Foundation Investigation and Design Report

Dry Facility at Southwest Corner of Highway 410-Courtneypark Drive Interchange
Highway 410, Eglington Avenue to Mayfield Road - Contract 2
Mississauga and Brampton, Ontario
Assignment No. 2016-E-0040, G.W.P. 2369-15-00

Submitted to:

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PART A

FOUNDATION INVESTIGATION REPORT
DRY FACILITY AT SOUTHWEST CORNER OF HIGHWAY 410 - COURTNEYPARK DRIVE INTERCHANGE
HIGHWAY 410, EGLINTON AVENUE TO MAYFIELD ROAD - CONTRACT 2
MISSISSAUGA AND BRAMPTON, ONTARIO
ASSIGNMENT NO. 2016-E-0040, GWP 2369-15-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detailed design of the rehabilitation of Highway 410 from Eglinton Avenue to Mayfield Road in the cities of Mississauga and Brampton, Ontario (MTO Agreement No. 2016-E-0040).

This report addresses the foundation investigation carried out in support of the dry facility design located at the southwest corner of the Highway 410 – Courtneypark Drive interchange.

The Terms of Reference and Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal, dated November 25, 2016, which forms part of the Consultant Agreement (No. 2016-E-0040) for this project. The Scope of Work for the dry facility is outlined in Golder's Change Request dated February 15, 2019. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for this project, dated May 2017.

2.0 SITE DESCRIPTION

The site is in the City of Mississauga, north of the Highway 401/403/410 interchange and south of the Derry Road interchange, as shown on the Key Plan is provided on Drawing 1. The dry facility is located on undeveloped land within the southwest quadrant of the Highway 410 – Courtneypark Drive interchange. Industrial developments surround the site.

The existing ground surface over the proposed dry facility varies from between about Elevation 188.2 m and 189.1 m. To the east of the proposed dry facility, the Highway 410 grade is at approximately Elevation 187.5 m, and to the north, Courtneypark Drive has been constructed on an embankment with its grade up to approximately Elevation 193 m.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on November 8, 2018 and March 4 and 5, 2019, during which time three boreholes (designated as Boreholes 17-7, SWM-1 and SWM-2) were advanced within the footprint of the proposed dry facility, as shown on Drawing 1. The borehole records are contained in Appendix A.

The borehole investigation was carried out using a CME-55 track-mounted drill rig, supplied and operated by Geo-Environmental Drilling Inc. of Acton, Ontario. The boreholes were advanced through the overburden using 152 mm and 203 mm outside diameter hollow stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter (35 mm inner diameter) split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)[1]. Considering the inside diameter of the split-spoon samplers, soil particles larger than 35 mm cannot be retrieved. The results of the in situ field tests (i.e., SPT "N"-values) as presented on the borehole records and in Section 4.0 are uncorrected.

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

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole SWM-1 to permit monitoring of the water level at the site. The installed piezometer consists of a 50 mm diameter PVC pipe, with a 1.5 m slotted screen sealed within a filter sand pack with the piezometer positioned near the bottom of the borehole. The borehole and annulus surrounding the piezometer pipe above the filter sand pack were backfilled to the ground surface with bentonite pellets. Piezometer installation details and water level readings are described on the borehole records in Appendix A. The remaining boreholes were backfilled to ground surface with bentonite, in accordance with Ontario Regulation 903 (Wells, as amended).

The field work was observed by a member of Golder's engineering staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further visual examination. Geotechnical laboratory index and classification testing, consisting of natural moisture contents, grain size distributions and Atterberg limits, was conducted on selected samples in accordance with MTO and / or ASTM Standards, as applicable. The results of the geotechnical laboratory testing are given on the borehole records provided in Appendix A, and on the geotechnical laboratory test figures in Appendix B.

The as-drilled borehole locations were surveyed by Golder personnel using a handheld GPS device with a horizontal accuracy of 0.1 m and a vertical accuracy of 0.1 m. The locations provided on the borehole records and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) coordinates and the ground surface elevations are referenced to geodetic datum. The borehole locations (including in geographic coordinates of latitude and longitude), ground surface elevations, and drilled depths are summarized below.

Borehole I.D.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude)	Easting (m) (Longitude)		
17-7	4,834,625.3 (43.651441)	290,450.2 (-79.677895)	188.5	10.8
SWM-1*	4,834,572.1 (43.650963)	290,485.6 (-79.677454)	188.0	10.9
SWM-2	4,834,551.6 (43.650779)	290,512.2 (-79.677124)	188.2	12.8

* Auger refusal was encountered at a depth of 2.8 m in Borehole SWM-1 on an obstruction; the drill rig was shifted 2 m south of the original borehole, and drilling and sampling continued from 2.8 m to 10.9 m.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 410 is located within the physiographic region known as the South Slope, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2].

The South Slope region is comprised of calcareous clay till with lacustrine clay and silt reworked by glaciers, with numerous scattered drumlins and deep valley cuts caused by streams flowing towards Lake Ontario. The surface topography slopes gradually and uniformly southwards towards Lake Ontario. The overburden within the majority of the South Slope area is underlain by shale bedrock of the Queenston and Georgian Bay Formations, which contain limestone interlayers.

4.2 Subsurface Conditions

The subsurface soil and groundwater conditions as encountered in the boreholes advanced during the investigation, including groundwater level readings, are presented on the borehole records provided in Appendix A. The results of the geotechnical laboratory testing are given on the borehole records provided in Appendix A, and on the geotechnical laboratory test figures in Appendix B.

The results of the in situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile and cross-section on Drawing 1 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. The interpreted stratigraphic profile and cross-section, as shown on Drawing 1, are simplifications of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes exists and is to be expected.

In general, the subsurface conditions encountered at the site consist of topsoil underlain by firm to stiff clayey silt fill, further underlain by a till deposit that varies from stiff to hard clayey silt till to very dense silt and sand till. A more detailed description of the subsurface conditions is provided in the following sections of this report.

4.2.1 Topsoil

An approximately 100 mm and 150 mm thick layer of topsoil was encountered at ground surface in Boreholes 17-7 and SWM-2, respectively.

4.2.2 Clayey Silt to Sandy Clayey Silt Fill

A 0.5 m to 2.9 m thick layer of fill was encountered at ground surface in Borehole SWM-1 and underlying the topsoil in Boreholes 17-7 and SWM-2; this fill layer extends to between approximately Elevation 185.5 m and 187.5 m as encountered in the boreholes. The fill consists of clayey silt, some sand to sandy clayey silt, and contains trace to some gravel, trace rootlets and trace organics.

The Standard Penetration Test (SPT) “N”-values measured within the cohesive fill range from 7 blows to 10 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

Grain size distribution testing was carried out on one sample of the cohesive fill and is presented on Figure B-1 in Appendix B. Atterberg limits testing was carried out one sample of the cohesive fill and measured a liquid limit of

[2] Chapman, L.J. and Putman, 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 30 per cent and a plastic limit of about 18 per cent, corresponding to a plasticity index of about 12 per cent. This Atterberg limits testing result is presented on Figure B-2 in Appendix B and indicates the fill consists of clayey silt of low plasticity. The natural water content measured on samples of the cohesive fill ranges from about 15 to 21 per cent, near the plastic limit of the material.

4.2.3 Clayey Silt Till to Silt and Sand Till

A till deposit was encountered underlying the cohesive fill in all boreholes. All boreholes terminated within the till deposit, penetrating it for a thickness of 7.8 m to 12.1 m. The till deposit is generally comprised of clayey silt, some sand to sandy clayey silt, trace to some gravel. However, the till does vary in composition, and grades with depth to a silt and sand till of slight plasticity, as encountered in Borehole SWM-2 below a depth of 8.7 m (Elevation 179.5 m).

