



**Foundation Investigation Report
Highway 17 Steel River Westerly for 4.3 km
Deep Cut**

Township of Tuuri

Station 10+060 to Station 10+220

Station 10+060, Centreline, Lat: 48.775690, Lon: -86.895400

Station 10+220, Centreline, Lat: 48.776066, Lon: -86.893302

**District Thunder Bay
Highway 17**

W.P. 6328-18-00

GEOCRES No. 42D-69

**Prepared for:
Ontario Ministry of Transportation NWR**

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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 and design services under the Northwest Region (NWR) Geotechnical Retainer Assignment. This assignment covers the proposed re-alignment of Highway 17 from Steel River westerly for 4.3 km. This report covers a deep cut area identified between Station 10+060 to 10+220. The proposed cut ranges significantly from approximately 7 m to 24 m in depth.

The site is located approximately 0.8 km west of the Steel River along Highway 17. The site coordinates are as follows:

- Station 10+060, CL, Latitude: 48.7757, Longitude: -86.8954
- Station 10+220, CL, Latitude: 48.7761, Longitude: -86.8933

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

The foundation investigation was carried out to investigate subsurface conditions from Station 10+060 to 10+220 along the proposed alignment. The investigation consisted of four boreholes. All initial borehole locations were determined through consultation with MTO, while 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. 42D-69 to this site.

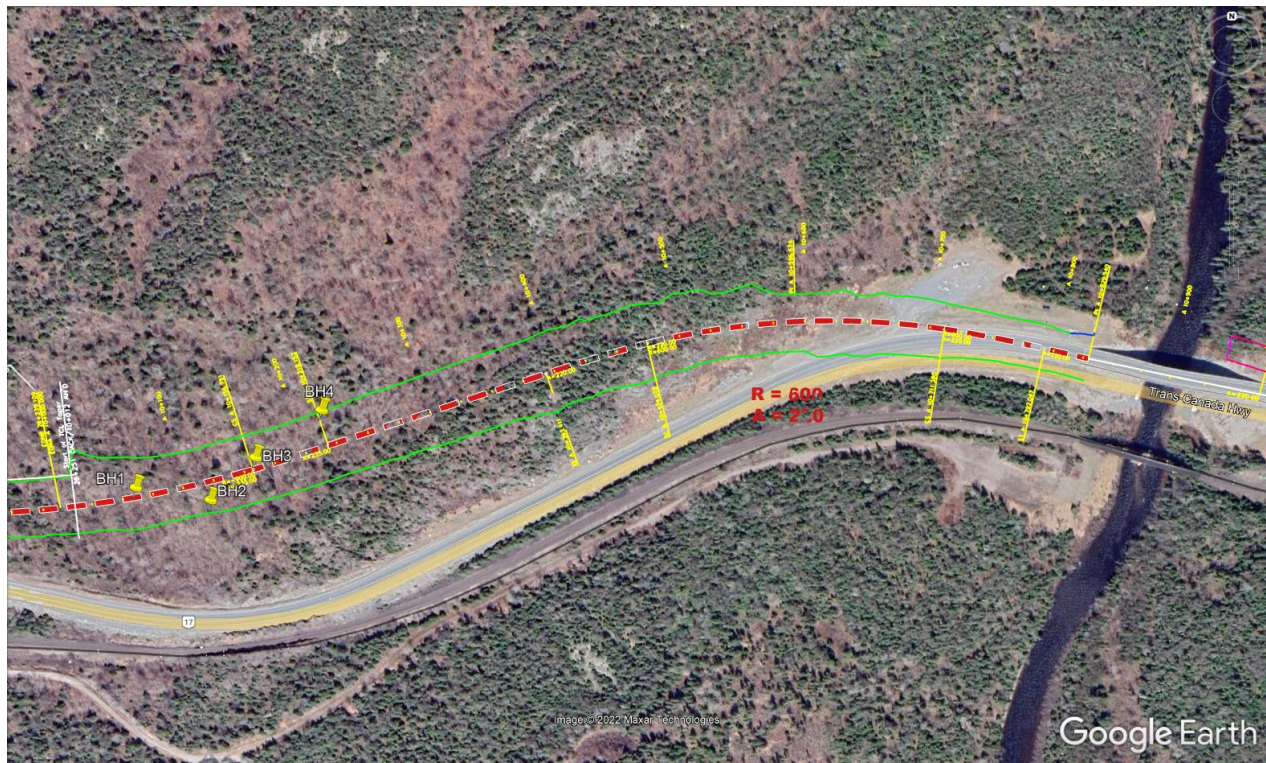


Figure 1.1: A Google Earth Image Illustrating the Site Location.

2 Site Description

The site is densely vegetated and located north of the current Highway 17 alignment. Trails were cleared to access the borehole locations with a drill rig. The general terrain is sloping upwards from west to east, until approximately Station 10+155, then undulates continuing east.

2.1 Surficial Geology

As defined by the Ontario Ministry of Natural Resources' Northern Ontario Engineering Geology Terrain Study (NOEGTS) 60, 1979, Map No. 5093 "Heron Bay", the site is in an area which borders bedrock knob terrain and outwash plain/valley terrain. The site is rugged with high local relief and is generally dry.

The site indicates the general landforms of the outwash plains with overburden ranging from 7 m to 24 m. The description of primary soils of gravel and secondary units of sand is typically confirmed from the field investigation.

3 Investigation Procedures

A geotechnical site investigation was undertaken from May 11, 2022 to May 18, 2022. The field investigation consisted of advancing a total of four boreholes. Initial borehole locations were established through consultation with MTO, while final borehole locations were adjusted to suit field conditions. Borehole locations are illustrated on the Borehole Location and Soil Strata Drawings provided in Appendix C.

