FINAL REPORT

FOUNDATION INVESTIGATION REPORT

Non-Structural Culvert Replacement, Highway 634, Township of Kendrey, District of Cochrane, Ontario

Agreement No. 5015-E-0007
Assignment No. 4
WO. 2016-11040
Geocres No. 42H-68

Prepared for:

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exp Services Inc.
February 21, 2017

Ontario Ministry of Transportation
Northeastern Region Geotechnical Section

Foundation Investigation Report
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Type of Document:
FINAL

Project Name:
Non-Structural Culvert Replacement, Highway 634
4km North of Highway 11 Junction, Township of Kendrey, Ontario

Project Number:
ADM-00233185-D0

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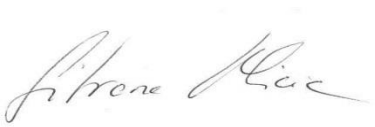

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February 21, 2017

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1 FOUNDATION INVESTIGATION REPORT

1.1 Introduction

This report presents the results of a geotechnical investigation completed by **exp** Services Inc. for the replacement of a Non-Structural Culvert on Highway 634, approximately 4.0 km north of the Highway 11 junction, in Kendrey Township, District of Cochrane. The work was undertaken under Agreement No. 5015-E-0007, Assignment No. 4. The terms of reference (TOR) were as presented in MTO letter dated October 3, 2016.

The purpose of the investigation is to determine the existing soil conditions in the vicinity of the existing culvert system to develop design for the replacement of the culvert, including construction recommendations. The site specific geotechnical investigation consisted of a field investigation including visual inspections, drilling, soil sampling, and laboratory testing.

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 completed for this project.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The Non-Structural Culvert is located along Hwy 634, at the approximate Station of 13+963 (based on a topographic survey provided by the MTO). Hwy 634 is a two lane, north/south roadway with approximately 1 m wide granular shoulders and a wooden guardrail system at the culvert location. The highway crosses above the Non-Structural Culvert with approximately 6.6 m of embankment fill above the culvert crown, and approximately 1.5H:1V west sideslope and 1.7H:1V east sideslope. The existing Non-Structural Culvert consists of a 1.8 m diameter CSP having a total length of approximately 35.5 m (based on the drawing provided by the MTO). Photographs of the site are included in Appendix A of this report. The culvert location and cross sectional profile are as shown on Drawing 1 in Appendix B.

During the site reconnaissance on November 8, 2016, the general site conditions were assessed. The existing creek flows from east to west. Vegetation at the site consists of large deciduous and coniferous trees and wild bushes. The inlet and outlet of the culvert are generally surrounded by low lying grasses, small shrubs and trees. The photos of inlet and outlet are included in Appendix A.

In general, the slopes of highway embankment are covered with grass and light vegetation, with trees and larger vegetation towards the embankment toes. Bedrock outcrops were not observed at the site. The riding surface of Hwy 634 comprises of asphalt surface treatment. The surface of Hwy 634 near the culvert location was in fair shape with a number of localized cracks on the asphalt. Based on the MTO provided information, at the culvert location, a sinkhole developed in late September 2016 on the west side of the roadway and it was repaired by excavating undermined pavement layers and backfilling the void with granular material.

All relevant photographs can be found in Appendix A.

1.2.2 Geological Setting

According the Ministry of Northern Development and Mines, Maps 2555 (Quaternary Geology of Ontario, East-Central Sheet, 1991) and 2543 (Bedrock Geology of Ontario, East-Central Sheet, 1991), the site is located on a till deposit underlain by Metasedimentary bedrock. The till deposit consists of undifferentiated, predominantly fine grained silty clay to silt. The Metasedimentary Rock Group comprises of wacke, siltstone, arkose, argillite, slate, mudstone, marble, chert, iron formation, minor metavolcanic rocks, conglomerate, arenite paragneiss, and migmatites.

1.3 Investigation Procedures

1.3.1 Site Investigation and Field Testing

The field investigation was performed November 8, 9 and 15, 2016. The field program consisted of drilling six (6) sampled boreholes. Boreholes NSC2, NSC3, NSC5, and NSC6 were completed with a track mounted CME-55 drill. Boreholes NSC1 and NSC4, however, could not be accessed with the drill. As such, portable tripod mounted drilling equipment was utilized for these boreholes. These boreholes were located as close as possible to the locations outlined in the TOR, with the locations shown on Drawing 1, included in Appendix B. The location details of all six boreholes are summarized on Table 1.1 as follows:

Table 1.1. The summary of borehole investigation information

Borehole No.	Coordination (MTM Zone 12)	Local Ground Surface Elevation (m)	Depth (m)
BH-NSC1	5461909.5N, 259501.0E	227.3	6.3
BH-NSC2	5461901.9N, 259513.9E	235.3	18.9
BH-NSC3	5461905.7N, 259518.0E	235.2	18.9
BH-NSC4	5461893.1N, 259529.9E	228.5	5.2
BH-NSC5	5461882.9N, 259517.9E	236.0	3.7
BH-NSC6	5461924.7N, 259514.2E	235.5	3.7

All drilling equipment utilized is owned and operated by Landcore Drilling out of Sudbury, Ontario.

The drilled boreholes were advanced to depths of approximately 3.8 to 18.9 m below ground surface. Drawings in Appendix B show the locations of all six boreholes and cross-sections of stratigraphy along the existing culvert alignment and the embankment.

The borehole locations (referenced to the MTM NAD83 coordinate system, Zone 12) and their ground surface elevations were surveyed by **exp** personnel following drilling using hand-held GPS equipment. The local, non-geodetic borehole elevations and water elevations were surveyed using a Temporary Benchmark (TBM) established on the west side shoulder at center line of culvert. The elevation of TBM (235.00 m) was assumed based on the CAD drawing provided by MTO. The locations of the boreholes and TBM are shown on the Drawing 1 in Appendix B.

During the drilling of the boreholes, soil samples were obtained directly from the augers or using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals ranging from 0.75 m to 1.5 m in depth as shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (Section 4.5.2) and used to provide an assessment of in-situ consistency or compactness condition of the soils. Since the conventional hammer of 63.5 kg was used for sampling done by a portable tripod, the corresponding blow counts were not factored.

Coring procedures were utilized to penetrate in-situ boulders. Coring was completed using NQ sized core barrels and NW casing.

Following completion of boreholes, groundwater level measurements were carried out from the boreholes. The drilled boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the *Ontario Water Resources Act*).

The fieldwork was supervised by members of **exp**'s engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System for Foundation Investigation Report, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags, and returned to **exp**'s Sudbury laboratory for additional visual, textual and olfactory examination. .

1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content on all samples and particle size distribution for approximately 25% of the collected soil samples. Atterberg limits test were carried out for cohesive soils. All of the laboratory tests were carried out according to MTO and/or ASTM Standards as appropriate. Standard Proctor Dry Density tests on selected bulk soil samples were also performed to determine the optimum moisture content of the soil.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses and plasticity chart are presented graphically in Appendix D.

1.3.3 Previous Investigation

No foundation reports are available in the MTO GEOCRES library for this site.

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. Laboratory test results are provided in Appendix D and Appendix E. The "Explanation of Terms Used in Report" preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and cross section subsurface profiles are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and cross section stratigraphic profiles are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

In general, the boreholes encountered asphalt surface treatment/asphalt and topsoil overlying cohesive and cohesionless fill materials, and native cohesionless soils and cobbles and boulders. Bedrock was not encountered at the locations of drilling. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

1.4.1 Asphalt Surface Treatment/Asphalt

Asphalt surface treatment layer was encountered at the surface of boreholes NSC2, NSC3, NSC5, and NSC6. The surficial asphalt ranged in thickness from approximately 25 to 76 mm. Underlying the surficial asphalt was a 76 to 177 mm thick layer of sand and gravel fill, followed by a second layer of asphalt. This lower layer of asphalt was approximately 100 mm thick at each borehole location. Asphalt thicknesses may further vary beyond the borehole locations.

1.4.2 Topsoil

A layer of topsoil was encountered at the surface of boreholes NSC1 and NSC4 and was approximately 100 mm and 150 mm thick, respectively. Topsoil thicknesses may further vary beyond the borehole locations.

1.4.3 Fill Materials

1.4.3.1 Cohesionless Fill Materials

At boreholes NSC2, NSC3, NSC5, and NSC6, cohesionless, granular fill materials were encountered between asphalt surface treatment and asphalt layer, and underlying the asphalt. The cohesionless fill materials extended to depths ranging between 2.3 m to 6.1 m below ground surface with elevations ranging between 229.2 m to 233.7 m. The explored thickness of this layer was between 2.0 m to 5.9 m.

The composition of this cohesionless fill materials generally consisted of sand with trace to some gravel, trace to some silt, and trace clay. The fill materials were generally brown in color, and moist. The SPT "N" values within this fill material ranged from 5 to 33 blows per 300 mm, suggesting loose to dense in compactness condition.

Laboratory testing performed on selected samples consisted of twenty (20) moisture content tests, four (4) grain size analyses, and one (1) particle size analysis. The test results are as follows:

Moisture Content:

- 2.7% to 19.0%

Grain Size Distribution:

- 0 to 10% gravel
- 77 to 89% sand
- 10 to 15% fines

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 1 in Appendix D.

1.4.3.2 Cohesive Fill Materials

Cohesive fill materials consisting of clayey silt were encountered below the cohesionless fill materials at boreholes NSC3, NSC5, and NSC6. The cohesive fill materials extended to depths ranging between 3.7 m to 7.6 m below ground surface with elevations ranging between 227.6 m to 232.3 m. The explored thickness of this layer was between 1.4 m to 3.0 m. Boreholes NSC5 and NSC6 were terminated within this layer.

The composition of this cohesive fill layer is clayey silt, some sand, and some organics. The material is brown to grey in color, and moist. The SPT "N" values within this layer ranged from 5 to 12 blows per 300 mm, suggesting firm to stiff in consistency.

Laboratory testing performed on selected samples consisted of six (6) moisture content tests, three (3) particle size analysis, and two (2) Atterberg Limits tests. A third Atterberg Limits test was attempted, however, insufficient sample quantity was available. The test results are as follows:

Moisture Content:

- 7.2% to 20.1%

Grain Size Distribution:

- 1 to 4% gravel
- 10 to 14% sand
- 47% to 51% silt; and

- 35 to 42% clay

Atterberg Limits:

- Liquid Limit: 33.9% to 35.0%
- Plastic Limit: 16.3% to 17.0%
- Plasticity Index: 17.0% to 18.7%

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the particle size analyses are also provided on Figure 2 in Appendix D, and the Atterberg Limits tests on Figure 6 in Appendix D.

