

## TECHNICAL MEMORANDUM

**DATE** October 17, 2018

**Project No.** 1541608 - 16000 (Part E)

**TO** Diane Villneff, PDEO  
MTO Northeastern Region Geotechnical Section

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**SUMMARY OF FOUNDATION INVESTIGATION AT CULVERT STA. 20+100, CLERGUE TWP.  
HIGHWAY 11, FROM WEST JUNCTION OF HIGHWAY 101 NORTHERLY 34.4 KM  
GWP 5205-10-00, AGREEMENT NUMBER 5015-E-0012, ASSIGNMENT NO. 16, PART E  
GEOCRES NUMBER 42A-126**

### 1.0 FOUNDATION INVESTIGATION

This Technical Memorandum presents a summary of the results of a foundation investigation and associated laboratory testing to support the design and construction of a temporary cut slope or temporary protection system (TPS) for the staged replacement of a centreline culvert located at Sta. 20+100, Clergue Twp. The Terms of Reference and Scope of Work were provided to us by email dated June 6, 2018. In summary Golder's scope of work includes a foundation investigation, factual reporting of the investigation results and selection of soil parameters to be used in support of the TPS design by others.

#### 1.1 SUBSURFACE INVESTIGATION

The field work for the foundation investigation was carried out on August 8, 2018, during which time one borehole (Borehole 18-1) was advanced at the location of the proposed culvert replacement on the left shoulder of Highway 11 adjacent to the existing culvert as shown on Drawing 1. The borehole was advanced using a truck-mounted CME-75 drill rig, supplied and operated by Landcore Drilling Ltd of Chelmsford Ontario.

The borehole was advanced through the overburden using 108 mm inner diameter hollow-stem augers. Soil samples were obtained in the borehole at 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 the Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were carried out in the cohesive strata for assessment of undrained shear strengths in accordance with ASTM D2573 (Standard Test Method for Field Vane Shear Test in Saturated Fine Grained Soils) using MTO Standard 'N' size vanes.

The field work was supervised on a full-time basis by a member of Golder's technical staff who: located the borehole in the field; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the borehole; and examined and cared for the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions and Atterberg limits tests were carried out on selected soil samples.

The groundwater level in the open borehole was observed during the drilling operations as described on the Record of Borehole sheet in Appendix A. The borehole was backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The as-drilled borehole location was measured by a member of our technical staff, referenced to the highway centerline at the existing culvert and converted into northing/easting coordinates from the drawings provided by MTO. The ground surface elevation of the highway centerline was obtained from the plan and profile drawing (Culvert – Sta. 20+100 Clergue - PLAN.tif) provided by MTO. The MTM NAD83 (Zone 12) northing and easting coordinates and geographical coordinates, ground surface elevations referenced to Geodetic datum and the borehole drilled depth are presented on the Record of Borehole sheet in Appendix A and summarized below.

BOREHOLE NUMBER	NORTHING (LATITUDE)	EASTING (LONGITUDE)	GROUND SURFACE ELEVATION	BOREHOLE DEPTH
1	5390054.9 (48.648620)	326780.5 (-80.701671)	278.0 m	14.3 m

## 1.2 SUBSURFACE CONDITIONS

The detailed subsurface soil and groundwater conditions encountered in the borehole and the results of in situ and laboratory testing are given on the Record of Borehole sheet contained in Appendix A. The results of geotechnical laboratory testing are presented on the Record of Borehole sheet and shown on Figures 1 to 6 contained in Appendix B. Plots of the results of the in situ field tests (i.e., SPT 'N' values and vane shear test results as presented on the Record of Borehole are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheet are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary beyond the borehole location.

### Embankment Fill

Borehole 18-1 was advanced through the existing Highway 11 embankment and penetrated a 5.9 m thick layer of fill. The embankment fill consists of a 2.7 m thick layer of granular material comprised of brown, moist sand, some gravel, trace to some silt (refer to Figure 1); cobbles were encountered within the granular fill from 100 mm to 1.5 m depths. Underling the granular fill a 3.2 m thick layer of silty clay fill was encountered extending to a depth of 5.9 m (Elevation 272.1 m). The silty clay fill is brown to grey, moist and contains trace sand (refer to Figure 2) and trace organics; a 200 mm thick seam of moist, brown sand and gravel fill was encountered interlayered with the silty clay fill at a depth of 3.2 m. Atterberg limits tests on two samples of the cohesive fill measured liquid limits of about 43 percent and 36 percent, plastic limits of about 19 per cent and 17 per cent, and corresponding plasticity indices of about 24 per cent and 18 per cent. The test results are presented on Figure 3 and indicate that the cohesive fill is silty clay of intermediate plasticity.

