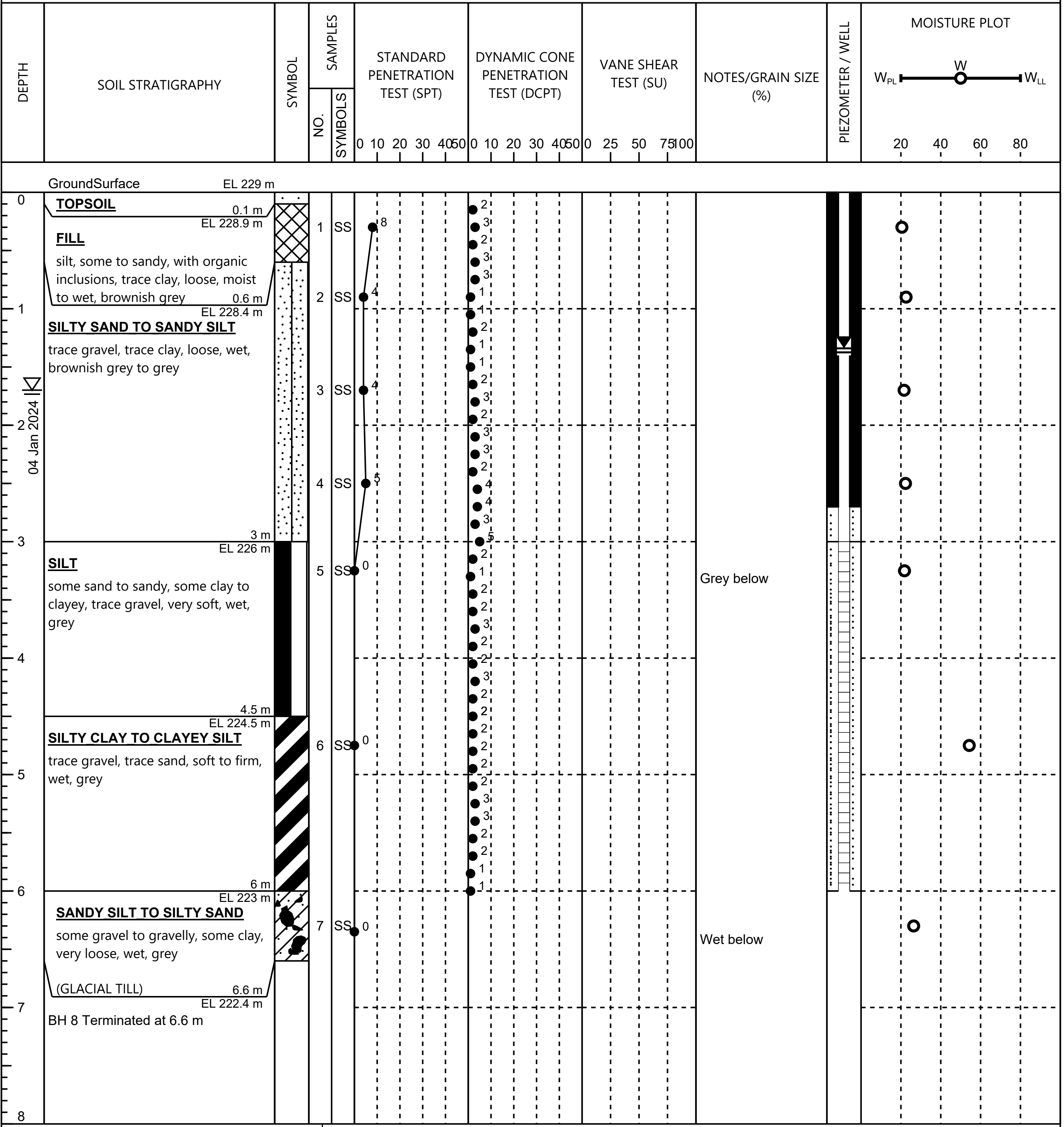
(GLACIAL TILL) 6.6 m EL 222.2 m

BH 7 Terminated at 6.6 m

Notes:
Borehole had water at 1.7 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.0 mbg (elev. 228.7m) on 01-31-24.

BOREHOLE LOG: BH 8

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622898
Northing: 4943291
Elevation:229 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-04



GroundSurface EL 229 m

TOPSOIL 0.1 m EL 228.9 m

FILL
silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brownish grey 0.6 m EL 228.4 m

SILTY SAND TO SANDY SILT
trace gravel, trace clay, loose, wet, brownish grey to grey 3 m EL 226 m

SILT
some sand to sandy, some clay to clayey, trace gravel, very soft, wet, grey 4.5 m EL 224.5 m

SILTY CLAY TO CLAYEY SILT
trace gravel, trace sand, soft to firm, wet, grey 6 m EL 223 m

SANDY SILT TO SILTY SAND
some gravel to gravelly, some clay, very loose, wet, grey

(GLACIAL TILL) 6.6 m EL 222.4 m

BH 8 Terminated at 6.6 m

Grey below

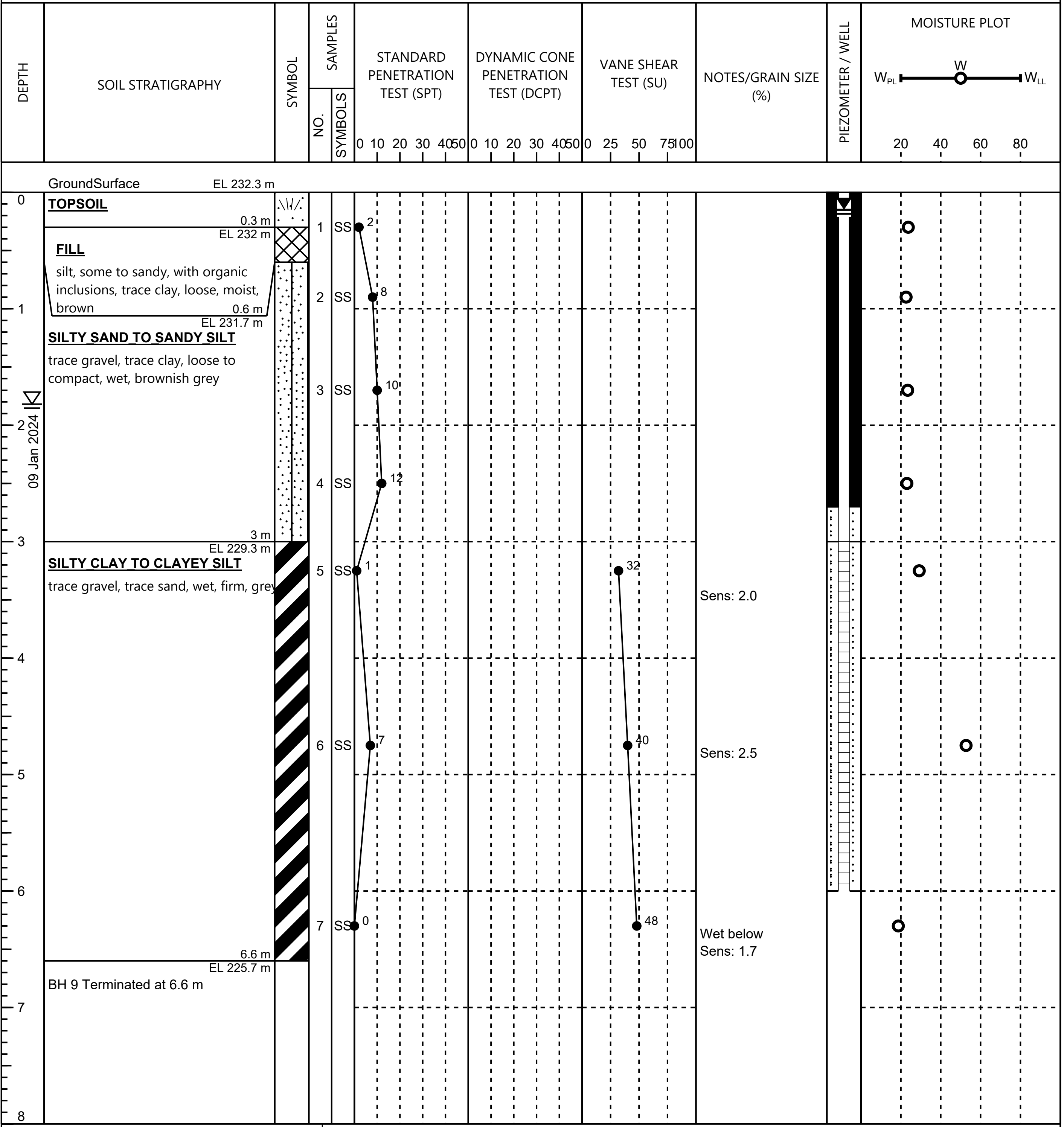
Wet below

Notes:
Borehole had water at 1.7 mbg and was open upon completion of drilling.
Stabilized water level measured at 1.3 mbg (elev. 227.7m) on 01-31-24.

GREEN GEOTECHNICAL

BOREHOLE LOG: BH 9

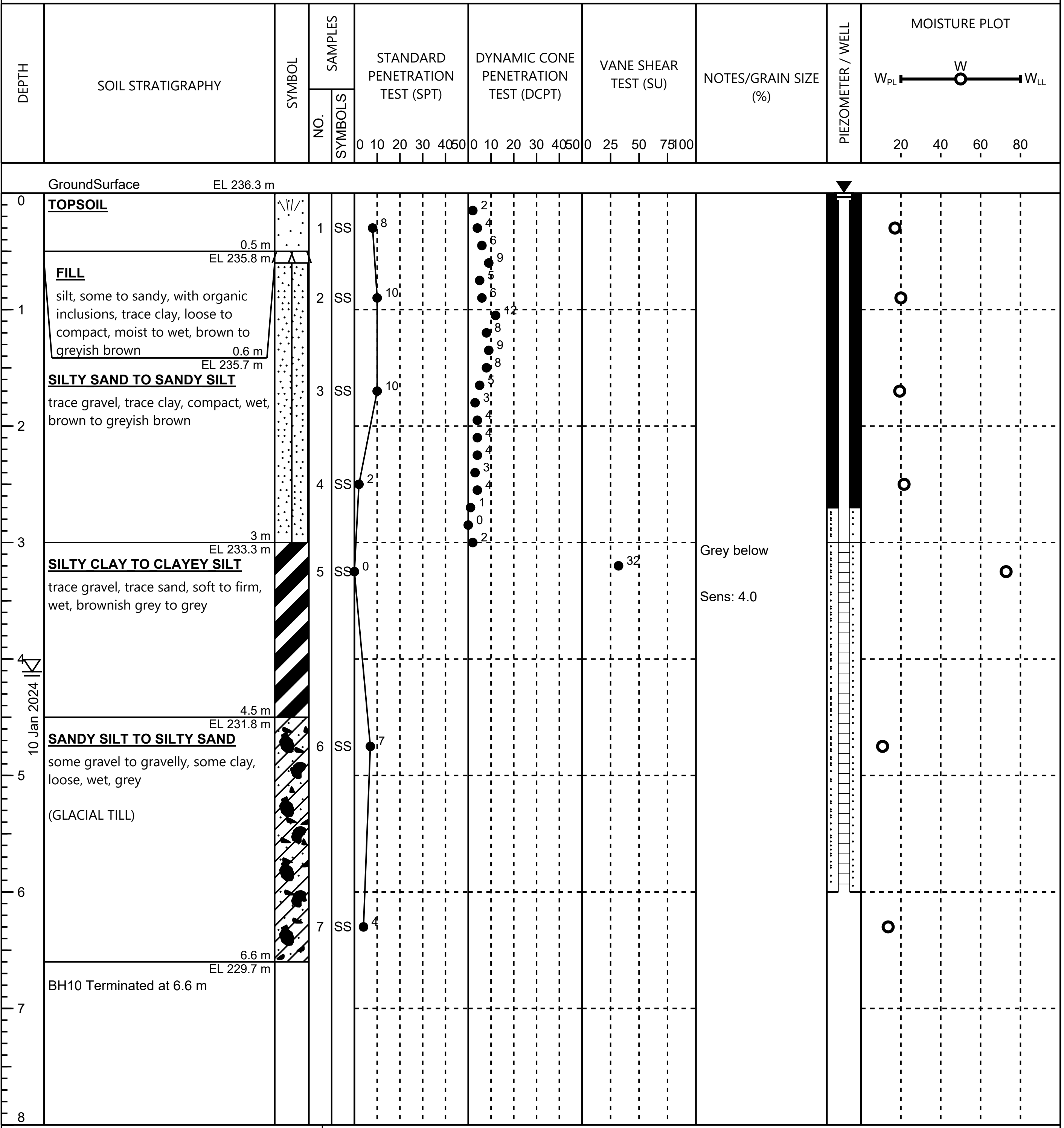
Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622966
Northing: 4942978
Elevation:232.3 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-09



Notes:
Borehole had water at 1.8 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.2 mbg (elev. 232.1m) on 02-01-24.

BOREHOLE LOG: BH10

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623094
Northing: 4942903
Elevation:236.3 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-10



GroundSurface EL 236.3 m

TOPSOIL

0.5 m
EL 235.8 m

FILL

silt, some to sandy, with organic inclusions, trace clay, loose to compact, moist to wet, brown to greyish brown

0.6 m
EL 235.7 m

SILTY SAND TO SANDY SILT

trace gravel, trace clay, compact, wet, brown to greyish brown

3 m
EL 233.3 m

SILTY CLAY TO CLAYEY SILT

trace gravel, trace sand, soft to firm, wet, brownish grey to grey

Grey below

Sens: 4.0

4.5 m
EL 231.8 m

SANDY SILT TO SILTY SAND

some gravel to gravelly, some clay, loose, wet, grey

(GLACIAL TILL)

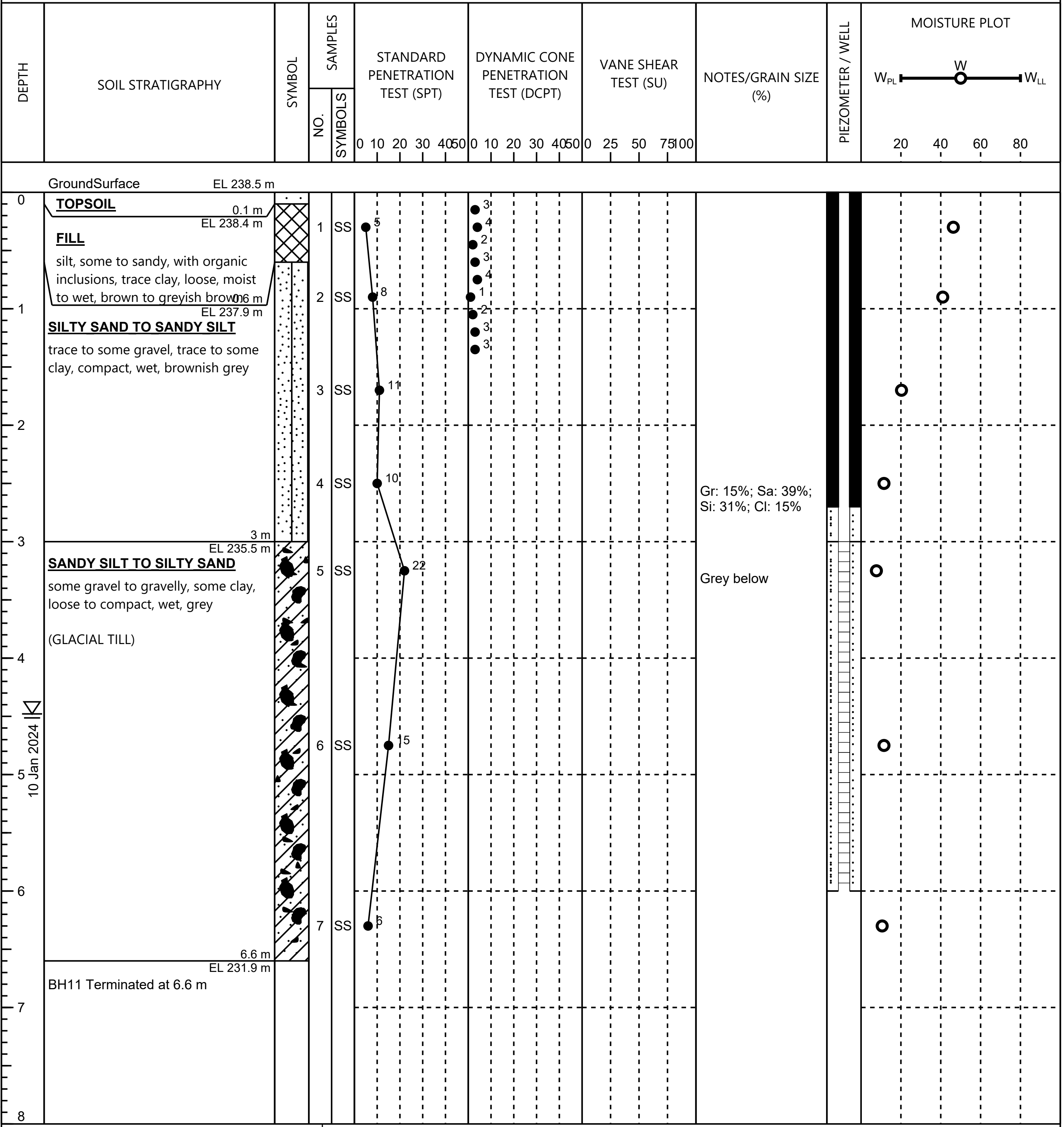
6.6 m
EL 229.7 m

BH10 Terminated at 6.6 m

Notes:
Borehole had water at 4.1 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.0 mbg (elev. 236.3m) on 02-01-24.

