REPORT

Geotechnical Exploration

Decker Creek Culvert Replacement, Thedford, Ontario

Submitted to:

The Municipality of Lambton Shores, by care of Black Creek Engineering Inc.

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Submitted by:

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Distribution List

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1.0 INTRODUCTION

This report presents the results of the geotechnical exploration and testing program carried out by WSP Canada Inc. (WSP) to support the design of the Decker Creek culvert replacement project in Thedford, Ontario, (referred to hereinafter as “the Site”). The project consists of the replacement of the existing corrugated steel pipe (CSP) culvert with a new open-footing precast concrete box culvert with precast concrete block end walls. The location of the site is shown on the Key Plan, Figure 1. The geotechnical work program was carried out in accordance with our proposed letter 2025CA395884-Rev1 dated April 24, 2025. Authorization to proceed was provided by The Municipality of Lambton Shores (The Municipality) on May 7, 2025.

The purpose of the exploration was to evaluate the subsurface soil, rock, and groundwater conditions at two test locations at the Site and summarize the results in a report providing geotechnical engineering recommendations for design of the proposed works. The preliminary design drawings dated May 14, 2025 provided by Black Creek Engineering Inc. (Black Creek) to WSP indicate that the proposed culvert will be approximately 23 m long, 4 m wide and 3m high. The approximate location of the existing and proposed culvert alignment is shown on the Borehole Location Plan, Figure 1. Based on the proposed profile, the soil cover thickness will be about 1.7 m below the travelled surface of Decker Road (Elevation 207.7 m) to the top of the concrete culvert (Elevation 206.0 m). The existing CSP culvert is assumed to be founded on shale bedrock between Elevation 202.4 m to 202.7 m.

The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. In addition, this report should be read in conjunction with the attached “Important Information and Limitations of This Report”. The reader’s attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

2.0 SITE DESCRIPTION AND GEOLOGICAL BACKGROUND

The site of the proposed culvert replacement is located on Decker Road, about 360 m west of Main Street in Thedford, Ontario. For the purposes of this report, Decker Road is assumed to be orientated in a west-east direction. The culvert alignment is nearly perpendicular to Decker Road and is considered to be oriented in a north-south direction.

The site lies within the physiographic region described in the “The Physiography of Southern Ontario, Second Edition” by Chapman and Putnam[1] as the Huron Fringe. The Huron Fringe is described as a narrow fringe of land along Lake Huron with soils predominantly characterized by boulders, gravel bars, and sand dunes interspersed with swamp lands. Based on the Ontario Department of Mines P.1065 entitled “Quaternary Geology, Southern Ontario, Parkhill Area”, the surficial soils in the immediate vicinity of the Site consist primarily of clayey silt till known as St. Joseph till. The site is reportedly underlain by Devonian-age grey limestone and shale of the Hamilton Group. Available water well records in the vicinity of the site indicate bedrock surface varying between about some 5.5 m to 6.7 m below ground surface (mbgs).

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[1] L.J Chapman and D.F. Putnam: The Physiography of Southern Ontario, Third Edition. Ontario Geological Survey, Special Volume 2, 1984.

3.0 EXPLORATION PROCEDURES

The field work for the geotechnical exploration was carried out on June 23 and 24, 2025 during which time two boreholes, identified as Boreholes BH-101 and BH-102 were advanced at the approximate locations shown on Figure 1. The table below summarizes the borehole locations, ground surface elevations, and borehole depths.

Borehole No.	Location (UTM 17T)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
BH-101	4778845.6	431920.1	207.8	11.0
BH-102	4778845.1	431910.2	207.7	8.7

The boreholes were drilled using track-mounted drilling equipment supplied and operated by a specialist drilling contractor licensed by the Ministry of the Environment, Conservation and Parks (MECP). Standard penetration testing and sampling was carried out in all boreholes at suitable intervals of depth using 35-millimetre (mm) inside diameter split spoon sampling equipment with an automatic hammer in accordance with ASTM International standard D1586: “Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils”. The samples obtained were brought to our laboratory for further examination and representative laboratory classification testing. The results of the in situ and laboratory testing are provided on the Record of Borehole sheets. The Standard Penetration Test (SPT) ‘N’ values[2] indicated on the Record of Borehole sheets and discussed herein are the values measured directly in the field and are unfactored.

Bedrock coring was carried out in borehole BH-102 using NQ sized coring equipment. Bedrock characteristics for Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock quality Designation (RQD), weathering and strength index, discontinuities, and classification data were recorded in the field based on visual examination of the recovered core samples upon extraction from the core barrel. The bedrock samples were photographed (Appendix C) and logged in the field and then placed in appropriate containers, labelled, and transported to our Burlington rock mechanics laboratory for further visual examination and classification, as well as unconfined compressive strength (UCS) testing. The results of the rock laboratory testing are included in Appendix A.

Classification of the rock mass quality of the bedrock with respect to the RQD is described based on Table 4.26 of the Canadian Foundation Engineering Manual (CFEM, 2023) while the strength of the bedrock core samples is based on Table 4.21 of CFEM (2023). The degree of weathering of the bedrock samples and the strength classification of the rock mass based on field identification are described in accordance with the International Society of Rock Mechanics (ISRM, 1985) standard classification system.

Analytical testing was carried out on select soil samples by a certified analytical laboratory (AGAT Laboratories). The analytical testing included analysis of resistivity, soluble chloride, conductivity, pH, and soluble sulphate parameters to evaluate the soils potential for corrosivity to steel and concrete. The results of the analytical laboratory testing on the soil samples are included in Appendix B.

Groundwater conditions were observed in the boreholes throughout the drilling operations. Upon completion of drilling and sampling, the boreholes were backfilled in accordance with the requirements of the Revised Regulations of Ontario (R.R.O) 1990, Ontario Regulation (O.Reg.) 903, as amended, of the Ontario Water

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[2] The SPT ‘N’ value is defined as the number of blows required by a 63.5-kilogram hammer dropped from a height of 760 mm to drive a split spoon sampler a distance of 300 mm into the soil after having first penetrated 150 mm.

Resources Act. The encountered groundwater levels are shown on the Records of Borehole sheets and discussed below.

Members of our engineering staff designated the borehole locations in the field, obtained clearances for underground utilities, monitored the drilling, logged the boreholes, cared for the samples collected and obtained water level measurements after completion of the drilling. The ground surface elevations at the borehole locations were surveyed by WSP and referenced to geodetic datum.

4.0 SUBSURFACE CONDITIONS

The subsurface soil, rock, and groundwater conditions encountered in the boreholes advanced during this exploration and testing program, together with the results of the field and laboratory testing carried out on selected soil and rock samples, are presented on the Record of Borehole sheets and the laboratory test figures following the text of this report. A copy of "*Abbreviations and Terms Used on Records of Boreholes and Test Pits*", "*List of Symbols*", and "*Lithological and Geotechnical Rock Description Terminology*" sheets are also provided to assist with the interpretation of the borehole records. The stratigraphic boundaries shown on the Record of Borehole sheets are approximate as they are inferred from non-continuous sampling, observations of drilling resistance and in situ testing. These indicated stratigraphic boundaries typically represent transitions between soil types rather than exact planes of geological change. In addition, the subsurface conditions should be expected to vary between and beyond borehole locations.

In general, the encountered subsurface conditions consisted of variable fill materials and buried topsoil overlying native deposits of sandy silty clay, sandy clayey silt, limestone and shale bedrock.

4.1 Soil Conditions

4.1.1 Asphalt and Variable Fill

Both of the boreholes were advanced through the pavement structure on Decker Road and encountered about 152 millimetres (mm) of asphalt.

Granular fill materials consisting of sand with varying amounts of silt and gravel were encountered beneath the asphalt at both of the borehole locations. The granular fill was about 0.5 m thick, with samples having water contents of about 4% to 7%. SPT 'N' values recorded within the granular fill ranged from 9 to 11 blows per 0.3 m of penetration, indicating a loose to compact state of compactness.

Cohesive fill materials comprising of sandy silty clay were encountered beneath the granular fill in both of the boreholes. The cohesive fill layers were about 3.1 m to 3.5 m thick and extended to depths of 3.8 to 4.1 mbgs. Organics (pockets of topsoil and rootlets), cobbles, boulders, and construction debris were typically encountered in the cohesive fill soils, with samples having water contents of about 15% to 24%. SPT 'N' values recorded within the cohesive fill ranged from 3 to 27 blows per 0.3 m of penetration, indicating a soft to very stiff consistency.

Underlying the cohesive fill in BH-101, a buried layer of topsoil was encountered. The topsoil layer was about 0.3 m thick and extended to a depth of 4.1 m. The SPT 'N' value recorded in the topsoil was 8 blows per 0.3 m of penetration, indicating a firm consistency. The measured moisture content of a sample of the topsoil layer yielded a water content of about 25%.

4.1.2 Sandy Silty Clay

Cohesive deposits of sandy silty clay were encountered beneath the buried topsoil layer in borehole BH-101. Where fully penetrated, the sandy silty clay was about 1.5 m in thickness. SPT ‘N’ values recorded within the cohesive deposit ranged from 3 to 8 blows per 0.3 m of penetration indicating a soft to firm consistency. Water contents of the cohesive deposits ranged from about 13% to 30%. A grain size distribution curve for a sample of the sandy silty clay is shown on Figure 2. An Atterberg limits test was conducted on one sample of the sandy silty clay, which indicated a liquid limit of about 29 %, a plastic limit of about 18%, and a plasticity index of about 11%. The results of the Atterberg limits test, as shown on Figure 3, indicate that the material is an inorganic silty clay of low plasticity.

Weathered shale pieces were observed within samples of the sandy silty clay. Although not specifically encountered in the boreholes, cobbles and boulders should be expected in the cohesive strata as these soils are glacially derived and in proximity to the bedrock surface.

