THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION REPORT
HIGHWAY 556 CULVERT REPLACEMENT AT STA 18+289
(TOWNSHIP OF DEROCHE)
REHABILITATION OF HIGHWAYS 556 & 532
DISTRICT OF ALGOMA, ONTARIO
ASSIGNMENT No.: 5020-E-0020
G.W.P. 5221-18-00

LATITUDE: 46.737661°, LONGITUDE: -84.143056°

GEOCRES Number: 41K-123

Report

to

AECOM Canada Ltd.

Date: April 13, 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 a centreline culvert, located at STA 18+289 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 6.4 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 (m)	Invert Elevation at Outlet (m)
Deroche 18+289	800 mm dia. CSP	31.26 m long	285.1 (south)	282.6 (north)

The existing culvert allows flow in a south to north direction under the approximately 4.5 m high embankment. The highway pavement surface is at approximate Elev. 289.4 m. In the area of the culvert, the south-facing slope is inclined at approximately 2H:1V. The overall north-facing slope is inclined at approximately 2H:1V; however, a section of the slope is as flat as 2.7H:1V while a local section is as steep as 0.5H:1V.

Based on visual observations, no signs of slope instability of the embankment were noted near the outlet of the culvert site; however, surficial erosion was observed on the unvegetated portion of the south-facing embankment slope (Photo 5, Appendix A). A small pond of water was observed at the culvert outlet. The south and north sides of the embankment at the toe of the slope were generally surrounded by thick mixed forest, with the embankment side slopes being lightly vegetated with some visible cobbles. In addition, the bottom of the existing culvert at the outlet was observed to be partially damaged by corrosion. Site photographs can be found in Appendix A.

Highway 556 consists of two, 3.25 m wide, paved lanes and narrow partially paved shoulders. The alignment in the immediate vicinity of the culvert is relatively straight, with curves further east and west of the site. The paved shoulders are narrow and are flanked by steel cable guiderails on both sides of the highway. Overhead utility lines are present on the south side of the highway. It is understood that the projected 2023 AADT for Highway 556 is 540. Granular entrances to rural properties are located approximately 95 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 cliffy 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 September 17 and October 19, 2022, and consisted of drilling and sampling five boreholes, designated as Boreholes 18289-01 to 18289-05, to depths of between 4.4 m and 15.7 m (Elev. 281.2 m and 273.7 m). Boreholes 18289-02 to 18289-04 were advanced through the existing highway embankment, while Boreholes 18289-01 and 18289-05 were advanced near the toe of the embankment near the existing inlet and outlet, 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 with a rod and level using a temporary benchmark identified as HCP 186 which is at an elevation of 289.23 m. 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 18289-02 to 18289-04 were drilled using a truck mounted CME 75 drill rig using 194 mm outside diameter hollow stem augers and/or wash boring technique with HQ casing and NQ coring equipment. Boreholes 18289-01 and 18289-05 were advanced with a portable drilling equipment also using wash boring technique but with BW casing and AW coring equipment. Soils 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 Borehole 18289-05 employed a half-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.

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 rock core samples for transport to Thurber's laboratory for further examination and testing.

The rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and Fracture Index (FI) were determined.

Groundwater conditions observed in open boreholes are not considered stabilized due to the introduction of water throughout the drilling operation. Groundwater level observations and water level readings in casing are shown on the Record of Borehole sheets. The borehole completion details are summarized below:

Borehole	Depth and Elevation of Borehole Base (m)	Northing and Easting MTM NAD83 Zone 13	Completion Details
18289-01	4.4 / 279.9	N 5 177 562.9 E 293 879.2	Backfilled with bentonite holeplug to surface.
18289-02	15.7 / 273.7	N 5 177 568.3 E 293 863.6	Backfilled with bentonite holeplug and asphalt patch at surface.
18289-03	8.2 / 281.2	N 5 177 577.7 E 293 877.1	Backfilled with bentonite holeplug and asphalt patch at surface.
18289-04	10.9 / 278.5	N 5 177 575.4 E 293 867.7	Backfilled with bentonite holeplug and asphalt patch at surface.
18289-05	5.9 / 278.2	N 5 177 590.3 E 293 864.6	Backfilled with bentonite holeplug to surface.

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 embankment 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. 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 gravel to gravelly silty sand embankment fill containing cobbles and possible boulders, underlain by native deposits of silty sand and gravel to silty sand containing cobbles and boulders. The overburden material was underlain by andesite/gneiss bedrock.

5.1 Topsoil

A 100 mm thick layer of organic silty sand topsoil was encountered at ground surface at Borehole 18289-05 at the toe of the embankment. A moisture content of 61 percent was measured on a sample of the topsoil. The topsoil thickness may vary in other areas of the site.

5.2 Asphalt

Boreholes 18289-02 to 18289-04 were advanced through the paved portion of Highway 556, and the asphalt was measured to be between 25 mm and 50 mm thick.

5.3 Embankment Fill

Granular embankment fill ranging in composition from gravel to sandy silty gravel to gravelly sand, containing cobbles and possible boulders was encountered underlying the asphalt in Boreholes 18289-02 to 18289-04, and beneath the topsoil in Borehole 18289-05. Cobbles were encountered at varying depths throughout the embankment fill and were cored using an 'NQ' size rock core barrel. Photographs of the cobbles observed in embankment fill cuttings from advancing Borehole 18289-03 are shown in Photographs 8 and 9 in Appendix A. From the recovered cored cobbles and observations of particle sizes in the embankment fill cuttings, the cobbles recovered are up to about 175 mm in size. Boulders may be present as well in the fill.

The embankment fill ranged in thickness from 1.2 m to 5.8 m and extended to depths of between 1.3 m and 5.8 m (Elev. 284.1 m and 282.8 m).

SPT 'N' values in the embankment fill ranged from 8 blows per 0.3 m penetration to 70 blows per 0.03 m of penetration (with typical values recorded between 11 and 58 blows per 0.3 m of penetration), indicating a loose to very dense condition. The SPT 'N' values varied widely as a result of split-spoon refusal on coarse gravel and cobbles, which were present throughout the fill. The drill casing was grinding for 0.6 m to 1.2 m in Borehole 18289-02 indicating presence of cobbles and boulders. A SPT 'N' value of "weight of hammer" was measured near the bottom of the layer in Borehole 18289-02. The measured moisture contents generally ranged from 2 percent to 19 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 plotted in Figures C-1A and C-1B of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	20 to 50
Sand	43 to 69
Silt	5 to 9
Clay	0
Silt & Clay	5 to 11

5.4 Silty Sand to Sandy Silt

A heterogeneous deposit of silty sand to sandy silt, trace gravel to gravelly, trace clay, containing gravel and sand interlayers was encountered at ground surface at Borehole 18289-01, and beneath the embankment fill in Boreholes 18289-02 to 18289-05. Cobbles sized particles were measured up to about 100 mm in the deposit, with a 300 mm boulder cored at the bottom of Borehole 18289-05. In Borehole 18289-05, the silty sand encountered near surface contained organics and wood fragments. The cohesionless deposit extends to a depth of 12.7 m (Elev. 276.7 m) and was 6.9 m thick in Borehole 18289-02, where the deposit was full penetrated. Except for Boreholes 18289-02, all other boreholes were terminated within the silty sand deposit between depths of about 4.4 m and 10.9 m (Elev. 281.2 m and 278.2 m).