The SPT 'N'-values measured within the granular fill are 12 blows and 36 blows per 0.3 m of penetration, indicating a compact to dense compactness condition. The moisture content of one sample of the granular fill is 6 per cent.

The SPT 'N'-values measured within the silty clay fill range from 9 blows to 10 blows per 0.3 m of penetration, and one field vane test measured an undrained shear strength of the silty clay greater than 100 kPa, indicating a stiff to very stiff consistency. The moisture content of two samples of the silty clay fill is 23 per cent and 29 per cent.

### **Clay “Crust”**

A 1.6 m thick cohesive deposit of wet, grey, clay was encountered below the embankment fill at a depth of 5.9 m (Elevation 272.1 m) and extended to a depth of 7.5 m (270.5 m).

The measured SPT “N”-values within the clay “crust” is 8 blows per 0.3 m of penetration and the measured vane undrained shear strength is about 48 kPa, together suggesting a firm consistency. The moisture content of one sample of the clay is 38 per cent. The result of a grain size distribution test on one of the clay is shown on Figure 4.

An Atterberg limit tests carried out a sample of this layer yielded a liquid limit of 63 per cent, a plastic limit of 26 per cent and a plasticity index of 37 per cent, indicating that the material is a clay of high plasticity as shown on Figure 5.

### **Clay and Silty Clay**

A cohesive deposit comprised of an upper 2.2 m thick stratum of wet, grey, clay and a lower 4.6 m thick stratum of silty clay was encountered below the clay “crust” at a depth of 7.5 m below ground surface (Elevation 270.5 m). Borehole 18-1 was terminated within the silty clay stratum at a depth of 14.3 m below ground surface elevation (Elevation 263.7 m).

The measured SPT “N”-values within the clay and silty clay stratum ranges from 0 blows (weight of rods/hammer) to 3 blows per 0.3 m of penetration. In-situ field vane tests carried out within the clay and silty clay stratum of the deposit measured undrained shear strengths of about 32 kPa. The sensitivity of these cohesive stratum is about 3. The field vane test results together with the SPT N-values suggest, that the clay and silty clay stratum have a soft to firm consistency. The result of a grain size distribution test on one of the samples of the silty clay stratum is presented on Figure 6.

An Atterberg limit test carried out on a sample of the lower stratum yielded a liquid limit of about 46 per cent, a plastic limit of about 20 per cent and plasticity index of about 26 per cent, indicating that the material is a silty clay of intermediate plasticity as shown on Figure 5.

### **Groundwater Conditions**

The groundwater level as measured in the open borehole upon completion of drilling at a depth of 6.2 m. Groundwater levels encountered in the boreholes during and shortly after drilling are generally not considered to be representative of stabilized groundwater levels. The result is noted on the Record of Borehole sheet below ground surface corresponding to Elevation 271.8 m.

### 1.3 CLOSURE

We trust the subsurface information presented in this section of the Technical Memorandum is sufficient for your immediate needs. If any clarification is required, please do not hesitate to contact this office.

#### GOLDER ASSOCIATES LTD.



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## 2.0 FOUNDATION DESIGN

This section of the Technical Memorandum provides foundation design recommendations for the proposed Temporary Support System at a culvert at Sta. 20+100 on Highway 11, Clergue Township. These recommendations are based on interpretation of the factual data obtained from the borehole advanced during the investigation. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasible foundation alternatives and carry out the design of the Temporary Protection System. The foundation investigation section of the Technical Memorandum, discussion, and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in the Foundation Investigation section of the memorandum. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

### 2.1 SOIL PARAMETERS

Based on discussions with MTO, we understand that a temporary roadway protection system (TPS) will be required to facilitate staged construction at this site. Alternatively, the left side of the existing embankment may be cut to an inclination of 1 Horizontal to 1 Vertical (1H:1V) to allow construction of the replacement culvert in stages.

The temporary support system could consist of either driven steel sheet piling or soldier piles and lagging where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds. Support to the system could be in the form of struts and wales and rakers or anchors. If adopted, the temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to the existing roadway.