4.1.3 Sandy Clayey Silt (Residual Soil, Extremely Weak Shale)

Layers of Sandy Clayey Silt (which is also classified as residual soil, or extremely weak shale) were encountered beneath the sandy silty clay BH-101 and beneath the cohesive fill in BH-102. Borehole BH-101 was terminated within the sandy clayey silt after exploring the stratum for about 5.4 m. Where fully penetrated in BH-102, the sandy clayey silt was about 0.8 m in thickness. SPT ‘N’ values recorded in the sandy clayey silt ranged from 51 blows per 0.3 m of penetration to 82 blows per 0.25 m of penetration, suggesting a hard state of compactness. Samples of the sandy clayey silt yielded water contents of about 8% to 10%.

4.2 Bedrock Conditions

Extremely weak shale bedrock was encountered at varying depths in boreholes BH-101 and BH-102. Actually at BH-101 auger drilling and SPT sampled was completed to the end of the borehole at 11.0 m below grade with no refusal to drilling. At BH-102 the bedrock cores encountered slabs of fresh limestone intercalated with layer of grey porous and weak shale and layers of dense residual soils, Borehole BH-101 and BH-102 were terminated in very dense sandy clayey silt and the extremely weak shale after exploring the layer for about 2.8 to 5.4 m. Where fully penetrated in borehole BH-102, the extremely weak shale layer was about 0.8 m thick.

Layers of Limestone and shale bedrock were encountered between the extremely weak shale layers in borehole BH-102 at a depth of 4.9 m. The layers generally consisted of grey, porous, slightly weathered, medium to very strong limestone to weak shale and was about 1.0 m thick. One UCS test was carried out on a sample of the limestone bedrock, indicating a UCS of 189.8 MPa.

The rock quality designation (RQD) ranged from 54% to 71% with an overall average value of 62%, indicating a rock mass of Fair quality as per Table 4.26 of the CFEM (2023).

4.3 Groundwater Conditions

Groundwater levels were observed in the boreholes during drilling as indicated on the Record of Borehole sheets. Groundwater was encountered in borehole BH-102 at a depth of 3.0 mbgs during drilling or about Elevation 204.7 m. Borehole BH-101 remained dry during drilling.

Groundwater levels should be expected to fluctuate seasonally and in response to significant precipitation events and adjacent Decker Creek water levels.

4.4 Analytical Testing

Two soil samples (one cohesive fill sample and one native sandy clayey silt) were collected and submitted for analyses of parameters used to assess corrosion potential to buried concrete and steel. A summary of the results of the analyses is presented below and the detailed test results and the Certificate of Analysis are presented in Appendix B.

Borehole, Sample I.D.	Parameters				
	Soluble Chloride (µg/g)	Soluble Sulphate (µg/g)	pH	Electrical Conductivity (mS/cm)	Resistivity (ohm-cm)
BH-101 Sa-5	96	58	8.21	0.30	3320
BH-102 Sa-7	76	363	8.37	0.64	1570

5.0 DISCUSSION

This section of the report provides our interpretation of the factual geotechnical data obtained during the field work and it is intended for the guidance of the design engineer. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own independent interpretation of the subsurface information provided as it affects their proposed construction means and methods, equipment selection, scheduling, pricing, and the like.

Our professional services for this assignment address only the geotechnical (physical) aspects of the subsurface conditions at this site. The geo-environmental (chemical) aspects, including the consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report and have not been addressed.

5.1 Interpreted Design Properties of Foundation Material

Based on the results of the boreholes, it is anticipated that the foundation material will consist of the encountered weathered bedrock and very dense to hard residual sandy clayey silt. In consideration of the weathered conditions and joint characteristics described above, the following interpreted design properties are recommended for the weathered bedrock and the sandy clayey silt:

- Unit weight (γ)= 21 kN/m^3
- Effective friction angle (Φ') = 34°

5.2 Culvert Foundation

It is understood that a new open-footing precast concrete box culvert with precast concrete block end walls will be replacing the existing CSP culvert. The proposed culvert is 22.5 m long, 4.42 m wide, and 3.05 m high. Based on the proposed profile, the soil cover thickness will be about 1.7 m below the travelled surface of Decker Road (Elevation 207.7 m) to the top of the concrete culvert (Elevation 206.0 m).

The open-footing culvert will be founded within bedrock, or hard sandy clayey silt and should be embedded below the creek bed and below any anticipated scour depth. In the absence of a site-specific scour hazard study a minimum of 600mm embedment against scour depth should be considered.

For design purposes, a factored geotechnical resistance at Ultimate Limit State (ULS) of 200 kilopascals may be used for a strip footing based on a minimum footing width of 1.0 m and a minimum embedment below the bottom of the creek of 0.6 m.

This above ULS resistance is valid for vertical loads only and it decreases significantly in the presence of load inclination. Preliminarily, the reduction factor of $(1-\theta/\Phi')^2$ would apply (θ = inclination of applied load from vertical, and Φ' = effective friction angle of the foundation material). However, the ULS resistance can be increased with increase of the embedment and foundation width. Preliminarily, for the given 600 mm embedment, the rate of increase of the factored resistance is about 4% for every 0.1 m of footing width increase. In addition, the factored resistance will increase by approximately 22% for every 0.3 m of embedment increase. If required, WSP can assist with more detailed geotechnical design.

The net geotechnical reaction at the Serviceability Limit State (SLS) defined based on 25 millimetre acceptable settlement for the footing founded on the bedrock or hard residual soils at this site will exceed the ULS resistance and as such the SLS condition is not a factor in the design.

Once prepared, the subgrade should be inspected by the geotechnical engineer.

For leveling purposes and immediate protection of the exposed subgrade, it is recommended a minimum of 75 mm thick layer of lean concrete (mud mat). The use of uniform sand (mortar sand) for fine-leveling of the precast panes should be avoided in consideration of the risk of scour, unless the embedment material against the footing is scour proof.

5.3 Sliding Resistances

The resistance to lateral forces/sliding resistance between the culvert base and founding rock should be calculated in accordance with CFEM (2023). The angle of interface friction, δ, and the unfactored coefficient of friction, tan δ, may be taken as 20 degrees and 0.36, respectively.

5.4 Backfill

Any existing topsoil, cohesive fill, organics, wet, or deleterious fill materials excavated from the site are not considered suitable as engineered backfill. The upper granular fill recovered from the pavement structure is suitable for reuse as general backfill for the road embankment below the future pavement structure, provided that is carefully sorter and stored separately from the general excavated soils.

Backfill for the culvert and end walls should consist of free-draining, non-frost susceptible granular materials such as OPSS Granular B or Granular A, placed in maximum 300 mm thick loose lifts and uniformly compacted to at least 98 per cent of SPMDD. Heavy compaction equipment should not be used immediately adjacent to the abutment walls or walls and roof of the culvert. The height of backfill adjacent to the culvert walls should be maintained as equal as possible on both sides of the culvert during all stages of backfill placement. The height of the backfill on each side of the culvert should differ by no more than 500 mm at any time.

The excavation for the culvert should exceed the width of the culvert by at least 1.5 metres on each side to allow for good workmanship and effective compaction of the fill.

Select Subgrade soils and recovered compactable soils from the excavation should be used to retore the pavement subgrade elevation. All this backfill material should be at suitable moisture contents to achieve the specified degree of field compaction. Materials should not be considered acceptable as backfill when the placement water content exceeds the optimum water content (as determined by the standard Proctor compaction testing ASTM International D698) by more than about 2 to 4 per cent. Further, material that is more than 3 per cent dry of the optimum water content should be wetter during compaction to reduce post-construction settlements or should not be used.

Inspections and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

5.5 Frost Depth

In accordance with the Ontario Provincial Standard Drawings (OPSD.3090.101) the design frost depth below the ground surface for the general area is estimated to be 1.0 m. Ideally, the culvert footings should be placed below the frost penetration, measured from the bottom of the creek. If the creek water level is expected to maintain a permanent low water level, the actual frost penetration may be less than stated above. Also, the encountered very dense to hard condition of the foundation material is likely to be less susceptible to frost heave. Therefore, if some movement due to potential frost heave can be tolerated, shallower foundations may be considered, but not less than 600 millimetres below the bottom of the creek.

To protect the pavement structure due to the frost penetration, frost tapers should be implemented as per OPSD 803.010.

5.6 Erosion Protection

Erosion protection should be provided at the culvert inlet area. Typically, rock protection can be provided over all surfaces with which culvert water is likely to be in contact. Treatment at the outlet should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

5.7 Lateral Earth Pressures

Subsurface walls and temporary support systems that may be installed as part of this project will be subjected to unbalanced earth pressures and must be designed to resist a pressure that can be calculated based on the following equation:

$$P = K[\gamma(h-h_w)+ \gamma' h_w + q] + \gamma_w h_w$$

Where: P = horizontal pressure at depth

h = depth of soil from grade to top of footing (m)

K = earth pressure coefficient

H_w = depth below groundwater level (m)

γ = bulk unit weight of soil (kN/m^3)

γ' = submerged unit weight of the exterior soil (kN/m^3)

γ_w = unit weight of water (kN/m^3)

q = total surcharge loading from adjacent equipment and/or materials (kPa) (kN/m^2), In addition to the above earth pressures, the increase of the earth pressure due to the dynamic compaction should be considered as per CHBDC (2019).

The groundwater elevations behind the culvert wall are expected to vary seasonally and considerably from low water to high groundwater that may raise to near the base of the road subgrade. Wall drains as per OPSD 803.010 should be provided at the level just above the anticipated long-term, or average water level in the creek.

The following table summarizes estimated soil parameter values recommended for use in the design of engineered backfill behind subsurface walls:

Soil Type	Bulk Soil Unit Weight* (kg/m^3)	Angle of Internal Friction (°)	Coefficient of Active Pressure (Ka)	Coefficient of Passive Pressure (Kp)	Coefficient of At-Rest Pressure (Ko)
Granular A (OPSS 1010)	2,100	35	0.27	3.69	0.43
Granular B Type I (OPSS 1010)	2,000	33	0.30	3.39	0.46

1. Saturated unit weights may be calculated by multiplying the bulk unit weights by 1.1; buoyant unit weights may be calculated by subtracting 1,000 kg/m^3 from the saturated unit weights. Hydrostatic pressures should be added where buoyant unit weights are assumed.
2. All granular compacted to at least 98% of the SPMDD

For unyielding, relatively rigid structures as the proposed culvert, the at-rest lateral earth pressure coefficients (Ko) should be used for design.

