415 LEGGET DRIVE SITE PLAN CONTROL APPLICATION FOR RENOVATIONS, FIT-UP AND NEW SITE DEVELOPMENTS

ACCESS PROPERTY DEVELOPMENT

GEOTECHNICAL REPORT

PROJECT NO.: 219-00058-03
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1 INTRODUCTION

1.1 CONTEXT

WSP was retained by Access Property Development (APD) to prepare this geotechnical report (the "Report") in support of a Site Plan Control application for the properties municipally known as 415 Legget Drive and 2700 Solandt Road ("the site"), in the City of Ottawa.

The purpose of the geotechnical investigation is to obtain subsurface information at the site by means of exploratory boreholes and a geophysical survey. The geotechnical investigation was divided into Phase 1, the investigation within the existing structure and Phase 2, the investigation for the new building construction. The geophysical investigation was carried out at the Site to determine the subsurface conditions between the geotechnical boreholes and Multichannel Analysis of Surface Waves (MASW) to determine the seismic site classification. This report will be submitted under a separate cover. This report presents the findings of the investigation and provides comments and recommendations which may affect the design of the proposed building upgrades and new constructions.

1.2 PROJECT AND SITE DESCRIPTION

It is understood that Access Property Development is intending to transform the existing office to serve as a storage facility by retrofitting the structure and constructing two new buildings.

There is an existing 18,084.7 m^2 (194,662 ft^2) two-storey flex/office building at 415 Legget Drive. Existing parking for the existing building is located at the north and east sides of the site. There is an existing stormwater pond at the northeast corner of the site. The redevelopment of the site is split into two (2) phases. Phase 1 includes the change of use from existing office and manufacturing occupancy building to 2-storey self storage and single-storey high bay warehousing occupancy. A partial removal of the second storey is proposed which will reduce the overall GFA of the building to approximately 14,347 m^2.

A site grading plan dated March 18, 2022 has been developed by the WSP team concurrently with this geotechnical report and is included in Appendix A. The geotechnical analysis and recommendations have been updated to take into account this proposed grading and foundation elevations noted on this recent site. The proposed development for Phase 2 consists of two (2) one-storey, storage warehouse buildings, with a proposed total gross floor area of approximately 18,580 m^2 (199,993.4 ft^2), to be located on existing parking areas north and east of the existing building at 415 Legget Drive. The two (2) warehouse buildings are proposed to contain light industrial warehousing and ancillary office uses with multiple sunken loading docks for commercial trucks. Building 'A' will be located north of the existing building at 415 Legget Drive and will have a gross floor area of 11,400 m^2. The Finished Floor Elevation (FFE) is currently set at elevation 78.50 m with the Underside of Footings (USF) elevation set at 76.10 m for this building. Building 'B' is proposed to be located east of the existing building and will have a gross floor area of 7,180 m^2. The FFE is currently set at elevation 77.65 m with the USF elevation set at 75.25 m for this building. It is also understood that Phase 2 of the project will require Site Plan approval.

On the northeast corner of the Site, to the north of Proposed Building B is an existing stormwater management pond.

1.3 OBJECTIVES AND LIMITATIONS

This report was prepared by WSP for A49 and Access Property Development in accordance with the agreed upon work order as detailed in the WSP proposal "*Renovation and Demolition Structural Engineering Services- 415 Legget Drive, Ottawa*", dated June 22, 2021. This report was prepared at the request of, and for the sole use of A49/ Access Property Development, according to the specific terms of the mandate given to WSP. The use of this report by any third party, as well as any decision based upon this report, is under that party's sole discretion and responsibility. WSP may not be held accountable for any possible damages resulting from third party decisions based on this report or its associated information.

Furthermore, any opinions regarding conformity with laws and regulations expressed in this report are technical in nature; the report is not and shall not, in any case, be considered as a legal opinion. Information in this report is only valid for the historical and supplemental borehole locations as described.

Reference should be made to the Limitations of this Report, attached in **Appendix E**, which follows the text but forms an integral part of this document.

2 SITE INVESTIGATION

2.1 SCOPE OF WORK

The geotechnical scope of work for this assignment included:

- A desktop study and review of existing geotechnical information in the general area;
- Laying out the boreholes and obtaining utility locates at the project site;
- Drilling exploratory boreholes within the interior of the building;
- In-situ soil sampling and testing, including Standard Penetration Testing (SPT) and shear vane testing;
- Obtaining soil samples for additional review;
- Laboratory testing;
- Geophysical survey to determine seismic shear wave velocities;
- Geotechnical analysis; and
- Preparation of this report which presents the results of the investigation and provides geotechnical recommendations related to the proposed building retrofit and the construction of the proposed buildings.

2.2 INVESTIGATION PROCEDURES

WSP carried out the geotechnical investigation in September and October 2021.

2.2.1 DESKTOP STUDY

Published surficial geology maps indicate the area is underlain by fine-textured glaciomarine deposits consisting of clay, silty clay and silt with minor sand and gravel deposits. To the north of the site, the surficial geology maps indicate alluvial deposits consisting of silty sand, silt, sand and clay. Bedrock geology includes sandstone of the Nepean Formation.

2.2.2 FIELD INVESTIGATION

WSP carried out a geotechnical drilling program within the existing building for Phase 1 between September 29 and October 4, 2021. The program consisted of drilling four boreholes through the existing concrete slab within the office space using hand portable drilling equipment supplied and operated by Ohlmann Geotechnical Services (OGS) Inc of Almonte, ON. The boreholes were advanced to depths ranging from of 4.9 m to 6.4 m below the existing slab surface.

WSP carried out a second geotechnical drilling program within the existing parking lots for the proposed Phase 2 buildings between September 24 and 29, 2021. The program consisted of drilling eight boreholes, seven within the existing parking lot and one in a landscaped area using a truck mounted CME drill rig, again supplied and operated by Ohlmann Geotechnical Services (OGS) Inc of Almonte, ON. The boreholes were advanced to depths ranging from of 2.8 m to 8.7 m below the existing ground surface.

WSP also carried out a seismic investigation at the site on September 20 and 21, 2021. The purpose of the seismic investigation was to determine the seismic site classification for the site, as well as produce several cross-sections showing the profile of bedrock or another bearing surface in 2-dimensions (2-D). The acquisition of three seismic lines oriented from southwest to northeast in the parking lots surrounding the existing building. These lines were then to be processed and analysed to determine a seismic site classification for the site, as well as three cross-sections showing a 2-D representation of the soil stratigraphy. The secondary scope or work was to highlight any stratigraphic layers of importance such as bedrock, or other potential bearing surfaces. Detailed results of the seismic investigation are included in Appendix D.

2.2.3 LABORATORY TESTING

Upon completion of drilling and in-situ testing, soil samples were returned to WSP's laboratory for further examination, classification and testing. The testing program consists of the determination of natural water content, grain size distribution, Atterberg limits (Plasticity) and chemical analyses of soil corrosivity (sulphate content, chloride content, pH, and resistivity). The results of determination of grain size distribution, natural water content and Atterberg limits results are summarized on the individual borehole logs and all laboratory test results are presented in Appendix C.

3 SUBSURFACE GEOTECHNICAL CONDITIONS

The subsurface conditions encountered within the boreholes are discussed in the following sections. Detailed descriptions of the soil and groundwater conditions encountered at each of the borehole locations are included in the individual borehole logs in **Appendix B**.

3.1 SOIL CONDITIONS

The following provides a general description of the major soil types encountered during the current geotechnical investigation. It should be noted that the following discussion includes some simplifications for the purposes of discussing broadly similar soil strata. It should also be noted that the differences in soil types and changes between various soil strata are often gradational, as opposed to precise boundaries of geological change.

A detailed description of the soil stratigraphy encountered at each borehole location is shown on the individual borehole log shown in **Appendix B**. Please note that the factual descriptions shown in each log takes precedence over the generalized (and simplified) descriptions presented below. Also, consider the fact that borehole represent the very location of these holes and not necessarily mean it represents the soil formation in the surrounding area.

3.1.1 INTERIOR INVESTIGATION

CONCRETE SLAB-ON-GRADE

Prior to the drilling of boreholes BH21-01i thru BH21-04i the concrete slab was scanned for rebar and subsurface obstructions. The results of the scanning did not indicate any reinforcement, either rebar or wire mesh, within the slab at these select locations. The thickness of the concrete slab ranged from 110 mm to 150 mm. No rebar or wire mesh was encountered during the coring of the concrete. A plastic vapour barrier was encountered between the concrete slab and the underlying layer of granular base.

Photos of cores of the concrete slab have been included in Drawing No. 3.

A layer of granular base which ranged in consistency from crushed sand and gravel to sandy gravel was encountered underlying boreholes BH21-2i thru BH21-4i. This layer extended to depths ranging from 0.23 m to 0.43 m below the existing ground surface and ranged in thickness from 0.1 m to 0.32 m. Grain size distributions of two sample of the granular base is presented in **Appendix C**. A summary of these grain size distributions is also presented in the table below.

Table 3.1 Results of Grain Size Analysis for Granular Base

BOREHOLE NO.	SAMPLE NO.	GRAIN SIZE DISTRIBUTION		
		% Gravel	% Sand	% Fines (< 75µm)
BH21-3i	Grab 1 (0.15 – 0.25)	72	26	2
BH21-2i	Grab 1 (0.15 – 0.3)	54	43	3

In borehole BH21-1i a layer of sand with trace gravel and trace silt was encountered underlying the concrete slab serving as a granular base. This layer extended to a depth of 0.37 m below the existing ground surface and was 0.22 m thick. A grain size distribution of one sample of this sand is presented in **Appendix C**. A summary of this grain size distribution is also presented in the table below.

Table 3.2 Results of Grain Size Analysis for Sand

BOREHOLE NO.	SAMPLE NO.	GRAIN SIZE DISTRIBUTION		
		% Gravel	% Sand	% Fines (< 75µm)
BH21-1i	Grab 1 (0.2 – 0.4)	9	84	7

GRANULAR FILL

Underlying the granular base in the boreholes a granular fill was encountered. This layer consists of gravel and cobble fragments and may contain sand and silt infilling. This layer of extended to depths ranging from 1.7 m to 2.0 m below the existing ground surface and ranged in thickness from 1.5 m to 1.7 m.

SILTY CLAY

Underlying the granular fill in the four boreholes is a layer of sensitive silty clay. This deposit generally consists of interlayered clay, silty clay and silt. Sand lenses may also be present. For simplicity this deposit is referred to in this report as silty clay (as this is the predominant soil type). The silty clay extended to the depth of drilling, up to 6.2 m below the existing ground surface.

The upper portion of the silty clay has been weathered to form a grey-brown crust. The weathered zone extended to depths ranging from approximately 3.7 m to 4.6 m below the existing ground surface. Standard penetration tests carried out within the weathered crust gave SPT ‘N’ values ranging from 3 blows to 31 blows per 305 mm of penetration, indicating a firm to hard consistency. The moisture content of one sample of weathered silty clay was 58 percent.

The silty clay below the depth of weathering is grey in colour. This unweathered silty clay extended to the termination depths, ranging from 5.3 m to 6.4 m below the existing ground surface. The SPT ‘N’ values within the unweathered silty clay ranged from 2 blows to 5 blows per 305 mm of penetration. Shear vane testing within the silty clay deposit yielded shear strengths ranging from 28 kPa to 79 kPa, indicating a firm to stiff consistency.

SAMPLER REFUSAL AND BEDROCK

Sampler refusal was not encountered at the boreholes within the building and the bedrock depth within the building footprint is inferred to be greater than the depth of drilling at the borehole locations, which ranged from 5.3 m to 6.4 m in depth.

3.1.2 EXTERIOR INVESTIGATION

PAVEMENT STRUCTURE

Asphaltic concrete was encountered in boreholes BH21-01s thru BH21-07s drilled in the paved areas. The asphaltic concrete ranged in thickness from 20 mm to 45 mm. Underlying the asphalt was a layer which ranged in consistency from sandy gravel to sand and gravel which served as a granular base. This layer ranged in thickness from 160 mm to 260 mm.

A grain size distribution of one sample of this sand and gravel is presented in **Appendix C**. A summary of this grain size distribution is also presented in the table below.

Table 3.3 Results of Grain Size Analysis for Sand and Gravel

BOREHOLE NO.	SAMPLE NO.	GRAIN SIZE DISTRIBUTION		
		% Gravel	% Sand	% Fines (< 75µm)
BH21-2s	Grab 1 (0.15 – 0.3)	66	27	7

The moisture content of select samples of granular fill ranged from 2 percent to 3 percent.

TOPSOIL

Underling the surface in borehole BH21-08s a layer of topsoil was encountered. This layer was 75 mm in thickness.

FILL

In borehole BH21-04 a layer of Silty Clay fill was encountered in borehole BH21-04s which extended from 0.2 m to 1.0 m below the existing ground surface. This layer was not encountered in any other borehole.

SILTY SAND/SAND AND SILT

A layer which ranged in consistency from silt and sand to silty sand was encountered underlying the pavement structure, fill or the topsoil in all the boreholes drilled at the site with the exception of boreholes BH21-01s and BH21-03s. This layer extended to depths ranging from 0.8 m to 2.3 m below the existing ground surface. The SPT "N" values within the silty sand ranged from 3 blows to 19 blows per 305 mm of penetration indicating a loose to compact state of packing. A grain size distribution of this silty sand/silt and sand is presented in **Appendix C**. A summary of this grain size distribution is also presented in the table below.

The moisture content of select samples of this native granular soil mixture ranged from 19 percent to 23 percent.

Table 3.4 Results of Grain Size Analysis for Sand and Silt

BOREHOLE NO.	SAMPLE NO.	GRAIN SIZE DISTRIBUTION			
		% Gravel	% Sand	% Silt	% Clay
BH21-5s	SS2 (0.8 – 1.4)	0	56	37	7

SILTY CLAY

Underlying the asphaltic concrete pavement structure, fill or sand and silt/silty sand a layer of sensitive silty clay was encountered. This deposit generally consists of interlayered clay, silty clay and silt. Sand lenses may also be present. For simplicity this deposit is referred to in this report as silty clay (as this is the predominant soil type).

The upper portion of the silty clay in boreholes BH21-01s thru BH21-03S and BH21-06s thru BH21-08s has been weathered to form a grey-brown crust. The weathered zone extended to depths ranging from approximately 1.5 m to 3.1 m below the existing ground surface. Standard penetration tests carried out within the weathered crust gave SPT 'N' values ranging from 3 blows to 15 blows per 305 mm of penetration, indicating a firm to hard consistency. The moisture content of select samples of weathered silty clay ranged from 6 percent to 49 percent.

The silty clay below the depth of weathering is grey in colour. In borehole BH21-01s and boreholes BH21-03s thru BH21-07s the unweathered silty clay layer was fully penetrated and extended to depths ranging from 3.7 m to 7.6 m below the existing ground surface. In borehole BH21-02s the borehole terminated within the unweathered silty clay layer at 8.1 m in depth. Borehole BH21-08s terminated at 2.8 m in depth due to auger refusal without encountering the unweathered silty clay. The

SPT ‘N’ values within the unweathered silty clay ranged from the weight of the SPT hammer to 3 blows per 305 mm of penetration. Shear vane testing within the silty clay deposit yielded shear strengths ranging from 23 kPa to 100 kPa, indicating a soft to very stiff consistency. The results of Atterberg limit testing was carried out on three samples of the silty clay gave plasticity index values of ranging from 9 percent to 29 percent and liquid limit values ranging from 20 percent to 53 percent, indicating a low to medium plasticity soil. The moisture content of select samples of unweathered silty clay ranged from 39 percent to 60 percent, which is near or above the liquid limit of the tested samples.

GLACIAL TILL

Underlying the silty clay in borehole BH21-01s and boreholes BH21-03s thru BH21-07s a layer of glacial till was encountered which extended to the depth of auger refusal, which ranged from 4.0 m to 8.7 m in depth. Glacial till is a heterogeneous mixture of clay, silt, sand and gravel with cobbles and boulders. During this investigation, the glacial till encountered consisted of silty clay with some gravel and some sand. Cobbles and boulders are typical within this deposit and should be anticipated during construction.

The SPT “N” values within the glacial till ranged from 2 to 5 blow to per 305 mm of penetration indicating a loose to very dense state of packing.

The moisture content of select samples of glacial till ranged from 11 percent to 48 percent.

AUGER REFUSAL AND BEDROCK

Auger refusal was encountered in all the exterior borehole with the exception of BH21-02s. The depth of auger refusal ranged from 2.8 m to 8.7 m in depth. Auger refusal was encountered in the boreholes drilled exterior of the building. This refusal may represent the bedrock surface or cobbles/boulders within the layer of glacial till. The depth of bedrock is inferred to be greater than 8.1 m in depth in borehole BH21-02s.

3.2 GROUNDWATER CONDITIONS

INTERIOR BOREHOLES

Boreholes BH21-1i thru BH21-3i were left open upon completion of drilling and groundwater was allowed to infiltrate into the borehole. Boreholes BH21-1i and BH21-2i were left open for 3 days and 2 days, respectively, and groundwater was found to be at 1.2 m below the existing ground surface. Borehole BH21-3i caved to 0.4 m in depth and was dry.

EXTERIOR BOREHOLES

Standpipe piezometers were installed in boreholes BH21-01s, BH21-03s, BH21-04s and BH21-07s. Groundwater observations were taken on October 19, 2021, approximately 3 weeks after the completion of the drilling operations and the results are summarized in the table below. It should be noted that water levels vary seasonably and are expected to be higher during the spring period.

Table 3.5 Observed Groundwater Levels

Borehole No.	Groundwater Level (m)
21-01s	0.6
21-03s	1.1
21-04s	2.9
21-07s	3.1

3.3 SUMMARY

The following table provides an overview of the soil strata encountered at each of the borehole locations.

Table 3.6 Simplified Soil and Groundwater Conditions – Interior Investigaiton

Borehole (Elev. m)	**Simplified Stratigraphy (Depth in metres)**					**Notes**
	Concrete Slab	Granular Base	Granular Fill	Weathered Silty Clay	Unweathered Silty Clay	
BH21-01i (78.5)	0 – 0.15	0.15 – 0.37	0.37 – 2.0	2.0 – 4.6	4.6 – 5.8	Water noted at 1.2 m in depth in open borehole.
BH21-02i (78.5)	0 – 0.13	0.13 – 0.23	0.23 – 1.7	1.7 - 4.1	4.1 - 5.3	Water noted at 1.2 m in depth in open borehole.
BH21-03i (78.5)	0 – 0.12	0.12 – 0.28	0.28 – 1.8	1.8 - 3.7	3.7 - 6.1	Borehole open to 0.4 m in depth and dry.
BH21-04i (78.5)	0 – 0.11	0.11 – 0.43	0.43 – 2.0	2.0 - 3.8	3.8 - 6.4	--

Table 3.7 Simplified Soil and Groundwater Conditions – Exterior Investigation – Building B

Borehole (Elev. m)	Simplified Stratigraphy (Depth in metres)								Measured Groundwater Depth (m)	Notes
	Asphaltic Concrete	Topsoil	Granular Base	Fill	Silty Sand	Weathered Silty Clay	Unweathered Silty Clay	Glacial Till		
21-01s (77.3)	0 - 0.04	--	0.04 - 0.3	--	--	0.3 - 3.1	3.1 - 4.6	4.6 - 4.9	0.6	Auger refusal at 4.9 m in depth.
21-02s (76.8)	0 - 0.03	--	0.03 - 0.23	--	0.23 - 0.83	0.83- 2.3	2.3 - 8.1	--	--	Borehole terminated at 8.1 m in depth.
21-03s (76.6)	0 - 0.02	--	0.02 - 0.2	--	--	0.2- 1.5	1.5 - 7.6	7.6 - 8.7	1.0	Auger refusal at 8.7 m in depth.

Table 3.8 Simplified Soil and Groundwater Conditions – Exterior Investigation – Building A

Borehole	Simplified Stratigraphy (Depth in metres)								Measured Groundwater Depth (m)	Notes
	Asphaltic Concrete	Topsoil	Granular Base	Fill	Silty Sand	Weathered Silty Clay	Unweathered Silty Clay	Glacial Till		
21-04s (77.4)	0 - 0.04	--	0.04 - 0.23	0.23 - 1.0	1.0 - 1.7		1.7 - 7.6	7.6 - 8.2	2.9	Auger refusal at 8.2 m in depth
21-05s (77.7)	0 - 0.02	--	0.02 -0.23	--	0.23 - 1.2		1.2 - 4.6	4.6 - 5.1	--	Auger refusal at 5.1 m in depth
21-06s (77.1)	0 - 0.045	--	0.045 - 0.21	--	0.21 - 0.85	0.85- 1.5	1.5 - 3.7	3.7 - 4.0	--	Auger refusal at 4.0 m in depth
21-07s (77.3)	0 - 0.04	--	0.04 - 0.2	--	0.2 - 1.2	1.2 - 1.5	1.5 - 6.5	--	3.1	Auger refusal at 6.5 m in depth
21-08s (77.3)	--	0 - 0.075		--	0.075 - 2.3	2.3 - 2.8	--	--	--	Auger refusal at 2.8 m in depth

4 RECOMMENDATIONS

4.1 GENERAL

This section of the report provides an engineering guidance related to the geotechnical design aspects of the project based on our interpretation of the available information described herein and project requirements. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, safety, and equipment capabilities. Reference should be made to the Limitations of this Report, attached in **Appendix E**, which follows the text but forms an integral part of this document.

The general subsurface conditions encountered outside the existing building consists of an asphalt pavement structure overlying sensitive silty clay. In some locations a thin layer of silty sand was encountered between the asphalt pavement structure and the silty clay. The general subsurface conditions encountered inside the existing building consists of a concrete slab on grade overlying a layer of fill which in turn is underlain by silty clay which extended to the depth of drilling. SPT sampler refusal was not encountered within the boreholes in the interior investigation and the bedrock depth is inferred to be greater than the depth of drilling at each location. Auger refusal was encountered during the exterior borehole investigation, which is inferred as bedrock.

4.2 SEISMIC SITE CLASSIFICATION

4.2.1 LIQUEFACTION

The soils at the site are not considered to be susceptible to seismic liquefaction based on the soil types encountered at the site, the SPT N-values and shear strength values collected within these soils and the groundwater level observed at the site.

4.2.1 SEISMIC SITE CLASSIFICATION

As outlined in the 2015 Ontario Building Code, building foundations must be designed to resist a minimum earthquake force. To support the determination of the seismic site classification, in-situ field testing consisting of a Multichannel Analysis of Surface Waves (MASW) was carried out the proposed locations of Buildings ‘A’ and ‘B’. The results of this testing were used to select a seismic site classification in accordance with Table 4.1.8.4.A of the 2015 OBC. The results of the MASW testing are included in Appendix D of this report. In summary, the results of the testing indicate a V_{s30} value of 376 m/s at the location of Building A and a V_{s30} value of 325 m/s at the location of Building B.

In accordance with the Ontario Building Code, the seismic site response for foundations placed on native silty clay or engineered fill would have a seismic site classification of Class C at Building ‘A’ and a seismic site classification of Class D at Building ‘B’ and the existing building.

4.3 SITE PREPARATION AND GRADING

At this time, only preliminary building details of the proposed buildings ‘A’ and ‘B’ are available and the proposed finished grade elevation have been indicated on the Site Grading Plan, see Appendix A. Based on our assessment of the subsurface conditions encountered on this site, a grade raise restriction of 1.0 m should be applied to areas beyond 2 metres of the existing or proposed buildings to limit potential settlement within the underlying silty clay. Areas within 2 metres of the existing or proposed building, will require light weight fill materials having a unit weight less than 6 kN/m^3. Lightweight Cellular Concrete (LCC) or EPS foam blocks should be used within 2 m of the existing or proposed building to increase the grading around these buildings. These lightweight fill materials can be cap with 200 mm of topsoil or concrete to provide landscaping features or hardscapes around the buildings. LCC and EPS foam blocks should not be placed near or below the observed groundwater levels or within the seasonal variation of the groundwater due to the buoyance affects. Material details for the LCC are provide in Section 4.5, Engineered Fill and Section 4.9 Foundation Wall Backfill and the material details for EPS are provided in section 4.6.1, Frost Protection.

It is recommended that WSP be retained to review the final site grading plan prior to construction to ensure that they are consistent with the recommendations of this report. It is also suggested that a supplemental geotechnical investigation could be carried out to obtain additional field tests and obtain additional samples of the sensitive silty clay to allow for oedometer consolidation laboratory testing to be carried out to confirm the preconsolidation pressure of silty clay and verify the need for light weight fill materials and the grading restrictions.

The existing topsoil and the existing asphaltic concrete should be removed from the entire new building footprints. At the completion of the topsoil stripping and prior to any placement of new fill, the subgrade within the building area should be proof-rolled. The purpose of the proof-rolling is to provide surficial densification and to locate any isolated areas of soft or loose soils. Unsuitable areas should be removed and replaced with compacted fill meeting the requirement described later in this report. Both stripping and proof-rolling operations should be observed and carried out to the satisfaction of geotechnical personnel. All stripping and earthwork activities should be performed in a manner consistent with good erosion and sediment control practices. Prior to placement of any new granular material, the exposed top of subgrade should be inspected and approved by qualified personnel to ensure drainage is maintained across the footprint of the foundation of the new warehouse buildings.

4.4 MATERIAL REUSE

The native soils (silty clay and glacial till) are not considered to be suitable for reuse as structural engineered fill. However, these soils could be reused in general earth borrow in non-structural areas (i.e., landscaping) depending upon its environmental suitability, which is not included as part of this assignment. The granular base immediately below the asphaltic concrete in the existing parking lots can be reused as engineered fill provided it is properly segregated from the silty clay below during its excavation.

It is anticipated that during the excavation for new foundations within the existing building the soils will become mixed and segregation is not realistic; therefore these excavated materials are not suitable for reuse, but could be used as general site fill in landscaped areas.

Excess soils will need to be properly removed from site based on the new environmental regulations. An environmental investigation maybe required if excess soils need to be removed from the site.

4.5 ENGINEERED FILL

Prior to placing engineered fill, the exposed subgrade should be inspected by qualified geotechnical personnel to confirm that the exposed soils are suitable and undisturbed and have been adequately cleaned of ponded water and all disturbed, loosened, softened, organic and other deleterious material. Remedial work (i.e. further sub-excavation and replacement) should be carried out as directed by geotechnical personnel.

Imported materials to be used for engineered fill should be approved by geotechnical personnel. In this regard, imported materials which meet the requirements for OPSS Granular A or Granular B Type I or II would be suitable for use as engineered fill under footings or other foundation elements.

Engineered fill within the two proposed buildings ‘A’ and ‘B’ should consist of light weight engineered fill materials having a unit weight no greater than 6 kilonewtons per cubic meter (kN/m^3), such as Lightweight Cellular Concrete (LCC) or EPS rigid foam blocks. Typical engineered backfill materials such as OPSS 1010 Select Subgrade Materials (SMM), Granular A, B, M, or O, clean sands, clear stone should not be used due to the excessive vertical stresses they would impose on the underlying silty clay. The lightweight cellular concrete (such as Cematrix CMEF-400) should have a minimum unconfined compressive strength of 0.4 Megapascals at 28 days after placement. EPS should have at least 690 kPa compressive strength under foundation loads, slabs and pavement. EPS having a compressive strength of at least 275 kPa can be used in landscaping areas. Both these lightweight fill materials require special installation and the manufactures installation guidelines should be followed.

The approved materials for engineered fill should be placed in maximum 300 mm loose lifts and be uniformly compacted to 98 percent of SPMDD throughout using suitable vibratory compaction equipment. The placement of engineered fill must be monitored by qualified geotechnical personnel on a full-time basis. The top surface of the engineered fill should be protected as necessary from construction traffic and should be sloped to provide positive drainage for surface water during the construction period.

The upper surface of the engineered fill should extend to a minimum of 1 m outside of the outer edge of the exterior building foundation envelope (in all directions) and should be sloped downward and outward at no steeper than 1 horizontal to 1 vertical (1H:1V). Engineered fill slopes that will become permanently exposed fill slopes at the development, if any, should be flattened to 2H:1V or flatter, and should be covered with topsoil and sodded or otherwise treated to reduce erosion. Maintenance will be required over the first several years until the vegetative mat has taken root.

The placement of fill for paved areas (parking areas and access roads) may be required at the site. Imported materials which meet the requirements for OPSS earth borrow would be suitable for use as fill. This fill should be compacted to at least 95 percent of SPMMD. The placement of the fill should be monitored by geotechnical personnel on a regular basis. Placement of the upper 450 mm should be monitored on a full-time basis.

4.6 FOUNDATIONS

4.6.1 FROST PROTECTION

All exterior footings and any footings located in unheated portions of the building should be protected against frost heave by providing a minimum of 1.8 m of earth cover or the thermal equivalent if insulation is used in areas where snow will remain during winter months. In areas where the exterior grade is cleared during the winter months and exposed to freezing temperature, such as sidewalks, paved areas, etc. foundations in these areas should be provided with a minimum of 1.8 m of earth cover or the thermal equivalent if insulation is used.

Higher bearing/USF elevations due to the underlying silty clay and in areas of below grade loading docks will require the installation of rigid insulation to provide the thermal equivalence and to provide general foundation wall backfill. Figures of various footing insulation details are shown in Figures 4 and 5 in Appendix A. This rigid insulation should be constructed of Expanded Polystyrene foam (EPS) sheets and blocks. In preparation for the insulation, a levelling mat consisting of 25 millimetres of concrete/mortar sand or 50 millimetres of lean concrete should be placed on the approved bearing surface. Care must be taken to ensure that the insulation is not damaged during construction. Joints should be carefully lap jointed and glued where and if possible. Footings may then be constructed on the surface of the insulation. The type of insulations should be selected such that the bearing pressure on the insulation placed under the footings does not exceed about 35 percent of the insulation’s quoted compressive strength. This is due to the time dependant creep characteristics of this material. For example, the allowable bearing pressures for several strengths of insulation are:

Table 4.1 Rigid Insulation Bearing Resistance Values

Insulation Type	SLS Resistance (kPa)	ULS Factored Resistance (kPa)
Dow SM	65	100
Dow Highload 40	90	135
Dow Highload 60	145	205
Dow Highload 100	240	340

The insulation which projects beyond the edge of the footings can consist of Dow SM or equivalent, except beneath pavements where HI 60 should be used beyond the footing. Groundwater and buoyance will need to be considered when placing EPS.

