THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION REPORT
TEMPORARY PROTECTION SYSTEM FOR HIGHWAY 556 CULVERT REHABILITATION AT STA 19+640 (TOWNSHIP OF VANKOUGHNET) REHABILITATION OF HIGHWAYS 556 & 532 DISTRICT OF ALGOMA, ONTARIO

ASSIGNMENT No.: 5020-E-0020
G.W.P. 5221-18-00

LATITUDE: 46.706060°, LONGITUDE: -84.238638°

GEOCRES Number: 41K-126

Report

to

AECOM Canada Ltd.

Date: April 24, 2023
File: 31719

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PART A: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for a temporary protection system for the proposed rehabilitation of a centreline culvert, located at STA 19+640 on Highway 556, in the Township of Vankoughnet, District of Algoma, Ontario.

The purpose of this investigation was to explore the subsurface conditions in the vicinity of the highway centreline near the culvert, 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 5.2 km east of the intersection with Highway 552 and approximately 16.2 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)
Vankoughnet 19+640	1000 mm dia. CSP	30.41 m long	279.5 (south)	276.9 (north)

The existing culvert allows flow in a south to north direction under the approximately 3.0 m high embankment cover over the existing culvert. Due to the steep terrain, the culvert features a concrete drop inlet (Photos 3 and 4, Appendix A). The highway pavement surface is at approximate Elev. 283.3 m. This section of highway is constructed partially in an earth/rock cut to the south and the terrain in the vicinity of the culvert, which includes the embankment slopes to the north and earth/rock cut to the south, is inclined at approximately 2H:1V.

Based on visual observations, no signs of slope instability of the highway embankment were noted near the inlet and outlet of the culvert site. The south side of the highway embankment, including the area of the culvert outlet, is generally surrounded by thick mixed forest. The ditch along the south shoulder is lightly vegetated with some visible cobbles and bedrock outcrops. 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 highway alignment in the immediate vicinity of the culvert is curved and rises from west to east. There is a guide rail along the north side of the highway. Overhead utility lines are present along the north side of the highway. It is understood that the projected 2023 AADT for Highway 556 is 540. A granular entrance to a rural property is located approximately 225 m west of the culvert.

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping, the site lies near an outwash plain and the primary materials are sandy and gravelly soils, with bedrock knobs and outcrops. The site topography in the immediate vicinity of the culvert is of 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 October 21 and November 3, 2022, and consisted of drilling and sampling two boreholes through the highway embankment, designated as Boreholes 19640-01 to 19640-02, to depths of 7.7 m and 6.6 m (Elev. 274.8 m and 277.5 m), respectively. The locations of the boreholes are presented on the

Record of Borehole sheets, included in Appendix B, and in the borehole location plan in Appendix D.

Utility clearances were obtained prior to mobilization to the site. The borehole co-ordinates were determined through off-set measurement from the highway centerline and existing culvert and as-drilled borehole elevations on the highway were obtained from the digital terrain model. The coordinate system MTM NAD 83, Zone 13 was used for the boreholes.

The boreholes were drilled using a truck-mounted CME 75 drill rig using wash boring technique with NW casing and NQ 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.

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 and coring operation.

The borehole completion details are summarized below:

Borehole	Depth and Elevation of Borehole Base (m)	Depth and Elevation of Well Tip (m)	Northing and Easting MTM NAD83 Zone 13	Completion Details
19640-01	7.7 / 274.8	None Installed	N 5 174 082.9 E 286 541.7	Backfilled with bentonite holeplug and asphalt patch at surface.
19640-02	6.6 / 277.5	None Installed	N 5 174 077.5 E 286 562.2	Backfilled with bentonite holeplug and asphalt patch at 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 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 specimen of the bedrock to assess the potential for sulphate attack on buried concrete structures, as well as the potential for corrosion associated with buried steel elements. 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 and the elevation of the soil-bedrock interface may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered consisted of sand to gravelly silty sand embankment fill containing cobbles and possible boulders, underlain by a native deposit of silty sand. The overburden material was underlain by basalt bedrock.