BOREHOLE LOG: BH11

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623223
Northing: 4942846
Elevation:238.5 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-10



Depth / Elevation	Soil Stratigraphy
EL 238.5 m	GroundSurface
0 – 0.1 m, EL 238.4 m	**TOPSOIL**
0.1 – 0.6 m, EL 237.9 m	**FILL** silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brown to greyish brown
0.6 – 3 m, EL 235.5 m	**SILTY SAND TO SANDY SILT** trace to some gravel, trace to some clay, compact, wet, brownish grey
3 – 6.6 m, EL 231.9 m	**SANDY SILT TO SILTY SAND** some gravel to gravelly, some clay, loose to compact, wet, grey (GLACIAL TILL)
	BH11 Terminated at 6.6 m

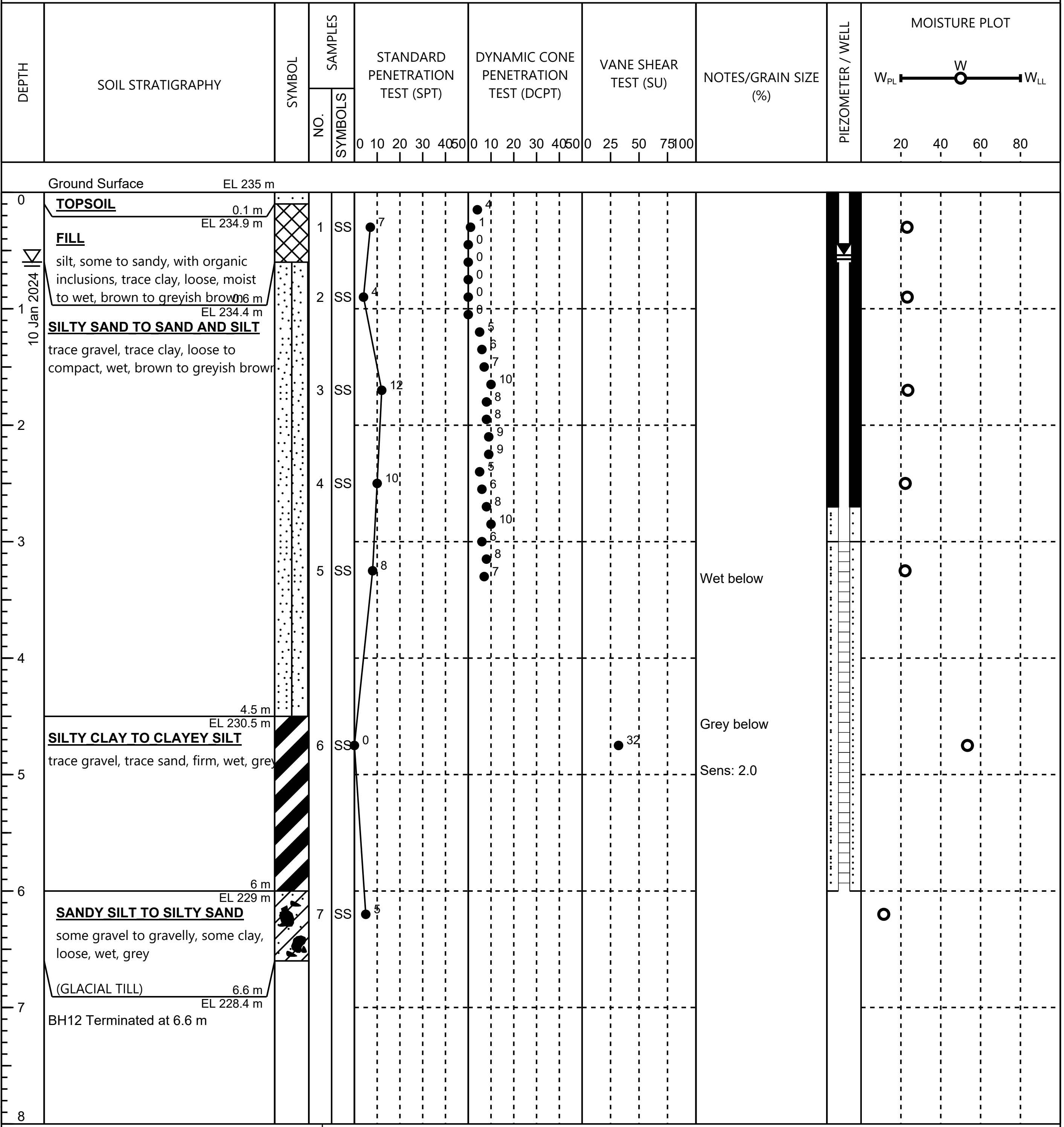
No.	Symbols	SPT	Notes/Grain Size (%)
1	SS	5	
2	SS	8	
3	SS	11	
4	SS	10	Gr: 15%; Sa: 39%; Si: 31%; Cl: 15%
5	SS	22	Grey below
6	SS	15	
7	SS	6	

DCPT: 3, 4, 2, 3, 4, 1, 2, 3, 3

Notes:
Borehole had water at 4.4 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.3 mbg (elev. 238.2m) on 02-01-24.

BOREHOLE LOG: BH12

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623115
Northing: 4942699
Elevation:235 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-10



Ground Surface EL 235 m

TOPSOIL 0.1 m EL 234.9 m

FILL

silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brown to greyish brown 0.6 m EL 234.4 m

SILTY SAND TO SAND AND SILT

trace gravel, trace clay, loose to compact, wet, brown to greyish brown 4.5 m EL 230.5 m

SILTY CLAY TO CLAYEY SILT

trace gravel, trace sand, firm, wet, grey 6 m EL 229 m

SANDY SILT TO SILTY SAND

some gravel to gravelly, some clay, loose, wet, grey

(GLACIAL TILL) 6.6 m EL 228.4 m

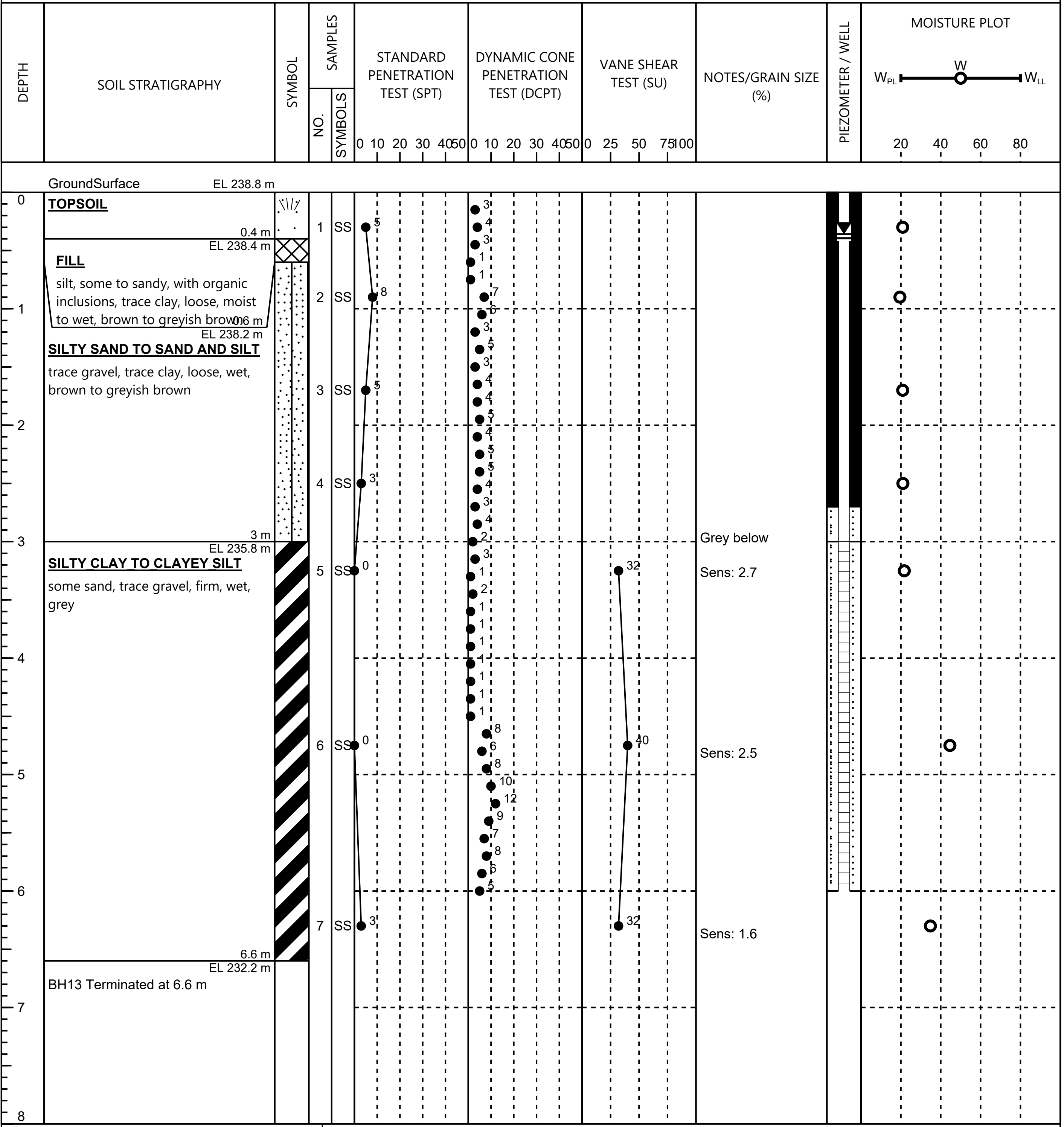
BH12 Terminated at 6.6 m

Notes:
Borehole had water at 0.6 mbg and caved at 4.9 mbg upon completion of drilling.
Stabilized water level measured at 0.5 mbg (elev. 234.5m) on 02-01-24.

RSLog / (DCPT) Soil Log w/ Piez w/ Vane / green-geotechnical-ltd. / admin / March 07, 2024 09:33 AM

BOREHOLE LOG: BH13

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623405
Northing: 4942594
Elevation:238.8 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-11

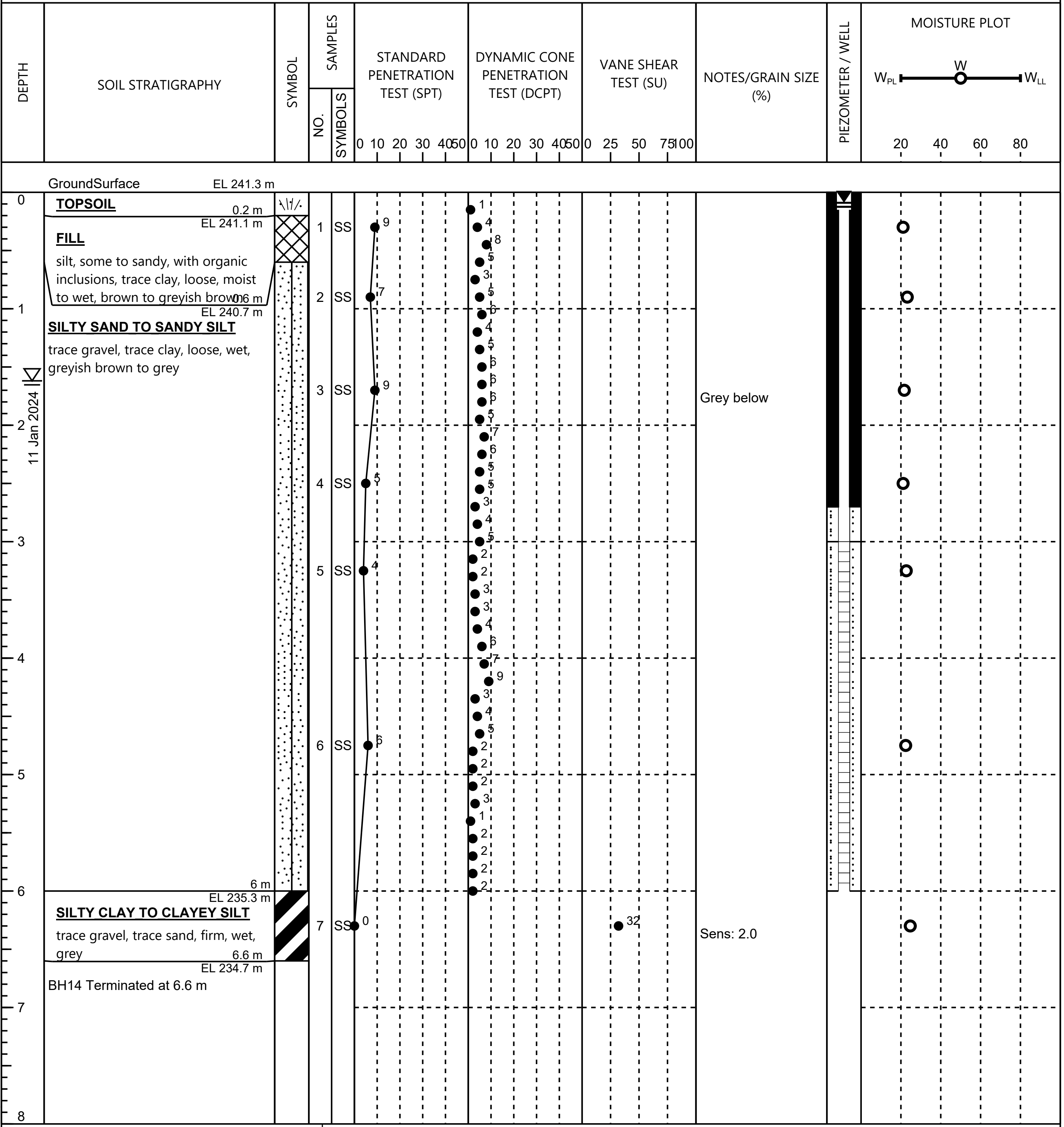


Notes:
Borehole was dry and caved at 4.3 mbg upon completion of drilling.
Stabilized water level measured at 0.4 mbg (elev. 238.4m) on 02-01-24.

