FOUNDATION INVESTIGATION
AND DESIGN REPORT
PROPOSED RECONSTRUCTION OF
NON-STRUCTURAL CULVERTS 21A, 24A, 25A AND 27A
TOWNSHIP OF COLLINGWOOD
HIGHWAY 26 FROM MEAFORD TO THORNBURY

G.W.P. 57-00-00
Agreement # 3006-E-0002

I.E.
Group

MTO GEOCRES No. 41A-206

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PART A – FOUNDATION INVESTIGATION

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out in July and September 2007 by Infrastructure Engineering Group Inc. (IEG) on behalf of Stantec Consulting Ltd. (Stantec).

This assignment involves the rehabilitation of the pavement structure on Highway 26 from 0.2 km east of the Thornbury west limit (Peel Street) westerly 10.06 km to the Town of Meaford east limit.

It includes the rehabilitation and extension of two existing structural culverts, as well as many non-structural culvert extensions and replacements. The project also includes intersection realignments, intersection improvements, construction of two new 1.5 km long passing lanes, minor horizontal and vertical alignment improvements and electrical work. The original assignment included the re-alignment of the Blue Mountains/Meaford Town Line which has been deleted from the assignment.

Foundation investigation and recommendations are required for the design and construction of culvert replacements and extension as part of the improvement of Highway 26. Two (2) structural culverts, twenty-four (24) non-structural culverts, two shale bin replacements, and a high cut area are to be investigated. There is a change in the scope of work to include two additional culvert extensions which were not part of the original scope of work for foundation investigations, and re-allocation of the foundations investigation work for three (3) CSP culverts to the geotechnical investigation portion of this assignment. This report covers the site of Culverts 21A, 24A, 25A and 27A in the Collingwood Township.

Four (4) non-structural culverts are listed in the following table for replacements as per the information supplied by the RFP documents. There is no work required for Culvert 27A as the project develops and as per the final culvert recommendations provided by Stantec. The foundation data and information for Culvert 27A are left in this report for future reference. The locations of these structures are shown in Appendix A, Borehole Location Plan, Drawing 1.

Table 1
Summary of location, structure type, dimensions

Culvert #	New Chainage (m)	Existing Culvert Type and Size, W X H	Existing Overfill (m)	Recommended Replacement Culvert Type and Size	Length (m)	U/S Culvert Invert (m)	D/S Culvert Invert (m)
21A	Relocate to 10+100	Concrete 1.5m X 1.2 m	1.9	Precast Concrete Box 1.5m X 0.9m	20.03	Under Develop-ment	Under Develop-ment
24A	Relocate 10+840	Concrete 1.5m X 0.9 m	0.8	Precast Concrete Box 2.7m X 0.9m	17.59	Under Develop-ment	Under Develop-ment
25A	Relocate 11+680	Concrete 0.9m X 0.6m	1.0	Precast Concrete Box 2.7m X 1.2m	18.20	Under Develop-ment	Under Develop-ment
27A	13+731	Concrete 1.8m X 1.2m	1.2	No Work Required	Not Applicable	Not Applicable	Not Applicable

The existing culverts are to be removed and replaced or relocated with new culverts, with box culverts being the preferred structures as per the PDR report. The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes and, based on the findings, to provide geotechnical recommendations for the foundation elements.

The work presented herein was undertaken under MTO G.W.P. 57-00-00, Agreement No. 3006-E-0002.

Authorization to complete this assignment was given by Mr. Dan Green, P. Eng., of Stantec Consulting Ltd., the TPM Consultant who is completing this assignment for MTO under Agreement # 3006-E-0002.

2.0 SITE DESCRIPTION

2.1 Site Location

These four (4) culverts are located on Highway 26, approximately 0.1 km to 3.7 km east of the junction of St. Vincent and Collingwood Townships. Table 1 summarizes the locations, structure types and dimensions of the existing and replacement culverts as recommended by the PDR and provided in the RFP documents. Locations of the individual culverts are illustrated in the Borehole Location Plan, Drawing 1 presented in Appendix A. The existing concrete culverts, although in good conditions, are hydraulically under capacity.

These culvert sites are generally located within drainage valleys or surface water flow paths. The overfill heights range approximately between 0.8 m and 1.9 m. The embankment slopes are typically 2.5H to 3H:1V and are grass covered. No signs of embankment slope instability were observed at the time of this foundation investigation. Site photographs taken during a site visit in March 2006 by Stantec are provided in Appendix C.

2.2 Physiography and Topography

The Town of Meaford is situated at the mouth of the Bighead River where the river enters Nottawasaga Bay, part of the Georgian Bay of Lake Huron.

The subsurface of the Town of Meaford is comprised of predominately silty clay, and smooth to gently sloping topography. Pockets of sand and gravelly sands exist which also exhibit smooth to gently sloping topography.

The Town is located on the coastal plain left by glacial Lake Algonquin. East of Meaford, the Algonquin shore cliff coincides with the base of the Niagara Escarpment. The coastal plain in this area consists of sand and gravel beach terraces overlying the bedrock. Overburden thickness is generally less than 5 m.

Bedrock consists of the shale and limestones of the Georgian Bay Formation. Grey, impure carbonate beds (limestone and dolomite) alternate with grey and blue/grey shale.

West of Meaford, the coastal plain consists of the same beach deposits as found in the east. To the west away from the Lake, overburden becomes a glacio-lacustrine derived silt to clayey till. Numerous drumlins of calcareous till with red shale inclusions are found in the Meaford area.

Progressing west on Highway 26 toward Owen Sound and the Niagara Escarpment, the bedrock types progress from Queenston shales, the Clinton and Cataract shales and dolomites to the cap rock of the Amabel dolomites and limestones. Overburden thickness can be as much as 15 m, but is generally less than 5 m.

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

Between July 22 and September 18, 2007, a Bombardier-mounted Diedrich drill rig and a truck-mounted CME 55 drill rig, supplied and operated by London Soil Test Ltd. of London, was used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Three (3) boreholes at each site were drilled and sampled to obtain data for foundation and bedding design of the proposed replacement culverts. The boreholes were drilled to a minimum depth of 3.0 m (or deeper if required) below the culvert inverts to provide sufficient subsurface information for the evaluation of bearing resistances or support of bedding material for the proposed culvert replacements.

It is noted that Borehoes 25A-1 and 27A-1 were hand drilled as the borehole locations were inaccessible to a drill rig.

The boreholes were advanced using continuous flight solid stem augers. Soil samples were retrieved at selected intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT). Samples were generally taken at intervals of depth of 0.75 m to the maximum depth of exploration.

The culvert locations are described as 21A, 24A, 25A and 27A. The culvert borehole numbering system was established from the catchment area numbering system used in the Drainage Report of this project, as agreed with Stantec. A letter “A” or “B” was also added after the culvert numbers to delineate Part A or Part B of this assignment.

For the purpose of proper management of the Borehole Logs within gINT, the borehole logging software, a preceding 0 was added to the culverts numbered 1 to 9, with a letter “A” or “B” also added after the culvert numbers to delineate Part A or Part B of this assignment, and the last number being the borehole number at the culvert site, i.e., “21A-1” refers to Borehole 1 at the location of Culvert 21 in Part A, etc.

Field pocket penetrometer was used on the retrieved SPT samples, where applicable, to determine the undrained shear strength of the cohesive soil deposits. These undrained shear strengths are used to supplement the properties of the cohesive soils. It is noted that the measured shear strength value would be slightly lower than the actual value due to sampling disturbance.

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. All boreholes were grouted with a bentonite/cement mix at completion of sampling in accordance with Ontario Regulation 903.

Our field engineer, Mr. Ralph Billings, P. Eng., working under the direction of the project engineer, Mr. Eric Chung, P. Eng., supervised the fieldwork. Our field staff cleared the location of buried utilities and logged the boreholes. The soil samples obtained were placed in labeled containers and transported to our London Office for further examination and laboratory testing.

The stations, offsets and ground surface elevations at the as drilled borehole locations were surveyed by AGM London and provided to Infrastructure Engineering Group Inc. for the purpose of this report.