5.1 Asphalt

Boreholes 19640-01 and 19640-02 were advanced through the paved portion of the Highway 556 embankment, and the thickness of asphalt was measured to be 45 mm and 50 mm, respectively.

5.2 Embankment Fill

Granular embankment fill consists of sand, some gravel, trace silt, trace clay to gravelly silty sand, containing cobbles and boulders was encountered underlying the asphalt in both boreholes. Cobbles and boulders were encountered at varying depths throughout the embankment fill, as shown in the borehole logs, and were cored using an ‘NQ’ size rock core barrel. Photographs of the gravels, cobbles, and boulders recovered during coring in the embankment fill are shown in

the Core Box Photographs in Appendix C. From the recovered soil cores and observations of embankment fill cuttings, the particle size ranges from 25 mm gravels to boulders up to about 205 mm.

The embankment fill extended to depths of 3.8 m and 2.9 m (Elev. 278.7 m and 281.2 m), in Borehole 19640-01 and 19640-02, respectively.

In general, the SPT 'N' values in the embankment fill ranged from 63 blows per 0.3 m of penetration to 50 blows for 0.03 m of penetration, indicating a very dense condition. A SPT 'N' value of 27 blows per 0.3 m of penetration was recorded in Borehole 19640-01, indicating the embankment fill is compact in places. The high SPT 'N' values and split-spoon refusal is attributed to presence of coarse gravels, cobbles, and boulders throughout the embankment fill. The measured moisture contents generally ranged from 1 percent to 15 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 Figure C-1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	12 to 46
Sand	42 to 78
Silt	10 to 15
Clay	0 to 1

5.3 Silty Sand

A deposit of silty sand, trace to some gravel, trace clay was encountered below the fill in Borehole 19640-01. The cohesionless deposit was 1.0 m thick and extends to a depth of 4.8 m (Elev. 277.7 m).

SPT 'N' values measured in the deposit were 13 blows per 0.3 m penetration and 50 blows per 0.05 m of penetration, indicating a compact to very dense condition. However, it should be noted that the high SPT 'N' value may be attributed to split-spoon refusal on bedrock. The measured moisture contents in the deposit generally ranged between about 13 percent and 19 percent.

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

Soil Particle	Percentage (%)
Gravel	9 to 17
Sand	41 to 44
Silt	39 to 41
Clay	3 to 6

Atterberg limit testing was completed on the fines portion of the samples of the deposit and was determined to be non-plastic.

5.4 Bedrock

Bedrock was encountered at depths of 4.8 m and 2.9 m (Elev. 277.7 m and 281.2 m) in Boreholes 19640-01 and 19640-02, respectively, and was proven by coring. It should be noted that bedrock slopes downward from east to west.

The bedrock consisted of slightly weathered to fresh, strong to very strong basalt with quartz veins. The basalt is fine grained, massive, and grey in colour. 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), %	72 to 100	94
Solid Core Recovery (SCR), %	0 to 95	64
Rock Quality Designation (RQD), %	0 to 95	58
Fracture Index (FI), per 0.3 m	0 to >10	1

The Rock Quality Designation (RQD) varied from 0 percent to 95 percent, indicating a rock mass of poor to excellent quality, but generally was within the fair quality range.

5.5 Groundwater Conditions

In general, water was introduced into the boreholes for drilling with wash boring methods and for coring and therefore, groundwater levels were not measured upon completion of drilling.

Water was measured to be at a depth of 3.6 m below the top of the drop inlet (Elev. 278.8 m). The water at the outlet was found to be surficial at approximately Elev. 276.9 m at the time of the investigation.

It should be noted that 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 basalt bedrock 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	**19640-01**
Sample	**Run 2**
Depth (m)	5.7
Elevation (m)	276.8
Sulphide (Na_2CO_3) %	<0.04
Chloride (µg/g)	23
Sulphate (µg/g)	10
pH	8.45
Conductivity (µS/cm)	308
Resistivity (Ohm-cm)	3,240

7. MISCELLANEOUS

Marathon Drilling of Greely, 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 Mr. Ian Ross, B.A.Sc. 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 Richmond Hill, Ontario.