SPT 'N' values in the cohesionless deposit ranged from 6 blows per 0.3 m penetration to 100 blows per 0.15 m of penetration, indicating a very loose to very dense condition. Like the embankment fill, the variable SPT 'N' values are attributed to split-spoon refusal on coarse gravel, cobbles, and boulders. Where required, NQ rock coring techniques were required to advance the boreholes through the coarse gravel, cobbles, and boulders within the deposit. Casing grinding was noted in the several boreholes and their locations are recorded on the record of boreholes. Photographs of cobbles and boulders are included in Appendix C. The measured moisture contents in the deposit generally ranged between about 1 percent and 26 percent, with one sample having a moisture content of about 59 percent.

The results of grain size analyses conducted on selected samples of the silty sand to sandy silt deposit are provided on the Record of Borehole sheets in Appendix B and plotted in Figures C-2A and C-2B of Appendix C. The results summarized as follows:

Soil Particle	Percentage (%)
Gravel	8 to 24
Sand	30 to 57
Silt	22 to 55
Clay	2 to 7

Atterberg limit testing was completed on one sample of the deposit. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B. The laboratory result indicates non-plastic behaviour.

5.4.1 Gravel to Sandy Silty Gravel Interlayer

Several interlayers were encountered within the silty sand deposit and are summarized below:

Borehole	Description	Depth Encountered (m)	Thickness (m)
18289-01	Sandy Silty Gravel	0.6 (Elev. 283.7 m)	1.7
18289-02	Gravel	5.8 (Elev. 283.6 m)	1.4
		10.1 (Elev. 279.3 m)	1.5
18289-04	Gravel and Sand	9.1 (Elev. 280.3 m)	1.8 [1]

Note 1: Prior to termination of borehole at a depth of 10.9 m below ground surface.

SPT 'N' values in the cohesionless deposit ranged from 23 blows per 0.3 m penetration to 50 blows per 0.075 m of penetration, indicating a compact to very dense condition. Coring was required to advance through this deposit in Borehole 18289-01 and 18289-04. The measured moisture contents in the deposit generally ranged between about 2 percent and 14 percent. The results of grain size analyses conducted on samples of the interlayers are provided on the Record of Borehole sheet in Appendix B, and plotted in Figure C-2C in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	50 to 83
Sand	15 to 31
Silt	17
Clay	2
Silt & Clay	2

5.5 Bedrock

In Borehole 18289-02, bedrock was encountered at a depth of 12.7 m (Elev. 276.7 m) and was proven by coring.

The bedrock consisted of slightly weathered to fresh andesite transitioning to a mafic gneiss. The andesite is medium grained, crystalline, and grey in colour. The mafic gneiss is fine to medium grained, foliated, grey / black and pink. Photographs of the bedrock core are provided in Appendix C. The rock core quality parameters are summarized below:

Rock Core Quality Parameters	Range	Average
Total Core Recovery (TCR), %	100	100
Solid Core Recovery (SCR), %	53 to 63	58
Rock Quality Designation (RQD), %	58 to 62	60
Fracture Index (FI), per 0.3 m	1 to >10	4

The Rock Quality Designation (RQD) varied from 58 percent to 62 percent indicating a rock mass of fair quality.

Point load testing (PLT) was conducted on specimens of the bedrock recovered in Borehole 18289-02. Point Load Strength Index values, $I_{s(50)}$, were calculated in accordance with ASTM D5731 and are summarized as follows:

Lithology	Point Load Test	$I_{s(50)}$ Average (MPa)	$I_{s(50)}$ Range (MPa)	Number of Tests
Andesite to Mafic Gneiss	Diametral	8.3	3.1 – 10.8	7

Based on the ranges of $I_{s(50)}$, the gneiss bedrock is classified as strong (R4) to extremely strong (R6) in accordance with Table 3.5 in CFEM (2006).

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5.6 Groundwater Conditions

Details of the water level observed in the boreholes upon completion of drilling are presented on the record of boreholes and summarized below.

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth	Elev.	
18289-01	October 14, 2022	0.3	284.0	Upon completion of drilling. [2]
18289-02	September 22, 2022	4.1	285.3	Upon completion of drilling. [1,3]
18289-03	September 22, 2022	1.4	287.0	Upon completion of drilling. [1,3]
18289-04	October 19, 2022	2.2	287.2	Upon completion of drilling. [1,3]
18289-05	-	-	-	Not measured. [4]

Note 1: Water level measured in casing.
Note 2: Water level measured in open borehole.
Note 3: Introduced water into borehole for drilling with wash boring methods and therefore, groundwater level at time of measurement was not considered stabilized.
Note 4: Introduced water into borehole for drilling with wash boring methods and therefore, groundwater level was not measured upon completion of drilling.

The water depth in the ditch at the inlet was observed at the time of the investigation and found to be less than 0.1 m deep. The ponded water near the outlet was found to be at approximately 0.3 m deep at the time of the investigation.

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

One sample of the gravelly sand fill 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	18289-04
Sample	**SS6**
Depth (m)	4.6 to 5.2
Elevation (m)	284.5
Sulphide (Na_2CO_3) %	0.09
Chloride (µg/g)	68
Sulphate (µg/g)	156
pH	9.05
Conductivity (µS/cm)	386
Resistivity (Ohm-cm)	2,590

7. MISCELLANEOUS

Marathon Drilling of Greely, Ontario, OGS Inc. of Almonte, Ontario, and Forage Fusion Drilling of Hawkesbury, Ontario supplied and operated the drilling, sampling, and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Messrs. Ian Ross, B.A.Sc., Sergey Gladkiy, B.A.Sc., Arman Hasan, M.Eng., and Ibrahim Khan, M.Eng. 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 laboratories. 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 Ms. Alysha Kobylinski, P.Eng., and Mr. Christopher Ng, P.Eng. The report was reviewed by Messrs. Fred Griffiths, P.Eng., and P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects at Thurber.

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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.

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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.

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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.

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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.

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Appendix A

Site Photographs

Photograph #1 – Highway 556 south embankment slope, facing East. Inlet at base of embankment slope surrounded by mixed forest (September 2022)

Photograph #2 – Toe of south embankment slope at culvert inlet facing West. Culvert visible in bottom corner (September 2022)

Photograph #3 – North-facing embankment slope from highway grade, facing West. Culvert not visible (September 2022)

Photograph #4 – North-facing embankment slope at highway grade, facing East. Culvert not visible (September 2022)

Photograph #5 – Surficial erosion of the unvegetated portion of the south-facing embankment slope, facing west.

Photograph #6 – Culvert inlet, covered by vegetation

Photograph #7 – Culvert outlet, surrounded by forest vegetation, facing south.

Photograph #8 – Soil cuttings from advancing borehole with augers in embankment fill at Borehole 18289-03. Note gravel and cobble-sized particles in soil cuttings.

Photograph #9 – Selection of gravel and cobble sized particles recovered from embankment fill soil cuttings from advancing borehole 18289-03 with augers. Largest cobble dimension in above photograph is approximately 175 mm.

