



## **FINAL REPORT**

### **FOUNDATION INVESTIGATION REPORT**

**Minnikau River Culverts Replacement, Highway 642, Site No. 41S-255/C, District  
of Kenora**

**Agreement No. 6014-E-0017**

**Assignment No. 7**

**GWP 6912-12-01**

**Geocres No. 52G-014**

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**exp Services Inc.**  
December 23, 2015

# Ontario Ministry of Transportation

## Foundation Investigation Report

Agreement No. 6014-E-0017

Assignment No. 7

GWP 6912-12-01

Geocres No. 52G-014

## Type of Document:

Final

## Project Name:

Foundation Investigation Report for Minnikau River Culverts Replacement  
Highway 642, Site No. 41S-255/C, District of Kenora

## Project Number:

ADM-00223648-F0

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## **PART I FOUNDATION INVESTIGATION REPORT**

### **1.1 Introduction**

This foundation investigation report presents the results of a geotechnical investigation completed by **exp** Services Inc. for the replacement of the three (3) Minnikau River Culverts, located on Highway 642, about 35 km east of the junction of Hwy 516 and Hwy 642, in the District of Kenora, the Ministry of Transportation (MTO) Northwestern Region. The work was undertaken under Agreement # 6014-E-0017, Assignment No. 7 (GWP 6912-12-01). The terms of reference (TOR) were as presented in the MTO letter dated July 7, 2015.

Based on preliminary information provided and our observations on site, the existing culverts are structural plate corrugated steel pipe with diameters of about 2.44 m and lengths ranging between about 18.31 m and 18.45 m. It is understood that the existing culverts were constructed at an unknown date, and are intended to be replaced with a new culvert or culverts along the same alignment.

The purpose of the investigation was to evaluate the subsurface conditions along the alignment, to permit detailed design for the replacement of the culverts. The site specific geotechnical investigation consisted of borings, soil sampling, borehole logging, and field and laboratory testing.

This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the investigation and the laboratory testing completed for this project.

### **1.2 Site Description and Geological Setting**

#### **1.2.1 Site Description**

As shown on Drawing 1 (Appendix B), the Minnikau River Culverts are located on Highway 642, about 35 km east of the junction of Hwy 516 and Hwy 642, in the District of Kenora, southeast of Sioux Lookout, Ontario. At the site, Hwy 642 is a two lane roadway, with a speed limit of 80 km/h and is about 7.0 m wide from edge of pavement to edge of pavement, with sand and gravel shoulders. Based on drawings provided, the roadway embankment is about 3.4 m high with side slopes of about 2H:1V.

Highway 642 at the Minnikau River Culverts location, runs generally in a northwest-southeast direction, and the Minnikau River generally flows from east to west. However, for simplicity and for the purposes of this report a “project north” has been established and project north is oriented perpendicular to the centerline of Hwy 642 (i.e. project north is in the same direction as true north’s northeast direction). The orientation of project north is presented on Drawing 1 in Appendix B. Hereinafter, the directions indicated in this report are in referenced to project north.

During the fieldwork on August 10, 11, 12 and 27, 2015, the general site conditions were assessed. Hwy 642 runs in a generally east and west direction and the water in the Minnikau River generally

flows from north to south beneath the highway. At the time of this investigation, the approximate river elevations at the inlet and outlet were about 391.42 m and 391.38 m, respectively, and the streambed elevations at the inlet and outlet were about 390.9 m and 390.7 m, respectively. The elevation of highway pavement centerline at the middle culvert centerline is about 394.10 m.

At the vicinity of the inlet and outlet of the culvert some minor vegetation was noted at both culvert ends. The surrounding area of the culvert at the east and west side of Hwy 642 was surfaced with tall grasses and forested further away from the culverts. The inlet and outlet appeared to be generally clear of debris and excess vegetation, and as such the flow does not appear to be restricted.

Select photographs are provided in Appendix A.

### 1.2.2 Geological Setting

According to the MNR Northern Ontario Engineering Geology Terrain Data Base Map, Ontario Geological Survey Map 5062, Scale 1:100,000, dated 1979, the underlying native soil at the site consists of sand till ground moraine overlying bedrock with a drift veneer, and subordinate landforms consisting of silt and sand glaciolacustrine plain. The topography of the site is indicated as low local relief with rolling to undulating terrain and mixed wet and dry surface conditions.

According to the Ministry of Northern Development and Mines (MNDM) Bedrock Geology of Ontario, West-Central Sheet Map No. 2542, Scale 1:1,000,000, dated 1991, the bedrock geology of the site is mafic to intermediate metavolcanic rock from the Neo to Mesoarchean Era (2.5 to 3.4 Ga), and generally consists of basaltic and andesitic flows, tuff and breccia. It may also contain, chert, iron formations, minor sedimentary and intrusive rocks along with related migmatites.

## 1.3 Investigation Procedures

### 1.3.1 Site Investigation and Field Testing

The field investigation was performed on August 10, 11, 12 and 27, 2015. The field program consisted of drilling four (4) sampled boreholes (BH301 to BH304). Two (2) boreholes were located within the highway, BH301 and BH302. BH301 was located about 4.2 m east of the east culvert centerline and about 2.7 m north of the highway centerline. BH302 was located about 4.2 m west of the west culvert centerline and about 1.9 m south of the highway centerline. An additional two (2) boreholes (BH303 and BH304) were advanced off of the highway. BH303 was located about 18 m west of the west culvert centerline and about 8.2 m north of the highway centerline on the inlet/upstream side of the culvert. BH304 was located about 11 m east of the culvert centerline and about 10 m south of the highway centerline on the outlet/downstream side of the culvert. The borehole locations are shown on Drawing 1 in Appendix B.

All the boreholes (BH301 to BH304) were advanced using a CME 850 track mounted drill rig. The drill rig was equipped with hollow stem continuous flight augers and standard soil sampling equipment (includes 51 mm outside diameter split spoon samplers and *in situ* shear vane testing equipment). In addition, the CME 850 drill rig was equipped with rock coring equipment (HQ size).

BH301 was advanced to a depth of about 9.8 m below ground surface, and rock coring techniques were used to continue the borehole beyond refusal to a depth of about 13.1 m below ground surface. Rock coring techniques were not used at the remaining three boreholes.

BH302 was advanced to about 13.6 m below ground surface, and the off-road boreholes (BH303 and BH304) were advanced, to depths of about 12.5 m and 6.7 m, respectively. BH302, BH303 and BH304 were terminated at auger and/or SPT refusal depths.

The borehole locations were referenced to the MTM ON-16 NAD83 coordinate system and their ground surface elevations were surveyed by **exp** personnel. The ground surface elevations, including top of water in the river, were referenced to a geodetic benchmark (BM) provided (nail in tree root) east of the site and south of the highway. The BM elevation is 393.900 m. The location of the BM is shown on Drawing 1, in Appendix B.

During the drilling of the boreholes (BH301 to BH304), soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586), and were generally performed at intervals of about 0.75 m. The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual and used to provide an assessment of *in-situ* compactness (cohesionless) or consistency (cohesive) soils.

Upon completion of the boreholes, groundwater level measurements were carried out in boreholes in accordance with the Ministry of Transportation guidelines. The measured groundwater levels after completion of drilling boreholes were recorded on borehole log sheets in Appendix C. The boreholes were backfilled with a mixture of bentonite and auger cuttings. The borehole decommissioning was in general accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the *Ontario Water Resources Act*).

The fieldwork was supervised by a member of **exp**'s engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM Standards for Soils Classification, and retrieved soil samples. All of the recovered soil samples were placed in labelled moisture-proof bags which, along with the rock cores, were brought to **exp**'s Thunder Bay laboratory for additional visual, textual and olfactory examination, and for subsequent examination by a geotechnical engineer and laboratory testing.

### 1.3.2 Laboratory Testing

All samples brought to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content and particle size distribution for approximately 25% of the collected soil samples. Atterberg Limits tests were carried out on select cohesive soil samples. All of the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate, at the **exp** laboratory in Thunder Bay, Ontario.

The laboratory test results are provided on the attached borehole log sheets in Appendix C as well as graphically in Appendix D.

In addition, chemical testing of two select soil samples were conducted. The soil samples were sent via courier, in a secure cooler under chain of custody, to Maxxam Analytics Inc., a CALA-

certified and accredited laboratory in Mississauga, Ontario. Details of the chemical testing are discussed below and the lab results are included in Appendix E.

## 1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the Borehole Records in Appendix C. Laboratory test results are provided in Appendix D. The “Explanation of Terms Used on Borehole Records” preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and stratigraphic sections are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and stratigraphic sections are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be interpreted as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions along the proposed culvert alignment consist of a layer of fill material composed of sand, overlying native sand, overlying clayey silt overlying silt, overlying silty sand and cobbles and boulders. A more detailed summary of the subsurface conditions encountered in the boreholes is provided in the following sections.

### 1.4.1 Poorly Graded Sand with Silt and Gravel Fill

Poorly graded sand with silt and gravel fill was encountered beneath the asphalt at BH301 and BH302, and beneath the rootmat at BH303. The asphalt thickness at BH301 and BH302 was about 25 mm. The rootmat thickness was about 100 mm. The fill was generally described as compact to very dense, brown, damp to moist, and containing occasional cobbles. The SPT “N” values ranged between 3 and 56 blows per 300 mm penetration, with an average “N” value of about 22. The fill extended to a depths ranging between about 1.1 m and 3.1 m below ground surface, and at elevations ranging between about 391.0 m and 391.6 m.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture content:

- 3.8% to 16.6%

Grain size distribution:

- 17% gravel;
- 78% sand and;
- 5% silt and clay size.

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 1, in Appendix D.

