THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
STRUCTURAL CULVERT No. 29-242/C1
HIGHWAY 17 DEIL'S CREEK CULVERT
TOWNSHIP OF HORTON, ON
G.W.P. 4076-13-00
AGREEMENT NUMBER: 4016-E-0014

GEOCRES NUMBER: 31F-202

SUBMITTED TO

McINTOSH PERRY CONSULTING ENGINEERS

LOCATION:
LATITUDE: 45.46873°
LONGITUDE: -76.62259°

JUNE 2018
20479

104, 2460 Lancaster Road, Ottawa ON K1B 4S5 T. 613 247 2121 F. 613 247 2185
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the rehabilitation of Deil's Creek Culvert located on Highway 17, within the Township of Horton, Ontario. Thurber carried out the investigation as a subconsultant to McIntosh Perry Consulting Engineers (MPCE) under Agreement No. 4016-E-0014.

A base plan was provided by MPCE for the preparation of this report.

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

2 SITE DESCRIPTION

Culvert 29-242/C1 is located at approximate Station 23+640 on Highway 17, approximately 30 m east of the Highway 17 / County Road 6 intersection in Renfrew County, Ontario. Within the project limits County Road 6 is also known as Gillan Road to the south and Lochwinnoch Road to the north of Highway 17. For clarity County Road 6 will be used to reference the cross streets.

The location of the culvert site is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

It is noted that for project orientation purposes, Highway 17 within the project limits, will be assumed to run west-east. Flow through the culvert is from south to north. The top of streambed elevation is approximately 136.0 m.

The existing 57 m long, open footed, concrete culvert has an internal span of 3.6 m and height of 1.5 m, (see the archival construction drawing for the culvert provided in Appendix A). The asphalt surface of the highway is at approximate Elevation 138.6 m and the cover over the culvert from shoulder to the top of the culvert is approximately 0.8 m.

It is understood that several deficiencies have been noted with the culvert and that MTO would like to explore alternatives for a holding strategy, with limited expenditures and repairs to the culvert until the highway is widened and the culvert is replaced for the ultimate four lane highway configuration.

At the culvert site, Highway 17 is undivided with one through lane in each direction, tapers for a westbound right and an eastbound left turn lane and an eastbound on-ramp. There is a paved gore area present in the southeast quadrant of the intersection. The Highway 17 / County Road 6

intersection is controlled with stop signs in the north and southbound lanes of County Road 6. Based on the drawings provided, the roadway cross-section at the culvert location consists of two, 3.7 m wide through lanes, two 3.6 m wide turning lanes and gravel shoulders. Concrete curb and gutters with catchbasins are present around the paved gore area, and concrete curb and gutters are present in the northeast and southwest quadrants of the intersection.

County Road 6 has one through lane in each direction with a northbound right turn ramp to access the Highway 17 eastbound speed change lane with gravel shoulders.

The existing embankment slopes at approximately 2H:1V to 2.5H:1V (Horizontal:Vertical) and are grass and brush covered; some trees are also present. Cattails were also present at the culvert inlet. Downstream from the culvert outlet, Deil's Creek flows west under County Road 6 through two CSP culverts. The creek banks north of the outlet slope up to a flat area that is grass and tree covered.

A buried telephone company utility is present near the culvert inlet and crosses the highway to the east of the culvert.

The storm water drainage in the area is to ditches, culverts, catchbasins and Deil's Creek.

Site photographs showing the general conditions at the site, and at the inlet and outlet are presented in Appendix D.

3 SITE INVESTIGATION

3.1 Previous Investigations

A draft preliminary GEOCRES report (31F-137, 2004) was reviewed. This investigation was carried out for the preliminary design of the proposed Highway 17 Underpass Structure at County Road 6 and included three boreholes designated CR6-1, CR6-2 and CR6-3. No reference to a final report could be found in the GEOCRES records.

3.2 Field Investigation

The field investigation was carried out between January 16th and 17th, 2018, and included advancing two boreholes. The approximate MTM Zone 9 locations and ground surface elevations of the boreholes are shown on Drawing No. 1, provided in Appendix A and are summarized in Table 3-1.

Table 3-1: Borehole Summary

Borehole	Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Borehole Termination Depth (m)	Borehole Termination Elevation (m)
17-1	Outlet	5036558.5	295234.5	137.2	8.7	128.5
17-2	Inlet	5036511.2	295195.8	136.7	7.2	129.5

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call to provide utility locates/clearances for the intended borehole locations.

The boreholes were advanced with a portable drill rig equipped with NQ size coring equipment.

The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in all boreholes during the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. All soil samples recovered from the boreholes were placed in moisture-proof containers and the samples were transported back to Thurber's Ottawa geotechnical laboratory for further examination and testing. Bedrock was cored following ASTM Standard D6032-08 in both boreholes with NQ size coring equipment. Bedrock core samples were stored in core boxes for transport.

The boreholes were backfilled with low-permeability bentonite pellets in general accordance with Ontario MOE Regulation 903.

The as-drilled locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber. The vertical datum used was the Temporary Benchmark (TBM) provided by MPCE and located near the northeast corner of the paved gore area. The TBM has a geodetic elevation of 138.067 m. The location of the TBM is indicated on Drawing No. 1 in Appendix A.

3.3 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples in accordance with current MTO standards. Grain size distribution analyses, and Atterberg Limits testing were also carried out on selected samples to MTO and ASTM standards. All recovered bedrock core was logged and core recoveries and RQD values were measured.

The geotechnical laboratory test results are presented on the Record of Borehole sheets in Appendix B and are illustrated on the figures in Appendix C.

4 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Overview / General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert inlet and outlet areas are presented on Drawing No. 1 in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions.

In general, the stratigraphy in the area of the boreholes is characterized by clay/silt fill overlying sandy silty clay (outlet), overlying silty sand (inlet), all underlain by bedrock. This stratigraphy is generally consistent with the stratigraphy encountered in the previous, 2004 report.

Based on the OGS 1:250 000 Scale Bedrock Geology Mapping of Ontario-Revision 1 (MRD126-REV1), the regional bedrock geology includes carbonate metasedimentary rocks, marble, calc-silicate rocks, skarn and tectonic breccias.

More detailed descriptions of the individual strata are presented below.

4.2 Clay with Sand Fill

A 50 mm thick rootmat layer was observed at the ground surface in Borehole 17-1.

A 600 mm thick, frozen, organic silt fill layer was observed at ground surface in Borehole 17-2. Sample recovery was poor. The moisture content of one sample was 39%.

A fill layer consisting predominantly of clay with sand was encountered in Borehole 17-1. The top of this layer was encountered at Elevation 137.1 m and the thickness of the layer was 1.4 m. The SPT 'N' values ranged from 9 to 10 however the ground was frozen at the time of the investigation which could have affected these values.

The moisture content of the samples tested ranged from 27% to 29%. The results of grain size analysis tests on a sample of the clay with sand fill indicated a gravel content of 0%, a sand content of 26%, a silt content of 53% and a clay content of 21%. Grain size analysis results are illustrated on Figure 1 in Appendix C.

The results of Atterberg Limits testing completed on a sample of the slay with sand fill indicated a liquid limit of 33, a plastic limit of 18, and a plasticity index 15. Atterberg Limits analysis results are illustrated on Figure 2 in Appendix C and indicate a low plastic clay (CL).

4.3 Sandy Silty Clay

A brown to grey sandy silty clay deposit was encountered beneath the fill layer in Borehole 17-1. The top of this layer was encountered at Elevation 135.6 m and the layer had a thickness of 1.5 m. The SPT N-values were 19 and 17 suggesting that this unit is very stiff.

The moisture content of the samples tested was 16% and 19%. The results of a grain size analysis test indicated a gravel content of 1%, sand content of 38%, a silt content of 43% and a clay content of 18%. Grain size analysis results are illustrated on Figure 3 in Appendix C.

The results of Atterberg Limits testing completed on a sample of this material indicated a liquid limit of 16, a plastic limit of 12, and a plasticity index 4. Atterberg Limits analysis results are illustrated on Figure 4 in Appendix C, and indicate a low plastic silty clay (CL-ML).

4.4 Silty Sand with Gravel

A sand deposit with varying amounts of silt and gravel was encountered beneath the sandy silty clay layer in Borehole 17-1 and beneath the fill layer in Borehole 17-2. The top of this layer was encountered at Elevations 134.1 m and 136.1 m. The thickness of this layer was 2.2 m and 3.6 m in Boreholes 17-1 and 17-2. The SPT 'N' values ranged from 7 to greater than 100; indicating a loose to very dense condition, but typically compact. Occasional cobbles were noted in both boreholes in this layer.