Special details may be required where the insulation projects under hard surfacing (such as asphalt paved areas or sidewalks) to avoid differential heaving over the edge of the insulation. Given the cold winter temperatures experienced in this part of Canada and the frost susceptible soils present in much of the Ottawa area, differential heaving is a design issue which can rarely be eliminated economically. It is usually most practical to spread the differential heaving over a greater distance so that its impact will be less severe. Differential heaving as a design issue should be considered in areas overlain by hard surfacing. The severity of the differential heaving can be reduced by:

- Maintaining a uniform subgrade level or, where the ground surface level changes (such as under a stairway or ramp), maintaining a uniform thickness of frost susceptible soil within the depth of frost penetration.
- Where the subgrade level must change, the transition should be accomplished by sloping the subgrade surface at no steeper than 3 horizontal to 1 vertical.
- Providing suitable transition details at the edge of insulated areas, as described above, to avoid drastic differences in the depth of frost penetration over short distances.
- Where possible, draining the granular backfill materials to carry away water which would readily feed ice lensing in the adjacent frost susceptible soil.
- Maintaining a uniform composition of the subgrade by using excavated backfill materials which, within the zone of frost penetration, match the surrounding soils.

If these design guidelines are applied to the details of the exterior construction works, it will help to control the impact of the differential heaving on the use of this facility by the owner.

In the event that foundations are to be constructed during the winter months, foundation soils are required to be protected from freezing temperatures using suitable construction techniques. Therefore, the base of all excavations should be insulated from freezing temperatures immediately upon exposure, until the time that heat can be supplied to the building interior and/or the foundations have sufficient earth cover to prevent freezing of the subgrade soils.

4.6.2 BEARING CAPACITY / RESISTANCES

For this assignment the geotechnical bearing resistances was evaluated for both the soils below the existing building and at the two proposed buildings.

For the analysis at the existing building, limited structural drawings were available showing the interior pad foundations and the perimeter strip foundations of the existing building. From these drawings it appears that the existing perimeter footings have been constructed at approximately 1.5 m below the existing ground surface. The existing internal foundations have been constructed at approximately 0.6 m below the existing floor slabs. The width of the existing perimeter strip foundations appears to be 1.2 m wide. The interior column pad foundations appear to vary in size from 1.7 m by 1.7 m to 2.75 m by 2.75 m.

It is understood that additional footings will be required for the retrofit, Table 4.2 provides various geotechnical resistances for both the existing and new foundations at various depths and sizes at different founding depths and subgrades. The minimum distance between existing and proposed foundations depends on the depth and location of the foundations relative to each other. New footings should be located at least 1.5 m from the edge of any existing foundation. Special consideration is required for foundation closer than this offset distance.

The geotechnical resistances for the two new proposed buildings are also provided in the table below. These geotechnical resistances take in account for additional site fill being limited to 1.0 m or less from existing grades and because of the sensitive nature of the underlying silty clay, lightweight fill materials, such as LCC or EPS are needed inside the new buildings and within 2 m of the proposed building footprints. These geotechnical resistances have been based on the FFE and USF elevations provided on the Site Plan, dated March 18, 2022 included in Appendix A.

If additional site fill is required, then these geotechnical resistances will need to be reviewed. As previously suggested, but not necessary, a supplemental geotechnical investigation with the additional field and laboratory testing could provide an opportunity to optimize the bearing resistances for Buildings ‘A’ and ‘B’.

Table 4.2 Summary of Geotechnical Resistances

Location	New/Existing Foundation Width, B (m)	Depth below Finished Floor Slab (m)	Founding Soils	Factored Ultimate Limit States, ULS (kPa)	Serviceability Limit States, SLS (kPa)
Phase I – Existing Building - Perimeter	1.2	1.5	Existing Granular Fill	205	90
	3.0	1.5	Existing Granular Fill	255	55
Phase I – Existing Building – Interior FFE = 78.485 m	1.5	0.6	Existing Granular Fill	215	210
	1.7	0.6	Existing Granular Fill	220	200
	2.1	0.6	Existing Granular Fill	230	160
	2.45 / 2.50	0.6	Existing Granular Fill	230	160
	2.75	0.6	Existing Granular Fill	250	110
	3.0	0.6	Existing Granular Fill	255	100
	3.0	1.5	Existing Granular Fill	255	90
Phase II – Proposed Building A - Perimeter FFE = 78.50 m USF = 76.10 m	1.2	2.4	Native Grey Silty Clay	85	40
	1.5	2.4	Native Grey Silty Clay	90	40
	2.0	2.4	Native Grey Silty Clay	95	40
Phase II – Proposed Building A - Interior FFE = 78.50 m USF = 77.3 m Light Weight Building Infill Materials Required	1.2	1.2	Weathered Silty Clay or Native Silty Sand	95	90
	1.5	1.2	Weathered Silty Clay or Native Silty Sand	100	95
	2.0	1.2	Weathered Silty Clay or Native Silty Sand	105	100
Phase II – Proposed Building B – Perimeter FFE = 77.65 m USF = 75.25 m	1.2	2.4	Native Grey Silty Clay	85	50
	1.5	2.4	Native Grey Silty Clay	90	45
	2.0	2.4	Native Grey Silty Clay	95	40
Phase II – Building B, Interior FFE = 77.65 m USF = 76.55 m Light Weight Building Infill Materials Required	1.2	1.1	Weathered Silty Clay	85	80
	1.5	1.1	Weathered Silty Clay	90	85
	2.0	1.1	Weathered Silty Clay	95	90

Provided that the foundation subgrade is properly prepared, and not unduly disturbed by construction activities, total and differential settlements associated with the above SLS resistance values are expected to be less than 25 mm and 20 mm, respectively.

All bearing surfaces should be checked, evaluated and approved at the time of construction by a geotechnical engineer who is familiar with the findings of this investigation and the design and construction of similar projects prior to placement of any concrete, back fill, etc.

Additional guidance related to bearing resistances can be provided based on preliminary designs. In particular, bearing resistances should be reviewed if the foundations are lower than previously indicated or if the foundation loads are too large for the assumed shallow foundation sizes.

4.7 SLAB ON GRADE

It is understood that at this point in the design, the concrete slab on grade is to remain inside the existing building for Phase 1 of this project.

The geotechnical resistance of the slab-on-grade itself at SLS will depend on the settlement characteristics of the soil below the slab, as well as the magnitude and geometry of loading. The geotechnical parameter typically used for analysis of settlement below a raft or slab is the vertical modulus of subgrade reaction. The modulus of vertical subgrade reaction is defined as:

$$K_{BxB}=q/\delta$$

Where:

q = applied bearing or contact pressure on footing

δ = settlement of footing under applied pressure q

Based on the field investigation a value of 75 MPa/m may be used for the modulus of subgrade reaction for the existing granular fill inside the existing building and for LCC fill within buildings 'A' and 'B' or 50 MPa/m may be used for the modulus of subgrade reaction for EPS foam blocks for Buildings A and B. A value of 20 MPa/m may be used for the modulus of subgrade reaction for very stiff weathered silty clay below.

The modulus of subgrade reaction is not a fundamental soil property, but is dependent upon the size and shape of the loaded area, soil type, relative stiffness of the raft and soil, duration of loading, etc. As a result, the modulus for a 300 mm square footing is typically used as a standard basis.

For loaded rectangular area greater than 300 mm square supported on granular fill the above value should be multiplied as follows:

$$k_{(BXB)} = k_{0.3}\left(\frac{3.28B+1}{6.56B}\right)^2$$

For loaded rectangular area greater than 300 mm square on silty clay the above value should be multiplied as follows:

$$k_{(BXB)} = k_{0.3}\left(\frac{0.3}{B}\right)$$

Where:

k_{BxB} = the modulus for a square loaded area of length and width B (kN/m^3)

$k_{0.3}$ = Use 75 MPa/m (existing granular fill in Phase I Building or LCC in Buildings 'A' and 'B')

$k_{0.3}$ = Use 50 MPa/m (EPS blocks in Buildings 'A' and 'B')

$k_{0.3}$ = Use 20 MPa/m (weathered very stiff silty clay) and

B = width of the loaded area;

For predictable performance of new floor slabs in Buildings A and B, the underslab fill should be prepared as previously described in Section 4.3 of this report. Provision should be made for at least 150 millimetres of OPSS Granular A to form the base for the floor slab in the Phase 1 Building. Follow manufacture recommendations for LCC and EPS within Buildings 'A' and 'B'.

4.8 LATERAL EARTH PRESSURES

This section applies to below grade walls or retaining walls where either earth or granular backfill is in contact with the wall. Areas with LCC and EPS blocks are used as backfill against these below grade structures, follow the manufactures design guidelines. Below grade walls that have earth or engineered fill up against them will be subject to lateral earth pressures. The following geotechnical parameters can be used for below grade walls that are backfill with granular materials.

Table 4.3 Lateral Earth Pressure Parameters (Granular Fills)

Parameter	OPSS Select Subgrade Material (SSM)	OPSS Granular A or Granular B, Type II
Unit Weight, γ_{moist}	20.0 kN/m^3	22.0 kN/m^3
Unit Weight, $\gamma_{submerged}$	10.0 kN/m^3	12.0 kN/m^3
Angle of Internal Friction (compacted), ϕ	32 degrees	35 degrees
Coefficient of Passive Earth Pressure, K_p	3.25	3.69
Coefficient of Active Earth Pressure, K_a	0.31	0.27
Coefficient of at-Rest Earth Pressure, K_o	0.47	0.43
Combined Active and Seismic Earth Pressure Coefficient, K_{AE}	0.61	0.55

4.8.1 STATIC LATERAL EARTH PRESSURE

The lateral static earth forces acting on permanent retaining walls and temporary shoring, etc. may be calculated using the following expressions:

$$P = \frac{1}{2} K\gamma H^2 \quad \text{and} \quad P_{surcharge} = KqH$$

Where:

P = lateral earth pressure forces (kN): earth force acts at $\frac{1}{3}$H and surcharge force acts at $\frac{1}{2}$H above the bottom of wall;

K = earth pressure coefficient; for unrestrained walls and structures where some movement is acceptable (such as retaining walls) use a coefficient of active earth pressure (K_a) and for restrained walls (such as basement walls) use the coefficient of earth pressure at rest (K_o)

γ = the moist unit weight of retained fill

H = the wall height (m)

q = the magnitude of any design surcharge at the ground surface, typically 12 kPa for standard vehicles;

Hydrostatic pressure should also be applied to the wall if submerged conditions are to be expected. Hydrostatic force should be applied at $\frac{1}{3}$H above bottom of the wall.

4.8.2 SEISMIC EARTH PRESSURE

Earth pressures will be higher under seismic loading conditions. The Mononobe-Okabe (M-O) method (see CFEM, 2006) is a pseudo-static analysis of seismic earth pressures during an earthquake. In order to account for seismic earth pressures, the total lateral thrust and its components during a seismic event (including both the seismic and static components) may be calculated as:

$$P_{AE} = ½\, K_{AE}\gamma H^2(1\text{-}k_v) \qquad \text{and} \qquad P_A = ½\, K_A\gamma H^2 \qquad \text{with} \qquad \Delta P_{AE} = P_{AE} - P_A$$

Where: P_{AE} = the total active seismic thrust component (kN);

P_A = Static component of the lateral thrust, acting at $\frac{1}{3}$H above bottom of the wall;

ΔP_{AE} = Dynamic component of the lateral thrust, acting at 0.6H above the bottom of the wall;

K_{AE} = the combined active earth pressure and seismic earth pressure coefficient;

K_A = the coefficient of static active earth pressure;

γ = the moist unit weight of retained fill;

H = the total height of the wall (m).

It should be noted that earth pressure distributions are applicable over the full height of the wall. It should also be noted that the above lateral earth pressures are unfactored for limit states design.

4.8.3 HYDRODYNAMIC PRESSURE

For granular backfilled walls in potentially submerged conditions, the hydrodynamic pressure should be taken into account using the following expression:

$$P_w = (7/12)\, k_h\gamma_w H^2$$

Where:

k_h = horizontal peak ground acceleration (0.28)

γ_w = unit weight of water (9.8 kN/m^3)

H = height of wall (m)

According to CFEM (2006) the total thrust of water on the wall during a seismic event is the sum of the hydrostatic and hydrodynamic forces. The hydrostatic and hydrodynamic forces should be applied at 1/3H above bottom of the wall.

4.8.4 SLIDING RESISTANCE

Sliding resistance can be calculated using the following unfactored friction coefficients.

Table 4.4 Summary of Sliding Coefficients

Condition	Unfactored Friction Coefficient, tan δ	Interfacial Friction Angle, δ (degrees)
Between Concrete and Engineered Granular Fill	0.4	22
Between Concrete and Native Silty Sand	0.45	24
Between Concrete and Native Silty Clay	0.3	17
Between Reinforced Concrete and Lean Concrete or Mud Slab	0.6	31

4.9 FOUNDATION WALL BACKFILL

For areas where the amount of grade raise surrounding the building is greater than 0.3 m, light weight fill materials such as LCC or EPS blocks are required to maintain satisfactory bearing pressures and avoid long term settlements of the underlying silty clay. Both materials require special installation methods and the installation guidelines from the manufacture should be closely followed.

For areas where the amount of grade raise surrounding the building is less than 0.3 m, the native soils at this site may be potentially frost susceptible and should not be used as backfill against exterior or unheated foundation elements (e.g., footing, foundation walls, sunken loading docks, etc.). To avoid problems with frost adhesion and heaving, these foundation elements should be backfilled with one or more of the following:

- Non-frost-susceptible sand and/or gravel which meets that gradation requirements for OPSS Granular A or Granular B;
- Existing non frost susceptible soils salvaged from onsite excavations provided that the material is reviewed by a qualified geotechnical personnel prior to reuse; and ,
- 19 millimetre clear crushed stone, which is separated from other soils with a Class II non-woven geotextile having an FOS not exceeding 100 microns to prevent loss of adjacent sand, or silty soils into the clear stone. It should be noted that the use of clear stone as foundation backfill may lead to unfavourable growing conditions for plant matter placed in overlying topsoil.

Backfill should be placed in shallow lifts, not exceeding 200 mm loose thickness, and compacted to 98% SPMDD where it is supporting any structures or services, or 95% in other areas.

To avoid damaging or laterally displacing the structures, care should be exercised when compacting fill adjacent to new structures. Heavy equipment should be kept a minimum of 1 m away from the structure during backfilling. The 1 m width adjacent to the wall should be compacted using hand-operated equipment unless otherwise authorized.

In areas where pavement or other hard surfacing will be in contact the building, differential frost heaving could occur between the granular fill (if sand or crushed stone is used) and other areas. To reduce this differential heaving, the backfill adjacent to the wall should be placed to form a frost taper. The frost taper should be brought up to pavement subgrade level from 1.5 metres below finished exterior grade at a slope of 3 horizontal to 1 vertical, or flatter, away from the wall. The fill should be placed in maximum 300-millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable vibratory compaction equipment.

4.10 SITE SERVICES

Excavation for new site services up to approximately 1.5 m below the existing ground surface are expected to be within the native silty sands or weathered silty clay. Below 1.5 m from the ground surface, grey sensitive silty clay will likely be encountered. The bedrock surface at the site is highly variable and could be encountered at depths as shallow as 2.8 m or deeper than 8.1 m. If bedrock is encountered within the service excavation, the bedrock removal could be carried out using line drilling and mechanical methods of rock removal (such as hoe ramming), however, this work would likely be slow and tedious. Based on the close distance to other structures, controlled blasting is not recommended.

Details of the proposed site services are not available at this time; however, it is assumed that they will include localized trenches throughout the site. Trenches can be temporarily supported using sloped excavations or trench boxes as outlined in Section 4.13.2 of this report.

The water and sewer services will need to be protected against freezing conditions and water-bearing services should be placed a minimum of 2.4 m below grade to provide protection from frost. Alternatively, equivalent insulation cover may be provided in lieu of burial.

Bedding and cover components for municipal services (water, storm sewer and sanitary sewer) should be in accordance with corresponding City of Ottawa Specifications and Standard Drawings W17 and S6. Service excavations that encounter bedrock at or above the bedding level do require different bedding requirements as shown in Standard Drawings W17 and S6. Recommendations for bedding and cover for the project specific heating and cooling distribution piping should be covered in the geotechnical report prepared for the Distribution Network (separate cover).

Bedding for site services should be in accordance with the relevant OPSD standard drawing and would typically consist of Granular “A” compacted to 95% SPMDD. Where wet or disturbed conditions are encountered in the base of the trench it may be necessary to over-excavate and replace unsuitable soils with compacted granular fill to provide a stable sub-grade for the bedding. The use of clear stone as a bedding and cover material is not recommended as the finer particles of the native soils and backfill may migrate into the voids of the clear stone, resulting in loss of pipe support.

Cover material above the spring line should consist of Granular “A” or Granular “B” material with a maximum particle size of 25 mm. Cover material should be compacted to a minimum of 95% SPMDD.

Backfill may consist of additional granular fill, or properly moisture conditioned native silty clay and should be compacted to 95% SPMDD (98% if below structures). Where backfill is within the frost depth, the backfill profile (above the minimum cover required) in the trench should be made to match the native soils on either side as much as is practical in order to minimize the potential for differential frost heave. As a result, portions of the silty clay above the water table may be retained, moisture conditioned (if necessary) and re-used.

Any service trenches which extend below the water table should have clay cut-offs installed across the trench at regular intervals (typically 100 m) to prevent the trench acting as a drain and lowering the groundwater table in the general area. These cut-offs should extend the full width of the trench and must completely penetrate the bedding, cover and any other granular materials in the trench.

The above are general guidelines for typical site services. All services installations should be completed in accordance with the relevant OPSS’s and OPSD’s for the particular application and size. WSP can provide additional review during detailed design based on the actual services proposed if required.

4.11 PAVEMENTS

The existing pavement structure at the site is quite thin with asphaltic concrete thickness varying from 20 mm to 45 mm and the underlying granular base is approximately 180 mm thick. This light duty flexible pavement will likely not be remaining in a serviceable condition after construction of the new buildings is complete. Either full depth replacement or partial depth replacement should be planned for this site after construction is complete. Partial depth replacement would consist of removing the broken asphaltic concrete, regrading the existing granular base, placing the recommendation additional granular base depending on the anticipated traffic loading and place new asphaltic concrete. If grade raise restriction do not allow for the additional thickness of the new pavement structure, then full depth reconstruction of the pavement areas would be necessary. For either option the asphalt pavement sections in the following section should be ultimately constructed.

4.11.1 FLEXIBLE PAVEMENTS

Detailed traffic loads have not been provided at this time, however based on the subsoil conditions encountered, conventional asphaltic (flexible) pavement designs are considered to be appropriate for proposed paved parking areas for cars and light weight trucks, driveways and access roads. Based on the results of this investigation and experience, the following asphaltic pavement design is recommended for the indicated areas.

Table 4.5 Recommended Pavement Structures

Pavement Layer	Light Duty Traffic and Parking Areas for Cars and Light weight trucks	Heavy Duty Traffic Areas (Delivery Trucks, Fire Routes, Access Roads, etc.)
Asphaltic Concrete	50 mm HL-3 or SP 12.5, Surface Course	40 mm HL-3 or SP 12.5, Surface Course 50 mm HL-8 or SP 19.0, Base Course
Granular Base Course	150 mm OPSS Granular "A"	150 mm OPSS Granular "A"
Granular Sub-base Course	300 mm of New OPSS Granular "B" or combined thickness of 300 mm with the existing granular base	450 mm New OPSS Granular "B" or combined thickness of 450 mm with the existing granular base

Asphalt materials and placement specifications should be in accordance with relevant Provincial standard specifications. The asphaltic cement should be PG 58-34.

A functional design life of eight to ten years has been used to establish the flexible pavement recommendations. This represents the number of years to the first rehabilitation, assuming regular maintenance is carried out. If required, a more refined pavement structure design can be performed based on specific traffic data and design life requirements provided by the client.

Sidewalks and Unit Pavers should be constructed. in general accordance with City of Ottawa Standard Specifications and Detail Drawings, such as No. SC4 and No. SC9, respectively.

4.11.2 RIGID PAVEMENTS

Rigid pavements could be considered sunken loading dock areas, in areas where heavy vehicles will be parked or standing for prolonged periods of time and in heavy trafficked entry and exit areas for heavy vehicles. Rigid pavement will perform better than a flexible section in these critical areas.

The following pavement structure is recommended for the rigid (concrete) pavement areas:

Table 4.6 Recommended Rigid Pavement Structure

Pavement Layer	Material
Rigid Pavement	180 mm of Concrete
Granular Base Course	400 mm OPSS Granular "A"

It would be prudent to provide the same subgrade level across rigid and flexible pavement sections and thus prevent the need to construct frost tapers.

The concrete should satisfy the requirements of CAN/CSA A 23.1 Class C-2 concrete with a minimum compressive strength of 32 MPa and should have a minimum flexural strength of 4.1 MPa. The base should be compacted to 100 percent of its standard Proctor maximum dry density.

The pavement could be expected to perform better in the long term if the granular backfill against the foundation walls is drained by means of a perforated pipe subdrain in a surround of 19 millimetre clear stone, fully wrapped in geotextile, which leads by gravity drainage to a positive outlet as outlined above.

It is recommended that WSP be retained to review the final pavement structure designs and drainage plans prior to construction to ensure that they are consistent with the recommendations of this report.

4.11.3 PAVEMENT TRANSITIONS

Excavation of the existing and reinstatement of the granular base material should be such that the surface of the new pavement matches the elevation of the existing pavement surface, as adjusted during the detailed design. Construction traffic is to be controlled to minimize damage and protect the integrity of the subgrade, base and subbase layers during construction. Butt joints, step joints, and tack coating are recommended to tie the new pavement with the existing pavement. In areas where the new pavement will abut the existing pavement, the depth of the granular sub-base should taper up or down at a 5 horizontal to 1 vertical, or flatter, to match the depths of the existing granular material(s) exposed in the existing pavement.

4.11.4 PAVEMENT DRAINAGE

Adequate drainage of the pavement granular materials and subgrade is important for the long-term performance of the pavement at this site. Site grading is recommended to provide positive drainage in the new pavement areas; the pavement subgrade should be shaped and crowned to promote drainage of the pavement area granular materials. The subgrade should be sloped at a minimum of 1 percent to provide adequate sheet flow. Where storm sewers are used to convey surface water runoff, stub drains should be constructed at each catch basin, and extend a minimum of 3 m in at least two directions from each catch basin at the pavement subgrade level. Perimeter drainage is also suggested.

Stub drains and perimeter subdrains should be a minimum of 300 mm below the bottom of the granular subbase and be connected to the catch basins to provide positive drainage. The subgrade drains should consist of 100 or 150 mm diameter geotextile wrapped perforated pipe, surrounded on all sides by at least 150 mm of 16 or 19-millimetre clear crushed stone. The pipes should be placed such that the top of the clear stone is at subgrade level.

4.11.5 CONSTRUCTION CONSIDERATIONS

The long-term performance of the pavement is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure uniform subgrade moisture and density conditions are achieved. In addition, the need for adequate drainage cannot be over-emphasized. The finished pavement surface and underlying subgrade should be free of depressions and should be sloped to provide effective surface drainage toward catch basins. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. Subdrains can also be placed at catch basins and along curb lines to further improve sub-surface drainage.

As part of the subgrade preparation, proposed parking areas and access roadways should be stripped of topsoil and other obvious objectionable material. Fill required to raise the grades to design elevations should conform to backfill requirements outlined in previous sections of this report. The subgrade should be properly shaped, crowned then proof-rolled in the full-time presence of a representative of this office. Soft or “spongy” subgrade areas should be sub-excavated and properly replaced with suitable approved backfill compacted to 98% SPMDD. Base and sub-base layers should be compacted to 100% of SPMDD.

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

4.12 CORROSION AND CEMENT TYPE

Four samples were submitted to Eurofins for testing related to soil corrosivity and potential exposure of concrete elements to sulphate attack. The results this testing is included in **Appendix C** and summarized in table below.

Table 4.7 Results of Soil Corrosivity Testing

Borehole/ Sample No.	Depth (m)	Chloride (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)	Sulphate (%)
BH21-1i	0.3-0.4m	0.004	0.24	8.12	4,170	0.04
BH21-4i	2.0-2.6m	0.006	0.20	8.07	5,260	0.02
BH21-2s	0.8 - 1.4	0.032	0.47	8.05	2,130	<0.01
BH21-5s	1.5 -2.1	0.018	0.29	8.18	3,570	0.01

The soil resistivity values show a moderate to high corrosive environment for buried steel elements. These values must be taken into consideration during design of below-grade steel elements.

The test results indicate a low soluble sulphate content and sulphate resistant Portland cement is not required.

4.13 CONSTRUCTION CONSIDERATIONS

It is understood that excavation work will be required as part of the overall construction of the new buildings 'A' and 'B'. Where work is required near the existing and new structural elements, the following recommendations are provided:

4.13.1 TEMPORARY DEWATERING

The groundwater level at the site was found to vary between 0.6 m and 3.1 m below the existing ground surface and is generally higher along the northeast portion of the site. This maybe the result of the stormwater management pond located at the southeast corner of the site. The groundwater appears to be within the native silty clay at the site. For excavations above the water table and slightly below (less than 0.5 m) the water table, it is likely that seepage into the excavations can be managed using properly filtered sumps, ditches, etc. For deeper excavations and excavations requiring long term dewatering (greater than 7 days), additional or more complex dewatering may be required, especially if the excavation enters the underlying bedrock. WSP can provide additional guidance based on the size and depth of anticipated excavations, if required during detailed design. If long term dewatering (greater than 7 days) then a hydrogeological analysis is required to determine the zone of influence and dewater activities may need to be tailored to not lower the groundwater at adjacent properties or structures.

Assuming that the new construction will be at or above the groundwater level observed in the standpipe piezometer then in this situation any groundwater inflows encountered would be expected to be low and manageable by pumping from closely spaced, properly filtered sumps. The excavation would not be expected to require a MOECC Environmental Activity and Sector Registration (EASR – which covers construction dewatering up to 400,000 l/day) or a Permit to Take Water (PTTW – which is required for dewatering in excess of 400,000 l/day). If substantially deeper excavations are required, fractured bedrock is encountered or construction is scheduled during wetter periods (such as the spring) then this assumption should be reviewed during detailed design. It should be noted that this discussion applies to groundwater flows. An assessment of the requirements for surface water diversion should be made by others.

The soils present at the site are expected to be sensitive to disturbance and proper control of the groundwater infiltration (by construction of sumps, use of well points, etc.) will be required to prevent excessive disturbance. Failure to adequately control groundwater inflows may result in disturbance of the subgrade and a need for over-excavation and replacement of disturbed subgrade soil.

4.13.2 TEMPORARY EXCAVATIONS

All excavations should be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA), Part III of Ontario Regulation 213/91.

The soils within the expected excavation include topsoil, silty sand and silty clay above the groundwater level. These soils above the groundwater level or depth of dewatering can be classified as Type 3 soils and Type 4 soils below the groundwater table (or depth of watering). These classifications must be reviewed and confirmed by a qualified person during excavation. Excavations within Type 3 soil require side slopes with a minimum gradient of 1 horizontal to 1 vertical and excavations within Type 4 soil require side slopes of 3 horizontal to 1 vertical.

If limited space is available, a temporary shoring system may be used. Once the location of the building and various excavations are determined the potential need for vertical shoring can be reviewed. The design of any the shoring system must be carried out by a professional engineer and take into consideration the stability of the excavation as well as the effect of the excavation upon the neighbouring buildings and structures. The contractor is typically responsible for the detailed design of temporary shoring.

If required, WSP can provide additional guidance based on preliminary excavation plans, depths, etc. during the detailed design phase of the project.

4.13.3 SUBGRADE PREPARATION

The geotechnical bearing resistances provided in Section 4.6 assume that the foundation soils will not be disturbed by construction activities. Proper de-watering and protection of exposed soil subgrades will be important to the construction of the foundations. All excavated surfaces should be kept free of frost, water, etc. during the course of construction. All excavated surfaces should be inspected by a qualified geotechnical engineer who is familiar with the findings of this investigation and the design and construction of similar structures.

The foundations soils at the site are expected to be sensitive to disturbance from ponded water and construction traffic if the subgrade for the foundations and floor slab is exposed for a prolonged duration and/or exposed to construction traffic then placement of a mud slab directly on the subgrade may be required to protect the subgrade from these elements.

4.13.4 WINTER CONSTRUCTION

Should construction be carried out during freezing temperatures, exposed frost susceptible subgrade fill should be protected immediately from freezing using one or a combination of: straw, propane heaters, polystyrene insulation, insulated tarpaulins, or other suitable means that prevent the underlying soil from freezing, which could cause frost heave.

5 CLOSURE

The Limitations of Report, as presented in **Appendix E**, are an integral part of this report.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

WSP Canada Inc.

Report prepared by:

Bruce D. Goddard

Bruce Goddard, P.Eng.

Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
B. Goddard
B. D. GODDARD
100143565
2022-03-29
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
D. FEGHALI
PROVINCE OF ONTARIO

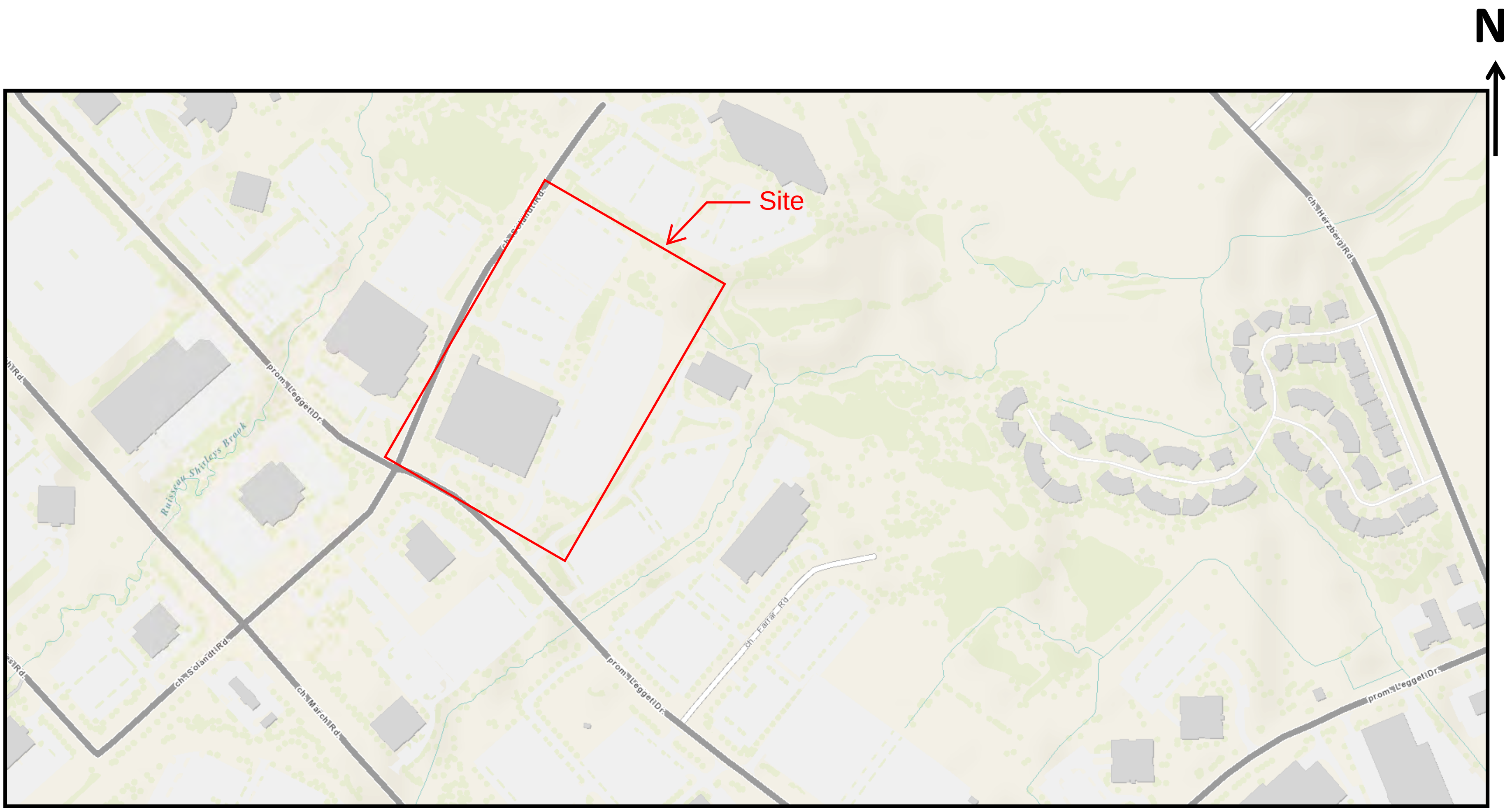
David Feghali, ing., P.Eng., PMP

Senior Geotechnical Engineer

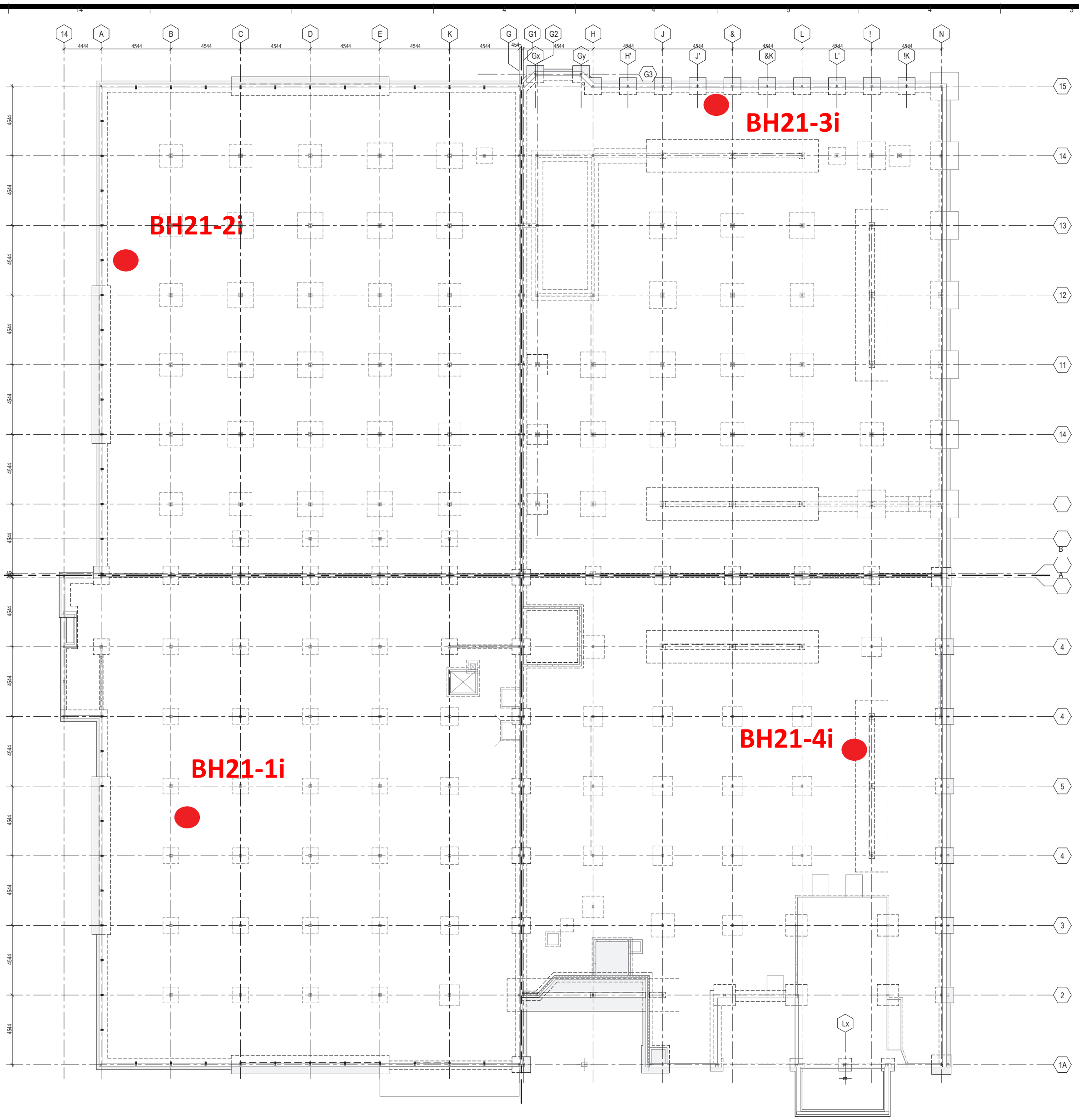
APPENDIX

A

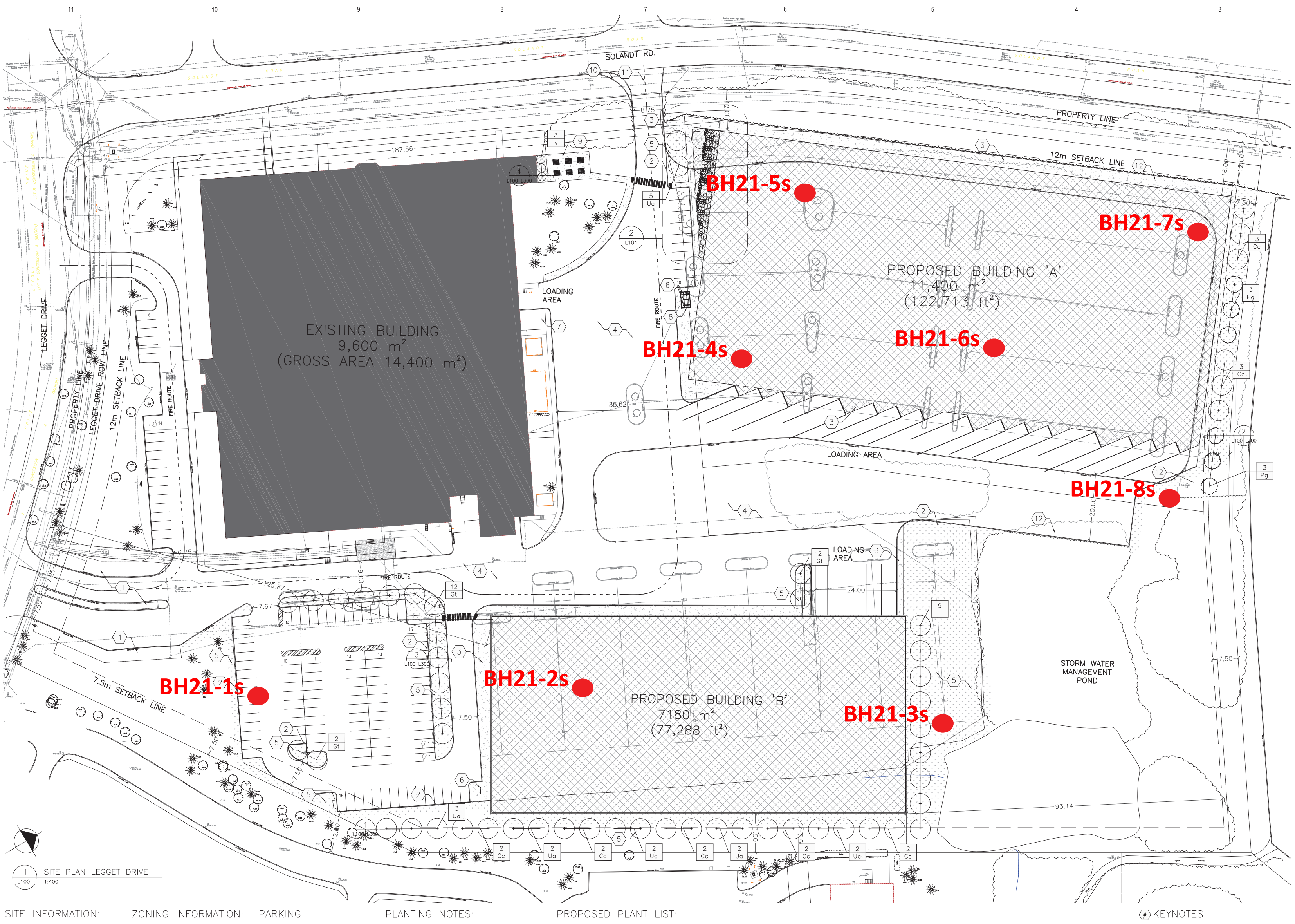
DRAWINGS



Client:	A49/Access Storage			Title:	Site Location Plan
Project#:	219-00058-0300058-03	DWG #:	1	Project:	Geotechnical Investigation 415 Legget Drive
Drawn:	DDWW	Approved:	BG		
Date:	October 2021	Scale:	N. T. S.		
Size:	Letter	Rev:	0		



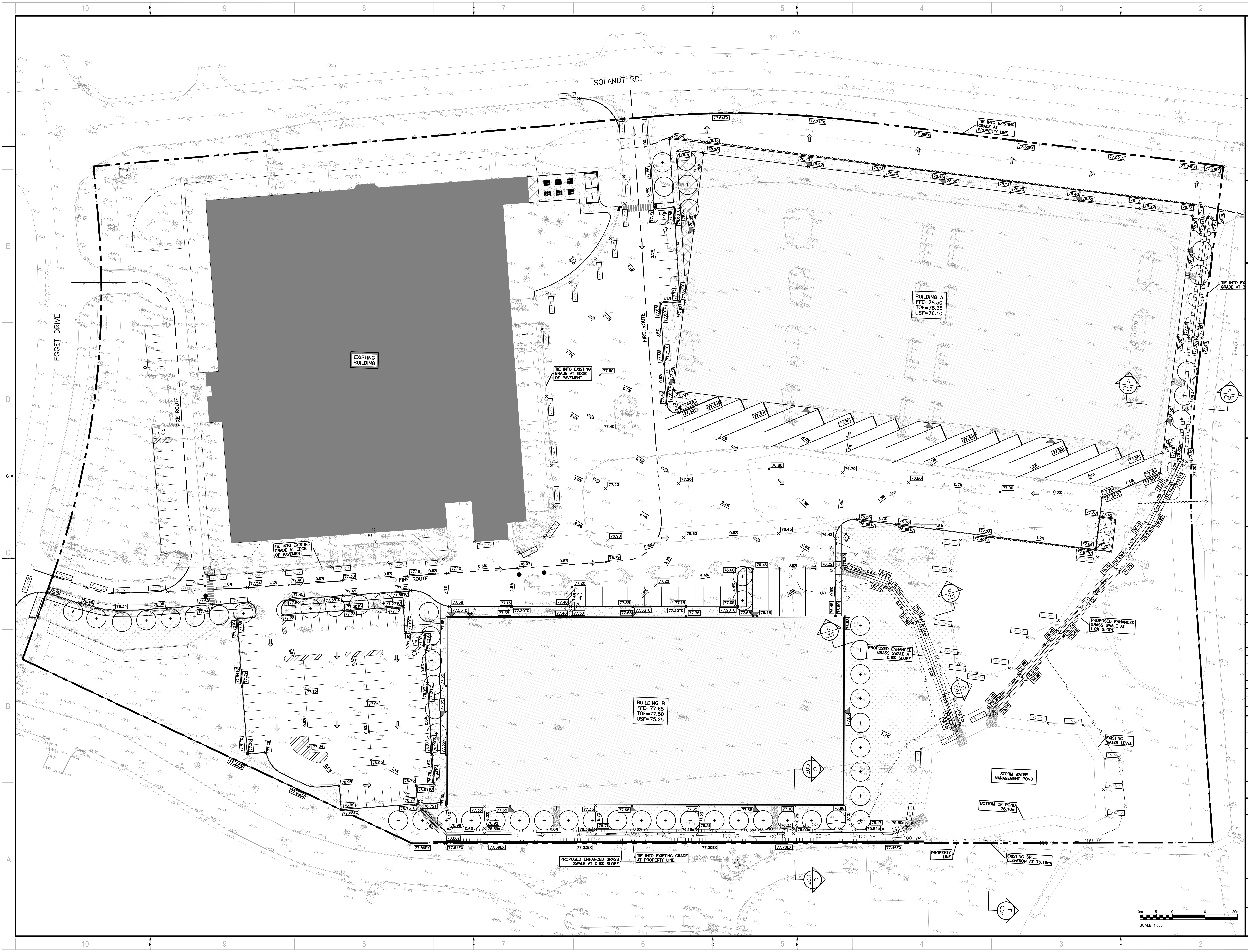
Client:	A49/Access Storage	Title:	Interior Borehole Location Plan
Project#:	219-00058-0300058-03	DWG #: 2A	Project: Geotechnical Investigation 415 Legget Drive
Drawn:	DDWW	Approved: BG	
Date:	October 2021	Scale: N. T. S.	wsp
Size:	Letter	Rev: 0	



Client:	A49/Access Storage		
Project#:	219-00058-0300058-03	DWG #:	2B
Drawn:	DDWW	Approved:	BG
Date:	October 2021	Scale:	N. T. S.
Size:	Letter	Rev:	0

Title: Exterior Borehole Location Plan

Project: Geotechnical Investigation
415 Legget Drive



CONSULTANT:

ARCHITECTURE | 49

1345 ROSEMOUNT AVENUE
CORNWALL, ONTARIO, CANADA K6J 3E5
TEL: 613-933-5602 | FAX: 613-936-0335 | ARCHITECTURE49.COM

CONSULTANT:

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300-2611 QUEENSVIEW DR.
OTTAWA, ONTARIO
CANADA K2H 8K2
PHONE: 613-829-2800
WWW.WSP.COM

KEY PLAN:

CLIENT:

ACCESS STORAGE

CLIENT REF. #: --

PROJECT:

415 LEGGET DRIVE
ACCESS STORAGE

SEAL:

LICENSED PROFESSIONAL ENGINEER
D. B. YANG
100230568
2022-03-25
PROVINCE OF ONTARIO

NORTH

DISCLAIMER: COPYRIGHT:

THIS DRAWING AND DESIGN IS COPYRIGHT PROTECTED WHICH SHALL NOT BE USED, REPRODUCED OR REVISED WITHOUT WRITTEN PERMISSION BY WSP. THE CONTRACTOR SHALL CHECK AND VERIFY ALL DIMENSIONS AND UTILITY LOCATIONS AND REPORT ALL ERRORS AND OMISSIONS PRIOR TO COMMENCING WORK.
THIS DRAWING IS NOT TO BE SCALED.

ISSUED FOR - REVISION:

IS	RE	DATE	DESCRIPTION
2		2022/03/18	REVISED AS PER CITY COMMENTS
1		2021/10/25	ISSUED FOR SPCA

PROJECT NO: 219-00058-03

DATE: MARCH 2018

ORIGINAL SCALE: 1:500

DESIGNED BY: D.Y.

DRAWN BY: J.T.

CHECKED BY: D.Y.

IF THIS BAR IS NOT 1" LONG, ADJUST YOUR PLOTTING SCALE.

25mm

DISCIPLINE: CIVIL

TITLE:

GRADING PLAN

SHEET NUMBER: C03

SHEET #: 4 OF 8

ISSUE: REVISED AS PER CITY COMMENTS

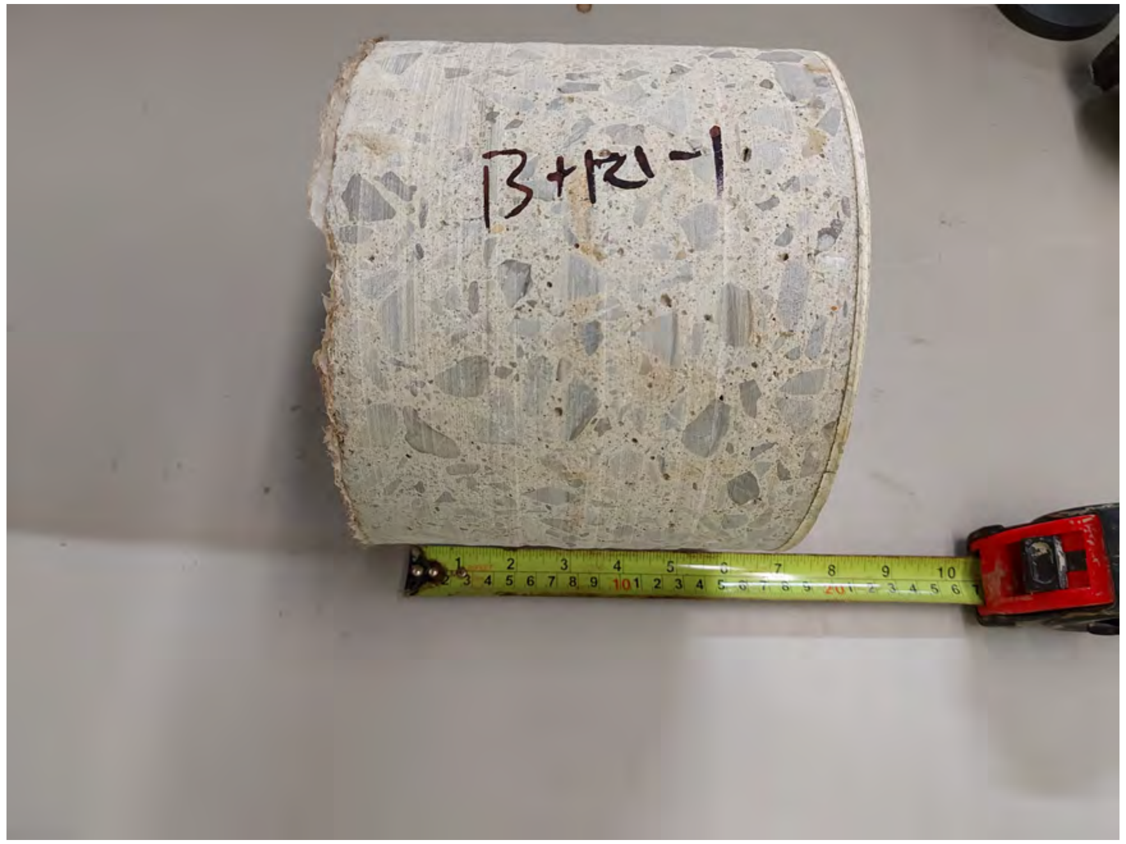
DATE OF: 2022/03/18

REV # 0

D07-12-21-0211

#18632

Borehole BH 21-01i



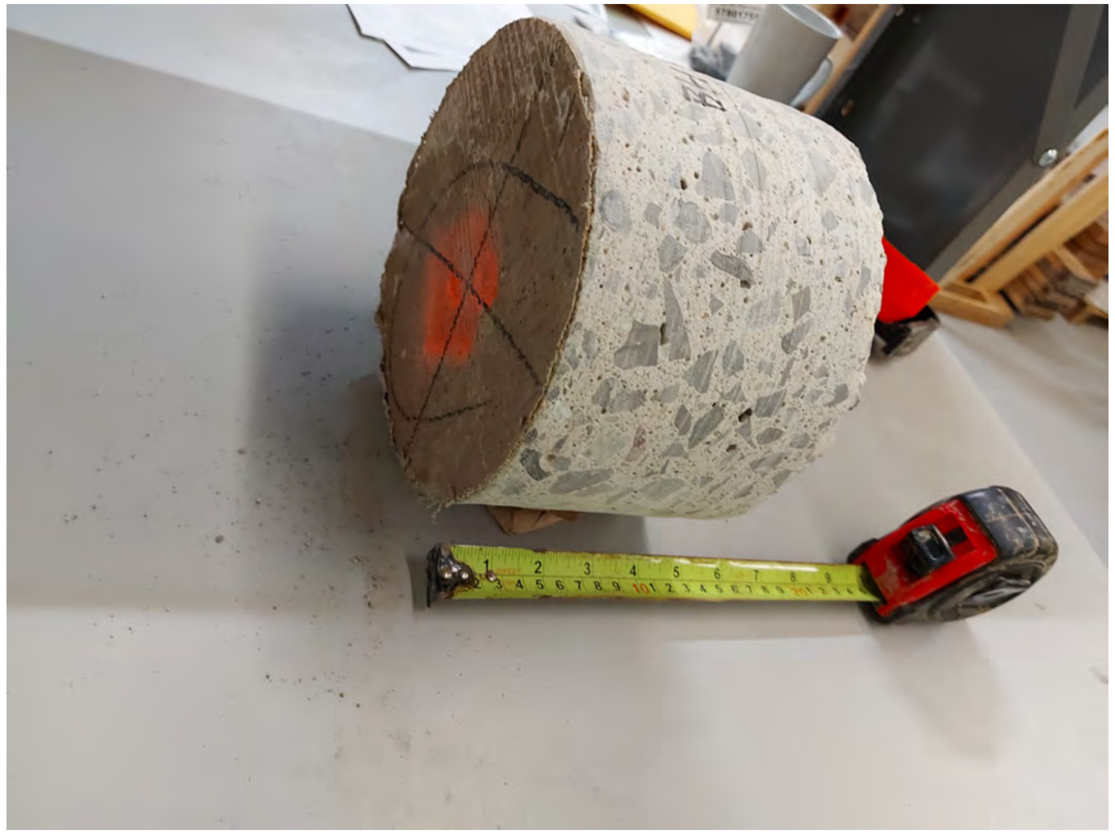
Side View

Top View

Client:	A49/Access Storage			Title:	Concrete Core Photos
Project#:	219-00058-03W	DWG #:	3A	Project:	Geotechnical Investigation 415 Legget Drive
Drawn:	DDWW	Approved:	BG		
Date:	October 2021	Scale:	N. T. S.		
Size:	Letter	Rev:	0		

Borehole BH 21-02i

Side View



Top View

Client:	A49/Access Storage			Title:	Concrete Core Photos
Project#:	219-00058-03W	DWG #:	3B	Project:	Geotechnical Investigation 415 Legget Drive
Drawn:	DDWW	Approved:	BG		
Date:	October 2021	Scale:	N. T. S.		
Size:	Letter	Rev:	0		

Borehole BH 21-03i

Side View

Top View

Client:	A49/Access Storage			Title:	Concrete Core Photos
Project#:	219-00058-03W	DWG #:	3C	Project:	Geotechnical Investigation 415 Legget Drive
Drawn:	DDWW	Approved:	BG		
Date:	October 2021	Scale:	N. T. S.		
Size:	Letter	Rev:	0		

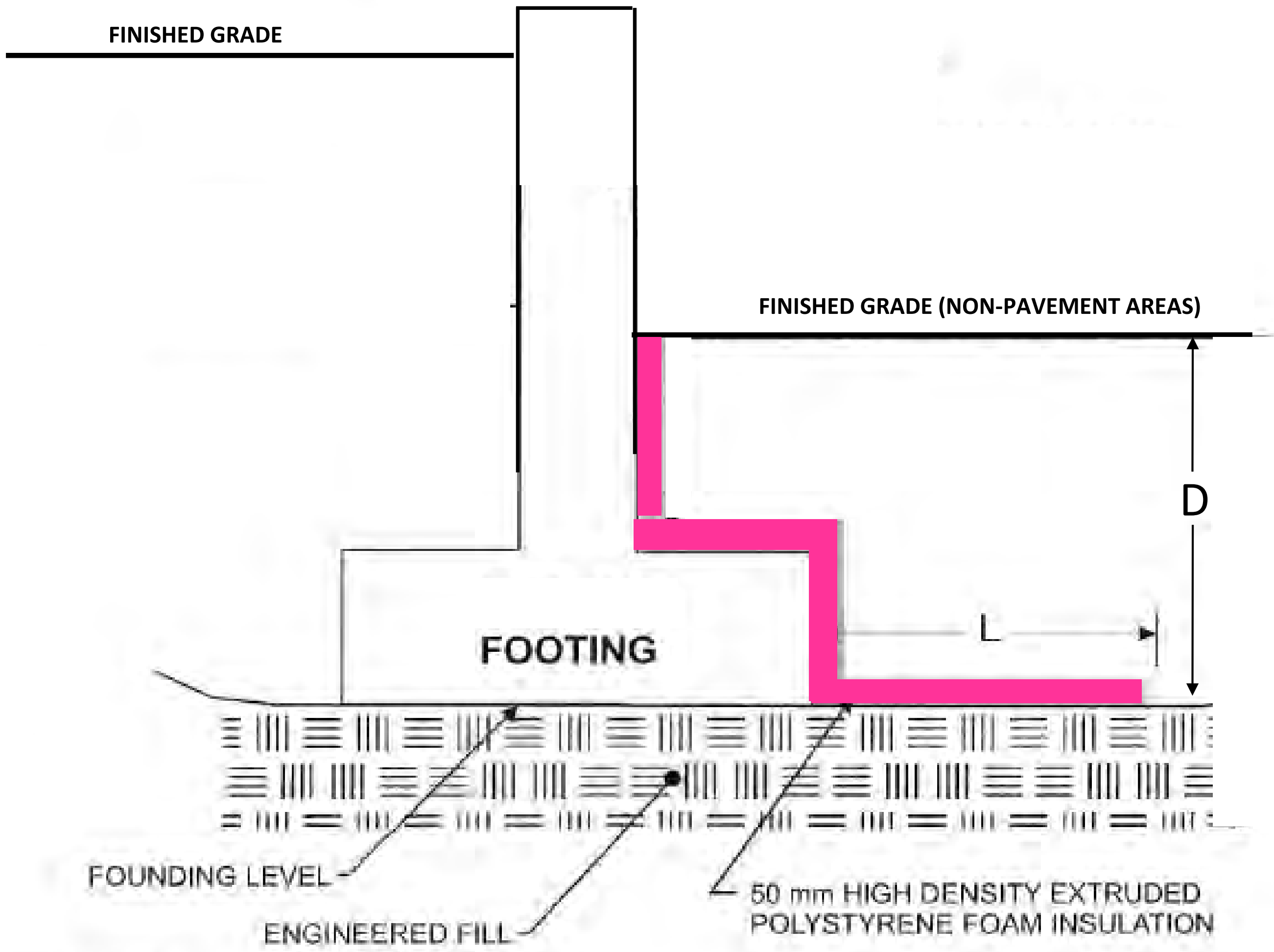
Borehole BH 21-04i

Side View

Top View

Client:	A49/Access Storage	Title:	Concrete Core Photos
Project#:	219-00058-03W	DWG #:	3D
Drawn:	DDWW	Approved:	BG
Date:	October 2021	Scale:	N. T. S.
Size:	Letter	Rev:	0

Project: Geotechnical Investigation
415 Legget Drive



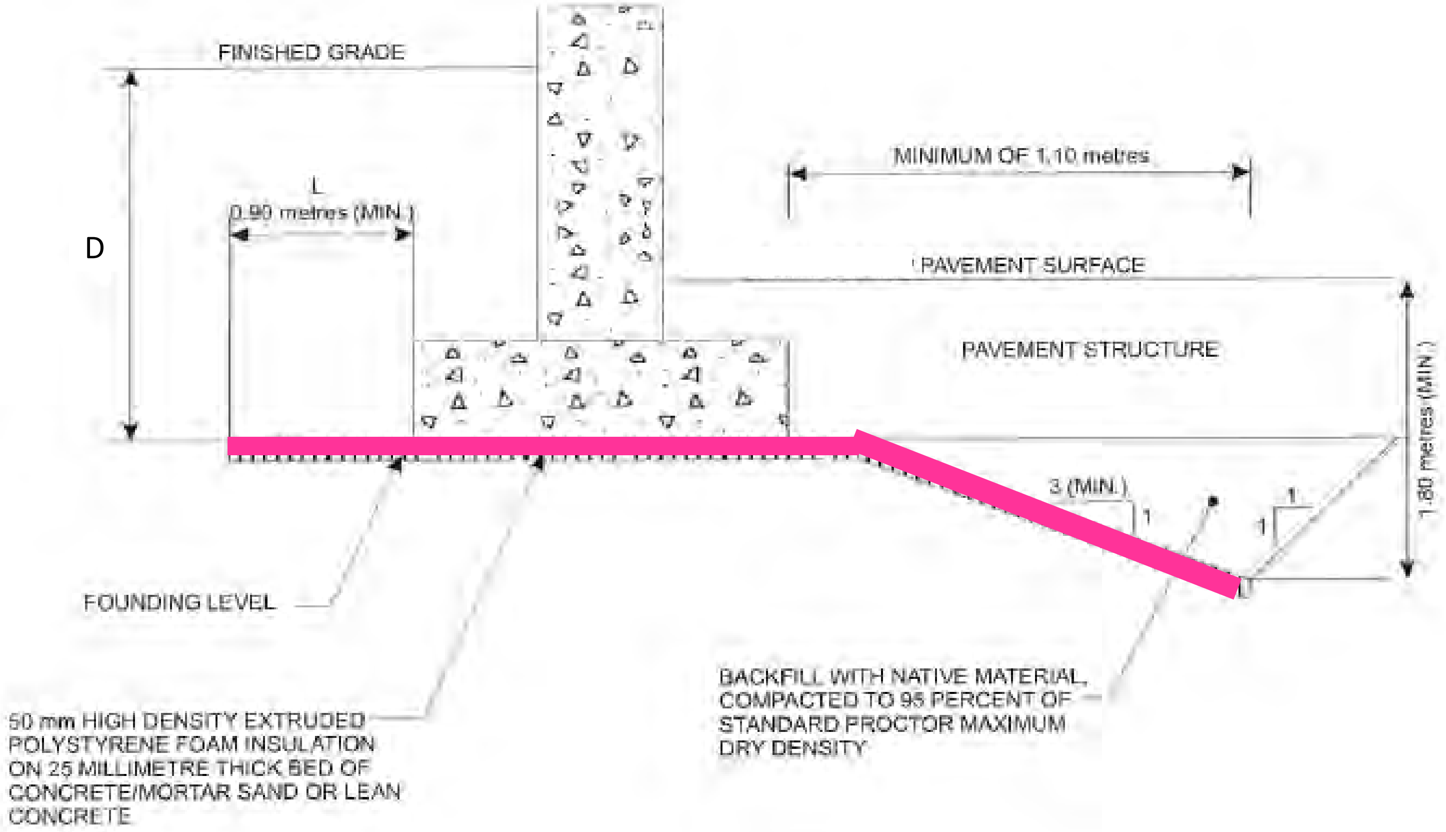
LEGEND

d	THICKNESS OF EARTH COVER ABOVE FROST SUSCEPTIBLE SOIL
L	PROJECTED LENGTH OF INSULATION

NOTES:

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GEOTECHNICAL REPORT
2. INSULATION JOINTS TO BE GLUED AND /OR LAPPED
3. FOR ADEQUATE FROST PROTECTION: D + L ≥ 1.8m

Client:	A49/Access Storage			Title:	Typical Exterior Foundation Wall Insulation Detail in Non-Paved Areas
Project #:	219-00058-03	DWG #:	4	Project:	Geotechnical Investigation - Phase 2 415 Legget Drive
Drawn:	BG	Approved:	DF		
Date:	March 2022	Scale:	N. T. S.		
Size:	Letter	Rev:	0		



LEGEND

D THICKNESS OF EARTH COVER ABOVE BOTTOM OF INSULATION
L PROJECTED LENGTH OF INSULATION

NOTES:
1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GEOTECHNICAL REPORT
2. INSULATION JOINTS TO BE GLUED AND /OR LAPPED
3. FOR ADEQUATE FROST PROTECTION: D + L ≥ 1.8m
4. ALLOWABLE BEARING PRESSURE FOR FOOTING DESIGN IS DEPENDANT ON INSULATION TYPE, REFER TO GEOTECHNICAL REPORT FOR ADDITIONAL RECOMENDATIONS

Client:	A49/Access Storage			Title:	Typical Exterior Foundation Wall and Load Dock Insulation Detail in Paved Areas
Project #:	219-00058-03	DWG #:	5	Project:	Geotechnical Investigation - Phase 2 415 Legget Drive
Drawn:	BG	Approved:	DF		
Date:	March 2022	Scale:	N. T. S.		
Size:	Letter	Rev:	0		

APPENDIX

B

BOREHOLE LOGS

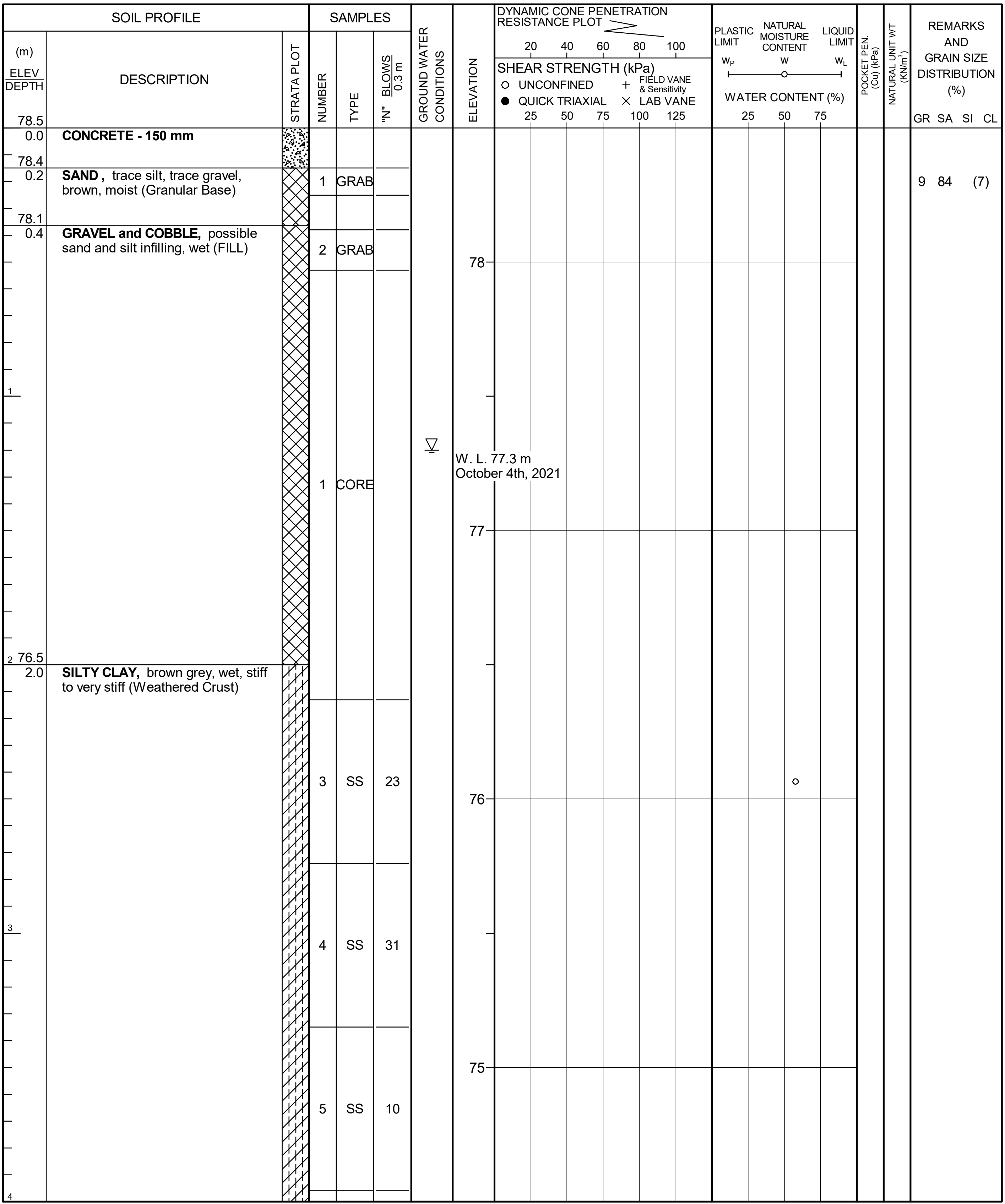
EXPLANATION OF TERMS USED IN BOREHOLE RECORDS

LOG OF BOREHOLE 21-01i

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:
Method: Hand Portable Drilling
Borehole Diameter: 76 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-29
Supervisor: DW
Reviewer: NC



(m) ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.5 0.0	**CONCRETE - 150 mm**					
78.4 0.2	**SAND ,** trace silt, trace gravel, brown, moist (Granular Base)	1	GRAB			9 84 (7)
78.1 0.4	**GRAVEL and COBBLE,** possible sand and silt infilling, wet (FILL)	2	GRAB			
		1	CORE		W. L. 77.3 m October 4th, 2021	
76.5 2.0	**SILTY CLAY,** brown grey, wet, stiff to very stiff (Weathered Crust)	3	SS	23		
		4	SS	31		
		5	SS	10		

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ∇ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-01i

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hand Portable Drilling	Date Started: 2021-09-29
Datum: Geodetic	Borehole Diameter: 76 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE & Sensitivity, ● QUICK TRIAXIAL, × LAB VANE (25 50 75 100 125)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (25 50 75)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m							
	SILTY CLAY, brown grey, wet, stiff to very stiff (Weathered Crust)(Continued)	▨	6	SS	8							
73.9 4.6	**SILTY CLAY,** grey, wet, firm	▨	7	SS	5		74					
		▨		VANE				+2.5				
		▨		VANE			73	+2				
72.7 5.8	END OF BOREHOLE Notes: 1. The blow counts shown on the log have been corrected for the 1/3 weight hammer. 2. Borehole is left open for 3 days. Groundwater noted at 1.2 m in depth. Borehole is open to 2.0 m in depth.											

Depth scale mark: 5

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-02i

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-30
Datum: Geodetic	Borehole Diameter: 76 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.5							
0.0	**CONCRETE - 130 mm**						
78.4 0.1	**CRUSHED SAND AND GRAVEL,** grey, moist (Granular Base)	1	GRAB				54 43(3)
78.3 0.2	**GRAVEL and COBBLES,** possible sand and silt infilling, wet (FILL)						
		2	GRAB			78	
		1	CORE		W. L. 77.3 m October 4th, 2021	77	
76.8 1.7	**SILTY CLAY,** brown grey, wet, very stiff (Weathered Crust)						
		3	SS	23			
		4	SS	31		76	
		5	SS	10			
		6	SS	8		75	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE; 25 50 75 100 125

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 25 50 75

POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (KN/m³)

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ∇ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Sheet No. 1 of 2

LOG OF BOREHOLE 21-02i

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-30
Datum: Geodetic	Borehole Diameter: 76 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE & Sensitivity, ● QUICK TRIAXIAL, × LAB VANE (25 50 75 100 125)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L / WATER CONTENT (%) (25 50 75)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m							
74.4		▨										
4.1	**SILTY CLAY,** grey, wet, stiff	▨	7	SS	5		74					
		▨		VANE				+ 3				
5		▨		VANE				+ 2.5				
73.2												
5.3	END OF BOREHOLE Notes: 1. 1. The blow counts shown on the log have been corrected for the 1/3 weight hammer. 2. Borehole is left open for 3 days. Groundwater noted at 1.2 m in depth. Borehole is open to 2.3 m in depth.											

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Sheet No. 2 of 2

LOG OF BOREHOLE 21-03i

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:
Method: Hollow Stem Augers
Borehole Diameter: 76 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-10-01
Supervisor: DW
Reviewer: NC

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.5						
0.0	**CONCRETE - 120 mm**					
78.4 0.1	**CRUSHED SANDY GRAVEL,** grey, moist (Granular Base)	1	GRAB			72 26 (2)
78.2 0.3	**GRAVEL and COBBLES,** possible sand and silt infilling, wet (FILL)	2	GRAB			
		1	CORE			
76.7 1.8	**SILTY CLAY,** brown grey, wet, very stiff (Weathered Crust)	3	SS	8		
		4	SS	15		
		5	SS	3		
74.8 3.7	**SILTY CLAY,** grey, wet, firm	6	SS	2		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE & Sensitivity; ● QUICK TRIAXIAL × LAB VANE: 25 50 75 100 125
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 25 50 75
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (KN/m^3)
ELEVATION: 78, 77, 76, 75
Depth: 1, 2, 3, 4

WSP SOIL LOG - OTTAWA GINT.GPJ SPL.GDT 22-3-25

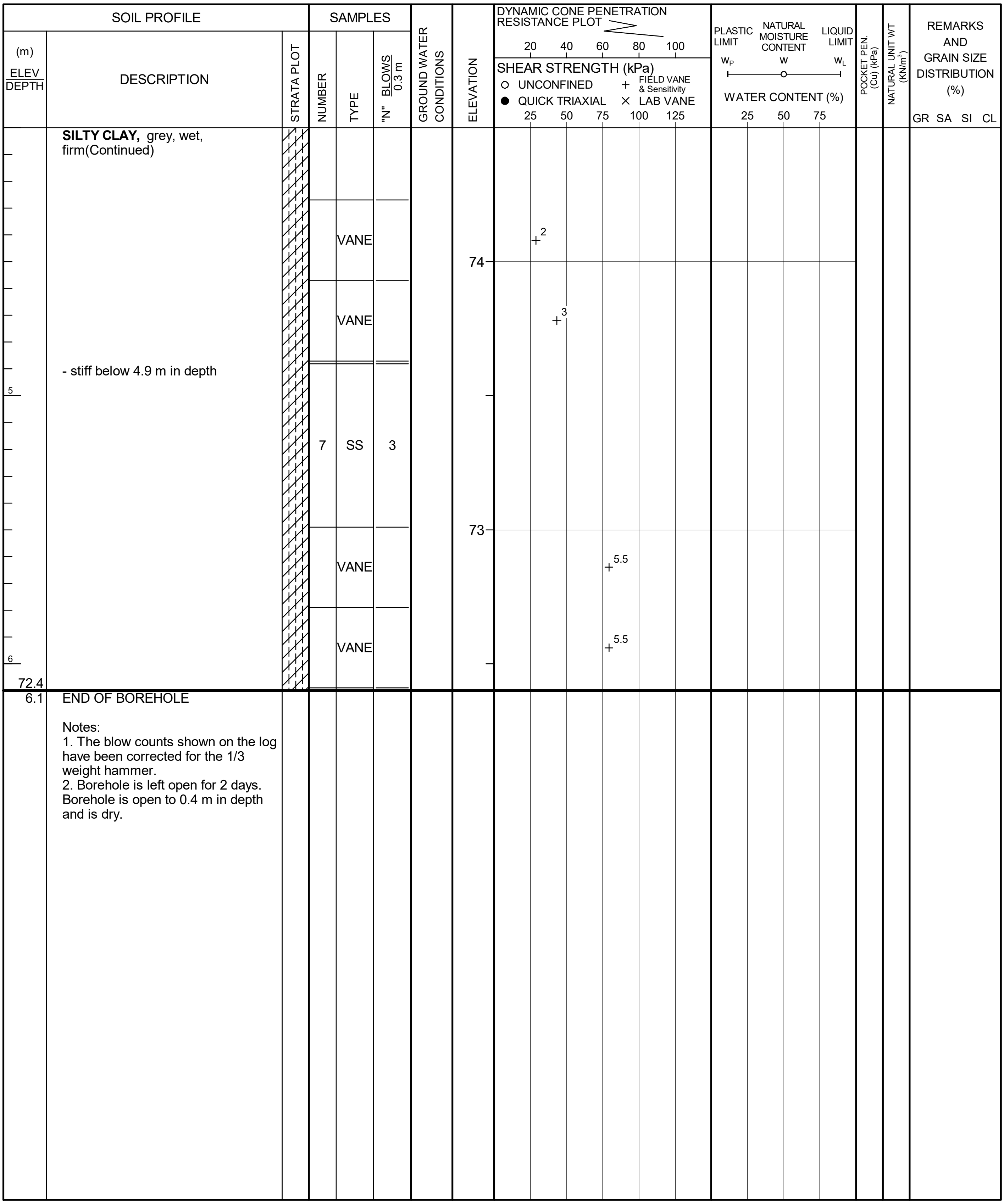
Continued Next Page

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ∇ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-03i

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-10-01
Datum: Geodetic	Borehole Diameter: 76 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC



(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m
	SILTY CLAY, grey, wet, firm(Continued)			
			VANE	
			VANE	
	- stiff below 4.9 m in depth			
		7	SS	3
			VANE	
			VANE	
72.4 6.1	END OF BOREHOLE			

Notes:
1. The blow counts shown on the log have been corrected for the 1/3 weight hammer.
2. Borehole is left open for 2 days. Borehole is open to 0.4 m in depth and is dry.

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-04i

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:
Method: Hollow Stem Augers
Borehole Diameter: 76 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-10-04
Supervisor: DW
Reviewer: NC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE (25, 50, 75, 100, 125)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) (25, 50, 75)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m							
78.5												
0.0	**CONCRETE - 110 mm**											
78.4 0.1	**CRUSHED SAND AND GRAVEL,** grey (Granular Base)		1	GRAB								
78.1 0.4	**GRAVEL and COBBLES,** possible sand and silt infilling, wet (FILL)		2	GRAB			78					
			1	CORE			77					
76.5 2.0	**SILTY CLAY,** brown grey, wet, stiff (Weathered Crust)		3	SS	12		76					
			4	SS	7							
			5	SS	14		75					
74.7 3.8	**SILTY CLAY,** grey, wet, firm to stiff											

Depth scale: 1, 2, 3, 4

Continued Next Page

GROUNDWATER ELEVATIONS

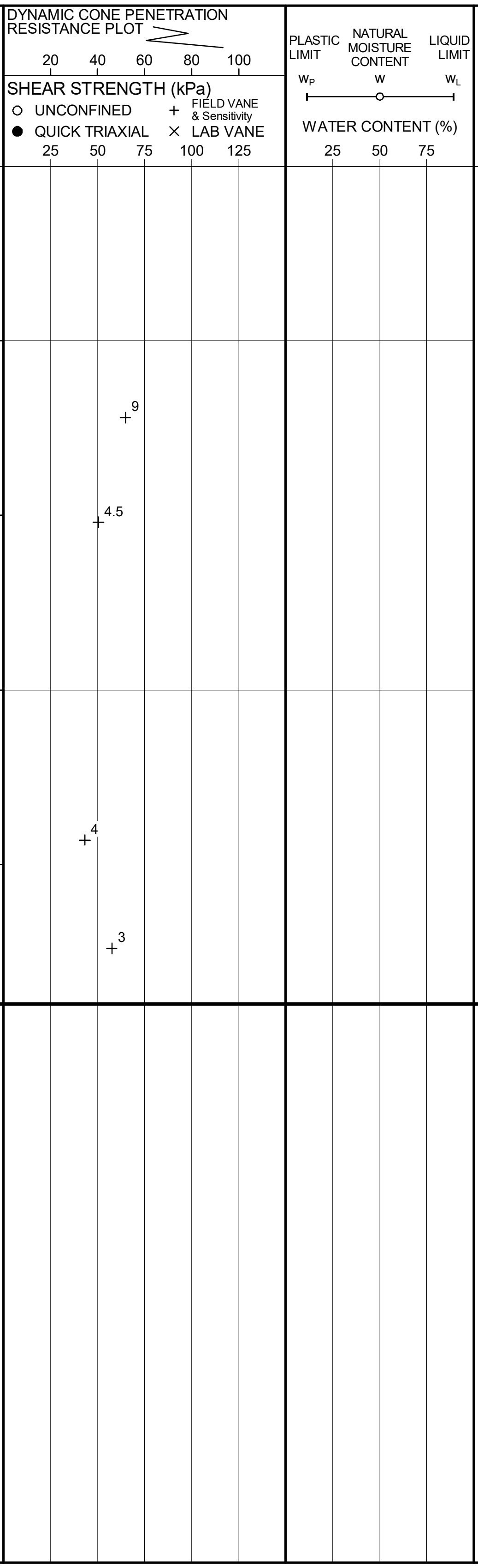
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-04i

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-10-04
Datum: Geodetic	Borehole Diameter: 76 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY, grey, wet, firm to stiff(Continued)		6	SS	2					
							74			
				VANE						
5				VANE						
			7	SS	4		73			
6				VANE						
				VANE						
72.1 6.4	END OF BOREHOLE Notes: 1. The blow counts shown on the log have been corrected for the 1/3 weight hammer.									



GROUNDWATER ELEVATIONS

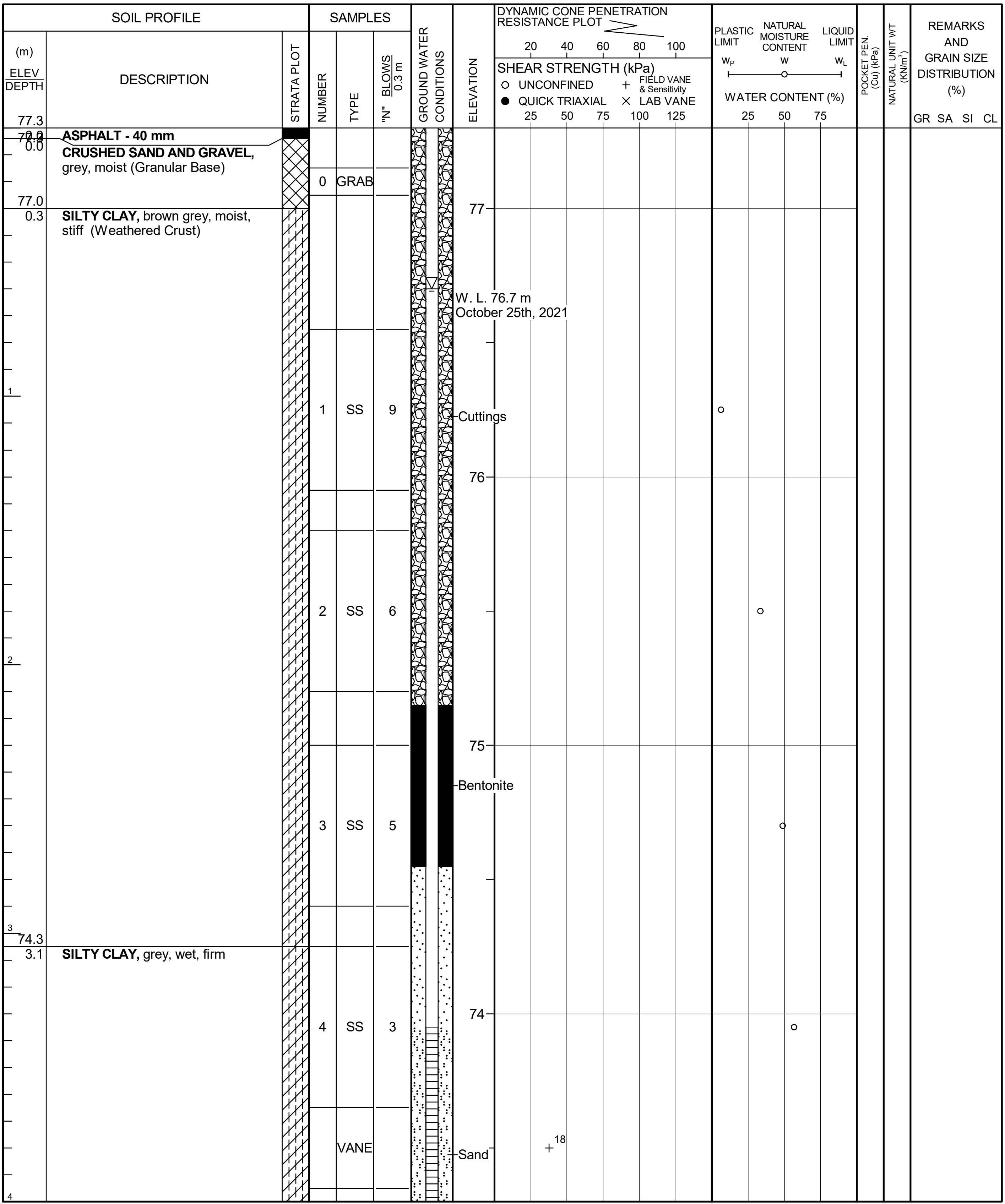
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Sheet No. 2 of 2

LOG OF BOREHOLE 21-01s

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:CME 75	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-24
Datum: Geodetic	Borehole Diameter: 203 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC



(m) ELEV DEPTH	DESCRIPTION
77.3 0.0	**ASPHALT - 40 mm**
0.0	**CRUSHED SAND AND GRAVEL,** grey, moist (Granular Base)
77.0 0.3	**SILTY CLAY,** brown grey, moist, stiff (Weathered Crust)
74.3 3.1	**SILTY CLAY,** grey, wet, firm

NUMBER	TYPE	"N" BLOWS 0.3 m
0	GRAB	
1	SS	9
2	SS	6
3	SS	5
4	SS	3
	VANE	

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-01s

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:CME 75	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-24
Datum: Geodetic	Borehole Diameter: 203 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT w LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION					
	SILTY CLAY, grey, wet, firm(Continued)			VANE		Screen	73	+ 4.5				
72.7 4.6	**CLAYEY SILTY SAND,** some gravel, grey, wet (GLACIAL TILL)		5	SS	50/0 mm				○			
72.4 4.9	END OF BOREHOLE											

Notes:
1. Borehole terminated at 4.9 m in depth after auger refusal.
2. Monitoring well installed at 4.9 m in depth
3. Date Groundwater Depth

Date	Groundwater Depth
October 15, 2021	0.6 m

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-02s

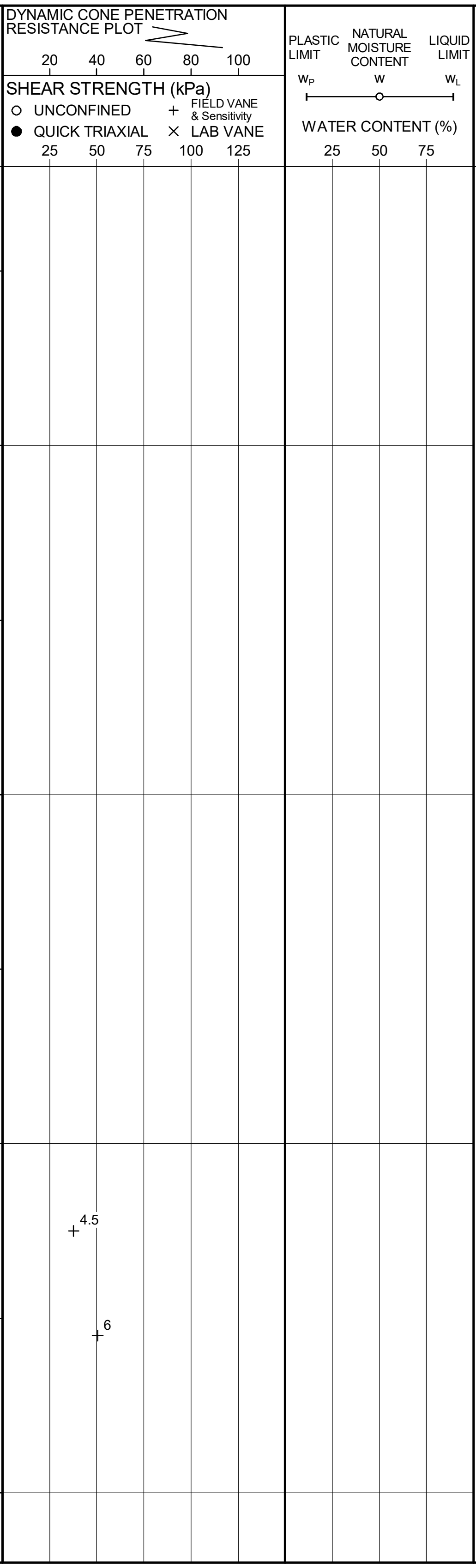
Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-27
Supervisor: DW
Reviewer: NC

(m) ELEV / DEPTH	DESCRIPTION
76.8	
76.8 0.0	**ASPHALT - 30 mm**
	CRUSHED SANDY GRAVEL, grey, moist (Granular Base)
76.6 0.2	**SILTY SAND,** trace gravel, grey, wet
76.0 0.8	**SILTY CLAY,** brown grey, moist, stiff (Weathered Crust)
74.5 2.3	**SILTY CLAY,** grey, wet, firm to very stiff

SAMPLES NUMBER	TYPE	"N" BLOWS / 0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	GRAB		66 27 (7)
2A 2B	SS	5	
3	SS	3	
4	SS	1	
	VANE		
	VANE		



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GROUNDWATER ELEVATIONS

Shallow/ Single Installation ∇ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

Sheet No. 1 of 3

WSP SOIL LOG - OTTAWA GINT.GPJ SPL.GDT 22-3-25

LOG OF BOREHOLE 21-02s

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:CME 75	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-27
Datum: Geodetic	Borehole Diameter: 203 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT w LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m							
	SILTY CLAY, grey, wet, firm to very stiff(Continued)		5	SS	1							
				VANE				+ 5				
				VANE			72	+ 6.5				
5												
			6	SS	WH							
				VANE			71	+ 7.5				
6				VANE				+ 9.5				
							70					
7			6	SS	WH							
				VANE				+ 5				
8				VANE			69	+ 3.5				

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES $+^3$, $\times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-02s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-27
Supervisor: DW
Reviewer: NC

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT w LIQUID LIMIT W_L / WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION					
68.8 8.1	END OF BOREHOLE Notes: 1. Borehole terminated at 8.1 m in depth and was open to upon to 6.7 m in depth. 2. Standing water in the borehole at 6.6 m in depth.											