Auger grinding was observed during drilling in the till in Boreholes SWM-1 and SWM-2, and auger refusal was encountered at a depth of 2.8 m in Borehole SWM-1, suggesting the presence of cobbles and/or boulders, which are commonly encountered in glacially derived materials and should be expected within this deposit. Shale fragments were encountered at depths below Elevation 179.8 m (8.2 m below ground surface) in the cohesive till deposit in Borehole SWM-1 and rock fragments were encountered at depths below Elevation 178.4 m (9.8 m below ground surface) in the non-cohesive till deposit in Borehole SWM-2.

The SPT “N”-values measured within the cohesive till deposit generally range from 12 blows to 72 blows per 0.3 m of penetration, with values of up to 100 blows for 0.1 m of penetration measured below a depth of about 9 m, suggesting a stiff to hard consistency. The SPT “N”-values measured within the non-cohesive till are 100 blows per 0.3 m of penetration, 102 blows per 0.3 m of penetration and 100 blows for 0.1 m of penetration, indicating a very dense compactness condition.

Grain size distribution testing was carried out on seven samples of the cohesive till deposit and one sample of the non-cohesive till deposit; the results are presented on Figure B-3 in Appendix B. Atterberg limits testing was carried out on six samples of the cohesive till deposit and one sample of the non-cohesive till deposit and measured liquid limits ranging from about 13 to 27 per cent, plastic limits ranging from about 11 to 16 per cent, and plasticity indices ranging from about 2 to 11 per cent. The Atterberg limits testing results are presented on Figure B-2 in Appendix B and indicate the till deposit is comprised predominantly of clayey silt of low plasticity, but that the zone encountered at the base of Borehole SWM-2 grades to silt and sand of slight plasticity. The natural water content measured on samples of the till deposit ranges from about 6 to 15 per cent, generally below or near the plastic limit of the deposit.

4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured during and upon completion of drilling operations, and are noted on the borehole records in Appendix A. Boreholes SWM-1 and SWM-2 were dry upon completion of drilling, and the water level was measured at a depth of 8.3 m below ground surface (Elevation 180.2 m) in Borehole 17-7 upon completion of drilling The groundwater level or dry borehole conditions as measured in the open boreholes do not represent the stabilized groundwater conditions.

Borehole SWM-1 was instrumented with a standpipe piezometer screened in the cohesive till deposit. The groundwater level recorded in the standpipe piezometer is shown on the borehole record in Appendix A and summarized in the table below.

Borehole I.D.	Screened Unit	Ground Surface Elevation (m)	April 18, 2019	
			Depth to Groundwater (m)	Groundwater Elevation (m)
SWM-1	Clayey Silt Till	188.0	4.0	184.0

The groundwater level at this site will be subjected to seasonal fluctuations and precipitation events; the water level should be expected to be higher during the spring season or during and following periods of heavy precipitation.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Darcy Hansen, E.I.T., and was reviewed by Ms. Nikol Kochmanová, P.Eng. a geotechnical engineer with Golder. Ms. Lisa Coyne, P.Eng., an MTO Foundations Designated Contact and Principal of Golder, conducted an independent technical and quality control review of the report.

Golder Associates Ltd.

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PART B

FOUNDATION DESIGN REPORT
DRY FACILITY AT SOUTHWEST CORNER OF HIGHWAY 410 - COURTNEYPARK DRIVE INTERCHANGE
HIGHWAY 410, EGLINGTON AVENUE TO MAYFIELD ROAD - CONTRACT 2
MISSISSAUGA AND BRAMPTON, ONTARIO
ASSIGNMENT NO. 2016-E-0040, GWP 2369-15-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides detail foundation design recommendations for the proposed dry facility located in the southwest quadrant of the Highway 410 – Courtneypark Drive interchange as part of the rehabilitation of Highway 410 from Eglinton Avenue to Mayfield Road in the cities of Mississauga and Brampton, Ontario (MTO Agreement No. 2016-E-0040). The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at this site. The discussion and recommendations presented are intended to provide the designers with sufficient information to complete the detail design of the proposed dry facility.

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

Based on Sheets 203 and 204 of the contract drawings prepared by AECOM, dated March 2019, the excavation base for the dry facility is proposed at approximately Elevation 185.5 m to 185.7 m. A low flow channel is proposed through the dry facility that has a 2 m bottom width and is 0.3 m deeper than the dry facility base. The base of the outlet headwall is proposed to extend to about Elevation 184.3 m. The existing ground surface over the proposed dry facility varies from about Elevation 188.2 m to 189.1 m. The maximum cut depth required for construction of the dry facility is about 4.3 m to install the headwall and about 3.3 m to install the geotextile and rip-rap treatment at the toe/base of the low flow channel.

The top of the cut slope surrounding the dry facility is proposed at approximately Elevation 187.5 m. The proposed interior slopes are oriented at 4 horizontal to 1 vertical (4H:1V) above Elevation 187.0 m, and 5H:1V below this elevation. The proposed side slopes within the low flow channel are oriented at 3H:1V.

6.2 Pond Base Stability

The following design groundwater level has been considered in developing the design recommendations for the proposed dry facility, based on the measured groundwater level of Elevation 184.0 m in the standpipe piezometer installed in Borehole SWM-1:

Pond Base Elevation	Design Groundwater Elevation (m)	Design Groundwater Level Relative to Pond Base
185.5 m to 185.7 m	185	0.5 m to 0.7 m below

Depressurizing/dewatering of the silt and sand till deposit is not required to ensure an adequate factor of safety against base instability in the dry facility, low flow channel or headwall excavations because the measured and design groundwater levels associated with the deeper portion of the till deposit are generally below the proposed base of excavation. In the case of the headwall, although the design groundwater elevation is about 0.7 m above the proposed excavation base elevation, depressurization/dewatering of the deeper portion of the till deposit is still not required for excavation base instability.

6.3 Global Stability of Pond Cut Slopes

Slope stability analyses have been performed using the commercially available program *SLIDE 2018*, developed by Rocscience Inc., at a critical section to verify that the proposed cut slopes have a global factor of safety under static conditions equal to or greater than 1.5. This minimum factor of safety is considered appropriate for the proposed dry facility side slopes considering the design requirements and the available field and laboratory testing data.

The following parameters have been used in the static global stability analyses, based on field and laboratory test data as well as accepted correlations (CHBDC, 2006; Bowles, 1984; and Kulhawy and Mayne, 1990):

Soil Deposit	Bulk Unit Weight (kN/m^3)	Effective Friction Angle	Undrained Shear Strength (kPa)
Firm to stiff clayey silt fill	20	-	50
Stiff to hard clayey silt to very dense silt and sand till	21	34°	-

The groundwater level used in the stability analyses is at Elevation 186.6 m, coincident with the 100-year water level provided on the contract drawings prepared by AECOM (Sheets 203 and 204), dated March 2019. This is considered a “worst case” condition as it is above the measured groundwater level in the piezometer. Under the dry facility operation, the stormwater is anticipated to drain away relatively quickly, such that the groundwater table in the surrounding relatively low permeability till would not rise (nor rapidly draw down) in conjunction with changes in the dry facility operating level.

The results of the static global stability analyses indicate that a factor of safety of 1.5 or greater is achieved for the global stability of permanent cut slopes oriented at 4H:1V above Elevation 187.0 m and 5H:1V below this level, both under operating conditions and fully drained conditions. Examples of the global static stability analyses are included on Figures 1 and 2 for the selected critical pond sections.

Recommendations for protection and enhancement of the surficial stability of the pond side slopes are provided in Section 6.4 (Surficial Stability and Erosion Protection).

6.4 Surficial Stability and Erosion Protection

The requirements for design of erosion protection measures for the inlet and outlet storm sewer pipes should be assessed by the Civil Designer’s hydraulic design engineer. As a minimum, rip-rap treatment for the inlet and outlet of the storm sewer pipes should be consistent with the standard presented in OPSD 810.010 (*Rip-Rap Treatment for Sewer and Culvert Outlets*) Rip-Rap Treatment Type A, with the rip-rap placed from the ditch bottom to above the pipe obvert, in combination with the proposed cut-off headwall. Rip-rap should be provided over the full extent of the side slopes and base grade below and adjacent to the sewer inlet / outlet locations.