5.8 Seismic Considerations

Based on the results of the exploration, seismic Site Class C is appropriate for this site. The site classification for seismic response presented in Table 4.1.8.4.-B of the 2024 Ontario Building Code relates to the average properties of the upper 30 m of support strata. The information obtained in the geotechnical field exploration was gathered from the upper 11 m. If required, an upgrade of the seismic class may be possible subject to further confirmation of dynamic soil and rock properties for the required depth of 30 m.

5.9 Excavations and Groundwater Control

All temporary excavations should be carried out in accordance with the latest edition of the Occupational Health and Safety Act and Regulations for Construction Projects (OHSA). The OHSA regulations governing excavation support and maximum side wall inclinations apply to excavations extending to depths of greater than 1.2 m below the adjacent ground surface.

Based on the results of the exploration, excavations for the proposed culvert replacement will encounter granular fill, cohesive fill, buried topsoil, firm to soft native sandy silty clay, hard native sandy clayey silt (weathered bedrock), and bedrock.

The encountered fill materials and buried topsoil, may be classified as Type 3 soils if dewatered. In the presence of seepage, the soils will degrade to Type 4.

The hard clayey silt and weathered bedrock should be classified as Type 2 soils.

In all cases, the OHSA soil type categories are based on generalized ground behaviour conditions with respect to the need for worker protection and compliance with the Act. Further, layered soil types or construction staging of excavations can change the OHSA categorization that might apply. During construction, the exposed ground should be observed by experienced geotechnical personnel to confirm the OHSA classification that will apply.

Stockpiling of soil beside the excavation/adjacent to the trench should be avoided to reduce the potential for instability of the open cut. The weight of the stockpiled soil could lead to basal instability of braced excavations or slope instability of unsupported excavations. Any stockpiles of excavated materials should be set back from the edge of the excavation by a lateral distance at least equal to the excavation depth.

Based on the subsurface soil and groundwater conditions encountered in the boreholes and the anticipated depths of the excavations shown on the design drawings, it is considered that the proposed works for the culvert replacement can be done using conventional open cut and supported excavation techniques provided that surface water and groundwater are adequately controlled.

Excavation within the bedrock may require specialized rock excavation tools and equipment.

Care should be taken to direct all surface water away from excavations. Groundwater seepage should be relatively minor within the anticipated excavation depths above the creek water level. Nevertheless, It is anticipated that the excavations should be below the groundwater level, therefore some form of proactive dewatering system or groundwater control measures will be required. Groundwater seepage into the excavation is also anticipated at or below the creek water level and some form of cofferdam system will be required. It is understood that a sandbag cofferdam system will be constructed in general accordance with OPSD. 221.020. Groundwater inflows should be controlled by conventional temporary dewatering methods. The groundwater should be lowered to at least 0.5 m below the underside of footing elevations. Depending on the time of construction, seasonal variation potentially resulting in groundwater levels higher than those encountered during the exploration should be expected. The contractor should be solely responsible for selecting and implementing appropriate dewatering measures.

5.10 Construction Considerations

Adequate support should be provided for any existing or proposed infrastructure which may be located within the zone of influence of the excavations as defined by a line drawn upwards and outwards from the base of the excavation at an inclination of 1 horizontal to 1 vertical.

Care should be taken during construction to avoid disturbance of the founding soils. All existing fill, topsoil, organics, and any soft, excessively wet, or loose soils should be stripped from the proposed founding areas prior to placement of the open-footing culvert.

Should trench liner boxes be used to reduce the lateral extent of the excavations, it should be noted that the box only provides protection for the workmen once in place. The liner box does not restrict movement of the excavation walls and any voids between the excavation wall and the trench liner box should be filled immediately to reduce the potential for loss of ground and support of adjacent utilities, roadway pavements, completed works, and the like.

5.11 Pavements

Prior to constructing any new or replacement pavement structures at the site, all uncontrolled fill, softened, loosened, organic, and/or otherwise deleterious materials should be removed from within the limits of the proposed pavements. Prior to placing Granular B subbase, the exposed subgrade should be heavily proof rolled with a non-vibratory steel wheel roller under the direction of the geotechnical engineer. Any excessively softened or loosened areas identified during this operation should be subexcavated and backfilled with approved OPSS granular material uniformly compacted to at least 98 per cent SPMDD.

The new pavement should be tapered to match the existing road structure to reduce the risks of localized damage along the construction joint.

Based on discussions with Black Creek and the Municipality, and as shown on the provided Proposed Plan & Profile Drawings, it is understood that the following pavement structure thicknesses are proposed:

Pavement Component	Design Thickness (millimetres)
x2 lifts of HL4 asphalt	100
Granular A (crushed) Base	150
Granular B Type II Subbase	300

The above-noted pavement structure is not intended to support heavy construction traffic. Depending on the actual types of construction equipment used and the prevailing weather conditions during construction, additional Granular B may be required to accommodate the construction traffic.

The Granular A base and Granular B subbase should be placed in maximum 300-millimetre thick loose lifts and uniformly compacted to at least 100 per cent of SPMDD in accordance with the current OPSS requirements and municipal standards. Short perforated stub drains should be provided at all catchbasins. All new catchbasins should be connected to a suitable hydraulic outlet. The subgrade surface should be sloped to promote drainage and prevent the build-up and stagnation of pore water within the granular base.

The asphaltic materials should be produced, placed and compacted in accordance with the current OPSS requirements and municipal standards. The asphalt should be compacted to at least 97% of the material’s Maximum Relative Density (MRD) as per municipal standards. Milled notches the depth of the surface course by 500 mm wide should be provided where the new pavements abut existing pavements and care should be taken to properly tack coat all butt joints and milled surfaces.

Care should be taken to ensure that construction and/or through traffic does not adversely impact the subgrade, roadway granulars and placement of the asphaltic materials. The pavement structure noted above is based on the assumption that construction will take place under dry weather and subgrade conditions. If the construction is not carried out during dry weather conditions, it may be necessary to increase the recommended thicknesses of the pavement structure and the geotechnical engineer should be allowed to re-evaluate the structure and construction requirements.

5.12 Corrosivity Conditions

One sample of the cohesive fill and one sample of the native sandy clayey silt was submitted to an analytical laboratory; the suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement / concrete to be used in construction and the need for corrosion protection of steel elements. The results of analytical tests are presented on the Certificate of Analysis in Appendix A and summarized in Section 4.4.

For potential sulphate attack on concrete, the results of the soil analysis were compared to Table 3 in CSA A23.1:24. The sulphate concentration was about 58 to 363 micrograms per gram, which is within the exposure class S-3 “Moderate” and would be considered negligible according to Table 7.2 of the MTO Gravity Pipe Design Guidelines (2014).

The resistivity results indicate that the soil corrosiveness for the sample of the native sandy clayey silt is severe (R value less than 2,000 ohm-cm) and moderate (R value is between 2,000 and 4,500 ohm-cm) for the sample of the cohesive fill (R value as per Table 3.2 of the MTO Gravity Pipe Design Guidelines (2014). Further, the measured pH is about 8.21 to 8.37. According to the MTO Gravity Pipe Design Guidelines (2014) a pH greater than 8.5 is considered strongly alkaline; both of which are indicative of an increased potential for corrosion. It should be noted that the water levels in the area are subject to seasonal fluctuations and variations due to the precipitation events and the soil/water chemistry could also be variable.

These recommendations are provided as guidance only; the structural designer should take the results of the laboratory testing and the potential for corrosion into consideration as part of the materials selection and design life of the casing pipe and appurtenances.

6.0 GEOTECHNICAL INSPECTIONS AND TESTING

During design, it would be beneficial for WSP to review the design drawings and specifications for consistency with the recommendations provided in this report. A regular program of geotechnical inspections and materials testing should be carried out during construction to confirm that the conditions being encountered are consistent with the results of the boreholes, to confirm that the intent of the recommendations provided are being met and that the various project and material specifications are being consistently achieved.

7.0 CLOSURE

We trust that this report is sufficient for your immediate requirements. If you have any questions regarding the contents of this report or require additional information, please do not hesitate to contact the undersigned.

Signature Page

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https://wsponlinecan.sharepoint.com/sites/ca-ca0053577.5884/shared documents/06. deliverables/ca0053577.5884-rpt-rev0-geotech_exploration_14aug2025.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: WSP Canada Inc. (WSP) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to WSP by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. WSP cannot be responsible for use of this report, or portions thereof, unless WSP is requested to review and, if necessary, revise the report.

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The report is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP by the Client, communications between WSP and the Client, and to any other reports prepared by WSP for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. WSP can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Ground Water Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, WSP does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that WSP interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: WSP will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client’s expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder’s report. WSP should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder’s report.

