

**FINAL  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
REPLACEMENT OF THE HIGHWAY 401 OVERPASS AT  
GANARASKA RIVER  
NORTHUMBERLAND COUNTY – PORT HOPE, ONTARIO  
ASSIGNMENT NO.: 4019-E-0021  
GWP 4068-14-00**



**THURBER ENGINEERING LTD.**



**FINAL  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
REPLACEMENT OF THE HIGHWAY 401 OVERPASS AT  
GANARASKA RIVER  
NORTHUMBERLAND COUNTY – PORT HOPE, ONTARIO  
ASSIGNMENT NO.: 4019-E-0021  
GWP 4068-14-00**

**SITE NO. 21X-0231/B0  
GEOCRES NO.: 30M16-078**

**Report  
to  
MCINTOSH PERRY | LEA JOINT VENTURE**

Latitude: 43.969469°  
Longitude: -78.294128°

August 2023  
Thurber File No.: 33099



## TABLE OF CONTENTS

### PART 1. FACTUAL INFORMATION

|     |  |    |
|-----|--|----|
| 1.  | INTRODUCTION.....  | 1  |
| 2.  | SITE DESCRIPTION.....                                    | 1  |
| 2.1 | General.....   | 1  |
| 2.2 | Site Geology.....  | 2  |
| 3.  | EXISTING INFORMATION .....                               | 2  |
| 4.  | SITE INVESTIGATION AND FIELD TESTING .....               | 3  |
| 5.  | LABORATORY TESTING .....                                 | 5  |
| 6.  | DESCRIPTION OF SUBSURFACE CONDITIONS.....                | 6  |
| 6.1 | Fill.....  | 6  |
| 6.2 | Organic Silt (OL to ML-OL to MH-OH).....                 | 8  |
| 6.3 | Clayey Silt (CL) .....                                   | 9  |
| 6.4 | Silty Sand to Sand with Silt (SM to SW-SM to SP-SM)..... | 9  |
| 6.5 | Glacial Till.....  | 10 |
| 6.6 | Bedrock .....  | 11 |
| 6.7 | Analytical Test Results .....                            | 12 |
| 6.8 | Groundwater Level .....                                  | 12 |
| 7.  | MISCELLANEOUS.....                                       | 13 |

### PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

|      |   |    |
|------|---|----|
| 8.   | GENERAL .....   | 15 |
| 8.1  | Existing Foundations .....                                      | 15 |
| 8.2  | Proposed Structure .....  | 16 |
| 8.3  | Applicable Codes and Design Considerations .....                | 16 |
| 9.   | SEISMIC CONSIDERATIONS .....                                    | 17 |
| 9.1  | Spectral and peak Acceleration Hazard Values .....              | 17 |
| 9.2  | CHBDC Seismic Site Classification and Performance Category..... | 17 |
| 9.3  | Liquefaction Potential .....                                    | 17 |
| 10.  | GEOTECHNICAL ASSESSMENT / CONSIDERATIONS.....                   | 18 |
| 11.  | EVALUATION OF DESIGN OPTIONS.....                               | 18 |
| 12.  | FOUNDATION DESIGN RECOMMENDATIONS .....                         | 20 |
| 12.1 | Caissons.....   | 20 |
| 12.2 | Driven Steel H-Piles .....                                      | 21 |
| 12.3 | Deep Foundations – Lateral Resistance .....                     | 22 |



|        |  |    |
|--------|--|----|
| 12.4   | Deep Foundations - Downdrag .....                        | 23 |
| 12.5   | Backfill and Lateral Earth Pressure .....                | 24 |
| 12.5.1 | Backfill .....   | 24 |
| 12.5.2 | Static Lateral Earth Pressure .....                      | 24 |
| 12.5.3 | Combined Static and Seismic Lateral Earth Pressure ..... | 25 |
| 12.6   | Frost Depth.....   | 26 |
| 12.7   | Cement Type and Corrosion Potential .....                | 26 |
| 12.8   | Embankment Settlement .....                              | 27 |
| 12.9   | Embankment Stability .....                               | 27 |
| 13.    | CONSTRUCTION CONSIDERATIONS .....                        | 28 |
| 13.1   | Excavation .....   | 28 |
| 13.2   | Temporary Protection Systems .....                       | 29 |
| 13.3   | Surface and Groundwater Control.....                     | 30 |
| 13.4   | Erosion Protection .....                                 | 30 |
| 14.    | CONSTRUCTION CONCERNS .....                              | 31 |
| 15.    | CLOSURE .....  | 33 |





## **APPENDICES**

|            |   |
|------------|---|
| Appendix A | Drawings  |
|            | General Arrangement Drawing                               |
|            | Borehole Locations and Stratra Drawing                    |
| Appendix B | Field Investigation and Testing                           |
|            | Symbols and Terms   |
|            | Record of Boreholes Sheets                                |
| Appendix C | Laboratory Testing  |
|            | Particle Size Analysis Figures                            |
|            | Atterberg Limits Figures                                  |
|            | Unconfined Compressive Strength Testing Results           |
|            | Analytical Testing Results                                |
|            | Bedrock Core Photographs                                  |
| Appendix D | Site Photographs  |
| Appendix E | Comparison of Foundation Alternatives                     |
| Appendix F | P-y Curves  |
| Appendix G | Slope Stability Analysis Figures                          |
| Appendix H | GSC Seismic Hazard  |
| Appendix I | List of Referenced Specifications and Contract Provisions |



**FINAL  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
REPLACEMENT OF THE HIGHWAY 401 OVERPASS AT GANARASKA RIVER  
NORTHUMBERLAND COUNTY – PORT HOPE, ONTARIO  
ASSIGNMENT NO.: 4019-E-0021  
GWP 4068-14-00**

**GEOCRES NO.: 30M16-078**

**PART 1. FACTUAL INFORMATION**

**1. INTRODUCTION**

This section of the report presents the factual findings obtained from both a preliminary and detailed foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the replacement of the Highway 401 Ganaraska River overpass structure located in Port Hope, Ontario. Thurber carried out the preliminary foundation investigation as a subconsultant to WSP Canada (WSP) under Agreement No. 4014-E-0014 and the detailed foundation investigation as a subconsultant to a LEA Consulting (LEA) and McIntosh Perry Consulting Engineers (MPCE) joint venture under Agreement No. 4019-E-0021, Assignment No. 18.

A General Arrangement (GA) drawing and base plan mapping were provided by LEA for the preparation of this report.

The purpose of these investigations was to explore the subsurface conditions at the site and, based on this data, provide a borehole location plan, record of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction of a replacement structure was developed in the course of the current investigation.

**2. SITE DESCRIPTION**

**2.1 General**

Site 21X-0231/B0 is located on Highway 401, approximately 0.45 km west of the Highway 401 County Road 28 underpass in Port Hope, Ontario. The location of the structure is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

Highway 401 at the location of the overpass has three through lanes in each direction. Traffic volumes on this section of Highway 401 are understood to be 50,000 AADT (2016). It is noted



that for project orientation purposes, Highway 401 will be assumed to be oriented east-west and the Ganaraska River to be oriented north-south with river flow to the south. The eastbound and westbound lanes are separated by a median barrier wall. There are steel beam guide rails located along the outside lanes east and west of the bridge and a concrete barrier where the highway crosses over the river.

Based on the historical contract documents, the existing three-span, steel plate girder structure is approximately 73.0 m long, and 29.0 m wide.

The lands surrounding the site consist of the Port Hope Conservation Area to the north of Highway 401. Corbitt's Dam and residential properties are located to the south of Highway 401. Storm water drainage in the area is to existing catch basins and the Ganaraska River. Site photographs showing the general conditions at the site are presented along Highway 401 and the Ganaraska River are presented in Appendix D.

The existing approach embankments range in height from approximately 10.7 m to 12.1 m. The embankment side slopes extend down at approximately 2H:1V. The slopes are vegetated with a combination of long grass and brush.

## **2.2 Site Geology**

The site is located within a physiographic region known as the Iroquois Plain. This area was formed by a body of water known as Lake Iroquois and is characterized by lacustrine deposits of sand, silts and clays. Along Highway 401, within the project limits, the principal overburden consists of till and clay with occasional drumlins (Chapman and Putnam, 1984).

## **3. EXISTING INFORMATION**

The GEOCRE Report 30M16-7 dated July 12<sup>th</sup>, 1957 presents the results of the investigations carried out for the design and construction of the existing bridge structure and approach embankments. The investigation included six boreholes for the structure. A supplemental approach embankment investigation was also carried out that included three short boreholes to refusal and five auger probe holes; the results were included as an addendum to the original investigation report. Two of the structure boreholes were advanced approximately 3.0 m into the limestone bedrock while all approach boreholes were advanced to refusal on inferred bedrock.

Prior to construction of the bridge and Highway 401 in 1957, the stratigraphy in the area of the bridge was generally described as surficial deposits of organic silt, overlying a thin deposit of very dense silty coarse sand. The overburden soil at the site is underlain by sound limestone bedrock



based on AXT rock coring. The Borehole Logs indicated the bedrock surface at around elevation 295 to 297 feet (89.9 to 90.5 m).

The report noted concerns regarding the stability of the embankments. Failure of the underlying soil was predicted during placement of the embankment fill (up to 35 feet (10.7 m) of fill). It was recommended in the supplemental investigation letter that a trench 1.5 m (5 ft.) deep, 9.1 m (30 ft.) wide and 30.5 m (100 ft.) long be excavated and the excavated material be replaced with properly compacted granular fill before commencing the embankment fill placement. It is not known if this subgrade treatment was carried out.

A Preliminary Foundation Investigation for replacement of this structure was carried out by Thurber in 2016 under Assignment No. 4014-E-0014. The site investigation and field-testing program was carried out between May 30<sup>th</sup> and June 1<sup>st</sup>, 2016, and included advancing four boreholes labelled 401 through 404. The results of the preliminary investigation boreholes have been included in the description of subsurface conditions that follows.

#### **4. SITE INVESTIGATION AND FIELD TESTING**

A detailed site investigation and field testing program was carried out between March 17<sup>th</sup> and April 14<sup>th</sup>, 2022, to supplement the 2016 preliminary investigation and included advancing eight boreholes labelled GR22-01 through GR22-08. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 4-1. The site is within MTM Zone 10. The as-drilled locations of the boreholes below the existing bridge were measured relative to existing site features to decimeter accuracy; the elevations of the boreholes below the existing bridge were surveyed to centimeter accuracy using a Nikon AP-8 Auto-Level. The as-drilled locations and elevations of all other boreholes were surveyed using a Trimble Catalyst DA2 global positioning system antenna with centimeter accuracy. The elevations were surveyed relative to the first order vertical benchmarks HCP 108 and HCP 109 west and east of the Ganaraska River with geodetic elevations of 106.144 m and 103.019 m, respectively.

**Table 4-1: Borehole Summary**

| Borehole No. | Drilled Location          | Northing (m) | Easting (m) | Ground Surface Elevation (m) | Termination Depth (m) |
|--------------|---------------------------|--------------|-------------|------------------------------|-----------------------|
| 401          | West abutment – WB Lane 3 | 4 870 654.5  | 401 513.7   | 106.0                        | 14.6                  |

| Borehole No. | Drilled Location          | Northing (m) | Easting (m) | Ground Surface Elevation (m) | Termination Depth (m) |
|--------------|---------------------------|--------------|-------------|------------------------------|-----------------------|
| 402          | West abutment – EB Lane 3 | 4 870 631.4  | 401 517.2   | 106.0                        | 19.7                  |
| 403          | East abutment – WB Lane 3 | 4 870 667.1  | 401 602.1   | 103.3                        | 19.8                  |
| 404          | East abutment – EB Lane 3 | 4 870 645.1  | 401 606.0   | 103.4                        | 15.3                  |
| GR22-01      | West abutment – North end | 4 870 676.0  | 401 511.2   | 98.7                         | 7.0                   |
| GR22-02      | West Pier – North end     | 4 870 679.1  | 401 532.2   | 97.6                         | 9.4                   |
| GR22-03      | East Pier – North end     | 4 870 686.5  | 401 576.5   | 95.5                         | 9.8                   |
| GR22-04      | East abutment – North end | 4 870 692.2  | 401 597.9   | 95.2                         | 10.5                  |
| GR22-05      | West Pier – Below WB      | 4 870 660.2  | 401 535.4   | 98.1                         | 7.8                   |
| GR22-06      | East Pier – Below WB      | 4 870 666.1  | 401 579.9   | 97.2                         | 7.7                   |
| GR22-07      | West Pier – Below EB      | 4 870 641.0  | 401 537.7   | 97.9                         | 10.7                  |
| GR22-08      | East Pier – Below EB      | 4 870 647.3  | 401 582.9   | 96.7                         | 10.5                  |

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locates/clearances in the vicinity of the intended borehole locations. In addition, MTO traffic operations was contacted to obtain ATMS Fibre utility locates and RW Electric was contacted to obtain MTO electric locates for the project limits.

Boreholes 401 through 404 were advanced with a CME truck mounted drill rig equipped with hollow stem augers. Boreholes GR22-01 through GR22-08 were advanced with a portable exploration drill rig utilizing a half-weight hammer and NW size casing and wash boring. The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber



personnel. Split spoon samples were collected at regular depth intervals in the boreholes via the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. All soil samples recovered from the boreholes were placed in moisture-proof containers and the samples were transported to Thurber's Pickering geotechnical laboratory for further examination and testing. Bedrock was cored in Boreholes 402 and 403 with HQ size coring equipment and Boreholes GR22-02 through GR22-04, GR22-07 and GR22-08 with NQ size coring equipment following ASTM Standard D6032-08. Bedrock core samples were stored in core boxes for transport.

A 25 mm diameter standpipe piezometer was installed in Borehole 403 and 38 mm diameter standpipe piezometers were installed into Boreholes GR22-03 and GR22-07 to allow for the measurement of the groundwater level at the site. Piezometer construction details are illustrated on the respective Record of Borehole sheets, provided in Appendix B. The piezometer in Borehole 403 was decommissioned in accordance with Ontario MOE Regulation 903 on May 31, 2016, after the final water level measurement. The piezometers in Boreholes GR22-03 and GR22-07 were decommissioned in accordance with Ontario MOE Regulation 903 on June 22, 2023.

The boreholes without piezometer installations were backfilled with a low-permeability combination of soil cuttings and bentonite pellets in accordance with Ontario MOE Regulation 903 as amended. All on-road boreholes were capped with 150 mm of cold patch asphalt underlain by 150 mm layer of concrete.

## **5. LABORATORY TESTING**

Laboratory testing was selected in general accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. More than 25% of the recovered soil samples were tested for grain size distribution and, where appropriate, Organic Content and Atterberg Limits in accordance with MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Selected samples of the rock core were submitted for unconfined compressive strength (UCS) testing. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate, sulphide and chloride concentrations was carried out on seven soil samples.

The results of geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and laboratory results are presented on the figures included in Appendix C.



## 6. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. Soil classification for the 2022 investigation is in accordance with ASTM D2487 with cohesive soils described as per current MTO Guidelines for Foundation Engineering Services. An overall description of the stratigraphy is given in the following sections, however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions. It must be recognized that soil and groundwater conditions may vary between and beyond sampled locations.

In general, the stratigraphy in the area of the boreholes is characterized by an asphalt pavement or topsoil underlain by embankment fill, overlying silty sand to sand with silt deposits and a native organic silt, overlying glacial till, which is underlain by limestone bedrock. The upper portion of the embankment fill generally consisted of silty sand with gravel with occasional cobbles. The lower portion of the embankment fill was more variable and included clay, silty sand some gravel, sandy silt, sandy clay and silty sand.

More detailed descriptions of the individual strata are presented below.

### 6.1 Fill

#### Asphalt

Four boreholes, numbered 401 through 404, were advanced through the existing Highway 401 pavement structure. The thickness of the asphalt measured at the borehole locations ranged from 240 mm to 350 mm.

#### Topsoil

Topsoil was encountered at surface in four boreholes, labelled GR22-01 through GR22-04, and ranged in thickness from 75 to 255 mm. It was noted that the topsoil was frozen at GR22-03.

#### Silty Sand with Gravel

Fill consisting predominantly of silty sand with varying amounts of gravel was encountered below the asphalt surface in Boreholes 401 through 404, below the topsoil in Boreholes GR22-01 and GR22-02 and at surface in Boreholes GR22-05 and GR22-08. The top of this layer ranged from elevation 105.7 m to 96.7 m. The thickness of this layer ranged from 1.9 m to 5.2 m. The SPT 'N' values ranged from 4 blows for 0.3 m of penetration to greater than 100 indicating a loose to very dense condition; but typically compact.



The moisture content of the samples tested ranged from 1% to 32%. The results of grain size analysis conducted on seven samples of this material are summarized in Table 6-1 and are illustrated on Figures C1 and C2 in Appendix C.

**Table 6-1: Gradation Results for Silty Sand with Gravel Fill**

| Soil Particle | Percentage (%) |    |
|---------------|----------------|----|
| Gravel        | 12 to 27       |    |
| Sand          | 43 to 68       |    |
| Silt          | 10 to 37       | 24 |
| Clay          |                | 21 |

#### Variable Fill

The embankment fill encountered beneath the upper granular embankment fill at Boreholes 401 through 404, beneath the topsoil in Boreholes GR22-03 and GR22-04, and at surface in Boreholes GR22-06 and GR22-07 consisted of a mixture with varying compositions of silt, clay, sand and gravel with occurrences of organics and rock fragments. The top of this layer ranged from elevation 101.1 m to 95.0 m. The thickness of this layer ranged from 1.3 m to 7.6 m. The SPT 'N' values ranged from 7 for 0.3 m of penetration to greater than 100 indicating a loose to very dense condition; but typically compact to dense. The clay fill was identified as having a firm to very stiff consistency. Probable voids were noted within the variable fill layer in Borehole GR22-06 based on the low blow counts and very poor sample recovery between depths of 3.0 and 4.6 m (elev. 94.2 m to 92.6 m).

The moisture content of the samples tested ranged from 3% to 67%. The results of grain size analysis conducted on seven samples of this material are summarized in Table 6-2 and are illustrated on Figures C3 and C4 in Appendix C.

**Table 6-2: Gradation Results for Variable Fill**

| Soil Particle | Percentage (%) |          |
|---------------|----------------|----------|
| Gravel        | 0 to 15        |          |
| Sand          | 9 to 93        |          |
| Silt          | 7 to 63        | 27 to 56 |
| Clay          |                | 9 to 35  |



The results of Atterberg Limits testing completed on three samples of the fine-grained embankment fill are summarized in Table 6-3 and are illustrated on Figure C10 in Appendix C. It should be noted that one sample of embankment fill was found to be non-plastic.

**Table 6-3: Atterberg Limit Results for Variable Fill**

| Parameter        | Value    |
|------------------|----------|
| Liquid Limit     | 21 to 36 |
| Plastic Limit    | 13 to 17 |
| Plasticity Index | 8 to 19  |

## 6.2 Organic Silt (OL to ML-OL to MH-OH)

A stratum of organic silt with varying amounts of sand and clay and occasional wood fibres was encountered beneath the fill layers in Boreholes 401 through 404, GR22-03 and GR22-04 and below the native sand layer in Boreholes GR22-01, GR22-02 and GR22-05. The top of this layer ranged from elevation 91.3 m to 94.1 m. The thickness of this layer ranged from 0.5 m to 3.6 m. The SPT 'N' values ranged from 3 blows for 0.3 m of penetration to greater than 100 indicating a very loose to very dense condition; but typically, loose to compact.

The moisture content of the samples tested ranged from 14% to 99%. The results of grain size analysis testing conducted on nine samples of this material are summarized in Table 6-4 and are illustrated on Figure C5 and C6 in Appendix C.

**Table 6-4: Gradation Results for Organic Silt**

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel        | 0 to 3         |
| Sand          | 3 to 46        |
| Silt          | 35 to 82       |
| Clay          | 3 to 28        |

The results of Atterberg Limits testing completed on seven samples of this material are summarized in Table 6-5 and are illustrated on Figures C11 and C12 in Appendix C. The test results indicate an organic silt ranging from non-plastic to high plasticity (ML-OL to MH-OH).

**Table 6-5: Atterberg Limit Results for Organic Silt**

| Parameter        | Value    |
|------------------|----------|
| Liquid Limit     | 25 to 61 |
| Plastic Limit    | 21 to 42 |
| Plasticity Index | 4 to 19  |

The results of an organic content test on one sample of the organic silt resulted in an organic content of 1.0%.

### **6.3 Clayey Silt (CL)**

A brown clayey silt deposit was encountered below the organic silt strata in Borehole 402. The top of this layer was identified at elevation 91.5 m. The thickness of this layer is 0.3 m.

The moisture content of the sample tested was 31%. The results of a grain size analysis tests indicated a gravel content of 0%, sand content of 16%, a silt content of 61% and a clay content 23%. Grain size analysis results are illustrated on Figure C7 in Appendix C.

The results of Atterberg Limits testing completed on this material indicated a liquid limit of 33, a plastic limit of 18, and a plasticity index of 15, indicating a clayey silt of low plasticity (CL). Atterberg Limits analysis results for the clay are illustrated on Figure C13 in Appendix C.

### **6.4 Silty Sand to Sand with Silt (SM to SW-SM to SP-SM)**

A native deposit consisting primarily of sand with varying amounts of silt was encountered beneath the fill in Boreholes GR22-01, GR22-02, GR22-05, GR22-07 and GR22-08. Occasional cobbles and boulders were noted within this layer. The top of this layer, where observed, ranges from elevation 95.8 to 93.7 m. The thickness of this layer ranged from 1.3 to 3.8 m. The SPT 'N' values ranged from 10 blows for 0.3 m of penetration to greater than 100 indicating a compact to very dense condition.

The moisture content of the sample tested ranged from 1% to 15%. The results of a grain size analysis testing conducted on five samples of this material are summarized in Table 6-6 and are illustrated on Figure C8 in Appendix C.

**Table 6-6: Gradation Results for Silty Sand to Sand**

| Soil Particle | Percentage (%) |   |
|---------------|----------------|---|
| Gravel        | 1 to 14        |   |
| Sand          | 70 to 90       |   |
| Silt          | 9 to 28        | 4 |
| Clay          |                | 9 |

## 6.5 Glacial Till

A stratum of glacial till consisting predominantly of silty sand and gravel was encountered beneath the fill in GR22-06, beneath the organic silt in Boreholes 403, 404, GR22-01, GR22-02, GR22-03 and GR22-04, beneath the native clay in Borehole 402, and beneath the native sand in Boreholes GR22-07 and GR22-08. Occasional to frequent cobbles and boulders were noted within the glacial till layer. Coring was required to get through this till layer in Borehole GR22-02. The top of this layer, where observed, ranges from elevation 92.7 m to 90.4 m. The thickness of this layer ranged from 0.2 m to 3.2 m. The SPT 'N' values ranged from 5 to greater than 100 indicating a loose to very dense condition; but typically compact to dense. Although cobbles or boulders were not encountered in all boreholes within the glacial till, it should be noted that glacial tills inherently contain cobbles and/or boulders.

The moisture content of the sample tested ranged from 4% to 27%. The results of a grain size analysis testing conducted on six samples of this material are summarized in Table 6-7 and are illustrated on Figures C9 in Appendix C.

**Table 6-7: Gradation Results for Glacial Till**

| Soil Particle | Percentage (%) |          |
|---------------|----------------|----------|
| Gravel        | 9 to 36        |          |
| Sand          | 28 to 81       |          |
| Silt          | 3 to 31        | 33       |
| Clay          |                | 11 to 12 |

The results of Atterberg Limits testing completed on two samples of the fines of this material found one sample to be non-plastic and the other to have a liquid limit of 21, a plastic limit of 15, and a plasticity index of 6, indicating silty, clayey sand (CL-ML) till in that instance. Atterberg Limit analysis results for the glacial till are illustrated on Figure C14 in Appendix C.

## 6.6 Bedrock

The overburden materials were underlain by a grey limestone bedrock. The bedrock surface ranges from elevation 87.1 m to 91.5 m in the boreholes where rock was cored. Photographs of the bedrock core are provided in Appendix B. Table 6-8 below summarizes the depths and elevations of the bedrock surface.

**Table 6-8 Top of Bedrock Elevation**

| Location      | Borehole | Ground Surface Elevation (m) | Depth Below Existing Grade (m) | Top of Bedrock Elevation (m) |
|---------------|----------|------------------------------|--------------------------------|------------------------------|
| West Abutment | 401      | 106.0                        | 14.5                           | 91.5*                        |
|               | 402      | 106.0                        | 15.0                           | 91.0                         |
|               | GR22-01  | 98.7                         | 6.9                            | 91.8*                        |
| West Pier     | GR22-02  | 97.6                         | 6.1                            | 91.5                         |
|               | GR22-05  | 98.1                         | 7.3                            | 90.8*                        |
|               | GR22-07  | 97.9                         | 7.4                            | 90.5                         |
| East Abutment | 403      | 103.3                        | 15.7                           | 87.6                         |
|               | 404      | 103.4                        | 14.9                           | 88.4*                        |
|               | GR22-04  | 95.2                         | 7.4                            | 87.8                         |
| East Pier     | GR22-03  | 95.5                         | 6.5                            | 89.0                         |
|               | GR22-06  | 97.2                         | 7.1                            | 90.1*                        |
|               | GR22-08  | 96.7                         | 6.6                            | 90.1                         |

\* Bedrock Inferred by SPT/auger refusal or short NQ core sample

Boreholes 402 and 403 were advanced into the bedrock by coring with HQ-size coring equipment and Boreholes GR22-02, GR22-03, GR22-04, GR22-07 and GR22-08 were advanced into the bedrock with NQ-size coring equipment. The bedrock within the top 0.5 m in Borehole 402 was moderately weathered and could be penetrated with the drill rig augers.

The bedrock encountered below the weathered bedrock in Borehole 402 and all other Boreholes had a total core recovery ranging from 44% to 100%, the solid core recovery ranging from 25% and 100% and the Rock Quality Designation (RQD) ranging from 0% to 100%. Based on the RQD value the bedrock is classified as very poor to excellent quality, but typically poor to fair.

The Unconfined Compressive Strength (UCS) of the limestone bedrock based on laboratory testing of selected samples ranged from 45.5 to 87.1 MPa, indicating medium strong to strong

bedrock based on the Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition. The UCS testing results are included in Appendix C.

## 6.7 Analytical Test Results

Two samples of the fill encountered at the site were submitted to Paracel Laboratories in Ottawa, Ontario and five samples of the native soils encountered at the site were submitted to SGS Canada Inc. in Lakefield, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, conductivity and resistivity. The analysis results are summarized in the Table 6-9. A copy of the test results is provided in Appendix C.

**Table 6-9: Results of Chemical Analysis**

| Borehole | Sample | Depth (m) | pH   | Resistivity (Ohm-cm) | Conductivity (µS/cm) | Chloride (µg/g) | Sulphate (µg/g) | Sulphide (%) |
|----------|--------|-----------|------|----------------------|----------------------|-----------------|-----------------|--------------|
| 401      | SS4    | 2.6       | 8.44 | 1,280                | 782                  | 365             | 21              | -            |
| 403      | SS3    | 1.8       | 8.26 | 826                  | 1,210                | 758             | 76              | -            |
| GR22-02  | SS6    | 4.1       | 7.57 | 1,820                | 550                  | 170             | 46              | < 0.04       |
| GR22-03  | SS5    | 3.4       | 8.00 | 1,610                | 622                  | 160             | 66              | < 0.04       |
| GR22-04  | SS4    | 4.9       | 7.15 | 2,240                | 447                  | 290             | 140             | < 0.04       |
| GR22-07  | SS5    | 3.3       | 8.67 | 719                  | 1,390                | 330             | 11              | < 0.04       |
| GR22-08  | SS5    | 3.4       | 8.75 | 2,090                | 479                  | 89              | 16              | < 0.04       |

## 6.8 Groundwater Level

The groundwater levels were measured in five standpipe piezometers installed in Boreholes 403, GR22-03 and GR22-07. The measurements are presented in the Record of Borehole sheets in Appendix B and in Table 6-10 below:

**Table 6-10. Measured Water Levels**

| Borehole | Date of Reading | Water Depth / Elevation (m) | Comment    |
|----------|-----------------|-----------------------------|------------|
| 403      | 2016-05-31      | 8.4 / 94.9                  | Piezometer |
| GR22-03  | 2022-03-30      | 2.0 / 93.5                  | Piezometer |
|          | 2022-03-31      | 1.9 / 93.6                  |            |
|          | 2022-08-23      | 1.8 / 93.7                  |            |
|          | 2022-08-24      | 1.8 / 93.7                  |            |
| GR22-07  | 2022-04-11      | 4.1 / 93.8                  | Piezometer |
|          | 2022-09-05      | 4.2 / 93.7                  |            |
|          | 2022-09-09      | 4.2 / 93.7                  |            |

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level is likely dependent on the dam controlled Ganaraska River and may be at a higher elevation after periods of significant and/or prolonged precipitation and spring snow melts.

The piezometer in Borehole 403 was decommissioned in accordance with Ontario MOE Regulation 903 on May 31, 2016. The piezometers in Boreholes GR22-03 and GR22-07 were decommissioned in accordance with Ontario MOE Regulation 903 on June 22, 2023.

## **7. MISCELLANEOUS**

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

Terex Drilling Solutions of Concord, Ontario supplied and operated the truck mounted CME drill rigs to carry out the drilling, sampling, and in-situ testing, standpipe piezometer installation and borehole decommissioning of the on-road boreholes. Marathon Underground of Ottawa, Ontario supplied and operated the portable drilling equipment to carry out the drilling, sampling, and in-situ testing, standpipe piezometer installation and borehole decommissioning of the off-road boreholes. Traffic control was performed in accordance with Ontario Book 7 for short duration closures; all signs, barrels, cones and traffic control personnel were provided by Direct Traffic Management of Mississauga, Ontario. The field investigations were supervised on a full-time basis by Mr. Justin Gray, P.Eng., Mr. Christopher Murray, P.Eng., and Mr. Joe Lin. Overall supervision of the field investigation program was provided by Mr. Christopher Murray, P.Eng.



Routine geotechnical laboratory testing was completed by Thurber's laboratory in Pickering, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario and SGS Canada Inc. in Lakefield, Ontario. Unconfined compressive strength testing was carried out by Thurber's laboratory in Oakville, Ontario. Organic content testing was carried out by SGS Canada Inc. in Lakefield, Ontario. Interpretation of the factual data and preparation of this report was completed by Mrs. Katya Walker, P.Eng., and Mr. Christopher Murray, P.Eng. The report was reviewed by Mr. Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.

Report Prepared By:



Katya Walker, M.Eng., P.Eng.  
Geotechnical Engineer



Christopher Murray, M.A.Sc., P.Eng.  
Geotechnical Engineer



Paul Carnaffan, M.Eng., P.Eng.  
Principal | Branch Manager  
Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.  
Designated Principal Contact  
Senior Geotechnical Engineer



**FINAL  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
REPLACEMENT OF THE HIGHWAY 401 OVERPASS AT GANARASKA RIVER  
NORTHUMBERLAND COUNTY – PORT HOPE, ONTARIO  
ASSIGNMENT NO.: 4019-E-0021  
GWP 4068-14-00**

**GEOCRES NO.: 30M16-078**

**PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**8. GENERAL**

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents foundation design recommendations to assist the project team in the design of the replacement of the Highway 401 overpass structure located at the Ganaraska River in Port Hope, Ontario. The discussion and recommendations presented in this report are based on the information provided by LEA Consulting (LEA), McIntosh Perry Consulting Engineers (MPCE) and the factual data obtained during the current field investigation. Thurber Engineering Limited (Thurber) carried out the assignment as a sub-consultant to MPCE under Agreement No. 4019-E-0021.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, LEA Consulting and McIntosh Perry Consulting Engineers 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 construction or design-build contractor 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.

**8.1 Existing Foundations**

The existing 3 span bridge was constructed in 1959. Based on the historical contract documents, the abutments were designed to be supported by steel BP12x53 (HP 310 x 79) piles driven to bedrock. The piles supporting the abutments are shown to include a back row of vertical piles and two front rows of piles battered at 1H:4V with approximate pile lengths of 9 m at the east abutment and 10.5 m at the west abutment. The design load for the piles was not noted on the contract





drawings. The piers are supported on 3.05 m diameter concrete caissons socketed approximately 0.3 m into bedrock. The abutment foreslopes are identified as being sloped at 2H:1V and covered with hand-laid rip-rap. The existing bridge foreslopes show signs of surficial erosion.

The GEOCREC report for this site, dated July 12<sup>th</sup>, 1957, summarizing the findings of the investigation for the bridge structure and approach embankments indicated that the organic silt stratum on both sides of the bridge would undergo large settlement and fail under the superimposed load of the approach embankments (in the order of 35 feet (10.7 m) in height. This was predicted to occur during or shortly after construction; keying the foundations into the bedrock to resist the lateral thrust from movement of the embankment or removing the poor subsoil were presented as options. The results of the borehole drilling indicate that the layer of organic silt was not removed during original construction (see Boreholes).

## 8.2 Proposed Structure

It is understood that the existing bridge structure will be replaced using staged construction with a structure widened to the north as shown in the General Arrangement (GA) provided by LEA and dated January 2023 and included in Appendix A. The proposed three span integral abutment bridge structure is 47 m wide and consists of a 39 m central span with 20 m outer spans. The piers are founded on rock socketed caissons and the abutments are founded on vertical steel H-piles driven to bedrock.

## 8.3 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations, existing ground surface conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC) version CSA S6-19.

In accordance with the CHBDC, the analysis and design of the structure takes into consideration the importance of the structure and the consequence associated with exceeding limit states. The importance category and consequence classification are defined by the Regulatory Authority, which, in this case, is the Ministry of Transportation, Ontario (MTO).

**Table 8-1: Bridge Structure Classification**

| Criteria                   | Classification      | CHBDC Section |
|----------------------------|---------------------|---------------|
| Importance Category        | Major Route Bridge  | 4.4.2         |
| Consequence Classification | Typical Consequence | 6.5.1         |



Accordingly, a consequence factor ( $\Psi$ ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances. If the consequence classification changes, the geotechnical assessment and recommendations provided within this report will need to be reviewed and revised.

As per Section 6.5.3 of the CHBDC, the degree of site prediction model understanding is considered to be *Typical* based on the current information.

The frost penetration depth and associated recommendations are provided in Section 12.6.

## **9. SEISMIC CONSIDERATIONS**

### **9.1 Spectral and peak Acceleration Hazard Values**

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC)<sup>1</sup>. The GSC seismic hazard calculation data sheet for this site for the *reference* ground condition (Site Class C) is presented in Appendix H. The site coefficients used to determine the design spectral acceleration values are a function of the Site Class, PGA and  $S_a(0.2)$ . The PGA value at this site provided by GSC for a *reference* Site Class C with a 2% probability of exceedance in 50 years (2475-year event) is 0.112 g. This value is to be scaled by the  $F(PGA)$  based on the *site-specific* Site Class, as discussed in Section 9.2.

### **9.2 CHBDC Seismic Site Classification and Performance Category**

In accordance with Section 4.4.3.2 of the CHBDC, the selection of the seismic site classification is based on the nature of soil deposit within the upper 30 m of the stratigraphy. As per Table 4.1 of the CHBDC, the Site Class has been classified as a Seismic Site Class D based on the standard penetration resistance.

### **9.3 Liquefaction Potential**

The susceptibility of the cohesionless soils at the site to experience liquefaction was assessed using the SPT data following the simplified method for cohesionless soil as outlined in Boulanger and Idriss (2014)<sup>2</sup>. The cohesionless foundation soils are not considered to be susceptible to liquefaction under the design earthquake.

---

<sup>1</sup> <https://earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/calc-en.php>

<sup>2</sup> Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.



The susceptibility of the cohesive soils at this site to experience liquefaction/cyclic softening was assessed following the Bray et al. (2004)<sup>3</sup> criteria using index properties. The results indicate that the cohesive material is generally not susceptible to cyclic mobility under the design earthquake with the exception of the thin native clay deposit encountered in Borehole 402 which is classified as moderately susceptible to cyclic mobility. However, based on the assessment with the inclusion of in-situ shear strengths, the cohesive soils are not considered susceptible to cyclic mobility or cyclic softening during a seismic event.

## **10. GEOTECHNICAL ASSESSMENT / CONSIDERATIONS**

Based on the results of the field and laboratory investigation, the review of historical information, and the information provided by MPCE & LEA with regards to the proposed project requirements, the geotechnical foundation design considerations include:

- The existing fill and native soils will not offer bearing resistance to support bridge abutments on shallow foundations; deep foundations will be required to provide the required geotechnical resistance and to ensure performance compatible with the existing structure foundations.
- Both approaches include a high fill (approximately 10 m to 12 m) constructed above organic silt. Historical documents indicate a concern regarding settlement and stability of the approach embankments during construction; and
- The existing bridge abutments are supported on steel H-piles driven to bedrock, some of the existing piles are battered and the existing piers are supported on concrete caissons on bedrock. The design of the new structure foundations will need to avoid conflict with the existing piles and avoid disturbance to the bedrock supporting the existing caissons.

## **11. EVALUATION OF DESIGN OPTIONS**

The results of the field and laboratory investigation and historical data indicate that the site soil stratigraphy generally consists of fill materials overlying organic silt overlying glacial till, underlain by limestone bedrock.