The moisture content of the samples tested ranged from 10% to 17%. The results of two grain size analysis tests indicated a gravel content of 29% and 32%, sand content of 47% and 58%, and a fines content (combined silt and clay size particles) of 13% and 21%. Grain size analysis results are illustrated on Figure 5 in Appendix C.

4.5 Marble Bedrock

The overburden materials were underlain by a white marble bedrock. Both boreholes were advanced into bedrock by coring with NQ-size coring equipment. Photographs of the bedrock core are provided in Appendix B.

A summary of the bedrock surface elevation is provided in Table 4-1.

Table 4-1: Bedrock Summary

Borehole	Location	Ground Surface Elevation (m)	Depth Below Existing Grade (m)	Top of Bedrock Elevation (m)
17-1	Outlet	137.2	5.2	132.0
17-2	Inlet	136.7	4.2	132.5

The total core recovery ranged from 70% to 100%, the solid core recovery ranged from 0% to 100% and the Rock Quality Designation (RQD) ranged from 0% to 78%. Based on the RQD value the bedrock is classified as poor to good quality. A vertical fracture was encountered throughout the first run of bedrock core in Borehole 17-2 and the SCR and RQD values were measured as 0% for this run.

4.6 Groundwater Conditions

Groundwater levels measured in the open boreholes were not considered representative due to the introduction of water into the borehole during coring operations.

The water level in the Deil's Creek Culvert was measured at the time of Thurber's field investigation at a depth of 1.5 m below the top of the culvert at the inlet; corresponding to Elevation 136.1 m.

Seasonal fluctuations of the water level in the culvert is to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

Standpipe piezometers were installed in all three boreholes advanced for the Highway 17 Underpass investigation and the final groundwater levels were measured in the piezometers in October 2003. The measured water level ranged from Elevation 136.3 m to 135.0 m from south to north.

5 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole locations, and determined the ground surface elevations based on a temporary benchmark provided by McIntosh Perry Consulting Engineers. Forage M3 Drilling Services Inc. of Hawkesbury, Ontario supplied and operated the drilling equipment to carry out the drilling, sampling, and in-situ testing. Traffic control consisting of signs and cones was provided by Thurber. The drilling, and sampling operations in the field were supervised on a full-time basis by Nick Weil of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred J. Griffiths, Ph.D., P.Eng.
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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 GENERAL

This report presents the interpretation of the factual data obtained from a foundation investigation conducted by Thurber for the rehabilitation of the Deil's Creek Culvert located on Highway 17, in the Township of Horton, Ontario. Geotechnical input is provided herein to assist the design team in assessment of an appropriate cofferdam alternative.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The following sections provide geotechnical recommendations for the rehabilitation of the existing Deil's Creek Culvert. The discussions and recommendations presented in this report are based on the information provided by McIntosh Perry Consulting Engineers (MPCE) and on the factual data obtained during the course of this investigation.

6.1 Proposed Rehabilitation of Existing Culvert

The existing, open footed, concrete culvert is 57 m long, and has an internal span of 3.6 m and height of 1.5 m. It is understood that several deficiencies have been noted with the existing culvert and that MTO would like to explore alternatives for a holding strategy, with limited expenditures and repairs to the culvert until the highway is widened and the culvert is replaced for the ultimate four lane highway configuration.

Culvert rehabilitation may include temporary patches to the culvert soffit and interior side walls. It is understood that two lanes of traffic must be maintained during any culvert rehabilitation works.

A cofferdam and temporary creek water diversion may be required to access the culvert for the repairs.

7 DESIGN DISCUSSION

7.1 Geotechnical Assessment

Based on the results of the field and laboratory investigation and the information provided by MPCE with regards to the proposed culvert rehabilitation, the geotechnical considerations include the following.

- Concrete patching below the creek water level may be required, a cofferdam and creek water diversion will be required to control surface water and groundwater, and allow access to the culvert for repairs.
- Depth to the bedrock surface was approximately 4.2 m and 5.2 m; corresponding to elevations of 132.5 m and 132.0 m at the inlet and outlet respectively.
- In general, the overburden materials at the site consist of silts and sands.
- The estimated hydraulic conductivity of the native soils based on gradation analysis are as follows:
  Sandy Silty Clay (CL-ML) = $4x10^{-8}$ cm/s
  Silty Sand with Gravel (SM) = $3x10^{-3}$ cm/s
- The results of the utility locates carried out prior to commencement of the field work indicate that there is an existing telephone company utility alignment located near the culvert inlet.

8 CREEK DIVERSION AND DEWATERING RECOMMENDATIONS

8.1 Dewatering

The Contractor must be prepared to control the groundwater and surface water flow at the site to permit repairs to the culvert to be conducted in the dry. It is recommended that the repairs to the culvert be conducted during a low flow season such as after the spring freshet or prior to the fall season.

Dewatering and surface water diversion must remain operational and effective until the repairs to the culvert are complete and then should be decommissioned.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert them to this responsibility and to design the systems in accordance with SP No. FOUN0003.

The Dewatering Systems Designer Fill-in information for SP No. FOUN0003 are as follows:

Design Storm Return Period	Preconstruction Survey Distance
*	**
Where required, fill-in information will be provided in the Hydraulic Report	N/A

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517 and SP 517F01; Amendment to OPSS 517, July 2017.

The Table A Fill-ins for SP 517F01 are as follows:

<table>
<tr><td colspan="2">IDF Curve Location</td><td colspan="5">Latitude: 45.46873°</td><td colspan="2">Longitude: -76.62259°</td></tr>
<tr><td colspan="8">Temporary Flow Passage Systems</td></tr>
<tr><td rowspan="2">Site Name / Station Reference</td><td rowspan="2">Minimum Return Period (Years)</td><td colspan="4">Return Period Flow Estimates (m^3/s)</td><td rowspan="2">Design Engineer Requirements (Note 1)</td></tr>
<tr><td>2 Year</td><td>5 Year</td><td>10 Year</td><td>25 Year</td></tr>
<tr><td>**</td><td>***</td><td>****</td><td>****</td><td>****</td><td>****</td><td>*****</td></tr>
<tr><td>Site 29-242/C1
Deil's Creek Culvert Crossing of Highway 17,
Approximate Station 23+640</td><td colspan="6">Where required, fill-in information will be provided in the Hydraulic Report</td></tr>
<tr><td colspan="8">Dewatering Systems</td></tr>
<tr><td colspan="3">Site Name / Station Reference</td><td colspan="3">Preconstruction Survey Distance (Note 2) (m)</td><td colspan="2">Design Engineer Requirements (Note 1)</td></tr>
<tr><td colspan="3">**</td><td colspan="3">******</td><td colspan="2">*****</td></tr>
<tr><td colspan="3">Site 29-242/C1
Deil's Creek Culvert Crossing of Highway 17,
Approximate Station 23+640</td><td colspan="3">N/A</td><td colspan="2">No</td></tr>
<tr><td colspan="8">Note:
1. "Yes" means the design Engineer and design-checking Engineer shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work. "No" means a minimum experience level is not required for the design Engineer and design-checking Engineer.

2. "N/A" indicates a preconstruction survey is not required.</td></tr>
</table>

The groundwater level will fluctuate. The minimum groundwater level elevation for the site should be taken as the water level of the design storm return period as defined by SP 517F01 and SP FOUN0003.

It is anticipated that stream diversion will be carried out with a cofferdam directing creek water through a pipe placed through the existing culvert.

The presences of silt and sand soils at the stream bed suggest that a sand bag cofferdam system will not be effective where work is required more the 1 m below the creek level. For preliminary assessment purposes, the use of interlocking sheet pile dewatering system is considered feasible in this situation.

The design of sheet pile system is the responsibility of the Contractor and should be completed in accordance with OPSS.PROV 539 and designed for Performance Level 2. Typical lateral earth pressure coefficients are provided in Table 8-1. The values provided are for a horizontal backslope behind, and a horizontal surface in front of the shoring system. The lateral earth pressure parameters provided in Table 8-1 will need to be adjusted to suit the site geometry, as needed.