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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

C_{pen} 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

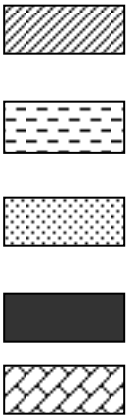
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, 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

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

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RECORD OF BOREHOLE No 18289-01 1 OF 1 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 177 562.9 E 293 879.2 ORIGINATED BY AH

DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Wash Boring, BW Casing Advance, AW Coring COMPILED BY AK

DATUM Geodetic DATE 2022.10.13 - 2022.10.14 LATITUDE 46.737549 LONGITUDE -84.142905 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.3	GROUND SURFACE							20 40 60 80 100	20 40 60		
0.0	Sandy **SILT**, trace gravel, trace clay Compact Dark Brown Wet		1	SS	17		284		○		8 30 55 7 Non-Plastic
283.7											
0.6	Sandy silty **GRAVEL**, trace clay Compact to Dense Brown Moist		2	SS	23						50 31 17 2
			1	AW	-				○		
	Coring from a depth of 1.0 to 1.5 m		2	AW	-		283				
			3	SS	31				○		
			3	AW	-						
282.0	Coring from a depth of 2.1 to 2.3 m						282				
2.3	Gravelly silty **SAND**, trace clay Very Dense Brownish Grey to Light Grey Wet		4	SS	82/0.25				○		24 50 22 4
	Coring from a depth of 2.7 to 3.2 m		4	AW	-						
			5	SS	50/0.075		281		○		
	Coring from a depth of 3.4 to 4.0 m		5	AW	-						
			6	SS	50/0.100				○		
	Coring from a depth of 4.1 to 4.4 m		6	AW	-						
279.9							280				
4.4	END OF BOREHOLE AT 4.4 m. BOREHOLE BACKFILLED WITH BENTONITE.										

NOTES:

1. The cored depth intervals and particle sizes of recovered gravels, and cobbles are summarized as follows

Depth (m)	Recovered
1.0 - 1.1	1 x 100 mm cobble
1.1 - 1.5	gravels up to 75 mm
1.5 - 2.3	gravels up to 50 mm
2.7 - 3.2	1 x 80 mm cobble, gravel up to 30 mm
3.4 - 4.0	gravels up to 50 mm
4.1 - 4.4	gravels up to 30 mm

2. Borehole terminated at a depth of 4.4 m as a result of casing refusal (seized casing) within the cobbles and boulder from a depth of 4.1 m to 4.4 m.

3. Water level at a depth of 0.3 m below ground surface (Elev. 284.0 m) in open borehole upon removal of casing, prior to abandonment.

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No 18289-02 1 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 177 568.3 E 293 863.6 ORIGINATED BY SG

DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.09.21 - 2022.09.22 LATITUDE 46.737597 LONGITUDE -84.143109 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.4	GROUND SURFACE										
0.0	**ASPHALT:** (25 mm)		1	SS	47/0.100		289		○		
	GRAVEL and **SAND**, trace non-plastic fines Compact Brown Wet (FILL)		2	SS	70/0.030				○		48 47 5 (SI+CL)
	Casing grinding from a depth of 0.6 m to 1.2 m		3	SS	30		288		○		
286.4			4	SS	17		287		○		
3.0	**GRAVEL** Loose Black Wet (FILL)		5	SS	8		286				
285.7	Casing grinding from a depth of 3.0 m to 3.7 m										
3.7	Gravelly **SAND**, trace non-plastic fines Very Loose to Very Dense Brown to Grey Wet (FILL)		6	SS	WH		285		○		34 57 9 (SI+CL)
	Casing grinding from a depth of 4.6 m to 5.8 m		7	SS	30				○ ○		
283.6							284				
5.8	**GRAVEL**, trace sand Dense Dark Brown to Grey Wet		8	SS	33		283				
282.2											
7.2	Silty **SAND**, trace gravel, trace clay Very Dense Grey Wet		9	SS	60/0.075		282		○		9 57 31 3
			10	SS	39/0.075		281		○		
							280				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No 18289-02 2 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 177 568.3 E 293 863.6 ORIGINATED BY SG

DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.09.21 - 2022.09.22 LATITUDE 46.737597 LONGITUDE -84.143109 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.3	Continued From Previous Page										
10.1	**GRAVEL**, some sand, trace non-plastic fines Very Dense Grey Wet		11	SS	50/0.120		279		○		83 15 2 (SI+CL)
277.8							278				
11.6	Silty **SAND**, trace gravel Very Dense Grey Wet		12	SS	11/0.750		277		○		
276.7											
12.7	Slightly weathered to fresh, massive, grey, medium grained, faintly porous strong **ANDESITE**		1	RUN	-		276			FI >10 4 3 2 4	RUN #1 TCR=100% SCR=53% RQD=62%
274.9							275			1	RUN #2 TCR=100% SCR=63% RQD=58%
14.5	Fresh, foliated, grey and pink, fine-medium grained, faintly porous, strong **MAFIC GNEISS**		2	RUN	-					1 5 2	
273.7							274			3	
15.7	END OF BOREHOLE AT 15.8 m. BOREHOLE BACKFILLED WITH BENTONITE, ASPHALT PATCH AT SURFACE. NOTES: 1. Water level at a depth of 4.1 m below ground surface in cased borehole upon completion of drilling.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE
$\frac{10}{}$

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THURBER

RECORD OF BOREHOLE No 18289-03 1 OF 1 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 177 577.7 E 293 877.1 ORIGINATED BY SG

DIST Algoma HWY 556 BOREHOLE TYPE CME 75, 194 mm OD HSA, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.09.22 - 2022.09.22 LATITUDE 46.737682 LONGITUDE -84.142933 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.4	GROUND SURFACE										
0.0	**ASPHALT:** (25 mm)										
0.0	**GRAVEL** and **SAND**, trace non-plastic fines Dense to Very Dense Brown Moist (FILL)		1	SS	82		289				
			2	SS	43						50 43 7 (SI+CL)
			3	SS	35		288				
287.2											
2.2	Gravelly **SAND**, trace non-plastic fines Compact to Very Dense Brown Moist (FILL)		4	SS	11		287				
			5	SS	43						26 66 8 (SI+CL)
			6	SS	98		286				
	Pockets of clayey silt from a depth of 4.5 to 5.6 m		7	SS	58		285				20 69 11 (SI+CL)
283.8							284				
5.6	Silty **SAND**, some gravel, trace clay Dense to Very Dense Grey Wet		8	SS	33		283				
	Auger grinding from a depth of 5.8 m to 6.1 m.						282				
	Split spoon refusal at a depth of 8.2 m.		9	SS	62						18 55 23 4
281.2											
8.2	END OF BOREHOLE AT 8.2 m. BOREHOLE BACKFILLED WITH BENTONITE, ASPHALT PATCH AT SURFACE.										

NOTES:
1. Water level measured at a depth of 1.4 m below ground surface (Elev. 287.0 m) in cased borehole upon completion of drilling not representative due to introduction of water for casing advancement.

+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No 18289-04 1 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 177 575.4 E 293 867.7 ORIGINATED BY IR

DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.10.18 - 2022.10.19 LATITUDE 46.737661 LONGITUDE -84.143056 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.4	GROUND SURFACE										
0.0	**ASPHALT:** (50 mm)										
0.0	Gravelly **SAND**, trace silt, containing cobbles Compact to Very Dense Brown Wet (FILL)		1	SS	38		289		○		
			2	SS	12		288		○		25 66 9 0
	No sample recovery from a depth of 2.3 to 2.9 m.		3	SS	26		287				
			4	SS	14		286		○		34 61 5 0
			5	SS	69/0.250				○		
284.1			6	SS	45		285				
5.3	Silty **SAND**, some gravel, trace clay Very Dense Brown to Grey Wet						284				
	Coring from a depth of 5.4 m to 6.6 m.		1	NQ	-						
			7	SS	50/0.075		283				
			8	SS	54		282		○		11 48 38 3
280.3			9	SS	50/0.025		281				
9.1	**GRAVEL** and **SAND**, containing cobbles Very Dense Grey Wet Coring from a depth of 9.3 to 9.6 m		2	NQ	-		280				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18289-04 2 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 177 575.4 E 293 867.7 ORIGINATED BY IR

DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.10.18 - 2022.10.19 LATITUDE 46.737661 LONGITUDE -84.143056 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	GRAVEL and **SAND**, containing cobbles and boulders Very Dense Grey Wet						279				
278.5			10	SS	50/0.075						
10.9	END OF BOREHOLE AT 10.9 m. BOREHOLE BACKFILLED WITH BENTONITE, SAND AND ASPHALT PATCH AT SURFACE. NOTES: 1. The cored depth intervals and particle sizes of recovered cobbles are summarized as follows: Depth (m) Recovered 5.4 - 6.7 125 mm cobble 6.7 - 7.6 gravels up to 75 mm 9.3 - 9.6 gravels up to 75 mm 2. Water level at a depth of 2.2 m below ground surface (Elev. 287.1 m) in cased borehole upon completion of drilling										

$+^3$, $\times^3$: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18289-05 1 OF 1 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 177 590.3 E 293 864.6 ORIGINATED BY IK

DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Wash Boring, BW Casing Advance, AW Coring COMPILED BY AK

DATUM Geodetic DATE 2022.09.17 - 2022.09.19 LATITUDE 46.737795 LONGITUDE -84.143097 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.1	GROUND SURFACE										
0.0	**TOPSOIL:** (100 mm)						284				
0.1	**GRAVEL** and sand, trace non-plastic fines Compact to Dense Brown Moist (FILL)		1	SS	47						
			2	SS	19						48 46 6 (SI+CL)
282.8							283				
1.3	Silty **SAND**, some gravel, containing organics and wood fragments Loose Dark Brown		3	SS	6						13 44 39 4
282.3											
1.8	Wet		1	AW	-						
	Gravelly Silty **SAND** to Silty **SAND**, trace gravel, containing cobbles Very Dense Grey Wet		4	SS	98		282				24 37 37 2
			2	AW	-						
	Casing Grinding Intervals (m): 1.3 - 2.0 2.0 - 2.6 2.6 - 2.9 2.9 - 3.5 3.5 - 3.9 4.0 - 4.6 4.9 - 5.3		5	SS	96		281				
			3	AW	-						
			6	SS	121		280				8 48 39 5
			4	AW	-						
			7	SS	100/0.15						
			5	AW	-		279				
278.5											
5.6	**GNEISS (BOULDER)**		1	RUN	-						
278.2											
5.9	END OF BOREHOLE AT 5.9 m. BOREHOLE BACKFILLED WITH BENTONITE.										

NOTES:

1. A half-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 5.9 m as a result of casing refusal (seized casing)

3. The cored depth intervals and particle sizes of recovered gravels, and cobbles are summarized as follows:

Depth (m)	Recovered
1.8 - 2.0	1 x 125 mm 1 x 60 mm
2.6 - 2.9	gravels up to 75 mm
3.5 - 4.0	gravels up to 75 mm
4.6 - 4.9	gravels up to 75 mm

$+^3$, $\times^3$: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

THURBER

Appendix C

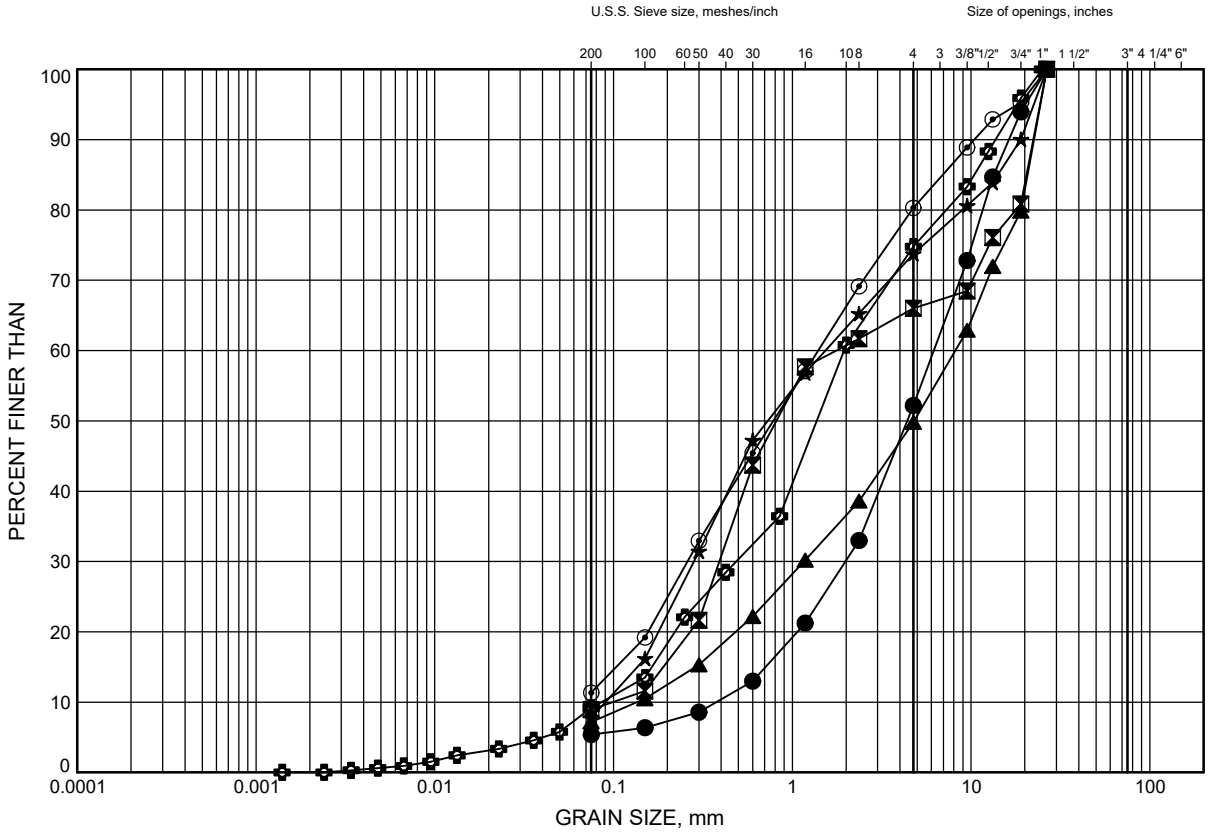
Geotechnical and Analytical Laboratory Test Results, and Core Photographs

Highway 556 Culvert Replacement at STA 18+289

GRAIN SIZE DISTRIBUTION

FIGURE C-1A

GRAVEL and SAND to SAND (FILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18289-02	0.99	288.41
⊠	18289-02	4.11	285.29
▲	18289-03	1.07	288.33
★	18289-03	3.28	286.12
⊙	18289-03	4.88	284.52
✿	18289-04	1.83	287.57

