REPORT

Foundation Investigation and Design Report

Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, Ontario
MTO G.W.P. 2022-22-00; W.P. 2014-23-01; Assignment 2022-E-0046

Submitted to:

Ministry of Transportation, Ontario

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Table of Contents

PART A

FOUNDATION INVESTIGATION REPORT
TEMPORARY WORKS – NICOLSTON CULVERT REHABILITATION
HIGHWAY 89, ALLISTON, SIMCOE COUNTY, ONTARIO
MTO G.W.P. 2022-22-00; W.P. 2014-23-01; ASSIGNMENT 2022-E-0046

1.0 INTRODUCTION

WSP Canada Inc. (WSP) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detail design of improvements to the Highway 89 / Essa 5th Line intersection, including widening of the Nottawasaga River bridge, and rehabilitation / replacement of the Nicolston Structural Culvert in Alliston, Ontario.

This report presents the results of the foundation investigation carried out in support of designing the temporary works (specifically the suggested temporary access roads) associated with the proposed rehabilitation (trenchless lining) of the Highway 89 Nicolston Structural Culvert (Site No. 30X-0678/C0). A separate report addresses the foundation investigation for the detail design of the Nicolston structural culvert and proposed widening of the Nottawasaga River bridge. It is the Contractor's responsibility for the design, construction and maintenance of all temporary works, including any access roads.

2.0 SITE DESCRIPTION

This section of Highway 89 is located between the towns of New Tecumseth and Cookstown, and between Essa 5th Line and Nottawasaga Resort Way. The culvert is located within the existing Highway 89 embankment that crosses over a ravine associated with a Nottawasaga River tributary watercourse. Access to the toe of the embankment and culvert inlet / outlet locations will be required at both the north and south side of the embankment to facilitate the culvert rehabilitation. The location of the culvert site and ravine are shown on Drawing 1.

The area to the south of Highway 89, beyond the vegetated / wooded ravine, is occupied by mobile homes (i.e. the Rolling Acres Camp), as well as the Nottawasaga Resort located further east. The area to the north of Highway 89 consists of heavily vegetated / wooded ravine which leads up to the tableland which is currently used for agricultural purposes. There are some residential and/or small business properties on the north side of Highway 89, directly east of the ravine and culvert site.

The north slope of the Nottawasaga tributary ravine is considered an environmentally sensitive area. There is a permanent cut slope (up to about 10 m high) into the tableland that runs parallel to Highway 89 and adjacent to Essa 5th Line, approximately 30 m west of the culvert. There were previous surficial stability issues within the cut slope west of the site, as outlined in a previous Foundation Report[1] and technical memorandum[2] issued to MTO and titled "*Permanent Remediation of Cut Slope Instabilities on Highway 89 near 5th Line, Essa Township, W.O. 2012-11010, GEOCRES No. 31D-537",* dated March 27, 2012. Based on observations of the cut slope during the current investigation, there was no obvious signs of instability or active erosion.

Highway 89 runs in an east-west direction at this location, and the Nottawasaga River tributary (and culvert) generally runs northeast-southwest. The embankment side-slopes are generally covered with trees and shrubs, with increasing wooded area surrounding the Nottawasaga tributary watercourse, which drains into the Nottawasaga River approximately 275 m southwest of the culvert. The highway embankment at the location of the culvert and suggested temporary access roads (hereafter referred to as access roads) generally ranges from

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[1] Golder Associates Ltd. 2009. *Foundation Investigation and Design Report: Highway 89 Nottawasaga River Bridge Rehabilitation/Widening & Retaining Wall and Cut Slope at Intersection of Essa 5th Line and Highway 89, Simcoe County, Ontario, G.W.P. 2503-04-00.*

[2] MERO. 2012. *Permanent Remediation of Cut Slope Instabilities on Highway 89 near 5th Line, Essa Township, W.O. 2012-11010, GEOCRES No. 31D-537"*

approximately 6 m to 9 m high, with existing side slopes of about 2 Horizontal : 1 Vertical (2H:1V). There is an existing retaining wall (up to about 1.5 m high) at the crest of the embankment on the north side of Highway 89. The retaining wall was assessed as part of a separate study for this project and is considered to be performing satisfactorily with no signs of distortion or distress. The exiting conditions at the proposed locations of the temporary access roads are shown in Photographs 1 and 2 below.

Photograph 1 – North access road location, looking east (Spring 2024)

Photograph 2 – South proposed access road location, looking west (Spring 2024)

Based on observations during the field investigation and the site reconnaissance of the existing retaining wall discussed in WSP's retaining wall technical memorandum[3], the existing Highway 89 embankment side-slopes in the vicinity of the culvert inlet / outlet and proposed access roads appear to generally be performing adequately and visual signs of instability or active erosion were limited to some localized zones within the tributary watercourse channel near the headwall / wingwall at the inlet (north) side (see Photograph 3) and above the headwall at the outlet (south) side (see Photograph 4). Localized erosion of the natural drainage path leading from the Highway 89 ditch to the watercourse tributary, east of the retaining wall, was also observed (see Photograph 5). The majority of the embankment slope between the base of the retaining wall and the bottom of the embankment slope appeared to be stable and was heavily vegetated at the time of observation (see Photograph 6).

[3] WSP. 2024. *Foundation Desktop Study and Site Reconnaissance, Existing Retaining Wall Northeast of Nicolston Culvert, Highway 89, Alliston, Simcoe County, MTO Assignment No. 2022-E-0046*. Technical Memorandum dated March 2025.

Photograph 3 – North culvert inlet, looking northwest (erosion near northeast side of culvert not shown) (Spring 2024)

Photograph 4 – South culvert outlet, looking northeast (erosion near headwall) (Fall 2024)

Photograph 5 – erosion east of the retaining wall, looking northwest (Spring 2024)

Photograph 6 – North embankment slope below retaining wall (Early Fall 2023)

The culvert rehabilitation is proposed to consist of lining the existing culvert. To access the inlet and outlet of the culvert, temporary access roads to the toe of the embankment from Highway 89 will be required. Based on the geometry of the ravine and location of the culvert, it is anticipated that access roads will be constructed east of the culvert location at the approximate locations shown on Drawing 1.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between April 15 and 23 and November 14 and 28, 2024, during which time a total of nine boreholes (designated Boreholes BH24-03 to BH24-11) were advanced at the locations shown on Drawing 1.

Boreholes BH24-03, BH24-04, BH24-09, and BH24-10 were advanced using 210 mm outside diameter (O.D.) hollow stem augers using a CME 75 truck-mounted drill supplied and operated by Atcost Drilling Inc. of Gormley, Ontario. Boreholes BH24-07, BH24-08 and BH24-11 were advanced using 210 mm O.D. hollow stem augers and mud rotary techniques using a CME 75 truck-mounted drill supplied and operated by TCI Field Services of Pickering, Ontario. Boreholes BH24-05 and BH24-06 were advanced using BW sized casing and wash boring techniques with portable equipment supplied and operated by OGS Inc. of Almonte, Ontario. Soil samples were generally obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm O.D. split spoon sampler. The split spoon sampler was driven with an automatic hammer in boreholes advanced with the truck mounted drill rigs in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586[4]). The split spoon sampler was driven with a full weight hammer lifted manually with assistance of a cathead and dropped from the SPT height in boreholes advanced with portable equipment. The split-spoon samplers used in the investigation generally limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension would not be sampled or represented in the grain size distributions. In-situ vane shear tests were carried out in cohesive soils for determination of undrained shear strengths in general accordance with the Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils (ASTM D2573[5]), using an MTO standard 'N'-size vane in boreholes advanced with the truck mount drill rig and an MTO standard 'B'-size vane in boreholes advanced with portable equipment. A Dynamic Cone Penetration Test (DCPT) was carried out at 0.3 m intervals below the sampled depth in Borehole BH24-08. The boreholes were backfilled upon completion in general accordance with Ontario Regulation 903 Wells (as amended) and capped at the roadway surface using cold patch asphalt.

The water level was typically measured in the open boreholes (or inside the hollow stem augers or BW casing) during and after drilling operations. Standpipe piezometers were installed in Boreholes BH24-03 and BH24-04 and were screened within a silt/silty sand fill and clayey silt deposit, respectively. The installed piezometers consist of a 50 mm diameter PVC pipe, with a 1.5 m long slotted screen within a filter sand pack. The boreholes and annulus surrounding the piezometer pipe above the filter sand pack were backfilled to near ground surface with bentonite pellets in general accordance with Ontario Regulation 903 Wells (as amended)[6]. The monitoring wells were capped with flushmount casings.

The field work was monitored on a full-time basis by a member of WSP's engineering staff who located the boreholes in the field, directed the sampling and in-situ testing operations, logged the boreholes, and examined the soil samples. The soil samples were identified in the field, placed in labelled containers, and transported to WSP laboratories in Mississauga and Whitby for further visual review and geotechnical laboratory testing. Index and classification testing consisting of natural moisture content, organic content, Atterberg limits and grain size

[4] ASTM D1586 Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

[5] ASTM D2573 Standard Test Method for Field Vane Strength Shear Test

[6] Ontario Regulation 903 Wells (as amended)

distribution were conducted on selected samples. All laboratory tests were carried out in general accordance with MTO and / or ASTM Standards, as applicable.

Two soil samples obtained from Boreholes BH24-03 and BH24-04 were submitted to a specialist analytical laboratory (Bureau Veritas Laboratories of Mississauga, Ontario) under chain of custody procedures for testing of electrical conductivity / resistivity, pH, and chemical analysis of sulphate, sulphide and chloride content, to assess the potential for the soil to cause deterioration to buried concrete and corrosion to steel.

The borehole coordinates were surveyed in the field by WSP personnel using a Trimble Catalyst DA2 Global Positioning System (GPS) unit and the elevation was obtained from the digital terrain model (DTM) developed for the project. The locations given on the borehole records and shown on Drawing 1 are positioned relative to NAD 83 MTM (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum (CGVD28 datum). The borehole locations, including the geographic (Latitude / Longitude) coordinates, the ground surface elevations, and borehole depths are summarized below.

Table 1: Summary of Boreholes

Borehole No.	NAD 83 MTM Northing (m) (Latitude, °)	NAD 83 MTM Easting (m) (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
BH24-03	4,891,998.5 (44.167577)	280,397.8 (-79.805134)	214.5	18.9
BH24-04	4,892,002.9 (44.167616)	280,382.3 (-79.805328)	214.2	18.9
BH24-05	4,891,977.2 (44.167385)	280,382.4 (-79.805326)	207.3	10.4
BH24-06	4,892,037.3 (44.167928)	280,443.4 (-79.804566)	209.8	9.8
BH24-07	4,892,019.7 (44.167769)	280,440.3 (-79.804604)	215.8	20.4
BH24-08	4,892,033.4 (44.167894)	280,489.0 (-79.803996)	217.5	21.3 [1]
BH24-09	4,891,999.0 (44.16758)	280,367.8 (-79.805509)	213.8	16.2
BH24-10	4,892,002.5 (44.167613)	280,413.3 (-79.80494)	215.0	16.2
BH24-11	4,892,016.0 (44.167736)	280,459.6 (-79.804363)	216.4	10.2

Note: Depth includes DCPT driven from a depth of 16.5 m to 21.3 m.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site generally lies within the physiographic region known as the Simcoe Lowlands, between two sections of the region known as the Peterborough Drumlin Field, as delineated in *The Physiography of Southern Ontario*[7].

[7] Chapman, L. J. and Putnam, D. F. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715 Scale 1:600,000.

Most of the Nottawasaga Basin was at one time part of the floor of Lake Algonquin and its surface beds are deltaic and lacustrine origin. Within the Nottawasaga Basin in the Alliston area where the culvert site is located, near the confluence of the Nottawasaga River and Boyne River are the Essa Flats[8]. The Essa Flats portion of the Basin comprises of a sandy loam soil. The surficial geology in the area adjacent to the Nottawasaga River are described as modern alluvial deposits consisting of clay, silt, sand, and gravel which may contain organics[9].

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes from the current investigation, including piezometer installation details and water level readings, and the results of the in-situ and laboratory tests, are provided on the borehole records in Appendix A. The results of the in-situ field tests (i.e., SPT "N"-values) as presented on the borehole records and in Section 4 are uncorrected. The detailed results of the geotechnical laboratory testing on soil samples are presented on the laboratory test figures in Appendix B. The results of the analytical testing are provided in Appendix C.

The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile on Drawing 2 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the soil encountered at this site consists of embankment fill associated with the highway (i.e. surficial layer of asphalt underlain by cohesive and non-cohesive fill) above peat or an organic silt, underlain by a clayey silt to clay deposit underlain by a till deposit consisting predominantly of clayey silt-silt and sand. More detailed descriptions of the major soil layers encountered in the boreholes as well as a summary of laboratory results are provided in the following sections.

4.2.1 Asphalt

An approximately 45 mm to 230 mm thick layer of asphalt was encountered at ground surface in Boreholes BH24-03, BH24-04, and BH24-07 to BH24-11.

4.2.2 Fill

A 3.5 m to 7.2 m thick layer of fill (cohesive and non-cohesive) was encountered below the asphalt in boreholes advanced through the road (BH24-03, BH24-04, BH24-07 to BH24-11) and a 1 m thick layer of silty sand fill was encountered at ground surface in Borehole BH24-05. The fill encountered in boreholes advanced through the road was primarily non-cohesive, consisting of sandy silt, silt and sand, clayey sand, silty sand, sand to gravelly sand, sandy silty gravel, and sandy gravel. The cohesive fill consisted of clayey silt to sandy clayey silt. Trace organics were encountered throughout the fill soils in the majority of boreholes and trace asphalt fragments were encountered in the fill at Borehole BH24-03. The lower portion of the fill soils typically contained timber and wood fragments and/or shell fragments near the fill / native soil interface. Fabric pieces were encountered in borehole BH24-07 between depths of 1.1 m and 2.1 m.

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[8] Ministry of Northern Development and Mines, Ontario. 1988. Aggregate resources inventory of Essa and Tosorontio Townships, Simcoe County, Southern Ontario; Ontario Geological Survey. Aggregate Resources Inventory Paper 113.

[9] Ontario Geological Survey. 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release – Data 128 – Revised.

The SPT 'N'-values measured within the non-cohesive fill range from 0 blows to 46 blows per 0.3 m of penetration, indicating a very loose to dense state of compactness.

The SPT 'N'-values measured within the cohesive fill range from 2 to 8 blows per 0.3 m of penetration. In-situ field vane tests carried out within the cohesive fill measured shear strengths ranging from 48 kPa to 67 kPa with a calculated sensitivity between about 10 and 13. The combined SPT and field vane test results suggest that the deposit has a generally firm to stiff consistency.

Grain size distribution tests were carried out on seven samples of the non-cohesive fill and the results are presented on Figure B1 in Appendix B. Atterberg limits testing was carried out on five samples of the non-cohesive fill. Four of the Atterberg limit tests measured the fines component of the non-cohesive fill as non-plastic. One Atterberg limits test taken on a fill sample containing organics from the lower portion of BH24-03 measured a liquid limit of about 27%, plastic limit of about 22%, and plasticity index of 5% (see Figure B2 in Appendix B) indicating the fines component of the fill is classified as a clayey silt-silt to silt or organic silt of low plasticity. A laboratory organic content test performed on the same sample from Borehole BH24-03 measured an organic content of about 5%.

A grain size distribution test carried out on one sample of the cohesive clayey silt fill is presented on Figure B3. An Atterberg limits test was carried out on one sample of the cohesive clayey silt fill and measured a liquid limit of about 33%, plastic limit of about 17%, and corresponding plasticity index of about 16%. The results of the Atterberg limits test are shown on the plasticity chart on Figure B4 and indicate the fill is classified as clayey silt of low plasticity.

The natural moisture content measured on samples of the non-cohesive fill range from 4% to 37%. The higher moisture contents can be attributed to the presence of organics and clayey interlayers. The natural moisture content measured on three samples of the cohesive fill range from 23% to 25%.

4.2.3 Organic Deposit – Peat (PT) / Organic Silt (OL)

A layer of peat (0.4 m thick) was encountered below the fill in Borehole BH24-09 at a depth of approximately 3.7 m below highway grade (Elevation 210.0 m). A 0.3 m thick layer of organic silt was encountered below the fill in Borehole BH24-10 at a depth of 4.2 m below highway grade (Elevation 210.8 m). The organic silt deposit contains wood pieces.

A SPT 'N'-value measured at the interface between the peat and the underlying sandy silt deposit was 5 blows per 0.3 m of penetration, suggesting a firm consistency. The natural moisture content measured on a sample of the peat was about 120%. The organic content of a sample of peat was measured to be about 33%.

A SPT 'N'-value measured at the interface between the organic silt and the overlying sandy silt fill was 0 blows (weight of hammer) per 0.3 m of penetration, suggesting a very loose state of compactness. The natural moisture content measured on a sample of the organic silt was 44%.

4.2.4 Sandy Silt (ML)

A 0.4 m thick deposit of brown to grey sandy silt was encountered below the organic deposit in Boreholes BH24-09 and BH24-10, respectively. The deposit was encountered between Elevations 209.7 m and 210.5 m respectively.

The SPT 'N'-values measured within this deposit were 5 blows and 8 blows per 0.3 m of penetration, indicating a loose state of compactness.

The natural moisture content measured on two samples of the deposit was about 21% and 22%.

4.2.5 Clayey Silt (CL) to Clay (CH)

A native cohesive deposit consisting of clayey silt to clay with varying amounts of sand and gravel was encountered at ground surface in Borehole BH24-06, below the fill in Boreholes BH24-03 to BH24-05, BH24-07, BH24-08 and BH24-11, and below the sandy silt deposit in Boreholes BH24-09 and BH24-10. The top of the clayey silt to clay deposit was encountered between Elevation 206.3 m and 213.4 m. Where the deposit was fully penetrated in three boreholes, it had a thickness of 8.8 m to 15.9 m. The deposit was penetrated for lengths between 6.5 m and 12.4 m in Boreholes BH24-03, BH24-05, BH24-06, BH24-08, BH24-10 and BH24-11 before the boreholes were terminated. In Borehole BH24-08, the DCPT suggests that the deposit thickness is approximately 14.2 m. The deposit contained pockets, laminations, and seams of gravel, sand and silt at various depths in Boreholes BH24-04, BH24-06, BH24-07, BH24-09, and BH24-10. In Borehole BH24-06 the deposit contained interlayers of organic silt and/or wood fragments from ground surface to a depth 3 m (Elevation 209.8 m to 206.8 m). In Borehole BH24-07, a 50 mm thick layer of organics and wood fragments was encountered above a 0.3 m thick layer of sandy silt at a depth of 6.4 m within the deposit.

The SPT ‘N’-values measured within this deposit range from 0 blows (i.e., weight of hammer) to 18 blows per 0.3 m of penetration, however, they generally range between 1 blow and 12 blows per 0.3 m of penetration. In-situ field vane tests carried out within this deposit generally measured undrained shear strengths ranging from 20 kPa to 86 kPa with a calculated sensitivity between about 1 and 12. Several field vane tests achieved refusal of the testing equipment (greater than 96 kPa), likely due to the presence of granular interlayers or gravel pieces. The combined SPT and field vane test results indicate that the deposit has a generally firm to stiff consistency.

Eleven grain size distribution tests were carried out on samples of the clayey silt to clay deposit and the results are shown on Figure B5A/B in Appendix B.

Atterberg limits tests were carried out on 24 samples of the cohesive deposit and measured liquid limits between about 26% and 70%, plastic limits between about 15% and 23%, and corresponding plasticity indices between about 11% to 49%. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B6A/B/C in Appendix B and classify the cohesive deposit as clayey silt to clay of low to high plasticity.

The natural moisture content measured on 31 samples of the clayey silt to clay deposit were between about 18% and 47%. The organic content of a sample from the upper portion of the cohesive deposit containing organic silt interlayers in Borehole BH24-06 was measured to be about 4%.

4.2.6 Clayey Silt-Silt (CL-ML) - Till

A clayey silt-silt and sand (till) deposit was encountered underlying the cohesive clayey silt to clay deposit in Boreholes BH24-04, BH24-07 and BH24-09. The till deposit was encountered between Elevation 196.2 m and 200.5 m. Boreholes BH24-04, BH24-07, and BH24-09 were terminated within the clayey silt-silt till deposit after penetrating it for lengths of 0.8 m to 2.9 m. The results of the DCPT performed in Borehole BH24-08 suggest the till deposit may be present at about Elevation 203 m.

The SPT ‘N’-values measured within this deposit range from 6 blows to 26 blows per 0.3 m of penetration. Two in-situ field vane tests carried out within this deposit in Borehole BH24-09 measured undrained shear strengths of approximately 67 kPa with a calculated sensitivity of about 3. The combined SPT and field vane test results suggest that the deposit generally has a stiff consistency.

Three grain size distribution tests were carried out on select samples of the clayey silt-silt till deposit and the results are shown on Figure B7 in Appendix B.

An Atterberg limits test carried out on three samples of the cohesive till deposit measured liquid limits of about 13% to 15%, plastic limits of about 9%, and corresponding plasticity indices of about 4% to 6%. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B8 in Appendix B and classify the till deposit as clayey silt-silt of low plasticity.

The natural moisture content measured on three samples of the clayey silt-silt till deposit was between about 9% and 11%.

4.3 Groundwater Conditions

The water levels measured in the open boreholes and/or within the hollow stem augers or BW casing at the time of the investigation are shown on the borehole records in Appendix A and are not considered representative of the stabilized hydrostatic water levels at the site. Standpipe piezometers were installed in Boreholes BH24-03 and BH24-04 to allow monitoring of the stabilized hydrostatic groundwater level at this site. The groundwater levels recorded in the piezometers are shown on the borehole records in Appendix A and are summarized below.

Table 2: Summary of Piezometer Installation and Water Level Readings

Borehole No. (Piezometer)	Depth (Elevation) of Screen Interval (m)	Depth (bgs) to Water Level (m)	Water Level Elevation (m)	Date of Water Level Reading
BH24-03	6.1 – 7.6 (208.4 – 206.9)	4.0	210.5	August 26, 2024
		4.3	210.2	November 25, 2024
BH24-04	4.6 – 6.1 (209.6 – 208.1)	3.8	210.4	August 26, 2024
		3.9	210.3	November 27, 2024

The groundwater levels at this site will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation and snow melt. Localized perched groundwater should also be anticipated above clayey zones within the fill soils.

4.4 Analytical Testing Results

Two soil samples were submitted for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. Detailed analytical test results are included in Appendix C and the test results are summarized below:

Table 3: Summary of Analytical Testing Results

Borehole No., Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Soluble Chloride (µg/g)	Soluble Sulphate (µg/g)	Sulphide (mg/kg)	Redox Potential (mV)
BH24-03, Sa#9	7.74	1800	561	200	35	2.4	270
BH24-04, Sa#8	7.56	5200	192	<20 *	49	3.3	270

Note: * Less than reportable detection limit.

5.0 CLOSURE

This foundation investigation report was prepared by Farhana Jabin, P.Eng., and Madison Kennedy, P.Eng., both Geotechnical Engineers with WSP. Kevin Bentley, P.Eng. a Geotechnical Engineer with WSP and MTO Principal Foundations Contact conducted a technical and quality control review of the report.

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PART B

FOUNDATION DESIGN REPORT
TEMPORARY WORKS - NICOLSTON CULVERT REHABILITATION
HIGHWAY 89, ALLISTON, SIMCOE COUNTY, ONTARIO
MTO W.P. G.W.P. 2022-22-00; 2014-23-01; ASSIGNMENT 2022-E-0046

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation engineering design recommendations for the temporary works associated with the Nicolston Structural Culvert (Site No. 30X-0678/C0) located at Station 16+443 of Highway 89 in Alliston, Ontario. The recommendations herein are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface exploration. The discussion and recommendations presented are intended to provide the designers with information to assess the feasibility of temporary works and particularly the design and construction of the suggested temporary access roads along the existing highway embankment for access to the culvert inlet / outlet as required for the proposed culvert rehabilitation (lining) operations.