Approximate key elevations are as follows:

- |                           |                   |
|---------------------------|-------------------|
| ▪ Existing top of asphalt | 106.0 m West side |
|                           | 103.3 m East side |

---

<sup>3</sup> Bray, J. D. et al. (2004b). Liquefaction susceptibility of fine-grained soils. Proc., 11th Int. Conf. on Soil Dynamics and Earthquake Engineering and 3rd Int. Conf. on Earthquake Geotechnical Engineering, D. Doolin et al., eds., Stallion Press, Singapore, 655–662



- Top of glacial till
  - 91.2 to 92.7 m West Abutment
  - 92.3 to 92.7 m West Pier
  - 90.4 to 92.6 m East Pier
  - 90.6 to 90.9 m East Abutment
- Top of bedrock
  - 91.0 to 91.8 m West Abutment
  - 90.5 to 91.5 m West Pier
  - 89.0 to 90.1 m East Pier
  - 87.6 to 88.4 m East Abutment

The following foundation alternatives were considered for the bridge replacement:

- Shallow Foundations
- Caissons (drilled shaft piles)
- Steel Piles (H-piles and pipe piles)
- Drilled-in Pipe Piles (down-the-hole hammer)
- Micropiles

These foundation alternatives are presented below and evaluated from a foundation perspective in terms of their respective advantages, disadvantages, risks and consequences. The evaluation is summarized in the table provided in Appendix E. A preferred foundation for the widening alternative from a geotechnical engineering perspective is recommended.

- Shallow Foundations

The existing fill, clay and organic silt will not offer sufficient bearing resistance to support bridge abutments, piers or retaining walls on shallow foundations. Shallow foundations bearing on undisturbed glacial till might be feasible if retaining walls are required near the toe of the embankment slopes.

- Caissons

Caisson foundations can offer high axial and lateral geotechnical resistance, particularly, when they are socketed into bedrock. Caissons are considered feasible at this site, however, restrictions or special measures would be required for caissons that require rock sockets if they are located too close to existing deep foundations end-bearing on the bedrock during staged construction. These measures may include extending a steel casing down into the socket, limiting the number of caissons that can be left open at any given time, and monitoring of the existing structure.

- Driven Steel Piles

Steel piles driven to refusal on or within the bedrock are considered feasible for the bridge abutments. The use of either steel H-piles or pipe piles could be considered at this site,

however, pipe piles fitted with a driving shoe to help seat the piles into the rock cause greater soil displacement than steel piles increasing the potential for disturbance of adjacent piles.

- Drilled in Pipe Piles

Drilled-in pipe piles are feasible from a foundations perspective at this site and would offer moderate to high geotechnical axial and lateral resistance. Drilled in pipe piles may be preferable over driven steel piles at the abutments if large lateral resistance is required.

- Micropiles

Micropiles would provide low to moderate axial compression loads. A larger number is required to achieve the same overall resistance as driven steel piles or caissons. In addition, they provide low lateral resistance for an individual micro-pile. Lateral resistance is often achieved by installing groups of micro-piles at different inclinations. The cost for micropiles is typically higher than for driven steel piles or caissons in order to achieve similar geotechnical resistance. Micropiles can offer an advantage where installation is required in areas with limited vertical clearance or for applications that also require significant uplift resistance.

## **12. FOUNDATION DESIGN RECOMMENDATIONS**

Based on an evaluation of foundation alternatives presented above and the geometry of the proposed Ganaraska River Bridge structure, the recommended foundation approach from a geotechnical perspective is to support the abutments on steel H-piles end-bearing on the bedrock and to support the piers on caissons socketed into the bedrock.

Foundation recommendations and considerations are presented in the following sections.

### **12.1 Caissons**

The replacement bridge piers may be founded on concrete caissons set into the bedrock. The geotechnical resistance will depend on both the caisson diameter and the socket length into sound bedrock. For design purposes, the upper 0.5 m of bedrock should be assumed to be weathered or highly fractured and should not be included in the design socket length. The factored geotechnical resistances provided in Table 12-1 below may be used for design:

**Table 12-1: Caisson Axial Capacity**

| Caisson Diameter (m) | Socket Length in Sound Rock (m) | Estimated Tip Elevation (m) |                             | Factored Geotechnical Resistance (Axial Compression (kN)) |                            |
|----------------------|---------------------------------|-----------------------------|-----------------------------|---|----------------------------|
|                      |                                 |                             |                             | ULS   | SLS                        |
|                      |                                 | West Pier                   | East Pier                   | Static ( $\phi_{gu}=0.4$ )                                | Static ( $\phi_{gs}=0.8$ ) |
| 1.2                  | 3.0                             | 86.5 to 87.5 <sup>(2)</sup> | 85.0 to 86.1 <sup>(2)</sup> | 7,400   | N/A <sup>(1)</sup>         |
| 1.5                  | 3.0                             |                             |                             | 9,250   | N/A <sup>(1)</sup>         |
| 3.0                  | 3.0                             |                             |                             | 27,500  | N/A <sup>(1)</sup>         |

**NOTES:**

1. The SLS condition will not govern for caissons end-bearing in the bedrock.
2. 1 m of weathered bedrock has been assumed above sound bedrock.

The factored geotechnical resistances include the following factors:

- Consequence factor ( $\Psi$ ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2):
  - $\phi_{gu} = 0.4$  (static analysis; typical degree of understanding)
  - $\phi_{gs} = 0.8$  (static analysis; typical degree of understanding)

Caissons must be installed in accordance with OPSS.PROV 903.

## 12.2 Driven Steel H-Piles

The abutments may be founded on steel HP 310x132 piles end-bearing on the bedrock.

The estimated pile tip elevations based on piles reaching refusal at the bedrock surface are summarized in Table 12-2.

**Table 12-2: Estimated Pile Tip Elevations**

| Foundation Element | Approximate Underside of Pile Cap Elevation (m) | Estimated Pile Tip Elevation (top of bedrock) (m) | Estimated Pile Length (m) |
|--------------------|---|---|---------------------------|
| East Abutment      | 98.5  | 87.6  | 10.9                      |
| West Abutment      | 101.0   | 91.0  | 10.0                      |

The design parameters for axial resistance of Grade 450W HP 310x132 steel piles driven to refusal on or in the limestone bedrock can be taken as:

- Factored axial geotechnical resistances at ULS 2,500 kN
- The SLS condition will not govern for piles founded on the bedrock

The factored geotechnical resistances provided include the following factors:

- Consequence factor ( $\Psi$ ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2):
  - $\phi_{gu} = 0.4$ , ULS (static analysis; typical degree of understanding)

*The structural resistance of the pile must be checked by the structural engineer which may govern the design.*

Driven piles must be installed in accordance with OPSS.PROV 903. The potential for conflict with the existing steel piles must be checked.

As the piles are to be driven to bedrock the pile tips of the new piles at the site should be protected from damage during driving with pile tip protection from an approved manufacturer such as Titus Steel (standard H-Point) or approved equivalent.

The appropriate pile driving note is “Piles to be driven to bedrock.”.

### **12.3 Deep Foundations – Lateral Resistance**

The lateral resistance for the soil adjacent to a vertical pile or caisson is developed on the face of the deep foundation element embedded in the foundation soils and estimated using P-y curves.

The P-y curves representing the response of the soil under static loading conditions are shown in Appendix F to allow for calculation of the *ultimate* lateral capacity of an individual pile or caisson. Calculation of the P-y curves considered the ground surface elevation (neglecting frost depth as per Section 12.6) at the piers and the underside elevations of the pile caps at the abutments as outlined above in Section 12.2. At the abutments, P-y curves have been provided for the upper 3 m of the piles cased in a loose sand-filled, corrugated steel pipe (CSP) as part of an integral

abutment foundation as well as with no CSP. The loose sand placed within the CSPs (if required) should consist of uniform sand with the gradation meeting the MTO specification. The values provided in Appendix F were calculated for a single, vertical HP 310x132 pile at the abutments and for a single, vertical 1.2 m, 1.5 m and 3.0 m diameter caisson at the piers and considering the soil parameters summarized in Table 12-3, below.

**Table 12-3: L-Pile Analysis – Soil Stratigraphy**

| Soil Stratum       | Bulk Unit Weight (kN/m <sup>3</sup> ) | Friction Angle (°) |
|--------------------|---------------------------------------|--------------------|
| Existing Fill      | 20.0                                  | 30                 |
| Organic Silt       | 19.0                                  | 29                 |
| Sand to Silty Sand | 20.0                                  | 30                 |
| Glacial Till       | 21.0                                  | 35                 |

A geotechnical resistance factor of 0.5 ( $\phi_{gu}$ ) and 0.8 ( $\phi_{gs}$ ) as per Table 6.2 of the CHBDC (static analysis – typical understanding) should be applied to the *ultimate* ULS and SLS values, respectively.

The ultimate lateral resistance force that can be mobilized by the embedded portion of a caisson socketed within sound bedrock is constant with depth and can be taken as 2.7 MN/m, 3.5 MN/m and 9.0 MN/m length of caisson into sound bedrock for 1.2, 1.5 and 3.0 m diameter caissons, respectively. A suitable reduction factor should be applied to this ultimate value in accordance with Table 6.2 of the CHBDC.

Where lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, the lateral resistance will also need to be further reduced based on the center-to-center spacing. The reduction factors to be used can be obtained from Figures C6.22, C6.23, and C6.24 of the Commentary to the CHBDC.

The lateral resistance of the soil acting against the deep foundations (steel piles or caissons) is dependent on several factors including the effective overburden stress and is therefore directly dependent on the proposed geometry of the proposed bridge and retaining walls. If there are any changes to the proposed structure, the soil response to lateral loading from the deep foundations in the form of p-y curves should be evaluated.

## 12.4 Deep Foundations - Downdrag

Provided the Highway 401 high fill widening to the north is constructed prior to installation of the new deep foundation elements and includes sub excavation of the organic silt below the footprint





of the widened embankment, the new deep foundations are not considered susceptible to down drag loading.

Given the predicted surface settlement of less than 25 mm (see Section 12.8) at the existing edge of pavement and the limited thickness of compressible soils encountered below the water table, the downdrag loading as a result of embankment widening to the north is considered to be negligible.

## **12.5 Backfill and Lateral Earth Pressure**

### **12.5.1 Backfill**

Structural backfill material should consist of Granular A or Granular B Type II meeting the OPSS.PROV 1010 specifications and SP110S06. The backfill must be in accordance with OPSS.PROV 902 and placed and compacted in accordance with OPSS.PROV 501 to the extents shown on OPSD 3101.150. The backfill should be compacted and compaction equipment to be used adjacent to the structure must be restricted in accordance with OPSS.PROV 501.07.02.

### **12.5.2 Static Lateral Earth Pressure**

Lateral earth pressure provided in the equations in the sections below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in the design.

Lateral earth pressures acting on vertical structures should be computed in accordance with the Section 6.12 of the CHBDC but under fully drained conditions, the lateral pressures are generally given by the following expression:

$$\sigma_h = K * (\gamma d + q)$$

where:

|            |   |   |
|------------|---|---|
| $\sigma_h$ | = | static lateral earth pressure on the wall at depth d (kPa)                |
| K          | = | static earth pressure coefficient (see table below)                       |
| $\gamma$   | = | unit weight of retained soil (see table below) adjusted below water level |
| d          | = | depth below top of fill where pressure is computed (m)                    |
| q          | = | value of any surcharge (kPa)  |

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for use in design of vertical walls for a horizontal backslope are shown in Table 12-4.

**Table 12-4: Static Earth Pressure Coefficients**

| Material                 | Unit Weight (kN/m <sup>3</sup> ) | K <sub>A</sub> (yielding wall) | K <sub>0</sub> (non-yielding wall) |
|--------------------------|----------------------------------|--------------------------------|------------------------------------|
| OPSS Granular A          | 22.8                             | 0.27                           | 0.43                               |
| OPSS Granular B Type II  | 22                               | 0.27                           | 0.43                               |
| Existing Embankment Fill | 20.5                             | 0.33                           | 0.50                               |

For rigid structures, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls. The ratio of wall movement to wall height required to mobilize the active condition would be approximately 0.002.

For static analysis, passive earth resistance in front of the abutments should be ignored, and therefore has not been provided.

### 12.5.3 Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14 of the CHBDC, structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using Mononobe Okabe Method with:

- $k_h = \frac{1}{2} * F(PGA) * PGA$ , for structures that allow 25 to 50 mm of movement, and
- $k_h = F(PGA) * PGA$ , for non-yielding walls

The coefficients of horizontal earth pressure for seismic loading presented in Table 12-5 may be used for vertical walls. The provided earth pressure coefficients are based on a 1 in 2475yr seismic event and a Seismic Site Class D.

**Table 12-5: Combined Static and Seismic Earth Pressure Coefficients**

| Material                | Unit Weight (kN/m <sup>3</sup> ) | K <sub>AE</sub> (yielding wall) | K <sub>AE</sub> (non-yielding wall) |
|-------------------------|----------------------------------|---------------------------------|-------------------------------------|
| OPSS Granular A         | 22.8                             | 0.31                            | 0.35                                |
| OPSS Granular B Type II | 22                               | 0.31                            | 0.35                                |



The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall/soil may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_{hAE} = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

|                |   |  |
|----------------|---|--|
| $\sigma_{hAE}$ | = | combined static and seismic lateral earth pressure on wall at depth d (kPa)                    |
| d              | = | depth below the top of the wall where pressure is computed (m)                                 |
| K              | = | static earth pressure coefficient<br>( $K_A$ for yielding walls, $K_o$ for non-yielding walls) |
| $\gamma$       | = | unit weight of retained soil (kN/m <sup>3</sup> ), adjusted below water level                  |
| $K_{AE}$       | = | combined static and seismic earth pressure coefficient   |
| H              | = | total height of the wall (m)   |

## 12.6 Frost Depth

The frost penetration depth at this site is 1.4 m as per OPSD 3090.101. Accordingly, a minimum of 1.4 m of earth cover, or equivalent insulation, must be provided above the base of the pile caps to serve as frost protection.

## 12.7 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in buried infrastructure. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The sulphate content in the soils is low ranging from 11 to 140 µg/g, see Section 6.7. The selection for class of concrete should include consideration of the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 6.7 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

## 12.8 Embankment Settlement

Detailed settlement calculations resulting from the embankment widening to the north have been provided in the Highway 401 High Fill Widening Report (Geocres: 30M16-079). In general, provided the organic silt outside of the existing embankment footprint below the new retaining structure is sub excavated, the results indicated that a maximum settlement of 30 mm can be expected within a month of fill placement at the east approach embankment and 50 mm can be expected at the west approach embankment with 30 mm occurring within the 1 month and the bulk completed by 6 months. The settlement is expected to be at a maximum value at the new north crest of embankment slope and linearly reduces to approximately 10 mm at the existing edge of pavement for both approaches.

The magnitude of the embankment self-compression constructed with granular materials is in the order of 0.5% of the newly reconstructed embankment height and is expected to occur during fill placement.

## 12.9 Embankment Stability

The existing high embankments are sloped at approximately 2H:1V. No evidence of global slope instability was noted during the field investigations. Erosion of the toe of both the east and west foreslope just behind the banks of the Ganaraska River was noted (see Photos in Appendix D).

Slope stability of the high fill widening to the north has been addressed in the Highway 401 High Fill Widening Report (Geocres: 30M16-079). Stability analysis results for the existing south embankment slopes and bridge fore slopes are summarized in the below table and provided in Appendix G.

**Table 12-6. Summary of Embankment Slope Stability Analysis Results**

| Location                                 | Slope Inclination | Factor of Safety          |                    |
|--|-------------------|---------------------------|--------------------|
|  |                   | Static Drained Conditions | Seismic Loading    |
| South Embankment Slope East of Ganaraska | 2H:1V             | 1.4<br>(Figure G1)        | 1.2<br>(Figure G2) |
| East Foreslope                           | 2H:1V             | 1.8<br>(Figure G3)        | 1.3<br>(Figure G4) |
| South Embankment Slope West of Ganaraska | 2H:1V             | 1.4<br>(Figure G5)        | 1.1<br>(Figure G6) |
| West Foreslope                           | 2H:1V             | 1.5<br>(Figure G7)        | 1.2<br>(Figure G8) |



The static analyses of the south embankment slope in Table 12-6 were carried out using a traffic surcharge of 16.8 kN/m applied to the highway lanes. The seismic analyses in Table 12-6 have been carried out using a horizontal ground acceleration of 0.071g, equal to  $\frac{1}{2}$  of the site adjusted PGA value (0.142g) corresponding to a 2% probability of occurrence in 50 years for a seismic Site Class D.

Based on this global stability assessment, the proposed east and west foreslopes were found to be stable under both static and seismic conditions. The existing embankment south side slopes at the east and west approaches were also found to be stable with a 1.4 factor of safety under static conditions.

Embankment reinstatement after construction of the bridge structure and associated widening to the north should be carried out in accordance with OPSS.PROV 206. The south embankment around the new bridge structure should be locally reconstructed with side slopes to match existing which are inclined at approximately 2H:1V using Granular A or Granular B Type II. The fill should be placed and compacted in accordance with OPSS.PROV 501.

Where newly placed embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSS 208.010. Fill should be placed started at the toe of the embankment and working upwards.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. Normal slope vegetation should be established as soon as possible after completion of the embankment fills to control surficial erosion in general accordance with OPSS.PROV 804.

### **13. CONSTRUCTION CONSIDERATIONS**

#### **13.1 Excavation**

All excavation must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The fill materials and native soils above the water table may be classified as Type 3 soil. The organic silt and soils below the groundwater level are classified as Type 4 soils. If an excavation penetrates more than one soil type, the entire excavation must be completed in accordance with the more stringent requirement.

Excavation should occur in a dewatered environment (see Section 13.3). Excavations must be planned and carried out in a manner that does not impact on the stability of the existing highway and bridge. The temporary cut slopes may have to be protected from precipitation and runoff to



avoid surficial instabilities. The duration of temporary open excavations and cut slopes should be minimized to reduce the likelihood of causing instability. Embankment and cut slope stability is the responsibility of the Contractor.

Excavation for the structure must be carried out in accordance with OPSS.PROV 902 as amended by SP109S12 and NSSP FOUN0003 and will be carried out through the existing fill and/or into the underlying native deposits. Please refer to Section 13.3 for designer fill-in recommendations. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor.

Material stockpiling is a temporary construction measure and the associated stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) and the construction of temporary construction access roads are also the Contractor's responsibility. Placement of the crane or temporary stockpiling must not destabilize the embankment or excavations.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 13.2.

### **13.2 Temporary Protection Systems**

Temporary Protection Systems will be required during staged construction of the new bridge structure and may be required for the wingwalls and for various stages of construction; temporary construction systems must be implemented in accordance with OPSS.PROV 539 as amended by SP105S09. Performance Level 2 (maximum 25 mm horizontal deflection) is considered appropriate where the protection supports the existing highway. More stringent performance levels may be required if the protection system is intended to support existing structures or utilities. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system.

The design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations. A suitable anchoring and/or bracing system may need to be incorporated into the temporary protection design to resist lateral earth pressure loadings.



Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the protection system installed through new granular fill material are provided in Table 12-4 for static conditions. Unit weights provided herein are to be adjusted when applied to depths below the water level. Unbalanced hydrostatic pressures should also be considered in the design of the protection systems. It is noted that the recommended earth pressure parameters assume horizontal surfaces in front and behind a vertical wall. The values must be adjusted to reflect geometric variations.

### **13.3 Surface and Groundwater Control**

Subgrade preparation and construction of foundations must be carried out in the dry. All excavations for foundation construction must be dewatered prior to the placement of concrete, as per OPSS.PROV 902 and NSSP FOUN0003.

The Contractor must be prepared to control the groundwater and surface water flow at the site to permit construction in a dry and stable excavation. Water from either surface flow and/or groundwater must be diverted away from the excavation at all times. Groundwater perched within the embankment fill and surface runoff will tend to seep into and accumulate in open excavations.

Excavations for the abutments are expected to be within the existing embankment fills, above the groundwater level. Dewatering at these locations is expected to be primarily related to removal of surface run-off. Therefore, it is anticipated that conventional sump and pump techniques should be sufficient at these locations. The piers are located along the banks of the Ganaraska River and excavations for caissons will extend below the groundwater and river water levels. Dewatering requirements may be substantial, including temporary steel liners and cofferdams, if caissons are to be constructed in the dry. Synthetic slurry and concrete placement using tremie techniques may be required. The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the dewatering systems in accordance with SP FOUN0003 which amends OPSS.PROV 902. A preconstruction survey is not required, thus Designer Fill-In \*\* in SP FOUN0003 should be "N/A".

Assessment of the dewatering requirements and the need for registration on the Environmental Activity and Sector Registry (EASR) or a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

### **13.4 Erosion Protection**

The Contractor should provide silt fences and erosion control blankets as per OPSS.PROV 805 and OPSD 219.110 throughout the duration of construction to prevent transport of silt/sediment.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. A vegetation cover should be established on all exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 803 OPSS.PROV 804. Slope vegetation should be established as soon as possible after completion of construction in order to limit surficial erosion and water should be prevented from running down an unprotected slope.

#### 14. CONSTRUCTION CONCERNS

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

- Obstructions (ie: boulders, buried debris)

Buried obstructions may be encountered during construction and interfere with excavations and installation of deep foundations and temporary protection/dewatering systems. The Contractor must be prepared to dislodge or penetrate obstructions. Where obstructions are encountered near the surface, the Contractor may choose to remove such obstructions, provided it does not destabilize the existing embankment or foundation elements.

- Slope Stability

Care must be taken during construction to ensure the stability of the high fill slopes during construction of the widening.

- Protection Systems

The potential for movements of the existing structure and/or highway embankment during excavation for new foundations. Appropriate temporary protection systems must be provided.

- Existing Foundations

It is noted that the proposed abutment and pier locations are in close proximity to the existing deep foundations. Removal of existing abutment piles may be required prior to installation of new H-Piles at the abutments depending on the existing pile layout and orientation.

- Vibration Monitoring

Vibrations in the existing structure should be monitored during pile or caisson installation during staged construction to ensure stability. Suggested text for a vibration monitoring NSSP has been included in Appendix I.





- Equipment Selection

The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing soils to support the proposed construction equipment and supplies.

The successful performance of the project will depend largely upon good workmanship and quality control during construction. Observation of the excavation, foundation construction and backfilling operations by qualified geotechnical personnel will be required during construction to confirm that the foundation recommendations are correctly implemented and material specifications are met.



## 15. CLOSURE

Engineering analysis and preparation of this report were carried out by Mr. Christopher Murray, P.Eng. The report was reviewed Mr. Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.  
Report Prepared By:



Christopher Murray, M.A.Sc., P.Eng.  
Geotechnical Engineer



Paul Carnaffan, M.Eng., P.Eng.  
Principal | Branch Manager  
Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.  
Designated Principal Contact  
Senior Geotechnical Engineer

## 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

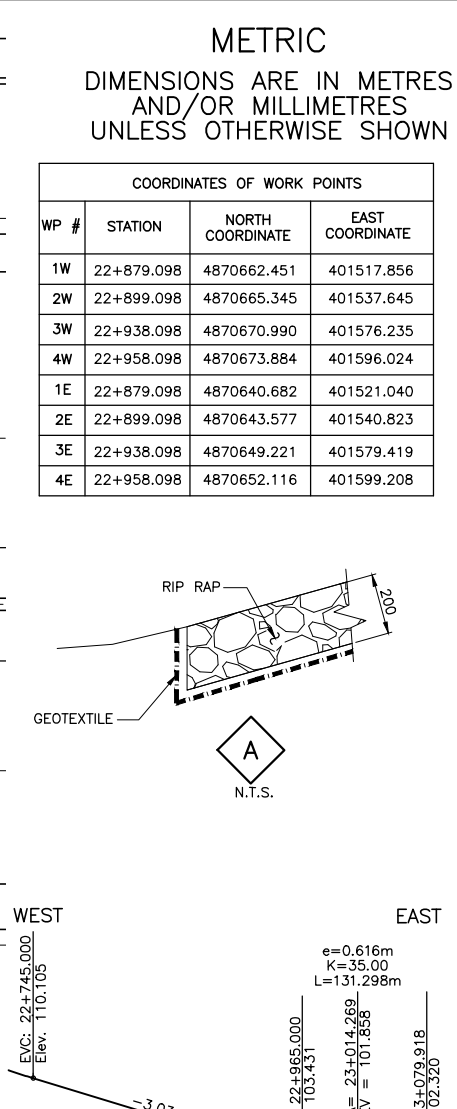
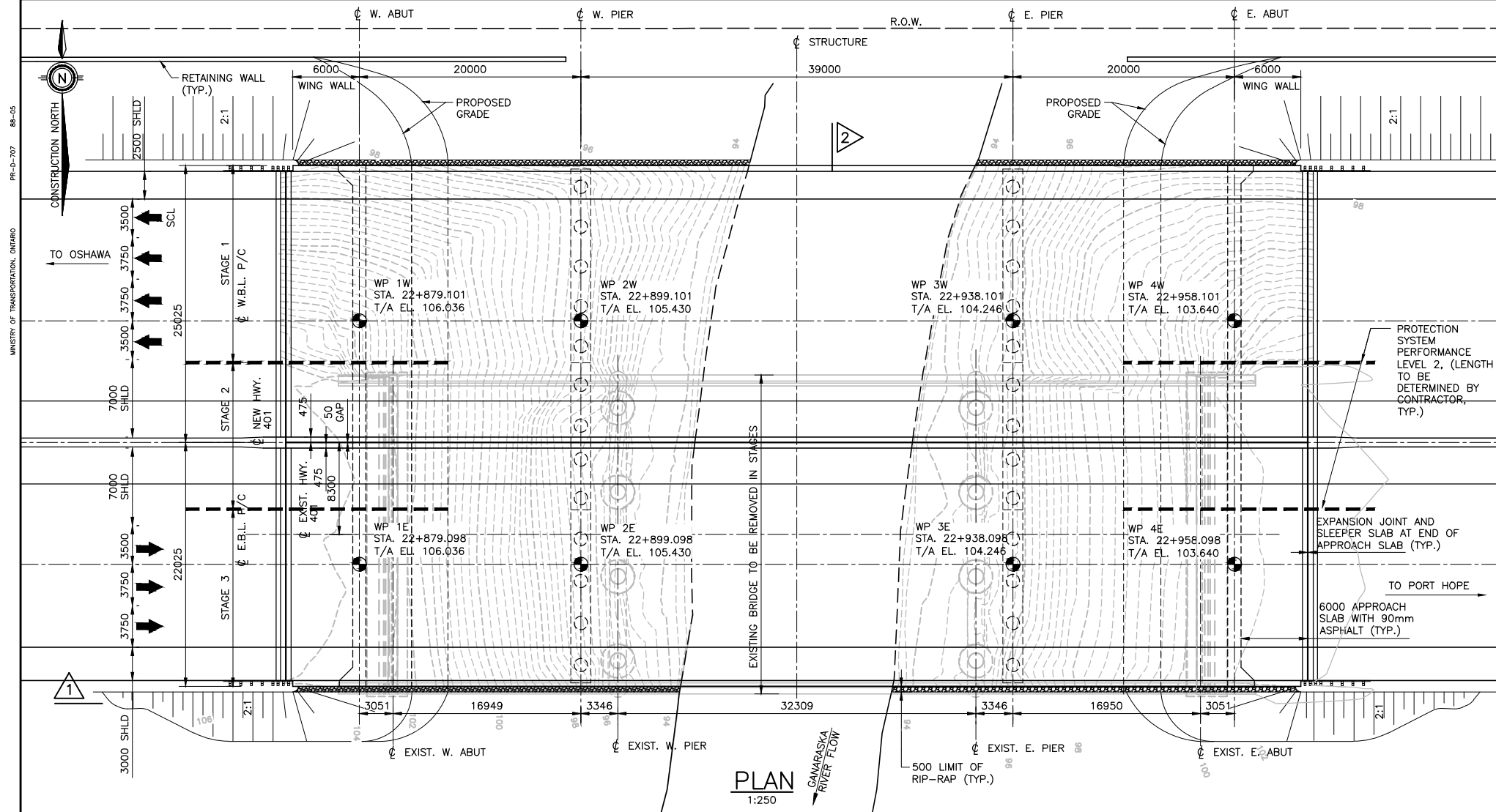
The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or 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 Drawings**

General Arrangement Drawing  
Borehole Locations and Stratra Drawing

DRAWING NAME: F:\21207\21207.18 Hwy 401 Cheate Rd & Ganaraska River Bridge Replacement Detail Design\4.5 CAD\4.5.2 Final CAD Drawings\Ganaraska\21207-Ganaraska-501-Ga.dwg  
CREATED: APR 2022  
MODIFIED: Jul 28, 2023-3:17pm



HWY. 401  
CONT No  
WP No 4082-14-01/4009-22-01

GANARASKA RIVER  
BRIDGE REPLACEMENT  
EBL & WBL  
GENERAL ARRANGEMENT

SHIELD

144



- GENERAL NOTES:**
- CLASS OF CONCRETE**  
ALL CONCRETE (UNLESS OTHERWISE NOTED) ..... 30 MPa  
CAISSONS ..... 35 MPa
- CLEAR COVER TO REINFORCING STEEL**  
DECK TOP ..... 70 ± 20  
BOT. .... 40 ± 10  
CAISSONS ..... 100 ± 25  
REMAINDER (UNLESS NOTED OTHERWISE) ..... 70 ± 20
- REINFORCING STEEL**  
1. REINFORCING STEEL SHALL BE GRADE 500W UNLESS OTHERWISE SPECIFIED.  
2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICE SHALL BE CLASS B.  
3. BAR MARKS WITH SUFFIX "S" DENOTE STAINLESS STEEL REINFORCEMENT. STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE MINIMUM YIELD STRENGTH OF 500 MPa.  
4. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS112-1, UNLESS INDICATED OTHERWISE.
- CONSTRUCTION NOTES**  
1. THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESS FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESS ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.  
2. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK, REQUIRED TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.  
3. BACKFILL SHALL NOT BE PLACED BEHIND THE ABUTMENTS UNTIL THE DECK SLAB IS IN PLACE AND HAS REACHED 70% OF ITS DESIGN STRENGTH.  
4. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.  
5. THE CONTRACTOR SHALL ENSURE THE STABILITY OF THE GIRDERS, UNTIL THE DECK IS CONSTRUCTED AND HAS ATTAINED A COMPRESSIVE STRENGTH OF 25 MPa.

PROFILE OF HWY 401 EBL/WBL CROWN  
N.T.S.

LIST OF DRAWINGS

- GENERAL ARRANGEMENT
- BOREHOLE LOCATIONS AND SOIL STRATA I
- BOREHOLE LOCATIONS AND SOIL STRATA II
- BOREHOLE LOCATIONS AND SOIL STRATA III
- CONSTRUCTION STAGING
- FOUNDATION LAYOUT AND DETAILS
- ABUTMENTS I
- ABUTMENTS II
- WINGWALLS
- PIER DETAILS
- STRUCTURAL STEEL I
- STRUCTURAL STEEL II
- STRUCTURAL STEEL III
- DECK DETAILS I
- DECK DETAILS II
- DECK REINFORCING I
- DECK REINFORCING II
- BARRIER WALL W/O RAILING, TL-5, EXTERIOR
- BARRIER WALL
- BARRIER WALL W/O RAILING, TL-5, MEDIAN
- BARRIER WALL
- 6000mm APPROACH SLAB I
- 6000mm APPROACH SLAB II
- EXPANSION JOINT (TYPE C) AND SLEEPER SLAB
- STRIP SEAL EXPANSION JOINT ASSEMBLY FOR BARRIER WALLS
- STRIP SEAL EXPANSION JOINT TYPE "C" DETAILS
- SEQUENCE OF EXPANSION JOINT INSTALLATION
- STANDARD DRAWING

LIST OF ABBREVIATIONS:

|        |                      |        |                                   |
|--------|----------------------|--------|-----------------------------------|
| ABUT.  | - ABUTMENT           | STA.   | - STATION                         |
| BRGS.  | - BEARINGS           | S.C.L. | - SPEED CHANGE LANE               |
| CONC.  | - CONCRETE           | SHLD   | - SHOULDER                        |
| ℄      | - CENTRE LINE        | T/A    | - TOP OF ASPHALT (FINISHED ELEV.) |
| C.J.   | - CONSTRUCTION JOINT | TYP.   | - TYPICAL                         |
| DIA.   | - DIAMETER           | U/S    | - UNDERSIDE                       |
| E.     | - EAST               | W.     | - WEST                            |
| E.B.L. | - EAST BOUND LANE    | W.B.L. | - WEST BOUND LANE                 |
| EL.    | - ELEVATION          | W.L.   | - WATER LEVEL                     |
| EXIST. | - EXISTING           | WP     | - WORKING POINT                   |
| HWY.   | - HIGHWAY            |        |                                   |
| MIN.   | - MINIMUM            |        |                                   |
| OG     | - ORIGINAL GROUND    |        |                                   |
| P/C    | - PROFILE CONTROL    |        |                                   |

APPLICABLE STANDARD DRAWINGS:

|               |  |
|---------------|--|
| OPSD- 912.430 | GUIDE RAIL SYSTEM, STEEL BEAM STRUCTURE CONNECTION   |
| OPSD-3101.150 | WALLS ABUTMENT, BACKFILL MINIMUM GRANULAR REQUIREMENT  |
| OPSD-3102.100 | WALLS ABUTMENT BACKFILL DRAIN  |
| OPSD-3370.100 | DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD   |
| OPSD-3419.100 | DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINT |

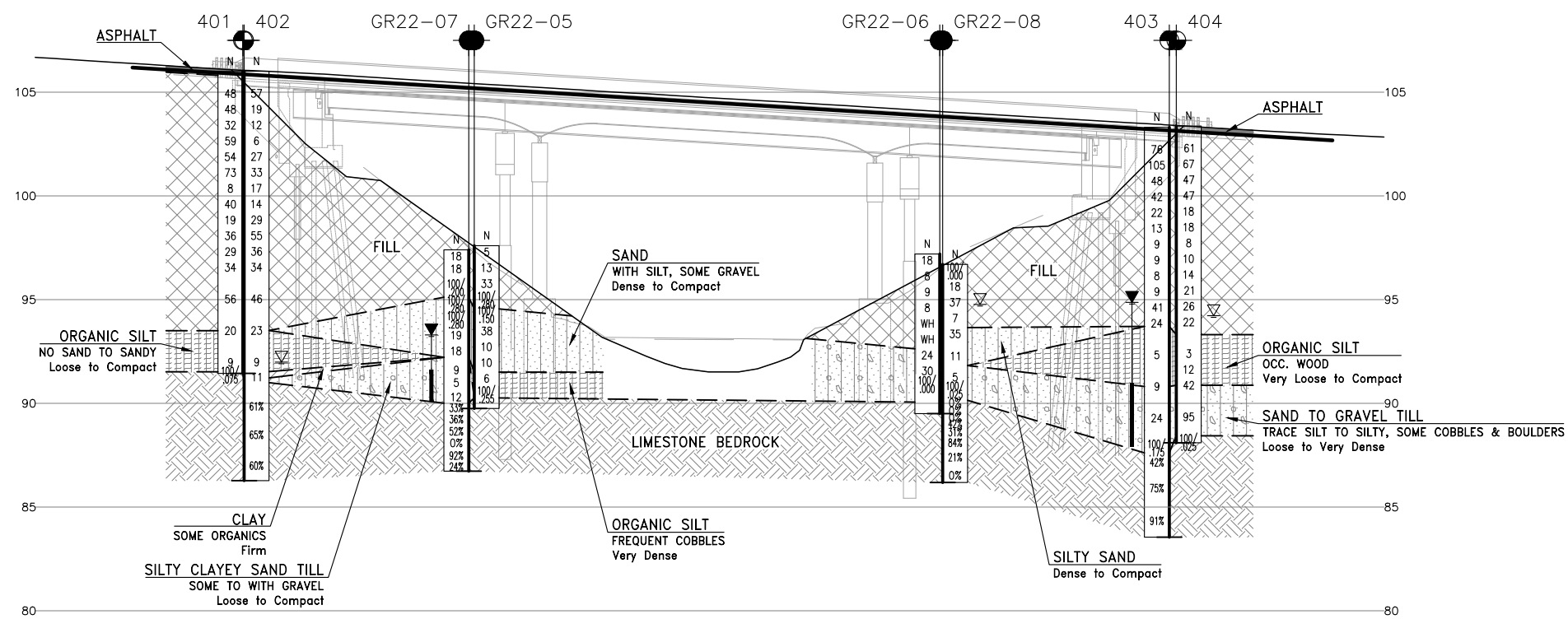
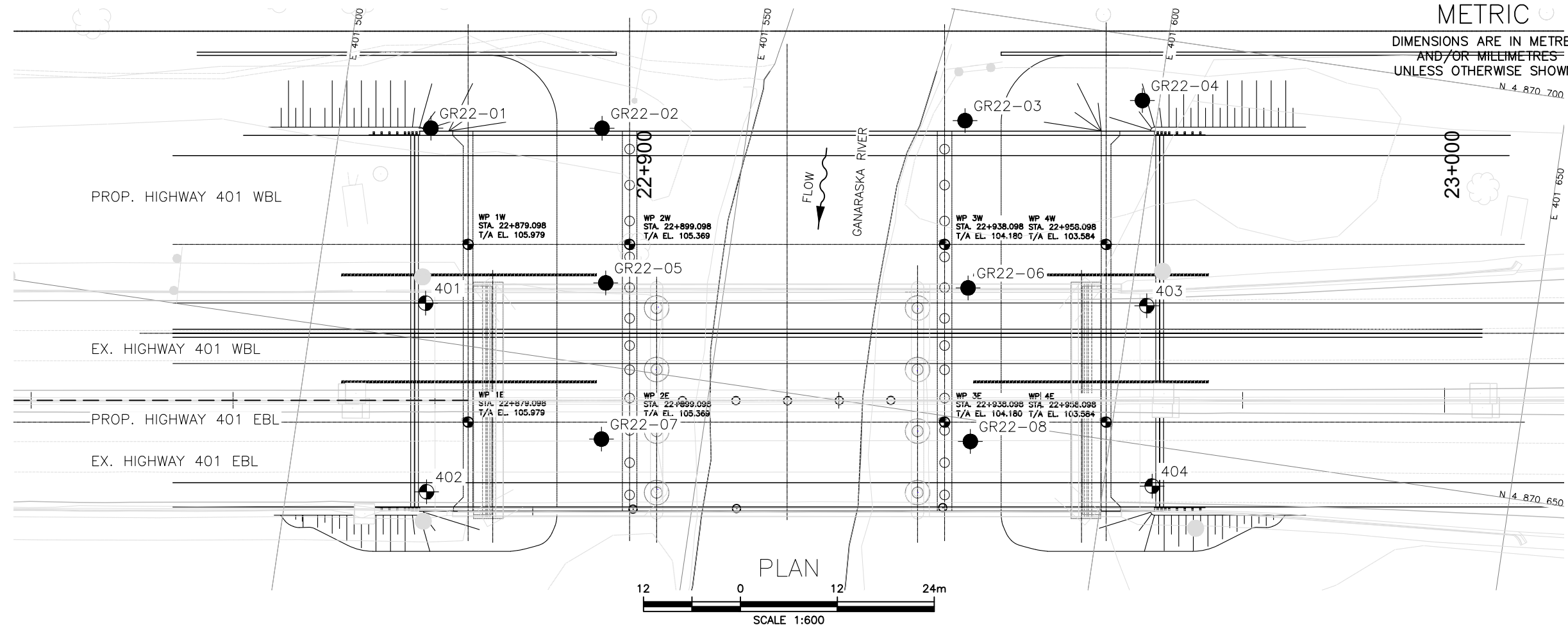
DRAFT

| REVISIONS | DATE | BY | DESCRIPTION                       |
|-----------|------|----|-----------------------------------|
| DESIGN CD | CHK  | PC | CODE CHBDC S6-19                  |
| DRAWN DT  | CHK  | CD | SITE 21X-0231/01 & 02/STRUCT -    |
|           |      |    | LOAD ONT CL-625/DATE JANUARY 2023 |
|           |      |    | SCHEME -                          |
|           |      |    | DWG 1                             |

