

Foundation Investigation and Design Report

Stormwater Management Ponds

Highway 400 Widening, from North of King Road to

South of Lloydtown-Aurora Road, King City, Ontario

MTO Agreement No. 2017-E-0016-015, G.W.P. 2835-02-00

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PART A

FOUNDATION INVESTIGATION REPORT
STORMWATER MANAGEMENT PONDS
HIGHWAY 400 WIDENING, FROM NORTH OF KING ROAD TO
SOUTH OF LLOYDTOWN-AURORA ROAD, KING CITY, ONTARIO
MTO AGREEMENT NO. 2017-E-0016-015, G.W.P. 2835-02-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detail design of the widening of Highway 400 from north of King Road to south of 16th Sideroad, and from north of 16th sideroad to south of Lloydtown-Aurora Road (i.e., from King Road to Lloydtown-Aurora Road).

This report addresses the foundation investigation carried out for three proposed stormwater management ponds (SWMPs) at the locations shown on Drawing 1. The purpose of this investigation is to establish the subsurface conditions at the location of the proposed SWMPs based on borehole drilling and geotechnical laboratory testing on selected samples.

This report was developed based on information from the current foundation investigation, supplemented with relevant information from Golder's previous foundation investigation carried out for a culvert within the project limits. The results of the previous foundation investigation are presented in the following report:

- **MTO GEOCRES 30M13-214:** "Foundation Investigation and Design Report, Culverts from Station 13+375 to Station 22+500, Highway 400 Widening from North of King Road to South Canal Bank Road, Regional Municipality of York, G.W.P. 2835-02-00", Golder Report Number 09-1111-0018-10, dated December 1, 2015.

2.0 PROJECT DESCRIPTION

Highway 400 is to be widened from north of King Road to south of 16th Sideroad, and from north of 16th sideroad to south of Lloydtown-Aurora Road (i.e. form King Road to Lloydtown-Aurora Road). As part of the proposed highway widening, three SWMPs are proposed adjacent to Highway 400, located about 1 km north of King Road, between about Station 13+250 and 13+650, as shown on Drawing 1. The SWMPs are designated as Pond 4NW, Pond 4SW and Pond 4NE. An existing culvert (Culvert 26) crosses Highway 400 at about Station 13+414 and crosses Highway 400 between the two proposed ponds to the north and the one proposed pond to the south.

The existing ground surface in the vicinity of the proposed SWMPs west of Highway 400 (i.e. Pond 4NW and Pond 4SW) ranges from about Elevation 302 m to 305 m and the existing ground surface in the vicinity of the proposed SWMP east of Highway 400 (i.e. Pond 4NE) ranges from about Elevation 303 m to 307 m.

The proposed SWMPs are located within a portion of the existing MTO Right-of-Way, however, the proposed SWMPs are primarily located on private property to be acquired by MTO. In the vicinity of the proposed SWMPs, the topography primarily consists of relatively flat terrain currently used for agricultural purposes.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation (GEOCRES 30M13-214)

As outlined in GEOCRES 30M13-214, a foundation investigation was carried out along Culvert 26 which included one borehole (designated as Borehole C26-1) located in the vicinity of Pond 4SW and Pond 4NW, and one borehole (designated as Borehole C26-4) located in the vicinity of Pond 4NE, at the locations shown on Drawing 1. Two other boreholes (designated as Boreholes C26-2 and C26-3) were advanced outside of the SWMP locations but within the Highway 400 embankment and are also shown on Drawing 1 for reference only. A copy of the borehole records are provided in Appendix A.

The borehole locations and ground surface elevations were surveyed by Callon Dietz Incorporated, Ontario Land Surveyors. The borehole locations (in MTM NAD 83 Zone 10 northing and easting coordinates and latitude and longitude), the ground surface elevations (referenced to Geodetic datum), and borehole depths are summarized below.

Borehole	Location (MTM NAD 83, Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
C26-1	4,865,850.9 (43.932624)	299,219.9 (-79.569504)	302.5	11.3
C26-2	4,865,855.6 (43.932666)	299,241.5 (-79.569234)	305.5	15.9
C26-3	4,865,862.7 (43.932730)	299,284.6 (-79.568698)	305.3	15.9
C26-4	4,865,862.2 (43.932727)	299,300.9 (-79.568495)	303.1	11.3

3.2 Current Investigation

The field work for the current foundation investigation was carried out in May 2020. At that time, a total of eight boreholes, designated as Boreholes SMP-1 to SMP-8, were advanced in the vicinity of the proposed SWMPs, at the locations shown on Drawing 1. The borehole records are provided in Appendix B.

The field investigation was carried out using a D-50T track-mounted drill rig, supplied and operated by Walker Drilling Inc. of Utopia, Ontario. The boreholes were advanced using 210 mm outside diameter continuous flight hollow stem augers. Soil samples were obtained from the boreholes at approximately 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with SPT procedures (ASTM D1586)¹. The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension would not be sampled or represented in the grain size distributions.

The groundwater conditions in the open boreholes were observed during the drilling operations and a standpipe piezometer was installed in Boreholes SMP-1, SMP-5 and SMP-6 to permit monitoring of the groundwater level at the borehole locations. The standpipe piezometers consist of 50 mm diameter PVC pipe, with a slotted screen sealed at a selected depth within the boreholes. The borehole and annulus surrounding the piezometer pipe above the screen sand pack was backfilled to the ground surface with bentonite pellets and a stick-up monument casing was provided at each piezometer location. Piezometer installation details and water level readings are described on the borehole records presented in Appendix B. All boreholes in which standpipe piezometers were not installed were backfilled to ground surface with bentonite upon completion, in general accordance with Ontario Regulation 903 (as amended).

The field work was observed on a full-time basis by a member of Golder's engineering staff, who located the boreholes, arranged for the clearance of underground utilities, directed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's geotechnical laboratory in Mississauga, Ontario where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO LS and/or ASTM standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

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

The borehole locations and the ground surface elevations were surveyed by Golder using a Trimble Geo7X with a minimum vertical and horizontal accuracy of 0.1 m. The borehole locations and elevations are referenced relative to MTM NAD 83 (Zone 10) northing and easting coordinates and to geodetic datum (HT2_0 / CGVD 1928:1978), respectively. The borehole locations (including northing/easting and latitude/longitude), ground surface elevations, and drilled depths are summarized below.

Pond ID	Borehole No.	MTM NAD 83 (Zone 10)		Ground Elevation (m)	Drilled Depth (m)
		Northing, m (Latitude, °)	Easting, m (Longitude, °)		
Pond 4SW (West of Highway 400)	SMP-1	4865739.18 (43.931619)	299234.44 (-79.569321)	302.4	9.8
	SMP-2	4865795.67 (43.932127)	299197.06 (-79.569788)	302.3	9.8
Pond 4NW (West of Highway 400)	SMP-3	4865897.56 (43.933044)	299194.01 (-79.569827)	302.5	9.8
	SMP-4	4865963.08 (43.933634)	299205.1 (-79.569689)	303.3	9.8
	SMP-5	4866036.24 (43.934292)	299169.62 (-79.570132)	304.3	9.8
Pond 4NE (East of Highway 400)	SMP-6	4865915.80 (43.933209)	299318.58 (-79.568275)	304.1	9.8
	SMP-7	4865973.00 (43.933724)	299292.01 (-79.568607)	304.3	9.8
	SMP-8	4866065.96 (43.934560)	299279.29 (-79.568766)	306.2	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This area of Highway 400 is within the physiographic region known as Oak Ridges Moraine (Chapman and Putman, 1984)². Along Highway 400 at the site, the Oak Ridge Moraines extends from about 2 km north of King Road to about 2 km south of Lloydtown-Aurora Road.

The Oak Ridges Moraine predominantly consists of sand and gravel, although in the King Township area these soils are often overlain by till. It is understood that during grading for the initial construction of Highway 400 through this area, deep cuts exposed up to about 10 m of till overlying the sand and gravel deposits.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the previous foundation investigation (C26-1 and C26-4) and the current foundation investigation (SMP-1 to SMP-8) are presented on the borehole records in Appendix A and B, respectively. The detailed results of the laboratory tests carried out as part of the current foundation investigation are provided in Appendix C.

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 cross-sections on Drawing 2 are inferred from non-continuous sampling, observations of drilling progress and the borehole results. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological

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

change and moreover, the interpreted stratigraphy shown on Drawing 2 represents a simplification of the subsurface conditions. Furthermore, subsurface conditions will vary between and beyond the borehole locations.

In general, the subsoils at the proposed SWMPs consist of topsoil underlain by cohesive till interlayered with non-cohesive silty sand and sandy silt to silt. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil / Organic Clayey Silt

A layer of topsoil / organic clayey silt was encountered at ground surface in all boreholes, ranging in thickness from about 100 mm to 700 mm.

The water content measured on two samples of the topsoil was 29 % and 32 %.

4.2.2 Clayey Silt-Silt and sand to Sandy Clayey Silt (Fill)

A 0.2 m to 2.0 m thick layer of cohesive fill was encountered underlying the topsoil in Boreholes SMP-3 to SMP-8, extending to depths ranging from 0.7 m to 2.3 m below ground surface (Elevations 304.7 m to 301.8 m). The fill composition varied from clayey silt-silt and sand to sandy clayey silt, trace gravel. The fill contained organics in Boreholes SMP-3 to SMP-8, and typically consisted of rootlets in Boreholes SMP-3 and SMP-4, and wood fragments in Borehole SMP-7.

The SPT “N” values measured within the fill layer range from 5 blows to 27 blows per 0.3 m of penetration, suggesting the fill has a firm to very stiff consistency, but is generally firm to stiff.

Grain size distribution tests were carried out on four samples of the fill from the current investigation and the results are shown on Figure C1 in Appendix C. Atterberg limits tests were carried out on four samples of the fill and measured liquid limits ranging from about 19 % to 32 %, plastic limits ranging from about 13 % to 18 %, and plasticity indices ranging from about 4 % to 14 %. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C2 in Appendix C and indicate the fill ranges from a clayey silt-silt to a clayey silt of low plasticity. The water contents measured on samples of the fill range from 14 % to 27 %. An organic content test was carried out on one sample of the fill (from Borehole SMP-7) and indicates the fill at this location has an organic content of 1.7%.

4.2.3 Sandy Clayey Silt to Clayey Silt

A 0.8 m and 1.4 m thick deposit of sandy clayey silt to clayey silt, trace gravel was encountered underlying the topsoil in Borehole SMP-2 and C26-4, extending to depths of 1.5 m below ground surface (Elevations 300.8 m and 301.6 m respectively). A silty sand layer containing clayey silt pockets was encountered between topsoil and the sandy clayey silt deposit in Borehole SMP-2 (See Section 4.2.5 for details).

The SPT “N” values measured within the sandy clayey silt to clayey silt deposit range from 5 blows to 7 blows per 0.3 m of penetration, suggesting the deposit has a firm consistency.

A grain size distribution test was carried out on one sample of the sandy clayey silt to clayey silt deposit from the current investigation and the results are shown on Figure C3 in Appendix C. An Atterberg limits test was carried out on one sample of the deposit and measured a liquid limit of about 19 %, a plastic limit of about 12 %, and a plasticity index of about 7 %. The results of the Atterberg limits test are shown on the plasticity chart on Figure C4 in Appendix C and indicate the deposit is a clayey silt of low plasticity. The water contents measured on samples of the deposit range from 17 % to 24 %.

4.2.4 Sandy Clayey Silt-Silt to Clayey Silt (Till)

A deposit of sandy clayey silt-silt to clayey silt (till), trace gravel was encountered in all boreholes. The deposit was encountered below the topsoil in Borehole SMP-1, below the fill in Boreholes SMP-3 to SMP-6 and SMP-8, and below the sandy clayey silt to clayey silt deposit and silty sand interlayers in Boreholes SMP-2, SMP-7, C26-1 and C26-4, at depths ranging from 0.7 m to 5.0 m below ground surface (Elevations 304.7 m to 299.3 m). The till deposit typically extended to the borehole termination depths of 9.8 m to 11.3 m below ground surface (Elevations 296.1 m to 291.2 m), except at Boreholes SMP-4 and SMP-5 where the deposit extended to depths of 7.1 m and 7.2 m (Elevations 296.2 m and 297.1 m, respectively). The till contained various seams and layers of sand to silty sand (See Section 4.2.5) and sandy silt to silt (See Section 4.2.6). Auger grinding and difficulties advancing the split-spoon sampler (spoon “bouncing” on obstructions) were recorded at varying depths while advancing through the till deposit at Boreholes SMP-2, SMP-3, SMP-8 and C26-4, suggesting the presence of cobbles and boulders within the deposit at these locations.

The SPT “N” values measured within the till range from 8 blows to 98 blows per 0.3 m of penetration, with one value of 100 blows for 0.25 m of penetration and one value of 55 blows for 0.08 m of penetration. These results suggest the cohesive till has a stiff to hard consistency.

Grain size distribution tests were carried out on three samples of the till from the previous investigation and the results are provided on the borehole records in Appendix A. Grain size distribution tests were carried out on twelve samples of the till from the current investigation and the results are shown on Figures C5A/B in Appendix C. Atterberg limits tests were carried out on seven samples of the till from the previous investigation and on twelve samples of the till from the current investigation; the tests measured liquid limits ranging from about 19 % to 30 %, plastic limits ranging from about 11 % to 17 %, and plasticity indices ranging from about 5 % to 13 %. The results of the Atterberg limits tests from the previous investigation are provided on the borehole records in Appendix A and the results of the Atterberg limits tests from the current investigation are shown on the plasticity chart on Figure C6A/B in Appendix C. The Atterberg limits tests indicate the till ranges from a clayey silt-silt to a clayey silt of low plasticity. The water contents measured on samples of the till range from 11 % to 21 %.

4.2.5 Silty Sand Interlayers

Various seams and interlayers of silty sand were encountered within the sandy clayey silt to clayey silt deposit and within the till deposit, in all boreholes excluding Borehole SMP-8. The silty sand interlayers contained varying amounts of gravel (i.e. trace gravel to gravelly) and contained clayey silt pockets in Boreholes SMP-1 and SMP-2. The upper silty sand interlayers encountered in Borehole SMP-2 contained organics and rootlets. The interlayers generally range in thickness from about 0.07 m to 2.0 m; the depth and thickness of the encountered interlayers are summarized in the table below.

Borehole	Depth to Top of Interlayer (m)	Elevation at Top of Interlayer (m)	Interlayer Thickness (m)
C26-1	0.6	301.9	0.6 (600 mm)
C26-4	4.2	298.9	1.4
SMP-1	3.7	298.7	1.0
SMP-2	0.3	302.0	0.4 (400 mm)
	1.0	301.3	0.15 (150 mm)
	1.5	300.8	0.4 (400 mm)
	3.0	299.3	2
SMP-3	2.0	300.5	0.1 (100 mm)
	2.7	299.8	0.076 (76 mm)
SMP-4	2.5	300.8	0.070 (70 mm)
	2.7	300.6	0.100 (100 mm)
SMP-5	2.8	301.5	1.5
	4.5	299.6	0.3 (300 mm)
SMP-6	2.6	301.5	0.5 (500 mm)
	4.5	299.6	1.7
SMP-7	2.3	302.0	0.4 (400 mm)
	4.5	300.0	0.5 (500 mm)

The SPT “N” values measured within the silty sand interlayers range from 3 blows to 36 blows per 0.3 m of penetration, indicating the silty sand interlayers have a very loose to dense compactness condition, but are generally compact.

A grain size distribution test was carried out on one sample of the silty sand interlayer from the previous investigation and the results are provided on the borehole record (Borehole C26-4) in Appendix A. Grain size distribution tests were carried out on three samples of the silty sand interlayers from the current investigation and the results are shown on Figure C7 in Appendix C.

4.2.6 Silt and sand to Silt Interlayers

Various seams and interlayers of silt and sand to silt were encountered within the till deposit in all boreholes excluding Borehole SMP-8. The silt and sand layers were generally non-cohesive and the predominantly silt layers were described as cohesive. The interlayers range in thickness from about 0.1 m to 2.7 m; the depth and thickness of the encountered interlayers are summarized in the table below.

Borehole	Depth to Top of Interlayer (m)	Elevation at Top of Interlayer (m)	Interlayer Thickness (m)
C26-1	3.7	298.8	0.8 (800 mm)
C26-4	7.6	295.5	0.3 (300 mm)
SMP-1	4.7	297.7	0.9 (900 mm)
SMP-2	5.6	296.7	0.8 (800 mm)
SMP-3	3.8	298.7	< 0.1 (100 mm)
SMP-4	7.1	296.2	2.7*
SMP-5	3.0	301.3	0.255 (255 mm)
	3.6	300.7	0.1 (100 mm)
	7.2	297.1	2.6*
SMP-6	3.1	301.0	0.8 (800 mm)
	5.1	299.0	0.075 (75 mm)
SMP-7	2.7	301.6	1.8

*indicates interlayer not fully penetrated (i.e. borehole terminated within the deposit).

The SPT “N” values measured within the silt and sand to silt interlayers typically range from 12 blows to 29 blows per 0.3 m of penetration, indicating the silt and sand to silt interlayers have a compact / stiff to very stiff level of compactness / consistency. One higher SPT “N” value of 81 was measured in the silt layer in Borehole SMP-5.

A grain size distribution test was carried out on one sample of the silt and sand to silt interlayer from the previous investigation and the results are provided on the borehole record (Borehole C26-1) in Appendix A. Grain size distribution tests were carried out on five samples of the sandy silt to silt interlayers from the current investigation and the results are shown on Figure C8 in Appendix C. Atterberg limits tests were carried out on five samples of the sandy silt to silt interlayers from the current investigation. The tests indicate one sample to be non-plastic and the remaining samples measured liquid limits ranging from about 15 % to 20 %, plastic limits ranging from about 12 % to 17 %, and plasticity indices ranging from about 2 % to 3 %. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C9 in Appendix C and indicate the sandy silt to silt interlayers range from non-plastic to slightly plastic. The water contents measured on samples of the silt and sand to silt interlayers range from 12 % to 22 %.

