FINAL REPORT

Foundation Investigation Report

Culvert Replacement (Site No. 21X-0474/C0)
Highway 401, Station 10+243 Cramahe Township, Northumberland County
MTO GWP 4054-17-00, Agreement No. 4016-E-0034-11

Submitted to:

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1773612-474

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1.0 INTRODUCTION

WSP Canada Inc. (WSP, formerly Golder Associates Ltd., amalgamated with 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-0474/C0. The foundation investigation services for this project have been delivered under MTO Agreement No. 4016-E-0034-11 as part of GWP 4054-17-00.

2.0 SITE DESCRIPTION

The orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and, therefore, may differ from the magnetic north shown on the foundations drawing. For the purposes of this report, Highway 401 is oriented in a west-east direction with the culvert positioned on a 30° skew to the highway in a southeast-northwest orientation; for simplicity, the culvert is described as being oriented in a north-south direction.

Culvert 21X-0474/C0 is located at about Station 10+243 on Highway 401 approximately 3 km west of County Road 30, Cramahe Township in Northumberland County. The site location is shown on the key plan in Drawing 1. The existing culvert consists of a 4.3 m wide by 2.4 m high (interior dimensions) reinforced concrete box structure, which was constructed in 1958. The culvert extends below the Highway 401 westbound lanes (WBL), center median, and eastbound lanes (EBL) over a total length of 73.2 m. Based on the information provided in WSP's Draft Structural Design Report dated September 2022, there is no current information available with respect to the existing culvert inverts. We understand the culvert is in good to fair condition but is close to its 75-year design service life.

At the culvert location, Highway 401 has an existing four-lane cross-section with paved shoulders separated by a paved median and a concrete tall wall barrier, transitioning to a grassy median immediately east of the existing culvert. Based on the cross-section drawings provided by WSP, the highway grade is at approximately Elevation 188.0 m, and there is approximately 1 m of fill above the top of the existing culvert. The EBL embankment is about 2 m high with the south side slope inclined at about 8 horizontals to 1 vertical (8H:1V). The WBL embankment is about 3 m high with the north side slope inclined at 6H:1V. The ground surface conditions at the culvert location are shown in Photographs 1 to 6 following the text of this report.

The watercourse flows from south to north at this site. Meadow marsh wetlands are present both upstream and downstream of the culvert, south, and north of Highway 401. The existing natural ground surface outside of the highway is at approximately Elevation 184.5 m to 185.5 m.

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.

3.0 INVESTIGATION PROCEDURES

The fieldwork for this investigation consisted of four boreholes (Boreholes 474-22-01 to 474-22-04). Boreholes 474-22-01, 474-22-03, and 474-22-04 were advanced in June and July 2022, and Borehole 474-22-02 was advanced in October 2022. The approximate borehole locations are shown in Drawing 1.

Boreholes 474-22-01 and 474-22-04, which are located near the proposed culvert inlet and outlets, were advanced using a track-mounted Multipower LAD drilling rig equipped with 83 mm inside diameter hollow stem augers. Boreholes 474-22-02 and 474-22-03, located on the highway platform, were advanced using a truck-mounted CME 55 drilling rig equipped with 108 mm inside 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 in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586[1]). Soil samples were obtained at vertical sampling intervals of about 0.76 m and 1.5 m.

The groundwater levels in the open boreholes were observed during and upon completion of the drilling operations, as described in the borehole records in Appendix A. Further, a standpipe piezometer was installed in Borehole 474-22-01 to observe the stabilized groundwater level at the site. Piezometer installation details are shown on the borehole record in Appendix A. Boreholes 474-22-02 to 474-22-04 were backfilled in general accordance with the intent of Ontario Regulation (O.Reg.) 903, as amended, and the site conditions were restored following completion of the fieldwork.

The fieldwork was supervised on a full-time basis by members of WSP's technical staff who located the boreholes in the field, supervised the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled 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 LS and/or ASTM Standards, as applicable at WSP's Ottawa laboratory.

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 as-drilled 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 below.

[1] ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Borehole No.	NAD83 CSRS CBNv6-2010.0 – MTM Zone 9		Ground Surface Elevation (m)	Drilled Depth (m)
	Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
474-22-01	4880883.5 (44.060540)	200617.5 (-77.800380)	185.0	7.5
474-22-02	4880872.8 (44.060450)	200640.1 (-77.800100)	187.9	14.3
474-22-03	4880845.5 (44.060210)	200683.3 (-77.799550)	187.5	14.0
474-22-04	4880833.4 (44.060110)	200707.7 (-77.799250)	185.3	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The culvert lies in the physiographic region known as the Iroquois Plain, as delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984)[2]. The Iroquois Plain physiographic region extends around the western part of Lake Ontario, from the Niagara River to the Trent River. The width of the plain varies from a few hundred meters to approximately 13 km north of the current Lake Ontario shoreline, and it extends inland to include a large area in the Trent River valley. The eastern portion of the South Slope in Northumberland County is covered by large drumlins that are generally oriented northeast-to-southwest.

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.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)[3], 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 Show Lake Formation.

4.2 General

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 detailed results of the geotechnical laboratory are presented in Appendix B. The results of the in-situ field tests (SPT N-values), 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

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

[3] Ontario Geological Survey 2011. 1:250 000 scale bedrock geology of Ontario; Ontario Geological Survey, Miscellaneous Release---Data 126-Revision 1.

