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A REPORT TO
SPHERE DEVELOPMENTS (KINGSTON) LP

A SUPPLEMENTARY GEOTECHNICAL INVESTIGATION FOR PROPOSED MIXED-USE DEVELOPMENT

875 KINGSTON ROAD

CITY OF PICKERING

REFERENCE NO. 2204-S019

MARCH 2023

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1.0 INTRODUCTION

In accordance with written authorization dated January 23, 2023, from Mr. Rohan Gawri of Sphere Developments (Kingston) LP, a supplementary geotechnical investigation was conducted at 875 Kingston Road, in the City of Pickering.

An initial geotechnical investigation was performed at the subject site in 2022 for a proposed mixed-use development with two-level underground parking. It is understood that the design has revised for four-level of underground parking. Thus, a supplementary investigation with deep boreholes is required to support the latest design.

The purpose of the supplementary investigation was to reveal addition subsurface, including the quality and strength of the shale bedrock, to determine the engineering properties of the disclosed subsoil bedrock for the design and construction of the mixed-use development with four-level underground parking. The geotechnical findings from both initial and supplementary investigation along with relevant geotechnical recommendations are presented in this report.

2.0 SITE AND PROJECT DESCRIPTION

The City of Pickering is situated on Iroquois (glacial lake) plain where, in places, the glacial till stratigraphy has been partly eroded by the water action of the glacial lake and filled with lacustrine sand, silt, clay and reworked till.

The subject site, encompassing a total area of 7,471.20 square metres, is located between Kingston Road and Highway 401, approximately 650 m east of Whites Road North in the City of Pickering. It is currently vacant with weed and tree growth. The existing site gradient generally descends towards the west and south.

Based on the revised site plan drawings prepared by Icon Architects Inc. dated March 1, 2023, it is understood that the property will be developed for a 17-storey mixed-use building with four levels of underground parking. The finished floor elevation (FFE) varies from El. 96.30 to 97.40 m and the P4 level is at El. 80.39 m.

3.0 FIELD WORK

The initial field work, consisting of seven (7) sampled boreholes, was performed between May 3 and 6, 2022. These boreholes were terminated at the refusal depth of augering, at 7.7 to 15.6 m from the prevailing ground surface. Upon the completion of borehole drilling and sampling, five (5) monitoring wells were installed in the selected boreholes to facilitate groundwater monitoring and hydrogeological assessment.

The supplementary field work, consisting of two (2) boreholes, extending to the depths of 15.5 m and 18.3 m, was completed between February 6 and 13, 2023. The boreholes and monitoring wells were illustrated on Drawing No. 1.

The boreholes were advanced at intervals to the sampling depths by a track-mounted machine using solid stem auger, and equipped with split spoon sampler for soil sampling. Split-spoon samples were recovered for soil classification and laboratory testing. Standard Penetration Tests, using the procedures described on the enclosed “List of Abbreviations and Terms,” were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or ‘N’ values) of the subsoil. The relative density of the non-cohesive strata and the consistency of the cohesive strata are inferred from the ‘N’ values. The field work was supervised and the findings were recorded by a Geotechnical Technician.

Refusal to augering occurred at a depth of 12.0 m and 13.5 m below the prevailing ground surface in supplementary boreholes. HQ (63.5 mm diameter) size rock cores were collected in both boreholes to assess the continuity and quality of bedrock up to a depth of 15.5 m and 18.3 m from the prevailing ground surface. The rock quality and the unconfined compressive strength of rock specimen have been assessed.

The ground elevation at each borehole location and monitoring well was determined using a hand-held Global Navigation Satellite System (GNSS) equipment and the spot elevations on the site plan provided by the client.

4.0 **SUBSURFACE CONDITIONS**

The boreholes were drilled on the weed covered area. The investigation has revealed that beneath a topsoil and a layer of earth fill in one of the boreholes, the area is underlain by silty clay and silty clay till deposit, overlying shale bedrock.

Detailed descriptions of the encountered subsurface conditions are presented on the enclosed Borehole Logs comprising Figures 1 to 9, inclusive. The revealed stratigraphy is plotted on the Subruface Profile, Drawing No. 2. The engineering properties of the disclosed soils are discussed herein.

4.1 **Topsoil** (All Boreholes)

The ground surface is covered by topsoil veneer, approximately 20 cm to 60 cm in thickness. Thicker topsoil may occur in low lying areas beyond the borehole locations.

4.2 **Earth Fill** (Borehole 1)

A layer of earth fill, extending to a depth of 1.5 m, was contacted beneath the topsoil layer in Borehole 1. It consisted of silty clay, with topsoil inclusions.

4.3 **Silty Clay Till/Silty Clay** (All Boreholes)

Beneath the topsoil and/or a layer of earth fill, silty clay and silty clay till deposits were contacted, extending to auger refusal depths of the boreholes. Grain size analyses were performed on four (4) representative samples of silty clay till and four (4) samples of silty clay; the results are plotted on Figures 8 and 9, respectively.

Atterberg Limits were also performed on four (4) selected samples and the results are plotted in the respective borehole log. The resulting Liquid Limit and Plastic Limit are summarized below:

Liquid Limit:	37% to 43%
Plastic Limit:	19% and 22%

Based on the results, this indicates both clay and clay till are medium in plasticity.

The natural water content of the clay and clay till samples were determined; the results range from 7% to 27%, with a median of 12%, indicating that the clay and clay till are in moist conditions.

The obtained ‘N’ values of the clay and clay till range from 8 to more than 100, with a median of 62 blows per 30 cm of penetration, indicating that the clay and clay till are stiff to hard, being generally hard in consistency.

The engineering properties of the clay and clay till are given below:

- High frost susceptibility and low water erodibility.
- Low permeability, with an estimated coefficient of permeability of 10^{-7} cm/sec and a percolation time of 80 min/cm.

- Both clay and clay till will be relatively stable in steep excavation; however, the sides of the excavation may slough due to prolonged exposure.
- Moderately high corrosivity to buried metal, with an estimated electrical resistivity of 3000 ohm·cm.

4.4 Shale Bedrock (All Boreholes)

During the initial investigation, shale fragments and refusal to augering was encountered in the boreholes, at a depth of 7.7 to 15.6 m (or El. 81.0 to 85.4 m). Subsequently, rock coring was performed at the supplementary boreholes at the refusal depth of 12.0 m and 13.5 m below the prevailing ground surface. HQ size rock cores extended to the depths of 15.5 m and 18.3 m. The quality and the soundness of bedrock are determined by interpreting the RC and the RQD of rock cores, as presented on the borehole logs.

Shale bedrock is a laminated, sedimentary, moderately soft rock composed predominantly of clay material. The shale is grey in colour.

The surface of the shale bedrock is generally fissured as a result of weathering. Infiltrated precipitation and groundwater from the overburden soils will often permeate the fissures in the rock and, in places, will be under subterranean artesian pressure. However, because the shale is a clay rock, it is considered to be a material of low permeability and a poor aquifer, and the groundwater yield from the rock will be limited. The water content values of the rock fragments or rock dust are determined in the range of 7% to 14%.

One rock specimen was selected from the cored samples for Unconfined Compression Test (CSA A23.2-14C) in our laboratory. The test results are presented in Figure 8 and summarized in Table 1.

Table 1 - Uniaxial Compressive Strength of Rock Specimen

Location	**Borehole 101**
Sample Depth	15.7-16.0 m
Elevation	79.9-80.2 m
Compressive Strength	15.2 MPa

The shale can be classified as “Weak Rock” of poor to excellent quality, with RQD values between 0% and 75%. The rock quality generally improves with depth. Sound shale is considered at a depth below 4 or 5 m from the rock level.

Weathered shale can be excavated with considerable effort using a heavy-duty excavator equipped with a rock-ripper. However, excavation will become progressively more difficult with depth into the sound shale. Efficient removal of the sound shale will require the aid of pneumatic hammering and/or blasting.

The shale is susceptible to disintegration and swelling upon exposure to air and water, with subsequent reversion to a clay soil, but the laminated limy and sandy layers would remain as rock slabs. When excavating into the sound shale, slight lateral displacement of the excavation wall is often experienced. This is due to the release of residual stress stored in the bedrock mantle and the swelling characteristic of the rock.

5.0 GROUNDWATER CONDITION

Records of groundwater were not feasible in the boreholes upon completion of drilling since potable water was used. However, groundwater was recorded in the monitoring wells on May 12 and June 14, 2022. These records are summarized in Table 2.

Table 2 - Groundwater Level in Monitoring Wells

Monitoring Well No.	**Ground Elevation (m)**	**Well Depth (m)**	**Measured Groundwater Level**			
			May 12, 2022		**June 14, 2022**	
			Depth (m)	**El. (m)**	**Depth (m)**	**El. (m)**
1	95.2	13.8	3.3	91.9	3.0	92.2
2	97.6	15.6	11.9	85.7	10.8	86.8
4	96.9	14.7	12.2	84.7	10.6	86.3
5	93.7	12.3	1.5	92.2	1.5	92.2
7	93.1	7.7	1.4	91.7	1.4	91.7

Groundwater was recorded in the monitoring wells at a depth of 1.4 to 12.2 m, or between El. 84.7 to 92.2 m. Based on the natural water content, soil stratigraphy and water levels, perched water exists in the sand and silt layers within the silty clay and silty clay till deposits and is subject to seasonal fluctuation. Continuous groundwater, however, is not anticipated within the depth of investigation. Detail groundwater condition of the site will be discussed in the hydrogeological report, under separate cover.

6.0 DISCUSSION AND RECOMMENDATIONS

The boreholes were drilled on the weed covered area. The investigation has revealed that beneath topsoil and a layer of earth fill in Borehole 1, the area is underlain by a stiff to hard silty clay and silty clay till deposits, overlying shale.

Groundwater was recorded in the monitoring wells at a depth of 1.4 to 12.2 m, or between El. 84.7 to 92.2 m.

Based on the site plan, the property will be developed for a 17-storey mixed-use building with four-level underground parking. The geotechnical findings which warrant special consideration are presented below:

1. With four-level underground parking, P4 level is at El. 80.39 m, which will extend into the shale bedrock. The shale bedrock is suitable to support the proposed buildings on conventional spread and strip footings.
2. Perimeter drainage and dampproofing of the foundation walls will be required for the underground structure.
3. Where slope excavation is not feasible, a brace shoring will be required.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 Foundations

It is understood that the proposed development will consist of four-level underground parking with the P4 level at El. 80.39 m. The bulk excavation is anticipated to extend into the shale bedrock. The building should be supported on shale bedrock, using conventional spread and strip footings. The recommended bearing pressures at Serviceability Limit State (SLS) and Ultimate Limit State (ULS) for the design of conventional footings on weather shale bedrock are provided:

- Maximum Bearing Pressure on weathered bedrock, at SLS = 1000 kPa
- Factored Ultimate Bearing Pressure, at ULS = 1500 kPa

The total and differential settlements of footings founded on weathered bedrock are estimated to be 25 mm and 20 mm, respectively.

Where the foundation is founded on sound shale bedrock, based on the compression test on the rock sample, the design bearing pressure of 2200 kPa (ULS) can be used for the design of footings founded on sound shale bedrock.

The sound bedrock is considered unyielding material where the total and differential settlements of footings are considered negligible. As such, the SLS value is not provided since it does not govern the design.

The foundation subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to ensure that the revealed conditions are compatible with the foundation design requirements.

The bedrock is subject to disintegration and swelling after it is exposed. A mud slab of lean mix concrete, approximately 80 mm in thickness, should be placed on the exposed shale bedrock immediately after it is inspected.

Footings exposed to weathering, or in unheated areas, should have at least 1.2 m of earth cover for protection against frost action. For an unheated underground parking garage with limited open access, a minimum earth cover of 0.9 m for interior footings and 0.6 m for perimeter footings is necessary for frost protection. Footings adjacent to the fresh air ducts, the entrance of the garage and other areas which may be exposed to the extreme temperature from the exterior should be provided with a minimum frost cover of 1.2 m or properly insulated.

The foundations should meet the requirements specified in the latest Ontario Building Code. The structure should be designed to resist an earthquake force using Site Classification ‘C’ (very dense soil/soft rock).

6.2 **Underground Structure**

Slight lateral displacement of the excavation walls is often experienced in sound rock, due to the release of residual stress in the bedrock mantle and the swelling characteristics of shale. In areas where the perimeter walls extend into the sound bedrock, a compressible material of sprayed foam, 80 to 100 mm in thickness, should be placed between the concrete wall and the sound rock for protection against stress release.