4.3 Groundwater Conditions

The unstabilized groundwater level was observed in the open boreholes upon completion of drilling, as presented on the borehole records in Appendix A and B.

As part of the previous foundation investigation, one standpipe piezometer was installed in Borehole C26-1 to permit the monitoring of the groundwater level at the borehole location. As part of the current foundation investigation, three standpipe piezometers were installed to permit the monitoring of the groundwater level at Boreholes SMP-1, SMP-5, and SMP-6. The screened zone of the standpipe piezometers, the depth to the groundwater level and corresponding groundwater elevation measured in the piezometers are summarized below.

SWMP ID	Borehole ID	Screened Stratigraphy	Screened Depth, m (Elevation, m)	Date of Reading	Depth to Water Level, m (Elevation, m)
Pond 4SW / Pond 4NW	C26-1	Clayey silt till / silt and sand	3.1 – 4.6 (299.4 - 297.9)	December 16, 2010	0.2 (302.3)
				February 1, 2011	0.5 (302.0)
				January 13, 2021	0.3 (302.2)
Pond 4SW	SMP-1	Clayey silty till / silty sand	0.9 – 4.1 (301.5 – 298.3)	May 14, 2020	0.5 (301.9)
				May 21, 2020	0.4 (302.0)
				January 13, 2021	0.8 (301.6)
Pond 4NW	SMP-5	Silty sand / sandy clayey silt-silt till	2.7 – 6.4 (301.6 – 297.9)	May 13, 2020	0.5 (303.8) ¹
				May 21, 2020	1.5 (302.8)
				January 13, 2021	1.6 (302.7)
Pond 4NE	SMP-6	Clayey silt till / silty sand / sandy silt	1.9 – 5.2 (302.2 – 298.9)	May 22, 2020	1.4 (302.7)
				January 13, 2021	1.4 (302.7)

Note 1. Water level obtained upon completion of installation and not representative of stabilized groundwater levels.

The groundwater levels noted above are subject to seasonal fluctuations and precipitation events and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

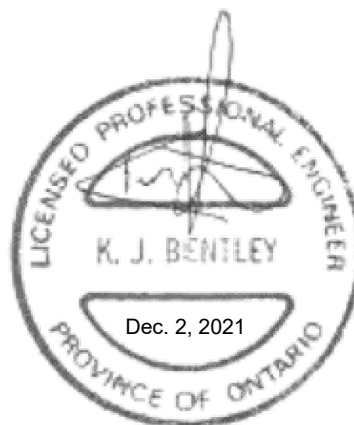
This Foundation Investigation Report was prepared by Mr. Carter Comish, E.I.T., and reviewed by Ms. Anastasia Poliacik, P.Eng., a geotechnical engineer with Golder. Mr. Kevin Bentley, P.Eng., an MTO Foundations Designated Contact and an Associate with Golder, conducted an independent technical and quality control review of the report.

Signature Page

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PART B

FOUNDATION DESIGN REPORT
STORMWATER MANAGEMENT PONDS
HIGHWAY 400 WIDENING, FROM NORTH OF KING ROAD TO SOUTH OF
LLOYDTOWN-AURORA ROAD, KING CITY, ONTARIO
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation recommendations for the design of three proposed stormwater management ponds (SWMPs) to be constructed as part of the Highway 400 Widening from north of King Road to south of 16th Sideroad, and from north of 16th sideroad to south of Lloydtown-Aurora Road (i.e. from King Road to Lloydtown-Aurora Road). The SWMPs are located between about Station 13+250 and 13+650, as shown on Drawing 1 and are designated as Pond 4NW, Pond 4SW and Pond 4NE. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the 2010 subsurface investigation and the current subsurface investigation at the proposed SWMP locations.

This foundation and investigation report with the interpretation and recommendations are for the use of MTO and shall not be used or relied upon for any other purposes 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 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. Contractors must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Project Understanding

6.2.1 Proposed Pond Details

The following table summarizes the details of the proposed SWMP design as shown on the drawing titled “Hwy 400_Pond Section_For Golder”, provided by MH on July 22, 2021.

Pond ID	Top of Pond Berm / Maintenance Access	Design Pond Base Elevation	Approximate Existing Ground Surface	Approximate Max Fill / Cut
Pond 4SW	303.5 to 304.1 m	302.4 m	302.5 m	0.1 m Cut
Pond 4NW	303.9 to 304.9 m	302.8 m	302.0 to 305.0 m	1 m Fill / 2 m Cut
Pond 4NE	304.0 to 305.8 m	302.7 m	303.0 to 306.0 m	1 m Fill / 4 m Cut

The base of Pond 4SW will generally be constructed at the existing ground surface. The base of Pond 4NW will generally be constructed about 1 m above the existing ground surface at the south end of the pond and about 0.5 m to 2 m below existing ground surface at the north end of the pond. The base of Pond 4NE will generally be constructed about 1 m to 4 m below existing ground surface.

The proposed perimeter berms range from about 1 m to 3 m in height with side slopes inclined at 2 Horizontal to 1 Vertical (2H:1V). The adjacent highway embankment side slopes are inclined at about 3H:1V.

It is understood the ponds are designed as “dry ponds” such that storm water storage will be temporary with no permanent pool water level.

6.2.2 Groundwater Levels

The highest groundwater levels measured in the standpipe piezometers installed in the vicinity of Pond 4SW, 4NW, and 4NE are near ground surface are at about Elevation 302.3 m, Elevation 302.8 m, and 302.7 m, respectively. The groundwater elevations were measured in December 2010 and May 2020 and have been used in developing the design recommendations and construction considerations for the proposed SWMPs.

6.3 Site Preparation

All topsoil, organic material, existing fill containing excessive organics or deleterious material, and any softened/loosened soils must be completely stripped / removed from below the footprint of the pond and pond berms. Consideration can be given to leaving the existing fill in place below the pond base and pond berms, provided the fill is competent and does not contain excessive organics or deleterious materials, as determined by the geotechnical engineer / qualified person. However, if settlement sensitive structures are proposed within the pond / pond berm footprint, then it is recommended that all existing fill be removed from below the footprint of the settlement sensitive structures.

Based on the encountered subsurface conditions in the boreholes advanced on site, stripping of the topsoil, organic material, and existing fill could extend up to the elevations and depths summarized below.

Pond	Anticipated Elevation (m) after Stripping	Anticipated Founding Soils after Stripping	Depth Below Pond Base Elevation (m)
Pond 4SW	301.7 – 302.0	Firm to very stiff to clayey silt till / Loose silty sand / Firm sandy clayey silt containing thin silty sand layers	0.7 - 0.4
Pond 4NW	301.8 – 302.5	Stiff to very stiff clayey silt till to clayey silt-silt till / Loose silty sand	1.0 – 0.3
Pond 4NE	302.0 - 302.7 ¹	Very stiff to hard clayey silt till / Compact silty sand to sandy silt / Firm clayey silt	0.0 - 0.7

¹ pond base elevation / subgrade

After stripping, the exposed founding soils should be inspected by a geotechnical engineer / qualified person (and proof-rolled as necessary) to identify pockets of any unsuitable soils, softened / loosened areas and/or poorly performing areas to be further subexcavated and replaced with suitable engineered fill.

After stripping and subexcavating any poorly performing areas, engineered fill will need to be placed to reach design subgrade levels. Suitable engineered fill may consist of earth fill (anticipated to be available from excavation of the SWMP and/or other cut areas at the site) that is free of organics / deleterious material with moisture contents typically within 2% of its optimum moisture content. Alternatively, engineered fill could consist of imported earth borrow as per OPSS.PROV 212 or select subgrade material as per OPSS.PROV 1010. The engineered fill shall be placed in accordance with OPSS.PROV 206 (*Grading*) and OPSS.PROV 501 (*Compacting*), as amended by SP 105S22.

6.4 Pond Design

6.4.1 Pond Base

As indicated by MH drainage and hydrogeology teams and consistent with other stormwater management ponds along this stretch of Highway 400, it is understood that a separation barrier is not required between the natural groundwater and the stormwater contained within the SWMPs. As a result, from a foundations perspective, a pond liner system is not considered to be required for all three SWMPs.

The soil at the pond base will need to be protected to resist erosion from the anticipated stormwater flows as discussed in Section 6.4.3.

6.4.2 Berm / Embankment

Pond berms / embankments may be constructed using engineered fill consisting of suitable earth fill (free of organics / deleterious material) anticipated to be available from excavation of the ponds and/or other cut areas at the site.

Alternatively, engineered fill could consist of imported earth borrow as per OPSS.PROV 212 or select subgrade material as per OPSS.PROV 1010. The engineered fill shall be placed in accordance with OPSS.PROV 206 (*Grading*) and OPSS.PROV 501 (*Compacting*), as amended by SP 105S22

6.4.3 Erosion Protection

The requirements for the design of erosion protection measures for the inlet and outlet storm sewer pipes of the SWMPs should be assessed by the hydraulic design engineer based on anticipated flow velocities and design precipitation events. 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, and OPSD 810.020 (*Rip-Rap Treatment for Ditch Inlets*). The rip-rap should be placed to above the pipe invert, in combination with cut-off headwalls or clay seals. Rip-rap should be provided over the full extent of the side slopes and base grade below and adjacent to the sewer inlet and outlet locations.

The pond / berm slopes should be vegetated as soon as practicable 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*). The soil at the pond base and interior side-slopes (i.e. anticipated wetted perimeter) should be assessed by the hydraulic engineer / pond designer to resist erosion during the design stormwater event. Vegetation may be adequate, otherwise, granular sheeting or rip-rap may be required depending on the anticipated flow velocities.

If vegetation protection is not in place before the winter season, an alternate protection, such as covering the slopes with stone or gravel sheeting or temporary erosion control blankets, is recommended to reduce the potential for remedial works required on the side slopes in the spring season prior to topsoil and seeding.

6.4.4 Global Stability

Global stability analyses of the SWMPs were carried out using the commercially available program Slide2 (Version 9.0), produced by Rocscience Inc., employing the Morgenstern-Price method of analysis. A target global factor of safety equal to or greater than 1.25 for short-term (undrained) and 1.43 for long-term (effective stress) conditions was considered appropriate for design (using a “typical consequence level” and “typical degree of site and prediction understanding”) as per the CHBDC (2019) and MTO’s “*Highway Standards Branch, Provisional*

Engineering Memorandum, Materials Engineering and Research Office (MERO) #2020-01" dated March 23, 2020.

The critical section of each pond location for global stability was assumed to be the approximate middle of the ponds (at Station 13+350 and 13+520), with the cross-section taken to be perpendicular to Hwy 400 to model the highest embankment height and assuming dry pond conditions. The soil parameters and groundwater elevations used for stability analyses are presented with the results of the analyses on Figures D-1 to D-6 in Appendix D. The parameters were estimated from empirical correlations with the borehole and Standard Penetration Test data, as well as consideration of geotechnical laboratory test data from these boreholes.

The results of the analyses, presented on Figures D-1 to D-6, present all slip surfaces with a factor of safety less than 1.43 which are considered surficial and will not impact operation of the highway and/or pond facilities. Based on the results, the global stability of all three ponds has a factor of safety greater than 1.43 and therefore meet the FoS for the short-term condition (target FoS of 1.25) and long-term condition (target FoS of 1.43).

The shallow slip surfaces shown on Figures D-1 to D-6 (with a factor of less than 1.43) are considered surficial (i.e., not global) and can be mitigated with periodic maintenance activities and selection of suitable earth fill for the berm construction combined with erosion protection measures, as outlined in Section 6.4.4.

6.5 Construction Considerations

6.5.1 Temporary Excavations

Excavations for the SWMPs and associated structures (culverts and inlet/outlet structures) are anticipated to extend up to about 4 m below ground surface through topsoil, clayey silt-silt and sand to sandy clayey silt (fill), sandy clayey silt to clayey silt, sandy clayey silt-silt to clayey silt (till), and silty sand. Cobbles and boulders were encountered or inferred at various depths within the till deposit in some of the boreholes. Conventional excavation equipment is expected to be suitable for excavation of the SWMPs.

All excavations should be carried out in accordance with the latest version of the Ontario Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The existing native and fill (non-till) soils are considered to be Type 3 soils, while the glacial till is 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.

6.5.2 Groundwater Control During Construction

Excavations for site preparation are anticipated to extend up to about 1 m below the measured groundwater levels. Although relatively minor groundwater seepage is anticipated from the low permeability clayey till matrix deposit, groundwater seepage or inflow is anticipated from the lenses and/or interlayers of water-bearing cohesionless soils within the till and from the fill above the till deposit. As such, depending on the groundwater levels during construction, localized advanced dewatering may be required to permit excavation of the pond footprints in dry conditions such that the base of the pond / pond side slopes remain stable and competent to allow for placement of erosion protection, as may be required.

Advanced dewatering may be in the form of shallow wells or ditches / trenches combined with sumps installed in advance of excavations. The groundwater level should be drawn down to 0.6 m below the base of the excavation over the entire pond footprints. Design of temporary dewatering systems is the responsibility of the Contractor

and it is recommended that a specialist dewatering subcontractor be retained to design and oversee dewatering operations.

Water takings in excess of 50,000 L/day are regulated by the Ministry of the Environment Conservation and Parks (MECP). Certain takings of groundwater and stormwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self-registration on the MECP's Environmental Activity and Sector Registry (EASR). Registry on the EASR replaces the need to obtain a Permit to Take Water (PTTW) for water taking and a Section 53 approval for discharge of water to the environment. A "Water Taking Plan" and a "Discharge Plan" are required by the MECP if water is taken in accordance with an EASR. In all cases, discharge under the EASR must be in accordance with a Discharge Plan (to be developed by a qualified professional). The Contractor will be responsible for obtaining any required discharge approvals. A Category 3 PTTW would be required for water takings in excess of 400,000 L/day.

Dewatering operations must be in accordance with OPSS.PROV 517 (*Dewatering*) and MTO's SP 517F01 (*Temporary Flow Passage System*). Given the apparent lack of infrastructure in the vicinity of the site and considering the foundation soils consist predominantly of competent till soils, a preconstruction condition survey is not considered to be required. As such, the fill-in in Table A of SP 517F01 should indicate that the preconstruction survey distance is "not applicable". However, it is recommended that the design engineer have a minimum of 5 years' experience in designing systems of similar nature and scope to the required work and therefore the fill-in in Table A of SP 517F01 should indicate "Yes" for the "Design Engineer Requirements". The remaining fill-ins of SP 517F01 should be provided by the drainage (hydrotechnical) engineer.

The contractor is responsible for the assessment and design of dewatering requirements, which depends on their chosen sequence of operations, method of temporary open cut excavation, as well as on the method and procedure for construction/operation/maintenance and decommissioning. It is recommended that the groundwater levels be measured closer to the time of construction, in order for the contractor to assess the dewatering requirements during construction. The contractor is also responsible for confirming that the radius of groundwater drawdown does not impact the existing embankment and any surrounding features, although this is not considered to be a concern considering the foundation soils consist predominantly of competent till soils.

If excavation operations are to progress during wet periods of the year (i.e., spring and fall), gravel sheeting in combination with Rip-Rap (or alternative erosion control measures) may be required to control erosion due to groundwater seepage and higher water flow (in particular, at the north end of Pond 4NE). Erosion control material should be comprised of a minimum thickness of 0.3 m of OPSS.PROV 1010 Granular A or Granular B Type II material. As a result, it is recommended that excavations for the SWMPs be carried out during the dry period of the year (i.e., summer months), however, this does not preclude the need for advanced dewatering or adequate surface water cut-off / diversion to stabilize excavated slopes prior to establishment of vegetative cover, which is the responsibility of the Contractor. An Operational Constraint for construction of the ponds during periods of low groundwater levels / precipitation (i.e., summer months) is provided in Appendix E.

Surface water and stormwater should be directed away from the excavation area to prevent ponding and/or flowing water that could result in disturbance and loosening/softening of the subgrade and/or impede construction of the pond drainage system. In particular, the existing drainage paths (into and from Culvert 26) that flow / drain into the proposed SWMP excavation areas may need to be diverted (temporarily or permanently) and/or controlled to avoid saturating / eroding the construction zone and pond footprints which could lead to instability during or after construction.

6.5.3 Piezometer Decommissioning

As noted above, it is recommended that the groundwater levels be measured closer to the time of construction, in order for the contractor to assess the dewatering / surface water infiltration flow diversion requirements during construction. The piezometers installed in Boreholes C26-1, SMP-1, SMP-5, SMP-6 should be decommissioned during construction and a Non-Standard Special Provision (NSSP) should be added to the Contract Documents; an example NSSP for this purpose is attached in Appendix E.

7.0 CLOSURE

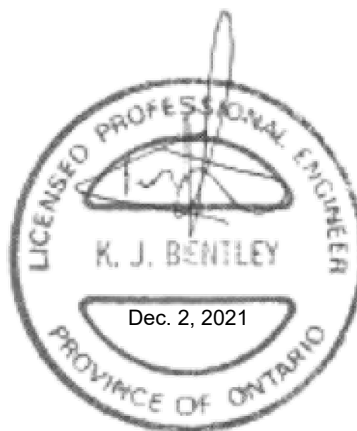
This Foundation Design Report was prepared by Ms. Anastasia Poliacik, P.Eng., a geotechnical engineer with Golder. Mr. Kevin Bentley, P.Eng., an Associate with Golder and MTO Foundations Designated Contact, conducted an independent quality control review of the report.

