LABORATORY

GEOTECHNICAL INVESTIGATION

PROPOSED DEVELOPMENT

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Proposed Development

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1. INTRODUCTION

Fisher Engineering Limited (Fisher) was retained by Dymon Group of Companies to carry out a Geotechnical Investigation for the proposed development at the property municipally addressed as 5210 Innes Road, Ottawa, Ontario, hereinafter referred to as the 'Site'.

The purpose of this investigation was to assess subsurface soil and groundwater conditions at the site and provide geotechnical parameters and make recommendations for the design/construction of the proposed new development.

Discussion of the findings and results of the Geotechnical Investigation are in accordance with the general terms of reference. This report was prepared specifically and solely regarding geotechnical aspects of the design & construction for the proposed development as detailed to Fisher at the time of the investigation.

2. SITE AND PROJECT DESCRIPTIONS

Site Settings

The site is located at the southeast corner of the intersection of Innes Road and Trim Road in Ottawa, and is bounded by Innes Road to the north, industrial properties to the east & south and Trim Road to the west, beyond which are commercial properties.

The subject property, which was vacant and covered with grass during the investigation, has an approximate area of 12,986m^2, is square.

Topography

The site is fairly flat and is approximately 0.6 to 1.0m below the adjacent roadways (Innes Road and Trim Road). Ground surface elevations vary from approximately 87.67m to 88.01m asl based on the topographic survey plan provided to Fisher.

Proposed Development

Site Plans, prepared by DCA- A Group of Architect, dated July 13, 2022, provided to Fisher during the current investigation show the proposed development consisting of a 3-storey, 18m high self- storage building with no underground levels. The proposed building will be located in the centre of the property with a footprint of 5,666m^2. Finished Floor Elevation (FFE) was given as 87.75m asl.

3. PREVIOUS SITE INVESTIGATION

Fisher previously conducted a geotechnical investigation, for a proposed building with a footprint of 2159m^2 which was to be located at the northwestern portion of the property. During the investigation, three (3) boreholes, BH1, BH2 and BH3, were advanced to depths of 18.3m to 25.32m below prevailing grade using dynamic cone penetration tests. A geotechnical report was submitted under FE-P 21-10993, dated March 19, 2021.

4. FIELD AND LABORATORY WORK

Subsurface soil exploration for the current Geotechnical Investigation was conducted concurrent with drilling for a Hydrogeological Investigation on September 20 - 23, 2022 and consisted of six (6) boreholes, BH101 to BH106, advanced to depths of 6.55m to 32.33m (corresponding elevations from 81.12m to 55.45m asl). Site Plan with borehole locations is presented in Appendix A.

A track mounted drill rig, equipped with solid stem augers/mud rotary, supplied by Terra Firma Environmental Services, was used for all drilling work.

The subsurface soils were sampled generally at regular intervals of depth using a split-spoon sampler following the procedure as detailed in the ASTM Standard specification D1586 for the Standard Penetration Test. Field tests to determine engineering parameters of the soil were carried out during drilling, which included Standard Penetration Tests (SPT). Sampling in the two (2) deep holes, BH101 and BH106, was carried out at depth of 9.14m to 24.41m and 32.33m respectively, covering elevations of 63.43m to 55.45m asl.

All recovered soil samples were placed in clear, sealable plastic bags in the field and transported to the Fisher Engineering laboratory for further examination, characterization and laboratory analyses.

Monitoring wells were installed in the boreholes, except BH3, to depth of 6.10m below prevailing grade on completion of drilling. Groundwater conditions were observed during and on completion of drilling.

Laboratory Analyses

Seven (7) representative soil samples from BH1, BH2 and BH3 were selected and submitted to Fisher Environmental laboratory for moisture content analyses during the initial geotechnical investigation. Six (6) samples from BH102, BH103 and BH104 were submitted for grain size, moisture and hydrometer analyses. The laboratory results, which are presented in Appendix C, are consistent with the field description for subsurface soils discussed in Section 4.0.

The soil samples recovered during the current investigation will be stored at the Fisher Engineering laboratory for a period of thirty (30) days after submitting this report and will be discarded thereafter unless otherwise instructed by the client.

Site Survey

Elevations at borehole/monitoring well locations were established by interpolating from a topographic survey plan, by Annis, O'Sullivan, Vollebekk Ltd, dated November 10, 2021, which was provided to Fisher during the investigation.

5. SUBSOIL CONDITIONS

Details of subsoil conditions encountered at borehole locations are shown in Appendix B – Log of Boreholes and are summarized as follows:

- **FILL/TOPSOIL** – A layer of dark brown clayey silt / topsoil was encountered in BH1 and BH3 to depth of 0.61m and was underlain by brown to greyish brown silty clay fill to maximum depth of 1.22m bgs. The encountered fill layers were moist, except in BH2, where the upper 0.60m was wet. SPT 'N' values were generally from 1 to 4 blows per 300mm penetration in the upper section of organic fill/topsoil changing to 9 to 11 blows per 300mm penetration in the lower section consisting of clayey silt. Moisture content in the lower section ranged from 34 to 37%. Fill depths/elevations are presented in Table 1.

Table 1: Fill Depths and Elevations

Borehole No.	BH101	BH102	BH103	BH104	BH105	BH106	BH1	BH2	BH3
Surface Elevation (m asl)	87.84	87.67	87.94	87.96	87.90	87.78	87.90	88.00	87.85
Depth of Borehole (m)	8.08	8.08	8.08	14.18	13.72	8.08	18.29	25.30	24.99
Elevation at Bottom of Borehole (m asl)	79.76	79.59	79.86	73.78	74.18	79.70	69.61	62.70	62.86
Depth of Fill/topsoil (m)	n/a	1.07	0.91	0.91	0.69	n/a	1.22	1.07	1.22
Elevation at Bottom of Fill (m asl)		86.60	87.03	87.05	87.21		86.68	86.93	86.63

- **SILTY CLAY to CLAY** – Brown to grey silty clay to clay deposits were encountered in all boreholes below the fill / organic topsoil. Standard penetration test (SPT) was advanced to 6.55m bgs in these layers with SPT 'N' values ranging from 14 to 0 blows per 300mm penetration and generally 0 to 4 blows at 2.5m indicating a very soft to stiff consistency. Moisture content ranged from 43 to 73% from the samples obtained in the section.

  DCPT was advanced at depths below which SPT ended in BH1 to BH3. The very soft (hammer falling under its own weight) to stiff silty clay/ clay deposits likely extend to depths of approximately 17.70m in BH1, 23.80m in BH2 and 18.30m in BH3 with DCPT values generally less than 15 blows per 300mm penetration. DCPT values at greater depths were generally greater than 40 blows per 300mm penetration indicating that the soils may contain clayey silt and /or silty/gravelly sand/crushed rock seams/layers or changed to boulder tills in this zone.

  Sampling /SPT testing were carried out in BH101 and BH106 below depth of 9.0m. The very soft to soft clay deposits encountered extended to depths of 18.29m in BH101 & 27.43m in BH 106.
- **CLAY WITH GRAVEL -** Grey, wet, soft clay with, layers of gravelly sand and pieces of rock, was encountered in BH101 below the soft clay, extending to approximate depth of 22.86m bgs.
- **GRAVELLY SAND** - Grey, wet, very dense gravelly sand, with pieces of crushed rock, was encountered below the soft clay/depth of 27.43m in BH106 extending to approximate depth of 31.39m bgs.
- **CRUSHED ROCK MATERIAL –** Grey, dry, crushed rock material with some clay/silt was encountered in BH101 and BH106 below the clayey gravelly sand extending to respective termination depths of 24.41m and 32.33m bgs. SPT 'N' values ranged from 26 to auger refusal at over 100 blows per 300mm indicating a very stiff to hard/very dense condition.
- **BEDROCK -** Refusal to auguring was encountered at depths of 24.41m and 32.33m in BH101 and BH106 respectively. Based on information available on the geological data for BH (ID 616330, drilled on the property across Trim Road) bedrock was encountered at depth of 39m.

Shear Wave Velocity measurements for Seismic Site Class determination were carried out by Geophysics GPR International Inc. on behalf of Fisher and a report submitted dated May 5, 2021. Based on the shear wave measurements, presented in Appendix D, the Median MASW Shear-Wave Velocity Sounding are:

i. less than 110 to 160 m/s from 0 to 21m,
ii. 200 to 250 m/s from 21 to 24m,
iii. 300 to 360 m/s from 24m to 40m and
iv. 1720 m/s below 40m.

The results indicate soft to stiff soils up to 40m depth and hard rock below.

Based on the preceding information we consider that refusal to auguring in BH101 and BH106 may be due to block/chunk of crushed rock/boulders. Bedrock is likely present around depth of 40m as indicated by shear wave velocity data.

To confirm bedrock depth, rock coring will be required, which may require also coring through obstructions/boulders etc.

6. GROUNDWATER CONDITIONS

Monitoring wells were installed in BH101, BH102, BH104, BH105 and BH106 during the field investigation and groundwater conditions observed during and on completion of drilling. Groundwater levels in the open boreholes were measured at 3.55m and 4.88m in BH103 and BH104 while BH102 and BH105 were dry. Boreholes BH101 and BH106 were drilled using mud rotary and consequently standing water levels on completion could not be ascertained. Groundwater levels measured on October 6, 2022 ranged from 1.72m to 2.39m bgs as detailed in Table 2. Details pertaining to groundwater are contained in the accompanying hydrogeological investigation report which was conducted by Fisher. Both reports should be read in conjunction when designing the subsurface portion of the building.

Table 2: Groundwater Depths and Elevations

Monitoring Well No.		BH(MW)101	BH(MW)102	BH103	BH(MW)104	BH(MW)105	BH(MW)106	BH1	BH2	BH3
Surface Elevation (m asl)		87.84	87.67	87.94	87.96	87.90	87.78	87.90	88.00	87.85
Depth of Well, m bgs		6.10	6.10	n/a	6.10	6.10	6.10	n/a	n/a	n/a
Elevation at well base, m asl		81.74	81.57		81.86	81.80	81.68			
Depth of BH, m bgs		24.41	6.55	6.55	6.55	6.55	32.33	18.29	25.30	24.99
Elevation at borehole base, m asl		63.43	81.12	81.39	81.41	81.35	55.45	69.61	62.70	62.86
In open borehole on Completion	GW level, m bgs	n/a - mud rotary	Dry	3.55	4.88	Dry	n/a - mud rotary	5.49	1.52	0.61
	GW Ele, m asl			84.39	83.08			82.41	86.48	87.24
6-Oct-22	GW level, m bgs	1.92	1.74	n/a	2.07	2.09	2.36	n/a	n/a	n/a
	GW Ele, m asl	85.92	85.93		85.89	85.81	85.42			

It should be noted that groundwater levels are subject to seasonal fluctuations. Groundwater levels measured in October are not necessarily representative of seasonal highwater levels at the site.

7. FOUNDATION CONSIDERATIONS

It was understood that the proposed development will consist of a 3-storey self-storage building with no underground levels. Finished ground floor elevation (FGFE) is proposed at 87.75m asl.

Subsurface stratigraphy consists of surficial fill overlying a thick layer of native, very soft to stiff, generally very soft to soft clayey deposit below 2.5m extending to approximate depth of 18.59m & 27.50m below prevailing grade in BH101 & BH102 respectively. Drilling was terminated in hard clay/rock material and very dense sand in BH101 & BH106 at depths of 24.41m & 32.33m respectively (63.43m and 55.45m asl).

According to MASW Shear-Wave velocity measurements, possibly hard rock is present at 40m bgs with a velocity value over 1700m/s.

7.1 Shallow Foundations

7.1.1 Conventional Strip /Spread Footings

Based on subsoil conditions observed during the investigation, native soils, within feasible shallow foundation depths, are not competent to support conventional spread/strip footings for the expected/anticipated large loads from the proposed building.

Table 3 presents a reference of approximate depths/elevations for conventional footings, along with corresponding bearing resistance for limit states design (SLS and ULS).

Table 3: Foundation Design for Conventional Footings

Building/Borehole			Elevation at BH surface (m asl)	Approx depth of footings at or below		Bearing Resistance	
				m bgs	m asl	at SLS (kPa)	at ULS (kPa)
Proposed Development	BH1	With no underground levels	87.90	1.35	86.55	50	60
	BH2		88.00	1.35	86.65	50	60
	BH4		87.85	1.50	86.35	100	120
	BH102		87.67	1.20	86.47	50	60
	BH103		87.94	1.10	86.84	50	60
	BH104		87.96	1.10	86.86	50	60
	BH105		87.90	1.00	86.90	50	60

Notes:

1. In Ottawa Region, all perimeter and exterior foundation elements or interior foundation elements in unheated areas should be provided with a minimum of 1.5m earth cover for frost protection.
2. Based on the subsurface investigation, the existing native silty clay/clay below 2.5m was in a very soft condition hence footings may experience excessive overall/differential settlements depending on the size of footing, thickness of the crust, surcharge loading due to grade raise and founding depths.
3. Footings must be founded on native soils and are subject to further site inspection.

7.1.2 Raft Foundation

A raft foundation would need to be sufficiently rigid so that the loads would be uniformly distributed over the entire building footprint. Total and differential settlement would be critical in controlling the design of the raft foundation.

Based on the subsurface investigation, the existing thick, very soft to soft clayey soils extend to depths of 18.29m to 27.43m below prevailing grades. Consequently, a raft slab foundation would be susceptible to significant long-term settlement in the high moisture soft to very soft clayey soils and differential settlements caused by inconsistency in depths/composition of soft stratum.

It is therefore concluded that it is not feasible or practical for the proposed building to be supported by a raft foundation alone.

7.2 Deep Foundations

Based on the subsurface soil conditions, piled foundations with structural cap/beam system are recommended**.** The piles could be used to transfer the structural loads through the soft clayey soils and would be founded into more competent bearing soils at further depths. Based on the results of deeper boreholes, depths with different bearing resistances may be utilized as outlined in the following sections.

7.2.1 Piles Founded into Very Dense Overburden Soils

A suitable pile foundation may be concrete filled steel pipe piles (driven closed-ended) or H-piles, with the pile end bearing founding into overburden soils at depths below 19m (area covered by BH101) to 28m (area covered by BH106).

For preliminary design purposes 245mm diameter steel piles, or H-piles with similar structural resistance, may be considered. Axial resistance of 750 kN at SLS and factored resistance of 1000 kN ULS may be used.

Due to variation in the composition of very dense/hard overburden soils from gravelly sand/clay to crushed rock, their variable depths below grades and potential variation in their thicknesses; behaviour of piles/pile groups supported in the overburden soils may vary and each pile may have to be tested by suitable method to ensure their load carrying capabilities.

It should be noted that bedrock surface could not be positively confirmed during this investigation as rock coring was not carried out. Refusal to auguring at depths of 24.41m in BH101 and 32.33m in BH106 may be due to the presence of chunks/blocks of hard rock and driven piles may puncture through it & extend deeper to hard rock. We consider that the opinion of piling contractors familiar with the subject area should be sought. Few test piles may have to be driven/tested initially to confirm the feasibility/suitability of this option.

7.2.2 Piles Founded into Bedrock

Based on the site Shear Wave Velocity measurements, the MASW wave velocity is greater than 1700m/s below 40.0m indicating hard rock.

We recommend that the abovementioned steel pipe piles or H-piles be driven practically to refusal into hard bedrock for higher bearing support. Factored geotechnical resistance of 1500 kN may be used for design.

The ULS factored geotechnical resistance of the pile should be equal to or greater than the structural resistance if the piles are driven into the bedrock using an appropriate design/set criterion with a hammer of sufficient energy.

7.2.3 Lateral Loading Resistance

Resistance to lateral loading could be derived from the soil resistance in front of the piles.

Based on the subsoil conditions and relative long length of piles, fully or partial battered piles may be required to mobilize lateral load resistance.

Geotechnical parameters presented in Table 4 may be used for the design of resistance to lateral loads.

Group action for lateral loading should be considered when pile spacing in the direction of loading is less than 8 pile diameters by reducing the coefficient of lateral subgrade reaction with the relevant reduction factor.

Table 4: Geotechnical parameters

Soil Property	Firm to Stiff Clayey Soils 0 - 3.0m	Very Soft to Soft Clayey Soils 3.0-18.3m (BH1), 3.0-27.4m (BH6)	Very Stiff Clayey Soils 18.3-22.9m (BH1)	Very Dense Sand 27.4-31.4m (BH6).
Total Unit weight (kN/m^3)	17.0	15.5	18.0	20
Undrained Shear Strength (Su kPa)	30-60	10-20	50-80	150-200

Drilled Cast -in -Place Concrete Caisson (CFAs)

Alternatively, drilled caissons, to be founded into sound bedrock, may be used. The caissons should be socketed into the rock to at least 1.5 times their design diameter.

In this case, factored geotechnical toe-bearing resistance of 2000 kPa at ULS may be used for caisson bearing design. Average factored shaft resistance of 30 kPa may be used for shaft resistance calculations.

However, considering the depth of bedrock, the volume of concrete required and spoil for disposal they may not be viable economically.

