



November 28, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

**VARIABLE MESSAGE SIGN #19
HIGHWAY 17 NORTHBOUND
APPROXIMATELY 3.0 KM SOUTH OF HIGHWAY 556
SAULT STE. MARIE, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5143-11-00**

Submitted to:
IBI Group
230 Richmond Street West, 5th Floor
Toronto, Ontario
M5V 1V6



GEOCRES NO.: 41K-95

Report Number: 10-1191-0006-19

Distribution:

6 Copies - Ministry of Transportation, Ontario, North Bay, ON (Northeastern Region)

1 PDF Copy - IBI Group, Toronto, ON

3 Copies - Golder Associates Ltd., Sudbury, ON

REPORT





Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

| | |
|--|----------|
| 1.0 INTRODUCTION..... | 1 |
| 2.0 SITE DESCRIPTION..... | 1 |
| 3.0 INVESTIGATION PROCEDURES | 1 |
| 4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY | 2 |
| 4.1 Regional Geology | 2 |
| 4.2 Site Stratigraphy | 2 |
| 4.2.1 Sand and Gravel (Fill) | 3 |
| 4.2.2 Sand and Gravel to Gravelly Sand..... | 3 |
| 4.2.3 Groundwater Conditions | 3 |
| 5.0 CLOSURE..... | 3 |

PART B - FOUNDATION DESIGN REPORT

| | |
|--|----------|
| 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS..... | 5 |
| 6.1 General..... | 5 |
| 6.2 Sign Foundation..... | 5 |
| 6.2.1 Spread Footing | 5 |
| 6.2.2 Caisson Foundation | 7 |
| 6.3 Construction Considerations..... | 7 |
| 7.0 CLOSURE..... | 8 |

TABLES

| | |
|---------|---------------------------------------|
| Table 1 | Evaluation of Foundation Alternatives |
|---------|---------------------------------------|

DRAWINGS

| | |
|-----------|-------------------|
| Drawing 1 | Borehole Location |
|-----------|-------------------|

PHOTOGRAPHS

APPENDICES

Appendix A Record of Boreholes

| |
|-----------------------------------|
| List of Symbols and Abbreviations |
| Record of Borehole BH-VMS#19 |



FOUNDATION REPORT
VMS #19 HIGHWAY 17 NORTHBOUND GWP 5143-11-00

Appendix B Laboratory Test Results

Figure B1 Grain Size Distribution – Sand and Gravel (Fill)

Figure B2 Grain Size Distribution – Sand and Gravel to Gravelly Sand

Appendix C Non-Standard Special Provisions

NSSP Obstructions

NSSP Working Slab



PART A

FOUNDATION INVESTIGATION REPORT
VARIABLE MESSAGE SIGN #19
HIGHWAY 17 NORTHBOUND APPROXIMATELY 3.0 KM SOUTH OF
HIGHWAY 556
SAULT STE. MARIE, ONTARIO
GWP 5143-11-00



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for a variable message sign (VMS #19) on Highway 17 northbound about 11 km north of Sault Ste. Marie, Ontario. The general location of the site is shown on the Key Plan on Drawing 1.

The terms of reference for the scope of work were outlined in MTO's Request for Proposal (RFP) dated January 11, 2010. Golder's Proposal P0-1191-0006, dated February 5, 2010, and subsequent Change Requests No. 1, dated December 3, 2010, and Revised Change Request No. 2, dated October 31, 2011, formed part of IBI's agreement (Number 5009-E-0018) for this project. The work was carried out in accordance with Golder's Quality Control Plan for this project dated August 23, 2010. The site plan was provided to Golder by EXP Services Inc. on behalf of IBI in September 2014.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed sign by methods of borehole drilling, in situ testing and laboratory testing on selected soil samples.

2.0 SITE DESCRIPTION

The proposed VMS #19 is to be located 4.5 m east of the Highway 17 edge of pavement at Station 19+991 in the Township of Aweres, approximately 3 km south of the intersection with Highway 556. This section of Highway 17 consists of two paved lanes of which the northbound shoulder is approximately 3.0 m wide consisting of about 2.5 m of pavement structure and 0.5 m of granular shoulder rounding. A shallow drainage ditch parallels the partially paved shoulder. The ground surface in the general area of the proposed structure location is at Elevation 315.8 m.

The topography of the site is generally flat but sloping down to Root River, which flows south along the west side of Highway 17 then crossing the highway about 70 m south of the proposed sign location. Site drainage is south-southwesterly to the river. The land use beyond the highway right-of-way in the proposed sign location area is generally rural. Photographs of the site are presented on Figure 1.

3.0 INVESTIGATION PROCEDURES

The subsurface investigation for the VMS #19 structure was carried out on December 12, 2011, at which time one sampled borehole, numbered BH-VMS#19, was drilled through the shoulder of the northbound lane, together with two Dynamic Cone Penetration Tests (DCPT-N and DCPT-S) advanced 2.5 m north and 2.5 m south of BH-VMS#19. On October 9, 2014, a new borehole (BH-VMS#19A) was advanced immediately adjacent to Borehole BH-VMS#19 without sampling to the bottom depth of the original borehole and drilled to 6.7 m depth; a DCPT was advanced from 6.7 m to refusal at 7.2 m depth. The borehole and DCPT locations are shown on Drawing 1.

The foundation investigation was carried out using a truck-mounted CME-55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The borehole was advanced using 108 mm inside diameter hollow stem augers, NW casing and NQ coring equipment. Soil samples were obtained at depth intervals of 0.75 m, using a 50 mm outside diameter split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586-08). The DCPTs were advanced to refusal at depths ranging from 1.7 m to 2.9 m below the existing ground level. Details of the subsurface conditions encountered at the borehole location are



shown on the Record of Borehole following the text of this report. The borehole was backfilled with bentonite upon completion in accordance with Ontario Regulation 903 (as amended).

