



FOUNDATION INVESTIGATION AND DESIGN REPORT

For

**NOISE BARRIER WALL ALONG HIGHWAY 401
WESTBOUND, LYNDE CREEK AREA
WHITBY, ONTARIO
W.O. 09-20009; W.P. 2123-10-00
REGIONAL MUNICIPALITY OF DURHAM
ASSIGNMENT NO. 2009-E-0038**

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PML Ref.: 10TF008A-LC
Index No.: 095FIR and 096FDR
GEOCRES No.: 30M15-321
March 27, 2018

PART A –FOUNDATION INVESTIGATION REPORT

For

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WESTBOUND, LYNDE CREEK AREA
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PART A - FOUNDATION INVESTIGATION REPORT

For

Noise Barrier Wall Along Highway 401 Westbound

Lynde Creek Area

Whitby Township, Regional Municipality of Durham, Ontario

W.O. 09-20009, W.P. 2123-10-00, Assignment No. 2009-E-0038

1. INTRODUCTION

AECOM Canada Ltd. has retained Peto MacCallum Ltd. (PML) on behalf of the Ministry of Transportation Ontario (MTO) to conduct the geotechnical investigation for the design and construction of approximately 193 m long Noise Barrier Wall (NBW), located along the north side of Highway 401, Lynde Creek area, in the Township of Whitby, Regional Municipality of Durham, Ontario.

AECOM requested PML by e-mail dated February 28, 2018 to complete the foundation investigation and report the findings for the installation of the proposed Noise Barrier Wall.

The proposal by PML, Change Order Request No. 1B dated October 13, 2017, was to drill four (4) boreholes spaced at 50.0 m interval, for the installation of proposed 193 m long Noise Barrier. Based on the General Arrangement (GA) drawing received on February 27, 2018, the total length of Noise Barrier Wall was reduced to 190 m.

This report presents a summary of the subsurface conditions within the project limit, based on four (4) boreholes advanced by PML under the current assignment (2009-E-0038).

2. SITE DESCRIPTION

The proposed NBW is located on the north side of Highway 401 westbound near Lynde Creek, in the Township of Whitby.

The topography of the project area is generally flat, except for the highway embankments. The area along the north side of highway is mostly residential. Highway 401 within the project limit is oriented in the east-west direction.



The land adjacent to the proposed Noise Barrier Wall is currently undeveloped lands.

3. FIELD INVESTIGATION PROCEDURES

The PML staff visited the site on November 10, 2017 to mark out the borehole locations. The underground services at the borehole locations were cleared by the respective utility companies. Public and private utility authorities were informed and all the utility clearance documents were obtained before the commencement of drilling work.

The fieldwork was carried out between November 13 and 21, 2017. The location of the boreholes in the field were established by PML staff using a portable GPS device. Subsequently, J.D. Barnes Limited, Ontario, under contract to PML carried out the survey of the borehole locations and elevations and provided the co-ordinates for locations in MTM NAD 83 northing and easting. PML used the survey data provided by J.D. Barnes Limited for preparation of this report. All elevations in this report are referred to geodetic datum and expressed in meters.

The drilling equipment from two different contractors were used for the field investigation. The drilling equipment used were owned and operated by Landshark Drilling and Drill Tech Drilling Limited who are specialist drilling contractors. The fieldwork was carried out under the full-time supervision of a PML field supervisor. The investigation included advancing four (4) boreholes numbered NBW-17-1 to NBW-17-4 to maximum depths ranging from 14.6 m to 16.8 m (El. 68.7 to El. 67.2). In view of the previously encountered soft and wet conditions in the Lynde Creek floodplain and new fill in the approach embankment, these four boreholes were advanced to a depth of 15 m instead of 6 m below the frost depth specified in the MTO Guidelines, i.e., a total depth of 7.2 m below the ground level. These boreholes were advanced using hollow stem augers powered by a truck-mounted drill rig. The locations of boreholes are shown on the attached Drawing NBW-1 provided in Appendix A.

A summary of the borehole coordinates and depths are provided on the table below.



Table 3 – Borehole Information

BOREHOLE NO.	COORDINATING		DEPTH (m)
	NORTHING	EASTING	
NBW-17-1	4 858 662.4	348 005.4	15.3
NBW-17-2	4 858 643.4	347 908.8	14.6
NBW-17-3	4 858 635.6	347 858.0	15.2
NBW-17-4	4 858 628.6	347 821.7	16.8

Representative soil samples were recovered from the boreholes at 0.75 m intervals to depths ranging from 7.5 m to 12.5 m, using a conventional 51 mm O.D split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Below these depths, the SPT samples were retrieved at 1.5 m intervals. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

The groundwater conditions at the borehole locations were observed during the drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in open boreholes. Upon completion of drilling, the boreholes were backfilled with bentonite/cement grout in accordance with the MTO guidelines and MOE Regulation 903 for borehole abandonment procedures.

The soil samples retrieved were returned to our laboratory for detail visual examination and index tests.

4. LABORATORY TEST PROCEDURES

Laboratory tests on representative SPT samples recovered during the fieldwork were carried out by the certified laboratory owned by PML, located in Toronto. The laboratory testing program included the following:

- Natural moisture content determinations (61)
- Grain size distribution analyses (17)
- Atterberg limits (10)



The laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow American Society for Testing Materials (ASTM) test procedures, with the exception of hydrometer test (LS-702). The results of the grain size distribution analyses are presented on Figures GS-NBW-1 to GS-NBW-5. The results of the Atterberg limit tests are provided on Figures PC-NBW-1 to PC-NBW-4. All of the test results are summarized on the attached Record of Borehole sheets.

5. SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Site Geology

The study area is located in the physiographic region known as the Iroquois Plain ("Physiography of Southern Ontario" by Chapman and Putnam and Map 1050 A of Lindsay-Peterborough Area, published by the Geological Survey of Canada). The Iroquois Plain extends to a distance of about 305 km around the Lake Ontario from the Niagara River at the west end to Trent River in the east end. In general, the plain is a mosaic of lacustrine sandy and clayey deposits with till plains and drumlins. Small drainage courses and creeks currently drain the area southerly towards Lake Ontario.

The site stratigraphy includes mixed soils underlain by bedrock of the Whitby Formation that typically comprises grey and black shale according to the Aggregate Resources Inventory of the Town of Whitby published by the Ontario Geological Survey, Paper 41. The bedrock in the immediate vicinity of the site is expected to be less than 15 m deep.

5.2 Subsurface Conditions

The underlying subsoil in the area of the proposed noise barrier wall consists mainly of cohesive fill material followed by glacial till deposit predominantly composed of silty sand. The subsoil consists of 1.5 m to 2.6 m of silty sand with gravel (pavement fill) followed by 7.9 m to 8.1 m of soft to hard clayey silt (fill) layer. However, the fill layer in Borehole NBW17-1 consisted of loose to compact clayey sand. The fill material is followed by compact to very dense silty sand/sandy silt (till) deposit to the maximum investigation depth of 16.8 (El. 67.2). For classification purposes, the soils encountered in the project area can be divided into four different zones.



- a) Silty Sand, With Gravel (Pavement Structure)
- b) Clayey Sand, Some Gravel (Fill)
- c) Clayey Silt, with Sand, Trace Gravel (Fill)
- d) Silty Sand, Trace/Some Gravel (Till)
- e) Sandy Silt, Trace Gravel (Till)

The subsurface conditions that may be expected in the proposed locations of the noise barrier wall, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix B of this report. The results of the Atterberg limit tests are shown on Figures PC-NBW-1 to PC-NBW-4 and the grain size distribution test results are presented on Figures GS-NBW-1 to GS-NBW-5. The borehole location plan and soil stratigraphy are shown on the Drawing NBW-1. A summary of soil strata encountered at each borehole location is as follows.

