



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 9 CULVERT REPLACEMENT
LLOYDTOWN, ONTARIO
LATITUDE: 44.000164°, LONGITUDE: -79.727996°
W.P. 2148-20-00, CULVERT NO. CV-0074-0009-0004**

GEOCRES Number: 30M13-235

Report

to

Parsons

Date: April 22, 2021
File: 30652



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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed Culvert No. CV-0074-0009-0004 replacement on Highway 9 in Lloydtown, Ontario.

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

Thurber was retained by the Parsons Inc to carry out this foundation investigation under the MTO Assignment Number 2019-E-0081.

2. SITE DESCRIPTION

The existing culvert is located on Highway 9, approximately 20 m west of the centreline of 11th Line Road King in Lloydtown, Ontario. The existing culvert is an 800 mm diameter Corrugated Steel Pipe (CSP), approximately 34 m long, running in a general south-north direction. The approximate culvert invert is at approximate Elevation 274.28 m at the inlet (south) and 274.08 m at the outlet (north). The culvert allows the surface drainage to flow in a northerly direction beneath the highway. The highway embankment is approximately 3.0 to 3.2 m in height.

The lands surrounding the culvert site generally consist of agricultural areas with localized



residential properties. The site topography is generally flat, with gentle cut slopes to the southeast of the site which are vegetated with grass and trees.

Based on published geological information, the general site area lies within the physiographic region known as the Schomberg Clay Plains. Varved clays overlying till plains are anticipated.

3. INVESTIGATION PROCEDURES

The field investigation and field testing for this project was carried out on March 1st, 2021, and consisted of drilling and sampling two (2) boreholes, labeled Boreholes HWY9-01 and HWY9-02, to a depth of approximately 8.2 m (base Elevation 268.7 m and 268.9m, respectively). Boreholes HWY9-01 and HWY9-02 were drilled through the existing highway embankment on the eastbound and westbound granular shoulder lanes, respectively.

The approximate locations of the boreholes from the investigation are shown on the Borehole Locations and Soil Strata Drawing included in Appendix C.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were surveyed and provided to Thurber by Parsons. The coordinate system MTM NAD 83 was used for the boreholes.

A truck-mounted CME-75 drill rig was used to advance the boreholes using solid stem augers. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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

Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

| Borehole Number | Borehole Depth / Base Elevation (m) | Completion Details |
|-----------------|-------------------------------------|--|
| HWY9-01 | 8.2 / 268.7 | Backfilled with bentonite holeplug to 0.6m, then sand and gravel cuttings to surface |



| Borehole Number | Borehole Depth / Base Elevation (m) | Completion Details |
|-----------------|-------------------------------------|--|
| HWY9-02 | 8.2 / 268.9 | Backfilled with bentonite holeplug to 0.6m, then sand and gravel cuttings to surface |

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses and Atterberg Limit testing, where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete, as well as the potential for corrosion associated with the structure, a sample of the fill from Borehole HWY9-01 was submitted to AGAT Laboratories., a CALA accredited analytical laboratory in Mississauga, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing from the investigation are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. 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 C. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered consisted of embankment fill, which was comprised of sand and gravel fill underlain by silty clay fill, which in turn was underlain by native silty clay. Descriptions of the individual strata are presented below.



5.1 Granular Fill

Granular fill consisting of silty sand and gravel was encountered at the surface of the granular shoulders. The thickness of the fill extended to a depth of 0.7 to 1.2 m (Elevation 276.2 m and 275.9 m).

SPT 'N' values in the granular fill were 26 blows and 58 blows for 0.3 m of penetration, indicating compact to very dense conditions. The measured moisture content in the fill ranged from 4 percent to 7 percent.

The results of grain size analyses conducted on selected samples of fills are illustrated on Figures B1 in Appendix B. The results are summarized as follows:

| Soil Particle | Silty Sand and Gravel Fill |
|---------------|----------------------------|
| Gravel | 22 to 26 |
| Sand | 62 to 64 |
| Silt | 12 |
| Clay | 4 |
| Silt & Clay | 10 |

5.2 Silty Clay Fill

Underlying the granular fill, dark brown silty clay fill which contained some sand, traces of gravel, and trace organics was encountered in both boreholes. Where fully penetrated, the silty clay fill was approximately 1.9 to 2.0 m thick and the base extended to depths of 2.6 and 3.2 m (Elevation 274.3 m and 273.9 m), respectively.

SPT 'N' values measured in the silty clay fill ranged from 7 blows to 29 blows for 0.3 m penetration, indicating firm to very stiff consistencies. The measured moisture content of the fill ranged from 10 percent to 27 percent.

The results of grain size analyses conducted on a selected sample of the silty clay fill are illustrated on Figure B2 in Appendix B. The results are summarized as follows:



| Soil Particle | Silty Clay Fill |
|---------------|-----------------|
| Gravel | 0 |
| Sand | 16 |
| Silt | 41 |
| Clay | 43 |

5.3 Silty Clay

Underlying the fills at both boreholes, brown silty clay, which contained some sand was encountered. Both boreholes were terminated within this native material.

SPT 'N' values recorded in the silty clay ranged from 7 blows to 26 blows per 0.3 m penetration, indicating firm to very stiff consistencies, typically stiff to very stiff. The measured moisture content of the fill ranged from 19 percent to 33 percent.

The results of grain size analyses conducted on selected sample of the silty clay are illustrated on Figure B3 in Appendix B. The results are summarized as follows:

| Soil Particle | Silty Clay |
|---------------|------------|
| Gravel | 0 |
| Sand | 11 to 13 |
| Silt | 46 to 67 |
| Clay | 20 to 43 |

The results of Atterberg Limits Testing on the selected silty clay samples are presented in Figure B4, and summarized below.

| Index Property | Value |
|----------------|----------|
| Liquid Limit | 38 |
| Plastic Index | 14 to 21 |

The results of the Atterberg Limits testing indicate that this deposit has typically medium plasticity with a group symbol of CI.

5.4 Groundwater Conditions

These groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. A summary of the water level measurements is provided in Table 5.2 below:



Table 5.2 - Groundwater Measurements

| Borehole | Date | Water Level (m) | | Remark |
|----------|---------------|-----------------|-----------|---------------|
| | | Depth | Elevation | |
| HWY9-01 | March 1, 2021 | 3.7 | 273.2 | Open Borehole |
| HWY9-02 | March 2, 2021 | 3.0 | 274.1 | Open Borehole |

Groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

One sample of the silty clay fill was submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 - Analytical Test Results

| Parameter | Units (soil) | Test Results |
|---------------------------|--------------|-----------------------|
| | | Borehole HWY9-01 SS#4 |
| | | Silty Clay Fill |
| Chloride | µg/g | 2420 |
| Sulphate | µg/g | <20 |
| pH | no unit | 7.42 |
| Conductivity | µS/cm | 4.20 |
| Resistivity (calculated) | ohms.cm | 238 |
| Redox Potential (average) | mV | 448.7 |

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on a field survey conducted by Parsons Inc.



Drilltech Drilling Ltd of Newmarket, 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. George Azzopardi of Thurber. The overall supervision of the field program was conducted by Mr. Rod de Castro, P.Eng, of Thurber.

Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by AGAT Laboratories.

Interpretation of the field data and preparation of this report was carried out by Mr. Rod de Castro, P.Eng. The report was reviewed by Mr. Jason Lee, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Thurber Engineering Ltd.

Rod de Castro, P.Eng.
Geotechnical Engineer



Jason Lee, P.Eng.
Principal, Senior Geotechnical Engineer



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





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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents foundation design recommendations for the proposed Culvert No. CV-0074-0009-0004 replacement on Highway 9 in Lloydtown, Ontario. The purpose of the investigation was to collect subsurface information and provide foundation recommendations for the proposed replacement of the existing 800 mm diameter CSP culvert with a new 1,050 mm diameter high-density polyethylene (HDPE) pipe by open-cut method.

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. The 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 subsurface stratigraphy revealed in the boreholes drilled near the proposed culvert alignment generally consists of pavement structure underlain by firm to very stiff cohesive embankment fills (typically silty clay fill) extending to depths of 2.6 and 3.2 m (Elevation 274.3 m and 273.9 m). Cohesive embankment fill was underlain by native, firm to very stiff silty clay. Groundwater elevations in the open boreholes were generally at Elevations 273.2 and 274.1 m.