The perimeter walls of the conventional underground structure should be designed to sustain a lateral earth pressure calculated using the soil parameters given in Section 6.7. Any applicable surcharge loads adjacent to the underground structure must also be considered in the design of the foundation walls.

The perimeter walls of conventional underground structures should be dampproofed and provided with a perimeter subdrain system. Backfill of open excavation should consist of free-draining granular material unless prefabricated drainage board is installed over the entire wall below grade, as shown in Drawing No. 3. At shoring location, prefabricated drainage board, such as Miradrain 6000, or equivalent, will be provided between the concrete wall and the shoring as shown on Drawing No. 4. The subdrains should be shielded by a fabric filter and covered with stone filter to prevent blockage by silting and discharge to a positive outlet.

The subgrade for slab-on-grade should consist of well compacted earth fill or bedrock. The concrete slab should be constructed on a granular bedding, consisting of 19-mm Crusher-Run Limestone (CRL), or equivalent, 15 cm in thickness, compacted to its maximum Standard Proctor dry density (SPDD).

The elevator pit, which normally extends a few metres below the floor level, should be designed as a submerged ‘tank’ structure with waterproofed pit walls and pit floor.

6.3 **Underground Services**

The subgrade for underground services should consist of sound native soils or properly compacted earth fill, free of organics. In areas where the subgrade consists of loose or wet soil, it should be subexcavated and replaced with bedding material, compacted to at least 98% SPDD.

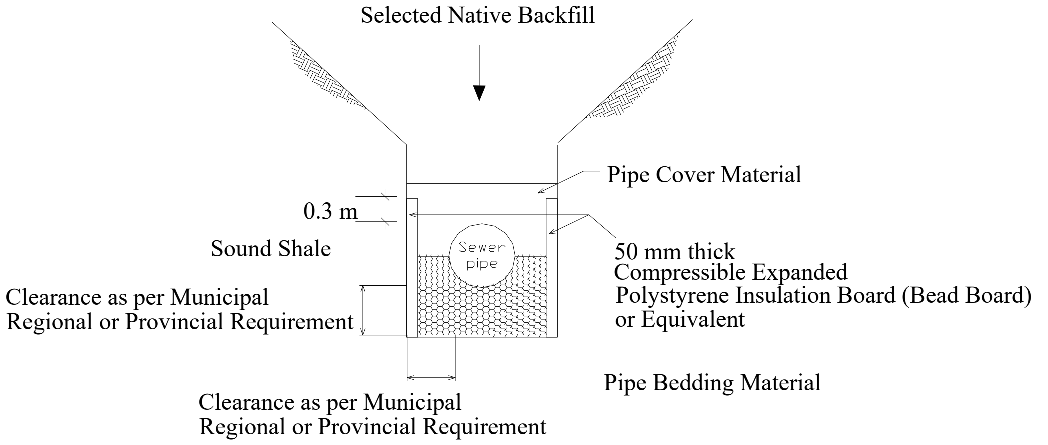
A Class ‘B’ bedding, consisting of compacted 19-mm CRL or equivalent, is recommended for construction of the underground services. The pipe joints connecting into the catch basins and manholes should be leak-proof, or wrapped with a waterproof membrane to prevent subgrade migration through leakage at joints resulting from inadvertent faulty installation.

Openings to subdrains and catch basins should be shielded with a fabric filter to prevent silting.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover with a thickness two times the diameter of the pipe should be in place at all times after completion of the pipe installation.

Where excavation for the services extends into the sound shale, the sides of trench should be sloped rather than vertical, due to the residual stress relief and the swelling characteristics of the shale. The side slopes should be no steeper than 2 vertical:1 horizontal. Alternatively, vertical trench walls can be lined with a cushioning foam layer and backfilled with sand up to 0.3 m above the crown of the pipe. The recommended scheme is illustrated in Diagram 1.

Diagram 1 - Sewer Installation in Sound Shale



NOTE: DRAWING NOT TO SCALE

All metal fittings for the underground services should be protected against soil corrosion. For estimation of anode weight requirements, the estimated electrical resistivity of the disclosed soil can be used. This, however, should be confirmed by testing the soil along the service pipe alignment at the time of site service construction. The proposed anode weight must meet the minimum requirement as specified by the City standard.

6.4 Backfilling in Trenches and Excavated Areas

The on-site inorganic soils are generally suitable for use as trench backfill. They should be free of deleterious materials or oversized (over 15 cm) boulders. The backfill should be compacted to 95% SPDD. The lift of each backfill layer should either be limited to a thickness of 20 cm, or the thickness should be determined by test strips.

The shale is susceptible to disintegration and swelling upon exposure to air and water, with subsequent reversion to a clay soil. If shale spoil is to be used immediately for structural backfill, it must be pulverized to sizes of 15 cm or less and compacted in lifts of less than 15 cm thick, and it will require continuous wetting during compaction.

Below concrete slab-on-grade, sidewalk, or within 1.0 m below the pavement subgrade, the backfill should be compacted to 98% SPDD with the water content at 2% to 3% drier than the optimum. This is to provide the required stiffness for pavement and slab-on-grade construction.

In normal construction practice, the problem areas of ground settlement largely occur adjacent to manholes, catch basins, services crossing, foundation walls and columns. In areas which are inaccessible to a heavy compactor, granular backfill should be used for compaction with light equipment.

6.5 Pavement Design

The recommended pavement design for on-grade access driveway is presented in Table 3.

Table 3 - Pavement Design for On-Grade Access Driveway

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	50	HL-8
Granular Base	150	Granular ‘A’
Granular Sub-base	300	Granular ‘B’

Where the pavement is to be built on structural slabs such as the underground parking structure, sufficient granular base and adequate drainage must be provided to prevent frost heaving in the pavement. In addition, an impervious membrane must be placed above the structural slab of the underground structure to prevent water leakage as well as to protect the reinforcing steel bars in the structure against brine corrosion. The recommended pavement to be placed above the underground structure is presented in Table 4.

Table 4 - Pavement Design on Structural Slab

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	50	HL-8
Granular Base	200	20-mm CRL or equivalent
Granular Sub-base	100	Free-Draining Sand Fill

Prior to placement of the granular bases, the soil subgrade should be proof-rolled and any soft spots should be rectified. In order to provide a stable subgrade for pavement construction, it is imperative that the subgrade within the 1.0 m zone below the underside of the granular base be compacted to at least 98% SPDD, with the moisture content at 2% to 3% drier than the optimum. This is to provide adequate stability for the pavement construction. The granular base and sub-base should be compacted to 100% SPDD.

The pavement subgrade will suffer a strength regression if water is allowed to saturate the mantle. Along the perimeter where runoff may drain onto the pavement, swale or an intercept subdrain system should be installed to prevent infiltrating precipitation from seeping into the granular bases (since this may inflict frost damage on the flexible pavement). At the lower spots around catch basins, subdrains consisting of filter-wrapped weepers should also be installed and they should be connected into the catch basins. The subdrains should be backfilled with free-draining granular material.

6.6 **Sidewalks, Interlocking Stone Pavement and Landscaping**

Interlocking stone pavement, sidewalks and landscaping structures in open areas should be designed to tolerate the frost-induced ground movement.

In areas where ground movement is not tolerable, such as in front of building entrances, the sidewalk and barrier-free ramp must be constructed on free-draining, non-frost-susceptible granular material such as Granular ‘B’. This material must extend to at least 0.3 to 1.2 m below the sidewalk, slab or pavement surface, depending on its tolerance on ground movement, and be provided with positive drainage, such as weeper subdrains connected to manholes or catch basins. Alternatively, the area can be properly insulated with 50-mm Styrofoam, or equivalent.

The final grading around structures must be such that it directs the runoff away from the structures.

6.7 **Soil Parameters**

The recommended soil parameters for the project design are given in Table 5.

Table 5 - Soil Parameters

Unit Weight and Bulk Factor	**Bulk Unit Weight (kN/m^3)**	**Estimated Bulk Factor**	
		Loose	**Loose**
Existing Earth Fill/Silty Clay	21.0	1.30	1.00
Silty Clay Till	22.5	1.33	1.05
Lateral Earth Pressure Coefficients	**Active K_a**	**At Rest K_o**	**Passive K_p**
Compacted Earth Fill	0.35	0.55	2.75
Silty Clay and Silty Clay Till	0.30	0.45	3.25
Coefficients of Friction			
Between Concrete and Granular Base		0.50	
Between Concrete and Natural Soils		0.35	

6.8 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. The types of material are classified in Table 6.

Table 6 - Classification of Material for Excavation

Material	Type
Shale	1
Silty Clay/Silty Clay Till	2
Earth Fill	3

Where safe sloped excavation is not feasible, a braced shoring will be required. The overburden and surcharge from any adjacent structures should be considered in the design of shoring. The recommendations for shoring design are attached in the Appendix.

In sound rock excavation, a vertical cut is acceptable provided that the bedding plane is horizontal. Any loose rock protruding from the excavation must be removed for safety.

After removing any protruding loose rock, an 80 to 100 mm thick spray foam is recommended on the rock face to prevent disintegration of the rock during construction. In addition, the compressible foam can prevent the excessive pressure on the concrete wall placed against the rock, due to release of intact stress from sound bedrock.

Any excavation into the shale will require considerable effort with a heavy-duty excavator equipped with a rock-ripper; however, excavation will become progressively more difficult with depth into the sound shale. Efficient removal of the sound shale will require the aid of pneumatic hammering.

Continuous groundwater is not anticipated within the depth of investigation. However, perched water may be encountered in the excavation. The groundwater yield, if any, will be slow in rate and limited in quantity and can be removed by pumping from conventional sumps.

6.9 **Monitoring of Performance**

It is recommended that close monitoring of vertical and lateral movement of the shoring wall should be carried out and frequent site inspections be conducted to ensure that the excavation does not adversely affect the structural stability of the adjacent buildings and the existing underground utilities. Extra bracing or support may be required if any movement is found excessive. The contractor should maintain the shoring to ensure any movement is within the design limit.

Vibration control and pre-construction survey is strongly recommended for the adjacent properties and structures prior to any excavation activities at the site. Our office can provide further advice or undertaking the vibration control and pre-construction survey as necessary.

7.0 LIMITATION OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Sphere Developments (Kingston) LP, and for review by its designated consultants and government agencies. The material in the report reflects the judgement of Yinglin Xiao, EIT. and Kin Fung Li, P.Eng., in light of the information available to it at the time of preparation.

Use of this report is subject to the conditions and limitations of the contractual agreement. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, is the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

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LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report, are as follows:

SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open (split spoon)
DS	Denison type sample
FS	Foil sample
RC	Rock core (with size and percentage recovery)
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—●—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

SOIL DESCRIPTION

Cohesionless Soils:

'N' (blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (blows/ft)	Consistency
less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0	Field vane test in borehole; the number denotes the sensitivity to remoulding
△	Laboratory vane test
□	Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

METRIC CONVERSION FACTORS

1 ft = 0.3048 metres
1lb = 0.454 kg
1 inch = 25.4 mm
1ksf = 47.88 kPa

JOB NO.: 2204-S019

LOG OF BOREHOLE: 1

FIGURE NO.: 1

PROJECT DESCRIPTION: Proposed Mixed-Use Development

METHOD OF BORING: Flight Auger (Tricone)

