



Soil Engineers Ltd.

CONSULTING ENGINEERS

GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE

90 WEST BEAVER CREEK ROAD, SUITE 100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

BARRIE
TEL: (705) 721-7863
FAX: (705) 721-7864

MISSISSAUGA
TEL: (905) 542-7605
FAX: (905) 542-2769

OSHAWA
TEL: (905) 440-2040
FAX: (905) 725-1315

NEWMARKET
TEL: (905) 853-0647
FAX: (905) 881-8335

MUSKOKA
TEL: (705) 721-7863
FAX: (705) 721-7864

HAMILTON
TEL: (905) 777-7956
FAX: (905) 542-2769

**A REPORT TO
1000383288 ONTARIO INC.**

**A GEOTECHNICAL INVESTIGATION FOR
PROPOSED RESIDENTIAL DEVELOPMENT**

277 AND 279 HAZEL STREET

CITY OF WATERLOO

REFERENCE NO. 2401-S069

APRIL 2024

DISTRIBUTION

Digital Copy – 1000383288 Ontario Inc.

Digital Copy – Soil Engineers Ltd. (Mississauga)

**TABLE OF CONTENTS**

1.0	INTRODUCTION	1
2.0	SITE AND PROJECT DESCRIPTION.....	1
3.0	FIELD WORK	1
4.0	SUBSURFACE CONDITIONS	2
4.1	Topsoil	2
4.2	Pavement Structure	2
4.3	Earth Fill	2
4.4	Sandy Silt	2
4.5	Silty Clay.....	3
4.6	Sandy Silt Till	3
5.0	GROUNDWATER CONDITION	4
6.0	DISCUSSION AND RECOMMENDATIONS.....	4
6.1	Site Preparation	5
6.2	Foundation	7
6.3	Slab-on-Grade Construction	8
6.4	Underground Services.....	8
6.5	Backfilling Trenches and Excavated Areas	9
6.6	Pavement Design.....	10
6.7	Soil Parameters	11
6.8	Excavation.....	11
7.0	LIMITATIONS OF REPORT	12

TABLES

Table 1 - Groundwater Levels	4
Table 2 - Pavement Design	10
Table 3 - Soil Parameters	11
Table 4 - Classification of Soils for Excavation	12

ENCLOSURES

Logs of Borehole.....	Figures 1 to 4
Grain Size Distribution Graphs.....	Figures 5 and 6
Borehole Location Plan	Drawing No. 1
Subsurface Profile.....	Drawing No. 2



1.0 **INTRODUCTION**

In accordance with the written authorization dated January 24, 2024, from Mr. Rathees Paramalingam of 1000383288 Ontario Inc., a geotechnical investigation was carried out at 277 and 279 Hazel Street in the City of Waterloo.

The purpose of the investigation was to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the design and construction of a proposed residential development.

2.0 **SITE AND PROJECT DESCRIPTION**

The subject site is located to the west of Bridgeport West in the City Waterloo, in the region where the surficial geology of Tavistock Till and Port Stanley Till intersect each other.

At the time of investigation, the subject property, located on the west side of Hazel Street, approximately 20 m south of Hickory Street West, consists of two single-detached residential dwellings with driveways. The site gradient slightly elevated from Hazel Street by approximately 0.8 to 1.2 m, is relatively flat with minor undulations.

Based on the conceptual site plan, prepared by Khalsa Design Inc. dated on March 23, 2023, the existing dwellings will be demolished for the development of a 6-storey residential building, with on-grade parking lot at the rear.

3.0 **FIELD WORK**

The field work, consisting of 4 boreholes extending to depths ranging from 6.4 to 7.8 m, was carried out on February 9, 2023. The locations of the boreholes are shown on Drawing No. 1.

The boreholes were advanced at intervals to the sampling depths by a track-mounted machine equipped with solid stem augers 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 relative density of the cohesionless 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.

The ground elevation at each borehole location was determined using a handheld equipment of the Global Navigation Satellite System.



4.0 **SUBSURFACE CONDITIONS**

Beneath the topsoil veneer or pavement structure, and a layer of earth fill, the subsoil predominantly consists of sandy silt, with layers of silty clay and sandy silt till.

Detailed descriptions of the encountered subsurface conditions are presented on the Logs of Borehole, comprising of Figures 1 to 4, inclusive. The soil stratigraphy is illustrated on the Subsurface Profile, Drawing No. 2. The engineering properties of the disclosed soils are discussed herein.

4.1 **Topsoil**

The revealed topsoil thickness in Boreholes 3 and 4 ranges from 20 to 23 cm. Thicker topsoil may be encountered in areas beyond the borehole locations, especially in local low-lying areas and/or treed areas.

4.2 **Pavement Structure**

Boreholes 1 and 2 are located on the paved driveway. The pavement structure consists of the asphalt concrete of 20 mm in thickness, overlying the granular fill ranging from 300 mm to 380 mm in thickness.

4.3 **Earth Fill**

A layer of earth fill was contacted beneath the topsoil veneer or pavement structure in all boreholes, extending to a depth of 1.0 to 2.3 m below the ground surface. The fill consists of dark brown sandy silt with sand and gravel and occasional topsoil inclusions. Gravelly sand fill was contacted in Borehole 1, at the depth of 1.5 m below grade.

4.4 **Sandy Silt**

Beneath the surficial topsoil or pavement structure, native sandy silt was contacted in all boreholes. Grain size analyses were performed on 3 representative samples of the sandy silt and the results are plotted on Figure 5.

The recorded 'N' values range from 10 to over 43, with a median of 20 blows per 30 cm penetration, indicating the sandy silt is compact to dense, generally being compact relative density.



The obtained natural water content values range from 14% to 18%, with a median of 17%, indicating that the sandy silt is generally in a wet condition.

The engineering properties of the sandy silt are listed below:

- High capillarity and water retention capability.
- Highly frost susceptible, with high soil-adfreezing potential.
- High water erodibility, the fine particles will migrate through small openings under seepage pressure.
- The shear strength is mainly derived from internal friction. The wet sandy silt is susceptible to dynamic disturbance, which will induce a build-up of pore water pressure, resulting in soil dilation and a reduction in shear strength.
- In excavation, the silts will slough readily, run with seepage, and boil under an approximate piezometric head of 0.4 m.

