



**FINAL
FOUNDATION INVESTIGATION REPORT
HIGHWAY 144 MCKEOWN CREEK CULVERT REHABILITATION (47X-0249/C0)
MCKEOWN TOWNSHIP, ONTARIO
ASSIGNMENT NO.: 5021-E-0039
GWP 5183-16-00**

GEOCRES NO.: 42A04-001

Location: Lat: 48.221314°, Long: -81.572635°

Client Name: AECOM Canada Ltd.

Date: December 13, 2024

File: 36917



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1. INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the rehabilitation of the McKeown Creek Culvert (Site No. 47X-0249/C0) which crosses beneath Highway 144 of in the Township of McKeown, Ontario. Thurber carried out the foundation investigation as a subconsultant to AECOM Canada Ltd. (AECOM) under Agreement No. 5021-E-0039.

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

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

2.1 General

The McKeown Creek Culvert site is located on Highway 144 approximately 18.7 km south of Highway 101 and approximately 50 m north of McKeown Road. The culvert site is near Sta. 13+773 McKeown Township (drawing B-1135-155-5, dated January 2023). For project purposes, Highway 144 is herein described as oriented north-south, and the creek is described as oriented east-west.

At the location of the culvert, Highway 144 is a two-lane highway and has a posted speed limit of 80 km/hr. The lane width is approximately 3.5 m per lane and the shoulders are unpaved with a width of approximately 1.0 m. Steel cable guiderails on wooden posts are present along both

sides of the highway. Traffic volumes on this section of Highway 144 are understood to have been 1,400 AADT in 2019.

Embankment slopes, in the vicinity of the culvert site, are inclined at approximately 2H:1V. The existing highway embankment side slopes at the site did not show any visible signs of global instability at the time of the investigation. Survey drawings dated January 2023 and provided by AECOM indicate that the road surface is at approximately elevation 326.8 m with a slight increase in elevation to the north.

The January 2023 survey drawings from AECOM indicated the water level was at elev. 323.5 m in August 2018. The creek water level was measured by Thurber to be at approximate elevation 324.0 m in July 2024. The creek crosses the highway nearly perpendicular to the highway alignment and away from the highway the creek flows in a meandering manner on both sides of Highway 144. The creek flows eastward ending at Kenogamissi Lake.

The site is in a rural setting and the area to the east and west of the highway alignment is marshy and grasses are located along the embankments, with occasional short trees along the ditch lines. A gravel access road is present from McKeown Road to the southeast of the culvert. A mix of agricultural land and woodlots can be found in the surrounding area, along with cottage properties at Kenogamissi Lake.

Photographs showing the existing conditions in the project area at the time of the field investigation are included in Appendix D for reference.

2.2 Existing Structure Information

The existing culvert is described in the Terms of Reference (TOR) as a single cell, reinforced, cast-in-place rigid frame box culvert. The structure has a reported height of 3.0 m, span of 4.9 m and a length of 29.3 m. The January 2023 survey drawings provided by AECOM indicate that the structure is 2.810 m in height, with a 4.875 m span and a length of 28.872 m and with the inlet and outlet at elev. 322.38 and 322.25 m, respectively.

The structure was constructed in 1964 as part of Contract 1964-0359. There is understood to be no record of previous rehabilitation of the culvert.

The June 2021 Structure Inspection Report indicates the structure is in fair condition and that the embankment slopes are in good condition. Transverse and longitudinal cracks were noted in the asphalt above the culvert.

Base plan mapping was provided by AECOM for the preparation of this report.

2.3 Existing Subsurface Information

A historical foundation investigation report was not available for this site within the online Geocres Library.

Bedrock Geology Map (MRD126)¹ indicates the site is underlain by tonalite and granodiorite of the foliated tonalite suite.

3. SITE INVESTIGATION AND FIELD TESTING

Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations. The foundation investigation and field-testing program was carried out between July 16 and 19, 2024 and consisted of two off-road boreholes identified as Boreholes 24-301 and 24-302. The boreholes were advanced using portable drilling methods, NW casing, and NQ coring equipment. A raft was utilized to create a level drilling platform at the toe of the slope/edge of the water.

A summary of the borehole coordinates, elevations, and termination depths is provided in Table 3-1. The as-drilled borehole elevations were surveyed by Thurber with a surveyor's level with a reported vertical accuracy of +/- 1.5 mm and were measured relative to benchmark HCP 930 (elev. 325.486 m). Horizontal locations were measured by Thurber relative to existing site features. The elevations and borehole coordinates were reviewed and referenced to the benchmarks and survey data provided by AECOM. The borehole coordinates and elevations are shown on the Borehole Location and Soil Strata drawing included in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 12.

