



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 556 CULVERT AT STA 10+119 (TOWNSHIP OF DEROCHE)
REHABILITATION OF HIGHWAYS 556 & 532
DISTRICT OF ALGOMA, ONTARIO
ASSIGNMENT NO.: 5020-E-0020
G.W.P. 5221-18-00

GEOCRES Number: 41K-127**

Report

to

AECOM Canada Ltd.

Date: April 24, 2023
File: 31719



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PART A: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) at the site of the proposed dewatering to facilitate replacement of a non-structural culvert, located at STA 10+119 on Highway 556, in the Township of Deroche, District of Algoma, Ontario.

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

Thurber carried out the investigation as a subconsultant to AECOM Canada Ltd. (AECOM), under the Ministry of Transportation, Ontario (MTO) Assignment No. 5020-E-0020.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

The existing culvert is located on Highway 556, approximately 14.5 km west of the intersection with Highway 532 near Searchmont, Ontario. For project orientation purposes, Highway 556 is herein described as oriented east-west, and the culvert is described as oriented north-south. Details of the existing culvert are as follows:



Township and Station	Culvert Size and Type	Length of Culvert (m)	Invert Elevation at Inlet ¹ (m)	Invert Elevation at Outlet ¹ (m)
Deroche 10+119	2740 mm dia. SPCSP	A 18.5 m long section and a 16.0 m long extension joined at an angle of 148 degrees ²	318.86 (south)	318.92 (north)

Note 1: Invert elevation is calculated from the surveyed obvert minus the diameter of the culvert.

2: Refer to the plan on the Borehole Location and Soil Strata Drawing in Appendix D.

Despite the outlet invert being at a slightly higher elevation than the inlet, the existing culvert allows flow in a south to north direction under the approximately 1.6 m high embankment (above the culvert obvert). The highway pavement surface is at approximate Elev. 323.1 m. In the area of the culvert, the south-facing slope is generally inclined at approximately 2H:1V, except immediately at the culvert inlet where slope is inclined at approximately 1H:1V. The north-facing slope is inclined at approximately 2H:1V.

Based on visual observations, no signs of slope instability of the embankment were noted near the outlet of the culvert site. Ponded water was observed at the culvert outlet. The embankment side slopes are lightly vegetated with some visible cobbles. Site photographs can be found in Appendix A.

Highway 556 consists of two, 3.25 m wide, paved lanes and narrow shoulders. The alignment in the immediate vicinity of the culvert is a local low point (vertical curve) and relatively straight, with horizontal curves beginning approximately 90 m and 240 m further east and west, respectively. The unpaved shoulders are narrow with no guardrails or guiderails. Overhead utility lines are present on the south side of the highway, with overhead lines crossing the highway approximately 17 m west of the culvert. It is understood that the projected 2023 AADT for Highway 556 is 540. Entrances to rural properties are located approximately 7 m and 60 m to the east and west of the culvert, respectively.

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping, the site lies in an outwash plain and valley train and the primary materials are sandy and gravelly soils, and bedrock knobs and outcrops. The site topography in the immediate vicinity of the culvert is of low relief consisting of plains and gullies and the surrounding area is generally described as moderate relief of a clifty volcanic rock signature.

Based on the OGS Map MRD126 titled “Bedrock Geology of Ontario”, dated 2011, the underlying bedrock at the site consists of mafic to intermediate metavolcanic rocks.



3. INVESTIGATION PROCEDURES

The field investigation and testing for this project was carried out between November 28 and December 12, 2022, and consisted of drilling and sampling two boreholes, designated as Boreholes 10119-01 and 10119-02, to depths of 5.0 m and 7.1 m, respectively (corresponding to Elev. 315.9 m and 313.0 m). Boreholes 10119-01 and 10119-02 were advanced near the toe of the embankment near the existing culvert outlet and inlet, respectively.

The Record of Borehole sheets for the boreholes are included in Appendix B.

Utility clearances were obtained prior to mobilization to the site. The ground surface elevations of the as-drilled borehole locations were surveyed in the field relative to known site features (i.e., obvert of existing culvert). The borehole co-ordinates were determined through off-set measurement from the highway centerline and existing culvert. The coordinate system MTM NAD 83, Zone 13 was used for the boreholes.

Boreholes 10119-01 and 10119-02 were advanced with a portable drilling equipment also using wash boring technique with BW casing and AW rock coring methods. Soil samples were obtained at selected intervals using a split-spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D1586. Soil sampling in both boreholes employed a third-weight hammer lifted manually and as such, a correction factor has been applied for the reported SPT N-values and thus, they are less reliable. AW coring methods with were used to core through cobbles in Borehole 10119-01.

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

Monitoring wells were installed in Boreholes 10119-01 and 10119-02. Each well consists of a 32 mm Schedule 40 PVC pipe with a 1.5 m long slotted screen, enclosed in a column of filter sand to permit groundwater level monitoring. Well installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets.

A Single Well Response Test (SWRT), or "slug" test, was carried out in 32 mm diameter wells installed in Boreholes 10119-01 and 10119-02, which were screened across native silty sand deposit.



