



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
TEMPORARY PROTECTION SYSTEM FOR HIGHWAY 556 CULVERT
REHABILITATION AT STA 14+495 (TOWNSHIP OF DEROCHE)
REHABILITATION OF HIGHWAYS 556 & 532
DISTRICT OF ALGOMA, ONTARIO
ASSIGNMENT No.: 5020-E-0020
G.W.P. 5221-18-00**

LATITUDE: 46.721743°, LONGITUDE: -84.179130°

GEOCRES Number: 41K-128

Report

to

AECOM Canada Ltd.

Date: May 26, 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 the design of a temporary protection system for the proposed rehabilitation of a centreline culvert, located at STA 14+495 on Highway 556, in the Township of Deroche, District of Algoma, Ontario.

The purpose of this investigation was to explore the subsurface conditions along the highway centreline near the culvert, and based on the data obtained, 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 10.9 km east of the intersection with Highway 552 and approximately 10.2 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. The culvert consists of two segments connected by a drop structure located north of the highway at about

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mid-embankment slope. Details of the segmented culvert are summarized below and presented on Figure A1 in Appendix A:

Township and Station	Culvert Size and Type	Length of Culvert Segment (m)	Invert Elevation at Inlet (m)	Invert Elevation at Outlet (m)
Deroche 14+495	800 mm dia. CSP	18.34 m long (south segment, under the highway proper)	339.3 (at south toe of highway embankment)	337.5 (at drop structure)
		7.42 m long (north segment, under the north embankment slope)	333.9 ¹ (at drop structure)	333.8 (at north toe of highway embankment)

Notes:

1. Invert elevation at the drop structure is approximated based on available cross-sections.
2. The top of drop structure connecting the two culvert segments is at Elev. 339.1 m.

The existing culvert allows flow in a south to north direction under the approximately 1.8 m high embankment cover over the existing culvert (south segment). The highway pavement surface is at approximate Elev. 341.0 m. This section of highway is constructed partially in an earth cut. The earth cut south of the highway is inclined at approximately 2H:1V while the embankment fill slope north of the highway is inclined at approximately 1.5H:1V, which features a 2 m wide mid-slope bench, where the drop structure is located. Immediately adjacent to the north toe of embankment is the Agawa Canyon Railroad (ACR) right-of-way.

Based on visual observations, no signs of slope instability of the embankment were noted near the inlet or outlet of the culvert site. The south side of the highway embankment, including the area of the culvert inlet, is generally surrounded by sparse vegetation with mixed forest higher up on the slope, south of the ditch line. The south embankment slope has thick mixed forest cover, and the ditch along the south shoulder is lightly vegetated with some visible cobbles. Site photographs can be found in Appendix A.

Highway 556 consists of two, 3.25 m wide, paved lanes and narrow partially paved shoulders. The alignment in the immediate vicinity of the culvert is relatively straight 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 top of the earth cut on the south side of the highway. It is understood that the projected 2023 AADT for Highway 556 is 540.

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping, the site lies



within an area of bedrock outcrops, near outwash plains and alluvial plains. 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 and generally sloping down to the Goulais River valley.

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 and metasedimentary and igneous rock of the Huronian Supergroup.

3. INVESTIGATION PROCEDURES

The field investigation and testing for this project was carried out on November 1 and 15, 2022, and consisted of drilling and sampling two boreholes through the highway embankment, designated as Boreholes 14495-01 to 14495-02, to depths of 8.6 m and 14.2 m (Elev. 332.3 m and 327.0 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 and triconing. 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:

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Borehole	Depth and Elevation of Borehole Base (m)	Depth and Elevation of Well Tip (m)	Northing and Easting MTM NAD83 Zone 13	Completion Details
14495-01	8.6 / 332.3	None Installed	N 5 175 813.3 E 291 094.7	Backfilled with bentonite holeplug and asphalt patch at surface.
14495-02	14.2 / 327.0	None Installed	N 5 175 822.1 E 291 112.1	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 sample of the silty sand fill to assess the potential for sulphate attack on buried concrete structures, as well as the potential for corrosion associated with buried steel elements. 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 consists of sand and gravel to silty sand fill, underlain by a deposit of native sandy gravel to silty sand. The deposit of sandy gravel to silty sand is in turn underlain by a layer of gravels and cobbles over basalt bedrock.



5.1 Asphalt

Boreholes 14495-01 and 14495-02 were advanced through the paved portion of the Highway 556 embankment, and the thickness of asphalt was measured to be 50 mm.

5.2 Embankment Fill

Embankment fill consisting of sand and gravel, trace silt, trace clay to silty sand, some gravel, trace clay, containing cobbles was encountered underlying the asphalt in both boreholes. Coarse gravels and cobbles were encountered at varying depths throughout the embankment fill, as shown in the borehole logs. Photograph of the gravels and cobbles recovered during coring in the embankment fill in Borehole 14495-01 is shown in the Core Box Photographs in Appendix C. From the recovered soil cores, the particle size ranges from 20 mm gravels to 180 mm cobbles.

The embankment fill extended to depths of 3.8 m and 4.5 m (Elev. 337.1 m and 336.7 m), in Borehole 14495-01 and 14495-02, respectively.

In general, the SPT 'N' values in the embankment fill ranged from 31 blows per 0.3 m of penetration to 50 blows for 0.08 m of penetration, indicating a dense to very dense condition. A SPT 'N' value of 14 blows per 0.3 m of penetration was recorded in Borehole 14495-01, indicating the embankment fill is compact in places. The high SPT 'N' values and split-spoon refusal is attributed to presence of coarse gravels, and cobbles throughout the embankment fill. The measured moisture contents generally ranged from 1 percent to 18 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	14 to 20
Sand	53 to 84
Silt	21 to 26
Clay	1



5.3 Sandy Gravel to Silty Sand

A deposit of sandy gravel to silty sand, some gravel, trace clay was encountered below the fill in both boreholes. The cohesionless deposit was 0.8 m and 3.1 m thick and extends to a depth of 4.6 m and 7.6 m (Elev. 336.3 m and 333.6 m) in Boreholes 14495-01 and 14495-02, respectively.

