



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
REPLACEMENT OF STRUCTURAL CULVERT No. 29-250/C  
FORESTERS FALLS CULVERT CROSSING OF HIGHWAY 17  
RENFREW COUNTY, ON  
W.P. 4113-01-01  
AGREEMENT NUMBER: 4014-E-0014**

**GEOCRES NUMBER: 31F-193**

**SUBMITTED TO  
WSP CANADA**

**LOCATION:**

**LATITUDE: 45.62172°  
LONGITUDE: -76.87045°**

**May 2018  
19-5161-263**



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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the replacement of the Foresters Falls culvert located on Highway 17, within Renfrew County. Thurber carried out the investigation as a subconsultant to WSP Canada (WSP) as part of Agreement No. 4014-E-0014.

No previous foundation investigation information for the subject culvert was available. General Arrangement (GA) drawings and base plan mapping were provided by WSP for the preparation of this report.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on this data, provide a borehole location plan, record of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

**2 SITE DESCRIPTION**

Culvert 29-250/C is located on Highway 17, approximately 30 m west of the intersection with Foresters Falls Road and approximately 1.0 km east of Cobden, Ontario. The location of the culvert is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

It is noted that for project orientation purposes, Highway 17 within the project limits, will be assumed to run west-east.

The existing culvert is an open bottom, rigid frame, cast-in-place concrete structure with an internal span of 5.5 m, height of 1.8 m and length of 33 m that carries creek flow from south to north below the highway. The GA drawing indicates that the of the top of stream bed elevation ranges from 123.68 m to 123.39 m at the inlet and outlet respectively.

At this location, Highway 17 is an undivided highway with one through lane in each direction with gravel shoulders. At the intersection with Foresters Falls Road, Highway 17 has a left hand turning lane in the eastbound direction and a right turn taper in the westbound direction. A steel cable guide rail is located along the south side of the highway and a combination of steel beam and steel cable guide rails is present along the north side. Based on the GA drawing, the roadway cross-section at the culvert location consists of a 3.92 m wide eastbound lane, a 3.75 m left turning lane and a 3.47 m wide westbound lane and 2.3 m wide gravel shoulders.

The site is located within a physiographic region known as the Muskrat Lake Ridges which is characterized as a steep scarp composed of Precambrian rocks overlain by a thin overburden deposit of sand and gravel.

The highway embankment slopes beside the inlet and outlet are graded at approximately 2H:1V (Horizontal:Vertical) and 3H:1V, respectively, and are grass and brush covered; no signs of erosion or instability were noted. Based on the GA drawing, the elevation of Highway 17 at the culvert is approximately 128.3 m and the elevation of the top of the existing culvert at the inlet and outlet ends is approximately 126.1 m and 125.9 m, respectively.

The lands south of Highway 17 near the project limits are generally agricultural with some brush cover. A residential property is located on the south side of the highway immediately adjacent to the culvert inlet. There is a concrete block retaining wall along the west creek bank adjacent to the private property. The creek channel appeared to be narrower on the south/upstream side than on the north/downstream side where brush and swampy terrain is present. The storm water drainage in the area is to existing culverts and ditches.

Site photographs showing the general conditions at the site, along the highway embankment and at the inlet and outlet are presented in Appendix D.

### 3 SITE INVESTIGATION

#### 3.1 Field Investigation

A field investigation was carried out between October 23<sup>rd</sup> and November 4<sup>th</sup>, 2015, based on initial plans for replacement of the culvert along the existing alignment. The investigation included advancing four boreholes (Boreholes 701 through 704). Due to obstructions in the fill material in Borehole 703 at a depth of approximately 1.4 m, an additional borehole (Borehole 703A) was advanced approximately 2 m to the north of the original borehole location. The approximate locations and elevations of the boreholes are illustrated on Drawing No. 1 provided in Appendix A and are summarized in Table 3-1.

Based on the December 2016 GA drawing provided by WSP, the replacement culvert is to be installed east of the existing culvert on a new skewed alignment offset approximately 7.5 m and 12.6 m from the existing centerline at the outlet and inlet, respectively.

A supplemental investigation was carried out on June 29<sup>th</sup> and 30<sup>th</sup>, 2017 and included advancing two additional boreholes (Boreholes 705 and 706). The approximate locations and elevations of the boreholes are illustrated on Drawing No. 1 provided in Appendix A and are summarized in Table 3-1.

**Table 3-1: Borehole Summary**

Borehole	Location	Latitude (degrees)	Longitude (degrees)	Ground Surface Elevation (m)	Depth (m)
701	Existing Culvert Inlet	45.62173	-76.87070	127.0	4.7
702	Highway 17	45.62170	-76.87050	128.2	9.0
703A	Highway 17	45.62186	-76.87060	128.1	4.5
704	Existing Culvert Outlet	45.62192	-76.87053	125.1	6.4
705	Proposed Culvert Inlet	45.62162	-76.87061	127.8	10.9
706	Proposed Culvert Outlet	45.62183	-76.87035	125.1	9.8

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call to provide utility locates/clearances for the intended borehole locations. Thurber also contacted USL-1 Underground Service Locaters Inc. of Ottawa, Ontario to provide private utility locate clearances for the boreholes located adjacent to the private property.

The boreholes completed during the 2015 field investigation were advanced using a CME75 truck mounted drill rig with NW casing for the roadway embankment boreholes, and portable drilling equipment for the inlet and outlet boreholes. The boreholes completed during the 2017 field investigation were advanced using a track mounted drill rig with NW casing at the inlet, and portable drilling equipment at the outlet.

The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in all boreholes during the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. In-situ shear vane testing was carried out within cohesive strata. All soil samples recovered from the boreholes were placed in moisture-proof containers and the samples were transported to Thurber's Ottawa laboratory for further examination and testing. Bedrock was cored in Borehole 702 and 705 using NQ size coring equipment following ASTM Standard D6032-08. Bedrock core samples were stored in core boxes for transport.

A 25 mm inside diameter PVC piezometer was installed in Borehole 704 to allow for measurement of the groundwater level at the site. The piezometer construction details are illustrated on the Record of Borehole sheet for Borehole 704, provided in Appendix B. The piezometer was decommissioned on December 16, 2015, after the water level was read.

The boreholes without a piezometer installation were backfilled with a low-permeability mixture of auger cuttings and bentonite pellets in general accordance with the intent of Ontario MOE Regulation 903. Boreholes advanced within paved areas were capped with 150 mm of cold patch asphalt.

The as-drilled locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber on December 16, 2015 (Boreholes 701 through 704) and on July 4, 2017 (Boreholes 705 and 706). The vertical datum used was a horizontal control monument (HCM) located on the culvert outlet. The HCM was identified on base plans provided by WSP as having a geodetic elevation of 125.974 m. The location of the HCM is indicated on Drawing No. 1 in Appendix A.

### **3.2 LABORATORY TESTING**

Natural moisture content determination and visual identification of all soil samples was completed in accordance with the current MTO standards. In addition, grain size distribution analyses, and Atterberg Limits testing were carried out on selected samples to MTO and ASTM standards. Point load Strength Index testing was carried out on select bedrock core samples in accordance with ASTM Standard D5731-16.

The geotechnical laboratory test results are presented on the Record of Borehole sheets in Appendix B and are illustrated on the figures in Appendix C.

Chemical analysis for determination of pH, resistivity, soluble sulphate and chloride concentrations was carried out on three soil samples. A copy of the chemical analysis results is provided in Appendix C.

## **4 DESCRIPTION OF SUBSURFACE CONDITIONS**

### **4.1 Overview / General**

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert area is presented on Drawing No. 1 in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions.

In general, the stratigraphy in the area of the of the boreholes is characterized by an asphalt pavement structure, overlying granular embankment fill overlying layers of silt, sand and clay, overlying a glacial till deposit, underlain by bedrock. It should be noted that cobbles and boulders were encountered in the embankment fill in Borehole 703A and within the glacial till deposit.

More detailed descriptions of the individual strata are presented below.

### **4.2 Asphalt**

Two boreholes were advanced through the Highway 17 pavement structure. The thickness of the asphalt at the borehole locations was 175 mm and 190 mm.

### **4.3 Fill – Silty Sand with Gravel**

In all boreholes, a fill layer consisting predominantly of sand with varying amounts of silt and gravel was encountered at surface or below the surficial layers. The top of this layer ranges from Elevation 128.1 m to 125.1 m. The thickness of the layer ranged from 1.0 m to 4.5 m. The SPT 'N' values ranged from 1 to 54 blows; indicating a very loose to very dense condition; but typically loose to compact. Frequent cobbles and boulders were encountered in Borehole 703 and 703A; coring techniques were required to advance the borehole.

The moisture content of the samples tested ranged from 3% to 22%. The results of grain size analysis conducted on samples of this material are summarized in Table 4-1 and are illustrated on Figures 1 and 2 in Appendix C.

**Table 4-1: Gradation Results for Fill**

<b>Soil Particles</b>	<b>%</b>
Gravel	2 to 36
Sand	47 to 79
Silt and Clay	10 to 27

### **4.4 Silt / Sandy Silt (ML)**

A stratum of silt with varying amounts of sand was encountered beneath the fill layer in Boreholes 701 and 704 and below the silty sand layer in Boreholes 705 and 706. The top of this layer ranges from Elevation 122.7 m to 124.5 m. The thickness of the layer ranged from 1.0 m to 1.8 m. The SPT 'N' values ranged from 3 to 18 blows; indicating a very loose to compact condition.

The moisture content of the samples tested ranged from 21% to 59%. The results of grain size analysis conducted on samples of this material are summarized in Table 4-2 and are illustrated on Figure 3 in Appendix C.

**Table 4-2: Gradation Results for Silt**

<b>Soil Particles</b>	<b>%</b>
Gravel	0 to 1
Sand	24 to 42
Silt	44 to 70
Clay	5 to 14

Based on the results of Atterberg Limits testing the material is a non-plastic silt.

#### **4.5 Silty Sand (SM) with Gravel**

A stratum of silty sand with gravel was encountered beneath the fill layer in Boreholes 702, 705 and 706. The silty sand with gravel contained trace amounts of organic matter in all three boreholes. The top of this layer ranges from Elevation 124.8 m and 124.1 m. The thickness of the layer ranged from 1.3 m to 2.3 m. The SPT 'N' values ranged from 5 to 26 blows; indicating a loose to compact condition.