Prior to conducting the “slug” tests, the monitoring wells were developed and purged to remove excess sediments that may have entered the well during installation, improve the transmissivity of the sand pack and well screen, and increase the representativeness of the natural groundwater of the soil deposit within the well. Following the development of the well, slug tests were conducted by inserting a datalogger into the well to monitor the recovery of the water level in the well. The dataloggers were set to record water levels every 0.125 to 0.5 seconds, based on the anticipated rate of recovery of the well. During the test, both electronic measurements from the datalogger and manual measurements were recorded until the water level in the well has recovered sufficiently. The electronic and manual measurements were then compared to each other for quality control.

The borehole completion details are summarized below:

Borehole	Depth and Elevation of Borehole Base (m)	Depth and Elevation of Well Tip (m)	Northing and Easting MTM NAD83 Zone 13	Completion Details
10119-01	5.0 / 315.9	5.0 / 315.9	N 5 173 959.6 E 287 838.8	32 mm diameter PVC pipe with a 1.5 m slotted screen.
10119-02	7.1 / 313.0	7.1 / 313.0	N 5 173 922.2 E 287 850.0	32 mm diameter PVC pipe with a 1.5 m slotted screen.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and natural moisture content determination. Selected samples were subjected to grain size distribution analyses (sieve and/or hydrometer). The results of this testing program are summarized on the Record of Borehole sheets in Appendix B and are shown on the figures included in Appendix C.

Testing was carried out on a sample of the gravelly sand fill to assess the potential for sulphate attack on buried concrete structures, as well as the potential for corrosion associated with buried steel elements of the structures. To assess the quality of the groundwater for disposal purposes, a groundwater sample was collected. The results of the analytical testing are summarized in this report and presented in Appendix C.



5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix B. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawing included in Appendix D. A description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered consisted of gravelly sand to gravelly silty sand embankment fill, underlain by native deposit of silty sand. Coarse gravel (up to 75 mm in diameter) and cobbles were encountered throughout the embankment fill, and native deposit. A boulder was encountered within the silty sand deposit.

5.1 Embankment Fill

Granular embankment fill consisting of gravelly sand, trace non-plastic fines to gravelly silty sand was encountered at ground surface at both borehole locations. Rootlets and wood fragments were noted in samples from Borehole 10119-02. Given that wood fragments were encountered at/near the bottom of the embankment, they could be from timber mats used as part of construction of the existing culvert (see Photograph #6 in Appendix C).

The embankment fill extended to depths of between 2.6 m and 2.9 m (Elev. 318.3 m and 317.2 m).

SPT 'N' values in the embankment fill ranged from 2 blows to 27 blows per 0.3 m penetration indicating a very loose to compact condition. Measured moisture contents in the gravelly sand fill in Borehole 10119-01 ranged from 6 percent to 11 percent, while moisture contents on samples of the gravelly silty sand fill in Borehole 10119-02, containing rootlets and wood fragments, ranged from 44 percent to 68 percent.

The results of grain size analyses conducted on selected samples of the embankment fill are provided on the Record of Borehole sheets in Appendix B and presented on Figure C-1 of Appendix C. The results are summarized as follows:



Soil Particle	Percentage (%)
Gravel	23 to 33
Sand	40 to 64
Silt and Clay	3 to 37

5.2 Silty Sand

A deposit of silty sand, some gravel, containing silt pockets, cobbles, and boulders was encountered beneath the embankment fill at depths of 2.6 m and 2.9 m (Elev. 318.3 m and 317.2 m) in Boreholes 10119-01 and 10119-02, respectively. Both boreholes were terminated within the silty sand deposit at a depth of 5.0 m and 7.1 m (Elev. 315.9 m and 313.0 m) in Boreholes 10119-01 and 10119-02, respectively. Coring was required to advance through this deposit in Borehole 10119-01.

SPT 'N' values in the silty sand deposit ranged from 6 blows per 0.3 m penetration to 32 blows per 0.076 m penetration, with typical 'N' values between 11 blows and 46 blows per 0.3 m penetration indicating a loose to very dense condition. The high SPT 'N' values are generally attributed to spoon refusal on a probable coarse gravel and/or cobbles. Measured moisture contents in the silty sand ranged from 5 percent to 14 percent.

The results of grain size analyses conducted on selected samples of the silty sand are presented on Figure C-2 in Appendix C and summarized as follows:

Soil Particle	Percentage (%)
Gravel	19 to 20
Sand	55 to 56
Silt	24
Clay	1

5.3 Groundwater Conditions

Groundwater levels in the monitoring wells were measured using a water level tape/dip meter and are presented below:

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth	Elevation	
10119-01	December 11, 2022	1.3	319.6	In monitoring well
	December 12, 2022	1.3	319.6	



Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth	Elevation	
	December 13, 2022	1.3	319.6	
	December 14, 2022	1.3	319.6	
10119-02	December 14, 2022	1.2	318.9	In monitoring well
	December 15, 2022	1.2	318.9	

These groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. ANALYTICAL LABORATORY TESTING

A sample of the native silty sand was submitted for analytical testing for corrosivity analysis and sulphide content. The analytical test results for the soil are presented in Appendix C and are summarized below.

