

## **Final Foundation Investigation 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



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Ministry of Transportation Ontario

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Project No. 165000903

January 2017

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# FINAL FOUNDATION INVESTIGATION REPORT

January 2017

## 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.

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## 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

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(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	4790320	4790308	4790308
Easting	240337	240329	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

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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.

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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;

STANTEC CONSULTING LTD.



Christopher McGrath, P.Eng.  
Associate- Senior Geotechnical Engineer



Raymond Haché, M.Sc., P.Eng.  
Designated Principal MTO Foundation Contact

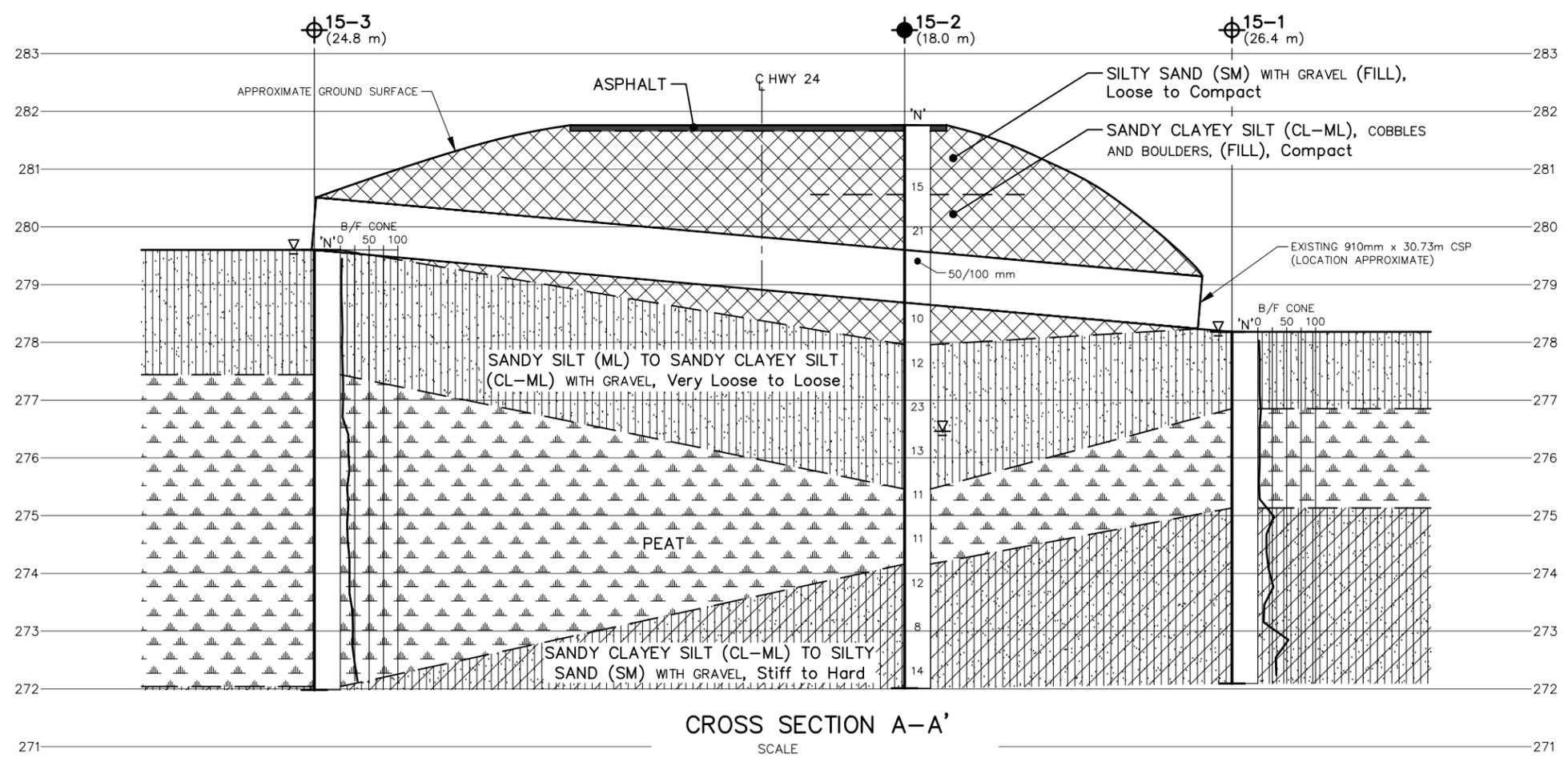
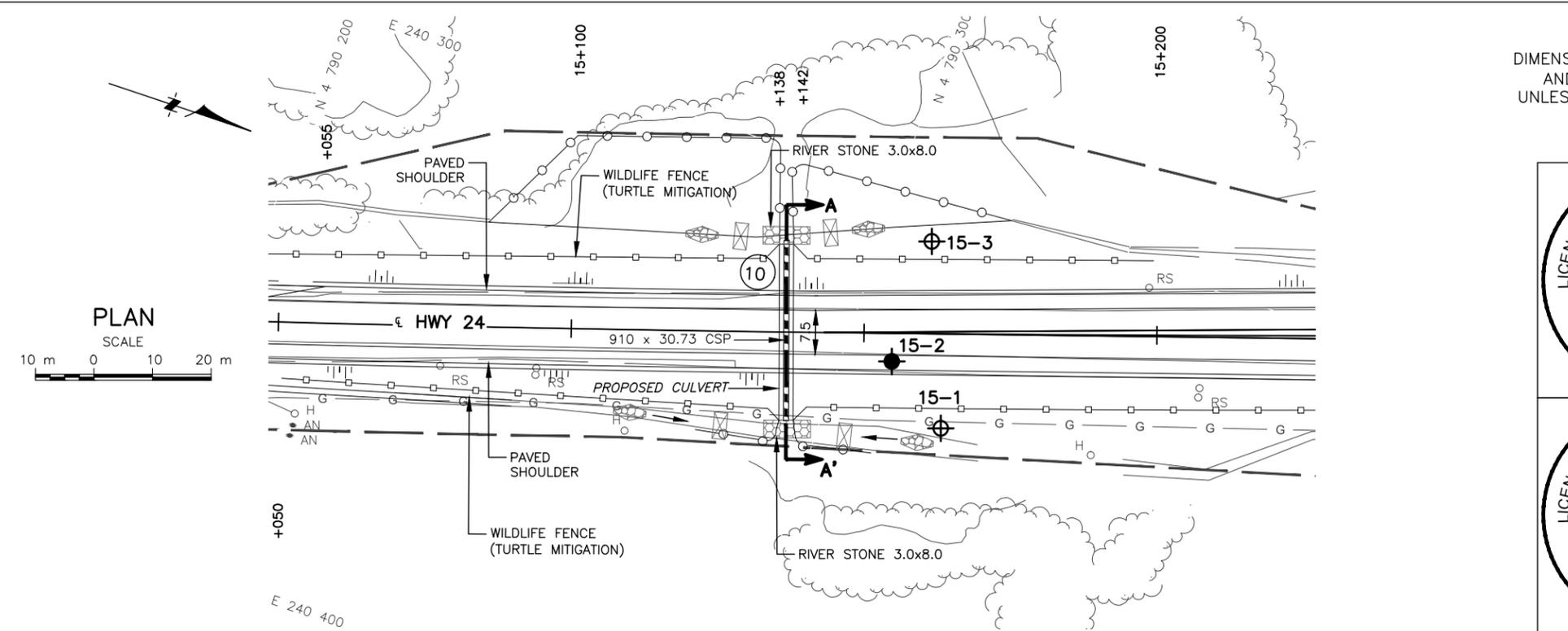