The Foundation Design Report (Part B of this report), including the discussion and recommendations are intended for the use of the MTO and their designers and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor or design-build proponents. Contractors undertaking the work must make their own interpretation based on the data presented in the Foundation Investigation Report (Part A of this report). Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the data provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Project Understanding

As part of this assignment, an assessment of both replacement and rehabilitation options for the Nicolston culvert were considered. Rehabilitation by lining the existing culvert was deemed the preferred option at this location. To facilitate the lining operation, temporary access roads / routes will need to be constructed from the Highway 89 grade to near the existing culvert inlet and outlet.

Based on the Temporary Access Road design drawing, it is shown that access routes / roads will be constructed east of the existing culvert, on both the north and south side of the embankment to access the inlet and outlet locations respectively. The approximate location of the proposed access roads is shown on Drawing 1. The proposed north access road alignment is shown to generally follow the existing embankment toe and has a proposed grade of 15%, with fill heights up to 3 m required to create a minimum 3 m wide road platform. Similarly, the south access road generally follows the existing embankment toe / drainage ditch with a proposed grade between 5% and 15%, with cuts and fills of up to about 0.5 m deep / high to create a minimum 3 m wide road platform. There is no temporary or permanent grade raise of Highway 89 planned at the retaining wall location, as part of the project.

It is understood that the location and geometry of the access roads are provided for conceptual and preliminary design purposes and detail design of the temporary works is to be carried out by the contractor. The intent of this foundation report is to check that the concept and preliminary design of the temporary works is feasible, using the interpreted soil parameters from the foundation investigation completed on site. If the location and/or configuration / profile of the access roads change, the discussion and recommendation provided in this section must be checked and revised as necessary. Detailed design of the temporary access roads and any impacts to the existing retaining wall and Highway 89 is the responsibility of the Contractor.

6.3 General Foundation Design Context

6.3.1 Consequences and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code CAN/CSA S6-19* (CHBDC, 2019) and its *Commentary*, the temporary works may be classified as a geotechnical system design for applications along a transportation corridor with medium to large traffic volumes and/or with potential impacts on other transportation corridors, resulting in a "typical consequence level" associated with exceeding limit states design.

In addition, given the project-specific foundation investigation carried out at this site (as presented in the Foundation Investigation Report or Part A of this report), in comparison to the degree of site understanding in Section 6.5 of CHBDC (2019), the level of confidence for design is considered to be a "typical degree of site and prediction model understanding." Accordingly, the appropriate corresponding consequence factor, Ψ, and geotechnical factors ϕ_{gu} and ϕ_{gs}, from Tables 6.1 and 6.2 of the CHBDC (2019) have been used for design.

In addition, reference is made to the MTO Material Engineering Research Office (MERO) Memorandum #2020-01 (dated March 23, 2020) for further guidance on selection of geotechnical resistance factors for the settlement and stability analyses for embankment fills, as applicable.

6.4 Existing Embankment and Proposed Access Roads

6.4.1 Global Stability

For due diligence purposes, a check of the global stability of the existing embankment configuration was carried out using the subsurface information collected as part of the current investigation. A subsequent global stability analysis was carried out where the existing embankment configuration is to be modified to accommodate the temporary access roads. In both cases, representative critical sections were analyzed where the existing embankment height was generally the greatest and near the watercourse, and where the most significant cut / fill areas are proposed for the access road design. It is noted that limited cuts (typically less than 0.5 m deep) are proposed along both access roads, and fills are generally located near the toe of the existing embankments.

Limit equilibrium slope stability analyses were performed on both the north and south sides of the embankment using the commercially available program Slide2 (Version 9) by RocScience Inc., employing the Morgenstern Price method of analysis. For all analyses, the Factor of Safety (FoS) of numerous potential failure surfaces were computed for the critical embankment cross sections in order to establish the minimum FoS. In general, circular slip surfaces were used in the analyses.

The long-term (effective stress) and short-term (undrained) conditions were analyzed for the existing embankment and conceptual temporary north and south access road configurations.

Target factors of safety of 1.54 and 1.33 for long-term (drained) and short-term (undrained) stability, respectively, is normally adopted in the design of permanent slopes under static conditions, per the 2019 CHBDC. Based on MERO (2020), a factor of safety of 1.43 for long-term conditions or 1.25 for short-term conditions could be considered for a typical consequence factor (Ψ) and a typical degree of understanding (Φ_{gu}), subject to acceptance by MTO.

For the non-cohesive soils present at the site, the effective stress parameters employed in the analysis were estimated from empirical correlations based on the results of the in-situ Standard Penetration Tests (SPT). The correlations proposed by the U.S. Navy (1986) were employed and the results were adjusted by engineering judgement based on precedent experience in similar soil conditions.

For the cohesive deposits, total stress parameters were employed in the analyses of the short-term, undrained conditions (i.e., temporary conditions). The total stress parameters (i.e., average mobilized undrained shear strength – s_u) for the cohesive soils were obtained from field vane test results, corrected using the Bjerrum's correction, or estimated from correlations with SPT results and other laboratory data (i.e., natural water content), where appropriate. Effective stress parameters were also assigned to the cohesive deposits to evaluate the stability based on long-term, drained conditions (i.e., permanent conditions). The effective stress parameters (i.e., effective friction angle – ϕ') for the cohesive deposits were estimated from empirical correlations based on the plasticity index. The correlations proposed by Mitchell (1993), Kulhawy and Mayne (1990), and Ladd et al. (1977) were employed and the results were adjusted using engineering judgement based on precedent experience in similar soil conditions.

The simplified stratigraphy and selected soil parameters employed in the analyses are summarized below.

Table 4: Soil Parameters for Stability Analyses

Idealized Stratigraphy	Soil Parameters			
	Bulk Unit Weight, γ (kN/m^3)	Long-Term or Effective Stress		Short-Term or Total Stress
		Angle of Internal Friction, ϕ (º)	Effective Cohesion, *c'* (kPa)	Shear Strength, S_u (kPa)
Existing Cohesive Fill	19	32	0	50
Existing Non-Cohesive Fill	19	32	0	-
New Granular Fill	20	32	0	-
Clayey Silt to Clay – Firm to Stiff	18 - 19	29 - 30	0	25 kPa (outside of embankment and non-preloaded zone) to 50 kPa (below existing embankment and preloaded zone)
Clayey Silt-Silt and Sand Till – Firm to Stiff	20 - 21	32	0	60

Stability analysis was carried out at the critical sections identified at approximately Highway 89 STA 16+430 for the south embankment slope and about STA 16+525 for the north embankment slope. The soil conditions encountered in the closest boreholes to each station were used to develop idealized stratigraphic sections used for the slope stability analyses. For the stability analysis, the groundwater level was assumed to vary between about 210.4 m (within the embankment) and 207.3 m (tributary watercourse level) at the south slope and between about Elevation 215.1 m (within the embankment) and 207.3 m (tributary watercourse level) at the north slope, as measured in the boreholes and/or monitoring wells, or at the tributary water level. The side-slope for the new fill used for the access road is assumed to be sloped at 2H:1V.

EXISTING EMBANKMENT CONFIGURATION: Based on the results of the analyses, the Factor of Safety (FoS) against global instability for the existing embankment is about 1.3 for the long-term (drained) conditions for slip surfaces passing through the travelled highway at the south and north embankment slopes (see Figure D1 and D3). The FoS for short-term (undrained) conditions for the existing embankment, although not considered to be applicable given that excess pore pressures have dissipated, was checked at the south and north embankments and indicates a factor of safety of 1.8 and 1.2 (see Figure D2 and D4), respectively. Factors of safety equal to 1.3 and as low as 1.2 are considered typical for long-term and short-term conditions for existing highway embankments as historical target factors of safety were lower than the current target minimum factors of safety of 1.43 and 1.25 (MERO, 2020) for new embankments. Given that the existing embankment has been in place for over 60 years, with the current highway profile having been in place for about 14 years with no indication of movement or instability, the existing embankment is considered to have an adequate FoS against the risk of global instability, pending MTO approval. It is noted that a slightly lower FoS equal to 1.2 was calculated for a shallow slip surface behind the existing retaining wall and near the crest of the embankment at the north embankment (Figure D3), however, this FoS will increase to greater than 2 with the construction of the temporary access road as discussed below and shown in Figure D7. It is noted that the FoS of the embankment is considered to be sensitive to the variable groundwater level within the embankment and the presence of variable strength finer grained soils that may be susceptible to surficial sloughing / surficial instability. This may explain the localized zones of erosion observed near and above the existing culvert inlet and outlet headwalls where remediation is planned as part of the rehabilitation.

MODIFIED EMBANKMENT CONFIGURATION AFTER CONSTRUCTION OF ACCESS ROADS: Based on the results of the analyses and for comparison purposes, the FoS against global instability of the embankment after construction of the temporary access roads is about 1.4 and 2.0 for the long-term (drained) conditions for slip surfaces passing through the travelled highway at the south and north embankment slopes (see Figure D5 and D7), resulting in a slight increase in FoS compared to the existing conditions. The FoS for short-term (undrained) conditions for the embankment after construction of the temporary access roads was checked at the south and north embankments and indicates a factor of safety of 1.8 and 1.2 (see Figure D6 and D8), resulting in no change to the FoS compared to the existing conditions.

In conclusion, the results of the long-term (drained) and short-term (undrained) global stability analyses indicate that the calculated FoS of the highway embankment with the modified access road configuration is equal to or greater than the FoS calculated for the existing embankment configuration, and are close to the target factors of safety in MERO (2020). Considering the highest embankments were modelled, the average global stability of the embankment is considered to meet the minimum factors of safety in MERO (2020)

Based on the results of the stability analysis, the presence of the access road is considered to increase the global stability of the Highway 89 embankment and is considered acceptable, pending MTO approval. It is recommended that the temporary access road configuration be permanently left in place as it effectively acts as a stabilizing toe berm / bench for the Highway 89 embankment slopes. Consideration will need to be given to using a granular soil core (or similar passive drainage system) for the access road to promote drainage of the existing embankment and reduce the risk of creating elevated groundwater levels which could lead to surficial sloughing and/or surficial instability of the embankment slopes. Additionally, given the results of the analysis, it is recommended that stockpiling of soil or loading from heavy equipment (e.g. cranes) not be carried out in close proximity to the crest of the embankment, especially near the existing retaining wall north of the culvert location. An example Operation Constraint has been included in Appendix E.

Surface water along the highway and in areas of construction activities must be diverted away from the embankment side-slope, especially above the culvert inlet / outlet and retaining wall areas. During construction, if surface water is not diverted, temporary surficial sloughing / surficial instability of the slopes could occur, resulting in the need for temporary protection systems or excavation support systems being required where the culvert headwall / wingwall modifications are proposed.

6.4.2 Settlement

Based on the configuration of the temporary access roads, up to 3 m and 1 m of new fill may be placed above the existing embankment and foundation soils for the north and south access roads respectively. For the 3 m grade raise on the north side of the embankment, it is estimated that up to 15 mm of immediate settlement would occur at the access road ground surface. The immediate settlement is anticipated to occur during or shortly after construction of the access road. Given the compressible nature of the underlying clayey soils at the site, consolidation settlement is expected to occur over time if the access road is to remain in place. If the access road is left in place permanently (as recommended to improve global stability of the embankment), an additional 65 mm of consolidation settlement is estimated to occur at the access road surface over several years. Given that the thickest fill for the access road is located about 20 m to 25 m away from the retaining wall and Highway 89 road shoulder, the settlement is not expected to impact the performance of the retaining wall or Highway 89 and is estimated to be less than 5 mm.

6.4.3 Access Road Construction and Erosion Protection

Construction of the access road should be in general accordance with OPSS.PROV 206 (Grading) and new embankment fill is to placed and compacted in accordance with OPSS.PROV 501 (Compacting). The footprint of the access road should be stripped of all topsoil and organic soils, including any loose / soft sediments within the existing drainage ditches, prior to placing new fill. Where new fill is to be placed on top of the existing embankment slope, the new fill should be keyed into existing fill as per OPSD 208.010 (Benching of Earth Slopes) to integrate the existing fill and the new fill along the interface and reduce the potential of creating a weak zone prone to sliding / instability.

Embankment fill for construction of the access road should consist of OPSS.PROV 1010 (Aggregates) granular materials such as Select Subgrade Material, Granular A or Granular B. Imported earth fill could also be considered, however, it is recommended that the material be granular or a suitable drainage layer / system be provided to allow for passive drainage of the existing embankment to prevent elevated groundwater levels forming in the existing embankment.

The access road cut and fill side slopes should be constructed at no steeper than 2H:1V to match the current embankment side-slopes. Cutting into the existing embankment should be avoided as per the suggested access road alignment and profile.

Based on the suggested access road location, portions of the existing drainage ditch along the toe of the existing embankment will be buried. The Contractor will need to effectively block / seal existing drainage paths and re-instate a new passive drainage system as part of the access road design, including construction of new drainage ditches and connections to natural drainage paths. The native material near the existing watercourse is prone to erosion and care should be taken to minimize disturbance to the native soils and watercourse during and after removal of the access road. For this reason, consideration should be given to designing a permanent access road and drainage system. Where high volumes of surface water runoff are anticipated / observed near the contacts between the native ravine walls and the new access road embankment (i.e. ditches and natural paths), suitable erosion protection, such as adequately sized rip-rap, must be used to control erosion. Typically, the existing erosion control measures (rip-rap sizes, vegetation type, etc.) used in the current ditches and drainage paths may be considered for use at the new location of drainage ditches and paths provided gradients are similar and areas are performing adequately. However, it is noted that a significant area of localized erosion was observed along the existing drainage ditch / path on the north embankment slope (east of the retaining wall) leading from the Highway 89 ditch to the Nottawasaga tributary watercourse (i.e. where the gradient slope suddenly increased). Based on the suggested access road location and profile, this localized eroded area will be filled with embankment soil and thus, the new drainage path will likely have a shallower slope but will need to have sufficient erosion protection to prevent similar erosion issues to occur in the future.

Temporary erosion control measures should be installed prior to, during and after construction of the access road and utilized until permanent erosion control measures are implemented, as applicable. Given the presence of the tributary watercourse in close proximity to the bottom of the access roads, appropriate environmental and sediment control measures will need to be implemented. Depending on whether the access road will be permanent or temporary (i.e. removed after construction is complete), the level of erosion control measures may vary.

To reduce surface water erosion on the embankment side slopes, temporary erosion control measures such as mulch, bonded fabric matrix (BFM), fiber reinforced matrix (FRM), or erosion control blankets (ECB), should be applied as per OPSS.PROV 804 (Temporary Erosion Control) as soon as possible during and after construction of the access road.

For permanent conditions of new embankment side slopes and where exposed existing cut or stripped slopes are to be re-established, consideration should be given to placing topsoil and seeding as per OPSS 802.PROV and OPSS.PROV 803 as soon as possible. If this protection is not in place before winter, then temporary erosion control measures will need to be implemented to reduce the potential for remedial work in the spring, prior to establishing vegetation.

6.5 Temporary Excavations

All temporary excavation work should be carried out in accordance with the Occupational Health and Safety Act and Regulations (OSHA) – Ontario Regulation 213 Construction Projects (as amended), and in general accordance with OPSS.PROV 206 (Grading), as applicable.

The non-cohesive and cohesive fill are classified as Type 3 soils above the groundwater level and Type 4 soils below the groundwater level. Similarly, the firm to stiff clayey silt to clay deposit is classified as Type 3 and Type 4 above and below the groundwater level, respectively.

Temporary excavations should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V) for Type 3 soils, and no steeper than 3 horizontal to 1 vertical (3H:1V) for Type 4 soils.

Excavation of the existing embankment and ravine slopes should be minimized where possible due to the potential impact to the stability of the embankment, and the potential for additional erosion of the native ravine slopes. Temporary excavations made into the Highway 89 embankment slope will require temporary protection systems as discussed in Section 6.6.

6.6 Temporary Protection Systems and Cofferdams

The use of temporary protection systems may be required to facilitate access to the culvert inlet / outlet during construction and a sheet pile cut-off wall or cofferdam may be required to control surface water and groundwater at the culvert inlet/outlet.

Temporary protection systems, if required, shall be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems) and Special Provision 105S09. The lateral movement of the temporary protection system at this site should meet Performance Level 2, as specified in OPSS.PROV 539, provided that any utilities, if present, can tolerate this magnitude of deformation. Surcharge loading from traffic, construction equipment, or any excavated material to be stockpiled adjacent to the temporary protection system must be incorporated into the design of the protection system.

Both sheet pile wall and/or soldier pile and timber lagging systems are considered feasible for the temporary protection system at this location based on the subsurface and groundwater conditions. The Contractor will need to be prepared to penetrate / remove any obstructions such as wood / timber pieces encountered in the fill and upper portion of the clayey silt to clay soils as indicated in the Foundation Investigation Report.

For the control / diversion of water in the watercourse, if a sheet pile cut-off wall is utilized the sheet piles would need to be driven to a sufficient depth into the native clayey silt to clay deposit to provide cut-off and act as a cantilever system. Cofferdams of this type may be constructed in general accordance with OPSS.PROV 539, as applicable.

The selection and design of the temporary protection system and any dewatering / flow diversion measures is the responsibility of the Contractor. The following geotechnical parameters are provided to support the conceptual design of any temporary protection system / cofferdam system.

Soil Type	Unit Weight, γ (kN/m^3)	Effective Friction Angle ϕ'(°)	Undrained Shear Strength, s_u (kPa)	Coefficient of Lateral Earth Pressure [1]		
				Active K_a	At Rest K_o	Passive K_p [2]
Loose to Very Dense Non-Cohesive (Silt to Silty Sand to Sand) Fill	19 - 20	30 - 32	-	0.33	0.50	3.00
Soft to Firm Cohesive (Clayey Silt) Fill	19 - 20	30 - 32	50	0.33	0.50	3.00
Firm to Stiff Clayey Silt to Clay	18 - 19	29 - 30	25 – 50	0.35	0.52	2.88
Firm to Stiff Clayey Silt-Silt Till	20 - 21	32	60	0.31	0.47	3.25

Notes:
1. The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure must be adjusted accordingly, per CHBDC Clause C6.12.1, Figures C6.28 (active earth pressure) and C6.29 (passive earth pressure), and Clause C6.12.2.2 (at-rest earth pressure).
2. The total passive resistance below the base of the excavation (i.e., adjacent to the temporary protection system) may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of CHBDC (2019) to account for the large strain that would be required for mobilization of the full passive resistance.
3. For cohesive deposits, an assessment for both the drained (ϕ') and undrained (s_u) cases should be made to establish the more conservative earth pressure condition for design.

Where temporary protection systems are used for the project, monitoring of the protection system is required as per OPSS.PROV 539 (Temporary Protection Systems).

It is noted that debris, timber and/or wood fragments were encountered within the fill and organic deposit in Boreholes BH24-03, BH24-05, BH24-06, BH24-09, and BH24-10. Any temporary protection systems or cofferdams will need to consider the presence of these potential obstructions which are described in more detail in the borehole records.

6.7 Existing Retaining Wall

The available background information for the existing retaining wall is summarized in WSP's technical memorandum titled "*Foundation Desktop Study and Site Reconnaissance, Existing Retaining Wall Northeast of Nicolston Culvert, Highway 89, Alliston, Simcoe County, MTO Assignment No. 2022-E-0046"*, dated August 22, 2024.

As-built drawings for the existing retaining wall are not available and it is not known whether the wall was constructed as a gravity wall or geogrid reinforced structure. However, the typical section drawing provided as part of the previous contract and field observations (i.e. fabric encountered in Borehole BH24-07 located adjacent to the wall) suggest that the wall may contain reinforcement strips or a geotextile may have been placed at the interface between the retaining wall fill and embankment fill.

The results of the global stability analysis in Section 6.4.1 calculated a factor of safety equal to 1.3 for slip surfaces behind the wall that would impact the highway. If the retaining wall is a gravity wall and reinforcement strips are not present, there is a potential for a slightly lower factor of safety equal to 1.2 as a shallow slip surface can form directly behind the block wall segments (see Figure D3). In either case, the FoS will increase to greater than 2 with the construction of the temporary access road as shown in Figure D7. As a result, it is recommended that temporary access road on the north side of the embankment remain in place permanently.

6.7.1 Retaining Wall Monitoring During Construction

It is our understanding that construction activities will be carried out adjacent to the existing retaining wall. Construction activities include temporarily shifting traffic to the (strengthened) highway shoulder above the western portion of the retaining wall and construction of a temporary access road below the eastern portion of the retaining wall. It is recommended that stockpiling of soil and/or use of heavily loaded cranes on Highway 89 above or near the existing retaining wall (i.e. where surcharge loading may impact the performance or stability of the wall) is to be avoided.

Based on the retaining wall desktop study assessment carried out as part of the current project and the results of the subsequent stability analyses, the retaining wall is considered to be performing adequately and is stable under the current conditions. However, given the relatively fine-grained nature and relatively low relative density / consistency of the existing fill soils and potential susceptibility to construction activities planned adjacent to the retaining wall, for due diligence purposes, it is recommended that monitoring of the retaining wall be carried out prior to, during and after construction activities near the wall. Construction activities adjacent to the wall include shoulder strengthening and associated operation of conventional construction equipment (e.g. compaction equipment, dump trucks or loaders) and/or temporary shifting of traffic close to the retaining wall.

A pre- and post-construction condition survey along the entire length of the retaining wall should be carried out. Visual and survey monitoring should be carried out during construction activities adjacent to the wall. Visual monitoring should identify and document any signs of distortion (rotation/tilting), cracking or separation of the retaining wall blocks, and/or cracking of the Highway 89 shoulder and pavement occurring parallel to the retaining wall, and the associated construction activity at the time of monitoring. Surface Monitoring (SM) points should be installed at the top of wall at a maximum spacing of 6 m along the length of the wall (assume 15 SM points for the 92 m long retaining wall). The SM points should be surveyed by a licensed surveyor in Ontario for horizontal and vertical displacements with an accuracy of +/- 2 mm. The SM points should have baseline readings (3 readings taken on 3 separate days) taken prior to construction activities near the wall. During construction, readings should be taken three times per week during construction activities adjacent to the wall (i.e., during shoulder strengthening and during traffic shift onto shoulder and during construction of temporary access road). The wall should be monitored on a weekly basis while construction activities are carried out at the toe of the north side of the embankment (i.e., culvert lining and/or culvert headwall modifications). It is recommended that review and alarm levels be set to 5 mm and 10 mm of wall displacement (vertical or horizontal), respectively. The CA should be contacted immediately when review and alarm limits are reached. If movements reach alarm levels, additional points may need to be installed and construction halted until the cause of wall movement is determined and stability of the embankment and wall is confirmed.

Although not anticipated, if the retaining wall is significantly impacted during construction such that the integrity is compromised, the wall will need to be repaired / reinstated in-kind with input from the design team, including the original wall designer (RisiStone) if possible. If as-built drawings are not available, a supplemental investigation would need to be carried out to determine if the retaining wall is a gravity wall or supported by reinforcing strips. Investigation techniques could include excavating select locations behind the blocks utilizing hydro-vacuum excavation to determine if reinforcing strips are present. Depending on the cause and extent of any impacts to the retaining wall, a remedial action plan would need to be developed with input by the Contractor, Contract Administrator, and design team as required.

An example Non-Standard Special Provision (NSSP) for monitoring of the retaining wall has been included in Appendix E.

7.0 CLOSURE

This foundation design report was prepared by Talha Irshad, a geotechnical analyst with WSP and Madison Kennedy, P.Eng., a Geotechnical Engineer with WSP. Kevin Bentley, P.Eng. a Geotechnical Engineer with WSP and MTO Principal Foundations Contact conducted a technical and quality control review of the report.

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MTI/MCK/KJB/al

https://wsponlinecan.sharepoint.com/sites/ca-ca00203320247/shared documents/05. technical/foundations/5 - reporting/6 - rpt temp works/3-final/ca0020332.0247_fidr_rev0_hwy89-culvert temp works_27mar2025.docx

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MERO. 2012. *Permanent Remediation of Cut Slope Instabilities on Highway 89 near 5th Line, Essa Township, W.O. 2012-11010, GEOCRES No. 31D-537"*

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WSP. 2024. *Foundation Desktop Study and Site Reconnaissance, Existing Retaining Wall Northeast of Nicolston Culvert, Highway 89, Alliston, Simcoe County, MTO Assignment No. 2022-E-0046.* Technical Memorandum dated March 2025.

