

FINAL REPORT

**Foundation Investigation Report
Storage Building at Walden Patrol Yard
- Waters Township, RR 55, Sudbury Area
WO 2011-11001, District 54
MTO GEOCRES No. 41I-271**

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March 30, 2011

ADM-00011530-A0

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1. FOUNDATION INVESTIGATION

1.1 Introduction

This report presents the results of a geotechnical investigation carried out by Trow Associates Inc. (Trow) for the proposed new storage structure located at Walden Patrol Yard, Waters Township on Sudbury Regional Road 55, District 54, Sudbury Area. The proposed 24.4 m x 42.7 m storage structure will replace the existing two sand domes. The structure will allow for inside loading and dumping. It will be similar to the building structures constructed at the Cartier Patrol Yard located on Hwy 144 in Sudbury Area for which Trow carried out Foundation Investigation and Design.

The work was undertaken under Agreement # 5009-E-0060, Assignment No. 1. The terms of reference were as presented in the Ministry of Transportation (MTO) letter dated December 03, 2010.

The purpose of the investigation is to establish the existing subsurface conditions at the proposed location of the Patrol Yard structure within the construction limits. The site specific geotechnical investigation was carried out by means of borehole drilling, bedrock coring, in situ testing, and subsequent geotechnical laboratory testing on selected samples. This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the investigation and the laboratory testing.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The proposed Patrol Yard is located on Sudbury Regional Road 55 in the Township of Waters approximately 2 km north of the Highway 17 interchange, MTO Northeastern Region (see Key Map on Drawing 1). The terrain at the structure site is relatively flat as shown on the photographs in Appendix A. At about 50 m northeast of the proposed structure, there is a steep depression. At present, there are two 30 m diameter sand domes at the proposed structure site and will be replaced by the new storage structure.

The site plan is as shown on the drawings in Appendix B (from the site map PLAN H-564-17-1, provided by MTO).

1.2.2 Geological Setting

According to Bedrock Geology of Ontario Map 2544 (Ministry of Northern Development and Mines, Ontario), the bedrock underlying the site is from the Paleoproterozoic geologic era (approximately 1.6 to 2.5 billion years old) and falls under Southern and Superior rocks which consists of volcanic rocks including mafic, intermediate and felsic metavolcanic rocks, intercalated metasedimentary rocks and epiclastic rocks.

According to Surficial Geology Map by the Province of Ontario's Ministry of Northern Development, Mines and Forestry (MNDMF), the surficial deposit in this area is a discontinuous layer of drift Precambrian deposit.

1.3 Investigation Procedures

1.3.1 General

The current field investigation was carried out between February 1 and 11, 2011, during which time five (5) boreholes (BH-1, BH-2, BH-3, BH-4, and BH-5) were drilled. The locations of the boreholes were strategically located adjacent to the existing sand domes to permit geotechnical investigation for the foundation of the proposed new building. Drawing No. 1 in Appendix B shows the locations of five boreholes. The depths of the boreholes were: 18 m (BH-1), 17.2 m (BH-2), 14.3 m (BH-3), 39.7 m (BH-4) and 19.8 m (BH-5).

The boreholes were advanced using track-mounted CME 55 drill rig, equipped with continuous flight hollow stem augers. All borehole drilling/sampling were operated by a specialist drilling contractor, LandCore Drilling Co. Ltd. During the drilling operation, soil samples were obtained using a 51 mm outside diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals shown on the attached borehole logs (Appendix C). The SPT "N" values were recorded and used to provide an assessment of in-situ consistency or relative density of non-cohesive soils. At BH-1 from 1.5 to 3.1 m, BH-3 below 9.1m, and BH-4 below 15.2 m depths, wash boring was utilized to facilitate taking representative samples at designated elevation with reasonable accuracy. A standpipe piezometer was installed in BH-3. Bedrock coring was performed in BH-2 and BH-4. NQ coring equipment was used to retrieve rock cores. After completion, boreholes were sealed in accordance with accepted practice for decommissioning of boreholes.

Field vane testing was completed in the boreholes throughout the cohesive soils to measure the in-situ undrained shear strength of the soils. The field vane used had dimensions of 150 mm long and 80 mm diameter. The field vane testing was conducted in accordance with ASTM D2573-08. Three 50 mm diameter "Shelby" tube samples

were also obtained in cohesive deposits to provide undisturbed samples for laboratory testing.

The fieldwork was co-ordinated and supervised by a member of Trow engineering staff. They located the boreholes, directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System for foundation report, and retrieved soil samples for subsequent laboratory testing and identification. All of the recovered soil samples were placed in appropriate labeled moisture-proof containers and transported to Trow's Sudbury and Brampton laboratories for further detailed visual examination and laboratory testing.

Details of the soil strata encountered in the boreholes are included in attached borehole log sheets in Appendix C, and plotted on the cross sections in Appendix B. The borehole locations and the ground surface elevations along the cross sections were surveyed by Trow personnel, with reference to the benchmark at the east of the south dome as shown in the site survey map provided by MTO (PLAN H-564-17-1) (Elev. 261.131 m).

1.3.2 Laboratory Testing

On all of the samples returned to the laboratory, further visual examination and classification were carried out. The laboratory testing program included natural water content (LS-701), grain size distribution tests (LS703/704) and Atterberg limits (LS-703/704) on approximately 25% of the collected soil samples. Consolidation and strength testing (unconfined compression test) were carried out on selected specimens from the recovered undisturbed samples.

The laboratory test results are provided on the borehole logs in Appendix C. The results of the grain size analyses, Atterberg limits, consolidation and strength test are also included in Appendix D.

1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. The "Explanation of Terms Used in Report" is shown in the first page of the borehole logs sheets in Appendix C and should be read in conjunction with this report.

Appendix B shows the borehole location plan and three cross section soil profiles. It has to be underlined that the stratigraphic boundaries indicated on the borehole log and cross section soil profiles are inferred from non-continuous sampling, observations of drilling progress, and field vane and Standard Penetration Tests results. These boundaries

typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Further, subsurface conditions may vary between and beyond the borehole locations.

In general, the stratigraphic sequence at the proposed structure site consists of top sand fill, underlain by upper silt deposits. The upper silt is underlain by silty clay followed by lower silt and underlain by weathered bedrock. A brief summary of the soil and groundwater conditions encountered in the boreholes is provided below.

1.4.1 Asphalt

At BH-3, BH-4 and BH-5, asphalt was encountered at ground surface. It has a thickness of about 25 mm and its top elevation is between about 261.0 and 261.6 m.

1.4.2 Sand and Gravel Fill

A layer of sand and gravel fill was encountered in all boreholes with a thickness ranging from 2.5 m to 3.1 m, corresponding to approximate bottom elevations of 258.5 and 257.9 m, respectively. At BH-3, BH-4 and BH-5, the sand and gravel fill was overlain by 25 mm thick asphalt whereas at BH-1 and BH-2 it was exposed at the ground surface.

The sand and gravel layer typically consisted of fine to coarse sand, fine to medium gravel, and trace to some silt. An approximately 0.1 m thick peat layer was encountered in BH-5 at elevation of 258.7 m. The sand and gravel layer is brown in color and frozen up to approximately 1.22 m depth. Below the frost line the fill is wet. Uncorrected SPT “N” values in the fill were in the range of 4 to 50 blows per 300 mm of penetration, corresponding to loose to dense compactness conditions, but more typically loose to compact conditions.

The results of the laboratory testing performed on selected samples of the sand and gravel fill layer are as follows:

- Moisture content:
 - 5.8% to 71.5% (peat)
- Grain size distribution:
 - 24 % to 28% gravel;
 - 40% to 42% sand; and
 - 32% to 34% silt and clay

The results of moisture content and grain size distribution tests are presented on the

record of the borehole sheet in Appendix C. The results of the grain size distribution tests are also presented on Figure 1 in Appendix D.

1.4.3 Upper Silt

Below the fill, a layer of silt (named upper silt layer) was encountered in all boreholes with a thickness ranging from about 1.4 m to 4.1 m. It extends to depths between 4.0 m and 7.0 m, corresponding to approximate elevations of 257.0 and 254.5 m, respectively. At BH-1, BH-3, BH-4 and BH-5, the upper silt layer was underlain by a silty clay layer, while at BH-2 it was underlain by sand and gravel.

The upper silt layer consists of trace to some of clay and trace of sand. At BH-2, the upper silt contains trace of organics. The upper silt is grey in color and wet. The uncorrected SPT “N” values range between 6 and 15 blows per 300 mm of penetration, classifying the upper silt as loose to compact in compactness condition.

The results of the laboratory testing performed on selected samples of the upper silt layer are as follows:

- Moisture content:
 - 19.8% to 31.6%
- Grain size distribution:
 - 1% to 2% sand;
 - 86% to 91% silt; and
 - 8% to 12% clay

The details of the moisture content and grain size distribution tests results are presented on the record of the borehole sheet in Appendix C. The results of the grain size distribution tests are also presented on Figure 2 in Appendix D.

1.4.4 Silty Clay

Beneath the upper silt, a stratum of silty clay was encountered in BH-1, BH-3, BH-4 and BH-5. This silty clay layer has a thickness ranging from about 5.2 m to 11.7 m. It extends to depths between 10.7 (BH-3) m and 16.2 (BH-4 and BH-5) m, corresponding to approximate elevations of 250.9 and 244.8 m, respectively.

The silty clay layer was grey in color, wet. At BH-5, the layer of deposit was varved with clayey silt. The individual layers of laminations varied in thickness from a few millimeters to a few centimeters, but in general were about one centimeter thick.

The field vane undrained shear strength values ranged from 18 kPa to 49 kPa indicating a soft to firm consistency. The vane strength distribution with depth is shown on Figure 9, Appendix D. The undrained shear strength of a silty clay sample (from BH-5 at Elev. 250.3 m) measured in the unconfined compression tests was 19 kPa. Sensitivity ranged from 2.5 to 6, indicating the silty clay is low to medium sensitive.

Laboratory testing performed on selected samples consisted of moisture content, grain size distribution, Atterberg Limits, consolidation and unconfined compression tests. The test results are as follows:

- Moisture content:
 - 22.2% to 49.3%
- Grain size distribution:
 - 1% to 2% sand;
 - 37% to 71% silt; and
 - 28% to 61% clay
- Atterberg limits:
 - Plastic limit, PL = 14-20%;
 - Liquid limit, LL = 26-49%; and
 - Plasticity index, PI = 10-35%
- Consolidation properties:
 - Preconsolidation pressure, $P_v' = 150$ kPa
 - Compression index, $C_c = 0.22$
 - Recompression index, $C_r = 0.02$
- Unconfined compressive strength:
 - 38 kPa

The details of the moisture content and grain size distribution tests results are presented on the record of the borehole sheet in Appendix C. The results of the grain size distribution tests are also presented on Figure 3 in Appendix D. The consolidation and unconfined compression strength test results are shown on Figures 6 and 7, respectively, in Appendix D. The plasticity chart showing the Atterberg limits test results is included on Figure 8, Appendix D.

1.4.5 Sand and Gravel

In BH-2 a sand and gravel layer was encountered below the upper silt layer. It is about 2.1 m thick and extends from Elev. 254.5 m to 252.4 m.