Signature Page

Golder Associates Ltd.



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Geotechnical Engineer



Kevin J. Bentley, P.Eng.
MTO Foundations Designated Contact, Associate

AMP/KB/ljv

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<https://golderassociates.sharepoint.com/sites/21998g/deliverables/wo15-hwy400wideninglloydtown/1swmp/4final/1786658-wo15rev020211202fidr-hwy400wideninglloydtown-swmp.docx>

REFERENCES

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Canadian Standards Associations (CSA) Group 2019. Canadian Highway Bridge Design Code and Commentary.

Hazen. 1911. Discussion of dams on sand foundations by A. C. Koenig. Transactions of the American Society of Civil Engineers, vol. 73, pp. 199–203.

Ontario Regulation 903 (Wells).

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

Ontario Provincial Standard Specification:

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation

OPSS 802 Construction Specification for Topsoil

OPSS.PROV 803 Construction Specification for Seed and Cover

OPSS.PROV 804 Construction Specification for Sodding

OPSS.PROV 1004 Material Specification for Aggregates – Miscellaneous

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

Special Provisions

SP 105S22 Amendment to OPSS 501

SP 517F01 Temporary Flow Passage System

ASTM International

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

Proprietary Software:

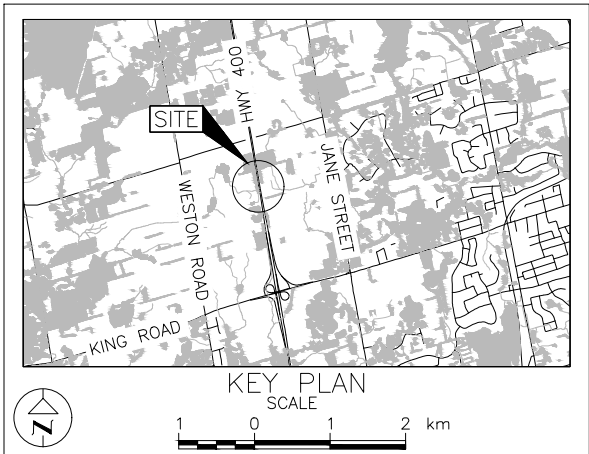
Rocscience Inc. SLIDE 2018

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

CONT No.
WP No.2835-02-00

HWY 400 WIDENING
STORMWATER MANAGEMENT PONDS
BOREHOLE LOCATIONS

SHEET



LEGEND

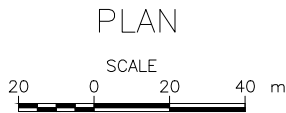
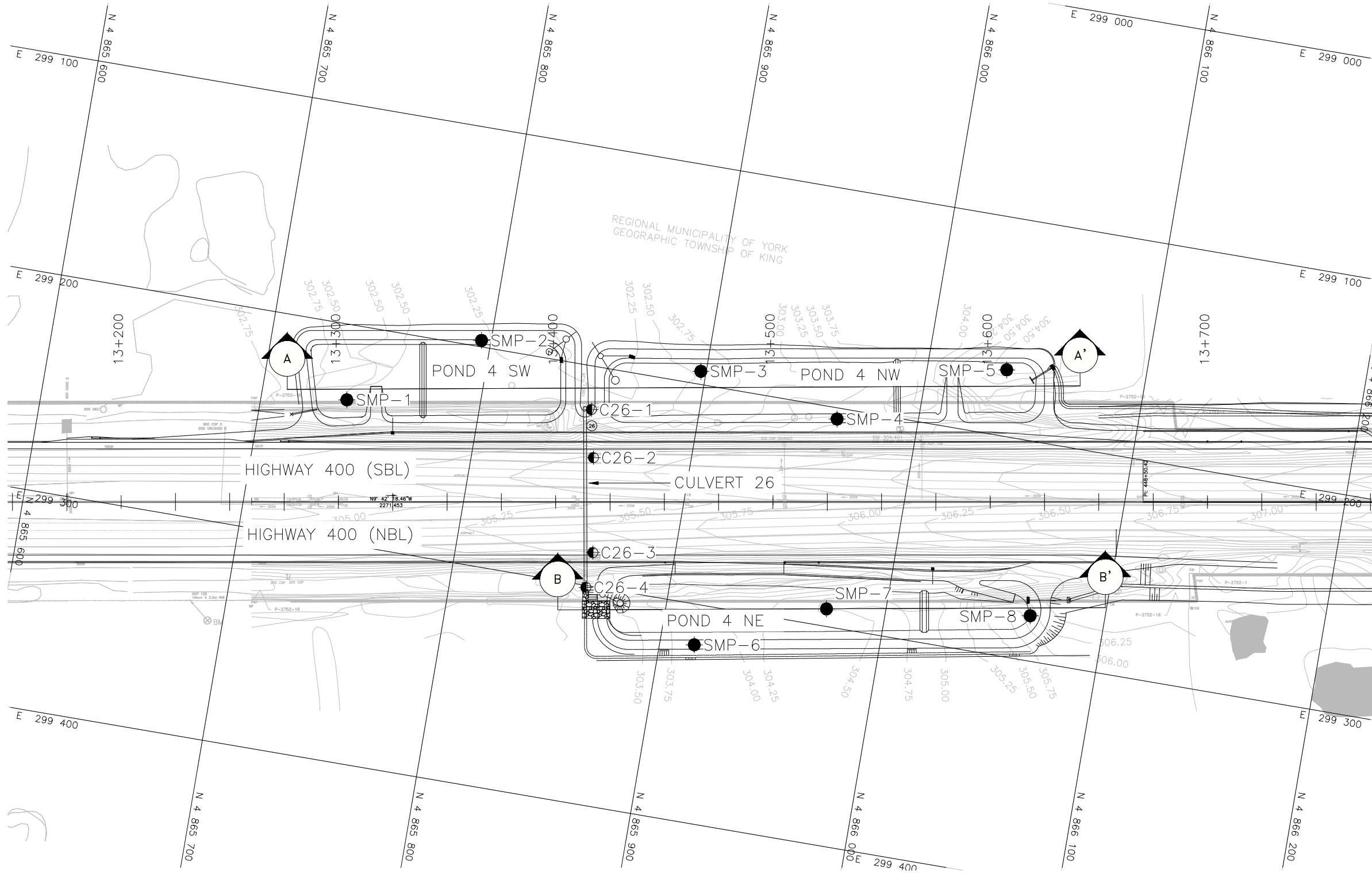
Borehole - Current Investigation

Borehole - Previous Investigation

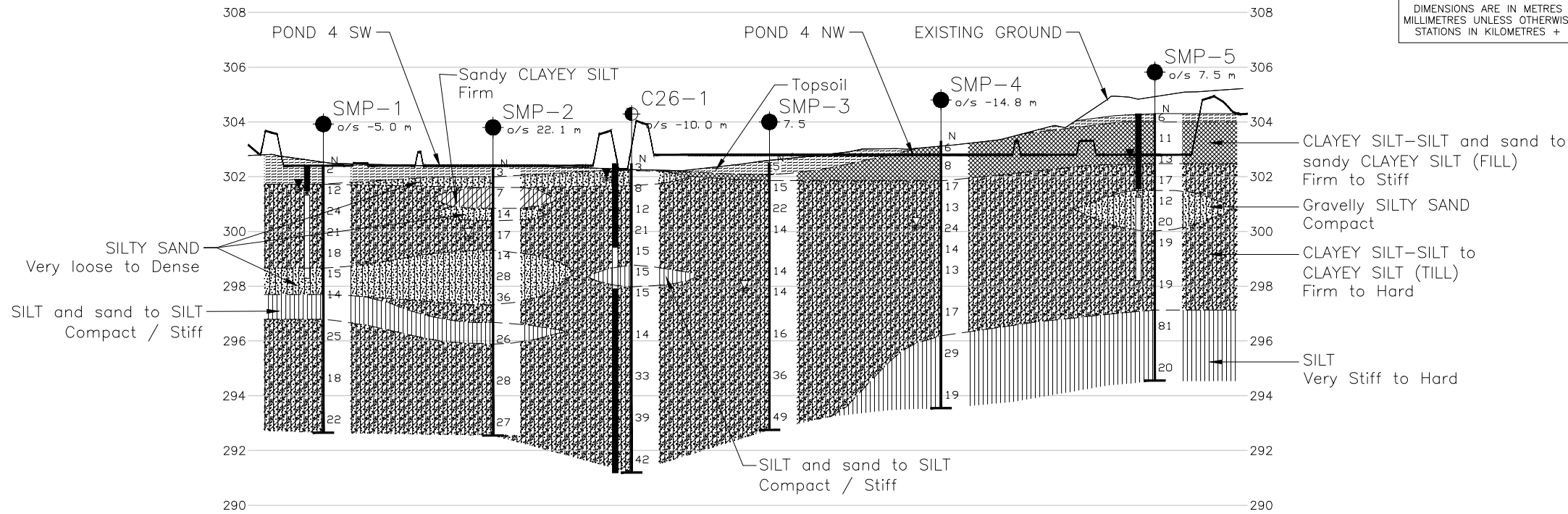
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C26-1	302.5	4865850.9	299219.9
C26-2	305.5	4865855.6	299241.5
C26-3	305.3	4865862.7	299284.6
C26-4	303.1	4865862.2	299300.9
SMP-1	302.4	4865739.2	299234.4
SMP-2	302.3	4865795.7	299197.1
SMP-3	302.5	4865897.6	299194.0
SMP-4	303.3	4865963.1	299205.1
SMP-5	304.3	4866036.2	299169.6
SMP-6	304.1	4865915.8	299318.6
SMP-7	304.3	4865973.0	299292.0
SMP-8	306.2	4866066.0	299279.3

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.

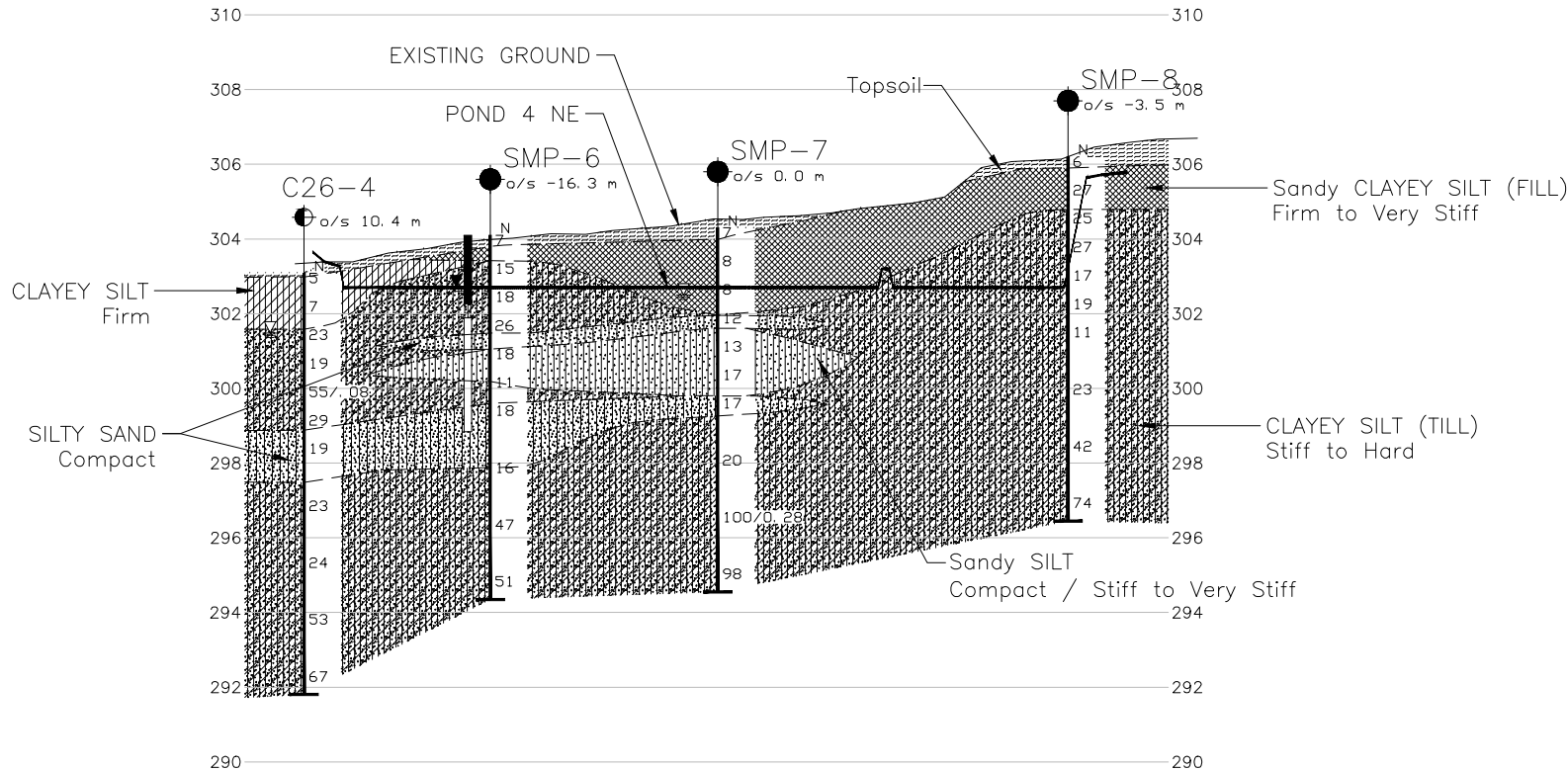
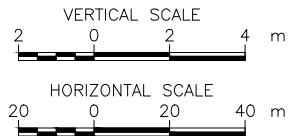
REFERENCE
Pond layout provided in digital format by MH, drawing file no. Hwy 400_Pond Sections_For Golder.dwg, received July 22, 2021.
Base plan provided in digital format by MH, drawing file no. X117116615Base (1).dwg, received June 15, 2021.
Topography plan provided in digital format by MH, drawing file no. X117116615Contours.dwg, received June 2, 2021.



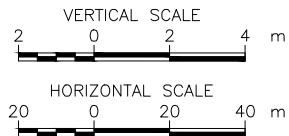
REVISION			
NO.	DATE	BY	REVISION
Geocres No. 30M13-237			
HWY. 400	PROJECT NO. 1786658		DIST.
SUBM'D. AP	CHKD. AP	DATE: 11/23/2021	SITE:
DRAWN: SA	CHKD. KJB	APPD. KJB	DWG. 1



CROSS-SECTION A - A'



CROSS-SECTION B - B'

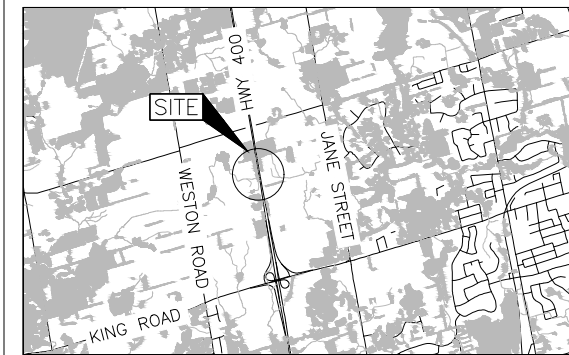


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.2835-02-00

HWY 400 WIDENING
STORMWATER MANAGEMENT PONDS

SHEET



KEY PLAN
SCALE
1 0 1 2 km

LEGEND

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C26-1	302.5	4865850.9	299219.9
C26-4	303.1	4865862.2	299300.9
SMP-1	302.4	4865739.2	299234.4
SMP-2	302.3	4865795.7	299197.1
SMP-3	302.5	4865897.6	299194.0
SMP-4	303.3	4865963.1	299205.1
SMP-5	304.3	4866036.2	299169.6
SMP-6	304.1	4865915.8	299318.6
SMP-7	304.3	4865973.0	299292.0
SMP-8	306.2	4866066.0	299279.3

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

Pond layout provided in digital format by MH, drawing file no. Hwy 400_Pond Sections_For Golder.dwg, received July 22, 2021.
Base plan provided in digital format by MH, drawing file no. X117116615Base (1).dwg, received June 15, 2021.
Topography plan provided in digital format by MH, drawing file no. X117116615Contours.dwg, received June 2, 2021.



