



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
SANDY CREEK CULVERT REPLACEMENT  
HIGHWAY 105, 7.3 KM NORTH OF HIGHWAY 657  
DISTRICT OF KENORA, ONTARIO  
LATITUDE: 50.684995°, LONGITUDE: -93.300164°**

**G.W.P. 6373-14-00, SITE NO. 41N-242/C**

**GEOCRES Number: 52K-16**

**Report**

**to**

**HATCH**

Date: March 16, 2022  
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**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Sandy Creek Culvert, which is to be replaced with a single-span bridge. The Sandy Creek Culvert is located on Highway 105, 7.3 km north of Highway 657 at Ear Falls, Ontario. Thurber carried out the investigation as a sub-consultant to Hatch under the Ministry of Transportation Ontario (MTO) Agreement Number 6017-E-0022, Assignment No. 25.

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

For preparation of this report, reference has been made to the following previous report:

- Final Foundation Investigation and Design Report, Sandy Creek Culvert Replacement, Highway 105, Site 41N-242/C, Station 18+280 (Unsurveyed Territory), GWP 6373-14-00, Geocres No. 52K-15, prepared by Englobe, dated August 23, 2018 (Reference 1).

**2. SITE DESCRIPTION**

The site is located on Highway 105, approximately 7.3 km north of Highway 657, near Ear Falls in the District of Kenora, Ontario. The current structure consists of three (3) CSP culverts that are each 2 m in diameter and approximately 35.6 m in length. The existing highway embankment currently supports two undivided lanes of Highway 105, running in a generally northwest – southeast direction. Sandy Creek flows from north to south at the culvert site.



As shown on a site plan, E-504931-105-1, provided by MTO, the highway at the culvert location is constructed on an embankment of approximately 6.5 m in height above the culvert inverts. The side slopes of the existing embankment are sloped at approximately 2H:1V with rockfill on the surface of the embankment slopes above the culvert; particularly on the south side of the embankment. Based on existing survey information, the existing top of the highway grade is at approximate Elevation 352.0 m, and the invert levels of the three culverts are each at approximate Elevation 345.5 m.

During the field investigation for this project, it was observed that surficial erosion and relatively deep gullying of the granular shoulder material has occurred along the south side of the embankment, in the vicinity of the existing culvert outlet, and extending to the northwest and southeast beyond the area protected by rockfill. The most pronounced erosion gullies were observed to the northwest of the culvert inlet. Photos of the erosion are provided in Appendix C.

The Ontario Structure Inspection Manual (OSIM) report prepared by MTO on January 8, 2018 reported several performance deficiencies at the site including transverse and centreline cracking of the asphalt surface at the north and south approaches to the culvert, excessive deformations and continuing movement of the CSPs, sagging of the culvert barrels, separation at the joints, damage at the culvert inlet ends, and foundation settlement and separation at the outlets.

Measurements collected in October 2014 indicate that the surface water level of Sandy Creek ranged from Elevation 346.64 m upstream to 346.57 m downstream of the culvert.

The lands surrounding the site predominantly consist of heavily forested areas with lakes and other tributaries. The local terrain consists of a low relief glaciolacustrine plain. Photographs of the culvert, surrounding area and surficial erosion are presented in Appendix C.

Based on published geological information, the culvert lies within an area consisting of glaciomarine deposits including silt and clay and minor sand. Based on local geological maps, the bedrock in the area is metasedimentary.

### **3. INVESTIGATION PROCEDURES**

The field investigation for the culvert replacement project was carried out between July 9<sup>th</sup> and 13<sup>th</sup>, 2019 and consisted of drilling two (2) boreholes, labeled Boreholes 19-01 and 19-02, and four (4) dynamic cone penetration tests (DCPTs), labeled DCPT 19-03 to 19-06. The locations of the boreholes and DCPTs were selected based on the Terms of Reference for this assignment, and a preliminary General Arrangement drawing provided by MTO for the proposed replacement



bridge. Boreholes 19-01 and 19-02 were drilled through the existing pavement near the locations of the proposed north and south bridge abutments to depths of 39.2 m (Elev. 312.7 m) and 31.7 m (Elev. 320.3 m) respectively. DCPTs 19-03 and 19-05 were conducted through the existing pavement near the proposed north abutment to depths of 26.3 and 26.8 m (Elev. 325.5 and 325.1 m), and DCPTs 19-04 and 19-06 were conducted near the proposed south abutment to depths of 25.9 and 24.5 m (Elev. 326.2 and 327.5 m).

The borehole logs from the current investigation are included in Appendix A, and the borehole logs from the previous investigation by Englobe (Reference 1) are included in Appendix E. The approximate locations of the boreholes from both investigations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from the cross sections and topographic drawings provided to Thurber by MTO. The coordinate system MTM NAD 83, Zone 16 was used for the boreholes.

A rubber-tired CME 75 drill rig was used to advance Boreholes 19-01 and 19-02 using solid stem augers and NW casing. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Vane testing was carried out in the cohesive foundation soils. NQ coring methods were used to advance Boreholes 19-01 and 19-02 into bedrock. Dynamic Cone Penetration Testing was conducted at DCPTs 19-03 to 19-06.

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

The rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

A 19 mm diameter standpipe piezometer was installed in Borehole 19-02 to permit measurement of the groundwater level. The piezometer was decommissioned on July 14, 2019 in general accordance with Ontario Regulation 903, as amended.

Completion details of the boreholes are summarized in Table 3.1.



**Table 3.1 – Borehole Completion Details**

<b>Borehole Number</b>	<b>Borehole Depth / Base Elevation (m)</b>	<b>Piezometer Tip Depth / Elevation (m)</b>	<b>Completion Details</b>
19-01	39.2 / 312.7	None installed	Caved to 4.9 m, bentonite holeplug from 4.9 m to 0.3 m, cement to surface.
19-02	31.7 / 320.3	31.1 / 320.9	Sand to 23.5 m, bentonite holeplug from 23.5 m to 0.3 m, cement to surface.

#### **4. LABORATORY TESTING**

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer) and Atterberg Limit testing, where appropriate. Point load tests and unconfined compressive strength (UCS) tests were also conducted on the bedrock cores. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

#### **5. DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawing included in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations. Description of the soil stratigraphy encountered in the previous boreholes is included in Reference 1.

In general, the subsurface conditions encountered consisted of embankment fill, overlying native silty clay, silt, silty sand to sandy silt, and sand deposits. The overburden soil deposits were underlain by metasedimentary bedrock. Descriptions of the individual strata are presented below.



## 5.1 Asphalt

A 50 to 75 mm thick layer of asphalt was encountered at the ground surface in Boreholes 19-01 and 19-02, which were drilled through the existing pavement on Highway 105.

## 5.2 Gravelly Sand Fill

In both boreholes, the asphalt was underlain by granular fill consisting of gravelly sand with trace silt, which was approximately 1 to 1.3 m thick and extended to depths of 1.1 to 1.4 m (Elev. 350.9 to 350.5 m). The gravelly sand fill was compact, based on SPT 'N' values of 14 to 19 blows per 0.3 m of penetration. The measured moisture content in the gravelly sand fill ranged from 4 to 8%.

The results of a grain size analysis conducted on a selected sample of the gravelly sand fill are illustrated on Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	29
Sand	64
Silt and Clay	7

## 5.3 Sand Fill

In Borehole 19-01, the gravelly sand fill was further underlain by embankment fill consisting of sand with trace gravel and trace silt. In Borehole 01 from Reference 1, a cobble was noted at a depth of 2.6 m within the sand fill. The sand fill was 4.2 m thick and extended to a depth of 5.6 m (Elev. 346.3 m). The sand fill ranged from compact to very loose in density, based on SPT 'N' values of 2 to 10 blows per 0.3 m of penetration. The measured moisture content in the sand fill ranged from 4 to 8%.

The results of a grain size analysis conducted on a selected sample of the sand fill are illustrated on Figure B2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	1
Sand	94
Silt and Clay	5



## 5.4 Silty Clay Fill

A 3.0 m thick layer of silty clay embankment fill containing trace sand and trace gravel was encountered below the gravelly sand fill in Borehole 19-02. The base of the silty clay fill was at 4.1 m depth (Elev. 347.9 m).

SPT 'N' values measured in the silty clay fill ranged from 0 to 8 blows for 0.3 m penetration. In-situ vane shear tests conducted in the silty clay fill measured undrained shear strengths of between 40 and 60 kPa. The results of the vane shear tests indicate that the silty clay fill is stiff to firm. The sensitivity of the silty clay fill ranged from 2 to 2.4, indicating a low to medium sensitivity. The measured moisture content in the silty clay fill ranged from 25 to 33%.

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

Soil Particle	Percentage
Gravel	0
Sand	1
Silt	48
Clay	51

## 5.5 Silty Clay

Native silty clay was encountered below the sand and silty clay embankment fill in both boreholes. The silty clay layer ranged in thickness from 3.1 m to 6.1 m and extended to depths of approximately 7.2 to 11.7 m (Elev. 344.8 to 340.2 m). The upper 1.6 m of the silty clay contained trace sand, organics and wood fragments in Borehole 19-01.

SPT 'N' values measured in the silty clay layer ranged from 0 to 5 blows for 0.3 m penetration. In-situ vane shear tests conducted in the silty clay layer measured undrained shear strengths of between 20 and 50 kPa. The results of the vane shear tests indicate that the silty clay is soft to firm. The sensitivity of the silty clay ranged from 1.5 to 2.0, indicating a low sensitivity. The measured moisture content in the silty clay layer ranged from 40 to 46%.

The results of grain size analysis and Atterberg Limit tests conducted on a sample of the silty clay layer are illustrated in Figures B4 and B8 in Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	0
Silt	65
Clay	35

Soil Property	Percentage
Liquid Limit	33
Plastic Limit	20

The results of the Atterberg Limit test indicate that the silty clay typically has a low plasticity with group symbol CL.

## 5.6 Silt

A layer of silt with trace to some clay and trace sand was encountered below the silty clay in both boreholes. The silt deposit was 3.1 to 6.1 m thick and extended to depths from 13.3 to 14.8 m (Elev. 338.7 to 337.1 m).

SPT 'N' values measured in the silt ranged from 1 to 9 blows per 0.3 m penetration, indicating a very loose to loose density. The moisture content of the silt ranged from 19 to 32%.

The results of grain size analyses conducted on samples of the silt are illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	0 to 5
Silt	87 to 89
Clay	8 to 11

## 5.7 Sandy Silt to Silty Sand

Underlying the silt layer, a deposit of sandy silt to silty sand containing trace clay was encountered in both boreholes. The deposit ranged in thickness from 4.6 to 8.3 m and extended to depths from 19.4 to 21.6 m (Elev. 332.5 to 330.4 m).



SPT 'N' values measured in the sandy silt to silty sand ranged from 1 to 24 blows per 0.3 m penetration, indicating a very loose to compact density. The moisture content of the deposit ranged from 16 to 26%.

The results of grain size analyses conducted on samples of the silty sand are illustrated in Figure B6 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	70 to 80
Silt	18 to 27
Clay	2 to 3

## 5.8 Sand

Sand containing trace silt, was encountered below the sandy silt to silty sand in both boreholes and was overlying the bedrock. At the north abutment, the sand layer was approximately 15.6 m thick and extended to bedrock contact in Borehole 19-01 at approximately 35.0 m depth (Elev. 316.9 m). At the south abutment, the sand was approximately 6.2 m thick and extended to bedrock contact in Borehole 19-02 at a depth of approximately 27.8 m (Elev. 324.2 m).

The four Dynamic Cone Penetration Tests (DCPTs) conducted at the site (DCPT-03 to DCPT-06) were terminated upon refusal of 100 blows per 0.3 m penetration at depths ranging from 24.5 to 26.8 m (Elev. 327.5 to 325.1 m). Based on the termination depths, it is anticipated that the DCPTs were all terminated within the sand deposit.

SPT 'N' values measured in the sand typically ranged from 10 to 62 blows per 0.3 m penetration, indicating that the sand is compact to very dense. The measured moisture content in the sand ranged from 12 to 22%.

The results of grain size analyses conducted on samples of the sand are illustrated in Figure B7 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	90 to 95
Silt and Clay	5 to 10

## 5.9 Bedrock

Boreholes 19-01 and 19-02 encountered metasedimentary bedrock underlying the overburden soils described above. The bedrock was grey and generally described as moderately weathered to fresh. Bedrock was proved by coring 4.2 m in Borehole 19-01 and 3.9 m in Borehole 19-02. Table 5.1 below summarizes the depths and elevations to the top of bedrock. Several boreholes from the previous investigation (Boreholes 01, 04 and 05) encountered auger refusal at similar elevations to Table 5.1, however the presence of bedrock was not confirmed by coring. Based on the variation in the bedrock surface between the boreholes, it is likely that the bedrock surface is sloping downward from the south to the north.

**Table 5.1 - Depths and Elevations of Top of Bedrock**

Borehole	Top of Bedrock	
	Depth (m)	Elevation (m)
19-01	35.0	316.9
19-02	27.8	324.2

Photographs of the rock cores are included in Appendix A.

Total Core Recovery (TCR) and Solid Core Recovery (SCR) in the bedrock was generally 100% in both boreholes, except for Run #1 in Borehole 19-01, where the TCR and SCR were 79%. The Rock Quality Designation (RQD) determined from the recovered cores ranged between 15% and 43% for Run #1 in both boreholes, and between 63% and 95% for the deeper core runs. The RQD results indicate that the rock quality varies from very poor to poor in the upper portion of the bedrock, to fair to excellent in the lower portion.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was greater than 10 in the upper portion of the rock, and ranged from 0 to 5 in the deeper rock.

Average unconfined compressive strengths (UCS) of the rock typically ranged between 61 and 210 MPa, indicating the rock is strong to very strong. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes, as well as unconfined compression tests that were conducted on one sample from each borehole. The UCS test results and a summary of the point load tests results are presented in Appendix B.



## 5.10 Groundwater Conditions

Groundwater conditions were observed during drilling operations and the groundwater level was measured in a standpipe piezometer installed in Borehole 19-02. A summary of the water level measurements is provided in Table 5.2 below:

**Table 5.2 - Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
19-01	July 13, 2019	-	-	Water added to borehole for core drilling – no measurement
19-02	July 12, 2019	2.4	349.6	In Piezometer
	July 13, 2019	2.4	349.6	
	July 14, 2019	2.5	349.5	

The groundwater level measured in piezometers installed in two previous boreholes (01 and 04) ranged from 2.1 to 3.3 m deep (Elev. 349.9 to 348.6 m) between September 19 and 25, 2017.

The groundwater level should be assumed to reflect the local creek water level. The surface water level of Sandy Creek upstream and downstream of the bridge was measured at Elevation 346.64 m upstream to 346.57 m downstream of the culvert in October 2014, as shown on the site plan provided by MTO.

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

## 6. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by MTO.

RPM Drilling of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Kevin Kweon. The overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng., of Thurber.



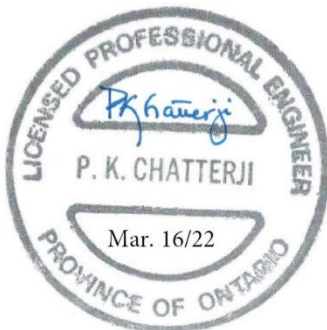
Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory. The UCS tests were conducted by Golder Associates Ltd. in Mississauga, Ontario.

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

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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7. GENERAL**

This report provides an interpretation of the geotechnical data in the factual report and presents foundation recommendations for design of the proposed Sandy Creek Culvert replacement; which is to be replaced with a single-span bridge.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The 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.

The site is located on Highway 105, approximately 7.3 km north of Highway 657, near Ear Falls in the District of Kenora, Ontario.

Information on the existing culvert was obtained from the MTO Terms of Reference, the Ontario Structure Inspection Manual (OSIM) prepared by MTO on January 8, 2018, and the site plan E-504931-105-1. The existing current structure consists of three (3) CSP culverts that are each 2 m in diameter and approximately 35.6 m in length. The existing highway embankment currently supports two undivided lanes of Highway 105, running in a generally northwest – southeast direction. Sandy Creek flows from north to south at the culvert site.



The highway at the culvert location is constructed on an embankment of approximately 6.5 m in height above the culvert inverts, and the side slopes of the existing embankment are sloped at approximately 2H:1V with rockfill on the surface of the embankment slopes above the culvert; particularly on the south side of the embankment. Surficial erosion and relatively deep gulying of the granular shoulder material has occurred along the south side of the embankment, extending beyond the rockfill protection. Based on existing survey information, the existing top of the highway grade is at approximate Elevation 352.0 m, and the invert levels of the three culverts are each at approximate Elevation 345.5 m.

Measurements collected in October 2014 indicate that the surface water level of Sandy Creek ranged from Elevation 346.64 m upstream to 346.57 m downstream of the culvert.

The General Arrangement (GA) drawing provided by MTO in February 2022 indicates that the replacement option planned for this site consists of a 29 m long single span, steel girder bridge, with 6 m long precast approach slabs at each abutment. The GA drawing depicts the bridge to be supported on H-pile foundations, with Retained Soil System (RSS) walls to retain the abutment fill.

A previous preliminary GA drawing dated May 2019, included sheet pile wall enclosures to retain the abutment fill before the design was updated to use RSS walls. Sheet pile wall recommendations are also included in this report.

The proposed works will include widening of the existing Highway 105 embankment, including fill placement on the existing slopes. Construction staging will be utilized during removal of the culvert and construction of the replacement bridge, which will include an inline temporary modular bridge (TMB) and temporary roadway protection systems to maintain one open lane for traffic. Additional embankment widening will be required to accommodate the TMB.

## **8. STRUCTURE FOUNDATIONS**

This section presents discussions on the proposed foundation alternatives for the proposed Sandy Creek bridge to replace the existing culvert.

In general, the subsurface stratigraphy at the site consists of embankment fill, varying from gravelly sand to silty clay, overlying deposits of firm to soft silty clay, very loose to compact silt to silty sand, and very loose to very dense sand, which are underlain by metasedimentary bedrock. The approximate bedrock elevation is 316.9 m at the north abutment and 324.2 m at the south abutment, indicating that the bedrock surface is likely sloping downward from the south to the



north. The groundwater level was measured in a piezometer at the south abutment at approximate Elevation 349.5 m.

Based on the subsurface conditions at the site, consideration was given to supporting the replacement bridge on the following foundation types:

- Spread footings placed on the existing embankment fill or native silty clay;
- Spread footings placed on engineered granular fill pads; and
- Steel H-piles driven to bedrock.

A comparison of the technical advantages and disadvantages of the alternative foundation options is presented in Appendix F.

### **8.1 Spread Footings on Existing Sand Fill / Silty Clay Fill / Native Silty Clay**

For founding the footings below the depth of frost (2.6 m) at this site, spread footings would need to be placed on the existing very loose sand fill at the north abutment and the firm silty clay fill at the south abutment, or lowered to be placed on native firm to soft silty clay at both abutments. This option is not recommended since the founding soils will not provide sufficient geotechnical resistance for footings and unacceptable settlement of the footings is likely to occur. In addition, footings placed on native soil would require significantly deep excavation through cohesionless fill that extends below the water table and would require dewatering.

### **8.2 Spread Footings on Engineered Fill Pads**

Spread footings placed on 1 to 1.5 m thick engineered granular fill pads are not recommended at this site, as the fill pads would likely be founded on the existing very loose sand fill at the north abutment and the firm silty clay fill at the south abutment. As noted in Section 8.1, these founding soils will not provide sufficient geotechnical resistance for footings and unacceptable settlement of the footings is likely to occur.

### **8.3 Steel H-Piles Driven to Bedrock**

#### **8.3.1 Pile Geotechnical Resistance**

Steel H-piles, driven to refusal on bedrock are recommended to support the replacement bridge abutments. The factored Geotechnical Resistances and the estimated tip elevations recommended for HP 310 x 110 piles driven to the bedrock surface are presented below in Table 8.1.

**Table 8.1 – Recommended Axial Geotechnical Resistances for Steel HP 310x110 Piles**

Foundation Element	Approximate Pile Tip Depth/Elevation Below Existing Ground (m)	Factored ULS Geotechnical Resistance Per Pile (kN)	SLS Resistance (kN)
North Abutment (Borehole 19-01)	35.0 / 316.9	2,800	Does not govern
South Abutment (Borehole 19-02)	27.8 / 324.2	2,800	Does not govern

The bedrock surface is anticipated to be sloping downward from the south abutment to the north abutment. Accordingly, the actual pile tip elevations may vary during installation, both longitudinally along the highway and laterally across the highway due to the uneven and sloping bedrock surface. The pile tip depths and elevations provided in Table 8.1 correspond to piles driven at the locations of Boreholes 19-01 and 19-02 only.

The axial geotechnical resistances based on the bedrock strength provided in Table 8.1 are expected to exceed the factored structural capacity of the pile. Accordingly, the structural capacity of the pile should be used for design (i.e. 2,000 kN per pile for HP 310 x 110, or 2,400 kN per pile for HP 310 x 132).

The SLS condition will not govern the design of piles founded on bedrock.

The structural resistance of the pile must be checked by the structural designer.

If there is no grade raise or embankment widening proposed, downdrag on the piles will not be an issue at this site.

### **8.3.2 H-Pile Installation**

Piles installation must be in accordance with OPSS.PROV 903.

Due to the possible presence of sloping bedrock or an uneven bedrock surface at the abutment locations, consideration should be given to equipping the pile tips with rock injector points from an approved manufacturer such as Titus Steel, or approved equivalent. This is to prevent the pile tip from sliding or skipping down the bedrock slope and to ensure the pile is fixed in a firm seat on the bedrock surface. Suggested text for an NSSP for sloping bedrock is included in Appendix H.



