# Foundation Investigation and Design Report

Highway 401 Eastbound Express and Collector Lanes between Victoria Park Avenue and Neilson Road – **Rehabilitation of Consilium Place Underpass Structure (Site 37X-1145/B0)**

Assignment No. 2021-E-0018
MTO Central Region
Geocres Number: 30M14-670

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AECOM Canada Ltd.

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# Part I: Foundation Investigation Report

## Highway 401 Eastbound Express and Collector Lanes between Victoria Park Avenue and Neilson Road – Rehabilitation of Consilium Place Underpass Structure (Site 37X-1145/B0)

# 1.0 Introduction

EXP Services Inc. (EXP) was retained by AECOM on behalf of The Ministry of Transportation (MTO) to provide detailed foundation investigation and engineering services for the proposed Highway 401 Eastbound rehabilitation and construction project. The findings, analyses and recommendations are presented in a Foundation Investigation Design Report created for each structure along the proposed highway. The work was undertaken under the additional scope to Assignment No. 2021-E-0018 as defined by AECOM on September 27, 2024. The scope of this report is specific to the proposed rehabilitation of the Consilium Place Overpass structure (Site 37X-1145/B0).

The General Arrangement (GA) drawing for the proposed rehabilitation of the Consilium Place Overpass structure was provided to EXP by AECOM. The purpose of the investigation was to evaluate the subsurface conditions along the structure alignment to support the detailed design for the proposed rehabilitation of the structure.

The site-specific geotechnical investigation consisted of boring, soil sampling, borehole logging, and field and laboratory testing. The field and laboratory work for this structure was performed by EXP. Based on collected geotechnical data; this report provides an assessment of the geotechnical issues, geotechnical design parameters, and geotechnical foundation design recommendations for the proposed structure. Geotechnical-related construction recommendations are also provided.

This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the investigation, and the laboratory testing completed for this project.

# 2.0 Structure Description

The GA drawing titled “*Hwy 401 EB Core & Collector Lane S-E McCowan Ramp Consilium Place Underpass”,* prepared by AECOM, dated August 2024, shows the preliminarily proposed rehabilitation work of the structure. A summary of the structure is as follows:

1. The existing structure is about 13.38 m long single span bridge. It is understood that the existing abutments and retaining wall foundations are supported on spread footings founded at about Elevation 158 m.
2. The superstructure of the existing single-span bridge is proposed to be rehabilitated, which involves:
    - replacement of approach slabs, and concrete raised median on deck and approaches, and asphalt and waterproofing system on deck;
    - excavation behind abutment walls, removal of existing ballast walls, reconstruction of ballast walls, new semi-integral abutment deck extensions and backfill;
    - removal of deteriorated concrete from deck top surface, deck ends, deck soffit, barrier walls, sidewalk, abutment walls, wingwalls and repair of concrete;
    - replacement of abutment bearings and replacement of expansion joint assemblies with new sleeper slabs and expansion joints
3. The existing foundations will remain to support the abutments and retaining walls.
4. No widening of the existing overpass structure is proposed.

These background documents are used for initial context to address the nature and scope of the investigation. It is understood that some changes might occur as a result of normal refinement or the findings of the geotechnical report.

# 3.0 Site Description and Geological Setting

## 3.1 Site Description

The site is located at the intersection of Highway 401 EB Core & Collector Lane S-E McCowan Ramp and Consilium Place, approximately 6.9 km east of Highway 404 in the City of Toronto, Ontario. The site is located south the Highway 401 and east of McCowan Road. In general, the terrain in this area is relatively flat, with the natural ground surface sloping gently towards the south. The Consilium Place pavement grade ranges between about Elevation 165.4 m to 166.7 m while Highway 401 EB Core & Collector Lane S-E McCowan Ramp pavement grade is at about Elevation 159.5 m at the structure site.

A site location plan is presented as Drawing 1 in Appendix C.

## 3.2 Geological Setting

Based on a review of geological maps of Southern Ontario (Chapman and Putnam, 1984; 2007), the site is situated within the South Slope physiographic region where the predominate landforms are Till Plains (Drumlinized) and Drumlins. The South Slope represents the southern slope of the Oak Ridges Moraine but also includes a strip south of the Peel Plain, extending from the Niagara Escarpment to the Trent River. The South Slope gradually, fairly and uniformly, slopes down towards Lake Ontario.

According to the Ministry of Northern Development and Mines, Map 2556 (Quaternary Geology of Ontario, Southern Sheet, 1991) the surface conditions in the vicinity of the project area consist of Halton Till predominately silt to silty clay matrix, high in matrix carbonate content and clast poor with occasional sand to silt zones. In addition, Map 2544 (Bedrock Geology of Ontario, Southern Sheet, 1991), the bedrock geology at the site consists of shale, limestone, dolostone and siltstone: Georgian Bay Formation, Blue Mountain Formation, Bilings Formation, Collingwood Member, Eastview Member.

# 4.0 Previous Geotechnical Investigation

No Previous geotechnical investigation report was identified at this structure location.

# 5.0 Field Investigation and Laboratory Analyses

## 5.1 Site Investigation and Field Testing

A site-specific investigation was undertaken by EXP between December 12, 2025, and December 13, 2025, and it included the following:

1. A walkover site assessment was carried out by a Geotechnical Engineer from EXP.
2. Subsequent to the borehole layouts in the field, existing utilities were cleared by public utility companies.
3. Two boreholes were completed for this structure (BH25-CV-01 and BH25-CV-02) as part of the field investigation. A summary of boreholes completed by EXP is listed in Table 1.1 below. The boreholes were drilled using a truck-mounted CME-75 machine (owned and operated by Drilltech drilling Ltd.) equipped with solid and hollow stem augers, mud rotary equipment, and fitted with capability for Standard Penetration Testing (SPT);
4. Soil samples in the boreholes were taken at frequent intervals of depth by the Standard Penetration Test method (SPT), in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer a vertical distance of

0.76 m to drive a 51 mm O.D. split barrel (SS-split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance, or the N-value, of the soil which is indicative of the compactness condition of granular (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils);

5. The fieldwork was supervised by a member of EXP's engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM Standards for Soils Classification, and retrieved soil samples for subsequent laboratory testing and identification.
6. All spoon samples obtained in the Standard Penetration Tests (SPT, ASTM D-1586) were placed in moisture proof bags after field classification. Samples were allocated from the spoon samples for moisture content testing without delay. They were subsequently re-examined under controlled laboratory conditions prior to assigning other laboratory tests.
7. Selected soil samples for corrosivity testing were sent to the Bureau Veritas Laboratories (formerly Maxxam Analytics), a CALA-certified and accredited laboratory in Mississauga, Ontario. The selected soil samples for the analytical testing were placed in a laboratory prepared glass jar, labelled, and stored in a secure cooler.
8. The borehole locations and their ground surface elevations were surveyed by EXP using a Trimble DA2 GNSS receiver with Trimble Catalyst GNSS positioning, having an accuracy of ±0.10 m horizontal and vertical directions. MTM NAD83 Zone 10 coordinates and the geodetic elevation for the boreholes are listed in Table 1.1 below. It can also be found on the Record of Borehole Sheet (Appendix D); and
9. Upon completion of drilling and field testing, the boreholes were backfilled with a mixture of bentonite and auger cuttings. The borehole decommissioning was in general accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the Ontario Water Resources Act).

**Table 1.1: Summary of boreholes completed by EXP**

| Borehole No. | Borehole Location | Location (MTM NAD83 Zone 10) | | Latitude | Longitude | Borehole Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|---|---|---|
| | | Northing | Easting | | | | |
| **BH25-CV-01** | ~7.4 m west of West Abutment, (Left Lane of EBL Consilium Pl) | 4848892.91 | 324619.07 | 43.779732 | -79.253783 | 166.4 | 6.7 |
| **BH25-CV-02** | ~7.6 m east of East Abutment, (Left Lane of EBL Consilium Pl) | 4848918.35 | 324650.57 | 43.77996 | -79.253391 | 166.5 | 6.7 |

## 5.2 Laboratory Testing

Laboratory testing was conducted on a minimum of 25% of samples collected. Selected samples were submitted for natural moisture content testing. In addition, grain size analysis (sieve and hydrometer) tests were performed on selected soil samples. Chemical analyses were also carried out on two soil samples. The samples were tested at the Bureau Veritas Laboratories (formerly Maxxam Analytics), a CALA-certified and accredited laboratory in Mississauga, Ontario. The laboratory tests performed at this site are summarized in table 1.2.

**Table 1.2: List of Laboratory Test Completed by EXP**

| Borehole No. | Moisture Content | Atterberg Limits | Sieve | Hydrometer | Corrosivity |
|---|---|---|---|---|---|
| **BH25-CV-01** | 8 | - | 2 | 2 | 1 |

| Borehole No. | Moisture Content | Atterberg Limits | Sieve | Hydrometer | Corrosivity |
|---|---|---|---|---|---|
| **BH25-CV-02** | 6 | 1 | 2 | 2 | 1 |

# 6.0 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix D. The "Explanation of Terms Used in Report" preceding the borehole logs in Appendix D forms an integral part of and should be read in conjunction with this report.

A borehole location plan and stratigraphic sections are provided in Appendix C. It should be noted that the stratigraphic boundaries indicated on the borehole log and stratigraphic sections are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be interpreted as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

The general stratigraphy encountered within the depths investigated of EXP's geotechnical investigation indicates the following sub-surface sequence: cohesionless fill overlaying native silty sand to sandy silt till.

A detailed description of the stratigraphy encountered is discussed further in subsequent sections. It should be noted that the following sections are based on the geotechnical investigation conducted by EXP.

## 6.1 Subsoils

### 6.1.1 Pavement Structure

A pavement structure consisting of asphalt and concrete was encountered at the surface of borehole BH25-CV-01, while only asphalt was encountered at the surface of borehole BH25-CV-02. The thickness of asphalt was about 178 mm in both boreholes & the thickness of concrete layer in BH25-CV-01 was about 178 mm.

### 6.1.2 Cohesionless Fill: Sand and Gravel to Gravelly Sand

Sand and Gravel to Gravelly Sand fill was encountered below the asphalt/concrete layer in both boreholes. The approximate elevations of the surface and base of each layer, thickness, description and SPT (N Value) encountered in the boreholes are summarized in Table 1.3 below:

**Table 1.3: Summary of Cohesionless Fill: Sand and Gravel to Gravelly Sand Layers**

| Borehole | Elevation (m) | | Layer Surface Depth (m) | Layer Thickness (m) | Layer Description | SPT "N" Value Range |
|---|---|---|---|---|---|---|
| | Top | Bottom | | | | |
| BH25-CV-01 | 165.9 | 160.4 | 0.6 | 5.5 | Sand and Gravel to Gravelly Sand | 21-49 |
| BH25-CV-02 | 166.3 | 160.4 | 0.2 | 5.9 | Sand and Gravel to Gravelly Sand | 20-64 |

This layer predominately consisted of sand and gravel with trace to some silt and occasionally encountered sandy silt with trace clay and trace organics, trace oxidized layer. The material was brown to brownish grey in colour and damp to moist. The SPT "N" values within this layer ranged from 20 to 64 blows per 300 mm penetration, corresponding to compact to very dense but generally compact to dense in compactness condition.