Table 5.2 –Summary of Soil Strata

BOREHOLE NO.	ELEVATIONS		SOIL TYPE
	FROM	TO	
NBW17-1	82.9	80.3	Silty Sand with Gravel (Pavement Fill)
	80.3	75.3	Loose to Compact Clayey Sand, Some Gravel (Fill)
	75.3	67.6	Dense to Very Dense Sandy Silt, Trace Gravel (Till)
NBW17-2	83.3	81.5	Silty Sand with Gravel (Pavement Fill)
	81.5	73.4	Stiff to Very Stiff Clayey Silt, with Sand, Trace Gravel (Fill)
	73.4	68.7	Dense to Very Dense Silty Sand, Some Gravel (Till)
NBW17-3	83.7	82.2	Silty Sand with Gravel (Pavement Fill)
	82.2	74.3	Soft to Very Stiff Clayey Silt With Sand, Trace Gravel (Fill)
	74.3	68.5	Compact to Very Dense Silty Sand, Trace/Some Gravel (Till)
NBW17-4	84.0	82.3	Silty Sand with Gravel (Pavement Fill)
	82.3	74.4	Soft to Very Stiff Clayey Silt, with Sand, Trace Gravel (Fill)
	74.4	67.2	Very dense Silty Sand, Some Gravel (Till)



5.3 Groundwater Conditions

The groundwater was encountered in all the boreholes upon completion of drilling. The groundwater level in each borehole is as follows.

Table 5.3 - Groundwater Levels in Boreholes

BOREHOLE NO.	ELEVATION OF WATER LEVEL (M)
NBW17-1	75.9
NBW17-2	78.1
NBW17-3	74.2
NBW17-4	77.0

The groundwater levels are subjected to seasonal fluctuations and precipitation patterns



6. CLOSURE

Mr. A. Hossein carried out the field investigations. Landshark Drilling and Drill Tech Drilling Limited supplied the drilling equipment used for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Ms. Asieh Khadem, M.Sc. Eng., EIT, Project Supervisor and reviewed by Mark Vasavithasan, M.Sc. Eng., P.Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Asieh Khadem, March 27, 2018

Asieh Khadem, M.Sc. Eng., EIT
Project Supervisor, Geotechnical Services



Mark Vasavithasan, M.Sc. Eng., P.Eng.
Senior Engineer, Geotechnical Services



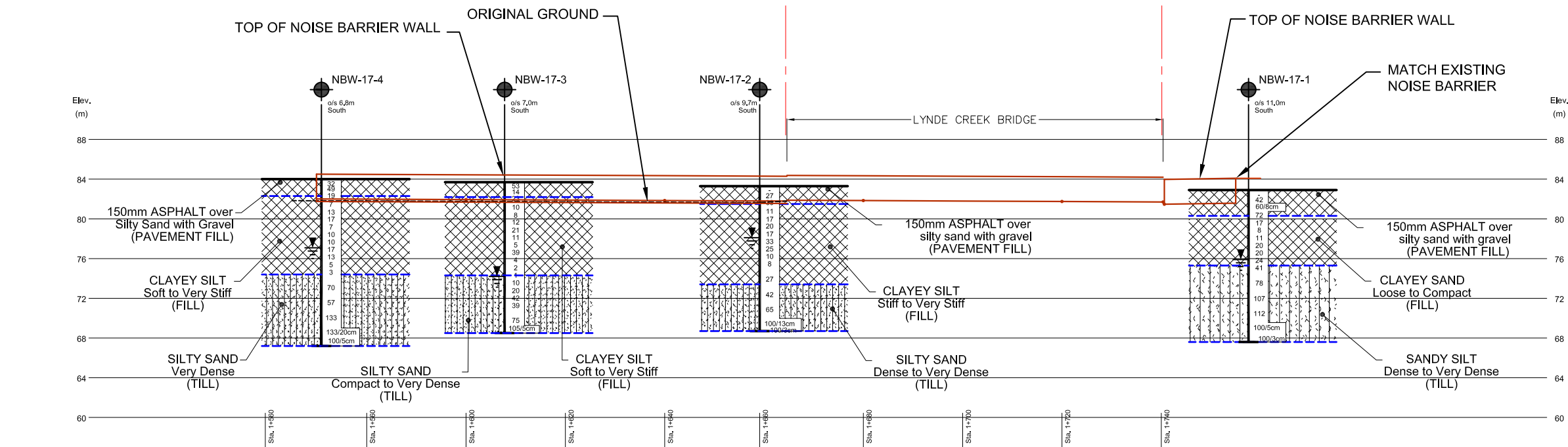
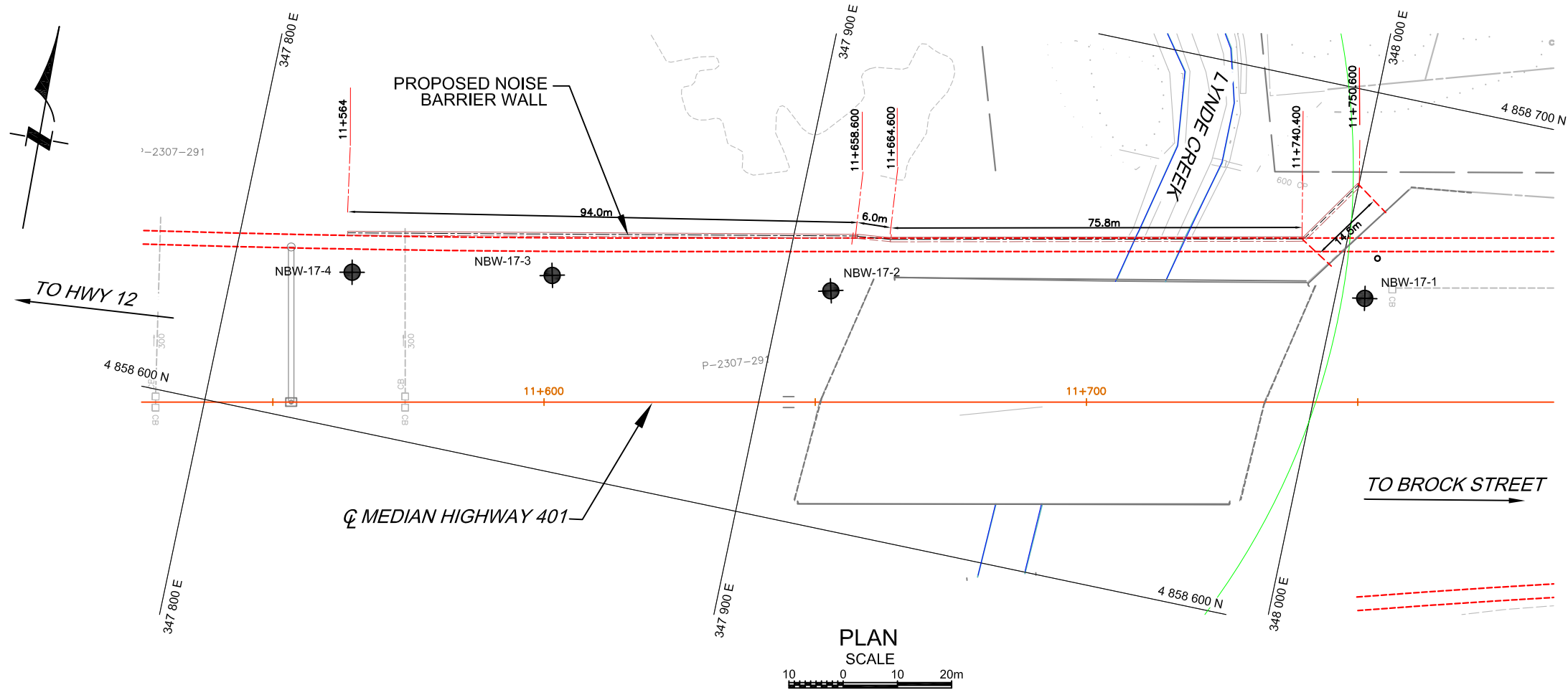
Carlos M.P. Nascimento, P.Eng.
Project Manager and
MTO Designated Principal Contact

AK/MV/CN:nk



APPENDIX A

Borehole Location Plans and Soil Strata Drawing NBW-1



PROFILE ALONG C/L OF NOISE BARRIER WALL

SCALE

HORIZONTAL

10 0 10 20m

VERTICAL

5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

CONT No
W.O. No 09-20009
W.P. No 2123-10-00

NOISE BARRIER WALL
HIGHWAY 401E- LYNDE CREEK AREA
GEOGRAPHIC TOWNSHIP OF WHITBY
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



LEGEND

- Borehole
- Borehole and Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of Investigation May 2017
- Penetration due to weight of hammer
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
NBW-17-1	82.9	4 858 662.4	348 005.4
NBW-17-2	83.3	4 858 643.4	347 908.8
NBW-17-3	83.7	4 858 635.6	347 858.0
NBW-17-4	84.0	4 858 628.6	347 821.7

