



Englobe

Soils Materials Environment

**Submitted To AECOM Canada Ltd.
189 Wyld Street Suite 103, North Bay, Ontario P1B 1Z2
On Behalf of the Ontario Ministry of Transportation**

**Bridge Rehabilitation – Boshkung Lake Bridge
Highway 118
Stations 15+782.5 to 15+822.5 – Township of Stanhope
Site No. 40-011
GWP 5140-13-00**

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

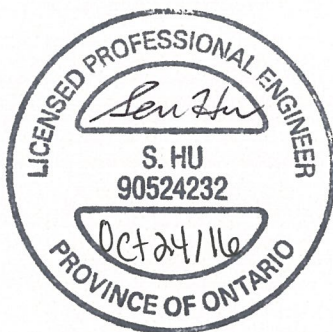
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Ref. No: 15/03/15019-F10

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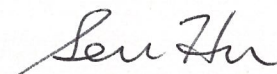
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Final Foundation Investigation and Design Report



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| REVISION AND PUBLICATION REGISTER | | |
|-----------------------------------|------------|---|
| Revision N° | Date | Modification And/Or Publication Details |
| 00 | 2016-06-22 | DRAFT FIDR Issued |
| 01 | 2016-10-24 | Final FIDR Issued |

| REPORT DISTRIBUTION | |
|-------------------------------------|--|
| 2 hard copies | AECOM |
| 5 hard copies and 1 electronic copy | MTO Project Manager |
| 1 hard copy and 1 electronic copy | MTO Pavement and Foundations Section, Foundation Group |
| 1 hard copy | File |

1 INTRODUCTION

Englobe Corp. (Englobe), formerly LVM-Merlex, a Division of EnGlobe Corp., has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation to provide subsurface data for the design of a temporary protection system to be implemented at the existing Boshkung Lake Bridge during the proposed structural rehabilitation and conversion to semi-integral abutments. The bridge is located on Highway 118, some 1.9 km west of the intersection between Highway 118 and Highway 35 in the Township of Stanhope (see Drawing No. 1 in Appendix 1).

The foundation investigation location was specified by the MTO in the Terms of Reference for work under Agreement No. PO 5014-E-0020: GWP 5140-13-00 for Detailed Design. The Terms of Reference for the scope of work are outlined in Englobe's Proposal P-14-168 Rev.1 dated January 21, 2015. The purpose of this investigation was to determine the subsurface conditions in the area of the bridge approaches in order to provide factual subsurface information and design recommendations for the temporary protection system to be implemented during rehabilitation activities. Englobe investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on selected samples.

2 SITE DESCRIPTION

The Boshkung Lake Bridge is located on Highway 118, between approximately Stations 15+782.5 to 15+822.5, Township of Stanhope (Site No. 40-011). The bridge is a single span steel girder structure of 40 m in length, which we understand was constructed in 1970s. The topography at the site is generally of low to moderate relief. The existing approach embankments for the bridge currently support two undivided lanes of highway, running in a west-east direction. Boshkung Lake flows from the north to the south at the bridge location (left to right). A visual review of the highway to the west and the east of the bridge indicates that, in general, the approaches are in fair to good condition (see Photo Essay in Appendix 4).

The topography at this site is located in a valley area. At the bridge location, the existing highway centreline is at Elevation 313.7 m at the east end and 312.7 m at the west end of the bridge. The highway pavement structure is constructed on the granular fill for the approach embankments, which overlies the natural earth deposits. The existing approach embankments extend out from the existing concrete wing walls in the area of the bridge, and have been built on slope angles of approximately 4H:1V or steeper at the west bank, and staged vertical slope at the east bank.

Infrastructure at the bridge location includes overhead wires to the south of the bridge location, crossing the highway to the east of the bridge. A weather/temperature station is located near

the bridge site and includes sensors within the deck to the west of the bridge approach. Underground services may also be present to the north and/or south of the platform, however, were outside Englobes area of investigation, as such, were not located at the time of investigation.

2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

This project is located in the Geomorphic Sub-province known as the Muskoka Ridges and Pockets. The topography on this section of Highway 118 is generally rolling. Significant deposits of earth overlie the bedrock. Within the project area, the native overburden primarily consists of silt with sand overlying the bedrock.

The bedrock in the area, based on Ontario Geologic Survey (OGS) Map MRD-126, consists of migmatitic rocks and gneisses of undetermined protolith of Precambrian Age.

3 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out on May 20th and May 21st, 2015 during which time a total of two (2) sampled boreholes were advanced through the approach slab and the approach embankment at each end of the bridge, with Borehole No. 1 advanced behind the west abutment to the right of centreline (right side), and Borehole No. 2 advanced behind the east abutment to the left of centreline (left side).

The field investigation was carried out using a truck mounted CME drilling rig equipped with hollow stem augers, standard augers, casing equipment, and routine geotechnical sampling equipment. The drill equipment is owned by Chrisdamat Management Ltd. and was operated by an Englobe drill crew. Soil samples were obtained at the borehole locations at regular intervals of depth using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures (ASTM D-1586). The SPT method involves advancing a 50 mm O.D. split spoon sampler with the force of a 63.5 kg hammer freely dropping 760 mm. The number of blows per 300 mm penetration was recorded as the “N” value. All samples taken during this investigation were stored in labeled airtight containers for transport to the Englobe North Bay laboratory for visual examination and select laboratory testing.

Groundwater conditions in the open boreholes were observed during the advancement of and immediately following completion of the individual boreholes. A single 19 mm diameter standpipe was installed in one open borehole prior to backfilling to allow for further monitoring of the local groundwater level. The remaining open borehole was backfilled upon completion with compacted auger cuttings in the general order from which they were removed, and where necessary, bentonite pellet backfill was added to the boreholes to bring the backfill up to grade in accordance with requirements of Ontario Regulation 903. At the borehole through the

embankment, the upper portion of the hole, where necessary, was backfilled with an asphalt cold patch to seal the existing asphalt surface.

The fieldwork for this investigation was carried out under the full time direction of a senior member of the Englobe engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to the Englobe North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in the laboratory. Laboratory testing of select samples included routine testing for natural moisture content determination and particle size analysis. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix 2), with a summary of results presented on the laboratory sheets in Appendix 3 (Figures Nos. L-1 to L-3 and Table No. L-4).

The location of the individual boreholes was determined in the field using highway chainage established by Callon Dietz Inc. (Callon Dietz) and offset relative to highway centreline. The MTO co-ordinates, northing and easting, were then established for the boring locations using coordinates from MTM Zone 10, NAD 83 CSRS. Elevations contained in this report are referenced to a geodetic datum. The borehole elevations are based on a survey carried out by Callon Dietz.

4 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Records of Borehole Logs (Appendix 2) and on Drawing No. 2 (Appendix 3). Please note that stratigraphic delineations presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, the results of SPT, plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location, and are shown on the drawings for illustration purposes only.

4.1 BOSHKUNG LAKE BRIDGE, TOWNSHIP OF STANHOPE

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Drawing No. 2, Appendix 3. During the course of the exploration program, two (2) sampled boreholes were put down at this site, with Borehole No. 1 advanced behind the west abutment to the right of centreline (right side), and Borehole No. 2 advanced behind the east abutment to the left of centreline (left side).

At the time of the subsurface investigation, the ground surface elevations at Borehole Nos. 1 and 2 were recorded at Elevations 312.7 m and 313.7 m, respectively.

4.1.1 Pavement Structure

At the surface at Borehole Nos. 1 and 2, a pavement structure consisting of 102 mm thick asphalt concrete overlying a 254 mm thick concrete approach slab was measured.

4.1.2 Sand Fill

Underlying the concrete approach slab at Borehole Nos. 1 and 2, a layer of brown sand fill, gravelly to trace gravel, trace silt, trace clay was penetrated. The natural moisture contents measured on samples of this deposit recovered from Borehole Nos. 1 and 2 were in the order of 3% to 12%, with the exception of a 23% natural moisture content measured on the one sample recovered near the bottom of the fill in Borehole No. 1. Gradation analyses were carried out on four (4) samples of this deposit recovered from Borehole Nos. 1 and 2, the results of which indicated 0% to 30% gravel size particles, 60% to 92% sand size particles, and 4% to 10 % silt and clay size particles (Figure No. L-1, Appendix 3). Results of grain size distribution testing carried out on four samples recovered from Borehole Nos. 1 and 2 indicate that the sand fill generally meets requirements of Granular "B" Type II stated in OPSS.PROV 1010. Based on SPT 'N' values of 4 to 73 blows per 300 mm penetration and 41 blows per 152 mm penetration, the relative density of this deposit was described as loose to very dense. This deposit was encountered to depths of 7.8 m and 3.4 m below grade at Borehole Nos. 1 and 2, respectively (Elevation 304.9 m and 310.3 m, respectively).

