



**THURBER** ENGINEERING LTD.

**FINAL**  
**FOUNDATION INVESTIGATION REPORT**  
**REHABILITATION OF ROOT RIVER CULVERT #4 (SITE 38S-053)**  
**HIGHWAY 17 - 1.9 KM SOUTH OF HIGHWAY 556**  
**AWERES TOWNSHIP**  
**G.W.P. 5181-13-00**  
  
**5016-E-0040**

**Geocres No.: 41K-104**

Report to:

**Ministry of Transportation Ontario**

Latitude: 46.625692°  
Longitude: -84.309784°

July 2018  
Thurber File: 17848

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**PART 1. FACTUAL INFORMATION**

**1 INTRODUCTION**

This section of the report presents the factual findings obtained from a foundation investigation completed at Highway 17 Root River Culvert #4 (38S-053) which is located approximately 1.9 km south of Highway 556 at Heyden within the Township of Aweres. Thurber Engineering Limited (Thurber) carried out the current investigation under Agreement No. 5016-E-0040.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation. A previous foundation investigation report that was obtained from the online Geocres library and reviewed in preparation of this report is as follows:

Soil Site Investigation at Proposed Highway 17 - Root River #4 Crossing (W.P. 909-57), Township of Aweres for Department of Highways of Ontario, dated 19<sup>th</sup> July, 1958.

**2 SITE DESCRIPTION**

The existing culvert is a twin celled open footed concrete culvert, each cell is reported to have a width of 4.3 m, a height of 2.7 m and a length of 26.8 m with obvert elevations of 314.9 m and strembed elevations of approximately 312.2 m. The culvert has a generally east to west alignment with flow through the culvert to the west.

At the location of the culvert, Highway 17 is a two-lane highway with paved shoulders. The Highway 17 fill height above the culvert is approximately 1.5 m with the centreline of the road surface at approximate elevation 316.9 m. The existing embankment slopes are inclined between 2.5H:1V and 3H:1V. Steel cable guide rails are present on both sides of the highway in the vicinity of the culvert. The land adjacent to the highway has occasional side roads with residential properties and is mainly vegetated with trees and shrubs. Traffic volumes on this section of Highway 17 are understood to be 6,300 AADT (2016).

**FINAL**

Select photographs showing the existing conditions in the area of the culvert are included in Appendix D for reference.

### 3 SITE INVESTIGATION AND FIELD TESTING

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locate clearances in the vicinity of the intended boreholes.

The site investigation and field testing program was carried out between October 19<sup>th</sup> and December 10<sup>th</sup>, 2017. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1. The site is within MTM Zone 13. The elevations were surveyed relative to first order vertical benchmark 0011993U466 which is a tablet set in a rock outcrop just north of the Root River #4 culvert site with an elevation of 321.162 m.

**Table 3-1: Borehole Summary**

<b>Borehole No.</b>	<b>Drilled Location</b>	<b>Approximate Northing (m)</b>	<b>Approximate Easting (m)</b>	<b>Ground Surface Elevation (m)</b>	<b>Sample Termination Depth (m)</b>
17-07	Northbound Roadway	5 165 154.0	281 076.0	316.7	12.4
17-08	Southbound Roadway	5 165 175.0	281 074.0	317.0	10.7
17-09	East side – inlet	5 165 165.0	281 090.0	313.7	11.3
17-10A	East side – inlet	5 165 188.0	281 094.0	313.3	6.7 <sup>1</sup>
17-10B <sup>2</sup>	East side – inlet	5 165 209.0	281 097.0	314.4	3.2
17-10C <sup>2</sup>	East side – inlet	5 165 190.0	281 091.0	314.7	8.7
17-11	West side – outlet	5 165 138.0	281 055.0	314.5	11.3 <sup>3</sup>
17-12	West side – outlet	5 165 170.0	281 057.0	313.7	1.8 <sup>4</sup>

<sup>1</sup> - Early termination due to Root River water level increase

<sup>2</sup> - Rock Probehole – Overburden not sampled

<sup>3</sup> - Borehole was advanced beyond sample termination depth by dynamic cone

<sup>4</sup> - Early termination due to cave in

The drilling was carried out using portable drilling equipment for Borehole 17-12, a truck mounted CME 75 drill rig for Borehole 17-08 and a track mounted CME 550 rig for all remaining off-road Boreholes. Borehole 17-07 was drilled starting with a truck mounted CME 75 drill rig and finishing with a track mounted CME 550 drill rig.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A 25.6 kg drop hammer was used to advance the splitspoon in Borehole 17-12. The N-values have been corrected to provide an estimate of the N-value that would have been obtained with a standard 64 kg hammer. Bedrock core samples were acquired with NQ sized coring equipment.



A 19 mm diameter standpipe piezometer was installed in Borehole 17-09 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the Record of Borehole sheet provided in Appendix B. Rising head hydraulic conductivity testing was carried out in the well prior to its abandonment. All other boreholes were backfilled with a low-permeability mixture of cuttings and bentonite pellets in accordance with Ontario MOE Regulation 903 as amended.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's geotechnical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

#### **4 LABORATORY TESTING**

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Grain size distribution analyses was also carried out on selected samples to MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate and chloride concentrations was carried out on one soil sample.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

##### **5.1 General**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. 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. It must be recognized that soil and groundwater conditions may vary between and beyond sampled locations.

The stratigraphy encountered through the embankment near the culvert is generally characterized by fill materials overlying sand and gravel deposits. Granite bedrock was encountered in the northeastern section of the site.

##### **5.2 Fill Material**

###### **5.2.1 Asphalt**

Boreholes 17-07 and 17-08 were drilled through the existing Highway 17 pavement and encountered a layer of asphalt with a thickness of 150 mm.

###### **5.2.2 Fill: Sand, Gravel and Silty Sand**

Below the asphalt in Borehole 17-07 and 17-08, below the organics in Borehole 17-09 and at ground surface in Borehole 17-11 was a layer of fill consisting of a granular deposit with varying amounts of sand, gravel and silt. The underside of the granular fill ranged from 1.5 to 4.0 m below surface (elev. 312.2 to 313.2 m). Occasional to frequent cobbles and

occasional boulders were present throughout the fill. Coring techniques were utilized to advance through the cobbles and boulders.

SPT tests conducted within the granular fill gave N-values ranging from 4 to greater than 100 blows, indicating a loose to very dense relative density, however the fill materials at this site are typically dense to very dense.

Moisture contents ranged from 2 to 14%. The results of grain size analyses conducted on six samples of the granular fill materials are summarized below and are illustrated on Figure C1 in Appendix C.

**Table 5-1: Gradation Results for Granular Fill**

Soil Particle	Percentage (%)
Gravel	25 to 56
Sand	40 to 60
Silt and Clay	4 to 15

### **5.3 Organics**

Boreholes 17-09 and 17-10A encountered a layer of organics consisting of wood and roots at ground surface with a thickness of 100 mm.

### **5.4 Sand to Silty Sand**

#### **5.4.1 Sand**

A sand deposit with varying amounts of silt and gravel was encountered in Boreholes 17-07, 17-08, 17-09, 17-10A and 17-11. Borehole 17-11 encountered an upper and lower sand deposit separated by a 2.6 m thick gravel deposit as described in the following Section 5.5. Borehole 17-11 was terminated within the lower sand deposit at a final sampled depth of 11.3 m (elev. 303.2 m). Where the sand layer was fully penetrated, the sand deposit ranged in thickness from 4.0 to 8.7 m with an underside elevation ranging from 303.5 to 309.2 m. Borehole 17-11 was extended below termination depth by performing a dynamic cone penetration test (DCPT) to a final elevation of 301.1 m.

SPT tests gave N-values ranging from 7 to greater than 100 blows per 300 mm of penetration indicating a loose to very dense relative density. In general the deposit is considered to be compact to dense.

The moisture content ranged between 3 to 19%. Gradation analyses were completed on five samples of the sand deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the grain size distribution curves for this material are included in Figure C2 of Appendix C. The results of the laboratory test are summarized as follows:

**Table 5-2: Gradation Results for Sand**

Soil Particle	Percentage (%)
Gravel	15 to 33
Sand	62 to 82
Silt and Clay	3 to 11

#### 5.4.2 Silty Sand (SM)

A silty sand deposit with gravel was encountered underlying the sand deposit in Borehole 17-09. The Borehole was terminated within this layer at a final depth of 11.3 m (elev. 302.4 m).

SPT tests conducted within the silty sand gave an N-value of 30 blows, indicating a dense relative density.

The moisture content was 10%. The results of grain size analysis conducted on one sample of the silty sand material indicate the material consists of 10% gravel, 49% sand and 41% silt and clay. The results are illustrated on Figure C3 in Appendix C.