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 30M15-321

HWY No	401	DIST	Central
SUBMD	TC	CHECKED	AK
DATE	MAR. 27, 2018	SITE	Lynde Creek
DRAWN	NA	CHECKED	MV
APPROVED	CN	DWG	NBW-1



APPENDIX B

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Analyses – Figures GS-NBW-1 to GS-NBW-5

Plasticity Chart – Figures PC-NBW-1 to PC-NBW-4

EXPLANATION OF TERMS USED IN REPORT

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 63.5kg, 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 OR DENSENESS.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

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

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE
F V FIELD VANE	

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u	1	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 STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL



ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	e_{max}	1, %	VOID RATIO IN LOOSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	e_{min}	1, %	VOID RATIO IN DENSEST STATE
ρ_w	kg/m ³	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m ³	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m ³	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m ³ /s	RATE OF DISCHARGE
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m ³	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No NBW17-1

1 OF 2

METRIC

G.W.P. 2123-10-00 LOCATION Co-ords: 4 858 662.4 N; 348 005.4 E ORIGINATED BY A.H.
DIST Central HWY 401 E BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.R.
DATUM Geodetic DATE 2017.12.13 - 2017.12.14 LATITUDE 43.866669 LONGITUDE -78.962469 CHECKED BY A.K.

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									WATER CONTENT (%)			
								○ UNCONFINED	+	FIELD VANE										
								● QUICK TRIAXIAL	×	LAB VANE										
82.9 0.0	GROUND SURFACE 150 mm ASPHALT over silty sand with gravel		1	AS	-															
			2	SS	42															
			3	SS	60/8cm															
	(PAVEMENT FILL)		4	SS	72															
80.3 2.6	CLAYEY SAND, some gravel Loose to compact, Grey, Moist		5	SS	17											21 57 18 4				
			6	SS	8															
			7	SS	11															
			8	SS	20											13 42 30 15				
			9	SS	20															
	(FILL)		10	SS	24											24 45 24 7				
75.3 7.6	SANDY SILT, trace gravel Dense to very dense, Brown, Damp		10A	SS	41															
			11	SS	78											4 29 57 10				
			12	SS	107															
			13	SS	112															
	(TILL)		14	SS	100/5cm															
67.9																				

Continued Next Page

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

RECORD OF BOREHOLE No NBW17-1

2 OF 2

METRIC

G.W.P. 2123-10-00 LOCATION Co-ords: 4 858 662.4 N; 348 005.4 E ORIGINATED BY A.H.
 DIST Central HWY 401 E BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.R.
 DATUM Geodetic DATE 2017.12.13 - 2017.12.14 LATITUDE 43.866669 LONGITUDE -78.962469 CHECKED BY A.K.

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									
67.9								20	40	60	80	100					
15.0																	
67.6																	
15.3	End of borehole		15	SS	100/3cm												
	Refusal on probable bedrock																
	<div><div>▽</div>Water level observed during drilling</div> <div><div>▼</div>Water level measured after completion of drilling</div> <div>NOTE: Borehole caved-in to the depth of 8.5m</div>																

RECORD OF BOREHOLE No NBW17-2

1 OF 2

METRIC

G.W.P. 2123-10-00 LOCATION Co-ords: 4 858 643.4 N; 347 908.8 E ORIGINATED BY A.H.
DIST Central HWY 401 E BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.R.
DATUM Geodetic DATE 2017.12.14 - 2017.12.15 LATITUDE 43.866504 LONGITUDE -78.963673 CHECKED BY A.K.

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										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
83.3	GROUND SURFACE						20	40	60	80	100									
0.0	150 mm ASPHALT over silty sand with gravel		1	AS	-															
			2	SS	27															
	(PAVEMENT FILL)		3	SS	33															
81.5	CLAYEY SILT, with sand, trace gravel																			
1.8	Stiff to very stiff, Grey, Moist to wet		4	SS	11															
			5	SS	17															
			6	SS	20															
			7	SS	17															
			8	SS	33															
			9	SS	25															
			10	SS	10															
	(FILL)		11	SS	8															
			12	SS	27															
73.4	SILTY SAND, some gravel																			
9.9	Dense to very dense, Brown, Moist		13	SS	42															
			14	SS	65															
	(TILL)		15	SS	100/13cm															
			16	SS	100/3cm															
68.7	End of borehole																			
14.6	Refusal on probable bedrock																			

Continued Next Page

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

2 OF 2

METRIC

DATUM Geodetic DATE 2017.12.14 - 2017.12.15 LATITUDE 43.866504 LONGITUDE -78.963673 CHECKED BY A.K.

[illegible]

1 OF 2

METRIC

DATUM Geodetic DATE 2017.12.19 - 2017.12.20 LATITUDE 43.866437 LONGITUDE -78.964306 CHECKED BY A.K.

PML LOGO-MTO STYLE 10TF008A- NBW.GPJ ONTARIO MTO.GDT 3/20/18

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

2 OF 2

METRIC

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			20	40				60	80	100
								SHEAR STRENGTH kPa						WATER CONTENT (%)	
68.7							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							

[illegible]

RECORD OF BOREHOLE No NBW17-4

1 OF 2

METRIC

G.W.P. 2123-10-00 LOCATION Co-ords: 4 858 628.6 N; 347 821.7 E ORIGINATED BY A.H.
DIST Central HWY 401 E BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.R.
DATUM Geodetic DATE 2017.12.20 - 2017.12.21 LATITUDE 43.866375 LONGITUDE -78.964757 CHECKED BY A.K.

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									WATER CONTENT (%)					
								○ UNCONFINED	+	FIELD VANE												
								● QUICK TRIAXIAL	×	LAB VANE												
84.0	GROUND SURFACE						20	40	60	80	100											
0.0	150 mm ASPHALT over silty sand with gravel		1	AS	32																	
			2	SS	49																	
	(PAVEMENT FILL)																					
82.3			3	SS	19																	
1.7	CLAYEY SILT, with sand, trace gravel																					
	Soft to very stiff, Grey, Moist to wet		4	SS	7											6 36 43 15						
			5	SS	13																	
			6	SS	17											8 48 37 7						
			7	SS	7																	
			8	SS	10																	
			9	SS	10											9 34 46 11						
			10	SS	17																	
			11	SS	13																	
	(FILL)		12	SS	5																	
			13	SS	3											0 49 38 13						
74.4	SILTY SAND, some gravel																					
9.6	Very dense, Brown, Damp		14	SS	70																	
			15	SS	57											18 45 29 8						
	(TILL)		16	SS	133																	
69.0																						