7.2.4 Deep Foundation Installation Discussion

It should be noted that for end-bearing piles, founded on or within bedrock, SLS condition generally do not govern the design as settlement of the pile founded in the bedrock is less than required for SLS.

- For group pile installation, the piles should be driven no closer than three pile widths/diameters centre to centre.
- Pile termination or set criteria will be dependent on the type of pile driving hammer, helmet, selected pile and pile length. Relaxation of the piles following the initial set would result from several processes, including: the dissipation of negative excess pore water pressures in the

overburden, the driving of adjacent piles and weathered bedrock conditions. Provisions must be made for restriking all the piles to design set criteria within 24 to 48 hours. If the criteria in not achieved during restriking, then those piles should be driven to design set criteria and the process should be repeated for the subject piles.

- Wall and/or base plate thicknesses should be sufficient to endure driving stresses to overcome obstructions and anticipated hard set. Pipe piles render themselves for visual observations in regards to any pile damage or bending. Specialized pile/foundation contractors familiar with the area should be consulted/retained for the piling operations.
- PDA testing and CASE method estimates of the installed piles should be carried out by the contactor at an early stage to verify both the transferred energy from the pile driving equipment and the load carrying capacity of the piles. Test piles should have sufficient structural capacity/stronger pile sections to sustain the proof load which will be twice the design factored geotechnical resistance.
- Static load testing could be carried out, rather than PDA testing, to confirmed the ULS geotechnical resistance of the piles.
- As the bedrock surface was not confirmed by rock coring and according to shear wave velocity measurements it appears it may be around depth of 40m, it is harder to decide regarding the feasible/practical design factored geotechnical resistance and pile depths. Depths of driven piles are anticipated to vary significantly across the site. For shallow depth, or hung-up piles, their capacities may have to be confirmed by appropriate field testing. Alternatively, a pre-determined depth may be selected and pre auguring carried out as required.
- Piling operations should be inspected on a full-time basis by geotechnical personnel to monitor the pile locations and plumbness, initial sets, penetrations on restrike, and check the integrity of the piles following installation.

8. CORROSION AND CEMENT TYPE

Two soil samples from BH3 and BH4 at depths of 1.52m to 1.98m were submitted to Fisher Environmental laboratories for chemical analyses related to potential sulphate attack on buried concrete. The laboratory results are presented in Appendix C.

Sulphate concentration in the soil sample is 13.4mg/kg and 24.0 mg/kg or 0.00134% and 0.0024%. According to CSA-A23. 1-09 Table 3, the results indicate negligible degree of exposure to sulphate attack.

Chloride contents in the samples were <10 ug/g or <0.001% indicating negligible impact on exposed ferrous metals. pH levels of 7.84 (BH3) and 7.81 (BH4) are within the expected range for subsurface soils (5-11).

9. EARTHQUAKE CONDITIONS

The 2012 OBC Subsection 4.1.8 stipulates that a building should be designed to meet the requirements of the Earthquake Load and Effects. Site Classification for Seismic Site Response (Table 4.1.8.4.A) was determined from the soil shear wave average velocity or Standard Penetration Resistance (N_{60}) and/or the undrained shear strength (Su) of the soils within upper 30m.

The Site Classification for Seismic Site Response was established/determined on the basis of MASW Vs 30 values. As shown in Appendix D, Vs30 = 158.0m /s and as set out in Table 4.1.8.4 A of the OBC, the subject Site may be designated as "Class E".

The terms, which are relevant to the geotechnical conditions at the Site, are acceleration- based Site coefficient Fa and velocity – based Site coefficient Fv and are detailed in Subsection 4.1.8 of the 2012 OBC.

10. EXCAVATION AND BACKFILL

No major problems would be encountered for the anticipated depth of excavation for footings/slab on grade/caps/structural beam installation and underground utilities. All excavation must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA).

Based on the subsurface investigation, the subsoils within the expected depth of excavation below the fill / organic topsoil consisted of firm to stiff silty clay to 2.5m bgs and can be classified as Type 3 soils in accordance with the Occupational Health and Safety Act (OHSA). The very soft silty clay/clay below 3.66m may be classified as Type 4 soils.

For open cut above 2.5m, the sides of slopes would need to be cut back at an inclination no steeper than 1 horizontal to 1 vertical (1H:1V). For slopes which are unsupported in the long-term, flatter side slopes may be required.

Groundwater levels were observed between 1.72m and 2.39m bgs on October 6, 2022 during the investigation. Groundwater seepage from fill layers or more permeable interbedded seams may be encountered in some local areas during excavation. No significant volume of water is expected and excavation for shallow foundation /piles cap installation should be in a 'dry' condition. Seepage, if any, may be handled by pumping from sump pits within the excavation area.

Materials to be used for backfill in service trenches should be suitable for compaction, i.e., free of organics and with moisture content within 2 percent of the optimum moisture value. The backfill material should be compacted in lifts of no more than 200mm in thickness and to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD) in the upper 1.0m from road subgrade or in settlement sensitive areas. Beyond these zones, a 95% SPMDD compaction criterion is considered acceptable.

Additionally, onsite excavated fill materials and native soils may be used as backfill in service trenches, provided that the excavated materials are free of organic soils /construction debris and are of suitable moisture content.

The local soils are dominated by clayey soils with high moisture content and can easily be lumped. To be used as backfill, some moisture must be removed and the soil maintained within optimum moisture content before breaking into small pieces and used as engineered fill under supervision.

For backfill against subsurface walls/footings/grade beams/pile caps and slab on grade construction of buildings, it is recommended that backfill materials consist of Granular Class 'B' aggregates.

11. SLAB ON GRADE AND PERMANENT DRAINAGE

For the subject site with proposed building with no basement, slab on grade may be constructed on native undisturbed silty clay and, or engineered fill. The native clayey soils above depth of 2.5m were generally in a firm to stiff condition.

For preliminary design, for slab on grade resting on the native silty clay, subgrade reaction modulus (K) value of 7500 kN/m^3 may be used. It should be noted that long-term consolidation settlement of the slab-on-grade will depend on the intensity and duration of the loading. Heavy loads for longer durations will result in increase in the stresses imparted to soft/very soft clays encountered below depth of 2.5m and induce consolidation settlements. If heavily loaded floor slab-on-grade is required, a raft slab supported by piles should be used.

For slab on grade construction, the prepared subgrade must be proof-rolled prior to placing upper layers of granular material. Any soft spots revealed during proof-rolling should be sub-excavated and backfilled with suitable granular materials, compacted to 98% SPMDD.

Engineered fill materials, compaction quality and finished subgrade proof-rolling should be supervised and inspected by engineering staff from Fisher. Engineered fill must be placed in layers of no more than 200mm and compacted to 98% SPMDD.

For backfill against the subsurface walls/grade beams and footings/pile caps it is recommended that backfill materials should consist of Granular Class 'B' aggregates.

Upon completion of foundation work, the floor slab should rest on a well compacted bed of 19mm clear stones at least 300mm thick. The stone bed would act as a barrier and prevent capillary rise of moisture from the subgrade to the floor slab.

Permanent drainage may not be required, provided that the exterior ground surface is 200mm lower than the building floor slab and should be sloped away from building perimeter walls.

Elevator shaft, if any, should be designed as a 'water tight' structure. Lower loading area/decks should be installed with perimeter sub-drainage and diverted to positive outlet.

12. UNDERGROUND UTILITIES

Pipe bedding and backfill material specifications and compaction criteria for water and sewer services should be in accordance with the pipe designer's recommendations and/or local municipal requirements.

If the excavation is deeper than 1.2m, the excavation sides should be sloped in accordance with requirements of OHSA. If this condition cannot be met, a temporary shoring system or trench box should be introduced.

For the subject site, it is expected that underground services/ sewer pipes would be founded over native silty clay. Granular Class 'A' aggregate is generally considered well suited to be used as pipe bedding material. However, it should be noted that the recommended type of bedding is to be placed on undisturbed subgrade above the groundwater level. If the construction methods will disturb the subgrade i.e. piping, existing footing, boulder removal etc. or existence of excess hydrostatic pressure, then higher-class bedding may have to be used combined with a geotextile. In some areas, localized dewatering may be required.

Trench backfill should be uniformly compacted to a density that minimizes the risk of long-term settlement. Selected on-site excavated native soils is considered suitable for re-use in trench backfilling, provided that organics/construction debris are sorted out and material are not allowed to be wet. Moisture content should be maintained within the optimum moisture content of 2%.

In normal sewer construction practice, the problem of road settlement largely occurs adjacent to manholes, catch basins and service crossings. In these areas, granular materials are generally required for backfill and compaction.

The backfill in the upper 1.0m from road subgrade or in settlement sensitive areas should be placed in maximum 200mm thick lifts and compacted to 98% SPMDD. Beyond these zones, a 95% SPMDD compaction criterion is considered acceptable.

13. PAVEMENT DESIGN

Associated pavement for driveways and parking will be developed on the site. Pavement structures can be constructed on the native soils, engineering fill, or possibly fill materials from the site, subject to design grade and further onsite inspection.

Prior to the construction of asphalt pavement, topsoil, organic soils and construction debris must be removed. The exposed base should be proof-rolled and supervised/approved by geotechnical personnel. Any soft spongy spots detected during proof-rolling should be sub-excavated and replaced with suitable materials in maximum 300mm thick lifts and compacted to 98% of SPMDD. The placement of engineering fill, if any, should be supervised and inspected by engineering staff from Fisher.

The finished subgrade must be contoured/graded and finally proof-rolled and approved by Fisher before placing the upper granular materials.

Granular materials will be used in construction of asphalt pavement base. Compaction for granular bases should reach 100% of Standard Proctor Maximum Dry Density.

Perforated pipe subdrains should be provided at subgrade level extending from the catch basins for a distance of at least 3-5m in four orthogonal directions, or longitudinally where parallel to a curb. Typical flexible pavement designs are presented in Table 5.

Table 5: Typical flexible pavement designs are as follows:

Layer	Heavy Duty	Medium Duty
Asphaltic Concrete	40 mm HL3	40 mm HL3
	65 mm HL8	50 mm HL8
19 mm Crushed Limestone	150 mm	150 mm
Granular B Sub-base	350 mm	200 mm

Pavement structure thicknesses should also meet the minimum local/municipal/regional Pavement Design Standards for the proposed development.

The asphalt material should meet the OPSS requirements for specified grade and be compacted to at least 92% of their MRD.

The above pavement designs are based on the current revealed the subsoils conditions, depending on the actual conditions of the pavement subgrade at the time of construction, it could be necessary to increase the thickness of the subbase and /or to place a woven geotextile beneath the granular base.

14. 14. TREE PLANTATION

On-site silty clay/clays are sensitive in nature and are susceptible to volume change/shrinkage upon withdrawal of water by some trees. Hence high-water demand trees should not be planted closer to structures than the anticipated height of the trees.

15. GENERAL COMMENTS

This report is limited in scope to those items specifically referenced in the text. The discussions and recommendations presented in this report are intended only as guidance for the named client, their design engineers and those directly involved in the implementation and regulation of the project.

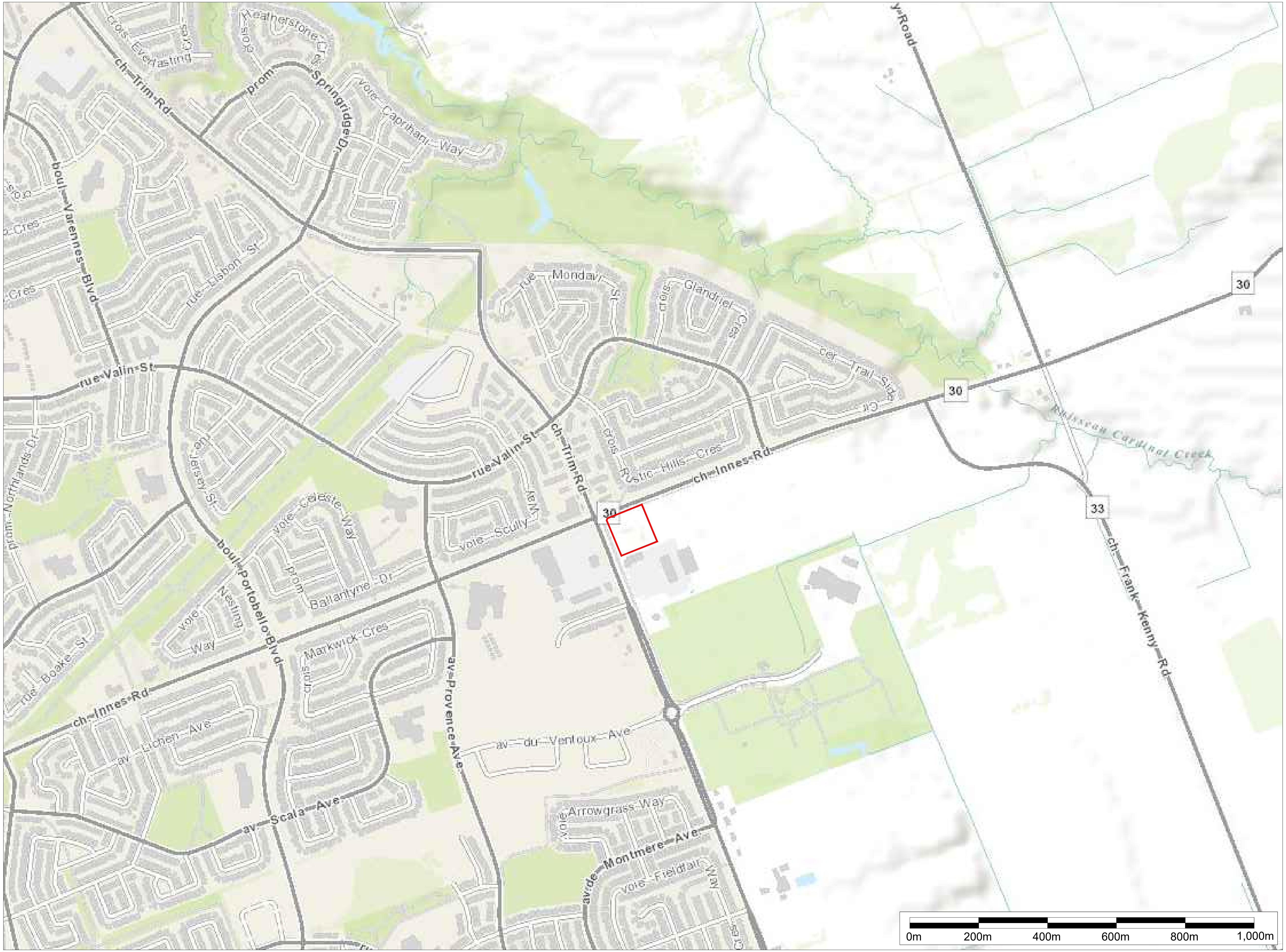
The information on which these recommendations are based is subject to confirmation by engineering personnel at the time of construction.

Localized variations in the subsoil conditions, and particularly the fill material, may be present between and beyond the boreholes on which the recommendations are made and will have to be verified during construction. As more specific subsurface information becomes available during excavations on the subject Site, this report should be updated.

Contractors bidding on or undertaking the work should decide on their own investigations, as well as their own interpretations of the factual borehole results. This concern specifically applies to the classification of the subsurface soils and the potential reuse of these soils on/off Site.

Contractors must draw their own conclusions as to how the near surface and subsurface conditions may affect them.