GREEN GEOTECHNICAL

BOREHOLE LOG: BH14

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623460
Northing: 4942378
Elevation:241.3 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-11



GroundSurface EL 241.3 m

TOPSOIL 0.2 m
EL 241.1 m

FILL
silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brown to greyish brown 0.6 m
EL 240.7 m

SILTY SAND TO SANDY SILT
trace gravel, trace clay, loose, wet, greyish brown to grey 6 m
EL 235.3 m

SILTY CLAY TO CLAYEY SILT
trace gravel, trace sand, firm, wet, grey 6.6 m
EL 234.7 m

BH14 Terminated at 6.6 m

1	SS	9		
2	SS	7		
3	SS	9		Grey below
4	SS	5		
5	SS	4		
6	SS	6		
7	SS	0	32	Sens: 2.0

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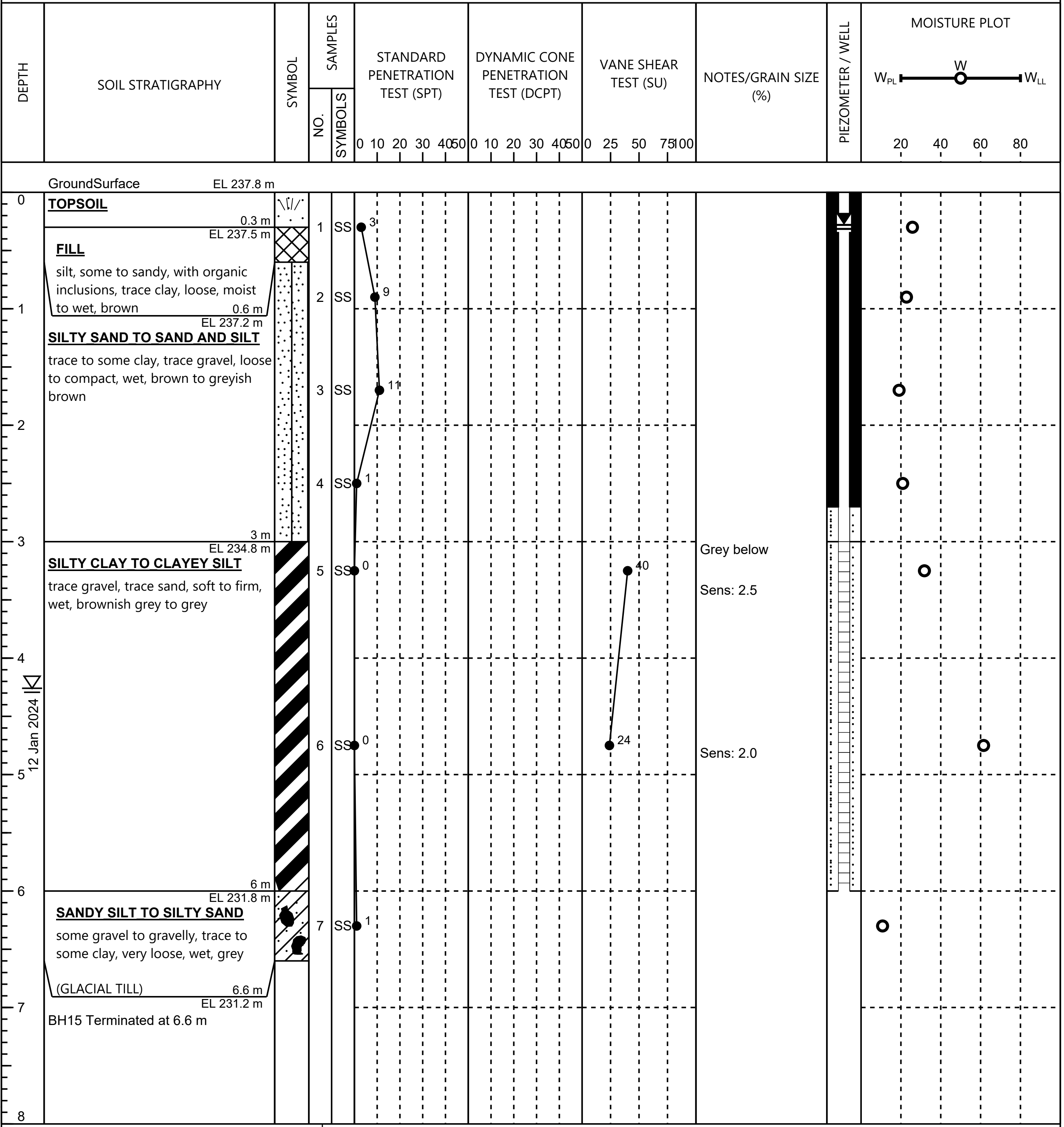
Notes:
Borehole had water at 1.6 mbg and caved at 4.6 mbg upon completion of drilling.
Stabilized water level measured at 0.1 mbg (elev. 241.2m) on 02-01-24.

BOREHOLE LOG: BH15

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623300
Northing: 4942456
Elevation:237.8 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-12



GroundSurface EL 237.8 m

TOPSOIL
0.3 m
EL 237.5 m

FILL
silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brown
0.6 m
EL 237.2 m

SILTY SAND TO SAND AND SILT
trace to some clay, trace gravel, loose to compact, wet, brown to greyish brown
3 m
EL 234.8 m

SILTY CLAY TO CLAYEY SILT
trace gravel, trace sand, soft to firm, wet, brownish grey to grey
6 m
EL 231.8 m

SANDY SILT TO SILTY SAND
some gravel to gravelly, trace to some clay, very loose, wet, grey

(GLACIAL TILL)
6.6 m
EL 231.2 m

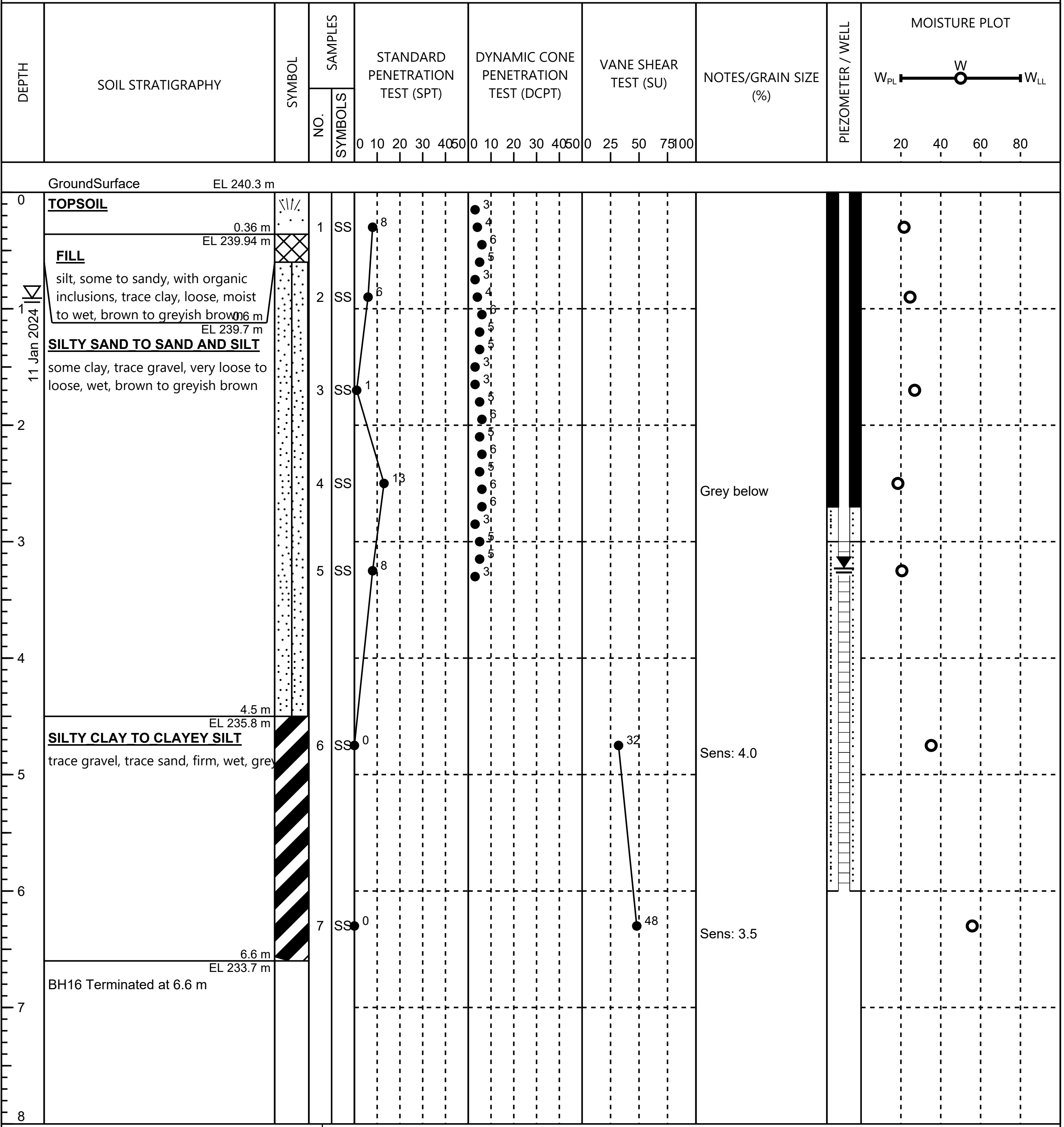
BH15 Terminated at 6.6 m

GREEN GEOTECHNICAL

Notes:
Borehole had water at 4.3 mbg and caved at 4.6 mbg upon completion of drilling.
Stabilized water level measured at 0.3 mbg (elev. 237.5m) on 02-01-24.

BOREHOLE LOG: BH16

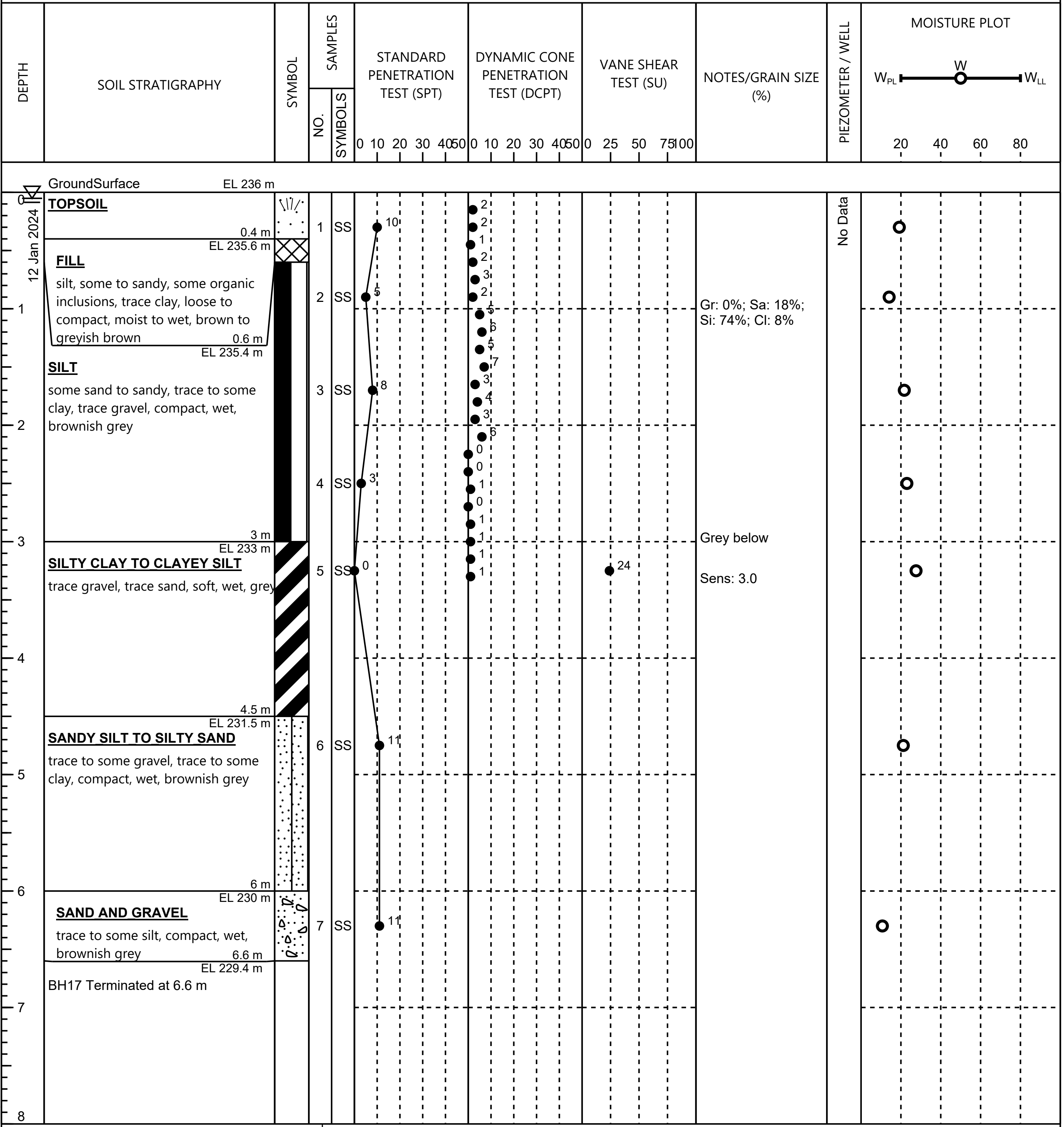
Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623313
Northing: 4942232
Elevation:240.3 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-11



Notes:
Borehole had water at 0.9 mbg and caved at 3.7 mbg upon completion of drilling.
Stabilized water level measured at 3.2 mbg (elev. 237.0m) on 02-01-24.