1.4.4 Organic Silty Sand

Organic silty sand was encountered underlying the topsoil in boreholes NSC1 (outlet) and NSC4 (inlet). The organic silty sand layer extended to depth of about 0.8 m below ground surface with elevations ranging between 226.5 m to 227.7 m. The explored thickness of this layer was between 0.6 m to 0.7 m.

The composition of this organic silty sand layer is silt and sand, and some rootlets. The material is dark brown in color and wet. The SPT “N” values within this layer ranged from 2 to 6 blows per 300 mm, suggesting very loose to loose in compactness condition.

Laboratory testing performed on selected samples consisted of two (2) moisture content tests. The test results are as follows:

Moisture Content:

- 22.4% to 45.7%

The results of the moisture content tests are provided on the record of borehole sheets in Appendix C.

1.4.5 Clayey Silty Sand

Native clayey silty sand was encountered below the organic silty sand in borehole NSC4 (inlet). The clayey silty sand layer was extended to depth of about 1.5 m below ground surface with elevation about 227.0 m. The explored thickness of this layer was about 0.7 m.

The composition of this layer is silt and sand with some clay and trace gravel. The material is brown in color, and compact. One SPT “N” value obtained within this layer was 11 blows per 300 mm, suggesting compact in compactness condition.

Laboratory testing performed on a selected sample consisted of one (1) moisture content test, and one (1) particle size analysis. An Atterberg Limits test was attempted, but insufficient sample quantity was available. The test results are as follows:

Moisture Content:

- 18.6%

Grain Size Distribution:

- 2% gravel
- 41% sand
- 32% silt; and
- 25% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the particle size analyses is also provided on Figure 3 in Appendix D.

1.4.6 Silty Sand and Gravel

Native silty sand and gravel was encountered below the fill layer in boreholes NSC2 and NSC3 and below the clayey silty sand layer in borehole NSC4 (inlet). The silty sand and gravel layer extended to depths ranging between 5.2 m to 13.7 m below ground surface with elevations ranging between 221.6 m to 226.1 m. The explored thickness of this layer was between 1.5 m to 7.6 m. Borehole NSC4 was terminated within this layer.

The composition of this silty sand and gravel is silt, sand and gravel, and trace clay. The material is brown to grey in color and moist to wet. The SPT “N” values within this layer ranged from 22 to 100 blows per 300 mm, suggesting compact to very dense, but generally dense in compactness condition.

Laboratory testing performed on a selected sample consisted of ten(10) moisture content test, and two (2) particle size analysis. The test results are as follows:

Moisture Content:

- 1.8% to 15.8%

Grain Size Distribution:

- 20% to 54% gravel
- 38% to 15% sand
- 29% to 36silt; and
- 2% to 6% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the particle size analyses is also provided on Figure 4 in Appendix D.

1.4.7 Sand and Silt

Native sand and silt was encountered below the organic silty sand layer in borehole NSC1 (outlet) and below silty sand and gravel in borehole NSC3. The sand and silt layer extended to depth ranging between 6.3 m to 16.2 m below ground surface with elevations ranging between 219.0 m to 221.0 m. The explored thickness of this layer was between 5.5 m to 7.1 m. Borehole NSC1 was terminated within this layer.

The composition of this sand and silt layer is sand, silt, trace to some gravel, trace clay, and occasional cobbles. The material is grey in color, and moist to wet. The SPT "N" values within this layer ranged from 13 to 100 blows per 300 mm, suggesting compact to very dense in compactness condition.

Laboratory testing performed on a selected samples consisted of eleven (11) moisture content tests and two (2) particle size analyses. The test results are as follows:

Moisture Content:

- 7.5% to 13.8%

Grain Size Distribution:

- 5% to 17% gravel
- 42% to 45% sand
- 38% to 43% silt, and
- 3% to 7% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the particle size analyses are also provided on Figures 5 in Appendix D.

1.4.8 Cobbles and Boulders

A layer of cobbles and boulders was encountered below silty sand and gravel in borehole NSC2 and below sand and silt in borehole NSC3. The cobbles and boulders layer extended to depth ranging about 18.9 m below ground surface at these locations with elevations ranging between 216.3 m to 216.4 m. The explored thickness of this layer was between 2.7 m to 5.2 m. At boreholes NSC1 (outlet) and NSC4 (inlet), the cobbles and boulders layer suspected to be encountered at SPT refusal depths of about 6.3 m and 5.2 m below ground surface at those locations with elevations about 221.0 m and 223.3 m, respectively. Boreholes NSC2 and NSC3 were terminated within this layer.

The composition of this layer is mainly cobbles and boulders with some gravel, some sand and silt. The combination of split spoon sampler and NQ coring were attempted to retrieve the sample within this layer. The SPT "N" values obtained within this layer were above 100 blows per 300 mm penetration. NQ coring attempted within this layer generally have no recovery, one sample with 0.3 m of boulder was recovered in borehole NSC2.

Laboratory testing performed on a selected recovered split spoon samples consisted of four (4) moisture content tests. The test results are as follows:

Moisture Content:

- 0.4% to 16.3%

The results of the moisture content tests are provided on the record of borehole sheets in Appendix C.

1.5 Groundwater Conditions

Since the wash boring method was used for drilling with the rig (NSC2 and NSC3) and portable tripod equipment (NSC1 and NSC4), accurate groundwater levels at the boreholes could not be measured in the open holes at the time of drilling operation. In boreholes NSC5 and NSC6 no groundwater was observed within the boreholes upon completion, the boreholes appeared dry and open.

The water level in the creek was measured at the time of investigation (November 2016) and it was approximately at Elevation 227.8 m and Elevation 226.5 m at inlet and outlet side of the existing culvert, respectively. Groundwater levels would be expected to reflect levels in the adjacent open water and to fluctuate seasonally. Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods.

1.6 Proctor Test

Two proctor tests were performed on selected bulk soil samples collected from the boreholes NSC3 and NSC6 at this site. The results are results are presented in Appendix E, and are summarized in Table 1.2, below.

Table 1.2. Proctor test result

Borehole/ Sample Identification	Soil Description	Sample Depth (m)	Moisture Content	Optimum Water Content	Maximum Dry Density (kg/m^3)
NSC3- AG1	Gravelly Sand Fill	0.0 – 0.76	3.2%	5.2%	2167
NSC6-AG1	Sand Fill	0.0 – 0.61	2.7%	7.3%	2126
	Clayey Silt Fill[1]		7.2% to 20.1%	15%-16%[1]	
	Silt and Sand/Silty Sand[1]		8.2% to 13.8%	10%-12%[1]	
	Silty Sand with Gravel[1]		2.6% to 15.8%	8%-10%[1]	

Note:

1. *A proctor test not performed on the soil type, however based on some available background data on similar soil samples, the optimum water content range is presented.*

2 CLOSURE

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Ian MacMillan, P.Eng., Nimesh Tamrakar, M.Eng, EIT., and Silvana Micic, Ph.D., P.Eng. It was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Shane Tobias.

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3 LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of exp may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by exp. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and exp's recommendations. Any reduction in the level of services recommended will result in exp providing qualified opinions regarding the adequacy of the work. exp can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to exp to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to exp by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. exp has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or

inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to exp.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to exp by its client ("Client"), communications between exp and the Client, other reports, proposals or documents prepared by exp for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. exp is not responsible for use by any party of portions of the Report.

USE OF 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 in whole or in part without the written consent of exp. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. exp is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

REPORT FORMAT

Where exp has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by exp have utilize specific software and hardware systems. exp makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are exp's instruments of professional service and shall not be altered without the written consent of exp.

Appendix A –
Site Photographs

Photo 1. Inlet side of Non-Structural Culvert (facing east) on November 8, 2016

Photo 2. Outlet side of Non-Structural Culvert (facing north-west) on November 8, 2016

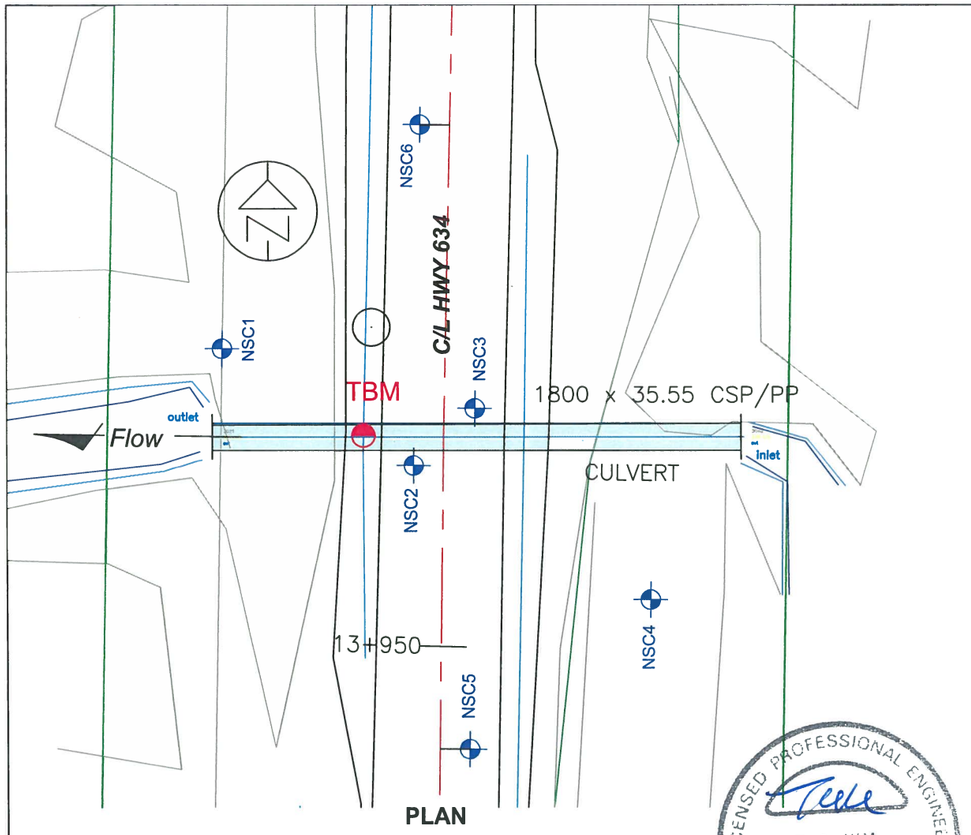
Photo 3. West Embankment (facing north) on November 8, 2016

Photo 4. East Embankment (facing north) on November 8, 2016

Photo 5. Temporarily Repaired Sinkhole on Western Side of Roadway (facing west) on November 8, 2016