Continued Next Page

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

RECORD OF BOREHOLE No NBW17-4

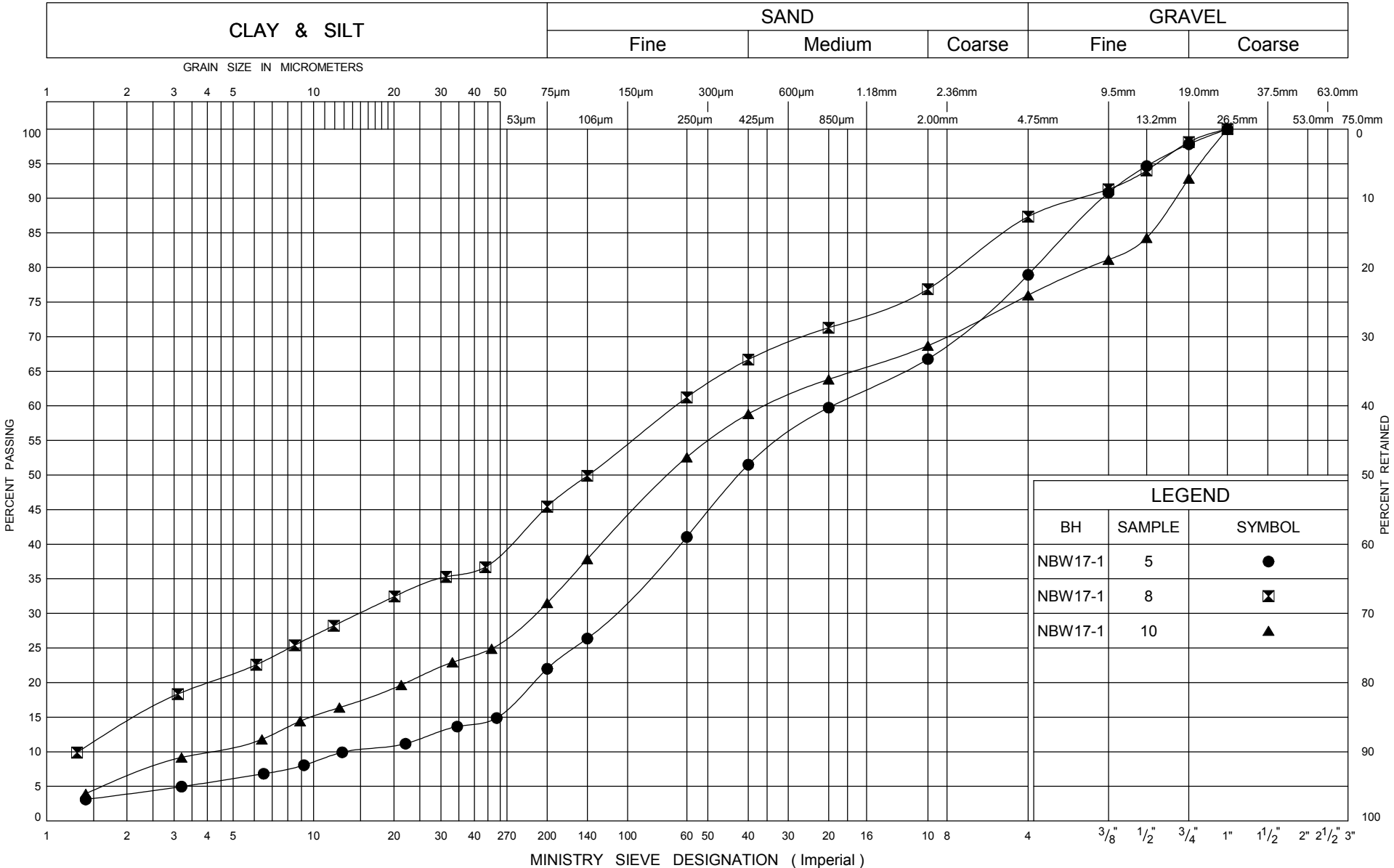
2 OF 2

METRIC

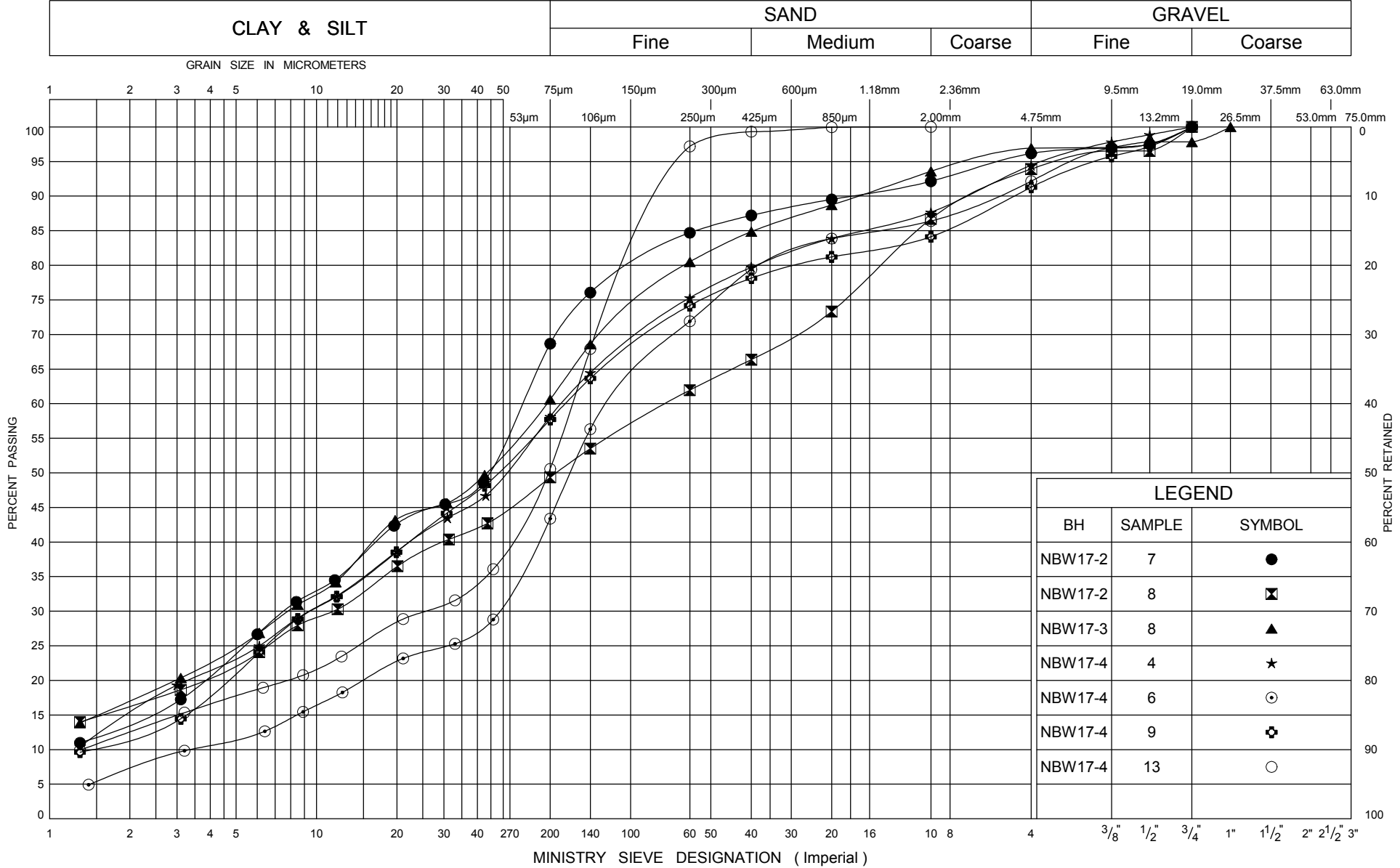
G.W.P. 2123-10-00 LOCATION Co-ords: 4 858 628.6 N; 347 821.7 E ORIGINATED BY A.H.
 DIST Central HWY 401 E BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.R.
 DATUM Geodetic DATE 2017.12.20 - 2017.12.21 LATITUDE 43.866375 LONGITUDE -78.964757 CHECKED BY A.K.

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									
69.0								20	40	60	80	100					
15.0	SILTY SAND, some gravel Very dense, Brown, Damp (<i>Cont.d</i>) (TILL)		17	SS	133/20cm		68										
67.2			18	SS	100/5cm												
16.8	End of borehole Refusal on probable bedrock <																