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.

4.3 Site Stratigraphy Overview

At the borehole locations, the subsurface conditions generally consist of the existing pavement structure (asphalt and pavement granular material) in boreholes advanced on the highway, or topsoil/peat in boreholes advanced at the culvert ends, underlain by a deposit of generally compact to dense silty sand to sand which contains thin silt and clayey silt interlayers. A more detailed description of the overburdened soil deposits encountered during the field investigation is provided in the following sections.

4.3.1 Pavement Structure and Embankment Fill

An approximately 75 mm and 175 mm thick layer of asphalt was encountered at the ground surface (i.e., Elevations 187.9 m and 187.5 m) in Boreholes 474-22-02 and 474-22-03, respectively, which were drilled through the outside shoulders of Highway 401 WBL and EBL.

Sand and gravel to silty sand fill were encountered below the asphalt in these boreholes. The top of this layer was encountered at Elevations 187.8 m and 187.3 m, and it extended to Elevations 185.7 m and 185.8 m with thicknesses of 2.1 m and 1.5 m in Boreholes 474-22-02 and 474-22-03, respectively. The recorded Standard Penetration Test (SPT) N-values within the fill ranged from 28 blows to 67 blows per 0.3 m of penetration indicating a compact to very dense state of compactness.

The measured moisture content of two samples of the fill was 3% and 7%. The results of grain size analysis testing carried out on one sample of the fill are shown in Figure B1 in Appendix B.

4.3.2 Topsoil/Peat

An approximately 200 mm thick layer of fibrous peat and a 300 mm thick layer of silty sand topsoil were encountered immediately below the ground surface (i.e., Elevations 185.0 m and 185.3 m) in Boreholes 474-22-01 and 474-22-03, which were advanced near the proposed north and south culvert ends, respectively.

4.3.3 Silty Sand (SM) to Sand (SP-SM)

A silty sand-to-sand deposit was encountered below the topsoil/peat in Boreholes 474-22-01 and 474-22-04 and the embankment fill in Boreholes 474-22-02 and 474-22-03. The top of this deposit was encountered between Elevations 184.8 m and 185.8 m. All boreholes were terminated in this deposit between Elevations 173.5 m and 177.5 m.

The recorded SPT N-values within the silty sand-to-sand deposit ranged from 0 blows (weight of hammer) to 79 blows per 0.3 m of penetration indicating very loose to very dense compactness conditions. The lower SPT N-values, in particular, those below approximately 3 m depth in Borehole 474-22-01 and low values at depth in other boreholes, are attributed to sample disturbance arising from groundwater inflow to the borehole and “heave” of silty sand to sand into the hollow stem augers, and such lower SPT N-values are not considered representative of the relative density of this deposit. In two instances, the split-spoon sampler did not penetrate the entire SPT depth due to refusal conditions (i.e., SPT N-values greater than 100 blows per 0.3 m) on inferred cobble and/or possible boulder obstructions. Therefore, in general, this deposit has a compact to dense relative density.

The measured moisture content of 13 samples of the silty sand to sand deposit ranged from 7% to 24%. The results of grain size analyses testing carried out on 12 samples of the silty to sand are provided in Figures B2 and

B3 in Appendix B. Atterberg limits tests were carried out on three samples of the deposit, which yielded non-plastic test results, as shown on the borehole records in Appendix A.

4.3.4 Silt (ML) to Clayey Silt-Silt (CL-ML) Interlayers

Interlayers of silt and clayey silt-silt were encountered within the silty sand-to-sand deposit in Boreholes 474-22-03 and 474-22-04. In Borehole 22-03, a 2.0 m thick silt interlayer was encountered at Elevation 183.7, immediately underlain by a 1.0 m thick interlayer of clayey silt-silt, while in Borehole 22-04, a 0.2 m thick clayey silt-silt interlayer was encountered at approximately Elevation 179.5 m, and a 0.9 m thick silt interlayer was encountered at approximately Elevation 177.8 m. These encountered interlayers are illustrated on the interpreted stratigraphic profile in Drawing 1, and such interlayers should be anticipated at varying depths/elevations and thicknesses throughout this deposit.

The recorded SPT N-values within the silt interlayers ranged from 15 to 39 blows per 0.3 m of penetration indicating a compact to dense state of compactness. One SPT N-value of 1 blow per 0.3 m of penetration was recorded in the clayey silt-silt interlayer in Borehole 474-22-03, suggesting a very soft consistency; however, limited sample was recovered in the split-spoon, and it is thus interpreted that this interlayer also contains silt soils that were disturbed by groundwater pressures during sampling, suggesting that this SPT N-value may not be representative of the consistency/relative density of this thin interlayer.

The measured moisture content of two samples of the silt to silt-clayey silt was 14% and 23%. The results of grain size analysis testing carried out on two samples of the silt interlayers are provided in Figure B4 in Appendix B.