Table 8-1: Static Lateral Earth Pressure Coefficient

Parameter	Sandy Silty Clay	Existing Fill	Silty Sand with Gravel
Soil Unit Weight, kN/m^3, γ	18	20	20
Angle of Internal Friction, ϕ	27°	30°	33°
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.55	0.50	0.46
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.38	0.33	0.29
Coefficient of Passive Earth Pressure, K_p (Unrestrained Wall)	2.63	3.00	3.35

The designer of the sheet pile system must ensure the penetration depth is sufficient to achieve surface water and groundwater control objectives, prevent basal heave and provide base fixity, lateral stability and incorporate traffic loading and surcharge loading due to construction equipment and their operations and shall consider the slope of embankments and location of existing utilities and trenches. Bracing and dead-man anchors could be included to enhance lateral resistance where required.

To limit the disturbance of the culvert foundation soils, culvert backfill and existing roadway embankment it is recommended that sheet piles in close proximity to the culvert and embankment be cut off and left in place in accordance with OPSS.PROV 539.

8.2 Site Restoration and Backfilling

Site restoration and backfilling activities after the culvert repairs have been completed shall be in accordance with OPSS 902. Where backfill for the culvert is required, it must consist of free draining granular material conforming to OPSS.PROV 1010 Granular A or B Type II material specifications. New imported material conforming to Select Subgrade Material (SSM) or better may be used for backfilling the areas outside the culvert backfill zone as required. Compaction of backfill materials should be carried out in accordance with OPSS.PROV 501.

It is important that construction and rehabilitation works do not undermine the existing footings.

Once the creek diversion is operational, the inside of the culvert should be inspected for erosion, scour and/or undermining of the footings and if encountered, repairs carried out with appropriate protection.

Replacement of any outlet treatments if required, should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces as soon as practical to protect against surficial erosion in general accordance with OPSS.PROV 804.

9 CONSTRUCTION CONCERNS

The planned construction methodology includes repairs to the existing culvert and requires the construction of a temporary cofferdam and water diversion.

Potential construction concerns include, but are not necessarily limited to, the following:

- An adequate and effective surface water management and dewatering plan must be implemented to repair the culvert in the dry.

- The results of the utility locates carried out prior to commencement of the investigation field work indicate that there is an existing utility alignment located in front of the culvert inlet. The exact location of any utility alignments will need to be determined prior to commencing construction.

The successful performance of this rehabilitation project will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations will be required as per MTO SP No. 109S12, amendment to OPSS 902 during construction to confirm that the foundation recommendations are correctly implemented and material specifications are met.

10 CLOSURE

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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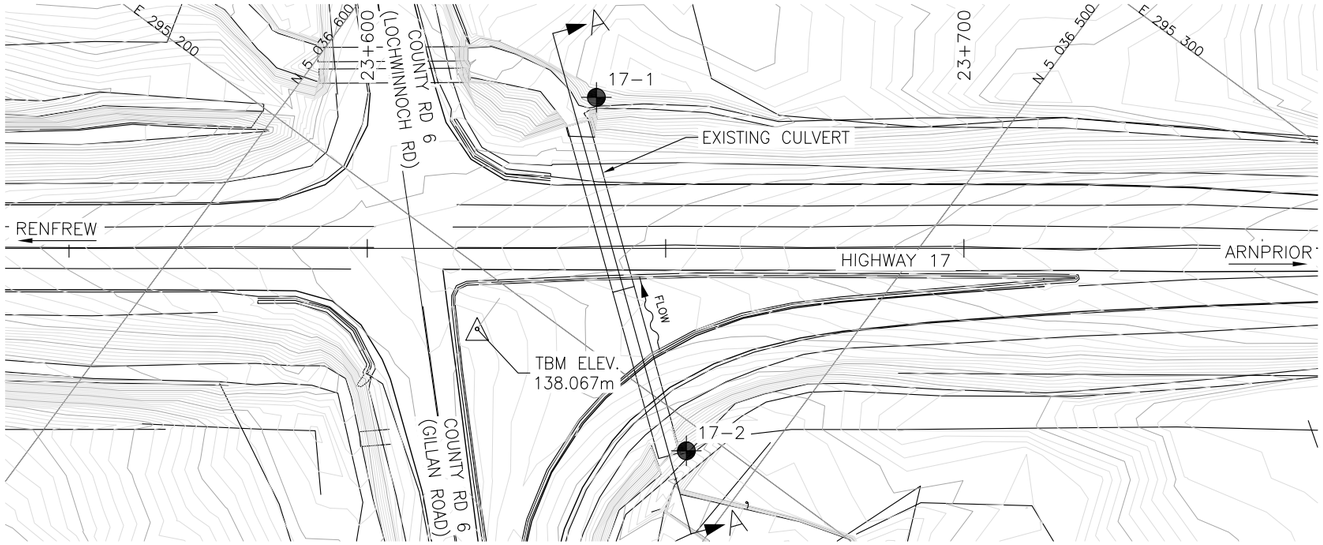
Senior Associate

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

APPENDIX A

BOREHOLE LOCATIONS AND SOIL STRATA DRAWING, JUNE 2018
CULVERT DRAWING, CONTRACT 73-186
BOREHOLE LOCATIONS AND SOIL STRATA DRAWING, MAY 2004

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

20 0 20 40m

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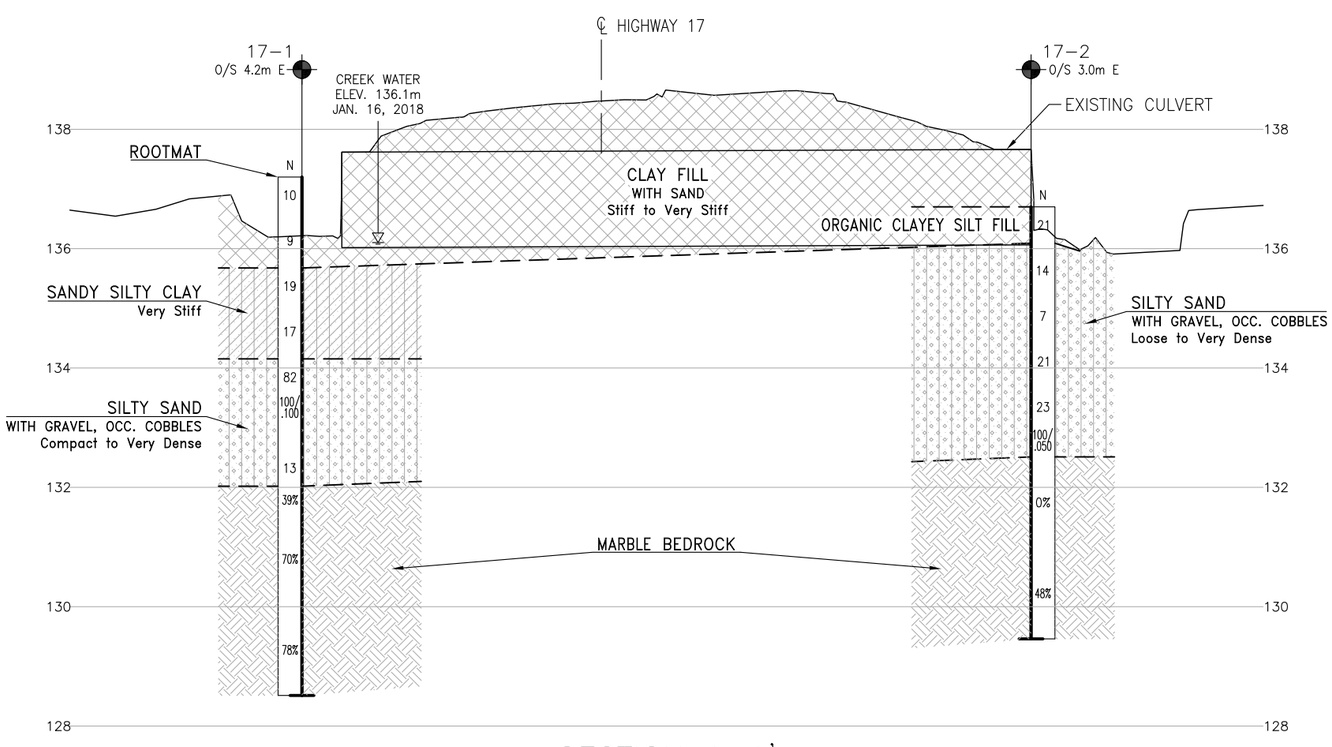


SECTION A–A'

10 0 10 20m H 1:500

2 0 2 4m V 1:100

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
K. T. C. POWER
100130652
2018/06/08
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
6/6/18
PROVINCE OF ONTARIO

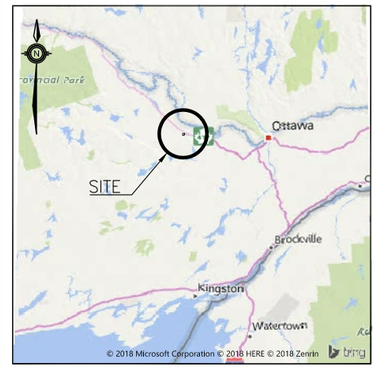
CONT No
GWP No 4076–13–00

SHEET

HIGHWAY 17
DEIL'S CREEK
CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

⊕	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
△	Temporary Benchmark
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
17–1	137.2	5 036 558.5	295 234.5
17–2	136.7	5 036 511.2	295 195.8

-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) Boreholes are shown in MTM Zone 9 coordinates.