### 5.5 Gravel

At ground surface in Borehole 17-12 and below the sand in Boreholes 17-07, 17-08 and 17-10A was a deposit of gravel with silt and sand. These boreholes were terminated within the gravel deposit at final depths of 1.8 to 12.4 m (elev. 304.3 to 311.9 m). A 2.6 m thick gravel deposit was encountered at a depth of 6.1 m (elev. 308.4 m) in Borehole 17-11 between the upper and lower sand deposit as described in the previous Section 5.4.1. Occasional to frequent cobbles and occasional boulders were encountered throughout this cohesionless deposit. Coring techniques were utilized to advance through the cobbles and boulders.

SPT tests gave N-values ranging from 76 to greater than 100 blows per 300 mm of penetration indicating a dense to very dense state of packing; the deposit was typically very dense. The N-values in Borehole 17-12 ranged from 1 to 18, indicating a very loose to compact relative density at this very shallow location.

Moisture contents ranged from 6 to 15%. Higher values of 19% and 49% were measured for the very loose surficial gravel in Borehole 17-12. Gradation analyses were completed on three samples of the gravel. The results are summarized on the Record of Borehole sheets in Appendix B and the grain size distribution curves for these samples are included in Figure C4 of Appendix C. The results of the laboratory tests are summarized as follows:

**Table 5-3: Gradation Results for Gravel**

Soil Particle	Percentage (%)
Gravel	52 to 70
Sand	24 to 47
Silt and Clay	1 to 6

## 5.6 Bedrock

Bedrock was proven by coring in Borehole 17-10B and 17-10C. Information on the bedrock surface is summarized in the following table:

**Table 5-4: Summary of Bedrock Elevations**

Borehole No.	Depth to Bedrock (m)	Bedrock Elevation (m)
17-10B	0.1	314.3
17-10C	5.5	309.2

The bedrock encountered within Boreholes 17-10B and 17-10C consisted of granite with occasional quartz veins. The Total Core Recovery (TCR) measured on the recovered bedrock core was 100%, the Solid Core Recovery (SCR) ranged from 45 to 78% and the Rock Quality Designation (RQD) ranged from 24 to 81%. Based on the measured RQD values, the bedrock is classified as very poor to good quality but predominantly ranges from poor to fair quality. The granite bedrock is estimated to be strong to very strong. Photographs of the bedrock core are provided in Appendix C.

## 5.7 Groundwater

Reliable water levels could not be recorded in most of the open boreholes due to water being introduced as part of the drilling operations. The groundwater water levels presented in Table 5-5: Groundwater Level Observations were measured in the standpipe piezometer installed in Borehole 17-09 and within the cased hole in Borehole 17-08, which was left in place overnight.

**Table 5-5: Groundwater Level Observations**

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
17-08	3.1	313.9	November 14, 2017
17-09	0.05	313.65	December 1, 2017
	0.00	313.70	December 9, 2017

The creek water level was also surveyed during the field investigation measured to be at a depth of 1.72 m below the culvert obvert (elev. 313.2 m) on December 12, 2017.

A rising head test was performed in Piezometer 17-09 to determine the hydraulic conductivity. The results indicated a K value of  $1.3 \times 10^{-4}$  m/s and are shown in Appendix C.

These observations are considered short term and it should be noted that the groundwater level at the time of construction and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

## 5.8 Analytical Testing

One sample of soil was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. The analysis results are summarized in the table below:

**Table 5-6: Analytical Results Summary**

Borehole	Sample	Depth (m)	Sulphate ( $\mu\text{g/g}$ )	pH	Resistivity (Ohm-cm)	Conductivity ( $\mu\text{S/cm}$ )	Chloride ( $\mu\text{g/g}$ )
17 - 10	SS2	0.8 – 1.4	69	6.20	3320	301	114

## 6 MISCELLANEOUS

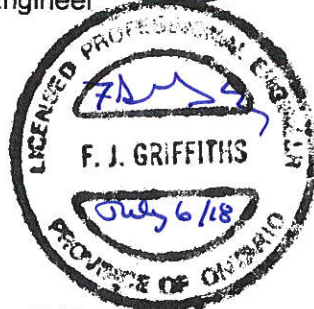
Borehole locations were selected by Thurber relative to existing site features and the anticipated foundation locations. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

George Downing Estate Drilling Ltd. of Hawksbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing, standpipe piezometer installation and borehole decommissioning. Leroy Construction of Blind River, Ontario supplied the traffic control equipment and personnel for TL-20A lane closures required for the on-road boreholes in conformance with Ontario Book 7 requirements. Short duration TL-6 shoulder closures were used for all off-road boreholes; all signs and cones for the shoulder closures were provided by Thurber. The field investigation was supervised on a full time basis by Ms. Deanna Pizycki, E.I.T. and Mr. Nick Weil of Thurber. Overall supervision of the investigation program was provided by Mr. Paul Carnaffan, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Miss Katya Edney, P.Eng. and Dr. Fred Griffiths, P.Eng.. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



Katya Edney, P.Eng.  
Geotechnical Engineer



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Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.  
Review Principal  
Senior Geotechnical Engineer

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**Appendix A.**

**Borehole Location Plan and Stratigraphic Drawings**



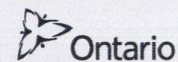
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 5181-13-00

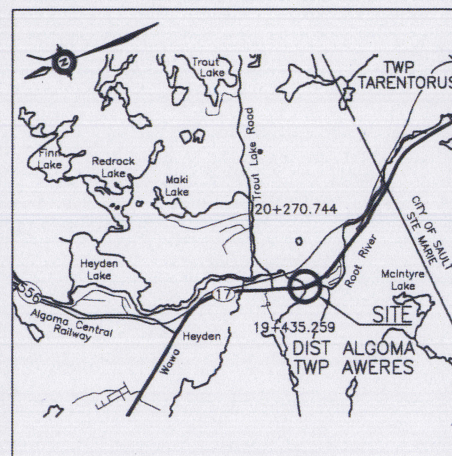
HIGHWAY 17  
ROOT RIVER CULVERT #4  
REHABILITATION  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

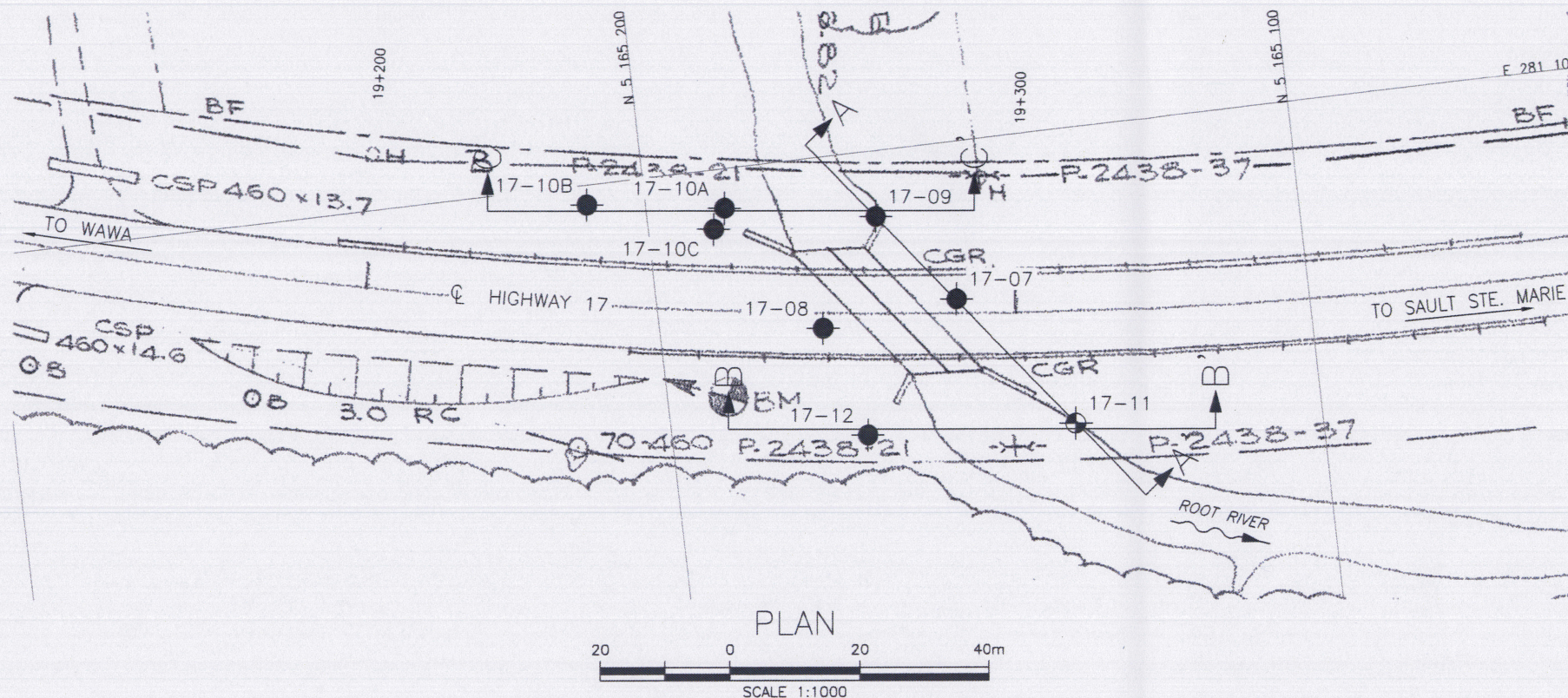
◆	Borehole
◆	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
↑	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-07	316.7	5 165 154.0	281 076.0
17-08	317.0	5 165 175.0	281 074.0
17-09	313.7	5 165 165.0	281 090.0
17-10A	313.3	5 165 188.0	281 094.0
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17-11	314.5	5 165 138.0	281 055.0
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-NOTES-