The design of the temporary roadway protection system, may be carried out using the following parameters:

SOIL TYPE	UNIT WEIGHT	INTERNAL ANGLE OF FRICTION	UNDRAINED SHEAR STRENGTH	COEFFICIENT OF EARTH PRESSURE		
	( $\gamma$ , kN/m <sup>3</sup> )	( $\phi$ , degrees)	( $C_u$ , kPa)	Active, $K_a$	At Rest, $K_o$	Passive, $K_p$
New Granular 'A'	22	35	-	0.27	0.43	3.65
New Granular 'B' Type II	21	35	-	0.27	0.43	3.65
New Granular 'B' Type I	21	32	-	0.31	0.47	3.23
Existing Sand (Fill) (compact to dense)	20	30	-	0.33	0.50	3.00

SOIL TYPE	UNIT WEIGHT	INTERNAL ANGLE OF FRICTION	UNDRAINED SHEAR STRENGTH	COEFFICIENT OF EARTH PRESSURE		
	( $\gamma$ , kN/m <sup>3</sup> )	( $\phi$ , degrees)	( $C_u$ , kPa)	Active, $K_a$	At Rest, $K_o$	Passive, $K_p$
Existing Silty Clay (Fill) (stiff to very stiff)	18	28	75	0.36	0.53	2.77
Clay (Crust) (Firm to stiff)	18	28	40	0.36	0.53	2.77
Clay to Silty Clay (soft to firm)	17	27	25	0.38	0.55	2.64

The temporary shoring design should be assessed for both the drained ( $\phi$ ) and undrained ( $c_u$ ) cases and the design should be based on the more conservative earth pressure conditions. Further, the total passive resistance of the temporary protection system below the base of the excavation should be calculated based on the values of  $K_p$  given above and then reduced by an appropriate factor of safety that considers the allowable wall movement as extrapolated from Figure C6.16 of the Canadian Highway Bridge Design Code (CHBDC, 2014) to account for the fact that a large strain would be required for full mobilization of the passive resistance.

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly. Design of the temporary support system should include an evaluation of base stability, soil squeezing stability and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM, 2006).

If a cut embankment staging strategy is adopted, the temporary cut slope should be made flatter (and no steeper) than 1H:1V and the stability of the slope should be checked to verify that the Factor of Safety of not less than 1.3 is achieved for the temporary condition, utilizing the above noted soil input parameters. Reconstruction of the roadway embankment should be made consistent with OPSD 208.010 (Benching of Earth Slopes) to integrate the new fill with the existing embankment fill and the cut slope faces. All embankment reconstruction should be carried out in accordance with OPSS.PROV 206 (Grading) and OPSS.PROV. 501 (Compacting).

## 2.2 CLOSURE

We trust the discussions and recommendations presented in this section of the Technical Memorandum are sufficient for your immediate needs. If any clarification is required, please do not hesitate to contact this office.

### GOLDER ASSOCIATES LTD.



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Attachments:                      Drawing 1 – Borehole Location  
                                            Appendix A – Record of Borehole 18-1  
                                            Appendix B – Laboratory Test Results

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

CONT No. . GWP No. 5205-10-00		 SHEET
HIGHWAY 11 BOREHOLE LOCATION		



KEY PLAN  
SCALE  
500 0 500 1000 m

LEGEND

Borehole - Current Investigation

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 12)			
No.	ELEVATION	NORTHING	EASTING
Borehole No. 18-1	278.0	5390054.9	326780.5

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			
Image - BING Imagery, ©2018 Microsoft Corporation Earthstar Geographics SIO			

NO.	DATE	BY	REVISION

Geocres No. 42A-126

HWY. 11	PROJECT NO. 1541608	DIST. .
SUBM'D..	CHKD..	DATE: 10/9/2018
DRAWN: SD	CHKD..	APPD. JMAC

SITE: .	DWG. 1
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**APPENDIX A**