### 1.4.2 Peat

Peat was encountered surfacing BH304 and beneath the fill at BH303. The peat was generally described as very soft to soft, dark brown to brown, moist to wet, containing trace sand to sandy, and trace silt. The SPT “N” values ranged between 0 (i.e. advanced by weight of hammer and rods alone) and 2 blows per 300 mm penetration, with an average “N” value of about 1. The peat thickness ranged between about 0.1 m and 1.3 m and extended to depths ranging between about 0.1 m and 2.4 m below ground surface. The peat extended to elevations ranging between about 390.2 m and 392.5 m. Laboratory testing performed on selected samples consisted of moisture content. The test results are as follows:

Moisture content:

- 11.7% to 112.6%

The results of the moisture content tests are provided on the record of borehole sheets in Appendix C.

### 1.4.3 Poorly Graded Sand to Poorly Graded Sand with Silt

Native poorly graded sand to poorly graded sand with silt was encountered beneath the fill at BH301 and BH302, and encountered beneath the peat at BH304. The native sand was generally described as very loose to loose, brown, moist to wet. Trace organics were observed at BH301 and some roots and rootlets were observed at BH304. At BH302, sand blowup, about 0.25 m to 1.0 m in thickness, was noted in the augers at about 3.8 m and 5.2 m depth, respectively. The SPT “N” values ranged between 0 (i.e. advanced by weight of hammer and rods alone) and 6 blows per 300 mm penetration, with an average “N” value of about 3. The native sand extended to depths ranging between about 0.9 m to 6.7 m below ground surface, with elevations ranging between about 387.3 m and 391.7 m.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture content:

- 7.1% to 18.8%

Grain size distribution:

- 0% to 13% gravel;
- 81% to 96% sand;
- 4% to 6% silt and clay size.

Total saturated unit weights have been calculated based on the moisture contents and are estimated to range from about 20.9 to 23.8 kN/m<sup>3</sup>.

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 1, in Appendix D.



#### 1.4.4 Clayey Silt

Clayey silt was encountered underlying the native sand at BH301 and underlying the peat at BH303. The clayey silt was generally described as very soft to stiff, grey, and wet. At BH301, occasional 10 mm interbedded peat layers were noted in the upper 5.2 m, and at about 6.1 m depth, the clayey silt was becoming varved. The SPT “N” values ranged between 0 (i.e. advanced by weight of hammer and rods alone) and 2 blows per 300 mm penetration, with an average “N” value of about 1. Four (4) *in situ* field vane test were performed and the results at ranged between about 21 kPa and 84 kPa, respectively. The clayey silt extended to depths ranging between about 5.3 m and about 7.0 m below ground surface, and elevations ranging between 387.0 m and 387.3 m.

Laboratory testing performed on selected samples consisted of moisture content, grain size distribution and Atterberg Limit tests. The test results are as follows:

Moisture content:

- 18.3% to 50.7%

Grain size distribution:

- 0% gravel;
- 6% to 9% sand;
- 64% to 66% silt; and
- 25% to 30% clay size.

Total saturated unit weights have been calculated based on the moisture contents and are estimated to range from about 16.8 to 21.0 kN/m<sup>3</sup>. Two (2) Atterberg Limits tests were performed on representative samples of the clayey silt (BH301-S6 and BH303-S5). The results indicated that the soil is of low plasticity. The data is shown on the plasticity chart, Figure 5. The liquid limit, plastic limit and plasticity index ranged between about 24 and 27, 14 and 15, and 9 and 13, respectively.

The results of the moisture content, grain size distribution and Atterberg Limits tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution are also provided on Figure 2 in Appendix D, and Atterberg Limits tests are provided on Figure 5 in Appendix D.

#### 1.4.5 Silt

Silt was encountered beneath the clayey silt at BH301 and BH303, and beneath the native sand at BH302 and BH304. The silt was described as very loose to compact, grey, and wet. At BH303, varved soils were noted from about 6.1 m to 7.0 m depth. The SPT “N” values ranged between 0 (i.e. advanced by weight of hammer and rods alone) and 20 blows per 300 mm penetration, with an average “N” value of about 6. Three (3) *in situ* field vane tests were performed, as some cohesive properties were noted, yielding results ranging between about 42 kPa and 133 kPa. The silt

extended to depths ranging between about 3.8 m and 9.2 m below ground surface. The silt extended to elevations ranging between about 383.5 m and 388.8 m.

Laboratory testing performed on selected samples consisted of moisture content, grain size distribution and Atterberg Limit tests. The test results are as follows:

Moisture content:

- 17% to 47.3%

Grain size distribution:

- 0% gravel;
- 1% to 11% sand;
- 84% to 90% silt; and
- 9% to <89% clay size.

Total saturated unit weights have been calculated based on the moisture contents and are estimated to range from about 17.2 to 21.2 kN/m<sup>3</sup>. Four (4) Atterberg Limits tests were performed on representative samples of the silt (BH301-S10, BH302-S10, BH303-S9 and BH304-S3) as some cohesive properties were noted. The results indicated that the soil is of low plasticity and the soil contained more cohesionless properties than cohesive properties. The data is shown on the plasticity chart, Figure 6. The values of the liquid limit, plastic limit and plasticity index ranged between about 19 and 21, 15 and 16, and 4 and 6, respectively.

The results of the moisture content, grain size distribution and Atterberg Limits tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution are also provided on Figure 3 in Appendix D, and Atterberg Limits tests are provided on Figure 6 in Appendix D.

#### 1.4.6 Silty Sand to Sandy Silt with Gravel

Silty sand was encountered beneath the silt at BH301, BH302 and BH303, and sandy silt with gravel was encountered underlying the silt at BH304. The silty sand to sandy silt with gravel was generally described as very loose to very dense at depth, grey, and wet. Occasional cobbles were noted at BH302 and BH304. Sand blowup in the augers was noted at BH301, BH302 and BH303, and the blowup thickness ranged between about 300 mm and 2.4 m. The SPT "N" values ranged between 0 (i.e. advanced by weight of hammer and rods alone) and 72 (i.e. SPT refusal) blows per 300 mm penetration, with an average "N" value of about 20. Two SPT N values of 100 were noted at refusal / termination depths and are unlikely to be representative of the silty sand or sandy silt with gravel. The silty sand and sandy silt with gravel extended to depths ranging between about 6.7 m and 13.6 m below ground surface, with elevations ranging between about 380.1 m and 385.9 m.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture content:

- 8.4% to 19.0%

Grain size distribution:

- 0% to 15% gravel;
- 19% to 68% sand;
- <32% to 59% silt; and
- 1% to <45% clay size.

Total saturated unit weights have been calculated based on the moisture contents and are estimated to range from about 20.8 to 23.4 kN/m<sup>3</sup>.

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figures 3 and 4, in Appendix D.

#### 1.4.7 Cobbles and Boulders

Cobbles and boulders were encountered underlying the silty sand at BH301. The borehole was extended using rock coring techniques about 3.3 m into the cobbles and boulders layer to a depth of about 13.1 m (380.9 m elevation) below ground surface.

### 1.5 Groundwater and Surface Water Conditions

Information on groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The groundwater levels encountered in the boreholes are shown on the borehole logs and presented below in Table 1.1.

Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods.

Table 1.1. Groundwater data

Borehole	Date Completed	Date Measured	Ground Surface Elevation <sup>2</sup>	Depth to Water <sup>3</sup>	Groundwater Elevation
BH301	Aug. 10/15	Aug. 10/15	394.01	1.78	392.23
BH302	Aug. 11/15	Aug. 11/15	394.04	2.85	391.19
BH303 <sup>4</sup>	Aug. 27/15	Aug. 27/15	392.63	1.07	391.56
BH304	Aug. 12/15	Aug. 12/15	392.57	0.30	392.27
Minnikau River WL Upstream (North) Side	--	Aug. 12/15			391.42 <sup>5</sup>

Borehole	Date Completed	Date Measured	Ground Surface Elevation <sup>2</sup>	Depth to Water <sup>3</sup>	Groundwater Elevation
Minnikau River WL Downstream (South) Side	--	Aug. 12/15	--	--	391.38 <sup>5</sup>
Notes: 1) All units in metres. 2) Elevations surveyed are referenced to a geodetic benchmark (BM) provided (nail in tree root) east of the site and south of the highway. The BM elevation is 393.900 m. 3) Depths are relative to ground surface. 4) Drilling at BH303 was completed on August 12, 2015. The borehole was left open to measure groundwater levels prior to backfilling on August 27, 2015. 5) Indicates highest elevation value of the top of surface water at Minnikau River.					

## 1.6 Chemical Analyses

Two soil samples were selected for chemical analyses and were sent via courier, in a secure cooler under chain of custody, to Maxxam Analytics Inc., a CALA-certified and accredited laboratory in Mississauga, Ontario. The analytical laboratory results are presented in Appendix E, and are summarized in Table 1.2, below.

Table 1.2. Corrosivity Chemical Analysis

Borehole	pH (unitless)	Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (μS/cm)
BH302-S5	5.99	<20	<20	27,000	38
BH303-S4B	7.34	<20	<20	5,600	178

## 1.7 CLOSURE

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigation and analysis.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Ahileas Mitsopoulos, P.Eng., Nimesh Tamrakar, M.Eng, EIT., Demetri N. Georgiou, MASc. P.Eng., and Silvana Micic, Ph.D., P.Eng. It was reviewed by TaeChul Kim, P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Elwin Farkas.

