Final Foundation Investigation and Design Report

Highway 24 Resurfacing and
Replacement of Culvert at
Station 15+138 (Site No. 10)
Township of South Dumfries, ON

G.W.P. 3065-11-00

Geocres No. 40P08-242

Stantec

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Ministry of Transportation Ontario

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Table of Contents

1.0 INTRODUCTION 1

2.0 SITE DESCRIPTION AND GEOLOGY 1

3.0 INVESTIGATION PROCEDURES 2
3.1 REVIEW OF PREVIOUS INVESTIGATION 2
3.2 FIELD INVESTIGATION – CULVERT SITE 2
3.3 LOCATION AND ELEVATION SURVEY 3
3.4 LABORATORY TESTING 3

4.0 SUBSURFACE CONDITIONS 4
4.1 SUBSURFACE PROFILE 4
4.1.1 PAVEMENT 4
4.1.2 Fill 4
4.1.3 Sandy SILT to Sandy Clayey SILT with Gravel 5
4.1.4 PEAT 5
4.1.5 Sandy Clayey SILT to Silty SAND with Gravel 5
4.1.6 Groundwater 6

5.0 CHEMICAL ANALYSIS 6

6.0 MISCELLANEOUS 7

7.0 CLOSURE 8

8.0 GENERAL BACKGROUND 9

9.0 ENGINEERING RECOMMENDATIONS 9
9.1 GEOTECHNICAL DESIGN PARAMETERS 9
9.2 CULVERT OPTIONS 10
9.3 FOUNDATION RECOMMENDATIONS 11
9.3.1 Shallow Foundation 11
9.4 TEMPORARY PROTECTION SYSTEMS 12
9.4.1 Lateral Earth Pressures 14
9.5 EMBANKMENTS 15
9.5.1 Embankment Construction 15
9.5.2 Stability of Slopes 15
9.5.3 Embankment Settlement 15
9.6 EROSION AND SCOUR PROTECTION 15
9.7 CONSTRUCTION STAGING 16
9.8 EXCAVATION AND BACKFILLING 16
9.9 UNWATERING 17
9.10 CEMENT TYPE AND CORROSION PROTECTION 17

10.0 SPECIFICATIONS 18

11.0 REFERENCES 18

12.0 CLOSURE 19

LIST OF TABLES

Table 1.1: Coordinates of Culverts on Highway 24, Township of South Dumfries, ON (MTM Zone 10) 1
Table 3.1: Borehole Summary 3
Table 3.2: Laboratory Testing for Culvert Site 3
Table 4.1: Inferred and Measured Groundwater levels 6
Table 5.1: Results of Chemical Analysis 6
Table 9.1: Geotechnical Model for Culvert 10
Table 9.2: Comparison of the Replacement Options for Culvert at Station 15+138........ 11
Table 9.3: Geotechnical Resistance for Shallow Foundation (Spread Footing)........ 12
Table 9.4: Comparison of Roadway Protection Systems 12
Table 9.5: Recommended Non-Seismic Earth Pressure Parameters (Horizontal Backfill) 14
Table 9.6: Recommended Non-Seismic Earth Pressure Parameters (2H:1V Backfill) 14
Table 10.1: Specifications Referenced in Report 18

LIST OF APPENDICES

APPENDIX A Drawing No. 1 – Borehole Location Plan and Soil Strata Plot
Site Photos

APPENDIX B Symbols and Terms Used on Borehole Records
Borehole Records

APPENDIX C Laboratory Test Results

APPENDIX D Notice to Contractor – Presence of Cobbles and Boulders

FOUNDATION INVESTIGATION REPORT
For
G.W.P 3065-11-00

Highway 24 – Replacement of Culvert at Station 15+138
Site No. 10
Township of South Dumfries

1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to undertake the detailed design for resurfacing of Highway 24, Township of South Dumfries, Ontario. The geotechnical investigations are required to support the design of the replacement of six non-structural culverts located on Highway 24 between Highway 5 and Glen Morris Road East. The culvert numbers along with their approximate easting and northing coordinates given in Table 1.1 below.

Table 1.1: Coordinates of Culverts on Highway 24, Township of South Dumfries, ON (MTM Zone 10)

Culvert Station (Site No.)	Easting	Northing	Culvert Station (Site No.)	Easting	Northing
15+138 (10)	240328.968	4790308.382	16+453 (17)	239955.403	4791538.822
15+738 (12)	240146.455	4790857.376	17+001 (23)	239823.628	4792085.529
16+167 (16)	240028.947	4791272.063	17+845 (29)	239596.513	4792892.253

This Foundation Investigation Report has been prepared specifically and solely for the replacement of Culvert No. 10 which is located at Station 15+138.

Project Number: G.W.P. 3065-11-00

Project Location: Highway 24, 265 m south of Scenic Drive/Howell Road

The work was carried out under MTO Agreement Number 3013-E-0019 with Stantec Consulting Ltd. , the Detailed Design Consultant for this project.

2.0 SITE DESCRIPTION AND GEOLOGY

Site Location

The site location is shown on the Key Plan inset to Drawing No. 1, provided in Appendix A. The existing Culvert crosses beneath Highway 24 near Station 15+138, approximately 0.27 km south of the intersection of Highway 24 and Scenic Drive/Howell Road.

General Site Description

It is noted that Highway 24 runs approximately north to south at the project location with chainage increasing from south to north. In the vicinity of the culvert, Highway 24 has a two lane rural cross-section with approximately 1 m wide paved shoulder with wood guide rails on both sides of the highway.

The culvert allows the water of the watercourses to flow from west to east under the highway. The road embankment has side slopes of approximately 1H:1V to 2H:1V. The paved surface of the highway is approximately 2.2 to 3.6 m higher than the ditches surface on both sides of the road. The area beyond the water course is covered with brush and trees. Site photos are shown in Appendix A.

Existing Culvert

The terms of reference indicate that the existing culvert type is a Corrugated Steel Pipe (CSP). The culvert has a diameter of 910 mm and a length of 30.73 m. The culvert is covered with approximately 1.5 m to 2.0 m of pavement structure and fill. The approximate alignment of the existing culvert is shown on Drawing No. 1 in Appendix A.

3.0 INVESTIGATION PROCEDURES

3.1 REVIEW OF PREVIOUS INVESTIGATION

A review of the Geocres report for the Alder Creek Culvert Replacement located 6.5 km north of the study area suggests that the surficial geology of the site consists of silty sand with gravel to silty gravel with sand till deposits. Depth of bedrock is anticipated greater than 10 m.

3.2 FIELD INVESTIGATION – CULVERT SITE

A field investigation consisting of three boreholes was carried out for this assignment. The boreholes were designated BH15-1, BH15-2, and BH15-3 and their locations are shown on the Borehole Location Plan, Drawing No.1 in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of public utilities.

The field drilling program was carried out on June 8, 15, and 16, 2015. One borehole (BH15-2) was advanced with hollow-stem augers using a truck mounted drill rig equipped for soil and bedrock sampling owned and operated by Downing Drilling of Hawkesbury, ON. Two boreholes (BH15-1 and BH15-3) were advanced using portable drilling equipment owned and operated by Sonic Soil Sampling of Concord, ON.

The subsurface stratigraphy encountered in each borehole was recorded in the field by experienced Stantec personnel. In BH15-2, split spoon samples were collected at regularly spaced intervals (typically every 760 mm) during the course of Standard Penetration Testing

(ASTM D1586). At boreholes BH15-1 and BH15-3, Dynamic Cone Penetration Testing (DCPT) was performed using a 70 lb weight; a 50% correction factor has been applied to the DCPT results presented on the borehole records. Samples were collected using a split spoon sampler advanced using a Pionjar jackhammer within approximately 1 m of the DCPT location. All samples recovered were returned to Stantec's Ottawa laboratory for detailed classification and testing.

Groundwater readings were carried out in open holes immediately upon completion of drilling. Boreholes were backfilled with auger cuttings mixed with bentonite.

3.3 LOCATION AND ELEVATION SURVEY

The borehole locations and geodetic elevations were surveyed in the field by Stantec personnel using a Trimble Geo XH GPS. The elevations are accurate to 0.1 m. Table 3.1 summarizes the borehole information.

Table 3.1: Borehole Summary

	Boreholes		
	BH15-1	**BH15-2**	**BH15-3**
MTM Zone 10 Coordinates Northing Easting	4790320 240337	4790308 240329	4790308 240307
Ground Surface Elevation, m	278.2	281.8	279.6
Total Depth Drilled, m	6.1	9.8	7.6
End of Borehole Elevation, m	272.1	272.0	272.0
Depth Augered, m	NA	9.8	NA
Depth of DCPT from ground surface	6.1	NA	7.6
Depth of Sampling	6.1	9.8	7.6
Number of Soil Samples	8	13	10

3.4 LABORATORY TESTING

All samples were taken to our Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Selected soil samples underwent gradation analysis, Atterberg limits testing and moisture content testing. Two samples were submitted to Parcel Laboratories of Ottawa for analysis of pH, soluble sulphate content, chloride content and resistivity. Laboratory testing summary is shown in the Table below.