SPT 'N' values measured in the deposit were 41 blows to 55 blows per 0.3 m penetration, indicating a dense to very dense condition. A SPT 'N' value of 50 blows per 0.13 m of penetration was recorded in Borehole 14495-02, the high SPT 'N' value may be attributed to split-spoon refusal on coarse gravels and/or cobbles in the underlying deposit. The measured moisture contents in the deposit generally ranged between about 4 percent and 14 percent.

The results of a grain size analysis conducted on a sample of the silty sand deposit are provided on the Record of Borehole sheets for Borehole 14495-02 in Appendix B and plotted in Figure C-2 of Appendix C. The results summarized as follows:

Soil Particle	Percentage (%)
Gravel	12
Sand	44
Silt	39
Clay	5

5.4 Gravels and Cobbles

A 4.0 m and 3.4 m thick layer of coarse gravels and cobbles, containing pockets of silt and sand, was encountered beneath the sandy gravel to silty sand deposit in Borehole 14495-01 and 14495-02, respectively. This layer of gravels and cobbles extends to a depth of 8.6 m (Elev. 332.3 m) prior to borehole termination in Borehole 14495-01, and 11.0 m (Elev. 330.2 m) prior to bedrock coring in Borehole 14495-02.

This deposit was penetrated using wash boring and NQ coring techniques. Photographs of the gravels, and cobbles recovered from this layer is shown in the Core Box Photographs in Appendix C. From the recovered soil cores, the particle size ranges from 30 mm gravels to 155 mm cobbles.

The measured moisture contents in the deposit generally ranged between about 7 percent and 15 percent.



The results of a grain size analysis conducted on a sample of the silt and sand pocket within the gravels and cobbles layer is provided on the Record of Borehole sheets for Borehole 14495-02 in Appendix B and plotted in Figure C-3 of Appendix C. The results summarized as follows:

Soil Particle	Percentage (%)
Gravel	1
Sand	39
Silt	55
Clay	5

Atterberg limits testing was complete on one sample of the deposit. The results indicate non-plastic behaviour and is presented on the Record of Borehole sheet in Appendix B.

5.5 Bedrock

Bedrock was encountered at a depth of 11.0 m (Elev. 330.2 m) in Borehole 14495-02 and was proven by coring.

The bedrock consisted of fresh, strong basalt. The basalt is fine grained, massive, and black 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), %	97 to 100	99
Solid Core Recovery (SCR), %	72 to 100	82
Rock Quality Designation (RQD), %	65 to 100	84
Fracture Index (FI), per 0.3 m	1 to 4	1

The Rock Quality Designation (RQD) varied from 65 percent to 100 percent, indicating a rock mass of fair to excellent quality.

5.6 Groundwater Conditions

The water level the boreholes upon completion of drilling is at a depth of 0.6 m below ground surface in both boreholes; however, water was introduced into the boreholes for drilling with wash boring methods, triconing, and for coring and therefore, groundwater levels were not measured upon completion of drilling.



The water level at the creek was approximately 0.3 m above the outlet invert level (Elev. 334.1 m) on November 7, 2022. 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 silty sand fill was submitted for analytical testing for corrosivity analysis and sulphide content. The analytical test results for the soil are presented in Appendix C and are summarized below.

Borehole	14495-01
Sample	SS 3
Depth (m)	1.8
Elevation (m)	339.1
Chloride ($\mu\text{g/g}$)	143
Sulphate ($\mu\text{g/g}$)	20
pH	6.32
Conductivity ($\mu\text{S/cm}$)	367
Resistivity (Ohm-cm)	2730

