



THURBER ENGINEERING LTD.

**FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
WESTBOUND VARIABLE MESSAGING SIGN ON HIGHWAY 11/17
SHABAQUA CORNERS, ONTARIO
AGREEMENT NO.: 6022-E-0038
ASSIGNMENT NO.: 3**

GEOCRES NO.: 52A12-001

Location: Lat: 48.589427°, Long: -89.865048°

Client Name: Ministry of Transportation

Date: December 22, 2023

File: 42414



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PART 1. FACTUAL INFORMATION

1. INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the relocation of a Variable Messaging Sign (VMS) on Highway 11/17 at Sta. 12+920 near Shabaqua Corners in Dawson Road Lots Township within the District of Thunder Bay, Ontario. Thurber carried out the foundation investigation for the Ontario Ministry of Transportation (MTO) under Retainer Agreement No. 6022-E-0038, Assignment No. 3.

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

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

2.1 General

The westbound VMS site is located on Highway 11/17 at Sta. 12+920 approximately 1,200 m east of Old Dawson Road near Shabaqua Corners, Ontario. The proposed VMS location is approximately 4 m north of the northern edge of pavement.

In the area of the VMS, Highway 11/17 is a two-lane highway with an additional passing lane in the east direction and has a posted speed limit of 90 km/h. The road surface near the VMS is at

approximate elevation 426.1 m. The shoulders to the highway are partially paved. The 2016 traffic volume for this section of Highway 11 is understood to be approximately 3,800 AADT.

The site is in a rural setting and the area adjacent to the highway is undeveloped and densely vegetated with mixed forests of coniferous and some deciduous trees and shrubs. Overhead utility lines were present along both sides of the highway.

Photographs of the project area are included in Appendix D. These photographs show the existing condition of the highway and VMS site at the time of the field investigation.

2.2 Site Geology

According to Crins et al. 2009¹ the project area is described as Ecoregion 3W (Lake Nipigon Ecoregion) within the Ontario Shield Ecozone. According to Wester et al. 2018² the ecoregion is subdivided into Ecodistrict 3W-2 (Savanne Ecodistrict). The project area is located in the south part of the ecodistrict, which is characterized by discontinuous morainal materials of variable depths, typically separated by bedrock outcrops. Bedrock Geology Map (M2542)³ indicates the site is underlain by mafic to intermediate metavolcanic rocks.

2.3 Existing Information

A historical foundation investigation report was not available for this site within the online Geocres Library.

Base plan mapping was provided by MTO for the preparation of this report.

3. SITE INVESTIGATION AND FIELD TESTING

The foundation investigation and field-testing program was carried out on October 20, 2023, and consisted of one off-road borehole drilled on the north side of the highway identified as 23-01. The borehole was advanced with a CME 55 track-mounted drill rig utilizing solid stem augers, NW casing and coring techniques. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

A summary of the borehole coordinates, elevations, and termination depths is provided in the table below. The as-drilled borehole elevations were estimated by Thurber following completion of the field program. Horizontal locations were measured by Thurber relative to existing site

¹ <https://files.ontario.ca/mnrf-ecosystemspart1-accessible-july2018-en-2020-01-16.pdf>

² <https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf>

³ <https://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/M2542/M2542.pdf>

features. The elevations and borehole coordinates were reviewed and referenced to the survey data provided by MTO. The borehole coordinates and elevations are shown on the Borehole Location and Soil Strata drawing included in Appendix A and on the individual Record of Borehole sheet included in Appendix B. The borehole coordinates are referenced to MTM Zone 15.

Table 3-1 Borehole Summary

Borehole	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth Below Ground Surface (m)
23-01	5,383,439.4	314,753.0	425.9	5.9

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586. Approximately 2.8 m of bedrock was cored in the borehole.

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

Following completion of the field investigation, the borehole was decommissioned in general in accordance with O. Reg. 903, as amended.

4. LABORATORY TESTING

Laboratory testing was selected in general accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Recovered soil samples were selected for grain size distribution testing in accordance with MTO and ASTM standards. The rock cores were photographed, and the total core recovery (TCR), solid core recovery (SCR), and rock quality designation (RQD) were measured. Unconfined compressive strength (UCS) and point load testing was carried out on select intact bedrock cores to assess the unconfined compressive strength (UCS) of the bedrock. The results of these tests are summarized on the Record of Borehole sheet included in Appendix B.

All laboratory test results from the field investigation are provided in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered subsurface conditions are presented on the Record of Borehole sheet included in Appendix B and on the Borehole Location and Soil Strata Drawing included in

Appendix A. A general description of the stratigraphy, based on the conditions encountered in the borehole, is given in the following sections. However, the factual data presented on the Record of Borehole sheet takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

In general, the encountered stratigraphy consists of sand and gravel fill overlying silty sand fill underlain by native sandy silt over bedrock.