The results of the drilling, sampling, in-situ testing and groundwater observations are summarized on the Record of Borehole sheets and enclosed in Appendix B.

3.2 Laboratory Analysis

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all retrieved soil samples. In addition, grain size analyses, Atterberg Limit tests and unit weight tests were performed on selected samples.

The results of the laboratory testing are presented on the Record of Borehole sheets and in the respective figures presented in Appendix B.

4.0 SUBSURFACE CONDITIONS

Reference is made to the respective appendix of each culvert site for the Record of Borehole sheets and Laboratory Test Results (Appendix B) for detailed subsurface soil, bedrock and groundwater conditions encountered in the boreholes. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, consequently, represent transitions between soil types rather than exact planes of geological change. The soil profiles depicting the subsurface conditions on the respective Borehole Locations will vary between and beyond the borehole locations.

In general, the subsurface deposits encountered in the boreholes put down on the shoulder area at the culvert sites consist of loose to compact embankment fill placed on dense to very dense sandy silt /silty sand till at Culverts 25A and 27 A and stiff to hard silty clay till at Culverts 21A and 24A. Subsurface profile also included shale bedrock as described in Section 4.5.

4.1 Fill, Topsoil

The boreholes at the shoulders generally encountered a 0.2 to 0.3 m thick layer of granular fill (shoulder gravel). The shoulder gravel is underlain by mixed fill materials consisting of predominantly silty clay to clayey silt with sand, gravel and localized zones of organic inclusions, and extended to or slightly below the bottom of the culverts.

The boreholes near the ends of the existing culverts generally encountered a 0.1 to 0.5 m thick layer of topsoil.

Standard penetration tests taken in the mixed fill yielded “N”-values from 6 to 29 blows per 0.3 m, indicative of typically loose to compact compactness condition. The measured natural moisture contents of the mixed fill ranged from 5 to 28%. The higher moisture contents reflect the presence of topsoil and organic matters, as well as wet silty clay.

Grain size distributions of these fill materials are shown on the first figure of the corresponding culvert site in Appendix B, e.g. Figure C-21A.1 refers to the first figure of Culvert 21A, etc.

Table of Figures of Laboratory Test Results

Culvert Number	Grain Size Figure
21A	C-21A.1
24A	C-24A.1
25A	C-25A.1
27A	C-27A.1

Unit weight of the fill was only determined on one sample due to the disturbance of the soil samples during sampling and sample retrieval. The unit weight of the clayey silt fill found at Borehole 27A-2 was measured to be at 23.4 kN/m^3.

4.2 Silty Sand to Clayey Gravelly Silty Sand (SM to SC-SM-SW)

At Boreholes 24A-1, 25A-1 and 25A-3, the topsoil layer was underlain by a clayey gravelly silty sand, silty sand and gravel and silty sand respectively and extended to depths between 1.52 and 2.29 m. Standard penetration tests yielded “N”-values of 7 to 69 blows per 0.3 m, indicative of loose to very dense compactness condition. The natural moisture contents were 6 and 19%. The loose to compact condition was encountered immediately below the topsoil layer.

Grain size analyses and Atterberg Limits determinations were performed and the results are plotted on the following figures of Appendix B.

Table of Figures of Laboratory Test Results

Culvert Number	Grain Size Figure	Atterberg Limits Figure
24A	C-24A.2	C-24A.3
25A	C-25A.2	C-25A.3

Three (3) Atterberg Limits determinations yielded the following results:

Atterberg Limits	Minimum	Maximum	Average
Liquid Limit (W_L)	16.0	27.0	21.0
Plastic Limit (W_P)	13.0	17.0	15.0
Plasticity Index (I_p)	3.0	10.0	6.0

4.3 Silty Clay Till (CL-CI)

At Culverts 21A and 24A, the topsoil layer at the ends of the culvert, under the embankment fill and clayey gravelly silty sand deposit, were underlain by a silty clay silt till stratum which extended to the full depths of boreholes at Culvert 21A, and/or underlain by shale bedrock at Culvert 24A.

Standard penetration tests taken within the silty clay till yielded "N"-values from 8 to over 100 blows per 0.3 m. The natural moisture contents were between 8 and 22%.

Grain size analyses and Atterberg Limits determinations were performed and the results are plotted on the following figures of Appendix B.

Table of Figures of Laboratory Test Results

Culvert Number	Grain Size Figure	Atterberg Limits Figure
21A	C-21A.2	C-21A.3
24A	C-24A.4	C-24A.5

Thirteen (13) Atterberg Limits determinations on the silty clay till (CL to CI) yielded the following results:

Atterberg Limits	Minimum	Maximum	Average
Liquid Limit (W_L)	26.0	50.0	37.2
Plastic Limit (W_P)	17.0	26.0	21.3
Plasticity Index (I_p)	11.0	24.0	16.2

Undrained shear strength of the silty clay till generally increased with increasing depths. Localized stiff layers of limited thickness were encountered at Borehole 21A-1.
The unit weight of the silty clay till was measured between 21.7 and 23.5 kN/m^3, with an average of 22.9 kN/m^3.

Based on the above field and laboratory test results, together with visual and tactile examination, the silty clay till deposit generally exhibited very stiff to hard consistency with localized stiff layers.

4.4 Sandy Silt to Silty Sand Till (SM-ML)

At Culverts 25A and 27A, the embankment fill, topsoil and silty sand layer (Borehole 25A-3) were underlain by a silty sand to sandy silt till stratum which extended to the full depths of the boreholes or underlain by shale bedrock (Boreholes 25A-2 and 25A-3). Standard penetration tests taken within the sandy silt to silty sand till yielded "N"-values of 2 to over 100 blows per 0.3 m. The very loose to compact conditions were encountered immediately under the surficial topsoil layer at Borehole 27A-1. Otherwise, this till deposit was in dense to very dense compactness condition. The natural moisture contents were between 6 and 13%.

A silty clay layer was penetrated within the sandy silt till in Borehole 27A-3 at 3.81 m depth. Its grain size distribution and Atterberg Limits are provided in Figures C-27A.4 and C-27A.5.

Grain size analyses and Atterberg Limits determinations were performed and the results are plotted on the following figures of Appendix B.

Table of Figures of Laboratory Test Results

Culvert Number	Grain Size Figure	Atterberg Limits Figure
25A	C-25A.4	C-25A.5
27A	C-27A.2	C-27A.3

Two (2) Atterberg Limits determinations on the sand to silt till yielded the following results:

Atterberg Limits	Minimum	Maximum	Average
Liquid Limit (W_L)	17.0	19.0	18.0
Plastic Limit (W_P)	14.0	14.0	14.0
Plasticity Index (I_p)	3.0	5.0	4.0

The unit weight of the sandy silt till was measured to be between 24.5 and 25.4 kN/m^3, with an average of 24.9 kN/m^3.

4.5 Shale Bedrock

The silty clay till at Culvert 24A and the sandy silt till at Culvert 25A were underlain by a stratum of grey shale of the Georgian Bay Formation. The surface of the shale bedrock at Borehole 24A-2 resembles a shale/till complex. Grey, impure carbonate beds (limestone and dolomite (10 to 20 mm thick layers) alternate with grey and blue/grey shale.

A grain size analysis and Atterberg Limits determinations were performed and the results are plotted on the following figures of Appendix B.

Table of Figures of Laboratory Test Results

Culvert Number	Grain Size Figure	Atterberg Limits Figure
24A	C-24A.6	C-24A.7

The results of the Atterberg Limits test are provided below:

Atterberg Limits	%
Liquid Limit (W_L)	37
Plastic Limit (W_P)	19
Plasticity Index (I_p)	18

Standard penetration tests yielded "N"-values over 100 blows per 0.3 m. The measured natural moisture contents ranged from 5 to 17%. The unit weight of a single sample was measured to be 21.9 kN/m^3.

4.6 Groundwater

The groundwater condition was monitored during and upon completion of sampling. On completion of drilling, groundwater levels noted in the boreholes are summarized in the following table.