Yours truly,

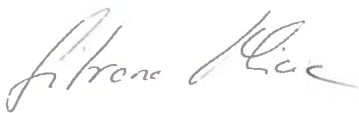
**exp Services Inc.**



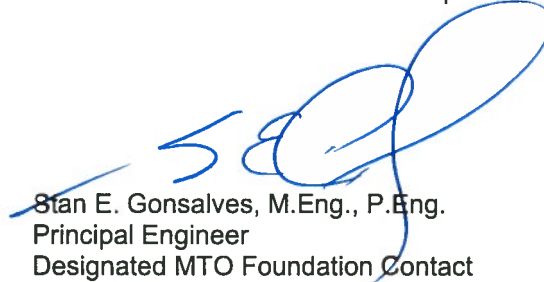
Nimesh Tamrakar, M.Eng., EIT.  
Technical Specialist



TaeChul Kim, M.E.Sc., P.Eng.  
Senior Geotechnical/Foundation Specialist

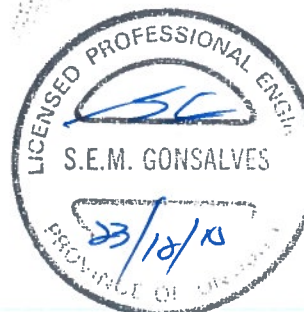


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Project Manager



Stan E. Gonsalves, M.Eng., P.Eng.  
Principal Engineer  
Designated MTO Foundation Contact

Encl.



## **Appendix A – Site Photographs**





Photo 1. Existing culvert inlet on north side of highway



Photo 2. Existing culvert outlet on south side of highway



Photo 3. Facing west on Highway 642 before the existing culvert



Photo 4. Facing east on Highway 642 before the existing culvert



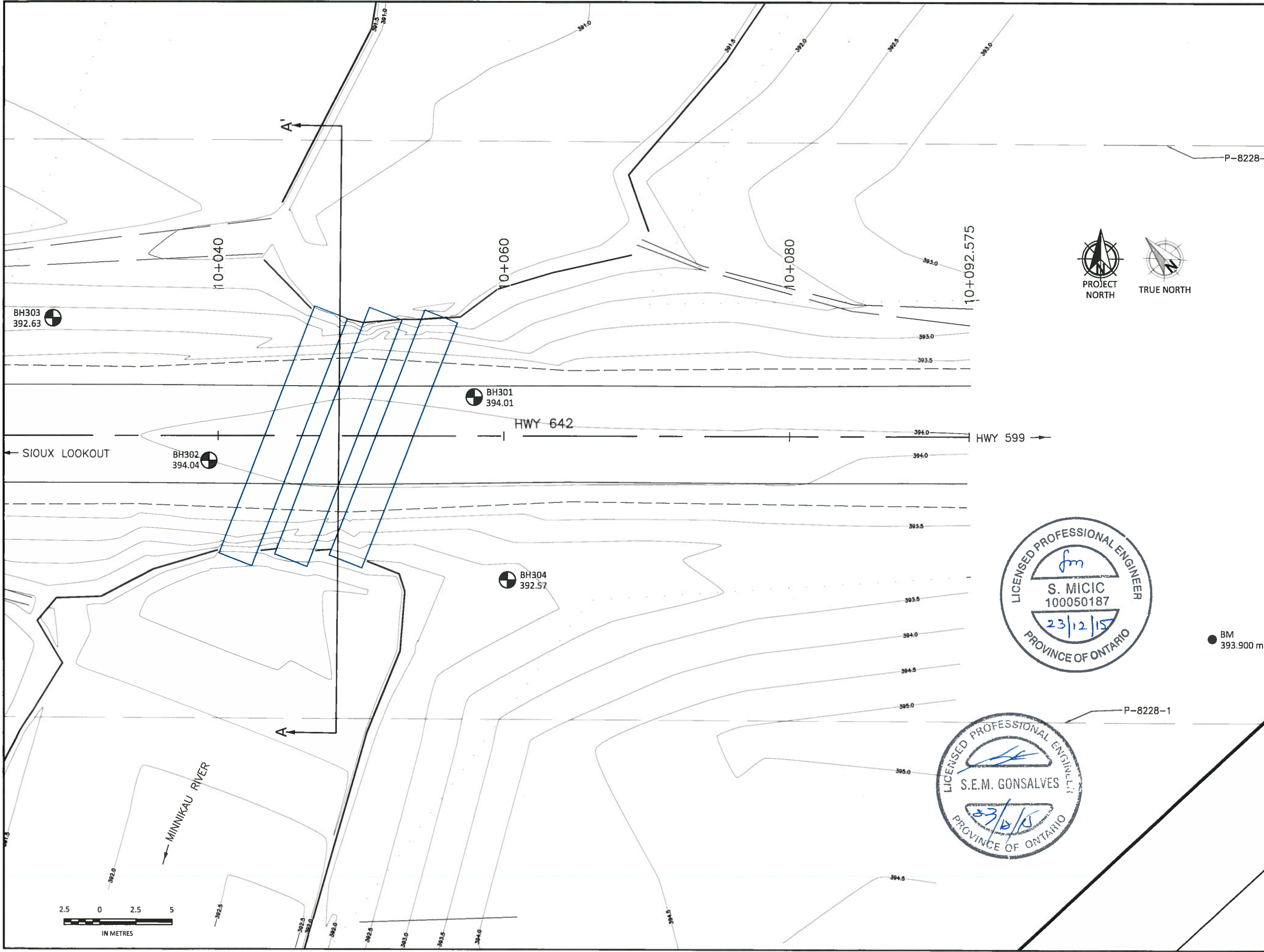


Photo 5. Embankment slope on north side facing west



Photo 6. Embankment slope on south side facing west

## **Appendix B – Drawings**



Agreement No. 6014-E-0017  
Assignment No. 7  
GWP 6912-12-01

MINNIKAU RIVER CULVERTS  
(Highway 642, District of Kenora, ON)  
PLAN

DWG  
1

exp.

exp Services Inc.

KEY PLAN

TOWNSHIP OF  
BENEDICKSON

DISTRICT OF KENORA  
GPT BLOCK No. 9

SIoux LOOKOUT

BANDEN LAKE

SITE

642

HWY 599

UNSURVEYED  
TERRITORY

LEGEND

BH301 BOREHOLE LOCATION  
394.01 GROUND SURFACE ELEVATION IN  
METRES

BM  
393.900 m GEODETIC ELEVATION IN METRES

BH No.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTH	EAST
BH301	394.01	5,536,130	404,875
BH302	394.04	5,536,137	404,860
BH303	392.63	5,536,148	404,867
BH304	392.57	5,536,118	404,873

NOTES

1. ALL DIMENSIONS ARE IN METRES.

2. BASE MAP PROVIDED BY CLIENT.

3. MTM COORDINATES BASE ON MTM ZONE ON-16  
PROJECTION, AS PER PROVIDED FIGURE.

4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY.  
THE PROPOSED STRUCTURE DETAILS/WORKS ARE  
SHOWN FOR ILLUSTRATION PURPOSES ONLY.

REVISIONS

DATE	BY	DESCRIPTION

GEOCREs No. 52G-014

Project No. ADM-00223648-F0

Date: December 11, 2015

Scale : 1:250

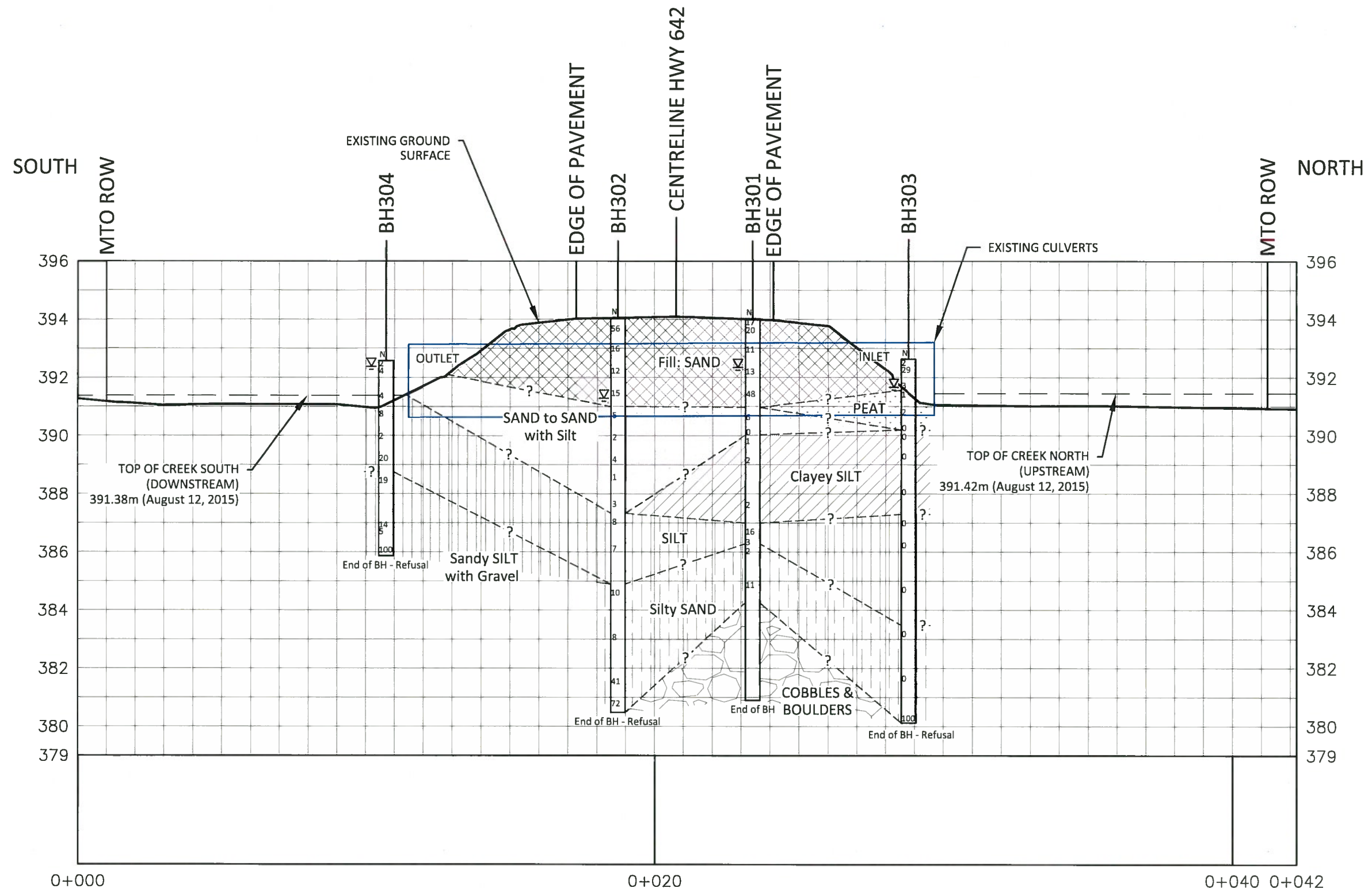
Drawn By: RM

Checked By: AM

Checked By: DG







A - A'  
PROFILE OF MINNIKAU RIVER CULVERTS



Agreement No. 6014-E-0017  
Assignment No. 7  
GWP 6912-12-01

MINNIKAU RIVER CULVERTS  
(Highway 642, District of Kenora, ON)  
Section A-A'

DWG  
2

\*exp.

exp Services Inc.