Interpretation of the field data and preparation of this report was carried out by Ms. Alysha Kobylinski, P.Eng. The report was reviewed by Messrs. Christopher Ng, 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

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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.

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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 near culvert location, facing East. Drop Inlet at ditch to the south. Rock outcrops visible on slope south of ditch (Google Streetview imagery, August 2018)

Photograph #2 – Highway 556 near culvert location, facing West. Drop Inlet at ditch to the south. Rock outcrops visible on slope south of ditch near horizontal curve (Google Streetview imagery, August 2018)

Photograph #3 – Safety grate over drop inlet at the culvert inlet (November 2022)

Photograph #4 – Inside drop inlet (November 2022)

Photograph #5 – Culvert outlet, surrounded by forest vegetation, facing south. (November 2022)

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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

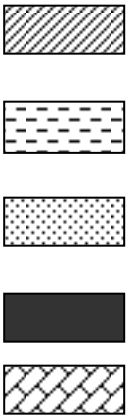
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

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Ontario

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RECORD OF BOREHOLE No 19640-01 1 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 174 082.9 E 286 541.7 ORIGINATED BY IR

DIST Algoma HWY 556 BOREHOLE TYPE CME75, NW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.10.21 - 2022.10.21 LATITUDE 46.706081 LONGITUDE -84.238782 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
282.5	GROUND SURFACE										
0.0 / 0.0	**ASPHALT** (45 mm)		1	SS	50/0.076		282		○		
	SAND, some gravel, trace silt, trace clay, to **SILTY SAND**, some gravel, trace silt, containing cobbles, and boulders Compact to Very Dense Grey Wet (FILL)		2	SS	50/0.050						20 64 15 1
	Coring from a depth of 1.1 m to 2.1 m		1	NQ	-		281				
			3	SS	27		280		○		12 78 10 0
	Split spoon refusal at a depth of 3.1 m		4	SS	50/0.025						
278.7	Coring from a depth of 3.1 m to 3.8 m		2	NQ	-		279				
3.8	**SILTY SAND**, trace to some gravel Compact to Very Dense Brown Wet		5	SS	13				○		9 44 41 6 Non-Plastic
277.7	Split spoon refusal at a depth of 4.8 m		6	SS	50/0.050		278		○		17 41 39 3 Non-Plastic
4.8	Slightly weathered to fresh, massive, fine grained, faintly porous, strong to very strong **BASALT** with quartz veins Grey		1	RUN	-					FI >10	RUN #1 TCR=100% SCR=0% RQD=0%
			2	RUN	-		277			2 1 5	RUN #2 TCR=100% SCR=54% RQD=30%
			3	RUN	-		276			2 0 3	RUN #3 TCR=100% SCR=95% RQD=95%
274.8							275			0 0 0	
7.7	END OF BOREHOLE AT 7.7 m. BOREHOLE BACKFILLED WITH BENTONITE AND SAND, ASPHALT PATCH AT SURFACE. NOTES: 1. The cored depth intervals and particle sizes of recovered gravels, cobbles, and boulders are summarized as follows: Depth (m) Recovered 1.1 - 2.1 1 x 205 mm, 1 x 90 mm, gravels up to 50 mm 3.1 - 3.8 no recovery										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19640-01 2 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 174 082.9 E 286 541.7 ORIGINATED BY IR

DIST Algoma HWY 556 BOREHOLE TYPE CME75, NW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.10.21 - 2022.10.21 LATITUDE 46.706081 LONGITUDE -84.238782 CHECKED BY CN

SOIL PROFILE			SAMPLES			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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	2. Water level not recorded in cased borehole upon completion of drilling due to introduction of water for rock coring.										