During construction, WSP should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder’s report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder’s report. Adequate field review, observation and testing during construction are necessary for WSP to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder’s responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that WSP be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that WSP be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. WSP takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

METHOD OF SOIL CLASSIFICATION

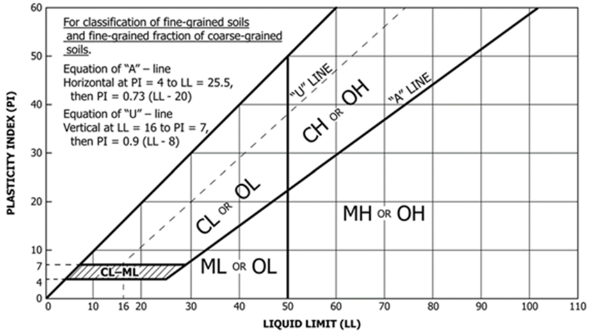
The WSP Canada Soil Classification[1] System is based on the Unified Soil Classification System (USCS) (after ASTM D2487)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content[6,9]	USCS Group Symbol[3,5,7]	Primary Group Name[2]
INORGANIC (Organic Content <30% by mass)	**COARSE-GRAINED SOILS** (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Clean Gravels with <5% fines [3] (by mass)	Well Graded	≥4 (and)	≥1 to ≤3	≤30%	GW	Well-graded GRAVEL [4,6]
				Poorly Graded	<4 (and/or)	<1 or >3		GP	Poorly graded GRAVEL [4,6]
			Gravels with >12% fines [3] (by mass)	Below A Line	n/a			GM	SILTY GRAVEL [4,6]
				Above A Line	n/a			GC	CLAYEY GRAVEL [4,5,6]
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Clean Sands with <5% fines [7] (by mass)	Well Graded	≥6 (and)	≥1 to ≤3		SW	Well-graded SAND [6,8]
				Poorly Graded	<6 (and/or)	<1 or >3		SP	Poorly graded SAND [6,8]
			Sands with >12% fines [7] (by mass)	Below A Line	n/a			SM	SILTY SAND [6,8]
				Above A Line	n/a			SC	CLAYEY SAND [5,6,8]

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content[B,H]	USCS Group Symbol[A]	Primary Group Name[A]
				Dilatancy	Dry Strength	Shine Test	Thread Diameter (mm)	Toughness (of 3 mm thread)			
INORGANIC (Organic Content <30% by mass)	**FINE-GRAINED SOILS** (≥50% by mass is smaller than 0.075 mm)	SILTS (Nonplastic or PI and LL plot **below A-Line** on Plasticity Chart below) [C]	Liquid Limit <50 [D]	Rapid	None to Low	Dull to None	3 to >6	Low/can't roll 3 mm	<15%	ML	SILT [H]
				None to Slow	Low to Medium	Dull to Slight	3 to 6	Low	15% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50 [D]	None to V.Slow	Low to Medium	Slight	3 to 6	Low to Medium	<15%	MH	ELASTIC SILT[H]
				None	Medium to High	Dull to Slight	1 to 3	Low to Medium	15% to <30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot **above A-Line** on Plasticity Chart below) [A]	Liquid Limit <50 [D]	None to Medium Slow	Medium to High	Slight to Shiny	1 to 3	Medium	<15%	CL	LEAN CLAY [A,E,F,G,H]
				None to V.Slow	Medium to High	Slight to Shiny	1 to 3	Medium	15% to <30%	OL	ORGANIC CLAY [E,F,G]
			Liquid Limit ≥50 [D]	None	High to V.High	Shiny	<1	High	<15%	CH	FAT CLAY [E,F,G,H]
				None	High	Shiny	<1 to 1	High	15% to <30%	OH	ORGANIC CLAY [E,F,G]
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures	Relatively lightweight, possibly spongy. Some water may squeeze from sample. Some shrinkage may occur on air drying. Sand fraction may be visible. Low to high dilatancy. Thread weak near plastic limit. Low to medium dry strength.						30% to <75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat	Lightweight, spongy. Much water squeezes from sample. Shrinks considerably on air drying (i.e., very high water content). Plant structure identiable to altered.						75% to 100%		PEAT

Coarse-Grained Soil Note(s):

1. Based on the material passing the 75 mm sieve.
2. If field sample contains or drilling observations indicate cobbles or boulders or both, add, "with cobbles" or "with cobbles and boulders". Include notes on the depth(s) encountered, and sizes if possible.
3. Gravels with 5% to 12% fines require dual symbols:
   (GW-GM) Well-graded GRAVEL with silt,
   (GW-GC) Well-graded GRAVEL with clay,
   (GP-GM) Poorly graded GRAVEL with silt,
   (GP-GC) Poorly graded GRAVEL with clay.
4. If soil contains ≥15% sand, add "with sand" to Group Name.
5. If fines classify as CL-ML, use dual symbol (GC-GM) or (SC-SM) for Group Symbol.
6. If the soil has an organic content (OC) 15%≤OC<30% the prefix "Organic" should be added before the Group Name. If the soil has an organic content 3%≤OC<15% add "with organic fines" to Group Name. If the soil contains >0% to ≤3% organics, the descriptor "trace organics" may be added.
7. Sands with 5% to 12% fines require dual symbols:
   (SW-SM) Well-graded SAND with silt,
   (SW-SC) Well-graded SAND with clay,
   (SP-SM) Poorly graded SAND with silt,
   (SP-SC) Poorly graded SAND with clay.
8. If soil contains ≥15% gravel, add "with gravel" to Group Name.



Fine-Grained Soil Note(s):

- **A.** If Atterberg limits plot above the A-line but in the 'hatched' area on the plasticity chart, soil is a (CL-ML) SILTY CLAY.
- **B.** If the soil contains >0% to ≤3% organics, the descriptor "trace organics" may be added.
- **C.** If fine-grained materials are nonplastic (i.e., a plastic limit (PL) cannot be measured), soil is a (ML) SILT.
- **D.** If soil has a liquid limit (LL) >30% to <50%, the term 'medium plasticity' may be included in the description, but the Group Name/Symbol is not changed.
- **E.** If soil contains 15% to <30% +No.200, add "with sand" or "with gravel".
- **F.** If soil contains ≥30% +No.200 mainly sand, add "Sandy" to Group Name.
- **G.** If soil contains ≥30% +No.200 mainly gravel, add "Gravelly" to Group Name.
- **H.** If the soil has an organic content (OC) 3%≤OC<15% add "with organic fines" to Group Name.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

GRADATIONAL COMPONENT TERMS

% (by mass)	Term
≤ 5	Use "trace"
> 5 to ≤ 12	Use "few"
> 12 to <30	Use "little"
≥ 30 to <50	Use "some"
≥ 50	Use "mostly"

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); Nd:

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

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven, pushed tube sampler, or geoprobe macro-core – note size
DS	Denison type sample
FS	Foil Sample
GS	Grab Sample
MC	Modified California Samples – note sample diameter and hammer weight
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split-spoon sampler (50 mm OD); larger sizes use MC
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in general accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in general accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\ \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
NP	nonplastic
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

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* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

PROJECT: CA0053577.5884

LOCATION: N 4778845.56; E 431920.13

RECORD OF BOREHOLE: BH101

SHEET 1 OF 2

BORING DATE: June 23, 2025

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg DROP, 760mm

DRILL RIG: Dietrich D50

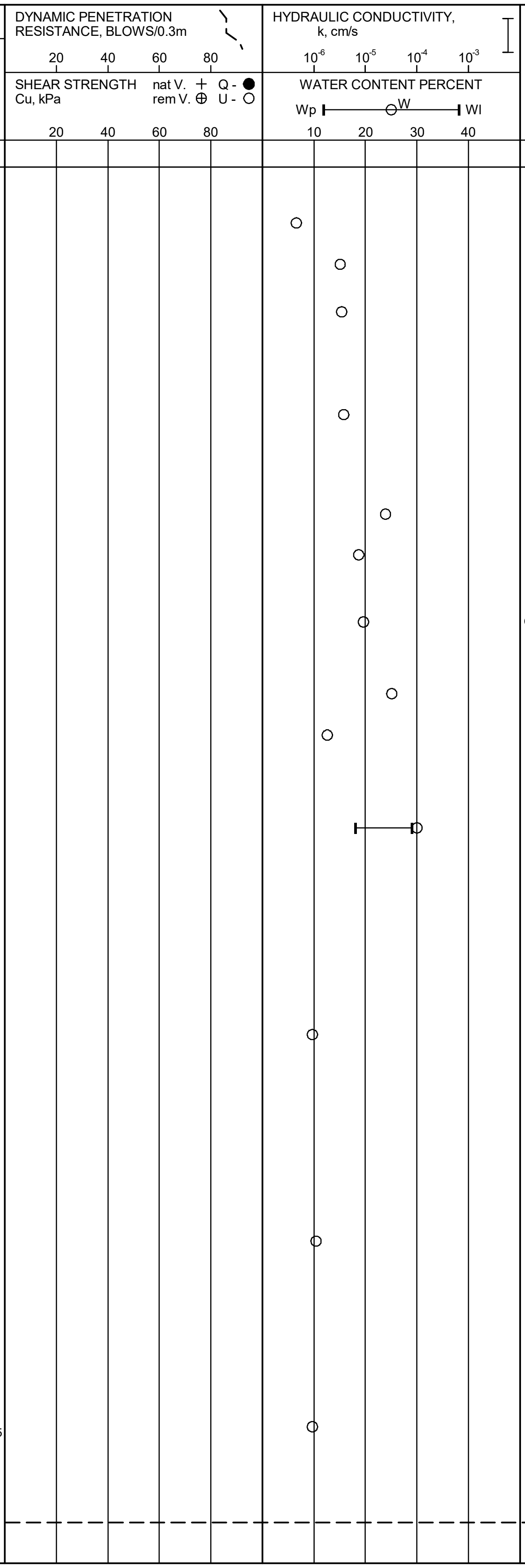
HAMMER TYPE: AUTOMATIC

BORING METHOD: Hollow Stem Auger 216 mm OD

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	207.79
ASPHALT (150 mm)	0.00
FILL - SAND and GRAVEL, some silt; brown; compact	0.15
FILL - Sandy SILTY CLAY, trace to some gravel; mottled brown; firm to stiff	207.12 0.67
FILL - Sandy SILTY CLAY, trace gravel; grey; soft	205.51 2.28
FILL - Sandy SILTY CLAY, some gravel, with brick pieces and organics; black; soft to stiff	204.96 2.83
TOPSOIL - CLAYEY, with rootlets and organics; black; firm	203.98 3.81
(CL) Sandy SILTY CLAY, with weathered shale pieces, trace gravel, organics, fossils; grey; firm to soft	203.68 4.11
(CL-ML) Sandy CLAYEY SILT; grey, friable (RESIDUAL SOIL); hard	202.23 5.56

CONTINUED NEXT PAGE

SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1A	SS	11		
1B				
2	SS	7		
3	SS	9		
4A	SS	3		
4B				
5	SS	11	CHEM	
6A	SS	8		
6B				
7	SS	3		1 32 44 23
8	SS	61		
9	SS	51		
10	SS	59/ 0.15		