The moisture content of the samples tested ranged from 19% to 31%. The results of grain size analysis conducted on samples of this material are summarized in Table 4-3 and are illustrated on Figure 4 in Appendix C.

**Table 4-3: Gradation Results for Silty Sand**

<b>Soil Particles</b>	<b>%</b>
Gravel	14 to 24
Sand	52 to 66
Silt and Clay	15 to 30

Based on the results of Atterberg Limits testing the fines of this material are non-plastic.

#### **4.6 Clay (CL to CI)**

A clay deposit was encountered beneath the silt/sandy silt in Boreholes 704 and 706. The top of clay layer (where present) ranges from Elevation 121.8 m to 122.7 m. The thickness of the layer ranged from 4.0 m to 5.3 m. In-situ shear vane test results indicated undrained shear strengths ranging from 85 kPa to greater than 100 kPa; indicating a stiff to very stiff consistency.

The moisture content of the samples tested ranged from 17% to 42%. The results of grain size analysis conducted on samples of this material are summarized in Table 4-4 and are illustrated on Figure 5 in Appendix C.

**Table 4-4: Gradation Results for Clay**

<b>Soil Particles</b>	<b>%</b>
Gravel	0 to 1
Sand	4 to 7
Silt	50 to 65
Clay	30 to 46

The results of Atterberg Limits testing completed on samples of this material are summarized in Table 4-5 and are illustrated on Figure 6 in Appendix C. The results indicate a clay of low to intermediate plasticity.

**Table 4-5: Atterberg Limits Test Results**

Liquid Limit	28 to 39
Plastic Limit	15 to 18
Plasticity Index	13 to 21

#### **4.7 Silty Sand with Gravel Till**

A glacial till layer consisting predominantly of silty sand with gravel was encountered below the silty sand layer in Borehole 702, below the sandy silt layer in Borehole 701 and below the clay layer in Borehole 706. This stratum has a top elevation of 116.4 m to 122.1 m and has a thickness of 1.1 to 1.7 m where completely penetrated. Boreholes 701 and 706 were terminated in this layer. The SPT 'N' values ranged from 13 to 110 blows; indicating a compact to very dense condition.

The moisture content of the samples tested ranged from 8% to 20%. The results of a grain size analysis test on samples of this material are summarized in Table 4-6 and are illustrated on Figure 7 in Appendix C.

**Table 4-6: Gradation Results for Glacial Till**

Soil Particles	%
Gravel	28 to 40
Sand	44 to 59
Silt and Clay	13 to 19

#### **4.8 Bedrock**

Granite bedrock was encountered beneath the glacial till stratum in Boreholes 702 and 705. The bedrock surface was encountered at Elevation 120.4 m in both boreholes. Both boreholes were advanced into bedrock by coring with NQ size coring equipment. Photographs of the bedrock core are provided in Appendix B. The total core recovery (TCR) ranged from 83% to 100%, the solid core recovery (SCR) ranged from 74% to 86% and the Rock Quality Designation (RQD) ranged from 44% to 97%. Based on the RQD value the bedrock is classified as fair to excellent quality.

The results of point load index testing indicate that the intact rock ranges from strong to very strong.

#### **4.9 Groundwater Conditions**

The groundwater level in the piezometer installed in Borehole 704 was measured on December 16, 2015, at a depth of 0.78 m; corresponding to Elevation 124.3 m. The groundwater level was measured in Borehole 701 in the open borehole prior to backfilling at Elevation 125.6 m.

The water level in the creek was measured at the time of Thurber's field investigations at Elevation 124.3 m. These observations are short-term readings to seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall. The groundwater level in the area of the culvert is expected to be heavily influenced by the water level in the creek.



## 5 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole locations, and determined the ground surface elevations based on contract drawings provided by WSP Canada. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario and Forage M3 Drilling Services Inc. of Hawkesbury, Ontario supplied and operated the drilling equipment to carry out the drilling, sampling, and in-situ testing. The drilling, and sampling operations in the field were supervised on a full-time basis by Mr. Simon Paxton, and Justin Gray of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.



Kenton C. Power, P.Eng.  
Geotechnical Engineer



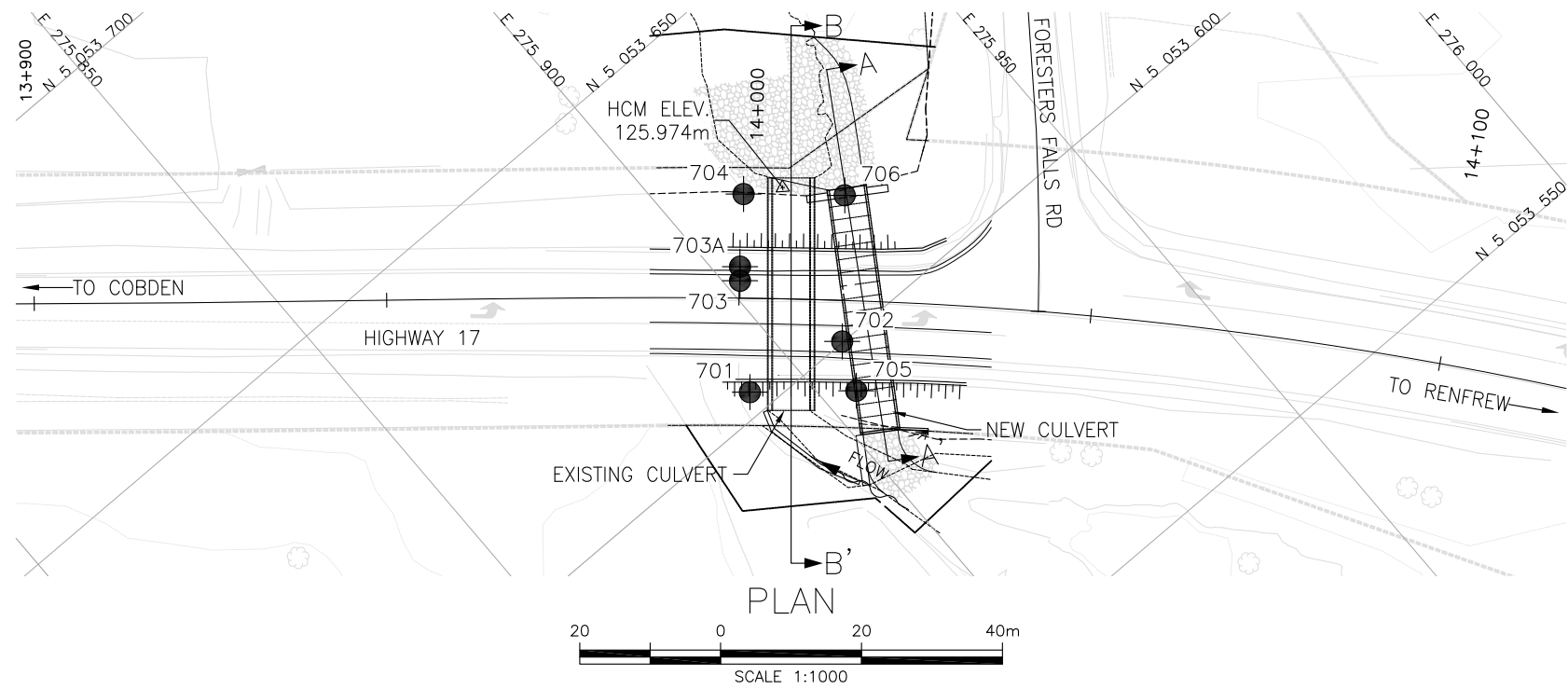
Paul Carnaffan, P.Eng.  
Principal, Senior Geotechnical Engineer



P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact

## **APPENDIX A**

### **BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS PRELIMINARY GENERAL ARRANGEMENT DRAWING**



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



CONT No  
WP No 4114-13-01

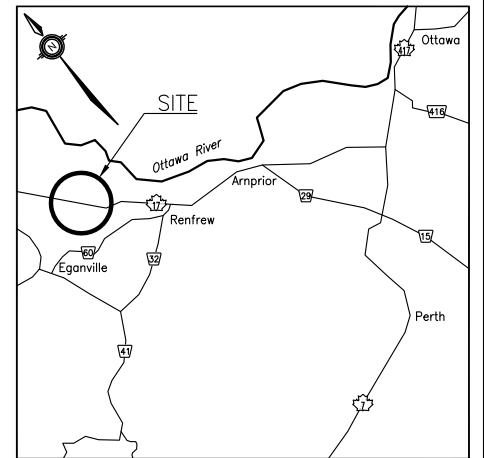
HIGHWAY 17  
FORESTERS FALLS ROAD  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