Traffic staging drawing of the proposed culvert replacement was obtained from Parsons. The existing culvert is an 800 mm diameter Corrugated Steel Pipe (CSP), approximately 34 m long, running in a general south-north direction. The approximate culvert invert is at approximate Elevation 274.28 m at the inlet (south) and 274.08 m at the outlet (north). The existing road grade at the culvert location is at about Elevation 277.2 m. The highway embankment is up to 3.0 to 3.2 m in height and the crown cover of the proposed culvert is approximately 2.1 m.

The traffic staging drawing and discussions with Parsons, indicate that a new 1,050 mm diameter high-density polyethylene (HDPE) pipe is being considered to provide increased hydraulic opening. The proposed invert levels of the HDPE pipe will remain the same as the existing CSP culvert. The horizontal alignment of the replacement culvert will remain the same as for the existing culvert. No grade raise is proposed at the culvert location.

The culvert replacement is proposed to be constructed utilizing a traffic staging, which would require a temporary open cut excavation with side slopes of 1H:1V for a short period of time (i.e. in the order of 3 to 4 hours) and shifting the traffic to the shoulder lane partially in order to satisfy traffic requirements.

The discussions and recommendations presented in this report are based on information provided by Parsons and on the factual data obtained during the course of the current investigation.

9. SUBGRADE PREPARATION, CULVERT BEDDING, AND BACKFILL

Culvert excavation will be through the pavement, road base granular, silty clay fill and into native silty clay. Performance of the replacement culvert will depend on the preparation of the subgrade. After the excavation reaches the design subgrade elevation, the exposed surface should be inspected to confirm that the subgrade is suitable and uniformly competent. Any remaining fill, topsoil, peat, disturbed soils, and any deleterious materials within the replacement culvert footprint must be removed and replaced with bedding materials compacted as per OPSS.PROV 501. The prepared subgrade should be protected from disturbance during construction.

A minimum 300 mm thick layer of bedding material conforming to OPSS PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the HDPE pipe culvert and compacted in accordance with OPSS 501 in the dry.

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSS 802.014, and as per the requirements of the CHBDC.



Backfilling for the culvert should be in accordance with OPSS 501, OPSS 902, and as per the CHBDC requirements. All fills should be placed in regular lifts and be compacted in accordance with OPSS PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 200 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used on the roof of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS PROV 501.

The culvert subgrade preparation, placement and compaction of granular bedding/backfill should be carried out in the dry. The installation of the HDPE pipe in open cut should follow OPSD 802.014 (Flexible Pipe Embedment in Embankment) and as per the requirements of the CHBDC.

10. FROST DEPTH

The depth of frost penetration at this site is approximately 1.4 m as per OPSD 3090.100. Based on the borehole data, The silty clay fill below the granular fills have low frost susceptibility. Frost treatment / taper for the culvert should be provided as per OPSD 803.031.

11. EXCAVATIONS, TEMPORARY CUT SLOPE AND GROUNDWATER CONTROL

The excavation must be carried out in accordance with OPSS 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of assessing temporary excavation slope requirements in compliance with the OHSA, the existing granular fills and cohesive fills above the water level may be classified as Type 3 soil. The native silty clay soil below the water table may be classified as Type 3 soil.

In general for open-cut excavation, temporary side slopes of 1 horizontal to 1 vertical are anticipated to remain stable through the fills and native soils. Some weathering of the excavation slopes may cause surficial instability (i.e. sloughing). Under no circumstances should any heavy equipment or stockpiled material be placed at the crests of the excavation.

Based on the proposed traffic staging for Highway 9 shown on the 60% drawing submission provided by Parsons, live traffic is anticipated to be near the crest of the temporary cut excavation. Slope stability analyses have been carried out for the proposed 3.5 m deep excavation with a temporary 1H:1V cut slope considering a live traffic surcharge load of 17 kPa situated approximately 1.2 m away from the crest of the excavation for both Stage A and B construction.



Limit equilibrium analyses were carried out using a commercially available computer program SLOPE/W. Results of the analyses are presented graphically in Figures 1 and 2 in Appendix D and summarized in the following table:

| Factors of Safety from Stability Analysis | | |
|---|-------------------------|---------------|
| Case | Factor of Safety | Figure |
| 1 Horizontal to 1 Vertical Sloped Excavation | | |
| Stage A Live Traffic 1.2 m North of Crest of Excavation | 1.3 | 1 |
| Stage B Live Traffic 1.2 m South of Crest of Excavation | 1.5 | 2 |

Based on the above analyses, the Factor of Safety for these cases are between 1.3 and 1.5, indicating the proposed configuration is considered acceptable from a geotechnical perspective and no global stability issues are anticipated for short-term conditions. The following should be considered during and after excavation of the temporary cut slopes:

- Excavations should be inspected regularly for evidence of instability.
- Surface water should be drained away from the side slopes of the proposed excavation.
- If any slope instability is observed (e.g. signs of sloughing, seepage, cracking or movement), remedial actions (e.g. slope flattening, backfilling the excavation, moving the traffic to the shoulder lane etc.) must be taken immediately to ensure the stability of the excavation and the safety of workers and live traffic.

Despite the acceptable Factor of Safety for the proposed configuration of the traffic staging, consideration should be given to shifting the traffic further away from the crest of the temporary excavation cut onto the adjacent shoulder lane.

The excavation and backfilling for the culvert replacement must be carried out in accordance with OPSS 902 and OPSS 401. Excavations will be carried out through the existing embankment fills and native silty clay.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions.

The groundwater elevations in the open boreholes ranged from Elevations 273.2 to 274.1 m. Higher groundwater levels may be expected during periods of significant and/or prolonged precipitation and spring snow melts, and perched water within the embankment fills.



Installation of the culvert should be carried out in the dry. It is anticipated that the base of the excavation will be at ~Elevation 273.8 m (i.e. subgrade elevation). It was noted during the field investigation that the groundwater was encountered near the embankment fills / native soil interface. It is anticipated that the perched water can be handled with sump pumps in localized areas.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility.

The dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01. Considering the conditions on site, a design Engineer and design-checking Engineer with a minimum of 5 years of experience in designing systems of similar nature and scope to the required work is not required, and thus Designer Fill-In ***** in SP517F01 should be "No".

The dewatering scheme must be effective to maintain the groundwater level below the base of excavation. Surface water must be drained away from the excavation. Dewatering must remain operational and effective until the culvert is installed and backfilled. Suggested wording for an NSSP in this regard is included in Appendix D.

12. TEMPORARY ROADWAY PROTECTION

It is understood that temporary roadway protection may be proposed if a temporary sloped excavation is not feasible due to traffic/construction constraints. The replacement of the culvert will require excavation to a depth in the order of 3.0 to 3.2 m below Highway 9 grade. Temporary roadway protection may be required to maintain a single lane of traffic at all times during culvert construction.

Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 and designed for Performance Level 2 (maximum 25 mm horizontal deflection) provided that the existing adjacent roadway can tolerate this magnitude of deflection.

Where excavation for the pipe installation is located in close proximity to live traffic lanes or existing buried utilities, roadway protection (temporary shoring) will be required. Given the subsurface conditions, both sheet piles or a braced soldier pile and wood lagging system may be considered as feasible options at this site. It is envisaged that the sheet piles and soldier piles should be embedded within the native silty clay. Such system will need to be implemented in conjunction with adequate groundwater control. It is anticipated that sump pumping will be required to maintain reasonably dry excavations throughout construction.



Design of the roadway protection system is the responsibility of the Contractor. The temporary shoring should be designed by a licensed Professional Engineer experienced in such designs, with consideration of adjacent traffic loads and any sloping retained surfaces.

The parameters given below should be used for roadway protection design:

| | | | |
|--|-----------|---|---|
| Soil Bulk Unit Weight | γ | = | 22 kN/m ³ (silty sand and gravel fill) |
| | | = | 18 kN/m ³ (silty clay fill) |
| | | = | 18 kN/m ³ (native silty clay) |
| Soil Submerged Unit Weight (below gwl) | γ' | = | 12 kN/m ³ (silty sand and gravel fill) |
| | | = | 8 kN/m ³ (silty clay fill) |
| | | = | 8 kN/m ³ (native silty clay) |
| Coefficient of Active Earth Pressure | K_a | = | 0.27 (silty sand and gravel fill) |
| | | = | 0.33 (silty clay fill) |
| | | = | 0.33 (native silty clay) |
| Coefficient of Passive Earth Pressure | K_p | = | 3.7 (silty sand and gravel fill) |
| | | = | 3.0 (silty clay fill) |
| | | = | 3.0 (native silty clay) |

13. EMBANKMENT RESTORATION

The existing Highway 9 embankment is approximately 3.0 to 3.2 m in height at the culvert location. The existing embankment slopes of 2.5H:1V and 2H:1V at the north and south embankments, respectively, appear to be stable. Provided that the embankment is reconstructed at the same slope inclination as the existing embankment, but not steeper than 2H:1V, the restored embankment slope should remain stable.