The fieldwork was supervised throughout by members of Golder's technical staff, who located the boreholes and DCPTs, arranged for the clearance of underground services and for traffic protection, supervised 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 Golder's Sudbury geotechnical laboratory, where the samples underwent further visual examination and laboratory classification testing (water contents and grain size distributions) of selected samples. All of the laboratory tests were carried out to MTO and/or ASTM standards, as appropriate.

The proposed sign location was staked in the field by IBI and subsequently surveyed by IBI's surveyors. The boreholes and DCPTs were located in the field by Golder relative to the stake. The ground surface elevation at the boreholes and DCPTs was inferred from the embankment cross-section survey provided by IBI. The coordinates of the boreholes and DCPTs and the ground surface elevations and drilled/driven depth are provided below.

| Borehole Number | MTM NAD83 Zone 13 Northing (m) | MTM NAD83 Zone 13 Easting (m) | Ground Surface Elevation (m) | Depth of Borehole/DCPT (m) |
|--------------------------|---------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|
| BH-VMS#19/ BH-VMS 19A | 5164496.7 5164497.5 | 281263.8 281263.3 | 316.2 | 4.6 6.7/7.2 |
| DCPT-N | 5164498.9 | 281262.7 | 316.2 | 1.7 |
| DCPT-S | 5164494.5 | 281265.0 | 316.2 | 2.9 |

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geology

Based on terrain mapping by the Ontario Geological Survey¹, the subsurface soils in the general area of the site consist of alluvial plain deposits comprising primarily sand and gravel. The bedrock in the vicinity of the site is characterized by Felsic Igneous and Metamorphic rocks of the early Precambrian Era also closely bordered by the Huronian Supergroup Rocks of the middle Precambrian Era².

4.2 Site Stratigraphy

Detailed descriptions of the subsurface soil and groundwater conditions as encountered in Borehole BH-VMS#19, advanced during this investigation, together with the results of the laboratory tests carried out on selected samples, are given on the Record of Borehole sheets and laboratory test figures included in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheet are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary beyond the borehole locations.

¹ Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160.

² Ministry of Natural Resources, 1980, Geological Highway Map, Northern Ontario, Map 2440.



4.2.1 Sand and Gravel (Fill)

A 90 mm thick layer of asphalt was encountered from ground surface underlain by a 0.3 m thick layer of sand and gravel fill.

A grain size distribution test was performed on one sample of the sand and gravel fill and the test result is presented on Figure B1.

The natural water content measured of the fill sampled is 4 per cent.

4.2.2 Sand and Gravel to Gravelly Sand

A 4.3 m thick non-cohesive deposit of sand and gravel to gravelly sand was encountered below the fill. Slow auger advance and grinding was noted from the surface of the deposit, requiring NW casing and wash boring method to be used to advance the borehole from 2.3 m depth to 4.6 m depth due to the presence of gravel and cobbles that jammed inside the casing at 3.6 m and 4.6 m depths. Refusal to further penetration was encountered in the deposit at depths of 1.7 m and 2.9 m in DCPT-N and DCPT-S.

One SPT 'N'-value measured within this deposit is 58 blows per 0.3 m of penetration with the remaining 'N'-values ranging from 52 blows per 0.3 m of penetration to 50 blows per 0.1 m of penetration, indicating a very dense relative density.

Grain size distribution tests were carried out on three representative samples of the non-cohesive deposit and the results are presented on Figure B2.

The natural water content measured on three samples of the deposit is 2 per cent, 5 per cent and 10 per cent.

4.2.3 Groundwater Conditions

The borehole was dry to a depth of 2.3 m prior to switching to NW casing and wash boring drilling methods. Upon completion of coring on October 9, 2014, the unstabilized water level was measured at 3.6 m below ground surface. The groundwater elevation will fluctuate seasonally depending on precipitation and local soil permeability and should be expected to rise during wet periods of the year.

5.0 CLOSURE

The fieldwork for this project was carried out by Mr. Ed Savard of Golder's Sudbury office under the coordination of Mr. David Muldowney, P.Eng. This report was prepared by Mr. Adam Core E.I.T. and the technical aspects were reviewed by Mr. André Bom, P.Eng. Mr. Jorge M. A. Costa, P.Eng., a Principal with Golder and Designated MTO Contact for Golder, conducted a quality control review of the report.



Report Signature Page

GOLDER ASSOCIATES LTD.

Adam Core, EIT
Geotechnical Engineering Intern



André Bom, P.Eng., PMP
Senior Geotechnical Engineer



Jorge M. A. Costa, P.Eng.
Designated MTO Contact, Principal

AC/AB/JMAC/kp

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

N:\Active\2010\1190 Sudbury\1191\10-1191-0006 IBI Various VMS\Reporting\VMS 19 Sault Ste Marie\Final\10-1191-0006 RPT 14Nov28 IBI VMS 19 Sault Ste Marie FIDR.Docx



PART B

FOUNDATION DESIGN REPORT
VARIABLE MESSAGE SIGN #19
HIGHWAY 17 NORTHBOUND APPROXIMATELY 3.0 KM SOUTH OF
HIGHWAY 556
SAULT STE. MARIE, ONTARIO
GWP 5143-11-00



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for the proposed variable message sign (VMS #19) on Highway 17 north of Sault Ste. Marie. The recommendations are based on interpretation of the factual data obtained from the borehole advanced during the subsurface investigation at this site and from site observations. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess feasible foundation design alternatives and to design the proposed sign foundation. As such, where comments are made on construction, they are provided only in order to highlight those aspects which could affect the planning of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Sign Foundation

We understand the proposed sign will be a pole centre mounted structure and will be located on the east side of Highway 17 at Station 19+991 facing the northbound traffic, with the center of the footing located approximately 4.5 m from the edge of the pavement.

Overhead sign supports are typically designed with a standard caisson foundation in accordance with the requirements in MTO's Sign Support Manual (2011). Based on the subsurface conditions at this site, the single-pole mounted sign could also be founded on a spread footing. Recommendations for foundation options are provided in Sections 6.2.1 and 6.2.2.