Borehole	10119-01
Sample	SS3
Depth (m)	2.0 to 2.6
Elevation (m)	318.6
Sulphide (Na_2CO_3) %	<0.04
Chloride ($\mu\text{g/g}$)	19
Sulphate ($\mu\text{g/g}$)	79
pH	7.38
Conductivity ($\mu\text{S/cm}$)	145
Resistivity (Ohm-cm)	6,880

7. SINGLE WELL RESPONSE TEST RESULTS

7.1 Hydraulic Conductivity

The SWRT results were analyzed using the Hvorslev method. The SWRT analysis plots are included in Appendix B. The hydraulic conductivity values calculated from the in-situ SWRTs are summarized in the following table:



Monitoring Well	Screen Interval (m bgs)	Screened Geology	Hydraulic Conductivity (m/s)
10119-01	3.4 – 4.9	Silty Sand, some gravel	1.8×10^{-5}
10119-02	5.6 – 7.1	Silty Sand, some gravel	6.2×10^{-7}

In addition to slug test analysis, the hydraulic conductivity of the subsurface soils was estimated using grain-size hydraulic conductivity correlations. In general, the accuracy of hydraulic conductivity values derived from grain size correlations is low in comparison to those from slug tests. Grain size distributions were obtained for samples of fill materials and silty sand at Boreholes 10119-1 and 10119-2 and are shown on Figures C-1 and C-2 in Appendix C. The hydraulic conductivity ranges estimated from the Hazen, and Kozeny-Carman grain size correlations are shown in the following table:

Geologic Material	Correlation Reference	Relevant Grain Size Information	Hydraulic Conductivity Range (m/s)
Fill Materials	Hazen	D10: 0.009 – 0.22 mm	8.1×10^{-7} to 4.8×10^{-4}
	Kozeny-Carman	D10: 0.009 – 0.22 mm	2.4×10^{-7} to 1.5×10^{-4}
Silty Sand, some gravel	Hazen	D10: 0.025 – 0.03 mm	6.3×10^{-6} to 9.0×10^{-6}
	Kozeny-Carman	D10: 0.025 – 0.03 mm	1.9×10^{-6} to 2.7×10^{-6}
Overall Hydraulic Conductivity Range for Fill Materials:			8.1×10^{-7} to 4.8×10^{-4}
Overall Hydraulic Conductivity Range for Silty Sand:			1.9×10^{-6} to 9.0×10^{-6}

8. MISCELLANEOUS

OGS Inc. of Almonte, Ontario supplied and operated the drilling, sampling, and in-situ geotechnical testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Messrs. Arie Simpson and Benoit Coote, EIT. The single well response tests were conducted by Mr. Benoit Coote, EIT. The overall management of the field program was conducted by Ms. Alysha Kobylinski, P.Eng.

Geotechnical laboratory testing on soil samples was carried out in Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by Paracel Laboratories Ltd., a CALA accredited analytical laboratory in Ottawa, Ontario.

Interpretation of the field data and preparation of this report was carried out by

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Ms. Alysha Kobylinski, P.Eng., Mr. Samuel Morton, GIT, and Mr. Christopher Ng, P.Eng. The report was reviewed by Messrs. David Hill, P.Eng., P.Geo., and P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects at Thurber.

Thurber Engineering Ltd.

Alysha Kobylinski, P.Eng.,
Geotechnical Engineer

Samuel Morton, M.Sc., GIT,
Hydrogeologist



Christopher Ng, P.Eng.,
Senior Geotechnical Engineer

David Hill, P.Eng., P.Geo.,
Senior Hydrogeological Engineer,
Associate



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

Client: AECOM

File No.: 31719

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) **Nature and Exactness of Soil and Contaminant Description:** Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) **Reliance on Provided Information:** The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) **Design Services:** The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) **Construction Services:** During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



Appendix A

Site Photographs



Photograph #1 – North highway embankment at culvert outlet, facing west (October 2022)



Photograph #2 – North highway embankment at culvert outlet, facing north (October 2022)



Photograph #3 – South highway embankment at culvert inlet, facing east.



Photograph #4 – South highway embankment at culvert inlet, facing southwest. (October 2022)



Photograph #5 – South highway embankment at culvert inlet, facing northeast (December 2022)



Appendix B

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


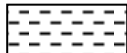



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No 10119-01

1 OF 1

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 173 959.6 E 287 838.8 ORIGINATED BY BC
DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Washboring, BW Casing Advance, AW Coring COMPILED BY AK
DATUM Geodetic DATE 2022.11.28 - 2022.11.28 LATITUDE 46.705006 LONGITUDE -84.221814 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)	
320.9	GROUND SURFACE							20	40	60	80	100							
0.0	Gravelly SAND , trace non-plastic fines Compact Brown Wet Coring from a depth of 1.5 m to 2.0 m		1	AS	-		320										33 64 3 (SI+CL)		
			2	SS	27														
			1	AW	-														
318.3			3	SS	17		319												
2.6	SILTY SAND some gravel, containing silt pockets, cobbles, and boulders Dense to Very Dense Light Brown Wet Coring from a depth of 2.7 m to 3.3 m						318												
			2	AW	-														
315.9			4	SS	46		317										19 56 24 1		
315.9	No sample recovery from a depth of 4.9 to 5.1 m.		5	SS	32/0.15		316												
5.0	END OF BOREHOLE AT 5.0 m Monitoring well installation consists of 31.8 mm diameter schedule 40 PVC pipe with 1.5 m slotted screen NOTES: 1. A third-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer. 2. The cored depth intervals and particle sizes of recovered cobbles and boulders are summarized as follows: Depth (m) Recovered 1.5 - 2.0 coarse gravels, and cobbles up to 100 mm 2.7 - 3.3 1 x 150 mm, 1 x 355 mm 3. Borehole terminated at a depth of 5.0 m after multiple attempts to clear blowback in casing. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2022.12.11 1.3 319.6 2022.12.12 1.3 319.6 2022.12.13 1.3 319.6 2022.12.14 1.3 319.6																		