Culvert Number	Groundwater Levels - Depth/Elevation (m)		
	Borehole 1	Borehole 2	Borehole 3
21A	3.40/230.92	3.40/231.13	BD&O
24A	BD&O	2.60/232.77	BD&O
25A	BD&O	BD&O	BD&O
27A	0.35/194.61	2.70/194.04	0.75/194.21

Note: BD&O means borehole dry and open at completion

In general, the groundwater was encountered as perched condition within the upper fill materials and in the wet to saturated granular deposits. At Culvert 27A, the water table was observed near the ground surface due to high creek water level at the time of investigation. The observed groundwater table represented the shallow groundwater condition at these culvert sites.

The groundwater condition will fluctuate seasonally and in response to weather events.

PART B – FOUNDATION DESIGN

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of foundation design of the proposed reconstruction of Culverts 21A, 24A, 25A and 27A in the Collingwood Township, based on our interpretation of the factual information obtained during this investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

These four (4) culverts are located on Highway 26, approximately 0.1 km to 3.7 km east of the junction of St. Vincent and Collingwood Townships. Table 1 summarizes the locations, structure types and dimensions of the existing and replacement culverts as recommended by the PDR and provided in the RFP documents. The PDR recommended replacement of Culvert 27A with a 3.6 m span by 1.5 m high structural culvert. There is no work required for Culvert 27A as the project develops and as per the final culvert recommendations provided by Stantec. The foundation data and information for Culvert 27A are left in this report for future reference. Locations of the individual culverts are illustrated in the Borehole Location Plan, Drawing 1 presented in Appendix A. The existing concrete culverts, although in good conditions, are hydraulically under capacity.

Table 1
Summary of location, structure type, dimensions

Culvert #	New Chainage (m)	Existing Culvert Type and Size, W X H	Existing Overfill (m)	Recommended Replacement Culvert Type and Size	Length (m)	U/S Culvert Invert (m)	D/S Culvert Invert (m)
21A	Relocate to 10+100	Concrete 1.5m X 1.2 m	1.9	Precast Concrete Box 1.5m X 0.9m	20.03	Under Develop-ment	Under Develop-ment
24A	Relocate 10+840	Concrete 1.5m X 0.9 m	0.8	Precast Concrete Box 2.7m X 0.9m	17.59	Under Develop-ment	Under Develop-ment
25A	Relocate 11+680	Concrete 0.9m X 0.6m	1.0	Precast Concrete Box 2.7m X 1.2m	18.20	Under Develop-ment	Under Develop-ment
27A	13+731	Concrete 1.8m X 1.2m	1.2	No Work Required	Not Applicable	Not Applicable	Not Applicable

These culvert sites are generally located within drainage valleys or surface water flow paths. The overfill heights range approximately between 0.8 m and 1.9 m. The embankment slopes are typically 2.5H to 3H:1V and are grass covered. No signs of embankment slope instability were observed at the time of this foundation investigation. Site photographs taken during a site visit in March 2006 by Stantec are provided in Appendix C.

The existing culverts are to be replaced with new culverts, with box culverts being the preferred structures as per the PDR report.

The recommended replacement culvert type and size were provided in the final culvert recommendations spreadsheet supplied by Stantec.

5.2 Summarized Construction Conditions

The following table summarizes the anticipated founding subgrade conditions for the replacement culverts, bedding and backfill requirements and the excavation/cut slope methodology, along with the applicable OPSD's for construction of the proposed replacement culverts. The anticipated foundation subgrade was established based on the invert elevations provided by Stantec, with anticipation of the bedding subgrade to be approximately 0.5 m below the box culvert invert (0.2 m concrete slab over 0.3 m of bedding material). Classification of the soil types for excavation in accordance with the latest amendment of OHSA and O. Reg. 213/91 are also provided in the following table.

Culvert #	ANTICIPATED FOUNDING SUBGRADE	BEDDING, BACKFILL	OHSA & O.Reg. 213/91 EXCAVATION SOIL TYPE*
21A	Stiff to hard silty clay till	OPSD 803.010	TYPE 3
24A	Compact clayey gravelly silty sand and very stiff to hard silty clay till or shale bedrock	OPSD 803.010	TYPES 3 AND 4
25A	Very dense sandy silt till and shale bedrock	OPSD 803.010	TYPE 3
27A	Dense to very dense sand to silt till	OPSD 803.010	TYPE 3

5.3 Foundations and Culvert Bedding

The closed box culverts should be designed to OPSS 1821 and CAN/CSA-S6-06 and to withstand the appropriate weight of overfill, traffic loadings (CL-625-ONT), temporary construction loads and critical loading effects during construction. If the base slab does not have adequate frost cover/protection, it should be designed for frost pressures.

As there was no hydrostatic pressure observed during borehole sampling, piping is not considered likely to occur at the founding subgrade of the culvert.

As per CAN/CSA-S6-06, Clause 1.9.5.6, a cut-off wall of sufficient depth and strength shall be provided at the ends of the culvert to prevent undermining. The depth of the cut-off wall should be designed cognizant of the hydraulic condition (CAN/CSA-S6-06, Section 1.9) and the frost depth of 1.4 m (OPSD 3090.101).

The top of Culvert C24A, C25A and C27A will be placed at depths of between 0.8 and 1.2 m below the finished grade and above the frost depth, adequate frost treatment (taper) should be provided in accordance with OPSD803.010. The excavation for the installation of the box culverts shall follow OPSS 902 and SSP902S01.

5.3.1 Non-Structural Box Culverts (C21A, C24A, C25A)

The bedding material, cover and backfill for non-structural precast concrete box culverts (<3m span) shall conform to OPSS 422 and SSP422S01. The bedding should be Granular “A” and should be 0.15 times of the width of the culvert, and should not be less than 150 mm and not more than 300 mm. The placement and compaction of the bedding layer should conform to OPSS 422.07.07. A 75 mm thick uncompacted Granular “A” or fine aggregates (OPSS 1002) shall be placed on the bedding layer as leveling course.

5.3.2 Box Culvert (C27A)

Based on the borehole results, spread footings may be used for the culvert walls, headwalls (wing walls) and retaining walls, and designed to bear on the undisturbed, dense to very dense sandy silt till to sand and silt till at the elevation and bearing resistances shown below:

Borehole Location	Highest Elevation (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa)
27A-1	193.65	800	400
27A-2	193.50	800	400
27A-3	194.40	800	400

A buried topsoil layer extends to a depth of 3.05 m (Elevation 193.69 m) at Borehole 27A-2, which is approximately 1m below the invert of the existing culvert. In view of the variable highest subgrade elevations for a proposed box culvert replacement, considerations could be given to raising the subgrade to a common elevation using engineered fill.

Preparation for engineered fill construction should consist of removing the topsoil layer and any deleterious material to expose the native, compact to very dense sandy silt to sand and silt till. The engineered fill subgrade should be inspected and approved by the Geotechnical Engineer ,or a Quality Verification Engineer (QVE) as per SSP199S48, prior to placement of the engineered fill. Depending on the geometry of the engineered fill subgrade, benching of the subgrade may be required to provide adequate and uniform support of the engineered fill.

The engineered fill should consist of OPSS Granular A, Granular B Type I or II, or Granular C material. It should be placed and compacted in thin lifts to 100% of the material`s standard Proctor maximum dry density (SPMDD), as determined using Method A of OPSS 501.08.02. The lift thickness of the engineered fill should be limited to between 150 mm and 300 mm depending on the compaction equipment used, as determined in the field by the Geotechnical Engineer. The engineered fill should be compacted under the full-time supervision of the Geotechnical Engineer or a QVE. Compaction tests should be carried out on each lift of fill placed to confirm that the specified degree of compaction has been achieved. Subsequent lifts of fill should not be placed until the specified degree of compaction of the current lift is achieved. A certificate of conformance shall be provided to the Contract Administrator as per the requirements of SSP199S48.

