Preliminary Foundation Investigation Report

Culvert 67
~30.3 km North of the Corner of HWY 17 and 72
Township of Echo
Station 11+537, Lat: 49.896129, Lon: -92.297128
District of Kenora
Highway 72

6021-E-0045 & 0046

Geocres No. 52F16-005

Prepared for:
Ontario Ministry of Transportation NWR
615 James Street South
Thunder Bay, ON
P7E 6P6

Prepared By:
TBT Engineering Limited
1918 Yonge Street
Thunder Bay, ON
P7E 6T9

March 26, 2024 TBTE Ref. No. 22-146-10

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Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ontario Ministry of Transportation Northwest Region (MTO) to provide foundation investigation services under the Northwest Region (NWR) Geotechnical Retainer Assignment. The site is located on Highway 72, approximately 30.3 north of the intersection of Highway 17 and Highway 72. The site coordinates are as follows:

- Station 11+537, Latitude: 49.896129°, Longitude: -92.297128°

A Google Earth image illustrating the site location can be seen in Figure 1.1.

The investigation consisted of two boreholes; one borehole was advanced at each of the invert and outlet of the culvert. The boreholes were advanced to depths of 6.7 and 8.2 m. Planned borehole locations were provided by the MTO in the Terms of Reference, however, final borehole locations were adjusted to suit field conditions. This report (Part A) describes the subsurface conditions encountered during the investigation.

The MTO Foundations Section has assigned Geocres No. 52F16-005 to this site.

Figure 1.1: A Google Earth Image Illustrating the Site Location.

2 Site Description

The existing embankments are within the MTO Right-of-Way but are near the tree line. The photos below were taken by TBTE during site recognisance. The area is generally flat, with embankment side slope of approximately 2.5H:1V. The embankment is approximately 4 m high at the culvert location. The culvert at the site has an inlet obvert elevation of 378.1 m and invert elevation of 376.6 m and an outlet obvert elevation of 377.7 m and invert elevation of 376.2 m..

Figure 2.1: Left Embankment Looking North June 28, 2023.

Figure 2.2: Right Embankment Looking South, June 28, 2023.

2.1 Surficial Geology

As defined by the Ontario Ministry of Natural Resources' Northern Ontario Engineering Geology Terrain Study (NOEGTS), Map No. 52KSE, the site is in an area which primarily consists of a clay/clayey glaciolacustrine delta. The area has low local relief and is generally dry.

Glaciolacustrine deltas are described in the NOEGTS as deposits with glaciolacustrine clay and silt at depths.

The presence of the above soils were confirmed from the field investigation.

3 Investigation Procedures

A geotechnical site investigation was undertaken on September 10, 2023 to September 11, 2023. The field investigation consisted of advancing a total of two boreholes. Borehole locations are illustrated on the Borehole Location and Soil Strata Drawings (Appendix C). The boreholes were advanced to depths of 6.7 and 8.2 m.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site. The boreholes were advanced using a drill rig mounted on an all-terrain carrier equipped with hollow stem augers, a casing advancement system and apparatus used to carry out Standard Penetration Testing as per ASTM D1586.

During the drilling operations for the boreholes, soil samples were obtained from the auger flights and using the techniques of the Standard Penetration Test (SPT). The SPT involves driving a 51 mm O.D. thick walled split barrel sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m is known as the SPT blow count (N). Following completion of the test, a representative soil sample is obtained from within the sampler. SPTs are typically taken at a frequency of every 0.75 m for the first 3 m of the borehole, and every 1.5 m afterwards, to the termination depth of the borehole. Sample frequency may vary due to circumstances experienced in the field.

In addition, thin-walled tube samples were taken within the cohesive materials, alternating with SPT samples. In-situ field vane testing was completed at select depths within the cohesive materials to obtain an indication of the material's undrained shear strength. In-situ field vane testing was completed as per ASTM D2573 with a tapered vane.

Test hole locations were surveyed by TBTE with a level and rod and referenced to a temporary benchmark at the centreline of the highway. The benchmark has an elevation of 379.4 m from the B&C-633-664-8 surface as provided by the client. A hand-held Garmin GPS device was used in the field to record coordinates of the borehole locations, based on North American Data 1983 NAD83 (CSRS) v6 (2010 epoch).

A summary of the borehole location data is provided below and on the Borehole Location and Soil Strata Drawings (Appendix C).

Table 3.1: Summary of Borehole Information.

Borehole Number	Co-ordinates	Surface Elevation (m)	Depth of Exploration (m)
1	Lat 49.8961861 Lon -92.2972601	377.3	6.7
2	Lat 49.8960568 Lon -92.2969603	377.1	8.2

A temporary standpipe piezometer was installed to a depth of 2.9 m within Borehole 2.

All boreholes and temporary standpipe piezometers have been backfilled and/or decommissioned with auger cuttings and bentonite in accordance with the Ontario Ministry of the Environment's Regulation 903, as amended by Regulation 128/03 (water well regulation under the Ontario Water Resource Act).