NO.	DATE	BY	REVISION
1	11/23/2021	SA/DD	Initial Design
2	11/23/2021	KJB	Final Design

Geocres No. 30M13-237

HWY. 400	PROJECT NO. 1786658	DIST. .
SUBM'D. AP	CHKD. AP	DATE: 11/23/2021
DRAWN: SA/DD	CHKD. KJB	APPD. KJB
		SITE: .
		DWG. 2

APPENDIX A

Borehole Records - GEOCRES 30M13-214

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>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , 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 cm² 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, G _s)
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)
Y	unit weight

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

COARSE-GRAINED SOILS

Compactness¹

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

- 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 grain size. 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.
- 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

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
- SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	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

(a) Index Properties (continued)

w	water content
w_L or LL	liquid limit
w_P or PL	plastic limit
I_P or PI	plasticity index $= (w_L - w_P)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index $= (w - w_P) / I_P$
I_c	consistency index $= (w_L - w) / I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
$C_{\alpha(e)}$	secondary compression index
C_{α}	rate of secondary compression
$C_{\alpha(e)}$	modified secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

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


Notes: 1
2

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

PROJECT		RECORD OF BOREHOLE		No C26-1		SHEET 1 OF 1		METRIC						
G.W.P. 2835-02-00		LOCATION		N 4865850.9 ; E 299219.9		ORIGINATED BY		TT						
DIST Central HWY 400		BOREHOLE TYPE		D-50 Track Mount, 108 mm Diameter Solid Stem Augers		COMPILED BY		SKB/HS						
DATUM Geodetic		DATE		December 9, 2010		CHECKED BY		SMM						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
302.5	GROUND SURFACE													
0.0	Organic CLAYEY SILT, trace rootlets		1	SS	3									
301.9	Soft Black Moist		2A	SS	8									
301.3	Silty SAND, trace to some clay, trace gravel		2B											
1.2	Loose Brown and grey Moist		3	SS	12									
	CLAYEY SILT, some sand, trace gravel, sand seams below 3 m (TILL)		4	SS	21									
	Firm to very stiff Brown to grey below 1.5 m Moist to wet below 3.0 m		5	SS	15									
298.8			6	SS	15									
3.7	SILT and SAND, trace clay Compact Grey Wet		7	SS	15									
298.0			8	SS	14									
4.5	CLAYEY SILT, trace to some sand, trace gravel (TILL)		9	SS	33									
	Stiff to hard Grey Moist to wet		10	SS	39									
			11	SS	42									
291.2	END OF BOREHOLE													
11.3	NOTES: 1. Water level in open borehole at a depth of 1.6 m (Elev. 300.9 m) upon completion of drilling. 2. Water level measurements in piezometer: Date Depth (m) Elev. (m) 12/16/10 0.2 302.3 02/01/11 0.5 302.0													

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 11/30/15 SIB

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

PROJECT		09-1111-0018		RECORD OF BOREHOLE No C26-2		SHEET 2 OF 2		METRIC								
G.W.P.		2835-02-00		LOCATION		N 4865855.6 ; E 299241.5		ORIGINATED BY								
DIST		Central HWY 400		BOREHOLE TYPE		D-90 Truck Mount, 101 mm Diameter Solid Stem Augers		COMPILED BY								
DATUM		Geodetic		DATE		December 22, 2010		CHECKED BY								
								SMM								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
289.6	CLAYEY SILT, trace to some sand, trace gravel (TILL) Stiff to hard Grey Moist		13	SS	72		290									
15.9	END OF BOREHOLE															
NOTES: 1. Borehole caved at a depth of 15.2 m (Elev. 290.3 m) upon completion of drilling. 2. Water level in open borehole at a depth of 4.6 m (Elev. 300.9 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 11/30/15 SIB


PROJECT 09-1111-0018		RECORD OF BOREHOLE No C26-3		SHEET 1 OF 2	METRIC
G.W.P. 2835-02-00		LOCATION N 4865862.7 ; E 299284.6		ORIGINATED BY SB	
DIST Central HWY 400		BOREHOLE TYPE D-90 Truck Mount, 101 mm Diameter Solid Stem Augers		COMPILED BY MAS/HS	
DATUM Geodetic		DATE December 23, 2010		CHECKED BY SMM	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED												
305.3	GROUND SURFACE						20	40	60	80	100									
0.0	ASPHALT																			
0.2	Silty sand and gravel, trace clay (FILL) Compact Brown Moist																			
			1	SS	24															
			2	SS	29									○						
303.1																				
2.2	Sandy CLAYEY SILT, trace gravel (TILL) Firm to very stiff Brown Moist														○					
			3	SS	15															
			4	SS	7										┌─○─┐				0 27 53 20	
			5	SS	28									○						
			6	SS	10										○					
299.7																				
5.6	SILT and SAND, trace clay, trace gravel Compact Grey Wet																			
			7	SS	19										○				3 62 30 5	
298.1																				
7.2	CLAYEY SILT, trace to some sand, trace gravel Stiff Grey Moist																			
			8	SS	14										┌─○─┐				0 8 72 20	
296.6																				
8.7	CLAYEY SILT, trace sand, trace gravel (TILL) Hard Grey Moist																			
			9	SS	40										○					
			10	SS	47										└─○─┐					
			11	SS	34										○					
			12	SS	30										○					

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA GDT 11/30/15 SIB

PROJECT		09-1111-0018		RECORD OF BOREHOLE No C26-3		SHEET 2 OF 2		METRIC								
G.W.P.		2835-02-00		LOCATION		N 4865862.7 ; E 299284.6		ORIGINATED BY								
DIST		Central HWY 400		BOREHOLE TYPE		D-90 Truck Mount, 101 mm Diameter Solid Stem Augers		COMPILED BY								
DATUM		Geodetic		DATE		December 23, 2010		CHECKED BY								
SMM																
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	10 20 30	γ	GR SA SI CL			
289.4	CLAYEY SILT, trace sand, trace gravel (TILL) Hard Grey Moist		13	SS	48		290									
15.9	END OF BOREHOLE															
NOTES: 1. Borehole caved at a depth of 15.2 m (Elev. 290.1 m) upon completion of drilling. 2. Water level in open borehole at a depth of 4.0 m (Elev. 301.3 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 11/30/15 SIB

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

APPENDIX B

Borehole Records - Current 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>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , 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 cm² 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, G _s)
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)
Y	unit weight

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

COARSE-GRAINED SOILS

Compactness¹

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

- 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 grain size. 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.
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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

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
- 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.

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MINISTRY OF TRANSPORTATION, ONTARIO

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t	time
FoS	factor of safety

II. STRESS AND STRAIN

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Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	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

(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
$C_{a(e)}$	secondary compression index
C_a	rate of secondary compression
$C_{a(e)}$	modified secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

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

Notes: 1
2

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

PROJECT		1786658 (W015)		RECORD OF BOREHOLE No SMP-1		SHEET 1 OF 1		METRIC											
G.W.P.		2835-02-00		LOCATION		N 4865739.2; E 299234.4 MTM NAD 83 ZONE 10 (LAT. 43.931619; LONG. -79.569321)		ORIGINATED BY CC											
DIST		Central HWY 400		BOREHOLE TYPE		210 mm O.D. Hollow Stem Power Auger		COMPILED BY ACK											
DATUM		HT2_0 (Geodetic)		DATE		May 14, 2020		CHECKED BY AMP											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40
302.4	GROUND SURFACE																		
0.0	TOPSOIL (700 mm)		1	SS	2														
301.7																			
0.7	CLAYEY SILT (CL), some sand, trace gravel (TILL) Stiff to very stiff Brown to grey below 2.3 m depth Moist		2	SS	12														1 14 57 28
			3	SS	24														
			4	SS	21														
			5	SS	18														
298.7																			
3.7	SILTY SAND (SM), containing clayey silt pockets Compact Grey Wet		6	SS	15														0 74 23 3
297.7			7A	SS	14														
4.7	SILT (ML) of slight plasticity, some sand Stiff Grey Moist		7B																0 15 74 11
296.8																			
5.6	CLAYEY SILT-SILT (CL-ML), trace to some sand, trace gravel (TILL) Very stiff Grey Moist		8	SS	25														
			9	SS	18														
			10	SS	22														
292.7																			
9.8	END OF BOREHOLE																		
NOTES:																			
1. Borehole caved to a depth of 8.4 m below ground surface (Elev. 294.0 m) after removing augers.																			
2. Water level measured in open borehole at a depth of 0.0 m below ground surface (Elev. 302.4 m) after removing augers.																			
3. Piezometer installed in separate borehole 1.3 m north of Borehole SMP-1.																			
4. Water measurements in piezometer as follows:																			
Date	Depth (m)	Elev. (m)																	
05/14/20	0.5	301.9																	
05/21/20	0.4	302.0																	
01/13/21	0.8	301.6																	

PROJECT		1786658 (W015)		RECORD OF BOREHOLE No SMP-2		SHEET 1 OF 1		METRIC							
G.W.P.		2835-02-00		LOCATION		N 4865795.7; E 299197.1 MTM NAD 83 ZONE 10 (LAT. 43.932127; LONG. -79.569788)		ORIGINATED BY CC							
DIST		Central HWY 400		BOREHOLE TYPE		210 mm O.D. Hollow Stem Power Auger		COMPILED BY ACK							
DATUM		HT2_0 (Geodetic)		DATE		May 14, 2020		CHECKED BY AMP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
302.3	GROUND SURFACE														
0.0	TOPSOIL (300 mm)														
301.6	SILTY SAND (SM), trace gravel, containing clayey silt pockets, organics Very loose Brown Moist		1A 1B	SS	3										
0.7			2A 2B 2C	SS	7										
300.9	SANDY CLAYEY SILT (CL), trace gravel, containing thin silty sand laminations Firm Brown Moist		3A 3B	SS	14										
1.5															
300.4			4	SS	17										
1.9	- 150 mm silty sand layer at 1.0 m depth														
299.3	SILTY SAND (SM), some gravel Compact Brown Wet		5	SS	14										
3.0	CLAYEY SILT (CL), trace to some sand, trace gravel (TILL) Stiff to very stiff Grey Moist		6	SS	28										
297.4	SILTY SAND (SM), trace gravel, containing clayey silt pockets Compact to dense Grey Wet		7A 7B	SS	36										
5.0	CLAYEY SILT-SILT (CL-ML), trace to some sand, trace gravel (TILL) Hard Grey Moist														
296.7	- Auger grinding at 5.5 m depth		8A 8B	SS	26										
5.6	SANDY SILT (ML) Compact Grey Wet														
295.9	CLAYEY SILT-SILT (CL-ML), trace to some sand, trace gravel (TILL) Very stiff Grey Moist		9	SS	28										
6.4															
292.6	END OF BOREHOLE		10	SS	27										
9.8	NOTES: 1. Borehole caved to a depth of 3.4 m below ground surface (Elev. 298.9 m) after removing augers. 2. Water level measured in open borehole at a depth of 2.5 m below ground surface (Elev. 299.8 m) after removing augers.														

PROJECT		1786658 (W015)		RECORD OF BOREHOLE No SMP-3		SHEET 1 OF 1		METRIC								
G.W.P.		2835-02-00		LOCATION		N 4865897.6; E 299194.0 MTM NAD 83 ZONE 10 (LAT. 43.933044; LONG. -79.569827)		ORIGINATED BY CC								
DIST		Central HWY 400		BOREHOLE TYPE		210 mm O.D. Hollow Stem Power Auger		COMPILED BY ACK								
DATUM		HT2 0 (Geodetic)		DATE		May 13, 2020		CHECKED BY AMP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
302.5	GROUND SURFACE							20	40	60	80	100				
0.0	TOPSOIL (460 mm)		1A	SS	5		302									
302.0			1B													
0.7	Sandy CLAYEY SILT (CL), trace gravel, containing organics and rootlets (FILL) Firm Dark to light brown Moist		2	SS	15											5 20 54 21
	CLAYEY SILT (CL), trace sand to sandy, trace gravel (TILL) Stiff to hard Brown to grey below 3.9 m depth Moist - 10 mm sand seam at 1.8 m depth - 100 mm sand layer at 2.0 m depth - 76 mm sand layer at 2.7 m depth		3	SS	22		301									
			4	SS	14		300									
							299									
	- Containing silt seams between 3.8 m and 4.4 m depth		5	SS	14		298									
			6	SS	14		297									
							296									2 9 69 20
	- Spoon bouncing at 6.1 m depth at start of sample		7	SS	16		295									
							294									
	- Spoon bouncing at 7.6 m depth at start of sample		8	SS	36		293									
			9	SS	49											
292.8	END OF BOREHOLE															
9.8	NOTES: 1. Borehole caved to a depth of 8.5 m below ground surface (Elev. 294.0 m) after removing augers. 2. Water level measured in open borehole at a depth of 4.6 m below ground surface (Elev. 297.9 m) after removing augers.															

PROJECT		1786658 (W015)		RECORD OF BOREHOLE		No SMP-4		SHEET 1 OF 1		METRIC				
G.W.P.		2835-02-00		LOCATION		N 4865963.1; E 299205.1 MTM NAD 83 ZONE 10 (LAT. 43.933634; LONG. -79.569689)		ORIGINATED BY		CC				
DIST		Central HWY 400		BOREHOLE TYPE		210 mm O.D. Hollow Stem Power Auger		COMPILED BY		ACK				
DATUM		HT2 0 (Geodetic)		DATE		May 14, 2020		CHECKED BY		AMP				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
303.3	GROUND SURFACE													
0.0	TOPSOIL (100 mm)													
	Sandy CLAYEY SILT (CL), trace gravel, containing organics and rootlets (FILL)		1	SS	6									
	Firm													
	Dark to light brown		2	SS	8									2 23 58 17
	Moist													
301.9	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace to some sand, trace gravel (TILL)		3	SS	17									
1.5	Stiff to very stiff													
	Brown to grey below 3.1 m depth													
	Moist		4	SS	13									
	- 70 mm sand layer at 2.5 m depth													
	- 100 mm sand layer at 2.7 m depth		5	SS	24									0 3 77 20
			6	SS	14									
			7	SS	13									
			8	SS	17									
296.2	SILT (ML) of slight plasticity													
7.1	Very Stiff		9	SS	29									
	Grey													
	Moist to wet													
			10	SS	19									0 0 86 14
293.6	END OF BOREHOLE													
9.8	NOTES:													
	1. Borehole caved to a depth of 8.8 m below ground surface (Elev. 294.5 m) after removing augers.													
	2. Water level measured in open borehole at a depth of 3.1 m below ground surface (Elev. 300.2 m) after removing augers.													



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

PROJECT		1786658 (W015)		RECORD OF BOREHOLE No SMP-6		SHEET 1 OF 1		METRIC															
G.W.P.		2835-02-00		LOCATION		N 4865915.8; E 299318.6 MTM NAD 83 ZONE 10 (LAT. 43.933209; LONG. -79.568275)		ORIGINATED BY CC															
DIST		Central HWY 400		BOREHOLE TYPE		210 mm O.D. Hollow Stem Power Auger		COMPILED BY ACK															
DATUM		HT2 0 (Geodetic)		DATE		May 22, 2020		CHECKED BY AMP															
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT REMARKS														
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p	W	W _L	γ	GR SA SI CL									
304.1	0.0	GROUND SURFACE																					
303.8	0.3	TOPSOIL (300 mm)		1	SS	7																	
303.4	0.7	Sandy CLAYEY SILT (CL), trace gravel, containing organics (FILL) Firm Brown Moist		2	SS	15								1 23 62 14									
		CLAYEY SILT (CL), trace to some sand to sandy, trace gravel (TILL) Very stiff Brown Moist		3	SS	18																	
301.5	2.6	SILTY SAND (SM) Compact Brown Wet		4A	SS	26																	
301.1	3.1	Sandy SILT (ML) Compact Brown Wet		5	SS	18							NP	0 20 74 6									
300.2	3.9	CLAYEY SILT (CL), some sand to sandy, trace gravel (TILL) Stiff Grey Moist to wet		6A	SS	11								1 14 51 34									
299.6	4.5	SILTY SAND (SM) Compact Grey Wet - 75 mm silt layer at 5.1 m depth		7A	SS	18																	
				7B																			
297.9	6.2	CLAYEY SILT (CL), some sand, trace gravel (TILL) Very stiff to hard Grey Moist		8A	SS	16																	
				8B																			
				9	SS	47																	
				10	SS	51								4 15 62 19									
294.4	9.8	END OF BOREHOLE																					
NOTES: 1. Borehole caved to a depth of 4.5 m below ground surface (Elev. 299.6 m) after removing augers. 2. Water level measured in a open borehole at a depth of 2.1 m below ground surface (Elev. 302.0 m) after removing augers. 3. Piezometer installed in separate borehole 1 m north of Borehole SMP-6. 4. Water measurements in piezometer as follows: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev. (m)</th> </tr> </thead> <tbody> <tr> <td>05/22/20</td> <td>1.4</td> <td>302.8</td> </tr> <tr> <td>01/13/21</td> <td>1.4</td> <td>302.7</td> </tr> </tbody> </table>															Date	Depth (m)	Elev. (m)	05/22/20	1.4	302.8	01/13/21	1.4	302.7
Date	Depth (m)	Elev. (m)																					
05/22/20	1.4	302.8																					
01/13/21	1.4	302.7																					

PROJECT 1786658 (W015)			RECORD OF BOREHOLE No SMP-7			SHEET 1 OF 1			METRIC								
G.W.P. 2835-02-00			LOCATION N 4865973.0; E 299292.0 MTM NAD 83 ZONE 10 (LAT. 43.933724; LONG. -79.568607)			ORIGINATED BY CC											
DIST Central HWY 400			BOREHOLE TYPE 210 mm O.D. Hollow Stem Power Auger			COMPILED BY ACK											
DATUM HT2 0 (Geodetic)			DATE May 22, 2020			CHECKED BY AMP											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
304.3	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL (300 mm)		1A	SS	7												
0.3	Sandy CLAYEY SILT (CL), containing rootlets, wood fragments (FILL) Firm to stiff Mottled dark brown to dark grey to black Moist		1B														
			2	SS	8												
			3A														
			3B														
			3C	SS	8												
302.0	SILTY SAND (SM) Compact Brown Wet		4A														
301.6			4B	SS	12												
2.7			4C														
	Sandy SILT (ML) of slight plasticity, trace gravel Stiff to very stiff Brown to grey below 3.1 m depth Moist - 3 mm sand seam at 3.5 m depth		5	SS	13												
			6	SS	17												
299.8	SILTY SAND (SM), trace gravel Compact Grey Wet		7A														
299.3			7B	SS	17												
5.0			7C														
	CLAYEY SILT (CL), some sand, trace gravel (TILL) Very stiff to hard Grey Moist		8	SS	20												
			9	SS	100/0.28												
			10	SS	98												
294.6	END OF BOREHOLE																
9.8	NOTES: 1. Borehole caved to a depth of 2.4 m below ground surface (Elev. 301.9 m) after removing augers. 2. Water level measured in open borehole at a depth of 1.8 m below ground surface (Elev. 302.5 m) after removing augers.																

