



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
HIGHWAY 556 CULVERT REPLACEMENT AT STA 21+258
(TOWNSHIP OF DEROCHE)
REHABILITATION OF HIGHWAYS 556 & 532
DISTRICT OF ALGOMA, ONTARIO
ASSIGNMENT No.: 5020-E-0020
G.W.P. 5221-18-00**

LATITUDE: 46.747476°, LONGITUDE: -84.109067°

GEOCRES Number: 41K-125

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 21+258 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) Agreement 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 3.4 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 21+258	800 mm dia. CSP	48 m long	230.5 (south)	225.2 (north)

The existing culvert allows flow in a south to north direction under the approximately 7.5 m high embankment. The highway pavement surface is at approximate Elev. 236.8 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 4H:1V while a local section is as steep as 0.7H:1V.

Based on visual observations, no signs of slope instability or erosion of the embankment were noted at the culvert site. The north and south sides of the embankment near the toe of the slope were surrounded by thick mixed forest. The water flowing through the culvert flows into the Goulais River approximately 25 m north of the culvert. 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 just east of the site. The paved shoulders are narrow and are flanked by steel beam 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 35 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. Alluvial plains with sandy and gravelly soils as well as organic terrain with peat and muck are also present in the area. The site topography in the immediate vicinity of the culvert is of low relief consisting of plains and terraces and the surrounding area is generally described as high 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 metavolcanic rock described as tonalite to granodiorite with a gneissic to foliated structure.



3. INVESTIGATION PROCEDURES

The field investigation and testing for this project was carried out between August 21 and October 26, 2022, and consisted of drilling and sampling five boreholes, designated as Boreholes 21258-01 to 21258-05, to depths of between 5.2 m and 18.9 m (Elev. 224.2 m and 217.4 m). Boreholes 21258-02 to 21258-04 were advanced through the existing highway embankment, while Boreholes 21258-01 and 21258-05 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 elevation of the as-drilled location for Borehole 21258-04 was surveyed in the field with a rod and level using a temporary benchmark identified as HCP 199 which is at an elevation of 240.61 m. The ground surface elevations of the remaining boreholes were determined by plotting the borehole locations, determined from physical measurements in the field, on the Digital Terrain Map (DTM) provided by AECOM. 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 21258-02 to 21258-04 were drilled using a truck mounted CME 75 drill rig using wash boring technique and HQ casing, while Boreholes 21258-01 and 21258-05 were advanced with a portable drilling equipment also using wash boring technique but with BW casing and AW coring equipment. 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 Borehole 21258-01 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. NQ coring methods were used to core through cobbles and boulders at some locations.

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.

Groundwater conditions observed in open boreholes are not considered stabilized due to the introduction of water throughout the drilling operation. A piezometer was installed in Borehole 21258-05, which consisted of 44 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen, enclosed in a column of filter sand to permit groundwater level monitoring. The



piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. The borehole completion details are summarized below:

Borehole	Depth and Elevation of Borehole Base (m)	Depth and Elevation of Piezometer Tip (m)	Northing and Easting MTM NAD83 Zone 13	Completion Details
21258-01	7.0 / 224.1	None Installed	N 5 178 645.3 E 296 472.1	Backfilled with bentonite holeplug to surface.
21258-02	18.9 / 218.3	None Installed	N 5 178 435.7 E 296 455.0	Backfilled with bentonite holeplug and asphalt patch at surface.
21258-03	12.8 / 223.9	None Installed	N 5 178 661.7 E 296 470.4	Backfilled with bentonite holeplug and asphalt patch at surface.
21258-04	18.9 / 217.4	None Installed	N 5 178 666.1 E 296 477.2	Backfilled with bentonite holeplug and asphalt patch at surface.
21258-05	5.2 / 220.6	4.8 / 221.0	N 5 178 692.7 E 296 463.7	44 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 native silty sand from Borehole 21258-04 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

Client: AECOM

File No.: 31719

E file: <https://thurberengineering.sharepoint.com/sites/31719/Shared Documents/Reports & Memos/05 - Culvert 21+258>

FIDR/TEL_31719_Hwy 556 Culvert 21+258 FIR Final.docx

Date: April 13, 2023

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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 embankment fill, underlain by native deposits of sandy silt to sand, and sand and gravel. Coarse gravel (up to 75 mm in diameter) and cobbles were encountered throughout the embankment fill, and native deposit. In addition, possible boulders were encountered within the sand and gravel deposit at depth.

5.1 Topsoil

A 75 mm thick layer of topsoil was encountered at ground surface at Borehole 21258-01 at the toe of the embankment. A moisture content of 38 percent was measured on a sample of the topsoil. The topsoil thickness may vary in other areas of the site.

5.2 Asphalt

Boreholes 21258-02 to 21258-04 were advanced through the paved portion of Highway 556, and the thickness of the asphalt measured ranged between 45 mm and 50 mm.

5.3 Embankment Fill

Granular embankment fill ranging in composition from gravel and sand, trace non-plastic fines to silty sand, trace gravel was encountered beneath the asphalt in Boreholes 21258-02 to 21258-04. Cobbles and possible boulders were encountered at varying depths throughout the embankment fill and were cored using an 'NQ' size rock core barrel.

The embankment fill extended to depths of between 6.1 m and 7.2 m (Elev. 231.1 m and 229.1 m).

SPT 'N' values in the embankment fill ranged from 4 blows per 0.3 m penetration to 100 blows per 0.1 m of penetration, with typical values recorded between 9 blows to 56 blows indicating a loose to very dense condition. The SPT 'N' values varied widely as a result of split-spoon refusal on coarse gravel (up to 75 mm in diameter), cobbles, and possible boulders, which were



present throughout the fill. The measured moisture contents generally ranged from 3 percent to 21 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-1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	34 to 63
Sand	33 to 60
Silt and Clay	4 to 7

5.4 Sand to Sandy Silt

Sand, trace gravel, trace silt, to sandy silt, trace gravel, and trace clay, containing rootlets in places, was encountered beneath the embankment fill in Boreholes 21258-02 to 21258-04, beneath the topsoil in Borehole 21258-01, and at ground surface in Borehole 21258-05. Where fully penetrated, the sandy silt to sand layer was 3.0 m to 7.6 m thick and extended to depths of between 3.0 m and 13.7 m (Elev. 224.1 m and 222.8 m). Boreholes 21258-01 and 21258-03 were terminated in the sand to sandy silt deposit at a depth of 7.0 m and 12.8 m (Elev. 224.2 m and 223.9 m), respectively. Coring was required to advance through this deposit. A photograph of coarse gravel recovered from coring is provided in Appendix C (Photograph 7).

SPT 'N' values in the sand to sandy silt deposit ranged from 0 blows (weight of hammer) to 35 blows per 0.3 m penetration, with typical values between 3 blows and 26 blows per 0.3 m penetration indicating a very loose to compact condition. A SPT 'N' value of 75 blows per 0.1 m of penetration was also recorded in Borehole 21258-01; however, the high 'N' value is attributed to spoon refusal on a probable cobble. Measured moisture contents in the sandy silt to sand ranged from 12 percent to 58 percent.

