



January 21, 2013

## FOUNDATION INVESTIGATION AND DESIGN REPORT

**ROADWAY PROTECTION  
REHABILITATION OF ENGLEHART RIVER BRIDGE  
SITE 47-032 ON HIGHWAY 11  
TOWNSHIP OF EVANTUREL, ONTARIO  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5302-05-00**

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REPORT





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# PART A

FOUNDATION INVESTIGATION REPORT  
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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the temporary roadway protection associated with the rehabilitation of the Highway 11 bridge crossing the Englehart River in the Township of Evanturel, north of Englehart, Ontario.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal (RFP), dated October 2011, and Request for Clarification Letter, dated December 12, 2011. Golder's proposal P1-1191-0032, dated December 2011, for foundation engineering services associated with this project is contained in Section 6.8 of MH's Technical Proposal that forms part of the Consultant's Agreement Number 5011-E-0009 for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated March 22, 2012. The General Arrangement (GA) drawing for the bridge was provided to Golder by MH in July 2012.

The purpose of this investigation is to establish the subsurface conditions within the vicinity of the proposed roadway protection for the Englehart River Bridge by methods of borehole drilling, in situ testing and laboratory testing on selected soil samples. The boreholes were located in the field by Golder relative to stakes installed by MH. The approximate location of the Highway 11 bridge crossing the Englehart River is shown on the Key Plan on Drawing 1.

## **2.0 SITE DESCRIPTION**

The Highway 11 bridge crossing Englehart River is located at the easterly entrance of Englehart in the New Liskeard area. The bridge was constructed around 1973, rehabilitated in 1993 and consists of a five-span structure with the abutments and piers supported on H-piles and has a concrete deck and steel girders.

In general, the topography in the vicinity of the bridge is flat with the Englehart River located about 30 m below the bridge deck. The banks of the river and the approach embankment side slopes are vegetated with grass. The area in the vicinity of the site is landscaped with trees. The surface of the roadway at the bridge is at about Elevation 210 m on the west side of the bridge and sloping up to about Elevation 211 m on the east side of the bridge. The river water level measured by others as noted was Elevation 179.4 m in February 1973.

## **3.0 INVESTIGATION PROCEDURES**

The fieldwork for the investigation associated with the proposed temporary roadway protection for the rehabilitation of the Englehart River Bridge was carried out between June 5 and 8, 2012. A total of four (4) boreholes were advanced as part of the investigation, one each at the east and west approach embankments (Boreholes ER-2 and ER-4, respectively) and one each at the east and west abutments (Boreholes ER-3 and ER-1, respectively), at approximately the locations shown on Drawing 1.

The field investigation was carried out using a track-mounted D-50 drilling rig supplied and operated by Walker Drilling of Utopia, Ontario.



The boreholes were advanced through the overburden using 108 mm inside diameter (I.D.) hollow-stem augers. In general, soil samples were obtained at intervals at depths of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler operated by automatic hammers on the drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were carried out in cohesive soils for determination of undrained shear strengths (ASTM D2573) using an MTO Standard 'N' size vane. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903-Wells (as amended).

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A.

The fieldwork was observed by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

Survey stakes offset from the Highway 11 centerline were installed by MH prior to the commencement of drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the applicable stakes installed by MH and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. The ground surface elevation at the borehole locations was surveyed by a member of our technical staff in reference to the ground surface elevations at applicable stakes installed by MH. The borehole locations shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
ER-1	5298433.9	389844.1	209.9	10.1
ER-2	5298493.2	390122.8	211.0	20.4
ER-3	5298495.2	390114.5	211.0	10.1
ER-4	5298436.2	389834.9	209.9	20.4



## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Published literature<sup>1</sup> indicates that the site is located in the transition zone between the Western Abitibi Subprovince of the Superior Province (to the north) and the Huronian Supergroup (to the south). The bedrock geology follows the river valley and consists of mafic metavolcanic rock (Geology of Ontario, OGS Special Volume 4<sup>1</sup>).

Terrain mapping by the Ontario Geological Survey<sup>2</sup>, describes the soils in the vicinity of the site as silty colluvial slopewash and debris creep sheet with minor talus.

### 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets in Appendix A. The results of the laboratory tests are also presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy, as encountered in the boreholes, is shown in profile on Drawing 1.

In general, the subsurface stratigraphy encountered at the site consists of pavement structure (asphalt and granular fill) underlain by deposits of sand to sandy silt and clayey silt.

#### 4.2.1 Asphalt

All of the boreholes were drilled through the pavement and penetrated through approximately 150 mm to 240 mm of asphalt.

#### 4.2.2 Fill

A deposit of brown, gravelly sand to sand and gravel fill containing trace silt, between 1.5 m and 2.2 m thick was encountered underlying the asphalt in all of the boreholes. The top of the fill was encountered between Elevation 210.8 m and 209.7 m. A 0.1 m thick seam of peat was encountered in Borehole ER-1 at Elevation 207.6 m.

SPT 'N'-values measured within the fill range from 14 blows to 51 blows per 0.3 m of penetration, indicating a compact to dense relative density.

A grain size distribution of a sample of the sand and gravel fill is shown on Figure B-1 in Appendix B.

<sup>1</sup> Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 1. Ministry of Northern Development and Mines, Ontario.

<sup>2</sup> Northern Ontario Engineering Geology Terrain Study, Ontario Geological Society, Map 5020 and 5021.



The natural water content measured on samples of the fill ranges between about 1 per cent and 2 per cent.

#### **4.2.3 Silty Sand to Sandy Silt**

A deposit of brown to grey, silty sand to sandy silt containing trace to some clay, between 2.9 m and 5.5 m thick was encountered underlying the fill in all of the boreholes. The top of the silty sand to sandy silt deposit was encountered at depths between 1.7 m and 2.4 m below ground surface, corresponding to between Elevation 209.3 m and 207.5 m. A 0.3 m thick seam of brown silty clay was encountered within the sand to sandy silt deposit in Borehole ER-1 at Elevation 206.9 m.

SPT 'N'-values measured within the silty sand to sandy silt deposit range from 1 blow to 25 blows per 0.3 m of penetration, indicating a very loose to compact relative density. In Borehole ER-2, a SPT 'N'-value of 44 blows per 0.3 m of penetration was measured, indicating a dense relative density at the top of the deposit.

The grain size distributions of five samples of the silty sand to sandy silt deposit are shown on Figure B-2 in Appendix B.

The natural water content measured on samples of the silty sand to sandy silt ranges between about 13 per cent and 28 per cent.

An Atterberg limits test was carried out on the sample of the silty clay seam and yielded a liquid limit of about 39 per cent, a plastic limit of about 16 per cent and a plasticity index of about 23 per cent. The result of the Atterberg limits testing is shown on the plasticity chart on Figure B-3 in Appendix B and indicates that the seam consists of silty clay of intermediate plasticity.

The natural water content measured on the sample of the silty clay seam is about 39 per cent.

#### **4.2.4 Silt**

A deposit of grey silt containing some clay and trace to some sand, between 1.2 m and 3.5 m thick was encountered underlying the silty sand to sandy silt in Boreholes ER-1, ER-2 and ER-4, between 5.3 m and 7.2 m below ground surface, corresponding to Elevations 204.6 m and 203.8 m, respectively. A 1.1 m thick deposit of silt was also encountered underlying the clayey silt in Borehole ER-2, at a depth of 19.3 m below ground surface at Elevation 191.7 m. Borehole ER-2 was terminated within the lower silt deposit.

SPT 'N'-values measured within the silt deposit range from 0 blows (weight of hammer) to 10 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of four samples of the silt are shown on Figure B-4 in Appendix B.

Atterberg limits testing carried out on two samples of the silt deposit yielded liquid limits ranging from about 17 per cent to 18 per cent, plastic limits ranging from about 14 per cent to 16 per cent and plasticity indices ranging from about 2 per cent to 3 per cent, as presented on Figure B-5, indicating a material of slight plasticity, while two other samples are non-plastic.

The natural water content measured on samples of the silt ranges between about 24 per cent and 27 per cent.