Date January 2023

Project 31719

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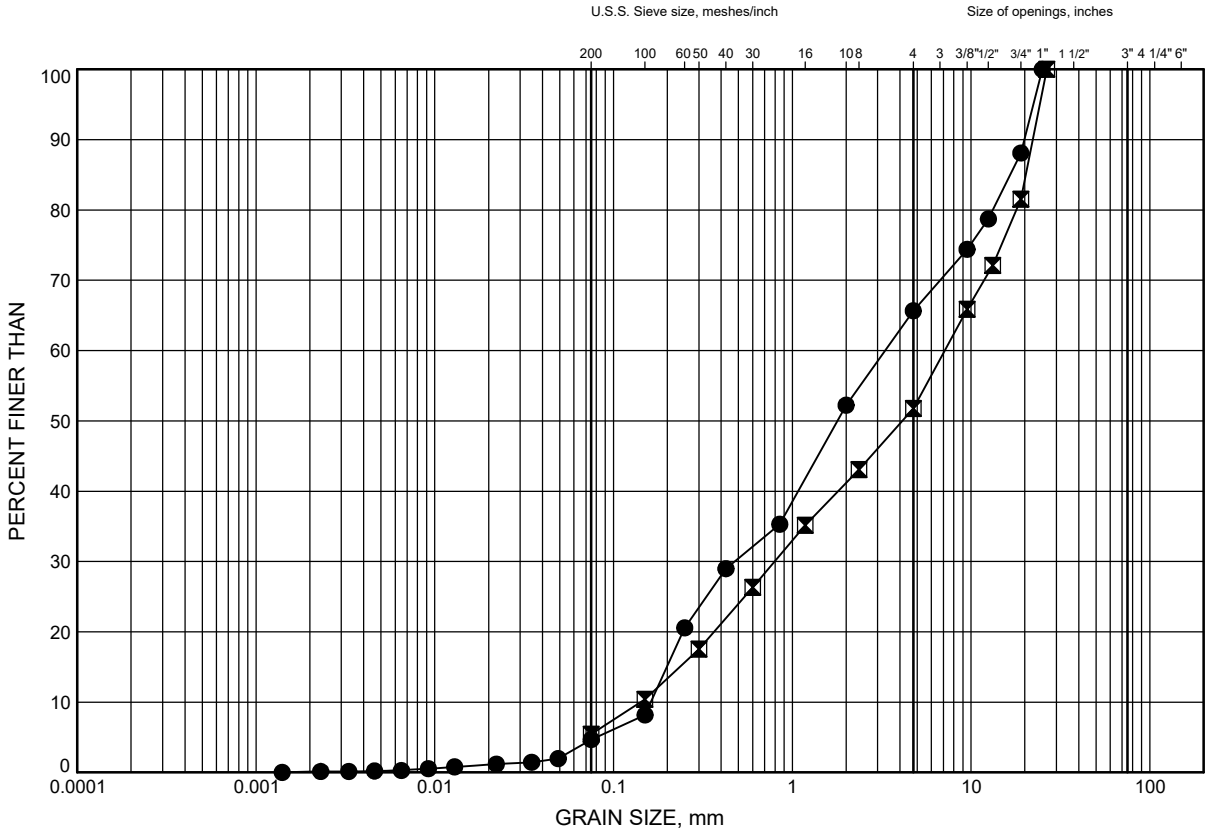
GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 1/17/23

Highway 556 Culvert Replacement at STA 18+289

GRAIN SIZE DISTRIBUTION

FIGURE C-1B

GRAVEL and SAND to SAND (FILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18289-04	3.35	286.05
⊠	18289-05	0.91	283.19

Date January 2023

Project 31719

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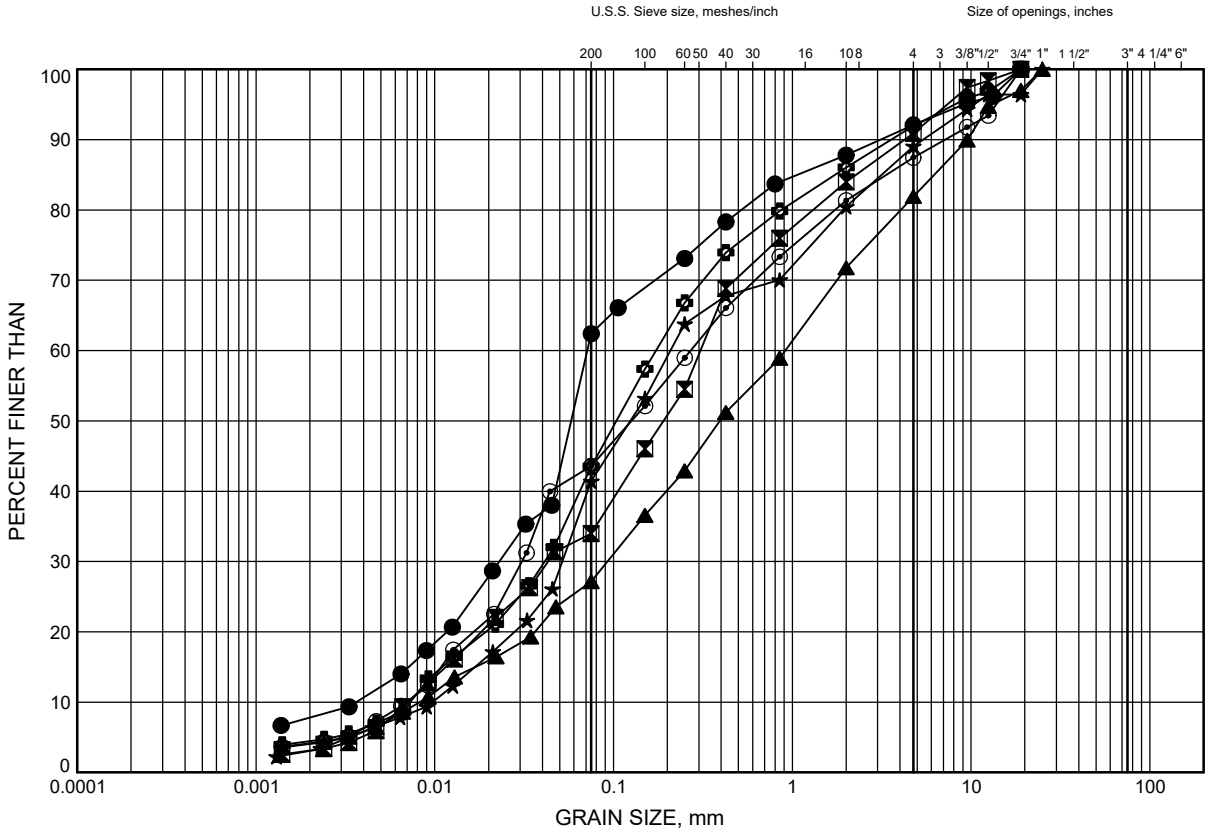
GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 1/17/23

Highway 556 Culvert Replacement at STA 18+289

GRAIN SIZE DISTRIBUTION

FIGURE C-2A

Silty SAND to Sandy SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18289-01	0.30	284.00
⊠	18289-02	7.73	281.67
▲	18289-03	7.92	281.48
★	18289-04	7.92	281.48
⊙	18289-05	1.56	282.54
✿	18289-05	4.27	279.83