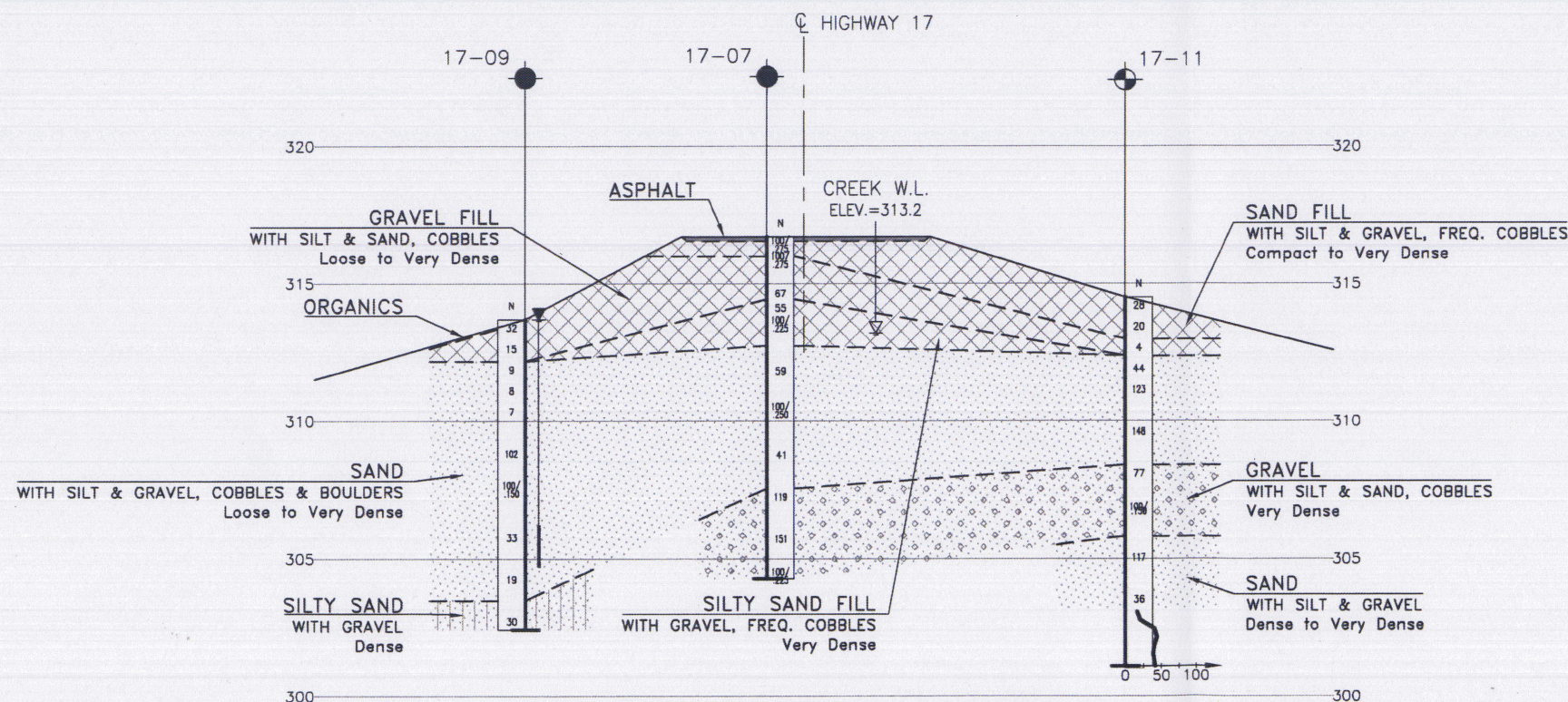
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 13.

GEOCRES No. 41K-104

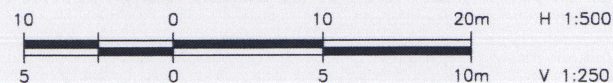


The existing culvert is a twin celled open footed concrete culvert, each cell is reported to have a width of 4.3 m, a height of 2.7 m and a length of 26.8 m with obvert elevations of 314.9 m and invert elevations of approximately 312.2 m. The highway 17 fill height above the culvert is approximately 1.5 m with the centreline of the road surface at approximate elevation 316.9 m. The existing embankment slopes are inclined between 2.5H:1V and 3H:1V.

NOTE: Ground surface in the stratigraphy plot is inferred between borehole elevations and is not based on elevation data.



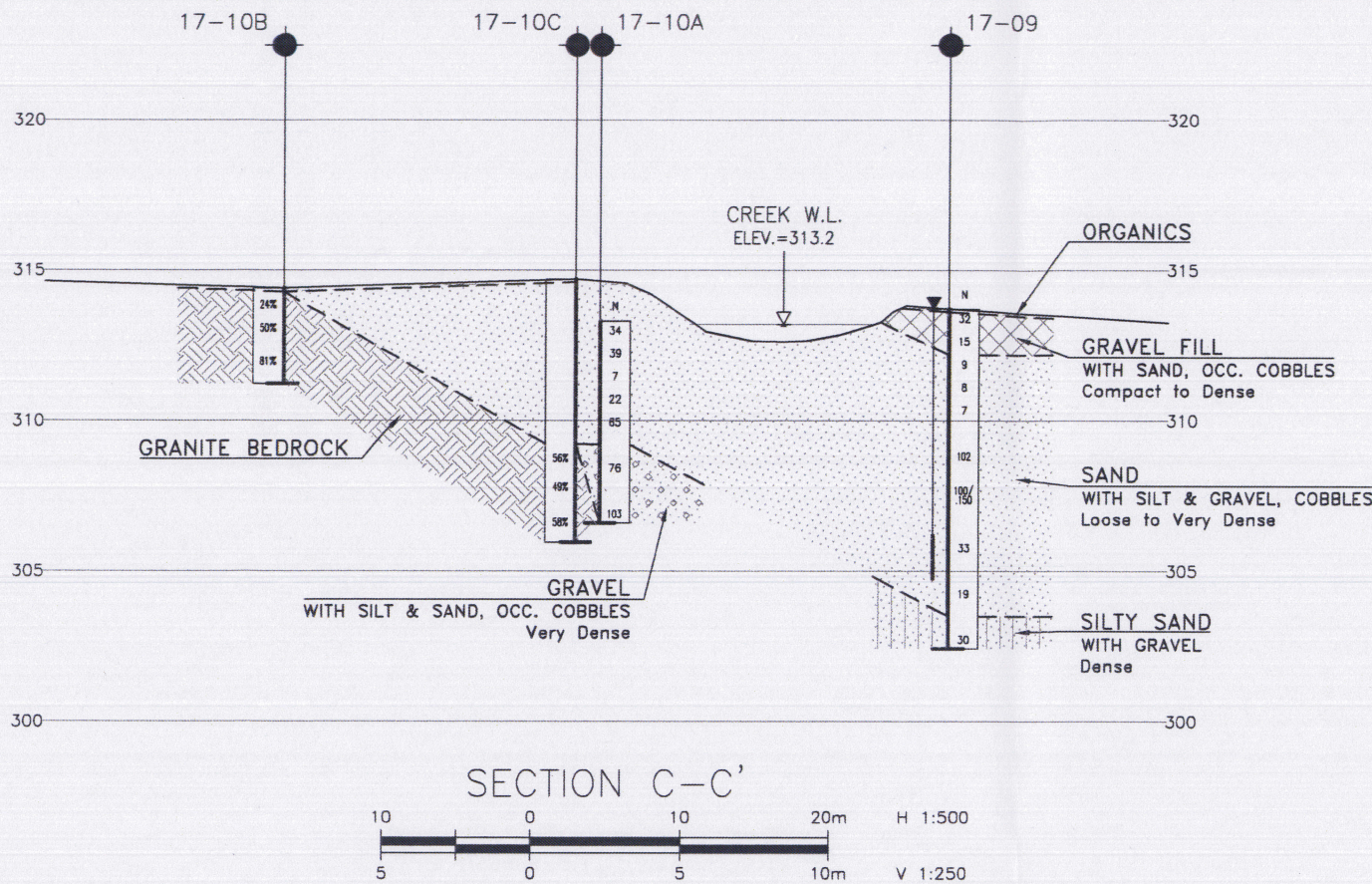
SECTION A-A'