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▽

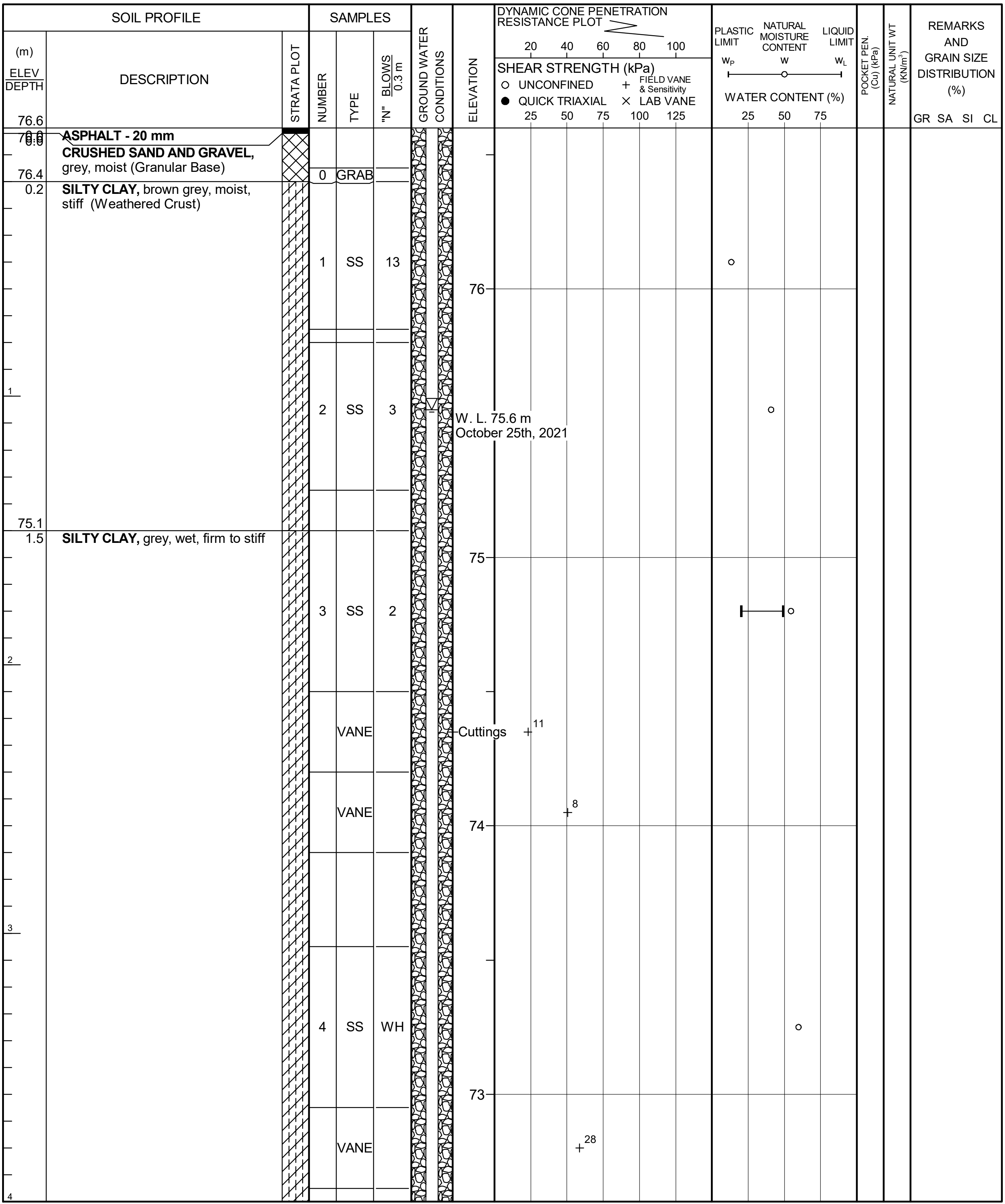
GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-03s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-24
Supervisor: DW
Reviewer: NC



(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS
76.6 0.0	**ASPHALT - 20 mm**				
76.6 0.0	**CRUSHED SAND AND GRAVEL,** grey, moist (Granular Base)	0	GRAB		
76.4 0.2	**SILTY CLAY,** brown grey, moist, stiff (Weathered Crust)	1	SS	13	
		2	SS	3	W. L. 75.6 m October 25th, 2021
75.1 1.5	**SILTY CLAY,** grey, wet, firm to stiff	3	SS	2	
			VANE		Cuttings
			VANE		
		4	SS	WH	
			VANE		

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

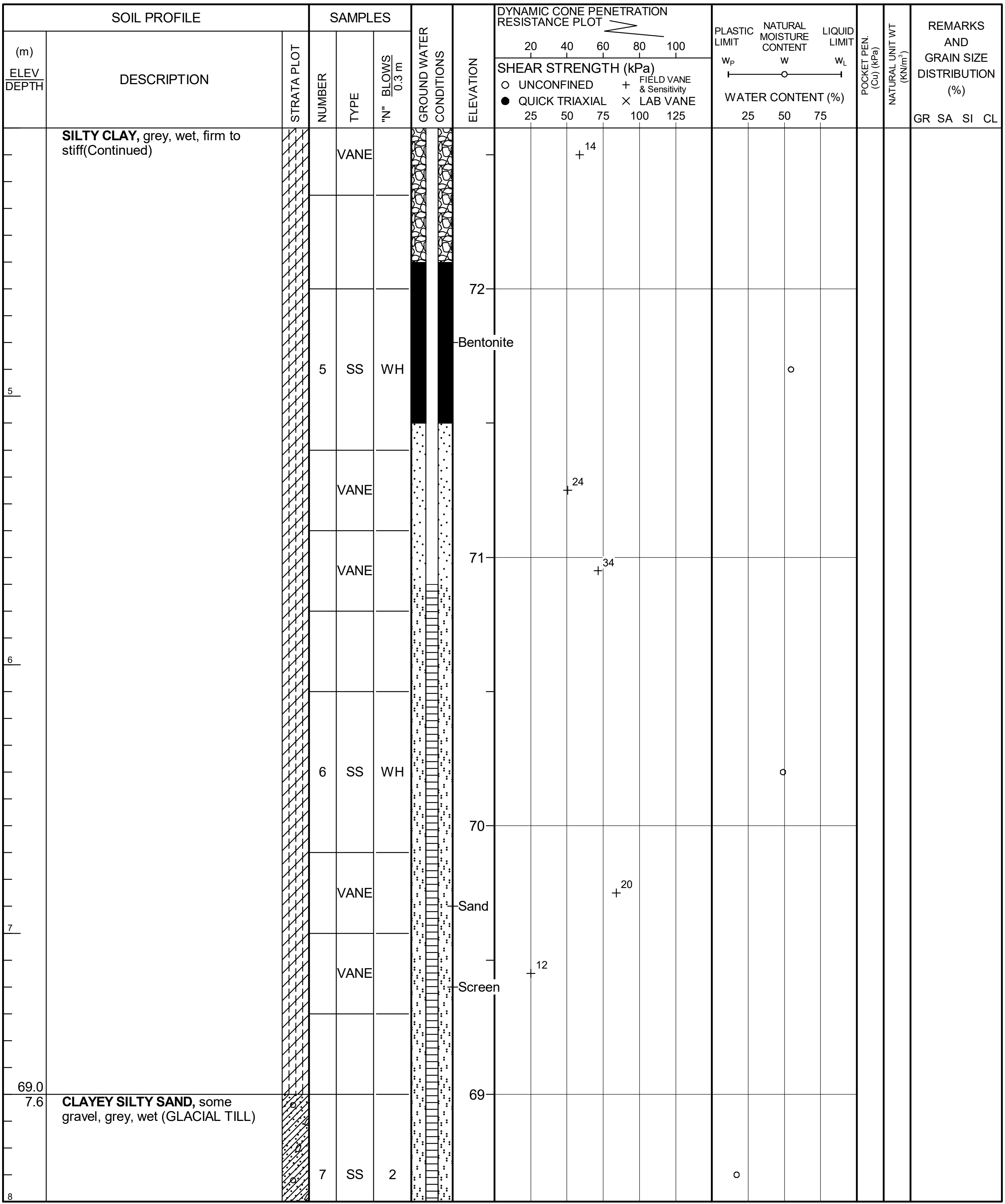
GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-03s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-24
Supervisor: DW
Reviewer: NC



ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m
	SILTY CLAY, grey, wet, firm to stiff(Continued)		VANE	
		5	SS	WH
			VANE	
			VANE	
		6	SS	WH
			VANE	
			VANE	
69.0 7.6	**CLAYEY SILTY SAND,** some gravel, grey, wet (GLACIAL TILL)	7	SS	2

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES

$+^{3}, \times^{3}$: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-03s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-24
Supervisor: DW
Reviewer: NC

SOIL PROFILE			SAMPLES									
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT w LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAYEY SILTY SAND, some gravel, grey, wet (GLACIAL TILL)(Continued)		8	SS	50/25 mm		68		○			
67.9 8.7	END OF BOREHOLE											

Notes:
1. Borehole terminated at 8.7 m in depth after auger refusal.
2. Standing water in the borehole at 0.15 m in depth.
3. Monitoring well installed at 8.7 m in depth
4. Date Groundwater Depth

Date	Groundwater Depth
October 15, 2021	1.0 m

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▽

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

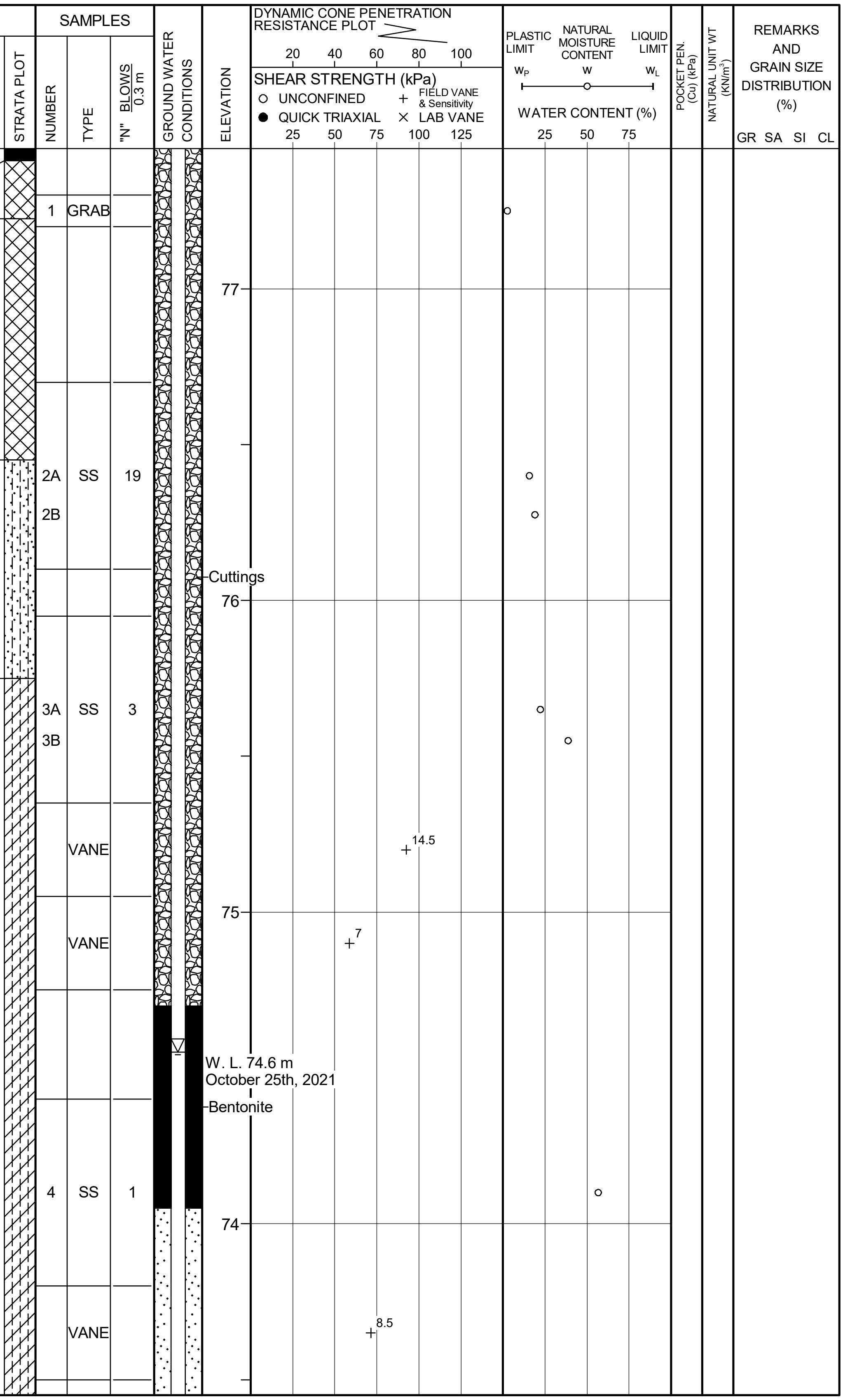
LOG OF BOREHOLE 21-04s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-27
Supervisor: DW
Reviewer: NC

SOIL PROFILE		SAMPLES		
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m
77.5				
77.4 0.0	**ASPHALT - 40 mm** **CRUSHED SAND AND GRAVEL,** grey, moist (Granular Base)	1	GRAB	
77.2 0.2	**SILTY CLAY,** some sand, brown, grey, moist (FILL)			
76.5 1.0	**SILTY SAND,** trace gravel, brown, moist, compact	2A 2B	SS	19
75.8 1.7	**SILTY CLAY,** grey, wet, stiff	3A 3B	SS	3
			VANE	
			VANE	
		4	SS	1
			VANE	



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GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ 8=3% Strain at Failure

Sheet No. 1 of 3

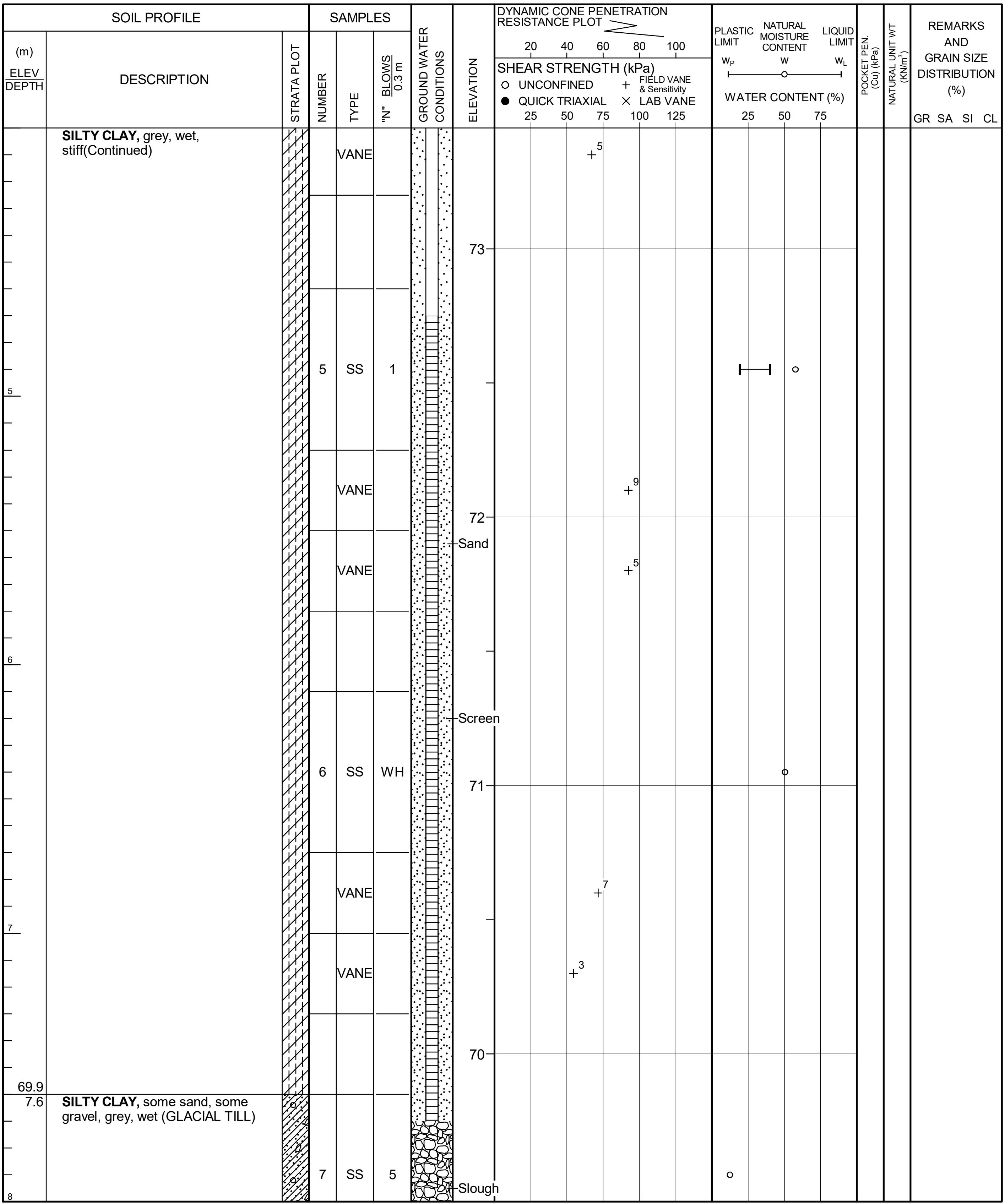
WSP SOIL LOG - OTTAWA GINT.GPJ SPL.GDT 22-3-25

LOG OF BOREHOLE 21-04s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-27
Supervisor: DW
Reviewer: NC



SILTY CLAY, grey, wet, stiff(Continued)

69.9
7.6
SILTY CLAY, some sand, some gravel, grey, wet (GLACIAL TILL)

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE 21-04s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-27
Supervisor: DW
Reviewer: NC

SOIL PROFILE			SAMPLES									
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
69.3	**SILTY CLAY,** some sand, some gravel, grey, wet (GLACIAL TILL)(Continued)											
8.2	END OF BOREHOLE Notes: 1. Borehole terminated at 8.2 m in depth after auger refusal. 2. Standing water in the borehole at 3.9 m in depth. 3. Monitoring well installed at 7.6 m in depth 4. Date Groundwater Depth -- October 15, 2021 2.9 m											

WSP SOIL LOG - OTTAWA GINT.GPJ SPL.GDT 22-3-25

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▽

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-05s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-28
Supervisor: DW
Reviewer: NC

SOIL PROFILE		SAMPLES										REMARKS AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) (25 50 75 100 125)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) (25 50 75)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m³)			GR	SA	SI	CL
77.7															
0.0	**ASPHALT - 20 mm** (FILL)														
77.7 0.0	**CRUSHED SAND AND GRAVEL,** grey, moist (Granular Base)	1	GRAB												
77.5 0.2	**SILTY SAND,** brown, moist, compact	2	SS	15											
		3A	SS	5								0	56	37	7
76.5 1.2	**SILTY CLAY,** grey, firm to stiff, wet	3B	SS												
		4	SS	1											
			VANE			+ 4.5									
			VANE			+ 5									

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Legend: ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE

LOG OF BOREHOLE 21-05s

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:CME 75	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-28
Datum: Geodetic	Borehole Diameter: 203 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS / 0.3 m							
	SILTY CLAY, grey, firm to stiff, wet(Continued)		5	SS	WH							
73.1 4.6	**SILTY CLAY,** some sand, some gravel, grey, wet (GLACIAL TILL)		6	SS	50/0 mm		73					
5												
72.6 5.1	END OF BOREHOLE Notes: 1. Borehole terminated at 5,1 m in depth after auger refusal. 2. Standing water in the borehole at 4.7 m in depth.											

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-06s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

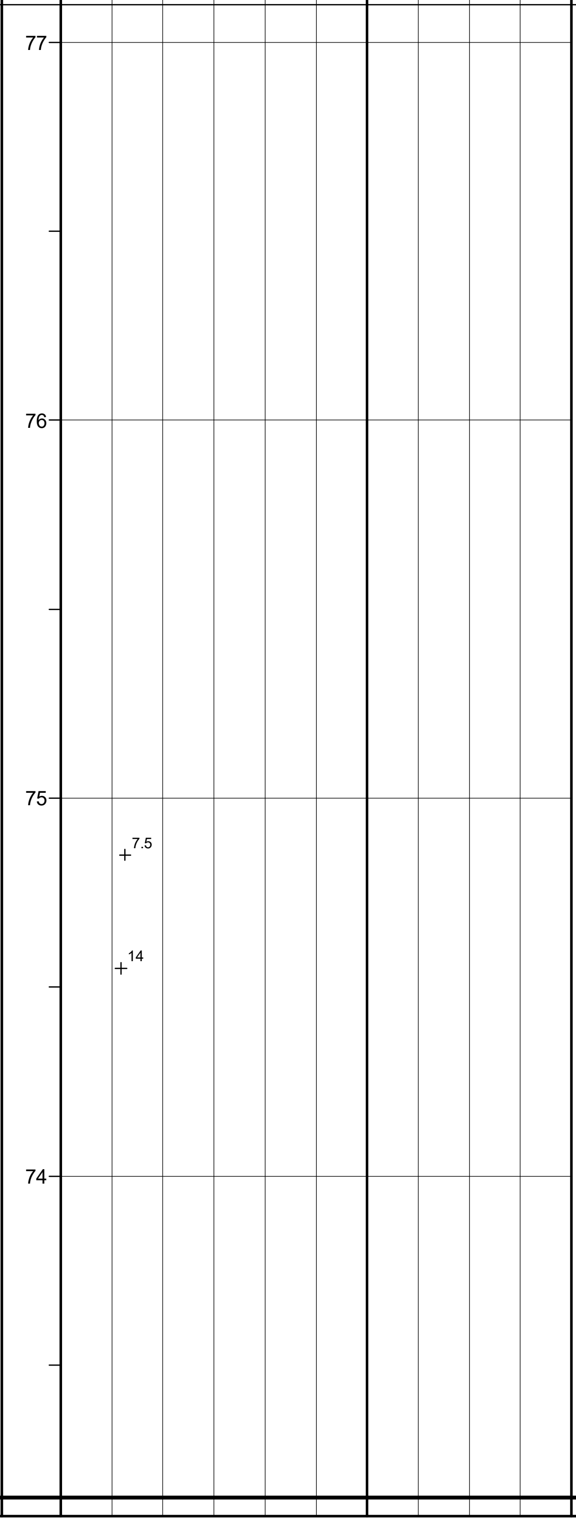
Project No.: 219-00058-03
Date Started: 2021-09-29
Supervisor: DW
Reviewer: NC

SOIL PROFILE		SAMPLES							
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
77.1 0.0	**ASPHALT - 45 mm** (FILL)								
77.1 0.0	**CRUSHED SAND AND GRAVEL,** grey, moist (Granular Base)	1	GRAB						
76.9 0.2	**SILTY SAND,** brown, moist								
76.3 0.9	**SILTY CLAY,** brown grey, moist, stiff (Weathered Crust)	2A 2B	SS	4					
75.6 1.5	**SILTY CLAY,** grey, wet, firm	3	SS	3					
			VANE						
			VANE						
		4	SS	WH					
73.5 3.7	**SILTY CLAY,** some sand, some gravel, grey, wet (GLACIAL TILL)	5	SS	50/25 mm					
73.2 4.0	END OF BOREHOLE								

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
25 50 75 100 125

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%)
25 50 75



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GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

Sheet No. 1 of 2

LOG OF BOREHOLE 21-06s

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:CME 75	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-29
Datum: Geodetic	Borehole Diameter: 203 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m							
	Notes: 1. Borehole terminated at 4.0 m in depth after auger refusal.											

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▽

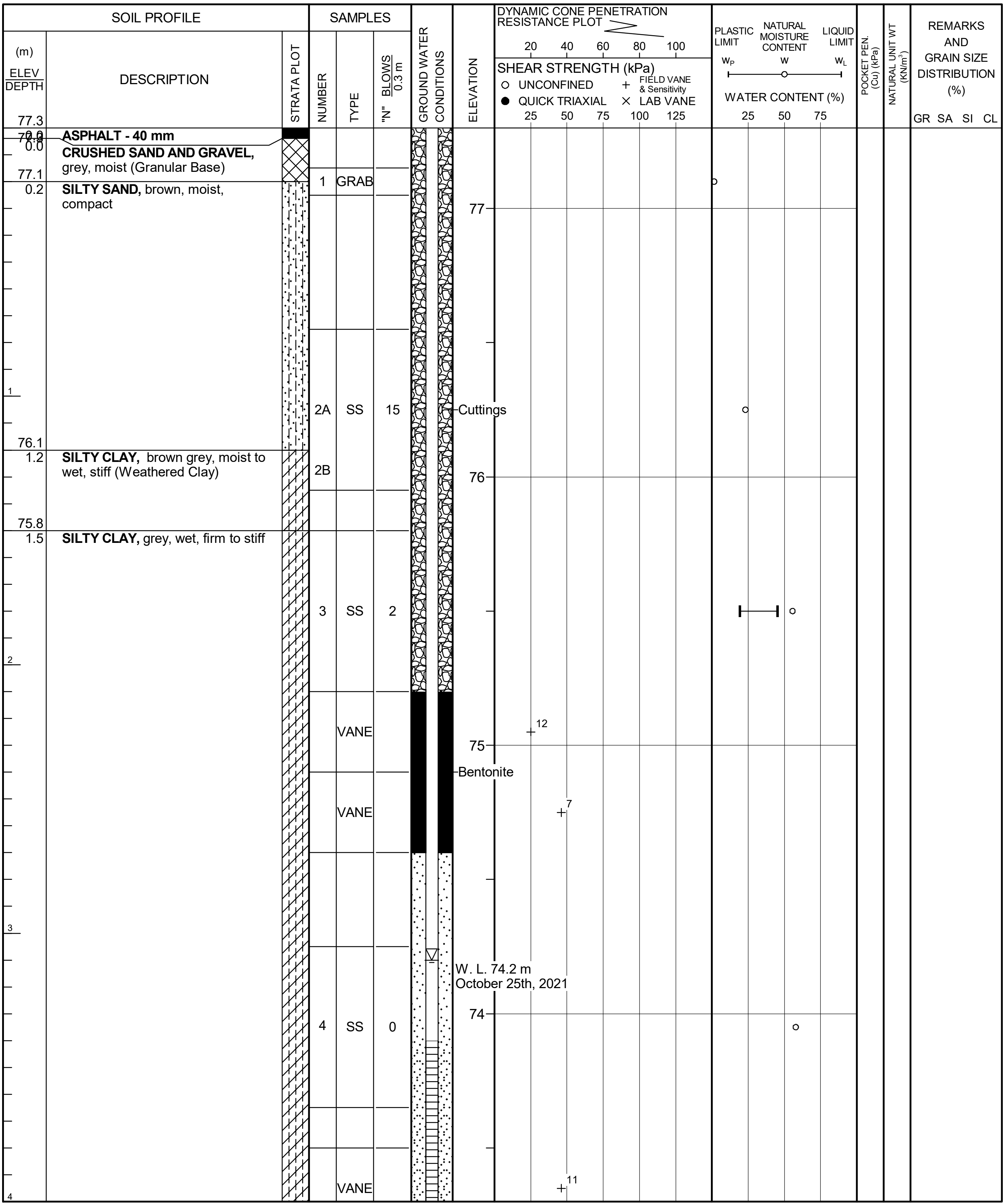
GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-07s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-29
Supervisor: DW
Reviewer: NC



ELEV DEPTH	DESCRIPTION
77.3	
0.0	**ASPHALT - 40 mm**
77.3 0.0	**CRUSHED SAND AND GRAVEL,** grey, moist (Granular Base)
77.1 0.2	**SILTY SAND,** brown, moist, compact
76.1 1.2	**SILTY CLAY,** brown grey, moist to wet, stiff (Weathered Clay)
75.8 1.5	**SILTY CLAY,** grey, wet, firm to stiff

NUMBER	TYPE	"N" BLOWS / 0.3 m
1	GRAB	
2A	SS	15
2B		
3	SS	2
	VANE	
	VANE	
4	SS	0
	VANE	

Continued Next Page

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES

$+^3, \times^3$: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

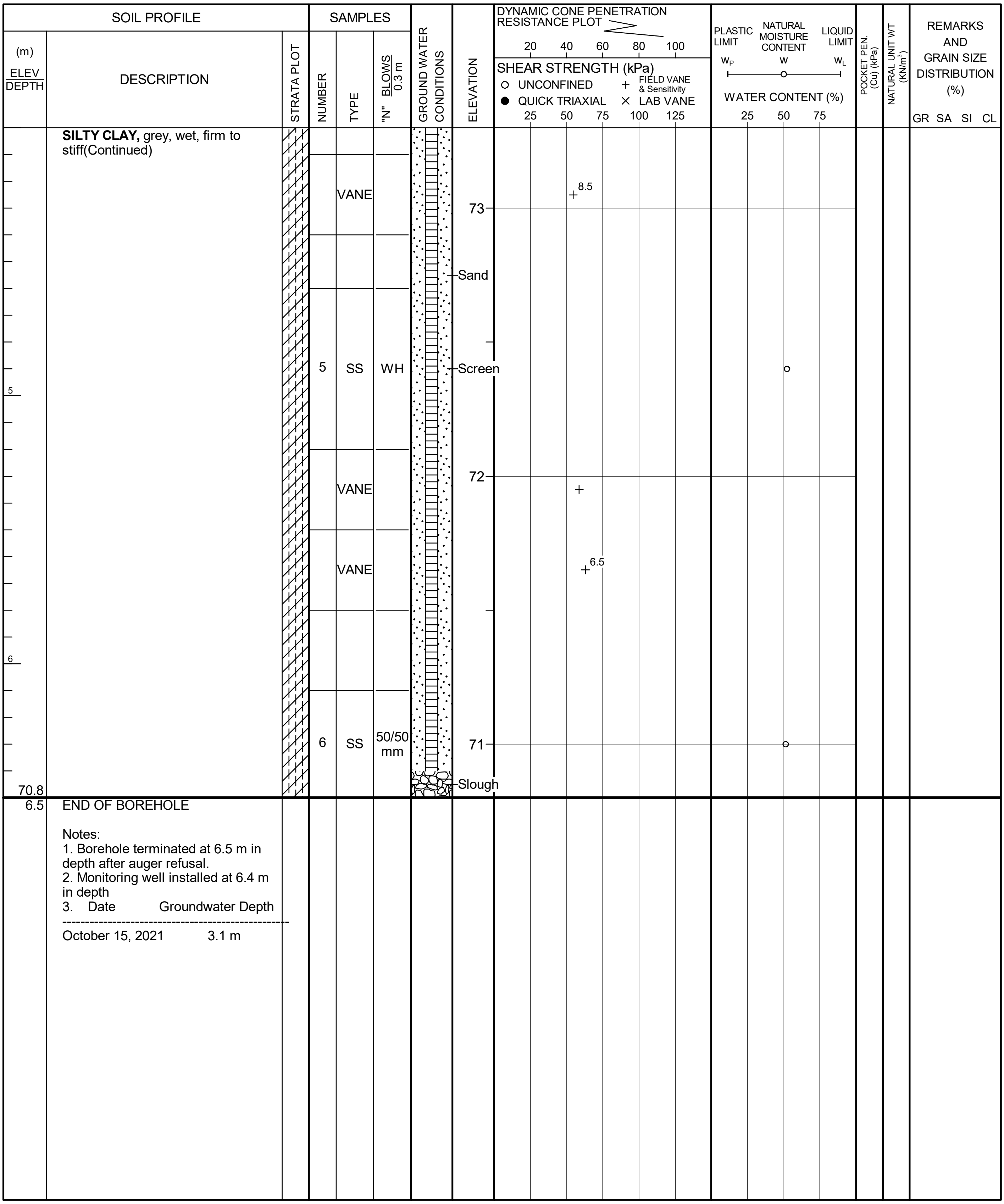
Sheet No. 1 of 2

LOG OF BOREHOLE 21-07s

Project: Access Storage - 415 Legget Drive
Client: Access Storage
Project Location: 415 Legget Drive, Ottawa, ON
Datum: Geodetic
BH Location: See Borehole Location Plan

DRILLING DATA
Rig Type:CME 75
Method: Hollow Stem Augers
Borehole Diameter: 203 mm
Core Diameter:

Project No.: 219-00058-03
Date Started: 2021-09-29
Supervisor: DW
Reviewer: NC



SILTY CLAY, grey, wet, firm to stiff(Continued)

END OF BOREHOLE

Notes:
1. Borehole terminated at 6.5 m in depth after auger refusal.
2. Monitoring well installed at 6.4 m in depth
3. Date Groundwater Depth

Date	Groundwater Depth
October 15, 2021	3.1 m

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE 21-08s

Project: Access Storage - 415 Legget Drive	**DRILLING DATA**	
Client: Access Storage	Rig Type:CME 75	Project No.: 219-00058-03
Project Location: 415 Legget Drive, Ottawa, ON	Method: Hollow Stem Augers	Date Started: 2021-09-29
Datum: Geodetic	Borehole Diameter: 203 mm	Supervisor: DW
BH Location: See Borehole Location Plan	Core Diameter:	Reviewer: NC

SOIL PROFILE (m) ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT w LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
77.3 0.0	**TOPSOIL - 75 mm**										
77.2 0.1	**SILTY SAND,** brown, moist, very loose to compact	1	GRAB			77					
		2	SS	10		76					
		3	SS	3							
75.0 2.3	**SILTY CLAY,** trace sand, brown, moist (Weathered Clay)	4	SS	50/0 mm		75					
74.5 2.8	END OF BOREHOLE Notes: 1. Borehole is open and dry upon completion										

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▼ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Explanation of Terms Used in the Record of Boreholes

Sample Type

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Dimension type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Spoon sample
SH	Shelby tube Sample
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

Penetration Resistance

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) required to drive a 50 mm (2 in) drive open sampler for a distance of 300 mm (12 in).

