



**FOUNDATION INVESTIGATION REPORT  
GRAYSTONE LAKE TIMBER CULVERT REPLACEMENT  
HIGHWAY 599  
THUNDER BAY DISTRICT  
AGREEMENT NO.: 4014-E-0023  
SITE NO.: 48W-189/C  
GEOCRES NO. 52G-13  
GWP: 6355-14-00**

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**PREPARED FOR:**  
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## Table of Contents

1. INTRODUCTION .....	1
2. SITE DESCRIPTION .....	1
3. REGIONAL GEOLOGY.....	3
4. INVESTIGATION PROCEDURES AND LABORATORY TESTING.....	4
5. DESCRIPTION OF SUBSURFACE CONDITIONS .....	6
5.1 Topsoil.....	8
5.2 Fill – Sand.....	8
5.3 Cobbles and Boulders.....	9
5.4 Sand and Gravel.....	9
5.5 Till.....	9
5.6 Bedrock .....	9
5.7 Groundwater.....	11
5.8 Chemical Test Results .....	12
6. MISCELLANEOUS .....	13
7. LIMITATIONS OF REPORT.....	14

## Appendices

LIMITATIONS OF REPORT .....	‘A’
DESCRIPTION OF TERMS .....	‘B’
DRAWINGS .....	‘C’
ENCLOSURES .....	‘D’
NON-STANDARD SPECIAL PROVISION.....	‘E’
CHEMICAL TEST RESULTS.....	‘F’

## List of Tables

Table 4-1: Details of Borehole Locations.....	6
Table 5-1: Summary of soil strata at the culvert inlet and outlet location (HA1A, HA1B, HA1C, HA3, BH5 and BH6) .....	7
Table 5-2: Summary of soil strata at the embankment location (BH2 and BH4) .....	8
Table 5-3: Summary of Particle size distribution - Fill – Sand.....	8
Table 5-4: Summary of Particle size distribution - Till – Sand and Gravel.....	9

Table 5-5: Bedrock Conditions and Parameters .....	11
Table 5-6: Groundwater Level Depths Measured in Boreholes .....	12
Table 5-7: Chemical Test Results – Soil Sample.....	12
Table 5-8: Chemical Test Results – Water Sample .....	12

## List of Figures

Figure 2-1 Location of existing culvert at Highway 599 (Looking East).....	2
Figure 2-2 Location of existing culvert at Highway 599 (Looking West).....	3

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**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

DST Consulting Engineers Inc. (DST) has been retained by the prime consultant, Planmac Engineering Inc. (Planmac), to conduct a foundation investigation and provide a report for the proposed culvert replacement on Highway 599. This work was carried out under Agreement No.: 4014-E-0023. This report addresses the field investigation, laboratory test program and factual report on conditions for the proposed culvert replacement (Part 2).

This report was initially submitted to Planmac and MTO in March 2017. It has been re-issued, at the request of WSP on behalf of MTO, with revisions to accommodate its updated (90%) design, including revisions to both its Drawings (Borehole Location Plan and Borehole Location Plan Soil Strata).

**2. SITE DESCRIPTION**

The site is located on Highway 599, approximately 330 km east of Kenora (Latitude 49.9815, Longitude -91.063), Station 11+100, in unsurveyed territory, in the District of Thunder Bay.

Highway 599 follows a sweeping course on a narrow peninsula between Ten Mile Lake to the north, and Graystone Lake to the south. At the site location, the two lakes are separated by the width of the highway and joined by the twin culverts beneath. There is no distinct drainage channel or section of river/creek joining the two lakes. The twin culverts are skewed beneath the highway and aligned north-west to south-east. The topography surrounding the site is generally of low relief, with gently undulating ground, over shallow bedrock. The area is densely vegetated with natural boreal forest.

The existing twin cell timber culvert structures at this location are 2.4 m in width, 1.7 m in height and 26.9 m in length, for each cell, with a thickness of soil cover of approximately 2.0 m. The existing culverts were built in 1899 as stated in the Ontario Structure Inspection Manual (OSIM),



and inspection by others indicates discoloured timbers, especially the east end, crushed bottom timber at the North and Centre cells, separated wall timbers between stacked timber, and decay of timber at water level.

The embankment height at the culvert location is approximately 3.6 to 4.0 m with existing embankment side slopes of approximately 2H:1V. The condition of the existing twin culverts at the time of the inspection is shown in Figures 2-1 and 2-2 below.



Figure 2-1 Location of existing culvert at Highway 599 (Looking East)



Figure 2-2 Location of existing culvert at Highway 599 (Looking West)

### 3. REGIONAL GEOLOGY

Geological information is available from the published *Ontario Geological Survey Map #52GNW* by the *Ontario Ministry of Natural Resources* for the Press Lake area. The map indicates that the local area landform is identified as Bedrock Knob (RN). Bedrock knob landscape is characterized by an irregular bedrock surface having complex multiple slopes of varying steepness. The cover of glacial deposits overlying the bedrock is generally thin and discontinuous. Much of the glacial overburden consists of boulders, and sand-rich till that was transported only a short distance by the ice.

Rock knobs (RN) are the dominant bedrock landform in the Press Lake map-area. The bedrock is often covered by a thin, discontinuous mantle of till, making the complex terrain unit (RN(MG/R)) quite common. Other subordinate landforms associated with bedrock knobs include glaciofluvial outwash (GO) and glaciolacustrine plains (LP). Bedrock knobs occur as a subordinate land form in a unit dominated by bedrock ridges north of Watcomb and Whiterock Lakes in the northeastern part of the map-area.

As indicated on the Bedrock Geology of Ontario West Central Sheet Map 2542, the site is underlain by supracrustal rocks of Archaen age consisting of (5) mafic to intermediate

metavolcanic rocks, comprising variably of basaltic and andesitic flows, tuffs and breccias, chert, iron formation, minor metasedimentary and intrusive rocks, and related migmatite rocks.

#### **4. INVESTIGATION PROCEDURES AND LABORATORY TESTING**

Site work was carried out in two phases. In phase one, a total of two boreholes (BH2 and BH4) and four hand auger holes (HA1A, HA1B, HA1C and HA3) were advanced to depths ranging from 7.2 m to 10.0 m and 0.6 m to 1.5 m respectively on September 28<sup>th</sup> to September 30<sup>th</sup>, 2015 utilizing a CME 55 drill rig equipped for geotechnical drilling, and a hand auger, with site supervision provided by DST. The hand augered holes reached refusal at shallow depths on rockfill and/or presumed bedrock. The second phase involved the drilling of two supplementary boreholes (BH5 and BH6) to depths of 5.4 m and 5.1 m respectively. Bedrock was proven to a depth of 3m in each of the supplementary boreholes. The second phase of the field investigation was carried out on 8<sup>th</sup> June 2016 utilizing a CME 55 drill rig equipped for geotechnical drilling, operated by Paddock Drilling Ltd. of Winnipeg, and supervised by DST.

The borehole and hand auger hole locations and cross sections are shown on the Borehole Location Plan and Drawings 1 and 2 in Appendix C. Borehole 2 was positioned north of the existing culvert at Station 11+105, 3.6 m left of centreline, and advanced to a depth of 10.0 m below existing surface. Borehole 4 was positioned south of the existing culvert at Station 11+088, 4.0 m right of centreline, and advanced to a depth of 7.2 m below existing surface. Borehole 5 was positioned north of the existing culvert at Station 11+096, 17.1 m right of centreline, and advanced to a depth of 5.4 m below existing surface. Borehole 6 was positioned south of the existing culvert at Station 11+090, 11.3 m left of centreline, and advanced to a depth of 5.1 m below existing surface.

Hand auger 1A was located at the inlet of the existing culvert at Station 11+100, 13.8 m left of centreline, and advanced to a depth of 1.0 m below surface. Hand auger 1B was located at the inlet of the existing culvert at Station 11+097, 14.0 m left of centreline, and advanced to a depth of 1.3 m below surface. Hand auger 1C was located at the inlet of the existing culvert at Station 11+092, 14.3 m left of centreline, and advanced to a depth of 0.6 m below surface. Hand auger 3 was located at the outlet of the existing culvert at Station 11+101, 19.7 m right of centreline, and advanced to a depth of 1.5 m below surface.

The borehole locations are referenced to the MTO Station numbering system as indicated on the drawings provided by the Ministry. The ground surface elevation at the borehole locations were

surveyed by DST personnel and referenced to benchmark 417.654 m N and W in root F0 0.30Φ Spruce (N = 5538789.7 m, E = 228602.2 m) as indicated on the drawings provided by the Ministry. Table 4-1 summarizes the detail of borehole locations and depths.

All boreholes were backfilled with either bentonite chips or a cement bentonite grout as described in Ontario Regulation 903 and its amendments and presented in Table 4.1 below. Augured boreholes were decommissioned by backfilling to the bottom of the road base with bentonite chips. Boreholes advanced by wash boring and cored for bedrock were decommissioned by backfilling with cement bentonite grout to ground surface.