ONTMT4S2 2020LIBRARY(MTO) - COPY, GLB MTO-31719.GPJ 23/3/14

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10119-02

1 OF 1

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 173 922.2 E 287 850.0 ORIGINATED BY BC
DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Washboring, BW Casing Advance, AW Coring COMPILED BY AK
DATUM Geodetic DATE 2022.12.10 - 2022.12.12 LATITUDE 46.704670 LONGITUDE -84.221667 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
320.1	GROUND SURFACE							20 40 60 80 100					
0.0	Gravelly SILTY SAND Very Loose to Loose Brown Wet (FILL) Trace rootlets to a depth of 0.2 m		1	AS	-								
			1	SS	2								23 40 33 4
	Trace organics from a depth of 1.5 to 2.1 m		2	SS	5								
	BW casing grinding at a depth of 2.0 m												
	Wood fragments in cuttings from a depth of about 2.1 to 2.9 m		1	AW	-								
317.2													
2.9	SILTY SAND some gravel Loose to Very Dense Grey Wet		3	SS	6								
			4	SS	11								20 55 24 1
	No sample recovery from a depth of 5.8 to 5.9 m.		5	SS	32/0.100								
	No sample recovery from a depth of 6.4 to 6.5 m.												
313.0			6	SS	32/0.075								
7.1	END OF BOREHOLE AT 7.1 m. Monitoring well instalation consists of 31.8 mm diameter schedule 40 PVC pipe with 1.5 m slotted screen NOTES: 1. A third-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer. 2. Borehole terminated at a depth of 7.1 m due to practical refusal with casing advancement. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2022.12.14 1.2 318.9 2022.12.15 1.2 318.9												

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



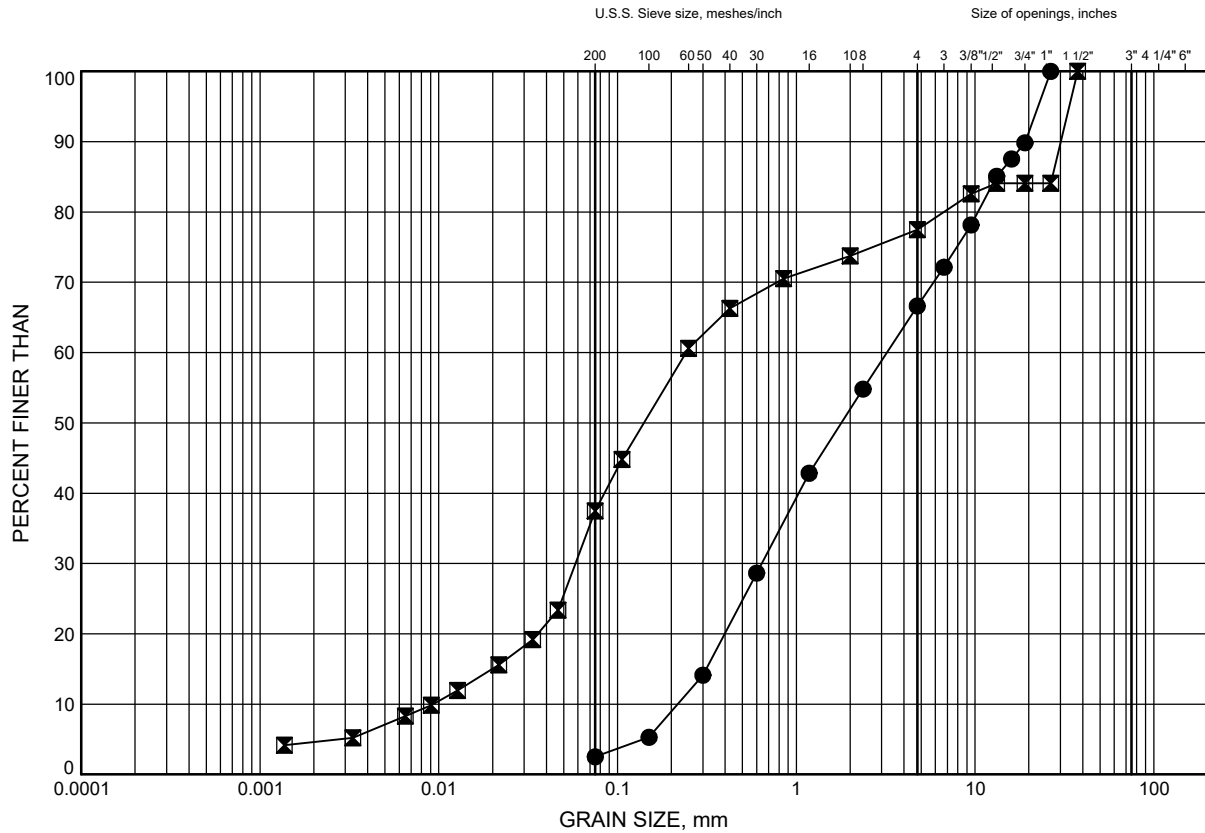
Appendix C

Geotechnical and Analytical Laboratory Test Results, Single Well Response Test Results and Sample Photographs