Table 3-1 Borehole Summary

| BOREHOLE NO. | LOCATION | NORTHING (m) | EASTING (m) | GROUND SURFACE ELEVATION (m) | TERMINATION DEPTH (m) |
|--------------|----------------------|--------------|-------------|------------------------------|-----------------------|
| 24-301 | Southeast of culvert | 5 342 653.4 | 262 277.0 | 324.5 | 7.0 |
| 24-302 | Northwest of culvert | 5 342 659.4 | 262 240.5 | 323.7 | 4.2 |

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586. Coring

¹ <http://www.geologyontario.mndm.gov.on.ca/mines/data/google/mrd126/doc.kml>

techniques were required to advance the boreholes. Bedrock was not encountered within the depth of investigation.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's Ottawa laboratory for further examination and testing.

A 32 mm diameter monitoring well was installed in each borehole to allow for measurements of the groundwater level after drilling. The details for the wells are illustrated on the respective Record of Borehole sheets provided in Appendix B. The monitoring wells were decommissioned in general accordance with O.Reg. 903, as amended upon completion of Single Well Response Tests.

4. LABORATORY TESTING

Laboratory testing was selected in general accordance with the April 2022 version of the MTO Guidelines for Foundation Engineering Services (GFES), Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Recovered soil samples were selected for grain size distribution in accordance with MTO and ASTM standards. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B.

Two soil samples from Borehole 24-301 and one soil sample from Borehole 24-302 were selected and submitted for organic content testing.

All laboratory test results from the field investigation are provided in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and on the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond borehole locations and sampled intervals. Soil classification is in general accordance with GFES April 2022 and the 5th Edition of the Canadian Foundation Engineering Manual.

In general, the stratigraphy encountered adjacent to the embankment consists of silt to silty sand overlying till.

5.1 Silt to Silty Sand

A layer of silt to silty sand with organics was encountered at ground surface in Boreholes 24-301 and 24-302. This layer had a thickness of 1.9 to 2.4 m (base elev. 321.3 to 322.1 m). SPT N-values ranging from weight of hammer to 22 blows were recorded in the silt to silty sand, indicating a very loose to compact relative density.

The recorded moisture contents ranged from 19 to 52%. The results of gradation analyses completed on two samples of the silt to silty sand are illustrated on Figure C1 of Appendix C. The results of the tests are summarized in the table below and on the Record of Borehole sheets in Appendix B.

| SOIL PARTICLE | PERCENTAGE (%) |
|---------------|----------------|
| Gravel | 0 |
| Sand | 1 – 77 |
| Silt | 22 – 91 |
| Clay | 1 – 8 |

Organic content testing was completed on three samples of the silt to silty sand. The results of the organic content tests are shown in Appendix C. The test results are also presented on the corresponding Record of Borehole sheets in Appendix B. The laboratory results indicate that the organic content of the layer ranges from 4 to 8%

5.2 Silty Sand Till

A silty sand with gravel till was noted below the silt to silty sand in Boreholes 24-301 and 24-302. Cobbles and boulders were frequently encountered and coring techniques were required to advance the borehole. The layer was not fully penetrated as both boreholes were terminated within this layer. Borehole 24-301 was terminated at a depth of 7.0 m (base elev. 317.5) and Borehole 24-302 was terminated at a depth of 4.2 m (base elev. 319.0 m). SPT N-values, where possible, ranged from 100 blows per 300 mm penetration to 100 blows per 50 mm and indicated a very dense relative density. The sample quantities retained was limited due to the density of the soil layer.

The recorded moisture contents in the till ranged from 7 to 16%. The results of gradation analyses completed on two samples of the till are illustrated on Figure C2 of Appendix C. The results of

the tests are summarized in the table below and on the Record of Borehole sheets in Appendix B.

| SOIL PARTICLE | PERCENTAGE (%) |
|---------------|----------------|
| Gravel | 24 – 26 |
| Sand | 35 – 48 |
| Silt | 25 – 39 |
| Clay | 1 – 2 |

5.3 Groundwater Level

The creek water level was measured by Thurber to be at approximate elevation 324.0 m in July 2024. Borehole 23-302 was drilled under 0.5 m of surface water.

Monitoring wells were installed in both boreholes to monitor the groundwater levels after completion of drilling. The measured groundwater levels are summarized in the table below.