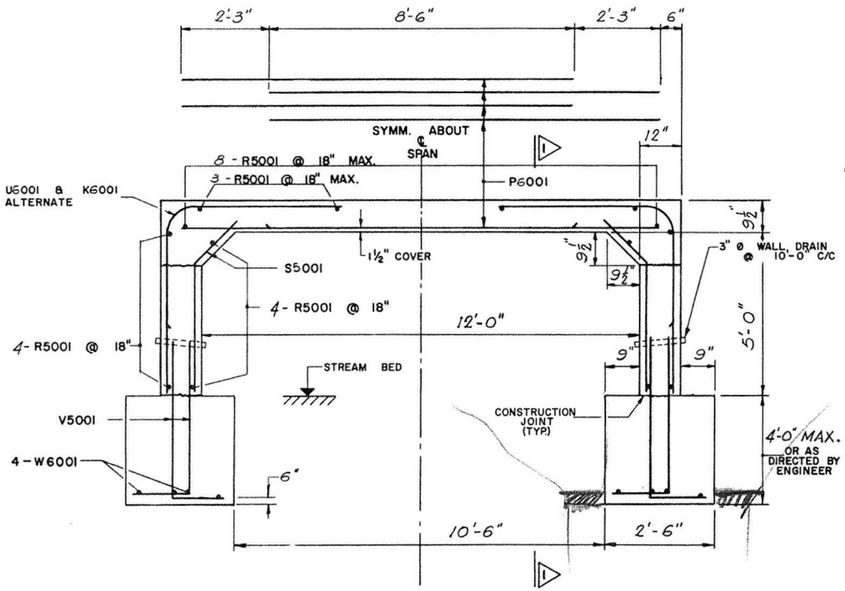
GEOCRES No. 31F-202

REVISIONS		
DATE	BY	DESCRIPTION

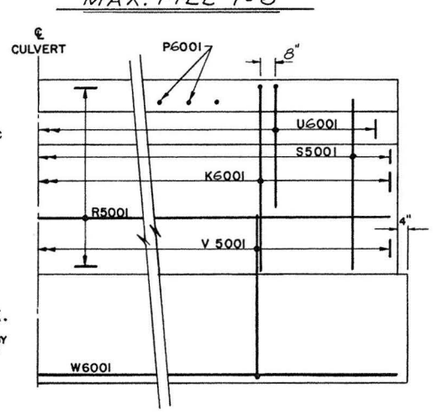
DESIGN	KP	CHK	–	CODE	LOAD	DATE	JUN 2018
DRAWN	MFA	CHK	KP	SITE	STRUCT	DWG	1

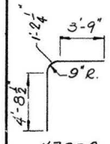
FILENAME: H:\Drafting\20000\20479\TED–20479–BHPP–DC.dwg
PLOTDATE: 6/5/2018 4:42 PM

CONT. No. 73-186	
W. P. No. 5-67-01	
CULVERT STATION 548+09	SHEET 65



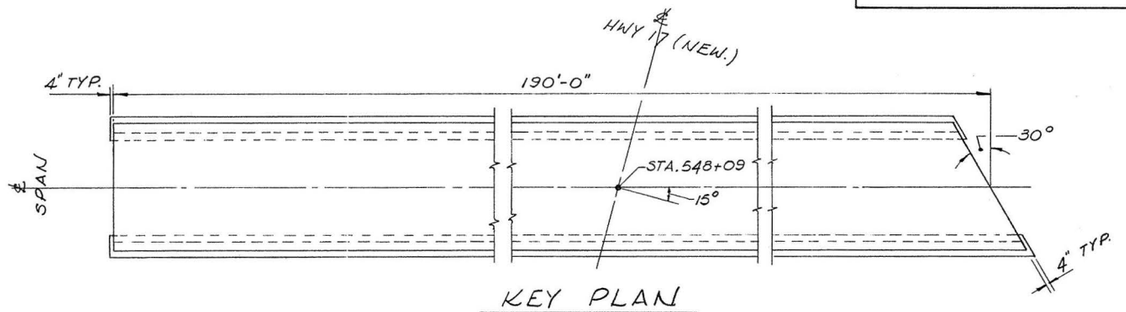
TYPICAL CULVERT SECTION



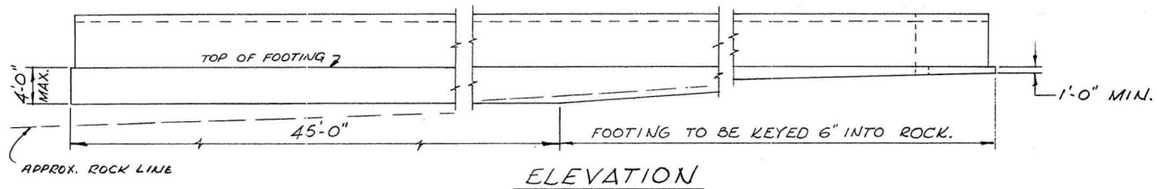


REINFORCING STEEL SCHEDULE FOR CULVERT					
MARK	Nº	SPAC.	LENGTH	DETAIL	REMARKS
P6001	276	8"	10'-9"	STRAIGHT	IN BOTTOM OF SLAB STAGGERED
K6001	276	16"	9'-3 1/4"	3'-3½" 3'-6" 1'-2 1/4" R=9"	IN SLAB AND LEG
U6001	276	16"	7'-11 3/4"		U6001 ALTERNATE WITH K6001
S5001	286	16"	5'-10½"	4'-2¾" 45° 1'-8"	INSIDE FACE OF LEG
R5001	240	18"	22'-6"	STRAIGHT 30 LINES. 8 PER LINE	DISTRIBUTION STEEL (MIN. LAP 1'-6")
V5001	572	16"	6'-9"	5'-8"	FOOTING DOWELS
W6001	64	—	22'-9"	STRAIGHT 8 LINES. 8 PER LINE	LONGITUDINAL IN FOOTING (LAP 2'-0")
P7002	13	—	12'-0"	STR.	BOT. OF SLAB. STAGGERED
K7002	19	8"	9'-7 3/4"	SEE DETAIL	IN SLAB & LEG.
R5002	10	18"	22'-6"	STR.	DISTRIBUTION STEEL
R5003	2	18"	23'-7	STR.	
R5004	2	18"	24'-8"	STR.	
R5005	1	18"	25'-9"	STR.	
R5006	1	18"	26'-10"	STR	
R5007	2	18"	27'-11"	STR	
R5008	2	18"	29'-0"	STR.	
R5009	10	18"	30'-0"	STR.	
W6002	4	—	22'-0"	STR.	LONGITUDINAL IN FOOTING.
W6003	4	—	30'-0"	STR.	

