FINAL REPORT

Foundation Investigation Report

Replacement of Structural Culvert 21X-0472/C0
Highway 401, Station 18+935 Cramahe Township, Northumberland County
MTO GWP 4054-17-00, Agreement No. 4016-E-0034

Submitted to:

Ministry of Transportation Ontario
1355 John Counter Boulevard, Kingston, Ontario K7L 5A3

Submitted by:

WSP Canada Inc.
1931 Robertson Road Ottawa, Ontario K2H 5B7

1773612-472

April 17 2024

GEOCRES No.: 31C04-005
Latitude: 44.055486°
Longitude: -77.818361°

Distribution List

1 e-Copy - MTO Eastern Region

1 e-Copy - MTO Foundations Section

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1.0 INTRODUCTION

WSP Canada Inc. (WSP, formerly Golder Associates Ltd., acquired by WSP in 2023) is working as part of the WSP Total Project Management team on behalf of the Ministry of Transportation, Ontario (MTO) to support the rehabilitation and widening of Highway 401 from 0.8 km east of Percy Street to 0.4 km west of Christiani Road in Northumberland County, Ontario. The foundation's scope of work includes preliminary design services for the replacement of three underpass structures and detailed design services for the replacement of four structural culverts.

This report presents the results of the foundation investigation carried out to support the detailed design of the replacement of Culvert 21X-0472/C0. The foundation investigation services for this project have been delivered under MTO Agreement No. 4016-E-0034 Assignment #11 as part of GWP 4054-17-00.

2.0 SITE DESCRIPTION

The existing Culvert 21X-0472/C0 is located on Highway 401 approximately 4.5 km west of County Road 30, at about Station 18+935 in Cramahe Township in Northumberland County. The site location is shown on the key plan in Drawing 1. For the purpose of this report, Highway 401 is oriented in a west-east direction with the culvert positioned on a skew to the highway in a northwest-southeast orientation; for simplicity, the culvert is described as being oriented in a north-south direction.

The existing culvert, which was constructed in 1958, consists of an 87.0 m long, 4.3 m span, 2.4 m high (interior dimensions) reinforced concrete box structure that carries creek flow from south to north below all lanes of Highway 401, on an approximately 25° skew to the highway. According to the original contract drawings (Contract No. 58-278, Plan & Profile STA 270+00 to STA 300+00, WP No. 127-57), the existing culvert inlet and outlet were to be constructed at Elevations 169.4 m and 169.0 m respectively. It is understood that the culvert is in good to fair condition but is close to its 75-year design service life.

Based on the Highway 401 Plan and Profile Drawing, Station 270+00 to Station 300+00, WP No. 127-57 dated July and September 1958, the original watercourse meandered at this site with the channel generally located west of the existing culvert (at approximately Station 293+90), and the watercourse was then realigned through the current culvert following its construction (see Figure 1 on the following page and a copy of this drawing in Appendix D following the text of this report). The original watercourse channel was at approximately Elevation 170.2 m (558.5 ft.) at the centreline of Highway 401.

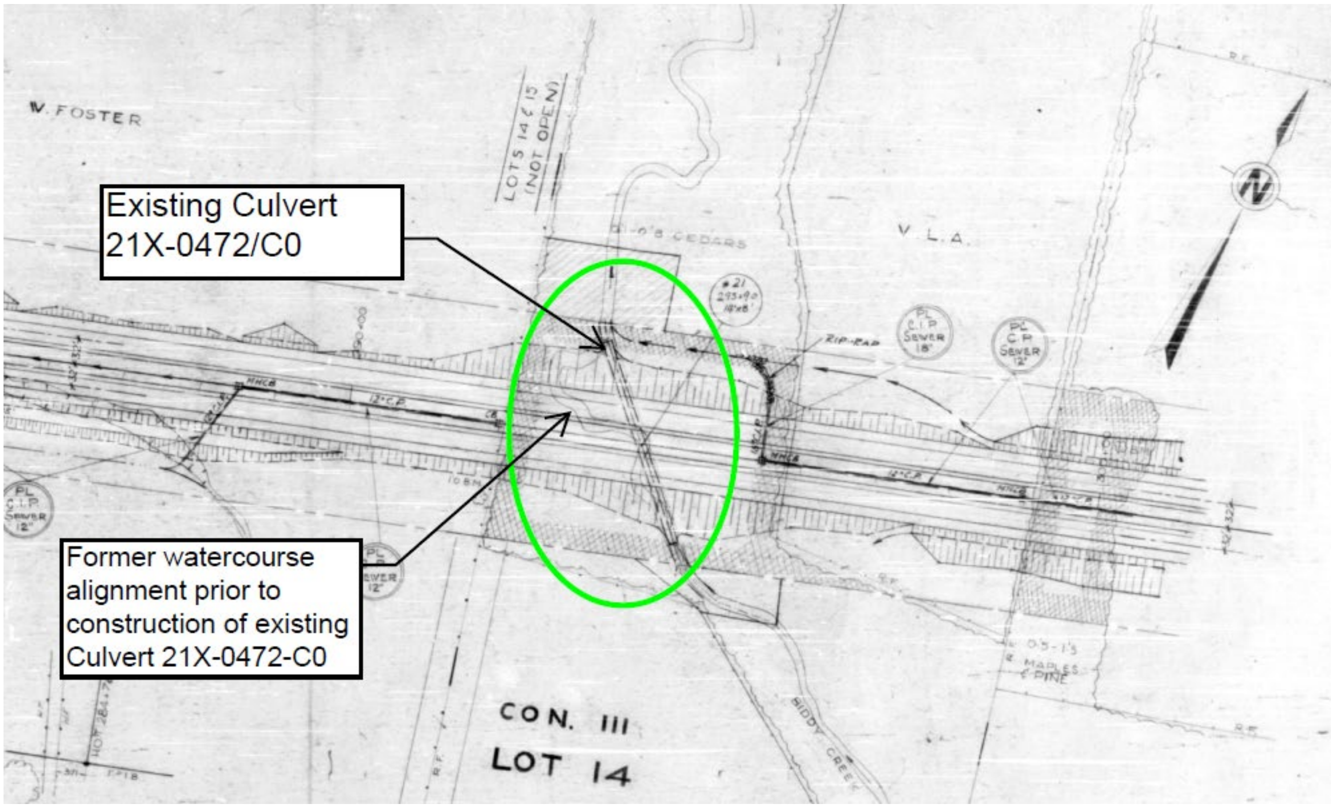

Figure 1: Original watercourse alignment relative to existing Culvert 21X-0472/C0 (from Highway 401 Plan and Profile Drawing, Station 270+00 to Station 300+00, WP No. 127-57 dated July and September 1958 – see Appendix D).

At the culvert location, Highway 401 has an existing four-lane cross-section with paved shoulders separated by a paved median and a tall concrete barrier wall. Steel beam guide rails are located on both outside shoulders of the highway in the vicinity of the culvert. The Highway 401 grade at the site ranges from approximately Elevation 179.7 m (WBL) to 180.0 m (EBL). The EBL and WBL embankments are up to about 9 m high relative to the surrounding ground surface in the watercourse valley which is at approximately Elevation 170.5 m to 171.5 m, with the existing embankment side slope inclined at about 3 horizontals to 1 vertical (3H:1V).

The area immediately surrounding the stream is vegetated with trees, shrubs, and brush both upstream and downstream of the culvert, and the surrounding lands are farmed.

Based on our site observations at the time of the field investigation and a review of the available site photographs/satellite images, the existing embankments in the culvert area appear to be performing satisfactorily. There was no visual evidence of instability (i.e., soil movement) on the embankment side slopes, nor tension cracks near the embankment crest that would be indicative of instability or significant settlement.

Site photographs showing the general conditions at the site, along the highway, and at the inlet and outlet, are presented in Appendix D.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out over a four-day period between June 28 and October 17, 2022, and included advancing four boreholes (472-22-01 to 472-22-04) in the general location of the proposed culvert alignment. The borehole locations are shown on Drawing 1.

Boreholes 472-22-01 and 472-22-04, which are located near the north and south culvert ends, respectively, were advanced using a track-mounted Multipower limited access (LAD) drill rig with 165 mm outer diameter hollow stem augers. Boreholes 472-22-02 and 472-22-03, which are located on the Highway 401 platform, were advanced using a truck-mounted CME 55 drill rig with 200 mm diameter hollow stem augers. Both drilling rigs were supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. (CCC) of Ottawa, Ontario.

Soil samples were obtained using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Soil samples were obtained at vertical sampling intervals of about 0.76 m and 1.5 m.

A monitoring well was installed at Borehole 472-22-01 to observe the groundwater level at the site. The monitoring well consists of a 52 mm outside diameter PVC tube with a 1.5 m long slotted screen. Well installation details are shown on the record for Borehole 472-22-01 provided in Appendix A. The boreholes without monitoring well were backfilled with bentonite mixed with soil cuttings, in general accordance with the intent of Ontario Regulation (O.Reg.) 903, as amended. The site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of WSP's technical staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers, and transported to WSP's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses, and Atterberg limits testing were carried out on selected soil samples, in accordance with MTO and/or ASTM Standards, as applicable.

One soil sample was sent to Eurofins Environmental Testing Canada Inc. (Eurofins) for basic chemical analysis related to the potential corrosion of buried steel elements and sulfate attack on buried concrete elements (corrosion and sulphate attack).