5.1 Fill

5.1.1 Sand and Gravel Fill

A fill layer consisting of sand and gravel was encountered at the ground surface in Borehole 23-01. The fill layer was 1.5 m thick (base elev. 424.4 m). SPT N-values in the fill ranged from 16 to 59 blows, indicating a compact to very dense relative density.

Moisture contents ranging from 3 to 4% were recorded in the sand and gravel fill. The results of a gradation analysis completed on a sample of the sand and gravel fill are illustrated on Figure C1 of Appendix C. The results of the test are summarized in the table below and on the Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)
Gravel	42
Sand	50
Silt	8
Clay	

5.1.2 Silty Sand Fill

A layer of silty sand fill was encountered below the sand and gravel fill. The fill layer was 0.5 m thick (base elev. 423.9 m). A SPT N-value of 24 blows was recorded, indicating a compact relative density.

A moisture content of 13% was recorded in the silty sand fill. The results of a gradation analysis completed on a sample of the silty sand fill are illustrated on Figure C2 of Appendix C. The results of the test are summarized in the table below and on the Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)
Gravel	18
Sand	47
Silt	29
Clay	6

5.2 Sandy Silt

A native layer of sandy silt was encountered below the fill in Borehole 23-01. The layer had a thickness of 1.1 m with an underside depth of 3.1 m (base elev. 422.8 m). Refusal blow counts were recorded in this layer, indicating a very dense relative density.

Moisture contents ranging from 4 to 8% were recorded.

5.3 Bedrock

Bedrock was proven by coring in Borehole 23-01. The bedrock encountered consisted of fresh jointed, grey, very strong gneiss. Photographs of the bedrock core are provided in Appendix C. The rock core quality measurements are summarized in the following table.

Table 5-1 Bedrock Details

Parameter	Range
Total Core Recovery (TCR), %	90 – 98
Solid Core Recovery (SCR), %	10 – 63
Rock Quality Designation (RQD), %	10 – 44
Fracture Index (fractures per 0.3 m)	1 – >10
Unconfined Compressive Strength Testing (MPa)	102 – 131

The upper 1 m of the bedrock is fractured. Based on the RQD, the bedrock quality is described as very poor to poor (CFEM 5th Edition, 2023). The results of UCS and point load testing indicate that the tested samples of the bedrock are very strong (CFEM 5th Edition, 2023). The results of the UCS and point load testing are included in Appendix C.

5.4 Groundwater Level

The groundwater level within Borehole 23-01 upon completion of drilling was at a depth of 1.0 m (elev. 424.9 m). This water level may not be representative since water was introduced into the borehole for bedrock coring.

It should be noted that the above value is considered a short-term reading and may not reflect the groundwater level at the time of construction. Seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

6. MISCELLANEOUS

The borehole locations reflect existing site features and access constraints. The as-drilled borehole locations and ground surface elevations were measured by Thurber following completion of the field program. RPM Drilling of Thunder Bay, Ontario, supplied and operated the drill rig used to drill, test, sample, and decommission the boreholes. Traffic control was performed in accordance with Ontario Book 7 and was provided by RPM Drilling of Thunder Bay, Ontario. The field investigation was supervised on a full-time basis by Mr. L. Scalena, EIT. Overall supervision of the field investigation program was provided by Mr. M. Eastman, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Oakville.

Interpretation of the factual data and preparation of this report was completed by M. Eastman, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.



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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents foundation design recommendations to assist the project team in the foundation design for the proposed Variable Messaging Sign (VMS) on Highway 11/17 at Sta. 12+920 near Shabaqua Corners in Dawson Road Lots Township within the District of Thunder Bay, Ontario. Thurber Engineering Ltd. (Thurber) carried out the foundation investigation for MTO under Retainer Agreement No. 6022-E-0038, Assignment No. 3. The discussion and recommendations presented in this report are based on information provided by MTO and the factual data obtained during the current field investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ontario Ministry of Transportation (MTO) and their designer, Arcadis, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, and scheduling and the like.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

7.1 Background Information

The westbound VMS site is located on Highway 11/17 at Sta. 12+920 approximately 1,200 m east of Old Dawson Road near Shabaqua Corners, Ontario. In the area of the VMS, Highway 11/17 is a two-lane highway with an additional passing lane in the east direction.

In general, the encountered stratigraphy consists of sand and gravel fill overlying silty sand fill underlain by native sandy silt over bedrock. Very strong Gneiss bedrock was encountered at a relatively shallow depth of 3.1 m. The upper 1 m of the bedrock is fractured. The groundwater level within Borehole 23-01 upon completion of drilling was at a depth of 1.0 m (elev. 424.9 m).