Photo 6. Non-structural culvert November 8, 2016

Appendix B – Drawings



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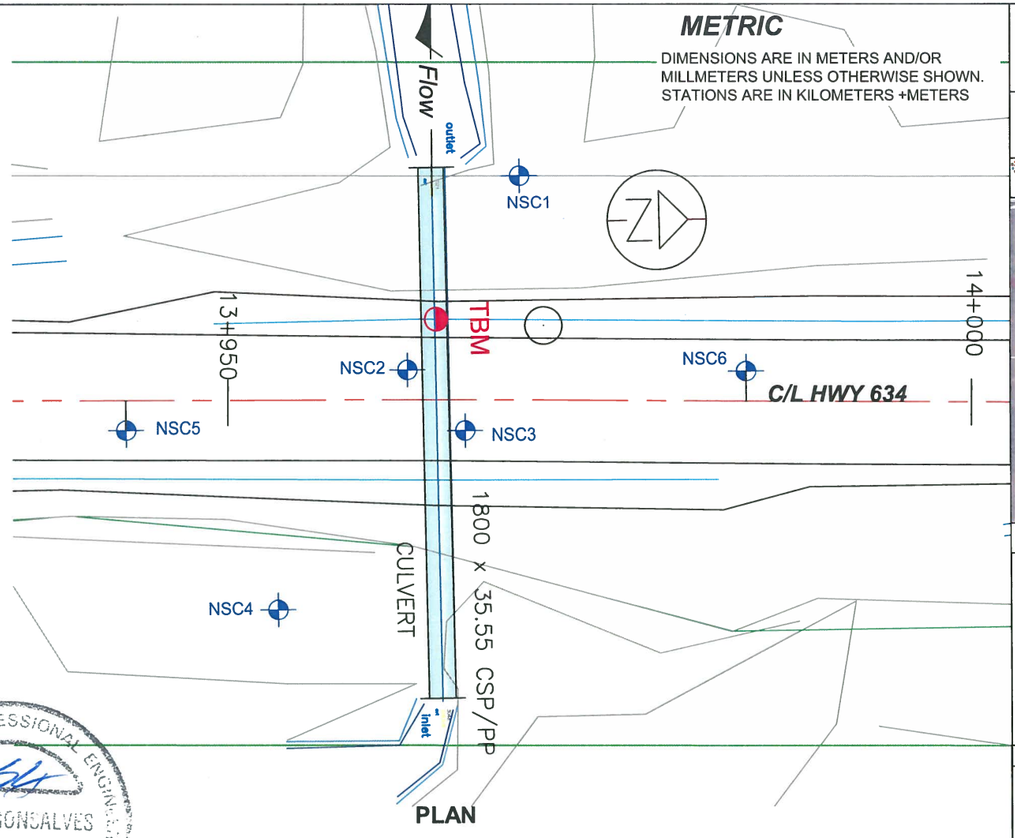

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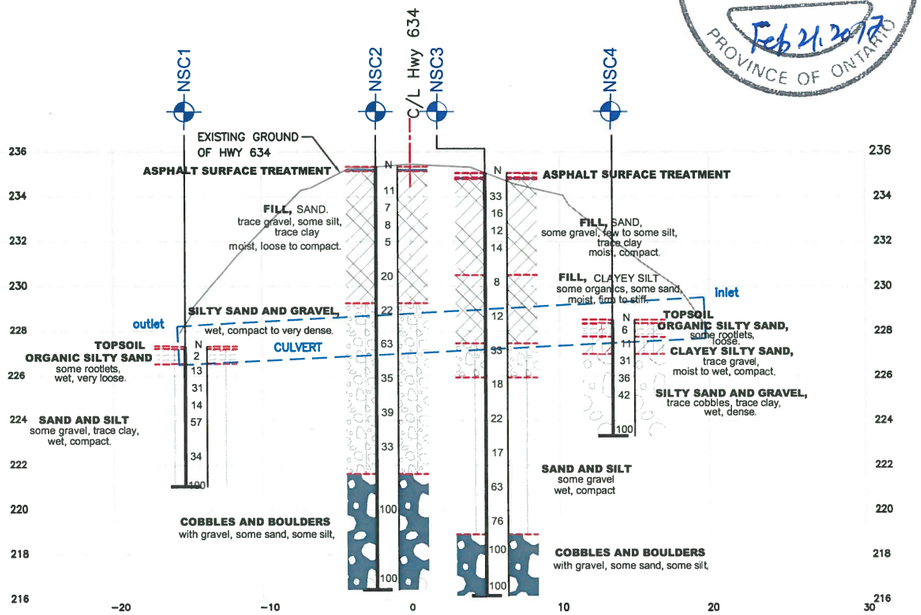
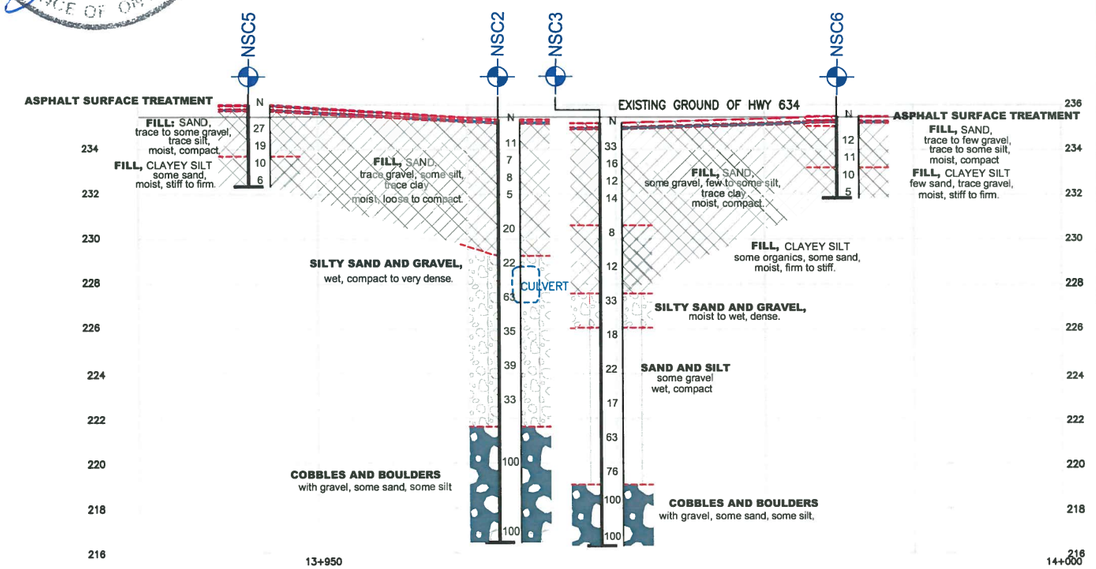


SECTION ALONG C/L CULVERT AT 13+963



SECTION ALONG C/L HWY 634

METRIC

DIMENSIONS ARE IN METERS AND/OR MILLMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS

Agreement No. 5015-E-0007
Assignment No. 4

NON- STRUCTURAL CULVERT/ HWY 634
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET

exp Services Inc.

LEGEND

- Location of Drilled Boreholes
- N — Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Temporary Bench Mark (EL. 235.0m)

SOIL STRATA SYMBOLS

- TOPSOIL
- ASPHALT SURFACE TREATMENT
- SILTY SAND/ SILT AND SAND
- FILL
- SILTY SAND AND GRAVEL
- COBBLES AND BOULDERS
- CLAYEY SILTY SAND
- ORGANIC SILTY SAND

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
NSC 1	227.3	5461909.5	259501.0
NSC 2	235.3	5461901.9	259513.9
NSC 3	235.2	5461905.7	259518.0
NSC 4	228.5	5461893.1	259529.9
NSC 5	235.9	5461882.9	259517.9
NSC 6	235.5	5461924.7	259514.2
TBM	235.0	5461903.9	259510.6

NOTE

1- Temporary benchmark elevation assumed based on the road profile drawing provided by MTO.

2- Elevations for the culvert based on the survey done by exp according to TBM elevation.

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 complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

HOR 0 12 m
VERT 0 8

14/02/2017	SM	SUBMISSION FOR MTO REVIEW
DATE	BY	DESCRIPTION
		GEOCRES NO. 42H-68
		PROJECT NO. ADM-00233185-D0

SUBM'D SM	CHECKED SM	DATE	14/02/2017
DRAWN SH	CHECKED SG	APPROVED SG	DWG. 1

LICENSED PROFESSIONAL ENGINEER T.-C. KIM Feb 21, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S.E.M. GONCALVES Feb 21/17 PROVINCE OF ONTARIO

Appendix C – Borehole Logs

Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil: mixture of soil and humus capable of supporting good vegetative growth.

Peat: fibrous fragments of visible and invisible decayed organic matter.

Fill: where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

Till: the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

Desiccated: having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

Stratified: alternating layers of varying material or color with the layers greater than 6 mm thick.

Laminated: alternating layers of varying material or color with the layers less than 6 mm thick.

Fissured: material breaks along plane of fracture.

Varved: composed of regular alternating layers of silt and clay.

Slickensided: fracture planes appear polished or glossy, sometimes striated.

Blocky: cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Lensed: inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

Seam: a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

Homogeneous: same color and appearance throughout.

Well Graded: having wide range in grain sized and substantial amounts of all predominantly on grain size.