Table 5-1 Summary of Measured Water Levels

| BOREHOLE | DATE OF READING | WATER DEPTH / ELEVATION (M) | COMMENT |
|----------|-----------------|-----------------------------|----------------|
| 24-301 | 2024/07/19 | 0.4 / 324.1 | Screen in Silt |
| | 2024/07/20 | 0.4 / 324.1 | |
| | 2024/07/22 | 0.4 / 324.1 | |
| | 2024/07/24 | 0.4 / 324.1 | |
| | 2024/09/16 | 0.3 / 324.2 | |
| | 2024/09/17 | 0.3 / 324.2 | |
| | 2024/09/18 | 0.3 / 324.2 | |
| 24-302 | 2024/07/20 | 0.5 / 323.2 | Screen in Till |
| | 2024/07/22 | 0.5 / 323.2 | |
| | 2024/07/24 | 0.5 / 323.2 | |
| | 2024/09/16 | 0.5 / 323.2 | |
| | 2024/09/17 | 0.5 / 323.2 | |
| | 2024/09/18 | 0.5 / 323.2 | |

It should be noted that the values above are considered short-term readings and may not reflect groundwater or surface water levels at the time of construction and that the surface water levels could respond quickly to precipitation events. Seasonal fluctuations of the groundwater are to be

expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation and spring snow melts.

A Single Well Response Test (SWRT), or “slug test”, was carried out in September 2024 in both monitoring wells by lowering the water level in the monitoring well and recording the recovery of the water level over time with a data logger. The slug test was analyzed using the Hvorslev method and a plot of the slug test results is included in Appendix B. The estimated hydraulic conductivity value calculated from the in-situ slug test is summarized in the following table.

Table 5-2 Single Well Response Test Results

| BOREHOLE | BOTTOM OF SCREEN DEPTH/ELEVATION (m) | SOIL IN ZONE OF SCREEN | ESTIMATED HYDRAULIC CONDUCTIVITY (m/s) |
|-----------------|---|-------------------------------|---|
| 24-301 | 2.4/322.1 | Silt | 6.1×10^{-7} |
| 24-302 | 4.2/319.0 | Silty sand with gravel | 1.7×10^{-5} |

It should be expected that the hydraulic conductivity will vary for the various soil deposits that were encountered.

The monitoring wells were decommissioned in general accordance with O.Reg. 903, as amended upon completion of the Single Well Response testing.

5.4 Analytical Testing

A soil sample was submitted for analytical testing. The analysis results are included in Appendix C and are summarized in the following table.

Table 5-3 Analytical Test Results

| | |
|-----------------------------|--------|
| BOREHOLE | 24-301 |
| SAMPLE | SS3B |
| DEPTH (m) | 1.7 |
| ELEVATION (m) | 323.0 |
| SOIL TYPE | Silt |
| CONDUCTIVITY (µS/cm) | 291 |
| pH | 7.06 |
| RESISTIVITY (Ohm-cm) | 3,430 |
| CHLORIDE (µg/g) | 49 |
| SULPHATE (µg/g) | 73 |
| SULPHIDE (%) | <0.01 |

6. MISCELLANEOUS

The borehole locations reflect existing site features and site constraints. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario, supplied and operated the portable drilling equipment used to drill, test and sample the boreholes. Traffic control was performed in accordance with Ontario Book 7 and was provided by Thurber. The field investigation was supervised on a full-time basis by Mr. I. Khan, EIT. Overall supervision of the field investigation program was provided by Mr. J. Pirani, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa. Analytical testing was completed by Paracel Laboratories Ltd. in Ottawa.



Interpretation of the factual data and preparation of this report was completed by Mr. J. Pirani, P.Eng. and Mr. S. Peters, P.Eng. The report was reviewed by Dr. F. Griffiths, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

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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

Borehole Locations and Strata Drawing

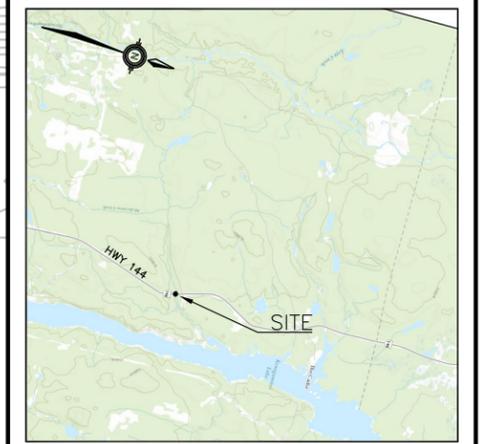
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 5183-16-00