All boreholes were advanced to refusal on bedrock using casing advancer. The refusal material was cored at all boreholes to confirm the presence of bedrock.

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 casing advancer and apparatus used to carry out Standard Penetration Testing. During the drilling operations for the boreholes, soil samples were obtained by using the techniques of the Standard Penetration Test (SPT). 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.

Borehole locations and elevations are taken from the Site Plan and cross section drawings provided by the MTO. A hand-held Garmin GPS device was used in the field to locate borehole locations. A summary of the borehole location data is provided in the table below, and on the enclosed 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: 48.7758693 Lon: -86.8953997	226.8	22.4
2	Lat: 48.7756077 Lon: -86.8946108	220.4	23.7
3	Lat: 48.7759041 Lon: -86.8941066	228.2	24.3
4	Lat: 48.7762363 Lon: -86.8934117	229.8	12.6

Standpipe piezometers were installed at Boreholes 2 and 4 to depths of 18.0 m and 12.0 m, respectively.

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

4 Laboratory Testing

Soil samples obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content 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, LS 701, ASTM C136, ASTM D4318, ASTM D2216. The results of this testing are shown on the borehole logs (Appendix A) and on the laboratory data reports (Appendix B).

Rock core samples were obtained at all boreholes. The rock core samples were subjected to Rock Quality Designation (RQD) determination, point-load testing, and detailed rock core logging. One point-load test is typically chosen per 1 m of recovered sample. Point-load testing follows ASTM D5731.

5 Subsurface Conditions

Details of the subsurface conditions are provided on the borehole logs in Appendix A and on the Borehole Location and Soil Strata drawings in Appendix C.

The generalized subsurface soils at this site consist of various mixtures of gravels, sands and silts with cobbles and boulders. Bedrock underlies the soils at all boreholes.

5.1 Gravel and Sands

Sand and gravel with a trace of silt and occasional to numerous cobbles and boulders was encountered at the surface of Boreholes 1, 2 and 3. Gravel with a trace to some sand and a trace of silt with numerous cobbles and boulders was encountered at the surface of Borehole 4. This stratum extends to depths ranging from 8.6 m to 10.2 m (elevation 210.3 m to 221.1 m). The results of five grain size analyses indicate the gravel and sands consist of 45-71% gravel, 27-50% sand and 2-8% silt/clay sized particles. This material is in a compact to very dense

condition based on SPT N-values ranging from 11 to 94 blows per 0.3 m, with one instance of 8 blows per 0.3 m, indicating a loose condition. Instances of N-values greater than 100 blows per 0.3 m may have been influenced by the presence of cobbles and/or boulders.

5.2 Sand

Sand with a trace of silt and some to a trace of gravel was encountered below the gravel at all borehole locations. The sand ranges in thickness from 0.9 m to 6.1 m and extends to depths ranging from 9.6 m to 14.7 m (elevation 206.5 m to 220.2 m). The sand is in a compact to dense condition based on SPT N-values ranging from 11 to 35 blows per 0.3 m. The results of three grain size analyses indicate the sand consists of 5-16% gravel, 80-88% sand and 4-7% silt/clay sized particles.

5.3 Silt

Sandy silt with a trace of gravel was encountered below the sand at Boreholes 1, 2 and 3. The silt has a thickness ranging from 3.8 m to 4.5 m and extends to depths ranging from 17.8 m to 19.2 m (elevation 202.6 m to 209.0 m). The results of one grain size analysis indicate this material consists of 1% gravel, 20% sand and 79% silt/clay sized particles. The condition of this material is generally compact with SPT N-values ranging from 13 to 29 blows per 0.3 m, however one instance of loose material (N-value 7) and one instance of dense material (N-value 44) was also encountered.

5.4 Till

Till consisting of a heterogeneous mixture of sand, silt and gravel was encountered at Boreholes 1, 2 and 3. Occasional cobbles were encountered within the till. The till was encountered beneath the silt and ranges in thickness from 1.9 m to 2.0 m and extends to depths ranging from 19.7 m to 21.6 m (elevations 199.6 m to 207.1 m). The results of one grain size analysis indicate this material consists of 20% gravel, 46% sand and 34% silt/clay sized particles. The condition of this material is compact to dense with SPT N-values ranging from 21 to 49 blows per 0.3 m. Instances of N-values greater than 100 blows per 0.3 m may have been on bedrock or influenced by the presence of cobbles and/or boulders.

5.5 Refusal and Bedrock

SPT refusal (100+ blows per 0.3 m) may have been encountered on cobbles or boulders at all boreholes. Bedrock was cored and sampled at all boreholes at depths/elevations summarized below.

Table 5.1: Bedrock Depths/Elevations.

Location	Bedrock Surface	
	Depth (m)	Elevation (m)
Borehole 1	19.7	207.1
Borehole 2	20.8	199.6
Borehole 3	21.6	206.6
Borehole 4	9.6	220.2

The bedrock consisted of amphibolite and metagabbro. Further details on the bedrock can be found on the rock core logs in Appendix A.

5.5.1 Rock Quality Designation (RQD)

The RQD is a measure of the number of fractures and jointing in a rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths greater than 100 mm to the total length cored. The RQD index is used to provide a classification for the rock quality according to the limits provided by the Canadian Foundation Engineering Manual (CFEM) which are shown below in Table 5.2.

Table 5.2: Classification of Rock with Respect to RQD Value.

RQD Classification	RQD Value (%)	Number of Occurrences
Very Poor Quality	< 25	0
Poor Quality	25 to 50	0
Fair Quality	50 to 75	0
Good Quality	75 to 90	3
Excellent Quality	90 to 100	5

The quality of bedrock encountered at this site varies from good to excellent. Across all bedrock samples the recovery of the cores ranged from 95-100% and the rock quality designation (RQD) ranged from 78-100%.