Table 1 (attached) summarizes the advantages, disadvantages, relative costs and risks/consequences of the foundation alternatives. Given the presence of the very dense sand and gravel deposit at this site, a spread footing is the preferred foundation alternative from a foundation perspective. As the very difficult drilling conditions encountered during borehole advancement due both to the presence of a very dense deposit and cobbles throughout the deposit, specialized down-the-hole hammer drilling equipment and protective casing would be required to construct the caisson foundation.

6.2.1 Spread Footing

Based on the depth of frost penetration isopleths for Northern Ontario in Ontario Provincial Standard Drawing (OPSD) 3090.100 (Foundation, Frost Penetration Depths for Northern Ontario), the spread footings at this site should be provided with 1.8 m of soil cover for frost protection.

A spread footing constructed on the properly prepared sand and gravel subgrade founded below the frost penetration depths (at/below Elevation 314.4 m) may be designed based on a factored geotechnical axial resistance of 700 kPa at Ultimate Limit States (ULS) assuming a 2 m to 3 m wide footing. A geotechnical axial reaction value of 350 kPa at Serviceability Limit States (for 25 mm settlement) may be used for design. The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing dimensions or founding depth differs from those given above. The geotechnical resistances provided above are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of



the footing, inclination of the load should be taken into account in accordance with Clauses 6.7.4 and C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC, 2006) and the related commentary.

Resistance to lateral forces/sliding resistance between the concrete footings and the prepared subgrade should be calculated in accordance with Section 6.7.5 of the CHBDC. For a cast-in-place concrete footing constructed on a compacted granular pad bedding, the coefficient of friction, $\tan \delta$, can be taken as 0.55. For a cast-in-place concrete footing constructed on a concrete working slab or on the native sand and gravel deposit, the coefficient of friction, $\tan \delta$, can be taken as 0.58 (NAVFAC, 1982). The above noted values are unfactored.

Based on the subsurface conditions encountered at the borehole location, and provided the groundwater level is maintained below the base of the excavation during construction, an open cut excavation of short duration may be possible for the proposed footing. The excavation for footing construction will extend into the very dense sand and gravel deposit. The excavation for the proposed footing should be carried out in accordance with the latest Occupational Health and Safety Act for Construction Projects (OHSA). When referencing OHSA, the fill materials should be considered as Type 3 Soil and the sand and gravel as a Type 1 soil.

In accordance with OHSA, for excavations within Type 1 soil (i.e., the sand and gravel deposit) above the groundwater table, the excavation may be cut at a slope of 1 horizontal (H) to 1 vertical (V) to within 1.2 m of its bottom and vertically below this level. An excavation below the groundwater level should be sloped at 2H to 1V or flatter. However, given the anticipated size of the excavation and observed dry conditions of the soil during the borehole investigation, dewatering of the soil and unwatering of the excavation of seepage water should be possible using standard construction techniques such as pumps and filtered sumps and the excavation side walls maintained at 1H to 1V. The sumps should be installed at least 1.0 m below the base of the excavation within a filtered pipe surround. The pumps should be installed immediately upon encountering the groundwater level and sufficient time should be given to allow for localized dewatering and lowering of the groundwater level prior to excavating to the foundation base level.

If the excavation is sloped as specified in the OHSA and noted in the report, excavation support would not be required. If the excavation is made at side slopes steeper than recommended, then excavation support will be required in accordance with the OHSA. Shoring will likely not be practical due to the very dense nature of the non cohesive stratum and the presence of the cobbles at the site at the proposed sign location. A trench box will likely be the most feasible method of worker protection when working within the excavation at this site.

During construction, stockpiles should be placed well away from the edge of the excavation, and their height should be controlled so they do not surcharge the sides of the excavation and/or the overall local embankment slope. For this site, the distance between the crest of the excavation and the toe of the stockpile should generally be greater than the diameter of the base of the stockpile.

All loose, softened or disturbed subgrade soils should be removed immediately prior to placement of concrete to minimize the potential for settlement of the structure. Therefore, OPSS 902 (Excavating and Backfilling - Structures) should be included in the Contract Documents, requiring inspection and approval of the foundation area by the Quality Verification Engineer (QVE) prior to footing construction, to ensure that the foundation area has been adequately prepared for construction of the spread footing.

If the footing cannot be constructed immediately upon inspection/approval of the foundation area by the QVE, we recommend that the prepared subgrade be protected by a concrete working as detailed in the Non-Standard Special Provision (NSSP) included in Appendix C or a minimum 300 mm thick granular working pad consisting of



compacted Granular 'B' Type II or Granular 'A' meeting the requirements in MTO's Special Provision OPSS.PROV1010 (Aggregates).

6.2.2 Caisson Foundation

A caisson foundation for the overhead sign support should be designed in accordance with the requirements in MTO's *Sign Support Manual* for standard sign sizes. The Sign Support Manual includes a standard caisson foundation design (Section 3 and Standard Drawings SS118-3, SS118-4 and SS118-5), in which the caisson is extended 5 m below the design frost depth (1.8 m for this site) except where bedrock is encountered within this depth. For sign foundation design for the Sault Ste. Marie site (VMS #19), the typical caisson founding level would therefore be 6.8 m below the ground surface.

The minimum design parameters values specified in MTO's Sign Support Manual for caissons is applicable to this foundation based on the minimum soil conditions for Case 1 (Cohesionless Soils):

- Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.

For cohesionless soils, the unfactored passive lateral earth pressure, P_p (kPa), distributed along the depth of the caisson foundation, may be calculated using the following equations:

$$P_p = K_p \gamma d_w \text{ above the groundwater table; and}$$

$$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w) \text{ below the groundwater table}$$

where K_p is the passive earth pressure coefficient;

γ is the bulk unit weight of the soil (kN/m^3);

γ' is the effective unit weight of the soil below the groundwater level (kN/m^3);

d is the depth below the ground surface (m); and

d_w is the depth to the groundwater level (m).