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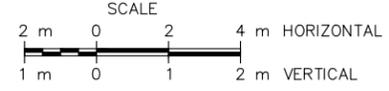
## **APPENDIX A**

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

Site Photos



CROSS SECTION A-A'



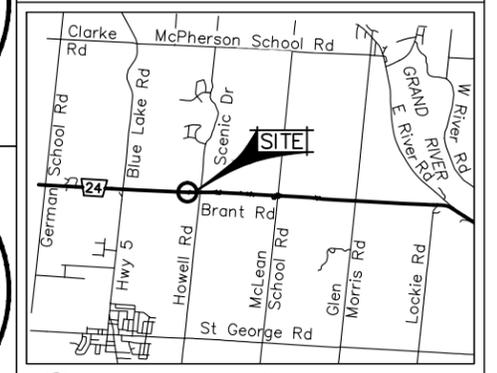
**METRIC**  
 DIMENSIONS ARE IN METRES  
 AND/OR MILLIMETRES  
 UNLESS OTHERWISE SHOWN

PLATE No  
**CONT**  
**WP 3065-11-00**



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

**SHEET**



**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	COORDINATES 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.

DATE	BY	DESCRIPTION
2017-01-09	CM	ADDED GEOGRES NUMBER

GEOGRES No 40P08-242

HWY No	HWY	DIST
24	AN	C10

DRAWN	CHECKED	DATE	APPROVED	DWG
GBB		2015-10-08		1



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



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



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:

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

#### Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 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, 4<sup>th</sup> 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:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 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
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>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	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25 - 0.5	12.5 - 25	2-4
<i>Firm</i>	0.5 - 1.0	25 - 50	4-8
<i>Stiff</i>	1.0 - 2.0	50 - 100	8-15
<i>Very Stiff</i>	2.0 - 4.0	100 - 200	15-30
<i>Hard</i>	>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:

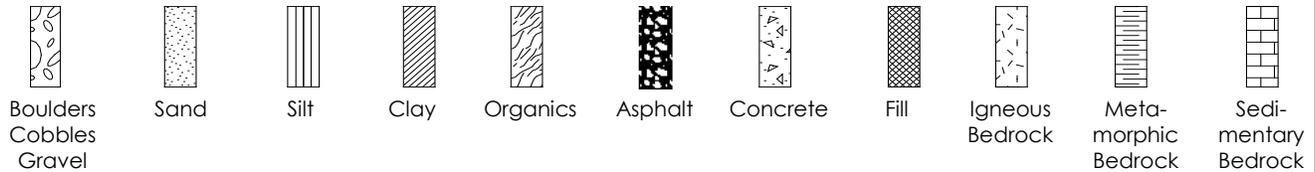
Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

### 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.



## 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
$\gamma$	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

1 OF 1

METRIC

W.P. 3065-11-00 LOCATION Hwy 24, Township of South Dumfries, 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

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
278.2 0.0	Sandy SILT (ML) Loose Grey, moist to wet, trace of organic material	[Hatched pattern]	1	SS		278	20 40 60 80 100	20 40 60 80 100	10 20 30	43		2 43 49 6 non-plastic	
276.9 1.3	PEAT Black, wet	[Wavy pattern]	2	SS		277				59			
			3	SS		276				202			
			4	SS		276				65			
275.1 3.1	Silty SAND (SM) with gravel to sandy SILT (ML) Compact to dense Grey, wet	[Dotted pattern]	5	SS		275						30 41 26 3 non-plastic	
			6	SS		274							
			7	SS		273							
			8	SS		273						8 33 53 6 non-plastic	
272.1 6.1	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												

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

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



# RECORD OF BOREHOLE No BH15-2

1 OF 1

**METRIC**

W.P. 3065-11-00 LOCATION Hwy 24, Township of South Dumfries, 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

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)												
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40	60	80	100	10	20	30	GR
281.8	100 mm ASPHALT		1	GS	-																					
280.0	Fill: loose to compact brown silty SAND (SM) with gravelly -moist		2	SS	15																				37 49 (14)	
280.6	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
			6	SS	12																					
278.0	Sandy SILT (ML) with gravel Compact Grey, moist to wet		7	SS	23																					
			8	SS	13																					14 31 45 10 non-plastic
			9	SS	11																					
275.5	PEAT Black, wet		10	SS	11																					
			11	SS	12																					
274.1	Silty SAND (SM) to sandy clayey SILT (CL-ML) Loose to compact Grey, wet		12	SS	8																					
			13	SS	14																					8 29 51 12
		14	SS	14																						
272.0	End of Borehole																									

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

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



# RECORD OF BOREHOLE No BH15-3

1 OF 1

METRIC

W.P. 3065-11-00 LOCATION Hwy 24, Township of South Dumfries, 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