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

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

2. COMPLETE REPORT

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

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

3. BASIS OF REPORT

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

4. USE OF THE REPORT

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

5. INTERPRETATION OF THE REPORT

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

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

7. INDEPENDENT JUDGEMENTS OF CLIENT

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

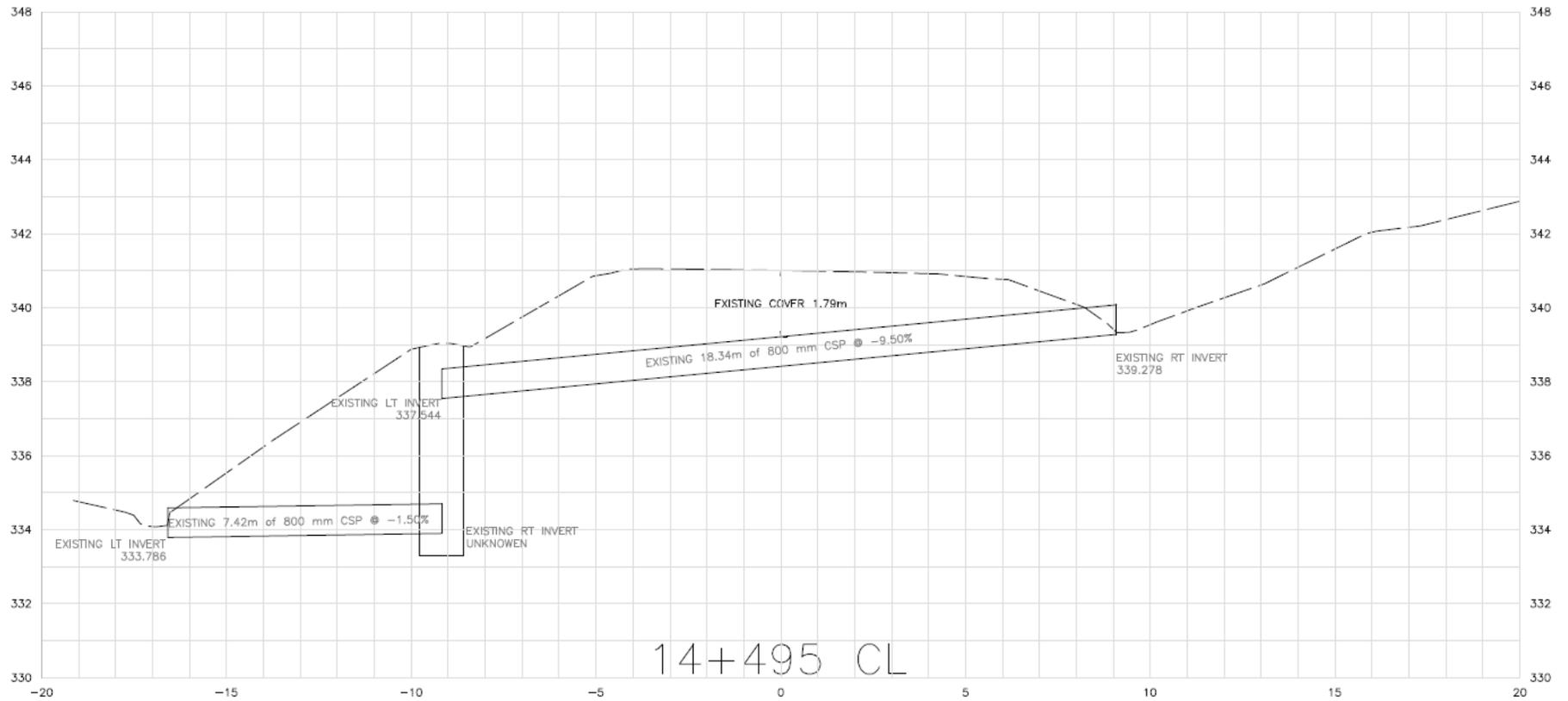


Appendix A

Profile of Existing Culvert and Site Photographs

Existing Culvert at STA 14+495 – Township of Deroche Highway 556 Culvert Rehabilitation MTO Agreement No. 5020-E-0020

Figure A1





Photograph #1 – Highway 556 near culvert location, facing East. Drop Inlet at ditch to the north. (Google Streetview imagery, August 2018)



Photograph #2 – Highway 556 near culvert location, facing West. Drop Inlet at ditch to the north. (November 2022)



Photograph #3 – Culvert inlet, surrounded by vegetation, facing north. (November 2022)



Photograph #4 – Culvert outlet, flowing into downstream / adjacent culvert that outlets into the leased land agreement with Algoma Central Railway. (November 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	TP Thin Wall Piston Sample	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	RC Rock Core	SC Soil Core
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$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 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 14495-01 1 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 175 813.3 E 291 094.7 ORIGINATED BY IR
 DIST Algoma HWY 556 BOREHOLE TYPE CME75, NW Casing Advance and Tricone, NQ Coring COMPILED BY AK
 DATUM Geodetic DATE 2022.11.01 - 2022.11.01 LATITUDE 46.721758 LONGITUDE -84.179290 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						
						20	40	60	80	100	20	40	60	GR SA SI CL
340.9	GROUND SURFACE													
0.0	ASPHALT(50 mm)													
	SILTY SAND some gravel, trace clay Compact to Very Dense Brown (FILL)		1	SS	61									
			2	SS	31									15 63 21 1
			3	SS	14									
			4	SS	50/0.100									
	Coring from a depth of 2.4 m to 2.6 m.		1	NQ	-									
			5	SS	43									20 53 26 1
337.1														
3.8	Sandy GRAVEL Dense Grey Wet		6	SS	41									
336.3														
4.6	GRAVELS and COBBLES containing pockets of silty sand Coring from a depth of 4.7 m and 4.9 m.		7	SS	50/0.152									
			2	NQ	-									
			8	SS	30/0.10									
	Coring from a depth of 5.9 m and 8.0 m.		9	SS	50/0.127									
			3	NQ	-									
			4	NQ	-									
332.3														
8.6	END OF BORE HOLE AT 8.6 m. BOREHOLE BACKFILLED WITH BENTONITE AND PATCHED WITH SAND AND ASPHALT AT SURFACE. NOTES: 1. The cored depth intervals and particle sizes of recovered gravels and cobbles are summarized as													

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Continued Next Page

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

RECORD OF BOREHOLE No 14495-01 2 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 175 813.3 E 291 094.7 ORIGINATED BY IR
 DIST Algoma HWY 556 BOREHOLE TYPE CME75, NW Casing Advance and Tricone, NQ Coring COMPILED BY AK
 DATUM Geodetic DATE 2022.11.01 - 2022.11.01 LATITUDE 46.721758 LONGITUDE -84.179290 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	20			40	60	80					
	Continued From Previous Page															
	follows: Depth (m) Recovered 2.4 - 2.6 1 x 180 mm, gravels between 20 and 40 mm 4.7 - 4.9 1 x 150 mm, 1 x 50 mm 5.9 - 8.0 gravels between 20 mm and 60 mm 8.0 - 8.4 1 x 100 mm, gravels between 30 mm to 40 mm 3. Borehole terminated at a depth of 8.6 m as a result of casing and tricone refusal within the granular deposit. 4. Water level at a depth of 0.6 m below ground surface in open borehole upon removal of casing prior to abandonment, but is not considered representative of the natural groundwater level due to the introduction of water for coring and tricone advancement.															