Laboratory testing performed on selected samples consisting of Eleven (11) moisture content and Three (3) grain size distribution tests. The test results are as follows:

Moisture Content:

- 3.2% to 11.9%

Grain Size Distribution:

- 20% to 34% gravel;
- 50% to 60% sand;
- 15% to 19% silt
- 1% to 3% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix D. The results of grain size distribution tests are also provided on Figure 1 in Appendix E.

### 6.1.3 Native: Silty sand / Sandy silt TILL

A native silty sand to sandy silt till deposit was encountered below cohesionless fill layer in both boreholes The approximate elevations of the surface and base of each layer, thickness, description and SPT (N Value) encountered in the boreholes are summarized in Table 1.6 below:

**Table 1.5: Summary of Silty Sand/Sandy Silt Till**

| Borehole | Elevation (m) | | Layer Surface Depth (m) | Layer Thickness (m) | Layer Description | SPT “N” Value Range |
|---|---|---|---|---|---|---|
| | Top | Bottom | | | | |
| BH25-CV-01 | 160.4 | 159.7 | 6.1 | 0.6 | Silty Sand | 22 |
| BH25-CV-02 | 160.4 | 159.8 | 6.1 | 0.6 | Sandy Silt | 23 |

This layer predominately consists of sand and silt with trace to some gravel, trace to some clay, trace oxidized layer. The material was grey in color and moist. The SPT “N” value within this layer ranged between 22 to 23 blows per 300 mm penetration, corresponding to compact in compactness condition.

Laboratory testing performed on selected sample consisted of Three (3) moisture content, One (1) grain size distribution and One(1) Atterberg Limit tests. The test results are as follows:

Moisture Content:

- 8.3% to 16.6%

Grain Size Distribution:

- 5% gravel;
- 43% sand.
- 41% silt.

- 11% clay

Atterberg Limits:

- Liquid Limit: 18%.
- Plastic Limit: 12%.
- Plasticity Index: 6%

The results of the moisture content, grain size distribution and Atterberg limits are provided on the record of borehole sheets in Appendix D. The results of grain size distribution and Atterberg limits tests are also provided on Figure 2 and 3 in Appendix E.

## 6.2 Groundwater Conditions

Groundwater levels were not encountered upon completion of the boreholes; both the boreholes were dry up to investigated depths upon completion of boreholes. Groundwater levels measured on completion of boreholes may not be considered stabilized and therefore may not represent the established long-term average groundwater table (phreatic surface).

It should be noted that fluctuations in the level of the groundwater may occur due to seasonal variations (precipitation, snowmelt, rainfall), local soil permeability, construction remediation activities, and other related factors.

## 6.3 Chemical Analyses

Two (2) soil samples were selected for chemical analysis during current investigation. The soils samples were tested at the Bureau Veritas Laboratories (formerly Maxxam Analytics), a CALA-certified and accredited laboratory in Mississauga, Ontario.

The analytical results are summarized in Table 1.6 below and are presented in Appendix D.

**Table 1.6: Summary of chemical analysis results**

| Sample Identification | pH (Unitless) | Soluble Chloride (ppm) | Soluble Sulphate (ppm) | Resistivity (ohm-cm) | Conductivity (umho/cm) | Redox Potential (mV) |
|---|---|---|---|---|---|---|
| BH25-CV-01, **SS6** | 7.88 | 400 | 130 | 870 | 1160 | 160 |
| BH25-CV-02, **SS6** | 7.78 | 230 | 170 | 1200 | 816 | 160 |

# 7.0 Closure

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigations and analyses.

Details of the limitations of this report are presented as Appendix A, “Limitations and Use of Report”.

This Foundation Investigation Report has been prepared by Bijaya Bhujel, Nimesh Tamrakar, M.Eng., P.Eng., and Thomas Lardner, Ph.D., P.Eng. It was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Bijaya Bhujel.

Yours truly,

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# Part II: Foundation Design Report

## Discussion and Engineering Recommendations for Rehabilitation of Consilium Place Underpass Structure (Site 37X-1145/B0)

# 8.0 Discussion and Recommendations

## 8.1 General

This section of the report provides geotechnical design recommendations for the design of the roadway protection system required (if any) for rehabilitation of the Consilium Place Overpass Structure. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation at the site and presented in Part I-Foundation Investigation Report. The interpretation and recommendations provided are intended solely to permit designers to assess roadway protection systems alternatives for bridge rehabilitation. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the work should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

Per the GA drawing, the existing structure is about 13.38 m long single span bridge structure supported on a spread footing founded at about Elevation 158 m. The Consilium Place pavement grade ranges between about Elevation 165.4 m to 166.7 m while Highway 401 EB Core & Collector Lane S-E McCowan Ramp pavement grade is at about Elevation 159.5 m at the structure site.

It is understood that the proposed rehabilitation of the Consilium Place Overpass Structure will not involve widening the existing structure or changing the existing total deadloads by more than 10%. The existing foundations are expected to remain and based on the contemplated traffic staging plan there will not be any unusual loads on the existing foundations. The rehabilitation program will involve replacement of approach slabs, concrete sidewalks and concrete raised median on deck and approaches, and asphalt and waterproofing system on deck; excavation behind abutment walls, removal of existing ballast walls, reconstruction of ballast walls, new semi-integral abutment deck extensions and backfill. The existing foundations will remain to support the abutments and retaining walls. It is anticipated that this work will require excavations of the embankment fills immediately behind the abutment walls/retaining walls to facilitate the rehabilitation work. Based on the GA drawing, the depth of excavation behind the abutment/retaining wall is expected to be about 2.5 m.

Based on subsoil conditions encountered at the site it is expected that excavation will be carried out through cohesionless fill. Groundwater levels were not encountered upon completion of the boreholes; both the boreholes were dry up to investigated depths upon completion of boreholes. Based on an assessment of the water levels observed in the borings and the subsurface conditions, the groundwater is not expected to be encountered within anticipated excavation depths of about 2.5 m below the existing road surface. It should be noted that fluctuations in the level of the groundwater may occur due to seasonal variations (precipitation, snowmelt, rainfall), local soil permeability, construction remediation activities, and other related factors. A detailed description of the soil and groundwater encountered is discussed in Part I of this report.

This part of the report addresses the geotechnical design of the foundation for the temporary roadway protection system by providing geotechnical design parameters that may be required in accordance with the latest edition of the *Canadian Highway Bridge Design Code (CHBDC, CAN/CSA-S6-19, 2019)*, the *Canadian Foundation Engineering Manual (CFEM, 2023)*, *Guideline for MTO Foundation Engineering Services, Version 03 (April 2022)* and generally accepted good practice. This structure has the potential to significantly affect alternate transportation corridors and is considered to be of “Typical Consequences Level” associated with exceeding Limit States Design (Section 6.5 and Commentary, CHBDC, 2019). A “Typical Degree of Site and Prediction Model Understanding” is considered appropriate based on the level of foundation investigation completed. Pertinent geotechnical resistance factors and consequence factors have been used in design. The report also addressed other geotechnical and construction considerations such as excavation, groundwater and surface water control and lateral earth pressure on structures.

## 8.2 Roadway Protection System

Roadway protection system for construction may be required to facilitate the rehabilitation work. The roadway protection system should be properly designed so that the lateral movement of any portion of the protection system will not exceed the established criterion for the structural performance level. The temporary support systems should be designed and constructed in accordance with OPSS.PROV 539 as amended by SP105S09. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS.PROV 539, provided that the existing, if any, adjacent utilities can tolerate this magnitude of deformation or re-routed away from excavation influence zone. The shoring system should be designed by a Professional Engineer, experienced in this type of work and employed by the contractor.

To safely support the excavation walls and minimize the impact to existing utilities in the embankment (if any), temporary shoring consisting of driven steel sheet piling or Soldier H-pile with lagging, should be practical options at this location. The subsurface condition at this site is suitable for both of these options. Where the depth requiring support is too much for cantilevered systems, bracing in the form of shores or Deadman anchors can be considered. A comparison of these two systems based on advantages and disadvantages, risks and relative costs is provided in Table 2.1.

It is considered that a sheet pile of sufficiently robust cross section could be driven through granular fill encountered at these sites, through the fill of abutments and native deposits. Difficulties with installation may occur where occasional cobbles and boulders are encountered in the fill (i.e., cobbles/boulders were not encountered in the boreholes drilled during this investigation, however by the nature of fill, presence of cobbles and boulders should be anticipated ), requiring their removal before further driving or fitted with a driving shoe. It is recommended that an NSSP be included in the Contract Documents to warn the Contractor of the possible presence of cobbles and/or boulders within the overburden soils or native deposits and an example of NSSP is included in Appendix J. Alternatively, an H-pile with lagging wall can be used as a vertical temporary shoring system. The H-piles are installed, and lagging is inserted between installed H-piles during excavation. Space between the excavation and lagging must be suitably backfilled and drained. Lagging wall material can be selected as wood (timber), steel or concrete.

**Table 2.1: Evaluation of temporary roadway protection system options**

| Support System | Advantages | Disadvantages | Relative Cost | Risk Consequences | Rank |
|---|---|---|---|---|---|
| Soldier H-Pile and Lagging | • Appropriate for shallow and deep installation<br>• Easy to install through potential obstructions | • May require bracing/ tieback anchors depending on depth of excavation into overburden | • Low cost of construction | • Piles could be long<br>• Potential for loss of soil through laggings | 1 |
| Driven Steel Sheet Piling | • Straightforward installation | • Possible obstructions within fill which may affect driving | • More expensive | • Installation may be difficult if obstructions are encountered in the fill | 2 |

Timber lagging may be sized as per Table 20.12 of the CFEM, 5th edition (Section 20.8.9). This is provided so the center-to-center spacing of the soldier piles does not exceed 3.0 m. Soldier piles should extend a minimum depth of 3.0 m below the planned excavation depth. The actual depth of embedment should be determined by balancing moments about the pile tip. Excavation can proceed following installation of the soldier piles. The unshored height of the excavation should not exceed 1.2 m at any given time. No excavation height should remain unshored for more than 24 hours. Any loose zones from behind the shoring should be prevented during installation of the protection system. If required, Granular A backfill should be placed and compacted behind the shoring wall.

For the relatively shallow depth of excavation anticipated, cantilevered systems may be adequate. However, depending on the actual excavation depth, embedment depth (i.e., an embedded depth of sheet piles can be approximately 2.0 to 2.5 times of its exposed height), and shoring system used, additional anchorage or tiebacks may be required. This must be confirmed by the shoring designer. Conventional practice is to incorporate either buried Deadman anchors, rakers or grouted soil anchors. Deadman anchors can be designed based on the earth pressure coefficients and soil parameters provided in Section 8.2.1 following. For this project, either continuous or individual concrete block anchors would likely be appropriate. Anchor resistance is provided by a combination of the dead weight and passive resistance. For the full passive resistance to be realized with no load transfer to the wall, the anchor needs to be fully beyond the active wedge acting on the wall. Pressure grouted soil anchors can be designed in a preliminary fashion in accordance with Section 20 of the CFEM (2023). Based on generally compact to dense cohesionless fill, the estimated factored (0.4) ULS resistance of grouted anchors would be approximately 40 kN/m length. Detailed design should be completed following the conception of the wall and when the associated loads have been established. Normally, such anchors are supplied and installed/tested by specialist vendors/contractors.