#### **4.2.5 Clayey Silt**

A deposit of grey, clayey silt containing trace to some sand, between 1.3 m and 13.5 m thick was encountered underlying the silty sand deposit in Borehole ER-3 and underlying the silt deposit in Boreholes ER-1, ER-2 and ER-4. The top of the clayey silt deposit was encountered at depths between 6.9 m and 8.8 m below ground surface, between Elevation 203.8 m and 201.1 m. Boreholes ER-1, ER-3 and ER-4 were terminated within the clayey silt deposit.

SPT 'N'-values measured within the clayey silt deposit range from 0 blows (weight of hammer) to 9 blows per 0.3 m of penetration and typically less than 4 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 39 kPa to 63 kPa. The SPT tests, together with the field vane tests, suggest the deposit has a firm to stiff consistency.

Atterberg limits testing carried out on five samples of the clayey silt deposit yielded liquid limits ranging from about 23 per cent to 31 per cent, plastic limits ranging from about 15 per cent to 18 per cent and plasticity indices ranging from about 5 per cent to 13 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-6 in Appendix B and indicate that the deposit consists of clayey silt of low plasticity.

The grain size distributions of three samples of the clayey silt are shown on Figure B-7 in Appendix B.

The natural water content measured on samples of the clayey silt ranges between about 25 per cent and 30 per cent.

#### **4.2.6 Groundwater Conditions**

Groundwater levels were measured in the open boreholes upon completion of drilling and are summarized below.

<b>Borehole</b>	<b>Depth to Groundwater Level Below Ground Surface (m)</b>	<b>Groundwater Elevation (m)</b>
ER-1	8.8	201.1
ER-2	4.6	206.4
ER-3	5.8	205.2
ER-4	3.7	206.2

Groundwater levels encountered in the boreholes during and shortly after drilling may not be representative of static levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Groundwater and river water levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.



## **5.0 CLOSURE**

The field person supervising the drilling program was Mr. Ed Savard. This report was prepared by Mr. Evan Childerhose, P.Eng. The technical aspects were reviewed by Mr. Jorge M. A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project, who also carried out a quality control review of the report.

## Report Signature Page

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# PART B

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## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

This section of the report provides an interpretation of the geotechnical data obtained during the investigation and recommendations on the foundation aspects of design of the proposed bridge rehabilitation works. The recommendations provided are intended for the guidance of the design engineer. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

### **6.1 General**

Golder was retained by MH to provide recommendations on temporary roadway protection for the rehabilitation of the Highway 11 bridge over the Englehart River in the Township of Eanturel, Ontario. As the structure will be rehabilitated in stages, with traffic reduced to one lane in the vicinity of the bridge, the excavations at the abutments and approach embankments will be supported by a temporary structure to maintain the stability of the existing roadway embankment.

The subsurface conditions at the west approach embankment at Boreholes ER-1 and ER-4 generally consist of between 2.4 m and 1.8 m of pavement structure (asphalt and gravelly sand to sand embankment fill), underlain by a stratum of silty sand to sandy silt 2.9 m and 5.5 m thick, underlain by a stratum of silt between 3.5 m and 1.0 m thick, and a deposit of clayey silt 1.3 m and 13.5 m thick at the respective boreholes. Boreholes ER-1 and ER-4 were terminated within the clayey silt stratum at Elevations 200.9 m and 189.5 m. The boreholes were terminated at depths of 10.1 m and 20.4 m below the roadway surface. The water level upon completion of drilling was measured at depths of 8.8 m and 3.7 m below the roadway surface corresponding to Elevation 201.1 m and 206.2 m.

The subsurface conditions at the east approach embankment at Boreholes ER-2 and ER-3 consist of 1.7 m and 2.3 m of pavement structure (asphalt and gravelly sand to sand and gravel embankment fill), underlain by a stratum of silty sand to sandy silt between 5.5 m and 4.9 m thick, a 1.2 m thick deposit of silt at one borehole and a deposit of clayey silt 10.9 m and 2.9 m thick, respectively. A 1.1 m thick deposit of silt was encountered underlying the clayey silt deposit in Borehole ER-2. Boreholes ER-2 and ER-3 were terminated in the silt and clayey silt deposits, respectively, at depths of 20.4 m and 10.1 m below the roadway surface, corresponding to Elevation 190.6 m and 200.9 m respectively. The water level upon completion of drilling was measured at depths of 4.6 m and 5.8 m below the roadway surface, corresponding to Elevation 206.4 m and 205.2 m, respectively.

Excavations will be required to expose the existing abutment pile caps. Based on the GA drawing provided by MH, the underside of the existing abutment pile caps is at about Elevation 204.0 m.

### **6.2 Excavations and Temporary Cut Slopes**

The proposed works will require excavations through the embankment fill behind the existing abutments in order to rehabilitate the existing abutments and other components of the bridge. Depending on the depth of excavation required for rehabilitation of the abutments, groundwater may be encountered, as the non-stabilized water level



at the approach embankments is higher than the underside of the existing abutment pile caps. The groundwater level is subject to fluctuations and the depth of excavation below the groundwater will depend on the time of year that the rehabilitation works are carried out. Also, perched groundwater may be present within the granular fill layers. Surficial water seepage into the excavations should be expected and will be greater during periods of sustained precipitation. Pumping from properly filtered sumps located at the base of the excavations may be required to provide groundwater control but should be located outside of the actual excavation limits required for the rehabilitation works. Surface water runoff should be directed away from the excavations at all times.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The fill materials at this site would be classified as Type 3 soils. The native very loose to compact silty sand to sandy silt, firm to stiff clayey silt and very loose to loose silt materials would be classed as Type 3 soils. Temporary open cut slopes within the fill materials and native soils should be maintained no steeper than 1 horizontal to 1 vertical. Flatter side slopes may be necessary in areas with saturated or loose granular soils.

### 6.3 Temporary Excavation Support Systems

Temporary protection systems are required to support the embankment fills as well as the native silty sand to sandy silt, silt and possibly clayey silt strata depending on the depth of excavation required for the rehabilitation of the abutments. Assuming the depth of excavation is required to the underside of the existing pile cap, which is at about Elevation 204 m, based on the GA drawing provided by MH, an excavation in the order of approximately 6 m to 7 m deep below the existing roadway surface will be required. The temporary support system could consist of either driven steel sheet piling or soldier piles and lagging where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds. If soldier piles and lagging is selected, pile installation should be in accordance with OPSS 903 (Deep Foundations). A comparison of the different applicable temporary support systems based on advantages, disadvantages, risks and relative costs is provided in Table 1 following the text of this report.

Support to the system could be in the form of struts and walers or rakers or anchors. The pull-out resistance ( $P_{ar}$  in kPa/m), for tremie grouted anchors in cohesionless soils can be estimated from the following equation as per the Canadian Foundation Engineering Manual (CFEM, 2006):

$$P_{ar} = \sigma'_z A_s L_s \alpha_g$$

where  $\sigma'_z$  = effective vertical stress at the midpoint of the load carrying length (in kPa)

$A_s$  = effective unit surface area of the anchor bond zone ( $m^2$ )

$L_s$  = effective length of the anchor bond zone (m)

$\alpha_g$  = anchorage coefficient dependent on the soil type and conditions (as given in Table 26.5 of CFEM, 2006)



For computation of the pull-out resistance ( $P_{ar}$  in kPa/m) in stiff to very hard clay soils can be estimated from the following equation (CFEM, 2006):

$$P_{ar} = \alpha_c A_s L_s s_u$$

where  $\alpha_c$  = reduction factor related to the undrained shear strength (as given on Figure 26.17 of CFEM, 2006)

$A_s$  = effective unit surface area of the anchor bond zone ( $m^2$ )

$L_s$  = effective length of the anchor bond zone (m)

$s_u$  = average undrained shear strength of the clay over the anchor length (kPa)

For the abutment/approach embankments on either side of the bridge, grouted soil anchors would have their fixed anchor length formed within the either the firm to stiff clayey silt or the very loose silt zones. Assuming that the nominal diameter of the anchor is 150 mm, the recommended ultimate bond stress for design of anchors is approximately 50 kPa/m. It should be noted, however, that the anchor capacity will not increase for bond lengths greater than about 8 m, and therefore, the length of the bond zone should be restricted to 8 m.