The borehole locations and elevations were surveyed by WSP using a Trimble R10 GPS unit referenced to the NAD83 CSRS CBNv6-2010.0 MTM Zone 9 geodetic datum. The Trimble R10 GPS data have a vertical accuracy of approximately 0.1 m and a horizontal accuracy of approximately 0.5 m in accordance with the requirements of MTO's Guideline for Foundation Engineering Services (Version 3.0). The borehole locations, including northing and easting coordinates, ground surface elevations, and drilled depths are summarized in Table 1.

Table 1: Summary of Borehole Locations

Borehole	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
472-22-01	4880364.9 (44.055670)	199153.0 (-77.818550)	171.0	6.7
472-22-02	4880342.1 (44.055460)	199177.6 (-77.818240)	179.7	14.3
472-22-03	4880322.2 (44.055290)	199198.7 (-77.817980)	180.0	14.0
472-22-04	4880300.2 (44.055090)	199221.3 (-77.817690)	171.5	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The culvert lies at the boundary of the physiographic regions known as the Iroquois Plain and South Slope, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984). The Iroquois Plain physiographic region extends around the western part of Lake Ontario, from Niagara River to Trent River. The width of the plain varies from a few hundred meters to approximately 13 km north of the Lake Ontario shoreline, and it extends inland to include a large area in the Trent River valley. In the area east of Colborne, the surficial glaciolacustrine deposits of the plain consist of sand, gravelly sand, and gravel, as well as nearshore and beach deposits.

The South Slope region lies between the Oak Ridges Moraine, to the north and the Iroquois Plain to the south. It covers approximately 940 square miles, extending from Niagara Escarpment to the Trent River. The eastern portion of the slope in Northumberland County is thickly covered by large drumlins pointing to the southwest. In Northumberland County, a shallow deposit of fine sand and silt can be found on the surface of the till. The South slope generally lies across the limestones of the Verulam and Lindsay Formations, the grey shales of the Georgian Bay Formation, and the reddish shales of the Queenston Formation.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM), the site is underlain by bedrock from the Middle Ordovician era consisting of limestone, dolostone, shale, arkose, and sandstone from the Ottawa Group, Simcoe Group and Shadow Lake Formation.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in-situ and laboratory testing from the investigation are shown on the borehole records presented in Appendix A. The results of the geotechnical laboratory are also presented in Appendix B. The results of the in-situ field tests, as presented in the borehole records and in Section 4, are uncorrected, and are based on the use of an automatic hammer. The results of the analytical testing completed on select soil samples are provided in Appendix C.

The borehole locations and the interpreted stratigraphic profile projected along the proposed culvert alignment are provided in Drawing 1. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic section in Drawing 1 are inferred from observations of the drilling progress and noncontinuous soil sampling and therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

At the borehole locations, the subsurface conditions generally consist of the existing pavement structure (asphalt and pavement granular material) at boreholes advanced on the highway, or topsoil/peat at boreholes advanced at the culvert ends, underlain by a series of interlayered deposits consisting of a generally compact to dense upper deposit of silty sand to sand, underlain by a till deposit that varies in composition from loose to dense silt and sand to silty sand to stiff to hard sandy clayey silt , underlain by a lower deposit of compact to dense silty sand to sand. A more detailed description of the overburden soil deposits encountered during the field investigation is provided in the following sections.

4.2.1 Topsoil

An approximately 100 mm thick layer of topsoil was encountered at the ground surface (i.e., Elevations 171.0 m and 171.5 m) at Boreholes 472-22-01 and 472-22-04, which were advanced near the proposed north and south culvert ends, respectively.

4.2.2 Pavement Structure and Embankment Fill

An approximately 200 mm and 300 mm thick layer of asphalt was encountered at ground surface (i.e., Elevations 179.7 m and 180.0 m) at Boreholes 472-22-02 and 472-22-03, respectively, which were drilled through the outside shoulders of Highway 401. The pavement structure fill was encountered below the asphalt at Elevations 179.5 m and 179.7 m with thickness of 0.7 m and 0.5 m at Boreholes 472-22-02 and 472-22-03, respectively.

Embankment fill consisting of silty sand, gravelly silty sand to sandy silt, and sand was encountered below the topsoil and pavement structure at Boreholes 472-22-02, to 472-22-04. The top of this layer was encountered at elevations ranging from 171.4 m to 179.2 m. The total thickness of the fill layer ranges from about 1.9 m to 6.7 m in the boreholes. The Standard Penetration Test (SPT) N-values measured within the embankment fill range from 4 blows to 110 blows per 0.3 m of penetration, but more typically about 35 to 54 blows indicating a generally dense to very dense state of compactness.

The measured water contents of four samples of the granular fill ranged from 6% to 8%. The results of grain size distribution testing carried out on four samples of the silty sand to sandy silt fill material are provided in Figure B1 in Appendix B.

4.2.3 Peat

A layer of fibrous peat was encountered below the embankment fill at Borehole 472-22-04. The top of this deposit was encountered at Elevation 169.5 m, and it has a thickness of 100 mm.

4.2.4 Upper Silty Sand (SM) to Sand (SP/SW)

An upper silty sand to sand deposit was encountered below the embankment fill at Boreholes 472-22-02 and 472-22-03 and below the peat at Borehole 472-22-04. The top of this layer was encountered at elevations ranging from 169.4 m to 172.8 m. The total thickness of this layer ranges from about 1.0 m to 1.9 m. The SPT N-values within the silty sand to sand layer ranged from 10 blows to 35 blows per 0.3 m of penetration, indicating a compact to dense state of compactness.

The measured water content of one tested sample of the silty sand to sand was 18%. The results of grain size distribution testing carried out on two samples of this material are provided in Figure B2 in Appendix B.

4.2.5 Non-Cohesive Till

A non-cohesive till deposit was encountered below the topsoil at Borehole 472-22-01 and below the silty sand to sand layer at Borehole 472-22-02; the top of this layer was encountered at Elevations 170.9 m and 171.0 m in these boreholes, and the total thickness of this till layer is 1.8 m and 3.3 m. This glacial till is described as silt and sand to silty sand to sandy silt containing trace amounts of clay and gravel, as well as cobbles and boulders. A layer of gravelly sand till containing some silt and cobbles and boulders was also encountered below cohesive till at Borehole 472-22-03. The top of this layer was encountered at Elevation 166.9 m, and the borehole was terminated upon reaching target depth after penetrating this layer for about 0.9 m.

The SPT N-values within this till layer ranged from 4 blows to 30 blows per 0.3 m of penetration, indicating a loose to dense state of compactness. The SPT N-value in the gravelly sand till was 72 blows per 0.3 m of penetration, representing a very dense condition.

The measured water contents of three tested samples of non-cohesive till ranged from 11% to 14%. The results of grain size distribution testing carried out on three samples of the silt and sand to silty sand till material are provided in Figure B3 in Appendix B. The results of Atterberg limits testing completed on a single sample of the silt and sand to silty sand till indicate a liquid limit of 13%, plastic limit of 11% and plasticity index of 2. The Atterberg Limits test results are provided on Figure B4 in Appendix B and indicate that the fines portion of this till is a silt of low plasticity (ML).

4.2.6 Cohesive Till

A deposit of sandy clayey silt till was encountered below the upper silt and sand at Boreholes 472-22-03 and 472-22-04; this cohesive till may represent a gradation from the non-cohesive till as described above. The cohesive till deposit contains varying amounts of gravel and cobbles and boulders. The top of this cohesive till layer was encountered at Elevations 168.4 m and 170.9 m, with a total thickness of about 2.4 m to more than 6.7 m; Borehole 472-22-04 was terminated in this layer at an Elevation of 161.7 m.

The SPT N-values within this till layer ranged from 11 blows to 80 blows per 0.3 m of penetration, but typically about 18 blows to 35 blows indicating a generally very stiff to hard consistency.

The measured water contents of four samples of this sandy clayey silt till ranged from 10% to 20%. The results of grain size distribution testing carried out on six samples of this till material are provided in Figure B5 in Appendix B. The results of Atterberg limits testing completed on five samples of the cohesive till indicate liquid limits ranging from 14% to 17%, plastic limits ranging from 10% to 12% and plasticity indices ranging from 4 to 5. The Atterberg Limits test results are provided on a plasticity chart on Figure B6 in Appendix B and confirm the cohesive portion of the till is a clayey silt-silt of low plasticity (CL-ML).

4.2.7 Lower Silty Sand (SM) to Sand (SP/SW)

A lower deposit of silty sand to sand with varying amounts of gravel was encountered below the non-cohesive till at Boreholes 472-22-01 and 472-22-02. The top of this layer was encountered at Elevations 167.7 m and 169.2 m. Boreholes 472-22-01 and 472-22-02 were both terminated in this layer at Elevations 164.3 and 165.4 m upon reaching the target depth for the boreholes.

The SPT N-values within the silty sand to sand layer ranged from 9 blows to 44 blows per 0.3 m of penetration, but more typically 23 blows to 44 blows indicating a generally compact to dense state of compactness.

The measured water contents of two tested samples of the silty sand to sand were 15% and 17%. The results of grain size distribution testing carried out on one sample of this material is provided in Figure B2 in Appendix B. The results of Atterberg limits testing completed on a single sample of the silty sand to sand indicate that the fines portion of this material is non-plastic.

4.3 Groundwater Conditions

A standpipe piezometer was installed at Borehole 472-22-01 to measure the groundwater level at the site. The groundwater level recorded in the piezometer is shown on the borehole record in Appendix A and is summarized in Table 2. The measured water levels indicate artesian conditions are present at the site.