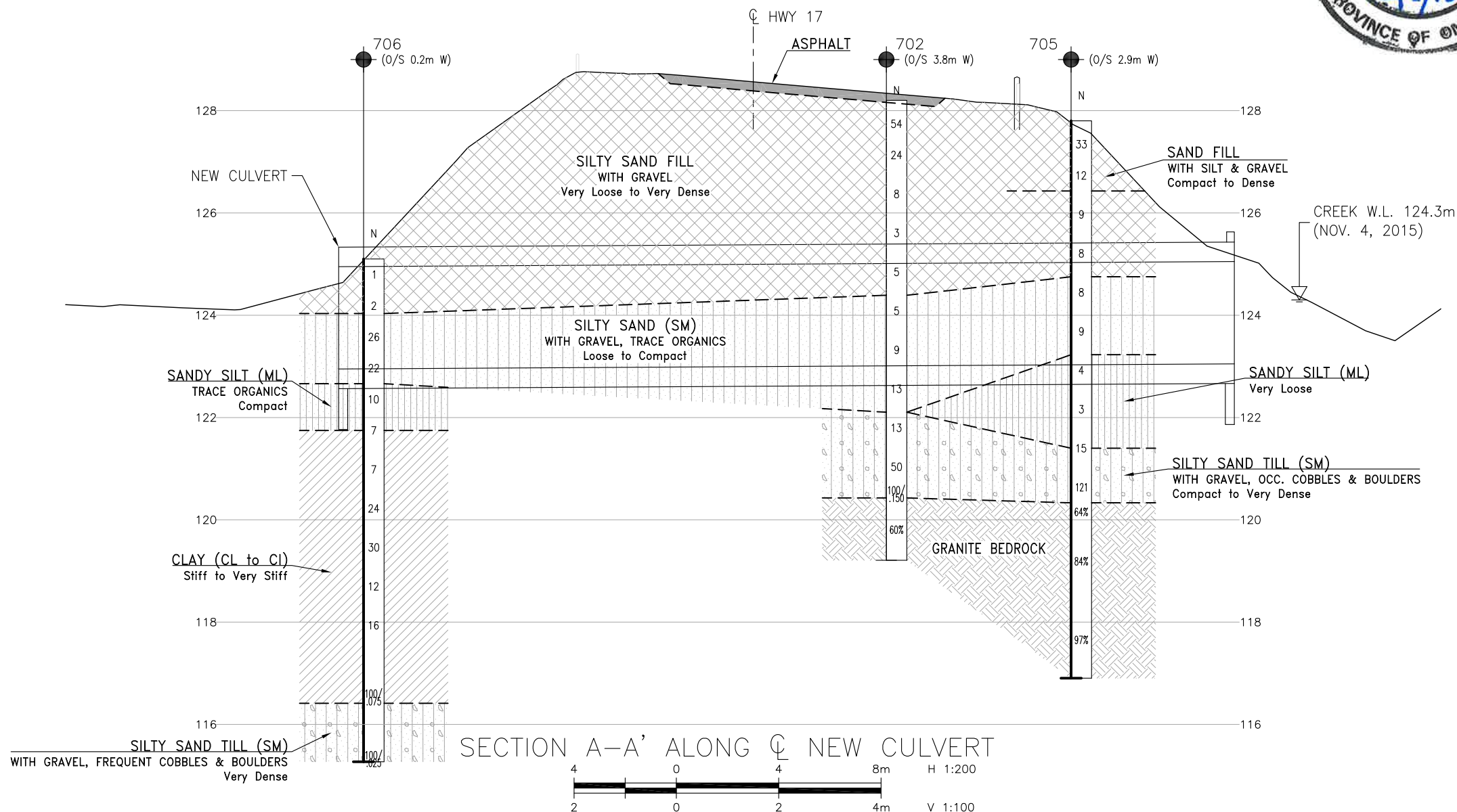
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
701	127.0	5 053 603.1	275 892.7
702	128.2	5 053 600.1	275 907.4
703	128.1	5 053 616.1	275 901.9
703A	128.1	5 053 617.6	275 903.2
704	125.1	5 053 625.1	275 910.3
705	127.8	5 053 590.9	275 900.2
706	125.1	5 053 614.3	275 919.5

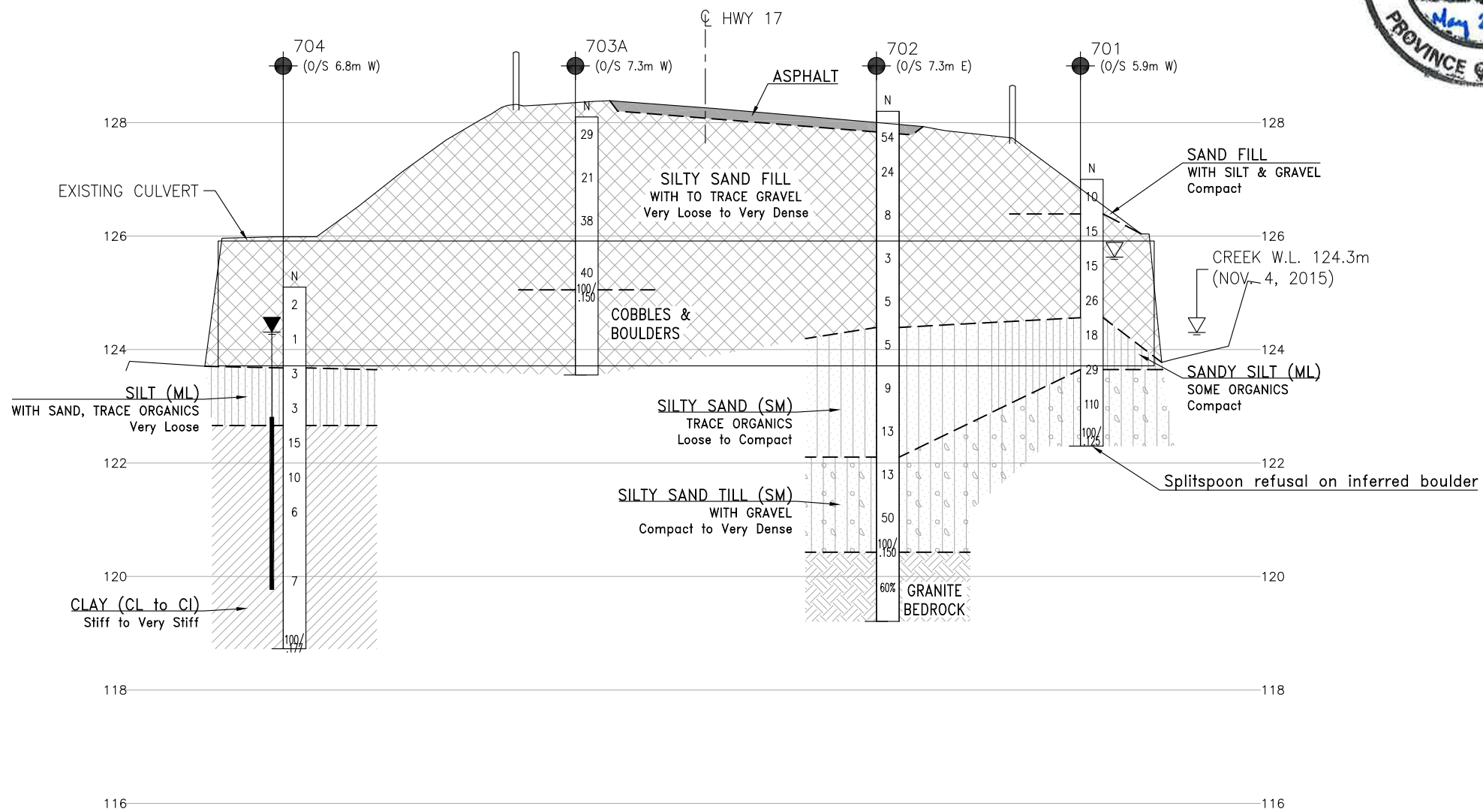
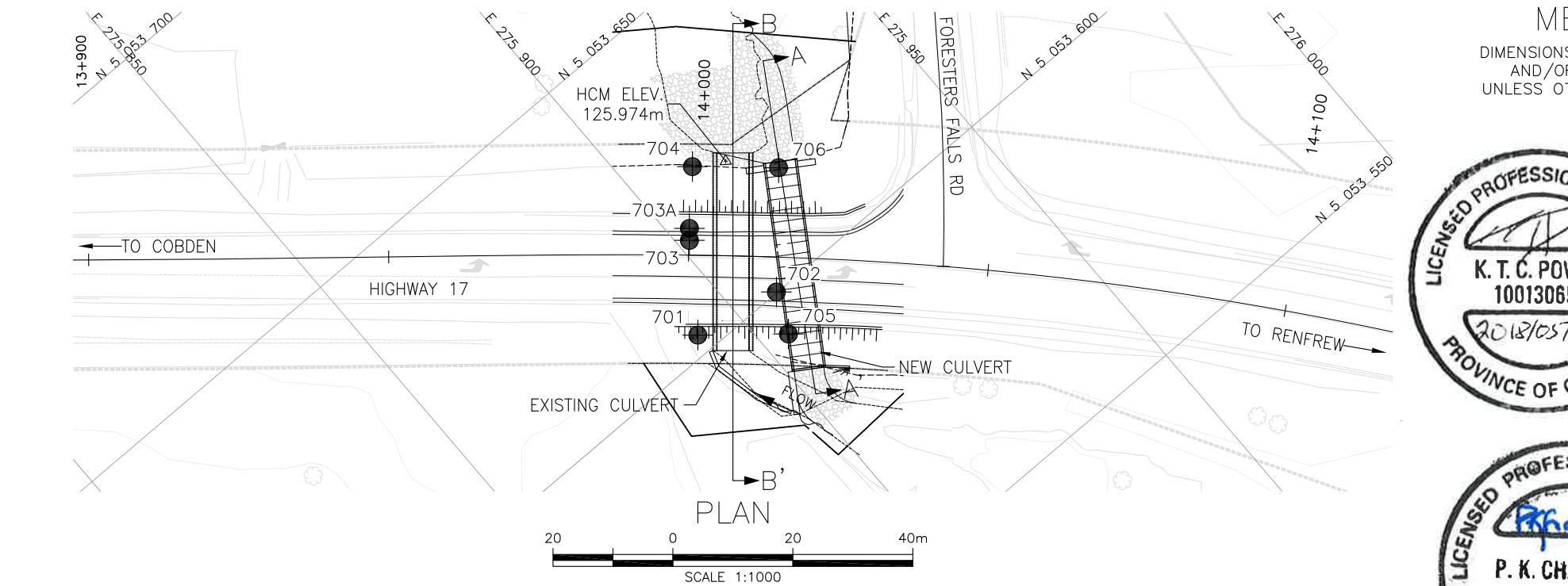
-NOTES-

- 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.
- Borehole locations are shown in MTM Zone 9 coordinates.