Foundations constructed on the engineered fill improved subgrade could be design to impose the following geotechnical resistances and reactions:

Type of Engineered Fill Material	Highest Elevation (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa)
OPSS Granular A	194.5	500	250
OPSS Granular B Type I	194.5	400	200
OPSS Granular C	194.5	300	150

The SLS value given above is based on a maximum settlement of 25 mm. This can be achieved provided that the founding subgrade is undisturbed during the construction.

Under inclined loading conditions, the bearing resistance at ULS should be reduced in accordance with Clause 6.7.4 of CAN/CSA-S6-06.

As there was no hydrostatic pressure observed during borehole sampling (within the sandy silt to sand and silt till), piping is not considered likely to occur at the founding subgrade of the culvert.

5.3.3 Open Footing & Spread Footing (C27A)

In view of the presence of fill in Borehole 27A-2 extending to a depth of 3.05 m (Elevation 193.69 m), which is approximately 1m below the invert of the existing culvert, considerations could also be given to replacing the existing culvert with an open footing culvert.

Based on the borehole results, spread footings may be used for the culvert walls, headwalls (wing walls) and retaining walls, and designed to bear on the undisturbed, dense to very dense sandy silt till to sand and silt till at the elevation and bearing resistances shown below:

Highest Elevation (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa)
193.50	800	400

The SLS value given above is based on a maximum settlement of 25 mm and estimated footing widths of between 1 and 3 m. This can be achieved provided that the founding subgrade is undisturbed during the construction.

Under inclined loading conditions, the bearing resistance at ULS should be reduced in accordance with Clause 6.7.4 of CAN/CSA-S6-06.

As there was no hydrostatic pressure observed during borehole sampling (within the sandy silt to sand and silt till), piping is not considered likely to occur at the founding subgrade of the culvert.

5.3.4 General

Fill materials could likely be encountered in the creek bed and below the design culvert invert elevations. The fill materials could be variable and unpredictable and considered unsuitable for providing indirect support of the culverts. Where encountered, the fill materials beneath the non-structural culvert should be removed to expose the native undisturbed subgrade, and replaced with additional compacted bedding material. Engineered fill could be constructed to raise the foundation subgrade to a common elevation for the structural culvert (27A).

Under unfavourable wet weather condition, the subgrade could become softened and unstable. If unstable condition persists, the thickness of the bedding material will have to be increased to 600 mm where saturated sand to silt subgrade is encountered for non-structural culverts.

The granular backfill shall meet the gradation requirements of OPSS 1010 for Granular “B” Type III, placed in lifts not exceeding 200 mm and compacted to at least 95% SPMDD in accordance with OPSS 501 and OPSS 422.07.11.

5.4 Lateral Earth Pressures

The lateral earth pressures acting on the culvert walls, headwalls (wing walls) and retaining walls will depend on the type and method of placement of the backfill materials and on the subsequent lateral movement of the structure whether it is restrained or unrestrained. The lateral earth pressures to be used in the design should be computed in accordance with Section 6.9 of the CAN/CSA-S6-06.

Granular backfill should be constructed behind the culvert walls, headwalls (wing walls) and retaining walls as per OPSD 3121.150, with particular attention to the frost taper requirement. The granular backfill should conform to OPSS 1010 for either Granular "A" or Granular "B" Type III. To maintain free draining characteristics in granular fill materials, the maximum percentage passing the No. 200 sieve (75 µm) should be limited to 5%.

The backfill should be constructed as per OPSS 902 and OPSS 501, and SSP 902S01. A perforated subdrain should be installed behind the walls with a positive outlet or wall drains as per OPSD 3190.100 to drain the granular fill above the stream water level. Alternatively, the culvert walls could be designed to resist hydrostatic pressure.

The lateral earth pressure, P_h, may be computed using the equivalent fluid pressures presented in Clause 6.9.2.3 of the CAN/CSA-S6-06, or employing the following equation based on unfactored earth pressure distributions:

$$P_h = K\ (\gamma h + q)$$

Where:

K = earth pressure coefficient, use value from table below

γ = unit weight of soil, = 21.2 kN/m^3 for Granular "B"
= 22.8 kN/m^3 for Granular "A"

h = depth below top of wall, m

q = live load surcharge, of 0.8 m of fill as per Clause 6.9.5, CAN/CSA-S6-06

Wall Type	**Earth Pressure Coefficient (K)**	
	Granular "A" $\phi = 35^o$	**Granular "B" $\phi = 30$ to 35^o**
Restrained Wall (K_o)	0.43	0.50 to 0.43
Unrestrained Wall (K_a)	0.27	0.33 to 0.27

The submerged unit weight of the backfill should be used for any submerged portion of the granular backfill when calculating the lateral earth pressure.

The above parameters are based on a horizontal back slope (not exceeding 5 degrees) behind the headwalls. A compaction surcharge equal to 12 kPa should be included in the lateral earth pressures for the structural design of the headwalls and retaining walls in accordance with Clause 6.9.3 of the CAN/CSA-S6-06.

Vibratory equipment for use behind abutments and retaining walls should be restricted in size as per current MTO practices.

5.5 Embankment Widening

The existing approach embankments are up to 3.5 m high adjacent to the proposed replacement culvert. For the widening of the embankment, the surficial topsoil and any deleterious materials should be stripped or excavated prior to placing fill materials. The embankment widening should then be constructed as per OPSD 202.010, 202.030 and 208.010, with emphasis on adequate benching of the subgrade for receiving the embankment fill. The fill to be used for embankment construction can either be imported silty clay or granular materials. Granular materials are preferred over silty clay for compaction and drainage.

Backfill adjacent to the structure should be carried out in conformance with OPSS 902, SSP902S01 and OPSD 3101.150, and the fill should be placed and compacted in accordance with OPSS 501.

Based on the findings of the field investigation, no foundation stability or settlement problems due to widening the approach embankments on the inorganic native soils are anticipated for embankment slope of 2.5H:1V and up to 3.5 m high. The fill placement should begin at the toe of the embankment, in leveled lifts and each lift compacted to at least 98% SPMDD. Benching into the existing embankment slope at 1 m high steps is recommended as per OPSD 208.010.

After stripping, the exposed subgrade should be inspected and approved by the geotechnical engineer. The approved subgrade should then be proof-rolled using a heavy compactor, as directed by the engineer. Unless the excavation is carried out in wet weather conditions, no unusual dewatering is anticipated during stripping and preparation of the subgrade to receive the embankment fills. Where necessary, dewatering can be carried out using gravity drainage and pumping from open filtered sumps in accordance with OPSS 517 and 902, and SSP902S01, with emphasis on the requirements of OPSS 518.

Measures should be incorporated into the design and staging to ensure that the slope surfaces are protected from surface erosion in accordance with the requirements of OPSS 577. Proper erosion control measures should be implemented both during construction of the embankment fills and permanently. Erosion control during construction should be carried out by installing silt fences. Properly designed erosion control blankets could also be placed on any new embankments and adjacent disturbed embankments after completion of fill placement. A vegetative cover should be established as soon as practical upon completion of fill placement to minimize the chances of surface erosion.

Revetments such as rip-rap blanket should be provided at the toe of the slope and the ends of the culvert to prevent erosion/scour by stream action in accordance with OPSS 511, SSP511S01, and

OPSD 810.010. The design of the rip-rap blanket should be carried out cognizant of the stream hydraulics.

5.6 Excavation, Groundwater Control and Temporary Support

Excavation for this project will involve the construction of the box culvert and shale bin. Depending on the design that is finally selected, the anticipated maximum depth of excavation below the existing grade of Highway 26 is between 3.5 and 5.0 m.

Excavation to depths of up to 5.0 m should not present any special difficulties using heavy excavation equipment, provided it is constructed in accordance with OPSS 501, 514, 517, 518, 539, 577 and, 902, SSP421S01, SSP422S01, SSP902S01 and OPSD 803.010 and 3121.150. However, the buried utilities along the west side of the embankment will likely be in conflict with the excavation. Excavation and protection procedures shall conform to SSP 105S19 and should be reviewed with the utility companies or authorities prior to construction.

Where loose/soft, organic and deleterious fill materials are exposed at the subgrade, the thickness of the bedding material will have to be increased. This applies to unstable subgrade condition resulted from wet weather. The procedures for additional excavation and bedding material are covered in OPSS 421, 422 514 and 902, SSP421S01, SSP422S01 and SSP902S01.