4 Laboratory Testing

Soil samples obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content, Atterberg limits tests, and grain size analysis. Typically, 100% of the recovered soil samples are tested for natural moisture content determination, and 25% of the recovered soil samples are chosen for grain size analysis and/or Atterberg limits testing, as applicable. The following test methods/standards are followed for the above testing: LS 602 (sieve analysis for aggregates), LS 701 (moisture content of soils), ASTM C136 (standard test method for sieve analysis of fine and coarse aggregates), ASTM D4318 (standard test for liquid, plastic, and plasticity index of soils), ASTM D2216 (standard test method for laboratory determination of water (moisture) content of soil and rock by mass). The results of this testing are shown on the borehole logs (Appendix A) and on the laboratory data reports (Appendix B).

5 Subsurface Conditions

Details of the subsurface conditions are provided on the borehole logs (Appendix A), and on the Borehole Location and Soil Strata Drawings (Appendix C).

The subsurface soils at this site generally consist of clay or topsoil overlying fill fills overlying organics, which overlie sands or clay and sand to the termination of the boreholes.

5.1 Topsoil

100 mm of topsoil was present at the surface of Borehole 2.

5.2 Fill

Sand and gravel with some silt and some organics was encountered underling the topsoil at Borehole 2 and extended to a depth of 1.0 m (elev. 376.1 m). Thickness of the fill is 0.9 m. The condition of this material is very loose to compact with an SPT N-value of 3 blows per 0.3 m.

5.3 Organics

An organic layer was identified underlying the fill at a depth of 1.0 m (elev. 376.1 m) at Borehole 2 and extended to a depth of 1.4 m (elev. 375.7 m). Moisture contents varied from 62 to 71 %.

5.4 Sand

Silty sand with some organics was present underlying the organics at Borehole 2 at a depth of 1.4 m (elev. 375.7 m) and extended to a depth of 2.3 m (elev. 374.8 m). The results of a grain size analysis indicates that this material can consist of 0% gravel, 68% sand, 32% silt/clay sized particles. The condition of this material is very loose with an SPT N-value of 1 blow per 0.3 m.

5.5 Clay and Sand

Clay with trace sand and trace gravel to clay and sand was encountered at the surface of Borehole 1 (elev. 377.3 m) and underlying the sand at Borehole 2 at a depth of 2.3 m (elev. 374.8 m). The clay has a varved structure starting at depths of 1.7 to 2.3 m (elev. 375.6 to 374.8 m). The varved clay has a layered structure with layers of varying colour, plasticity and silt content. This material extended to the termination of the boreholes at a depth of 6.7 to 8.2 m (elev. 368.9 to 370.6 m). Atterberg limits testing indicates that this material is clay of low to medium plasticity, with the natural moisture content at or above the liquid limit. The results of three grain size analyses indicate that this material can consist of 0-2 % gravel, 29-44 % sand, 56-69 % silt/clay sized particles. This material generally has a very soft consistency based on SPT N-values of 1 blow per 0.3 m with one SPT N-value of 9 indicating this material has a stiff consistency at a depth of 8.0 m (elev. 369.1 m) and a firm to stiff consistency based on field vane tests ranging from 45 to 67 kPa, however, it is expected that presence of varves overestimated the test results.

5.6 Groundwater

Casing advancement with water was utilized at the boreholes during drilling operations. Elevated water levels may have been recorded due to this drilling method and water levels may not have stabilized. A temporary standpipe piezometer was installed to a depth of 2.9 m at

Borehole 2. Water level readings were taken upon completion and afterwards, as shown below. Observed groundwater levels have been provided in the table below. Groundwater levels may vary from season to season and from the effects of heavy precipitation events. Based on the B&C-633-664-8 surface as provided by the client, water level within the downstream culvert was 377.4 m on June 2021.

Table 5.1: Observed Groundwater Levels.

Location	Surface Elevation (m)	Groundwater Level on Completion of Drilling		Groundwater Level After Completion		
		Depth (m)	Elev. (m)	Depth (m)	Elev. (m)	Time After Comp. (hrs)
Borehole 1	377.3	3.7	373.6	-	-	-
Borehole 2	377.1	0.0	377.1	-	-	-

6 Miscellaneous

Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering Limited. The field operations were supervised by Ian Baumann and Allan Finke. Laboratory testing was supervised by Forch Valela, C.Tech. This report was prepared and reviewed by Dean Vale, P.Eng., and Steven Seller, P.Eng. (TBTE’s designated principal contact identified for MTO Foundation Engineering).

7 Limitations

Conclusions and recommendations presented in this report are based on the information determined at a limited number of borehole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of the dewatering procedures which may be considered during construction cannot readily be determined from site investigation or boreholes. These conditions include local and seasonal fluctuations of the groundwater level, changes in soil conditions between borehole locations, thin and/or discontinuous layers of highly permeable soils, etc.

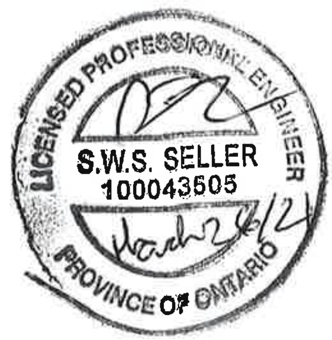
In no way does the information contained within this report reflect any environmental aspect of the site or soil.