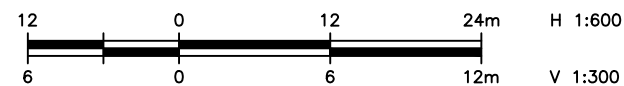
DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

SECTION  
1:100

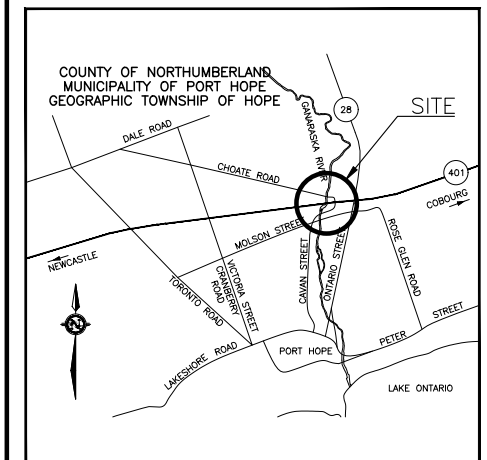




PROFILE ALONG HIGHWAY 401 EBL

CONT No  
WP NoHIGHWAY 401  
GANARASKA RIVER  
BRIDGE REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario



KEYPLAN

LEGEND

|      |   |
|------|---|
| ●    | Borehole (Current Investigation by Thurber) |
| ●    | Borehole (Previous Investigation by Others) |
| 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                               |

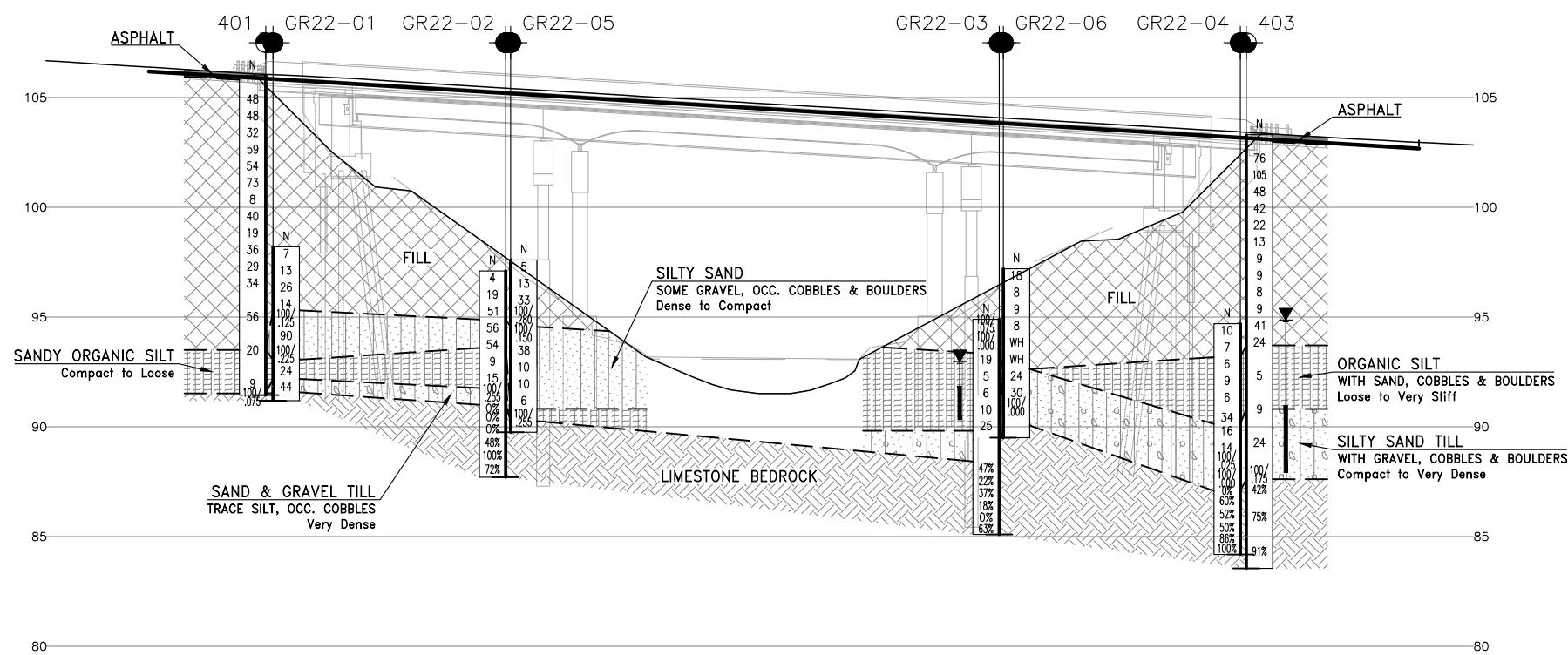
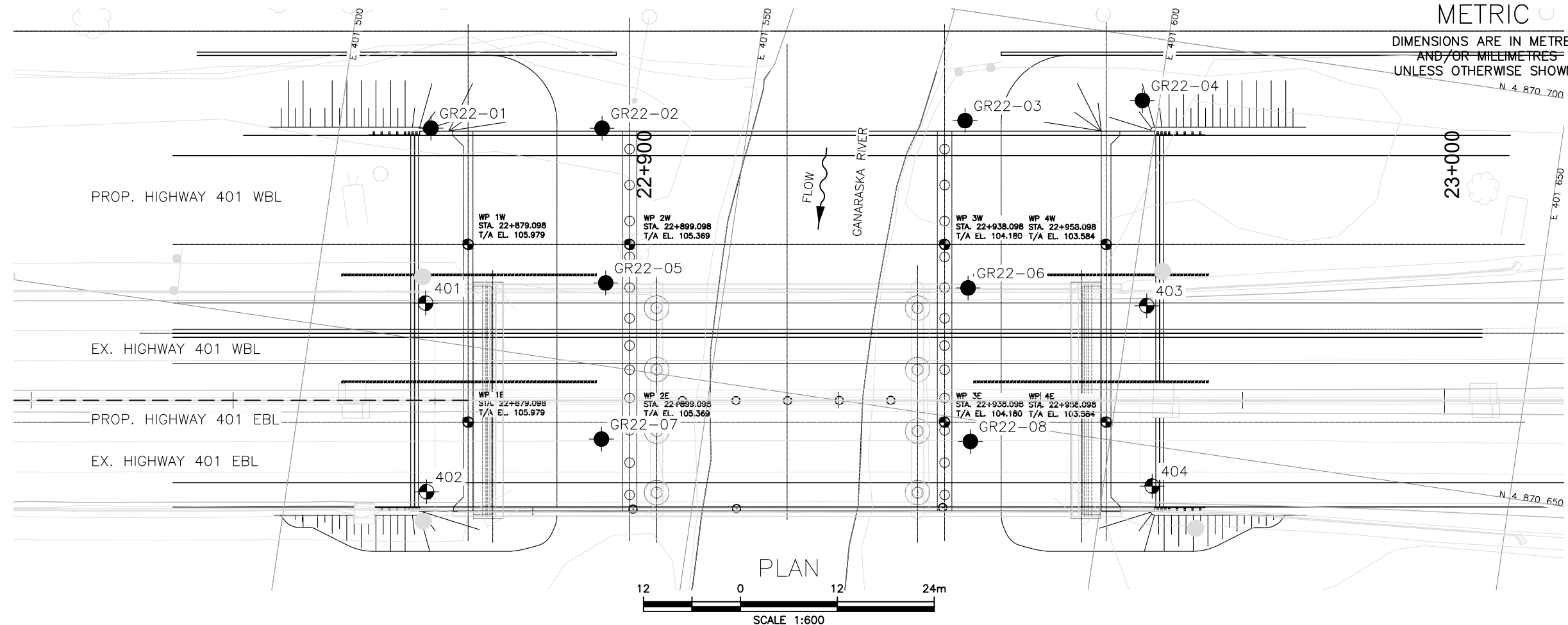
| NO      | ELEVATION | NORTHING    | EASTING   |
|---------|-----------|-------------|-----------|
| GR22-01 | 98.2      | 4 870 676.0 | 401 511.2 |
| GR22-02 | 97.1      | 4 870 679.1 | 401 532.2 |
| GR22-03 | 94.9      | 4 870 686.5 | 401 576.5 |
| GR22-04 | 94.7      | 4 870 692.2 | 401 597.9 |
| GR22-05 | 97.6      | 4 870 660.2 | 401 535.4 |
| GR22-06 | 97.2      | 4 870 666.1 | 401 579.9 |
| GR22-07 | 97.4      | 4 870 641.0 | 401 537.7 |
| GR22-08 | 96.7      | 4 870 647.3 | 401 582.9 |
| 401     | 106.0     | 4 870 654.5 | 401 513.7 |
| 402     | 106.0     | 4 870 631.4 | 401 517.2 |
| 403     | 103.3     | 4 870 667.1 | 401 602.1 |
| 404     | 103.4     | 4 870 645.1 | 401 606.0 |

-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. 30M16-078

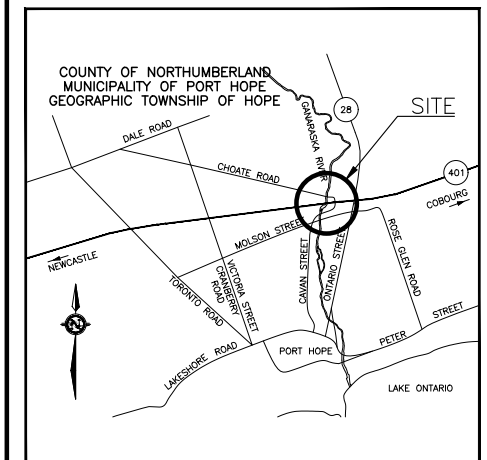
| REVISIONS | DATE | BY       | DESCRIPTION |
|-----------|------|----------|-------------|
| DESIGN    | CM   | CHK -    | CODE        |
| DRAWN     | MFA  | CHK CM   | SITE        |
| LOAD      | DATE | SEP 2022 |             |
| STRUCT    | DWG  | 1        |             |



PROFILE ALONG HIGHWAY 401 WBL

CONT No  
WP NoHIGHWAY 401  
GANARASKA RIVER  
BRIDGE REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario



KEYPLAN

## LEGEND

|      |   |
|------|---|
| ●    | Borehole (Current Investigation by Thurber) |
| ●    | Borehole (Previous Investigation by Others) |
| 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   |
|---------|-----------|-------------|-----------|
| GR22-01 | 98.2      | 4 870 676.0 | 401 511.2 |
| GR22-02 | 97.1      | 4 870 679.1 | 401 532.2 |
| GR22-03 | 94.9      | 4 870 686.5 | 401 576.5 |
| GR22-04 | 94.7      | 4 870 692.2 | 401 597.9 |
| GR22-05 | 97.6      | 4 870 660.2 | 401 535.4 |
| GR22-06 | 97.2      | 4 870 666.1 | 401 579.9 |
| GR22-07 | 97.4      | 4 870 641.0 | 401 537.7 |
| GR22-08 | 96.7      | 4 870 647.3 | 401 582.9 |
| 401     | 106.0     | 4 870 654.5 | 401 513.7 |
| 402     | 106.0     | 4 870 631.4 | 401 517.2 |
| 403     | 103.3     | 4 870 667.1 | 401 602.1 |
| 404     | 103.4     | 4 870 645.1 | 401 606.0 |

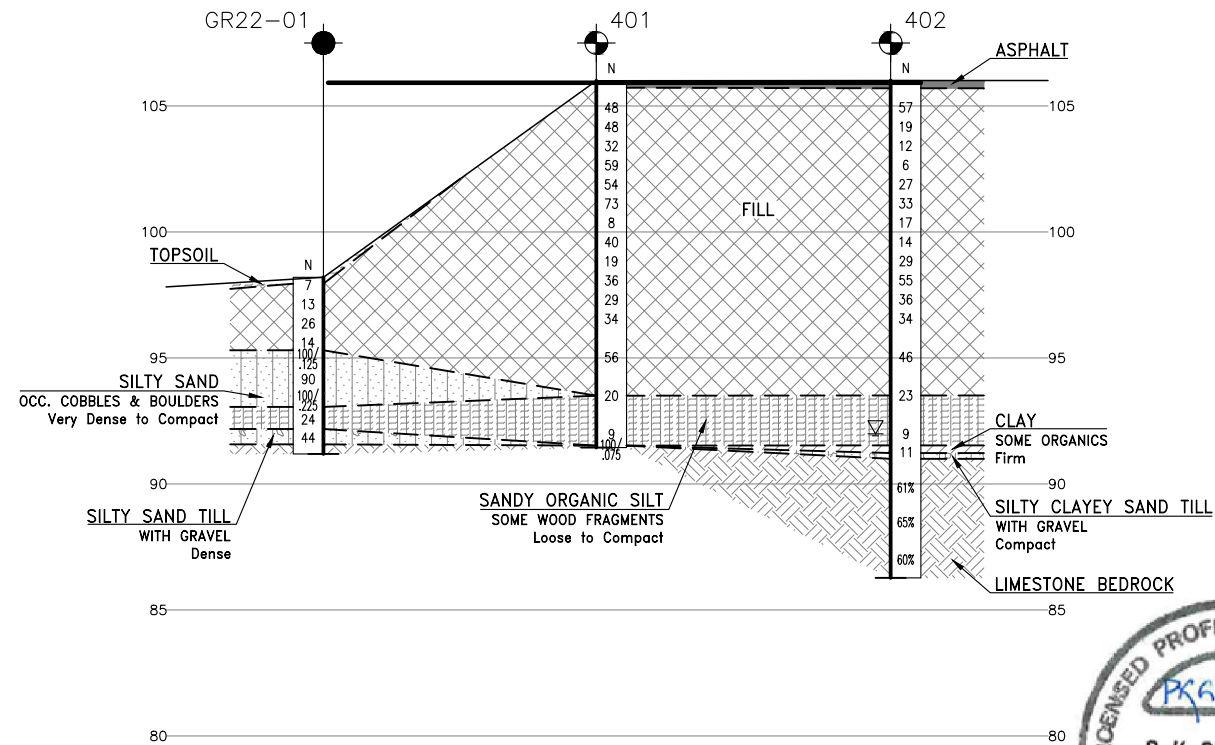
## -NOTES-

- 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.

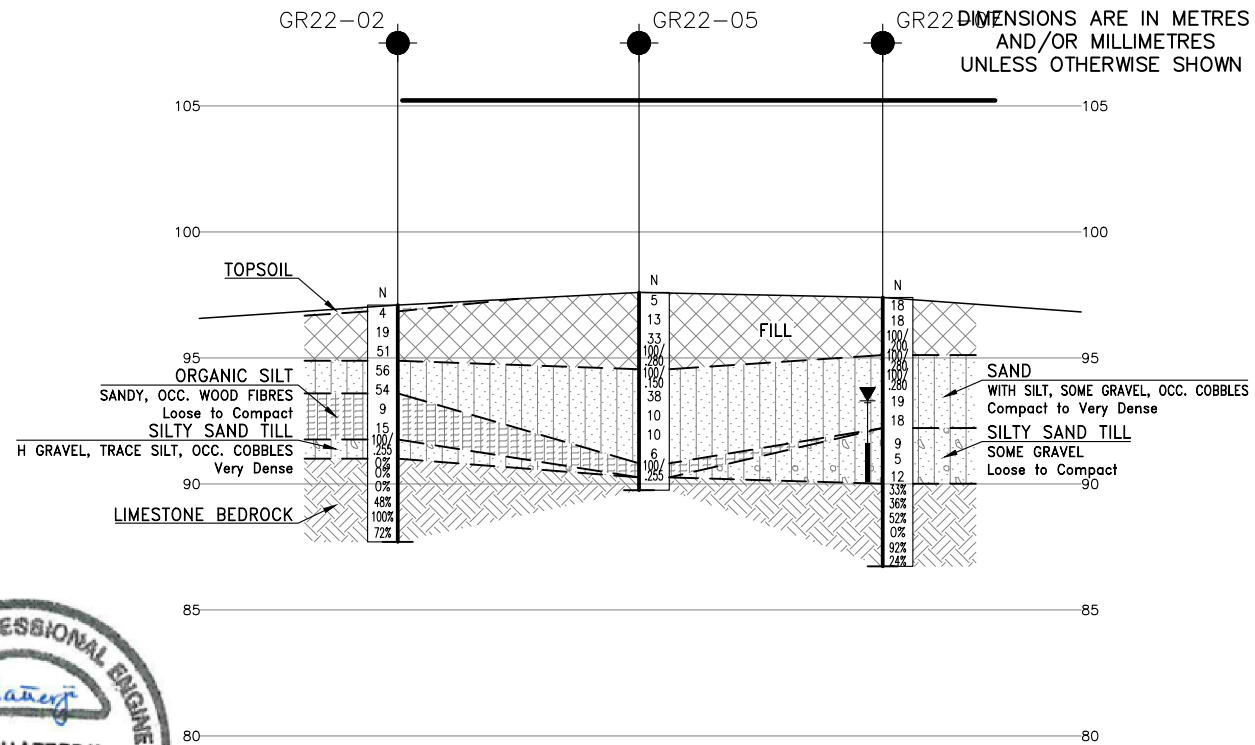
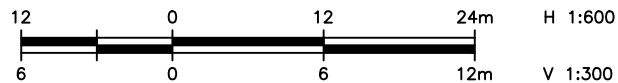
GEOCRES No. 30M16-078

| REVISIONS | DATE | BY       | DESCRIPTION |
|-----------|------|----------|-------------|
| DESIGN    | CM   | CHK -    | CODE        |
| DRAWN     | MFA  | CHK CM   | SITE        |
| LOAD      | DATE | SEP 2022 |             |
| STRUCT    | DWG  | 2        |             |

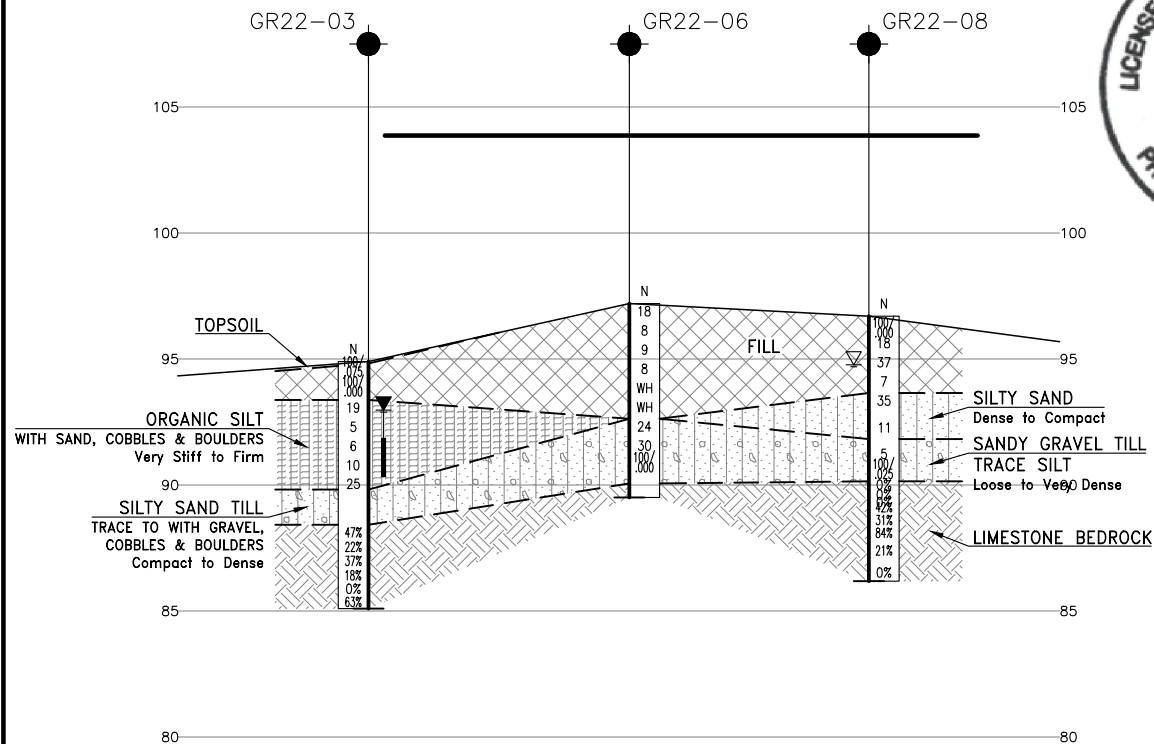
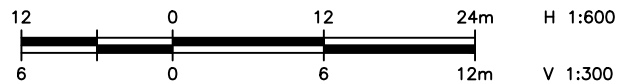




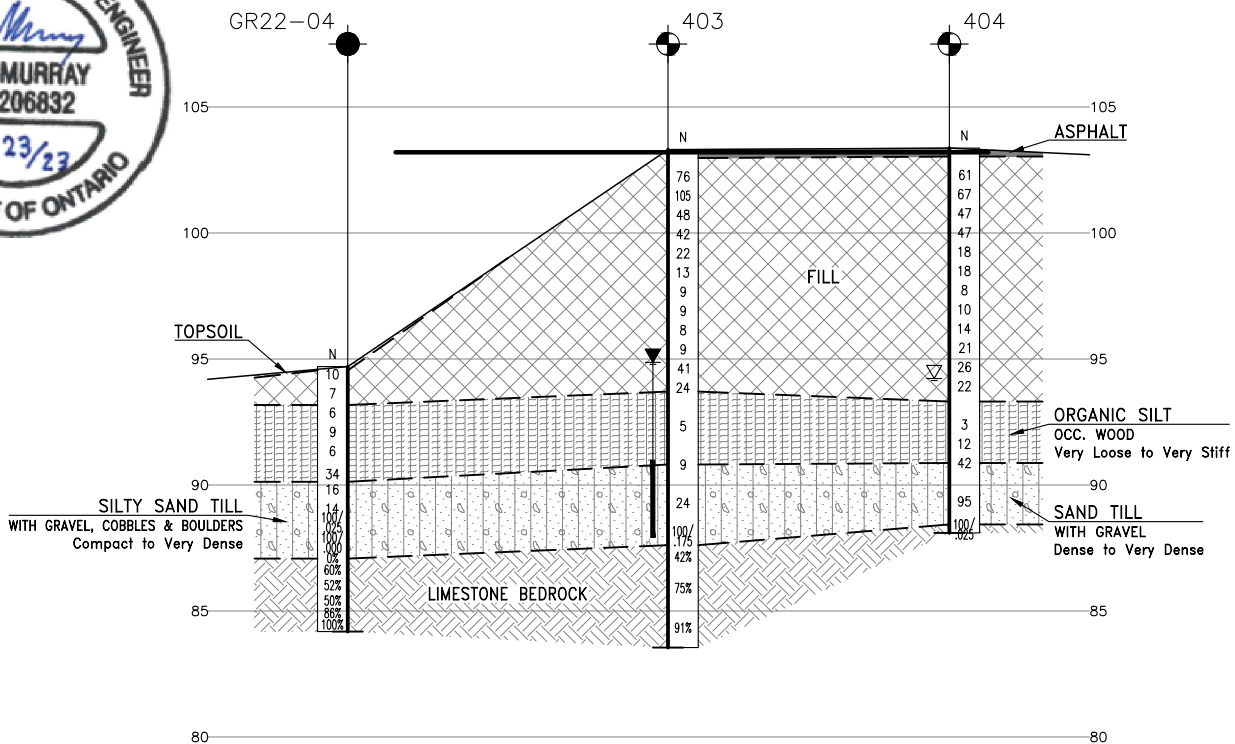
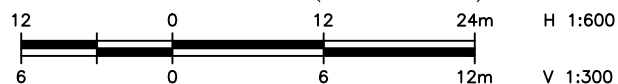
SECTION A-A (W. ABUT.)



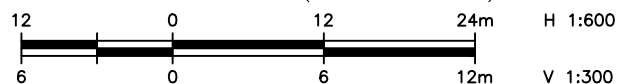
SECTION B-B (W. PIER)



SECTION C-C (E. PIER)



SECTION D-D (E. ABUT.)

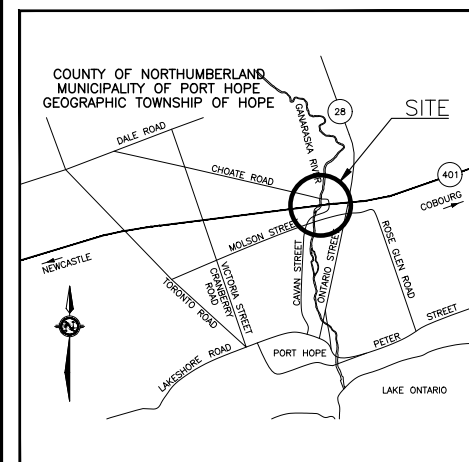


METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWNCONT No  
WP NoHIGHWAY 401  
GANARASKA RIVER  
BRIDGE REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario



KEYPLAN

## LEGEND

|      |   |
|------|---|
| ●    | Borehole (Current Investigation by Thurber) |
| ●    | Borehole (Previous Investigation by Others) |
| 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   |
|---------|-----------|-------------|-----------|
| GR22-01 | 98.2      | 4 870 676.0 | 401 511.2 |
| GR22-02 | 97.1      | 4 870 679.1 | 401 532.2 |
| GR22-03 | 94.9      | 4 870 686.5 | 401 576.5 |
| GR22-04 | 94.7      | 4 870 692.2 | 401 597.9 |
| GR22-05 | 97.6      | 4 870 660.2 | 401 535.4 |
| GR22-06 | 97.2      | 4 870 666.1 | 401 579.9 |
| GR22-07 | 97.4      | 4 870 641.0 | 401 537.7 |
| GR22-08 | 96.7      | 4 870 647.3 | 401 582.9 |
| 401     | 106.0     | 4 870 654.5 | 401 513.7 |
| 402     | 106.0     | 4 870 631.4 | 401 517.2 |
| 403     | 103.3     | 4 870 667.1 | 401 602.1 |
| 404     | 103.4     | 4 870 645.1 | 401 606.0 |

## -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. 30M16-078

| REVISIONS | DATE | BY       | DESCRIPTION |
|-----------|------|----------|-------------|
| DESIGN    | CM   | CHK -    | CODE        |
| DRAWN     | MFA  | CHK CM   | SITE        |
| LOAD      | DATE | SEP 2022 |             |
| STRUCT    | DWG  | 3        |             |





## **Appendix B   Field Investigation and Testing**

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<br>$W_L < 35\%$        | 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<br>$35\% < W_L < 50\%$ | 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<br>$W_L > 50\%$        | MH           | Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.                             |
|                      |  | CH           | Inorganic clays of high plasticity, fat clays.   |
|                      |  | OH           | Organic clays of high plasticity, organic silts.   |
| HIGHLY ORGANIC SOILS |  | Pt           | Peat and other organic soils.  |

Note -  $W_L$  = Liquid Limit



## 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 401

1 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 654.5 E 401 513.7 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG  
 DATUM Geodetic DATE 2016.05.31 - 2016.05.31 CHECKED BY KCP

| SOIL PROFILE  |  |            | SAMPLES |                   |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|--|------------|---------|-------------------|------------|----------------------------|-----------------|---|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE              | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 | ○ UNCONFINED      + FIELD VANE              |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 | ● QUICK TRIAXIAL    × LAB VANE              |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         | WATER CONTENT (%) |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 106.0         |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 0.0           | 280 mm ASPHALT   |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 105.7         |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 0.3           | Silty sand with gravel<br>Dense to very dense<br>Brown<br>FILL |            | 1       | GS                |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 2       | SS                | 48         |                            | 105             |   |  |  |  |                                    |                                     |                                   |  | 20 67 13<br>(SH+CL)  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 3       | SS                | 48         |                            | 104             |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 4       | SS                | 32         |                            | 103             |   |  |  |  |                                    |                                     |                                   |  |  |
|               | -gravel and cobbles  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 5       | SS                | 59         |                            | 102             |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 6       | SS                | 54         |                            | 101             |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               | -gravel and cobbles  |            | 7       | SS                | 73         |                            | 100             |   |  |  |  |                                    |                                     |                                   |  |  |
| 101.1         |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 4.9           | Sandy silt to sandy clay<br>Loose to dense<br>Brown<br>FILL    |            | 8       | SS                | 8          |                            | 99              |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 9       | SS                | 40         |                            | 98              |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 10      | SS                | 19         |                            | 97              |   |  |  |  |                                    |                                     |                                   |  | 3 30 44 23   |
|               | -clayey  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 11      | SS                | 36         |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 12      | SS                | 29         |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            | 13      | SS                | 34         |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |            |         |                   |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |

Continued Next Page

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

# RECORD OF BOREHOLE No 401

2 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 654.5 E 401 513.7 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG  
 DATUM Geodetic DATE 2016.05.31 - 2016.05.31 CHECKED BY KCP

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE                                     | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|---|------------|---------|------|------------|----------------------------|---|---|--|--|--|--|--|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |   | SHEAR STRENGTH kPa                          |  |  |  |  |  |
|               |   |            |         |      |            |                            |   | ○ UNCONFINED + FIELD VANE                   |  |  |  |  |  |
|               |   |            |         |      |            |                            |   | ● QUICK TRIAXIAL × LAB VANE                 |  |  |  |  |  |
|               |   |            |         |      |            |                            | WATER CONTENT (%)                                   |   |  |  |  |  |  |
|               |   |            |         |      |            |                            | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |   |  |  |  |  |  |
|               |   |            |         |      |            |                            | W P W W L   |   |  |  |  |  |  |
|               |   |            |         |      |            |                            | 20 40 60 80 100                                     |   |  |  |  |  |  |
|               |   |            |         |      |            |                            | 20 40 60 80 100                                     |   |  |  |  |  |  |
|               |   |            |         |      |            |                            | 20 40 60  |   |  |  |  |  |  |
| 95.6          | Continued From Previous Page  |            |         |      |            |                            |   |   |  |  |  |  |  |
| 10.4          | Sand with silt<br>Very dense<br>Brown<br>FILL   |            | 14      | SS   | 56         |                            | 95  |   |  |  |  |  |  |
|               |   |            |         |      |            |                            | 94  |   |  |  |  |  |  |
| 93.5          |   |            | 15      | SS   | 20         |                            |   |   |  |  |  |  |  |
| 12.5          | Sandy Organic SILT (ML-OL)<br>Compact to loose<br>Dark brown<br>- some wood fragments |            |         |      |            |                            | 93  |   |  |  |  |  | 0 36 51 13   |
|               |   |            | 16      | SS   | 9          |                            | 92  |   |  |  |  |  | 0 33 51 16   |
| 91.5          |   |            |         |      |            |                            |   |   |  |  |  |  |  |
| 91.4          | Weathered Limestone Bedrock   |            | 17      | SS   | 100        |                            |   |   |  |  |  |  |  |
| 14.6          | End of Borehole on Inferred Bedrock   |            |         |      | 75mm       |                            |   |   |  |  |  |  |  |





ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

# RECORD OF BOREHOLE No 402

1 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 631.4 E 401 517.2 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG  
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

| SOIL PROFILE  |  |   | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | UNIT<br>WEIGHT<br><br>$\gamma$<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |  |  |  |  |  |  |
|---------------|--|---|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|---|--|--|--|--|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT  | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |    |    |    |     |   |   |  |  |  |  |  |  |
| 106.0         |  |   |         |      |            |                            |                 | 20  | 40 | 60 | 80 | 100 |   |   |  |  |  |  |  |  |
| 0.0           | 300 mm ASPHALT   |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 105.7         |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 0.3           | Silty sand with gravel, occasional<br>cobbles<br>Loose to very dense<br>Brown<br>FILL                    |   | 1       | GS   |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 2       | SS   | 57         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 3       | SS   | 19         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 4       | SS   | 12         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 5       | SS   | 6          |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 100.5         | - cobbles  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 6       | SS   | 27         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 7       | SS   | 33         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 5.5           | Silty sand with gravel, occasional<br>cobbles<br>Compact to very dense<br>Brown to greyish-brown<br>FILL |  | 8       | SS   | 17         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 9             | SS   |   | 14      |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 10            | SS   |   | 29      |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 11            | SS   |   | 55      |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 100.0         |  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 12      | SS   | 36         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 99.5          |  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   | 13      | SS   | 34         |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 99.0          |  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 98.5          |  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 98.0          |  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 97.5          |  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 97.0          |  |  |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |   |         |      |            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 402

2 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 631.4 E 401 517.2 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG  
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

| SOIL PROFILE                 |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE  | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |   | UNIT<br>WEIGHT<br><br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |  |  |
|------------------------------|---|------------|---------|------|------------|----------------------------|--|---|--|--|---|---|--|--|--|
| ELEV<br>DEPTH                | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |  | SHEAR STRENGTH kPa                          |  |  |   |   |  |  |  |
|                              |   |            |         |      |            |                            |  | 20 40 60 80 100                             |  |  |   |   |  |  |  |
|                              |   |            |         |      |            |                            |  | 20 40 60 80 100                             |  |  |   |   |  |  |  |
| Continued From Previous Page |   |            |         |      |            |                            | UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |   |  |  | PLASTIC LIMIT<br>W P<br>NATURAL MOISTURE CONTENT<br>W<br>LIQUID LIMIT<br>W L<br>WATER CONTENT (%)<br>20 40 60 |   |  |  |  |
| 95.5                         |   |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |
| 10.5                         | Silty sand<br>Dense<br>Brown to greyish-brown<br>FILL   |            | 14      | SS   | 46         |                            | 95   |   |  |  |   |   |  |  |  |
|                              |   |            |         |      |            |                            | 94   |   |  |  |   |   |  |  |  |
| 93.5                         |   |            | 15      | SS   | 23         |                            |  |   |  |  |   |   |  |  |  |
| 12.5                         | Organic SILT (MH-OH)<br>Loose to compact<br>Greyish-brown to dark brown                           |            |         |      |            |                            | 93   |   |  |  |   |   |  |  |  |
|                              |   |            | 16      | SS   | 9          |                            | 92   |   |  |  |   |   |  |  |  |
| 91.5                         |   |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |
| 14.5                         | CLAY (CL), some organics  |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |
| 91.2                         | Firm  |            | 17      | SS   | 11         |                            |  |   |  |  |   |   |  |  |  |
| 14.8                         | Dark brown  |            |         |      |            |                            | 91   |   |  |  |   |   |  |  |  |
| 15.0                         | Silty, Clayey SAND (SC-SM) with<br>gravel TILL  |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |
| 90.5                         | Compact<br>Grey   |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |
| 15.5                         | Moderately weathered BEDROCK<br>- augered to 15.5 m   |            | 1       | HQ   |            |                            | 90   |   |  |  |   |   |  |  |  |
|                              | BEDROCK<br>Limestone<br>Slightly weathered<br>Thinly to moderately bedded<br>Fair Quality<br>Grey |            | 2       | HQ   |            |                            | 89   |   |  |  |   |   |  |  |  |
|                              |   |            | 3       | HQ   |            |                            | 88   |   |  |  |   |   |  |  |  |
|                              |   |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |
| 86.3                         |   |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |
| 19.7                         | End of Borehole   |            |         |      |            |                            |  |   |  |  |   |   |  |  |  |

ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 402

3 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 631.4 E 401 517.2 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG  
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

| SOIL PROFILE |   |            | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT |    |    |    |     | PLASTIC LIMIT<br>W <sub>p</sub> | NATURAL MOISTURE CONTENT<br>W | LIQUID LIMIT<br>W <sub>L</sub> | UNIT WEIGHT<br>γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|---|------------|---------|------|------------|-------------------------|-----------------|--|----|----|----|-----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| ELEV DEPTH   | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                         |                 | 20                                       | 40 | 60 | 80 | 100 |                                 |                               |                                |                  |                                       |
|              | Continued From Previous Page  |            |         |      |            |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
|              | Groundwater level was measured in open borehole at 14.0m BGS (elev. 92.0 m) on 2016/06/01 |            |         |      |            |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |









ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

# RECORD OF BOREHOLE No 403

1 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 667.1 E 401 602.1 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG  
 DATUM Geodetic DATE 2016.05.30 - 2016.05.30 CHECKED BY KCP

| SOIL PROFILE  |  |   | SAMPLES |      |            | GROUND WATER<br>CONDITIONS  | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |          |
|---------------|--|---|---------|------|------------|---|-----------------|---|--|--|--|--|--|----------|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT  | NUMBER  | TYPE | "N" VALUES |   |                 | SHEAR STRENGTH kPa                          |  |  |  |  |  |          |
| 103.3         |  |   |         |      |            |   |                 | 20 40 60 80 100                             |  |  |  |  |  |          |
| 0.0           | 350 mm ASPHALT   |   |         |      |            |   |                 |   |  |  |  |  |  |          |
| 103.0         |  |   |         |      |            |   |                 |   |  |  |  |  |  |          |
| 0.3           | Silty sand with gravel<br>Compact to very dense<br>Brown<br>FILL             |   | 1       | GS   |            |   | 103             |   |  |  |  |  |  | 20 40 60 |
|               |  |   | 2       | SS   | 76         |   |                 |   |  |  |  |  |  |          |
|               |  |   | 3       | SS   | 105        |   |                 |   |  |  |  |  |  |          |
|               |  |   | 4       | SS   | 48         |   |                 |   |  |  |  |  |  |          |
|               |  |   | 5       | SS   | 42         |   |                 |   |  |  |  |  |  |          |
|               |  |   | 6       | SS   | 22         |   |                 |   |  |  |  |  |  |          |
|               |  |   | 7       | SS   | 13         |   |                 |   |  |  |  |  |  |          |
| 97.8          |  |   |         |      |            |   |                 |   |  |  |  |  |  |          |
| 5.5           | Clay, trace sand<br>Firm<br>Brown to greyish-brown<br>FILL                   |  | 8       | SS   | 9          |  | 100             |   |  |  |  |  |  | 20 40 60 |
|               |  |   | 9       | SS   | 9          |   |                 |   |  |  |  |  |  |          |
|               |  |   | 10      | SS   | 8          |   |                 |   |  |  |  |  |  |          |
|               |  |   | 11      | SS   | 9          |   |                 |   |  |  |  |  |  |          |
| 95.4          |  |   |         |      |            |   |                 |   |  |  |  |  |  |          |
| 7.9           | Silty sand some gravel<br>Compact to dense<br>Brown to greyish-brown<br>FILL |  |         |      |            |  | 99              |   |  |  |  |  |  | 20 40 60 |
|               |  |   | 12      | SS   | 41         |   |                 |   |  |  |  |  |  |          |
|               |  |   | 13      | SS   | 24         |   |                 |   |  |  |  |  |  |          |
| 93.7          |  |   |         |      |            |   |                 |   |  |  |  |  |  |          |
| 9.6           | Organic SILT (MH-OH) occasional<br>wood pieces                               |  |         |      |            |  | 94              |   |  |  |  |  |  | 20 40 60 |

ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

Continued Next Page

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

## METRIC

| SOIL PROFILE                 |   |            |                 |            |                         |
|------------------------------|---|------------|-----------------|------------|-------------------------|
| ELEV<br>DEPTH                | DESCRIPTION   | STRAT PLOT | SAMPLES         | "N" VALUES | GROUND WATER CONDITIONS |
|                              |   |            |                 |            |                         |
| Continued From Previous Page |   |            |                 |            |                         |
| 90.8                         | Organic SILT (MH-OH) occasional wood pieces Loose to compact Grey to brown                            |            | 14 SS 5         |            |                         |
| 92.5                         | Silty SAND (SM) with gravel TILL Compact to very dense Brown to grey                                  |            | 15 SS 9         |            |                         |
|                              |   |            | 16 SS 24        |            |                         |
| 87.6                         |   |            | 17 SS 100/175mm |            |                         |
| 15.7                         | BEDROCK Limestone Moderately weathered to fresh Thinly to moderately bedded Poor to good quality Grey |            | 1 HQ            |            |                         |
|                              |   |            | 2 HQ            |            |                         |
|                              |   |            | 3 HQ            |            |                         |
| 83.5                         |   |            |                 |            |                         |
| 19.8                         | End of Borehole   |            |                 |            |                         |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

## METRIC

[illegible]

# RECORD OF BOREHOLE No 404

1 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 645.1 E 401 606.0 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG  
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                      |  |  |  | UNIT<br>WEIGHT<br><br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|--|--|--|--|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa   |  |  |  |   |  |
|               |  |            |         |      |            |                            |                 | ○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL    × LAB VANE |  |  |  |   |  |
|               |  |            |         |      |            |                            |                 | WATER CONTENT (%)<br>P L      W      L                           |  |  |  |   |  |
| 103.4         |  |            |         |      |            |                            |                 |  |  |  |  |   |  |
| 0.0           | 240 mm ASPHALT   |            |         |      |            |                            |                 |  |  |  |  |   |  |
| 103.0         |  |            |         |      |            |                            |                 |  |  |  |  |   |  |
| 0.3           | Sand with silt and gravel<br>Compact to dense<br>Brown<br>FILL |            | 1       | GS   |            |                            | 103             |  |  |  |  |   |  |
|               |  |            | 2       | SS   | 61         |                            | 102             |  |  |  |  |   |  |
|               |  |            | 3       | SS   | 67         |                            | 101             |  |  |  |  |   |  |
|               |  |            | 4       | SS   | 47         |                            | 100             |  |  |  |  |   |  |
|               |  |            | 5       | SS   | 47         |                            | 99              |  |  |  |  |   |  |
|               |  |            | 6       | SS   | 18         |                            | 98              |  |  |  |  |   |  |
|               |  |            | 7       | SS   | 18         |                            | 97              |  |  |  |  |   |  |
| 98.2          |  |            | 8       | SS   | 8          |                            | 96              |  |  |  |  |   |  |
| 5.2           | Clay<br>Firm<br>Brown<br>FILL                                  |            | 9       | SS   | 10         |                            | 95              |  |  |  |  |   |  |
|               |  |            | 10      | SS   | 14         |                            | 94              |  |  |  |  |   |  |
| 95.4          |  |            | 11      | SS   | 21         |                            | 93              |  |  |  |  |   |  |
| 7.9           | Sand with silt<br>Compact<br>Greyish-brown<br>FILL             |            | 12      | SS   | 26         |                            | 92              |  |  |  |  |   |  |
|               |  |            | 13      | SS   | 22         |                            | 91              |  |  |  |  |   |  |

Continued Next Page

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

# RECORD OF BOREHOLE No 404

2 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 645.1 E 401 606.0 ORIGINATED BY JAG  
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG  
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |  |  | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES   |                            |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |  |                                    |                                     |                                   |   |  |
| 93.3          | Continued From Previous Page   |            |         |      |              |                            |                 |  |  |  |                                    |                                     |                                   |   |  |
| 10.1          | Organic SILT (MH-OH)<br>Very loose to compact<br>Dark brown  |            | 14      | SS   | 3            |                            | 93              |  |  |  |                                    |                                     |                                   |   | 0 3 74 23  |
|               |  |            |         |      |              |                            | 92              |  |  |  |                                    |                                     |                                   |   |  |
|               |  |            |         | 15   | SS           | 12                         |                 |  |  |  |                                    |                                     |                                   |   |  |
| 90.9          | SAND (SP) with gravel TILL<br>Dense to very dense<br>Brown to grey   |            | 16      | SS   | 42           |                            | 91              |  |  |  |                                    |                                     |                                   |   |  |
| 12.5          |  |            |         |      |              |                            | 90              |  |  |  |                                    |                                     |                                   |   | 16 81 3<br>(SI+CL)   |
|               |  |            |         | 17   | SS           | 95                         |                 | 89   |  |  |                                    |                                     |                                   |   |  |
| 88.4          | Weathered Limestone BEDROCK<br>- augered to 15.3 m   |            | 18      | SS   | 100/<br>25mm |                            |                 |  |  |  |                                    |                                     |                                   |   |  |
| 14.9          |  |            |         |      |              |                            |                 |  |  |  |                                    |                                     |                                   |   |  |
| 88.1          |  |            |         |      |              |                            |                 |  |  |  |                                    |                                     |                                   |   |  |
| 15.3          | End of Borehole on inferred bedrock<br>Groundwater level was measured in<br>open borehole at 9.1 m BGS<br>(elev. 94.3 m) on 2016/06/01 |            |         |      |              |                            |                 |  |  |  |                                    |                                     |                                   |   |  |

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

# RECORD OF BOREHOLE No GR22-01

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.9697101°, Long: -78.294713° Highway 401/ Ganaraska River, MTM z10: N 4 870 676.0 E 401 511.2 ORIGINATED BY JZL  
 HWY 401 BOREHOLE TYPE Portable / NW Casing COMPILED BY AO  
 DATUM Geodetic DATE 2022.04.13 - 2022.04.14 CHECKED BY CM

| SOIL PROFILE  |   |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                      |    |    |     |  | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|---|------------|---------|------|---------------|----------------------------|-----------------|--|----|----|-----|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES    |                            |                 | SHEAR STRENGTH kPa   |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 | ○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL    × LAB VANE |    |    |     |  |                                    |                                     |                                   |  |  |
| 98.7          | Ground Surface  |            |         |      |               |                            | 20              | 40   | 60 | 80 | 100 |  |                                    |                                     |                                   |  |  |
| 0.0<br>98.4   | TOPSOIL (255 mm)  |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 0.3           | SILTY SAND some gravel<br>Occasional Cobbles and Boulders<br>Loose to compact<br>Brown<br>FILL  |            | 1       | SS   | 7             |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            | 2       | SS   | 13            |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 95.8          |   |            | 3       | SS   | 26            |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            | 4       | SS   | 14            |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 2.9           | SILTY SAND (SM)<br>Occasional Cobbles and Boulders<br>Very dense<br>Brown   |            | 5       | SS   | 100/<br>125mm |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            | 6       | SS   | 90            |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 93.6          |   |            | 7       | SS   | 100/<br>225mm |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 5.1           | ORGANIC SILT<br>Compact<br>Dark grey  |            | 8       | SS   | 24            |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 92.7          |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 6.0           | SILTY SAND with Gravel<br>Dense<br>Brown<br>GLACIAL TILL  |            | 9       | SS   | 44            |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 91.8          |   |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
| 91.9<br>7.0   | PROBABLE LIMESTONE<br>BEDROCK   |            | 1       | NO   | -             |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |
|               | End of Borehole<br>Note: A half-weight hammer was used<br>to advance the split-spoon sampler.<br>The "N" values presented above have<br>been adjusted to provide an estimate<br>of the "N" value that would have been<br>obtained with a standard hammer. |            |         |      |               |                            |                 |  |    |    |     |  |                                    |                                     |                                   |  |  |

DOUBLE LINE 33089 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No GR22-02

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969735°, Long: -78.294451° Highway 401/ Ganaraska River, MTM z10: N 4 870 679.1 E 401 532.2 ORIGINATED BY JZL  
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2022.04.12 - 2022.04.12 CHECKED BY CM

| SOIL PROFILE  |  |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br><br><b>γ</b><br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)   |
|---------------|--|------------|---------|------|---------------|----------------------------|-----------------|---|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|---|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES    |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |                                    |                                     |                                   |   |   |
| 97.6          | Ground Surface   |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 0.0<br>97.3   | TOPSOIL (255 mm)   |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 0.3           | SILTY SAND with gravel<br>Occasional Cobbles<br>Loose to very dense<br>Brown<br>FILL   |            | 1       | SS   | 4             |                            | 97              |   |  |  |  |                                    |                                     |                                   |   | 19 44 37<br>(SI+CL)   |
|               |  |            | 2       | SS   | 19            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
|               |  |            | 3       | SS   | 51            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 95.4          |  |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 2.2           | SAND (SP-SM) with silt<br>Occasional Cobbles<br>Very dense<br>Brown-grey   |            | 4       | SS   | 56            |                            | 95              |   |  |  |  |                                    |                                     |                                   |   | 1 90 9<br>(SI+CL)   |
|               |  |            | 5       | SS   | 54            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 94.1          |  |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 3.5           | ORGANIC SILT, Sandy<br>Occasional wood fibres<br>Loose to compact<br>Dark grey   |            | 6       | SS   | 9             |                            | 94              |   |  |  |  |                                    |                                     |                                   |   | 0 35 45 20  |
|               |  |            | 7       | SS   | 15            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
|               |  |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 92.3          |  |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 5.3           | SILTY SAND with Gravel<br>Occasional Cobbles<br>Very dense<br>Grey   |            | 8       | SS   | 100/<br>255mm |                            | 92              |   |  |  |  |                                    |                                     |                                   |   | FI  |
| 91.5          | GLACIAL TILL   |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 6.1           | LIMESTONE BEDROCK<br>Slightly weathered to fresh<br>Grey<br>Fine grained<br>Thinly to medium bedded<br>Strong to very strong |            | 1       | RUN  | -             |                            | 91              |   |  |  |  |                                    |                                     |                                   |   | RUN #1<br>TCR=66%<br>SCR=33%<br>RQD=0%<br>RUN #2<br>TCR=100%<br>SCR=78%<br>RQD=0%<br>RUN #3<br>TCR=97%<br>SCR=75%<br>RQD=0%<br>RUN #4<br>TCR=84%<br>SCR=76%<br>RQD=48%<br>RUN #5<br>TCR=100%<br>SCR=100%<br>RQD=100%<br>RUN #6<br>TCR=82%<br>SCR=82%<br>RQD=72% |
|               |  |            | 2       | RUN  | -             |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
|               |  |            | 3       | RUN  | -             |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
|               |  |            | 4       | RUN  | -             |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
|               |  |            | 5       | RUN  | -             |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
|               |  |            | 6       | RUN  | -             |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |
| 88.2          |  |            |         |      |               |                            | 89              |   |  |  |  |                                    |                                     |                                   |   |   |
| 9.4           | End of Borehole  |            |         |      |               |                            |                 |   |  |  |  |                                    |                                     |                                   |   |   |

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No GR22-03

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969796°, Long: -78.293898° Highway 401/ Ganaraska River, MTM z10: N 4 870 686.5 E 401 576.5 ORIGINATED BY JZL  
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2022.03.28 - 2022.03.28 CHECKED BY CM

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|--|---|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |   |   |
| 95.5          | Ground Surface  |            | 1       | SS   | 100/75mm   |                            |                 |   |  |  |   |   |
| 0.0<br>0.1    | TOPSOIL (75mm) (frozen)<br><br>SILTY SAND with organics<br>frequent cobbles and boulders<br>very dense<br>FILL                    |            | 2       | SS   | 100/0mm    |                            |                 |   |  |  |   |   |
| 94.0          |   |            |         |      |            |                            |                 |   |  |  |   |   |
| 1.5           | ORGANIC SILT with sand<br>Frequent Cobbles and Boulders to<br>2.1m<br>Very stiff to firm<br>Dark grey                             |            | 3       | SS   | 19         |                            |                 |   |  |  |   |   |
|               |   |            | 4       | SS   | 5          |                            |                 |   |  |  |   | 0 16 62 22  |
|               |   |            | 5       | SS   | 6          |                            |                 |   |  |  |   | Organic Content<br>= 1.0%                         |
|               |   |            | 6       | SS   | 10         |                            |                 |   |  |  |   |   |
|               |   |            | 7       | SS   | 25         |                            |                 |   |  |  |   |   |
| 90.4          |   |            |         |      |            |                            |                 |   |  |  |   |   |
| 5.1           | SILTY SAND (SM) with gravel<br>Frequent Cobbles and Boulders<br>Dense<br>Grey<br>GLACIAL TILL                                     |            | 1       | NQ   | -          |                            |                 |   |  |  |   | 15 40 33 12                                       |
|               |   |            | 2       | NQ   | -          |                            |                 |   |  |  |   |   |
|               |   |            | 3       | NQ   | -          |                            |                 |   |  |  |   |   |
| 89.0          |   |            |         |      |            |                            |                 |   |  |  | FI  |   |
| 6.5           | LIMESTONE BEDROCK<br>Moderately to slightly weathered<br>Grey<br>Fine grained<br>Thinly to medium bedded<br>Strong to very strong |            | 4       | RUN  | -          |                            |                 |   |  |  | 7   | RUN #4<br>TCR=95%<br>SCR=62%<br>RQD=47%           |
|               |   |            | 5       | RUN  | -          |                            |                 |   |  |  | >10   | RUN #5<br>TCR=59%<br>SCR=35%<br>RQD=22%           |
|               |   |            | 6       | RUN  | -          |                            |                 |   |  |  | 5   | RUN #6<br>TCR=100%<br>SCR=85%<br>RQD=37%          |
|               |   |            | 7       | RUN  | -          |                            |                 |   |  |  | 10  | RUN #7<br>TCR=97%<br>SCR=90%<br>RQD=18%           |
|               |   |            | 8       | RUN  | -          |                            |                 |   |  |  | 4   | RUN #8<br>TCR=87%<br>SCR=75%<br>RQD=0%            |
|               |   |            | 9       | RUN  | -          |                            |                 |   |  |  | 10  | RUN #9<br>TCR=100%<br>SCR=100%<br>RQD=63%         |
| 85.7          |   |            |         |      |            |                            |                 |   |  |  | 3   |   |
| 9.8           | End of Borehole   |            |         |      |            |                            |                 |   |  |  |   |   |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No GR22-03

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969796°, Long: -78.293898° Highway 401/ Ganaraska River, MTM z10: N 4 870 686.5 E 401 576.5 ORIGINATED BY JZL  
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2022.03.28 - 2022.03.28 CHECKED BY CM

| SOIL PROFILE                 |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |  |  |  |  | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|------------------------------|--|------------|---------|------|------------|----------------------------|-----------------|--|--|--|--|--|---|--|--|---|--|
| ELEV<br>DEPTH                | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |  |  |  | WATER CONTENT (%)<br>W P W W L                      |  |  |   |  |
| Continued From Previous Page |  |            |         |      |            |                            |                 |  |  |  |  |  |   |  |  |   |  |
|                              | Monitoring well installed consists of 38-mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen.<br><br>Water level readings:<br>DATE DEPTH (m) ELEV. (m)<br>2022.03.30 2.0 93.5<br>2022.03.31 1.9 93.6<br>2022.08.23 1.8 93.7<br>2022.08.24 1.9 93.7<br>Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer. |            |         |      |            |                            |                 |  |  |  |  |  |   |  |  |   |  |

# RECORD OF BOREHOLE No GR22-04

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969844°, Long: -78.293631° Highway 401/ Ganaraska River, MTM z10: N 4 870 692.2 E 401 597.9 ORIGINATED BY JZL  
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2022.03.17 - 2022.03.18 CHECKED BY CM

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC LIMIT      NATURAL<br>MOISTURE LIMIT      LIQUID LIMIT |  |                   | UNIT<br>WEIGHT<br><br>γ                   | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|---|--|--|--|-------------------|---|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES   |                            |                 | SHEAR STRENGTH kPa                          |  | WATER CONTENT (%)  |  |                   |   |   |
| 95.2          | Ground Surface   |            |         |      |              |                            |                 | 20 40 60 80 100                             |  | W P      W      W L  |  |                   | GR SA SI CL                               |   |
| 0.0           | TOPSOIL (150 mm)   |            |         |      |              |                            |                 | 20 40 60 80 100                             |  |  |  | kN/m <sup>3</sup> |   |   |
| 0.2           | CLAYEY SILT with sand<br>Trace Organics<br>Very stiff to stiff<br>Dark brown-grey<br>FILL                                      |            | 1       | SS   | 10           |                            | 95              |   |  |  |  |                   |   |   |
|               |  |            | 2       | SS   | 7            |                            | 94              |   |  |  |  |                   |   |   |
| 93.7          |  |            |         |      |              |                            |                 |   |  |  |  |                   |   |   |
| 1.5           | ORGANIC SILT<br>Loose to dense<br>Dark brown   |            | 3       | SS   | 6            |                            | 93              |   |  |  |  |                   | 0 15 82 3                                 |   |
|               |  |            | 4       | SS   | 9            |                            | 92              |   |  |  |  |                   |   |   |
|               |  |            | 5       | SS   | 6            |                            | 91              |   |  |  |  |                   |   |   |
| 90.6          |  |            | 6       | SS   | 34           |                            | 90              |   |  |  |  |                   |   |   |
| 4.6           | SILTY SAND with Gravel<br>Frequent Cobbles and Boulders<br>Compact to very dense<br>GLACIAL TILL                               |            | 7       | SS   | 16           |                            | 89              |   |  |  |  |                   |   |   |
|               |  |            | 8       | SS   | 14           |                            | 88              |   |  |  |  |                   |   |   |
|               |  |            | 9       | SS   | 100/<br>25mm |                            | 87              |   |  |  |  |                   |   |   |
| 87.8          |  |            | 10      | SS   | 100/<br>0mm  |                            | 86              |   |  |  |  |                   |   |   |
| 7.4           | LIMESTONE BEDROCK<br>Moderately weathered to fresh<br>Grey<br>Fine grained<br>Thinly to medium bedded<br>Strong to very strong |            | 1       | RUN  | -            |                            |                 |   |  |  |  | FI                |   |   |
|               |  |            | 2       | RUN  | -            |                            |                 |   |  |  |  | 6                 | RUN #1<br>TCR=75%<br>SCR=58%<br>RQD=0%    |   |
|               |  |            | 3       | RUN  | -            |                            |                 |   |  |  |  | 3                 | RUN #2<br>TCR=92%<br>SCR=92%<br>RQD=60%   |   |
|               |  |            | 4       | RUN  | -            |                            |                 |   |  |  |  | 5                 | RUN #3<br>TCR=86%<br>SCR=73%<br>RQD=52%   |   |
|               |  |            | 5       | RUN  | -            |                            |                 |   |  |  |  | 6                 | RUN #4<br>TCR=100%<br>SCR=100%<br>RQD=50% |   |
|               |  |            |         |      |              |                            |                 |   |  |  |  | 4                 | RUN #5<br>TCR=100%<br>SCR=92%             |   |
|               |  |            |         |      |              |                            |                 |   |  |  |  | 1                 |   |   |
|               |  |            |         |      |              |                            |                 |   |  |  |  | 3                 |   |   |

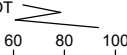
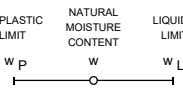

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

Continued Next Page

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

RUN #1  
 TCR=75%  
 SCR=58%  
 RQD=0%  
 RUN #2  
 TCR=92%  
 SCR=92%  
 RQD=60%  
 RUN #3  
 TCR=86%  
 SCR=73%  
 RQD=52%  
 RUN #4  
 TCR=100%  
 SCR=100%  
 RQD=50%  
 RUN #5  
 TCR=100%  
 SCR=92%

## METRIC

| SOIL PROFILE   |                              |   | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br> |  |  |  |  |  | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT<br> |  |   | UNIT WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--|------------------------------|---|---------|------|------------|-------------------------|-----------------|--|--|--|--|--|--|--|--|---|--|---------------------------------------|
| ELEV DEPTH   | DESCRIPTION                  | STRAT PLOT  | NUMBER  | TYPE | "N" VALUES |                         |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED    + FIELD VANE<br>● QUICK TRIAXIAL    × LAB VANE   | WATER CONTENT (%)<br>20 40 60 80 100      20 40 60 |  |  |  |  |  |  |   |  |                                       |
|  | Continued From Previous Page |   |         |      |            |                         |                 |  |  |  |  |  |  |  |  |   |  |                                       |
| 84.7   | LIMESTONE BEDROCK            |  | 6       | RUN  | -          |                         | 85              |  |  |  |  |  |  |  |  | 1 | RQD=86%<br>RUN #6<br>TCR=100%<br>SCR=100%    |                                       |
| 10.5   | End of Borehole              |   |         |      |            |                         |                 |  |  |  |  |  |  |  |  | 0 | RQD=100%                                     |                                       |
| <p>Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.</p> |                              |   |         |      |            |                         |                 |  |  |  |  |  |  |  |  |   |  |                                       |

# RECORD OF BOREHOLE No GR22-05

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969564°, Long: -78.294415° Highway 401/ Ganaraska River, MTM z10: N 4 870 660.2 E 401 535.4 ORIGINATED BY JZL  
 HWY 401 BOREHOLE TYPE Portable / NW Casing COMPILED BY AO  
 DATUM Geodetic DATE 2022.04.11 - 2022.04.11 CHECKED BY CM

| SOIL PROFILE  |   |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |                |   | UNIT<br>WEIGHT<br><br><b>γ</b><br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |    |                    |    |
|---------------|---|------------|---------|------|---------------|----------------------------|-----------------|---|----|----|----|---|----------------|---|---|---|----|--------------------|----|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES    |                            |                 | SHEAR STRENGTH kPa                          |    |    |    | WATER CONTENT (%)                                       |                |   |   | GR  | SA | SI                 | CL |
|               |   |            |         |      |               |                            |                 | 20  | 40 | 60 | 80 | 100   | W <sub>P</sub> | W |   | W <sub>L</sub>                                    |    |                    |    |
| 98.1          | Ground Surface  |            |         |      |               |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
| 0.0           | SILTY SAND with Gravel<br>Occasional Cobbles<br>Loose to compact<br>Brown<br>FILL   |            | 1       | SS   | 5             |                            |                 |   |    |    |    | ○   |                |   |   |   |    |                    |    |
|               |   |            | 2       | SS   | 13            |                            |                 |   |    |    |    | ○   |                |   |   |   |    |                    |    |
|               |   |            | 3       | SS   | 33            |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
|               |   |            | 4       | SS   | 100/<br>280mm |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
| 95.1          |   |            |         |      |               |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
| 3.0           | SAND (SW-SM) with silt, some<br>Gravel<br>Dense to loose<br>Grey  |            | 5       | SS   | 100/<br>150mm |                            |                 |   |    |    |    | ○   |                |   |   |   |    |                    |    |
|               |   |            | 6       | SS   | 38            |                            |                 |   |    |    |    | ○   |                |   |   |   | 14 | 74   12<br>(SI+CL) |    |
|               |   |            | 7       | SS   | 10            |                            |                 |   |    |    |    | ○   |                |   |   |   |    |                    |    |
|               |   |            | 8       | SS   | 10            |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
|               |   |            | 9       | SS   | 6             |                            |                 |   |    |    |    | ○   |                |   |   |   |    |                    |    |
| 91.3          |   |            |         |      |               |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
| 6.8           | ORGANIC SILT, frequent Cobbles<br>Very dense<br>Dark grey   |            | 10      | SS   | 100/<br>255mm |                            |                 |   |    |    |    |   |                | ○ |   |   | 3  | 46   35   16       |    |
| 90.8          |   |            |         |      |               |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
| 7.3           | PROBABLE LIMESTONE<br>BEDROCK   |            | 1       | NQ   | -             |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
| 90.3          |   |            |         |      |               |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |
| 7.8           | End of Borehole<br><br>Note: A half-weight hammer was used<br>to advance the split-spoon sampler.<br>The "N" values presented above have<br>been adjusted to provide an estimate<br>of the "N" value that would have been<br>obtained with a standard hammer. |            |         |      |               |                            |                 |   |    |    |    |   |                |   |   |   |    |                    |    |

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

# RECORD OF BOREHOLE No GR22-06

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969611°, Long: -78.29386°  
Highway 401/ Ganaraska River, MTM z10: N 4 870 666.1 E 401 579.9 ORIGINATED BY JZL  
HWY 401 BOREHOLE TYPE Portable / NW Casing COMPILED BY AO  
DATUM Geodetic DATE 2022.03.31 - 2022.03.31 CHECKED BY CM

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | UNIT<br>WEIGHT<br><br><b>γ</b><br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |                    |                   |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|---|--|--------------------|-------------------|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |   |  |                    |                   |
|               |  |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |   |  |                    |                   |
| 97.2          | Ground Surface   |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |
| 0.0           | SANDY CLAYEY SILT<br>Occasional rock fragments<br>Compact to loose<br>Brown<br>FILL  |            | 1       | SS   | 18         |                            |                 |   |  |  |  |   |  | 2 35 63<br>(SI+CL) |                   |
|               |  |            | 2       | SS   | 8          |                            |                 |   |  |  |  |   |  |                    |                   |
| 95.7          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |
| 1.5           | SAND with silt<br>Loose<br>Brown<br>FILL   |            | 3       | SS   | 9          |                            |                 |   |  |  |  |   |  |                    | 0 93 7<br>(SI+CL) |
|               |  |            | 4       | SS   | 8          |                            |                 |   |  |  |  |   |  |                    |                   |
| 94.2          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |
| 3.0           | SAND with gravel, probable voids<br>Occasional wood pieces<br>Very loose<br>Grey<br>FILL   |            | 5       | SS   | 1          |                            |                 |   |  |  |  |   |  |                    |                   |
|               |  |            | 6       | SS   | WH         |                            |                 |   |  |  |  |   |  |                    |                   |
| 92.6          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |
| 4.6           | SILTY SAND (SM) trace gravel<br>Compact to very dense<br>Brown to grey<br>GLACIAL TILL   |            | 7       | SS   | 24         |                            |                 |   |  |  |  |   |  |                    |                   |
|               |  |            | 8       | SS   | 30         |                            |                 |   |  |  |  |   |  |                    |                   |
|               |  |            | 9       | SS   | 100/       |                            |                 |   |  |  |  |   |  | 9 67 24<br>(SI+CL) |                   |
|               | -Frequent Cobbles and Boulders<br>below 6.2m   |            |         |      | 150mm      |                            |                 |   |  |  |  |   |  |                    |                   |
| 90.1          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |
| 7.1           | PROBABLE LIMESTONE<br>BEDROCK  |            | 1       | NQ   | -          |                            |                 |   |  |  |  |   |  |                    |                   |
| 89.5          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |
| 7.7           | End of Borehole  |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |
|               | Note: A half-weight hammer was used<br>to advance the split-spoon sampler.<br>The "N" values presented above have<br>been adjusted to provide an estimate<br>of the "N" value that would have been<br>obtained with a standard hammer. |            |         |      |            |                            |                 |   |  |  |  |   |  |                    |                   |

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2



# RECORD OF BOREHOLE No GR22-07

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969391°, Long: -78.2943901°  
Highway 401/ Ganaraska River, MTM z10: N 4 870 641.0 E 401 537.7 ORIGINATED BY JZL  
HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO  
DATUM Geodetic DATE 2022.04.06 - 2022.04.06 CHECKED BY CM

| SOIL PROFILE  |  |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | UNIT<br>WEIGHT<br><br><b>γ</b><br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |  |  |  |  |  |  |
|---------------|--|------------|---------|------|---------------|----------------------------|-----------------|---|----|----|----|-----|---|---|--|--|--|--|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES    |                            |                 | SHEAR STRENGTH kPa                          |    |    |    |     |   |   |  |  |  |  |  |  |
| 97.9          | Ground Surface   |            |         |      |               |                            |                 | 20  | 40 | 60 | 80 | 100 |   |   |  |  |  |  |  |  |
| 0.0           | CLAYEY SILT, sandy<br>Occasional Rock fragments<br>Compact to dense<br>Brown<br>FILL   |            | 1       | SS   | 18            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 2       | SS   | 18            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 3       | SS   | 100/<br>280mm |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 95.6          |  |            |         |      |               |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 2.3           | SAND (SW-SM) with silt, some<br>gravel<br>Very dense to compact<br>Grey-brown  |            | 4       | SS   | 100/<br>280mm |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 5       | SS   | 100/<br>280mm |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 6       | SS   | 19            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 7       | SS   | 18            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 92.7          |  |            |         |      |               |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 5.2           | SILTY SAND (SM) some gravel<br>Loose to compact<br>Grey<br>GLACIAL TILL  |            | 8       | SS   | 9             |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 9       | SS   | 5             |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 10      | SS   | 12            |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 90.5          |  |            |         |      |               |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
| 7.4           | LIMESTONE BEDROCK<br>Slightly weathered to fresh<br>Grey<br>Fine grained<br>Thinly to medium bedded<br>Strong to very strong |            | 1       | RUN  | -             |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 2       | RUN  | -             |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 3       | RUN  | -             |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 4       | RUN  | -             |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |
|               |  |            | 5       | RUN  | -             |                            |                 |   |    |    |    |     |   |   |  |  |  |  |  |  |

Continued Next Page

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

## METRIC

| SOIL PROFILE   |                   |            |         |                            |                 |
|--|-------------------|------------|---------|----------------------------|-----------------|
| ELEV<br>DEPTH  | DESCRIPTION       | STRAT PLOT | SAMPLES | GROUND WATER<br>CONDITIONS | ELEVATION SCALE |
| <div>DYNAMIC CONE PENETRATION RESISTANCE PLOT<div><div>20406080100</div><div></div></div><div>SHEAR STRENGTH kPa<div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div><div>WATER CONTENT (%)<div><div>PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT</div><div>w p w w L</div></div></div></div></div>   |                   |            |         |                            |                 |
| Continued From Previous Page   |                   |            |         |                            |                 |
| 87.2   | LIMESTONE BEDROCK |            | 6       | RUN                        | -               |
| 10.7   | End of Borehole   |            |         |                            |                 |
| <div>Monitoring well installed consists of 38-mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen.</div> <div>Water level readings:<div>DATE      DEPTH (m)    ELEV. (m)</div><div>2022.04.11     4.1       93.3</div></div> <div>Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.</div> |                   |            |         |                            |                 |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No GR22-08

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969442°, Long: -78.293825° Highway 401/ Ganaraska River, MTM z10: N 4 870 647.3 E 401 582.9 ORIGINATED BY JZL  
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2022.04.01 - 2022.04.01 CHECKED BY CM

| SOIL PROFILE  |   |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                                  |                                | UNIT<br>WEIGHT<br><br><b>γ</b><br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|--------------|----------------------------|-----------------|---|----------------------------------|--------------------------------|---|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES   |                            |                 | SHEAR STRENGTH kPa                          |                                  |                                |   |   |
| 96.7          | Ground Surface  |            |         |      |              |                            |                 | 20 40 60 80 100                             | PLASTIC<br>LIMIT                 | NATURAL<br>MOISTURE<br>CONTENT | LIQUID<br>LIMIT   |   |
| 0.0           | SILTY SAND with Gravel<br>Occasional Rock fragments<br>Loose to dense<br>Brown<br>FILL                                |            | 1       | SS   | 100/<br>0mm  |                            |                 | 20 40 60 80 100                             | ○ UNCONFINED<br>● QUICK TRIAXIAL | + FIELD VANE<br>× LAB VANE     | W <sub>P</sub> W      W <sub>L</sub>                    |   |
|               |   |            | 2       | SS   | 18           |                            | 96              |   |                                  |                                |   |   |
|               |   |            | 3       | SS   | 37           |                            | 95              |   |                                  |                                |   | 18 59 23<br>(SI+CL)                               |
|               |   |            | 4       | SS   | 7            |                            | 94              |   |                                  |                                |   |   |
| 93.7          |   |            |         |      |              |                            |                 |   |                                  |                                |   |   |
| 3.0           | SILTY SAND (SM)<br>Dense to compact<br>Brown-grey   |            | 5       | SS   | 35           |                            | 93              |   |                                  |                                |   |   |
|               |   |            | 6       | SS   | 11           |                            | 92              |   |                                  |                                |   | 3 84 4 9  |
| 91.8          |   |            |         |      |              |                            |                 |   |                                  |                                |   |   |
| 4.9           | GRAVEL with Sand trace Silt<br>Loose to very dense<br>Grey<br>GLACIAL TILL  |            | 7       | SS   | 5            |                            | 91              |   |                                  |                                |   |   |
|               |   |            | 8       | SS   | 100/<br>25mm |                            |                 |   |                                  |                                |   |   |
| 90.1          |   |            |         |      |              |                            |                 |   |                                  |                                |   |   |
| 6.6           | LIMESTONE BEDROCK<br>Moderately weathered<br>Grey<br>Fine grained<br>Thinly to medium bedded<br>Strong to very strong |            | 1       | RUN  | -            |                            | 90              |   |                                  |                                |   | RUN #1<br>TCR=100%<br>SCR=65%<br>RQD=0%           |
|               |   |            | 2       | RUN  | -            |                            |                 |   |                                  |                                |   | RUN #2<br>TCR=50%<br>SCR=25%<br>RQD=0%            |
|               |   |            | 3       | RUN  | -            |                            |                 |   |                                  |                                |   | RUN #3<br>TCR=100%<br>SCR=100%<br>RQD=0%          |
|               |   |            | 4       | RUN  | -            |                            | 89              |   |                                  |                                |   | RUN #4<br>TCR=92%<br>SCR=85%<br>RQD=42%           |
|               |   |            | 5       | RUN  | -            |                            |                 |   |                                  |                                |   | RUN #5<br>TCR=74%<br>SCR=66%<br>RQD=31%           |
|               |   |            | 6       | RUN  | -            |                            | 88              |   |                                  |                                |   | RUN #6<br>TCR=96%<br>SCR=96%<br>RQD=84%           |
|               |   |            | 7       | RUN  | -            |                            | 87              |   |                                  |                                |   | RUN #7<br>TCR=44%<br>SCR=46%                      |