In the design of the foundations, the passive resistance within the upper 1.8 m below ground surface should be neglected to account for frost action. In addition, for foundation design, full passive resistance will be mobilized only where the ground surface in front of and behind the caissons is level. The K_p value for the sand and gravel deposit is 3.7 (i.e., for a friction angle, Φ , equal to 35°) and the bulk unit weight may be taken as 21 kN/m^3 . Where sloping ground is present adjacent to the caisson foundation or where the foundation will be installed at the crest of an embankment, the K_p values used in the calculation of the passive resistance should be adjusted to account for the presence of the sloping ground.

6.3 Construction Considerations

The excavation around and above the spread footing should be backfilled using granular material such as OPSS.PROV 1010 (Aggregates) Granular 'A' or 'B' (Type I or II) placed in 300 mm loose lifts and uniformly compacted to not less than 95 per cent of the standard Proctor maximum dry density of the material as placed



compacted in accordance with OPSS 501 (Compacting). The use of native excavated materials as backfill is not recommended.

The final grade surrounding the sign support should be sloped to promote drainage of surface water and from the pavement structure away from the pavement and sign, to the adjacent ditch and surfaced with topsoil and seed in accordance with OPSS 804 (Seed and Cover), or granular sheeting in accordance with OPSS.PROV 1004 (Aggregates - Miscellaneous). If the resulting side slopes in the immediate vicinity of the sign support foundation are steeper than 2 Horizontal to 1 Vertical, the slope should be covered with R-10 Rip-Rap, in accordance with OPSS.PROV 1004 (Aggregates - Miscellaneous), to reduce the potential for erosion of the slope locally.

We recommend that NSSPs be included in the Contract Documents to warn the contractor of the following items which is expected to affect the installation of the variable message sign foundation:

- **Obstructions:** The contractor should be alerted to the presence of cobble and potentially boulder size material within the native cohesionless soils at the VMS #19 site.

7.0 CLOSURE

This report was prepared by Mr. Adam Core E.I.T. and the technical aspects were reviewed by Mr. André Bom, P.Eng., and Mr. Jorge M. A. Costa, P.Eng., a Principal with Golder. Mr. Costa, also a Designated MTO Contact for Golder, conducted a quality control review of the report.



Report Signature Pages

GOLDER ASSOCIATES LTD.


Adam Core, EIT
Geotechnical Engineering Intern



André Bom, P.Eng., PMP
Senior Geotechnical Engineer



Jorge M. A. Costa, P.Eng.
Designated MTO Contact, Principal

AC/AB/JMAC/kp

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

N:\Active\2010\1190 Sudbury\1191\10-1191-0006 IBI Various VMS\Reporting\VMS 19 Sault Ste Marie\Final\10-1191-0006 RPT 14Nov28 IBI VMS 19 Sault Ste Marie FIDR.Docx



REFERENCES

- Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA-S6-06, 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.
- Ministry of Natural Resources, 1980, Geological Highway Map, Northern Ontario, Map 2440.
- Ministry of Transportation, Ontario, 2011. Sign Support Manual. Policy, Planning & Standards Division, Engineering Standards Branch, Bridge Office
- Occupational Health and Safety Act and Regulation for Construction Projects, January 2006.
- Ontario Geological Survey, Ministry of Natural Resources 2005. Ministry of Northern Development and Mines, and Northeast Science and Information Section, Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160.
- Unified Facilities Criteria, U.S. Navy. 1982. NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.

STANDARDS

ASTM International

- | | |
|---------------|---|
| ASTM D1586-08 | Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils |
|---------------|---|

Ontario Provincial Standard Drawings

- | | |
|---------------|---|
| OPSD 3090.100 | Foundation, Frost Penetration Depths for Northern Ontario |
|---------------|---|

Ontario Provincial Standard Specifications

- | | |
|---------------|--|
| OPSS 501 | Construction Specification for Compacting |
| OPSS 902 | Construction Specification for Excavating and Backfilling – Structures |
| OPSS.PROV1010 | Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material |

Ontario Water Resources Act

- | | |
|------------------------|--------------------|
| Ontario Regulation 903 | Wells (as amended) |
|------------------------|--------------------|



FOUNDATION REPORT
VMS #19 HIGHWAY 17 NORTHBOUND GWP 5143-11-00

Table 1: Evaluation of Foundation Alternatives

| Options | Rank | Advantages | Disadvantages | Relative Costs | Risks/Consequences |
|----------------|------|--|---|---|---|
| Spread Footing | 1 | <ul style="list-style-type: none">■ Conventional construction.■ Design easily adaptable for non-standard sign size/configuration.■ Shallow depth founding level.■ As the overburden is Type 1 soil the lower 1.2 m of the excavation within the stratum can be made vertically reducing the overall size of the excavation/volume of material excavated | <ul style="list-style-type: none">■ Temporary shoring may be required for support of excavation side wall to footing subgrade elevation if groundwater is present within the excavation depth.■ May require a large footing to satisfy overturning resistance requirement. | <ul style="list-style-type: none">■ Much lower overall cost compared to caisson.■ Additional costs required for control of overburden sloughing and/or groundwater, as applicable. | <ul style="list-style-type: none">■ Risk of requiring dewatering during construction depending on season of construction. |
| Caisson | 2 | <ul style="list-style-type: none">■ Typical caisson foundation alternative for a sign of standard size. | <ul style="list-style-type: none">■ Very difficult drilling through very dense sand and gravel deposit with cobbles present. Specialized down-the-hole hammer drilling equipment likely required.■ Temporary liner for soil support required during installation.■ Unwatering within liner for concrete placement in the dry or placement by tremie methods below water.■ May require a levelling pad (fill or excavation of slope) to accommodate drilling equipment. | <ul style="list-style-type: none">■ Cost is higher than spread footings, due to need to mobilize drilling rig to site. | <ul style="list-style-type: none">■ Risk of need for placement of concrete by tremie methods if unable to unwater within caisson liner. |