8 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate to contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Dean Vale, P.Eng.
Geotechnical Engineer



Steve Steller, P.Eng.
Senior Engineer
Principal Contact for MTO Foundations

9 References

Braja M. Das, *Fundamentals of Geotechnical Engineering*, 4th ed. Stamford, CT, USA: Cengage Learning, 2013.

D.E. Becker *et al.*, *Canadian Foundation Engineering Manual*, 4th ed. Richmond, BC, Canada: The Canadian Geotechnical Society, 2006.

Ontario Ministry of Northern Development and Mines; Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS), 2005

APPENDIX A
Borehole Logs

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EXPLANAITION OF TERMS

N Value: The Standard Penetration Test (SPT) N value is the number of blows required to cause a standard 51mm O.D. split barrel sampler to penetrate 0.3m into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kg, falling freely a distance of 0.76m. For penetrations of less than 0.3m N values are indicated as the number of blows for the penetration achieved. Average N value is denoted thus $\bar{N}$.

Dynamic Cone Penetration Test: Continuous penetration of a conical steel point (51mm O.D. 60˚ cone angle) driven by 475 J impact energy on 'A' size drill rods. The resistance to cone penetration is measured as the number of blows for each 0.3m advance of the conical point into the undisturbed ground.

Soils are described by their composition and consistency/condition.

Consistency: Cohesive soils are described on the basis of their undrained shear strength (c_u) as follows:

C_u (kPa)	0-12	12-25	25-50	50-100	100-200	>200
	Very Soft	Soft	Firm	Stiff	Very Stiff	Hard

Condition: Cohesionless soils are described on the basis of denseness as indicated by SPT N values as follows:

N (Blows/0.3m)	0-4	4-10	10-30	30-50	>50
	Very Loose	Loose	Compact	Dense	Very Dense

Minor Soil Components: Terminology used to represent the amount of minor components based on their percent of the sample by weight as follows:

% by weight	0-10	10-20	20-35	35-50
	Trace	Some	"ey" or "y"	And

ABBREVIATIONS AND SYMBOLS

Field Sampling, Insitu Testing, Laboratory Testing

S S	Split Spoon	T P	Thin Wall Piston
A S	Auger	O S	Osterberg
W S	Wash	R C	Rock Core
S T	Slotted Tube	P H	T W Advanced Hydraulically
B S	Block	P M	T W Advanced Manually
C S	Chunk	F S	Foil
V T	Vane Test (kPa)	P P	Pocket Penetrometer (kg/cm^2)
T W	Thin Wall Shellby Tube		

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EXPLANAITION OF TERMS Cont’d.

Stress and Strain

u_w	kPa	Pore Water Pressure
u		Pore Pressure Ratio
σ	kPa	Total Normal Stress
σ'	kPa	Effective Normal Stress
τ	kPa	Shear Stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal Stress
ε	%	Linear Strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal Strains
E	MPa	Young’s Modulus
G	kPa	Modulus of Shear Deformation
m	MPa	Constrained Modulus
μ		Coefficient of Friction

Mechanical Properties of Soil

m_v	kPa^{-1}	Coefficient of Volume Change
C_c		Compression Index
C_s		Swelling Index
C_a		Rate of Secondary Consolidation
c_v	m^2/s	Coefficient of Consolidation
H	m	Drainage Path
T_v		Time Factor
U	%	Degree of Consolidation
P'_o	kPa	Effective Overburden Pressure
P'_c	kPa	Preconsolidation Pressure
τ_f	kPa	Shear Strength
c'	kPa	Effective Cohesion Intercept
ϕ'	°	Effective Angle of Internal Friction
c_u	kPa	Undrainded Shear Strength
s		Sensitivity

Physical Properties of Soil

ρ_s	kg/m^3	Density of Solid Particles	e	%	Void Ratio	e_{min}	%	Void Ratio in Densest State
γ_s	kN/m^3	Unit Weight of Solid Particles	n	%	Porosity	I_D		Density Index $=\frac{e_{max}-e}{e_{max}-e_{min}}$
ρ_w	kg/m^3	Density of Water	w	%	Water Content	D	mm	Grain Diameter
γ_w	kN/m^3	Unit Weight of Water	s_r	%	Degree of Saturation	D_n	mm	n Percent Diameter
ρ	kg/m^3	Density of Soil	w_L	%	Liquid Limit	C_U		Uniformity Coefficient
γ	kN/m^3	Unit Weight of Soil	w_P	%	Plastic Limit	h	m	Hydraulic Head or Potential
ρ_d	kg/m^3	Density of Dry Soil	w_S	%	Shrinkage Limit	q	$m\ ^3/_5$	Rate of Discharge
γ_d	kN/m^3	Unit Weight of Dry Soil	I_P	%	Plasticity Index = w_L-w_P	v	m/s	Discharge Velocity
ρ_{sat}	kg/m^3	Density of Saturated Soil	I_L		Liquidity Index = $\frac{w-w_P}{I_P}$	i		Hydraulic Gradient
γ_{sat}	kN/m^3	Unit Weight of Saturated Soil	I_C		Consistency Index = $\frac{w_L-w}{I_P}$	k	m/s	Hydraulic Conductivity
ρ'	kg/m^3	Density of Submerged Soil	e_{max}	%	Void Ratio in Loosest State	j	kN/m^3	Seepage Force
γ'	kN/m^3	Unit Weight of Submerged Soil						