4.4 Groundwater Conditions

Groundwater levels were measured within the open boreholes upon completion of drilling and within the standpipe piezometer installed in Borehole 474-22-01. The observed groundwater levels are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Elevation (m)	Date	Reading
474-22-01	185.0	0.4	184.6	October 13, 2022	Standpipe Piezometer
		0.7	184.3	October 19, 2022	
		-0.5[1]	185.5	May 16, 2023	
474-22-02	187.9	4.6	183.3	October 17, 2022	Open Borehole
474-22-03	187.5	3.2	184.3	July 28, 2022	Open Borehole
474-22-04	185.3	0.9	184.4	July 4, 2022	Open Borehole

Note: The negative groundwater level measured within the standpipe piezometer in Borehole 474-22-01 represents a groundwater level above the existing ground surface and potential artesian conditions.

The groundwater levels at this site will be subject to fluctuations both seasonally and as a result of precipitation events.

4.5 Analytical Testing Results

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

Borehole No.	Sample Depth (m)	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
474-22-04	1.5-2.1	0.013	0.13	0.89	8.15	1,124

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. James Sullivan and Mr. Ben Waetcher, under the overall direction of Mr. Kenton Power, P.Eng. This Foundation Investigation Report was prepared by Tibor Berecz, P.Eng. and reviewed by Kenton Power, P.Eng., Senior Geotechnical Engineer. Ms. Lisa Coyne, P.Eng., Geotechnical Engineering Fellow and MTO Principal Foundations Contact conducted an independent technical and quality review of this report.

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https://wsponlinecan.sharepoint.com/sites/ca-ca00122984565/shared documents/06. deliverables/474/3-final/1773612 gwp 4045-17-00 fidr rev0 culvert 474 2024-03-05.docx

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Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition

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Ministry of Northern Development of Mines. Bedrock Geology of Ontario – Southern Sheet, Ontario Geological Survey – Map 2544.

Ministry of Transportation, MTO Gravity Pipe Design Guidelines, MTO Drainage and Hydrology Design and Contract Standards Office, May 2014

Occupational Health and Safety Act and Regulation for Construction Projects (as amended)

ASTM International

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 422	Construction Specification for Installation of Precast Reinforced Concrete Box Culverts with Span 3m or Less in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 803	Construction Specification for Vegetative Cover
OPSS.PROV 804	Construction Specification for Temporary Erosion Control
OPSS.PROV 902	Construction Specification for Excavating and Backfilling - Structures
OPSS.PROV 1002	Material Specification for Aggregates – Concrete
OPSS.PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS.PROV 1860	Material Specification for Geotextiles

Ontario Provincial Standard Drawings (OPSD)

OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario

Ontario Water Resource Act

Regulation 903	Wells (as amended)

PHOTOGRAPHS

PHOTOGRAPHS 1 TO 6

Photograph 1: Highway 401 Westbound Lane, Facing East

Photograph 2: Highway 401 EBL & Existing Culvert Inlet (South End), Facing West

Photograph 3: Existing Culvert Outlet (North End), Facing North

Photograph 4: Existing Culvert Outlet (North End), Facing East

Photograph 5: Highway 401 Westbound Lane, North Embankment Side Slope, Facing East

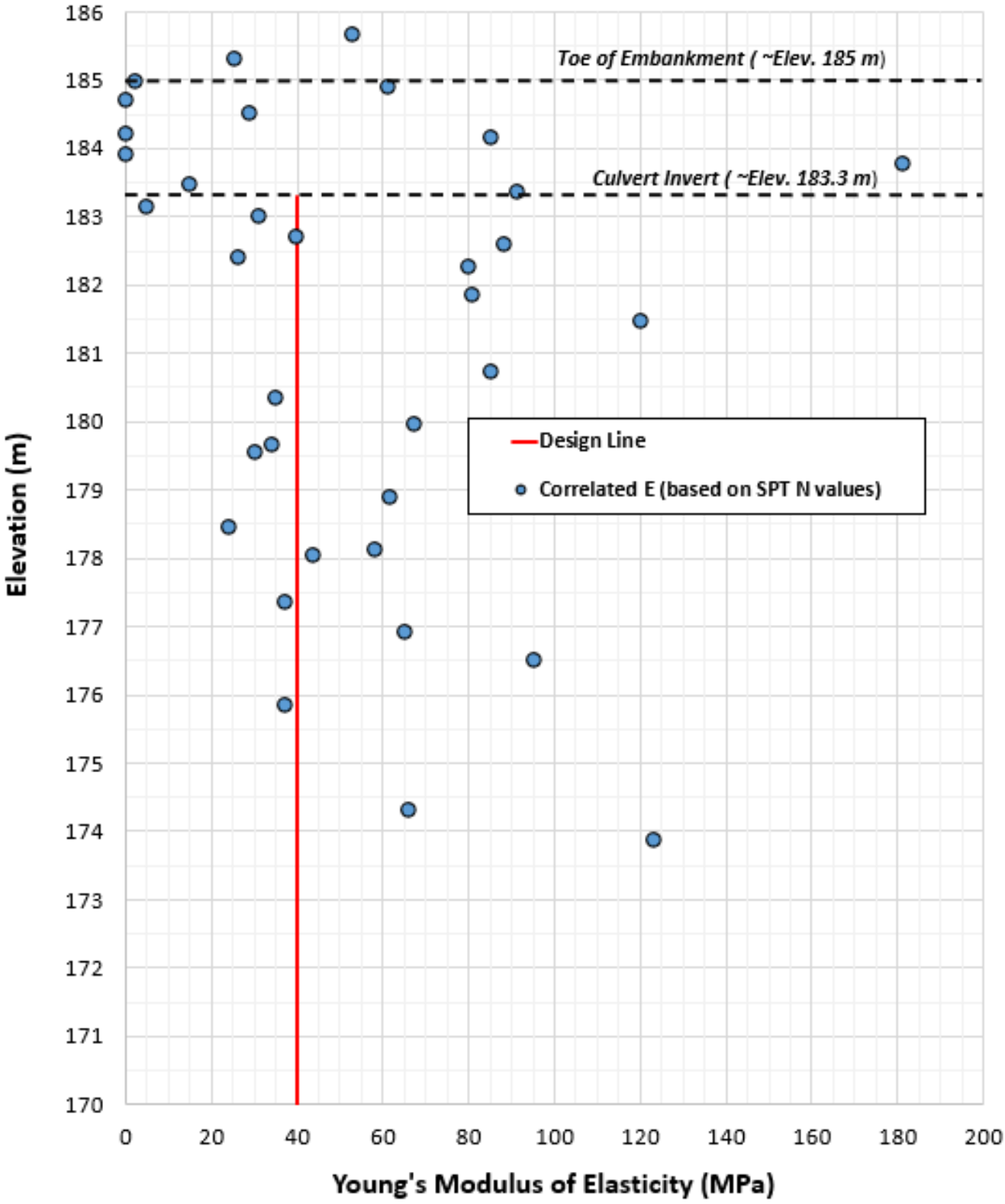
Photograph 6: Highway 401 Eastbound Lane, South Embankment Side Slope, Facing East