WH – Samples sinks under "weight of hammer"

Dynamic Cone Penetration Resistance, N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) to drive uncased a 50 mm (2 in) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in).

Textural Classification of Soils

Classification	Particle Size
Boulders	> 200 mm
Cobbles	75 mm - 200 mm
Gravel	4.75 mm - 75 mm
Sand	0.075 mm – 4.75 mm
Silt	0.002 mm-0.075 mm
Clay	<0.002 mm

Coarse Grain Soil Description (50% greater than 0.075 mm)

Terminology	Proportion
Trace	0-10%
Some	10-20%
Adjective (e.g. silty or sandy)	20-35%
And (e.g. sand and gravel)	> 35%

Soil Description

a) Cohesive Soils(*)

Consistency	Undrained Shear Strength (kPa)	SPT "N" Value
Very soft	<12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very stiff	100-200	15-30
Hard	>200	>30

(*) Hierarchy of Shear Strength prediction

1. Lab triaxial test
2. Field vane shear test
3. Lab. vane shear test
4. SPT "N" value
5. Pocket penetrometer

b) Cohesionless Soils

Density Index (Relative Density)	SPT "N" Value
Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Soil Tests

w	Water content
w_p	Plastic limit
w_l	Liquid limit
C	Consolidation (oedometer) test
CID	Consolidated isotropically drained triaxial test
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement
D_R	Relative density (specific gravity, Gs)
DS	Direct shear test
ENV	Environmental/ chemical analysis
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified proctor compaction test
SPC	Standard proctor compaction test
OC	Organic content test
U	Unconsolidated Undrained Triaxial Test
V	Field vane (LV-laboratory vane test)
γ	Unit weight

APPENDIX

C

LABORATORY TESTING RESULTS

ATTERBERG LIMITS

ASTM D4318

Date:	19-Oct-21	Job No.:	219-00058-03
Project Name:	415 Legget Drive	Tech.:	LEK
Borehole/Sample No.:	BH21-1i / SS3 / 1.5-2.1m		

Liquid Limit Test

Number of Shocks	33	23	16
Tin No.			
Tin + Wet soil	29.9	37.5	29.1
Tin + Dry soil	26.5	34.3	25.8
Wt. of Water	3.4	3.2	3.3
Wt. of Tin	19.8	28.2	19.8
Wt. of Dry Soil	6.7	6.1	6.0
Water Content	51	53	55

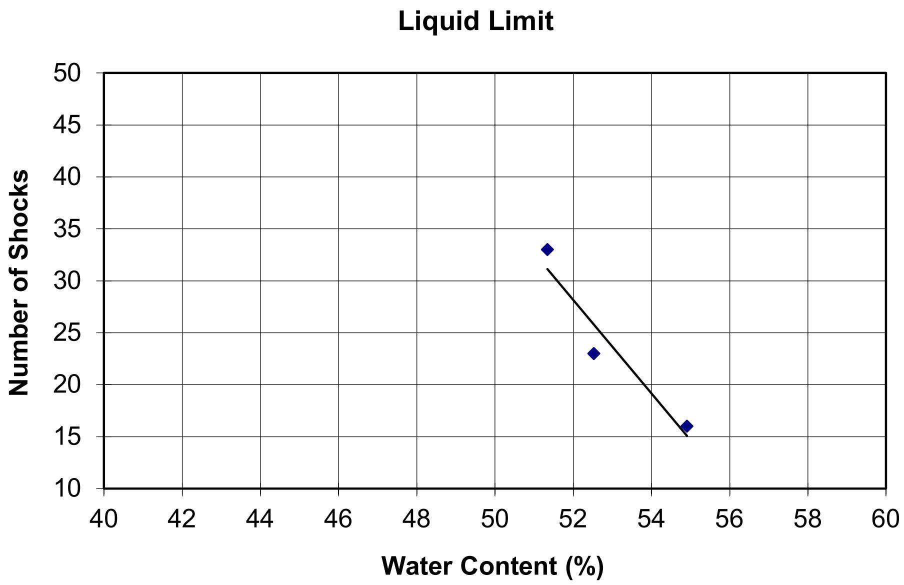
Plastic Limit Test

Tin No.		
Tin + Wet soil	29.4	28.5
Tin + Dry soil	27.7	27.0
Wt. of Water	1.7	1.6
Wt. of Tin	19.8	19.7
Wt. of Dry Soil	7.9	7.3
Water Content	22	22

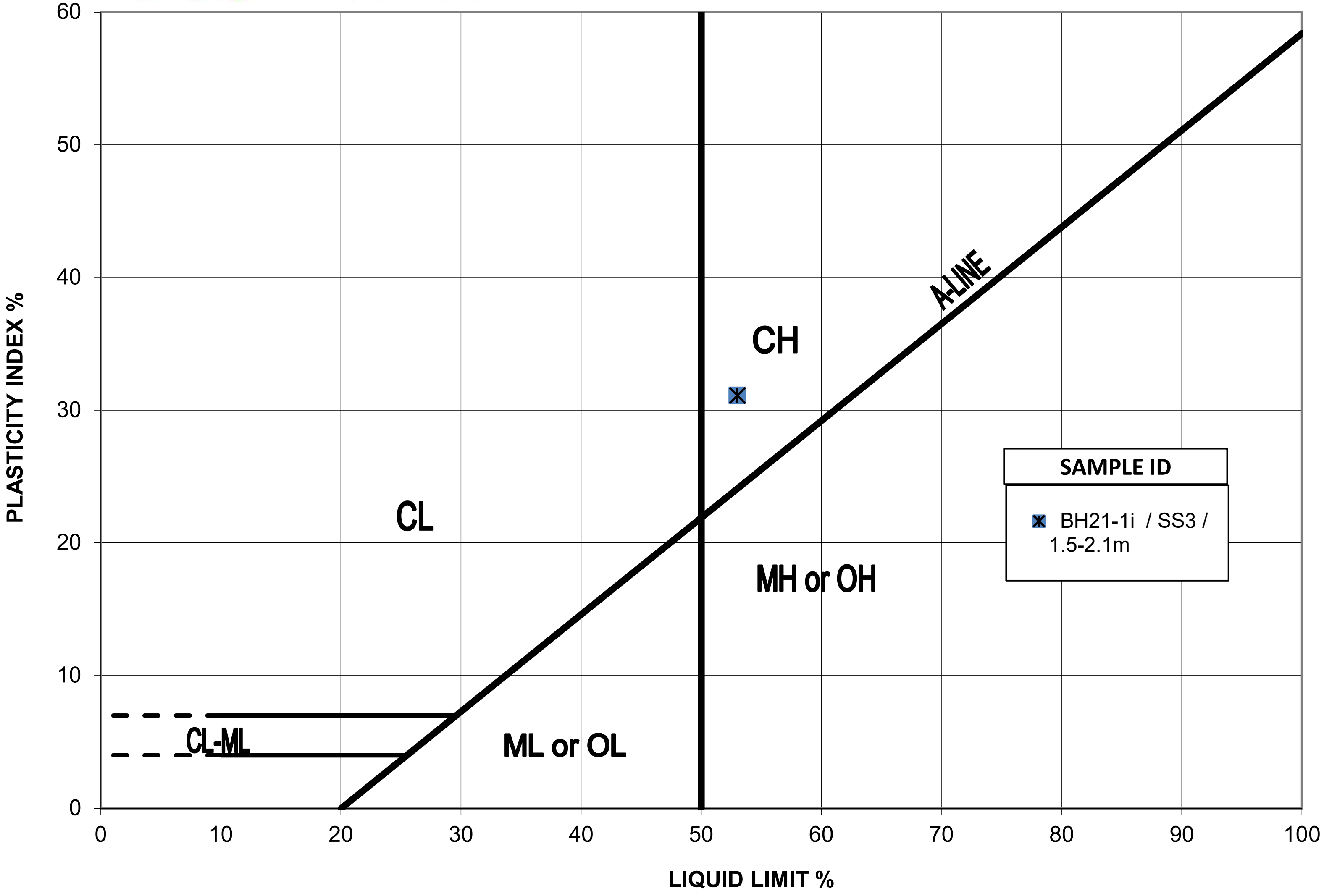
Liquid Limit, (W_L)	53
Plastic Limit, (WP)	22
Plasticity Index (I_P=W_L-W_P)	31

Control Results

Liquid Limit, (W_L)	31
Plastic Limit, (WP)	20
Plasticity Index (I_P=W_L-W_P)	11



Atterberg Limits Plasticity Chart
415 Legget Drive
219-00058-03



ATTERBERG LIMITS

ASTM D4318

Date:	19-Oct-21	Job No.:	219-00058-03
Project Name:	415 Legget Drive	Tech.:	LEK
Borehole/Sample No.:	BH21-3s / SS3 / 1.5-2.1m		

Liquid Limit Test

Number of Shocks	33	24	15
Tin No.			
Tin + Wet soil	35.9	38.9	36.4
Tin + Dry soil	33.5	35.4	33.7
Wt. of Water	2.4	3.5	2.7
Wt. of Tin	28.5	28.3	28.4
Wt. of Dry Soil	5.0	7.1	5.3
Water Content	48	49	51

Plastic Limit Test

Tin No.		
Tin + Wet soil	27.8	35.2
Tin + Dry soil	26.6	34.1
Wt. of Water	1.3	1.1
Wt. of Tin	20.0	28.6
Wt. of Dry Soil	6.5	5.5
Water Content	19	21

Liquid Limit, (W_L) 49

Plastic Limit, (WP) 20

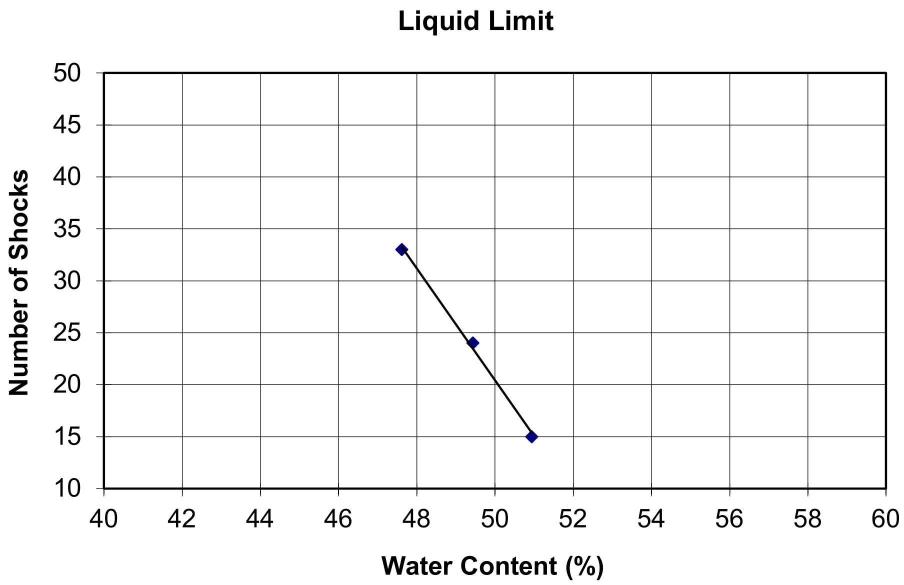
Plasticity Index (I_P=W_L-W_P) 29

Control Results

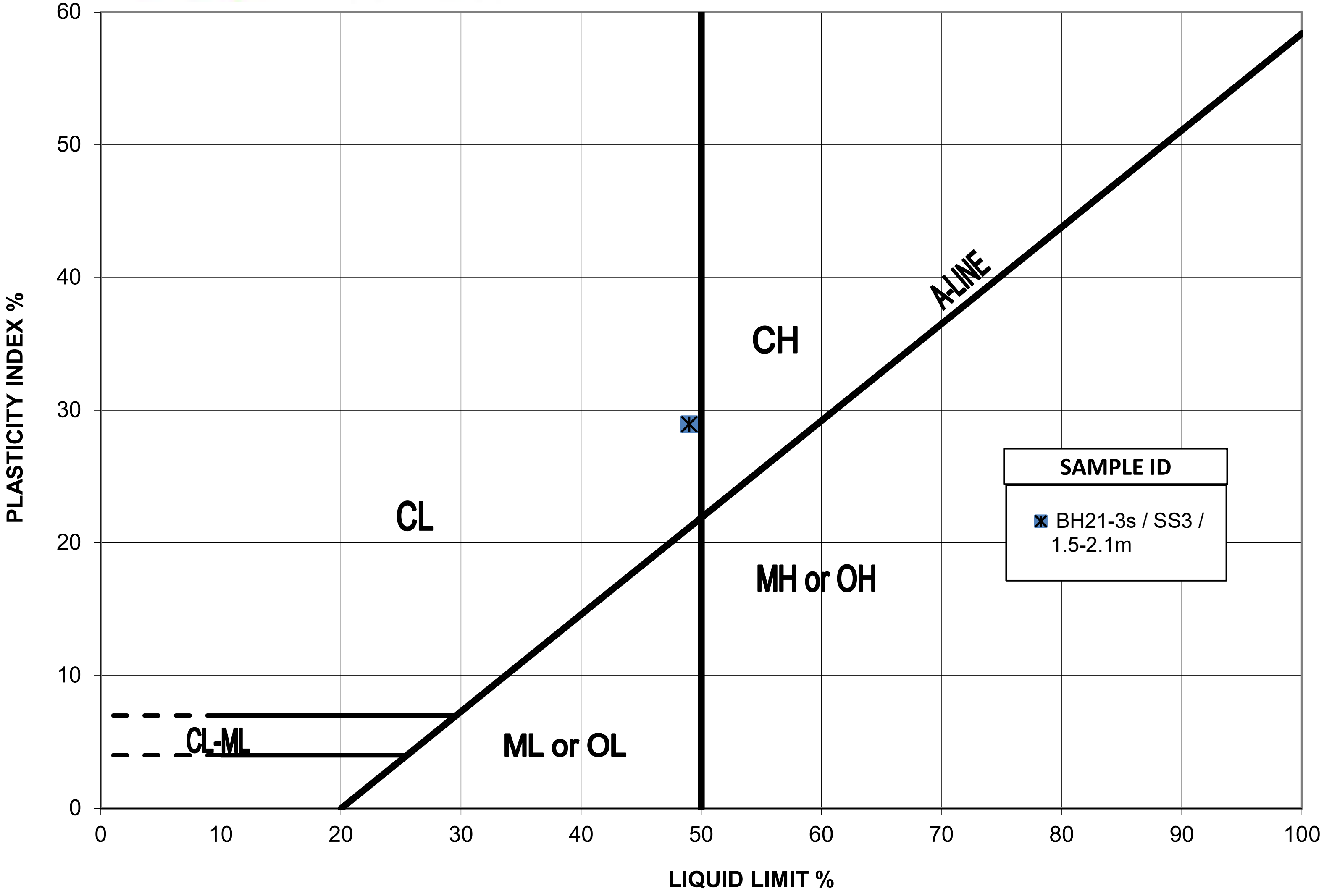
Liquid Limit, (W_L) 31

Plastic Limit, (WP) 20

Plasticity Index (I_P=W_L-W_P) 11



Atterberg Limits Plasticity Chart
415 Legget Drive
219-00058-03



ATTERBERG LIMITS

ASTM D4318

Date:	19-Oct-21	Job No.:	219-00058-03
Project Name:	415 Legget Drive	Tech.:	LEK
Borehole/Sample No.:	BH21-4s / SS5 / 4.6-5.2m		

Liquid Limit Test

Number of Shocks	18	24	33
Tin No.			
Tin + Wet soil	31.2	24.8	25.7
Tin + Dry soil	27.9	21.8	22.5
Wt. of Water	3.3	3.0	3.2
Wt. of Tin	19.8	14.1	14.2
Wt. of Dry Soil	8.1	7.7	8.2
Water Content	41	40	39

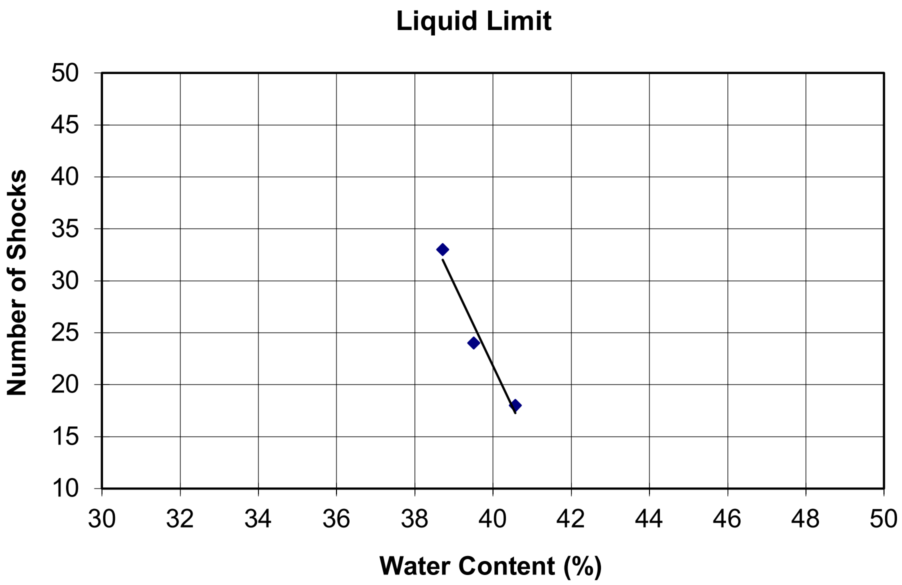
Plastic Limit Test

Tin No.		
Tin + Wet soil	39.3	29.7
Tin + Dry soil	37.6	28.2
Wt. of Water	1.7	1.6
Wt. of Tin	28.5	20.0
Wt. of Dry Soil	9.1	8.2
Water Content	19	19

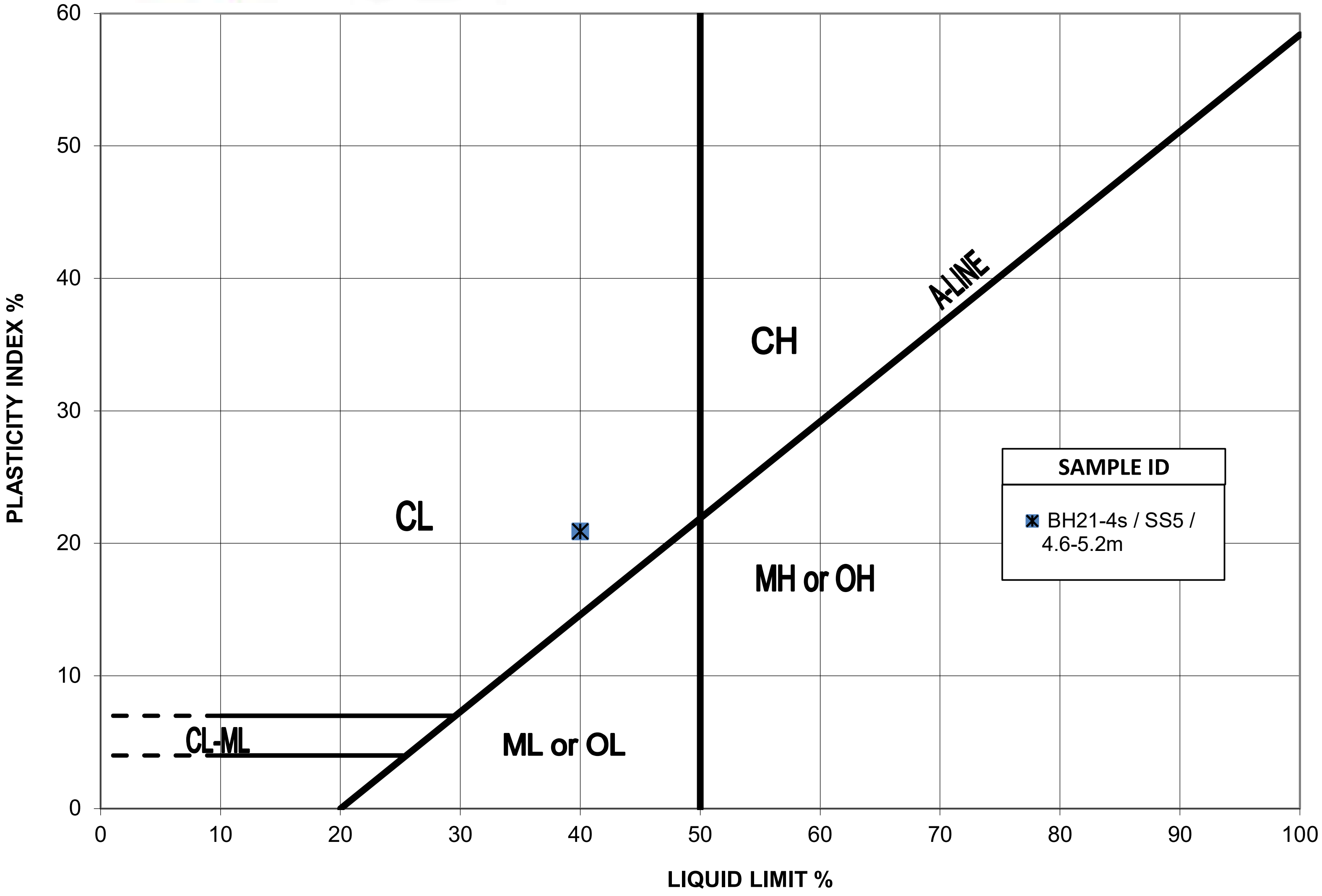
Liquid Limit, (W_L)	40
Plastic Limit, (WP)	19
Plasticity Index (I_P=W_L-W_P)	21

Control Results

Liquid Limit, (W_L)	31
Plastic Limit, (WP)	20
Plasticity Index (I_P=W_L-W_P)	11



Atterberg Limits Plasticity Chart
415 Legget Drive
219-00058-03



ATTERBERG LIMITS

ASTM D4318

Date:	19-Oct-21	Job No.:	211-00058-03
Project Name:	415 Legget Drive	Tech.:	LEK/NLO
Borehole/Sample No.:	BH21-7s / SS3A / 1.5-2.1m		

Liquid Limit Test

Number of Shocks	33	23	16
Tin No.			
Tin + Wet soil	36.9	37.0	37.5
Tin + Dry soil	34.3	34.2	34.6
Wt. of Water	2.6	2.8	3.0
Wt. of Tin	28.3	28.1	28.1
Wt. of Dry Soil	6.0	6.2	6.4
Water Content	44	45	46

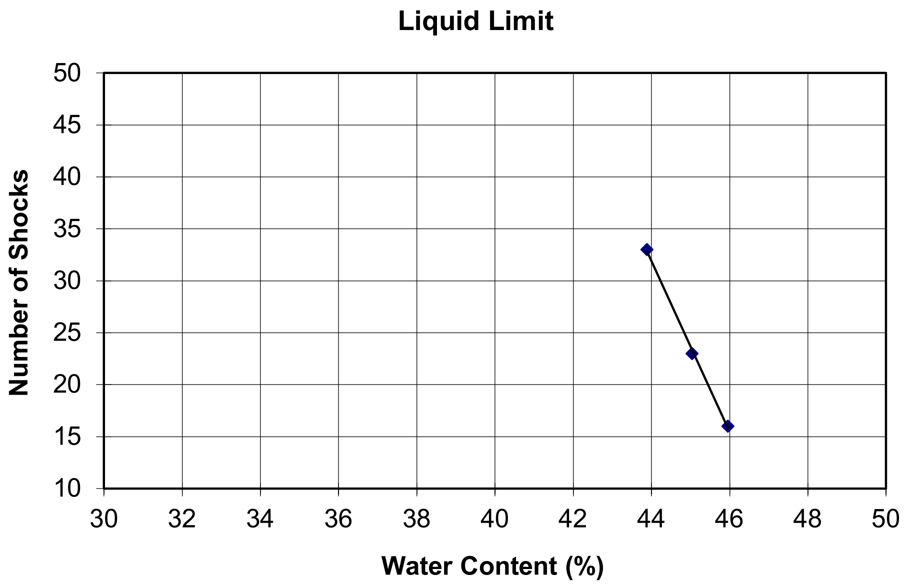
Plastic Limit Test

Tin No.		
Tin + Wet soil	25.4	34.3
Tin + Dry soil	24.5	33.4
Wt. of Water	0.9	0.9
Wt. of Tin	19.9	28.5
Wt. of Dry Soil	4.6	4.8
Water Content	19	19

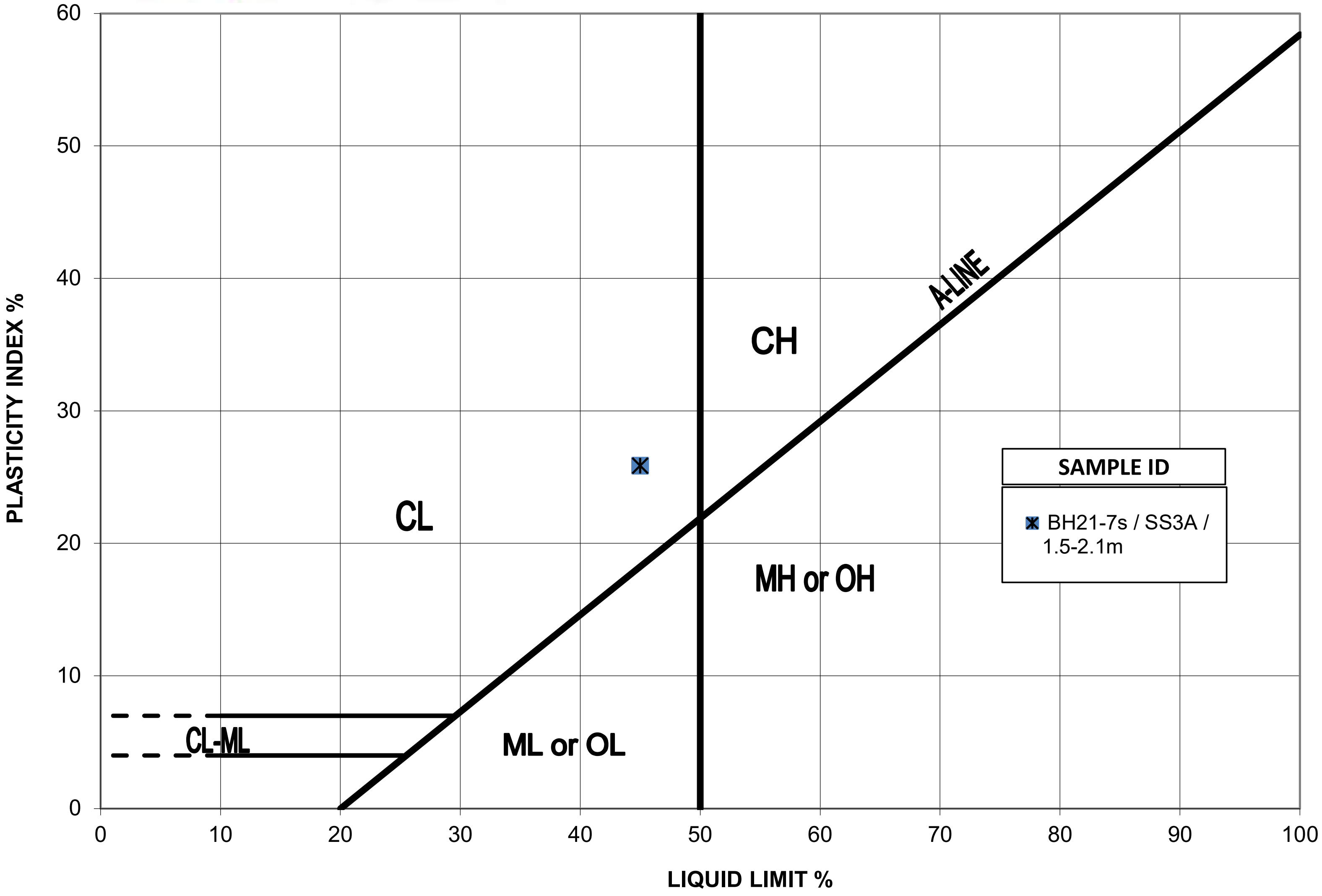
Liquid Limit, (W_L)	45
Plastic Limit, (WP)	19
Plasticity Index (I_P=W_L-W_P)	26