RECORD OF BOREHOLE No 1

METRIC

W.P. 6033-19-00	LOCATION Station 11+533 o/s 11.0m Lt of C/L N:5528983.916; E:355286.613 MTM Zone:		ORIGINATED BY AF
DIST NWR HWY 72	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY ZA/TG
DATUM Geodetic	DATE 2023.09.10 - 2023.09.10	LATITUDE 49.8961861 LONGITUDE -92.2972601	CHECKED BY DV

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
377.3 / 0.0	CLAY - trace sand to Sandy, trace gravel, trace organics, wood fibers, grey, very soft	1	SS	1		Water level @ 3.7 m on completion.
375.6 / 1.7	CLAY & SAND to Sandy - varved, grey, very soft to firm	2	SS	1		2 29 (69)
		3	TW			
		4	SS	1	Water level (approx. 373.6)	
		5	SS	1		
						Cave @ 5.9 m. 0 44 (56)
		6	SS	1		
370.6 / 6.7	End of Borehole @ 6.7 m.					

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; ELEVATION SCALE (377–371); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE PP=Pocket Penetrometer (Kg/cm²)

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 2

METRIC

W.P. 6033-19-00 LOCATION Station 11+541 o/s 13.9m Rt of C/L N:5528969.74; E:355308.284 MTM Zone: ORIGINATED BY AF

DIST NWR HWY 72 BOREHOLE TYPE Hollow Stem Auger COMPILED BY ZA/TG

DATUM Geodetic DATE 2023.09.11 - 2023.09.11 LATITUDE 49.8960568 LONGITUDE -92.2969603 CHECKED BY DV

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
377.1					Water @ surface.
377.0 / 0.0	TOPSOIL - 100 mm				
0.1	FILL - SAND & GRAVEL - some organics, some silt, brown, very loose				
376.1 / 1.0	ORGANICS - brown	1	SS	3	
375.7 / 1.4	SAND - Silty, some organics, grey, very loose	2	SS	1	0 68 (32) Non Plastic.
374.8 / 2.3	CLAY to CLAY & SAND - varved, grey, very soft to stiff	3	SS	1	Temporary standpipe installed to 2.8 m.
		4	TW		
		5	SS	1	0 38 (62)
		6	SS	1	Cave @ 7.2 m.
		7	SS	9	
368.9 / 8.2	End of Borehole @ 8.2 m.				

Elevation scale: 377, 376, 375, 374, 373, 372, 371, 370, 369

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

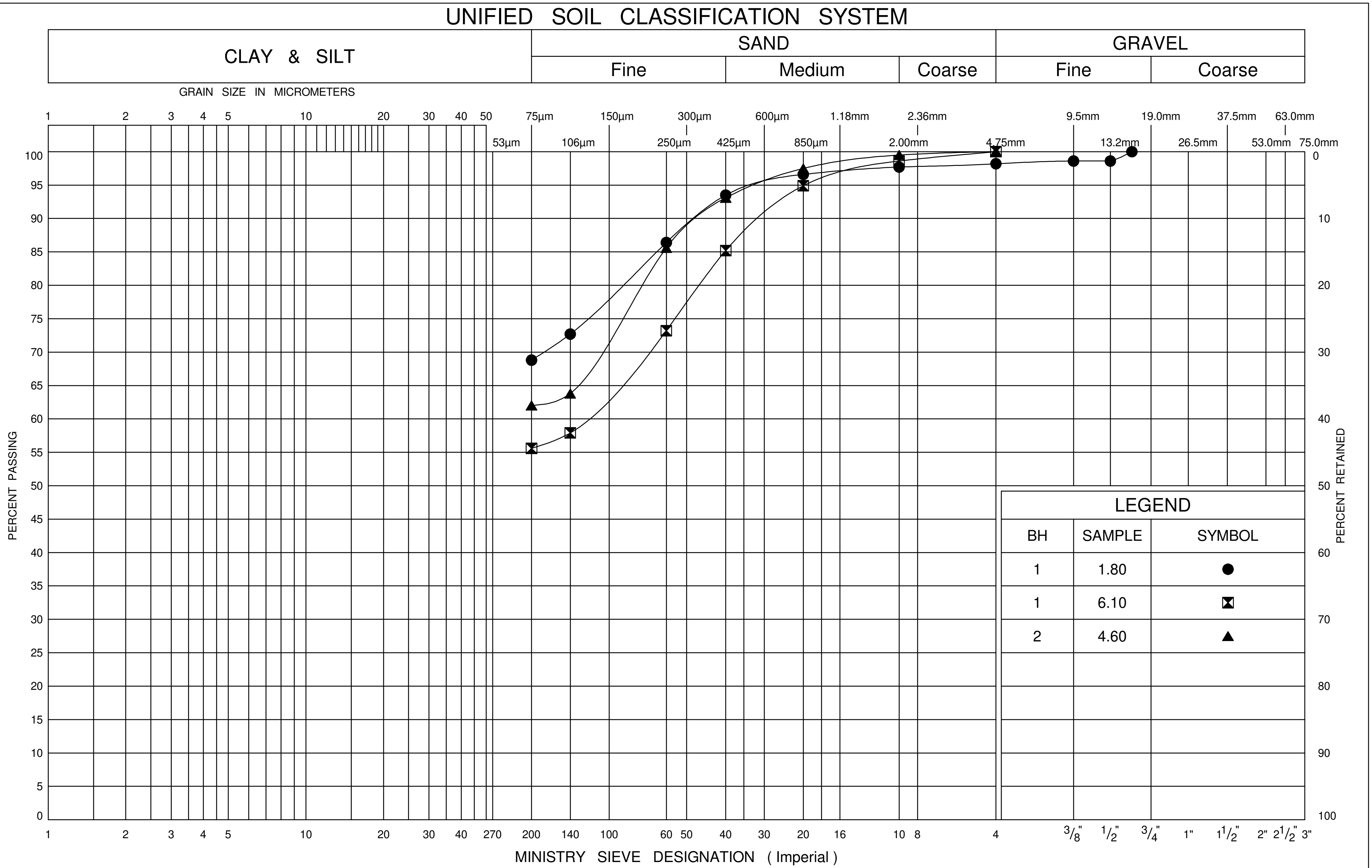
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE PP=Pocket Penetrometer (Kg/cm²)