PROJECT		1786658 (W015)		RECORD OF BOREHOLE No SMP-8		SHEET 1 OF 1		METRIC								
G.W.P.		2835-02-00		LOCATION		N 4866066.0; E 299279.3 MTM NAD 83 ZONE 10 (LAT. 43.934560; LONG. -79.568766)		ORIGINATED BY CC								
DIST		Central HWY 400		BOREHOLE TYPE		210 mm O.D. Hollow Stem Power Auger		COMPILED BY ACK								
DATUM		HT2 0 (Geodetic)		DATE		May 21, 2020		CHECKED BY AMP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
306.2	GROUND SURFACE							20	40	60	80	100				
0.0	TOPSOIL (300 mm)		1A	SS	6		306									
0.3	Sandy CLAYEY SILT (CL), containing organics (FILL) Firm to very stiff Mottled brown Moist		1B													0 25 55 20
			2	SS	27		305									
304.8	CLAYEY SILT (CL), some sand to sandy, trace gravel (TILL) Stiff to hard Grey Moist		3	SS	25											1 24 55 20
1.5			4	SS	27		304									
			5	SS	17		303									
			6	SS	19		302									
			7	SS	11		301									
			8	SS	23		300									
			9	SS	42		299									
							298									
							297									
296.5	- Auger grinding below 8.2 m depth		10	SS	74											2 12 62 24
296.5	END OF BOREHOLE															
9.8	NOTES: 1. Borehole caved to a depth of 8.8 m below ground surface (Elev. 297.4 m) after removing augers. 2. Borehole dry on completion of drilling and removal of augers.															

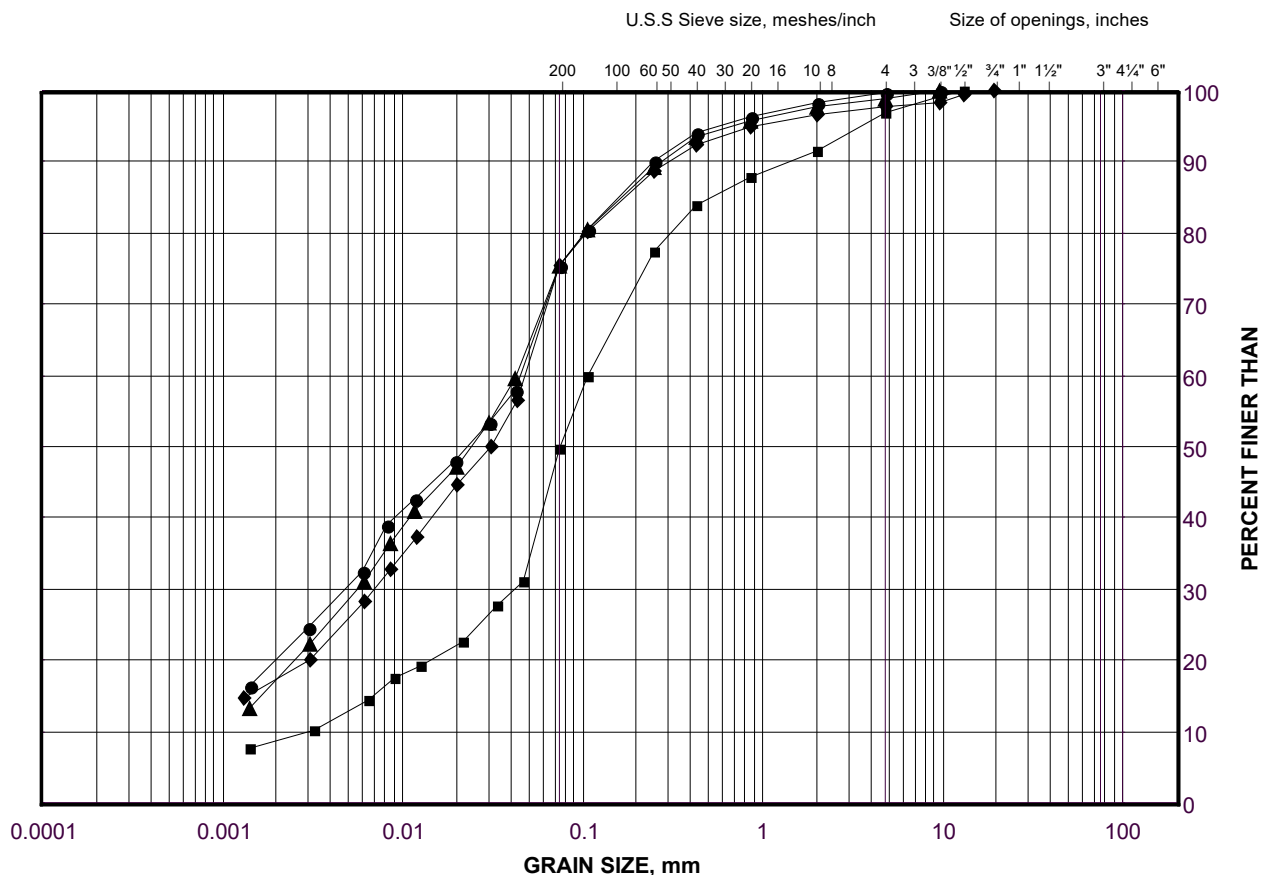
APPENDIX C

Laboratory Test Results - Current Investigation

GRAIN SIZE DISTRIBUTION

CLAYEY SILT-SILT and sand (CL-ML) to sandy CLAYEY SILT (FILL)

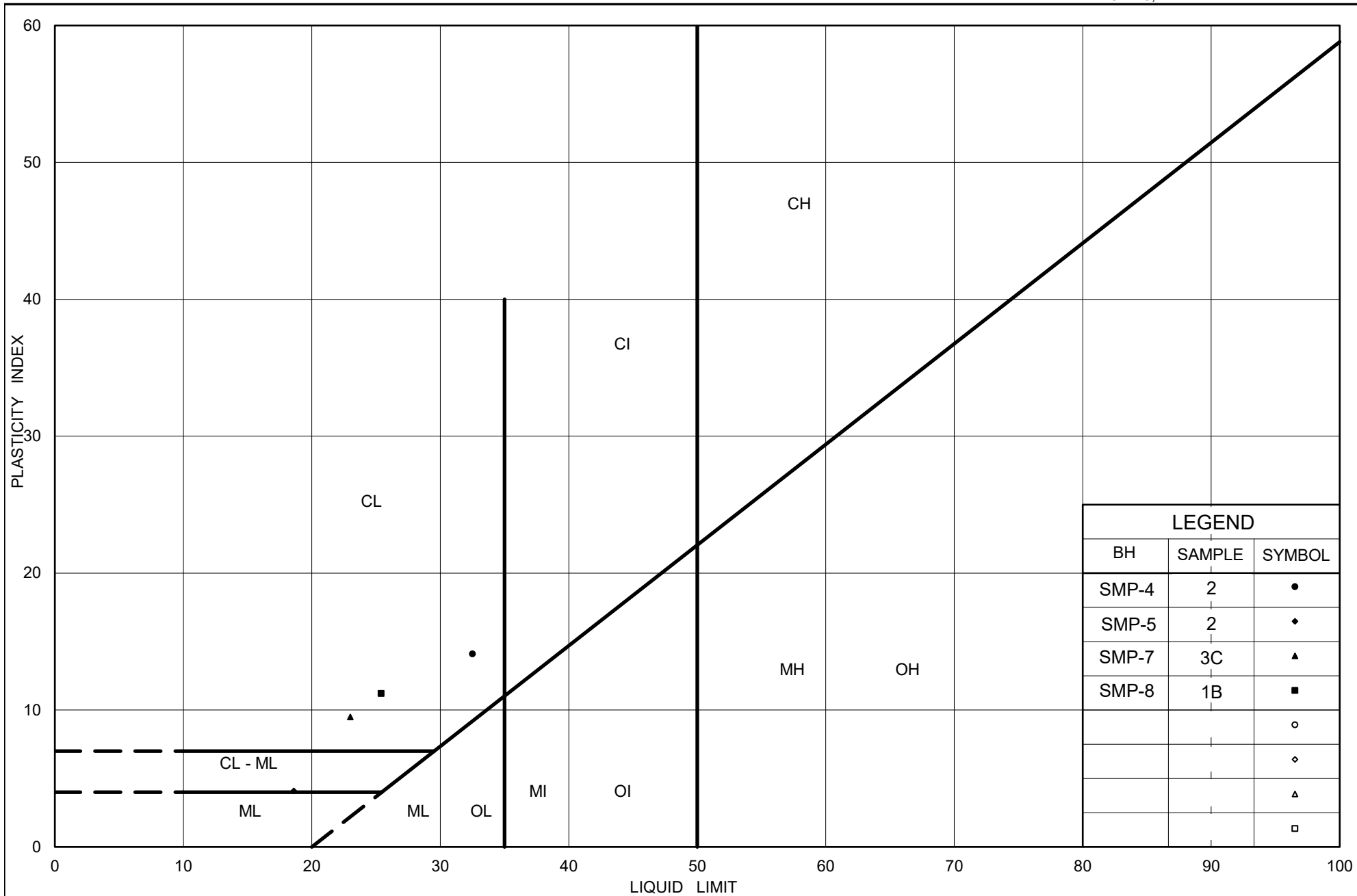
FIGURE C-1



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SMP-8	1B	305.8
■	SMP-5	2	303.2
◆	SMP-4	2	294.2
▲	SMP-7	3C	302.4



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PLASTICITY CHART CLAYEY SILT-SILT and sand (CL-ML) to sandy CLAYEY SILT (FILL)

Figure No. C-2

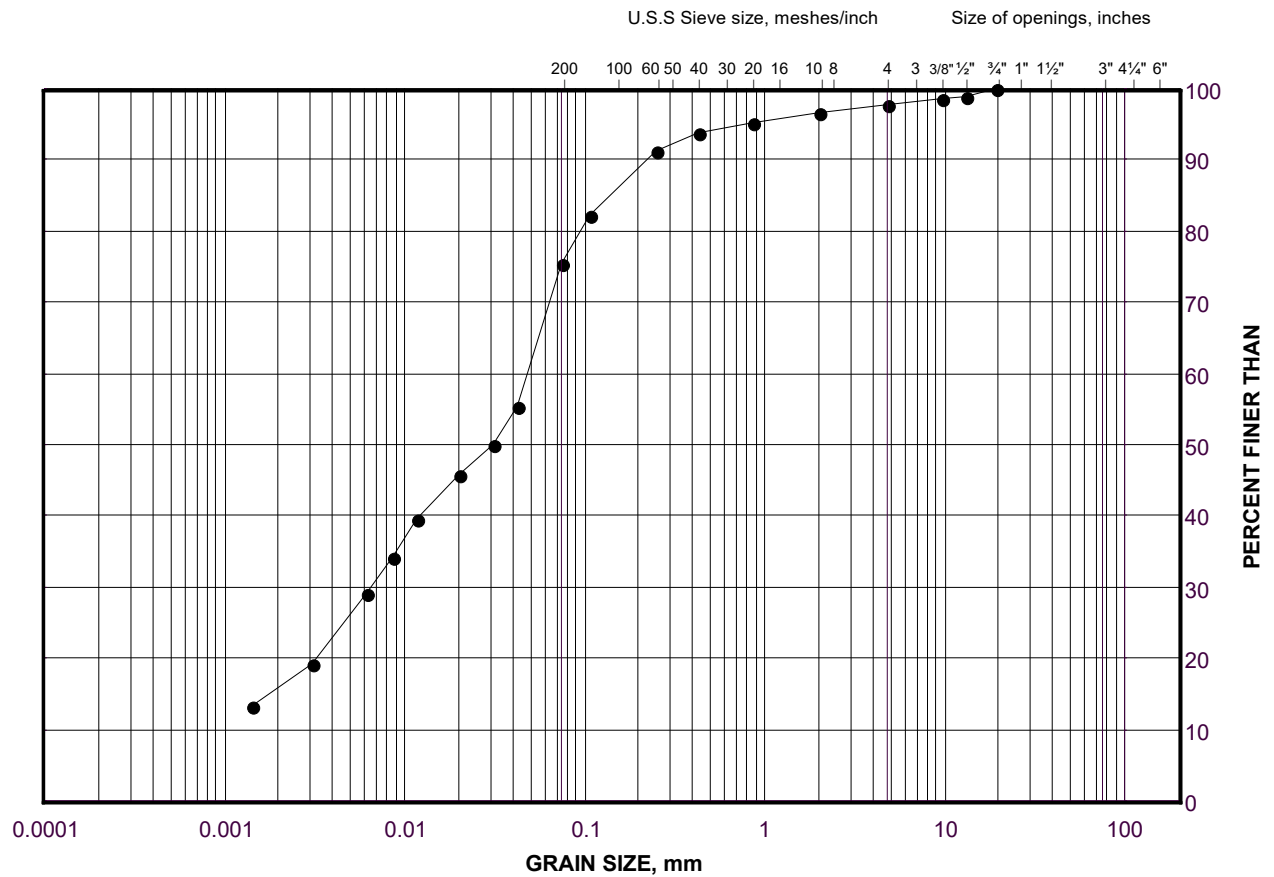
Project No. 1786658 (WO15)

Checked By: AMP

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT (CL)

FIGURE C-3



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

LEGEND

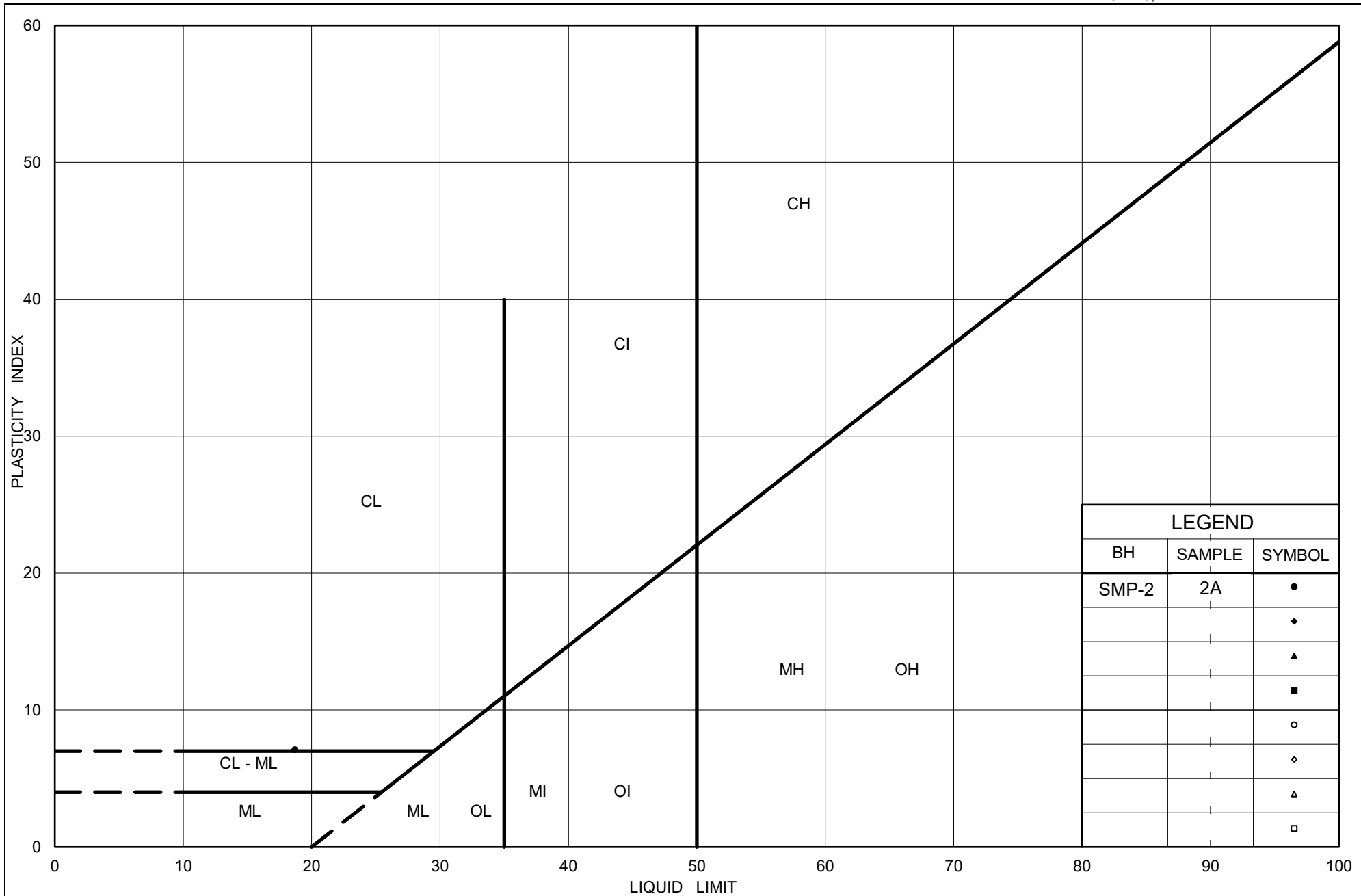
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	SMP-2	2A	301.4

Project Number: 1786658 (WO15)

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Golder Associates

Date: 29-Jul-21



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PLASTICITY CHART Sandy CLAYEY SILT (CL)