5.5.2 Point-Load Testing

To estimate the strength of the bedrock encountered at this site, multiple point-load tests were completed on the core samples. The point-load test results are provided below in Table 5.3.

Table 5.3: Estimated Uniaxial Compressive Strength of Bedrock Samples.

Borehole	Sample	Depth from Ground Surface (m)	Estimated Uniaxial Compressive Strength* (MPa)
1	RC #1	20.16	293
1	RC #2	21.32	203
1	RC #2	22.32	212
2	RC #1	21.18	218
2	RC #2	22.30	250
2	RC #2	23.60	266
3	RC #1	21.70	255
3	RC #2	22.87	213
3	RC #2	23.90	207
4	RC #1	10.03	190
4	RC #2	11.19	276
4	RC #2	12.30	184

* Estimated in accordance with ASTM D5731-16.

Based on the range of estimated uniaxial compressive strengths of 184 MPa to 293 MPa, the bedrock is classified as “very strong” to “extremely strong”, according to the CFEM 4th Edition.

5.6 Groundwater

The groundwater levels were read 24 hours and 48 hours after completion of drilling within the standpipe piezometers installed to depths of 18.0 m and 12.0 m at Boreholes 2 and 4, respectively. Observed groundwater levels have been provided below. Water level readings are not taken upon completion of drilling where water is introduced to the boreholes to facilitate the advancement of casing and rock coring. This supply of water will potentially elevate water levels and provide misleading information. Groundwater levels may vary from season to season and from the effects of heavy precipitation events.

Table 5.4: Observed Groundwater Levels.

Location	Surface Elevation (m)	Groundwater Level, Depth (m)
Borehole 2	220.4	7.4 (24 hrs after completion)
Borehole 4	229.8	4.9 (48 hrs after completion)

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. The field operations were supervised by Glen Hephner. Laboratory testing was supervised by Forch Valela, C.Tech. This report was prepared and reviewed by Steven Anderson, P.Eng., and Steven Seller, P.Eng. (TBTE's designated principal contact identified for MTO Foundation Engineering projects).

7 Limitations

Conclusions presented in this report are based on the information determined at a limited number of test hole 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.

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



Steven Anderson, P.Eng.
Project Engineer



Steven Seller, P.Eng.
Senior Engineer
Principal Contact for MTO Foundations

APPENDIX A

Borehole Logs and Core Logs

EXPLANATION 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 Shelby Tube		

EXPLANATION 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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	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	Undrained 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 /s	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

1 OF 1

METRIC

W.P. 6328-18-00 LOCATION N:5404167.412; E:312487.306 MTM Zone:14 ORIGINATED BY GH
 DIST NWR HWY 17 BOREHOLE TYPE Casing Advancer COMPILED BY TG
 DATUM Geodetic DATE 2022.05.17 - 2022.05.18 LATITUDE 48.7758693 LONGITUDE -86.8953997 CHECKED BY SS

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
226.8 0.0	SAND & GRAVEL - trace silt, occasional cobbles, brown, compact to dense						226									47 48 (5)	
			1	SS	11												
			2	SS	12												
			3	SS	33												
			4	SS	48												
			5	SS	40												
			6	SS	100+												
			7	SS	100+												
	----- - numerous cobbles & boulders		8	SS	100+										No Recovery.		
															No Recovery.		
216.6 10.2	SAND - trace gravel, trace silt, brown, very loose to compact						216								8 86 (6)		
			9	SS	30												
			10	GRAB													
212.8 14.0	SILT - Sandy, trace gravel, occasional cobbles, grey, loose to compact						214								1 20 (79)		
			11	GRAB													
			12	SS	14												
			13	SS	7												
209.0 17.8	TILL - SAND & SILT - some gravel, occasional cobbles, grey, dense						210									No Recovery.	
			14	SS	49												
207.1 19.7	BEDROCK - AMPHIBOLITE See rock core logs for full detail		1	RC			208								RC #1 REC 97% RQD 90%		
	----- - METAGABBRO See rock core logs for details		2	RC													
204.4 22.4	End of Borehole @ 22.4 m.																

ONTARIO MTO MOD 20-656-6 MTO STEEL RIVER.GPJ ONTARIO MTO.GDT 22-11-3

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 6328-18-00 LOCATION N:5404138.404; E:312545.324 MTM Zone:14 ORIGINATED BY GH
 DIST NWR HWY 17 BOREHOLE TYPE Casing Advancer COMPILED BY TG
 DATUM Geodetic DATE 2022.05.15 - 2022.05.16 LATITUDE 48.7756077 LONGITUDE -86.8946108 CHECKED BY SS

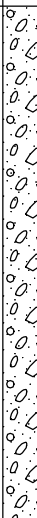


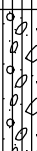

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
220.4																	
0.0	SAND & GRAVEL - trace silt, numerous cobbles & boulders, brown, compact to dense																Water level @ 7.4 m 24 hours after completion.
			1	SS	15												
			2	GRAB													53 44 (3)
			3	SS	100+												No recovery.
			4	SS	100+												No recovery.
			5	SS	100+												
			6	SS	100+												No recovery.
210.3																	
10.1	SAND - trace gravel, trace silt, brown, compact to dense		7	SS	22												
			8	SS	35												5 88 (7)
206.5			9	SS	15												
13.9	SILT - Sandy, brown, compact to dense																
			10	SS	13												
			11	SS	44												No recovery.
202.6																	
17.8	TILL - SAND - Silty, some gravel, occasional cobbles, grey, compact to very dense		12	SS	27												Standpipe installed to 18.0 m.
			13	SS	100+												20 46 (34)
199.6																	
20.8	BEDROCK - METAGABBRO See rock core logs for details		1	RC													RC #1 REC 100% RQD 88%
			2	RC													RC #2 REC 95% RQD 95%
196.7																	
23.7	End of Borehole @ 23.7 m.																