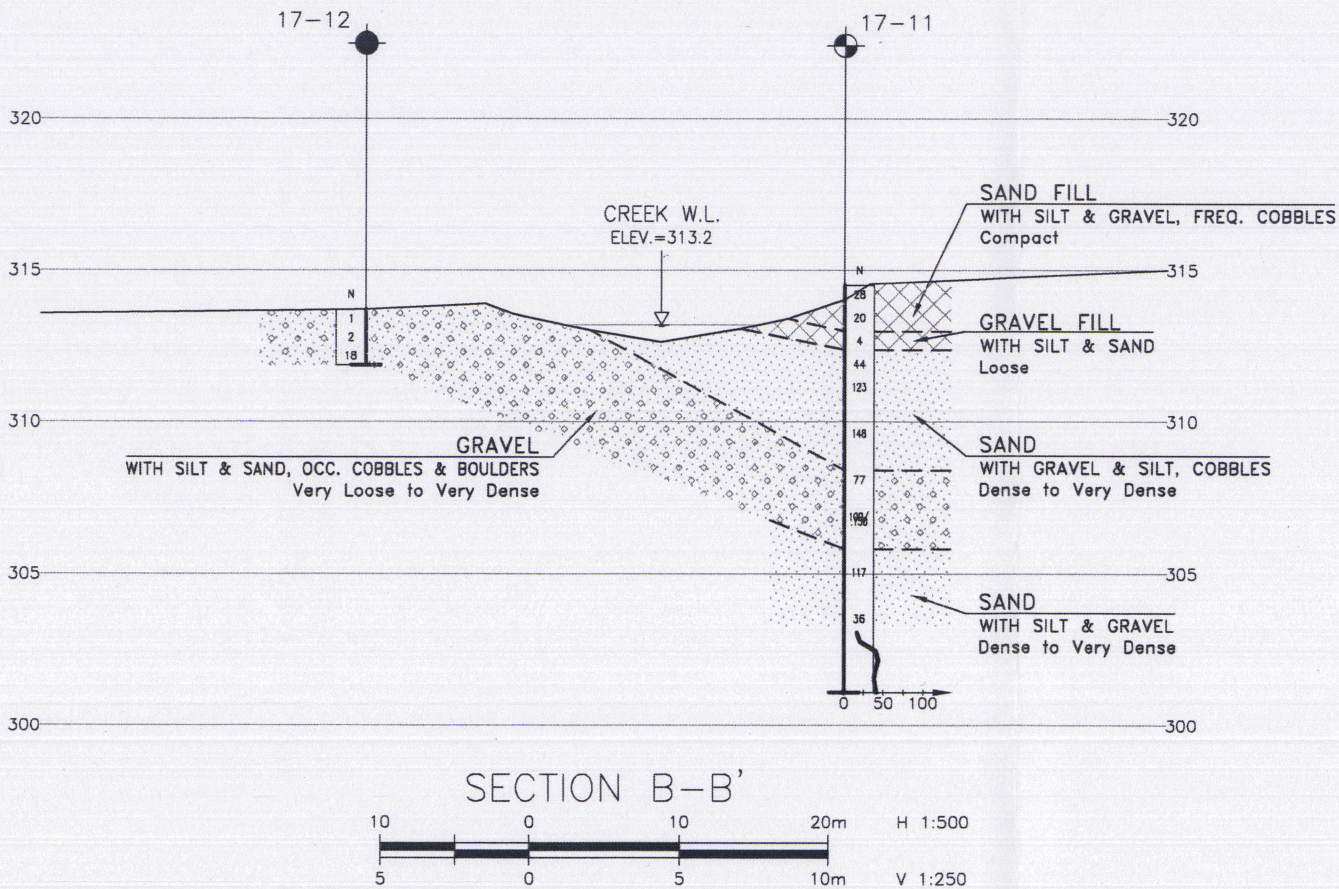
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DESIGN CM	CHK	CODE	LOAD
DRAWN MFA	CHK CM	SITE	STRUCT
			DWG 1



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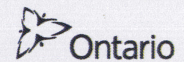
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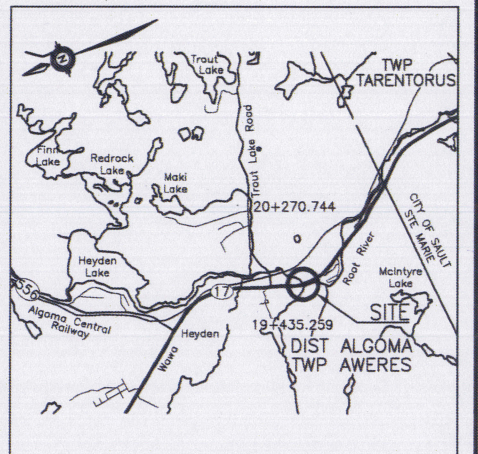
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GWP No 5181-13-00

HIGHWAY 17  
ROOT RIVER CULVERT #4  
REHABILITATION  
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
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17-09	313.7	5 165 165.0	281 090.0
17-10A	313.3	5 165 188.0	281 094.0
17-10B	314.4	5 165 209.0	281 097.0
17-10C	314.7	5 165 190.0	281 091.0
17-11	314.5	5 165 138.0	281 055.0
17-12	313.7	5 165 170.0	281 057.0

-NOTES-

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- Coordinate system is MTM NAD 83 Zone 13.

GEOCRE No. 41K-104

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CM	CHK	CODE
DRAWN	MFA	CHK CM	SITE
			STRUCT
			DWG 2
			DATE JUL 2018



**Appendix B.**

**Record of Borehole Sheets**



## **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).

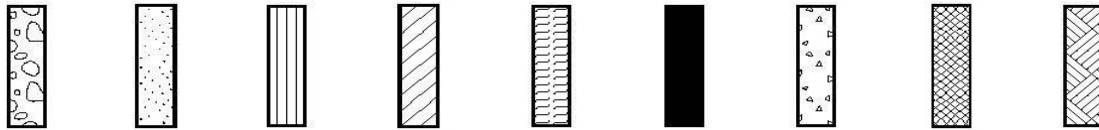
### **DYNAMIC CONE PENETRATION TEST (DCPT):**

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 17-07

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 154.0 E 281 076.0 ORIGINATED BY DJP/NW  
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.10.19 - 2017.11.28 CHECKED BY FG

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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
316.7								20	40	60	80	100							
0.0	ASPHALT (150 mm)																		
0.2	FILL SAND with silt and gravel frequent cobbles very dense brown		1	SS	100\									o					39 49 12 (SI+CL)
316.0					275mm														
0.7	FILL GRAVEL with silt and sand frequent cobbles very dense brown - zone of cobbles and boulders at 0.9 m		2	SS	100\									o					
					275mm														
314.4			3	SS	67									o					
2.3	FILL SILTY SAND with gravel frequent cobbles very dense brown		4	SS	55									o					
			5	SS	100\									o					
					225mm														
312.7																			
4.0	SAND (SP-SM) with silt and gravel occasional to frequent cobbles and boulders dense to very dense grey																		
			6	SS	59									o					27 62 11 (SI+CL)
	- 180 mm cobble at 5.2 m																		
	- 100 mm cobble at 5.8 m																		
			7	SS	100\									o					
	- 80 mm cobble at 6.5 m				250mm														
	- 120 mm cobble at 6.8 m																		
	- 100 mm cobble at 7.2 m																		
			8	SS	41									o					
307.6																			
9.1	GRAVEL(GP-GM) with silt and sand frequent cobbles very dense brown		9	SS	119									o					70 24 6 (SI+CL)

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

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# RECORD OF BOREHOLE No 17-07

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 154.0 E 281 076.0 ORIGINATED BY DJP/NW  
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.10.19 - 2017.11.28 CHECKED BY FG

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 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
	GRAVEL(GP-GM) with silt and sand frequent cobbles very dense brown		10	SS	151		306										
								305									
304.3			11	SS	100\												
12.4	End of Borehole				225mm												

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# RECORD OF BOREHOLE No 17-08

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 175.0 E 281 074.0 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.11.14 - 2017.11.15 CHECKED BY FG