As can be seen in Table 2.1, the Soldier H-Pile and Lagging is ranked as more practical for this project due to possible obstructions that may be present within fill layer. Design and construction specifications for the chosen roadway protection system should be prepared in accordance with OPSS. PROV 539. Pilling should be in accordance with OPSS. PROV 903. Cantilevered walls should be designed for the earth pressures coefficient presented in Section 8.2.1 of this report and earth pressure diagram shown in CFEM Figure 20.15. Besides design and construction of the temporary protection system, the Contractor is also responsible for its materials, maintenance, monitoring and removal. According to OPSS 539, the protection system shall be removed from the right-of-way, unless it is specified in the Contract Documents that the protection system may be left in place. Where the piles are left in place, the top shall be removed at least 1.2 m below the finished grade level.

### 8.2.1 Lateral Earth Pressure

Temporary roadway protection systems should be designed to resist lateral earth pressure. The expression for calculating lateral earth pressure is given by:

$P = K (\gamma h + q)$ for non-braced cut, or $K (0.65\gamma H + q)$ for braced support
where:
P = earth pressure intensity at depth h, kPa
K = earth pressure coefficient
$\gamma$ = unit weight of retained soil, kN/m$^3$
q = surcharge near wall, kPa
h = depth to point of interest, m
H= total depth of excavation, m

The above expression does not consider hydrostatic pressure, which must be included for the groundwater levels measured on the site. However, a properly designed and constructed soldier pile and lagging wall will be permeable and therefore hydrostatic pressure acting on the restrained height may be discounted. The surcharge should include soil loading above the retained soil and other loading adjacent to the wall.

For the design purposes, the unfactored static earth pressure parameters given in Table 2.2 can be used (assuming wall friction is neglected, the back wall is vertical, and the ground surface is horizontal both on the retained side as well as in front of the toe):

**Table 2.2: Material types and unfactored earth pressure properties under static conditions**

| Abutment | Elevation | Material | Unfactored Friction Angle ϕ' (o) | Coefficient of Lateral Earth Pressure[1] | | | Unit Weight $\gamma$ (kN/m$^3$) | GWL (m) |
|---|---|---|---|---|---|---|---|---|
| | | | | ($K_a$) | ($K_p$) | ($K_o$) | | |
| West | 165.9 to 163 | Sand and Gravel to Gravelly Sand Fill (compact to dense) | 34 | 0.28 | 3.54 | 0.44 | 21 | N/A |
| | 163 to 160.4 | Gravelly Sand Fill (compact) | 32 | 0.31 | 3.25 | 0.47 | 21 | |
| | 160.4 to 159.7 | Silty sand Till (compact) | 32 | 0.31 | 3.25 | 0.47 | 21 | |
| East | 166.3 to 163.9 | Sand and Gravel to Gravelly Sand Fill (compact to very dense) | 34 | 0.28 | 3.54 | 0.44 | 21 | N/A |
| | 163.9 to 160.4 | Gravelly Sand Fill (compact) | 32 | 0.31 | 3.25 | 0.47 | 21 | |
| | 160.4 to 159.8 | Silty sand Till (compact) | 32 | 0.31 | 3.25 | 0.47 | 21 | |

*Notes:*

*1.0 $K_a$ = active earth pressure coefficient; $K_p$= passive earth pressure coefficient; $K_o$ = coefficient of earth pressure at rest*

## 8.3 Construction Considerations

### 8.3.1 Excavation

Based on the GA drawing and correspondence with AECOM, the proposed depth of excavation is about 2.5 m below the roadway.

All excavations must be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act (OHSA) and good construction practice. The existing fills which should be excavated for the rehabilitation of the Overpass Structure (i.e., uncontrolled fill) are considered Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavations (i.e., those that are open only for a short period) above the groundwater table may be made with side slopes not steeper than about 1H:1V, while the temporary slopes below the groundwater table have to be formed at 3H:1V unless a suitable dewatering system is installed to lower the water level below the base of the excavation.

### 8.3.2 Groundwater and Surface Water Control

As mentioned in Section 6.2, based on an assessment of the water levels observed in the borings and the subsurface conditions, no groundwater was encountered within the depth investigated. The groundwater levels are anticipated to be below borehole investigation depth (i.e. 159.7 m) across the Consilium Place Overpass structure. Water may also be perched in the fill at higher levels during wet periods.

Based on the rehabilitation works planned at these sites, an excavation is planned to extend to about ~Elevation 162.9 m which would be above the groundwater level. However, if any perched water encountered within the fill, it is anticipated that control of seepage can be accomplished by conventional pumping from sumps in oversize excavations. This dewatering can likely be achieved by gravity drainage and pumping from strategically placed sumps with side ditches. Confirmation of control should be verified before general excavation to final levels.

Surface water should always be directed away from the excavation area(s). Dewatering/unwatering shall be carried out in accordance with OPSS.PROV 517 and SP517F01. It is the responsibility of the Contractor to propose a suitable dewatering system based on the time of construction, water levels, and flow conditions. The method used should not undermine the existing utilities/ structures (if any). Alternatively, and in accordance with SP 517F01, the dewatering systems may be completed by a design Engineer and design-checking Engineer with a minimum of 5 years' experience.

## 8.4 Corrosion Protection

Two (2) soil samples were selected for chemical analysis during current investigation. The testing was completed to determine the potential degradation of the concrete in the presence of soluble sulphates and the potential of corrosion of exposed steel used in foundations and buried infrastructure. The analyses results are summarized in Table 1.6 of this report.

The pH, resistivity, and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH values ranged from 7.78 to 7.88 which is within the normal range of soil pH of 5.5 to 8.5 (AASHTO, 2000/MTO Gravity Pipe Design Guidelines, May 2007). The chemical data indicates, resistivity of tested soil was ranged between 870 – 1200 ohm-cm, which suggests severe potential for corrosion of buried metallic elements as per Table 3.2 of the MTO Gravity Pipe Design Guideline. The measured chloride content was ranged between 230 to 400 ppm (µg/g) which indicates a very low to low potential for additional corrosion (Molinas and Mommandi, 2009).

Based on these results, some level of corrosion protection for buried metallic elements is required, depending upon the material type. However, coating of steel H Piles is not done in general practice. It is up to the designer to determine the requirements of appropriate protective coating measures to ensure that all aspects of CHBDC 2014, Section 2 "Durability" requirements are followed. The test results provided in Table 1.9 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

The maximum water-soluble sulphate content of the soils tested is under 20 ppm (µg/g), i.e. <0.002% and being less than 0.10%, does not require sulphate resistant cement.

## 8.5 Obstructions

Cobbles and/or boulders were noted to be contained within the glacial till and should always be anticipated in the glacial and interglacial soil, owing to their mode of deposition. Possible rubble/obstructions should also be anticipated within the existing fills. Therefore care (i.e., pile flange reinforcement or fitted with a driving shoe) has to be taken during the installation of elements of temporary protection systems or may also impact excavations. It is recommended that an NSSP be included in the Contract Documents to warn the Contractor of the possible presence of cobbles and/or boulders within the overburden soil. An example of an NSSP is included in Appendix F.

## 8.6 Geotechnical Instrumentation and Monitoring

Monitoring of the effect of the construction for the rehabilitation of the existing structure should be conducted. Provided that the unwatering/dewatering (if any) and shoring are carried out in accordance with specifications and good practice, a significant impact on the existing bridge/walls foundation is not anticipated. However, monitoring of movements of adjacent structure(s), shoring system, and vibrations during rehabilitation of the structure is recommended.

The Geotechnical Instrumentation and Monitoring Plan (GIMP) shall include typical installation details, locations of installed instruments, and review procedures. Besides the existing structures, the monitoring of temporary protection systems, if any, should be performed in accordance with OPSS.PROV 539. Therefore, for this site the following elements of monitoring are anticipated:

### 8.6.1 Precondition and postcondition surveys

A precondition survey of all existing structures should be conducted prior to construction activities within the expected Zone of Influence with the goal of creating a baseline of pre-existing conditions and defects. Expected structures include the existing roadway and accruements including the pavement surface, traffic barriers, and overhead lighting, including all accruements, and potential existing utility infrastructure.

The precondition survey should note the existing conditions of each structure, identifying existing wear-and-tear and potential deficiencies or defects. Documentation for each instance of a defect or deficiency should include the location, size, orientation, and any other relevant details. Photographic records for each occurrence are also required. The results shall be summarized and submitted as a precondition survey report. Upon review of the precondition survey report, additional monitoring, such as crack gauges, may be required.

Upon completion of the proposed works, a postcondition survey may be conducted as required to identify potential impacts on existing structures from the construction activities. A postconstruction report shall review the defects and deficiencies identified in the preconstruction survey and identify any new defects or deficiencies.

### 8.6.2 Movements of Existing Structure

Survey points should be used to monitor movements of the existing overpass structure. The monitoring plan will include the following:

- Install survey points along the existing bridge (min 6 m c/c) and the existing adjacent abutment and bridge deck (min 5m c/c).
- The location of survey points is to be coordinated with the construction team to prevent conflict during the proposed work.
- Monitoring frequency will be:
    - Preconstruction: Minimum 3 baseline readings, one month prior to construction
    - During construction: Daily readings during active construction.
    - Post construction: Biweekly after completion and then after four weeks, if there is little to no settlement continue surveying once a month for three months; or until the engineer is satisfied with performance.
- The criteria for evaluation of settlement shall be based on the following action levels:

  Structure Limits:

  1. Review Level: If a maximum value of 5 mm relative to the baseline readings is reached, the method and rate or sequence of construction shall be reviewed or modified to mitigate further ground displacements.

2. Alert Level: If a maximum value of 10 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.

Pavement Surface Limits:

1. Review Level: If a maximum deformation of 300 horizontal: 1 vertical relative to the baseline readings is reached, the method and rate or sequence of construction shall be reviewed or modified to mitigate further ground displacements.
2. Alert Level: If a maximum deformation of 150 horizontal: 1 vertical 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.

### 8.6.3 Movements of Temporary Protection Systems

The minimum requirements for monitoring temporary protection system should include the survey measurements of scaled targets attached to the shoring wall at the specified elevations. The scaled targets should be placed at a maximum spacing of 6 m with targets placed at the extreme ends and the targets distributed between the outer limits. The survey targets shall be monitored for horizontal displacement from the vertical at the frequency specified. The limit for horizontal deformation is 0.1% of the excavated height or a maximum horizontal displacement is 25 mm, and the limit of angular distortion is 1:200 (as per OPSS.PROV 539 Performance Level 2).

Shoring Limits shall follow OPSS.PROV 539, Performance Level 2:

1. Review Level: If a maximum value of 15 mm relative to the baseline readings is reached, the method and rate or sequence of construction shall be reviewed or modified to mitigate further ground displacements.
2. Alert Level: If a maximum of 25 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.