### 8.3.3 Pile Lateral Resistance

The geotechnical lateral resistance acting on an H-pile pile in cohesive soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$k_s = 67 S_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 S_u \quad (\text{kPa})$$

Where  $S_u$  = undrained shear strength (kPa)  
 $D$  = pile width or diameter (m)

The geotechnical lateral resistance acting on an H-pile in cohesionless soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$k_s = n_h z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (\text{kPa})$$

Where  $z$  = depth of embedment of pile (m)  
 $D$  = pile width or diameter (m)  
 $n_h$  = coefficient related to soil relative density ( $\text{kN/m}^3$ )  
 $\gamma'$  = effective unit weight ( $\text{kN/m}^3$ )  
 $K_p$  = passive earth pressure coefficient

For analysis of the interaction between a pile and the surrounding soil, the above equations and parameters recommended in Table 8.2 below, may be used. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

**Table 8.2 – Soil Parameters for Lateral Pile Resistance**

Abutment	Elevation (m)	$\gamma'$ Unit Weight* ( $\text{kN/m}^3$ )	$n_h$ ( $\text{kN/m}^3$ )	$K_p$	$S_u$ (kPa)	Soil Conditions
North (19-01)	351.9 to 350.5	19	3,000	3.0	-	Compact Gravelly Sand Fill
	350.5 to 349.5	18	3,000	3.0	-	Compact Sand Fill (Above Water Table)
	349.5 to 346.3	10*	2,000	3.0	-	Very Loose Sand Fill (Below Water Table)

Abutment	Elevation (m)	$\gamma'$ Unit Weight* (kN/m <sup>3</sup> )	$n_h$ (kN/m <sup>3</sup> )	$K_p$	$S_u$ (kPa)	Soil Conditions
	346.3 to 340.2	9*	-	-	25	Soft to Firm Silty Clay
	340.2 to 332.5	10*	1,500	2.8	-	Loose to Very Loose Silt to Sandy Silt
	332.5 to 316.9	10*	2,000	3.0	-	Compact to Dense Sand
South (19-02)	352.0 to 350.9	19	3,000	3.0	-	Compact Gravelly Sand Fill
	350.9 to 349.5	19	-	-	60	Stiff Silty Clay Fill (Above Water Table)
	349.5 to 347.9	9*	-	-	40	Firm Silty Clay Fill (Below Water Table)
	347.9 to 344.8	9*	-	-	25	Firm to Soft Silty Clay
	344.8 to 330.4	10*	1,500	2.8	-	Very Loose to Compact Silt to Silty Sand
	330.4 to 324.2	10*	2,000	3.0	-	Compact Sand

\*Bouyant unit weight below groundwater level

The spring constant,  $K_s$ , for analysis may be obtained by the expression,  $K_s = k_s L D$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $D$  is the pile width (m) and  $L$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} L D$ . This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Section C.6.11.3.4 of CHBDC 2019.

Horizontal loads may be resisted by means of battered piles (i.e. for H-pile case) if load requirements exceed the available lateral pile resistances.



#### **8.4 Frost Cover**

The depth of frost penetration at this site is approximately 2.6 m, as per OPSD 3090.100. Typically, the base of all footings must be provided with a minimum of 2.6 m of earth cover as protection against frost action.

If steel H-piles are adopted, the base of concrete pile caps should be provided with a minimum of 2.6 m of earth cover as protection against frost action. Alternately, consideration could be given to utilizing horizontal header beams instead of concrete pile caps, in which case the frost cover requirement would not apply.

### **9. EXCAVATION AND GROUNDWATER CONTROL**

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the granular fill, sand fill and silty clay fill above the groundwater level, as well as the native silty clay soils at this site are classified as Type 3 soils. The sand fill below the groundwater level and the native silt, native silty sand to sandy silt and native sand are classified as Type 4 soils.

Excavation and backfilling for the bridge construction should be carried out in accordance with OPSS 902. Excavations for construction of the abutment stems and RSS walls, and removal of the existing culverts will be carried out through the existing granular fill, sand fill, silty clay fill, and into the native silty clay. Any excavations below the groundwater or creek water level will require dewatering to lower the water level below the base of the excavation to permit construction in the dry and facilitate compaction of the backfill materials. In particular, seepage from the permeable sand fill should be expected when excavating below the groundwater and creek level.

A preliminary hydrogeological assessment was carried out by Thurber and summarized in the following memorandum, which is included in Appendix I:

- Memorandum – Preliminary Hydrogeological Assessment, Sandy Creek Culvert Replacement, Highway 105, 7.3 km North of Highway 657, District of Kenora, Ontario, File: 33098, dated March 16, 2022.

The hydrogeological assessment indicates that dewatered excavations for the abutment stem and RSS wall construction, which are below the measured groundwater level of 349.5 m and will extend as deep as Elevation 347.5 m, are anticipated to require water taking at rates near 400,000 L/day, and would require registration on the Environmental Activity and Sector Registry (EASR), or potentially a Permit to Take Water (PTTW). The hydrogeological assessment was based on



limited hydrogeological data only. Additional site investigation including installation of groundwater monitoring wells and conducting in situ hydraulic conductivity tests (“slug tests”) would be required to obtain additional data for a more detailed assessment.

In order to maintain dry excavations, the abutment stems and RSS walls could be constructed within watertight sheetpile enclosures. To form an effective groundwater cut-off, the sheetpiles should be embedded a minimum of 2 m into the underlying silty clay below the fill and sand layers where the foundations will be constructed. Provided that the sheetpiles have sufficient embedment, do not leak, and form a good seal with the silty clay or silt, the groundwater flow rate through the silty clay or silt is anticipated to be less than 50,000 L/day per abutment (assuming only half of the road is excavated at a time). In this case, registration on the EASR or a PTTW would not be required.

The design of dewatering systems, if utilized, is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902. SP FOUN0003 has been included in Appendix H.

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517. A preconstruction survey is not required, thus Designer Fill-In \*\* in SP FOUN0003 should be “N/A”. It is recommended that a Professional Engineer with greater than 5 years of experience in designing dewatering systems be retained. The dewatering plan must be signed/sealed by the P.Eng.

Dewatering must remain operational and effective until the excavations are complete and backfilled as necessary. Suggesting wording for an NSSP on Dewatering and Water-tight Sheetpile Enclosures is included in Appendix H.

## **10. ABUTMENT WALLS**

### **10.1 Retained Soil System (RSS) Walls**

The GA drawings indicate that the Highway 105 replacement bridge will utilize RSS wingwalls at the abutments. The RSS walls are shown to be approximately 6 to 12 m long in total and divided into stepped segments. The wall segments increase in heights from 1.7 to 3.2 m, with a base of approximate Elev. 349 m for the 3.2 m high walls closest to the abutments.

The contract drawings should include information on the longitudinal alignment of the RSS walls in plan, the top and base elevations of the walls in profile, cross-sectional space constraints and an NSSP for the RSS walls.



The performance of an RSS is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to excessive settlements and distortion of the RSS and, in severe cases, to possible failure of the system, especially when performing in the proximity to the watercourse. The foundation of the entire RSS mass should be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

The borehole information indicates that the soil conditions at and below the proposed wall base levels generally consist of very loose to dense sand fill, sand, and firm to soft silty clay below the groundwater level. To provide a uniformly competent subgrade, the RSS mass should be founded on an engineered granular fill pads. For a 2.5 m wide (from the wall panel to the furthest extent of the reinforcing strip) RSS mass (approximately 80% of the wall height), the fill pads should be a minimum of 1.5 m thick. The top of the engineered fill pads should be embedded a minimum of 1 m below the final ground surface at the wall location and setback a minimum of 2 m from the crest of the abutment forward slopes. As the base of RSS walls and the fill pads will extend below the groundwater table, dewatering or construction within watertight sheetpile enclosures will be required to maintain dry excavations and avoid potential wash out of fine materials within the fill pads. Any topsoil, organics, loose fill, and any soft/wet material should be stripped from the footprint of the RSS. The subgrade under the RSS foundations should be proof-rolled or inspected and any loose or soft areas sub-excavated and replaced with well compacted granular materials prior to placing the walls.

The engineered fill pad material placed under the RSS mass should consist of OPSS Granular A or Granular B Type II and should be placed and compacted in accordance with OPSS.PROV 501. The bedding should extend at least 500 mm beyond the limits of the entire RSS mass.

RSS walls founded on this material may be designed using the following geotechnical resistances:

**Table 10.1 – Geotechnical Resistances for RSS Walls**

<b>Geotechnical Resistance</b>	<b>Wall Height up to 3.2 m (with 1.5 m thick engineering fill pad)</b>
Factored Geotechnical Resistance at ULS (kPa)	160
Geotechnical Reaction at SLS (kPa)	110

The geotechnical resistances at SLS correspond to settlement up to 25 mm at the base of the RSS wall. The geotechnical resistance is for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design should be reduced in accordance with



the CHBDC 2019, Clause 6.10.5.3.

The entire block of reinforced earth should be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall may be estimated using an ultimate friction coefficient of 0.5 for an engineered granular fill subgrade.

The proprietary RSS system should meet the Ministry's specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design. The internal stability of the RSS wall should be analysed by the supplier/designer of the proprietary product selected for this site.

## 10.2 Sheet pile Walls

Sheet pile enclosures may be considered at the abutments to retain the abutment fill as an alternative to RSS walls or conventional abutment walls. The sheet piles would provide containment and resistance to lateral earth pressures from the approach fill.

Lateral stability of the sheet pile walls should be checked by the wall designer and the depths of penetration or sheet pile tip elevations determined using the geotechnical design parameters presented in Table 10.2.

The coefficients of passive earth pressure ( $K_p$ ) are provided for a horizontal ground surface in front of the sheet pile wall. For sloping ground in front of the sheet pile wall, the recommended values for the coefficients of passive earth pressure ( $K_p$ ) should be reduced.

**Table 10.2 – Soil Parameters for Sheet Pile Wall Design**

Abutment	Elevation (m)	$\gamma'$ Unit Weight* (kN/m <sup>3</sup> )	$\Phi$ (Angle of Internal Friction)	$K_a$	$K_p$	Soil Conditions
North (19-01)	351.9 to 350.5	19	30	0.33	3.0	Compact Gravelly Sand Fill
	350.5 to 349.5	18	30	0.33	3.0	Compact Sand Fill (Above Water Table)
	349.5 to 346.3	10*	30	0.33	3.0	Very Loose Sand Fill (Below Water Table)
	346.3 to 340.2	9*	25	0.41	2.5	Soft to Firm Silty Clay
	340.2 to 332.5	10*	28	0.36	2.8	Loose to Very Loose Silt to Sandy Silt



Abutment	Elevation (m)	$\gamma'$ Unit Weight* (kN/m <sup>3</sup> )	$\Phi$ (Angle of Internal Friction)	$K_a$	$K_p$	Soil Conditions
	332.5 to 316.9	10*	30	0.33	3.0	Compact to Dense Sand
South (19-02)	352.0 to 350.9	19	30	0.33	3.0	Compact Gravelly Sand Fill
	350.9 to 349.5	19	25	0.41	2.5	Stiff Silty Clay Fill (Above Water Table)
	349.5 to 347.9	9*	25	0.41	2.5	Firm Silty Clay Fill (Below Water Table)
	347.9 to 344.8	9*	25	0.41	2.5	Firm to Soft Silty Clay
	344.8 to 330.4	10*	28	0.36	2.8	Very Loose to Compact Silt to Silty Sand
	330.4 to 324.2	10*	30	0.33	3.0	Compact Sand

\*Bouyant unit weight below groundwater level

In general, backfill to the sheet pile walls should be in accordance with OPSS 902 and should consist of Granular A, Granular B Type II or III material. All granular material should meet the specifications of OPSS.PROV 1010. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501. If backfill is used behind the sheet pile walls, the coefficients of lateral earth pressure provided in Table 11.1 below should be used.

Full hydrostatic pressure should be considered assuming a water level at least equal to the design creek water level. The actual pressure distribution acting on the sheet piles is a function of the construction sequence and the relative flexibility of the wall, and these factors must be considered when designing the walls.

Design of the permanent sheet pile walls must consider environmental conditions such as road salts or fluctuating water levels that may cause corrosion and reduce the service life of the structure. The native soils in front of the sheet piles should be protected from creek erosion so that the sheet piles do not lose lateral support.

## 11. LATERAL EARTH PRESSURES

Backfill placed behind the bridge abutments should be placed in accordance with OPSS 902. All backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II or Type III conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 3101.150, as appropriate. Compaction equipment to be used adjacent to the walls should be restricted in accordance with OPSS.PROV 501.

Earth pressures acting on the abutment walls may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill and the underlying native soils. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K^*(\gamma h + q)$$

Where  $p_h$  = horizontal pressure on the wall at depth  $h$  (kPa)

$K$  = earth pressure coefficient (see table below)

$\gamma$  = unit weight of retained soil (see table below)

$H$  = depth below top of fill where pressure is computed (m)

$Q$  = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment walls are dependent on the material used as backfill. Typical values are shown in Table 11.1.

**Table 11.1 – Coefficients of Lateral Earth Pressure (K)**

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Existing Sand and Gravel Fill $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)
Active $K_A$ (Unrestrained Wall)	0.27	0.38*	0.31	0.46*



Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Existing Sand and Gravel Fill $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)
At rest $K_0$ (Restrained Wall)	0.43	-	0.47	-
Passive $K_P$ (Movement Towards Soil Mass)	3.7	-	3.3	-

\* For abutment walls, if required

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill which linearly decreases to 0 kPa at a depth of 1.7 m (for Granular B Type I) or at a depth of 2.0 m (for Granular A or B Type II).

## 12. TEMPORARY ROADWAY PROTECTION SYSTEM

The temporary roadway protection system should be implemented in accordance with OPSS PROV 539 and designed for Performance Level 2.

Options for roadway protection at this site include a soldier pile-lagging system or interlocking sheet piles. The soil parameters in Table 10.2 in Section 10 above may be used for the design of the temporary roadway protection system with horizontal backfill.

Full hydrostatic pressure should be considered assuming a water level at least equal to the design creek water level.

The design of temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors have to be considered when



designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

### 13. TEMPORARY MODULAR BRIDGE

An inline temporary modular bridge (TMB) is planned at this site for traffic staging purposes during construction of the replacement bridge. It is understood that the design of the temporary bridge is the responsibility of the contractor. The contractor will be responsible to retain a Professional Engineer, experienced in bridge design, to design the temporary bridge.

Widening of the Highway 105 embankment will be required to accommodate the width of the TMB. The widening will induce settlement of the foundation silty clay. Embankment widening, settlement and stability are discussed in Section 16 below. The TMB foundations should be constructed 3 months after the embankment widening to allow for settlement to be largely completed.

The modular bridge may be supported on precast concrete footings founded on engineered granular fill pads. Based on the project drawings, it is anticipated that the concrete footings will be 2.5 m wide and placed at approximately 1 m below the existing highway grade level, or approximate Elev. 351 m. The footings should be placed on engineered granular fill pads with a minimum thickness of 2 m, consisting of OPSS Granular A or Granular B Type II, placed in 150 mm thick lifts and compacted to 100% of the SPMDD at  $\pm 2\%$  of Optimum Moisture Content (OMC).

The footings should be embedded a minimum of 0.5 m below the finished grade in front of the footing. In order to meet the required ULS resistance below, the front edge of the footings should be set back a minimum of 3 m from the crest of the forward slopes at the top of the footing level.

The following geotechnical resistances are recommended for design of minimum 2.5 m wide concrete spread footings placed on minimum 2 m thick engineered granular fill pads prepared as outlined above with the underside of the fill pad at approximate Elev. 349 m:

<b>Geotechnical Resistance</b>	<b>Temporary Modular Bridge with 2.5 m Wide Spread Footings on 2.0 m Thick Engineered Fill Pads</b>
Factored Geotechnical Resistance at ULS	210
Geotechnical Resistance at SLS (for up to 25 mm settlement)	100



Resistance to lateral forces/sliding resistance between the concrete pad and the underlying Granular A or B Type II engineered fill should be calculated assuming an ultimate coefficient of friction of 0.55.

As discussed in Section 16, the forward slopes in front of the TMB abutments should be no steeper than 2H:1V and protected from erosion.

Since the contractor will be responsible for the temporary modular bridge design, it is recommended that the contractor retain a geotechnical consultant who is RAQs qualified at the medium complexity level (RAQs Category – Geotechnical Structures and Embankment – Medium Complexity) to design the footings and stable slopes in front of the footings for the temporary modular bridge. All final reports and drawings must be sealed and signed by a Professional Engineer, who shall also be a RAQs Designated Contact. An NSSP for this effect is attached in Appendix H.

#### **14. SEISMIC CONSIDERATIONS**

In accordance with the CHBDC 2019, the selection of the seismic site class is based on the soil conditions encountered in the upper 30 m of the stratigraphy. In view of the presence of firm to soft silty clay, and loose to very loose silt and silty sand to sandy silt deposits, the site is classified as Site Class E in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2,475-year return period seismic event at this site is 0.043 g as per the National Building Code of Canada (NBCC).

In accordance with Section 6.14.7 of the CHBDC 2019, retaining structures should be designed using active ( $K_{AE}$ ) and passive ( $K_{PE}$ ) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 14.1 may be used:



**Table 14.1 – Earth Pressure Coefficients for Earthquake Loading**

Condition	Earth Pressure Coefficient (K)				
	OPSS Granular A or Granular B Type II $\phi = 35^\circ$ , $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I $\phi = 32^\circ$ , $\gamma = 21.2 \text{ kN/m}^3$	Existing Granular Fill $\phi = 30^\circ$ ; $\gamma = 19 \text{ kN/m}^3$	Existing Sand Fill $\phi = 30^\circ$ ; $\gamma = 18 \text{ kN/m}^3$	Existing Silty Clay Fill / Native Silty Clay $\phi = 25^\circ$ ; $\gamma = 19 \text{ kN/m}^3$
Active ( $K_{AE}$ )*	0.30	0.34	0.37	0.37	0.44
At Rest ( $K_{OE}$ )**	0.53	0.57	0.60	0.60	0.68
Passive ( $K_{PE}$ )	3.6	3.2	2.9	2.9	2.4

\* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

\*\* After Woods

In view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

## 15. SCOUR AND EROSION PROTECTION

Erosion protection should be provided along any soil surfaces that may be in contact with the creek flow. In particular, adequate erosion protection must be provided to prevent loss of soils in front of the abutment walls.

Significant surficial erosion of the granular shoulder material along the south side of the embankment was observed during the field investigation. The eroded portion will likely be removed during excavation of the existing embankment to convert the culvert site to a bridge; however it is recommended that additional erosion protection should be added to the approach embankment slopes beyond the bridge abutments to prevent future loss of material. To channelize surface water flow to the erosion protection measures, an asphalt barrier curb in general accordance with OPSS 601.010 with a rock-lined ditch or other measures may be considered.

The erosion protection must be designed by specialists experienced in this field.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS.PROV 804.



## **16. APPROACH EMBANKMENTS, WIDENING, AND FORWARD SLOPES**

### General

The existing Highway 105 embankment at the culvert location is approximately 6.5 m in height with side slopes of approximately 2H:1V. The side slopes of the approach embankments appear to be in stable condition, however as noted above, the south side of the embankment show significant signs of surficial erosion along the granular highway shoulder.

The proposed works include widening of the existing Highway 105 approach embankments, including fill placement on the existing slopes. Widening is also required to accommodate the width of the temporary modular bridge (TMB).

Embankment construction and widening should be carried out in accordance with OPSS.PROV 206. The embankment material may consist of imported Granular A, Granular B Type II, or Granular B Type III material.

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

### Permanent Embankment Widening

The permanent widening of the approach embankments includes placement of up to 2 m thick and 3 m wide granular fill on the existing embankment slopes. The fill placement is expected to induce approximately 30 to 45 mm of settlement on the foundation silty clay under the widened section. The settlement is expected to be complete within 3 months of the completion of the fill placement. Maintenance of the existing pavement and shoulder may be required if the settlements have an impact on the highway pavement. Provided that the embankment widening is constructed of Granular A or B Type II, with a side slope of not steeper than 2H:1V, Figures G1 and G2 in Appendix G show that the embankments are expected to be stable, with a Factor of Safety of 1.5 for the short and long-term conditions. Proper steps must also be taken to mitigate erosion as described in Section 15, including erosion protection for the toes of the embankment slopes.

### TMB Embankment Widening

The proposed embankment widening to accommodate the TMB will cause up to 60 mm foundation settlement. Approximately 50% of the settlement will occur within one month following



fill placement. The settlement is expected to be mostly complete in approximately 3 to 4 months after fill placement. The widening fill should be placed 3 months ahead of construction of the TMB footings.

Based on the drawings, the base of the TMB footings will be at approximate Elev. 351 m, which will involve sub-excavation of approximately 1 m. Based on the footing base of Elev. 351 m, and provided that the embankment widening is constructed of Granular A or B Type II, with a side slope of 2H:1V, Figures G3 and G4 in Appendix G show that the temporary embankments are expected to be stable, with a Factor of Safety of 1.3 for the short and long-term conditions. Proper steps must also be taken to mitigate erosion as described in Section 15, including erosion protection for the toes of the embankment slopes.

#### Bridge Abutment Forward Slopes

The stability of the forward slopes in front of the replacement bridge and TMB abutments was also analysed.

The GA drawing shows the permanent bridge forward slopes to be inclined at approximately 2H:1V in front of the RSS abutment walls. The forward faces of the RSS walls must be setback a minimum of 2 m from the crest of the abutment forward slopes. Figures G5 and G6 in Appendix G show the stability analyses of the forward slopes, with Factors of Safety of 1.5 for the short-term and 1.4 for the long-term condition. Based on the typical degree of understanding for the site conditions, the Factor of Safety of 1.4 for the long-term condition is considered to be acceptable, and the forward slopes are expected to be stable.

The GA drawings show the TMB forward slopes to be inclined at approximately 2H:1V with a mid-height bench. The TMB footings should be setback a minimum of 2 m from the crest of the forward slopes (recommended to be 3 m in Section 13). Figures G7 and G8 in Appendix G show the TMB forward slopes are expected to be stable, with Factors of Safety of 1.7 and 1.6 for the short and long-term conditions respectively.

## **17. CONSTRUCTION CONCERNS**

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

- Cobbles, boulders and other buried obstructions may be encountered in the existing embankment fill and may interfere with excavation. Suggested wording for an NSSP on obstructions is included in Appendix H.



- The water level in the creek may fluctuate and be at higher elevation at the time of construction than indicated in the report.
- A suitable dewatering / unwatering system or groundwater cutoff must be employed during construction of pile stems and RSS walls to enable excavation in the dry and prevent sloughing and instability of the excavation walls.
- Firm to soft native silty clay deposits are present at this site and settlements will occur due to the proposed embankment widening.
- Appropriate erosion protection must be provided to prevent further loss of material along the highway embankment side slopes.
- The Contractor's selection of construction equipment and methodology should include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structures or fill (i.e., as a pad for crane support). Site conditions may limit the type of equipment suitable for use during construction. The design and safety of any temporary works is the responsibility of the Contractor. Suggested wording for an NSSP on Geotechnical Assessment for the use of heavy construction equipment is included in Appendix H.

