



**Proposed Bell Conduit Crossing Under Highway 401  
West of Simcoe Street South  
Oshawa, Ontario**

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## 1. Introduction

This report presents the results of a Geotechnical Investigation carried out for the proposed Bell conduit crossing under Highway 401 in Oshawa, Ontario.

The site is located in the area of Simcoe Street South and Highway 401 in the City of Oshawa, Ontario. It is understood that the proposed Bell crossing will be installed by Horizontal Directional Drilling (HDD) trenchless techniques under Highway 401. Based on preliminary project information, a bore pit will each be located on the north and south sides of Highway 401. The distance between the bore pits will be about 160 m in length. The proposed installation will be a 760 mm casing with an approximate invert depth of at least 9 m below the existing Highway 401 grade.

The purpose of this geotechnical investigation was to determine the subsurface soil and groundwater conditions at the site by drilling two (2) boreholes on each side of Highway 401 along the proposed crossing alignment, and based on this information, to provide an engineering report with geotechnical comments and recommendations pertaining to the proposed installation.

The information contained in this report in no way reflects on the environmental aspects of the soils, which has not been addressed as this is beyond our terms of reference. Should specific information be required, additional drilling and/or testing may be required.

The comments and recommendations given in this report are based on the assumption that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or the requirement of additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

## 2. Procedure

The fieldwork for this investigation was carried out on December 18 and 19, 2019. A total of four (4) sampled boreholes (Boreholes 1, 2, 3 and 4) were drilled at the approximate locations shown on the attached Borehole Location Plan (Drawing No. 1).

The boreholes were advanced to about 8.2 to 14.0 m below existing ground surface, using a drill rig adapted for soil sampling purposes owned and operated by a specialist drilling contractor.

In each borehole, representative samples of the subsurface overburden soils were recovered at regular intervals using conventional 50 mm O.D. split barrel sampler driven in accordance with Standard Penetration Test procedures (ASTM D1586). Water level observations were carried out in the open boreholes during the course of the fieldwork. Subsequent water level observations were carried out in a piezometer installed in each borehole.

A Dynamic Cone Penetration Test (DCPT) was also carried out in Borehole 1 from about 3.7 m and in Borehole 2 from about 6.1 m below existing ground surface. This test consists of driving a 51 mm diameter, 60 degree apex Steel Cone, attached to the drill rods into the undisturbed ground by applying the same energy as in the SPT method. The number of blows required to advance the cone for each 300 mm (1 foot) is recorded and the result of the test is a continuous record of driving resistance which indicates variations in the relative density (compactness condition) of the subsurface deposits.

Prior to the commencement of drilling operations, underground services were cleared to minimize the risk of contacting any such services during the drilling operations. A representative of EXP was present throughout the drilling operations to monitor and direct the drilling and sampling operations, logged the borings, made groundwater observations during and upon completion of drilling, processed the recovered samples and prepared the borehole logs. All recovered samples were returned to EXP's Brampton laboratory for testing which included moisture content and unit weight determinations on selected samples.

The locations of the boreholes were determined in the field by EXP Services Inc. based on markings of the Bell alignment and bore pit locations by surveyors retained by the client. The top of borehole elevations were derived from SOKKIA TopNET Live RTK Network with the use of a SOKKIA GCX3 Controller.

### 3. Surface Conditions

#### 3.1 Soil

The detailed soil profile encountered in each borehole and the results of laboratory moisture content determinations are indicated on the attached borehole logs. It should be noted the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change.

The "Notes on Sample Descriptions" preceding the borehole logs form an integral part of and should be read in conjunction with this report.

The following is a brief description of the soil conditions encountered during the investigation:

##### 3.1.1 Topsoil

Topsoil cover of about 100 to 150 mm in thickness was encountered at the ground surface at all borehole locations.

##### 3.1.2 Fill

Fill, comprising sandy silt to clayey silt, was encountered below the topsoil cover at all borehole locations. The fill material is brown to dark grey/black in colour, contains a trace of sand and gravel. Some organic inclusions with occasional brick fragments were noted in the recovered fill samples. The fill has a moisture content ranging from about 10 to 37 percent of dry mass and extends to depths of about 1.5 to 5.5 m below existing ground surface (El. ~95.7 to 91.2 m).

##### 3.1.3 Silty Clay

The fill is underlain by a silty clay deposit in Boreholes 1, 2 and 3. The silty clay is brown to grey in colour and contains a trace of sand. With recorded 'N'-values of 7 to 26, the silty clay has a firm to very stiff consistency. The silty clay extends to depths of about 4.0, 5.5 and 5.5 m below existing grade in Boreholes 1, 2 and 3 (El. ~93.2, 90.2 and 90.3 m), respectively.

Atterberg Limits tests were carried out on two (2) selected silty clay samples. The test results are presented in Appendix A and summarized in Table 1 below.

**Table 1: Summary of Atterberg Limits**

Sample	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	Sample Description
BH 1 SS5	3.0 – 3.7	56	20	36	Inorganic clays of high plasticity
BH 3 SS6	4.6 – 5.2	35	16	19	Inorganic clays of low plasticity

### 3.1.4 Sandy Silt to Silty Sand

A sandy silt to silty sand deposit was encountered below the silty clay in Boreholes 1 to 3 and below the fill in Borehole 4. This deposit is generally grey in colour and contains a trace of gravel with occasional clay seams. The sandy silt to silty sand has a moisture content ranging from about 6 to 21 percent of dry mass. With recorded 'N'-value of 4 to over 100, the sandy silt to silty sand is in a loose to very dense state. All boreholes were terminated in the sandy silt to silty sand deposit at approximate depths of 8.2 to 14.0 m below existing grade (El. ~88.4 to 81.7 m).

Six (6) Grain Size and Hydrometer analysis were carried out on selected soil samples. The test results are presented in Appendix A and summarized in Table 2 below.

**Table 2: Summary of Grain Size Analysis**

Sample	Depth (m)	Gravel	Sand	Silt	Clay	Sample Description
BH 1 SS6	4.6 – 5.2	6.4	37.9	44.1	11.6	Sand and Silt, some clay, trace gravel
BH 2 SS7	6.1 – 6.7	9.8	37.0	38.2	15.0	Sand & Silt, trace clay, trace gravel
BH 2 SS8	7.6 – 8.2	8.0	47.6	33.7	10.7	Silty Sand, some clay trace gravel
BH 3 SS7	6.1 – 6.7	9.5	34.1	37.4	19.0	Sandy Silt, some clay, trace gravel
BH 3 SS8	7.6 – 8.2	11.5	50.3	28.9	9.3	Silty Sand, some gravel, trace clay
BH 4 SS9	7.6 – 8.2	11.8	47.8	30.6	9.8	Silty Sand, some gravel, trace clay

## 3.2 Groundwater Conditions

Groundwater conditions were assessed by taking readings in open holes during the course of the fieldwork and in a piezometer installed in each borehole. Short-term groundwater level observations are recorded on the attached borehole logs and summarized in Table 3 below.

***It should be noted that the ownership, maintenance and decommissioning of the piezometers is the responsibility of the client. When the piezometers are no longer required, they must be decommissioned in accordance with the procedure outlined in the Ontario Water Resources Act – R.R.O. 1990, Regulation 90 – Amended to O. Reg. 128/03.***

**Table 3: Summary of Observed Groundwater Levels**

Borehole Number	Date of Completion	Depth to Groundwater Level Below Existing Grade/Elevation (m)		
		On Completion	December 25, 2019	January 2, 2020
1	December 18, 2019	~1.8 / ~95.2	~2.1 / 95.1	~2.0 (~95.2)
2	December 18, 2019	~3.0 / ~92.7	~5.6 / ~90.1	~5.5 / ~90.2
3	December 19, 2019	~11.1 / ~84.7	~1.2 / ~94.6	~1.2 / ~94.6
4	December 19, 2019	~6.9 / ~89.8	~5.4 / 91.3	~5.5 / 91.2

It should be noted that the water levels observed in wet season will likely be higher than those observed above.

Seasonal fluctuations in groundwater levels at the site should be anticipated.



## 4. Geotechnical Assessment

This section of the report provides discussions and geotechnical recommendations for the proposed Bell conduit installation crossing under Highway 401 west of Simcoe Street West in Oshawa. It is understood that the tunnel diameter will be about 760 mm and the length will be about 160 m between the bore pits. The tunnel liner invert level will be set at a minimum of 9 m below the existing Highway 401 grades.

The interpretations are based on factual data presented in this report.

### 4.1 Expected Ground Condition along Pipe Alignment

The following ground conditions are evident from the investigation data:

- a) The soil conditions at the proposed crossing horizon under Highway 401 consists of loose to very dense sandy silt to silty sand.
- b) Groundwater seepage is expected to be within the zone where the proposed Bell conduit invert will be located.

Given the soil and groundwater conditions, soft ground trenchless methods maybe used to install the proposed conduit.

The proposed Bell crossing horizon under Highway 401 will be confined in the sandy silt to silty sand deposit below the observed groundwater levels. Based on the preliminary design information, the invert level of the pipe between Boreholes 2 and 3 will range from approximately 87.0 to 89.0 m. At this level, the sandy silt to silty sand can be considered as “flowing” in accordance with the Tunnelman’s Ground Classification for Soils shown in Table 4. Tunnelling in this material will require full and immediate roof and face support at all times. The appropriate use of soil conditioning agents, (e.g. adding bentonite slurry, foam or polymers and combinations thereof) and possible pre-consolidation ground improvement, are essential measures for controlled tunnelling through the “flowing” soils. During tunnelling through the “flowing” soils, it will be necessary to closely monitor the spoil consistency and adjust the type and amount of conditioner to ensure that the material has the proper consistency to balance earth and water pressures so as to minimize the potential for flowing ground. The flowing ground condition at the tunnel face could result in over-excavation and consequent surface settlement. The non-cohesive soils and glacial derived soils will be abrasive, and therefore foaming agents and polymers are required for soil conditioning to reduce abrasion and consequent machine wear.



**Table 4: Tunnelman's Ground Classification for Soil<sup>1</sup>**

Classification		Behaviour	Typical Soil Types
Firm	-	Heading can be advanced without initial support, and final lining can be constructed before ground starts to move.	Loess above water table; hard clay, marl, cemented sand and gravel when not highly overstressed.
Raveling	Slow raveling	Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed, due to loosening or to over-stress and "brittle" fracture (ground separates or breaks along distinct surfaces, opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes, otherwise the ground is slow raveling.	Residual soils or sand with small amounts of binder may be fast raveling below the water table, slow raveling above. Stiff fissured clays may be slow or fast raveling depending upon degree of overstress.
	Fast raveling		
Squeezing	-	Ground squeezes or extrudes plastically into tunnel, without visible fracturing or loss of continuity, and without perceptible increase in water content. Ductile, plastic yield and flow due to overstress.	Ground with low frictional strength. Rate of squeeze depends on degree of overstress. Occurs at shallow to medium depth in clay of very soft to medium consistency. Stiff to hard clay under high cover may move in combination of raveling at excavation surface and squeezing at depth behind surface.
Running	Cohesive -running	Granular materials without cohesion are unstable at a slope greater than their angle of repose (approx. 30° -35°). When exposed at steeper slopes they run like granulated sugar or dune sand until the slope flattens to the angle of repose.	Clean, dry granular materials. Apparent cohesion in moist sand, or weak cementation in any granular soil, may allow the material to stand for a brief period of raveling before it breaks down and runs. Such behavior is cohesive-running.
	running		

Classification		Behaviour	Typical Soil Types
Flowing	-	A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as from the face, crown, and walls, and can flow for great distances, completely filling the tunnel in some cases.	Below the water table in silt, sand, or gravel without enough clay content to give significant cohesion and plasticity. May also occur in highly sensitive clay when such material is disturbed.
swelling	-	Ground absorbs water, increases in volume, and expands slowly into the tunnel.	Highly preconsolidated clay with plasticity index in excess of about 30, generally containing significant percentages of montmorillonite.