Uniformly Graded: predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002	0.006	0.02	0.06	0.2	0.6	2.0	6.0	20	60	200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5≤Pp≤10%
Little	15≤Pp≤25%
Some	30≤Pp≤45%
Mostly	50≤Pp≤100%

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	N<5
Loose	5≤N<10
Compact	10≤N<30
Dense	30≤N<50
Very Dense	50≤N

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

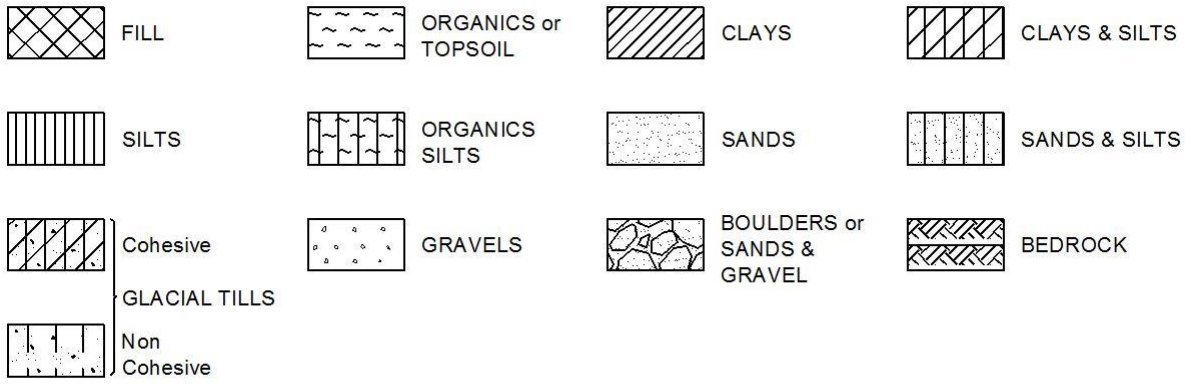
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

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
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
μ	1	Coefficient of friction

MECHANICALL PROPERIES OF SOIL

m_v	kPa^{-1}	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m^2/s	Coefficient of consolidation
H	m	Drainage path
T_V	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	kPa	Effective overburden pressure
σ'_P	kPa	Preconsolidation pressure
τ_f	kPa	Shear strength
c'	kPa	Effective cohesion intercept
ϕ'	$-^\circ$	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	$-^\circ$	Apparent angle of internal friction
τ_R	kPa	Residual shear strength
τ_r	kPa	Remoulded shear strength
S_t	1	Sensitivity = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	Density of solid particles
γ_s	kN/m^3	Unit weight of solid particles
ρ_w	kg/m^3	Density of water
γ_w	kN/m^3	Unit weight of water
ρ	kg/m^3	Density of soil
γ	kN/m^3	Unit weight of soil
ρ_d	kg/m^3	Density of dry soil
γ_d	kN/m^3	Unit weight of dry soil
ρ_{sat}	kg/m^3	Density of saturated soil
γ_{sat}	kN/m^3	Unit weight of saturated soil
ρ'	kg/m^3	Density of submerged soil
γ'	kN/m^3	Unit weight of submerged soil
e	1, %	Void ratio
n	1, %	Porosity
w	1, %	Water content
S_r	%	Degree of saturation
W_L	%	Liquid limit
W_P	%	Plastic limit
W_s	%	Shrinkage limit
I_P	%	Plasticity index = $(W_L - W_P)$
I_L	%	Liquidity index = $(W - W_P)/I_P$
I_C	%	Consistency index = $(W_L - W)/I_P$
e_{max}	1, %	Void ratio in loosest state
e_{min}	1, %	Void ratio in densest state
I_D	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
D_n	mm	N percent - diameter
C_u	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m^3/s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m^3	Seepage force

RECORD OF BOREHOLE No NSC1

1 OF 1

METRIC

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461909.5N, 259501.0E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE Portable Tripod Drill COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.15 - 2016.11.15 LATITUDE 49.2935 LONGITUDE -81.3728 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.3	Ground Surface										
227.2	**TOPSOIL** (~ 100 mm thick)										
227.1 / 0.1	**ORGANIC SILTY SAND,** some rootlets, dark brown, wet, very loose.		1	SS	2		227		○		
226.5											
0.8	**SAND AND SILT,** some gravel, trace clay, grey, wet, compact.		2	SS	13				○		15 37 45 3
	with cobbles below ~ 1.5 m depth.		3	SS	31		226		○		
			4	SS	14		225		○		
	dense below ~ 3.1 m depth.		5	SS	57		224		○		
			6	SS	34		223		○		17 42 38 3
							222				
221.0	gravelly below ~ 6.1 m depth.		7	SS	100				○		
6.3	**END OF BOREHOLE** SPT refusal, suspected coobles and boulder @ ~6.3 m										

NOTES:
1. This drawing is to be read with the subject report and project numbers as presented above.
2. Multiple attempts made to advance borehole below SPT refusal
3. Could not core at this depth with portable equiment utilized
4. Since washboring technique was used to advance borehole groundwater level was not measured in open hole.
5. At the time of investigation water level in the creek at inlet and outlet side were at approximate Elevation 227.8 m and Elevation 226.5 m, respectively.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No NSC2 1 OF 2 METRIC

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461901.9N, 259513.9E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/HSA/NW/NQ COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.09 - 2016.11.09 LATITUDE 49.29344 LONGITUDE -81.62263 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.3	Road Surface										
235.0	**ASPHALT SURFACE TREATMENT** (~ 25 mm thick)										
235.2	**FILL,** sand and gravel, some silt, brown, moist.		1	AUGER							
	ASPHALT (~ 100 mm thick)										
	FILL: SAND trace gravel, some silt, trace clay brown, moist, loose to compact. no gravel, compact below ~ 0.8 m depth.		2	SS	11		235				0 85 (15)
	loose below ~ 1.5 m depth.		3	SS	7		234				
			4	SS	8		233				
	-25 mm silty clay seam at ~ 3.0 m depth -Switch to wash boring below 3.05 m		5	SS	5		232				
	trace gravel, trace silt, trace clay, compact below ~ 4.6 m depth.		6	SS	20		231				4 82 12 2
229.2							230				
6.1	**SILTY SAND AND GRAVEL,** brown to grey, wet, compact to very dense.		7	SS	22		229				
	brown, very dense below ~ 7.6 m depth.		8	SS	63		228				
			9	SS	35		227				
	- becoming silty gravel, some sand, trace clay, grey, wet		10	SS	39		226				
							225				54 15 29 2
							224				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No NSC2

2 OF 2 **METRIC**

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461901.9N, 259513.9E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/HSA/NW/NQ COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.09 - 2016.11.09 LATITUDE 49.29344 LONGITUDE -81.62263 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY SAND AND GRAVEL, brown to grey, wet, compact to very dense. *(continued)*		11	SS	33		223		○		
221.6							222				
13.7	**COBBLES AND BOULDERS** , with gravel, some sand, some silt, -Auger refusal on suspected boulders, switch to NQ coring from @ 13.7 m, no recovery.		12	NQ			221				
	- becoming sandy gravel, some silt, grey, wet, very dense.		13	SS	100		220		○		
	-becoming cobbles and boulders - Switch to NQ coring from @ 16.8 m , recovered 0.3 m of boulders.		14	NQ			219		○		
							218				
216.4			15	SS	100		217		○		
18.9	**END OF BOREHOLE** Borehole terminated @ ~18.9 m										

NOTES:
1. This drawing is to be read with the subject report and project numbers as presented above.
2. Since washboring technique was used to advance borehole groundwater level was not measured in open hole.
3. At the time of investigation water level in the creek at inlet and outlet side were at approximate Elevation 227.8 m and Elevation 226.5 m, respectively.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No NSC3 1 OF 2 METRIC

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461905.7N, 259518.0E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/HSA/NW/NQ COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.08 - 2016.11.08 LATITUDE 49.29347 LONGITUDE -81.62257 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.2	Road Surface										
235.0 0.2	**ASPHALT SURFACE TREATMENT** (~ 25 mm thick)						235				
234.9 0.3	**FILL,** sand and gravel, some silt, brown, moist. **ASPHALT** (~ 100 mm thick)		1	AUGER							
	FILL: SAND, some gravel, few to some silt, trace clay, brown, moist, compact		2	SS	33		234				
			3	SS	16		233				0 89 8 3
			4	SS	12						
			5	SS	14		232				
230.6							231				
4.6	**FILL: CLAYEY SILT,** some organics, some sand, brown and grey, moist, firm to stiff.		6	SS	8		230				
			7	SS	12		229				1 14 47 38
227.6							228				
7.6	**SILTY SAND AND GRAVEL,** grey, moist to wet, dense.		8	SS	33		227				
226.1											
9.1	**SAND AND SILT,** some gravel, grey, wet, compact.		9	SS	18		226				
			10	SS	22		225				
							224				

Continued Next Page

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

RECORD OF BOREHOLE No NSC3 2 OF 2 METRIC

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461905.7N, 259518.0E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/HSA/NW/NQ COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.08 - 2016.11.08 LATITUDE 49.29347 LONGITUDE -81.62257 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND AND SILT, some gravel, grey, wet, compact. *(continued)* - becoming more sand		11	SS	17		223		○		
	becoming sand and silt		12	SS	63		222		○		5 45 43 7
			13	SS	76		221				
219.0							220		○		
16.2	**COBBLES AND BOULDERS** with gravel, some sand, some silt, -Auger refusal on suspected boulders, switch to NQ coring from @ 16.2 m, no recovery. - becoming more gravel		14	NQ			219		○		
			15	SS	100		218				
			16	SS	100		217		○		
216.3											
18.9	**END OF BOREHOLE** Borehole terminated @ ~18.9 m										

NOTES:
1. This drawing is to be read with the subject report and project numbers as presented above.
2. Since water used for the coring, groundwater level was not measured in open hole.
3. At the time of investigation water level in the creek at inlet and outlet side were at approximate Elevation 227.8 m and Elevation 226.5 m, respectively.

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

RECORD OF BOREHOLE No NSC4

1 OF 1 **METRIC**

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461893.1N, 259529.9E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE Portable Tripod Drill COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.15 - 2016.11.15 LATITUDE 49.29336 LONGITUDE -81.62241 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.5	Ground Surface										
228.4	**TOPSOIL** (~ 150 mm thick)										
0.2	**ORGANIC SILTY SAND,** some rootlets, dark brown, loose.		1	SS	6		228				
227.7											
0.8	**CLAYEY SILTY SAND,** trace gravel, brown, moist to wet, compact.		2	SS	11						2 41 32 25
227.0							227				
1.5	**SILTY SAND AND GRAVEL,** trace cobbles, trace clay, brown to grey, wet, dense to very dense.		3	SS	31						
	- becoming sand and silt with gravel		4	SS	36		226				
			5	SS	42						20 38 36 6
							225				
	- becoming more cobbles		6	SS	100		224				
223.3											
5.2	**END OF BOREHOLE** SPT refusal, suspected cobbles and boulder @ ~5.2 m										

NOTES:
1. This drawing is to be read with the subject report and project numbers as presented above.
2. Multiple attempts made to advance borehole below SPT refusal
3. Could not core at this depth with portable equiment utilized
4. Since washboring technique was used to advance borehole groundwater level was not measured in open hole.
5. At the time of investigation water level in the creek at inlet and outlet side were at approximate Elevation 227.8 m and Elevation 226.5 m, respectively.