KEY PLAN

LEGEND

N

STANDARD PENETRATION TEST  
(BLOWS/0.3 m)

▽

MEASURED WATER LEVEL IN OPEN  
BOREHOLE

BH No.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTH	EAST
BH301	394.01	5,536,130	404,875
BH302	394.04	5,536,137	404,860
BH303	392.63	5,536,148	404,867
BH304	392.57	5,536,118	404,873

NOTES

1. ALL DIMENSIONS ARE IN METRES.

2. BASE MAP PROVIDED BY CLIENT.

3. MTM COORDINATES BASE ON MTM ZONE ON-16 PROJECTION, AS PER PROVIDED FIGURE.

4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. THE PROPOSED STRUCTURE DETAILS/WORKS ARE SHOWN FOR ILLUSTRATION PURPOSES ONLY.

5. RIVER WATER LEVEL IS THE HIGHEST VALUE MEASURED FOR BOTH UP AND DOWNSTREAM ELEVATIONS

REVISIONS

DATE	BY	DESCRIPTION

GEOCREs No. 52G-014

Project No. ADM-00223648-P0

Date: December 11, 2015

Horizontal Scale : 1:150

Drawn By: RM

Vertical Scale : 1:150

Checked By: AM

Checked By: DG

## **Appendix C – Borehole Logs and Bedrock Core Photos**

# Explanation of Terms Used on Borehole Records

## SOIL DESCRIPTION

Terminology describing common soil genesis:

*Topsoil:* mixture of soil and humus capable of supporting good vegetative growth.

*Peat:* fibrous fragments of visible and invisible decayed organic matter.

*Fill:* where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

*Till:* the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

*Desiccated:* having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

*Stratified:* alternating layers of varying material or color with the layers greater than 6 mm thick.

*Laminated:* alternating layers of varying material or color with the layers less than 6 mm thick.

*Fissured:* material breaks along plane of fracture.

*Varved:* composed of regular alternating layers of silt and clay.

*Slickensided:* fracture planes appear polished or glossy, sometimes striated.

*Blocky:* cohesive soil that can be broken down into small angular lumps which resist further breakdown.

*Lensed:* inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

*Seam:* a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

*Homogeneous:* same color and appearance throughout.

*Well Graded:* having wide range in grain sized and substantial amounts of all predominantly on grain size.

*Uniformly Graded:* predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION											
CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		
<div><div>0.002</div><div>0.006</div><div>0.02</div><div>0.06</div><div>0.2</div><div>0.6</div><div>2.0</div><div>6.0</div><div>20</div><div>60</div><div>200</div></div>											
EQUIVALENT GRAIN DIAMETER IN MILLIMETRES											
CLAY (PLASTIC) TO				FINE		MEDIUM		CRS.		FINE COARSE	
SILT (NONPLASTIC)				SAND				GRAVEL			
UNIFIED SOIL CLASSIFICATION											

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	$5 \leq Pp \leq 10\%$
Little	$15 \leq Pp \leq 25\%$
Some	$30 \leq Pp \leq 45\%$
Mostly	$50 \leq Pp \leq 100\%$

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	$N < 5$
Loose	$5 \leq N < 10$
Compact	$10 \leq N < 30$
Dense	$30 \leq N < 50$
Very Dense	$50 \leq N$

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

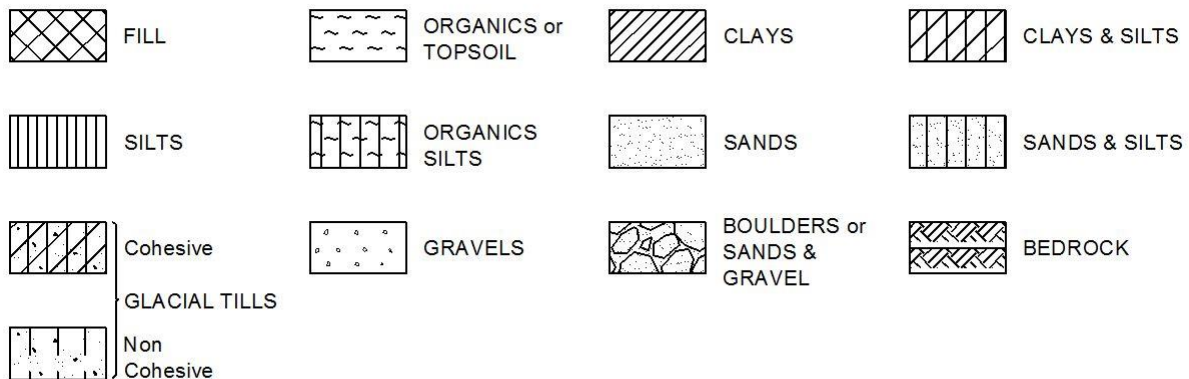
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

## STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



## WATER LEVEL MEASUREMENT



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe



## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

### STRESS AND STRAIN

$u_w$	kPa	Pore water pressure
$r_u$	1	Pore pressure ratio
$\sigma$	kPa	Total normal stress
$\sigma'$	kPa	Effective normal stress
$\tau$	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
$\varepsilon$	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
$\mu$	1	Coefficient of friction

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	Coefficient of volume change
$c_c$	1	Compression index
$c_s$	1	Swelling index
$c_r$	1	Recompression index
$c_v$	m <sup>2</sup> /s	Coefficient of consolidation
H	m	Drainage path
$T_v$	1	Time factor
U	%	Degree of consolidation
$\sigma'_{v0}$	kPa	Effective overburden pressure
$\sigma'_p$	kPa	Preconsolidation pressure
$\tau_f$	kPa	Shear strength
$c'$	kPa	Effective cohesion intercept
$\phi'$	—°	Effective angle of internal friction
$c_u$	kPa	Apparent cohesion intercept
$\phi_u$	—°	Apparent angle of internal friction
$\tau_R$	kPa	Residual shear strength
$\tau_r$	kPa	Remoulded shear strength
$S_t$	1	Sensitivity = $c_u/\tau_r$

### PHYSICAL PROPERTIES OF SOIL

$P_s$	kg/m <sup>3</sup>	Density of solid particles
$\gamma_s$	kN/m <sup>3</sup>	Unit weight of solid particles
$\rho_w$	kg/m <sup>3</sup>	Density of water
$\gamma_w$	kN/m <sup>3</sup>	Unit weight of water
$\rho$	kg/m <sup>3</sup>	Density of soil
$\gamma$	kN/m <sup>3</sup>	Unit weight of soil
$\rho_d$	kg/m <sup>3</sup>	Density of dry soil
$\gamma_d$	kN/m <sup>3</sup>	Unit weight of dry soil
$\rho_{sat}$	kg/m <sup>3</sup>	Density of saturated soil
$\gamma_{sat}$	kN/m <sup>3</sup>	Unit weight of saturated soil
$\rho'$	kg/m <sup>3</sup>	Density of submerged soil
$\gamma'$	kN/m <sup>3</sup>	Unit weight of submerged soil
$e$	1, %	Void ratio
$n$	1, %	Porosity
$w$	1, %	Water content
$S_r$	%	Degree of saturation
$W_L$	%	Liquid limit
$W_P$	%	Plastic limit
$W_s$	%	Shrinkage limit
$I_p$	%	Plasticity index = $(W_L - W_P)$
$I_L$	%	Liquidity index = $(W - W_P)/I_p$
$I_C$	%	Consistency index = $(W_L - W)/I_p$
$e_{max}$	1, %	Void ratio in loosest state
$e_{min}$	1, %	Void ratio in densest state
$I_D$	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
$D_n$	mm	N percent - diameter
$C_u$	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m <sup>3</sup> /s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m <sup>3</sup>	Seepage force

# RECORD OF BOREHOLE No BH301

1 OF 1

METRIC

W.P. GWP No. 6912-12-01 LOCATION Minnikau River Culverts (Site No. 41S-255/C) MTM ON-16 5,536,130N 404,875E ORIGINATED BY EF  
 DIST 61 HWY Hwy 642 BOREHOLE TYPE CME 850 Track Carrier / HSA / HQ COMPILED BY AM/RM  
 DATUM Geodetic DATE 8.10.15 - 8.10.15 CHECKED BY DG