APPENDIX A – SITE AND LOCATION PLANS



FISHER ENGINEERING
400 Esna Park Dr., #15
Markham, Ontario
L3R 3K2
Tel: 905 475-7755
Fax: 905 475-7718

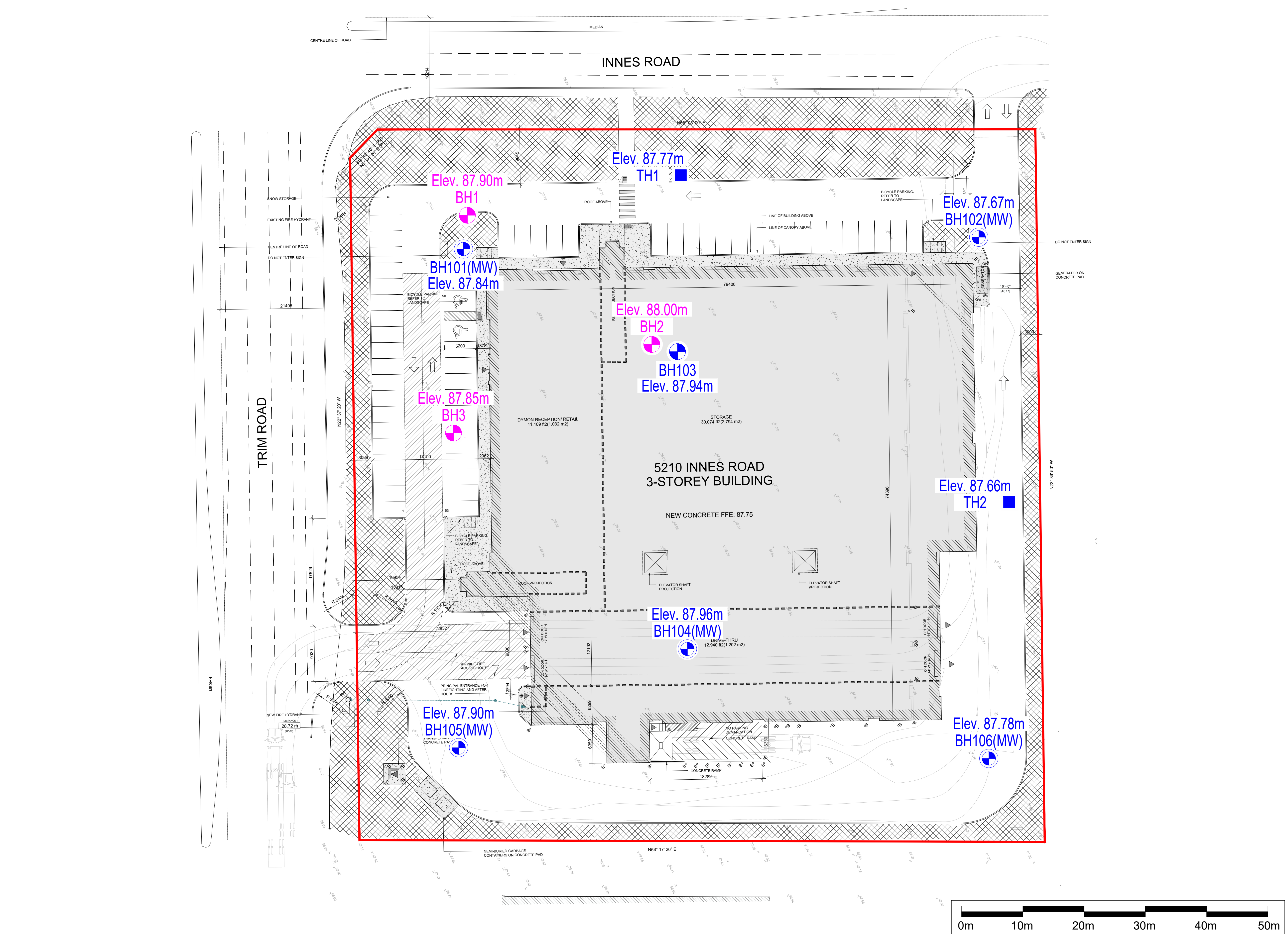
NORTH
N

LEGEND
SITE BOUNDARY

PROJECT NAME AND ADDRESS
GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS
5210 Innes Road,
Ottawa, ON

FIGURE A1:
SITE LOCATION PLAN

PROJECT NO.	SHEET NO.
FE-P 22-12469/70	A1
DATE: 6 October 2022	
SCALE: AS SHOWN	



FISHER ENGINEERING
400 Esna Park Dr., #15
Markham, Ontario
L3R 3K2
Tel: 905 475-7755
Fax: 905 475-7718

NORTH

LEGEND

- SITE BOUNDARY
- EXISTING BOREHOLE LOCATION
- BOREHOLE WITH MONITORING WELL LOCATION
- BOREHOLE LOCATION
- TEST HOLE LOCATION

PROJECT NAME AND ADDRESS

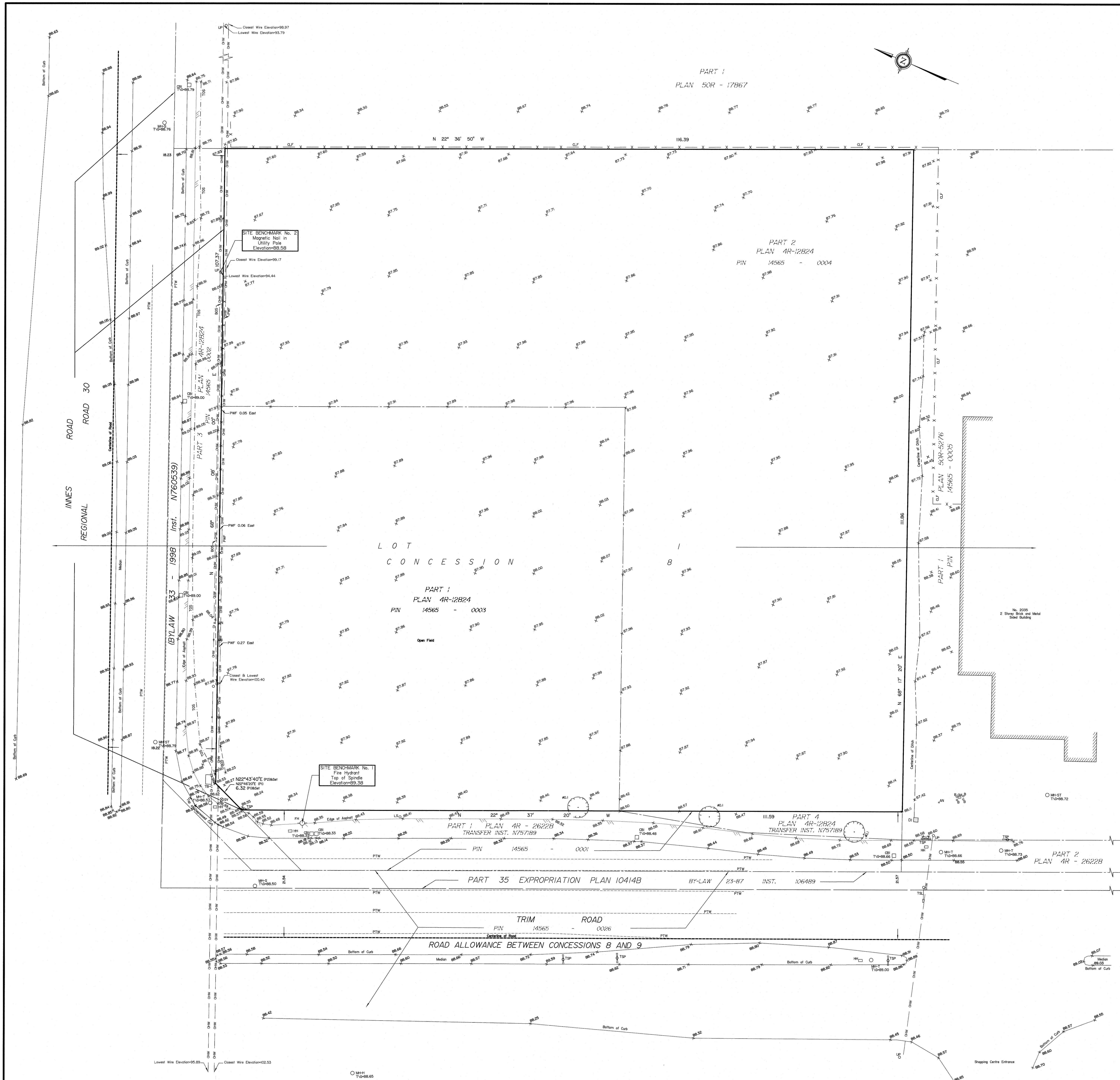
GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

5210 Innes Road,
Ottawa, ON

FIGURE A2:

SITE PLAN WITH BOREHOLES / MONITORING WELL AND TEST HOLE LOCATIONS

PROJECT NO. FE-P 22-12469/70	SHEET NO. A2
DATE 6 October 2022	
SCALE AS SHOWN	



TOPOGRAPHICAL PLAN OF

PART OF LOT 1
CONCESSION 8
GEOGRAPHIC TOWNSHIP OF CUMBERLAND
CITY OF OTTAWA

Surveyed by Annis, O'Sullivan, Vollebekk Ltd.

Scale 1 : 250

10 7.5 5.0 2.5 0 5 10 Metres

Metric

DISTANCES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048

Nov. 10, 2021 — Date

E.H. Herweyer O.L.S.

SITE AREA = 12992 m²

Bearings are grid, derived from Can-Net 2016 Real Time Network GPS and are referenced to Specified Control Points 01919680184 and 019198434761, MTM Zone 9 (76°30' West Longitude) NAD-83 (original).

For bearing comparisons, a rotation of 0°43'10" counter-clockwise was applied to bearings on plan P1.

ELEVATION NOTES

1. Elevations shown are geodetic and are referred to benchmark 001196530190 having an elevation of 89.11m.
2. It is the responsibility of the user of this information to verify that the job benchmark has not been altered or disturbed and that it's relative elevation and description agrees with the information shown on this drawing.

Notes & Legend

Symbol	Denotes	
—□—	"	Survey Monument Planted
—■—	"	Survey Monument Found
SSIB	"	Short Standard Iron Bar
IB	"	Iron Bar
(WIT)	"	Witness
Meas.	"	Measured
(AOG)	"	Annis, O'Sullivan, Vollebekk Ltd.
(P1)	"	Plan 4R-12824
(P2)	"	Plan 4R-26228
FH	"	Fire Hydrant
MH-ST	"	Maintenance Hole (Storm Sewer)
MH-S	"	Maintenance Hole (Sanitary)
MH-T	"	Maintenance Hole (Traffic)
GV	"	Gas Valve
HH	"	Handhole
TB-C	"	Cable Terminal Box
PWF	"	Post and Wire Fence
PTW	"	White Paint Lines
UP	"	Utility Pole
AN	"	Anchor
LS	"	Light Standard
CB	"	Catch Basin
CBI	"	Catch Basin Inlet
—— OHW ——	"	Overhead Wires
BOS	"	Bottom of Slope
TOS	"	Top of Slope
Ø	"	Diameter
+ 65.00	"	Location of Elevations
+ 65.00	"	Top of Concrete Curb Elevation
C/L	"	Centreline
	"	Deciduous Tree
GM	"	Gas Meter
TSP	"	Traffic Signal Post
CLF	"	Chain Link Fence
TSL	"	Traffic Light

Ontario Land Surveyors
ANNIS, O'SULLIVAN, VOLLEBEKK LTD.
14 Concourse Gate, Suite 500
Nepean, Ont. K2E 7S6
Phone: (613) 727-0850 / Fax: (613) 727-1079
Email: Nepean@aovltd.com

Job No. E-1106-21 Dymon Group 5210 Innes Rd Topo D5 | NH

APPENDIX B – LOG OF BOREHOLES

LOG OF BOREHOLE

FISHER ENGINEERING

NO. BH101(MW) SHEET 1 of 3

PROJECT NO.: FE-P# 22-12469/70

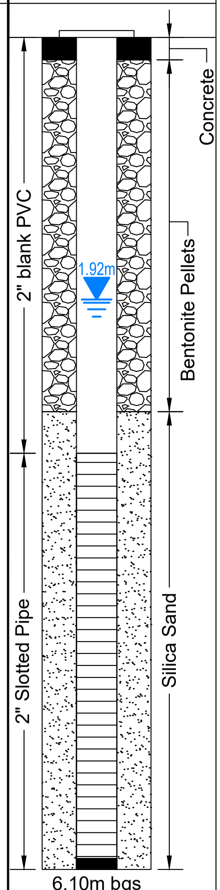
PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Mud Rotary

DRILLING DATE: 21 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES – LAB ID	Type NO.	"N" VALUE	PENETRATION TESTING (SPT) ▲ 20 40 60 80 / SHEAR STRENGTH (Kpa) ✚ 20 40 60 80	VAPOUR READING (ppm) □ 20 40 60 80 / MOISTURE CONTENT (%) ● 10 20 30 40	PIEZOMETER OR WELL CONSTRUCTION
0	0			87.84						
0–30	0–9.14	Augered to 9.14m								
30	9.14	CLAY: Grey, wet, very soft	hatched	9.14 / 78.70		SS-1	0	▲ 0		



Groundwater Depth (m): on completion: N/A, Mud Rotary; on 6 October 2022: 1.92m

DRAWN: D.C. | LOGGED: J.Y. | CHECKED: C.W.

FISHER ENGINEERING

LOG OF BOREHOLE

NO. BH101(MW) SHEET 2 of 3

PROJECT NO.: FE-P# 22-12469/70

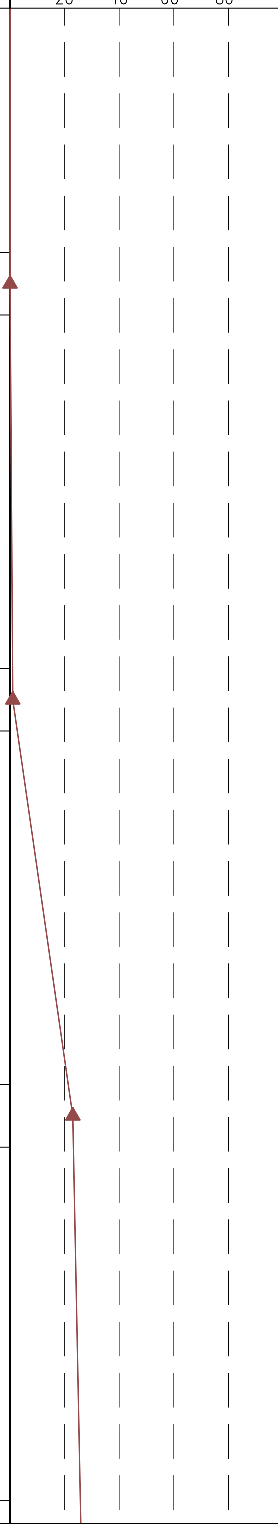
PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Mud Rotary

DRILLING DATE: 21 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: LAB ID	Type NO.	"N" VALUE	PENETRATION TESTING (SPT) / SHEAR STRENGTH (Kpa)	VAPOUR READING (ppm) / MOISTURE CONTENT (%)	PIEZOMETER OR WELL CONSTRUCTION
36	11	CLAY: Grey, wet, very soft								
40–42						SS-2	0			
50–52						SS-3	1			
60	18.29	CLAY: Grey, layers of gravelly sand, pieces of crushed rock, very moist to wet, very stiff/compact		18.29/69.55						
60–62						SS-4	23			



Groundwater Depth (m): on completion: N/A, Mud Rotary; on 6 October 2022: 1.92m

DRAWN: D.C. LOGGED: J.Y. CHECKED: C.W.

FISHER ENGINEERING

LOG OF BOREHOLE

NO. BH101(MW) SHEET 3 of 3

PROJECT NO.: FE-P# 22-12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Mud Rotary

DRILLING DATE: 21 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: LAB ID	SAMPLES: Type NO.	SAMPLES: "N" VALUE
71						SS-5	26
75	23	CRUSHED ROCK: Grey, some silt/clay, wet, very dense		22.86 / 64.98			
79.5	24	Auger refusal @ 24.41m probably due to chunk/piece of rock				SS-6	100+
80		End of borehole at 24.41m		24.41 / 63.43			

PENETRATION TESTING (SPT) ▲ 20 40 60 80

SHEAR STRENGTH (Kpa) ✚ 20 40 60 80

VAPOUR READING (ppm) □ 20 40 60 80

MOISTURE CONTENT (%) ● 10 20 30 40

PIEZOMETER OR WELL CONSTRUCTION

Depth scale: feet 70–104; meters 22–32

Groundwater Depth (m): on completion: N/A, Mud Rotary; on 6 October 2022: 1.92m

DRAWN: D.C. | LOGGED: J.Y. | CHECKED: C.W.