### 8.6.4 Vibration

For bridge structures in good condition, OPSS.PROV 120 may be used to provide a limit of peak particle velocity (PPV), (noting that other entities having jurisdiction in particular settings may have more stringent regulations). Experience with monitoring construction activities such as piling, drilling and hoe ramming has indicated that the noted threshold limit is not likely to be exceeded. However, it is recommended that site-personnel vibration monitoring takes place only during active construction of the temporary roadway protection systems.

The suggested vibration monitoring plan is described in the following.

1. Vibration monitoring should be conducted to verify the vibration levels near the existing structure and the utilities identified in the area.
2. No vibration monitoring is required for private or commercial building(s) which is not present in the zone of influence for construction for this structure.
3. A normal background vibration reading produced by no construction related activities should be taken one month prior to construction activity.
4. Attended vibration monitoring can be conducted by a qualified technician during construction. The vibration monitoring program should include monitoring with seismograph near the structure to confirm the magnitude of the vibration produced by construction activity. The seismograph consists of an ISEE geophone and base fitted with an internal

battery can be considered. The qualified technician attending during construction activity should take readings from the seismograph and make notes of construction activities that produced the vibration events.

5. If excessive vibration levels were to be found, modifications to the construction techniques, potentially utilizing lighter or smaller equipment or less aggressive usage would be required.
6. Once construction activity is substantially complete, a final report should be prepared summarizing all vibration measurements made during that phase of construction.

The limits are as follows:

1. Review levels are any PPV of 15 mm/second at a frequency of 40 Hz or less OR a PPV of 40 mm/second at frequencies greater than 40 Hz.
2. Alert levels are any PPV of 20 mm/second at a frequency of 40 Hz or less OR a PPV of 50 mm/second at frequencies greater than 40 Hz

## 8.7 Potential Impacts on Existing SSE Tunnel Structure

As discussed in detail in Section 2.0 Site Description, the construction activities at this location is limited to retrofit of the existing bridge to a semi-integral bridge. This will involve excavation behind the existing abutments to a maximum depth of approximately 2.5 m, isolated to immediately behind the abutments. The new bridge structure does not involve a grade change. Given that no foundation enhancement is planned, any load increases on the structure as transferred to the foundations is inferred to be less than 10% or foundation improvements would have been triggered. The centreline of the tunnel alignment in the zone of interest is offset to the east of the west abutment, with the crown about 9m below the underside of the footing foundation of the bridge.

During construction, the proposed excavation depths and extents potentially represent a temporary reduction in surcharge load over a section of the tunnel, with corresponding uplift stress on any impacted zone. Given the limited extent of the proposed excavation and the geometric setting relative to the existing SSE Tunnel structure, this temporary reduction in stress at tunnel level, if any, is expected to be small (less than 10 kPa) and is not expected to cause an impact on the tunnel.

The lack of grade change and proposed works for the Consilium Place bridge represent a potential change in load from the previous conditions to the proposed conditions of less than 10%. This infers that stresses at the footing level would potentially increase no more than 10%. Any such stress will be distributed with depth. This condition is expected to have negligible impact on the existing SSE Tunnel structure at depth.

# 9.0 Closure

The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the team responsible for the design of the works described herein.

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigations and analyses.

Details of the limitations of this report are presented as Appendix A, "Limitations and Use of Report".

This Foundation Investigation and Design Report has been prepared by Nimesh Tamrakar, M.Eng., P.Eng and Thomas Lardner, PhD., P.Eng. It was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact.

Yours truly,

EXP Services Inc.

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Encl.

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# Appendix A – Limitations and Use of Report

# LIMITATIONS AND USE OF REPORT

## BASIS OF REPORT

This report (“Report”) is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of exp may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by exp. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and exp’s recommendations. Any reduction in the level of services recommended will result in exp providing qualified opinions regarding the adequacy of the work. exp can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to exp to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

## RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to exp by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. exp has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to exp.

## STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

## COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to exp by its client (“Client”), communications between exp and the Client, other reports, proposals or documents prepared by exp for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. exp is not responsible for use by any party of portions of the Report.

## USE OF REPORT

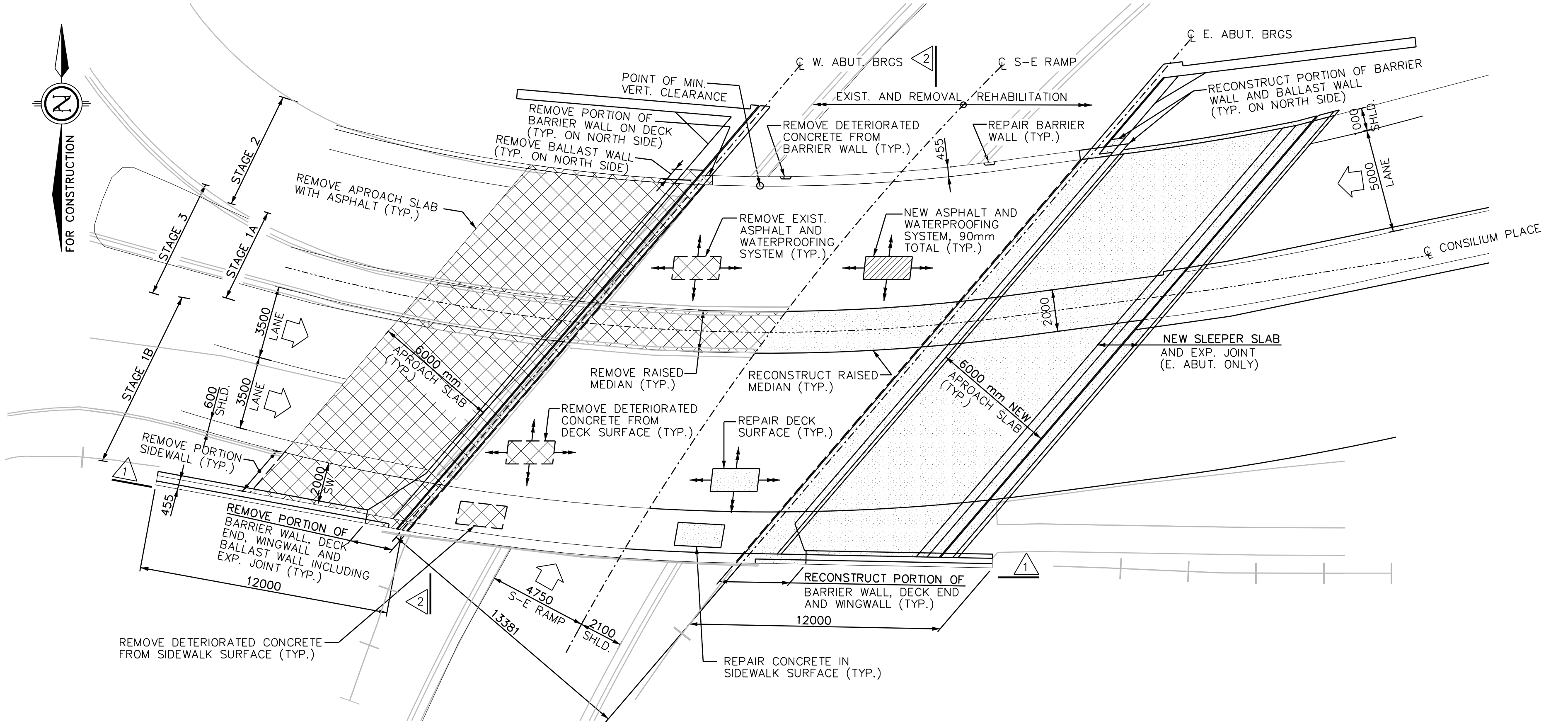
The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of exp. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. exp is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

## REPORT FORMAT

Where exp has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by exp have utilize specific software and hardware systems. exp makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems. Regardless of format, the documents described herein are exp’s instruments of professional service and shall not be altered without the written consent of exp.

# Appendix B – General Arrangement Drawings

2017-08
ANSI-D
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
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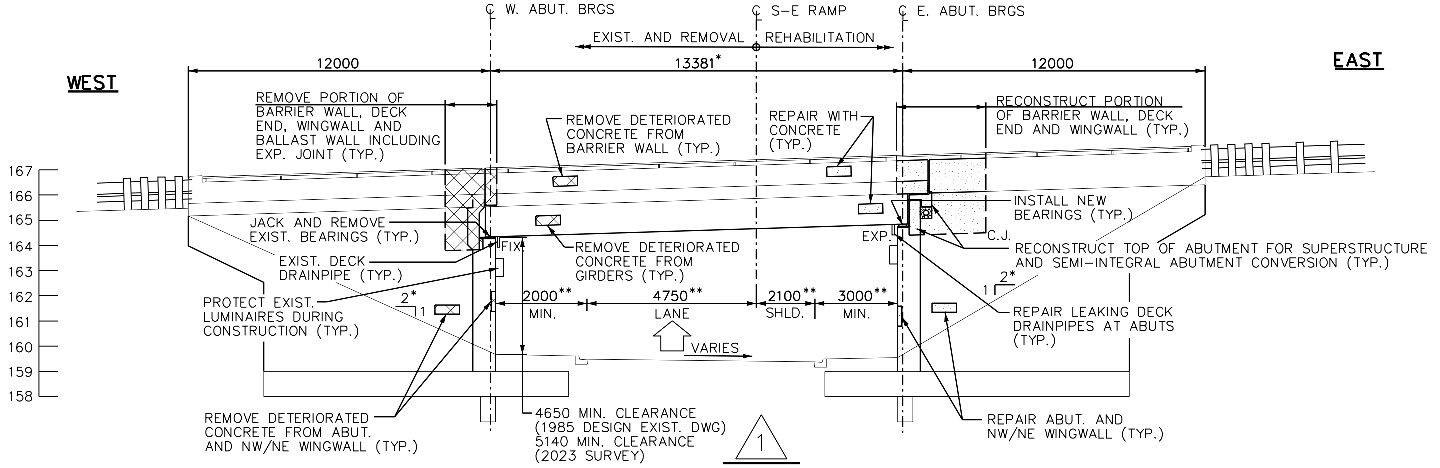
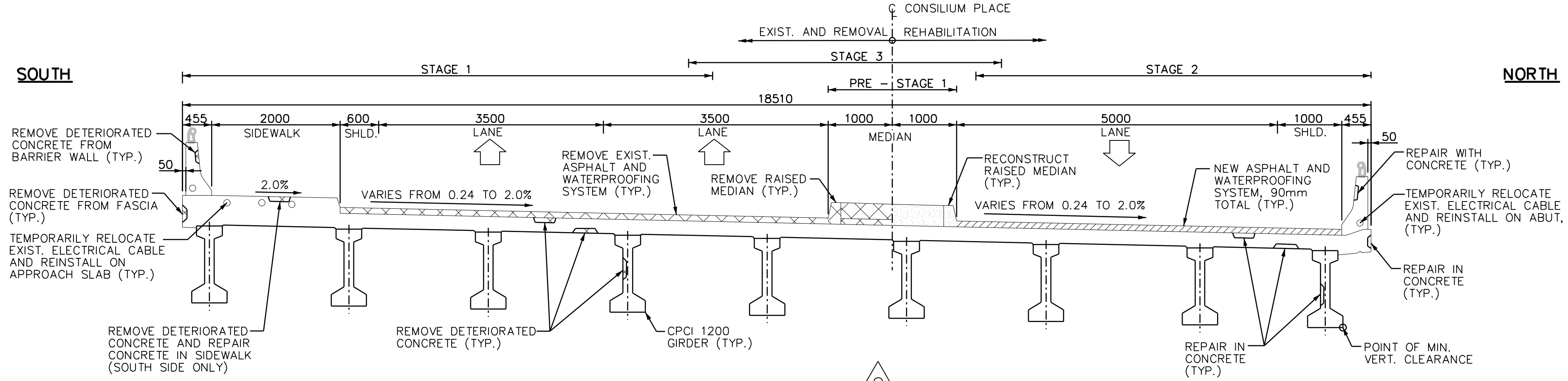


1
1:150

*: MEASUREMENTS PERPENDICULAR TO ℄ OF ABUTMENT BEARINGS
**: MEASUREMENTS PERPENDICULAR TO ℄ OF S-E RAMP.
UNLESS OTHERWISE NOTICES.