It is anticipated that there will be no grade raise or embankment widening at this site for the culvert replacement, and therefore settlement of the embankment is not a concern. Any settlement due to changes in the culvert configuration is expected to be less than 25 mm provided proper compaction of fills is carried out. Additional settlement would be induced if the final configuration includes additional fill to raise or widen the embankment.

Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS.PROV 206. The embankment material may consist of imported Granular A, Granular B Type II, or Granular B Type III material. The existing embankment fills should not be reused to restore the embankment.



In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert inlet and outlet, and within the culvert/embankment footprint. Inspection and approval of the foundation subgrade by qualified geotechnical personnel should be conducted.

14. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field and in accordance with OPSD 810.010, OPSS 511 and OPSS.PROV 1004. Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

A clay seal should be used at the inlet to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS.PROV 1205. A geo-synthetic clay liner may be used in place of a compacted clay seal.

15. SUITABILITY OF SOIL FOR REUSE

The materials that will be removed from the culvert excavations are anticipated to consist of asphalt pavement, granular fills, silty clay fills and native silty clay.

The existing embankment fills should not be reused to backfill above the culvert granular zone and under the highway pavement. Imported granular material such as Granular B Type I or Select Subgrade Material (SSM) should be used as backfill above the culvert granular zone and compacted. Suggested wording for an NSSP in this regard is included in Appendix D.

However, all excavated material (with the exception of topsoil) can be used for slope flattening in accordance with OPSD 202.010 provided they are free of organics, frozen materials, and at a suitable moisture content for re-compaction.

16. CORROSION & SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on one silty clay fill sample indicate the following:

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E file: H:\30000-39999\30000-30999\30652 - Highway 9 and 12 Culvert Replacement 2019-E-0081\Reports & Memos\Highway 9\Final\TEL_30652_Highway 9 Culvert Replacement FIDR Final.docx



- The potential for sulphate attack on concrete from the surrounding soil is considered to be negligible due to the low concentration of sulphate in the sample tested. The effect of road de-icing salt should also be considered when selecting the class of concrete.
- The potential for corrosion on metal structural elements is considered to be very severe, based on the low resistivity of the samples tested.
- The effect of road de-icing salt should be considered when selecting corrosion protection measures.

17. CONSTRUCTION CONCERNS

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

- A suitable dewatering / unwatering system must be employed to enable culvert construction in the dry and prevent subgrade disturbance, sloughing and instability of the excavation.
- The groundwater level may fluctuate and be at higher elevation at the time of construction than indicated in the report.
- The Contractor's selection of construction equipment and methodology should include assessment of the existing embankment and native ground conditions to enable safe temporary excavations for culvert replacement. Site conditions may limit the type of equipment suitable for use during construction. Any temporary slopes should be inspected regularly for evidence of instability during construction. The design and safety of any temporary works is the responsibility of the Contractor.

18. CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. Rod de Castro, P.Eng.. The report was reviewed by Mr. Jason Lee, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Thurber Engineering Ltd.

Rod de Castro, P.Eng.
Geotechnical Engineer



Jason Lee, P.Eng.
Principal, Senior Geotechnical Engineer



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





Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

| CLASSIFICATION | PARTICLE SIZE | VISUAL IDENTIFICATION |
|----------------|--------------------|---|
| Boulders | Greater than 200mm | same |
| Cobbles | 75 to 200mm | same |
| Gravel | 4.75 to 75mm | 5 to 75mm |
| Sand | 0.075 to 4.75mm | Not visible particles to 5mm |
| Silt | 0.002 to 0.075mm | Non-plastic particles, not visible to the naked eye |
| Clay | Less than 0.002mm | Plastic particles, not visible to the naked eye |

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

| TERMINOLOGY | PROPORTION |
|---------------------------------|---------------|
| Trace or Occasional | Less than 10% |
| Some | 10 to 20% |
| Adjective (e.g. silty or sandy) | 20 to 35% |
| And (e.g. sand and gravel) | 35 to 50% |

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

| DESCRIPTIVE TERM | UNDRAINED SHEAR STRENGTH (kPa) | APPROXIMATE SPT ⁽¹⁾ 'N' VALUE |
|------------------|--------------------------------|--|
| Very Soft | 12 or less | Less than 2 |
| Soft | 12 to 25 | 2 to 4 |
| Firm | 25 to 50 | 4 to 8 |
| Stiff | 50 to 100 | 8 to 15 |
| Very Stiff | 100 to 200 | 15 to 30 |
| Hard | Greater than 200 | Greater than 30 |

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

| DESCRIPTIVE TERM | SPT "N" VALUE |
|------------------|-----------------|
| Very Loose | Less than 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very Dense | Greater than 50 |

5. LEGEND FOR RECORDS OF BOREHOLES


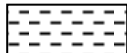



| | | | |
|---|---|--|------------------------|
| SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE | SS Split Spoon Sample | WS Wash Sample | AS Auger (Grab) Sample |
| | TW Thin Wall Shelby Tube Sample | TP Thin Wall Piston Sample | |
| | PH Sampler Advanced by Hydraulic Pressure | PM Sampler Advanced by Manual Pressure | |
| | WH Sampler Advanced by Self Static Weight | RC Rock Core | SC Soil Core |

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level
 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.

EXPLANATION OF ROCK LOGGING TERMS

| <u>ROCK WEATHERING CLASSIFICATION</u> | | <u>SYMBOLS</u> | |
|---------------------------------------|---|---|-------------------|
| Fresh (FR) | No visible signs of weathering. | | |
| Fresh Jointed (FJ) | Weathering limited to the surface of major discontinuities. |  | CLAYSTONE |
| Slightly Weathered (SW) | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material. |  | SILTSTONE |
| Moderately Weathered (MW) | Weathering extends throughout the rock mass, but the rock material is not friable. |  | SANDSTONE |
| Highly Weathered (HW) | Weathering extends throughout the rock mass and the rock is partly friable. |  | COAL |
| Completely Weathered (CW) | Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved. |  | Bedrock (general) |

| <u>DISCONTINUITY SPACING</u> | | <u>STRENGTH CLASSIFICATION</u> | | | |
|------------------------------|-----------------------|--------------------------------|---|---------------------|---|
| Bedding | Bedding Plane Spacing | Rock Strength | Approximate Uniaxial Compressive Strength | | Field Estimation of Hardness* |
| | | | (MPa) | (psi) | |
| Very thickly bedded | Greater than 2m | Extremely Strong | Greater than 250 | Greater than 36,000 | Specimen can only be chipped with a geological hammer |
| Thickly bedded | 0.6 to 2m | | | | |
| Medium bedded | 0.2 to 0.6m | Very Strong | 100-250 | 15,000 to 36,000 | Requires many blows of geological hammer to break |
| Thinly bedded | 60mm to 0.2m | Strong | 50-100 | 7,500 to 15,000 | Requires more than one blow of geological hammer to break |
| Very thinly bedded | 20 to 60mm | | | | |
| Laminated | 6 to 20mm | Medium Strong | 25.0 to 50.0 | 3,500 to 7,500 | Breaks under single blow of geological hammer. |
| Thinly Laminated | Less than 6mm | | | | |

| <u>TERMS</u> | | | | | |
|-------------------------------------|--|-----------------------|-------------|--------------|--|
| Total Core Recovery: (TCR) | Core recovered as a percentage of total core run length. | Weak | 5.0 to 25.0 | 750 to 3,500 | Can be peeled by a pocket knife with difficulty |
| Solid Core Recovery: (SCR) | Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. | Very Weak | 1.0 to 5.0 | 150 to 750 | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| Rock Quality Designation: (RQD) | Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length. | Extremely Weak (Rock) | 0.25 to 1.0 | 35 to 150 | Indented by thumbnail |
| Uniaxial Compressive Strength (UCS) | Axial stress required to break the specimen | | | | |
| Fracture Index: (FI) | Frequency of natural fractures per 0.3m of core run. | | | | |

