Foundation Investigation and Design Report

Noise Barrier Wall
Highway 401 Improvements from 0.6 km East of Essex Road 42 to 1.5 km West of Merlin Road, Tilbury
MTO DB 2020-3011, West Region

Submitted to:

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FOUNDATION INVESTIGATION REPORT
Noise Barrier Wall
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Dillon Consulting Limited (Dillon) on behalf of Coco Paving (Coco) to provide detailed foundation engineering services as part of the Design-Build (DB) project for the Highway 401 improvements from 0.6 kilometres (km) east of Essex Road 42 easterly about 11.2 km to 1.5 km west of Merlin Road. As part of DB 2020-3011, Highway 401 will be widened from 4 to 6 lanes with the new lanes constructed towards the median. This report specifically addresses the noise barrier wall that is incorporated into the overall project. The terms of reference for the scope of work are outlined in MTO's Request for Proposal and in Golder's proposal dated October 17, 2019. The work was carried out in accordance with our Quality Control Plan for Foundations Engineering dated November 2012.

The new noise barrier wall will be located along the south shoulder of the eastbound lanes and extend from about Sta. 17+063 Twp. of Tilbury North to Sta. 10+550 Twp. of Tilbury East.

2.0 SITE DESCRIPTION

2.1 General

The project is located, as shown on the Key Plan on Drawing 1, approximately 1.3 km west of Tilbury, Ontario. The area of the site is generally flat and land use is primarily agricultural. At the location of the proposed noise barrier wall, Highway 401 has been constructed on embankment fill approaching the Queen Street overpass structure.

2.2 Site Geology

The site lies in the physiographic region of southern Ontario known as the St. Clair Clay Plains, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984[1]). Within this region, Essex County and the southwestern part of Kent County are normally discussed as a sub-region known as the Essex Clay Plain. The clay plain was deposited during the retreat of ice sheets (late Pleistocene Era) when a series of glacial lakes inundated the area. In general, the ice sheets deposited materials with a glacial-till-like gradation in the Essex County area. Depending on the locations of the glacial ice sheets and depths of water in the ice-contact glacial lakes, the materials may have been directly deposited at the contact between the ice sheet and the bedrock or, as the lake levels rose and the ice sheets retreated and floated, the soil and rock debris within and at the base of the ice were deposited through the lake water (glaciolacustrine depositional environment). The term "glacial till", in its common usage, often indicates a very dense or hard composition resulting from consolidation and densification under the weight of the ice sheet and the mineral soil particles typically have a distribution of grain sizes ranging from cobbles to clay. In many areas of Essex County, however, the majority of the soils described as "glacial till" were deposited through water and have a soft to firm consistency below an upper "crust" that has since become stiff to hard through weathering and desiccation. The bedrock is reportedly at about elevation 135 to 140 m, or

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

about 35 to 40 below the ground surface[2], and is described as limestone, dolostone and shale belonging to the Dundee Formation of the Hamilton Group[3].

3.0 INVESTIGATION PROCEDURES

The field work was carried out between August 16 and September 14, 2021 during which time ten boreholes, identified as BH-101 to BH-110, were drilled for the proposed new noise barrier wall. The Record of Borehole sheets are attached to this report and the results of laboratory testing are provided in Appendix A.

The approximate locations of the boreholes are shown on the Borehole Location Plan, Drawing 1. It is noted that these boreholes were drilled along the Highway 401 eastbound median shoulder, based on lane restrictions in place for construction operations at the time of the investigation. The table below summarizes the approximate borehole location coordinates, ground surface elevations at the borehole locations and borehole depths.

Borehole	Approximate Location				Ground Surface Elevation (m)	Depth (m)
	Northing (m)	Easting (m)	Latitude (°)	Longitude (°)		
BH-101	4,681,073.7	309,973.7	42.269221	-82.437287	178.2	10.5
BH-102	4,681,097.1	310,073.5	42.269431	-82.436077	178.3	11.3
BH-103	4,681,119.5	310,170.3	42.269632	-82.434903	179.8	10.5
BH-104	4,681,139.6	310,267.0	42.269812	-82.433731	181.7	10.7
BH-105	4,681,162.6	310,363.9	42.270019	-82.432556	182.6	10.7
BH-106	4,681,210.2	310,553.8	42.270447	-82.430253	182.6	10.5
BH-107	4,681,233.2	310,651.7	42.270652	-82.429067	181.2	10.4
BH-108	4,681,255.9	310,748.4	42.270856	-82.427894	179.5	10.4
BH-109	4,681,279.2	310,845.7	42.271065	-82.426715	178.2	10.4
BH-110	4,681,300.4	310,944.0	42.271255	-82.425522	178.2	11.1

The field work was carried out using track-mounted drilling equipment supplied and operated by a specialist drilling contractor. In the boreholes, samples of the overburden were obtained at generally 0.76 metre (m) intervals of depth using 50 millimetre (mm) outside diameter split spoon sampling equipment in accordance with ASTM D1586 using an automatic hammer. The results of the Standard Penetration Testing (SPT), as presented

[2] Sado, E.V. and Fought, R.B., 1981, *Bedrock Topography of the Chatham Area, Southern Ontario*, Ontario Geological Survey Preliminary Map P.2436, Bedrock Topography Series, Scale 1:50,000

[3] Ontario Geological Survey, 1991, *Bedrock Geology of Ontario, Southern Sheet,* Ontario Geological Survey, Map 2544, Scale 1:1,000,000.

on the Record of Borehole sheets and in Section 4, are unmodified (not standardized for hammer efficiency, borehole diameter, rod length, etc.).

The samplers limit the maximum particle size that can be sampled and tested to about 40 mm. Therefore, particles that may exist within the soils that are larger than this dimension will not be sampled or represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, are known to be present in the native soils, as discussed in the text of this report.

The boreholes were terminated about 10.4 to 11.3 m below the existing ground surface. Groundwater conditions in the boreholes were observed throughout the drilling operations. Upon completion of drilling and sampling, the boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended).

The field work was monitored on a full-time basis by Golder staff who also located the boreholes in the field, monitored the drilling, sampling and in situ testing operations and logged the boreholes. The samples were identified in the field, placed in labelled containers and transported to Golder's London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, grain size distribution analyses and Atterberg limits determinations, were carried out on selected soil samples. The results of the testing are shown on the Record of Borehole sheets and in Appendix A.

In addition, Peto MacCallum Ltd. (PML) carried out a preliminary foundation investigation at this site in October 2019, the results of which were provided in the following report:

- PML Report 19KF029A titled "Detail Design Foundation Investigation and Design Report for Widening of Queen Street Overpasses, Site Nos. 06X-0051/B1 & B2, Highway 401 – Station 17+860, Township of Tilbury, Chatham-Kent, Ontario, GWP 3034-19-01, WP 3041-19-01 & 3043-19-01, Assignment No. 3017-E-0006/0007, Work Item No. 06", GEOCRES No. 40J8-75, dated December 2019.

The Records of Boreholes and the related laboratory testing data from that report are attached in Appendix B. The approximate locations of the boreholes are shown on the Borehole Location Plan, Drawing 1. The table below summarizes the borehole location coordinates, ground surface elevations at the borehole locations and borehole depths.

Borehole	Approximate Location				Ground Surface Elevation (m)	Depth (m)
	Easting (m)	Northing (m)	Latitude (°)	Longitude (°)		
BH QEB	310 477.4	4 681 197.2	42.270321	-82.43118	182.5	30.0
BH QWB	310 434.6	4 681 187.4	42.270233	-82.43169	182.5	30.0

4.0 SUBSURFACE CONDITIONS

4.1 General

Detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the geotechnical laboratory testing carried out on selected samples, are presented on the borehole records and figures in Appendices A and B. The stratigraphic boundaries shown on the borehole records are inferred from

non-continuous samples and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsurface conditions will vary between and beyond the borehole locations.

Groundwater levels/conditions encountered in the boreholes during and shortly after drilling may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized. Groundwater levels and seepage conditions in the area will fluctuate seasonally and in response to precipitation events.

In general, the subsurface conditions encountered in the boreholes consist of fill materials overlying a deposit of silty clay to clayey silt till. These ground conditions are described in additional detail below.

4.2 Soil Conditions

4.2.1 Fill and Topsoil

Granular fill materials associated with the existing pavements were encountered at the shoulder surface in all of the boreholes, except Boreholes 104 and 105 which were drilled through the pavement and encountered 175 mm of asphalt overlying granular fill. The granular fill materials were about 0.8 to 1.5 m thick. The compact to very dense granular fill materials had Standard Penetration Test (SPT) N values ranging from 10 to 86 blows per 0.3 m of penetration. Samples of the granular fill had water contents ranging from about 8 to 9 per cent.

Silty clay embankment fill materials were encountered beneath the granular materials between about elevations 177.4 and 181.8 m. The silty clay fill was about 1.5 to 4.4 m thick at the borehole locations. The firm to hard clayey fill had SPT N values of 5 to 16 blows per 0.3 m of penetration. Samples of the silty clay fill had water contents that ranged from about 11 to 31 per cent. Atterberg limits determinations completed on samples of the silty clay fill indicated plastic limits of about 18 to 20 per cent and liquid limits of about 37 to 48 per cent. These data are shown on the Plasticity Chart on Figure A-1 in Appendix A. Grain size distribution curves for samples of the silty clay fill are provided on Figure A-2.

Layers of silty topsoil were encountered beneath the embankment fill in BH-104 and BH-105. These layers were about 0.3 m thick at the borehole locations. Samples of the buried topsoil had water contents of about 23 and 55 per cent.

4.2.2 Silty Clay to Clayey Silt Till

Beneath the fill and buried topsoil, where encountered, silty clay to clayey silt till was encountered at about elevation 175.2 to 177.5 m. All of the boreholes were terminated in the silty clay to clayey silt till after exploring it for about 4.4 to 8.8 m. The clayey silt to silty clay till had Standard Penetration Test (SPT) N values ranging from 1 to 25 blows per 0.3 m of penetration. Field vane shear tests attempted in the softer zones of the till indicated undrained shear strengths ranging from about 67 to 115 kilopascals (kPa). Based on the vane shear strength measurements in conjunction with the SPT N values, the silty clay to clayey silt till has a stiff to very stiff consistency.

Samples of the silty clay to clayey silt till had water contents that ranged from about 10 to 23 per cent. Atterberg limits determinations completed on samples of the till indicated plastic limits of about 15 to 22 per cent and liquid

limits of about 32 to 50 per cent. These data are shown on the Plasticity Chart on Figure A-3 in Appendix A. Grain size distribution curves for samples of the silty clay to clayey silt till are provided on Figure A-4.

A layer of silty sand was encountered within the silty clay to clayey silt till in BH-105 at elevation 173.5 m. The silty sand was about 0.4 m thick with a water content of about 12 per cent.

Although not explicitly encountered during the borehole investigation for the noise barrier walls or in the previous investigation and foundation construction at the Queen Street bridge site, cobbles and boulders are known to be present in the glacial till strata in this area of Ontario.

