

GEOCRES No:
41K-80

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REPORT ON

**FOUNDATION INVESTIGATION AND DESIGN
VARIABLE MESSAGE SIGN #7
HIGHWAY 17 EASTBOUND, EAST OF FOURNIER ROAD
G.W.P 5671-04-00
MINISTRY OF TRANSPORTATION, ONTARIO
SAULT STE. MARIE, ONTARIO**

Submitted to:

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GEOCRES NO. 41K-80 ✓

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November 24, 2006



06-1191-021-7

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PART A

**FOUNDATION INVESTIGATION REPORT
VARIABLE MESSAGE SIGN #7
HIGHWAY 17 EASTBOUND, EAST OF FOURNIER ROAD
G.W.P 5671-04-00
MINISTRY OF TRANSPORTATION, ONTARIO
SAULT STE. MARIE, ONTARIO**

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) to carry out a foundation investigation as part of the detailed design for a variable message sign (VMS) truss structure on Highway 17 Eastbound, east of Fournier Road in Sault Ste. Marie, Ontario, for the Ministry of Transportation, Ontario (MTO). 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 Golder's proposal P61-9106, dated March 2, 2006, that formed part of the Consultant's Agreement (Number 5005-E-0054) for this project. The work was carried out in accordance with Golder's Quality Control Plan for this project dated May 2006. The plans and profiles detailing the proposed sign location were provided to Golder by IBI in September 2006.

2.0 SITE DESCRIPTION

The site is located on Highway 17 approximately 440 m east of Fournier Road at Station 13+085 in Sault Ste. Marie, Ontario. The section of Highway 17 is an urban section with a curb and gutter system and grass shoulders. The ground surface at the proposed structure location is at approximately Elevation 189.5 m.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The subsurface investigation work for the VMS structure was carried out by Golder on August 23, 2006, at which time two sampled boreholes, numbered BH06-1 and BH06-2, were advanced at the locations shown on Drawing 1.

The foundations investigation was carried out using a truck-mounted CME-55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The boreholes were advanced using hollow stem augers. Soil samples were obtained, where possible, at intervals ranging from 0.75 m to 1.5 m in depth, using a 50 mm outside diameter split-spoon sampler in accordance with Standard Penetration Test procedures (ASTM D1586-99). Both boreholes were advanced to a depth of 12.8 m below the existing ground surface. The groundwater conditions in the open boreholes were observed during the drilling operations, and the results of the water level measurements are shown on the Record of Borehole sheets following the text of this report. The boreholes were backfilled with bentonite holeplug through the native deposits in accordance with Ontario Regulation 128 (Amendment to O. Reg. 903).

The fieldwork was supervised throughout by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services and traffic control, 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 testing. Classification testing such as water content and grain size distribution was carried out to MTO and/or ASTM Standards, as relevant.

The boreholes were located using references to existing site features (light poles, etc.). Northing and easting coordinates were not provided so stations and offsets were determined. The elevations, referenced to the geodetic datum, were obtained from a site survey conducted by surveyors retained by IBI. The elevations and stations and offsets are depicted on the Record of Borehole sheets and on Drawing 1.

4.0 GENERAL SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology and Site Stratigraphy

The dominant landform in the vicinity of the site is a sand and gravel glaciofluvial outwash plain, with a subordinate sand and gravel glaciolacustrine plain (Northern Ontario Engineering Geology Terrain Study, OGS Map 5012). The bedrock is characterized by sandstone, conglomerate and shale of the Jacobsville Formation.

4.2 Subsurface Conditions

Detailed descriptions of the subsurface conditions at this site are provided in the following sections of this report, and the detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected samples, are given on the Record of Borehole sheets following the text of this report. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

Boreholes BH06-1 and BH06-2 were drilled through the westbound and eastbound right lanes of Highway 17, respectively. The ground surface is at Elevation 189.5 m at both boreholes. In general, the boreholes encountered asphalt and granular road base fill overlying sand.

4.2.1 Asphalt and Fill

Between 0.4 m and 0.6 m of Granular 'A' fill was encountered in the boreholes beneath 0.2 m of asphalt.