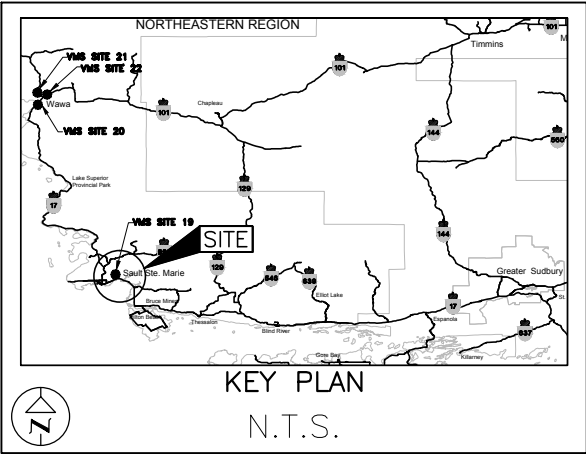
Prepared by: AB Reviewed by: JMAC

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

CONT No.
GWP No. 5143-11-00

VARIABLE MESSAGE SIGN #19
HIGHWAY 17 NORTHBOUND, SAULT STE. MARIE
BOREHOLE LOCATION

SHEET



LEGEND

Approximate Borehole Location
 Approximate Dynamic Cone Penetration Test Location

| BOREHOLE CO-ORDINATES | | | |
|-----------------------|-----------|-----------|----------|
| No. | ELEVATION | NORTHING | EASTING |
| BH-VMS#19 | 316.2 | 5164496.7 | 281263.8 |
| BH-VMS#19A | 316.2 | 5164497.5 | 281263.3 |
| DCPT-N | 316.2 | 5164498.9 | 281262.7 |
| DCPT-S | 316.2 | 5164494.5 | 281265.0 |

NOTES

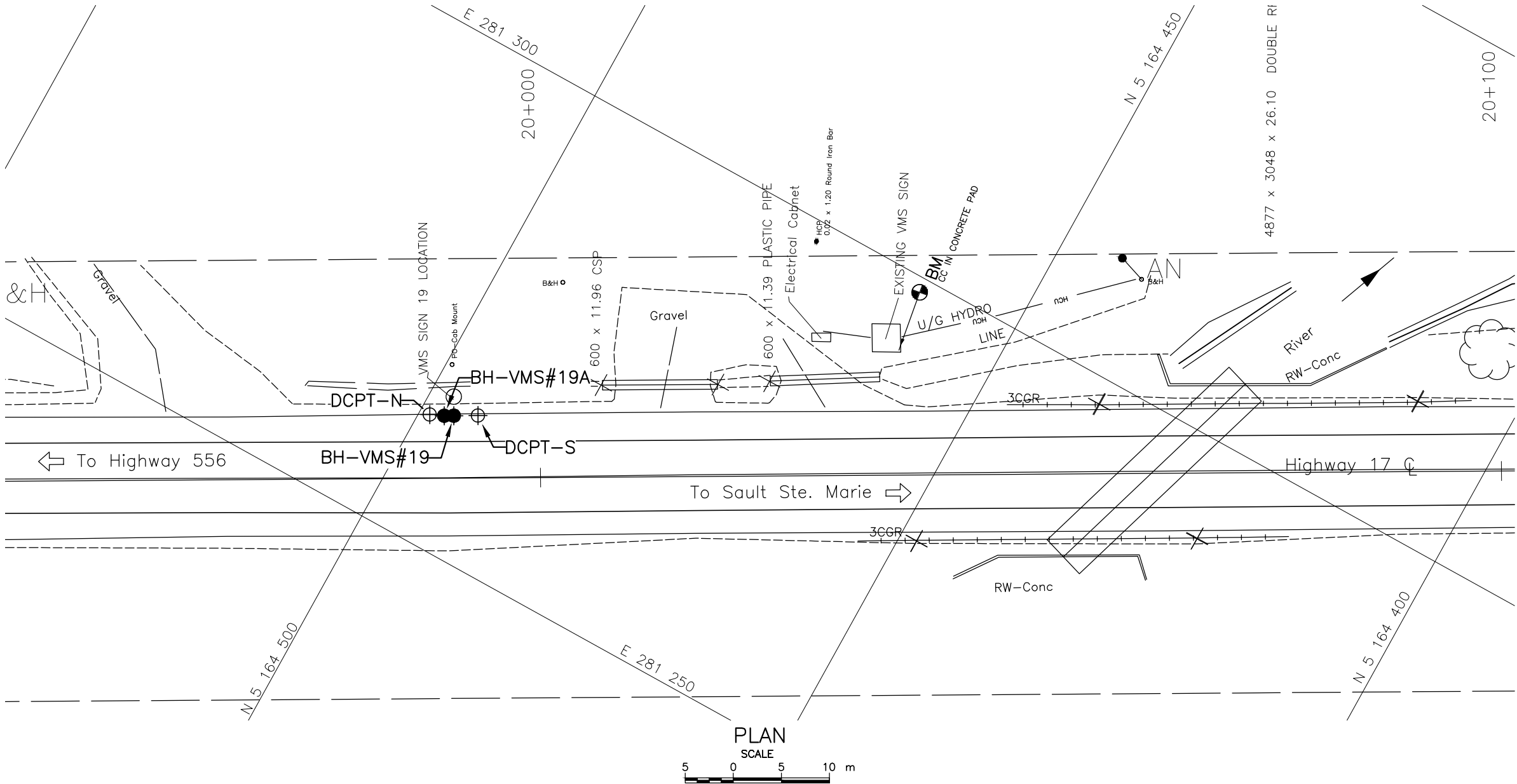
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

Key plan provided in digital format by IBIGroup, drawing file no. TWG-TM28429-2A.dwg, received October 7, 2014.
Base plans provided in digital format by IBIGroup, drawing file no. VMS SIGN 19.dwg, received Sep 03, 2014.