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									WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE									
394.0	Asphalt		S1A	SS	17													
390.0	<b>ASPHALT</b> - about 25 mm		S1B	SS	20													
	<b>Poorly Graded SAND with Silt and Gravel (FILL)</b> - compact to dense, brown, damp to moist, occasional cobbles in upper 0.8 m, crushed material in upper 0.1 m		S2	SS	11													
		S3	SS	13														
			SS	48														
391.0																		
3.1	<b>Poorly Graded SAND with Silt</b> - loose to very loose, brown, wet, trace organics		S4	SS	6													
			S5A	SS	0													
390.0			S5B	SS	1													
4.0	<b>Clayey SILT</b> - very soft to stiff, grey, wet, occasional 10 mm interbedded peat layers in upper 5.2 m		S6	SS	2													
			S7	VANE														
			S8	SS	2													
	- becoming varved at about 6.1 m depth		S9	VANE														
387.0			S10	SS	16													
7.0	<b>SILT</b> - very loose to compact, grey, wet		S11A	SS	3													
386.3			S11B	SS	2													
7.7	<b>Silty SAND</b> - very loose to compact, grey, wet																	
			S12	SS	11													
	- about 610 mm of sand blow up at about 8.8 m depth																	
384.2																		
9.8	<b>COBBLES and BOULDERS</b>		S13	CORE														
			S14	CORE														
380.9																		
13.1	<b>End of Borehole</b>																	





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

# RECORD OF BOREHOLE No BH302

1 OF 1

METRIC

W.P. GWP No. 6912-12-01 LOCATION Minnikau River Culverts (Site No. 41S-255/C) MTM ON-16 5,536,137N 404,860E ORIGINATED BY EF  
DIST 61 HWY Hwy 642 BOREHOLE TYPE CME 850 Track Carrier / HSA COMPILED BY AM/RM  
DATUM Geodetic DATE 8.11.15 - 8.11.15 CHECKED BY DG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE							Wp                      W                      WL				
394.0	Asphalt							20	40	60	80	100							
390.0	ASPHALT - about 25 mm Poorly Graded SAND with Silt and Gravel (FILL) - very dense to compact, brown, damp to wet, occasional cobbles		S1	SS	56														
			S2	SS	16														
			S3	SS	12														
			S4	SS	15														
391.0																			
3.1	Poorly Graded SAND - very loose to loose, brown, wet		S5	SS	5														
	- about 250 mm sand blowup at about 3.8 m depth		S6	SS	2														
			S7	SS	4														
	- about 1.0 m sand blowup at about 5.2 m depth			SS	1														
				SS	3														
387.3			S8	SS	8														
6.7	SILT - loose, grey, wet		S9	VANE															
			S10	SS	7														
			S11	VANE															
384.9																			
9.2	Silty SAND - loose to very dense, grey, wet		S12	SS	10														
	- about 760 mm sand blowup at about 10.7 m depth		S13	SS	8														
	- about 1.2 m sand blowup at about 12.2 m depth		S14	SS	41														
	- occasional cobbles and boulders at about 12.8 m depth																		
			S15	SS	72														
380.5																			
13.6	End of Borehole - refusal to auger																		

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

# RECORD OF BOREHOLE No BH303

1 OF 1

METRIC

W.P. GWP No. 6912-12-01 LOCATION Minnikau River Culverts (Site No. 41S-255/C) MTM ON-16 5,536,148N 404,867E ORIGINATED BY EF  
 DIST 61 HWY Hwy 642 BOREHOLE TYPE CME 850 Track Carrier / HSA COMPILED BY AM/RM  
 DATUM Geodetic DATE 8.12.15 - 8.27.15 CHECKED BY DG

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									
392.6	Rootmat		S1A	SS	2												GR SA SI CL
392.0	<b>ROOTMAT</b> - very soft, brown, moist, trace gravel		S1B	SS	29												
391.6	<b>Poorly Graded SAND with Silt and Gravel (FILL)</b> - compact to very loose, brown, moist to wet, occasional cobbles and boulders, trace peat		S2A	SS	3												
1.1	<b>PEAT</b> - very soft to soft, dark brown, wet, trace sand, trace silt		S2B	SS	1												
			S3	SS	2											112.6	
390.2			S4A	SS	0											86.2	
2.4	<b>Clayey SILT</b> - very soft to soft, grey, wet		S4B	SS	0												
			S5	SS	0												0 6 64 30
			S6	VANE													Field Vane = 22 kPa
			S7	SS	0												
387.3			S8	VANE													Field Vane = 21 kPa
5.3	<b>SILT</b> - very loose, grey, wet		S9	SS	0												0 4 84 12
	- becoming varved from about 6.1 m to 7.0 m depth		S10	SS	0												
			S11	VANE													Field Vane = 42 kPa
			S12	SS	0												0 11 (89)
383.5																	
9.2	<b>Silty SAND</b> - very loose, grey, wet, fine grained		S13	SS	0												
	- about 2.4 m sand blowup at about 10.7 m depth		S14	SS	0												0 55 (45)
380.1	- about 300 mm sand blowup at about 12.1 m depth		S15	SS	100												
12.5	- becoming very dense at about 12.2 m depth																
	<b>End of Borehole</b> - refusal to auger and SPT																