The pond slopes above the operating water level should be vegetated as soon as possible after construction to minimize the potential for erosion due to surface water run-off, either by placement of topsoil in accordance with OPSS 802 (*Topsoil*) and seeding in accordance with OPSS.PROV 804 *(Seed and Cover)* or pegged sod in accordance with OPSS.PROV 803 *(Sodding).*

Although the dry facility will be maintained above the groundwater level at this site, relatively minor groundwater seepage may occur from water “perched” within lenses or interlayers of more permeable silt/sand soils within the clayey silt till deposit, if these are encountered during excavation. Determination of the frequency, extent and exact locations of such seepage zones from the limited borehole data is not possible, although such zones are expected to be minimal as the excavation is above the groundwater table, and any such interlayers are anticipated to be of limited lateral extent. An observational approach is recommended involving examination of the cut slopes during and following construction to identify any areas of water-bearing non-cohesive soils. If seepage continues and contributes to sloughing, treatment of the area with a granular drainage blanket (consisting of OPSS.PROV 1010 Granular B Type II, for example) could be addressed by the Construction Contract Administrator.

6.5 Construction Considerations

6.5.1 Excavations for Pond Construction

The proposed dry facility will require excavation to maximum depths of up to 3.1 m below the present ground surface. Permanent and temporary excavations for the pond and any associated drainage structures, if required, will be made through topsoil, existing firm to still fill layers, and into the stiff to hard clayey silt to silt and sand till; cobbles and boulders were inferred at various depths within the till deposits in most of the boreholes. Conventional excavation equipment is expected to be suitable for construction of the dry facility.

If temporary excavations are required within or adjacent to the proposed dry facility for drainage structures (e.g. for drainage pipes, drainage structures or headwalls), the existing firm to stiff fill is considered to be a Type 3 soil and the stiff to hard / very dense till deposits are considered to be Type 2 soil according to the Occupational Health & Safety Act & Regulation (OHSA) for Construction Projects. As such, temporary open-cut excavations should be completed with side slopes no steeper than 1H:1V. All excavations must be carried out in accordance with the latest edition of the OHSA.

6.5.2 Groundwater Control During and Following Construction

As discussed in Section 6.2, the groundwater level at the dry facility is approximately Elevation 184 m, which is about 1.5 m to 1.7 m below the design pond base elevation and 0.3 m below the headwall base elevation. It is recognized that this groundwater level may fluctuate; therefore, for design purposes, it is considered that this water level could be up to approximately 1 m higher, at Elevation 185 m. Although not specifically encountered as part of this investigation, lenses or interlayers of more permeable silts or sands may exist within the clayey silt till deposit and could contribute to relatively minor seepage upon exposure during excavation.

It is anticipated that groundwater seepage can be controlled by pumping from properly filtered sumps within the excavation. As discussed above, depressurizing/dewatering of the silt and sand till deposit is not required during construction or operation of the dry facility, as the groundwater level is below the pond base.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Darcy Hansen, E.I.T., and was reviewed by Ms. Nikol Kochmanová, P.Eng. a geotechnical engineer with Golder. Ms. Lisa Coyne, P.Eng., an MTO Foundations Designated Contact and Principal of Golder, conducted an independent technical and quality control review of the report.

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Canadian Standards Association (CSA). 2014. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-14*. CSA Special Publication.

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.

Kulhawy, F.H. and Mayne, P.W. 1990. *Manual on Estimating Soil Properties for Foundation Design*. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.

ASTM International:

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

Commercial Software:

Slide 2018 by Rocscience Inc.

Ontario Provisional Standard Drawing:

OPSD 810.010 Rip-Rap Treatment for Sewer and Culvert Outlets

Ontario Provincial Standard Specification:

OPSS 802 Construction Specification for Topsoil

OPSS.PROV 803 Construction Specification for Sodding

OPSS.PROV 804 Construction Specification for Seed and Cover

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91 Construction Projects (as amended)

MINISTRY OF TRANSPORTATION, ONTARIO

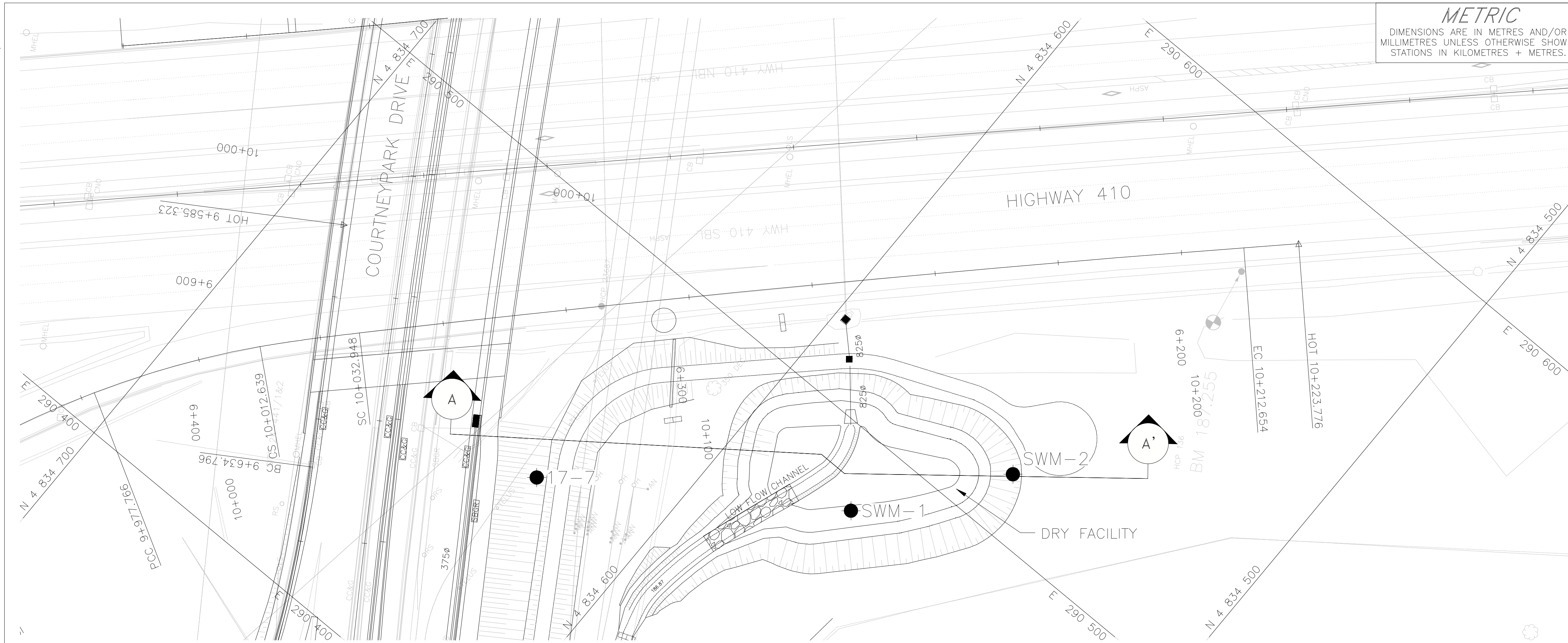
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2019–2014
GWP No. 2369–15–00