Table 2: Summary of Groundwater Conditions

Borehole	Screened Interval	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Elevation (m)	Date
472-22-01	Sand	171.0	-0.4[1]	171.4	December 14, 2022
			-0.9[1]	171.9	May 16, 2023

Note:

1. Negative readings indicate height above existing grade i.e., artesian groundwater conditions.

A higher water level (at Elevation 175.3 m) was measured in the open Borehole 472-22-02 (which was drilled through the Highway 401 embankment) upon completion of drilling; this may not represent the stabilized water level at this location, but it does indicate that water-bearing soils and artesian conditions should be expected at the site.

The groundwater level observations 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.

4.4 Analytical Laboratory Testing Results

One soil sample was submitted to Eurofins for chemical testing/analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix C and are summarized in Table 3.

Table 3: Summary of Analytical Test Results for Steel Corrosion and Sulphate Attack Parameters

Borehole	Sample Depth (m)	Chloride (%)	Sulphate (%)	Electrical Conductivity (m^S/cm)	pH	Resistivity (ohm-cm)
472-22-04	0.8-1.4	0.014	0.06	0.55	8.15	1,818

5.0 CLOSURE

This Foundation Investigation Report was prepared by Kinjal Gajjar, a geotechnical consultant and reviewed by Kenton Power, P.Eng., a senior geotechnical engineer. Lisa Coyne, P.Eng., a Geotechnical Engineering Fellow and MTO Principal Foundations Contact for WSP, conducted an independent technical and quality review of this report.

WSP Canada Inc.

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Lisa Coyne, P.Eng.
MTO Principal Foundations Contact

KG/KCP/LCC/yj

https://golderassociates.sharepoint.com/sites/11407g/wo11 colborne to brighten/3. reporting/5-culvert 472/3-final/gwp 4054-17-00 final fidr rev0 21x-0472c0 2024-03-11 (1773612).docx

DRAWING

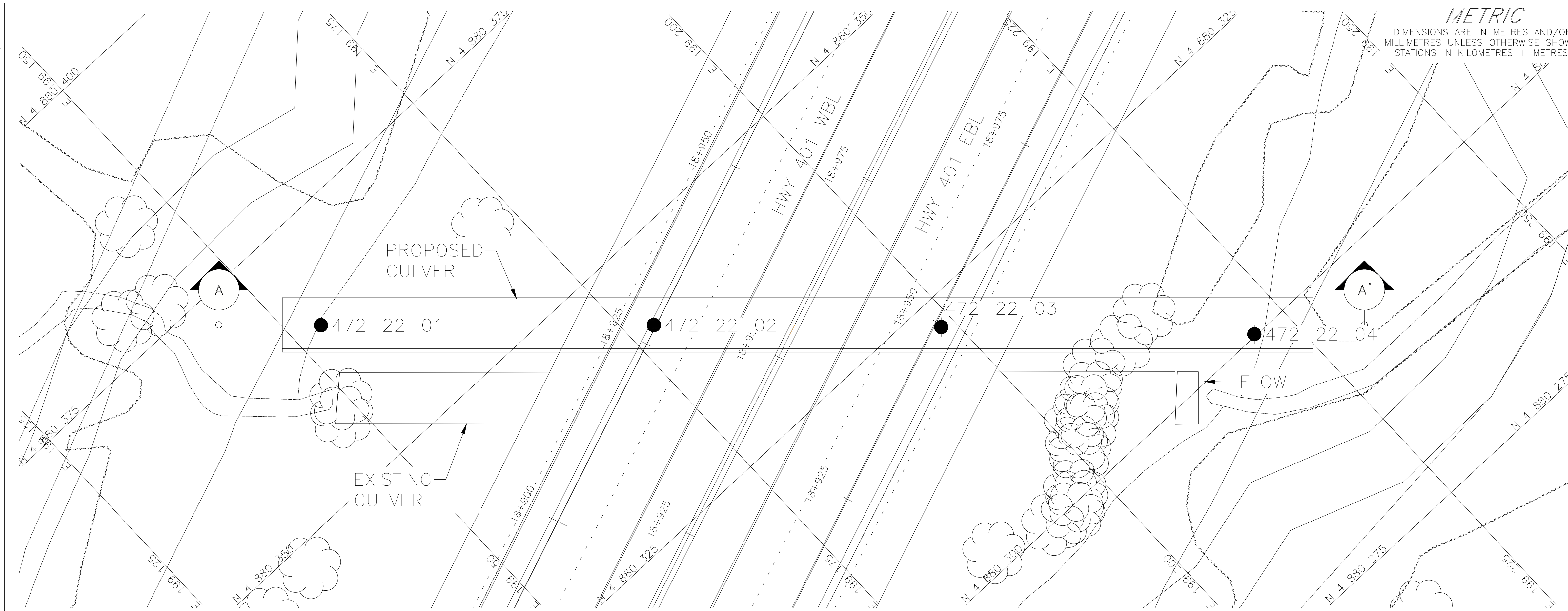
Drawing 1 – Borehole Location and Soil Strata

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

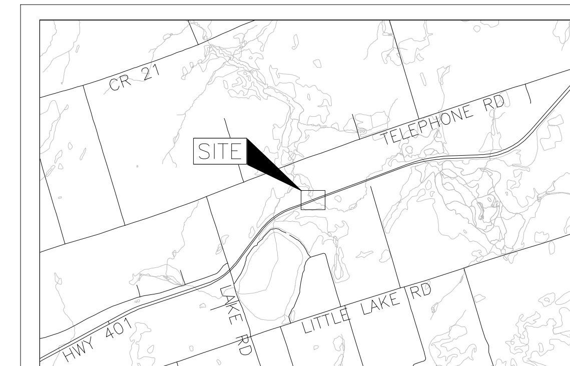
CONT No.
GWP No. 4054-17-00

HIGHWAY 401 WIDENING
REPLACEMENT OF CULVERT 21X-0472/C0
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



PLAN
SCALE
5 0 5 10 m



KEY PLAN
SCALE
1 0 1 2 km

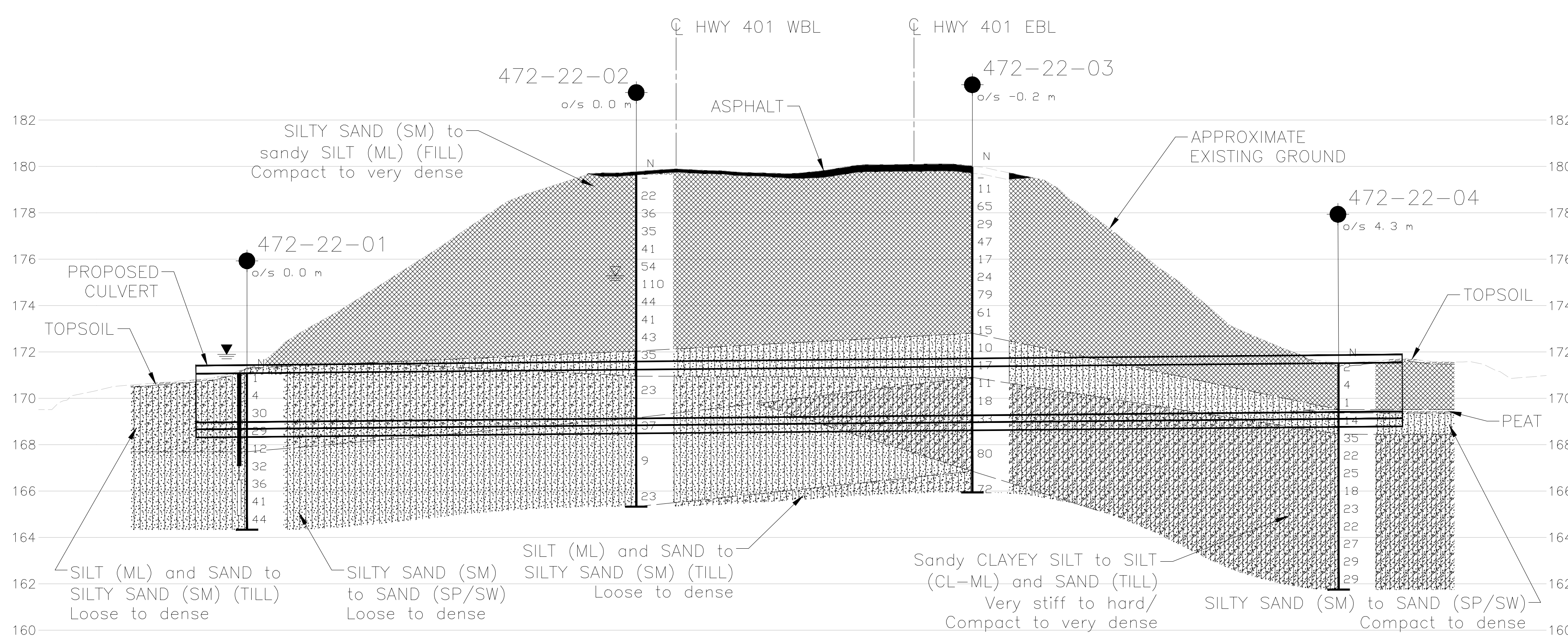
LEGEND

- 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, measured on May 16, 2023
- WL upon completion of drilling

BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 9

No.	ELEVATION	NORTHING	EASTING
472-22-01	171.0	4880364.9	199153.0
472-22-02	179.7	4880342.1	199177.6
472-22-03	180.0	4880322.2	199198.7
472-22-04	171.5	4880300.2	199221.3

Structural Site Location Latitude: 44.05548 Longitude: -77.81836



PROFILE

VERTICAL SCALE
2.5 0 2.5 5 m

HORIZONTAL SCALE
5 0 5 10 m

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. Mainline-8Lane proposed alignment for Culvert Sections_ACAD (updated – April 12 2022).dwg, received APR. 14, 2022.