4.1.3 Silt

Underlying the sand fill deposit at Borehole No. 1, a deposit of grey silt, with sand, trace clay was penetrated. The natural moisture contents measured on samples of this deposit were in the order of 26 to 34%. An hydrometer analysis was carried out on one (1) sample of this deposit, the results of which indicated 0% gravel size particles, 25% sand size particles, 75% silt size particles, and 0% clay size particles (Figure No. L-2, Appendix 3). Based on observation of the spilt spoon sampler advanced 300 mm using the static weight of hammers for the SPT testing in the deposit, the relative density of this deposit was described as very loose. Borehole No. 1 was terminated in this deposit at a depth of 9.8 m below grade (Elevation 302.9 m).

4.1.4 Bedrock

Underlying the sand fill deposit at Borehole No.1, the bedrock was proven by diamond core drilling. The bedrock was described as pink granite with black gneiss. Based on RQD values of 50 to 65%, the bedrock was described as fair to good quality. Sampling in the bedrock was terminated at a depth of 6.4 m below grade at Borehole No. 1 (Elevation 307.3 m). It should be noted that, where encountered, the underlying bedrock surfaces in this area can be very erratic in nature, varying substantially in elevation over short horizontal distances.

4.1.5 Previous Investigations

A previous foundation investigation (Project No. 3782), was carried out at this location in 1967 by the William Trow Associates Limited. The results of this previous investigation as shown on a Drawing No. 1 indicated the subsurface soils nearby the bridge approach consisted of sand overlying the gneiss bedrock encountered at elevations ranging from 304.5 m to 299.3 m (see Enclosure No. 5, Appendix 5).

4.2 GROUNDWATER DATA

The lake water level was measured at Elevation 307.5 m on May 21, 2015 during the foundation investigation period. Measurements of the groundwater table and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. A standpipe was installed in Borehole No. 1 to obtain the water level post borehole completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix 2) and shown on the Borehole Locations and Soil Strata Drawing No. 2 in Appendix 3.

At the time of this investigation, the water level was measured at Elevation 307.5 m on May 21st, 2015 at Borehole No. 1. The water level reading at Elevation 310.1 m measured at Borehole No. 2 had probably not yet stabilized since it was taken upon completion of borehole on May 20th, 2015.

The groundwater and lake water levels should be expected to fluctuate seasonally/yearly.

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

A foundation investigation was carried out at the Boshkung Lake Bridge for the design of a temporary protection system to be provided for the proposed bridge rehabilitation and conversion to semi-integral abutments. The bridge is located between approximately Stations 15+782.5 to 15+822.5 in the Township of Stanhope, and is identified as Site No. 40-011. The existing bridge is a 40 m long single span steel girder structure.

The existing highway at the bridge location supports two undivided lanes of traffic running in a west-east direction. Based on data from this foundation investigation, the embankment supporting the existing pavement structure at this site has generally been constructed with a sand fill overlying native silts and/or bedrock. The subsurface conditions encountered during this investigation are compatible with the conditions encountered during the 1967 Investigation, Reference 67-F-291M.

The conversion to semi-integral abutments will require the removal of the ballast walls. It is anticipated that an excavation some 1.2 m deep will be required behind the existing abutments to carry out the bridge rehabilitation and convert the Boshkung Lake Bridge to a semi-integral abutment structure. As such, a protection system will be required at the west and east abutments of the bridge to support an excavation some 1.2 m deep behind the abutments and maintain an active lane of traffic. Based on data from this foundation investigation, the embankment fill behind the abutments supporting the approach slabs and pavement structure generally consists of sand fill. No obstructions were encountered in either borehole.

5.2 EXCAVATION AND DEWATERING

The fill below the pavement structure and approach slabs is considered as a Type 3 soil in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. As such, to remain stable above the water table, side walls of temporary open excavations would have to be cut back to an angle not exceeding 1H:1V. Some additional 1.2 m deep excavations (i.e. to Elevation 311.5 m at the bridge west end, and to Elevation 312.5 m at the bridge east end) will be required at the rear of the abutments to allow the rehabilitation work to be carried out on the ballast walls. The existing width of the bridge approach is insufficient to allow the construction of a 1H:1V slope parallel to the active traffic lane. As such, a vertical excavation adjacent to the active traffic lane will be required and a protection system, installed perpendicular to the abutments, will be needed to support the active traffic lane. Conceptual shoring locations are illustrated on Figure No. SK-1 in Appendix 6.

Excavations must be maintained in a dewatered condition at all times during excavation and foundation construction. The water level in the boreholes at the time of this investigation was recorded at Elevations 307.5 m to 310.1 m. This level is well below the anticipated depth of excavation (Elevations 311.5 m to 312.5 m); therefore it is not anticipated that the groundwater

table will be encountered during the shallow excavations at the abutments. If a deeper excavation is required to be advanced below the prevailing groundwater table (estimated at elevation 307.5 m), then groundwater control in accordance with OPSS 517 will have to be carried out.

5.3 PROTECTION SYSTEM

The results of this investigation indicated that, underlying the pavement structure (asphalt concrete and concrete approach slabs), a sand fill, gravelly to trace gravel, trace silt, trace clay was encountered, in a very dense to loose state of compactness. At the west approach, the fill was underlain by native silts at Elevation 304.9 m. At the east approach, the fill deposit was underlain by bedrock at Elevation 310.3 m.

The required depth of anticipated excavation, directly behind the abutments, will be relatively shallow, in the order of 1.2 m (Elevation 311.5 m at the west abutment and 312.5 m at the east abutment). In consideration of the anticipated soil conditions, the use of sheet piles of sufficiently robust cross section could be considered for a protection system. In order to fix the sheet toe, the sheeting should be driven to a depth of a minimum of 1.2 m below the required depth of excavation. At this depth, the toe of sheeting would be established in the sand fill deposit. Considering the limited depth of excavation and provided a sheet pile of sufficiently robust structural section is used, a whaler and raker may not be required if the top of the sheet pile wall is fixed to the existing approach slab. If fixing the sheet pile walls to the approach slab is not feasible, a whaler with raker or a tieback system would have to be installed. If tiebacks are required, the resistance (R) for grouted anchors located outside the active failure wedge in cohesionless soils can be estimated from the following equation from Section 26.12.4.1 of the Canadian Foundation Engineering Manual (4th Edition):

$$R = \sigma_z' A_s L_s \alpha_g$$

Where: σ_z' = effective vertical stress at the midpoint of the load carrying bond length

A_s = effective unit surface area of the anchor

L_s = effective embedment length of the anchor

α_g = anchorage coefficient use 1.0 for granular backfill

For tieback design, a triangular earth pressure distribution over the height of the cut would be appropriate for design.

Unless the pull-out resistance (capacity) of the tieback anchor is proven with a load test program, the allowable anchor load (as suggested by the Canadian Foundation Engineering Manual, 4th Edition), is commonly obtained by dividing the computed capacity of the anchor by a factor of safety of 3. Alternatively, proprietary anchor systems can be used with the capacity and installation to be confirmed by the anchor system manufacturer.

If excavation to a greater depth than the anticipated 1.2 m is required, then the shoring system would have to be advanced to a greater depth, dependant on the final depth of excavation below the top of pavement. Based on the results of this investigation, the sand fill and the native materials do not appear to contain obstructions. As obstructions were not encountered in the overburden at the approach boreholes, sheet piles are also considered acceptable for use in deeper excavations through the embankment fills if the sheet piles are terminated above Elevation 310.3 m.

Considering the cohesionless nature of the embankment fills (granular pavement structure over sand fills), a rectangular apparent pressure distribution over the height of the excavation would be appropriate for design of the temporary shoring. The width of the apparent rectangular pressure distribution, over the height of excavation, can be considered equal to $0.65 \cdot K_a \cdot \gamma \cdot H$, where:

K_a = active earth pressure,

γ = unit weight, and

H = height of the wall above the base of excavation.

Surcharge loads from the active lane of traffic must also be considered for designing the temporary protection system.

A table outlining the possible temporary shoring protection/flexible retaining systems and their relative advantages, disadvantages, and costs, as well as comments on the viability of the methods is provided on Table A in Appendix 6.

The protection system can be designed using the lateral earth pressure parameters provided in Section 5.4 Lateral Earth Pressures below.