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19640-02 1 OF 1 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 174 077.5 E 286 562.2 ORIGINATED BY IR

DIST Algoma HWY 556 BOREHOLE TYPE CME75, NW Casing Advance, NQ Coring COMPILED BY AK

DATUM Geodetic DATE 2022.03.11 - 2022.03.11 LATITUDE 46.706033 LONGITUDE -84.238513 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.1	GROUND SURFACE										
0.0	**ASPHALT**, (50 mm)						284				
0.0	**SAND** and **GRAVEL**, to Silty **GRAVEL** and **SAND**, containing cobbles Very Dense Brown Wet (FILL)		1	SS	63				○		46 42 11 1
			2	SS	50/0.152		283				
	Split spoon refusal at a depth of 0.9 m										
	Split spoon refusal at a depth of 1.6 m		3	SS	50/0.076						
							282				
	Split spoon refusal at a depth of 2.5 m and 2.7 m		4	SS	50/0.076				○		
			5	SS	50/0.076						
281.2	Coring from a depth of 2.7 m 2.8 m		1	NQ	-						
2.9	Slightly weathered to fresh, massive, grey, fine grained, faintly porous, strong to very strong, **BASALT** with quartz veins		1	RUN	-		281			FI 1 2	RUN #1 TCR=96% SCR=93% RQD=66%
			2	RUN	-		280			1 2	RUN #2 TCR=100% SCR=86% RQD=86%
			3	RUN	-					0 0	RUN #3 TCR=86% SCR=66% RQD=66%
			4	RUN	-		279			0 3	RUN #4 TCR=72% SCR=27% RQD=27%
			5	RUN	-		278			0 0 0	RUN #5 TCR=100% SCR=90% RQD=48%
277.5										0	
6.6	END OF BOREHOLE AT 6.6 m BOREHOLE BACKFILLED WITH BENTONITE AND SAND, ASPHALT PATCH AT SURFACE.										

NOTES:

1. The cored depth intervals and particle sizes of recovered gravels, cobbles, and boulders are summarized as follows:
Depth (m) Recovered
2.7 - 2.8 1x105 mm, gravels up to 25 mm

2. Water level not recorded in cased borehole upon completion of drilling due to introduction of water for rock coring.

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

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

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THURBER

Appendix C

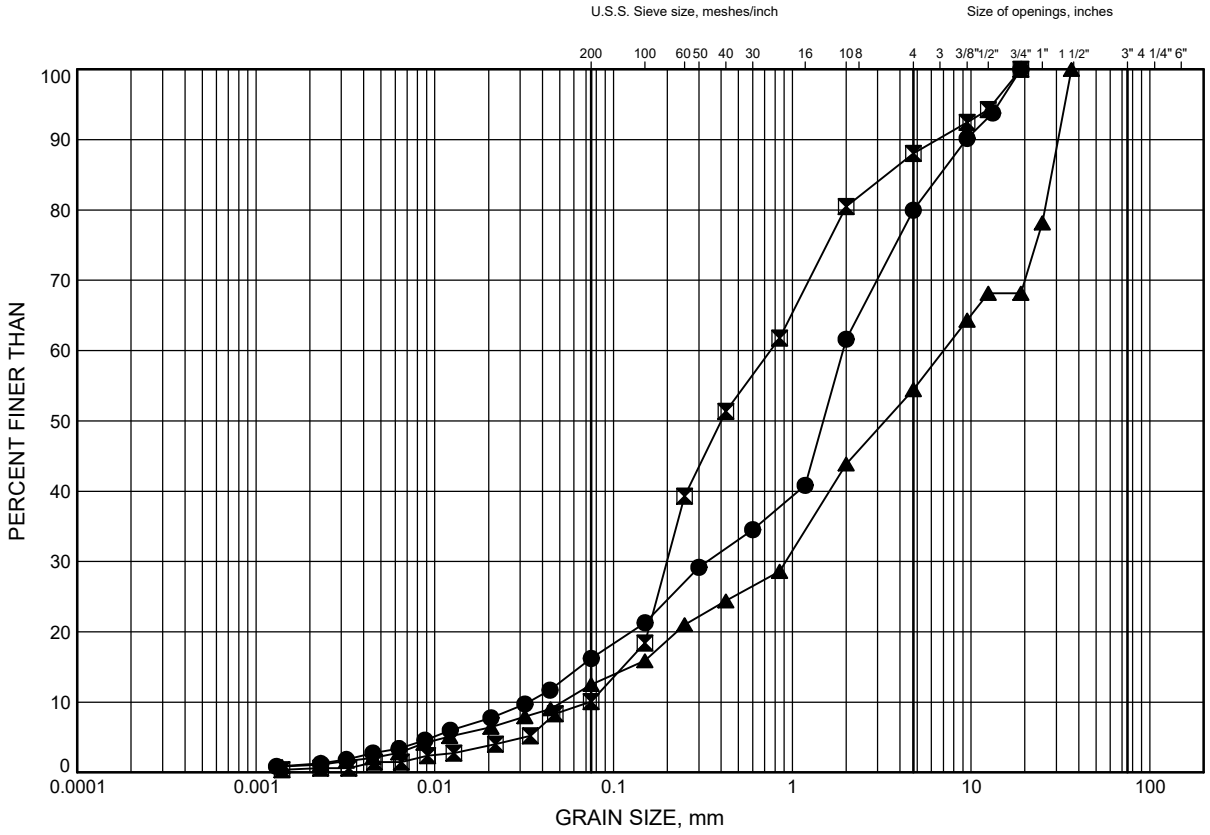
Geotechnical and Analytical Laboratory Test Results, and Core Photographs