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 (%)  GR   SA   SI   CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)								
								20   40   60   80   100				W <sub>P</sub> W      W <sub>L</sub>								
317.0																				
0.0	ASPHALT (150 mm)						317													
0.2	FILL SAND with silt and gravel very dense to dense brown		1	SS	110														38   52   10 (SI+CL)	
316.0																				
1.1	FILL SILTY SAND with gravel dense brown		2	SS	37		316												25   60   15 (SI+CL)	
315.5																				
1.5	FILL GRAVEL with silt and sand - occasional to frequent cobbles below 1.5 m very dense to dense brown		3	SS	60		315													
			4	SS	43														50   42   8 (SI+CL)	
							314													
			5	SS	40															
313.2																				
3.8	SAND (SP-SM) with silt and gravel occasional to frequent cobbles loose to very dense brown		6	SS	12		313													
			7	SS	11															
							312													
			8	SS	17															
							311													
			9	SS	7															
							310													
			10	SS	100		309													
					100mm															
307.9																				
9.1	GRAVEL (GP-GM) with silt and sand frequent cobbles very dense brown		11	SS	100		308													
					50mm															

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 17-08

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 175.0 E 281 074.0 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.11.14 - 2017.11.15 CHECKED BY FG

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	WATER CONTENT (%)								
	Continued From Previous Page						307										
306.4	GRAVEL (GP-GM) with silt and sand frequent cobbles very dense brown		12	SS	100												
10.7	End of Borehole Groundwater observed in cased BH at elev. 313.9 m on Nov. 15, 2017 during drilling operations				0mm												

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# RECORD OF BOREHOLE No 17-09

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 165.0 E 281 090.0 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.11.28 - 2017.11.30 CHECKED BY FG

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 (%)  GR   SA   SI   CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
313.7								20	40	60	80	100							
0.0																			
0.1																			

Continued Next Page

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

# RECORD OF BOREHOLE No 17-09

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 165.0 E 281 090.0 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.11.28 - 2017.11.30 CHECKED BY FG

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									
303.5	Continued From Previous Page																
10.2	SILTY SAND (SM) with gravel dense brown		10	SS	30											10 49 41 (SI+CL)	
302.4																	
11.3	End of Borehole  Water Levels in Well 2017.12.01 0.05 mbgs 2017.12.09 0.00 mbgs																

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# RECORD OF BOREHOLE No 17-10A

1 OF 1

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 188.0 E 281 094.0 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.12.03 - 2017.12.03 CHECKED BY FG

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 (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE	20	40	60	80		100	W <sub>P</sub>	W	W <sub>L</sub>			
313.3																				
0.0	<b>ORGANICS</b> wood and roots  <b>SAND (SP)</b> with gravel, occasional cobbles loose to very dense brown		1	SS	34		313							○						
0.1														○						
			2	SS	39										○					
									312											
			3	SS	7										○					
									311							○				
			4	SS	22											○				15 82 3 (SI+CL)
							310							○						
309.2																				
4.1	<b>GRAVEL (GP-GM)</b> with silt and sand occasional cobbles very dense		6	SS	76		309							○					53 42 5 (SI+CL)	
			7	SS	103				307						○					
306.6																				
6.7	Borehole terminated due to flooding																			

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# RECORD OF BOREHOLE No 17-10B

1 OF 1

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 209.0 E 281 097.0 ORIGINATED BY DJP  
 HWY 17 BOREHOLE TYPE HW Casing / HQ Coring COMPILED BY KE  
 DATUM Geodetic DATE 2017.12.04 - 2017.12.04 CHECKED BY FG

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								
314.4								20	40	60	80	100				
0.0	Unsampled Overburden															
0.1	GRANITE BEDROCK occasional quartz veins moderately weathered to fresh strong grey with pink intrusions		1	RUN			314									RUN #1 TCR=100% SCR=45% RQD=24%
			2	RUN			313									RUN #2 TCR=100% SCR=61% RQD=50%
			3	RUN			312									RUN #3 TCR=100% SCR=78% RQD=81%
311.2																
3.2	End of Borehole															


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# RECORD OF BOREHOLE No 17-10C

1 OF 1

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 190.0 E 281 091.0 ORIGINATED BY DJP  
 HWY 17 BOREHOLE TYPE HW Casing / HQ Coring COMPILED BY KE  
 DATUM Geodetic DATE 2017.12.08 - 2017.12.09 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT  W P	NATURAL MOISTURE CONTENT  W	LIQUID LIMIT  W L	UNIT WEIGHT  $\gamma$  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									WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
314.7 0.0	Unsampled Overburden						20	40	60	80	100	20	40	60					
309.2 5.5	GRANITE BEDROCK occasional quartz veins slightly to highly weathered grey with pink intrusions		1	RUN			314									RUN #1 TCR=100% SCR=65% RQD=56%			
			2	RUN			313										RUN #2 TCR=100% SCR=56% RQD=49%		
			3	RUN			312												
306.0 8.7	End of Borehole						311									RUN #3 TCR=100% SCR=62% RQD=58%			
							310												
							309												
							308												
							307												
							306												

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

20  
15  
10

(%) STRAIN AT FAILURE




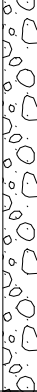

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# RECORD OF BOREHOLE No 17-11

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 138.0 E 281 055.0 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.11.30 - 2017.11.30 CHECKED BY FG

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							WATER CONTENT (%)  20 40 60
								<div><div><div>20406080100</div><div>20406080100</div></div><div><div>○ UNCONFINED</div><div>● QUICK TRIAXIAL</div></div><div><div>+ FIELD VANE</div><div>× LAB VANE</div></div></div>							
314.5															
0.0	FILL SAND with silt and gravel frequent cobbles compact brown		1	SS	28		314							42 51 7 (SH+CL)	
			2	SS	20										
313.0							313								
1.5	FILL GRAVEL with silt and sand loose brown		3	SS	4										
312.4															
2.1	SAND (SP) with gravel and silt occasional to frequent cobbles dense to very dense grey		4	SS	44		312							26 64 10 (SH+CL)	
			5	SS	123		311								
			6	SS	148		310								
							309								
308.4															
6.1	GRAVEL (GP-GM) with silt and sand occasional cobbles very dense grey		7	SS	77		308								
			8	SS	100\		307								
					150mm										
305.8							306								
8.7	SAND (SP) with silt and gravel very dense to dense grey		9	SS	117		305								

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 17-11

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 138.0 E 281 055.0 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.11.30 - 2017.11.30 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			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	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page													
303.2	SAND (SP) with silt and gravel very dense to dense grey		10	SS	36		304							33 62 5 (SI+CL)
11.3	End of sampled Borehole DCPT carried out from 11.3 to 13.4 m						303							
301.1							302							
13.4	End of DCPT at 13.4 m													

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# RECORD OF BOREHOLE No 17-12

1 OF 1

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 170.0 E 281 057.0 ORIGINATED BY DJP  
 HWY 17 BOREHOLE TYPE Manual COMPILED BY KE  
 DATUM Geodetic DATE 2017.12.10 - 2017.12.10 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
313.7 0.0	GRAVEL (GP) with sand occasional cobbles and boulders very loose to compact brown		1	SS	1												52 47 1 (SI+CL)
			2	SS	2												
			3	SS	18												
311.9 1.8	Borehole terminated due to cave-in																
	Note: A 40% (25.6 kg) drop hammer was used to advance the splitspoon sampler. The "N" values presented above have been corrected to provide an estimate of the "N" value that would have been obtained with a standard 64 kg hammer.																