Date January 2023

Project 31719

THURBER

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Chkd. AK

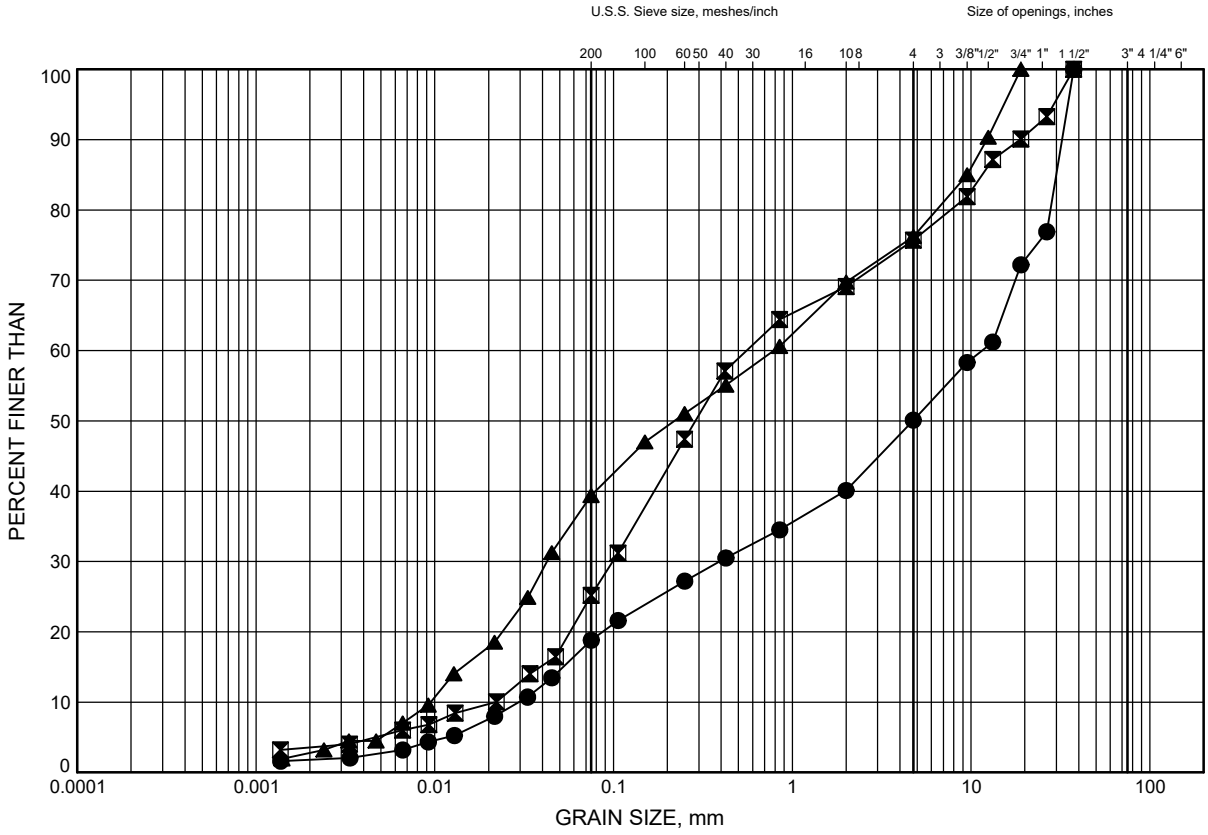
GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 1/17/23

Highway 556 Culvert Replacement at STA 18+289

GRAIN SIZE DISTRIBUTION

FIGURE C-2B

Sandy Silty GRAVEL 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)
●	18289-01	0.91	283.39
⊠	18289-01	2.49	281.81
▲	18289-05	2.29	281.81

Date April 2023

Project 31719

THURBER

Prep'd AN

Chkd. AK

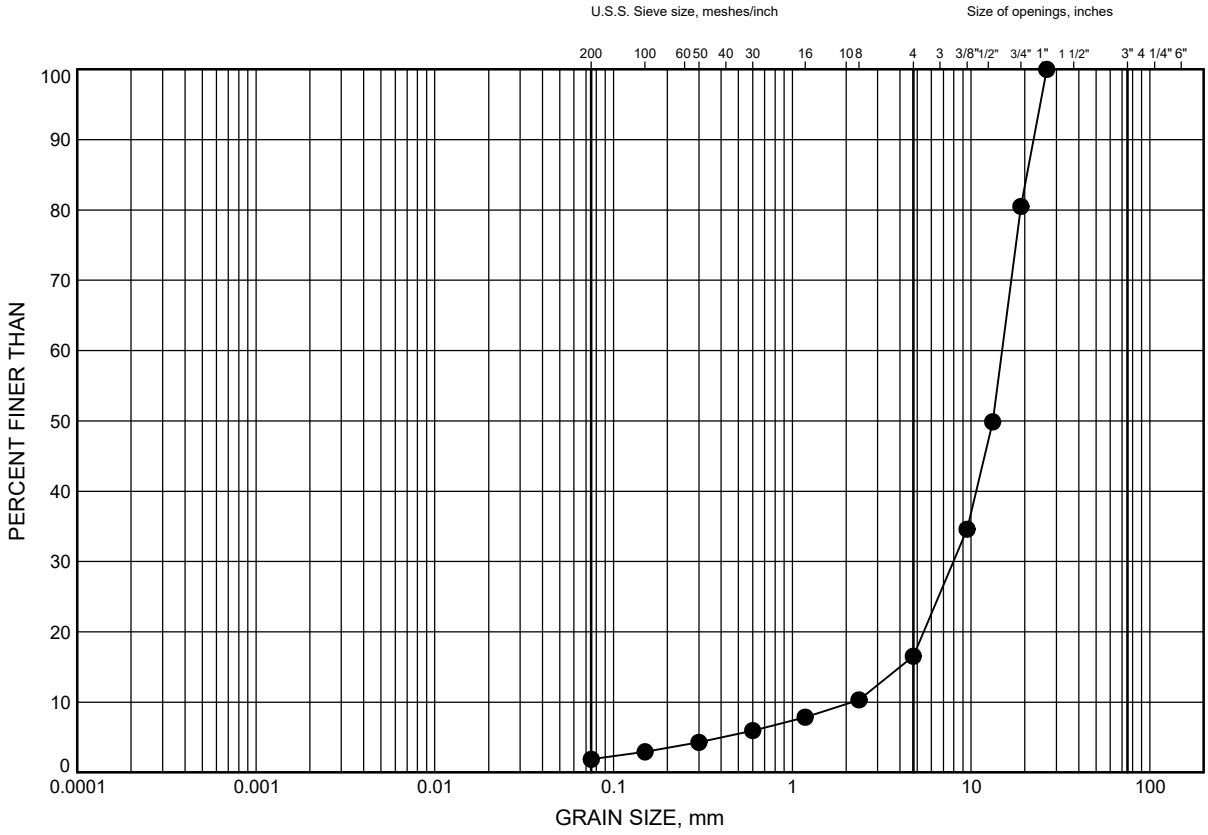
GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 4/4/23

Highway 556 Culvert Replacement at STA 18+289

GRAIN SIZE DISTRIBUTION

FIGURE C-2C

GRAVEL (Interlayer)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18289-02	10.82	278.58

Date January 2023

Project 31719

THURBER

Prep'd AN

Chkd. AK

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 1/17/23

NQ 1 – 1.0 m – 1.1 m
NQ 2 – 1.1 m – 1.5 m
NQ 3 – 1.5 m – 2.3 m
NQ 4 – 2.7 m – 3.2 m
NQ 5 – 3.4 m – 4.0 m
NQ 6 – 4.1 m – 4.4 m

Borehole 18289-01 - Cored Gravel and Cobbles

Run 1 – 12.7 m – 14.5 m
Run 2 – 14.5 m – 15.7 m

Borehole 18289-02 – Cored Bedrock

NQ 1 – 0.2 m – 2.0 m
NQ 2 – 2.6 m – 2.9 m
NQ 3 – 3.5 m – 4.0 m
NQ 4 – 4.6 m – 4.9 m
Run 1 – 5.6 m – 5.9 m

Borehole 18289-05 – Cored Gravel and Cobbles

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731

Job No:	31719	**Date Drilled:**	21-Sep-22
Project Name:	HIGHWAY 556 CULVERT REPLACEMENT AT STA 18+289 (TOWNSHIP OF DEROCHE)	**Date Tested:**	17-Feb-23
		Tester:	AK
Core Size:	NQ **BH No :** 18289-02	**Client:**	MTO

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS[1] (MPa)	Rock Type	Rock Strength[1] (after 4th Ed CFEM)
1	1	13.1	D	20.9	45.0	73.8	9.3	214.6	Andesite to Mafic Gneiss	Very Strong
2	1	13.4	D	24.0	45.0	51.1	10.7	246.0	Andesite to Mafic Gneiss	Extremely Strong
3	1	13.7	D	15.5	45.0	49.7	6.9	159.4	Andesite to Mafic Gneiss	Very Strong
4	1	14.0	D	19.6	45.0	52.9	8.7	200.9	Andesite to Mafic Gneiss	Very Strong
5	2	14.3	D	24.2	45.0	49.5	10.8	248.3	Andesite to Mafic Gneiss	Extremely Strong
6	2	14.6	D	18.4	45.0	50.4	8.2	188.9	Andesite to Mafic Gneiss	Very Strong
7	2	14.9	D	6.9	45.0	48.2	3.1	70.9	Andesite to Mafic Gneiss	Strong

Note: 1 Correlation factor to obtain UCS values is 23.