The water in the stream can be controlled by temporary diversion or dam and pump method. Saturated fine granular soils (sand, silty sand, silt and sandy silt) could be encountered during excavation, and groundwater control will be required to handle surface runoff and minor seepage. The minor groundwater ingress can be controlled using intercept ditches and pumping from filtered sump pits.

It is noted that a “Permit To Take Water” (PTTW, Regulation 387/04) will be required from the MOE (Ministry of Environment) when the total quantity of water to be handled exceeds 50,000 litres/day while employing temporary pumping of water, flow passages through culverts, stream diversion or dam and pump method as groundwater control measures (unwatering). It may take up to 90 days for MOE to review an application and issue a permit. It is understood that the amount of water to be handled will be based on a two-year storm event.

It should be pointed out that if the founding soil is disturbed, excessive settlements could occur after structural loads are applied. The founding level will be located below the stream bed and, therefore, care should be exercised to minimize disturbance to the bedding subgrade. Any disturbed subgrade should be sub-excavated and replaced with thickened and compacted bedding material.

All excavation must be carried out in compliance with the requirements of the Occupational Health and Safety Act (OHSA). For this purpose, the unsaturated upper fill and loose to compact sandy soils encountered at this site are classified as Type 3 soils and the very stiff to hard clayey silt to silty clay soils are classified as Type 2 soils. Saturated cohesionless soils are classified as Type 4 soils.

For the Type 2 soils, the excavation shall be cut to near vertical in the bottom 1.2 m and then trimmed back to 1H:1V. Within the Type 3 soils and above the water table, the excavation shall be cut to no steeper than 1H : 1V throughout. Side slopes of 3H:1V or flatter shall be used for excavation within Type 4 soils.

Temporary support within the overfill of the existing and new culverts may be required to facilitate culvert construction and to maintain access for construction and local traffic, and emergency vehicles. The staging of different phases of this work should be examined to determine if roadway protection is required. Roadway protection is generally a contractor design/build item in accordance with SSP 105S19 and current MTO practices.

5.7 Frost Protection

This project is located in the Owen Sound Operations District. The design frost penetration depth for this project is 1.4 m in accordance with OPSD 3090.101. All foundations and spread footings should be provided with at least 1.4 m of soil cover for adequate frost protection.

5.8 Scour Depth

The footings should be founded below the anticipated local and general scour depths as per CAN/CSA-S6-06, Clause 1.9, Hydraulic Design. The permissible velocities of the various soil types which will be exposed at the streambeds (based on American Society of Civil Engineers publication, 1926, reprinted as Design Chart 2.17, MTO Drainage Management Manual 1997) are provided in the following table:

Soil Type	Permissible Velocity (m/sec)
Sand	0.6
Silty Sand	0.7
Sandy Silt	0.8
Silt	0.8
Sandy Silt Till	1.2
Clayey Silt	1.5
Silty Clay	1.5
Silty Clay Till	1.8

6.0 STATEMENT OF LIMITATION

We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

The Limitations of Report, as quoted in Appendix D, is an integral part of this report.

We trust that we have completed the assignment within the Terms of Reference for this project. If there are any questions concerning this report, please do not hesitate to contact our office.

Yours truly,
Infrastructure Engineering Group Inc.

LICENSED PROFESSIONAL ENGINEER
E.Y. CHUNG
8345506
PROVINCE OF ONTARIO

Eric Y. Chung, M.Eng., P.Eng.
Designated MTO Contact

Joseph Law, P.Eng.
Project Manager

LICENSED PROFESSIONAL ENGINEER
J. C-Y. LAW
PROVINCE OF ONTARIO

Tom O'Dwyer, P. Eng.
Quality Review Engineer

Appendix A

Drawings 1 & 2

Borehole Location Plan & Profile

METRIC

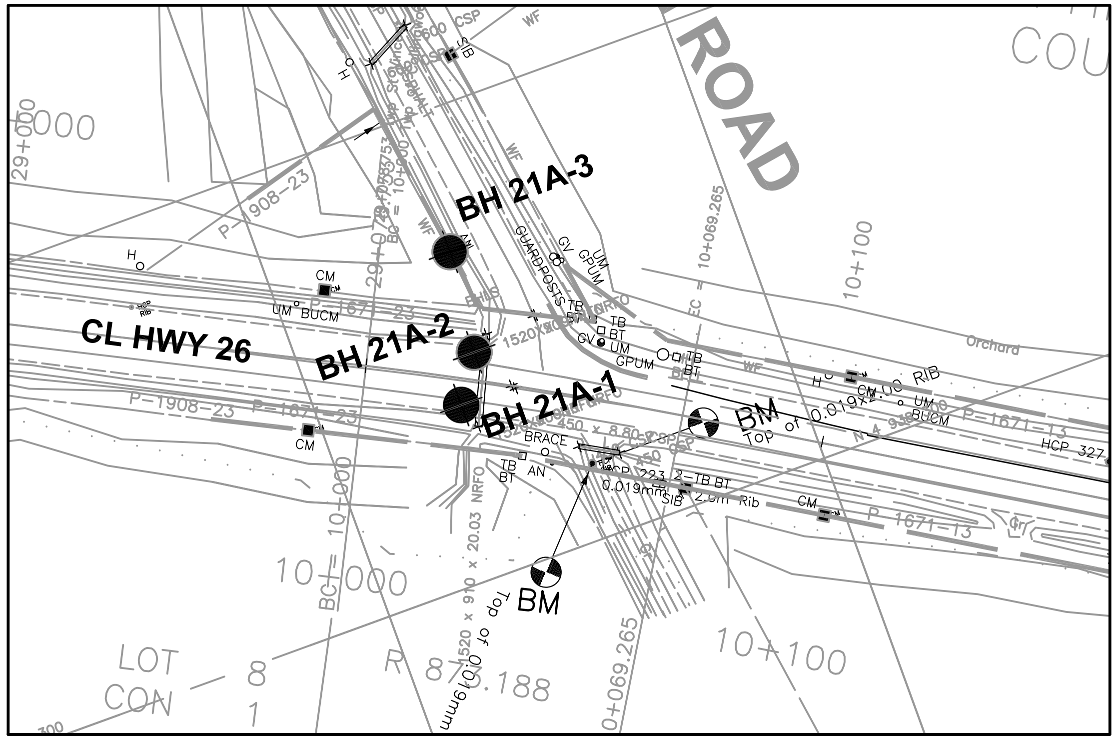
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