2
1:50

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

Ontario Ministry of Transportation

CONT
WP

HWY 401 EB CORE & COLLECTOR LANE
S-E McCOWAN RAMP CONSILIUM PLACE UNDERPASS
GENERAL ARRANGEMENT

SHEET
S21

AECOM

## GENERAL NOTES:

1. CLASS OF CONCRETE:..............................................30 MPa
2. CLEAR COVER TO REINFORCEMENT:

DECK: TOP...........................................................70±20
BOTTOM.......................................................50±10
REMAINDER...............................................................70±20

UNLESS NOTED OTHERWISE.

3. REINFORCING STEEL:

- REINFORCING STEEL SHALL BE GRADE 500W UNLESS OTHERWISE SPECIFIED.
- BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
- STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE MINIMUM YIELD STRENGTH OF 500 MPa.
- BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12-1 UNLESS INDICATED OTHERWISE.
- UNLESS SHOWN OTHERWISE TENSION LAP SPLICES SHALL BE CLASS B.

## CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL VERIFY ALL RELEVANT DIMENSIONS, ELEVATIONS AND DETAILS ON SITE AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR PRIOR TO PROCEEDING WITH REHABILITATION WORK.
2. TYPICAL AREAS OF REPAIRS ARE INDICATED ON THE DRAWINGS. WHERE REPAIR LIMITS ARE NOT SHOWN, LIMITS SHALL BE IDENTIFIED BY THE CONTRACT ADMINISTRATOR.
3. SAW CUT IN CONCRETE, WHERE DESIGNATED, SHALL BE 25mm DEEP OR TO THE FIRST LAYER OF REINFORCING STEEL, WHICHEVER IS LESS.
4. LOCATIONS OF THE EXISTING UTILITY DUCTS SHOWN ON THE DRAWINGS ARE APPROXIMATE AND SHALL BE VERIFIED IN THE FIELD BY THE CONTRACTOR PRIOR TO START OF CONSTRUCTION.
5. ANY DAMAGE DURING CONSTRUCTION TO THE EXISTING STRUCTURES, UTILITIES AND ADJACENT PROPERTIES NOT DESIGNATED FOR REPAIR SHALL BE REPAIRED GOOD BY THE CONTRACTOR TO THE SATISFACTION OF THE CONTRACT ADMINISTRATOR AND AT NO COST TO THE OWNER.
6. THE CONTRACTOR SHALL PROVIDE DEBRIS PLATFORMS AND NECESSARY CONTAINMENT MEASURES TO COLLECT FALLING CONCRETE AND CONSTRUCTION DEBRIS SUCH THAT NO DEBRIS OR MATERIALS RESULTING FROM THE REMOVAL WORK FALLS INTO ROADWAYS AND OTHER AREAS BELOW THE BRIDGE.
7. THE CONTRACTOR IS FULLY RESPONSIBLE FOR ADEQUATE PROTECTION OF ALL UTILITIES, SERVICES, ROADWAYS ETC. DURING CONSTRUCTION OPERATIONS.

## LIST OF ABBREVIATIONS:

| | |
|---|---|
| ABUT. | DENOTES ABUTMENT |
| BRGS. | DENOTES BEARINGS |
| E | DENOTES EAST |
| EXIST. | DENOTES EXISTING |
| EXP. | DENOTES EXPANSION |
| HWY | DENOTES HIGHWAY |
| S-E | DENOTES SOUTH TO EAST |
| SHLD | DENOTES SHOULDER |
| SW | DENOTES SIDEWALK |
| TYP. | DENOTES TYPICAL |
| W | DENOTES WEST |

## LEGEND:

| | |
|---|---|
| ☐ | CONCRETE TO REMAIN |
| ⊠ | REMOVAL |
| ░ | NEW CONCRETE |
| ▨ | NEW ASPHALT |

## LIST OF DRAWINGS:

| | |
|---|---|
| R1-01. | GENERAL ARRANGEMENT |
| R1-02. | CONSTRUCTION STAGING |
| R1-03. | JACKING AND BEARINGS DETAILS |
| R1-04. | REMOVAL DETAILS - I |
| R1-05. | REMOVAL DETAILS - II |
| R1-06. | WEST ABUTMENT REHABILITATION DETAILS |
| R1-07. | EAST ABUTMENT REHABILITATION DETAILS |
| R1-08. | 6000mm APPROACH SLAB DETAIL |
| R1-09. | EXPANSION JOINT (TYPE C) AND SLEEPER SLAB |
| R1-10. | STRIP SEAL EXPANSION JOINT - TYPE C DETAILS |
| R1-11. | SEQUENCE OF EXPANSION JOINT INSTALLATION |
| R1-12. | STANDARD AND MISCELLANEOUS DETAILS |
| R1-13. | EMBEDDED ELECTRIAL WORK |

## APPLICABLE STANDARD DRAWINGS

| | |
|---|---|
| OPSD 3349.101 | DRAINAGE OF EXISTING DECK BELOW ASPHALT WEARING SURFACE |
| OPSD 3370.100 | DECK WATERPROOFING, HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD DETAILS |
| OPSD 3370.101 | DECK WATERPROOFING, HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS |
| OPSD 3390.100 | DECK DRIP CHANNEL |
| OPSD 3950.100 | JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE |

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |

| | | | | |
|---|---|---|---|---|
| DESIGN S.S. | CHK J.J. | CODE CAN/CSA S6-19 | LOAD CL 625-ONT | DATE AUG. 2024 |
| DRAWN O.Z. | CHK S.S. | SITE 37X-1145/B0 | | DWG R1-01 |

CADD FILE NAME : C:\Users\otto.zheng\Desktop\Hwy401 Victoria to Netail\S.E. Mccowan Ramp\R1-01_S-E Mccowan Ramp_ga.dgn

# Appendix C – Borehole Location Plan and Stratigraphic Profile

CONT No.
ASSIG No. 2021–E–0018
GWP No.

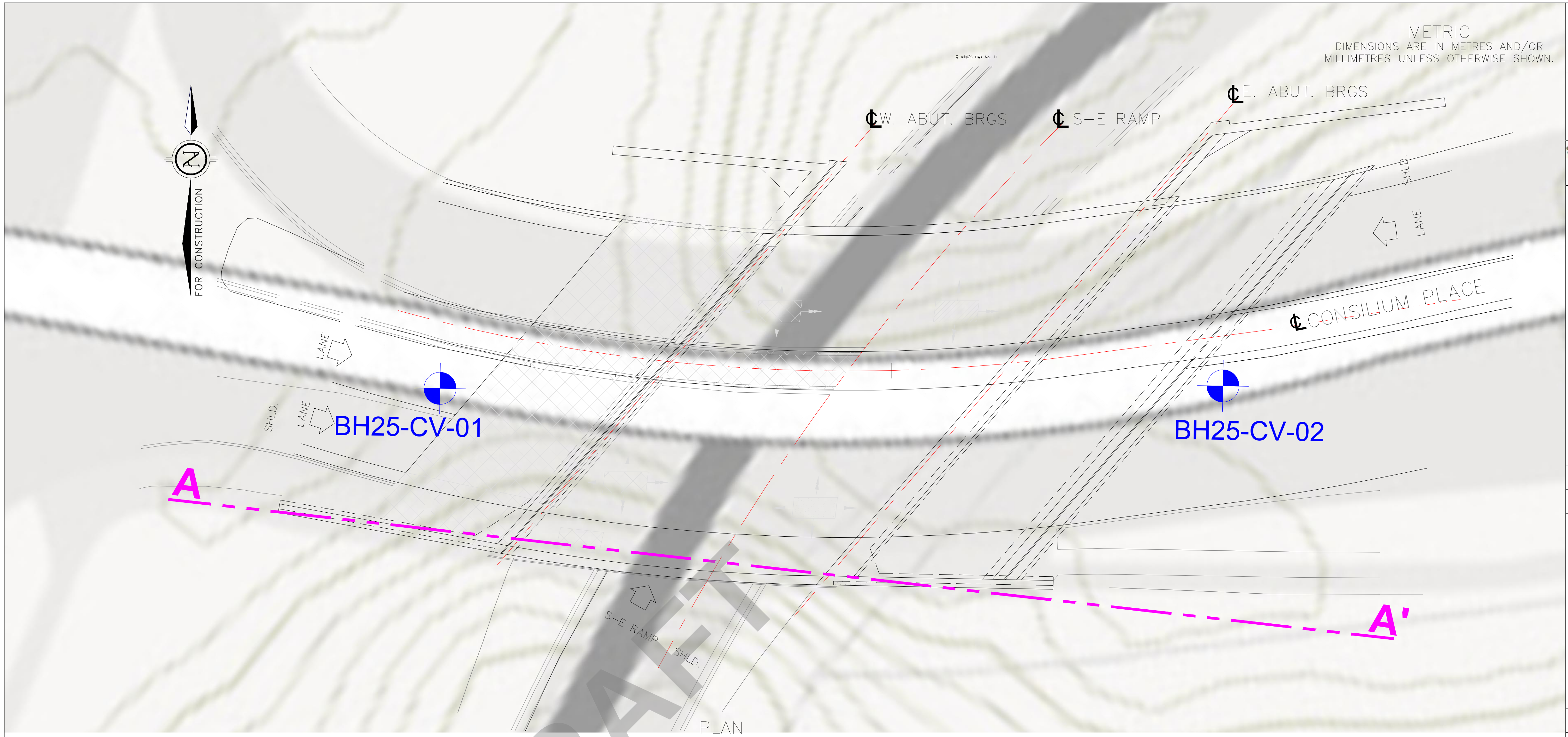
SHEET 1

Highway 401 Eastbound Express and Collector Rehabilitation of Consilium Place Underpass Structure
Latitude: 43.779837°, Longitude: -79.253617°