## 18. CLOSURE

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

Thurber Engineering Ltd.



Mark Farrant, P.Eng.  
Associate, Senior Geotechnical Engineer



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Review Principal, Designated MTO Contact



## **Appendix A**

### **Record of Borehole Sheets**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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


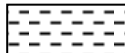



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

# UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ( $W_L < 30\%$ ).
		CI	Inorganic clays of medium plasticity, silty clays. ( $30\% < W_L < 50\%$ ).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

## EXPLANATION OF ROCK LOGGING TERMS

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

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

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

# RECORD OF BOREHOLE No 19-01

1 OF 5

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 524.8 E 283 581.8 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2019.07.12 - 2019.07.13 LATITUDE 50.685000 LONGITUDE -93.300265 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%) W <sub>P</sub> W      W <sub>L</sub>				GR	SA	SI	CL	
351.9	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (50mm)							20	40	60	80	100								
	Gravelly SAND, trace silt Compact Brown Moist (FILL)		1	GS			351						○					29	64	7 (SI+CL)
350.5			1	SS	19								○							
1.4	SAND, trace gravel, trace silt Compact to Very Loose Light Brown Moist (FILL)		2	SS	10		350						○							
			3	SS	3		349						○							
			4	SS	2		348						○							
			5	SS	2		347						○					1	94	5 (SI+CL)
346.3	Silty CLAY, trace sand, trace organics, wood chips Firm Grey Moist		6	SS	5		346							○						
344.7	Silty CLAY Soft to Firm Grey Moist (CL)		7	SS	0		345			+										
7.2			8	SS	0		344							○						
							343			1.7 +										
							342							○				0	0	65 35

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 19-01

2 OF 5

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 524.8 E 283 581.8 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2019.07.12 - 2019.07.13 LATITUDE 50.685000 LONGITUDE -93.300265 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
	Continued From Previous Page							20 40 60 80 100		20 40 60			
	Silty <b>CLAY</b> Soft to Firm Grey Moist (CL)		9	SS	1		341	2.0 +					
340.2													
11.7	<b>SILT</b> , some clay Loose to Very Loose Grey Moist		10	SS	5		340	2.0 +					
							339						
			11	SS	1		338						
337.1													
14.8	Sandy <b>SILT</b> , trace clay Very Loose to Loose Grey Wet		12	SS	1		337						
							336						
			13	SS	6		335						
							334						
			14	SS	9		333						
332.5													
19.4	<b>SAND</b> , trace silt Compact Grey Wet						332						

Continued Next Page

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

# RECORD OF BOREHOLE No 19-01

3 OF 5

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 524.8 E 283 581.8 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2019.07.12 - 2019.07.13 LATITUDE 50.685000 LONGITUDE -93.300265 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page		15	SS	10											
	SAND, trace silt Compact Grey Wet						331									
							330									
							329									
			16	SS	19		328									
							327									
							326									
			17	SS	20		325									
							324									
							323									
							322									
	Becoming Dense to Very Dense		18	SS	39											

Continued Next Page

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

# RECORD OF BOREHOLE No 19-01

4 OF 5

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 524.8 E 283 581.8 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2019.07.12 - 2019.07.13 LATITUDE 50.685000 LONGITUDE -93.300265 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100				W <sub>P</sub> W W <sub>L</sub>				
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
	<b>SAND</b> , trace silt Dense to Very Dense Grey Wet						321									
							320									
							319									
			19	SS	62		318									
316.9							317								FI	
35.0	<b>BEDROCK:</b> (METASEDIMENTARY), moderately weathered, grey, strong to very strong  Sub-horizontal fracture (25mm) at 35.5m and (50mm) at 36.0m  Sub-vertical fractures (200mm) at 36.2m and (75mm) at 37.5m  Sub-horizontal fractures (50mm) at 36.8m, (25mm) at 37.1m and 37.4m		1	RUN			316								>10 >10 2 2 1 0 1 1 2 2 0 1 1 2	RUN #1 TCR=79% SCR=79% RQD=43% UCS=107MPa (Average-Point Load)  RUN #2 TCR=100% SCR=100% RQD=63% UCS=106MPa (Average-Point Load) UCS TEST =61MPa  RUN #3 TCR=100% SCR=100% RQD=82% UCS=69MPa (Average-Point Load)
			2	RUN			315									
			3	RUN			314									
							313									
312.7																
39.2	END OF BOREHOLE AT 39.2m. BOREHOLE CAVED TO 4.9m BELOW GROUND SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m,															

Continued Next Page

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

ONTMT4S2 26535-MTO.GPJ 2017TEMPLATE(MTO).GDT 10/15/19

## METRIC

[illegible]

# RECORD OF BOREHOLE No 19-02

1 OF 4

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 515.6 E 283 607.4 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2019.07.09 - 2019.07.11 LATITUDE 50.684919 LONGITUDE -93.299903 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
352.0	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED    + FIELD VANE</div><div>● QUICK TRIAXIAL    × LAB VANE</div></div>					
0.0 0.1	<b>ASPHALT:</b> (75mm)		1	GS									
	Gravelly <b>SAND</b> , trace silt Compact Brown Moist (FILL)		1	SS	14		351						
350.9													
1.1	Silty <b>CLAY</b> , trace sand, trace gravel Stiff to Firm Grey/Brown Moist (FILL)		2	SS	8		350						0   1   48   51
			3	SS	4								
			4	SS	0		349						
347.9							348						
4.1	Silty <b>CLAY</b> , trace sand, trace gravel Firm to Soft Grey Wet		5	SS	0		347						
			6	SS	1		346						
344.8							345						
7.2	<b>SILT</b> , trace clay, trace sand Loose to Very Loose Grey Wet		7	SS	9		344						
			8	SS	4		343						0   5   87   8

Continued Next Page

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

# RECORD OF BOREHOLE No 19-02

2 OF 4

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 515.6 E 283 607.4 ORIGINATED BY KK  
 DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2019.07.09 - 2019.07.11 LATITUDE 50.684919 LONGITUDE -93.299903 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL LIMIT      MOISTURE      LIQUID CONTENT      LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%) W <sub>p</sub> W      W <sub>L</sub>				GR	SA	SI	CL	
	Continued From Previous Page							20	40	60	80	100								
	<b>SILT</b> , trace clay, trace sand Very Loose Grey Wet		9	SS	3		341							○						
							340							○						
				10	SS	3		339												
338.7																				
13.3	Silty <b>SAND</b> , trace clay Loose to Compact Grey Wet		11	SS	6		338							○						
							337													
				12	SS	11		336						○						
				13	SS	24		335						○						
								334							○					
				14	SS	24		333												

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 19-02

3 OF 4

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 515.6 E 283 607.4 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2019.07.09 - 2019.07.11 LATITUDE 50.684919 LONGITUDE -93.299903 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC      NATURAL      LIQUID LIMIT      MOISTURE      LIMIT CONTENT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE					w <sub>p</sub> w      w <sub>L</sub>				
	Continued From Previous Page						20	40	60	80	100						
	Silty <b>SAND</b> , trace clay Compact Grey Wet		15	SS	12										o	0 80 18 2	
330.4																	
21.6	<b>SAND</b> , trace silt Compact Grey Wet																
			16	SS	13										o		
															o		
			17	SS	15											0 95 5 (SI+CL)	
324.2			18	SS	100/												
27.8	<b>BEDROCK:</b> (METASEDIMENTARY), moderately weathered to fresh, grey, very strong Highly fractured (50mm) at 27.8m and 28.2m  Sub-horizontal fractures (50mm) at 27.9m and 28.23m  Sub-horizontal fracture (75mm) at 29.0m				0.075												
			1	RUN												RUN #1 TCR=100% SCR=100% RQD=15% UCS=179MPa (Average-Point Load)	
			2	RUN												RUN #2 TCR=100% SCR=100% RQD=95% UCS=136MPa (Average-Point Load) UCS TEST =131MPa	

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 19-02

4 OF 4

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 515.6 E 283 607.4 ORIGINATED BY KK  
 DIST Kenora HWY 105 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2019.07.09 - 2019.07.11 LATITUDE 50.684919 LONGITUDE -93.299903 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																				
	Continued From Previous Page																											
320.3	Sub-horizontal fracture (50mm) at 30.6m, 30.8m and 31.6m		3	RUN			321																					
31.7	END OF BOREHOLE AT 31.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 6.10m slotted screen.  WATER LEVEL READINGS <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2109.07.12</td> <td>2.4</td> <td>349.6</td> </tr> <tr> <td>2019.07.13</td> <td>2.4</td> <td>349.6</td> </tr> <tr> <td>2019.07.14</td> <td>2.5</td> <td>349.5</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2109.07.12	2.4	349.6	2019.07.13	2.4	349.6	2019.07.14	2.5	349.5															
DATE	DEPTH(m)	ELEV.(m)																										
2109.07.12	2.4	349.6																										
2019.07.13	2.4	349.6																										
2019.07.14	2.5	349.5																										

## METRIC

[illegible]

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

RECORD OF BOREHOLE No DCPT19-03 2 OF 3 METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 527.8 E 283 576.4 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2019.07.13 - 2019.07.13 LATITUDE 50.685027 LONGITUDE -93.300342 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
Continued From Previous Page														
							341							
							340							
							339							
							338							
							337							
							336							
							335							
							334							
							333							
							332							

Continued Next Page

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

**RECORD OF BOREHOLE No DCPT19-03 3 OF 3 METRIC**

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 527.8 E 283 576.4 ORIGINATED BY KK  
 DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2019.07.13 - 2019.07.13 LATITUDE 50.685027 LONGITUDE -93.300342 CHECKED BY MEF

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL LIMIT      MOISTURE      LIQUID CONTENT      LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			W <sub>p</sub> W      W <sub>L</sub> WATER CONTENT (%)						
	Continued From Previous Page								20   40   60   80   100						
									331						
									330						
									329						
									328						
									327						
									326						
325.5															
26.3	END OF DCPT AT 26.3m UPON REFUSAL.														

ONTMT452 26535-MTO.GPJ 2017TEMPLATE(MTO).GDT 10/11/19

RECORD OF BOREHOLE No DCPT19-04 1 OF 3 METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 514.0 E 283 610.2 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2019.07.11 - 2019.07.11 LATITUDE 50.684904 LONGITUDE -93.299863 CHECKED BY MEF

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)									
						○ UNCONFINED			+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE							
352.0	GROUND SURFACE																	
0.0	Start DCPT from surface																	

Continued Next Page

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

RECORD OF BOREHOLE No DCPT19-04 2 OF 3 METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 514.0 E 283 610.2 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2019.07.11 - 2019.07.11 LATITUDE 50.684904 LONGITUDE -93.299863 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80					
	Continued From Previous Page						342									
							341									
							340									
							339									
							338									
							337									
							336									
							335									
							334									
							333									

Continued Next Page

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

RECORD OF BOREHOLE No DCPT19-04 3 OF 3 METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 514.0 E 283 610.2 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2019.07.11 - 2019.07.11 LATITUDE 50.684904 LONGITUDE -93.299863 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
	Continued From Previous Page							20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	GR SA SI CL
							332									
							331									
							330									
							329									
							328									
							327									
326.2 25.9	END OF DCPT AT 25.9m UPON REFUSAL.															

ONTMT452 26535-MTO.GPJ 2017TEMPLATE(MTO).GDT 10/11/19

## METRIC

[illegible]

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

**RECORD OF BOREHOLE No DCPT19-05 2 OF 3 METRIC**

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 528.7 E 283 584.0 ORIGINATED BY KK  
 DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2019.07.11 - 2019.07.11 LATITUDE 50.685035 LONGITUDE -93.300234 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	W <sub>p</sub> W W <sub>L</sub>				
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100						
341														
340														
339														
338														
337														
336														
335														
334														
333														
332														

Continued Next Page

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

RECORD OF BOREHOLE No DCPT19-05 3 OF 3 METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 528.7 E 283 584.0 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2019.07.11 - 2019.07.11 LATITUDE 50.685035 LONGITUDE -93.300234 CHECKED BY MEF

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE			WATER CONTENT (%)							
	Continued From Previous Page								20 40 60 80 100							
									331							
									330							
									329							
									328							
									327							
									326							
325.1																
26.8	END OF DCPT AT 26.8m UPON REFUSAL.															

ONTMT452 26535-MTO.GPJ 2017TEMPLATE(MTO).GDT 10/11/19

## METRIC

[illegible]

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

RECORD OF BOREHOLE No DCPT19-06

2 OF 3

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 511.6 E 283 605.4 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2019.07.13 - 2019.07.13 LATITUDE 50.684882 LONGITUDE -93.299931 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
							341							
							340							
							339							
							338							
							337							
							336							
							335							
							334							
							333							
							332							

Continued Next Page

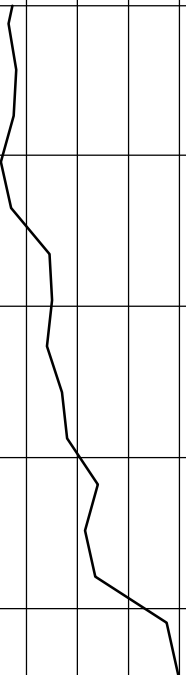
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No DCPT19-06

3 OF 3

METRIC

WP# 6373-14-01 LOCATION Sandy Creek Culvert Replacement N 5 616 511.6 E 283 605.4 ORIGINATED BY KK  
DIST Kenora HWY 105 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2019.07.13 - 2019.07.13 LATITUDE 50.684882 LONGITUDE -93.299931 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL LIMIT      MOISTURE      CONTENT      LIQUID W <sub>P</sub> W      W <sub>L</sub>			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE		WATER CONTENT (%)				
	Continued From Previous Page							20   40   60   80   100		20   40   60				
														
327.5														
24.5	END OF DCPT AT 24.5m UPON REFUSAL.													