7.2 Proposed Work

It is understood that the proposed VMS will be pole mounted.

7.3 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed VMS, existing ground surface conditions and in accordance with the following:

- MTO Sign Support Manual (2019)
- Canadian Highway Bridge Design Code (CHBDC) version CSA S6-19

8. FOUNDATION DESIGN RECOMMENDATIONS

8.1 Foundation Type

Given the soil stratigraphy, relatively shallow depth to bedrock and groundwater conditions encountered during the course of the current field investigation, caisson foundation may be considered to support the new pole mounted VMS.

Spread footings are also considered a feasible alternative but would require excavations in close proximity to the existing highway requiring a temporary protection system and groundwater control to construct the footing in the dry.

8.2 Caisson Foundation

The geotechnical parameters presented in the table in Appendix E may be used for caisson foundation design.

8.2.1 Caisson Length

In accordance with Standard Drawings SS118-3 and SS118-11 (attached in Appendix F) from the MTO Sign Support Manual (2019), the standard caisson length, L , for a single pole mounted VMS is 6 m below frost depth. The depth of frost penetration at this site is 2.3 m. A Note to Designer on Standard Drawing SS118-3 also indicates that if sound rock is encountered at a depth of $Y <$

L from the bottom of the frost layer (2.3 m), the actual caisson length below frost depth may be reduced to: $Y + (L - Y)/2$, upon Ministry's approval.

Based on the subsurface conditions encountered in Borehole 23-01, top of bedrock was encountered at a depth of 3.1 m below ground surface. For design purposes, sound bedrock may be taken at a depth of 3.6 m below ground surface. As a guide, assuming the standard caisson length, L, for a single pole mounted VMS to be 6 m below frost depth and in conjunction with the above equation, $Y = 3.6 - 2.3 = 1.3$ m and the actual caisson length below frost depth becomes $1.3 + (6 - 1.3)/2 = 3.65$ m. The overall caisson length would be $3.65 + 2.3 = 5.95$ m. This implies a minimum rock socket length of 2.85 m. This reduction in overall caisson length will need to be approved by MTO as indicated in Standard Drawing SS118-3. It is recommended that the designers confirm the required caisson length and rock socket length to resist uplift and lateral loads and discuss with MTO on the final caisson length, from which the depth of bedrock coring can be established for construction.

8.2.2 Caisson Installation

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

The caisson equipment supplied by the Contractor must be capable of advancing through the existing dense overburden soils and penetrate or push aside potential obstructions. Coring equipment will be required to form the rock socket within the very strong bedrock without fracturing the sidewalls.

Caisson construction will require use of temporary liners seated into the bedrock surface to support the sidewalls, minimize groundwater inflow and enable machine-cleaning of the socket base. An NSSP to this effect is provided in Appendix F.

8.3 Spread Footings

A footing founded directly on bedrock is considered feasible to support the pole mounted VMS provided the following conditions are satisfied:

1. The main design criterion for sign foundations is to ensure that the geotechnical resistance is sufficient to withstand the maximum design wind load. Given the geometry of the design layout, the wind loading would impose uplift of the footing that needs to be resisted by the dead load of the soil backfill above the footing. Should this not be sufficient, rock anchors will be required to hold down the footing. It is recommended that the designers assess if anchors are required.

2. MTO approval is required as this foundation alternative deviates from the standard caisson design.
3. Due to the close proximity of the sign location to the existing highway embankment, construction of this spread footing will likely require temporary protection (shoring) to support the highway during footing excavation. It is the Contractor's responsibility to design a suitable temporary protection system that will not adversely impact the adjacent travelling lane. Due to the presence of very strong bedrock at shallow depth, driven sheet pile shoring will not be practical at this site. Braced shoring may be required.
4. Dewatering may be required within an open excavation for footing construction. It is the Contractor's responsibility to design a suitable dewatering system.

The existing fill and native sandy silt deposit should be excavated and spread footing should be founded directly on bedrock. The bedrock was encountered in Borehole 23-01 at elevation 422.8 m.

A spread footing founded directly on undisturbed bedrock can be designed with a factored geotechnical resistance at ULS of 2,000 kPa. The SLS condition does not govern design for a footing founded on bedrock.

The above geotechnical resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the geotechnical resistance must be adjusted in accordance with Section 6.10.2 and 6.10.5.3 of the CHBDC.

The horizontal resistance against sliding between a cast-in-place concrete footing and the underlying bedrock can be computed using an unfactored coefficient of friction of 0.7.