HWY 556 Culvert Replacement at Sta. 19+640

GRAIN SIZE DISTRIBUTION

FIGURE C1

SAND to Gravelly Silty SAND (FILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19640-01	0.4	282.1
⊠	19640-01	2.6	279.9
▲	19640-02	0.3	283.8

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 2/27/23

Date February 2023

W.P. 5221-18-00

THURBER

Prep'd AN

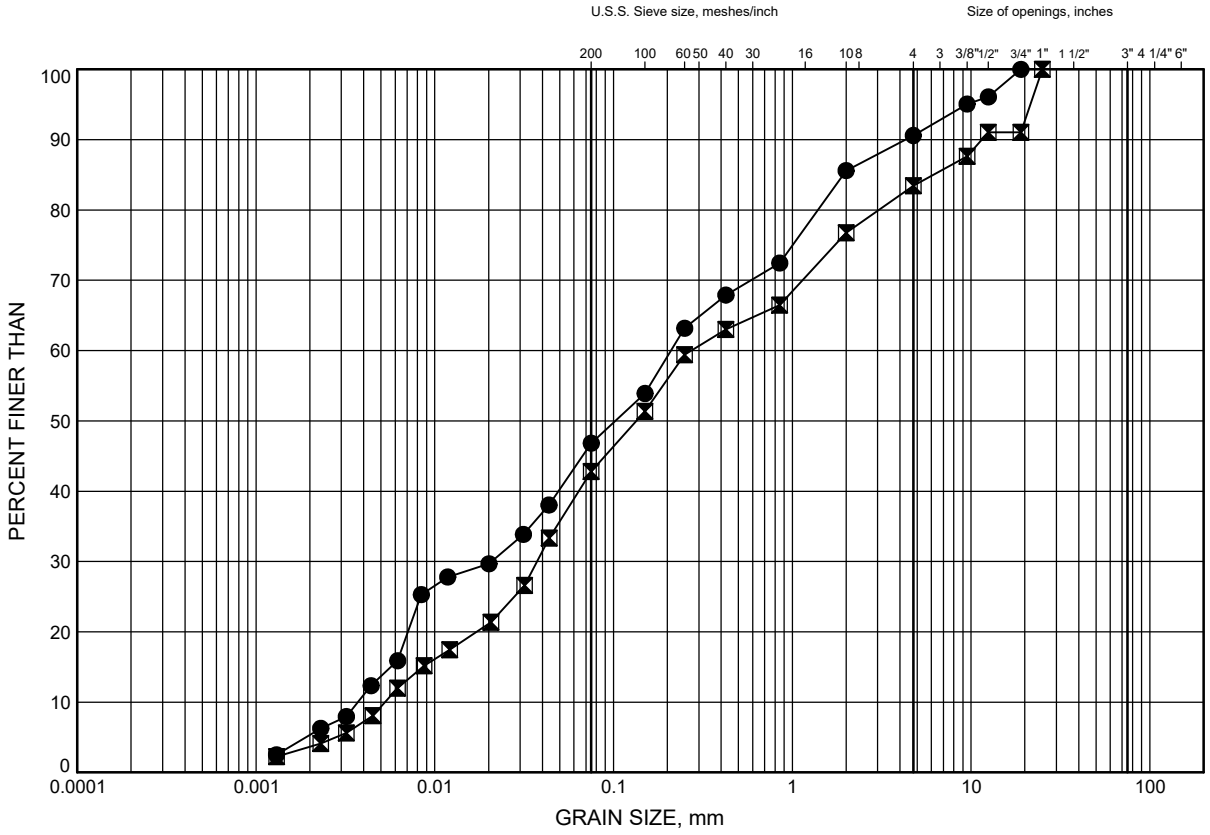
Chkd. AK

HWY 556 Culvert Replacement at Sta. 19+640

GRAIN SIZE DISTRIBUTION

FIGURE C2

Silty SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19640-01	4.1	278.4
⊠	19640-01	4.7	277.8