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 HWY 9-01

1 OF 1

METRIC

W.P. 2148-20-00 LOCATION MTM NAD83-10: N 4 873 367.4 E 286 515.8 ORIGINATED BY GA
 HWY 9 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM MTM NAD83-10 DATE 2021.01.03 - 2021.01.03 LATITUDE LONGITUDE CHECKED BY RD

| 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 | | | | | | | | | | | |
| 276.9 | GROUND SURFACE | | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | WATER CONTENT (%) | | | | | | |
| 0.0 | Silty SAND and GRAVEL Very Dense Brown Moist (FILL) | | 1 | SS | 58 | | | 20 | 40 | 60 | 80 | 100 | PLASTIC LIMIT W _P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | GR | SA | SI | CL |
| 276.2 | | | | | | | | | | | | | | | | 26 | 64 | 10 (SI+CL) | |
| 0.7 | Silty CLAY , trace sand, occasional gravel, trace organics Very Stiff to Stiff Dark Brown Wet (FILL) | | 2 | SS | 16 | | 276 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | 3 | SS | 10 | | 275 | | | | | | | | | 0 | 16 | 41 | 43 |
| | | | | | | | | | | | | | | | | | | | |
| 274.3 | | | 4 | SS | 7 | | | | | | | | | | | | | | |
| 2.6 | Silty CLAY , some sand Firm to Very Stiff Brown Wet | | | | | | 274 | | | | | | | | | | | | |
| | | | 5 | SS | 10 | | | | | | | | | | | 0 | 11 | 46 | 43 |
| | | | | | | | | | | | | | | | | | | | |
| | | | 6 | SS | 16 | | 273 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | 7 | SS | 13 | | 272 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | 271 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | 8 | SS | 12 | | 270 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | 9 | SS | 26 | | 269 | | | | | | | | | | | | |
| 268.7 | | | | | | | | | | | | | | | | | | | |
| 8.2 | END OF BOREHOLE AT 8.2m. BOREHOLE OPEN TO 8.2m AND WATER LEVEL AT 3.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, THEN SAND AND GRAVEL TO SURFACE. | | | | | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No HWY 9-02

1 OF 1

METRIC

W.P. 2148-20-00 LOCATION MTM NAD83-10: N 4 873 385.2 E 286 511.8 ORIGINATED BY GA
 HWY 9 BOREHOLE TYPE Soild Stem Augers COMPILED BY AN
 DATUM MTM NAD83-10 DATE 2021.01.03 - 2021.01.03 LATITUDE LONGITUDE CHECKED BY RD

| 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 | | WATER CONTENT (%) W _P W W _L | | | | | | |
| 277.1 | GROUND SURFACE | | | | | ▽ | 277 | 20 | 40 | 60 | 80 | 100 | | | | |
| 0.0 | Silty SAND AND GRAVEL , trace gravel Dense Brown Moist (FILL) | | 1 | SS | 46 | | | | | | | | | ○ | | |
| | | | | | | | | | | | | | | | | |
| 275.9 | | | 2 | SS | 26 | | | | | | | | | ○ | | 22 62 12 4 |
| 1.2 | Silty CLAY , some sand and gravel Stiff Dark Brown Moist (FILL) | | | | | | | | | | | | | | | |
| | | | 3 | SS | 29 | | | | | | | | ○ | | | |
| | | | | | | | | | | | | | | | | |
| | | | 4 | SS | 9 | | | | | | | | ○ | | | |
| 273.9 | | | | | | | 274 | | | | | | | | | |
| 3.2 | Silty CLAY , occasional sand, some organics at 3.1 m Stiff to Very Stiff Brown Wet | | 5 | SS | 10 | | | | | | | | | | ┌─○─┐ | |
| | | | | | | | | | | | | | | | | |
| | | | 6 | SS | 10 | | | | | | | ○ | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 7 | SS | 15 | | | | | | | ○ | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 8 | SS | 18 | | | | | | | ○ | | | | |
| | | | | | | 270 | | | | | | | | | | |
| | | | 9 | SS | 21 | | | | | | | | ○ | | | |
| 268.9 | | | | | | 269 | | | | | | | | | | |
| 8.2 | END OF BOREHOLE AT 8.2m. BOREHOLE OPEN TO 8.2m AND WATER LEVEL AT 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, THEN SAND AND GRAVEL TO SURFACE. | | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to
Sensitivity