Should grouted rock anchors be required to resist uplift forces on the footing, the following parameters may be used for design of the anchors. The upper 1 m of the bedrock is highly fractured and the bedrock below this 1 m is less fractured. The minimum bond length of a fully grouted anchor should be 1 m into the less fractured sound bedrock. The anchor may have to be longer to satisfy the uplift load requirement. The factored rock-grout bond strength at ULS recommended for design of the anchors is provided below:

- Top of bedrock to 1 m depth: 100 kPa
- Sound bedrock below 1 m depth: 600 kPa

The Contractor's coring equipment must be able to penetrate the very strong Gneiss bedrock with UCS of around 100 to 130 MPa.

Pre-production performance testing should be carried out to confirm the design anchor capacities prior to installation of the production anchors. All production anchors should be proof tested to confirm their carrying capacities.

Pre-production performance testing should be carried out on at least one sacrificial test anchor. For permanent anchors, double corrosion protection must be provided to all production anchors.

Proof and performance testing should be carried out in accordance with the latest version of OPSS.PROV 942.

9. CONSTRUCTION CONCERNS

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

- Obstructions may be encountered during construction and interfere with excavations and installation of deep foundations. The Contractor must be prepared to dislodge or penetrate obstructions.
- For alternative spread footing foundation option, excavation will be required adjacent to Highway 11/17. The proximity of the highway and stability of the excavation slopes must be considered in the design and selection of excavation protection and dewatering systems.
- Consideration will have to be given to the proximity of nearby overhead utility lines and special attention will need to be taken into account during construction to avoid any damage to the utilities.
- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing soils to support the proposed construction equipment and supplies.

The successful performance of the project will depend largely upon good workmanship and quality control during construction. Subgrade examination and field density testing should be carried out by qualified personnel during construction to confirm that foundation recommendations are correctly implemented, and material specifications are met.



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10. CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. M. Eastman, P.Eng. The report was reviewed by Dr. S. Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) **Nature and Exactness of Soil and Contaminant Description:** Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) **Reliance on Provided Information:** The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) **Design Services:** The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) **Construction Services:** During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