4.3 Groundwater Conditions

All of the boreholes remained free of observable water during drilling between August 16 and September 14, 2021. Based on our experience in the area and explorations in the general site area, the long-term groundwater level is inferred to be between about elevation 175 and 176 m.

5.0 CLOSURE

This report was prepared by Michael E. Beadle, P.Eng., an Associate with Golder Associates Ltd. An independent quality review of this report was carried out by Lisa C. Coyne, P.Eng., the Designated MTO Foundations Contact for this assignment.

Golder Associates Ltd.

Michael E. Beadle, P.Eng.
Associate

Lisa C. Coyne, P.Eng.
Principal, Designated MTO Foundations Contact

MEB/LCC/cr

https://golderassociates.sharepoint.com/sites/124899/project files/6 deliverables/ph 1000-fdn/rpts/r07-rev0 noise barrier wall/20141385-1000-r07-rev0 (final) fidr noise barrier wall_27oct2021.docx

PART B

FOUNDATION DESIGN REPORT
Noise Barrier Wall
Highway 401 Improvements from 0.6 km East of Essex Road 42 to 1.5 km West of Merlin Road, Tilbury
MTO DB 2020-3011, West Region

6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical recommendations for design of the noise barrier wall foundations by the proprietary wall designer. The recommendations are based on our interpretation of the factual information obtained during the current investigation and previous investigation completed by others as outlined in Part A of this report. This Foundation Investigation and Design Report, with the interpretation and recommendations, is intended for the use of the proprietary wall designer. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of factual information provided as it may affect equipment section, proposed construction methods and scheduling.

6.2 Noise Barrier Wall Foundations

The noise barrier walls should be constructed in accordance with Ontario Provincial Standard Specification (OPSS) 760 (*Noise Barrier Systems,* dated November 2014). Support for the noise barrier wall is expected to be provided by caissons (drilled shafts). For the assessments described below, the resistance provided by the upper 1 m of soil should be neglected to account for frost action. In addition, should the shafts be located within 1 m of the edge of embankment, the shaft depths should be increased by 0.5 in accordance with OPSS 760.

Geotechnical parameters for design of the caisson foundations for the proposed noise barrier wall are provided in the table below based on the subsurface conditions encountered in the boreholes. These parameters are based on field and laboratory test data as well as on accepted correlations and the analysis was tempered by engineering judgment based on experience in similar soils.

Location	Soil Design Parameter	
	Undrained	Drained
Highway 401 Eastbound Lanes Sta. 17+000 Twp. Of Tilbury North to Sta. 10+550 Twp. Of Tilbury East	S_u = 100 kPa	c' = 0, ϕ' = 27 degrees

Both undrained shear strength (s_u) and drained parameters (effective cohesion ($c_э$) and effective friction angle ($\phi_э$)) have been provided; it is recommended that the caisson design be checked for both the undrained and the drained conditions, and the greater of the two calculated caisson depths shall govern.

6.3 Construction Considerations

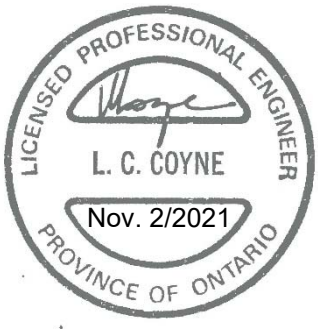
As noted above, the caisson foundations should be constructed in accordance with OPSS 760.

As indicated in Part A of this report, while not explicitly encountered in any of the boreholes during the investigation, cobbles and boulders are known to exist in the silty clay to clayey silt till strata and the contractor should be prepared to address their presence, if required. In accordance with DBSP903 (*Deep Foundations*), the contractor is required to maintain sidewall stability throughout the excavation of the caisson and concrete placement. Caisson auger holes in the clayey fill and silty clay to clayey silt till are expected to be stable in the short-term (i.e., concrete placed the same day as augering), while some ravelling of the upper granular fill should be expected. Provided that ravelling of the granular fill is not significant, temporary liners will likely not be necessary.

7.0 CLOSURE

This report was prepared by Michael E. Beadle, P.Eng., an Associate with Golder Associates. An independent quality review of this report was carried out by Lisa C. Coyne, P.Eng., the Designated MTO Foundations Contact for this assignment.

Golder Associates Ltd.



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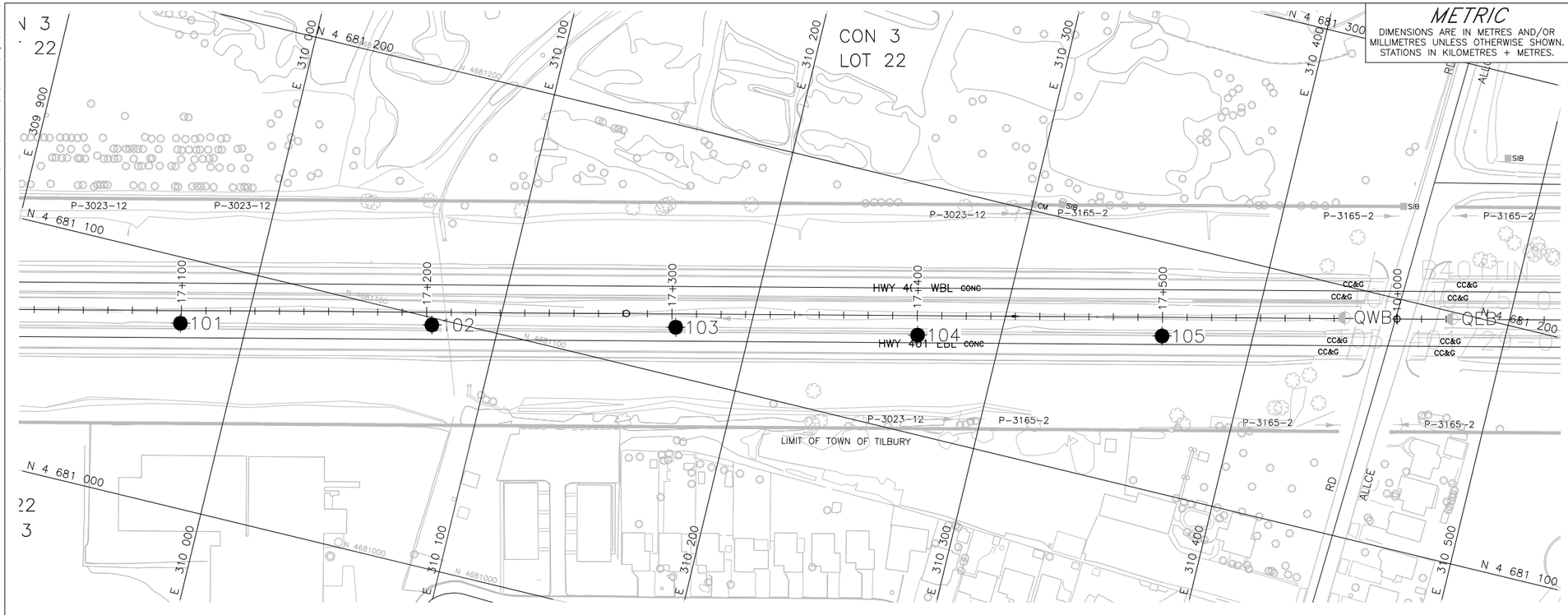
Principal, Designated MTO Foundations Contact

MEB/LCC/cr

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
20 0 20 40 m

METRIC

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

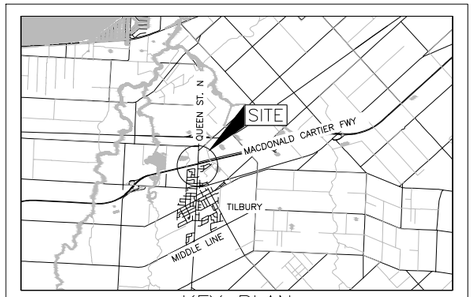
CONT No. DB 2020-3011
GWP No. 3034-19-01

NOISE BARRIER WALL

BOREHOLE LOCATION PLAN

SHEET

GOLDER
MEMBER OF WSP



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
QWB	182.5	4681187.4	310434.6
QEB	182.5	4681197.2	310477.4
101	178.2	4681073.7	309973.7
102	178.3	4681097.1	310073.5
103	179.8	4681119.5	310170.3
104	181.7	4681139.6	310267.0
105	182.6	4681162.6	310363.9
106	182.6	4681210.2	310553.8
107	181.2	4681233.2	310651.7
108	179.5	4681255.9	310748.4
109	178.2	4681279.2	310845.7
110	178.2	4681300.4	310944.0

LICENSED PROFESSIONAL ENGINEER
M.E. BEADLE
Nov. 01, 2021
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
L.C. COYNE
Nov. 01, 2021
PROVINCE OF ONTARIO

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.

REFERENCE

Base plans provided in digital format by Dillon Consulting , drawing file nos. B401TIN1.dwg and B401TIE1.dwg, received September 2021.
Alignment provided in digital format by Dillon, file no. Contract 2020-3011 – Alignment (Highway 401).xml, received October 1, 2021.

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 40J8-82

HWY. 401	PROJECT NO. 20141385		DIST. .
SUBM'D. MD	CHKD. MEB	DATE: 11/1/2021	SITE: .
DRAWN: SA	CHKD. MEB	APPD. LCC	DWG. 1

PLOT DATE: November 3, 2021
FILENAME: S:\Clients\MTO\Hwy_401_Essex_Rd_#\09_PROJ\20141385_Dillon\02_PROD\0001_Noise_Barrier_Wall\20141385-0001-BEC-0001.dwg

APPENDIX A

Records of Boreholes and Laboratory Test Results – 2021 Investigation

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

3. 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.
4. 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 $\gamma = \rho g$ (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_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No 101

SHEET 1 OF 1 **METRIC**

PROJECT 20141385
G.W.P. 3034-19-01
LOCATION N 4681073.7; E 309973.7 MTM NAD 83 ZONE 11 (LAT. 42.269221; LONG. -82.437287)
ORIGINATED BY MD
DIST HWY 401
BOREHOLE TYPE
COMPILED BY
DATUM Geodetic
DATE August 16, 2021
CHECKED BY MEB

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.2	GROUND SURFACE						178				
0.0	SAND (SM) and gravel, some silt (FILL) Compact Brown			SS	15						
177.4							177				
0.8	FILL - SILTY CLAY (CL-CI), some sand, trace topsoil Stiff Brown-grey		1	SS	9						1 12 40 47
			2	SS	11		176				
			3	SS	9						
175.2							175				
3.1	SILTY CLAY (CL-CI), some sand, trace gravel Stiff to very stiff Brown turning grey at a depth of 6.1 m		4	SS	19						1 15 41 43
			5	SS	15		174				
			6	SS	13						
			7	SS	12		173				2 15 39 44
			8	SS	8						
			9	SS	9		172				
			10	SS	5						
			11	SS	3		171				0 17 40 43
			12	SS	6						
167.7			13	SS	7		170				
10.5	END OF BOREHOLE						169				
							168				