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

RECORD OF BOREHOLE No NSC5

1 OF 1 **METRIC**

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461882.9N, 259517.9E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/Hollow Stem Auger COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.08 - 2016.11.08 LATITUDE 49.29326 LONGITUDE -81.62257 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
236.0	Road Surface										
236.0 / 0.0	**ASPHALT SURFACE TREATMENT** (~ 76 mm thick)										
235.8 / 0.2											
235.7 / 0.3	**FILL,** sand and gravel, trace to some silt, brown, moist.										
	ASPHALT (~ 100 mm thick)										
	FILL: SAND, trace to some gravel, trace silt, brown, moist, compact.		1	AUGER							
			2	SS	27		235				2 88 (10)
			3	SS	19		234				
233.7 / 2.3	**FILL: CLAYEY SILT,** some sand, brown, moist, stiff to firm.		4	SS	10						
			5	SS	6		233				1 10 47 42
232.3 / 3.7	**END OF BOREHOLE** Borehole terminated @ ~3.7 m depth										

NOTES:
1. This drawing is to be read with the subject report and project numbers as presented above.
2. Borehole dry in open hole.

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

RECORD OF BOREHOLE No NSC6

1 OF 1 **METRIC**

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461924.7N, 259514.2E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/Hollow Stem Auger COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.09 - 2016.11.09 LATITUDE 49.29364 LONGITUDE -81.62263 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.5	Road Surface										
235.5 / 0.0	**ASPHALT SURFACE TREATMENT** (~ 25 mm thick)										
235.3 / 0.2	**FILL,** sand and gravel, some silt, brown, moist.										
235.2 / 0.3	**ASPHALT** (~ 100 mm thick)										
	FILL: SAND, trace to few gravel, trace to some silt, brown, moist, compact		1	AUGER			235		○		10 77 (13)
			2	SS	12				○		
			3	SS	11		234		○		
233.2											
2.3	**FILL: CLAYEY SILT,** few sand, trace gravel, brown, moist, stiff to firm.		4	SS	10		233		○		4 10 51 35
			5	SS	5				○		
231.8							232				
3.7	**END OF BOREHOLE** Borehole terminated @ ~3.7 m depth										

NOTES:
1. This drawing is to be read with the subject report and project numbers as presented above.
2. Borehole dry in open hole.

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

RECORD OF BOREHOLE No NSC6

1 OF 1 **METRIC**

W.P. 2016-11040 LOCATION Non-Structural Culvert, MTM-12, 5461924.7N, 259514.2E ORIGINATED BY ST

DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/Hollow Stem Auger COMPILED BY ST

DATUM Local (non-geodetic) DATE 2016.11.09 - 2016.11.09 LATITUDE 49.29364 LONGITUDE -81.62263 CHECKED BY IM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.5	Road Surface										
235.5 / 0.0	**ASPHALT** (~ 25 mm thick)										
235.2 / 0.3	**FILL,** sand and gravel, some silt, brown, moist.										
235.2 / 0.3	**ASPHALT** (~ 100 mm thick)										
	FILL: SAND, trace to few gravel, trace to some silt, brown, moist, compact		1	AUGER			235		○		10 77 (13)
			2	SS	12				○		
			3	SS	11		234		○		
233.2											
2.3	**FILL: CLAYEY SILT,** few sand, trace gravel, brown, moist, stiff to firm.		4	SS	10		233		○		4 10 51 35
			5	SS	5				○		
231.8							232				
3.7	**END OF BOREHOLE** Borehole terminated @ ~3.7 m depth										

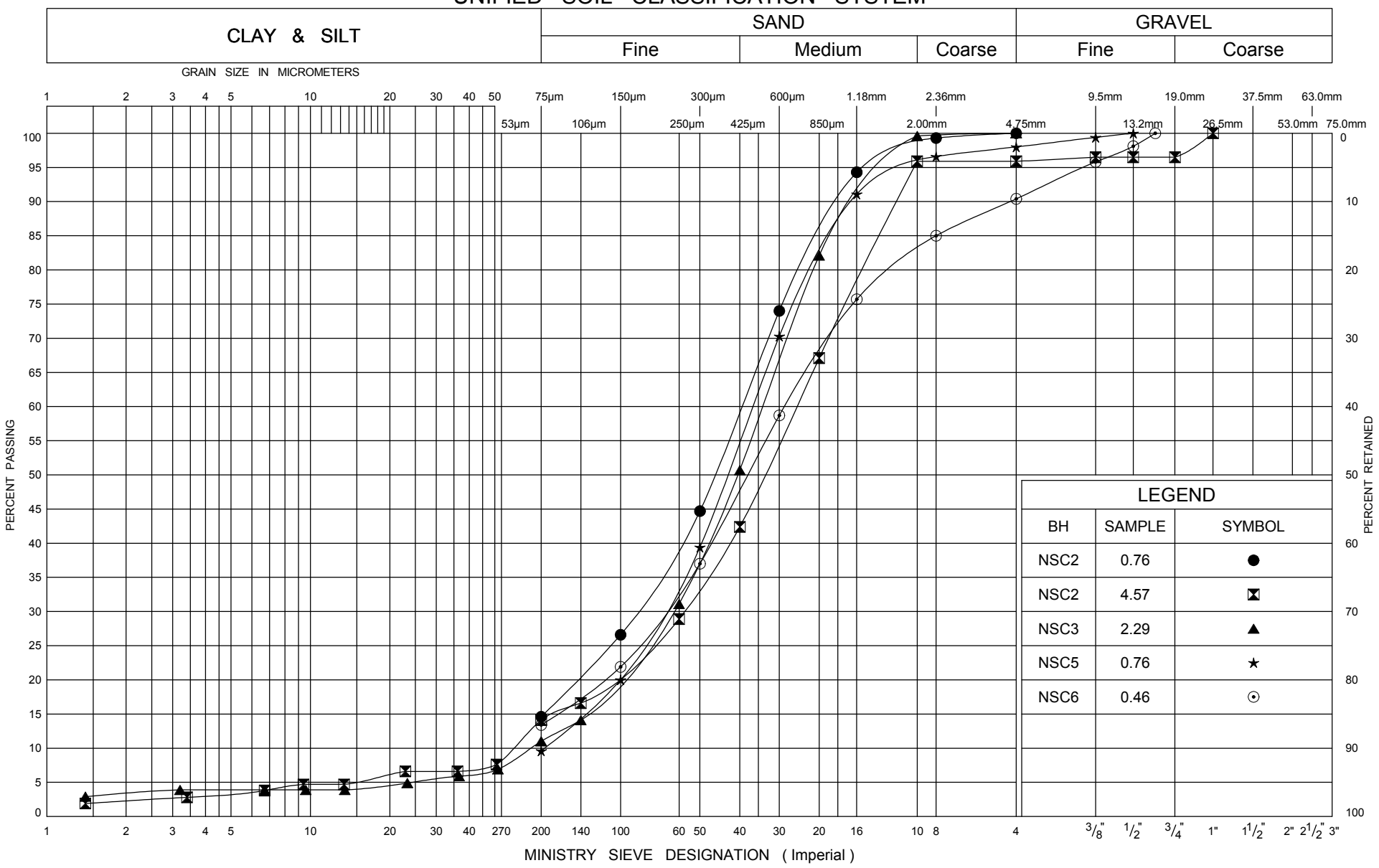
NOTES:
1. This drawing is to be read with the subject report and project numbers as presented above.
2. Borehole dry in open hole.