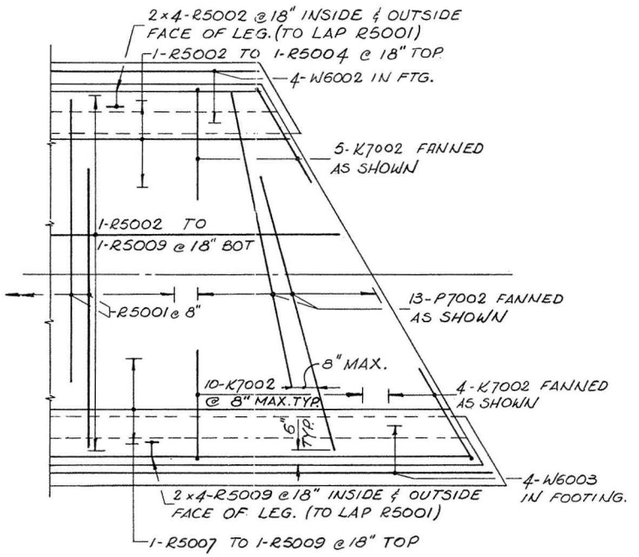
DRAWING NOT TO SCALE



KEY PLAN



ELEVATION



PART PLAN
AT S. END OF CULVERT

GENERAL NOTES

- CLASS OF CONCRETE 3000 PSI.
- CLEAR COVER TO REINFORCING STEEL 3" EXCEPT AS NOTED.
- ALL EXPOSED CORNERS TO BE CHAMFERED ¾".
- NO CONCRETE SHALL BE PLACED FOR ANY FOOTING, UNTIL THE DEPTH OF THE EXCAVATION AND CHARACTER OF THE FOUNDATION MATERIAL HAVE BEEN APPROVED BY THE ENGINEER.
- FILL SHALL BE PLACED AT BOTH SIDES OF CULVERT SIMULTANEOUSLY.
- CULVERT AND WINGWALLS SHALL BE BUILT IN ACCORDANCE WITH M.T.C. FORM 9.
- REINFORCING STEEL SHALL BE HARD GRADE.
- STEEL FOR THIS CULVERT (INCLUDING WINGWALLS WHERE APPLICABLE) SHALL BE BUNDLED SEPARATELY AND MARKED WITH STATION NUMBER.
- WALL DRAINS SHALL BE BITUMINIZED FIBRE PIPE. VERTICAL LOCATION OF WALL DRAINS SHALL BE DETERMINED IN FIELD BY THE ENGINEER.
- I.F. DENOTES INSIDE FACE.
- O.F. DENOTES OUTSIDE FACE.
- E.F. DENOTES EACH FACE.
- FOR GRANULAR BACKFILL REQUIREMENTS SEE DD809 A, B & C.

CULVERT & WINGWALL QUANTITIES		
	CULVERT	WINGWALLS
WT. OF REINF. STEEL	13.52 TONS	TONS
VOLUME OF CONCRETE	253.55 CU. YDS.	CU. YDS.

SS 114-1

B.S. - M.J.D.

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

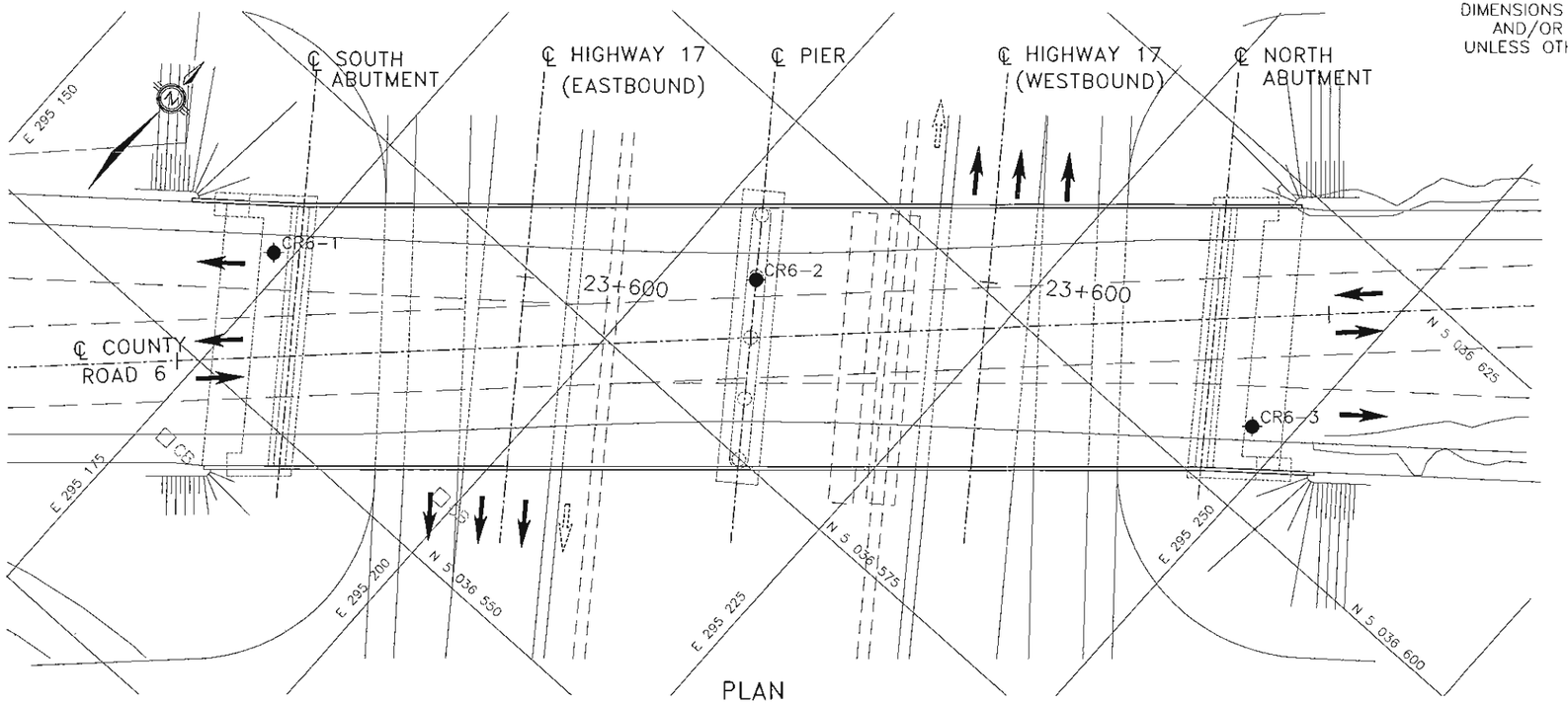
HWY.17
GWP NO. 647-92-00

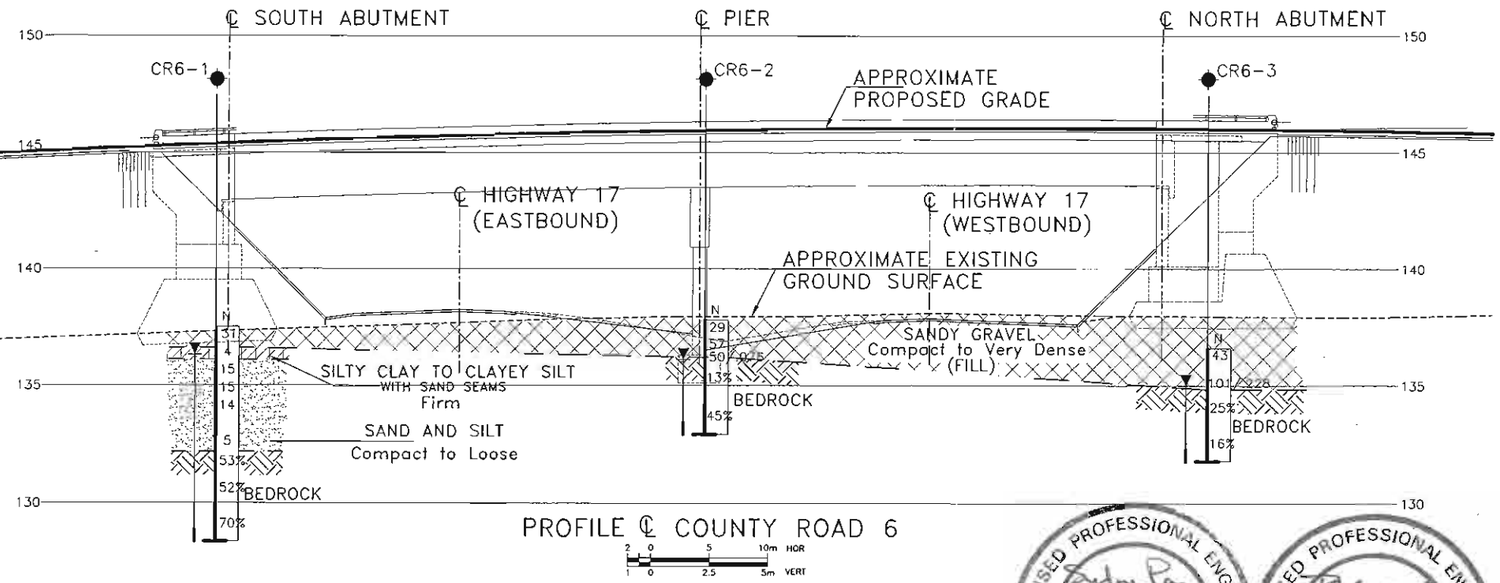
HIGHWAY 17 TWINNING
COUNTY ROAD 6 UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

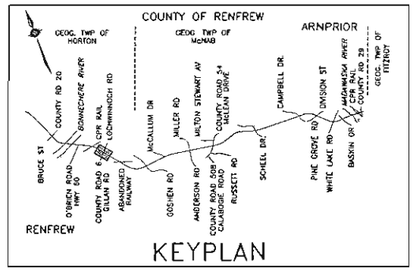
SHEET

engineers architects planners

THURBER ENGINEERING LTD.