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

GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No 102

SHEET 1 OF 1

METRIC

PROJECT 20141385
G.W.P. 3034-19-01
LOCATION N 4681097.1; E 310073.5 MTM NAD 83 ZONE 11 (LAT. 42.269431; LONG. -82.436077)
ORIGINATED BY MD
DIST HWY 401
BOREHOLE TYPE
COMPILED BY
DATUM Geodetic
DATE August 12, 2021
CHECKED BY MEB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.3	GROUND SURFACE								
0.0	SAND (SM) and gravel, some silt (FILL) Compact Brown			SS	12		178		
177.5									
0.8	SILTY CLAY (CL-CI) with sand seams, trace to some topsoil, trace gravel (FILL) Firm to stiff Brown-grey		1	SS	7		177		
			2	SS	9				0 30 33 37
			3	SS	5		176		
175.3									
3.1	SILTY CLAY (CL-CI), some sand, trace gravel Firm to stiff Brown turning grey at a depth of 5.3 m		4	SS	6		175		
			5	SS	7				1 19 43 37
			6	SS	15		174		
			7	SS	7		173		
			8	SS	8		172		
			9	SS	7				
			10	SS	6		171		
			11	SS	3		170		2 16 39 43
			12	SS	3		169		
167.0							168		
11.3	END OF BOREHOLE								

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 (%)
10 20 30

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

RECORD OF BOREHOLE No 103

SHEET 1 OF 1

METRIC

PROJECT 20141385

G.W.P. 3034-19-01

LOCATION N 4681119.5; E 310170.3 MTM NAD 83 ZONE 11 (LAT. 42.269632; LONG. -82.434903)

ORIGINATED BY MD

DIST HWY 401

BOREHOLE TYPE

COMPILED BY

DATUM Geodetic

DATE August 16, 2021

CHECKED BY MEB

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
179.8	GROUND SURFACE										
0.0	SAND (SM) and gravel, some silt (FILL) Compact to very dense Brown			SS	18						
			1	SS	86		179		○		
178.3											
1.5	SILTY CLAY (CL-CI), some sand, trace to some topsoil (FILL) Stiff Brown-grey		2	SS	9		178		○		3 19 37 41
			3	SS	14				○		
176.8							177				
3.1	SILTY CLAY (CL-CI), some sand, trace gravel Very stiff becoming soft Brown turning grey at a depth of 6.1 m		4	SS	11				○		
			5	SS	16		176		○		
			6	SS	23		175		○		2 15 40 43
			7	SS	18				○		
			8	SS	9		174		○—		3 15 40 42
			9	SS	7		173		○		
			10	SS	10		172		○		
			11	SS	4		171		○		
			12	SS	4				○		
			13	SS	3		170		○		
169.3											
10.5	END OF BOREHOLE										

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

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

RECORD OF BOREHOLE No 104

SHEET 1 OF 1

METRIC

PROJECT 20141385

G.W.P. 3034-19-01

LOCATION N 4681139.6; E 310267.0 MTM NAD 83 ZONE 11 (LAT. 42.269812; LONG. -82.433731)

ORIGINATED BY MD

DIST HWY 401

BOREHOLE TYPE

COMPILED BY

DATUM Geodetic

DATE August 17, 2021

CHECKED BY MEB

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 (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.7	GROUND SURFACE										
0.0	ASPHALT (175 mm)										
0.2	SAND (SM) and gravel, some silt (FILL) Dense Brown			SS	36						
			1	SS	31						
180.0											
1.7	SILTY CLAY (CL-CI), some sand, trace gravel, trace topsoil (FILL) Stiff Brown-grey		2	SS	13						
			3	SS	10						
			4	SS	13						
			5	SS	13						1 16 45 38
			6A 6B	SS	13						
176.5											
176.2	SILTY TOPSOIL Black										
5.5	SILTY CLAY (CL-CI), some sand, trace gravel Very stiff becoming firm Brown turning grey at a depth of 8.4 m		7	SS	17						1 14 42 43
			8	SS	25						
			9	SS	20						
			10	SS	19						
			11	SS	10						
			12	SS	7						
			13	SS	8						
171.0											
10.7	END OF BOREHOLE										

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No 105

SHEET 1 OF 1 **METRIC**

PROJECT 20141385
G.W.P. 3034-19-01
DIST HWY 401
DATUM Geodetic
LOCATION N 4681162.6; E 310363.9 MTM NAD 83 ZONE 11 (LAT. 42.270019; LONG. -82.432556)
BOREHOLE TYPE
DATE August 17, 2021
ORIGINATED BY MD
COMPILED BY
CHECKED BY MEB

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 (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.6	GROUND SURFACE										
0.0	ASPHALT (175 mm)										
0.2	SAND (SM) and gravel, some silt (FILL) Compact Brown			SS	21		182				
180.9			1	SS	10						
1.7	SILTY CLAY (CL-CI), some sand, trace gravel, some topsoil (FILL) Stiff Brown-grey		2	SS	8		181				
			3	SS	6		180				2 15 42 41
			4	SS	9		179				
			5A 5B	SS	10						
			6	SS	8		178				
			7A 7B	SS	12		177				
176.6	SILTY TOPSOIL Black								54.6		
6.3	SILTY CLAY (CL-CI), some sand, trace gravel Stiff to very stiff Brown		8	SS	18		176				
			9	SS	11						0 12 49 39
			10	SS	14		175				
			11	SS	12		174				
173.3											
9.3	SILTY SAND (CL-SM), trace gravel Compact Brown		12A 12B	SS	24		173				
172.8											
9.8	SILTY CLAY (CI), some sand Stiff to very stiff Grey		13	SS	14		172				
171.9											
10.7	END OF BOREHOLE										

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

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GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No 106

SHEET 1 OF 1

METRIC

PROJECT 20141385
G.W.P. 3034-19-01
LOCATION N 4681210.2; E 310553.8 MTM NAD 83 ZONE 11 (LAT. 42.270447; LONG. -82.430253)
ORIGINATED BY MD
DIST HWY 401
BOREHOLE TYPE
COMPILED BY
DATUM Geodetic
DATE September 7, 2021
CHECKED BY MEB

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 (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.6	GROUND SURFACE										
0.0 / 181.8	SAND (SM) and gravel, some silt (FILL) Brown										
0.8 / 177.4	SILTY CLAY (CL-CI), some sand, trace gravel, trace topsoil (FILL) Stiff to very stiff		1	SS	13		182				
			2	SS	11		181				1 16 41 42
			3	SS	11		180				
			4	SS	10		179				
			5	SS	11						
			6	SS	11		178				
5.2 / 172.2	SILTY CLAY (CL-CI), some sand, trace gravel Stiff to very stiff Brown turning to grey at a depth of 8.2 m		7	SS	12		177	50			1 13 39 47
			8	SS	12		176				
			9	SS	12		175				
			10	SS	13						
			11	SS	14		174				
			12	SS	11		173				2 15 41 42
			13	SS	12						
10.4	END OF BOREHOLE										

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

RECORD OF BOREHOLE No 107

SHEET 1 OF 1

METRIC

PROJECT 20141385

G.W.P. 3034-19-01

LOCATION N 4681233.2; E 310651.7 MTM NAD 83 ZONE 11 (LAT. 42.270652; LONG. -82.429067)

ORIGINATED BY MD

DIST HWY 401

BOREHOLE TYPE

COMPILED BY

DATUM Geodetic

DATE September 14, 2021

CHECKED BY MEB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.3	GROUND SURFACE						181				
0.0	SAND (SM) and gravel, some silt (FILL) Brown										
180.5							180				
0.8	SILTY CLAY (CL-CI), some sand, trace gravel, trace topsoil (FILL) Stiff Brown-grey		1	SS	15						
			2	SS	9		179				
			3	SS	9						
			4	SS	15		178				2 18 40 40
177.5											
3.8	SILTY CLAY (CL-CI), some sand, trace gravel Stiff becoming firm Brown turning grey at a depth of 8.2 m		5	SS	11		177				
			6	SS	11						
			7	SS	8		176				
			8	SS	9		175				
			9	SS	12						1 17 39 43
			10	SS	15		174				
			11	SS	8		173				
			12	SS	6		172				
170.9			13	SS	5		171				
10.4	END OF BOREHOLE										

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No 108

SHEET 1 OF 1 **METRIC**

PROJECT 20141385
G.W.P. 3034-19-01
DIST HWY 401
DATUM Geodetic

LOCATION N 4681255.9; E 310748.4 MTM NAD 83 ZONE 11 (LAT. 42.270856; LONG. -82.427894)
BOREHOLE TYPE
DATE September 14, 2021

ORIGINATED BY MD
COMPILED BY
CHECKED BY MEB

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 (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.5	GROUND SURFACE						179				
0.0 / 178.7	SAND (SM) and gravel, some silt (FILL) Brown										
0.8 / 178.0	SILTY CLAY (CL-CI) with sand and gravel (FILL) Stiff Brown		1	SS	11		178				
1.5 / 176.5	SILTY CLAY (CL-CI), some sand, trace gravel (FILL) Stiff Brown-grey		2	SS	14						
			3	SS	10		177	48			1 11 37 51
3.1 / 175.7	SILTY CLAY (CL-CI), some sand, some topsoil Stiff Brown-grey		4	SS	11		176				
3.8	SILTY CLAY (CL-CI), some sand, trace gravel Very stiff becoming firm Brown turning grey at a depth of 6.1 m		5	SS	8						
			6	SS	16		175				3 16 39 42
			7	SS	13		174				
			8	SS	8						
			9	SS	6		173				3 17 39 41
			10	SS	5		172				
			11	SS	3		171	>96 +			
			12	SS	3		170	× × + +			
169.1											
10.4	END OF BOREHOLE										

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

RECORD OF BOREHOLE No 109

SHEET 1 OF 1

METRIC

PROJECT 20141385

G.W.P. 3034-19-01

LOCATION N 4681279.2; E 310845.7 MTM NAD 83 ZONE 11 (LAT. 42.271065; LONG. -82.426715)

ORIGINATED BY MD

DIST HWY 401

BOREHOLE TYPE

COMPILED BY

DATUM Geodetic

DATE September 4, 2021

CHECKED BY MEB

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
178.3	GROUND SURFACE						178				
0.0	SAND (SM) and gravel, some silt (FILL) Brown										
177.5							177				
0.8	SILTY CLAY (CI), some sand, trace gravel, trace topsoil (FILL) Stiff Brown-grey		1	SS	12						
			2	SS	9		176				0 13 38 49
			3	SS	10						
175.3							175				
3.1	SILTY CLAY (CL-CI), some sand, trace gravel Very stiff to firm Brown turning grey at a depth of 5.4 m		4	SS	12						
			5	SS	15		174				
			6	SS	12						11 16 36 37
			7	SS	6		173				
			8	SS	6		172	>96 +, >96 +			
			9	SS	4		171				
			10	SS	4		170	>96 +, >96 +			3 19 38 40
			11	SS	3		169				
167.9							168				
10.4	END OF BOREHOLE										