The fieldwork was supervised on a full-time basis by DST personnel who located the boreholes in the field, arranged for clearance of subsurface utilities, supervised the drilling and in-situ testing operations, retrieved samples, logged the boreholes, and supervised the backfilling of boreholes and reinstatement of drilling locations. Soil samples were obtained from the auger flights and from the split spoon sampler used for the Standard Penetration Test (SPT). The SPT testing was carried out in accordance with the procedures described in ASTM D1586. The number of blows required to drive the sampler 300 mm is known as the standard penetration blow count (N) which provides an indication of the condition or consistency of the soil. The soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's geotechnical testing laboratory in Thunder Bay for further analyses.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory testing included chemical tests, natural moisture contents, particle size analyses on selected soil samples, and point load index testing on selected sample of rock core. A total of twenty-nine (29) natural moisture contents and nine (9) particle size analyses, seven (7) point load tests and two (2) sets of chemical tests have been carried out. Laboratory test results are presented in the Boreholes Logs and graphical plots attached in Appendix D (Enclosures).

Table 4-1: Details of Borehole Locations

Borehole ID	Station	Elevation (m)*	Depth (m)	Offset (m)	Completion Details
HA 1A	11+100	414.3	1.0	13.8 Lt	Borehole backfilled with bentonite chips from bottom to ground surface.
HA 1B	11+097	414.7	1.3	14.0 Lt	Borehole backfilled with bentonite chips from bottom to ground surface.
HA 1C	11+092	415.1	0.6	14.3 Lt	Borehole backfilled with bentonite chips from bottom to ground surface.
BH2	11+105	417.3	10.0	3.6 Lt	Borehole backfilled with cement bentonite grout from the bottom to ground surface.
HA3	11+101	413.7	1.5	19.7 Rt	Borehole backfilled with bentonite chips from bottom to ground surface.
BH4	11+088	417.3	7.2	4.0 Rt	Borehole backfilled with cement bentonite grout from the bottom to ground surface.
BH5	11+096	413.4	5.4	17.1 Rt	Borehole backfilled with cement bentonite grout from the bottom to ground surface.
BH6	11+090	415.3	5.1	11.3 Lt	Borehole backfilled with cement bentonite grout from the bottom to ground surface.

## 5. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions are presented based on the information obtained during the site investigation and the subsequent laboratory testing program.

A generalized ground profile through the existing embankment and outside the embankment footprint is based on the conditions encountered in the boreholes and consists of the following:

- Embankment fill comprising loose to compact sand with gravel to some gravel, some silt to trace of silt is encountered in all four boreholes, and three hand auger holes. Occasional cobbles and boulders were encountered within the embankment fill.
- Topsoil was encountered at surface in hand auger holes (1A, 1B, 1C, and 3) and Borehole 5.
- Cobbles and boulders were encountered underlying the embankment sand fill, in Boreholes 2 and 5.
- This is underlain by compact sand and gravel with trace of silt, and trace of organic material in Borehole 5. Trace of organics was encountered within the sand and gravel layer in Borehole 5.
- A thin layer of very dense sand till was encountered below the sand and gravel layer in Borehole 5.

- Meta-volcanic bedrock was encountered underlying the embankment fill in Boreholes 4 and 6, below the cobbles and boulders in Borehole 2, and below the sand till in Borehole 5.

The soil strata at the culvert location have been summarized in Tables 5-1 and 5-2 and details descriptions are provided below.

Attempts to undertake SPT testing in the layer of cobbles and boulders in boreholes 2 and 5 were unsuccessful due to the SPT rod bouncing on cobbles/boulders. As a result, the wash boring method was used to penetrate this layer.

In the embankment fill layer, SPT 'N'-values of more than 50 are indicative of embedded cobbles and boulders within this layer and are not representative of the relative density of this material.

Table 5-1: Summary of soil strata at the culvert inlet and outlet location (HA1A, HA1B, HA1C, HA3, BH5 and BH6)

Layer	Depth (m)	Elevation (m)	Comments
Topsoil	0.0 to 0.2	414.3 to 414.1	HA 1A
	0.0 to 0.2	414.7 to 414.5	HA 1B
	0.0 to 0.2	415.1 to 414.9	HA 1C
	0.0 to 0.2	413.7 to 413.5	HA3
	0.0 to 0.1	413.4 to 413.3	BH5
Fill – Sand	0.2 to 1.0	414.1 to 413.3	HA 1A
	0.2 to 1.3	414.5 to 413.4	HA 1B
	0.2 to 0.6	414.9 to 414.5	HA 1C
	0.2 to 1.5	413.5 to 412.2	HA3
	0.1 to 0.8	413.3 to 412.6	BH5
	0.0 to 2.3	415.3 to 413.0	BH6
Cobbles and Boulders	0.8 to 1.5	412.6 to 411.9	BH5
Sand and Gravel	1.5 to 2.3	411.9 to 411.1	BH5
Till	2.3 to 2.4	411.1 to 411.0	BH5
Bedrock	2.4 to 5.4	411.0 to 408.0	BH5
	2.3 to 5.1	413.0 to 410.2	BH6

Table 5-2: Summary of soil strata at the embankment location (BH2 and BH4)

Layer	Depth (m)	Elevation (m)	Comments
Fill – Sand	0.0 to 3.6	417.3 to 413.7	BH2
	0.0 to 4.0	417.3 to 413.3	BH4
Cobbles and Boulders	3.6 to 6.9	413.7 to 410.4	BH2
Bedrock	6.9 to 10.0	410.4 to 407.3	BH2
	4.0 to 7.2	413.3 to 410.1	BH4

### 5.1 Topsoil

Topsoil was encountered at surface in Hand augers 1A, 1B, 1C, 3 and Borehole 5 at depths from 0.0 to 0.2 m (Elev. 414.3 to 414.1 m, Elev. 414.7 to 414.5 m, Elev. 415.1 to 414.9 m, Elev. 413.7 to 413.5 m and Elev. 413.4 to 413.3 m).

### 5.2 Fill – Sand

Sand fill with various portions of gravel and silty to trace silt was encountered below the topsoil in Boreholes 1A, 1B, 1C, 3, at surface in Boreholes 2, 4 and 6 and below the topsoil in Borehole 5 at depths from 0.2 to 1.0 m (Elev. 414.1 to 413.3 m), 0.2 to 1.3 m (Elev. 414.5 to 413.4 m), 0.2 to 0.6 m (Elev. 414.9 to 414.5 m), 0.2 to 1.5 m (Elev. 413.5 to 412.2 m), 0.0 to 3.6 m (Elev. 417.3 to 413.7 m), 0.0 to 4.0 m (Elev. 417.3 to 413.3 m), 0.0 to 2.3 m (Elev. 415.3 to 413.0 m) and 0.1 to 0.8 (Elev. 413.3 to 412.8 m) with thicknesses of 0.8 m, 1.1 m, 0.4 m, 1.3 m, 3.6 m, 4.0 m, 2.3 m and 0.7 m respectively.

SPT 'N' values vary from 2 to 30, indicating a very loose to compact condition. The higher SPT 'N' values (>50) within the layer likely indicate the presence of occasional cobbles and boulders within the material. The natural moisture contents of the sand fill material vary from 2 % to 24 %. The laboratory test results are summarized in Table 5-3.

Table 5-3: Summary of Particle size distribution - Fill – Sand

Laboratory Results – Particle size distribution	
Gravel %	12 to 28
Sand %	55 to 75
Fines %	8 to 33



### 5.3 Cobbles and Boulders

Inferred cobbles and boulders were encountered in Boreholes 2 and 5 at depths from 3.6 m to 6.9m

(Elev. 413.7 to 410.4 m) and 0.8 to 1.5 m (Elev. 412.6 to 411.9 m) with thicknesses of 3.3 m and 0.7 m respectively. A soil matrix for this deposit is a possibility, whether permeable sand and/or gravel, or less permeable soil.

### 5.4 Sand and Gravel

Sand and gravel was encountered below the cobbles and boulders in Borehole 5 at a depth of 1.5 to 2.3 m (Elev. 411.9 to 411.1 m), with a thickness of 0.8 m.

A SPT 'N' value of 27 was recorded, indicating a compact condition. Trace of organics was also encountered within the sand and gravel layer. The natural moisture content of the sand and gravel layer was 15 %.

### 5.5 Till

Sand with gravel and silt was encountered below the sand and gravel layer in Borehole 5 at depths of 2.3 to 2.4 m (Elev. 411.1 to 411.0 m) with a thickness of 0.1 m.

The natural moisture content of the material was 12 %. The laboratory test results are summarized in Table 5-4.