## Notes:

1. From U.S. Department of Transportation Federal Highway Administration (2009). Technical Manual for Design and Construction of Road Tunnels – Civil Elements. Publication No. FHWA-NHI-10-034.

It will be difficult to control volume losses at the tunnel face (and the consequential settlements) in the non-cohesive soils below the groundwater table. Generally, flowing and / or running materials will tend to collapse onto the shield of the Tunnel Boring Machine (TBM) immediately behind the cutter head into the over-cut annulus created by the difference between the TBM excavation diameter and the shield diameter. This convergence will lead to higher surface settlements, independent of maintaining earth pressure balance target pressures at the tunnel face and within the TBM chamber and screw conveyor. Any proposed machine should be adequately equipped to deal with such expected ground conditions.

## 4.2 Trenchless Installation Method

As mentioned before we understand that tunneling is considered for the installation of the Bell conduit under Highway 401. We also understand that two (2) bore pits, one on either side of Highway 401, will be excavated for launching and receiving the proposed conduit.

Based on the results of the investigation, it is our opinion that trenchless methods will be feasible for installing the proposed conduit. The procedures should follow OPSS 450 and industrial standards. The advantages, disadvantages and ranking of trenchless methods considered to be applicable at this site are presented in Table 5 for completeness. We understand that HDD has been selected as the preferred approach.

**Table 5: Trenchless Installation Methods Comparison and Ranking**

Installation Method	Advantages	Disadvantages	Rank
Jack and Bore	<ul style="list-style-type: none"> <li>Handles wide variety of ground conditions</li> <li>Minimal surface disruption</li> <li>Very accurate (slope of 0.2% easily achieved)</li> <li>Relative simple operation</li> <li>Common use in Ontario</li> <li>Short mobilization time</li> <li>Suitable for steel pipes up to 1.8 m in diameter</li> </ul>	<ul style="list-style-type: none"> <li>Requires large area for jacking shaft and support equipment</li> <li>Relatively high construction costs</li> <li>Obstructions problematic</li> <li>Short and long term settlement</li> <li>Fluid to support annular space</li> <li>Pipe can be difficult to steer/direct</li> <li>Dewatering required along route</li> </ul>	3
Horizontal Directional Drilling (HDD)	<ul style="list-style-type: none"> <li>Handles wide variety of ground conditions</li> <li>Steerable both horizontally and vertically to maintain and adjust alignment</li> <li>Does not require staging pits if site is able to accommodate maximum entry and exit angles</li> <li>Suitable for tunneling under groundwater table</li> <li>Local contractors available</li> <li>Short mobilization time</li> <li>Rapid drilling</li> <li>Only minor settlement if fluid well controlled</li> <li>Suitable for installation of pipes up to 1.5 m in diameter and longer lengths</li> </ul>	<ul style="list-style-type: none"> <li>Potential for inadvertent drilling returns</li> <li>Requires drilling fluid to maintain the bore which could allow subsidence</li> <li>May require longer bore or staging pits</li> <li>Obstructions problematic, but alignment can be adjusted to avoid obstructions</li> </ul>	1
Microtunneling Technique	<ul style="list-style-type: none"> <li>Handles wide variety of ground conditions</li> <li>Steerable horizontally to maintain and adjust alignment</li> <li>Suitable for tunneling under groundwater table</li> <li>Alignment can be adjusted to avoid obstructions</li> <li>Suitable for installation of pipes with minimum 1.5 m in diameter and 150 m length</li> </ul>	<ul style="list-style-type: none"> <li>Obstructions problematic</li> <li>Requires large area for jacking shaft and support equipment</li> <li>Requires sophisticated equipment</li> </ul>	2

### 4.3 Tunneling using HDD

Due to the varying vertical alignment of the Bell conduit, constructing the tunnel through the fill, silty clay and silty sand to sandy silt using HDD is considered feasible. HDD can drill up to about 1,500 m in length with steering capacity for typical pipe diameters ranging between 100 mm and 1,500 mm. The diameter of the proposed tunnel constructed by HDD for the proposed conduit is expected to be around 760 mm. Primary support is not required, as a drilling fluid is used for temporary support and transportation of the cuttings. The risk of loss of drilling fluid is minimal since the tunnel is at least 3 m below the road grade of the Highway 401 and located primarily within a compact to very dense sandy silt to silty sand deposit. High density polyethylene pipes can be utilized at this site.

Directional drilling is a two-step process. First, a small diameter pilot hole is drilled the entire length of the proposed pipeline. Behind the bit, the motor is powered by bentonite slurry, which is pumped through the drill string from the bore entrance. The slurry acts as a lubricant and helps force the soil back to the surface. After the pilot hole is complete, pulling back reaming tools, from the pipe insertion point to the rig side, enlarges the pilot hole. To achieve the appropriate bore size it may be necessary to perform several reaming operations. Generally, all reaming procedures prior to the actual product installation are referred to as pre-reams, and the final ream to which the product pipe is attached is referred to as the back-ream. After the pre-reams, the pulling head and connecting product pipe are attached to the reamer using a swivel, a device that isolates the product pipe from the rotation of the drill pipe. The product pipe is then pulled behind the final reamer back through the directional drill path to the exit pit on the rig side. Ontario Provincial Standards Specifications (OPSS 450), Construction Specifications for Pipeline and Utility Installation by HDD should be applied during construction.

According to OPSS 450 the work site for pipeline installation in soil by HDD should be graded or filled to provide a level working areas for the drilling rig. However, if the space for the entry and exit points is restricted so bore entry and exit angles exceed the recommended values in ASTM F1962-11 (bore entry angles should be in the range of 8° to 20° from the ground surface, while bore exit angles should be relatively shallow; preferably 10°) the bore would be initiated from bore pits.

One of the risks associated with directional drilling is the escape of drilling mud into the environment as a result of a spill, tunnel collapse or the rupture of mud to the surface, commonly referred to as “frac-out”. Frac-outs are caused when excessive drilling pressure results in drilling mud propagating vertically toward the surface. The risk of frac-outs can be reduced through proper mix design and careful monitoring.

The drilling fluid used for the HDD operation should be selected by the HDD contractor taking into account that the drilling fluid should be able to:

- transport all drill cuttings to the surface;
- cleaning off build-up on drill bits and reamer cutters;
- cooling the downhole tools;
- lubricating to reduce the friction between the product pipe and the bore wall; and,
- stabilize the bore path against squeezing by exerting a positive hydraulic pressure against the bore wall.

Proper control of the gel strength is important to minimize the possibility of hydrofracture caused by excessive downhole pressures.

The possible presence of cobbles within the sandy silt to silty sand deposit along the tunnel alignment might create problems for directional drilling construction as well. A high torque capacity boring machine will help in breaking down cobbles and boulders.

Contractors bidding on this project should be required to submit their bore plan and methodology, including specifications for drilling fluid, maximum and minimum pressures utilized for excavation during the HDD process, prevention of hydrofracturing, locations of relief pits, drilling fluid recycling and disposal plan, emergency measures and materials to be used in case of hydrofracture etc., for review by the geotechnical engineer. All components of the drilling fluid must meet the requirements of ANSI (American National Standard Institute) Certified 60.

#### 4.4 Bore Pits

Based on preliminary project information, it is anticipated that the bore pits will be excavated to about 5.0 m below existing grade, i.e. El. ~92.0 m assuming the existing grade is at El. 97.0 m. The excavation for the pits will require shoring and excavation support to conduct work safely, protect surrounding site features and limit the area impacted by construction.

Boreholes 1 and 4 were drilled in the vicinity of the bore pits located to the south and north of Highway 401, respectively. Native sandy silt to silty sand and fill were expected at the bottom of the South and North bore pits, respectively. Based on short term water level observations in the piezometers installed, the bottom of the South bore pit is expected to be below the observed groundwater level and the North bore pit bottom will be above. A base slab protecting the subgrade soil at the pit bottom should therefore be considered. It is recommended that the groundwater should be depressed to at least 1 m below the bottom of the pits to facilitate excavation and construction.



#### 4.4.1 Excavation

The excavations for the bore pits will extend through fill, native silty clay and into the underlying sandy silt to silty sand deposit. Excavation of the South bore pit will extend below the observed groundwater level and groundwater is anticipated at about the base of the North bore pit.

Open cut excavation can be considered if space constraint is not an issue at the pit locations. The side slopes should be cut as per the OSHA regulations. The fill and silty clay can both be considered as Type 3 soil. The sandy silt to silty sand below groundwater table would be considered as Type 4 soil.

If shoring is considered, the overburden soil can be supported by steel sheet piles. The sheet piles should be designed for the lateral earth pressure given in Section 4.4.2 of this report. Alternatively, soldier piles and lagging schemes can be considered. Based on the observed water levels, dewatering will be required at the South bore pit location. The design and installation of temporary shoring is the responsibility of the Contractor.

The overburden materials may be excavated with large conventional equipment such as a mechanical backhoe. It should be noted that obstructions may be encountered in the fill stratum. Provisions must be made in the excavation contract for the removal of possible obstructions.

To facilitate excavation and construction, the groundwater should be temporarily depressed to at least 1 m below the base of the pits. Dewatering will be required prior to excavating the bore pits to reduce groundwater seepage and soil collapse into the excavation. The dewatering system should be designed by an engineer specializing in such system. The system should be installed, operated, maintained and monitored by competent personnel.

Even with positive dewatering system, minor water seepage should be expected in the sandy silt to silty sand deposit or fill. This minor seepage can be handled, if necessary, by pumping from properly constructed and filtered sumps located within the bore pits. ***It should be noted that groundwater control measures that extract more than 50,000 L/day of water would be subjected to a Permit to Take Water (PTTW), as regulated by the Ministry of the Environment, Conservation and Parks (MECP).***



#### 4.4.2 Lateral Earth Pressure

Temporary shoring should be designed using the state-of-the-practice information presented in the fourth edition of the Canadian Foundation Engineering Manual. The excavation support system should be designed to resist earth pressure of the soils and hydrostatic pressure. The shoring design and construction should be carried out by a specialist contractor.

The lateral earth pressure, water and surcharge loadings acting on pits walls may be calculated from the following equation:

$$p = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2$$

where	$p$	=	unfactored lateral earth pressure in kPa acting at depth $h$ ;
	$K$	=	earth pressure coefficient a value of 0.55 is recommended (lateral yielding not allowed);
	$\gamma$	=	unit weight of retained soil, a value of 22 kN/m <sup>3</sup> may be assumed
	$h_1$	=	depth in metres above the water table
	$\gamma'$	=	effective unit weight of soil, a value of 12 kN/m <sup>3</sup> may be assumed
	$\gamma_w$	=	unit weight of water (10 kN/m <sup>3</sup> )
	$h_2$	=	depth in metres below the water table; and
	$q$	=	equivalent value of surcharge on the ground surface in kPa

The parameters recommended for horizontal earth pressures are for horizontal back slopes. For sloping backfill, the design requirements outlined in Section C6.91(c) of the Canadian highway Bridge Design Code should be used.