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No 110

SHEET 1 OF 1

METRIC

PROJECT 20141385
G.W.P. 3034-19-01
LOCATION N 4681300.4; E 310944.0 MTM NAD 83 ZONE 11 (LAT. 42.271255; LONG. -82.425522)
ORIGINATED BY MD
DIST HWY 401
BOREHOLE TYPE
COMPILED BY
DATUM Geodetic
DATE September 14, 2021
CHECKED BY MEB

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 (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.2	GROUND SURFACE						178				
0.0	SAND (SM) and gravel, some silt (FILL) Brown										
177.4							177				
0.8	SILTY CLAY (CI), some sand, trace gravel, trace roots (FILL) Stiff Brown		1	SS	11						
			2	SS	9						0 15 38 47
175.9							176				
2.3	SILTY CLAY (CL-CI), some sand, trace gravel Stiff to soft Brown turning grey at a depth of 3.8 m		3	SS	8						
			4	SS	14		175				
			5	SS	9						2 16 41 41
			6	SS	6		174				
			7	SS	4		173				
			8	SS	6		172				
			9	SS	4		171				
			10	SS	3						1 17 39 43
			11	SS	1		170				
			12	SS	2		169				
167.1							168				
11.1	END OF BOREHOLE										

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

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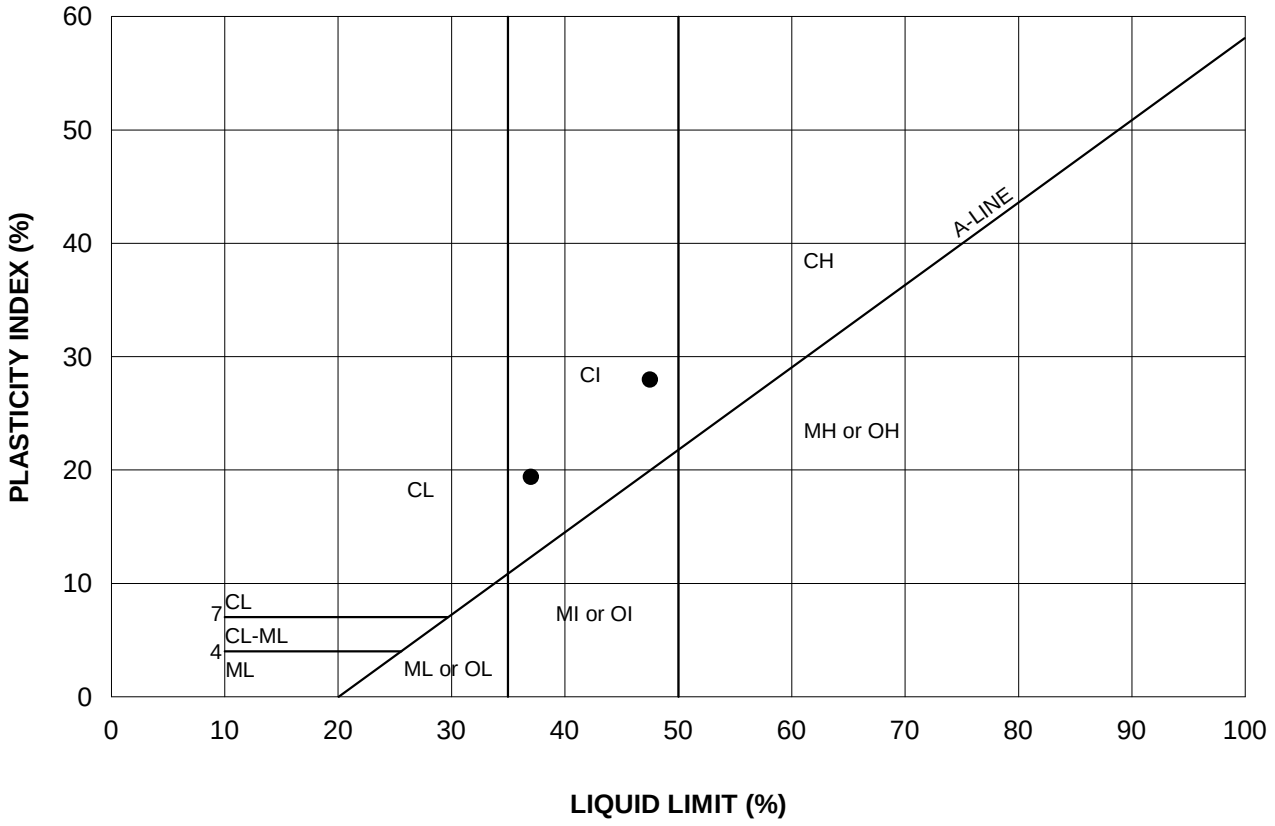

PROJECT	NOISE BARRIER WALL DB 2020-3011
TITLE	**PLASTICITY CHART CLAYEY FILL**

GOLDER

PROJECT No.			20141385	FILE No. A-1
				SCALE AS SHOWN REV. 0
DRAWN	MEB	OCT 1/21		**FIGURE A-1**
CHECK				

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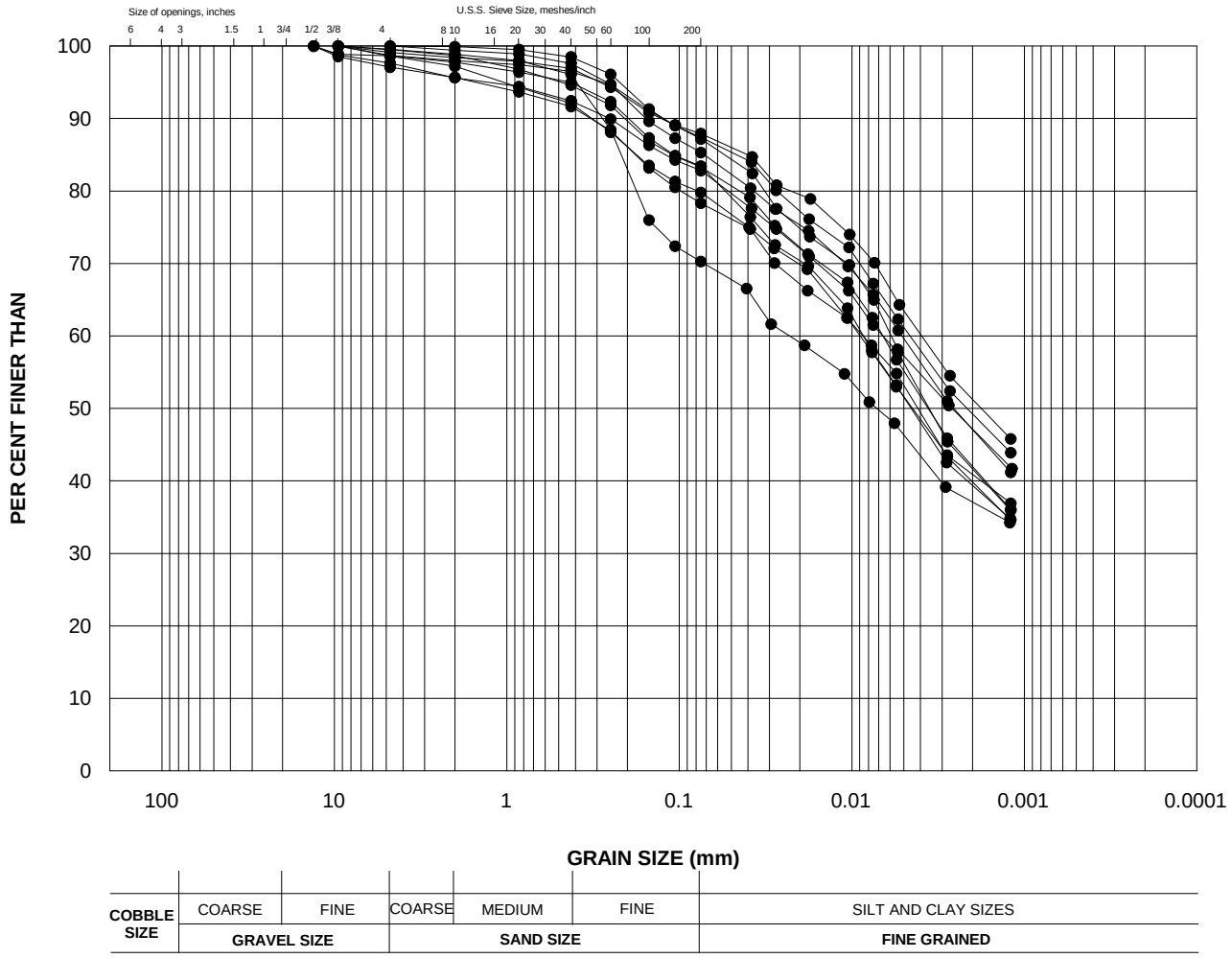