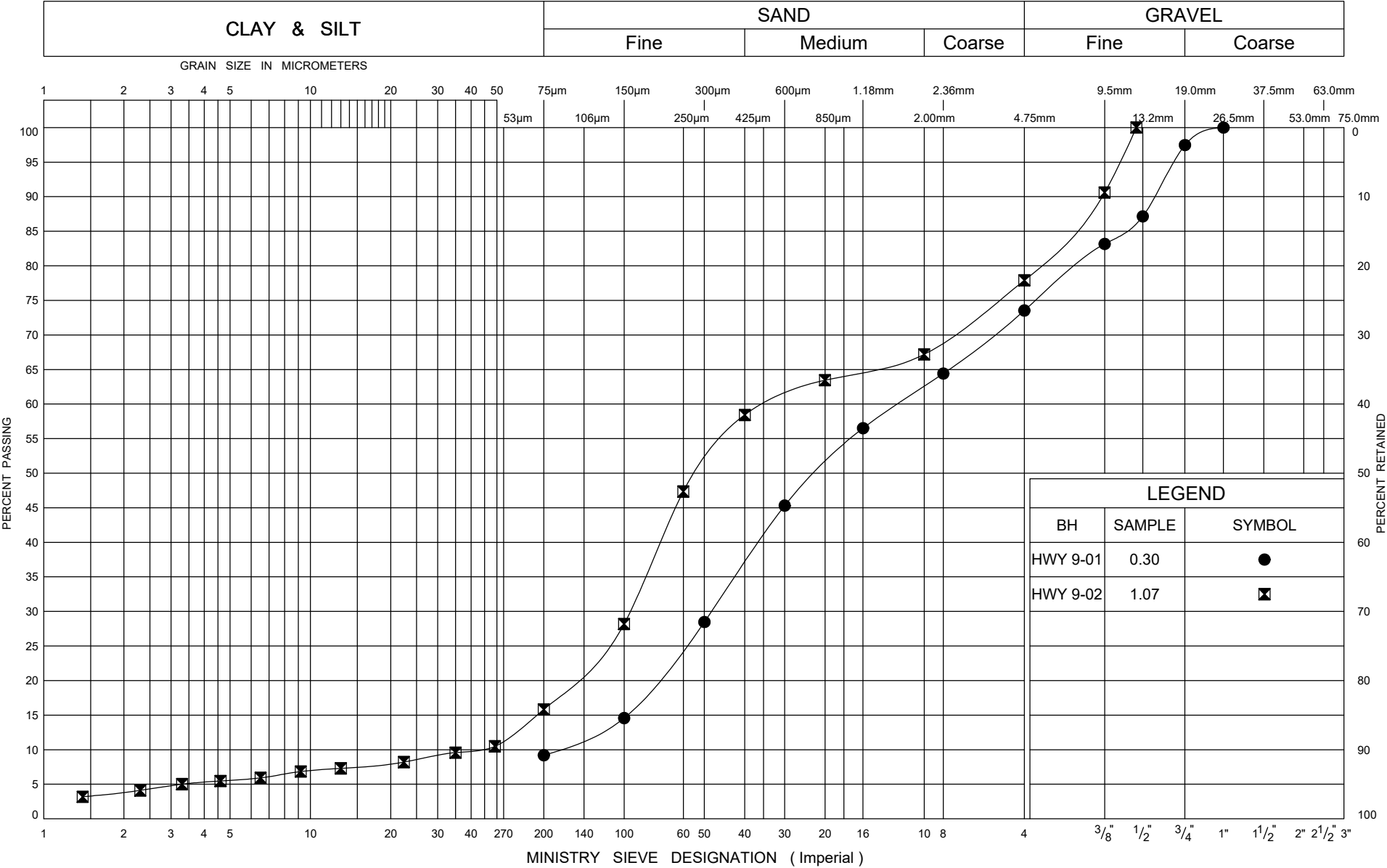
20
15
10

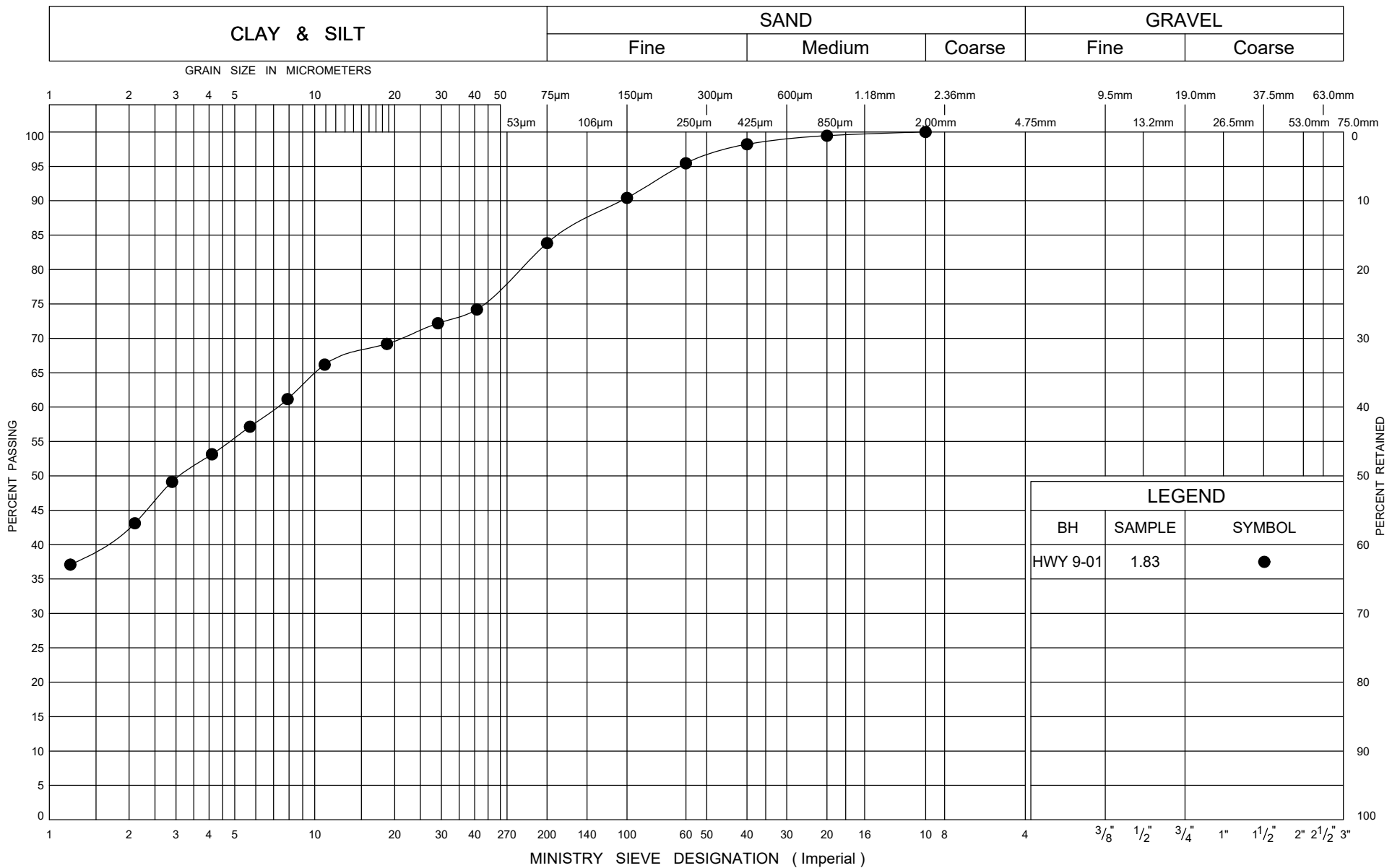
(%) STRAIN AT FAILURE

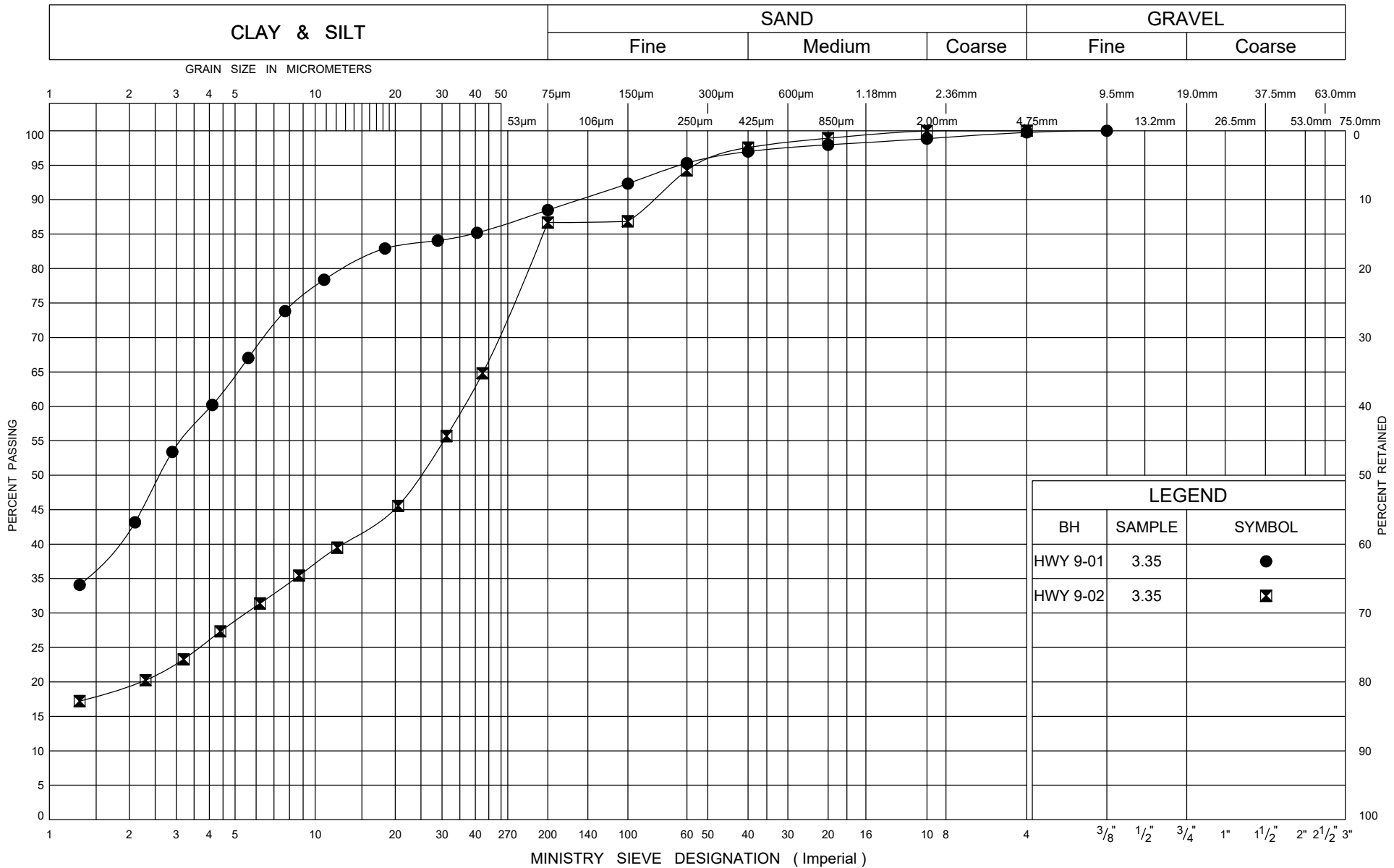


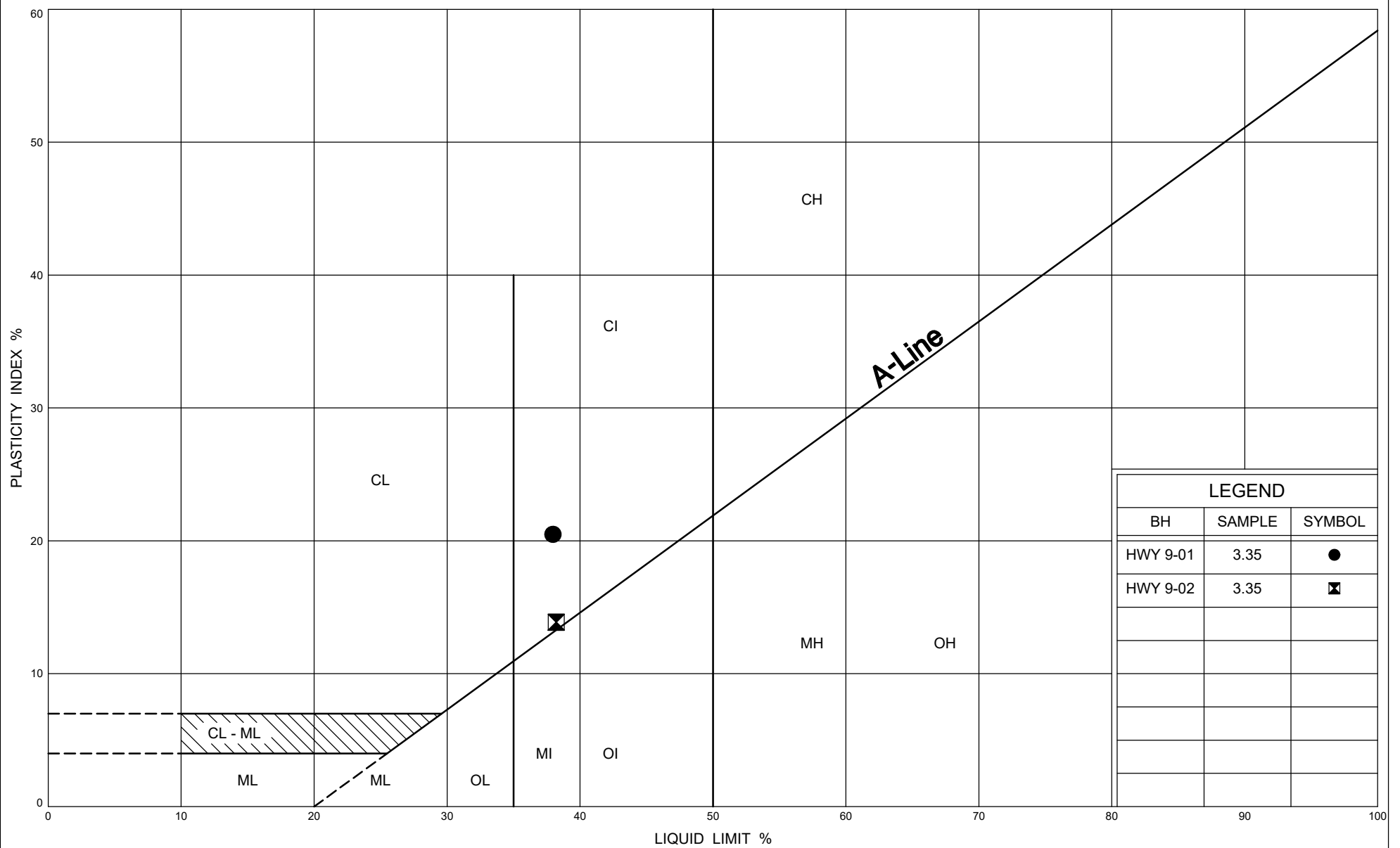
Appendix B

Geotechnical and Analytical Laboratory Test Results









CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666

ATTENTION TO: Rod de Castro

PROJECT: Highway 9 Culvert Replacement

AGAT WORK ORDER: 21T719152

SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganics Report Writer

DATE REPORTED: Mar 15, 2021

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days following analysis, unless expressly agreed otherwise in writing. Please contact your Client Project Manager if you require additional sample storage time.
- AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.
- This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
- The test results reported herewith relate only to the samples as received by the laboratory.
- Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.
- All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 21T719152

PROJECT: Highway 9 Culvert Replacement

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: THURBER ENGINEERING LTD

SAMPLING SITE: York Region, ON

ATTENTION TO: Rod de Castro

SAMPLED BY: GA

Corrosivity Package

DATE RECEIVED: 2021-03-08

DATE REPORTED: 2021-03-15

| | | | | HWY9-01, SS-4 |
|--------------------------------|----------|-------|-------|---------------------|
| SAMPLE DESCRIPTION: | | | | (7 1/2-9 1/2) |
| SAMPLE TYPE: | | | | Soil |
| DATE SAMPLED: | | | | 2021-03-01 22:00 |
| Parameter | Unit | G / S | RDL | 2193011 |
| Chloride (2:1) | µg/g | | 20 | 2420 |
| Sulphate (2:1) | µg/g | | 20 | <20 |
| pH (2:1) | pH Units | | NA | 7.42 |
| Electrical Conductivity (2:1) | mS/cm | | 0.005 | 4.20 |
| Resistivity (2:1) (Calculated) | ohm.cm | | 1 | 238 |
| Redox Potential 1 | mV | | NA | 458.9 |
| Redox Potential 2 | mV | | NA | 445.2 |
| Redox Potential 3 | mV | | NA | 442.1 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

- 2193011** EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results. Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.
- Dilution required, RDL has been increased accordingly.
- 2193012** EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results. Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



Nivine Basly

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD PROJECT:

Highway 9 Culvert Replacement SAMPLING SITE: York

Region, ON

AGAT WORK ORDER: 21T719152

ATTENTION TO: Rod de Castro

SAMPLED BY: GA

Soil Analysis

RPT Date: Mar 15, 2021

| RPT Date: Mar 15, 2021 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | METHOD BLANK SPIKE | | MATRIX SPIKE | |