Table 5-4: Summary of Particle size distribution - Till – Sand and Gravel

Laboratory Results – Particle size distribution	
Gravel %	26
Sand %	50
Fines %	24

### 5.6 Bedrock

Bedrock was encountered in Boreholes 2, 4, 5, and 6 at depths of 6.9 m (Elev. 410.4 m), 4.0 m (Elev. 413.3 m), 2.4 m (Elev.411.0 m) and 2.3 m (Elev. 413.0 m) respectively. Therefore, the bedrock surface level is expected to vary considerably and unpredictably throughout the site,

The bedrock comprises of a mix of volcanic, volcanoclastic and igneous rocks that have been subjected to varying degrees of metamorphism to form stronger, tougher rocks that are more resistant to weathering. The rocks encountered during drilling at the site may be generally



described as Medium grey, very strong, fresh, fine grained, Meta-Volcanic, with closely to moderately spaced, very tight to partly open, smooth planar, clean to surface stained and quartz coated, joints, dipping at 20°-30°, and 60°-70°. A strongly developed Eutaxitic texture is present dipping at 70°-80° with flattened, elongate fragments of rock between 1-50mm in thickness and 5-20mm long. Local pyrite and chalcopyrite mineralization is present. The rock core photos and point load test results can be seen in Appendix D (Enclosures).

In Borehole 2, Total Core Recovery (TCR) and Solid Core Recovery (SCR) was 100%. Rock Quality Designation (RQD) was found to range from 74 % to 100 % indicating a Good to Excellent Rock. In Borehole 4, Total Core Recovery (TCR) and Solid Core Recovery (SCR) was found between 97 % and 100 %. Rock Quality Designation (RQD) was found to range from 87 % to 100 % indicating a Good to Excellent Rock. In Borehole 5, Total Core Recovery (TCR) and Solid Core Recovery (SCR) was found to range from 96 % to 100%. Rock Quality Designation (RQD) was found to range from 81 % to 100 % indicating a Good to Excellent Rock. In Borehole 6, Total Core Recovery (TCR) and Solid Core Recovery (SCR) was found to range from 85 % to 100%. Rock Quality Designation (RQD) was found to range from 62 % to 78 % indicating a Fair to Good Rock.

The estimates for unconfined compressive strength of the intact rock, as derived from the point load test results, vary between 162 and 249 MPa at Borehole 2, 168 and 186 MPa at Borehole 4, 231 MPa in Borehole 5 and 248 to 265 MPa in Borehole 6, indicating a very strong to extremely strong rock.

A summary of the bedrock conditions encountered in the boreholes, and the parameters determined in the laboratory are provided in Table 5.5 below.

Table 5-5: Bedrock Conditions and Parameters

ID	Bedrock Depth (m)	Bedrock Elevation	Core Length (m)	TCR (%)	SCR (%)	RQD (%)	Rock <sup>1</sup> Quality	Point Load Index	UCS Strength (MPa)	Strength <sup>2</sup> Classification
BH2	6.9	410.4	3.1	100	100	74-100	Fair to Excellent	7.7 to 11.8	162-249	R5 Very Strong
BH4	4.0	413.3	3.2	97-100	97-100	87-100	Good to Excellent	8.0 to 8.9	168-186	R5 Very Strong
BH5	2.4	411.0	3.0	96-100	96-100	81-100	Good to Excellent	11	231	R5 Very Strong
BH6	2.3	413.0	2.8	85-100	85-100	62-78	Fair to Good	11.8 to 12.6	248-265	R5/R6 Very Strong to Extremely Strong

<sup>1</sup>After Table 3.10 CFEM 2006

<sup>2</sup>After Table 3.5 CFEM 2006

## 5.7 Groundwater

Groundwater levels in the boreholes where seepage was noted were measured upon completion of borehole drilling and prior to backfilling of the borehole. This information is included on the borehole logs in Appendix D.

At the time of the field investigation, groundwater was observed in Hand Auger 1A, 3 and in Boreholes 4, 5 and 6 on completion of drilling (see Table 5-6). The water level of the lakes was recorded during the first and second phase of the field investigation at elevations 413.7 m and 413.9 m respectively. The interpreted groundwater table at the site is close to or slightly above the lake level.

Given the permeable nature of the stratigraphy at this site, groundwater levels can be expected to vary as the lake water level varies with seasonal and local precipitation events.

Table 5-6: Groundwater Level Depths Measured in Boreholes

Borehole	Groundwater Depth (m)	Groundwater Elev. (m)
HA 1A	1.0	413.3
BH2	3.9	413.4
HA3	0.4	413.3
BH4	3.8	413.5
BH5	0.5	412.9
BH6	2.1	413.2

## 5.8 Chemical Test Results

Selected soil samples were submitted to ALS Laboratories, Thunder Bay for chemical analyses (pH, sulphate, conductivity, resistivity and Chloride) to assess the potential for corrosion and sulphate attack on buried structures.

The results are presented below in Table 5-7 and 5-8 and discussed in Section 7.16. Copies of the Laboratory Certificate of Analyses are provided in Appendix 'F'.

Table 5-7: Chemical Test Results – Soil Sample

Sample ID	Moisture (%)	Sulphate (mg/kg)	Chloride (mg/kg)	pH	Conductivity (umhos/cm)	Resistivity (ohm - cm)
BH2 @ 3.6 m depth	13.2	139	<20	6.04	148	6760

Table 5-8: Chemical Test Results – Water Sample

Sample ID	Sulphate (mg/L)	Chloride (mg/L)	pH	Conductivity (umhos/cm)	Resistivity (ohm - cm)
Lake sample	1.21	0.13	7.14	31.1	32155

## **6. MISCELLANEOUS**

Site investigation fieldwork was carried out from September 25<sup>th</sup> to September 28<sup>th</sup>, 2015 (Phase 1) and June 8<sup>th</sup>, 2016 (Phase 2) utilizing a CME 55 drill rig supervised by DST personnel. Soil samples retrieved during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analysis. Interpretation of the data and preparation of the report was completed by Selorm Danku, Geotechnical Engineer P.Eng., and approved by Mike Fabius, Senior Geotechnical Engineer, P. Eng.

## **7. LIMITATIONS OF REPORT**

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

Prepared by:



Selorm Danku, P.Eng.  
Geotechnical Engineer

Approved by:



Mike Fabius, P.Eng.  
Senior Geotechnical Engineer

**APPENDIX 'A'**  
**LIMITATIONS OF REPORT**

# **LIMITATIONS OF REPORT**

## **GEOTECHNICAL STUDIES**

The data, conclusions and recommendations which are presented in this report, and the quality thereof, are based on a scope of work authorized by the Client. Note that no scope of work, no matter how exhaustive, can identify all conditions below ground. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. Conditions can also change with time. It is recommended practice that DST Consulting Engineers be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

Any results from an analytical laboratory or other subcontractor reported herein have been carried out by others, and DST Consulting Engineers Inc. cannot warranty their accuracy. Similarly, DST cannot warranty the accuracy of information supplied by the client.

**Appendix B**

**DESCRIPTION OF TERMS**



## EXPLANATION OF TERMS USED IN REPORT

**SPT 'N' VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE OF THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51 mm O.D. SPLIT BARREL SAMPLES TO PENETRATE 0.3 m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76 m. FOR PENETRATION OF LESS THAN 0.3 m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST (DCPT):** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51 mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3 m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

### ***SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS***

#### **TEXTURAL CLASSIFICATION OF SOILS**

BOULDERS	COBBLES	GRAVEL	SAND	SILT	CLAY
GREATER THAN 200 mm	75 TO 200 mm	4.75 TO 75 mm	0.075 TO 4.75 mm	0.002 TO 0.075 mm	LESS THAN 0.002 mm

#### **COARSE GRAIN SOIL DESCRIPTION (50% GREATER THAN 0.075 mm)**

TERMINOLOGY	TRACE OR OCCASIONAL	SOME	WITH	ADJECTIVE (e.g. SILTY OR SANDY)	AND (e.g. SAND AND SILT)
	LESS THAN 10%	10 TO 20%	20 TO 30%	30 TO 40%	40 TO 60%

#### **CONSISTENCY\*: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $C_u$ ) AND SPT 'N' VALUES AS FOLLOWS**

$C_u$ (kPa)	0 – 12	12 – 25	25 – 50	50 - 100	100 - 200	> 200
N (BLOWS / 0.3 m)	<2	2 - 4	4 - 8	8 - 15	15 - 30	>30
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

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

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

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

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100 mm+ IN LENGTH EXPRESSED AS A PERCENTAGE OF THE LENGTH OF THE CORING RUN.

THE **ROCK QUALITY DESIGNATION (R.Q.D)** FOR MODIFIED RECOVERY IS:

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

#### **LEGEND OF RECORDS FOR BOREHOLES: SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE**

SS	SPLIT SPOON SAMPLE	WS	WASH SAMPLE
TW	THIN WALL SHELBY TUBE SAMPLE	AS	AUGER (GRAB) SAMPLE
PH	SAMPLER ADVANCED BY HYDRAULIC PRESSURE	TP	THIN WALL PISTON SAMPLE
WH	SAMPLER ADVANCED BY SELF STATIC WEIGHT	PM	SAMPLER ADVANCED BY MANUAL PRESSURE
SC	SOIL CORE	RC	ROCK CORE
	WATER LEVEL	$SENSITIVITY = \frac{UNDISTURBED\ SHEAR\ STRENGTH}{REMOLDED\ SHEAR\ STRENGTH}$	

\*HIERARCHY OF SOIL STRENGTH PREDICTION: **1)** LABORATORY TRIAXIAL TESTING. **2)** FIELD INSITU VANE TESTING. **3)** LABORATORY VANE TESTING. **4)** SPT VALUES. **5)** POCKET PENETROMETER.