This sand and gravel layer includes trace of silt. It is brown in color and wet. The uncorrected SPT “N” value is 22 blows per 300 mm penetration indicating a compact relative density. The natural water content performed on a selected sample of the sand and gravel layer was 8.6%. The result of moisture content test is presented on the record of the borehole sheet in Appendix C.

1.4.6 Lower Silt

A layer of silt (named lower silt layer) was encountered in BH-1, BH-3, BH-4 and BH-5 below the silty clay layer and in BH-2 below the sand and gravel layer. This lower silt layer has a thickness ranging from about 3.0 m to 8.2 m. It extends to depths between 14.1 m and 24.4 m, corresponding to approximate elevations of 247.4 and 236.6 m, respectively. BH-5 was terminated in this layer at a depth of approximately 19.8 m, elevation of 241.2 m. At BH-1, BH-2 and BH-3, the lower silt layer was underlain by weathered bedrock, while at location of BH-4 the layer was underlain by sand.

The lower silt layer consists of trace of gravel, sand and clay. It is grey in color and wet. Based on “N” values (6 to 19) obtained from the SPT, the compactness of the lower silt was loose to compact.

The results of the laboratory testing performed on selected samples of the lower silt layer are as follows:

- Moisture content:
 - 21.8% to 34.8%
- Grain size distribution:
 - 0% to 1% gravel;
 - 0% to 2% sand;
 - 90% to 97% silt; and
 - 2% and 10% clay

The details of the moisture content and grain size distribution tests results are presented on the record of the borehole sheet in Appendix C. The results of the grain size distribution tests are also presented on Figure 4 in Appendix D.

1.4.7 Sand

Sand was encountered in BH-4 below the lower silt and was underlain by highly weathered bedrock. This layer of sand is about 11.9 m thick and extends from Elev. 236.6 m to 224.7 m.

The deposit consists of some of silt and clay. It is grey in color and wet. The uncorrected SPT “N” values range between 9 and 22 blows per 300 mm, classifying the sand as very loose to very dense in compactness condition.

The results of the laboratory testing performed on selected samples of this sand layer are as follows:

- Moisture content:
 - 15.5% to 23.3%
- Grain size distribution:
 - 83% sand; and
 - 17% silt and clay

The details of the moisture content and grain size distribution test results are presented on the record of the borehole sheet in Appendix C. The results of the grain size distribution tests are also presented on Figure 5 in Appendix D.

1.4.8 Bedrock

Beneath the lower silt layer at BH-1, BH-2 and BH-3 and the sand layer at BH-4, weathered rock was encountered at depths ranging from 13.7 m to 36.3 m below existing ground surface (Elev. 247.9 m to 224.7 m). Bedrock coring was performed in BH-2 and BH-4. At BH-2, this weathered rock extends from about 14.1 m (approximately at elevation of 247.4 m) to 17.2 m (approximate elevation of 244.3 m) depth at the borehole termination. At BH-4, it extends from about 36.3 m (approximately at elevation of 224.7 m) to 39.7 m (approximate elevation of 221.4 m) depth at the borehole termination.

The total core recovery (TCR) was good, with values ranging from 88.3% to 100%. On the basis of the rock quality designation (RQD) index values which range between 50% to 100%, the rock quality is estimated to be “fair” to “excellent”, and the average of value of approximately 76% suggesting a rock of generally “good” quality.

Rock core photographs are presented in Appendix E.

1.5 Groundwater Conditions

The groundwater levels at the site were estimated during field borehole drilling and the change of the sample moist contents in depth. In addition, the groundwater level is measured in a piezometer installed in BH-3. The ground water levels encountered in the boreholes are also shown in Table 1.1. It should be noted that the groundwater level is subject to seasonal fluctuations.

Table 1.1 Groundwater levels at the site

| Borehole No. | Date of drilling | Water level | |
|--------------|------------------|-------------|----------------|
| | | Depth, (m) | Elevation, (m) |
| BH-1 | February/02/2011 | 3.2 | 257.8 |
| BH-2 | February/02/2011 | 3.2 | 258.3 |
| BH-3 | February/11/2011 | 3.2 | 258.4 |
| BH-4 | February/07/2011 | 3.2 | 257.8 |
| BH-5 | February/09/2011 | 3.6 | 257.4 |

1.6 Closure

Field staff from Trow's Sudbury office supervised the field work. This report has been prepared by S. Micic, Ph.D., P.Eng and A. Geremew, Ph.D., and reviewed by S. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact.

Trow Associates Inc.

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Silvana Micic, Ph.D, P.Eng.
Geotechnical Engineer




S.E. Gonsalves, M.Eng., P.Eng.
Principal Engineer
Designated MTO Foundation Contact



APPENDIX A: PHOTOGRAPHS

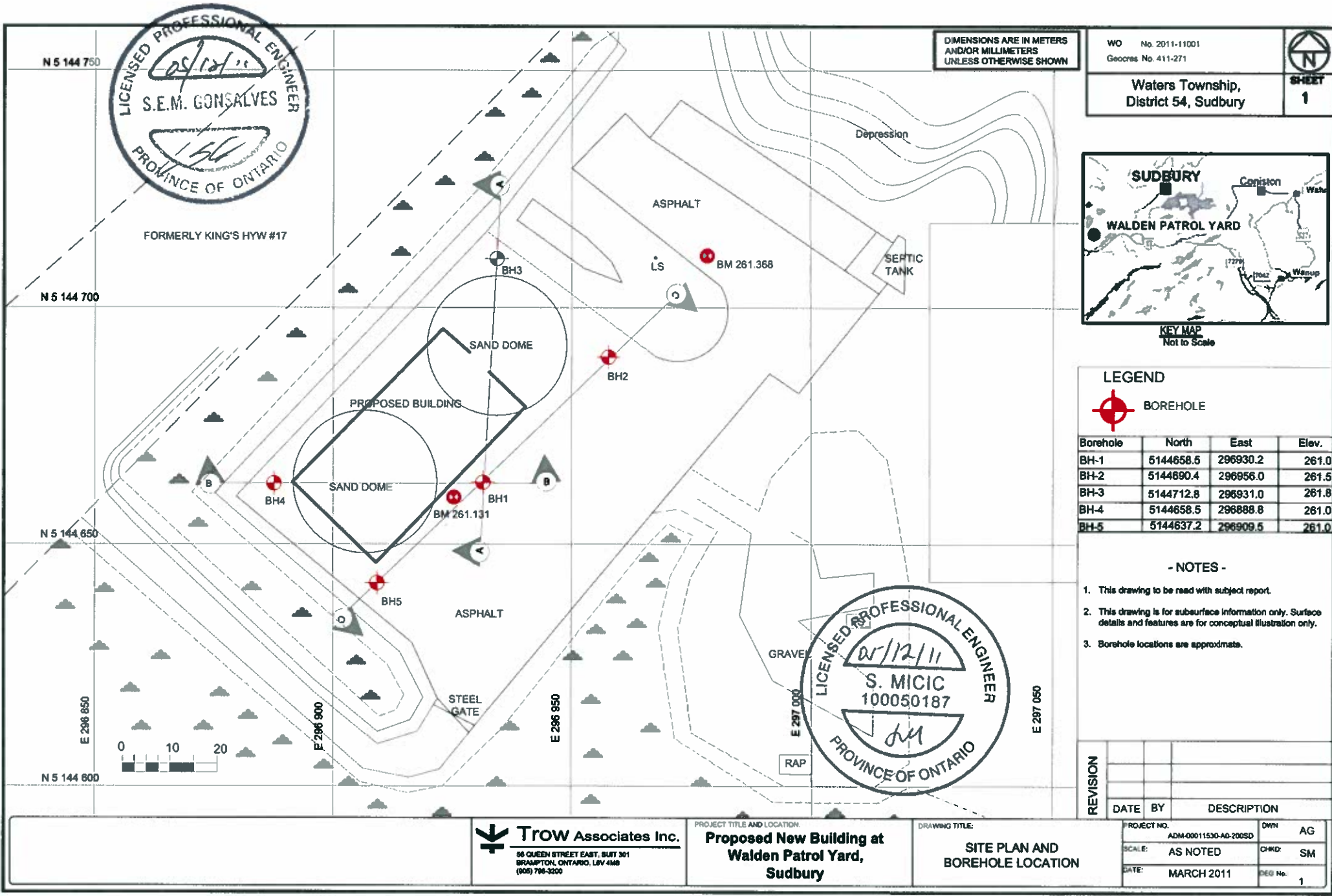


Photograph 1. Site View (facing to southwest)



Photograph 2. Site View (facing to northeast)

APPENDIX B: DRAWINGS

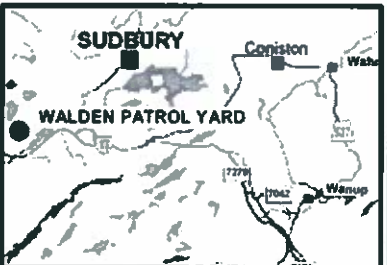


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AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

WO No. 2011-11001
Geocres No. 411-271

Waters Township,
District 54, Sudbury

SHEET
1



KEY MAP
Not to Scale

LEGEND



BOREHOLE

| Borehole | North | East | Elev. |
|----------|-----------|----------|-------|
| BH-1 | 5144658.5 | 296930.2 | 261.0 |
| BH-2 | 5144690.4 | 296956.0 | 261.5 |
| BH-3 | 5144712.8 | 296931.0 | 261.8 |
| BH-4 | 5144658.5 | 296888.8 | 261.0 |
| BH-5 | 5144637.2 | 296909.5 | 261.0 |

- NOTES -

1. This drawing to be read with subject report.
2. This drawing is for subsurface information only. Surface details and features are for conceptual illustration only.
3. Borehole locations are approximate.