ASTM International

ASTM D1586 Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

ASTM D2573 Standard Test Method for Field Vane Strength Shear Test

Ministry of Transportation, Ontario

Provincial Engineering Memorandum #20201, Material Engineering and Research Office (MERO), March 23, 2020

Commercial Software

Slide2 (Version 9) by Rocscience Inc.

Ontario Provisional Standard Drawing:

OPSD 208.010 Benching of Earth Slopes

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 802	Construction Specifications for Topsoil
OPSS.PROV 803	Construction Specifications for Sodding
OPSS.PROV 804	Construction Specifications for Temporary Erosion Control
OPSS.PROV 1010	Material Specifications for Aggregates – Base Subbase, Select Subgrade, and Backfill Material

Special Provision

Special Provision 105S09	Amendment to OPSS 539, November 2014

Ontario Regulations

Ontario Regulation 213	Construction Projects (as amended)
Ontario Regulation 903	Wells (as amended)

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MINISTRY OF TRANSPORTATION, ONTARIO

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

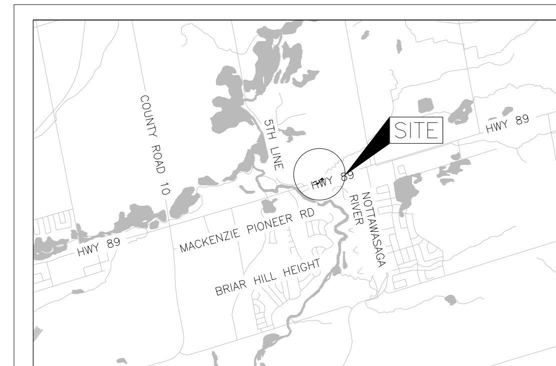
CONT No.
WP No. 2014-23-01

SHEET

HIGHWAY 89
NICOLSTON CULVERT TEMPORATY WORKS
BOREHOLE LOCATIONS PLAN

wsp

PLAN
SCALE
5 0 5 10 m



KEY PLAN
SCALE
1 0 1 2 km

LEGEND
● Borehole – Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH24-03	214.5	4891998.5	280397.8
BH24-04	214.2	4892002.9	280382.3
BH24-05	207.3	4891977.3	280382.4
BH24-06	209.8	4892037.3	280443.4
BH24-07	215.8	4892019.7	280440.3
BH24-08	217.5	4892033.4	280489.0
BH24-09	213.8	4891999.0	280367.8
BH24-10	215.0	4892002.5	280413.3
BH24-11	216.4	4892016.0	280459.6

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.

REFERENCE
Base plans provided in digital format by WSP, drawing file no. BC-785-89-1.dwg, received September 26, 2024.
GA provided in digital format b WSP, drawing file no. CA0020332.0247 Culvert – Genaral Arrangement.dwg, received September 26, 2024.
Retaining Wall provided in digital format by WSP, drawing file no. B-785-89-1.dwg, received on October 10, 2024.

LICENSED PROFESSIONAL ENGINEER M. C. KENNEDY 100547814 Mar.27, 2025 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER K. J. BENTLEY Mar. 27, 2025 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D04-010

HWY. 89		PROJECT NO. CA0020332.0247	DIST.
SUBM'D. MCK	CHKD. MCK	DATE: 3/26/2025	SITE:
DRAWN: DD/SA	CHKD. MCK	APPD. KJB	DWG. 1

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

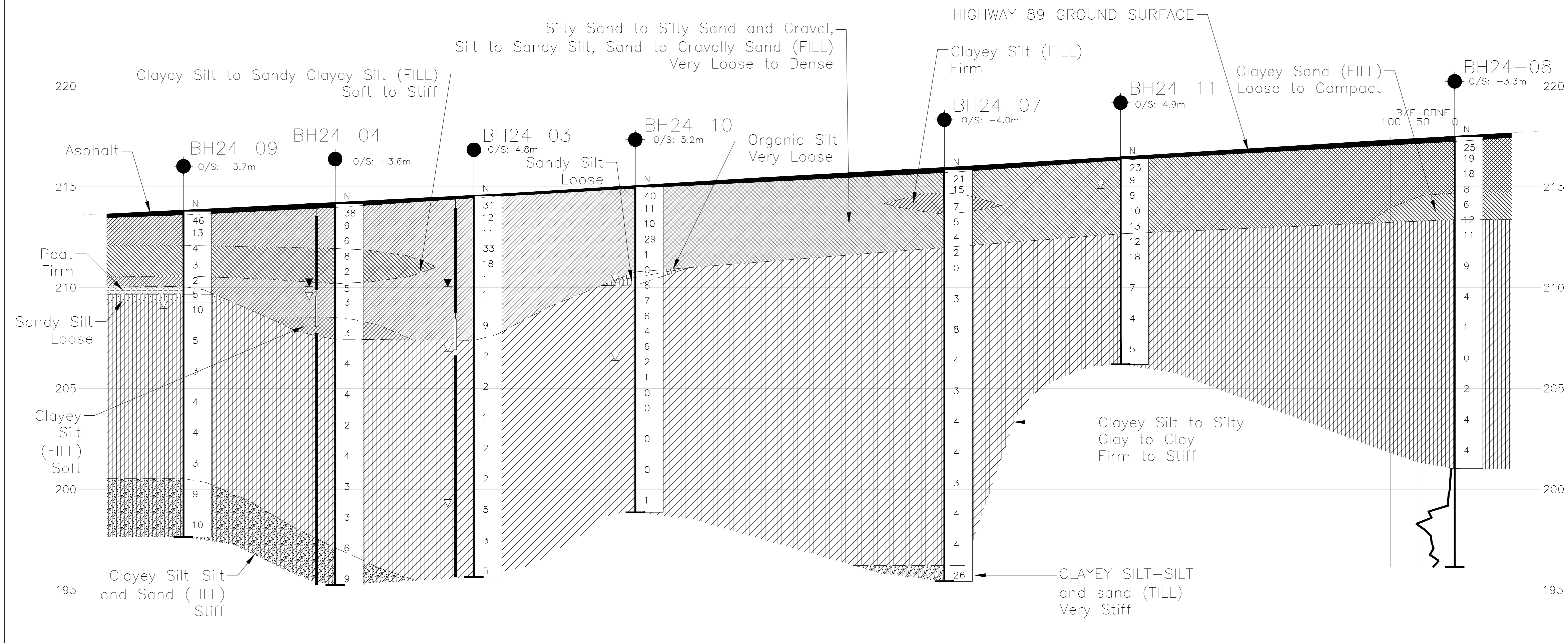
CONT No.
WP No. 2014-23-01

SHEET

HIGHWAY 89
NICOLSTON CULVERT TEMPORARY WORKS

SOIL STRATA

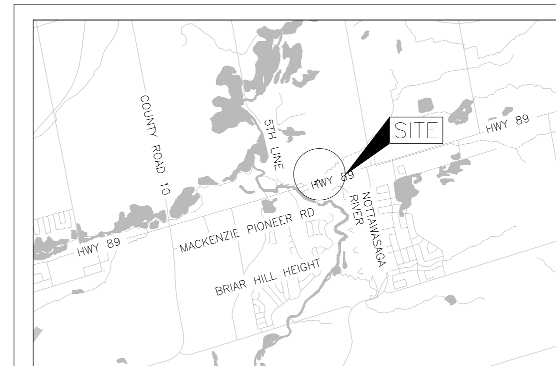
wsp



PROFILE A-A'

VERTICAL SCALE 2.5 0 2.5 5 m

HORIZONTAL SCALE 5 0 5 10 m



KEY PLAN
SCALE 1 0 1 2 km

LEGEND

- ● Borehole – Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▼ WL in piezometer
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH24-03	214.5	4891998.5	280397.8
BH24-04	214.2	4892002.9	280382.3
BH24-05	207.3	4891977.3	280382.4
BH24-06	209.8	4892037.3	280443.4
BH24-07	215.8	4892019.7	280440.3
BH24-08	217.5	4892033.4	280489.0
BH24-09	213.8	4891999.0	280367.8
BH24-10	215.0	4892002.5	280413.3
BH24-11	216.4	4892016.0	280459.6

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.

REFERENCE

Base plans provided in digital format by WSP, drawing file no. BC-785-89-1.dwg, received September 26, 2024.
GA provided in digital format b WSP, drawing file no. CA0020332.0247 Culvert – Genaral Arrangement.dwg, received September 26, 2024.

LICENSED PROFESSIONAL ENGINEER M. C. KENNEDY 100547814 Mar. 27, 2025 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER K. J. BENTLEY Mar. 27, 2025 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D04-010

HWY. 89	PROJECT NO. CA0020332.0247		DIST.
SUBM'D. MCK	CHKD. MCK	DATE: 3/26/2025	SITE:
DRAWN: SA	CHKD. MCK	APPD. KJB	DWG. 2

PLOT DATE: March 26, 2025
FILENAME: S:\Clients\MTO\Hwy_89_Culvert\99_PROJ\CA0020332_0247\40_PROJ\0010_Temporary_Works_Culvert\CA0020332_0247-0010-BD-0002.dwg

APPENDIX A

Record of Boreholes

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS
MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
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)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (*i.e.,* SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (*i.e.,* some sand)
≤ 10	trace (*i.e.,* trace fines)

1. Only applicable to components not described by Primary Group Name.
2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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 friction (f_s) are recorded electronically at 25 mm penetration intervals.

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

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 or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

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.

COARSE-GRAINED SOILS

Compactness[1]

Term	SPT 'N' (blows/0.3m)[2]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

1. 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.
2. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED 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 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.

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.

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
FoS	factor of safety

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

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

(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	non-plastic
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
$C_{\alpha(e)}$	secondary compression index
C_α	rate of secondary compression
$C_{\alpha(\varepsilon)}$	modified 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 = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
c′	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
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 or 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

Ontario

RECORD OF BOREHOLE No. BH24-03

METRIC

PROJECT	CA0020332.0247		
G.W.P.	2022-E-0046	LOCATION	N 4891998.5; E 280397.8 NAD83 / MTM Zone 10 (LAT. 44.167577; LONG. -79.805134)
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers
DATUM	Surface Elevation:214.5 m	DATE	Apr 15, 2024 - Apr 16, 2024
ORIGINATED BY	KR	COMPILED BY	MTI
CHECKED BY	MCK		

Soil Profile

ELEV. / DEPTH	DESCRIPTION
214.5 / 0.0	ASPHALT (45 mm)
214.4 / 0.1	SILTY SAND (SM) and gravel, (FILL) Dense Brown Moist
214.1 / 0.5	SILTY SAND (SM), trace gravel, trace organics, containing asphalt fragments, (FILL) Dense to compact Brown Moist
213.1 / 1.4	Sandy SILT (ML), trace gravel, trace organics, containing clayey silt pockets (FILL) Compact Brown Moist - 1.5 to 2.1 m: occasional clay pockets - 2.3 to 2.6 m: observed low plasticity
212.0 / 2.6	Gravelly SAND (SP), trace fines, (FILL) Dense Brown Moist
211.6 / 3.0	SILT (ML) and sand, trace clay, trace gravel, (FILL) Compact to very loose Brown Moist to wet - 3.8 m: becoming wet below a depth of 3.8 m - 6.1 to 6.4 m: Timber and wood fragments encountered in split spoon - 6.4 to 6.7 m: containing trace organics
207.4 / 7.2	CLAY (CH) to CLAYEY SILT (CL), trace sand Firm to stiff Grey Wet

Samples

NUMBER	TYPE	"N" VALUES	ELEVATION SCALE (approx.)	WATER CONTENT	GR	SA	SI	CL	REMARKS
1A / 1B	SS	31	214						
2	SS	12		○					
3	SS	11	213	○					
4A / 4B	SS	33	212	○					
5	SS	18	211						
6	SS	1		○ NP	1	45	48	6	
7	SS	1	210						
8A / 8B	SS	9	208	⊢○	3	42	47	8	OC = 4.7%
9	SS	2	207						
10	SS	2	205	⊢—○—⊣	0	1	25	74	

Groundwater level (▼) at approx. elev. 210.4 m.

Shear strength field vane readings (⊕ / ×) plotted at approx. elev. 206 and 204.9.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): × ⊕ Field Vane, Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined

WATER CONTENT (%): PL (W_p), NMC (W), LL (W_l); NP Nonplastic; 20 40 60

UNIT WEIGHT γ kN/m³

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

RECORD OF BOREHOLE No. BH24-03

Sheet 2 of 2 — METRIC

PROJECT: CA0020332.0247			
G.W.P.: 2022-E-0046	LOCATION: N 4891998.5; E 280397.8 NAD83 / MTM Zone 10 (LAT. 44.167577; LONG. -79.805134)	ORIGINATED BY: KR	
DIST: Central HWY: 89	BOREHOLE TYPE: 210 mm O.D. Hollow Stem Augers	COMPILED BY: MTI	
DATUM: Surface Elevation:214.5 m	DATE: Apr 15, 2024 - Apr 16, 2024	CHECKED BY: MCK	

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR SA SI CL
	CLAY (CH) to CLAYEY SILT (CL), trace sand Firm to stiff Grey Wet				204	
		11	SS	1	203	
		12	SS	2	202	
					201	
		13	SS	2	200	
		14	SS	5	199	
					198	
		15	SS	3	197	0 3 46 51
	- 18.3 to 18.9 m: trace sand, trace gravel	16	SS	5	196	
195.6 18.9	End of Borehole				195	

Column headings: SOIL PROFILE (ELEV. / DEPTH, DESCRIPTION, STRATA PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUNDWATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT; SHEAR STRENGTH (kPa) (× Field Vane, ⊕ Remoulded, ■ Pocket Pen, ● Quick Triaxial, ○ Unconfined) 20 40 60 80 100; WATER CONTENT (%) PL NMC LL, W_p W W_l, NP Nonplastic, 20 40 60; UNIT WEIGHT γ kN/m³; GR SA SI CL; REMARKS

Notes:
1. Water encountered inside augers at a depth of 7.5 m (Elev. 207.0 mASL) during drilling.
2. Water level measured inside augers at a depth of 15.2 m (Elev. 199.3 mASL) on 16-Apr-2024, prior to resuming drilling at a depth of 16.8 m.
3. Water level measured inside augers at a depth of 5.9 m (Elev. 208.6 mASL) upon completion of drilling..
4. Water level measured inside piezometer at a depth of 4.0 m (Elev. 210.5 mASL) on 26-Aug-2024.
5. Water level measured inside piezometer at a depth of 4.3 m (Elev. 210.2 mASL) on 25-Nov-2024.

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario

wsp

RECORD OF BOREHOLE No. BH24-04

METRIC

PROJECT	CA0020332.0247		
G.W.P.	2022-E-0046	LOCATION	N 4892002.9; E 280382.3 NAD83 / MTM Zone 10 (LAT. 44.167616; LONG. -79.805328)
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers
DATUM	Surface Elevation:214.2 m	DATE	Apr 16, 2024 - Apr 18, 2024
ORIGINATED BY	KR	COMPILED BY	MTI
CHECKED BY	MCK		

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
0.0	ASPHALT (170 mm)							
214.0 / 0.2	Gravelly SILTY SAND (SM) to SAND (SP-SM), some gravel (FILL) Loose to dense Brown, oxidation staining Moist	1A / 1B	SS	38				
213.2 / 0.9	SILTY SAND (SM) to Sandy SILT (ML), containing clayey silt pockets (FILL) Loose Brown Moist - 1.8 m: becoming wet below 1.8 m	2A / 2B	SS	9				
		3	SS	6				
211.9 / 2.2	Sandy CLAYEY SILT (CL), trace gravel, (FILL) Soft to firm Grey, oxidation staining Moist - 3.0 m: becoming wet below 3.0 m	4	SS	8				
		5	SS	2				
210.2 / 4.0	SILTY SAND (SM), trace clay, containing clayey silt pockets to a depth of 4.42 m, (FILL) Loose to very loose Brown Wet - 4.6 m: trace organics below a depth of 4.6 m	6	SS	5				
		7	SS	3	0	63	33	4
208.5 / 5.6	CLAYEY SILT (CL), trace sand, trace gravel, trace organics, trace shell fragments, (FILL) Soft Grey, greenish-yellow to blueish-grey staining Wet	8	SS	3				
207.4 / 6.7	SILTY CLAY (CI), trace sand Firm to stiff Grey Moist to wet	9	SS	4	0	2	25	73
		10	SS	4				

Elevation scale: 214, 213, 212, 211, 210, 209, 208, 207, 206, 205

Dynamic cone penetration resistance plot: 20 40 60 80 100

Shear strength (kPa): + Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined

Water content (%): PL (W_p), NMC (W), LL (W_l); 20 40 60; NP Nonplastic

Sample 7: NP

Unit weight γ kN/m³

REMARKS

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario | wsp

RECORD OF BOREHOLE No. BH24-04

METRIC

PROJECT	CA00020332.0247				
G.W.P.	2022-E-0046	LOCATION	N 4892002.9; E 280382.3 NAD83 / MTM Zone 10 (LAT. 44.167616; LONG. -79.805328)	ORIGINATED BY	KR
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers	COMPILED BY	MTI
DATUM	Surface Elevation:214.2 m	DATE	Apr 16, 2024 - Apr 18, 2024	CHECKED BY	MCK

Column headings: SOIL PROFILE (ELEV. / DEPTH, DESCRIPTION, STRATA PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUNDWATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) (○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Field Vane, × Remoulded); WATER CONTENT (%) (PL W_p, NMC W, LL W_l; NP Nonplastic; 20 40 60); UNIT WEIGHT γ kN/m³; GR SA SI CL; REMARKS

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	SILTY CLAY (CI), trace sand Firm to stiff Grey Moist to wet				204				
		11	SS	2	203	0	0	38	62
	- 12.2 to 12.8 m: trace sand, trace gravel	12	SS	4	202				
		13	SS	3	201 / 200				
	- 15.2 m: trace gravel, trace sand, containing gravelly sand laminations below a depth of 15.2 - 15.2 m: becoming wet below a depth of 15.2 m	14	SS	3	199 / 198				
197.1 / 17.1	CLAYEY SILT-SILT (CL-ML) and SAND, trace gravel, (TILL) Firm to stiff Grey Moist	15 A / 15 B	SS	6	197 / 196				
		16	SS	9		4	46	39	11
195.2 / 18.9	End of Borehole				195				

Notes:
1. Water was encountered at a depth of 4.6 m (Elev. 209.6 mASL) during drilling on 16-Apr-2024.
2. Water level measured inside piezometer at a depth of 5.0 m (Elev. 209.2 m) upon installation.
2. Water level measured inside piezometer at a depth of 3.8 m (Elev. 210.4 mASL) on 26-Aug-2024.
3. Water level measured inside piezometer at a depth of 3.9 m (Elev. 210.3 mASL) on 27-Nov-2024.

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

Ontario

wsp

RECORD OF BOREHOLE No. BH24-05

Sheet 1 of 2

METRIC

PROJECT	CA00020332.0247		
G.W.P.	2022-E-0046	LOCATION	N 4891977.2; E 280382.4 NAD83 / MTM Zone 10 (LAT. 44.167385; LONG. -79.805326)
DIST	Central	HWY	89
BOREHOLE TYPE	Washboring, BW Casing; Portable Equipment		
DATUM	Surface Elevation:207.3 m	DATE	Nov 26, 2024 - Nov 27, 2024
ORIGINATED BY	AM		
COMPILED BY	MTI		
CHECKED BY	MCK		

ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL	REMARKS
0.0	SILTY SAND (SM), some clay, trace gravel, trace organics containing wood fragments (FILL) Very Loose Grey Wet	FILL	1	SS	0		207	1	49	34	16	
			2A	SS	2							
206.3 1.0	CLAY (CH) Soft to firm Grey Moist to wet	CLAY	2B				206					
			3	SS	2							
			4	SS	2		205					
			5	SS	4		204 / 203					
			6	SS	3	▽ (approx. 201.8)	202					
			7	SS	4		201					
			8	SS	4		200 / 199					
			9	SS	3		198					

Water content: sample 1 — NP (Nonplastic).

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): + Field Vane, × Remoulded, ■ Pocket Pen, ● Quick Triaxial, ○ Unconfined

WATER CONTENT (%): PL (W_p), NMC (W), LL (W_l); NP Nonplastic; 20 40 60

UNIT WEIGHT γ kN/m³

Continued on Next Page

+³, ×³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario

wsp

PROJECT	CA0020332.0247	RECORD OF BOREHOLE No. BH24-05	Sheet 2 of 2	METRIC
G.W.P.	2022-E-0046	LOCATION	N 4891977.2; E 280382.4 NAD83 / MTM Zone 10 (LAT. 44.167385; LONG. -79.805326)	ORIGINATED BY AM
DIST	Central HWY 89	BOREHOLE TYPE	Washboring, BW Casing; Portable Equipment	COMPILED BY MTI
DATUM	Surface Elevation:207.3 m	DATE	Nov 26, 2024 - Nov 27, 2024	CHECKED BY MCK

SOIL PROFILE; SAMPLES; GROUNDWATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Field Vane, × Remoulded; WATER CONTENT (%): PL (W_p), NMC (W), LL (W_l), NP Nonplastic (20 40 60); UNIT WEIGHT γ kN/m³; GR SA SI CL; REMARKS

ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH	WATER CONTENT	UNIT WEIGHT	GR SA SI CL	REMARKS
	CLAY (CH) Soft to firm Grey Moist to wet						197	⊕× , ×				
196.9 / 10.4	End of Borehole Note: 1. Water level measured at a depth of 5.5 mbgs (Elev. 201.8 m) inside the casing upon completion of drilling.						196					
							195					
							194					
							193					
							192					
							191					
							190					
							189					
							188					

+³, ×³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

wsp

PROJECT CA0020332.0247

RECORD OF BOREHOLE No. BH24-06

Sheet 1 of 1

METRIC

G.W.P. 2022-E-0046	LOCATION N 4892037.3; E 280443.4 NAD83 / MTM Zone 10 (LAT. 44.167928; LONG. -79.804566)	ORIGINATED BY	AM
DIST Central HWY 89	BOREHOLE TYPE Washboring, BW Casing; Portable Equipment	COMPILED BY	MTI
DATUM Surface Elevation:209.8 m	DATE Nov 14, 2024	CHECKED BY	MCK

ELEV. / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL	REMARKS
0.0	CLAYEY SILT (CL) some sand to sandy, trace gravel, trace organics containing wood fragments Firm Brown to grey Moist	1	SS	4							
208.9 / 0.9	CLAYEY SILT (CL) and SAND, trace organics, containing wood fragments and interlayers of organic silt Firm Grey to blackish-grey Moist	2	SS	5		209					
		3	SS	5		208	1	40	35	24	OC = 4.3%
		4	SS	4		207					
206.8 / 3.0	CLAY (CH), trace sand, trace organics to a depth of 3.7 m Soft to firm Grey Moist to wet - 3.7 m: Field vane refusal to advance - 3.7 to 5.2 m: Containing gravel pockets	5	SS	5		206					
		6	SS	3							
	- 4.6 m: Field vane refusal to advance	7	SS	5	▽	205					
						204					
		8	SS	4		203					
		9	SS	4		202					
						201					
		10	SS	5							
200.0 / 9.8	End of Borehole					200					

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT; SHEAR STRENGTH (kPa) — × Field Vane, ⊕ Remoulded, ■ Pocket Pen, ● Quick Triaxial, ○ Unconfined; 20 40 60 80 100. WATER CONTENT (%) — PL W_p, NMC W, LL W_l; NP Nonplastic; 20 40 60. UNIT WEIGHT γ kN/m³. STRATA PLOT.

Notes:
1. Water level measured at a depth of 5.2 mbgs (Elev. 204.6 m) upon completion of drilling.