**Appendix C.**  
**Laboratory Testing**

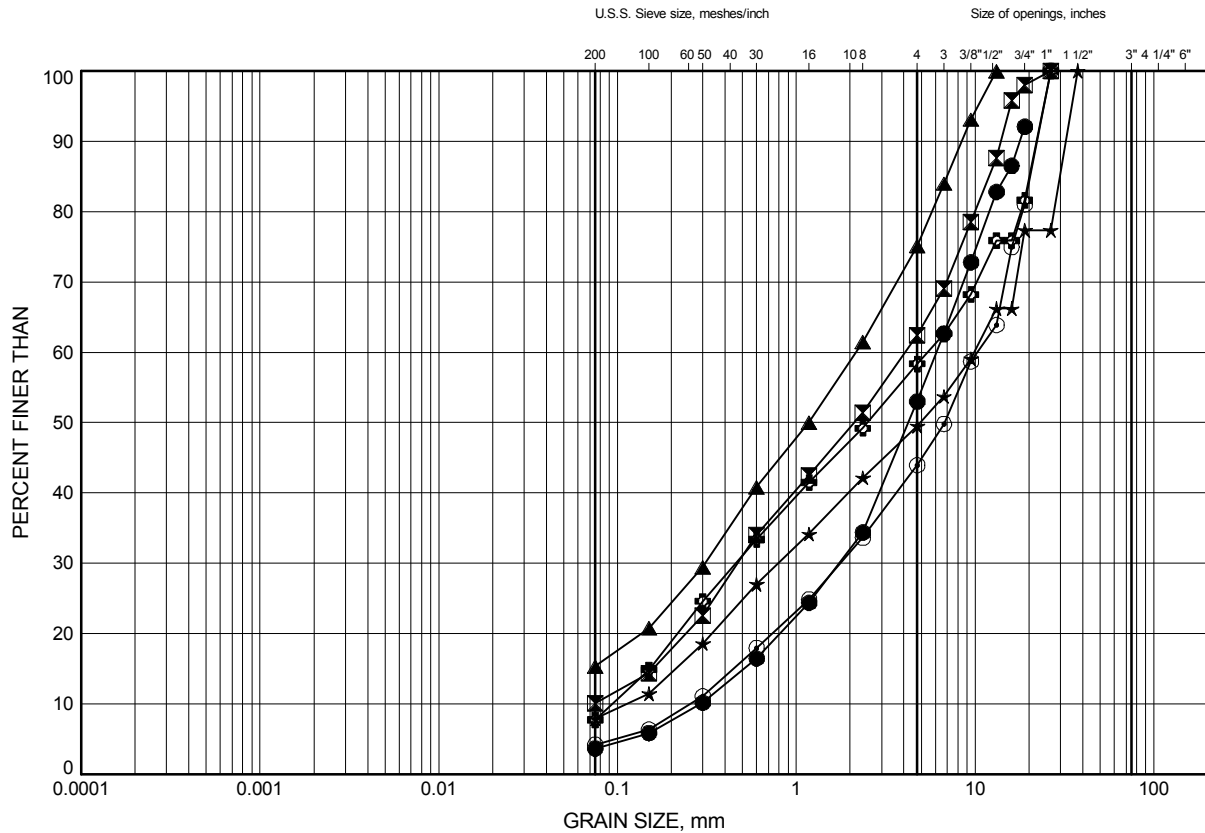
## **Appendix C.1**

### **Particle Size Analysis Figures**

# SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C1

## FILL MATERIALS



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-07	0.37	316.34
⊠	17-08	0.38	316.66
▲	17-08	1.22	315.82
★	17-08	2.59	314.45
⊙	17-09	1.07	312.64
⊕	17-11	0.30	314.22

Date February 2018

GWP# 5181-13-00

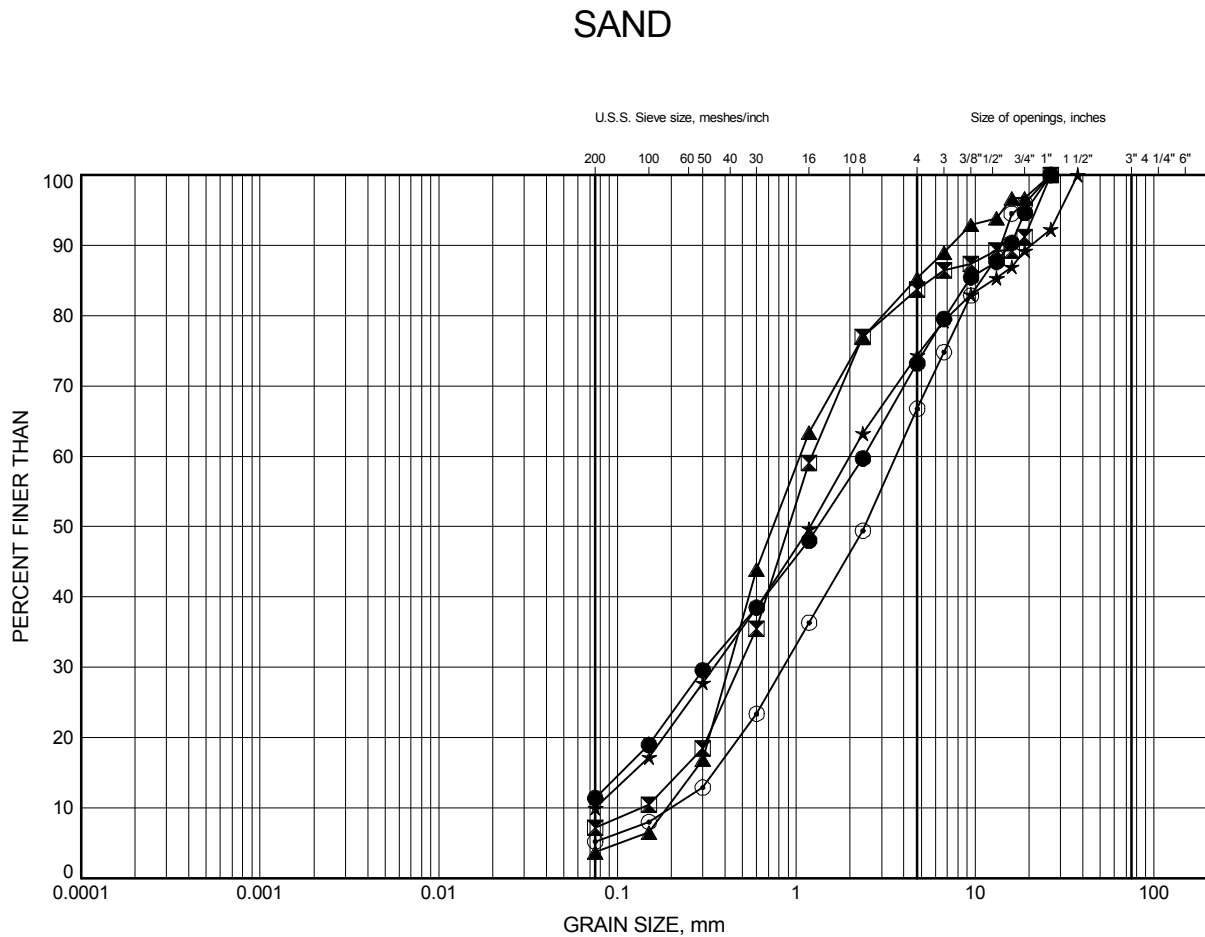


Prep'd KE

Chkd. FG

# SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C2



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-07	4.88	311.83
⊠	17-09	7.92	305.78
▲	17-10A	2.59	310.73
★	17-11	2.59	311.93
⊙	17-11	10.97	303.55