REVISION

| DATE | BY | DESCRIPTION |
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|-------------|-----------------------|---------|----|
| PROJECT NO. | ADM-00011530-AD-200SD | DWN | AG |
| SCALE: | AS NOTED | CHKD: | SM |
| DATE: | MARCH 2011 | DES No. | 1 |

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PROJECT TITLE AND LOCATION:
**Proposed New Building at
Walden Patrol Yard,
Sudbury**

DRAWING TITLE:
**SITE PLAN AND
BOREHOLE LOCATION**

A-A Cross Section

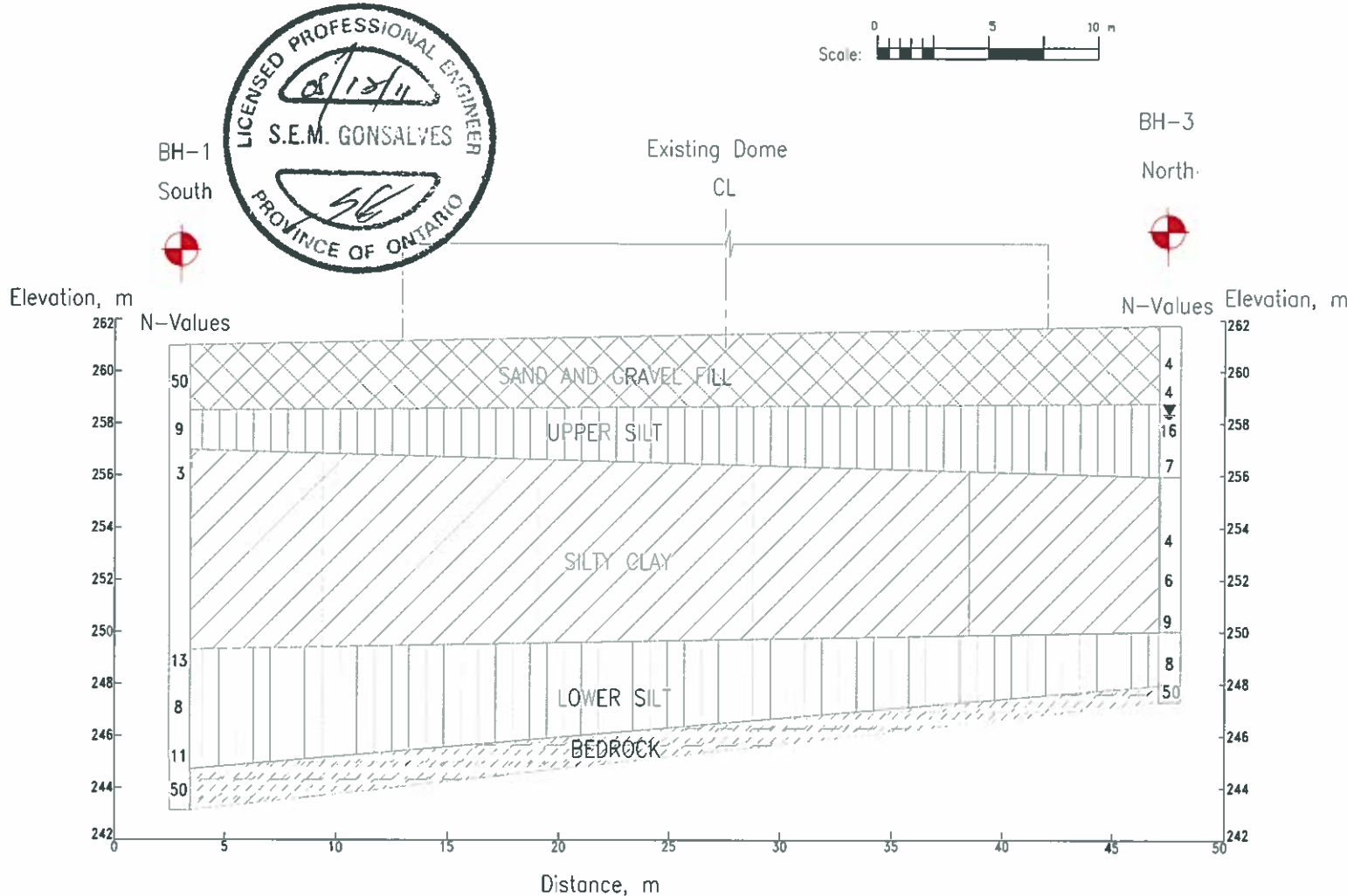
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WO No. 2011-11001
Geocras No. 411-271



**Waters Township,
District 54, Sudbury**

SHEET
2



KEY MAP
Not to Scale

LEGEND



BOREHOLE
LICENSED
Water Level



~~- NOTES~~

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| | SCALE: AS NOTED | | CHKD: SM |
| | DATE: MARCH 2011 | | DEG No: 2 |
| | | | |

SOIL STRATA SYMBOLS



SAND AND GRAVEL FILL



SILT



SILTY CLAY



BEDROCK

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PROJECT TITLE AND LOCATION

Proposed New Building at Walden Patrol Yard, Sudbury

| |
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| DRAWING TITLE |
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A-A CROSS-SECTION

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| PROJECT # | |
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DWN: 45

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ADM-00011530-AD-200S

AG

SCALE:

AS NOTED

CHKD: SM

DATE: _____

MARCH 2011

DEG No.

B-B Cross Section

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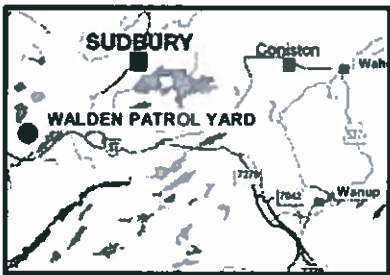
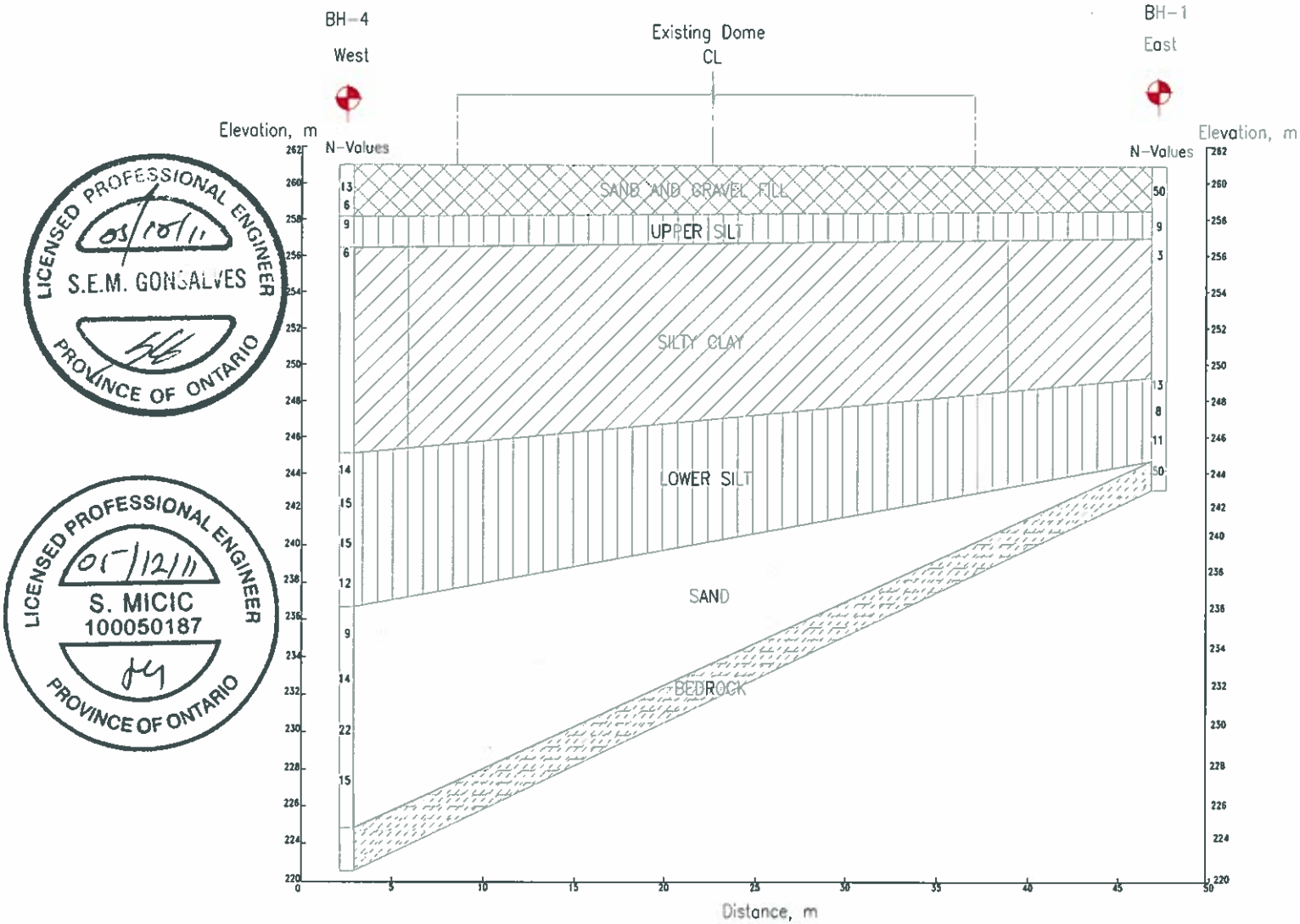
WO No. 2011-11001
Geocres No. 411-271



Waters Township,
District 54, Sudbury

SHEET
3

Scale: 0 5 10 m



KEY MAP
Not to Scale

LEGEND



BOREHOLE

- NOTES -

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SOIL STRATA SYMBOLS:



SAND AND GRAVEL FILL



SILT



SILTY CLAY



SAND



BEDROCK



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PROJECT TITLE AND LOCATION:

Proposed New Building at
Walden Patrol Yard,
Sudbury

DRAWING TITLE:

B-B CROSS-SECTION

REVISION

DATE

BY

DESCRIPTION

PROJECT NO.

ADM-00011530-A0-2005D

DWN:

AG

SCALE

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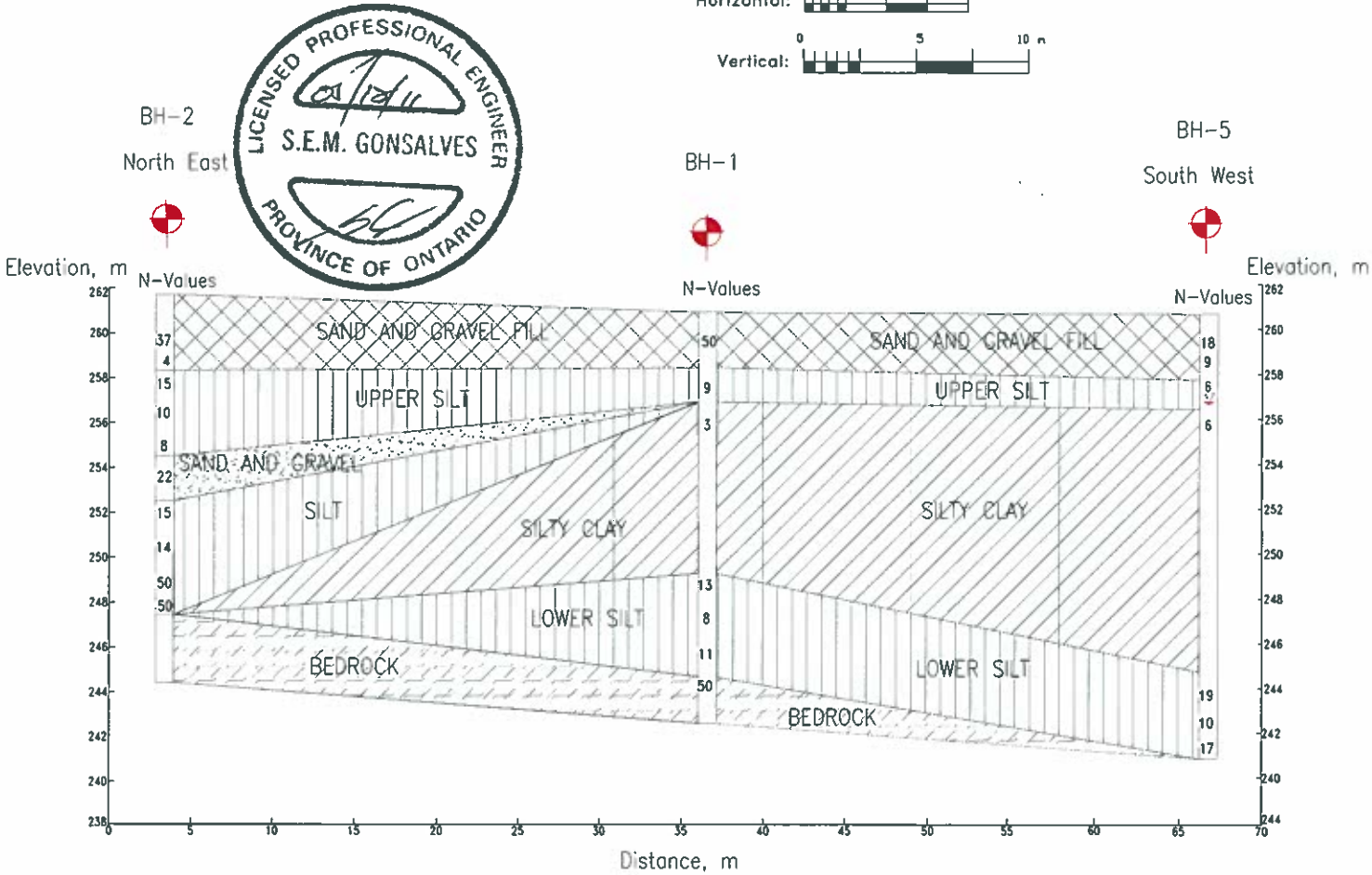
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MARCH 2011