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

RECORD OF BOREHOLE No 14495-02 1 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 175 822.1 E 291 112.1 ORIGINATED BY IR
 DIST Algoma HWY 556 BOREHOLE TYPE CME75, NW Casing Advance, NQ Coring COMPILED BY AK
 DATUM Geodetic DATE 2022.11.15 - 2022.11.15 LATITUDE 46.721837 LONGITUDE -84.179062 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							
							20 40 60 80 100								
341.2	GROUND SURFACE														
0.0	ASPHALT(50 mm)		1	SS	50/0.12										
	SAND and GRAVEL to SAND, some gravel, trace non-plastic fines Very Dense Grey Moist (FILL) No sample recovery from a depth of 0.8 m to 0.9 m		2	SS	50/0.12										
	No sample recovery from a depth of 1.5 m to 1.7 m		3	SS	50/0.12										
	No sample recovery from a depth of 2.3 m to 2.4 m		4	SS	50/0.12										
			5	SS	50/0.07										
			6	SS	88									14 84	2 (SI+CL)
336.7	SILTY SAND some gravel, trace clay Dense to Very Dense Grey Wet		7	SS	55										
4.5			8	SS	46									12 44 39	5
			9	SS	50/0.12										
333.6	GRAVELS and COBBLES containing pockets of silt and sand Coring of gravel and cobbles between depths of 7.7 m and 9.1 m		1	NQ	-										
7.6			10	SS	50/0.12									1 39 55	5 Non-Plastic

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Continued Next Page

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

RECORD OF BOREHOLE No 14495-02 2 OF 2 METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 175 822.1 E 291 112.1 ORIGINATED BY IR
 DIST Algoma HWY 556 BOREHOLE TYPE CME75, NW Casing Advance, NQ Coring COMPILED BY AK
 DATUM Geodetic DATE 2022.11.15 - 2022.11.15 LATITUDE 46.721837 LONGITUDE -84.179062 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
330.2	GRAVELS and COBBLES containing pockets of silt and sand		11	SS	50/0.076		331										
11.0	Fresh, massive, black, fine grained, strong BASALT		2	NQ	-											FI	RUN #1 TCR=100% SCR=100% RQD=100%
			1	RUN	-		330									4	
			2	RUN	-											1	RUN #2 TCR=97% SCR=75% RQD=65%
							329									2	
																3	
																0	
							328									0	RUN #3 TCR=100% SCR=72% RQD=86%
			3	RUN	-											2	
327.0																1	
14.2	END OF BOREHOLE AT 14.2 m. BOREHOLE BACKFILLED WITH BENTONITE AND PATCHED WITH SAND AND ASPHALT AT SURFACE. NOTES: 1. The cored depth intervals and particle sizes of recovered gravels and cobbles are summarized as follows: Depth (m) Recovered 7.7 - 9.1 1 x 40 mm, 1 x 70 mm 10.1 - 11.0 1 x 155 mm, gravels between 30 mm and 60 mm 2. Water level at a depth of 0.6 m below ground surface in open borehole upon removal of casing prior to abandonment, but is not considered representative of the natural groundwater level due to the introduction of water for rock coring.																

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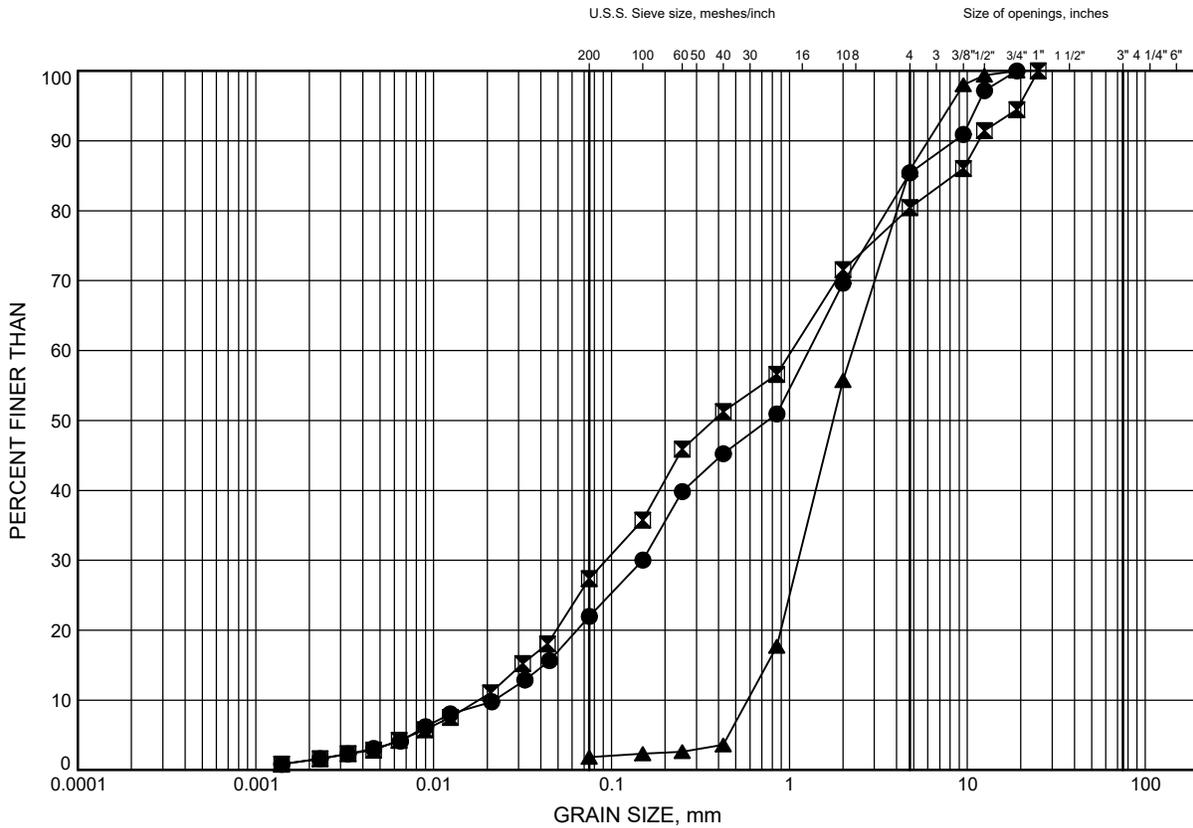
Appendix C