Date February 2018

GWP# 5181-13-00



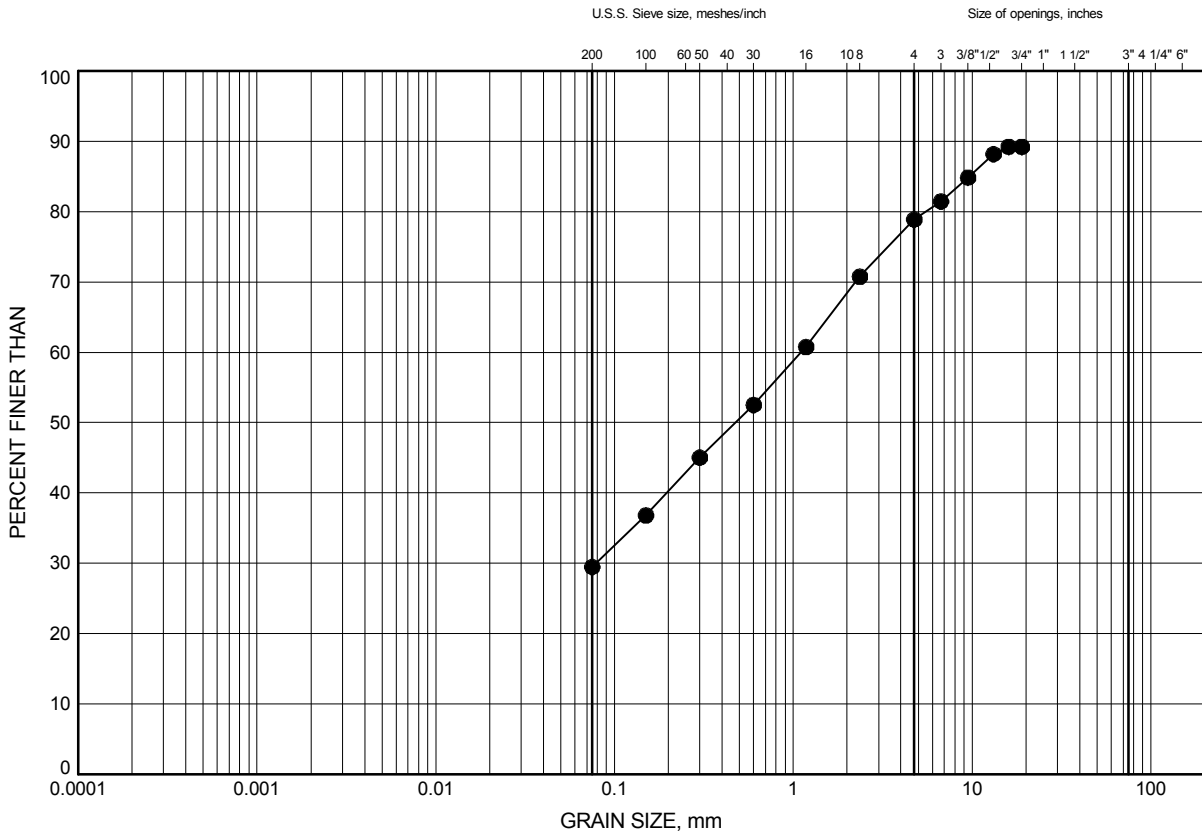
Prep'd KE

Chkd. FG

# SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C3

## SILTY SAND



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-09	10.97	302.73

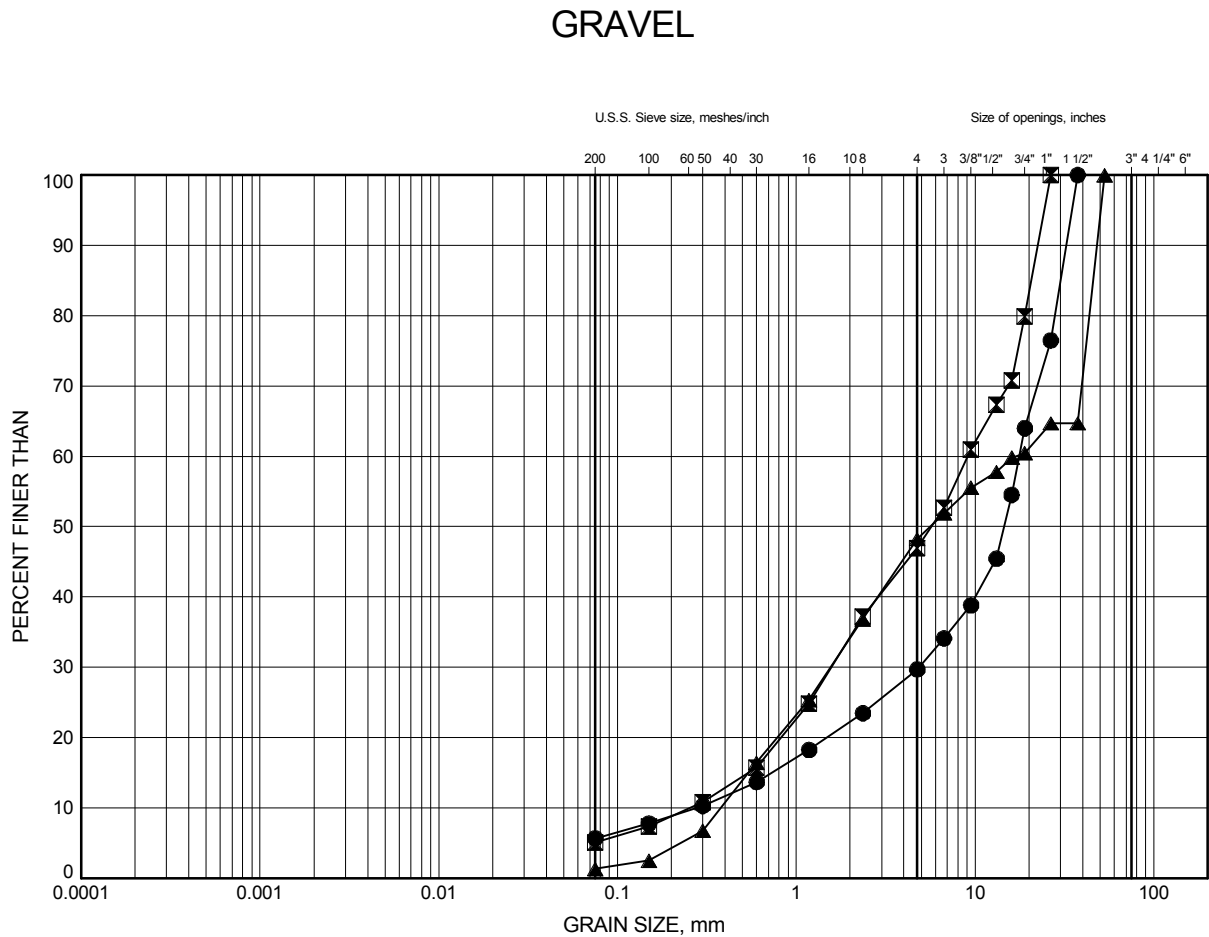
Date February 2018  
GWP# 5181-13-00



Prep'd KE  
Chkd. FG

# SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C4



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-07	9.45	307.26
⊠	17-10A	4.88	308.44
▲	17-12	0.15	313.55

Date February 2018

GWP# 5181-13-00



Prep'd KE

Chkd. FG



## **Appendix C.2**

### **Hydraulic Conductivity Analysis**

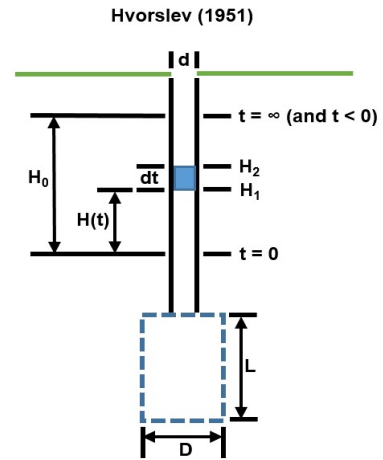
In-Situ Hydraulic Conductivity Test  
Hvorslev Analysis  
Method based on NAFAC Soil Mechanics Design Manual 7.01

INPUT DATA	Rising Head Test
<b>Borehole 17-09</b>	
Static Water Level	0.0 mbgs
Well Diameter (d)	0.051 m
Borehole Diameter (D)	0.114 m
Length of Intake (L)	4.27 m
Initial Unbalanced Head (H <sub>0</sub> )	3.13 m
<b>Shape Factor (F)</b>	6.21

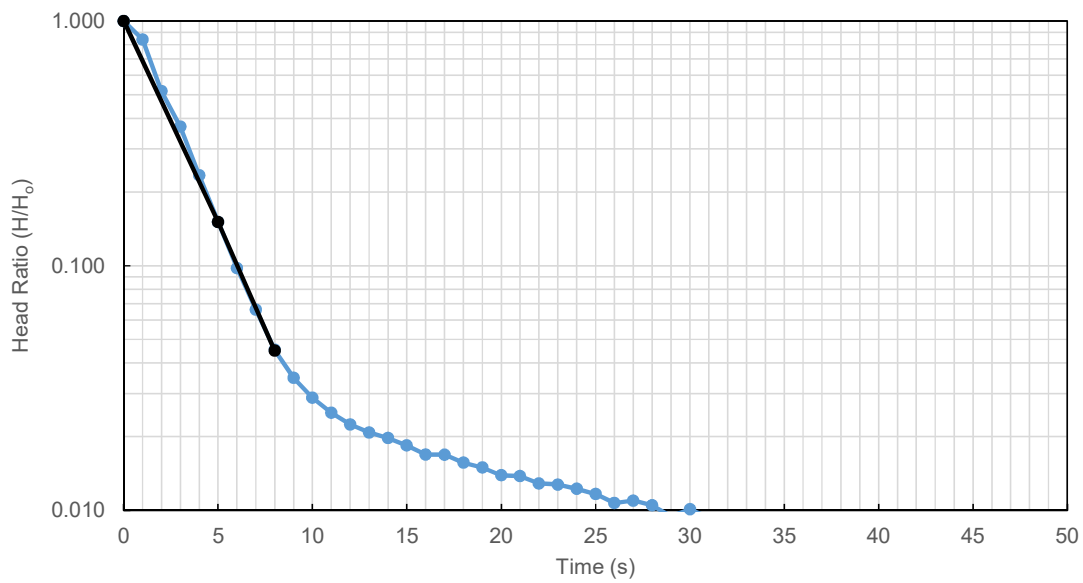
$$K = \frac{A}{F(t_2 - t_1)} \ln \left( \frac{H_1}{H_2} \right)$$