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PROJECT

NOISE BARRIER WALL
DB 2020-3011

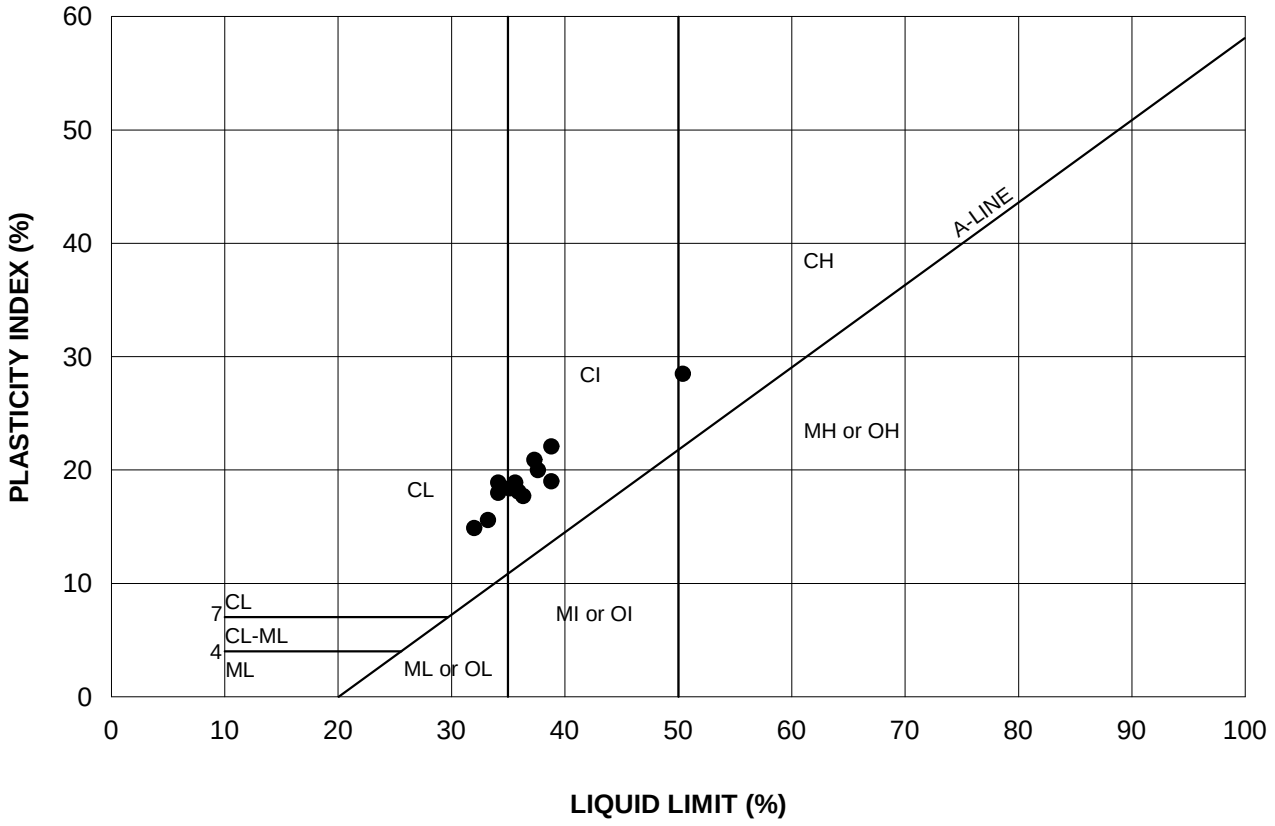
TITLE

GRAIN SIZE DISTRIBUTION
CLAYEY FILL

GOLDER

PROJECT No.		20141385	**FILE No.**	
			SCALE AS SHOWN	**REV.** 0
DRAWN	MEB	OCT 4/21		
CHECK				

FIGURE A-2



PROJECT	NOISE BARRIER WALL DB 2020-3011
TITLE	**PLASTICITY CHART** **SILTY CLAY TO CLAYEY SILT TILL**

PROJECT No.			20141385	FILE No.	A-3
				SCALE AS SHOWN	REV. 0
DRAWN	MEB		OCT 1/21		
CHECK					

GOLDER

FIGURE A-3

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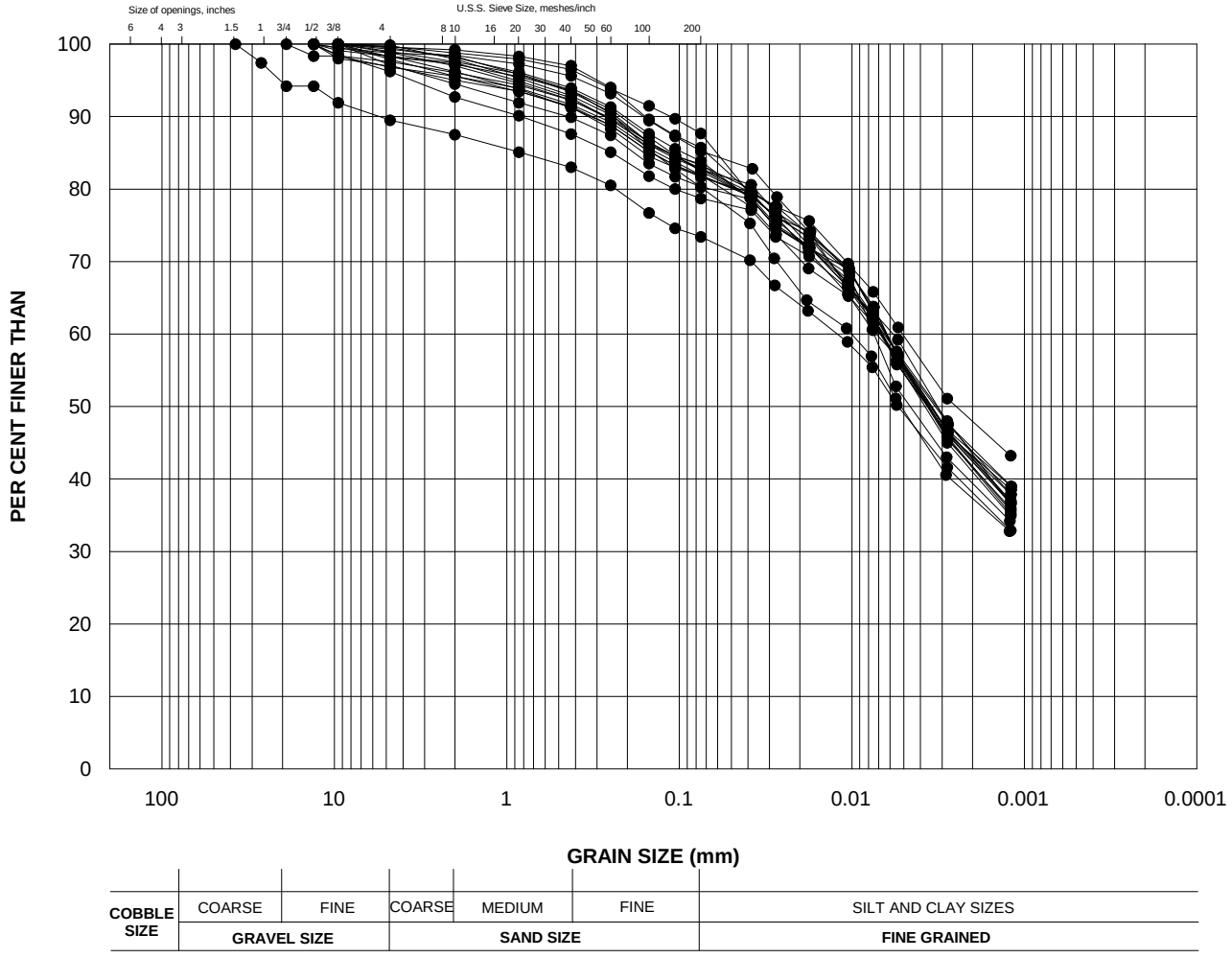


C:\Users\Mbeadle\OneDrive - Golder Associates\User Drive\401 DB Essex\Foundation Reports\Noise Wall\A-4.grf

PROJECT

NOISE BARRIER WALL
DB 2020-3011

TITLE

GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT TILL

GOLDER

PROJECT No.			20141385	**FILE No.**	
				SCALE AS SHOWN	**REV.** 0
DRAWN	MEB		OCT 4/21		
CHECK					

FIGURE A-4

APPENDIX B

Records of Boreholes and Laboratory Test Results – Previous Investigation

RECORD OF BOREHOLE No QEB

1 OF 3

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 681 197.2 N; 310 477.4 E ORIGINATED BY J.O.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.

DATUM Geodetic DATE 2019.10.01 - 2019.10.02 LATITUDE 42.270321 LONGITUDE -82.431176 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	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, × LAB VANE) (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
182.5	Ground										
0.0	gravelly SAND Compact, Brown, Moist (FILL)		1	SS	21		182		○		
			2	SS	16				○		
			3	SS	10		181		○		
			4	SS	8		180		○		
	sity clay to clayey silt		5	SS	10		179		○		
			6	SS	9				⊢○⊣		6 17 37 40
			7	SS	10		178		○		
			8	SS	6		177		○		
175.8			9	SS	8		176		○		
6.7	SILTY CLAY TO CLAYEY SILT, some sand, trace gravel Stiff to very stiff, Grey, Moist (TILL)			VANE				>>			
			10	SS	16		175		⊢○⊣		1 20 41 38
			11	SS	14		174		○		
			12	SS	9		173		○		
			13	SS	8		172		○		
				VANE			171	+2			
			14	SS	8		170		⊢○⊣		1 17 40 42
167.5				VANE			169	>>			
							168				

Continued Next Page

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

RECORD OF BOREHOLE No QEB 2 OF 3 METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 681 197.2 N; 310 477.4 E ORIGINATED BY J.O.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.

DATUM Geodetic DATE 2019.10.01 - 2019.10.02 LATITUDE 42.270321 LONGITUDE -82.431176 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	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
167.5											
15.0	*(Cont'd)* SILTY CLAY TO CLAYEY SILT, some sand, trace gravel Stiff, Grey, Moist (TILL)		15	SS	9		167		○		
							166				
			16	SS	10		165		○		
			17	SS	7		164		○		
				VANE			163	+1			
			18	SS	6				⊢○⊣		2 19 38 41
				VANE			162	+1			
							161				
							160				
			19	SS	5				○		
				VANE			159	+2			
							158				
							157				
			20	SS	7				⊢○⊣		4 15 38 43
				VANE			156	+2			
							155				
							154				
			21	SS	6		153		○		
152.5				VANE				+1			

Continued Next Page

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

RECORD OF BOREHOLE No QEB

3 OF 3 **METRIC**

G.W.P. 3034-19-00 LOCATION Coords: 4 681 197.2 N; 310 477.4 E ORIGINATED BY J.O.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.

DATUM Geodetic DATE 2019.10.01 - 2019.10.02 LATITUDE 42.270321 LONGITUDE -82.431176 CHECKED BY N.R.

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 × LAB VANE 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
152.5 30.0	End of borehole										

▼ Groundwater level measured in monitoring well

NOTES:
1. Groundwater was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers.

Monitoring Well Readings:

Date	Depth (m)	Elev.
Oct.11/'19	DRY	-
Oct.24/'19	7.0	175.5
Oct.28/'19	7.0	175.5

Monitoring Well Legend:
- Stick-up Monument
- Bentonite
- Filter Sand
- 19 mm PVC Screen
- Filter Bottom

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

RECORD OF BOREHOLE No QWB

1 OF 3 **METRIC**

G.W.P. 3034-19-00 LOCATION Coords: 4 681 187.4 N; 310 434.6 E ORIGINATED BY J.O.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.

DATUM Geodetic DATE 2019.10.03 - 2019.10.04 LATITUDE 42.270233 LONGITUDE -82.431695 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	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, × LAB VANE) (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
182.5	Ground										
0.0	gravelly SAND Compact, Brown, Moist (FILL)		1	SS	18		182		○		
			2	SS	15				○		
			3	SS	23		181		○		
			4	SS	17		180		○		
			5	SS	7		179		○		16 73 7 4
			6	SS	18				○		
	sity clay to clayey silt		7	SS	8		178		⊖		
			8	SS	9		177		⊖		2 17 37 44
175.8	silty sand		9	SS	9		176		⊖		
6.7	SILTY CLAY TO CLAYEY SILT, some sand, trace gravel Stiff, Grey, Moist (TILL)		10	SS	15		175		⊖		
			11	SS	14		174		⊖		1 16 38 45
			12	SS	11		173		⊖		
			13	SS	9		172		⊖		
			14	TW			171		⊖		
				VANE			170		⊖		1 17 40 42 P_c = 365 kPa C_c = 0.17 e_o = 0.637 SG = 2.709
167.5							169		⊖		
							168	+1			

Continued Next Page

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

RECORD OF BOREHOLE No QWB 2 OF 3 METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 681 187.4 N; 310 434.6 E ORIGINATED BY J.O.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.