Continued Next Page

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

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

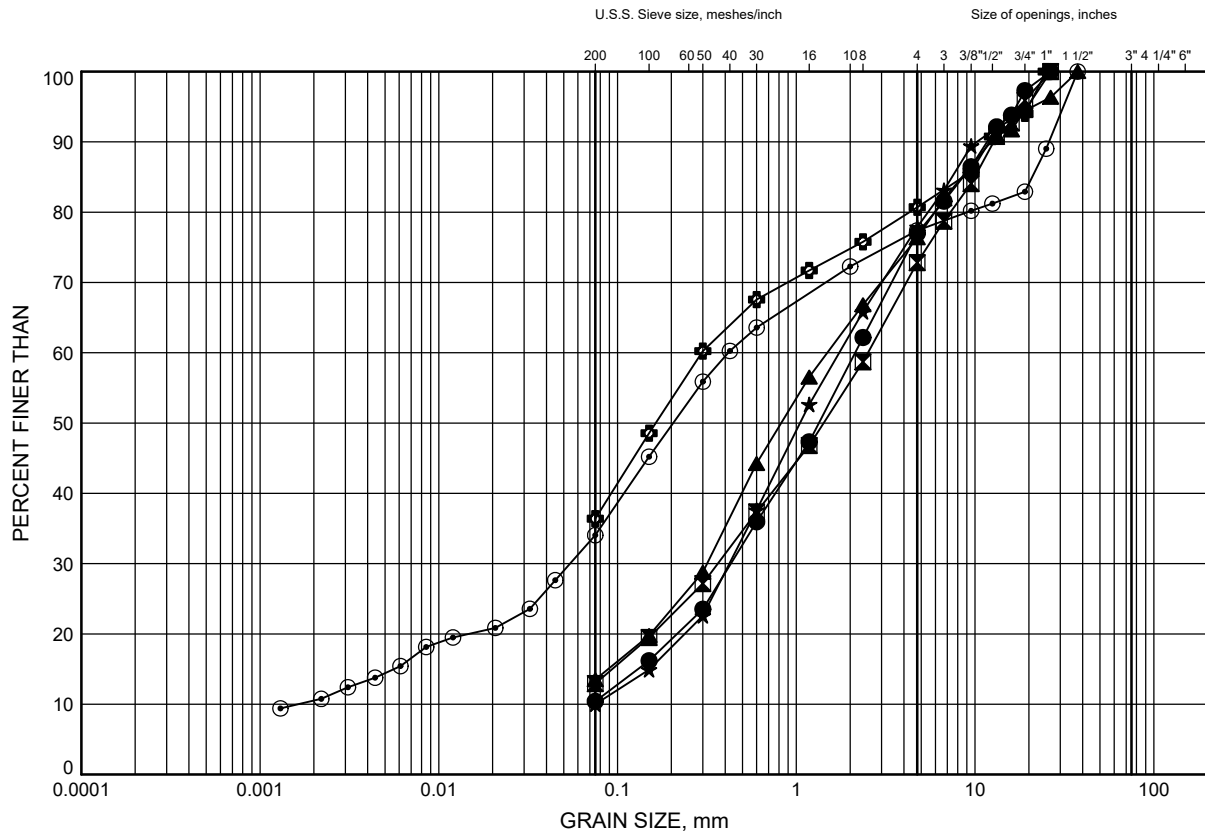


## **Appendix C   Laboratory Testing**

Particle Size Analysis Figures  
Atterberg Limits Figures  
Unconfined Compressive Strength Testing Results  
Analytical Testing Results  
Bedrock Core Photographs

# GRAIN SIZE DISTRIBUTION

FILL: Silty Sand with Gravel



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 401      | 1.1       | 104.9     |
| ⊠      | 402      | 4.1       | 101.9     |
| ▲      | 403      | 2.6       | 100.7     |
| ★      | 404      | 3.4       | 100.0     |
| ⊙      | GR22-01  | 1.8       | 96.9      |
| ⊕      | GR22-02  | 1.1       | 96.5      |

Date September 2022

GWP# 4068-14-00

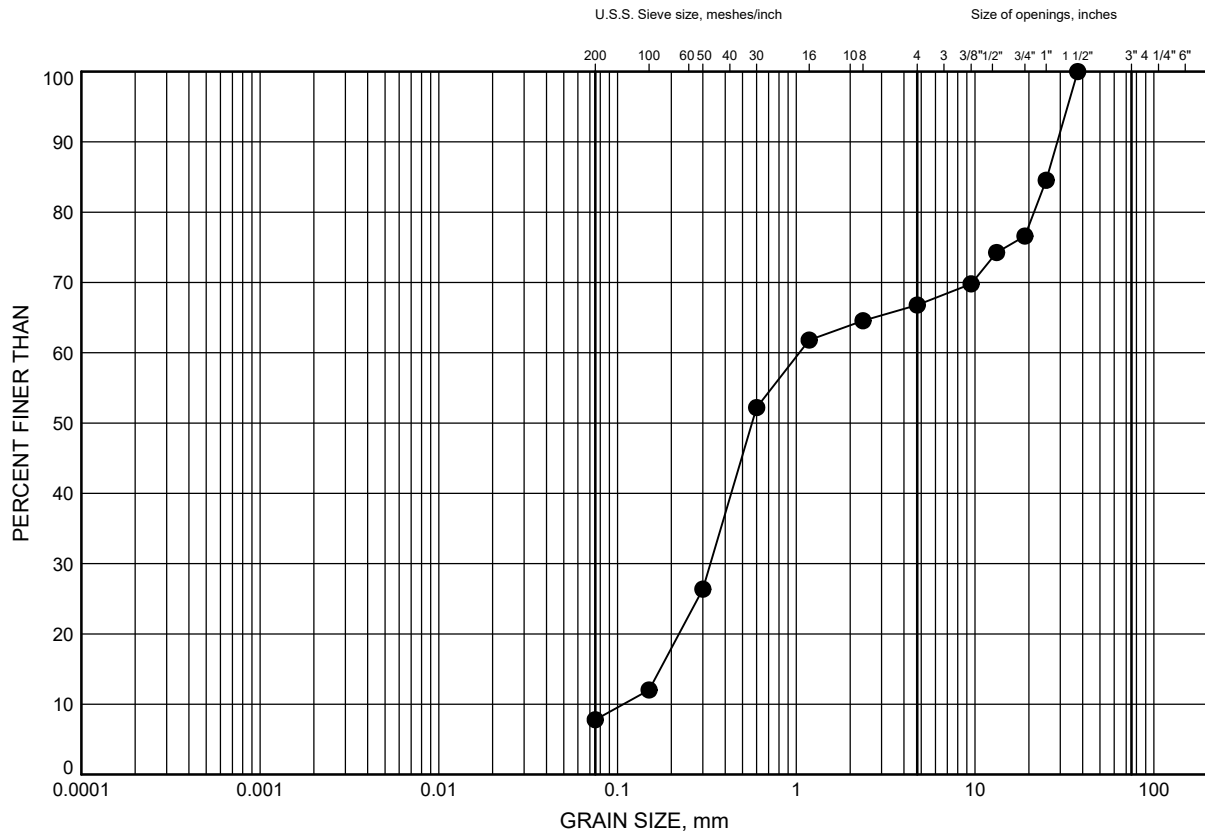


Prep'd AO

Chkd. CM

# GRAIN SIZE DISTRIBUTION

FILL: Silty Sand with Gravel



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | GR22-08  | 1.8       | 94.9      |

Date September 2022

GWP# 4068-14-00

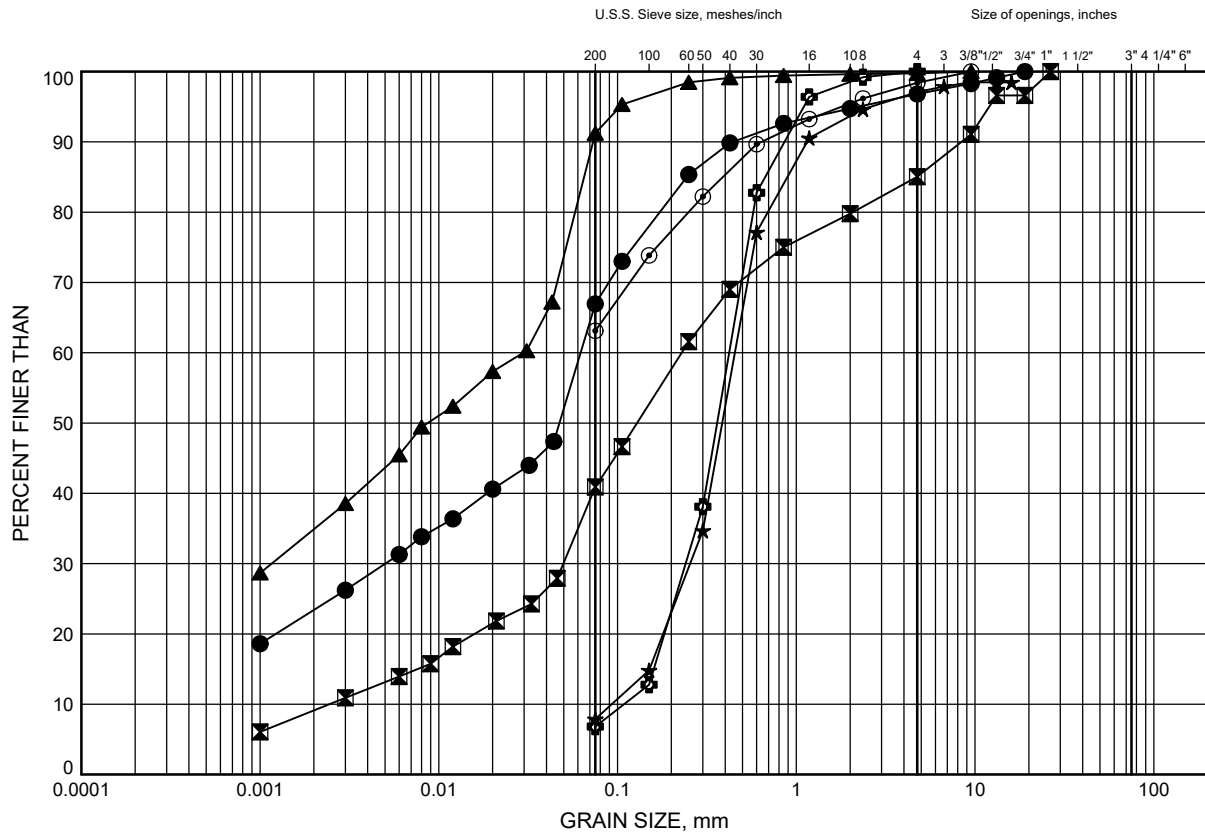


Prep'd AO

Chkd. CM

# GRAIN SIZE DISTRIBUTION

FILL: Variable



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 401      | 7.2       | 98.8      |
| ⊠      | 402      | 8.7       | 97.3      |
| ▲      | 403      | 6.4       | 96.9      |
| ★      | 404      | 9.4       | 93.9      |
| ⊙      | GR22-06  | 0.3       | 96.9      |
| ⊕      | GR22-06  | 1.8       | 95.4      |

Date September 2022

GWP# 4068-14-00



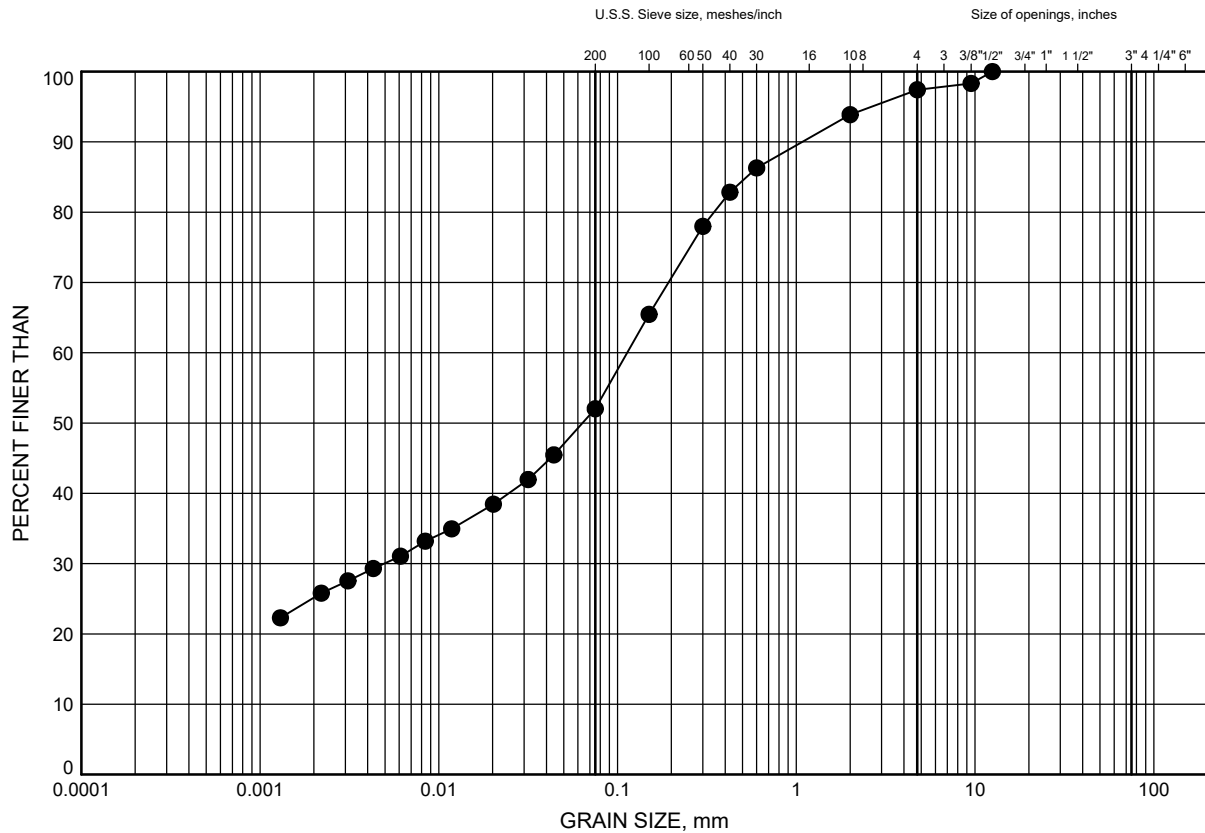
Prep'd AO

Chkd. CM



# GRAIN SIZE DISTRIBUTION

FILL: Variable



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | GR22-07  | 1.1       | 96.8      |

Date September 2022

GWP# 4068-14-00

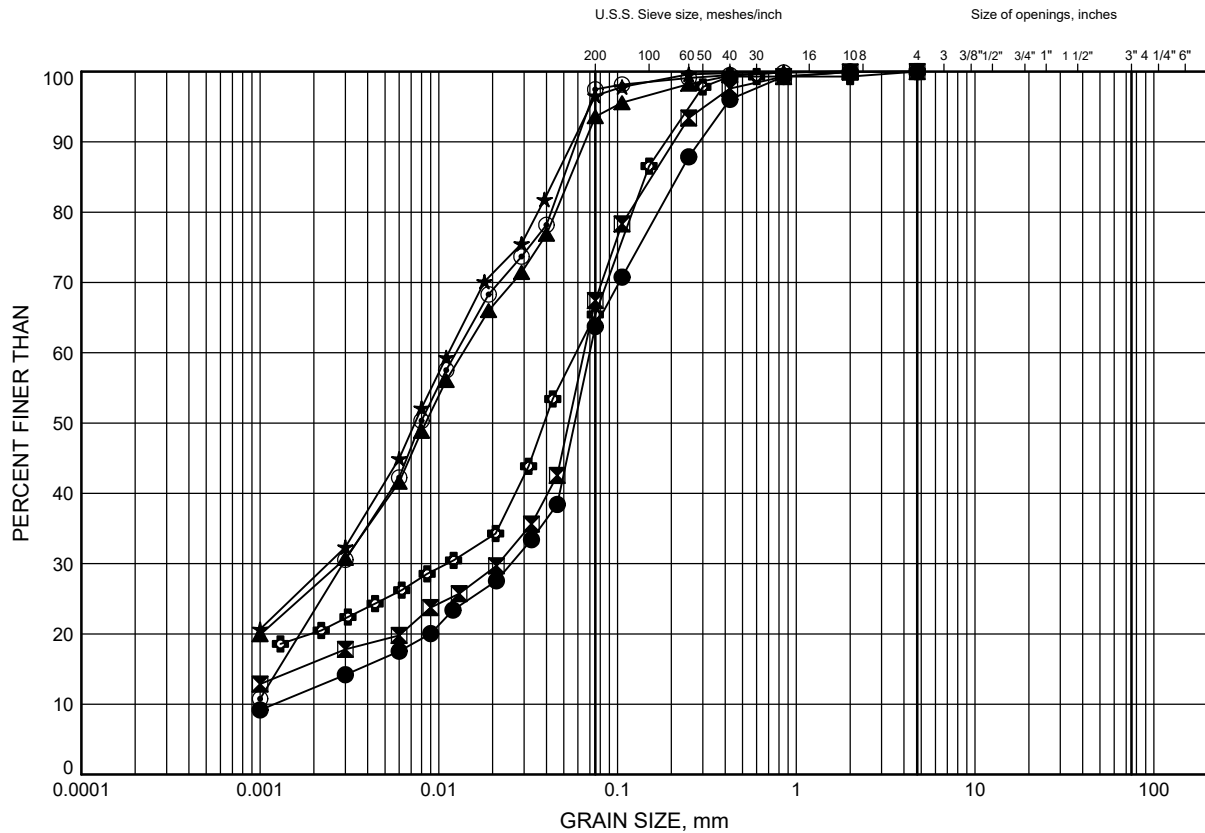


Prep'd AO

Chkd. CM

# GRAIN SIZE DISTRIBUTION

## Organic Silt (ML-OL to MH-OH)



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 401      | 12.6      | 93.3      |
| ⊠      | 401      | 14.0      | 92.0      |
| ▲      | 402      | 14.0      | 92.0      |
| ★      | 403      | 11.0      | 92.3      |
| ⊙      | 404      | 11.0      | 92.4      |
| ⊕      | GR22-02  | 4.9       | 92.7      |

Date September 2022

GWP# 4068-14-00

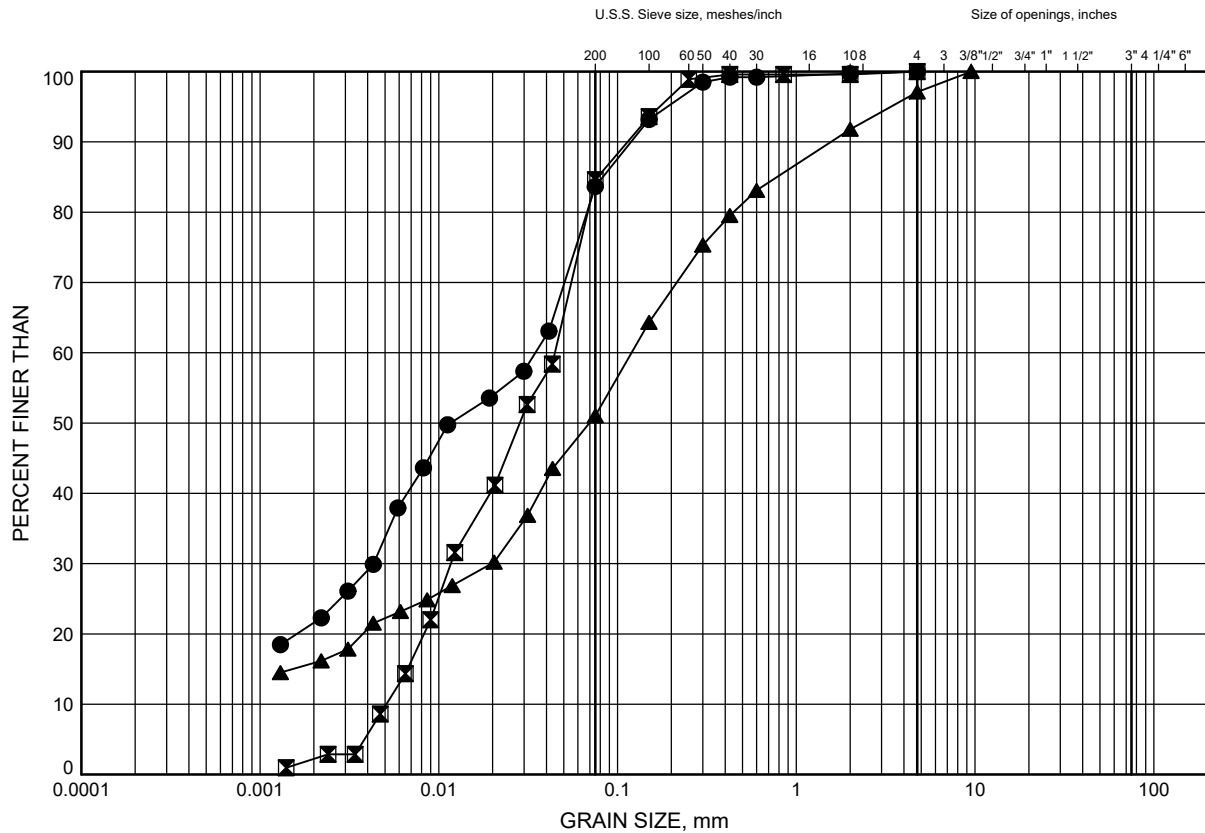


Prep'd AO

Chkd. CM

# GRAIN SIZE DISTRIBUTION

## Organic Silt (ML-OL to MH-OH)



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | GR22-03  | 2.6       | 92.9      |
| ⊠      | GR22-04  | 1.8       | 93.4      |
| ▲      | GR22-05  | 7.1       | 91.0      |

Date September 2022

GWP# 4068-14-00

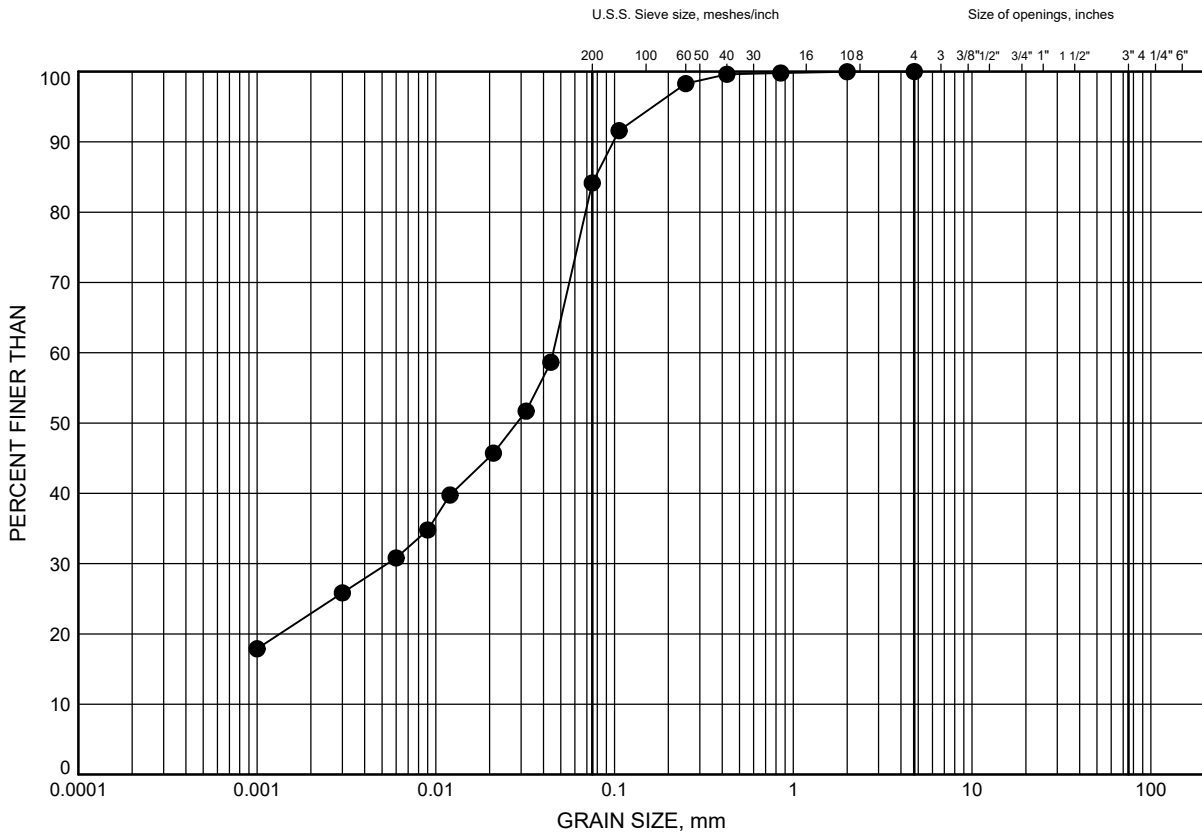


Prep'd AO

Chkd. CM

# GRAIN SIZE DISTRIBUTION

## Clayey Silt (CL)



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 402      | 14.6      | 91.4      |

Date September 2022

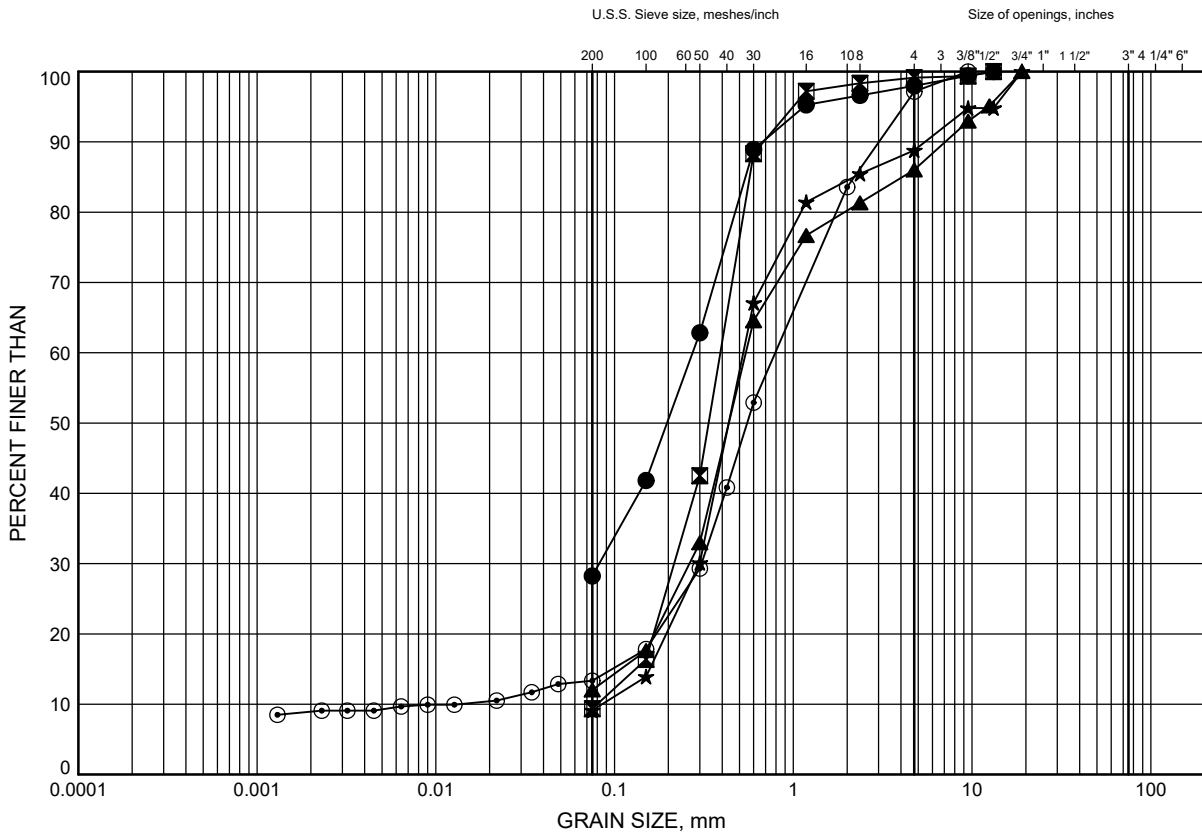
GWP# 4068-14-00



Prep'd AO

Chkd. CM

# Silty Sand to Sand with silt (SM to SP-SM to SW-SM)



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | GR22-01  | 4.1       | 94.6      |
| ⊠      | GR22-02  | 2.6       | 95.0      |
| ▲      | GR22-05  | 4.1       | 94.0      |
| ★      | GR22-07  | 4.9       | 93.0      |
| ⊙      | GR22-08  | 4.4       | 92.3      |

Date September 2022

GWP# 4068-14-00

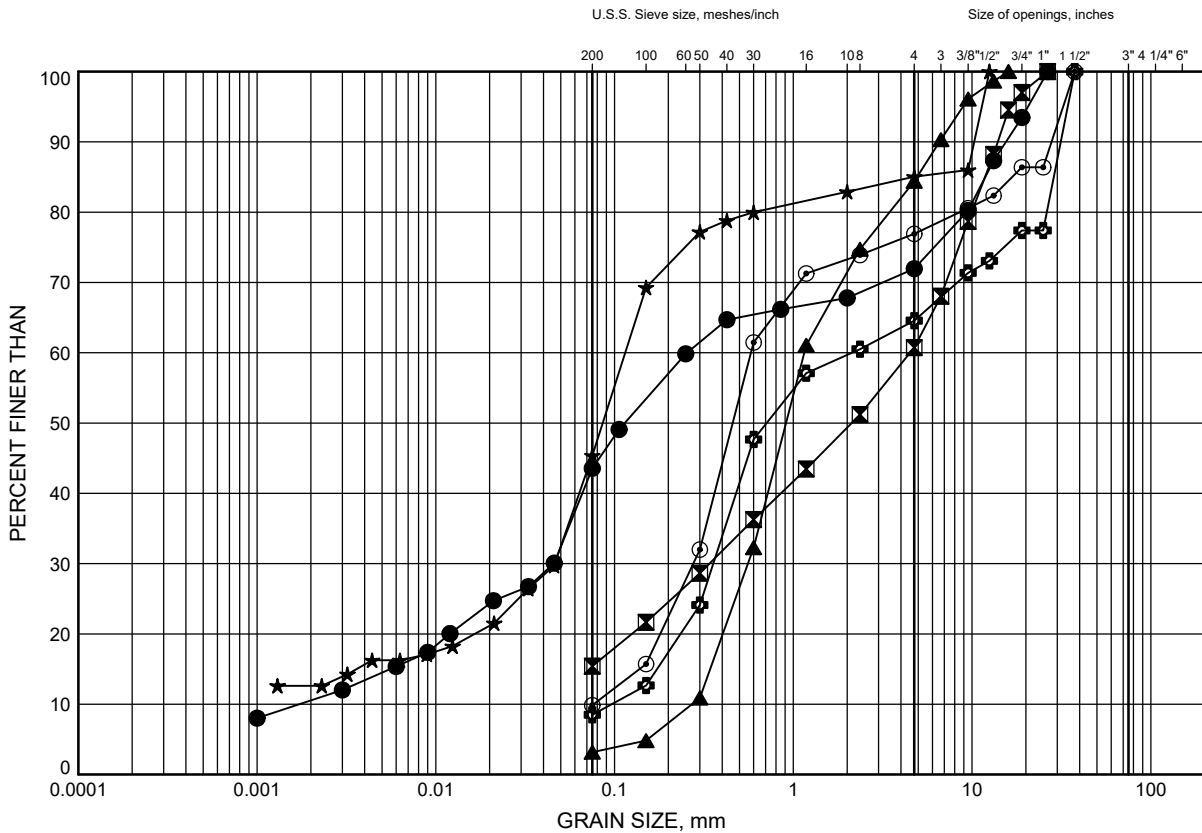


Prep'd AO

Chkd. CM

# GRAIN SIZE DISTRIBUTION

## Glacial Till



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 402      | 14.9      | 91.1      |
| ⊠      | 403      | 14.0      | 89.3      |
| ▲      | 404      | 13.7      | 89.7      |
| ★      | GR22-03  | 5.1       | 90.4      |
| ⊙      | GR22-06  | 5.6       | 91.6      |
| ⊕      | GR22-07  | 6.4       | 91.5      |

Date September 2022

GWP# 4068-14-00



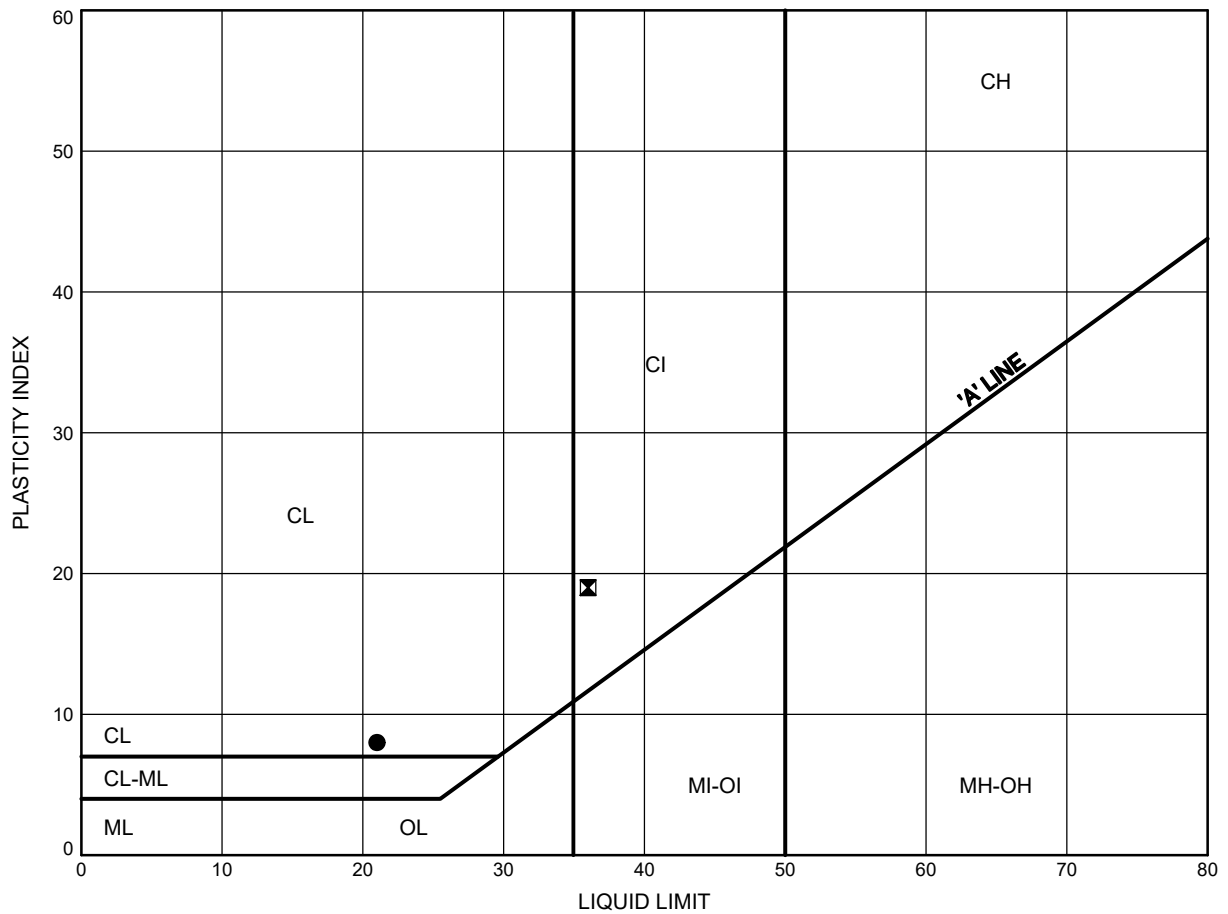
Prep'd AO

Chkd. CM

# Highway 401 Choate and Ganaraska Detailed Design ATTERBERG LIMITS TEST RESULTS

FIGURE C10

Fill: Variable



## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 401      | 7.2       | 98.8      |
| ⊠      | 403      | 6.4       | 96.9      |