DEG No:

3

C-C Cross Section



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Geocres No. 411-271

Waters Township,
District 54, Sudbury



SHEET
4



KEY MAP
Not to Scale

LEGEND



- NOTES -

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3. Borehole locations are approximate.

REVISION

| DATE | BY | DESCRIPTION |
|------|----|-------------|
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SOIL STRATA SYMBOLS:



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PROJECT TITLE AND LOCATION:
**Proposed New Building at
Walden Patrol Yard,
Sudbury**

DRAWING TITLE:
C-C CROSS-SECTION

| | |
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| PROJECT NO. ADM-00011530-A0-2005D | DWN: AG |
| SCALE AS NOTED | CHKD: SM |
| DATE MARCH 2011 | DEG No. 4 |

APPENDIX C: BOREHOLE LOGS

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

| C_u (kPa) | 0 – 12 | 12 – 25 | 25 – 50 | 50 – 100 | 100 – 200 | >200 |
|-------------|-----------|---------|---------|----------|------------|------|
| | VERY SOFT | SOFT | FIRM | STIFF | VERY STIFF | HARD |

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

| N (BLOWS/0.3m) | 0 – 5 | 5 – 10 | 10 – 30 | 30 – 50 | >50 |
|----------------|------------|--------|---------|---------|------------|
| | VERY LOOSE | LOOSE | COMPACT | DENSE | VERY DENSE |

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

| RQD (%) | 0 – 25 | 25 – 50 | 50 – 75 | 75 – 90 | 90 – 100 |
|---------|-----------|---------|---------|---------|-----------|
| | VERY POOR | POOR | FAIR | GOOD | EXCELLENT |

JOINT AND BEDDING:

| SPACING | 50mm | 50 – 300mm | 0.3m – 1m | 1m – 3m | >3m |
|----------|------------|------------|------------|---------|------------|
| JOINTING | VERY CLOSE | CLOSE | MOD. CLOSE | WIDE | VERY WIDE |
| BEDDING | VERY THIN | THIN | MEDIUM | THICK | VERY THICK |

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

| | | | |
|----|---------------------|----|---------------------------|
| SS | SPLIT SPOON | TP | THINWALL PISTON |
| WS | WASH SAMPLE | OS | OSTERBERG SAMPLE |
| ST | SLOTTED TUBE SAMPLE | RC | ROCK CORE |
| BS | BLOCK SAMPLE | PH | TW ADVANCED HYDRAULICALLY |
| CS | CHUNK SAMPLE | PM | TW ADVANCED MANUALLY |
| TW | THINWALL OPEN | FS | FOIL SAMPLE |

STRESS AND STRAIN

| | | |
|--------------------------------------|-----|-------------------------------|
| u_w | kPa | PORE WATER PRESSURE |
| r_u | 1 | PORE PRESSURE RATIO |
| σ | kPa | TOTAL NORMAL STRESS |
| σ' | kPa | EFFECTIVE NORMAL STRESS |
| τ | kPa | SHEAR STRESS |
| $\sigma_1, \sigma_2, \sigma_3$ | kPa | PRINCIPAL STRESSES |
| ϵ | % | LINEAR STRAIN |
| $\epsilon_1, \epsilon_2, \epsilon_3$ | % | PRINCIPAL STRAINS |
| E | kPa | MODULUS OF LINEAR DEFORMATION |
| G | kPa | MODULUS OF SHEAR DEFORMATION |
| μ | 1 | COEFFICIENT OF FRICTION |

MECHANICAL PROPERTIES OF SOIL

| | | |
|----------------|-----------------------|--------------------------------------|
| m_v | kPa^{-1} | COEFFICIENT OF VOLUME CHANGE |
| c_c | 1 | COMPRESSION INDEX |
| c_s | 1 | SWELLING INDEX |
| c_a | 1 | RATE OF SECONDARY CONSOLIDATION |
| c_v | m^2/s | COEFFICIENT OF CONSOLIDATION |
| H | m | DRAINAGE PATH |
| T_v | 1 | TIME FACTOR |
| U | % | DEGREE OF CONSOLIDATION |
| σ'_{vo} | kPa | EFFECTIVE OVERBURDEN PRESSURE |
| σ'_p | kPa | PRECONSOLIDATION PRESSURE |
| τ_f | kPa | SHEAR STRENGTH |
| c' | kPa | EFFECTIVE COHESION INTERCEPT |
| ϕ' | ° | EFFECTIVE ANGLE OF INTERNAL FRICTION |
| c_u | kPa | APPARENT COHESION INTERCEPT |
| ϕ_u | ° | APPARENT ANGLE OF INTERNAL FRICTION |
| τ_R | kPa | RESIDUAL SHEAR STRENGTH |
| τ_r | kPa | REMOULDED SHEAR STRENGTH |
| S_i | 1 | SENSITIVITY = c_u / τ_r |

PHYSICAL PROPERTIES OF SOIL

| | | | | | | | | |
|-----------------------|------------------------|--------------------------------|------------------|------|---------------------------------------|------------------|------------------------|--|
| P_s | kg/m^3 | DENSITY OF SOLID PARTICLES | e | 1, % | VOID RATIO | e_{min} | 1, % | VOID RATIO IN DENSEST STATE |
| γ_s | kN/m^3 | UNIT WEIGHT OF SOLID PARTICLES | n | 1, % | POROSITY | I_D | 1 | DENSITY INDEX = $\frac{e_{\text{max}} - e}{e_{\text{max}} - e_{\text{min}}}$ |
| P_w | kg/m^3 | DENSITY OF WATER | w | 1, % | WATER CONTENT | D | mm | GRAIN DIAMETER |
| γ_w | kN/m^3 | UNIT WEIGHT OF WATER | s_r | % | DEGREE OF SATURATION | D_n | mm | N PERCENT – DIAMETER |
| P | kg/m^3 | DENSITY OF SOIL | w_L | % | LIQUID LIMIT | C_u | 1 | UNIFORMITY COEFFICIENT |
| γ' | kN/m^3 | UNIT WEIGHT OF SOIL | w_p | % | PLASTIC LIMIT | h | m | HYDRAULIC HEAD OR POTENTIAL |
| P_d | kg/m^3 | DENSITY OF DRY SOIL | w_s | % | SHRINKAGE LIMIT | q | m^3/s | RATE OF DISCHARGE |
| γ_d | kN/m^3 | UNIT WEIGHT OF DRY SOIL | I_p | % | PLASTICITY INDEX = $(w_L - w_p)$ | v | m/s | DISCHARGE VELOCITY |
| P_{sat} | kg/m^3 | DENSITY OF SATURATED SOIL | I_L | 1 | LIQUIDITY INDEX = $(w - w_p) / I_p$ | i | 1 | HYDRAULIC GRADIENT |
| γ_{sat} | kN/m^3 | UNIT WEIGHT OF SATURATED SOIL | I_C | 1 | CONSISTENCY INDEX = $(w_L - w) / I_p$ | k | m/s | HYDRAULIC CONDUCTIVITY |
| P' | kg/m^3 | DENSITY OF SUBMERGED SOIL | e_{max} | 1, % | VOID RATIO IN LOOSEST STATE | j | kN/m^2 | SEEPAGE FORCE |
| γ' | kN/m^3 | UNIT WEIGHT OF SUBMERGED SOIL | | | | | | |

RECORD OF BOREHOLE No BH-1

1 OF 1

METRIC

W.P. WO 2011-11001 LOCATION Walden Patrol Yard, North Sand Dome ORIGINATED BY CS
 DIST 54, Sudbury HWY 17 - RR 55 BOREHOLE TYPE CME Hollow Steam Auger/Diamond COMPILED BY AG
 DATUM Geodetic DATE 2011 02 02 - 2011 02 02 CHECKED BY SM

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | | |
|--|--|------------|---------|------|------------|----------------------------|-----------------|---|----------------------------|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|-------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED ● QUICK TRIAXIAL | + FIELD VANE × LAB VANE | | | | | | | | | |
| 261.0 | Ground Surface | | 1 | AS | | | | | | | | | | | | | | |
| 0.0 | SAND and GRAVEL FILL (SW), trace to some silt, brown, damp (frozen to 1.2 m) | | 2 | SS | 50 | | | | | | | | | | | | | |
| 258.5 | - hard augering from 1.8 to 2.3 m - wash bored/cored from 1.5 to 3.1 m | | | | | | | | | | | | | | | | | |
| 2.5 | SILT (ML), trace clay, trace sand, grey, wet, loose | | 3 | SS | 9 | | | | | | | | | | | | | |
| 257.0 | | | | | | | | | | | | | | | | | | |
| 4.0 | SILTY CLAY (CL), trace sand, grey, wet, soft | | 4 | SS | 3 | | | | | | | | | | | | | |
| | | | 5 | SS | WH | | | | | | | | | | | | | |
| | | | 6 | SS | WH | | | | | | | | | | | | | |
| | | | 7 | SS | WH | | | | | | | | | | | | | |
| | | | 8 | SS | WH | | | | | | | | | | | | | |
| 249.3 | | | 9 | SS | 13 | | | | | | | | | | | | | |
| 11.7 | SILT (ML), trace clay, grey, wet, compact | | 10 | SS | 8 | | | | | | | | | | | | | |
| | - loose | | 11 | SS | 11 | | | | | | | | | | | | | |
| | - compact | | | | | | | | | | | | | | | | | |
| 244.3 | | | | | | | | | | | | | | | | | | |
| 16.8 | WEATHERED BEDROCK | | | | 50 | | | | | | | | | | | | | |
| 243.1 | | | | | | | | | | | | | | | | | | |
| 18.0 | END OF BOREHOLE | | | | | | | | | | | | | | | | | |
| NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by Trow is required before use by others. 3. "WH" means "Weight of Hammer" | | | | | | | | | | | | | | | | | | |