DATUM Geodetic DATE 2019.10.03 - 2019.10.04 LATITUDE 42.270233 LONGITUDE -82.431695 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	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 × LAB VANE) (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
167.5											
15.0	*(Cont'd)* CLAYEY SILT TO SILTY CLAY, some sand, trace gravel Stiff, Grey, Moist (TILL)		15	SS	6		167				2 17 39 42
				VANE				>>			
			16	SS	8		166		○		
				VANE			165	+2			
			17	SS	5		164				2 17 37 44
				VANE				+1			
			18	SS	6		163		○		
				VANE			162	+1			
							161				
							160				
			19	SS	4				○		
				VANE			159	+2			
							158				
							157				
			20	SS	6				○		
				VANE			156	+2			
							155				
							154				
			21	SS	8						0 19 38 43
152.5				VANE			153	+1			

Continued Next Page

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

RECORD OF BOREHOLE No QWB

3 OF 3 **METRIC**

G.W.P. 3034-19-00 LOCATION Coords: 4 681 187.4 N; 310 434.6 E ORIGINATED BY J.O.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.

DATUM Geodetic DATE 2019.10.03 - 2019.10.04 LATITUDE 42.270233 LONGITUDE -82.431695 CHECKED BY N.R.

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 × LAB VANE 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
152.5 30.0	End of borehole										

▼ Groundwater level measured in monitoring well

NOTES:
1. Groundwater was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers.

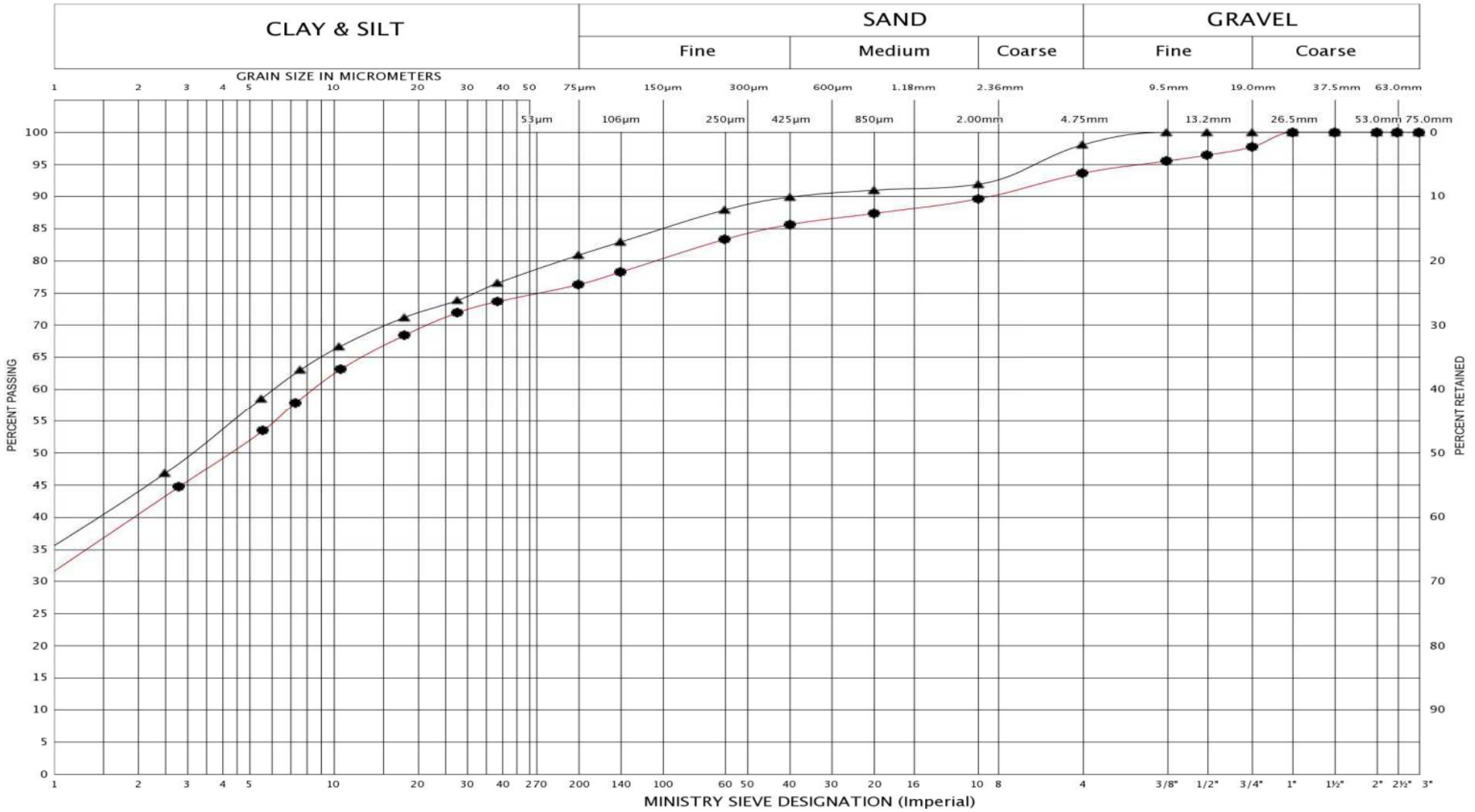
Monitoring Well Readings:

Date	Depth (m)	Elev.
Oct.11/'19	DRY	-
Oct.24/'19	4.8	177.7
Oct.28/'19	5.6	176.9

Monitoring Well Legend:
- Stick-up Monument
- Bentonite
- Filter Sand
- 19 mm PVC Screen
- Filter Bottom

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

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	QEB	QWB
	SAMPLE	6	8
	SYMBOL	●	▲

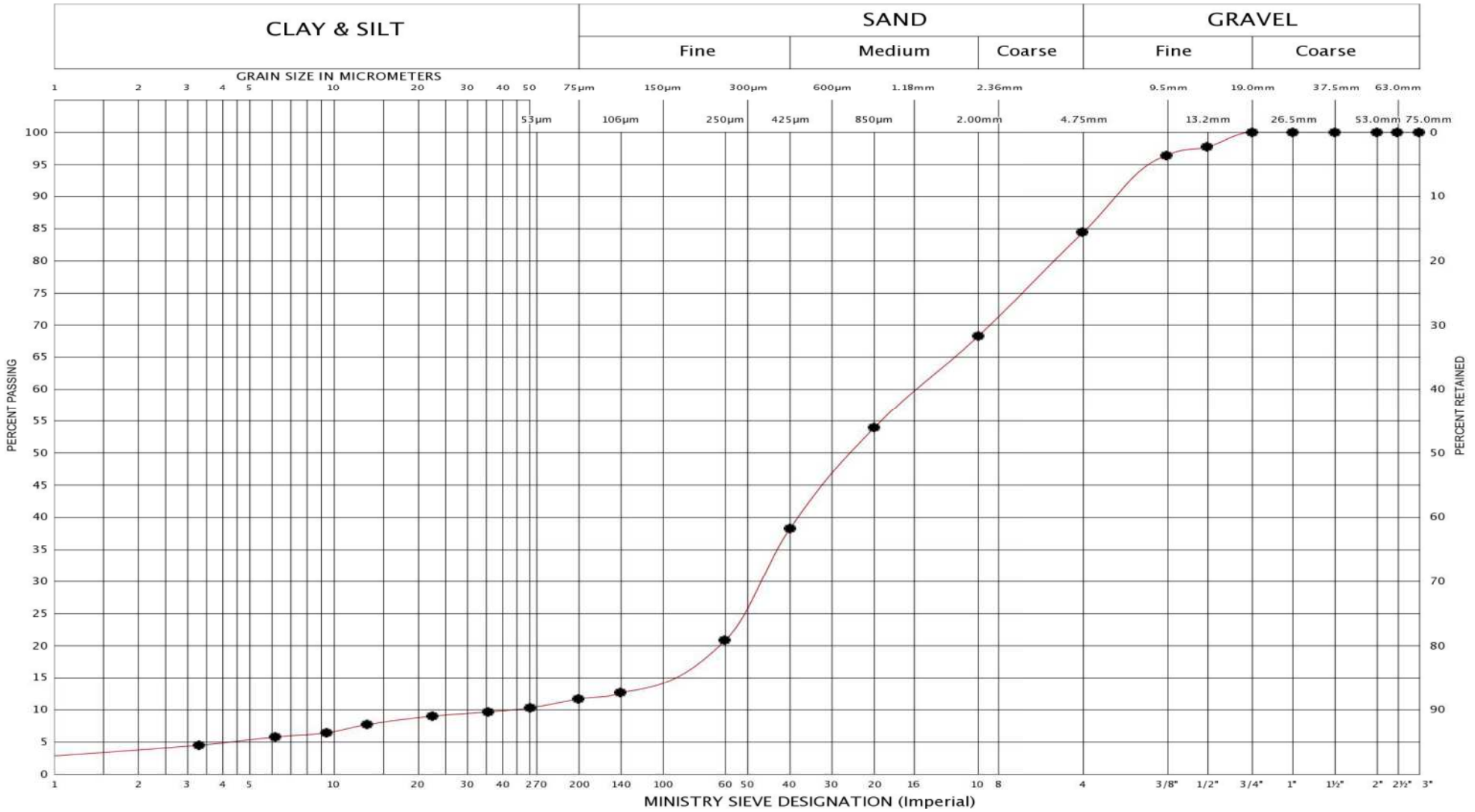
Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, Some Sand , Trace Gravel (Fill)

FIG No.:	GS-QS-1
HWY :	401
GWP	3034-19-00

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
	BH	QWB
	SAMPLE	5
	SYMBOL	●