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 6328-18-00 LOCATION N:5404171.414; E:312582.335 MTM Zone:14 ORIGINATED BY GH
DIST NWR HWY 17 BOREHOLE TYPE Casing Advancer COMPILED BY TG
DATUM Geodetic DATE 2022.05.13 - 2022.05.15 LATITUDE 48.7759041 LONGITUDE -86.8941066 CHECKED BY SS

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
20 40 60 80 100								○ UNCONFINED	+ FIELD VANE	20 40 60 80 100	w _p	w						w _L
								● QUICK TRIAXIAL	× LAB VANE									
228.2 0.0	SAND & GRAVEL - trace silt, occasional cobbles, brown, compact to very dense					228												
			1	SS	14													
			2	SS	20													45 50 (5)
			3	SS	25													
			4	SS	53													
			5	SS	94													55 37 (8)
			6	SS	100+													No recovery.
	SAND - trace gravel, trace silt, brown, compact ----- - occasional cobbles		7	SS	33											No recovery.		
219.6 8.6			8	SS	21													
			9	SS	23													
			10	SS	11													
			11	SS	27													
213.5 14.7	SILT - Sandy, trace gravel, occasional cobbles, compact		12	SS	21													
			13	SS	29													
			14	SS	17													
209.0 19.2	TILL - SAND & SILT - some gravel, grey, compact		15	SS	21													
206.6 21.6	BEDROCK - METAGABBRO See rock core logs for details		1	RC		206										RC #1 REC 100% RQD 78%		
			2	RC													RC #2 REC 95% RQD 95%	
203.9 24.3	End of Borehole @ 24.3 m.					204												

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 6328-18-00 LOCATION N:5404208.425; E:312633.35 MTM Zone:14 ORIGINATED BY GH
 DIST NWR HWY 17 BOREHOLE TYPE Casing Advancer COMPILED BY TG
 DATUM Geodetic DATE 2022.05.11 - 2022.05.12 LATITUDE 48.7762363 LONGITUDE -86.8934117 CHECKED BY SS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				w _p w w _L								
229.8							20	40	60	80	100					GR	SA	SI	CL	
0.0	GRAVEL - trace to some sand, trace silt, numerous cobbles and boulders, grey, loose to very dense		1	SS	8											Water level @ 4.9 m 48 hours after completion.				
			2	SS	100+															
			3	SS	100+															
			4	SS	100+															
			5	SS	52															
			6	SS	22															
221.1																No recovery, on boulder.				
8.7	SAND - some gravel, trace silt, occasional cobbles, brown, dense		7	SS	32															
220.2																71	27	(2)		
9.6	BEDROCK - METAGABBRO See rock core logs for details		1	RC																
			2	RC																
217.2																RC #1 REC 97% RQD 95%				
12.6	End of Borehole @ 12.6 m.																			
																RC #2 REC 95% RQD 81%				
																Standpipe installed to 12.0 m.				

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PP=Pocket Penetrometer (Kg/cm²)

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP		Project #:	20-656-6	Site:	Steel River	Logger:	L Cosby	Borehole #:	BH1
		Lab #:	1016 and 1017	Client:	MTO	Date:	11-Aug-22	Page #:	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES
							# OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
From 19.70	1/1	97%	90%	AMPHIBOLITE - greenish grey, foliated, greasy, veined, fine-grained, intact and broken pieces	H-VH	U	2	F	D	C	RP	O/C	N/T	- calcite veins throughout - 20 mm vein at 21.0 m
To 21.20								F	F	C	RU	O/C	N/T	
From 21.20	1/2	100%	100%	METAGABBRO - greenish grey, massive, veined, fine-grained, mainly intact	H-VH	U	2	F	D	C	RP	O/C	N/T	- calcite veins throughout
To 22.40								F	F	M	RP	O	N/T	
From 22.40														
To 0.00														
From 0.00														
To 0.00														
From 0.00														
To 0.00														

NOTES:

Strength (MPa)

VH = Very High = >200

H = High = 50-200

M = Medium = 15-50

L = Low = 4-15

VL = Very Low = 1-4

Weathering

U = Unweathered (No signs)

S = Slightly (Oxidized)

M = Moderately (Discoloured)

H = Highly (Friable)

C = Completely (Soil-like)

Type

B = Bedding joint

J = Cross Joint

F = Fault

S = Shear Plane

Orientation

F = Flat (0-20°)

D = Dipping (20-50°)

V = Near Vertical (>50°)

Spacing

VW = Very wide = >3m

W = Wide = 1-3m

M = Moderate = 0.3-1m

C = Close = 5-30cm

VC = Very close = <5cm

Roughness

RU = Rough undulating

RP = Rough planar

SU = Smooth undulating

SP = Smooth planar

LU = Slicken sided undulating

LP = Slicken sided planar

Aperture

O = Open

C = Closed

F = Filled

Filling

T = Tight, hard

O = Oxidized

SA = Slightly altered, clay free

S = Sandy, Clay free

Si = Sandy, silty, minor clay

NC = Non-softening clay

SC = Swelling, softening clay

N = No filling

*Strength shown above is estimated and not measured laboratory values



FULL ROCK CORE: Dry



FULL ROCK CORE: Wet



ROCK CORE: Detail #1



ROCK CORE: Detail #2

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP		Project #:	20-656-6	Site:	Steel River	Logger:	L Cosby	Borehole #:	BH2
		Lab #:	1003 and 1004	Client:	MTO	Date:	11-Aug-22	Page #:	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES
							# OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
From 20.80	1/1	100%	88%	METAGABBRO - greenish grey, massive, veined, lightly foliated medium- to coarse-grained, mainly intact	H-VH	U	2	F	F	C	RP	O	N/O	- calcite veins throughout - some red staining on fracture surfaces
To 22.20								F	D	M	SU	O	N/O	
From 22.20	1/2	95%	95%	METAGABBRO - greenish grey, massive, veined, lightly foliated medium- to coarse-grained, mainly intact	H-VH	U	1	F	F	C	RP	O/C	N/T	- calcite veins throughout
To 23.70														
From 23.70														
To 0.00														
From 0.00														
To 0.00														
From 0.00														
To 0.00														