# Record of Borehole 18-1



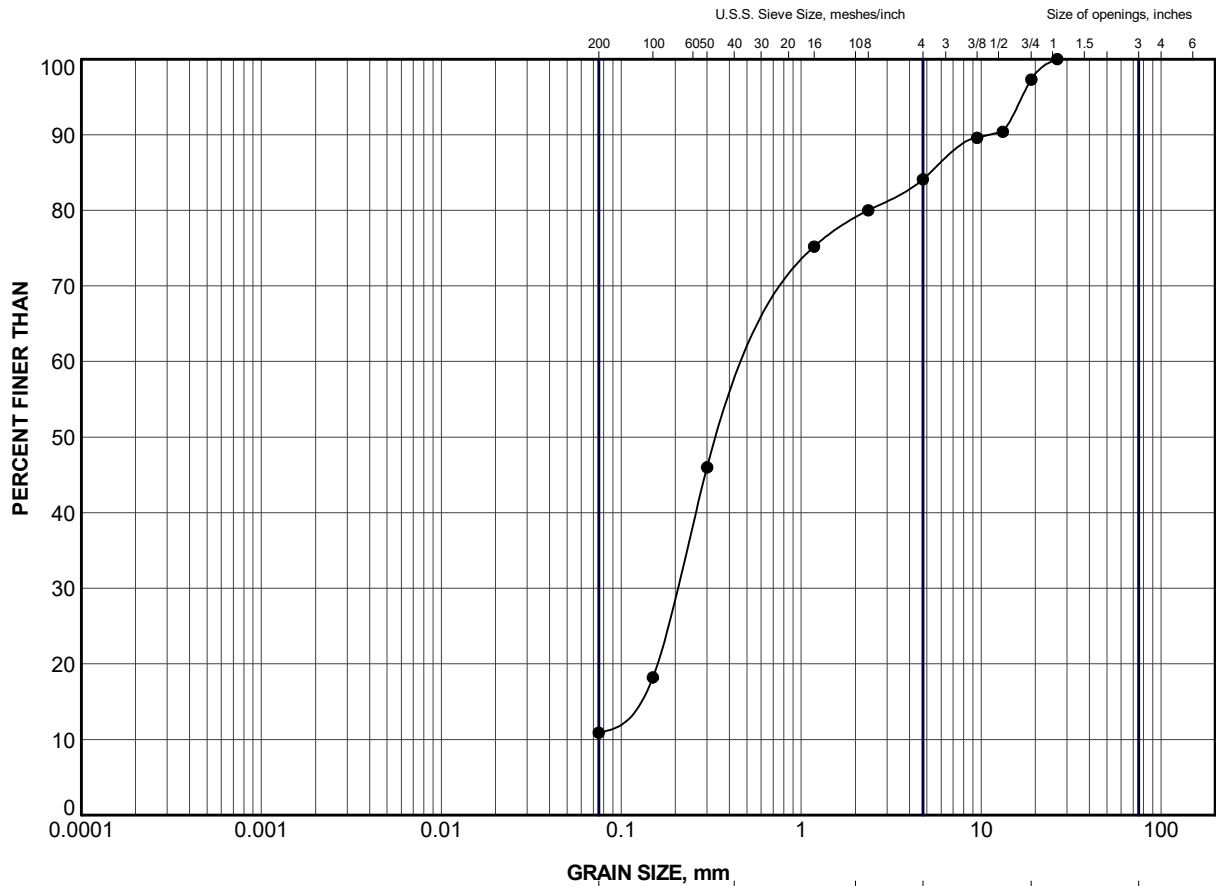
GTA-MTO 001 S:\CLIENTS\MTO\HWY 11\02 DATA\GINT\1541608.GPJ GAL-GTA.GDT 10/5/18

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

**APPENDIX B**

# Laboratory Test Results



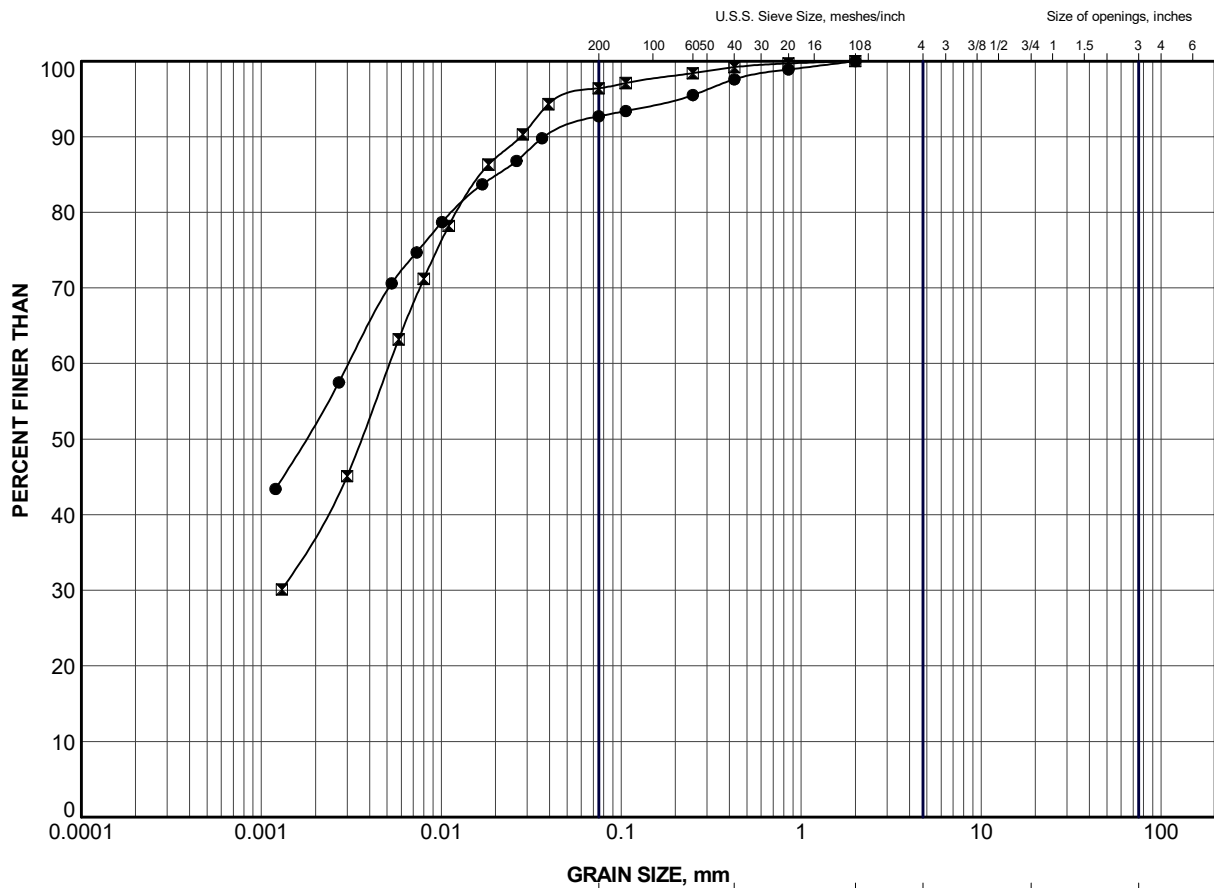


CLAY AND SILT	GRAIN SIZE, mm			Cobble Size	
	fine	medium	coarse	fine	coarse
	SAND SIZE			GRAVEL SIZE	

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	18-1	1	276.2

PROJECT		HIGHWAY 11 Assignment 16 Part E - Foundation Investigation Culvert Sta. 20+100 Clergue Twp.			
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> SAND (FILL)			
PROJECT No. 1541608 (16000)		FILE No. 1541608_LAB_FIG.GPJ			
DRAWN	TR	Sep 2018	SCALE	N/A	REV.
CHECK	MCK	Sep 2018	<b>FIGURE 1</b>		
APPR	JBH	Sep 2018			
GOLDER		SUDBURY, ONTARIO			