For piezometers of perforated extension of length "L"

$$F = \frac{2\pi L}{\ln \left( \frac{L}{R} \right)}$$



**K = 1.3E-04 m/s**



DATE: 12-Feb-18

PREPARED: KE

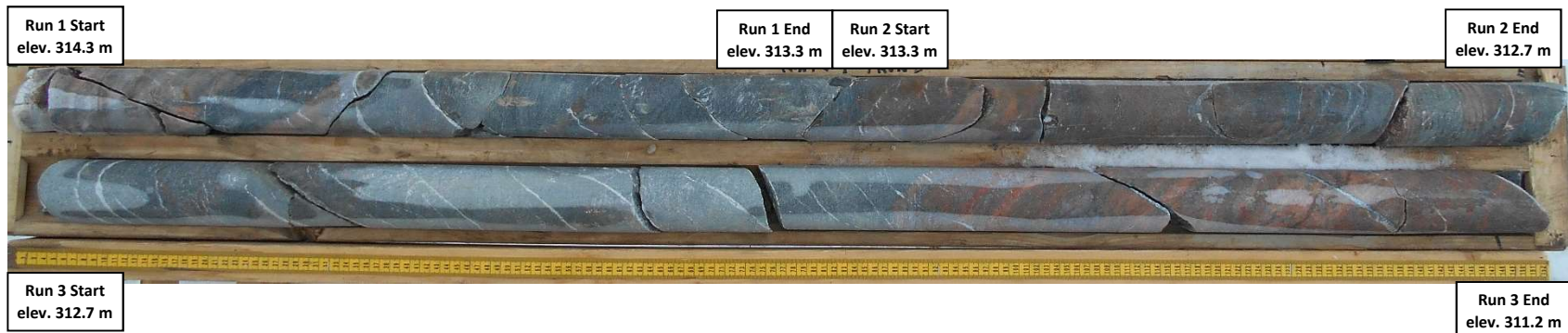
PROJECT: 17848

CHECKED: FG

### **Appendix C.3**

#### **Bedrock Core Photos**

**Borehole 17-10B**  
**Run 1 to 3 (of 3)**  
**Elevation 314.3 m to 311.3 m**



**Borehole B17-10C**  
**Run 1 to 3 (of 3)**  
**Elevation 309.2 m to 306.0 m**

Run 1 Start  
elev. 309.2 m

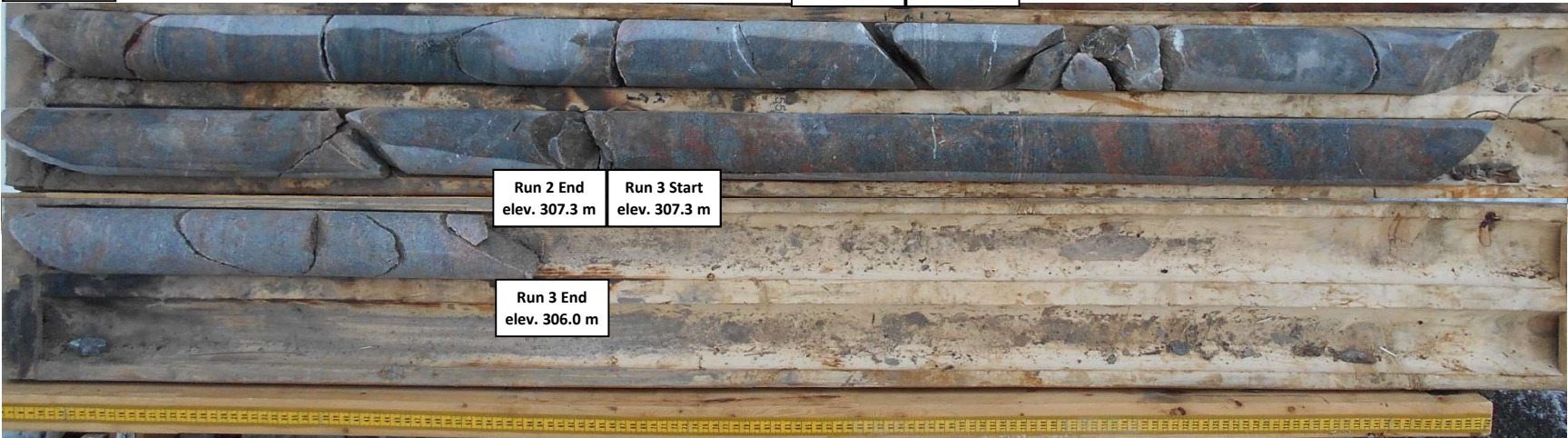
Run 1 End  
elev. 308.3 m

Run 2 Start  
elev. 308.3 m

Run 2 End  
elev. 307.3 m

Run 3 Start  
elev. 307.3 m

Run 3 End  
elev. 306.0 m



**Foundation Investigation**  
**Highway 17 SSM to Goulais**  
**Township of Aweres, Ontario**

**Root River Culvert #4**  
**Project No.: 17848**

**Appendix C.4**  
**Analytical Testing Results**

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Katya Edney

Client PO:  
Project: 17848 SSM to Goulais  
Custody: 39588

Report Date: 29-Jan-2018  
Order Date: 23-Jan-2018

**Order #: 1804148**

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

Paracel ID	Client ID
<del>1804148-01</del>	<del>17-4 SS3 5-7'</del>
<del>1804148-02</del>	<del>17-6 SS2 2'6"-4'6"</del>
1804148-03	17-10 SS2 2'6"-4'6"
<del>1804148-04</del>	<del>17-14 SS 3A 4'-4'6"</del>

Approved By:



Mark Foto, M.Sc.  
Lab Supervisor

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO:

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	25-Jan-18	25-Jan-18
Conductivity	MOE E3138 - probe @25 °C, water ext	25-Jan-18	25-Jan-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	23-Jan-18	24-Jan-18
Resistivity	EPA 120.1 - probe, water extraction	25-Jan-18	25-Jan-18
Solids, %	Gravimetric, calculation	26-Jan-18	29-Jan-18



Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO:

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

		Client ID:	17-4 SS3 5-7'	17-6 SS2 2'6"-4'6"	17-10 SS2 2'6"-4'6"	17-14 SS 3A 4'-4'6"
		Sample Date:	21-Nov-17	25-Nov-17	10-Dec-17	10-Dec-17
		Sample ID:	1804148-01	1804148-02	1804148-03	1804148-04
		MDL/Units	Soil	Soil	Soil	Soil
<b>Physical Characteristics</b>						
% Solids	0.1 % by Wt.		94.9	94.2	87.0	83.4
<b>General Inorganics</b>						
Conductivity	5 uS/cm		165	605	301	502
pH	0.05 pH Units		7.01	6.36	6.20	6.20
Resistivity	0.10 Ohm.m		60.7	16.5	33.2	19.9
<b>Anions</b>						
Chloride	5 ug/g dry		29 [1]	234 [1]	114 [1]	247 [1]
Sulphate	5 ug/g dry		103 [1]	230 [1]	69 [1]	88 [1]

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO:

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

### 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>									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO:

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	85.2	5	ug/g dry	87.4			2.5	20	
Sulphate	47.3	5	ug/g dry	48.0			1.5	20	
<b>General Inorganics</b>									
Conductivity	1250	5	uS/cm	1250			0.2	6.2	
pH	7.61	0.05	pH Units	7.58			0.4	10	
Resistivity	7.99	0.10	Ohm.m	7.97			0.2	20	
<b>Physical Characteristics</b>									
% Solids	83.2	0.1	% by Wt.	83.4			0.3	25	

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO:

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

### Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	187	5	ug/g	87.4	99.2	78-113			
Sulphate	153	5	ug/g	48.0	105	78-111			

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO:

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

**Qualifier Notes:**

***Login Qualifiers :***

Sample - One or more parameter received past hold time - pH, Chloride, Sulphate, and Conductivity.

*Applies to samples: 17-4 SS3 5-7', 17-6 SS2 2'6"-4'6", 17-10 SS2 2'6"-4'6", 17-14 SS 3A 4'-4'6"*

***Sample Qualifiers :***

1 : Holding time had been exceeded upon receipt of the sample at the laboratory.

**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**

REHABILITATION OF ROOT RIVER CULVERT #4 (SITE 38S-053)  
HIGHWAY 17 - 1.9 KM SOUTH OF HIGHWAY 556



**Photo 1. Looking south along Highway 17 at the Root River #4 Culvert crossing  
(October 10, 2017)**



**Photo 2. Looking north along Highway 17 at the Root River #4 Culvert crossing  
(October 10, 2017)**



REHABILITATION OF ROOT RIVER CULVERT #4 (SITE 38S-053)  
HIGHWAY 17 - 1.9 KM SOUTH OF HIGHWAY 556



**Photo 3. Looking east (upstream) from Root River #4 Culvert (October 10, 2017)**



**Photo 4. Looking at Root River #4 Culvert Inlet (October 10, 2017)**



REHABILITATION OF ROOT RIVER CULVERT #4 (SITE 38S-053)  
HIGHWAY 17 - 1.9 KM SOUTH OF HIGHWAY 556



**Photo 5. Looking west (downstream) from Root River #4 Culvert (October 10, 2017)**



**Photo 6. Looking at Root River #4 Culvert Outlet (October 10, 2017)**