ONL\_MOT\_F-15137-CG - ADM-00223648-F0 - MTO 7 - MINNIKAU RIVER CULVERTS.GPJ ON\_MOT\_GDT 11/18/15



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

# RECORD OF BOREHOLE No BH304

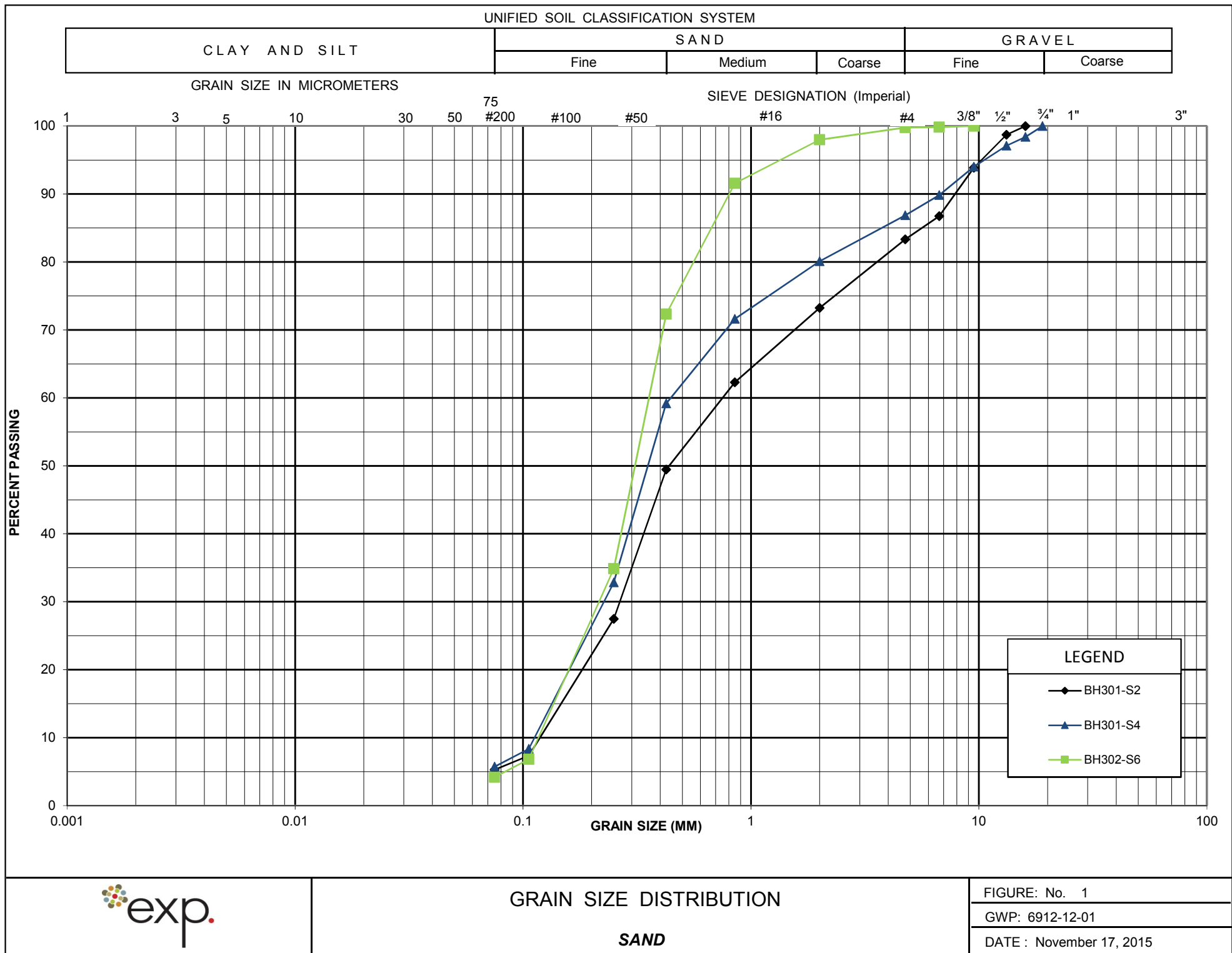
1 OF 1

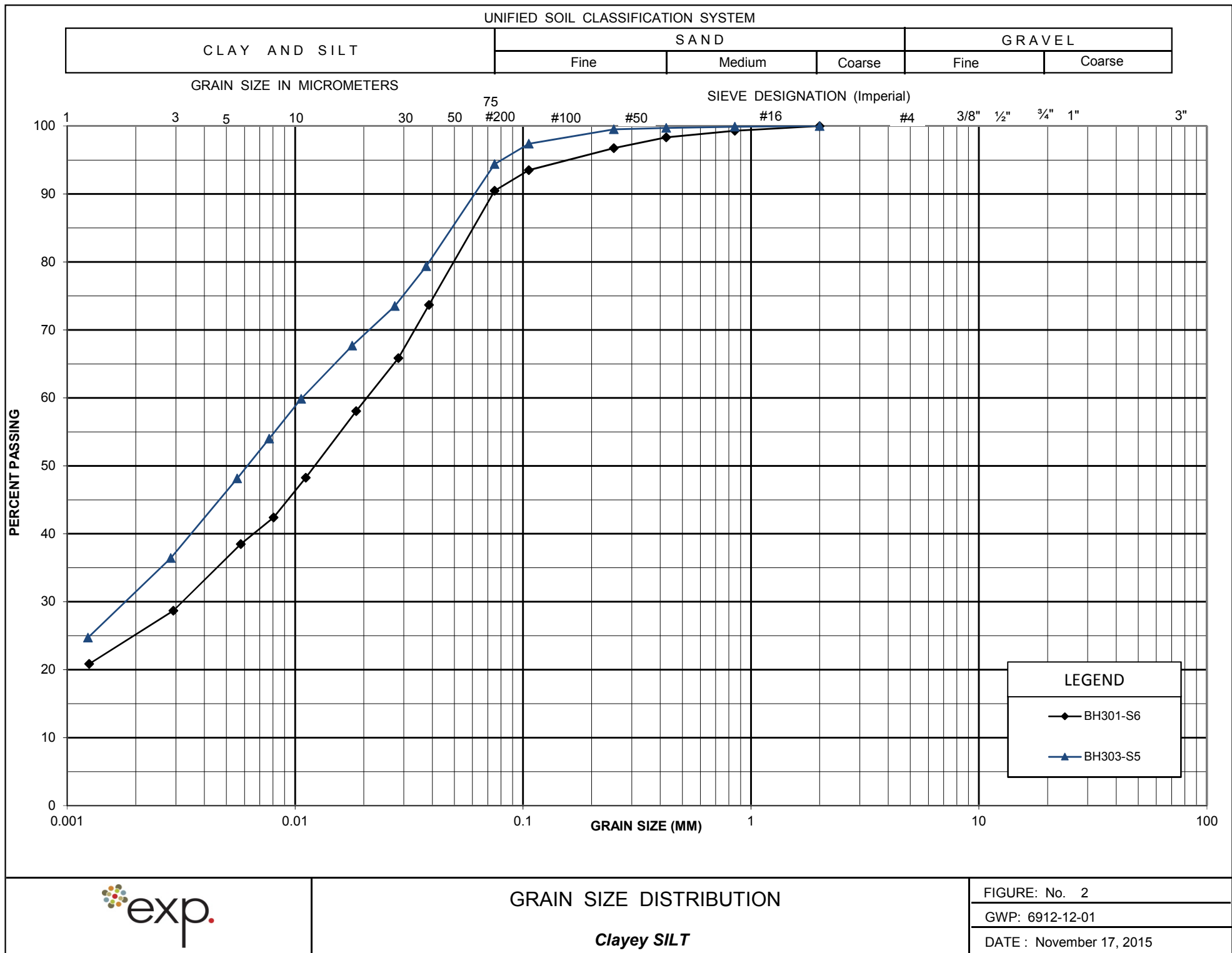
METRIC

W.P. GWP No. 6912-12-01 LOCATION Minnikau River Culverts (Site No. 41S-255/C) MTM ON-16 5,536,118N 404,873E ORIGINATED BY EF  
DIST 61 HWY Hwy 642 BOREHOLE TYPE CME 850 Track Carrier / HSA COMPILED BY AM/RM  
DATUM Geodetic DATE 8.11.15 - 8.12.15 CHECKED BY DG

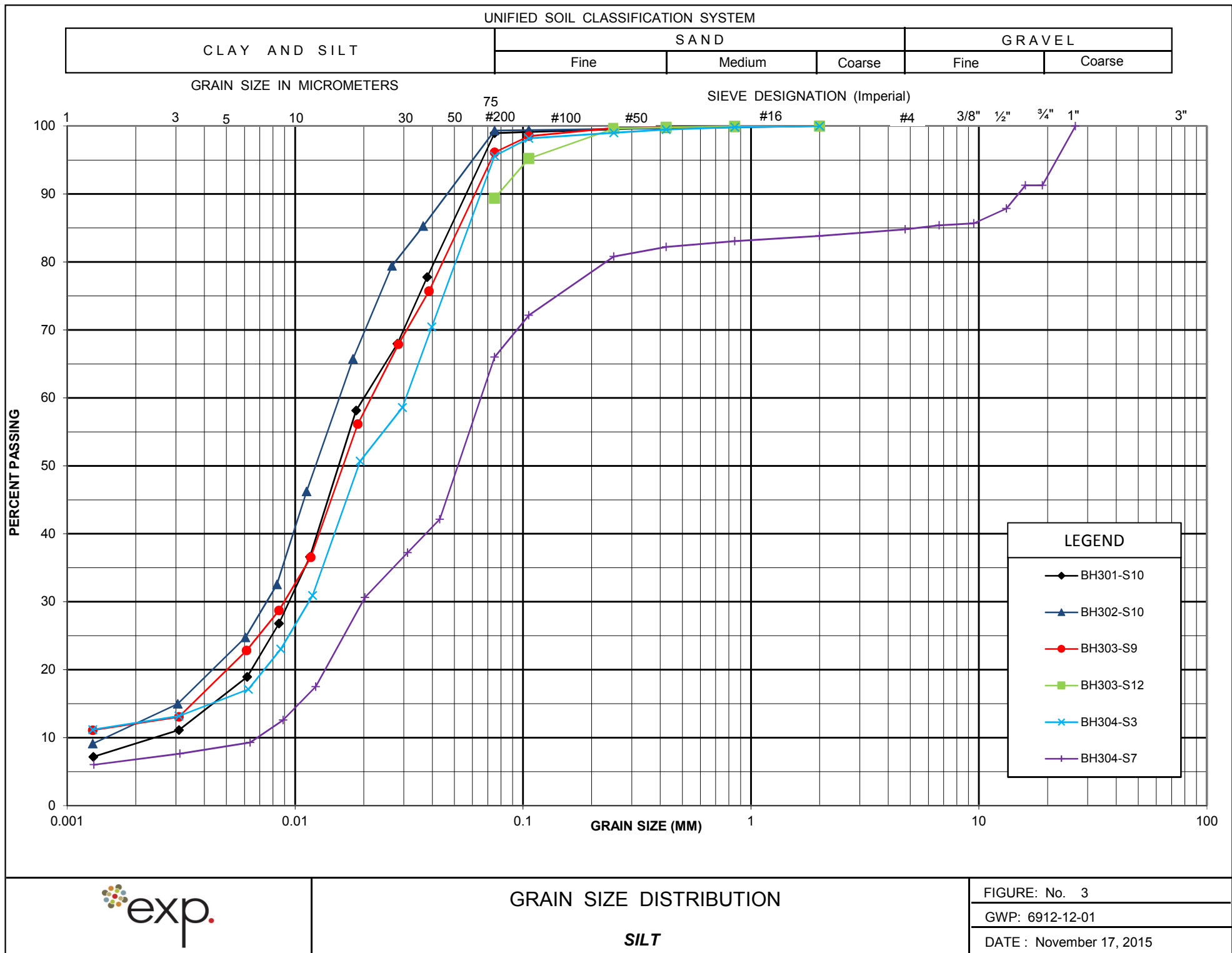
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE											
392.6 0.1	Peat		S1A	SS	2									○					
	<b>PEAT</b> - soft, brown, moist to wet, some sand to sandy, trace silt		S1B	SS	4											○			
391.7 0.9	<b>Poorly Graded SAND with Silt</b> - very loose to loose, brown, moist, some roots and rootlets																		
	<b>SILT</b> - very loose to compact, grey, moist to wet		S2	SS	4											○			
			S3	SS	8											○			
			S4	SS	2											○			
			S5	SS	20											○			
388.8 3.8	- about 610 mm blowup at about 3.7 m depth																		
	<b>Sandy SILT with Gravel</b> - compact to loose, brown to grey at depth, wet			SS	19														
			S6	SS	14										○				
	- occasional cobbles at about 5.2 m depth																		
			S7	SS	5										○				
	- becoming very dense at about 6.1 m depth		S8	SS	100										○				
385.9 6.7	<b>End of Borehole</b> - refusal to auger and SPT																		