# **Appendix C**

## **DRAWINGS**



TEN MILE LAKE

**METRIC**  
DIMENSIONS ARE IN METRES  
AND / OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETERS + METERS



AG No 4014-E-0023  
WP No 6355-14-00  
SITE No 48W-0189/C0  
GEOCRES No 52G-13

CULVERT REPLACEMENT  
GRAYSTONE LAKE  
STA 11+048 TO STA 11+148  
Survey 14-07 Revised  
BOREHOLE LOCATION PLAN

SHEET  
1



FLOW

HA1A

BH2

HA1B

EXISTING CULVERT

HA1C

BH6

PROPOSED CULVERT (OPTION 1)

11+100

HA3

BH4

BH5

413.5

413.0

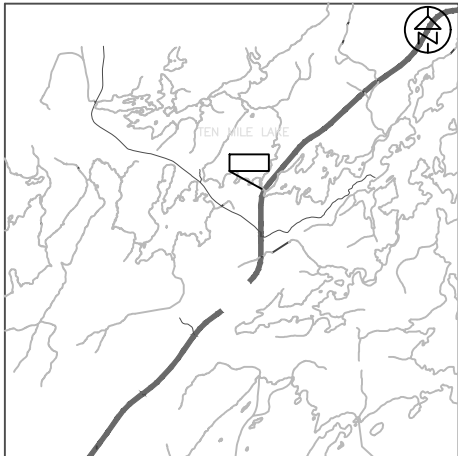
11+080

FLOW

GRAYSTONE LAKE

PLAN MAP  
Scale 1:250

0 5m 10m



KEY PLAN

LEGEND

Borehole

Hand Auger Hole

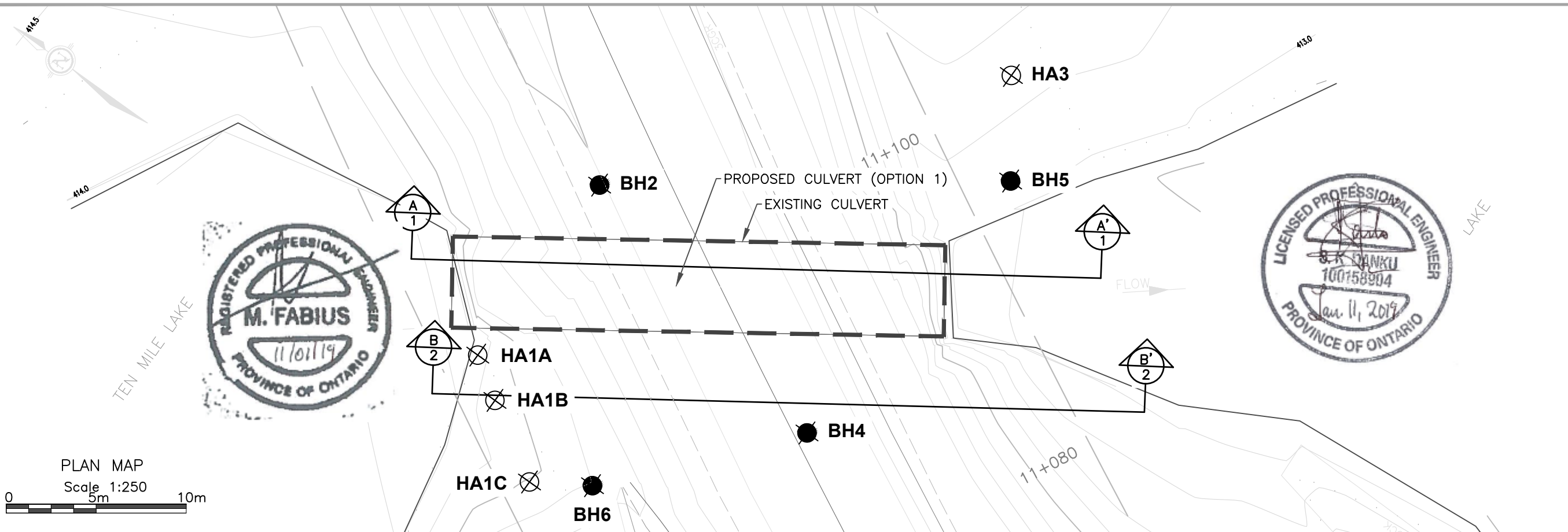
No.	Elev. (m)	MTM Zone 15		Survey	
		North (m)	East (m)	Station	Offset
HA1A	414.3	5538767	228549	11+100	13.8 m LT
HA1B	414.7	5538765	228547	11+097	14.0 m LT
HA1C	415.1	5538760	228545	11+092	14.3 m LT
BH2	417.3	5538767	228560	11+105	3.6 m LT
HA3	413.7	5538751	228579	11+101	19.7 m RT
BH4	417.3	5538749	228556	11+088	0.7 m RT
BH5	413.4	5538748	228574	11+096	17.1 m RT
BH6	415.3	5538757	228547	11+090	11.3 m LT

REV	DATE	ISSUE	DRAWN BY	CHECKED	APPROVAL
1	15-Jun-16	DRAFT	EM	PDS	MK
2	10-Dec-16	DRAFT	RW	PDS	MK
3	25-Oct-18	DRAFT	CS	SD	BV

**NOTE:**  
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

**DST** consulting engineers  
DST Consulting Engineers Inc.  
605 Hewitson Street  
Thunder Bay, ON P7B 5V5  
Ph: (807) 623-2929  
Fx: (807) 623-1792  
Email: thunderbay@dstgroup.com

DRAWING 1



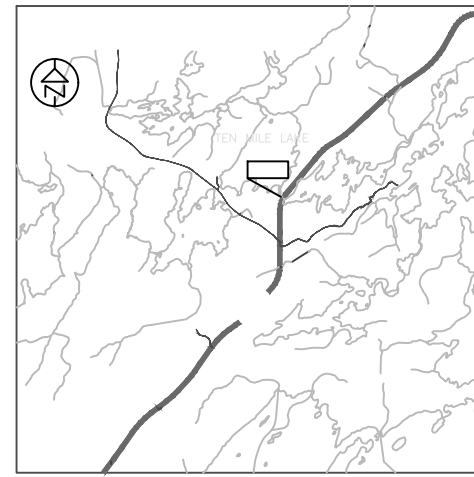
AG No 4014-E-0023  
WP No 6355-14-00  
SITE No 48C-0189/C0  
GEOCRES No 52G-13

CULVERT REPLACEMENT  
GRAYSTONE LAKE  
STA 11+048 TO STA 11+148

SHEET  
2

Survey 14-07 Revised

BOREHOLE LOCATION PLAN  
SOIL STRATA



KEY PLAN

LEGEND

Borehole

Hand Auger Hole

SPT (BLOWS/300 mm)