Table 3.2: Laboratory Testing for Culvert Site

Laboratory Testing	**Moisture Content**	**Organic Content**	**Gradation Analysis**	**Atterberg Limits**	**Chemical Analysis**
Number of Tests	30	4	8	7	2

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

4.0 SUBSURFACE CONDITIONS

4.1 SUBSURFACE PROFILE

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided.

In general, the subsurface stratigraphy consisted of a pavement structure and fill over silt (sandy silt to sandy clayey silt with gravel) underlain by peat over sandy clayey silt to silty sand with gravel.

Borehole location plans and stratigraphic section of the soils encountered within the boreholes are provided on Drawing No. 1 in Appendix A.

4.1.1 PAVEMENT

100 mm of asphalt pavement was encountered in BH15-2.

4.1.2 Fill

Fill material was encountered beneath the asphalt pavement in BH15-2. The fill consisted of brown silty sand with gravel and brown sandy clayey silt. The fill was approximately 3.8 m thick and extended to the elevation of 278.0 m.

In this layer, the SPT N-values ranged from 10 to 21 blows per 0.3 m suggesting a loose to compact consistency. Fill material was described as moist.

Moisture content and grain size distribution tests carried out on representative samples of the fill yielded the following results:

Gravel:	10 and 37%
Sand:	31 and 49%
Silt and Clay:	14 and 59%
Moisture Content:	5 to 12%

The grain size distribution curve for the fill material is provided in Figure No. 1 in Appendix C.

One Atterberg Limit test was also performed on the fill samples. The Atterberg Limit test yielded plasticity index of 5 and liquid limit of 20. The results suggest a low plasticity. The results are shown in Figure No. 4 of Appendix C.

4.1.3 Sandy SILT to Sandy Clayey SILT with Gravel

Sandy silt to sandy clayey silt with gravel (silt) layer was encountered on ground surface in BH15-1 and BH15-3 and beneath the fill in BH15-2. The silt to was approximately 1.3 m, 2.5 m, and 2.2 m thick and extended to elevation of 276.9 m, 275.5 m, and 277.4 m in BH15-1, BH15-2, and BH15-3, respectively.

In this layer, the SPT N-values ranged from 12 to 23 blows per 0.3 m and the DCPT results ranged from 2 to 4. The results suggest very loose to compact consistency. The silt was described as moist to wet. This layer also contained organic material in BH15-1 and BH15-3.

Moisture content, Atterberg limits, and grain size distribution tests carried out on a representative sample of the silt yielded the following results:

Gravel:	2 to 24%
Sand:	26 to 43%
Silt:	43 to 49%
Clay:	6 to 10%
Moisture Content:	13 to 59%

The grain size distribution curve for the silt is provided in Figure No. 2 of Appendix C.

Three Atterberg Limit tests were also performed on the silt samples. The Atterberg Limit test yielded plasticity index of 4 and liquid limit of 26 for one sample and non-plastic for two samples. The results suggest a low plasticity. The results are shown in Figure No. 4 of Appendix C.

4.1.4 PEAT

A peat layer was encountered beneath the silt in all boreholes. The peat layer was approximately 1.7 m, 1.3 m, and 5.4 m thick and extended to the elevations of 275.1 m, 274.1 m, and 272.0 m, respectively.

The moisture content tests on samples of the peat layer were 65% and 379%. The organic content tests results were 52%, 57%, 38%, and 63% for samples SS3 in BH15-1, SS10 in BH15-2, SS4 in BH15-3, and SS7 in BH15-3, respectively.

4.1.5 Sandy Clayey SILT to Silty SAND with Gravel

A sandy clayey silt to silty sand with gravel layer was encountered beneath the peat in all boreholes. The deposit extended to the termination depths of the boreholes.

In this layer, the SPT N-values ranged from 8 to 14 blows per 0.3 m and the DCPT results ranged from 2 to 53. The results suggest a loose to compact consistency.

Moisture content, Atterberg limits, and grain size distribution tests carried out on representative samples of the sandy clayey silt to silty sand with gravel yielded the following results:

Gravel:	8 to 30%
Sand:	29 to 41%
Silt:	26 to 53%
Clay:	3 to 12%
Moisture Content:	8 to 26%

The grain size distribution curves for the sandy clayey silt to silty sand with gravel deposit are provided in Figure No. 3 of Appendix C.

Three Atterberg Limit tests were also performed on the sandy clayey silt to silty sand with gravel samples. The Atterberg Limit test yielded plasticity index of 4 and liquid limit of 17 for one sample and non-plastic for two samples. The results suggest a low plasticity. The results are shown in Figure No. 4 of Appendix C.

4.1.6 Groundwater

The groundwater levels were inferred from samples moisture states at the time of drilling. Groundwater levels are provided in the Table below.

Table 4.1: Inferred and Measured Groundwater levels

Borehole No.	Observation/Measurement Date	Groundwater Depth (m)	Ground Surface Elevation(m)	Groundwater Elevation (m)
BH15-4	June 15, 2015	0.0 (inferred)	278.2	278.2
BH15-5	June 8, 2015	5.3	281.8	276.4
BH15-6	June 16, 2015	0.0 (inferred)	279.6	279.6

Fluctuations in the groundwater due to seasonal variations or in response to a particular precipitation event should be anticipated.

5.0 CHEMICAL ANALYSIS

Two soil samples were submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphate and chloride concentration, and resistivity. The analysis results are provided in Table 5.1.

Table 5.1: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
BH15-1	SS2a	0.7 to 1.3	7.28	366	14	13.7
BH15-2	SS6	3.8 to 4.4	7.64	181	73	15.4

6.0 MISCELLANEOUS

The field work was carried out under the supervision of Athir Nader, E.I.T., under the direction of Christopher McGrath, P.Eng.

USL-1 Underground Service Locators Inc. of Ottawa, Ontario, carried out the private and public utility locates for the boreholes.

The CME 75 drilling equipment drilling equipment was supplied and operated by Downing Drilling of Hawkesbury, Ontario on June 8, 2015. Portable drilling equipment was supplied and operated by Sonic Soil Sampling of Concord, Ontario on June 15 and 16, 2015.

Elevation and location survey of the borehole locations was carried out by Stantec personnel.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory.

This report was prepared by Athir Nader, and reviewed by Christopher McGrath and Raymond Haché, MTO Designated Principal Contact.

7.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted;

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FOUNDATION INVESTIGATION REPORT
For
G.W.P 3065-11-00
Site No. 10
Highway 24 – Replacement of Culvert at Station 15+138
Township of South Dumfries

8.0 GENERAL BACKGROUND

Project Purpose/Justification

Resurfacing of Highway 24, Township of South Dumfries, Ontario is proposed. Foundation investigations were carried out to support the detailed design of the replacement of six culverts located on Highway 24 between Highway 5 and Glen Morris Road East. The results of the foundation investigation and the geotechnical engineering recommendations for the replacement of a Culvert at Station 15+138 are presented in this report.

Proposed Structures

The terms of reference indicate that the existing culvert type is a Corrugated Steel Pipe (CSP). The existing culvert has a diameter of 910 mm and a length of 30.73 m and is covered with approximately 1.5 m to 2.0 m of pavement structure and fill. The invert elevation of the existing culvert is between elevations of 278.1 m and 278.4 m.

The existing CSP culvert will be replaced with 2.4 m by 1.8 m and 30.5 long pre-cast concrete box culvert. The alignment of the proposed culvert replacement will match the existing culvert alignment. The proposed invert elevations of the culvert at upstream and downstream ends are 278.4 m and 278.1 m respectively.

Construction Staging & Detours

It is understood that a short term local road detour is not anticipated for the culvert replacement.

The culvert replacement will require roadway protection. Since each half of the culvert will be replaced separately, a single lane could be used with highway traffic being controlled by a continual flagging operation or temporary lights.

9.0 ENGINEERING RECOMMENDATIONS

9.1 GEOTECHNICAL DESIGN PARAMETERS

The soil conditions at this site generally consist of a pavement structure and fill over sandy silt to sandy clayey silt with gravel (silt) underlain by peat over sandy clayey silt to silty sand with gravel.

For design purposes, the following soils profile will be used:

Table 9.1: Geotechnical Model for Culvert

Approximate Elevation		Soil Type	Design Properties
From	To		
281.8	280.6	FILL: silty SAND with gravel Loose to compact	Total Unit Weight = 20 kN/m^3 Friction Angle, ϕ = 32° E' = 15 MPa
280.6	278.0	FILL: sandy clayey SILT Compact Cobbles and boulders	Total Unit Weight = 19.0 kN/m^3 Undrained Shear Strength= 50 kPa Friction Angle, ϕ = 30° (drained) E' = 10 MPa
278.0	275.5	Sandy SILT to sandy clayey SILT with gravel Very loose to loose	Total Unit Weight = 19.0 kN/m^3 Undrained Shear Strength= 50 kPa Friction Angle, ϕ = 28° (drained) E' = 9 MPa
275.5	274.1	PEAT	NA
274.1	272.0	Sandy clayey SILT to silty SAND with gravel Loose to compact	Total Unit Weight = 19.8 kN/m^3 Friction Angle, ϕ = 29° E' = 11 MPa

A design water level elevation of 278.4 m will be considered for the culvert site. This water level reflects the minimum possible water flow in the culvert. It is assumed that peat is stable and been compressed during and after the construction of the original culvert. Stantec is not aware of any settlement or other issues regarding the presence of peat beneath the culvert. Therefore, if peat is not exposed and does not cause settlement or other issues during the construction of the new culvert, peat could remain and not be removed. Stantec should be contacted if found otherwise.