BOREHOLE LOG: BH17

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 623113
Northing: 4942351
Elevation:236 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-12



GroundSurface EL 236 m

TOPSOIL
0.4 m
EL 235.6 m

FILL
silt, some to sandy, some organic inclusions, trace clay, loose to compact, moist to wet, brown to greyish brown
0.6 m
EL 235.4 m

SILT
some sand to sandy, trace to some clay, trace gravel, compact, wet, brownish grey
3 m
EL 233 m

SILTY CLAY TO CLAYEY SILT
trace gravel, trace sand, soft, wet, grey
4.5 m
EL 231.5 m

SANDY SILT TO SILTY SAND
trace to some gravel, trace to some clay, compact, wet, brownish grey
6 m
EL 230 m

SAND AND GRAVEL
trace to some silt, compact, wet, brownish grey
6.6 m
EL 229.4 m

BH17 Terminated at 6.6 m

Gr: 0%; Sa: 18%; Si: 74%; Cl: 8%

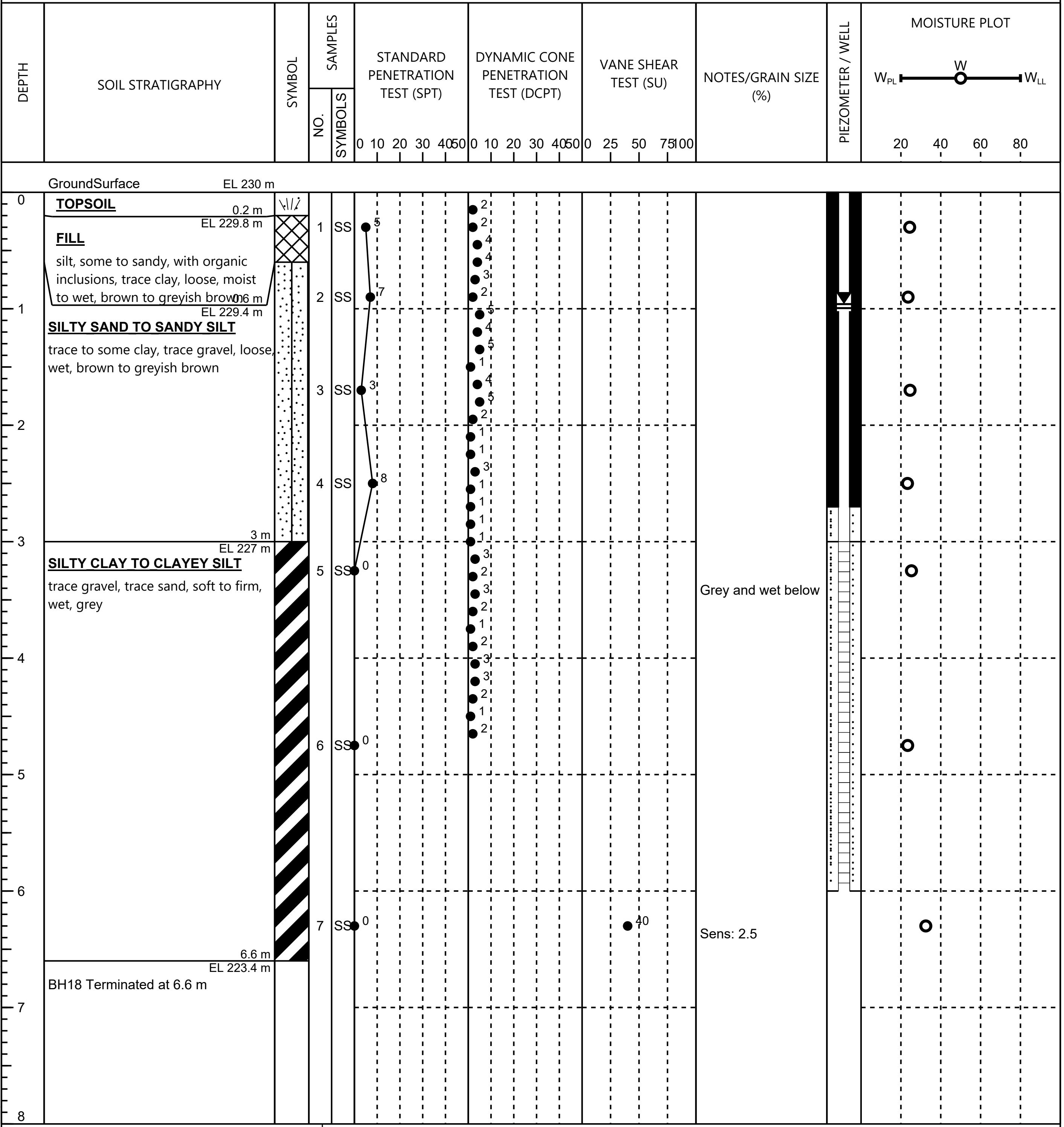
Grey below

Sens: 3.0

Notes:
Borehole had flowing artesian conditions and was open upon completion of drilling.
No well installed due to the encountered flowing artesian conditions.

BOREHOLE LOG: BH18

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622914
Northing: 4942754
Elevation: 230 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-10



GroundSurface EL 230 m

TOPSOIL 0.2 m EL 229.8 m

FILL

silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brown to greyish brown 0.6 m EL 229.4 m

SILTY SAND TO SANDY SILT

trace to some clay, trace gravel, loose, wet, brown to greyish brown 3 m EL 227 m

SILTY CLAY TO CLAYEY SILT

trace gravel, trace sand, soft to firm, wet, grey 6.6 m EL 223.4 m

BH18 Terminated at 6.6 m

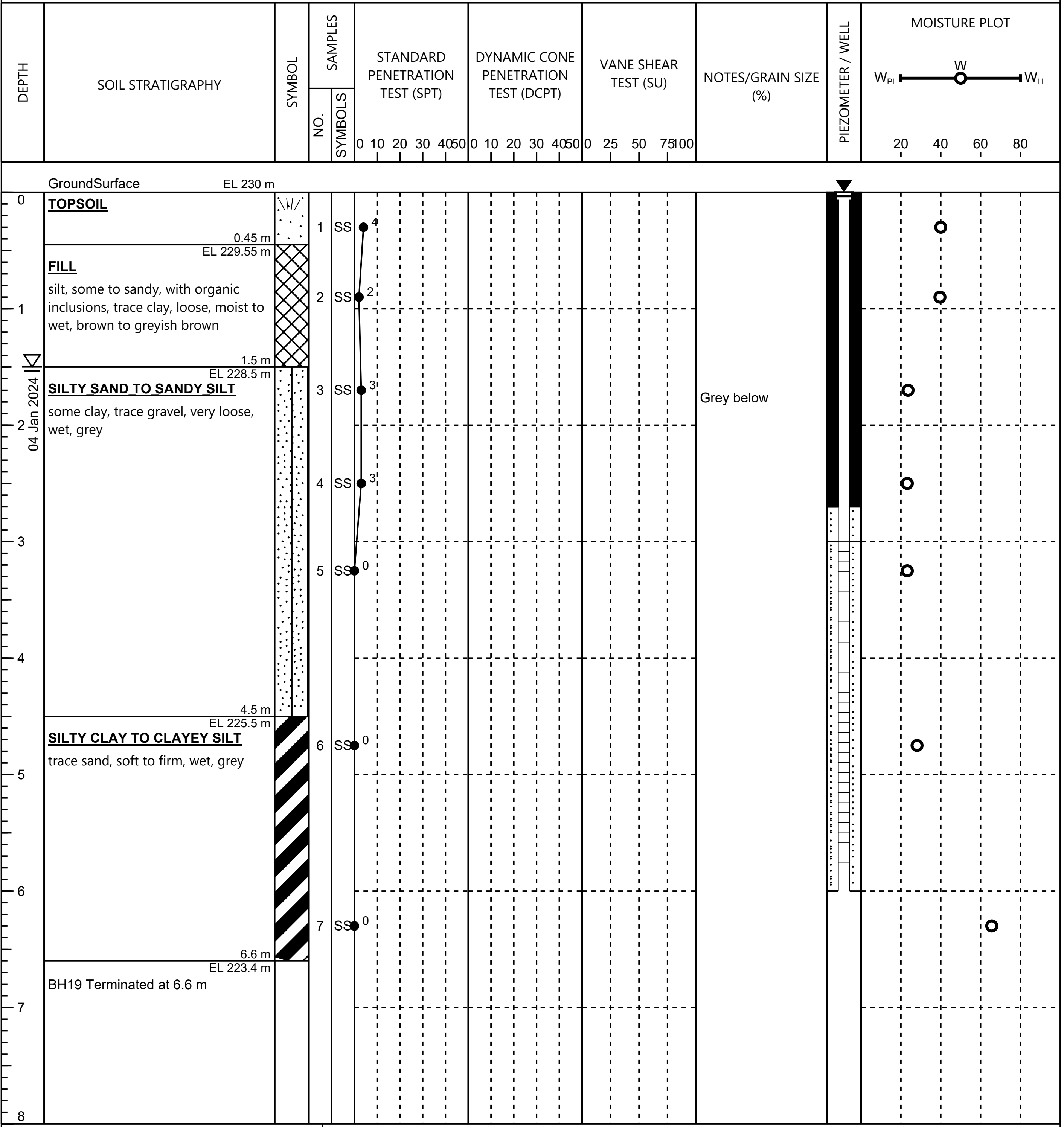
Grey and wet below

Sens: 2.5

Notes:
Borehole had no water and was open upon completion of drilling.
Stabilized water level measured at 1.0 mbg (elev. 229.0m) on 02-01-24.

BOREHOLE LOG: BH19

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622771
Northing: 4943009
Elevation:230 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-04



GroundSurface EL 230 m

TOPSOIL

0.45 m
EL 229.55 m

FILL

silt, some to sandy, with organic inclusions, trace clay, loose, moist to wet, brown to greyish brown

1.5 m
EL 228.5 m

SILTY SAND TO SANDY SILT

some clay, trace gravel, very loose, wet, grey

4.5 m
EL 225.5 m

SILTY CLAY TO CLAYEY SILT

trace sand, soft to firm, wet, grey

6.6 m
EL 223.4 m

BH19 Terminated at 6.6 m

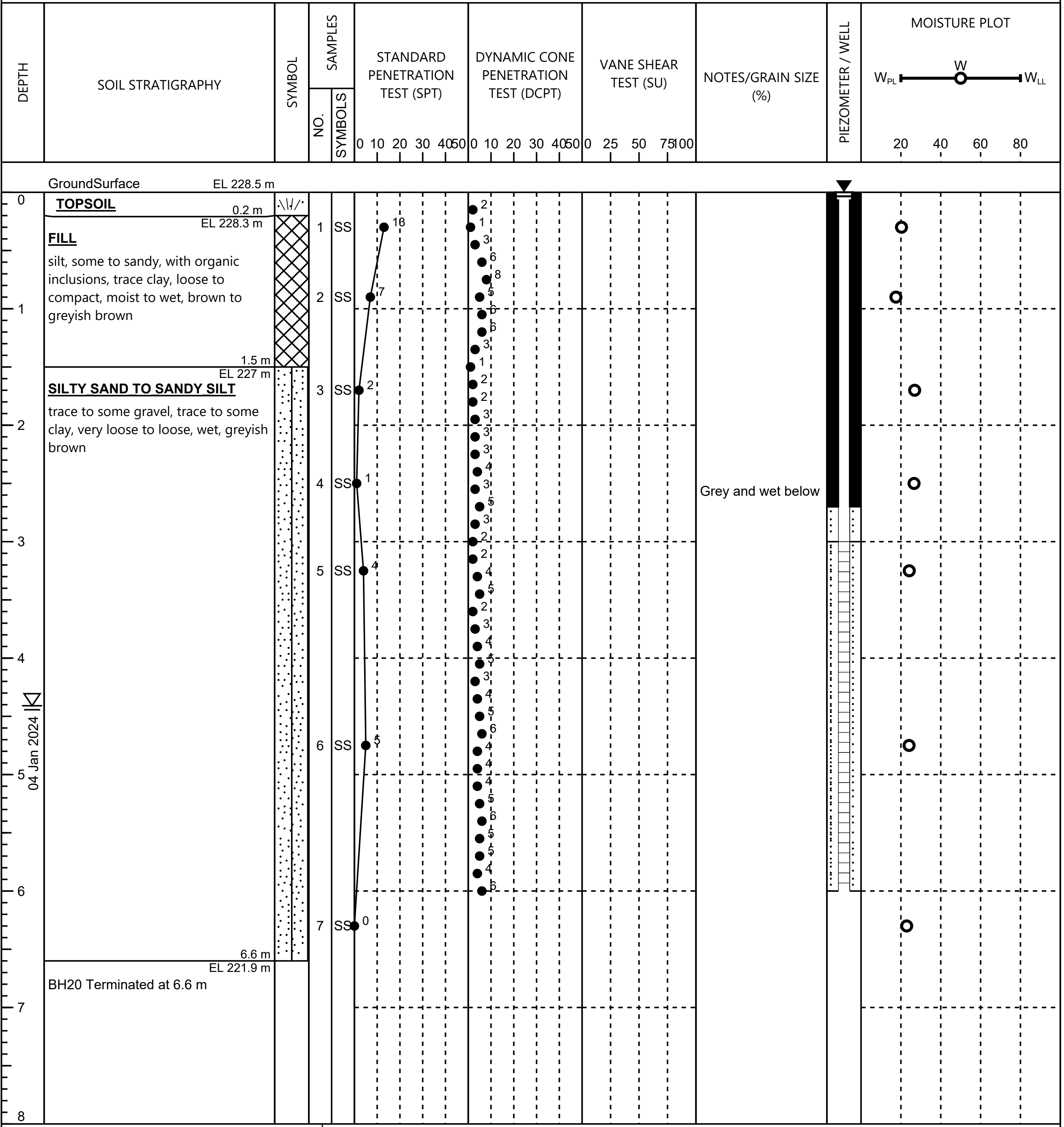
1	SS	4
2	SS	2
3	SS	3
4	SS	3
5	SS	0
6	SS	0
7	SS	0

Grey below

Notes:
Borehole had water at 1.5 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.0 mbg (elev. 230.0m) on 02-01-24.

BOREHOLE LOG: BH20

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622581
Northing: 4943086
Elevation:228.5 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-04



GroundSurface EL 228.5 m

TOPSOIL
0.2 m
EL 228.3 m

FILL

silt, some to sandy, with organic inclusions, trace clay, loose to compact, moist to wet, brown to greyish brown

1.5 m
EL 227 m

SILTY SAND TO SANDY SILT

trace to some gravel, trace to some clay, very loose to loose, wet, greyish brown

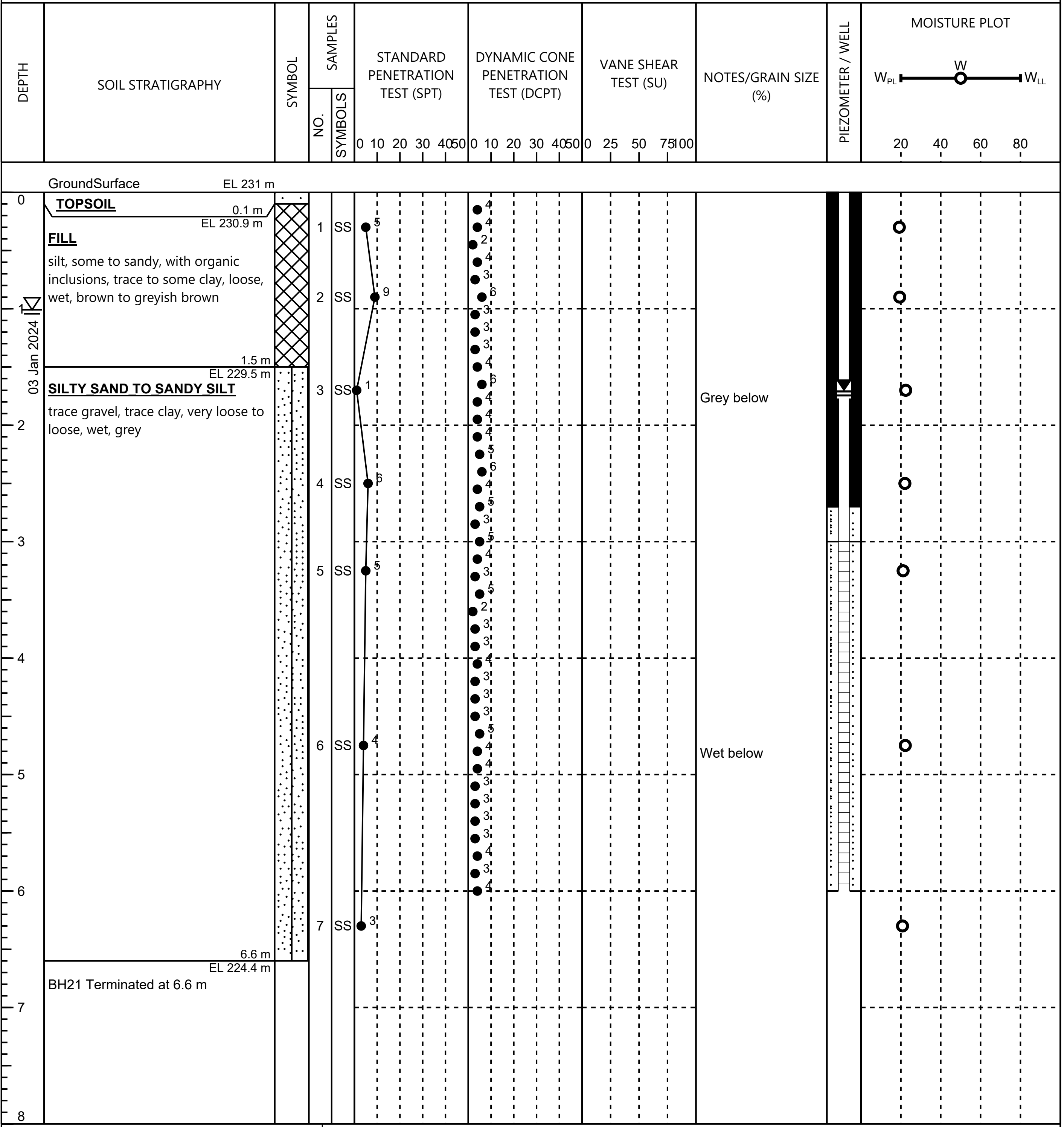
6.6 m
EL 221.9 m

BH20 Terminated at 6.6 m

Notes:
Borehole had water at 4.4 mbg and caved at 5.2 mbg upon completion of drilling.
Stabilized water level measured at 0.0 mbg (elev. 228.5m) on 02-01-24.