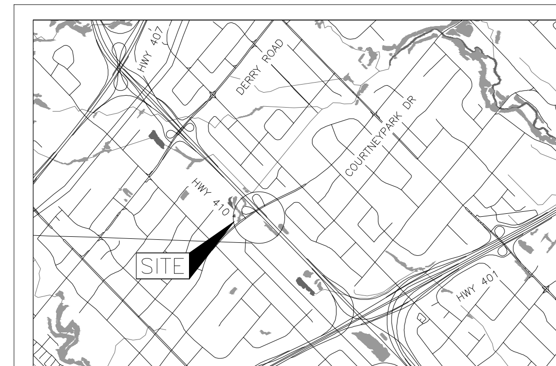
SHEET

HIGHWAY 410
DRY FACILITY
BOREHOLE LOCATIONS AND SOIL STRATA

GOLDER



PLAN
SCALE
10 0 10 20 m



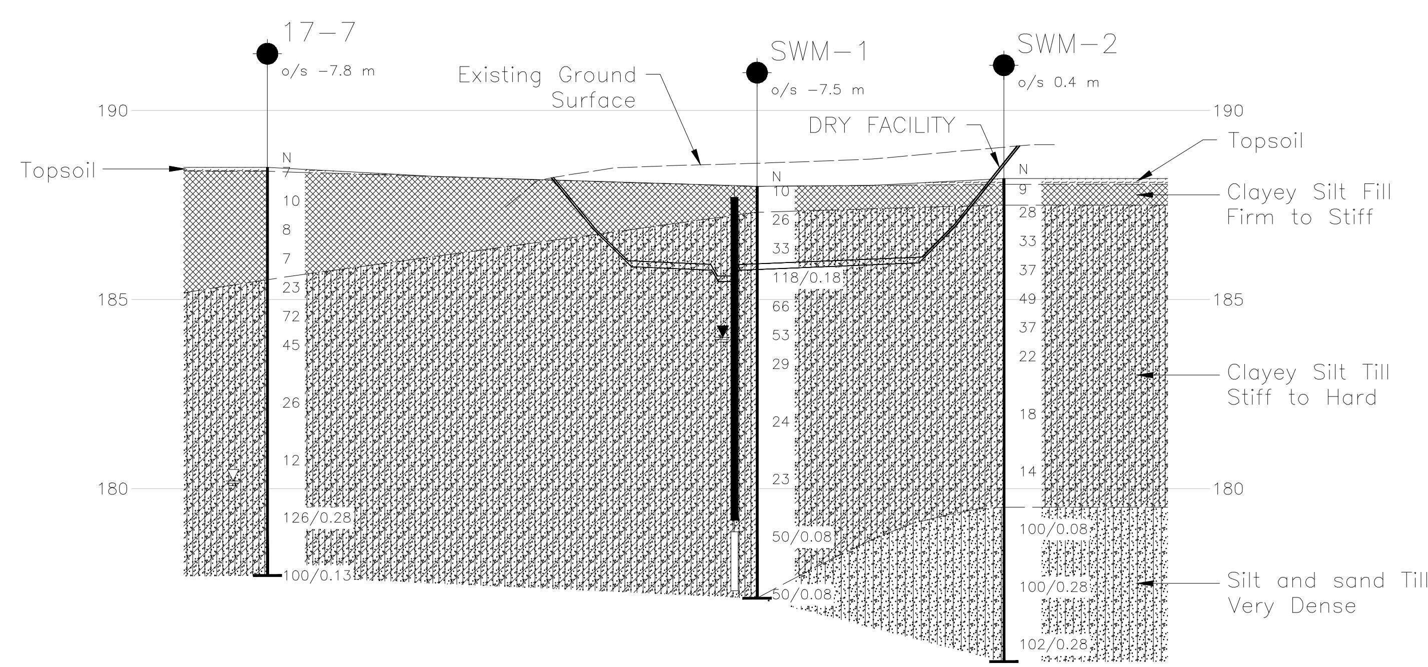
KEY PLAN
SCALE
10 0 10 20 m

LEGEND

- ● Borehole – Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▼ WL in piezometer, measured on April 8, 2019
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
17–7	188.5	4834625.3	290450.2
SWM–1	188.0	4834572.1	290485.6
SWM–2	188.2	4834551.6	290512.2



PROFILE A – A'
HORIZONTAL SCALE
10 0 10 20 m
VERTICAL SCALE
2 0 2 4 m

NOTES

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

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

REFERENCE

Base plans provided in digital format by AECOM, drawing file nos. ACAD_X–60543038–C–ALI–HWY 410.dwg, X–60543038–C–Courtneypark–NC – Addendum.dwg, received April 04, 2019.
ACAD–X–60543038–C–Base.dwg, received April, 12, 2019 and Dry Facility Profiles Acad 2013 Scale 500.dwg, received April 16, 2019.

LICENSED PROFESSIONAL ENGINEER L.C. COYNE May 01, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 May 01, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

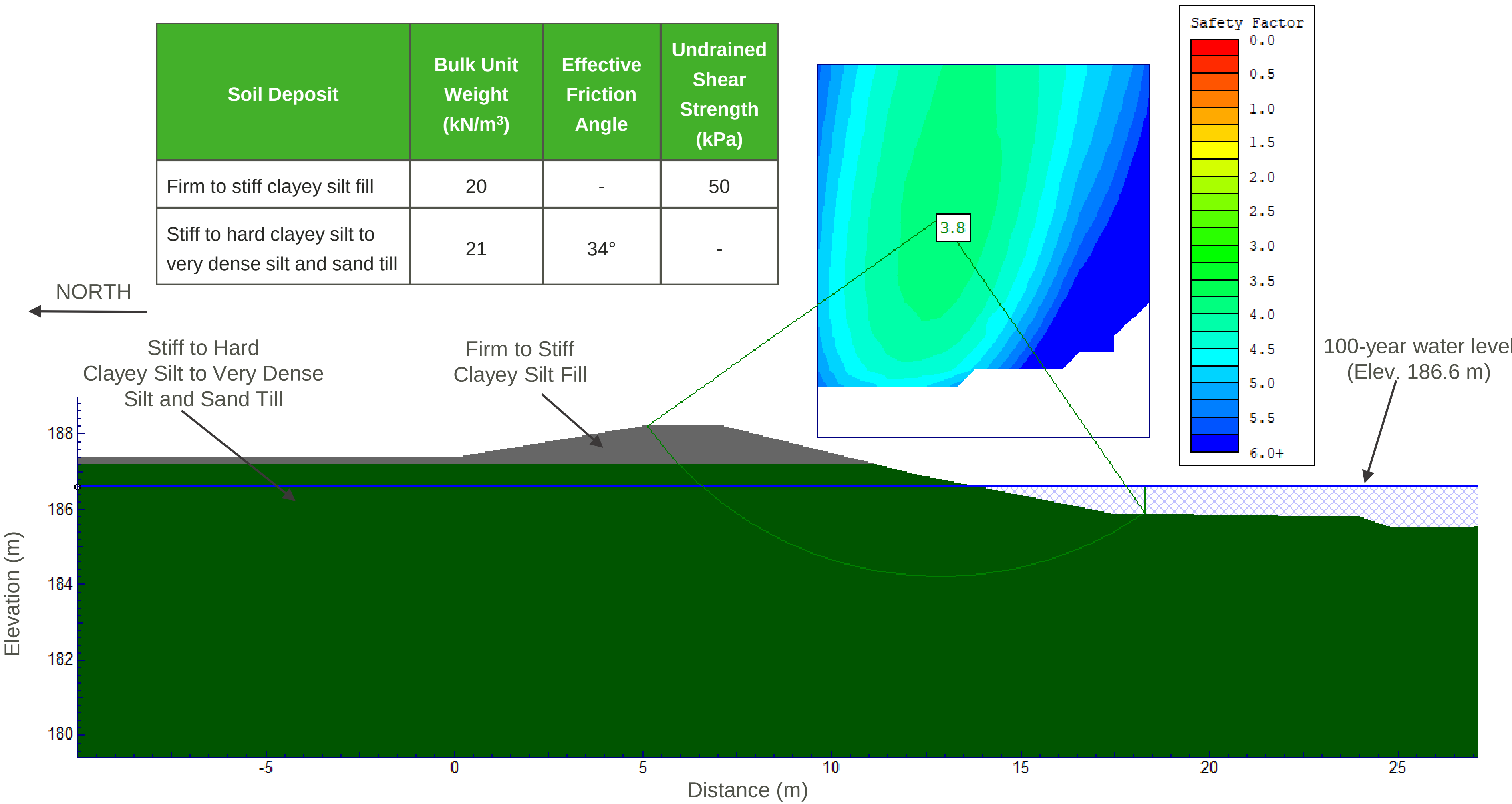
Geocres No. 30M12–444

HWY. 410	PROJECT NO. 1669996		DIST. CENTRAL
SUBM'D. NK	CHKD. DH	DATE: 05/01/2019	SITE:
DRAWN: DD	CHKD. NK	APPD. LCC	DWG. 1