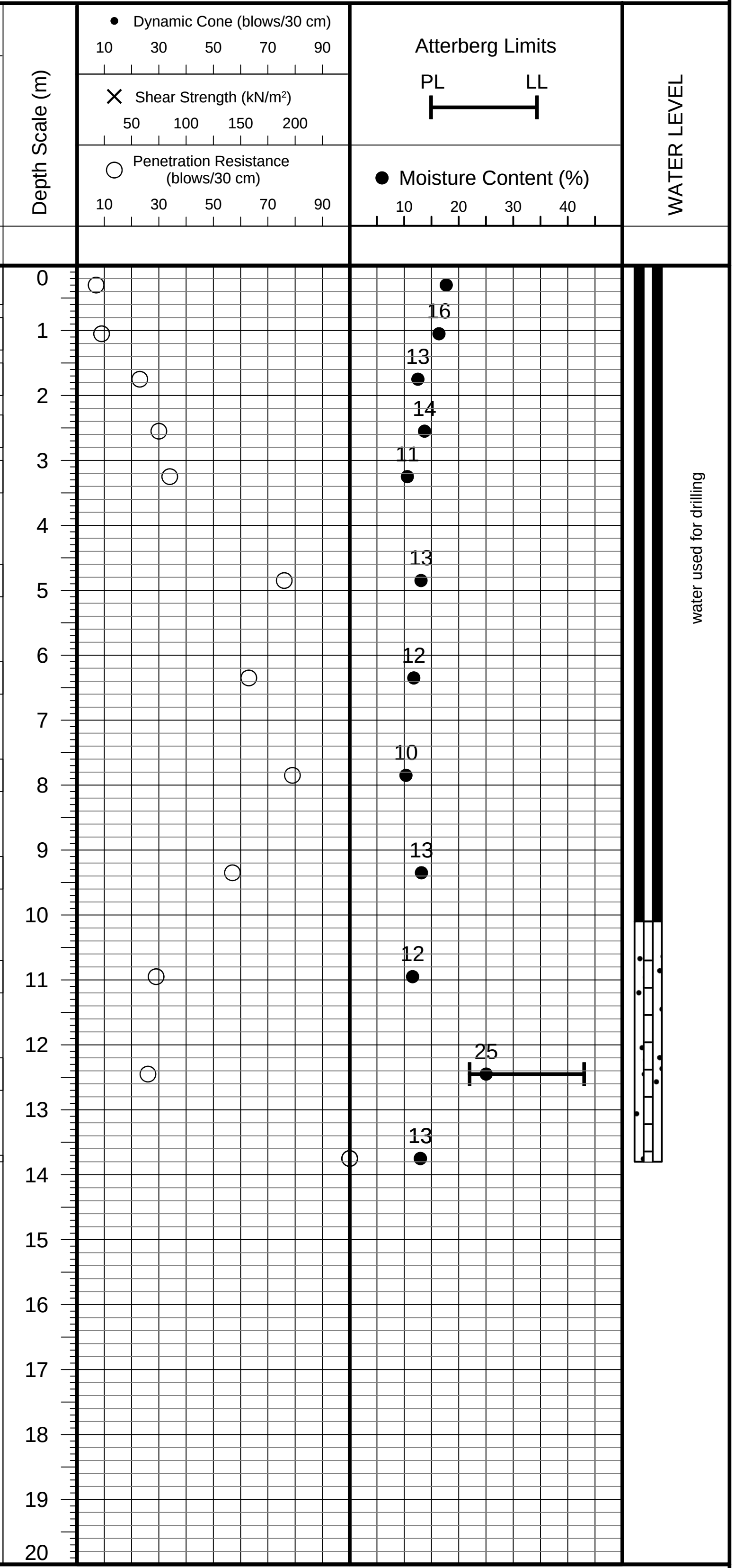
PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: May 3, 2022

El. (m) Depth (m)	SOIL DESCRIPTION
95.2	Ground Surface
0.0	**20 cm Topsoil** **EARTH FILL** Brown to dark brown silty clay occ. topsoil inclusions
93.7 1.5	Very stiff to hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers brown grey
83.5 11.7	Grey, very stiff **SILTY CLAY** a trace to some sand medium plasticity occ. shale fragments
81.4 13.8	**END OF BOREHOLE** **due to auger refusal on probable bedrock** Installed 50 mm Ø monitoring well to 13.8 m completed with 3.1 m screen Sand backfill from 10.1 to 13.8 m Bentonite seal from 0.0 m to 10.1 m Provided with a monument steel casing

SAMPLES

Number	Type	N-Value
1	DO	7
2	DO	9
3	DO	23
4	DO	30
5	DO	34
6	DO	76
7	DO	63
8	DO	79
9	DO	57
10	DO	29
11	DO	26
12	DO	50/13



Soil Engineers Ltd.

JOB NO.: 2204-S019

LOG OF BOREHOLE: 2

FIGURE NO.: 2

PROJECT DESCRIPTION: Proposed Mixed-Use Development

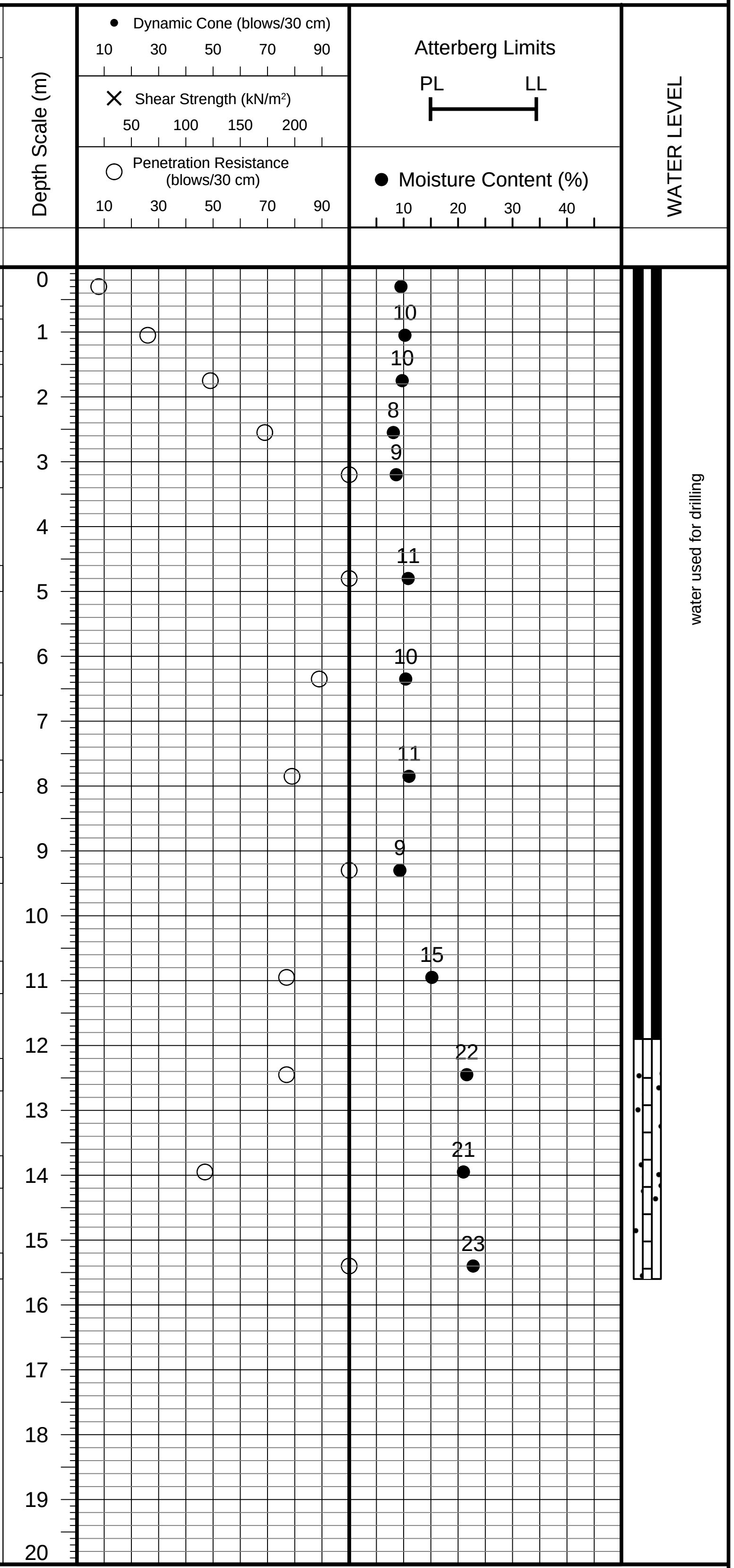
METHOD OF BORING: Flight Auger (Tricone)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: May 3, 2022

El. (m) Depth (m)	SOIL DESCRIPTION
97.6	Ground Surface
0.0	**20 cm Topsoil**
	Stiff to hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers weathered brown grey
85.9 11.7	Grey, hard **SILTY CLAY** a trace to some sand medium plasticity occ. shale fragments
82.0 15.6	**END OF BOREHOLE** **due to auger refusal on probable bedrock** Installed 50 mm Ø monitoring well to 15.6 m completed with 3.1 m screen Sand backfill from 11.9 to 15.6 m Bentonite seal from 0.0 m to 11.9 m Provided with a monument steel casing

SAMPLES		
Number	Type	N-Value
1	DO	8
2	DO	26
3	DO	49
4	DO	69
5	DO	50/23
6	DO	50/28
7	DO	89
8	DO	79
9	DO	50/28
10	DO	77
11	DO	77
12	DO	47
13	DO	50/23



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JOB NO.: 2204-S019

LOG OF BOREHOLE: 3

FIGURE NO.: 3

PROJECT DESCRIPTION: Proposed Mixed-Use Development

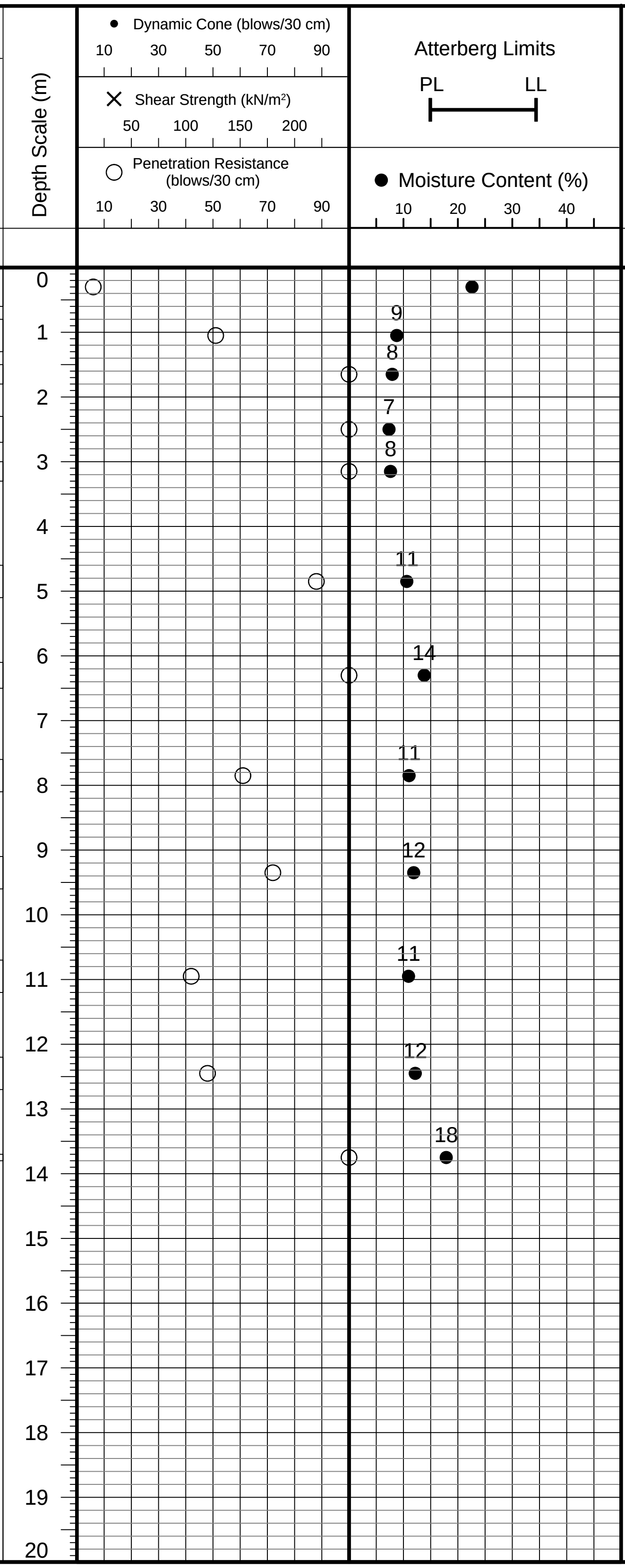
METHOD OF BORING: Flight Auger (Tricone)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: May 4, 2022

El. (m) Depth (m)	SOIL DESCRIPTION
94.8 0.0	Ground Surface **60 cm Topsoil**
	Hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers weathered brown grey
81.6 13.2	Grey, hard **SILTY CLAY** a trace to some sand medium plasticity occ. shale fragments
81.0 13.8	**END OF BOREHOLE** **due to auger refusal on probable bedrock**