| | | | |
|--------------------|--------------------------|------------------|--------------|
| | | | |
| NO. | DATE | BY | REVISION |
| Geocres No. 41K-95 | | | |
| HWY. 17 | PROJECT NO. 10-1191-0006 | | DIST. . |
| SUBM'D. AC | CHKD. . | DATE: 11/28/2014 | SITE: VMS#19 |
| DRAWN: TB | CHKD. AB | APPD. JMAC | DWG. 1 |



Photograph 1: Looking south from proposed sign location (October 2014)



Photograph 2: Looking north from proposed sign location (October 2014)





APPENDIX A

Record of Borehole



LIST OF SYMBOLS

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

I. GENERAL

| | |
|-------------|---------------------------------------|
| π | 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 |
| FoS | factor of safety |

II. STRESS AND STRAIN

| | |
|--------------------------------|--|
| γ | shear strain |
| Δ | change in, e.g. in stress: $\Delta \sigma$ |
| ε | linear strain |
| ε_v | volumetric strain |
| η | coefficient of viscosity |
| ν | Poisson's ratio |
| σ | total stress |
| σ' | effective stress ($\sigma' = \sigma - u$) |
| σ'_{vo} | initial effective overburden stress |
| $\sigma_1, \sigma_2, \sigma_3$ | principal stress (major, intermediate, minor) |
| σ_{oct} | mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$ |
| τ | 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 |
| γ' | 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_α | 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 |
| σ'_p | pre-consolidation stress |
| OCR | over-consolidation ratio = σ'_p / σ'_{vo} |

(d) Shear Strength

| | |
|------------------|--|
| τ_p, τ_r | peak and residual shear strength |
| ϕ' | effective angle of internal friction |
| δ | angle of interface friction |
| μ | 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 ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

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

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



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 |
| DS | Denison type sample |
| FS | Foil sample |
| RC | Rock core |
| SC | Soil core |
| SS | Split-spoon |
| 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.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: 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 cm² 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) Non-Cohesive (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

| | c_u, s_u | |
|------------|------------|----------------|
| | kPa | 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 ¹ |
| CIU | consolidated isotropically undrained triaxial test with porewater pressure measurement ¹ |
| 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 ₄ | concentration of water-soluble sulphates |
| UC | unconfined compression test |
| UU | unconsolidated undrained triaxial test |
| V | field vane (LV-laboratory vane test) |
| γ | unit weight |

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

V. MINOR SOIL CONSTITUENTS

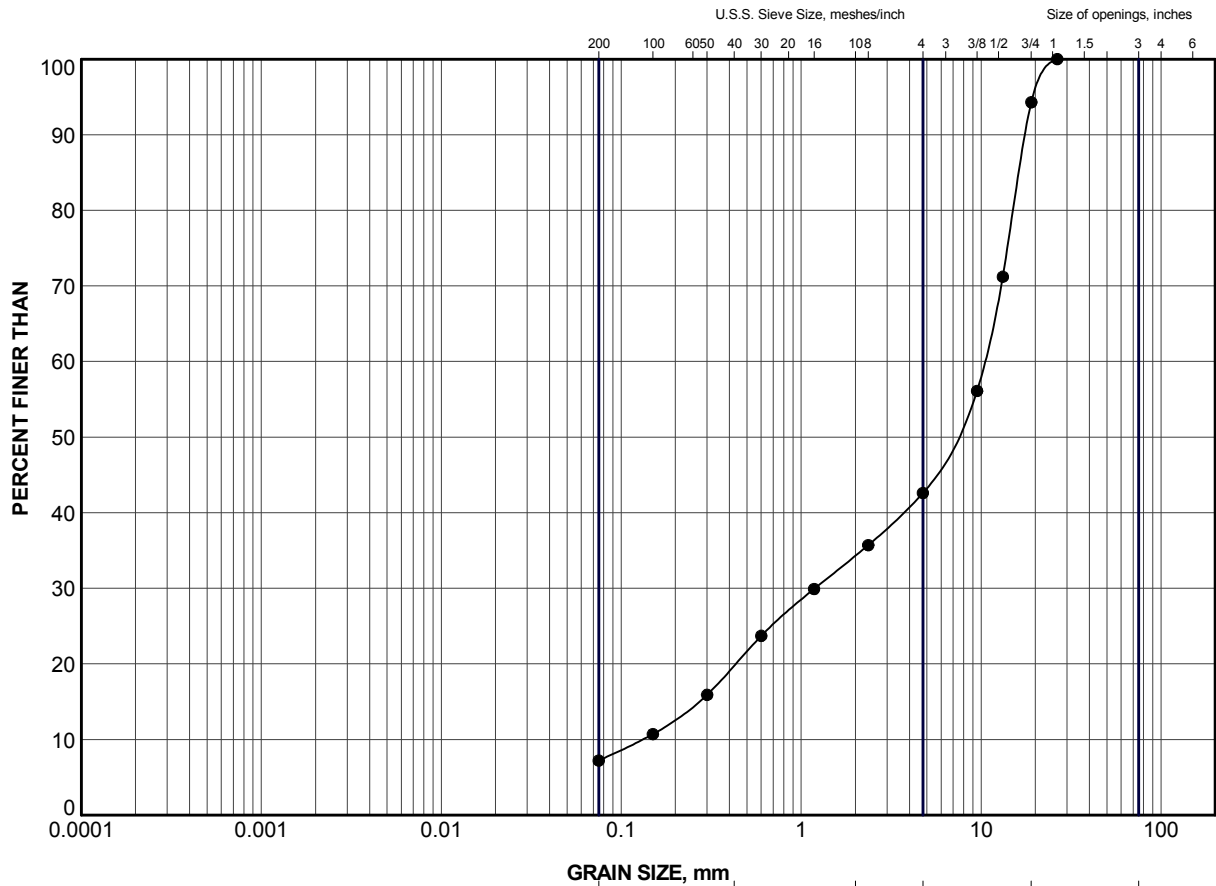
| Per cent by Weight | Modifier | Example |
|--------------------|--|---|
| 0 to 5 | Trace | Trace sand |
| 5 to 12 | Trace to Some (or Little) | Trace to some sand |
| 12 to 20 | Some | Some sand |
| 20 to 30 | (ey) or (y) | Sandy |
| over 30 | And (non-cohesive (cohesionless)) or With (cohesive) |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