4.5 **Silty Clay**

The silty clay was contacted in Boreholes 1, 3 and 4 at various depths. It contains sand seams and occasional fine gravel.

The obtained 'N' value of 14 was contacted beneath the earth fill in Borehole 1, showing the clay is stiff in consistency. The lower clay is contacted beneath the sandy silt, having 'N' values of over 50 blows per 30 cm of penetration, showing that the lower clay is hard in consistency.

The obtained natural water content values of 11%, 14%, 15% and 17% indicated that the silty clay is generally in a moist condition.

The engineering properties of the silty clay are listed below:

- High frost susceptibility and low water erodibility.
- In excavation, the clays will be stable in relatively steep cuts; however, prolonged exposure may lead to localized sloughing.

4.6 **Sandy Silt Till**

A layer of sandy silt till was encountered beneath the sandy silt in Boreholes 1, 2 and 3. It is cemented and consists of a trace to some clay, and is laminated with sand and silt seams and layers.



The recorded 'N' value of 78 to over 100 blows for 30 cm penetration, indicating the sandy silt till is very dense in relative density. The natural water content value range from 10% to 14%, with a median of 13% indicated that the sandy silt till is generally in a moist condition.

The engineering properties of the sandy silt till are listed below:

- Highly frost susceptible and low water erodibility.
- The till will be relatively stable in relatively steep excavation; however, if remained open for an extended period of time, localized sloughing may occur.

5.0 **GROUNDWATER CONDITION**

Upon completion of borehole drilling, groundwater levels were recorded in all 4 boreholes, ranging from 2.7 to 3.2 metres below ground surface, or between El. 330.4 m and El. 330.9 m. The recorded water levels are presented in Table 1.

Table 1 - Groundwater Levels

BH No.	Ground Elevation (m)	Measured Groundwater Levels	
		Depth (m)	Elevation (m)
1	333.6	3.2	330.4
2	333.9	3.0	330.9
3	333.6	2.7	330.9
4	333.5	3.0	330.5

The recorded water levels in the sandy silt stratum generally represent the local groundwater regime and is subject to seasonal fluctuations.

6.0 **DISCUSSION AND RECOMMENDATIONS**

Beneath the topsoil veneer or pavement structure, and a layer of earth fill, the subsoil consists of sandy silt, with layers of silty clay and sandy silt till at various depths.

Groundwater levels were recorded at depths ranging from 2.7 to 3.2 metres below ground surface, or from El. 330.4 to 330.9 m, representing the groundwater regime at the subject site and is subject to seasonal fluctuations.

It is understood that the existing dwellings will be demolished for the development of a 6-storey residential building, with on-grade parking lot at the rear. The following geotechnical considerations warrant special attention:



1. The topsoil must be stripped for development; it can be reused for general landscaping purposes only. Once the existing dwellings are demolished, the cavities must be backfilled with selected earth fill in properly compacted to engineered fill specifications.
2. The existing earth fill is not suitable to support any structure that is sensitive to movement. It should be subexcavated, sorted free of any organic, topsoil, and/or other deleterious material, before reusing for structural backfill.
3. Engineered fill and/or sound native soils are suitable for supporting structure with conventional spread and strip footings. The foundation subgrade must be inspected to ensure its compatibility with the design and suitability to support the proposed structure.
4. A Class 'B' bedding, consisting of compacted 19-mm Crusher-Run Limestone (CRL), is recommended for the construction of underground services. Where services installation extends into the saturated silt, or where dewatering is required, a Class 'A' concrete bedding should be considered for pipe support.
5. All excavation must be carried out in accordance with O. Reg. 213/91. Excavation extending into the saturated soils and/or below groundwater level will require dewatering.

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, and the assessment given herein is general in nature based on the borehole findings. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 **Site Preparation**

The topsoil and vegetation at the ground surface must be removed for development. All structures must be demolished and the debris must be removed off site for the development. The cavities must be backfilled with selected earth fill and compacted to engineered fill specifications.

The existing earth fill is not suitable to support any structure that is sensitive to movement. It should be subexcavated, sorted free of any organic, topsoil, and/or other deleterious material, before reusing for structural backfill.

The requirements for engineering fill construction are presented below:

1. The existing topsoil must be stripped. The exposed subgrade must be inspected and proof-rolled prior to any fill placement. Badly weathered soil or ploughed earth should be sorted free of organics or deleterious material, if any, aerated prior to reuse for



- engineered fill construction. The existing earth fill can be reused provided it is sorted free of deleterious materials, aerated and properly re-compacted in layers.
2. Inorganic soils must be used, and they must be uniformly compacted in 20 cm thick lifts to at least 98% Standard Proctor Dry Density (SPDD) up to the proposed finished grade. The soil moisture must be properly controlled near the optimum. If the foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% SPDD.
 3. If the engineered fill is compacted with the moisture content on the wet side of the optimum, the underground services and pavement construction should not begin until the pore pressure within the fill mantle has completely dissipated. This must be further assessed at the time of the engineered fill construction.
 4. If imported fill is to be used, it should be inorganic soils, free of deleterious or any material with environmental issue (contamination). Any potential imported earth fill from off site must be reviewed for geotechnical and environmental quality by the appropriate personnel as authorized by the developer or agency, before it is hauled to the site.
 5. The engineered fill must not be placed during the period where freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow. If the engineered fill is to be left over the winter months, adequate earth cover, or equivalent, must be provided for protection against frost action.
 6. The fill operation must be supervised and monitored in full time basis by a technician under the direction of a geotechnical engineer.
 7. The engineered fill must extend over the entire graded area; the engineered fill envelope and finished elevations must be clearly and accurately defined in the field, and they must be precisely documented by qualified surveyors.
 8. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who supervised the fill replacement in order to document the locations of the excavation and/or to supervise reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.
 9. The foundation and underground services subgrade must be inspected by the geotechnical consulting firm that supervised the engineered fill placement. This is to ensure that the foundations and service pipes are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.
 10. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the foundations must be properly reinforced and designed by structural engineer for the project. The total and



differential settlements of 25 mm and 20 mm, respectively, should be considered in the design of the foundations founded on engineered fill.