Figure No. C-4

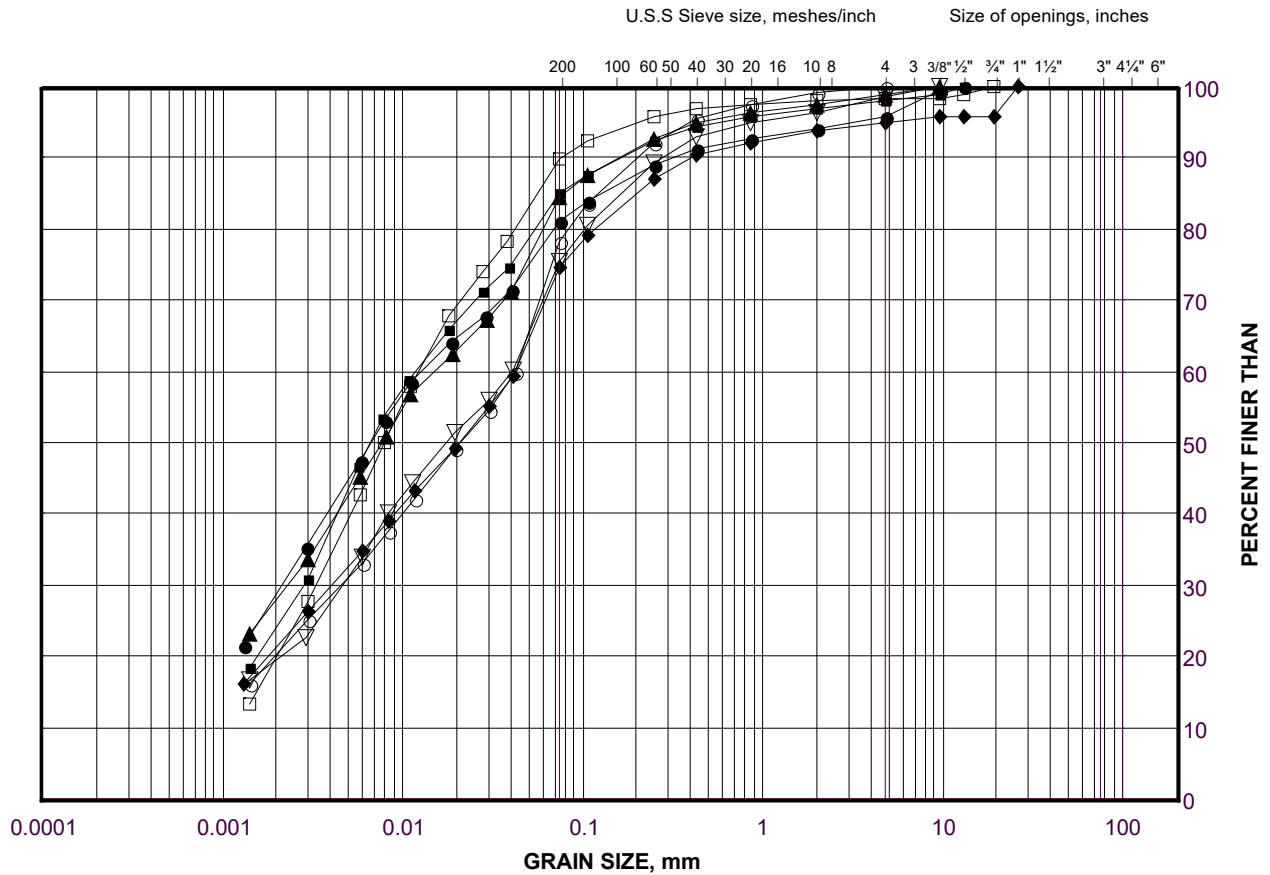
Project No. 1786658 (WO15)

Checked By: AMP

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) (TILL)

FIGURE C-5A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SMP-6	10	294.7
■	SMP-8	10	296.8
◆	SMP-3	2	301.5
▲	SMP-1	2	301.4
▽	SMP-8	3	304.4
○	SMP-5	3B	302.4
□	SMP-3	7	296.1

Project Number: 1786658 (WO15)

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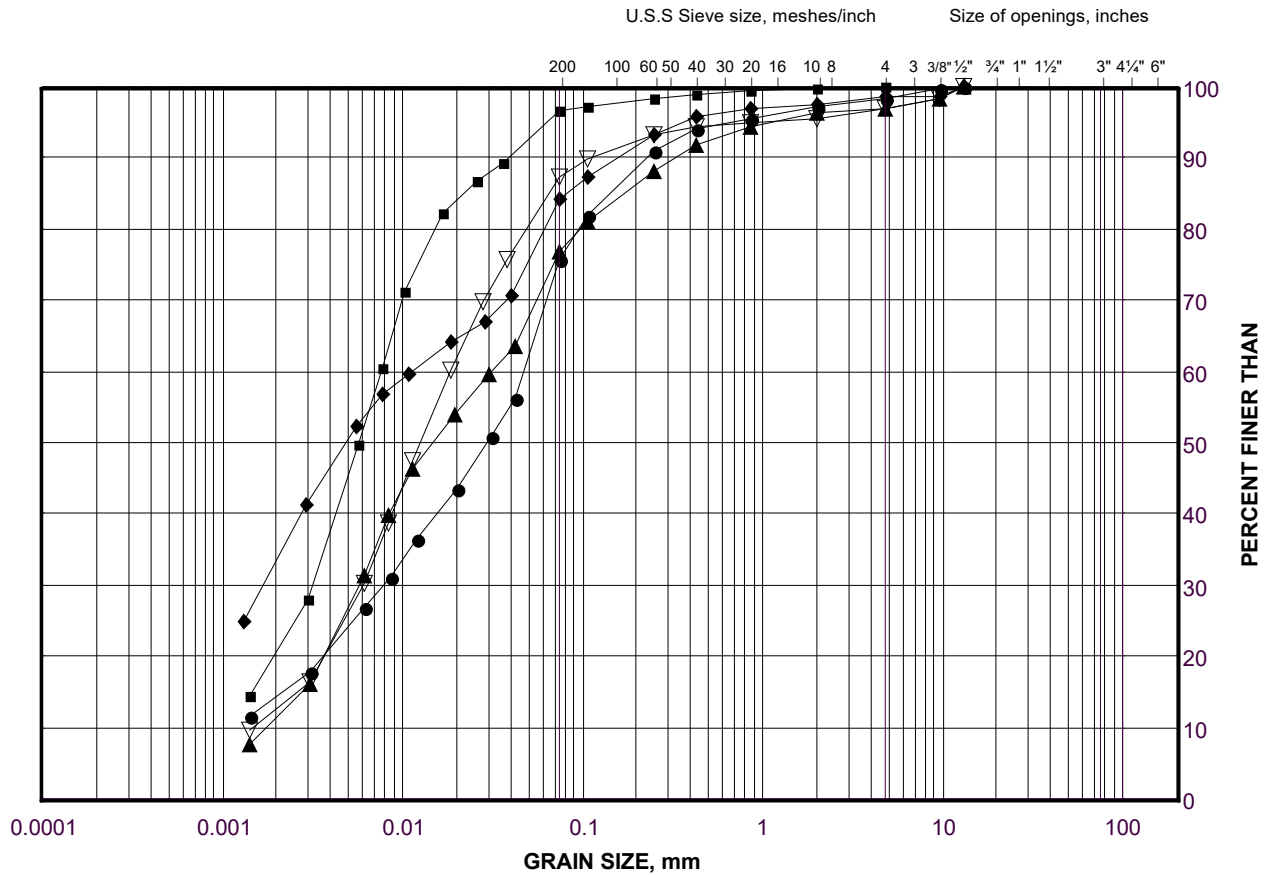
Golder Associates

Date: 29-Jul-21

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) (TILL)

FIGURE C-5B



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

LEGEND

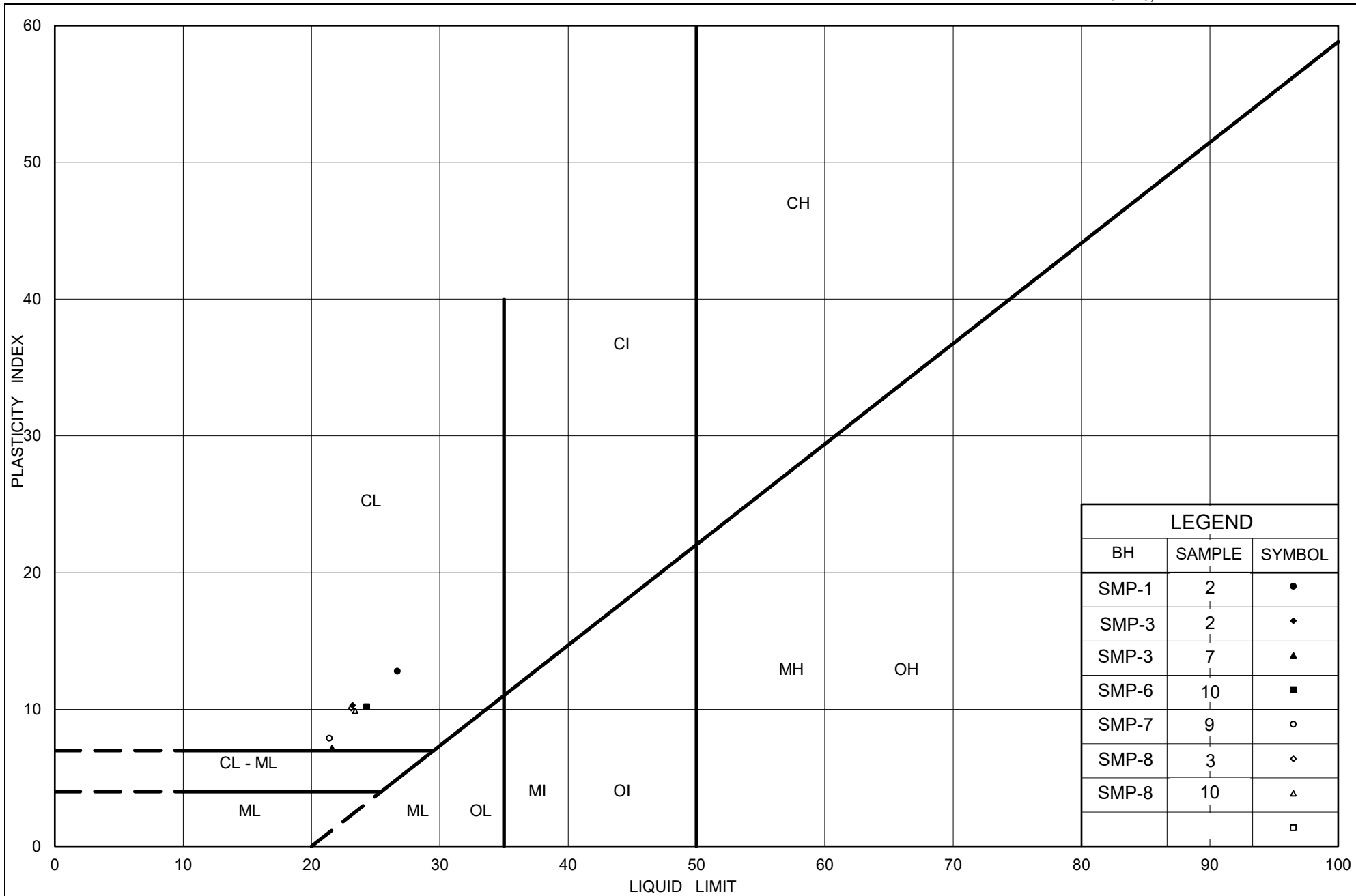
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SMP-6	2	304.0
■	SMP-4	5	300.9
◆	SMP-6	6B	300.0
▲	SMP-5	6B	300.0
▽	SMP-2	7B	297.3

Project Number: 1786658 (WO15)

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Date: 29-Jul-21



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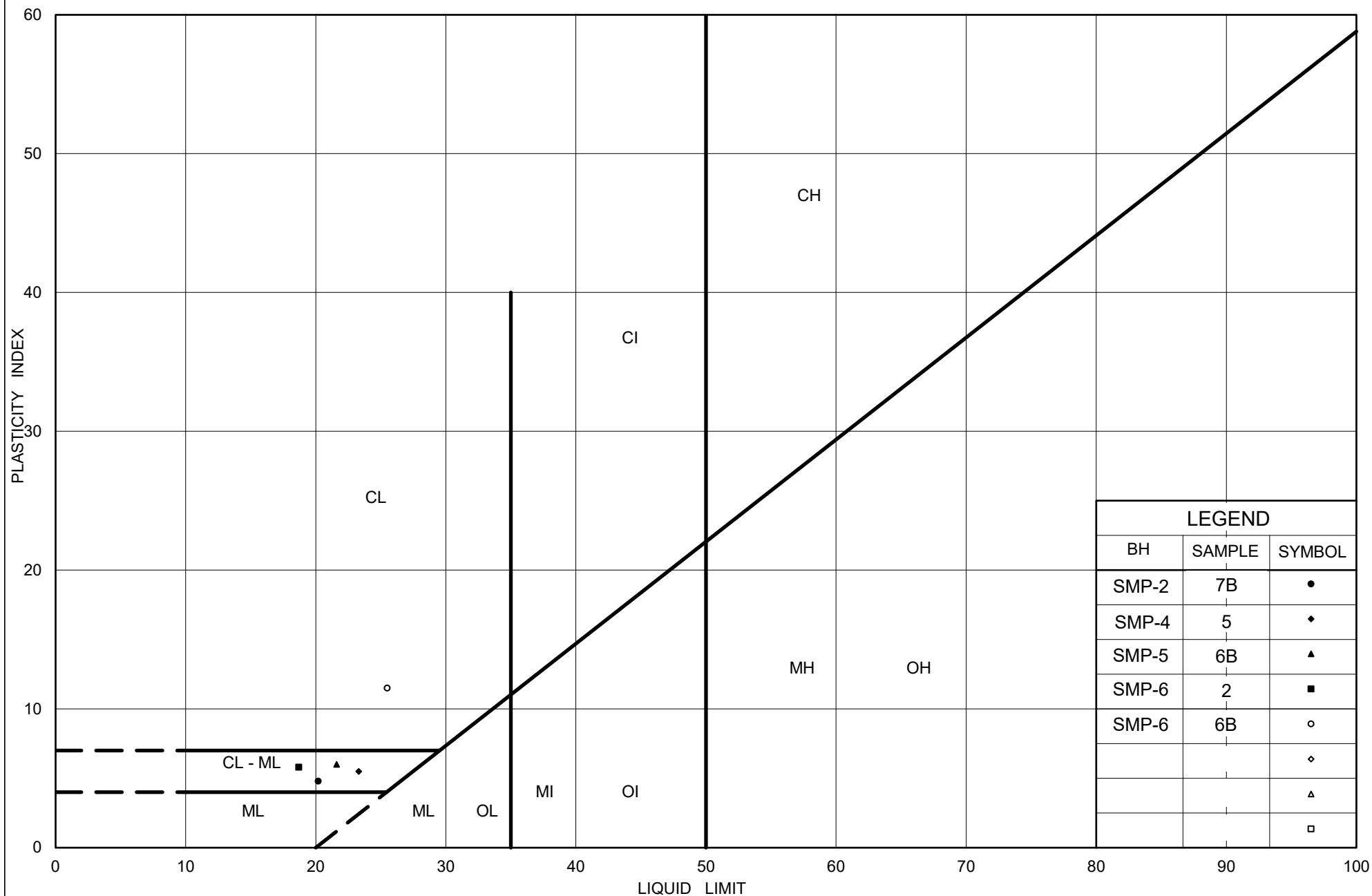
PLASTICITY CHART

Sandy CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) (TILL)

Figure No. C-6A

Project No. 1786658 (WO15)

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PLASTICITY CHART

Sandy CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) (TILL)

Figure No. C-6B

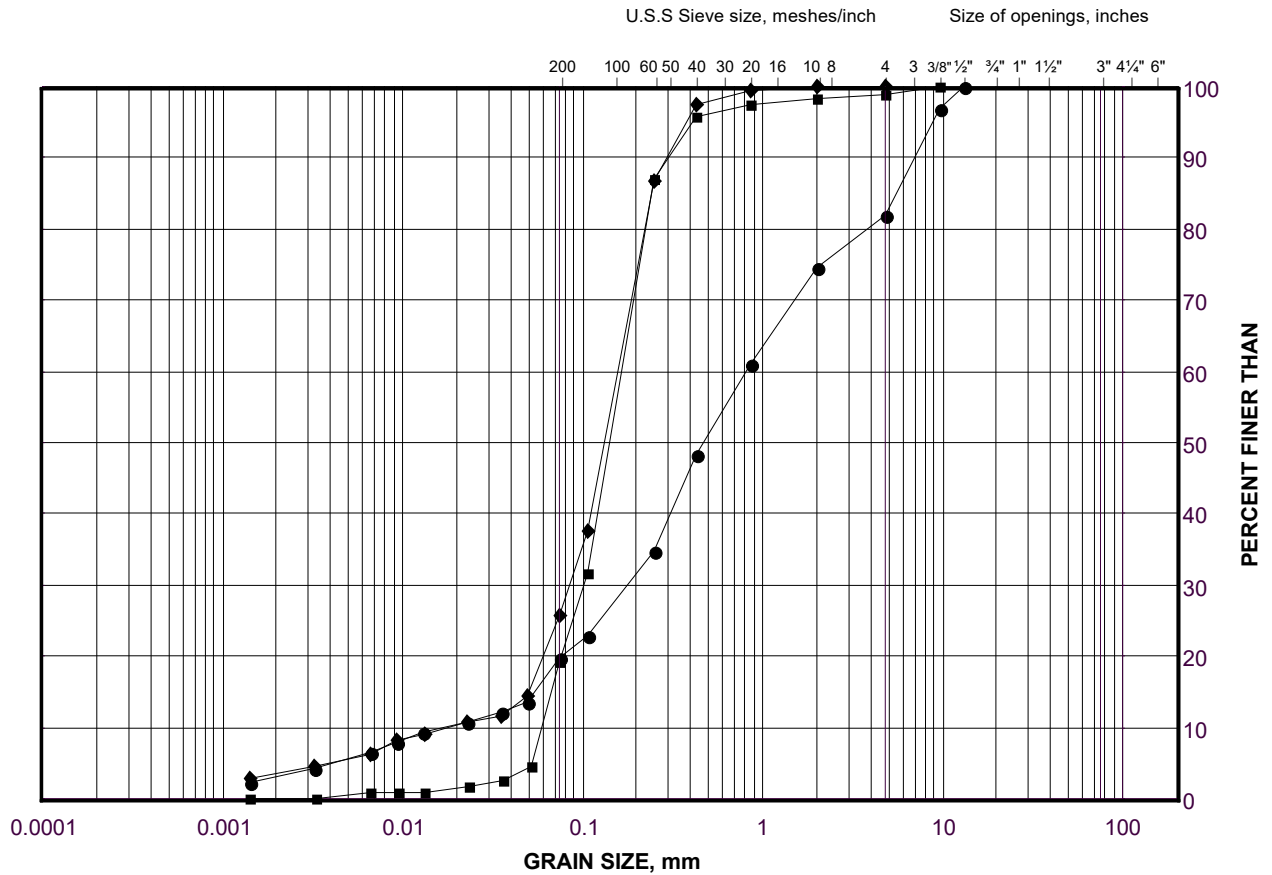
Project No. 1786658 (WO15)