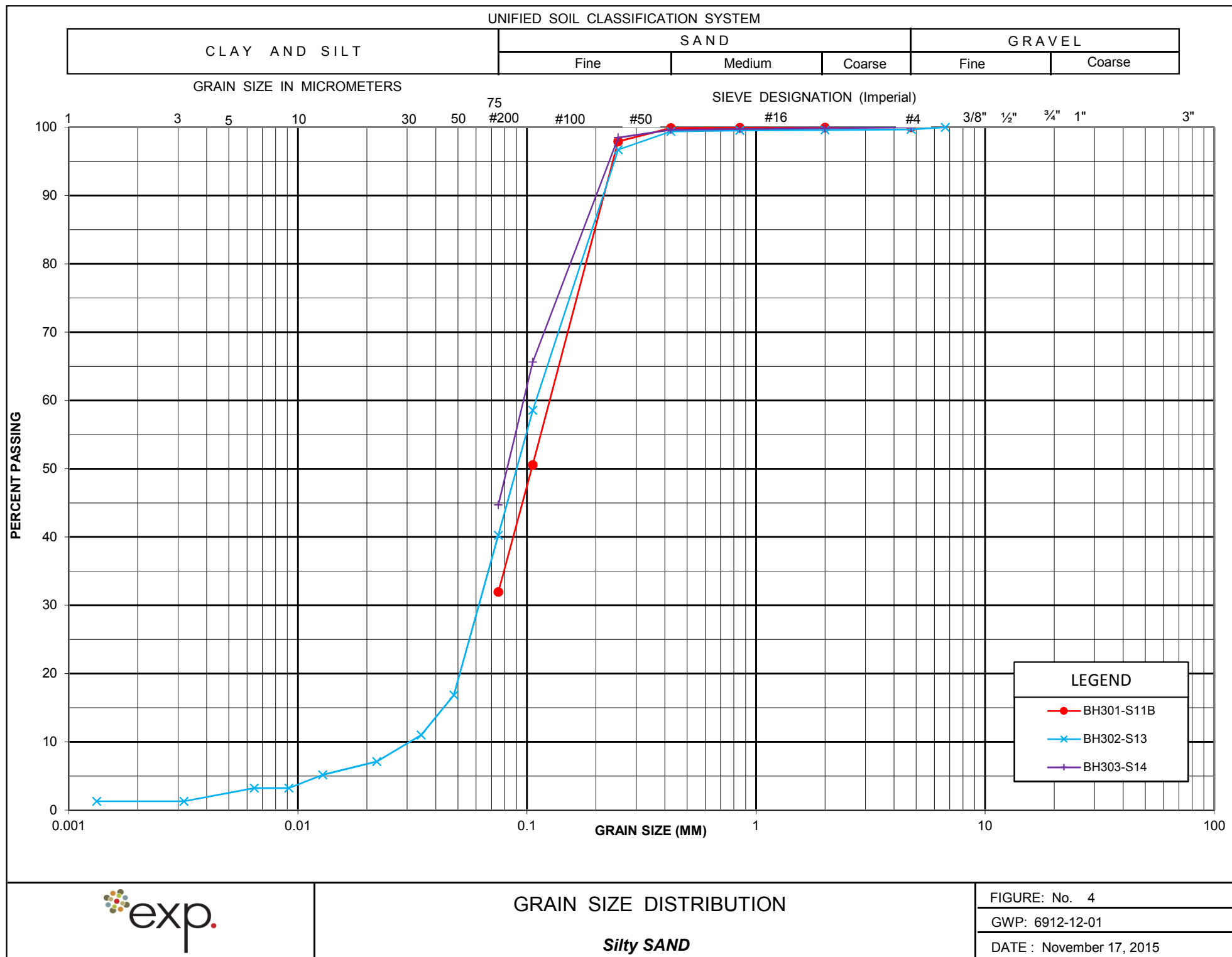
## **Appendix D – Laboratory Data**



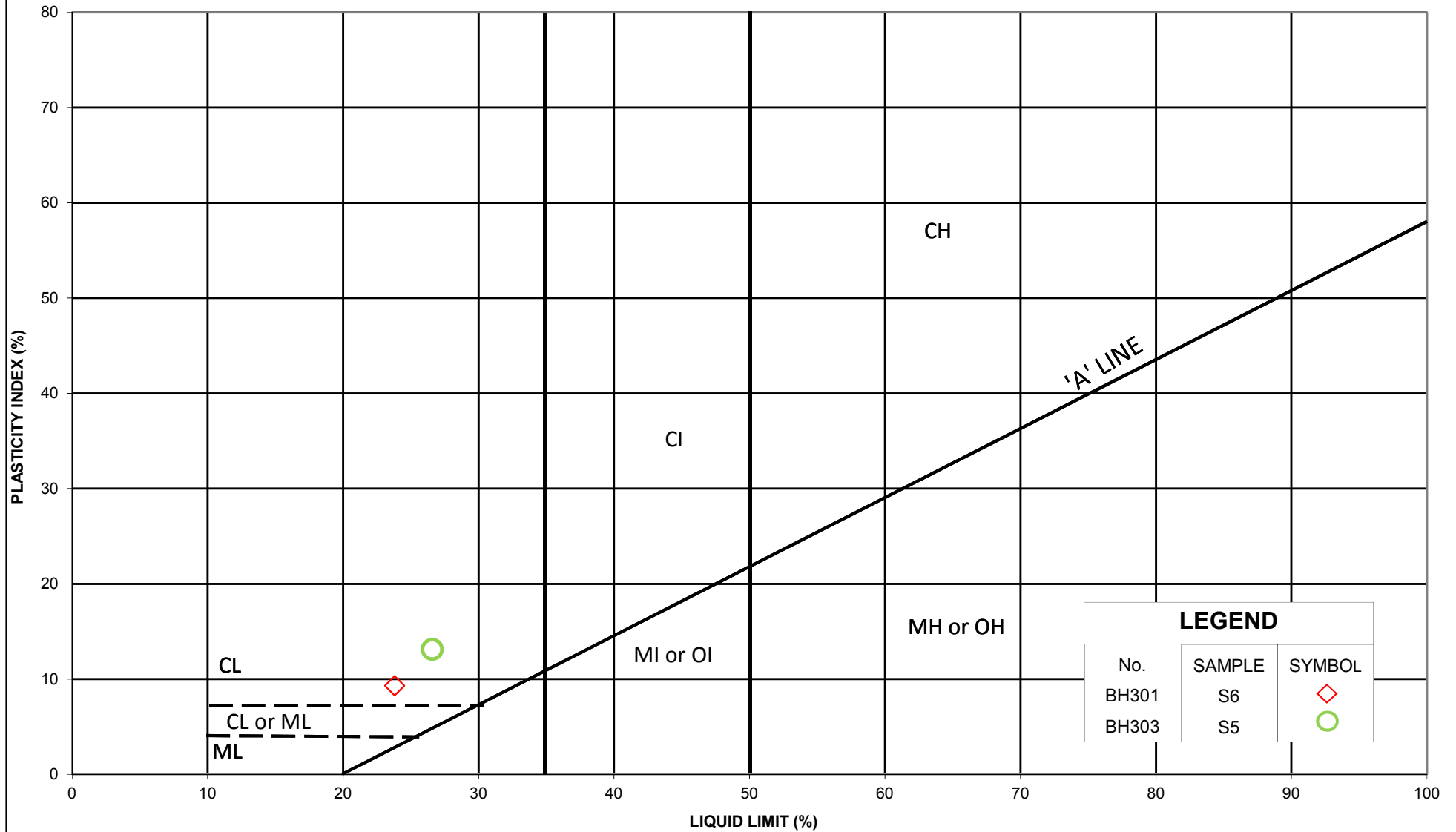




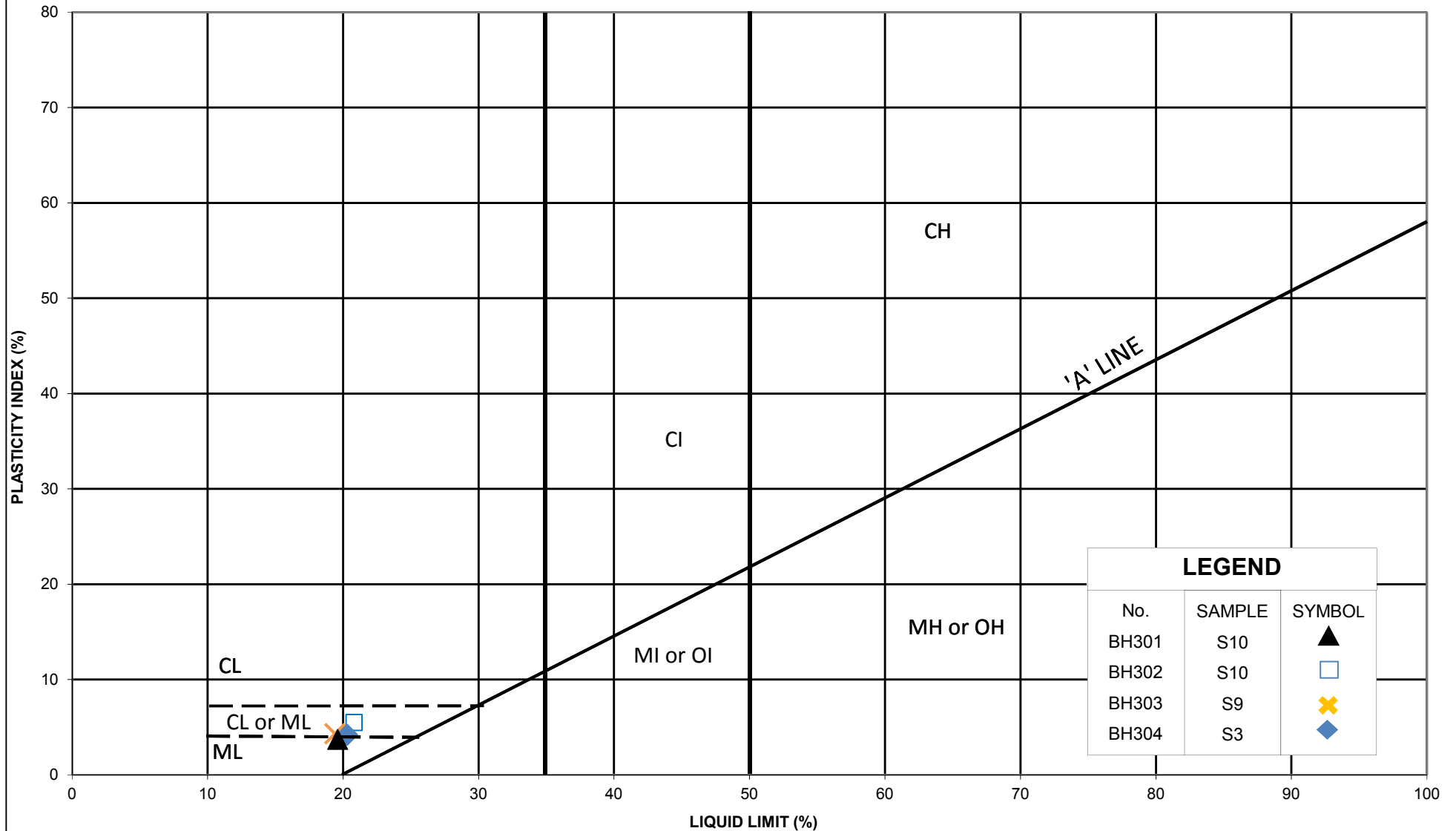




**Minnikau River Culvert (Site No. 41S-255/C)**  
**GWP No. 6364-14-01, Highway 642, District of Kenora, Ontario**



**Minnikau River Culvert (Site No. 41S-255/C)**  
**GWP No. 6912-12-01, Highway 642, District of Kenora, Ontario**



## **Appendix E – Chemical Analyses**

Your Project #: ADM-00223648-F0  
Site Location: SIOUX LOOKOUT, ONTARIO  
Your C.O.C. #: NA