SAMPLES Number	Type	N-Value
1	DO	6
2	DO	51
3	DO	50/13
4	DO	50/23
5	DO	50/13
6	DO	88
7	DO	50/28
8	DO	61
9	DO	72
10	DO	42
11	DO	48
12	DO	50/5



WATER LEVEL

water used for drilling

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Page: 1 of 1

JOB NO.: 2204-S019

LOG OF BOREHOLE: 4

FIGURE NO.: 4

PROJECT DESCRIPTION: Proposed Mixed-Use Development

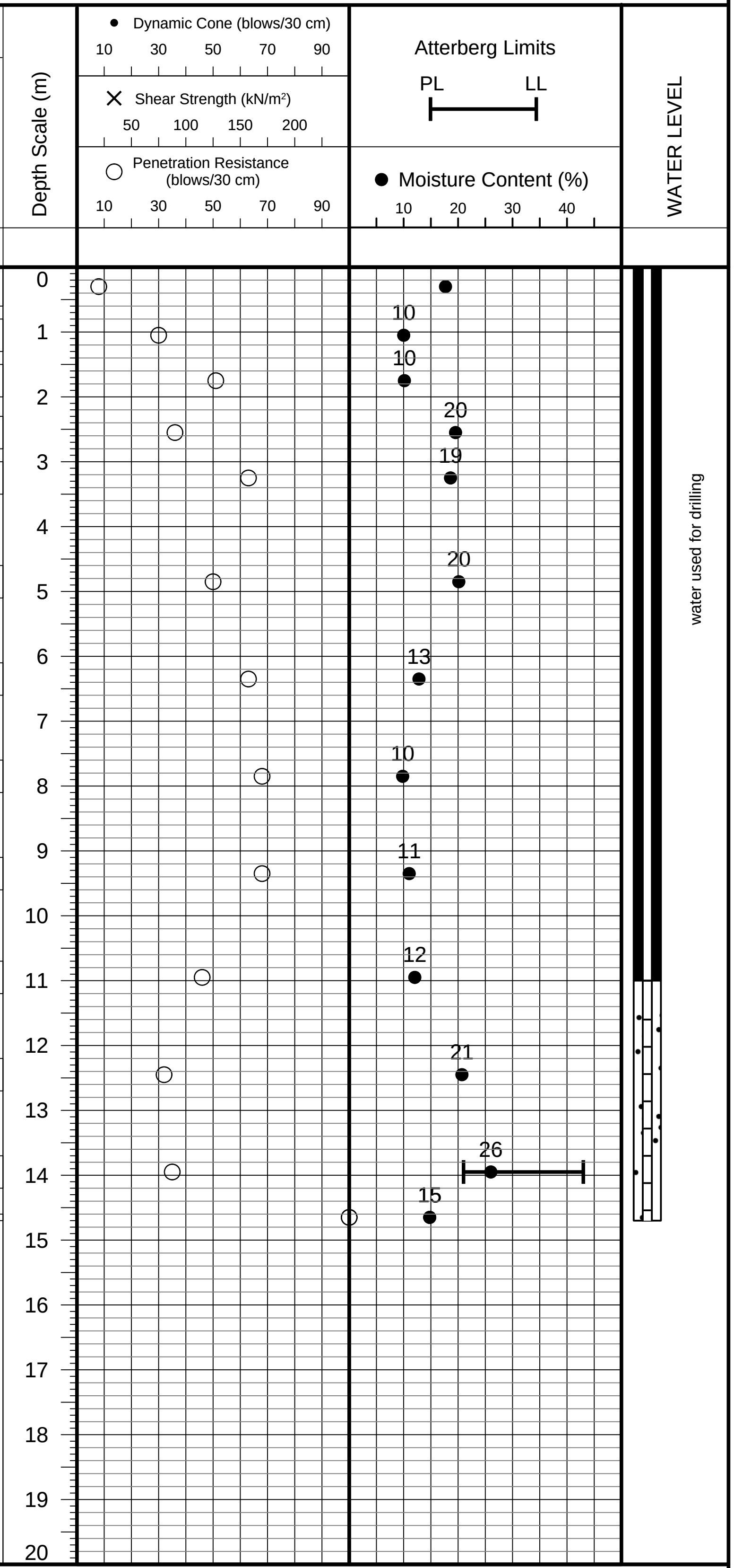
METHOD OF BORING: Flight Auger (Tricone)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: May 5, 2022

El. (m) Depth (m)	SOIL DESCRIPTION
96.9	Ground Surface
0.0	**36 cm Topsoil**
	Brown, very stiff to hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers weathered
94.7 2.2	Hard **SILTY CLAY** a trace to some sand medium plasticity brown grey
91.3 5.6	Grey, hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers
85.2 11.7	Grey, hard **SILTY CLAY** a trace to some sand medium plasticity occ. shale fragments
82.2 14.7	**END OF BOREHOLE** **due to auger refusal on probable bedrock** Installed 50 mm Ø monitoring well to 14.7 m completed with 3.1 m screen Sand backfill from 11.0 to 14.7 m Bentonite seal from 0.0 m to 11.0 m Provided with a monument steel casing

SAMPLES		
Number	Type	N-Value
1	DO	8
2	DO	30
3	DO	51
4	DO	36
5	DO	63
6	DO	50
7	DO	63
8	DO	68
9	DO	68
10	DO	46
11	DO	32
12	DO	35
13	DO	50/8



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JOB NO.: 2204-S019

LOG OF BOREHOLE: 5

FIGURE NO.: 5

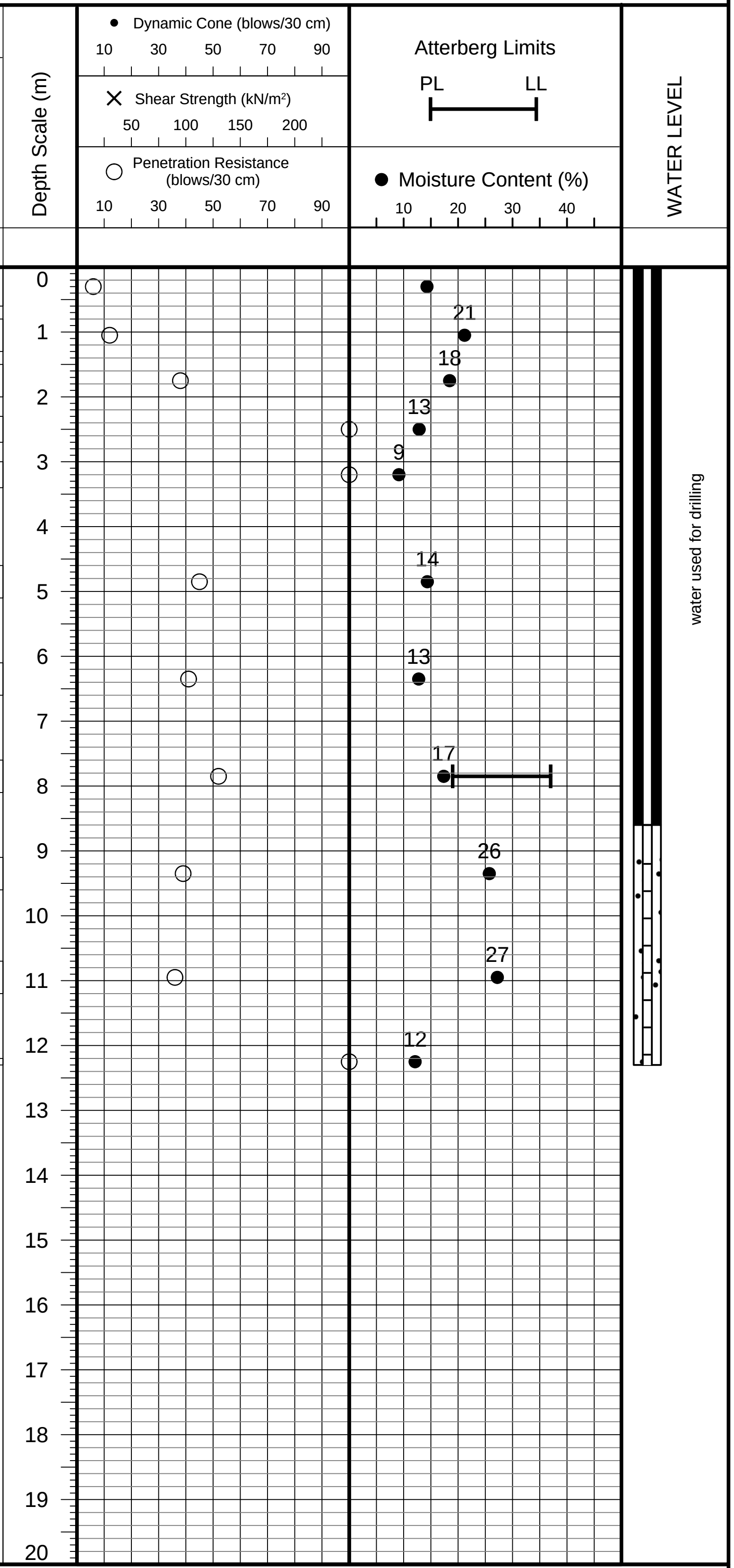
PROJECT DESCRIPTION: Proposed Mixed-Use Development

METHOD OF BORING: Flight Auger (Tricone)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: May 4, 2022

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
93.7 0.0	Ground Surface **60 cm Topsoil**	1	DO	6
	weathered Stiff to hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers	2	DO	12
		3	DO	38
		4	DO	50/23
		5	DO	50/25
	brown grey	6	DO	45
		7	DO	41
		8	DO	52
85.1 8.6	Grey, hard **SILTY CLAY** a trace to some sand medium plasticity	9	DO	39
		10	DO	36
	occ. shale fragments	11	DO	50/8
81.4 12.3	**END OF BOREHOLE** **due to auger refusal on probable bedrock** Installed 50 mm Ø monitoring well to 12.3 m completed with 3.1 m screen Sand backfill from 8.6 to 12.3 m Bentonite seal from 0.0 m to 8.6 m Provided with a monument steel casing			



Soil Engineers Ltd.

JOB NO.: 2204-S019

LOG OF BOREHOLE: 6

FIGURE NO.: 6

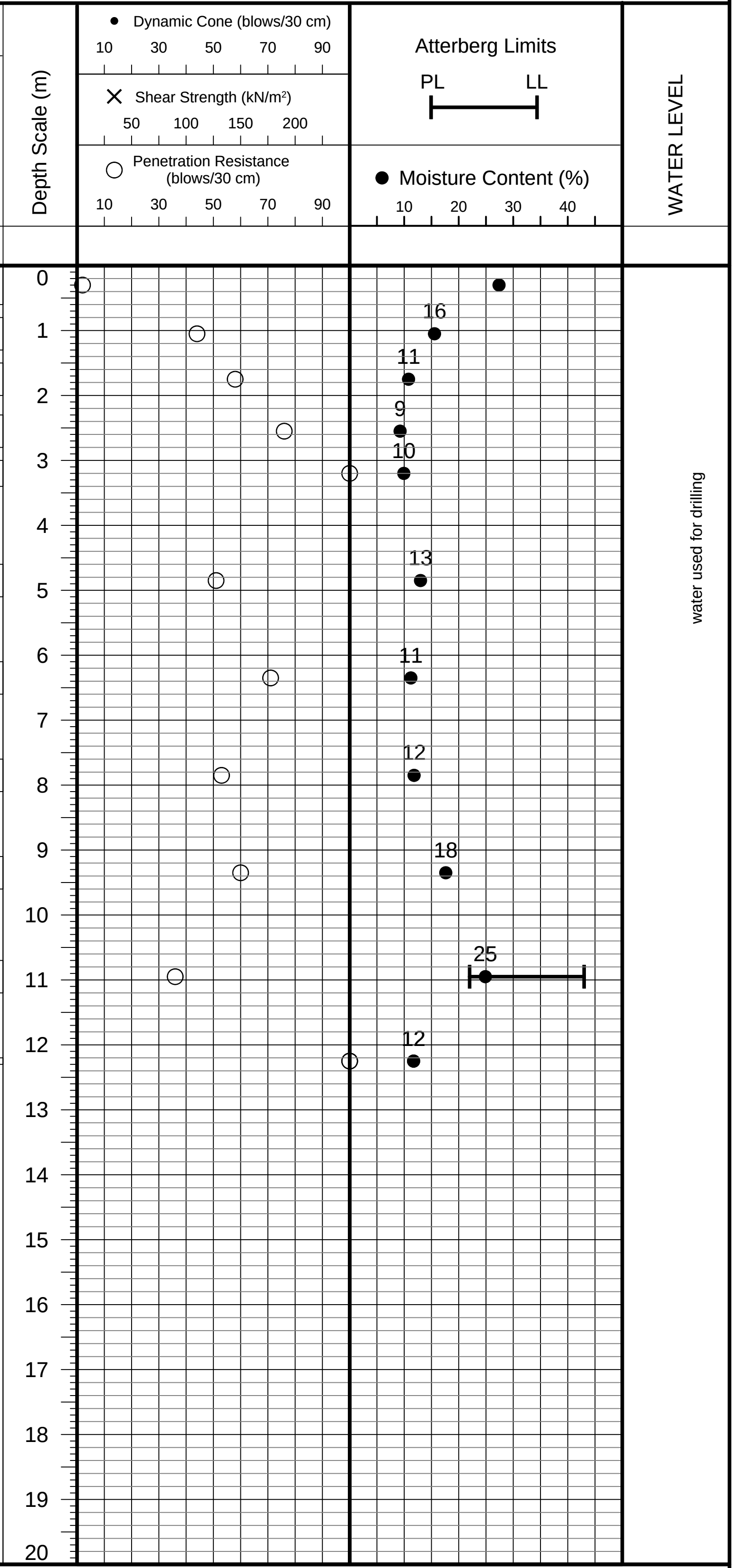
PROJECT DESCRIPTION: Proposed Mixed-Use Development