The above ultimate bond stress values are unfactored values. In accordance with the Canadian Highway Bridge Design Code (CHBDC, 2006) Section 6.6.2, a factor of 0.4 should be applied to the ultimate resistance to obtain the factored geotechnical resistance at Ultimate Limit States (ULS).

Where necessary, adequate support must be provided for structures, such as existing foundations or utilities, which may be present adjacent to the excavations. In accordance with the CFEM (2006) Subsection 26.16, structural loads may be carried by either direct underpinning of the foundations or by providing additional support to the excavation face.

It is recommended that the existing structure, as well as the temporary support structure, be monitored for settlement and lateral movement while excavation, pile/sheet driving or other construction activities are carried out at the site. The type, location and number of settlement monitoring points and lateral movement points and frequency of readings should be developed by the bridge designer to ensure that the magnitude of tolerable movements is not exceeded.

### 6.3.1 Lateral Earth Pressures

The temporary excavation support system should be designed and constructed in accordance with Ontario Provincial Standard Specification (OPSS) 539 (Temporary Protection Systems). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539. The contractor is responsible for the complete detailed design of the protection system.

The design of braced soldier pile and lagging walls should be based on a rectangular earth pressure distribution using the design parameters given below. Where the support to the wall is provided by rakers or anchors, the wall design should be based on a triangular earth pressure distribution using the design parameters given below. The raker/anchor support must be designed to accommodate the loads applied from earth and groundwater pressures and surcharge pressures from area, line or point loads as well as the impact of sloping ground behind



the system. Passive toe restraint to the soldier piles may be determined using a triangular pressure distribution acting over an equivalent width equal to three times the pile socket diameter.

The unfactored triangular earth pressure distribution ( $p$  in  $\text{kN/m}^2$ ; increasing with depth), can be calculated as follows:

$$\begin{aligned} p &= K_a (\gamma H + q) \\ \text{where } K_a &= \text{active coefficient of earth pressure} \\ H &= \text{the depth of the excavation at any point (m)} \\ \gamma &= \text{soil unit weight (kN/m}^3\text{)} \\ q &= \text{surcharge for traffic and other loading (kN/m}^2\text{)} \end{aligned}$$

For a braced excavation in granular fill and native cohesionless soils, the unfactored rectangular earth pressure distribution ( $p$  in  $\text{kN/m}^2$ ; constant with depth), can be calculated as follows:

$$\begin{aligned} p &= K_a (0.65 \gamma H + q) \\ \text{where } K_a &= \text{active coefficient of earth pressure} \\ H &= \text{the total depth of the excavation (m)} \\ \gamma &= \text{soil unit weight (kN/m}^3\text{)} \\ q &= \text{surcharge for traffic and other loading (kN/m}^2\text{)} \end{aligned}$$

For a braced excavation in soft to firm cohesive soil, the unfactored rectangular earth pressure distribution ( $p$  in  $\text{kN/m}^2$ ; varying with depth), can be calculated as follows:

$$\begin{aligned} p &= 0 \text{ at ground surface increasing linearly to a depth of } 0.25 H_T \text{ to:} \\ p &= \gamma H_T - 4 m S_u \text{ at } 0.25 H_T \text{ and from } 0.25 H_T \text{ to } H_T \text{ below ground surface} \\ \text{where } H_T &= \text{the total depth of the excavation (m)} \\ \gamma &= \text{soil unit weight (kN/m}^3\text{)} \\ q &= \text{surcharge for traffic and other loading (kN/m}^2\text{)} \\ m &= 0.4 \text{ if an extensive soft clay layer underlies the excavation} \\ &= 1.0 \text{ if more resistant layer is present at the excavation base} \\ S_u &= \text{undrained shear strength (kN/m}^2\text{)}. \end{aligned}$$

The support systems may be designed using the following parameters:





SOIL TYPE	COEFFICIENT OF EARTH PRESSURE			INTERNAL ANGLE OF FRICTION ( $\phi$ , degrees)	UNIT WEIGHT ( $\gamma$ , kN/m <sup>2</sup> )	UNDRAINED SHEAR STRENGTH ( $S_u$ , kPa)
	Active, $K_a$	At Rest, $K_o$	Passive, $K_p$			
Existing Granular Fill	0.33	0.50	3.0	30	20	-
Sand to Sandy Silt	0.36	0.53	2.8	28	18	-
Silt	0.36	0.53	2.8	28	18	-
Clayey Silt*	0.38	0.55	2.7	27	17	-
	1.0	1.0	1.0	-	17	40

Note: \*Design Temporary Protection System on the more conservative (higher) earth pressure value.

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficients should be adjusted accordingly.

## 7.0 CLOSURE

This report was prepared by Mr. Evan Childerhose, P.Eng. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and a Principal with Golder, reviewed the technical aspects and conducted an independent quality control review of the report.

## Report Signature Page

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Northern Ontario Engineering Geology Terrain Study, Ontario Geological Society, Map 5044.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
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ASTM D2573	Standard Test Method for Field Vane Shear Test in Cohesive Soil
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Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91 Construction Projects as amended by O. Reg. 443/09

Ontario Provincial Standard Specification:

OPSS 539	Construction Specification for Temporary Protection Systems
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OPSS 903	Construction Specification for Deep Foundations
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Ontario Water Resources Act:

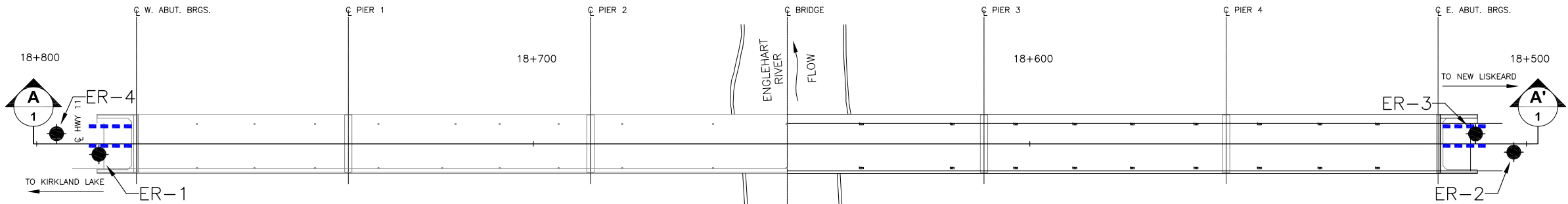
Ontario Regulation 372/97 Amendment to Ontario Regulation 903, Wells (as Amended)