| PROJECT | | 10-1191-0006 | | RECORD OF BOREHOLE | | No BH-VMS#19/19A | | 1 OF 1 | | METRIC | | | | | | | | | | | | | | | | | |
|---------------|--|--------------|---------|--------------------|------------|--|-----------------|---------------|--|--------|--|---|--|--|--------------------|--|--|-------------------|--|--|-------------|--|--|---------------------------------------|--|--|--|
| G.W.P. | | 5143-11-00 | | LOCATION | | N 5164496.7; E 281263.8 | | ORIGINATED BY | | EHS/MT | | | | | | | | | | | | | | | | | |
| DIST | | HWY 17 | | BOREHOLE TYPE | | 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring | | COMPILED BY | | DAM | | | | | | | | | | | | | | | | | |
| DATUM | | GEODETIC | | DATE | | December 12, 2011 and October 9, 2014 | | CHECKED BY | | AB | | | | | | | | | | | | | | | | | |
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | | | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT | | | SHEAR STRENGTH kPa | | | WATER CONTENT (%) | | | UNIT WEIGHT | | | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | ELEVATION SCALE | | | | | | | | | | | | | | | | | | | | |
| 316.2 | GROUND SURFACE | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.0 | ASPHALT (90 mm) | | 1 | AS | - | | 316 | | | | | | | | | | | | | | | | | | | | |
| 0.3 | Sand and gravel, trace silt (FILL) Brown Moist SAND and GRAVEL to Gravelly SAND, some silt, cobbles Very dense Brown Moist to wet Slow auger advance with augers grinding below 0.3 m depth. Switched to NW casing and wash boring at 2.3 m depth. Slow casing advance and grinding. About 0.2 m of gravel and cobbles jammed inside casing at 3.6 m depth. Casing cleaned out using NQ Core barrel. Advanced NQ Core barrel to 4.6 m depth and gravel and cobbles jammed inside barrel / casing at 4.6 m depth. | | 2 | SS | 58 | | 315 | | | | | | | | | | | | | | | | | | | | |
| | | | 3 | SS | 50/0.13 | | 314 | | | | | | | | | | | | | | | | | | | | |
| | | | 4 | SS | 50/0.13 | | 313 | | | | | | | | | | | | | | | | | | | | |
| | | | 5 | SS | 96/0.23 | | 312 | | | | | | | | | | | | | | | | | | | | |
| | | | 6 | SS | 50/0.08 | | 311 | | | | | | | | | | | | | | | | | | | | |
| | | | 7 | SS | 17/0.15 | | 310 | | | | | | | | | | | | | | | | | | | | |
| | | | 8 | SS | 52 | | | | | | | | | | | | | | | | | | | | | | |
| | | | 9 | SS | 75 | | | | | | | | | | | | | | | | | | | | | | |
| 309.5 | START OF DCPT | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 309.0 | END OF BOREHOLE/DCPT | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.2 | Notes: 1. On December 12, 2011 borehole dry prior to start of wash boring at 2.3 m depth. 2. On December 12, 2011 DCPT-N and DCPT-S advanced 2.5 m north and 2.5 m south of borehole and encountered refusal (i.e. DCPT bouncing) at 1.7 m and 2.9 m below ground surface respectively (DCPT-N not shown above). 3. On December 12, 2011, original borehole terminated at 4.6 m depth. Returned to site on October 9, 2014 and advanced deeper borehole 1 m north of original borehole. 4. On October 9, 2014 water level at a depth of 3.6 m below ground surface (Elev. 312.6 m) upon completion of drilling. | | | | | | | | | | | | | | | | | | | | | | | | | | |



APPENDIX B

Laboratory Test Results



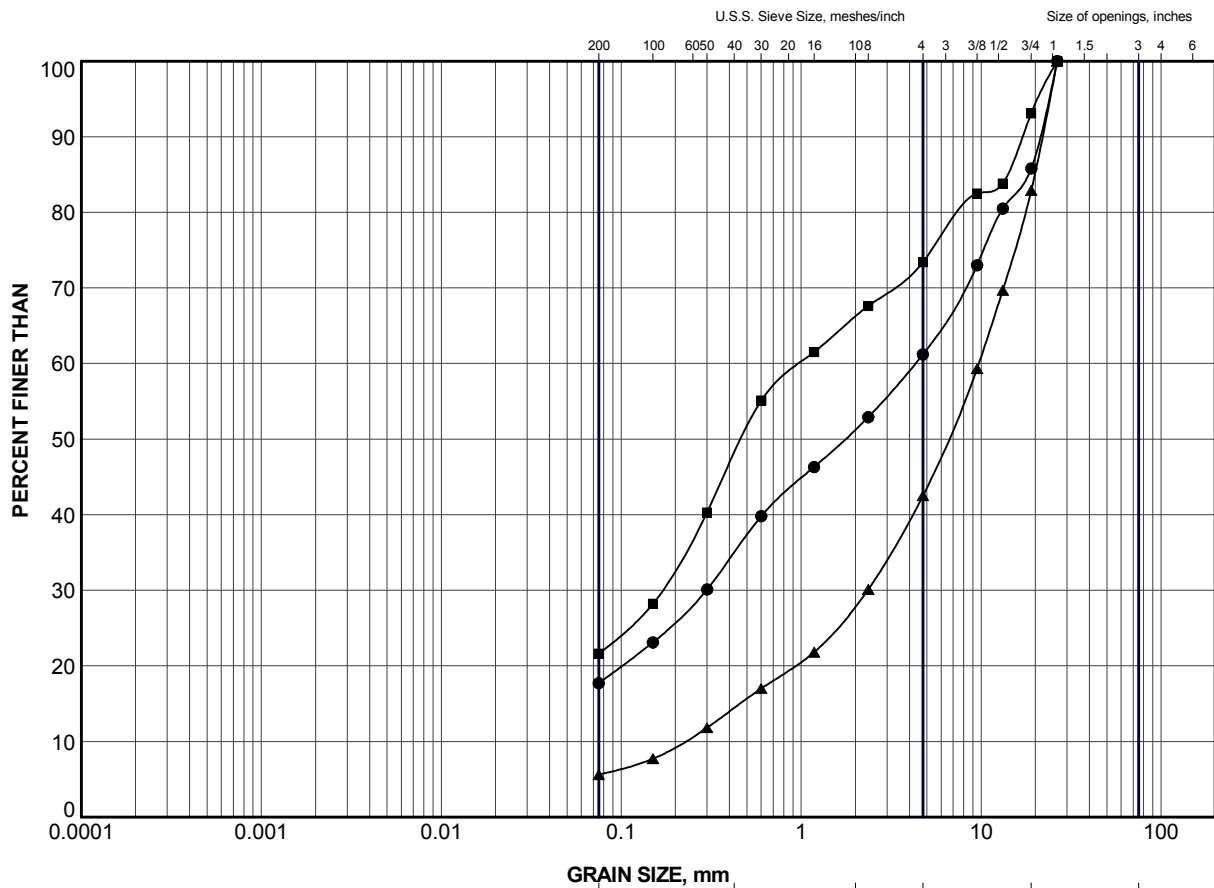
| GRAVEL SIZE, mm | | | | | | |
|-----------------|-----------|--------|--------|-------------|--------|-------------|
| CLAY AND SILT | fine | medium | coarse | fine | coarse | Cobble Size |
| | SAND SIZE | | | GRAVEL SIZE | | |