Water level at completion of drilling

Fill

Organics

Topsoil

Till

Bedrock

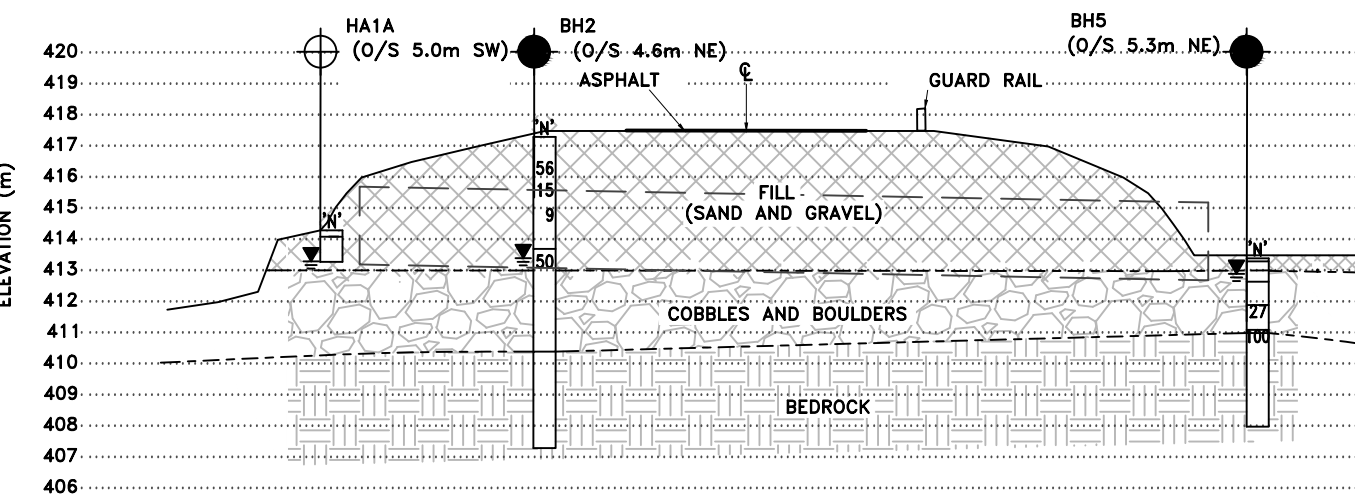
Sand

Silt

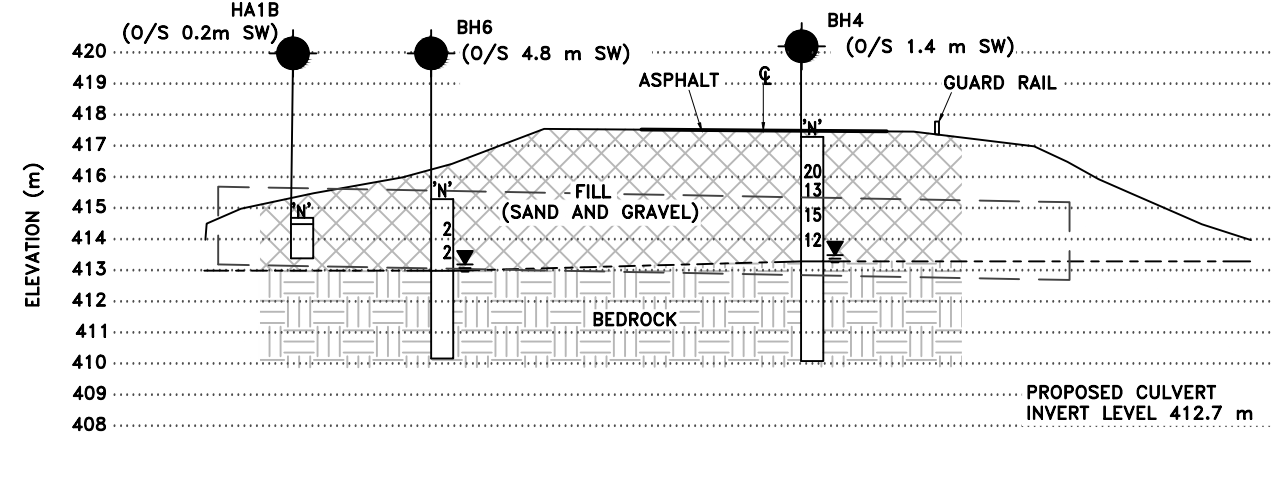
Clay

Sand & Gravel

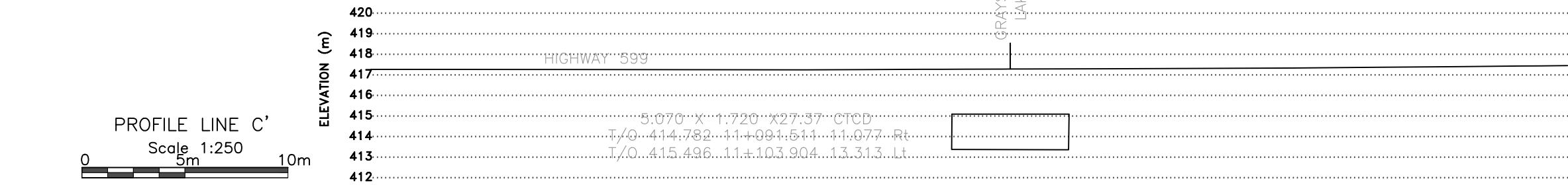
Boulders



CROSS SECTION A-A'  
Scale 1:250



CROSS SECTION B-B'  
Scale 1:250



PROFILE LINE C-C'  
Scale 1:250

No.	Elev. (m)	MTM Zone 15		Survey	
		North (m)	East (m)	Station	Offset
HA1A	414.3	5538767	228549	11+100	13.8 m LT
HA1B	414.7	5538765	228547	11+097	14.0 m LT
HA1C	415.1	5538760	228545	11+092	14.3 m LT
BH2	417.3	5538767	228560	11+105	3.6 m LT
HA3	413.7	5538751	228579	11+101	19.7 m RT
BH4	417.3	5538749	228556	11+088	0.7 m RT
BH5	413.4	5538748	228574	11+096	17.1 m RT
BH6	415.3	5538757	228547	11+090	11.3 m LT

REV	DATE	ISSUE	DRAWN BY	CHECKED	APPROVAL
1	15-Jun-16	DRAFT	EM	POS	MK
2	7-Nov-16	DRAFT	RW	SD	MK
3	10-Dec-16	DRAFT	RW	POS	MK
4	3-Mar-17	DRAFT	RW	TL	MF
5	25-Oct-18	DRAFT	CS	SD	MF

**NOTE:**  
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

DST Consulting Engineers Inc.  
605 Hewitson Street  
Thunder Bay, ON P7B 5V5  
Ph: (807) 623-2929  
Fx: (807) 623-1792  
Email: thunderbay@dstgroup.com

**Appendix D**  
**ENCLOSURES**

# RECORD OF BOREHOLE No HA1A

1 OF 1

METRIC

W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY CH  
 DIST                      HWY 599 BOREHOLE TYPE HAND AUGER COMPILED BY SA  
 DATUM Geodetic DATE 2029 09 15 CHECKED BY BV

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						
414.3	GROUND SURFACE																
414.1	TOPSOIL		HA1	AS													
0.2	FILL - SAND, SOME GRAVEL, TRACE SILT BROWN		HA2	AS													
413.3			HA3	AS													
1.0	END OF BOREHOLE AT 1.0 m																

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

ENCLOSURE 1

# RECORD OF BOREHOLE No HA1B

1 OF 1

**METRIC**

W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY CH  
 DIST                      HWY 599 BOREHOLE TYPE HAND AUGER COMPILED BY SA  
 DATUM Geodetic DATE 2029 09 15 CHECKED BY BV

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 ○ UNCONFINED      + FIELD VANE □ QUICK TRIAXIAL    × LAB VANE									PLASTIC LIMIT w <sub>p</sub> NATURAL MOISTURE CONTENT w      LIQUID LIMIT w <sub>L</sub> WATER CONTENT (%)		
414.7	GROUND SURFACE							20	40	60	80	100							
414.5	TOPSOIL		HA1	AS			414												
0.2	FILL - SAND, WITH GRAVEL, TRACE SILT BROWN		HA2	AS															
			HA3	AS															
			HA4	AS															
413.4	END OF BOREHOLE AT 1.3 m																	28 64 (8) AUGER REFUSAL	
1.3																			

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



ENCLOSURE 2

# RECORD OF BOREHOLE No HA1C

1 OF 1

**METRIC**

W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY CH  
 DIST                      HWY 599 BOREHOLE TYPE HAND AUGER COMPILED BY SA  
 DATUM Geodetic DATE 2029 09 15 CHECKED BY BV

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			20	40	60	80	100		
415.1	GROUND SURFACE													
414.9	TOPSOIL - ORGANIC SAND		HA1	AS			415							19 65 (16)
0.2	FILL - SAND, SOME GRAVEL, SOME SILT		HA2	AS										
414.5														
0.6	END OF BOREHOLE AT 0.6 m													AUGER REFUSAL

ON\_MOT-HIGH VANES GS-TB-020407 - GREYSTONE.GPJ DST\_MIN.GDT 8/7/16

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

ENCLOSURE 3



# RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY CH  
 DIST                      HWY 599 BOREHOLE TYPE HOLLOW STEM AUGER - 80 mm ID/ NQ CORING COMPILED BY SA  
 DATUM Geodetic DATE 2028 09 15 CHECKED BY BV

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE □ QUICK TRIAXIAL    × LAB VANE								
417.3	GROUND SURFACE						20	40	60	80	100					
	FILL - SAND, WITH SILT, SOME GRAVEL LOOSE TO COMPACT  OCCASIONAL BOULDERS		AS1	AS												
			AS2	AS	56+											
			SS1	SS	15											
			SS2	SS	9											
			AS3	AS												
413.7 3.6	COBBLES AND BOULDERS															
			SS3	SS	50+											

ON\_MOT-HIGH VANES GS-TB-020407 - GREYSTONE.GPJ DST\_MIN.GDT 8/7/16

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

RECORD OF BOREHOLE No HA3

1 OF 1

METRIC

W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY CH  
 DIST                      HWY 599 BOREHOLE TYPE HAND AUGER COMPILED BY SA  
 DATUM Geodetic DATE 2029 09 15 CHECKED BY BV

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			20	40	60	80	100		
413.7	GROUND SURFACE													
413.5	TOPSOIL - ORGANIC		HA1	AS										
0.2	FILL - SAND, SILTY, SOME GRAVEL DENSE TO COMPACT GREY		SS1	SS	30		413							
	OCCASIONAL BOULDERS													
			SS2	SS	110									12 55 (33)
412.2	END OF BOREHOLE AT 1.5 m													AUGER REFUSAL
1.5														

ON\_MOT-HIGH VANES GS-TB-020407 - GREYSTONE.GPJ DST\_MIN.GDT 8/7/16

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



ENCLOSURE 5

# RECORD OF BOREHOLE No BH4

1 OF 1

METRIC

W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY CH  
 DIST                      HWY 599 BOREHOLE TYPE HOLLOW STEM AUGER - 80 mm ID/ NQ CORING COMPILED BY SA  
 DATUM Geodetic DATE 1930 09 15 CHECKED BY BV