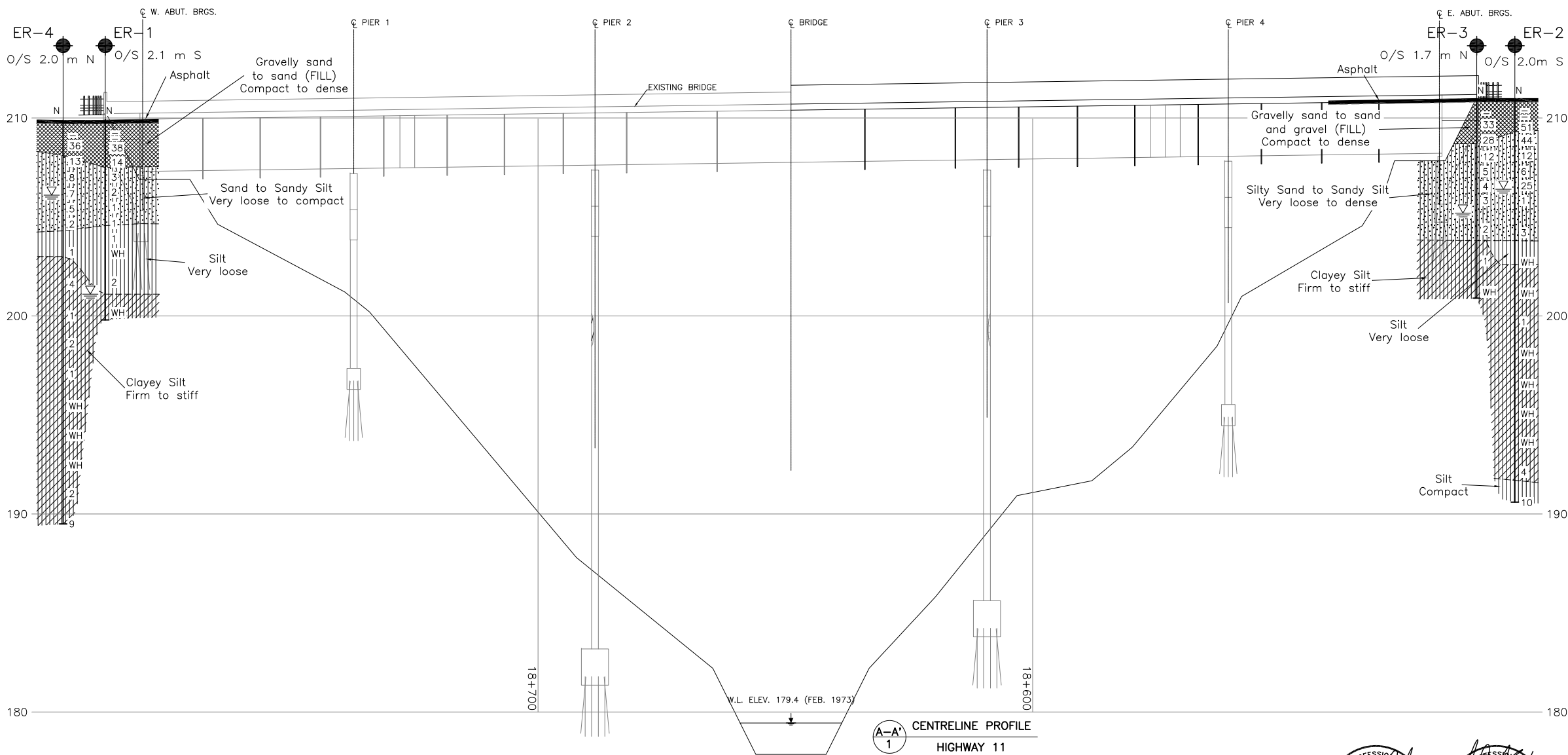
**FOUNDATION REPORT - ENGLEHART RIVER BRIDGE, SITE 47-032  
HIGHWAY 11, GWP 5302-05-00**

**Table 1: Evaluation of Temporary Support System Alternatives**

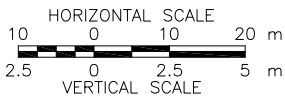
<b>Support System Type</b>	<b>Rank</b>	<b>Advantages</b>	<b>Disadvantages</b>	<b>Relative Costs</b>	<b>Risks/Consequences</b>
Driven Steel Sheet Piling	1	<ul style="list-style-type: none"><li>■ Straightforward installation</li></ul>	<ul style="list-style-type: none"><li>■ Limited load bearing capacity in shallow soils and the firm to stiff cohesive strata may be inadequate for tieback anchors.</li></ul>	<ul style="list-style-type: none"><li>■ Low cost of construction</li></ul>	-
Soldier Pile and Lagging Wall	2	<ul style="list-style-type: none"><li>■ Appropriate for both shallow and deep installations</li></ul>	<ul style="list-style-type: none"><li>■ Additional installation effort</li><li>■ May require tieback anchors depending on depth of embedment into overburden.</li></ul>	<ul style="list-style-type: none"><li>■ Less cost effective</li></ul>	<ul style="list-style-type: none"><li>■ Piles tend to run in deep soils</li><li>■ Potential for loss of soil as lagging is installed</li></ul>



PLAN



CENTRELINE PROFILE  
HIGHWAY 11



**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WP No. 5302-05-00

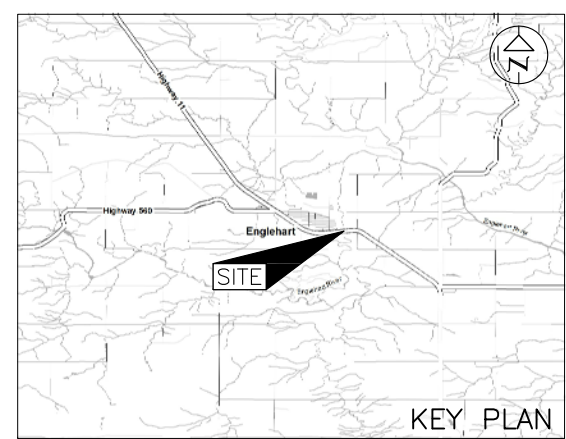
ENGLEHART (BLANCHE) RIVER  
HIGHWAY 11 BRIDGE 47-032  
BOREHOLE LOCATIONS AND SOIL  
STRATA



SHEET



**Golder Associates Ltd.**  
SUDBURY, ONTARIO, CANADA



KEY PLAN

LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▽ WL upon completion of drilling
- Temporary Protection System

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
ER-1	209.9	5298433.9	389844.1
ER-2	211.0	5298493.2	390122.8
ER-3	211.0	5298495.2	390114.5
ER-4	209.9	5298436.2	389834.9

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file nos. 47032-01.dwg, received July 23, 2012.



NO.	DATE	BY	REVISION
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100	DEC 2012	TB	CHDK.



# APPENDIX A

## Record of Boreholes



## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

### I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

#### Dynamic Cone Penetration Resistance; $N_d$ :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

<b>PH:</b>	Sampler advanced by hydraulic pressure
<b>PM:</b>	Sampler advanced by manual pressure
<b>WH:</b>	Sampler advanced by static weight of hammer
<b>WR:</b>	Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) Cohesive Soils Consistency

	kPa	$C_u, S_u$	psf
Very soft	0 to 12		0 to 250
Soft	12 to 25		250 to 500
Firm	25 to 50		500 to 1,000
Stiff	50 to 100		1,000 to 2,000
Very stiff	100 to 200		2,000 to 4,000
Hard	over 200		over 4,000

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

**Note:** 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

### V. MINOR SOIL CONSTITUENTS

Percent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. GENERAL

$\pi$	3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

#### (a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

#### (a) Index Properties (continued)

w	water content
$w_l$ or LL	liquid limit
$w_p$ or PL	plastic limit
$I_p$ or PI	plasticity index = $(w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index = $(w - w_p) / I_p$
$I_C$	consistency index = $(w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

#### (b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

#### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_\alpha$	secondary compression index
$m_v$	coefficient of volume change
$C_v$	coefficient of consolidation (vertical direction)
$C_h$	coefficient of consolidation (horizontal direction)
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$C_u, S_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$





## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

### BEDDING THICKNESS

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

### JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

### GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

### CORE CONDITION

#### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

#### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

#### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

### DISCONTINUITY DATA

#### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

#### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

#### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

#### Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT <u>11-1191-0032</u>		<b>RECORD OF BOREHOLE No ER-1</b>		1 OF 1 <b>METRIC</b>								
W.P. <u>5302-05-00</u>		LOCATION <u>N 5298433.9; E 389844.1</u>		ORIGINATED BY <u>EHS</u>								
DIST <u>          </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>AC</u>								
DATUM <u>GEODETIC</u>		DATE <u>June 5, 2012</u>		CHECKED BY <u>EC</u>								
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT		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	SHEAR STRENGTH kPa				WATER CONTENT (%)
209.9	GROUND SURFACE											
0.0	ASPHALT (240 mm)											
0.2	Gravelly sand to sand, trace silt (FILL) Compact to dense Brown Moist	1	AS	-								
		2	AS	-								
		3	SS	38								
		4	SS	14								
207.5	Peat seam encountered at 2.3 m depth.											
2.4	SAND to Sandy SILT, trace to some clay Very loose Brown to grey Wet  SILTY CLAY seam encountered at 3.0 m depth.	5	SS	3								
		6a	SS	2								
		6b	SS	2								
		7	SS	1								
		8	SS	1								
204.6												
5.3	SILT, some clay, trace to some sand Very loose Grey Wet	9	SS	1								
		10	SS	WH								
		11	SS	2								
201.1												
8.8	CLAYEY SILT Firm Grey Wet	12	SS	WH								
199.8												
10.1	END OF BOREHOLE  Note:  1. Water level at a depth of 8.8 m below ground surface (Elev. 201.1 m) upon completion of drilling.											