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

LOGGED: MD

CHECKED: DB

PROJECT: CA0053577.5884

RECORD OF BOREHOLE: BH101

SHEET 2 OF 2

LOCATION: N 4778845.56; E 431920.13

BORING DATE: June 23, 2025

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg DROP, 760mm

DRILL RIG: Dietrich D50

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Hollow Stem Auger 216 mm OD	(CL-ML) Sandy CLAYEY SILT; grey, friable (RESIDUAL SOIL); hard	▨		11	SS	56/ 0.15		○		
11		END OF BOREHOLE Note(s): 1. Borehole dry upon completion.		196.82 10.97							
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

LOGGED: MD

CHECKED: DB

PROJECT: CA0053577.5884

LOCATION: N 4778845.05; E 431910.24

RECORD OF BOREHOLE: BH102

SHEET 1 OF 2

BORING DATE: June 23-24, 2025

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg DROP, 760mm

DRILL RIG: Dietrich D50

HAMMER TYPE: AUTOMATIC

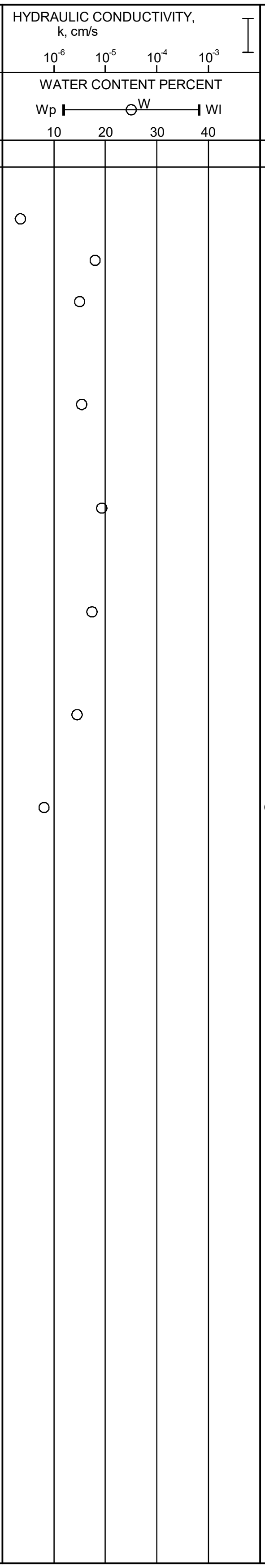
BORING METHOD: Hollow Stem Auger, 216 mm OD

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
	GROUND SURFACE	207.74				
0	ASPHALT (150 mm)	0.00				
	FILL - SAND and GRAVEL, some silt; brown; loose	0.15	1A	SS	9	
	FILL - Sandy SILTY CLAY, trace gravel, with organics; brown grey; firm to very stiff	207.13 0.61	1B			
1			2	SS	8	
2			3	SS	9	
			4	SS	3	
3			5	SS	9	
4			6	SS	27	
	(CL-ML) Sandy CLAYEY SILT, grey; friable (RESIDUAL SOIL); hard	203.63 4.11	7	SS	82/ 0.25	CHEM
5	Borehole continued on Record of Drillhole BH102	202.86 4.88				

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}



PIEZOMETER OR STANDPIPE INSTALLATION

GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

∇

DEPTH SCALE 1 : 50

LOGGED: MD

CHECKED: DB

GTA-BHS 005 S:\CLIENTS\THE_MUNICIPALITY_OF_LAMBTON_SHORES\DECKER_CREEK_CULVERT\02_DATA\GINT\DECKER_CREEK_CULVERT.GPJ GAL-MIS.GDT 8/5/25 MK May 2025

PROJECT: CA0053577.5884

RECORD OF DRILLHOLE: BH102

SHEET 2 OF 2

LOCATION: N 4778845.05 ;E 431910.24

DRILLING DATE: June 23-24, 2025

DATUM: Geodetic

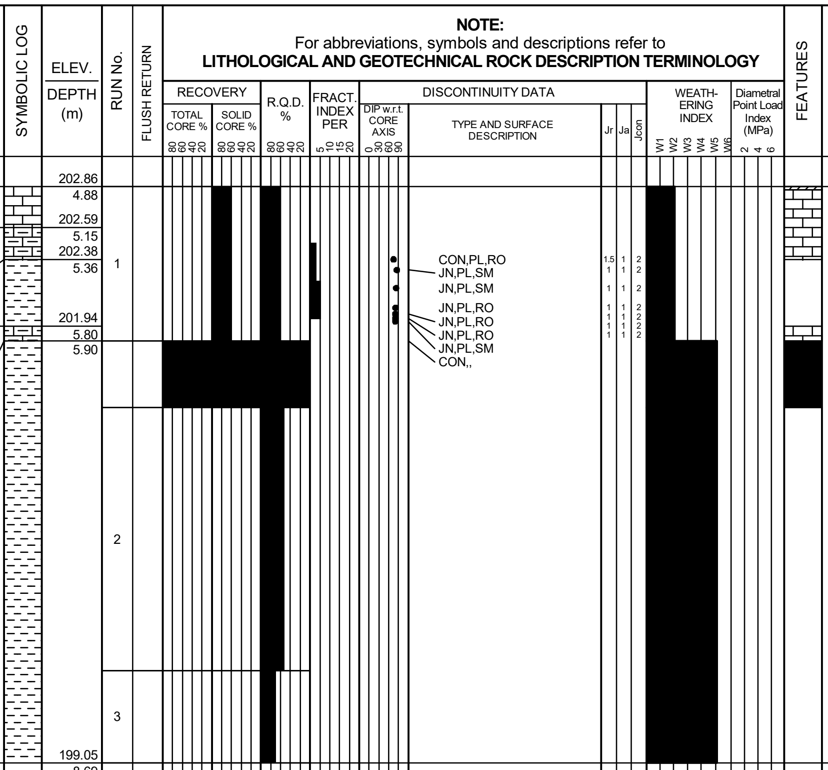
INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Dietrich D50

DRILLING CONTRACTOR: London Soil Test Ltd.

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.
		Cont'd from Record of Borehole BH102	202.86	
5	Rotary Drill NQ Core	Slightly weathered, grey, porous, medium strong LIMESTONE with calcite	4.88	
		Slightly weathered, grey, porous, medium strong SHALEY LIMESTONE	202.59 5.15	1
		Slightly weathered, grey, porous, low strength SHALE	202.38 5.36	
6		Slightly weathered, grey, porous, medium strong SHALEY LIMESTONE	201.94 5.80	
		Grey, porous, extremely weak, low strength SHALE	5.90	
7				2
8				3
		END OF DRILLHOLE	199.05 8.69	
9		Note(s):		
		1. Groundwater encountered at 3.05 m (Elev. 204.69 m) on June 23, 2025.		
10				
11				
12				
13				
14				



TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon
CON,PL,RO	1.5	1	2
JN,PL,SM	1	1	2
JN,PL,SM	1	1	2
JN,PL,RO	1	1	2
JN,PL,RO	1	1	2
JN,PL,RO	1	1	2
JN,PL,SM	1	1	2
CON,,			

FEATURES / PIEZOMETER:

BC

Hard Layer

UCS = 189.8 MPa (5.15 m - 5.36 m)