9.2 CULVERT OPTIONS

It is understood that the current CSP culvert will be replaced by a 2.4 m x 1.8 m pre-cast concrete box culvert. It is understood that retaining walls/head walls will not be required for culvert replacement.

The thickness of the peat and the moisture content of the peat samples test in BH 15-2, when compared to those observed in BH15-1 and BH15-3, suggests that the peat may have compressed as much as 2.0 m under the embankment load, assuming that none of the peat was removed at the time of initial construction. The proposed new 1.8 m by 2.4 m box culvert to replace the existing 910 mm diameter pipe culvert will result in a net unloading of the peat which should halt the settlements if they are on-going and otherwise should not produce any new settlements.

The soil conditions at the site should be suitable to support the culvert options. Table 9.2 compares the culvert structure options from a constructability perspective.

Table 9.2: Comparison of the Replacement Options for Culvert at Station 15+138

Option	Advantages	Disadvantages	Relative Cost	Risk/ Consequences	Rank
Precast Rigid Frame Box	• Low bearing pressure on the firm clayey silt • Use of precast sections reduces construction period • Slightly less unwatering volume	• Needs heavy lifting equipment • Poorer hydraulic performance	Medium		1
Rigid Frame Open Footing		• Higher bearing pressure on the firm silty clay • Slower construction process • Greater unwatering volume require • Poorer hydraulic performance • Concrete not readily available • Requires RSS at inlet	High	• Higher risk of unwatering related issues • Concrete curing process	4
Open Bottom Steel Arch with Concrete Footing	• Low material and installation cost	• Requires RSS at inlet • Concrete not readily available	Low to Medium	• Higher risk of unwatering related issues • Concrete curing process	3
Corrugated Steel Pipe	• Low material and installation cost	• Maintenance Requirements	Low	• Corrosion of steel • Short design life	2

The comparison indicates that the preferred culvert replacement option is a precast rigid frame box. Additional recommendations regarding bedding and backfill material is provided in Section 9.8.

9.3 FOUNDATION RECOMMENDATIONS

The design recommendations presented in the following sections have been developed in accordance with the requirements and methods described in the Canadian Highway Bridge Design Code (CHBDC, 2006).

9.3.1 Shallow Foundation

This section provides recommendations for the design of spread footings founded on undisturbed soil.

9.3.1.1 Geotechnical Vertical Resistance

The geotechnical resistances provided in Table 9.3 may be used in the design, provided the footings are placed on undisturbed soil.

Table 9.3: Geotechnical Resistance for Shallow Foundation (Spread Footing)

Founding Element	Founding Elevation (m)	Culvert Dimension (m)	Factored Geotechnical Resistance at ULS_f (kPa)	Geotechnical Resistance at SLS (kPa)
Spread footing on undisturbed soil	± 278.1	2.4 x 30.5	150	100

In accordance with Section 6.6.2 of the CHBDC, a resistance factor of 0.5 has been applied in calculating the factored geotechnical resistance at Ultimate Limit State (ULS_f).

The axial reaction at SLS corresponds to a vertical deflection (settlement) of 25 mm. It is noted that the thickness of the peat and the moisture content of the peat in BH15-2 compared to that observed in BH15-1 and BH15-3 suggests that peat may have compressed as much as 2.0 m assuming that none of the peat was removed prior to roadway construction. The new 1.8 m by 2.4 m box culvert will reduce the net load on the peat and will not trigger new consolidation settlements.

9.3.1.2 Geotechnical Horizontal Resistance (Sliding)

The unfactored horizontal resistance of spread footings may be calculated using the following unfactored coefficients of friction:

0.55 Between OPSS Granular A and concrete
0.45 between native soil and concrete

In accordance with Table 6.1 of the CHBDC, a resistance factor against sliding of 0.8 should be applied to obtain the resistance at ULS_f.

9.4 TEMPORARY PROTECTION SYSTEMS

A culvert invert elevation of approximately 278.1 m will require a maximum excavation depth of approximately 4.2 m. Based on the recommended excavation site slope of 1.5H:1V (Section 9.7) a temporary roadway protection will be required for the culvert replacement. The roadway protection or the culvert replacement will necessitate excavation below the groundwater levels. As such, unwatering of the excavation will be required for the culvert replacement, and may also be required during installation of the roadway protection system.

The following table compares the available roadway protection options considered for the culvert replacement:

Table 9.4: Comparison of Roadway Protection Systems

Option	Advantages	Disadvantages	Relative Cost	Risk & Consequences
H-Piles with timber lagging; struts/rakers	• Simple installation	• Dewatering more difficult	Low	• Possible lack of ground stability when extending below the water table

Option	Advantages	Disadvantages	Relative Cost	Risk & Consequences
Steel sheet pile (SSP); rakers/ tieback anchors or internal bracing	• No unwatering required during roadway protection installation • The excavation level is expected to extend to the sandy clayey silt to silty clay soil. A coffered sheet pile approach would allow for a construction area kept dry using conventional unwatering practices	• Difficult to drive/install in dense soil with cobbles	High	• Damage or loss of sheet pile walls during driving

Since the excavation is expected to extend to about elevation 277.6 m, and the water level at elevation 278.4 m, the use of a simple soldier pile wall along the centerline of the road is not likely a feasible option. The bottom of the sandy silt to sandy clayey silt with gravel layer is as high as elevation 275.5 m. It should be noted that the sandy silt to sandy clayey silt with gravel layer would behave as an aquitard relative to the underlying peat and sandy clayey silt to silty sand with gravel layer and that sub-artesian conditions will develop during the excavation period where the water level in the piezometer head in the deeper layer may be 1 m or more above the excavation depth.

The contractor may choose to use coffered sheet piles to control groundwater issues. Assuming the water table to be 2.5 m above the excavation depth it is anticipated that provided the sheet piles are driven to at least 2.0 m below the excavation depth, conventional sump pumping from within the sheet piled excavation would be feasible. Sheet piles would be strutted or driven deeper to provide horizontal stability. A Notice to Contractor is provided in Appendix D which alerts the Contractor of the presence of cobbles and boulders in the soil.

The contractor will ultimately be responsible to develop and implement a roadway protection system meeting the requirements of OPSS 539, including establishing appropriate geotechnical design parameters.

Shoring design should meet the requirements of Performance Level 2 as per OPSS 539 and should consider traffic loading. Performance Level 2 specifies a Maximum Angular Distortion of 1:200 and a Maximum Horizontal Displacement of 25 mm. Pile and raker spacing must be designed not to exceed these limits. Horizontal movement should be monitored throughout the culvert replacement process as described in OPSS 539. The monitoring requirements outlines in OPSS 539 are considered to be appropriate for this project.

9.4.1 Lateral Earth Pressures

9.4.1.1 Lateral Earth Pressures under Static Conditions

Earth pressures will need to be considered in the design of the temporary roadway protection system.

Computation of earth pressures should be in accordance with Section 6.9 of the CHBDC and the Occupational Health and Safety Act Regulations for Construction Projects. The distribution of earth pressures acting on the protection system could be estimated using the Canadian Foundation Engineering Manual. For retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. The unfactored soil parameters provided in Table 9.1 may be used for design of walls and protection systems with a horizontal backfill. The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6.6 of the CHBDC.

Values for K_a, K_o, K_p, and γ are provided in Tables 9.5 and 9.6 for horizontal and 2H:1V backfill.

Table 9.5: Recommended Non-Seismic Earth Pressure Parameters (Horizontal Backfill)

Parameter	OPSS Gran A and Gran B Type II	FILL: silty SAND with gravel	FILL: sandy clayey SILT	Sandy SILT to sandy clayey SILT with gravel	Sandy clayey SILT to silty SAND with gravel
Bulk Unit Weight, γ (kN/m^3)	22.0	20.0	19.0	19.0	19.8
Effective Friction Angle	35°	32°	30°	28°	29°
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.47	0.50	0.53	0.52
Coefficient of Active Earth Pressure (K_a)	0.27	0.31	0.33	0.36	0.35
Coefficient of Passive Earth Pressure (K_p)	3.69	3.25	3.00	2.77	2.88

Table 9.6: Recommended Non-Seismic Earth Pressure Parameters (2H:1V Backfill)

Parameter	OPSS Gran A and Gran B Type II	FILL: silty SAND with gravel	FILL: sandy clayey SILT	Sandy SILT to sandy clayey SILT with gravel	Sandy clayey SILT to silty SAND with gravel
Bulk Unit Weight, γ (kN/m^3)	22.0	20.0	19.0	19.0	19.8
Effective Friction Angle	35°	32°	30°	28°	29°
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.47	0.50	0.53	0.52
Coefficient of Active Earth Pressure (K_a)	0.39	0.47	0.53	0.62	0.57

9.5 EMBANKMENTS

The roadway profile at the culvert location will not be raised above the existing profile. Some minor embankment widening may be carried out to accommodate construction staging.

9.5.1 Embankment Construction

Embankment construction should be carried out in conformance with SP 206503.