LEGEND

●	Bore Hole
⊕	Dynamic Cone Penetration Test (cone)
◈	Bore Hole & Cone
N	Blows/ 0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/ 0.3m (60° Cone, 475 J/blow)
PH	Pressure, Hydraulic
▼	WL at Time of Investigation
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CR6-1	137.5	5 036 561.3	295 173.5
CR6-2	137.8	5 036 587.5	295 206.5
CR6-3	136.6	5 036 606.5	295 247.0

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations . Between Bore Holes the boundaries are assumed from geological evidence .

LICENSED PROFESSIONAL ENGINEER
S. PANG
May 28/04
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 28/04
PROVINCE OF ONTARIO

REVISIONS		
MAY. 04	SP	ISSUED AS DRAFT FOR REVIEW
DATE	BY	DESCRIPTION

DESIGN SP	CHK PKC	CHBDC 2000	LOAD	DATE MAY.2004	
DRAWN SS	CHK SP	SITE 29-408	STRUCT	DWG.	

APPENDIX B

RECORD OF BOREHOLE SHEETS
BEDROCK CORE PHOTOGRAPHS

THURBER

SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

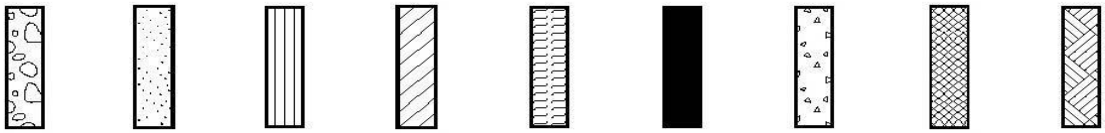
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

THURBER

STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel
Sand
Silt
Clay
Organics
Asphalt
Concrete
Fill
Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

THURBER

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L= Liquid Limit

THURBER

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
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 structures are preserved.

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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-1 1 OF 1 METRIC

GWP# 4076-13-00 LOCATION Site 29-242/C1 Deil's Creek Culvert, MTM Zone 9: N 5 036 558.5 E 295 234.5 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY CM

DATUM Geodetic DATE 2018.01.16 - 2018.01.17 CHECKED BY KP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 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
137.2											
0.0 / 0.1	**50 mm ROOTMAT**						137				
	Clay with sand Stiff to very stiff Brown **FILL**		1	SS	10						
			2	SS	9		136				0 26 53 21
135.6											
1.5	**SANDY SILTY CLAY (CL-ML)** Very stiff Brown to grey		3	SS	19		135				
			4	SS	17						1 38 43 18
134.1											
3.0	**SILTY SAND (SM) with gravel** - occasional cobbles Compact to very dense Grey		5	SS	82		134				32 47 21 (SI+CL)
			6	SS	100/ 100mm						
	- 180 mm Cobble at 3.9 m						133				
			7	SS	13						
132.0											
5.2	**MARBLE BEDROCK** Slightly weathered Poor to good quality Medium grained White		1	RUN			132				RUN #1 TCR=100% SCR=100% RQD=39%
			2	RUN			131				RUN #2 TCR=100% SCR=72% RQD=70%
			3	RUN			130				RUN #3 TCR=100% SCR=100% RQD=78%
128.5							129				
8.7	End of Borehole										

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

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

ONTMT4S 20479 DEIL'S CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 5/6/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-2 1 OF 1 METRIC

GWP# 4076-13-00 LOCATION Site 29-242/C1 Deil's Creek Culvert, MTM Zone 9: N 5 036 511.2 E 295 195.8 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY CM

DATUM Geodetic DATE 2018.01.17 - 2018.01.17 CHECKED BY KP

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
136.7											
0.0	Organic clayey silt - frozen Brown		1	SS	21						
136.1	**FILL**										
0.6	**SILTY SAND (SM) with gravel** Loose to very dense Brown to grey		2	SS	14		136				
			3	SS	7		135				29 58 13 (SI+CL)
			4	SS	21		134				
			5	SS	23		133				
132.5	- 175 mm Cobble at 4.0 m		6	SS	100/ 50mm						
4.2	**MARBLE BEDROCK** Slightly weathered Poor to good quality Medium grained White		1	RUN			132				RUN #1 TCR=97% SCR=0% RQD=0% *vertical fracture throughout Run#1
			2	RUN			131				RUN #2 TCR=70% SCR=67% RQD=48%
129.5							130				
7.2	End of Borehole										

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

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

ONTMT4S 20479 DEIL'S CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 5/6/18

Borehole 17-1

Box 1 (of 2)

Elevation 132.0 m to 129.6 m

THURBER ENGINEERING LTD.

Foundation Investigation
Site 29-242/C1 Deil's Creek Culvert
Highway 17
Renfrew County, Ontario

G.W.P. No.: 4076-13-00

Project No.: 20479

Borehole 17-1

Box 2 (of 2)

Elevation 129.6 m to 128.5 m

THURBER ENGINEERING LTD.

Foundation Investigation
Site 29-242/C1 Deil's Creek Culvert
Highway 17
Renfrew County, Ontario

G.W.P. No.: 4076-13-00

Project No.: 20479

Borehole 17-2

Box 1 (of 1)

Elevation 132.6 m to 129.5 m

THURBER ENGINEERING LTD.

Foundation Investigation
Site 29-242/C1 Deil's Creek Culvert
Highway 17
Renfrew County, Ontario