Control Results

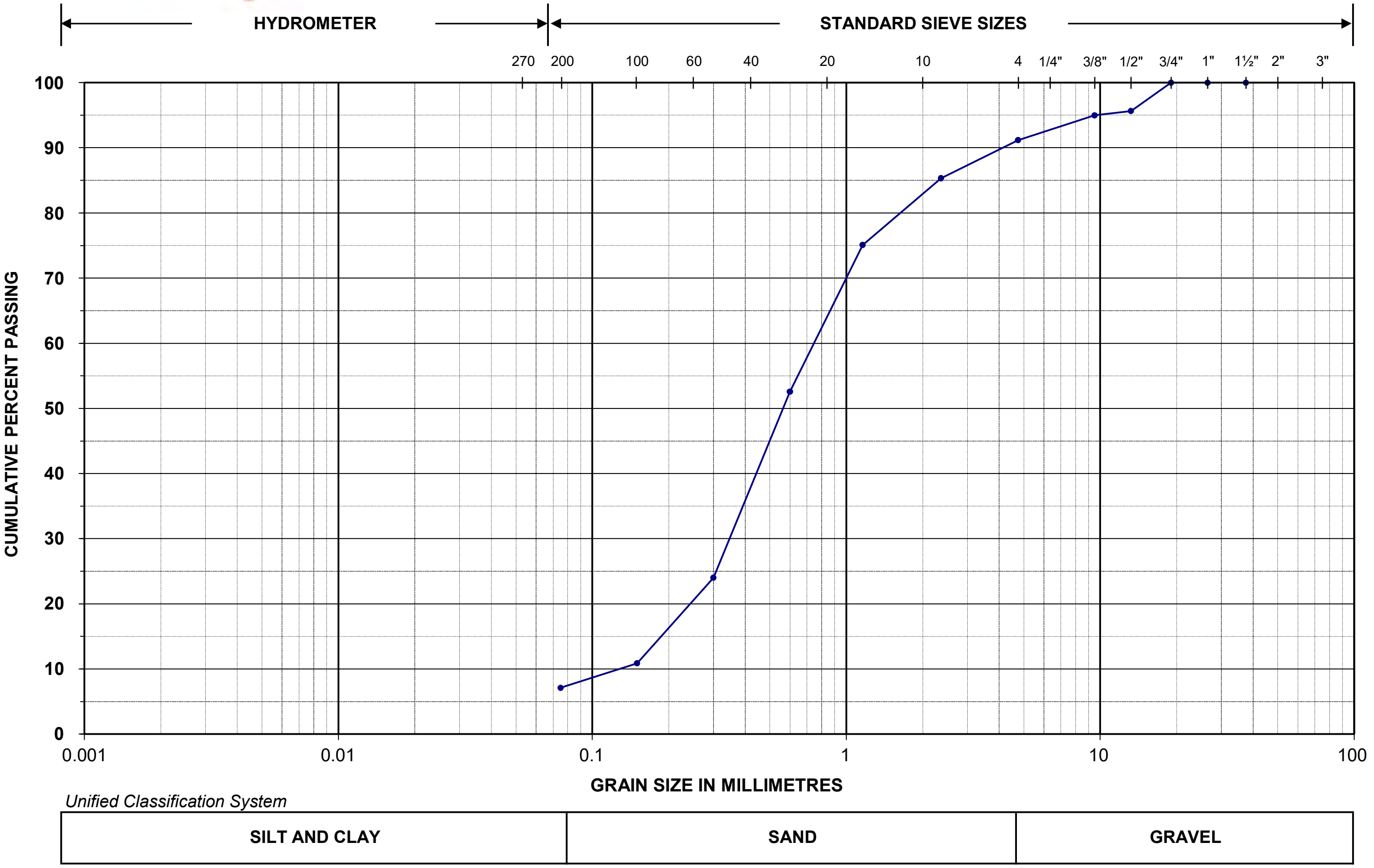
Liquid Limit, (W_L)	31
Plastic Limit, (WP)	20
Plasticity Index (I_P=W_L-W_P)	11



Atterberg Limits Plasticity Chart
415 Legget Drive
211-00058-03



PARTICLE SIZE DISTRIBUTION



Project Name: 415 Legger Drive

Project No.: 219-00058-03

Location ID.: BH21-1i

Sample No./Depth: Grab 1 / 0.2-0.25m

Sieve Size	% Passing Coarse	Sieve Size	% Passing Fine
37.5 mm	100.0	**2.36 mm**	85.3
26.5 mm	100.0	**1.16 mm**	75.1
19.0 mm	100.0	**0.60 mm**	52.6
13.2 mm	95.6	**0.30 mm**	24.0
9.5 mm	95.0	**0.15 mm**	10.9
4.75 mm	91.2	**0.075 mm**	7.1

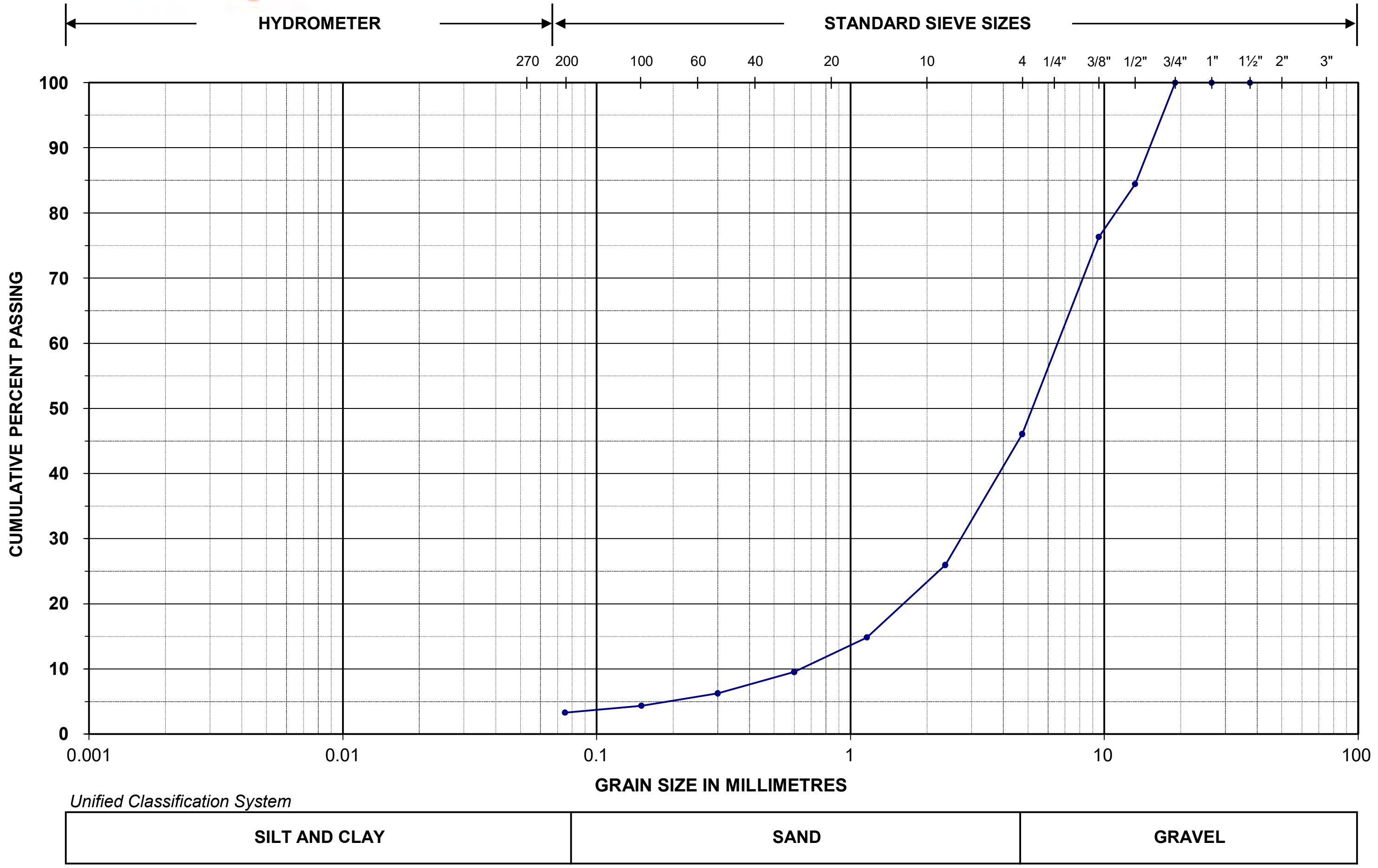
Note: More information is available upon request.

Tested by: LEK

Reviewed by:

Date: 15-Oct-21

PARTICLE SIZE DISTRIBUTION



Project Name: 415 Legget Drive

Project No.: 219-00058-03

Location ID.: BH21-2i

Sample No./Depth: Grab 1 / 0.08-0.15m

Sieve Size	% Passing Coarse	Sieve Size	% Passing Fine
37.5 mm	100.0	2.36 mm	26.0
26.5 mm	100.0	1.16 mm	14.8
19.0 mm	100.0	0.60 mm	9.5
13.2 mm	84.4	0.30 mm	6.2
9.5 mm	76.3	0.15 mm	4.4
4.75 mm	46.1	0.075 mm	3.3

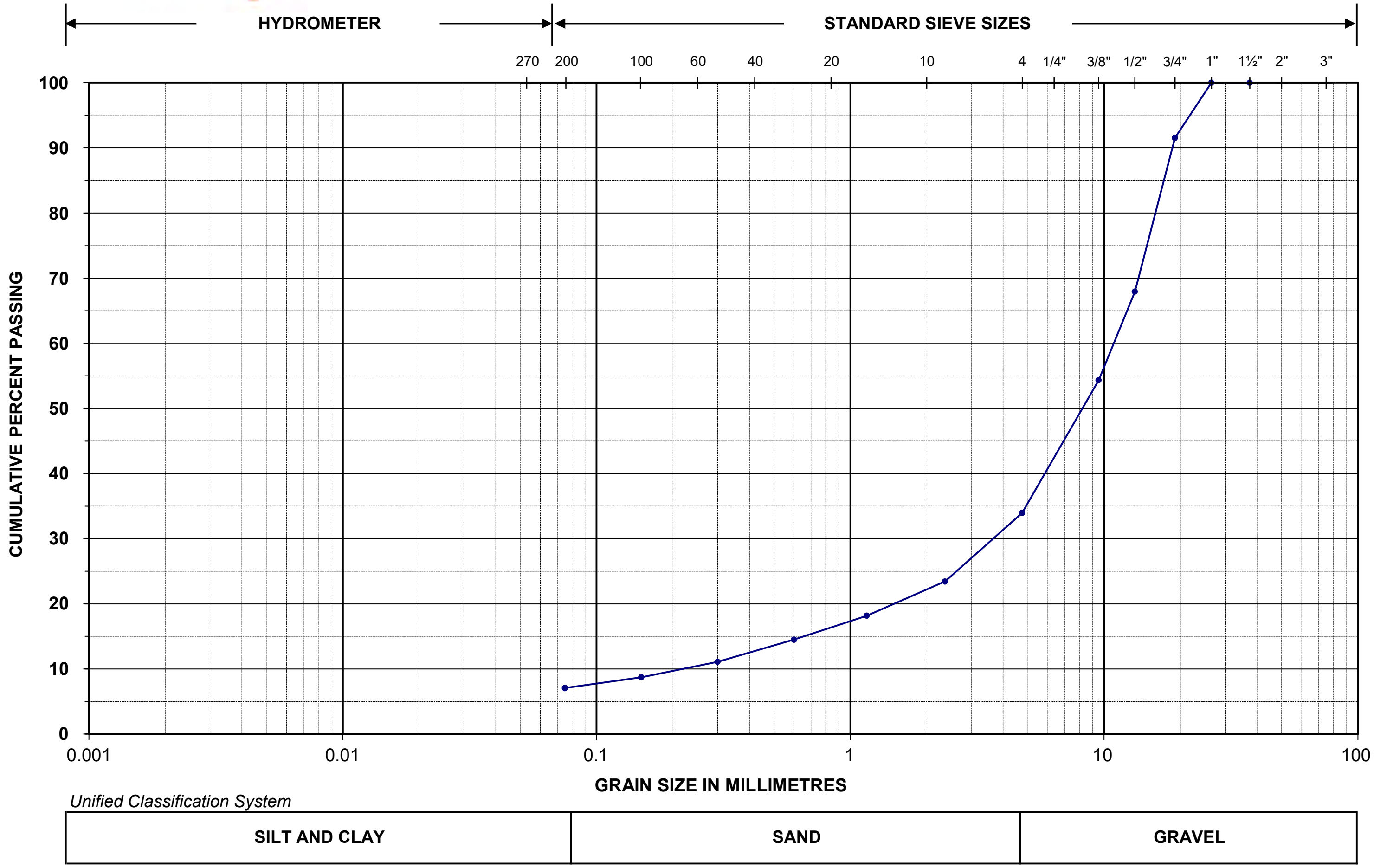
Note: More information is available upon request.

Tested by: LEK/NLO

Reviewed by:

Date: 15-Oct-21

PARTICLE SIZE DISTRIBUTION



Project Name: 415 Legget Drive

Location ID.: BH21-2s

Project No.: 219-00058-03

Sample No./Depth: Grab 1 / 0.15-0.30m

Sieve Size	% Passing Coarse	Sieve Size	% Passing Fine
37.5 mm	100.0	**2.36 mm**	23.4
26.5 mm	100.0	**1.16 mm**	18.2
19.0 mm	91.5	**0.60 mm**	14.5
13.2 mm	67.9	**0.30 mm**	11.1
9.5 mm	54.3	**0.15 mm**	8.7
4.75 mm	33.9	**0.075 mm**	7.1

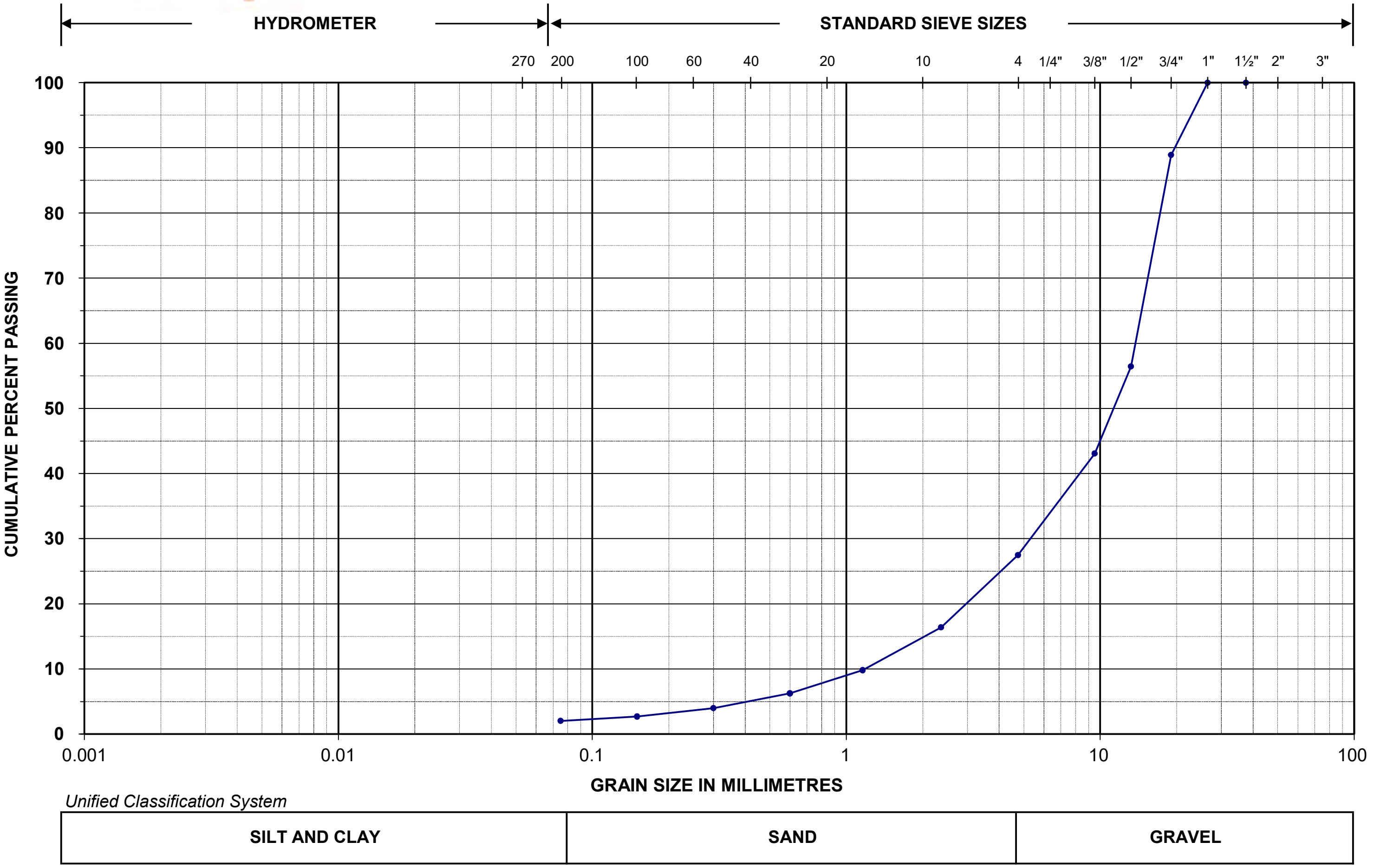
Note: More information is available upon request.

Tested by: LEK

Reviewed by:

Date: 19-Oct-21

PARTICLE SIZE DISTRIBUTION



Project Name: 415 Legget Drive
Project No.: 219-00058-03
Location ID.: BH21-3i
Sample No./Depth: Grab 1 / 0.15-0.25m

Sieve Size	% Passing Coarse	Sieve Size	% Passing Fine
37.5 mm	100.0	**2.36 mm**	16.4
26.5 mm	100.0	**1.16 mm**	9.8
19.0 mm	88.9	**0.60 mm**	6.3
13.2 mm	56.4	**0.30 mm**	4.0
9.5 mm	43.1	**0.15 mm**	2.7
4.75 mm	27.5	**0.075 mm**	2.0

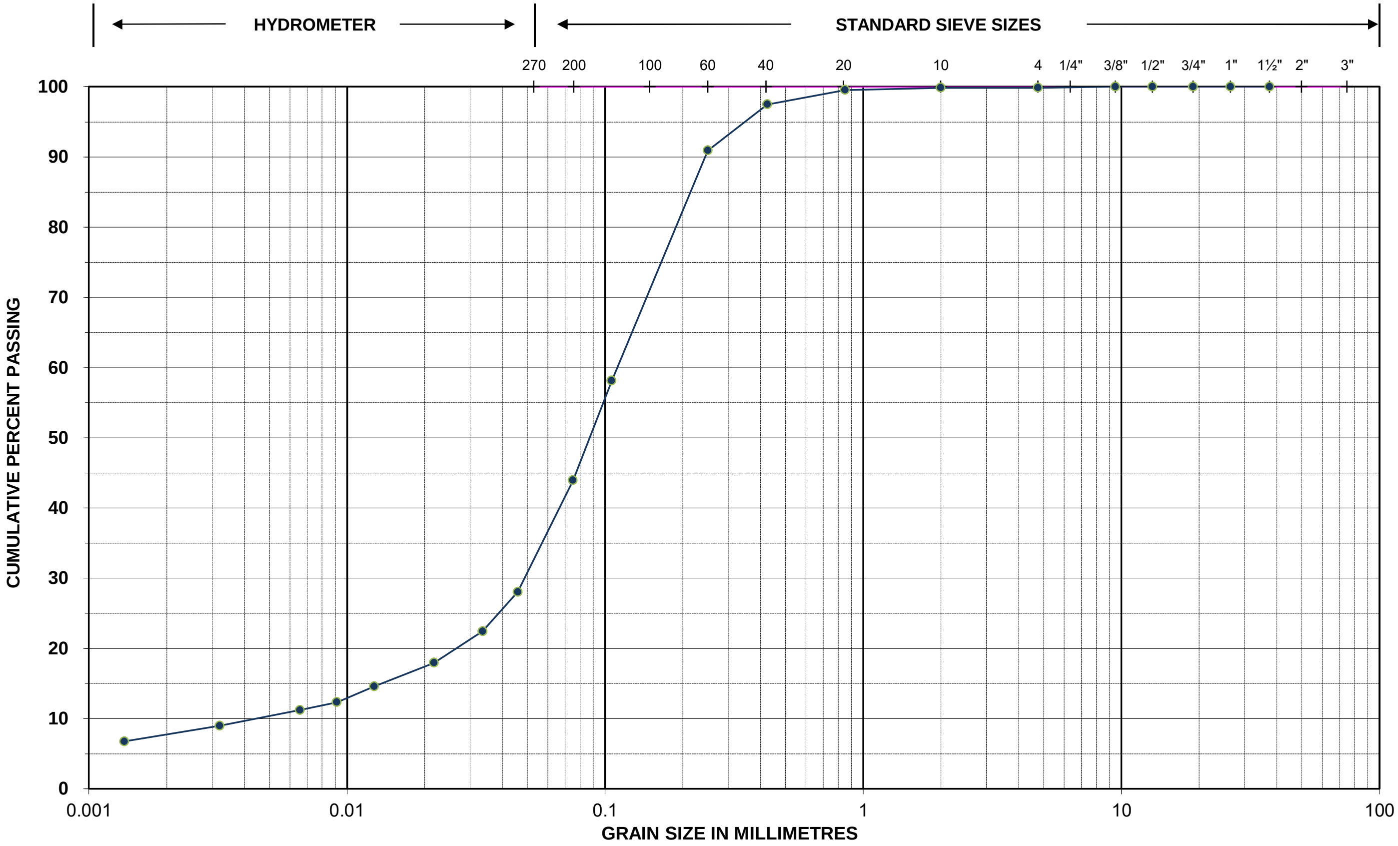
Note: More information is available upon request.

Tested by: LEK

Reviewed by:

Date: 15-Oct-21

PARTICLE SIZE DISTRIBUTION LS702/ASTM D422



Unified Classification System

SILT AND CLAY	SAND	GRAVEL

Project Name: 415 Legget Drive **Project No.:** 219-00058-31

Location ID.: BH21-5s **Sample No./Depth:** SS2 / 0.8-1.4m

Sieve Size	% Passing Coarse	Sieve Size	% Passing Fine	Hydrometer (mm)	% Passing
37.5 mm	100.0	**2.00 mm**	99.9	**0.046**	28.0
26.5 mm	100.0	**0.850 mm**	99.5	**0.022**	18.0
19.0 mm	100.0	**0.425 mm**	97.5	**0.009**	12.3
13.2 mm	100.0	**0.250 mm**	90.9	**0.003**	9.0
9.50 mm	100.0	**0.106 mm**	58.1	**0.001**	6.7
4.75 mm	99.9	**0.075 mm**	43.9		

Note: More information is available upon request. Tested by: NLO/LEK Reviewed by: K Conlon Date: 20/Oct/21

Certificate of Analysis

Client: WSP (Ottawa)
2611Queensview Dr.
Ottawa, ON
K2B 8K1
Attention: Nathan Christie
PO#:
Invoice to: WSP Canada Inc.

Report Number: 1964299
Date Submitted: 2021-10-07
Date Reported: 2021-10-14
Project: 219-00058-03
COC #: 214930

				Lab I.D.	1587905	1587906	1587907	1587908
				Sample Matrix	Soil	Soil	Soil	Soil
				Sample Type				
				Sampling Date	2021-09-30	2021-10-03	2021-09-27	2021-09-28
				Sample I.D.	BH21-1i 0.3-0.4m	BH21-4i 2.0-2.6m	BH21-2s SS2	BH21-5s SS4
Group	**Analyte**	**MRL**	**Units**	**Guideline**				
Anions	Cl	0.002	%		0.004	0.006	0.032	0.018
	SO4	0.01	%		0.04	0.02	<0.01	0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.24	0.20	0.47	0.29
	pH	2.00			8.12	8.07	8.05	8.18
	Resistivity	1	ohm-cm		4170	5260	2130	3570

Guideline =

*** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX

D

GEOPHYSICAL SURVEY

2021-10-29

Confidential

Access Property Development Inc.
100 Canadian Road, Suite 300
Toronto, ON M1R 4Z5
(416) 288-2405

Subject: Technical Memorandum – Seismic Investigation, 415 Legget Drive, Ottawa, ON

Dear Sir:

WSP Canada Inc. (WSP) is pleased to provide Access Property Development Inc. with the following technical note which summarizes the methodology behind the seismic investigation, the data analysis and results of the study.

We trust that this information is sufficient for your current needs. If you have any questions or require further information, please contact us.

Yours sincerely,

Andrew Nicol

Andrew Nicol, M.Sc.
Geophysicist

AN

Appendix A: Figures

WSP ref.: 219-00058-03

Suite 300
2611 Queensview Drive
Ottawa, ON, Canada K2B 8K2

T: +1 613 829-2800
F: +1 613 829-8299
wsp.com

TECHNICAL MEMORANDUM

SCOPE OF WORK

WSP Canada Inc. carried out a seismic investigation at 415 Legget Drive in Kanata, ON (**Drawing 1**) on September 20 and 21, 2021.

The purpose of the investigation was to determine the seismic site classification for the site, as well as produce several cross-sections showing the profile of bedrock or another bearing surface in 2-dimensions (2-D).

The scope of work included the acquisition of three seismic lines oriented from southwest to northeast in the parking lots surrounding the existing building. These lines were then to be processed and analysed to determine a seismic site classification for the site, as well as three cross-sections showing a 2-D representation of the soil stratigraphy. The secondary scope or work was to highlight any stratigraphic layers of importance such as bedrock, or other potential bearing surfaces.

SEISMIC INVESTIGATION

METHODOLOGY

MULTI-CHANNEL SURFACE WAVE ANALYSIS (MASW)

MASW is a geophysical technique that is widely used to determine shear-wave velocity (Vs) for multiple applications. MASW uses a seismic source, generally a sledgehammer, and vertically oriented geophones to determine the shear-wave velocity of the subsurface at the location being studied.

The recorded ground motion is processed and analyzed using a specialized software package called SeisImager SW to analyze the propagation velocity of surface waves. The velocity of seismic waves are frequency dependent. The MASW technique relies on this relationship to characterize the wave velocity at different depths in the subsurface. For example, the measured response of a lower frequency wave contains information from a deeper layer than a higher frequency wave due to the longer wavelength.

A transformation method (phase-shift, tau-pi, f-k, etc.) is used to display the waveform in the phase velocity–frequency domain where the dispersion curve is picked. This curve is used to relate the phase velocity to its corresponding frequency component. Subsequently, a least-mean squares inversion is performed to generate a 1-D shear-velocity (Vs) profile for the area of the top 30 m of the stratigraphy.

SURVEY DESIGN

The seismic study was conducted in the northern and southern parking lots at 415 Legget Drive. Lines 1 and 2 were acquired in the northern parking lot, whereas Line 3 was acquired in the southern parking lot.

The seismic survey was designed to attain a depth of measurement of 30 meters and was conducted with the following equipment:

- 24-channel Geometrics Seismograph;

- 24, 4.5Hz geophones;
- 135-meter seismic spread cable, with 5-meter take-outs;
- 16-pound sledgehammer;

Survey parameters were as follows:

- Geophone spacing of 3.0 or 4.0 meters;
- Sample rate of 0.125ms;
- Record length of 1.0s.

DATA ANALYSIS

MASW

The workflow used to conduct the analysis of the seismic data using the MASW method to obtain shear-wave (S-wave) velocity is as follows:

- Inspect seismic shot records (**Figure 2**);
- Combine line segments and apply survey geometry;
- Perform transformation to phase-velocity–frequency domain (**Figure 3**);
- Pick dispersion curves;
- Generate initial model; and
- Calculate 2-D S-wave velocity model through inversion (**Figure 4**);
- Calculate Vs30 to provide site classification.

BEARING LAYER PROFILE

The determination of the top of a bearing layer was accomplished by correlating 2-D seismic velocity section with borehole logs.

As bedrock was not cored, it is assumed that a significant bearing layer was encountered at the point of refusal of advancement of the split-spoon, or where the N-value blow count was recorded as being greater than N=50.

In the case of 415 Legget Drive, an apparent bearing layer is present in the form of a glacial till. This till layer is encountered in boreholes BH21-1s, BH21-3s, BH21-4s, BH21-5s and BH21-6s at varying depths.

RESULTS

LINE 1

Line 1 intersects two boreholes, BH 21-5s in the southwest which saw refusal at a depth of 5.1 meters, and BH21-7s in the northeast which saw refusal at 6.5 meters. The Vs which corresponds to this refusal is approximately 300m/s.

In BH21-5s this refusal occurs in a silty clay layer determined to be a glacial till during logging of the borehole samples. This layer has an N-value of 50/0mm which is indicative of a very dense soil.

The top of the very dense soil layer is seen at a depth of 6 meters at the start of Line 1 (**Figure 5**), the layer climbs to a minimum depth of roughly 4 meters around 30 meters from the start of the line before falling to a depth of approximately 7 meters at the northern end of the line.

There is a zone of soft soil, characterized by a Vs less than 180m/s in the near surface between 1.5 and 4.1 meters for the intervals between 0-12 meters and 50-138 meters along Line 1.

LINE 2

Line 2 intersects three boreholes, BH 21-4s, BH 21-6s and BH 21-8s from southwest to northeast. These boreholes saw refusal at 8.2m, 4.0m and 2.8m respectively, of which both BH21-4s and BH21-6s see refusal within the glacial till. These refusals show a trend of decreasing soil stiffness to the south with a Vs of approximately 300m/s.

The soil layers along Line 2 (**Figure 6**) shows a gradual thinning of the thickness of the overburden above the very dense glacial till from roughly 11 meters in the south to 3 meters in the north. The soft soil layer (Vs<180m/s) also thins from the south, 6m thick, to the north, less than 1m thick.

LINE 3

Line 3 (**Figure 7**) intersects three boreholes BH 21-1s in the southwest, BH 21-2s and BH 21-3s in the northeast. These boreholes saw refusals at 4.9m, 8.1m and 8.7m respectively. The corresponding Vs of 300m/s corresponds to the refusals in BH21-1s and BH21-3s, however, there is a 2m discrepancy with BH21-2s. At this location, the borehole log makes no mention of glacial till, or refusal, therefore the glacial till is likely closer to a depth of 9.5-10m.

The very dense glacial till layer is encountered at a depth of 4.6m in BH21-1s on the southern end of the line. The same glacial till was seen in BH21-3s at 8.2m at the northern end of the line. The Vs profile shows that the glacial till layer (Vs=300m/s) drops to a depth of approximately 11 meters at a distance of 114 meters from the southern end of the line. The variation in the topography of the glacial till layer observed along Line 3 explains why the glacial till was not encountered in BH21-2s.

SUMMARY

The site at 415 Legget Drive saw significant differences in seismic wave velocities across the site, with maximum velocities in the northwest and significantly slower velocities in the southeast. The stratigraphic layer in this location with significant strength appears to be a glacial till layer which is observed in boreholes between 2.8 meters and 8.7 meters deep. The bedrock is beneath this layer, but a determination of the bedrock profile is difficult to estimate as it was not encountered in the boreholes.

Seismic data analysed using the MASW technique was used to develop a more thorough understanding of the soil stratigraphy, and successfully mapped the top of glacial till with a Vs of approximately 300m/s (green layer in **Figures 5, 6 & 7**).

SITE CLASSIFICATION

Upon review of the development plan and the significant variations in seismic velocity observed at 415 Legget Drive, it was determined that a seismic site class should be provided for both Building A and Building B as separate entities.

BUILDING A

To produce a seismic site classification for Building A in the northwest of the site, both Line 1 and Line 2 were considered. Review of the data showed that Line 1 generally had higher observed Vs values compared to Line 2, thus the maximum and minimum Vs30 values calculated at 2 points along Line 2 (6m & 160m) were used to determine the average Vs30 value for Building A (**Figure 8**).

Analysis of Line 2 produced a $Vs_{30,min}$ of 267 m/s, a $Vs_{30,max}$ of 485 m/s and a $Vs_{30,avg}$ of 376 m/s. Based on Table 4.1.8.4.-A in the National Building Code of Canada, 2015 a site classification of “C” can be considered for Building A.