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



Soil Particle	Percentage (%)
Gravel	0 to 18
Sand	23 to 94
Silt	6 to 74
Clay	0 to 11

5.5 Sandy Silty Clay Interlayer

An interlayer of sandy silty clay, containing trace gravel and rootlets, was encountered within the silty sand deposit in Borehole 21258-04. The top of the sandy silty clay layer was encountered at a depth of 7.9 m (Elev. 228.4 m) and extended to a depth of 8.7 m (Elev. 227.6 m).

An SPT 'N' value measured in the sandy silt clay was 0 blows (weight of hammer) per 0.3 m penetration while an in-situ field vane was conducted using an MTO 'N' sized vane measured a undrained shear strength of 42 kPa, indicating a very soft to firm consistency. The measured moisture content from the sample of sandy silt clay was 39 percent.

The results of a grain size analysis conducted on the sample of the sandy silty clay is presented on Figure C-3 in Appendix C and summarized as follows:

Soil Particle	Percentage (%)
Gravel	5
Sand	29
Silt	28
Clay	38

5.6 Gravel and Sand to Sand and Gravel

Gravel with sand to sand and gravel, containing trace silt, cobbles and possible boulders was encountered in Boreholes 21258-02, 21258-04, and 21258-05 at depths of between 3.0 m and 13.7 m (Elev. 224.1 m and 222.8 m). These boreholes were terminated in the sand with gravel to gravel with sand layer at depths of between 5.2 m and 18.9 m (Elev. 220.6 m and 217.4 m). Coring was required to advance the boreholes through cobbles and boulders at several intervals in this deposit. A photograph of coarse gravel recovered from coring is provided in Appendix C (Photograph 8).

SPT 'N' values in the gravel to sand deposit ranged from 11 blows to 47 blows per 0.3 m penetration, indicating a compact to dense condition. Measured moisture contents in the granular deposit ranged from 5 percent to 14 percent.



The results of grain size analyses conducted on selected samples of the sand and gravel are presented on Figure C-4 in Appendix C and summarized as follows:

Soil Particle	Percentage (%)
Gravel	15 to 57
Sand	40 to 80
Silt and Clay	3 to 6

5.7 Groundwater Conditions

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

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth	Elevation	
21258-01	-	-	-	Not measured. <small>Note 1</small>
21258-02	August 24, 2022	10.3	226.9	Not stabilized. <small>Note 2.</small>
21258-03	October 20, 2022	Dry to 2.5	-	Borehole caved to 2.5 m upon removal of casing.
21258-04	August 23, 2022	12.0	224.3	Not stabilized. <small>Note 2.</small>
21258-05	October 26, 2022	2.6	223.2	Measurements from piezometer
	October 27, 2022	2.5	223.3	

Note 1: Introduced water into borehole for drilling with wash boring methods and therefore, groundwater level was not measured upon completion of drilling.

Note 2: Introduced water into borehole for drilling with wash boring methods and therefore, groundwater level at time of measurement was not considered stabilized.

Boreholes 21258-01 and 21258-5 were terminated in running sands at depths of 7.0 m and 5.2 m respectively.

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

Two samples of the native silty sand were submitted for analytical testing for corrosivity analysis. The analytical test results for the soil are presented in Appendix C and are summarized below.



Borehole Sample	21258-03 SS9B	21258-04 SS9A
Depth (m)	7.6 to 8.2	7.6 to 7.9
Elevation (m)	228.8	228.6
Sulphide (Na ₂ CO ₃) %	<0.04	--
Chloride (µg/g)	26	752
Sulphate (µg/g)	8	54
pH	6.78	6.54
Conductivity (µS/cm)	284	1140
Resistivity (Ohm-cm)	3,520	875

7. MISCELLANEOUS

Downing Drilling Ltd. of Greely, Ontario, Forage Fusion Drilling of Hawkesbury, Ontario, and OGS Inc. of Almonte, 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. Arman Hasan, M.Eng., Ian Ross, B.A.Sc., and Akash Agnihotri, C.Tech. 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. and SGS Canada Inc., CALA accredited analytical laboratories in Ottawa and Lakefield, Ontario, respectively.

Interpretation of the field data and preparation of this report was carried out by Messrs. Cory Zanatta, P.Eng., and 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.

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.

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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 – Outlet of Culvert 21+258. Looking South-West. (August 2022)



Photograph #2 – Inlet of Culvert 21+258. Looking East. (August 2022)



Photograph #3 – North-facing embankment slope at STA 21+258, highway grade, facing East.
(August 2022)



Photograph #4 – North-facing embankment slope at STA 21+258, highway grade, facing West.
(August 2022)



Photograph #5 – South-facing embankment slope at STA 21+258, looking West. (August 2022)



Photograph #6 – South-facing embankment slope at STA 21+258, looking East. (August 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

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			

RECORD OF BOREHOLE No 21258-01

1 OF 1

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 645.3 E 296 472.1 ORIGINATED BY AH
DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Wash Boring, BW Casing Advance, AW Coring COMPILED BY AO
DATUM Geodetic DATE 2022.10.15 - 2022.10.17 LATITUDE 46.747325 LONGITUDE -84.108995 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						
231.1	GROUND SURFACE													
0.0	TOPSOIL: (75 mm)													
0.2	SILTY SAND some gravel, trace clay, containing rootlets and cobbles Loose Greyish Brown Moist to Wet		1	SS	5									
			2	SS	7									
	Coring of cobbles from a depth of 1.4 m and 1.5 m													
229.6			1	AW	-									
1.5	SAND , trace non-plastic fines Compact Light Greyish Brown Moist		3	SS	14									
			4	SS	21									
228.1														
3.0	Silty SAND Compact to Dense Light Greyish Brown Moist to wet		5	SS	30									
			6	SS	26									
			7	SS	75/0.100									
	Split-spoon refusal at a depth of 4.7 m													
	No core recovery from a depth of 4.7 m to 6.4 m		2	AW	-									
			8	SS	35									
224.2														
7.0	END OF BOREHOLE AT 7.0 m. BOREHOLE BACKFILLED WITH BENTONITE.													
	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. Unable to advance borehole beyond a depth of 7.0 m due to heaving sands within the casing despite several clean out attempts.													

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21258-02

1 OF 3

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 435.7 E 296 455.0 ORIGINATED BY AA
DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.08.23 - 2022.08.24 LATITUDE 46.745438 LONGITUDE -84.109215 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 (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _P w w _L WATER CONTENT (%)							
237.2	GROUND SURFACE							20	40	60	80	100									
0.0	ASPHALT: (50 mm) GRAVEL and SAND , trace non-plastic fines to SAND and GRAVEL , trace non-plastic fines, containing cobbles Very Dense to Dense Dark Brownish Grey Moist (FILL) Coring of cobbles from a depth of 1.2 m and 1.5 m Coring of cobbles from a depth of 2.7 m and 3.0 m No sample recovery from a depth of 3.0 m to 3.2 m		1	SS	68		237														
0.1			2	SS	34		236														
			1	NQ	-																
			3	SS	45		235														
			4	SS	56																
			2	NQ	-																
			5	SS	44/0.150		234														
233.4	Silty SAND , trace gravel Loose to Dense Greyish Brown Moist to Wet (FILL)		6	SS	38		233														
3.8			7	SS	10		232														
231.1	Sandy SILT , trace clay Loose to Compact Greyish Brown Moist to Wet No sample recovery from a depth of 7.6 m to 8.2 m		8	SS	9		231														
6.1							230														
			9	SS	21		229														
228.0	SAND , trace non-plastic fines Compact Greyish Brown Wet		10	SS	24		228														
9.1																					