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario

wsp

PROJECT	CA0020332.0247	**RECORD OF BOREHOLE No. BH24-07** Sheet 1 of 3	**METRIC**
G.W.P.	2022-E-0046	LOCATION N 4892019.7; E 280440.3 NAD83 / MTM Zone 10 (LAT. 44.167769; LONG. -79.804604)	ORIGINATED BY AM
DIST	Central HWY 89	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers and Mud Rotary	COMPILED BY MTI
DATUM	Surface Elevation:215.8 m	DATE Nov 26, 2024	CHECKED BY MCK

ELEV. --------- DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
0.0	Asphalt (150 mm)									
215.7 0.2	SILTY SAND (SM), trace to some gravel (FILL) Compact Brown Moist	1	SS	21	215					
214.8		2A	SS	15						
1.1	CLAYEY SILT (CL) trace sand, trace gravel (FILL) Firm Brownish grey Moist - 1.1 to 1.2 m: Clayey Gravel pocket - 1.1 to 2.1 m: Fabric pieces encountered in split spoon samples	2B								
		3	SS	7	214					
213.6 2.2	SILTY SAND (SM) (FILL) Loose Brownish grey Moist	4	SS	5	213					
		5	SS	4						
212.1 3.7	Sandy CLAYEY SILT (CL), trace organics to a depth of 4.4 m Soft to stiff Brown to grey Wet	6	SS	2	212	plotted	0	23	58	19
	- 4.6 to 5.2 m: SPT 'N'-value disturbed by field vane	7	SS	0	211					
					210					
	- 6.4 m: 50 mm layer containing organics and wood fragments - 6.4 to 6.7 m: Sandy Silt Layer	8A / 8B	SS	3	209					
208.7 7.2	CLAY (CH) Firm to stiff Grey Moist to wet	9	SS	8	208	plotted				
					207					
		10	SS	4	206					

Column headings: GROUNDWATER CONDITIONS; STRATA PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH (kPa): × Field Vane, ⊕ Remoulded, ■ Pocket Pen, ● Quick Triaxial, ○ Unconfined; WATER CONTENT (%) PL W_p, NMC W, LL W_l, NP Nonplastic, 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

PROJECT	CA0020332.0247	**RECORD OF BOREHOLE No. BH24-07**	Sheet 2 of 3 **METRIC**
G.W.P.	2022-E-0046	LOCATION N 4892019.7; E 280440.3 NAD83 / MTM Zone 10 (LAT. 44.167769; LONG. -79.804604)	ORIGINATED BY AM
DIST	Central HWY 89	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers and Mud Rotary	COMPILED BY MTI
DATUM	Surface Elevation:215.8 m	DATE Nov 26, 2024	CHECKED BY MCK

Legend (shear strength, kPa): × Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined

SOIL PROFILE

ELEV. / DEPTH	DESCRIPTION	REMARKS
	CLAY (CH) Firm to stiff Grey Moist to wet	Field Vane > 96 kPa
202.6 / 13.3	SILTY CLAY (CI) Soft to stiff Grey Wet - 16.8 to 17.4 m: No sample recovery - 18.4 m: 5 mm sand layer encountered	
196.2 / 19.6	CLAYEY SILT-SILT (CL-ML) and SAND trace gravel (TILL) Very stiff Grey Moist	

SAMPLES

NUMBER	TYPE	"N" VALUES
11	SS	3
12	SS	4
13	SS	4
14	SS	3
15	SS	4
16	SS	4

Elevation scale: 205, 204, 203, 202, 201, 200, 199, 198, 197, 196

Shear strength (kPa) axis: 20, 40, 60, 80, 100. Water content (%) axis: 20, 40, 60 (PL W_p, NMC W, LL W_l; NP Nonplastic). Unit weight γ kN/m³. GR SA SI CL.

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

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RECORD OF BOREHOLE No. BH24-07

METRIC

PROJECT	CA0020332.0247		
G.W.P.	2022-E-0046	LOCATION	N 4892019.7; E 280440.3 NAD83 / MTM Zone 10 (LAT. 44.167769; LONG. -79.804604)
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers and Mud Rotary
DATUM	Surface Elevation:215.8 m	DATE	Nov 26, 2024
ORIGINATED BY	AM	COMPILED BY	MTI
CHECKED BY	MCK		

ELEV. / DEPTH	DESCRIPTION (SOIL PROFILE)	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	CLAYEY SILT-SILT (CL-ML) and SAND trace gravel (TILL) Very stiff Grey Moist		17	SS	26						2 46 38 14	
195.4 / 20.4	End of Borehole						195					
							194					
							193					
							192					
							191					
							190					
							189					
							188					
							187					
							186					

Note:
1. Water level not measured due to introduction of water during drilling operations.

Shear strength legend: X Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined

Plot scales: 20 40 60 80 100 (DCPT/shear); 20 40 60 (water content); PL W_p, NMC W, LL W_l; NP Nonplastic

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

RECORD OF BOREHOLE No. BH24-08

Sheet 1 of 3 **METRIC**

PROJECT: CA0020332.0247			
G.W.P.: 2022-E-0046	LOCATION: N 4892033.4; E 280489 NAD83 / MTM Zone 10 (LAT. 44.167894; LONG. -79.803996)	ORIGINATED BY: AM	
DIST: Central	HWY: 89	BOREHOLE TYPE: 210 mm O.D. Hollow Stem Augers	COMPILED BY: MTI
DATUM: Surface Elevation:217.5 m	DATE: Nov 27, 2024		CHECKED BY: MCK

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (kPa)	WATER CONTENT	GR SA SI CL	REMARKS
0.0	Asphalt (230 mm)								
217.2 / 0.2	SILTY SAND (SM) to Sandy SILT (ML), trace gravel (FILL) Loose to compact Brown Moist to wet	1	SS	25	217		○		
		2	SS	19			○		
		3	SS	18	216		○		
	- 2.4 to 2.8 m: containing clayey silt pockets and oxidation staining	4A / 4B / 4C	SS	8	215				
214.7 / 2.8	CLAYEY SAND (SC) trace to some gravel (FILL) Loose to compact Brown to grey with oxidation staining Moist to wet - 3.2 to 3.7 m: pocket of sandy clayey silt	5A / 5B	SS	6	214				
		6A / 6B	SS	12					
213.4 / 4.1	SILTY CLAY (CI) Stiff Grey Moist	7	SS	11	213		├○──┤	0 10 29 61	
					212				
		8	SS	9	211				
						×			Field Vane > 96 kPa
210.3 / 7.2	CLAY (CH) Firm to stiff Grey Moist				210				
		9	SS	4			├──○──┤		
					209	⊕ ×			
		10	SS	1	208				

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

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RECORD OF BOREHOLE No. BH24-08

 METRIC

PROJECT	CA00020332.0247		
G.W.P.	2022-E-0046	LOCATION	N 4892033.4; E 280489 NAD83 / MTM Zone 10 (LAT. 44.167894; LONG. -79.803996)
ORIGINATED BY	AM		
DIST	Central	HWY	89
BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers	COMPILED BY	MTI
DATUM	Surface Elevation:217.5 m	DATE	Nov 27, 2024
CHECKED BY	MCK		

Column headings: SOIL PROFILE (ELEV. / DEPTH; DESCRIPTION; STRATA PLOT); SAMPLES (NUMBER; TYPE; "N" VALUES); GROUNDWATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): + Field Vane, × Remoulded, ■ Pocket Pen, ● Quick Triaxial, ○ Unconfined; WATER CONTENT (%): PL W_p, NMC W, LL W_l (20 40 60); NP Nonplastic; UNIT WEIGHT γ kN/m³; GR SA SI CL; REMARKS

ELEV. / DEPTH	DESCRIPTION
	CLAY (CH) Firm to stiff Grey Moist
202.7 / 14.8	SILTY CLAY (CI) Firm to stiff Grey Wet
201.0 / 16.5	END OF SAMPLED BOREHOLE Dynamic Cone Penetration Test (DCPT) (Blows per 0.3 m)

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
11	SS	0	0	3	18	79
12	SS	2				
13	SS	4				
14	SS	4				

Elevation scale: 207, 206, 205, 204, 203, 202, 201, 200, 199, 198

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

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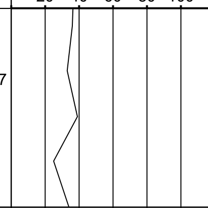
PROJECT	CA0020332.0247	RECORD OF BOREHOLE No. BH24-08	Sheet 3 of 3	METRIC
G.W.P.	2022-E-0046	LOCATION	N 4892033.4; E 280489 NAD83 / MTM Zone 10 (LAT. 44.167894; LONG. -79.803996)	ORIGINATED BY AM
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers	COMPILED BY MTI
DATUM	Surface Elevation:217.5 m	DATE	Nov 27, 2024	CHECKED BY MCK

ELEV. / DEPTH	DESCRIPTION (SOIL PROFILE)	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) (○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, X Field Vane)	WATER CONTENT (%) PL W_p / NMC W / LL W_l (NP Nonplastic) 20 40 60	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	END OF SAMPLED BOREHOLE Dynamic Cone Penetration Test (DCPT) (Blows per 0.3 m)						197					
196.1 21.3	End of Borehole Note: 1. Borehole dry inside of augers upon completion of DCPT.						196					
							195					
							194					
							193					
							192					
							191					
							190					
							189					
							188					

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

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RECORD OF BOREHOLE No. BH24-09

Sheet 1 of 2 **METRIC**

PROJECT	CA0020332.0247		
G.W.P.	2022-E-0046	LOCATION	N 4891999; E 280367.8 NAD83 / MTM Zone 10 (LAT. 44.16758; LONG. -79.805509)
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers
DATUM	Surface Elevation:213.8 m	DATE	Apr 18, 2024 - Apr 22, 2024
ORIGINATED BY	KR	COMPILED BY	MTI
CHECKED BY	MCK		

SOIL PROFILE

ELEV. / DEPTH	DESCRIPTION
0.0	ASPHALT (180 mm)
213.6 / 0.2	SILTY SAND (SM), some gravel to gravelly, (FILL) Dense Brown Moist
212.9 / 0.9	Sandy SILT (ML), trace gravel, (FILL) Compact Brown Moist
212.1 / 1.7	CLAYEY SILT (CL), trace sand, trace gravel, trace organics (FILL) Stiff Brown Moist
210.6 / 3.2	Sandy SILT (ML). trace clay, trace organics, wood pieces, (FILL) Very loose Brown, blackish spots Wet
210.0 / 3.7	Peat (PT) Firm Black Wet
209.7 / 4.1	Sandy SILT (ML), trace organics, Loose Brown, oxidation staining and blackish staining Wet
209.3 / 4.5	CLAY (CH) to CLAYEY SILT (CL), trace sand, trace gravel Firm to stiff Brown Wet - 6.1 m: becoming grey and wet below a depth of 6.1 m - 9.1 to 9.7 m: containing sand pockets

SAMPLES

NUMBER	TYPE	"N" VALUES	Water content / other	GR	SA	SI	CL	REMARKS
1A	SS	46						
1B								
2A	SS	13						
2B								
3A	SS	4						
3B								
4	SS	3		0	8	44	48	
5	SS	2						
6A	SS	5	MC= 120					OC = 33.2%
6B								
7	SS	10						
8	SS	5		0	4	21	75	
9	SS	3						
10	SS	4						

ELEVATION SCALE: 213, 212, 211, 210, 209, 208, 207, 206, 205, 204

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ Unconfined; ● Quick Triaxial; ■ Pocket Pen; ⊕ Remoulded; × Field Vane

WATER CONTENT (%): PL (W_p), NMC (W), LL (W_l): 20 40 60; NP Nonplastic

UNIT WEIGHT γ kN/m³

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

RECORD OF BOREHOLE No. BH24-09

METRIC

PROJECT	CA0020332.0247				
G.W.P.	2022-E-0046	LOCATION	N 4891999; E 280367.8 NAD83 / MTM Zone 10 (LAT. 44.16758; LONG. -79.805509)	ORIGINATED BY	KR
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers	COMPILED BY	MTI
DATUM	Surface Elevation:213.8 m	DATE	Apr 18, 2024 - Apr 22, 2024	CHECKED BY	MCK

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR SA SI CL	REMARKS
	CLAY (CH) to CLAYEY SILT (CL), trace sand, trace gravel Firm to stiff Brown Wet				203			
		11	SS	4				
					202			
		12	SS	3				
					201			
200.5 13.3	CLAYEY SILT-SILT (CL-ML) and sand, trace gravel (TILL) Stiff Grey Moist				200			
		13	SS	9			4 41 43 12	
					199			
		14	SS	10				
					198			
197.6 16.2	End of Borehole Notes: 1. Borehole was advanced to a depth of 4.6 m on 18-Apr-2024. Water level measured inside augers at a depth of 4.6 m (Elev. 209.2 m) prior to drilling on 22-Apr-2024. 2. Borehole dry upon completion of drilling.				197			
					196			
					195			
					194			

Column headings: SOIL PROFILE; STRATA PLOT; SAMPLES; GROUNDWATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ⊕ Field Vane, ■ Remoulded, ⊗ Pocket Pen, ● Quick Triaxial, ○ Unconfined; WATER CONTENT (%) PL W_p, NMC W, LL W_l (20 40 60), NP Nonplastic; UNIT WEIGHT γ kN/m³.

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

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PROJECT CA00020332.0247

RECORD OF BOREHOLE No. BH24-10

METRIC

G.W.P. 2022-E-0046 | LOCATION N 4892002.5; E 280413.3 NAD83 / MTM Zone 10 (LAT. 44.167613; LONG. -79.80494) | ORIGINATED BY KR

DIST Central HWY 89 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY MTI

DATUM Surface Elevation:215.0 m | DATE Apr 22, 2024 - Apr 23, 2024 | CHECKED BY MCK

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
0.0	ASPHALT (70 mm)								
214.9 / 0.1	Gravelly SILTY SAND (SM) (FILL), Dense, Brown, Moist	1	SS	40					
214.2 / 0.8	Sandy GRAVEL (GP-GM), trace to some fines, (FILL), Compact, Grey, Moist	2	SS	11					
213.6 / 1.4	Sandy SILT (ML) trace gravel, (FILL), Very loose to compact, Brown and grey, Moist to wet	3	SS	10	○	2	25	68	5
	- 2.3 m: becoming wet below a depth of 2.3 m - 2.3 m: containing trace organics and silty clay pockets between a depth of 2.3 m and 2.9 m	4	SS	29	○				
	- 3.0 to 3.7 m: containing wood fragments between a depth of 3.0 m and 3.7 m	5	SS	1	○ NP	0	46	48	6
		6A	SS	0	○				
210.8 / 4.2	ORGANIC SILT (OL), containing wood pieces, Very loose, Blackish grey, Wet	6B			○				
210.5 / 4.5	Sandy SILT (ML), trace clay, trace organics, Loose, Grey, Wet	7A	SS	8	○				
210.1 / 4.9	CLAYEY SILT (CL) to SILTY CLAY (CI), trace sand, trace gravel, Firm to stiff, Grey, Wet	7B			○				
		8	SS	7	├○┤	0	9	38	53
		9	SS	6					
		10	SS	4					
		11	SS	6					
		12	SS	2					
		13	SS	1					
	- 9.9 m: containing silt seams below a depth of 9.9 m								

Other column headings: STRATA PLOT; GROUNDWATER CONDITIONS; ELEVATION SCALE (214, 213, 212, 211, 210, 209, 208, 207, 206); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, X Field Vane; WATER CONTENT (%): PL W_p, NMC W, LL W_l (20 40 60), NP Nonplastic; UNIT WEIGHT γ kN/m³; REMARKS.

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario

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PROJECT	CA0020332.0247	**RECORD OF BOREHOLE No. BH24-10**	Sheet 2 of 2		**METRIC**
G.W.P.	2022-E-0046	LOCATION	N 4892002.5; E 280413.3 NAD83 / MTM Zone 10 (LAT. 44.167613; LONG. -79.80494)	ORIGINATED BY	KR
DIST	Central HWY 89	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers	COMPILED BY	MTI
DATUM	Surface Elevation:215.0 m	DATE	Apr 22, 2024 - Apr 23, 2024	CHECKED BY	MCK

ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	CLAYEY SILT (CL) to SILTY CLAY (CI), trace sand, trace gravel Firm to stiff Grey Wet		14	SS	0							
			15	SS	0		204					
							203					
			16	SS	0		202					
			17	SS	0		201					
							200					
			18	SS	1		199				0 1 28 71	
198.8 16.2	End of Borehole Notes: 1. Water encountered inside augers it a depth of 4.6 m (Elev. 210.4 mASL) during drilling on 22-Apr-2024. 2. Borehole dry at a depth of 6.1 m (Elev. 208.9 mASL) before resuming drilling on 23-Apr-2024. 3. Water encountered inside augers at a depth of 8.4 m (Elev. 206.6 mASL) during drilling on 23-Apr-2024. 4. Borehole dry upon completion of drilling.						198 197 196					

Shear strength legend: × Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined. DCPT scale: 20 40 60 80 100. Water content: PL (W_p), NMC (W), LL (W_l); NP Nonplastic; scale 20 40 60.

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

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PROJECT CA0020332.0247	**RECORD OF BOREHOLE No. BH24-11**	Sheet 1 of 2	**METRIC**
G.W.P. 2022-E-0046	LOCATION N 4892016; E 280459.6 NAD83 / MTM Zone 10 (LAT. 44.167736; LONG. -79.804363)	ORIGINATED BY	AM
DIST Central HWY 89	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY	MTI
DATUM Surface Elevation:216.4 m	DATE Nov 28, 2024	CHECKED BY	MCK

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH (kPa)	WATER CONTENT (%)	GR SA SI CL	REMARKS
0.0	Asphalt (75 mm)									
216.3 / 0.1	SILTY SAND (SM), some gravel (FILL) Compact Brown Moist	1	SS	23		216				
215.6 / 0.8	Sandy SILTY GRAVEL (GM) (FILL) Loose Grey Moist	2	SS	9	▽ (approx. 215.1)					
215.0 / 1.4	Sandy SILT (ML), trace gravel (FILL) Loose to compact Brown to grey Wet	3	SS	9		215		○	4 26 66 4	
		4	SS	10		214		○		
	- 3.2 to 3.4 m: gravel fill layer encountered - 3.4 to 3.7 m: sand to silty sand fill layer	5A / 5B / 5C	SS	13		213				
212.7 / 3.7	SILTY CLAY (CI), trace sand, trace gravel Stiff to very stiff Grey Moist	6	SS	12				├○──┤		
		7	SS	18		212				
210.8 / 5.6	CLAY (CH) Soft to stiff Grey Wet					211				
		8	SS	7		210		├─○───┤		
							×			Field Vane >96 kPa
		9	SS	4		209				
						208	×			Field Vane >96 kPa
		10	SS	5		207		├──○──┤		

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): × Field Vane, ⊕ Remoulded, ■ Pocket Pen, ● Quick Triaxial, ○ Unconfined; WATER CONTENT (%): PL W_p, NMC W, LL W_l (20 40 60), NP Nonplastic; UNIT WEIGHT γ kN/m³

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

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PROJECT CA0020332.0247	**RECORD OF BOREHOLE No. BH24-11** Sheet 2 of 2		**METRIC**
G.W.P. 2022-E-0046	LOCATION N 4892016; E 280459.6 NAD83 / MTM Zone 10 (LAT. 44.167736; LONG. -79.804363)	ORIGINATED BY	AM
DIST Central HWY 89	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY	MTI
DATUM Surface Elevation:216.4 m	DATE Nov 28, 2024	CHECKED BY	MCK

ELEV. / DEPTH	DESCRIPTION (SOIL PROFILE)	STRATA PLOT	NUMBER (SAMPLES)	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) 20 40 60 80 100	WATER CONTENT (%) PL W_p / NMC W / LL W_l 20 40 60	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	CLAY (CH) Soft to stiff Grey Wet							⊕ ~25; × ~85				
206.2 / 10.2	End of Borehole						206					
	Note: 1. Water level measured at a depth of 1.3 mbgs (Elev. 215.1 m) inside of augers upon completion of drilling.						205					
							204					
							203					
							202					
							201					
							200					
							199					
							198					
							197					

Legend (shear strength): × Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined

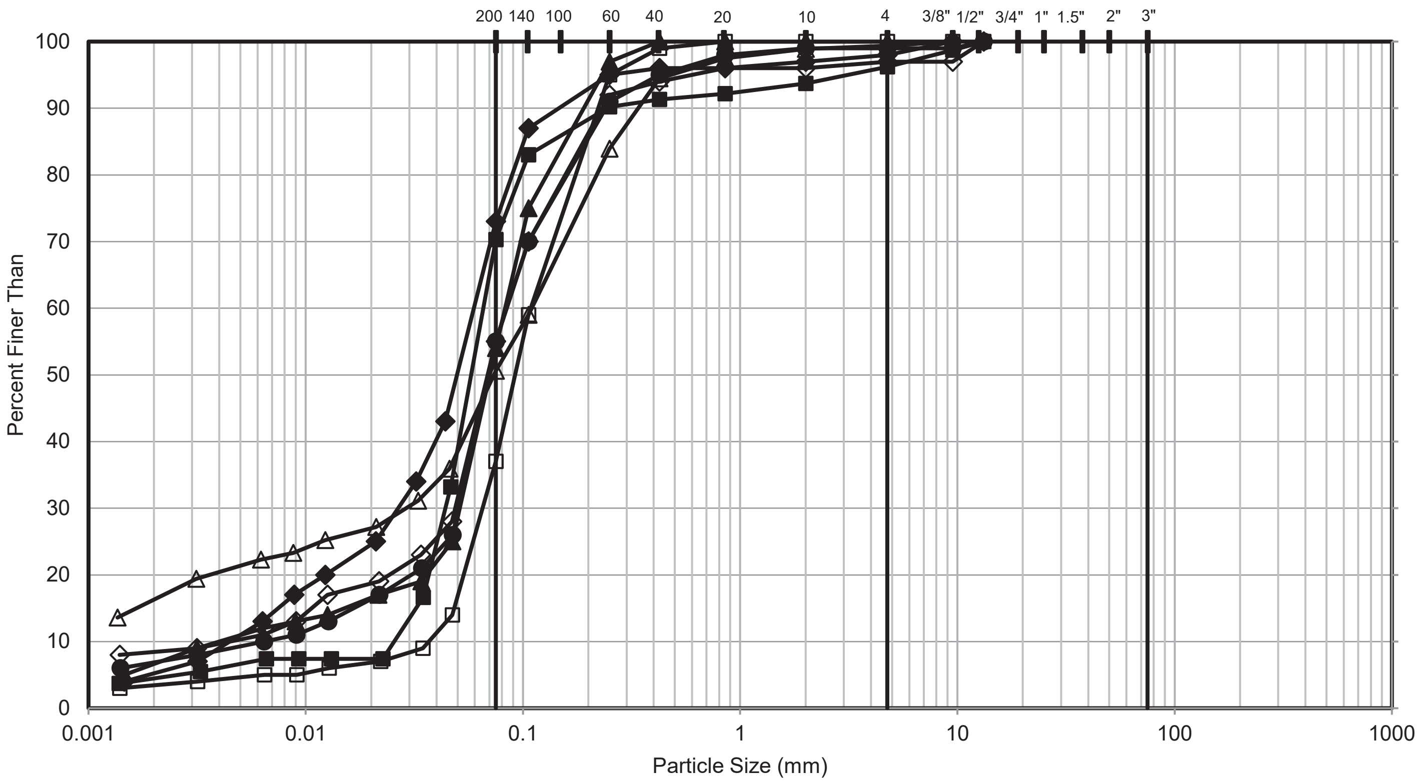
NP Nonplastic

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION



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

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	BH24-11	3	1.5 - 2.1	214.9 to 214.3
◆	BH24-10	3	1.5 - 2.1	213.5 to 212.9
▲	BH24-10	5	3.0 - 3.7	212.0 to 211.3
●	BH24-03	6	3.8 - 4.4	210.7 to 210.1
□	BH24-04	7	4.6 - 5.2	209.6 to 209.0
◇	BH24-03	8B	6.4 - 6.7	208.1 to 207.8
△	BH24-05	1	0.0 - 0.6	207.3 to 206.7

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Ministry of Transportation, Ontario