The final shoring design should be prepared by a shoring designer/contractor. It is not possible to comment on specific design details until this design is completed. Unless otherwise advised, support of excavation walls, ground adjacent to anticipated construction activity and structures adjacent to the construction, must be provided by the contractor.

The shoring system must be designed for the worst condition that might apply. The foregoing comments are for general guidance only. It is recommended that the shoring construction be inspected continuously by qualified personnel.

Technical specifications must ensure that the Contractor submits a groundwater and surface water control plan describing the proposed method for control. EXP will be pleased to review and comment on the contractor's proposed dewatering system.

#### 4.4.3 Backfilling

It is anticipated that backfilling work will be required at any pits to return site condition to pre-construction grades. The following comments and recommendations are provided for backfilling such excavations.

Based on the available borehole information, and laboratory tests, the excavated soils will consist of fill, silty clayey and sandy silt to silty sand. This natural on-site excavated soil can be used as backfill, provided the material is within 2 percent of optimum moisture as determined in the standard proctor test. All excavations should be backfilled with inorganic on-site soils placed in maximum 300 mm thick lifts and compacted to at least 98 percent standard Proctor maximum dry density (SPMDD). Any organic, excessively wet, or otherwise deleterious material should not be used for backfilling purposes. Any shortfall of suitable on-site excavated material can be made up with imported and approved materials. For ease of compaction and quality control, importation of granular fill such as Ontario Provincial Standard Specifications (OPSS) 1010 granular 'B' is recommended where structural backfill is required.

All backfill and compaction operations should be monitored by qualified geotechnical personnel to approve material, to evaluate placement operations, and to verify that the specified degree of compaction is being achieved throughout the fill. The drill mud in the annular space should be permitted to solidify to provide support for the pipe and surrounding soils.

If the excavated areas are located within Ministry of Transportation Ontario's (MTO) right-of-ways, the backfilling should be carried out to satisfy MTO specifications/requirements. Unshrinkable fill may be required by MTO for backfilling excavated areas.

#### 4.5 Monitoring and Contingency Plans

Settlement around the tunnel would be due ground loss or "immediate" settlement caused by tunneling. The immediate settlement is a direct result of the overcut and movement of ground at the heading during tunneling. The factors that influence the immediate settlement include the soil strength and the method of tunneling. Based on soil characteristics of the site, an experienced contractor should be able to keep the settlement under 10 mm. Technical specifications should ensure that:

- The use of over-cutters (excavating to a diameter greater than the pipe diameter) is kept under 10 mm;
- The overcut area is grouted in a timely manner; and
- The program of instrumentation is carried out as per MTO guidelines.

## 5. Instrumentation and Monitoring

### 5.1 General

Settlements should be monitored during construction to ensure compliance with MTO guidelines and the contract requirements. The instrumentation program should adequately verify effects of tunneling on the overlying highway and obtain advance warning of ground movements. The scope and layout of settlement instruments should be in general accordance with the MTO guidelines (Settlement Monitoring Guideline – Tunneling). This should include a series of surface monitoring points placed at a maximum spacing of 5 metres along the entire length of the proposed tunnel. All monitoring points located in the unpaved portion of the right-of-way are to be founded below the frost penetration depth, which is typically 1.2 metres in this area.

A reading schedule should be as follows:

- A minimum two (2) sets of readings prior to construction.
- A minimum of three (3) sets of readings each day during construction provided the movements are within the anticipated limits. Otherwise, the reading frequency may have to be increased.
- Monitoring of movements is required during work stoppages, such as non-operation periods (off-shifts) or weekends, where a minimum of 3 sets of reading shall be taken daily.
- Following the completion of the installation, reading must be taken once per day for seven (7) days and then weekly for one month.
- The frequency of monitoring at any stage can be adjusted based on the magnitude of movements observed during and after the completion of installation.

Instrumentation plans should be finalized once the contractor and installation method are selected. The instrumentation plans and monitoring schedule should be submitted to the MTO for final approval.

Control of ground settlement on this project depends on the behavior of soil at the tunnel face and on the tunneling methodology employed by the contractor. It is recommended that the volume of the material removed from the tunnel be monitored and continuously compared to the rate of tunnel advance. This would provide some indication if any over-excavation was taking place.

## 5.2 Criteria for Assessment of Roadway Subsidence

The criteria for evaluation of settlement should be based on the following action levels:

1. *Review Level:* If a maximum value of 10 mm relative to the baseline readings is reached, the method, rate or sequence of construction, or ground stabilization measures shall be reviewed or modified to mitigate further ground displacements.
2. *Alert Level:* If a maximum of 15 mm relative to the baseline readings is reached, the contractor shall be required to cease construction operation or to execute pre-planned measures to secure the site to mitigate further unacceptable settlement and to assure safety of public.

## 6. Closure

This report was completed for Tolossi Group Inc. to assess the subsoil conditions for the proposed crossing. Our comments are restricted to the site evaluated and the topics discussed. The comments and recommendations given in this report are based on the assumption that the current design concept as described above will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications from a geotechnical viewpoint.

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

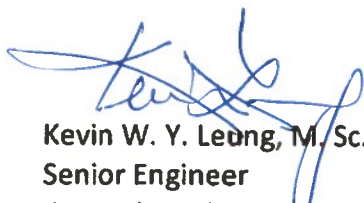
The information contained in this report in no way reflects on the environmental aspects of the soils. More specific information with respect to the conditions between samples, or the lateral and vertical extent of materials may become apparent during excavation operations. The interpretation of the borehole information must, therefore, be validated during excavation operations. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent; should this occur, EXP Services Inc. should be contacted to assess the situation and additional testing and reporting may be required. EXP Services Inc. has qualified personnel to provide assistance in regards to future geotechnical issues related to this property.

EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations in the report.


We trust this report is satisfactory for your purposes. Should you have any questions or comments, please do not hesitate to contact this office.

Yours truly,

EXP Services Inc.

  
Kevin W. Y. Leung, M. Sc., P. Eng.  
Senior Engineer  
Geotechnical Division



  
Peter T.L. Chan, P. Eng.  
Alternate MTO Designated Contact  
Vice President, Geotechnical Division



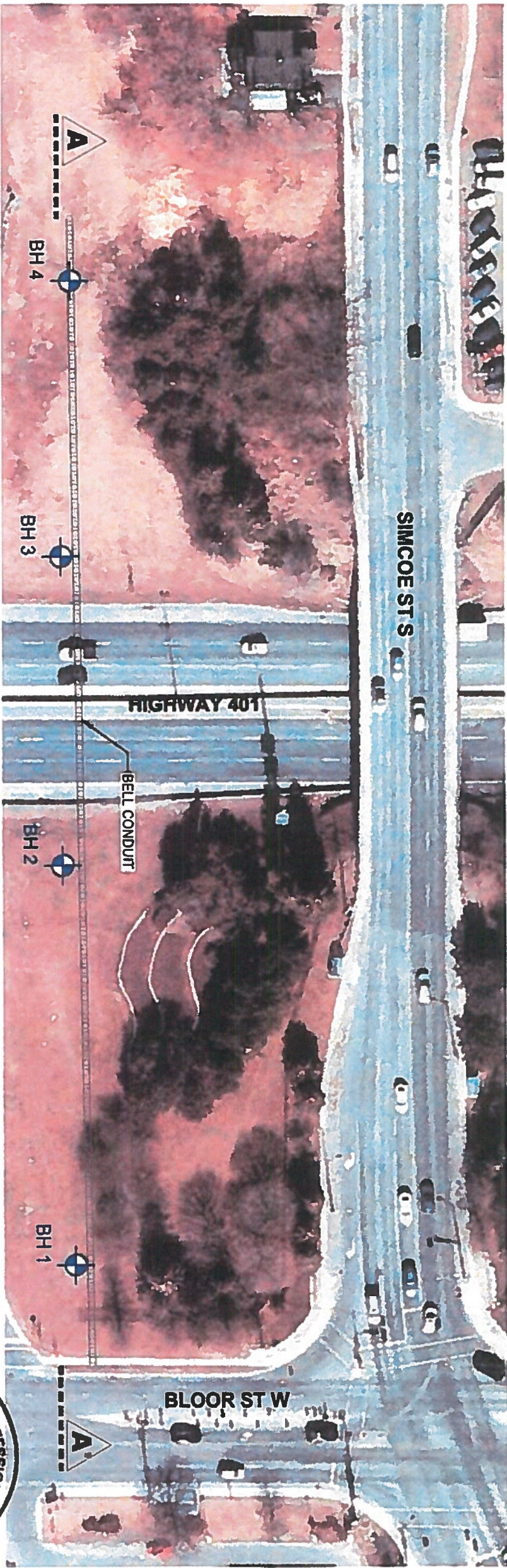
## Drawings

Borehole Location Plan

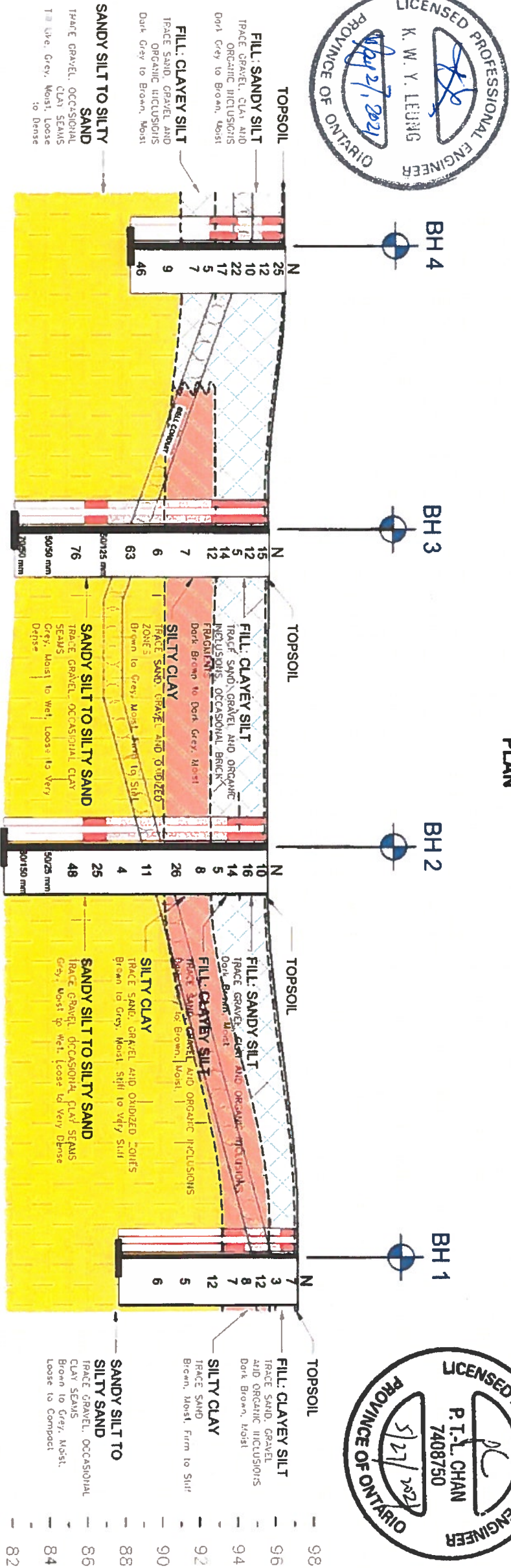
Borehole Logs



METRIC  
DIMENSIONS ARE IN METERS AND/OR  
MILLIMETERS UNLESS OTHERWISE SHOWN  
STATIONS ARE IN KILOMETERS +METERS



PLAN



SECTION A-A

DIRECTIONAL DRILLING OF BELL CONDUIT  
CROSSING HIGHWAY 401 WEST OF SIMCOE  
STREET SOUTH  
OSHAWA, ONTARIO



BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET  
1

exp. EXP Services Inc.