Continued Next Page

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

RECORD OF BOREHOLE No 21258-02

2 OF 3

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 435.7 E 296 455.0 ORIGINATED BY AA
 DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.08.23 - 2022.08.24 LATITUDE 46.745438 LONGITUDE -84.109215 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE				W _p W W _L					
								● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page							20	40	60	80	100	20	40	60		GR SA SI CL
223.5 13.7 																	

Continued Next Page

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

METRIC

[illegible]

RECORD OF BOREHOLE No 21258-03

1 OF 2

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 661.7 E 296 470.4 ORIGINATED BY IR
DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.10.20 - 2022.10.20 LATITUDE 46.747471 LONGITUDE -84.109018 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								
236.7	GROUND SURFACE							20	40	60	80	100				
0.0	ASPHALT:(45 mm) Gravelly SAND , trace silt, containing crushed rock fragments Compact to Dense Brown to Grey Wet (FILL)		1	SS	28											
			2	SS	30								○			34 60 6 0
			3	SS	46											
			4	SS	37								○			
			5	SS	37											
232.1			6	SS	9								○			
4.6	Silty SAND , trace gravel, containing cobbles Loose Greyish Brown Wet (FILL)		7	SS	4								○			
229.8			8	SS	7								○			6 66 27 1
6.9	Silty SAND , trace gravel Loose to Compact Brown Wet		9	SS	17								○			
227.9			10	SS	17								○			4 84 12 0
8.7	SAND , trace gravel, trace silt Loose to Compact Brown Wet		11	SS	16								○			
													○			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21258-03

2 OF 2

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 661.7 E 296 470.4 ORIGINATED BY IR
DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.10.20 - 2022.10.20 LATITUDE 46.747471 LONGITUDE -84.109018 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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
	SAND, trace gravel, trace silt Loose to Compact Brown Wet		12	SS	9		226										
							225										
			13	SS	18		224										
223.8																	
12.8	END OF BOREHOLE AT 12.8 m. BOREHOLE BACKFILLED WITH BENTONITE, SAND, AND ASPHALT PATCH AT SURFACE. NOTES: 1: Borehole dry upon completion of drilling.																

RECORD OF BOREHOLE No 21258-04

1 OF 3

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 666.1 E 296 477.2 ORIGINATED BY AA
DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.08.21 - 2022.08.23 LATITUDE 46.747511 LONGITUDE -84.108929 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _P w w _L					GR	SA	SI	CL
236.3	GROUND SURFACE							20	40	60	80	100								
0.9	ASPHALT:(50 mm)																			
	GRAVEL and SAND, trace non-plastic fine to SAND and GRAVEL, trace non-plastic fines, containing cobb;es Loose to Very Dense Brownish Grey Moist (FILL)		1	SS	112		236							○						44 49 7 (SI+CL)
			2	SS	67									○						
							235							○						
			3	SS	67									○						
	Coring of cobbles from a depth of 2.1 m and 2.3 m No sample recovery from a depth of 2.3 m to 2.4 m Coring of cobbles from a depth of 2.4 m and 3.0 m		1	NQ	-															
			4	SS	100/0.08		234													
			2	NQ	-															
	No sample recovery from a depth of 3.0 m to 3.1 m Coring of cobbles from a depth of 3.1 m and 3.8 m		5	SS	100/0.10															
			3	NQ	-		233													
			6	SS	114									○						
							232							○						
			7	SS	40									○						52 41 7 (SI+CL)
							231													
			8	SS	6		230							○						
229.2																				
7.2	Silty SAND, some gravel, trace clay, containing organics Very Loose Dark Brown Wet						229													
228.4			9	SS	WH									○						18 42 31 9
7.9	Sandy, siltyCLAY, trace gravel, trace rootlets Very Soft to Firm Grey Moist to Wet						228							○						5 29 28 38
227.6																				
8.7	Silty SAND, some clay, trace gravel Compact Brownish Grey Moist to Wet		10	SS	16		227							○						

Continued Next Page

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

RECORD OF BOREHOLE No 21258-04

2 OF 3

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 666.1 E 296 477.2 ORIGINATED BY AA
DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.08.21 - 2022.08.23 LATITUDE 46.747511 LONGITUDE -84.108929 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE								
								● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page							20 40 60 80 100				W _P W W _L				
224.1	Silty SAND , some clay, trace gravel Compact Brownish Grey Moist to Wet		11	SS	10		226						○	1 59 29 11		
							225									
12.2	SAND and GRAVEL , trace non-plastic fines, containing cobbles Compact to Dense Greyish Brown Moist		12	SS	25		224						○			
							223						○			
			13	SS	19		222						○			
	Coring of cobbles and boulders from a depth of 14.3 m and 15.2 m		4	NQ	-		221						○			
			14	SS	19		220									
	Coring of cobbles and boulders from a depth of 15.8 m and 16.8 m		5	NQ	-		219						○	47 47 6 (SI+CL)		
			15	SS	36		218						○			
	Coring of cobbles and boulders from a depth of 17.4 m and 18.3 m		6	NQ	-											
			16	SS	11								○			
217.4																
18.9	END OF BOREHOLE AT 18.9 m. BOREHOLE BACKFILLED WITH BENTONITE, ASPHALT PATCH AT SURFACE.															
	NOTES: 1. Water level measured at a depth of															

Continued Next Page

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

RECORD OF BOREHOLE No 21258-04

3 OF 3

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 666.1 E 296 477.2 ORIGINATED BY AA
 DIST Algoma HWY 556 BOREHOLE TYPE CME 75, Wash Boring, HW Casing Advance, NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.08.21 - 2022.08.23 LATITUDE 46.747511 LONGITUDE -84.108929 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			20	40	60	80	100					
	Continued From Previous Page																
	12.0 m below ground surface in cased borehole not representative natural water level due to the introduction of water from casing advancement.																

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RECORD OF BOREHOLE No 21258-05

1 OF 1

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 178 692.7 E 296 463.7 ORIGINATED BY AH
DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Wash Boring, BW Casing Advance, AW Coring COMPILED BY AO
DATUM Geodetic DATE 2022.10.25 - 2022.10.26 LATITUDE 46.747751 LONGITUDE -84.109107 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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
225.8	GROUND SURFACE							20	40	60	80	100							
0.0	Silty SAND to Sandy SILT , trace gravel, trace clay, containing organics and occasional wood fragments Very Loose to Compact Light Greyish Brown to Brown Moist to Wet		1	SS	1												2 35 56 7		
			2	SS	3														
			3	SS	3														
			4	SS	12													3 82 11 4	
222.8																			
3.0	GRAVEL and SAND , trace non-plastic fines, containing cobbles Compact to Dense Greyish Brown Moist to Wet Coring of cobbles from a depth of 3.7 m and 3.8 m Coring of cobbles from a depth of 4.4 m and 4.6 m		5	SS	25														
			1	AW	-														
			6	SS	47														57 40 3 (SI+CL)
			2	AW	-														
			7	SS	22														
220.6																			
5.2	END OF BOREHOLE AT 5.2 m. Monitoring well installation consists of 44 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. NOTES: 1. Unable to advance borehole beyond a depth of 5.2 m due to heaving sands within the casing despite several clean out attempts. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2022.10.26 2.6 223.2 2022.10.27 2.5 223.3																		