LOG OF BOREHOLE

NO. BH102(MW) SHEET 1 of 1

FISHER ENGINEERING

PROJECT NO.: FE–P# 22–12469/70

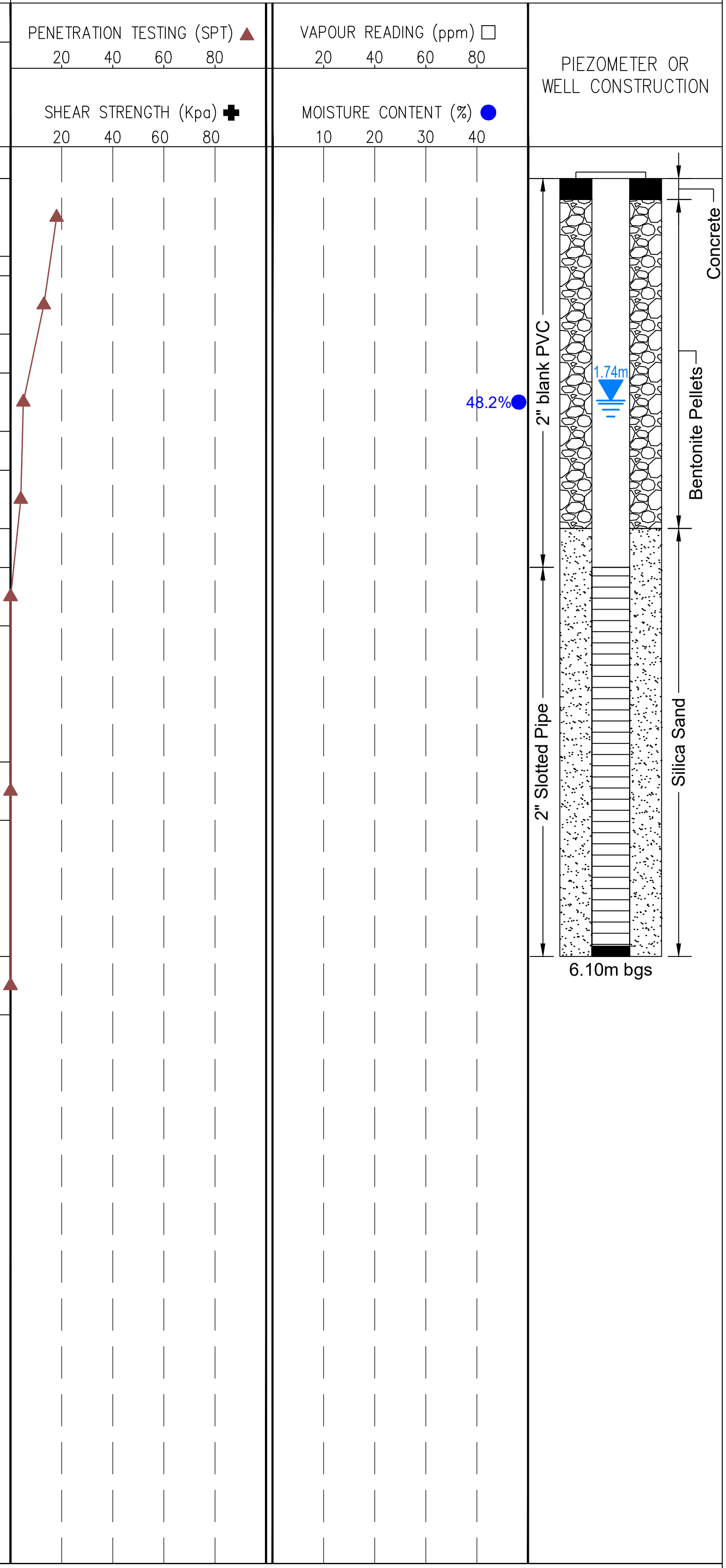
PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Solid Stem

DRILLING DATE: 22 September, 2022

Depth (m)	Soil Profile – Description	Elev. / Depth (m)	Lab ID	Type No.	"N" Value
0		87.67			
0–0.13	~5" TOPSOIL	0.13 / 87.54			
0.13–1.07	FILL: Dark greyish brown silty clay, trace sand, roots & topsoil, moist	1.07 / 86.60	22–9177–1	SS–1	18
				SS–2	13
1.07–6.55	SILTY CLAY: Grey, moist to wet, stiff to very soft		22–9177–2	SS–3	5
				SS–4	4
	Wet @ 3.35m			SS–5	0
				SS–6	0
		6.55 / 81.12		SS–7	0
6.55	End of borehole at 6.55m				



Groundwater Depth (m): on completion: Dry; on 6 October 2022: 1.74m

DRAWN: D.C. LOGGED: J.Y. CHECKED: C.W.

LOG OF BOREHOLE

NO. BH103 SHEET 1 of 1

PROJECT NO.: FE–P# 22–12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Solid Stem

DRILLING DATE: 20 September, 2022

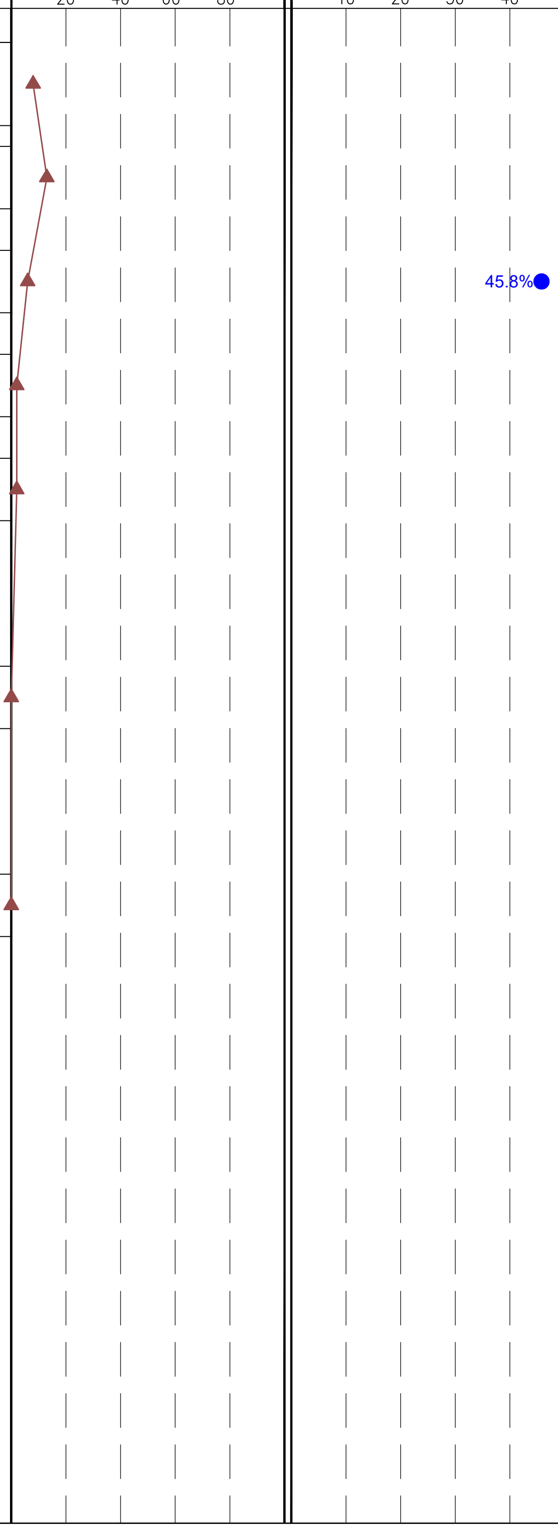
DEPTH (meters)	DESCRIPTION	ELEV. DEPTH (m)	LAB ID	Type NO.	"N" VALUE
0		87.94			
	~4" TOPSOIL				
	FILL: Dark grey silty clay, trace sand, roots, topsoil & topsoil mixed soils, moist		22–9177–3	SS–1	8
0.91	SILTY CLAY: Greenish grey, moist, stiff to very soft	0.91 / 87.03		SS–2	13
			22–9177–4	SS–3	6
				SS–4	2
3.35	SILTY CLAY: Grey, moist to wet, very soft	3.35 / 84.59		SS–5	2
	Wet @ 4.57m			SS–6	0
				SS–7	0
6.55	End of borehole at 6.55m	6.55 / 81.39			

Depth scale: 0–10 m (0–34 feet)

PENETRATION TESTING (SPT) ▲ 20 40 60 80 | VAPOUR READING (ppm) □ 20 40 60 80

SHEAR STRENGTH (Kpa) ✚ 20 40 60 80 | MOISTURE CONTENT (%) ● 10 20 30 40

PIEZOMETER OR WELL CONSTRUCTION



Groundwater Depth (m): on completion: 3.55m

DRAWN: D.C.	LOGGED: J.Y.	CHECKED: C.W.

LOG OF BOREHOLE

FISHER ENGINEERING

NO. BH104(MW) SHEET 1 of 1

PROJECT NO.: FE-P# 22-12469/70

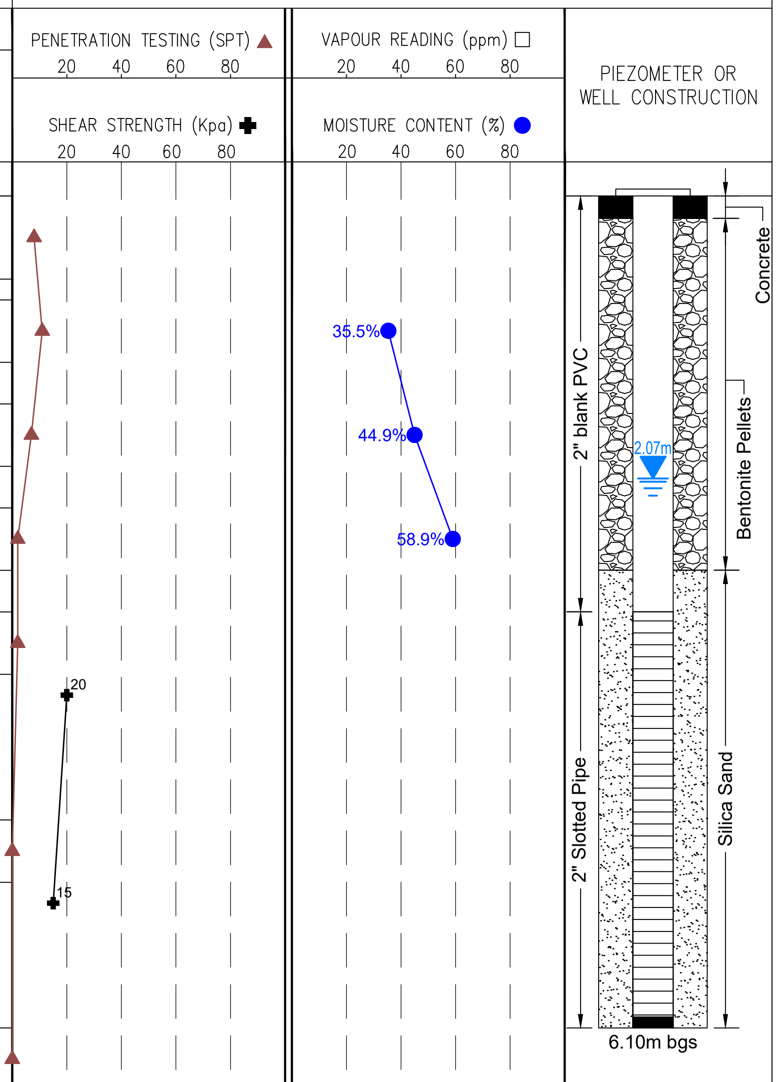
PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Solid Stem

DRILLING DATE: 20 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	LAB ID	Type NO.	"N" VALUE
0	0		87.96			
		~5" TOPSOIL	0.13 / 87.83			
		FILL: Dark grey silty clay, trace sand, gravel, roots & topsoil, moist	0.91 / 87.05	22-9177-5	SS-1	8
		SILTY CLAY: Grey, moist, stiff to firm	2.44 / 85.52		SS-2	11
				22-9177-6	SS-3	7
		SILTY CLAY: Grey, moist, very soft	3.11 / 84.85		SS-4	2
		SILTY CLAY: Grey, moist to wet, very soft Shear Vane Test was carried out @ 3.66m & 5.18m	6.55 / 81.41		SS-5	2
					SS-6	0
					SS-7	0
		End of borehole at 6.55m				



Groundwater Depth (m): on completion: 4.88m; on 6 October 2022: 2.07m

DRAWN: D.C. | LOGGED: J.Y. | CHECKED: C.W.

LOG OF BOREHOLE

FISHER ENGINEERING

NO. BH105(MW) SHEET 1 of 1

PROJECT NO.: FE–P# 22–12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Solid Stem

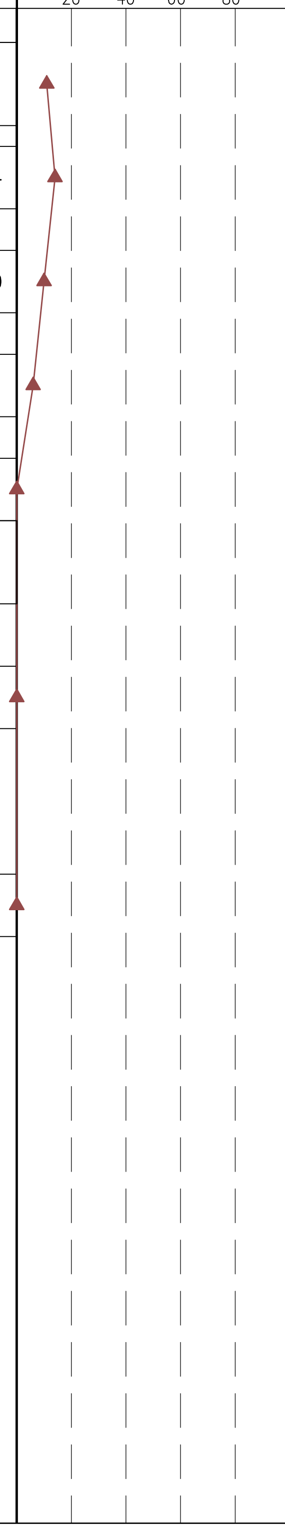
DRILLING DATE: 20 September, 2022

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
	87.90
~4" TOPSOIL	0.10 / 87.80
FILL: Dark grey to reddish brown silty clay, trace sand & roots, moist	0.69 / 87.21
SILTY CLAY: Grey, moist, stiff	2.44 / 85.46
SILTY CLAY: Grey, moist, firm	3.14 / 84.76
CLAY: Grey, moist, very soft	6.55 / 81.35
End of borehole at 6.55m	

SAMPLES – LAB ID	Type NO.	"N" VALUE
22–9177–7	SS–1	11
	SS–2	14
22–9177–8	SS–3	10
	SS–4	6
	SS–5	0
	SS–6	0
	SS–7	0

PENETRATION TESTING (SPT) ▲ 20 40 60 80

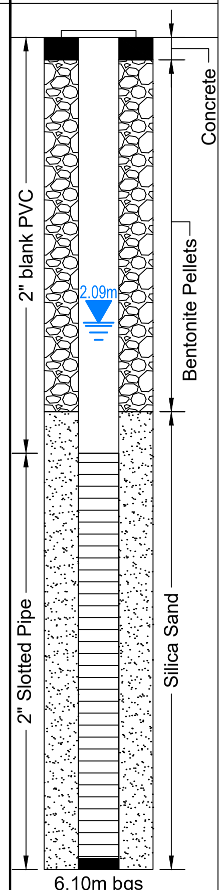
SHEAR STRENGTH (Kpa) ✚ 20 40 60 80



VAPOUR READING (ppm) □ 20 40 60 80

MOISTURE CONTENT (%) ● 10 20 30 40

PIEZOMETER OR WELL CONSTRUCTION



Groundwater Depth (m): on completion: Dry; on 6 October 2022: 2.09m

DRAWN: D.C. LOGGED: J.Y. CHECKED: C.W.

LOG OF BOREHOLE

NO. BH106(MW) SHEET 1 of 4

PROJECT NO.: FE-P# 22-12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Mud Rotary

DRILLING DATE: 22 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: LAB ID	Type NO.	"N" VALUE
0	0			87.78			
0–30	0–9.14	Augered to 9.14m					
30	9.14	CLAY: Grey, wet, very soft	hatched	9.14 78.64		SS-1	0

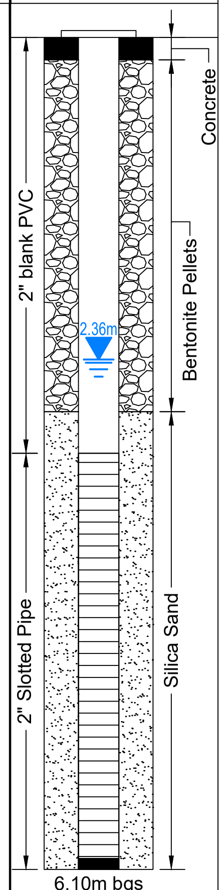
PENETRATION TESTING (SPT) ▲: 20 40 60 80

SHEAR STRENGTH (Kpa) ✚: 20 40 60 80

VAPOUR READING (ppm) □: 20 40 60 80

MOISTURE CONTENT (%) ●: 10 20 30 40

PIEZOMETER OR WELL CONSTRUCTION



Groundwater Depth (m): on completion: N/A, Mud Rotary; on 6 October 2022: 2.36m

DRAWN: D.C. | LOGGED: J.Y. | CHECKED: C.W.

FISHER ENGINEERING

LOG OF BOREHOLE

NO. BH106(MW) SHEET 2 of 4

PROJECT NO.: FE-P# 22-12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Mud Rotary

DRILLING DATE: 22 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: LAB ID	Type NO.	"N" VALUE	PENETRATION TESTING (SPT) 20 40 60 80 / SHEAR STRENGTH (Kpa) 20 40 60 80	VAPOUR READING (ppm) 20 40 60 80 / MOISTURE CONTENT (%) 10 20 30 40	PIEZOMETER OR WELL CONSTRUCTION
36	11	CLAY: Grey, wet, very soft								
38										
40	12					SS-2	0	0		
42	13									
44										
46	14									
48										
50	15					SS-3	0	0		
52	16									
54										
56	17									
58										
60	18					SS-4	0	0		
62	19									
64										
66	20									
68										
70	21									

Groundwater Depth (m): on completion: N/A, Mud Rotary; on 6 October 2022: 2.36m

DRAWN: D.C. LOGGED: J.Y. CHECKED: C.W.