ONTARIO_MTO APPENDIX C - BOREHOLE LOGS - FINAL VERSION - MAY 8, 2011.GPJ_ONTARIO MOT.GDT_05/10/11

1 OF 1

METRIC

| | | | | | | |
|-------|------------------------|-------------------|--|---------------------------------------|-------------|-----------|
| W.P. | <u>WO 2011-11001</u> | LOCATION | <u>Walden Patrol Yard, North Sand Dome</u> | ORIGINATED BY | <u>CS</u> | |
| DIST | <u>54, Sudbury HWY</u> | <u>17 - RR 55</u> | BOREHOLE TYPE | <u>CME Hollow Steam Auger/Diamond</u> | COMPILED BY | <u>AG</u> |
| DATUM | <u>Geodetic</u> | DATE | <u>2011 02 01 - 2011 02 02</u> | CHECKED BY | <u>SM</u> | |

[illegible]

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

METRIC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | |
|---|---|------------|---------|------|------------|-------------------------|-----------------|--|----------------------------|---------------------------------|-------------------------------|--------------------------------|--|--|-------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | WATER CONTENT (%) |
| | | | | | | | | ○ UNCONFINED ● QUICK TRIAXIAL | + FIELD VANE × LAB VANE | | | | | | |
| 261.6 | Ground Surface | | | | | | | | | | | | | | |
| 260.9 | ASPHALT | | 1 | AS | | | | | | | | | | | |
| | SAND FILL (SW), fine to coarse gravel, some silt, crunchy at approximately 1.4 m, brown, damp (frozen to 0.9 m) | | 2 | SS | 4 | | | | | | | | | | |
| | - loose | | 3 | SS | 4 | | | | | | | | | | |
| 258.7 | | | | | | | | | | | | | | | |
| 2.9 | SILT (ML), some sand and gravel, trace clay, wet, compact | | 4 | SS | 16 | | | | | | | | | | |
| | - some clay, grey, wet, loose | | 5 | SS | 7 | | | | | | | | | | |
| 256.1 | | | | | | | | | | | | | | | |
| 5.5 | SILTY CLAY (CL), trace sand, grey, wet, soft | | 6 | SS | WH | | | | | | | | | | |
| | - becomes more silt | | 7 | SS | 4 | | | | | | | | | | |
| | - becomes soft to firm | | 8 | SS | 6 | | | | | | | | | | |
| | - wash bore from 9.1 m | | 9 | SS | 9 | | | | | | | | | | |
| | - becomes stiff | | | | | | | | | | | | | | |
| 250.0 | | | | | | | | | | | | | | | |
| 11.6 | SILT (ML), trace clay, grey, wet, loose | | 10 | SS | 8 | | | | | | | | | | |
| 247.9 | | | | | | | | | | | | | | | |
| 13.7 | WEATHERED BEDROCK | | 11 | SS | 50 | | | | | | | | | | |
| 247.3 | | | | | | | | | | | | | | | |
| 14.3 | END OF BOREHOLE | | | | | | | | | | | | | | |
| NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by Trow is required before use by others. 3. "WH" means "Weight of Hammer" 4. Standpipe piezometer is installed to a depth of 13.7 m. It is sealed with bentonite between 13.2 and 13.7 m, 10.2 and 10.7 m, and 0 and 0.5 m. | | | | | | | | | | | | | | | |

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

RECORD OF BOREHOLE No BH-4

1 OF 2

METRIC

W.P. WO 2011-11001 LOCATION Walden Patrol Yard, North Sand Dome ORIGINATED BY CS
DIST 54, Sudbury HWY 17 - RR 55 BOREHOLE TYPE CME Hollow Steam Auger/Diamond COMPILED BY AG
DATUM Geodetic DATE 2011 02 07 - 2011 02 09 CHECKED BY SM

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | |
|---------------|---|------------|--------------|------|------------|----------------------------|-----------------|---|--------------|------------------------------------|-------------------------------------|-----------------------------------|--|--|-------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | WATER CONTENT (%) |
| | | | | | | | | ○ UNCONFINED | + FIELD VANE | | | | | | |
| | | | | | | | | ● QUICK TRIAXIAL | × LAB VANE | | | | | | |
| 261.0 | Ground Surface | | | | | | | | | | | | | | |
| 260.0 | ASPHALT | | 1 | AS1 | | | | | | | | | | | |
| | SAND and GRAVEL FILL (SW), some clay, trace silt, brown, damp, loose to compact (frozen to 0.9 m) | | 2 | SS | 13 | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | - wet, loose | 3 | SS | 6 | | | | | | | | | 24 42 (34) |
| 258.1 | SILT (ML), some clay, trace sand, grey, wet, loose | | 4 | SS | 9 | | | | | | | | | 0 2 86 12 | |
| 2.9 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 256.5 | SILTY CLAY (CL), trace sand, grey, wet, firm | | 5 | SS | 6 | | | | | | | | | | |
| | | | 6 | TW | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 7 | SS | WH | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 8 | SS | WH | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 9 | SS | WH | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 10 | SS | WH | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 11 | SS | WH | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | - wash bored from 15.2 m | | 12 | SS | WH | | | | | | | | | | |
| 244.9 | SILT (ML), trace sand, trace clay, grey, wet, compact | | | | | | | | | | | | | | |
| 16.2 | | | 13 | SS | 14 | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 14 | SS | 15 | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 15 | SS | 15 | | | | | | | | | | 0 2 97 2 |
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ONTARIO_MTO_APPENDIX C - BOREHOLE LOGS - FINAL VERSION - MAY 8, 2011.GPJ_ONTARIO.MOT.GDT_05/10/11

Continued Next Page

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

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

RECORD OF BOREHOLE No BH-5

1 OF 1

METRIC

W.P. WO 2011-11001 LOCATION Walden Patrol Yard, North Sand Dome ORIGINATED BY CS
DIST 54, Sudbury HWY 17 - RR 55 BOREHOLE TYPE CME Hollow Steam Auger/Diamond COMPILED BY AG
DATUM Geodetic DATE 2011 02 09 - 2011 02 09 CHECKED BY SM

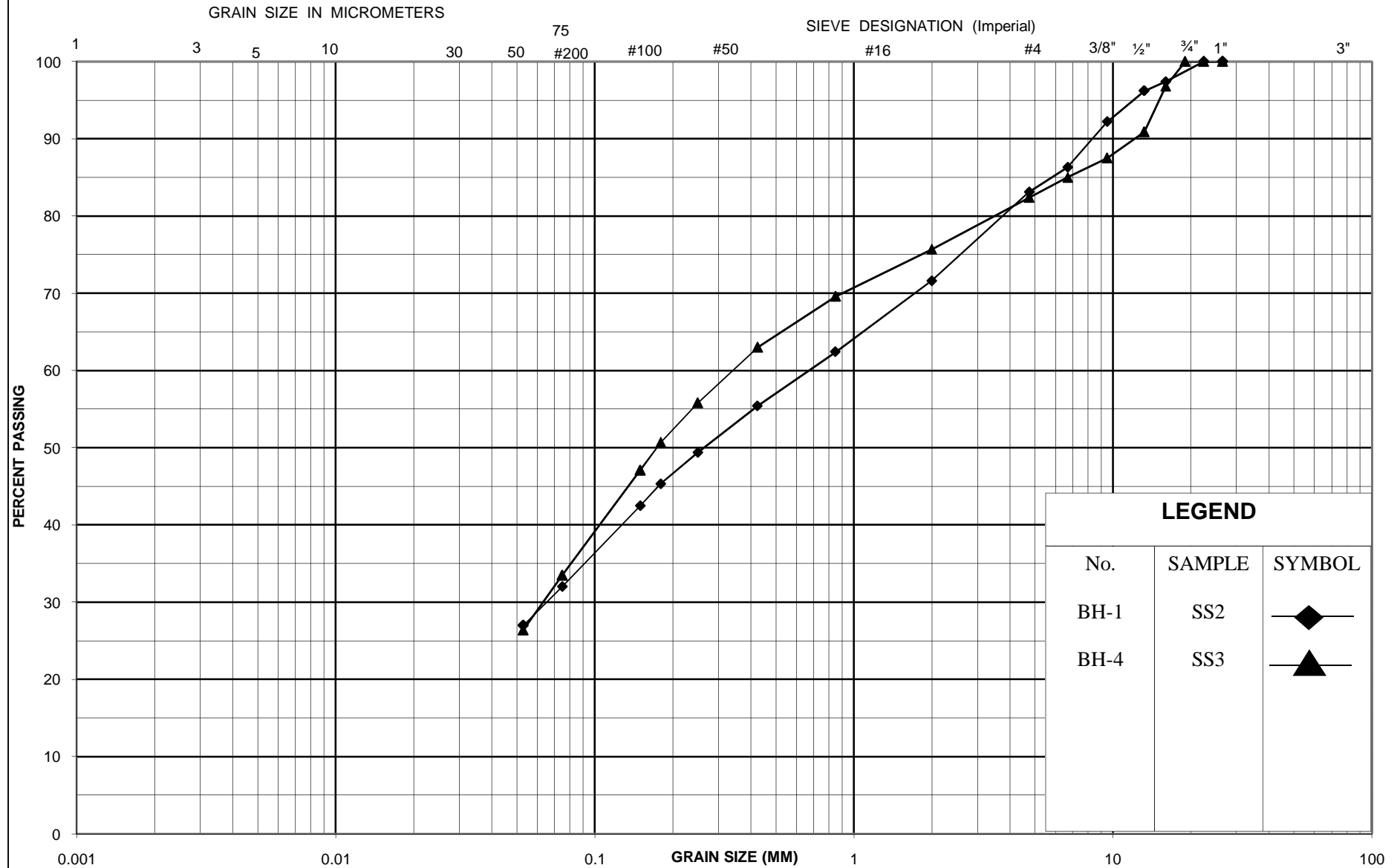
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|----------------------------|------------------------------------|-------------------------------------|-----------------------------------|--|--|-------------------|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | WATER CONTENT (%) | |
| | | | | | | | | ○ UNCONFINED ● QUICK TRIAXIAL | + FIELD VANE × LAB VANE | | | | | | | |
| 261.0 | Ground Surface | | | | | | | 20 40 60 80 100 | | | | | | | | |
| 260.0 | ASPHALT | | 1 | AS | | | | | | | | | | | | |
| | SAND FILL (SW), some fine gravel, trace silt, brown, damp, loose to compact (frozen to 1.2 m) | | 2 | SS | 18 | | | | | | | | | | | |
| | - wet at 1.8 m | | 3 | SS | 9 | | | | | | | | | | | |
| | - 0.1 m peat, black, wet | | | | | | | | | | | | | | | |
| 257.9 | | | | | | | | | | | | | | | | |
| 3.1 | SILT (ML), trace clay, trace sand, grey, wet, loose | | 4 | SS | 6 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 256.5 | | | | | | | | | | | | | | | | |
| 4.5 | SILTY CLAY (CL), trace sand, grey, wet, soft | | 5 | SS | 6 | | | | | | | | | | | |
| | - becomes varved, firm | | | | | | | | | | | | | | | |
| | | | 6 | SS | WH | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 7 | SS | WH | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 8 | SS | WH | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 9 | TW | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 10 | SS | WH | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 11 | SS | WH | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 12 | TW | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 244.8 | | | | | | | | | | | | | | | | |
| 16.2 | SILT (ML), trace clay, grey, wet, compact | | 13 | SS | 19 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 14 | SS | 10 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 241.2 | | | 15 | SS | 17 | | | | | | | | | | | |
| 19.8 | END OF BOREHOLE | | | | | | | | | | | | | | | |
| | NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by Trow is required before use by others. 3. "WH" means "Weight of Hammer" | | | | | | | | | | | | | | | |