|------------------------|-------|-----------|-----------|--------|-----|--------------|--------------------|-------------------|--------------------|----------|-------------------|-------|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper |

Corrosivity Package

| | | | | | | | | | | | | | | | |
|-------------------------------|---------|---------|------|------|------|---------|------|-----|------|------|-----|------|------|-----|------|
| Chloride (2:1) | 2197917 | | 53 | 53 | 0.0% | < 2 | 91% | 70% | 130% | 104% | 80% | 120% | 107% | 70% | 130% |
| Sulphate (2:1) | 2197917 | | 7 | 7 | NA | < 2 | 94% | 70% | 130% | 102% | 80% | 120% | 104% | 70% | 130% |
| pH (2:1) | 2193011 | 2193011 | 7.42 | 7.40 | 0.3% | NA | 100% | 90% | 110% | | | | | | |
| Electrical Conductivity (2:1) | 2193011 | 2193011 | 4.20 | 4.36 | 3.7% | < 0.005 | 110% | 80% | 120% | | | | | | |
| Redox Potential 1 | 1 | | | | | | 100% | 90% | 110% | | | | | | |

Comments: NA signifies Not Applicable.

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By:


Nivine Basily

Method Summary

CLIENT NAME: THURBER ENGINEERING LTD PROJECT:

Highway 9 Culvert Replacement SAMPLING SITE: York

Region, ON

AGAT WORK ORDER: 21T719152

ATTENTION TO: Rod de Castro

SAMPLED BY: GA

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|--------------------------------|--------------|--|---------------------------|
| Soil Analysis | | | |
| Chloride (2:1) | INOR-93-6004 | modified from SM 4110 B | ION CHROMATOGRAPH |
| Sulphate (2:1) | INOR-93-6004 | modified from SM 4110 B | ION CHROMATOGRAPH |
| pH (2:1) | INOR 93-6031 | MSA part 3 & SM 4500-H+ B | PH METER |
| Electrical Conductivity (2:1) | INOR-93-6036 | modified from MSA PART 3, CH 14 and SM 2510 B | EC METER |
| Resistivity (2:1) (Calculated) | INOR-93-6036 | McKeague 4.12, SM 2510 B, SSA #5 Part 3 | CALCULATION |
| Redox Potential 1 | INOR-93-6066 | modified G200-09, SM 2580 B | REDOX POTENTIAL ELECTRODE |
| Redox Potential 2 | INOR-93-6066 | modified G200-09, SM 2580 B | REDOX POTENTIAL ELECTRODE |
| Redox Potential 3 | INOR-93-6066 | modified G200-09, SM 2580 B | REDOX POTENTIAL ELECTRODE |



5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Company: Thorben Engineering Ltd
Contact: Rod de Castro
Address: 103 - 2010 Winston Churchill Park Drive
Oakville ON L6W 5R7
Phone: 905 829 8666 Fax: _____
Reports to be sent to:
1. Email: rodcastro@thorben.ca
2. Email: _____

Project: Highway 9 & Highway 12 Culvert Replacement
 Site Location: Hudson York Region & Durham Region, ON
 Sampled By: GA
 AGAT Quote #: _____ PO: _____
 Please note: If quotation number is not provided, client will be billed full price for analysis.