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80	100	20	40	60	80	100	10
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							
277.4 2.2	PEAT Black, wet		2	SS																			
			3	SS																			
			4	SS																			
			5	SS																			
			6	SS																			
			7	SS																			
			8	SS																			
			9	SS																			
			10	SS																			
272.0 272.6 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																						

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

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

# APPENDIX C

Laboratory Test Result

# Unified Soil Classification System

	SAND			Gravel	
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse



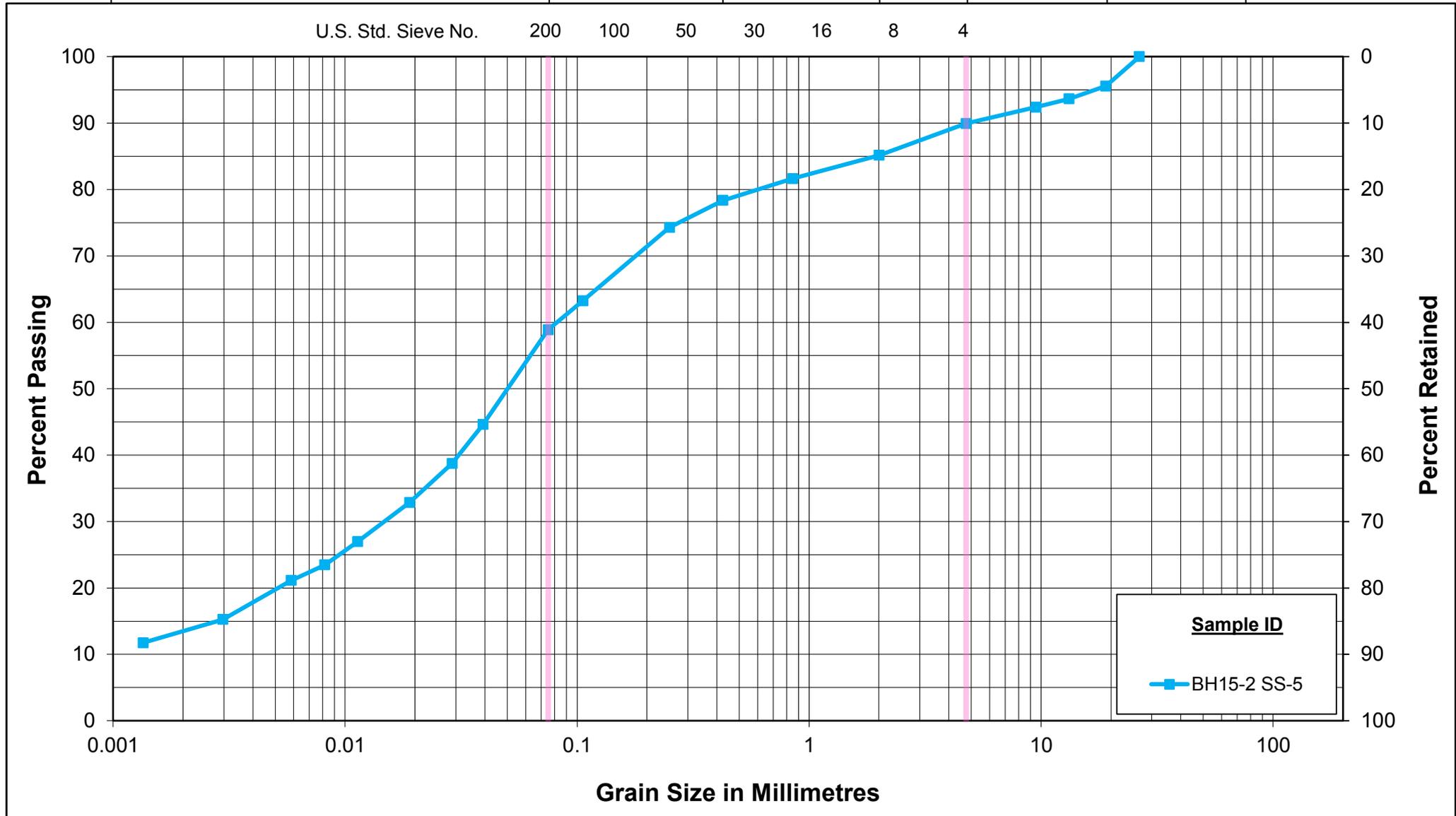
GRAIN SIZE DISTRIBUTION  
 FILL: silty SAND (SM) with gravel