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 (%)		
								○ UNCONFINED      + FIELD VANE										
						□ QUICK TRIAXIAL      × LAB VANE												
417.3	GROUND SURFACE							20	40	60	80	100						
	FILL - SAND, WITH GRAVEL, TRACE SILT COMPACT BROWN		AS1	AS			417											
			SS1	SS	20		416										15 76 (10)	
			SS2	SS	13													
							415											
			SS3	SS	15												23 69 (8)	
			SS4	SS	12	414												
413.3																		
4.0	BEDROCK						413									Water level at 3.8 m, taken after drilling		
	DARK GREENISH GREY, VERY STRONG, FRESH, FINE GRAINED, META-VOLCANICS WITH CLOSELY TO MODERATELY SPACED, VERY TIGHT TO TIGHT, SMOOTH PLANAR TO SMOOTH STEPPED, CLEAN TO SURFACE STAINED AND OCCASIONAL QUARTZ-INFILLED, JOINTS, DIPPING AT 10°-20°, AND 30°-40. LOCAL PYRITE AND CHALCOPYRITE MINERALIZATION.		RC1	RC	TCR 97% SCR 97%		412									RQD = 87%		
			RC2	RC	TCR 100% SCR 100%		411									RQD = 100%		
410.1																		
7.2	END OF BOREHOLE AT 7.2 m																	

ON\_MOT-HIGH VANES GS-TB-020407 - GREYSTONE.GPJ DST\_MIN.GDT 8/7/16

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

# RECORD OF BOREHOLE No BH5

1 OF 1

METRIC

W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY AC  
DIST                      HWY 599 BOREHOLE TYPE SOLID STEM AUGER - 80 mm ID/ WASH BORING/ NQ CORING COMPILED BY EM  
DATUM Geodetic DATE 2016 08 06 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE □ QUICK TRIAXIAL    × LAB VANE									
413.4	GROUND SURFACE							20	40	60	80	100					
413.3	TOPSOIL		AS1	AS			413										
0.1	SAND COARSE GRAINED, WITH GRAVEL TRACE ROOTLETS, BROWN/GREY OCCASIONAL COBBLES COBBLES AND BOULDERS																
412.7			AS2	RC			412										
0.8																	
411.9	SAND AND GRAVEL TRACE, TRACE ORGANICS, BLACK TO GREY		SS3	SS	27		411										
1.5																	
411.1	TILL		SS4	SS	100+		411										
412.0	SAND SOME GRAVEL, SOME SILT BEDROCK		RC1	RC	TCR 100% SCR 100%		410										
2.4																	
	MEDIUM GREY, VERY STRONG, FRESH, FINE GRAINED META-VOLCANICS WITH CLOSELY TO MODERATELY SPACED, VERY TIGHT TO PARTLY OPEN, SMOOTH PLANAR, CLEAN TO SURFACE STAINED AND QUARTZ COATED, JOINTS, DIPPING AT 20°-30°, AND 60°-70°. EUTAXITIC TEXTURE IS PRESENT WITH FLATTENED, ELONGATE FRAGMENTS OF ROCK BETWEEN 1-50MM IN THICKNESS AND 5-20MM LONG. LOCAL PYRITE AND CHALCOPYRITE MINERALIZATION.		RC2	RC	TCR 100% SCR 100%		409										
			RC3	RC	TCR 100% SCR 100%												
408.0	END OF BOREHOLE AT 5.4 m						408										
5.4																	

ON\_MOT-HIGH VANES GS-TB-020407 - GREYSTONE.GPJ DST\_MIN.GDT 8/7/16

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

ENCLOSURE 7

# RECORD OF BOREHOLE No BH6

1 OF 1

METRIC

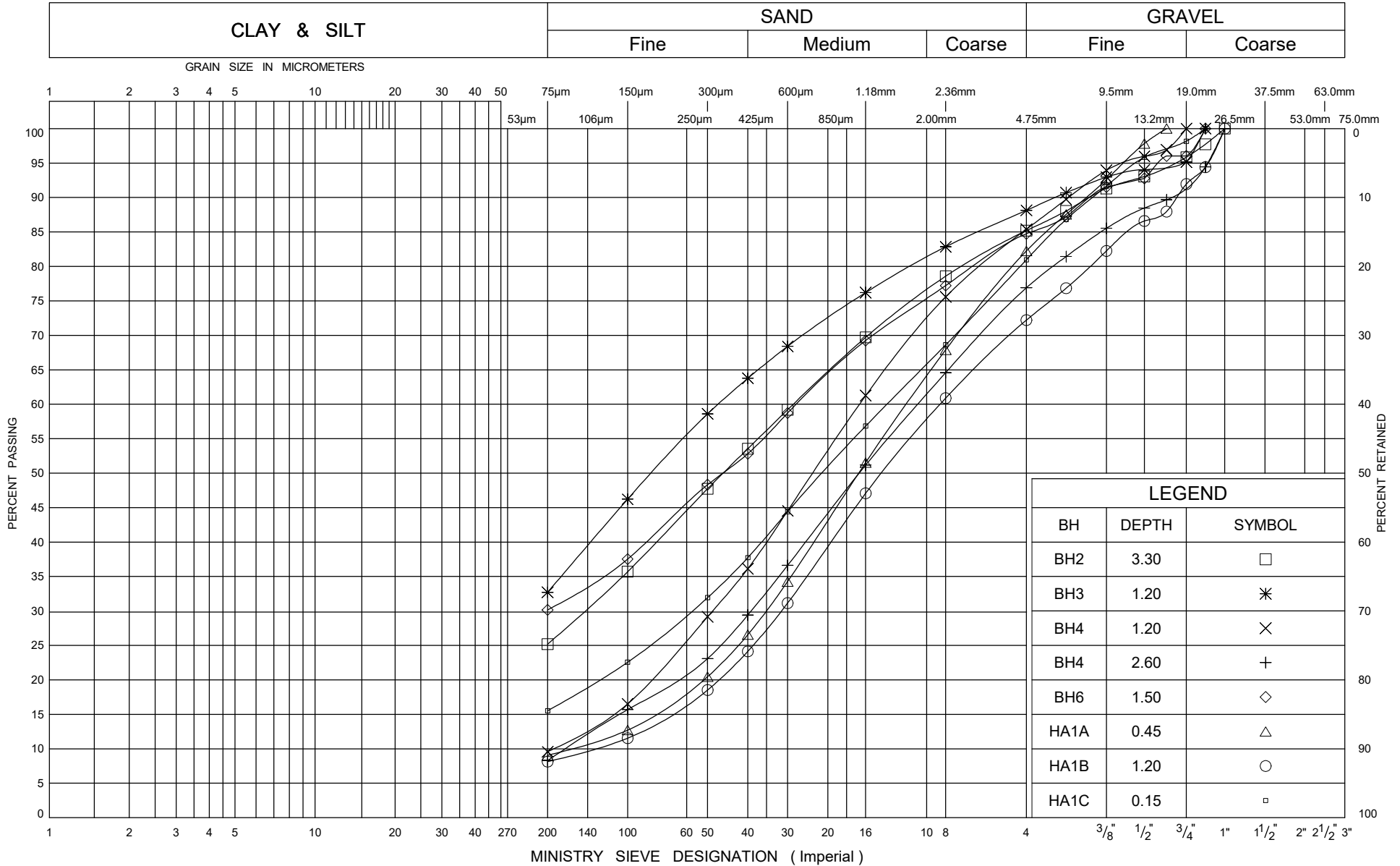
W.P. GWP 6355-14-00 LOCATION GRAYSTONE LAKE CULVERT ORIGINATED BY AC  
 DIST                      HWY 599 BOREHOLE TYPE HOLLOW STEM AUGER - 80 mm ID/ WASH BORING/ NQ CORING COMPILED BY EM  
 DATUM Geodetic DATE 2016 08 06 CHECKED BY SD

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			20	40	60	80	100		
415.3	GROUND SURFACE												
	FILL SAND WITH SILT, SOME GRAVEL BROWN		AS1	AS		415							
	TRACE ORGANICS		AS2	AS	2	414							
			SS3	SS	2								15 55 (30)
413.0	BEDROCK					413							Water level at 2.1 m, taken after drilling
2.3	MEDIUM GREY TO DARK BLuish-GREY, VERY STRONG TO EXTREMELY STRONG, FRESH, FINE GRAINED META-VOLCANICS WITH CLOSELY TO MODERATELY SPACED, VERY TIGHT TO TIGHT, SMOOTH PLANAR TO SMOOTH UNDULATING, CLEAN TO SURFACE STAINED AND QUARTZ COATED, JOINTS, DIPPING AT 20°-30°, 30°-40°, 60°-70°, AND 70°-80°. EUTAXITIC TEXTURE IS PRESENT DIPPING AT 70°-80°. WITH FLATTENED, ELONGATE FRAGMENTS OF ROCK BETWEEN 1-15MM IN THICKNESS AND 5-60MM LONG. LOCAL PYRITE AND CHALCOPYRITE MINERALIZATION.		RC1	RC	TCR 98% SCR 98%	412							RQD = 78%
			RC2	RC	TCR 100% SCR 100%	411							RQD = 62%
410.2	END OF BOREHOLE AT 5.1 m												
5.1													