4.2.2 Sand

A deposit of reddish brown sand containing trace silt and trace to no gravel was encountered below the fill at depths of 0.6 m and 0.8 m in boreholes BH06-1 and BH06-2, respectively.

The measured Standard Penetration Test (SPT) 'N' values within the sand deposit ranged from 3 blows to 22 blows per 0.3 m of penetration, indicating that the deposit has a very loose to compact relative density. The boreholes were terminated at a depth of 12.8 m below ground surface within the sand deposit.

The natural water content of the sand deposit ranged from about 4 percent to 27 percent. Grain size distribution tests on several samples of the sand are shown on Figure 1.

4.2.3 Groundwater Conditions

Details of the groundwater conditions and water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets following the text of this report. In general, the samples taken in the boreholes were noted to be moist to wet. The groundwater level observed in the open boreholes BH06-1 and BH06-2 was at 8.9 m depth below the existing ground surface upon completion of drilling, corresponding to Elevation 180.6 m. It should be noted that these water levels do not represent stabilized water levels and that groundwater elevations will vary depending on precipitation and local soil permeability.

4.3 Closure

The fieldwork was carried out by an intermediate technician from our Sudbury office under the coordination of Mr. André Bom, P.Eng. This report was prepared by Ms. Kerry Salvatori Lee, P.Eng., and was reviewed by Ms. Sarah Poot, P.Eng., Senior Geotechnical Engineer. Mr. Fintan J. Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted a quality control review of the report.

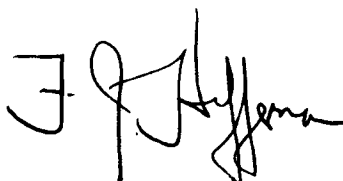
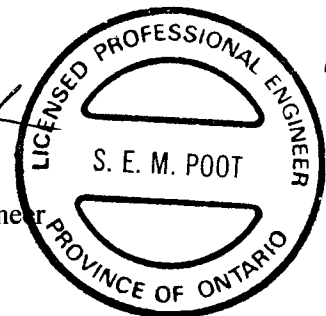
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November 2006

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PART B

**FOUNDATION DESIGN REPORT
VARIABLE MESSAGE SIGN #7
HIGHWAY 17 EASTBOUND, EAST OF FOURNIER ROAD
G.W.P 5671-04-00
MINISTRY OF TRANSPORTATION, ONTARIO
SAULT STE. MARIE, ONTARIO**

5.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides foundation design recommendations for the proposed variable message sign foundations. The recommendations are based on interpretation of the factual data obtained from the boreholes 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 the feasible alternatives and to design the proposed sign foundations. 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.

5.2 Foundations in Soil

At this truss sign location (Highway 17, Station 13+085), very loose to compact sand was encountered. Caisson foundations for overhead sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual*. The *Sign Support Manual* includes a standard caisson foundation design (Section 8 and Standard Drawings SS118-6, SS118-7 and SS118-8), in which the caisson are extended 5 m below the design frost depth except where bedrock is encountered within this depth. For sign foundation design, the frost depth in the Sault Ste. Marie area may be taken as 2.0 m. The typical caisson founding level would therefore be 7.0 m below the ground surface. The depth to bedrock is greater than the standard foundation length; therefore, the foundations for these sign supports should be designed as caissons in soil. The standard design is based on the following minimum soil conditions:

- **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.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where there are extensive poor fill materials or materials softer or looser than those of the standard cases.

The soils at this site are cohesionless. Based on the review of the subsurface information, the sand at depth at this sign location has a friction angle that does not meet the input parameters used in developing the standard; therefore, the standard caisson foundation design cannot be applied. For these subsurface conditions, a site-specific design is required. The stratigraphy and design parameters for the subsurface conditions encountered in the boreholes at the sign support locations are given in Table 1.

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:

$$\begin{aligned} P_p &= K_p \gamma d_w && \text{above the groundwater table; and} \\ P_p &= K_p \gamma d_w + K_p \gamma' (d - d_w) && \text{below the groundwater table} \end{aligned}$$

where K_p is the passive earth pressure coefficient;
 γ is the bulk unit weight (kN/m³);
 γ' is the effective unit weight below the groundwater level (kN/m³);
 d is the depth below the ground surface (m); and
 d_w is the depth to the groundwater level (m).