PROJECT

Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

CONSULTANT

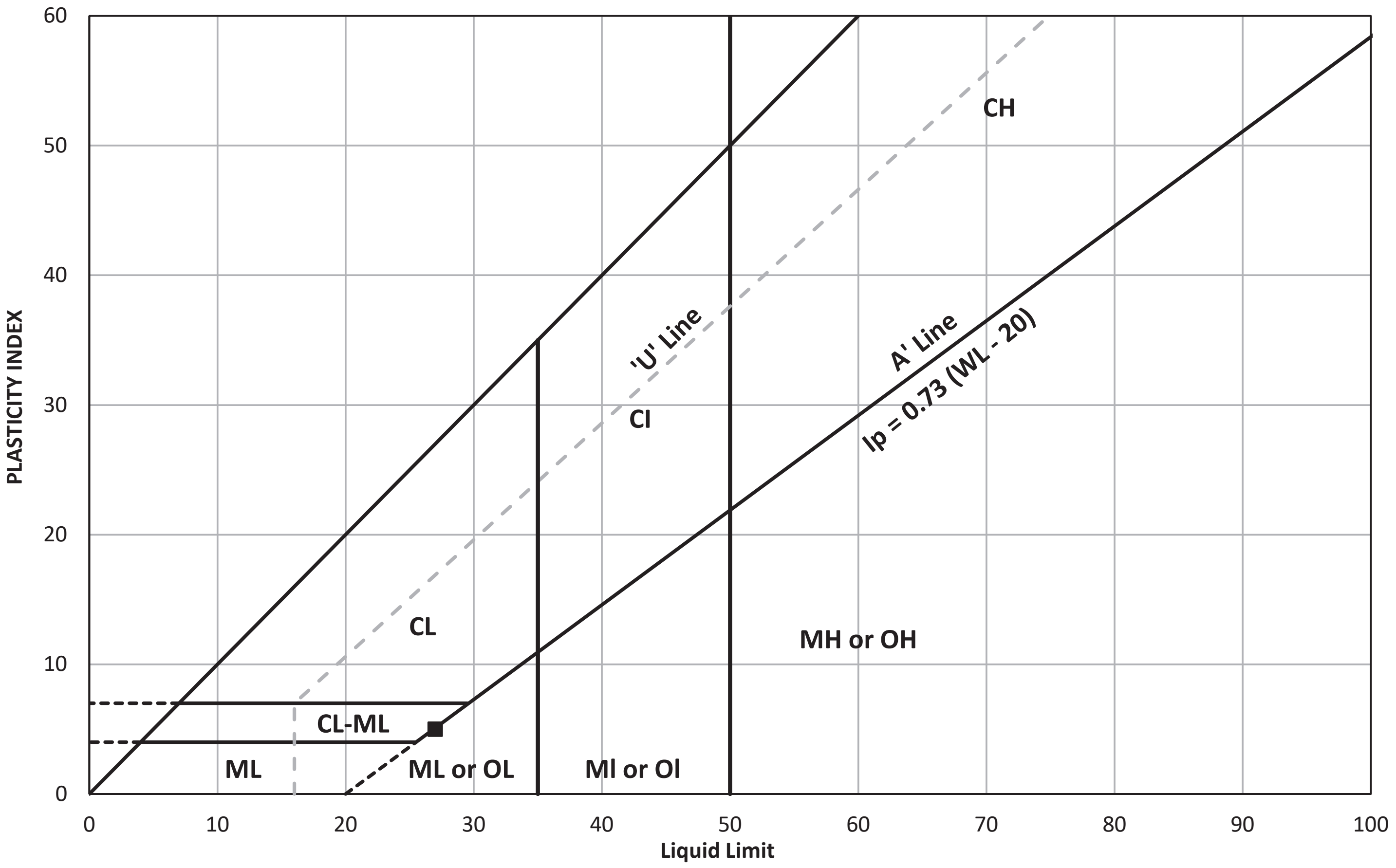
YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE

Sandy SILT (ML) to SILTY SAND (SM) - FILL

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B1

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	BH24-03	8B	6.4 - 6.7	26.7	27	22	5	0.94

CLIENT
Ministry of Transportation, Ontario

PROJECT
Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

CONSULTANT
wsp

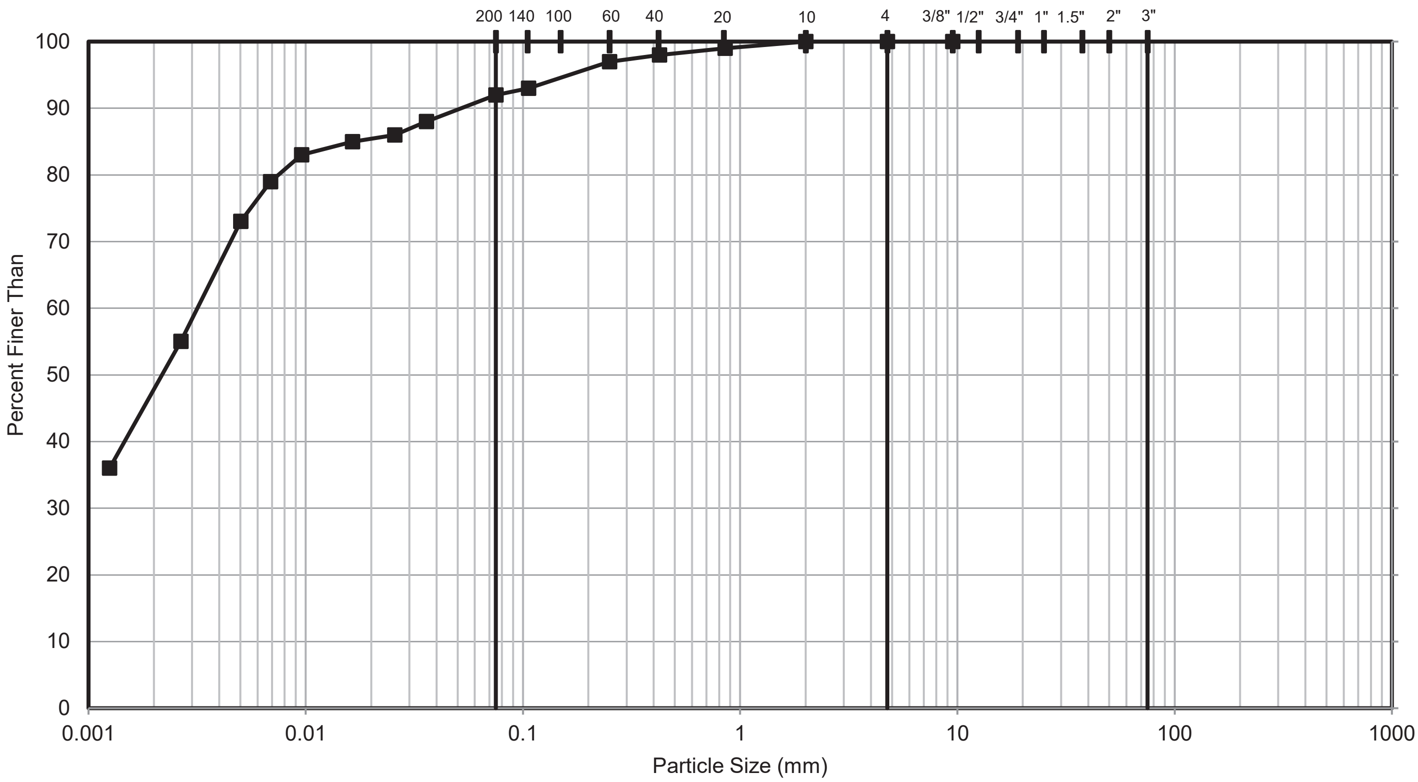
YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE
Sandy SILT (ML) to SILTY SAND (SM) - FILL

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B2

PATH: https://wsponlinecan.sharepoint.com/sites/CA-CA00203320247/Shared Documents/05. Technical/Foundations/5 - Reporting/6 - RPT Temp Works/1-Pre-draft/Appendix B - Lab Figures | FILE NAME: Atterberg Output MTO - TempWorks.xlsm

GRAIN SIZE DISTRIBUTION



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

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	BH24-09	4	2.4 - 2.9	211.3 to 210.9

CLIENT

Ministry of Transportation, Ontario

PROJECT

Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

CONSULTANT

wsp

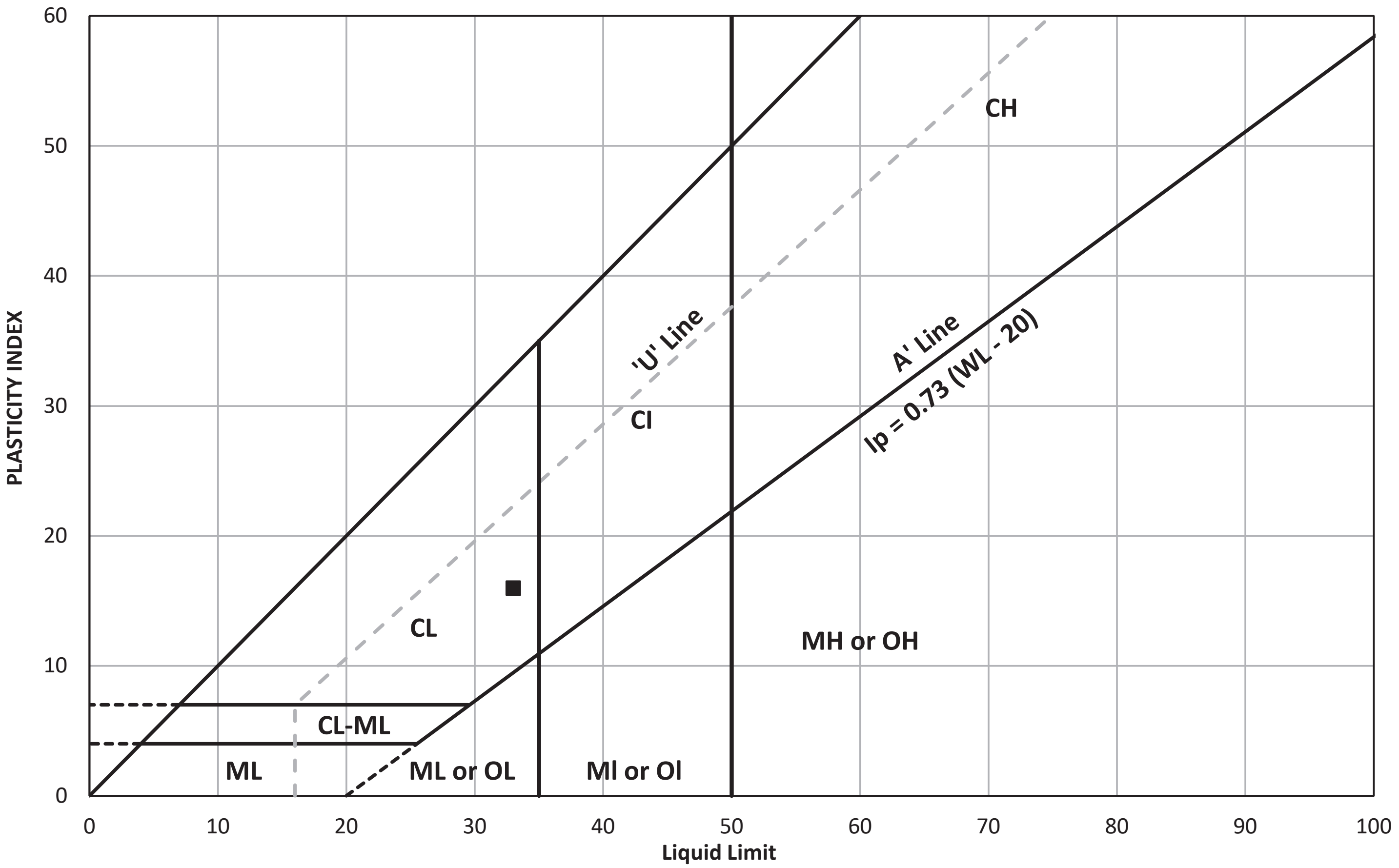
YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE

CLAYEY SILT (CL) - FILL

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B3

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	BH24-09	4	2.4 - 2.9	25.4	33	17	16	0.53

CLIENT
Ministry of Transportation, Ontario

PROJECT
Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

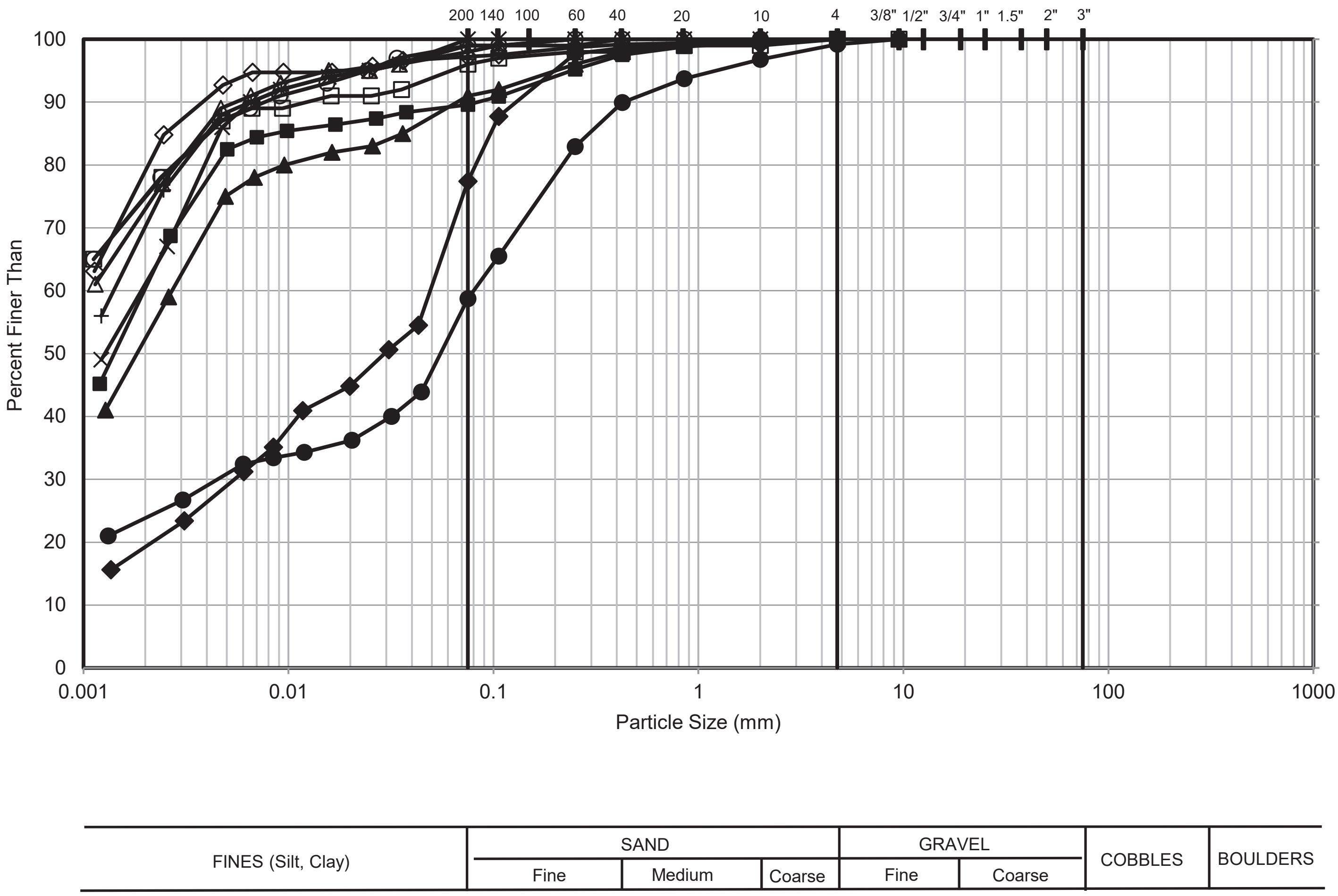
CONSULTANT

YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE
CLAYEY SILT (CL) - FILL

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B4

GRAIN SIZE DISTRIBUTION



Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	BH24-08	7	4.6 - 5.2	212.9 to 212.3
◆	BH24-07	6	3.8 - 4.4	212.0 to 211.4
▲	BH24-10	8	5.3 - 5.9	209.7 to 209.1
●	BH24-06	3	1.5 - 2.1	208.3 to 207.7
□	BH24-09	8	6.1 - 6.7	207.7 to 207.1
◇	BH24-08	11	10.7 - 11.3	206.8 to 206.2
△	BH24-04	9	7.6 - 8.2	206.5 to 205.9
○	BH24-03	10	9.1 - 9.8	205.4 to 204.8
×	BH24-04	11	10.7 - 11.3	203.5 to 202.9
+	BH24-10	18	15.2 - 15.9	199.8 to 199.2

CLIENT

Ministry of Transportation, Ontario

PROJECT

Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

CONSULTANT

wsp

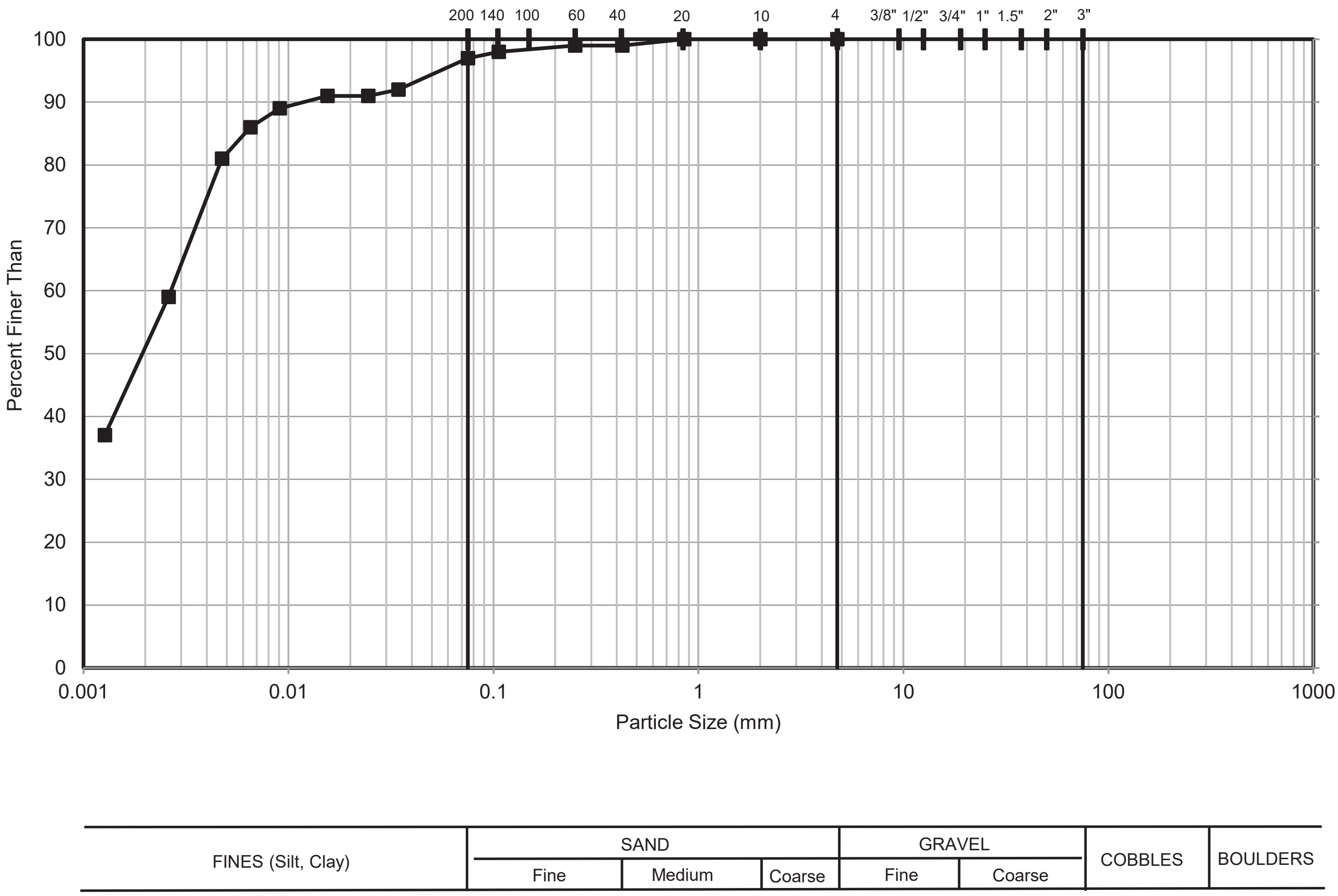
YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE

CLAYEY SILT (CL) to CLAY (CH)

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B5A

GRAIN SIZE DISTRIBUTION



Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	BH24-03	15	16.8 - 17.4	197.8 to 197.2

CLIENT

Ministry of Transportation, Ontario

PROJECT

Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

CONSULTANT

wsp

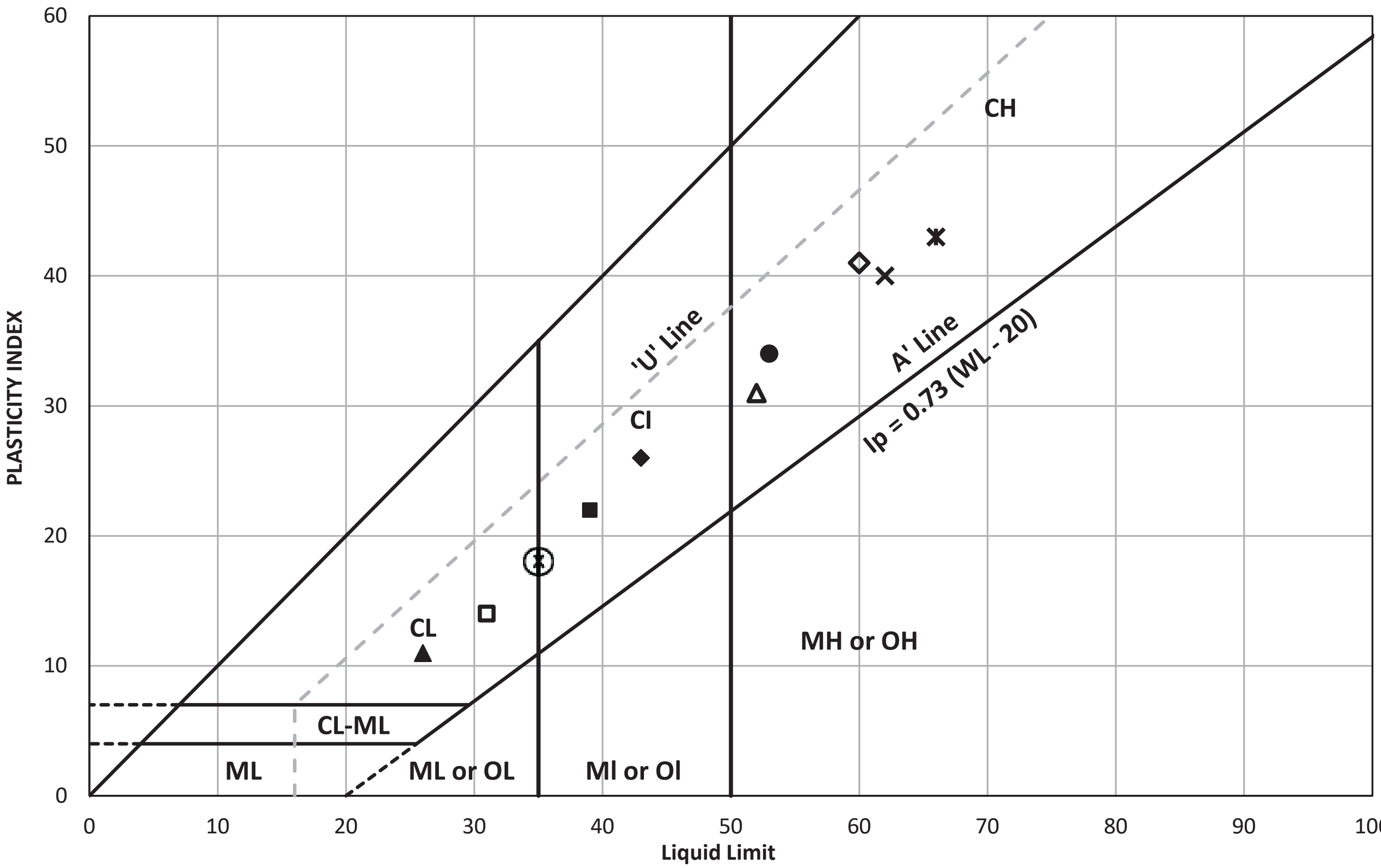
YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE

CLAYEY SILT (CL) to CLAY (CH)

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B5B

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	BH24-08	7	4.6 - 5.2	19.5	39	17	22	0.11
◆	BH24-11	6	3.8 - 4.4	22.5	43	17	26	0.21
▲	BH24-07	6	3.8 - 4.4	25.8	26	15	11	0.98
●	BH24-11	8	6.1 - 6.7	28.3	53	19	34	0.27
✳	BH24-08	9	7.6 - 8.2	42.7	66	23	43	0.46
⊗	BH24-10	8	5.3 - 5.9	24.2	35	17	18	0.40
□	BH24-06	3	1.5 - 2.1	47.3	31	17	14	2.16
◇	BH24-07	9	7.6 - 8.2	27.5	60	19	41	0.21
△	BH24-09	8	6.1 - 6.7	35.7	52	21	31	0.47
×	BH24-11	10	9.1 - 9.8	39.3	62	22	40	0.43

CLIENT
Ministry of Transportation, Ontario

PROJECT
Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

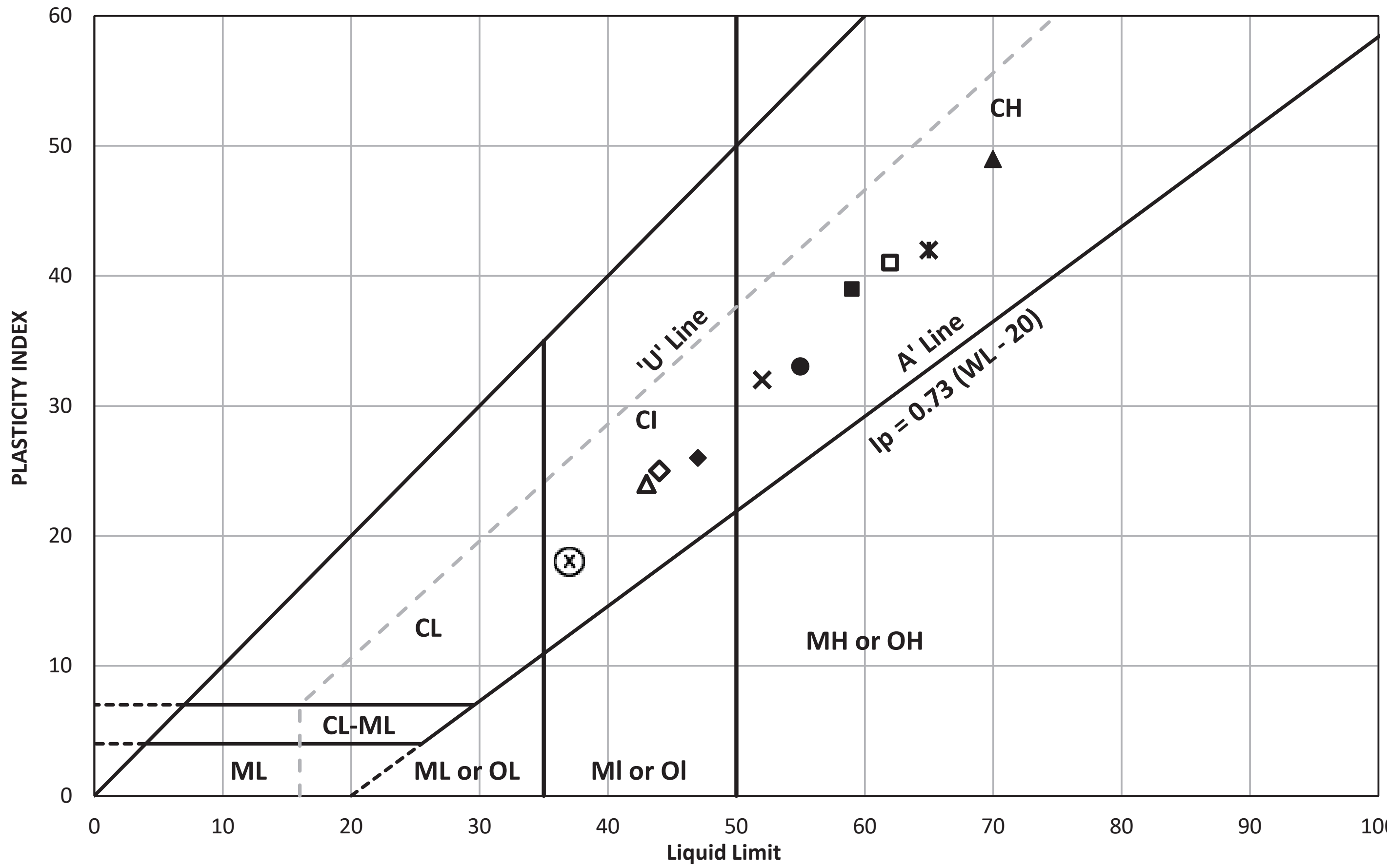
CONSULTANT: wsp

YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE
CLAYEY SILT (CL) to CLAY (CH)

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B6A

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	BH24-08	11	10.7 - 11.3	42.2	59	20	39	0.57
◆	BH24-04	9	7.6 - 8.2	32.4	47	21	26	0.44
▲	BH24-06	6	3.8 - 4.4	42.1	70	21	49	0.43
●	BH24-03	10	9.1 - 9.8	42.3	55	22	33	0.62
✳	BH24-07	11	10.7 - 11.3	39.8	65	23	42	0.40
⊗	BH24-04	11	10.7 - 11.3	27	37	19	18	0.44
□	BH24-05	5	3.8 - 4.4	42.6	62	21	41	0.53
◇	BH24-08	14	15.2 - 15.9	29	44	19	25	0.40
△	BH24-07	13	13.7 - 14.3	33	43	19	24	0.58
×	BH24-06	10	9.1 - 9.8	32.7	52	20	32	0.40

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Ministry of Transportation, Ontario

PROJECT
Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

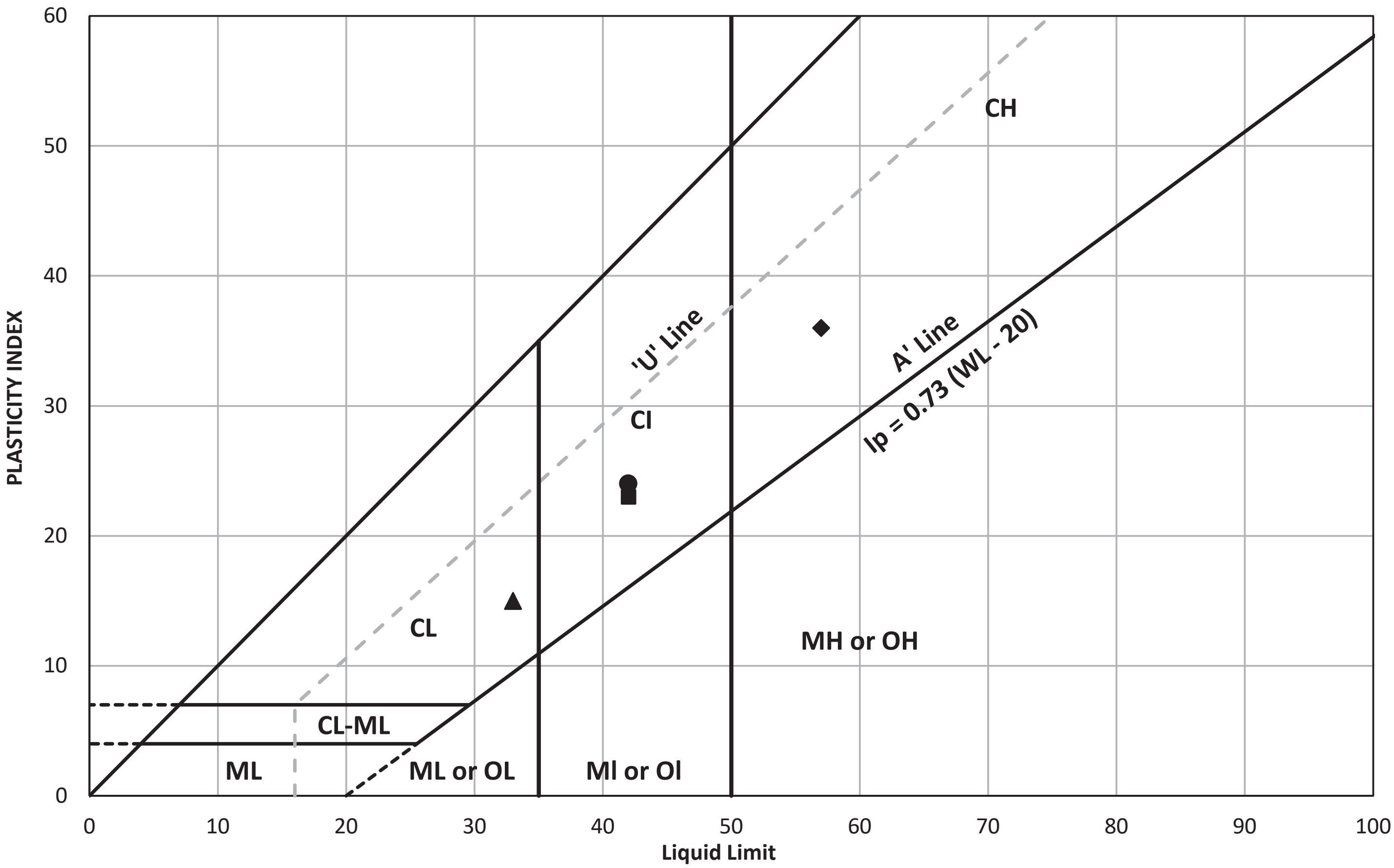
CONSULTANT: wsp

YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE
CLAYEY SILT (CL) to CLAY (CH)

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B6B

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	BH24-10	18	15.2 - 15.9	36.6	42	19	23	0.77
◆	BH24-05	8	7.6 - 8.2	40.5	57	21	36	0.54
▲	BH24-03	15	16.8 - 17.4	28.4	33	18	15	0.69
●	BH24-07	16	18.3 - 18.9	33.2	42	18	24	0.63

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PROJECT
Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

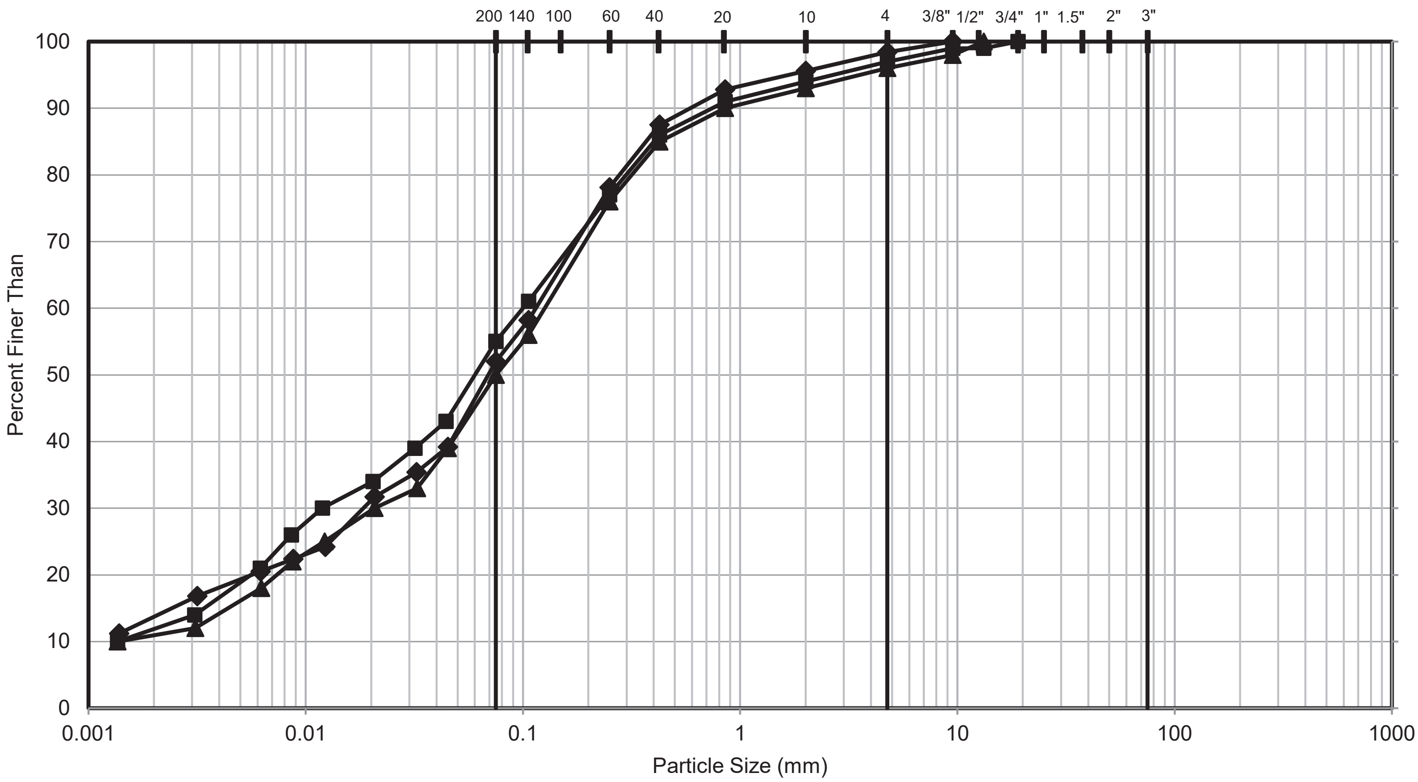
CONSULTANT
wsp

YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE
CLAYEY SILT (CL) to CLAY (CH)

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B6C

GRAIN SIZE DISTRIBUTION



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

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	BH24-09	13	13.7 - 14.3	200.1 to 199.5
◆	BH24-07	17	19.8 - 20.4	196.0 to 195.4
▲	BH24-04	16	18.3 - 18.9	195.9 to 195.3

CLIENT

Ministry of Transportation, Ontario

PROJECT

Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

CONSULTANT

wsp

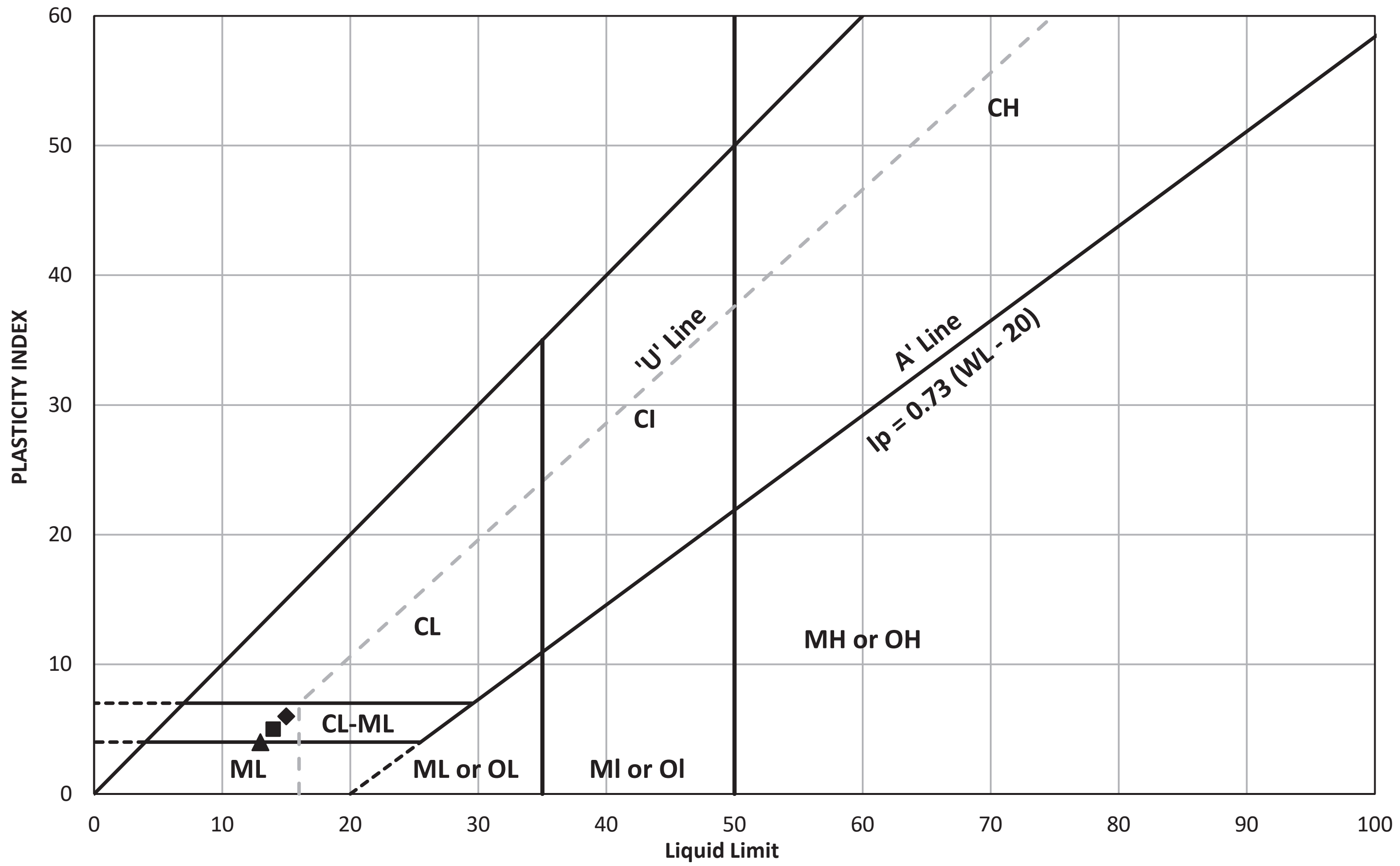
YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE

CLAYEY SILT - SILT (CL-ML) - TILL

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B7

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	BH24-09	13	13.7 - 14.3	10.7	14	9	5	0.34
◆	BH24-07	17	19.8 - 20.4	9.5	15	9	6	0.08
▲	BH24-04	16	18.3 - 18.9	9.3	13	9	4	0.08

CLIENT
Ministry of Transportation, Ontario

PROJECT
Temporary Works - Nicolston Culvert Rehabilitation
Highway 89, Alliston, Simcoe County, ON.,
MTO G.W.P. 2022-22-00; W.P. 2014-23-01

CONSULTANT

wsp

YYYY-MM-DD	2025-02-02
DESIGNED	-
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE
CLAYEY SILT - SILT (CL-ML) - TILL

PROJECT NO.	CONTROL	REV.	FIGURE
CA0020332.0247	0	0	B8

PATH: https://wsponlinecan.sharepoint.com/sites/CA-CA0020332024 7/Shared Documents/05. Technical/Foundations/5 - Reporting/6 - RPT Temp Works/1-Pre-draft/Appendix B - Lab Figures | FILE NAME: Atterberg Output MTO - TempWorks.xlsm

APPENDIX C

Analytical Test Results

Your Project #: CA0020332.0247, TASK 900.910
Site Location: ALLISTON, ONTARIO
Your C.O.C. #: N/A

Attention: Madison Kennedy

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2024/05/03
Report #: R8134623
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C4C4317
Received: 2024/04/25, 14:52

Sample Matrix: Soil
Samples Received: 9

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	9	2024/04/30	2024/05/01	CAM SOP-00463	MOE E3013 m
Conductivity	9	2024/04/30	2024/04/30	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	9	N/A	2024/05/01	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	9	N/A	2024/04/30	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	9	2024/04/29	2024/04/29	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	9	2024/05/02	2024/05/03	CAM SOP-00421	SM 24 2580 B
Resistivity of Soil	9	2024/04/26	2024/04/30	CAM SOP-00414	SM 24 2510 m
Sulphate (20:1 Extract)	9	2024/04/30	2024/05/01	CAM SOP-00464	MOE E3013 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, EPA, APHA or the Quebec Ministry of Environment.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by Bureau Veritas Calgary (19th), 4000 19th Street NE , Calgary, AB, T2E 6P8
(2) Offsite analysis requires that subcontracted moisture be reported.

Your Project #: CA0020332.0247, TASK 900.910
Site Location: ALLISTON, ONTARIO
Your C.O.C. #: N/A

Attention: Madison Kennedy

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2024/05/03
Report #: R8134623
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C4C4317

Received: 2024/04/25, 14:52

(3) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode. The test is therefore, not SCC accredited for this matrix.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Ankita Bhalla, Project Manager
Email: Ankita.Bhalla@bureauveritas.com
Phone# (905) 817-5700
==
This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		YZU407		YZU408	YZU409			YZU409	
Sampling Date		2024/04/09		2024/04/10	2024/04/10			2024/04/10	
COC Number		N/A		N/A	N/A			N/A	
	UNITS	**BH24-01 SA-5**	**RDL**	**BH24-01 SA-9**	**BH24-01 SA-12**	**RDL**	**QC Batch**	**BH24-01 SA-12 Lab-Dup**	**QC Batch**
Calculated Parameters									
Resistivity	ohm-cm	410		870	4100		9358051		
CONVENTIONALS									
Redox Potential	mV	270	N/A	270	270	N/A	9368559	270	9368559
Inorganics									
Soluble (20:1) Chloride (Cl-)	ug/g	1400	40	550	21	20	9364082		
Conductivity	umho/cm	2470	2	1160	244	2	9364027		
Available (CaCl2) pH	pH	7.76		7.86	7.85		9361710		
Soluble (20:1) Sulphate (SO4)	ug/g	94	20	83	79	20	9364092		
Sulphide	mg/kg	3.2 (1)	0.5	1.5 (1)	1.8 (1)	0.5	9365692		

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Extracted past method specified hold time

BUREAU VERITAS

Bureau Veritas Job #: C4C4317
Report Date: 2024/05/03

WSP Canada Inc.
Client Project #: CA0020332.0247, TASK 900.910
Site Location: ALLISTON, ONTARIO
Sampler Initials: MTI

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		YZU410	YZU411			YZU411		
Sampling Date		2024/04/08	2024/04/08			2024/04/08		
COC Number		N/A	N/A			N/A		
	UNITS	**BH24-02 SA-2+3**	**BH24-02 SA-05**	**RDL**	**QC Batch**	**BH24-02 SA-05 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters								
Resistivity	ohm-cm	1200	2400		9358051			
CONVENTIONALS								
Redox Potential	mV	270	270	N/A	9368559			
Inorganics								
Soluble (20:1) Chloride (Cl-)	ug/g	330	100	20	9364082	110	20	9364082
Conductivity	umho/cm	843	420	2	9364027			
Available (CaCl2) pH	pH	8.05	7.96		9361710			
Soluble (20:1) Sulphate (SO4)	ug/g	40	24	20	9364092	24	20	9364092
Sulphide	mg/kg	1.8 (1)	0.9 (1)	0.5	9365692			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Extracted past method specified hold time

Bureau Veritas ID		YZU412		YZU413		YZU414		
Sampling Date		2024/04/08		2024/04/09		2024/04/15		
COC Number		N/A		N/A		N/A		
	UNITS	**BH24-02 SA-10**	**QC Batch**	**BH24-02 SA-12**	**QC Batch**	**BH24-03 SA-9**	**RDL**	**QC Batch**
Calculated Parameters								
Resistivity	ohm-cm	3500	9358051	4100	9358051	1800		9358051
CONVENTIONALS								
Redox Potential	mV	270	9368559	270	9368559	270	N/A	9368559
Inorganics								
Soluble (20:1) Chloride (Cl-)	ug/g	80	9364082	64	9364082	200	20	9364082
Conductivity	umho/cm	284	9364027	246	9364027	561	2	9364027
Available (CaCl2) pH	pH	7.92	9361710	7.90	9361722	7.74		9361710
Soluble (20:1) Sulphate (SO4)	ug/g	34	9364092	31	9364092	35	20	9364092
Sulphide	mg/kg	1.6 (1)	9365692	1.1 (1)	9365692	2.4 (1)	0.5	9365692