NOTES:

Strength (MPa)

VH = Very High = >200

H = High = 50-200

M = Medium = 15-50

L = Low = 4-15

VL = Very Low = 1-4

Weathering

U = Unweathered (No signs)

S = Slightly (Oxidized)

M = Moderately (Discoloured)

H = Highly (Friable)

C = Completely (Soil-like)

Type

B = Bedding joint

J = Cross Joint

F = Fault

S = Shear Plane

Orientation

F = Flat (0-20°)

D = Dipping (20-50°)

V = Near Vertical (>50°)

Spacing

VW = Very wide = >3m

W = Wide = 1-3m

M = Moderate = 0.3-1m

C = Close = 5-30cm

VC = Very close = <5cm

Roughness

RU = Rough undulating

RP = Rough planar

SU = Smooth undulating

SP = Smooth planar

LU = Slicken sided undulating

LP = Slicken sided planar

Aperture

O = Open

C = Closed

F = Filled

Filling

T = Tight, hard

O = Oxidized

SA = Slightly altered, clay free

S = Sandy, Clay free

Si = Sandy, silty, minor clay

NC = Non-softening clay

SC = Swelling, softening clay

N = No filling

*Strength shown above is estimated and not measured laboratory values



FULL ROCK CORE: Dry



FULL ROCK CORE: Wet



ROCK CORE: Detail #1



ROCK CORE: Detail #2

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP		Project #:	20-656-6	Site:	Steel River	Logger:	L Cosby	Borehole #:	BH3
		Lab #:	991 and 992	Client:	MTO	Date:	11-Aug-22	Page #:	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES
							# OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
From 21.60	1/1	100%	78%	METAGABBRO - greenish grey, massive, veined, fine-grained, intact and broken pieces	H-VH	U	3	F	F	C	RP	O	N	- calcite veins throughout - slight schistosity on fractured surfaces
To 22.80								F	V	C	RU	C	T	
								F	D	N/A	SP	O	SA	
From 22.80	1/2	95%	95%	METAGABBRO - greenish grey, massive, veined, fine-grained, mainly intact	H-VH	U	2	F	F	C	RP	O	N	- calcite veins throughout
To 24.30								F	D	M	RP	C	T	
From 24.30														
To 0.00														
From 0.00														
To 0.00														
From 0.00														
To 0.00														

NOTES:

Strength (MPa)

VH = Very High = >200

H = High = 50-200

M = Medium = 15-50

L = Low = 4-15

VL = Very Low = 1-4

Weathering

U = Unweathered (No signs)

S = Slightly (Oxidized)

M = Moderately (Discoloured)

H = Highly (Friable)

C = Completely (Soil-like)

Type

B = Bedding joint

J = Cross Joint

F = Fault

S = Shear Plane

Orientation

F = Flat (0-20°)

D = Dipping (20-50°)

V = Near Vertical (>50°)

Spacing

VW = Very wide = >3m

W = Wide = 1-3m

M = Moderate = 0.3-1m

C = Close = 5-30cm

VC = Very close = <5cm

Roughness

RU = Rough undulating

RP = Rough planar

SU = Smooth undulating

SP = Smooth planar

LU = Slicken sided undulating

LP = Slicken sided planar

Aperture

O = Open

C = Closed

F = Filled

Filling

T = Tight, hard

O = Oxidized

SA = Slightly altered, clay free

S = Sandy, Clay free

Si = Sandy, silty, minor clay

NC = Non-softening clay

SC = Swelling, softening clay

N = No filling

*Strength shown above is estimated and not measured laboratory values



FULL ROCK CORE: Dry



FULL ROCK CORE: Wet



ROCK CORE: Detail #1



ROCK CORE: Detail #2

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP		Project #:	20-656-6	Site:	Steel River	Logger:	L Cosby	Borehole #:	BH4
		Lab #:	976 and 977	Client:	MTO	Date:	11-Aug-22	Page #:	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES
							# OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
From 9.60	1/1	97%	95%	METAGABBRO - greenish grey, massive, veined, medium-grained, mainly intact	H-VH	U	2	F	F	M	RP	O	N	- calcite veins throughout - some sulfides present
To 11.10								F	D	N/A	RU	O	N	
From 11.10	1/2	95%	81%	METAGABBRO - greenish grey, massive, veined, medium- to fine-grained, mainly intact	H-VH	U	2	F	F	C	RP	O	N	- calcite veins throughout - some sulfides present
To 12.60								F	V	C	RP	C	T	
From 12.60														
To 0.00														
From 0.00														
To 0.00														
From 0.00														
To 0.00														

NOTES:

Strength (MPa)

VH = Very High = >200
H = High = 50-200
M = Medium = 15-50
L = Low = 4-15
VL = Very Low = 1-4

Weathering

U = Unweathered (No signs)
S = Slightly (Oxidized)
M = Moderately (Discoloured)
H = Highly (Friable)
C = Completely (Soil-like)