Company: _____
Contact: _____
Address: _____
Email: _____

| | | |
|--|------------------------------------|---|
| <input type="checkbox"/> Regulation 153/04 | <input type="checkbox"/> Sewer Use | <input type="checkbox"/> Regulation 558 |
| Table _____ Indicate One | <input type="checkbox"/> Sanitary | <input type="checkbox"/> CCME |
| <input type="checkbox"/> Ind./Corn | <input type="checkbox"/> Storm | <input type="checkbox"/> Prov. Water Quality Objectives (PWO) |
| <input type="checkbox"/> Res./Park | | <input type="checkbox"/> Other _____ Indicate One |
| <input type="checkbox"/> Agriculture | | |
| Soil Texture (Check One) | Region _____ Indicate One | |
| <input type="checkbox"/> Coarse | <input type="checkbox"/> MISA | |
| <input type="checkbox"/> Fine | | |

☐ Yes ☒ No☐ Yes ☒ No

| | |
|-----------|---------------|
| B | Biota |
| GW | Ground Water |
| O | Oil |
| P | Paint |
| S | Soil |
| SD | Sediment |
| SW | Surface Water |

Field Filtered - Metals, Hg, CrVI

O. Reg 153

Metals and Inorganics

☐ All Metals ☐ 153 Metals (excl. Hydrides)
☐ Hydride Metals ☐ 153 Metals (Incl. Hydrides)

ORPs: ☐ B-HWS ☐ Cl ☐ CN
☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ Hg

Full Metals Scan

Regulation/Custom Metals

Nutrients: ☐ TP ☐ NH₃ ☐ TKN
☐ NO₃ ☐ NO₂ ☐ NO₃+NO₂

VOC ☐ BTEX ☐ THM ☐

PHCs F1 - F4

ABNS

PAHs

PCBs: ☐ Total ☐ Aroclors

Organochlorine Pesticides

TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs

Sewer Use

Community Packages

[illegible]

| | |
|-----|---|
| 11 | 1 |
| 12 | 1 |
| 13 | 1 |
| 14 | 1 |
| 15 | 1 |
| 16 | 1 |
| 17 | 1 |
| 18 | 1 |
| 19 | 1 |
| 20 | 1 |
| 21 | 1 |
| 22 | 1 |
| 23 | 1 |
| 24 | 1 |
| 25 | 1 |
| 26 | 1 |
| 27 | 1 |
| 28 | 1 |
| 29 | 1 |
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| 31 | 1 |
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| 33 | 1 |
| 34 | 1 |
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| 39 | 1 |
| 40 | 1 |
| 41 | 1 |
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| 50 | 1 |
| 51 | 1 |
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| 56 | 1 |
| 57 | 1 |
| 58 | 1 |
| 59 | 1 |
| 60 | 1 |
| 61 | 1 |
| 62 | 1 |
| 63 | 1 |
| 64 | 1 |
| 65 | 1 |
| 66 | 1 |
| 67 | 1 |
| 68 | 1 |
| 69 | 1 |
| 70 | 1 |
| 71 | 1 |
| 72 | 1 |
| 73 | 1 |
| 74 | 1 |
| 75 | 1 |
| 76 | 1 |
| 77 | 1 |
| 78 | 1 |
| 79 | 1 |
| 80 | 1 |
| 81 | 1 |
| 82 | 1 |
| 83 | 1 |
| 84 | 1 |
| 85 | 1 |
| 86 | 1 |
| 87 | 1 |
| 88 | 1 |
| 89 | 1 |
| 90 | 1 |
| 91 | 1 |
| 92 | 1 |
| 93 | 1 |
| 94 | 1 |
| 95 | 1 |
| 96 | 1 |
| 97 | 1 |
| 98 | 1 |
| 99 | 1 |
| 100 | 1 |

1134

Sectionally, based on the High Onset of Onset (HOO) (N/A)

[illegible]

| | | | | | | |
|--|-------------------|-------|--|----------------|----------------|---------------------------|
| Samples Relinquished By (Print Name and Sign): Roi de Castro <i>R-C</i> | Date: Mar 8/21 | Time: | Samples Received By (Print Name and Sign): | Date: | Time: | |
| Samples Relinquished By (Print Name and Sign): <i>[Signature]</i> | Date: | Time: | Samples Received By (Print Name and Sign): John Chrysosha | Date: Mar 8 | Time: 11:20 | Page <u>1</u> of <u>1</u> |
| Samples Relinquished By (Print Name and Sign): <i>[Signature]</i> | Date: | Time: | Samples Received By (Print Name and Sign): John Chrysosha | Date: Mar 8 | Time: 4:20 | Nº: T 104071 |

Work Order #: 21T719152

Cooler Quantity: _____

Arrival Temperatures:

| | | |
|------|------|------|
| 10.4 | 10.6 | 10.4 |
| 8.8 | 9 | 8.6 |

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes: no ice

Regular TAT ☒ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

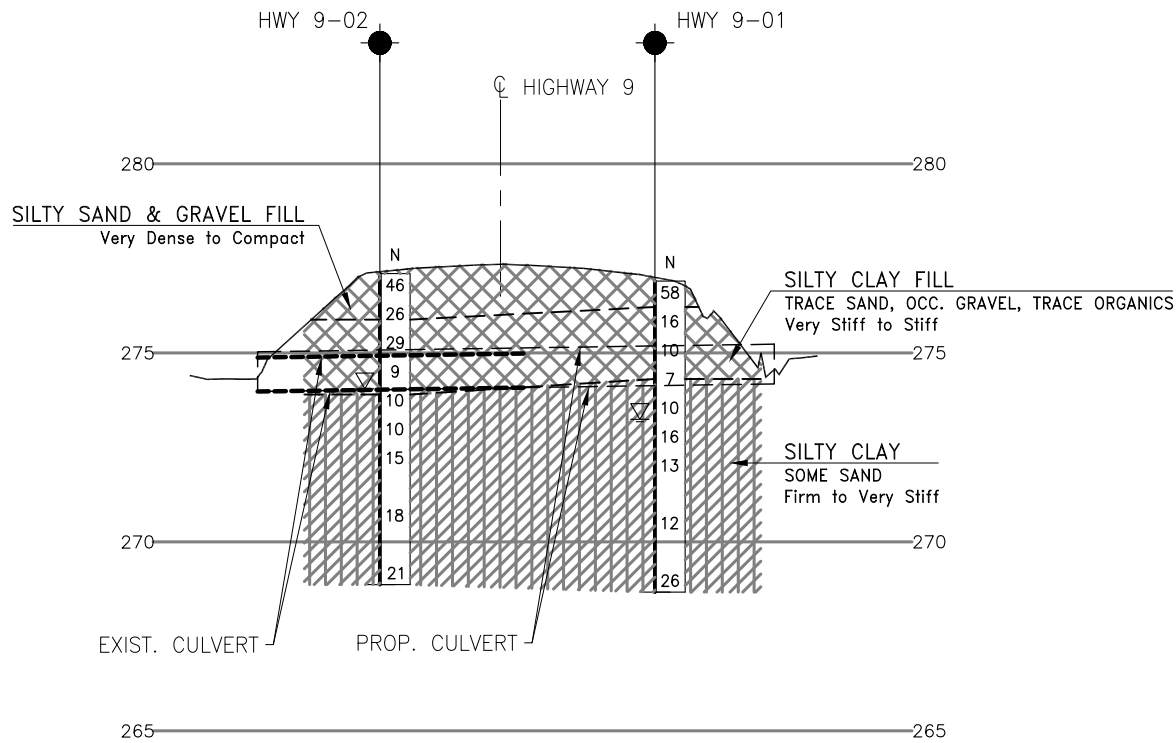
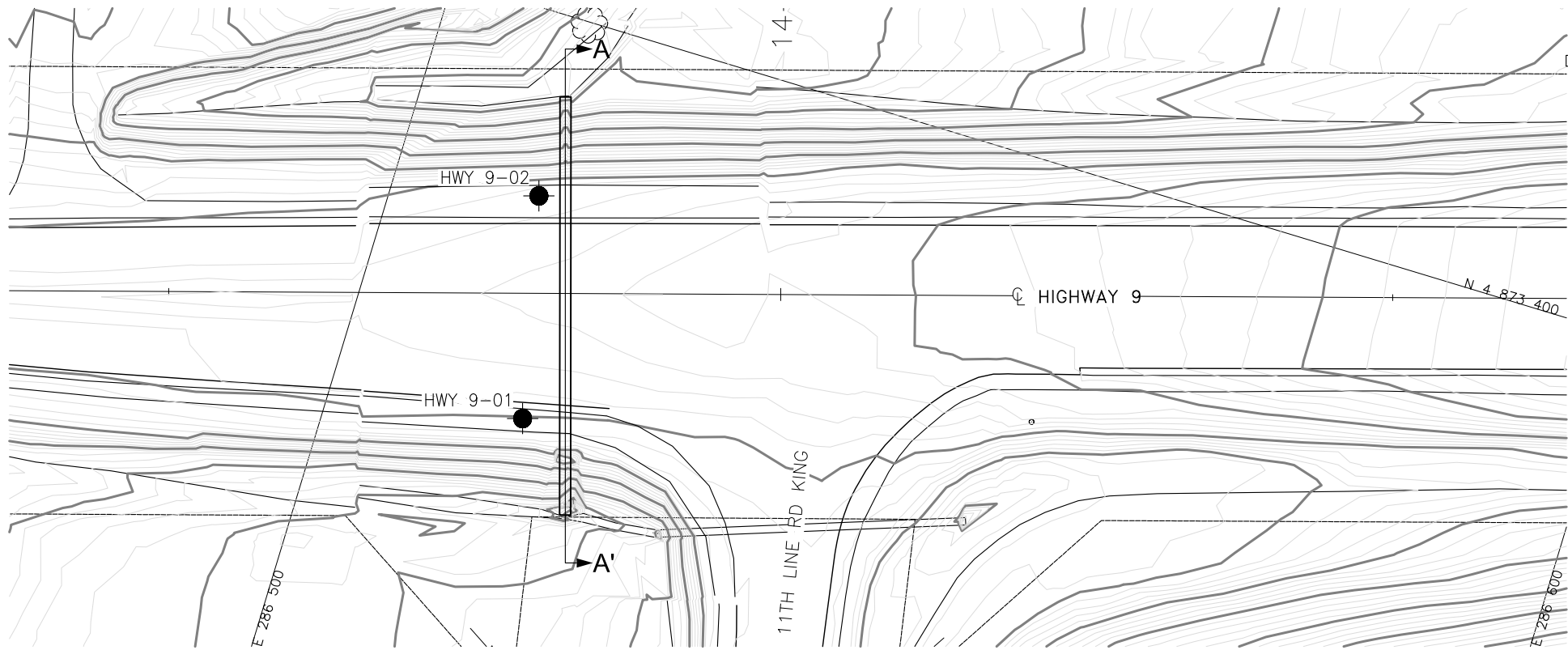
Please provide prior notification for rush TAT
*TAT is exclusive of weekends and statutory holidays