Date September 2022

GWP# 4068-14-00



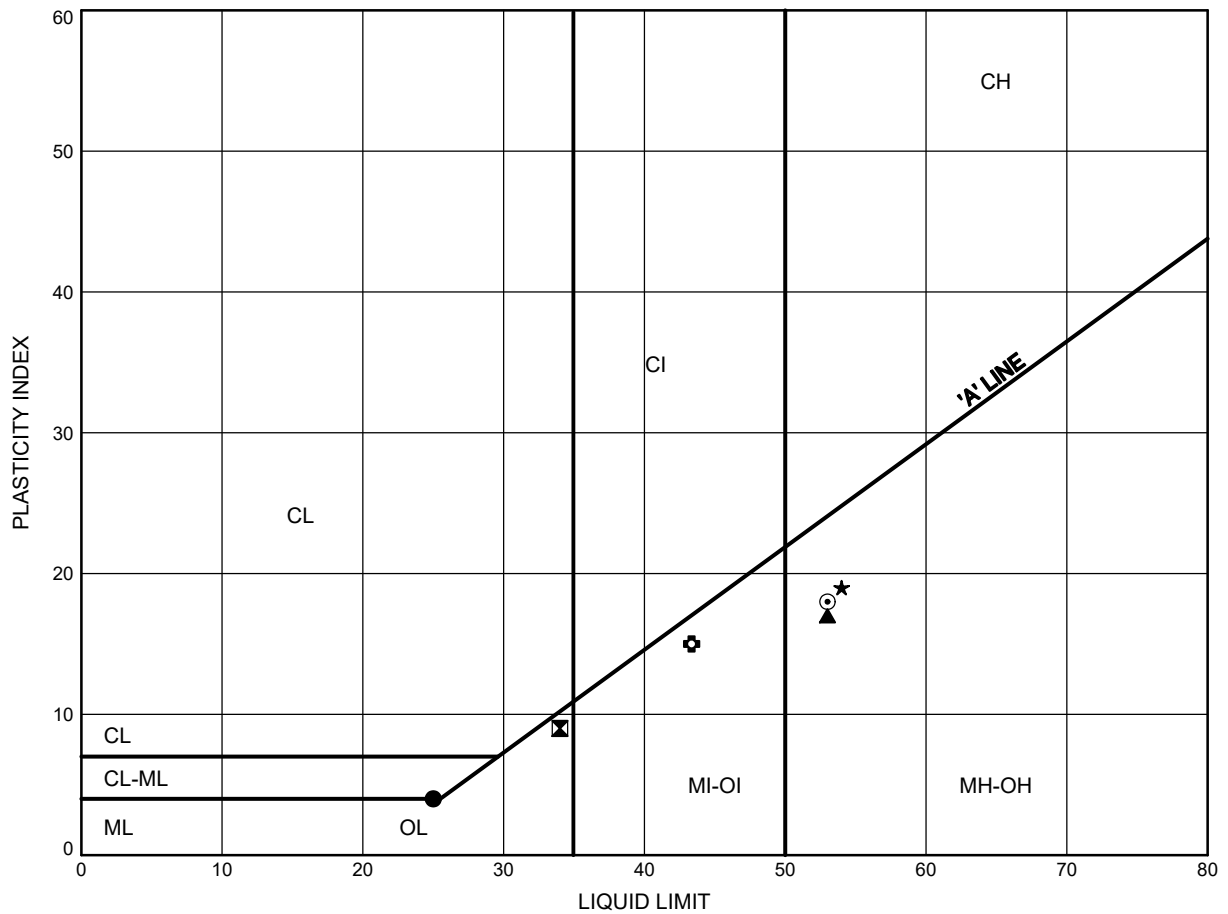
Prep'd AO

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C11

Organic Silt (ML-OL to MH-OH)



**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 401      | 12.6      | 93.3      |
| ⊠      | 401      | 14.0      | 92.0      |
| ▲      | 402      | 14.0      | 92.0      |
| ★      | 403      | 11.0      | 92.3      |
| ⊙      | 404      | 11.0      | 92.4      |
| ⊕      | GR22-04  | 1.8       | 93.4      |

Date September 2022  
 GWP# 4068-14-00



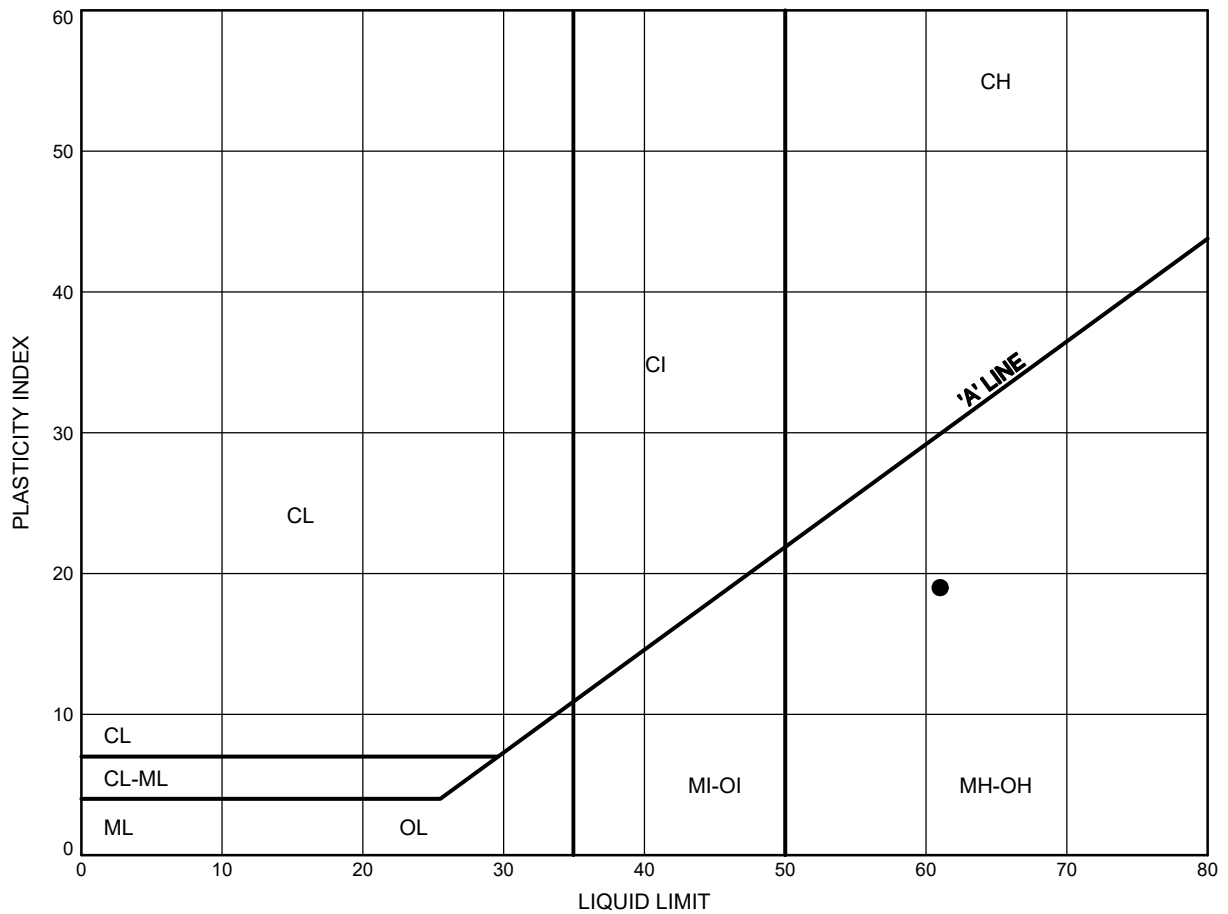
Prep'd AO  
 Chkd. CM



Highway 401 Choate and Ganaraska Detailed Design  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C12

Organic Silt (ML-OL to MH-OH)



**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | GR22-04  | 2.6       | 92.6      |

Date September 2022

GWP# 4068-14-00



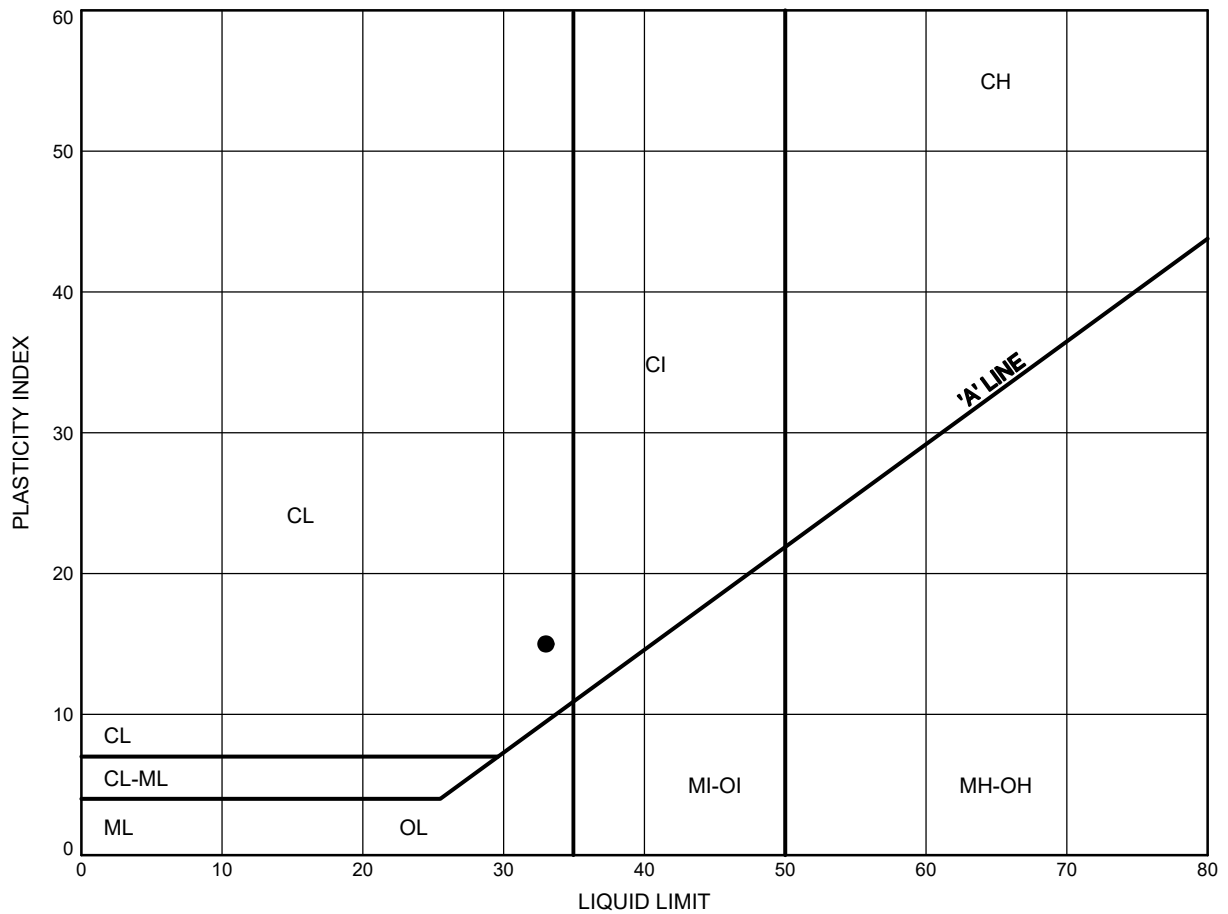
Prep'd AO

Chkd. CM

# Highway 401 Choate and Ganaraska Detailed Design ATTERBERG LIMITS TEST RESULTS

FIGURE C13

Clay (CL)



## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 402      | 14.6      | 91.4      |

Date September 2022

GWP# 4068-14-00



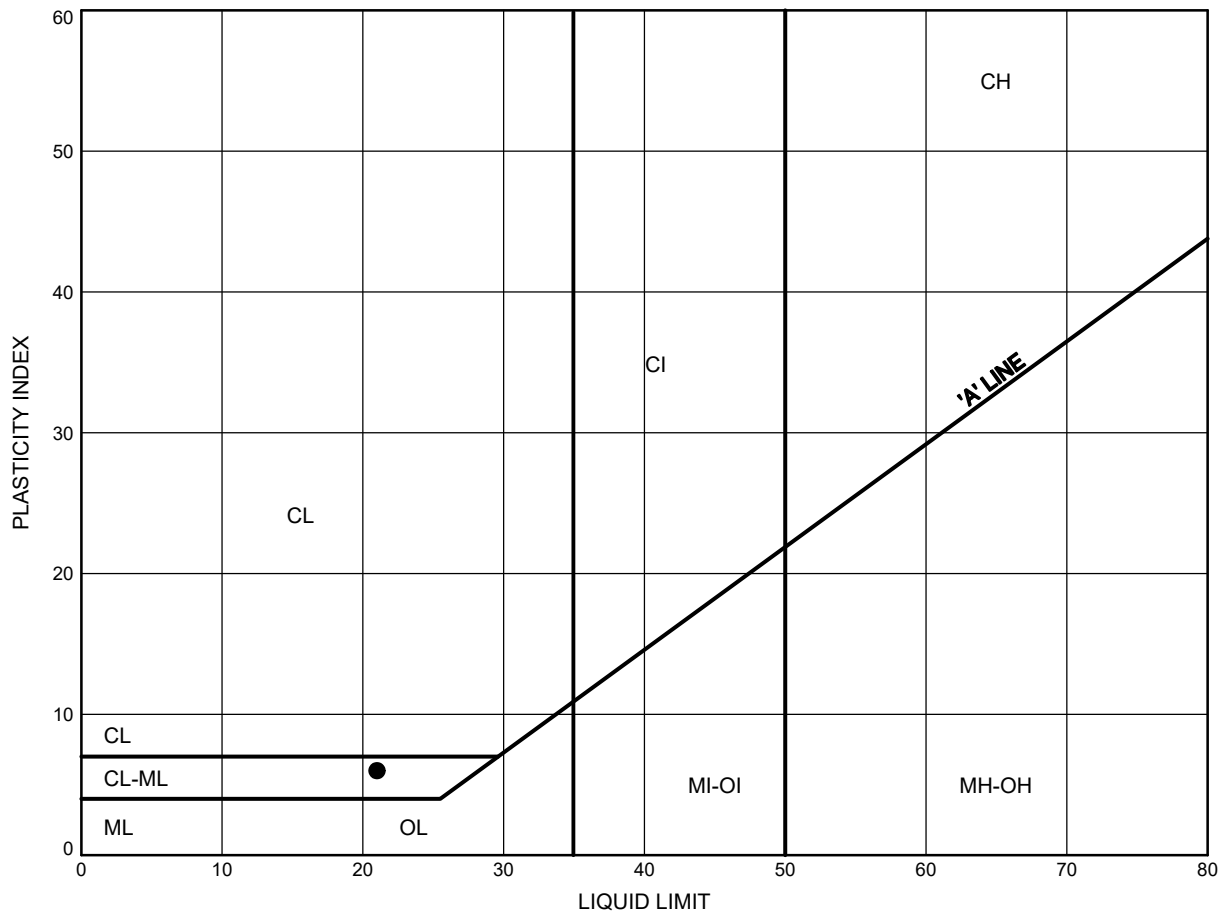
Prep'd AO

Chkd. CM

# Highway 401 Choate and Ganaraska Detailed Design ATTERBERG LIMITS TEST RESULTS

FIGURE C14

## Glacial Till



### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 402      | 14.9      | 91.1      |

Date September 2022

GWP# 4068-14-00



Prep'd AO

Chkd. CM

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B4S5  
Attn: Chris Murray

Client PO:  
Project: 19-5161-263  
Custody: 27349

Report Date: 15-Jun-2016  
Order Date: 13-Jun-2016

**Order #: 1625054**

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

| Paracel ID            | Client ID                      |
|-----------------------|--------------------------------|
| <del>1625054-01</del> | <del>301 SS3 (5'-7')</del>     |
| <del>1625054-02</del> | <del>304 SS4 (7'6"-9'6")</del> |
| 1625054-03            | 401 SS4 (7'6"-9'6")            |
| 1625054-04            | 403 SS3 (5'-7')                |

Approved By:



Mark Foto, M.Sc.  
Lab Supervisor

Certificate of Analysis  
**Client:** Thurber Engineering Ltd.  
**Client PO:**

Report Date: 15-Jun-2016  
 Order Date: 13-Jun-2016  
**Project Description: 19-5161-263**

|                                 |               |                     |                 |                     |                     |                 |
|---------------------------------|---------------|---------------------|-----------------|---------------------|---------------------|-----------------|
|                                 |               | <b>Client ID:</b>   | 301 SS3 (5'-7') | 304 SS4 (7'6"-9'6") | 401 SS4 (7'6"-9'6") | 403 SS3 (5'-7') |
|                                 |               | <b>Sample Date:</b> | 31-May-16       | 01-Jun-16           | 31-May-16           | 30-May-16       |
|                                 |               | <b>Sample ID:</b>   | 1625054-01      | 1625054-02          | 1625054-03          | 1625054-04      |
|                                 |               | <b>MDL/Units</b>    | Soil            | Soil                | Soil                | Soil            |
| <b>Physical Characteristics</b> |               |                     |                 |                     |                     |                 |
| % Solids                        | 0.1 % by Wt.  |                     | 90.5            | 91.9                | 95.2                | 97.5            |
| <b>General Inorganics</b>       |               |                     |                 |                     |                     |                 |
| Conductivity                    | 5 uS/cm       |                     | 1220            | 1260                | 782                 | 1210            |
| pH                              | 0.05 pH Units |                     | 8.21            | 8.35                | 8.44                | 8.31            |
| Resistivity                     | 0.10 Ohm.m    |                     | 8.17            | 7.96                | 12.8                | 8.26            |
| <b>Anions</b>                   |               |                     |                 |                     |                     |                 |
| Chloride                        | 5 ug/g dry    |                     | 650             | 670                 | 365                 | 758             |
| Sulphate                        | 5 ug/g dry    |                     | 27              | 48                  | 21                  | 76              |



# FINAL REPORT

CA40013-APR22 R1

**Client:** Thurber Engineering Ltd.

**Project:** 33099,

**Project Manager:** Chris Murray

**Samplers:** Joe (Zhou) Lin

MATRIX: SOIL

|               |               |             |
|---------------|---------------|-------------|
| Sample Number | 5             | 6           |
| Sample Name   | HF-22-06-SS43 | GR22-04-SS4 |
| Sample Matrix | Soil          | Soil        |
| Sample Date   | 5/03/2022     | 15/03/2022  |

| Parameter                    | Units    | RL    | Result | Result |
|------------------------------|----------|-------|--------|--------|
| <b>Corrosivity Index</b>     |          |       |        |        |
| Corrosivity Index            | none     | 1     | 14     | 4      |
| Soil Redox Potential         | mV       | no    | 237    | 169    |
| Sulphide (Na2CO3)            | %        | 0.04  | < 0.04 | < 0.04 |
| pH                           | pH Units | 0.05  | 8.51   | 7.15   |
| Resistivity (calculated)     | ohms.cm  | -9999 | 1100   | 2240   |
| <b>General Chemistry</b>     |          |       |        |        |
| Conductivity                 | uS/cm    | 2     | 905    | 447    |
| <b>Metals and Inorganics</b> |          |       |        |        |
| Moisture Content             | %        | 0.1   | 20.0   | 38.0   |
| Sulphate                     | µg/g     | 0.4   | 25     | 140    |
| <b>Other (ORP)</b>           |          |       |        |        |
| Chloride                     | µg/g     | 0.4   | 510    | 290    |



# FINAL REPORT

CA40225-JUL22 R1

**Client:** Thurber Engineering Ltd.

**Project:** 33099, Hwy 401 Choate and Ganaraska DD

**Project Manager:** Chris Murray

**Samplers:** Joe Lin

MATRIX: SOIL

| Sample Number | 5             | 6                   | 7              | 8               | 9               | 10              | 11            | 12             |
|---------------|---------------|---------------------|----------------|-----------------|-----------------|-----------------|---------------|----------------|
| Sample Name   | CR22-01 SS3   | GR22-02 SS6         | GR22-03 SS5    | GR22-07 SS5     | GR22-08 SS5     | DC22-05 SS10    | DC22-07 SS3   | DC22-11 SS10   |
| Sample Matrix | 5'-7'<br>Soil | 12'6"-14'6"<br>Soil | 10'12'<br>Soil | 10'-12'<br>Soil | 10'-12'<br>Soil | 30'-23'<br>Soil | 5'-7'<br>Soil | 25'27"<br>Soil |
| Sample Date   | 17/05/2022    | 12/04/2022          | 28/03/2022     | 06/04/2022      | 11/04/2022      | 02/06/2022      | 19/05/2022    | 25/05/2022     |

| Parameter                    | Units    | RL    | Result | Result | Result | Result | Result | Result | Result | Result |
|------------------------------|----------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>Corrosivity Index</b>     |          |       |        |        |        |        |        |        |        |        |
| Corrosivity Index            | none     | 1     | 14     | 6      | 9      | 14     | 9      | 6      | 4      | 4      |
| Soil Redox Potential         | mV       | no    | 314    | 279    | 191    | 272    | 287    | 284    | 279    | 227    |
| Sulphide (Na2CO3)            | %        | 0.04  | < 0.04 | < 0.04 | < 0.04 | < 0.04 | < 0.04 | < 0.04 | < 0.04 | < 0.04 |
| pH                           | pH Units | 0.05  | 8.34   | 7.57   | 8.00   | 8.67   | 8.75   | 8.41   | 8.34   | 8.77   |
| Resistivity (calculated)     | ohms.cm  | -9999 | 1150   | 1820   | 1610   | 719    | 2090   | 2470   | 7630   | 4600   |
| <b>General Chemistry</b>     |          |       |        |        |        |        |        |        |        |        |
| Conductivity                 | uS/cm    | 2     | 867    | 550    | 622    | 1390   | 479    | 405    | 131    | 222    |
| <b>Metals and Inorganics</b> |          |       |        |        |        |        |        |        |        |        |
| Moisture Content             | %        | 0.1   | 22.6   | 30.5   | 20.6   | 9.7    | 12.2   | 17.0   | 8.4    | 10.2   |
| Sulphate                     | µg/g     | 0.4   | 17     | 46     | 66     | 11     | 16     | 5.4    | 12     | 67     |
| <b>Other (ORP)</b>           |          |       |        |        |        |        |        |        |        |        |
| Chloride                     | µg/g     | 0.4   | 340    | 170    | 160    | 330    | 89     | 5.4    | 13     | 8.4    |

**Borehole 402**  
**RUN 1 to 3 (of 3)**  
**Elevation 90.5 m to 86.3 m**



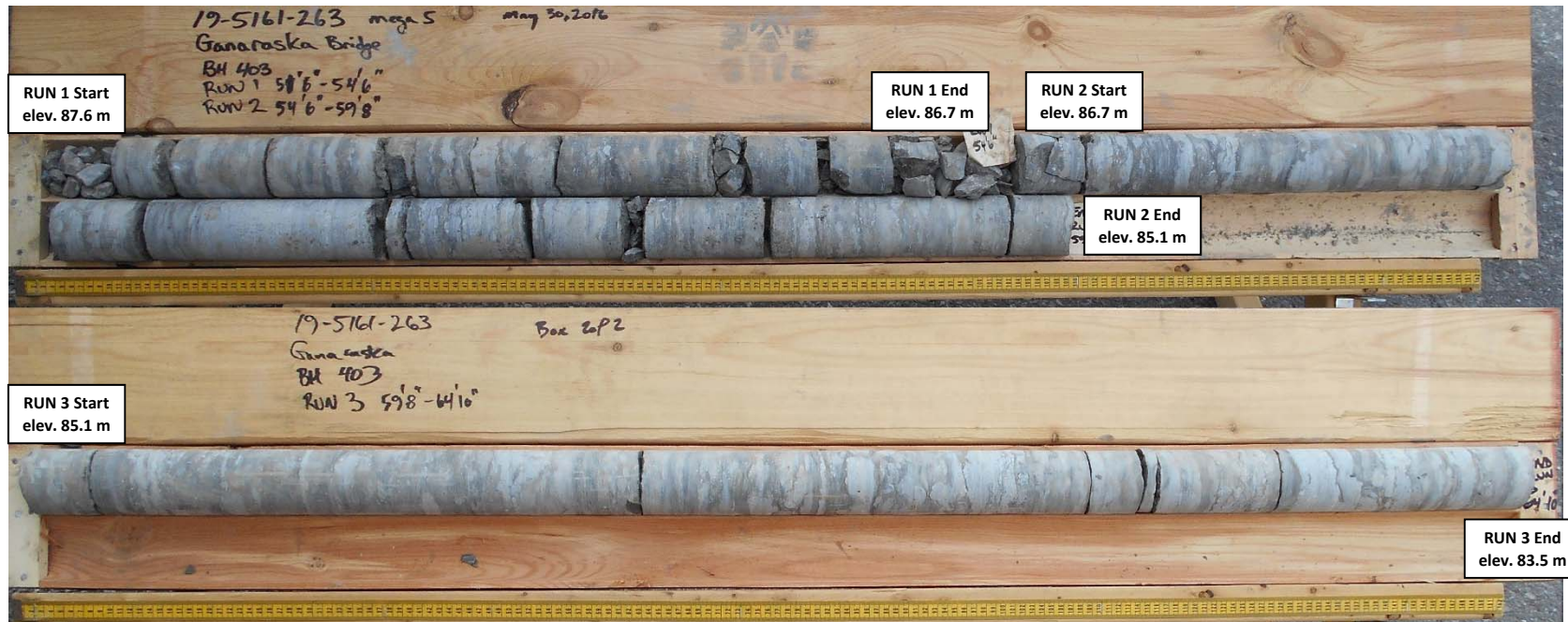
**THURBER** ENGINEERING LTD.

**Foundation Investigation**  
**Highway 401 – Ganaraska River Bridge**  
**Site 21-231**  
**Township of Hope, Ontario**

**GWP: 4068-14-00**  
**Project No.: 19-5161-263**



**Borehole 403**  
**RUN 1 to 3 (of 3)**  
**Elevation 87.6 m to 83.5 m**



**Foundation Investigation**  
**Highway 401 – Ganaraska River Bridge**  
**Site 21-231**  
**Township of Hope, Ontario**

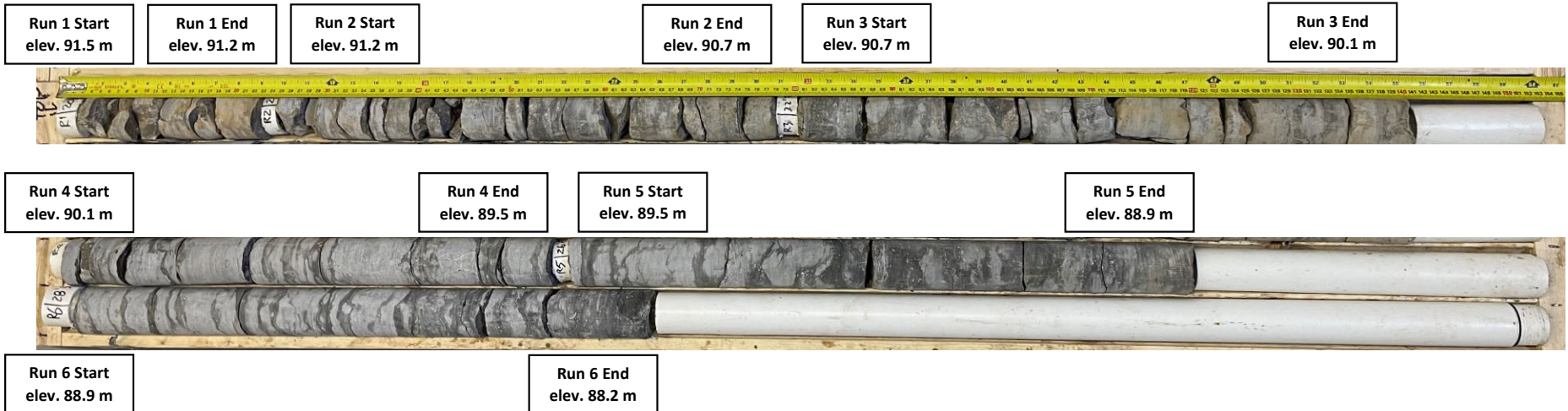
**GWP: 4068-14-00**  
**Project No.: 19-5161-263**

# Borehole GR22-02

Runs 1 to 6

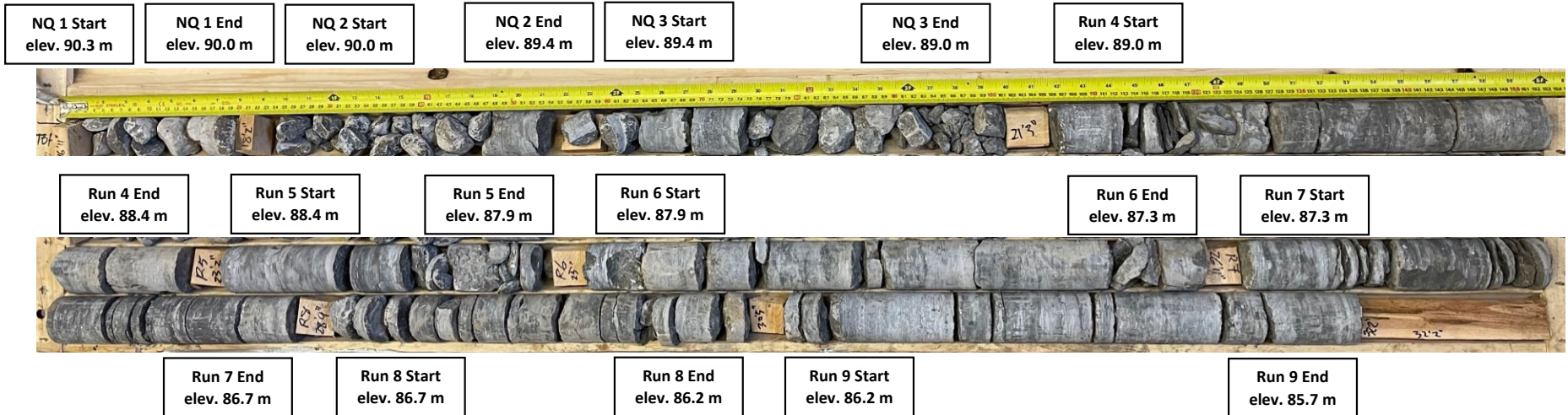
Depth 6.1 to 9.4 m

Elevation 91.5 to 88.2 m



# Borehole GR22-03

NQ 1 to NQ3; Runs 4 to 9  
Depth 5.1 to 9.8 m  
Elevation 90.3 to 85.7 m



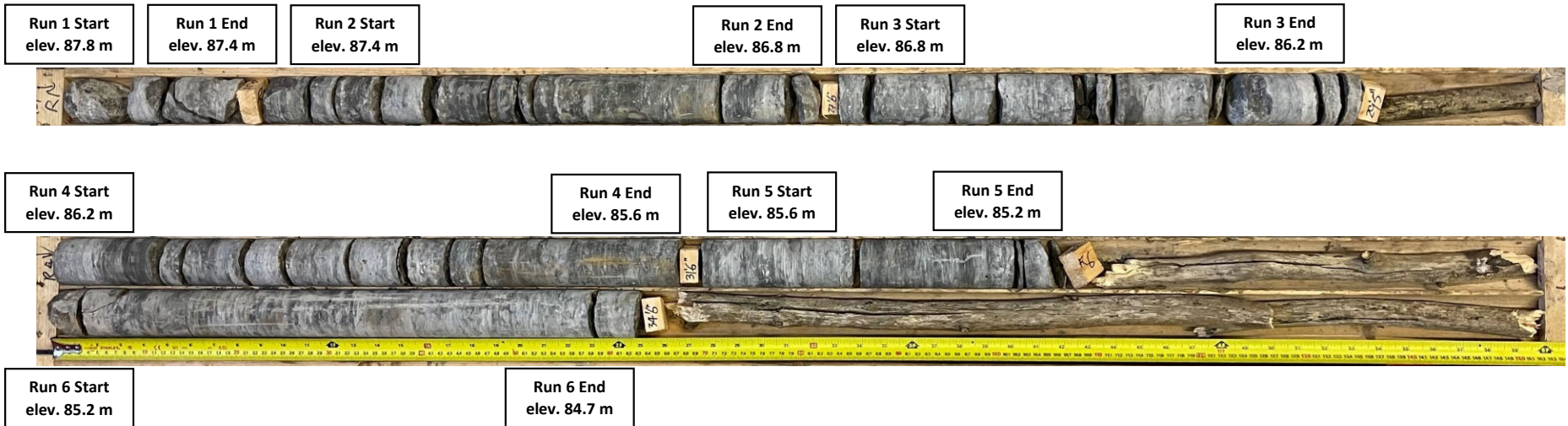


# Borehole GR22-04

Runs 1 to 6

Depth 7.4 to 10.5 m

Elevation 87.8 to 84.7 m



**THURBER** ENGINEERING LTD.

**Geotechnical Investigation**  
**Highway 401 – Ganaraska River Bridge**  
**Site 21X-0231/B0**  
**Port Hope, Ontario**

**GWP: 4068-14-00**  
**BH GR22-04**  
**Project No.: 33099**

## Borehole GR22-05

NQ 1

Depth 7.3 to 7.8 m

Elevation 90.8 to 90.3 m

NQ 1 Start  
elev. 90.8 m

NQ 1 End  
elev. 90.3 m



Geotechnical Investigation  
Highway 401 – Ganaraska River Bridge  
Site 21X-0231/B0  
Port Hope, Ontario

GWP: 4068-14-00  
BH GR22-05  
Project No.: 33099

**Borehole GR22-06**  
**NQ 1**  
**Depth 7.1 to 7.7 m**  
**Elevation 90.1 to 89.5 m**

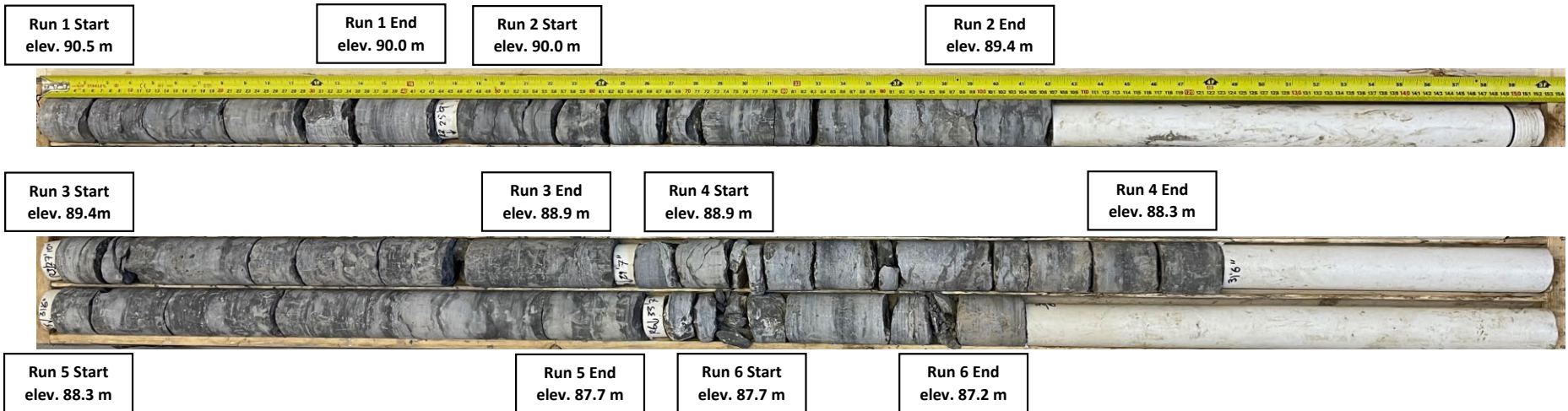
Run 1 Start  
elev. 90.1 m

Run 1 End  
elev. 89.5 m



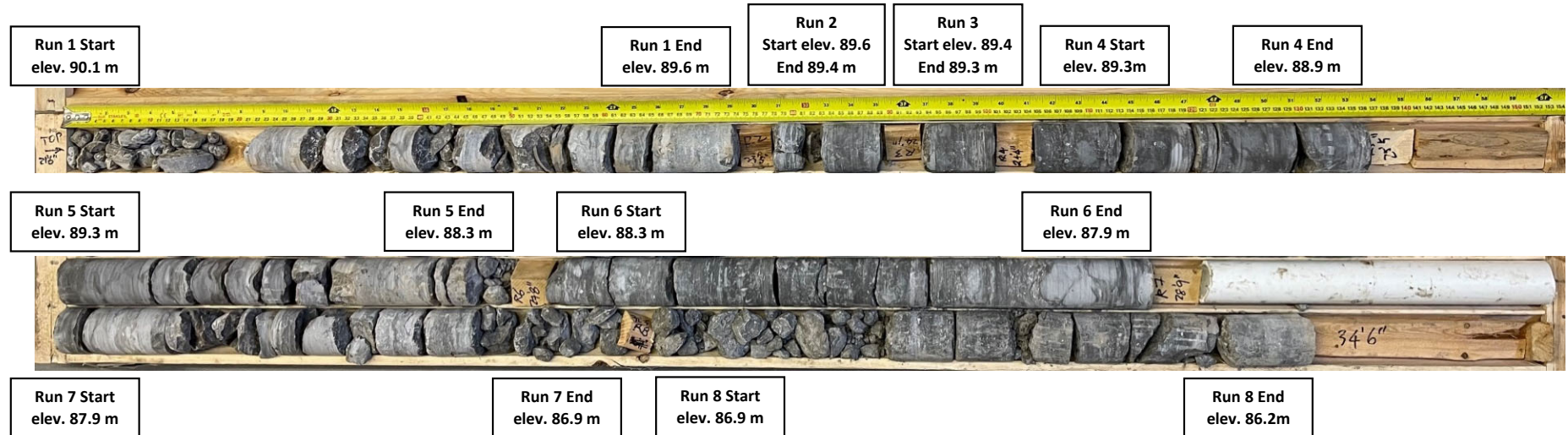
# Borehole GR22-07

Runs 1 to 6  
Depth 7.4 to 10.7 m  
Elevation 90.5 to 87.2 m



# Borehole GR22-08

**Runs 1 to 8**  
**Depth 6.6 to 10.5 m**  
**Elevation 90.1 to 86.2 m**





## UNCONFINED COMPRESSION TEST REPORT

### ASTM D7012-14

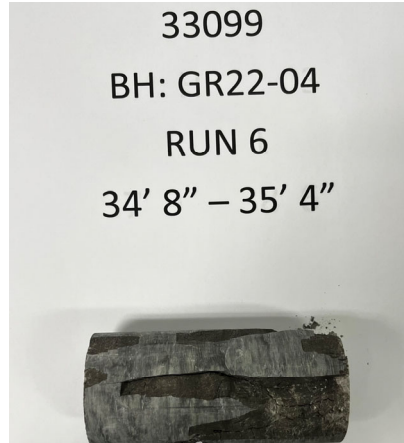
|               |                            |              |           |
|---------------|----------------------------|--------------|-----------|
| CLIENT:       | McIntosh Perry             | FILE NUMBER: | 33099     |
| PROJECT NAME: | Hwy 401 Choate & Ganaraska | REPORT DATE: | 29-Aug-22 |
| BOREHOLE No.: | GR22-04                    | TEST DATE:   | 16-Aug-22 |
| SAMPLE No.:   | Run 6                      |              |           |
| SAMPLE DEPTH: | 34' 8" - 35' 4"            |              |           |
| DESCRIPTION:  | Limestone                  |              |           |

|  |        |                                   |       |
|--|--------|-----------------------------------|-------|
| Avg. Height (cm):                        | 10.7   | Weight (g):                       | 568.5 |
| Avg. Diameter (cm):                      | 5.1    | Wet Density (kg/m <sup>3</sup> ): | 2,653 |
| H. to Dia. Ratio**:                      | 2.1:1  | Dry Density (kg/m <sup>3</sup> ): | 2,642 |
| Cross Sectional Area (cm <sup>2</sup> ): | 20.03  | Moisture Content* (%):            | 0.4   |
| Sample Volume (cm <sup>3</sup> ):        | 214.32 |                                   |       |