Figure No. 1a

Project No. 165000903

# Unified Soil Classification System

	SAND			Gravel	
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse

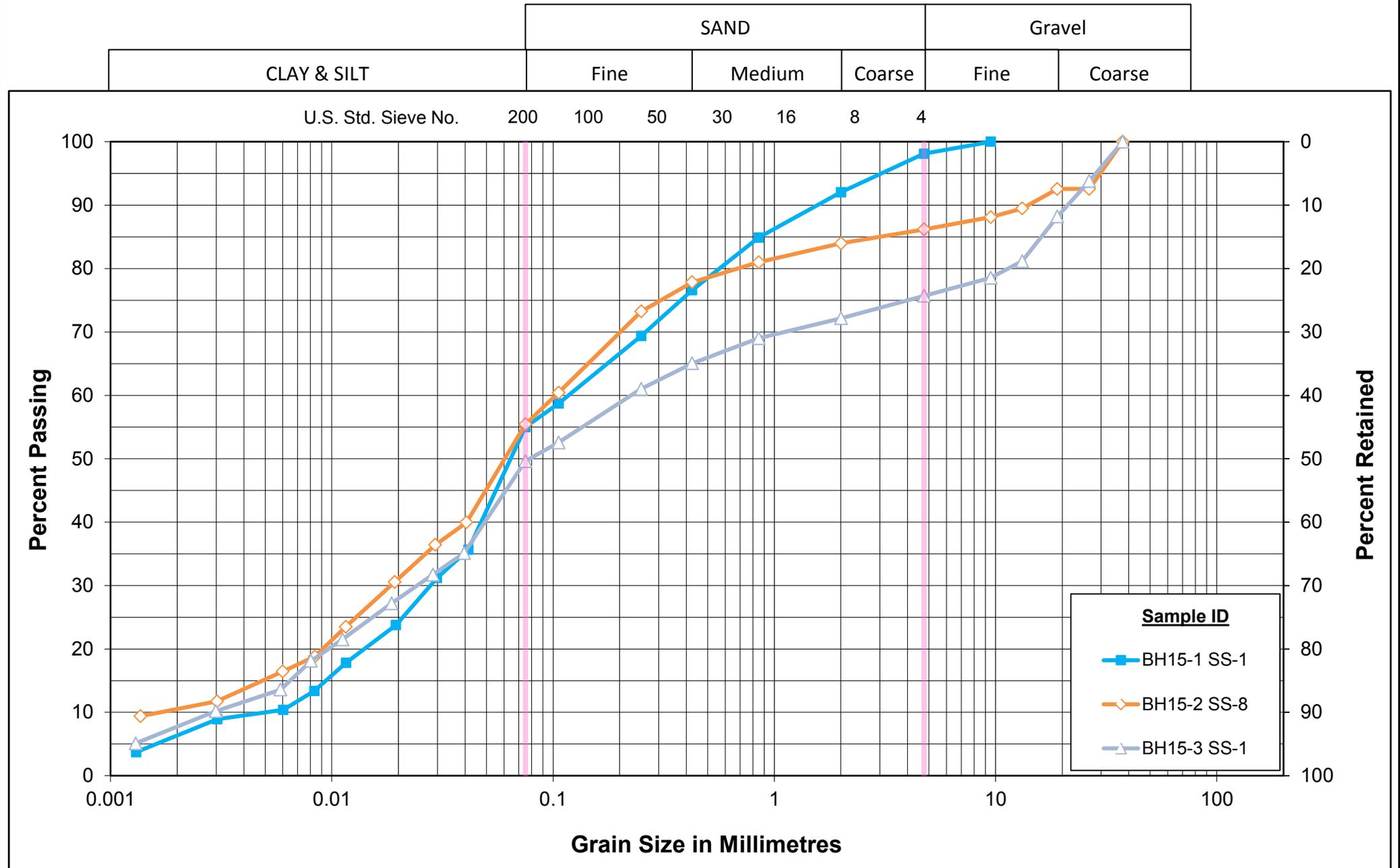


**GRAIN SIZE DISTRIBUTION**  
**FILL: sandy clayey SILT (CL-ML)**

Figure No. 1b

Project No. 165000903

# Unified Soil Classification System

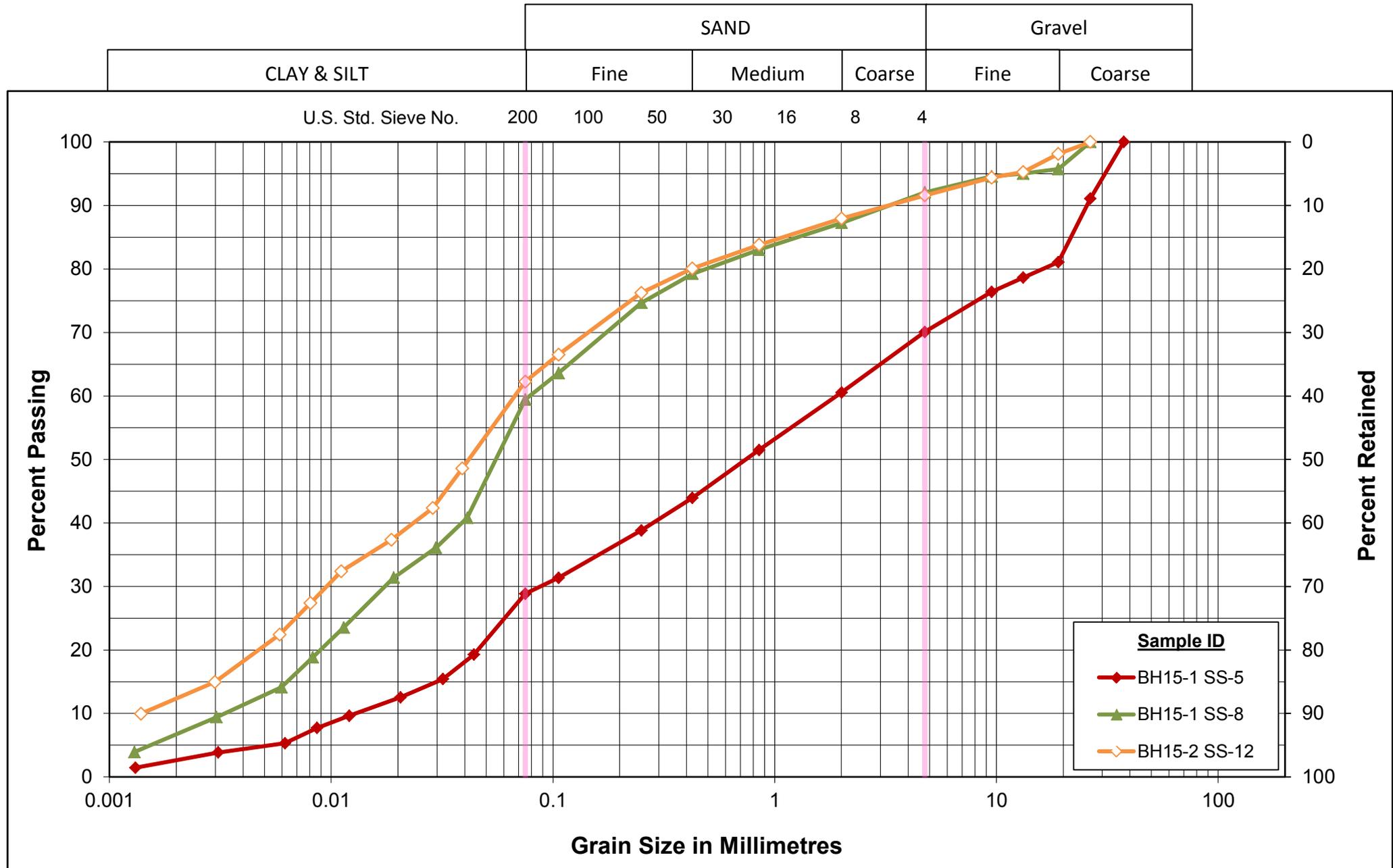


GRAIN SIZE DISTRIBUTION  
Sandy SILT (ML) to sandy clayey SILT (CL-ML)  
with gravel