BOREHOLE LOG: BH21

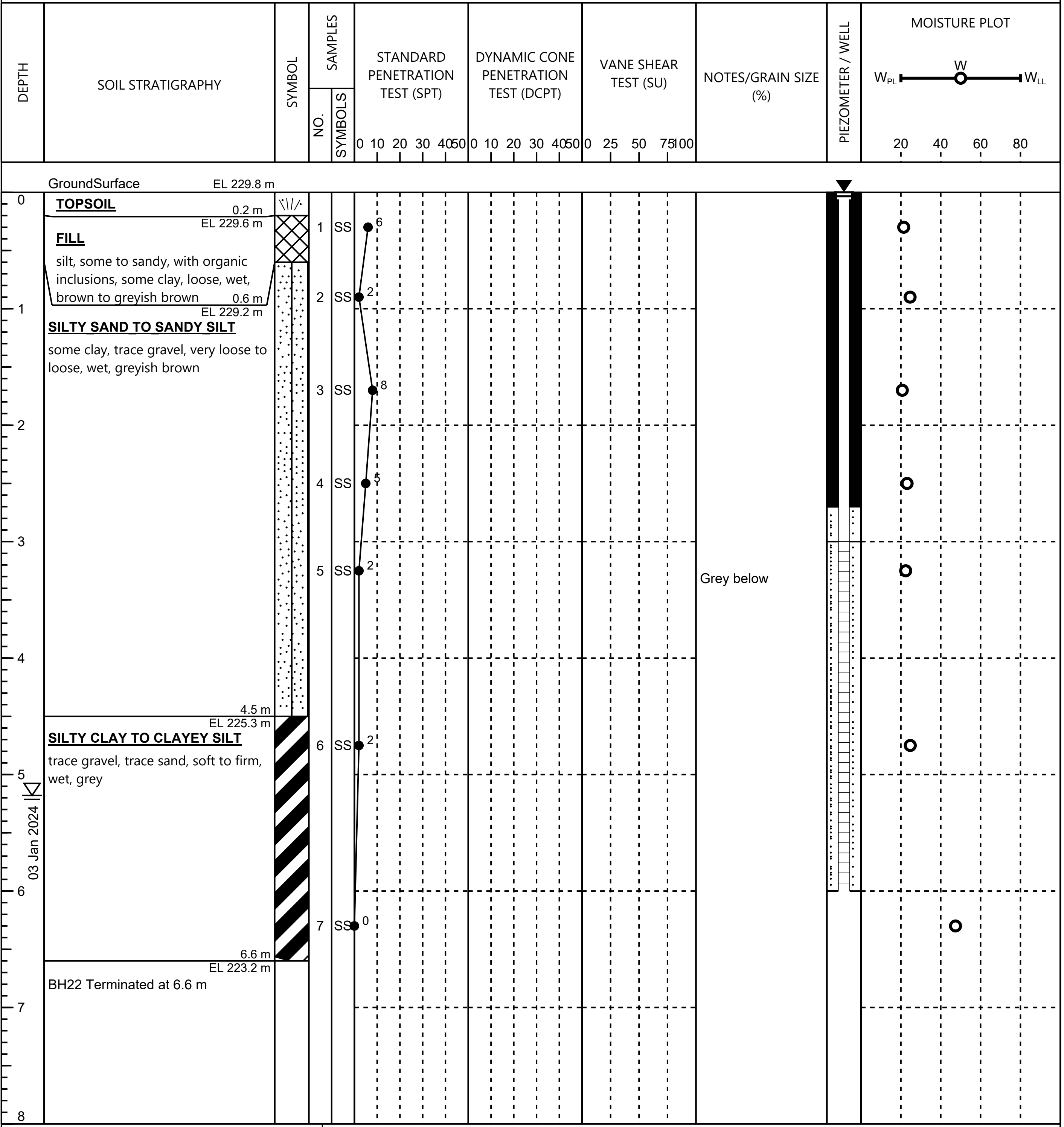
Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622377
Northing: 4943067
Elevation:231 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-03



Notes:
Borehole had water at 1.0 mbg and caved at 5.9 mbg upon completion of drilling.
Stabilized water level measured at 1.7 mbg (elev. 229.3m) on 02-01-24.

BOREHOLE LOG: BH22

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622472
Northing: 4942938
Elevation:229.8 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-03



GroundSurface EL 229.8 m

TOPSOIL
0.2 m
EL 229.6 m

FILL
silt, some to sandy, with organic inclusions, some clay, loose, wet, brown to greyish brown
0.6 m
EL 229.2 m

SILTY SAND TO SANDY SILT
some clay, trace gravel, very loose to loose, wet, greyish brown
4.5 m
EL 225.3 m

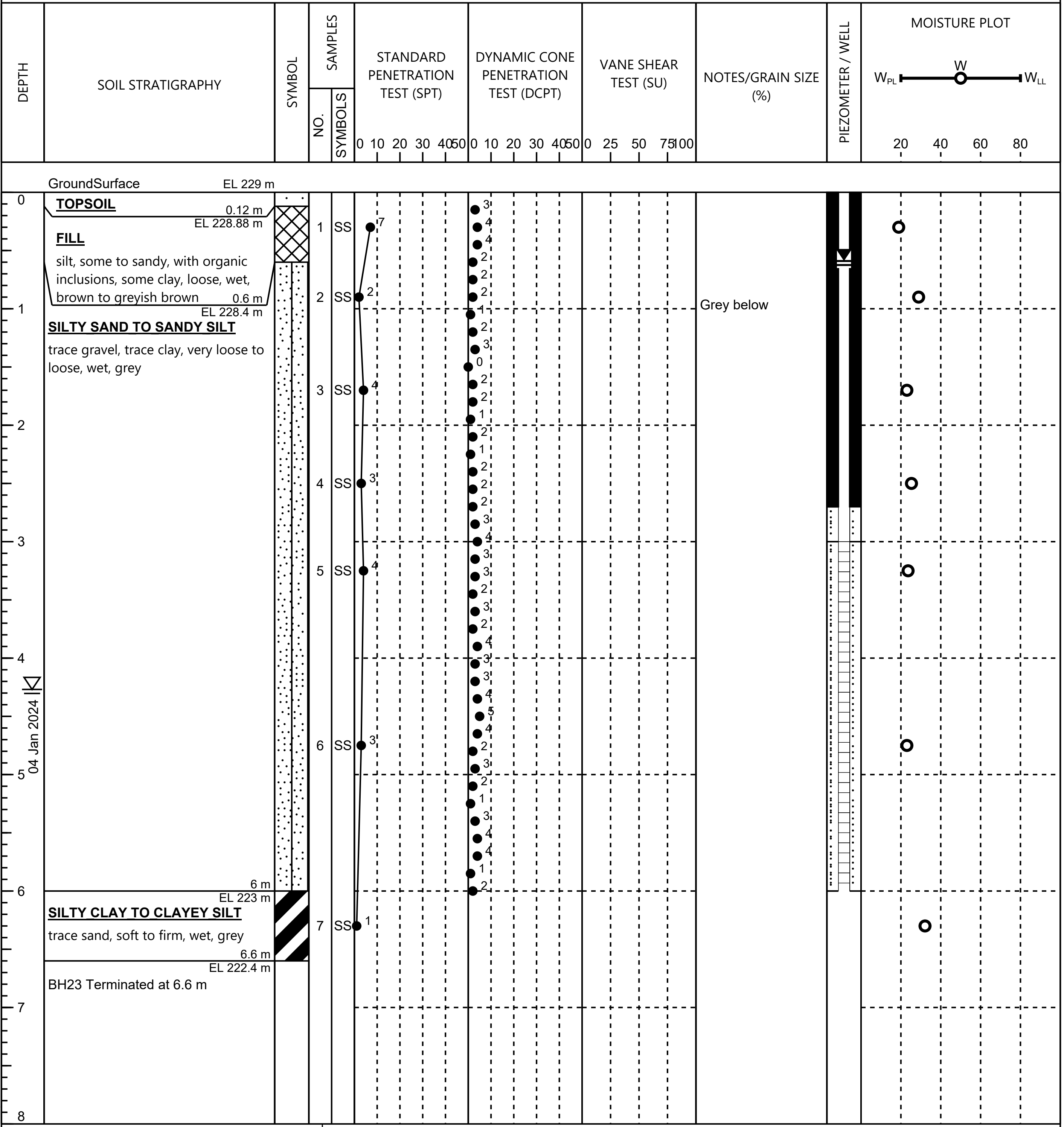
SILTY CLAY TO CLAYEY SILT
trace gravel, trace sand, soft to firm, wet, grey
6.6 m
EL 223.2 m

BH22 Terminated at 6.6 m

Notes:
Borehole had water at 5.2 mbg and caved at 5.8 mbg upon completion of drilling.
Stabilized water level measured at 0.0 mbg (elev. 229.8m) on 02-01-24.

BOREHOLE LOG: BH23

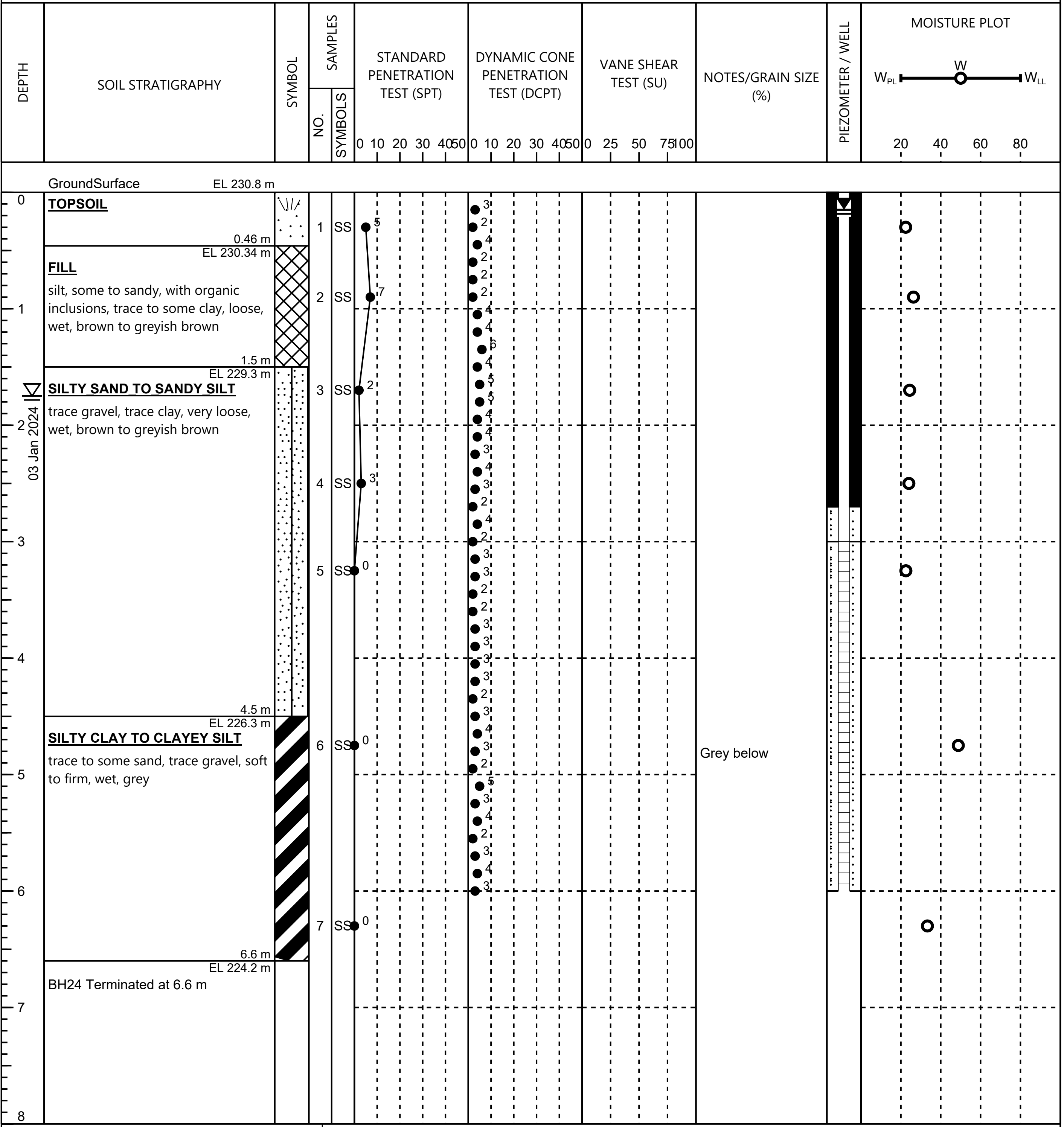
Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622579
Northing: 4942915
Elevation:229 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-04



Notes:
Borehole had water at 4.3 mbg and was open upon completion of drilling.
Stabilized water level measured at 0.6 mbg (elev. 228.4m) on 02-01-24.

BOREHOLE LOG: BH24

Project: Hawk Ridge Heights Residential Development
Project No.: 23-117
Site Address: Hawkridge Golf Course, Severn, ON
Client: LIV Communities
Easting: 622615
Northing: 4942743
Elevation:230.8 m
Logged By: NC/SO
Reviewed By: TK
Investigation Date: 2024-01-03



GroundSurface EL 230.8 m

TOPSOIL

0.46 m
EL 230.34 m

FILL

silt, some to sandy, with organic inclusions, trace to some clay, loose, wet, brown to greyish brown

1.5 m
EL 229.3 m

SILTY SAND TO SANDY SILT

trace gravel, trace clay, very loose, wet, brown to greyish brown

4.5 m
EL 226.3 m

SILTY CLAY TO CLAYEY SILT

trace to some sand, trace gravel, soft to firm, wet, grey

6.6 m
EL 224.2 m

BH24 Terminated at 6.6 m

NO.	SYMBOLS	SPT	NOTES/GRAIN SIZE (%)
1	SS	5	
2	SS	7	
3	SS	2	
4	SS	3	
5	SS	0	
6	SS	0	Grey below
7	SS	0	

Notes:
Borehole had water at 1.8mbg and caved at 3.4mbg upon completion of drilling.
Stabilized water level measured at 0.2 mbg (elev. 230.6m) on 02-01-24.