The temporary protection system should be designed and constructed to comply with OPSS.PROV 539. In consideration of the location of the protection system and traffic volume, a Performance Level 2 is considered appropriate. The protection system should be removed upon completion of the work.

5.4 LATERAL EARTH PRESSURES

Lateral earth pressures should be computed in accordance with the Canadian Highway Bridge Design Code (CHBDC). The design parameters for the fill and native materials are as follows:

| PARAMETER | SAND FILL | SILT |
|--|-----------|------|
| Unit Weight (kN/m^3) | 19.0 | 18.0 |
| Angle of Internal Friction | 30° | 28° |
| Coefficient of Active Earth Pressure (K_a) | 0.33 | 0.36 |

| PARAMETER | SAND FILL | SILT |
|---|-----------|------|
| Coefficient of Passive Earth Pressure (K_p) | 3.0 | 2.77 |
| Coefficient of Earth Pressure at Rest (K_o) | 0.5 | 0.53 |

For rigid, restrained, structures (i.e. rigid portals, box culverts, bridge abutments, etc.), the “at-rest” condition (K_o) applies. For flexible structures (i.e. free standing retaining walls, flexible walls (including tied flexible walls), etc.) the “active” condition (K_a) applies. The “passive” condition (K_p) applies when the wall is in compression (in a direction opposite to the wall loading).

5.5 BACKFILL AND COMPACTION

The existing backfill at the abutments was generally in a very dense to loose condition. Following completion of the rehabilitation and prior to backfilling the excavation, the existing subgrade should be proof rolled with a minimum of five overlapping passes of a hand operated vibratory compactor with a minimum weight of 400 kg (or a centrifugal force of 50 kN). Backfilling should be carried out in accordance with OPSS 902 and compaction should be carried out in accordance with OPSS 501.

5.6 CONSTRUCTION CONCERNS

Considering the relatively shallow depth of expected excavations and nature of the approach fill and native materials, no major construction concerns are anticipated if the works are carried out in general conformance to that discussed herein. The contractor should be prepared to deal with these materials for the temporary protection system, dewatering and other construction activities.

6 STATEMENT OF LIMITATIONS

The design recommendations given in this geotechnical report are applicable only to the project described in the text and only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known, in our analysis certain assumptions had to be made. The actual conditions may however, vary from those assumed, in which case changes and modifications may be required to our geotechnical recommendations. We recommend, therefore, that we be retained and provided the opportunity during the design stage to review the design drawings, site survey information, proposed elevations, etc. to verify that they are consistent with our recommendations or the assumptions made in our analysis. It is further recommended that we be retained to review the final design drawings and specifications relative to the geotechnical recommendations.

If, during construction, conditions in the field vary from those assumed at the design stage, an engineer from this office must be notified immediately.

Proper subgrade preparation, groundwater control, compaction, etc. are all critical aspects of the bearing capacity of native soils. It must be noted that different aspects of the geotechnical design are based on the assumption that Englobe will be retained during site preparation and construction of the proposed works to ensure that both the geotechnical site characteristics and the construction operations/techniques are consistent with our recommendations. Should Englobe not be involved during the full construction phase, our liability is strictly limited to the factual information contained herein only.

The comments in this report are intended solely for the guidance of the design engineer and address the geotechnical conditions only, at this preliminary design stage. The number of boreholes required to determine the localized conditions between boreholes directly affecting construction costs, equipment, scheduling, etc. would in fact be greater than what has been carried out for design purposes. Therefore, contractors bidding on this project or undertaking this work should make their own interpretations of the factual borehole results and carry out further work as they deem necessary to assess the scope of the project.

Section 5 of this reported is intended for the use of the client and the design team only and is not intended to be included in the tender documents. Inclusion of the factual information (Sections 1 to 4 inclusive) in the tender documents is furnished merely for the general information of bidders and is not in any way warranted or guaranteed by or on behalf of the owner or the owner's consultants and its subconsultants or the consultants' or subconsultants' employees, and neither the owner nor its consultants or its employees shall be liable for any representations negligent or otherwise contained in the documents.

Appendix 1 Key Plan

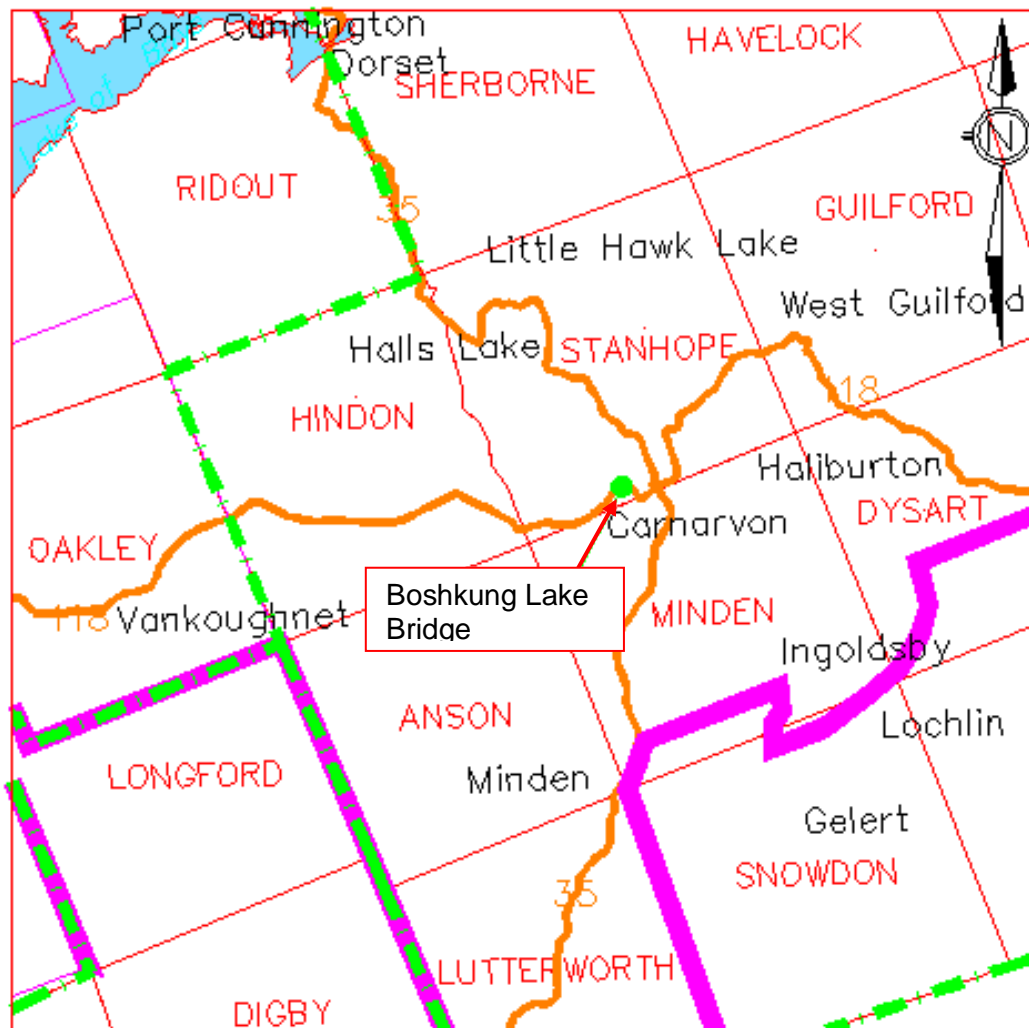
Drawing No. 1

Key Plan

MACRO KEY PLAN

Drawing No.1

NOT TO SCALE



FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 5140-13-00

Highway 118

Boshkung Lake Bridge

Site No. 40-011

Township of Stanhope



Reference No: 15/03/15019-F10

September 2016

Appendix 2 Subsurface Data

| | |
|------------------------|-----------------------------------|
| Enclosure No. 1 | List of Abbreviations and Symbols |
| Enclosure Nos. 2 and 3 | Record of Borehole Sheet |

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) | Relative Density |
|-------------------|------------------|
| 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 |

SAMPLE DESCRIPTION NOTES:

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.
2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.
3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.
4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