METHOD OF BORING: Flight Auger (Tricone)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: May 6, 2022

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
94.0 0.0	Ground Surface **45 cm Topsoil**	1	DO	2
	Hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers weathered	2	DO	44
		3	DO	58
		4	DO	76
		5	DO	50/28
	brown grey	6	DO	51
		7	DO	71
		8	DO	53
		9	DO	60
83.9 10.1	Grey, hard **SILTY CLAY** a trace to some sand medium plasticity	10	DO	36
	occ. shale fragments	11	DO	50/8
81.7 12.3	**END OF BOREHOLE** **due to auger refusal on probable bedrock**			



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JOB NO.: 2204-S019

LOG OF BOREHOLE: 7

FIGURE NO.: 7

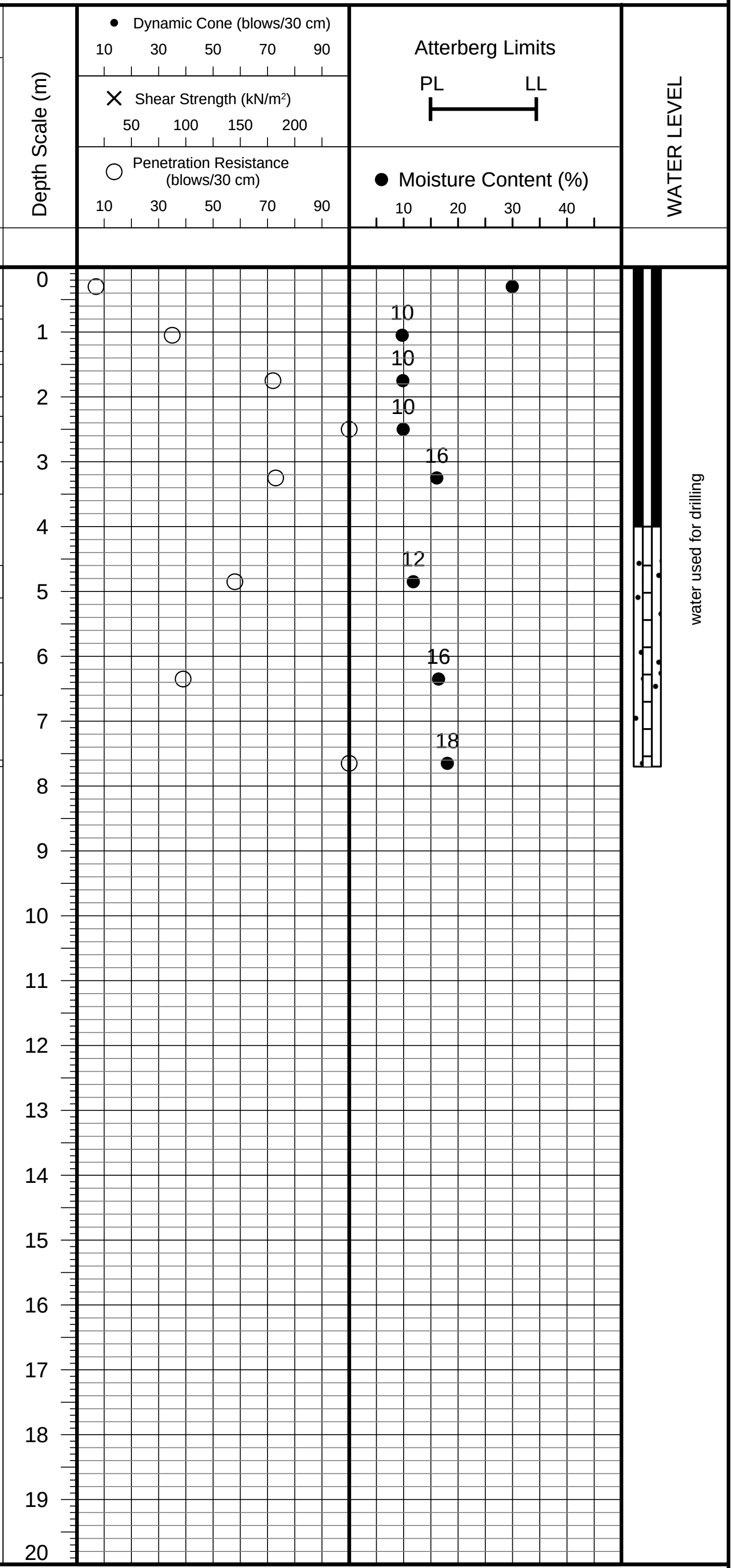
PROJECT DESCRIPTION: Proposed Mixed-Use Development

METHOD OF BORING: Flight Auger (Tricone)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: May 5, 2022

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
93.1 0.0	Ground Surface **60 cm Topsoil**	1	DO	7
	weathered Hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers	2	DO	35
		3	DO	72
		4	DO	50/28
		5	DO	73
	brown grey	6	DO	58
87.5 5.6	Grey, hard **SILTY CLAY** a trace to some sand medium plasticity	7	DO	39
	occ. rock fragments	8	DO	50/5
85.4 7.7	**END OF BOREHOLE** **due to auger refusal on probable boulder** Installed 50 mm Ø monitoring well to 7.7 m completed with 3.1 m screen Sand backfill from 4.0 to 7.7 m Bentonite seal from 0.0 m to 4.0 m Provided with a monument steel casing			



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JOB NO.: 2204-S019

LOG OF BOREHOLE: 101

FIGURE NO.: 8

PROJECT DESCRIPTION: Proposed Mixed-Use Development

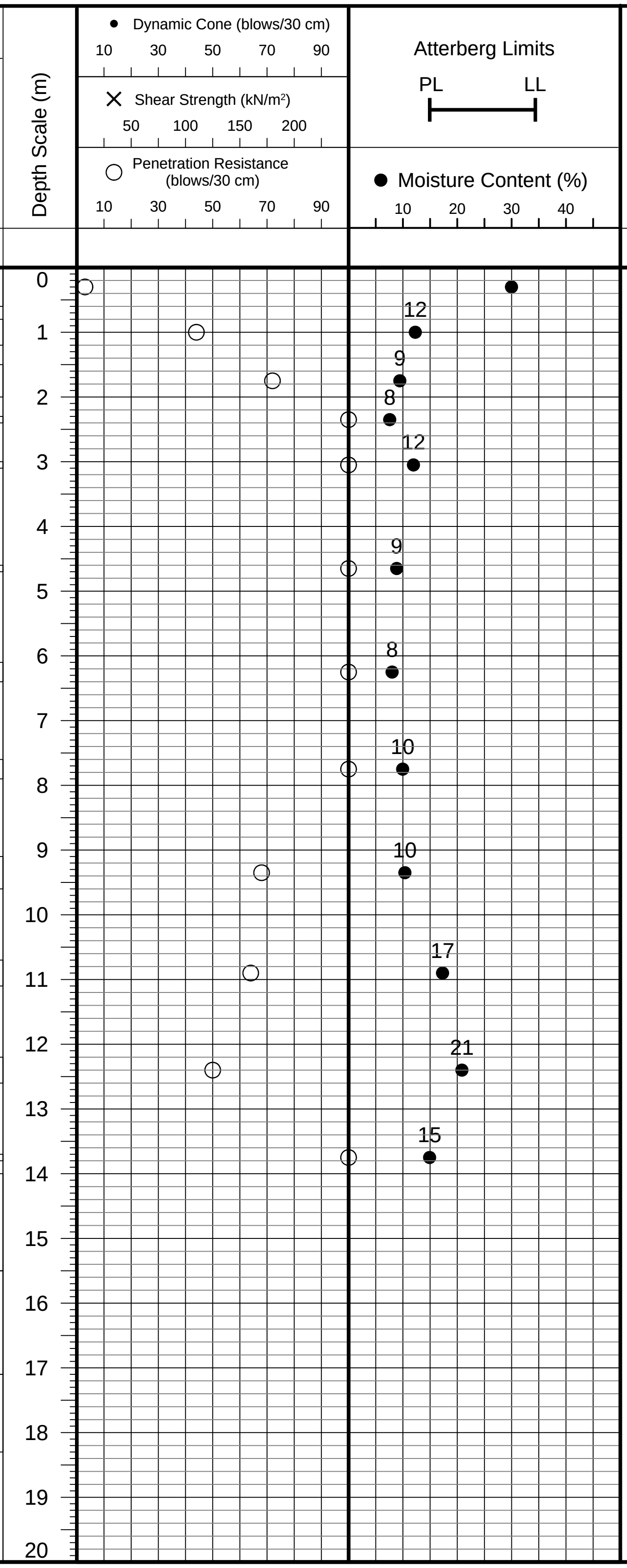
METHOD OF BORING: Flight Auger (Hollow Stem)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: February 8, 2023

El. (m) Depth (m)	SOIL DESCRIPTION
95.9	Ground Surface
0.0	**36 cm Topsoil**
	weathered
	brown grey
	Hard **SILTY CLAY TILL** some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers
84.4 11.5	Grey, hard **SILTY CLAY** a trace to some sand
82.4 13.5	Grey **SHALE BEDROCK**
77.6 18.3	**END OF BOREHOLE**

SAMPLES		
Number	Type	N-Value
1	DO	3
2	DO	44
3	DO	72
4	DO	50/15
5	DO	50/10
6	DO	50/15
7	DO	50/15
8	DO	50/15
9	DO	68
10	DO	64
11	DO	50
12	DO	50/8
1	RC RQD	90% 22%
2	RC RQD	100% 57%
3	RC RQD	83% 75%