FISHER ENGINEERING

LOG OF BOREHOLE

NO. BH106(MW) SHEET 3 of 4

PROJECT NO.: FE–P# 22–12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Mud Rotary

DRILLING DATE: 22 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	LAB ID	Type NO.	"N" VALUE
70–90	22–27	CLAY: Grey, wet, very soft				SS-5	0
						SS-6	1
90–103	27–31	GRAVELLY SAND: Grey, some clay/silt, pieces of crushed rock, wet, very dense		27.43 / 60.35		SS-7	100+
						SS-8	76
103–105	31–32	CRUSHED ROCK: Grey, wet, very dense. Auger refusal @ 32.33m probably due to chunk/piece of rock		31.39 / 56.39			

Depth scale (feet): 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104

Depth scale (meters): 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32

PENETRATION TESTING (SPT) ▲ 20 40 60 80

SHEAR STRENGTH (Kpa) ✚ 20 40 60 80

VAPOUR READING (ppm) □ 20 40 60 80

MOISTURE CONTENT (%) ● 10 20 30 40

PIEZOMETER OR WELL CONSTRUCTION

Groundwater Depth (m): on completion: N/A, Mud Rotary; on 6 October 2022: 2.36m

DRAWN: D.C. LOGGED: J.Y. CHECKED: C.W.

LOG OF BOREHOLE

FISHER ENGINEERING

NO. BH106(MW) SHEET. 4 of 4

PROJECT NO.: FE-P# 22-12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Mud Rotary

DRILLING DATE: 22 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	LAB ID	Type NO.	"N" VALUE	PENETRATION TESTING (SPT) 20 40 60 80 / SHEAR STRENGTH (Kpa) 20 40 60 80	VAPOUR READING (ppm) 20 40 60 80 / MOISTURE CONTENT (%) 10 20 30 40	PIEZOMETER OR WELL CONSTRUCTION
104–106	32	CRUSHED ROCK: Grey, wet, very dense. Auger refusal @ 32.33m probably due to chunk/piece of rock		32.33 55.45		SS-9	100+			
		End of borehole at 32.33m								
108	33									
110										
112	34									
114	35									
116										
118	36									
120										
122	37									
124	38									
126										
128	39									
130										
132	40									
134	41									
136										
138	42									
140										

Groundwater Depth (m): on completion: N/A, Mud Rotary; on 6 October 2022: 2.36m

DRAWN: D.C. LOGGED: J.Y. CHECKED: C.W.

FISHER ENGINEERING

LOG OF BOREHOLE

NO. BH1 SHEET 1 of 1

PROJECT NO.: FE-P 21-10991

PROJECT NAME: GEOTECHNICAL INVESTIGATION

LOCATION: 5210 Innes Road, Ottawa

DRILLING METHOD: Geo-probe Solid Steam

DRILLING DATE: 8 March 2021

SOIL PROFILE

GROUND SURFACE (m asl): 87.90

Elev. Depth (m)	Description
87.90	FILL: organic silty clay, dark, brown, moist
0.61/87.29	FILL: silty clay, trace of rootlets, clayey particles, greyish brown, moist, silt
1.22/86.68	SILTY CLAY: greyish brown, moist, firm to soft
	Grey clay below 4.57m wet
	DCPT from 5.33m
9.14/78.76	
	become harder at 17.69m
18.29/69.61	End of BH at 18.29m

SAMPLES

TYPE	NUMBER	"N" VALUE
SS	1	2
SS	2	10
SS	3	7
SS	4	4
SS	5	3
SS	6	1
PFUW		
	7	2
	8	3
	9	3
	10	3
	11	4
	12	4
	13	4
	14	4
	15	4
	16	4
	17	5
	18	5
	19	5
	20	5
	21	6
	22	7
	23	7
	24	6
	25	7
	26	7
	27	8
	28	8
	29	8
	30	8
	31	9
	32	10
	33	11
	34	10
	35	>50/ 6"
	36	50/ 2"

PENETRATION TESTING (SPT) ▲ 20 40 60 80

SHEAR STRENGTH (Kpa) ● 40 80 120 160

VAPOUR READING (ppm) □ 20 40 60 80

MOISTURE CONTENT (%) ○ 10 20 30 40

PIEZOMETER OR WELL CONSTRUCTION

Groundwater Depth (m): On Completion: 5.49m

PEUW: Drup Under Hammer Weight

LOGGED: ZA

CHECKED: FF

FISHER ENGINEERING

LOG OF BOREHOLE NO. BH2 SHEET 1 of 1

PROJECT NO.: FE-P 21-10991

PROJECT NAME: GEOTECHNICAL INVESTIGATION

LOCATION: 5210 Innes Road, Ottawa

DRILLING METHOD: Geo-probe Solid Steam

DRILLING DATE: 9 March 2021

SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: "N" VALUE	PENETRATION TESTING (SPT) ▲ 20 40 60 80 / SHEAR STRENGTH (Kpa) 40 80 120 160	VAPOUR READING (ppm) □ 20 40 60 80 / MOISTURE CONTENT (%) ○ 10 20 30 40	PIEZOMETER OR WELL CONSTRUCTION
GROUND SURFACE (m asl)	88.00						
FILL: silty clay, some rootlets, brown, wet		SS	1	1			
FILL: silty clay, greyish brown, trace of rootlets	0.61/87.39	SS	2	11			
SILTY CLAY: grey, moist, firm to soft	1.07/86.93	SS	3	4			
		SS	4	5			
clay below 3.05m; very soft below 3.05m		SS	5	1			
DCPT from 3.66m	3.66/84.34	PFUW					
soft below 7.92m	7.92/80.08		7	2			
			8	3			
			9	3			
			10	3			
			11	3			
			12	3			
			13	3			
			14	3			
			15	3			
			16	4			
			17	4			
			18	4			
			19	4			
			20	4			
			21	5			
			22	4			
			23	5			
			24	4			
			25	5			
			26	6			
			27	5			
			28	5			
			29	5			
			30	5			
			31	6			
			32	5			
			33	6			
			34	5			
			35	6			
			36	7			
			37	6			
			38	6			
			39	6			
			40	6			
			41	7			
			42	7			
			43	7			
			44	6			
			45	7			
			46	7			
			47	7			
			48	7			
			49	7			
			50	7			
			51	8			
			52	7			
			53	8			
			54	8			
			55	8			
			56	9			
			57	8			
			58	8			
			59	21			
become harder at 24.08m			60	54			
			61	81			
			62	74			
			63	94			
End of BH at 25.30m	25.30/62.70		64	Bounce	Refusal to cone penetration at 25.3m possibly due to bedrock.		

Groundwater Depth (m): On Completion 1.52m

PEUW: Drup Under Hammer Weight | LOGGED: ZA | CHECKED: FF

LOG OF BOREHOLE NO. BH3 SHEET 1 of 1

FISHER ENGINEERING

PROJECT NO.: FE-P 21-10991

PROJECT NAME: GEOTECHNICAL INVESTIGATION

LOCATION: 5210 Innes Road, Ottawa

DRILLING METHOD: Geo-probe Solid Steam

DRILLING DATE: 9 March 2021

SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE (m asl)	87.85
FILL: organic silty clay, trace of rootlets, bake to dark brown, moist	0.61/ 87.24
FILL: silty clay, trace of rootlets greyish brown, moist	1.22/ 86.63
SILTY CLAY: grey, moist, stiff to very stiff DCPT from 3.66m become harder below 24.08m Bounce at 24.99m	25.30/ 62.55
End of BH at 25.30m	

SAMPLES: TYPE	NUMBER	"N" VALUE
SS	1	3
SS	2	9
SS	3	9
SS	4	15
SS	5	21
	6	19
	7	19
	8	16
	9	14
	10	12
	11	11
	12	9
	13	8
	14	7
	15	6
	16	6
	17	5
	18	6
	19	7
	20	7
	21	9
	22	9
	23	10
	24	12
	25	12
	26	11
	27	10
	28	10
	29	12
	30	11
	31	12
	32	12
	33	13
	34	14
	35	12
	36	13
	37	11
	38	11
	39	14
	40	12
	41	12
	42	13
	43	13
	44	15
	45	16
	46	14
	47	14
	48	15
	49	17
	50	18
	51	18
	52	17
	53	19
	54	66
	55	59
	56	52
	57	51
	58	45
	59	47
	60	58
	61	37
	62	36
	63	65
	64	38
	65	38
	66	42
	67	29
	68	46
	69	64
	70	42
	71	43
	72	34
	73	55
	74	43
	75	67
	76	>50/ 3"

PENETRATION TESTING (SPT) ▲ 20 40 60 80

SHEAR STRENGTH (Kpa) 40 80 120 160

VAPOUR READING (ppm) □ 20 40 60 80

MOISTURE CONTENT (%) ○ 10 20 30 40

PIEZOMETER OR WELL CONSTRUCTION

Refusal to cone penetration at 25.3m possibly due to bedrock.

Groundwater Depth (m): On Completion: 0.61m

PEUW: Drup Under Hammer Weight

LOGGED: ZA

CHECKED: FF

LOG OF BOREHOLE

NO. TH1 SHEET 1 of 1

PROJECT NO.: FE-P# 22-12469/70

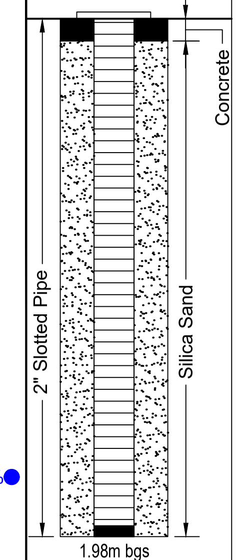
PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Solid Stem

DRILLING DATE: 23 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: LAB ID	Type NO.	"N" VALUE	PENETRATION TESTING (SPT) / SHEAR STRENGTH (Kpa)	VAPOUR READING (ppm) / MOISTURE CONTENT (%)
				87.77					
0–5	0–1.52	Augered to 1.52m							
5–6.5	1.52–1.98	SILTY CLAY: Grey, moist, soft		1.52 / 86.25		SS-1	7	▲ (SPT)	47.3%
	1.98	End of test hole at 1.98m		1.98 / 85.79					



Groundwater Depth (m): on completion: Dry

DRAWN: D.C. LOGGED: J.Y. CHECKED: C.W.

LOG OF BOREHOLE

NO. TH2 SHEET 1 of 1

PROJECT NO.: FE-P# 22-12469/70

PROJECT NAME: GEOTECHNICAL & HYDROGEOLOGICAL INVESTIGATIONS

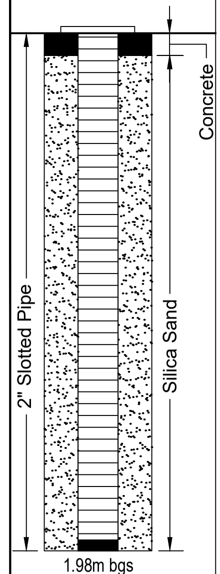
LOCATION: 5210 Innes Road, Ottawa, ON

DRILLING METHOD: Truck, Solid Stem

DRILLING DATE: 23 September, 2022

DEPTH (feet)	DEPTH (meters)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: LAB ID	Type NO.	"N" VALUE	PENETRATION TESTING (SPT) 20 40 60 80 / SHEAR STRENGTH (Kpa) 40 80 120 160	VAPOUR READING (ppm) 20 40 60 80 / MOISTURE CONTENT (%) 10 20 30 40
0	0			87.66					
		Augered to 1.52m							
		SILTY CLAY: Grey, moist, soft		1.52 / 86.14		SS-1	6	▲ (SPT)	42.8%
		End of test hole at 1.98m		1.98 / 85.68					

PIEZOMETER OR WELL CONSTRUCTION



Groundwater Depth (m): on completion: Dry

DRAWN: D.C. | LOGGED: J.Y. | CHECKED: C.W.

APPENDIX C – MOISTURE CONTENT

FISHER ENGINEERING

CERTIFIED BY CCIL

Project Name:	Geotechnical Investigation	***F.E. Lab #:***	22-495
Client:	Dymon Group of Companies	***Date Sampled:***	20-Sep-2022
Project ID:	22-12470	***Date Received:***	26-Sep-2022
Location:	5210 Innes Road Ottawa, Ontario	***Date Reported:***	18-Oct-2022

Certificate of Analysis

Analyses	Matrix	Quantity	Testing Date	Method Reference
Moisture Content	Soil	6	26-Sep-22	ASTM D2216
Grain Size (Sieve Analysis)	Soil	0	N.A.	LS-602
Grain Size (Hydrometer)	Soil	5	12-Oct-22	LS-702
Atterberg test	Soil	0	N.A.	LS-703/704

Authorized by: Behnam Sayad-Pour

Behnam Sayad Pour Zanjani
Geo-Lab Supervisor

Certificate of Analysis

Analysis Requested:	Moisture Content	***Sample Description:***	6 Soil Sample(s)

Sample Info	BH2 SS3	BH3 SS3	BH4 SS2	BH4 SS3	BH4 SS4	TH1
Sample Depth (m)	1.53-1.98	1.53-1.98	0.76-1.22	1.53-1.98	2.29-2.75	1.53-1.98
Moisture Content (%)	48.2	45.8	35.5	44.9	58.9	47.3

Sample Info	TH2					
Sample Depth (m)	1.53-1.98					
Moisture Content (%)	42.8					

F.E. Job #: 22-495

Certificate of Analysis

Analysis Requested:	Grain Size (Hydrometer)
Sample Description:	5 Soil Sample(s)

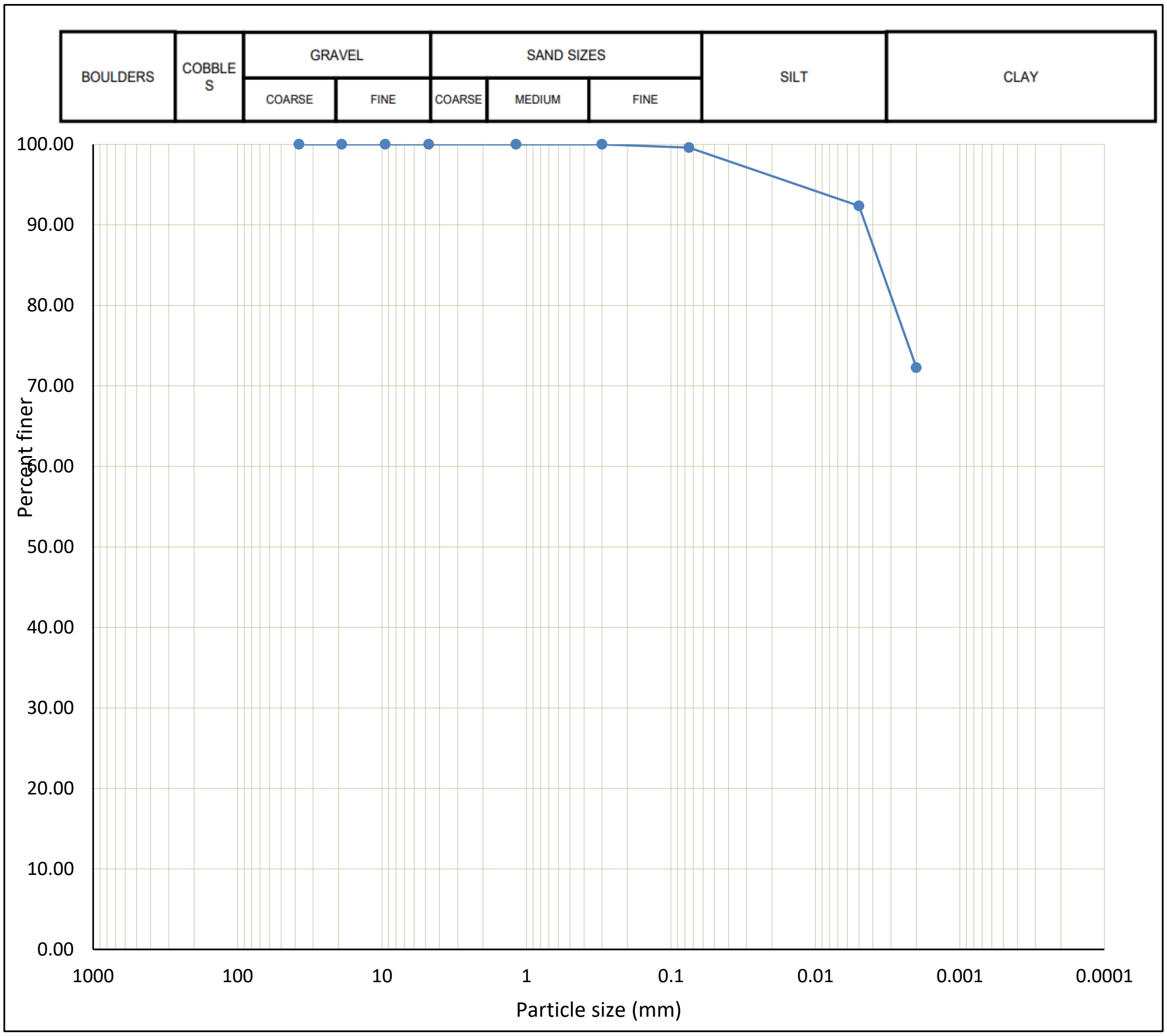
Sample Info	***22-508 BH2 SS3***	***22-509 BH3 SS3***	***22-510 BH4 SS2***	***22-511 TH1***	***22-512 TH2***	
Sample Depth (m)	***1.53-1.98***	***1.53-1.98***	***0.76-1.22***	***1.53-1.98***	***1.53-1.98***	
Grain Size (%)						
>19mm	0.0	0.0	0.0	0.0	0.0	
9.5mm-19mm	0.0	0.0	0.0	0.0	0.0	
4.75mm-9.5mm	0.0	0.0	0.0	0.0	0.0	
1.18mm-4.75mm	0.0	0.0	0.0	0.0	0.0	
300um-1.18mm	0.0	0.2	0.0	0.0	0.0	
75um-300um	0.4	0.6	0.6	0.4	0.2	
5um-75um	7.2	9.7	15.1	10.8	11.9	
2um-5um	20.1	15.9	14.2	14.8	15.4	
<2um	72.3	73.6	70.1	74.0	72.5	
Clay	**72**	**74**	**70**	**74**	**72**	
Silt	**27**	**26**	**29**	**26**	**27**	
Sand	**0**	**1**	**1**	**0**	**0**	
Gravel	**0**	**0**	**0**	**0**	**0**	