GEOCRES No. 31F-193



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KP	CHK -	CODE
DRAWN	MFA	CHK KP	SITE 29-250/C/STRUCT
			LOAD
			DATE FEB 2018
			DWG 1



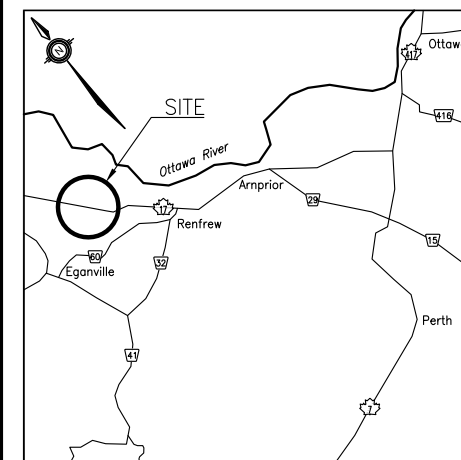
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



CONT No  
WP No 4114-13-01

HIGHWAY 17  
FORESTERS FALLS ROAD  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

WSP



KEYPLAN

LEGEND

●	Borehole
⊙	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▽	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
701	127.0	5 053 603.1	275 892.7
702	128.2	5 053 600.1	275 907.4
703	128.1	5 053 616.1	275 901.9
703A	128.1	5 053 617.6	275 903.2
704	125.1	5 053 625.1	275 910.3
705	127.8	5 053 590.9	275 900.2
706	125.1	5 053 614.3	275 919.5

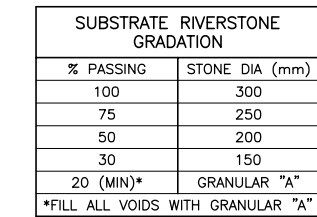
**-NOTES-**

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
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- 3) Borehole locations are shown in MTM Zone 9 coordinates.

**GEOCRES No. 31F-193**

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KP	CHK -	CODE
DRAWN	MFA	CHK KP	SITE 29-250/C/STRUCT
			LOAD
			DATE FEB 2018
			DWG 2





SCOPE OF WORK:

THE FOLLOWING SCOPE OF WORK IS NOT INTENDED TO BE AN EXHAUSTIVE LIST OF ALL ITEMS REQUIRED TO COMPLETE THE WORK, NOR IS IT INTENDED TO PROVIDE A SEQUENCE OF CONSTRUCTION ACTIVITIES.

/ STAGE 1:

1. INSTALL ENVIRONMENTAL PROTECTION, TEMPORARY CONCRETE BARRIERS AND TRAFFIC CONTROL MEASURES. RELOCATE UTILITIES AS REQUIRED.
2. REALIGN FORESTERS FALLS ROAD.

STAGE 2:

3. INSTALL PROTECTION SYSTEMS AND TEMPORARY FLOW PASSAGE SYSTEMS.
4. EXCAVATE FOR NEW CULVERT.
5. INSTALL BEDDING AND CONSTRUCT NEW APRON WALL.
6. INSTALL NEW PRECAST CULVERT AND GABION WALLS.
7. BACKFILL CULVERT.
8. REGRADE AND PAVE ROADWAY.
9. MODIFY TRAFFIC CONTROL MEASURES TO SUIT SEASONAL SHUTDOWN CONDITIONS.

STAGE 3:

10. RELOCATE TEMPORARY CONCRETE BARRIERS AND DETOUR TRAFFIC TO NORTH SIDE OF STRUCTURE.
11. REPEAT STEPS 3 TO 7 FOR SOUTH HALF OF CULVERT.
12. COMPLETE RETAINING WALL AND HEADER WALL CONSTRUCTION.
13. BACKFILL CULVERT, GRADE AND PAVE ROADWAY. REMOVE TEMPORARY WIDENING.
14. REMOVE TRAFFIC CONTROL MEASURES AND OPEN ROADWAY TO NORMAL TRAFFIC.

### STAGE 4:

15. INSTALL SUBSTRATE RIVERSTONE AND REALIGN CREEK INTO NEW CULVERT.
16. CONSTRUCT NEW ARMOURING STONE WALL.
17. REMOVE EXISTING CONCRETE BLOCK WALL AND EXISTING RETAINING WALL.
18. REMOVE TEMPORARY FLOW PASSAGE SYSTEM.
19. INFILL EXISTING CULVERT.
20. REMOVE ENVIRONMENTAL PROTECTION MEASURES.



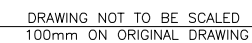
N.T.S.

C/C  
AL  
HE

PRELIMINARY

2017/12/7

NOT FOR CONSTRUCTION



1:150 EXISTING CULVERT AND STREAMBED NOT SHOWN FOR CLARITY



1:50



1:50

GENERAL NOTES:

1. CLASS OF CONCRETE
- CLASS OF CONCRETE SHALL BE 30 MPa.
2. CLEAR COVER TO REINFORCING STEEL
- |                                   |        |
|-----------------------------------|--------|
| PRECAST CONCRETE                  | 40 ±10 |
| REMAINDER, UNLESS NOTED OTHERWISE | 70 ±20 |
3. REINFORCING STEEL
- REINFORCING STEEL SHALL BE GRADE 400W, UNLESS OTHERWISE SPECIFIED.
- UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES SHALL BE CLASS B.
- BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.

**4. CONSTRUCTION NOTES**

THE DESIGN-BUILDER SHALL VERIFY ALL DIMENSIONS AND ELEVATIONS OF THE EXISTING STRUCTURE AND ALL DETAILS ON SITE.

FOR STAGING AND MAINTENANCE OF TRAFFIC SEE GRADING  
DRAWINGS AND SPECIFICATIONS.

THE DESIGN-BUILDER IS RESPONSIBLE FOR THE DESIGN AND INSTALLATION OF ALL TEMPORARY STRUCTURES, CONSTRUCTION PLATFORMS AND DEBRIS CONTAINMENT SYSTEMS ETC.

ALL ELEVATIONS ARE TO GEODETIC DATUM.  
BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH  
SIDES OF CULVERT KEEPING THE HEIGHT OF THE BACKFILL  
APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE  
IN ELEVATION BE GREATER THAN 500mm.

THE PROPONENT SHALL REVIEW ALL FACTUAL GEOTECHNICAL DATA.

UTILITIES SHOWN ON DRAWING ARE REPRESENTATIVE ONLY.  
DESIGN-BUILDER TO PERFORM LOCATES.

THE DESIGN-BUILDER SHALL DESIGN PROTECTION SYSTEMS AND TEMPORARY FLOW PASSAGE SYSTEMS TO PERMIT EXCAVATION, REMOVAL AND RECONSTRUCTION OF THE CULVERT, BACKFILLING OPERATIONS AND AS REQUIRED TO COMPLETE THE WORK. THE DESIGN-BUILDER SHALL BE RESPONSIBLE FOR DETERMINING THE REQUIRED LENGTH AND DEPTH OF ALL PROTECTION SYSTEMS.

## 5. DESIGN NOTES

THE CULVERT SHALL BE DESIGNED TO THE FOLLOWING MINIMUM CRITERIA:

SOFFIT ELEVATION	EL. 125.050 U/S
	EL. 124.950 D/S
CLEAR SPAN	5000mm
FROST DEPTH	1900mm
TOP OF CLAY SEAL	300mm ABOVE HIGH WATER LINE
STREAMBED ELEVATIONS SHALL BE AS NOTED ON DRAWINGS.	

APPLICABLE STANDARD DRAWINGS:

OPSD 3101.150	WALLS ABUTMENT, BACKFILL MINIMUM GRANULAR REQUIREMENTS
OPSD 3102.100	WALL ABUTMENT BACKFILL DRAIN
OPSD 3941.200	FIGURES IN CONCRETE, SITE NUMBER AND DATE LAYOUT

## LIST OF ABBREVIATIONS

D/S	DENOTES	DOWNSTREAM
SHLD	DENOTES	SHOULDER
C.J.	DENOTES	CONSTRUCTION JOINT
U/S	DENOTES	UPSTREAM
W.L.	DENOTES	WATER LEVEL
W.P.	DENOTES	WORK POINT
①	DENOTES	NUMBER IN SCOPE OF WORK
T/P	DENOTES	TOP OF PAVEMENT

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. STAGING I
4. STAGING II
5. STAGING III

[illegible]

## **APPENDIX B**

### **RECORD OF BOREHOLE SHEETS BEDROCK CORE PHOTOGRAPHS**



## **SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS**

### **TERMINOLOGY DESCRIBING COMMON SOIL GENESIS**

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
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 materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of 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

### **RECOVERY:**

For soil samples, the recovery is recorded as the length of the soil sample recovered.

### **N-VALUE:**

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

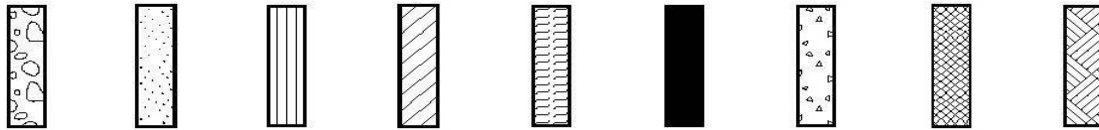
### **DYNAMIC CONE PENETRATION TEST (DCPT):**

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "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 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



### STRATA PLOT:

Strata plots symbolize the soil and 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      Bedrock

### TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

### TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

### SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

### TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50



### MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note -  $W_L$  = Liquid Limit



## EXPLANATION OF ROCK LOGGING TERMS

### ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

### TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

### DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

### STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

# RECORD OF BOREHOLE No 701

1 OF 1

METRIC

W.P. 4114-13-01 LOCATION Site 29-250/C Foresters Falls Rd. Culvert N 5 053 603.1 E 275 892.7 ORIGINATED BY SMP  
 HWY 17 BOREHOLE TYPE NQ Casing COMPILED BY SMP  
 DATUM Geodetic DATE 2015.10.28 - 2015.10.28 CHECKED BY KP

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  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								20 40 60 80 100									20 40 60		
								○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE											
127.0																			
0.0	Sand with silt and gravel Compact Brown to grey FILL		1	SS	10									○			29 61 10 (SI+CL)		
126.4																			
0.6	Silty sand with gravel Compact Brown to grey FILL		2	SS	15										○				
			3	SS	15										○				
			4	SS	26									○			36 47 17 (SI+CL)		
124.5																			
2.4	Sandy SILT (ML) Compact Grey		5	SS	18									○					
	- Some organics at 3 m		6	SS	29											○	0 30 57 13		
123.6																			
3.4	Silty SAND (SM) with gravel TILL Compact to Very Dense Grey		7	SS	110									○			40 44 16 (SI+CL)		
122.3			8	SS	100/									○					
4.7	End of Borehole Splitspoon refusal on inferred boulder Groundwater measured in open borehole at 1.4 m BGS (elev. 125.6 m)				125mm														