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



|                                  |             |
|----------------------------------|-------------|
| AVG. RATE OF STRAIN TO FAILURE:  | 0.250 MPa/s |
| MAXIMUM COMPRESSIVE LOAD:        | 174.5 kN    |
| UNCONFINED COMPRESSIVE STRENGTH: | 87.1 MPa    |

Note: \* The moisture content was obtained before the test.  
 \*\* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: GF  
 REVIEWED BY: WM

33099 - UCS - GR22-04 Run 6 - August 17, 2022

## UNCONFINED COMPRESSION TEST REPORT

### ASTM D7012-14

|               |                            |              |           |
|---------------|----------------------------|--------------|-----------|
| CLIENT:       | McIntosh Perry             | FILE NUMBER: | 33099     |
| PROJECT NAME: | Hwy 401 Choate & Ganaraska | REPORT DATE: | 29-Aug-22 |
| BOREHOLE No.: | GR22-07                    | TEST DATE:   | 16-Aug-22 |
| SAMPLE No.:   | Run 5                      |              |           |
| SAMPLE DEPTH: | 32' 6" - 33' 2"            |              |           |
| DESCRIPTION:  | Limestone                  |              |           |

|  |        |                                   |       |
|--|--------|-----------------------------------|-------|
| Avg. Height (cm):                        | 18.9   | Weight (g):                       | 999.3 |
| Avg. Diameter (cm):                      | 5.0    | Wet Density (kg/m <sup>3</sup> ): | 2,650 |
| H. to Dia. Ratio**:                      | 3.8:1  | Dry Density (kg/m <sup>3</sup> ): | 2,639 |
| Cross Sectional Area (cm <sup>2</sup> ): | 19.95  | Moisture Content* (%):            | 0.4   |
| Sample Volume (cm <sup>3</sup> ):        | 377.06 |                                   |       |

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



|                                  |             |
|----------------------------------|-------------|
| AVG. RATE OF STRAIN TO FAILURE:  | 0.250 MPa/s |
| MAXIMUM COMPRESSIVE LOAD:        | 102.8 kN    |
| UNCONFINED COMPRESSIVE STRENGTH: | 51.5 MPa    |

Note: \* The moisture content was obtained before the test.  
\*\* Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: GF  
REVIEWED BY: WM

33099 - UCS - GR22-07 Run 5 - August 17, 2022

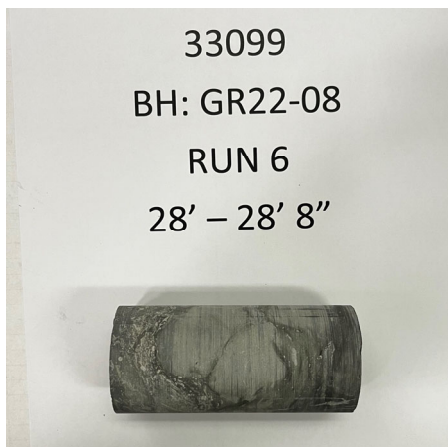
## UNCONFINED COMPRESSION TEST REPORT

### ASTM D7012-14

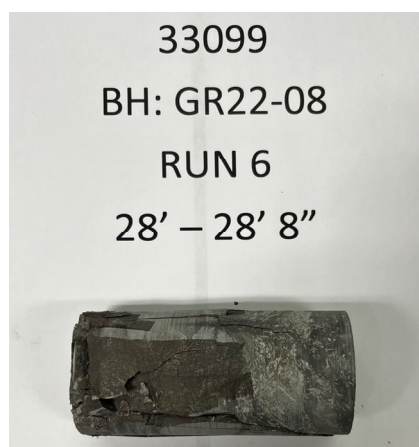
|               |                            |              |           |
|---------------|----------------------------|--------------|-----------|
| CLIENT:       | McIntosh Perry             | FILE NUMBER: | 33099     |
| PROJECT NAME: | Hwy 401 Choate & Ganaraska | REPORT DATE: | 29-Aug-22 |
| BOREHOLE No.: | GR22-08                    | TEST DATE:   | 16-Aug-22 |
| SAMPLE No.:   | Run 6                      |              |           |
| SAMPLE DEPTH: | 28' - 28' 8"               |              |           |
| DESCRIPTION:  | Limestone                  |              |           |

|  |        |                                   |       |
|--|--------|-----------------------------------|-------|
| Avg. Height (cm):                        | 10.6   | Weight (g):                       | 556.3 |
| Avg. Diameter (cm):                      | 5.0    | Wet Density (kg/m <sup>3</sup> ): | 2,652 |
| H. to Dia. Ratio**:                      | 2.1:1  | Dry Density (kg/m <sup>3</sup> ): | 2,638 |
| Cross Sectional Area (cm <sup>2</sup> ): | 19.79  | Moisture Content* (%):            | 0.5   |
| Sample Volume (cm <sup>3</sup> ):        | 209.80 |                                   |       |

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



|                                  |             |
|----------------------------------|-------------|
| AVG. RATE OF STRAIN TO FAILURE:  | 0.250 MPa/s |
| MAXIMUM COMPRESSIVE LOAD:        | 90.0 kN     |
| UNCONFINED COMPRESSIVE STRENGTH: | 45.5 MPa    |

Note: \* The moisture content was obtained before the test.  
\*\* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: GF  
REVIEWED BY: WM

33099 - UCS - GR22-08 Run 6 - August 17, 2022



## **Appendix D   Site Photographs**



Photo 1: Looking east along the north side of the Hwy 401 Ganaraska River Bridge



Photo 2: Looking east along the north widening area at the Hwy 401 Ganaraska River Bridge





Photo 3: Looking east from the west foreslope under the Hwy 401 Ganaraska River Bridge



Photo 4: Looking south at the west foreslope from north edge of the Hwy 401 Ganaraska River Bridge.





Photo 5: Highway 401 Overpass at The Ganaraska River east foreslope looking from the North



Photo 6: Highway 401 Overpass at The Ganaraska River west foreslope looking from the North



Photo 7: Ganaraska River Bridge west foreslope looking from the river bank just north of the structure





## **Appendix E   Comparison of Foundation Alternatives**



### Comparison of Foundation Alternatives

| Comment                     | Drilled-in Pipe Piles   | Driven Steel H-Piles   | Caissons   | Micropiles   | Spread Footings on Native Soils  |
|-----------------------------|---|--|--|--|--|
| <b>Advantages:</b>          | <p>Moderate to high geotechnical resistance</p> <p>Better alignment control than caissons</p> <p>Higher lateral resistance than driven piles can be achieved with a sufficiently long rock socket</p> | <p>High axial resistance</p> <p>Relatively quick installation</p> <p>Readily available equipment</p> | <p>High axial geotechnical resistance.</p> <p>Readily available equipment</p> <p>Higher lateral resistance can be achieved with a sufficient rock socket length</p>  | <p>Provide resistance in both tension and compression</p> <p>Easily installed in areas with limited headroom</p>   | <p>Quicker installation and lower costs than deep foundations.</p>   |
| <b>Disadvantages:</b>       | <p>Higher cost than driven piles</p> <p>Fewer contractors with appropriate equipment</p> <p>Slower installation than driven piles</p>   | <p>Low lateral resistance for short piles</p> <p>Depth to rock may be too short at piers</p>         | <p>Can be difficult to clean and inspect the base.</p> <p>Temporary steel liners and/or synthetic slurry may be required for excavation.</p> <p>Likely requires concrete to be placed using tremie techniques.</p> | <p>Low resistance to lateral load</p> <p>Lower axial compression resistance than other deep foundation options</p> <p>Higher cost than other alternatives for similar resistance</p> | <p>Provide a lower geotechnical resistance than deep foundations</p> <p>Native soils providing acceptable bearing resistance are too deep to be practical for abutments</p> <p>Significant dewatering would be required at the piers</p> |
| <b>Risks / Consequences</b> | Potential impact on adjacent driven piles   | Piles are damaged during driving / add additional piles to pile group                                |  |  |  |
| <b>Relative Cost:</b>       | <b>Moderate</b>   | <b>Moderate</b>  | <b>High</b>  | <b>High</b>  | <b>Low to Moderate</b>   |
| <b>Conclusion:</b>          | <b>FEASIBLE</b>   | <b>RECOMMENDED FOR ABUTMENTS</b>   | <b>RECOMMENDED FOR PIERS</b>   | <b>FEASIBLE</b>  | <b>NOT RECOMMENDED</b>   |



## **Appendix F   P-y Curves**

SOIL P-Y CURVES  
Ganaraska River Bridge

HP310x132: East Abutment with 3 m CSP, Underside Elev. 98.5m

| Elev. (m)  | 97.5   |          | 96.5   |          | 95.5   |          | 94.5   |          | 93.5   |          | 92.5   |          | 91.5   |          | 90.5   |          | 89.5   |          | 88.5   |          |  |  |  |  |  |  |  |  |
|------------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--|--|--|--|--|--|--|--|
| P-y Curves | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) |  |  |  |  |  |  |  |  |
| Static     | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      |  |  |  |  |  |  |  |  |
|            | 0.0039 | 1.2      | 0.0039 | 1.2      | 0.0049 | 143.3    | 0.0094 | 448.4    | 0.0012 | 54.4     | 0.0013 | 52.8     | 0.0012 | 57.3     | 0.0064 | 1194.0   | 0.0059 | 1237.1   | 0.0055 | 1284.4   |  |  |  |  |  |  |  |  |
|            | 0.0078 | 2.4      | 0.0078 | 2.4      | 0.0049 | 143.7    | 0.0096 | 456.3    | 0.0023 | 108.7    | 0.0027 | 105.5    | 0.0025 | 114.6    | 0.0068 | 1249.9   | 0.0064 | 1298.6   | 0.0060 | 1353.1   |  |  |  |  |  |  |  |  |
|            | 0.0117 | 3.7      | 0.0117 | 3.7      | 0.0050 | 144.1    | 0.0098 | 464.3    | 0.0035 | 163.1    | 0.0040 | 158.3    | 0.0037 | 172.0    | 0.0072 | 1299.1   | 0.0068 | 1357.5   | 0.0065 | 1421.2   |  |  |  |  |  |  |  |  |
|            | 0.0157 | 4.9      | 0.0157 | 4.9      | 0.0050 | 144.5    | 0.0099 | 472.2    | 0.0046 | 217.5    | 0.0053 | 211.0    | 0.0050 | 229.3    | 0.0076 | 1348.4   | 0.0072 | 1416.4   | 0.0069 | 1489.2   |  |  |  |  |  |  |  |  |
|            | 0.0196 | 6.1      | 0.0196 | 6.1      | 0.0050 | 144.9    | 0.0101 | 480.2    | 0.0058 | 271.8    | 0.0066 | 263.8    | 0.0062 | 286.6    | 0.0080 | 1397.7   | 0.0077 | 1475.3   | 0.0074 | 1557.3   |  |  |  |  |  |  |  |  |
|            | 0.0235 | 7.3      | 0.0235 | 7.3      | 0.0050 | 145.3    | 0.0103 | 488.2    | 0.0070 | 326.2    | 0.0080 | 316.6    | 0.0074 | 343.9    | 0.0084 | 1446.9   | 0.0081 | 1534.2   | 0.0079 | 1625.3   |  |  |  |  |  |  |  |  |
|            | 0.0274 | 8.6      | 0.0274 | 8.6      | 0.0051 | 145.7    | 0.0105 | 496.1    | 0.0081 | 380.6    | 0.0093 | 369.3    | 0.0087 | 401.2    | 0.0088 | 1496.2   | 0.0086 | 1593.1   | 0.0083 | 1693.4   |  |  |  |  |  |  |  |  |
|            | 0.0313 | 9.8      | 0.0313 | 9.8      | 0.0051 | 146.1    | 0.0106 | 504.1    | 0.0093 | 434.9    | 0.0106 | 422.1    | 0.0099 | 458.6    | 0.0092 | 1545.5   | 0.0090 | 1652.0   | 0.0088 | 1761.5   |  |  |  |  |  |  |  |  |
|            | 0.0352 | 11.0     | 0.0352 | 11.0     | 0.0051 | 146.5    | 0.0108 | 512.0    | 0.0104 | 489.3    | 0.0120 | 474.9    | 0.0111 | 515.9    | 0.0096 | 1594.8   | 0.0094 | 1710.9   | 0.0093 | 1829.5   |  |  |  |  |  |  |  |  |
|            | 0.0391 | 12.2     | 0.0391 | 12.2     | 0.0051 | 146.9    | 0.0110 | 520.0    | 0.0116 | 543.7    | 0.0133 | 527.6    | 0.0124 | 573.2    | 0.0100 | 1644.0   | 0.0099 | 1769.9   | 0.0097 | 1897.6   |  |  |  |  |  |  |  |  |
|            | 0.0430 | 13.5     | 0.0430 | 13.5     | 0.0051 | 147.2    | 0.0111 | 528.0    | 0.0128 | 598.0    | 0.0146 | 580.4    | 0.0136 | 630.5    | 0.0104 | 1693.3   | 0.0103 | 1828.8   | 0.0102 | 1965.6   |  |  |  |  |  |  |  |  |
|            | 0.0470 | 14.7     | 0.0470 | 14.7     | 0.0052 | 147.6    | 0.0113 | 534.6    | 0.0139 | 652.4    | 0.0159 | 633.1    | 0.0149 | 687.8    | 0.0108 | 1742.6   | 0.0107 | 1887.7   | 0.0107 | 2033.7   |  |  |  |  |  |  |  |  |
|            | 0.0509 | 15.9     | 0.0509 | 15.9     | 0.0084 | 203.7    | 0.0115 | 540.7    | 0.0151 | 706.7    | 0.0173 | 685.9    | 0.0161 | 745.2    | 0.0112 | 1791.8   | 0.0112 | 1946.6   | 0.0112 | 2101.8   |  |  |  |  |  |  |  |  |
|            | 0.0548 | 17.1     | 0.0548 | 17.1     | 0.0116 | 259.8    | 0.0116 | 546.8    | 0.0162 | 761.1    | 0.0186 | 738.7    | 0.0173 | 802.5    | 0.0116 | 1841.1   | 0.0116 | 2005.5   | 0.0116 | 2169.8   |  |  |  |  |  |  |  |  |
|            | 0.0587 | 18.4     | 0.0587 | 18.4     | 0.0140 | 259.8    | 0.0140 | 546.8    | 0.0195 | 761.1    | 0.0223 | 738.7    | 0.0208 | 802.5    | 0.0140 | 1841.1   | 0.0140 | 2005.5   | 0.0140 | 2169.8   |  |  |  |  |  |  |  |  |
|            | 0.0626 | 19.6     | 0.0626 | 19.6     | 0.0163 | 259.8    | 0.0163 | 546.8    | 0.0227 | 761.1    | 0.0260 | 738.7    | 0.0243 | 802.5    | 0.0163 | 1841.1   | 0.0163 | 2005.5   | 0.0163 | 2169.8   |  |  |  |  |  |  |  |  |

HP310x132: West Abutment with 3 m CSP, Underside Elev. 101.0m

| Elev. (m)  | 100.0  |          | 99.0   |          | 98.0   |          | 97.0   |          | 96.0   |          | 95.0   |          | 94.0   |          | 93.0   |          | 92.0   |          | 91.0   |          |  |  |  |  |  |  |  |  |
|------------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--|--|--|--|--|--|--|--|
| P-y Curves | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) |  |  |  |  |  |  |  |  |
| Static     | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      |  |  |  |  |  |  |  |  |
|            | 0.0039 | 1.2      | 0.0039 | 1.2      | 0.0049 | 143.3    | 0.0094 | 448.4    | 0.0107 | 695.2    | 0.0107 | 834.2    | 0.0107 | 973.3    | 0.0013 | 80.2     | 0.0013 | 80.0     | 0.0013 | 84.5     |  |  |  |  |  |  |  |  |
|            | 0.0078 | 2.4      | 0.0078 | 2.4      | 0.0049 | 143.7    | 0.0096 | 456.3    | 0.0108 | 699.6    | 0.0108 | 839.5    | 0.0108 | 979.4    | 0.0025 | 160.3    | 0.0027 | 159.9    | 0.0026 | 169.1    |  |  |  |  |  |  |  |  |
|            | 0.0117 | 3.7      | 0.0117 | 3.7      | 0.0050 | 144.1    | 0.0098 | 464.3    | 0.0109 | 704.0    | 0.0109 | 844.8    | 0.0109 | 985.6    | 0.0038 | 240.5    | 0.0040 | 239.9    | 0.0038 | 253.6    |  |  |  |  |  |  |  |  |
|            | 0.0157 | 4.9      | 0.0157 | 4.9      | 0.0050 | 144.5    | 0.0099 | 472.2    | 0.0109 | 708.4    | 0.0109 | 850.1    | 0.0109 | 991.8    | 0.0050 | 320.6    | 0.0054 | 319.9    | 0.0051 | 338.1    |  |  |  |  |  |  |  |  |
|            | 0.0196 | 6.1      | 0.0196 | 6.1      | 0.0050 | 144.9    | 0.0101 | 480.2    | 0.0110 | 712.8    | 0.0110 | 855.4    | 0.0110 | 998.0    | 0.0063 | 400.8    | 0.0067 | 399.8    | 0.0064 | 422.6    |  |  |  |  |  |  |  |  |
|            | 0.0235 | 7.3      | 0.0235 | 7.3      | 0.0050 | 145.3    | 0.0103 | 488.2    | 0.0111 | 717.2    | 0.0111 | 860.7    | 0.0111 | 1004.1   | 0.0075 | 481.0    | 0.0081 | 479.8    | 0.0077 | 507.2    |  |  |  |  |  |  |  |  |
|            | 0.0274 | 8.6      | 0.0274 | 8.6      | 0.0051 | 145.7    | 0.0105 | 496.1    | 0.0111 | 721.6    | 0.0111 | 866.0    | 0.0111 | 1010.3   | 0.0088 | 561.1    | 0.0094 | 559.8    | 0.0089 | 591.7    |  |  |  |  |  |  |  |  |
|            | 0.0313 | 9.8      | 0.0313 | 9.8      | 0.0051 | 146.1    | 0.0106 | 504.1    | 0.0112 | 726.1    | 0.0112 | 871.3    | 0.0112 | 1016.5   | 0.0100 | 641.3    | 0.0107 | 639.8    | 0.0102 | 676.2    |  |  |  |  |  |  |  |  |
|            | 0.0352 | 11.0     | 0.0352 | 11.0     | 0.0051 | 146.5    | 0.0108 | 512.0    | 0.0113 | 730.5    | 0.0113 | 876.6    | 0.0113 | 1022.6   | 0.0113 | 721.4    | 0.0121 | 719.7    | 0.0115 | 760.8    |  |  |  |  |  |  |  |  |
|            | 0.0391 | 12.2     | 0.0391 | 12.2     | 0.0051 | 146.9    | 0.0110 | 520.0    | 0.0114 | 734.9    | 0.0114 | 881.8    | 0.0114 | 1028.8   | 0.0125 | 801.6    | 0.0134 | 799.7    | 0.0128 | 845.3    |  |  |  |  |  |  |  |  |
|            | 0.0430 | 13.5     | 0.0430 | 13.5     | 0.0051 | 147.2    | 0.0111 | 528.0    | 0.0114 | 739.3    | 0.0114 | 887.1    | 0.0114 | 1035.0   | 0.0138 | 881.8    | 0.0148 | 879.7    | 0.0141 | 929.8    |  |  |  |  |  |  |  |  |
|            | 0.0470 | 14.7     | 0.0470 | 14.7     | 0.0052 | 147.6    | 0.0113 | 534.6    | 0.0115 | 743.7    | 0.0115 | 892.4    | 0.0115 | 1041.2   | 0.0150 | 961.9    | 0.0161 | 959.6    | 0.0153 | 1014.3   |  |  |  |  |  |  |  |  |
|            | 0.0509 | 15.9     | 0.0509 | 15.9     | 0.0084 | 203.7    | 0.0115 | 540.7    | 0.0116 | 748.1    | 0.0116 | 897.7    | 0.0116 | 1047.3   | 0.0163 | 1042.1   | 0.0175 | 1039.6   | 0.0166 | 1098.9   |  |  |  |  |  |  |  |  |
|            | 0.0548 | 17.1     | 0.0548 | 17.1     | 0.0116 | 259.8    | 0.0116 | 546.8    | 0.0116 | 752.5    | 0.0116 | 903.0    | 0.0116 | 1053.5   | 0.0175 | 1122.3   | 0.0188 | 1119.6   | 0.0179 | 1183.4   |  |  |  |  |  |  |  |  |
|            | 0.0587 | 18.4     | 0.0587 | 18.4     | 0.0140 | 259.8    | 0.0140 | 546.8    | 0.0140 | 784.2    | 0.0140 | 941.0    | 0.0140 | 1097.8   | 0.0210 | 1122.3   | 0.0226 | 1119.6   | 0.0215 | 1183.4   |  |  |  |  |  |  |  |  |
|            | 0.0626 | 19.6     | 0.0626 | 19.6     | 0.0163 | 259.8    | 0.0163 | 546.8    | 0.0163 | 784.2    | 0.0163 | 941.0    | 0.0163 | 1097.8   | 0.0245 | 1122.3   | 0.0263 | 1119.6   | 0.0250 | 1183.4   |  |  |  |  |  |  |  |  |

SOIL P-Y CURVES  
Ganaraska River Bridge

HP310x132: East Abutment without CSP, Underside Elev. 98.5m

| Elev. (m)  | 97.5   |          | 96.5   |          | 95.5   |          | 94.5   |          | 93.5   |          | 92.5   |          | 91.5   |          | 90.5   |          | 89.5   |          | 88.5   |          |  |  |  |  |  |  |  |  |
|------------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--|--|--|--|--|--|--|--|
| P-y Curves | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) |  |  |  |  |  |  |  |  |
| Static     | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      |  |  |  |  |  |  |  |  |
|            | 0.0018 | 11.8     | 0.0020 | 30.9     | 0.0049 | 143.3    | 0.0094 | 448.4    | 0.0012 | 54.4     | 0.0013 | 52.8     | 0.0012 | 57.3     | 0.0064 | 1194.0   | 0.0059 | 1237.1   | 0.0055 | 1284.4   |  |  |  |  |  |  |  |  |
|            | 0.0021 | 12.6     | 0.0023 | 33.4     | 0.0049 | 143.7    | 0.0096 | 456.3    | 0.0023 | 108.7    | 0.0027 | 105.5    | 0.0025 | 114.6    | 0.0068 | 1249.9   | 0.0064 | 1298.6   | 0.0060 | 1353.1   |  |  |  |  |  |  |  |  |
|            | 0.0024 | 13.3     | 0.0026 | 35.8     | 0.0050 | 144.1    | 0.0098 | 464.3    | 0.0035 | 163.1    | 0.0040 | 158.3    | 0.0037 | 172.0    | 0.0072 | 1299.1   | 0.0068 | 1357.5   | 0.0065 | 1421.2   |  |  |  |  |  |  |  |  |
|            | 0.0027 | 14.0     | 0.0029 | 38.1     | 0.0050 | 144.5    | 0.0099 | 472.2    | 0.0046 | 217.5    | 0.0053 | 211.0    | 0.0050 | 229.3    | 0.0076 | 1348.4   | 0.0072 | 1416.4   | 0.0069 | 1489.2   |  |  |  |  |  |  |  |  |
|            | 0.0030 | 14.6     | 0.0032 | 40.4     | 0.0050 | 144.9    | 0.0101 | 480.2    | 0.0058 | 271.8    | 0.0066 | 263.8    | 0.0062 | 286.6    | 0.0080 | 1397.7   | 0.0077 | 1475.3   | 0.0074 | 1557.3   |  |  |  |  |  |  |  |  |
|            | 0.0033 | 15.2     | 0.0035 | 42.5     | 0.0050 | 145.3    | 0.0103 | 488.2    | 0.0070 | 326.2    | 0.0080 | 316.6    | 0.0074 | 343.9    | 0.0084 | 1446.9   | 0.0081 | 1534.2   | 0.0079 | 1625.3   |  |  |  |  |  |  |  |  |
|            | 0.0036 | 15.8     | 0.0037 | 44.6     | 0.0051 | 145.7    | 0.0105 | 496.1    | 0.0081 | 380.6    | 0.0093 | 369.3    | 0.0087 | 401.2    | 0.0088 | 1496.2   | 0.0086 | 1593.1   | 0.0083 | 1693.4   |  |  |  |  |  |  |  |  |
|            | 0.0040 | 16.4     | 0.0040 | 46.7     | 0.0051 | 146.1    | 0.0106 | 504.1    | 0.0093 | 434.9    | 0.0106 | 422.1    | 0.0099 | 458.6    | 0.0092 | 1545.5   | 0.0090 | 1652.0   | 0.0088 | 1761.5   |  |  |  |  |  |  |  |  |
|            | 0.0043 | 16.9     | 0.0043 | 48.6     | 0.0051 | 146.5    | 0.0108 | 512.0    | 0.0104 | 489.3    | 0.0120 | 474.9    | 0.0111 | 515.9    | 0.0096 | 1594.8   | 0.0094 | 1710.9   | 0.0093 | 1829.5   |  |  |  |  |  |  |  |  |
|            | 0.0046 | 17.4     | 0.0046 | 50.5     | 0.0051 | 146.9    | 0.0110 | 520.0    | 0.0116 | 543.7    | 0.0133 | 527.6    | 0.0124 | 573.2    | 0.0100 | 1644.0   | 0.0099 | 1769.9   | 0.0097 | 1897.6   |  |  |  |  |  |  |  |  |
|            | 0.0049 | 17.9     | 0.0049 | 52.4     | 0.0051 | 147.2    | 0.0111 | 528.0    | 0.0128 | 598.0    | 0.0146 | 580.4    | 0.0136 | 630.5    | 0.0104 | 1693.3   | 0.0103 | 1828.8   | 0.0102 | 1965.6   |  |  |  |  |  |  |  |  |
|            | 0.0052 | 18.3     | 0.0052 | 54.3     | 0.0052 | 147.6    | 0.0113 | 534.6    | 0.0139 | 652.4    | 0.0159 | 633.1    | 0.0149 | 687.8    | 0.0108 | 1742.6   | 0.0107 | 1887.7   | 0.0107 | 2033.7   |  |  |  |  |  |  |  |  |
|            | 0.0084 | 23.2     | 0.0084 | 74.9     | 0.0084 | 203.7    | 0.0115 | 540.7    | 0.0151 | 706.7    | 0.0173 | 685.9    | 0.0161 | 745.2    | 0.0112 | 1791.8   | 0.0112 | 1946.6   | 0.0112 | 2101.8   |  |  |  |  |  |  |  |  |
|            | 0.0116 | 28.0     | 0.0116 | 95.5     | 0.0116 | 259.8    | 0.0116 | 546.8    | 0.0162 | 761.1    | 0.0186 | 738.7    | 0.0173 | 802.5    | 0.0116 | 1841.1   | 0.0116 | 2005.5   | 0.0116 | 2169.8   |  |  |  |  |  |  |  |  |
|            | 0.0140 | 28.0     | 0.0140 | 95.5     | 0.0140 | 259.8    | 0.0140 | 546.8    | 0.0195 | 761.1    | 0.0223 | 738.7    | 0.0208 | 802.5    | 0.0140 | 1841.1   | 0.0140 | 2005.5   | 0.0140 | 2169.8   |  |  |  |  |  |  |  |  |
|            | 0.0163 | 28.0     | 0.0163 | 95.5     | 0.0163 | 259.8    | 0.0163 | 546.8    | 0.0227 | 761.1    | 0.0260 | 738.7    | 0.0243 | 802.5    | 0.0163 | 1841.1   | 0.0163 | 2005.5   | 0.0163 | 2169.8   |  |  |  |  |  |  |  |  |

HP310x132: West Abutment without CSP, Underside Elev. 101.0m

| Elev. (m)  | 100.0  |          | 99.0   |          | 98.0   |          | 97.0   |          | 96.0   |          | 95.0   |          | 94.0   |          | 93.0   |          | 92.0   |          | 91.0   |          |  |  |  |  |  |  |  |  |
|------------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--|--|--|--|--|--|--|--|
| P-y Curves | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) |  |  |  |  |  |  |  |  |
| Static     | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      |  |  |  |  |  |  |  |  |
|            | 0.0018 | 11.8     | 0.0020 | 30.9     | 0.0049 | 143.3    | 0.0094 | 448.4    | 0.0107 | 695.2    | 0.0107 | 834.2    | 0.0107 | 973.3    | 0.0013 | 80.2     | 0.0013 | 80.0     | 0.0013 | 84.5     |  |  |  |  |  |  |  |  |
|            | 0.0021 | 12.6     | 0.0023 | 33.4     | 0.0049 | 143.7    | 0.0096 | 456.3    | 0.0108 | 699.6    | 0.0108 | 839.5    | 0.0108 | 979.4    | 0.0025 | 160.3    | 0.0027 | 159.9    | 0.0026 | 169.1    |  |  |  |  |  |  |  |  |
|            | 0.0024 | 13.3     | 0.0026 | 35.8     | 0.0050 | 144.1    | 0.0098 | 464.3    | 0.0109 | 704.0    | 0.0109 | 844.8    | 0.0109 | 985.6    | 0.0038 | 240.5    | 0.0040 | 239.9    | 0.0038 | 253.6    |  |  |  |  |  |  |  |  |
|            | 0.0027 | 14.0     | 0.0029 | 38.1     | 0.0050 | 144.5    | 0.0099 | 472.2    | 0.0109 | 708.4    | 0.0109 | 850.1    | 0.0109 | 991.8    | 0.0050 | 320.6    | 0.0054 | 319.9    | 0.0051 | 338.1    |  |  |  |  |  |  |  |  |
|            | 0.0030 | 14.6     | 0.0032 | 40.4     | 0.0050 | 144.9    | 0.0101 | 480.2    | 0.0110 | 712.8    | 0.0110 | 855.4    | 0.0110 | 998.0    | 0.0063 | 400.8    | 0.0067 | 399.8    | 0.0064 | 422.6    |  |  |  |  |  |  |  |  |
|            | 0.0033 | 15.2     | 0.0035 | 42.5     | 0.0050 | 145.3    | 0.0103 | 488.2    | 0.0111 | 717.2    | 0.0111 | 860.7    | 0.0111 | 1004.1   | 0.0075 | 481.0    | 0.0081 | 479.8    | 0.0077 | 507.2    |  |  |  |  |  |  |  |  |
|            | 0.0036 | 15.8     | 0.0037 | 44.6     | 0.0051 | 145.7    | 0.0105 | 496.1    | 0.0111 | 721.6    | 0.0111 | 866.0    | 0.0111 | 1010.3   | 0.0088 | 561.1    | 0.0094 | 559.8    | 0.0089 | 591.7    |  |  |  |  |  |  |  |  |
|            | 0.0040 | 16.4     | 0.0040 | 46.7     | 0.0051 | 146.1    | 0.0106 | 504.1    | 0.0112 | 726.1    | 0.0112 | 871.3    | 0.0112 | 1016.5   | 0.0100 | 641.3    | 0.0107 | 639.8    | 0.0102 | 676.2    |  |  |  |  |  |  |  |  |
|            | 0.0043 | 16.9     | 0.0043 | 48.6     | 0.0051 | 146.5    | 0.0108 | 512.0    | 0.0113 | 730.5    | 0.0113 | 876.6    | 0.0113 | 1022.6   | 0.0113 | 721.4    | 0.0121 | 719.7    | 0.0115 | 760.8    |  |  |  |  |  |  |  |  |
|            | 0.0046 | 17.4     | 0.0046 | 50.5     | 0.0051 | 146.9    | 0.0110 | 520.0    | 0.0114 | 734.9    | 0.0114 | 881.8    | 0.0114 | 1028.8   | 0.0125 | 801.6    | 0.0134 | 799.7    | 0.0128 | 845.3    |  |  |  |  |  |  |  |  |
|            | 0.0049 | 17.9     | 0.0049 | 52.4     | 0.0051 | 147.2    | 0.0111 | 528.0    | 0.0114 | 739.3    | 0.0114 | 887.1    | 0.0114 | 1035.0   | 0.0138 | 881.8    | 0.0148 | 879.7    | 0.0141 | 929.8    |  |  |  |  |  |  |  |  |
|            | 0.0052 | 18.3     | 0.0052 | 54.3     | 0.0052 | 147.6    | 0.0113 | 534.6    | 0.0115 | 743.7    | 0.0115 | 892.4    | 0.0115 | 1041.2   | 0.0150 | 961.9    | 0.0161 | 959.6    | 0.0153 | 1014.3   |  |  |  |  |  |  |  |  |
|            | 0.0084 | 23.2     | 0.0084 | 74.9     | 0.0084 | 203.7    | 0.0115 | 540.7    | 0.0116 | 748.1    | 0.0116 | 897.7    | 0.0116 | 1047.3   | 0.0163 | 1042.1   | 0.0175 | 1039.6   | 0.0166 | 1098.9   |  |  |  |  |  |  |  |  |
|            | 0.0116 | 28.0     | 0.0116 | 95.5     | 0.0116 | 259.8    | 0.0116 | 546.8    | 0.0116 | 752.5    | 0.0116 | 903.0    | 0.0116 | 1053.5   | 0.0175 | 1122.3   | 0.0188 | 1119.6   | 0.0179 | 1183.4   |  |  |  |  |  |  |  |  |
|            | 0.0140 | 28.0     | 0.0140 | 95.5     | 0.0140 | 259.8    | 0.0140 | 546.8    | 0.0140 | 784.2    | 0.0140 | 941.0    | 0.0140 | 1097.8   | 0.0210 | 1122.3   | 0.0226 | 1119.6   | 0.0215 | 1183.4   |  |  |  |  |  |  |  |  |
|            | 0.0163 | 28.0     | 0.0163 | 95.5     | 0.0163 | 259.8    | 0.0163 | 546.8    | 0.0163 | 784.2    | 0.0163 | 941.0    | 0.0163 | 1097.8   | 0.0245 | 1122.3   | 0.0263 | 1119.6   | 0.0250 | 1183.4   |  |  |  |  |  |  |  |  |

# Ganaraska River Bridge

**1.2m Caisson: East Pier, Ground Surface Elev. 95.5 m**

[illegible]

**1.5m Caisson: East Pier, Ground Surface Elev. 95.5 m**

[illegible]

# Ganaraska River Bridge

**3.0m Caisson: East Pier, Ground Surface Elev. 95.5 m**

[illegible]

**1.2m Caisson: West Pier, Ground Surface Elev. 97.0 m**

[illegible]