ON\_MOT-HIGH VANES GS-TB-020407 - GREYSTONE.GPJ DST\_MIN.GDT 8/7/16

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

# UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation  
Ontario

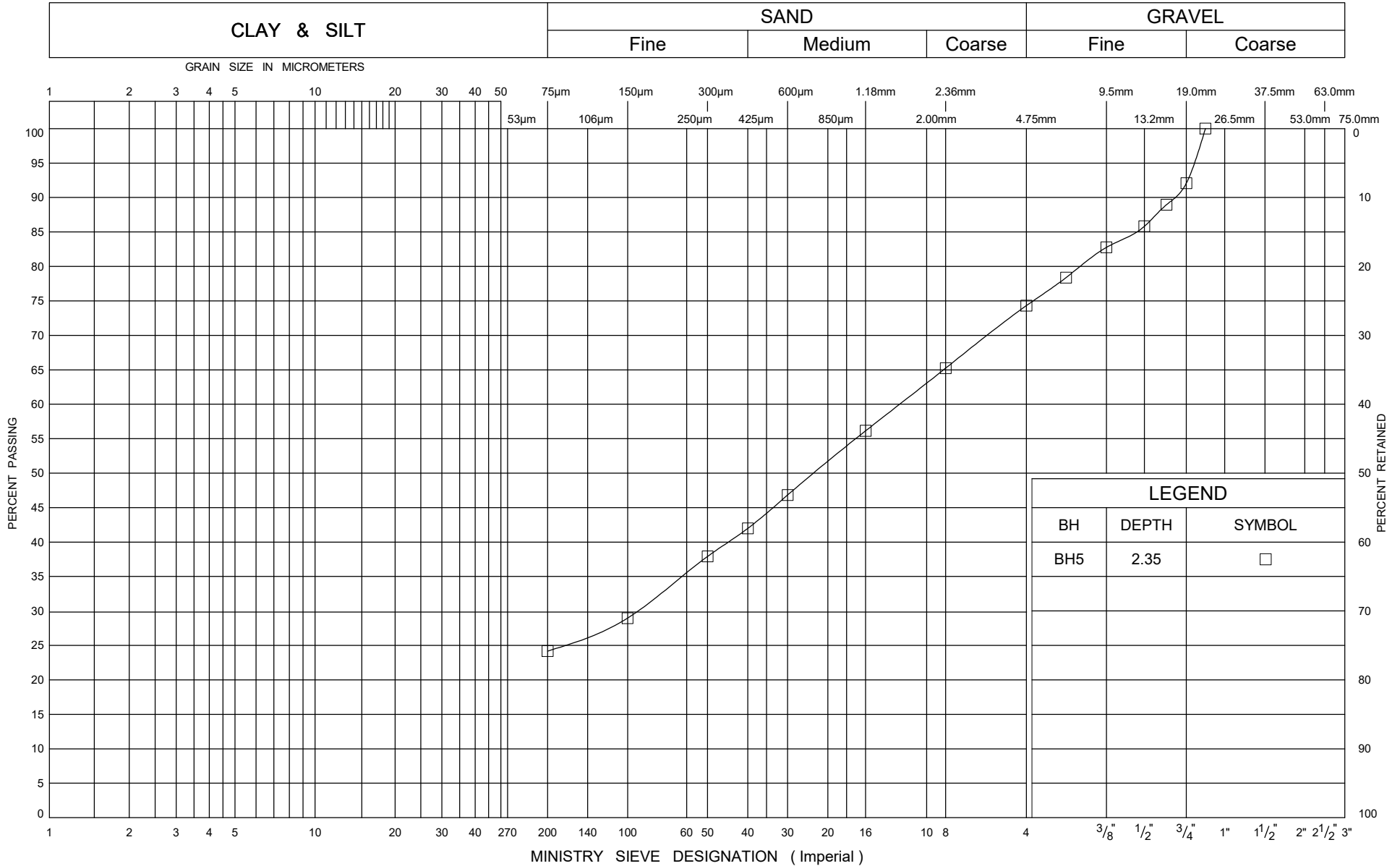
## GRAIN SIZE DISTRIBUTION FILL - SAND

ENCLOSURE 9

GWP 6355-14-00

GRAYSTONE LAKE

# UNIFIED SOIL CLASSIFICATION SYSTEM




Ministry of  
Transportation  
Ontario

## GRAIN SIZE DISTRIBUTION TILL

ENCLOSURE 10


W P GWP 6355-14-00

GRAYSTONE LAKE


	<b>Project</b>	15 Culverts Replacement AG # 4014-E-0023	<b>Borehole Number</b>	BH2		
	<b>Project Number</b>	GS-TB-020407	<b>Box Number</b>	1	of	1
	<b>Client</b>	Planmac Engineering	<b>Depth (m)</b>	6.9	to	10.0






	<b>Project</b>	15 Culverts Replacement AG # 4014-E-0023	<b>Borehole Number</b>	BH4		
	<b>Project Number</b>	GS-TB-020407	<b>Box Number</b>	1	of	1
	<b>Client</b>	Planmac Engineering	<b>Depth (m)</b>	4.0	to	7.2



	<b>Project</b>	15 Culverts Replacement AG # 4014-E-0023	<b>Borehole Number</b>	BH5		
	<b>Project Number</b>	GS-TB-020407	<b>Box Number</b>	1	of	1
	<b>Client</b>	Planmac Engineering	<b>Depth (m)</b>	2.4	to	5.4



	<b>Project</b>	15 Culverts Replacement AG # 4014-E-0023	<b>Borehole Number</b>	BH6		
	<b>Project Number</b>	GS-TB-020407	<b>Box Number</b>	1	of	1
	<b>Client</b>	Planmac Engineering	<b>Depth (m)</b>	2.3	to	5.1



**JOB NO.:** GS-TB-020407

This spreadsheet is based on information from 'Suggested Method for Determining Point Load Strength', International Society for Rock Mechanics Commission on Testing Methods, 1985.

\* Valid or Invalid based on description of break according to Fig 4 from 'Suggested Method for Determining Point Load Strength'

$I_s$ = uncorrected point load strength	$D_e^2 = D^2$ for diametral tests	$F$ = size correction factor
$P$ = load	$D_e^2 = 4A/\pi$ for axial tests	$F = (D_e/50)^{0.45}$ or Fig. 7 from 'Suggested Method for Determining Point Load Strength'
$D_e$ = equivalent core diameter	where $A = WD$	$F = \text{SQRT}(D_e/50)$ for tests near the standard (50 mm) size
	$I_s = P/D_e^2$	Size Correction $I_{s(50)} = F \times I_s$
Uniaxial Compressive Strength = $C_o = 21 \times I_s (50)$ 21 is from: "Using the Point Load Test to Determine the Uniaxial Compressive Strength of Coal Measure Rock", Peng SS, Mark C, eds. Proceedings of the 19th International Conference on Ground Control in Mining. Morgantown, WV: West Virginia University.		

Borehole #	Test No.	Depth (m)	Test Type	*Valid or Invalid	W(mm) (enter for axial only)	D(mm)	Load P P(lbf)	Load P (kN)	I <sub>s</sub> = P/D <sub>e</sub> <sup>2</sup> (MPa)	F	I <sub>s(50)</sub> (MPa)	Uniaxial Compressive Strength (MPa)
Pinder												
BH2	PL#1	7.00	DIAM	V		36.3	2640		8.91	0.87	7.72	162
	PL#2	9.30	DIAM	V		36.3	4050		13.67	0.87	11.84	249
BH4	PL#3	4.30	DIAM	V		36.3	2740		9.25	0.87	8.01	168
	PL#4	5.60	DIAM	V		36.3	3030		10.23	0.87	8.86	186
BH5	PL#5	3.50	DIAM	V		63.3	8910		9.89	1.11	11.00	231
BH6	PL#6	2.70	DIAM	V		63.3	10210		11.33	1.11	12.60	265
	PL#7	4.90	DIAM	V		63.3	9580		10.64	1.11	11.83	248
										Min.	7.7	162
										Avg.	10.3	216
										Max.	12.6	265



**Appendix E**

**NON-STANDARD SPECIAL  
PROVISION**

**COBBLES IN THE FILL STRATUM - Item No. 1**

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Non-Standard Special Provision

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This special provision covers the cobbles and boulders in subsurface stratum.

The Contractor is advised of the following foundation conditions:

Occasional cobbles were identified within the fill within the advanced borehole locations. The contractor shall aware of potential for encountering cobbles or boulders at the site during excavation or installation of temporary roadway protection.

**BEDROCK - Item No. 2**

---

Non-Standard Special Provision

---

This special provision covers the presence of bedrock at the culvert replacement location.

The Contractor is advised of the following foundation conditions:

Shallow sloping bedrock is to be expected at the culvert replacement location. Excavation in the strong to extremely strong bedrock would require either pre-drilling or blasting, and/or hoe ramming depending on the required extent of rock removal. The contractor shall be aware of encountering bedrock at the site during excavation or installation of temporary roadway protection.