HIGHWAY 144
CULVERT 47X-0249/CO
MCKEOWN CREEK CULVERT
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET
1



KEYPLAN

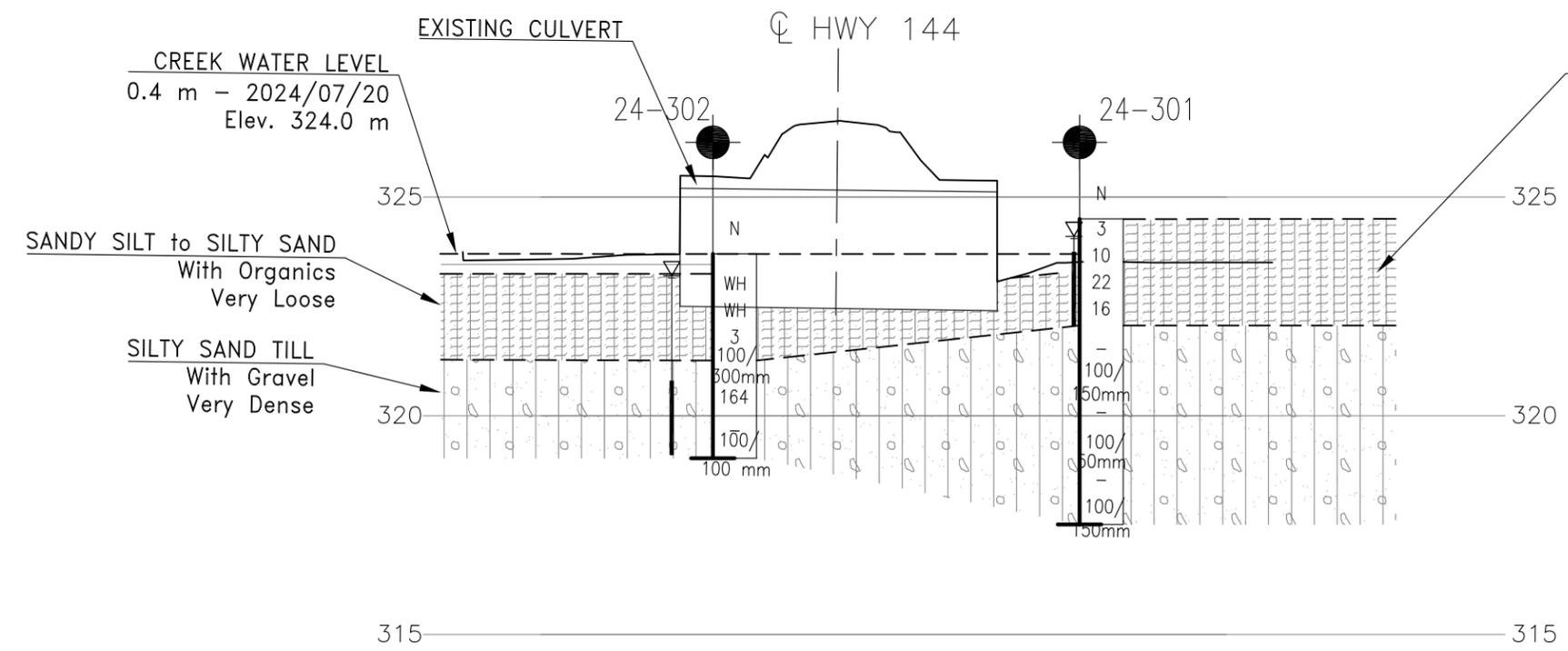
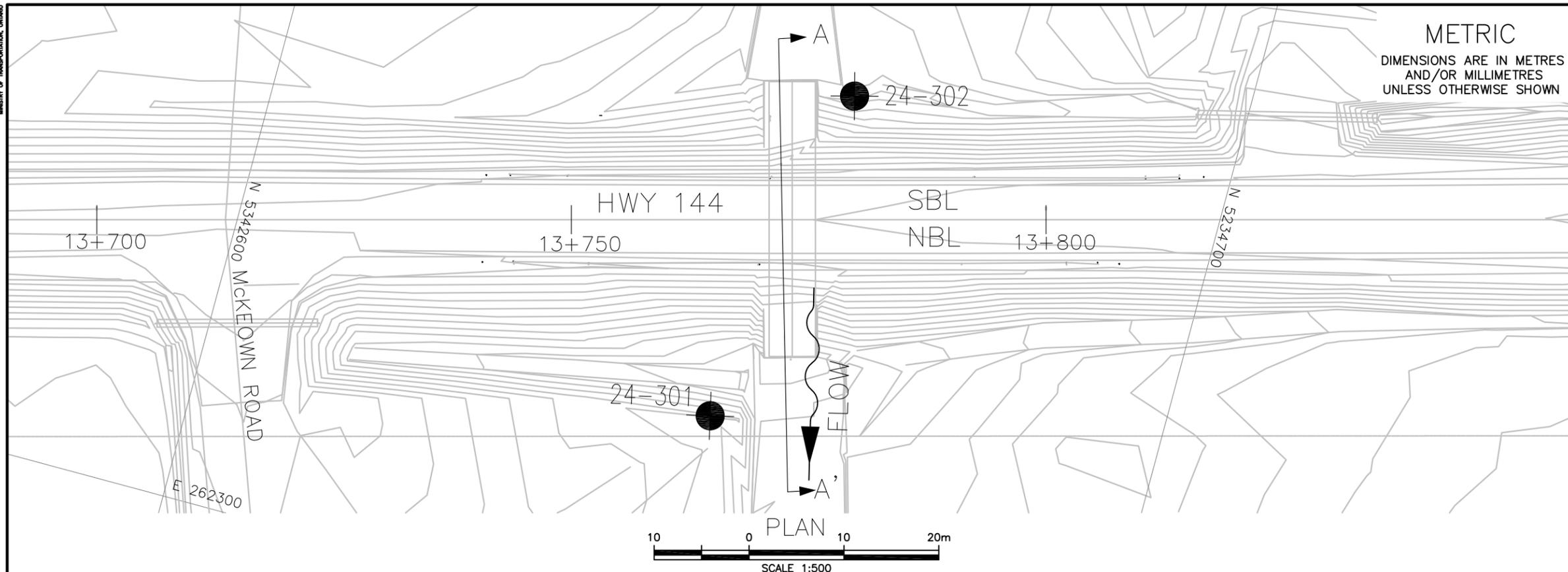
LEGEND