NO.	DATE	BY	REVISION

Geocres No. 31C04-005

HWY. 401		PROJECT NO. 1773612	DIST. EASTERN
SUBM'D. KG	CHKD. KG	DATE: 04/17/2024	SITE: 21X-0472/C0
DRAWN: ZS	CHKD. KCP	APPD. LCC	DWG. 1

APPENDIX A

Borehole Records

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.

LIST OF SYMBOLS
MINISTRY OF TRANSPORTATION, ONTARIO

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
σ_1, σ_2, σ_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 $= \sigma'_p / \sigma'_{vo}$

(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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING CLASSIFICATION

Fresh (W1): no visible sign of rock material weathering.

Slightly Weathered (W2): discoloration indicates weathering of rock mass material on discontinuity surfaces. **Less than 5%** of rock mass is altered or weathered.

Moderately Weathered (W3): less than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Highly Weathered (W4): more than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Completely Weathered (W5): 100% of the rock mass is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact.

Residual Soil (W6): all rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

AXJ Axial Joint
BD Bedding
BC Broken Core
CC Continuous Core
CL Closed
CO Contact
CU Curved
CT Coated
FLT Fault
FOL Foliation
FR Fracture
GO Gouge
IN Infilled
IR Irregular
JN Joint
KV Karstic Void
K Slickensided
LC Lost Core
MB Mechanical Break
PL Planar
PO Polished
RO Rough
SA Slightly Altered
SH Shear
SM Smooth
SR Slightly Rough
SY Stylolite
UN Undulating
VN Vein
VR Very Rough

ISRM Intact Rock Material Strength Classification

Grade	Description	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak rock	0.25 – 1.0
R1	Very weak rock	1.0 – 5.0
R2	Weak rock	5.0 – 25
R3	Medium strong rock	25 – 50
R4	Strong rock	50 -100
R5	Very strong rock	100 -250
R6	Extremely strong rock	>250

RECORD OF BOREHOLE No 472-22-01

SHEET 1 OF 1 **METRIC**

PROJECT 1773612
G.W.P. 4054-17-00
LOCATION N 4880364.9; E 199153.0 MTM NAD ZONE 9 (LAT. 44.055670; LONG. -77.818550)
ORIGINATED BY JS
DIST Eastern HWY 401
BOREHOLE TYPE LAD Multipower Track Mounted, 165 mm OD Hollow Stem Augers
COMPILED BY ZS/KG
DATUM GEODETIC
DATE June 28, 2022
CHECKED BY KCP/LCC

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.0	GROUND SURFACE					
0.0	TOPSOIL					
0.1	Brown, Moist, SILT (ML) and sand, trace gravel, contains cobbles and boulders (TILL), Loose, Grey-brown, Wet	1	SS	1		
		2	SS	4	o (at 170)	4 42 (54)
169.5 / 1.5	SILTY SAND to sandy SILT (SM/ML), some clay, some gravel, contains cobbles and boulders (TILL), Compact to dense, Grey-brown, Moist	3	SS	30		
		4	SS	29	o	15 31 45 9
		5	SS	12		
167.7 / 3.4	Gravelly SAND (SW), trace silt, Compact to dense, Brown, Wet	6	SS	32		
		7	SS	36	o	22 73 (5)
165.8 / 5.2	SAND (SP), some silt, Dense, Brown, mottled, Wet	8	SS	41		
		9	SS	44		
164.3 / 6.7	END OF BOREHOLE					

NOTES:

1. Artesian flow out of hollow stem augers was observed at 6.7 m depth during drilling. Drilling was halted and well installed. Groundwater level was at 0.4 m above ground surface (Elev. 171.4 m) immediately after well installation

2. Water level measured in standpipe piezometer.

Date	Depth(m)	Elev.(m)
Dec.14/22	-0.4	171.4
May 16/23	-0.9	171.9

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (170, 169, 168, 167, 166, 165); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

Foundation Design

RECORD OF BOREHOLE No 472-22-02 SHEET 1 OF 2 METRIC

PROJECT 1773612
G.W.P. 4054-17-00 LOCATION N 4880342.1; E 199177.6 MTM NAD ZONE 9 (LAT. 44.055460; LONG. -77.818240) ORIGINATED BY BW
DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 200 mm OD Hollow Stem Augers COMPILED BY ZS/KG
DATUM GEODETIC DATE October 18, 2022 CHECKED BY KCP/LCC

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
179.7	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
0.2	Gravelly SILTY SAND to SAND and GRAVEL (SM) (PAVEMENT STRUCTURE) (FILL) Brown Moist	1	AS	-		179					
178.8 / 0.9	SILTY SAND (SM), some gravel, trace clay (FILL) Dense Brown Moist	2	SS	22							
		3	SS	36		178	o	13	48	29	10
177.6 / 2.1	Gravelly SILTY SAND (SM) to sandy SILT (ML), some gravel, trace clay (FILL) Dense to very dense Brown Moist	4	SS	35		177					
		5	SS	41		176					
		6	SS	54	∇		o	13	28	51	8
		7	SS	110		175					
		8	SS	44		174					
		9	SS	41		173					
		10	SS	43							
172.1 / 7.6	SAND (SP-SM), some gravel, trace silt, trace clay Dense Brown Moist	11	SS	35		172		12	75	9	4
171.0 / 8.7	SILT (ML) and sand, trace gravel, some clay, contains cobbles and boulders (TILL) Compact Brown to light brown Moist	12	SS	23		171 / 170	⊢o⊣	5	37	42	16
169.2 / 10.5	SILTY SAND to SAND (SW/SM), trace gravel Loose to dense Brown Wet	13	SS	37		169 / 168					

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

RECORD OF BOREHOLE No 472-22-02 SHEET 2 OF 2 METRIC

PROJECT 1773612
G.W.P. 4054-17-00 LOCATION N 4880342.1; E 199177.6 MTM NAD ZONE 9 (LAT. 44.055460; LONG. -77.818240) ORIGINATED BY BW
DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 200 mm OD Hollow Stem Augers COMPILED BY ZS/KG
DATUM GEODETIC DATE October 18, 2022 CHECKED BY KCP/LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---					
	SILTY SAND to SAND (SW/SM), trace gravel Loose to dense Brown Wet	14	SS	9	167	○
					166	
165.4		15	SS	23		
14.3	END OF BOREHOLE					

NOTES:

1. Water level measured in open borehole at a depth of 4.4 m (Elev. 175.3 m) upon completion of drilling.

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

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

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RECORD OF BOREHOLE No 472-22-03 SHEET 1 OF 2 METRIC

PROJECT	1773612		
G.W.P.	4054-17-00	LOCATION	N 4880322.2; E 199198.7 MTM NAD ZONE 9 (LAT. 44.055290; LONG. -77.817980)
DIST	Eastern	HWY	401
BOREHOLE TYPE	CME 55 Truck Mounted, 200 mm OD Hollow Stem Augers		
DATUM	GEODETIC	DATE	July 24, 2022
ORIGINATED BY	JS	COMPILED BY	ZS/KG
CHECKED BY	KCP/LCC		

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.0	GROUND SURFACE				
0.0	ASPHALT (300 mm)				
179.7 / 0.3	Gravelly SAND (SW) (PAVEMENT STRUCTURE) (FILL) Brown Moist	1	AS	-	
179.2 / 0.8	SILTY SAND (SM), some clay, some gravel (FILL) Compact to very dense Brown Wet to moist	2	SS	11	
		3	SS	65	
		4	SS	29	12 44 (44)
		5	SS	47	
		6	SS	17	
		7	SS	24	
174.8 / 5.2	SILTY SAND (SM), trace gravel, some clay, organics (FILL) Very dense Brown Moist	8	SS	79	
		9	SS	61	10 46 (44)
172.8 / 7.2	SAND (SW), some gravel, trace silt, contains organics and woody debris Dark brown, with black staining Moist	10	SS	15	
172.4 / 7.6	SILTY SAND (SM), some gravel Compact Dark brown to brown Moist to wet	11	SS	10	20 56 (24)
		12	SS	17	
170.9 / 9.1	Sandy CLAYEY SILT to SILT (CL-ML) and sand, trace gravel, contains cobbles and boulders (TILL) Compact to very dense Grey w~PL	13	SS	11	12 31 38 19
		14	SS	18	2 46 (52)
		15	SS	33	0 22 59 19

Elevation scale: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

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

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Foundation Design

RECORD OF BOREHOLE No 472-22-03 SHEET 2 OF 2 METRIC

PROJECT 1773612

G.W.P. 4054-17-00 LOCATION N 4880322.2; E 199198.7 MTM NAD ZONE 9 (LAT. 44.055290; LONG. -77.817980) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 200 mm OD Hollow Stem Augers COMPILED BY ZS/KG

DATUM GEODETIC DATE July 24, 2022 CHECKED BY KCP/LCC

ELEV DEPTH	DESCRIPTION (SOIL PROFILE) — CONTINUED FROM PREVIOUS PAGE —	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (WATER CONTENT %)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy CLAYEY SILT to SILT (CL-ML) and sand, trace gravel, contains cobbles and boulders (TILL) Compact to very dense Grey w~PL		16	SS	80						
166.9 13.1	Gravelly SAND (SW), some silt, contains cobbles and boulders (TILL) Very dense Grey Wet						167				
			17	SS	72		166				
166.0 14.0	END OF BOREHOLE NOTE: 1. Water was added to the hollow stem augers once drilling extended below approximately 12 m depth (Elev. 168.0 m) to assist in washing out cuttings.										