Checked By: AMP

GRAIN SIZE DISTRIBUTION

Gravelly SILTY SAND (SM) to SILTY SAND (SM)

FIGURE C-7



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

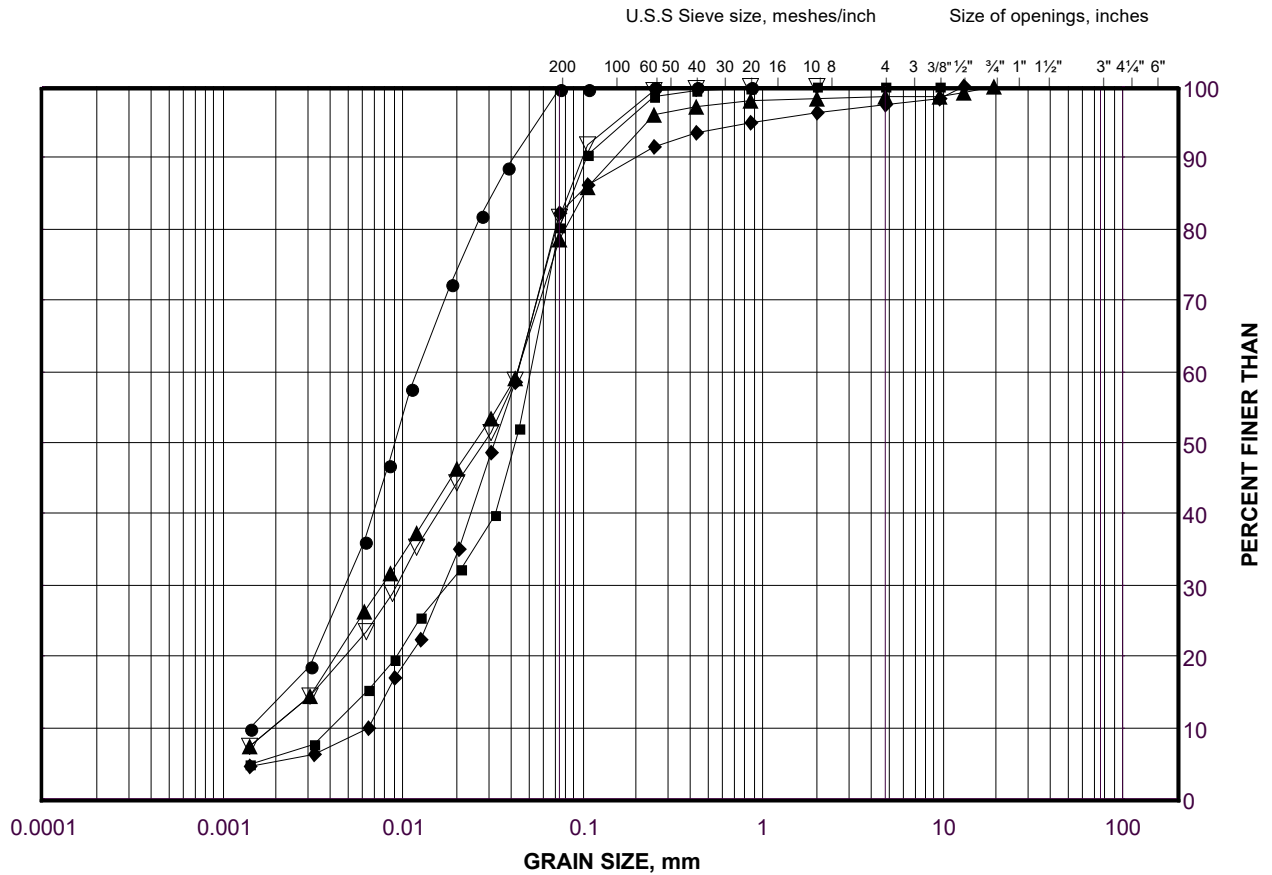
LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SMP-5	4B	301.5
■	SMP-2	5	300.0
◆	SMP-1	6	298.3

GRAIN SIZE DISTRIBUTION

Sandy SILT (ML) to SILT (ML)

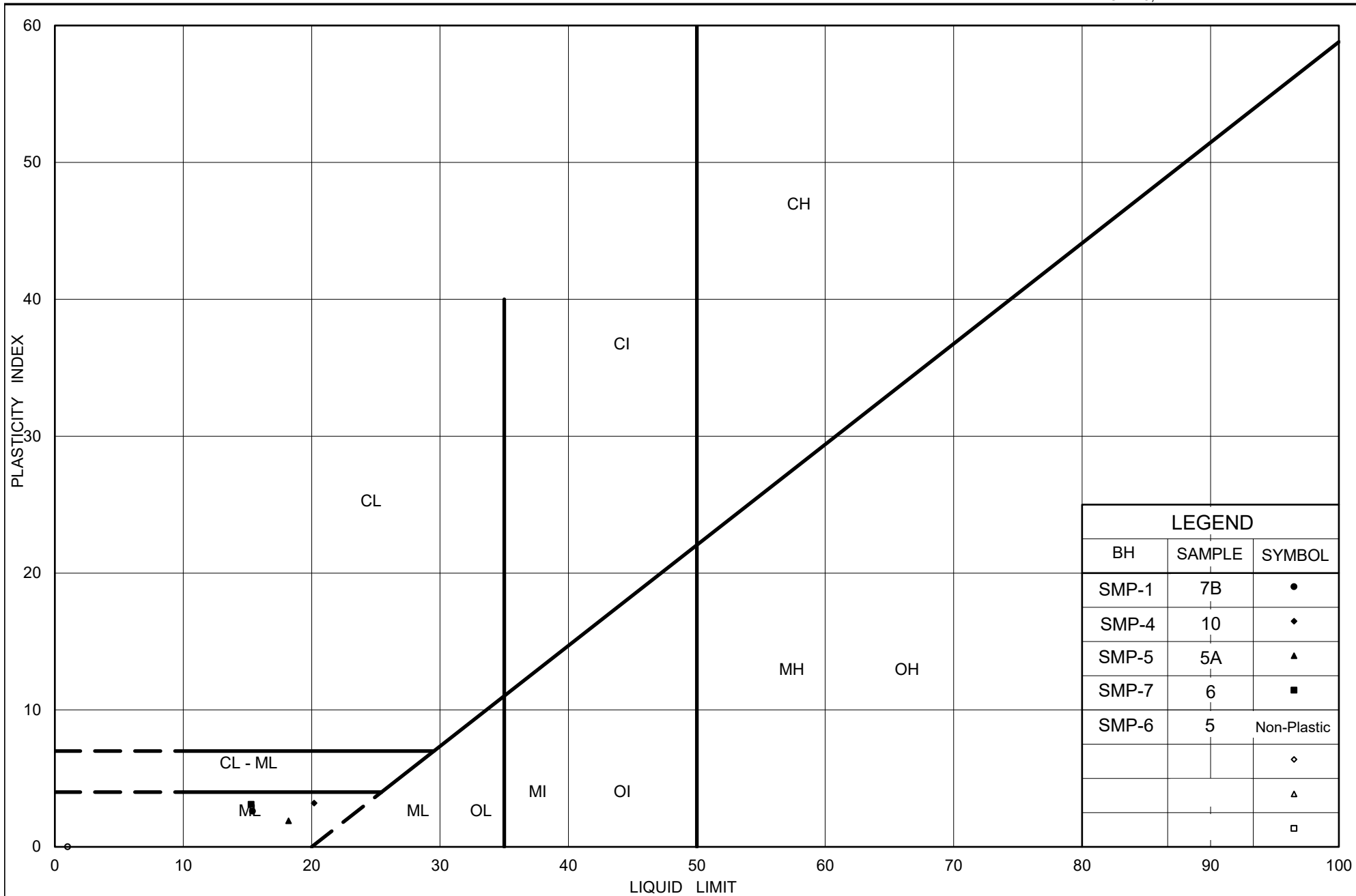
FIGURE C-8



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SMP-4	10	293.8
■	SMP-6	5	300.8
◆	SMP-5	5A	301.2
▲	SMP-7	6	300.2
▽	SMP-1	7B	297.4



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PLASTICITY CHART

Sandy SILT (ML) to SILT (ML)

Figure No. C-9

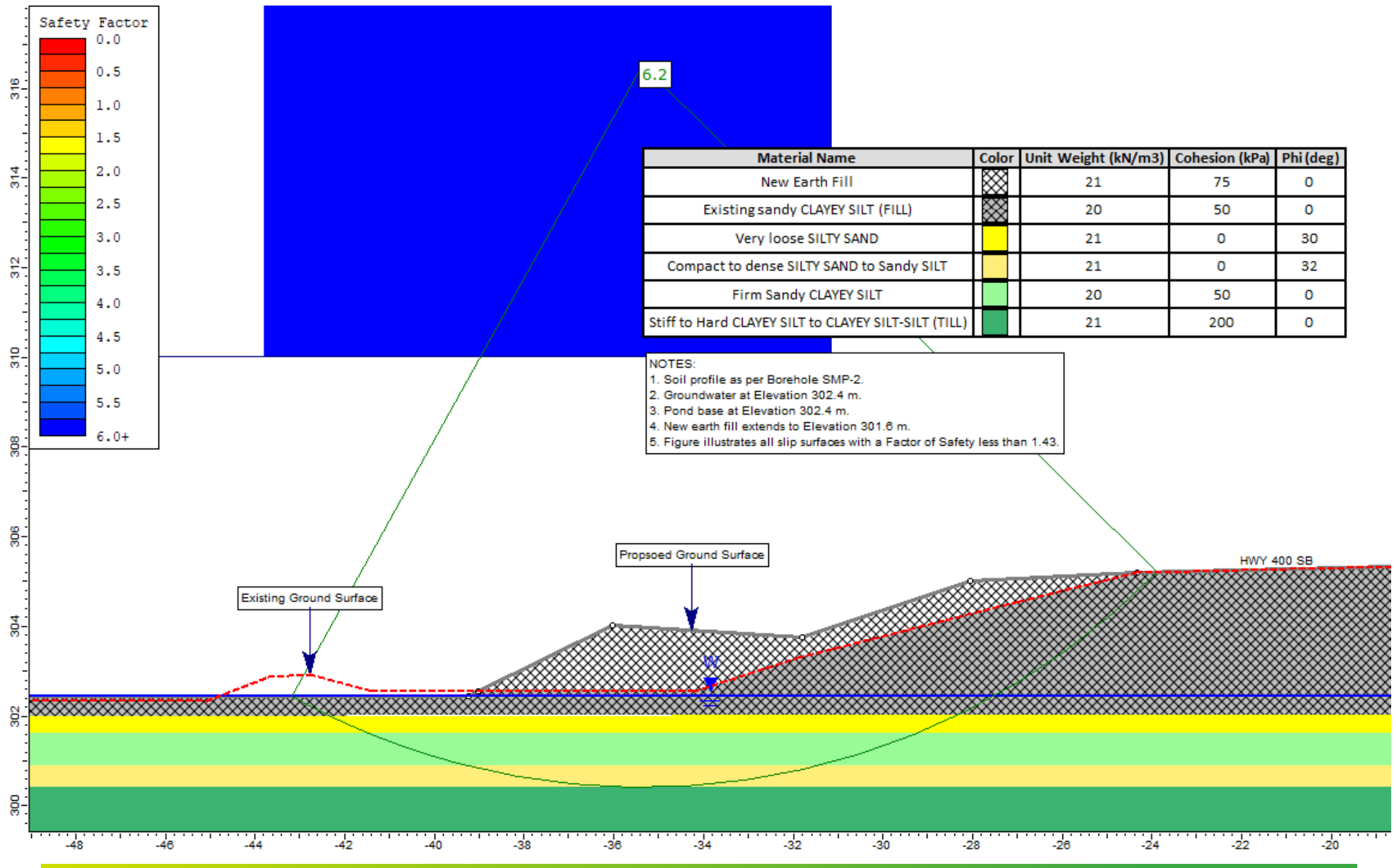
Project No. 1786658 (WO15)