FIGURES

Figure 1 Settlement Parameters – Elastic Modulus

Settlement Parameters - Modulus of Elasticity

Figure 1



Date: June 2023
Project No: 1773612 WO#11

Analysis By: DAM
Reviewed By: LCC

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.

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

PROJECT 1773612

RECORD OF BOREHOLE No 474-22-01 SHEET 1 OF 1 METRIC

G.W.P. 4054-17-00 LOCATION N 4880883.5; E 200617.5 MTM NAD ZONE 9 (LAT. 44.060540; LONG. -77.800380) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE LAD Multipower Track Mounted, 83 mm I.D. Hollow Stem Augers COMPILED BY ZS

DATUM GEODETIC DATE June 27 & 28, 2022 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
185.0	GROUND SURFACE										
0.0	Fibrous PEAT (PT), some sand										
0.2	SILTY SAND (SM) Very loose to compact Brown Wet		1	SS	WH						
			2	SS	WH		184				
			3A 3B	SS	3		183				
			4	SS	11				○		0 67 (33)
182.0							182				
3.0	SAND (SP), trace silt Loose Brown Wet		5	SS	5*						
			6	SS	5*		181		○		0 94 (6)
			7	SS	7*		180				
179.7											
5.3	SILTY SAND (SM) Loose Brown Wet		8	SS	8*				○		0 73 (27)
			9	SS	4*		179				
							178				
177.5											
7.5	END OF BOREHOLE										

NOTES:

* SPT N values impacted by sample disturbance due to groundwater conditions and heave within hollow stem augers.

1. Between 0.6 m and 1.5 m of heaving occured prior to sampling for each of samples 5 to 9.

2. Borehole terminated due to excessive heave inside augers.

3. Water level measured in standpipe piezometer:

Date	Depth(m)	Elev.(m)
Oct.12/22	0.4	184.6
Oct.19/22	0.7	184.3
May16/23	-0.5	185.5

4. The negative groundwater level measure represents a groundwater level above the existing ground surface and potential artesian conditions.

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

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PROJECT 1773612

RECORD OF BOREHOLE No 474-22-02 SHEET 1 OF 2 METRIC

G.W.P. 4054-17-00 LOCATION N 4880872.8; E 200640.1 MTM NAD ZONE 9 (LAT. 44.060450; LONG. -77.800100) ORIGINATED BY BW

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm I.D. Hollow Stem Augers COMPILED BY ZS

DATUM GEODETIC DATE October 17, 2022 CHECKED BY KCP

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 ● QUICK TRIAXIAL + FIELD VANE × 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
187.9	GROUND SURFACE										
0.0	ASPHALT (75 mm)										
0.1	Gravelly SILTY SAND (SM) (FILL) Dense to very dense Brown Moist		1	AS	-						
			2	SS	32		187		○		
			3	SS	67		186				
185.7											
2.2	SILTY SAND (SM) to gravelly SILTY SAND Loose to very dense Brown Moist to wet		4	SS	12		185				
			5	SS	15				○		
			6	SS	79		184		○	NP	14 49 30 7
			7	SS	14	▽	183				
			8	SS	37						
			9	SS	51		182				
			10	SS	37		181		○	NP	0 86 10 4
			11	SS	30		180				
							179				
			12	SS	11		178				
			13	SS	30		177				
							176				

Continued Next Page

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

PROJECT 1773612

RECORD OF BOREHOLE No 474-22-02 SHEET 2 OF 2 METRIC

G.W.P. 4054-17-00 LOCATION N 4880872.8; E 200640.1 MTM NAD ZONE 9 (LAT. 44.060450; LONG. -77.800100) ORIGINATED BY BW

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm I.D. Hollow Stem Augers COMPILED BY ZS