Embankment slopes should be constructed at no steeper than 2H:1V. The existing slopes should be benched as per OPSD 208.010 if widening is proposed. New fill materials should consist of OPSS Select Subgrade Material (or better) placed in 300 mm thick lifts compacted to at least 95% Standard Proctor Maximum Dry Density.

9.5.2 Stability of Slopes

No sign of embankment instability was observed during the foundation drilling. Stantec is not aware of a history of slope instabilities at the culvert location. The proposed slopes will be reinstated at 2H:1V or gentler.

The proposed slopes are considered stable with respect to deep seated failures with factors of safety of greater than 1.3. Surficial and toe failures could occur if proper erosion control is not provided for the new embankments.

9.5.3 Embankment Settlement

The profile and footprint of the existing embankment is not anticipated to be significantly altered.

Settlement of the underlying soil is anticipated to be less than 25 mm. Self-settlement of the new fill material is anticipated to be less than 25 mm and should occur during construction.

9.6 EROSION AND SCOUR PROTECTION

All slopes within 3 m of the culvert inlets and outlets should be surfaced with rip-rap at least 300 mm thick placed on a Class II non-woven filter fabric.

Normal slope vegetation should be established as soon as possible after completion of embankment fills in order to control surficial erosion.

A clay seal should be provided at the inlet of the culvert to prevent seepage through the backfill material. The clay seal should be constructed as follows:

- Clay should meet OPSS 1205 specifications.
- At least 0.6 m thick.
- Extend from 0.3 m above the high water level to the full depth of excavation.
- Seal should not be located beneath the pavement structure.

The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site.

9.7 CONSTRUCTION STAGING

The culvert replacement is anticipated to involve a staged construction. This will involve the closure of one lane at a time for a short duration using appropriate traffic control. Two options are being evaluated for the construction staging:

Option 1: Support the excavation with temporary roadway protection near the centerline of the highway. Recommendations for temporary roadway protection are provided in Section 9.4.

Option 2: Temporarily lowering the profile of the roadway at the culvert and replacing the culvert without temporary roadway protection. Recommendations for temporary excavation side slope are presented in Section 9.8.

9.8 EXCAVATION AND BACKFILLING

Excavation and backfill for the new culvert should be carried out in accordance with:

- OPSS 902
- MTOD 803.021

Bedding and backfill material should be provided for the culvert as per the appropriate OPSD specification. The bedding material should include a 275 mm thick layer of OPSS Granular A consisting of a 75 mm thick uncompacted levelling course over a 200 mm thick compacted layer. Organic soil encountered within the footprint of the bedding layer should be subexcavated and the bedding layer thickness increased accordingly. The backfill material should consist of free-draining, non-frost susceptible granular material such as OPSS Granular A or Granular B Type I. The bedding and backfill material should be placed in 300 mm thick lifts compacted to at least 95% SPMDD.

The groundwater level should be lowered at least 0.5 m below the subgrade level of the culverts to provide a stable base during placement of culvert bedding material.

OPSD 3090.101 indicates that the frost penetration depth at the site is 1.4 m. The frost penetration depth should be used for the design of the culvert frost taper.

Side slopes for open cut excavations (if any) should conform to Occupational Health and Safety Act (OHSA) regulations for Construction Projects. The soils encountered at the site may be classified as Type 3 Soil. The excavation walls should be sloped from its bottom with a slope having a minimum gradient of 1H:1V. Excavation below the water table will require gentler slopes. If the excavation extends to the peat layer, the soils encountered at the site may be classified as Type 4 Soil and the excavation walls should be sloped from its bottom with a slope having a minimum gradient of 3H:1V.

9.9 UNWATERING

Replacement of the culvert will require excavation below the groundwater level encountered during the investigation. Control of groundwater during construction is required. The groundwater level should be lowered to at least 0.5 m below the subgrade level of the culvert to provide a stable base during placement of culvert bedding material.

The native soils within the anticipated depth of excavation have a low to moderate hydraulic conductivity, in the order of 10^{-4} to 10^{-6} cm/s. However, if the excavation extends to the peat layer, high hydraulic conductivity is anticipated in the order of 10^{-1} cm/s. For the case of sheet piles extending to at least 1.0 m below the bottom of excavation, unwatering of the culvert excavation using conventional sump and pump techniques should be adequate.

9.10 CEMENT TYPE AND CORROSION PROTECTION

Two samples of the native soils were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The testing was completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in Table 5.1.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The soluble sulphate concentrations for the samples were 14 µg/g and 73 µg/g. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU (General Use) Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH values were 7.28 and 7.64 which are within what is considered the normal range for soil pH of 5.5 to 9.0. The pH levels of the tested soil do not indicate a highly corrosive environment. The test results provided in Table 5.1 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

10.0 SPECIFICATIONS

The following specifications are referenced in this report:

Table 10.1: Specifications Referenced in Report

Document	Title
OPSD 3090.101	Foundation, Frost Depths for Southern Ontario
OPSS 539	Construction Specification for Temporary Protection System
OPSS 902	Construction Specification for Excavation and Backfilling – Structures
MTO 803.021	Bedding and Backfill for Precast Concrete Box Culvert
OPSS 1205	Material Specification for Clay Seal

11.0 REFERENCES

ASTM. 1999. Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). ASTM International, West Conshohocken, PA.

ASTM. 2000. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) (ASTM D2487). ASTM International, West Conshohocken, PA.

CHBDC. 2006. Canadian Highway Bridge Design Code. Canadian Standards Association, Mississauga, Ontario.

12.0 CLOSURE

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

This report was prepared by Athir Nader, and reviewed by Christopher McGrath and Raymond Haché.

Respectfully submitted,

STANTEC CONSULTING LTD.

LICENSED PROFESSIONAL ENGINEER
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17/01/19
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Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact

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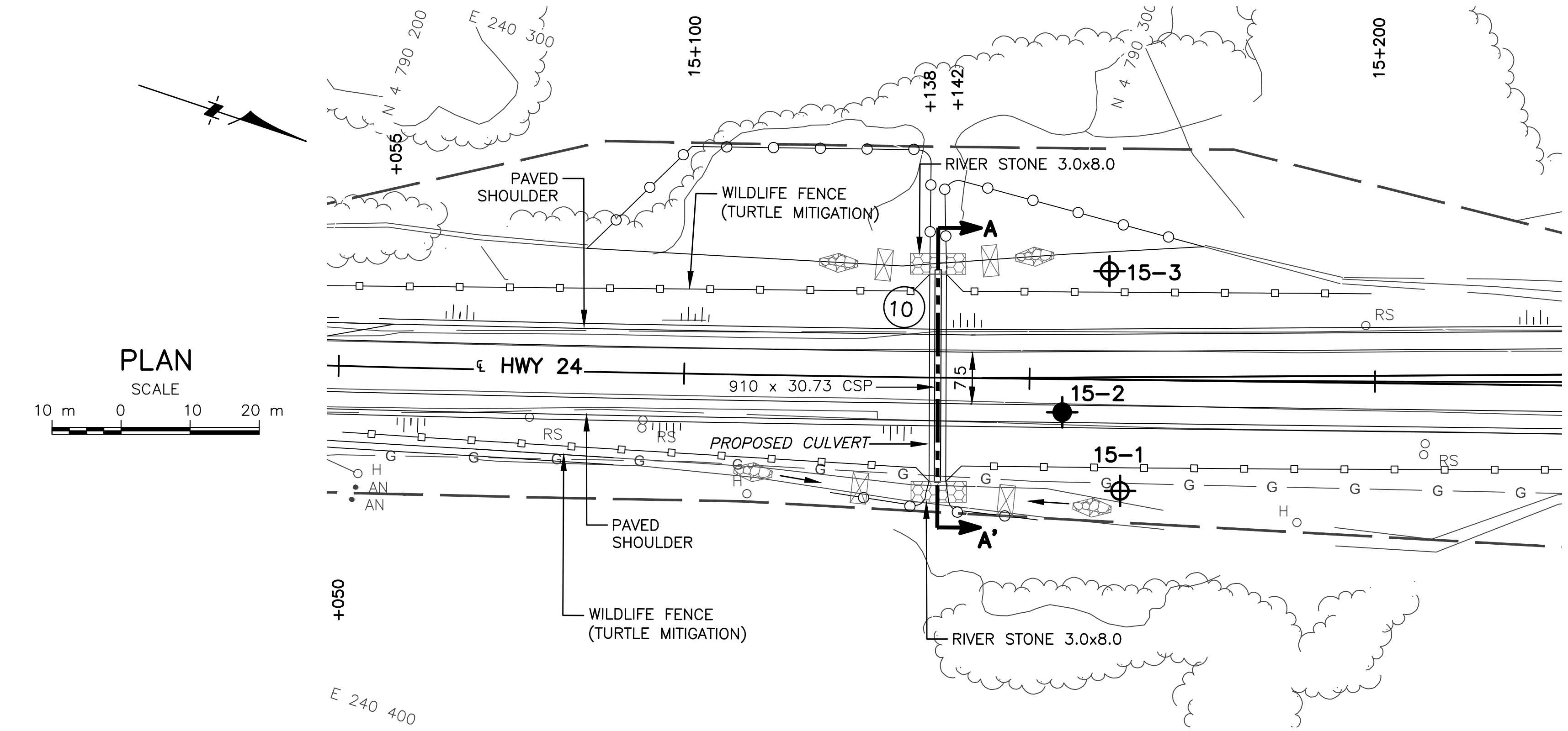
APPENDIX A