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|---------------|--------|----------|
| ● | BH-VMS#19/19A | 1 | 316.0 |

| | | | | | | | | | | | |
|-------------|------|----------|--------------|-----|------|---|--|--|----------------|--|--|
| PROJECT | | | | | | HIGHWAY 17 VARIABLE MESSAGE SIGN #19 | | | | | |
| TITLE | | | | | | GRAIN SIZE DISTRIBUTION SAND AND GRAVEL (FILL) | | | | | |
| PROJECT No. | | | 10-1191-0006 | | | FILE No. | | | 1011910006.GPJ | | |
| DRAWN | TB | Nov 2014 | SCALE | N/A | REV. | FIGURE B1 | | | | | |
| CHECK | AB | Nov 2014 | | | | | | | | | |
| APPR | JMAC | Nov 2014 | | | | | | | | | |





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

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|---------------|--------|----------|
| ● | BH-VMS#19/19A | 2 | 315.1 |
| ■ | BH-VMS#19/19A | 4 | 313.8 |
| ▲ | BH-VMS#19/19A | 9 | 309.8 |

| | | | | | |
|---|------|--------------|--|-------------------------|-----|
| PROJECT | | | | | |
| HIGHWAY 17 VARIABLE MESSAGE SIGN #19 | | | | | |
| TITLE | | | | | |
| GRAIN SIZE DISTRIBUTION SAND AND GRAVEL TO GRAVELLY SAND | | | | | |
| PROJECT No. | | 10-1191-0006 | | FILE No. 1011910006.GPJ | |
| DRAWN | TB | Nov 2014 | | SCALE | N/A |
| CHECK | AB | Nov 2014 | | REV. | |
| APPR | JMAC | Nov 2014 | | FIGURE B2 | |





APPENDIX C

Non-Standard Special Provisions

OBSTRUCTIONS

Non-Standard Special Provision

As part of the work for the construction of VMS #19, the Contractor shall be alerted to the very dense relative density of the sand and gravel to gravelly sand deposit and the presence of cobbles and potentially boulder size material in the native deposit. Construction of a caisson foundation for the support of the sign will have to be carried out by equipment suitable for penetrating through the very dense and coarse non-cohesive deposit, such as by down-the-hole hammer drilling or churn drilling techniques or a suitable auger that is able to remove cobbles and potentially boulder size obstructions.

WORKING SLAB - Item No.

Special Provision

1.0 SCOPE

This Special Provision covers the requirements for the supply and placement of a concrete working slab under structure foundations.

2.0 REFERENCES

This Special Provision refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 902 Excavating and Backfilling - Structures

3.0 DEFINITIONS - Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS - Not Used

5.0 MATERIALS

Concrete for working slabs shall have a minimum 28 day strength of 20 MPa.

6.0 EQUIPMENT - Not Used

7.0 CONSTRUCTION

7.01 Excavation

Excavation for the working slab shall be according to OPSS 902.

7.02 Protection of Founding Soil

Following inspection and approval of the prepared subgrade, a working slab with a minimum thickness of 100 mm shall be placed on the foundation subgrade as specified in the Contract Documents.

7.03 Protection of Founding Bedrock

The surface of the footing founding rock shall be exposed, cleaned and any loose or fractured parts removed so that sound rock is exposed. The working slab shall be placed on the exposed cleaned sound founding rock surface as specified in the Contract Documents.

Thickness of the mass concrete pad shall depend on the slope and irregularities in the exposed founding rock surface. A nominal thickness and a footprint plan view area has been specified on the Contract Documents

7.04 Dewatering

Dewatering shall be carried out according to OPSS 902.

8.0 QUALITY ASSURANCE - Not Used

9.0 MEASUREMENT FOR PAYMENT - Not Used

10.0 BASIS OF PAYMENT

10.01 Working Slab - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

| | |
|---------------|-------------------|
| Africa | + 27 11 254 4800 |
| Asia | + 852 2562 3658 |
| Australasia | + 61 3 8862 3500 |
| Europe | + 356 21 42 30 20 |
| North America | + 1 800 275 3281 |
| South America | + 55 21 3095 9500 |

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