11. In sewer construction, the engineered fill is considered to have the same structural proficiency as a native inorganic soil.

6.2 **Foundation**

The proposed 6-storey slab-on-grade building can be supported on conventional spread and strip footings founded on engineered fill and/or sound native soil beneath the earth fill. Based on the borehole information, the recommended bearing pressures at Serviceability Limit State (SLS) and Ultimate Limit State (ULS) for the design of conventional strip and spread footings founded onto the sound native soil and/or engineered fill are presented below:

- **Maximum Bearing Pressure at SLS = 100 kPa**
- **Factored Ultimate Bearing Pressure at ULS = 150 kPa**

The total and differential settlements of footing designed for the recommended bearing pressure at SLS are estimated at 25 mm and 20 mm, respectively.

Very dense/hard subsoil is contacted at least 6 m below existing grade, near the termination depths of the boreholes. Where high soil bearing pressures are required, additional deeper boreholes will be necessary for deep foundation design.

Alternatively, soil improvement methods such as Controlled Modulus Columns (CMC) or Rammed Aggregate Piers (RAP) can be used to improve the soil bearing pressures for foundation design. These methods must be properly designed by specialists with extensive experience of the methods and the improved soil bearing pressures will be certified by the respective design-build specialist.

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

Footings exposed to weathering, or in unheated areas, should have at least 1.4 m of earth cover for protection against frost action.

If the wet subgrade is evident during the footing excavation, a concrete mud-slab of lean mix concrete, 8 to 10 cm in thickness, should be poured immediately after subgrade preparation and inspection to protect the approved subgrade against disturbance by the construction traffic.



The foundation should meet the requirements specified by the latest Ontario Building Code, and the structures can be designed to resist a minimum earthquake force using Site Classification 'D' (stiff soil).

6.3 **Slab-on-Grade Construction**

The subgrade of the slab-on-grade must consist of sound native soil or well compacted inorganic earth fill or engineered fill. The subgrade should be inspected and assessed by proof-rolling prior to slab-on-grade construction. Where loose or soft subgrade is detected, it should be subexcavated and replaced with inorganic material, compacted to at least 98% Standard Proctor Dry density (SPDD) in lifts no more than 20 cm in thickness.

The concrete slab should be constructed on a minimum 15 cm thick granular base, consisting of 19-mm Crusher-Run Limestone (CRL), or equivalent, compacted to its maximum SPDD.

Where an elevator is proposed, the elevator pit, which is usually constructed below the slab-on-grade, should be designed as a submerged 'tank' structure with waterproofed pit walls and pit floor. Otherwise, proper perimeter and underfloor drainage system should be implemented. These subdrains should be separately connected to a positive outlet.

The external grading must be designed to drain surface runoff away from the structure to minimize the frost heave phenomenon generally associated with the disclosed soils.

6.4 **Underground Services**

The subgrade for underground services should consist of sound native soils or properly compacted earth fill. Where soft or loose soil is encountered at the invert level, it must be subexcavated and replaced with properly compacted bedding material.

A Class 'B' bedding, consisting of compacted 19-mm CRL, or equivalent, is recommended for construction of the underground services. The bedding material should be compacted to at least 98% SPDD. Where wet subgrade is evident, a Class 'A' concrete bedding should be considered for proper pipe support.

The pipe joints connecting into manholes and catch basins should be leak-proof or wrapped with an appropriate waterproof membrane to prevent migration of fines due to leakage, leading to a loss of subgrade support and subsequent pipe collapse.

Openings to subdrains and catch basins should be shielded by a fabric filter to prevent silting. In order to prevent pipe floatation when the service trench is deluged with water derived from



precipitation, a soil cover with a thickness of at least the diameter of the pipe should be in place at all times after completion of the pipe installation.

The service pipes and metal fittings should be protected against corrosion. For estimation of anode weight requirements, the electrical resistivities of the disclosed soils presented in Table 3 can be used.

6.5 **Backfilling Trenches and Excavated Areas**

The on-site inorganic soils, above the saturated zone, are suitable for trench backfill. Any wet soils will require aeration prior to their use as structural backfill.

The backfill material should consist of inorganic soil, compacted to at least 95% SPDD. In areas below the slab-on-grade and in the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% SPDD with a moisture content 2% to 3% drier than the optimum. This is to provide the required stiffness for floor or pavement construction. The lift of each backfill layer should be limited to a thickness of 20 cm, or the thickness should be determined by test strips at the time of compaction.

In normal construction practice, the problem areas of pavement settlement largely occur adjacent to foundation walls, columns, manholes, catch basins and services crossings. In areas which are inaccessible to a heavy compactor, sand backfill which can be appropriately compacted using a smaller vibratory compactor should be used.

One must be aware of possible consequences during trench backfilling and exercise caution as described below:

- To backfill a deep trench, one must be aware that the future settlement is to be expected, unless the sides are flattened to 1V:2H, and the lifts of the fill and its moisture content are stringently controlled; i.e. lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 98% SPDD, with the moisture content on the wet side of the optimum.
- It is often difficult to achieve uniform compaction of the backfill in the lower vertical section of a trench which is an open cut or is stabilized by a trench box, particularly in the sector close to the trench walls or the sides of the box. These sectors must be backfilled with sand and the compaction must be carried out diligently, prior to the placement of the backfill above this sector, i.e., in the upper sloped trench section. This measure is necessary in order to prevent consolidation of inadvertent voids and loose backfill which will compromise the compaction of the backfill in the upper section.



- In areas where the underground services construction is carried out during the winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement as the frost recedes, and repair costs will be incurred prior to the final surfacing of the new pavement and slab-on-grade construction.
- When construction is carried out in the winter, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in-situ soil have a water content on the dry side of the optimum, it would be impossible to wet the soil due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction. Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as when the trench box is removed. The above will invariably cause backfill settlement that may become evident within several years after construction.