Drawing No. 1 – Borehole Location Plan and Soil Strata Plot

Site Photos



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

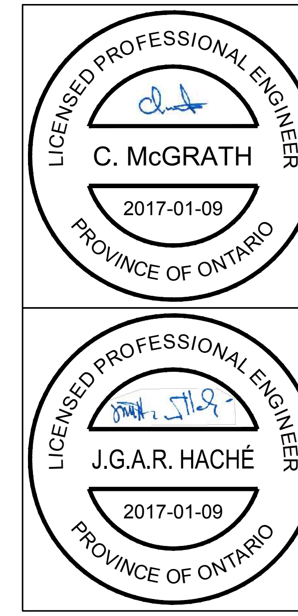
PLATE No

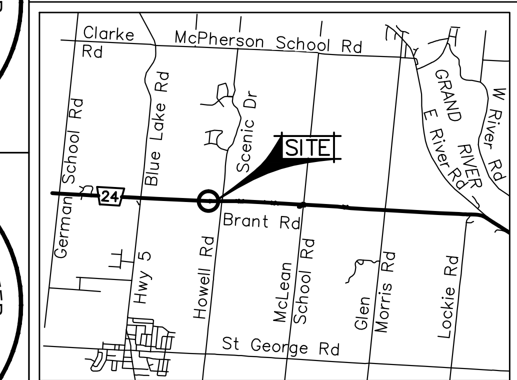
CONT WP 3065-11-00

SHEET

HWY 24, TWP OF S DUMFRIES, ON
CULVERT AT STA 15+138 (SITE 10)
BOREHOLE LOCATIONS & SOIL STRATA

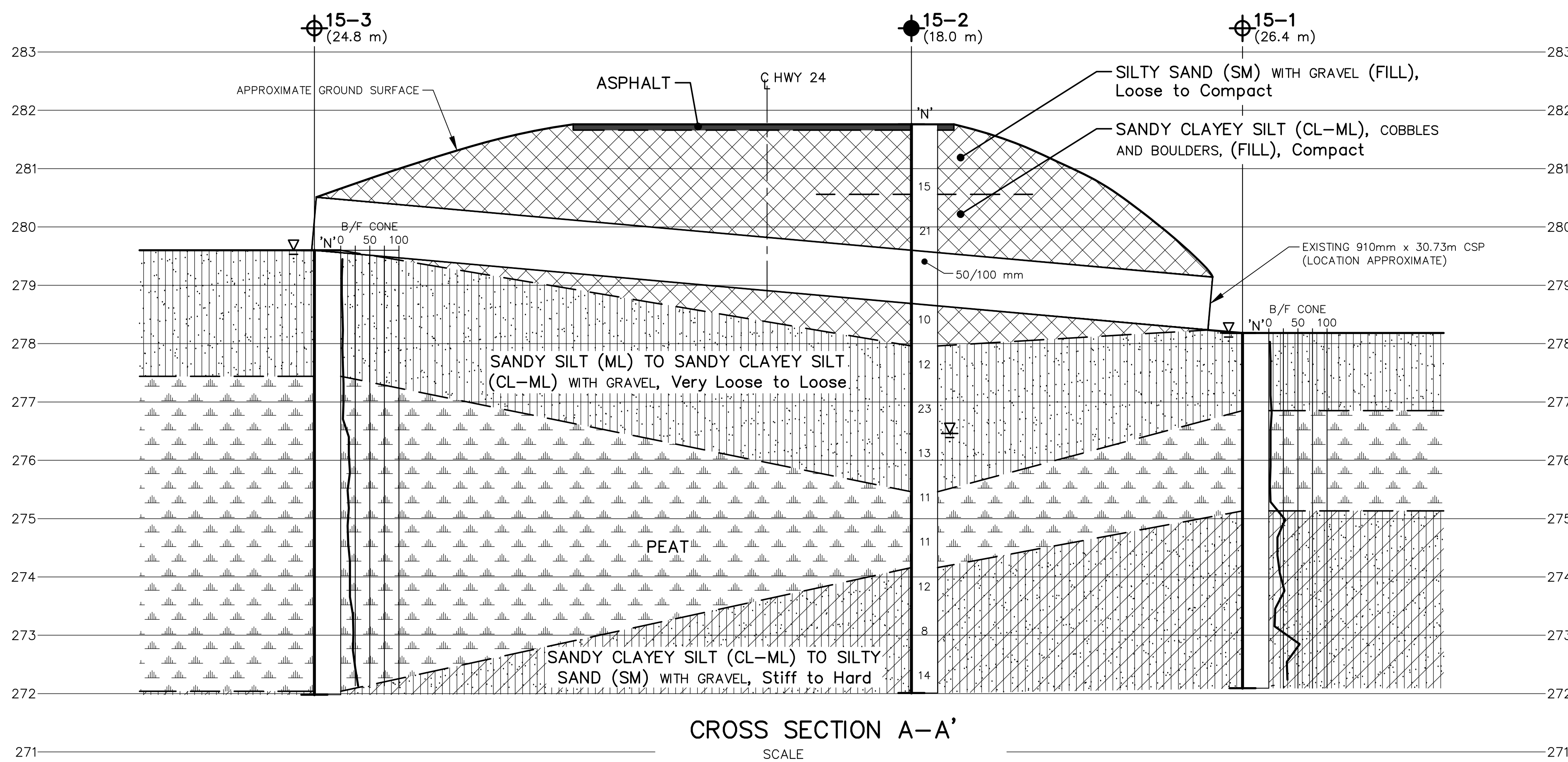
Stantec





KEY PLAN

1 km 0 1 2 3 km



CROSS SECTION A-A'

SCALE

2 m 0 2 4 m HORIZONTAL

1 m 0 1 2 m VERTICAL

LEGEND

●	Borehole
⌖	Dynamic Cone Penetration Test (Cone)
(x.x m)	Offset from Cross Section Line in meters
N	Blows/0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
▽	Inferred WL at time of investigation, June 2015

No	ELEVATION	MTM ZONE 10 COORDINATES NORTH	EAST
15-1	278.2	4 790 319.9	240 337.1
15-2	281.8	4 790 308.4	240 329.0
15-3	279.6	4 790 308.4	240 307.4

NOTES

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

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS DATE	BY	DESCRIPTION
2017-01-09	CM	ADDED GEOCRES NUMBER

GEOCRES No 40P08-242

HWY No HWY	24		DIST
SUBM'D AN	CHECKED	DATE 2015-10-08	SITE C10
DRAWN GBB	CHECKED	APPROVED	DWG 1

Stantec	Project No.: 165000903	GWP: 3065-11-00	Site Photographs
	Project Name: Culvert 10, Highway 24 Pavement Rehabilitation, Township of South Dumfries, ON		Date: June 8, 2015

Site Photo No.: 1	Looking north on BH15-2

Site Photo No.: 2	Looking south on BH15-2

Stantec	Project No.: 165000903	GWP: 3065-11-00	Site Photographs
	Project Name: Culvert 10, Highway 24 Pavement Rehabilitation, Township of South Dumfries, ON		Date: June 8, 2015

Site Photo No.: 3	Looking west toward BH15-3 on BH15-2

Site Photo No.: 4	Looking east toward BH15-1 on BH15-2

Stantec	Project No.: 165000903	GWP: 3065-11-00	Site Photographs
	Project Name: Culvert 10, Highway 24 Pavement Rehabilitation, Township of South Dumfries, ON		Date: June 15, 2015

Site Photo No.: 5	Looking east on BH15-3

Site Photo No.: 6	Looking north on BH15-1

APPENDIX B

Symbols and Terms Used on Borehole Records

Borehole Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

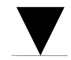
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

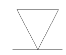
Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT


measured in standpipe, piezometer, or well


inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_U	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

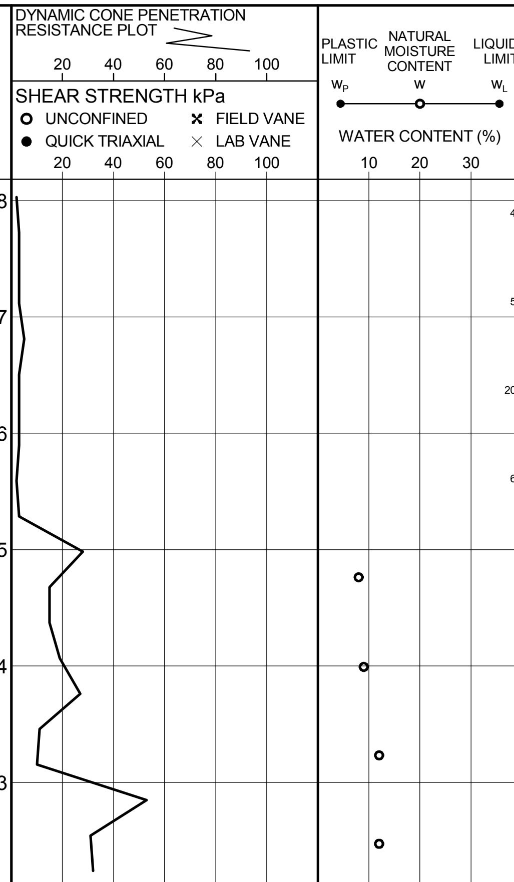
	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