Geotechnical and Analytical Laboratory Test Results, and Core Photographs

Highway 556 Culvert Rehabilitation at STA 14+495
GRAIN SIZE DISTRIBUTION

FIGURE C-1

SAND to SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14495-01	1.0	339.9
⊠	14495-01	3.4	337.5
▲	14495-02	4.1	337.1

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 3/10/23

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

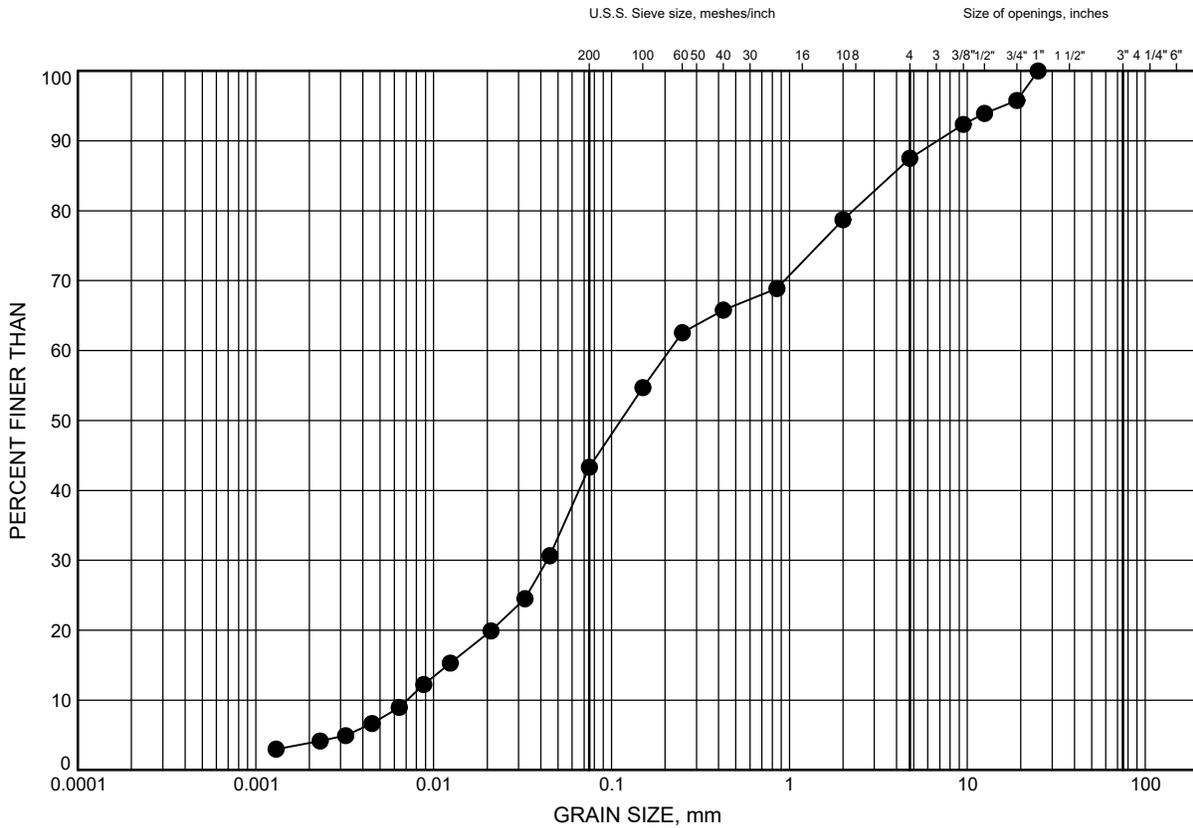


Prep'd AN
 Chkd. AK

Highway 556 Culvert Rehabilitation at STA 14+495
GRAIN SIZE DISTRIBUTION

FIGURE C-2

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14495-02	6.4	334.8

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 3/10/23

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

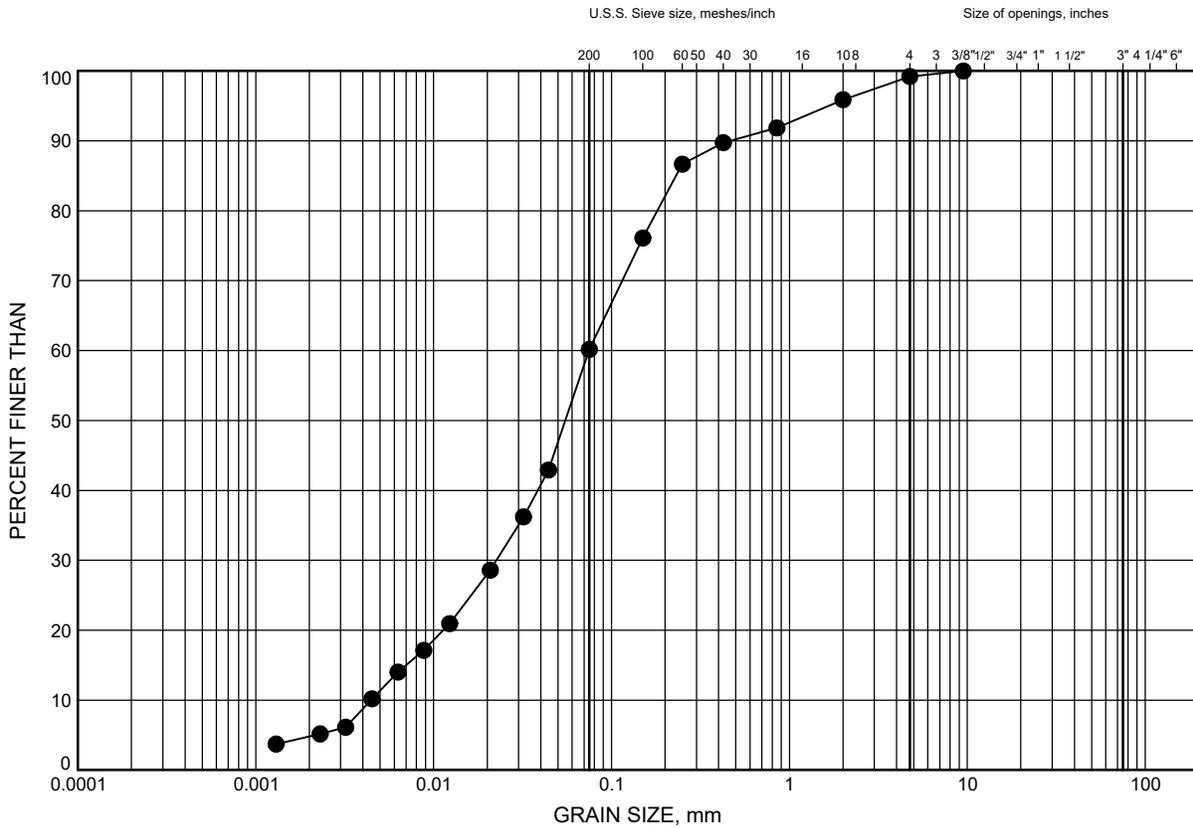


Prep'd AN
 Chkd. AK

Highway 556 Culvert Rehabilitation at STA 14+495
GRAIN SIZE DISTRIBUTION

FIGURE C-3

SILT and SAND (Pockets)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14495-02	9.3	331.9

GRAIN SIZE DISTRIBUTION - THURBER MTO-31719.GPJ 3/10/23

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



Prep'd AN
 Chkd. AK

Certificate of Analysis

Thurber Engineering Ltd. (Pickering)

1795 Ironstone Manor, Unit 1
Pickering, ON L1W 3W9
Attn: Ali Rajaei

Client PO:
Project: 31719/10
Custody:

Report Date: 10-Feb-2023
Order Date: 3-Feb-2023

Order #: 2306047

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

Paracel ID	Client ID
2306047-01	19741-01 / SS#7
2306047-02	14495-01 / SS#3

Approved By:



Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis

Report Date: 10-Feb-2023

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 3-Feb-2023

Client PO:

Project Description: 31719/10

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	7-Feb-23	7-Feb-23
Conductivity	MOE E3138 - probe @25 °C, water ext	7-Feb-23	7-Feb-23
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	8-Feb-23	8-Feb-23
Resistivity	EPA 120.1 - probe, water extraction	7-Feb-23	7-Feb-23
Solids, %	CWS Tier 1 - Gravimetric	6-Feb-23	7-Feb-23

Certificate of Analysis

Report Date: 10-Feb-2023

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 3-Feb-2023