WATER LEVEL

Dry upon Completion

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JOB NO.: 2204-S019

LOG OF BOREHOLE: 102

FIGURE NO.: 9

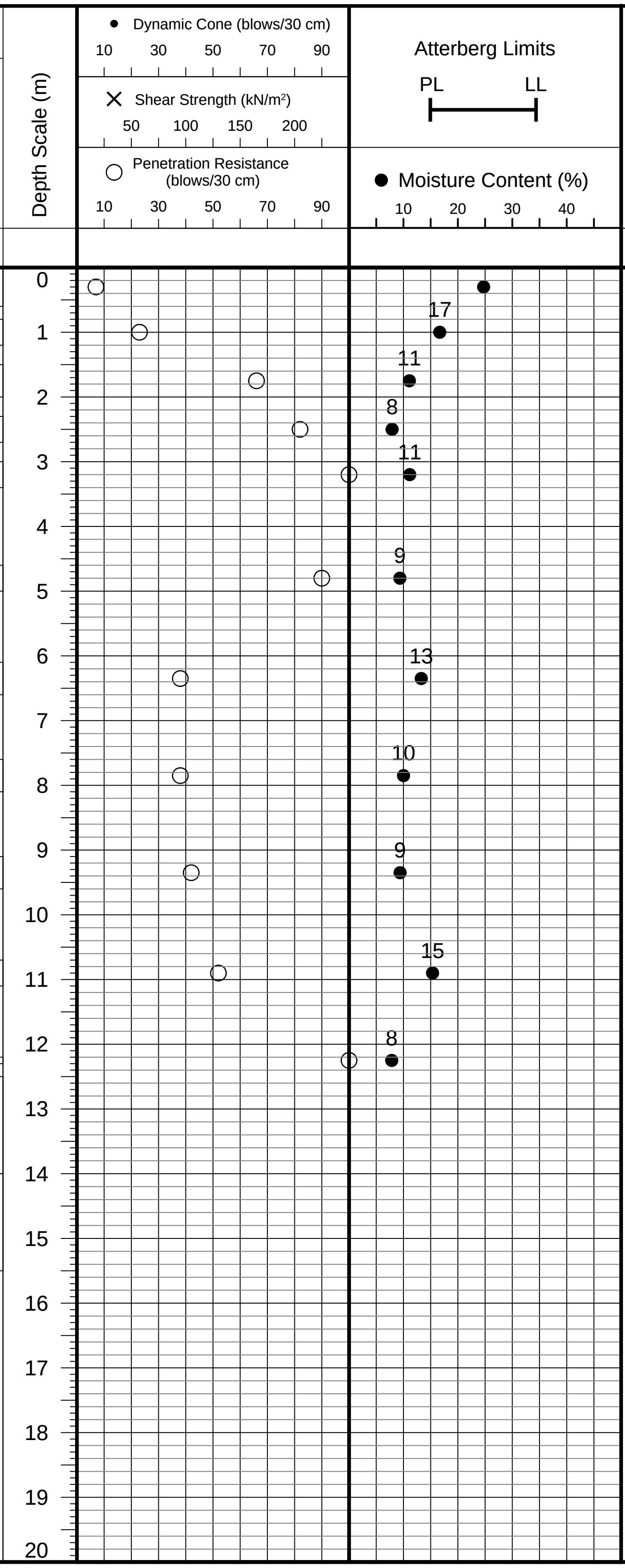
PROJECT DESCRIPTION: Proposed Mixed-Use Development

METHOD OF BORING: Flight Auger
(Hollow Stem)

PROJECT LOCATION: 875 Kingston Road, City of Pickering

DRILLING DATE: February 6, 2023

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
94.1	Ground Surface			
0.0	**36 cm Topsoil**	1	DO	7
	weathered			
		2	DO	23
		3	DO	66
		4	DO	82
		5	DO	50/15
	brown grey			
	Very stiff to hard **SILTY CLAY TILL**	6	DO	90
	some sand to sandy a trace of gravel occ. cobbles and boulders occ. sand and silt seams and layers	7	DO	38
		8	DO	38
		9	DO	42
	wet sand layer	10	DO	52
82.1 12.0		11	DO	50/8
	Grey **SHALE BEDROCK**	1	RC RQD	92% 0%
		2	RC RQD	100% 43%
78.6 15.5	**END OF BOREHOLE**			



WATER LEVEL

Dry upon Completion

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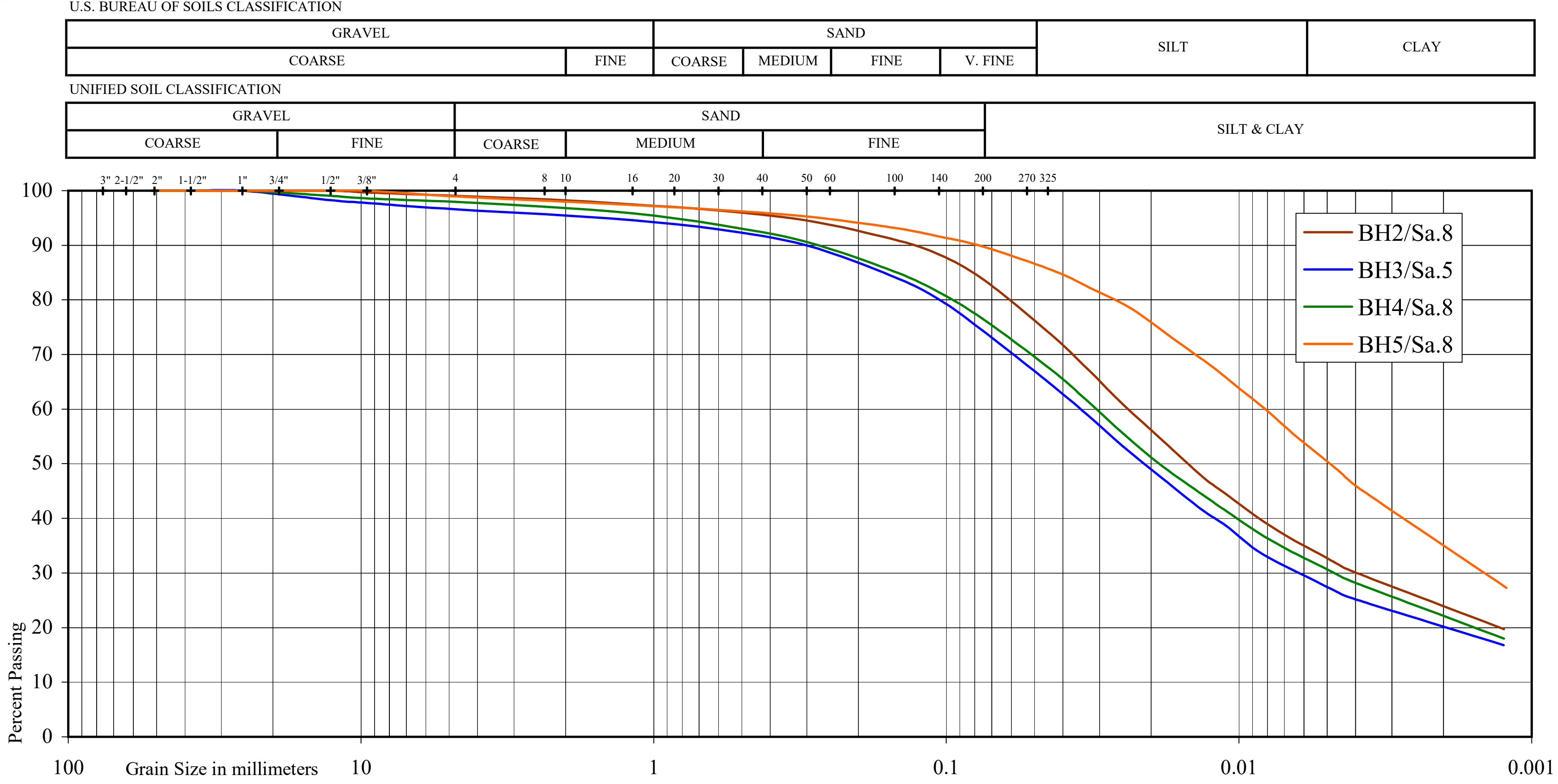
GRAIN SIZE DISTRIBUTION

Reference No: 2204-S019



Project: Proposed Mixed-Use Development

Location: 875 Kingston Road, City of Pickering

Borehole No:	2	3	4	5
Sample No:	8	5	8	8
Depth (m):	7.6	3.0	7.6	7.6
Elevation (m):	90.0	91.8	89.3	86.1

BH/Sa.:	2/8	3/5	4/8	5/8
Liquid Limit (%) =	-	-	-	37
Plastic Limit (%) =	-	-	-	19
Plasticity Index (%) =	-	-	-	18
Moisture Content (%) =	11	8	10	17
Estimated Permeability (cm./sec.) =	10^{-7}	10^{-7}	10^{-7}	10^{-7}

Classification of Sample [& Group Symbol]: SILTY CLAY TILL

some sand to sandy, a trace of gravel

Figure 10

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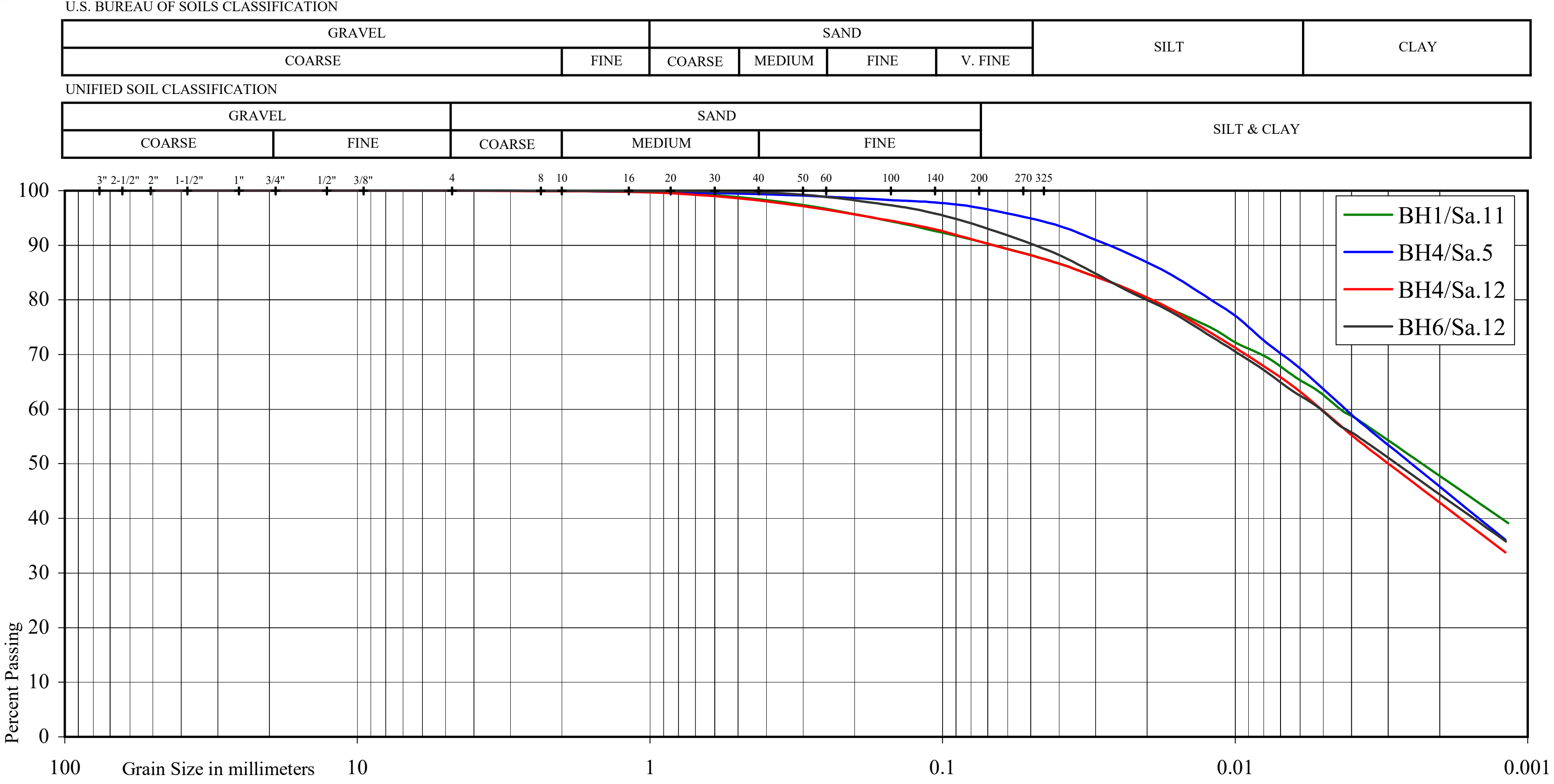
GRAIN SIZE DISTRIBUTION