**Photo A1: Borehole 19-01 Bedrock Core Sample**

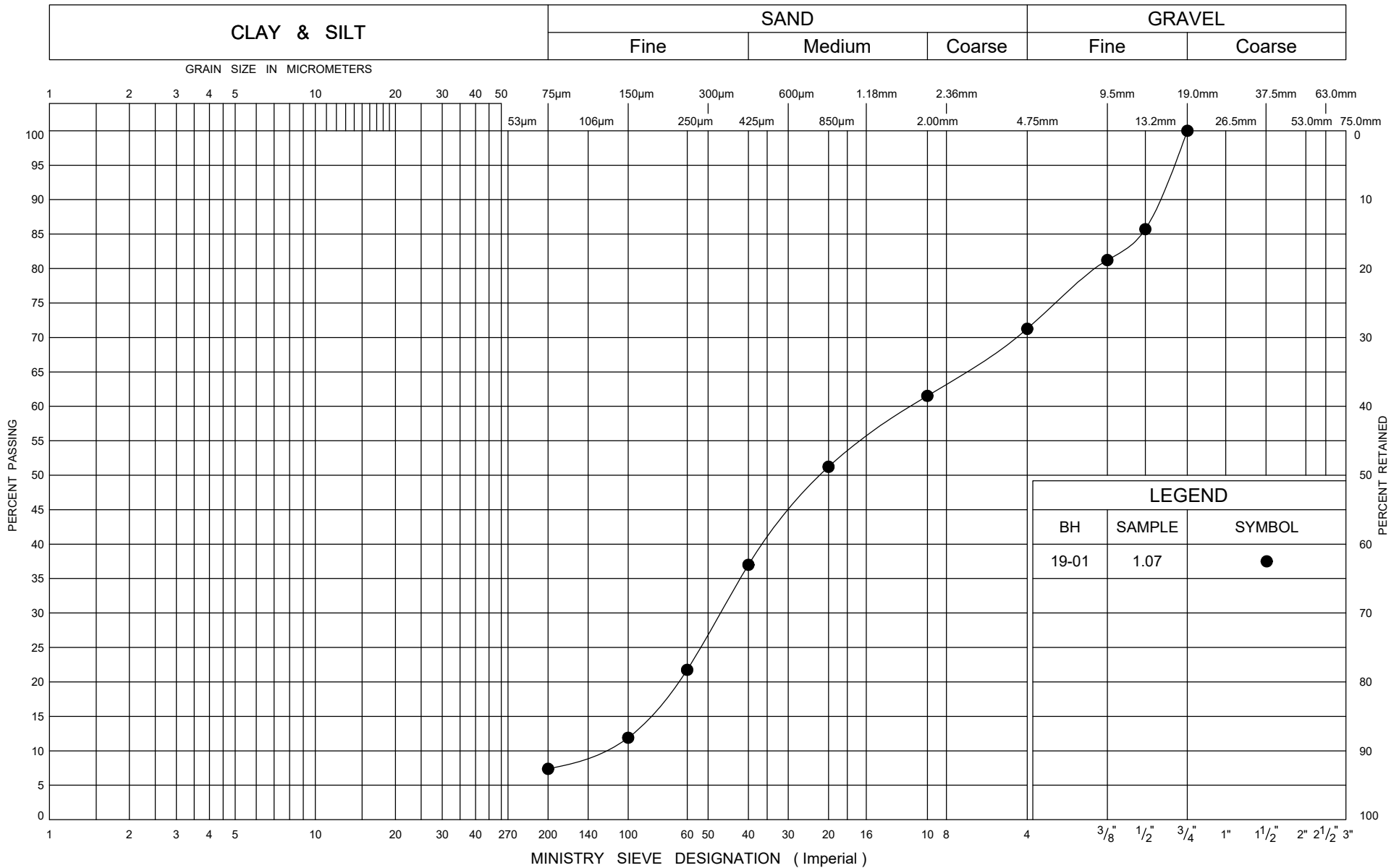


**Photo A2: Borehole 19-02 Bedrock Core Sample**



## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results**



Ministry of  
Transportation

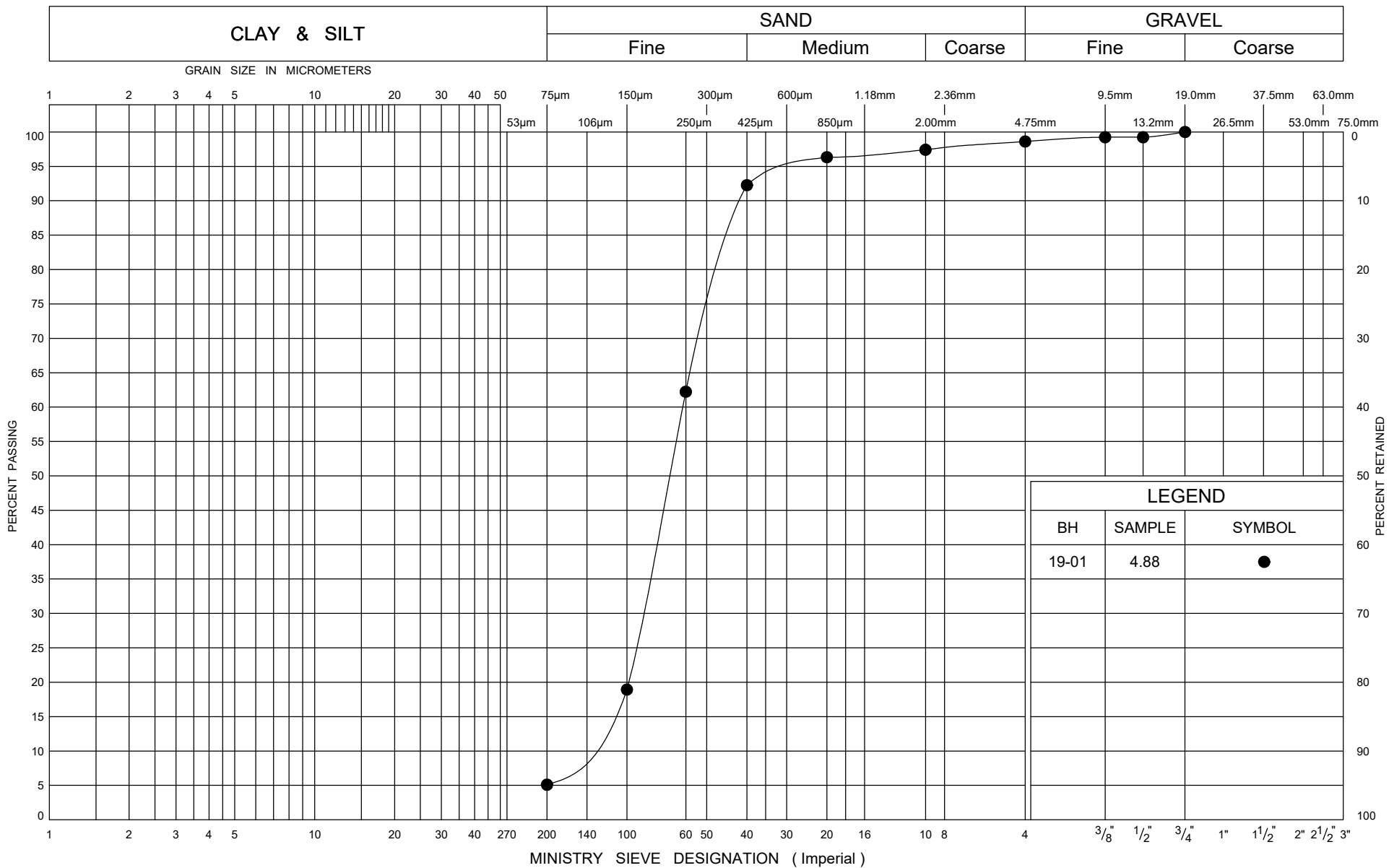
## GRAIN SIZE DISTRIBUTION

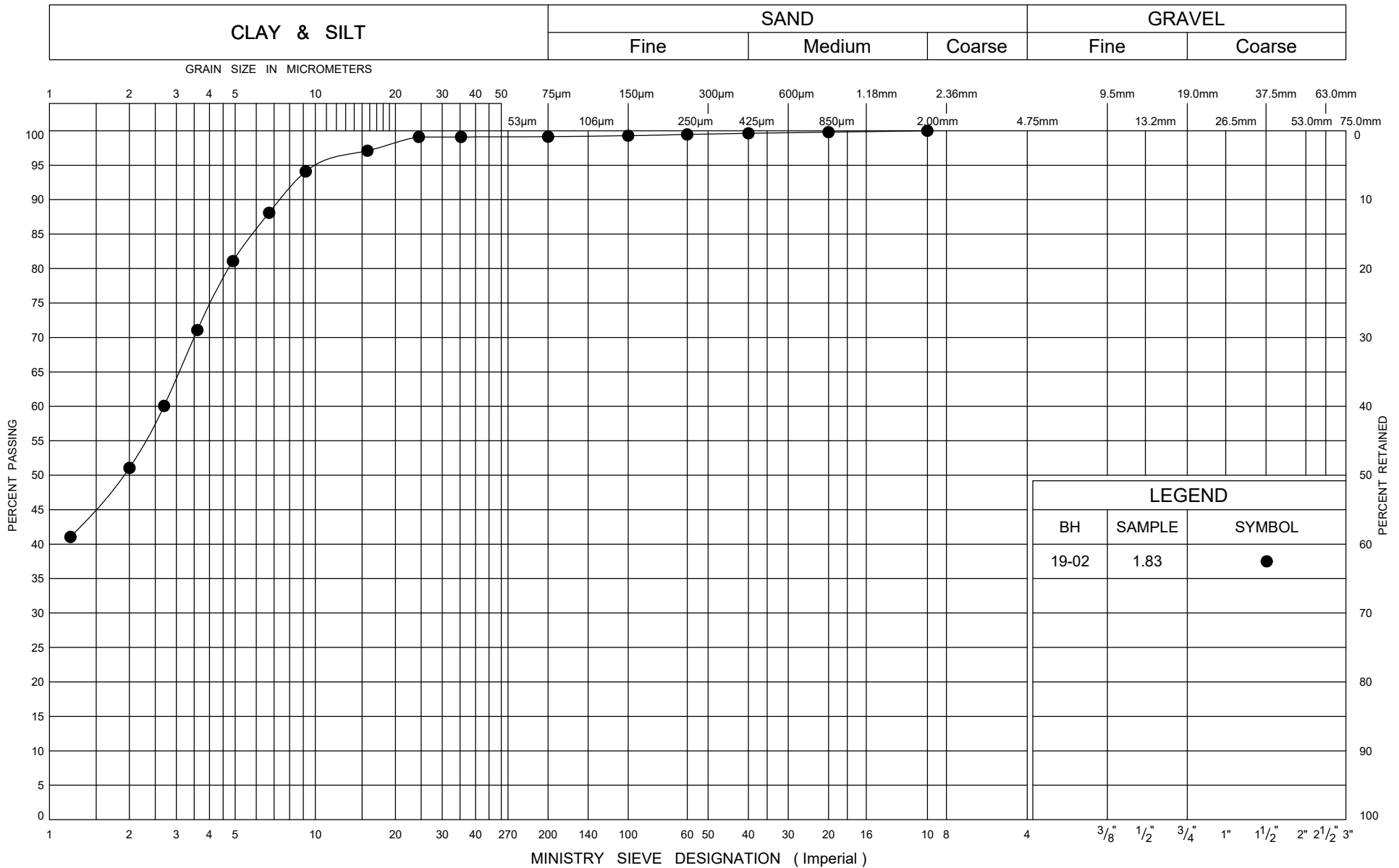
### Gravelly SAND FILL

FIG No B1

W P 6373-14-01

Sandy Creek Culvert Replacement





Ministry of  
Transportation

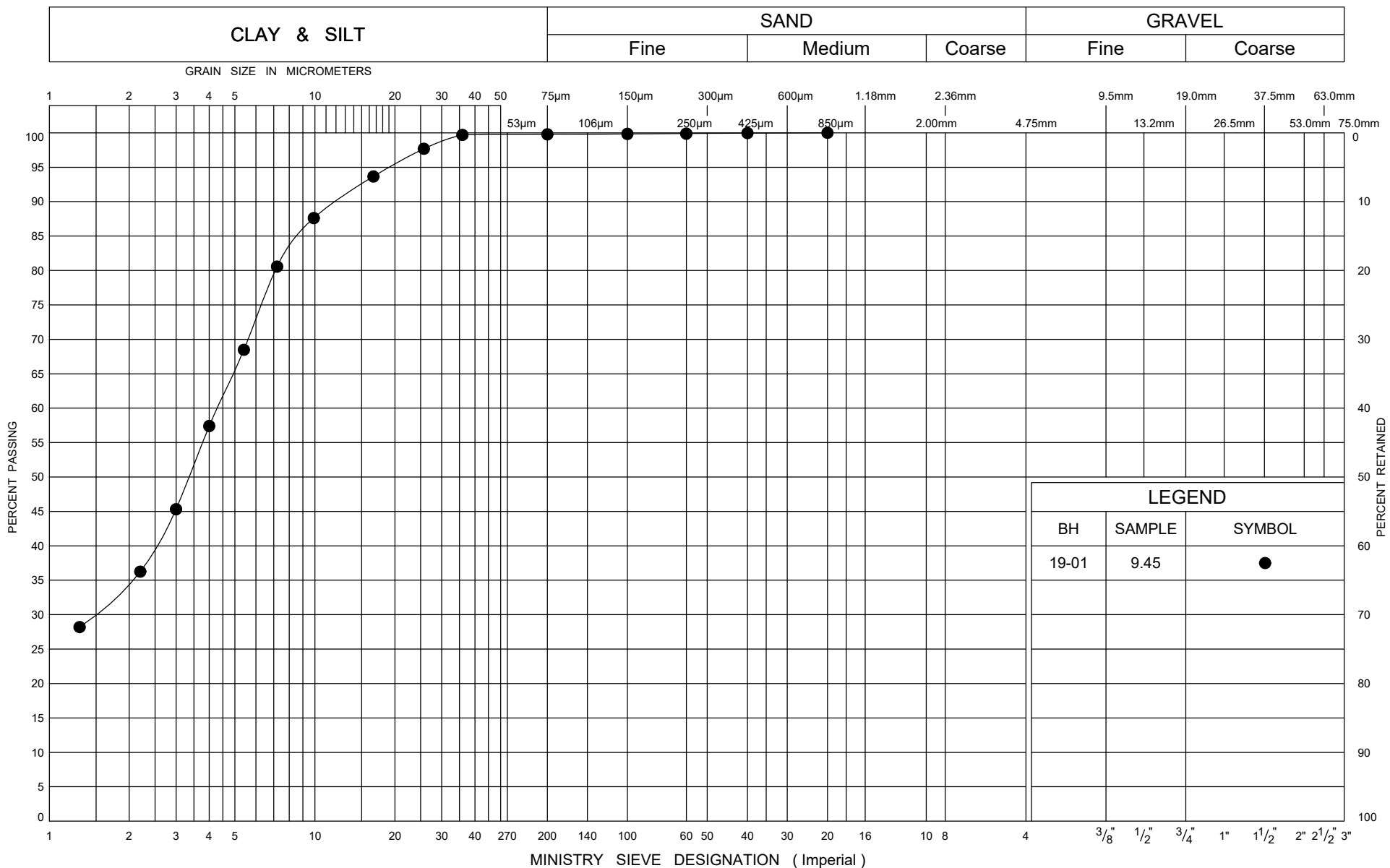
## GRAIN SIZE DISTRIBUTION

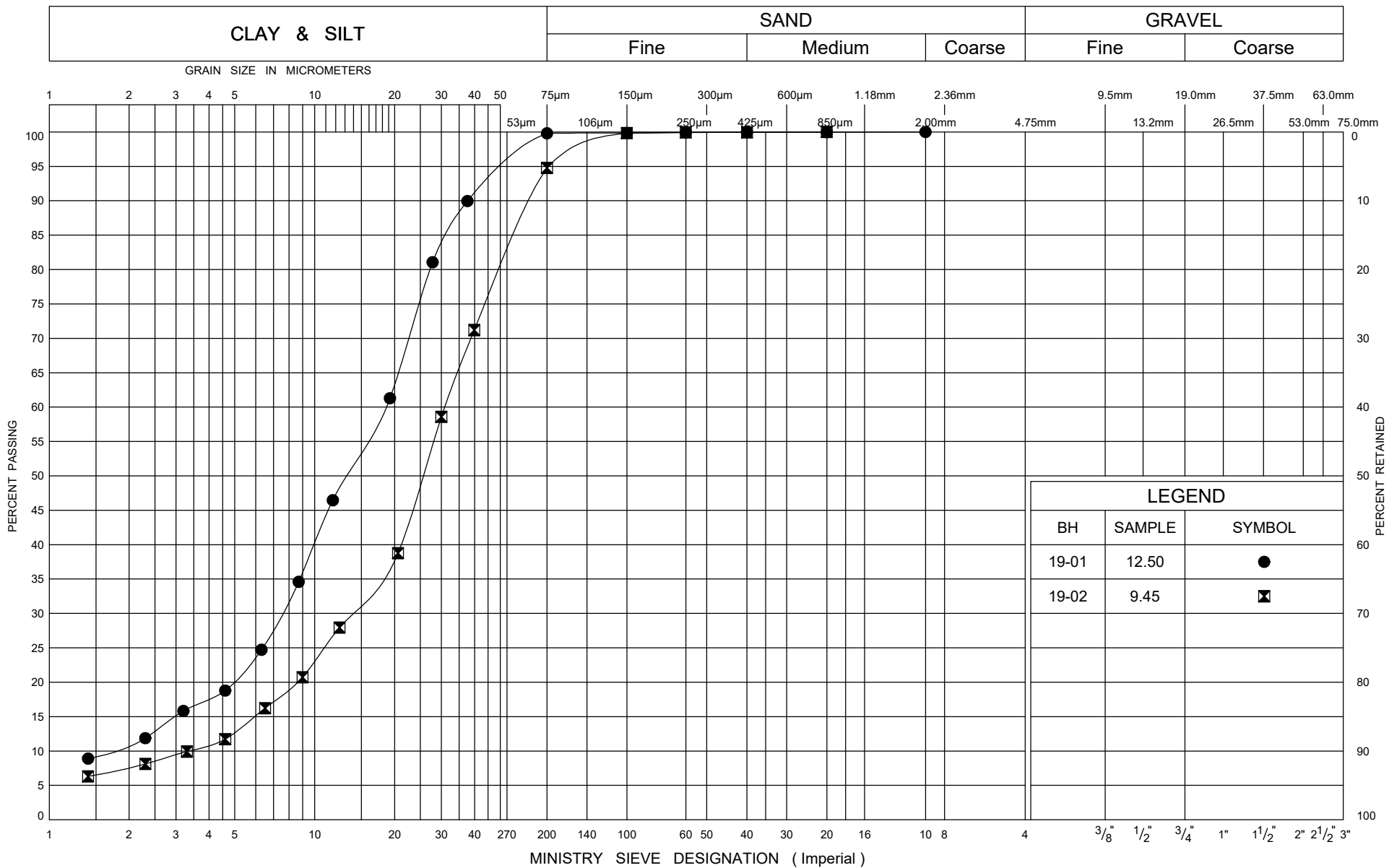
### Silty CLAY FILL

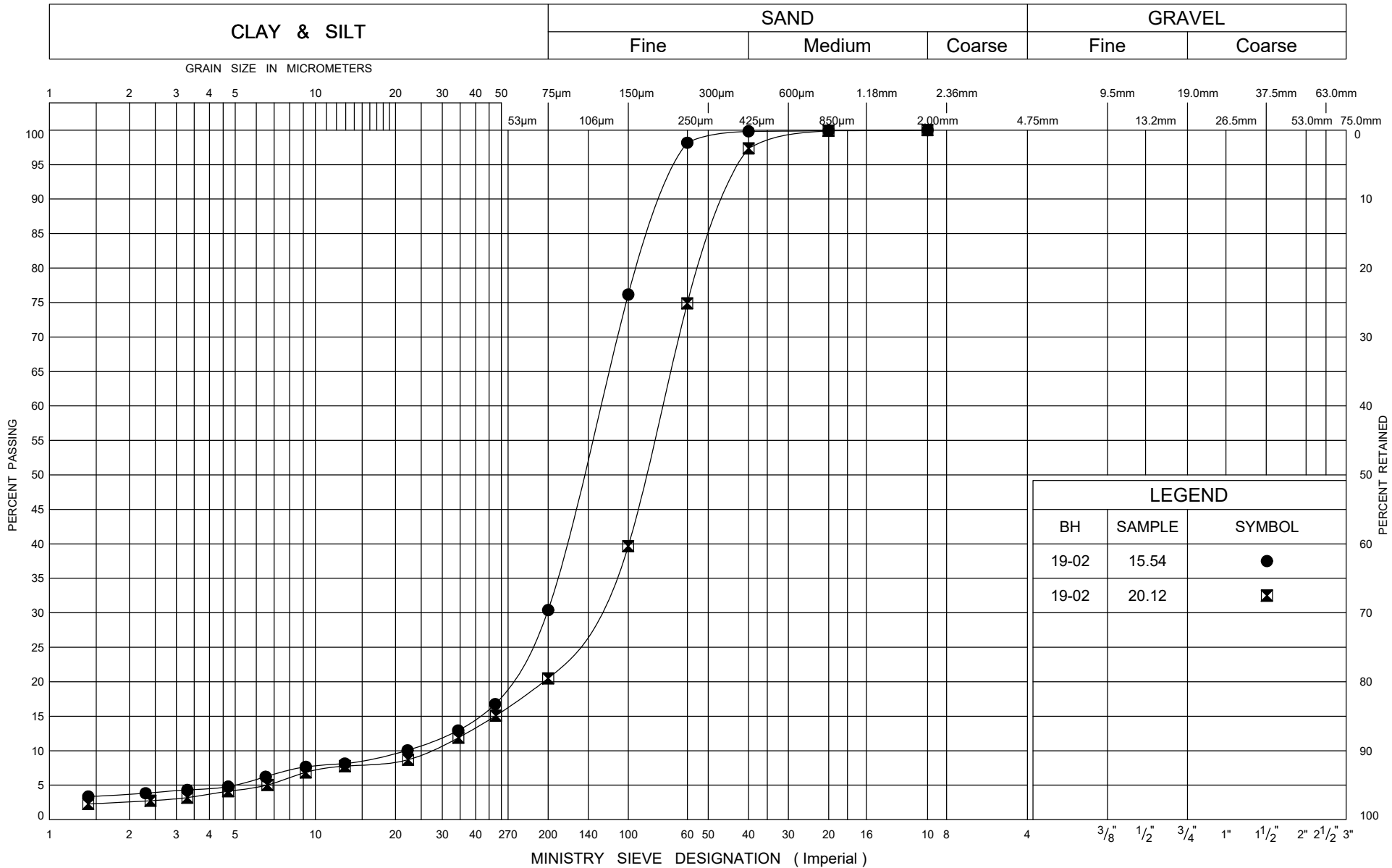
FIG No B3

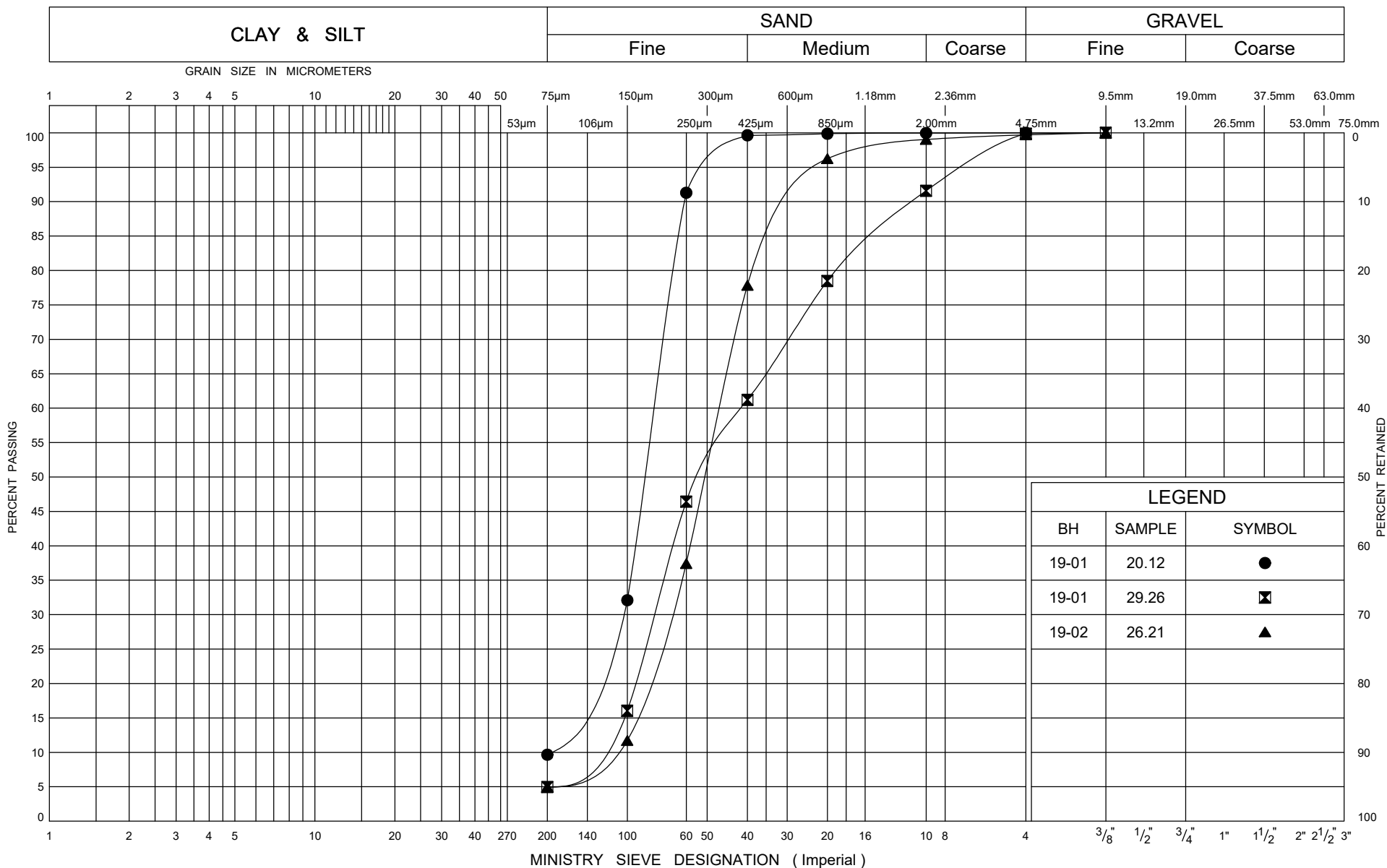
W P 6373-14-01

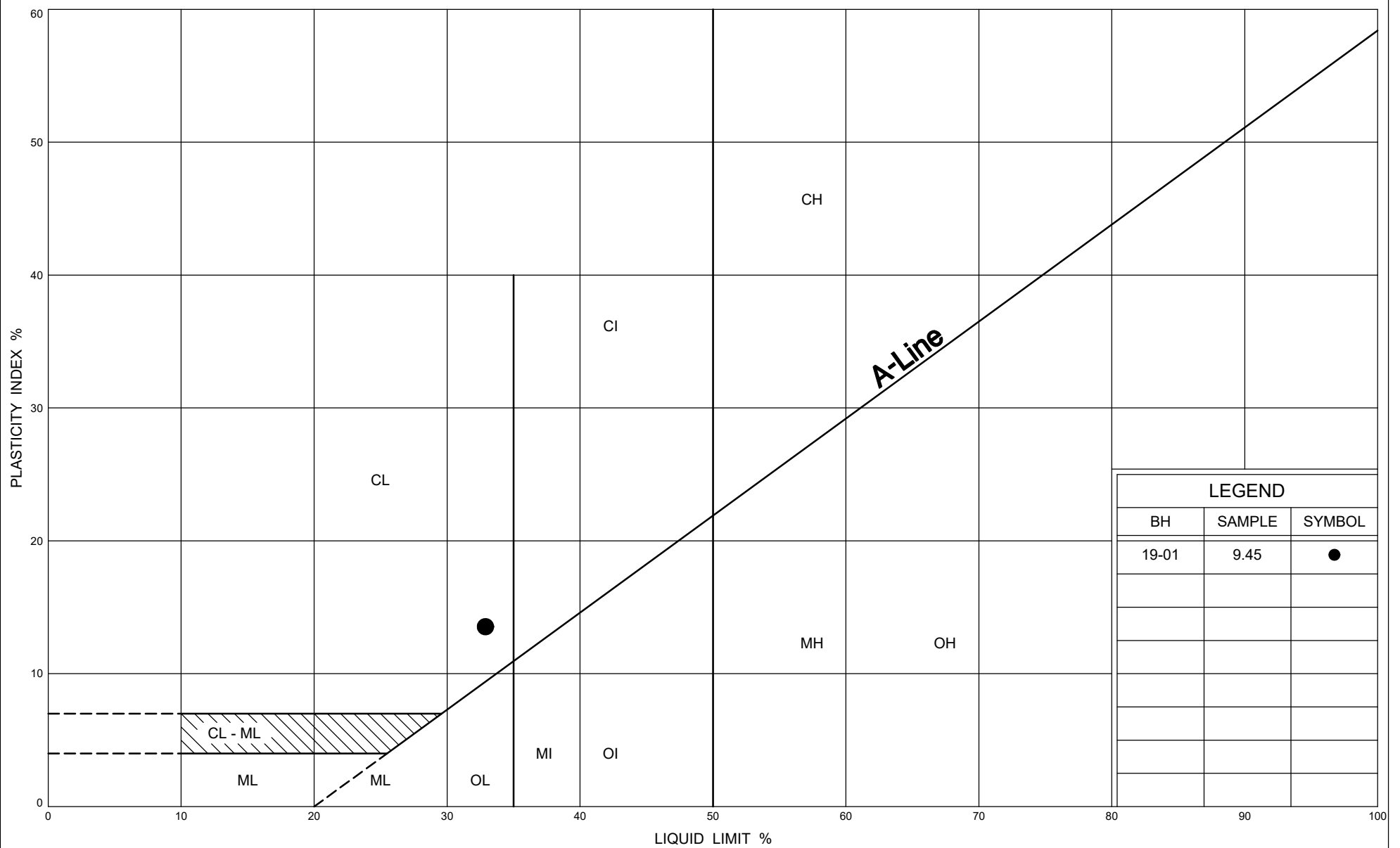
Sandy Creek Culvert Replacement











# POINT LOAD TEST SHEET

# ASTM D5731-08

<b>Job No:</b>	26535
<b>Client:</b>	HATCH
<b>Project Name:</b>	Sandy Creek Culvert
<b>Core Size:</b>	NQ <b>BH No :</b> 19-01