6.6 **Pavement Design**

The recommended pavement design for the on-grade parking lot is provided in Table 2.

Table 2 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL3
Asphalt Binder Light Duty and Heavy Duty	60	HL8
Granular Base	150	Granular 'A' or equivalent
Granular Sub-base Light Duty Heavy Duty	300 400	Granular 'B' or equivalent

In preparation of the pavement subgrade, all topsoil and compressible material should be removed. The subgrade should be proof-rolled and inspected. Any soft spots identified must be subexcavated and replaced with inorganic earth fill.

The subgrade within 1.0 m below the underside of the granular sub-base must be compacted to at least 98% SPDD, with a water content at 2% to 3% drier than the optimum. All the granular bases should be compacted to 100% SPDD.

The pavement subgrade will suffer a strength regression if water is allowed to infiltrate the mantle. The following measures should be incorporated in the construction procedures and pavement design:



- The pavement subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- In extreme cases during the wet seasons, if soft or weak subgrade is identified, it can be replaced by compacted granular material to compensate for the inadequate strength of the soft or weak subgrade. This can be assessed during construction.

6.7 Soil Parameters

The recommended soil parameters for the project design are given in Table 3.

Table 3 - Soil Parameters

<u>Unit Weight and Bulk Factor</u>	<u>Unit Weight (kN/m³)</u>		<u>Estimated Bulk Factor</u>	
	<u>Bulk</u>	<u>Submerged</u>	<u>Loose</u>	<u>Compacted</u>
Sandy Silt	20.0	10.0	1.25	1.00
Sandy Silt Till	22.5	12.5	1.25	1.03
Silty Clay	21.0	11.0	1.33	1.03

<u>Lateral Earth Pressure Coefficients</u>	<u>Active K_a</u>	<u>At Rest K_o</u>	<u>Passive K_p</u>
Compacted Earth Fill	0.40	0.55	2.50
Sandy Silt/Silty Clay	0.33	0.50	3.00
Sandy Silt Till	0.28	0.44	3.53

<u>Estimated Coefficients of Permeability (K) and Percolation Time (T)</u>	<u>K (cm/sec)</u>	<u>T (min/cm)</u>
Silty Clay/Sandy Silt Till	10 ⁻⁶ to 10 ⁻⁷	50 to Over 80+
Sandy Silt	10 ⁻⁴ to 10 ⁻⁶	12 to 50

<u>Estimated Electrical Resistivities</u>	<u>(ohm·cm)</u>
Silty Clay	3500
Sandy Silt/Sandy Silt Till	4000 to 5500

<u>Coefficients of Friction</u>	
Between Concrete and Granular Base	0.50
Between Concrete and Native Soils or Compacted Earth Fill	0.35

6.8 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. The types of soils to be excavated are classified in Table 4.

**Table 4 - Classification of Soils for Excavation**

Material	Type
Sound Till and Silty Clay	2
Earth Fill, drained/moist Sandy Silt	3
Saturated Soil	4

Excavation above the water level, water seepage can be controlled by conventional pumping from sumps. Any excavation extending into the saturated soil will require extensive construction dewatering.

Prospective contractors should assess the in situ subsurface conditions for soil cuts by digging test pits to at least 0.5 m below the intended bottom of excavation prior to excavating. These test pits should be allowed to remain open for a period of at least 4 hours to assess the trenching conditions.

7.0 **LIMITATIONS OF REPORT**

This report was prepared by Soil Engineers Ltd. for the account of 1000383288 Ontario Inc., and for review by its designated consultants, contractors and government agencies. The material in the report reflects the judgement of Daric Yang, B.A.Sc. and Kin Fung Li, P.Eng., in light of the information available to it at the time of preparation.

Use of the 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, are 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.

SOIL ENGINEERS LTD.

Daric Yang, B.A.Sc.

Kin Fung Li, P.Eng.
DY/KFL:dd

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

Standard Penetration Resistance or 'N' Value:

The number of blows of a 63.5 kg hammer falling from a height of 76 cm required to advance a 51 mm outer diameter drive open sampler 30 cm into undisturbed soil, after an initial penetration of 15 cm.

Plotted as '○'

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows per each 30 cm of penetration of a 51 mm diameter, 90° point cone driven by a 63.5 kg hammer falling from a height of 76 cm.

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/30 cm)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
>50	very dense

Cohesive Soils:

Undrained Shear Strength (kPa)	'N' (blows/30 cm)	Consistency
<12	<2	very soft
12 to <25	2 to <4	soft
25 to <50	4 to <8	firm
50 to <100	8 to <15	stiff
100 to 200	15 to 30	very stiff
>200	>30	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