Reference No: 2204-S019



Project: Proposed Mixed-Use Development

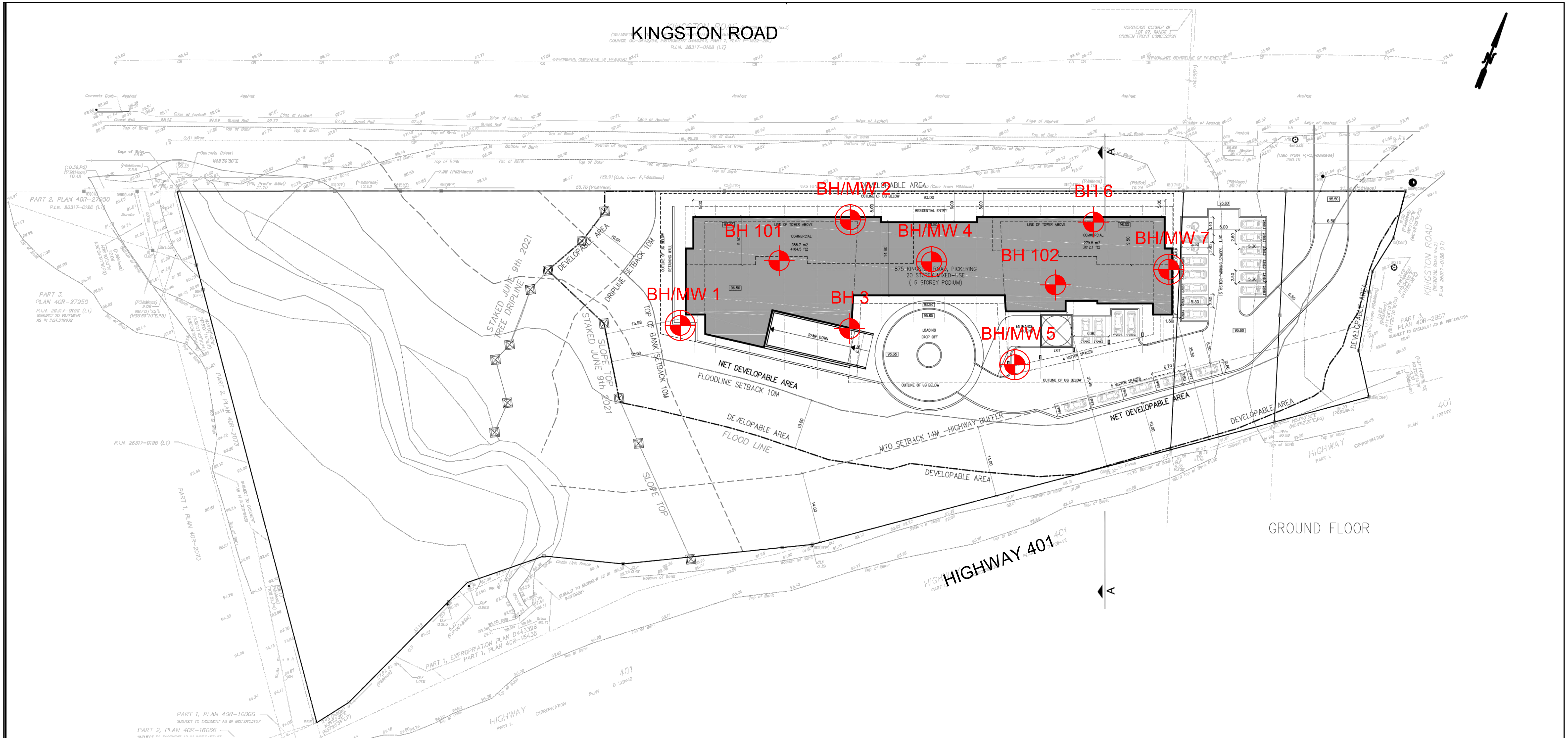
Location: 875 Kingston Road, City of Pickering

Borehole No:	1	4	4	6
Sample No:	11	5	12	10
Depth (m):	12.2	3.0	13.7	10.7
Elevation (m):	83	93.9	83.2	83.3

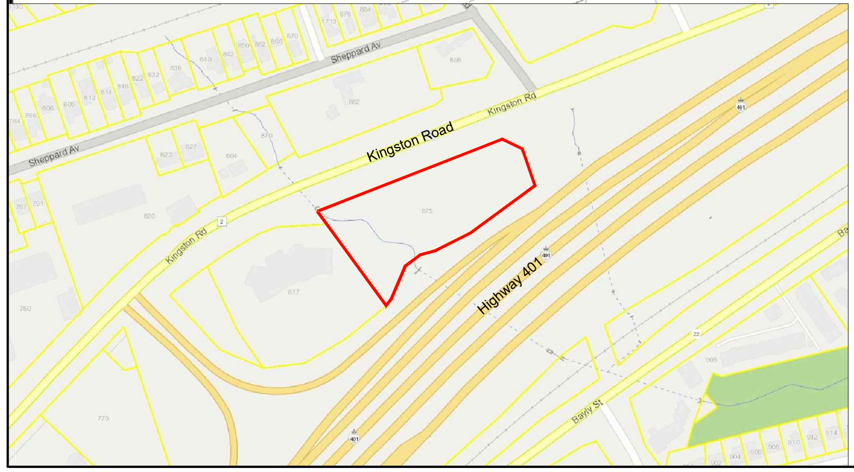
BH/Sa.:	1/11	4/5	4/12	6/10
Liquid Limit (%) =	43	-	43	42
Plastic Limit (%) =	22	-	22	22
Plasticity Index (%) =	21	-	21	20
Moisture Content (%) =	25	19	26	25
Estimated Permeability (cm./sec.) =	10^{-7}	10^{-7}	10^{-7}	10^{-7}

Classification of Sample [& Group Symbol]: SILTY CLAY
a trace to some sand

Figure 11



Key Plan (N.T.S.)



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Borehole and Monitoring Well Location Plan

SITE: 875 Kingston Road, City of Pickering

DESIGNED BY: Y.X.	**CHECKED BY:** K.F.L.	**DWG NO.:** 1	
SCALE: 1:750	**REF. NO.:** 2204-S019	**DATE:** February 2023	**REV** -

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SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

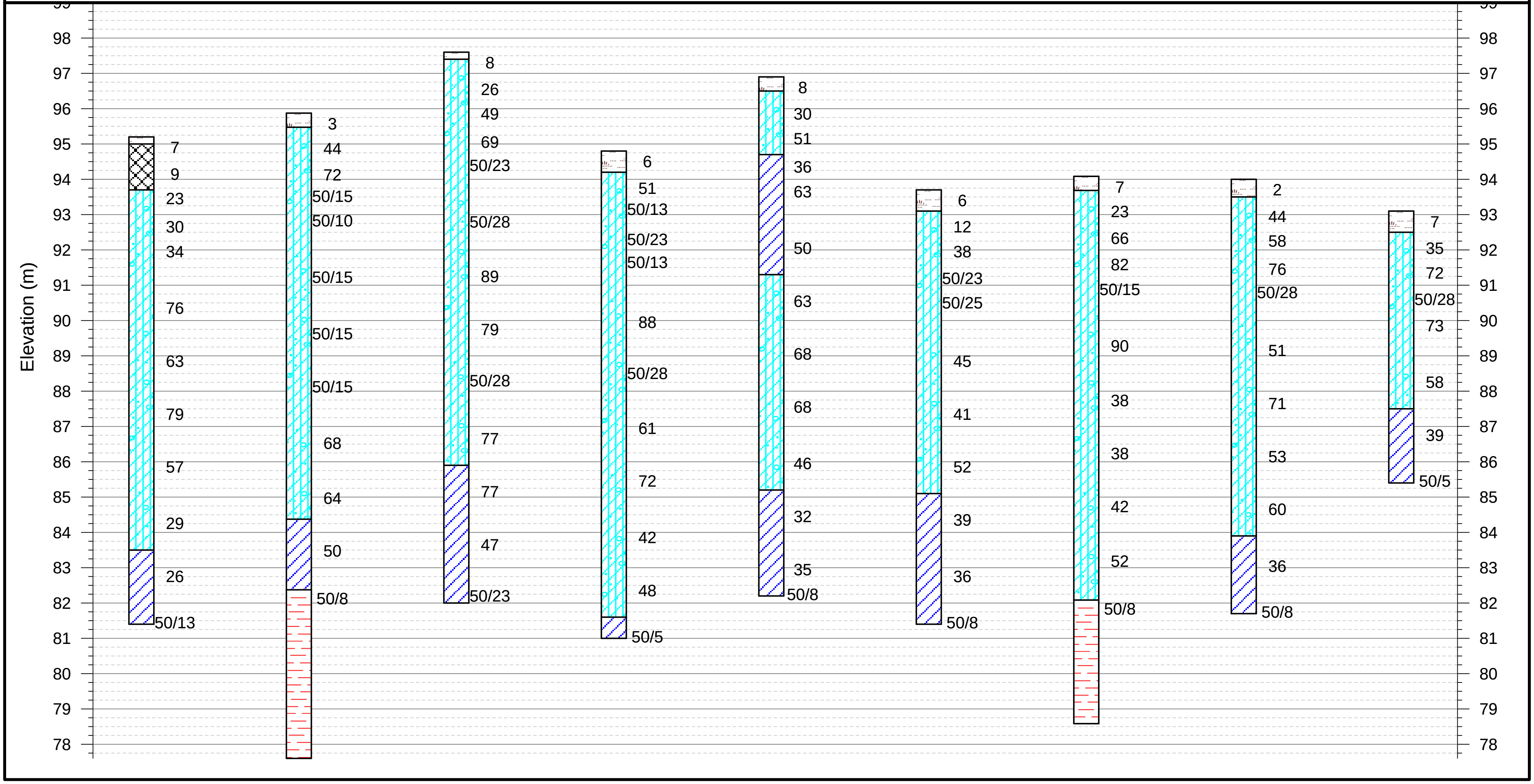
JOB NO.: 2204-S019
REPORT DATE: July 2022 & February 2023
PROJECT DESCRIPTION: Proposed Mixed-Use Development

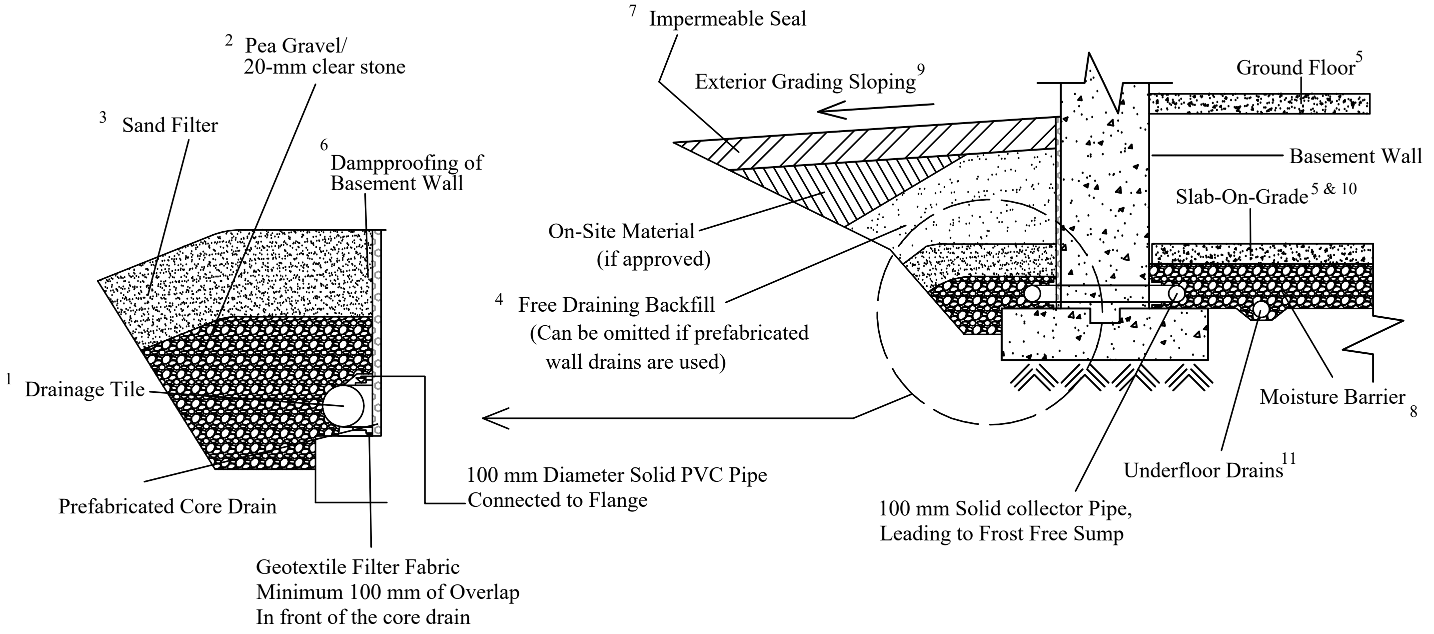
PROJECT LOCATION: 875 Kingston Road, City of Pickering

LEGEND

- ▨ FILL
- ▨ SILTY CLAY
- ▨ SILTY CLAY TILL
- ▨ TOPSOIL
- ▨ SHALE

BH No.:	1	101	2	3	4	5	102	6	7
El. (m):	95.2	95.87	97.6	94.8	96.9	93.7	94.08	94	93.1





NOTES:

1. **Drainage tile**: consists of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet. Invert to be at minimum of 150 mm (6") below underside of basement floor slab.