ONTARIO_MTO_APPENDIX C - BOREHOLE LOGS - FINAL VERSION - MAY 8, 2011.GPJ_ONTARIO MOT.GDT_05/10/11

APPENDIX D: LABORATORY DATA

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |

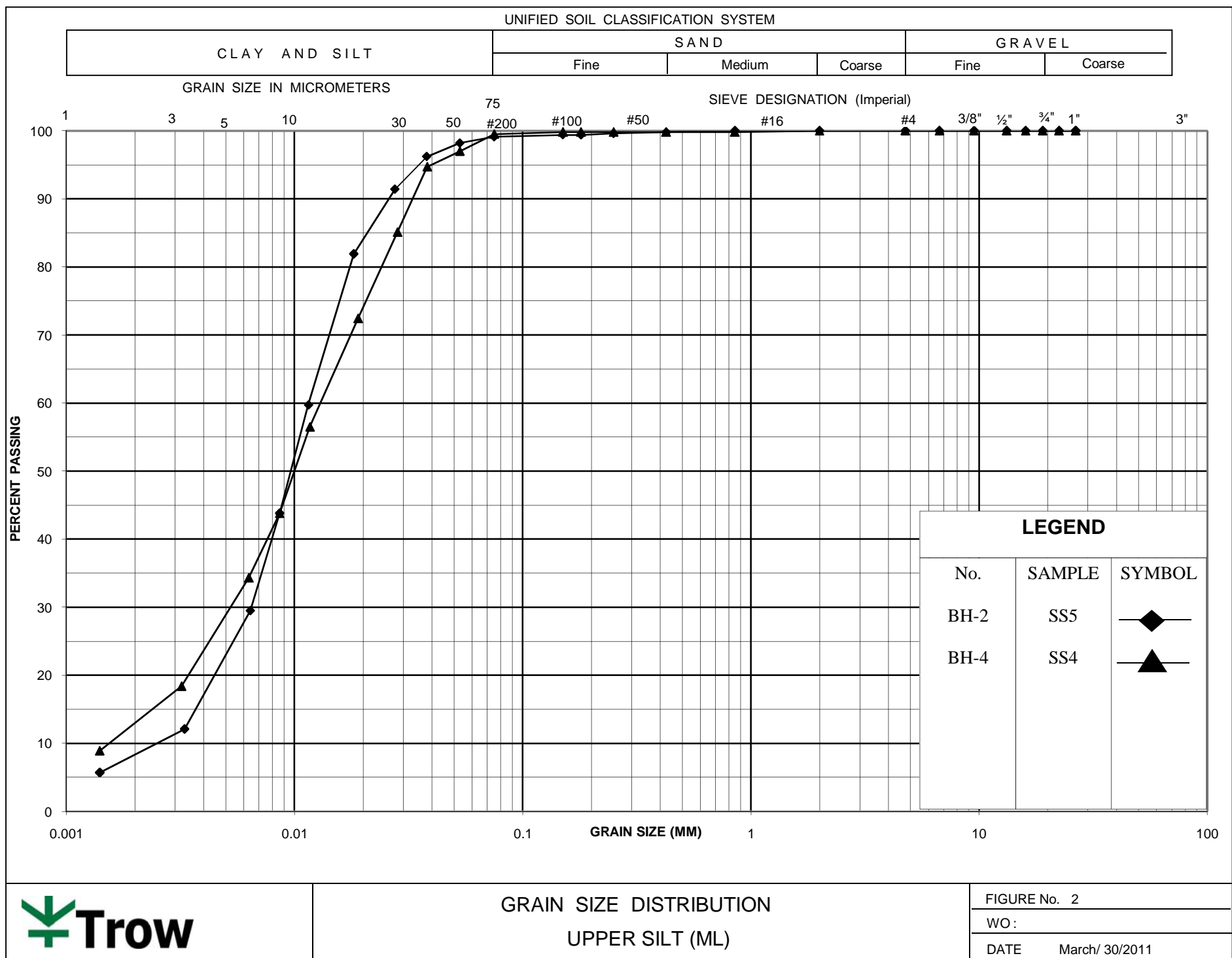


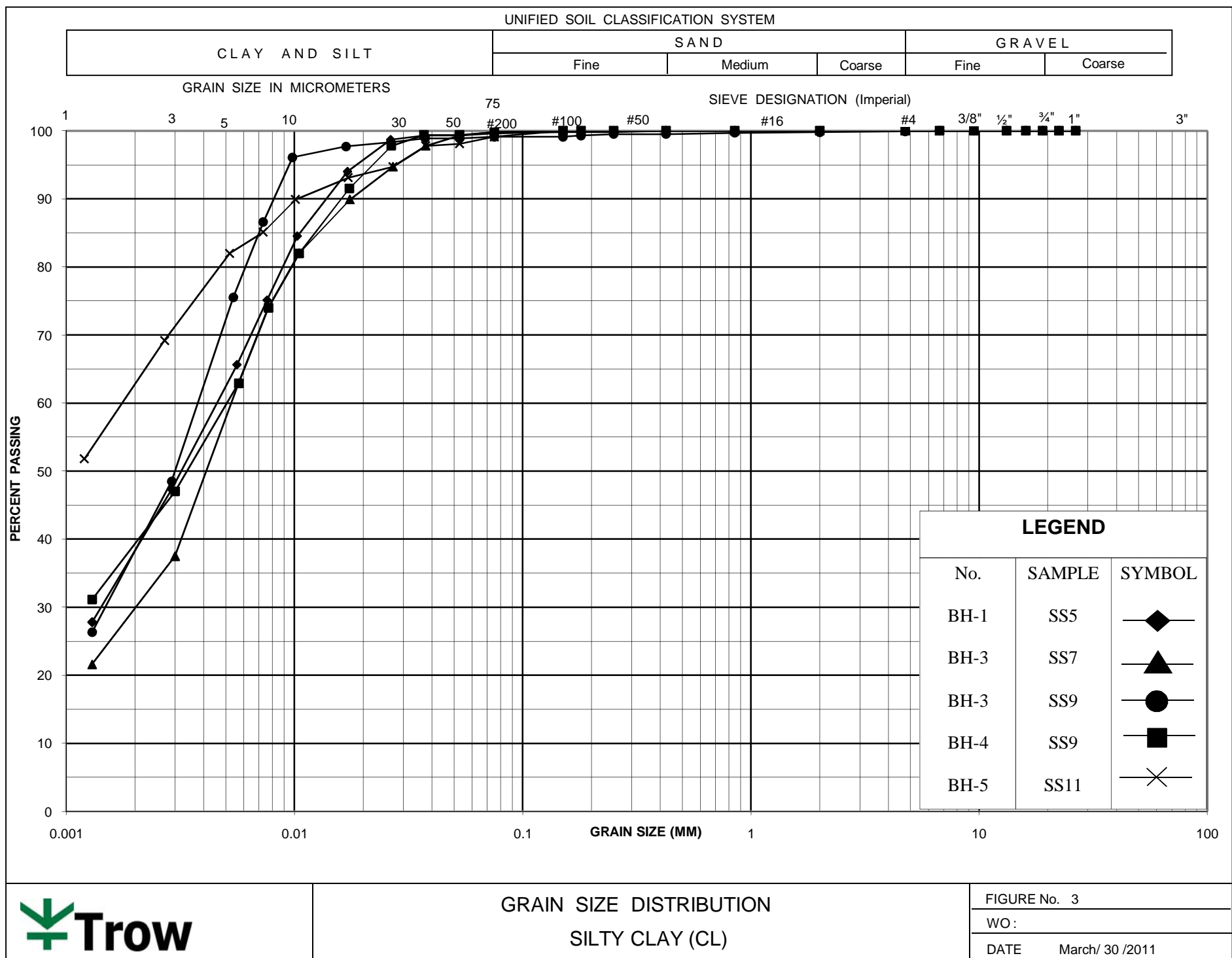
GRAIN SIZE DISTRIBUTION
SAND AND GRAVEL (SW)

FIGURE No. 1

WO:

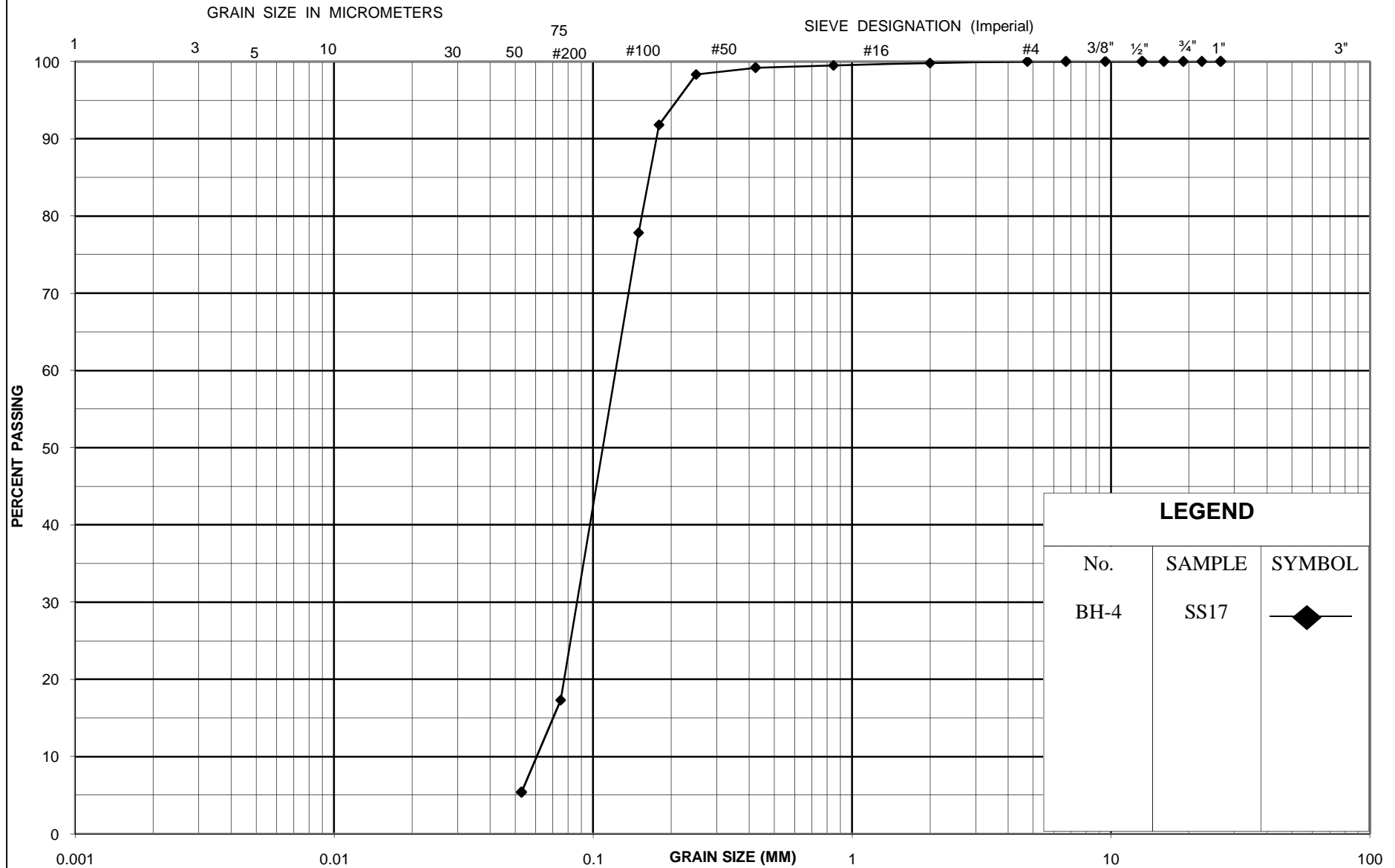
DATE March/30 /2011





UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |



GRAIN SIZE DISTRIBUTION
SAND (SM)