METRIC

RECORD OF BOREHOLE NO. 1



REFERENCE 15/04/15019 DATUM Geodetic LOCATION N 4989843.9 E366366.9 - Stanhope Twp., Station 15+780 ORIGINATED BY JL
 PROJECT GWP 5140-13-00, Highway 118 - F10 BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers COMPILED BY SH
 CLIENT AECOM DATE (Started) 21 May 2015 TIME (Completed) 9:35:00 AM CHECKED BY MAM
 DATE (Completed) 21 May 2015

| SOIL PROFILE | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | 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 (%) | | | | | | | | | | | |
| 312.7 | Ground Surface | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.0 | 102 mm Asphalt | | | | | | | | | | | | | | | | | | | | | | | | |
| 312.3 | 254 mm Concrete | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.4 | Sand FILL- sand, gravelly to trace gravel, trace silt, trace clay | | 1 | SS | 73 | | | | | | | | 30 60 (10) | | | | | | | | | | | | |
| | brown, moist | | 2 | SS | 17 | | | | | | | | | | | | | | | | | | | | |
| | (very dense/loose) | | 3 | SS | 16 | | | | | | | | | | | | | | | | | | | | |
| | | | 4 | SS | 5 | | | | | | | | | | | | | | | | | | | | |
| | | | 5 | SS | 11 | | | | | | | | 13 83 (4) | | | | | | | | | | | | |
| | | | 6 | SS | 6 | | | | | | | | | | | | | | | | | | | | |
| | | | 7 | SS | 4 | | | | | | | | | | | | | | | | | | | | |
| | | | 8 | SS | 7 | | | | | | | | 0 92 (8) | | | | | | | | | | | | |
| 304.9 | SILT - with sand, trace clay moist | | 9 | SS | WH | | | | | | | | | | | | | | | | | | | | |
| 7.8 | Grey, wet | | | | | | | | | | | | | | | | | | | | | | | | |
| | (very loose) | | | | | | | | | | | | | | | | | | | | | | | | |
| 302.9 | End of Sampling | | 10 | SS | WH | | | | | | | | 0 25 75 0 (NP) | | | | | | | | | | | | |
| 9.8 | End of Borehole | | | | | | | | | | | | | | | | | | | | | | | | |
| COMMENTS | | | | | | | + 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE | | | | | | | | | | | | | | | | | | |
| | | | | | | | WATER LEVEL RECORDS <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) 21/5/15 9:40:00 AM</td> <td>5.2</td> <td>-</td> </tr> <tr> <td>2)</td> <td>-</td> <td>-</td> </tr> <tr> <td>3)</td> <td>-</td> <td>-</td> </tr> </tbody> </table> | | | | | | | Date (dd/mm/yy)/Time | Water Depth (m) | Cave In (m) | 1) 21/5/15 9:40:00 AM | 5.2 | - | 2) | - | - | 3) | - | - |
| Date (dd/mm/yy)/Time | Water Depth (m) | Cave In (m) | | | | | | | | | | | | | | | | | | | | | | | |
| 1) 21/5/15 9:40:00 AM | 5.2 | - | | | | | | | | | | | | | | | | | | | | | | | |
| 2) | - | - | | | | | | | | | | | | | | | | | | | | | | | |
| 3) | - | - | | | | | | | | | | | | | | | | | | | | | | | |

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

MEL-GEO 15019 - BOREHOLE LOGS - F10.GPJ MEL-GEO.GDT 20/6/16

METRIC

RECORD OF BOREHOLE NO. 2



REFERENCE 15/04/15019 DATUM Geodetic LOCATION N 4989877.0 E366397.9 - Stanhopen Twp., Station 18+825 ORIGINATED BY JL
 PROJECT GWP 5140-13-00, Highway 118 - F10 BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers COMPILED BY SH
 CLIENT AECOM DATE (Started) 20 May 2015 TIME
 DATE (Completed) 20 May 2015 (Completed) 11:10:00 AM CHECKED BY MAM

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | 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 | | | | |
| 313.7 | Ground Surface | | | | | | | | | | | | | | |
| 0.0 | 102 mm Asphalt | | | | | | | | | | | | | | |
| 313.3 | 254 mm Concrete | | | | | | | | | | | | | | |
| 0.4 | Sand FILL- sand, some to trace gravel, trace silt, trace clay brown, moist (compact/very dense) | | 1 | SS | 20 | | | | | | | | | | |
| | | | 2 | SS | 13 | | | | | | | | | | |
| | | | 3 | SS | 17 | | | | | | | | | | |
| | | | 4 | SS | 5 | | | | | | | | | | |
| | | | 5 | SS | 41/152 mm | | | | | | | | | | |
| 310.3 | Auger Refusal Start Rock Coring | | | | | | | | | | | | | | |
| 3.4 | Bedrock - pink granite/thin black gneiss Fair quality | | 6 | RC | Rec.=98% RQD=50% | | | | | | | | | | |
| | | | 7 | RC | Rec.=100% RQD=65% | | | | | | | | | | |
| 307.3 | End of Sampling End of Borehole | | | | | | | | | | | | | | |
| 6.4 | | | | | | | | | | | | | | | |
| COMMENTS | | | | | | | + 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE | | | WATER LEVEL RECORDS | | | | | |
| | | | | | | | Date (dd/mm/yy)/Time | | | Water Depth (m) | | Cave In (m) | | | |
| | | | | | | | 1) 20/5/15 4:15:00 PM | | | 3.6 | | 4.6 | | | |
| | | | | | | | 2) | | | - | | - | | | |
| | | | | | | | 3) | | | - | | - | | | |
| The stratification lines represent approximate boundaries. The transition may be gradual. | | | | | | | | | | | | | | | |

MEL-GEO 15019 - BOREHOLE LOGS - F10.GPJ MEL-GEO.GDT 20/6/16

Appendix 3 Borehole Plan and Lab Data

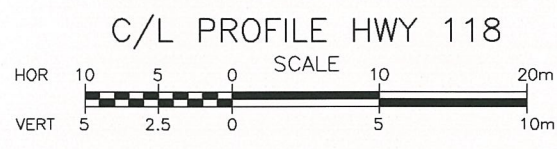
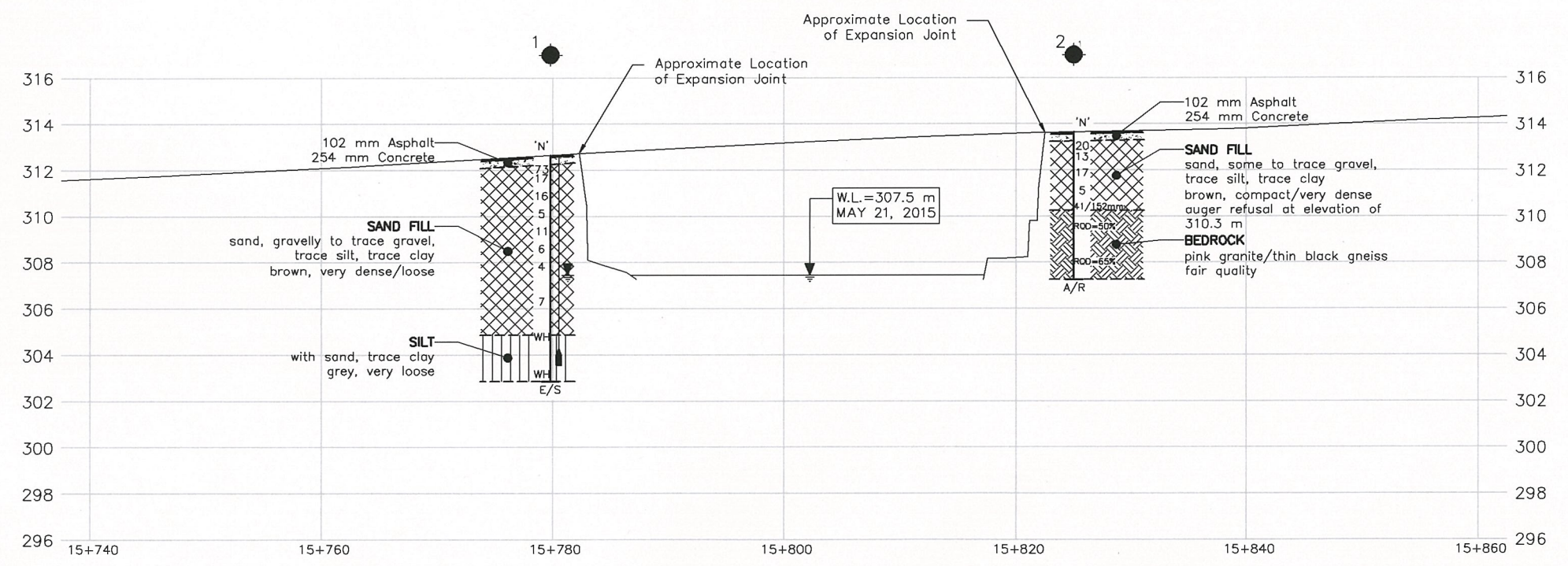
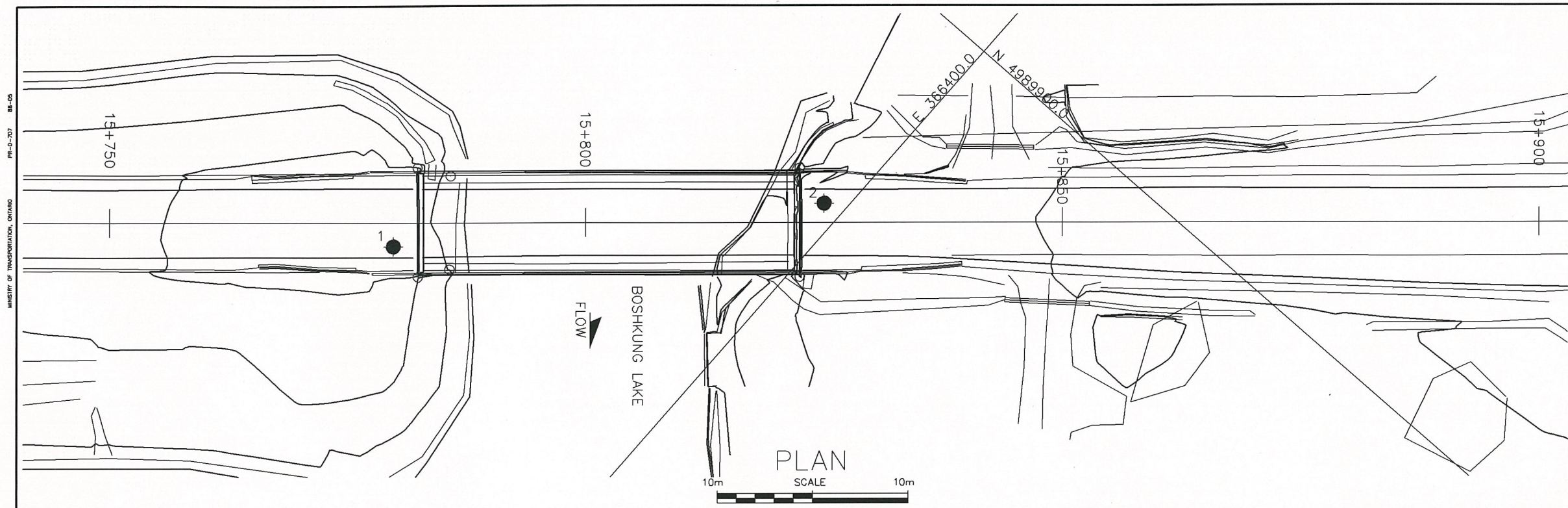
Drawing No. 2: Borehole Locations and Soil Stratigraphy