For 'Same Day' analysis, please contact your AGAT CPM



Appendix C

Borehole Locations and Soil Strata Drawing



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

CONT No
WP No 2148-20-00

HIGHWAY 9
CULVERT REPLACEMENT

BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

| NO | ELEVATION | NORTHING | EASTING |
|----------|-----------|-------------|-----------|
| HWY 9-01 | 276.9 | 4 873 367.4 | 286 515.8 |
| HWY 9-02 | 277.1 | 4 873 385.2 | 286 511.8 |

-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 10.

GEOCRES No. 30M13-235



| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|--------|---------------|
| DESIGN | RD | CHK | CODE |
| DRAWN | AN | CHK RD | SITE |
| | | | LOAD |
| | | | STRUCT |
| | | | DWG 1 |
| | | | DATE MAR 2021 |



Appendix D
List of OPSSs and OPSDs and Suggested Wording for NSSP

1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 401 (Construction Specification for Trenching, Backfilling and Compacting)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS PROV 511 (Rip Rap, Rock Protection and Granular Sheeting)
- OPSS PROV 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation)
- Special Provision No 517F01 (Temporary Flow Passage System)
- 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 – Structures)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSS PROV 1004 (Material Specification for Aggregates – Miscellaneous)
- OPSS PROV 1005 (Material Specification for Aggregates – Streambed Material)
- OPSS PROV 1205 (Material Specification for Clay Seal)
- OPSD 202.010 (Slope Flattening Using Surplus Excavated material on Earth or Rock Embankment)
- OPSD 810.010 (General Rip-Rap Layout for Sewer and Culvert Outlets)
- OPSD 802.014 (Flexible Pipe Embedment in Embankment, Original Ground: Earth or Rock)
- OPSD 3090.1010 (Foundation Frost Penetration Depths for Southern Ontario)

2. Suggested Text for NSSP on “Temporary Excavation and Live Traffic at 1.2 m from the Crest of Excavation ”

The Contractor is advised of the following site conditions:

- Under no circumstances should any heavy equipment or stockpiled material be placed at the crests of the temporary excavation. In addition, the live lane traffic during the

staged construction of the culvert replacement should be no closer than 1.2 m from the crest of the sloped excavation.

The Contractor shall consider the following during and after excavation of the temporary cut slopes:

- Excavations shall be inspected regularly for evidence of instability.
- Surface water shall be drained away from the side slopes of the proposed excavation.
- If any slope instability is observed (e.g. signs of sloughing, seepage, cracking or movement), remedial actions (e.g. slope flattening, backfilling the excavation, moving the traffic to the shoulder lane etc.) shall be taken immediately to ensure the stability of the excavation and the safety of workers and live traffic.

3. Suggested Wording for NSSP on Dewatering

Effective dewatering shall be designed and provided by the Contractor during culvert excavation, bedding placement and backfilling to allow the work to proceed in the dry. Excavation below the groundwater level will lead to subgrade softening. The dewatering system must be effective to maintain the water level below the final subgrade level throughout construction. The dewatering system must remain operational and effective until the culvert is installed and backfilled.

4. Suggested Wording for NSSP on Suitability of Soil for Reuse

The existing embankment fills should not be reused to backfill above the culvert granular zone and under the highway pavement. Imported granular material such as Granular B Type I or Select Subgrade Material (SSM) should be used as backfill above the culvert granular zone and compacted.

However, all excavated material (with the exception of topsoil) can be used for slope flattening in accordance with OPSD 202.010 provided they are free of organics, frozen materials, and at a suitable moisture content for re-compaction.







Appendix E

Slope Stability Analyses Figures

FIGURE 1

HIGHWAY 9 CULVERT STAGE A - SLOPE STABILITY ANALYSIS

| Color | Name | Model | Unit Weight (kN/m ³) | Cohesion' (kPa) | Phi' (°) |
|---|--|--------------|----------------------------------|-----------------|----------|
|  | Silty Clay - Stiff | Mohr-Coulomb | 18 | 5 | 30 |
|  | Silty Clay Fill - Stiff | Mohr-Coulomb | 18 | 0 | 30 |
|  | Silty Clay Fill - V. Stiff | Mohr-Coulomb | 19 | 0 | 30 |
|  | Silty Sand & Gravel Fill - V. Dense to Compact | Mohr-Coulomb | 22 | 0 | 35 |

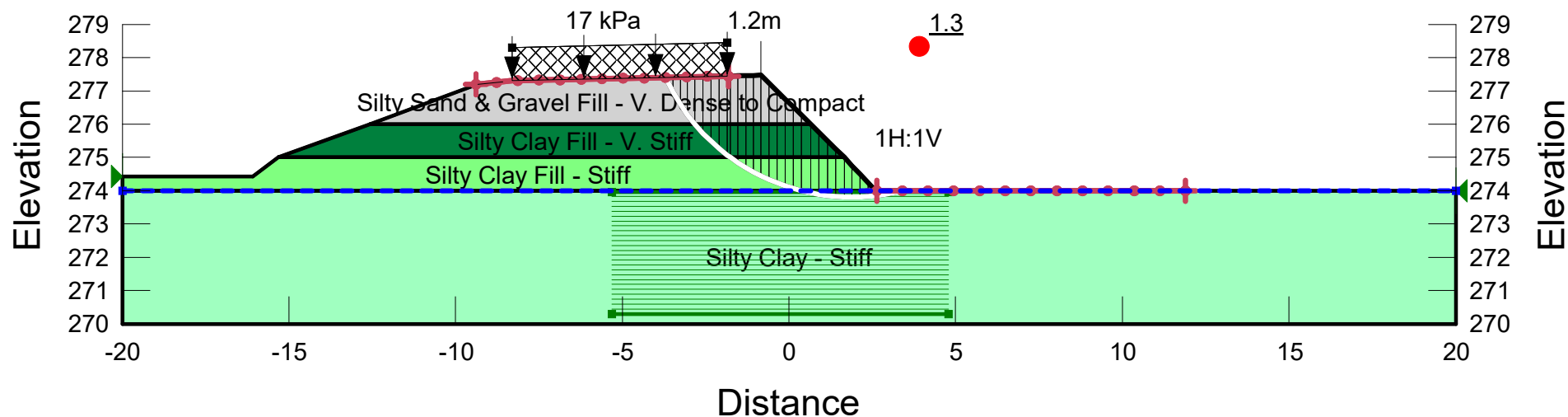




FIGURE 2

HIGHWAY 9 CULVERT STAGE B - SLOPE STABILITY ANALYSIS

| Color | Name | Model | Unit Weight (kN/m³) | Cohesion' (kPa) | Phi' (°) |
|---|-------------------------|--------------|---------------------|-----------------|----------|
|  | Granular A or B Type II | Mohr-Coulomb | 22 | 0 | 35 |
|  | Silty Clay - Stiff | Mohr-Coulomb | 18 | 5 | 30 |