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 472-22-04 SHEET 1 OF 1 METRIC

PROJECT 1773612
G.W.P. 4054-17-00
LOCATION N 4880300.2; E 199221.3 MTM NAD ZONE 9 (LAT. 44.055090; LONG. -77.817690)
ORIGINATED BY JS
DIST Eastern HWY 401
BOREHOLE TYPE LAD Multipower Track Mounted, 165 mm OD Hollow Stem Augers
COMPILED BY ZS/KG
DATUM GEODETIC
DATE July 6, 2022
CHECKED BY KCP/LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	Water Content / Limits	GR	SA	SI	CL
171.5	GROUND SURFACE								
0.0 / 0.1	TOPSOIL Dark brown Moist	1	SS	2					
	SILTY SAND (SM), some gravel, trace to some clay (FILL) Very loose Light brown Moist to wet	2	SS	4					
170.6 / 0.9	SAND (SP), some silt, some gravel, trace clay, contains organics (FILL) Loose Dark brown Moist to wet	3	SS	1					
169.5	Fibrous PEAT (PT), contains woody debris								
2.1	SAND (SW), some gravel, trace to some silt, contains organics Compact Dark drown wet	4	SS	14					
168.5 / 3.1	Sandy CLAYEY SILT to SILT (CL-ML) and sand, trace gravel, contains cobbles and boulders (TILL) Very stiff to hard/ dense to compact Grey Moist to wet	5	SS	35					
		6	SS	22	plotted	9	27	(64)	
		7	SS	25					
		8	SS	18	plotted	4	38	(58)	
		9	SS	23					
		10	SS	22	plotted	1	39	(60)	
		11	SS	27					
		12	SS	29					
		13	SS	29					
161.8 / 9.8	END OF BOREHOLE								

Elevation scale: 171, 170, 169, 168, 167, 166, 165, 164, 163, 162

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE:

1. Borehole was advanced using a head of water within the hollow stem augers below 6.1 m depth to control ground/sample disturbance.

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

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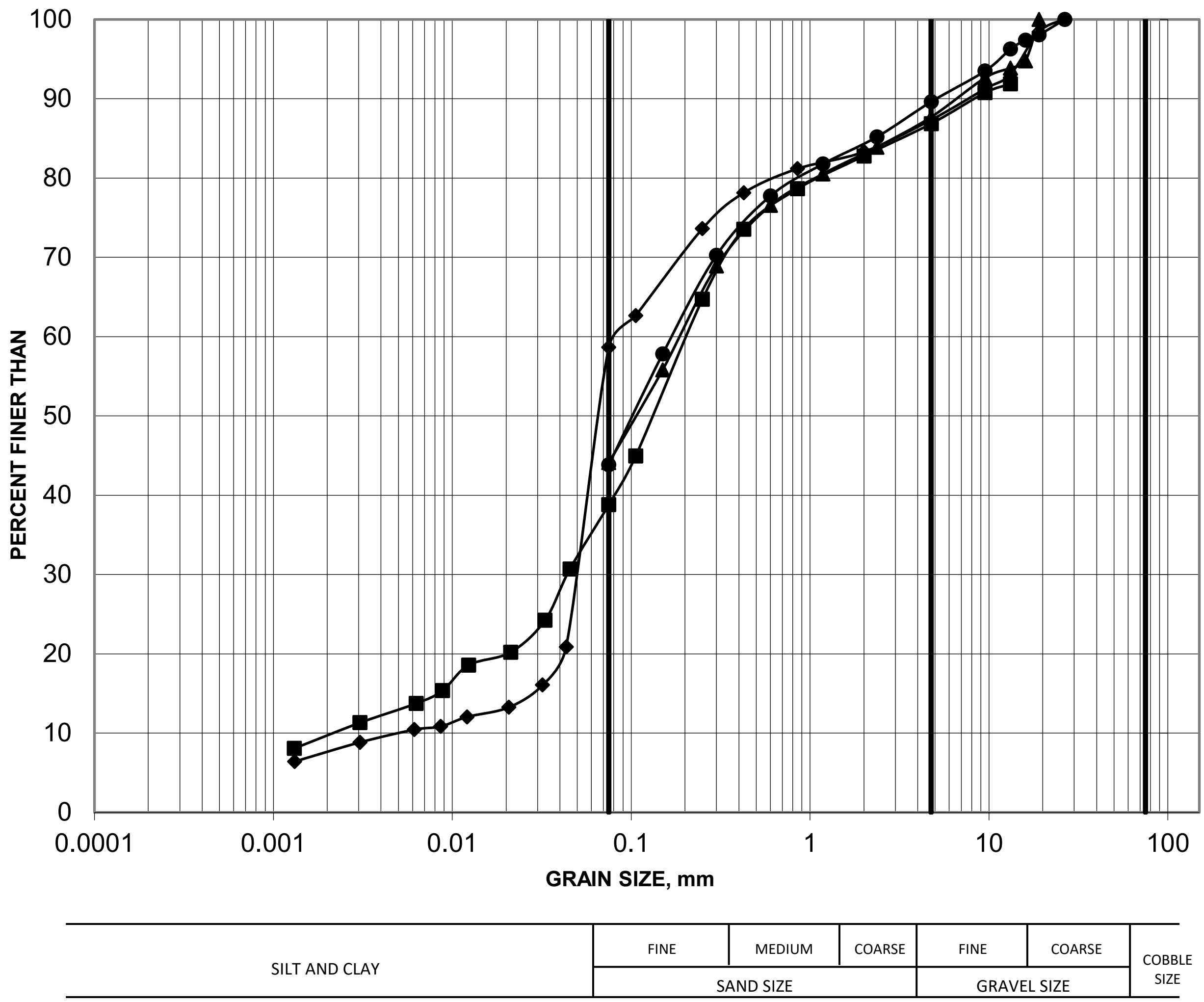
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY SAND (SM) TO SAND SILT (ML) FILL



			Constituents (%)			
Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■ 472-22-02	3	1.52-2.13	13	48	29	10
◆ 472-22-02	6	3.81-4.42	13	28	51	8
▲ 472-22-03	4	2.29-2.90	12	44	44	
● 472-22-03	9	6.10-6.71	10	46	44	

Project: 1773612_WO 11

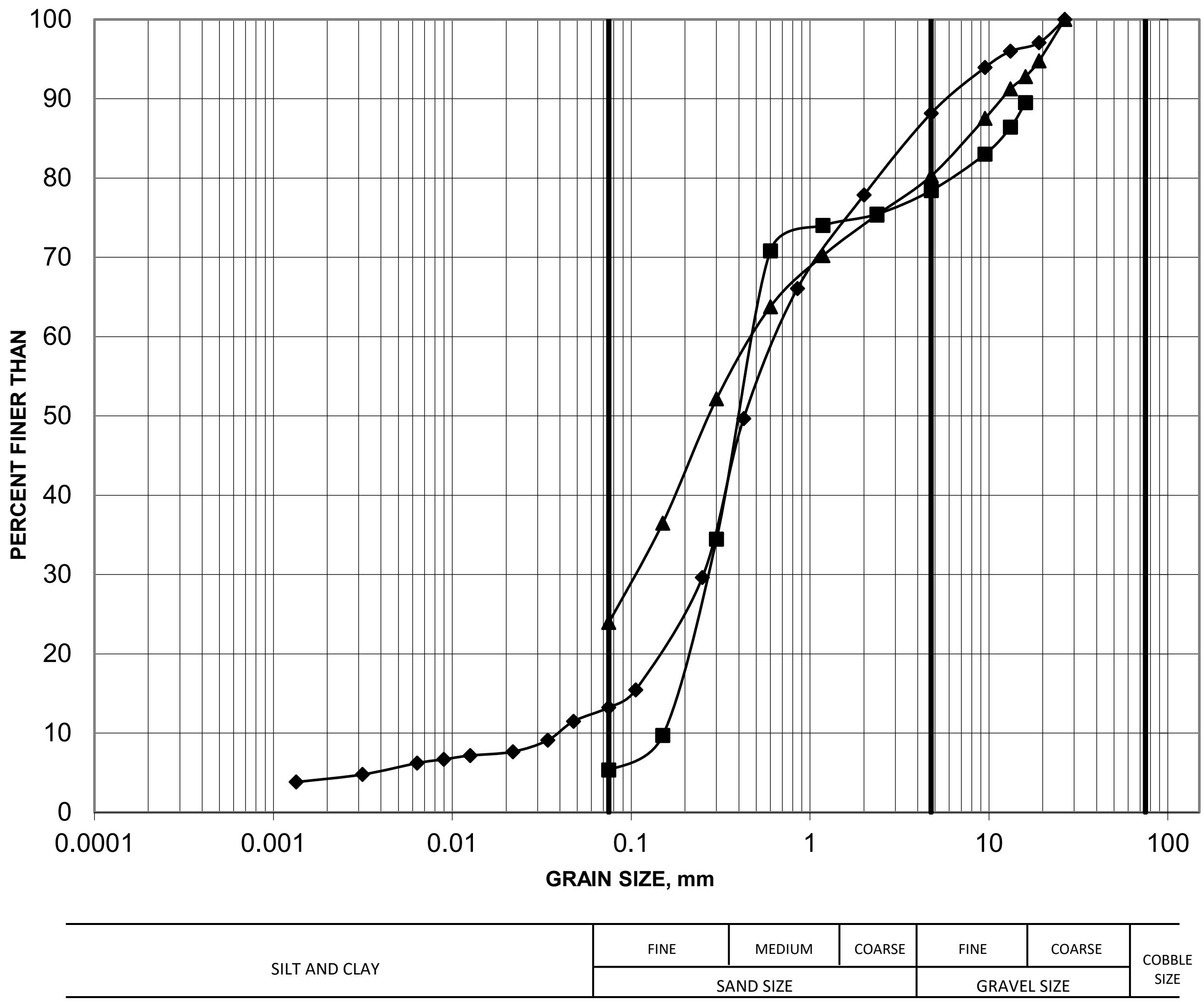
GOLDER MEMBER OF WSP

Created by: KG
Checked by: KCP

https://golderassociates.sharepoint.com/sites/11407g/WO11 Colborne to Brighten/2. Technical Work/5. Lab/5-Culvert 472/Figures/