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 702

1 OF 1

METRIC

W.P. 4114-13-01 LOCATION Site 29-250/C Foresters Falls Rd. Culvert N 5 053 600.1 E 275 907.4 ORIGINATED BY SMP  
 HWY 17 BOREHOLE TYPE HSA COMPILED BY SMP  
 DATUM Geodetic DATE 2015.11.04 - 2015.11.04 CHECKED BY KP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P                      W                      W L					GR	SA	SI	CL
												20   40   60   80   100								
128.2																				
0.0		175 mm ASPHALT																		
0.2		Silty sand with gravel					128													
127.6		Very dense																		
0.6		Brown and Grey																		
		FILL																		
		Silty sand with gravel																		
		Very loose to compact																		
		Brown to grey																		
		FILL																		

ONTMT4S 19-5161-263 FORRESTER'S FALL RD.GPJ 2012TEMPLATE(MTO).GDT 26/2/18

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 703A

1 OF 1

METRIC

W.P. 4114-13-01 LOCATION Site 29-250/C Foresters Falls Rd. Culvert N 5 053 617.6 E 275 903.2 ORIGINATED BY SMP  
 HWY 17 BOREHOLE TYPE HSA COMPILED BY SMP  
 DATUM Geodetic DATE 2015.11.03 - 2015.11.03 CHECKED BY KP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
								20 40 60 80 100											
128.1																			
0.0	Silty sand with to trace gravel - frequent cobbles and boulders below 3.0 m Compact to dense Brown FILL		1	SS	29		128												
			2	SS	21		127												
			3	SS	38		126												
			4	SS	40														
125.0			5	SS	100/		125												
3.0	Cobbles and boulders - borehole advanced with NW casing below 3.1 m		6	NW	150mm		124												
123.5	End of Borehole																		
4.5																			

ONTMT4S 19-5161-263 FORRESTER'S FALL RD.GPJ 2012TEMPLATE(MTO).GDT 26/2/18

# RECORD OF BOREHOLE No 704

1 OF 1

METRIC

W.P. 4114-13-01 LOCATION Site 29-250/C Foresters Falls Rd. Culvert N 5 053 625.1 E 275 910.3 ORIGINATED BY SMP  
HWY 17 BOREHOLE TYPE NQ Casing COMPILED BY SMP  
DATUM Geodetic DATE 2015.10.23 - 2015.10.23 CHECKED BY KP

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  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
								20 40 60 80 100 20 40 60 80 100								
125.1																
0.0	Silty sand trace gravel Very Loose Brown FILL		1	SS	2		125									
			2	SS	1		124									2 77 21 (SI+CL)
123.7																
1.4	Silt (ML) with sand trace organics Very loose Grey		3	SS	3		123									
			4	SS	3		123									1 24 70 5
122.7																
2.4	CLAY (CL to CI) Stiff to very stiff Grey		5	SS	15		122									
			6	SS	10		121									1 4 65 30
			7	SS	6		120									
	- Undrained shear greater than 100 kPa		10	SS	7		119									0 4 50 46

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 705

1 OF 2

METRIC

W.P. 4114-13-01 LOCATION Site 29-250/C Foresters Falls Rd. Culvert N 5 053 590.9 E 275 900.2 ORIGINATED BY JAG  
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY JAG  
DATUM Geodetic DATE 2017.06.29 - 2017.06.29 CHECKED BY KP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
127.8													
0.0	Sand with silt and gravel Compact to dense Brown FILL		1	SS	33		127						
			2	SS	12								
126.5							126						
1.4	Silty sand with gravel Loose Brown to grey FILL		3	SS	9								
			4	SS	8		125						
124.8													
3.0	Silty SAND (SM) with gravel, trace wood and organic matter Loose Grey/brown		5	SS	8		124						24 52 24 (SI+CL)
			6	SS	9								
123.3	- wood pieces at 4.6m						123						0 42 44 14
4.6	Sandy SILT (ML) Very loose to loose Grey		7	SS	4								
			8	SS	3		122						
121.4			9	SS	15								
6.4	Silty SAND (SM) with gravel TILL, occasional cobbles and boulders Compact to very dense Grey						121						28 59 13 (SI+CL)
			10	SS	121								
120.4							120						RUN #1 TCR=100% SCR=100% RQD=64%
7.5	GRANITE BEDROCK Slightly weathered Fair to excellent quality Strong to very strong Grey		1	NW									RUN #2 TCR=100% SCR=100% RQD=84%
			2	NW			119						
							118						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

ONTMT4S 19-5161-263 FORRESTER'S FALL RD GPJ 2012TEMPLATE(MTO)GDT 26/2/18

# RECORD OF BOREHOLE No 705

2 OF 2

METRIC

W.P. 4114-13-01 LOCATION Site 29-250/C Foresters Falls Rd. Culvert N 5 053 590.9 E 275 900.2 ORIGINATED BY JAG  
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY JAG  
 DATUM Geodetic DATE 2017.06.29 - 2017.06.29 CHECKED BY KP

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100									
116.9	Continued From Previous Page <b>GRANITE BEDROCK</b> Slightly weathered Fair to excellent quality Strong to very strong Grey		3	NW			117										RUN #3 TCR=100% SCR=100% RQD=97%
10.9	End of Borehole																



# RECORD OF BOREHOLE No 706

1 OF 1

METRIC

W.P. 4114-13-01 LOCATION Site 29-250/C Foresters Falls Rd. Culvert N 5 053 614.3 E 275 919.5 ORIGINATED BY JAG  
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY JAG  
DATUM Geodetic DATE 2017.06.30 - 2017.06.30 CHECKED BY KP

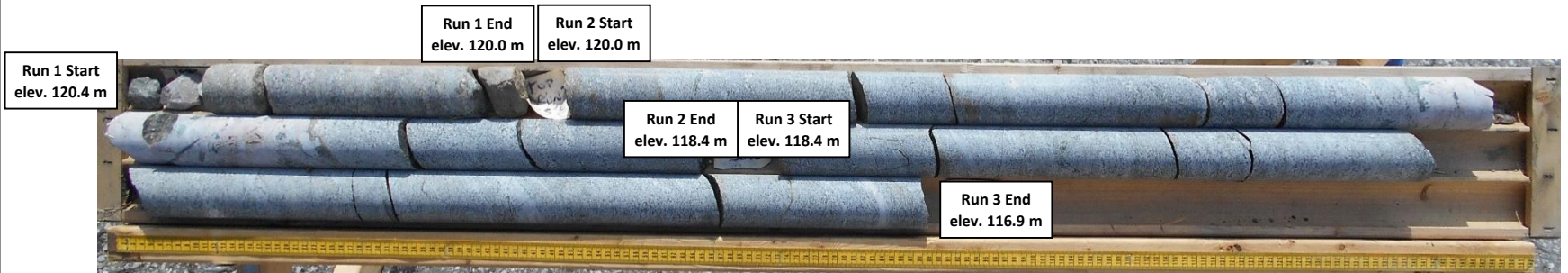
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>				<div>PLASTIC LIMIT</div> <div>NATURAL MOISTURE CONTENT</div> <div>LIQUID LIMIT</div> <div>W P W W L</div>		
							<div>20406080100</div> <div>WATER CONTENT (%)</div>						
125.1													
0.0													
0.1	100mm TOPSOIL												
	Silty sand with gravel Very loose Brown FILL		1	SS	1								
124.1			2	SS	2								18 55 27 (SI+CL)
1.1	Silty SAND (SM) with gravel, trace wood and organic matter Compact Brown to grey		3	SS	26								
			4	SS	22								19 66 15 (SI+CL)
122.7													
2.4	Sandy SILT (ML), trace organic matter Compact Grey		5	SS	10								
121.8			6	SS	7								
3.4	CLAY (CL to CI) Stiff to very stiff Grey		7	SS	7								
			8	SS	24								
			9	SS	30								0 7 63 30
			10	SS	12								
			11	SS	16								0 6 54 40
116.4			12	SS	100/ 75mm								
8.7	Silty SAND (SM) with gravel TILL - frequent cobbles and boulders Very dense Grey												
115.3			13	SS	100/ 25mm								
9.8	End of Borehole												

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

**Borehole 705**  
**Run 1 to 3 (of 3)**  
**Elevation 120.4 m to 116.9 m**

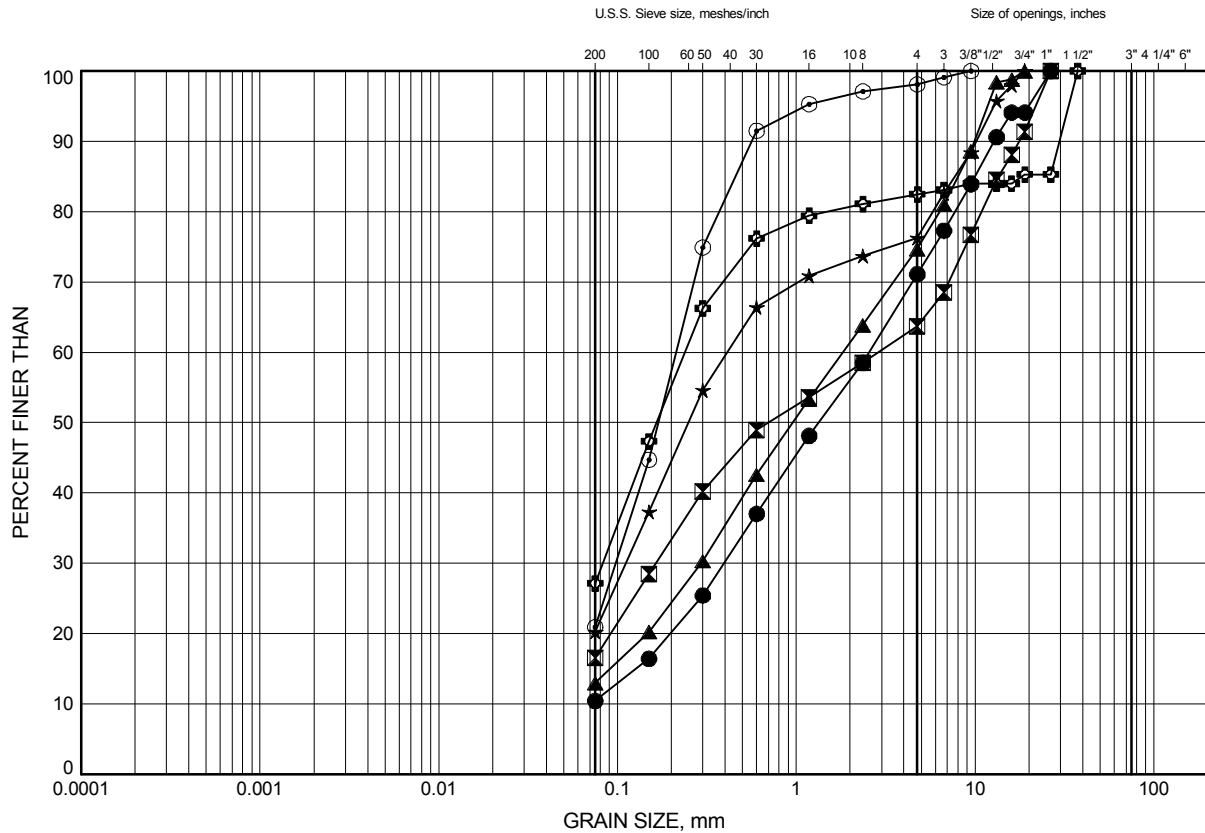


**APPENDIX C**  
**LABORATORY TEST RESULTS**

29-250/C Foresters Falls Rd. Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 1