Figure Nos. L-1 and L-2: Grain Size Distribution Curves

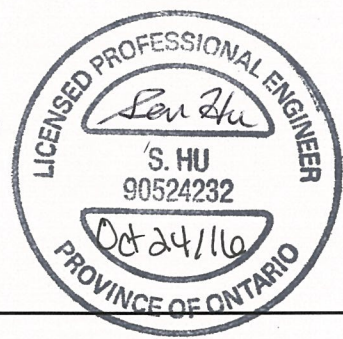
Table No. L-3: Lab Test Summary Sheet

PR-0-207 88-05
MINISTRY OF TRANSPORTATION, ONTARIO


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DATE PLOTTED: 9/20/2016 1:28:54 PM BY: RYAN GRASSER

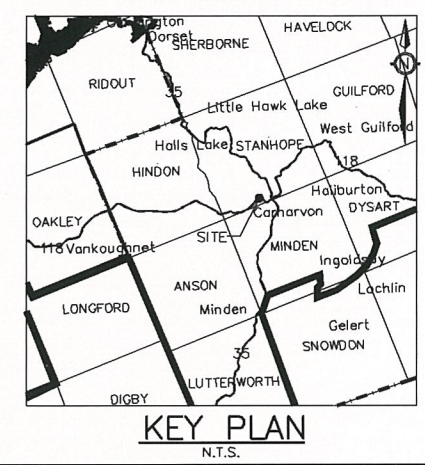








This drawing is for subsurface information only. Surface details and features are for conceptual illustration. The proposed structure location is shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.



2016-10-27

| | |
|--|--|
| DISTRICT CONT. No. GWP No. 5140-13-00 |  DRAWING 2 |
| HWY 118 BOSHKUNG LAKE BRIDGE SITE NO. 40-011 | |
| BOREHOLE LOCATIONS AND SOIL STRATIGRAPHY | |



| LEGEND | | | | |
|---|--|--|--|--|
|  | Borehole | | | |
|  | Blows/0.3 m (Std Pen Test, 475 J/blow) | | | |
|  | Water Level at Time of Investigation | | | |
|  | Auger Refusal at Elevation | | | |
|  | End of Sampling | | | |
|  | Piezometer | | | |

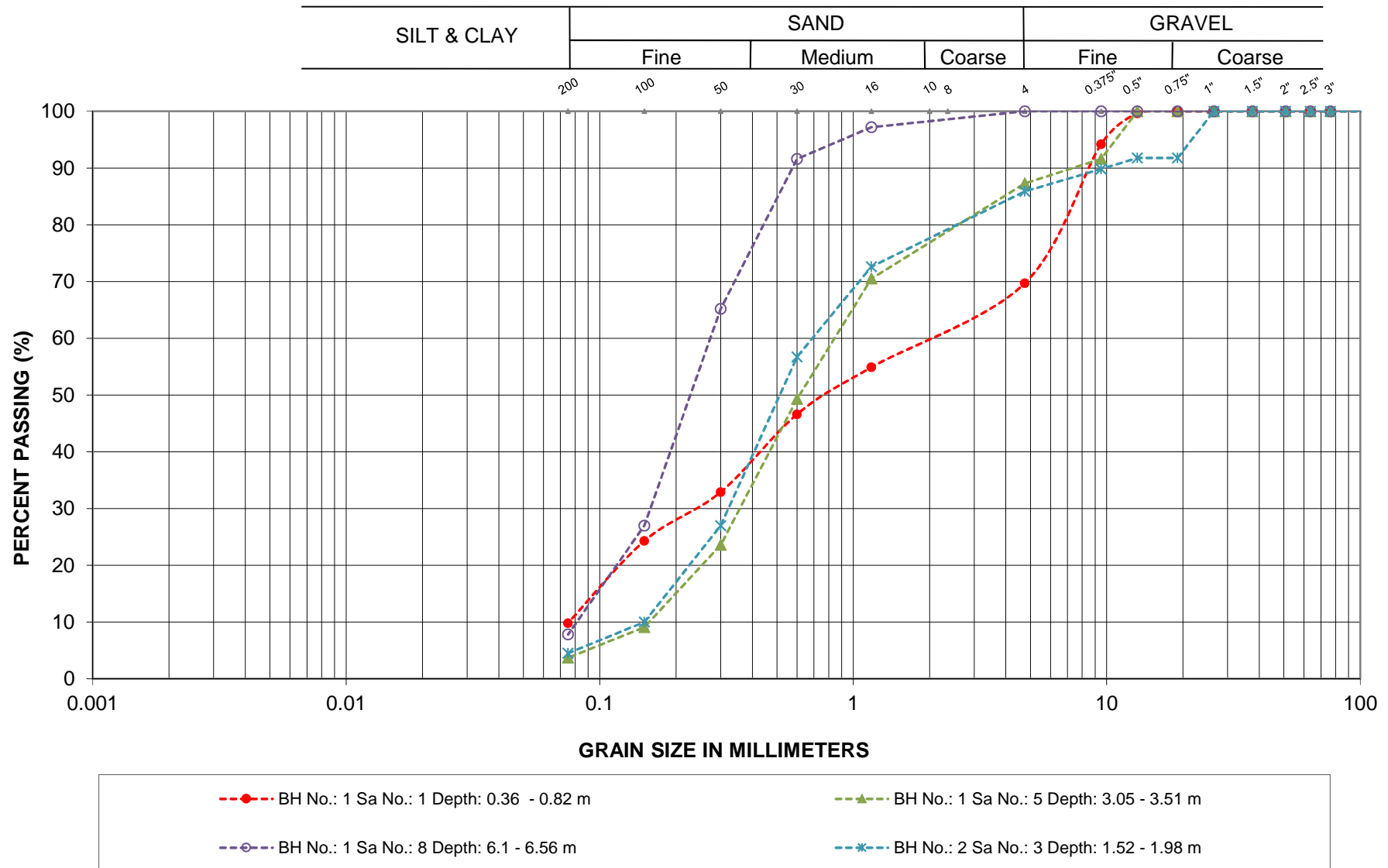
| BOREHOLE No. | ELEVATION | O/S | NORTHING | EASTING |
|--------------|-----------|---------|-----------|----------|
| 1 | 312.7 | 2.5m Rt | 4989843.9 | 366366.9 |
| 2 | 313.7 | 2.0m Lt | 4989877.0 | 366397.9 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

NOTES:
The boundaries between soil strata have been established at the borehole locations only. The boundaries illustrated and stratigraphy between boreholes on this drawing are assumed based on borehole data and may vary. They are intended for design only.