GRAIN SIZE DISTRIBUTION	FIGURE B2

SILTY SAND (SM) TO SAND (SP/SW)



			Constituents (%)			
Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■ 472-22-01	7	4.57-5.18	22	73	5	
◆ 472-22-02	11	7.62-8.23	12	75	9	4
▲ 472-22-03	11	7.62-8.23	20	56	24	

Project: 1773612_WO 11

GOLDER
MEMBER OF WSP

Created by: KG
Checked by: KCP

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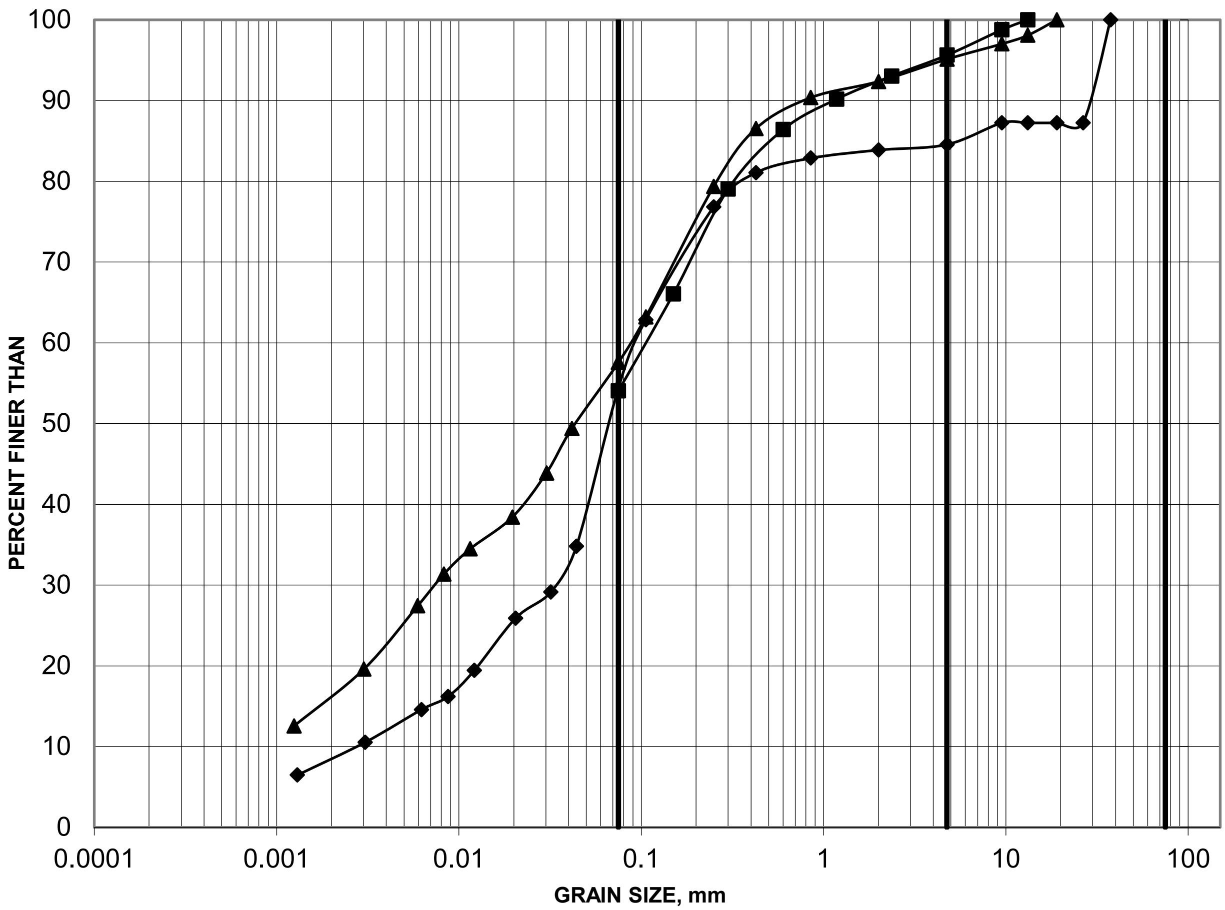
GRAIN SIZE DISTRIBUTION	FIGURE B3

SILT (ML) AND SAND TO SILTY SAND (SM) TILL



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

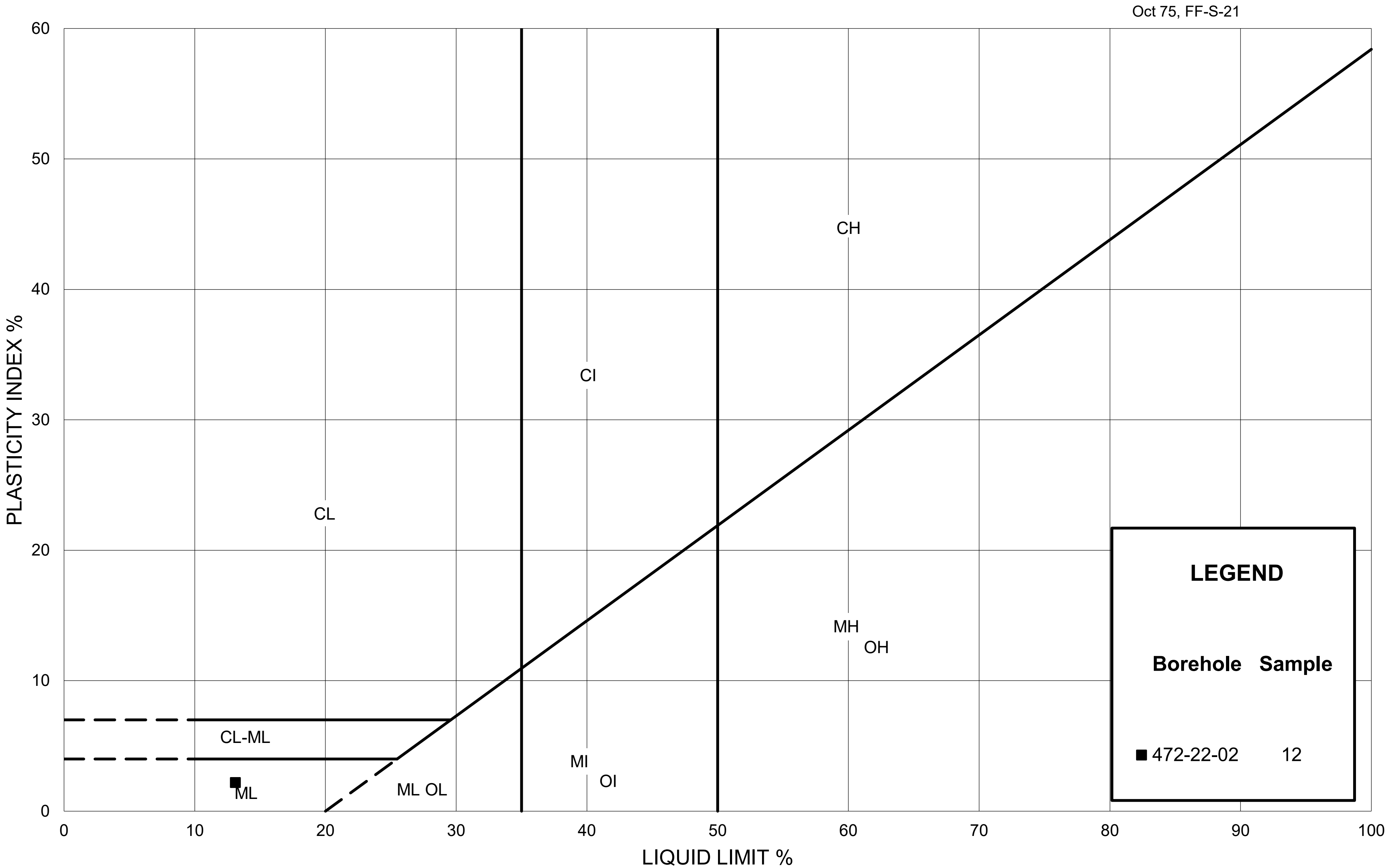
			Constituents (%)			
Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■ 472-22-01	2	0.76-1.37	4	42	54	
◆ 472-22-01	4	2.29-2.90	15	31	45	9
▲ 472-22-02	12	9.14-9.75	5	37	42	16