Date Drilled:	13-Jul-19
Date Tested:	09-Sep-19
Tester:	BS
Reviewed by:	RD

[illegible]



## POINT LOAD TEST SHEET

ASTM D5731-08

Date Drilled:	11-Jul-19
Date Tested:	09-Sep-19
Tester:	BS
Reviewed by:	RD

[illegible]

## UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

### ASTM D7012

#### SAMPLE IDENTIFICATION

PROJECT NUMBER	19116987(2000)	SAMPLE NUMBER	Run 2
PROJECT NAME	Thurber Engineering/Lab Testing/Miss	SAMPLE DEPTH, m	36.48-36.73
BOREHOLE NUMBER	19-01	DATE:	July, 2019

#### TEST CONDITIONS

MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.22

#### SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.54	WATER CONTENT, (specimen) %	0.10
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m <sup>3</sup>	27.29
SAMPLE AREA, cm <sup>2</sup>	17.62	DRY UNIT WT., kN/m <sup>3</sup>	27.26
SAMPLE VOLUME, cm <sup>3</sup>	185.72	SPECIFIC GRAVITY	-
WET WEIGHT, g	516.97	VOID RATIO	-
DRY WEIGHT, g	516.45		

#### VISUAL INSPECTION

#### FAILURE SKETCH



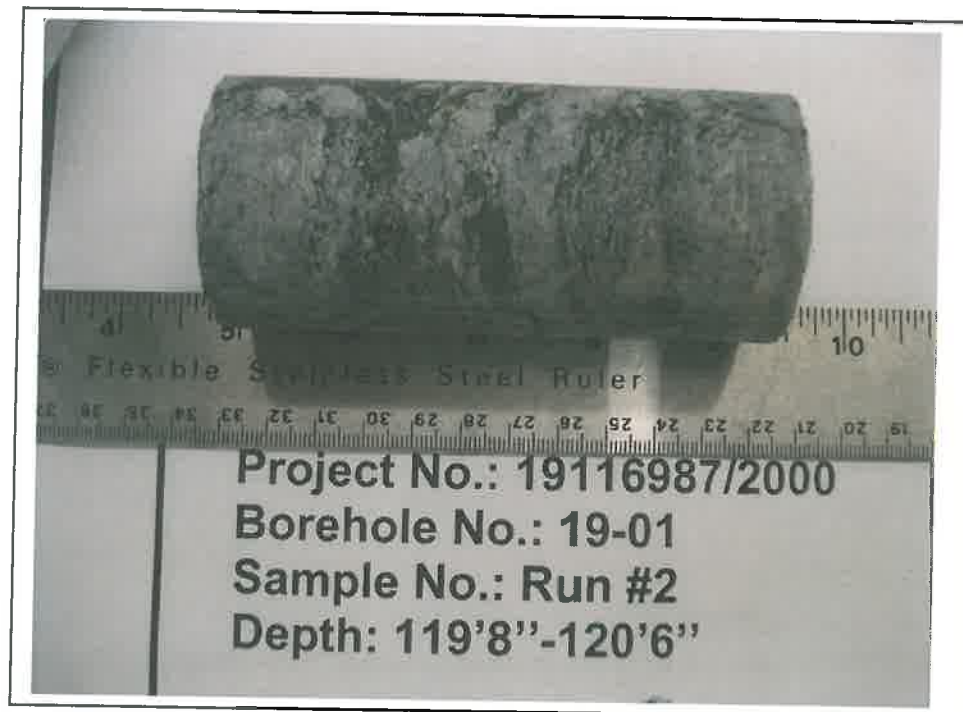
#### TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	60.6
----------------------	-----	---------------------------	------

REMARKS:

Checked By: 

**Golder Associates**



BEFORE COMPRESSION



AFTER COMPRESSION

Date Aug. 1, 2019  
Project 19116987(2000)

**Golder Associates**

Drawn Frank  
Chkd. 111

# UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

## ASTM D7012

### SAMPLE IDENTIFICATION

PROJECT NUMBER	19116987(2000)	SAMPLE NUMBER	Run 2
PROJECT NAME	Thurber Engineering/Lab Testing/Miss	SAMPLE DEPTH, m	29.3-29.59
BOREHOLE NUMBER	19-02	DATE:	July, 2019

### TEST CONDITIONS

MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.27

### SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.77	WATER CONTENT, (specimen) %	0.10
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m <sup>3</sup>	26.43
SAMPLE AREA, cm <sup>2</sup>	17.61	DRY UNIT WT., kN/m <sup>3</sup>	26.40
SAMPLE VOLUME, cm <sup>3</sup>	189.61	SPECIFIC GRAVITY	-
WET WEIGHT, g	511.21	VOID RATIO	-
DRY WEIGHT, g	510.70		

### VISUAL INSPECTION

### FAILURE SKETCH



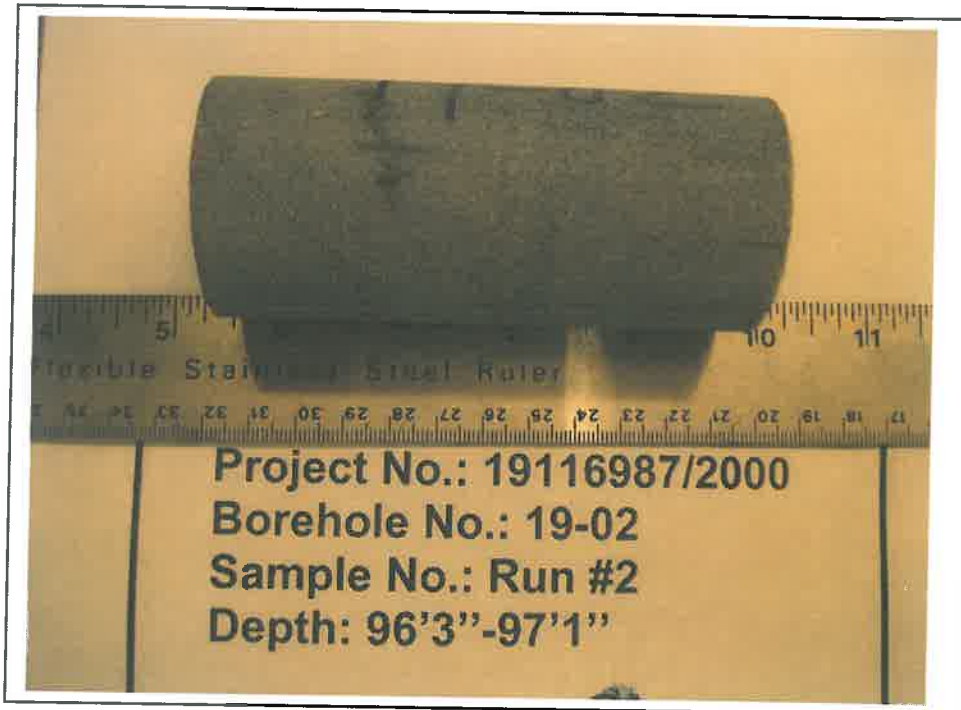
### TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	131.4
----------------------	-----	---------------------------	-------

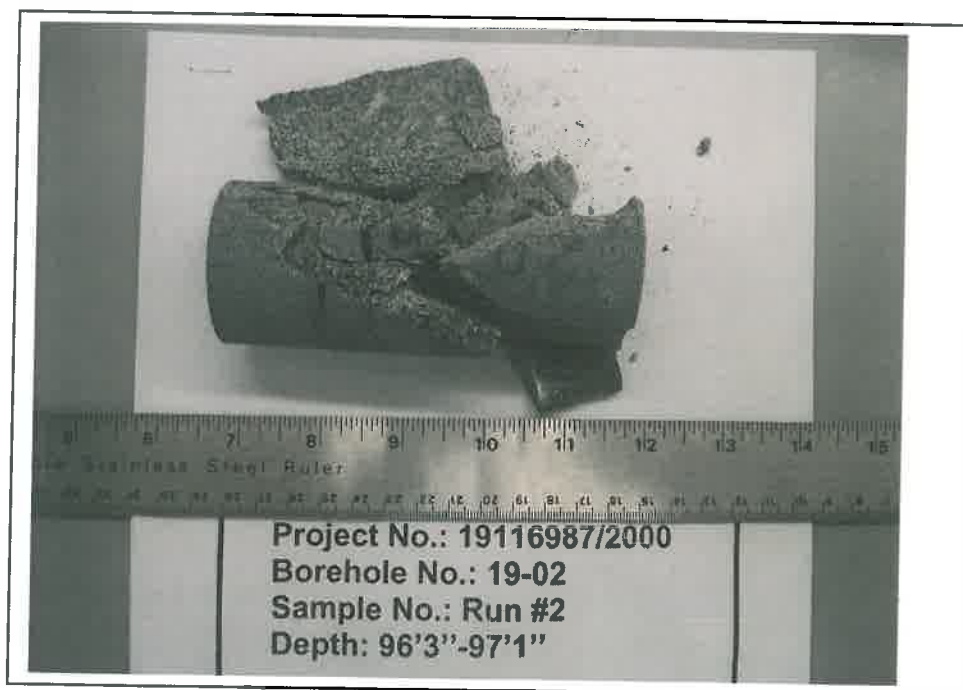
REMARKS:

Checked By: 

**Golder Associates**



BEFORE COMPRESSION



AFTER COMPRESSION

Date Aug. 1, 2019  
Project 19116987(2000)

**Golder Associates**

Drawn Frank  
Chkd. LM



## **Appendix C**

### **Site Photographs**



**Photo C1: Southeast approach facing northwest**

**(Date taken: July 14, 2019)**



**Photo C2: Northwest approach facing southeast**

**(Date taken: July 14, 2019)**



**Photo C3: Culvert inlet, facing east**

**(Date taken: July 14, 2019)**



**Photo C4: North side of southeast approach embankment, facing southeast**

**(Date taken: July 14, 2019)**



**Photo C5: North side of northwest approach embankment, facing southeast**

**(Date taken: July 14, 2019)**



**Photo C6: Culvert outlet and rockfill surface on south side of embankment, facing southeast approach (Date taken: July 14, 2019)**



**Photo C7: South side of southeast approach embankment, facing northwest**

**(Date taken: July 14, 2019)**



**Photo C8: South side of northwest approach embankment with rockfill surface, facing northwest**

**(Date taken: July 14, 2019)**



**Photo C9: South side of northwest approach embankment with surficial erosion, facing northwest**

**(Date taken: July 14, 2019)**



**Photo C10: South side of northwest approach embankment with surficial erosion, facing southeast (Date taken: July 14, 2019)**



**Photo C11: Surficial erosion of granular shoulder on south side of embankment, facing southeast  
(Date taken: July 14, 2019)**



**Photo C12: Close-up of erosion located northwest of culvert outlet and rockfill surface, facing north (Date taken: July 14, 2019)**



**Photo C13: Close-up of erosion located northwest of culvert outlet and rockfill surface, facing east  
(Date taken: July 14, 2019)**



**Photo C14: Surficial erosion of granular shoulder on south side of embankment, southeast of culvert outlet, facing northwest (Date taken: July 14, 2019)**

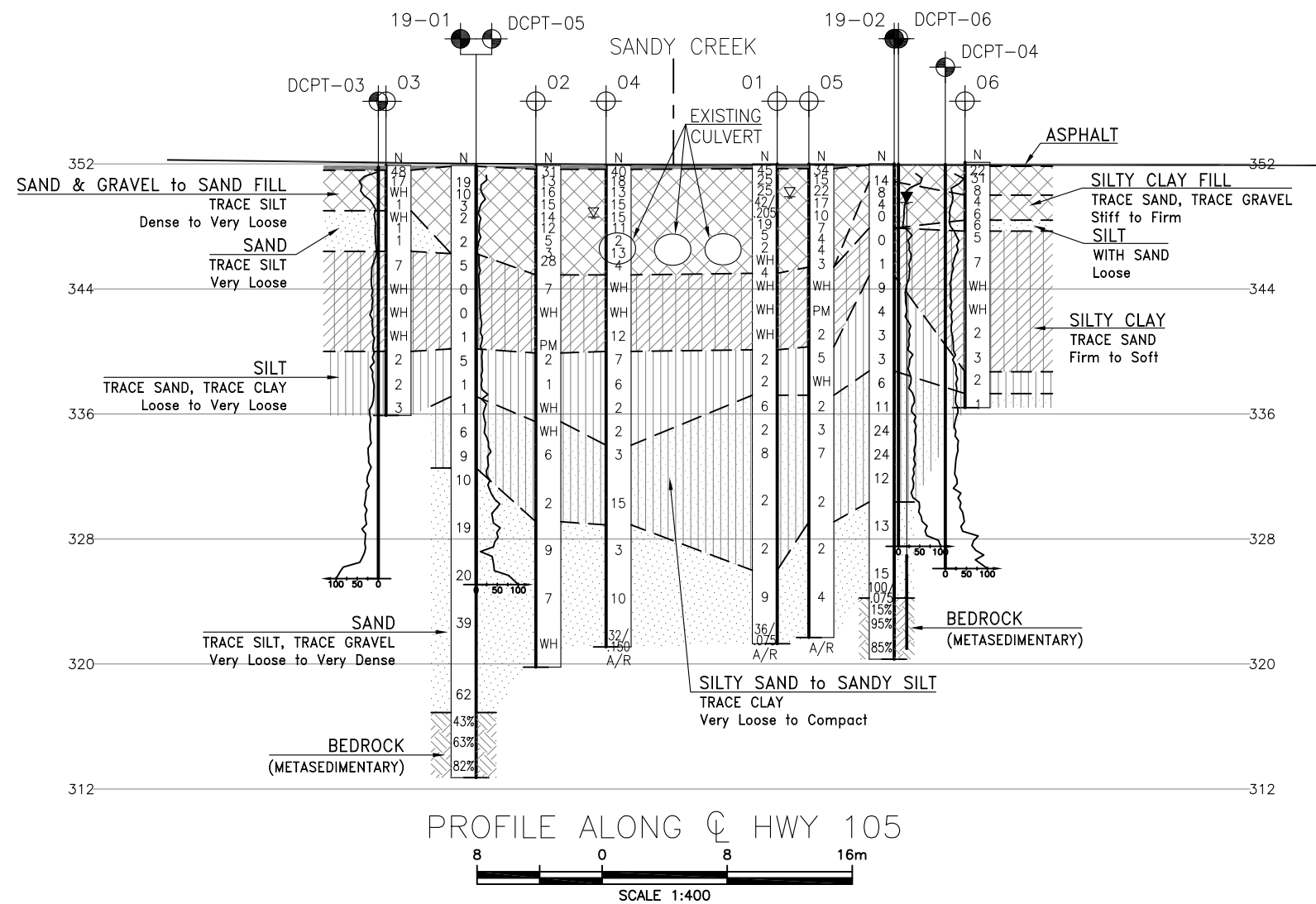
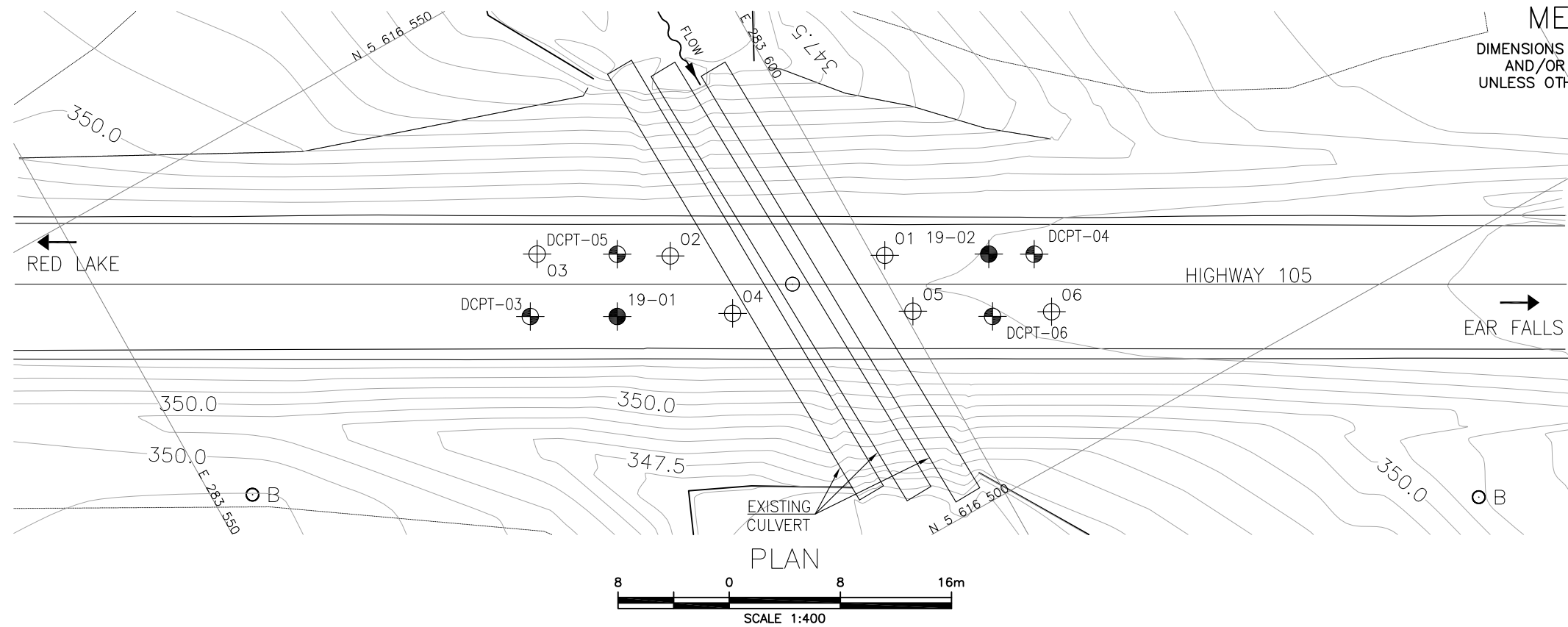


**Photo C15: Close-up of erosion located southeast of culvert outlet and rockfill surface, facing north (Date taken: July 14, 2019)**



## **Appendix D**

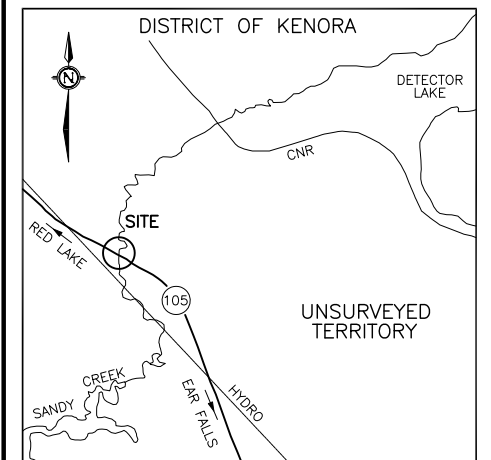
### **Borehole Locations and Soil Strata Drawing**



CONT No 2022-6023  
WP No 6373-14-01

HIGHWAY 105  
SANDY CREEK CULVERT  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

**HATCH**



KEYPLAN

LEGEND

	Borehole
	Borehole (By Others)
	Dynamic Cone Penetration Test
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
01	352.0	5 616 519.2	283 600.8
02	351.9	5 616 526.7	283 587.3
03	351.9	5 616 531.5	283 579.0
04	351.9	5 616 520.9	283 589.2
05	352.0	5 616 514.7	283 600.6
06	352.1	5 616 509.8	283 609.3
19-01	351.9	5 616 524.8	283 581.8
19-02	352.0	5 616 515.6	283 607.4
DCPT-03	351.9	5 616 527.8	283 576.4
DCPT-04	352.0	5 616 514.0	283 610.2
DCPT-05	351.9	5 616 528.7	283 584.0
DCPT-06	352.0	5 616 511.6	283 605.4

-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 16.

GEOCRES No. 52K-16

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK	PKC
DRAWN	BH	CHK	MEF
CODE	LOAD	DATE	MAR 2022
SITE	41N-242/C	STRUCT	DWG 1



## **Appendix E**

### **Record of Borehole Sheets (Previous Investigation)**

## LIST OF ABBREVIATIONS & DESCRIPTION OF TERMS

The abbreviations and terms, used to describe retrieved samples and commonly employed on the borehole logs, on the figures and in the report are as follows:

### 1. ABBREVIATIONS

AS	Auger Sample
CS	Chunk Sample
DS	Denison type sample
FS	Foil Sample
NFP	No Further Progress
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
RC	Rock core with size & percentage of recovery
SS	Split Spoon
ST	Slotted Tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash Sample
WH	Sampler advanced by static weight of hammer and/or rods
Rec	% recovery from individual run of rock core
RQD	Rock quality designation (%)

### 2. PENETRATION RESISTANCE/"N"

*Dynamic Cone Penetration Test (DCPT):*

A continuous profile showing the number of blows for each 300 mm of penetration of a 50 mm diameter 60° cone attached to AW rod driven by a 63 kg hammer falling 760 mm.

Plotted as —●—●—●—●—

*Standard Penetration Test (SPT) or "N" Values*

The number of blows of a 63 kg hammer falling 760 mm required to advance a 50 mm O.D. drive open sampler 300 mm.

### 3. SOIL DESCRIPTION

a) *Cohesionless Soils:*

"N" (blows/0.3 m)	Compactness Condition
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

b) *Cohesive Soils:*

Undrained Shear Strength (kPa)	Consistency
Less than 12	very soft
12 to 25	soft
25 to 50	firm
50 to 100	stiff
100 to 200	very stiff
over 200	hard

### 3. SOIL DESCRIPTION (Cont'd)

c) *Bedrock:*

RQD (%)	Classification
Less than 25	Very poor quality
25 to 50	Poor quality
50 to 75	Fair quality
75 to 90	Good quality
90 to 100	Excellent quality

d) *Method of Determination of Undrained Shear Strength of Cohesive Soils:*

+ 3.2 - Field Vane test in borehole.  
The number denotes the sensitivity to remoulding.