The above site classification is based on the current building design, which is slab-on-grade and uses existing grade as the zero reference of the Vs30 profile.

It should be noted for design and construction purposes that a lower velocity clay layer is thicker on the southern portion of Line 2 creating a localized area of reduced stability. This area corresponds to the southeast corner of Building A.

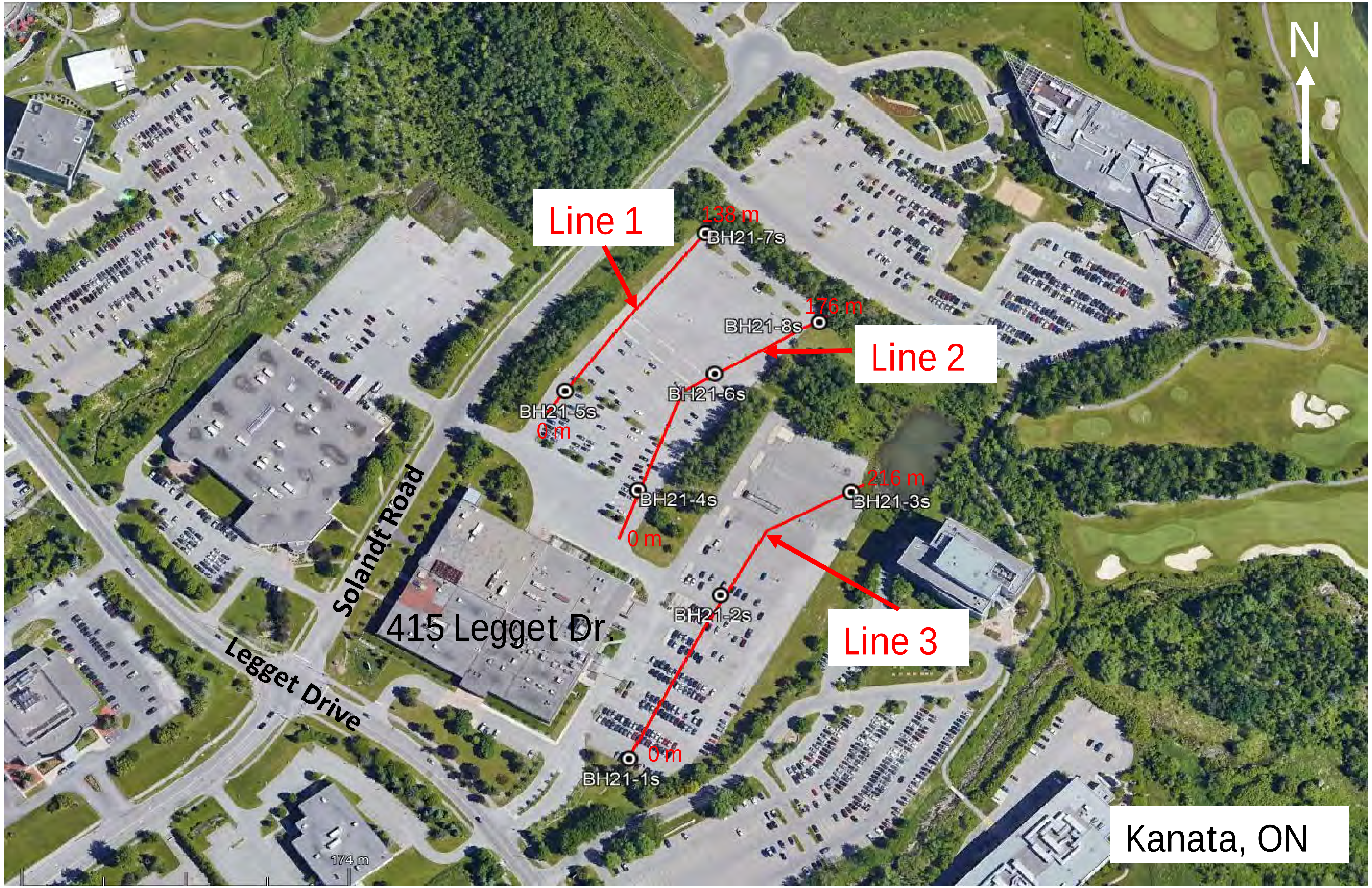
BUILDING B

To produce a seismic site classification for Building B in the southeast of the site Line 3 was considered. Analysis of the data showed that Line 3 recorded the lowest observed Vs values on the site. The maximum and minimum Vs30 values were calculated at 60m and 6m along Line 3, respectively. The $Vs_{30,min}$ observed was 274 m/s, a $Vs_{30,max}$ of 377 m/s and a $Vs_{30,avg}$ of 325 m/s (**Figure 9**). Based on Table 4.1.8.4.-A in the National Building Code of Canada, 2015 a site classification of “D” can be considered for Building B.

The above site classification is based on the current building design, which is slab-on-grade and uses existing grade as the zero reference of the Vs30 profile.

DISCLAIMER

The above seismic site classification is based solely on the average Vs value derived from this seismic study and can be superseded by other geotechnical information including, but not limited to, the presence of sensitive soils, liquefiable soils, peat, more than 3 m of soft clays, high water saturation, etc. The reader should refer to section 4.1.8.4 of the National Building Code of Canada, 2015 Edition for more information regarding the requirements for seismic site classification.



LEGEND:

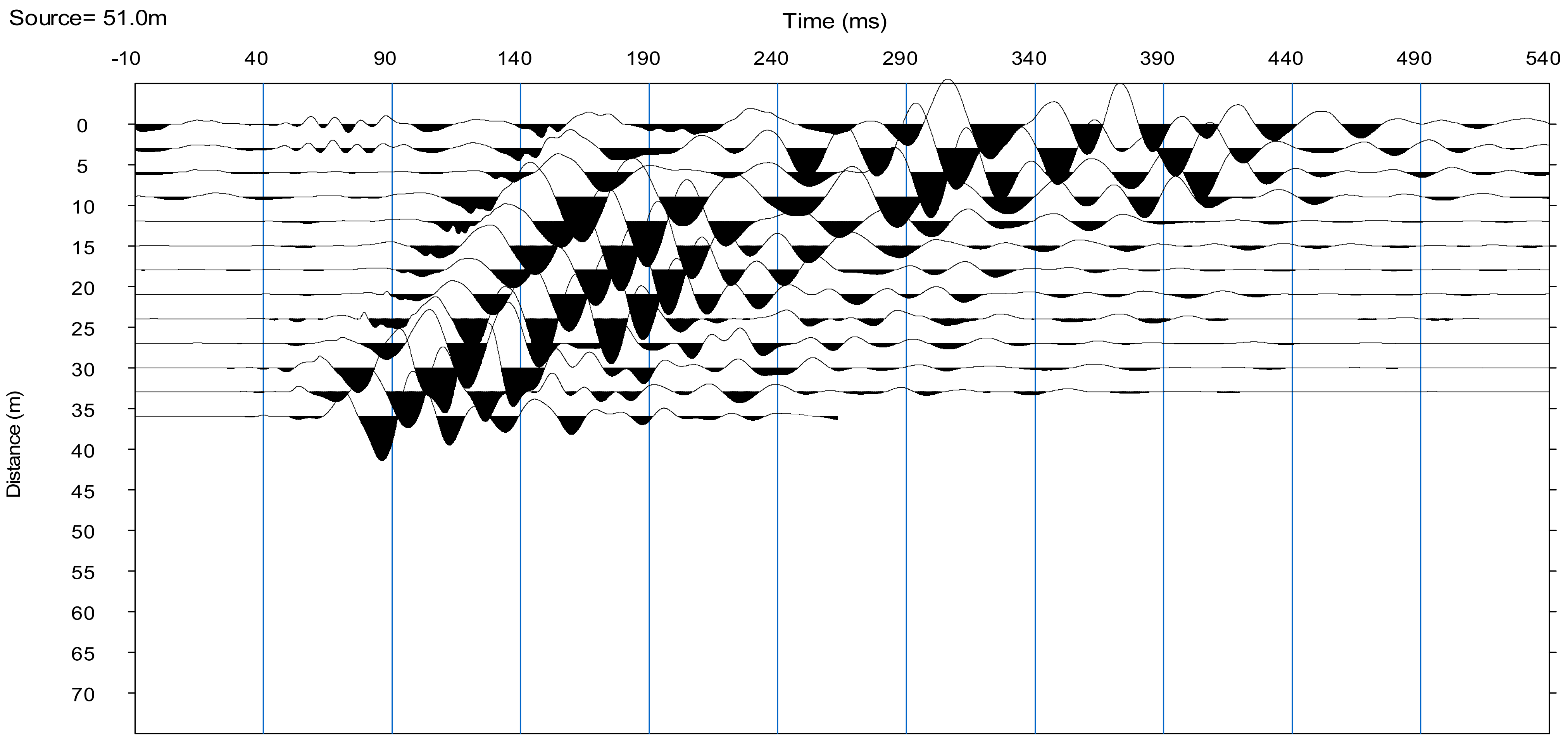
▬ SEISMIC LINE

TITLE:	SITE LAYOUT
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION
CLIENT:	ACCESS STORAGE

PROJECT NO.:	219-00058-03
REVIEWED BY:	
DATE:	Oct-21
DRAWING 1	

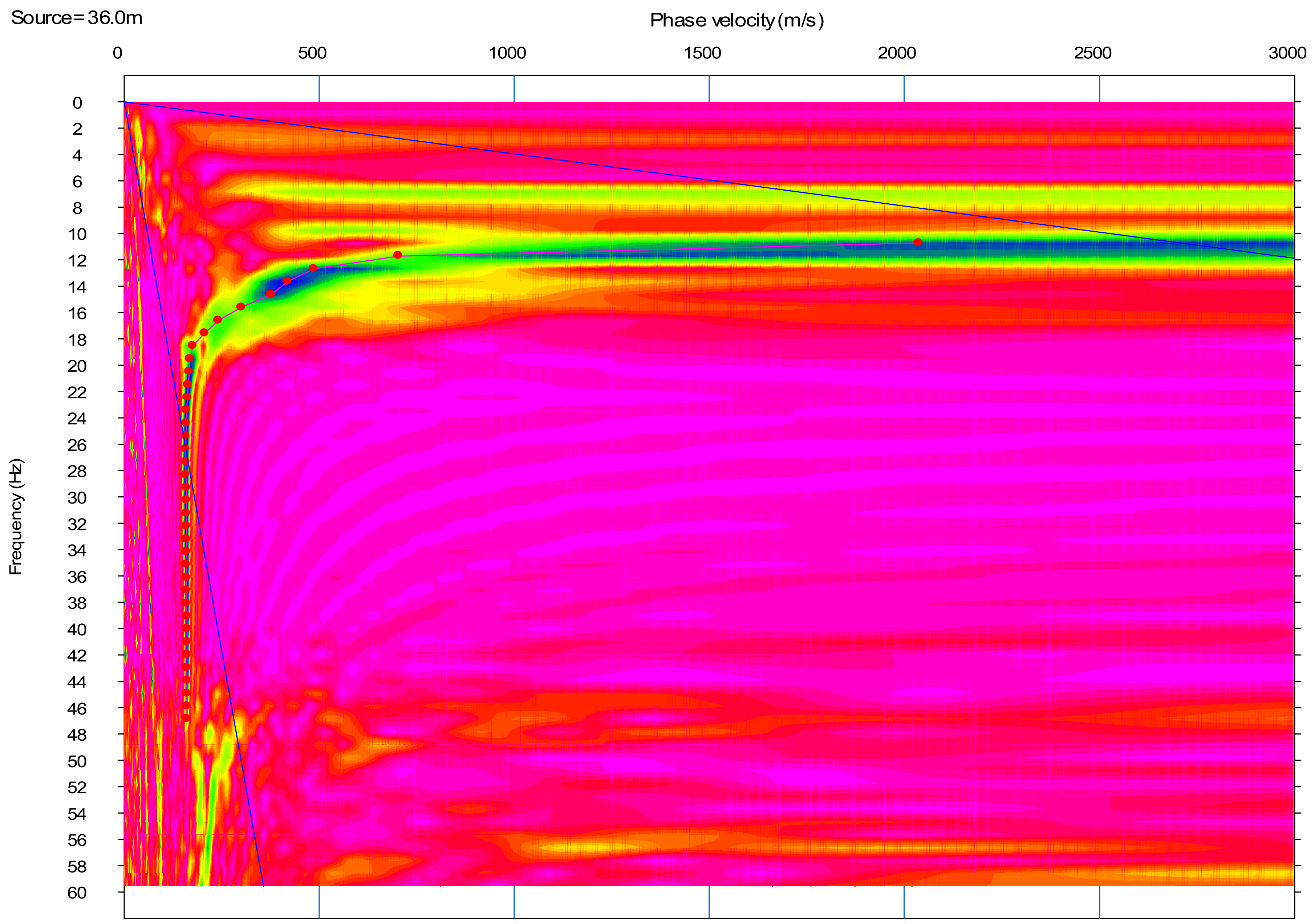
Site photo looking southwest along Line 2 in the parking lot at 415 Legget Drive, Kanata.

TITLE:	SITE PHOTO	PROJECT NO.:	219-00058-03
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION	REVIEWED BY:	0
		DATE:	Oct-21
CLIENT:	ACCESS STORAGE	FIGURE 1	



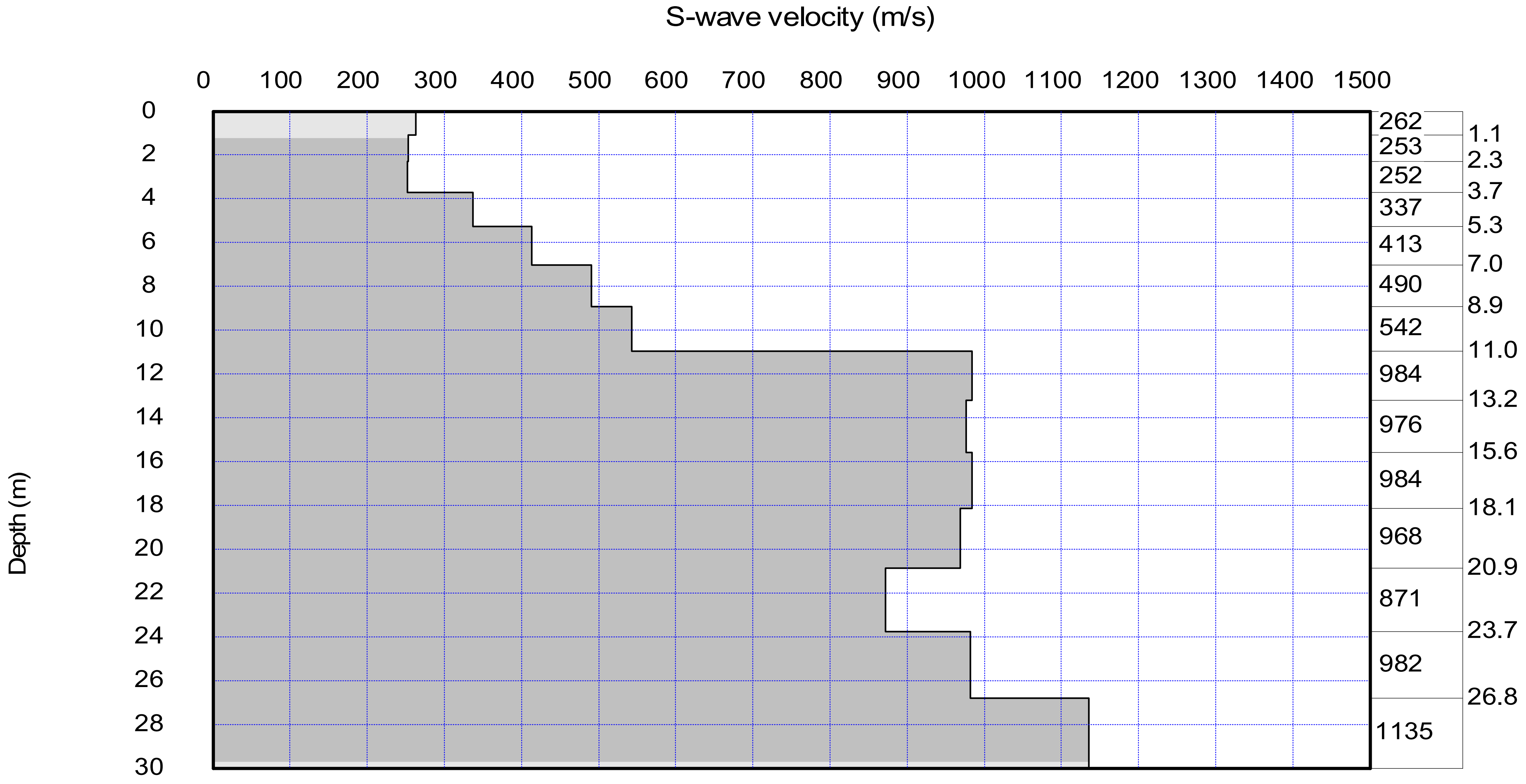
Seismic shot record for source location 36.0m. The data has a high-cut filter applied to remove high frequency noise.

TITLE:	SEISMIC SHOT RECORD	PROJECT NO.:	219-00058-03
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION	REVIEWED BY:	0
		DATE:	Oct-21
CLIENT:	ACCESS STORAGE	FIGURE 2	



Phase-velocity/frequency diagram showing phase-velocity picks for the associated frequencies.

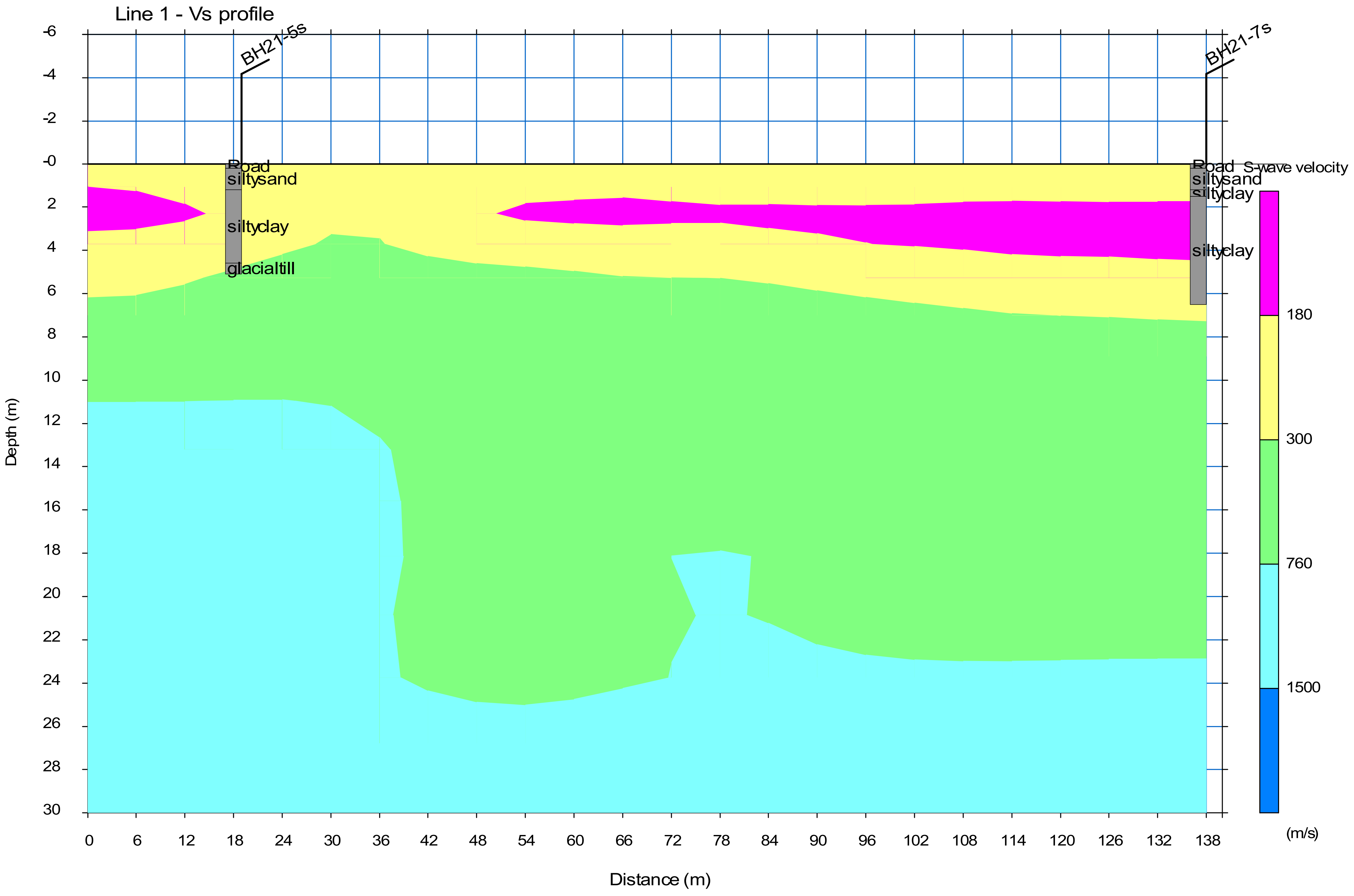
TITLE:	PHASE-VELOCITY/FREQUENCY DIAGRAM	PROJECT NO.:	219-00058-03
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION	REVIEWED BY:	0
		DATE:	Oct-21
CLIENT:	ACCESS STORAGE	FIGURE 3	



Average Vs30 = 595.7 m/s

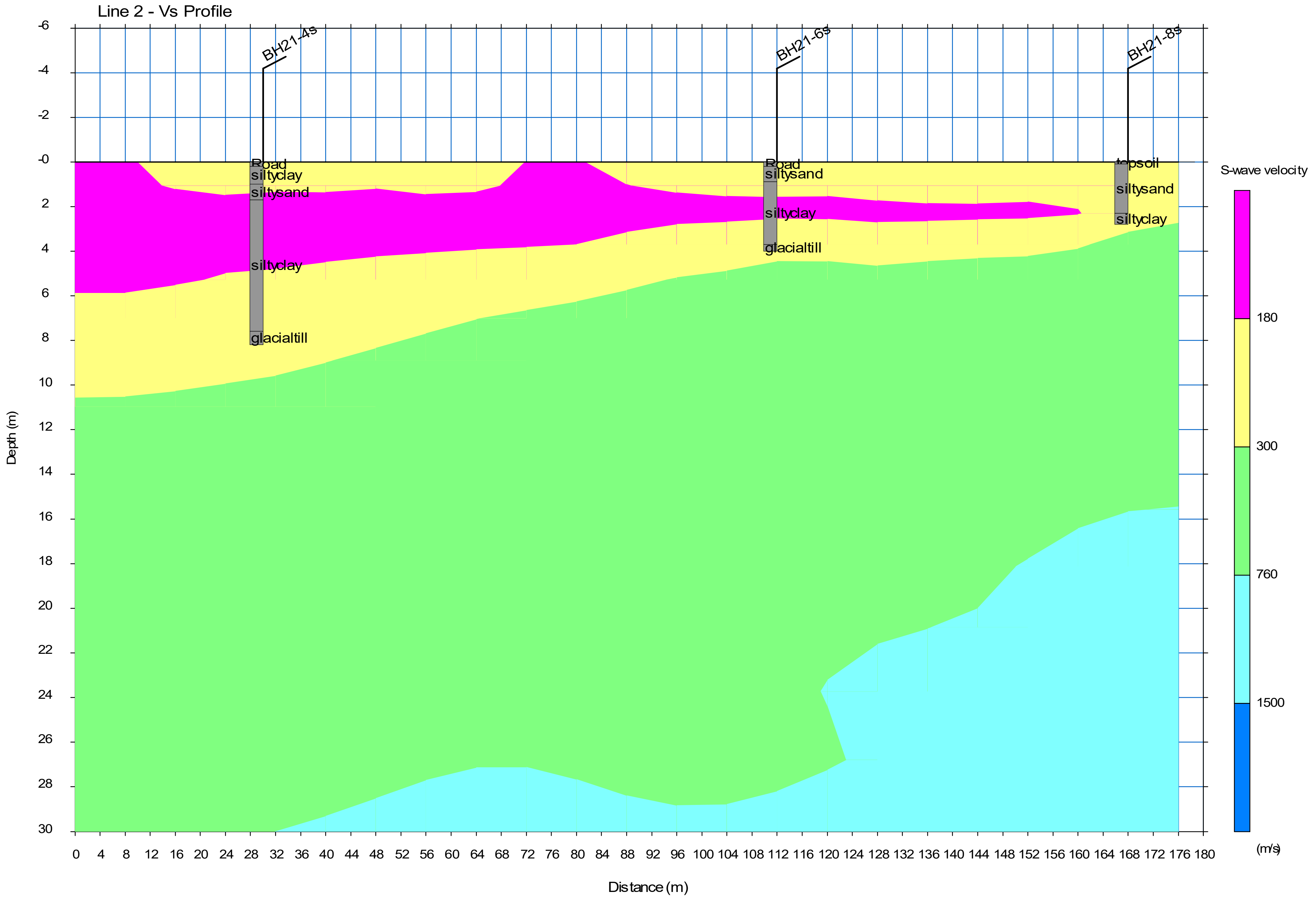
Inverted 1-D shear-wave velocity model at 24.0 meters along the seismic line. Note 0.0 meters is at the southwestern end of the line.

TITLE:	1-D SHEAR-WAVE VELOCITY PROFILE	PROJECT NO.:	219-00058-03
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION	REVIEWED BY: DATE:	0 Oct-21
CLIENT:	ACCESS STORAGE	FIGURE 4	



Shear-wave velocity profile for Line 1.

TITLE:	V_S PROFILE - LINE 1	PROJECT NO.:	219-00058-03
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION	REVIEWED BY:	0
		DATE:	Oct-21
CLIENT:	ACCESS STORAGE	FIGURE 5	



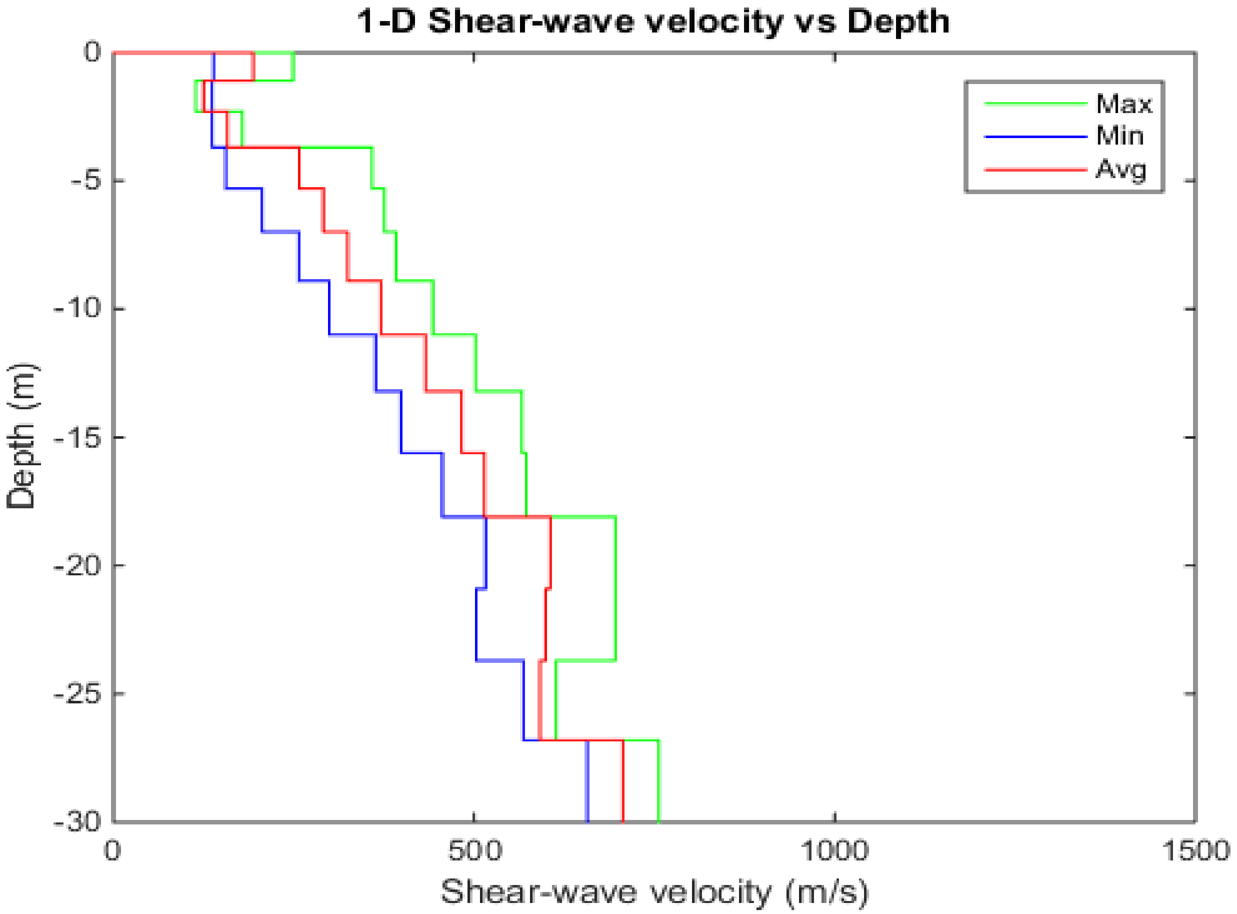
Shear-wave velocity profile for Line 2.

TITLE:	V_S PROFILE - LINE 2	PROJECT NO.:	219-00058-03
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION	REVIEWED BY:	0
		DATE:	Oct-21
CLIENT:	ACCESS STORAGE	FIGURE 8	

Seismic Site Classification

Table: Maximum, minimum and average Vs30 (m/s) 1-D profiles for Building A.

	Minimum	Average	Maximum	Site Class
Velocity	274	325	377	D



An average Vs30 of 325m/s denoting a site class of "D" can be considered for the site of Building B.

TITLE:	SEISMIC SITE CLASSIFICATION - BUILDING B	PROJECT NO.: 219-00058-03
PROJECT:	415 LEGGET DRIVE GEOTECHNICAL INVESTIGATION	REVIEWED BY: 0 DATE: Oct-21
CLIENT:	ACCESS STORAGE	FIGURE 9

APPENDIX

E

LIMITATIONS OF THIS REPORT

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to WSP Canada Incorporated (WSP) at the time of preparation. Unless otherwise agreed in writing by WSP, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.