LEGEND

- Borehole Location (2019)  
Standard Penetration Test (Blow/30.3 m)  
Groundwater Level in Piezometer  
Piezometer

SIMPLIFIED STRATIGRAPHY

- TOPSOIL  
SILTY CLAY  
FILL  
SANDY SILT TO SILTY SAND

BH No	ELEV	COORDINATE (DECIMAL DEGREES)	LONGITUDE	LATITUDE
BH 1	97.2	-78.856577	43.886526	43.881063
BH 2	95.7	-78.856643	43.887025	43.881516
BH 3	95.8	-78.857025	43.881516	43.881063
BH 4	96.7	-78.857107	43.881063	43.881063

NOTES

- The boundaries and soil type have been established only at the borehole locations. Between boreholes the boundaries are assumed and may be subject to considerable error.
- Soil samples will be retained in storage for 3 months and then destroyed unless the client advises otherwise.
- Topsoil quantities and/or volume of unsuitable fill should not be established from the information provided at the borehole locations.
- Borehole elevations should not be used to design building(s) or floor slab(s) or parking lot(s) grades.
- The drawing is to be read with subject report, project number as shown below.
- See report for site data.
- Soil test locations are approximate.
- Dimension shown on this drawing are in metric units, unless otherwise noted.

SCALE



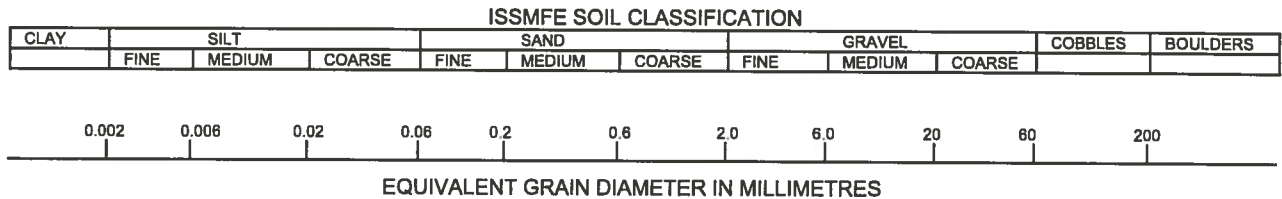
PROJECT NO. BRM-00607084-AD  
SUBNO. JA CHECKED KL DATE 2021-05-26  
DRAWN JA CHECKED KL APPROVED KL DWG. 1



## Notes On Sample Descriptions

## Drawing 1A

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by EXP Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.



CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

**UNIFIED SOIL CLASSIFICATION**

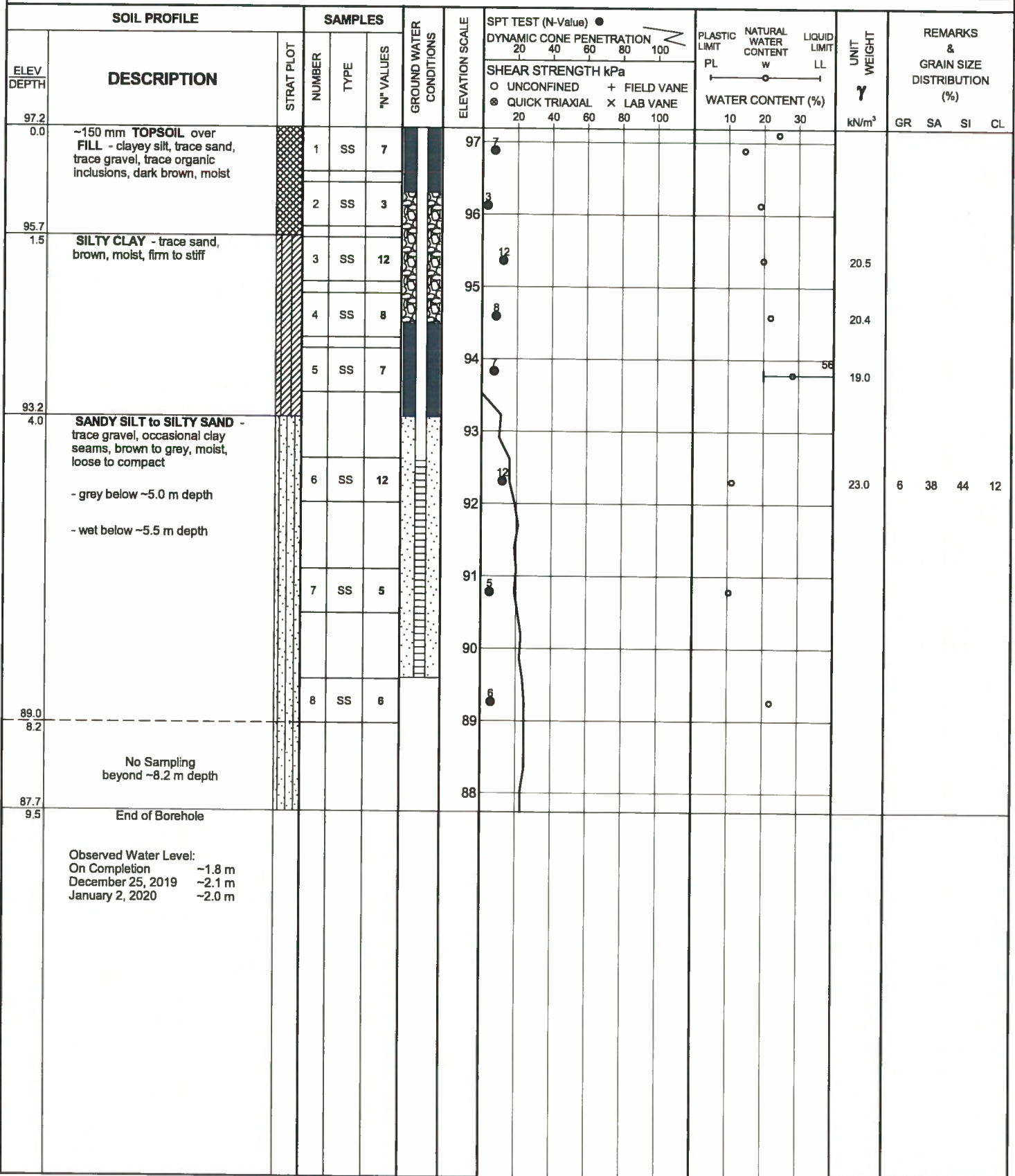
2. **Fill:** Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.
3. **Till:** The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

# RECORD OF BOREHOLE No 1

SHEET 1 OF 1

**METRIC**

**PROJECT NO.** BRM-00607084-BD      **LOCATION** Bell Crossing Highway 401 West of Simcoe Street, Oshawa      **ORIGINATED BY** DP  
**North:**      **East:**      **BOREHOLE TYPE** Solid Stem Augers      **COMPILED BY** KL  
**DATUM** Geodetic      **DATE** 12/18/2019 - 12/18/2019      **CHECKED BY** KL



+ 3, x 3. Numbers refer to      ○ 3% STRAIN AT FAILURE  
Sensitivity

## RECORD OF BOREHOLE No 2

SHEET 1 OF 1

METRIC

PROJECT NO. BRM-00607084-BD

LOCATION Bell Crossing Highway 401 West of Simcoe Street, Oshawa

ORIGINATED BY DP

North: East:

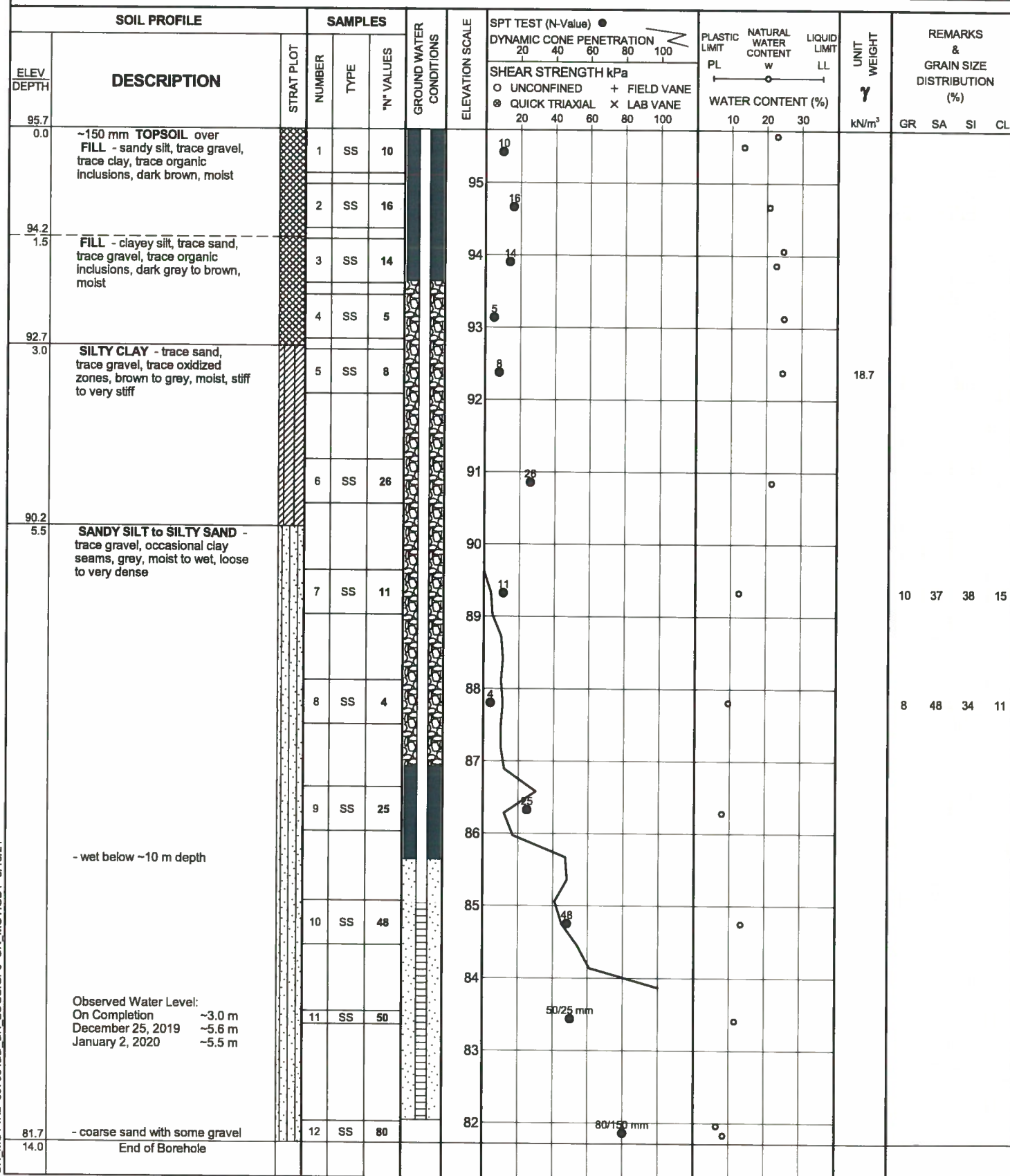
BOREHOLE TYPE Hollow Stem Augers

COMPILED BY KL

DATUM Geodetic

DATE 12/18/2019 - 12/18/2019

CHECKED BY KL



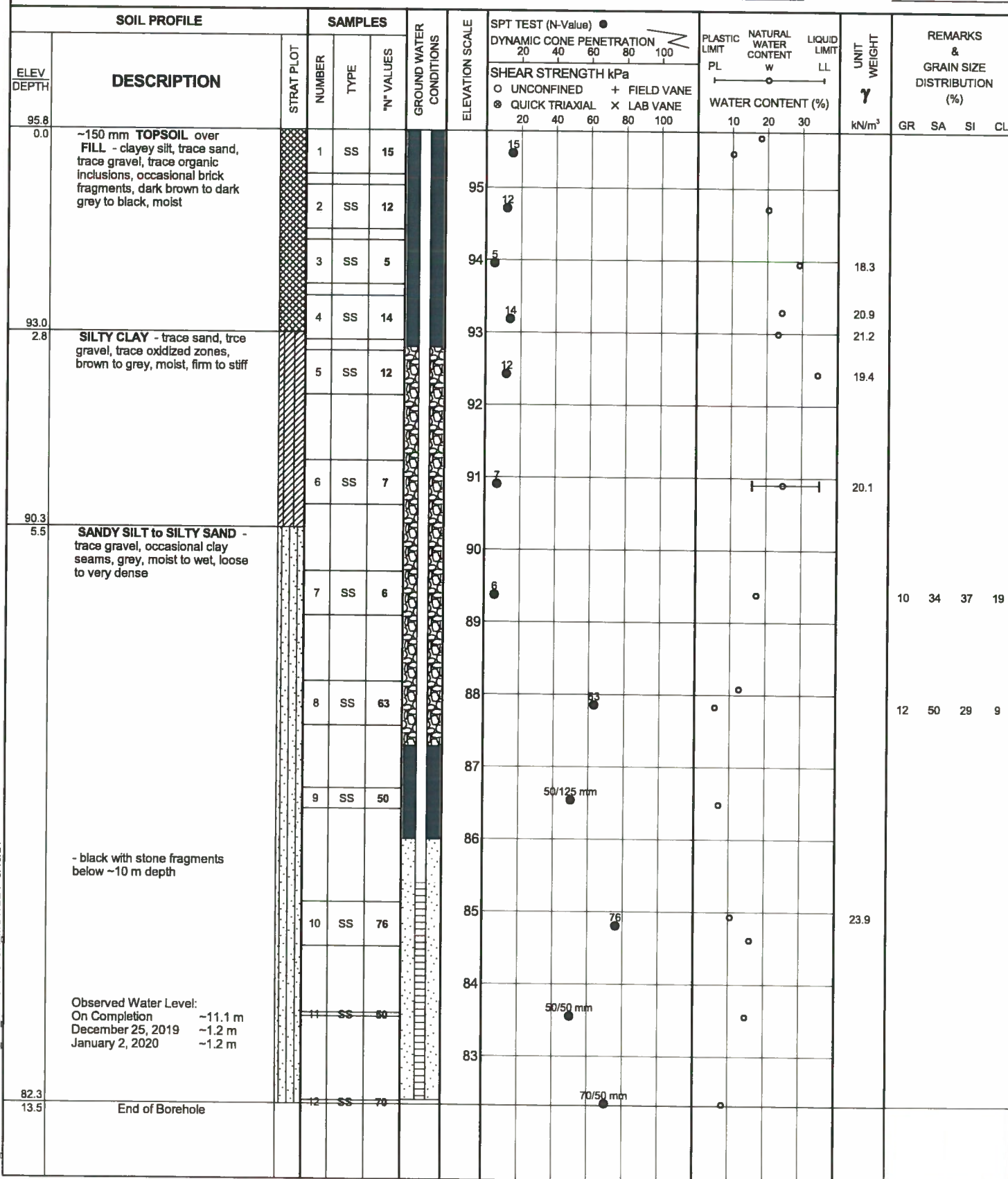
+ 3 × 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No 3

SHEET 1 OF 1

METRIC

PROJECT NO. BRM-00607084-BD LOCATION Bell Crossing Highway 401 West of Simcoe Street, Oshawa ORIGINATED BY DP  
 North: \_\_\_\_\_ East: \_\_\_\_\_ BOREHOLE TYPE Hollow Stem Augers COMPILED BY KL  
 DATUM Geodetic DATE 12/19/2019 - 12/19/2019 CHECKED BY KL



+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON MOT4KL 607084BD\_BH LOGS.GPJ ON MOT.GDT 5/19/21



# RECORD OF BOREHOLE No 4

SHEET 1 OF 1

**METRIC**

PROJECT NO. BRM-00607084-BD

LOCATION Bell Crossing Highway 401 West of Simcoe Street, Oshawa

ORIGINATED BY DP

North: \_\_\_\_\_ East: \_\_\_\_\_

BOREHOLE TYPE Solid Stem Augers

COMPILED BY KL

DATUM Geodetic

DATE 12/19/2019 - 12/19/2019

CHECKED BY KL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● DYNAMIC CONE PENETRATION		PLASTIC LIMIT PL	NATURAL WATER CONTENT w	LIQUID LIMIT LL	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100						WATER CONTENT (%)
96.7 0.0	~100 mm <b>TOPSOIL</b> over <b>FILL</b> - sandy silt, trace gravel, trace clay, trace organic inclusions, dark gray to brown, moist		1	SS	25		96	25					20.8	GR SA SI CL	
			2	SS	12		95	12							
	- trace peat		3	SS	10		94	10							20.7
			4	SS	22		93	22							23.2
			5	SS	17		92	17							
93.0 3.7	<b>FILL</b> - clayey silt, trace sand, trace gravel, trace organic inclusions, dark gray to black, moist		6	SS	5		91	5							
			7	SS	7	90	7								
91.2 5.5	<b>SANDY SILT to SILTY SAND</b> - trace gravel, occasional clay seams, till like, grey, moist, loose to dense		8	SS	9		89	9							
			9	SS	46			46							
88.4 8.2	End of Borehole														
	Observed Water Level: On Completion ~6.9 m December 25, 2019 ~5.4 m January 2, 2020 ~5.5 m														

+ 3, X 3: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE



## Appendix A

Atterberg Limits Test Results  
Grain Size and Hydrometer Test Results



exp Services Inc.  
1595 Clark Boulevard, Brampton  
Ontario, Canada, L6T 4V1  
Telephone: (905) 793-9800  
Fax: (905) 793-0641

# Plasticity Index Test Report

ST03

Project No.: BRM-00609068-A0

Sample Number: 334646-3

Date Sampled: December 18, 2019

Date Received: December 19, 2019

Sample Location: Depth: 3.0 - 3.7 m

Date Reported: December 23, 2019

Borehole No: BH1 / SS5

## Liquid Limit

Trial Number	1	2	3	4	
Number of Blows	42	28	18		
Moisture Tin No.	2	10	11		
Mass of Soil and Tin, g	27.480	26.389	27.397		
Mass of Dry Soil and Tin, g	23.782	22.491	23.480		
Mass of Tin, g	16.826	15.491	16.742		
Mass of Water, g	3.698	3.898	3.917		
Mass of Dry Soil, g	6.956	7.000	6.738		
Water Content	53.2%	55.7%	58.1%		

## Plastic Limit

Trial Number	1	2	3
Moisture Tin No.	12	13	14
Mass of Soil and Tin, g	24.537	24.996	27.420
Mass of Dry Soil and Tin, g	23.005	23.602	25.636
Mass of Tin, g	15.399	16.674	16.681
Mass of Water, g	1.532	1.394	1.784
Mass of Dry Soil, g	7.606	6.928	8.955
Water Content	20.1%	20.1%	19.9%

## Summary of Results

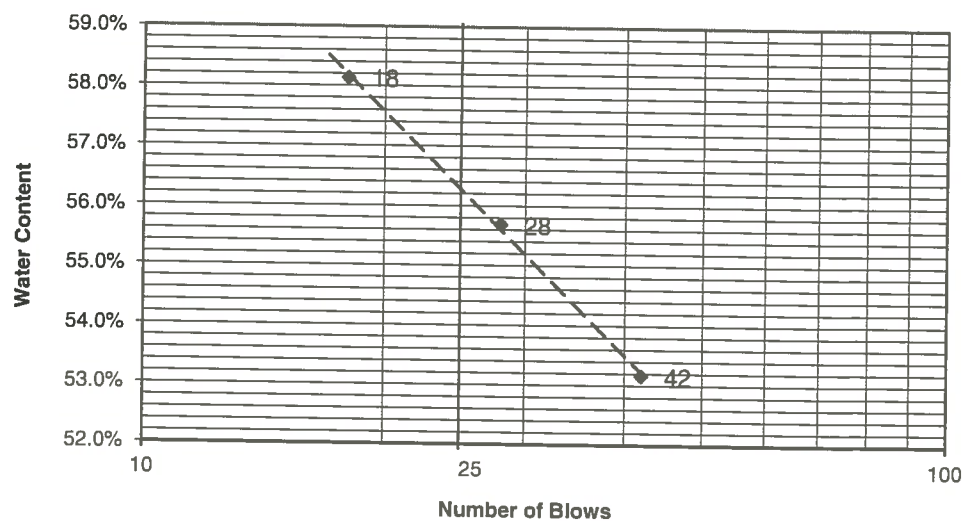
Liquid Limit (LL): 56

Plastic Limit (PL): 20

Plasticity Index (PI): 36

CH

## Flow Curve



Tested By: **AP**

Checked By:   
**Arcadio Petrola, CET**  
Senior Lab. Technician



exp Services Inc.  
1595 Clark Boulevard, Brampton  
Ontario, Canada, L6T 4V1  
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Fax: (905) 793-0641

# Plasticity Index Test Report

ST03

Project No.: BRM-00609068-A0

Sample Number: 334756-3

Date Sampled: December 19, 2019

Date Received: December 20, 2019

Sample Location: Depth: 4.6 - 5.2 m

Date Reported: December 23, 2019

Borehole No: BH3 / SS6

## Liquid Limit

Trial Number	1	2	3	4	
Number of Blows	39	23	13		
Moisture Tin No.	4	5	7		
Mass of Soil and Tin, g	26.401	27.745	28.127		
Mass of Dry Soil and Tin, g	23.703	24.894	25.039		
Mass of Tin, g	15.503	16.647	16.800		
Mass of Water, g	2.698	2.851	3.088		
Mass of Dry Soil, g	8.200	8.247	8.239		
Water Content	32.9%	34.6%	37.5%		

## Plastic Limit

Trial Number	1	2	3
Moisture Tin No.	25	28	29
Mass of Soil and Tin, g	31.534	27.951	26.539
Mass of Dry Soil and Tin, g	29.508	26.252	25.205
Mass of Tin, g	16.631	15.601	16.676
Mass of Water, g	2.026	1.699	1.334
Mass of Dry Soil, g	12.877	10.651	8.529
Water Content	15.7%	16.0%	15.6%