Last Modified: March 6, 2023

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Certificate of Analysis

Thurber Engineering Ltd. (Pickering)
1795 Ironstone Manor, Unit 1
Pickering, ON L1W 3W9
Attn: Ali Rajaei

Client PO: 31719/10
Project:
Custody: 65093

Report Date: 22-Nov-2022
Order Date: 4-Nov-2022

Order #: 2245456

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

Paracel ID	Client ID
2245456-01	18289-04 / SS#6
2245456-02	19640-01 / RUN#2
2245456-03	21258-03 / SS#9B

Approved By:

Milan Ralitsch, PhD
Senior Technical Manager

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	17-Nov-22	17-Nov-22
Conductivity	MOE E3138 - probe @25 °C, water ext	18-Nov-22	18-Nov-22
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	14-Nov-22	15-Nov-22
Resistivity	EPA 120.1 - probe, water extraction	18-Nov-22	22-Nov-22
Solids, %	CWS Tier 1 - Gravimetric	14-Nov-22	15-Nov-22

Summary of Criteria Exceedances

(If this page is blank then there are no exceedances)

Only those criteria that a sample exceeds will be highlighted in red

Regulatory Comparison:

Paracel Laboratories has provided regulatory guidelines on this report for informational purposes only and makes no representations or warranties that the data is accurate or reflects the current regulatory values. The user is advised to consult with the appropriate official regulations to evaluate compliance. Sample results that are highlighted have exceeded the selected regulatory limit. Calculated uncertainty estimations have not been applied for determining regulatory exceedances.

Sample	Analyte	MDL / Units	Result	-	-

Certificate of Analysis

Report Date: 22-Nov-2022

Client: **Thurber Engineering Ltd. (Pickering)**

Order Date: 4-Nov-2022

Client PO: **31719/10**

Project Description:

	Client ID:	18289-04 / SS#6	19640-01 / RUN#2	21258-03 / SS#9B	-		
	Sample Date:	19-Oct-22 00:00	22-Oct-22 00:00	20-Oct-22 00:00	-	-	-
	Sample ID:	2245456-01	2245456-02	2245456-03	-		
	Matrix:	Rock	Rock	Soil	-		
	MDL/Units						
Physical Characteristics							
% Solids	0.1 % by Wt.	99.4	98.9	85.7	-	-	-
General Inorganics							
Conductivity	5 uS/cm	386 [1]	308	284	-	-	-
pH	0.05 pH Units	9.05	8.45	6.78	-	-	-
Resistivity	0.1 Ohm.m	25.9	32.4	35.2	-	-	-
Anions							
Chloride	5 ug/g	68	23	26	-	-	-
Sulphate	5 ug/g	156	10	8	-	-	-

Method Quality Control: Blank

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

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	158	5	ug/g	160			1.7	20	
Sulphate	82.2	5	ug/g	82.8			0.6	20	
General Inorganics									
Conductivity	242	5	uS/cm	242			0.2	5	
pH	12.34	0.05	pH Units	12.33			0.1	10	
Resistivity	41.4	0.10	Ohm.m	41.3			0.2	20	
Physical Characteristics									
% Solids	82.0	0.1	% by Wt.	82.3			0.4	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	252	5	ug/g	160	91.8	82-118			
Sulphate	201	5	ug/g	82.8	118	80-120			

Qualifier Notes:

Sample Qualifiers :

1: This analysis was conducted after the accepted holding time had been exceeded.

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 unlesss otherwise noted.

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

PARACEL LABORATORIES LTI

Paracel ID: 2245456

Paracel Order Number (Lab Use Only)	Chain Of Custody (Lab Use Only)
2245456	№ 65093

Client Name: Thurber Engineering Ltd.	Project Ref:	Page __ of __
Contact Name: Ali Rajaei	Quote #: 22-754	**Turnaround Time**
Address: Unit 1, 1795 Ironstone Manor, Pickering, ON, L1W 3W9	PO #: 31719/10	☐ 1 day ☐ 3 day
Telephone: 416.575.9069	E-mail: ARAJAEI@THURBER.CA cc: AKOBYLINSKI@THURBER.CA	☐ 2 day ☒ Regular
		Date Required:

☐ REG 153/04 ☐ REG 406/19	Other Regulation	Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)
☐ Table 1 ☐ Res/Park ☐ Med/Fine	☐ REG 558 ☐ PWQO	
☐ Table 2 ☐ Ind/Comm ☐ Coarse	☐ CCME ☐ MISA	
☐ Table 3 ☐ Agri/Other	☐ SU - Sani ☐ SU - Storm	
☐ Table ___	Mun: ___	
For RSC: ☐ Yes ☐ No	☐ Other:	

	Sample ID/Location Name	Matrix	Air Volume	# of Containers	Sample Taken: Date	Sample Taken: Time	Required Analysis: PH	Resistivity	Chloride	Sulphide	Sulphate	Conductivity
1	18289-04/SS#6	Rock		1	Oct 19/22		✓	✓	✓	✓	✓	✓
2	19640-01/RUN#2	Rock		1	Oct 22/22		✓	✓	✓	✓	✓	✓
3	21258-03/SS#9B	Soil		1	Oct 20/22		✓	✓	✓	✓	✓	✓
4												
5												
6												
7												
8												
9												
10												

Comments: Rock samples to be crushed/Pulverized as Per Paracel email (on Nov 2, 2022)

Method of Delivery: RABBEX

Relinquished By (Sign):	Received By Driver/Depot:	Received at Lab:	Verified By:
Relinquished By (Print): A. Rajaei	Date/Time: 04-NOV-22 11:23	Date/Time: 04/NOV/22 14:35	Date/Time: NOV 7 2022 8:56
Date/Time: NOV 3, 2022	Temperature: 21.4 °C	Temperature: 3.3 °C	pH Verified: ☐ By:

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Subcontracted Analysis

Thurber Engineering Ltd. (Pickering)
1795 Ironstone Manor, Unit 1
Pickering, ON L1W 3W9
Attn: Ali Rajaei

Paracel Report No. **2245456**
Client Project(s):
Client PO: **31719/10**
Reference: **#22-754 Corrosivity**
CoC Number: **65093**

Order Date: 04-Nov-22
Report Date: 25-Nov-22

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
2245456-01	18289-04 / SS#6	Sulphide, solid
2245456-02	19640-01 / RUN#2	Sulphide, solid
2245456-03	21258-03 / SS#9B	Sulphide, solid

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

25-November-2022

Paracel Laboratories
Attn : Dale Robertson

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

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

Date Rec. : 15 November 2022
LR Report: **CA12656-NOV22**
Reference: Project#: 2245456