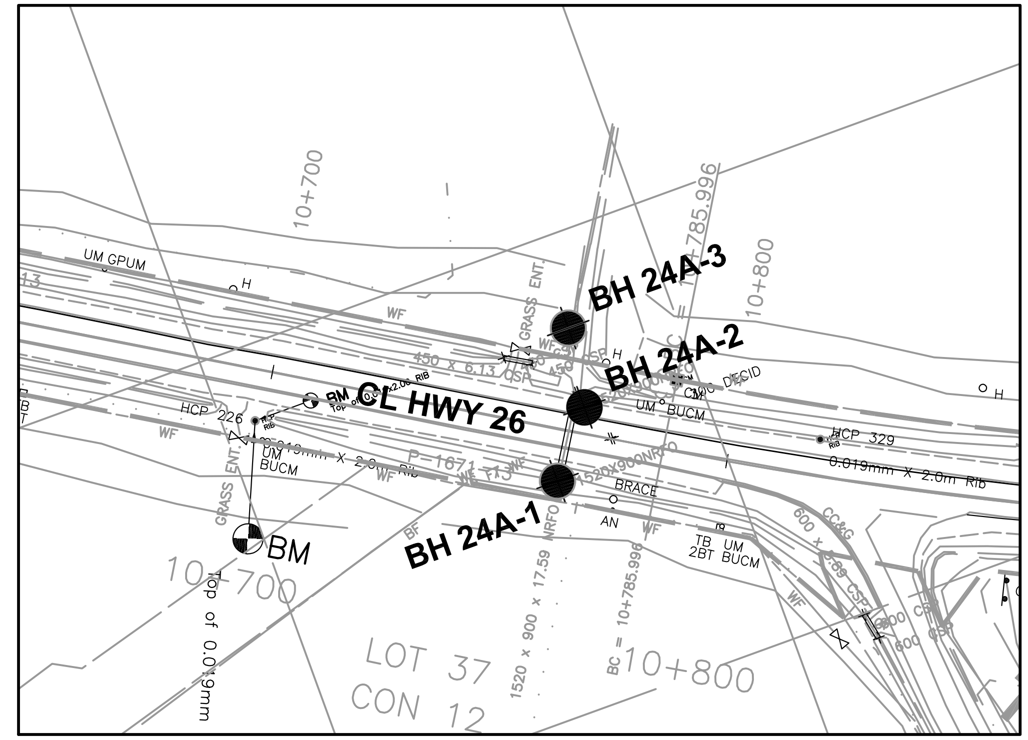
CONT No xxxx–xxxx
WP No GWP 57–00–00

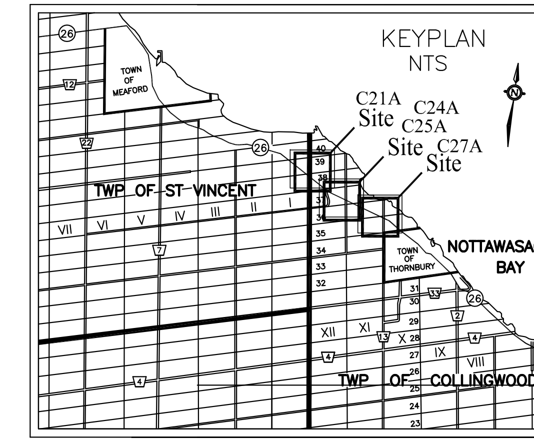
Culvert # C21A, C24A, C25A & C27A
Highway 26
BOREHOLE LOCATION PLAN

SHEET 1

I.E. Group — Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

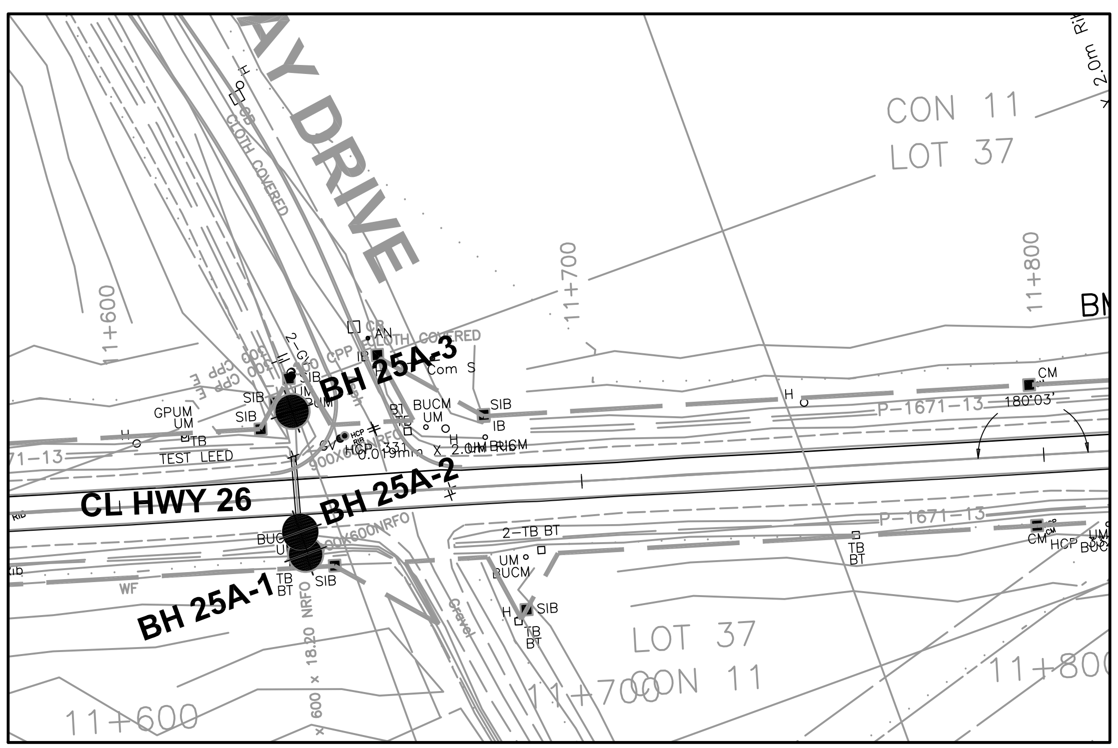


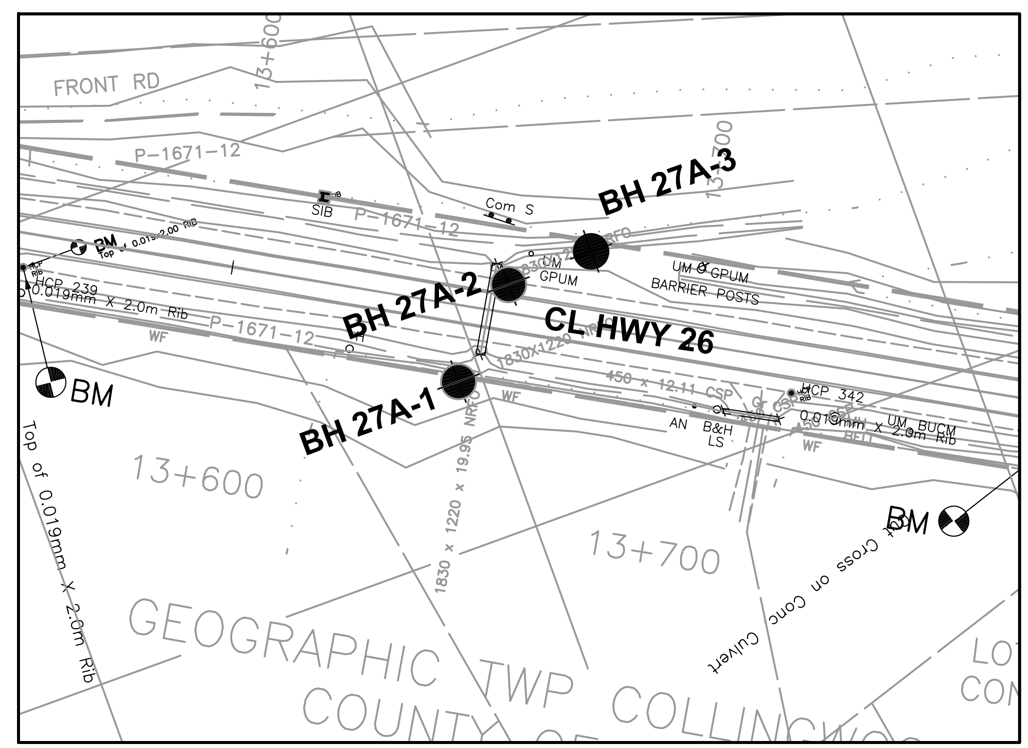




LEGEND

Symbol	Description
●	Bore Hole
⊕	Dynamic Cone Penetration Test (Cone)
⊕	Bore Hole & Cone
N	Blows/0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
▼	W L at time of investigation
	Standpipe





NOTES

1. THE COMPLETE FOUNDATION INVESTIGATION AND DESIGN REPORT FOR THIS PROJECT AND OTHER RELATED DOCUMENTS MAY BE EXAMINED AT THE ENGINEERING MATERIALS OFFICE, DOWNSVIEW. INFORMATION CONTAINED IN THIS REPORT AND RELATED DOCUMENTS ARE SPECIFICALLY EXCLUDED IN ACCORDANCE WITH THE CONDITIONS OF SECTION GC2.01 of OPS GEN. COND.