F.E. Job #: 22-495

Grain Size Distribution

Sample ID: 22-508 BH2 SS3 1.53-1.98

Gravel: 0%   Sand: 0%   Silt: 27%   Clay: 72%



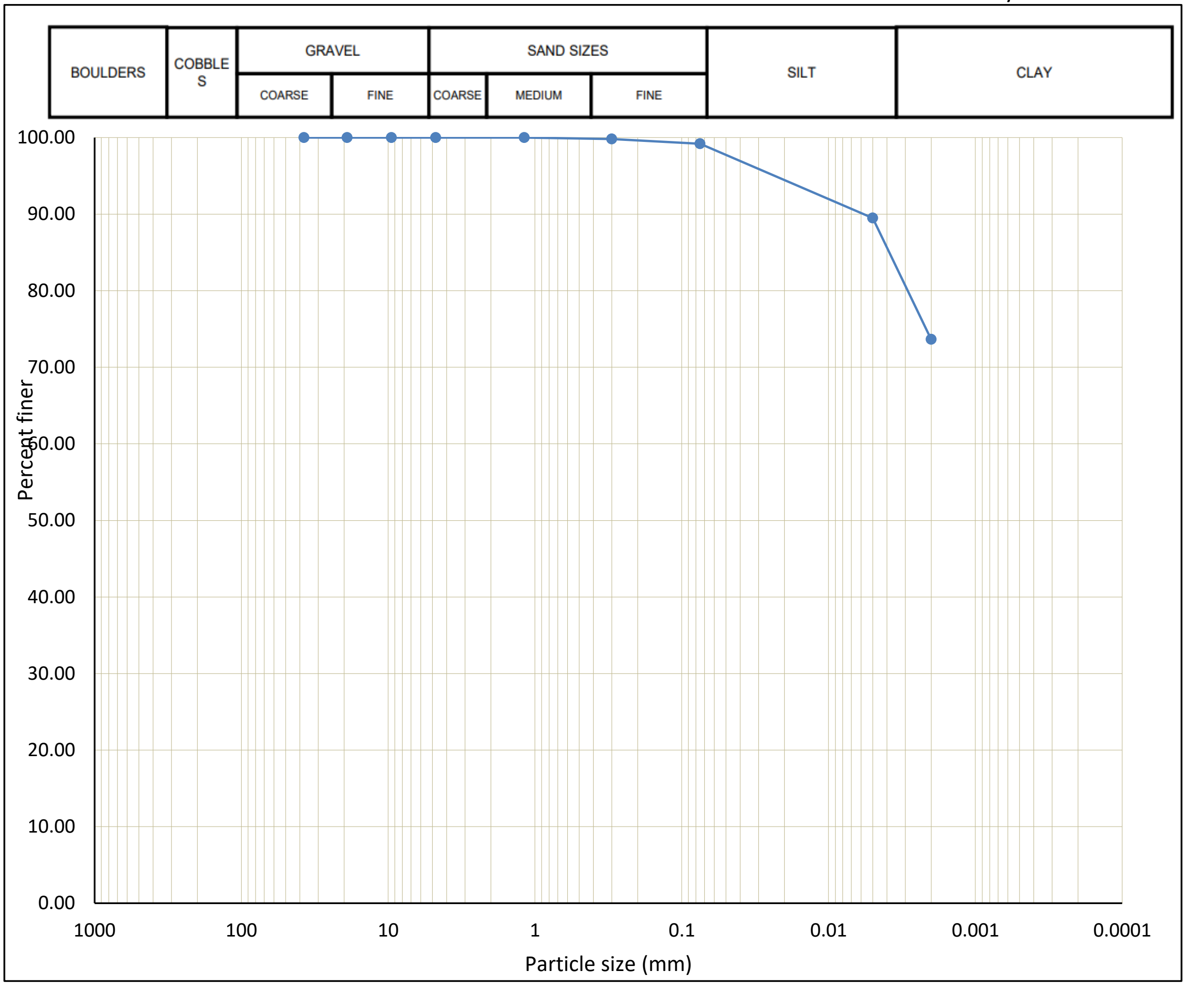
Sample ID: 22-508 BH2 SS3 1.53-1.98		
Diameter	***Weight (%)***	***Grain Size***
>4.75mm	0.0	Gravel
1.18mm-4.75mm	0.0	Coarse Sand
300um-1.18mm	0.0	Medium Sand
75um-300um	0.4	Fine Sand
5um-75um	7	Silt
2um-5um	20	
<2um	72	Clay

F.E. Job #: 22-495

Grain Size Distribution

Sample ID: 22-509 BH3 SS3 1.53-1.98

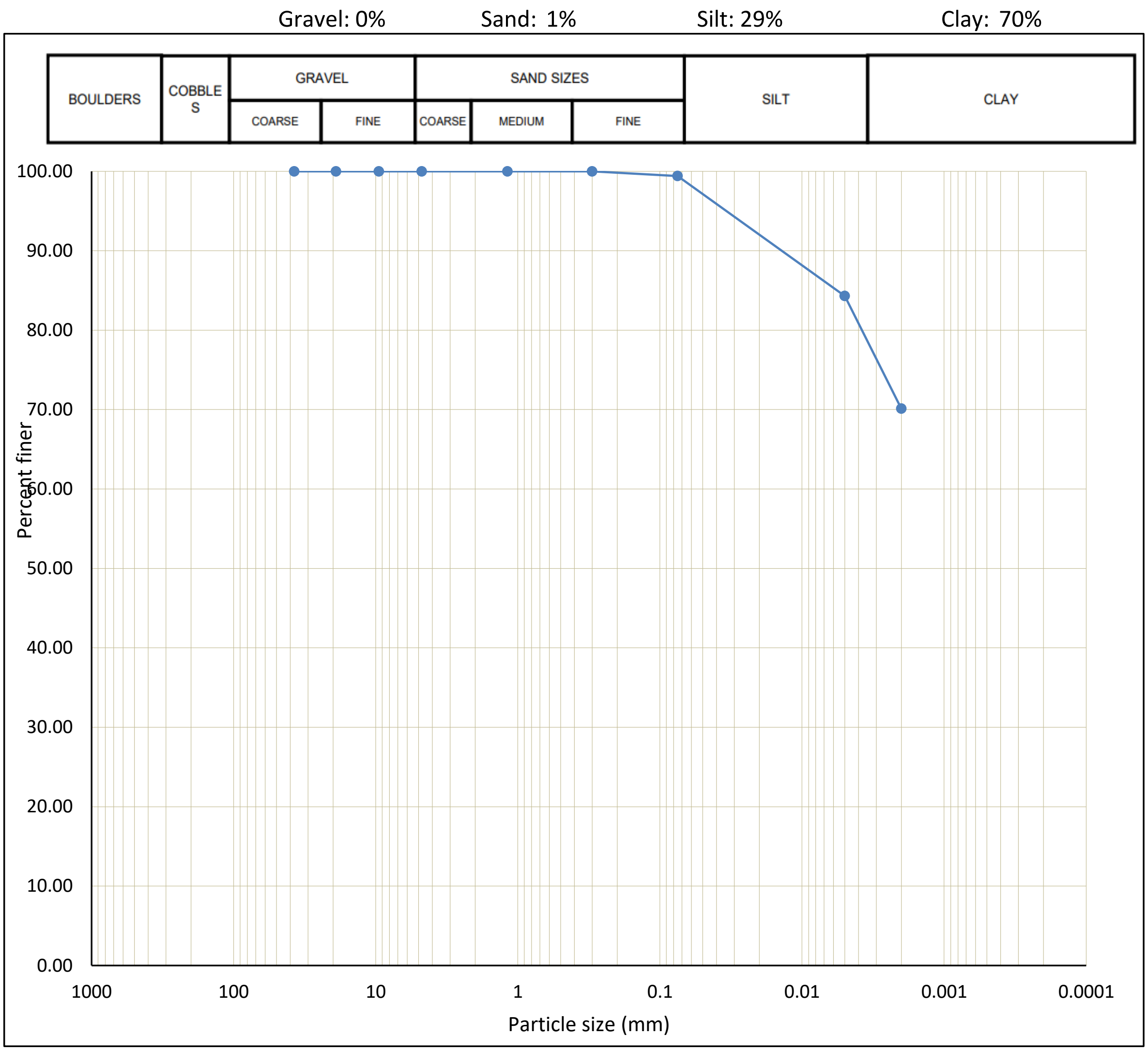
Gravel: 0% Sand: 1% Silt: 26% Clay: 74%



Sample ID: 22-509 BH3 SS3 1.53-1.98		
Diameter	***Weight (%)***	***Grain Size***
>4.75mm	0.0	Gravel
1.18mm-4.75mm	0.0	Coarse Sand
300um-1.18mm	0.2	Medium Sand
75um-300um	0.6	Fine Sand
5um-75um	10	Silt
2um-5um	16	
<2um	74	Clay

Grain Size Distribution

Sample ID: 22-510 BH4 SS2 0.76-1.22

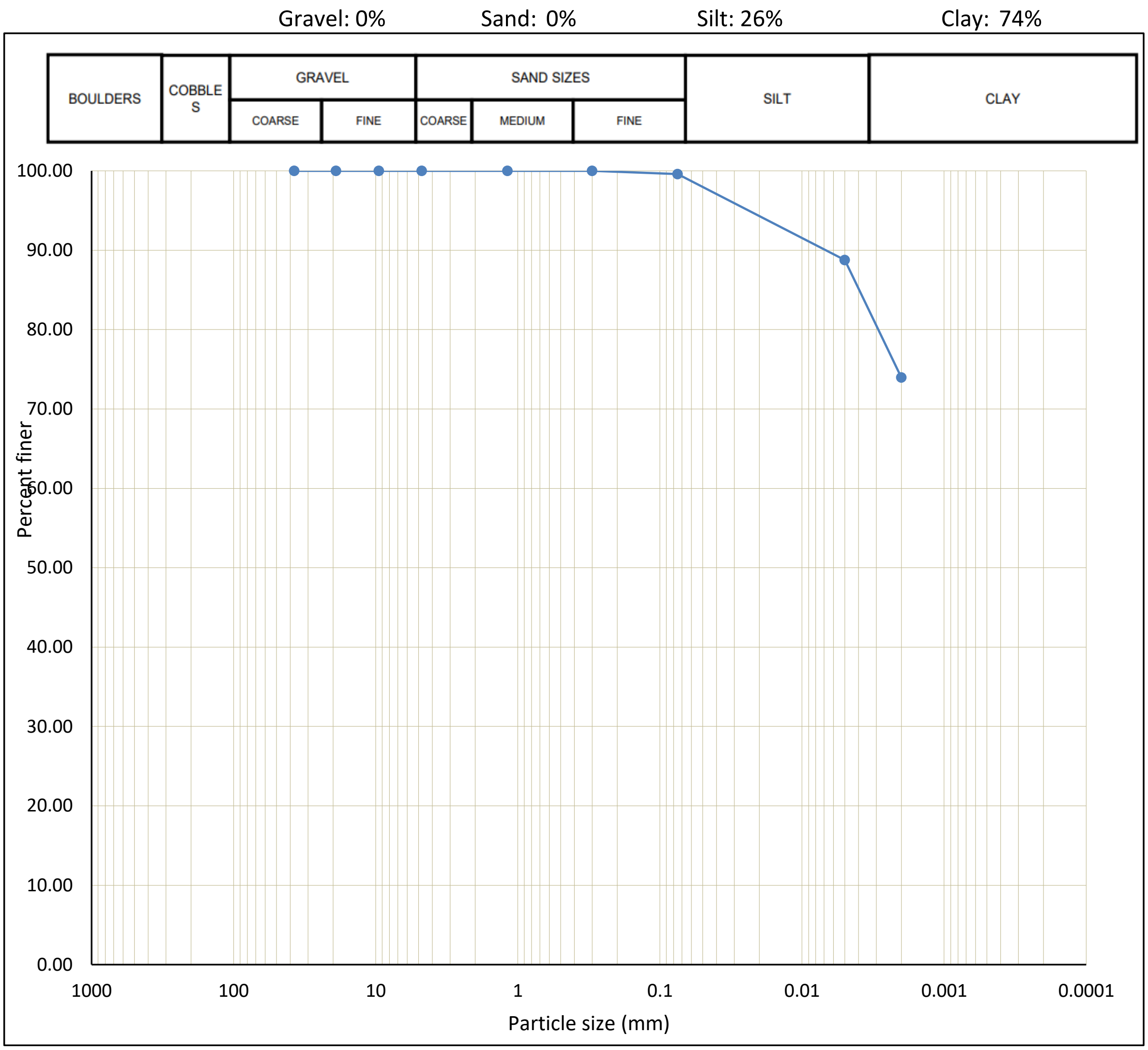


Sample ID: 22-510 BH4 SS2 0.76-1.22		
Diameter	***Weight (%)***	***Grain Size***
>4.75mm	0.0	Gravel
1.18mm-4.75mm	0.0	Coarse Sand
300um-1.18mm	0.0	Medium Sand
75um-300um	0.6	Fine Sand
5um-75um	15	Silt
2um-5um	14	
<2um	70	Clay

F.E. Job #: 22-495

Grain Size Distribution

Sample ID: 22-511 TH1 1.53-1.98

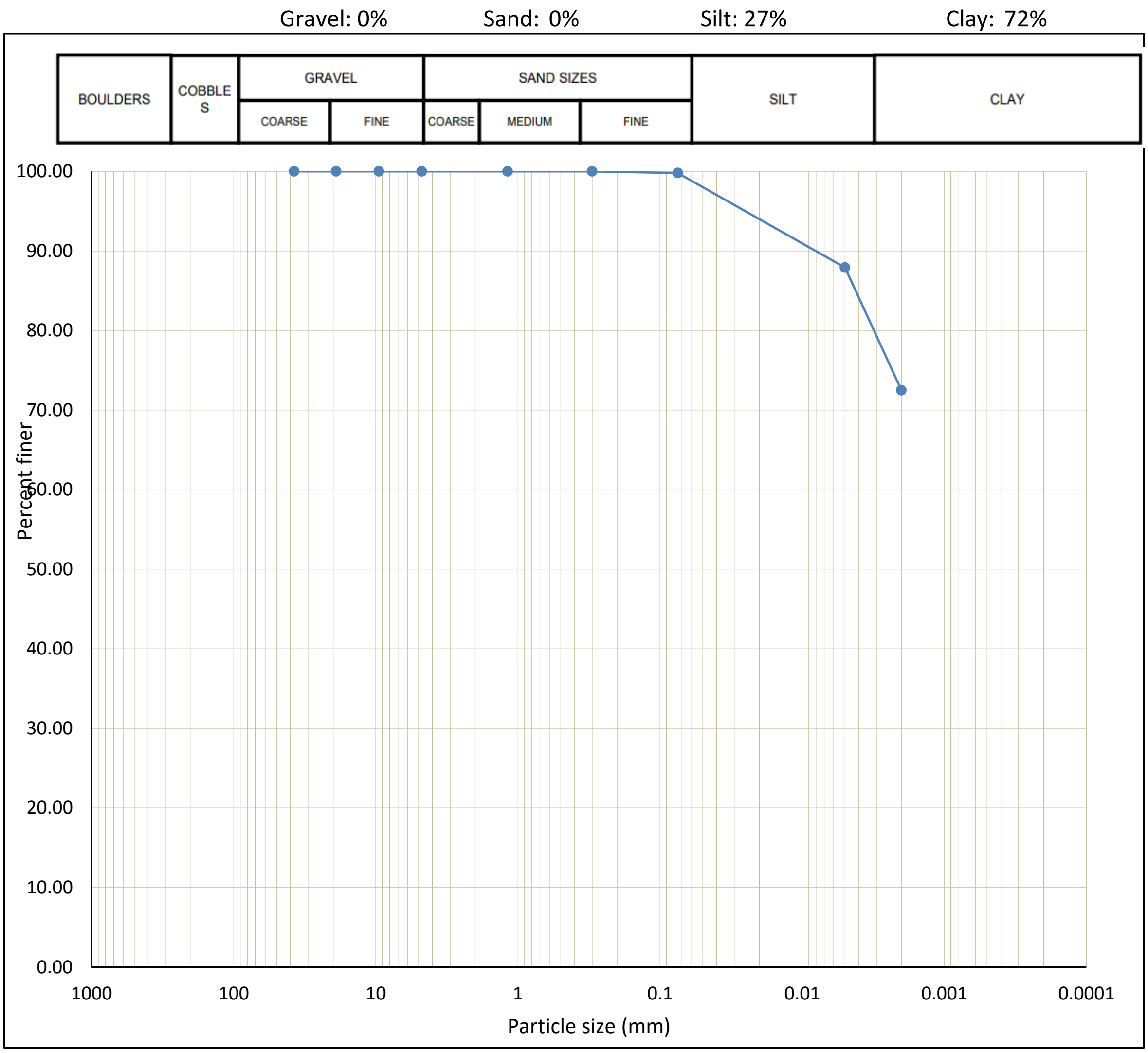


Sample ID: 22-511 TH1 1.53-1.98		
Diameter	***Weight (%)***	***Grain Size***
>4.75mm	0.0	Gravel
1.18mm-4.75mm	0.0	Coarse Sand
300um-1.18mm	0.0	Medium Sand
75um-300um	0.4	Fine Sand
5um-75um	11	Silt
2um-5um	15	
<2um	74	Clay

F.E. Job #: 22-495

Grain Size Distribution

Sample ID: 22-512 TH2 1.53-1.98



Sample ID: 22-512 TH2 1.53-1.98		
Diameter	***Weight (%)***	***Grain Size***
>4.75mm	0.0	Gravel
1.18mm-4.75mm	0.0	Coarse Sand
300um-1.18mm	0.0	Medium Sand
75um-300um	0.2	Fine Sand
5um-75um	12	Silt
2um-5um	15	Clay
<2um	72	

FISHER ENGINEERING

GEOTECHNICAL-LABORATORY

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Hours: 9AM - 5PM M-F
Call for Emergency Response

LAB JOB No:

Standard Laboratory Request Form: Chain of Custody

CLIENT INFORMATION

Name:
Contact:
Address: 5210 INNES
Email:
Fax: Fax results ☐
Phone: Email results ☑

PROJECT INFORMATION

Project Name: 5210 INNES
Project ID: 22-12470
Sampled By:

TURNAROUND TIME (TAT): Check ONE if all samples are the same/or see below.