# BOREHOLE LOCATION PLAN & SOIL STRATA

**EXP SERVICES INC.**

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

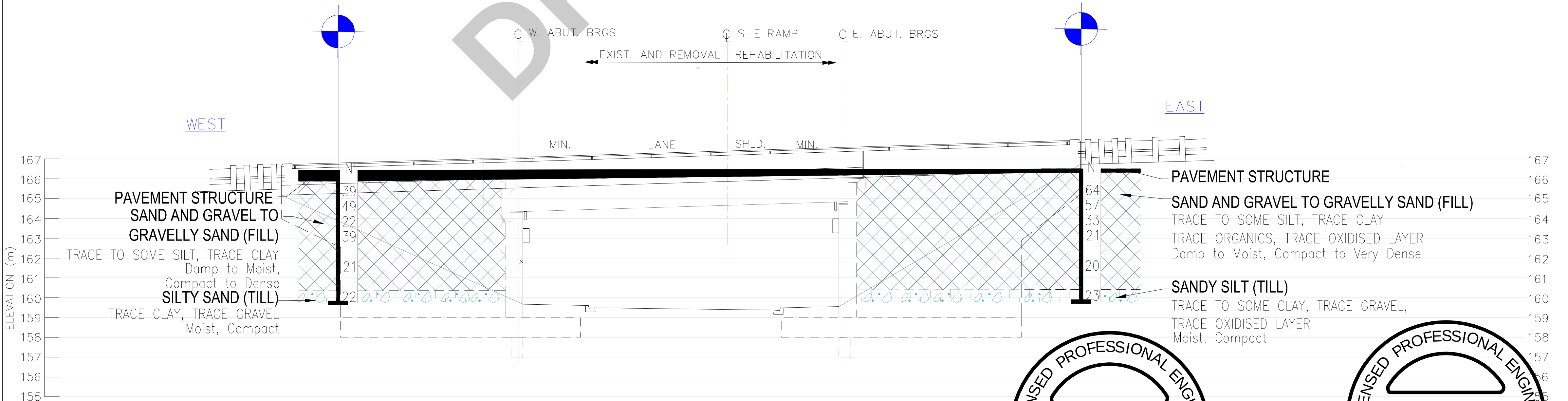


PLAN

0 1 5
Scale (m)

## BH25-CV-01

## BH25-CV-02



SECTION **A-A'**

T.R.A. LARDNER
100118263
MAR. 13, 2026

S.E.M. GONSALVES
16533010
MAR. 13, 2026

KEY PLAN
N.T.S.

## LEGEND

|  |  |
|---|---|
| ⊕ | Borehole |
| N | Blows/0.3m (Std. Pen. Test, 475 J/blow) |

## SOIL STRATA SYMBOLS

|  |  |
|---|---|
| ■ | PAVEMENT STRUCTURE |
| ▨ | FILL |
| ▨ | SANDY SILT TO SILTY SAND (TILL) |

## BOREHOLE CO–ORDINATES/ NAD 83/ MTM ON–10

| BH No. | ELEV. | NORTHING | EASTING |
|---|---|---|---|
| BH25–CV–01 | 166.4 | 4848892.91 | 324619.07 |
| BH25–CV–02 | 166.5 | 4848918.35 | 324650.57 |

## NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

SUBMISSION FOR MTO REVIEW

| REVISIONS NO | DATE | BY | DESCRIPTION |
|---|---|---|---|
|  |  |  |  |
| 01 | 13/MAR/2026 | TL | ISSUED FOR USE |

| | | | |
|---|---|---|---|
| PROJECT No. ADM-22000797-A0 | | GEOCRES No. - | |
| SUBM'D SH | CHKD. NT | DATE Dec. 23, 2025 | SITE 37X-1145/B0 |
| DRAWN SH | CHKD. TL | APPRD SG | DWG 01 |

FILE NAME: \\PBRMFSG001\Data_Zeus\2003–Brampton\Proposals\Projects\International\Hwy 401 & Victoria Park Av. to Nelson\Reports\CONSILIUM PLACE UNDERPASS\Autocad\GA_S–E McCowan Ramp, Consilium Place Underpass.dwg
MODIFIED: 2025–12–23 14:28

# Appendix D – Borehole Logs

# Explanation of Terms Used on Borehole Records

## SOIL DESCRIPTION

Terminology describing common soil genesis:

*Topsoil:* mixture of soil and humus capable of supporting good vegetative growth.

*Peat:* fibrous fragments of visible and invisible decayed organic matter.

*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.

*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.

Terminology describing soil structure:

*Desiccated:* having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

*Stratified:* alternating layers of varying material or color with the layers greater than 6 mm thick.

*Laminated:* alternating layers of varying material or color with the layers less than 6 mm thick.

*Fissured:* material breaks along plane of fracture.

*Varved:* composed of regular alternating layers of silt and clay.

*Slickensided:* fracture planes appear polished or glossy, sometimes striated.

*Blocky:* cohesive soil that can be broken down into small angular lumps which resist further breakdown.

*Lensed:* inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

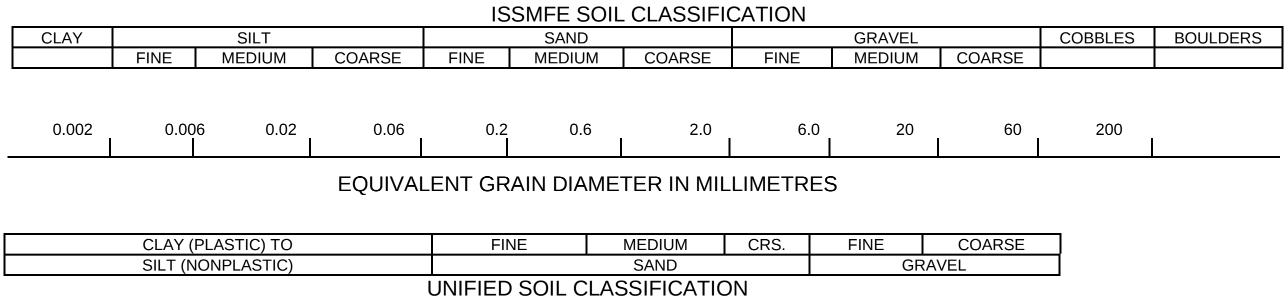
*Seam:* a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

*Homogeneous:* same color and appearance throughout.

*Well Graded:* having wide range in grain sized and substantial amounts of all predominantly on grain size.

*Uniformly Graded:* predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.



Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Canadian Foundation Engineering Manual (CFEM):

Table a: Percent or Proportion of Soil

| Term | Description | Criteria |
|---|---|---|
| “trace” | trace gravel, trace sand, etc. | 1% - 10% |
| “some” | some gravel, some sand, etc. | 10% - 20% |
| Adjective | gravelly, sandy, silty and clayey | 20% - 35% |
| “and” | and gravel, and sand, etc. | >35% |
| Noun | gravel, sand, silt, clay | >35% and main fraction |

The
standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test ‘N’ value:

Table b: Apparent Density of Cohesionless Soil

| | ‘N’ Value (blows/0.3 m) |
|---|---|
| Very Loose | N<5 |
| Loose | 5≤N<10 |
| Compact | 10≤N<30 |
| Dense | 30≤N<50 |
| Very Dense | 50≤N |

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test ‘N’ values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

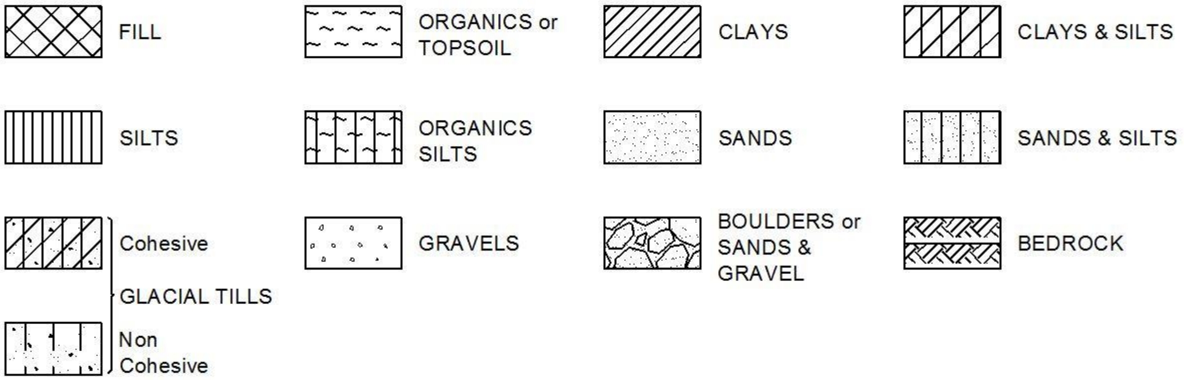
Table c: Consistency of Cohesive Soil

| Consistency | Vane Shear Measurement (kPa) | ‘N’ Value |
|---|---|---|
| Very Soft | <12.5 | <2 |
| Soft | 12.5-25 | 2-4 |
| Firm | 25-50 | 4-8 |
| Stiff | 50-100 | 8-15 |
| Very Stiff | 100-200 | 15-30 |
| Hard | >200 | >30 |

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

## STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



## WATER LEVEL MEASUREMENT

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

| | |
|---|---|
| SS | Split spoon sample (obtained from the Standard Penetration Test) |
| WS | Wash sample |
| BS | Bulk sample |
| TW | Thin wall sample or Shelby tube |
| PS | Piston sample |
| AS | Auger sample |
| VT | Vane test |
| GS | Grab sample |
| HQ, NQ, etc. | Rock core samples obtained with the use of standard size diamond drilling bits |

### STRESS AND STRAIN

| | | |
|---|---|---|
| $u_w$ | kPa | Pore water pressure |
| $r_u$ | 1 | Pore pressure ratio |
| $\sigma$ | kPa | Total normal stress |
| $\sigma'$ | kPa | Effective normal stress |
| $\tau$ | kPa | Shear stress |
| $\sigma_1, \sigma_2, \sigma_3$ | kPa | Principal stresses |
| $\varepsilon$ | % | Linear strain |
| $\varepsilon_1, \varepsilon_2, \varepsilon_3$ | % | Principal strains |
| E | kPa | Modulus of linear deformation |
| G | kPa | Modulus of shear deformation |
| $\mu$ | 1 | Coefficient of friction |

### MECHANICALL PROPERIES OF SOIL

| | | |
|---|---|---|
| $m_v$ | kPa$^{-1}$ | Coefficient of volume change |
| $c_c$ | 1 | Compression index |
| $c_s$ | 1 | Swelling index |
| $c_r$ | 1 | Recompression index |
| $c_v$ | m$^2$/s | Coefficient of consolidation |
| H | m | Drainage path |
| $T_V$ | 1 | Time factor |
| U | % | Degree of consolidation |
| $\sigma'_{v0}$ | kPa | Effective overburden pressure |
| $\sigma'_P$ | kPa | Preconsolidation pressure |
| $\tau_f$ | kPa | Shear strength |
| $c'$ | kPa | Effective cohesion intercept |
| $\phi'$ | –° | Effective angle of internal friction |
| $c_u$ | kPa | Apparent cohesion intercept |
| $\phi_u$ | –° | Apparent angle of internal friction |
| $\tau_R$ | kPa | Residual shear strength |
| $\tau_r$ | kPa | Remoulded shear strength |
| $S_t$ | 1 | Sensitivity = $c_u/\tau_r$ |