METRIC CONVERSION FACTORS

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

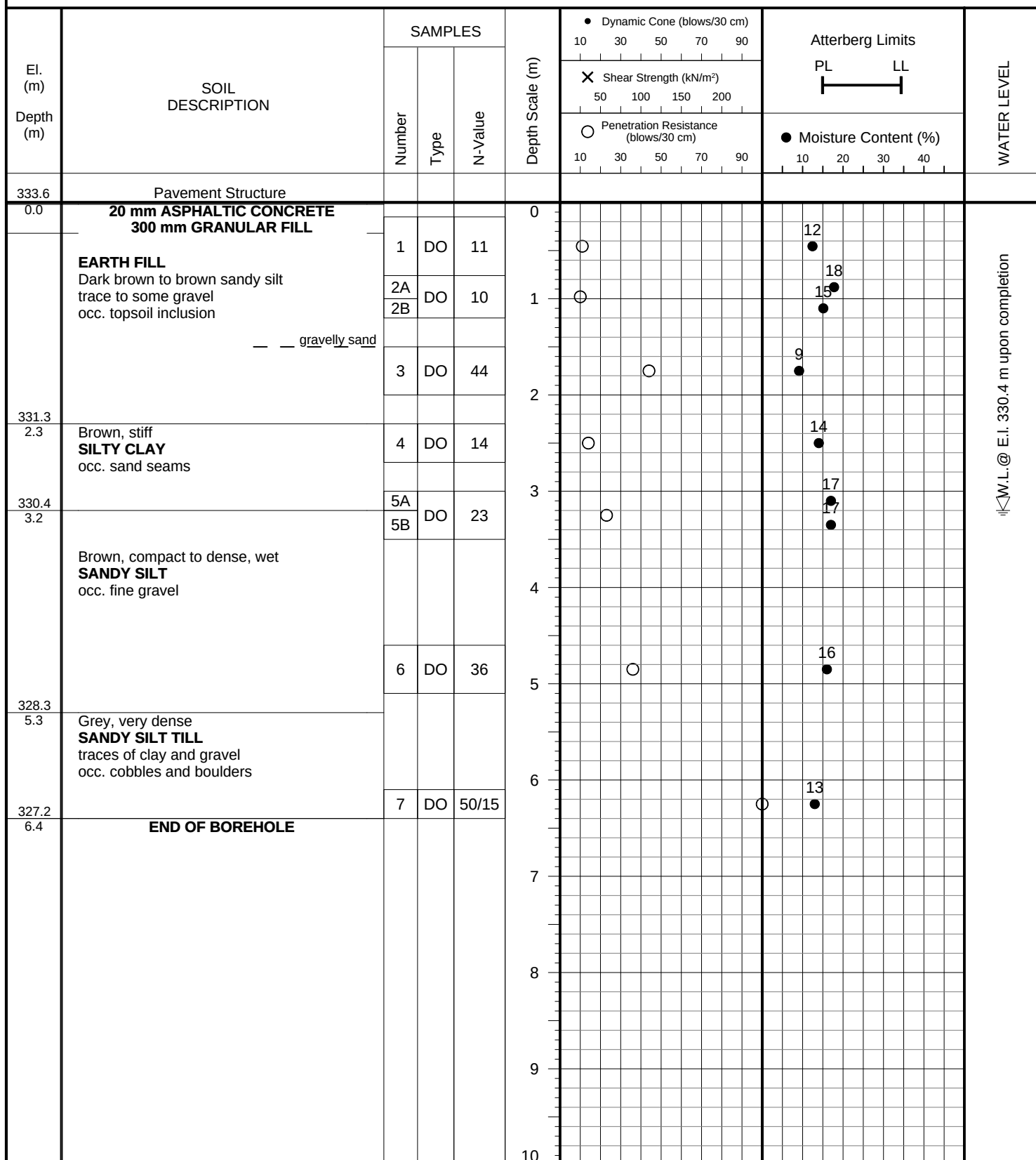


Soil Engineers Ltd.

CONSULTING ENGINEERS

GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE

JOB NO.: 2401-S069

LOG OF BOREHOLE:**1****FIGURE NO.: 1****PROJECT DESCRIPTION:** Proposed Residential Development**METHOD OF BORING:** Soild Flight Augers**PROJECT LOCATION:** 277 to 279 Hazel Street, City of Waterloo**DRILLING DATE:** February 9, 2024**Soil Engineers Ltd.**

JOB NO.: 2401-S069

LOG OF BOREHOLE:

2

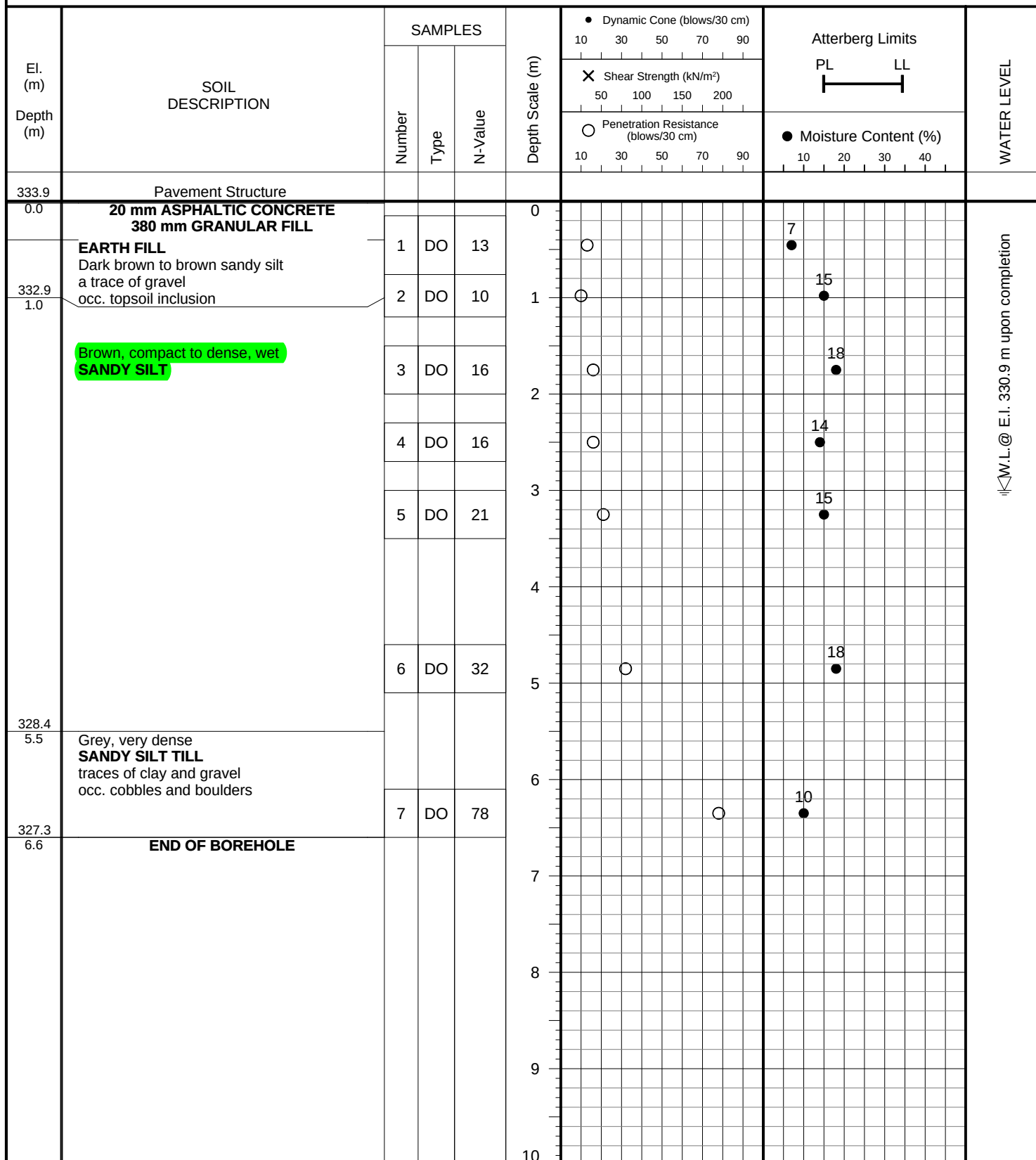
FIGURE NO.: 2

PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Soild Flight Augers

PROJECT LOCATION: 277 to 279 Hazel Street, City of Waterloo

DRILLING DATE: February 9, 2024



Soil Engineers Ltd.

JOB NO.: 2401-S069

LOG OF BOREHOLE:

3

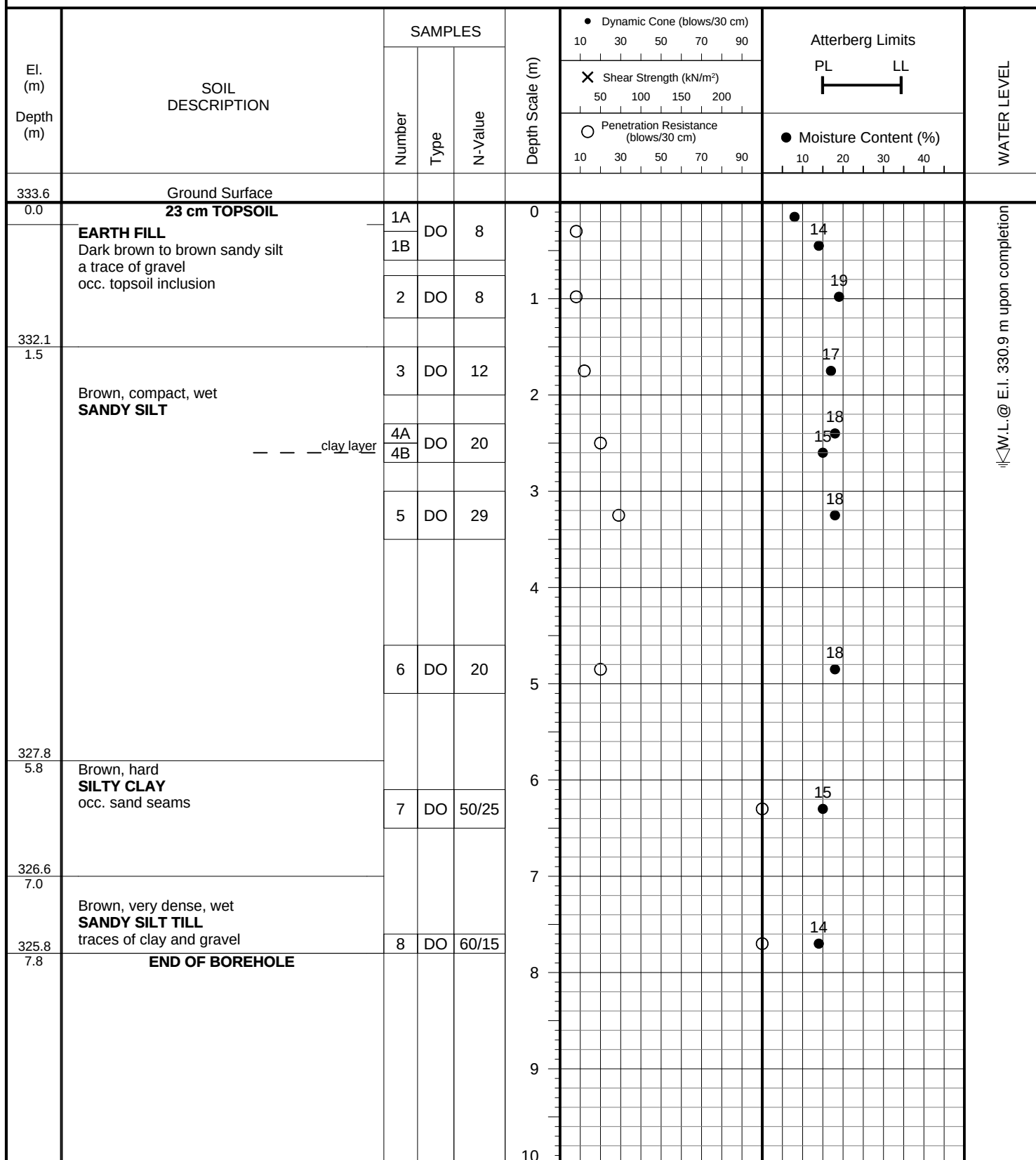
FIGURE NO.: 3

PROJECT DESCRIPTION: Proposed Residential Development

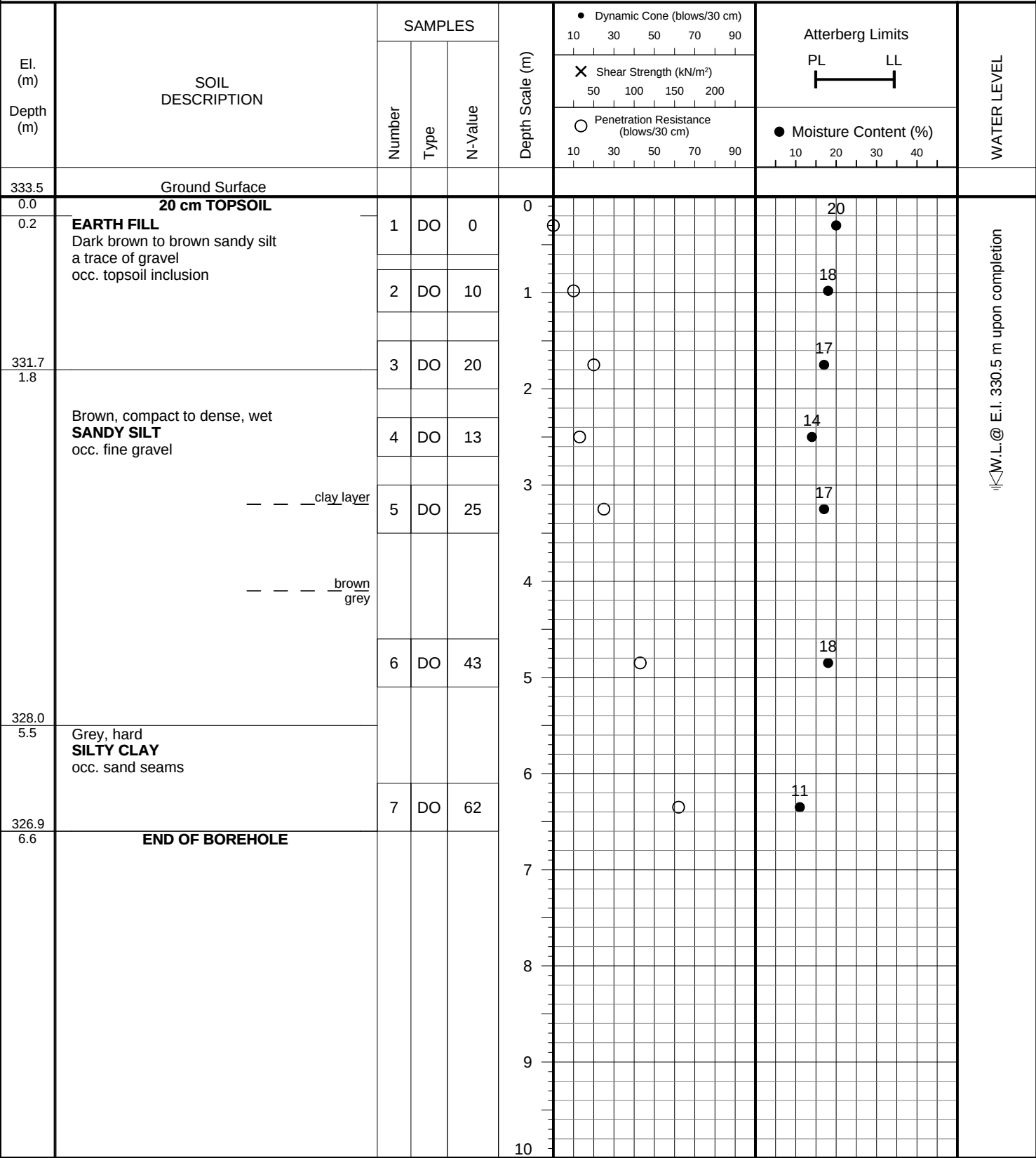
METHOD OF BORING: Soild Flight Augers

PROJECT LOCATION: 277 to 279 Hazel Street, City of Waterloo

DRILLING DATE: February 9, 2024



Soil Engineers Ltd.

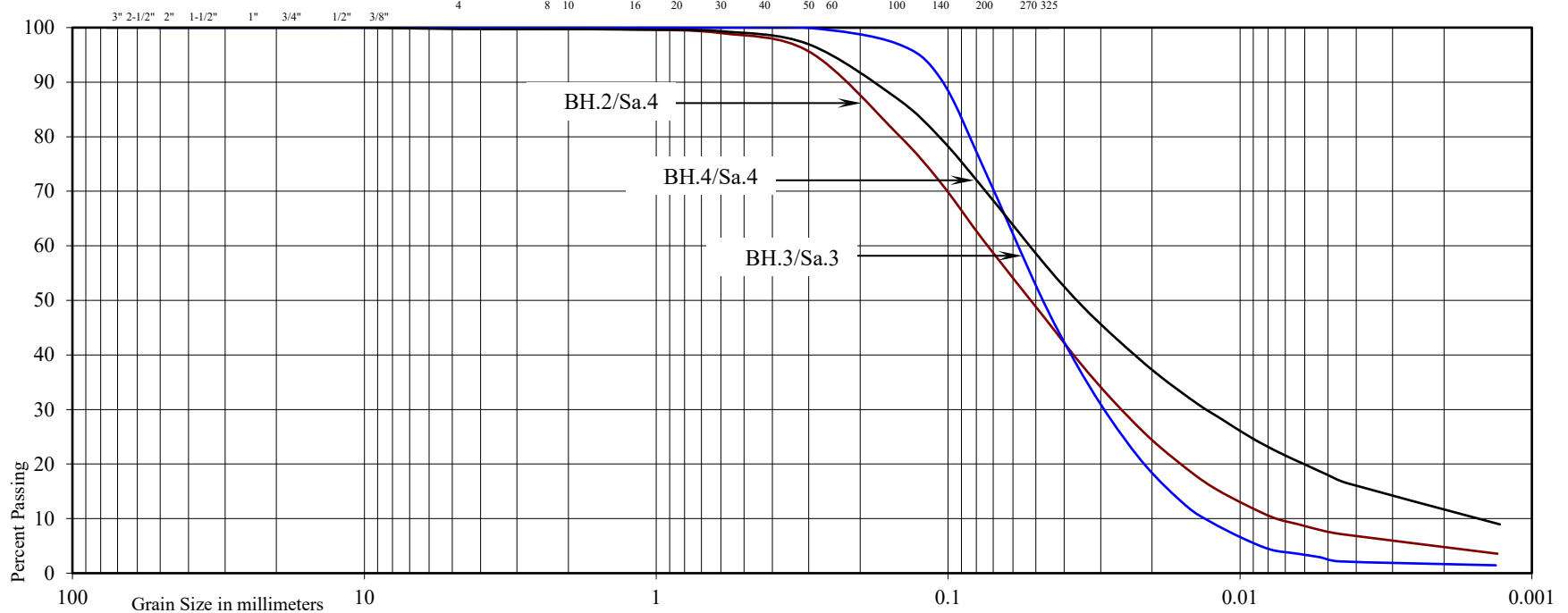


U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL			SAND				SILT	CLAY
COARSE		FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND				SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE		