APPENDIX B

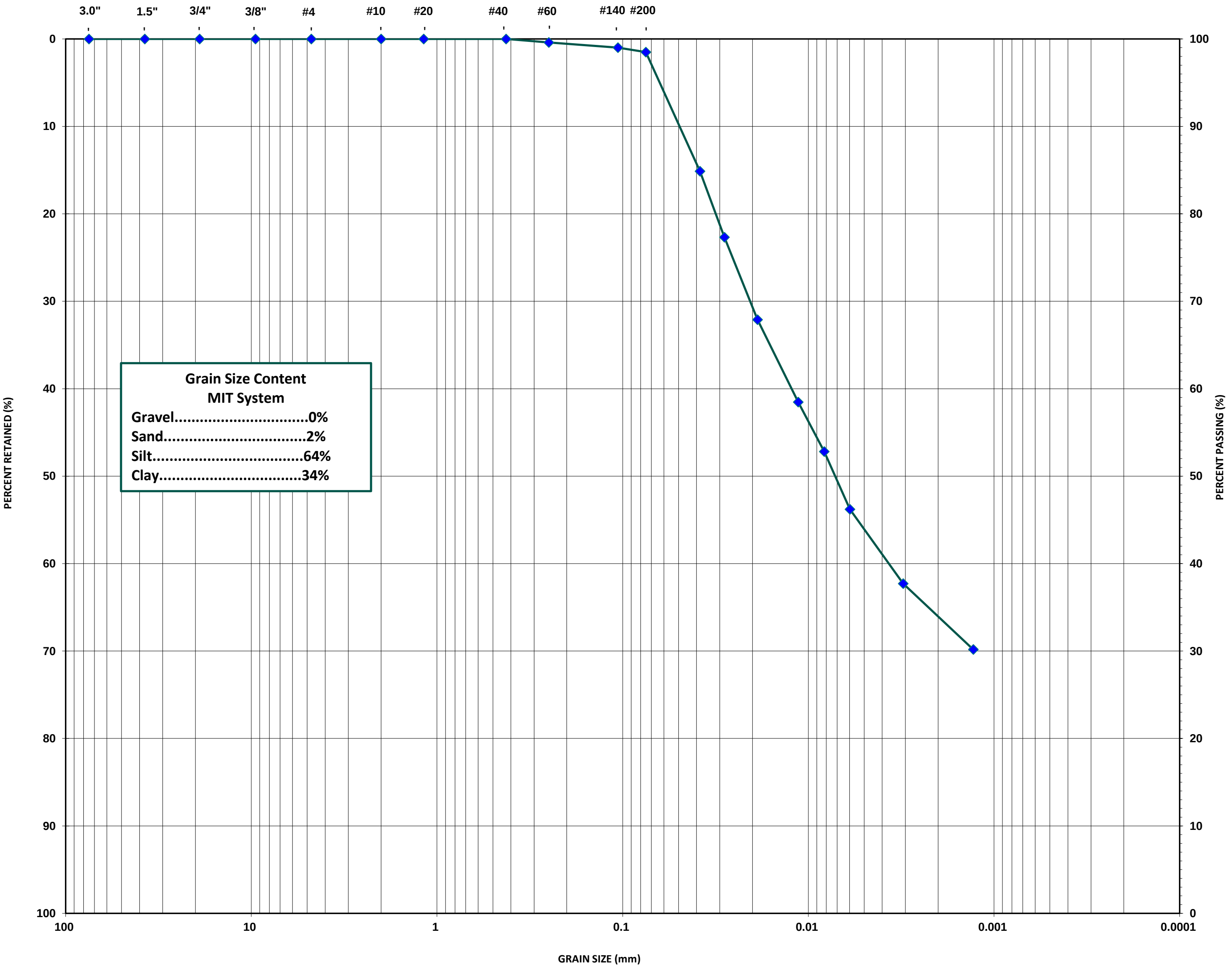
576 Bryne Drive, Unit 'O'
Barrie, ON
L4N 9P6

Hydrometer Analysis Form

Project Number:	23-117-01	**Location:**	Severn, ON	**Project Name:**	Hawk Ridge Residential Development
Sample Date:	January 8, 2024	**Test Date:**	February 1, 2024	**Client Name:**	LIV (Hawk Ridge) LP
Sample Description:	Clayey silt, trace sand	**Lab Number:**	146	**Tested By:**	J. Duguid
Sample Location:	Severn, ON	**Sample Depth:**	10 to 11.5'	**Sampled By:**	NC
Borehole Hole:	1	**Sample Number:**	5		
Estimated Septic T-Time:		N/A		Unified Soil Classification	ML

Grain Size Distribution

U.S. Standard Sieve Sizes



Grain Size Content
MIT System
Gravel................................0%
Sand..................................2%
Silt....................................64%
Clay.................................34%

MIT System	Gravel	Coarse	Medium	Fine	Silt	Clay
		Sand				

Unified System	Coarse	Fine	Coarse	Medium	Fine	Silt and Clay
	Gravel		Sand			

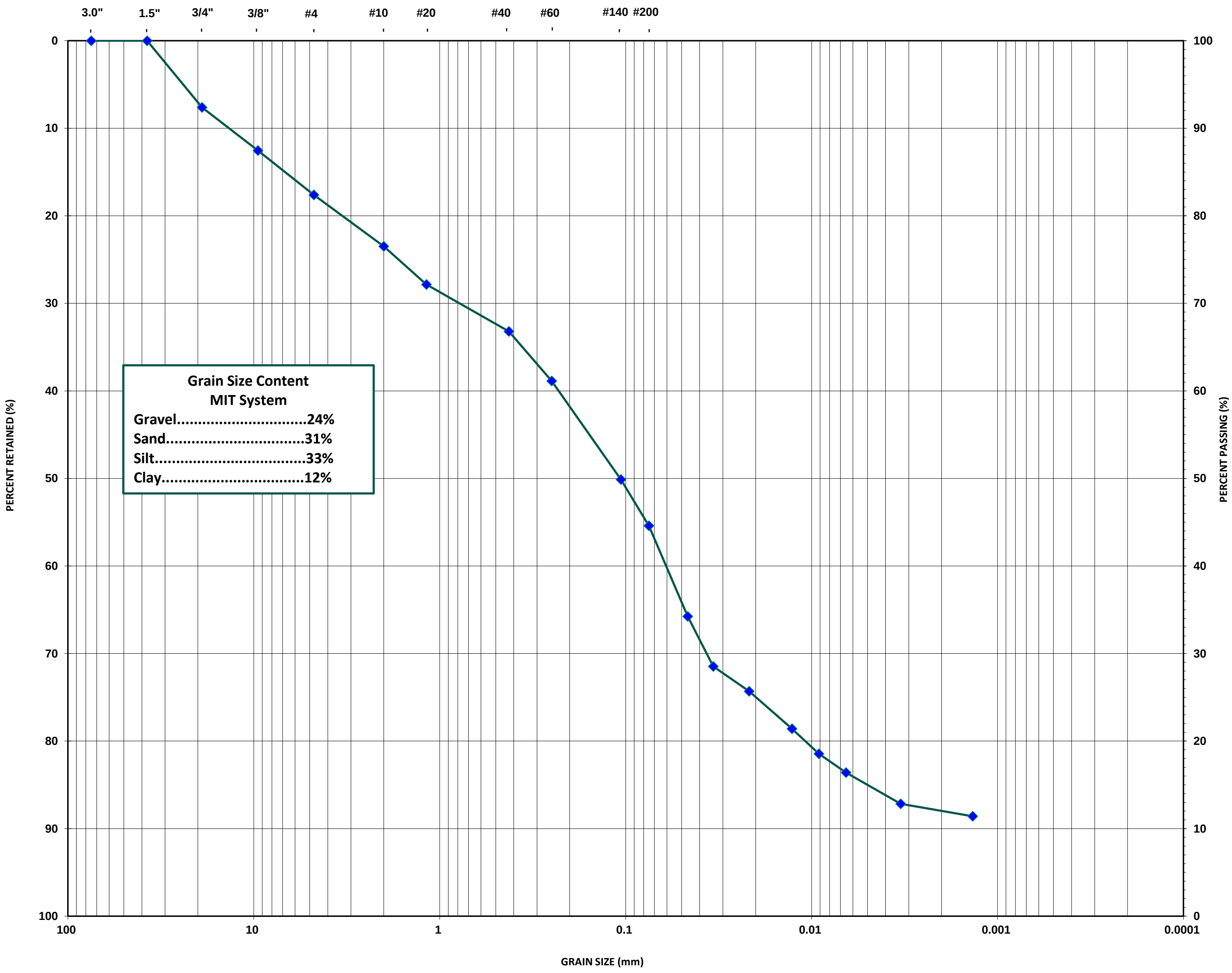
576 Bryne Drive, Unit 'O'
Barrie, ON
L4N 9P6

Hydrometer Analysis Form

Project Number:	**23-117-01**	**Location:**	**Severn, ON**	**Project Name:**	**Hawk Ridge Residential Development**
Sample Date:	**January 5, 2024**	**Test Date:**	**February 1, 2024**	**Client Name:**	**LIV (Hawk Ridge) LP**
Sample Description:	**Silty, gravelly sand, some clay**	**Lab Number:**	**147**	**Tested By:**	**J. Duguid**
Sample Location:	**Severn, ON**	**Sample Depth:**	**10 to 11.5'**	**Sampled By:**	**NC**
Borehole Hole:	**6**	**Sample Number:**	**5**		
Estimated Septic T-Time:	**N/A**	**Unified Soil Classification**	**SM**		

Grain Size Distribution

U.S. Standard Sieve Sizes



Grain Size Content
MIT System
Gravel..............................24%
Sand................................31%
Silt...................................33%
Clay.................................12%

MIT System	Gravel	Coarse	Medium	Fine	Silt	Clay
		Sand				

Unified System	Coarse	Fine	Coarse	Medium	Fine	Silt and Clay
	Gravel		Sand			

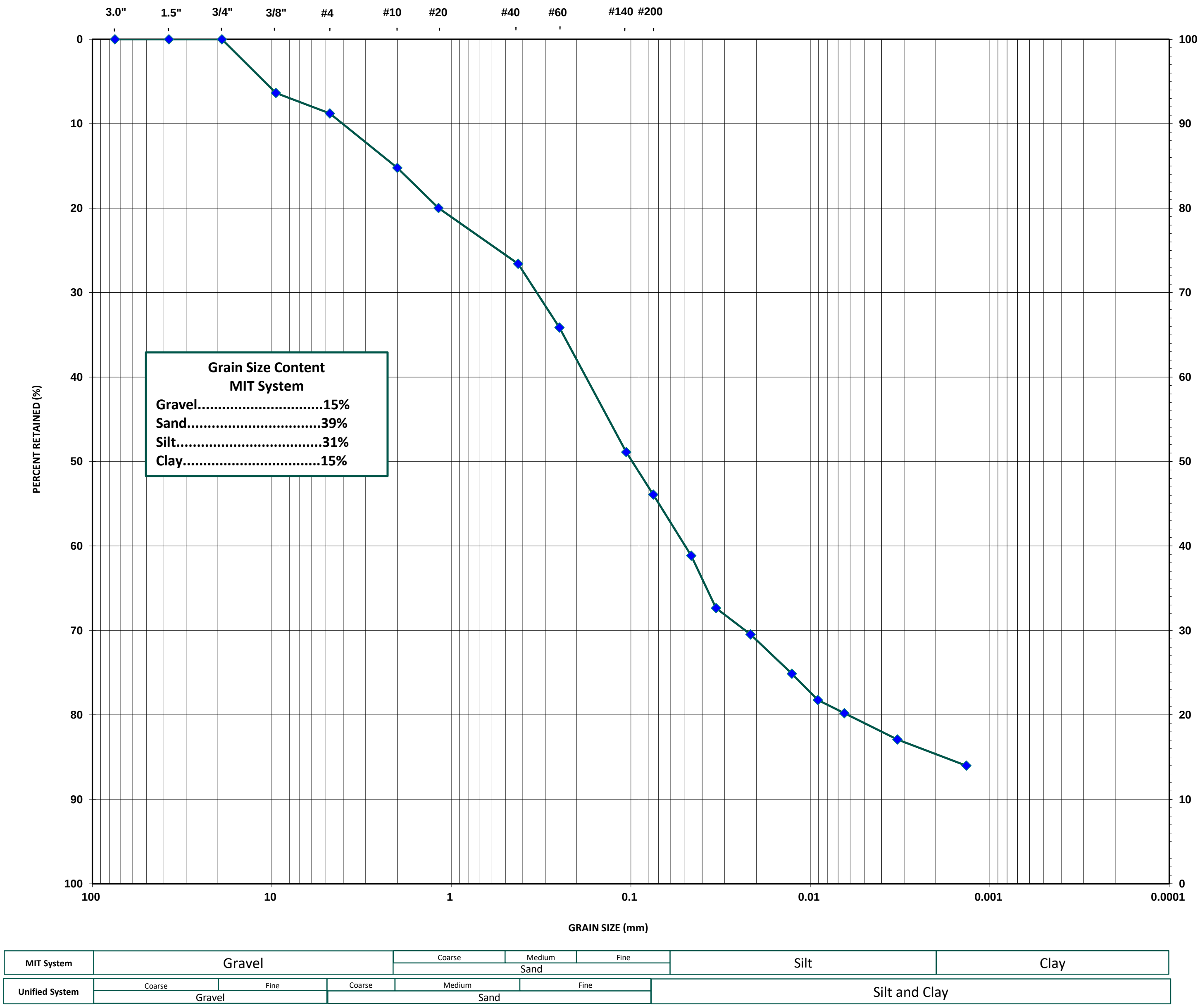
576 Bryne Drive, Unit 'O'
Barrie, ON
L4N 9P6

Hydrometer Analysis Form

Project Number:	23-117-01	**Location:**	Severn, ON	**Project Name:**	Hawk Ridge Residential Development
Sample Date:	January 9, 2024	**Test Date:**	February 1, 2024	**Client Name:**	LIV (Hawk Ridge) LP
Sample Description:	Silty sand, some gravel, some clay	**Lab Number:**	148	**Tested By:**	J. Duguid
Sample Location:	Severn, ON	**Sample Depth:**	7.5 to 9'	**Sampled By:**	NC
Borehole Hole:	11	**Sample Number:**	4		
Estimated Septic T-Time:	N/A	Unified Soil Classification	SM		

Grain Size Distribution

U.S. Standard Sieve Sizes



Grain Size Content
MIT System
Gravel..............................15%
Sand................................39%
Silt...................................31%
Clay.................................15%