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

ONTARIO MTO ADM-00233185-D0 - HWY 634 NON STRUCTURAL CULVERT .GPJ ONTARIO MTO.GDT 2/3/17

Appendix D – Laboratory Data

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

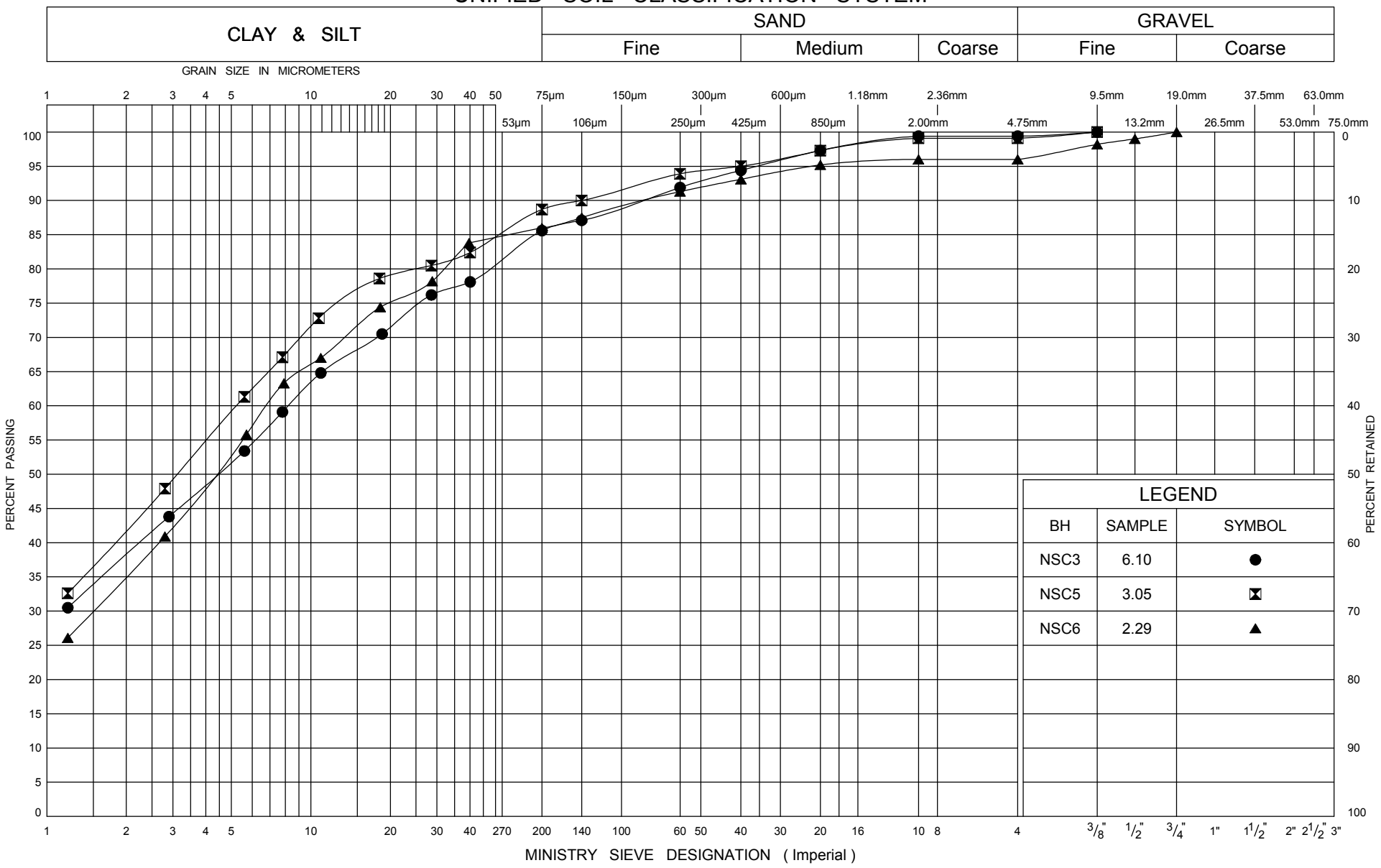
GRAIN SIZE DISTRIBUTION

FIG No 1

W P

Assignment 4

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

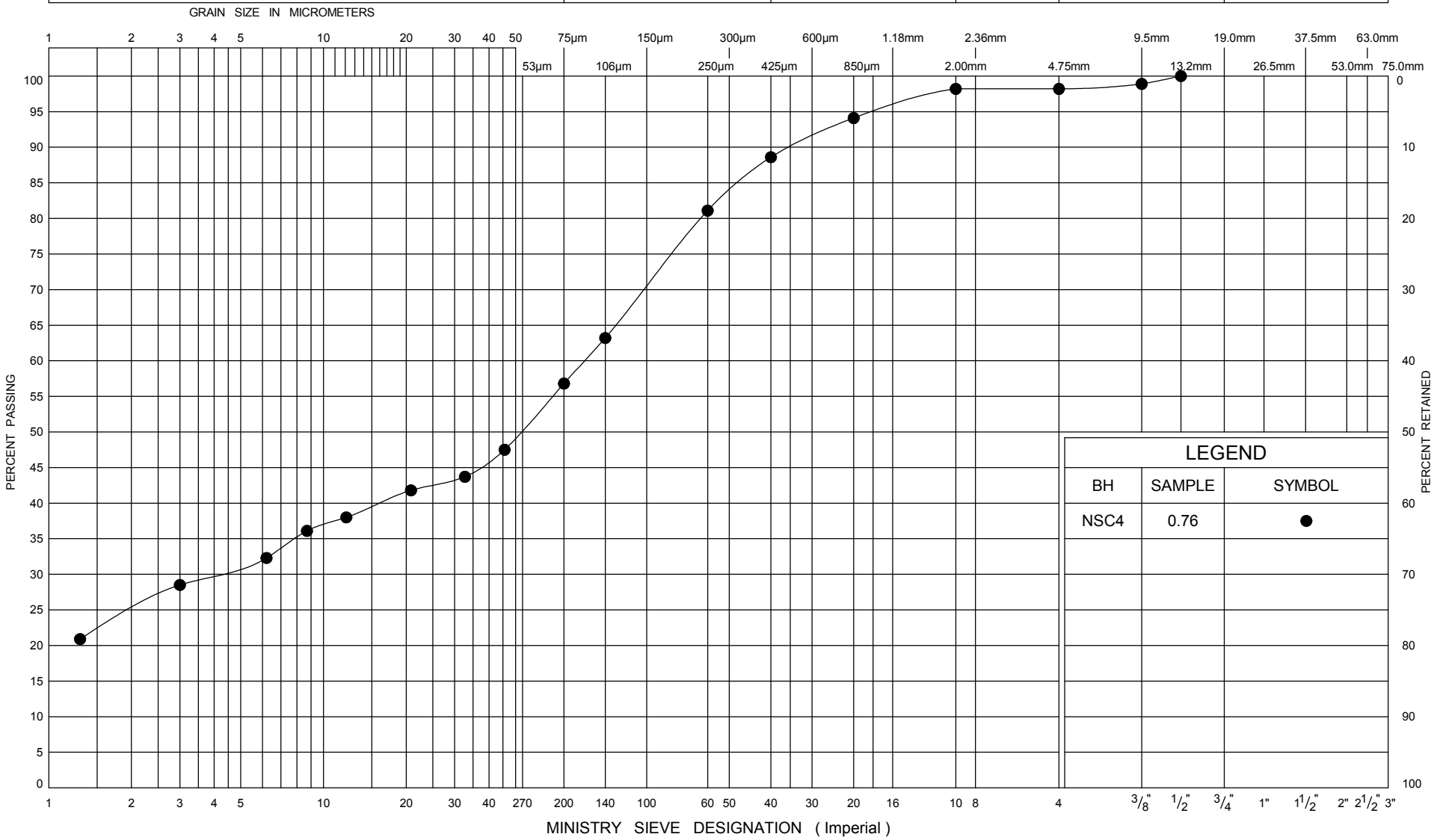
FIG No 2

W P

Assignment 4

ONTARIO MOT GRAIN SIZE ADM-00233185-D0 - HWY 634 CULVERTS.GPJ ONTARIO MOT.GDT 12/16/16

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

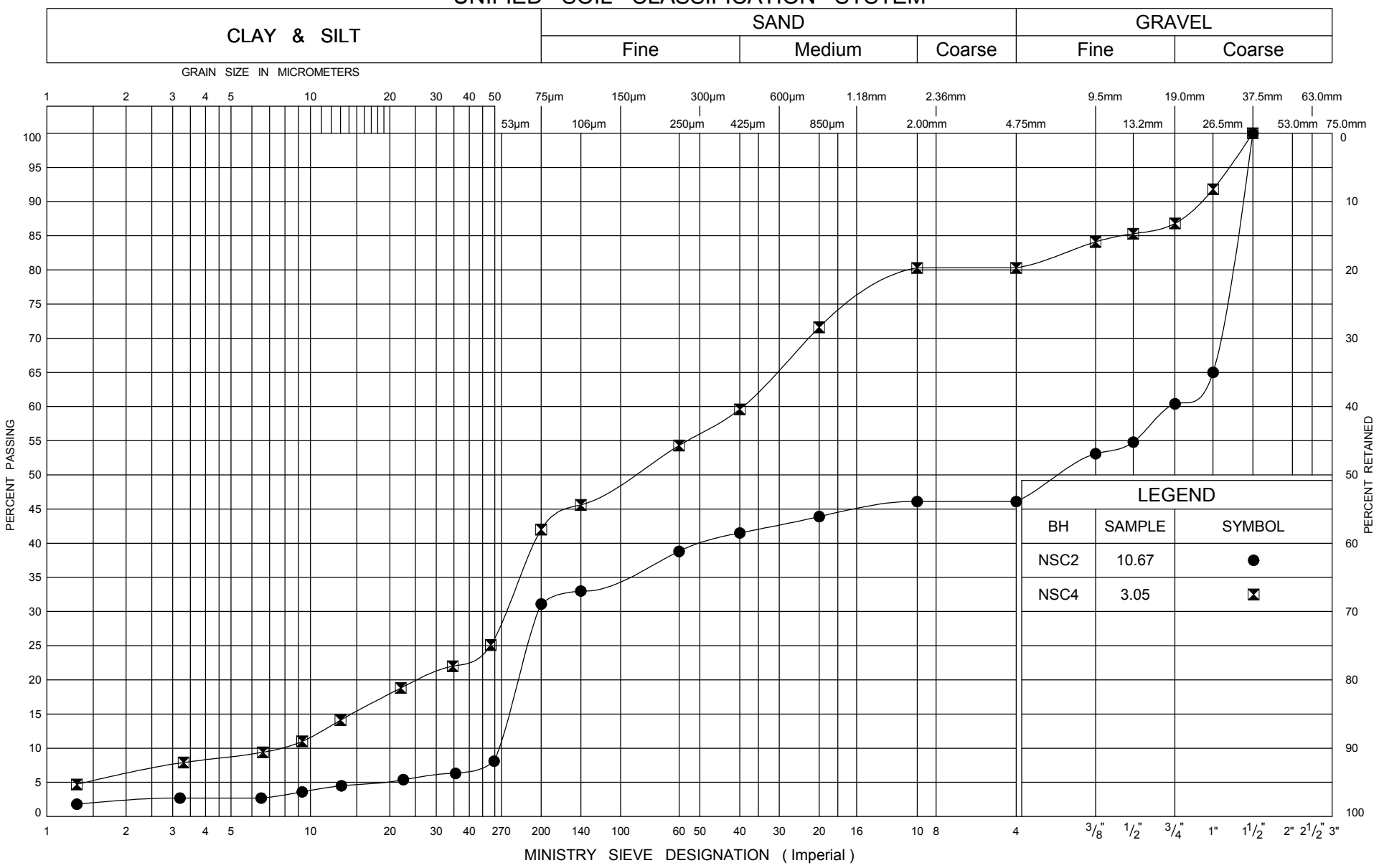
FIG No 3

W P

Assignment 4

ONTARIO MOT GRAIN SIZE ADM-00233185-D0 - HWY 634 CULVERTS.GPJ ONTARIO MOT.GDT 12/16/16

UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO MOT GRAIN SIZE ADM-00233185-D0 - HWY 634 CULVERTS.GPJ ONTARIO MOT.GDT 12/16/16