DATUM GEODETIC DATE October 17, 2022 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	20 40 60		
	SILTY SAND (SM) to gravelly SILTY SAND Loose to very dense Brown Moist to wet		14	SS	5*				○	NP	20 45 23 6
							175				
							174				
173.6			15	SS	61				○		29 45 20 6
14.3	END OF BOREHOLE										

NOTES:

1. Water level measured at a depth of 4.6 m (Elev. 183.3 m) upon completion of drilling.

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

PROJECT 1773612

RECORD OF BOREHOLE No 474-22-03 SHEET 1 OF 2 METRIC

G.W.P. 4054-17-00 LOCATION N 4880845.5; E 200683.3 MTM NAD ZONE 9 (LAT. 44.060210; LONG. -77.799550) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm I.D. Hollow Stem Augers COMPILED BY ZS

DATUM GEODETIC DATE July 28, 2022 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
187.5	GROUND SURFACE										
0.0	ASPHALT (175 mm)										
0.2	SAND (SP) and gravel, trace silt (FILL) Brown Moist		1	AS	-		187		○		44 48 (8)
186.9 / 0.6	SILTY SAND (SM), some gravel (FILL) Compact Brown to grey Moist		2	SS	28						
185.8 / 1.7	SILTY SAND (SM), trace gravel Compact to dense Brown Moist		3	SS	23		186				
			4	SS	29		185		○		8 49 (43)
			5	SS	43	▽	184				
183.7 / 3.8	SILT (ML) Dense Grey Moist		6	SS	39						
			7	SS	39		183		○		0 3 87 10
			8	SS	37		182				
181.7 / 5.8	CLAYEY SILT-SILT (CL-ML), trace to some sand Firm Brown to grey Wet		9	SS	1*		181				
180.7 / 6.8	SILTY SAND (SM), trace gravel Compact to dense Brown Wet		10	SS	15		180				
			11	SS	13		179				
			12	SS	20		178				
			13	SS	43		177		○		3 56 (41)
	- Hard augering below 11.6 m depth (Elev. 175.9 m), contains cobbles and boulders						176				

Continued Next Page

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

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PROJECT 1773612

RECORD OF BOREHOLE No 474-22-03 SHEET 2 OF 2 METRIC

G.W.P. 4054-17-00 LOCATION N 4880845.5; E 200683.3 MTM NAD ZONE 9 (LAT. 44.060210; LONG. -77.799550) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm I.D. Hollow Stem Augers COMPILED BY ZS

DATUM GEODETIC DATE July 28, 2022 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
	--- CONTINUED FROM PREVIOUS PAGE ---									
	SILTY SAND (SM), trace gravel Compact to dense Brown Wet		14	SS	100/0.15		175			
							174			
173.5			15	SS	100/0.10					
14.0	END OF BOREHOLE SPLIT-SPOON REFUSAL									
	NOTES: 1. Water level measured at a depth of 3.2 m (Elev. 184.3 m) upon completion of drilling									

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

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PROJECT 1773612

RECORD OF BOREHOLE No 474-22-04 SHEET 1 OF 1 METRIC

G.W.P. 4054-17-00 LOCATION N 4880833.4; E 200707.7 MTM NAD ZONE 9 (LAT. 44.060100; LONG. -77.799250) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE LAD Multipower Track Mounted, 83 mm I.D. Hollow Stem Augers COMPILED BY ZS

DATUM GEODETIC DATE July 4, 2022 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
185.3	GROUND SURFACE										
0.0 / 185.1	TOPSOIL - SILTY SAND (SM), some organics, Dark brown, Moist		1	SS	1		185				
0.3	SILTY SAND (SM), Loose to compact, Brown to grey, Moist to wet		2	SS	WH	▽					
			3	SS	6		184		○		1 54 (45)
			4	SS	17		183				
			5	SS	5*		182				
			6	SS	7*				○		0 81 (19)
			7	SS	9*		181				
179.5			8	SS	14		180				
	CLAYEY SILT-SILT (CL-ML), trace sand, Brown, Wet										
6.0	SILTY SAND (SM), Compact, Brown, Wet		9	SS	24		179				
			10	SS	23		178				
177.8											
7.5	SILT (ML) and sand, Compact, Brown, Wet		11	SS	15				○		0 44 (56)
176.9							177				
8.4	Gravelly SILTY SAND (SM), Compact, Brown, Wet		12	SS	16						
			13	SS	28		176		○		26 45 (29)
175.6											
9.8	END OF BOREHOLE										

NOTES:

1. Water level measured at a depth of 0.9 m (Elev. 184.4 m) upon completion of drilling.

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

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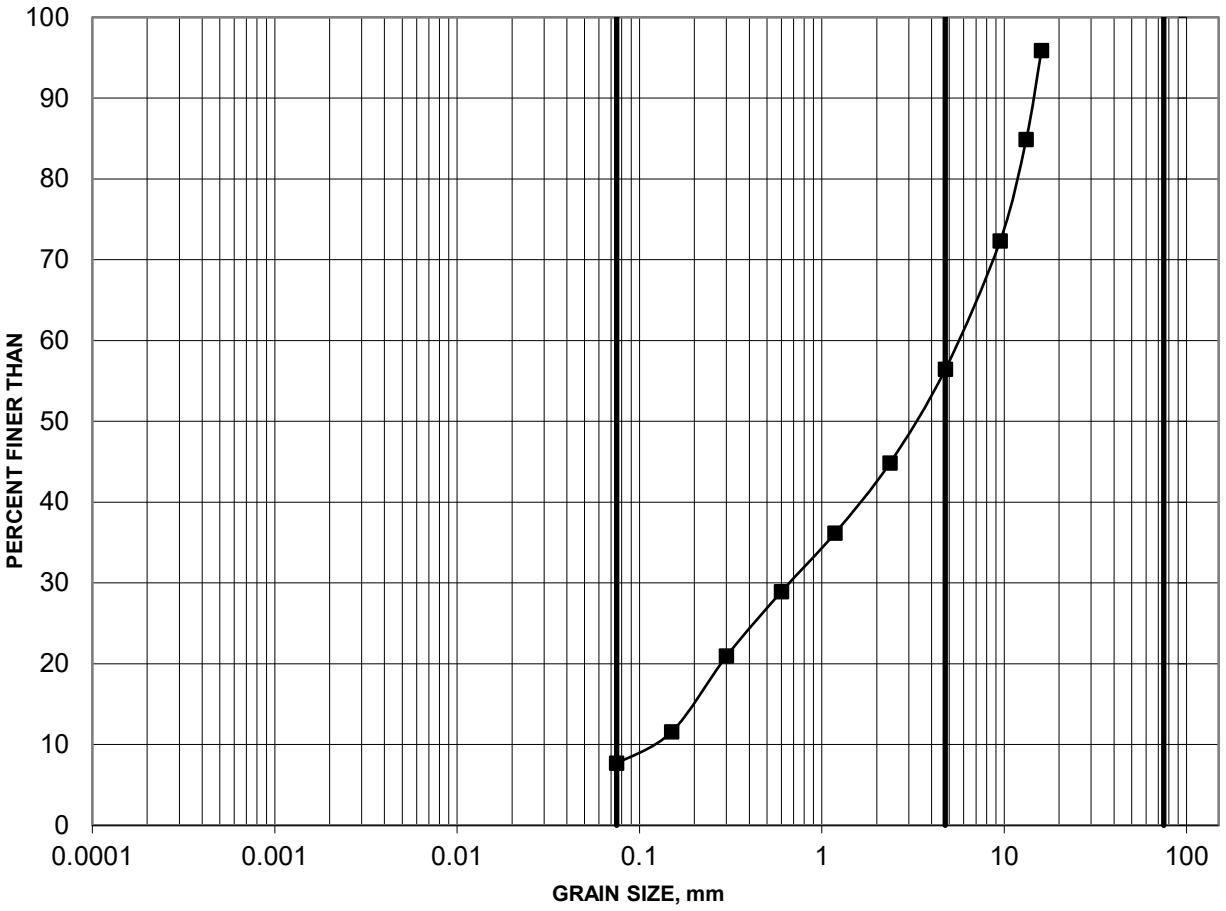
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND (SP) FILL



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

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	474-22-03	1	0.18-0.46	44	48		8

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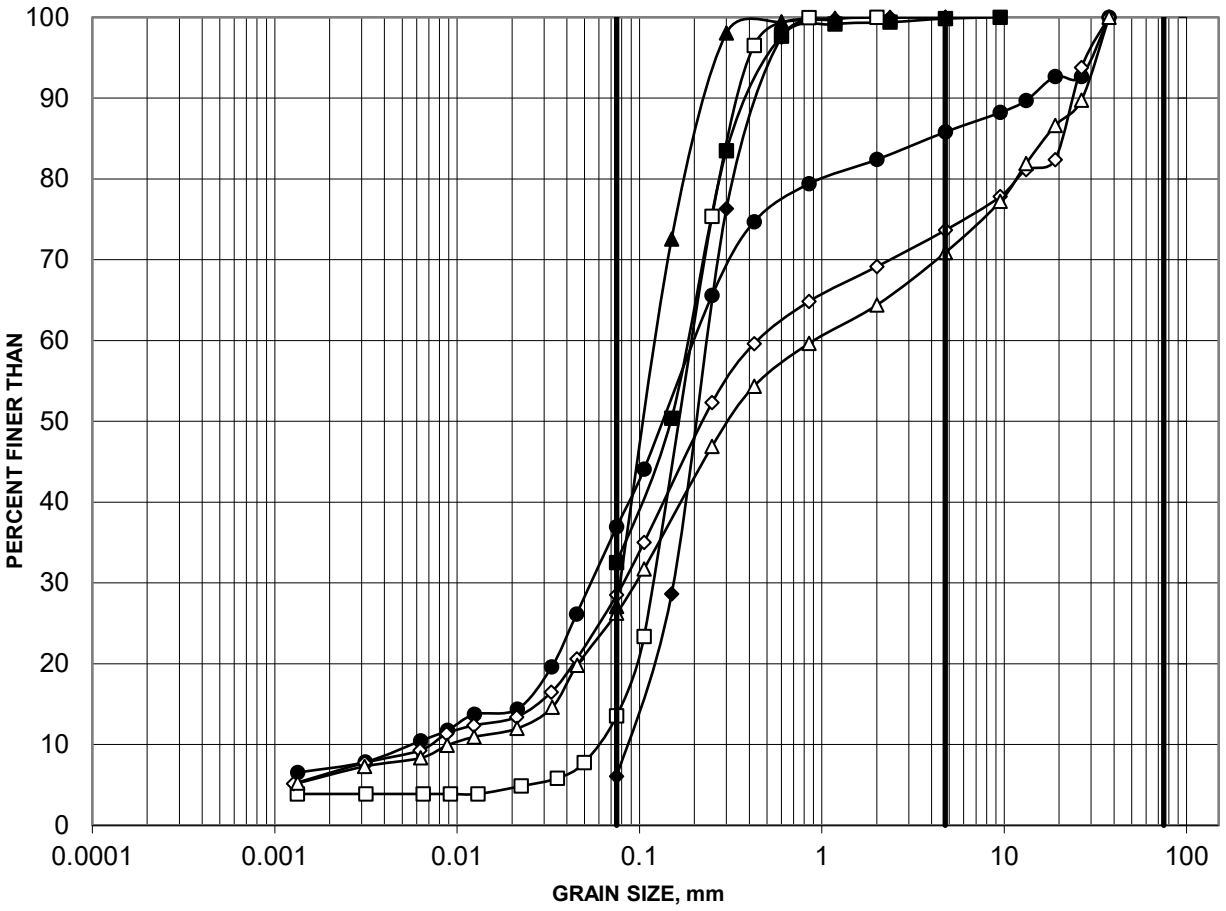
GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY SAND (SM) to SAND (SP-SM)