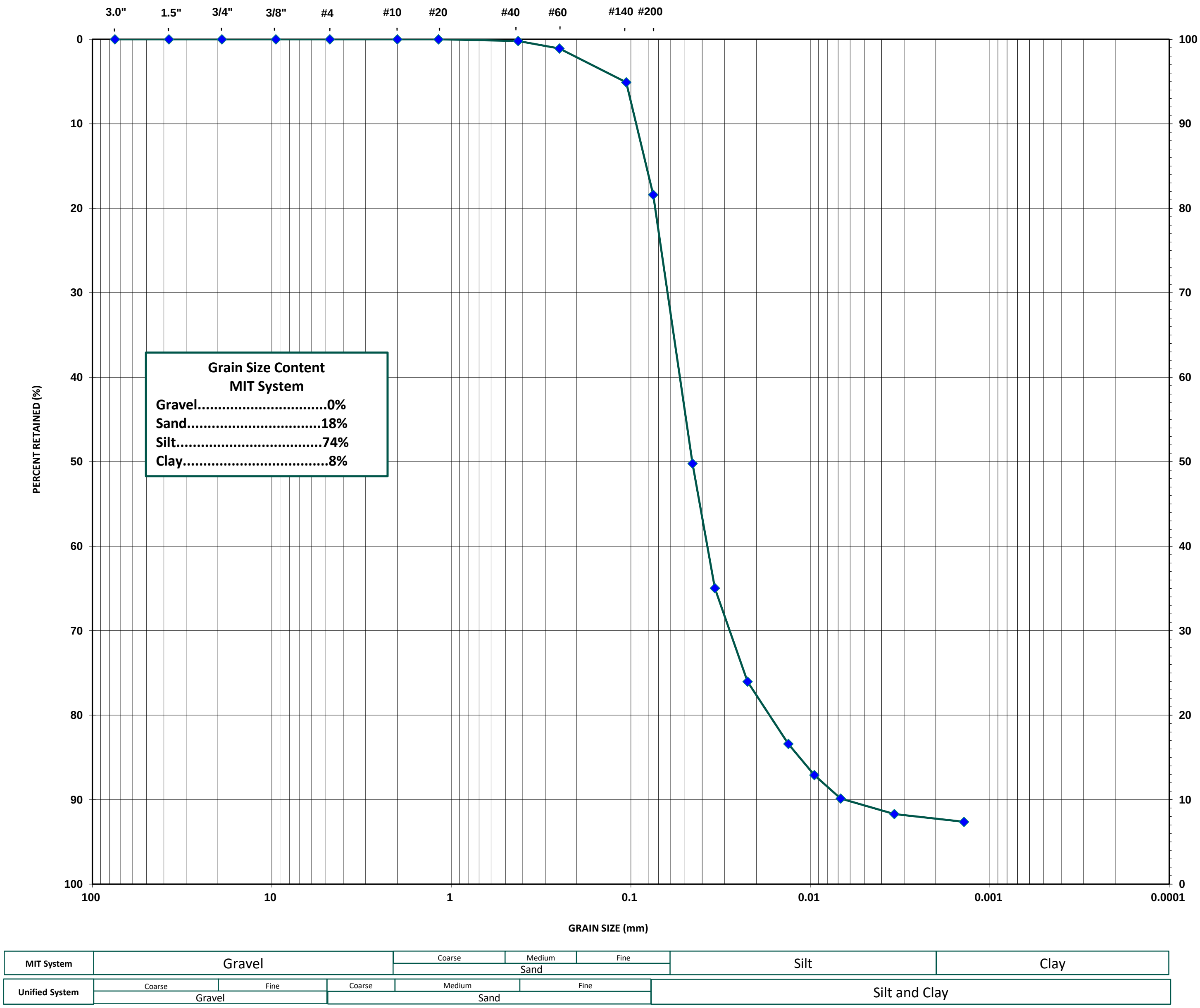
576 Bryne Drive, Unit 'O'
Barrie, ON
L4N 9P6

Hydrometer Analysis Form

Project Number:	**23-117-01**	**Location:**	**Severn, ON**	**Project Name:**	**Hawk Ridge Residential Development**
Sample Date:	**January 11, 2024**	**Test Date:**	**February 1, 2024**	**Client Name:**	**LIV (Hawk Ridge) LP**
Sample Description:	**Silt, some sand, trace clay**	**Lab Number:**	**149**	**Tested By:**	**J. Duguid**
Sample Location:	**Severn, ON**	**Sample Depth:**	**2 to 4'**	**Sampled By:**	**NC**
Borehole Hole:	**17**	**Sample Number:**	**2**		
Estimated Septic T-Time:		**N/A**		**Unified Soil Classification**	**SM**

Grain Size Distribution

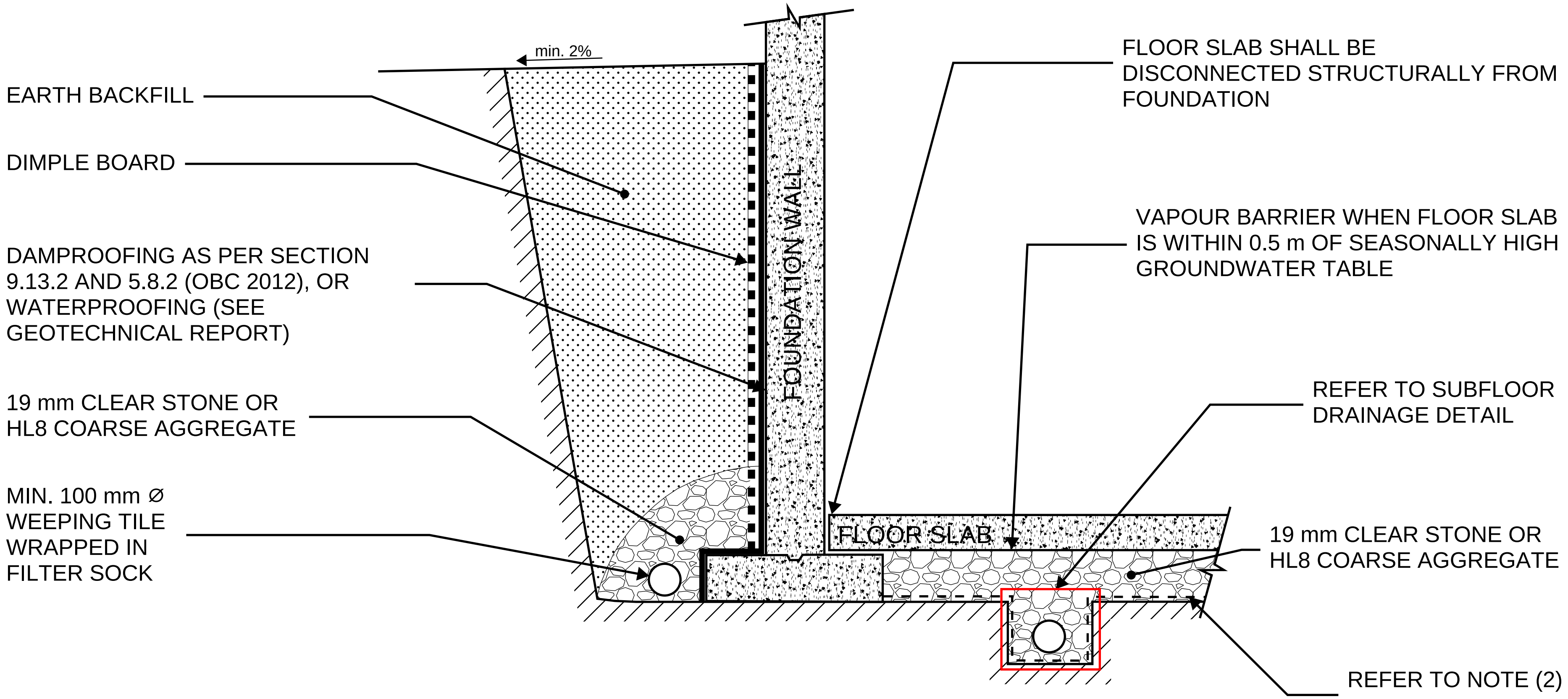
U.S. Standard Sieve Sizes



Grain Size Content
MIT System

Gravel................................0%
Sand.................................18%
Silt....................................74%
Clay...................................8%

APPENDIX C



NOTES:

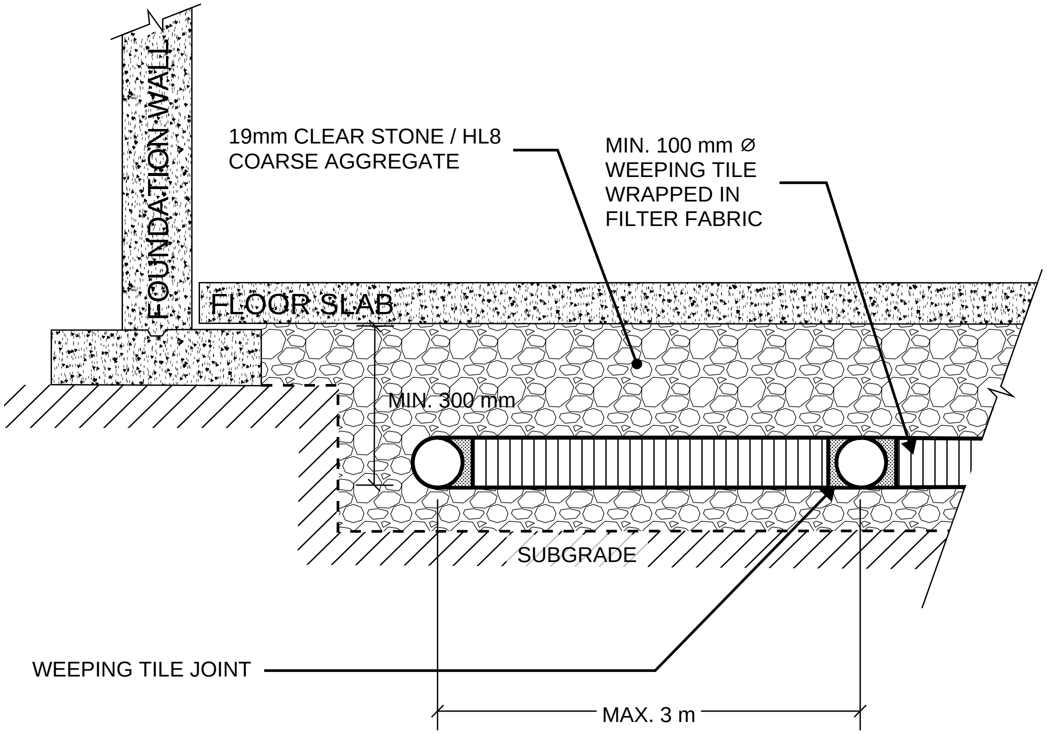
1. TYPICAL SCHEMATIC ONLY. MUST BE READ IN CONJUNCTION WITH GEOTECHNICAL REPORT.
2. WHEN THE SUBGRADE CONSISTS OF COHESIONLESS SOIL, IT MUST BE SEPARATED FROM THE SUBFLOOR DRAINAGE LAYER USING A NON-WOVEN GEOTEXTILE (TERRAFIX 360R OR EQUIVALENT)
3. NOT TO SCALE

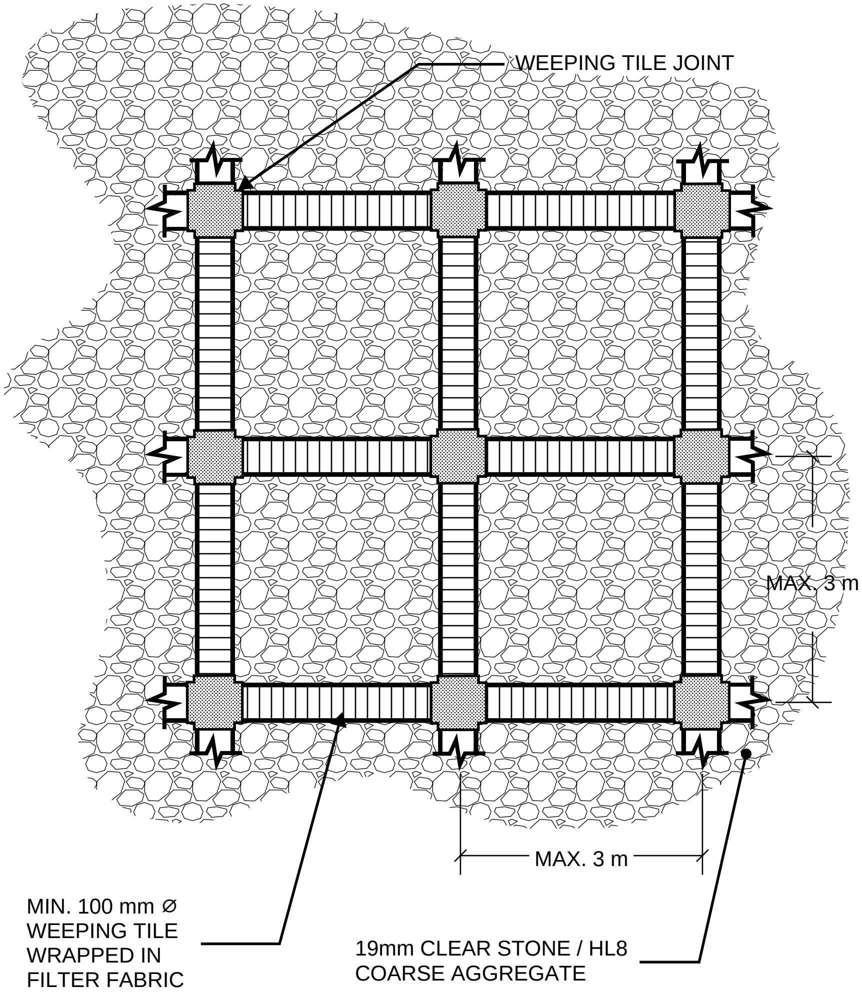
Title:

TYPICAL BASEMENT DRAINAGE SCHEMATIC (OPEN EXCAVATION)

GREEN GEOTECHNICAL

576 Bryne Drive, Unit 'O', Barrie, ON
705-503-9626
info@greengeo.ca





NOTES:

1. TYPICAL SCHEMATIC ONLY. MUST BE READ IN CONJUNCTION WITH GEOTECHNICAL REPORT.
2. WHEN THE SUBGRADE CONSISTS OF COHESIONLESS SOIL, IT MUST BE SEPARATED FROM THE SUBFLOOR DRAINAGE LAYER USING A NON-WOVEN GEOTEXTILE (TERRAFIX 360R OR EQUIVALENT)
3. UNDERFLOOR DRAINAGE SHOULD OUTLET TO PERIMETER DRAINAGE SYSTEM AND/OR SUMP PUMP
4. NOT TO SCALE

Title:

UNDERFLOOR DRAINAGE (SLAB WITHIN 1m OF SEASONALLY HIGH GWT)

GREEN GEOTECHNICAL

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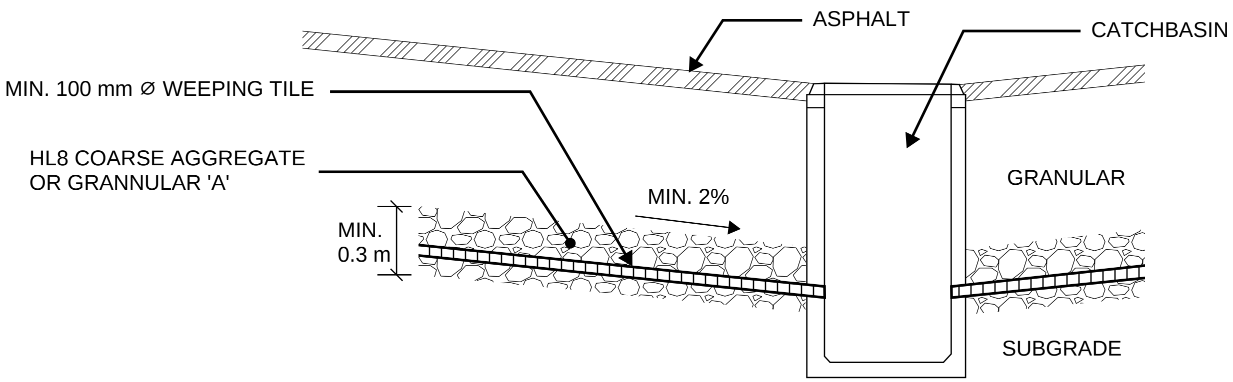
705-503-9626
info@greengeo.ca