Checked By: AMP

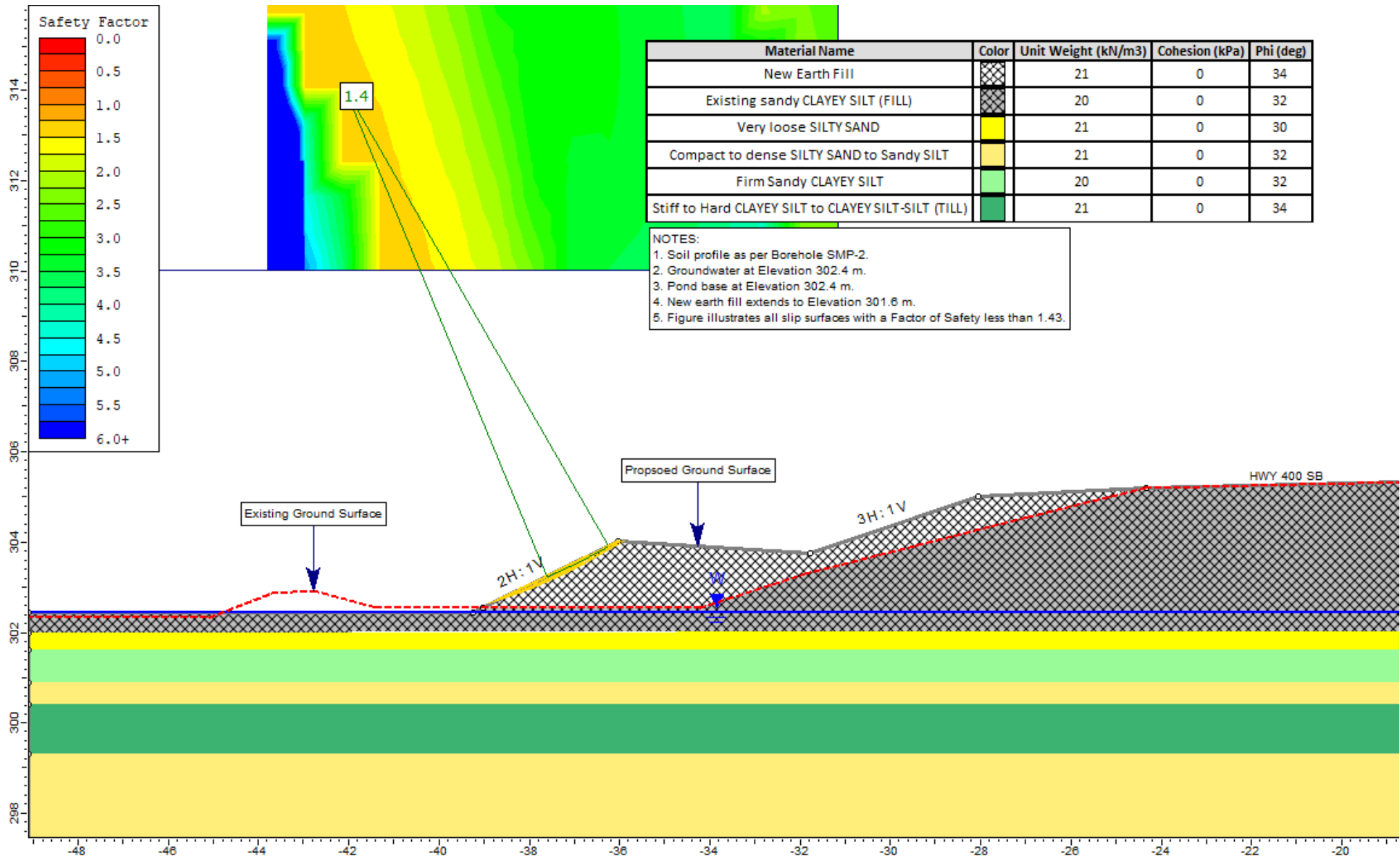
APPENDIX D

Stability Analysis Results

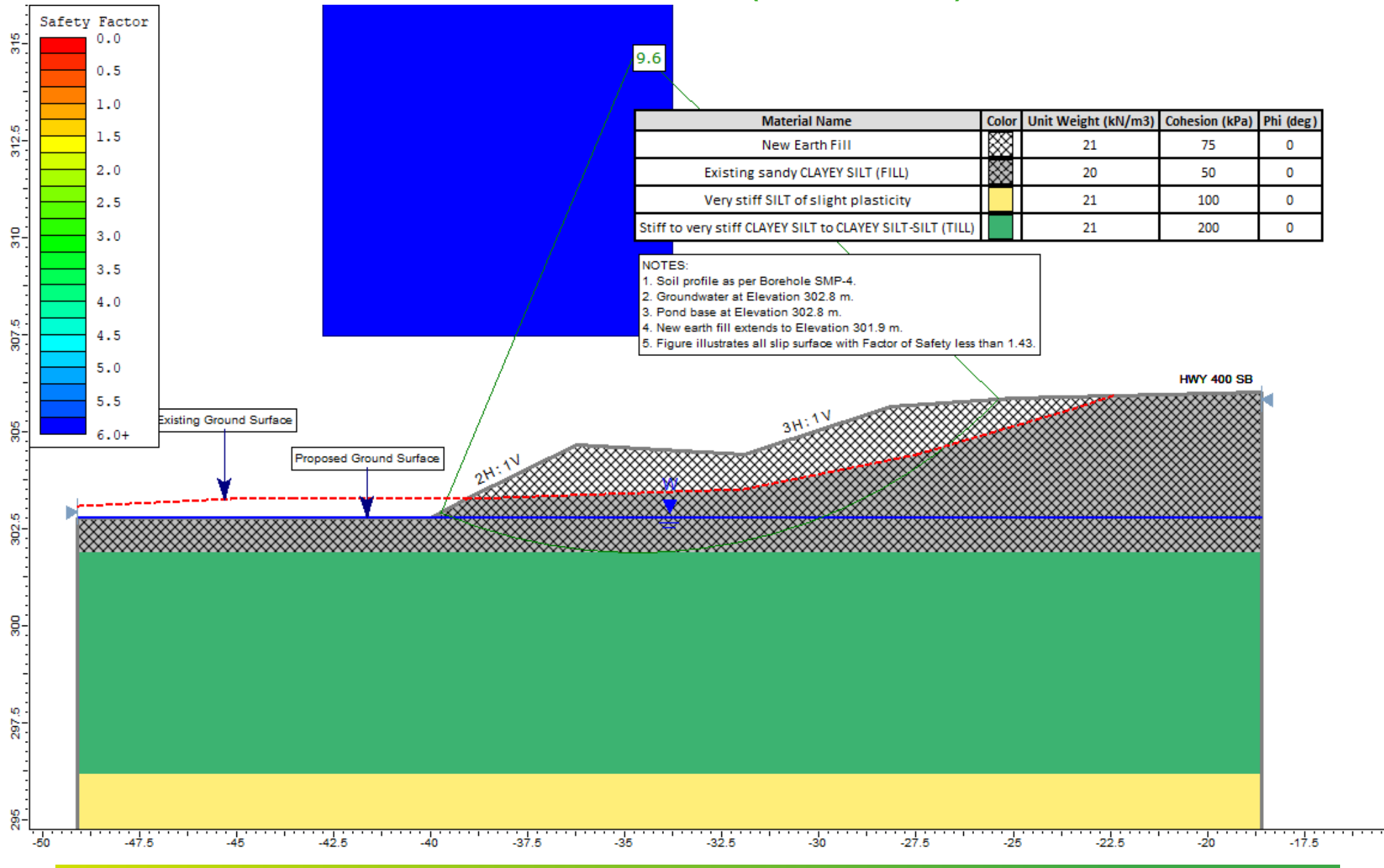
POND 4 SW – Short Term (Undrained) Condition



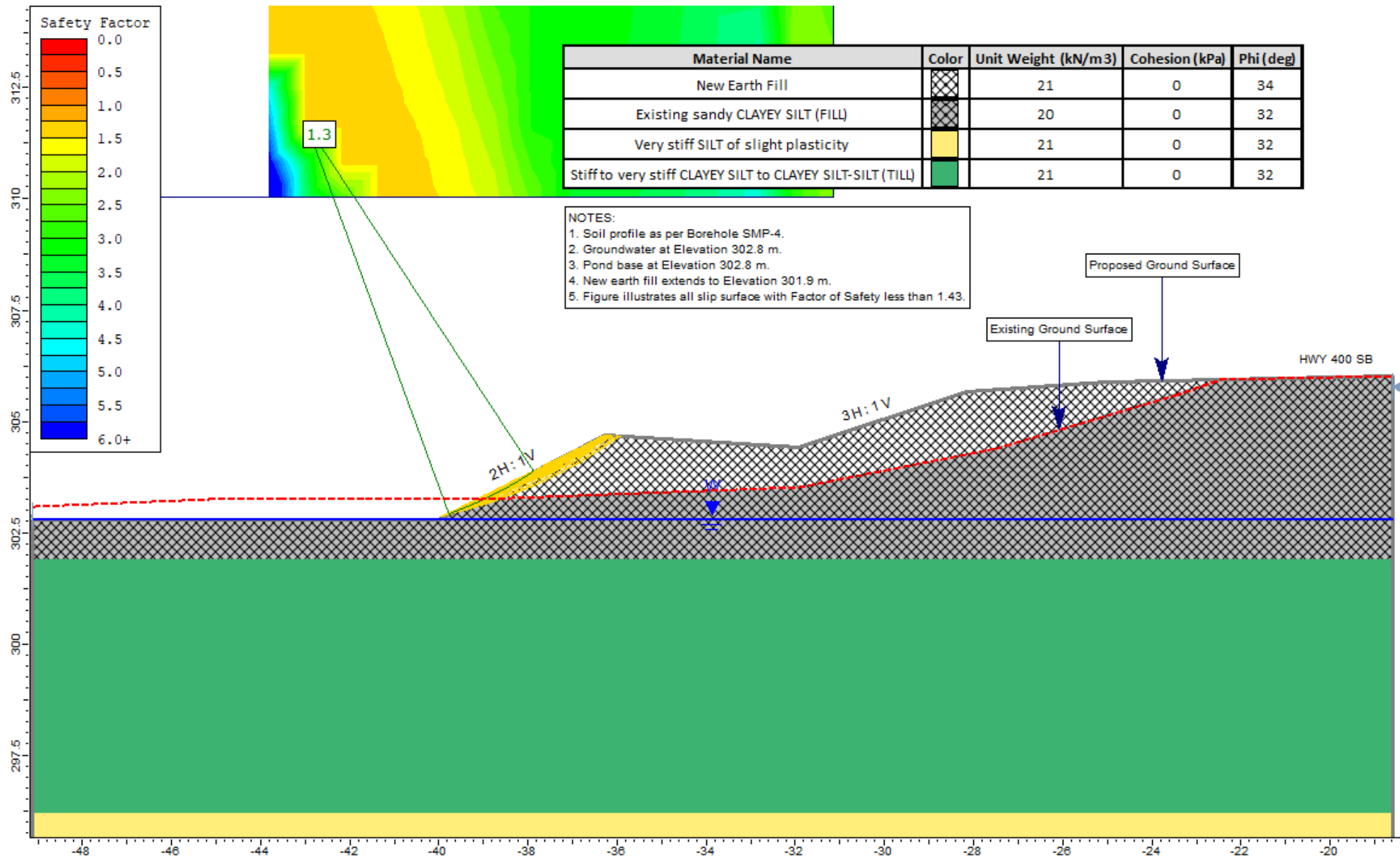
POND 4 SW – Long Term (Drained) Condition



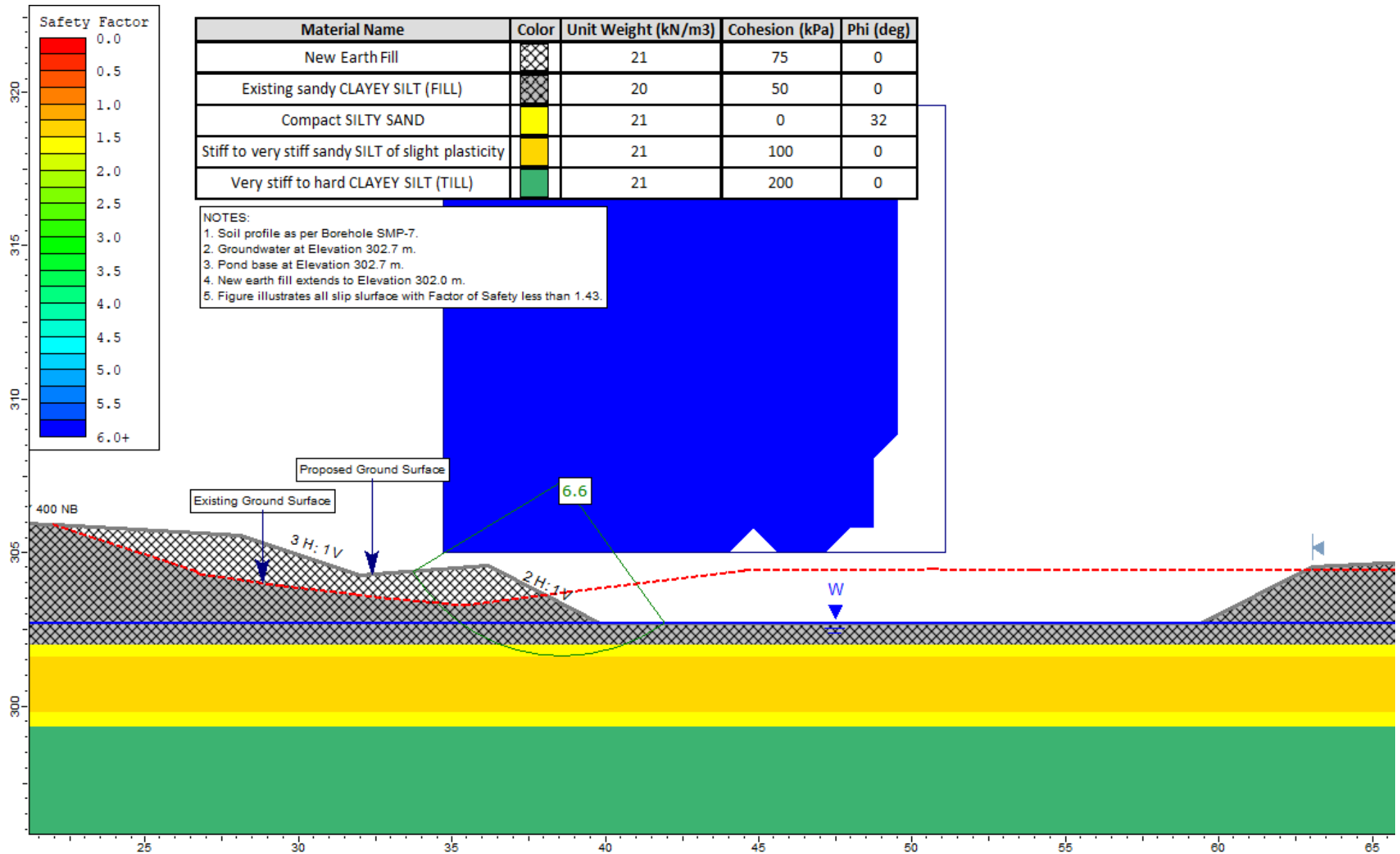
POND 4 NW – Short Term (Undrained) Condition



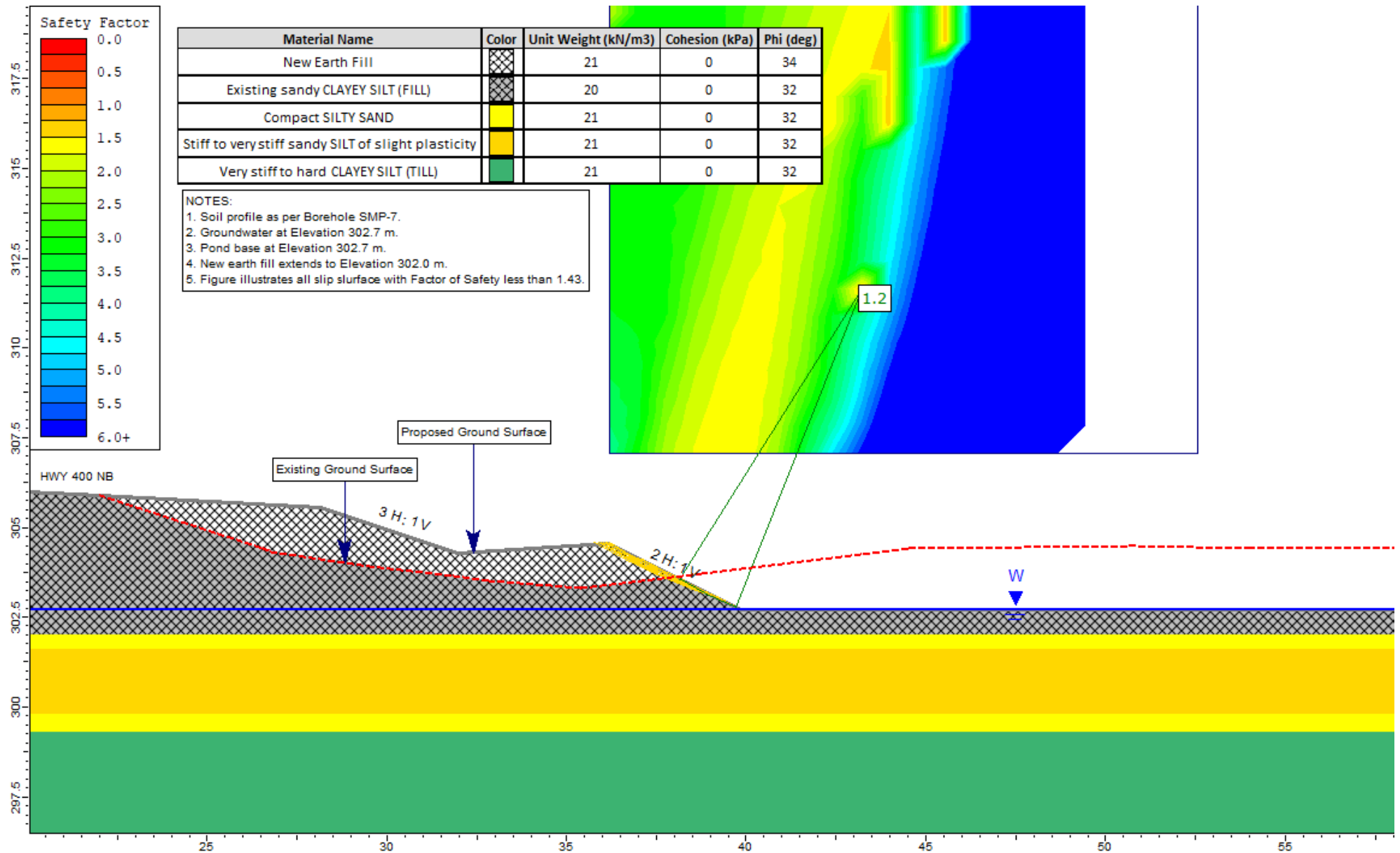
POND 4 NW – Long Term (Drained) Condition



POND 4 NE – Short Term (Undrained) Condition



POND 4 NE – Long Term (Drained) Condition



APPENDIX E

Notice to Contractors / Non-Standard Special Provisions

DECOMMISSIONING OF PIEZOMETERS - Item No.

Non-Standard Special Provision

1.0 SCOPE

This special provision covers the requirements for the decommissioning of the piezometers located in the vicinity of the proposed stormwater management ponds.

Standpipe piezometers were installed in Boreholes C26-1, SMP-1, SMP-5, and SMP-6. The piezometers have been left in place to allow for monitoring of groundwater levels up to the time of construction. The piezometer locations (relative to MTM NAD 83 Zone 10 and in latitude and longitude), piezometer diameters, borehole diameter, and piezometer depth are summarized below.

Standpipe Piezometer Identification	Approximate Location		PVC Pipe and Screen diameter / Borehole diameter	Depth (Below Ground Surface) to Tip of Screen
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
C26-1	4,865,850.9 (43.932624)	299,219.9 (-79.569504)	50 mm / 108 mm	4.6 m
SMP-1	4865739.18 (43.931619)	299234.44 (-79.569321)	50 mm / 210 mm	4.0 m
SMP-5	4866036.24 (43.934292)	299169.62 (-79.570132)	50 mm / 210 mm	6.1 m
SMP-6	4865915.80 (43.933209)	299318.58 (-79.568275)	50 mm / 210 mm	5.2 m

2.0 REFERENCES – Not Used

3.0 DEFINITIONS – Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS – Not Used

5.0 MATERIALS – Not Used

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION

As part of the construction activities the contractor shall properly decommission the standpipe piezometers prior to the start of the construction works. The abandonment method for standpipe piezometers must satisfy the minimum requirements of Ontario Regulation 903 Wells, as amended under the Ontario Water Resources Act. In addition, the contractor shall provide a written record of the decommissioning procedure to the Contract Administrator. The record shall include plugging material used, depth of plugging material and limit of the PVC standpipe/screen removal.

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT – Not Used

10.0 BASIS OF PAYMENT

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

OPERATIONAL CONSTRAINT – SWMP Construction During Summer Season

Special Provision

SWMP Construction During Dry Periods

Groundwater seepage or inflow into excavations for the stormwater management ponds (SWMPS) should be anticipated from the lenses and/or interlayers of water-bearing cohesionless soils within the till and from the fill above the till deposit. Perched groundwater conditions are anticipated within the fill during periods of high precipitation and especially in the Spring season. To minimize groundwater inflow into the excavations and to limit saturation and instability of the pond base and pond side slopes due to groundwater seepage during construction, excavations for the SWMPS shall be carried out during the dry period of the year (i.e., Summer season), when precipitation and groundwater levels are anticipated to be the lowest. However, any advanced dewatering and surface water diversion / control to maintain a stabilized pond base and side-slope until erosion protection / vegetative cover has been established is the responsibility of the Contractor.

If excavation operations are to progress during wet periods of the year (i.e., Spring or Fall), gravel sheeting in combination with Rip-Rap (or alternative erosion control measures) may be required to control erosion due to groundwater seepage and higher water flows (in particular, at the north end of Pond 4NE). It is recommended that the groundwater levels in the monitoring wells be measured closer to the time of construction, in order for the contractor to assess the temporary dewatering requirements and temporary erosion control measures required during construction.



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