Project: 1773612_WO 11

GOLDER
MEMBER OF WSP

Created by:	KG
Checked by:	KCP

https://golderassociates.sharepoint.com/sites/11407g/WO11 Colborne to Brighten/2. Technical Work/5. Lab/5-Culvert 472/Figures/



Ministry of Transportation

Ontario

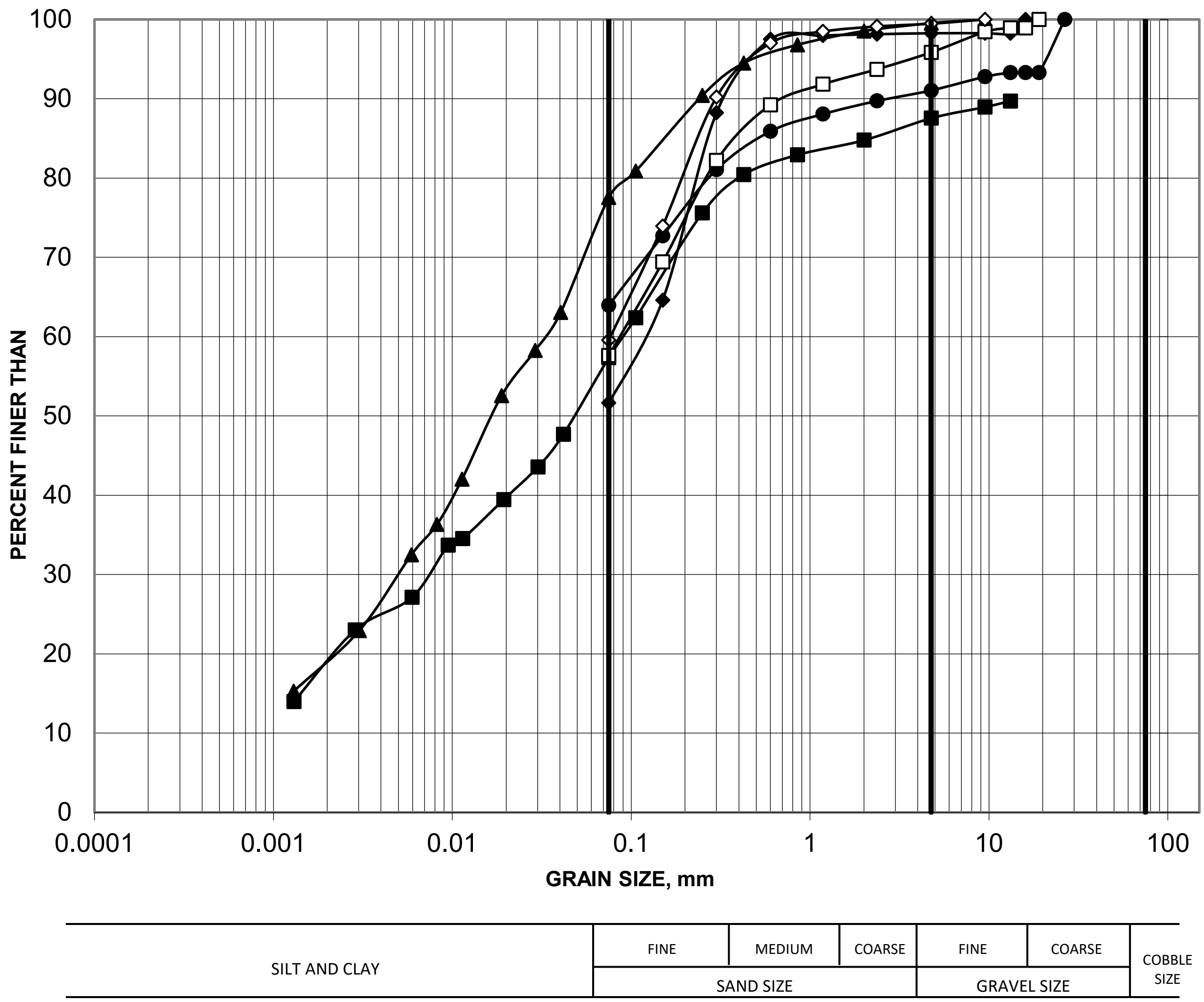
PLASTICITY CHART

SILT (ML) AND SAND TO SILTY SAND (SM) TILL

Figure:	B4
Project:	1773612_W011
Created By: KG	Checked By: KCP

GRAIN SIZE DISTRIBUTION	FIGURE B5

SANDY CLAYEY SILT (CL-ML) TILL



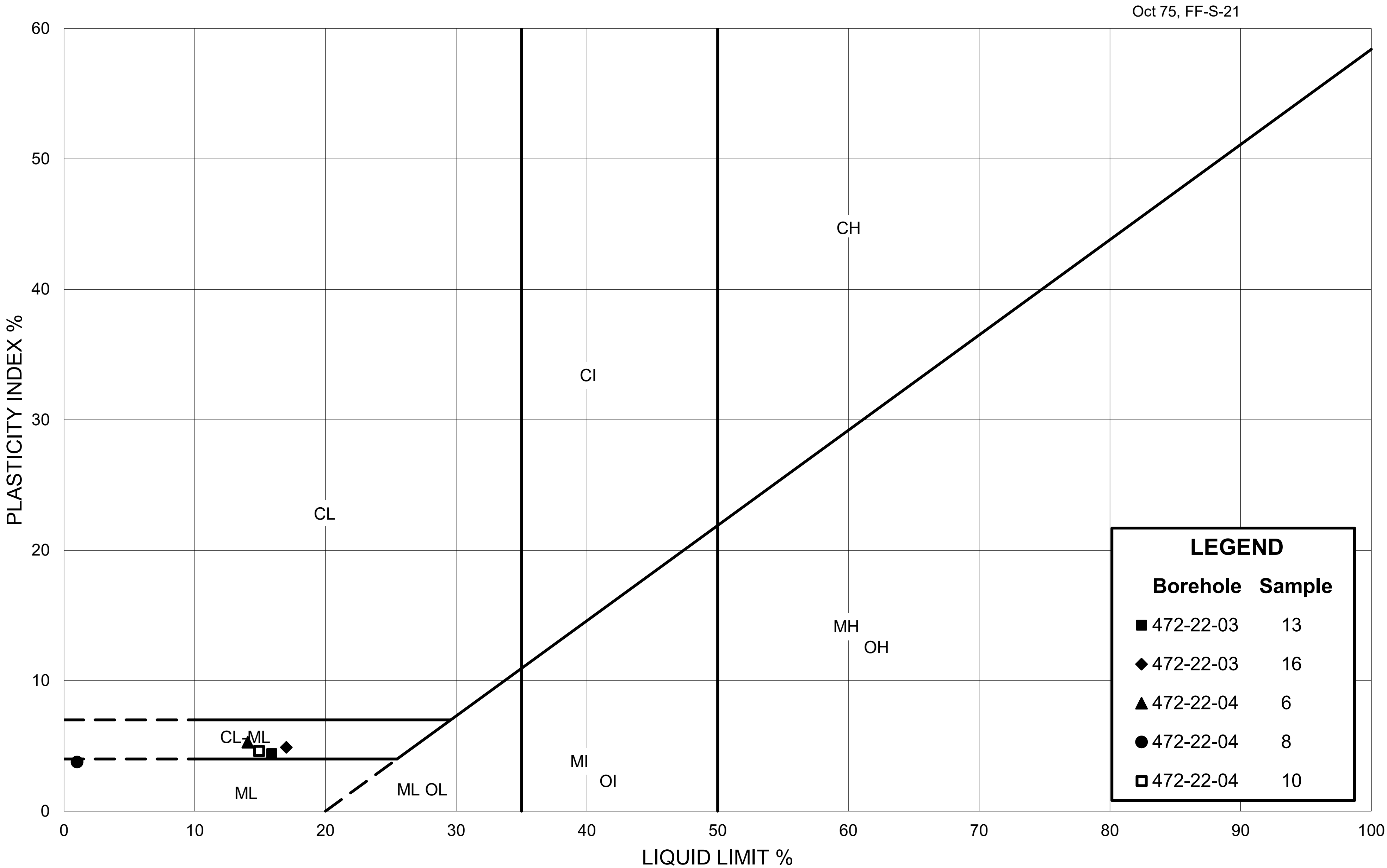
Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■ 472-22-03	13	9.14-9.75	12	31	38	19
◆ 472-22-03	14	9.91-10.52	2	46	52	
▲ 472-22-03	15	10.67-11.28	0	22	59	19
● 472-22-04	6	3.81-4.42	9	27	64	
□ 472-22-04	8	5.33-5.94	4	38	58	
◇ 472-22-04	10	6.86-7.47	1	39	60	

Project: 1773612_WO 11

GOLDER
MEMBER OF WSP

Created by: KG
Checked by: KCP

https://golderassociates.sharepoint.com/sites/11407g/WO11 Colborne to Brighten/2. Technical Work/5. Lab/5-Culvert 472/Figures/