**Fill - Silty Sand with Gravel**



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	701	0.30	126.68
⊠	701	1.60	125.38
▲	702	0.34	127.87
★	702	1.80	126.41
⊙	704	0.91	124.23
⊕	706	0.84	124.28

Date February 2018  
W.P. 4114-13-01

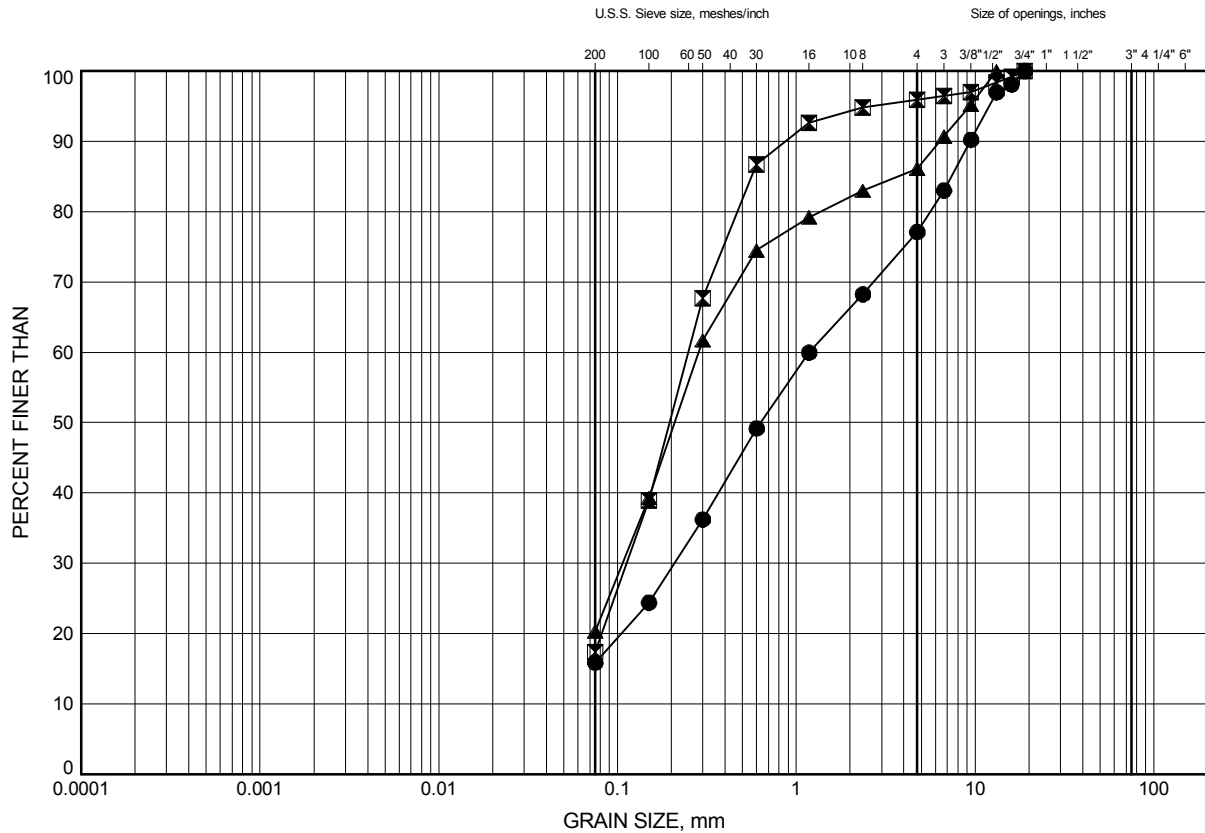


Prep'd KCP  
Chkd. PC

29-250/C Foresters Falls Rd. Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 2

**Fill - Silty Sand with Gravel**



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	703A	0.30	127.78
⊠	703A	1.07	127.02
▲	703A	2.47	125.62

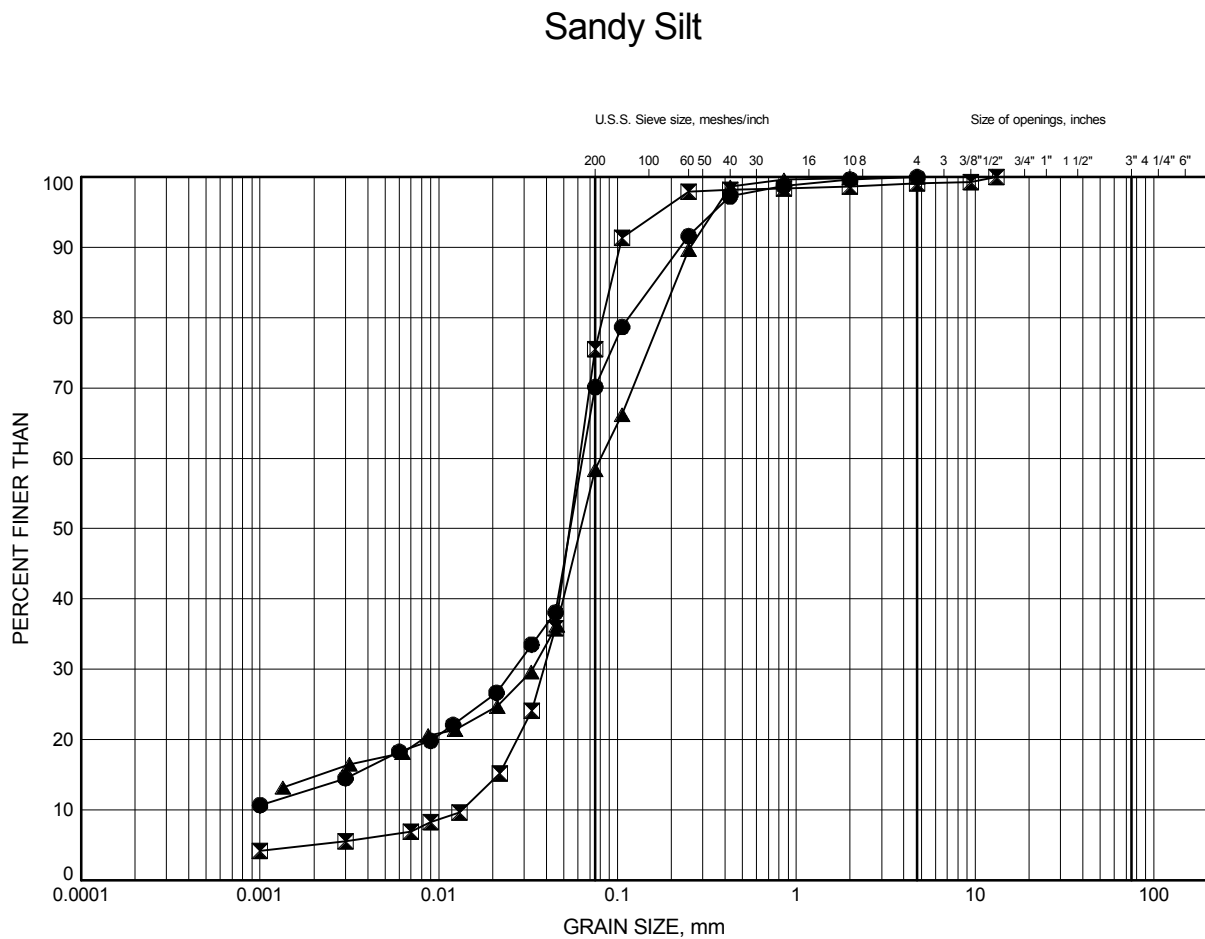
Date February 2018  
W.P. 4114-13-01



Prep'd KCP  
Chkd. PC

29-250/C Foresters Falls Rd. Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 3



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	701	3.17	123.81
⊠	704	2.13	123.01
▲	705	4.88	122.96