PROJECT 11-1191-0032			RECORD OF BOREHOLE No ER-2			1 OF 2 METRIC						
W.P. 5302-05-00			LOCATION N 5298493.2; E 390122.8			ORIGINATED BY EHS						
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AC						
DATUM GEODETIC			DATE June 5 and 6, 2012			CHECKED BY EC						
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					
211.0	GROUND SURFACE											
0.0	ASPHALT (150 mm)											
0.2	Gravelly sand to sand and gravel, trace silt (FILL) Dense Brown Moist		1	AS	-							
			2	AS	-							
			3	SS	51							
209.3												
1.7	Silty SAND to Sandy SILT, trace to some clay Very loose to dense Brown to grey Moist to wet		4	SS	44							1 30 51 18
			5	SS	12							
			6	SS	6							
			7	SS	25							
			8	SS	1							
			9	SS	3							0 27 60 13
203.8												
7.2	SILT, some sand, some clay Very loose Grey Wet		10	SS	WH							0 15 68 17
202.6												
8.4	CLAYEY SILT Firm to stiff Grey Wet											
			11	SS	WH							
			12	SS	1							
			13	SS	WH							
			14	SS	WH							

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:

PROJECT <u>11-1191-0032</u>		<b>RECORD OF BOREHOLE No ER-2</b>				2 OF 2 <b>METRIC</b>								
W.P. <u>5302-05-00</u>		LOCATION <u>N 5298493.2; E 390122.8</u>				ORIGINATED BY <u>EHS</u>								
DIST <u>          </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>AC</u>								
DATUM <u>GEODETIC</u>		DATE <u>June 5 and 6, 2012</u>				CHECKED BY <u>EC</u>								
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						
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100						
191.7	CLAYEY SILT Firm to stiff Grey Wet		15	SS	WH									
			16	SS	WH									
			17	SS	4									
191.3	SILT, trace to some clay, trace sand Compact Grey Wet													
190.6			18	SS	10									
20.4	END OF BOREHOLE  Note:  1. Water level at a depth of 4.6 m below ground surface (Elev. 206.4 m) upon completion of drilling.													

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:

PROJECT 11-1191-0032			RECORD OF BOREHOLE No ER-3			1 OF 1 METRIC						
W.P. 5302-05-00			LOCATION N 5298495.2; E 390114.5			ORIGINATED BY EHS						
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AC						
DATUM GEODETIC			DATE June 8, 2012			CHECKED BY EC						
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					
211.0	GROUND SURFACE											
0.0	ASPHALT (240 mm)											
0.2	Gravelly sand to sand and gravel, trace silt (FILL) Compact to dense Brown Moist		1	AS	-							55 40 (5)
			2	SS	33							
			3	SS	28							
208.7												
2.3	Silty SAND, trace to some clay Very loose to compact Grey Wet		4	SS	12							
			5	SS	5							0 59 27 14
			6	SS	4							
			7	SS	3							
			8	SS	2							
203.8												
7.2	CLAYEY SILT, trace to some sand Firm Grey Wet		9	SS	1							
			10	SS	WH							0 0 73 27
200.9												
10.1	END OF BOREHOLE											
	Note: 1. Water level at a depth of 5.8 m below ground surface (Elev. 205.2 m) upon completion of drilling.											

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT 11-1191-0032			RECORD OF BOREHOLE No ER-4			1 OF 2 METRIC		
W.P. 5302-05-00			LOCATION N 5298436.2; E 389834.9			ORIGINATED BY EHS		
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AC		
DATUM GEODETIC			DATE June 7, 2012			CHECKED BY EC		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 20 40 60 80 100 PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%) 20 40 60 UNIT WEIGHT γ kN/m <sup>3</sup>
209.9	GROUND SURFACE							
0.0	ASPHALT (200 mm)							
0.2	Gravelly sand, trace silt (FILL) Dense Brown Moist		1	AS	-			
			2	SS	36		209	
208.1								
1.8	SAND and SILT to Silty SAND, trace to some clay, trace gravel Very loose to compact Brown to grey Moist to wet		3	SS	13		208	
			4	SS	8			
			5	SS	7		207	
			6	SS	5		206	
			7	SS	2		205	
204.3								
5.6	SILT, some clay, trace to some sand Very loose Grey Wet		8	SS	1		204	
203.0								
6.9	CLAYEY SILT, trace to some sand Firm to stiff Grey Wet		9	SS	4		203	
			10	SS	1		202	
			11	SS	2		201	
			12	SS	1		200	
							199	
							198	
							197	
							196	
							195	

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:



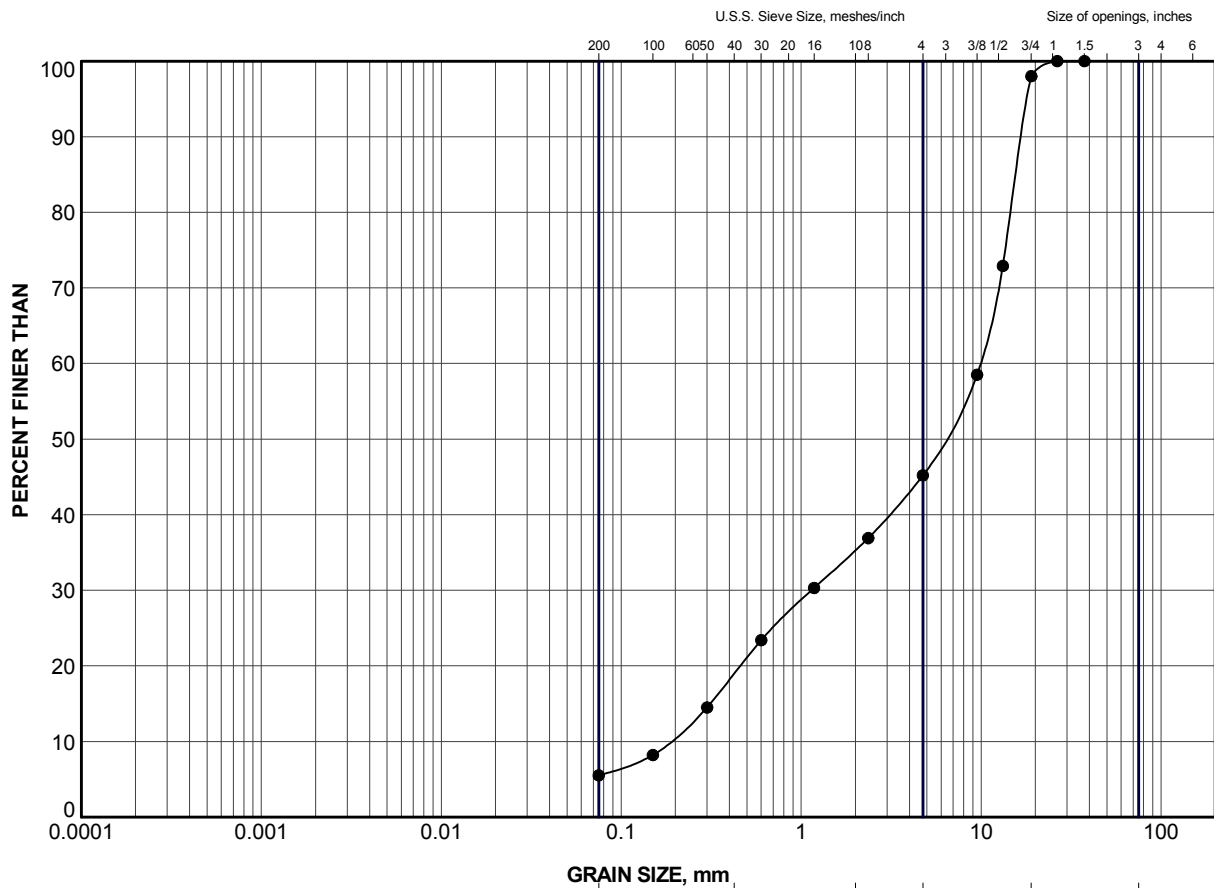
+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