RECORD OF BOREHOLE No BH15-1

METRIC

W.P. 3065-11-00	LOCATION Hwy 24, Township of South Dumfried, ON	N: 4 790 320 E: 240 337	ORIGINATED BY AN
DIST South Dumfries HWY 24	BOREHOLE TYPE Portable Equipment, DCPT - Pionjar Split spoon Sampler		COMPILED BY AN
DATUM Geodetic	DATE 2015 06 15 - 2015 06 15		CHECKED BY CM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
278.2 / 0.0	Sandy SILT (ML) Loose Grey, moist to wet, trace of organic material	1	SS		2 43 49 6 non-plastic
		2	SS		
276.9 / 1.3	PEAT Black, wet	3	SS		
		4	SS		
275.1 / 3.1	Silty SAND (SM) with gravel to sandy SILT (ML) Compact to dense Grey, wet	5	SS		30 41 26 3 non-plastic
		6	SS		
		7	SS		
		8	SS		8 33 53 6 non-plastic
272.1 / 6.1	End of Borehole				



End of Borehole

-Split spoon sampler was advanced using a Pionjar jackhammer
-DCPT was carried out using a 70 lb weight hammer and 30 in. drop
-DCPT values corrected for 50% of the field values

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

STN13-ONTARIO MTO STANTEC 165000903 - PAVEMENT REHAB HWY 24 - MTO.GPJ ONTARIO MOT.GDT 10/14/15

RECORD OF BOREHOLE No BH15-2

METRIC

Stantec

W.P. 3065-11-00 LOCATION Hwy 24, Township of South Dumfried, ON N: 4 790 308 E: 240 329 ORIGINATED BY AN

DIST South Dumfries HWY 24 BOREHOLE TYPE Hollow Stem Augers - Split spoon Sampler COMPILED BY AN

DATUM Geodetic DATE 2015 06 08 - 2015 06 08 CHECKED BY CM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
281.8						
281.7 / 0.1	100 mm ASPHALT					
	Fill: loose to compact brown silty SAND (SM) with gravelly -moist	1	GS	-		37 49 (14)
		2	SS	15		
280.6 / 1.2	Fill: compact brown sandy clayey SILT (CL-ML) -moist -cobbles and boulders between 2.4 m and 2.7 m	3	SS	21		
		4	SS	100		
		5	SS	10		10 31 46 13
278.0 / 3.8	Sandy SILT (ML) with gravel Compact Grey, moist to wet	6	SS	12		
		7	SS	23	▽	
		8	SS	13		14 31 45 10 non-plastic
275.5 / 6.3	PEAT Black, wet	9	SS	11		(w = 81)
		10	SS	11		(w = 190)
274.1 / 7.6	Silty SAND (SM) to sandy clayey SILT (CL-ML) Loose to compact Grey, wet	11	SS	12		
		12	SS	8		8 29 51 12
		13	SS	14		
272.0 / 9.8	End of Borehole					

ELEVATION SCALE: 281, 280, 279, 278, 277, 276, 275, 274, 273

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O 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 (%): 10 20 30

UNIT WEIGHT γ kN/m³

✖ 3, × 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH15-3

METRIC

Stantec

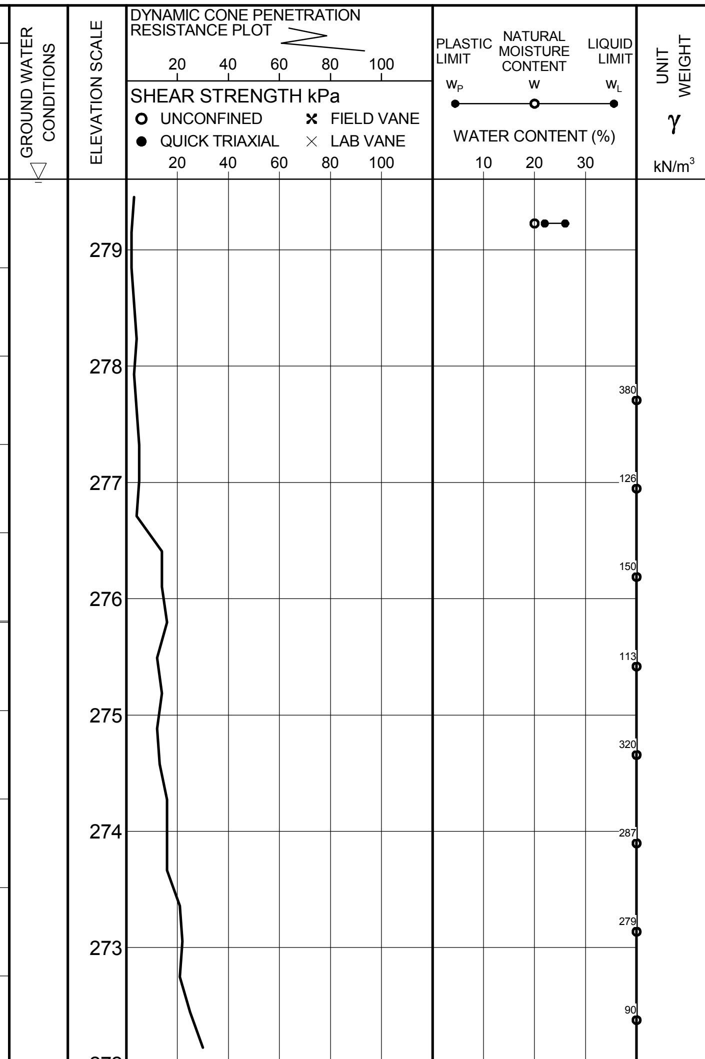
W.P. 3065-11-00 | LOCATION Hwy 24, Township of South Dumfried, ON | N: 4 790 308 E: 240 307 | ORIGINATED BY AN

DIST South Dumfries HWY 24 | BOREHOLE TYPE Portable Equipment, DCPT - Pionjar Split spoon Sampler | COMPILED BY AN

DATUM Geodetic | DATE 2015 06 15 - 2015 06 16 | CHECKED BY CM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.6 / 0.0	Sandy clayey SILT (CL-ML) with gravel Very loose to loose Grey, moist to wet, trace of organic material	1	SS		24 26 43 7
		2	SS		
277.4 / 2.2	PEAT Black, wet	3	SS		
		4	SS		
		5	SS		
		6	SS		
		7	SS		
		8	SS		
		9	SS		
		10	SS		
272.0					
272.0 / 7.6	Sandy clayey SILT (CL-ML) Compact Grey, wet				
	End of Borehole				

-Split spoon sampler was advanced using a Pionjar jackhammer
-DCPT was carried out using a 70 lb weight hammer and 30 in. drop
-DCPT values corrected for 50% of the field values