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



Appendix C

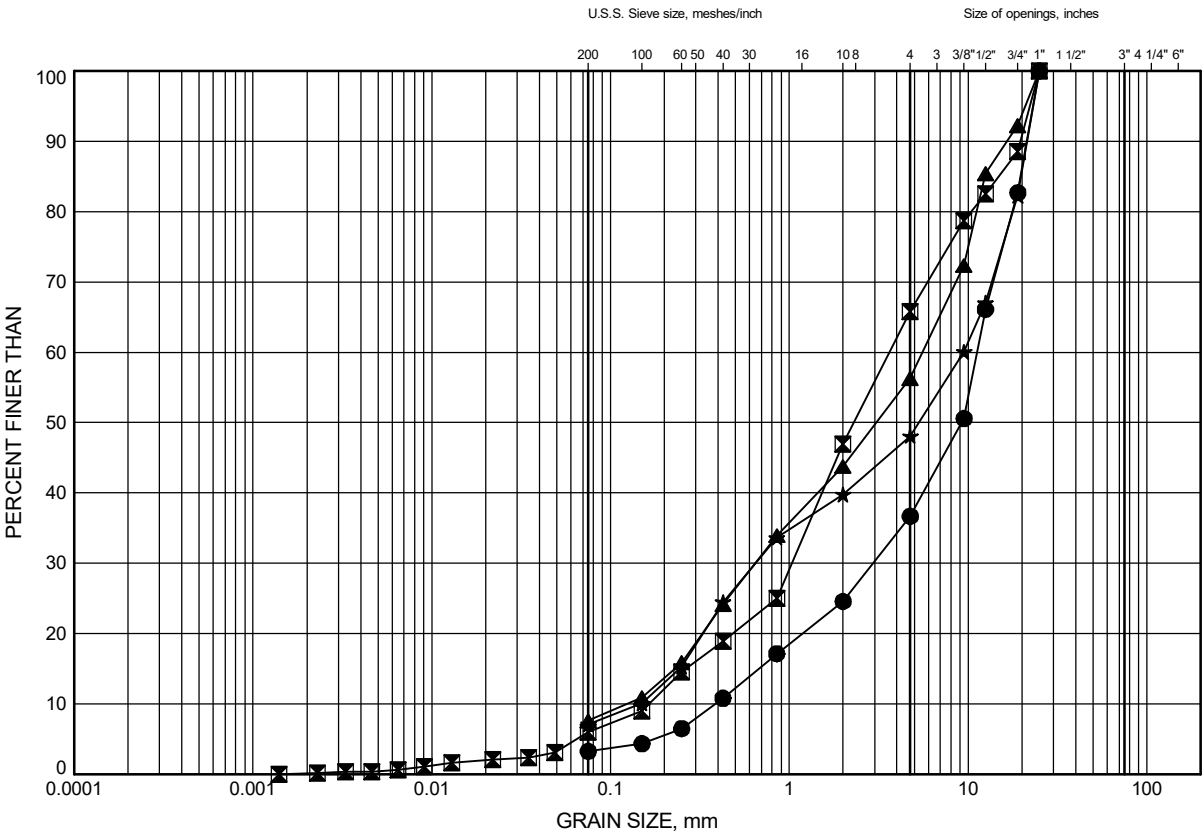
Geotechnical and Analytical Laboratory Test Results, and Core Photographs

Highway 556 Culvert Replacement at STA 21+258

GRAIN SIZE DISTRIBUTION

FIGURE C-1

GRAVEL to Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21258-02	1.1	236.1
⊠	21258-03	1.8	234.8
▲	21258-04	0.4	236.0
★	21258-04	4.9	231.5

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 23-4-27

Date January 2023

W.P. 5221-18-00



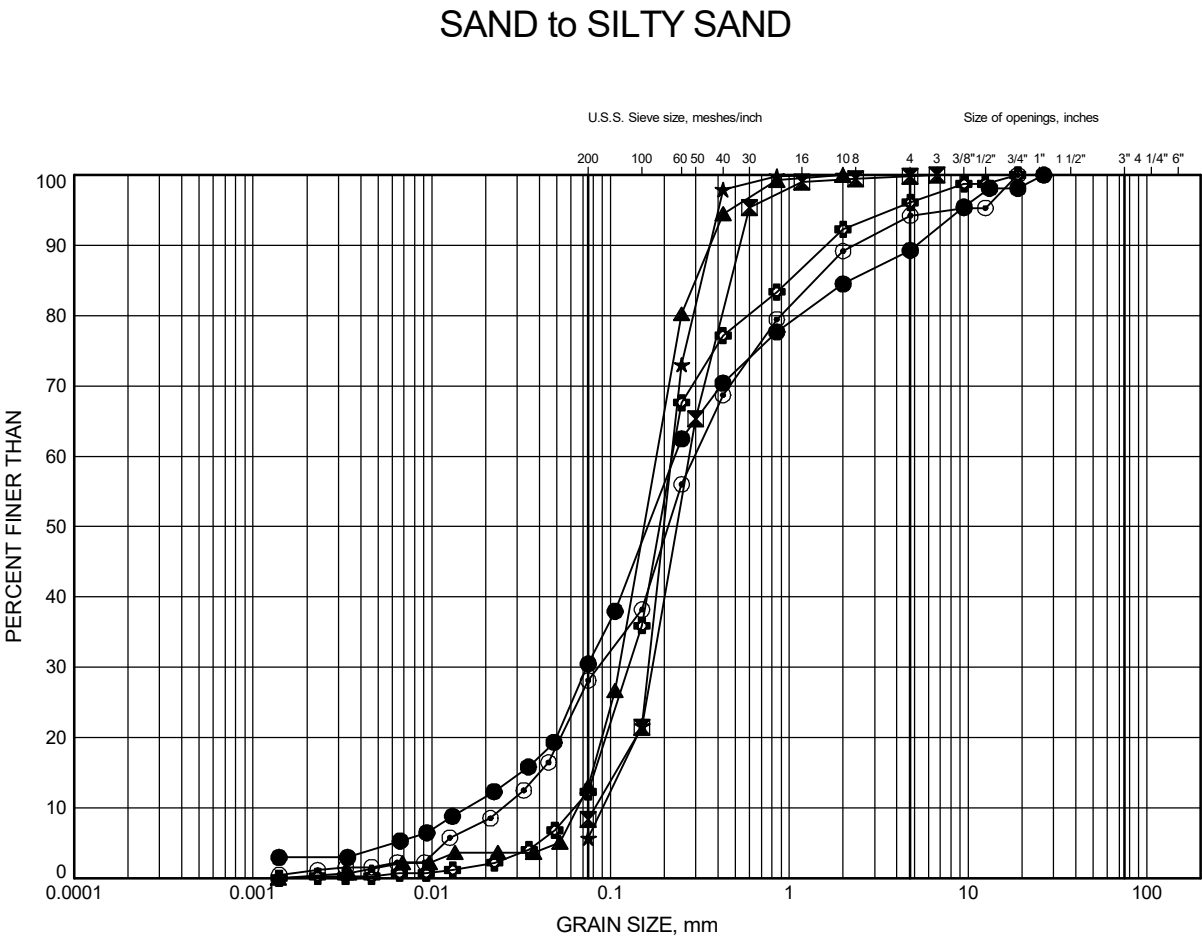
Prep'd CZ

Chkd. CN

Highway 556 Culvert Replacement at STA 21+258

GRAIN SIZE DISTRIBUTION

FIGURE C-2A



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21258-01	1.1	230.1
⊠	21258-01	2.6	228.5
▲	21258-01	4.1	227.0
★	21258-02	11.0	226.2
⊙	21258-03	7.2	229.5
⊕	21258-03	9.0	227.6