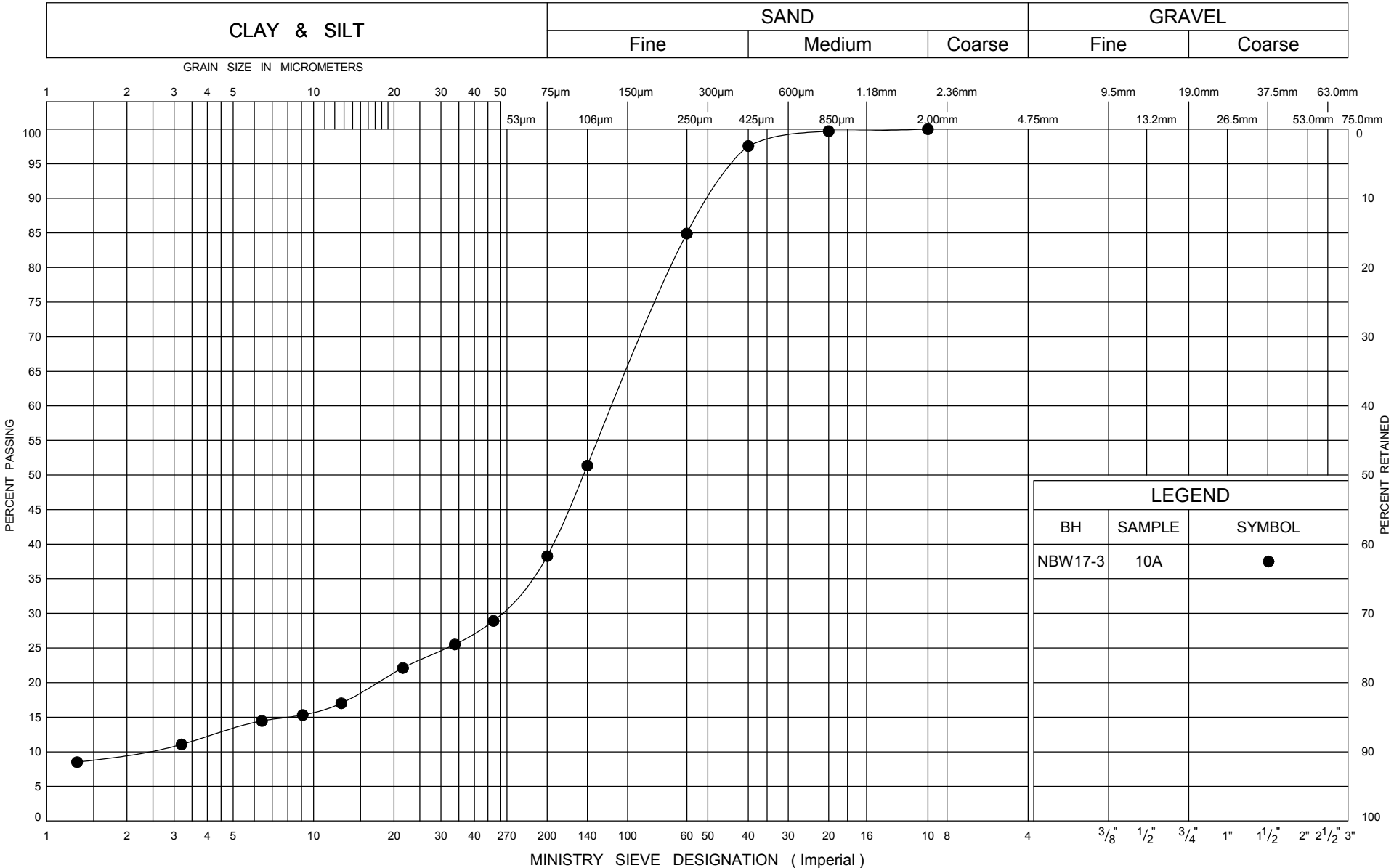
UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



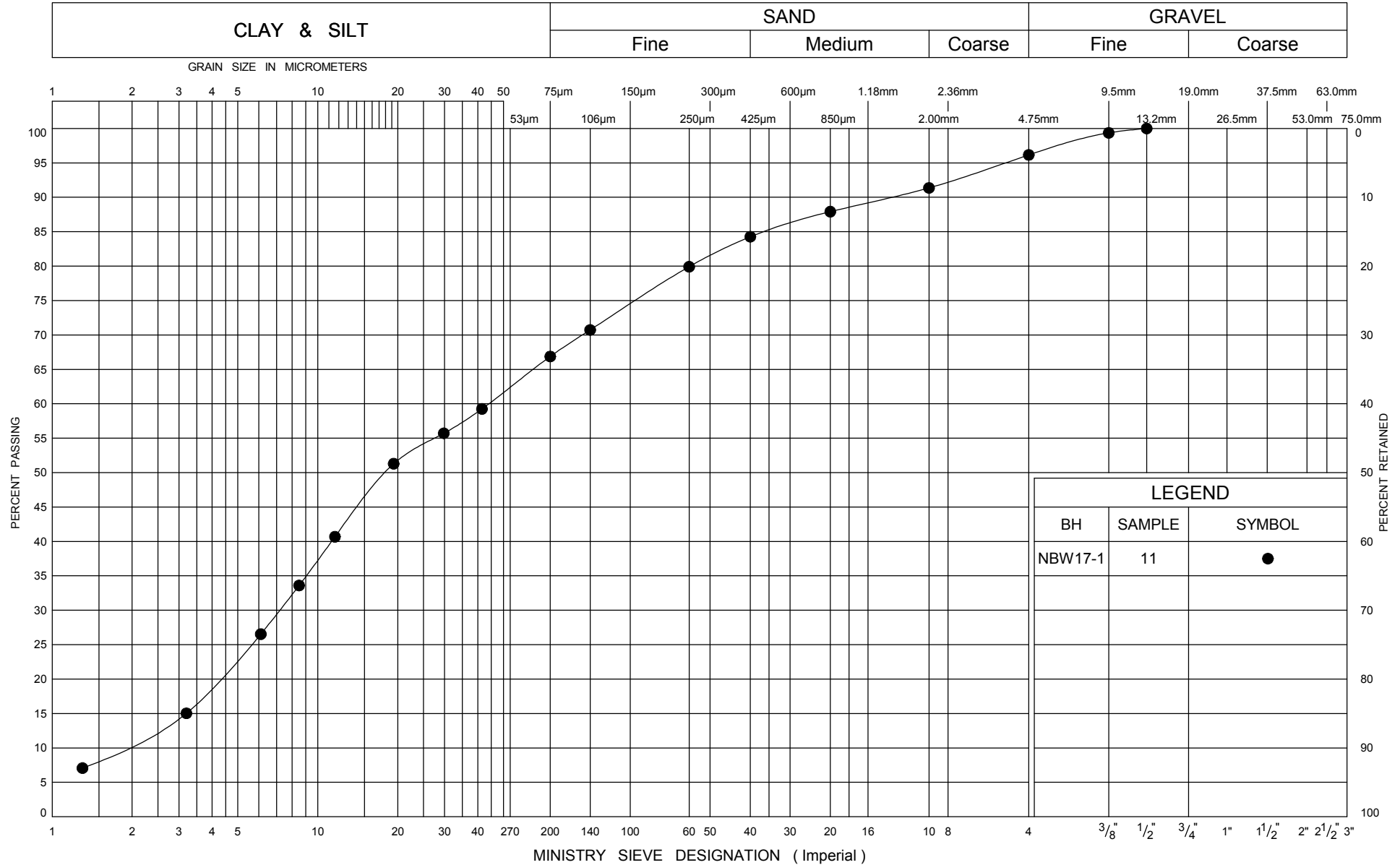
UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
SILTY SAND, with gravel (FILL)

FIG No GS-NBW-3
HWY 401
WP 2123-10-00

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

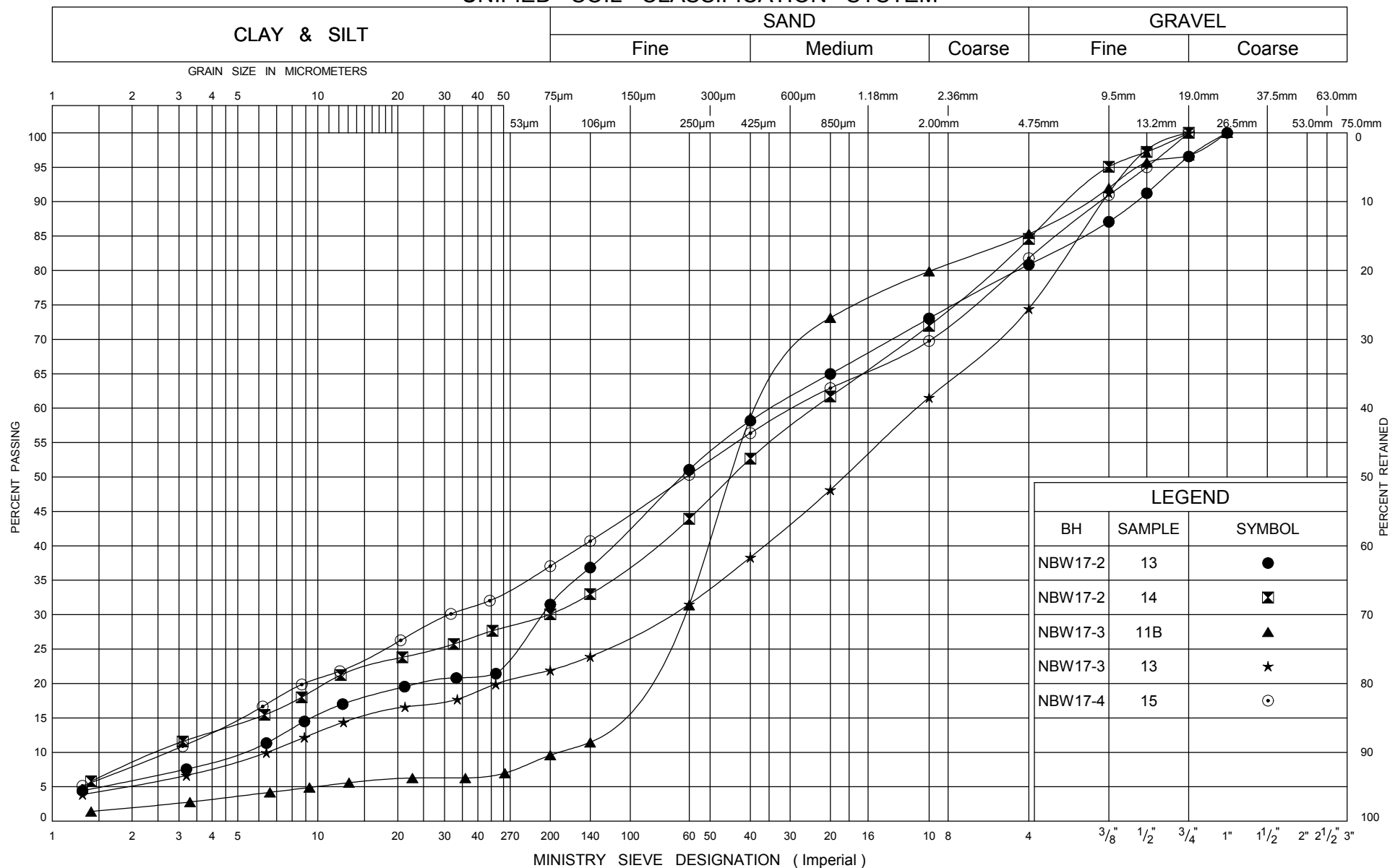
SANDY SILT, trace gravel (TILL)