ONTARIO MTO MOD 10 - ECHO 11+537 CULVERT 45.GPJ ONTARIO MTO.GDT 3-25-24

APPENDIX B
Laboratory Test Data



BH	SAMPLE	SYMBOL
1	1.80	●
1	6.10	⊠
2	4.60	▲

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Ontario

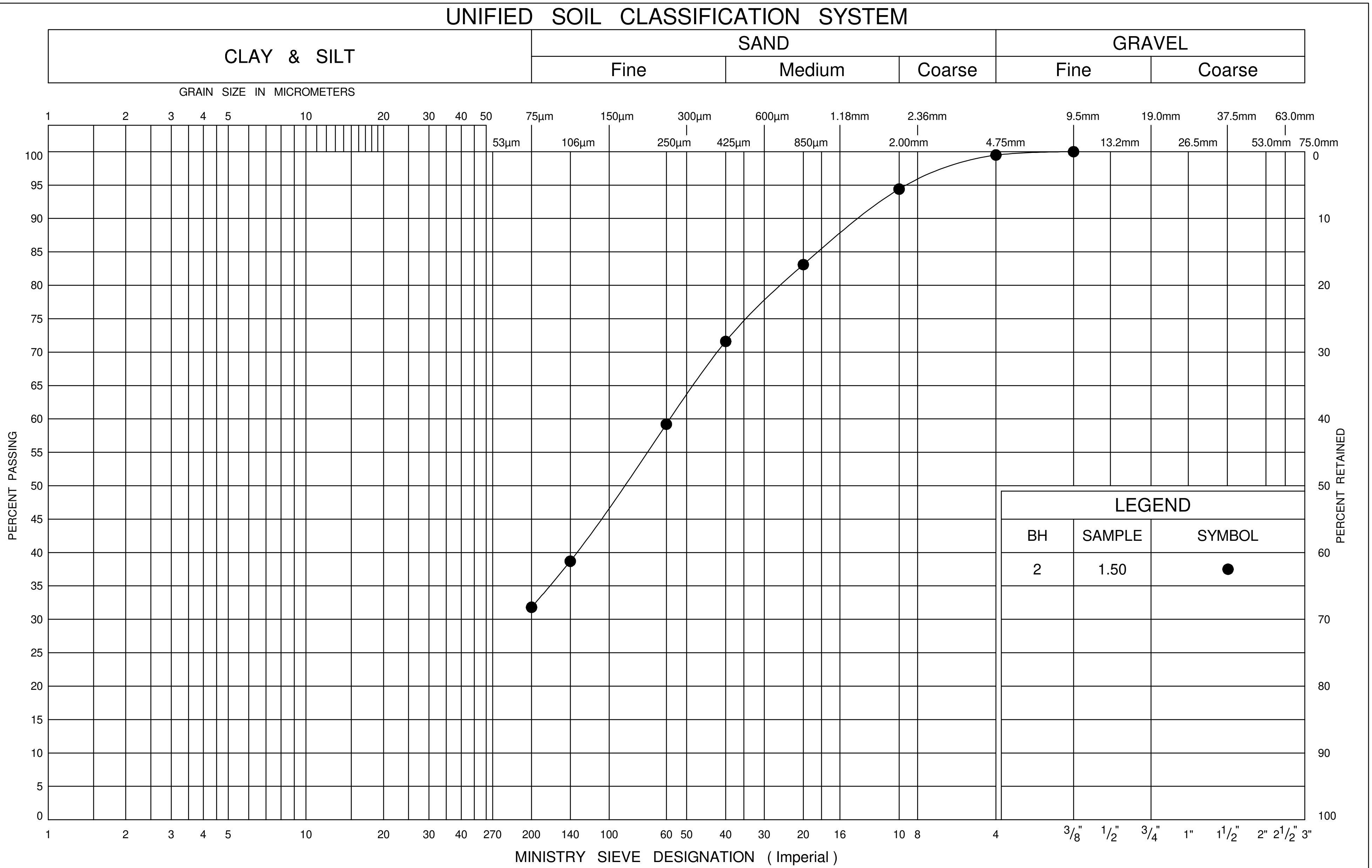
GRAIN SIZE DISTRIBUTION
CLAY & SAND

FIG No 1

W P 6033-19-00

22-146-10

78 12 M



LEGEND		
BH	SAMPLE	SYMBOL
2	1.50	●

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Ontario