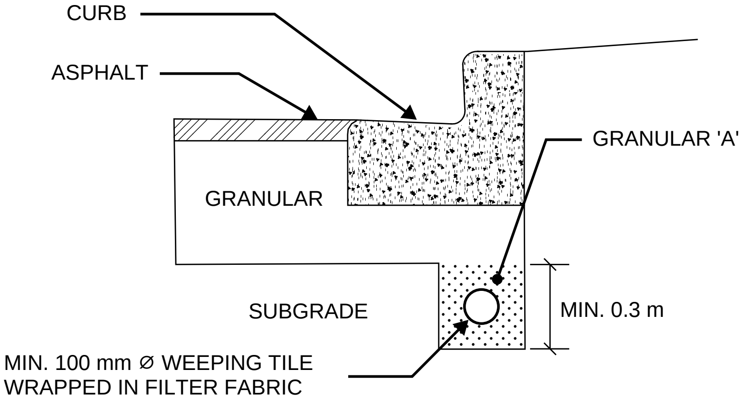
APPENDIX D

LONGITUDINAL SUBDRAIN CONNECTION TO CATCHBASIN

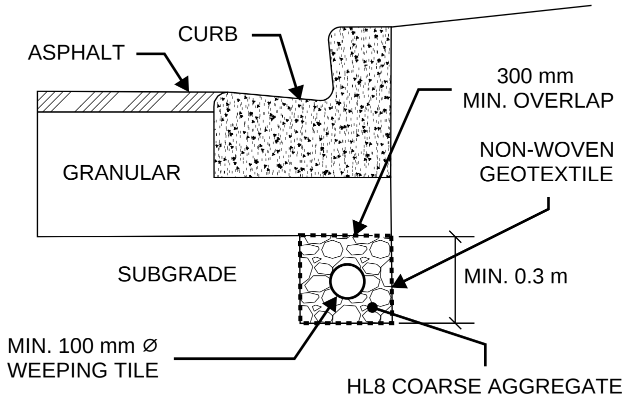


URBAN CROSS SECTIONS

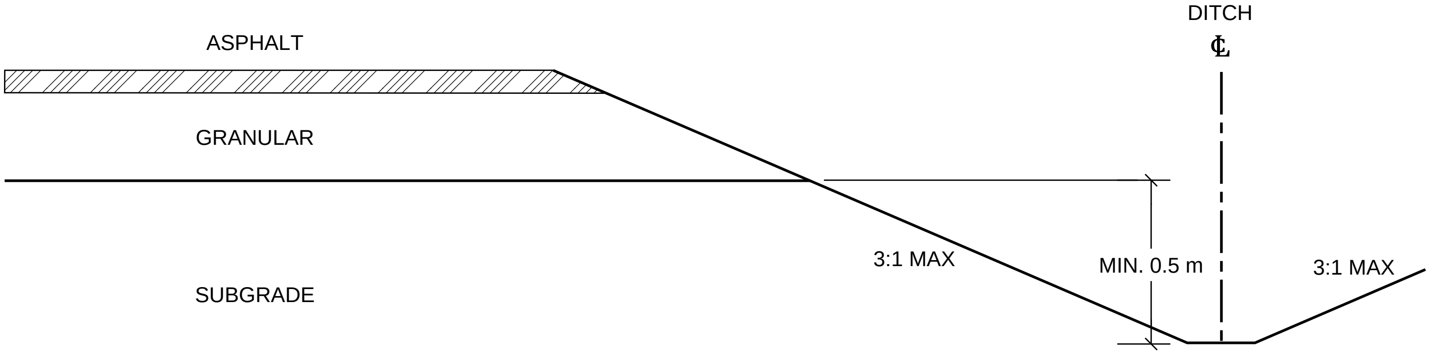
WEEPING TILE WITH FILTER FABRIC



WEEPING TILE WITHOUT FILTER FABRIC



RURAL CROSS SECTIONS



Title:

PAVEMENT DRAINAGE ALTERNATIVES

GREEN GEOTECHNICAL

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705-503-9626
info@greengeo.ca

APPENDIX E

ENGINEERED FILL SPECIFICATIONS

Overview

- Engineered Fill is a pre-approved material which has been placed under the full-time supervision of Green Geotechnical, including testing and inspection during construction to ensure subgrade stability, material quality, proper lift thickness, and adequate compaction have all been maintained.
- Engineered Fill is used to accommodate structural loads (such as for foundations, slabs, etc.) where site grades are being altered, or in order to accommodate structural design loads.
- Prior to concrete placement for footings and poured walls on Engineered Fill, Green Geotechnical must inspect the foundation subgrade soils, and reinforcing steel respectively.

Design

- Engineered fill material must be free of organic inclusions, construction debris, and any other deleterious material.
- Ideally, granular type soils, with less than 8% fines, such as OPSS 1010 Granular 'B,' are used.
- In sites where a high groundwater table or where wet conditions exist, (even with dewatering operations), in order to achieve stable layers and the specified compaction on the first one to two lifts, OPSS 1010 Granular 'B' Type II or 50 mm crusher run limestone may be advisable.
- The determination of whether the site soils are suitable for reuse as Engineered Fill, or if an imported material is to be used, is at the discretion of the opinion of the Geotechnical Engineer.
- Post construction settlement of the Engineered Fill is to be expected. The timeframe that this occurs varies based on the type of material used. Typically, time intervals of the following can be used:

	Self-Consolidation Settlement		**Foundation Loading Settlement**	
Material	**Settlement Rate**	**Time Rate**	**Settlement Rate**	**Time Rate**
Granular 'B' or Coarser	Minimal (0.2% D)	Immediate	Minor (0.5", 12mm)	Immediate
Fine Sand	Minimal (0.5% D)	1-50 hours	Minor (0.75", 19mm)	1-50 hours
Sandy Silt	Minor (0.75% D)	2-30 days	Minor (1", 25mm)	2-30 days
Clayey Silt	Moderate (1% D)	3-6 months	Moderate (1.25", 31mm)	3-6 months
Silty Clay	Major (1.5% D)	6-7 years	Major (1.5", 37mm)	6-7 years

D is the depth of the Engineered Fill

- It is imperative for avoiding excessive settlements that the construction of foundations take into account the post-construction settlement period.
- Engineered Fill is to extend a minimum of 1m beyond the base of any structure's foundations, and project down to the subgrade at a slope with a maximum steepness of 1H:1V.
- An allowable design bearing capacity of 150 kPa (SLS) can usually be used for Engineered Fill constructed on a stable, approved subgrade.
  - This is unless a different bearing capacity for the Engineered Fill has been recommended by the Geotechnical Engineer, based on the properties of the site soils.
- The Engineered Fill is to extend at least 1m above the highest foundation base elevation to provide the Engineered Fill at founding level(s) protection from frost, precipitation, runoff, wind, and weathering.
- Poured concrete footings are to be a minimum width of 0.6m for strip footings and 1.0m for individual footings.

- Reinforcing steel comprised of two (2) continuous 15M bars at the top and bottom of foundation walls, and 15M bars spaced at 0.3m in column pad footings, are required in all poured concrete foundations.

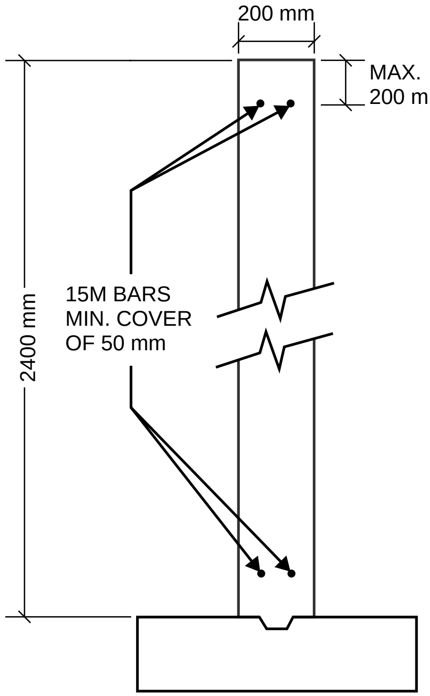
Construction

- Surveying should be done by the earthworks contractor or the surveying contractor to ensure that Engineered fill elevations and footprint are accurate and meet the specifications outlined in this document.
- The elevations should be provided to Green Geotechnical by the earthworks contractor or the surveying contractor at each placed lift of material, for recording compaction levels by elevation, and to ensure proper lift thickness.
- Topsoil and uncontrolled fill/deleterious material are to be excavated, leaving a stable, dry, native subgrade.
- Dewatering may be required, depending on the groundwater conditions at the site.
- Prior to the placement of any Engineered Fill, Green Geotechnical must approve the stability of the exposed native subgrade for Engineered Fill placement.
- Depending on the groundwater conditions and soil type at the site, a proof-roll with a heavy compaction roller or rubber-tire front-end loader with a full bucket may be required on the subgrade. Any noted unstable areas will have to be sub-excavated and brought back up with the placement of Engineered Fill.
- As previously mentioned, if wet conditions exist at the site, for the first one to two lifts of the Engineered Fill, the use of OPSS 101 Granular 'B' Type II or 50 mm crusher run limestone may be advisable.
- All material must be compacted to at least 98% SPMDD (Standard Proctor Maximum Dry Density) within 2% of OMC (Optimum Moisture Content).
- Green Geotechnical will take a sample of the Engineered Fill material to determine its SPMDD, OMC, and gradation.
- Green Geotechnical must test the compaction of the placed Engineered Fill at each lift.
- In wet site conditions, it is typically advisable that the first lift be static rolled, and that all subsequent lifts be compacted with vibration. In dry site conditions, compaction by vibration can occur at all lifts.
- Engineered Fill material shall be placed in maximum 150mm loose lifts.
    - The only exception to this is in the first one to two lifts placed in wet site conditions. Here, loose lifts shall be a maximum of 300mm-450mm.
- Engineered Fill should not be placed during months where freezing temperatures occur.

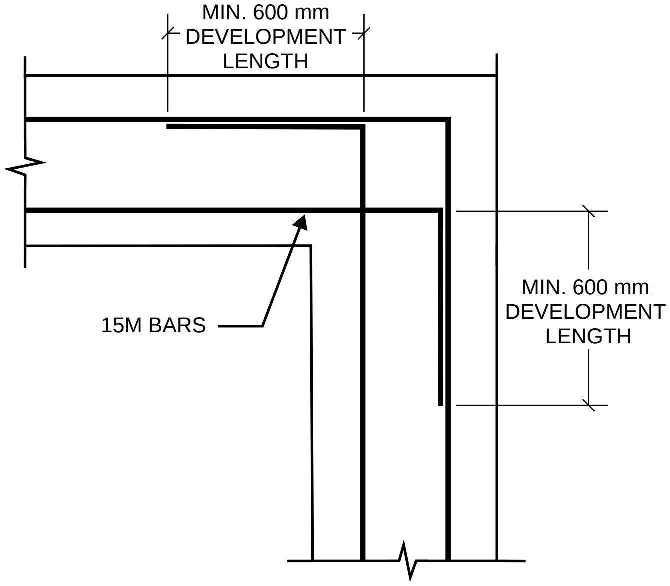
Certification

- Green Geotechnical must be present during Engineered Fill construction to approve the native subgrade, approve of and take a sample of the material, as well as record compaction and lift thickness at every lift.
    - Following this, a letter signed and sealed by a P.Eng. will be submitted certifying the Engineered Fill as being properly constructed, and displaying the field records.
- Green Geotechnical must inspect the foundation subgrade immediately prior to the placement of concrete for footings.
    - Following this, a letter signed and sealed by a P.Eng. will be submitted certifying the Engineered Fill foundation subgrade as being adequate to support the design bearing capacity.
- Green Geotechnical must inspect the reinforcing steel in the foundation walls prior to the placement of concrete. See the attached Typical Reinforced Wall Detail for more information.
    - Following this, a letter signed and sealed by a P.Eng. will be submitted certifying the reinforcing steel as being placed in accordance with the design.

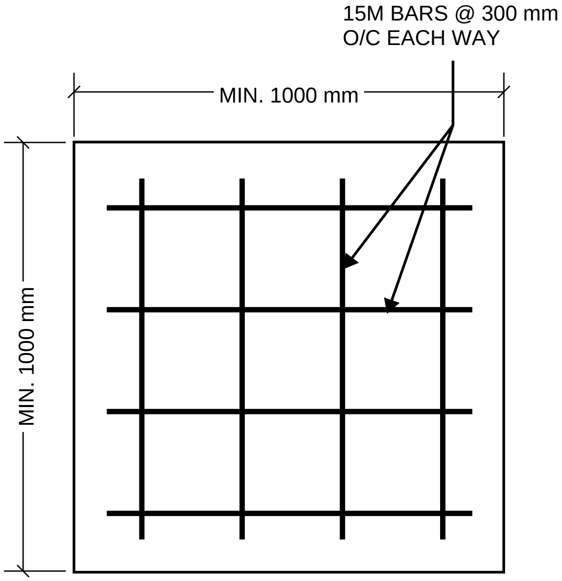
TYPICAL REINFORCED WALL



TYPICAL SPLICING AT CORNERS

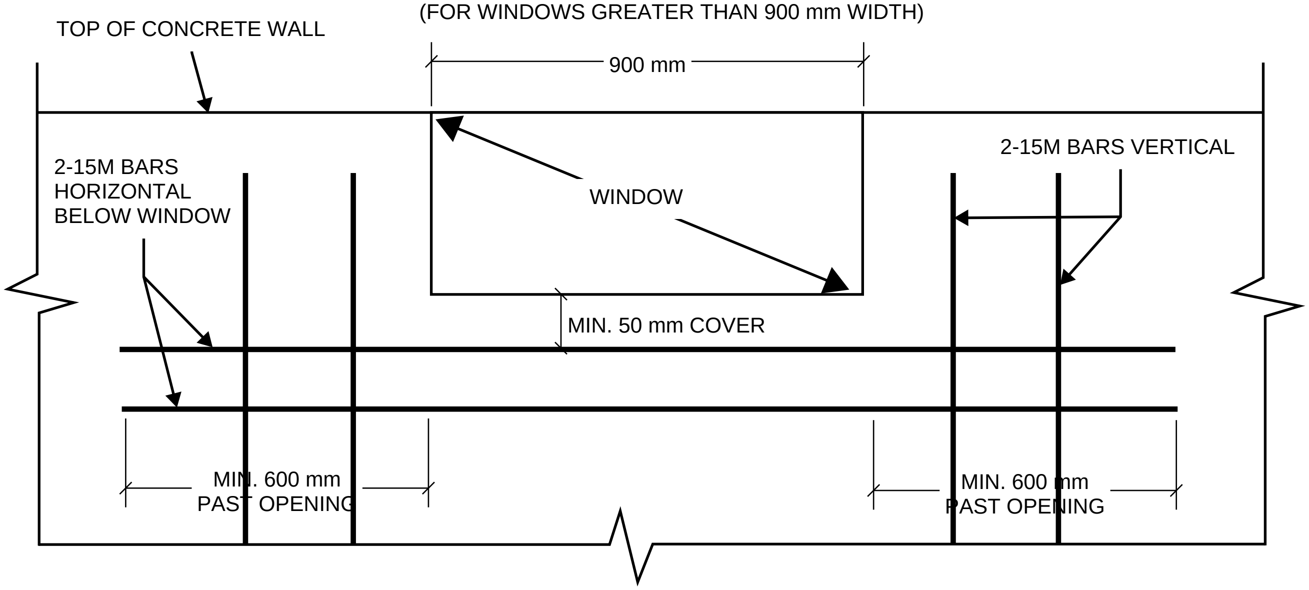


TYPICAL REINFORCEMENT OF COLUMN FOOTINGS



TYPICAL WINDOW REINFORCING

(FOR WINDOWS GREATER THAN 900 mm WIDTH)



NOTES:

1. REINFORCING STEEL C.S.A G30.18-09 GRADE 400
2. CONCRETE MINIMUM 28 DAY STRENGTH 20 MPa
3. BASE OF ALL FOOTING EXCAVATIONG TO BE INSPECTED AND APPROVED PRIOR TO PLACING FORMWORK
4. TO BE USED IN CONJUNCTION WITH STRUCTURAL REPORT
5. DRAWINGS ARE NOT TO SCALE

Title:

TYPICAL REINFORCED WALL DETAILS FOR HOUSES ON ENGINEERED FILL

GREEN GEOTECHNICAL

576 Bryne Drive, Unit 'O', Barrie, ON
705-503-9626
info@greengeo.ca