Base plan and alignment provided in digital format by Callon Dietz on February 26, 2016
Coordinates based on MTM Zone 10 NAD83 CSRS

GEOCRES No. 31E-370

| REVISIONS | | DESCRIPTION | | DATE SEP/16 | |
|-----------|-----|-------------|-------------|-------------|--------|
| JUN/16 | DM | DRAFT | | | |
| SEP/16 | DM | FINAL | | | |
| DESIGN | CHK | CODE | LOAD | | |
| DRAWN | DM | CHK SH | SITE 40-011 | STRUCT | SCHEME |
| | | | | | DWG 2 |

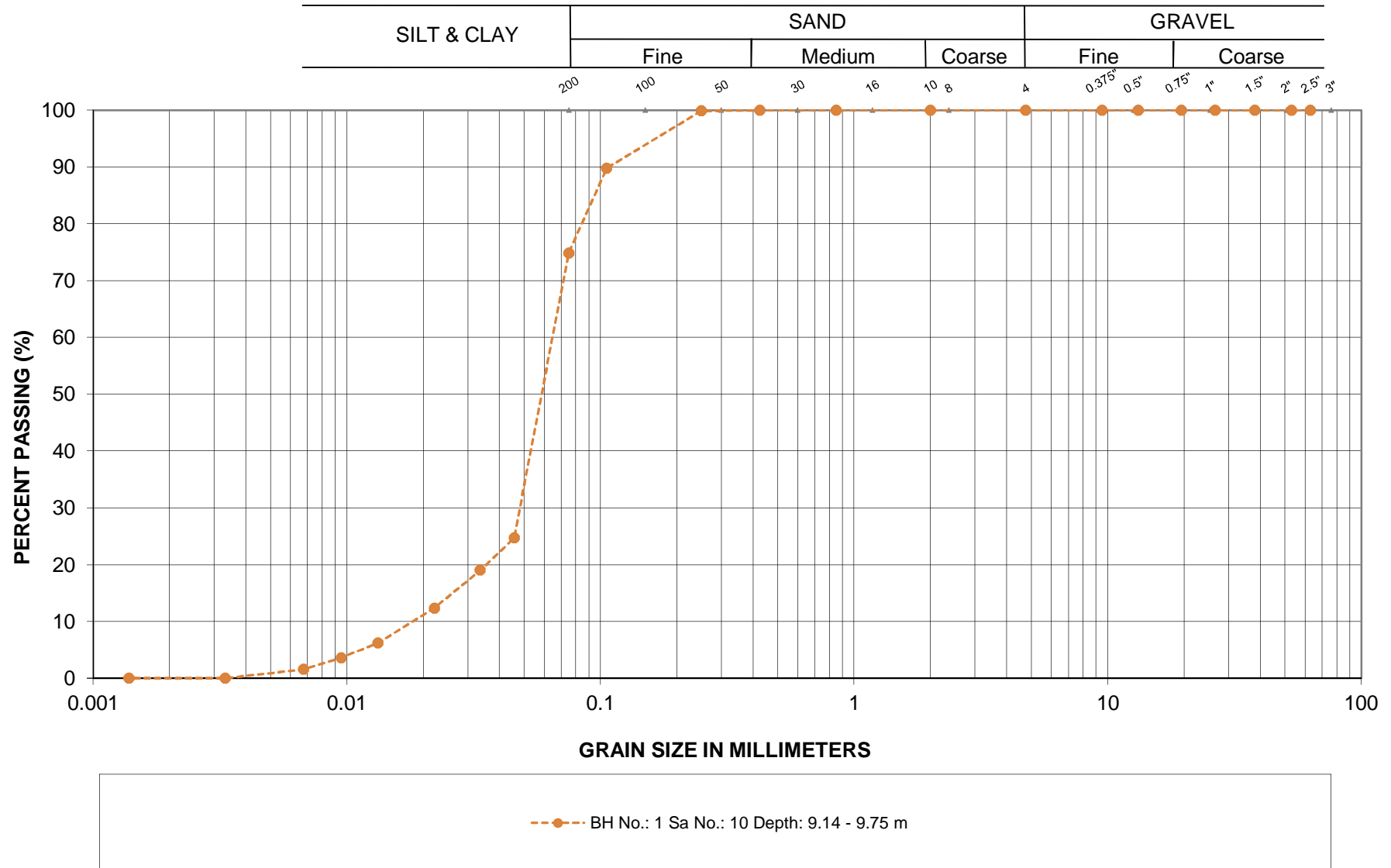
GRAIN SIZE ANALYSIS

LOCATION: Boshkung Lake Bridge
 Hwy 118, Station 15+782.5 to 15+822.5
 TWP of Stanhope

Sand FILL
 Englobe Corp.

FIGURE L-1

GRAIN SIZE ANALYSIS



LOCATION: Boshkung Lake Bridge
Hwy 118, Station 15+782.5 to 15+822.5
TWP of Stanhope

SILT
Englobe Corp.

FIGURE L-2

Laboratory Tests - Summary Sheet



| Borehole No. | Sample No. | Depth | Grain Size Analysis | | | | NMC | Atterberg Limits | | | SPT 'N' | USCS | Unit Weight (kN/m3) | Remarks |
|--------------|------------|-------|---------------------|---------------|---------------|---------------|------|------------------|--------|--------|-----------|------|---------------------|----------------|
| | | | Gravel Size (%) | Sand Size (%) | Silt Size (%) | Clay Size (%) | | LL (%) | PL (%) | IP (%) | | | | |
| 1 | 1 | 0.6 | 30 | 60 | 10 | | 4.1 | | | | 73 | | | |
| | 2 | 1.0 | | | | | 3.5 | | | | 17 | | | |
| | 3 | 1.8 | | | | | 5.2 | | | | 16 | | | |
| | 4 | 2.5 | | | | | 4.4 | | | | 5 | | | |
| | 5 | 3.3 | 13 | 83 | 4 | | 3.3 | | | | 11 | | | |
| | 6 | 4.0 | | | | | 4.4 | | | | 6 | | | |
| | 7 | 4.8 | | | | | 12.1 | | | | 4 | | | |
| | 8 | 6.3 | 0 | 92 | 8 | | 23.0 | | | | 7 | | | |
| | 9 | 7.9 | | | | | 34.4 | | | | WH | | | |
| | 10 | 9.4 | 0 | 25 | 75 | 0 | 25.6 | | | | WH | | | Non-plasticity |
| | | | | | | | | | | | | | | |
| 2 | 1 | 0.6 | | | | | 3.2 | | | | 20 | | | |
| | 2 | 1.1 | | | | | 3.5 | | | | 13 | | | |
| | 3 | 1.8 | 14 | 81 | 5 | | 3.0 | | | | 17 | | | |
| | 4 | 2.5 | | | | | 3.5 | | | | 5 | | | |
| | 5 | 3.2 | | | | | 4.3 | | | | 41/152 mm | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
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Appendix 4 Photo Essay

Enclosure No. 4:

Photo Essay

Bridge East side– Looking West

Photo: 1



Bridge East side– Pavement Cracks at East of Borehole No.2

Photo: 2



Project: Hwy 118 – Boshkung Lake Bridge, Station 15+782.5 to 15+822.5, Township of Stanhope