# APPENDIX B

## Laboratory Test Results




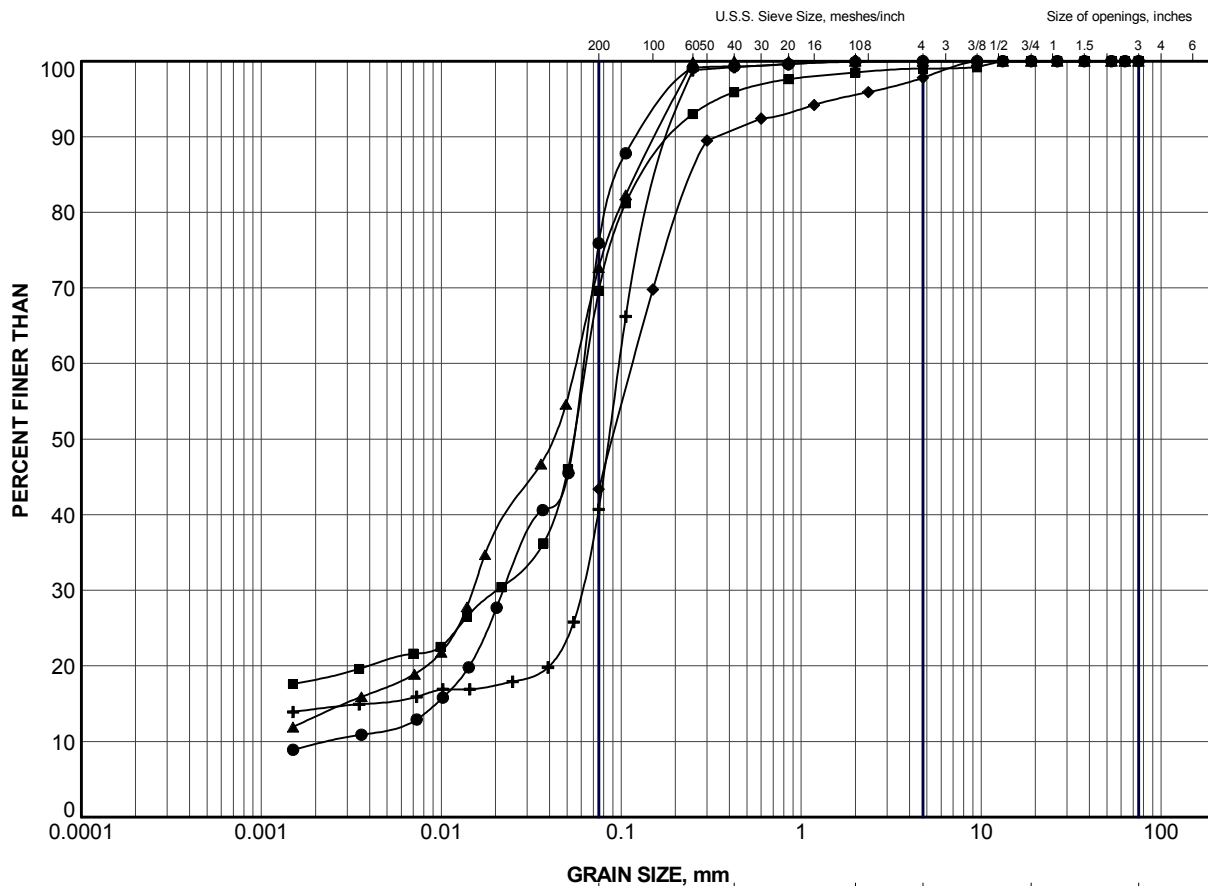


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-3	1	210.6

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
GRAIN SIZE DISTRIBUTION Sand and gravel (FILL)					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B-1</b>		



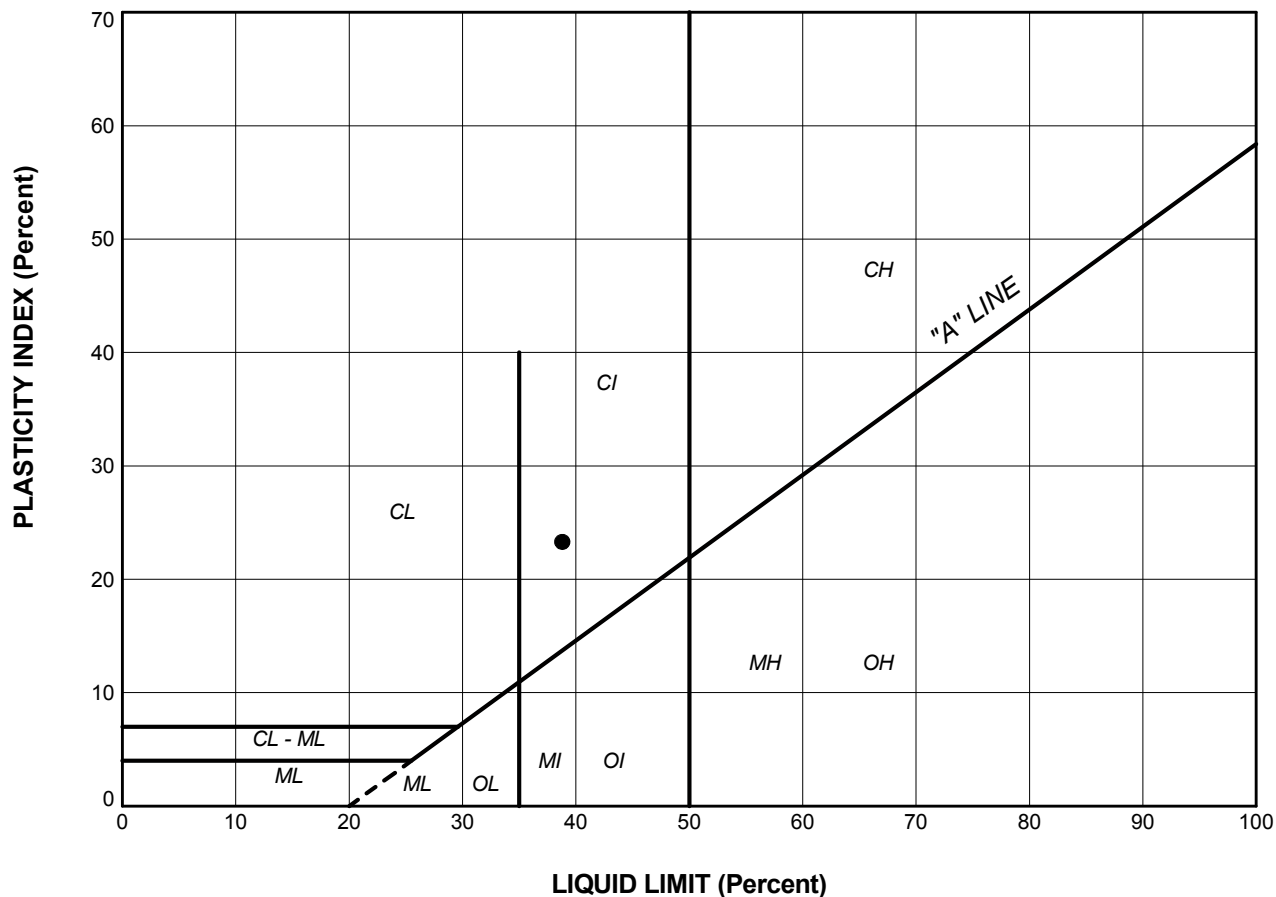
CLAY AND SILT		GRAVEL SIZE, mm				Cobble Size	
		fine	medium	coarse	fine		coarse
		SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-1	7	205.9
■	ER-2	4	209.2
▲	ER-2	9	204.6
+	ER-3	5	207.7
◆	ER-4	3	207.9