FIGURE No. 5

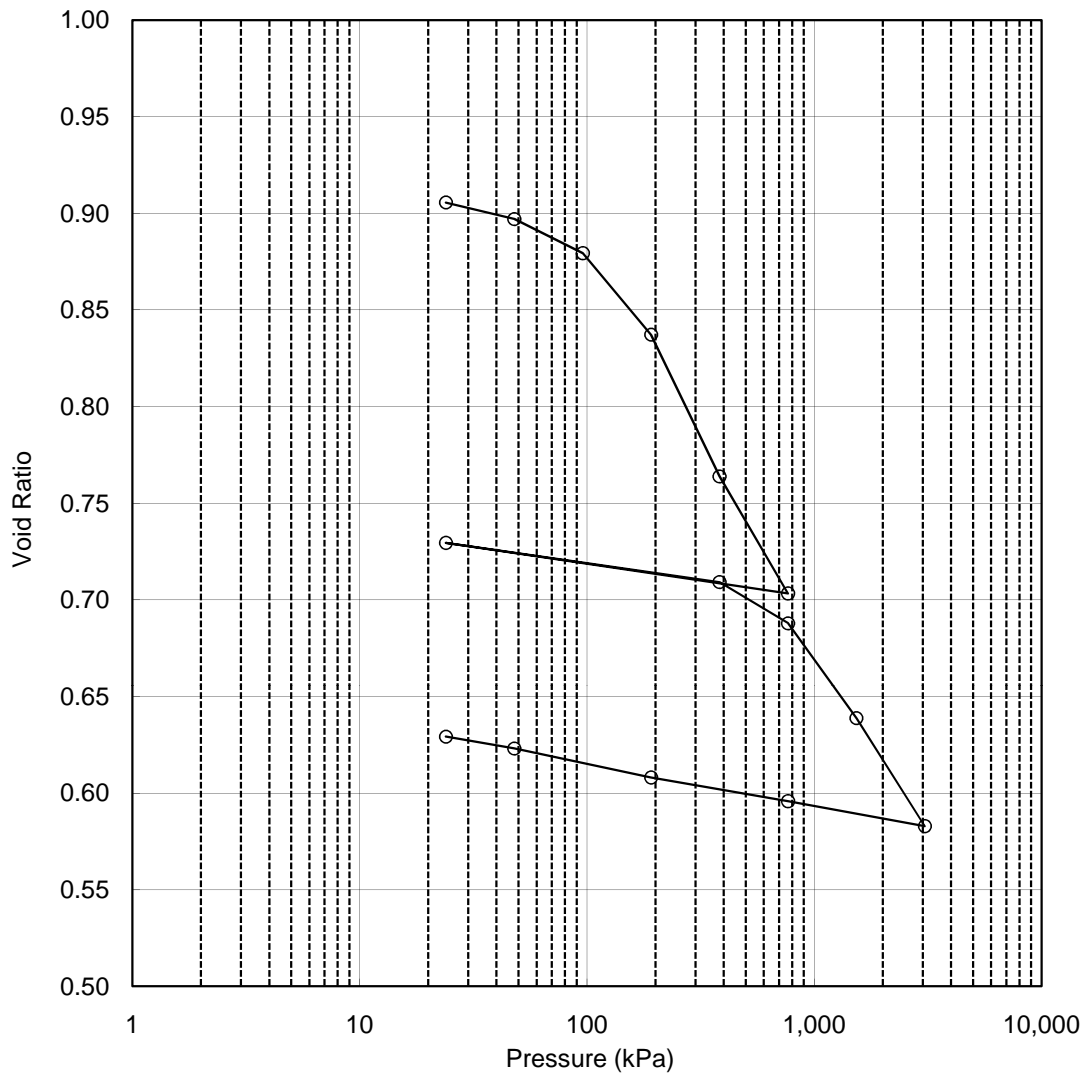
WO:

DATE March/ 30/ 2011

BH-5 TW9, 10.9m depth

FIGURE 6

CONSOLIDATION TEST
e vs Pressure



$e_o = 0.92$

$\omega = 37\%$

Ground Elev.= 261.0 m

GWL Elev. = 257.4 m

GWL Depth= 3.6 m

Sample Depth= 10.9 m

$Pv' = 118 \text{ kPa}$

$Pc' = 190 \text{ kPa}$

$Cc = 0.22$

$Cr = 0.024$

$OCR = 1.6$

Project No. : ADM-00011530-A0-200SD

Date : March/30 /2011



Prepared By : TS

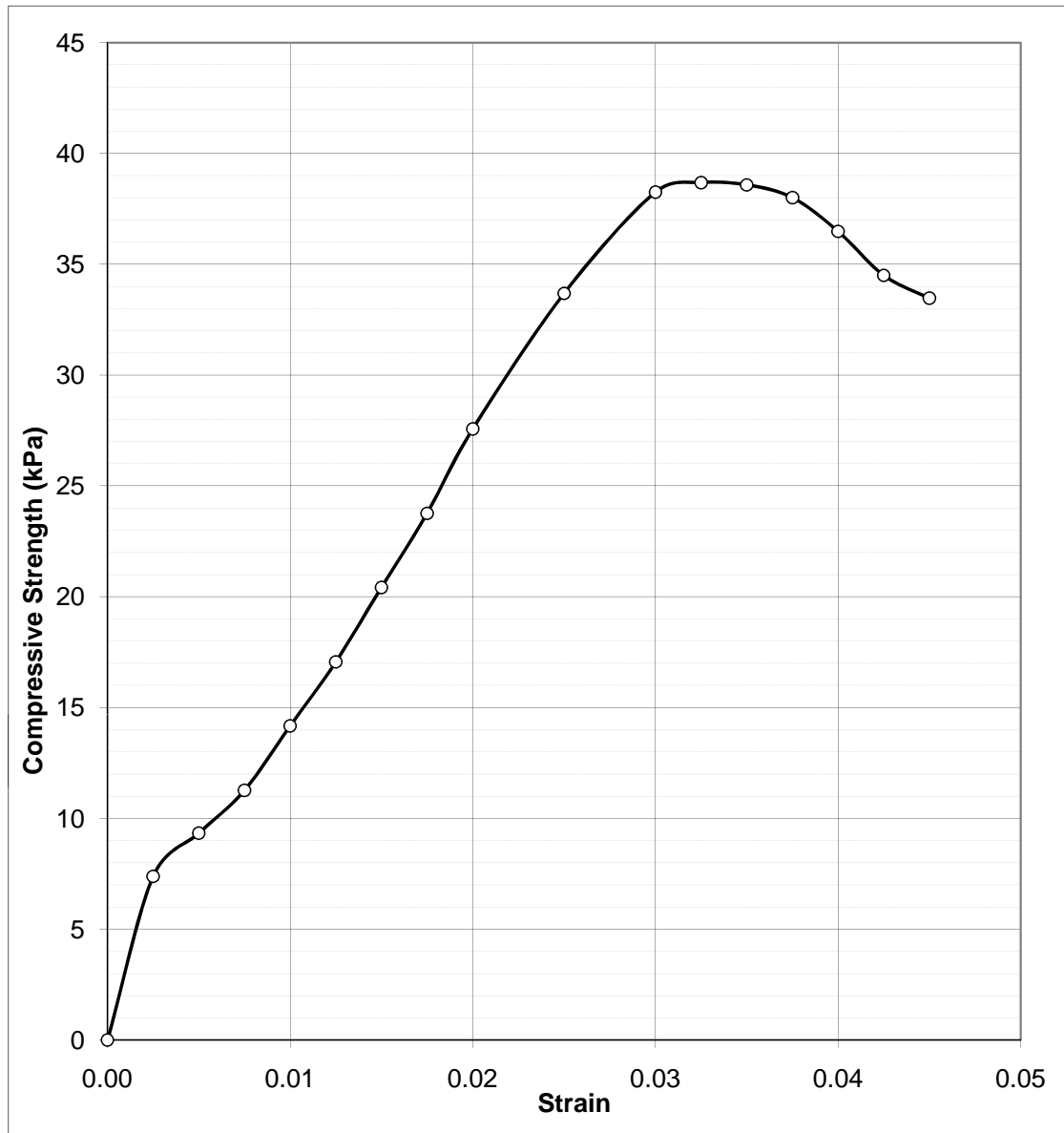
Checked By : SM

C:\Documents and Settings\T S Ahn\Desktop\EXP\Vermer and Walden Patrol Yard - A Geremew\Walden Patrol Yard\Excel files\Walden Patrol Yard-BH5 10.9 m Consolidation_Trow.xls