Client PO:

Project Description: 31719/10

Client ID:	19741-01 / SS#7	14495-01 / SS#3	-	-
Sample Date:	06-Nov-22 09:00	01-Nov-22 09:00	-	-
Sample ID:	2306047-01	2306047-02	-	-
MDL/Units	Soil	Soil	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	94.6	96.8	-	-
----------	--------------	------	------	---	---

General Inorganics

Conductivity	5 uS/cm	50 [1]	367 [1]	-	-
pH	0.05 pH Units	6.69 [1]	6.32 [1]	-	-
Resistivity	0.10 Ohm.m	201 [1]	27.3 [1]	-	-

Anions

Chloride	10 ug/g dry	<10 [1]	143 [1]	-	-
Sulphate	10 ug/g dry	<10 [1]	20 [1]	-	-

Certificate of Analysis

Report Date: 10-Feb-2023

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 3-Feb-2023

Client PO:

Project Description: 31719/10

Method Quality Control: Blank

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

Certificate of Analysis
 Client: **Thurber Engineering Ltd. (Pickering)**
 Client PO:

Report Date: 10-Feb-2023
 Order Date: 3-Feb-2023
 Project Description: **31719/10**

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	21.0	10	ug/g	22.0			4.6	35	
Sulphate	10.5	10	ug/g	11.7			11.0	35	
General Inorganics									
Conductivity	127	5	uS/cm	130			2.4	5	
pH	7.53	0.05	pH Units	7.55			0.3	2.3	
Resistivity	78.7	0.10	Ohm.m	76.9			2.4	20	
Physical Characteristics									
% Solids	94.5	0.1	% by Wt.	94.6			0.1	25	

Certificate of Analysis

Report Date: 10-Feb-2023

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 3-Feb-2023

Client PO:

Project Description: 31719/10

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	120	10	ug/g	22.0	98.1	82-118			
Sulphate	112	10	ug/g	11.7	101	80-120			

Certificate of Analysis

Report Date: 10-Feb-2023

Client: Thurber Engineering Ltd. (Pickering)

Order Date: 3-Feb-2023

Client PO:

Project Description: 31719/10

Qualifier Notes:

Login Qualifiers :

Sample - One or more parameter received past hold time - Conductivity, Chloride, Sulphate, Sulphide

Applies to samples: 19741-01 / SS#7, 14495-01 / SS#3

Sample Qualifiers :

- 1 : Holding time had been exceeded upon receipt of the sample at the laboratory or prior to the analysis being requested.