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

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	474-22-01	4	2.29-2.90	0	67	33	
◆	474-22-01	6	3.81-4.42	0	94	6	
▲	474-22-01	8	5.33-5.94	0	73	27	
●	474-22-02	6	3.81-4.42	14	49	30	7
□	474-22-02	10	6.86-7.47	0	86	10	4
◇	474-22-02	14	12.19-12.80	26	45	23	6
△	474-22-02	15	13.72-14.33	29	45	20	6

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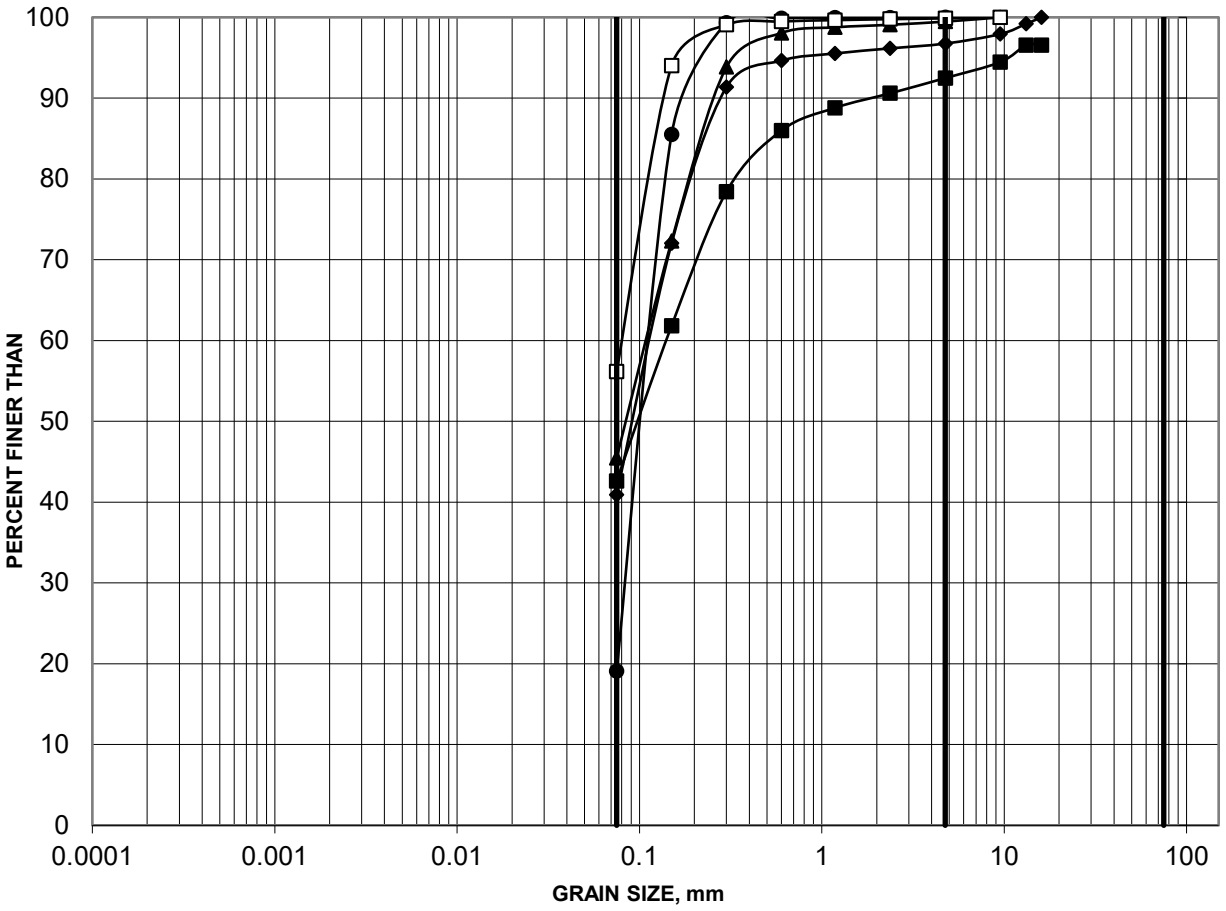
GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY SAND (SM) to SAND (SP-SM)