BH-5 TW9, 10.7-11.1m depth

FIGURE 7

Unconfined Compressive Test
Compressive Strength vs. Strain



$\omega = 37\%$

Ground Elev.= 261.0 m

GWL Elev. = 257.4 m

GWL Depth= 3.6 m

Sample Depth= 10.7-11.1 m

Project No. : ADM-00011530-A0-200SD

Date : March/ 30 /2011

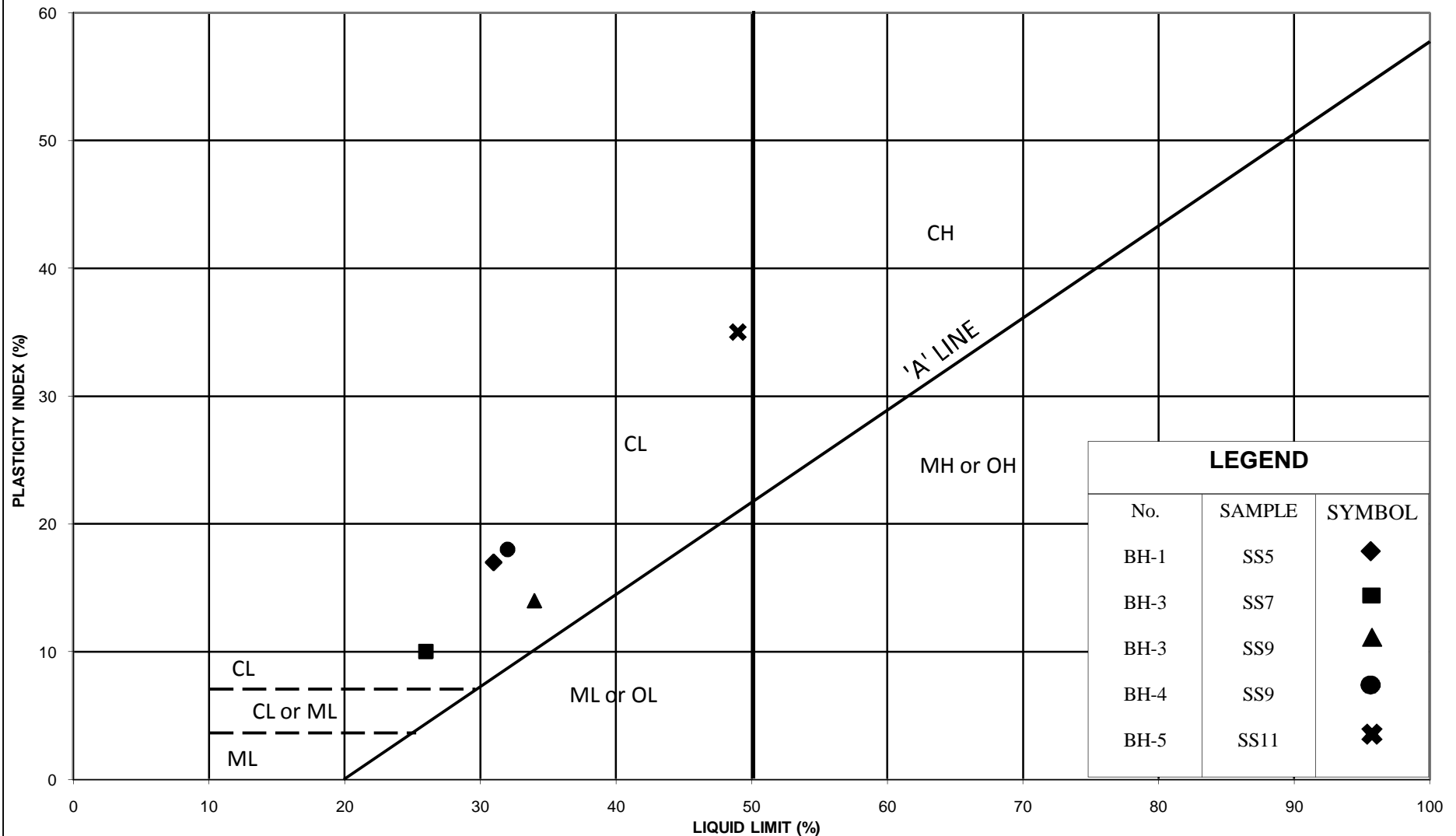


Prepared By : TS

Checked By : SM

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WALDEN PATROL YARD



PLASTICITY CHART: UNIFIED SYSTEM
SILTY CLAY (CL)

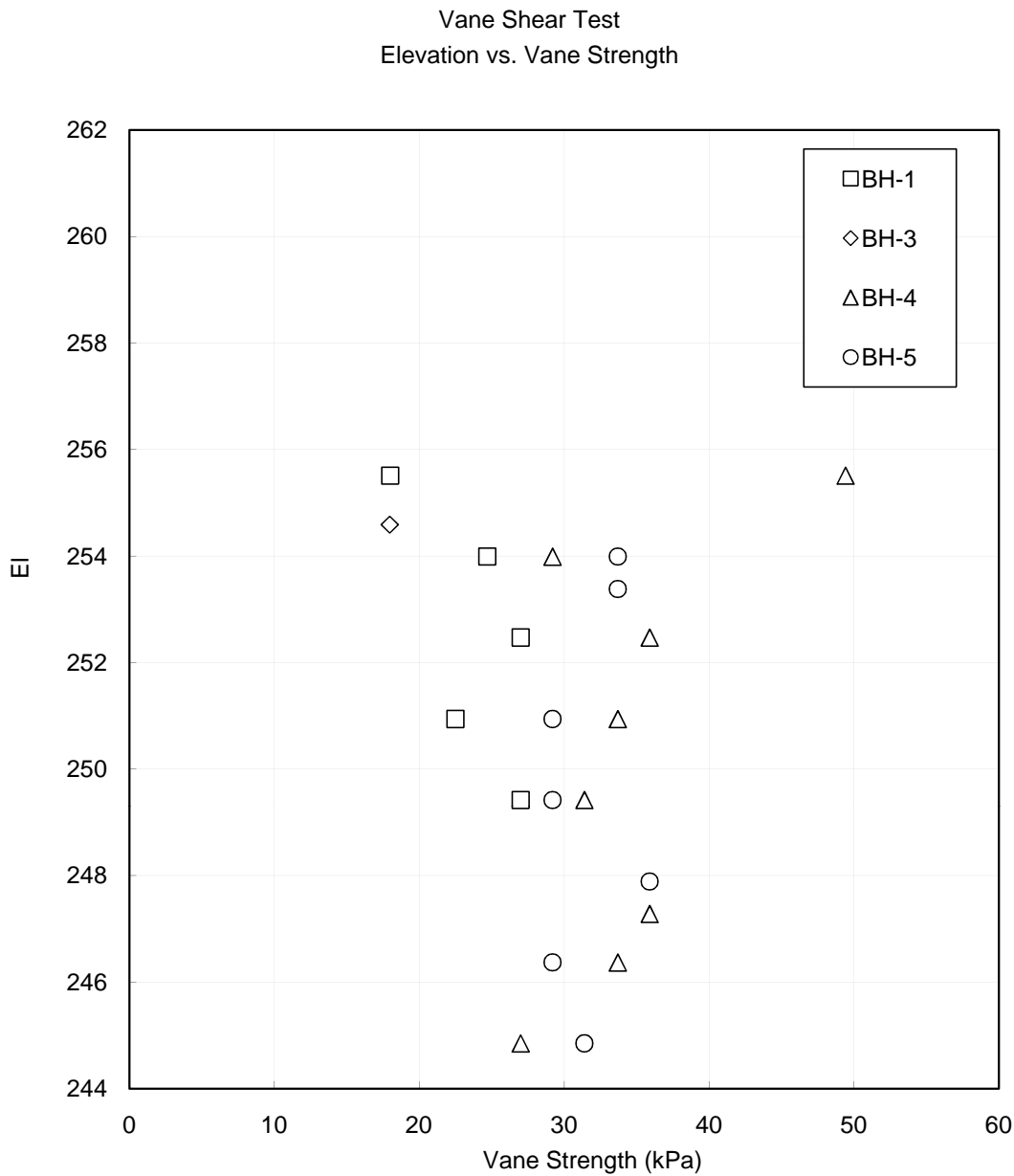
FIGURE No. 8

WO:

DATE March/ 30/2011

Strength Profile (Silty Clay)

FIGURE 9



Ground Elev.= 261 - 261.5 m

GWL Elev. = 257.8 (BH 3) and 257.4 (BH 5) m

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Date : March/ 30/ 2011



Prepared By : TS

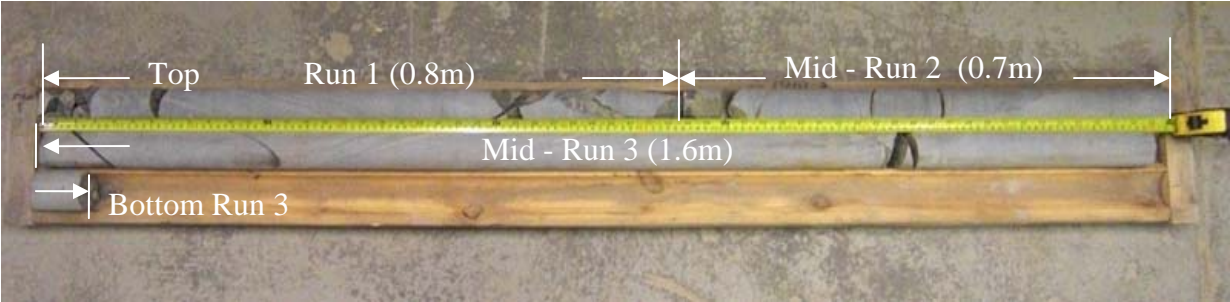
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APPENDIX E: ROCK CORE PHOTOGRAPHS

PHOTOGRAPH 1 BH-2

(a) Overall

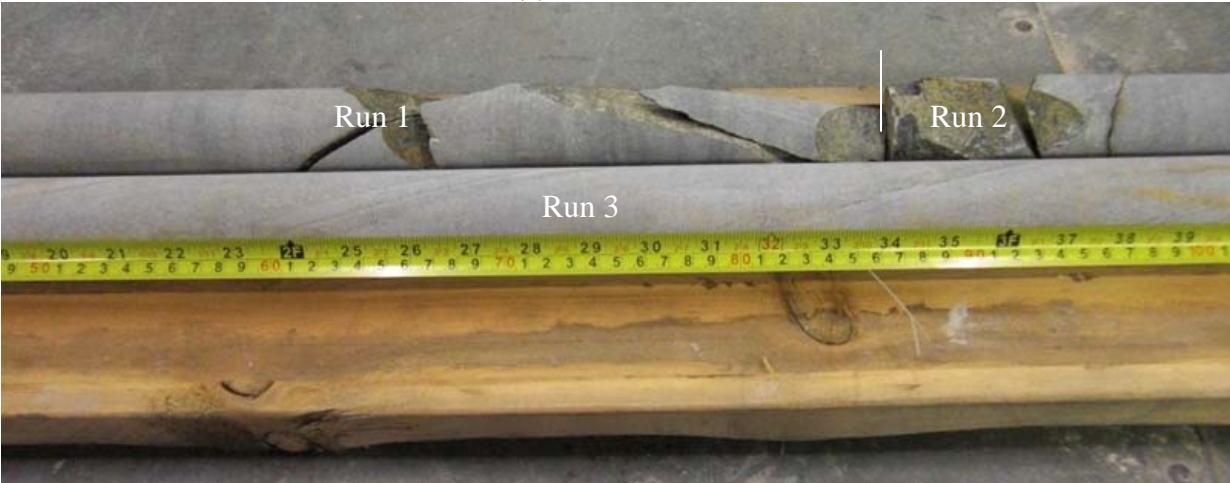


(b) Top



PHOTOGRAPH 1 BH-2

(c) Middle -1



(d) Middle -2



PHOTOGRAPH 1

BH-2

(e) Middle -3



(f) Bottom



PHOTOGRAPH 2 BH-4

(a) Overall



(b) Top



PHOTOGRAPH 2

BH-4

(c) Middle - 1



(d) Middle - 2



PHOTOGRAPH 2

BH-4

(e) Bottom