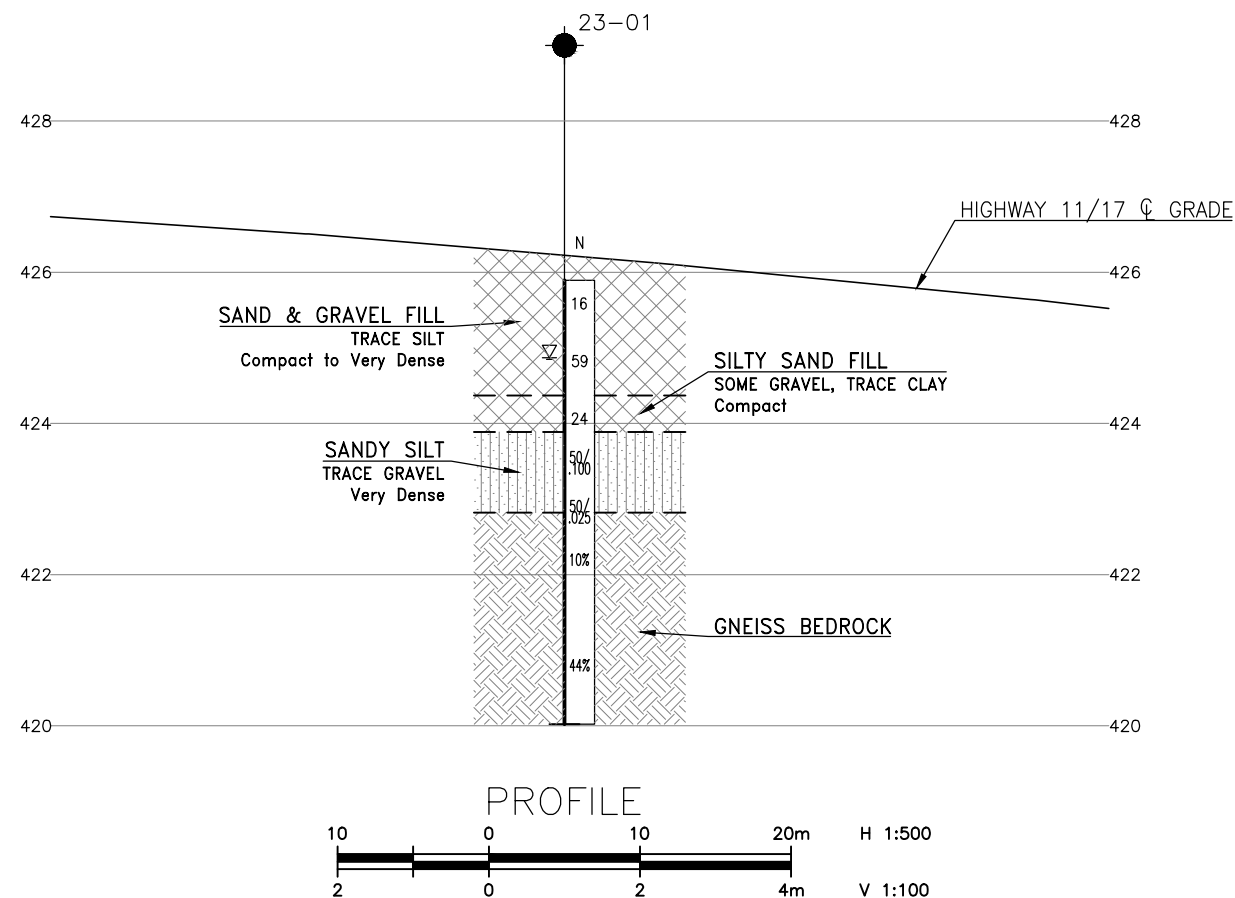
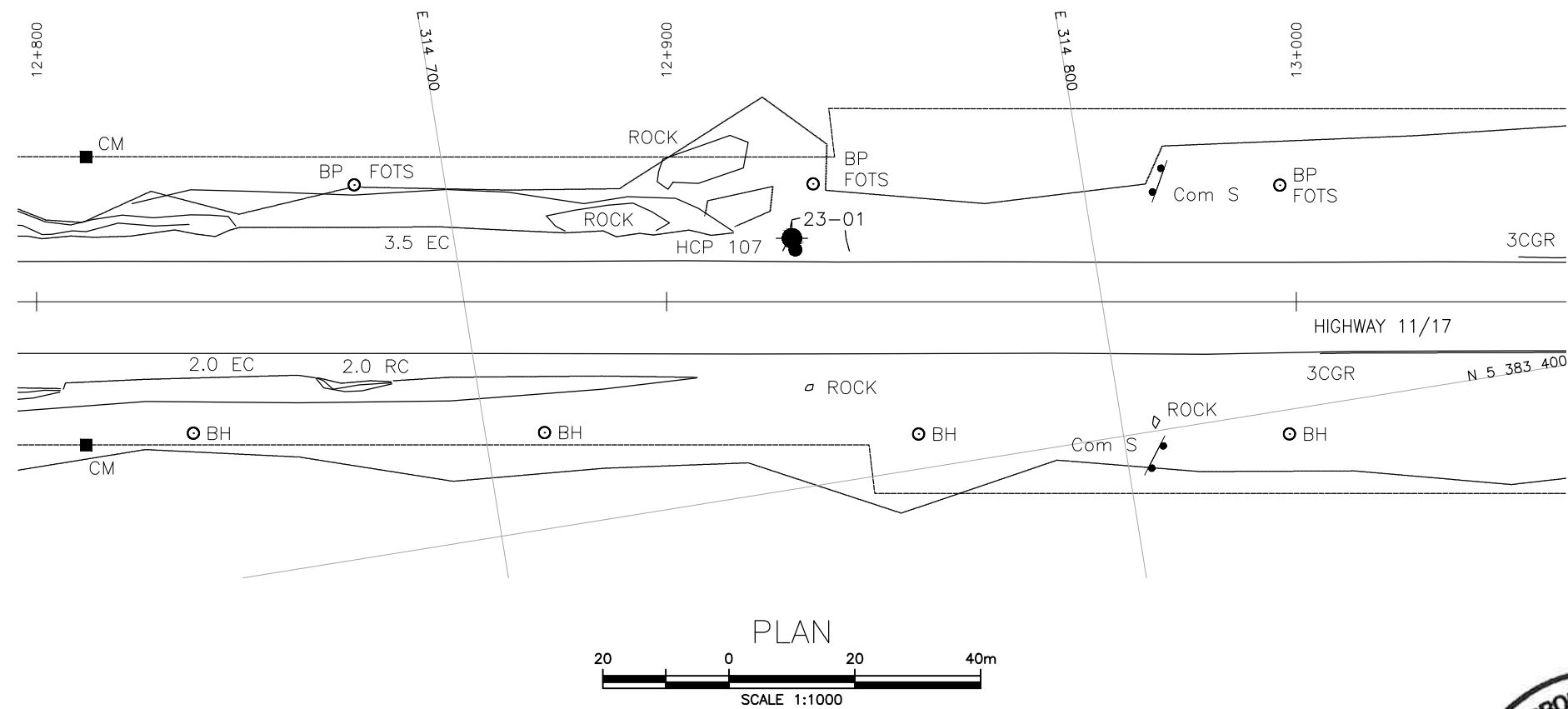
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