2. **Pea gravel**: at 150 mm (6") on the top and sides of drain. If drain is not placed on concrete footing, provide 100 mm (4") of pea gravel below drain. The pea gravel may be replaced by 20 mm clear stone provided that the drain is covered by a porous geotextile membrane of Terrafix 270R or equivalent.

3. **Filter material**: consists of C.S.A. fine concrete aggregate. A minimum of 300 mm (12") on the top and sides of gravel. This may be replaced by an approved porous geotextile membrane of Terrafix 270R or equivalent.

4. **Free-draining backfill**: OPSS Granular 'B' or equivalent, compacted to 95% to 98% (maximum) Standard Proctor dry density. Do not compact closer than 1.8 m (6') from wall with heavy equipment. This may be replaced by on-site material if prefabricated wall drains (Miradrain) extending from the finished grade to the bottom of the basement wall are used.

5. **Do not backfill** until the wall is supported by the basement floor slab and ground floor framing, or adequate bracing.

6. **Dampproofing** of the basement wall is required before backfilling

7. **Impermeable backfill seal** of compacted clay, clayey silt or equivalent. If the original soil in the vicinity is a free-draining sand, the seal may be omitted.

8. **Moisture barrier**: 19-mm CRL or compacted OPSS Granular 'A', or equivalent. The thickness of this layer should be 150 mm (6") minimum.

9. **Exterior Grade**: slope away from basement wall on all the sides of the building.

10. **Slab-On-Grade** should not be structurally connected to walls or foundations.

11. **Underfloor drains*** should be placed in parallel rows at 6 to 8 m (20'-25') centre, on 100 mm (4") of pea gravel with 150 mm (6") of pea gravel on top and sides. The spacing should be at least 300 mm (12") between the underside of the floor slab and the top of the pipe. The drains should be connected to positive sumps or outlets. Do not connect the underfloor drains to the perimeter drains.

*Underfloor drains can be deleted where not required.

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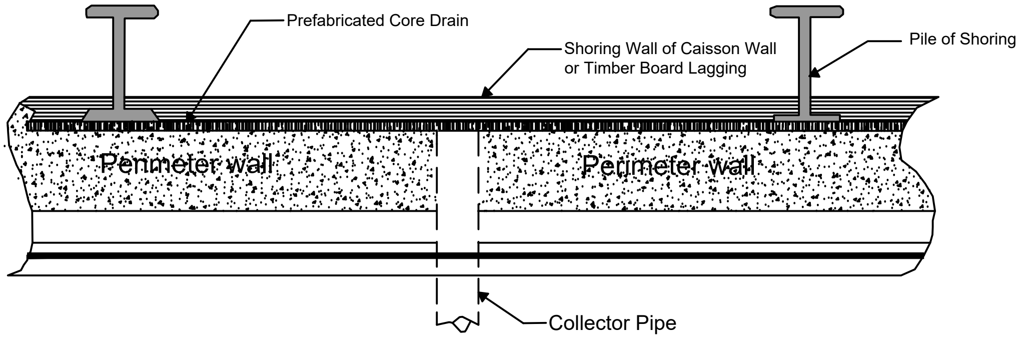
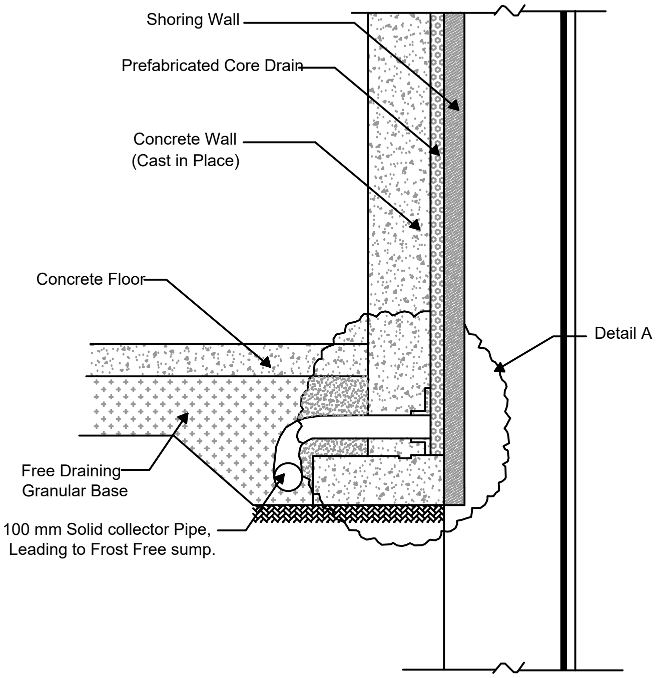
PERMANENT PERIMETER DRAINAGE SYSTEM

SITE: 875 Kingston Road, City of Pickering

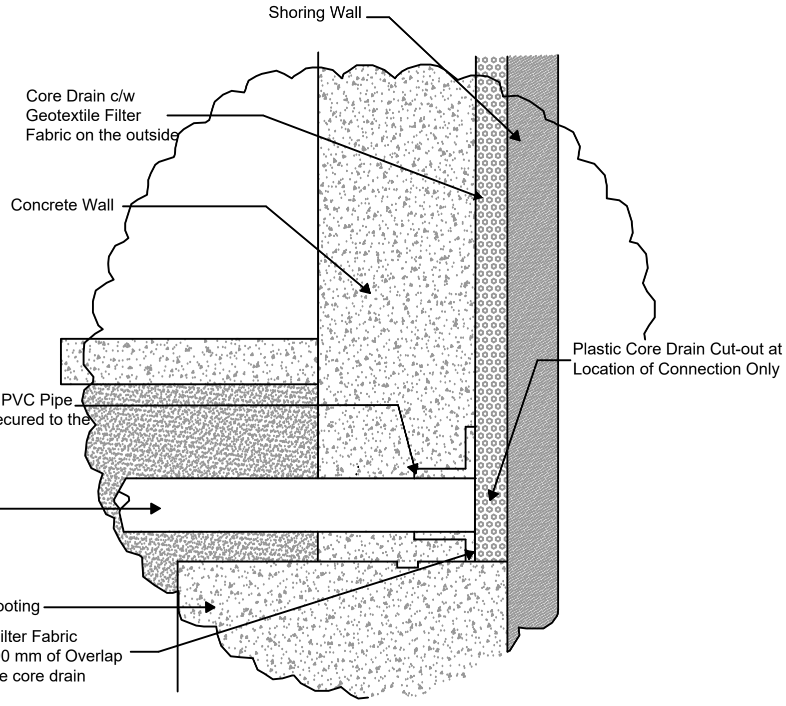
DESIGNED BY: K.L.	**CHECKED BY:** B.S.	**DWG NO.:** 3	
SCALE: N.T.S.	**REF. NO.:** 2204-S019	**DATE:** July 2022	**REV** -



PLAN



TYPICAL SECTION



DETAIL A

NOTES:

1. A continuous blanket of prefabricated drainage system, Miradrain 6000 or equivalent, should extend continuously from the top of footings to the ground surface.

2. All joints of the Miradrain should be taped. All openings above the concrete footing must be covered with filter fabric to prevent intrusion of fresh concrete into the core of the drain.

3. Backfill behind the lagging board must be free draining. Filter fabric or straw should be used to prevent loss of fines behind the lagging.

4. The perimeter drainage and any subfloor drainage systems must be kept separate.

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Permanent Perimeter Drainage System

SITE: 875 Kingston Road, City of Pickering

DESIGNED BY: K.F.L. | **CHECKED BY:** B.S. | **DWG NO.:** 4

SCALE: N.T.S. | **REF. NO.:** 2204-S019 | **DATE:** July 2022 | **REV** -

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FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (905) 881-8335	FAX: (705) 684-8522	FAX: (905) 542-2769

APPENDIX

SHORING DESIGN

REFERENCE NO. 2204-S019

SHORING SYSTEM

Shoring will be required in an excavation to protect the workers and limit the horizontal and vertical movements of adjacent properties.

A shoring system consisting of soldier piles and lagging boards can be used in an excavation where slight movement in the adjacent properties is tolerable. In an area with close proximity of adjacent structure and the excavation will be extending below the foundation level where any movement in the adjacent properties is a concern, an interlocking caisson wall is more appropriate.

The design and construction of the shoring system should be carried out by a specialist designer and contractor experienced in this type of construction. All specifications for the design of the shoring system should be in accordance with the latest edition of the Canadian Foundation Engineering Manual (CFEM).

LATERAL EARTH PRESSURE

For single and multiple level supporting systems, the lateral earth pressure distributions on the shoring walls are shown on Drawing A1. The design soil parameters are provided in the geotechnical report.

The lateral earth pressure expressions do not include hydrostatic pressure buildup behind the shoring. If the wall is designed to be watertight or undrained, such as a caisson wall, the anticipated hydrostatic pressure must be included behind the structure.

PILE PENETRATION

The depth of pile support into shale bedrock should be at least 1 m below the bottom of excavation.

The shoring system should be designed for a factor of safety of F = 2.

For anchor supported shoring system, the global factor of safety against sliding and overturning of the anchored block of soil must also be considered.

The steel soldier piles in the shoring system must be installed in pre-augured holes. The lower portion will have to be filled with 20 MPa (3000 psi) concrete to the excavation level. The upper portion of the pile within the excavation depth should be filled with lean mix concrete or non-shrinkable cementitious filler (U-fill).

LAGGING

The following thicknesses of lagging boards have been recommended in CFEM:

Thickness of Lagging	Maximum Spacing of Soldier Piles
50 mm (2 in)	1.5 m (5 ft)
75 mm (3 in)	2.5 m (8 ft)
100 mm (4 in)	3.0 m (10 ft)

Local experience has indicated that the lagging board thickness of 75 mm has been adequate for soldier pile spacing of 3 m for soil conditions similar to those encountered at the subject site. However, it is important to consider all local conditions, such as the duration of excavation, the weather likely to be encountered through the construction period, seasonal variations in the ground water and ice lensing causing frost heave and softening of soils in determining the lagging thickness. During winter months, the shoring should be covered with thermal blankets to prevent frost penetration behind the shoring system which may result in unacceptable movements.

During construction of shoring, all the spaces behind the lagging board must be filled with free-draining granular fill. If wet conditions are encountered, the space between the boards should be packed with a geotextile filter fabric or straw to prevent the loss of fine particles.

TIEBACK ANCHORS

The minimum spacing and the depths of the soil anchors should be as recommended in the CFEM.

All drilled holes for tieback anchors should be temporarily cased or lined to minimize the risk of caving. Systems involving high grout pressures should be avoided if working near other basements or buried services.

The tieback anchor lengths can be estimated using an adhesion value of 60 kPa in the clay till, or 300 kPa in shale. Full scale load tests should be carried out on the tieback anchors in each type of soils and at each level of anchor support at the site to confirm the design parameters and the adhesion values. The test anchors should be loaded in a pattern as described in CFEM, to 200% of the design load or until there is a significant increase in the pullout rate. In the latter case, the design load must be limited to 50% of the maximum load at which the pullout increases. Based on the results of the pullout test, it may be necessary to modify the anchor design of the production anchors.

Each tieback anchor must be proof-loaded to 133% of the design load, and the anchor must be capable of sustaining this load for a minimum of 10 minutes without creep. The load may then be relaxed to 100% of the design and locked in. The higher the lock-in loads, the less will be the outward movement on the shoring wall after excavation.

RAKERS

An alternative to tieback anchor support of the shoring is to use raker footings. Rakers inclining at an angle of 45º, founded in the shale bedrock deposit below the bottom of excavation should be designed for the allowable bearing pressure of 750 kPa.

The raker footings should be located outside the zone of influence of the buried portion of the soldier piles at a distance of not less than 1.5 of the length of embedment of the soldier pile.

To prevent undermining of the raker footing, no excavation should be made within two times the width of raker footing on the opposite side of the raker.

MONITORING OF PERFORMANCE

Close monitoring of the vertical and lateral movement of the shoring system, by inclinometers or by survey on targets, should be carried out at the site. Extra bracing or support may be required if any movement is found excessive. The contractor should maintain the shoring to ensure any movement is within the design limit.