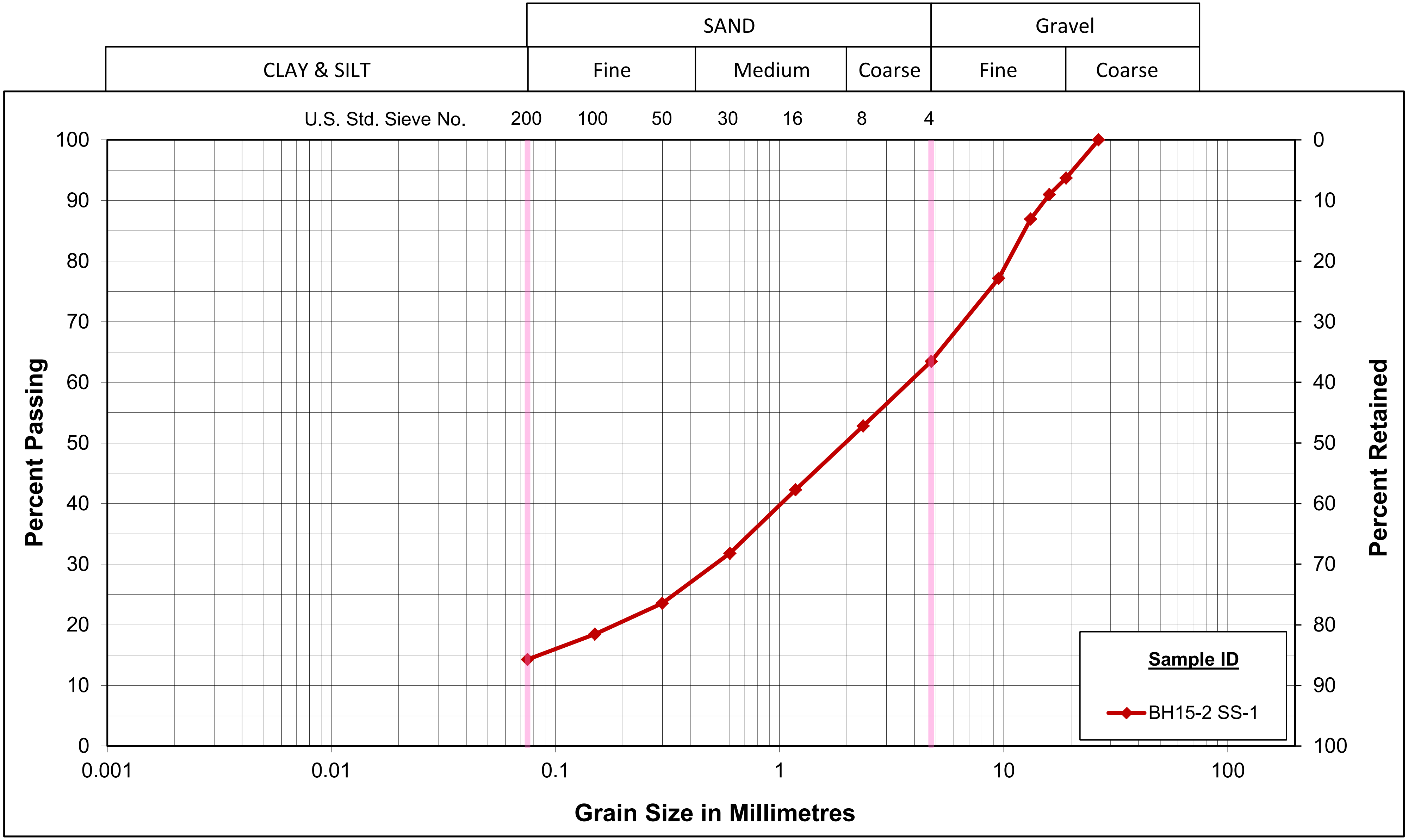


×3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

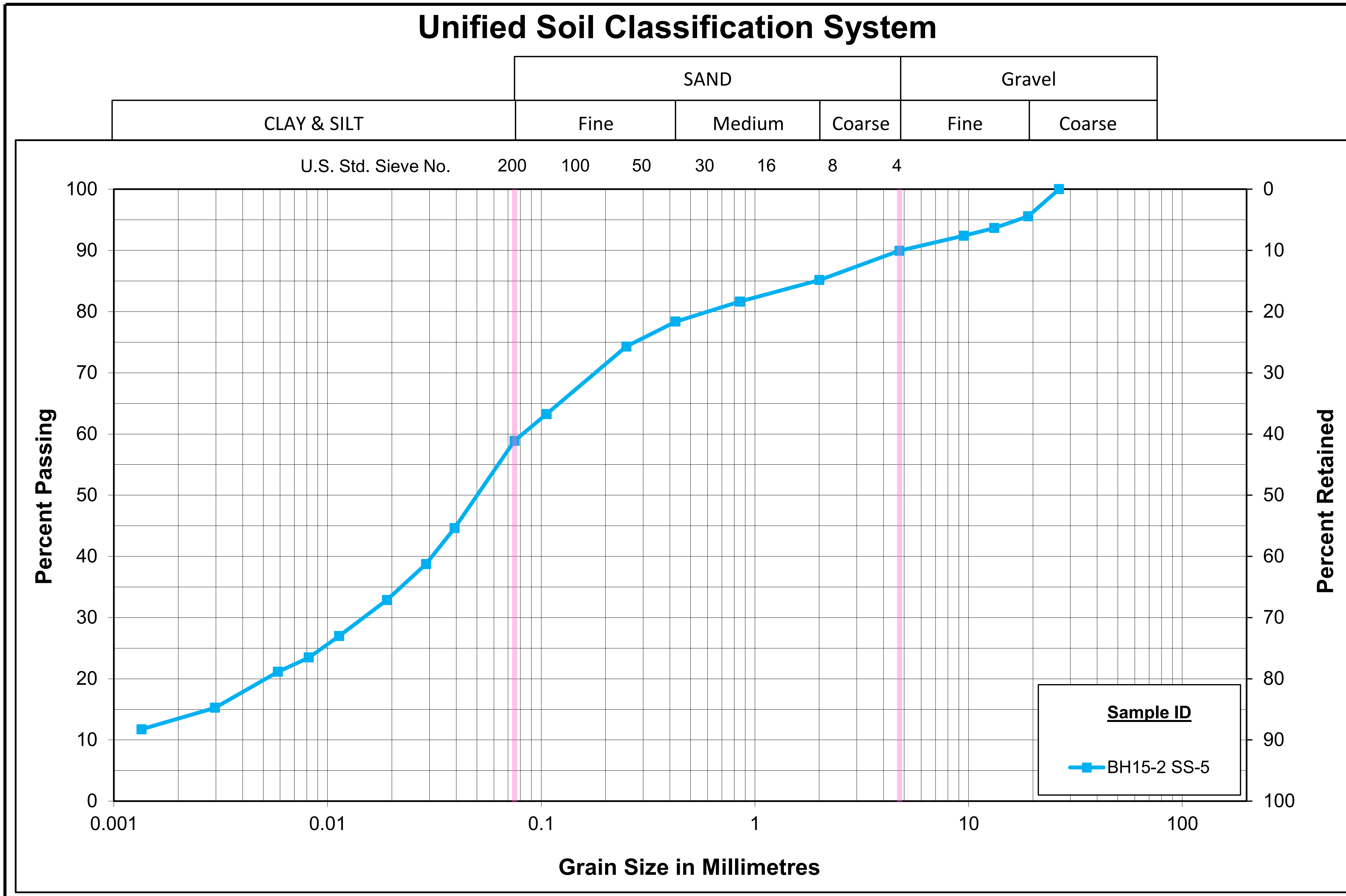
APPENDIX C

Laboratory Test Results

Unified Soil Classification System



Stantec	GRAIN SIZE DISTRIBUTION FILL: silty SAND (SM) with gravel	Figure No. 1a Project No. 165000903



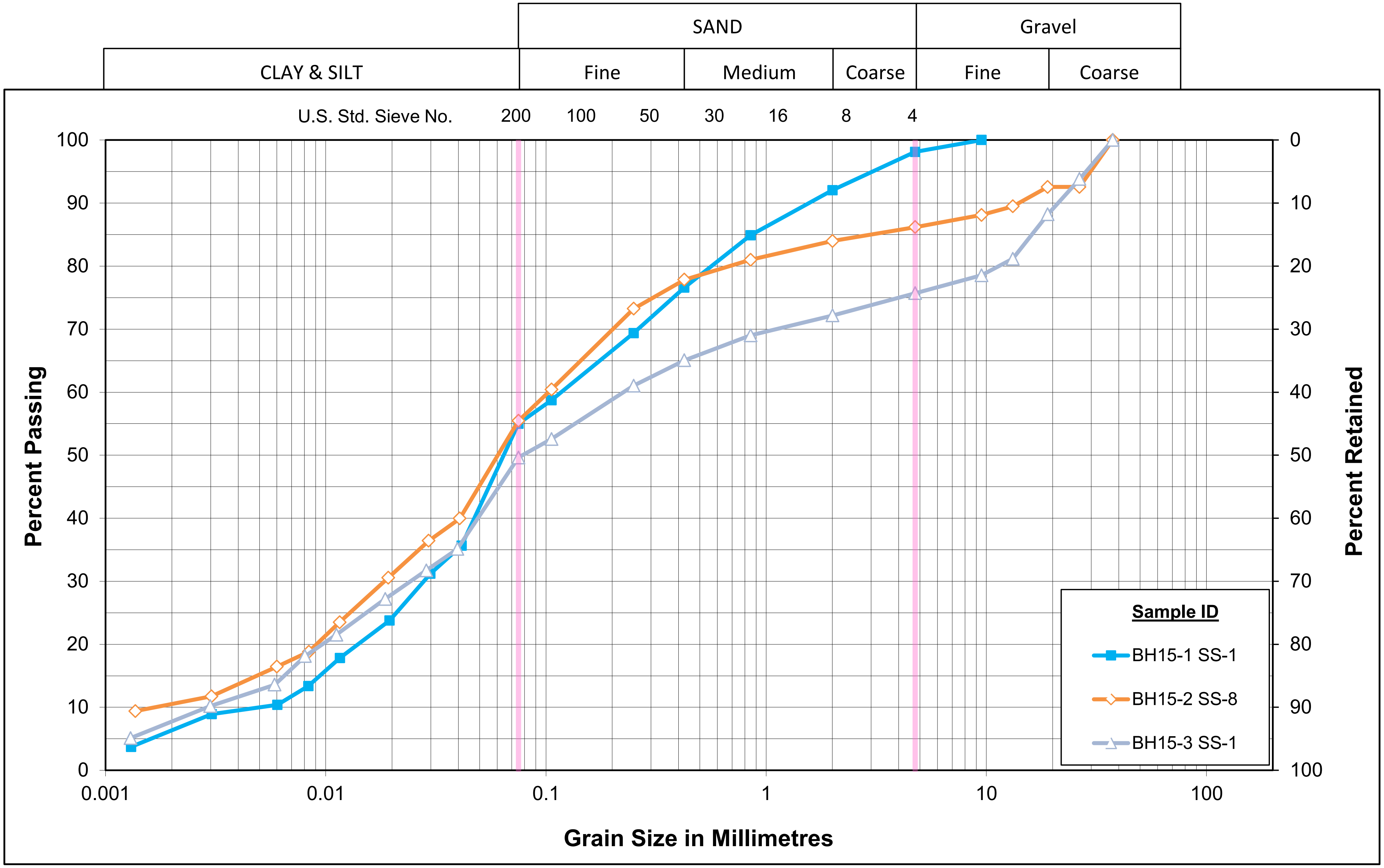
GRAIN SIZE DISTRIBUTION

FILL: sandy clayey SILT (CL-ML)