- Borehole
- Historic Borehole
- 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

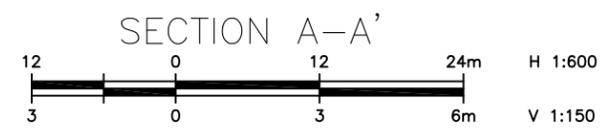
| NO | ELEVATION | NORTHING | EASTING |
|--------|-----------|-------------|-----------|
| 24-301 | 324.5 | 5 342 653.4 | 262 277.0 |
| 24-302 | 323.7 | 5 342 659.4 | 262 240.5 |

- 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 12.

GEOCRES No. 42A04-001



ORGANIC SILT
Very Loose to Compact



| DATE | BY | DESCRIPTION |
|-----------|--------|---------------|
| DESIGN JP | CHK SP | CODE |
| DRAWN RH | CHK CM | SITE |
| | | LOAD |
| | | STRUCT |
| | | DATE DEC 2024 |
| | | DWG 1 |



APPENDIX B

Symbols and Terms
Record of Boreholes Sheets



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).

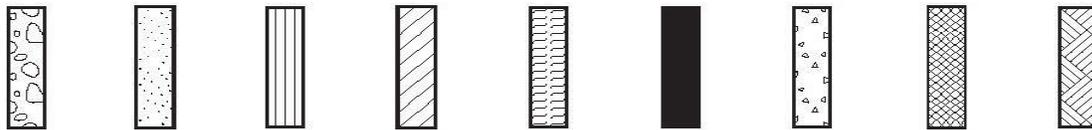
DYNAMIC CONE PENETRATION TEST (DCPT):

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.



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 |



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 or 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



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 |

RECORD OF BOREHOLE No 24-301

1 OF 1

METRIC

GWP# 5183-16-00 LOCATION Lat: 48.221339°, Long: -81.57234° McKeown Creek Culvert MTM z12 N 5 342 653.4 E 262 277.0 ORIGINATED BY IK
 HWY 144 BOREHOLE TYPE Portable Tripod, NW Casing, NQ Coring COMPILED BY JP
 DATUM Geodetic DATE 2024.07.16 - 2024.07.18 CHECKED BY

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | |
|--------------|--|------------|---------|------|---------------|-------------------------|-----------------|--|----|----|----|-----|--|--|---------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | | | PLASTIC LIMIT W _p |
| 324.5 | Ground Surface | | | | | | | | | | | | | | |
| 0.0 | SILT with organics very loose to compact dark brown | | 1 | SS | 3 | | | | | | | | | | |
| | | | 2 | SS | 10 | | | | | | | | | | Organic Content: 3.9% |
| | | | 3 | SS | 22 | | | | | | | | | | Organic Content: 7.5% |
| | | | 4 | SS | 16 | | | | | | | | | | 0 1 91 8 |
| 322.1 | SILTY SAND with gravel interbedded silt seams frequent cobbles and boulders very dense grey GLACIAL TILL - 230 mm boulder at 2.7 m - 120 mm cobble at 4.6 m - 100 mm cobble at 5.8 m | | 5 | NQ | - | | | | | | | | | | |
| | | | 6 | SS | 100/ 150mm | | | | | | | | | | |
| | | | 7 | NQ | - | | | | | | | | | | |
| | | | 8 | SS | 100/ 50mm | | | | | | | | | | |
| | | | 9 | NQ | - | | | | | | | | | | |
| | | | 10 | SS | 100/ 150mm | | | | | | | | | | |
| 317.5 | End of Borehole Monitoring Well installed: Schedule 40 PVC standpipe with 25-mm diameter and 0.9-m slotted screen. Stick-up cover installed at ground surface. Water Level Readings: DATE DEPTH (m) ELEV. (m) 2024/07/19 0.4 324.1 2024/07/20 0.4 324.1 2024/07/22 0.4 324.1 2024/07/24 0.4 324.1 | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | |

DOUBLE LINE 36917 GINT LOGS (300).GPJ 2012TEMPLATE(MTO).GDT 12-12-24

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

RECORD OF BOREHOLE No 24-302

1 OF 1

METRIC

GWP# 5183-16-00 LOCATION Lat: 48.22137°, Long: -81.572842° McKeown Creek Culvert MTM z12 N 5 342 659.4 E 262 240.5 ORIGINATED BY IK
 HWY 144 BOREHOLE TYPE Portable Tripod, NW Casing, NQ Coring COMPILED BY JP
 DATUM Geodetic DATE 2024.07.19 - 2024.07.19 CHECKED BY

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|--|-----------------|---|--|--|--|--|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| | | | | | | 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | | | | | | | | |
| | | | | | | WATER CONTENT (%) | | | | | | | | |
| | | | | | | W P | W | W L | | | | | | |
| 323.7 | Water Surface | | | | | | | | | | | | | |
| 0.0 | WATER | | | | | | | | | | | | | |
| 323.2 | | | | | | | | | | | | | | |
| 0.5 | SANDY SILT to SILTY SAND with organics very loose dark brown | | 1 | SS | WH | | | | | | | | | |
| | | | 2 | SS | WH | | | | | | | | | |
| | | | 3 | SS | 3 | | | | | | | | | |
| | | | 4 | SS | 100/300mm | | | | | | | | | |
| | | | 5 | NQ | - | | | | | | | | | |
| 321.3 | SILTY SAND with gravel occasional cobbles and boulders very dense grey GLACIAL TILL | | 6 | SS | 164 | | | | | | | | Organic Content: 4.4% 0 77 22 1 | |
| 2.4 | | | 7 | NQ | - | | | | | | | | 24 35 39 2 | |
| | - 90 mm cobble at 4.0 m | | | | | | | | | | | | | |
| 319.0 | | | 8 | SS | 100/100mm | | | | | | | | | |
| 4.7 | End of Borehole Monitoring Well installed: Schedule 40 PVC standpipe with 25-mm diameter and 1.5-m slotted screen. Stick-up cover installed at ground surface. Water Level Readings: DATE DEPTH (m) ELEV. (m) 2024/07/20 0.5 323.2 2024/07/22 0.5 323.2 2024/07/24 0.5 323.2 | | | | | | | | | | | | | |