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 23-4-27

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

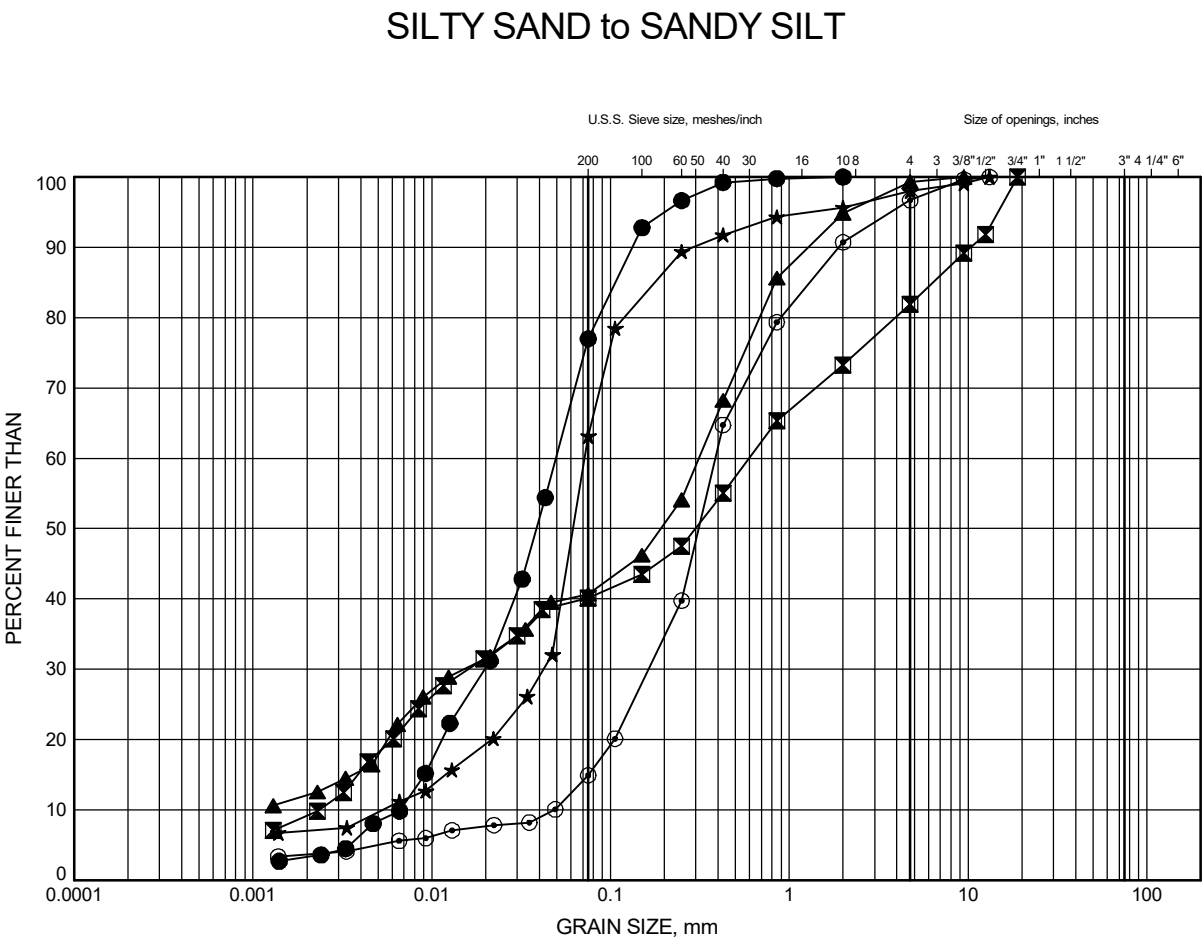


Prep'd CZ
Chkd. CN

Highway 556 Culvert Replacement at STA 21+258

GRAIN SIZE DISTRIBUTION

FIGURE C-2B



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21258-02	6.4	230.8
⊠	21258-04	7.8	228.6
▲	21258-04	11.0	225.4
★	21258-05	0.3	225.5
⊙	21258-05	2.6	223.2

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 23-4-27

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

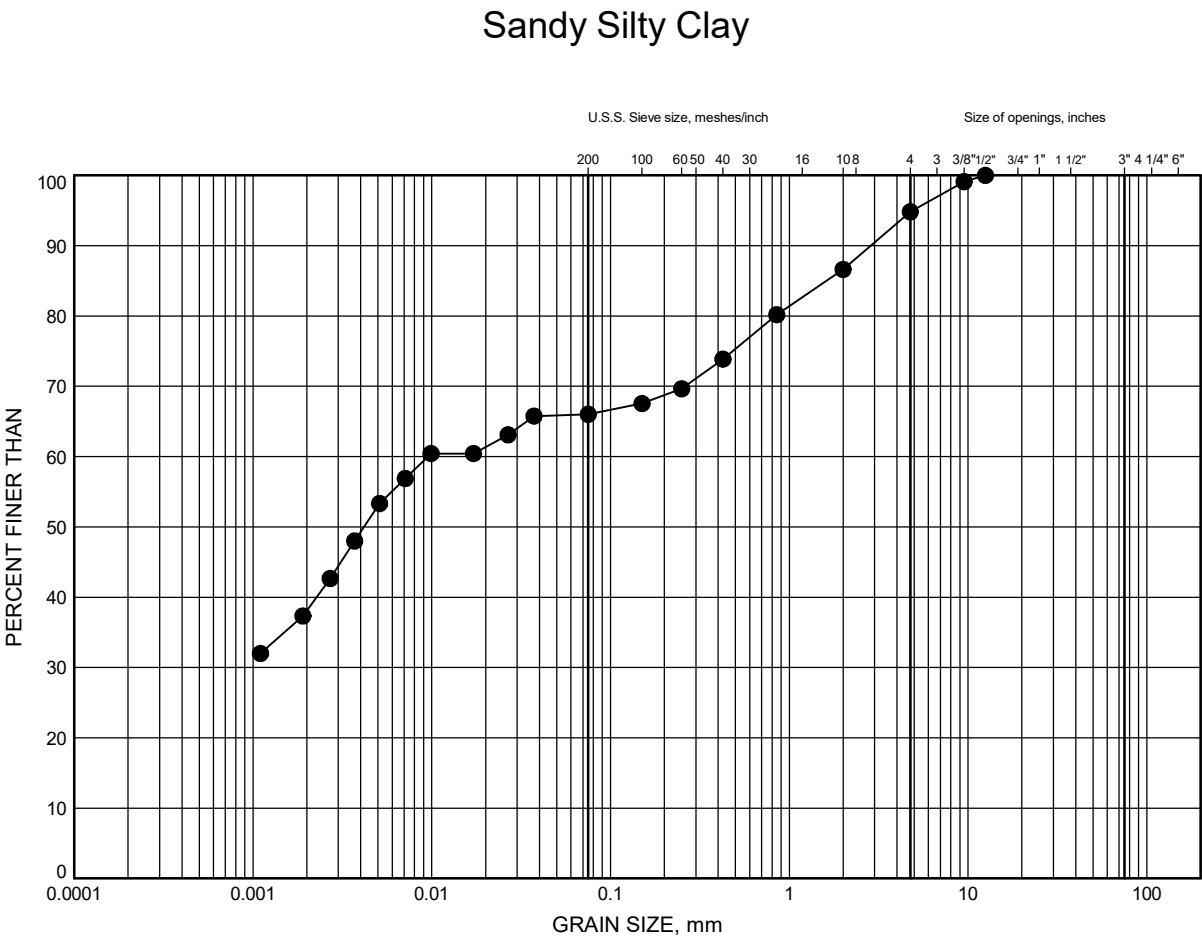


Prep'd CZ
Chkd. CN

Highway 556 Culvert Replacement at STA 21+258

GRAIN SIZE DISTRIBUTION

FIGURE C-3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21258-04	8.1	228.3