GRAIN SIZE DISTRIBUTION
SAND - Silty

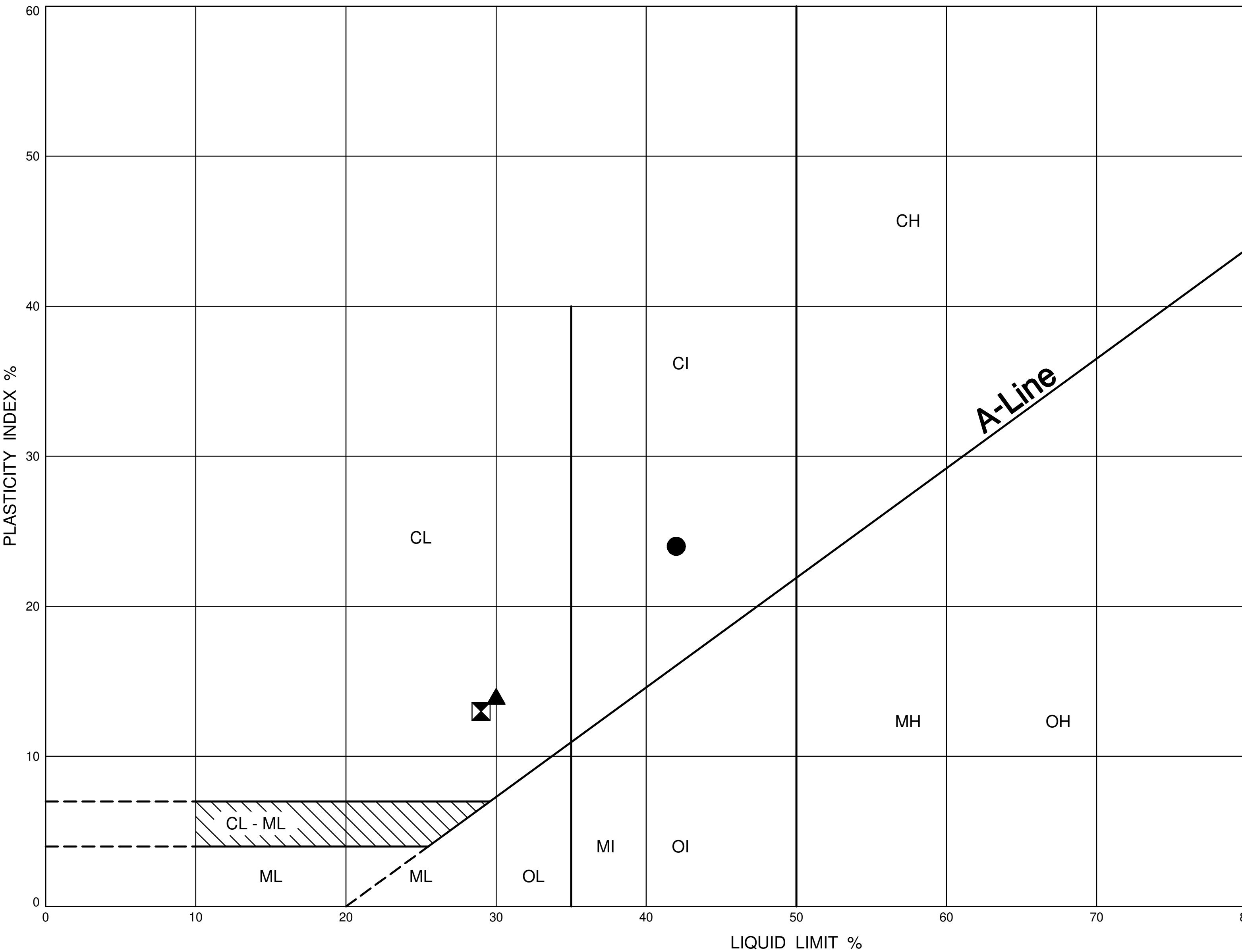
FIG No 2

W P 6033-19-00

22-146-10

ONTARIO MOT GRAIN SIZE 10 - ECHO 11+537 CULVERT 45.GPJ ONTARIO MOT.GDT 1-11-24

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
1	1.80	●
1	6.10	⧗
2	4.60	▲

ONTARIO MOT PLASTICITY CHART 10 - ECHO 11+537 CULVERT 45.GPJ ONTARIO MOT.GDT 1-11-24

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Ontario

PLASTICITY CHART

.