## Summary of Results

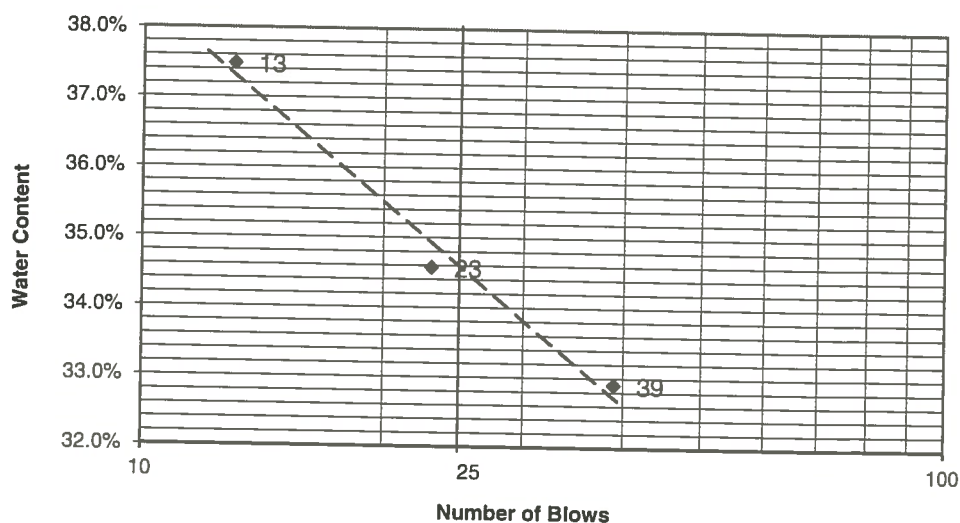
Liquid Limit (LL): 35

Plastic Limit (PL): 16

Plasticity Index (PI): 19

CL

## Flow Curve



Tested By: **AP**

Checked By:   
**Arcadio Petrola, CET**  
Senior Lab. Technician



exp Services Inc.  
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Ontario, Canada, L6T 4V1  
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Fax: (905) 793-0641

# Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 334744-1

Report No.: 1

Date Reported: 23-Dec-19

Project No.: brm-00607084-bd

Project Name: GEO KL-Bell Crossing Hwy 401 at Simcoe Street South,  
Oshawa, Ontario-Geotechnical Investigation

## Grain Size Proportion (%)

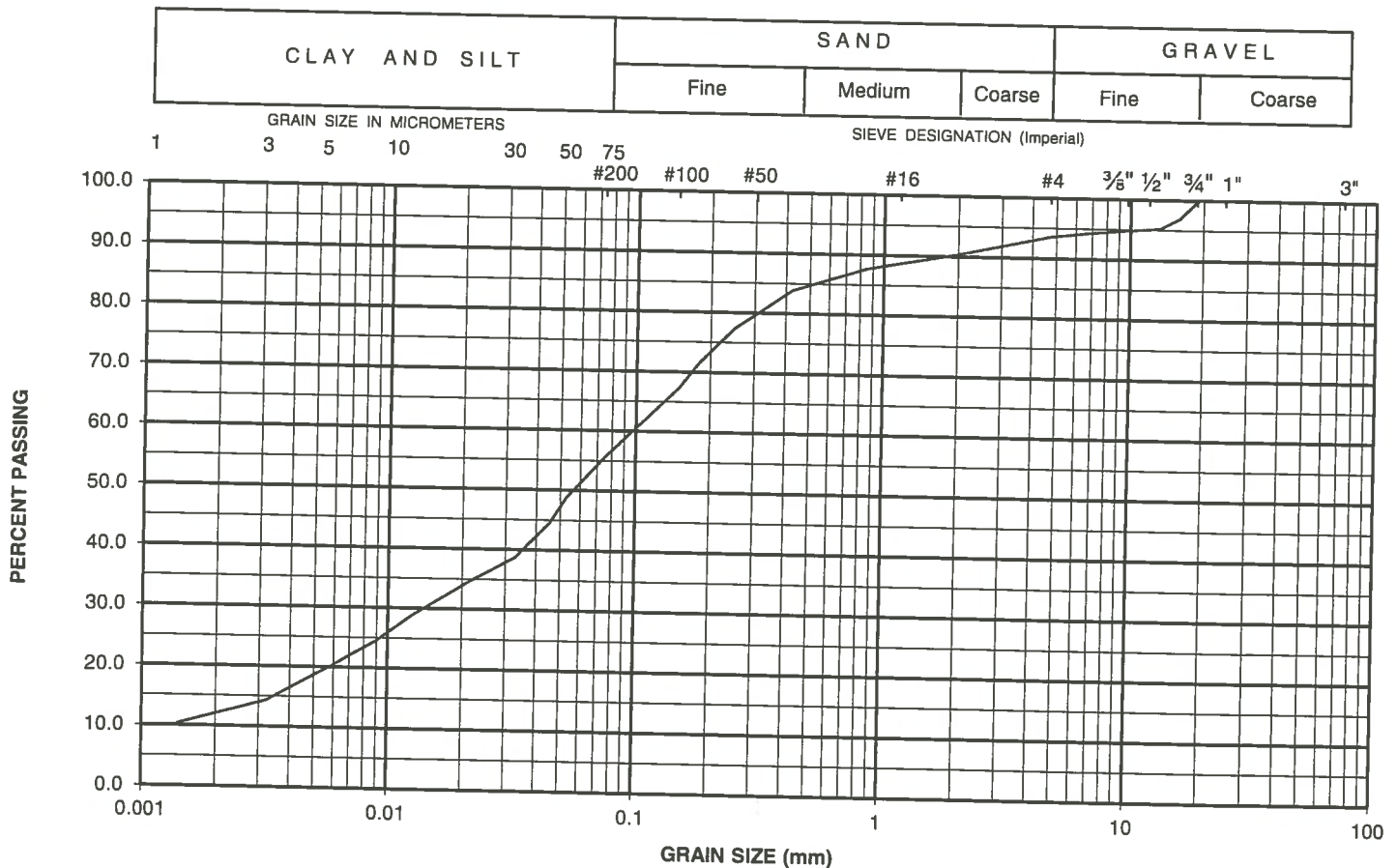
Gravel (> 4.75mm):	6.4
Sand (> 75µm, < 4.75mm):	37.9
Silt (> 2µm, < 75µm):	44.1
Clay (< 2µm):	11.6
Total:	100.0

## Sample Information

Location: BH 1  
Sample Method: SS  
Sample No.: 6  
Depth: 4.6 - 5.2 m  
Sample Description: Silt and Sand, some Clay; trace Gravel; Brown  
Sampled By: exp Brampton  
Sampling Date: 12/18/2019  
Date Received: 12/19/2019  
Client Sample ID:  
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0327	38.7
22.4	100.0	0.0210	34.4
19	100.0	0.0124	28.7
16	97.0	0.0089	24.4
13.2	95.2	0.0063	20.9
9.5	94.8	0.0032	14.3
6.7	94.3	0.0014	10.3
4.75	93.6		
2	90.3		
0.85	87.7		
0.425	83.9		
0.25	77.4		
0.18	71.6		
0.15	67.4		
0.075	55.6		
0.053	48.8		
0.0452	44.5		

## UNIFIED SOIL CLASSIFICATION SYSTEM



Project Manager: Kevin Leung

Approved By: Original Signed By  
Willie Rodych, Lab Supervisor

Date Approved: 23-Dec-19



exp Services Inc.  
1595 Clark Boulevard, Brampton  
Ontario, Canada, L6T 4V1  
Telephone: (905) 793-9800  
Fax: (905) 793-0641

# Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 334745-1

Report No.: 2

Date Reported: 23-Dec-19

Project No.: brm-00607084-bd

Project Name: GEO KL-Bell Crossing Hwy 401 at Simcoe Street South,  
Oshawa, Ontario-Geotechnical Investigation

## Grain Size Proportion (%)

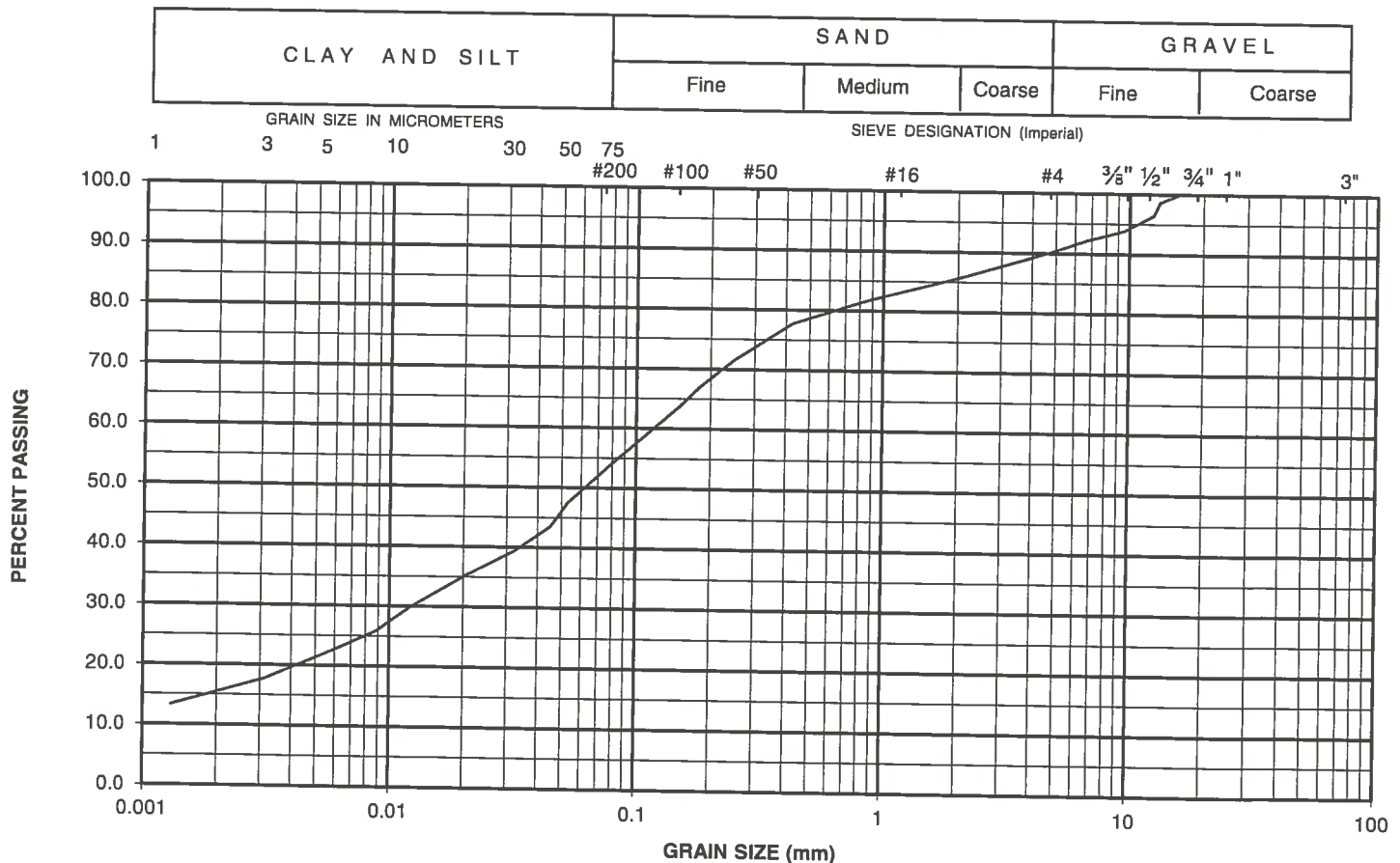
Gravel (> 4.75mm):	9.8
Sand (> 75µm, < 4.75mm):	37.0
Silt (> 2µm, < 75µm):	38.2
Clay (< 2µm):	15.0
Total:	100.0