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 23-1-12

Date January 2023

W.P. 5221-18-00



Prep'd CZ

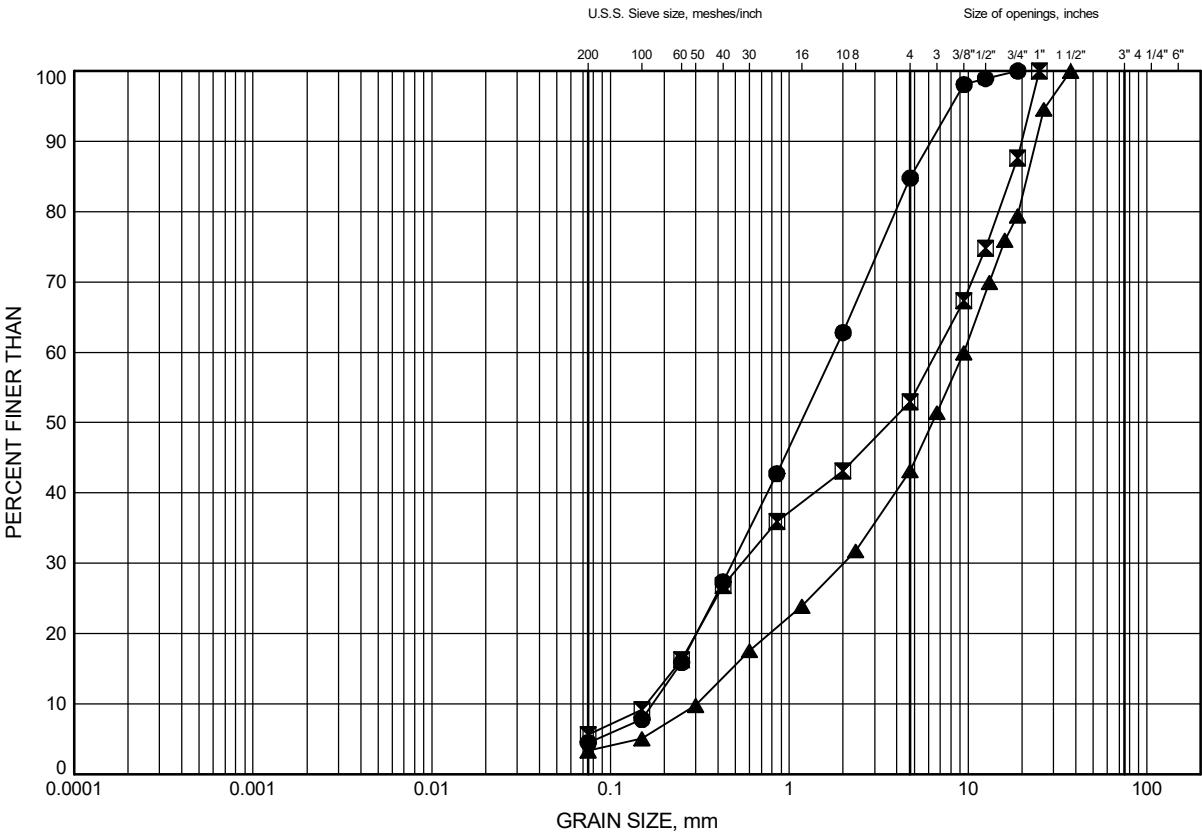
Chkd. CN

Highway 556 Culvert Replacement at STA 21+258

GRAIN SIZE DISTRIBUTION

FIGURE C-4

SAND and GRAVEL to GRAVEL and SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21258-02	14.0	223.1
⊠	21258-04	17.1	219.3
▲	21258-05	4.1	221.7

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 23-4-27

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



Prep'd CZ
Chkd. CN



Photograph #7 – Core sample from AW1 core of Borehole 21258-01. (October 2022)



Photograph #8 – Core sample from AW1 and AW2 core of Borehole 21258-05. (October 2022)

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

Certificate of Analysis

Report Date: 22-Nov-2022

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 4-Nov-2022

Client PO: 31719/10

Project Description:

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

Certificate of Analysis

Report Date: 22-Nov-2022

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 4-Nov-2022

Client PO: 31719/10

Project Description:

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	-	-

Certificate of Analysis

Report Date: 22-Nov-2022

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 4-Nov-2022

Client PO: 31719/10

Project Description:

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					

Certificate of Analysis

Report Date: 22-Nov-2022

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 4-Nov-2022

Client PO: 31719/10

Project Description:

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	

Certificate of Analysis

Report Date: 22-Nov-2022

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 4-Nov-2022

Client PO: 31719/10

Project Description:

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			

Certificate of Analysis

Report Date: 22-Nov-2022

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 4-Nov-2022

Client PO: 31719/10

Project Description:

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 unless otherwise noted.

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

Any use of these results implies your agreement that our total liability in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.



Client Name: <i>Thurber Engineering Ltd.</i>	Project Ref:	Page <u> </u> of <u> </u>
Contact Name: <i>Ali Rajaei</i>	Quote #: <i>22-754</i>	Turnaround Time <input type="checkbox"/> 1 day <input type="checkbox"/> 3 day <input type="checkbox"/> 2 day <input checked="" type="checkbox"/> Regular
Address: <i>Unit 1, 1795 Ironstone Manor, Pickering, ON, L1W 3W9</i>	PO #: <i>31719/10</i>	
Telephone: <i>416-575-9069</i>	E-mail: <i>ARAJAEI@THURBER.CA</i> <i>CC: AKOBYLINSKI@THURBER.CA</i>	
Date Required: _____		

<input type="checkbox"/> REG 153/04 <input type="checkbox"/> 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)		Required Analysis															
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> Table _____ For RSC: <input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> REG 558 <input type="checkbox"/> PWQO <input type="checkbox"/> CCME <input type="checkbox"/> MISA <input type="checkbox"/> SU - Sani <input type="checkbox"/> SU - Storm Mun: _____ <input type="checkbox"/> Other: _____	Matrix	Air Volume	# of Containers	Sample Taken	PH	Resistivity	Chloride	Sulphide	Sulphate	Conductivity								
Sample ID/Location Name					Date	Time													
1 <i>18289-04/SS#6</i>		<i>Rock</i>		<i>1</i>	<i>Oct 19/22</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>							
2 <i>19640-01/RUN#2</i>		<i>Rock</i>		<i>1</i>	<i>Oct 22/22</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>							
3 <i>21258-03/SS#9B</i>		<i>Soil</i>		<i>1</i>	<i>Oct 20/22</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>							
4																			
5																			
6																			
7																			
8																			
9																			
10																			