FIG No 3

W P 6022-E-0033

22-146-10

APPENDIX C
Borehole Location and Soil Strata Drawings

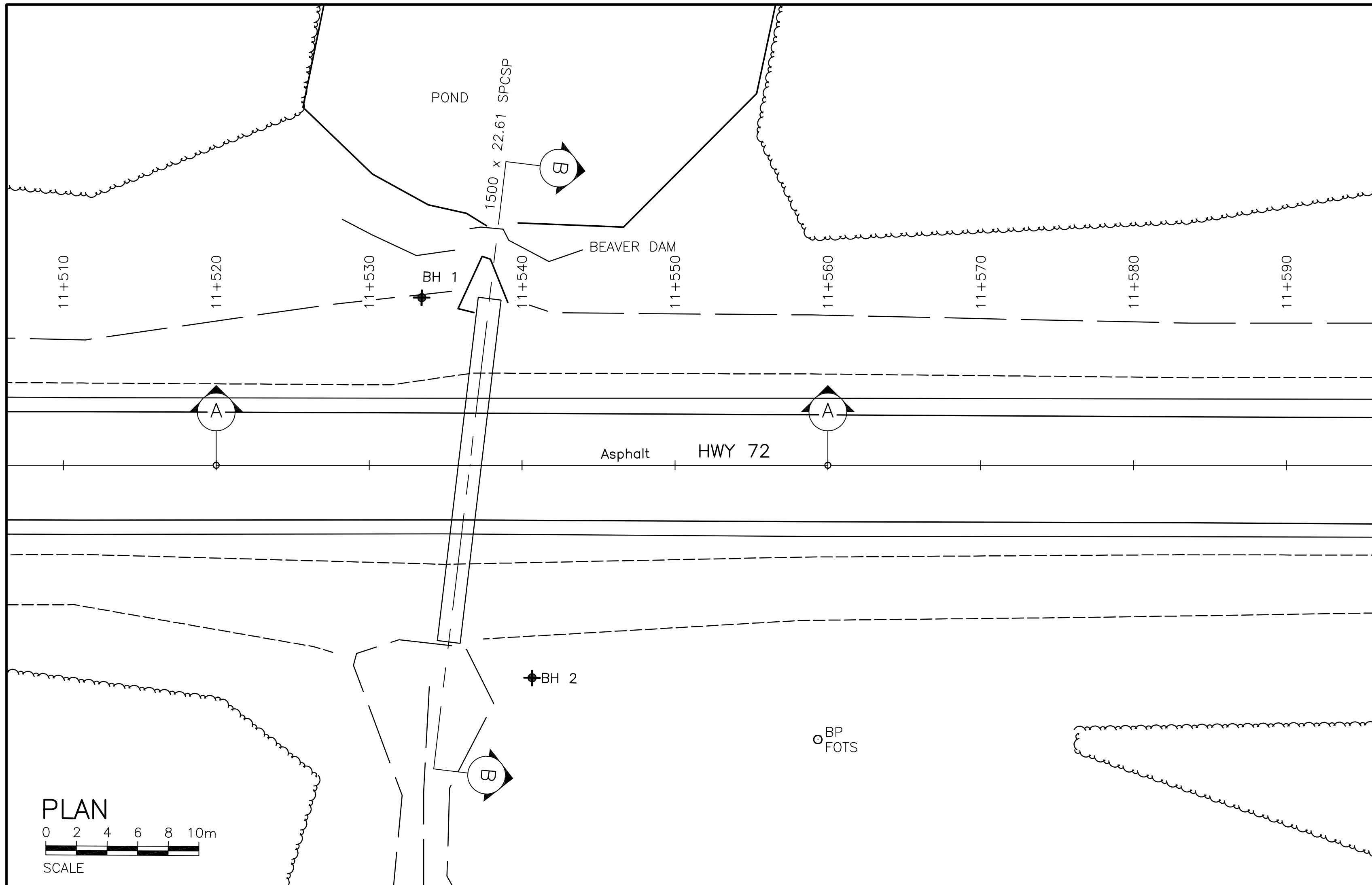
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

Ontario Ministry of Transportation	
GEOCRES	52F16-005
CONT	-
GWP	6033-19-00

SOIL STRATA
STA 11+537 CULVERT #67
HIGHWAY 72, TOWNSHIP OF ECHO

SHEET
-

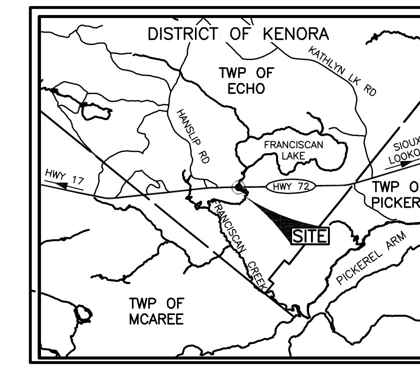
TBT ENGINEERING CONSULTING GROUP



PLAN
0 2 4 6 8 10m
SCALE

D. VALE 100117156 LICENSED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO

S.W.S. SELLER 100043505 LICENSED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO



KEY PLAN
2.0 km 0 2.0 km

SOIL STRATA SYMBOLS

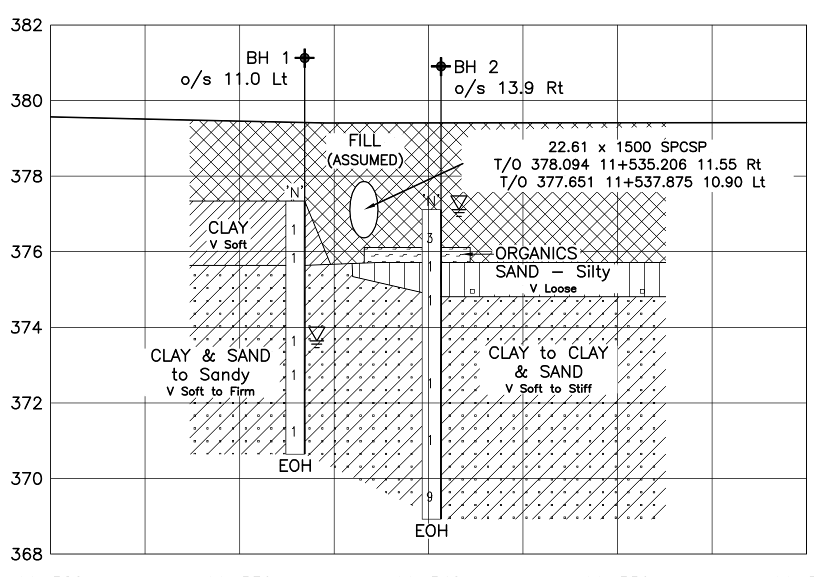
ORGANICS
SAND - Silty
FILL
SAND & CLAY
CLAY

LEGEND

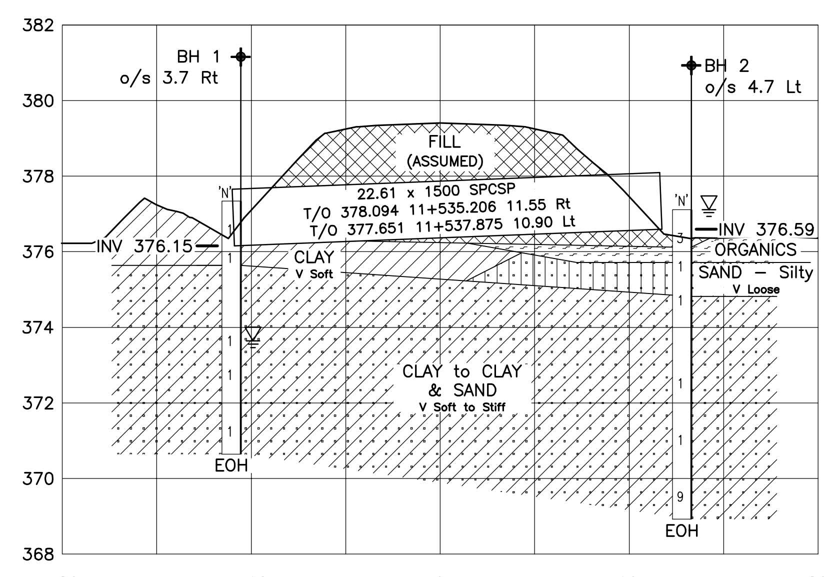
✦	Borehole
'N'	Std Pen Test (Blows/0.3m)
⊻	Water Level on Completion
EOH	End of Borehole

No	ELEVATION	CO-ORDINATES (MTM 16) NORTH	EAST
BH 1	377.3	16 5 528 984	355 287
BH 2	377.1	16 5 528 970	355 308

-NOTE-
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.



PROFILE A-A
HOR 0 2 4 6 8 10m
VERT 0 1 2 3 4 5m
SCALE



SECTION B-B
HOR 0 2 4 6 8 10m
VERT 0 1 2 3 4 5m
SCALE

DRAWING REFERENCED FROM B&C 5-22-72-3 PROVIDED BY CLIENT.

REVISIONS		
2	SS	ISSUED IN FINAL 26/03/24
1	SS	ISSUED FOR REVIEW

DESIGN XX	CHK XX	CODE XXXXXX	LOAD XXXX	DATE 12/01/24
DRAWN TG	CHK SS	SITE XXXXX		DWG 1

FILE NAME: Y:\Projects\2022\22-146 MTO, NWR Geotechnical Retainer\22-146-10 - Hwy 72 & 664 FND\Drawings_Culvert Drawings\10_Culvert 45 Echo 11+537 out in draft\Echo 11+537 Culvert 45 FINAL.dwg
MODIFIED: 2024-03-26 12:34

APPENDIX D
Site Photographs

Left Embankment
Looking North, June 28, 2023.

Right Embankment
Looking South, June 28, 2023.