Date February 2018  
W.P. 4114-13-01

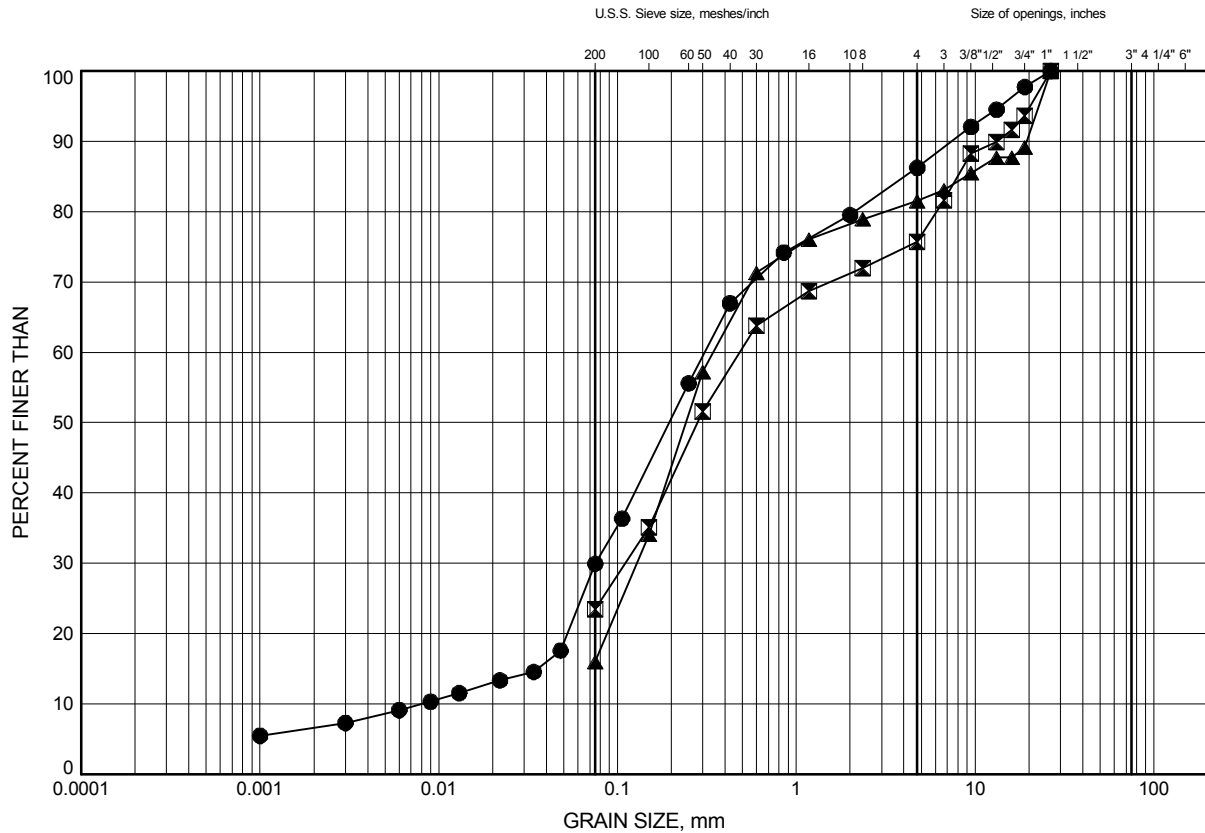


Prep'd KCP  
Chkd. PC

29-250/C Foresters Falls Rd. Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 4

**Silty Sand with Gravel**



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	702	4.88	123.33
⊠	705	3.35	124.48
▲	706	2.13	122.99

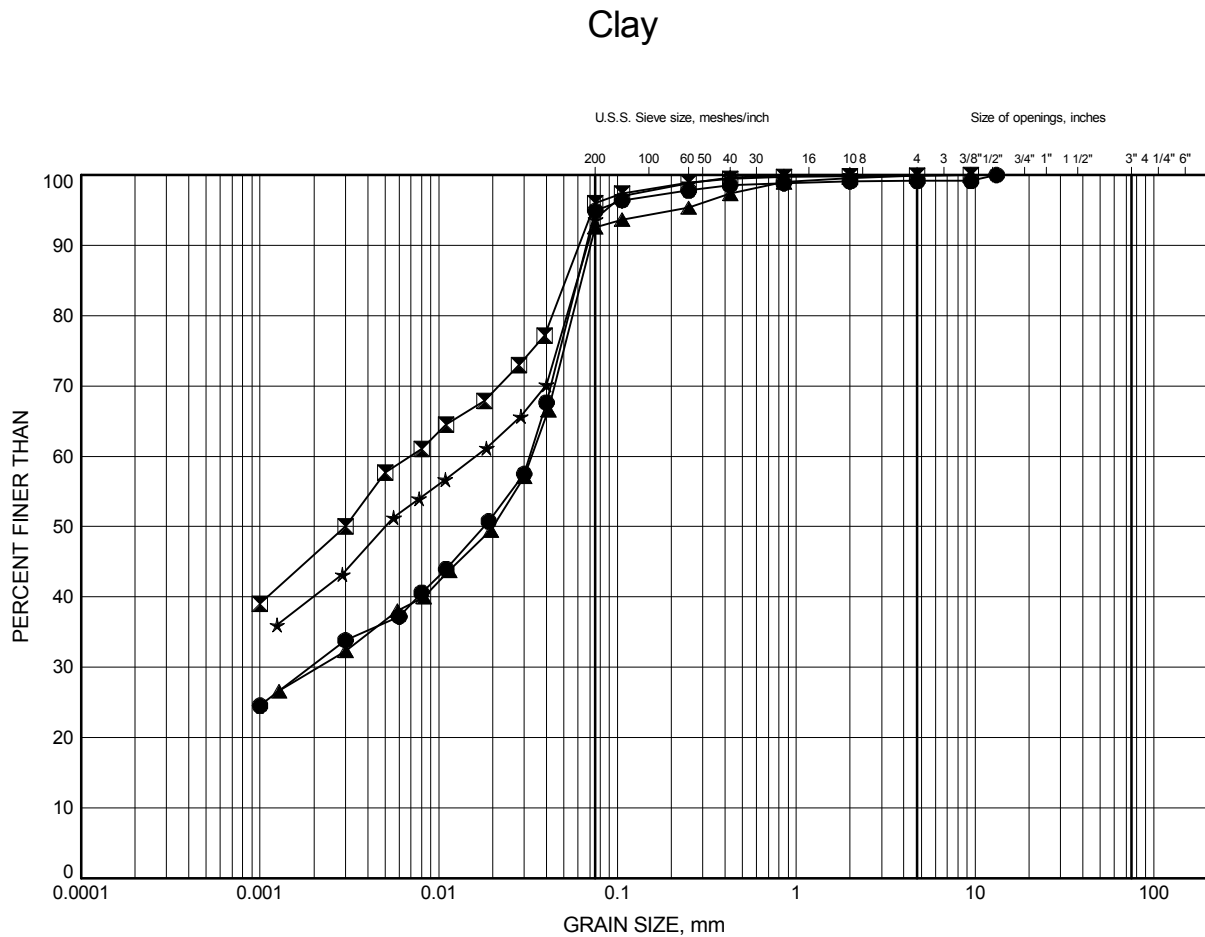
Date February 2018  
W.P. 4114-13-01



Prep'd KCP  
Chkd. PC

29-250/C Foresters Falls Rd. Culvert  
GRAIN SIZE DISTRIBUTION

FIGURE 5



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	704	3.35	121.79
⊠	704	5.18	119.96
▲	706	5.64	119.48
★	706	7.16	117.96

Date February 2018  
W.P. 4114-13-01

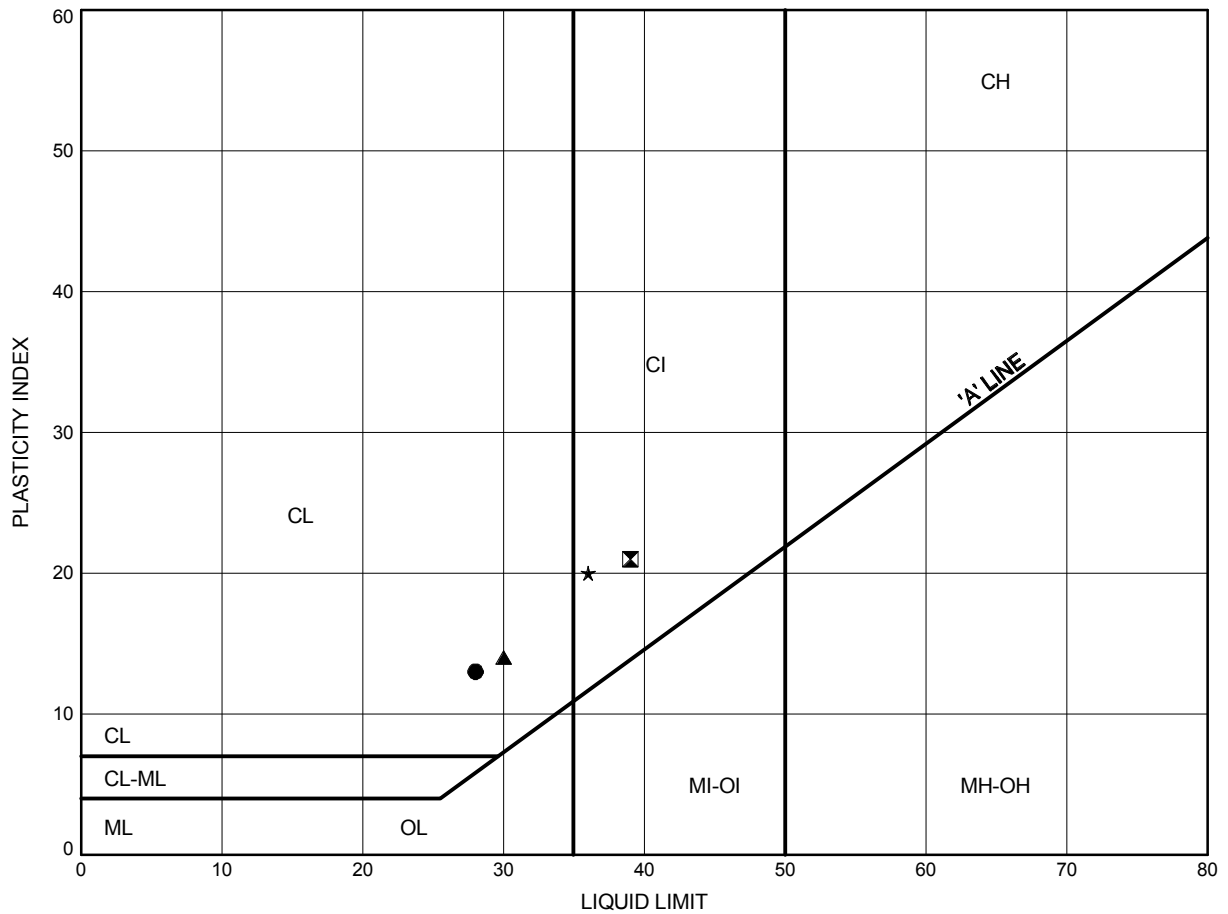


Prep'd KCP  
Chkd. PC



29-250/C Foresters Falls Rd. Culvert  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE 6



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	704	3.35	121.79
⊠	704	5.18	119.96
▲	706	5.64	119.48
★	706	7.16	117.96