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The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

APPENDIX A

Borehole Locations and Strata Drawing



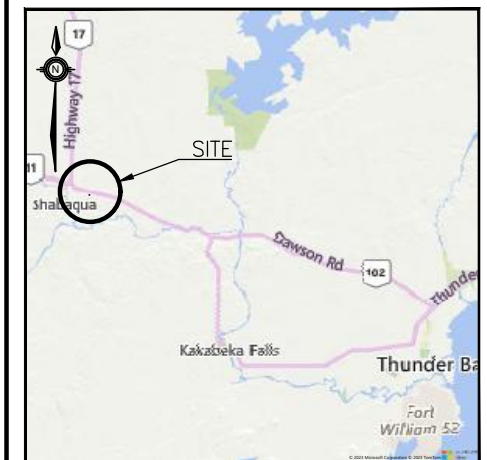
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 6022-E-0038

HIGHWAY 11/17
SHABAQUA WB VMS






BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No.

[illegible]

APPENDIX B

Record of Boreholes Sheet

RECORD OF BOREHOLE No 23-01

1 OF 1

METRIC

W.P. 6022-E-0038 LOCATION N 5 383 439.4 E 314 753.0 ORIGINATED BY LS
DIST Thunder Bay HWY 11/17 BOREHOLE TYPE CME 55 Track-Mount, SSA (108 mm O.D.)/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2023.10.20 - 2023.10.20 LATITUDE 48.589422 LONGITUDE -89.865070 CHECKED BY MKE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
425.9	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>							
0.0	SAND and GRAVEL , trace silt Compact to Very Dense Dark Brown - Brown Moist (FILL)		1	SS	16		425								42 50 8 (SI+CL)
424.4			2	SS	59		425								
1.5	Silty SAND , some gravel, trace clay Compact Brown - Grey Moist (FILL)		3	SS	24		424								18 47 29 6
423.9							424								
2.0	Sandy SILT , trace gravel Very Dense Grey Moist		4	SS	50/ 0.100		423								
422.8	GNEISS BEDROCK , very strong, fresh, thickly bedded, grey		5	SS	50/ 0.025		423							FI	
3.1	Horizontal fractures at 3.3, 3.7, 3.9 and 4.1m		1	RUN			422							>10	RUN #1 TCR=90% SCR=10% RQD=10%
	Vertical fracture from 3.2 to 4.2m						422							7	
	Sub-vertical fractures (25mm) at 3.4, 3.5 and 3.6m		2	RUN			421							4	
	Vertical fracture (150mm) at 4.3m						421							5	
	Sub-vertical fractures (25mm to 50mm) at 4.4, 4.6, 4.7, 4.9, 5.5, 5.6, 5.7 and 5.8m						421							3	RUN #2 TCR=98% SCR=63% RQD=44% UCS=101.8MPa UCS=131.1MPa (PLT)
420.0	Horizontal fractures at 5.0 and 5.3m													1	
														2	
5.9	END OF BOREHOLE AT 5.9m. BOREHOLE OPEN TO 2.5m AND WATER LEVEL AT 1.0m UPON COMPLETION.													3	