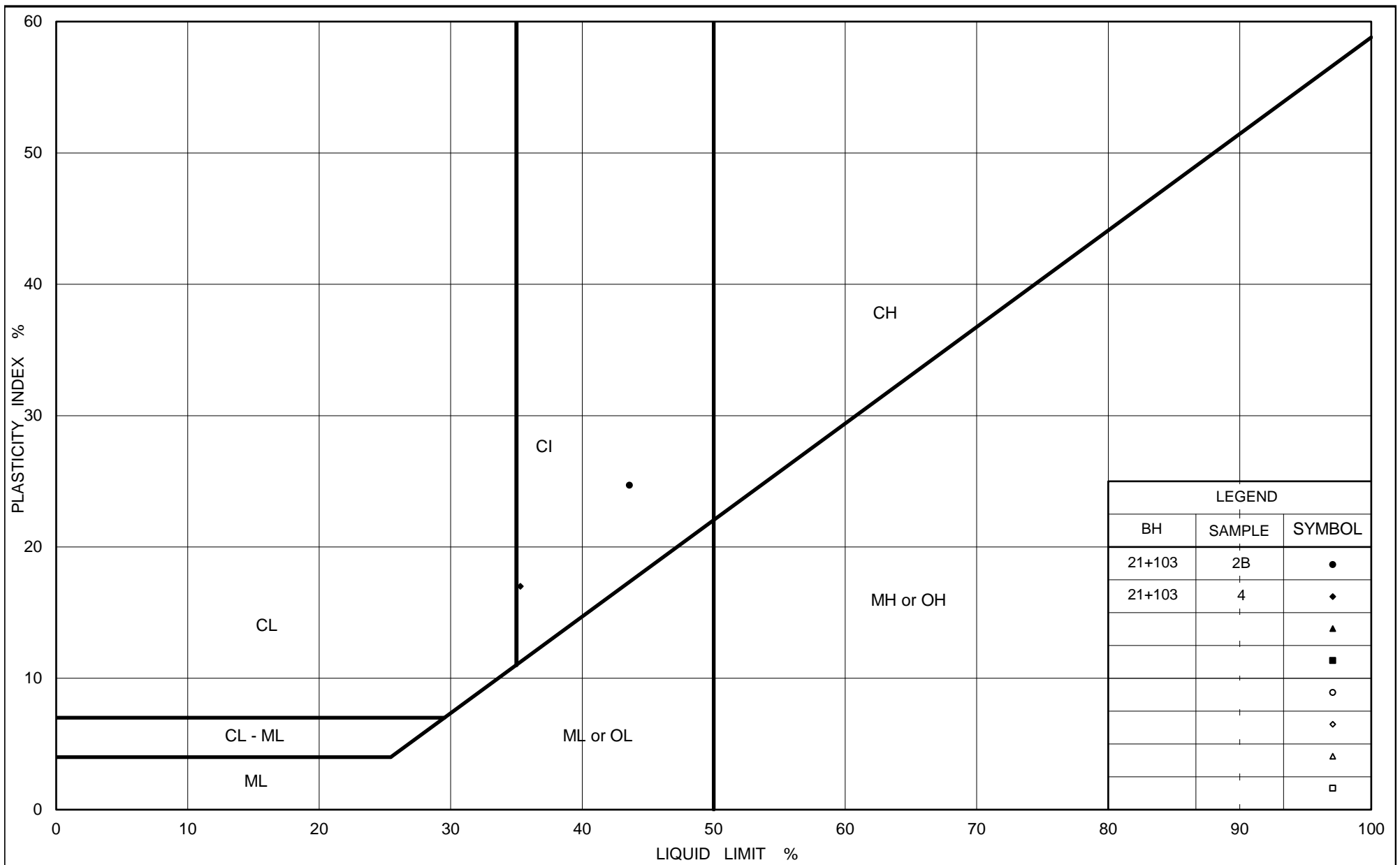


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

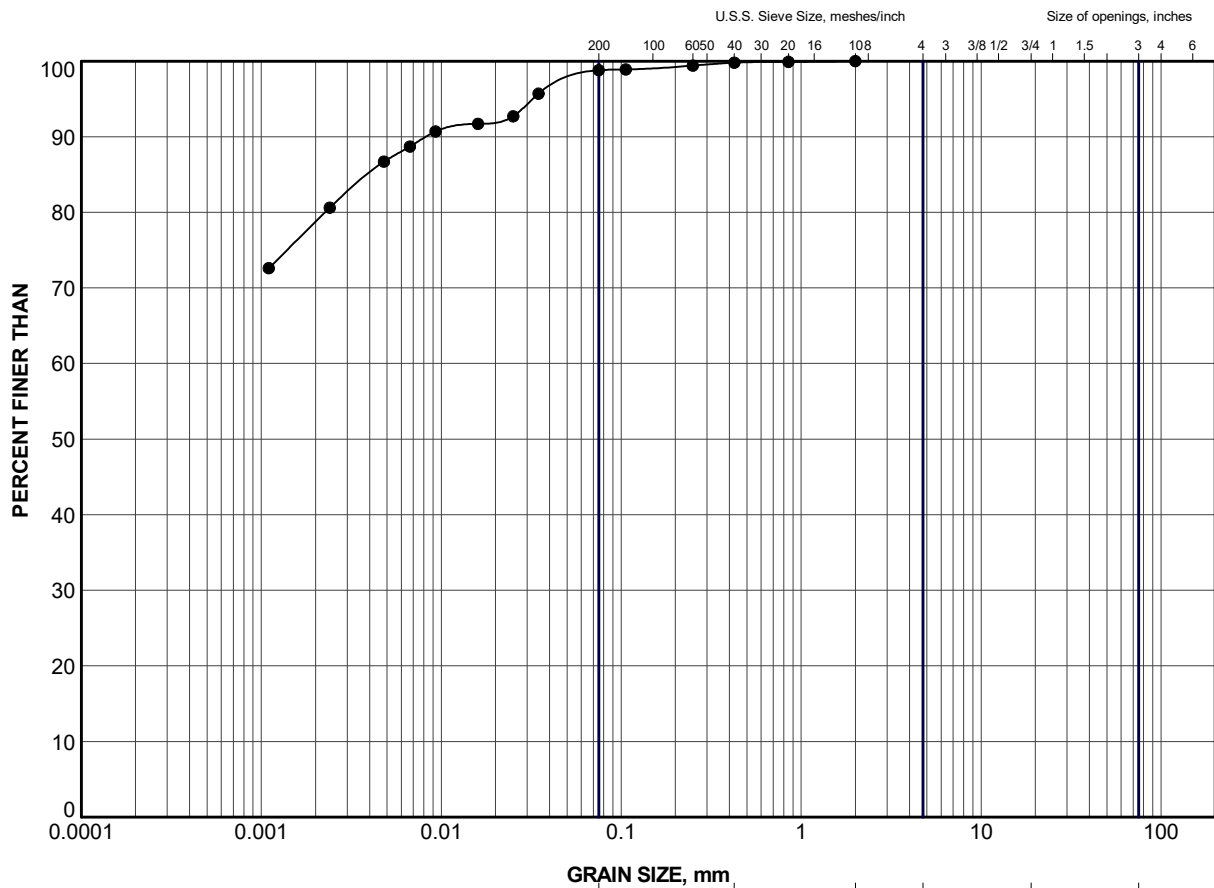
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	18-1	2B	275.3
⊠	18-1	4	274.0