PLOT DATE: May 1, 2019
FILENAME: S:\Clients\MTO\Hwy_410_courtneypark\99_PROJ\1669996\40_PROD\0004_SWM_Pond\1669996-0004-BC-0001.dwg

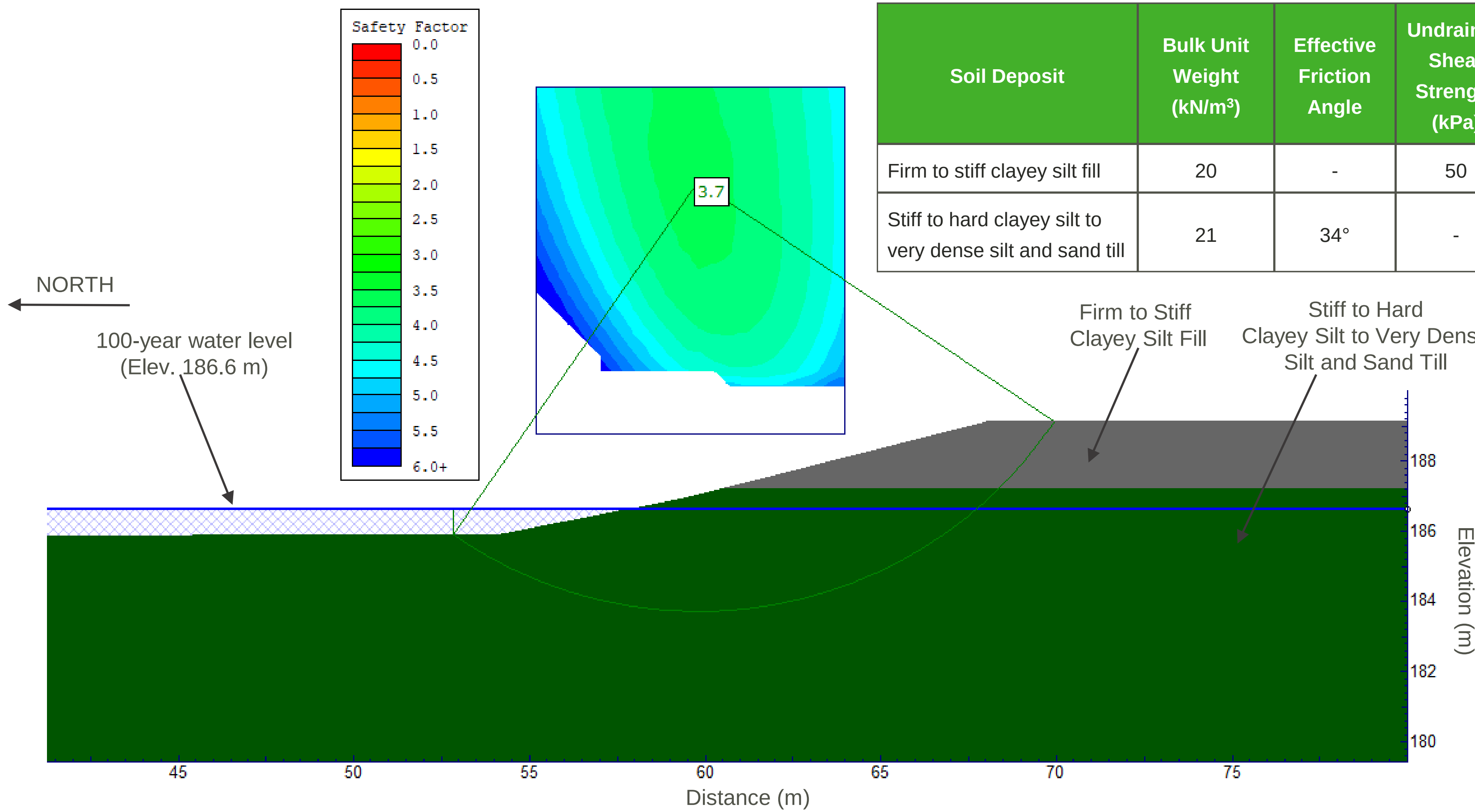
Static Slope Stability Analysis
Dry Facility – North Slope

Soil Deposit	Bulk Unit Weight (kN/m³)	Effective Friction Angle	Undrained Shear Strength (kPa)
Firm to stiff clayey silt fill	20	-	50
Stiff to hard clayey silt to very dense silt and sand till	21	34°	-



Static Slope Stability Analysis
Dry Facility – South Slope

Soil Deposit	Bulk Unit Weight (kN/m^3)	Effective Friction Angle	Undrained Shear Strength (kPa)
Firm to stiff clayey silt fill	20	-	50
Stiff to hard clayey silt to very dense silt and sand till	21	34°	-



APPENDIX A

Borehole Records

LIST OF SYMBOLS

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 $= (w_l - w_p)$
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 $= \sigma'_p / \sigma'_{vo}$

(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 $= \tan\delta$
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

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. 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.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; 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, 60º 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

Piezo-Cone Penetration Test (CPT)

A 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 (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
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, G_s)
DS	direct shear test
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	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

RECORD OF BOREHOLE No 17-7

SHEET 1 OF 1 **METRIC**

PROJECT 1669996
G.W.P. 2369-15-00
DIST Central HWY 410
DATUM Geodetic

LOCATION N 4834625.3; E 290450.2 MTM NAD 83 ZONE 10 (LAT. 43.651441; LONG. -79.677895)
BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME55 Track Mounted Drill Rig
DATE November 08, 2018

ORIGINATED BY SK
COMPILED BY EN
CHECKED BY AMP

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.5	GROUND SURFACE							
0.0	TOPSOIL (100 mm)							
0.1	Sandy clayey silt, some sand, trace gravel, trace rootlets, trace organic (FILL) Firm to stiff Brown, oxidization staining Moist	1	SS	7		188		
		2	SS	10		187		
		3	SS	8			○ ├──┤	3 20 45 32
		4	SS	7		186	○	
185.5 / 3.0	Sandy CLAYEY SILT to CLAYEY SILT with SAND, trace to some gravel (TILL) Stiff to hard Brown to grey Moist to wet	5	SS	23		185	○	
		6	SS	72		184		
		7	SS	45		183	○ ├──┤	4 29 42 25
	- Grey below 6.1 m depth (Elev. 182.4 m)	8	SS	26		182	○	
	- Wet below 7.0 m depth (Elev. 181.5 m)					181		
		9	SS	12	▽	180	○	
		10	SS	126/0.28		179	○	12 41 36 11
						178		
177.7		11	SS	100/0.13				
10.8	END OF BOREHOLE							

NOTES:

1.Water level measured in on open borehole at a depth of 8.3 m below ground surface (Elev. 180.2 m) upon completion of drilling and removal of augers.

Legend: 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. UNIT WEIGHT γ kN/m³.