FIG No GS-NBW-4

HWY 401

WP 2123-10-00

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

SILTY SAND, trace/some gravel (TILL)

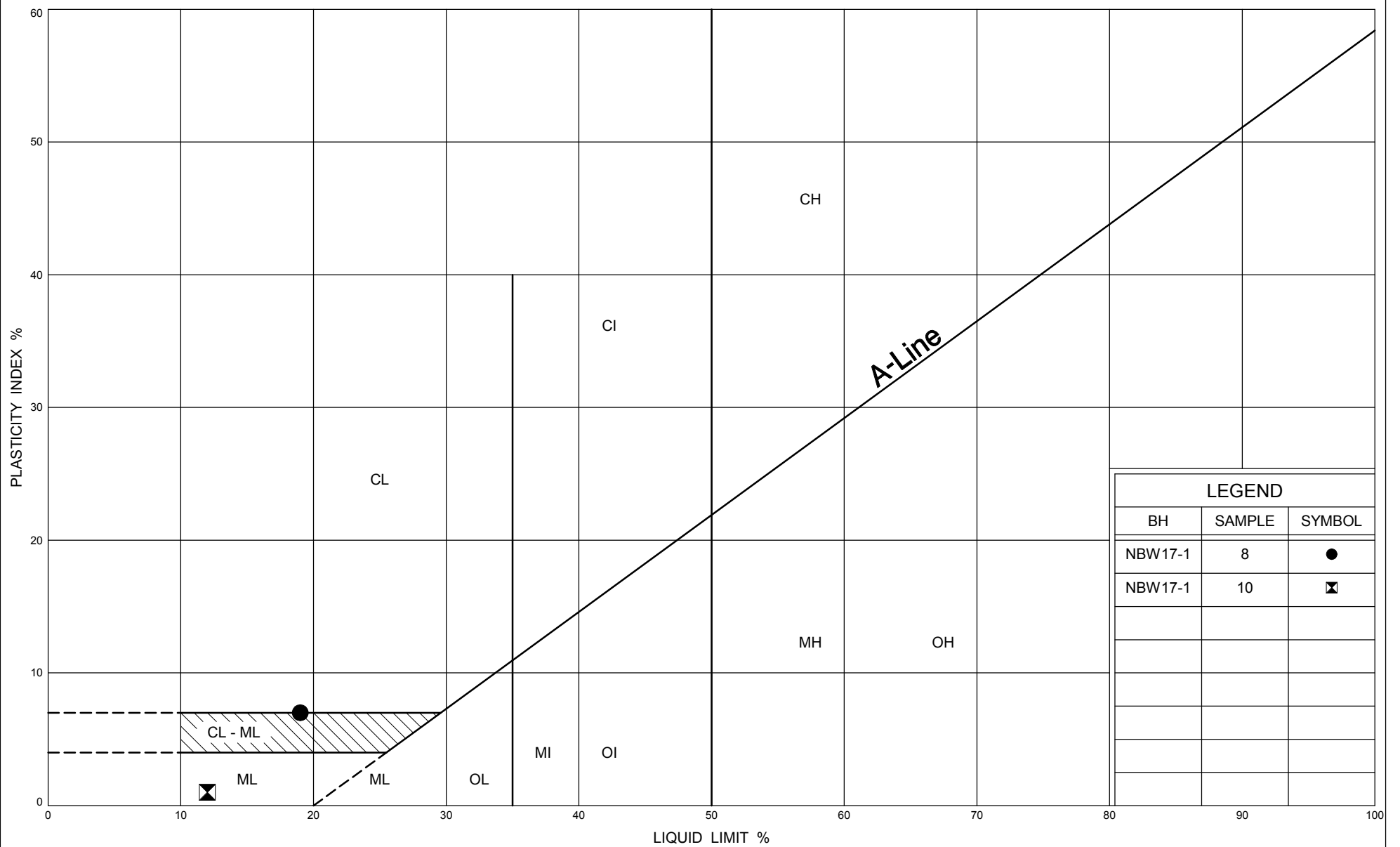
FIG No GS-NBW-5

HWY 401

WP 2123-10-00

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Transportation

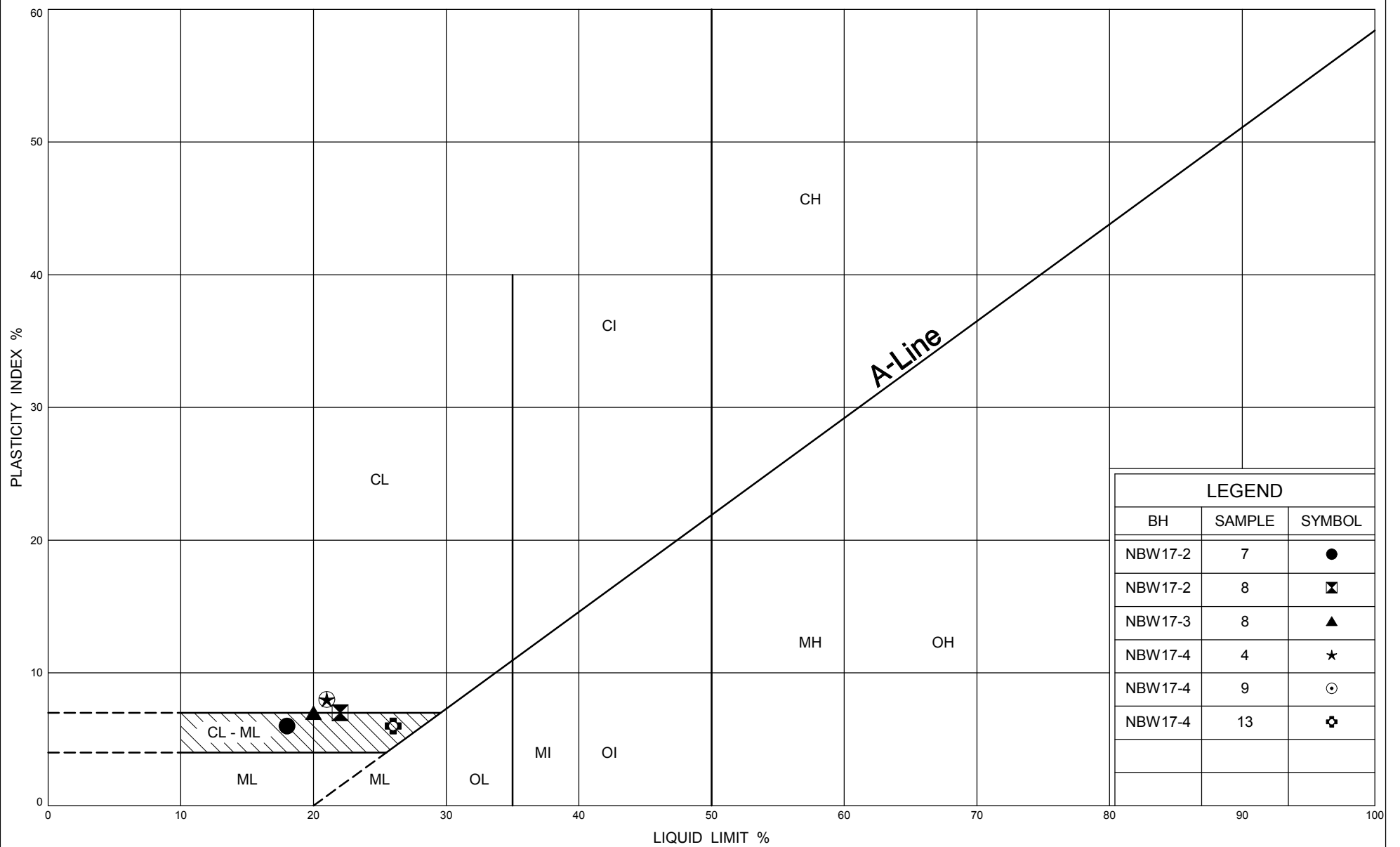
PLASTICITY CHART

CLAYEY SAND, some gravel (FILL)

FIG No PC-NBW-1