### PHYSICAL PROPERTIES OF SOIL

| | | |
|---|---|---|
| $P_s$ | kg/m$^3$ | Density of solid particles |
| $\gamma_s$ | kN/m$^3$ | Unit weight of solid particles |
| $\rho_w$ | kg/m$^3$ | Density of water |
| $\gamma_w$ | kN/m$^3$ | Unit weight of water |
| $\rho$ | kg/m$^3$ | Density of soil |
| $\gamma$ | kN/m$^3$ | Unit weight of soil |
| $\rho_d$ | kg/m$^3$ | Density of dry soil |
| $\gamma_d$ | kN/m$^3$ | Unit weight of dry soil |
| $\rho_{sat}$ | kg/m$^3$ | Density of saturated soil |
| $\gamma_{sat}$ | kN/m$^3$ | Unit weight of saturated soil |
| $\rho'$ | kg/m$^3$ | Density of submerged soil |
| $\gamma'$ | kN/m$^3$ | Unit weight of submerged soil |
| $e$ | 1, % | Void ratio |
| $n$ | 1, % | Porosity |
| $w$ | 1, % | Water content |
| $S_r$ | % | Degree of saturation |
| $W_L$ | % | Liquid limit |
| $W_P$ | % | Plastic limit |
| $W_s$ | % | Shrinkage limit |
| $I_P$ | % | Plasticity index = $(W_L - W_P)$ |
| $I_L$ | % | Liquidity index = $(W - W_P)/I_P$ |
| $I_C$ | % | Consistency index = $(W_L - W)/I_P$ |
| $e_{max}$ | 1, % | Void ratio in loosest state |
| $e_{min}$ | 1, % | Void ratio in densest state |
| $I_D$ | 1 | Density index = $(e_{max} - e)/(e_{max} - e_{min})$ |
| D | mm | Grain diameter |
| $D_n$ | mm | N percent - diameter |
| $C_u$ | 1 | Uniformity coefficient |
| h | m | Hydraulic head or potential |
| q | m$^3$/s | Rate of discharge |
| v | m/s | Discharge velocity |
| i | 1 | Hydraulic gradient |
| k | m/s | Hydraulic conductivity |
| j | kN/m$^3$ | Seepage force |

# RECORD OF BOREHOLE No BH25-CV-01

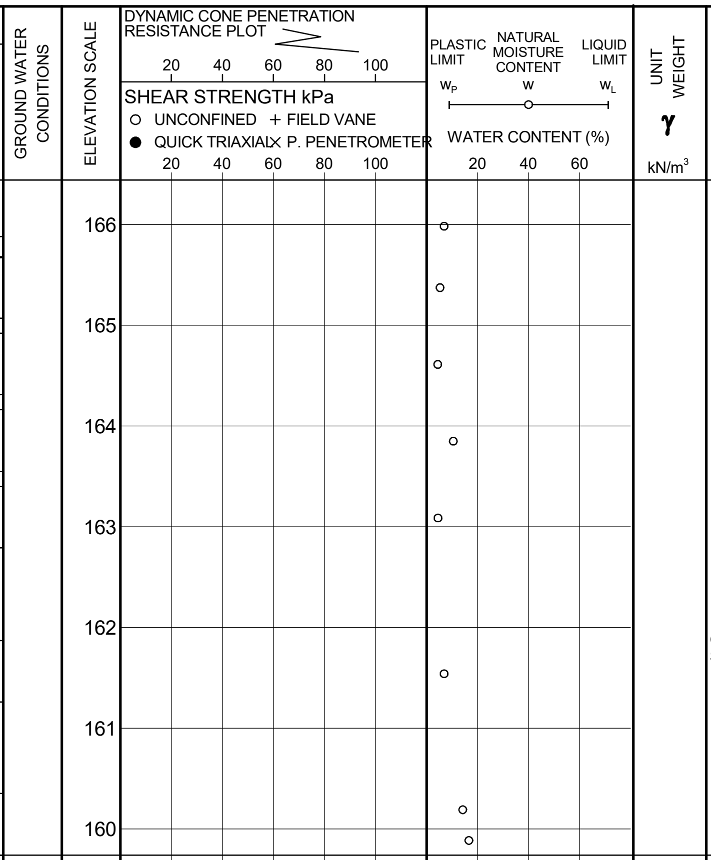
1 OF 1

**METRIC**

W.P. ADM-22000797-A0
LOCATION **Hwy 401-Consilium Pl, Toronto, ON, MTM ON-10, 324619.07 E, 4848892.91 N**
ORIGINATED BY BB
DIST Toronto HWY 401
BOREHOLE TYPE Truck Mount CME75/ SSA
COMPILED BY BB
DATUM Geodetic
DATE 2025.12.12 - 2025.12.12
LATITUDE 43.779732
LONGITUDE -79.253783
CHECKED BY NT

| SOIL PROFILE | | SAMPLES | | | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | GR | SA | SI | CL |
| 166.4 | GROUND SURFACE | | | | | | | |
| 0.0 | **PAVEMENT STRUCTURE**, 178 mm of asphalt, and 178 mm of concrete | | | | | | | |
| 165.9<br>0.6 | **SAND AND GRAVEL TO GRAVELLY SAND (FILL)**, trace to some silt, brown to brownish grey, damp to moist, compact to dense | AS1 | AS | - | | | | |
| | | SS2 | SS | 39 | | | | |
| | | SS3 | SS | 49 | 34 | 50 | 15 | 1 |
| | -100mm grey sandy silt, trace clay, trace organics layer at ~2.64 m. | SS4 | SS | 22 | | | | |
| | | SS5 | SS | 39 | | | | |
| | | SS6 | SS | 21 | Corrosivity Sample<br>23 | 56 | 18 | 3 |
| 160.4<br>6.1 | **SILTY SAND (TILL)**, trace clay, trace gravel, grey, moist, compact | SS7 | SS | 22 | | | | |
| 159.7<br>6.7 | **END OF BOREHOLE** | | | | | | | |

NOTE:
1) Borehole open to 5.6 m below grade upon completion of drilling.
2) No groundwater was encountered in open borehole.



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

$\circ^{3\%}$ STRAIN AT FAILURE

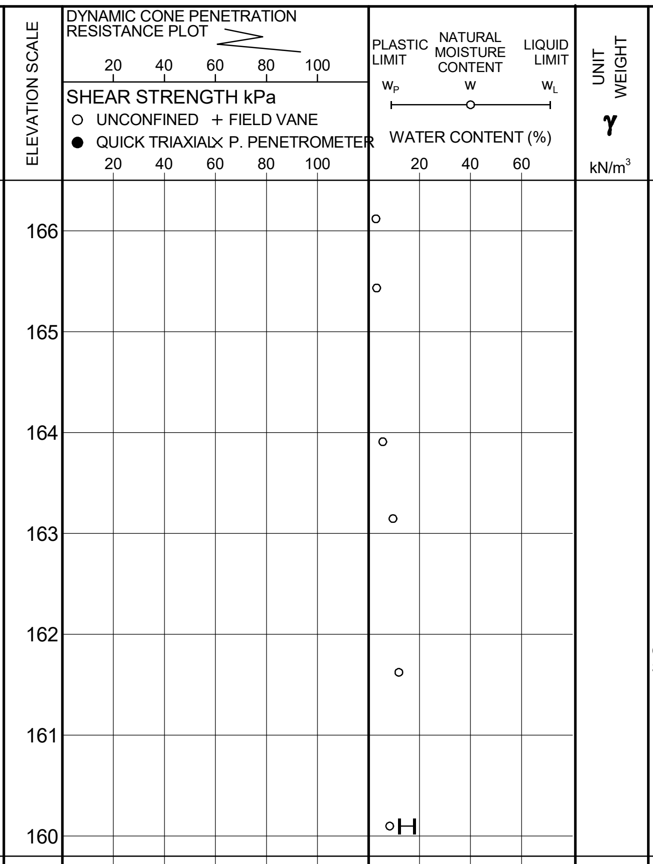
# RECORD OF BOREHOLE No BH25-CV-02

1 OF 1

**METRIC**

W.P. ADM-22000797-A0
LOCATION **Hwy 401-Consilium Pl,Toronto, ON, MTM ON-10, 324650.57 E, 4848918.35N**
ORIGINATED BY BB
DIST Toronto HWY 401
BOREHOLE TYPE Truck Mount CME75/ SSA
COMPILED BY BB
DATUM Geodetic
DATE 2025.12.12 - 2025.12.13
LATITUDE 43.77996
LONGITUDE -79.253391
CHECKED BY NT

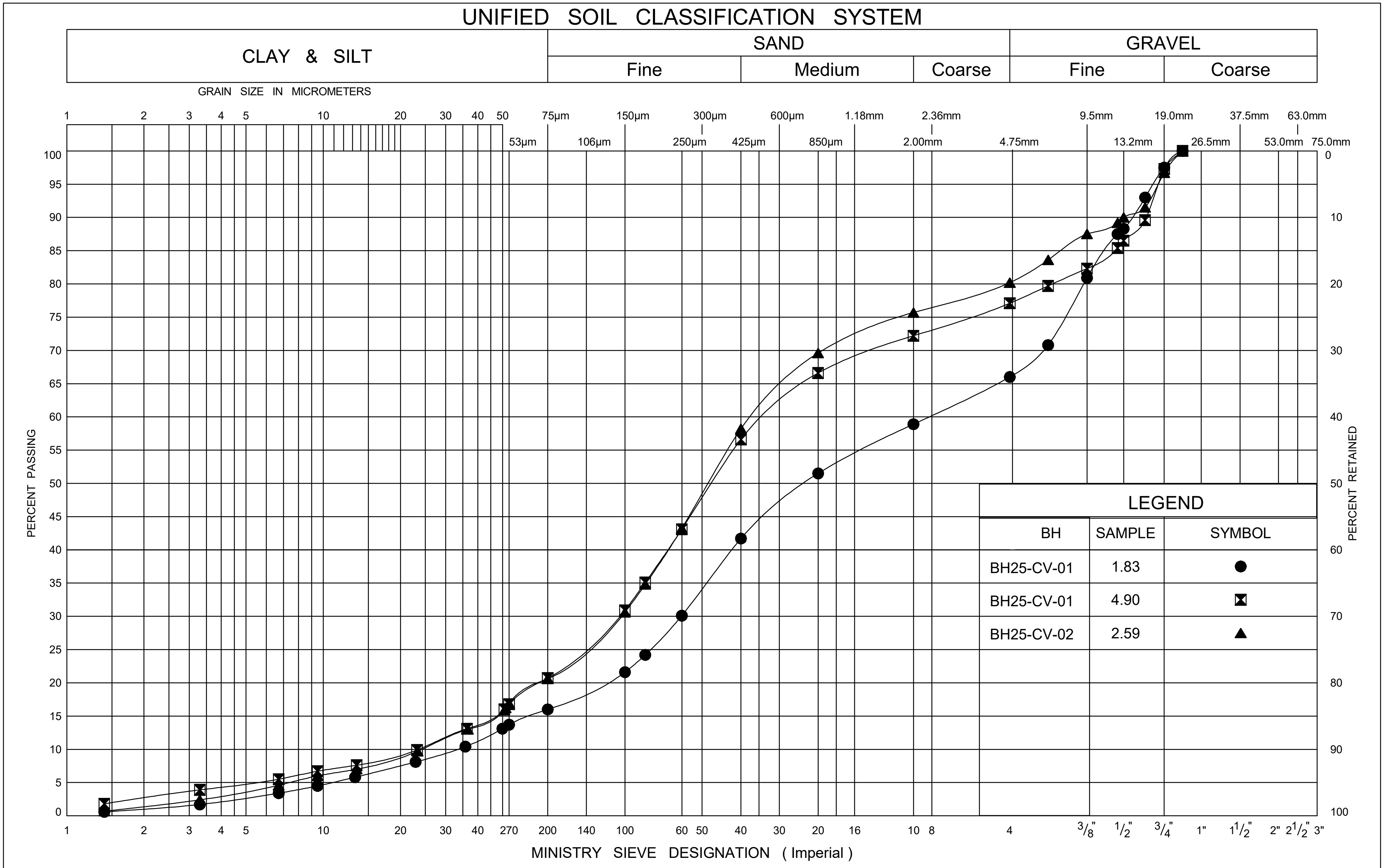
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | GR | SA | SI | CL |
| 166.5 | GROUND SURFACE | | | | | | | | | |
| 166.3<br>0.0 | **PAVEMENT STRUCTURE**, 178 mm of asphalt | | | | | | | | | |
| 0.2 | **SAND AND GRAVEL TO GRAVELLY SAND (FILL)**, trace to some silt, trace clay, trace organics, trace oxidised layer, brown, damp to moist, compact to very dense | | AS1 | AS | - | | | | | |
| | | | SS2 | SS | 64 | | | | | |
| | | | SS3 | SS | 57 | | | | | |
| | | | SS4 | SS | 33 | | 20 | 60 | 19 | 1 |
| | - trace organics at a depth ~3.4 m depth. | | SS5 | SS | 21 | | | | | |
| | | | SS6 | SS | 20 | | Corrosivity Sample | | | |
| 160.4<br>6.1 | **SANDY SILT (TILL)**trace gravel, trace to some clay, trace oxidised layer, grey, moist, compact | | SS7 | SS | 23 | | 5 | 43 | 41 | 11 |
| 159.8<br>6.7 | **END OF BOREHOLE**<br><br>NOTE:<br>1) Borehole open to 5.5 m below grade upon completion of drilling.<br>2) No groundwater was encountered in open borehole. | | | | | | | | | |