D - Laboratory Vane Test

" - Compression test in laboratory

For a saturated cohesive soil the undrained shear strength is taken as one-half of the undrained compressive strength.

e) *Soil Moisture:*

Moisture	Described as
Dry	Below optimum moisture content
Moist	Near optimum moisture content
Wet	Above optimum moisture content

### 4. TERMINOLOGY

Terminology used for describing soil strata is based on the proportion of individual particle sizes present in the samples (please note that, with the exception of those samples subject to a grain-size analysis, all samples were classified visually and the accuracy of visual examination is not sufficient to determine exact grain sizing):

Trace, or occasional	Less than 10%
Some	10 to 20%
With	20 to 30%
Adjective (i.e. silty or sandy)	30 to 40%
And (i.e. sand and gravel)	40 to 60%

Terminology for cobbles and boulders is based on auger response and field observations:

Occasional	Obstructions encountered in borehole, however advance is not impeded
Numerous	Obstructions are essentially continuous over drilled length

## METRIC

## RECORD OF BOREHOLE NO. 01



REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616519.2 E 283600.8 - (Unsurveyed Territory), Station 18+271 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 18 September 2017 TIME   
 DATE (Completed) 18 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
352.0	Ground Surface													
0.0	305 mm asphalt 460 mm crushed gravel  FILL - sand, gravelly, trace silt  brown  (dense/compact)		1	SS	45									41 55 (4)
			2	SS	25									
			3	SS	25									35 59 (6)
			4	SS	42/205 mm									
			5	SS	19									
			6	SS	5									
347.6	EMBANKMENT FILL - sand, with silt  grey  (very loose)		7	SS	2									
4.4			8	SS	WH									
			9	SS	4									0 77 (23)
345.0	SILTY CLAY - trace sand  occasional silt varves  trace wood upper 600 mm  (firm)		10	SS	WH									
7.0			11	SS	WH									0 1 50 49
	Continued Next Page													
COMMENTS							+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 100 kPa ○ 3% STRAIN AT FAILURE		WATER LEVEL RECORDS Date (dd/mm/yy)/Time    Water Depth (m)    Cave In (m) 1) 19/9/17 5:00:00 PM    2.1    - 2) 20/9/17 8:00:00 PM    2.1    - 3) 25/9/17 10:00:00 AM    2.1    -					

The stratification lines represent approximate boundaries. The transition may be gradual.

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MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC**

# RECORD OF BOREHOLE NO. 01



REFERENCE	P-0014089-0-00-100-01	DATUM	Geodetic	LOCATION	N 5616519.2 E 283600.8 - (Unsurveyed Territory), Station 18+271	ORIGINATED BY	JL
PROJECT	GWP 6373-14-00, Hwy 105	BOREHOLE TYPE	Track Mounted Mobile B37X - Hollow Stem Augers	COMPILED BY	DM		
CLIENT	Planmac Engineering Inc.	DATE (Started)	18 September 2017	TIME (Completed)		CHECKED BY	AT
		DATE (Completed)	18 September 2017				

[illegible]

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

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**METRIC**

# RECORD OF BOREHOLE NO. 01



REFERENCE	P-0014089-0-00-100-01	DATUM	Geodetic	LOCATION	N 5616519.2 E 283600.8 - (Unsurveyed Territory), Station 18+271	ORIGINATED BY	JL
PROJECT	GWP 6373-14-00, Hwy 105	BOREHOLE TYPE	Track Mounted Mobile B37X - Hollow Stem Augers	COMPILED BY	DM		
CLIENT	Planmac Engineering Inc.	DATE (Started)	18 September 2017	TIME			
		DATE (Completed)	18 September 2017	(Completed)		CHECKED BY	AT

[illegible]

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

## METRIC

## RECORD OF BOREHOLE NO. 02



REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616526.7 E 283587.8 - (Unsurveyed Territory), Station 18+286 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 20 September 2017 TIME   
 DATE (Completed) 21 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
351.9	Ground Surface												
0.0	255 mm asphalt 460 mm crushed gravel  FILL - sand, gravelly to some gravel, trace silt  (dense/very loose)		1	SS	31								
			2	SS	13								
			3	SS	16								37 58 (5)
			4	SS	15								
			5	SS	14								
			6	SS	12								
			7	SS	5								
			8	SS	3								
	trace wood encountered at a depth of 6.0 m		9	SS	28								18 75 (7)
344.9	SILTY CLAY, trace sand, trace wood grey (very stiff/stiff) occasional silt varves hydrocarbon odor detected at 7.6 m depth		10	SS	7								
7.0			11	SS	WH								
	Continued Next Page												
COMMENTS							+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 100 kPa ○ 3% STRAIN AT FAILURE						
							WATER LEVEL RECORDS Date (dd/mm/yy)/Time      Water Depth (m)      Cave In (m) 1)                                      -                                      - 2)                                      -                                      - 3)                                      -                                      -						

The stratification lines represent approximate boundaries. The transition may be gradual.

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MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC**

## RECORD OF BOREHOLE NO. 02



REFERENCE	P-0014089-0-00-100-01	DATUM	Geodetic	LOCATION	N 5616526.7 E 283587.8 - (Unsurveyed Territory), Station 18+286	ORIGINATED BY	JL
PROJECT	GWP 6373-14-00, Hwy 105	BOREHOLE TYPE	Track Mounted Mobile B37X - Hollow Stem Augers	COMPILED BY	DM		
CLIENT	Planmac Engineering Inc.	DATE (Started)	20 September 2017	TIME			
		DATE (Completed)	21 September 2017	(Completed)		CHECKED BY	AT

[illegible]

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC****RECORD OF BOREHOLE NO. 02**

REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616526.7 E 283587.8 - (Unsurveyed Territory), Station 18+286 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 20 September 2017 TIME   
 DATE (Completed) 21 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20	40	60	80	100	20	40	60	
	Continued from Previous Page		18	SS	2										
329.1							330								
22.8	SAND - trace gravel, trace silt (loose/very loose)						329								
			19	SS	9		328								
							327								
							326								
							325								
			20	SS	7		324								
							323								
							322								
							321								
321.0			21	SS	WH										
30.9	End of Sampling Start DCPT														
	Continued Next Page														

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.DDT 27/11/17

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**METRIC****RECORD OF BOREHOLE NO. 02**

REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616526.7 E 283587.8 - (Unsurveyed Territory), Station 18+286 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 20 September 2017 TIME   
 DATE (Completed) 21 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1) Continued from Previous Page	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40					
319.8 32.1	DCPT Practical Refusal End of Borehole													

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC**

## RECORD OF BOREHOLE NO. 03



REFERENCE	P-0014089-0-00-100-01	DATUM	Geodetic	LOCATION	N 5616531.5 E 283579.0 - (Unsurveyed Territory), Station 18+296	ORIGINATED BY	JL
PROJECT	GWP 6373-14-00, Hwy 105	BOREHOLE TYPE	Track Mounted Mobile B37X - Hollow Stem Augers	COMPILED BY	DM		
CLIENT	Planmac Engineering Inc.	DATE (Started)	25 September 2017	TIME			
		DATE (Completed)	25 September 2017	(Completed)		CHECKED BY	AT

[illegible]

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC****RECORD OF BOREHOLE NO. 03**

REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616531.5 E 283579.0 - (Unsurveyed Territory), Station 18+296 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 25 September 2017 TIME   
 DATE (Completed) 25 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued from Previous Page											
340.0			11	SS	WH		341					0 0 63 37
11.9	SILT - trace sand, trace clay grey (very loose)		12	SS	2		340					0 0 94 6
							339					
			13	SS	2		338					
	silty clay layers encountered						337					
			14	SS	3		336					
335.9	End of Sampling End of Borehole											
16.0												

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC****RECORD OF BOREHOLE NO. 04**

REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616520.9 E 283589.2 - (Unsurveyed Territory), Station 18+282 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 21 September 2017 TIME   
 DATE (Completed) 22 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE		STRATA PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)												
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)		NUMBER	TYPE			"N" VALUES	20						40	60	80	100	20	40	60					
351.9	Ground Surface																								
0.0	255 mm asphalt 660 mm crushed gravel  FILL - gravelly sand to sand, some gravel, trace silt  brown  (dense/very loose)		1	SS	40								36 59 (5)												
			2	SS	18																				
			3	SS	15								20 74 (6)												
			4	SS	13																				
			5	SS	15																				
			6	SS	15																				
			7	SS	11																				
			8	SS	2																				
			9	SS	13								14 79 (7)												
344.9	SILTY CLAY - trace sand with silt varves grey (very stiff)		10	SS	4																				
7.0																									
	(firm)		11	SS	WH								0 1 59 40												
	Continued Next Page																								
COMMENTS						+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 100 kPa ○ 3% STRAIN AT FAILURE		<b>WATER LEVEL RECORDS</b> <table border="1"> <thead> <tr> <th>Date (dd/mm/yy)/Time</th> <th>Water Depth (m)</th> <th>Cave In (m)</th> </tr> </thead> <tbody> <tr> <td>1) 23/9/17 7:50:00 AM</td> <td>3.3</td> <td>▽ - 變</td> </tr> <tr> <td>2) 23/9/17 5:30:00 PM</td> <td>3.3</td> <td>▽ -</td> </tr> <tr> <td>3) 25/9/17 8:00:00 AM</td> <td>3.3</td> <td>▽ -</td> </tr> </tbody> </table>						Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)	1) 23/9/17 7:50:00 AM	3.3	▽ - 變	2) 23/9/17 5:30:00 PM	3.3	▽ -	3) 25/9/17 8:00:00 AM	3.3	▽ -
Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)																							
1) 23/9/17 7:50:00 AM	3.3	▽ - 變																							
2) 23/9/17 5:30:00 PM	3.3	▽ -																							
3) 25/9/17 8:00:00 AM	3.3	▽ -																							
The stratification lines represent approximate boundaries. The transition may be gradual.																									

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**METRIC**

# RECORD OF BOREHOLE NO. 04



REFERENCE	P-0014089-0-00-100-01	DATUM	Geodetic	LOCATION	N 5616520.9 E 283589.2 - (Unsurveyed Territory), Station 18+282	ORIGINATED BY	JL
PROJECT	GWP 6373-14-00, Hwy 105	BOREHOLE TYPE	Track Mounted Mobile B37X - Hollow Stem Augers	COMPILED BY	DM		
CLIENT	Planmac Engineering Inc.	DATE (Started)	21 September 2017	TIME			
		DATE (Completed)	22 September 2017	(Completed)		CHECKED BY	AT

[illegible]

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC****RECORD OF BOREHOLE NO. 04**

REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616520.9 E 283589.2 - (Unsurveyed Territory), Station 18+282 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 21 September 2017 TIME   
 DATE (Completed) 22 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>		
	Continued from Previous Page														
			18	SS	2										
328.9							330								
23.0	SAND - trace gravel, trace silt (very loose/loose)						329								
			19	SS	3		328								
							327								
							326								
							325								
			20	SS	10		324								
							323								
							322								
321.1			21	SS	32/150 mm										
30.8	Auger Refusal End of Borehole														

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

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**METRIC**

## RECORD OF BOREHOLE NO. 05



REFERENCE	P-0014089-0-00-100-01	DATUM	Geodetic	LOCATION	N 5616514.7 E 283600.6 - (Unsurveyed Territory), Station 18+269	ORIGINATED BY	JL
PROJECT	GWP 6373-14-00, Hwy 105	BOREHOLE TYPE	Track Mounted Mobile B37X - Hollow Stem Augers	COMPILED BY	DM		
CLIENT	Planmac Engineering Inc.	DATE (Started)	22 September 2017	TIME (Completed)		CHECKED BY	AT
		DATE (Completed)	23 September 2017				

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT			NATURAL MOISTURE CONTENT			LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
352.0	Ground Surface						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>					
0.0	305 mm asphalt 460 mm crushed gravel  FILL - gravelly sand to sand, some gravel, trace silt  brown  (dense/loose)		1	SS	34							○							
			2	SS	15							○							
			3	SS	22							○							
			4	SS	17							○							
			5	SS	10							○							
			6	SS	7							○							
			7	SS	4							○							
	grey wet at a depth of 5.3 m		8	SS	4							○							
			9	SS	3							○							
345.4	SILTY CLAY - trace sand																		
6.6	grey  (very stiff/firm)		10	SS	WH														
			11	SS	PM														
	Continued Next Page																		

COMMENTS	+ <sup>3</sup> , × <sup>3</sup> : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 100 kPa  ○ 3% STRAIN AT FAILURE	WATER LEVEL RECORDS			
		Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)	
		1)	-	▽	-
		2)	-	▽	-
		3)	-	▽	-

The stratification lines represent approximate boundaries. The transition may be gradual

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC**

## RECORD OF BOREHOLE NO. 05



REFERENCE	<u>P-0014089-0-00-100-01</u>	DATUM	<u>Geodetic</u>	LOCATION	<u>N 5616514.7 E 283600.6 - (Unsurveyed Territory), Station 18+269</u>	ORIGINATED BY	<u>JL</u>
PROJECT	<u>GWP 6373-14-00, Hwy 105</u>	BOREHOLE TYPE	<u>Track Mounted Mobile B37X - Hollow Stem Augers</u>	COMPILED BY	<u>DM</u>		
CLIENT	<u>Planmac Engineering Inc.</u>	DATE (Started)	<u>22 September 2017</u>	TIME			
		DATE (Completed)	<u>23 September 2017</u>	(Completed)		CHECKED BY	<u>AT</u>

[illegible]

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC****RECORD OF BOREHOLE NO. 05**

REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616514.7 E 283600.6 - (Unsurveyed Territory), Station 18+269 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 22 September 2017 TIME   
 DATE (Completed) 23 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
	Continued from Previous Page						20	40	60	80	100	20	40	60	GR SA (SI CL)		
329.1	SAND - trace gravel, trace silt grey (very loose)		18	SS	2												
329																	
328																	
327																	
326																	
325																	
324																	
323																	
322																	
321.7	Auger Refusal End of Borehole																
30.3																	

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC**

## RECORD OF BOREHOLE NO. 06



REFERENCE	<u>P-0014089-0-00-100-01</u>	DATUM	<u>Geodetic</u>	LOCATION	<u>N 5616509.8 E 283609.3 - (Unsurveyed Territory), Station 18+259</u>	ORIGINATED BY	<u>JL</u>
PROJECT	<u>GWP 6373-14-00, Hwy 105</u>	BOREHOLE TYPE	<u>Track Mounted Mobile B37X - Hollow Stem Augers</u>	COMPILED BY	<u>DM</u>		
CLIENT	<u>Planmac Engineering Inc.</u>	DATE (Started)	<u>23 September 2017</u>	TIME			
		DATE (Completed)	<u>23 September 2017</u>	(Completed)		CHECKED BY	<u>AT</u>

[illegible]

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17

**METRIC****RECORD OF BOREHOLE NO. 06**

REFERENCE P-0014089-0-00-100-01 DATUM Geodetic LOCATION N 5616509.8 E 283609.3 - (Unsurveyed Territory), Station 18+259 ORIGINATED BY JL  
 PROJECT GWP 6373-14-00, Hwy 105 BOREHOLE TYPE Track Mounted Mobile B37X - Hollow Stem Augers COMPILED BY DM  
 CLIENT Planmac Engineering Inc. DATE (Started) 23 September 2017 TIME   
 DATE (Completed) 23 September 2017 (Completed)  CHECKED BY AT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							W <sub>p</sub> W                      W <sub>L</sub>		
								○ UNCONFINED                      + FIELD VANE							WATER CONTENT (%)		
								● QUICK TRIAXIAL                      × LAB VANE									
	Continued from Previous Page							20   40   60   80   100									
	with silt layers		11	SS	2		342										
	transition to clayey silt at a depth of 11.9 m						341										
							340										
			12	SS	3												
							339										
338.7																	
13.4	SILT, trace sand, trace clay (very loose)		13	SS	2		338										
337.3																	
14.8	SILTY SAND  grey (very loose)						337										
			14	SS	1												
336.4																	
15.7	End of Sampling End of Borehole																

MEL-GEO P-0014089 - SANDY CREEK LOGS.GPJ MEL-GEO.GDT 27/11/17



## **Appendix F**

### **Foundation Comparison**

### COMPARISON OF FOUNDATION ALTERNATIVES FOR REPLACEMENT BRIDGE

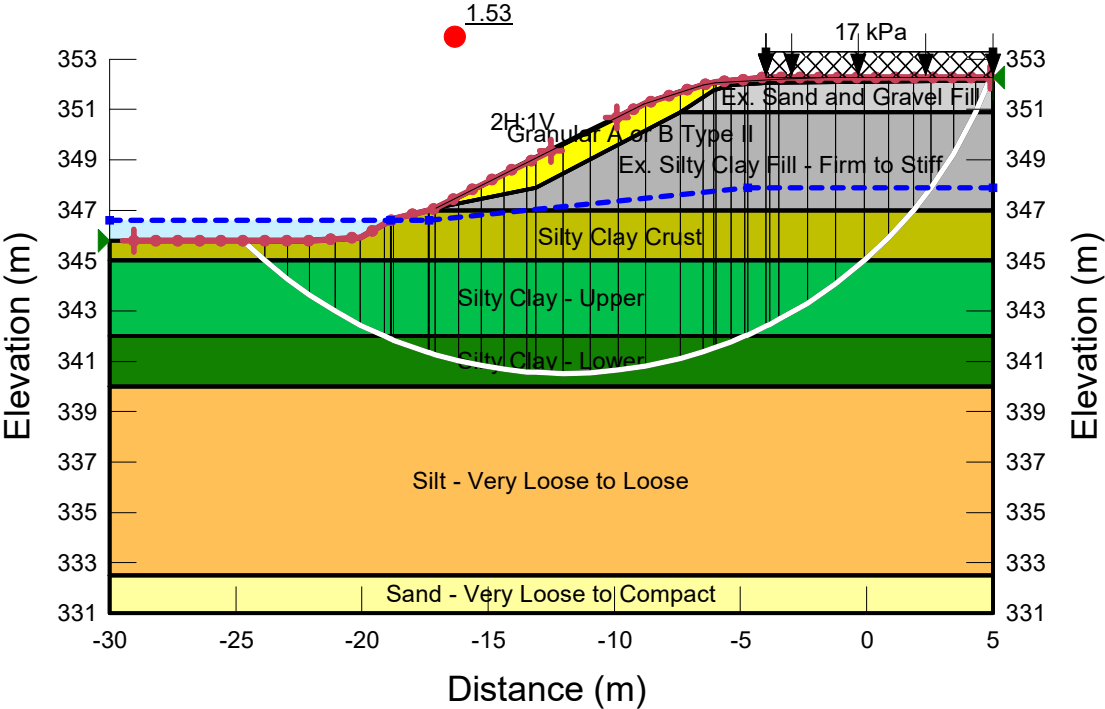
Spread Footings on Existing Fill or Native Silty Clay	Spread Footings on Engineered Granular Fill Pads	Steel H-Piles Driven to Bedrock
<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Generally lower cost than pile foundations.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Low geotechnical resistance on very loose and firm existing fill or firm to soft native silty clay and unacceptable settlement likely to occur.</li> <li>ii. Deeper excavation through cohesionless soil below the water table to construct footings and provide adequate frost protection.</li> <li>iii. Additional efforts may be required to dewater the cohesionless soils to below the founding level.</li> </ul>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher founding elevation requiring less excavation and dewatering below the water table than footings on existing fill or native soil</li> <li>ii. Generally lower cost than pile foundations.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Low geotechnical resistance on very loose and firm existing fill and unacceptable settlement likely to occur.</li> <li>ii. Spread footings placed above the frost depth would experience frost heave leading to deformation and cracking of the asphalt pavement.</li> </ul>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Piles will develop high geotechnical resistance on bedrock.</li> <li>ii. Minimal excavation or dewatering required.</li> <li>iii. Minimal risk of settlement.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher unit cost than footings.</li> </ul>
<b>NOT RECOMMENDED</b>	<b>NOT RECOMMENDED</b>	<b>RECOMMENDED</b>



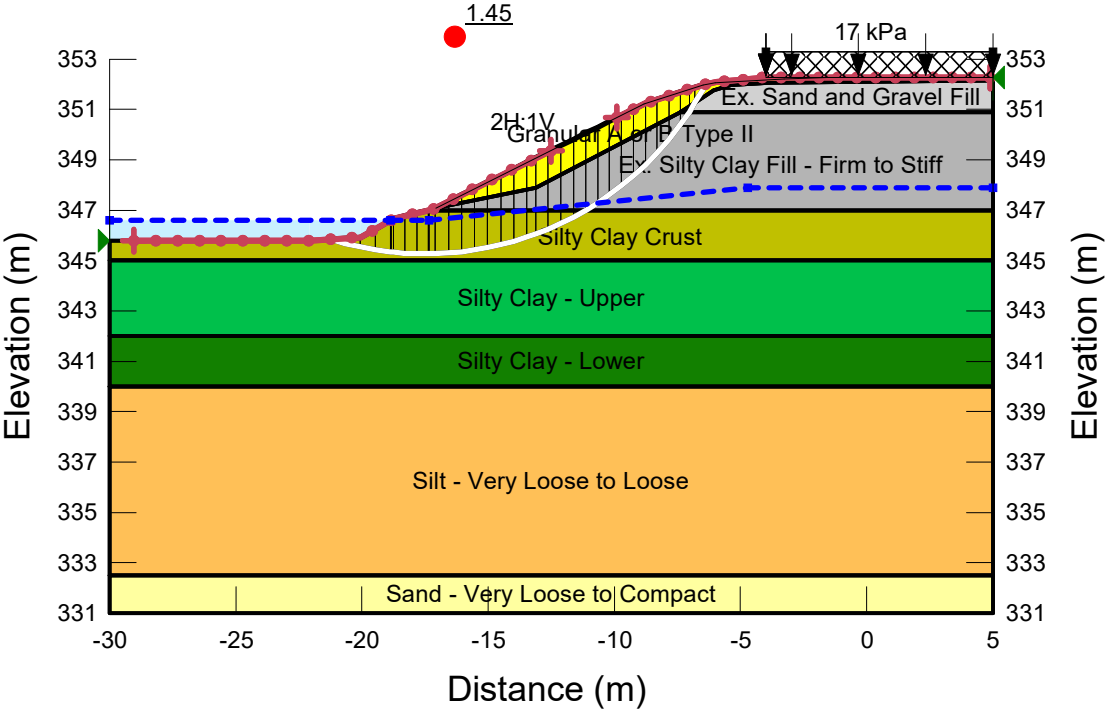
## **Appendix G**

### **Slope Stability Analyses**

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<div></div>	Ex. Sand and Gravel Fill	Mohr-Coulomb	21					0	32
<div></div>	Ex. Silty Clay Fill - Firm to Stiff	Undrained (Phi=0)	19				40		
<div></div>	Granular A or B Type II	Mohr-Coulomb	22					0	35
<div></div>	Sand - Very Loose to Compact	Mohr-Coulomb	20					0	30
<div></div>	Silt - Very Loose to Loose	Mohr-Coulomb	20					0	28
<div></div>	Silty Clay - Lower	S=f(depth)	17	30	3	36			
<div></div>	Silty Clay - Upper	Undrained (Phi=0)	17				30		
<div></div>	Silty Clay Crust	Undrained (Phi=0)	19				60		