Type

B = Bedding joint
J = Cross Joint
F = Fault
S = Shear Plane

Orientation

F = Flat (0-20°)
D = Dipping (20-50°)
V = Near Vertical (>50°)

Spacing

VW = Very wide = >3m
W = Wide = 1-3m
M = Moderate = 0.3-1m
C = Close = 5-30cm
VC = Very close = <5cm

Roughness

RU = Rough undulating
RP = Rough planar
SU = Smooth undulating
SP = Smooth planar
LU = Slicken sided undulating
LP = Slicken sided planar

Aperture

O = Open
C = Closed
F = Filled

Filling

T = Tight, hard
O = Oxidized
SA = Slightly altered, clay free
S = Sandy, Clay free
Si = Sandy, silty, minor clay
NC = Non-softening clay
SC = Swelling, softening clay
N = No filling

*Strength shown above is estimated and not measured laboratory values



FULL ROCK CORE: Dry



FULL ROCK CORE: Wet



ROCK CORE: Detail #1

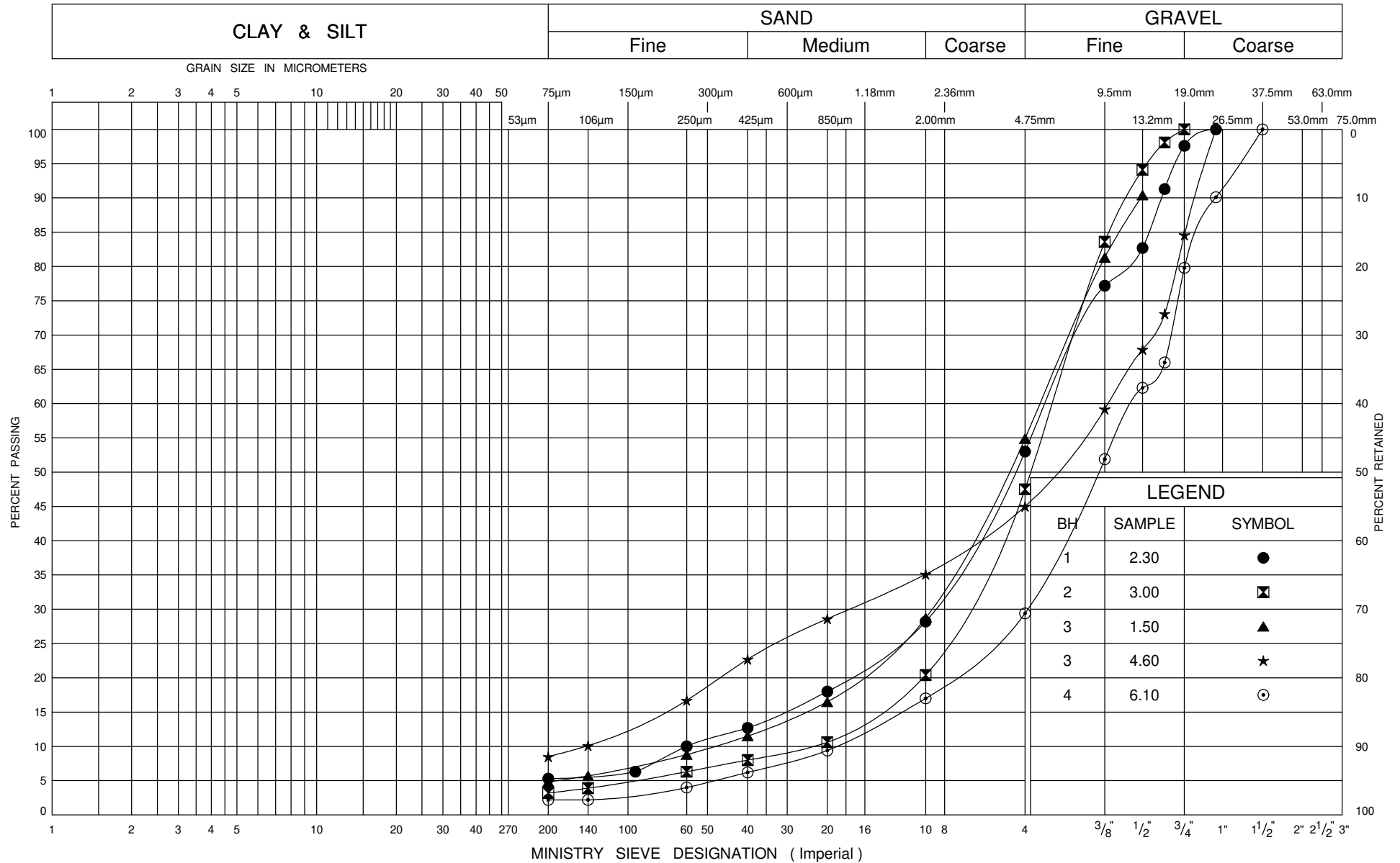


ROCK CORE: Detail #2

APPENDIX B

Laboratory Test Data

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

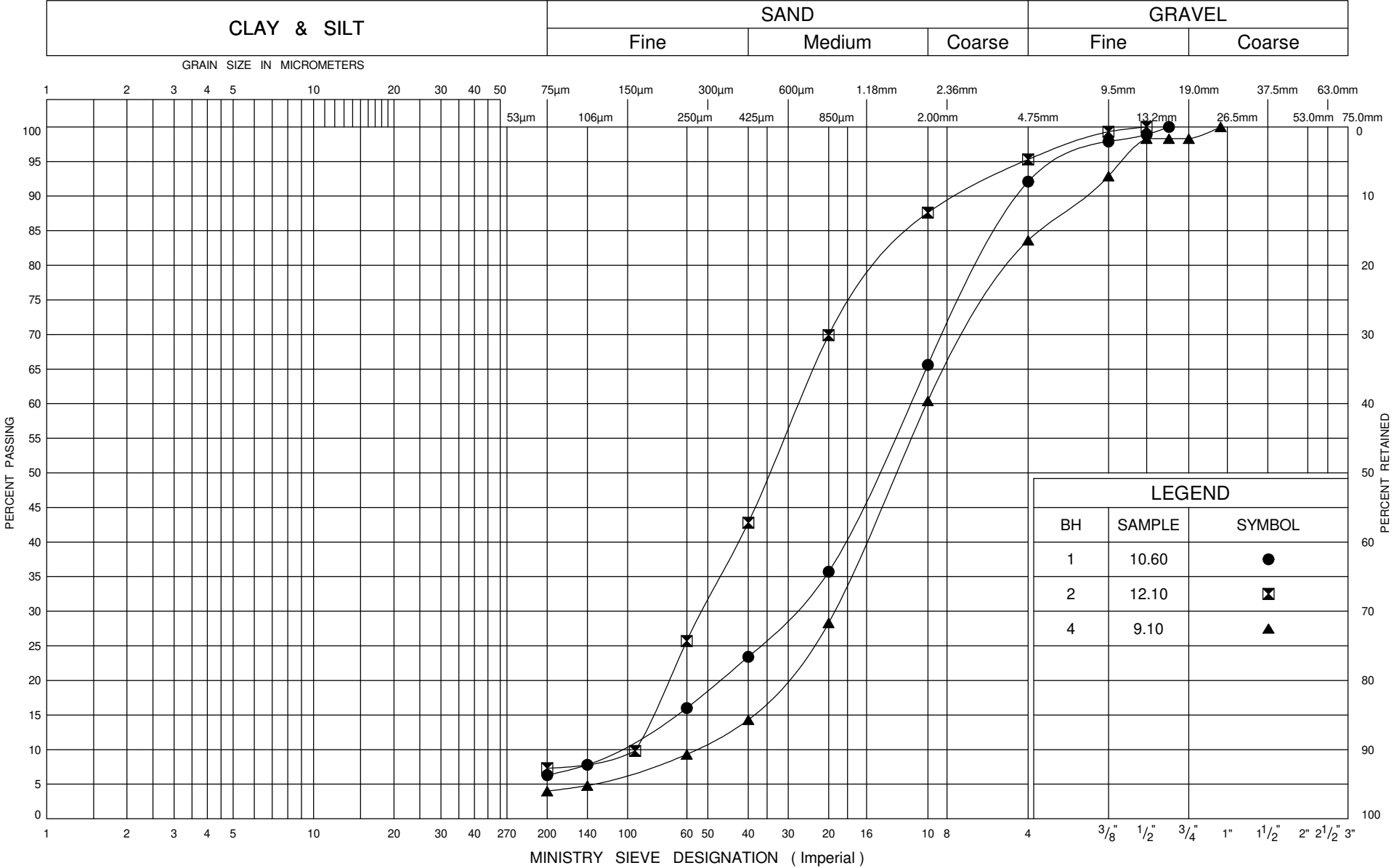