Culvert Replacement at Sta. 10+119
GRAIN SIZE DISTRIBUTION

FIGURE C1

Gravelly SAND to Gravelly SILTY SAND (FILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10119-01	0.3	320.6
⊠	10119-02	1.2	318.9

Date February 2023
W.P. 5221-18-00

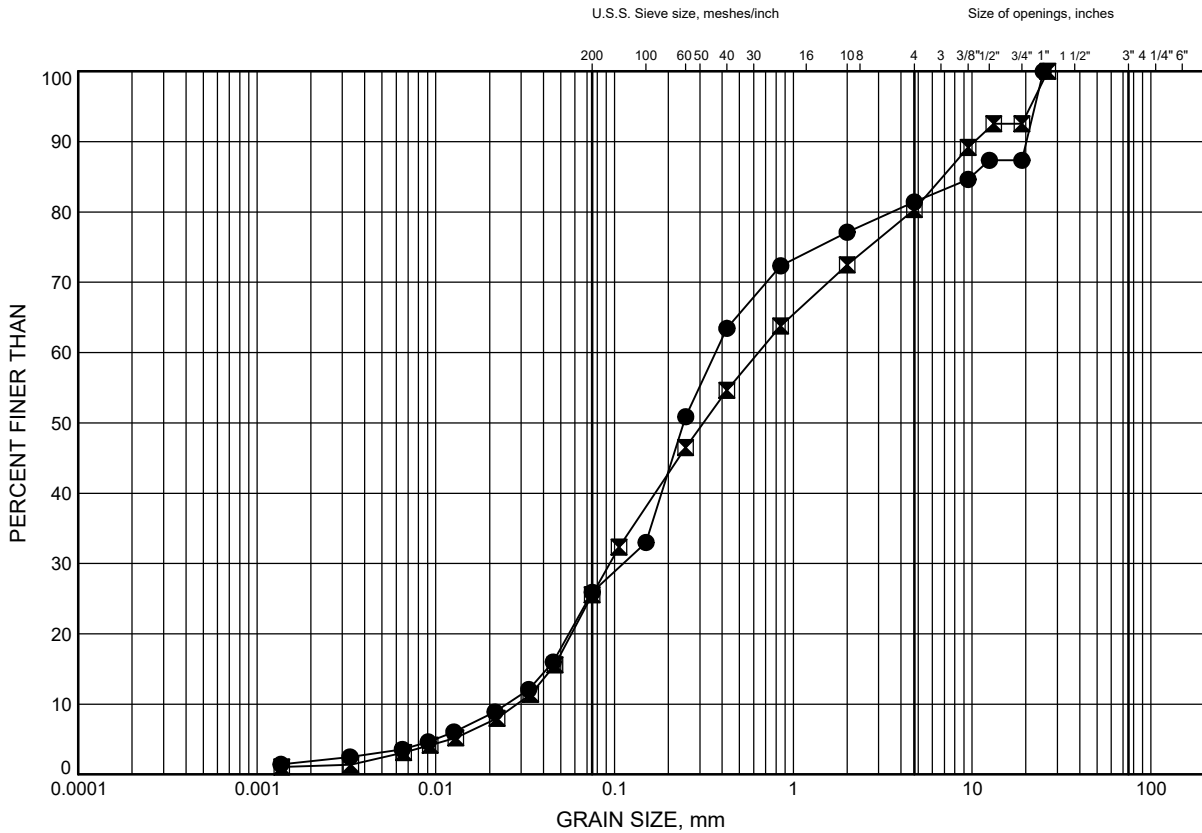


Prep'd AN
Chkd. AK

Culvert Replacement at Sta. 10+119
GRAIN SIZE DISTRIBUTION

FIGURE C2

SILTY SAND to Gravelly SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10119-01	4.3	316.6
⊠	10119-02	4.8	315.3

Date February 2023
W.P. 5221-18-00



Prep'd AN
Chkd. AK



Photograph #6 – Wood fragments recovered in Borehole 10119-02 (December 2022)

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Anderson de Oliveira

Client PO:
Project:
Custody:

Report Date: 5-Jan-2023
Order Date: 22-Dec-2022

Order #: 2252371

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

Paracel ID
2252371-01

Client ID
10119-01 SS#3 (6'6"-8'6")

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 05-Jan-2023

Order Date: 22-Dec-2022

Project Description:

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	28-Dec-22	28-Dec-22
Conductivity	MOE E3138 - probe @25 °C, water ext	28-Dec-22	28-Dec-22
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	28-Dec-22	28-Dec-22
Resistivity	EPA 120.1 - probe, water extraction	28-Dec-22	28-Dec-22
Solids, %	CWS Tier 1 - Gravimetric	23-Dec-22	23-Dec-22

Certificate of Analysis

Report Date: 05-Jan-2023

Client: Thurber Engineering Ltd.