The lateral earth pressure may be assumed to act over an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance. In the design of the foundations, the passive resistance within the upper 2.0 m below ground surface should be neglected to account for frost action.

5.3 Construction Considerations

It is recommended that an NSSP be included in the Contract Documents to warn the Contractor of the following item which is expected to affect the installation of the variable message sign foundations:

- **Control of overburden soils for caisson foundations:** Excavations for the sign foundations will be advanced through generally cohesionless soils, which should be expected to be unstable, especially close to or below the groundwater level at this site. It should be anticipated that the caisson holes will have to be advanced using a temporary liner in order to minimize ground loss during drilling and concrete placement. The contractor is responsible to ensure that appropriate construction procedures and equipment are used for the caisson construction.

This NSSP has been developed by Golder and is attached in Appendix A.

5.4 Closure

This report was prepared by Ms. Kerry Salvatori Lee, P.Eng., a Geotechnical Engineer, and the technical aspects were reviewed by Ms. Sarah Poot, P.Eng., a Senior Geotechnical Engineer with Golder. Mr. Fintan J. Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted a quality control review of the report.

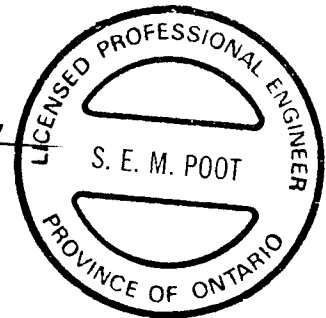
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TABLE 1
DESIGN PARAMETERS FOR SOIL
G.W.P 5671-04-00
VMS #7, SAULT STE. MARIE

<i>Borehole No.</i>	<i>Stratum</i>	<i>Depth¹ (m)</i>	<i>Groundwater Depth (m)</i>	<i>Design Parameters²</i>			
				Φ'	γ	γ'	K_p
BH06-1 and BH06-2	Granular 'A' (Fill)	0 to 0.8	8.9	-	-	-	-
	Very loose to compact sand	Below 0.8		28	18	8	2.8

NOTES:

1. Depths are given below the ground surface at the borehole location.
2. Design parameters: ϕ' = effective friction angle (degrees);
 γ = bulk unit weight (kN/m³);
 γ' = effective unit weight below the groundwater level (kN/m³); and
 K_p = passive earth pressure coefficient.

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N 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

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.)

Consistency

	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

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.

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 test¹
CIU consolidated isotropically undrained triaxial test with porewater pressure measurement¹
 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.

LIST OF SYMBOLS

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

I. General		(a) Index Properties (continued)	
π	3.1416	w	water content
$\ln x$	natural logarithm of x	w_L	liquid limit
$\log_{10} x$	x or log x, logarithm of x to base 10	w_p	plastic limit
g	acceleration due to gravity	I_p	plasticity index = $(w_L - w_p)$
t	time	w_s	shrinkage limit
F	factor of safety	I_L	liquidity index = $(w - w_p)/I_p$
V	volume	I_C	consistency index = $(w_L - w)/I_p$
W	weight	e_{max}	void ratio in loosest state
II. STRESS AND STRAIN		e_{min}	void ratio in densest state
γ	shear strain	I_D	density index = $(e_{max} - e)/(e_{max} - e_{min})$ (formerly relative density)
Δ	change in, e.g. in stress: $\Delta \sigma$	(b) Hydraulic Properties	
ϵ	linear strain	h	hydraulic head or potential
ϵ_v	volumetric strain	q	rate of flow
η	coefficient of viscosity	v	velocity of flow
ν	Poisson's ratio	i	hydraulic gradient
σ	total stress	k	hydraulic conductivity (coefficient of permeability)
σ'	effective stress ($\sigma' = \sigma - u$)	j	seepage force per unit volume
σ'_{vo}	initial effective overburden stress	(c) Consolidation (one-dimensional)	
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)	C_c	compression index (normally consolidated range)
σ_{oct}	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$	C_r	recompression index (over-consolidated range)
τ	shear stress	C_s	swelling index
u	porewater pressure	C_a	coefficient of secondary consolidation
E	modulus of deformation	m_v	coefficient of volume change
G	shear modulus of deformation	c_v	coefficient of consolidation
K	bulk modulus of compressibility	T_v	time factor (vertical direction)
III. SOIL PROPERTIES		U	degree of consolidation
(a) Index Properties		σ'_p	pre-consolidation pressure
$\rho(\gamma)$	bulk density (bulk unit weight*)	OCR	over-consolidation ratio = σ'_p/σ'_{vo}
$\rho_d(\gamma_d)$	dry density (dry unit weight)	(d) Shear Strength	
$\rho_w(\gamma_w)$	density (unit weight) of water	τ_p, τ_r	peak and residual shear strength
$\rho_s(\gamma_s)$	density (unit weight) of solid particles	ϕ'	effective angle of internal friction
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)	δ	angle of interface friction
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s/\rho_w$) (formerly G_s)	μ	coefficient of friction = $\tan \delta$
e	void ratio	c'	effective cohesion
n	porosity	c_{u, s_u}	undrained shear strength ($\phi = 0$ analysis)
S	degree of saturation	p	mean total stress $(\sigma_1 + \sigma_3)/2$
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)	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_i	sensitivity