Ministry of Transportation
Ontario

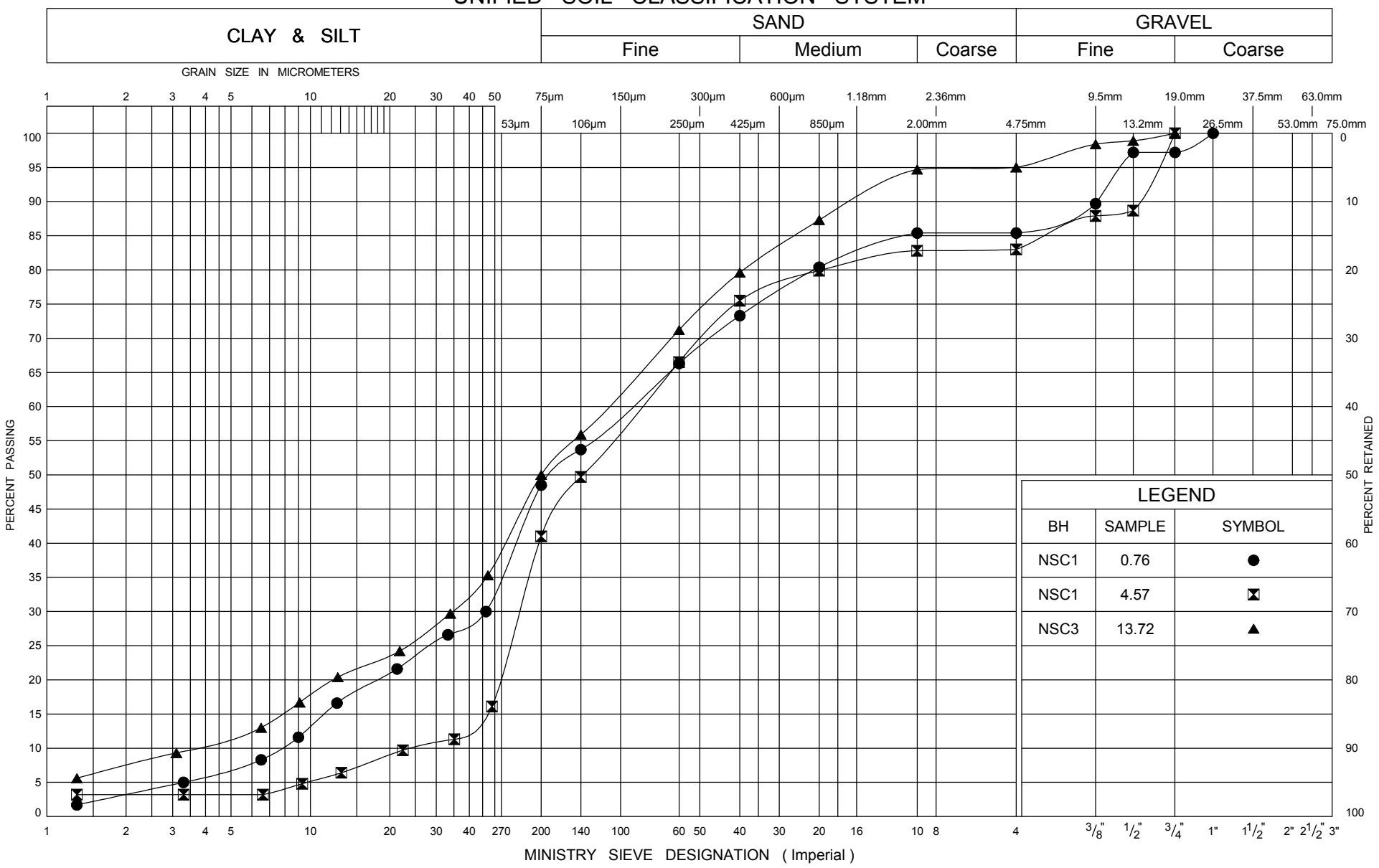
GRAIN SIZE DISTRIBUTION

FIG No 4

W P

Assignment 4

UNIFIED SOIL CLASSIFICATION SYSTEM



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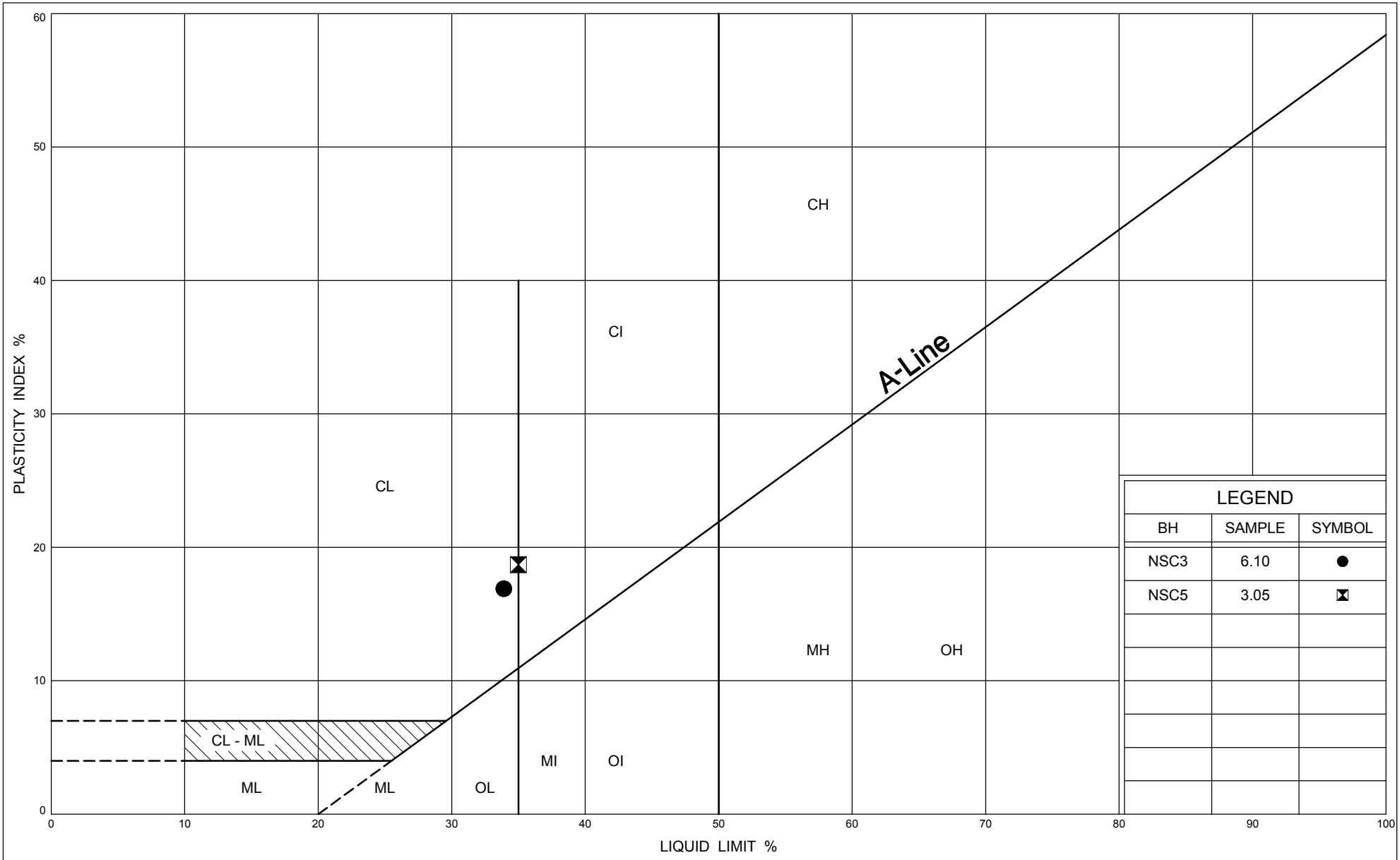
GRAIN SIZE DISTRIBUTION

FIG No 5

W P

Assignment 4

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART ADM-00233185-D0 - HWY 634 CULVERTS.GPJ ONTARIO MOT.GDT 12/16/16

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Ontario

PLASTICITY CHART

FIG No 6

W P

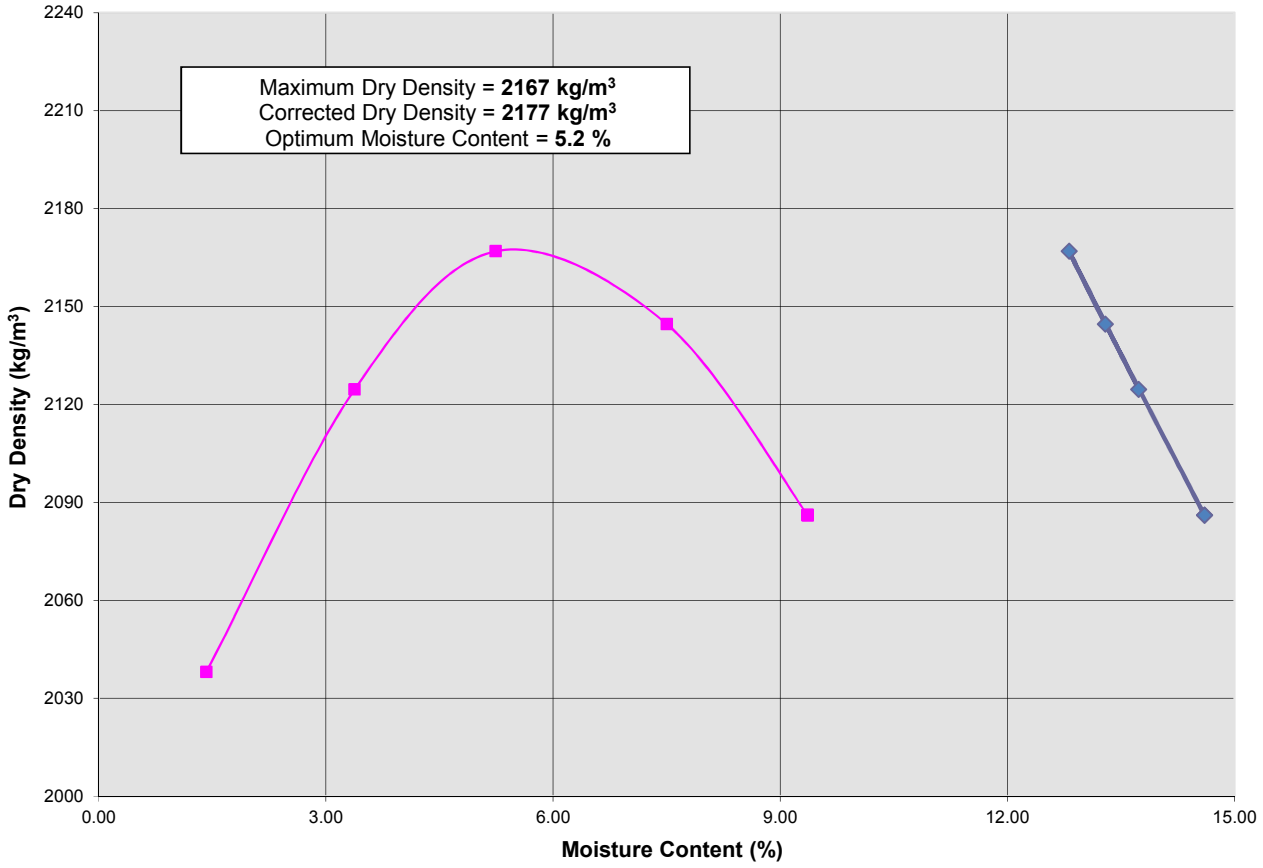
Assignment 4

Appendix E –
Proctor Test Results

exp. Services inc.
885 Regent St.
Sudbury, Ontario
P3E 5M4
Telephone: (705) 674-9681
Facsimile: (705) 674-8271

ASTM-698-Standard Proctor Laboratory Test

Job #:	**ADM-00233185-D0**
Job Name:	**5015-E-0007 Assignment #4 - Foundation**
Date:	**9-Dec-16**
Ticket:	**50861**
Sample:	**NSC 3 - 1 AG**