Ministry of Transportation
Ontario

PLASTICITY CHART

SANDY CLAYEY SILT (CL-ML) TILL

Figure:	B6
Project:	1773612_W011
Created By: KG	Checked By: KCP

APPENDIX C

Analytical Laboratory Test Results

Certificate of Analysis

eurofins | Environment Testing

Client:	Golder Associates Ltd (Ottawa) 1931 Robertson Road, Ottawa, Ontario .		Report Number: Date Submitted: Date Reported: Project: COC #:	1985544 2022-09-07 2022-09-15 1773612-W011 899907
Attention:	Mr. Kenton Power			
PO#:				
Invoice to:	Golder Associates Ltd			

Dear Kenton Power:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: ______________________________

Emma-Dawn Ferguson, Chemist

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: https://directory.cala.ca/.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

eurofins | Environment Testing

Client:	Golder Associates Ltd (Ottawa) 1931 Robertson Road, Ottawa, Ontario .	Report Number:	1985544
		Date Submitted:	2022-09-07
		Date Reported:	2022-09-15
		Project:	1773612-W011
		COC #:	899907
Attention:	Mr. Kenton Power		
PO#:			
Invoice to:	Golder Associates Ltd		

Group	Analyte	MRL	Units	Guideline	1649736 Soil 2022-07-14 CR26-22-01 Sa3/5-7'	1649737 Soil 2022-07-20 H-22-02 Sa2/2.5-4.5'	1649738 Soil 2022-07-19 L-22-01 Sa2/2.5-4.5'	1649739 Soil 2022-07-26 471-22-03 Sa3/5-7'
				Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.				
Anions	Cl	0.002	%		0.058	0.005	0.007	0.016
	SO4	0.01	%		0.01	0.01	<0.01	0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		1.27	0.25	0.23	0.44
	pH	2.00			8.88	9.89	9.32	9.24
	Resistivity	1	ohm-cm		787	4000	4348	2273

Group	Analyte	MRL	Units	Guideline	1649740 Soil 2022-07-06 472-22-04 Sa2/2.5-4.5'	1649741 Soil 2022-07-27 473-22-03 Sa2/2.5-4.5'	1649742 Soil 2022-07-04 474-22-04 Sa3/5-7'
				Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
Anions	Cl	0.002	%		0.014	0.011	0.013
	SO4	0.01	%		0.06	<0.01	0.13
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.55	0.36	0.89
	pH	2.00			8.15	9.01	8.15
	Resistivity	1	ohm-cm		1818	2778	1124

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

eurofins Environment Testing

Client:	Golder Associates Ltd (Ottawa) 1931 Robertson Road, Ottawa, Ontario .	Report Number:	1985544
Attention:	Mr. Kenton Power	Date Submitted:	2022-09-07
PO#:		Date Reported:	2022-09-15
Invoice to:	Golder Associates Ltd	Project:	1773612-W011
		COC #:	899907

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 429467 **Analysis/Extraction Date** 2022-09-13 **Analyst** IP **Method** Cond-Soil			
Electrical Conductivity		90	90-110
pH	7.24	101	90-110
Resistivity			
Run No 429500 **Analysis/Extraction Date** 2022-09-14 **Analyst** IP **Method** AG SOIL			
SO4	<0.01 %	104	70-130
Run No 429575 **Analysis/Extraction Date** 2022-09-14 **Analyst** CK **Method** C CSA A23.2-4B			
Chloride	<0.002 %		90-110

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX D

Site Photographs and 1958 Drawings

Photograph 1: Existing Culvert Location Looking Downstream

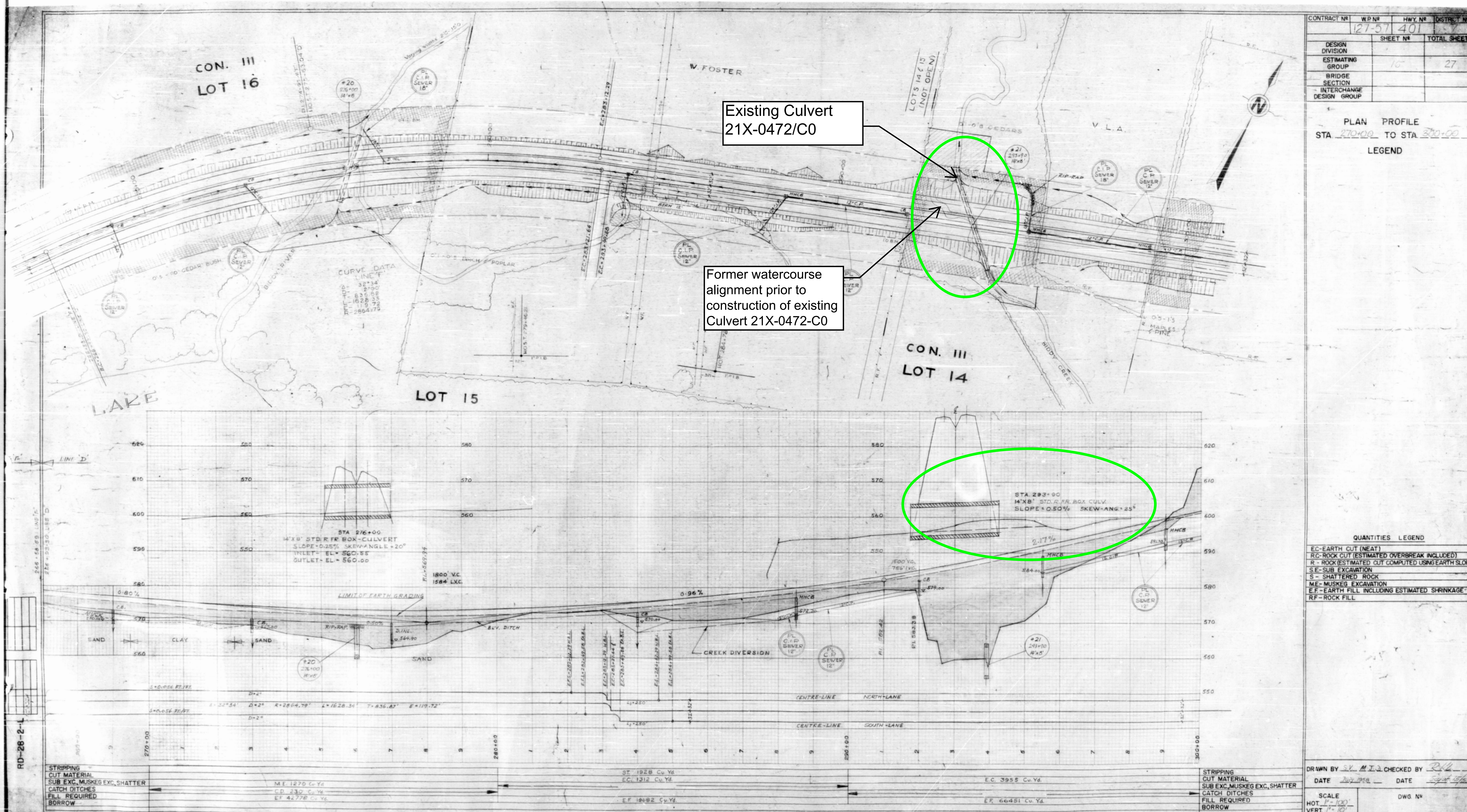
Photograph 2: Looking Northwest from South Side of Highway 401 Eastbound Lanes

Photograph 3: Highway 401 Eastbound Lane, Looking Eastward

Photograph 4: Location of Borehole 472-22-01 on North Side of Highway 401

Photograph 5: Existing North Embankment Side Slope Looking Eastbound

Photograph 6: Existing North Toe of Side Slope Looking East


Existing Culvert
21X-0472/C0
Former watercourse alignment prior to construction of existing Culvert 21X-0472-C0
CON. III
LOT 16
LOT 15
CON. III
LOT 14
LOTS 14 & 15 (NOT OPEN)
W. FOSTER
LAKE
CURVE DATA
STA. 293+90
14'X8' STD. R. FR. BOX CULV.
SLOPE=0.50% SKEW-ANG.=25°
STA. 276+00
14'X8' STD. R. FR. BOX CULVERT
SLOPE=0.25% SKEW-ANGLE=20°
INLET-EL.=560.55
OUTLET-EL.=560.00
LIMIT OF EARTH GRADING
CREEK DIVERSION
CENTRE-LINE NORTH-LANE
CENTRE-LINE SOUTH-LANE
SAND
CLAY
STRIPPING
CUT MATERIAL
SUB EXC. MUSKEG EXC. SHATTER
CATCH DITCHES
FILL REQUIRED
BORROW
CONTRACT Nº
W.P. Nº
HWY. Nº
DISTRICT Nº
127-57
401
SHEET Nº
TOTAL SHEETS
DESIGN DIVISION
ESTIMATING GROUP
BRIDGE SECTION
INTERCHANGE DESIGN GROUP
27
PLAN PROFILE
STA 270+00 TO STA 300+00
LEGEND
QUANTITIES LEGEND
E.C.-EARTH CUT (NEAT)
R.C.-ROCK CUT (ESTIMATED OVERBREAK INCLUDED)
R.-ROCK (ESTIMATED CUT COMPUTED USING EARTH SLOPES)
S.E.-SUB EXCAVATION
S.-SHATTERED ROCK
M.E.-MUSKEG EXCAVATION
E.F.-EARTH FILL INCLUDING ESTIMATED SHRINKAGE
R.F.-ROCK FILL
DRAWN BY
CHECKED BY
DATE
SCALE
HOR. 1"=100'
VERT. 1"=10'
DWG. Nº
RD-28-2-L

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