G.W.P. No.: 4076-13-00

Project No.: 20479

APPENDIX C

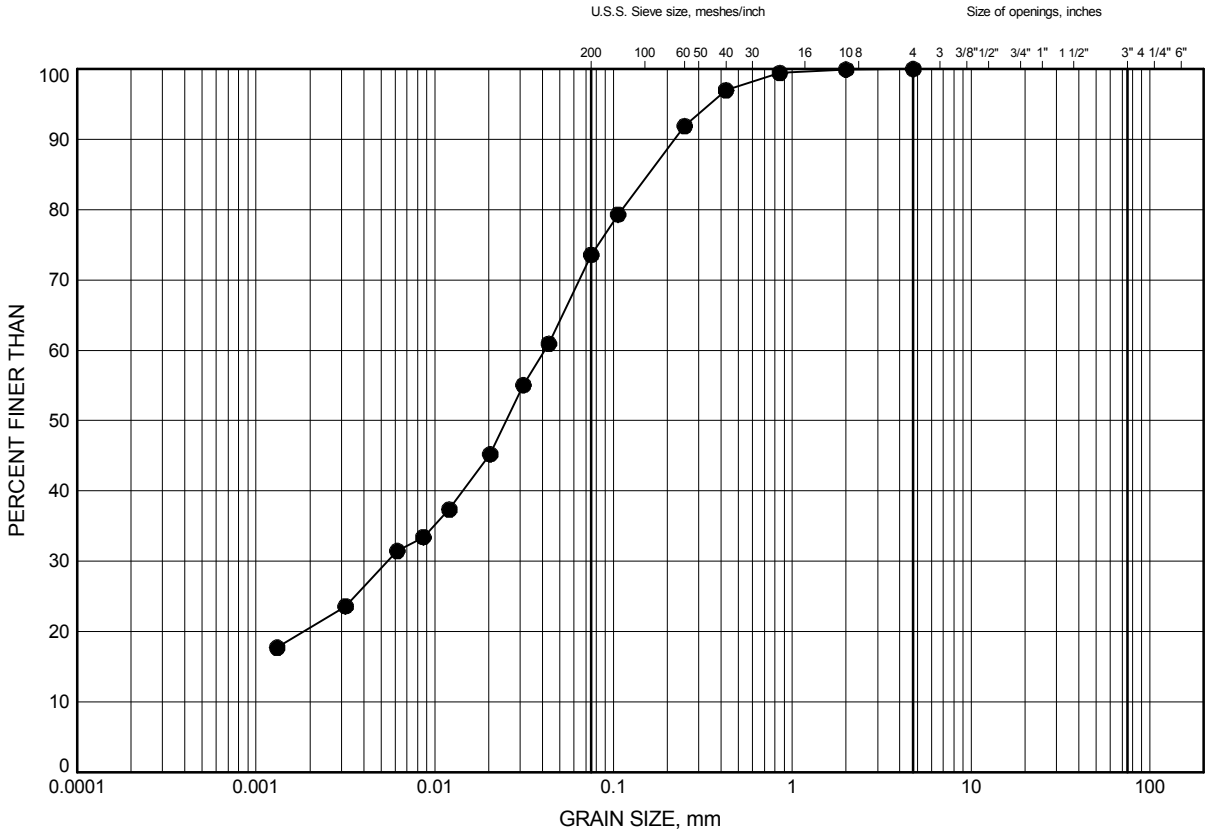
LABORATORY TEST RESULTS

Site 29-242/C1 Deil's Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE 1

Clay with Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	1.07	136.09

Date June 2018

GWP# 4076-13-00

THURBER

Prep'd KCP

Chkd. FG

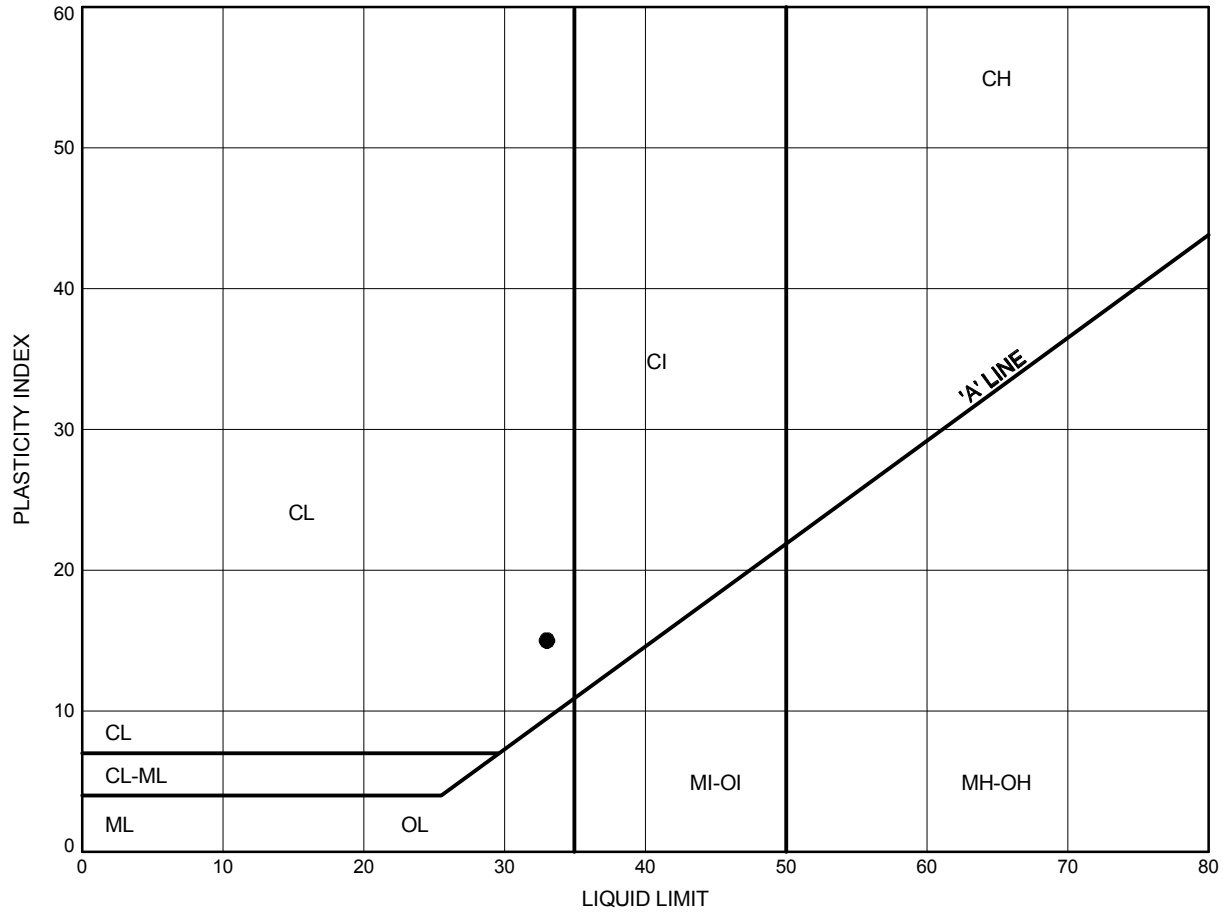
GRAIN SIZE DISTRIBUTION - THURBER 20479 DEIL'S CREEK CULVERT.GPJ 7/6/18

Site 29-242/C1 Deil's Creek Culvert

ATTERBERG LIMITS TEST RESULTS

FIGURE 2

Clay with Sand Fill



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	1.07	136.09

Date June 2018

GWP# 4076-13-00

THURBER

Prep'd KCP

Chkd. FG

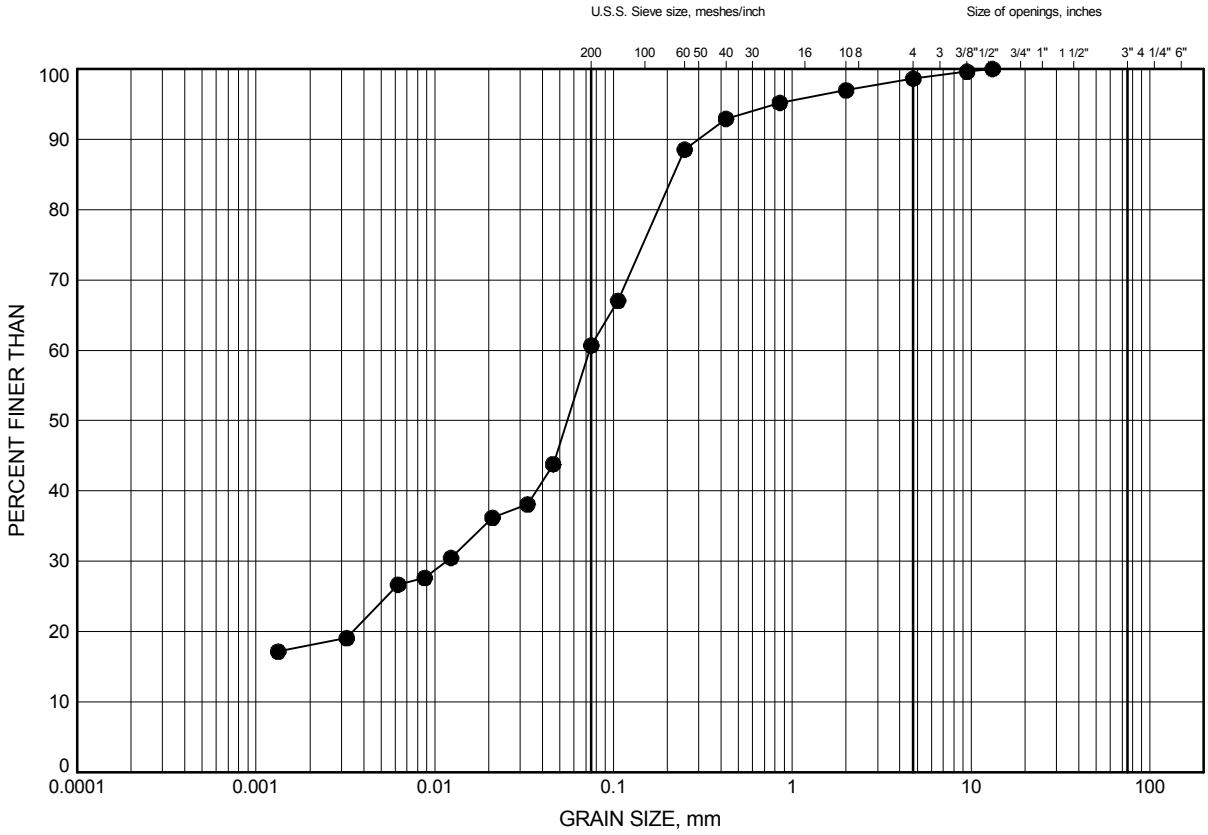
THURBALT 20479 DEIL'S CREEK CULVERT.GPJ 7/6/18