SOIL P-Y CURVES  
Ganaraska River Bridge

1.5m Caisson: West Pier, Ground Surface Elev. 97.0 m

| Elev. (m)  | 95.5   |          | 94.5   |          | 93.5   |          | 92.5   |          | 91.5   |          | 90.5   |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|------------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| P-y Curves | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Static     | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0137 | 132.6    | 0.0133 | 215.5    | 0.0111 | 251.6    | 0.0138 | 307.4    | 0.0013 | 215.1    | 0.0005 | 118.9    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0147 | 135.5    | 0.0144 | 220.7    | 0.0124 | 260.9    | 0.0148 | 316.8    | 0.0035 | 325.2    | 0.0027 | 298.1    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0157 | 138.3    | 0.0154 | 225.7    | 0.0136 | 269.7    | 0.0158 | 325.8    | 0.0056 | 400.3    | 0.0050 | 413.5    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0168 | 140.9    | 0.0165 | 230.5    | 0.0149 | 277.9    | 0.0169 | 334.5    | 0.0078 | 460.3    | 0.0072 | 507.0    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0178 | 143.4    | 0.0176 | 235.1    | 0.0162 | 285.6    | 0.0179 | 342.9    | 0.0099 | 511.6    | 0.0094 | 588.0    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0188 | 145.8    | 0.0186 | 239.4    | 0.0174 | 293.0    | 0.0189 | 351.1    | 0.0121 | 556.9    | 0.0116 | 660.8    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0198 | 148.2    | 0.0197 | 243.7    | 0.0187 | 300.0    | 0.0199 | 358.9    | 0.0142 | 597.8    | 0.0139 | 727.6    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0209 | 150.4    | 0.0208 | 247.7    | 0.0199 | 306.7    | 0.0209 | 366.6    | 0.0164 | 635.4    | 0.0161 | 789.7    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0219 | 152.6    | 0.0218 | 251.6    | 0.0212 | 313.1    | 0.0220 | 374.0    | 0.0185 | 670.2    | 0.0183 | 848.1    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0229 | 154.6    | 0.0229 | 255.4    | 0.0225 | 319.3    | 0.0230 | 381.3    | 0.0207 | 702.9    | 0.0205 | 903.3    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0240 | 156.7    | 0.0239 | 259.1    | 0.0237 | 325.2    | 0.0240 | 388.3    | 0.0229 | 733.7    | 0.0228 | 955.9    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0250 | 158.6    | 0.0250 | 262.6    | 0.0250 | 331.0    | 0.0250 | 395.2    | 0.0250 | 762.8    | 0.0250 | 1006.2   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0406 | 188.0    | 0.0406 | 314.2    | 0.0406 | 400.9    | 0.0406 | 499.9    | 0.0406 | 969.5    | 0.0406 | 1352.3   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0563 | 217.4    | 0.0563 | 365.8    | 0.0563 | 470.8    | 0.0563 | 604.5    | 0.0563 | 1176.2   | 0.0563 | 1698.4   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0675 | 217.4    | 0.0675 | 365.8    | 0.0675 | 470.8    | 0.0675 | 604.5    | 0.0675 | 1176.2   | 0.0675 | 1698.4   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0788 | 217.4    | 0.0788 | 365.8    | 0.0788 | 470.8    | 0.0788 | 604.5    | 0.0788 | 1176.2   | 0.0788 | 1698.4   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

3.0m Caisson: West Pier, Ground Surface Elev. 97.0 m

| Elev. (m)  | 95.5   |          | 94.5   |          | 93.5   |          | 92.5   |          | 91.5   |          | 90.5   |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|------------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| P-y Curves | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) | y (m)  | P (kN/m) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Static     | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      | 0.0000 | 0.0      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0253 | 245.9    | 0.0270 | 436.9    | 0.0259 | 586.3    | 0.0389 | 866.0    | 0.0057 | 905.5    | 0.0050 | 1160.6   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0276 | 251.9    | 0.0291 | 446.5    | 0.0281 | 600.7    | 0.0399 | 872.9    | 0.0097 | 1072.1   | 0.0091 | 1410.4   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0298 | 257.5    | 0.0312 | 455.6    | 0.0303 | 614.4    | 0.0409 | 879.7    | 0.0137 | 1195.9   | 0.0132 | 1592.5   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0321 | 262.9    | 0.0333 | 464.3    | 0.0325 | 627.5    | 0.0419 | 886.4    | 0.0178 | 1296.8   | 0.0173 | 1739.8   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0343 | 268.0    | 0.0354 | 472.6    | 0.0346 | 639.9    | 0.0429 | 893.0    | 0.0218 | 1383.0   | 0.0214 | 1865.1   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0365 | 272.9    | 0.0375 | 480.6    | 0.0368 | 651.8    | 0.0440 | 899.5    | 0.0258 | 1458.8   | 0.0255 | 1975.3   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0388 | 277.5    | 0.0395 | 488.3    | 0.0390 | 663.2    | 0.0450 | 905.9    | 0.0299 | 1526.9   | 0.0296 | 2074.1   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0410 | 282.0    | 0.0416 | 495.7    | 0.0412 | 674.1    | 0.0460 | 912.2    | 0.0339 | 1589.0   | 0.0336 | 2164.1   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0433 | 286.3    | 0.0437 | 502.8    | 0.0434 | 684.7    | 0.0470 | 918.4    | 0.0379 | 1646.2   | 0.0377 | 2247.0   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0455 | 290.5    | 0.0458 | 509.7    | 0.0456 | 694.9    | 0.0480 | 924.5    | 0.0419 | 1699.4   | 0.0418 | 2324.1   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0478 | 294.4    | 0.0479 | 516.4    | 0.0478 | 704.7    | 0.0490 | 930.5    | 0.0460 | 1749.1   | 0.0459 | 2396.3   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0500 | 298.3    | 0.0500 | 522.9    | 0.0500 | 714.3    | 0.0500 | 936.4    | 0.0500 | 1796.0   | 0.0500 | 2464.3   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.0813 | 351.3    | 0.0813 | 618.2    | 0.0813 | 848.1    | 0.0813 | 1118.9   | 0.0813 | 2149.3   | 0.0813 | 2969.5   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.1125 | 404.3    | 0.1125 | 713.5    | 0.1125 | 981.9    | 0.1125 | 1301.4   | 0.1125 | 2502.5   | 0.1125 | 3474.6   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.1350 | 404.3    | 0.1350 | 713.5    | 0.1350 | 981.9    | 0.1350 | 1301.4   | 0.1350 | 2502.5   | 0.1350 | 3474.6   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|            | 0.1575 | 404.3    | 0.1575 | 713.5    | 0.1575 | 981.9    | 0.1575 | 1301.4   | 0.1575 | 2502.5   | 0.1575 | 3474.6   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |





- The following assumptions were made in the analysis:
1. The analysis was completed for a vertical element (i.e. no inclination) and flat ground
  2. These curves are for static loading. Seismic effects have not been included.
  3. The effects of construction disturbance is not considered.
  4. Depth above frost should be ignored in design

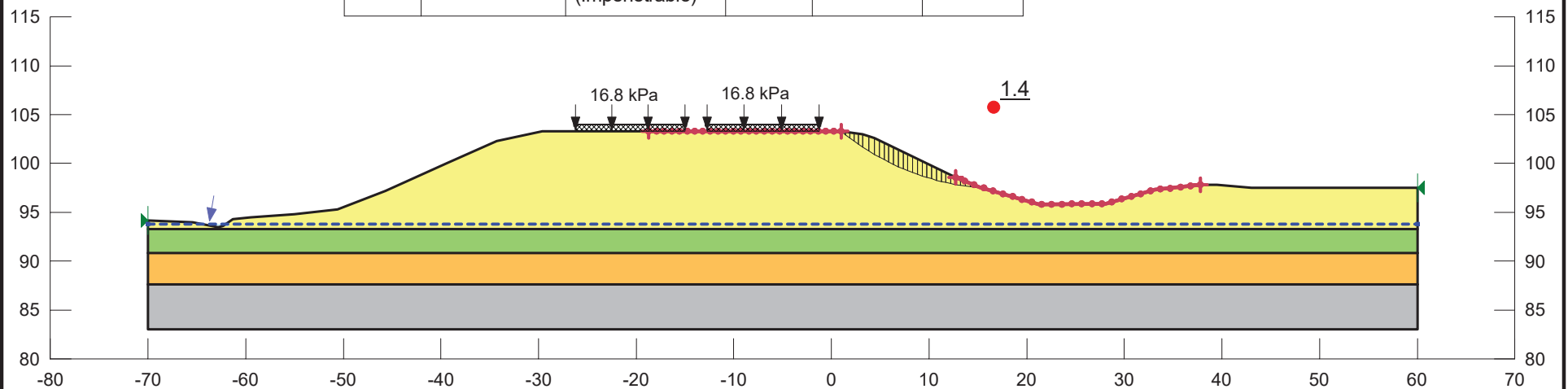
- NOTES:
1. **The p-y data provided is unfactored.** Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors ( $\phi_{gu}$  and  $\phi_{gs}$ ) provided in the CHBDC
  2. If lateral spacing between an adjacent structural element is less than four equivalent diameters, suitable reduction factors based on center to center spacing should be applied based on tables of the CHBDC





## **Appendix G Slope Stability Analysis Figures**





| Color   | Name             | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|------------------|--------------------------------|---------------------|--------------------------|------------------------------|
|  | 1) Existing Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           |
|  | 2) Organic Silt  | Mohr-Coulomb                   | 18                  | 0                        | 27                           |
|  | 3) Glacial Till  | Mohr-Coulomb                   | 21                  | 0                        | 35                           |
|  | 4) Bedrock       | Bedrock (Impenetrable)         |                     |                          |                              |

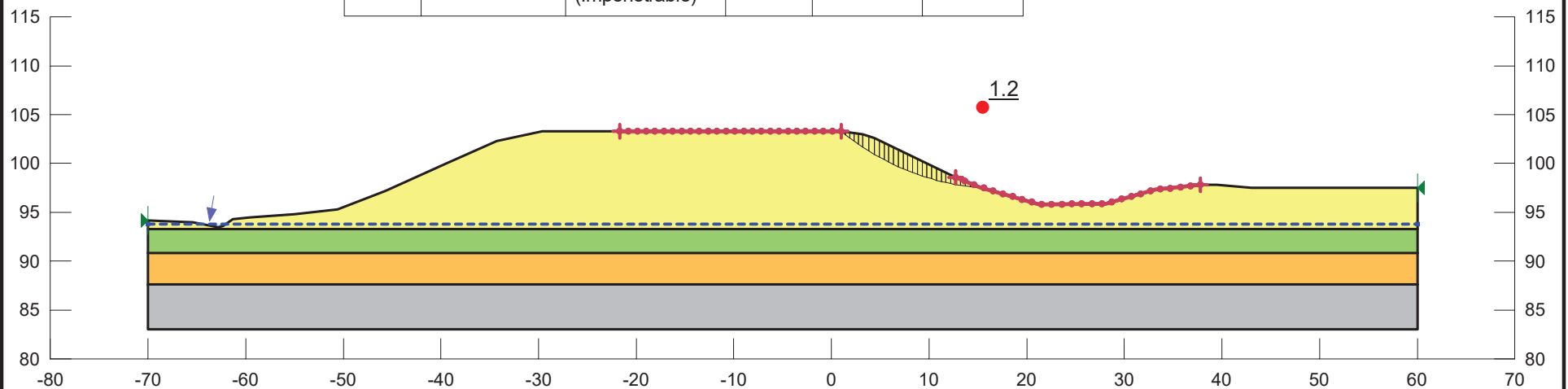


|  |                                     |                |
|--|-------------------------------------|----------------|
| Project<br><b>Ganaraska River Bridge</b>                     |                                     |                |
| Analysis<br><b>Existing East Approach South Slope Static</b> |                                     |                |
| Seismic Coefficient<br>H: 0g, V: 0g                          | Last Run<br>09/16/2022, 11:05:19 AM | Scale<br>1:630 |

Additional Details  
 Name: Ganaraska River Bridge  
 Comments: Global Slope Stability  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (1, 103.3) m, Exit: (15.583721, 97.486771) m  
 Center: (17.386198, 123.20847) m, Radius: 25.784773 m

**Figure G1**

| Color   | Name             | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|------------------|--------------------------------|---------------------|--------------------------|------------------------------|
|  | 1) Existing Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           |
|  | 2) Organic Silt  | Mohr-Coulomb                   | 18                  | 0                        | 27                           |
|  | 3) Glacial Till  | Mohr-Coulomb                   | 21                  | 0                        | 35                           |
|  | 4) Bedrock       | Bedrock (Impenetrable)         |                     |                          |                              |

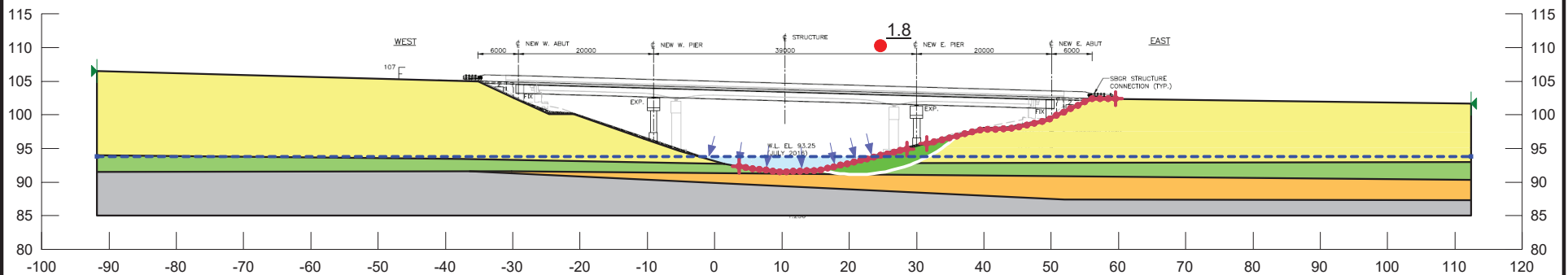



|   |                                     |                |
|---|-------------------------------------|----------------|
| Project<br><b>Ganaraska River Bridge</b>                      |                                     |                |
| Analysis<br><b>Existing East Approach South Slope Seismic</b> |                                     |                |
| Seismic Coefficient<br>H: 0.071g, V: 0g                       | Last Run<br>09/16/2022, 11:05:22 AM | Scale<br>1:630 |

Additional Details  
 Name: Ganaraska River Bridge  
 Comments: Global Slope Stability  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (1, 103.3) m, Exit: (15.583721, 97.486771) m  
 Center: (17.386198, 123.20847) m, Radius: 25.784773 m





**Figure G2**

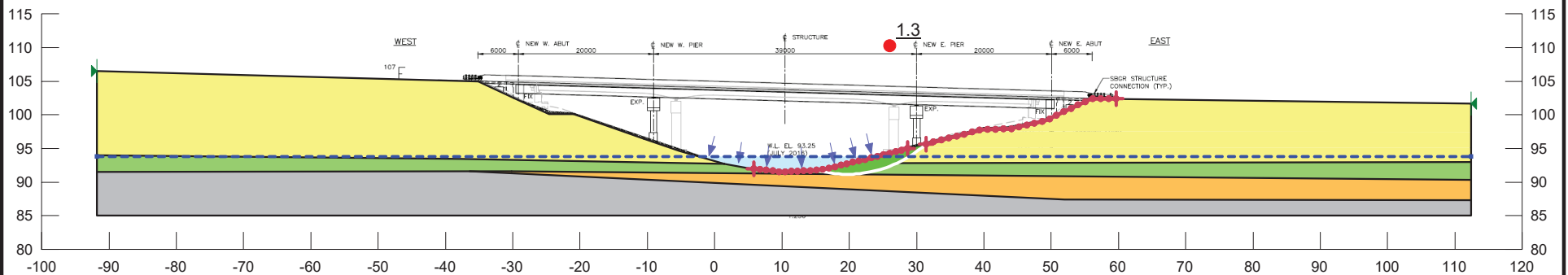
| Color   | Name               | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|--------------------|--------------------------------|---------------------|--------------------------|------------------------------|-----------|------------------|
| <span style="display:inline-block; width:15px; height:15px; background-color:yellow; border:1px solid black;"></span>     | 1) Embankment Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           | 0         | 1                |
| <span style="display:inline-block; width:15px; height:15px; background-color:lightgreen; border:1px solid black;"></span> | 2) Organic Silt    | Mohr-Coulomb                   | 18                  | 0                        | 27                           | 0         | 1                |
| <span style="display:inline-block; width:15px; height:15px; background-color:orange; border:1px solid black;"></span>     | 3) Glacial Till    | Mohr-Coulomb                   | 21                  | 0                        | 35                           | 0         | 1                |
| <span style="display:inline-block; width:15px; height:15px; background-color:gray; border:1px solid black;"></span>       | 4) Bedrock         | Bedrock (Impenetrable)         |                     |                          |                              |           | 1                |




|   |                     |  |                         |  |  |  |
|---|---------------------|--|-------------------------|--|--|--|
|  | Project             |  | Ganaraska River Bridge  |  | Additional Details   |  |
|   | Analysis            |  | East Foreslope Static   |  | Name: Ganaraska River Bridge                                   |  |
|   | Seismic Coefficient |  | Last Run                |  | Comments: Global Slope Stability                               |  |
|   | H: g, V: g          |  | 09/15/2022, 03:16:24 PM |  | Method: Morgenstern-Price, Half-Sine                           |  |
|   |                     |  | Scale                   |  | Minimum Slip Surface Depth: 1.5 m                              |  |
|   |                     |  | 1:914                   |  | Entry: (36.02833, 96.866117) m, Exit: (15.754686, 91.797615) m |  |
|   |                     |  |                         |  | Center: (21.136498, 113.35157) m, Radius: 22.215686 m          |  |




**Figure G3**

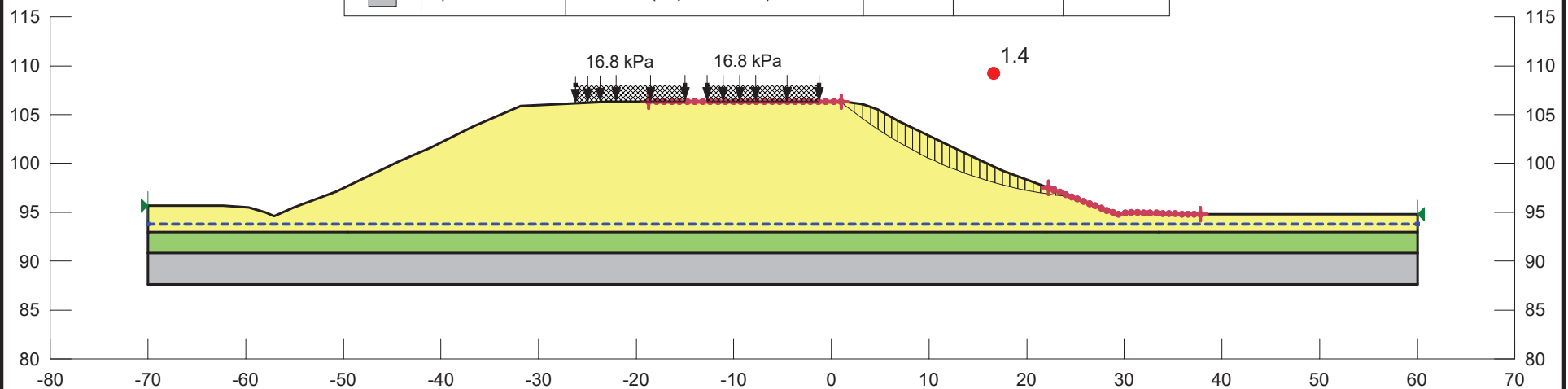
| Color   | Name               | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|--------------------|--------------------------------|---------------------|--------------------------|------------------------------|-----------|------------------|
|  | 1) Embankment Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           | 0         | 1                |
|  | 2) Organic Silt    | Mohr-Coulomb                   | 18                  | 0                        | 27                           | 0         | 1                |
|  | 3) Glacial Till    | Mohr-Coulomb                   | 21                  | 0                        | 35                           | 0         | 1                |
|  | 4) Bedrock         | Bedrock (Impenetrable)         |                     |                          |                              |           | 1                |



|   |                     |  |                         |  |   |  |
|---|---------------------|--|-------------------------|--|---|--|
|  | Project             |  | Ganaraska River Bridge  |  | Additional Details                                      |  |
|   | Analysis            |  | East Foreslope Seismic  |  | Name: Ganaraska River Bridge                            |  |
|   | Seismic Coefficient |  | Last Run                |  | Comments: Global Slope Stability                        |  |
|   | H: 0.071g, V: 0g    |  | 09/15/2022, 03:16:27 PM |  | Method: Morgenstern-Price, Half-Sine                    |  |
|   |                     |  | Scale                   |  | Minimum Slip Surface Depth: 1.5 m                       |  |
|   |                     |  | 1:914                   |  | Entry: (31.4, 95.658) m, Exit: (15.118981, 91.764157) m |  |
|   |                     |  |                         |  | Center: (19.64987, 108.8037) m, Radius: 17.631649 m     |  |

**Figure G4**




| Color   | Name             | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|------------------|--------------------------------|---------------------|--------------------------|------------------------------|
|  | 1) Existing Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           |
|  | 2) Organic Silt  | Mohr-Coulomb                   | 18                  | 0                        | 27                           |
|  | 4) Bedrock       | Bedrock (Impenetrable)         |                     |                          |                              |

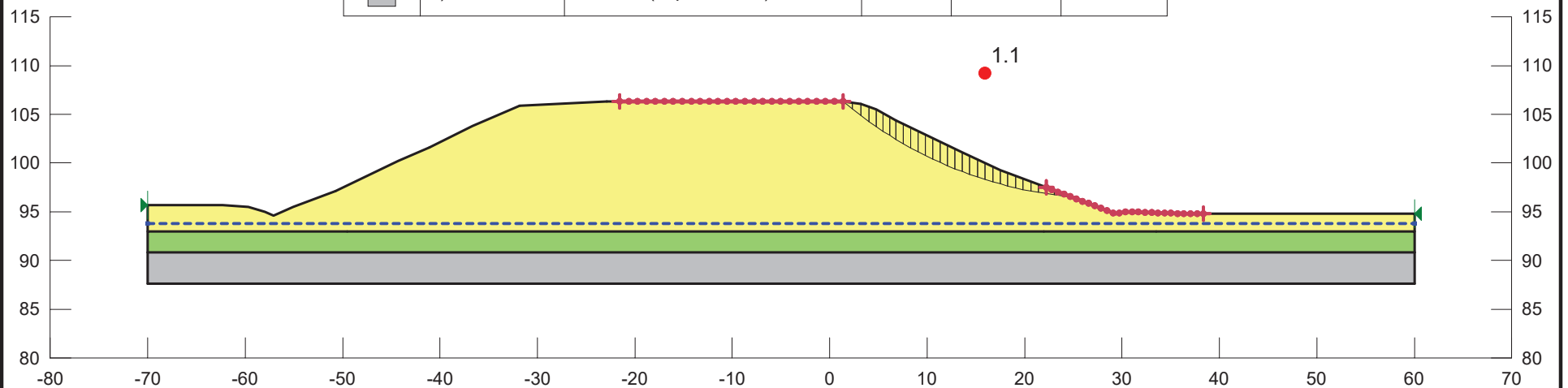


|  |                                     |                |
|--|-------------------------------------|----------------|
| Project<br><b>Ganaraska River Bridge</b>                     |                                     |                |
| Analysis<br><b>Existing West Approach South Slope Static</b> |                                     |                |
| Seismic Coefficient<br>H: 0g, V: 0g                          | Last Run<br>09/16/2022, 11:44:11 AM | Scale<br>1:630 |

Additional Details  
 Name: West Approach  
 Comments: Global Slope Stability  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (1, 106.3) m, Exit: (24.610374, 96.583379) m  
 Center: (28.198409, 138.84561) m, Radius: 42.414268 m

**Figure G5**

| Color   | Name             | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|------------------|--------------------------------|---------------------|--------------------------|------------------------------|
|  | 1) Existing Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           |
|  | 2) Organic Silt  | Mohr-Coulomb                   | 18                  | 0                        | 27                           |
|  | 4) Bedrock       | Bedrock (Impenetrable)         |                     |                          |                              |

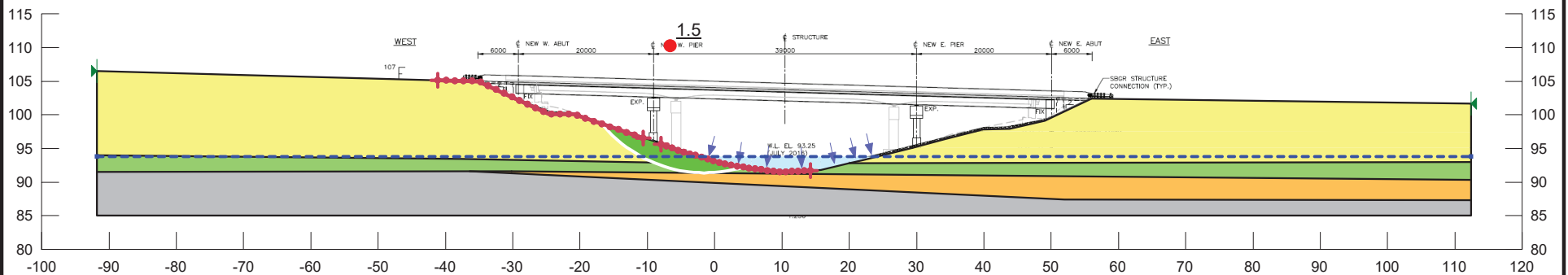


|  |                         |       |
|--|-------------------------|-------|
| Project                                    |                         |       |
| Ganaraska River Bridge                     |                         |       |
| Analysis                                   |                         |       |
| Existing West Approach South Slope Seismic |                         |       |
| Seismic Coefficient                        | Last Run                | Scale |
| H: 0.071g, V: 0g                           | 09/16/2022, 11:44:08 AM | 1:630 |

Additional Details  
Name: West Approach  
Comments: Global Slope Stability  
Method: Morgenstern-Price, Half-Sine  
Minimum Slip Surface Depth: 1.5 m  
Entry: (1.4, 106.3) m, Exit: (24.695835, 96.55088) m  
Center: (28.596931, 138.58031) m, Radius: 42.210084 m

**Figure G6**

| Color   | Name               | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|--------------------|--------------------------------|---------------------|--------------------------|------------------------------|-----------|------------------|
| <span style="display:inline-block; width:15px; height:15px; background-color:yellow; border:1px solid black;"></span>     | 1) Embankment Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           | 0         | 1                |
| <span style="display:inline-block; width:15px; height:15px; background-color:lightgreen; border:1px solid black;"></span> | 2) Organic Silt    | Mohr-Coulomb                   | 18                  | 0                        | 27                           | 0         | 1                |
| <span style="display:inline-block; width:15px; height:15px; background-color:orange; border:1px solid black;"></span>     | 3) Glacial Till    | Mohr-Coulomb                   | 21                  | 0                        | 35                           | 0         | 1                |
| <span style="display:inline-block; width:15px; height:15px; background-color:gray; border:1px solid black;"></span>       | 4) Bedrock         | Bedrock (Impenetrable)         |                     |                          |                              |           | 1                |



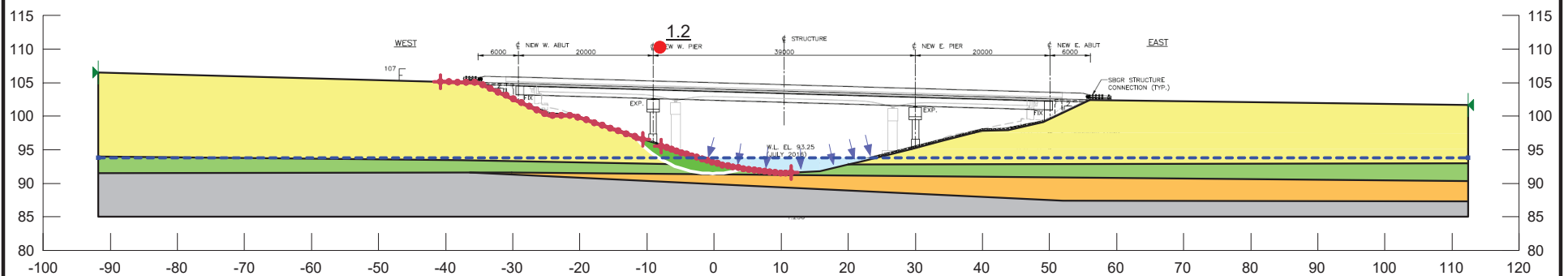
|  |                                     |                |
|--|-------------------------------------|----------------|
| Project<br><b>Ganaraska River Bridge</b> |                                     |                |
| Analysis<br><b>West Foreslope Static</b> |                                     |                |
| Seismic Coefficient<br>H: g, V: g        | Last Run<br>09/15/2022, 03:16:33 PM | Scale<br>1:914 |


Additional Details  
 Name: Ganaraska River Bridge  
 Comments: Global Slope Stability  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (-16.750881, 98.643159) m, Exit: (4.2376647, 92.215521) m  
 Center: (-1.4446544, 111.1421) m, Radius: 19.761173 m

**Figure G7**



| Color  | Name               | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|--|--------------------|--------------------------------|---------------------|--------------------------|------------------------------|-----------|------------------|
| <span style="background-color: yellow; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span>     | 1) Embankment Fill | Mohr-Coulomb                   | 20                  | 0                        | 30                           | 0         | 1                |
| <span style="background-color: lightgreen; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span> | 2) Organic Silt    | Mohr-Coulomb                   | 18                  | 0                        | 27                           | 0         | 1                |
| <span style="background-color: orange; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span>     | 3) Glacial Till    | Mohr-Coulomb                   | 21                  | 0                        | 35                           | 0         | 1                |
| <span style="background-color: gray; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span>       | 4) Bedrock         | Bedrock (Impenetrable)         |                     |                          |                              |           | 1                |



|   |                     |                         |                        |  |   |
|---|---------------------|-------------------------|------------------------|--|---|
|  | Project             |                         | Ganaraska River Bridge |  | <b>Additional Details</b><br>Name: Ganaraska River Bridge<br>Comments: Global Slope Stability<br>Method: Morgenstern-Price, Half-Sine<br>Minimum Slip Surface Depth: 1.5 m<br>Entry: (-11.858212, 96.965673) m, Exit: (4.3885916, 92.189753) m<br>Center: (-0.20973233, 106.56938) m, Radius: 15.096963 m |
|   | Analysis            |                         | West Foreslope Seismic |  |   |
|   | Seismic Coefficient | Last Run                | Scale                  |  |   |
|   | H: 0.071g, V: 0g    | 09/15/2022, 03:16:30 PM | 1:914                  |  |   |

**Figure G8**



## **Appendix H GSC Seismic Hazard**

# 2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836  
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 43.969N 78.294W

User File Reference: Hwy 401 Ganaraska River Bridge

2022-08-12 17:17 UT

Requested by: C. Murray, Thurber Engineering

|                                       |          |       |        |       |
|---------------------------------------|----------|-------|--------|-------|
| Probability of exceedance per annum   | 0.000404 | 0.001 | 0.0021 | 0.01  |
| Probability of exceedance in 50 years | 2 %      | 5 %   | 10 %   | 40 %  |
| Sa (0.05)                             | 0.163    | 0.086 | 0.049  | 0.014 |
| Sa (0.1)                              | 0.204    | 0.114 | 0.069  | 0.021 |
| Sa (0.2)                              | 0.178    | 0.104 | 0.066  | 0.023 |
| Sa (0.3)                              | 0.140    | 0.085 | 0.056  | 0.020 |
| Sa (0.5)                              | 0.105    | 0.066 | 0.044  | 0.016 |
| Sa (1.0)                              | 0.059    | 0.038 | 0.025  | 0.008 |
| Sa (2.0)                              | 0.029    | 0.019 | 0.012  | 0.003 |
| Sa (5.0)                              | 0.007    | 0.004 | 0.003  | 0.001 |
| Sa (10.0)                             | 0.003    | 0.002 | 0.001  | 0.001 |
| PGA (g)                               | 0.112    | 0.063 | 0.038  | 0.012 |
| PGV (m/s)                             | 0.087    | 0.052 | 0.033  | 0.010 |

**Notes:** Spectral ( $S_a(T)$ , where  $T$  is the period in seconds) and peak ground acceleration (PGA) values are given in units of  $g$  ( $9.81 \text{ m/s}^2$ ). Peak ground velocity is given in  $\text{m/s}$ . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity  $450 \text{ m/s}$ ). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

## References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)  
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites [www.EarthquakesCanada.ca](http://www.EarthquakesCanada.ca) and [www.nationalcodes.ca](http://www.nationalcodes.ca) for more information



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada



## **Appendix I   List of Referenced Specifications and Contract Provisions**



1. The following Special Provisions and OPSS Documents referenced in this report:

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 539
- OPSS.PROV 803
- OPSS.PROV 804
- OPSS.PROV 805
- OPSS.PROV 902
- OPSS.PROV 903
- OPSS.PROV 1010
- OPSD 208.010
- OPSD 219.110
- OPSD 3090.101
- OPSD 3101.150
- SP105S09
- SP109S12
- SP110S06
- FOUN0003

2. Contract Provision – Presence of Existing Piles

“The proposed piles are to be advanced in close proximity to the piles supporting the existing piers and abutments. Although the pile layout on the structural drawings has been selected to avoid conflict with piles supporting the existing bridge piers and abutments the potential for conflict still exists.

Should the new piles encounter the existing piles the Contractor shall report the conflict to Contract Administrator to determine if adjustment to the pile driving program is required.”

3. Contract Provision – Obstructions

“Obstructions such as cobbles and boulders should be expected within the existing fill and glacial till layers. The obstructions may interfere with pile installation. The Contractor should be prepared to remove, dislodge or otherwise penetrate these obstructions to advance the piles to the specified tip elevation/resistance while meeting the specified deflection tolerances.”

## **VIBRATION MONITORING**

Item No.

---

Special Provision

---

### **1.0 SCOPE**

This special provision describes requirements to carry out vibration monitoring on both the existing bridges and newly constructed bridges during the staged construction of deep foundations for the Highway 401 Choate Road and Ganaraska River Bridge replacements.

### **2.0 REFERENCES – Not Used**

### **3.0 DEFINITIONS**

For the purpose of this specification, the following definitions apply:

**Peak Particle Velocity (PPV)** means the maximum component velocity in millimetres per second that ground particles move as a result of energy released from explosive detonations.

**Preconstruction Survey** means a detailed record, accompanied by film or video, as necessary, of the condition of private or public property including bridges, prior to the commencement of construction activities that may cause undue ground vibrations.

### **4.0 DESIGN AND SUBMISSION REQUIREMENTS**

#### **4.1 Vibration Monitoring Plan Submission**

The Contractor shall submit details of the vibration monitoring plan to the Contract Administrator for review at least three (3) weeks prior to the start of rock excavation or construction of deep foundations. All submissions shall bear the signature and seal of Professional Engineer licensed to practice in the Province of Ontario. The submittals shall satisfy the specifications and at a minimum contain the following specific information:

- a) Equipment and methods used by the Contractor to perform the work that may cause undue vibration
- b) Qualifications of the vibration monitoring specialist.
- c) Details regarding the proposed instrumentation.
- d) Proposed location of instruments on the existing Highway 401 Choate Road Bridge, Highway 401 Ganaraska River Bridge, nearby dam, Hope Street Sanitary Pump Station, utilities and building structures.
- e) Method of monitoring, proposed frequency of readings and proposed frequency of submission of readings to Contract Administrator.
- f) Proposed methods for adjusting deep foundation construction methods if readings show vibrations exceeding the specified limits.

## **4.2 Preconstruction Survey**

When construction activities such as rock excavation or installation of deep foundations that may cause significant ground vibrations will be carried out, a condition survey of property and structures that may be affected by the work shall be carried out.

The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, dams, utilities, and structures, within a distance of 100 metres from the construction activity.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

## **5.0 MATERIALS – Not Used**

## **6.0 EQUIPMENT**

## **7.2 Monitoring Equipment**

All monitoring equipment shall be capable of measuring and recording ground vibration (PPV) up to 200 mm/s in the vertical, transverse, and radial directions. The equipment shall have been calibrated within the last 12 months either by the manufacturer or other qualified agent. Proof of calibration shall be submitted to the Contract Administrator prior to commencement of any monitoring operations.

## **7.0 CONSTRUCTION**

### **7.1 Monitoring**

#### **7.1.1 General**

The Contractor shall employ a vibration monitoring consultant to carry out monitoring for PPV. During rock excavation, deep foundation construction or other construction activities that may cause undue ground vibration. Ground vibration (PPV) shall be monitored at the closest portion of any utility, residence, structure, or facility. The monitoring equipment shall be repositioned as required.

#### **7.1.2 Ground Vibration**

Ground vibration as measured by PPV shall be limited to the maximum levels shown in Table 1.

**TABLE 1**  
**Maximum Peak Particle Velocity (PPV) Values**

| <b>Element</b>                                  | <b>Frequency (Hz)</b> | <b>PPV (mm/s)</b> |
|---|-----------------------|-------------------|
| Structures and Pipelines                        | $\leq 40$             | 20                |
|   | $> 40$                | 50                |
| Concrete and Grout<br>< 72 hours from placement | N/A                   | 10                |

If the vibration readings are not within the limits stated above, the Contractor must alter the deep foundation installation procedures until the vibrations at the existing bridge structure, residential/commercial/industrial buildings and/or utilities, as applicable, are within acceptable levels.

## **7.2 Records**

The results of ground vibration monitoring shall be made available to the Contract Administrator for site review at the end of each working day that rock excavation, deep foundation construction or other construction activities that may cause undue ground vibration was carried out.

## **7.3 Damage**

Upon completion of installation or deep foundations or immediately following the receipt of a complaint, a site condition survey shall be performed to determine if any damage has resulted. The Contractor shall record all incidents of any damage, which shall be reported immediately in writing to the Contract Administrator. All other complaints shall be reported to the Contract Administrator in writing within 24 hours of receipt. Each complaint report shall include the name and address of the complainant, time received, and description of the circumstances that led to the complaint.

## **8.0 QUALITY ASSURANCE – Not Used**

## **9.0 MEASUREMENT FOR PAYMENT – Not Used**

## **10.0 BASIS OF PAYMENT**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.