BOREHOLE NO.	ELEV.	UTM CO–ORDINATES		BOREHOLE NO.	ELEV.	UTM CO–ORDINATES		BOREHOLE NO.	ELEV.	UTM CO–ORDINATES		BOREHOLE NO.	ELEV.	UTM CO–ORDINATES	
		NORTH	EAST			NORTH	EAST			NORTH	EAST			NORTH	EAST
C21A–1	234.32	4938338	224430	C24A–1	234.17	4937949	225064	C25A–1	223.23	4937665	225891	C27A–1	194.96	4937035	227795
C21A–2	234.54	4938347	224437	C24A–2	235.37	4937962	225075	C25A–2	224.29	4937670	225892	C27A–2	196.74	4937051	227812
C21A–3	232.12	4938370	224439	C24A–3	234.07	4937980	225077	C25A–3	223.05	4937695	225899	C27A–3	194.96	4937052	227831

SCALE

100m — 0 — 50m

REVISIONS			
13/03/09	J.L.	Final	
15/01/08	J.L.	Draft	
DATE	BY	DISCRIPTION	

MTO GEOCRES No. 41A–206

HWY No.	HWY 26		DIST	Owen Sound
SUBM'D J.L.	CHECKED E.C.	DATE 15/01/08	SITE	21A, 24A, 25A & 27A
DRAWN J.L.	CHECKED J.L.	APPROVED E.C.	DWG	1

METRIC

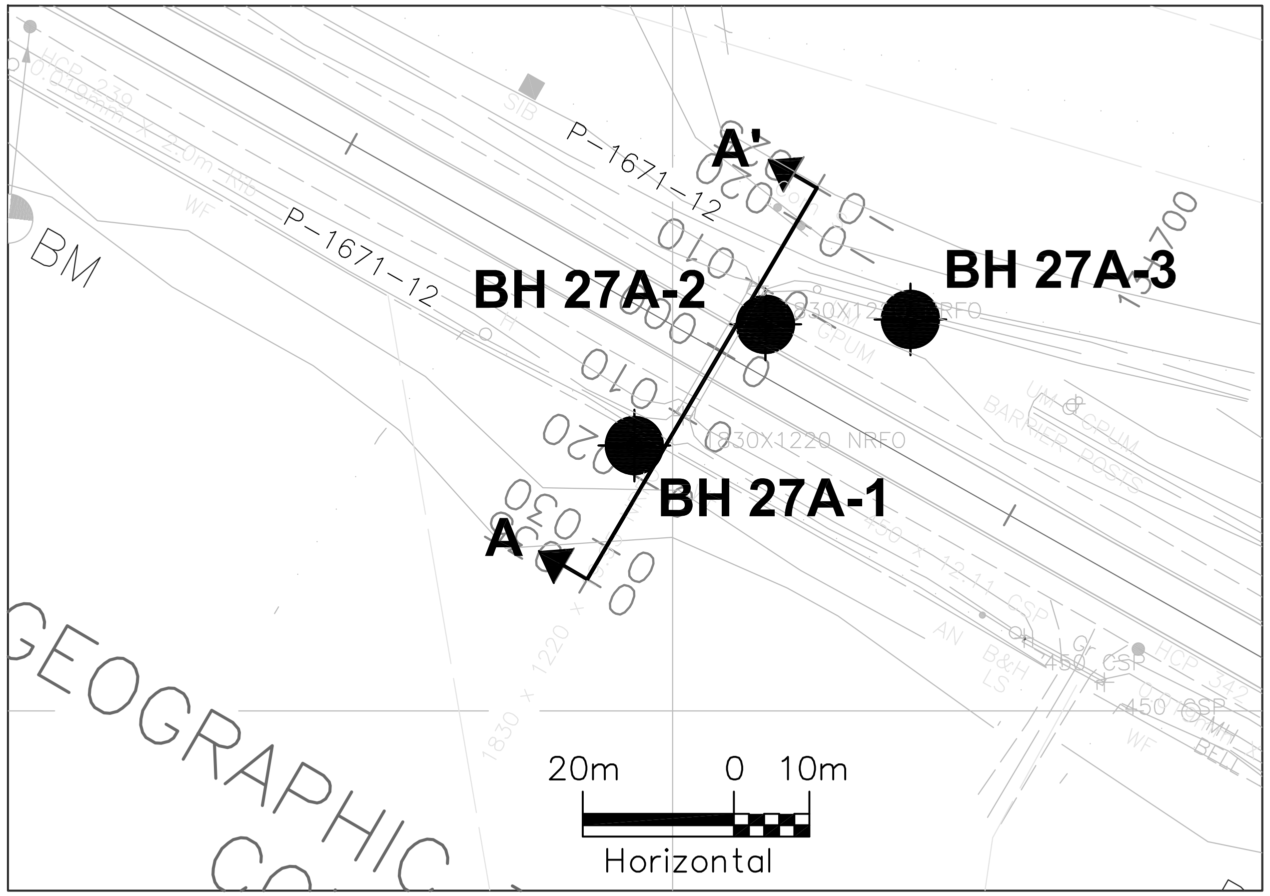
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No xxxx–xxxx
WP No GWP 57–00–00

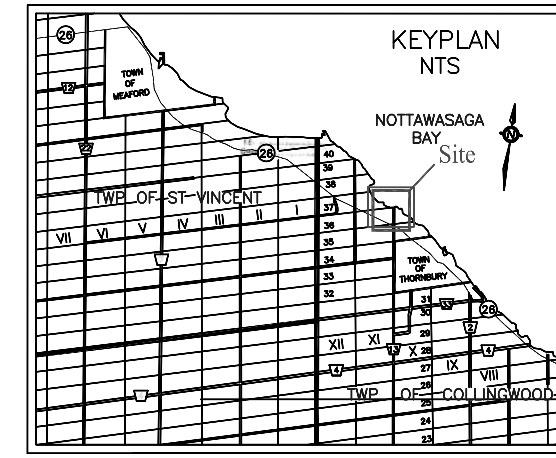
Culvert C27A
Highway 26
BORE HOLE LOCATIONS & SOIL STRATA

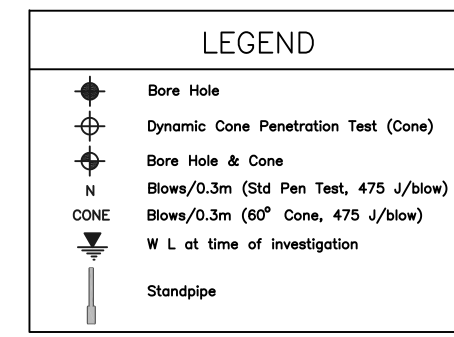
SHEET 2

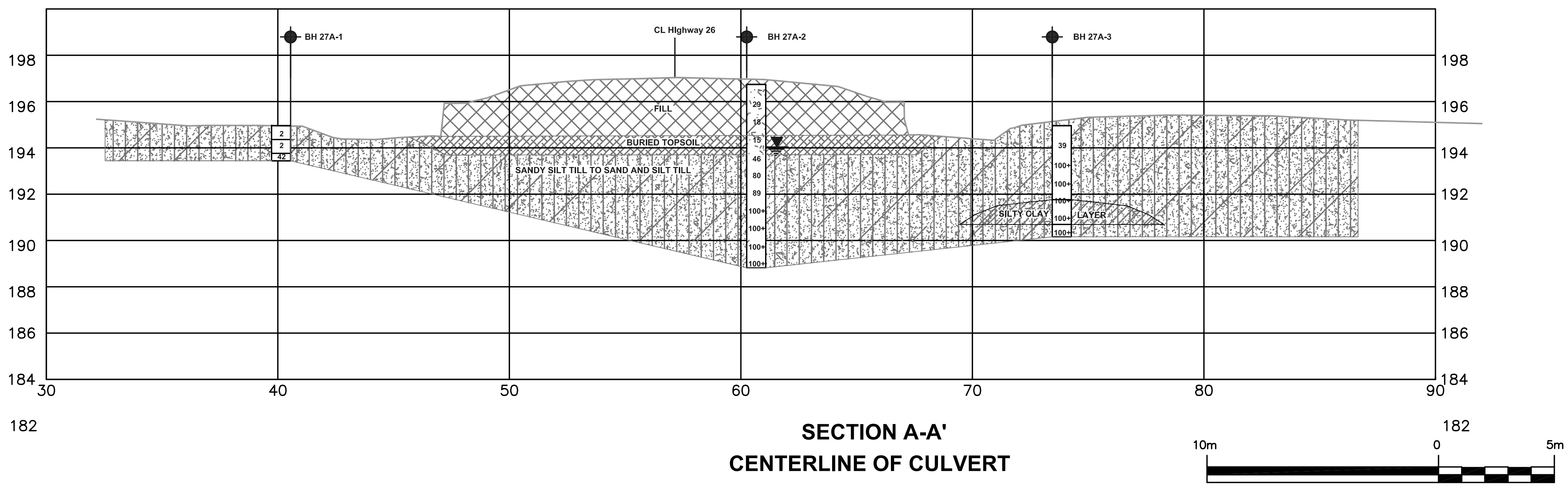
I.E. Group — Infrastructure Engineering Group Inc. Pavement & Construction Materials Consulting Engineers — GTA • Kitchener • London • Windsor