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

RECORD OF BOREHOLE No SWM-1

SHEET 1 OF 1 — **METRIC**

PROJECT 1669996
G.W.P. 2369-15-00
DIST Central HWY 410
DATUM Geodetic
LOCATION N 4834572.1; E 290485.6 MTM NAD ZONE (LAT. 43.650963; LONG. -79.677454)
BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig
DATE March 4, 2019
ORIGINATED BY SE
COMPILED BY EN
CHECKED BY NK

ELEV DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
188.0	GROUND SURFACE									
0.0	Sandy clayey silt, some gravel, trace orgranics (FILL) Stiff Brown Moist	1	SS	10						
187.3 / 0.7	CLAYEY SILT, some sand to with sand, trace to some gravel, containing shale fragments below 8.2 m (TILL) Very stiff to hard Brown to grey below 4.5 m Moist - Auger grinding at 0.8 m	2	SS	26	187					
		3	SS	33	186		4	16	57	23
		4	SS	118/0.18						
	- Auger refusal encountered at 2.8 m, borehole was moved 2 m south and drilling continued. - Auger grinding at 2.8 m to 3.0 m	5	SS	66	185					
		6	SS	53	184					
		7	SS	29	183		8	25	48	19
	- Auger grinding at 5.2 m				182					
		8	SS	24	181					
		9	SS	23	180					
	- Auger grinding at 8.2 m - Shale fragments encountered below 8.2 m				179					
		10	SS	50/0.08						
	- Auger grinding at 9.8 m to 10.7 m				178					
177.1		11	SS	50/0.08			7	33	49	11
10.9	END OF BOREHOLE									

NOTES:

1. Auger refusal was encountered in the original borehole at a depth of 2.8 m (Elev. 185.2 m). The borehole was moved 2 m south, and drilling continued.

2. Open borehole dry upon completion of drilling and installation of piezometer.

3. Water level in piezometer measured at a depth of 4.0 m below ground surface (Elev. 184.0 m) on April 18, 2019.

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; STRAT PLOT; 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; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

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GOLDER

Foundation Design

RECORD OF BOREHOLE No SWM-2

SHEET 1 OF 1

METRIC

PROJECT 1669996

G.W.P. 2369-15-00

LOCATION N 4834551.6; E 290512.2 MTM NAD ZONE (LAT. 43.650779; LONG. -79.677124)

ORIGINATED BY SE

DIST Central HWY 410

BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig

COMPILED BY EN

DATUM Geodetic

DATE March 5, 2019

CHECKED BY NK

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.2	GROUND SURFACE						
0.0	TOPSOIL (150 mm)				188		
0.2	Clayey silt, some sand, trace gravel, trace rootlets (FILL) Stiff Brown Moist	1	SS	9		○	
187.5 / 0.7	Sandy CLAYEY SILT, trace to some gravel (TILL) Stiff to hard Mottled brown to grey below 4.2 m Moist	2	SS	28	187		
		3	SS	33	186		
		4	SS	37		○ ├─┤	8 24 46 22
		5	SS	49	185		
		6A / 6B	SS	37	184		
		7	SS	22	183	○	
		8	SS	18	182		
		9	SS	14	181	├─┤	5 20 51 24
	- Auger grinding at a depth of 8.2 m				180		
179.5 / 8.7	SILT and SAND, trace to some gravel, trace to some clay (TILL) Very dense Grey Moist	10	SS	100/0.08	179	○	
	- Trace rock fragments at 9.8 m				178		
	- Auger grinding from 9.2 m to 10.7 m	11	SS	100/0.28	177	○ H	7 47 39 7
		12	SS	102/0.28	176		
175.4 / 12.8	END OF BOREHOLE						

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Borehole dry on completion of drilling.

2. Borehole caved to 10.4 m on removal of augers.

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY_410_COURTNEYPARK\02_DATA\GINT\HWY_410_COURTNEYPARK.GPJ GAL-GTA.GDT 19-4-17

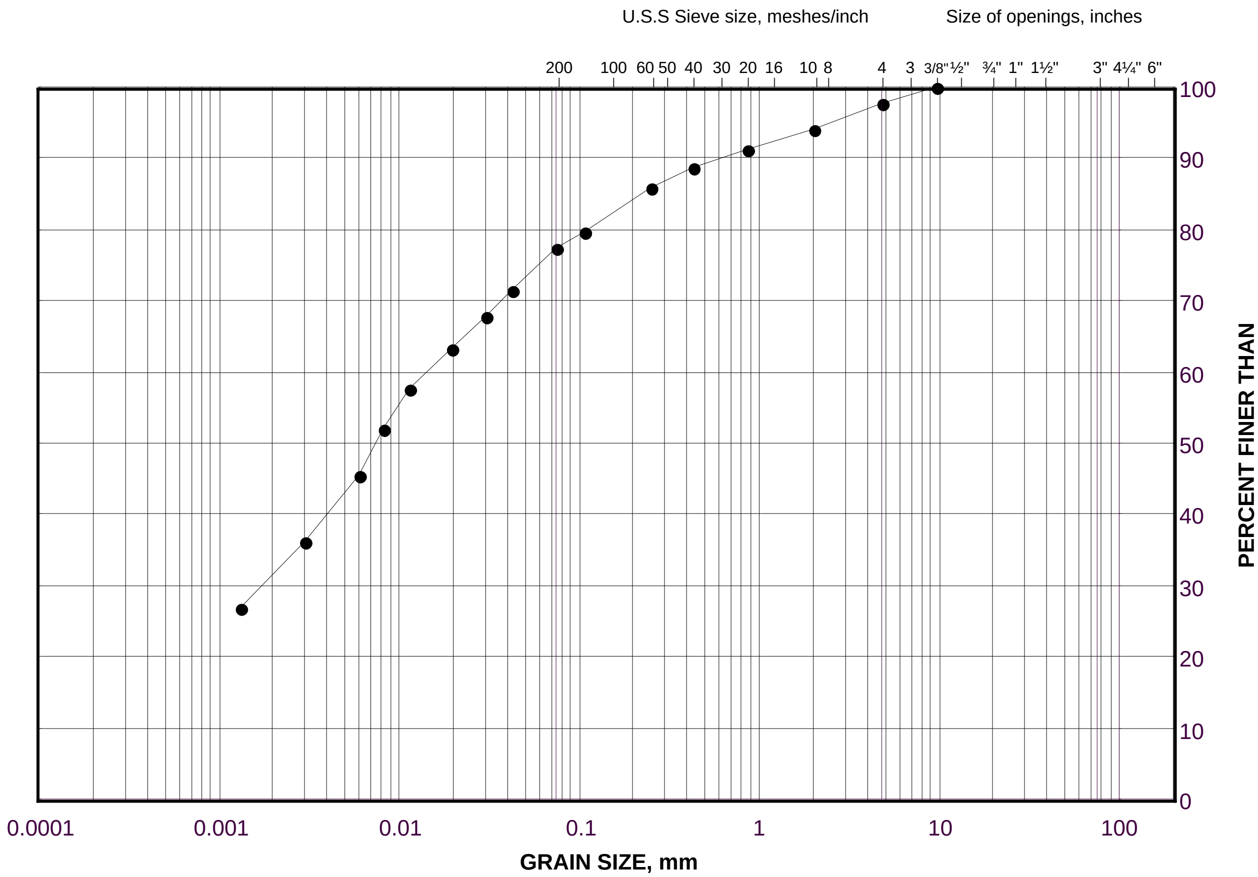
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt Fill