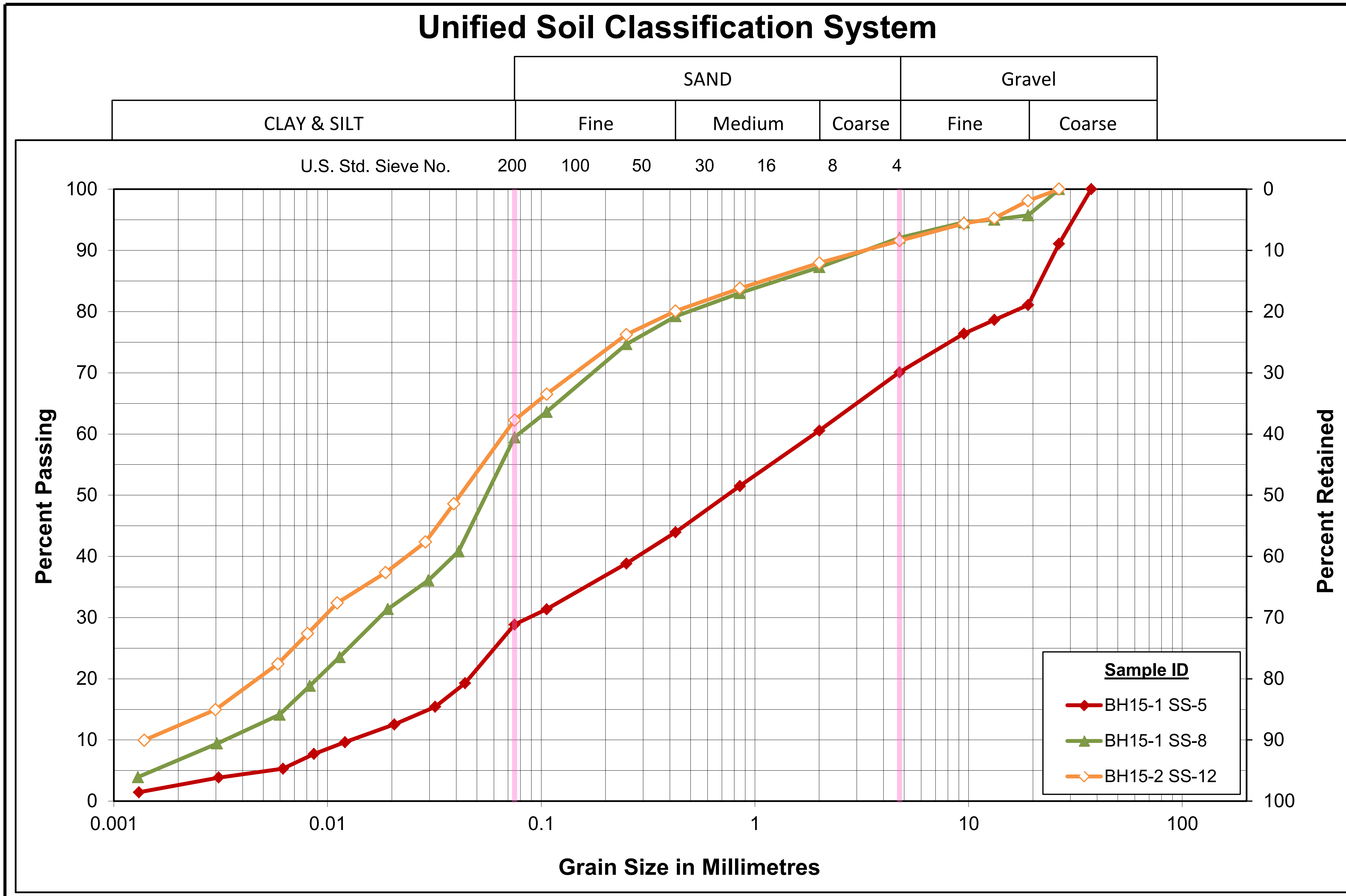
Figure No. 1b

Project No. 165000903

Unified Soil Classification System



Stantec	GRAIN SIZE DISTRIBUTION Sandy SILT (ML) to sandy clayey SILT (CL-ML) with gravel	Figure No. 2 Project No. 165000903

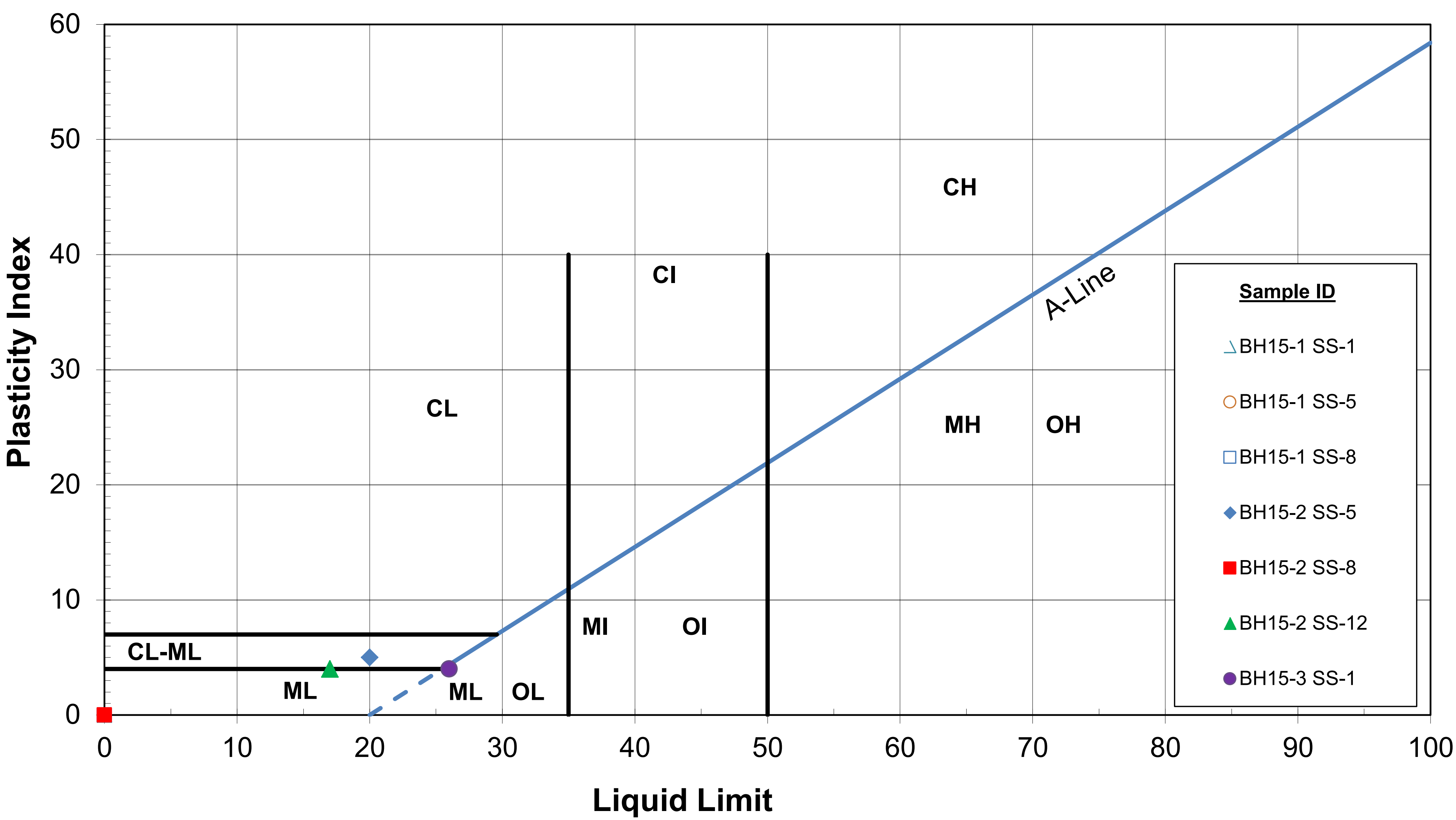


Stantec

GRAIN SIZE DISTRIBUTION
Sandy clayey SILT (CL-ML) to silty SAND (SM) with gravel

Figure No. 3

Project No. 165000903



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PLASTICITY CHART

Figure No. 4

Project No. 165000903

APPENDIX D

Notice to Contractor – Presence of Cobbles and Boulders

NOTICE TO CONTRACTOR – Cobbles and Boulders

Special Provision

Cobbles and Boulders within Soil

Cobbles and boulders were inferred during drilling of the boreholes at several of the culvert replacement locations. Cobbles and boulders were inferred during drilling and the observations are documented in the Foundation Investigations noted below. It recommended that the bidder review the Foundation Investigation Reports and borehole records provided in the Reports with respect to the presence of cobbles and boulders.

Presence of cobbles and boulders are noted in the following Foundation Investigation Report:

- Foundation Investigation and Design Report titled Highway 24 Resurfacing and Replacement of Culvert at Station 15+138 (Site No. 10) Township of South Dumfries, ON
  (Project No. 165000903)