Date February 2023

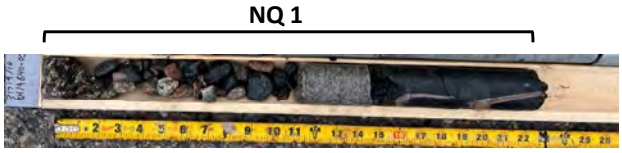
W.P. 5221-18-00

THURBER

Prep'd AN

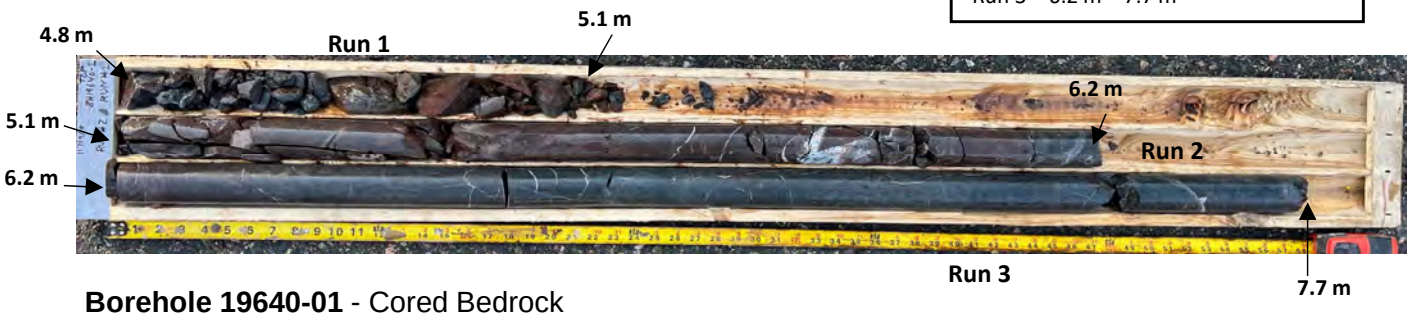
Chkd. AK

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 2/27/23

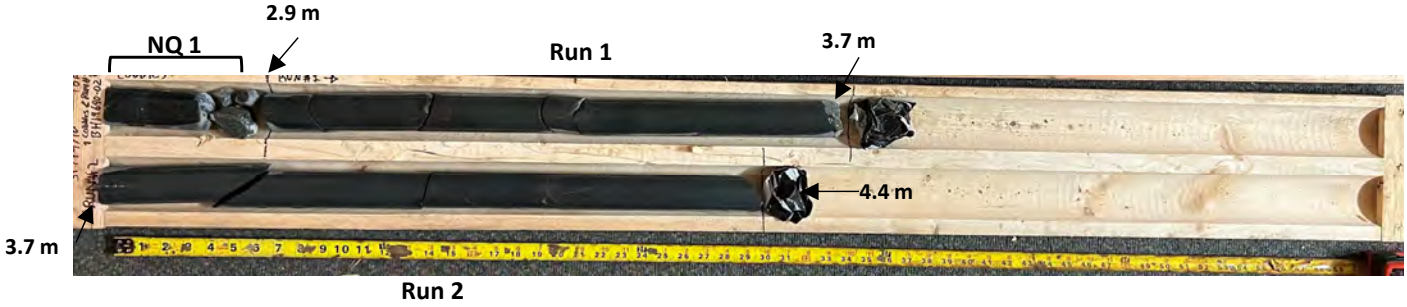


Borehole 19640-01 - Cored Gravel and Cobbles

NQ 1 – 1.1 m – 2.1 m
NQ 2 – 3.1 m – 3.8 m (no recovery)
Run 1 – 4.8 m – 5.1 m
Run 2 – 5.1 m – 6.2 m
Run 3 – 6.2 m – 7.7 m



Borehole 19640-01 - Cored Bedrock



Borehole 19640-02 - Cored Gravel and Cobbles, Bedrock

NQ 1 – 2.7 m – 2.8 m
Run 1 – 2.9 m – 3.7 m
Run 2 – 3.7 m – 4.4 m
Run 3 – 4.4 m – 4.8 m
Run 4 – 4.8 m – 5.3 m
Run 5 – 5.3 m – 6.6 m

Borehole 19640-02 – Cored Bedrock

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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.