GRAIN SIZE DISTRIBUTION SAND & GRAVEL / GRAVEL

FIG No 1

W P 6328-18-00

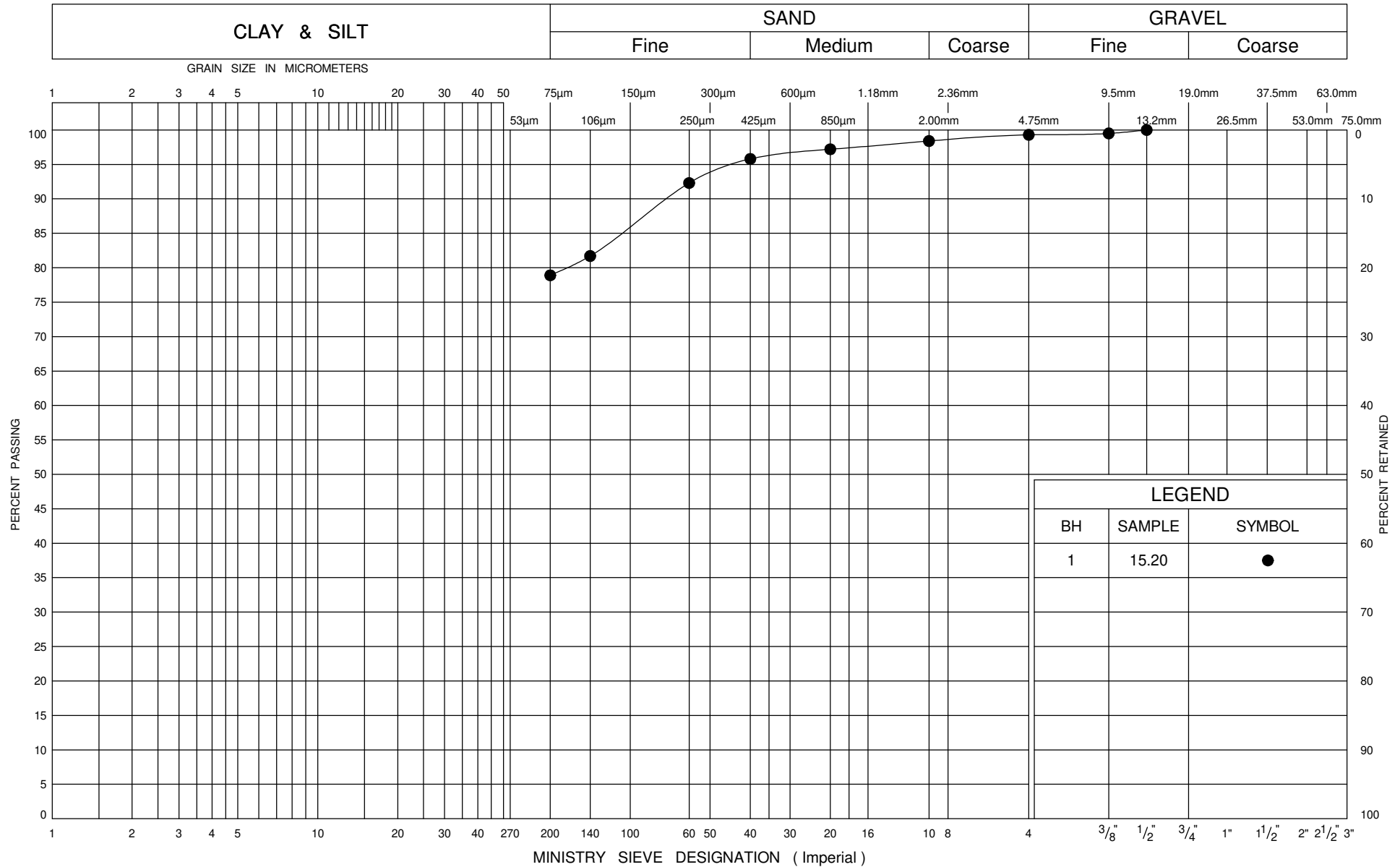
Steele River Hwy 17

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
BH	SAMPLE	SYMBOL
1	10.60	●
2	12.10	⊠
4	9.10	▲

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

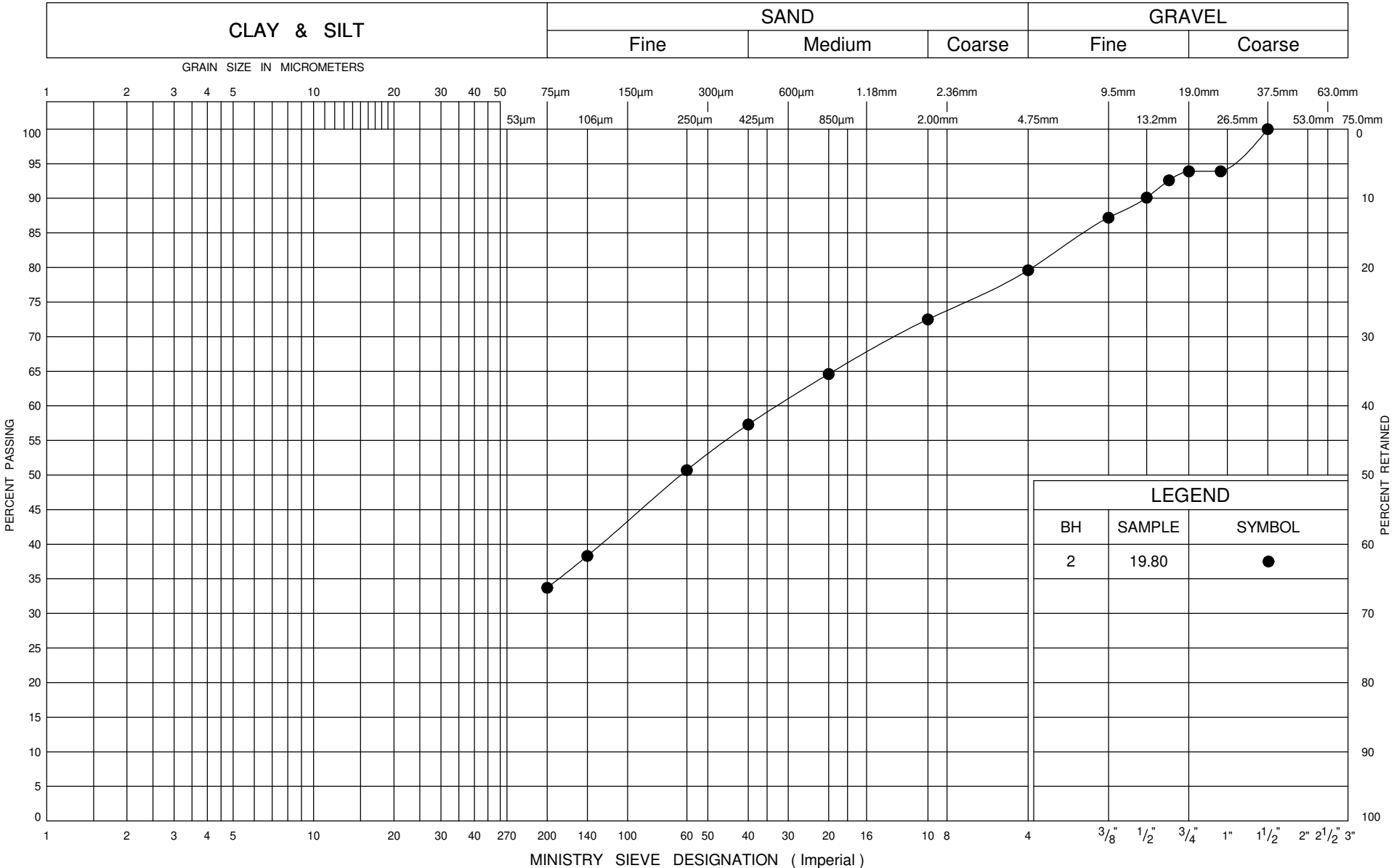
SILT - Sandy

FIG No 3

W P 6328-18-00

Steele River Hwy 17

UNIFIED SOIL CLASSIFICATION SYSTEM



APPENDIX C
Borehole Location and Soil Strata Drawings