HWY 401

WP 2123-10-00



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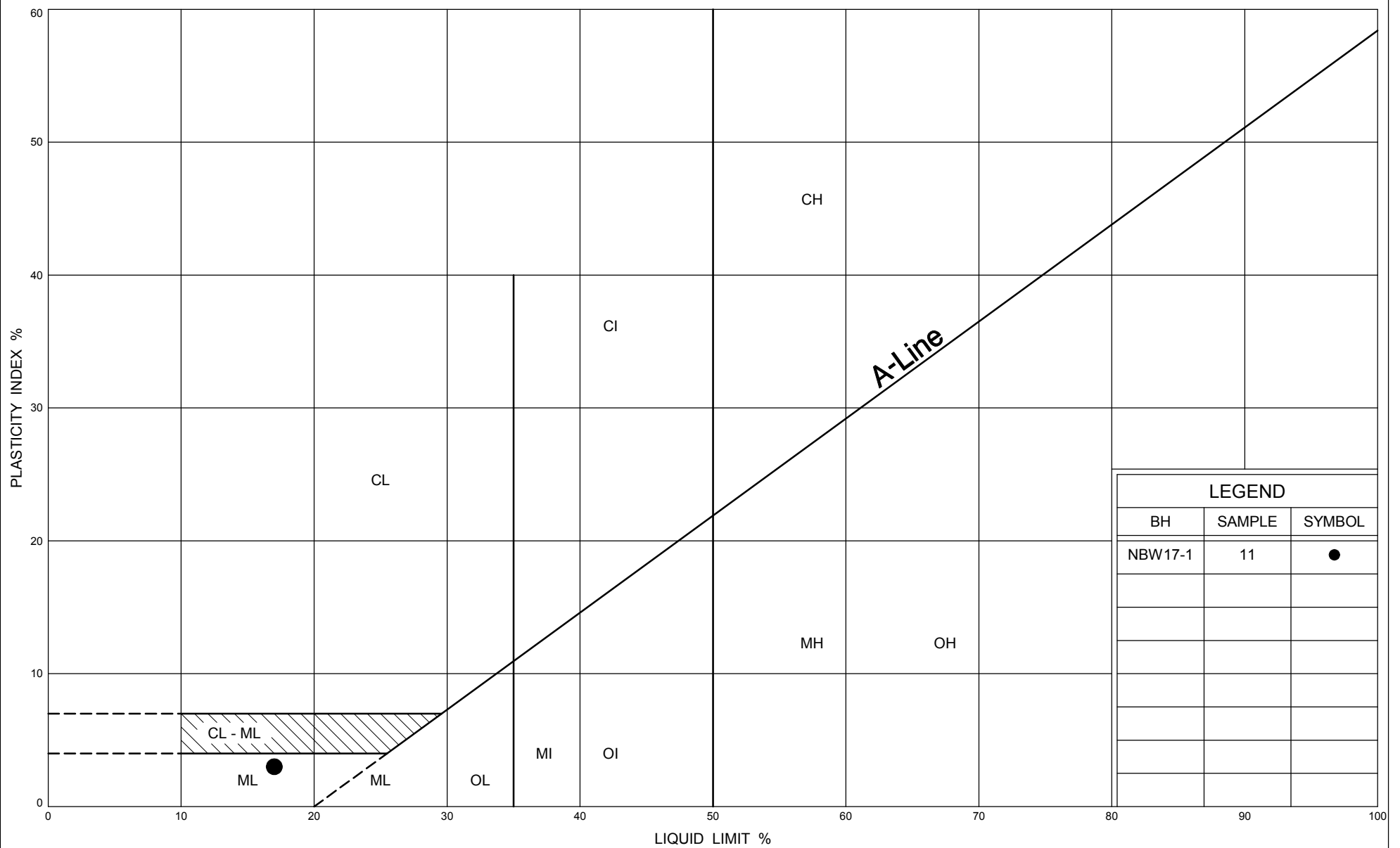
PLASTICITY CHART

CLAYEY SILT, with sand, trace gravel (FILL)

FIG No PC-NBW-2

HWY 401

WP 2123-10-00



LEGEND		
BH	SAMPLE	SYMBOL
NBW17-1	11	●



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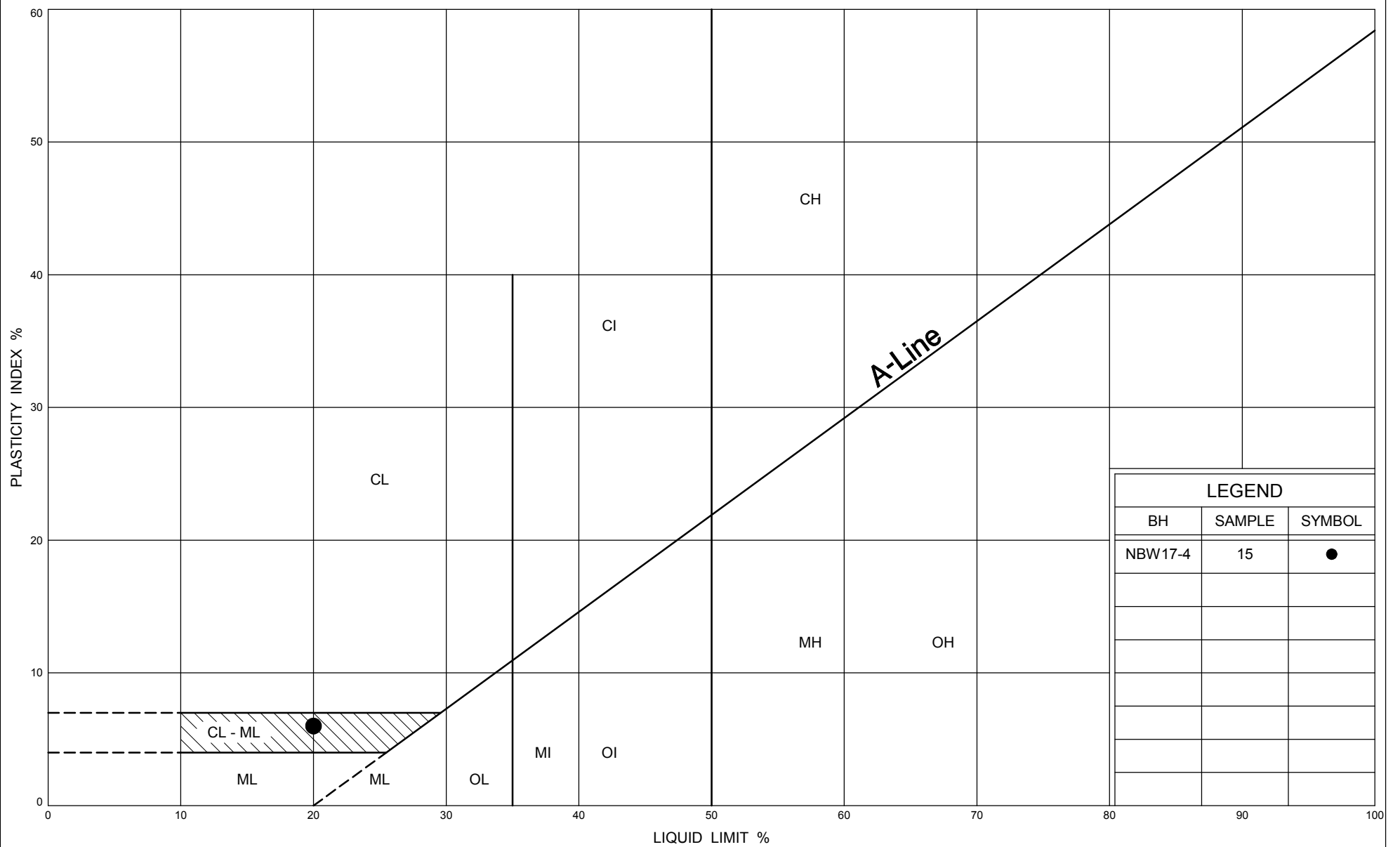
PLASTICITY CHART