Comments: <i>Rock samples to be crushed/pulverized as per Paracel email (on Nov 2, 2022)</i>			Method of Delivery: <i>RABBEX</i>	
Relinquished By (Sign): <i>[Signature]</i>	Received By Driver/Depot: <i>[Signature]</i>	Received at Lab: <i>[Signature]</i>	Verified By: <i>[Signature]</i>	
Relinquished By (Print): <i>A. Rajaei</i>	Date/Time: <i>04-Nov-22 11:23</i>	Date/Time: <i>Nov 15/22 14:35</i>	Date/Time: <i>Nov 7 2022 8:36</i>	
Date/Time: <i>Nov 3, 2022</i>	Temperature: <i>21.4</i> °C	Temperature: <i>3.3</i> °C	pH Verified: <input type="checkbox"/> By: _____	

Certificate of Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Alysha Kobylnski

Client PO:
Project: 31719 Hwys 556 & 532
Custody:

Report Date: 8-Sep-2022
Order Date: 1-Sep-2022

Order #: 2236448

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

Paracel ID	Client ID
2236448-01	17032-04 SS10B (31'-32')
2236448-02	21258-04 SS9A (25'-26')

Approved By:



Milan Ralitsch, PhD
Senior Technical Manager

Certificate of Analysis

Report Date: 08-Sep-2022

Client: Thurber Engineering Ltd.

Order Date: 1-Sep-2022

Client PO:

Project Description: 31719 Hwys 556 & 532

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	7-Sep-22	9-Jul-22
Conductivity	MOE E3138 - probe @25 °C, water ext	7-Sep-22	7-Sep-22
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	6-Sep-22	7-Sep-22
Resistivity	EPA 120.1 - probe, water extraction	7-Sep-22	7-Sep-22
Solids, %	Gravimetric, calculation	6-Sep-22	7-Sep-22

Certificate of Analysis

Report Date: 08-Sep-2022

Client: Thurber Engineering Ltd.

Order Date: 1-Sep-2022

Client PO:

Project Description: 31719 Hwys 556 & 532

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: 08-Sep-2022

Client: Thurber Engineering Ltd.

Order Date: 1-Sep-2022

Client PO:

Project Description: 31719 Hwys 556 & 532

Client ID:	17032-04 SS10B (31'-32')	21258-04 SS9A (25'-26')	-	-	
Sample Date:	19-Aug-22 09:00	21-Aug-22 09:00	-	-	-
Sample ID:	2236448-01	2236448-02	-	-	-
Matrix:	Soil	Soil	-	-	-
MDL/Units					

Physical Characteristics

% Solids	0.1 % by Wt.	82.9	78.2	-	-	-	-
----------	--------------	------	------	---	---	---	---

General Inorganics

Conductivity	5 uS/cm	36	1140	-	-	-	-
pH	0.05 pH Units	6.89	6.54	-	-	-	-
Resistivity	0.1 Ohm.m	274	8.75	-	-	-	-

Anions

Chloride	5 ug/g	<5	752	-	-	-	-
Sulphate	5 ug/g	<5	54	-	-	-	-

Certificate of Analysis

Report Date: 08-Sep-2022

Client: Thurber Engineering Ltd.

Order Date: 1-Sep-2022

Client PO:

Project Description: 31719 Hwys 556 & 532

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					

Certificate of Analysis

Report Date: 08-Sep-2022

Client: Thurber Engineering Ltd.

Order Date: 1-Sep-2022

Client PO:

Project Description: 31719 Hwys 556 & 532

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	127	5	ug/g	123			2.9	20	
Sulphate	62.9	5	ug/g	62.2			1.1	20	
General Inorganics									
Conductivity	567	5	uS/cm	569			0.3	5	
pH	6.74	0.05	pH Units	6.68			0.9	10	
Resistivity	17.6	0.10	Ohm.m	17.6			0.3	20	
Physical Characteristics									
% Solids	93.8	0.1	% by Wt.	94.1			0.3	25	

Certificate of Analysis

Report Date: 08-Sep-2022

Client: Thurber Engineering Ltd.

Order Date: 1-Sep-2022

Client PO:

Project Description: 31719 Hwys 556 & 532

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	228	5	ug/g	123	105	82-118			
Sulphate	163	5	ug/g	62.2	100	80-120			

Certificate of Analysis

Report Date: 08-Sep-2022

Client: Thurber Engineering Ltd.

Order Date: 1-Sep-2022

Client PO:

Project Description: 31719 Hwys 556 & 532

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 unless otherwise noted.

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

Any use of these results implies your agreement that our total liability in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.



Parcel Order Number
(Lab Use Only)

2236448

Chain Of Custody
(Lab Use Only)

Client Name: Thurber Engineering	Project Ref: 31719 Hwy 556 & 532	Page 1 of 1
Contact Name: Alysha Kobylinski	Quote #:	Turnaround Time <input type="checkbox"/> 1 day <input type="checkbox"/> 3 day <input type="checkbox"/> 2 day <input checked="" type="checkbox"/> Regular
Address: 104 - 2460 Lancaster Rd Ottawa, ON K1B 4S5	PO #:	
Telephone: 226-748-9593	E-mail: akobylinski@thurber.ca	
Date Required:		

<input type="checkbox"/> REG 153/04 <input type="checkbox"/> REG 406/19 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/Fine <input type="checkbox"/> REG 558 <input type="checkbox"/> PWQO <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> CCME <input type="checkbox"/> MISA <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> SU - Sani <input type="checkbox"/> SU - Storm <input type="checkbox"/> Table _____ For RSC: <input type="checkbox"/> Yes <input type="checkbox"/> No		Other Regulation Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)	Required Analysis															
Sample ID/Location Name		Matrix	Air Volume	# of Containers	Sample Taken		pH	Resistivity	chloride	sulphide	sulphate	Conductivity						
					Date	Time												
1	17032-04 SS10B (31'-32')	S		1	Aug. 19, 22		✓	✓	✓	✓	✓	✓						
2	21258-04 SS9A (25'-26')	S		1	Aug. 21, 22		✓	✓	✓	✓	✓	✓						
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

Comments:				Method of Delivery:			
Relinquished By (Sign): A. Oliveira	Received By Driver/Depot:	Received By Lab: Mehmet	Verified By: Walk in				
Relinquished By (Print): Anderson de Oliveira	Date/Time:	Date/Time: Sept 1/22 17:00	Date/Time: SEP 20/22 11:11				
Date/Time: Sep 01, 2022 @ 16:53	Temperature: °C	Temperature: 23.1 °C	pH Verified: <input type="checkbox"/> By: NA				

**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

25-November-2022

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 (Na ₂ CO ₃) %
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