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Sample ID	Sample Date & Time	Sulphide (Na2CO3) %
1: Analysis Start Date		23-Nov-22
2: Analysis Start Time		15:05
3: Analysis Completed Date		25-Nov-22
4: Analysis Completed Time		09:27
5: QC - Blank		< 0.04
6: QC - STD % Recovery		118%
7: QC - DUP % RPD		10%
8: RL		0.02
9: 18289-04 / SS#6	19-Oct-22	0.09
10: 19640-01 / Run#2	22-Oct-22	< 0.04
11: 21258-03 / SS#9B	20-Oct-22	< 0.04

RL - SGS Reporting Limit

Note: Results may be unreliable if analysis was performed past the 28 day holding time.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

OnLine LIMS

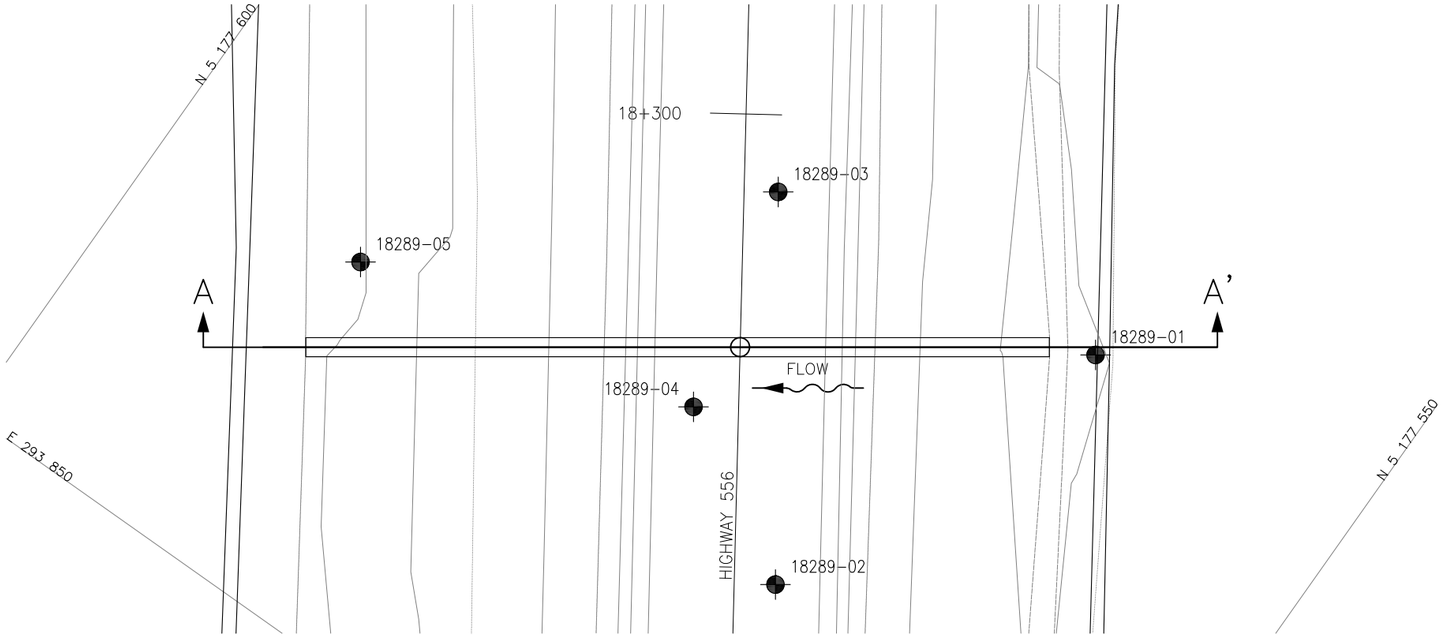
0003134145

THURBER

Appendix D

Borehole Locations and Soil Strata Drawing

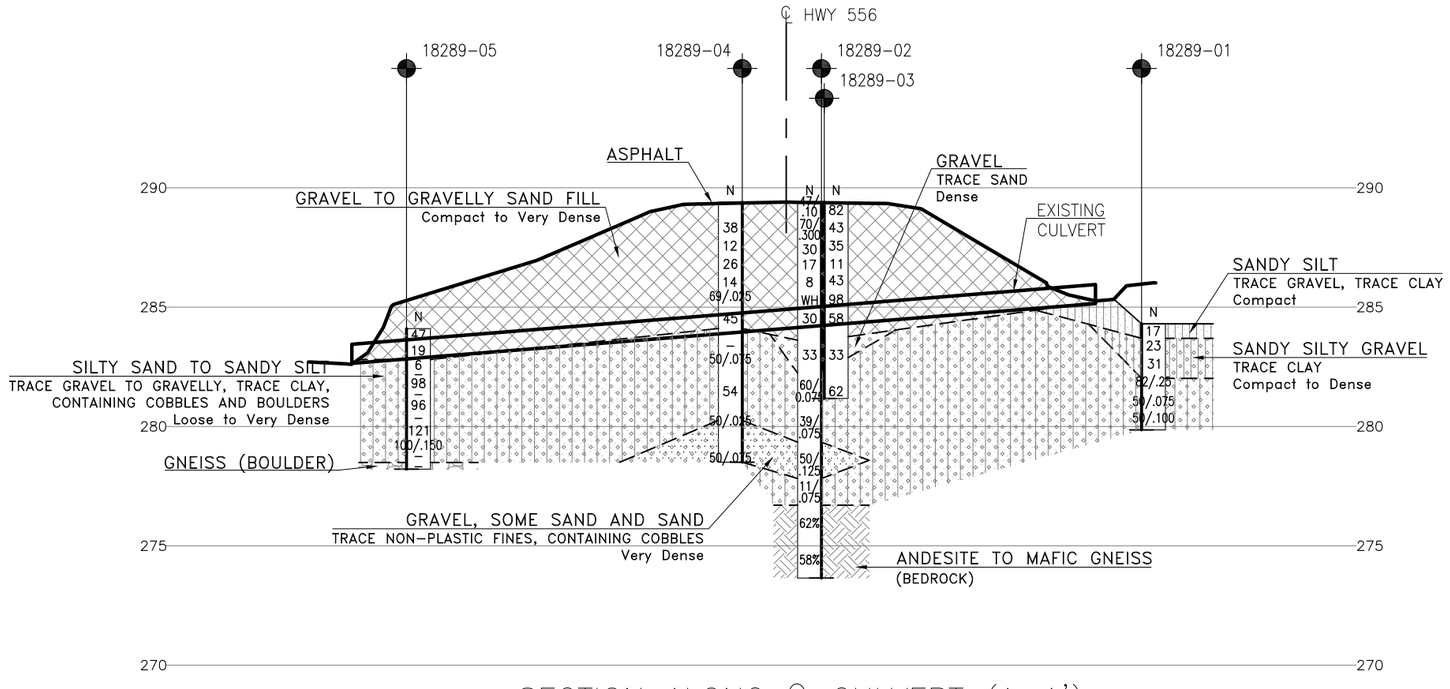
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

5 0 5 10m

SCALE 1:250



SECTION ALONG ℄ CULVERT (A–A')

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 5221-18-00

HIGHWAY 556
STATION 18+289
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
18289-01	284.3	5 177 562.9	293 879.2
18289-02	289.4	5 177 568.3	293 863.6
18289-03	289.4	5 177 577.7	293 877.1
18289-04	289.4	5 177 575.4	293 867.7
18289-05	284.1	5 177 590.3	293 864.6

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
2023/04/13
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C.C. NG
100086170
2023/04/13
PROVINCE OF ONTARIO

-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-123

REVISIONS		
DATE	BY	DESCRIPTION

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

FILENAME: H:\Drafting\31000\31719\TED-31719-PLPR-CUL.dwg
PLOTDATE: 4/4/2023 5:50 PM