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

Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
474-22-03	4	2.29-2.90	8	49	43	
474-22-03	13	10.67-11.28	3	56	41	
474-22-04	3	1.52-2.13	1	54	45	
474-22-04	6	3.81-4.42	0	81	19	
474-22-04	11	7.62-8.23	0	44	56	

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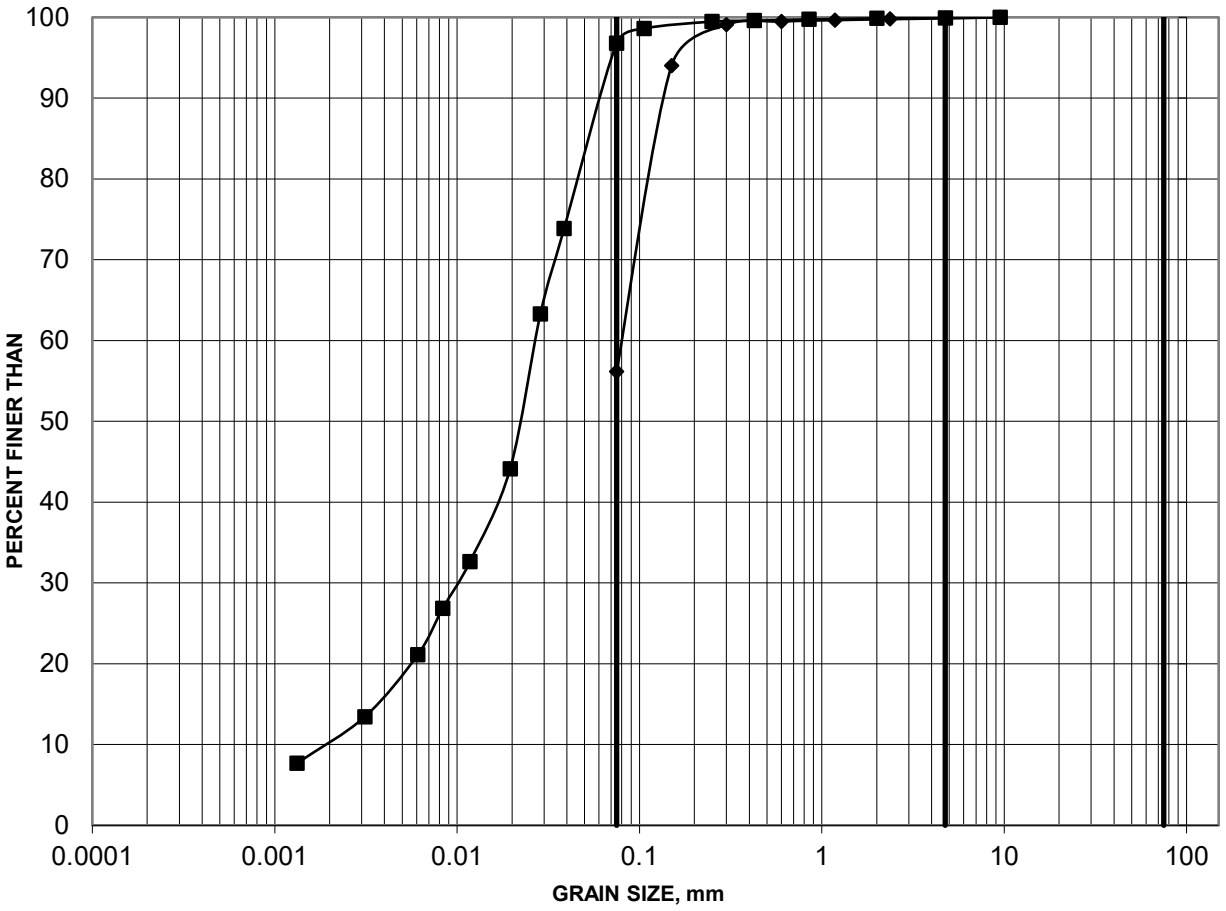
GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT (ML)



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

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	474-22-03	7	4.57-5.18	0	3	87	10
◆	474-22-04	11	7.62-8.23	0	44		56

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APPENDIX C

Analytical Laboratory Test Results

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
.
Attention: Mr. Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1985544
Date Submitted: 2022-09-07
Date Reported: 2022-09-15
Project: 1773612-W011
COC #: 899907

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:

Emma-Dawn Ferguson 2022.09.15 12:07:37 -04'00'

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
.
Attention: Mr. Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1985544
Date Submitted: 2022-09-07
Date Reported: 2022-09-15
Project: 1773612-W011
COC #: 899907

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					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'
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			8.66	9.89	9.32	9.24
	Resistivity	1	ohm-cm		787	4000	4348	2273

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.		
					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'
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

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
.
Attention: Mr. Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1985544
Date Submitted: 2022-09-07
Date Reported: 2022-09-15
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

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