Appendix D

Borehole Locations and Soil Strata Drawing



KEYPLAN

LEGEND

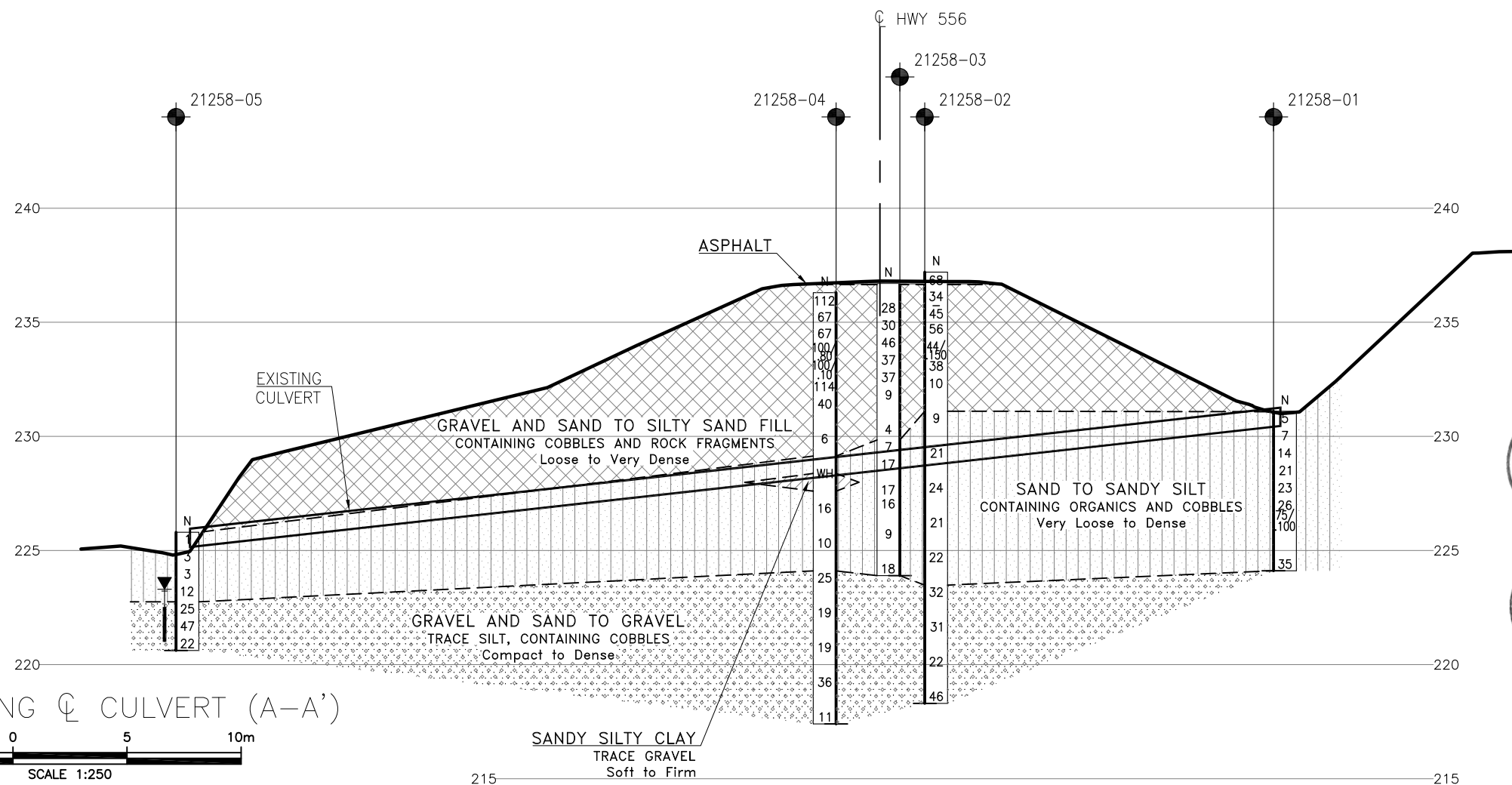
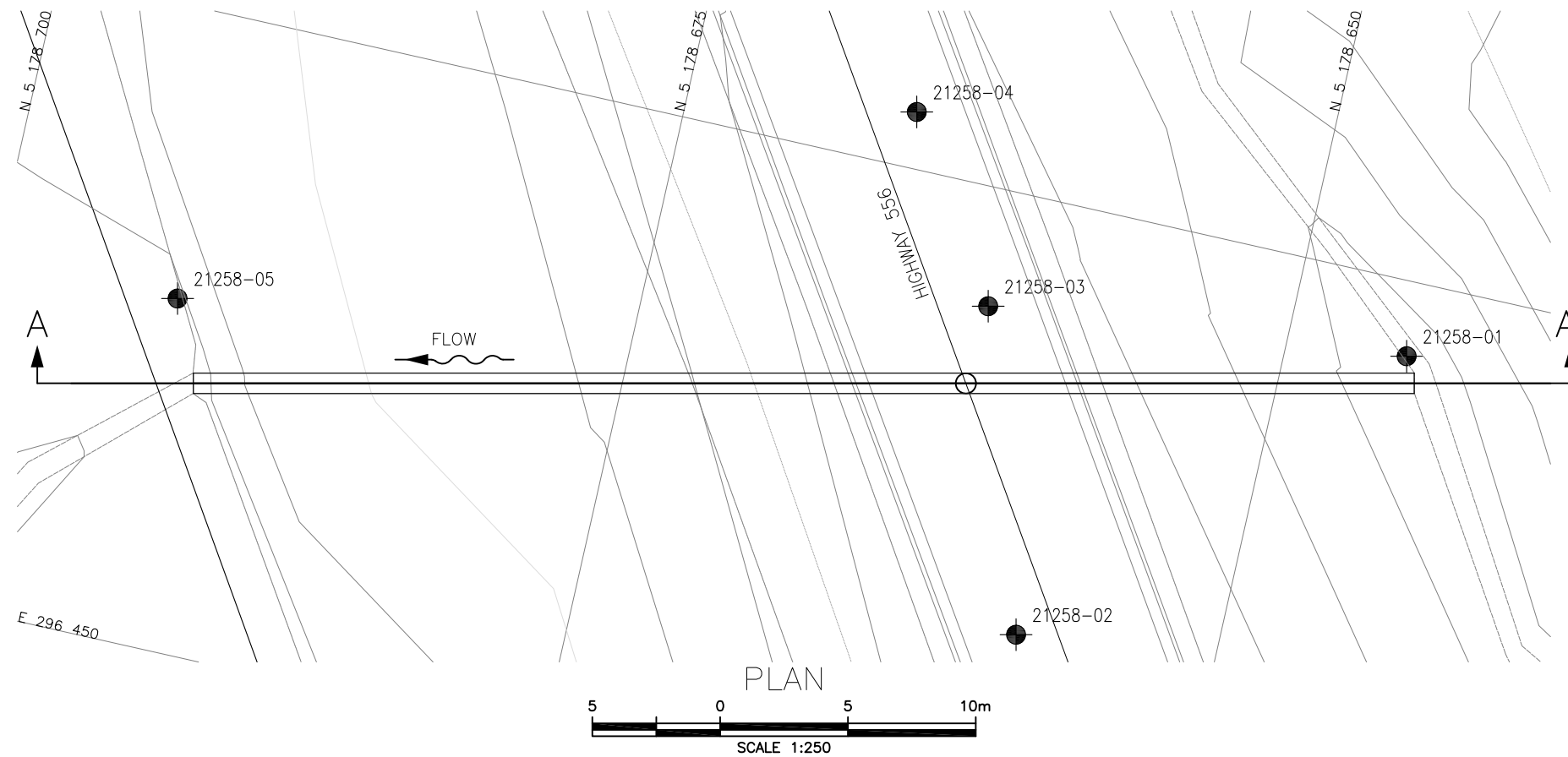
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-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-125

SECTION ALONG \mathbb{Q} CULVERT (A-A')

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