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

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

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

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

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



Paracel Order Number (Lab Use Only) 2306047	Chain Of Custody (Lab Use Only) Nº
--	---

Client Name: Thurber Engineering Ltd.	Project Ref:	Page <u> </u> of <u> </u>
Contact Name: Ali Rajaei	Quote #:	
Address: 1815 IRONSTONE MANOR SUITE 11, PICKERING, ON, L1W 3W9	PO #: 31719/10	Turnaround Time <input type="checkbox"/> 1 day <input type="checkbox"/> 3 day <input type="checkbox"/> 2 day <input checked="" type="checkbox"/> Regular
Telephone: 416-575-9069	E-mail: ARAJAEI@THURBER.CA CC: AKOBYLINSKI@THURBER.CA	
		Date Required: _____

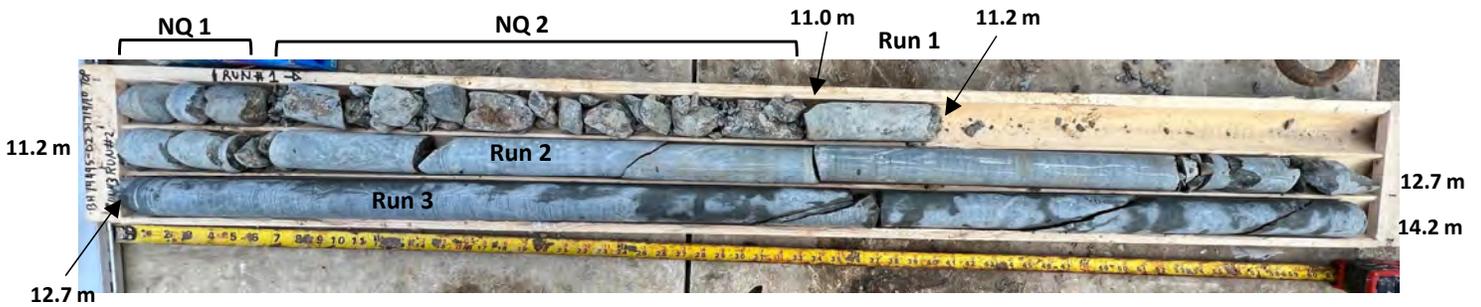
REG 153/04 <input type="checkbox"/> REG 406/19 <input type="checkbox"/>		Other Regulation		Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)		Required Analysis									
Table 1	Res/Park	Med/Fine	REG 558	PWQO	Matrix	Air Volume	# of Containers	Sample Taken		PH	Resistivity	Chloride	Sulphide	Sulphate	Conductivity
Table 2	Ind/Comm	Coarse	CCME	MISA				Date	Time						
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	soil		1	Nov 8 / 22		✓	✓	✓	✓	✓	✓
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	soil		1	Nov 1 / 22		✓	✓	✓	✓	✓	✓
<input type="checkbox"/>															
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<input type="checkbox"/>															

Comments:		Method of Delivery: Rabbex	
Relinquished By (Sign): <i>[Signature]</i>	Received By Driver/Depot: <i>[Signature]</i>	Received at Lab: Catherine McElyea	Verified By: <i>[Signature]</i>
Relinquished By (Print): A. Rajaei	Date/Time: 03-FEB-23, 13:00	Date/Time: Feb 4/23 14:50	Date/Time: Feb 6/23 12:24
Date/Time: Feb 2, 2023	Temperature: 13.5 °C	Temperature: 4.4 °C	pH Verified: <input type="checkbox"/> <i>[Signature]</i>



Borehole 19640-01 - Cored Gravels, and Cobbles

NQ 1 – 2.4 m – 2.6 m
NQ 2 – 4.7 m – 4.9 m
NQ 3 – 5.9 m – 8.0 m
NQ 4 – 8.0 – 8.4 m



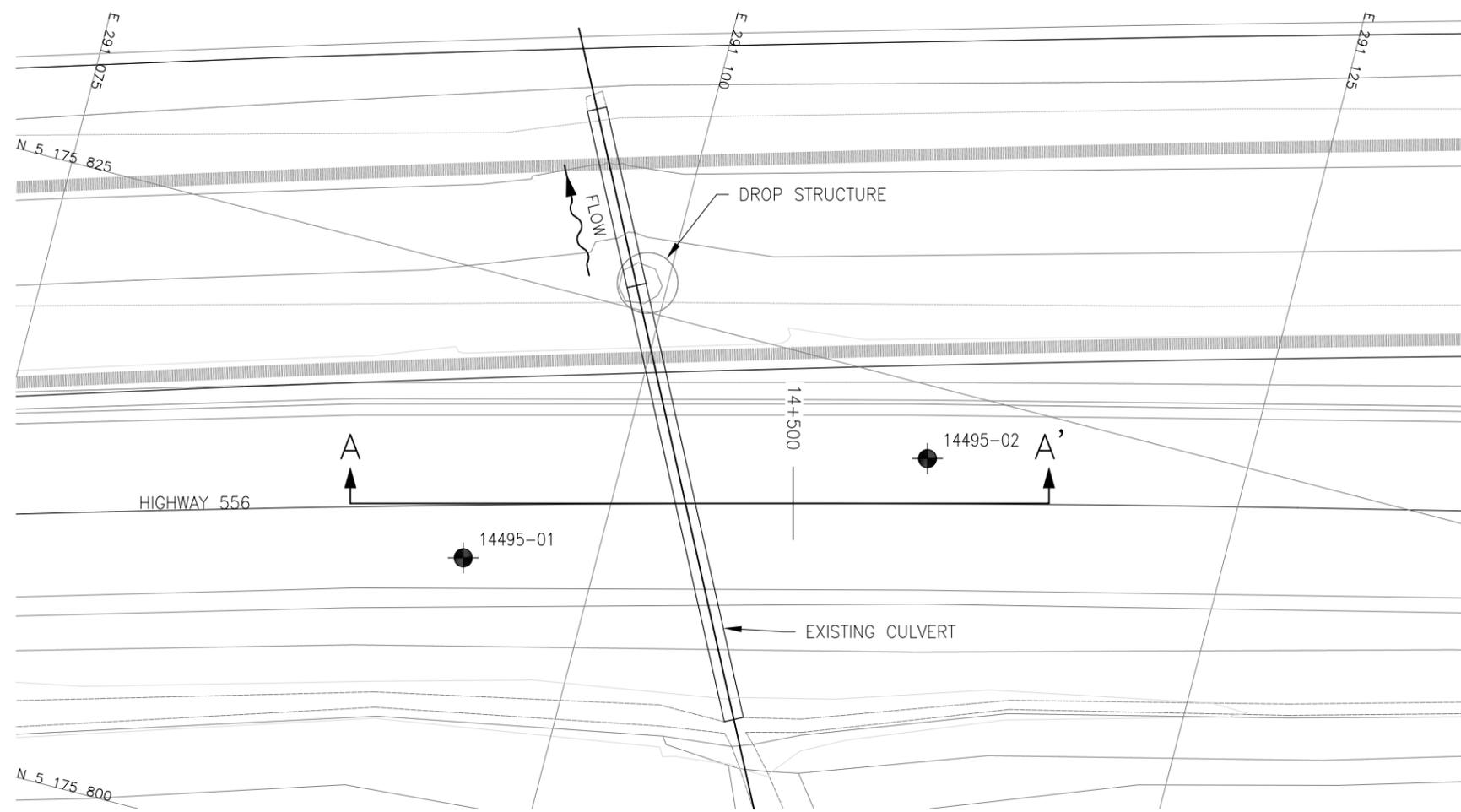
Borehole 14495-02 - Cored Gravels and Cobbles, and Bedrock