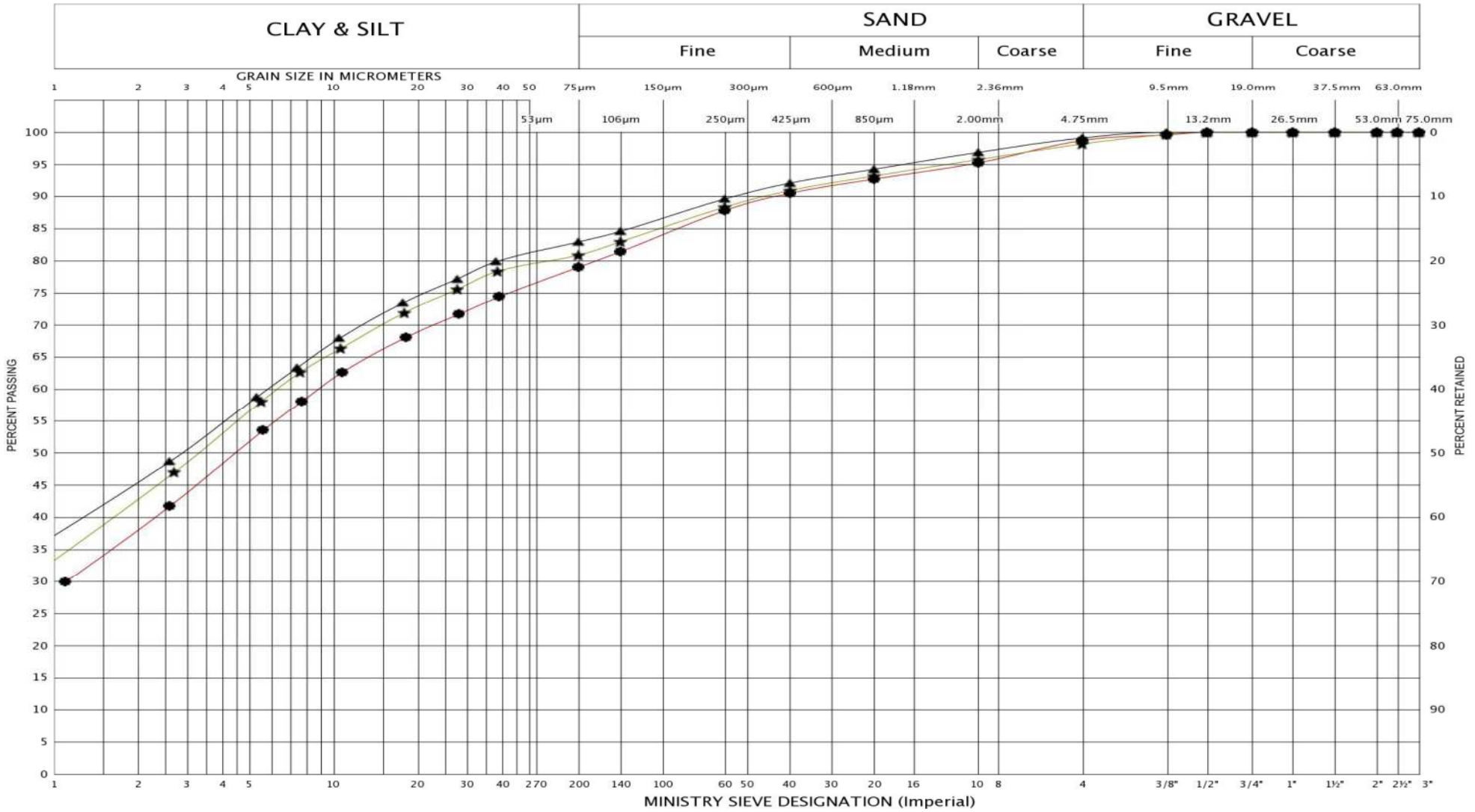
Ontario

GRAIN SIZE DISTRIBUTION

Gravelly Sand, Trace Silt and Trace Clay (Fill)

FIG No.:	GS-QS-2
HWY :	401
GWP	3034-19-00

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	QEB	QWB	QWB
	SAMPLE	10	11	15
	SYMBOL	●	▲	★

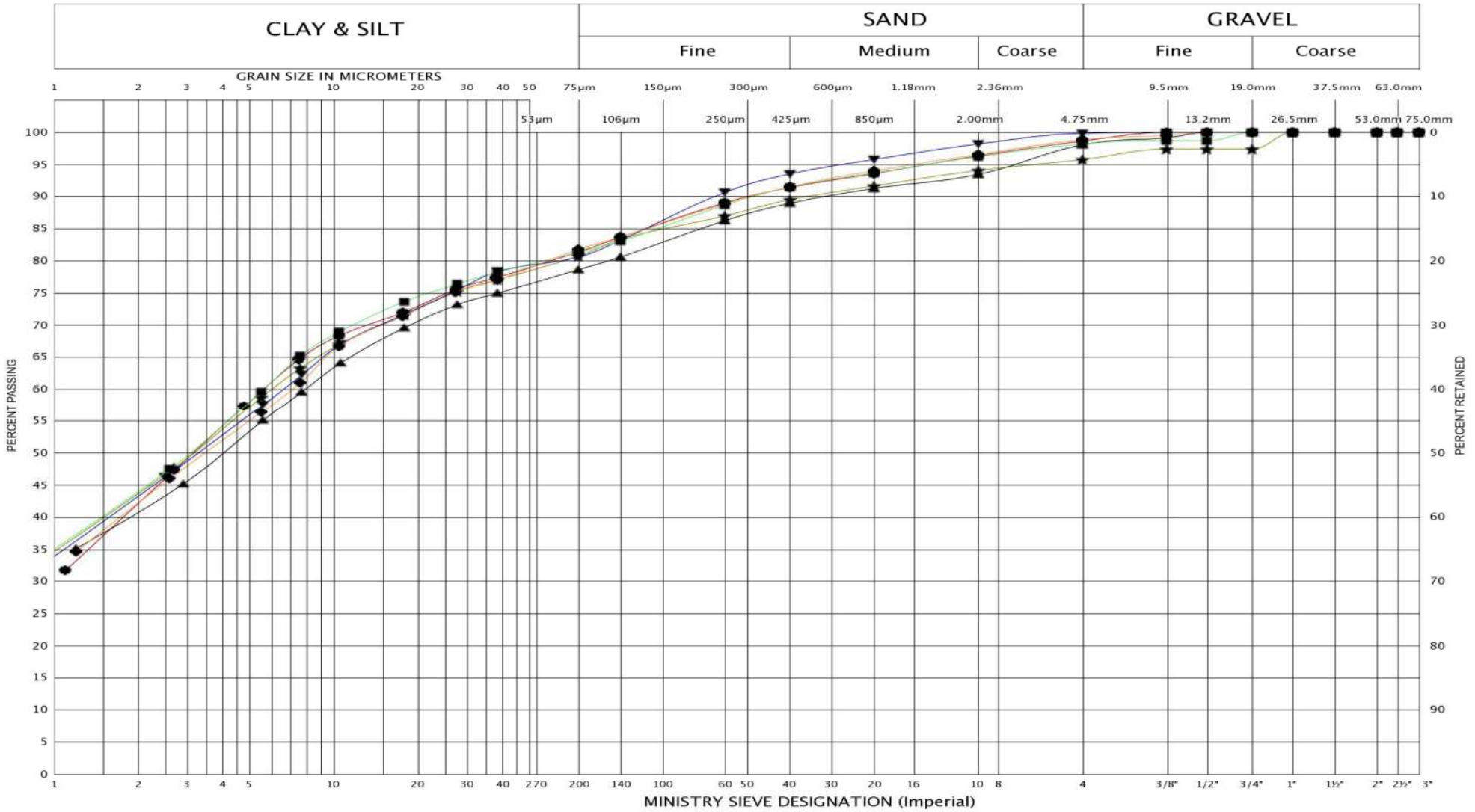
Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, Some Sand, Trace Gravel (Till)

FIG No.:	GS-QS-3
HWY :	401
GWP	3034-19-00

UNIFIED SOIL CLASSIFICATION SYSTEM



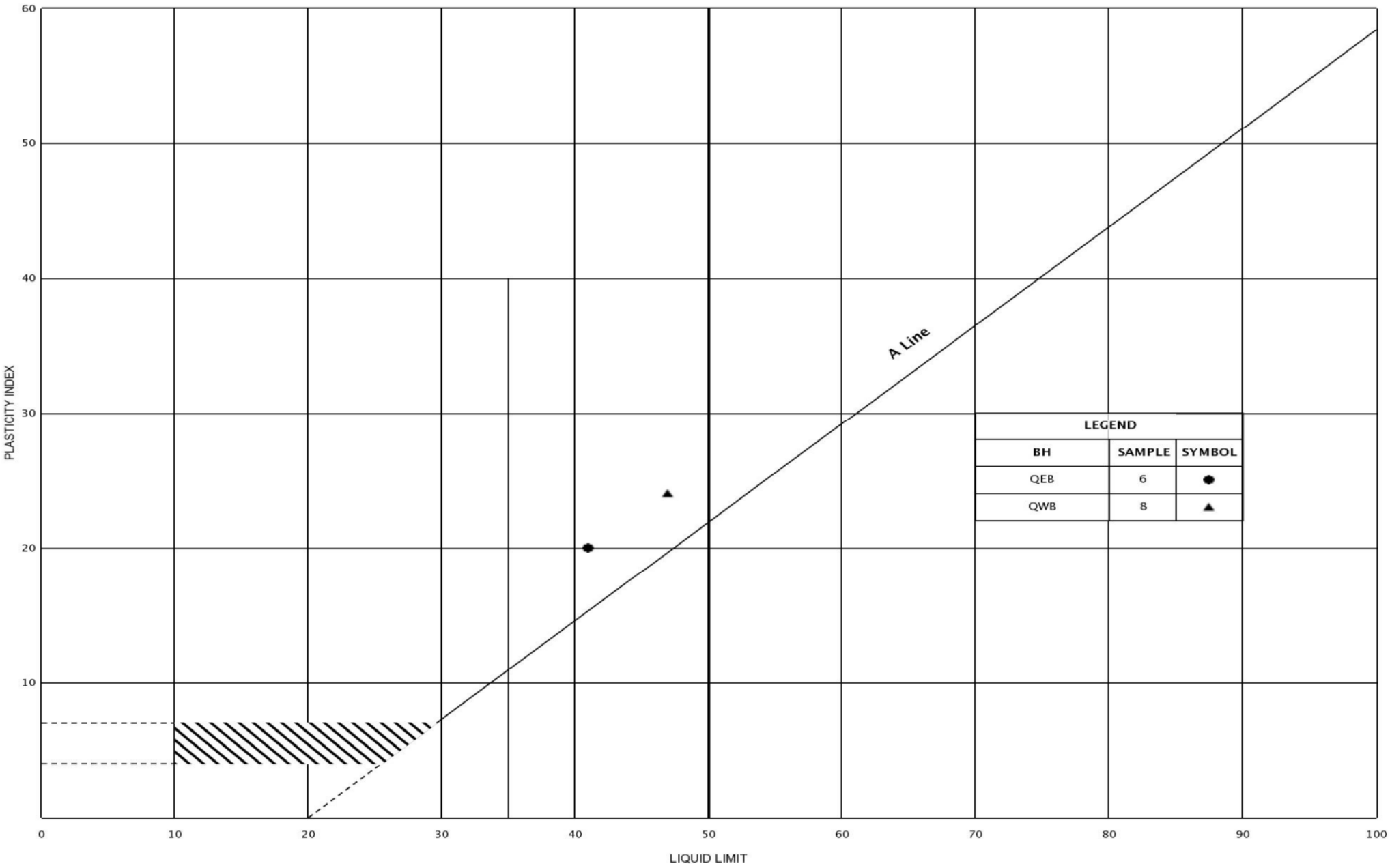
LEGEND	BH	QEB	QEB	QEB	QWB	QWB	QWB
	SAMPLE	14	18	20	21	17	14
	SYMBOL	●	▲	★	▼	■	◆

Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, Some Sand, Trace Gravel (Till)