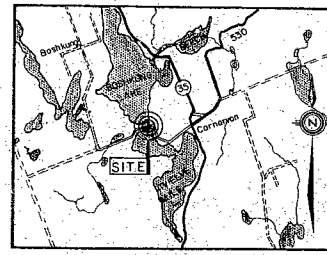
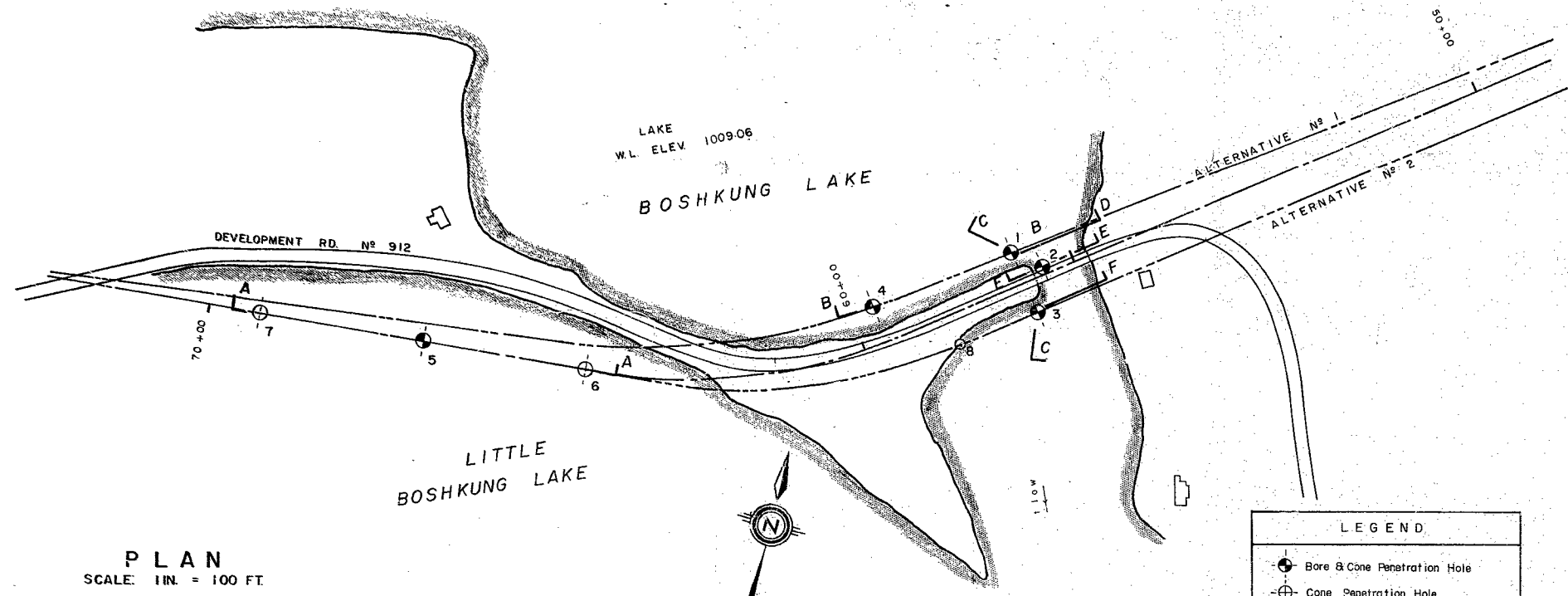
Photos Provided By: Englobe

Date: May, 2015

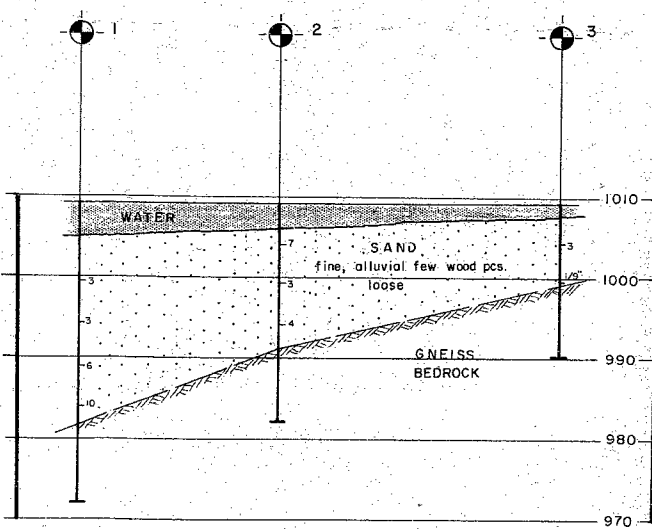
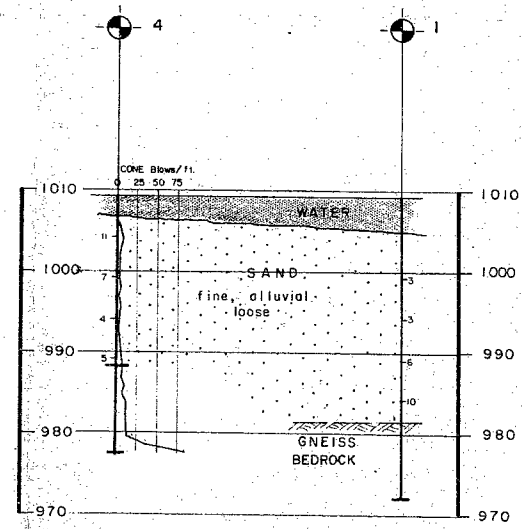
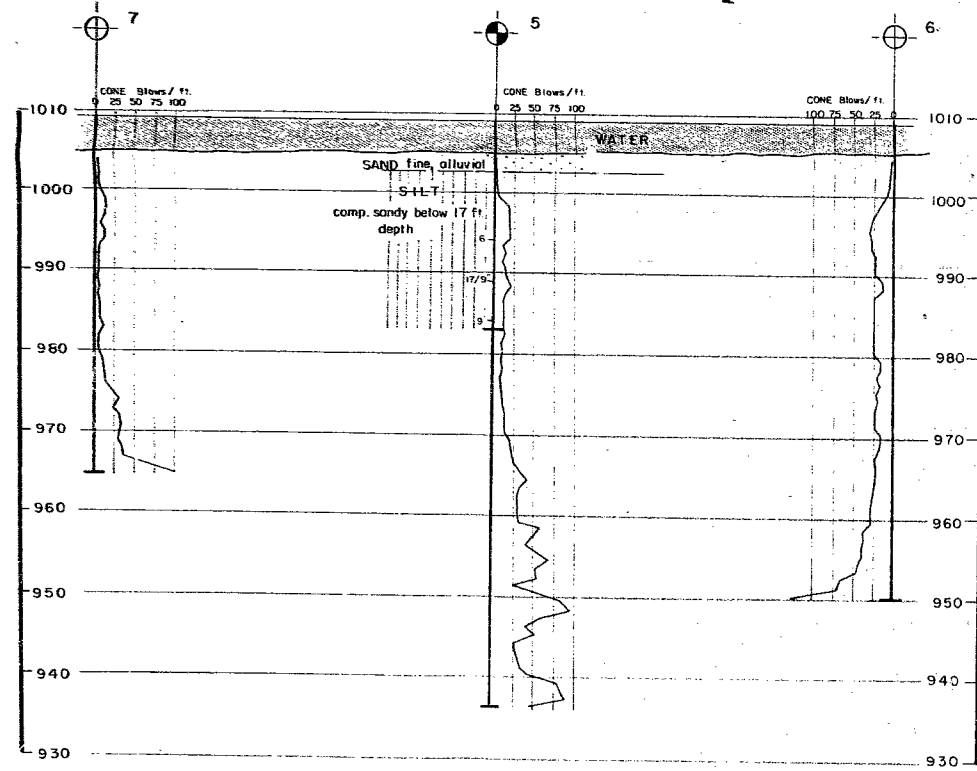
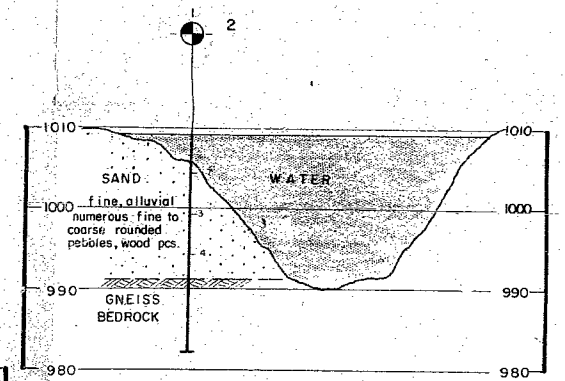
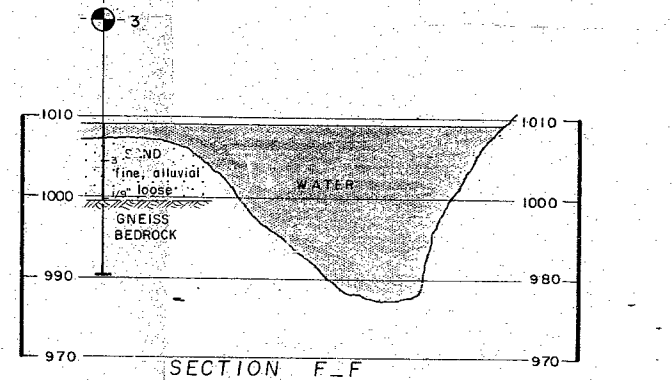
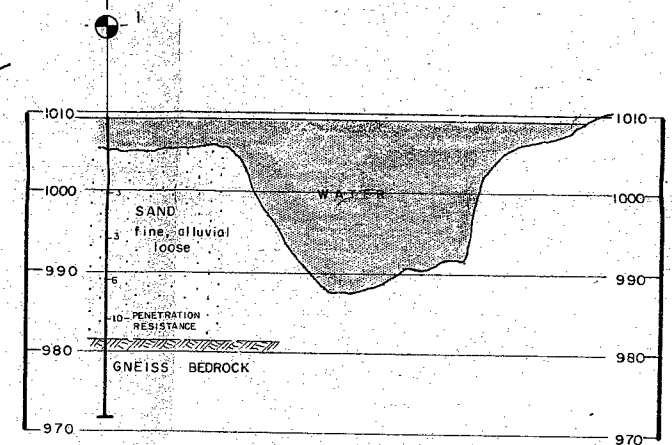
Appendix 5 Historical Data