PROJECT				
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032				
TITLE				
GRAIN SIZE DISTRIBUTION Sandy Silt to Silty Sand				
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ
DRAWN	TB	Sep 2012	SCALE	N/A
CHECK	EC	Sep 2012	REV.	
APPR	JMAC	Sep 2012	FIGURE B-2	





**SOIL TYPE**  
 C = Clay  
 M = Silt  
 O = Organic

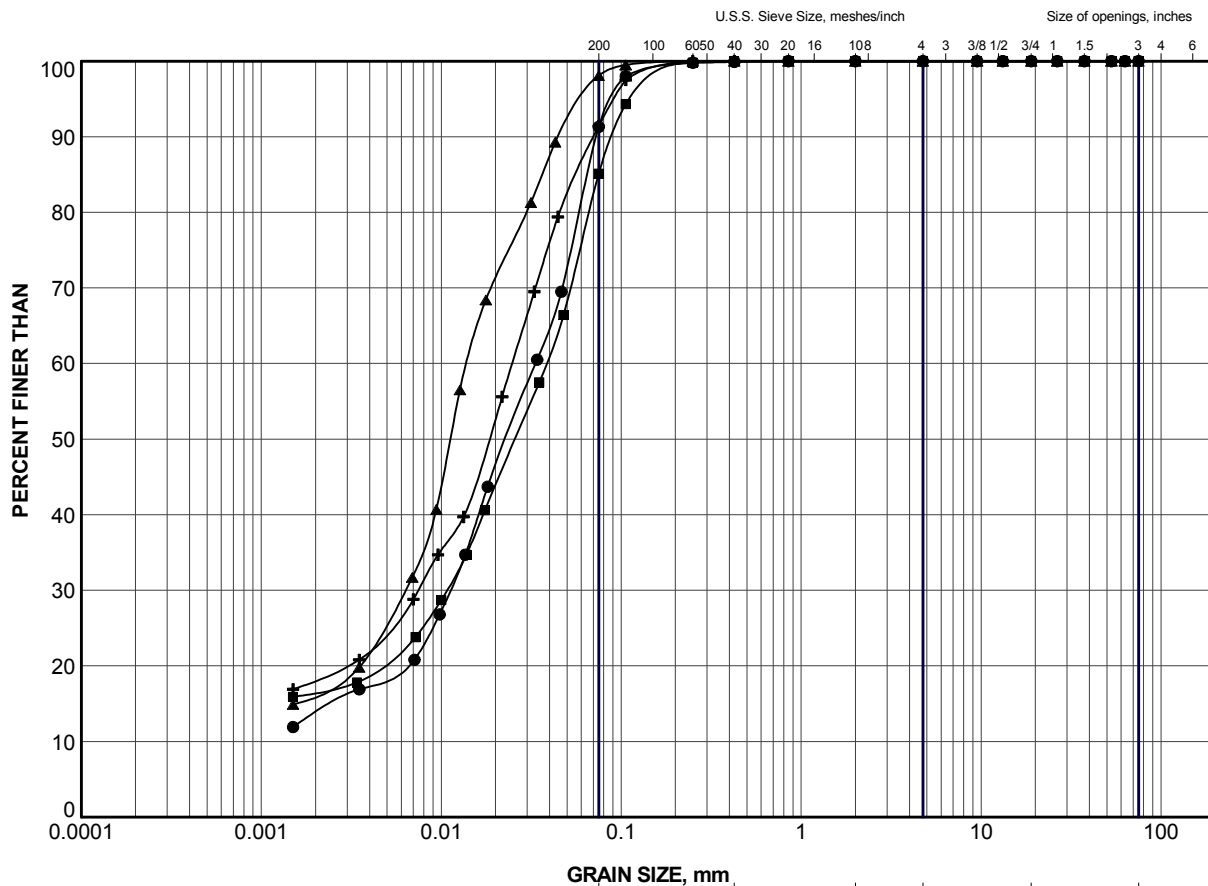
**PLASTICITY**  
 L = Low  
 I = Intermediate  
 H = High

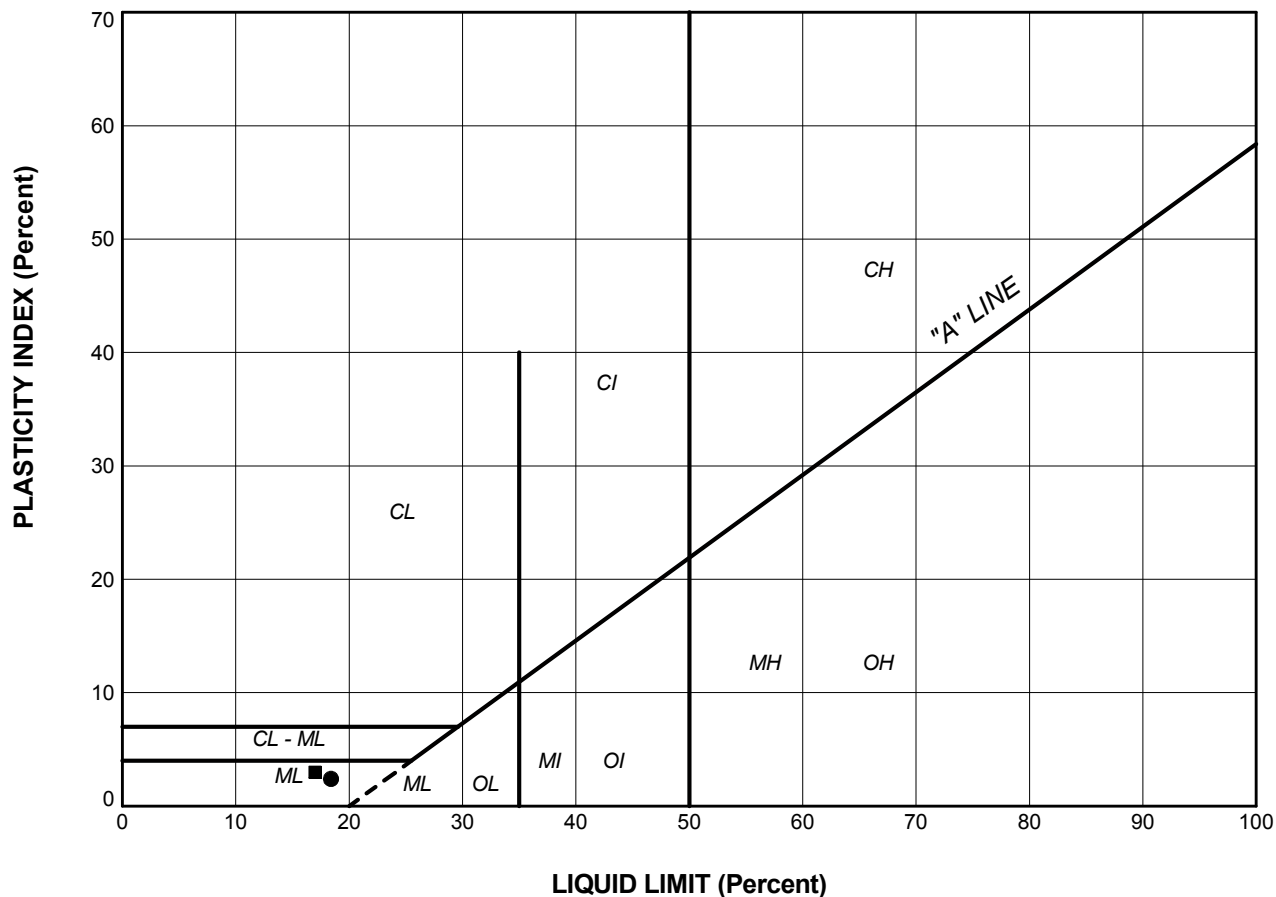
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	ER-1	6a	39	16	23