Date February 2018  
W.P. 4114-13-01

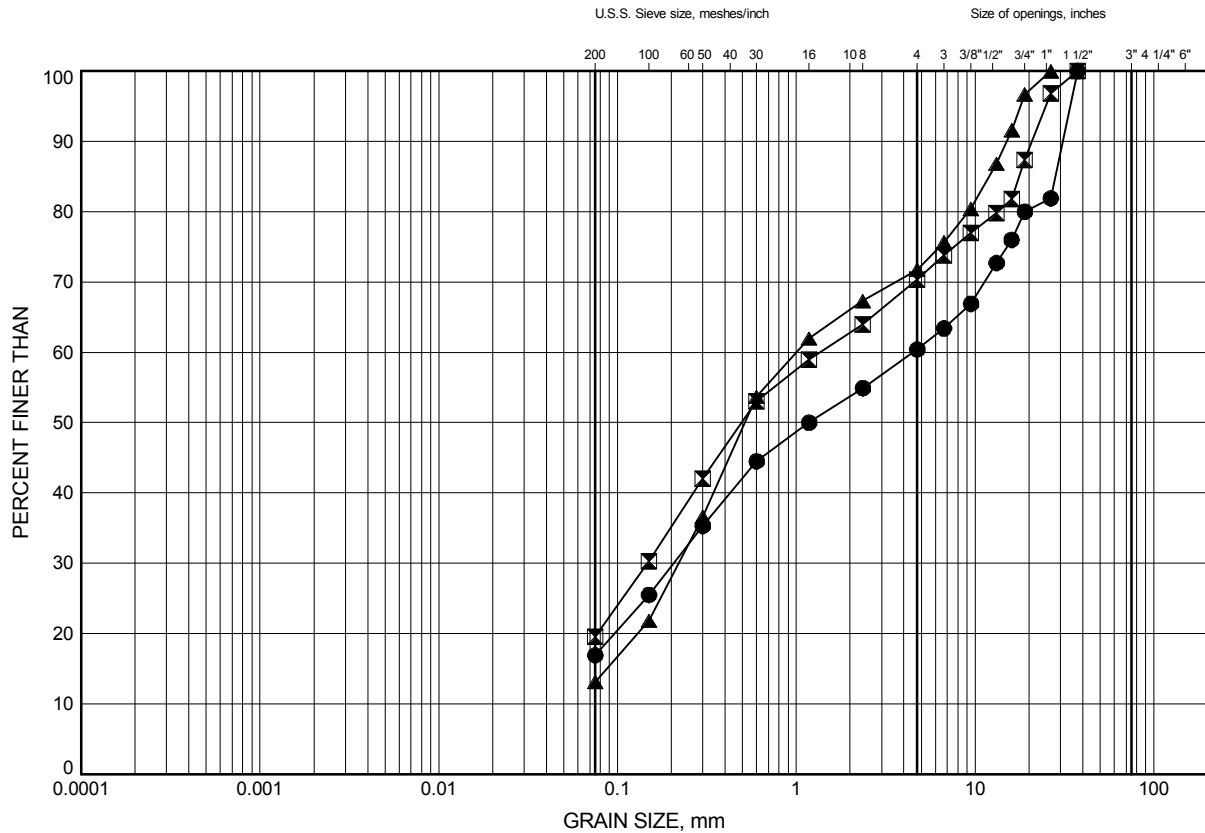


Prep'd KCP  
Chkd. PC

29-250/C Foresters Falls Rd. Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 7

**Silty Sand with Gravel - Till**



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	701	3.96	123.02
⊠	702	7.16	121.04
▲	705	7.16	120.67

Date February 2018  
W.P. 4114-13-01



Prep'd KCP  
Chkd. PC

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Unit 107  
Ottawa, ON K1B4S5  
Attn: Kenton Power

Client PO: 19-5161-263 Task 60  
Project: Forester Falls  
Custody: 14059

Report Date: 14-Jul-2017  
Order Date: 10-Jul-2017

**Order #: 1728119**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1728119-01	705, SS6, 12'6"-14'6"
1728119-02	706, SS3, 4'-6'

Approved By:



Dale Robertson, BSc  
Laboratory Director

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 19-5161-263 Task 60

Report Date: 14-Jul-2017

Order Date: 10-Jul-2017

Project Description: Forester Falls

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	12-Jul-17	12-Jul-17
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	11-Jul-17	12-Jul-17
Resistivity	EPA 120.1 - probe, water extraction	13-Jul-17	13-Jul-17
Solids, %	Gravimetric, calculation	12-Jul-17	12-Jul-17

Certificate of Analysis  
**Client: Thurber Engineering Ltd.**  
**Client PO: 19-5161-263 Task 60**

Report Date: 14-Jul-2017

Order Date: 10-Jul-2017

**Project Description: Forester Falls**

<b>Client ID:</b>	705, SS6, 12'6"-14'6"	706, SS3, 4'-6'	-	-
<b>Sample Date:</b>	29-Jun-17	30-Jun-17	-	-
<b>Sample ID:</b>	1728119-01	1728119-02	-	-
<b>MDL/Units</b>	Soil	Soil	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	76.0	80.1	-	-
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**General Inorganics**

pH	0.05 pH Units	7.34	7.26	-	-
Resistivity	0.10 Ohm.m	15.4	14.7	-	-

**Anions**

Chloride	5 ug/g dry	298	297	-	-
Sulphate	5 ug/g dry	75	131	-	-

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO: 19-5161-263 Task 60

Report Date: 14-Jul-2017

Order Date: 10-Jul-2017

Project Description: Forester Falls

### Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 19-5161-263 Task 60

Report Date: 14-Jul-2017

Order Date: 10-Jul-2017

Project Description: Forester Falls

### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	304	5	ug/g dry	298			2.0	20	
Sulphate	76.2	5	ug/g dry	74.7			2.0	20	
<b>General Inorganics</b>									
pH	7.57	0.05	pH Units	7.60			0.4	10	
Resistivity	27.8	0.10	Ohm.m	28.1			1.1	20	
<b>Physical Characteristics</b>									
% Solids	80.8	0.1	% by Wt.	80.9			0.1	25	

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 19-5161-263 Task 60

Report Date: 14-Jul-2017

Order Date: 10-Jul-2017

Project Description: Forester Falls

**Method Quality Control: Spike**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	402	5	ug/g	298	104	78-113			
Sulphate	178	5	ug/g	74.7	103	78-111			



Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 19-5161-263 Task 60

Report Date: 14-Jul-2017

Order Date: 10-Jul-2017

Project Description: Forester Falls

**Qualifier Notes:**

None

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Unit 107  
Ottawa, ON K1B4S5  
Attn: Kenton Power

Client PO:  
Project: 19-5161-263  
Custody:

Report Date: 13-Nov-2015  
Order Date: 10-Nov-2015

**Order #: 1546148**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1546148-01	BH704 SS4 6' to 8'
<del>1546148-02</del>	<del>BH601 SS4 6' to 8'</del>
<del>1546148-03</del>	<del>BH501 SS6 10.5' to 12.5'</del>

Approved By:

*Mark Foto*

~~Mark~~ Foto, M.Sc.  
Lab Supervisor

## Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 13-Nov-2015

Order Date: 10-Nov-2015

Project Description: **19-5161-263****Analysis Summary Table**

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	12-Nov-15	12-Nov-15
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	11-Nov-15	11-Nov-15
Resistivity	EPA 120.1 - probe, water extraction	12-Nov-15	12-Nov-15
Solids, %	Gravimetric, calculation	12-Nov-15	12-Nov-15

**Certificate of Analysis**
**Client: Thurber Engineering Ltd.**
**Client PO:**
**Report Date: 13-Nov-2015**
**Order Date: 10-Nov-2015**
**Project Description: 19-5161-263**

<b>Client ID:</b>		BH704 SS4 6' to 8'	BH601 SS4 6' to 8'	BH501 SS6 10.5' to 12.5'	-
<b>Sample Date:</b>		22-Oct-15	19-Oct-15	27-Oct-15	-
<b>Sample ID:</b>		1546148-01	1546148-02	1546148-03	-
<b>MDL/Units</b>		Soil	Soil	Soil	-
<b>Physical Characteristics</b>					
% Solids	0.1 % by Wt.	81.9	76.3	91.8	-
<b>General Inorganics</b>					
pH	0.05 pH Units	7.56	7.73	7.99	-
Resistivity	0.10 Ohm.m	25.3	31.2	157	-
<b>Anions</b>					
Chloride	5 ug/g dry	129	70	6	-
Sulphate	5 ug/g dry	27	112	7	-

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 13-Nov-2015

Order Date: 10-Nov-2015

Project Description: **19-5161-263**

**Method Quality Control: Blank**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 13-Nov-2015

Order Date: 10-Nov-2015

Project Description: **19-5161-263**

**Method Quality Control: Duplicate**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	7.0	5	ug/g dry	7.1			0.5	20	
Sulphate	24.3	5	ug/g dry	25.1			3.6	20	
<b>General Inorganics</b>									
pH	8.11	0.05	pH Units	7.99			1.5	10	
Resistivity	24.8	0.10	Ohm.m	25.3			1.9	20	
<b>Physical Characteristics</b>									
% Solids	78.2	0.1	% by Wt.	77.6			0.7	25	

## Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 13-Nov-2015

Order Date: 10-Nov-2015

Project Description: **19-5161-263****Method Quality Control: Spike**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	100	5	ug/g	7.1	93.3	78-113			
Sulphate	104	5	ug/g	25.1	79.1	78-111			

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 13-Nov-2015

Order Date: 10-Nov-2015

**Project Description: 19-5161-263**

**Qualifier Notes:**

None

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.



**APPENDIX D**  
**SITE PHOTOGRAPHS**



**Figure 1: Roadway platform looking east towards Foresters Falls Road**



**Figure 2: Looking north towards existing culvert inlet and the proposed location to the right**





**Figure 3: Looking upstream from Culvert 29-250/C**



**Figure 4: Culvert 29-250/C outlet looking east**





**Figure 5: Looking downstream from Culvert outlet**



**Figure 6: South embankment looking east from existing culvert towards proposed inlet**





**Figure 7: North embankment looking east from existing culvert towards proposed outlet**