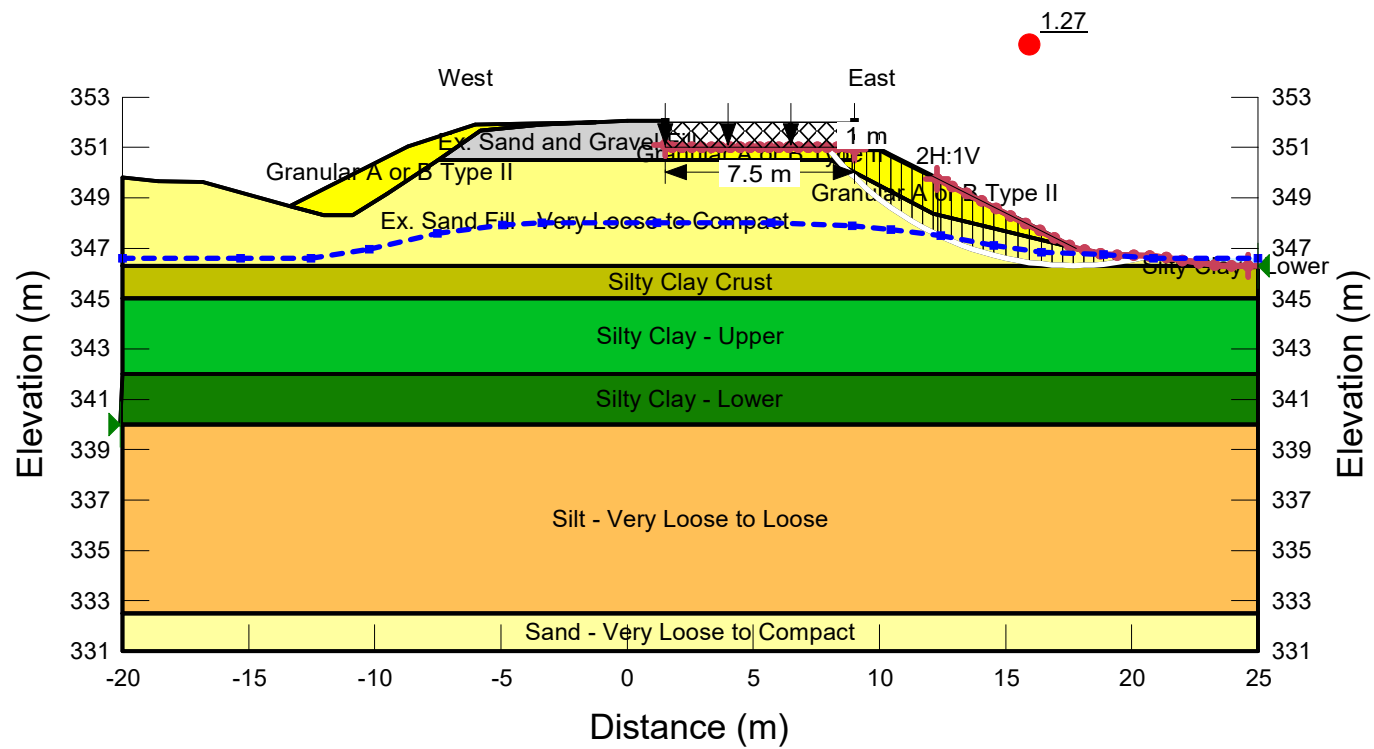
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<div></div>	Ex. Silty Clay Fill - Firm to Stiff	Mohr-Coulomb	19	0	30
<div></div>	Granular A or B Type II	Mohr-Coulomb	22	0	35
<div></div>	Sand - Very Loose to Compact	Mohr-Coulomb	20	0	30
<div></div>	Silt - Very Loose to Loose	Mohr-Coulomb	20	0	28
<div></div>	Silty Clay - Lower	Mohr-Coulomb	17	3	30
<div></div>	Silty Clay - Upper	Mohr-Coulomb	17	3	30
<div></div>	Silty Clay Crust	Mohr-Coulomb	19	3	30



TMB Side (18+300) - Undrained









FIGURE G'

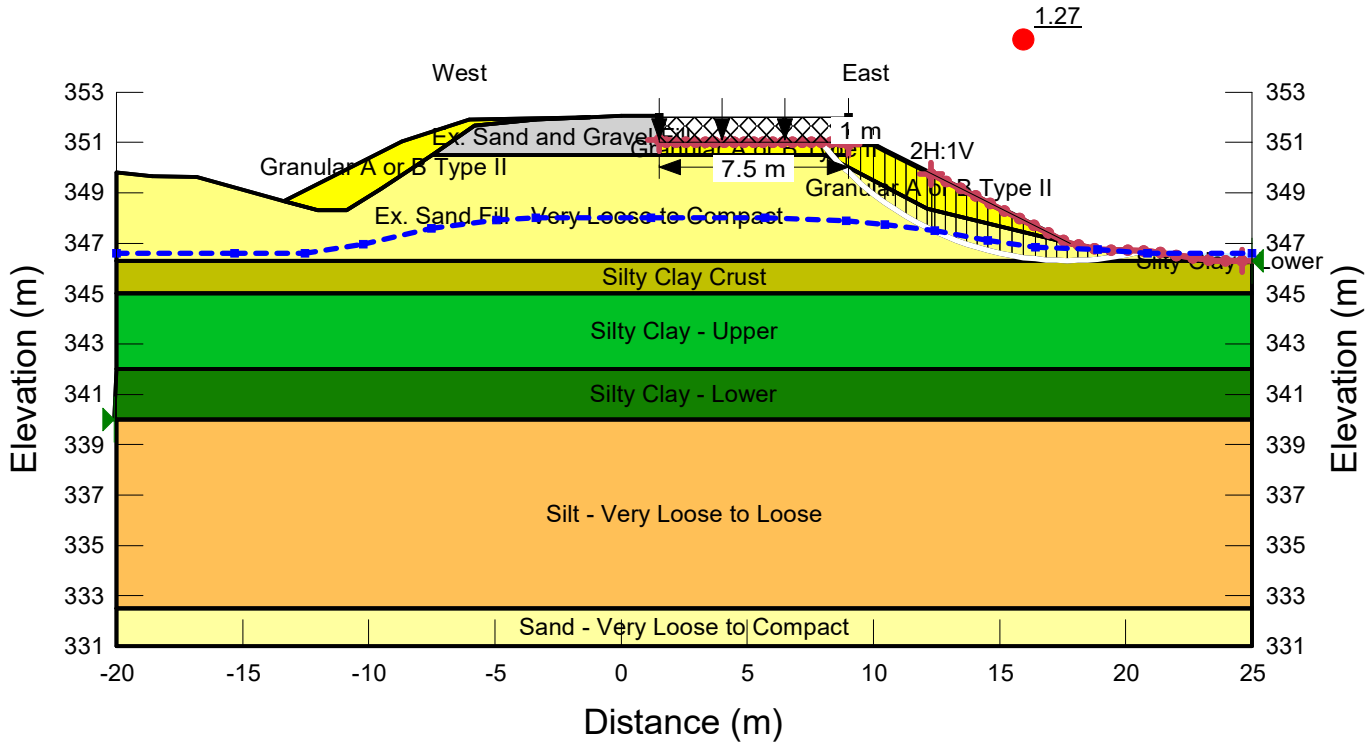
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<div></div>	Ex. Sand Fill - Very Loose to Compact	Mohr-Coulomb	18					0	30
<div></div>	Granular A or B Type II	Mohr-Coulomb	22					0	35
<div></div>	Sand - Very Loose to Compact	Mohr-Coulomb	20					0	30
<div></div>	Silt - Very Loose to Loose	Mohr-Coulomb	20					0	28
<div></div>	Silty Clay - Lower	S=f(depth)	17		30	3	36		
<div></div>	Silty Clay - Upper	Undrained (Phi=0)	17	30					
<div></div>	Silty Clay Crust	Undrained (Phi=0)	19	60					



TMB Side (18+300) - Drained

FIGURE G4

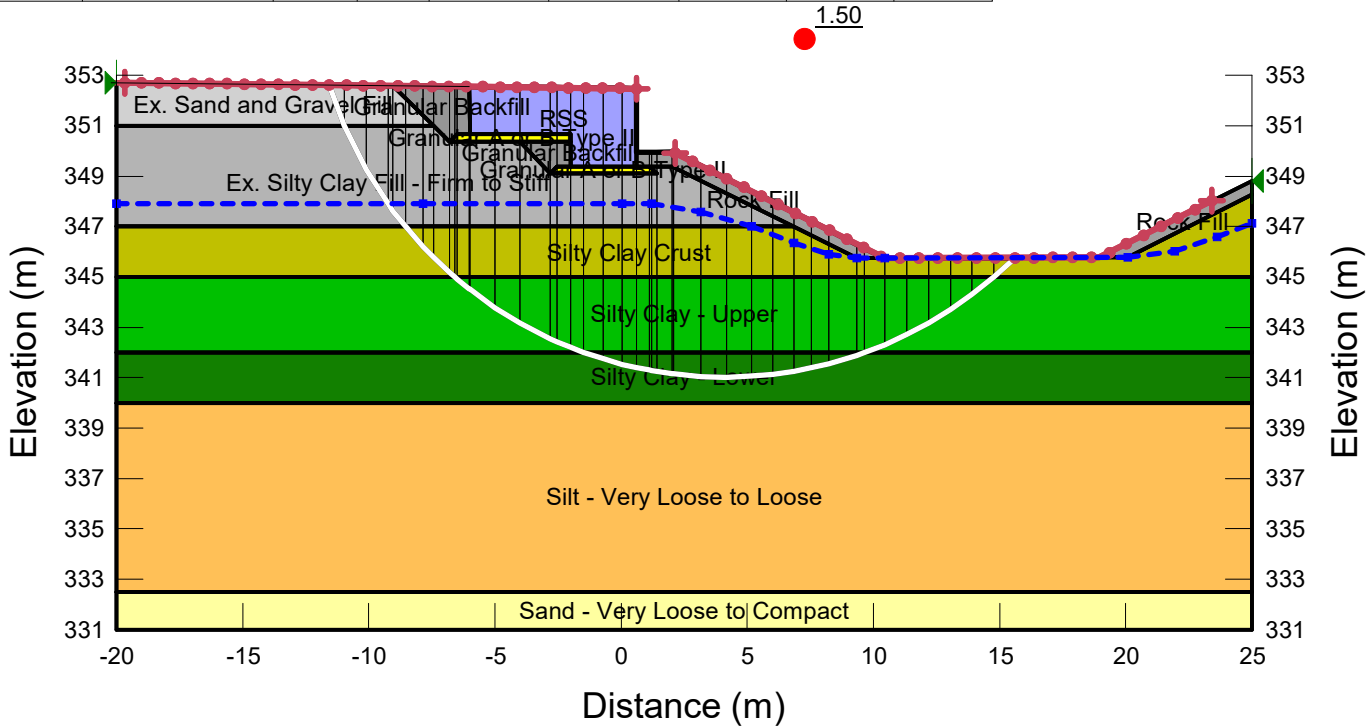
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
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	Ex. Sand Fill - Very Loose to Compact	Mohr-Coulomb	18	0	30
	Granular A or B Type II	Mohr-Coulomb	22	0	35
	Sand - Very Loose to Compact	Mohr-Coulomb	20	0	30
	Silt - Very Loose to Loose	Mohr-Coulomb	20	0	28
	Silty Clay - Lower	Mohr-Coulomb	17	3	30
	Silty Clay - Upper	Mohr-Coulomb	17	3	30
	Silty Clay Crust	Mohr-Coulomb	19	3	30



RSS Forward (South Abutment) - Undrained

FIGURE G5

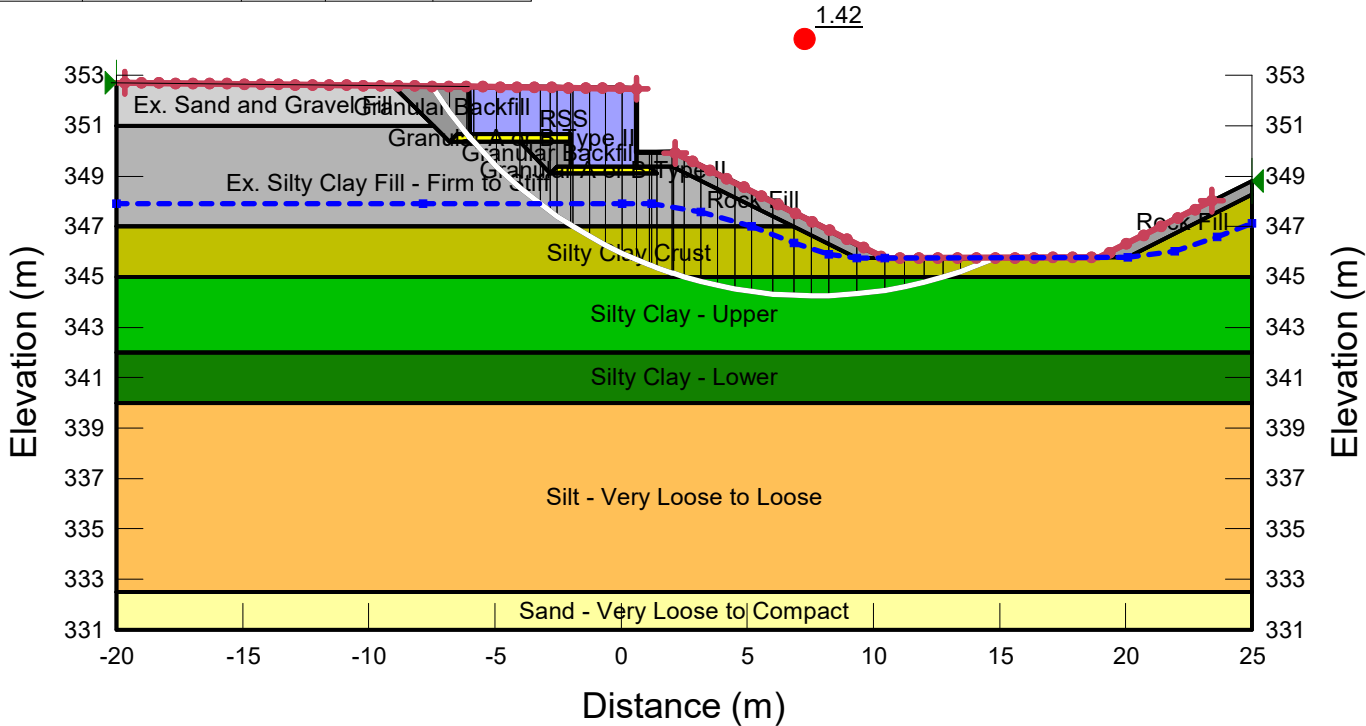
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<div></div>	Ex. Sand and Gravel Fill	Mohr-Coulomb	21					0	32
<div></div>	Ex. Silty Clay Fill - Firm to Stiff	Undrained (Phi=0)	19				40		
<div></div>	Granular A or B Type II	Mohr-Coulomb	22					0	35
<div></div>	Granular Backfill	Mohr-Coulomb	21					0	32
<div></div>	Rock Fill	Mohr-Coulomb	19					0	42
<div></div>	RSS	Mohr-Coulomb	22					200	34
<div></div>	Sand - Very Loose to Compact	Mohr-Coulomb	20					0	30
<div></div>	Silt - Very Loose to Loose	Mohr-Coulomb	20					0	28
<div></div>	Silty Clay - Lower	S=f(depth)	17	30	3	36			
<div></div>	Silty Clay - Upper	Undrained (Phi=0)	17				30		
<div></div>	Silty Clay Crust	Undrained (Phi=0)	19				60		



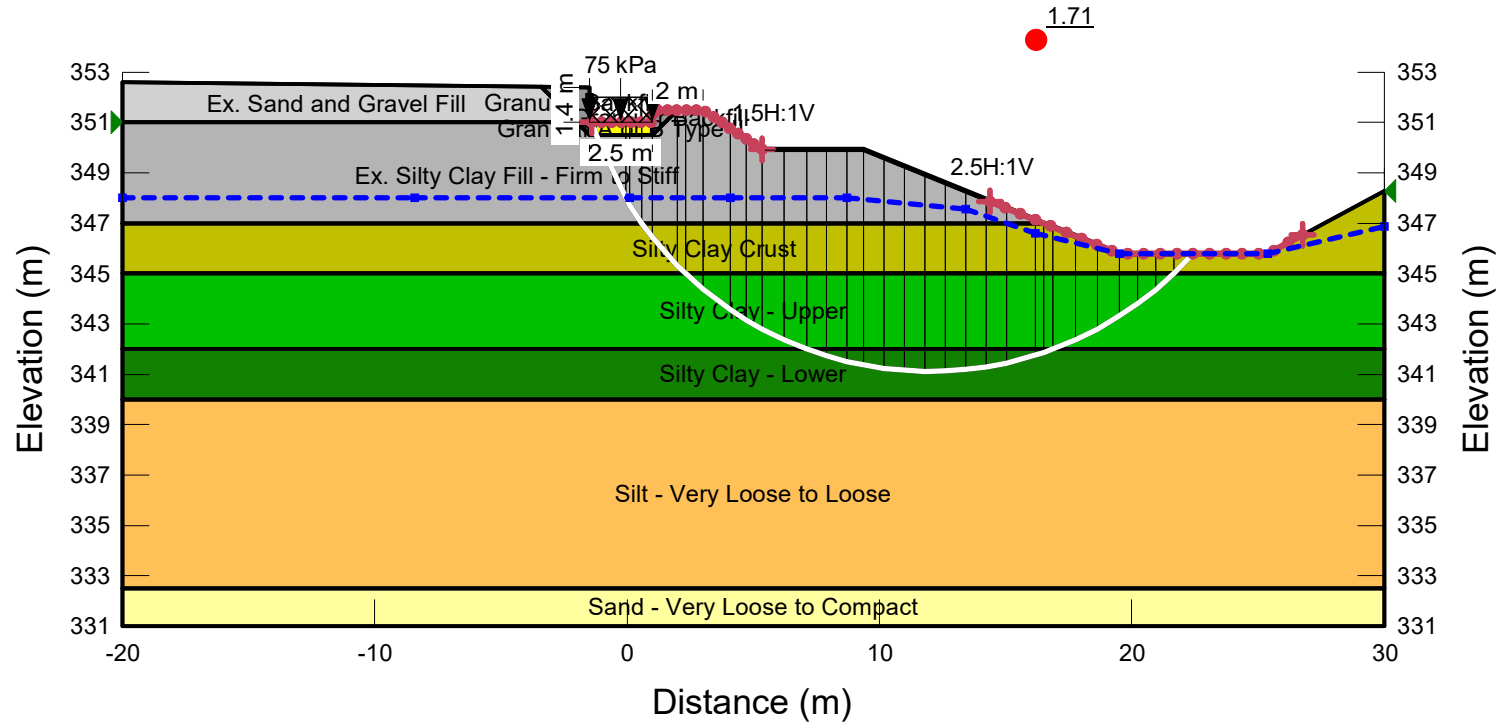
RSS Forward (South Abutment) - Drained

FIGURE G6

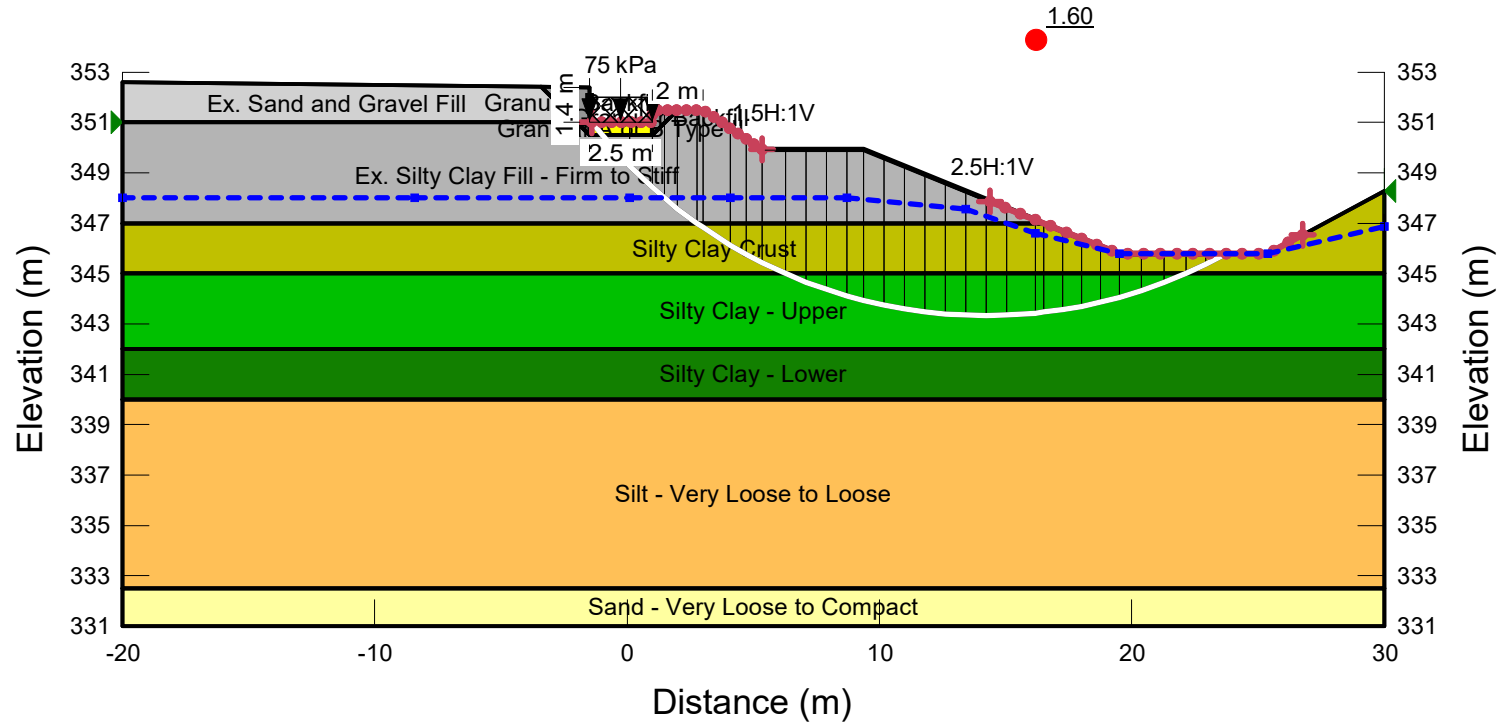
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<div></div>	Ex. Sand and Gravel Fill	Mohr-Coulomb	21	0	32
<div></div>	Ex. Silty Clay Fill - Firm to Stiff	Mohr-Coulomb	19	0	30
<div></div>	Granular A or B Type II	Mohr-Coulomb	22	0	35
<div></div>	Granular Backfill	Mohr-Coulomb	21	0	32
<div></div>	Rock Fill	Mohr-Coulomb	19	0	42
<div></div>	RSS	Mohr-Coulomb	22	200	34
<div></div>	Sand - Very Loose to Compact	Mohr-Coulomb	20	0	30
<div></div>	Silt - Very Loose to Loose	Mohr-Coulomb	20	0	28
<div></div>	Silty Clay - Lower	Mohr-Coulomb	17	3	30
<div></div>	Silty Clay - Upper	Mohr-Coulomb	17	3	30
<div></div>	Silty Clay Crust	Mohr-Coulomb	19	3	30