Figure No. 2

Project No. 165000903

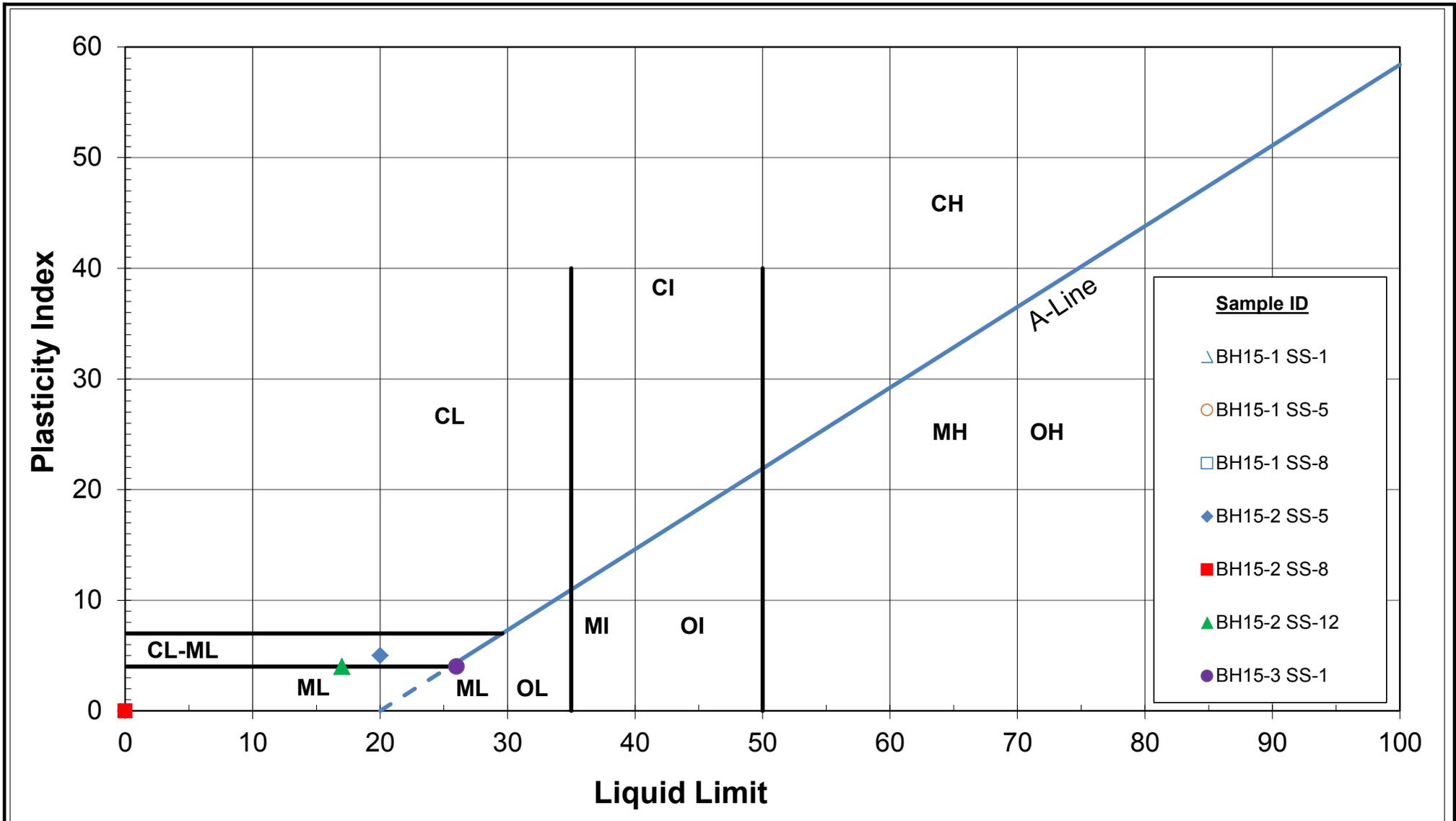
# Unified Soil Classification System



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

Figure No. 3

Project No. 165000903



# PLASTICITY CHART

Figure No. 4

Project No. 165000903