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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

# Appendix E – Laboratory Data



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# GRAIN SIZE DISTRIBUTION

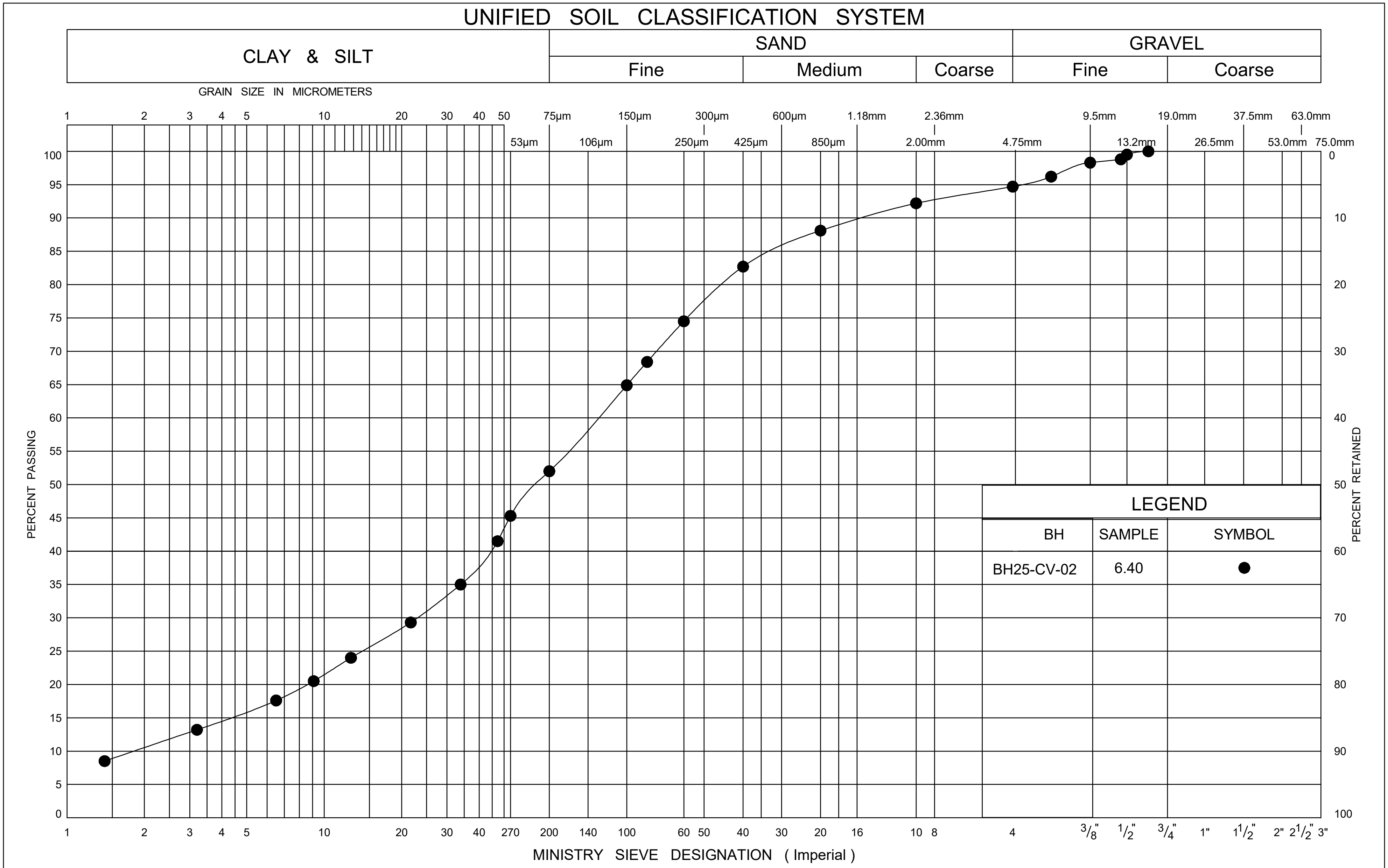
## SAND AND GRAVEL TO GRAVELLY SAND (FILL)

FIG No 1

W P ADM-22000797-A0

Hwy. 401 EB Express and Collector

ONTARIO MOT GRAIN SIZE CONSILIUM PLACE UNDERPASS -V2.GPJ ONTARIO MOT.GDT 12/23/25



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# GRAIN SIZE DISTRIBUTION

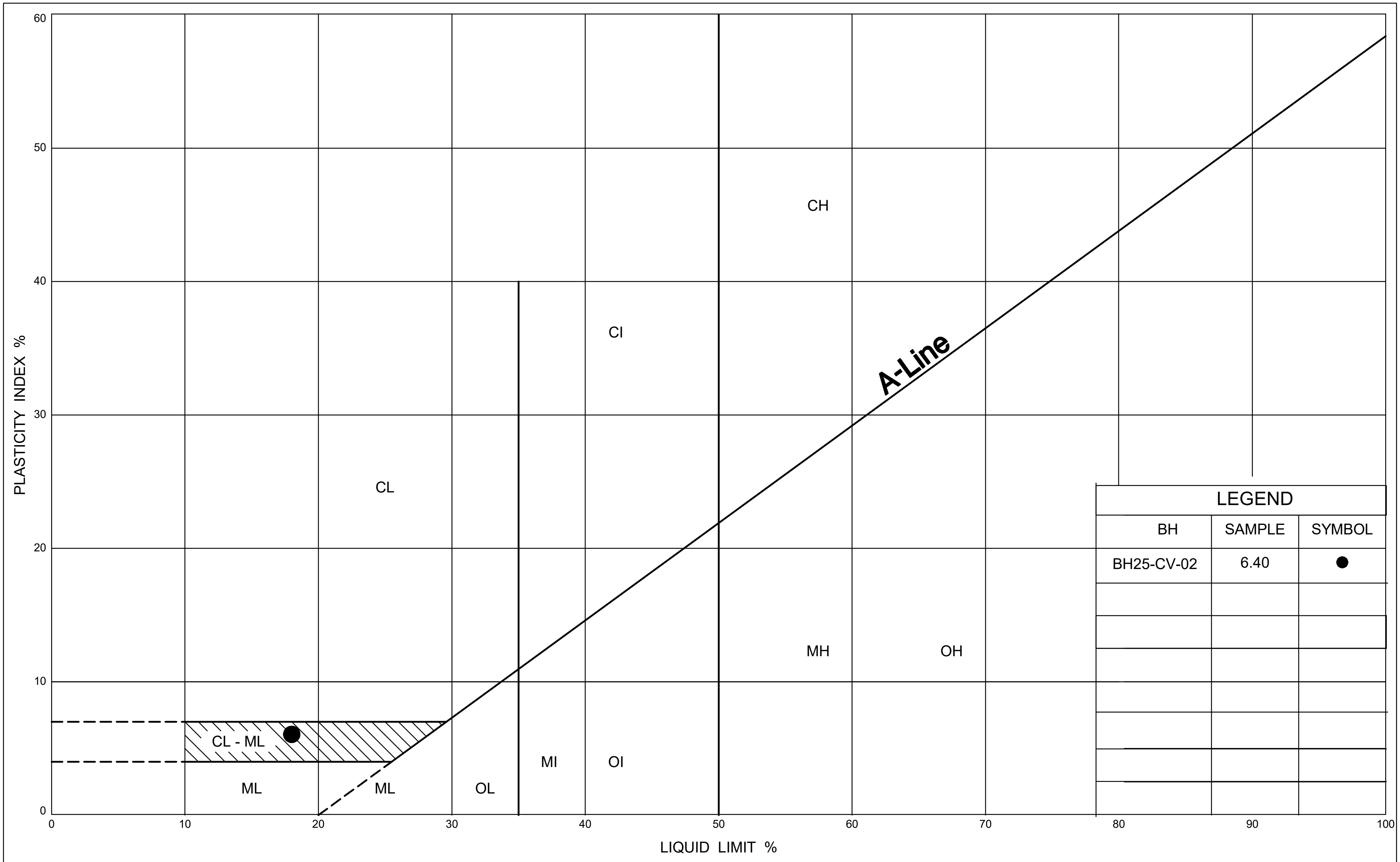
## SILTY SAND TO SANDY SILT (TILL)

FIG No 2

W P ADM-22000797-A0

Hwy. 401 EB Express and Collector

ONTARIO MOT GRAIN SIZE CONSILIUM PLACE UNDERPASS -V2.GPJ ONTARIO MOT.GDT 12/23/25



| LEGEND | | |
|---|---|---|
| BH | SAMPLE | SYMBOL |
| BH25-CV-02 | 6.40 | ● |

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# PLASTICITY CHART
## SILTY SAND TO SANDY SILT (TILL)

FIG No 3

W P ADM-22000797-A0

Hwy. 401 EB Express and Collector

# Appendix F – Non-Standard Special Provisions (NSSP)

## NSSP FOR POSSIBLE OBSTRUCTIONS

### Scope of Work

The Contractor should be aware that the existing fill and native soil could contain cobbles and boulders or rubble as inferred from difficulties in advancing augers/auger grinding. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for piling or for temporary shoring through these materials.

### Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.