NQ 1 – 7.7 m – 9.2 m
NQ 2 – 10.1 m – 11.0 m
Run 1 – 11.0 m – 11.2 m
Run 2 – 11.2 m – 12.7 m
Run 3 – 12.7 m – 14.2 m



Appendix D

Borehole Locations and Soil Strata Drawing



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No WP No 5221-18-00	 SHEET
HIGHWAY 556 STATION 14+495 CULVERT BOREHOLE LOCATIONS AND SOIL STRATA	



KEYPLAN
LEGEND

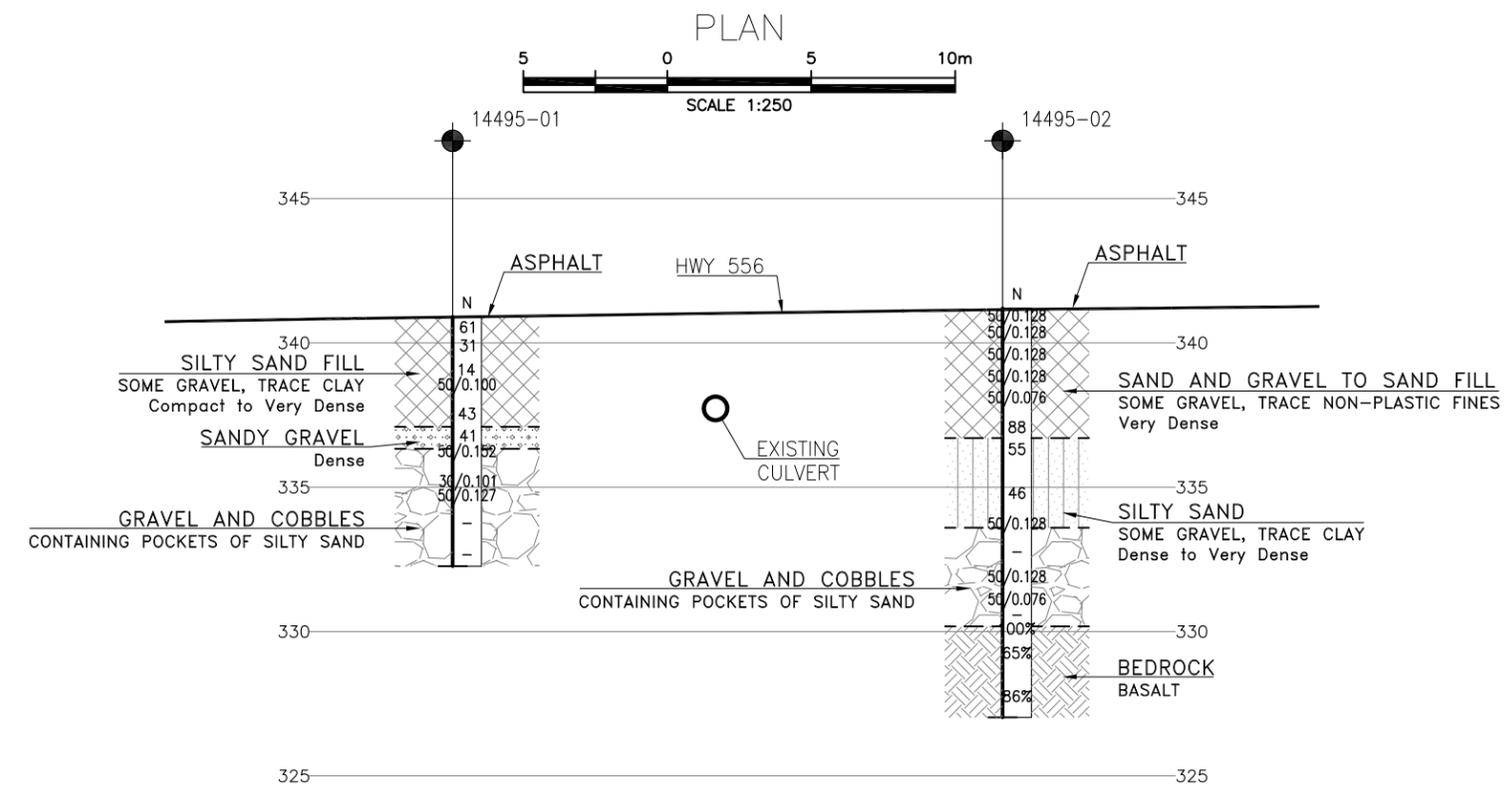
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
14495-01	340.9	5 175 813.3	291 094.7
14495-02	341.2	5 175 822.1	291 112.1



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

GEOCRES No. 41K-128



SECTION ALONG HWY 556 (A-A')



REVISIONS	DATE	BY	DESCRIPTION

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