FIGURE B-1



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-7	3	186.7

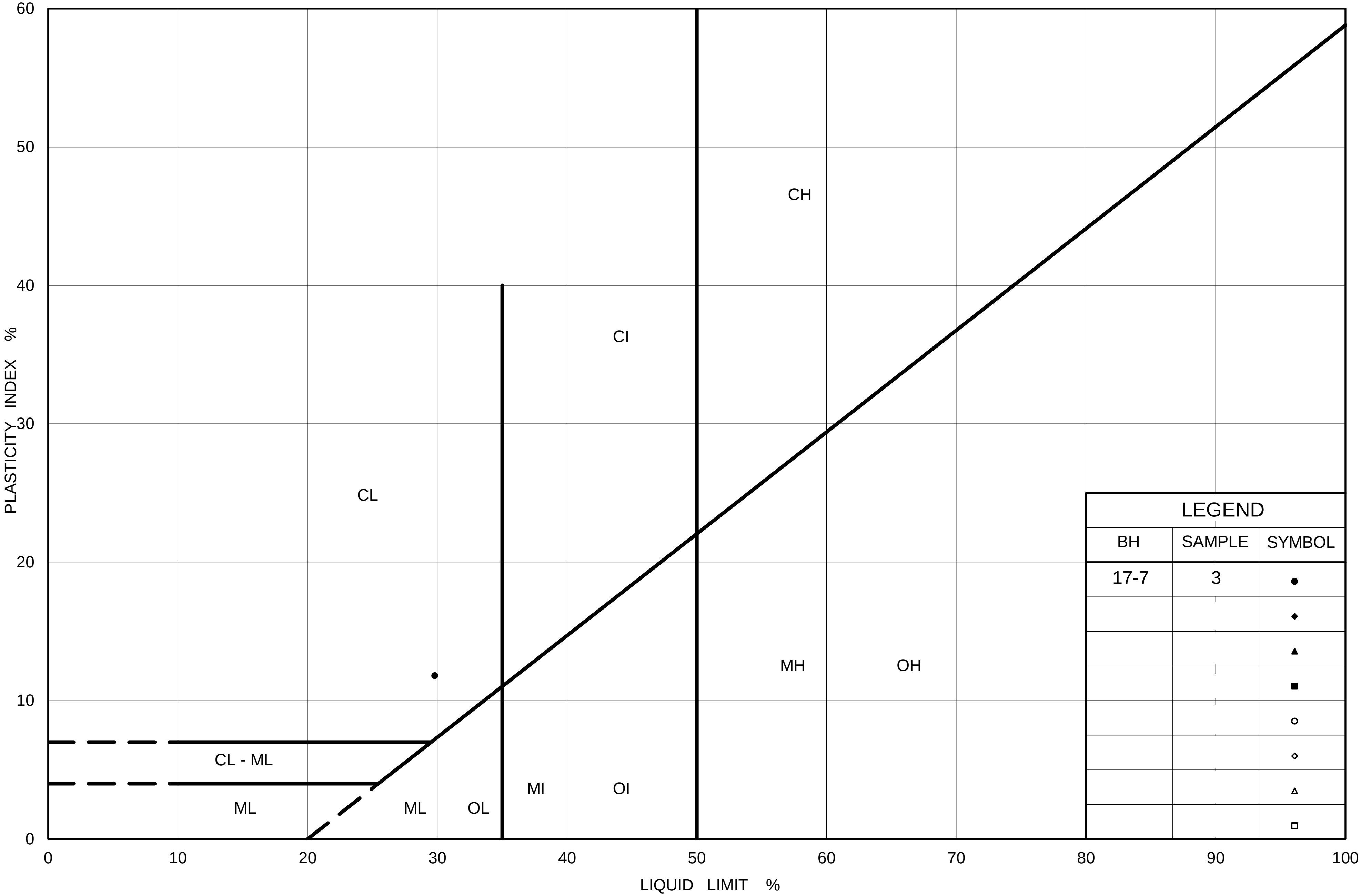
Project Number: 1669996

Checked By: NK

Golder Associates

Date: 17-Apr-19

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Sandy Clayey Silt Fill

Figure No. B-2

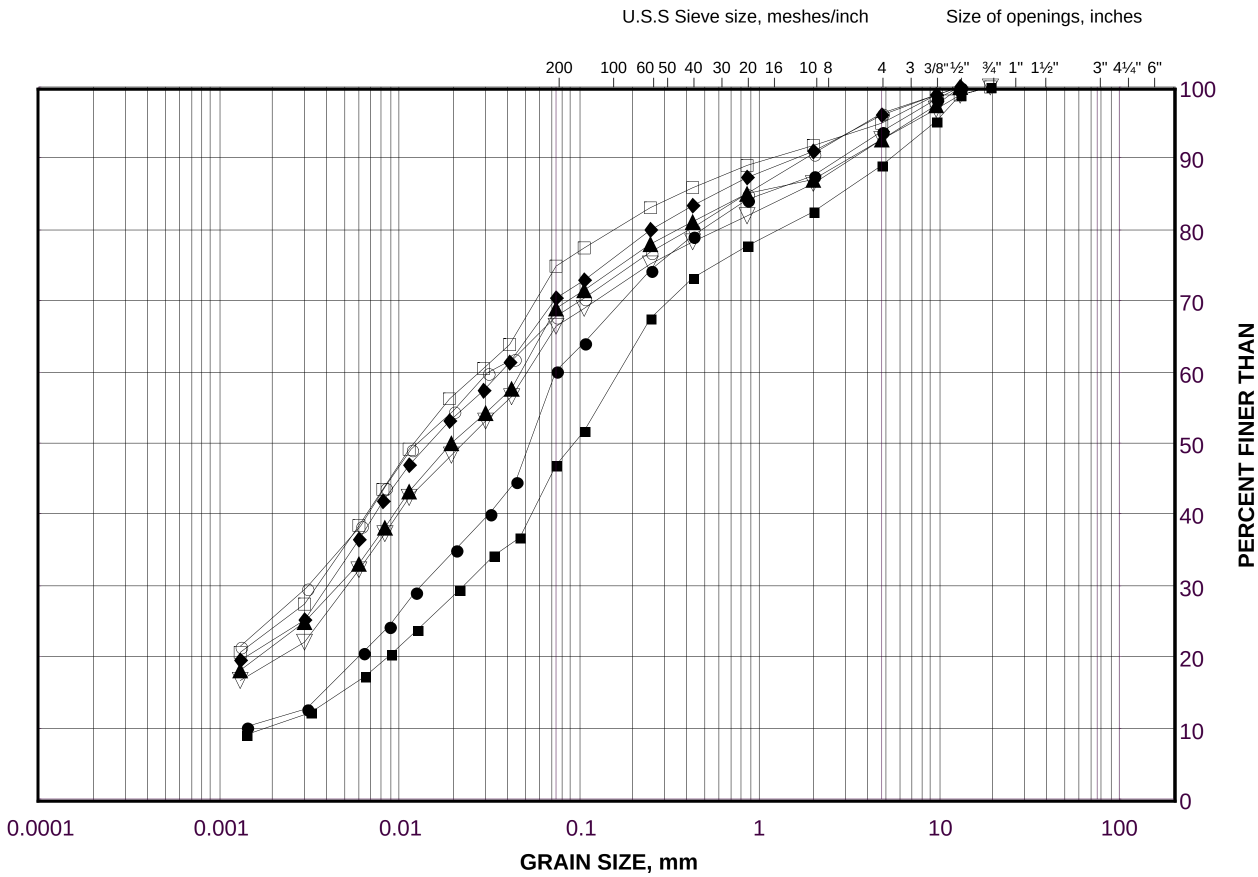
Project No. 1669996 (2200)

Checked By: NK

GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B-3A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SWM-1	10	177.0
■	17-7	10	179.2
◆	SWM-1	3	186.2
▲	SWM-2	4	185.6
▽	SWM-1	7	182.9
❍	17-7	7	183.6
□	SWM-2	9	180.3