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
(1) Extracted past method specified hold time

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		YZU414			YZU415		
Sampling Date		2024/04/15			2024/04/16		
COC Number		N/A			N/A		
	UNITS	**BH24-03 SA-9 Lab-Dup**	**RDL**	**QC Batch**	**BH24-04 SA-8**	**RDL**	**QC Batch**
Calculated Parameters							
Resistivity	ohm-cm				5200		9358051
CONVENTIONALS							
Redox Potential	mV				270	N/A	9368559
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g				<20	20	9364082
Conductivity	umho/cm	564	2	9364027	192	2	9364027
Available (CaCl2) pH	pH				7.56		9361722
Soluble (20:1) Sulphate (SO4)	ug/g				49	20	9364092
Sulphide	mg/kg				3.3	0.5	9365692

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		YZU407	YZU408	YZU408	YZU409	YZU410	YZU411		
Sampling Date		2024/04/09	2024/04/10	2024/04/10	2024/04/10	2024/04/08	2024/04/08		
COC Number		N/A	N/A	N/A	N/A	N/A	N/A		
	UNITS	**BH24-01 SA-5**	**BH24-01 SA-9**	**BH24-01 SA-9 Lab-Dup**	**BH24-01 SA-12**	**BH24-02 SA-2+3**	**BH24-02 SA-05**	**RDL**	**QC Batch**
Physical Testing									
Moisture-Subcontracted	%	16	15	16	17	5.4	6.7	0.30	9368179

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas ID		YZU412	YZU413	YZU414	YZU415		
Sampling Date		2024/04/08	2024/04/09	2024/04/15	2024/04/16		
COC Number		N/A	N/A	N/A	N/A		
	UNITS	**BH24-02 SA-10**	**BH24-02 SA-12**	**BH24-03 SA-9**	**BH24-04 SA-8**	**RDL**	**QC Batch**
Physical Testing							
Moisture-Subcontracted	%	17	15	30	21	0.30	9368179

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

Bureau Veritas ID: YZU407
Sample ID: BH24-01 SA-5
Matrix: Soil

Collected: 2024/04/09
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361710	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU408
Sample ID: BH24-01 SA-9
Matrix: Soil

Collected: 2024/04/10
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361710	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU408 Dup
Sample ID: BH24-01 SA-9
Matrix: Soil

Collected: 2024/04/10
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson

Bureau Veritas ID: YZU409
Sample ID: BH24-01 SA-12
Matrix: Soil

Collected: 2024/04/10
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361710	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

TEST SUMMARY

Bureau Veritas ID: YZU409 Dup
Sample ID: BH24-01 SA-12
Matrix: Soil

Collected: 2024/04/10
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR

Bureau Veritas ID: YZU410
Sample ID: BH24-02 SA-2+3
Matrix: Soil

Collected: 2024/04/08
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361710	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU411
Sample ID: BH24-02 SA-05
Matrix: Soil

Collected: 2024/04/08
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361710	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU411 Dup
Sample ID: BH24-02 SA-05
Matrix: Soil

Collected: 2024/04/08
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU412
Sample ID: BH24-02 SA-10
Matrix: Soil

Collected: 2024/04/08
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR

Bureau Veritas Job #: C4C4317
Report Date: 2024/05/03

WSP Canada Inc.
Client Project #: CA0020332.0247, TASK 900.910
Site Location: ALLISTON, ONTARIO
Sampler Initials: MTI

TEST SUMMARY

Bureau Veritas ID: YZU412
Sample ID: BH24-02 SA-10
Matrix: Soil

Collected: 2024/04/08
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361710	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU413
Sample ID: BH24-02 SA-12
Matrix: Soil

Collected: 2024/04/09
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361722	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU414
Sample ID: BH24-03 SA-9
Matrix: Soil

Collected: 2024/04/15
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361710	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas ID: YZU414 Dup
Sample ID: BH24-03 SA-9
Matrix: Soil

Collected: 2024/04/15
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR

Bureau Veritas Job #: C4C4317
Report Date: 2024/05/03

WSP Canada Inc.
Client Project #: CA0020332.0247, TASK 900.910
Site Location: ALLISTON, ONTARIO
Sampler Initials: MTI

TEST SUMMARY

Bureau Veritas ID: YZU415
Sample ID: BH24-04 SA-8
Matrix: Soil

Collected: 2024/04/16
Shipped:
Received: 2024/04/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9364082	2024/04/30	2024/05/01	Alina Dobreanu
Conductivity	AT	9364027	2024/04/30	2024/04/30	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9368179	N/A	2024/05/01	Ashley Henderson
Sulphide in Soil	SPEC	9365692	N/A	2024/04/30	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9361722	2024/04/29	2024/04/29	Taslima Aktar
Redox Potential	COND	9368559	2024/05/02	2024/05/03	Gurparteek KAUR
Resistivity of Soil		9358051	2024/04/30	2024/04/30	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9364092	2024/04/30	2024/05/01	Alina Dobreanu

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	3.3°C

Results relate only to the items tested.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9361710	Available (CaCl2) pH	2024/04/29			100	97 - 103			0.44	N/A
9361722	Available (CaCl2) pH	2024/04/29			100	97 - 103			0.11	N/A
9364027	Conductivity	2024/04/30			102	90 - 110	<2	umho/cm	0.55	10
9364082	Soluble (20:1) Chloride (Cl-)	2024/05/01	NC	70 - 130	86	70 - 130	<20	ug/g	6.5	35
9364092	Soluble (20:1) Sulphate (SO4)	2024/05/01	91	70 - 130	90	70 - 130	<20	ug/g	0.52	35
9365692	Sulphide	2024/04/30	86	75 - 125	101	75 - 125	<0.5	mg/kg	24	30
9368179	Moisture-Subcontracted	2024/05/01					<0.30	%	3.2	20
9368559	Redox Potential	2024/05/03			103	95 - 105			0.50	35

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Cristina Carriere, Senior Scientific Specialist

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics

Suwan (Sze Yeung) Fock, B.Sc., Scientific Specialist

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

NONT-2024-04-2573

ello Road, Mississauga, Ontario L5N 2L8
7-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
.91/6

WORK ORDER

CHAIN OF CUSTODY RECORD

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)	
Company Name:	WSP Canada Inc	Company Name:	WSP Canada Inc	Quotation #:	
Contact Name:	Canada Accounts Payable	Contact Name:	Madison Kennedy	P.O. #/ AFE#:	CA0020332.0247, task 900.910
Address:	6925 Century Ave. Suite ~~100~~ 600	Address:	6925 Century Ave. Suite ~~100~~ 600	Project #:	
	Mississauga, ON		Mississauga, ON L5N 7K2	Site Location:	Alliston, Ontario
Phone:	905-567-4444 Fax: 905-567-6561	Phone:	~~289-838-4608~~ 778-228-5756 Fax: 905-567-6561	Site #:	
Email:	CAPayablesInvoice@wsp.com	Email:	muhammad.irshad@wsp.com; madison.kennedy@wsp.com	Site Location Province:	Ontario

Turnaround Time (TAT) Required

- [X] Regular TAT (5-7 days) Most analyses

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Rush TAT (Surcharges will be applied)

- [ ] 1 Day
- [ ] 2 Days
- [ ] 3-4 Days

Date Required:

Rush Confirmation #:

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS DRINKING WATER CHAIN OF CUSTODY

Sampled By: MTI + KR

Regulation 153

- [X] Table 1
- [ ] Table 2
- [ ] Table 3
- [ ] Table ____
- [ ] Res/Park
- [ ] Ind/Comm
- [ ] Agri/ Other
- [ ] Med/ Fine
- [ ] Coarse

FOR RSC (PLEASE CIRCLE) Y / N

Other Regulations

- [ ] CCME
- [ ] MISA
- [ ] PWQO
- [ ] Other (Specify)
- [ ] REG 558 (MIN. 3 DAY TAT REQUIRED)
- [ ] REG 406 Table ____
- [ ] Sanitary Sewer Bylaw
- [ ] Storm Sewer Bylaw

Region ____

Include Criteria on Certificate of Analysis: Y / N

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

LABORATORY USE ONLY

CUSTODY SEAL Y / N Present	Intact	COOLER TEMPERATURES
N	N	3/5/2

COOLING MEDIA PRESENT: Y / N (Y circled)

Analysis Requested

#	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	Corrosivity Package (+ Sulphide)	HOLD- DO NOT ANALYZE	COMMENTS
1	BH24-01 SA-5	2024-04-09	PM	SOIL	2								X		2 Jars (250 mL and 120 mL)
2	BH24-01 SA-9	2024-04-10	AM	SOIL	2								X		2 Jars (250 mL and 120 mL)
3	BH24-01 SA-12	2024-04-10	AM	SOIL	2								X		2 Jars (250 mL and 120 mL)
4	BH24-02 SA-2+3	2024-04-08	AM	SOIL	2								X		2 Jars (250 mL and 120 mL)
5	BH24-02 SA-05	2024-04-08	AM	SOIL	2								X		2 Jars (250 mL and 120 mL)
6	BH24-02 SA-10	2024-04-08	PM	SOIL	2								X		2 Jars (250 mL and 120 mL)
7	BH24-02 SA-12	2024-04-09	AM	SOIL	2								X		2 Jars (250 mL and 120 mL)
8	BH24-03 SA-9	2024-04-15	PM	SOIL	2								X		2 Jars (250 mL and 120 mL)
9	BH24-04 SA-8	2024-04-16	PM	SOIL	2								X		2 Jars (250 mL and 120 mL)
10															

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	BV JOB #
M. Talha Irshad (signature)	2024-04-25	~~[illegible]~~ 7:50 PM	(signature)	2024/04/25	19:52	

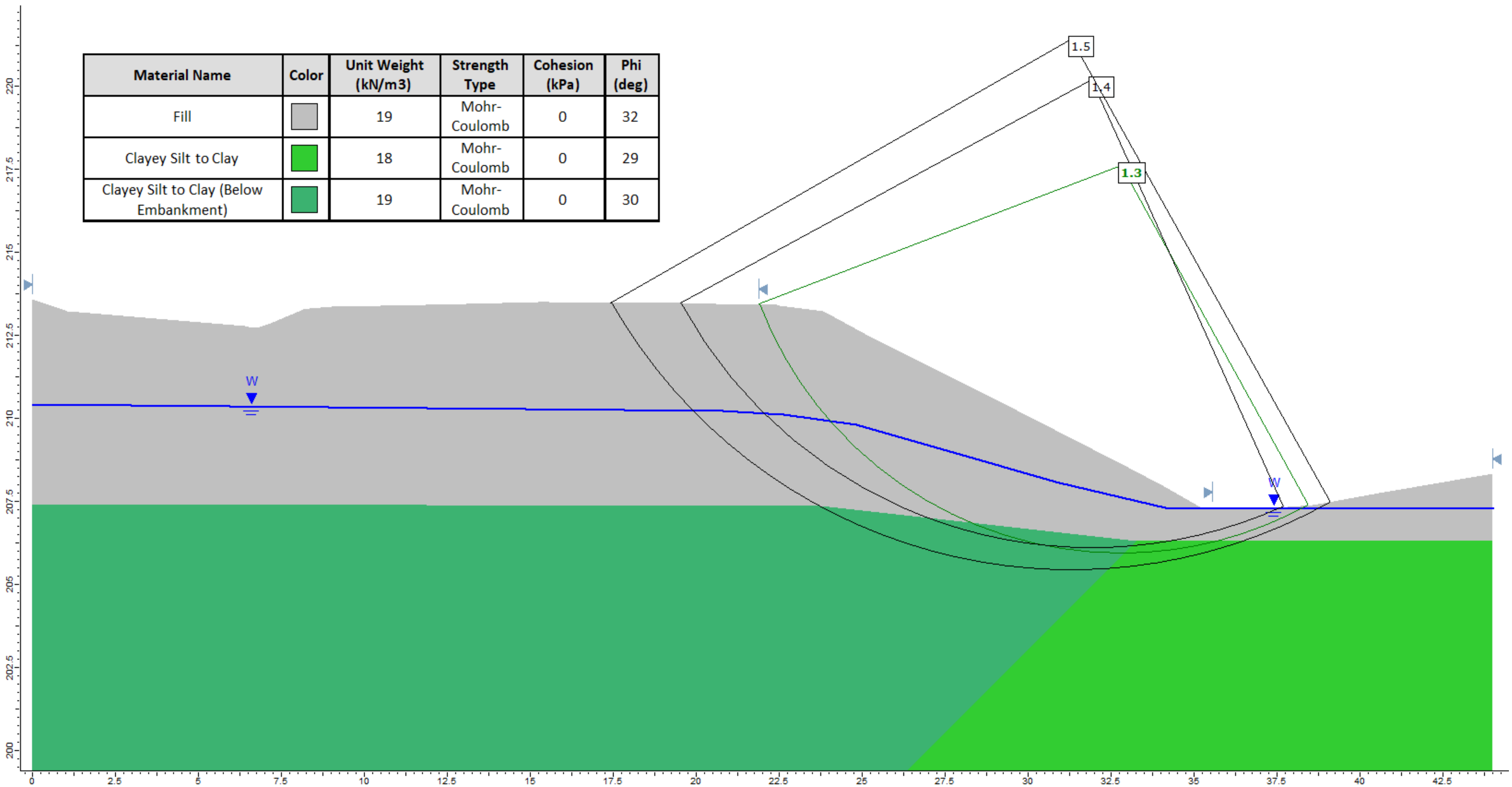
APPENDIX D

Stability Analysis Results

Stability Analysis Results (Drained Condition)

Existing South Embankment Slope

Figure D1



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Clayey Silt to Clay		18	Mohr-Coulomb	0	29
Clayey Silt to Clay (Below Embankment)		19	Mohr-Coulomb	0	30

Date: March 2025

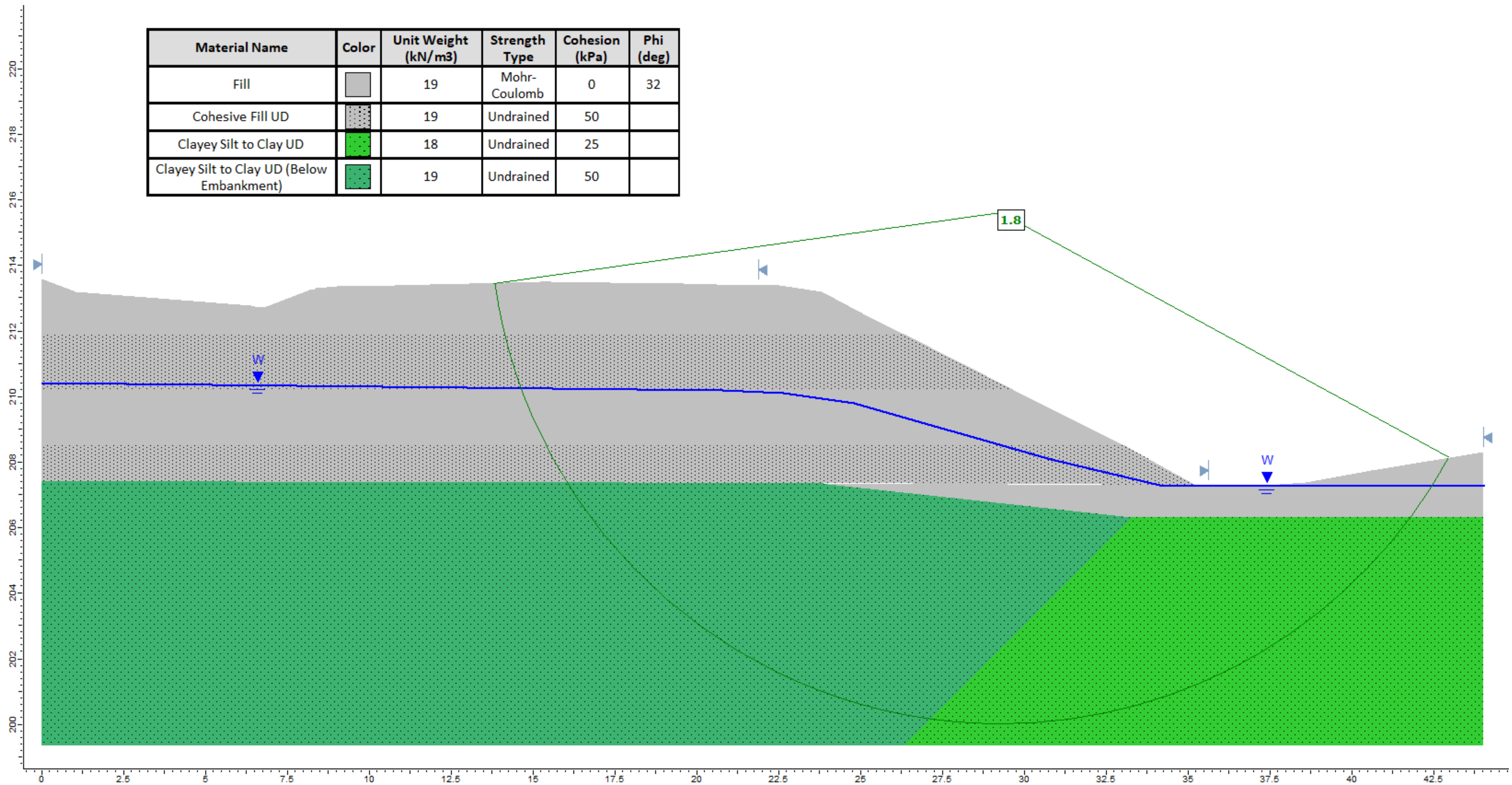
Project No: CA0020332.0247

Analysis By: MCK/MTI **Reviewed By:** KJB

Stability Analysis Results (Undrained Condition)
Existing South Embankment Slope

Figure D2

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Cohesive Fill UD		19	Undrained	50	
Clayey Silt to Clay UD		18	Undrained	25	
Clayey Silt to Clay UD (Below Embankment)		19	Undrained	50	



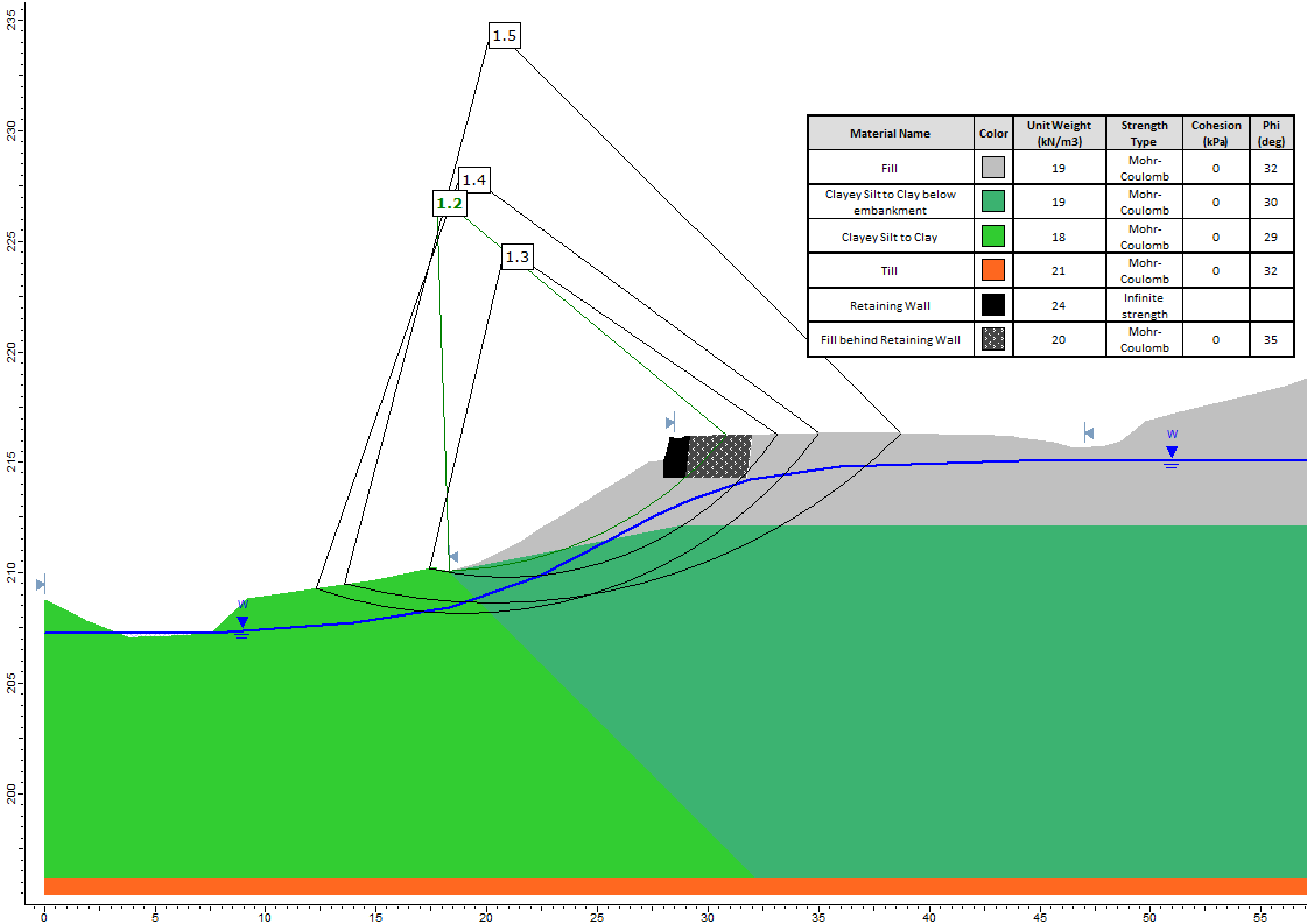
Date: March 2025
Project No: CA0020332.0247

Analysis By: MCK/MTI **Reviewed By:** KJB

Stability Analysis Results (Drained Condition)

Existing North Embankment Slope

Figure D3



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Clayey Silt to Clay below embankment		19	Mohr-Coulomb	0	30
Clayey Silt to Clay		18	Mohr-Coulomb	0	29
Till		21	Mohr-Coulomb	0	32
Retaining Wall		24	Infinite strength		
Fill behind Retaining Wall		20	Mohr-Coulomb	0	35