DOUBLE LINE 36917 GINT LOGS (300).GPJ 2012TEMPLATE(MTO).GDT 12-12-24



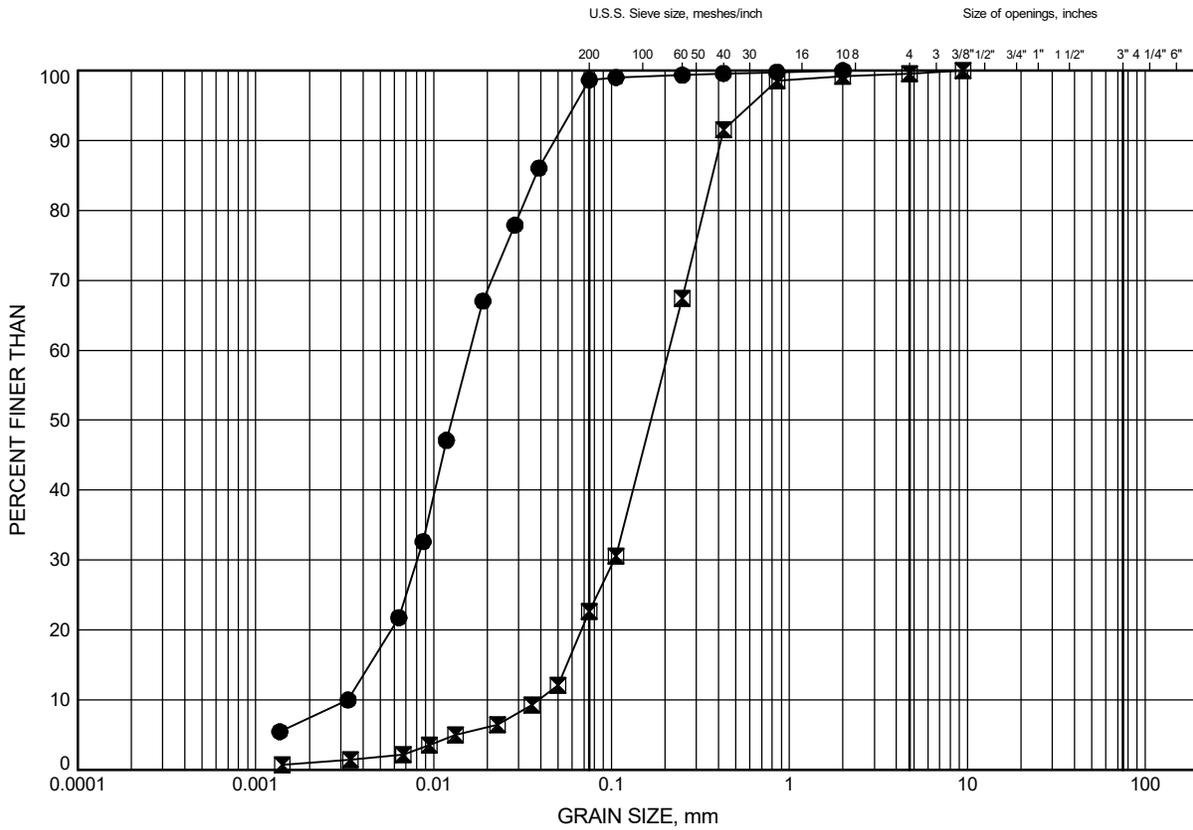
APPENDIX C

Particle Size Analysis Figures
Analytical Testing Results

Highway 144 Culvert (47X-0249/C0)
GRAIN SIZE DISTRIBUTION

FIGURE C1

Silty Sand to Silt



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

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 24-301 | 2.1 | 322.4 |
| ⊠ | 24-302 | 2.1 | 321.6 |