Order Date: 22-Dec-2022

Client PO:

Project Description:

Client ID:	10119-01 SS#3 (6'6"-8'6")	-	-	-
Sample Date:	28-Nov-22 09:00	-	-	-
Sample ID:	2252371-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	89.2	-	-	-
----------	--------------	------	---	---	---

General Inorganics

Conductivity	5 uS/cm	145	-	-	-
pH	0.05 pH Units	7.38	-	-	-
Resistivity	0.10 Ohm.m	68.8	-	-	-

Anions

Chloride	10 ug/g dry	19	-	-	-
Sulphate	10 ug/g dry	79	-	-	-

Certificate of Analysis

Report Date: 05-Jan-2023

Client: Thurber Engineering Ltd.

Order Date: 22-Dec-2022

Client PO:

Project Description:

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	10	ug/g						
Sulphate	ND	10	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Report Date: 05-Jan-2023

Client: Thurber Engineering Ltd.

Order Date: 22-Dec-2022

Client PO:

Project Description:

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	18.8	10	ug/g	19.3			2.3	35	
Sulphate	78.2	10	ug/g	78.5			0.4	35	
General Inorganics									
Conductivity	137	5	uS/cm	134			2.3	5	
pH	7.36	0.05	pH Units	7.37			0.1	2.3	
Resistivity	72.9	0.10	Ohm.m	74.5			2.3	20	
Physical Characteristics									
% Solids	96.7	0.1	% by Wt.	97.1			0.5	25	

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 05-Jan-2023

Order Date: 22-Dec-2022

Project Description:

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	122	10	ug/g	19.3	103	82-118			
Sulphate	184	10	ug/g	78.5	105	80-120			

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 05-Jan-2023

Order Date: 22-Dec-2022

Project Description:

Qualifier Notes:

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

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

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

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

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



OTTAWA • KINGSTON • NIAGARA

Client Name: <u>Thurber Engineering</u>	Project Reference:	TAT: <input checked="" type="checkbox"/> Regular [] 3 Day [] 2 Day [] 1 Day Date Required: _____
Contact Name: <u>Anderson</u>	Quote #	
Address: <u>2460 Lancaster Rd</u>	PO #	
Telephone: <u>613-770-7957</u>	Email Address: <u>Adeoliveira@thurber.ca</u>	

Criteria: [] O. Reg. 153/04 Table [] O. Reg. 153/11 (Current) Table [] RSC Filing [] O. Reg. 558/00 [] PWQO [] CCME [] SUB (Storm) [] SUB (Sanitary) Municipality: _____ [] Other: _____

Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)

Required Analyses

Parcel Order Number:		Matrix	Air Volume	# of Containers	Sample Taken		pH	Resistivity	Conductivity	Chloride	Sulphate	Sulfide					
Sample ID/Location Name					Date	Time											
1	10119-01 SS#3 (6'6"-8'6")				28/11/22	-	X	X	X	X	X	X					
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Comments: Please e-mail results to Adeoliveira@thurber.ca ~~Disregard~~ Hold time Method of Delivery: Walking

Relinquished By (Print & Sign): <u>Richard Howarth</u>	Received by Driver/Depot:	Received at Lab:	Verified By:
Date/Time: <u>2022/12/22 3:01 PM</u>	Date/Time: _____	Date/Time: <u>2022-12-22 2:45 PM</u>	Date/Time: <u>DEC 22 2022 15:46</u>
Temperature: _____ °C	Temperature: _____ °C	Temperature: <u>20.4</u> °C	pH Verified [] By: _____

Subcontracted Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104

Ottawa, ON K1B4S5

Attn: Anderson de Oliveira

Paracel Report No. **2252371**

Client Project(s):

Client PO:

Reference: **Standing Offer**

CoC Number:

Order Date: 22-Dec-22

Report Date: 23-Jan-23

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
2252371-01	10119-01 SS#3 (6'6"-8'6")	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

19-January-2023

Date Rec. : 30 December 2022
LR Report: CA13967-DEC22
Reference: Project#: 2252371

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide (Na ₂ CO ₃) %
1: Analysis Start Date		17-Jan-23
2: Analysis Start Time		15:25
3: Analysis Completed Date		19-Jan-23
4: Analysis Completed Time		09:27
5: QC - Blank		< 0.04
6: QC - STD % Recovery		103%
7: QC - DUP % RPD		6%
8: RL		0.02
9: 10119-01 SS#3 (6'6"-8'6")	28-Nov-22	< 0.04

RL - SGS Reporting Limit

Note: Sample was past the 28 day holding time for Sulphide analysis when received; result may be unreliable. Processed past holding time as per client's standing instructions.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety



THURBER ENGINEERING LTD.