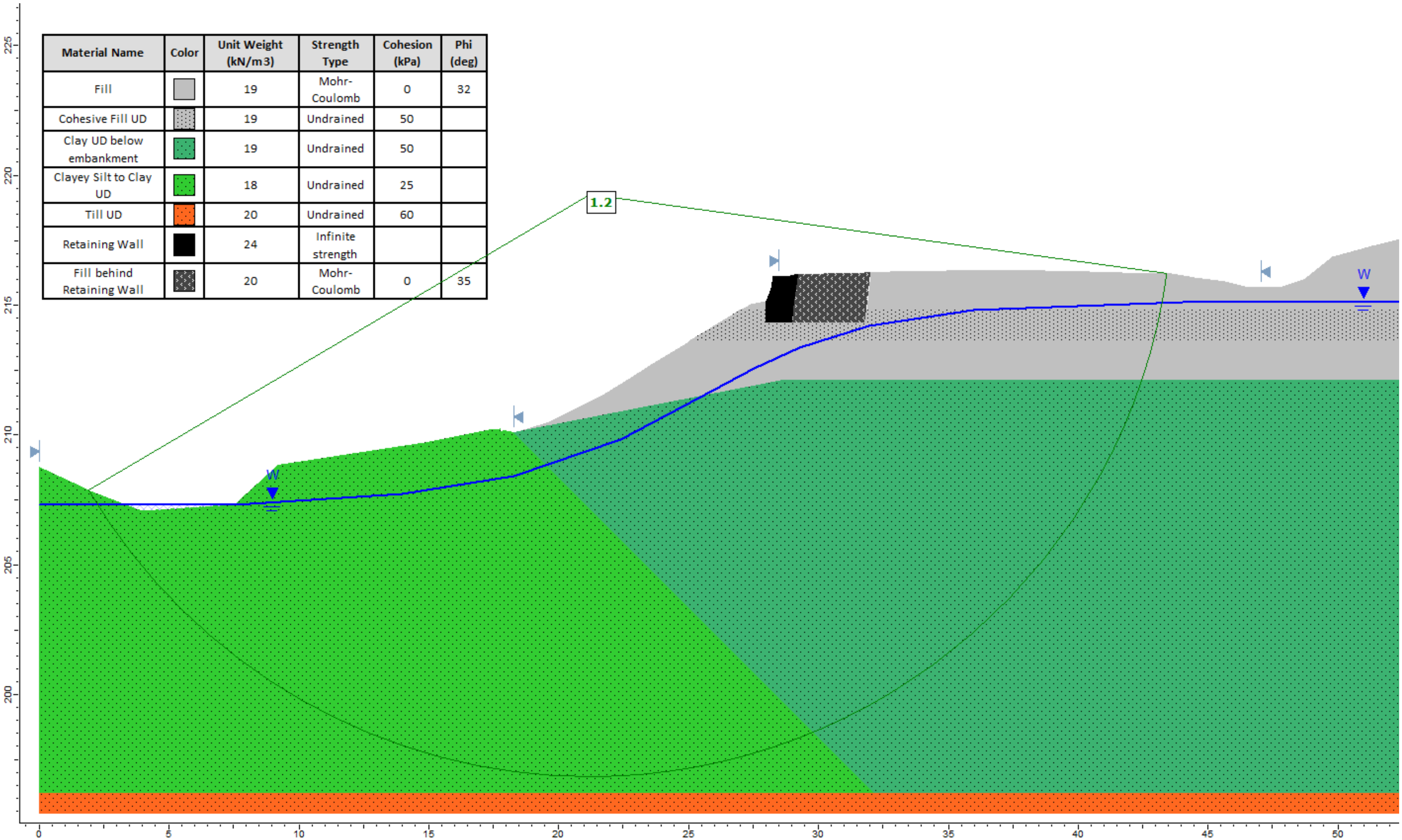
Date: March 2025

Project No: CA0020332.0247

Analysis By: MCK/MTI **Reviewed By:** KJB

Stability Analysis Results (Undrained Condition)
Existing North Embankment Slope

Figure D4



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Cohesive Fill UD		19	Undrained	50	
Clay UD below embankment		19	Undrained	50	
Clayey Silt to Clay UD		18	Undrained	25	
Till UD		20	Undrained	60	
Retaining Wall		24	Infinite strength		
Fill behind Retaining Wall		20	Mohr-Coulomb	0	35

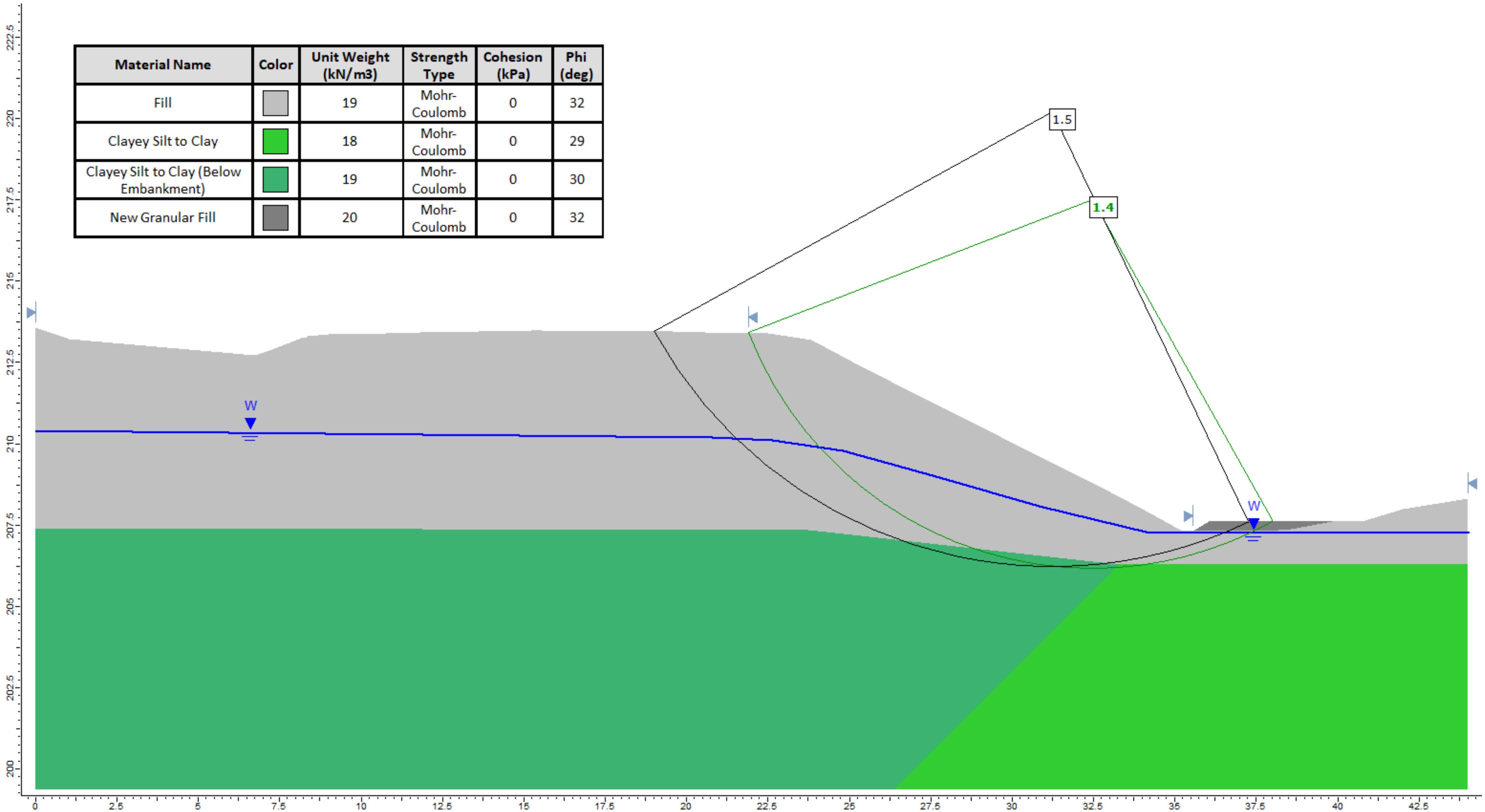
Date: March 2025
Project No: CA0020332.0247

Analysis By: MCK/MTI **Reviewed By:** KJB

Stability Analysis Results (Drained Condition)

Existing South Embankment Slope with Access Road

Figure D5



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Clayey Silt to Clay		18	Mohr-Coulomb	0	29
Clayey Silt to Clay (Below Embankment)		19	Mohr-Coulomb	0	30
New Granular Fill		20	Mohr-Coulomb	0	32

Date: March 2025

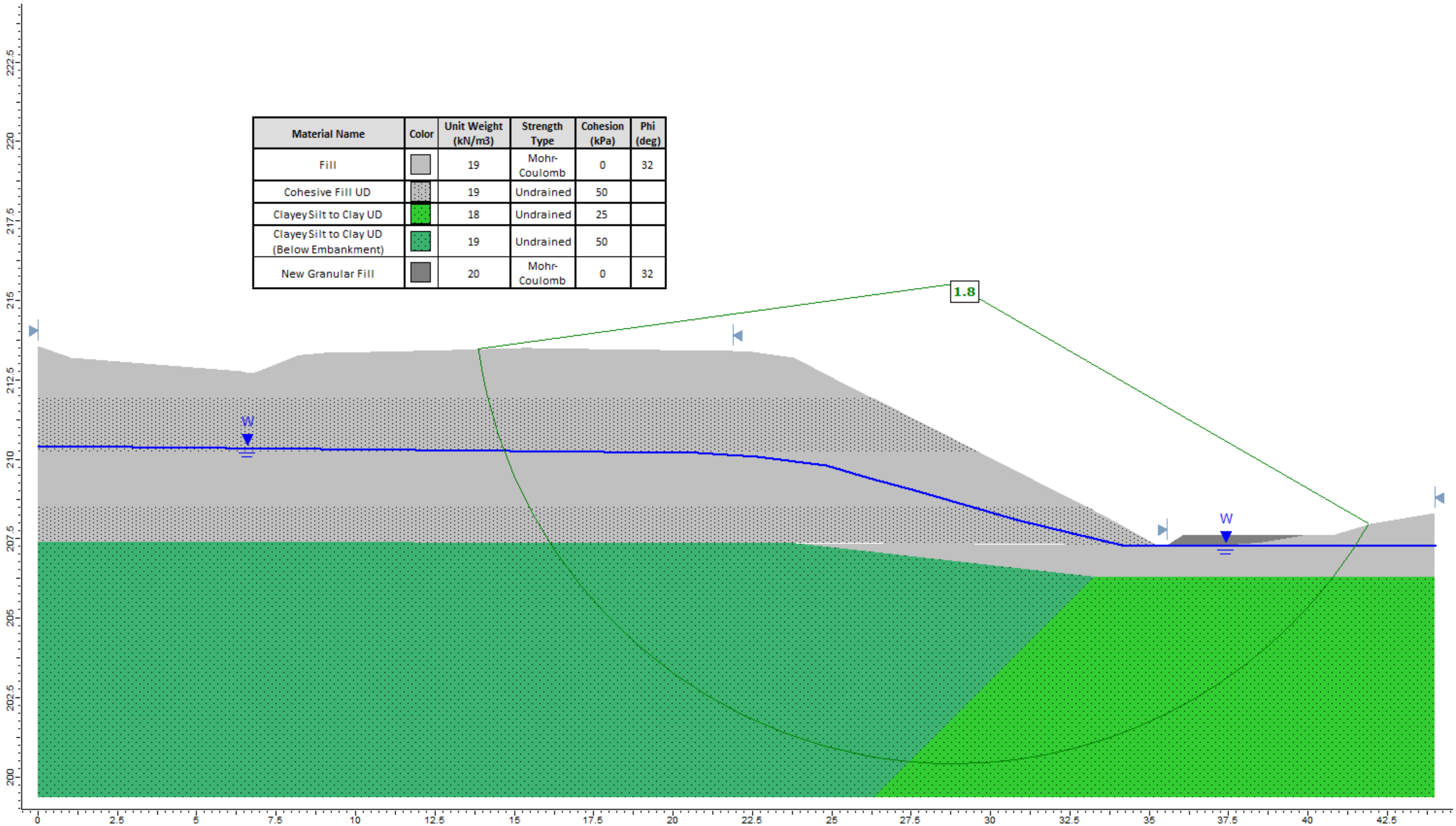
Project No: CA0020332.0247

Analysis By: MCK/MTI **Reviewed By:** KJB

Stability Analysis Results (Undrained Condition)

Existing South Embankment Slope with Access Road

Figure D6



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Cohesive Fill UD		19	Undrained	50	
ClayeySilt to Clay UD		18	Undrained	25	
ClayeySilt to Clay UD (Below Embankment)		19	Undrained	50	
New Granular Fill		20	Mohr-Coulomb	0	32

Date: March 2025

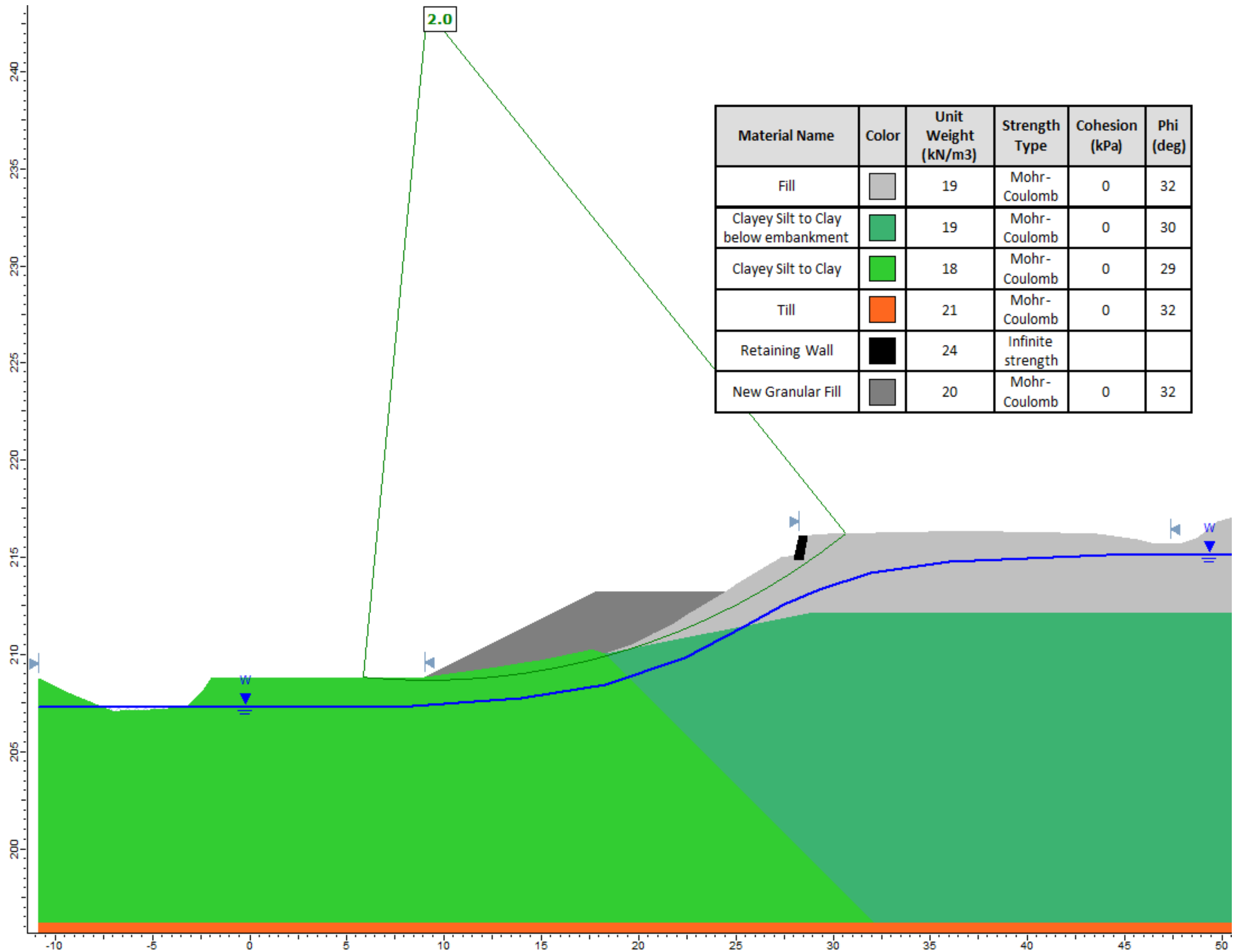
Project No: CA0020332.0247

Analysis By: MCK/MTI **Reviewed By:** KJB

Stability Analysis Results (Drained Condition)

Existing North Embankment Slope with Access Road

Figure D7



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Clayey Silt to Clay below embankment		19	Mohr-Coulomb	0	30
Clayey Silt to Clay		18	Mohr-Coulomb	0	29
Till		21	Mohr-Coulomb	0	32
Retaining Wall		24	Infinite strength		
New Granular Fill		20	Mohr-Coulomb	0	32

Date: March 2025

Project No: CA0020332.0247

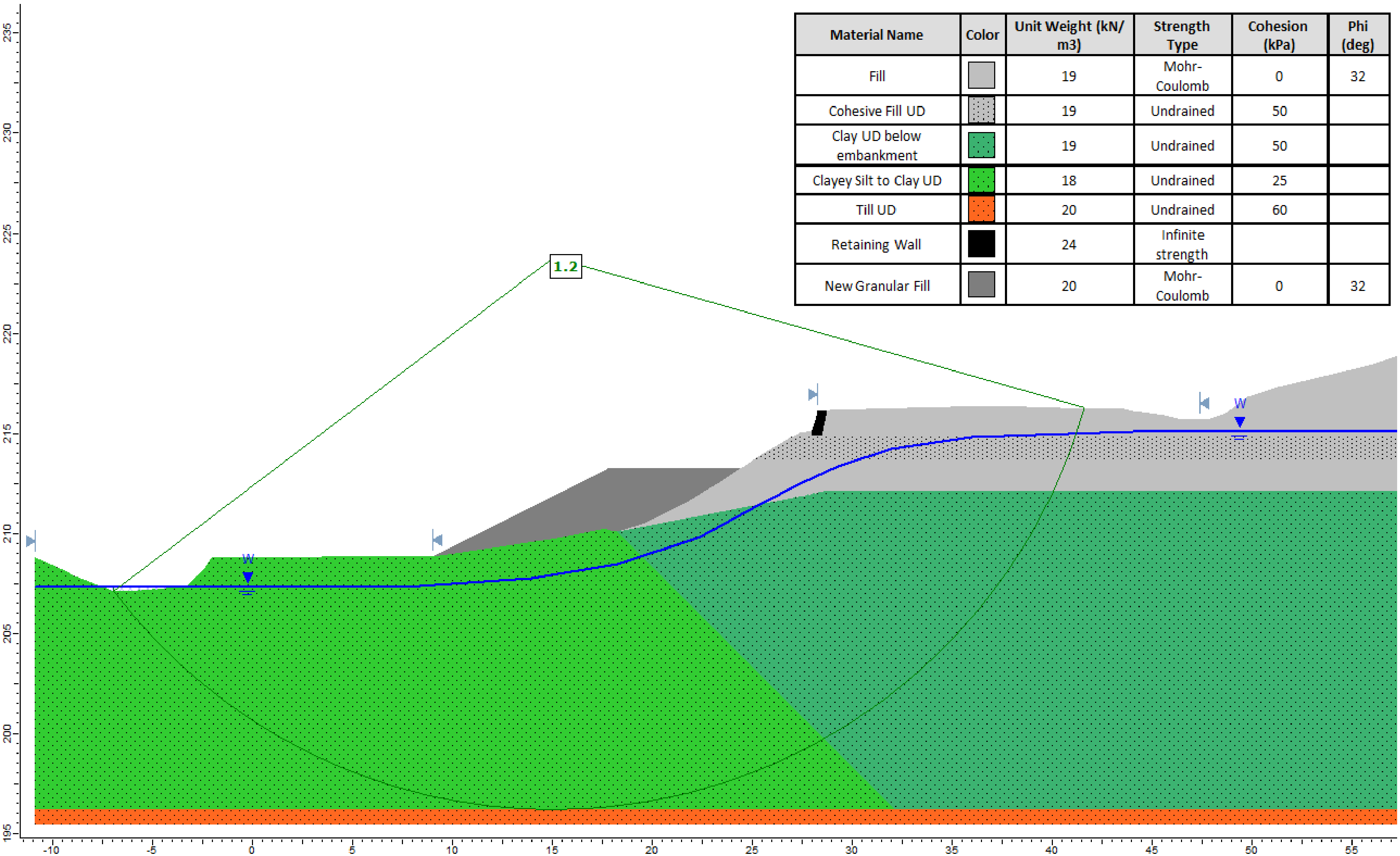
Analysis By: MCK/MTI **Reviewed By:** KJB

Stability Analysis Results (Undrained Condition)

Existing North Embankment Slope with Access Road

Figure D8

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill		19	Mohr-Coulomb	0	32
Cohesive Fill UD		19	Undrained	50	
Clay UD below embankment		19	Undrained	50	
Clayey Silt to Clay UD		18	Undrained	25	
Till UD		20	Undrained	60	
Retaining Wall		24	Infinite strength		
New Granular Fill		20	Mohr-Coulomb	0	32



Date: March 2025

Project No: CA0020332.0247

Analysis By: MCK/MTI **Reviewed By:** KJB

APPENDIX E

Non-Standard Special Provisions

MONITORING OF THE RETAINING WALL NORTHEAST OF NICOLSTON STRUCTURAL CULVERT - Item No.

Non-Standard Special Provision

Preconstruction Survey

A pre- and post-construction condition survey of the entire length of the existing NE retaining wall along the top of the north side of the embankment above/west of the Nicolston Structural Culvert (Site No. 30X-0678/C0) shall be carried out by the Contractor and provided to the Contract Administrator.

Pre-construction condition surveys shall be carried out a minimum of one (1) week prior to commencement of construction activities in the vicinity of the retaining wall (including traffic staging). The survey shall include, as a minimum, the identification and description of existing differential settlements, including movement or distortion (shifting/rotation/tilting), visible cracking or separation. Defects shall be described, including dimensions, wherever possible, and be accompanied by digital photographs or digital video, as appropriate to record areas of significant concern.

Visual Monitoring

Visual monitoring of the wall shall be carried out by the Contractor on a weekly basis during construction activities adjacent to the retaining wall.

Construction activities adjacent to the wall include but are not limited to shoulder strengthening and associated operation of heavy equipment adjacent to the wall, during temporary shifting / staging of the Highway 89 WB traffic closer to the guide rail and wall, construction of any temporary access road below the wall, and any other construction activity in close proximity that could influence the performance of the retaining wall.

Visual monitoring shall identify and document locations where there is evidence of movement or distortion (shifting/rotation/tilting), cracking or separation of the retaining wall blocks, and/or movement or cracking of the adjacent guide rail / Highway 89 shoulder or pavement parallel to the retaining wall. The associated construction activity at the time of monitoring is to also be documented.

Any signs of significant movement or distortion should be reported to the Contract Administrator immediately upon observation, and a copy of the monitoring report provided to the Contact Administrator each week.

Installation and Survey of Surface Monitoring (SM) Points

Installation and Survey

Surface Monitoring (SM) points shall be installed by the Contractor at the top of wall at a maximum spacing of 6 m for the entire length of wall (assume 15 SM points for 92 m long wall). The SM points shall consist of fixed survey targets or PK nails secured to the top of the wall. The Contractor shall retain a Registered Ontario Land Surveyor to survey the SM points in horizontal and vertical directions (i.e. northing, easting, and geodetic elevation to a repeatable accuracy of +/- 2 mm).

The SM points are to be installed and surveyed prior to and during construction activities as outlined in the next section.

Frequency of Survey Readings

Baseline readings (3 readings on 3 consecutive days) shall be surveyed at all SM points at least one week prior to construction activities adjacent to the wall. Survey readings are to be taken three (3) times per week during construction activities adjacent to the wall. The frequency of readings can be reduced to weekly for construction activities conducted near toe of the north embankment (i.e. culvert lining, flow diversion or cofferdam installation, etc.) with the permission of the Contract Administrator.

A copy of the survey readings (in tabular and graphical format) and movements relative to the baseline data shall be provided to the CA within 24 hours of completing the survey.

Reporting Requirements and Action Plans

Based on the monitoring of the retaining wall, the following represents trigger levels that define magnitude of movement and corresponding action:

Review level: If 5 mm of relative movement (horizontal or vertical) to the baseline reading is reached, the Contractor shall review or modify the construction activities adjacent to the retaining wall to mitigate further displacement. If Review Level is exceeded, the Contractor shall immediately notify the Contract Administrator and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert Levels from being reached. All construction work shall be continued such that the Alert Level is not reached.

Alert level: If a maximum 10 mm of relative movement (horizontal or vertical) relative to the baseline readings is reached, the Contractor shall cease construction operations, inform the Contract Administrator and execute pre-planned measurements to secure the site and to mitigate further movements and to assure safety of public and maintain traffic. No construction shall take place until all of the following conditions are satisfied:

i. The cause of movement has been identified
ii. The Contractor submits a corrective/preventative plan complete with Request to Proceed
iii. Any approved corrected and/or preventative measure deemed necessary by the Contractor is implemented
iv. Operations shall not proceed until the Contract Administrator has issued a Notice to Proceed for each corrective/preventative plan.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation of all labour, equipment and materials to do the work described in this non-standard specification.

<u>OPERATIONAL CONSTRAINT</u> – Stockpiling and/or Cranes on Highway 89

Non-Standard Special Provision

The Contractor is advised that surcharge loads from stockpiling of soil and/or heavy equipment (e.g. crawler cranes or heavy lift mobile cranes) that are in excess of allowable traffic and conventional construction equipment loading (i.e. excess loads) shall not be permitted on top of the highway embankment (i.e. Highway 89 road surface, shoulders or platform widened surfaces) between Station 16+400 and 16+550. In particular, excess surcharge loads shall be avoided near and above the existing retaining wall on the north side of the Highway 89 embankment at the Nicolston Culvert location (i.e. northeast retaining wall).

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