SANDY SILT, trace gravel (till)

FIG No PC-NBW-3

HWY 401

WP 2123-10-00



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PLASTICITY CHART

SILTY SAND, trace/some gravel (TILL)

FIG No PC-NBW-4

HWY 401

WP 2123-10-00

PART B – FOUNDATION DESIGN REPORT

for

**NOISE BARRIER WALL ALONG HIGHWAY 401
WESTBOUND, LYNDE CREEK AREA
WHITBY, ONTARIO
W.O. 09-20009; W.P. 2123-10-00
REGIONAL MUNICIPALITY OF DURHAM
ASSIGNMENT NO. 2009-E-0038**

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PML Ref.: 10TF008A-LC
Index No.: 096FDR
GEOCRES No.: 30M15-321
March 27, 2018



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Appendix C – List of Standard Specifications Relevant to Report
Non-Standard Special Provisions (NSSP)

PART B - FOUNDATION DESIGN REPORT

For

Noise Barrier Wall along Highway 401 Westbound

Lynde Creek Area

Whitby Township, Regional Municipality of Durham, Ontario

W.O. 09-20009, W.P. 2123-10-00, Assignment No. 2009-E-0038

7. INTRODUCTION

This foundation investigation and design report with the interpretation and recommendations are intended for the use of AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation 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 contractors 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 only to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual information provided in Part A of the report, as it may affect equipment selection, proposed construction methods and scheduling.

8. PROJECT DESCRIPTION

This report provides foundation design recommendations based on interpretation of the geotechnical data presented in the factual report (Part A). This section of the report provides foundation recommendations for the design of proposed Noise Barrier Wall (NBW) structure along Highway 401, Lynde creek area in the Regional Municipality of Durham, Ontario. Based on the preliminary GA drawing, dated February 27, 2018 provided by AECOM, the proposed Noise Barrier wall will be about 6.7 m high and a total length of 190 m.

The discussions and recommendations presented in this report are based on the information provided by AECOM and the factual data obtained during the geotechnical investigation carried out by PML under the current assignment.

9. DESIGN OF NOISE BARRIER WALL FOUNDATIONS

The passive resistance of deep foundations within the frost penetration depth should be neglected. As per OPSD 3090.101, the frost penetration depth for the area is 1.2 m.



A site-specific caisson foundation design may be carried out by the structural engineer using the following equations to calculate the unfactored passive lateral earth pressure, P_p (kPa), distributed along the length of the caisson, assuming the stratigraphy and geotechnical design parameters given in Table 9.

$$P_p = K_p \gamma d_w \quad \text{Above the ground water table}$$

$$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w) \quad \text{Below the ground water table}$$

K_p = passive earth pressure coefficient

γ = unit weight of backfill material above assumed water level (kN/m³)

γ' = unit weight of submerged backfill ($\gamma - \gamma_w$) material below assumed water level (kN/m³)

γ_w = 9.8 (kN/m³)

d = depth below the ground surface (m)

d_w = depth to the groundwater level (m)

Table 9 – Geotechnical Design Parameters for Noise Barrier Wall Foundations

BOREHOLE NO.	ELEVATIONS		SOIL TYPE	DESIGN PARAMETERS		
	FROM	TO		BULK UNIT WEIGHT kN/m ³	SHEAR STRENGTH (C_u), kPa	INTERNAL FRICTION ANGLE
NBW17-1	75.3	67.6	Dense to Very Dense Sandy Silt, Trace Gravel (Till)	20	0	32°
NBW17-2	73.4	68.7	Dense to Very Dense Silty Sand, Some Gravel (Till)	22	0	34°
NBW17-3	74.3	68.5	Compact to Very Dense Silty Sand, Trace/Some Gravel (Till)	21	0	32°
NBW17-4	74.4	67.2	Very dense Silty Sand, Some Gravel (Till)	22	0	34°



10. CONSTRUCTION CONSIDERATION

Water-bearing non-cohesive fill or native soils should be expected and groundwater may flow into the caisson foundation hole during or after the completion of drilling. Therefore, appropriate equipment and procedures will be required to minimize ground loss during drilling and placement of concrete. This may require the use of temporary or permanent liners, and/or the use of drilling mud.

The underlying subsoils along this section of Highway 401 generally comprised of glacial till deposits. Presence of cobbles and/or boulders within the glacial till deposit may be expected. Appropriate equipment and procedures may be required to penetrate these obstructions during the installation of caisson. A Non-Standard Special Provisions (NSSP) may be included in the Contract Documents to alert the contractor.



11. CLOSURE

This Foundation Investigation and Design Report was prepared by Ms. A. Khadem, M.Sc. Eng., EIT., Project Supervisor, and reviewed by Mr. M. Vasavithasan, M.Sc. Eng., P.Eng. Senior Engineer, Geotechnical Services.

Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Asieh Khadem, March 27, 2018

Asieh Khadem, M.Sc. Eng., EIT
Project Supervisor, Geotechnical Services



Carlos M.P. Nascimento, P.Eng.
Project Manager and
MTO Designated Principal Contact

AK/MV/CN:nk



Mark Vasavithasan, M.Sc. Eng., P.Eng.
Senior Engineer, Geotechnical Services



APPENDIX C

List of Standard Specifications Relevant to Report
Non-Standard Special Provisions (NSSP)



LIST OF STANDARD SPECIFICATIONS RELEVANT TO REPORT

DOCUMENT	TITLE
OPSS 903	Construction Specification for Deep Foundations
SP 799F01	Construction Specification for the Installation of Noise Barrier
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario



NON-STANDARD SPECIAL PROVISIONS (NSSP)

NSSP 1 – Obstructions During Caisson Construction

The Contractor shall be advised that cobbles and boulders may present within the fill and glacial till deposit encountered at this site. The Contractor shall be responsible for selecting construction methods and equipment that will enable operations to advance through the embankment fill and/or glacial till including zones where cobbles and boulders are encountered.

NSSP 2 – Water Bearing Soils During Caisson construction

Water-bearing non-cohesive native or fill soils should be expected and groundwater may flow into the caisson foundation hole during or after the completion of drilling. Therefore, appropriate equipment and procedures will be required to minimize ground loss during drilling and concrete placement. This may include the use of temporary or permanent liner, and/or the use of drilling mud.

NSSP 3 – Maintaining Sides and Bases of Excavations for Noise Barrier Wall Foundations Without Disturbance

The Contractor is advised that excavations for deep foundations for noise barriers will extend through ground that is susceptible to disturbance under conditions of unbalanced hydrostatic head.

The sides and base of an excavation for noise barrier foundations shall be maintained without disturbance until installation of that foundation is completed. Although the construction methods remain the responsibility of the Contractor, consideration may be given to the following aspects:

- For construction in-the-dry, the prevailing groundwater level shall be lowered to a minimum of 0.5 m below the base of excavation. For construction in-the-wet, tremie techniques would be required. Temporary liner or mud drilling may be considered to facilitate construction of the excavations.

Concrete for piles installed in pre-augured holes or caissons should be poured as soon as practicable and within 4 hours after completion of excavation.