Project: Proposed Residential Development

Location: 277 and 279 Hazel Street, City of Waterloo

Borehole No: 2 3 4

Sample No: 4 3 4

Depth (m): 2.3 1.5 2.2

Elevation (m): 331.6 332.1 331.3

BH./Sa. 2/4 3/3 4/4

Liquid Limit (%) = - - -

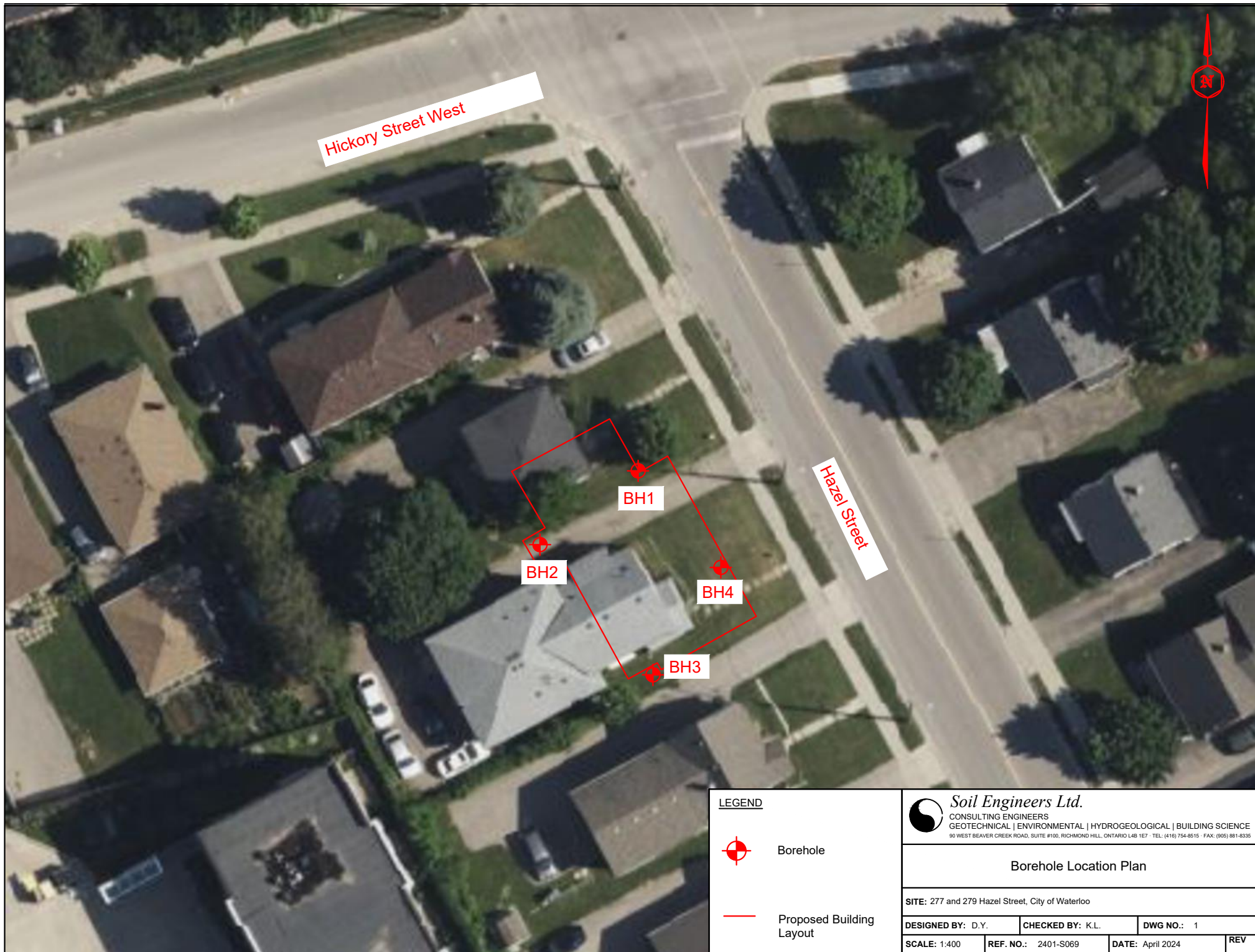
Plastic Limit (%) = - - -

Plasticity Index (%) = - - -

Moisture Content (%) = 14 17 14

Estimated Permeability (cm./sec.) = 10^{-4} 10^{-4} 10^{-6}

Classification of Sample [& Group Symbol]: SANDY SILT, a trace to some clay



LEGEND



Borehole



Proposed Building
Layout



Soil Engineers Ltd.

CONSULTING ENGINEERS
GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 TEL: (416) 754-8515 FAX: (905) 881-8335

Borehole Location Plan

SITE: 277 and 279 Hazel Street, City of Waterloo

DESIGNED BY: D.Y.

CHECKED BY: K.L.

DWG NO.: 1

SCALE: 1:400

REF. NO.: 2401-S069

DATE: April 2024

REV



Soil Engineers Ltd.

CONSULTING ENGINEERS

GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE

SUBSURFACE PROFILE

DRAWING NO. 2

SCALE: AS SHOWN

JOB NO.: 2401-S069

REPORT DATE: April 2024

PROJECT DESCRIPTION: Proposed Residential Development

PROJECT LOCATION: 277 to 279 Hazel Street, City of Waterloo

LEGEND

	ASPHALT		GRANULAR		SANDY SILT TILL		TOPSOIL
	FILL		SANDY SILT		SILTY CLAY		

WATER LEVEL (END OF DRILLING)