+³, ×³: Numbers refer to
Sensitivity

20
15
10

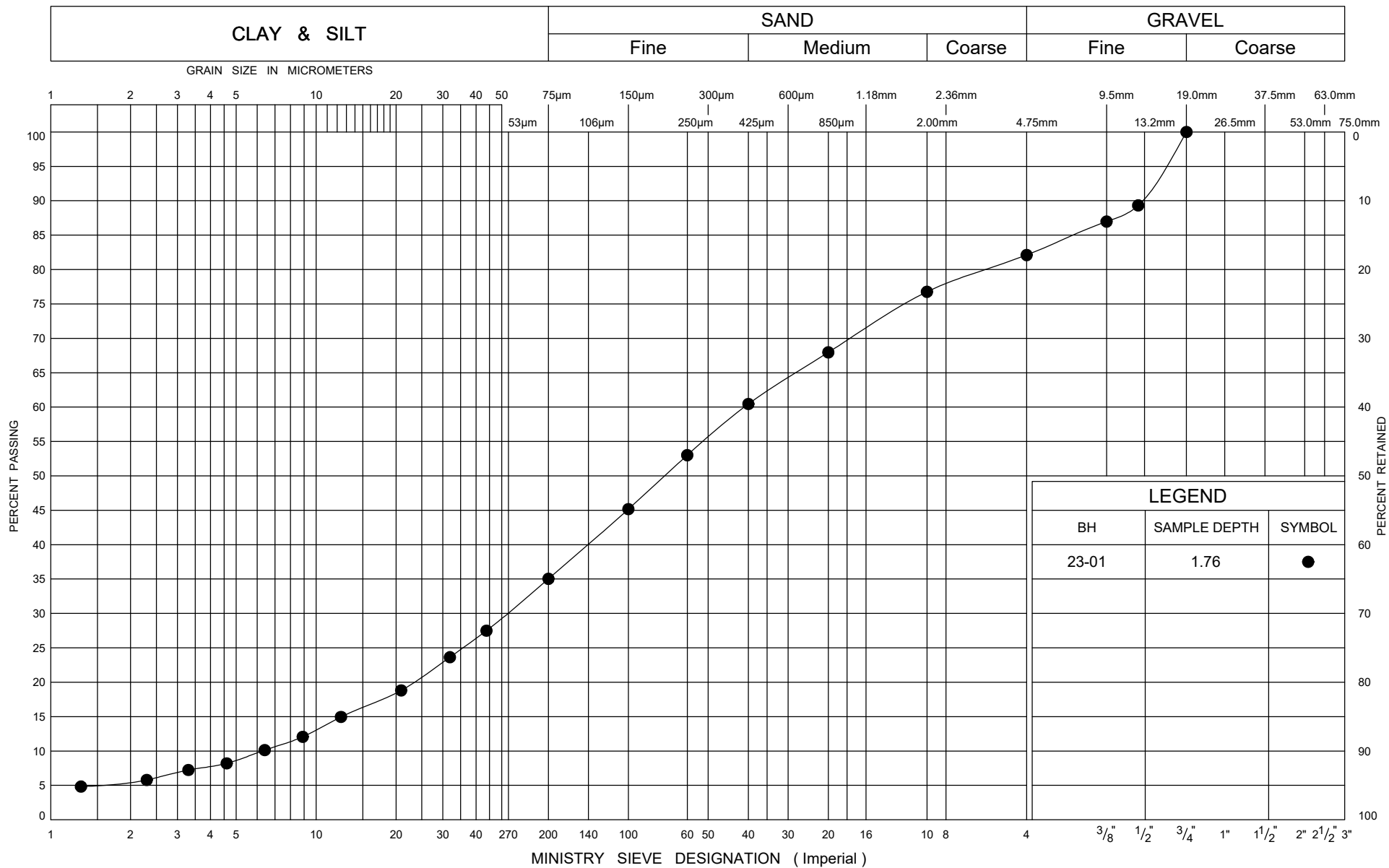
(%) STRAIN AT FAILURE

APPENDIX C

Laboratory Test Results



FIG No C1
W.P. 6022-E-0038





THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 42414

Project Name: Shabaqua WB VMS

Core Size: NQ BH No : 23-01

Date Drilled: 20-Oct-23

Date Tested: 03-Nov-23

Tester: BS

Client: MTO

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	2	5.7	D	13.3	47.5	64.6	5.5	131.1	Gneiss	Very Strong
2										
3										
4										
5										
6										
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

* Correlation factor to obtain UCS values is 24.

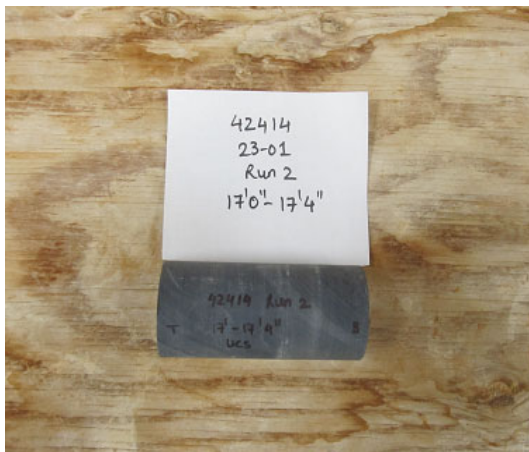
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

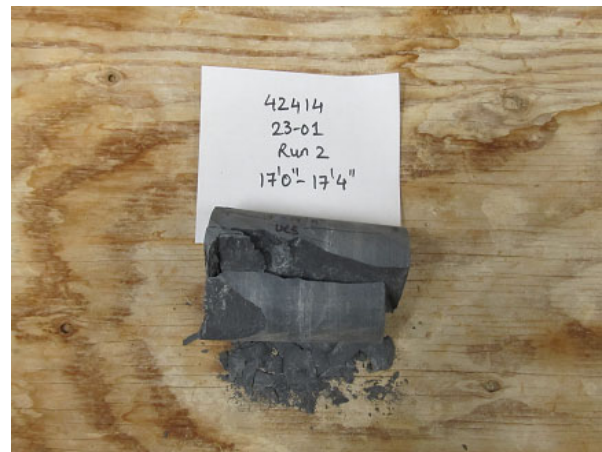
CLIENT: Ministry Of Transportation, Ontario FILE NUMBER: 42414
PROJECT NAME: Shabaqua WB VMS REPORT DATE: 1-Dec-23
BOREHOLE No.: 23-01 TEST DATE: 3-Nov-23
SAMPLE No.: RUN 2
SAMPLE DEPTH: 5.18-5.28 m
DESCRIPTION: Gneiss