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
PLASTICITY CHART Silty Clay					
PROJECT No.		11-1191-0032		FILE No. 11-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-3		

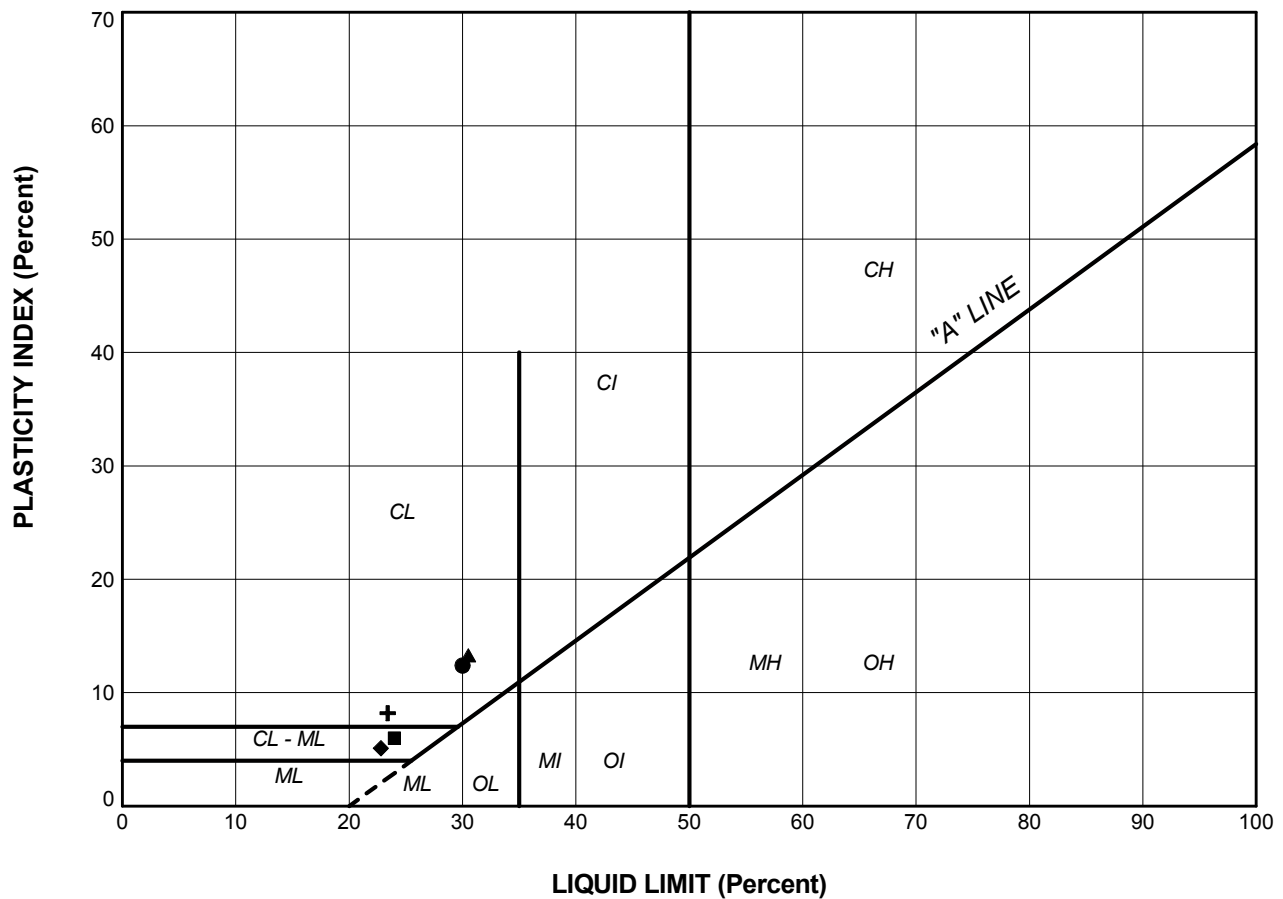






PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
PLASTICITY CHART Silt					
PROJECT No.		11-1191-0032		FILE No. 11-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-5		

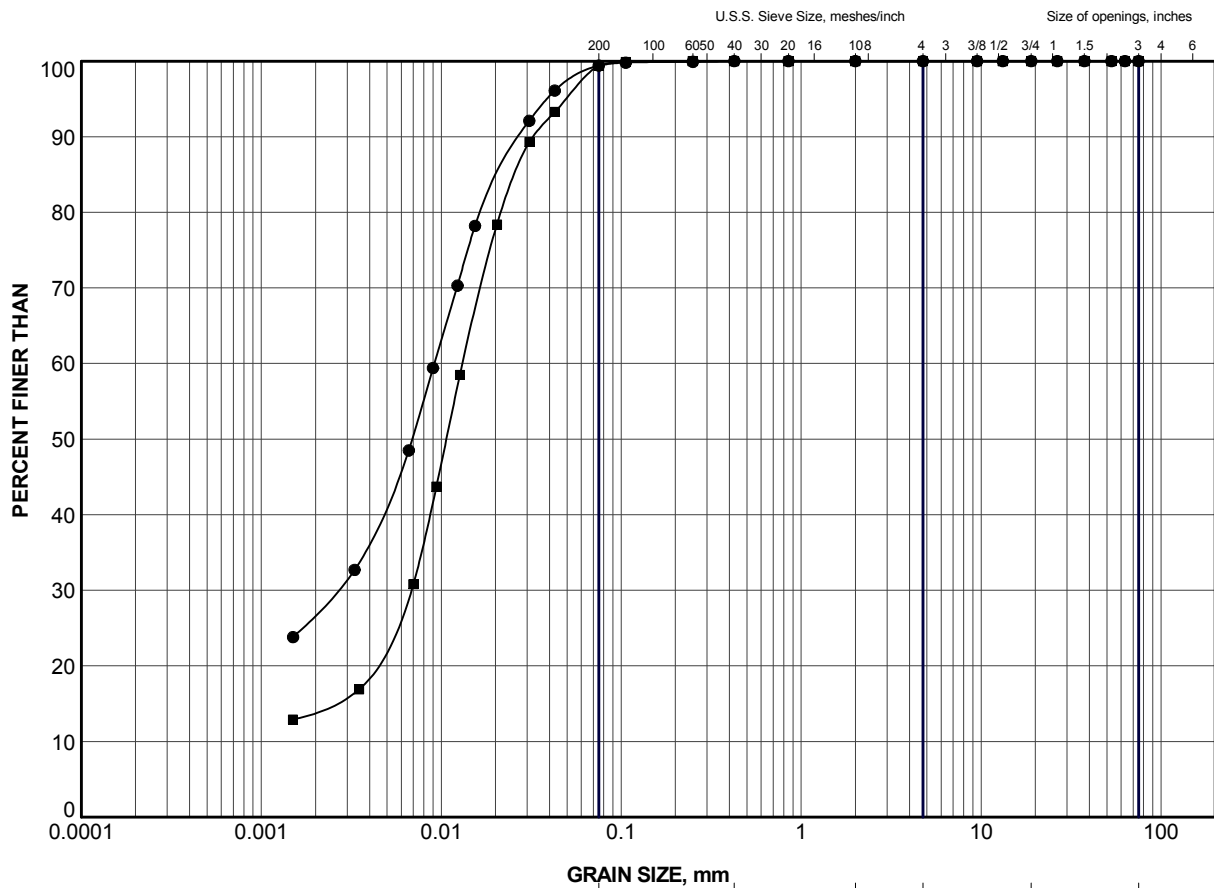




<b>LEGEND</b>					
SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	ER-2	15	30	18	12
■	ER-2	17	24	18	6
▲	ER-3	10	31	17	13
+	ER-4	12	23	15	8
◆	ER-4	17	23	18	5

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
PLASTICITY CHART Clayey Silt					
PROJECT No. 11-1191-0032		FILE No. 11-1191-0032+BH09.GPJ			
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			<b>FIGURE B-6</b>		





GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-3	10	201.6
■	ER-4	17	189.8

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
GRAIN SIZE DISTRIBUTION Clayey Silt					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-7		



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