## Sample Information

Location: BH 2  
Sample Method: SS  
Sample No.: 7  
Depth: 6.1 - 6.7 m  
Sample Description: Silt and Sand, some Clay; trace Gravel; Grey  
Sampled By: exp Brampton  
Sampling Date: 12/18/2019  
Date Received: 12/19/2019  
Client Sample ID:  
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0450	43.5
22.4	100.0	0.0323	39.4
19	100.0	0.0208	35.4
16	100.0	0.0122	29.9
13.2	98.6	0.0088	25.8
12.5	96.5	0.0063	23.1
9.5	93.9	0.0031	17.7
6.7	92.2	0.0013	13.3
4.75	90.2		
2	85.6		
0.85	81.6		
0.425	77.7		
0.25	71.6		
0.18	67.0		
0.15	63.7		
0.075	53.1		
0.053	47.5		

## UNIFIED SOIL CLASSIFICATION SYSTEM



Project Manager: Kevin Leung

Approved By: Original Signed By  
Willie Rodych, Lab Supervisor

Date Approved: 23-Dec-19



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# Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 334746-1

Report No.: 3

Date Reported: 23-Dec-19

Project No.: brm-00607084-bd

Project Name: GEO KL-Bell Crossing Hwy 401 at Simcoe Street South,  
Oshawa, Ontario-Geotechnical Investigation

## Grain Size Proportion (%)

Gravel (> 4.75mm): 8.0  
Sand (> 75µm, < 4.75mm): 47.6  
Silt (> 2µm, < 75µm): 33.7  
Clay (< 2µm): 10.7  
Total: 100.0

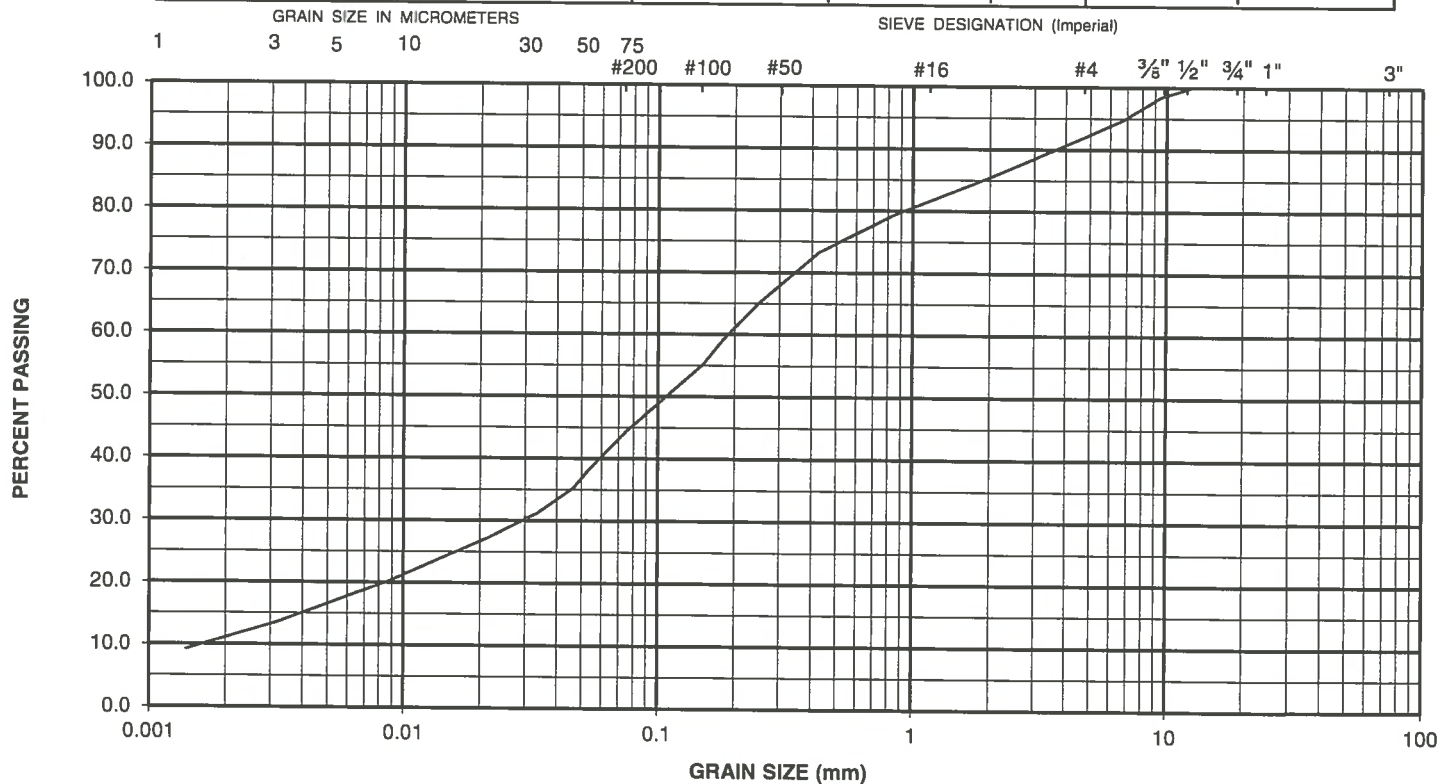
## Sample Information

Location: BH 2  
Sample Method: SS  
Sample No.: 8  
Depth: 7.6 - 8.2 m  
Sample Description: Silty Sand, some Clay; trace Gravel; Grey  
Sampled By: exp Brampton  
Sampling Date: 12/18/2019  
Date Received: 12/19/2019  
Client Sample ID:  
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0465	35.3
22.4	100.0	0.0334	31.2
19	100.0	0.0214	27.2
16	100.0	0.0126	23.1
13.2	100.0	0.0090	20.4
12.5	100.0	0.0064	18.2
9.5	98.4	0.0032	13.6
6.7	94.7	0.0014	9.2
4.75	92.0		
2	85.5		
0.85	79.4		
0.425	73.2		
0.25	65.2		
0.18	59.2		
0.15	55.2		
0.075	44.4		
0.053	38.1		

## UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Project Manager: Kevin Leung

Approved By: Original Signed By  
Willie Rodych, Lab Supervisor

Date Approved: 23-Dec-19





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Fax: (905) 793-0641

# Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 334830-1

Report No.: 4

Date Reported: 24-Dec-19

Project No.: brm-00607084-bd

Project Name: GEO KL-Bell Crossing Hwy 401 at Simcoe Street South,  
Oshawa, Ontario-Geotechnical Investigation

## Grain Size Proportion (%)

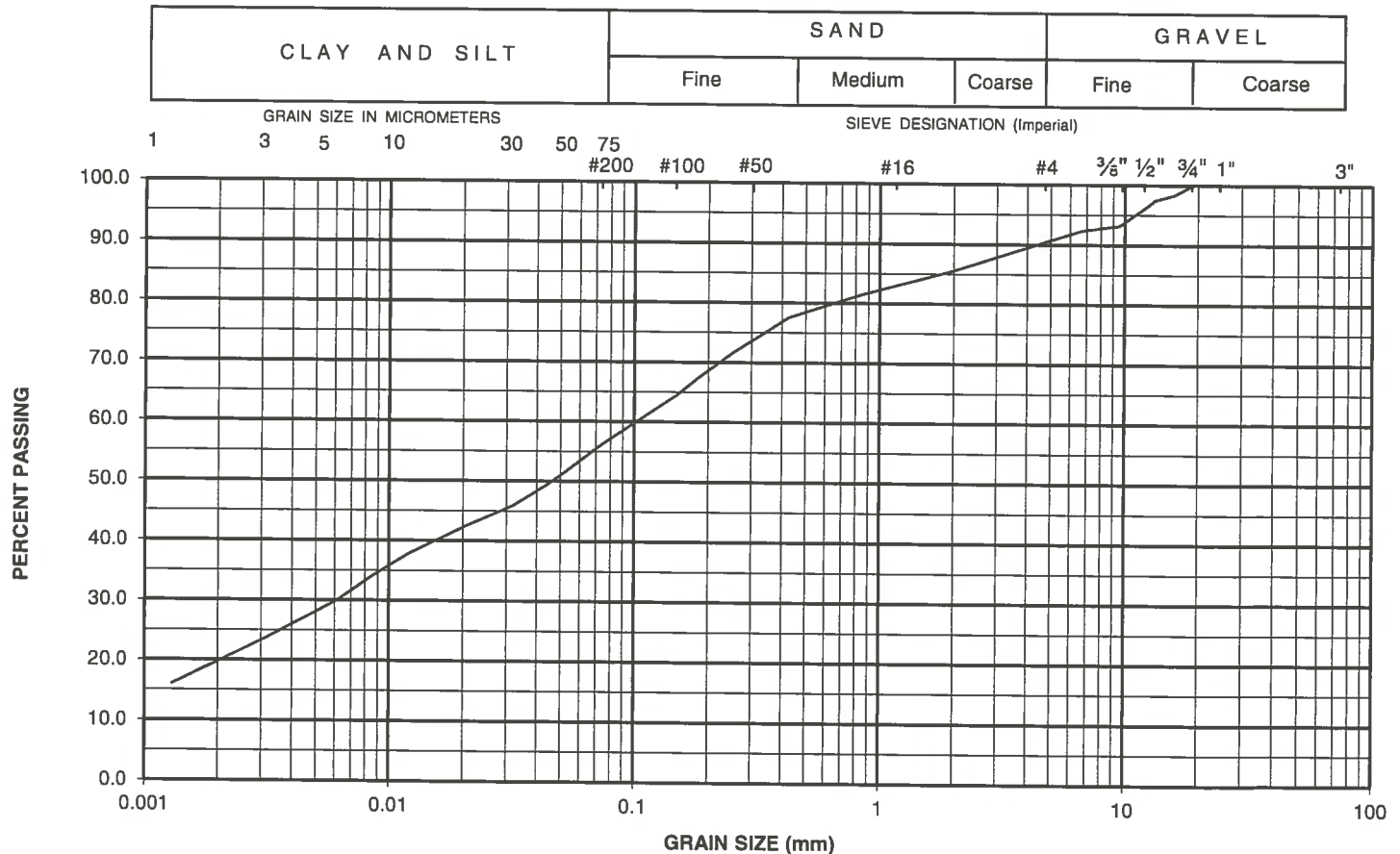
Gravel (> 4.75mm): 9.5  
Sand (> 75µm, < 4.75mm): 34.1  
Silt (> 2µm, < 75µm): 37.4  
Clay (< 2µm): 19.0  
Total: 100.0

## Sample Information

Location: BH 3  
Sample Method: SS  
Sample No.: 7  
Depth: 6.1 - 6.7 m  
Sample Description: Sandy Silt, some Clay; trace Gravel; Grey  
Sampled By: exp Brampton  
Sampling Date: 12/19/2019  
Date Received: 12/20/2019  
Client Sample ID:  
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0444	49.5
22.4	100.0	0.0319	45.9
19	100.0	0.0204	42.4
16	98.4	0.0120	37.8
13.2	97.4	0.0085	34.0
12.5	96.6	0.0061	29.9
9.5	93.2	0.0031	23.6
6.7	92.4	0.0013	16.0
4.75	90.5		
2	85.6		
0.85	81.5		
0.425	77.5		
0.25	71.5		
0.18	67.3		
0.15	64.6		
0.075	56.4		
0.053	51.8		