Enclosure No. 5:

Historical Drawing



| LEGEND | | | |
|--------|------------------------------|---------|---------|
| ⊕ | Bore & Cone Penetration Hole | | |
| ⊙ | Cone Penetration Hole | | |
| ○ | Probe | | |
| No. | ELEVATION | STATION | OFFSET |
| 1 | 1009.1 | 57+39 | 50' Rt. |
| 2 | 1009.1 | 57+17 | 15' Lt. |
| 3 | 1009.1 | 57+39 | 50' Lt. |
| 4 | 1009.1 | 59+60 | 50' Rt. |
| 5 | 1009.1 | 66+70 | |
| 6 | 1009.1 | 64+26 | |
| 7 | 1009.1 | 69+22 | |



SCALE: HOR. 1 IN. = 20 FT.
VERT. 1 IN. = 10 FT.

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

William Trow & Associates Ltd.
FOUNDATION INVESTIGATION

PROPOSED BRIDGE REPLACEMENT

BOSHKUNG NARROWS BRIDGE

TWP. MINDEN ONTARIO

PROJ. 3782 DATE AUG. 1967 DWG. No. 1

SCALE: HOR. 1 IN. = 50 FT.
VERT. 1 IN. = 10 FT.

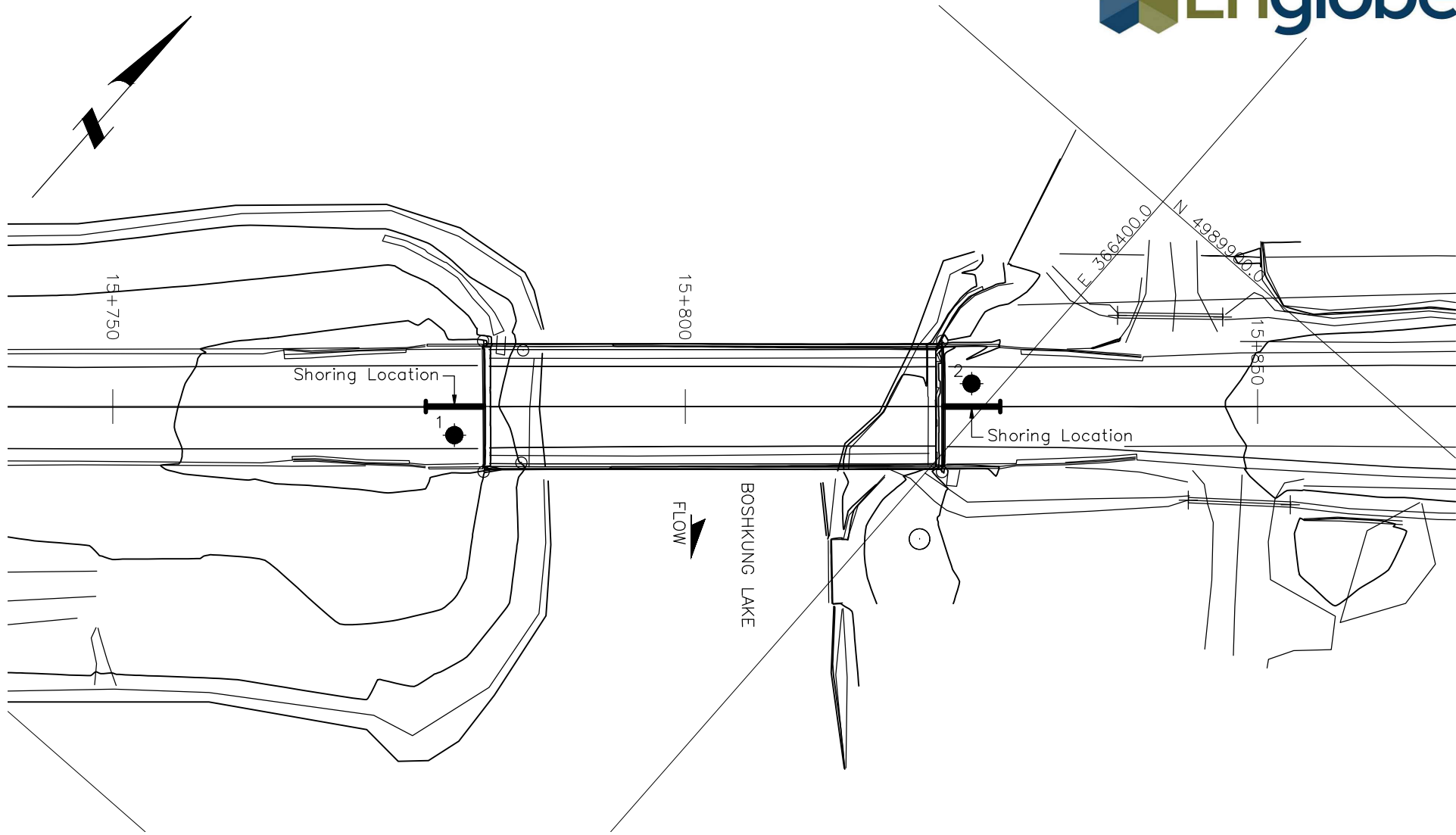
SCALE: HOR. 1 IN. = 20 FT.
VERT. 1 IN. = 10 FT.

Appendix 6 Design Data

| | |
|------------------|------------------------------------|
| Table A: | Comparison of Shoring Alternatives |
| Figure No. SK-1: | Conceptual Shoring Location Plan |

Table A – Comparison of Protection System Alternatives

| Method | Depth Range (m) | Advantages | Disadvantages | Remarks | Estimated Costs |
|---|-----------------|---|---|---|-----------------------|
| Wood Sheeting | 1.5 – 5 | -Low cost, -Easily installed in good ground conditions | -Limited by soil conditions, -Limited depth of installation, -Low strength, -discontinuous | Recommended due to low cost. | \$ 650/m ² |
| Steel Sheet Piles | 5 – 21 | -High strength, continuous, -Readily available | -Limited by soil conditions (i.e. obstructions) | Recommended, as long as sheet piles are terminated not lower than elevation 310.3 m behind the east abutment. | \$ 650/m ² |
| Pre-cast concrete panels | 3 – 10 | -Durable -Assists in minimizing seepage | -Limited depths -Can be damaged during installation -Limited by soil conditions (i.e. obstructions) | Not considered due to higher cost | |
| Soldier piles and lagging | 5 – 25 | -Easy installation -Readily available -Adaptable to various ground conditions | -Pre-drilling may be required -Possible ground loss | Higher cost than steel sheet piles | \$ 725/m ² |
| Tangent/ Secant/ Staggered Drilled Piles | 10 – 18 | -Readily available -Adaptable to various ground conditions | -Possible ground loss and/or seepage -Poor alignment tolerance | Not Considered due to higher costs | |
| Concrete Diaphragm | 10 – 30 | -High Strength -Durable -Can be permanent | -High cost -Requires specialized equipment/ control | Not Considered due to higher costs | |
| Micropiles with reinforced shotcrete face | | -Can be installed in various ground conditions -High strength -Good tolerance | -High Cost -Requires specialized equipment | Not Considered due to higher costs | |



METRIC

Dimensions are in meters
and/or millimeters unless
otherwise shown. Stations are
in kilometers + meters.

Highway 118, Township of Stanhope - Boshkung Lake Bridge
Conceptual Shoring Location Plan

FIGURE SK-1