**Attention: Ahileas Mitsopoulos/Michael S**

exp Services Inc  
Thunder Bay Branch  
1142 Roland St  
Thunder Bay, ON  
P7B 5M4

**Report Date: 2015/09/15**  
Report #: R3661790  
Version: 1 - Final

**CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B5I2028**

**Received: 2015/09/09, 09:30**

Sample Matrix: Soil  
# Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	6	N/A	2015/09/15	CAM SOP-00463	EPA 325.2 m
Conductivity	6	N/A	2015/09/14	CAM SOP-00414	OMOE E3138 v2 m
pH CaCl2 EXTRACT	6	2015/09/14	2015/09/14	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	6	2015/09/11	2015/09/14	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	6	N/A	2015/09/14	CAM SOP-00464	EPA 375.4 m

**Remarks:**

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

Maxxam Analytics is accredited for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

\* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

**Encryption Key**

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Hina Siddiqui, Project Manager –Environmental Customer Service

Email: HSiddiqui@maxxam.ca

Phone# (905) 817-5700

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B5I2028  
Report Date: 2015/09/15

exp Services Inc  
Client Project #: ADM-00223648-F0  
Site Location: SIOUX LOOKOUT, ONTARIO  
Sampler Initials: EF

### RESULTS OF ANALYSES OF SOIL

Maxxam ID			AYK667	AYK668	AYK669	AYK670	AYK670	AYK671		
Sampling Date			2015/08/12 14:00	2015/08/14 17:00	2015/08/17 10:00	2015/08/20 01:15	2015/08/20 01:15	2015/08/11 12:00		
COC Number			NA	NA	NA	NA	NA	NA		
	<b>UNITS</b>	<b>Criteria</b>	<b>BH101-S10</b>	<b>BH104-S2</b>	<b>BH201-S9</b>	<b>BH204-S4</b>	<b>BH204-S4 Lab-Dup</b>	<b>BH302-S5</b>	<b>RDL</b>	<b>QC Batch</b>

<b>Calculated Parameters</b>										
Resistivity	ohm-cm	-	7400	5700	15000	4800		27000		4186431
<b>Inorganics</b>										
Soluble (20:1) Chloride (Cl)	ug/g	-	41	45	<20	57	45	<20	20	4188251
Conductivity	umho/cm	<b>470</b>	135	176	65	208	208	38	2	4188121
Available (CaCl2) pH	pH	-	7.93	7.56	7.50	6.98		5.99	N/A	4188358
Soluble (20:1) Sulphate (SO4)	ug/g	-	<20	<20	<20	<20	<20	<20	20	4188113

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

Lab-Dup = Laboratory Initiated Duplicate

Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)

Table 1: Full Depth Background Site Condition Standards

Soil - Agricultural or Other Property Use

N/A = Not Applicable

Maxxam ID			AYK672		
Sampling Date			2015/08/12 13:00		
COC Number			NA		
	<b>UNITS</b>	<b>Criteria</b>	<b>BH303-S4B</b>	<b>RDL</b>	<b>QC Batch</b>
<b>Calculated Parameters</b>					
Resistivity	ohm-cm	-	5600		4186431
<b>Inorganics</b>					
Soluble (20:1) Chloride (Cl)	ug/g	-	<20	20	4188251
Conductivity	umho/cm	<b>470</b>	178	2	4188121
Available (CaCl2) pH	pH	-	7.34	N/A	4188358
Soluble (20:1) Sulphate (SO4)	ug/g	-	<20	20	4188113
RDL = Reportable Detection Limit					
QC Batch = Quality Control Batch					
Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)					
Table 1: Full Depth Background Site Condition Standards					
Soil - Agricultural or Other Property Use					
N/A = Not Applicable					

Maxxam Job #: B5I2028  
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## TEST SUMMARY

**Maxxam ID:** AYK667  
**Sample ID:** BH101-S10  
**Matrix:** Soil

**Collected:** 2015/08/12  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4188251	N/A	2015/09/15	Deonarine Ramnarine
Conductivity	AT	4188121	N/A	2015/09/14	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4188358	2015/09/14	2015/09/14	Neil Dassanayake
Resistivity of Soil		4186431	2015/09/14	2015/09/14	Cristina Carriere
Sulphate (20:1 Extract)	KONE/EC	4188113	N/A	2015/09/14	Alina Dobreanu

**Maxxam ID:** AYK668  
**Sample ID:** BH104-S2  
**Matrix:** Soil

**Collected:** 2015/08/14  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4188251	N/A	2015/09/15	Deonarine Ramnarine
Conductivity	AT	4188121	N/A	2015/09/14	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4188358	2015/09/14	2015/09/14	Neil Dassanayake
Resistivity of Soil		4186431	2015/09/14	2015/09/14	Cristina Carriere
Sulphate (20:1 Extract)	KONE/EC	4188113	N/A	2015/09/14	Alina Dobreanu

**Maxxam ID:** AYK669  
**Sample ID:** BH201-S9  
**Matrix:** Soil

**Collected:** 2015/08/17  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4188251	N/A	2015/09/15	Deonarine Ramnarine
Conductivity	AT	4188121	N/A	2015/09/14	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4188358	2015/09/14	2015/09/14	Neil Dassanayake
Resistivity of Soil		4186431	2015/09/14	2015/09/14	Cristina Carriere
Sulphate (20:1 Extract)	KONE/EC	4188113	N/A	2015/09/14	Alina Dobreanu

**Maxxam ID:** AYK670  
**Sample ID:** BH204-S4  
**Matrix:** Soil

**Collected:** 2015/08/20  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4188251	N/A	2015/09/15	Deonarine Ramnarine
Conductivity	AT	4188121	N/A	2015/09/14	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4188358	2015/09/14	2015/09/14	Neil Dassanayake
Resistivity of Soil		4186431	2015/09/14	2015/09/14	Cristina Carriere
Sulphate (20:1 Extract)	KONE/EC	4188113	N/A	2015/09/14	Alina Dobreanu

**Maxxam ID:** AYK670 Dup  
**Sample ID:** BH204-S4  
**Matrix:** Soil

**Collected:** 2015/08/20  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4188251	N/A	2015/09/15	Deonarine Ramnarine



Maxxam Job #: B5I2028  
Report Date: 2015/09/15

exp Services Inc  
Client Project #: ADM-00223648-F0  
Site Location: SIOUX LOOKOUT, ONTARIO  
Sampler Initials: EF

## TEST SUMMARY

**Maxxam ID:** AYK670 Dup  
**Sample ID:** BH204-S4  
**Matrix:** Soil

**Collected:** 2015/08/20  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	4188121	N/A	2015/09/14	Neil Dassanayake
Sulphate (20:1 Extract)	KONE/EC	4188113	N/A	2015/09/14	Alina Dobreanu

**Maxxam ID:** AYK671  
**Sample ID:** BH302-S5  
**Matrix:** Soil

**Collected:** 2015/08/11  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4188251	N/A	2015/09/15	Deonarine Ramnarine
Conductivity	AT	4188121	N/A	2015/09/14	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4188358	2015/09/14	2015/09/14	Neil Dassanayake
Resistivity of Soil		4186431	2015/09/14	2015/09/14	Cristina Carriere
Sulphate (20:1 Extract)	KONE/EC	4188113	N/A	2015/09/14	Alina Dobreanu

**Maxxam ID:** AYK672  
**Sample ID:** BH303-S4B  
**Matrix:** Soil

**Collected:** 2015/08/12  
**Shipped:**  
**Received:** 2015/09/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4188251	N/A	2015/09/15	Deonarine Ramnarine
Conductivity	AT	4188121	N/A	2015/09/14	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4188358	2015/09/14	2015/09/14	Neil Dassanayake
Resistivity of Soil		4186431	2015/09/14	2015/09/14	Cristina Carriere
Sulphate (20:1 Extract)	KONE/EC	4188113	N/A	2015/09/14	Alina Dobreanu

Maxxam Job #: B5I2028  
Report Date: 2015/09/15

exp Services Inc  
Client Project #: ADM-00223648-F0  
Site Location: SIOUX LOOKOUT, ONTARIO  
Sampler Initials: EF

### GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	3.3°C
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**Results relate only to the items tested.**

Maxxam Job #: B5I2028  
Report Date: 2015/09/15

## QUALITY ASSURANCE REPORT

exp Services Inc  
Client Project #: ADM-00223648-F0  
Site Location: SIOUX LOOKOUT, ONTARIO  
Sampler Initials: EF

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
4188113	Soluble (20:1) Sulphate (SO <sub>4</sub> )	2015/09/14	113	70 - 130	102	70 - 130	<20	ug/g	NC	35		
4188121	Conductivity	2015/09/14			99	90 - 110	<2	umho/cm	0	10	117	75 - 125
4188251	Soluble (20:1) Chloride (Cl)	2015/09/15	NC	70 - 130	101	70 - 130	<20	ug/g	NC	35		
4188358	Available (CaCl <sub>2</sub> ) pH	2015/09/14			99	97 - 103			1.9	N/A		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

Maxxam Job #: B5I2028  
Report Date: 2015/09/15

exp Services Inc  
Client Project #: ADM-00223648-F0  
Site Location: SIOUX LOOKOUT, ONTARIO  
Sampler Initials: EF

### VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

*Cristina Carriere*

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Cristina Carriere, Scientific Services

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