- Notes: 1 $\tau = c' + \sigma' \tan \phi'$
 2 Shear strength = (Compressive strength)/2

PROJECT 06-1191-021-7		RECORD OF BOREHOLE No BH06-1		1 OF 1 METRIC	
W.P. 5671-04-00		LOCATION Station 13+074.1, Offset 11.3 Left		ORIGINATED BY DFM	
DIST HWY 17		BOREHOLE TYPE Power Auger, 108mm ID Hollow Stem Augers		COMPILED BY AB	
DATUM Geodetic		DATE 08/23/06		CHECKED BY SEP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
189.5	GROUND SURFACE													
0.0	Asphalt													
0.2	Granular 'A' (FILL)													
188.9														
0.6	Sand, trace to no gravel, trace silt Very loose to compact Reddish brown Moist		1	DO	19									
			2	DO	17									0 96 4 0
			3	DO	10									
			4	DO	6									
			5	DO	6									
			6	DO	4									2 97 1 0
			7	DO	4									
			8	DO	6									
			9	DO	3									
			10	DO	18									2 96 2 0
			11	DO	21									
176.7														
12.8	End of Borehole													
	Notes: 1. Water level at 8.9m depth (Elev. 180.6m) upon completion of drilling.													

MIS-MTO 001 06-1191-021 SOIL.GPJ GAL-MISS.GDT 11/22/06

MIS-MTO 001 06-1191-021 SOIL.GPJ GAL-MISS.GDT 11/22/06

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

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

CONT No.
WP No.5671-04-00

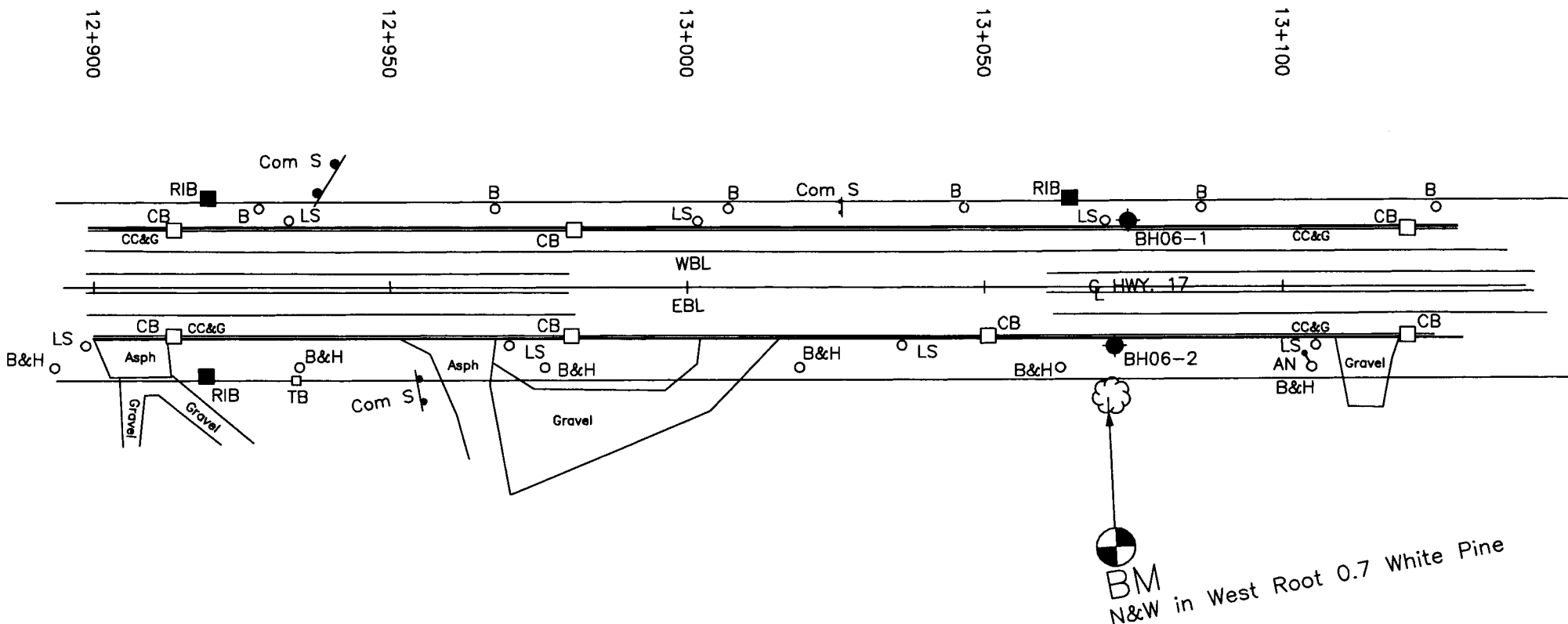


HIGHWAY 17, SAULT STE. MARIE
OVERHEAD SIGN STATION 13+085
BOREHOLE LOCATION PLAN

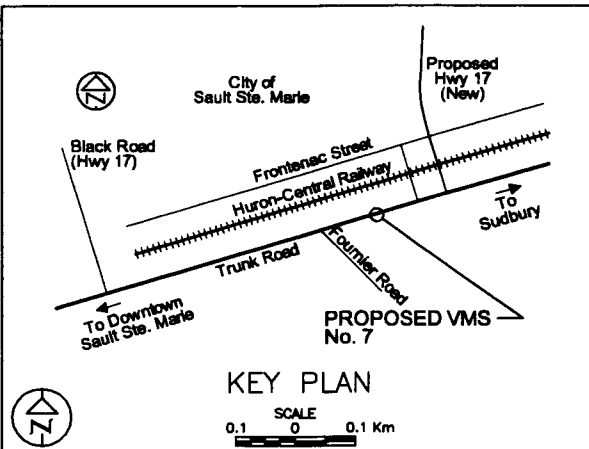
SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



PLAN
SCALE
10 0 10 20 m



LEGEND

● Borehole

No.	ELEVATION	STATION	OFFSET
BH06-1	189.51	13+074.1	11.3 LEFT
BH06-2	189.46	13+071.8	10.1 RIGHT

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, Downview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by IBI, drawing file no. SB06019SAULT.dwg, dated September, 2006, received September 25, 2006.