STD - Standard (5-7 bus. days)		Standard Charge	Reg. Business Hrs. 9am to 5pm Samples received after 2pm are considered next day orders.
3D - Three-Day (72 hrs.)		+25% SURCHARGES MAY APPLY Custom quotations (if applicable) will be reflected on final billing. CALL for: Emergencies, Bulk Quotes, or other Questions.	

BILLING INFORMATION

Purchase Order No:
Verbal Authorization:
Credit Card Type (e.g. MC/Visa/AMEX…):
Credit Card #:
Expiry Date:

LAB SAMPLE ID	CLIENT'S SAMPLE ID AND DESCRIPTION	SAMPLING DATE/TIME	SAMPLE MATRIX	CONTAINER NO. and TYPE	TAT (Above)	Moisture Content	Sieve Analysis	Hydrometer	Atterberg Limits	Proctor					NOTES
1	BH2 5-6.5'	Sep20	Soil	bag	STD	✓	✗	✓							
2	BH4 2.5'-4'	↓	Soil	bag	↓	↓	✗	✓							
	5'-6.5'	↓	Soil	bag	↓	↓	✗								
	10-11.5'	↓	Soil	bag	↓	↓	✗								
3	BH3 5-6.5'	↓	Soil	bag	↓	↓		✓							
4	TH1 5'-6.5	↓	Soil	bag	↓	↓		✓							
5	TH2 5'-6.5'	↓	Soil	bag	↓	↓		✓							

Relinquished by:
Name: (print) JAMAL, Clive
Signature: [signature]
Date & Time: Sep 26
Method of Shipment: by hand

Client's Comments:

Regulatory Requirements:

OPSS Reg.

Purpose for sampling:

Road Base **Engineering Fill**
Road Subbase **Soil Classification**
Subgrade **Other**
Backfill

Received by (Internal):
Name:
Date & Time:

Arrival Temperature °C:
Laboratory Remarks:

Revision 1.03 : March 2022

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www.fisherenvironmental.com

Client:	Dymon Group of Companies	***F.E. Job #:***	21-6138
Address:		***Project Name:***	Geotechnical
		Project ID:	FE-P 21-10991
		Date Sampled:	8, 9-Mar-2021
Tel.:		***Date Received:***	10-Mar-2021
Email:		***Date Reported:***	17-Mar-2021
Attn.:		***Location:***	5210 Innes Road Ottawa, ON

Certificate of Analysis

Analyses	Matrix	Quantity	Date Extracted	Date Analyzed	Lab SOP	Method Reference
Moisture Content	Soil	7	N/A	12-Mar-21	Support Procedures F-99	Carter (1993)

Fisher Environmental Laboratories is accredited by CALA (the Canadian Association for Laboratory Accreditation Inc.) for specific parameters as required by Ontario Regulation 153/04. All analytical testing has been performed in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act published by Ontario Ministry of the Environment.

Authorized by:

Roger Lin, Ph. D., C. Chem.
Laboratory Manager

Results related only to the items tested

Certificate of Analysis

Analysis Requested:	Moisture Content
Sample Description:	7 Soil Sample(s)

Parameter	***21-6138-1*** BH1 0.75-1.35m	***21-6138-2*** BH1 2.25-2.85m	***21-6138-3*** BH1 4.55-5.15m	***21-6138-4*** BH2 1.50-2.10m	***21-6138-5*** BH2 3.00-3.60m	***21-6138-6*** BH3 0.75-1.35m
Moisture Content (%)	37	44	73	48	68	34

Parameter	***21-6138-7*** BH3 2.25-2.85m					
Moisture Content (%)	43					

QA/QC Report

Parameter	**Blank**	**RL**	**LCS**	**AR**	**Duplicate**	**AR**
			Recovery (%)		**RPD (%)**	
Moisture Content (%)	<0.1	0.1	100	70-130	4.0	0-20

LEGEND:

RL - Reporting Limit
LCS - Laboratory Control Sample
AR - Acceptable Range
RPD - Relative Percent Difference

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Client: Dymon Group of Companies
Address:

Tel.:
Email:
Attn.:

F.E. Job #: 22-9178
Project Name: Geotechnical & Hydrogeotechnical
Project ID: FE-P 22-12470
Date Sampled: 23-Sep-2022
Date Received: 26-Sep-2022
Date Reported: 3-Oct-2022
Location: 5210 Innes Road
Ottawa, ON

Certificate of Analysis

Analyses	Matrix	Quantity	Date Extracted	Date Analyzed	Lab SOP	Method Reference
pH	Soil	2	26-Sep-22	26-Sep-22	pH-EC-SAR F-16	SW-846, 9045D
Chloride	Soil	2	N/A	28-Sep-22	Chloride F-20	SM 4500-Cl-E
Sulphate	Soil	2	26-Sep-22	28-Sep-22	Sulphate F-21	SM 4500-SO_4

Fisher Environmental Laboratories is accredited by CALA (the Canadian Association for Laboratory Accreditation Inc.) for specific parameters as required by Ontario Regulation 153/04. All analytical testing has been performed in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act published by Ontario Ministry of the Environment.

Authorized by:

Roger Lin, Ph. D., C. Chem.
Laboratory Manager

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Ronggen (Roger) Lin
CHEMIST

Results related only to the items tested

Certificate of Analysis

Analysis Requested:	pH, Sulphate, Chloride
Sample Description:	2 Soil Sample(s)

Parameter	***22-9178-1*** BH3 1.52-1.98m	***22-9178-2*** BH4 1.52-1.98m				**Soil Standards** *
pH *(pH unit)*	7.85	7.81				(5-11) 5-9

* Surface soil pH value from 5 - 9, Sub-surface soil pH value from 5-11.

QA/QC Report

Parameter	**LCS**	**AR**	**Duplicate**	**AR**		
			Absolute Difference *(pH Unit)*			
pH *(pH unit)*	7.10	6.90-7.20	0.16	<0.3		

LEGEND:

LCS - Laboratory Control Sample

AR - Acceptable Range

Certificate of Analysis

Analysis Requested:	pH, Sulphate, Chloride
Sample Description:	2 Soil Sample(s)

Parameter	***22-9178-1*** BH3 1.52-1.98m	***22-9178-2*** BH4 1.52-1.98m				
	Concentration (µg/g)					
Chloride in Soil	<10	<10				

< result obtained was below RL (Reporting Limit).

QA/QC Report

Parameter	**Blank**	**RL**	**LCS**	**AR**	**MS**	**AR**
	(µg/g)		**Recovery (%)**		**Recovery (%)**	
Chloride in Soil	<10	10	99	70-130	89	70-130

Parameter	**Duplicate**	**AR**				
	RPD (%)					
Chloride in Soil	0.4	0-20				

LEGEND:

RL - Reporting Limit
LCS - Laboratory Control Sample
MS - Matrix Spike
AR - Acceptable Range
RPD - Relative Percent Difference

Certificate of Analysis

Analysis Requested:	pH, Sulphate, Chloride
Sample Description:	2 Soil Sample(s)

Parameter	***22-9178-1*** BH3 1.52-1.98m	***22-9178-2*** BH4 1.52-1.98m				
Sulphate *(mg/kg)*	13.4	24.0				

QA/QC Report

Parameter	**Blank**	**RL**	**LCS/Spike**	**AR**	**Duplicate**	**AR**
	(mg/kg)		**Recovery (%)**		**RPD (%)**	
Sulphate	<1	1	96	70-130	7.4	0-30

LEGEND:

RL - Reporting Limit
LCS - Laboratory Control Sample
AR - Acceptable Range
RPD - Relative Percent Difference

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laboratory@fisherenvironmental.com

LAB JOB #: 22-9178

CHAIN OF CUSTODY 2588

CLIENT INFORMATION
Company Name:
Contact:
Address: 5210 INNES
Phone:
Fax: Fax results? Y/N
Email: Email results? Y/N

PROJECT INFORMATION
Project Name: 5210 INNES 5210 Innes Road. Ottawa.
Project ID: 22-12470 Geotechnical & hydrogeotechnical
Sampled By:

TURNAROUND TIME (TAT) REQUIRED
STD - Standard (5-7 working days)
SR - Semi Rush (48 hours) 50%
R - Rush (24 hours) 75%
SD - Same Day - 100% 100%
Surcharges apply; Sample received after 2pm will be considered received the next business day
Working Time: Monday-Friday 9:00am-5:00pm

BILLING INFORMATION
Purchase Order #:
Verbal Authorization:
Credit Card (type):
Credit Card #:
Expiry Date:

LAB SAMPLE ID	CLIENT'S SAMPLE ID AND DESCRIPTION	SAMPLING DATE/TIME	SAMPLE MATRIX	CONTAINER # & TYPE	TAT (Above)	Metals	PHCs	VOCs	PAHs	PCBs	Asbestos	SO4	Cl	PH	NOTES
1	BH3 5-6.5		Soil	bag	STD							✓	✓	✓	
2	BH4 5-6.5		Soil	bag	STD							✓	✓	✓	

Relinquished by: (Signature & Print) Clive, Jamaz
Date & Time:
Method of Shipment: by hand
Received by: (Signature & Print)
Date & Time: Sept 26, 22

Client's Comments:
Arrival Temperature (°C):
Laboratory Remarks:

Regulatory Requirements
Reg. 153
Table________
☐ Residential / Parkland
☐ Industrial / Commercial
☐ Agricultural
Soil Texture
☐ Coarse ☐ Med/Fine

Sewer Use
☐ Sanitary
☐ Storm
Region ________

Reg. 558
☐ TCLP

Revision: 2.2

APPENDIX D – SHEAR WAVE TESTS RESULTS

May 6, 2021

Dymon Group of Companies
2-1830 Walkley Road
Ottawa, Ontario K1H 8K3

Attn: James Byck
Email: jbyck@dymon.ca

Re: Shear Wave Velocity Sounding - Proposed New Development,
5210 Innes Road, Ottawa, Ontario
Fisher Project #: FE-P-21-10991

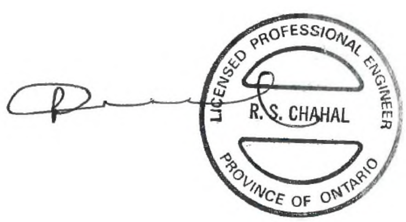
We enclose the report prepared by Jean-Luc Arsenault, M.A.Sc., P.Eng., of Geophysics GPR International Inc. documenting the results of shear-wave velocity sounding at the above noted site.

The sounding/survey was performed on April 26, 2021. Shear wave velocity measurements were recommended in order to determine/confirm the Site Class for the building design at the subject site and/or the approximate depth of bedrock.

Average Vs values determined through MASW method varied from 100m/s to 200m/s in upper 20m, 200m/s to 400m/s in 20m to 40m depth range with an overall average Vs30 of 158m/s. The above Sounding indicate that sound bedrock is located at the approximate depth of 40m below grade. We recommend that few deeper boreholes be carried out to determine the subsurface conditions down to the bedrock level to determine liquification potential or presence of very soft/sensitive clays etc.

The above average shear wave velocity measurement (Vs30) of 158m/s also confirm that Site Class 'E' be used for the building design purposes.

Fisher Engineering Limited



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Rajinder Chahal, P. Eng.
Senior Project Engineer
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rajinder@fisherenvironmental.com

GEOPHYSICS GPR INTERNATIONAL INC.

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May 5th, 2021 Transmitted by email: Sean@fisherenvironmental.com

Our Ref.: GPR-21-02934-02

Mr. Sean Fisher, M.Sc.
Project manager
Fisher Environmental Ltd.
15 - 400 Esna Park Dr.
Markham ON K1J 9G2

Subject: **<u>Shear Wave Velocity Sounding for the Site Classe Determination</u>**
Innes Road and Trim Road, Ottawa (ON)

[Project: FE-P 21-10991]

Dear Sir,

Geophysics GPR International inc. has been mandated by Fisher Environmental Ltd. to carry out seismic shear wave surveys on a vacant field located at the east corner of Innes Road and Trim Road, in Ottawa (ON). The geophysical investigation used the Multi-channel Analysis of Surface Waves (MASW), the Spatial AutoCorrelation (SPAC), and the seismic reflection methods to determine the Site Class.

The surveys were carried out on April 26th, 2021, by Mr. Dominic Déraps, tech. geoph. and Mr. Timothy Ward, tech. Figure 1 shows the regional location of the site and Figure 2 illustrates the location of the seismic spreads. Both figures are presented in the Appendix.

The following paragraphs briefly describe the survey design, the principles of the testing methods, and the results presented in tables and graphs.

MASW PRINCIPLE

The *Multi-channel Analysis of Surface Waves* (MASW) and the *SPatial AutoCorrelation* (SPAC or MAM for *Microtremors Array Method*) are seismic methods used to evaluate the shear wave velocities of subsurface materials through the analysis of the dispersion properties of the Rayleigh surface waves ("ground roll"). The MASW is considered an "active" method, as the seismic signal is induced at known location and time in the geophones' spread axis. Conversely, the SPAC is considered a "passive" method, using the low frequency "signals" produced far away. The method can also be used with "active" seismic source records. The dispersion properties are expressed as a change of phase velocities with respect to frequencies. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. The inversion of the Rayleigh wave dispersion curve yields a shear wave (V_S) velocity depth profile (sounding). Figure 3 schematically outlines the basic operating procedure for the MASW method.

Figure 4 illustrates an example of one of the MASW/SPAC records, the corresponding spectrogram analysis and resulting 1D V_S model. The SPAC method allows deeper Vs soundings, but generally with a lower resolution for the surface portion. Its dispersion curve can then be merged with the one of higher frequency from the MASW to calculate a more complete inversion.

INTERPRETATION

The main processing sequence involved data inspection and edition when required; spectral analysis ("phase shift" for MASW, and "cross-correlation" for SPAC); picking the fundamental mode; and 1D inversion of the MASW and SPAC shot records using the SeisImagerSW™ software. The data inversions used a nonlinear least squares algorithm.

In theory, all the shot records for a given seismic spread should produce a similar shear-wave velocity profile. In practice, however, differences can arise due to energy dissipation, local surface seismic velocities variations, and/or dipping of overburden layers or rock. In general, the precision of the calculated seismic shear wave velocities (V_S) is of the order of 15% or better.

More detailed descriptions of these methods are presented in *Shear Wave Velocity Measurement Guidelines for Canadian Seismic Site Characterization in Soil and Rock*, Hunter, J.A., Crow, H.L., et al., Geological Surveys of Canada, General Information Product 110, 2015.

SURVEY DESIGN

The main seismic acquisition spread used a geophone spacing of 4.0 metres, with 24 geophones. A shorter seismic spread, with geophone spacing 1.0 metre, was centered on the main one, and was dedicated to the near surface materials. The seismic records counted 4096 data, sampled at 1000 µs for the MASW surveys, and 50 µs for the seismic refraction. The records included a pre-trigged portion of 10 ms. A stacking procedure was also used to improve the Signal / Noise ratio for the seismic records.