Avg. Height (cm):	9.7	Weight (g):	470.2
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,794
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m ³):	2,550
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	168.29		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	176.7 kN
UNCONFINED COMPRESSIVE STRENGTH:	101.8 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

23-01 Run 2 UCS



THURBER ENGINEERING LTD.

ROCK CORE PHOTOGRAPH

Borehole 23-01, Runs 1 and 2 (of 2), 3.1 to 5.9 m



APPENDIX D

Site Photographs



Photo 1: Looking west at traffic control set-up (*taken on October 20, 2023*)



Photo 2: Looking east at Borehole 23-01 during drilling (*taken on October 20, 2023*)

APPENDIX E

Geotechnical Parameters for Caisson Foundation Design

TABLE 1
FOUNDATION DESIGN PARAMETERS
VARIABLE MESSAGE SIGN (VMS) SUPPORT
HIGHWAY 11/17, SHABAQUA CORNERS, ONTARIO

Location	Reference Borehole	Reference Simplified Subsurface Stratigraphy For Design	Depth Below Existing Ground Surface (m)	Foundation Design Parameters						
				q_u (kPa)	ϕ' (deg.)	n_h (MN/m ³)	K_p	γ (kN/m ³)	γ' (kN/m ³)	Design Groundwater Depth below G.S. (m)
VMS #1	23-01	Very dense Sandy Silt	2.3* – 3.1	-	32	4.0	3.2	-	11	2
		Gneiss Bedrock (fractured)	3.1 – 3.6	-	42	15.0	5.0	23	-	
		Gneiss Bedrock (sound)	Below 3.6	-	-	-	-	-	-	
This location if applicable	-	New Fill (if used) (see Note 3)	Variable height above ground surface	-	30	3.0	3.0	20	-	Below base of new fill

* Design frost depth

Notes:

1. This table must be read in conjunction with the text of this report.
2. In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance in front of the caisson within the upper 2.3 m below final grade should be neglected in the foundation design.
3. If new fill is placed, some caissons may be partially embedded within the new fill.
4. If detailed analysis is deemed necessary, a coefficient of horizontal subgrade reaction for sound gneiss can be provided upon request.

LEGEND

q_u	=	Unconfined Compressive Strength ($= 2 \times C_u$, undrained shear strength) (kPa)
ϕ'	=	Angle of Internal Friction (degrees)
n_h	=	Coefficient related to soil density (MN/m^3 or $\times 10^3 \text{ kN/m}^3$)
K_p	=	Coefficient of Passive Earth Pressure
γ	=	Soil Unit Weight (kN/m^3)
γ'	=	Submerged Soil Unit Weight (kN/m^3) – to be used only for cohesionless soils below the groundwater table

APPENDIX F

Suggested Text for NSSP and Referenced Standard Drawings

1. Suggested text for NSSP on “Construction of Caissons”

Caisson installation shall be in accordance with OPSS.PROV 903 and the following:

Caisson installation at this site will require excavation through cohesionless soils below the groundwater table and construction of socket in the underlying bedrock. The Contractor is advised of the following:

- The cohesionless soil above the bedrock is susceptible to disturbance under conditions of unbalanced hydrostatic head and measures must be employed to maintain sidewall stability in the caisson excavation and prevent collapse/washing of cohesionless soils into the rock socket. Selection of the methods and equipment employed to achieve this is the responsibility of the Contractor.
- Caisson installation may encounter cobbles, boulders and/or large rock fragments in the soils overlying the bedrock. The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating such obstructions.
- The bedrock consists of very strong gneiss bedrock. The strength and hardness of this rock must be taken into account when selecting equipment to advance the caisson into rock. Equipment supplied to construct the rock socket must be capable of excavating the bedrock to the specified socket dimension without disturbing or fracturing the bedrock forming the sidewalls and base of the socket. Blasting to facilitate the removal of bedrock is not permitted.
- The rock socket must be formed entirely within the bedrock below the level of any cobbles and boulders. Any length of caisson above the bedrock surface will not be considered part of the specified length of rock socket.