FIG No.:	GS-QS-4
HWY :	401
GWP	3034-19-00

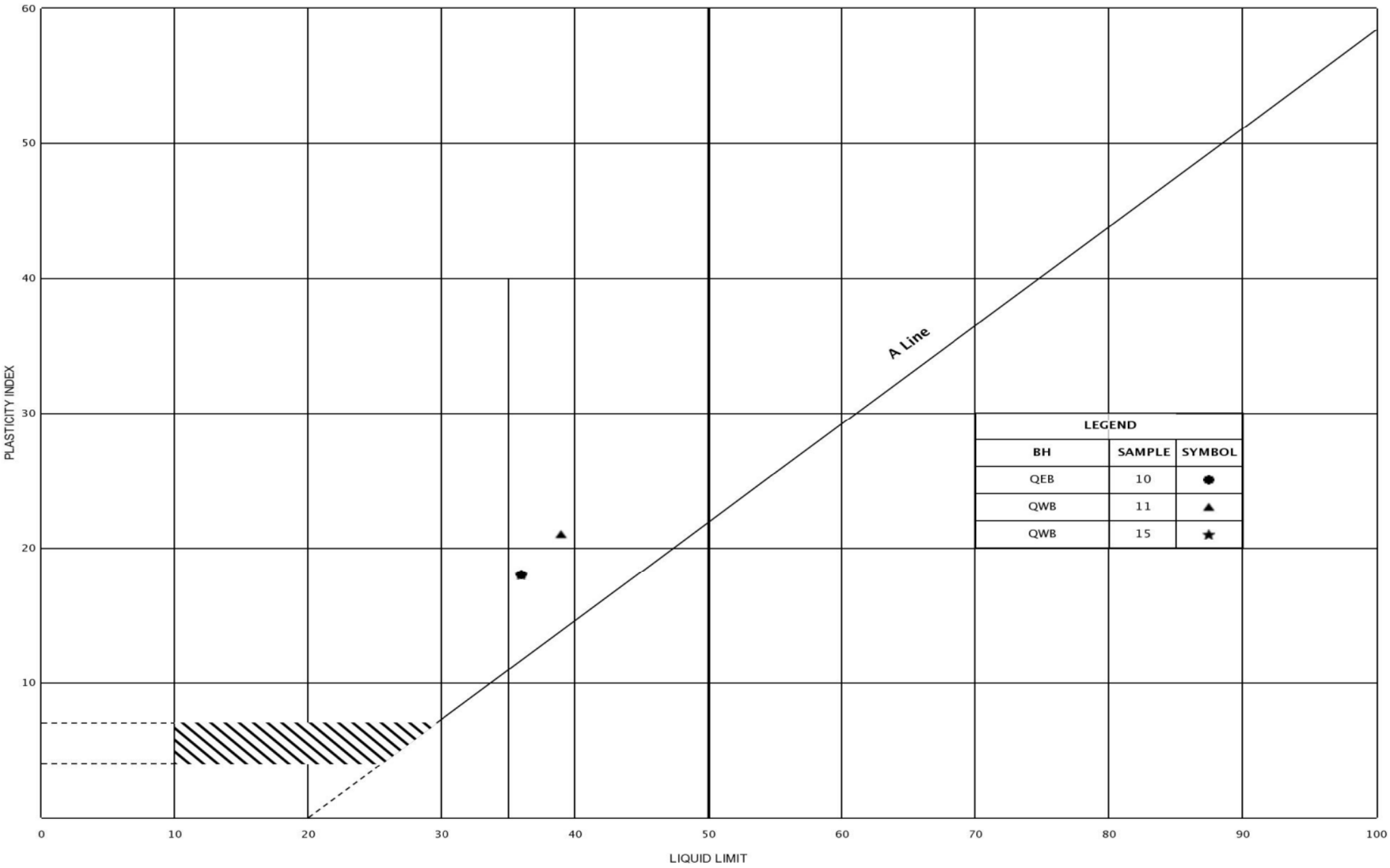


Ontario

PLASTICITY CHART

SILTY CLAY, Some Sand, Trace Gravel (Fill)

FIG No.:	PC- QS-1
HWY.:	401
GWP	3034-19-00

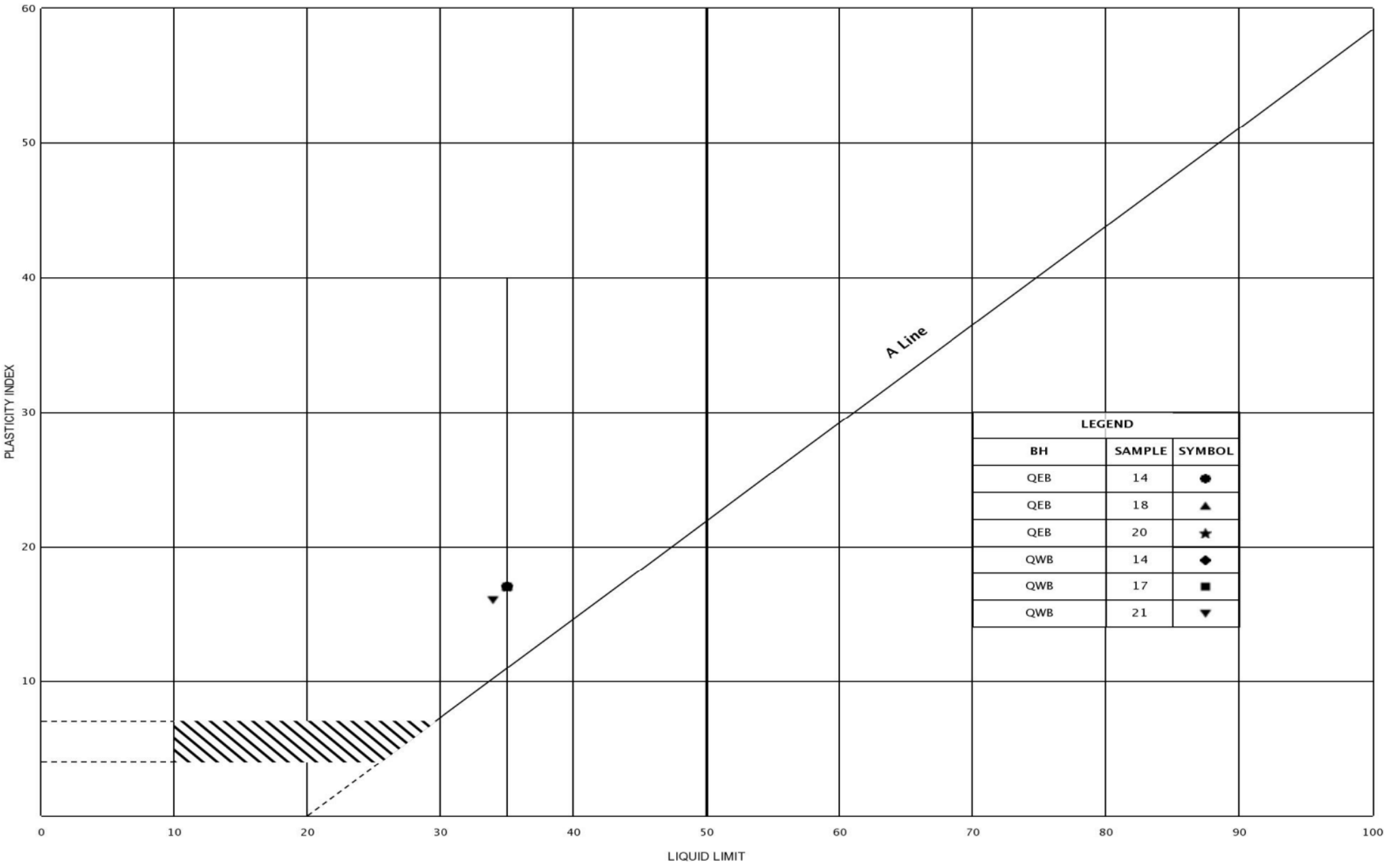


Ontario

PLASTICITY CHART

SILTY CLAY, Some Sand, Trace Gravel (Till)

FIG No.:	PC- QS-2
HWY.:	401
GWP	3034-19-00



Ontario

PLASTICITY CHART

CLAYEY SILT, Some Sand, Trace Gravel (Till)

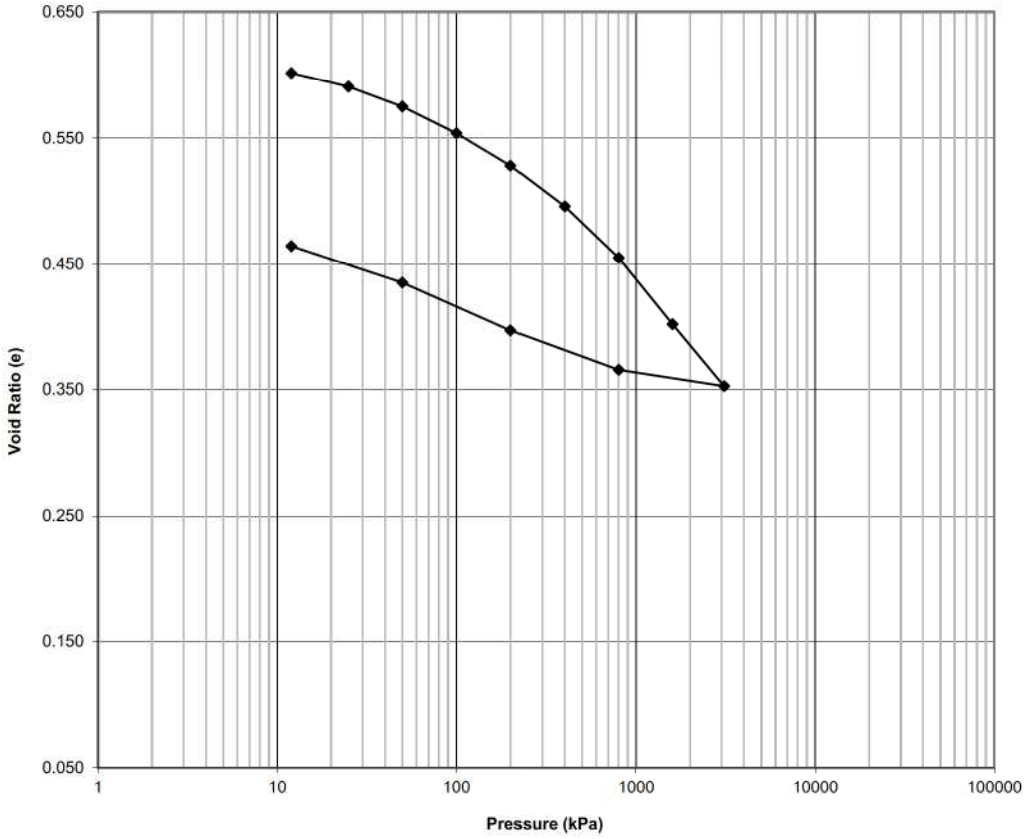
FIG No.:	PC- QS-3
HWY.:	401
GWP	3034-19-00

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Consolidation Test Results
(ASTM D2435)
Highway 401,CA 3017-E-0006,Task 006-4 Bridges Detail Design

Borehole QWB, Sample TW 14, Depth 13.7-14.3 m

Void Ratio versus Log of Pressure



SOIL TYPE:	Grey Clayey Silt						
e_0	=	0.637		W_L	=	35	FIGURE No: Q-1
W_0	=	22.8	%	W_P	=	18	Highway 401,CA 3017-E-0006,Task 006-4 Bridges Detail Design
γ	=	19.9	kN/m³	PI	=	17	
							PML Ref: 19KF029A

golder.com