The seismic records were produced with a seismograph Terraloc PRO2 (from ABEM Instrument), and the geophones were 4.5 Hz. An 8 kg sledgehammer was used as the energy source with impacts being recorded off both ends of the seismic lines.

The shear wave depth sounding can be considered as the average of the bulk area within the geophone spread, especially for its central half-length.

RESULTS

From seismic reflection (NMO using V_S), four reflectors were calculated at 20, 25, 30 and 42 metres deep. From seismic resonance (V_P), four equivalent reflectors were calculated at 18, 24, 33 and 40 metres deep. The deepest reflector could reasonably be associated to the rock. These results were used as initial parameters for the basic geophysical model, prior to the MASW dispersion curves modeling and inversions.

The MASW calculated V_S results are illustrated at Figure 5. The Table 1 shows the V_S values calculated between the surface and the rock.

The $\overline{V}_{S30}$ value results from the harmonic mean of the shear wave velocities, from the surface to 30 metres deep. It is calculated by dividing the total depth of interest (30 metres) by the sum of the time spent in each velocity layer from the surface down to 30 metres, as:

$$\overline{V}_{S30} = \frac{\sum_{i=1}^{N} H_i}{\sum_{i=1}^{N} H_i/V_i} \quad | \quad \sum_{i=1}^{N} H_i = 30 \text{ m}$$

(N: number of layers; H_i : thickness of layer "i" ; V_i : V_S of layer "i")

Thus, the $\overline{V}_{S30}$ value represents the seismic shear wave velocity of an equivalent homogeneous single layer response, between the surface and 30 metres deep.

The calculated $\overline{V}_{S30}$ value of the actual site is 158.0 m/s (cf. Table 2), corresponding to the Site Class “E”. It must be noted that very low seismic velocities were calculated for the clayey materials, from approximately 1.5 to 12 metres deep. Some low seismic velocities were also calculated from the surface to approximately 1.5 metres deep, and from approximately 12 to 21 metres deep.

CONCLUSION

Geophysical surveys were carried out on a vacant field located east of the intersection of Innes Road and Trim Road, in Ottawa (ON), to identify the Site Class. The seismic surveys used the MASW and the SPAC analysis, and the seismic reflection method to calculate the $\overline{V}_{S30}$ value. Its calculation is presented at Table 2.

The $\overline{V}_{S30}$ value of the actual site is 158 m/s, corresponding to the Site Class “E” ($\overline{V}_{S30} <$ 180 m/s), as determined through the MASW and SPAC methods, Table 4.1.8.4.A of the NBC, and the Building Code, O. Reg. 332/12. It must be noted that very low to low seismic values were calculated from the surface to approximately 21 metres deep. A geotechnical assessment of the corresponding materials should be produced for the potential of liquefaction, the clay degree of sensitivity, and possibly other critical parameters.

It must also be noted that other geotechnical information gleaned on site; including the presence of liquefiable soils, very soft clays, high moisture content etc. (cf. Table 4.1.8.4.A of the NBC) can supersede the Site classifications provided in this report based on the $\overline{V}_{S30}$ value.

The V_S values calculated are representative of the in-situ materials and are not corrected for the total and effective stresses.

Hoping the whole to your satisfaction, we remain yours truly.

Jean-Luc Arsenault, M.A.Sc., P.Eng.
Senior Project Manager

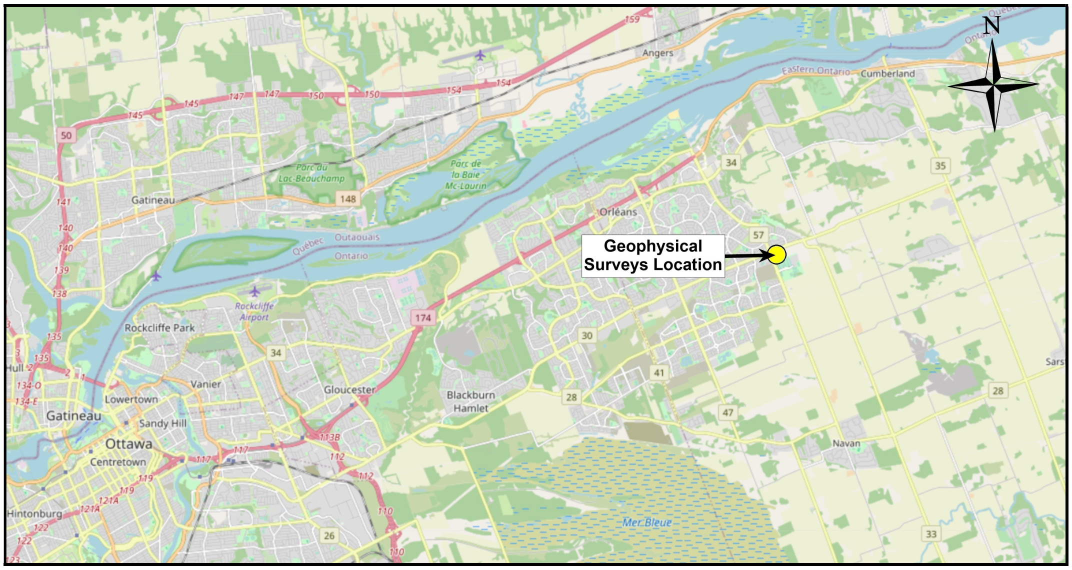

Figure 1: Regional location of the Site
(source: *OpenStreetMap©*)

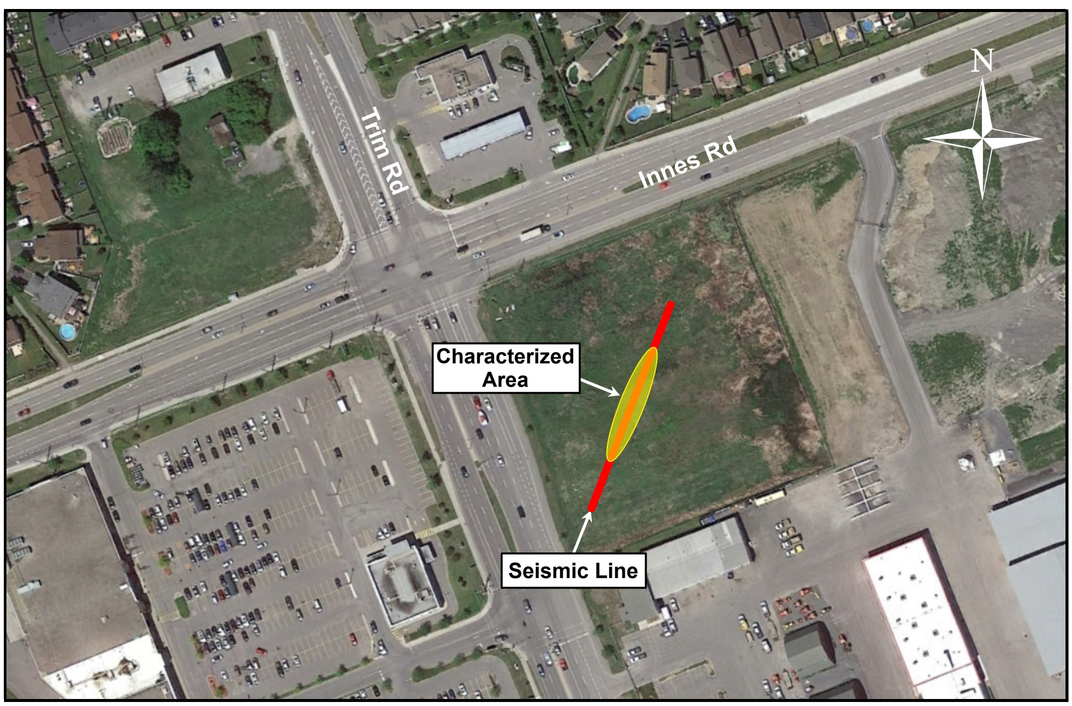

Figure 2: Location of the Seismic Lines
(source: *Google Earth™*)

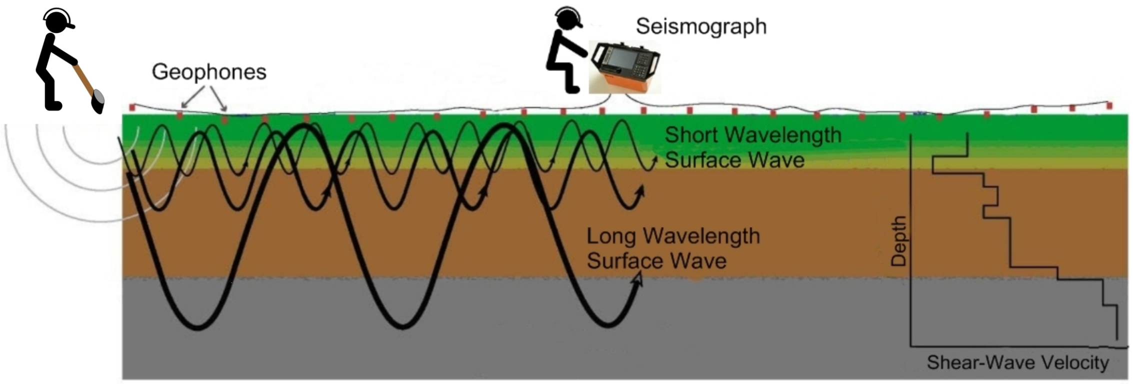

Figure 3: MASW Operating Principle

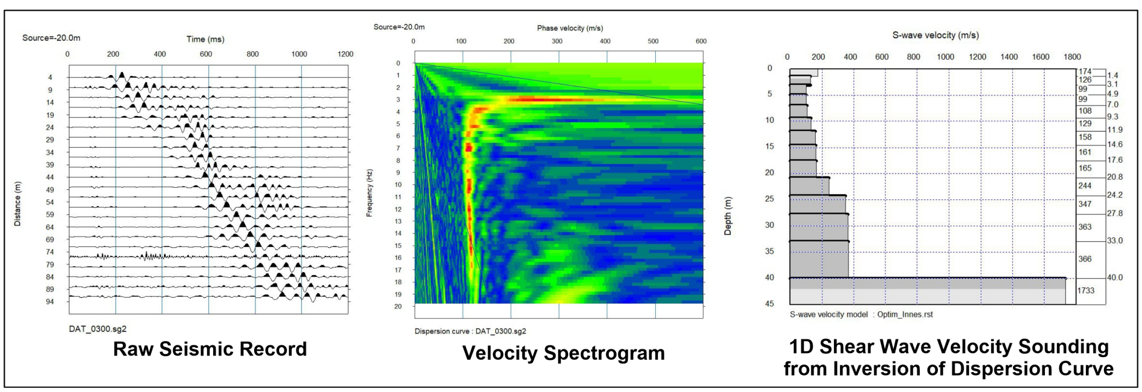

Figure 4: Example of a MASW/SPAC record, Rayleigh wave Velocity - Frequency Dispersion Curve and resulting 1D Shear Wave Velocity Model

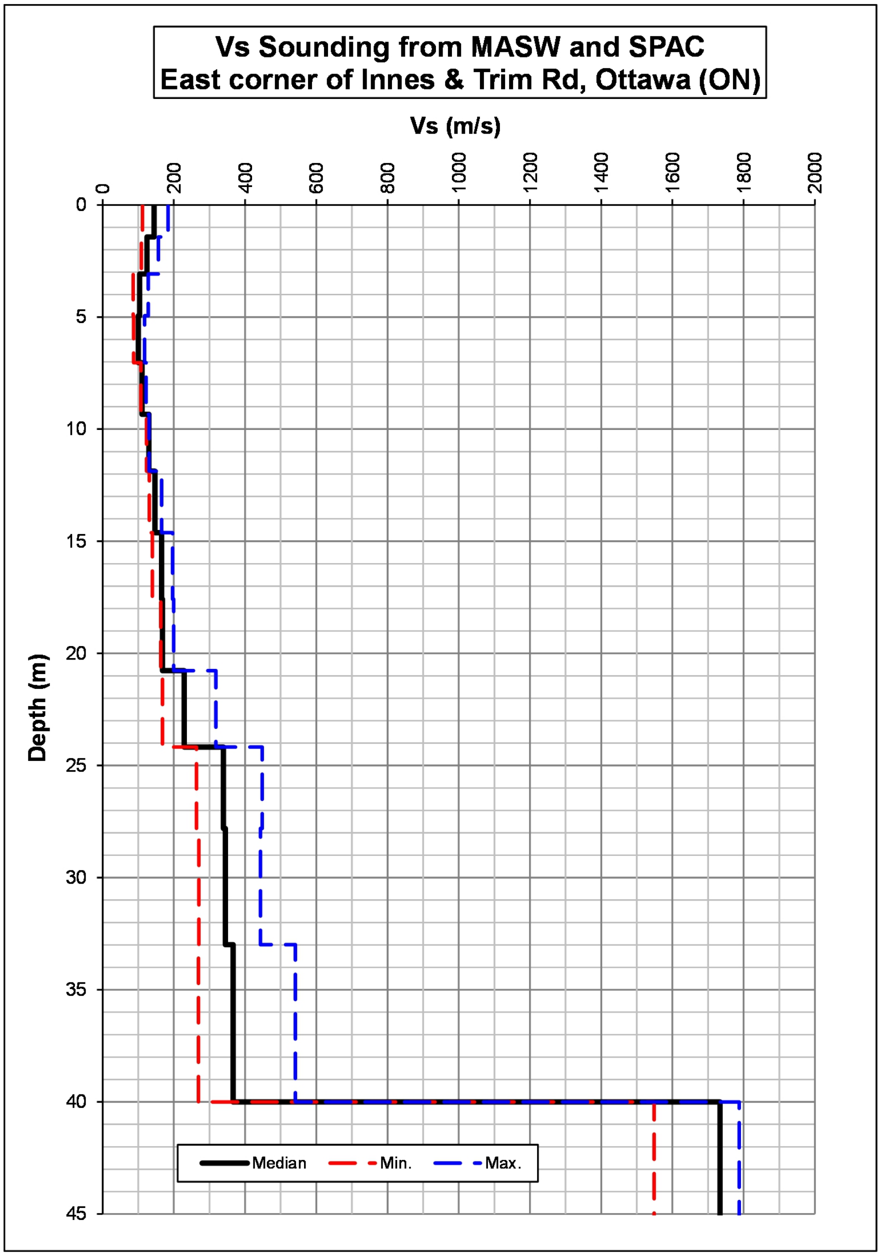

Figure 5: MASW Shear-Wave Velocity Sounding

TABLE 1

Calculated V_S values

Depth (m)		Vs (m/s)		
from	to	Min.	Median	Max.
0	1.43	111.5	144.7	183.6
1.43	3.08	108.7	124.3	156.5
3.08	4.95	85.7	104.0	128.3
4.95	7.03	87.1	100.4	118.0
7.03	9.34	107.6	110.4	122.0
9.34	11.87	123.0	129.9	130.7
11.87	14.62	131.0	147.0	165.6
14.62	17.58	139.5	165.6	196.5
17.58	20.77	163.2	167.7	199.7
20.77	24.18	168.2	228.9	318.0
24.18	27.80	263.4	339.3	447.8
27.80	32.98	270.1	344.4	443.0
32.98	40.00	269.0	366.6	541.2
40.0	plus	1548.3	1733.6	1787.5

TABLE 2

V_{S30} Calculation for the Site Class (actual site)

Depth	Vs			Thickness	Cumulative Thickness	Delay for Med. Vs	Cumulative Delay	Vs at given Depth
	Min.	Median	Max.					
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	**111.5**	**144.7**	183.6	**Grade Level (April 26, 2021)**				
1.43	**108.7**	**124.3**	**156.5**	1.43	1.43	0.009875	0.009875	144.7
3.08	**85.7**	**104.0**	**128.3**	1.65	3.08	0.013258	0.023133	133.0
4.95	**87.1**	**100.4**	**118.0**	1.87	4.95	0.017971	0.041104	120.3
7.03	**107.6**	**110.4**	**122.0**	2.09	7.03	0.020788	0.061893	113.6
9.34	**123.0**	**129.9**	**130.7**	2.31	9.34	0.020911	0.082804	112.8
11.87	**131.0**	**147.0**	**165.6**	2.53	11.87	0.019464	0.102268	116.0
14.62	**139.5**	**165.6**	196.5	2.75	14.62	0.018695	0.120963	120.8
17.58	**163.2**	**167.7**	199.7	2.97	17.58	0.017914	0.138877	126.6
20.77	**168.2**	228.9	318.0	3.19	20.77	0.019001	0.157878	131.6
24.18	263.4	339.3	447.8	3.41	24.18	0.014881	0.172759	139.9
27.80	270.1	344.4	443.0	3.63	27.80	0.010687	0.183446	151.6
30				2.20	30.00	0.006382	0.189828	158.0

V_{S30} (m/s)	**158.0**
Class	**E [(1)]**

(1) Conditional to geotechnical assessment results of the materials associated with the very low to low seismic velocity values, for the potential of liquefaction, the clay degree of sensitivity, and/or other critical parameters.