Hard Layer

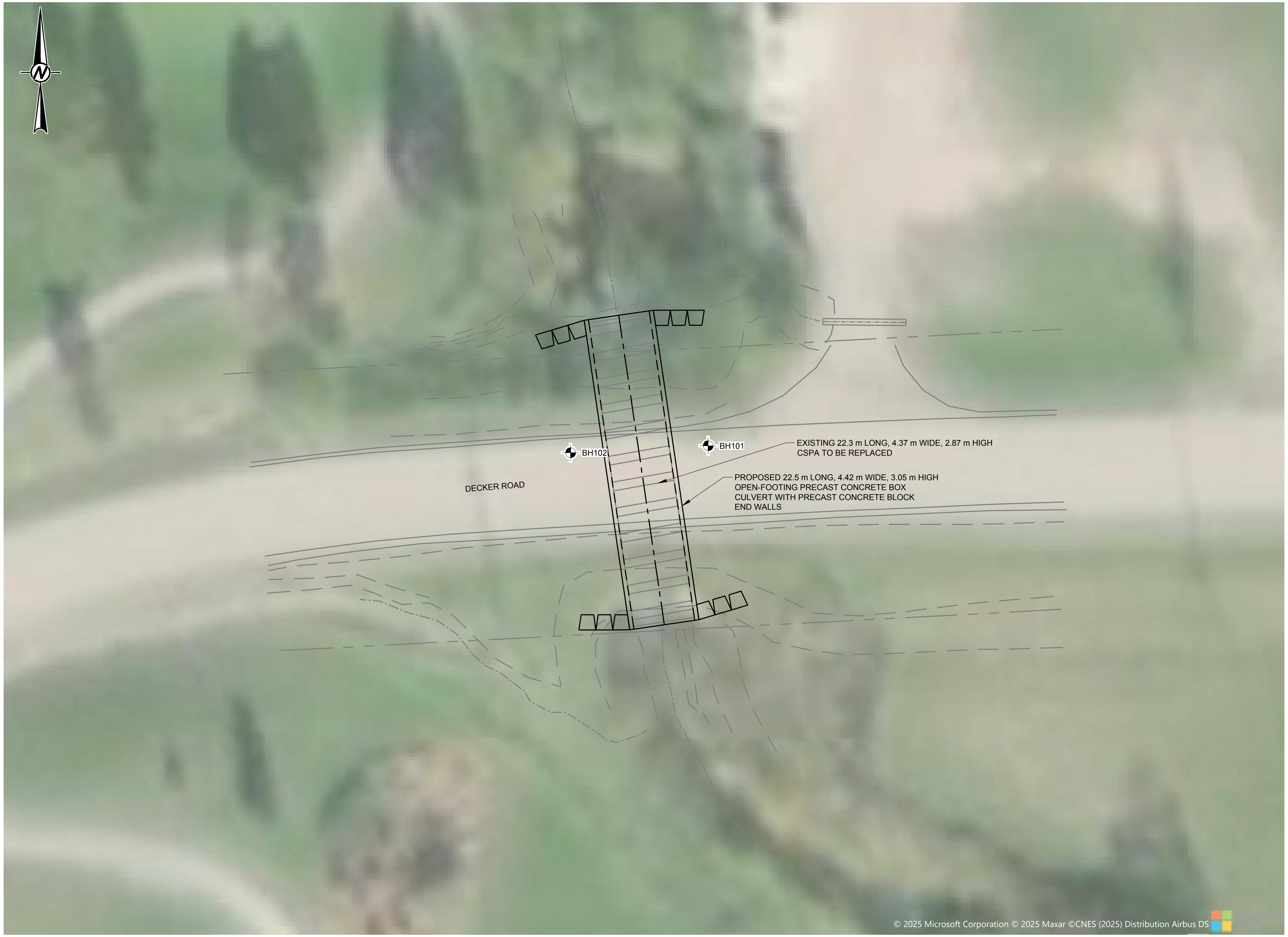
LC

DEPTH SCALE

1 : 50

LOGGED: MD

CHECKED: DB

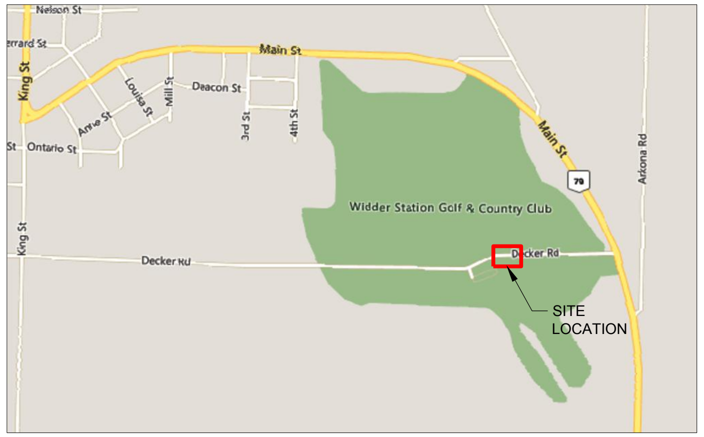


EXISTING 22.3 m LONG, 4.37 m WIDE, 2.87 m HIGH
CSPA TO BE REPLACED

PROPOSED 22.5 m LONG, 4.42 m WIDE, 3.05 m HIGH
OPEN-FOOTING PRECAST CONCRETE BOX
CULVERT WITH PRECAST CONCRETE BLOCK
END WALLS

© 2025 Microsoft Corporation © 2025 Maxar ©CNES (2025) Distribution Airbus DS

KEY MAP



LEGEND

⊕ APPROXIMATE BOREHOLE LOCATION

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD83, COORDINATES SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

FINAL

0 5 10
1:300 METRES

CLIENT
THE MUNICIPALITY OF LAMBTON SHORES

CONSULTANT

YYYY-MM-DD	2025-07-22
DESIGNED	OC/JM
PREPARED	OC/JM
REVIEWED	MD
APPROVED	MD

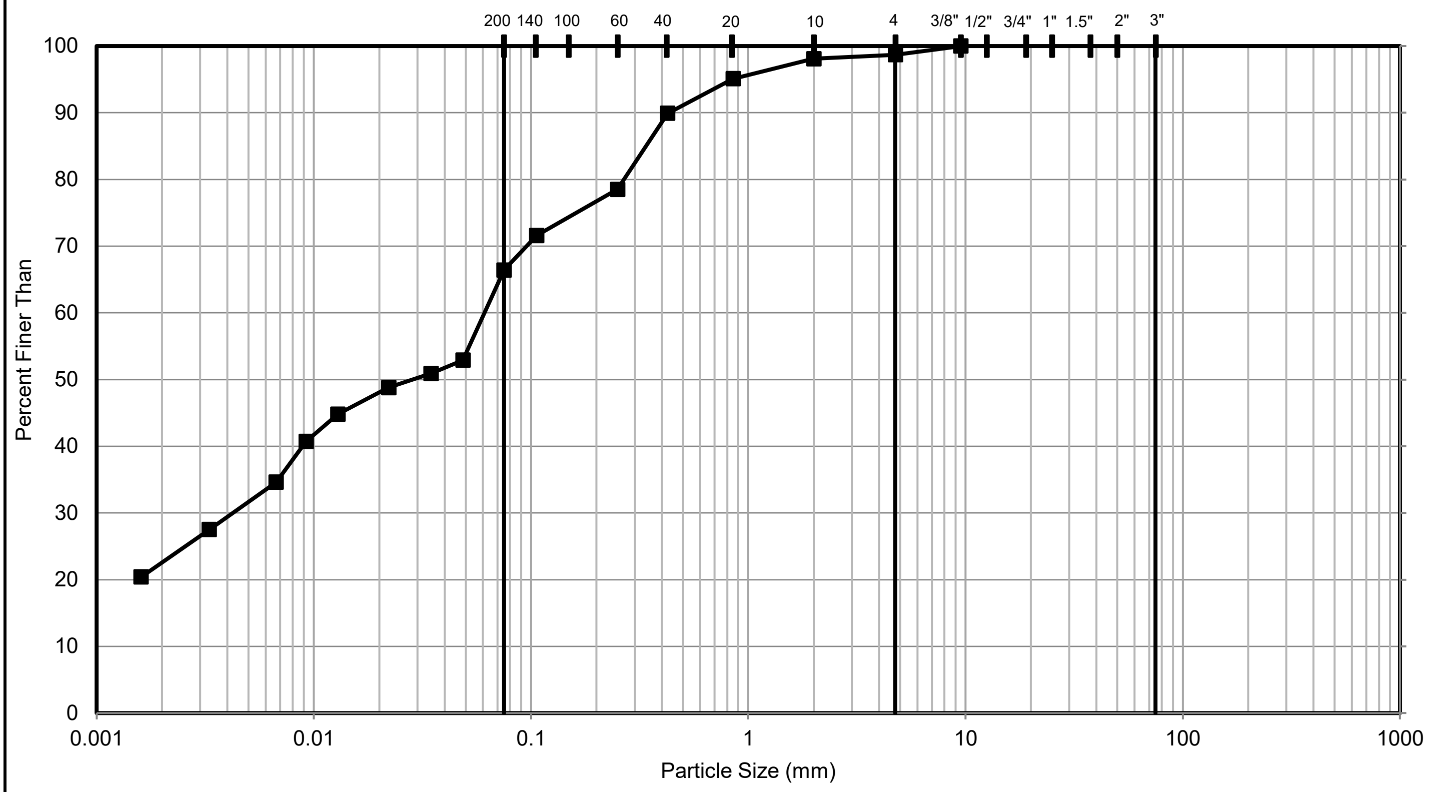
PROJECT
GEOTECHNICAL EXPLORATION AND TESTING PROGRAM
DECKER CREEK CULVERT REPLACEMENT
THEDFORD, ONTARIO

TITLE
BOREHOLE LOCATION PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
CA0053577.5884	0001	A	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Borehole Number	Sample Number	Depth (m)	Elevation (m)
■	BH-101	7	4.5 - 5.2	202.6 - 203.3

CLIENT
The Municipality of Lambton Shores
9577 Port Franks Road
Thedford, ON N0M 2N0