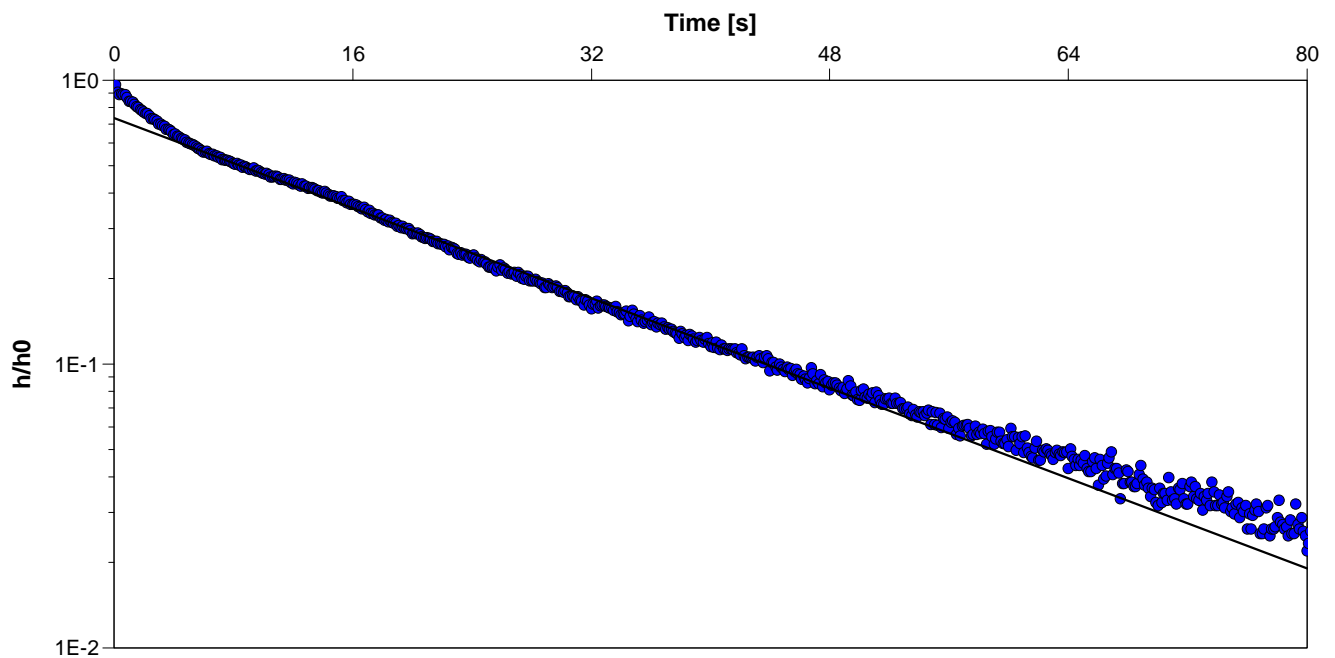
Slug Test Analysis Report

Project: Highway 556 & 532 Rehabilitation Design

Number: 31719

Client: AECOM Canada Ltd.

Location: Deroche, Ontario	Slug Test: 10119-01	Test Well: 10119-01
Test Conducted by: BC		Test Date: 2022-12-15
Analysis Performed by: SM	SWRT Analysis	Analysis Date: 2022-12-21
Aquifer Thickness:		
Checked by: DH		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [m/s]	
10119-01	1.8×10^{-5}	



THURBER ENGINEERING LTD.

Slug Test Analysis Report

Project: Highway 556 & 532 Rehabilitation Design

Number: 31719

Client: AECOM Canada Ltd.

Location: Deroche, Ontario

Slug Test: 10119-02

Test Well: 10119-02

Test Conducted by: BC

Test Date: 2022-12-15

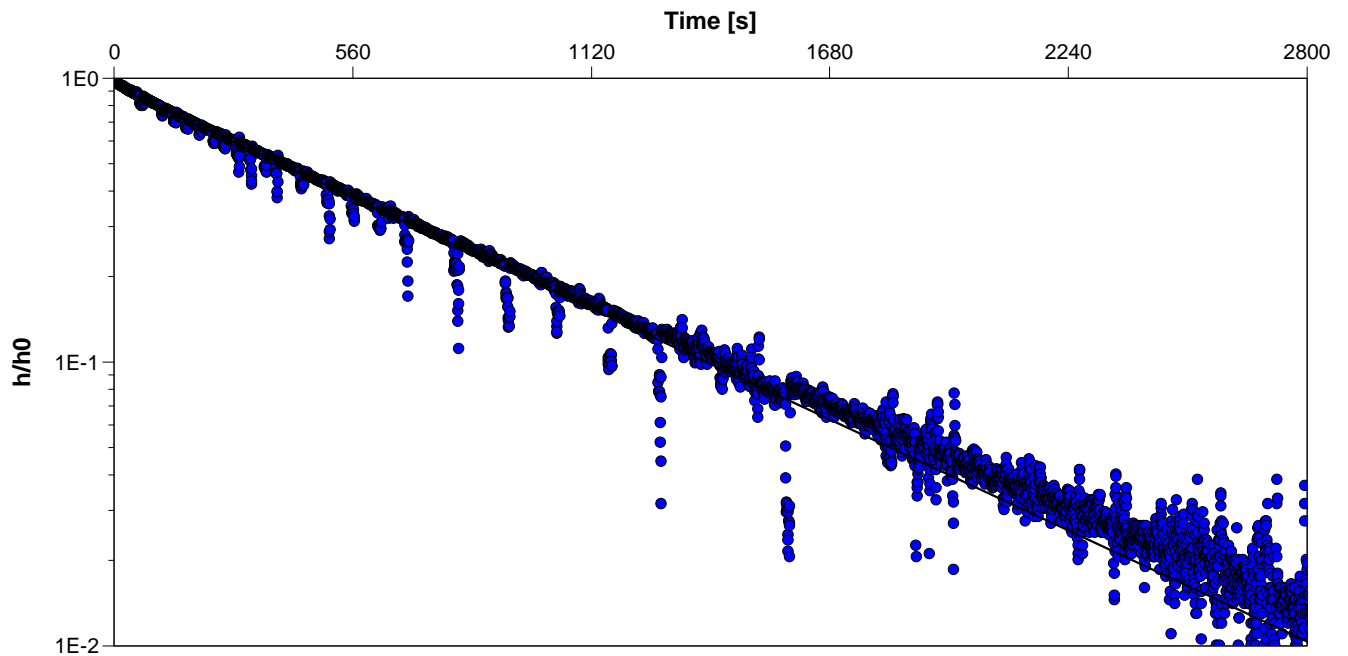
Analysis Performed by: SM

SWRT Analysis

Analysis Date: 2022-12-21

Aquifer Thickness:

Checked by: DH



Calculation using Hvorslev

Observation Well

Hydraulic Conductivity
[m/s]

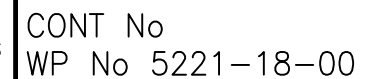
10119-02

6.2×10^{-7}



Appendix D

Borehole Locations and Soil Strata Drawing








SHEET



KEYPLAN

LEGEND

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

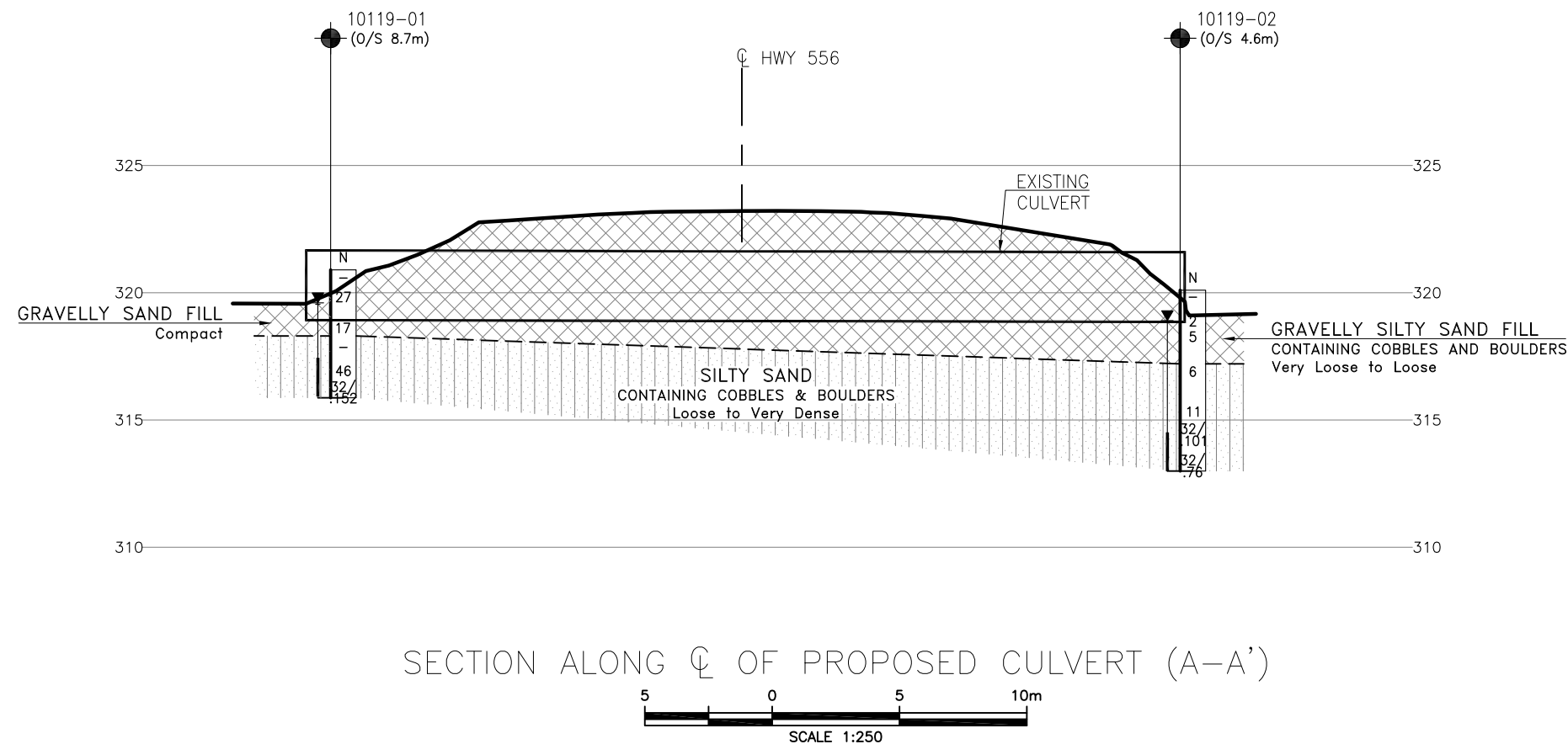
NO	ELEVATION	NORTHING	EASTING
10119-01	320.9	5 173 959.6	287 838.8
10119-02	320.1	5 173 922.2	287 850.0



-NOTES-

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

GEOCRES No. 41K-127



SECTION ALONG C OF PROPOSED CULVERT (A-A')

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	AK	CHK	PKC	CODE	LOAD	DATE	APR 2023		
DRAWN	AN	CHK	AK	SITE	STRUCT	DWG	1		