Any use of these results implies your agreement that our total liabilty 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.

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

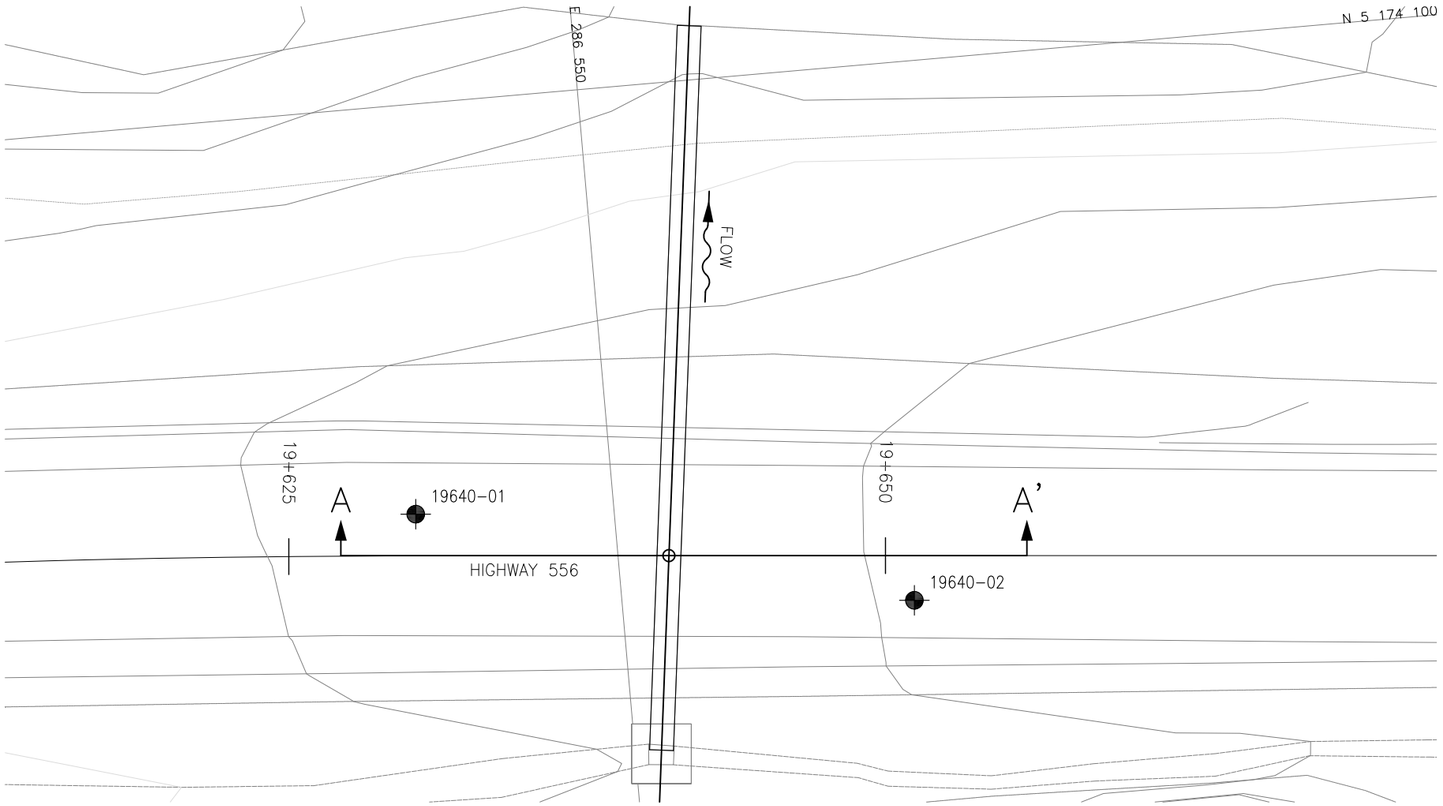
Results relate only to the sample tested. Data reported represents the sample submitted to SGS. Reproduction of this analytical report in full or in part is prohibited without prior written approval. Please refer to SGS General Conditions of Services located at https://www.sgs.ca/en/terms-and-conditions (Printed copies are available upon request.)
Test method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.
SGS Canada Inc. Environment-Health & Safety statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