Site 29-242/C1 Deil's Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE 3

Sandy Silty Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	2.59	134.57

Date March 2018

GWP# 4076-13-00

THURBER

Prep'd KCP

Chkd. FG

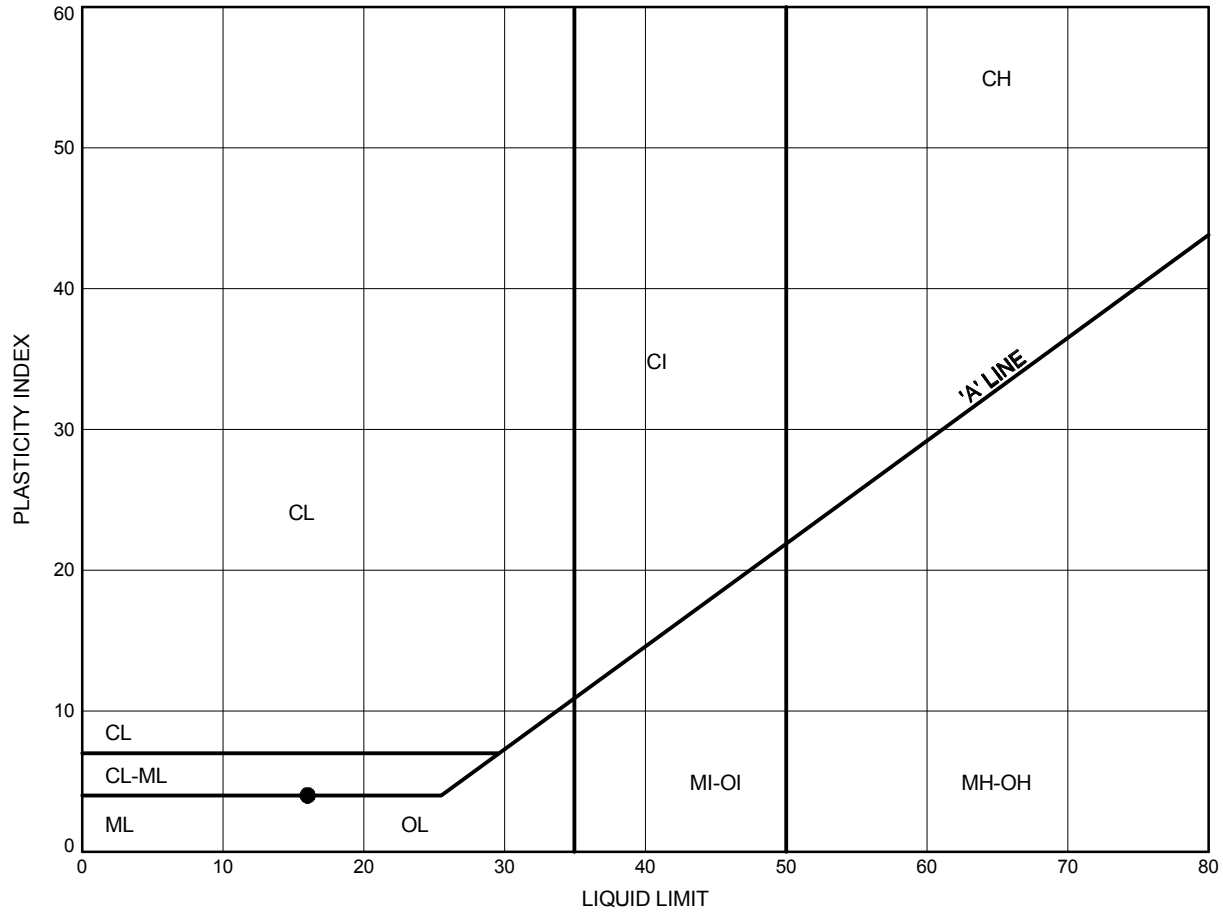
GRAIN SIZE DISTRIBUTION - THURBER 20479 DEIL'S CREEK CULVERT.GPJ 22/3/18

Site 29-242/C1 Deil's Creek Culvert

ATTERBERG LIMITS TEST RESULTS

FIGURE 4

Sandy Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	2.59	134.57

Date June 2018

GWP# 4076-13-00

THURBER

Prep'd KCP

Chkd. FG

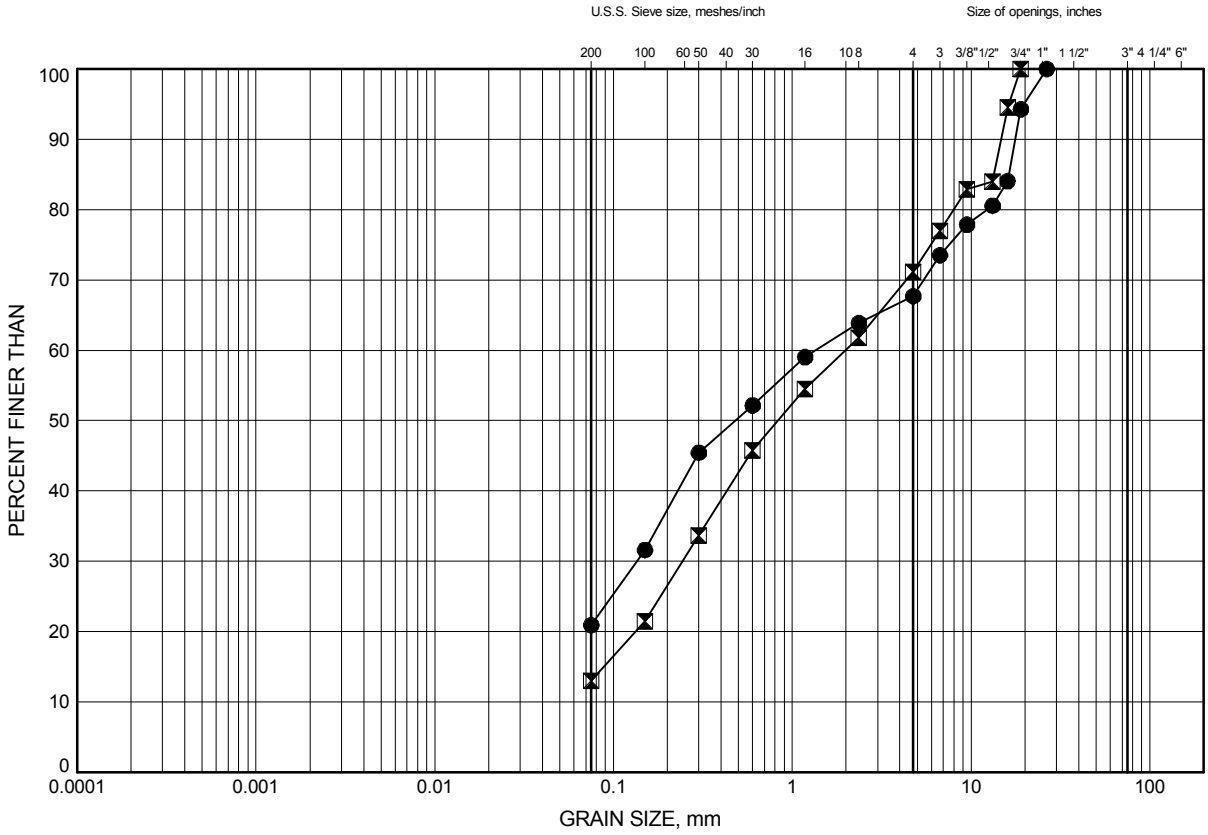
THURBALT 20479 DEIL'S CREEK CULVERT.GPJ 7/6/18

Site 29-242/C1 Deil's Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE 5

Silty Sand with Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	3.35	133.81
⊠	17-2	1.83	134.92

Date March 2018

GWP# 4076-13-00

THURBER

Prep'd KCP

Chkd. FG

GRAIN SIZE DISTRIBUTION - THURBER 20479 DEIL'S CREEK CULVERT.GPJ 22/3/18

APPENDIX D

SITE PHOTOGRAPHS

Photograph 1: Roadway platform and embankment at culvert inlet looking southwest

Photograph 2: Looking upstream from culvert inlet

Note all photographs were taken on December 20th, 2017.

Photograph 3: Looking west along ditchline towards the existing culvert outlet

Photograph 4: Looking downstream from culvert outlet

Note all photographs were taken on December 20th, 2017.

Photograph 5: Looking southeast from County Road 6 towards culvert outlet

Note all photographs were taken on December 20th, 2017.

APPENDIX E

LIST OF REFERENCED SPECIFICATIONS

LIST OF REFERENCED SPECIFICATIONS

OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling of Structures
OPSS.PROV 1010	Material Specification for Aggregates-Base, Subbase, Select Subgrade, and Backfill Material
Special Provision 109S12	Amendment to OPSS 902, March 2018
Special Provision 517F01	Amendment to OPSS 517, July 2017
Special Provision FOUN0003	Dewatering Structure Excavations, March 2018