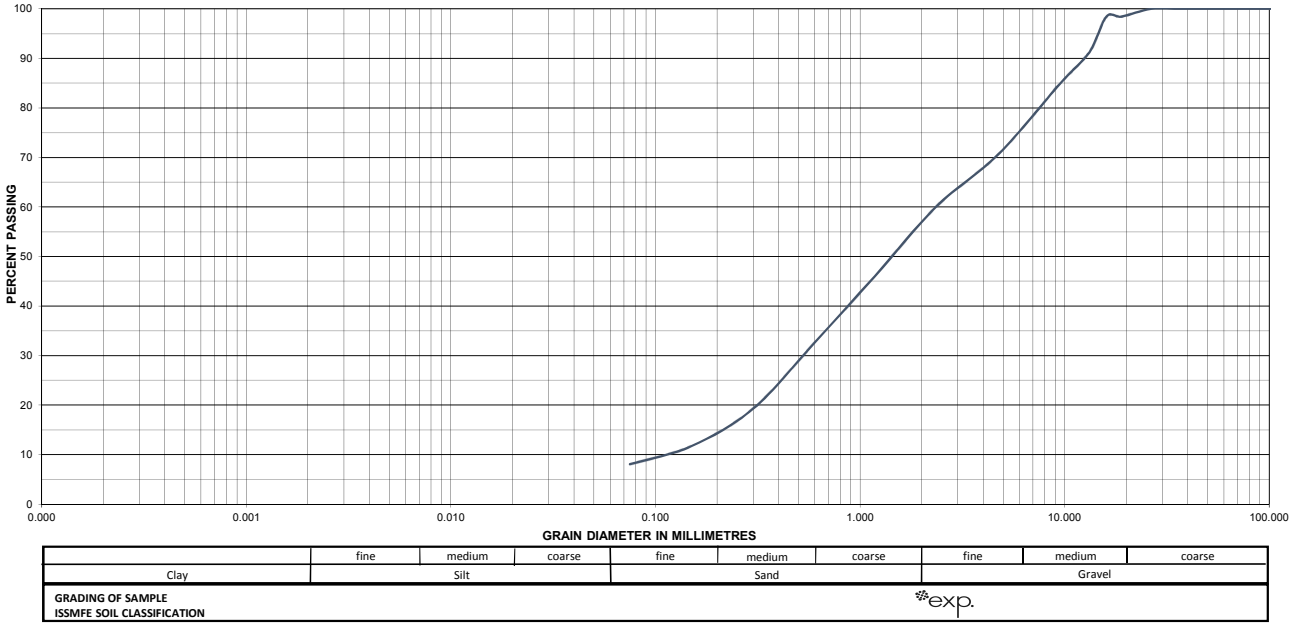
Robert J. Ferguson, C.E.T
Manager,
Field & Laboratory Services

Brittany Pellerin
Laboratory Technician
Materials Testing

exp Services Inc.
885 Regent Street
Sudbury, Ontario
P3E 5M4
Telephone: (705) 674-9681
Facsimile: (705) 674-8271

Grain Size Analysis

Job #: ADM-00233185-D0
Job Name: 5015-E-0007 Assignment #4 - Foundation
Client: MTO - Northeastern Region
Date: December 13, 2016
Ticket #: 50861
Sample: NSC 3 - 1 AG
Depth: 0-2.5



Sieve Size Gravel Particle Diameter (mm)	Percent Passing	Sieve Size Sand Particle Diameter (mm)	Percent Passing
150	100.0	1.18	46.0
53	100.0	0.600	32.6
37.5	100.0	0.300	19.3
26.5	100.0	0.150	11.7
19.0	98.4	0.075	8.0
16.0	98.4		
13.2	91.2		
9.50	84.9		
4.75	70.7		
2.36	60.1		

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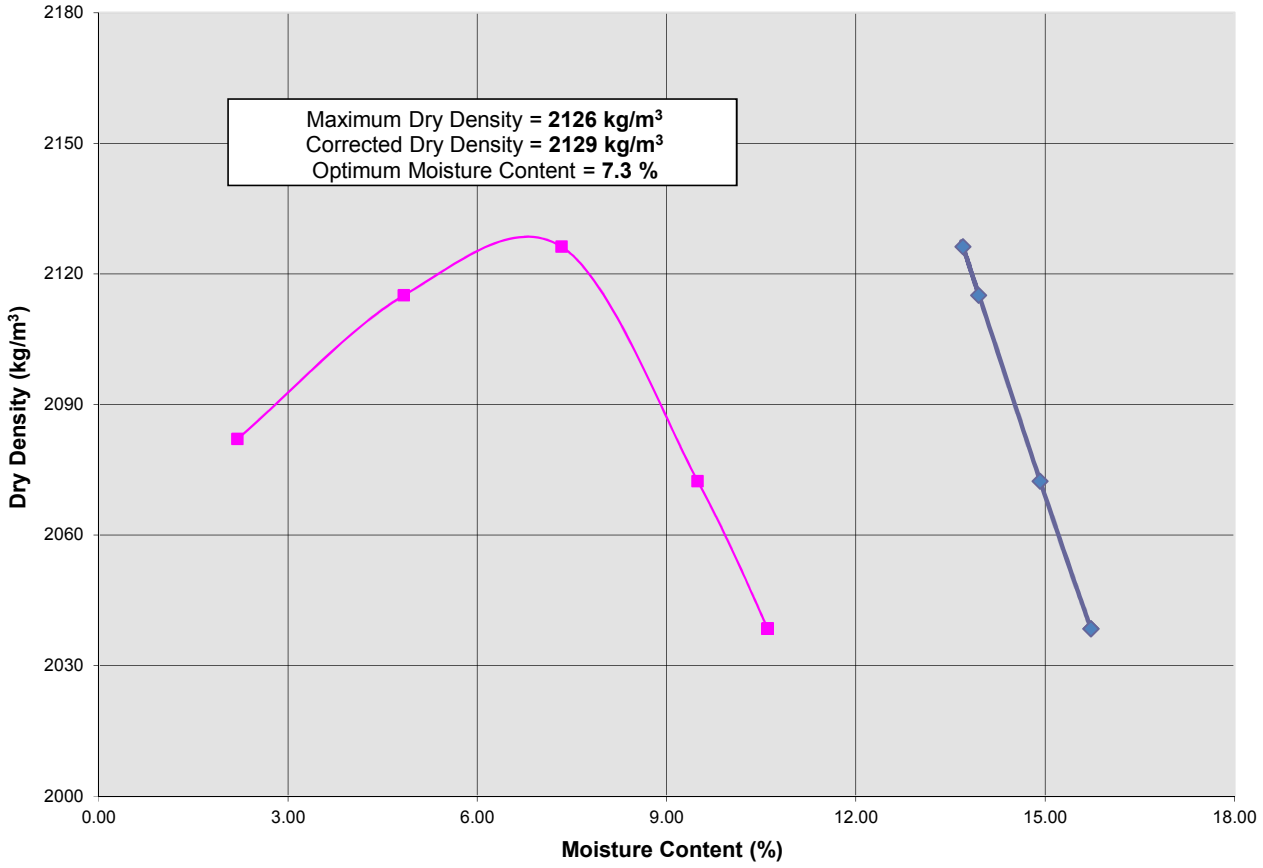
Facsimile: (705) 674-8271

ASTM-698-Standard Proctor Laboratory Test

Job #:	**ADM-00233185-D0**
Job Name:	**5015-E-0007 Assignment #4 - Foundation**
Date:	**9-Dec-16**
Ticket:	**50881**
Sample:	**NSC 6 - 1 AG**



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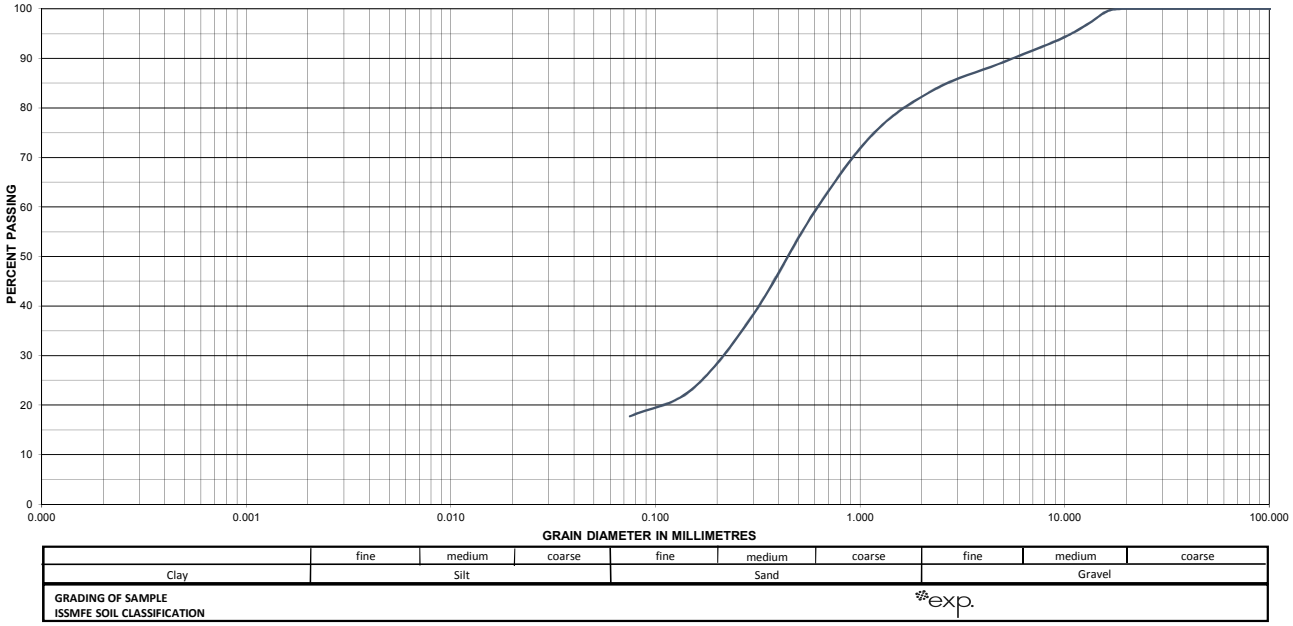
885 Regent Street
Sudbury, Ontario
P3E 5M4
Telephone: (705) 674-9681
Facsimile: (705) 674-8271

Grain Size Analysis

Job #: ADM-00233185-D0
Job Name: 5015-E-0007 Assignment #4 - Foundation
Client: MTO - Northeastern Region
Date: December 13, 2016
Ticket #: 50881
Sample: NSC 6 - 1 AG
Depth: 0-2'



Sieve Size Gravel Particle Diameter (mm)	Percent Passing	Sieve Size Sand Particle Diameter (mm)	Percent Passing
150	100.0	1.18	75.1
53	100.0	0.600	59.1
37.5	100.0	0.300	38.2
26.5	100.0	0.150	23.1
19.0	100.0	0.075	17.7
16.00	99.4		
13.20	97.1		
9.50	93.9		
4.75	88.9		
2.36	83.9		

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