THURBER

Appendix D

Borehole Locations and Soil Strata Drawing

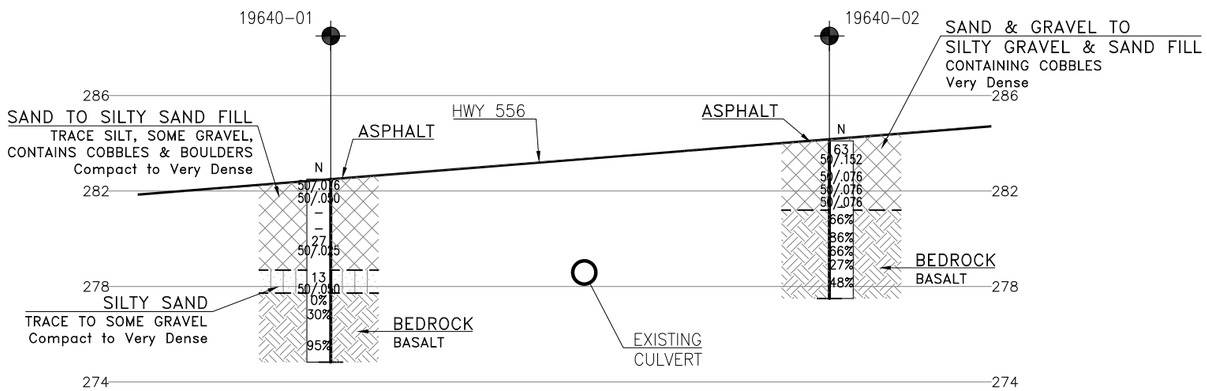
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

5 0 5 10m

SCALE 1:250



SECTION ALONG HWY 556 (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 19+640
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
19640-01	282.5	5 174 082.9	286 541.7
19640-02	284.1	5 174 077.5	286 562.2

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
2023/04/24
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C.C. NG
100086170
2023/04/24
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-126

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	AK	CHK	PKC	CODE	LOAD
DRAWN	AN	CHK	AK	SITE	STRUCT

DATE APR 2023
DWG 1

FILENAME: H:\Drafting\31000\31719\TED-31719-PLPR-CUL.dwg
PLOTDATE: 4/4/2023 5:31 PM