**WATER LEVEL FLACTUATION - Item No. 3**

---

Non-Standard Special Provision

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This special provision covers the fluctuating water level.

It should be noted that depending on the season, depth of excavation and amount of water level through the creek may vary. The contractor should be prepared to tackle this situation. The contractor should be noted of the high water table and surface water fluctuation for dewatering operation.



**Appendix F**

**CHEMICAL TEST  
RESULTS**



DST Thunder Bay  
ATTN: Selorm Danku  
DST Consulting Engineers Inc.  
1120 Premier Way , Suite 200  
Thunder Bay ON P7B 0A3

Date Received: 01-DEC-15  
Report Date: 09-DEC-15 14:53 (MT)  
Version: FINAL

Client Phone: 807-345-3620

## Certificate of Analysis

Lab Work Order #: L1708981  
Project P.O. #: NOT SUBMITTED  
Job Reference:  
C of C Numbers:  
Legal Site Desc:

Rikki Thomson  
Account Manager

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ADDRESS: 1081 Barton Street, Thunder Bay, ON P7B 5N3 Canada | Phone: +1 807 623 6463 | Fax: +1 807 623 7598  
ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1708981-1	GRAYSTONE							
Sampled By:	Client on 01-DEC-15 @ 00:01							
Matrix:	Soil							
<b>Physical Tests</b>								
Conductivity		148		4.0	umhos/cm	07-DEC-15	07-DEC-15	R3325981
% Moisture		13.2		0.10	%	04-DEC-15	05-DEC-15	R3325347
pH		6.04		0.10	pH units		07-DEC-15	R3326423
Resistivity		6760		100	ohm cm	07-DEC-15	07-DEC-15	R3325976
<b>Leachable Anions &amp; Nutrients</b>								
Chloride		<20		20	mg/kg	04-DEC-15	08-DEC-15	R3327616
<b>Anions and Nutrients</b>								
Sulphate		139		20	mg/kg	04-DEC-15	08-DEC-15	R3327616

\* Refer to Referenced Information for Qualifiers (if any) and Methodology.

## Reference Information

### Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-WT	Soil	Chloride in Soil	EPA 300.0
EC-WT	Soil	Conductivity (EC)	EPA 9050A
A representative subsample is tumbled with de-ionized (DI) water. The ratio of water to soil is 2:1 v/w. After tumbling the sample is then analyzed by a conductivity meter.			
MOISTURE-WT	Soil	% Moisture	Gravimetric: Oven Dried
PH-WT	Soil	pH	MOEE E3137A
Soil samples are mixed in the deionized water and the supernatant is analyzed directly by the pH meter.			
RESISTIVITY-WT	Soil	Resistivity	MOECC E3138
Resistivity on a soil is a 2:1 extraction of DI water to soil. Sample is tumbled for 30 min. Conductivity of the extraction is taken and the inverse is calculated for resistivity.			
SO4-WT	Soil	Sulphate	EPA 300.0

\*\* ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

### Chain of Custody Numbers:

#### GLOSSARY OF REPORT TERMS

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*

*mg/kg ww - milligrams per kilogram based on wet weight of sample*

*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*

*mg/L - unit of concentration based on volume, parts per million.*

*< - Less than.*

*D.L. - The reporting limit.*

*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*

*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*

*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

## Quality Control Report

Workorder: L1708981

Report Date: 09-DEC-15

Page 1 of 2

Client: DST Thunder Bay  
DST Consulting Engineers Inc. 1120 Premier Way , Suite 200  
Thunder Bay ON P7B 0A3

Contact: Selorm Danku

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<b>CL-WT</b>	<b>Soil</b>							
<b>Batch</b>	<b>R3327616</b>							
<b>WG2226771-3</b>	<b>CRM</b>	<b>AN-CRM-WT</b>						
Chloride			102.9		%		70-130	08-DEC-15
<b>WG2226771-2</b>	<b>LCS</b>							
Chloride			95.9		%		70-130	08-DEC-15
<b>WG2226771-1</b>	<b>MB</b>							
Chloride			<20		mg/kg		20	08-DEC-15
<b>EC-WT</b>	<b>Soil</b>							
<b>Batch</b>	<b>R3325981</b>							
<b>WG2227671-1</b>	<b>MB</b>							
Conductivity			<4.0		umhos/cm		4	07-DEC-15
<b>MOISTURE-WT</b>	<b>Soil</b>							
<b>Batch</b>	<b>R3325347</b>							
<b>WG2226652-2</b>	<b>LCS</b>							
% Moisture			95.5		%		90-110	05-DEC-15
<b>WG2226652-1</b>	<b>MB</b>							
% Moisture			<0.10		%		0.1	05-DEC-15
<b>PH-WT</b>	<b>Soil</b>							
<b>Batch</b>	<b>R3326423</b>							
<b>WG2228014-1</b>	<b>LCS</b>							
pH			6.99		pH units		6.7-7.3	07-DEC-15
<b>SO4-WT</b>	<b>Soil</b>							
<b>Batch</b>	<b>R3327616</b>							
<b>WG2226771-3</b>	<b>CRM</b>	<b>AN-CRM-WT</b>						
Sulphate			110.5		%		60-140	08-DEC-15
<b>WG2226771-2</b>	<b>LCS</b>							
Sulphate			96.2		%		70-130	08-DEC-15
<b>WG2226771-1</b>	<b>MB</b>							
Sulphate			<20		mg/kg		20	08-DEC-15

# Quality Control Report

Workorder: L1708981

Report Date: 09-DEC-15

Page 2 of 2

## Legend:

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Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

## Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

---

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.



DST Thunder Bay  
ATTN: Bernie Villegas  
DST Consulting Engineers Inc.  
605 Hewitson street  
Thunder Bay ON P7B 5V5

Date Received: 19-OCT-15  
Report Date: 21-OCT-15 10:30 (MT)  
Version: FINAL

Client Phone: 807-626-1310

## Certificate of Analysis

Lab Work Order #: L1689521  
Project P.O. #: NOT SUBMITTED  
Job Reference: GS-TB-020407  
C of C Numbers:  
Legal Site Desc:

Rikki Thomson  
Account Manager

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ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

\* Refer to Referenced Information for Qualifiers (if any) and Methodology.



QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Chloride (Cl)	B	L1689521-1, -2, -3, -4, -5
Matrix Spike	Chloride (Cl)	MS-B	L1689521-1, -2, -3, -4, -5

Sample Parameter Qualifier key listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-L-IC-N-TB	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
EC-TITR-TB	Water	Conductivity	APHA 2510 B
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
PH-TITR-TB	Water	pH	APHA 4500-H
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
SO4-IC-N-TB	Water	Sulfate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			

\*\* ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
TB	ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA

Chain of Custody Numbers:

**GLOSSARY OF REPORT TERMS**  
Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.  
mg/kg - milligrams per kilogram based on dry weight of sample  
mg/kg ww<sub>w</sub>t - milligrams per kilogram based on wet weight of sample  
mg/kg l<sub>w</sub>t - milligrams per kilogram based on lipid weight of sample  
mg/L - unit of concentration based on volume, parts per million.  
< - Less than.  
D.L. - The reporting limit.  
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.  
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.  
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

## Quality Control Report

Workorder: L1689521

Report Date: 21-OCT-15

Page 1 of 3

Client: DST Thunder Bay  
DST Consulting Engineers Inc. 605 Hewitson street  
Thunder Bay ON P7B 5V5

Contact: Bernie Villegas

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-L-IC-N-TB		Water						
Batch	R3293233							
WG2196265-6	LCS							
Chloride (Cl)			99.7		%		90-110	20-OCT-15
WG2196265-5	MB							
Chloride (Cl)			<0.10		mg/L		0.1	20-OCT-15
EC-TITR-TB		Water						
Batch	R3292437							
WG2195669-2	LCS							
Conductivity (EC)			97.8		%		90-110	19-OCT-15
WG2195669-1	MB							
Conductivity (EC)			<3.0		uS/cm		3	19-OCT-15
PH-TITR-TB		Water						
Batch	R3292437							
WG2195669-2	LCS							
pH			6.02		pH		5.9-6.1	19-OCT-15
SO4-IC-N-TB		Water						
Batch	R3293233							
WG2196265-6	LCS							
Sulfate (SO4)			98.7		%		90-110	20-OCT-15
WG2196265-5	MB							
Sulfate (SO4)			<0.30		mg/L		0.3	20-OCT-15

# Quality Control Report

Workorder: L1689521

Report Date: 21-OCT-15

Page 2 of 3

## Legend:

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Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

## Sample Parameter Qualifier Definitions:

---

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.

---

# Quality Control Report

Workorder: L1689521

Report Date: 21-OCT-15

Page 3 of 3

## Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
-------------------------	-----------	---------------	----------------	---------	-----------	-------	-----------

## Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.  
EHTR: Exceeded ALS recommended hold time prior to sample receipt.  
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.  
EHT: Exceeded ALS recommended hold time prior to analysis.  
Rec. HT: ALS recommended hold time (see units).

### Notes\*:

Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.  
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1689521 were received on 19-OCT-15 09:25.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.