PROJECT
GEOTECHNICAL EXPLORATION AND TESTING PROGRAM
DECKER CREEK CULVERT REPLACEMENT
THEDFORD, ONTARIO

CONSULTANT

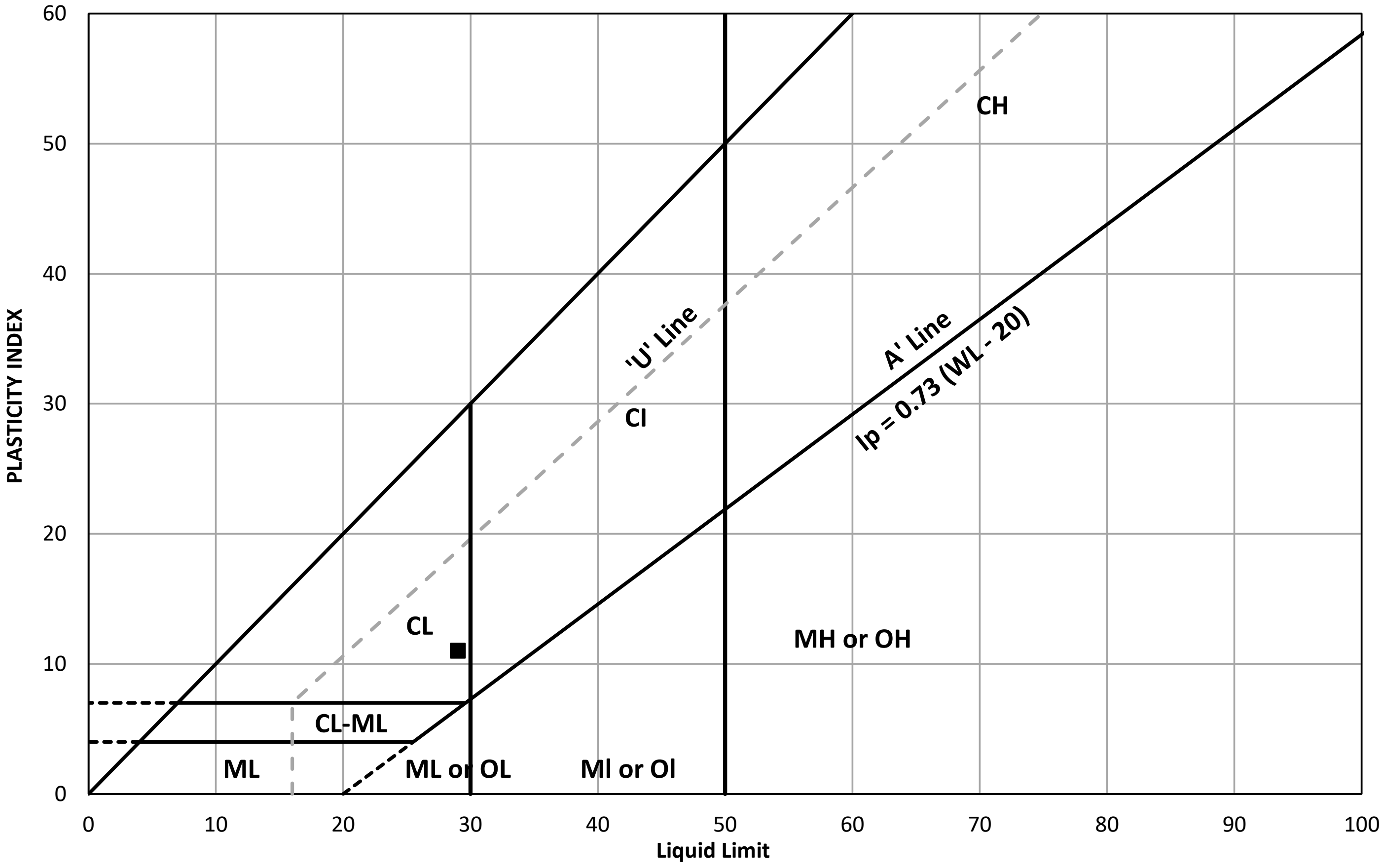
YYYY-MM-DD	2025-07-25
DESIGNED	MD
PREPARED	MD
REVIEWED	PG
APPROVED	PG

TITLE
GRAIN SIZE DISTRIBUTION
(CL) SANDY SILTY CLAY

PROJECT NO.	CONTROL	REV.	FIGURE
CA0053577.5884	0	0	2

PATH: https://wsponline-my.sharepoint.com/personal/mark_demelo_wsp_com/Documents/0 Projects/Decker Creek/geotech lab | FILE NAME: Geotech Report Figure - GSD.xlsm

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Elevation
■	BH-101	7	4.6 - 5.2	28	29	18	11	202.6 - 203.2

CLIENT
The Municipality of Lambton Shores
9577 Port Franks Road
Thedford, ON N0M 2N0

PROJECT
GEOTECHNICAL EXPLORATION AND TESTING PROGRAM
DECKER CREEK CULVERT REPLACEMENT
THEDFORD, ONTARIO

CONSULTANT

wsp

YYYY-MM-DD	2025-07-25
DESIGNED	MD
PREPARED	MD
REVIEWED	PG
APPROVED	PG

TITLE
PLASTICITY CHART
(CL) SANDY SILTY CLAY

PROJECT NO.	CONTROL	REV.	FIGURE
CA0053577.5884	0	0	3

PATH: https://wsponline-my.sharepoint.com/personal/mark_demelo_wsp_com/Documents/0 Projects/Decker Creek/geotech lab | FILE NAME: Geotech Report Figure - Limits.xlsm

APPENDIX A

Rock Laboratory Test Results

DECKER CREEK CULVERT REPLACEMENT ROCK MECHANICS TESTING

ASTM D7012 METHOD C

WSP CANADA INC.
309 Exeter Road, Unit 1
London, Ontario, N6L 1C1

Attention: Mark Demelo, P. Eng.
Geotechnical Engineer

PROJECT NO.: CA0053577.5884
DATE: 10-JULY-2025

WSP CANADA INC.
3450 HARVESTER ROAD, SUITE 100
BURLINGTON, ONTARIO, L7N 3W5

1 Introduction

WSP Canada Inc., a division of WSP Global Inc. (“WSP”) is pleased to present the results of laboratory testing conducted on rock core samples provided by WSP Canada Inc. (“WSP”). The testing was conducted in WSP’s rock mechanics laboratory located in Burlington, Ontario.

2 Methodology

A total of one (1) specimen was prepared and tested from core samples received in the WSP laboratory. Core sample was NQ drill size, nominally 47.6mm diameter. Testing was conducted in accordance with ASTM D7012, “Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures”. Summary tables of the test results are attached as are the pre-test and post-test photographs.

All specimens were tested in their as-received moisture condition.

3 Results

The attached core data summary spreadsheet contains a comments column with a description of the failure mode for each specimen. A mention of “brittle failure” indicates that the specimen failed suddenly and completely with a rapid release of stored energy. The phrase “through intact rock” indicates that no portion of the main failure plane contained any pre-existing planes of weakness (veins, healed joints, foliation planes, etc.).

4 Disclaimer

This report has been prepared for the client named on the front of the report to be used subject to the terms and conditions of its contract with WSP. The data presented in this report has been performed based on the testing standards noted and in accordance with generally accepted rock engineering practices. WSP cannot be held responsible for any designs by others based on the data presented. Any other use of, or reliance on, this report by any third party is at that party’s sole risk. No other warranty, expressed or implied, is made.

If you have any questions with regards to the results of the testing conducted, please do not hesitate to contact the undersigned at your convenience.

Yours truly,
WSP Canada Inc.

PREPARED BY

Saeed Rafieepour, M.Sc.
Senior Laboratory Technician

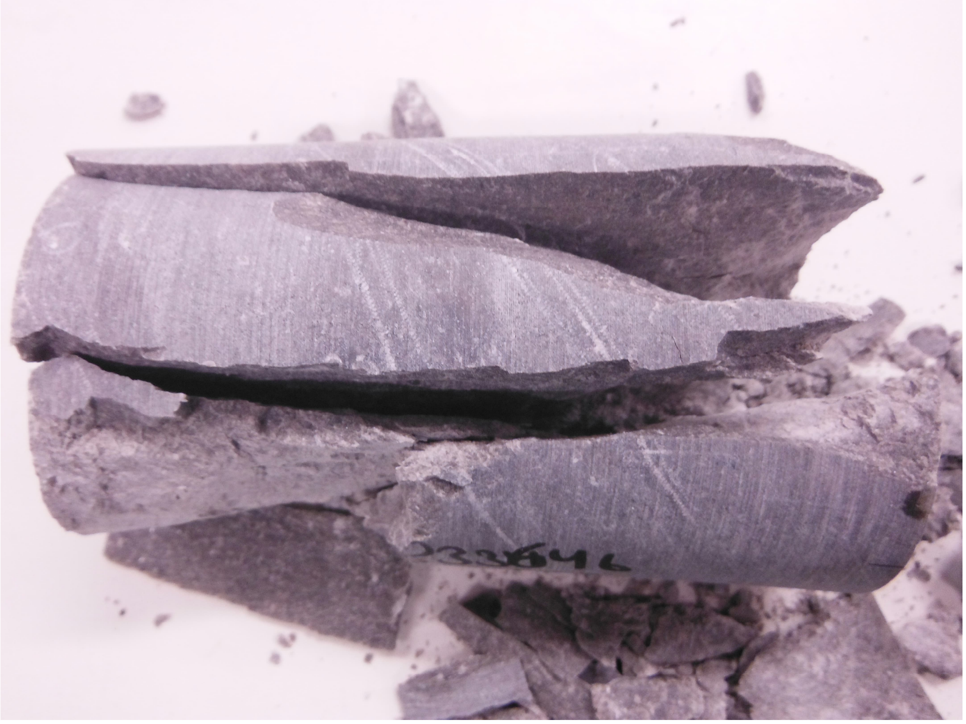
APPROVED BY

Kellen Shenton, P.Geo.
Senior Geoscientist

sr/KS

Laboratory ID	Test Type	Borehole #	Sample ID	Depth from	Depth to	Length	Diameter	Mass	L/D	Density	Load	Sigma 1	Comments
				(m)	(m)	(mm)	(mm)	(g)		(kg/m^3)	(kN)	(MPa)	
R33646	UCS	BH-101	UCS-1	5.25	5.35	100.27	47.18	478.8	2.13	2731	331.86	189.8	Brittle failure through intact rock.

Client: WSP Canada Inc.	**Project No.:** CA0053577.5884
Borehole and Sample ID: BH-101, UCS-1	
Depth: 5.25m – 5.35m	**Laboratory ID:** R33646



APPENDIX B

Rock Core Photographs

Run 1, BH-102, 4.88m to 6.34m

Run 2, BH-102, 6.34m to 8.08m

Run 3, BH-102, 8.08m to 8.69m

Run 3 - Shale

Weathered Shale

APPENDIX C

Analytical Laboratory Test Results

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: WSP CANADA INC.
309 EXETER ROAD, UNIT #1
LONDON, ON N6L1C1
(519) 652-0099

ATTENTION TO: Mark Demelo

PROJECT: CA0053577.5884

AGAT WORK ORDER: 25L314521

SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganic Team Lead

DATE REPORTED: Jul 03, 2025

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.
- AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.
- This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
- The test results reported herewith relate only to the samples as received by the laboratory.
- Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.
- All reportable information is available on request from AGAT Laboratories, in accordance with ISO/IEC 17025:2017, ISO/IEC 17025:2005 (Quebec), DR-12-PALA and/or NELAP Standards.
- This document is signed by an authorized signatory who meets the requirements of the MELCCFP, CALA, CCN and NELAP.
- For environmental samples in the Province of Quebec: The analysis is performed on and results apply to samples as received. A temperature above 6°C upon receipt, as indicated in the Sample Reception Notification (SRN), could indicate the integrity of the samples has been compromised if the delay between sampling and submission to the laboratory could not be minimized.

Certificate of Analysis

AGAT WORK ORDER: 25L314521
PROJECT: CA0053577.5884

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: WSP CANADA INC.
ATTENTION TO: Mark Demelo
SAMPLING SITE:
SAMPLED BY:MD

Corrosivity Package

DATE RECEIVED: 2025-06-26
DATE REPORTED: 2025-07-03

Parameter	Unit	G / S	RDL	6847147
SAMPLE DESCRIPTION:				BH-101-5
SAMPLE TYPE:				Soil
DATE SAMPLED:				2025-06-23 12:00
Chloride (2:1)	µg/g		2	96
Sulphate (2:1)	µg/g		2	58
pH (2:1)	pH Units		NA	8.21
Electrical Conductivity (2:1)	mS/cm		0.005	0.301
Resistivity (2:1) (Calculated)	ohm.cm		1	3320
Redox Potential 1	mV		NA	207
Redox Potential 2	mV		NA	176
Redox Potential 3	mV		NA	168

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

6847147 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
NIVINE BASILY
CHEMIST

Certified By:

Quality Assurance

CLIENT NAME: WSP CANADA INC.
PROJECT: CA0053577.5884
SAMPLING SITE:

AGAT WORK ORDER: 25L314521
ATTENTION TO: Mark Demelo
SAMPLED BY:MD

Soil Analysis

RPT Date: Jul 03, 2025			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	6846225		8	8	NA	< 2	96%	70%	130%	98%	80%	120%	96%	70%	130%
Sulphate (2:1)	6846225		152	151	0.7%	< 2	100%	70%	130%	103%	80%	120%	101%	70%	130%
pH (2:1)	6846225		5.02	5.18	3.1%	NA	94%	80%	120%						
Electrical Conductivity (2:1)	6846225		0.242	0.226	6.8%	< 0.005	100%	80%	120%						
Redox Potential 1	6847147					NA	100%	90%	110%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Duplicate NA: results are under 5X the RDL and will not be calculated.