GRAIN SIZE DISTRIBUTION - THURBER 36917 GINT LOGS (300).GPJ 8-30-24

Date August 2024
 GWP# 5183-16-00

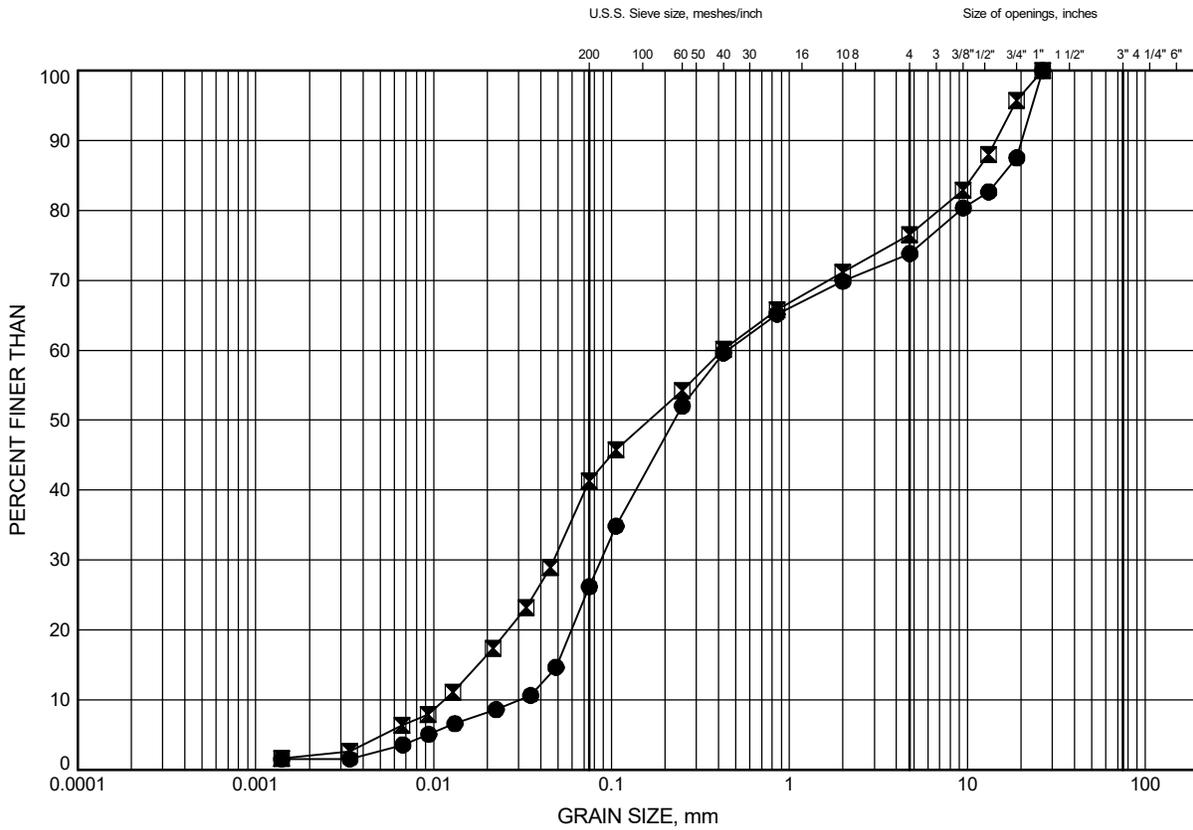


Prep'd RH
 Chkd. CM

Highway 144 Culvert (47X-0249/C0)
GRAIN SIZE DISTRIBUTION

FIGURE C2

Glacial Till



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

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 24-301 | 5.3 | 319.2 |
| ⊠ | 24-302 | 3.4 | 320.4 |

GRAIN SIZE DISTRIBUTION - THURBER 36917 GINT LOGS (300).GPJ 8-30-24

Date .. August 2024 ..
 GWP# .. 5183-16-00 ..



Prep'd .. RH ..
 Chkd. .. CM ..



Stantec Consulting Ltd.
2781 Lancaster Rd, Suite 100 A&B, Ottawa ON K1B 1A7

August 19, 2024
File: 121625731

Client: Thurber Engineering, File #36917.10

Reference: ASTM-D2974 Organic Content, Highway 144

The following table summarizes three Organic Content results.

| Source | Depth | Date Sampled | Organic Content |
|-------------|-------------|---------------|-----------------|
| 24-301 SS2 | 2'-4' | July 16, 2024 | 7.5 |
| 24-301 SS1B | 8''-2' | July 16, 2024 | 3.9 |
| 24-302 SS3A | 5'6''-6'6'' | July 16, 2024 | 4.4 |

Sincerely,

Stantec Consulting Ltd.

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com

Certificate of Analysis

Thurber Engineering Ltd.

Suite 125, 2611 Queensview Drive
Ottawa, ON K2B 8K2
Attn: Jamil Pirani

Client PO:
Project: 36917 Task 10
Custody: 72914

Report Date: 11-Sep-2024
Order Date: 28-Aug-2024

Order #: 2435340

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

| Parcel ID | Client ID |
|------------|---------------------|
| 2435340-01 | 24-301 SS3B (5'-6') |

Approved By:



Mark Foto, M.Sc.

Lab Supervisor

Certificate of Analysis

Report Date: 11-Sep-2024

Client: Thurber Engineering Ltd.

Order Date: 28-Aug-2024

Client PO:

Project Description: 36917 Task 10

| | | | | | |
|---------------------|---------------------|---|---|---|---|
| Client ID: | 24-301 SS3B (5'-6') | - | - | - | - |
| Sample Date: | 16-Jul-24 00:00 | - | - | - | - |
| Sample ID: | 2435340-01 | - | - | - | - |
| Matrix: | Soil | - | - | - | - |
| MDL/Units | | | | | |

Physical Characteristics

| | | | | | | |
|----------|--------------|------|---|---|---|---|
| % Solids | 0.1 % by Wt. | 84.3 | - | - | - | - |
|----------|--------------|------|---|---|---|---|

General Inorganics

| | | | | | | |
|--------------|---------------|----------|---|---|---|---|
| Conductivity | 5 uS/cm | 291 [1] | - | - | - | - |
| pH | 0.05 pH Units | 7.06 [1] | - | - | - | - |
| Resistivity | 0.1 Ohm.m | 34.3 [1] | - | - | - | - |

Anions

| | | | | | | |
|----------|---------|--------|---|---|---|---|
| Chloride | 10 ug/g | 49 [1] | - | - | - | - |
| Sulphate | 10 ug/g | 73 [1] | - | - | - | - |



APPENDIX D

Site Photographs



Photo 1: Culvert outlet, looking east (*taken July 2024*).



Photo 2: East embankment condition, looking south (*taken July 2024*).



Photo 3: Culvert inlet, looking west (*taken July 2024*).



Photo 4: West embankment condition, looking north (*taken July 2024*).