PROJECT		HIGHWAY 11 Assignment 16 Part E - Foundation Investigation Culvert Sta. 20+100 Clergue Twp.			
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> SILTY CLAY (FILL)			
PROJECT No. 1541608 (16000)		FILE No. 1541608_LAB_FIG.GPJ			
DRAWN	TR	Sep 2018	SCALE	N/A	REV.
CHECK	MCK	Sep 2018	<b>FIGURE 2</b>		
APPR	JBH	Sep 2018			





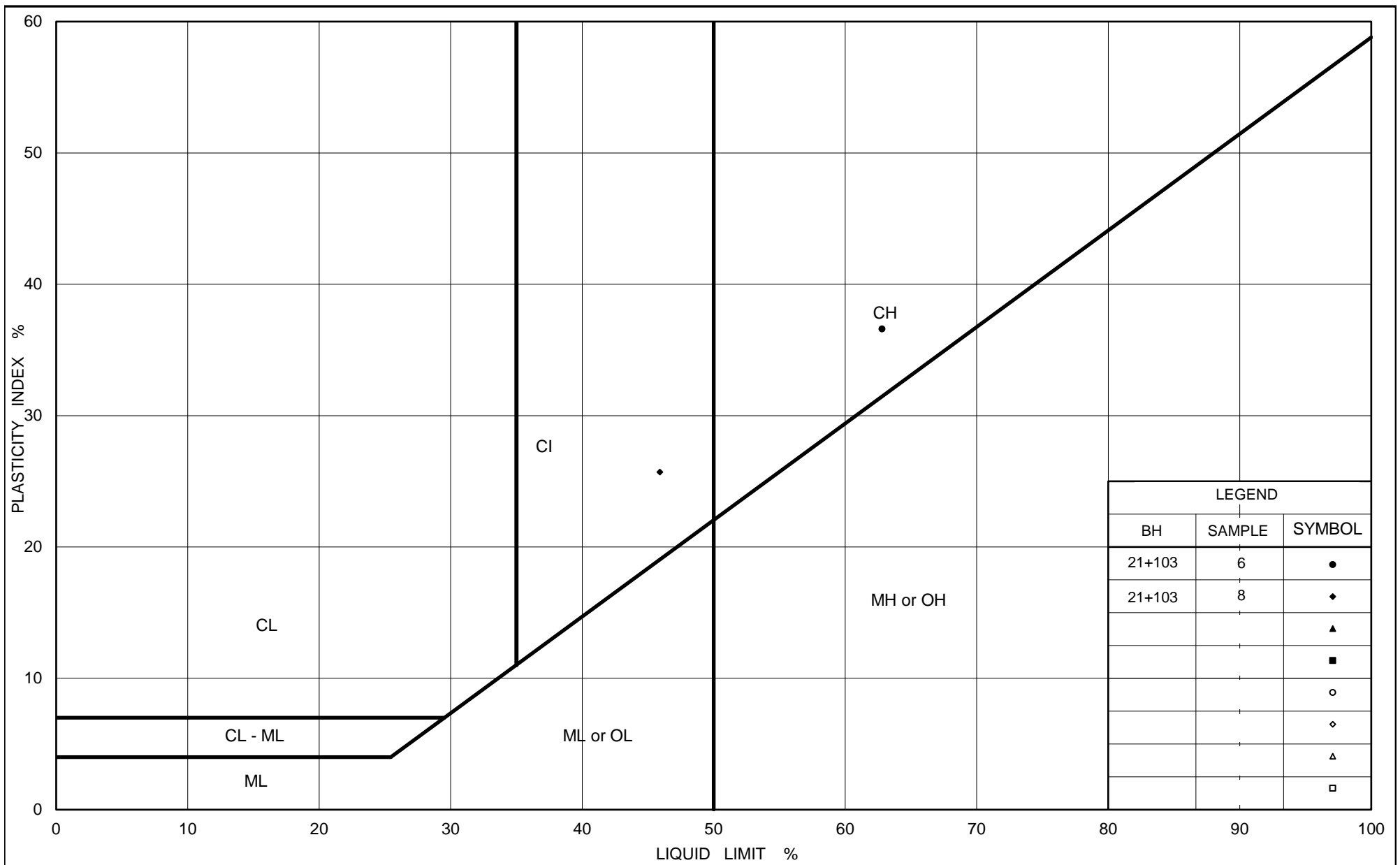


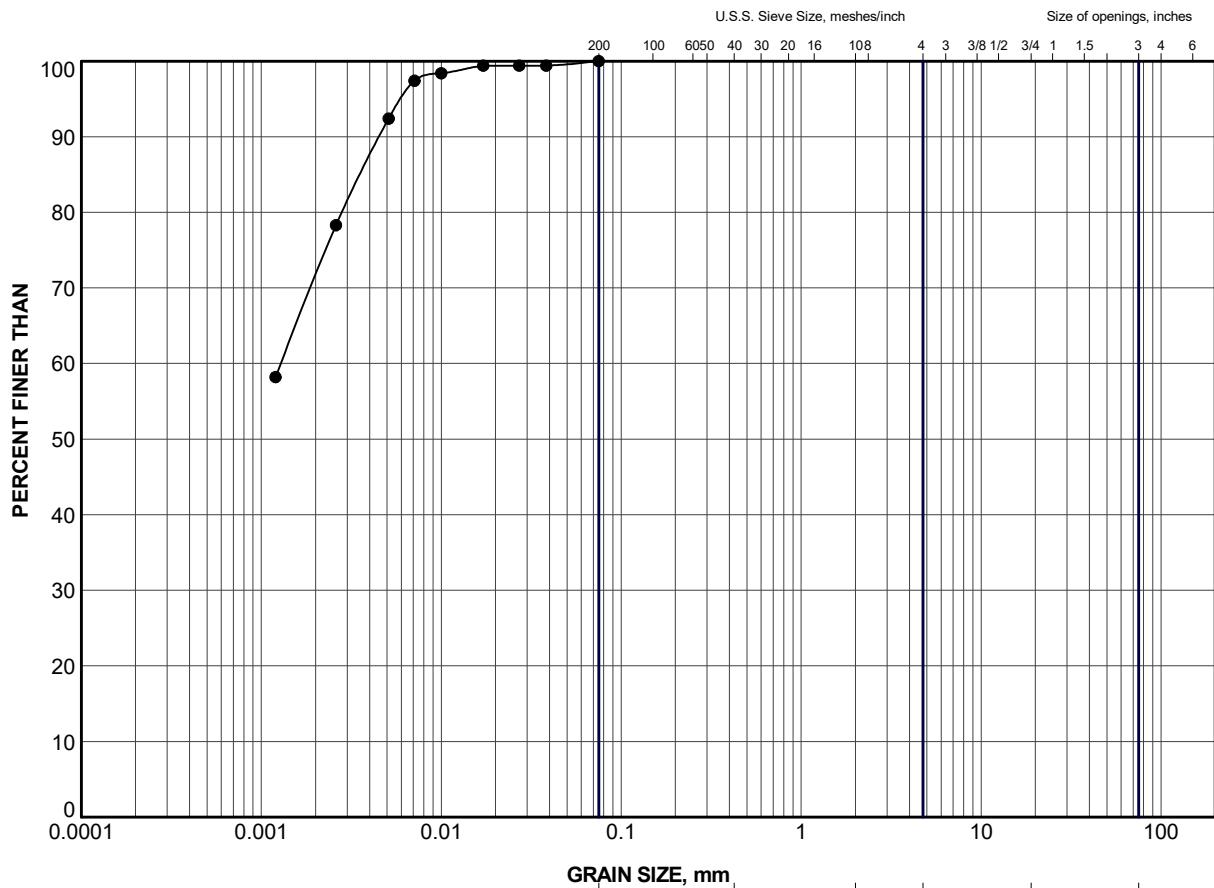
GRAIN SIZE, mm					
CLAY AND SILT			fine	medium	coarse
			SAND SIZE		GRAVEL SIZE
			fine	coarse	Cobble Size

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	18-1	6	271.7

PROJECT		HIGHWAY 11 Assignment 16 Part E - Foundation Investigation Culvert Sta. 20+100 Clergue Twp.			
TITLE		GRAIN SIZE DISTRIBUTION CLAY			
PROJECT No. 1541608 (16000)		FILE No. 1541608_LAB_FIG.GPJ			
DRAWN	TR	Sep 2018	SCALE	N/A	REV.
CHECK	MCK	Sep 2018	FIGURE 4		
APPR	JBH	Sep 2018			
GOLDER		SUDBURY, ONTARIO			






CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	18-1	8	267.4

PROJECT		HIGHWAY 11 Assignment 16 Part E - Foundation Investigation Culvert Sta. 20+100 Clergue Twp.			
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> SILTY CLAY			
PROJECT No. 1541608 (16000)		FILE No. 1541608_LAB_FIG.GPJ			
DRAWN	TR	Sep 2018	SCALE	N/A	REV.
CHECK	MCK	Sep 2018	<b>FIGURE 6</b>		
APPR	JBH	Sep 2018			
 <b>GOLDER</b> SUDBURY, ONTARIO					