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
NIVINE BASILY
CHEMIST

Certified By:

Method Summary

CLIENT NAME: WSP CANADA INC.
PROJECT: CA0053577.5884
SAMPLING SITE:

AGAT WORK ORDER: 25L314521
ATTENTION TO: Mark Demelo
SAMPLED BY:MD

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE

AGAT Laboratories

Have feedback?
Scan here for a quick survey!

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Laboratory Use Only

Work Order #: 25L314521

Cooler Quantity: 1 SML

Arrival Temperatures: 8.3 | 8.5 | 8.6

Depot Temperatures: 5.3 | 6.5 |

Custody Seal Intact: ☐ Yes ☐ No ☒ N/A

Notes: loose ice

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: WSP Canada Inc

Contact: Mark Demelo

Address: 309 Exeter Road Unit 1
N6L 1C1 London ON Canada

Phone: 519-331-4206 Fax:

Reports to be sent to:

1. Email: mark.demelo@wsp.com
2. Email:

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture

Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Regulation 406
Table *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture

☐ Regulation 558

☐ CCME

☐ Sewer Use
☐ Sanitary ☐ Storm

Region

☐ Prov. Water Quality Objectives (PWQO)

☐ Other

Indicate One

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT **(Rush Surcharges Apply)**

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CSR

Project Information:

Project: CA0005377.5884

Site Location:

Sampled By: MD

AGAT Quote #: PO:

Please note: If quotation number is not provided, client will be billed full price for analysis.

Is this submission for a Record of Site Condition (RSC)?
☐ Yes ☐ No

Report Guideline on *Certificate of Analysis*
☐ Yes ☐ No

Legal Sample ☐

Invoice Information:

Bill To Same: Yes ☐ No ☐

Company:

Contact:

Address:

Email: CAPayablesInvoice@wsp.com

Sample Matrix Legend

GW	Ground Water	**SD**	Sediment
O	Oil	**SW**	Surface Water
P	Paint	**R**	Rock/Shale
S	Soil		

	Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC	O. Reg 153						O. Reg 406			O. Reg 558									
							Y/N	Metals & Inorganics	Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	BTEX, F1-F4 PHCs	VOC	PAHs	PCBs: Aroclors ☐	Regulation 406 Characterization Package pH, Metals, BTEX, F1-F4	EC, SAR	Regulation 406 SPLP Rainwater Leach mSPLP: ☐ Metals ☐ VOCs ☐ SVOCs ☐ OC	Landfill Disposal Characterization TCLP: TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	[✓ Corrosivity:] ☐ Moisture ☐ Sulphide							Potentially Hazardous or High Concentration (Y/N)
1.	BH-101-5	Jun 23 2025	12:00 AM PM	2		Soil Corrosivity Package																			
2.			AM PM																						
3.			AM PM																						
4.			AM PM																						
5.			AM PM																						
6.			AM PM																						
7.			AM PM																						
8.			AM PM																						
9.			AM PM																						
10.			AM PM																						
11.			AM PM																						

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Mark Demelo MD	06,26,2025		Kelsey Anderson KA	062625	410 AM
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
			Andy	June 26, 2025	2PM
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time

Page ____ of ____

Nº: T - 167983

Pink Copy - Client | Yellow Copy - AGAT | White Copy- AGAT

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: WSP CANADA INC.
309 EXETER ROAD, UNIT #1
LONDON, ON   N6L1C1
(519) 652-0099

ATTENTION TO: Mark Demelo

PROJECT: CA0053577.5884

AGAT WORK ORDER: 25L321214

SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganic Team Lead

DATE REPORTED: Jul 21, 2025

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

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- *All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.*
- *AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.*
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- *The test results reported herewith relate only to the samples as received by the laboratory.*
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- *All reportable information is available on request from AGAT Laboratories, in accordance with ISO/IEC 17025:2017, ISO/IEC 17025:2005 (Quebec), DR-12-PALA and/or NELAP Standards.*
- *This document is signed by an authorized signatory who meets the requirements of the MELCCFP, CALA, CCN and NELAP.*
- *For environmental samples in the Province of Quebec: The analysis is performed on and results apply to samples as received. A temperature above 6°C upon receipt, as indicated in the Sample Reception Notification (SRN), could indicate the integrity of the samples has been compromised if the delay between sampling and submission to the laboratory could not be minimized.*

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 25L321214

PROJECT: CA0053577.5884

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Mark Demelo

SAMPLING SITE:

SAMPLED BY:MD

Corrosivity Package

DATE RECEIVED: 2025-07-15

DATE REPORTED: 2025-07-21

			SAMPLE DESCRIPTION:	BH-102-7
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2025-07-14 08:00
Parameter	**Unit**	**G / S**	**RDL**	**6892600**
Chloride (2:1)	µg/g		2	76
Sulphate (2:1)	µg/g		2	363
pH (2:1)	pH Units		NA	8.37
Electrical Conductivity (2:1)	mS/cm		0.005	0.636
Resistivity (2:1) (Calculated)	ohm.cm		1	1570
Redox Potential 1	mV		NA	153
Redox Potential 2	mV		NA	115
Redox Potential 3	mV		NA	120

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

6892600 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
NIVINE BASILY
CHEMIST

Quality Assurance

CLIENT NAME: WSP CANADA INC.
PROJECT: CA0053577.5884
SAMPLING SITE:

AGAT WORK ORDER: 25L321214
ATTENTION TO: Mark Demelo
SAMPLED BY:MD

Soil Analysis

RPT Date: Jul 21, 2025			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	6890268		10	10	NA	< 2	100%	70%	130%	98%	80%	120%	97%	70%	130%
Sulphate (2:1)	6890268		14	14	1.2%	< 2	106%	70%	130%	102%	80%	120%	96%	70%	130%
pH (2:1)	6891306		9.60	9.82	2.3%	NA	90%	80%	120%						
Electrical Conductivity (2:1)	6891306		0.301	0.276	8.6%	< 0.005	97%	80%	120%						
Redox Potential 1	6892600					NA	100%	90%	110%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Duplicate NA: results are under 5X the RDL and will not be calculated.

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
NIVINE BASILY
CHEMIST

Certified By: N Basily

Method Summary

CLIENT NAME: WSP CANADA INC.

PROJECT: CA0053577.5884

SAMPLING SITE:

AGAT WORK ORDER: 25L321214

ATTENTION TO: Mark Demelo

SAMPLED BY:MD

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE

AGAT Laboratories

Have feedback?
Scan here for a quick survey!

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Laboratory Use Only

Work Order #: 25L321214

Cooler Quantity: 1 SML
Arrival Temperatures: 3.8 | 4.4 | 3
~~Depot~~ Temperatures: 2.5 | 2.9 | 3.0
Custody Seal Intact: ☐ Yes ☐ No ☑ N/A
Notes: LIT

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: WSP Canada Inc.
Contact: Mark.Demelo@wsp.com
Address: 309 Exeter Road Unit 1
London, ON, N6L 1C1
Phone: 519-331-4706 Fax:
Reports to be sent to:
1. Email:
2. Email:

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table ______ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Regulation 406
Table ______ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
☐ Regulation 558
☐ CCME

☐ Sewer Use
☐ Sanitary ☐ Storm
______ Region
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
______ *Indicate One*

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply): ______

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CSR

Project Information:

Project: CA0053577.5884
Site Location:
Sampled By: MD
AGAT Quote #: ______ PO: ______
Please note: If quotation number is not provided, client will be billed full price for analysis.

Is this submission for a **Record of Site Condition (RSC)?**
☐ Yes ☐ No

Report Guideline on *Certificate of Analysis*
☐ Yes ☐ No

Legal Sample ☐

Invoice Information:

Bill To Same: Yes ☐ No ☐

Company: Send to standard WSP
Contact:
Address: accounts payable email, cc
Email: mark.demelo@wsp.com
reference project number.

Sample Matrix Legend

GW	Ground Water	**SD**	Sediment
O	Oil	**SW**	Surface Water
P	Paint	**R**	Rock/Shale
S	Soil		

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC	O. Reg 153						O. Reg 406			O. Reg 558								Potentially Hazardous or High Concentration (Y/N)
						Y / N	Metals & Inorganics	Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	BTEX, F1-F4 PHCs	VOC	PAHs	PCBs: Aroclors ☐	Regulation 406 Characterization Package pH, Metals, BTEX, F1-F4	EC, SAR	Regulation 406 SPLP Rainwater Leach mSPLP: ☐ Metals ☐ VOCs ☐ SVOCs ☐ OC	Landfill Disposal Characterization TCLP: TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	[✓ Corrosivity] ☐ Moisture ☐ Sulphide							
1. BH-102-9	2025/07/14	8am AM PM	2		Corrosivity Package																			
2.		AM PM																						
3.		AM PM																						
4.		AM PM																						
5.		AM PM																						
6.		AM PM																						
7.		AM PM																						
8.		AM PM																						
9.		AM PM																						
10.		AM PM																						
11.		AM PM																						

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
			Kelsey Anderson Kp	071525	8AM
				July 15	2:15pm

Page 1 of 1

N°: T - 167984

Pink Copy - Client | Yellow Copy - AGAT | White Copy - AGAT wsp.com