## UNIFIED SOIL CLASSIFICATION SYSTEM



Project Manager: Kevin Leung

Approved By: Original Signed By  
Willie Rodych, Lab Supervisor

Date Approved: 24-Dec-19



exp Services Inc.  
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Ontario, Canada, L6T 4V1  
Telephone: (905) 793-9800  
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# Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 334831-1

Report No.: 5

Date Reported: 24-Dec-19

Project No.: brm-00607084-bd

Project Name: GEO KL-Bell Crossing Hwy 401 at Simcoe Street South,  
Oshawa, Ontario-Geotechnical Investigation

## Grain Size Proportion (%)

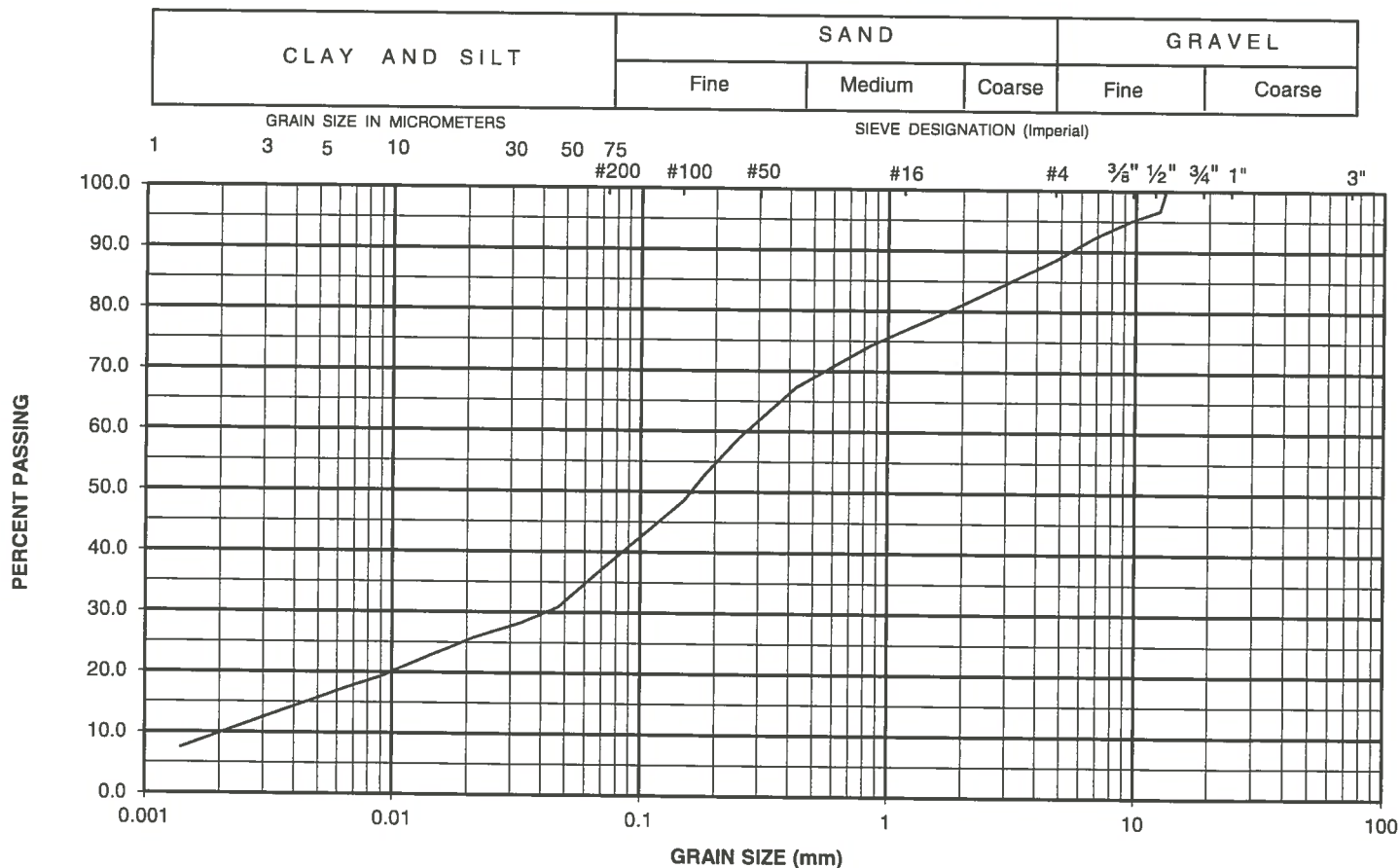
Gravel (> 4.75mm): 11.5  
Sand (> 75µm, < 4.75mm): 50.3  
Silt (> 2µm, < 75µm): 28.9  
Clay (< 2µm): 9.3  
Total: 100.0

## Sample Information

Location: BH 3  
Sample Method: SS  
Sample No.: 8  
Depth: 7.6 - 8.2 m  
Sample Description: Silty Sand, some Gravel; trace Clay; Grey  
Sampled By: exp Brampton  
Sampling Date: 12/19/2019  
Date Received: 12/20/2019  
Client Sample ID:  
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0470	30.9
22.4	100.0	0.0335	28.3
19	100.0	0.0214	25.8
16	100.0	0.0126	21.9
13.2	100.0	0.0090	19.3
12.5	96.7	0.0064	17.3
9.5	95.0	0.0032	12.9
6.7	92.2	0.0014	7.5
4.75	88.5		
2	81.1		
0.85	74.3		
0.425	67.3		
0.25	58.9		
0.18	52.7		
0.15	48.6		
0.075	38.2		
0.053	32.8		

## UNIFIED SOIL CLASSIFICATION SYSTEM



Project Manager: Kevin Leung

Approved By: Original Signed By  
Willie Rodych, Lab Supervisor

Date Approved: 24-Dec-19



exp Services Inc.  
1595 Clark Boulevard, Brampton  
Ontario, Canada, L6T 4V1  
Telephone: (905) 793-9800  
Fax: (905) 793-0641

# Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 334832-1

Report No.: 6

Date Reported: 24-Dec-19

Project No.: brm-00607084-bd

Project Name: GEO KL-Bell Crossing Hwy 401 at Simcoe Street South.  
Oshawa, Ontario-Geotechnical Investigation

## Grain Size Proportion (%)

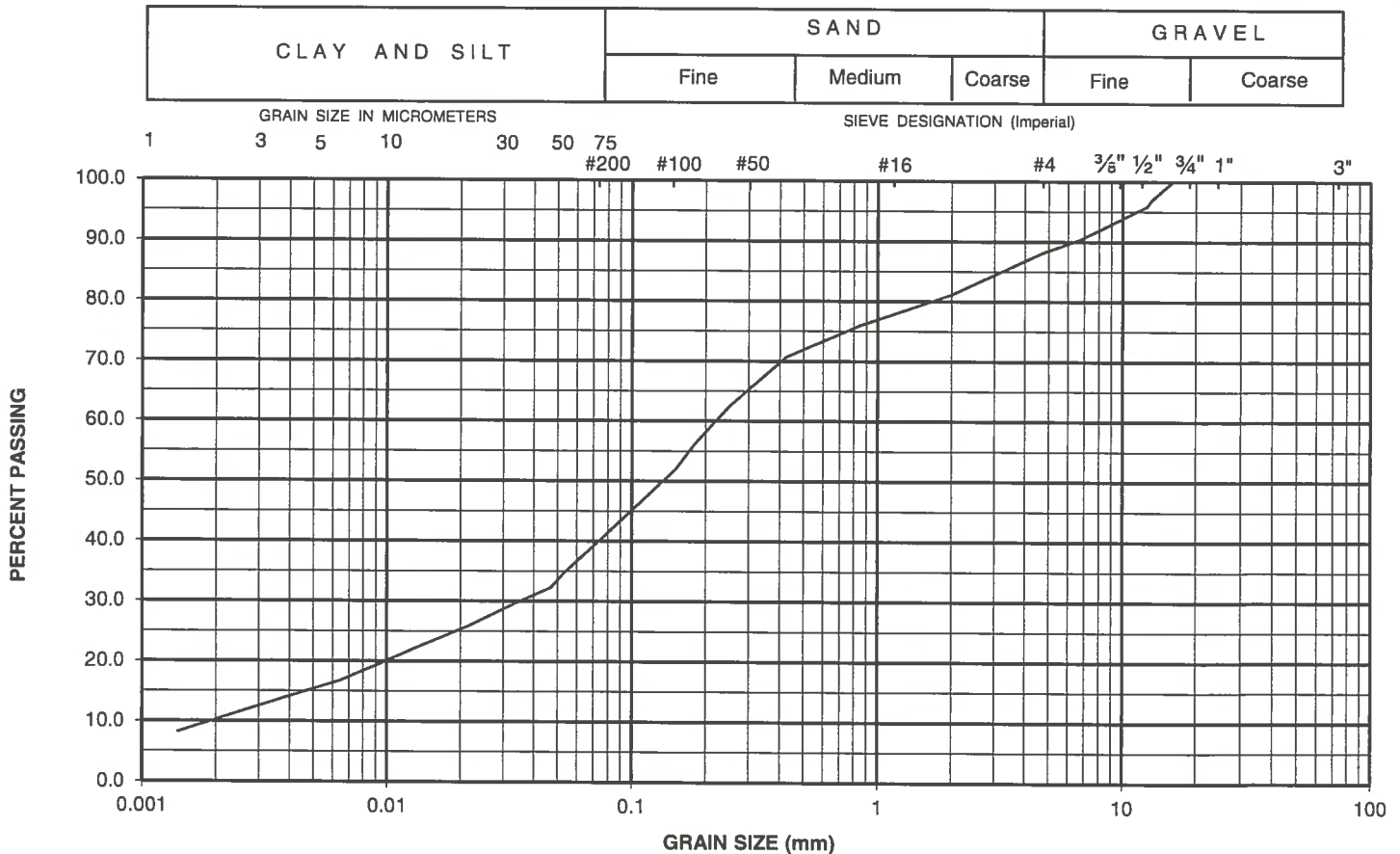
Gravel (> 4.75mm): 11.8  
Sand (> 75µm, < 4.75mm): 47.8  
Silt (> 2µm, < 75µm): 30.6  
Clay (< 2µm): 9.8  
Total: 100.0

## Sample Information

Location: BH 4  
Sample Method: SS  
Sample No.: 2  
Depth: 7.6 - 8.2 m  
Sample Description: Silty Sand, some Gravel; trace Clay; Grey  
Sampled By: exp Brampton  
Sampling Date: 12/19/2019  
Date Received: 12/20/2019  
Client Sample ID:  
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0467	32.2
22.4	100.0	0.0334	29.6
19	100.0	0.0214	25.8
16	100.0	0.0126	21.9
13.2	97.1	0.0090	19.3
12.5	95.9	0.0064	16.7
9.5	93.4	0.0032	12.9
6.7	90.4	0.0014	8.2
4.75	88.2		
2	81.1		
0.85	76.0		
0.425	70.7		
0.25	62.5		
0.18	56.2		
0.15	51.9		
0.075	40.3		
0.053	34.6		

## UNIFIED SOIL CLASSIFICATION SYSTEM



Project Manager: Kevin Leung

Approved By: Original Signed By  
Willie Rodych, Lab Supervisor

Date Approved: 24-Dec-19