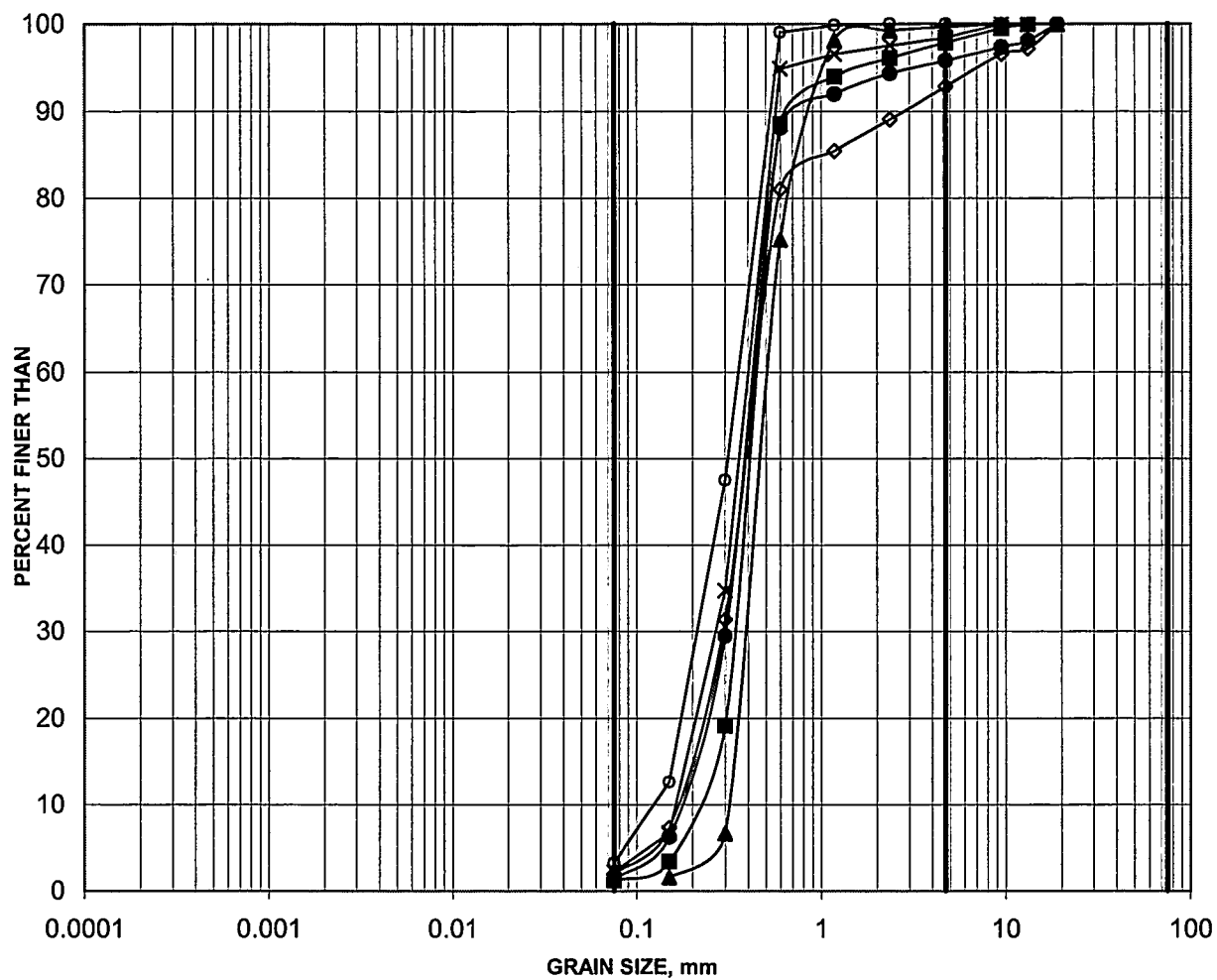


NO.	DATE	BY	REVISION
Geocres No. 41K-80			
HWY. 17		PROJECT NO.06-1191-021-7 DIST.	
SUBM'D. KSL	CHKD. SEP	DATE: NOV 2006	SITE:
DRAWN: RN	CHKD.	APPD. FJH	DWG. 1

GRAIN SIZE DISTRIBUTION

Sand

FIGURE 1



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

	Borehole	Sample	Elevation (m)
○	06-1	2	187.7
■	06-1	6	184.7
×	06-1	10	178.5
◇	06-2	2	187.7
▲	06-2	5	185.3
●	06-2	8	181.5

APPENDIX A

NON-STANDARD SPECIAL PROVISIONS (NSSPs)

CONCRETE SIGN SUPPORT STRUCTURE FOOTINGS - Item No.
EXCAVATION - Item No.

Non-Standard Special Provision

This special provision is to highlight the construction concerns for the installation of VMS#7 (Sault Ste. Marie). The Contactor shall be alerted that the overburden soils at the sign location include cohesionless and water-bearing sands, which are susceptible to soil cave-in, sloughing and boiling. The contractor is responsible to ensure that appropriate construction procedures and equipment are used for the caisson construction.