Project Number: 1669996

Checked By: NK

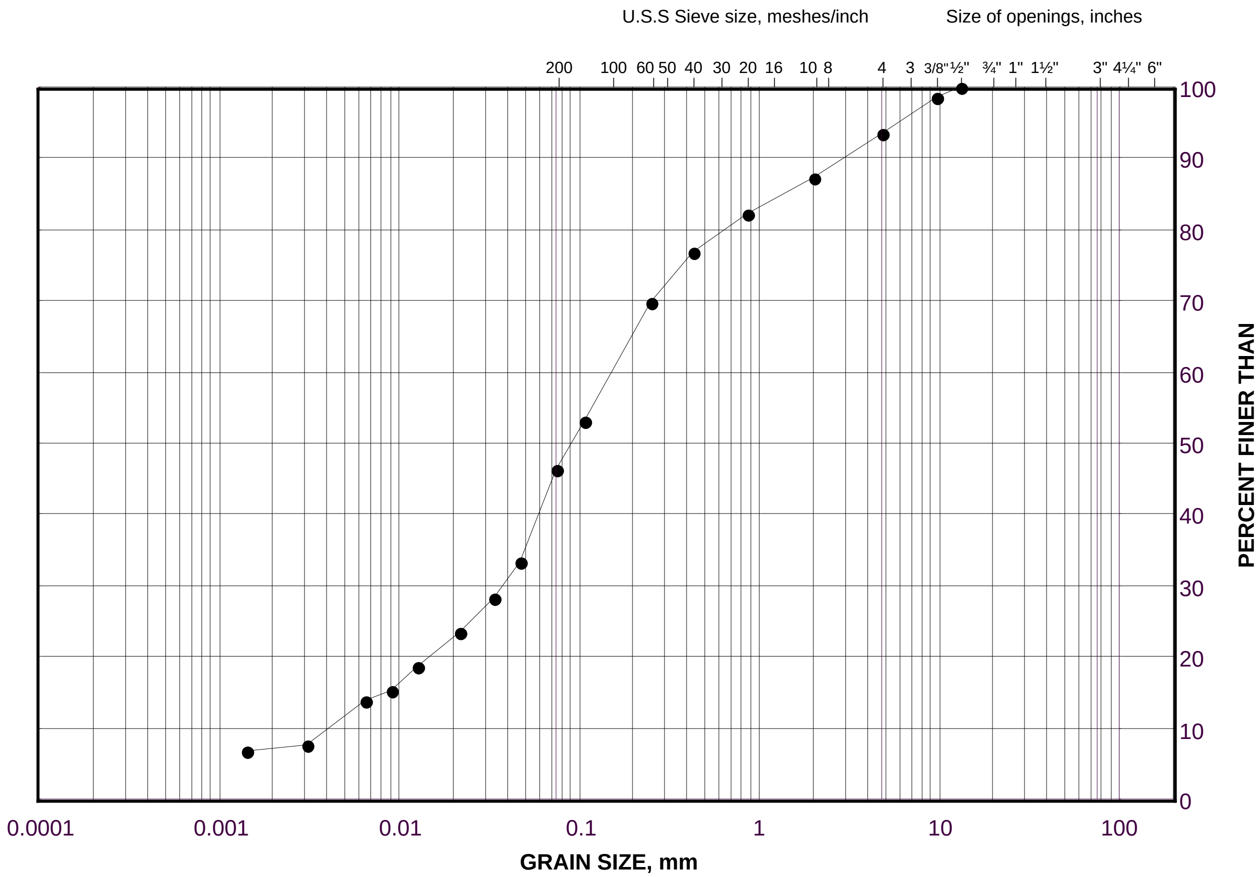
Golder Associates

Date: 17-Apr-19

GRAIN SIZE DISTRIBUTION

Silt and Sand Till

FIGURE B-3B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SWM-2	11	177.2

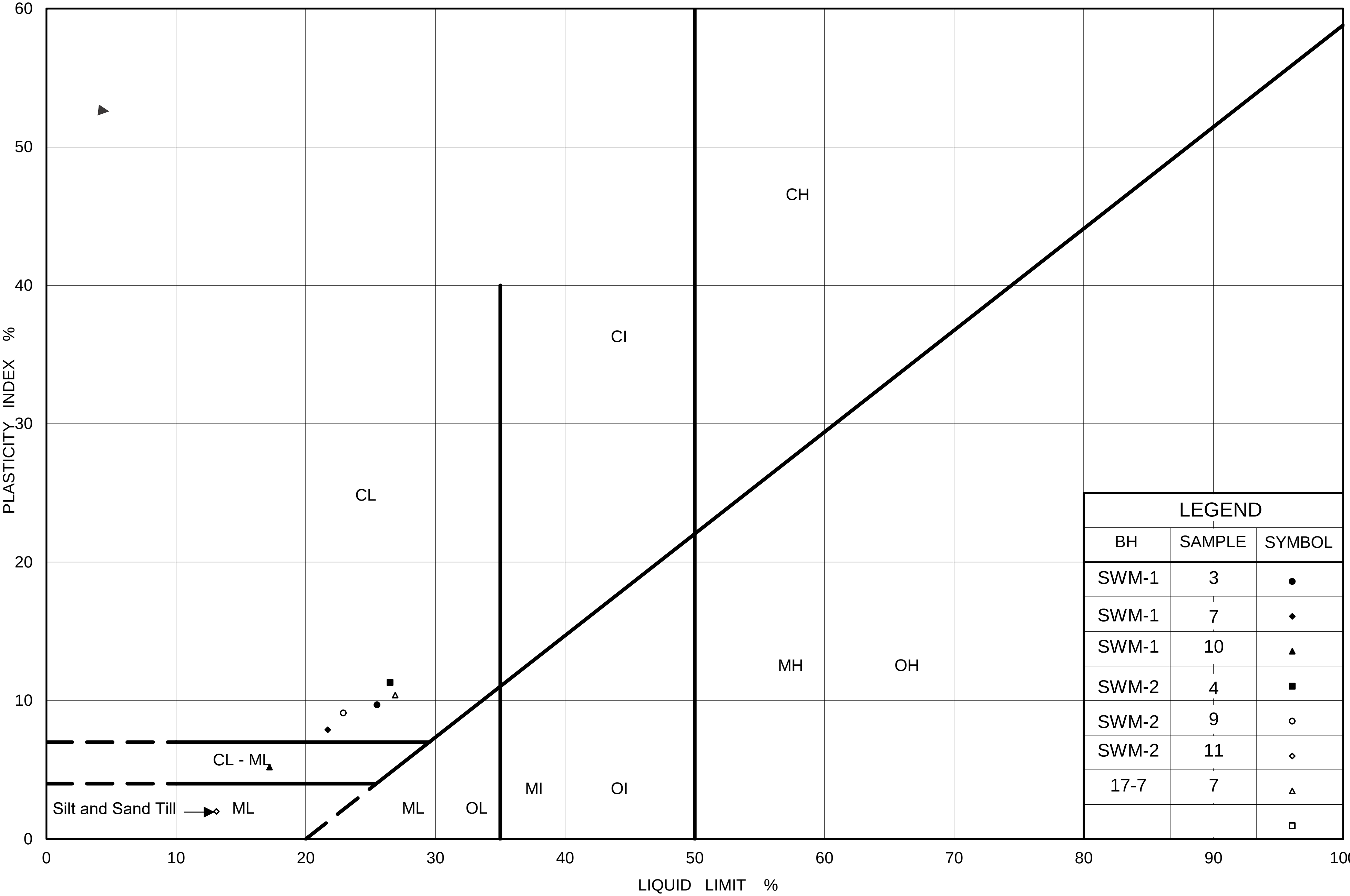
Project Number: 1669996

Checked By: NK

Golder Associates

Date: 17-Apr-19

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
SWM-1	3	●
SWM-1	7	◆
SWM-1	10	▲
SWM-2	4	■
SWM-2	9	○
SWM-2	11	◇
17-7	7	△
		□

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Ontario

PLASTICITY CHART

Clayey Silt Till to Silt and Sand Till

Figure No. B-4

Project No. 1669996 (2200)

Checked By: NK

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