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<div></div>	Ex. Sand and Gravel Fill	Mohr-Coulomb	21					0	32
<div></div>	Ex. Silty Clay Fill - Firm to Stiff	Undrained (Phi=0)	19				40		
<div></div>	Granular A or B Type II	Mohr-Coulomb	22					0	35
<div></div>	Granular Backfill	Mohr-Coulomb	21					0	32
<div></div>	Sand - Very Loose to Compact	Mohr-Coulomb	20					0	30
<div></div>	Silt - Very Loose to Loose	Mohr-Coulomb	20					0	28
<div></div>	Silty Clay - Lower	S=f(depth)	17	30	3	36			
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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<div></div>	Ex. Sand and Gravel Fill	Mohr-Coulomb	21	0	32
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<div></div>	Granular Backfill	Mohr-Coulomb	21	0	32
<div></div>	Sand - Very Loose to Compact	Mohr-Coulomb	20	0	30
<div></div>	Silt - Very Loose to Loose	Mohr-Coulomb	20	0	28
<div></div>	Silty Clay - Lower	Mohr-Coulomb	17	3	30
<div></div>	Silty Clay - Upper	Mohr-Coulomb	17	3	30
<div></div>	Silty Clay Crust	Mohr-Coulomb	19	3	30





## **Appendix H**

### **List of OPSSs and OPSDs and Suggested Wording for NSSP**

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

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS PROV 517 (Construction Specification for Dewatering)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)
- OPSS PROV 539 (Construction Specification for Temporary Protection Systems)
- OPSS PROV 804 (Construction Specification for Seed and Cover)
- OPSS 902 (Construction Specification for Excavating and Backfilling – Structures)
- OPSS PROV 903 (Construction Specification for Deep Foundations)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSD 601.010 (Asphalt Curb and Asphalt Curb with Gutter)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)
- OPSD 3101.150 (Walls Abutment, Backfill Minimum Granular Requirements)

## **2. Suggested Wording for NSSPs**

- **“Obstructions”**

Excavations in the existing embankment fill may encounter obstructions such as cobbles and boulders embedded in the fill. Such obstructions may impede excavation progress. The Contractor shall be prepared to remove these obstructions to achieve the design depths.

- **“Sloping Bedrock”**

Based on the possibility of encountering sloping bedrock at the abutments at this site, the pile driving notes on the foundation tender drawings should include the following in case sloping bedrock is encountered:

- Abutment H-piles to be driven to bedrock. Upon initial contact with the bedrock:
  - a) Apply 10 blows at 10% of the hammer energy. Record the penetration.

- b) Apply 10 blows at 50% of the hammer energy. If the penetration under 10 blows is less than 12.5 mm, the pile is set.
- c) If the penetration under 10 blows is greater than 12.5 mm, refer the issue to the design team for resolution.

- **“Dewatering”**

Effective dewatering shall be designed and provided by the Contractor during excavation for abutment stem and pile cap construction, RSS wall construction, and backfilling as necessary to allow the work to proceed in the dry. Excavation below the creek and groundwater level will lead to subgrade softening. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final subgrade level throughout construction.

In order to reduce the dewatering flow rates to below the limits that would require a Category 3 Permit to Take Water (PTTW) (less than 400,000 L/day), then a watertight sheetpile enclosure is envisaged around the RSS wall and pile cap excavations. The watertight sheetpile enclosure should be driven sufficiently deep into the native silty clay below the excavations to form a groundwater cut-off in the fill, native sand, and/or native silt in which the excavations will take place. Design of the watertight sheetpile enclosures is the responsibility of the Contractor.

The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV.517. A preconstruction survey is not required, thus Designer Fill-In \*\* in SP FOUN0003 should be “N/A”. Special Provision FOUN0003 is included below.

- **“Temporary Modular Bridge”**

The Contractor is responsible for the detailed design of the Temporary Modular Bridge (TMB) including, but not limited to, slope stability of the temporary excavation slope in front of the TMB abutment footings, determination of bearing capacity for the abutment footings and safe footing set back distance from the open excavation, as well as the performance of the temporary footings throughout construction. As a minimum, the front edge of the modular bridge footings shall be set back a minimum three (3) metres from the top of the temporary excavation. The temporary excavation slope shall be no steeper than two (2) horizontal to one (1) vertical. The contractor is responsible for retaining a RAQS approved Licensed Geotechnical Engineer with a medium-complexity rating (RAQs Category – Geotechnical Structures and Embankment – Medium Complexity) to confirm all aspects of the modular bridge slope stability and foundation design. All final reports and drawings must be sealed and signed by a Professional Engineer, who shall also be a RAQS Designated Contact.

- **“Geotechnical Assessment for the Use of Heavy Construction Equipment”**

## **GEOTECHNICAL ASSESSMENT - Item No.**

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Special Provision

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### **TABLE OF CONTENTS**

<b>1.0</b>	<b>SCOPE</b>
<b>2.0</b>	<b>REFERENCES</b>
<b>3.0</b>	<b>DEFINITIONS - Not Used</b>
<b>4.0</b>	<b>DESIGN AND SUBMISSION REQUIREMENTS</b>
<b>5.0</b>	<b>MATERIALS - Not Used</b>
<b>6.0</b>	<b>EQUIPMENT - Not Used</b>
<b>7.0</b>	<b>CONSTRUCTION - Not Used</b>
<b>8.0</b>	<b>QUALITY ASSURANCE - Not Used</b>
<b>9.0</b>	<b>MEASUREMENT FOR PAYMENT - Not Used</b>
<b>10.0</b>	<b>BASIS OF PAYMENT</b>
<b>1.0</b>	<b>SCOPE</b>

Geotechnical assessment and reporting to provide geotechnical recommendations for the use of heavy construction equipment on the valley slopes, approach embankments and adjacent to foundation elements.

#### **2.0 REFERENCES**

Foundation Investigation Report, Sandy Creek Culvert Replacement, Highway 105, 7.3 km North of Highway 657, District of Kenora, Ontario, Latitude: 50.684995°, Longitude: -93.300164°, G.W.P. 6373-14-00, SITE No. 41N-242/C, (Geocres No. 52K-16), dated March 16, 2022.

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

##### **4.1 Design Requirements**

The use of heavy construction equipment and in particular heavy lifting cranes may be required during removal and replacement of the bridge deck and construction of the detour bridge. The impact of the heavy equipment loads on the underlying soils, river valley slopes and existing bridge foundations must be considered during selection of the methodology and equipment employed for construction.

Prior to commencement of construction, the Contractor shall retain a Geotechnical Consultant to assess the impact of the proposed equipment loads and construction methodology and determine requirements and/or restrictions necessary to safely support the loads without a foundation or slope failure. All Foundation Engineering services required for this project shall be performed by consultant(s) listed as accepted under the MTO's RAQS for providing services under the specialty of Geotechnical (Structures and Embankments) – Medium Complexity.

The assessment shall include, but not be limited to, the following:

- Review of available geotechnical information and supplementing with additional subsurface information as required in the equipment pad/access road areas;
- Determining appropriate setback distances for heavy equipment from the detour bridge abutments and their foundations, and from the crests of the creek valley slopes and detour embankment side slopes;
- Determining permissible ground pressure that may be applied to the foundation soils by the equipment, such as through a combination of crane pad design and sub-excavation;
- Providing recommendations for distribution of equipment loads to limit the lateral deflections of foundation piles of the existing and detour bridges;
- If use of a crane pad and/or sub-excavation is not feasible, an alternative pile-supported platform system may be considered. The Contractor shall provide recommendations for crane pad design to transfer the crane loads for lifting girders to the ground during replacement of the existing bridge deck or placement of the detour bridge through the alternative pile-supported platform system, if necessary.

#### **4.2 Submission Requirements**

At least two (2) weeks prior to mobilization of heavy construction equipment to the site, the Contractor shall submit a report detailing the findings of the geotechnical assessment to the Contract Administrator. The report shall be signed and sealed by the Geotechnical Consultant and provide the following, as a minimum:

- Appropriate setback distances for heavy equipment from existing/new structures and creek valley slopes;
- Permissible ground pressures which may be applied to the foundation soils by heavy equipment;
- Recommendations for distribution of equipment loads to limit lateral deflections of existing and new foundation piles;
- Recommendations for pile-supported platform systems to support heavy equipment, if required.

#### **10.0 BASIS OF PAYMENT**

Payment at the Contract price for the above tender items shall be full compensation for all labour to do the work.

Payment for costs associated with heavy construction equipment necessary to complete the work, such as design and construction of temporary works, supply, mobilization/de-mobilization, and operation shall be made under the associated items.

## **DEWATERING STRUCTURE EXCAVATIONS - Item No.**

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Special Provision No. FOUN0003

March 8, 2018

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### **Amendment to OPSS 902, November 2010**

OPSS 902, November 2010, Construction Specification for Excavating and Backfilling - Structures is amended as follows:

#### **902.02 REFERENCES**

Section 902.02 of OPSS 902 is amended by the addition of the following:

#### **Ontario Provincial Standard Specifications, Construction**

OPSS 517      Dewatering  
OPSS 805      Temporary Erosion and Sediment Control Measures

#### **902.03 DEFINITIONS**

Section 903.03 of OPSS 902 is amended by the addition of the following:

**Automatic Transfer Switch** means as defined in OPSS 517.

**Cofferdam** means as defined in OPSS 539.

**Cut-Off Wall** means as defined in OPSS 517.

**Design Storm Return Period** means as defined in OPSS 517.

**Dewatering System** means as defined in OPSS 517.

**Groundwater Control System** means as defined in OPSS 517.

**Plug** means as defined in OPSS 517.

**Sediment** means as defined in OPSS 517.

**Sediment Control Measure** means as defined in OPSS 517.

**Temporary Flow Passage System** means as defined in OPSS 517.

**Unwatering** means as defined in OPSS 517.

**Vegetated Discharge Area** means as defined in OPSS 517.

**Waterbody** means as defined in OPSS 517.

**Watercourse** means as defined in OPSS 517.

## **902.04 DESIGN AND SUBMISSION REQUIREMENTS**

### **902.04.01 Design Requirements**

#### **902.04.01.01 Dewatering**

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a [\* Designer Fill-In, See Notes to Designer] year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

### **902.04.02 Submission Requirements**

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

#### **902.04.02.01 Working Drawings**

Working Drawings for the dewatering system shall be according to OPSS 517.

#### **902.04.02.02 Preconstruction Survey**

When a groundwater control system by wells or a well point system will be used, 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, water wells, Utilities, and structures, within a distance of [\*\* Designer Fill-In, See Notes to Designer] metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website <https://www.ontario.ca/environment-and-energy/map-well-records> or its successor site.

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.

#### **902.04.02.03 Milestone Inspections**

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

## **902.07 CONSTRUCTION**

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

#### **902.07.04                      Dewatering Structure Excavation**

##### **902.07.04.01                      General**

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

##### **902.07.04.02                      Discharge of Water**

The discharge of water shall be according to OPSS 517.

##### **902.07.04.03                      Monitoring**

Monitoring shall be according to OPSS 517.

##### **902.07.04.04                      System Amendments**

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

##### **902.07.04.05                      Removal**

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

NOTES TO DESIGNER:

Designer Fill-Ins

- \* Fill in the design storm return period according to MTO Drainage Design Standard TW-1.
- \*\* Fill in the preconstruction survey distance as recommended by the foundation engineer.

WARRANT: Include with this standard tender item only on the recommendation of a foundation engineer.

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.



## **Appendix I**

### **Preliminary Hydrogeological Assessment Memorandum**



**THURBER** ENGINEERING LTD.

To:

Dale Wiersema, P.Eng.  
HATCH

Date: March 16, 2022

From:

Mahmoud Meskar, P.Eng.  
David Hill, P.Geo., P.Eng.

File: 33098

**MEMORANDUM – PRELIMINARY HYDROGEOLOGICAL ASSESSMENT  
SANDY CREEK CULVERT REPLACEMENT  
HIGHWAY 105, 7.3 KM NORTH OF HIGHWAY 657  
DISTRICT OF KENORA, ONTARIO**

## **1. INTRODUCTION**

Thurber Engineering Ltd. (Thurber) prepared a foundation investigation and design report (FIDR) for the proposed replacement of the Sandy Creek Culvert, which is to be replaced with a bridge. The Sandy Creek Culvert is located on Highway 105, approximately 7.3 km north of Highway 657, near Ear Falls in the District of Kenora, Ontario. Thurber has been requested to provide a preliminary hydrogeological assessment based on existing information of the temporary excavation proposed for the abutments and retained soil system (RSS) walls.

This preliminary assessment has been prepared based on the information provided in the following report and drawing:

- Foundation Investigation and Design Report, Sandy Creek Culvert Replacement, Highway 105, 7.3 km North of Highway 657, District of Kenora, Ontario, March 16, 2022.
- Sandy Creek, General Arrangement, Dwg. 1, CONT WP 6373-14-01, dated October 2021, by Ministry of Transportation Ontario (MTO), Northwestern Region, Structural Section.

## **2. BACKGROUND INFORMATION**

Based on a review of the above referenced FIDR report, it is understood that two boreholes (labeled as 19-01 and 19-02) and four dynamic cone penetration tests (DCPTs) (labeled as DCPT 19-03 to 19-06) were drilled in July 2019 along with a 19 mm diameter standpipe piezometer, which was installed in borehole 19-02. In general, the subsurface conditions encountered consisted of embankment fill, overlying native silty clay, silt, silty sand to sandy silt, and sand



deposits. The overburden soil deposits were underlain by metasedimentary bedrock. The locations of the boreholes and monitoring well are shown in Appendix D, and record of borehole sheets are presented in Appendix A of the referenced FIDR.

### 3. DISCUSSION AND RESULTS

No wells were installed at the site and the piezometer(s) installed during the preliminary investigation have been decommissioned. As such, this memorandum does not include hydrogeological testing such as single well response tests or additional stabilized groundwater level measurements beyond those measured during the initial investigation. This preliminary hydrogeological assessment has been prepared based on available geotechnical information.

#### 3.1 Hydraulic Conductivity

The hydraulic conductivity of the subsurface soil was estimated using the Kozeny-Carman and Hazen grain size correlations. The estimated hydraulic conductivity values of the soil samples are summarized in the following table.

**Table 1: Hydraulic Conductivity (K) Estimates Using Grain Size Correlations**

Soil Type	Hydraulic Conductivity (m/s) using Hazen	Hydraulic Conductivity (m/s) using Kozeny-Carman
Gravelly sand fill	$1.6 \times 10^{-4}$	$4.8 \times 10^{-5}$
Sand fill	$1.5 \times 10^{-4}$	$4.4 \times 10^{-5}$
Silt	$3.3 \times 10^{-8}$ to $1.1 \times 10^{-7}$	$9.8 \times 10^{-9}$ to $3.3 \times 10^{-8}$
Sandy silt to silty sand	$5.1 \times 10^{-6}$ to $7.6 \times 10^{-6}$	$1.5 \times 10^{-6}$ to $2.3 \times 10^{-6}$
Sand	$5.6 \times 10^{-5}$ to $2.0 \times 10^{-4}$	$1.7 \times 10^{-5}$ to $5.9 \times 10^{-5}$

#### 3.2 Dewatering Assessment

Groundwater taking for construction dewatering is governed by the Ontario Water Resources Act (OWRA), Environmental Protection Act (EPA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

If the water taking rate will be greater than 50,000 L/day and less than 400,000 L/day, then registration on the Environmental Activity and Sector Registry (EASR) will be required. If the water taking rate will be greater than 400,000 L/day, then a Category 3 Permit To Take Water (PTTW) will be required. On July 1, 2021, changes to EASR registrations came into effect, and storm



water values no longer contribute to EASR maximum water taking rates. Storm water values are still, however, applicable to maximum water taking rates for PTTWs. A preliminary assessment of the water taking rate and the need for water taking permitting is provided herein; however, additional analyses may be required to confirm the water taking rate.

A review of the preliminary General Arrangement (GA) drawing provided by MTO indicates that a replacement option planned for this site consists of a single 29-m long span bridge with 6 m long approach slabs at each abutment. The preliminary GA drawing depicts the bridge to be supported on H-pile foundations, with RSS retaining wall enclosures to retain the abutment fill. Based on the preliminary GA drawing, the lowest proposed underside elevation of the abutments and RSS walls foundation pads will be about 347.5 m. Based on the subsurface information, the abutments are expected to be installed primarily in the fill and also within a thin, shallow sand, overlying the silty clay. The groundwater level measured on July 14, 2019, at the nearby standpipe piezometer installed in borehole 19-02 was used for preliminary dewatering estimate. The hydraulic conductivity was selected using the grain size correlations for the coarsest sample of fill as a conservative approach. Based on the preliminary GA drawing, the dimensions and conditions that were assumed for the preliminary dewatering assessment are provided in Table 2 below.

**Table 2: Summary of Assumed Excavation and Groundwater Conditions**

<b>Assumed Excavation Dimensions (m)</b>	<b>Assumed Lowest Excavation Elevation (m)</b>	<b>Assumed Groundwater Elevation (m)</b>	<b>Geologic Unit to Dewater</b>	<b>Assumed Hydraulic Conductivity (m/s)</b>
8.0 x 8.0 (excavating only half of the road at a time)	347.5	349.5	Primarily Fill	$4.8 \times 10^{-5}$ to $1.6 \times 10^{-4}$

For the purpose of estimating water taking flow rates, it was assumed that surface water flow would be directed around the excavations such that surface water will not enter the excavations at a significant rate. Additionally, it was assumed that no groundwater control is required to remove the existing CSP culverts and any works within the creek bed, if any.

The water taking will be temporary in nature for the purpose of construction dewatering for installation of the infrastructure. Dewatering rates were estimated using the Dupuit analytical solution. The radius of influence was calculated using the Sichardt equation. It is assumed the water level will be required to be lowered to about 1 m below the proposed excavation, or to elevation 346.5 m, in order to facilitate a dry, stable work area.



If one abutment is constructed at a time, and only half of the road is excavated at a time, the estimated preliminary peak water taking rate including a safety factor of three is just below 400,000 L/day.

The preliminary estimate indicates that registration on the EASR would be required at a minimum, as the preliminary water taking rate is between 50,000 and 400,000 L/day. However, the preliminary water taking rate is very close to the limit required for a Category 3 PTTW and has a high degree of uncertainty due to the limited hydrogeological data. Accordingly, additional measures should be implemented to maintain the water taking rates below 400,000 L/day if registration on the EASR is to be implemented. These measures could include:

- Raising the base of the RSS walls to require a shallower excavation below the groundwater level.
- Constructing the RSS walls and abutment stems within watertight, sheet pile enclosures driven into the underlying silty clay or silt or deeper to form a groundwater cut off and reduce the groundwater infiltration rate. The water taking rate for groundwater flow through the silty clay or silt is estimated to be much less than 50,000 L/day per abutment assuming the sheet piles do not leak and that they form a good seal with the silty clay or silt a minimum 2 m below the top of the silty clay or silt in all locations.

A Hydrogeological Report including a Water Taking Report and Discharge Report would be required as part of the EASR registration process. The Water Taking Report and Discharge Report must include an impact assessment as well as mitigation measures, a monitoring plan, and a contingency plan.

If measures to control the water taking rate to below 400,000 L/day cannot be implemented at this site, and since the assumed hydraulic conductivity value has a high degree of uncertainty as they were estimated using grain size correlations, then it is recommended that additional hydrogeological investigation and assessment be conducted. This would allow for a more accurate assessment of the water taking rate to be made; and for obtaining sufficient data to apply for a Category 3 PTTW if required instead of registration on the EASR. Additional investigation should include installing monitoring well(s) in shallow coarse fill and/or shallow sand and silt, conducting single well response tests (slug tests), measuring additional stabilized groundwater level measurements, and collecting a groundwater quality sample and creek water sample to be compared against the Provincial Water Quality Objectives (PWQOs).



The duration required to receive a PTTW from the Ministry of the Environment, Conservation and Parks (MECP) once it has been received in good order is typically 3 to 5 months, assuming no further field work or significant revisions are required. An EASR registration would be filed by the contractor and does not require a review period.

#### **4. CLOSURE**

We trust the above provides the information you require at this time. If you have any questions regarding this memorandum, please do not hesitate to contact us.

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