BOREHOLE LOCATION PLAN







SECTION A-A'
CENTERLINE OF CULVERT

REVISIONS DATE	BY	DISCRIPTION
13/03/09	J.L.	Final
31/01/08	J.L.	Draft

Geocres : 41A–206

NOTES
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2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES AND BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.
3. SUBGRADE ELEVATION OF THE EXISTING FOOTING NOT KNOWN AND IS ESTIMATED TO BE AT 1.2m BELOW THE CREEK BED.
4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

BOREHOLE NO.	ELEVATION	UTM CO–ORDINATES NORTH	EAST
27A–1	194.96	4937035	227795
27A–2	196.74	4937051	227812
27A–3	194.96	4937052	227831

HWY No. HWY 26			DIST Owen Sound
SUBM'D J.L.	CHECKED E.C.	DATE 31/01/08	SITE Culvert C27A
DRAWN J.L.	CHECKED J.L.	APPROVED E.C.	DWG 2

Appendix B

Explanation of Terms Used in Report
Record of Borehole Sheet
Laboratory Test Results

Culvert Site	**Borehole Logs**	**Grain Size**	**Atterberg Limits**
21A	21A-1 to 3	Figures C-21A.1 & 2	Figure C-21A.3
24A	24A-1 to 3	Figures C-24A1, 2, 4 & 6	C-24A.3, 5 & 7
25A	25A-1 to 3	Figures C25A.1, 2 & 4	Figures C25A.3 & 5
27A	27A-1 to 3	Figures C27A.1, 2 & 4	Figures C27A.3 & 5

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 475 J 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 (R Q D), FOR MODIFIED RECOVERY, IS:

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

JOINTING 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

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	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_α	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_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

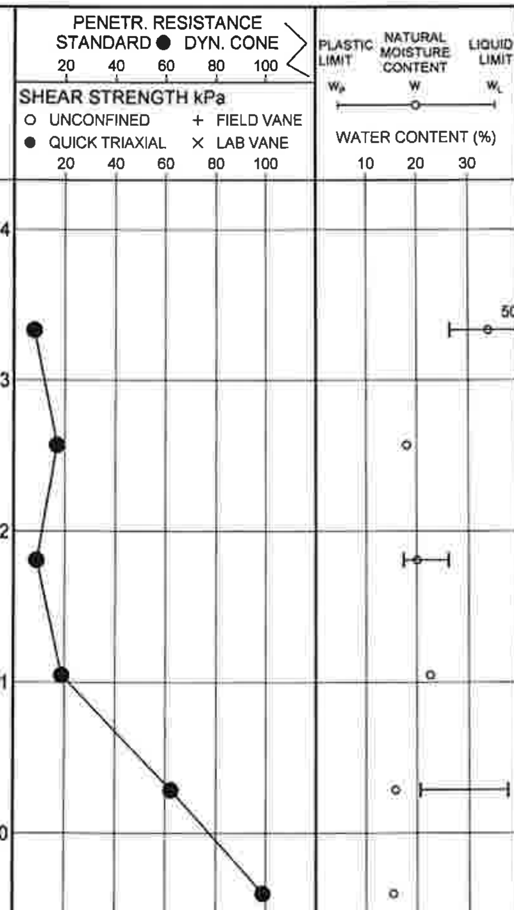
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
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	1	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$
I_C		CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
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 21A-1

METRIC

W.P.	GWP 57-00-00	LOCATION	Northing - 4938336, Easting - 224430
DIST	Owen Sound HWY 26	BOREHOLE TYPE	S/S Augering, 110 mm dia.
DATUM	Geodetic	DATE	09.17.07 - 09.17.07
ORIGINATED BY	JL	COMPILED BY	JL
CHECKED BY	EC		

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	NATURAL MOISTURE CONTENT / LIMITS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.32	Ground							
0.00	150mm sand and gravel FILL							
	Silty CLAY TILL (CL-CH) Moist, stiff to hard, embedded sand and gravel; brown	1	SPT	8		50		4 4 47 45 (92)
		2	SPT	17			21.7	
		3	SPT	9			23.5	6 9 61 23 (85)
		4	SPT	19	∇			Water level measured @ 3.4m @ completion
	grey	5	SPT	63				0 2 63 35 (98)
		6	SPT	100+				
229.44 4.88	End of Borehole							



+³, ×³: Numbers refer to Sensitivity   O¹⁵⁰ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 21A-2

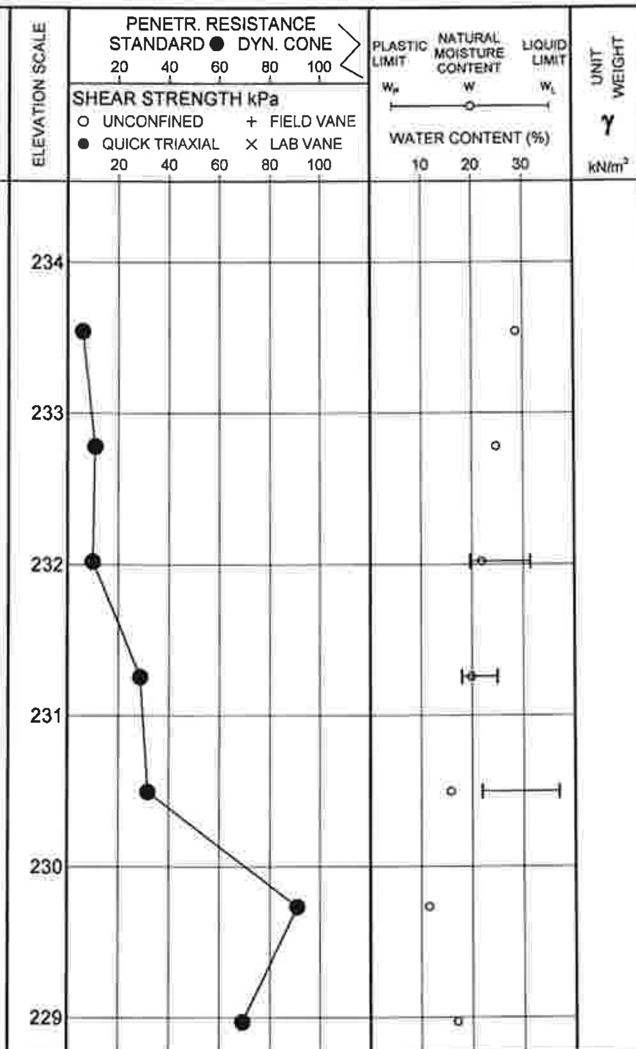
METRIC

W.P. GWP 57-00-00 | LOCATION Northing - 4938347, Easting - 224437 | ORIGINATED BY JL

DIST Owen Sound HWY 26 | BOREHOLE TYPE S/S Augering, 110 mm dia. | COMPILED BY JL

DATUM Geodetic | DATE 07.24.07 - 07.24.07 | CHECKED BY EC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.53	Ground					
0.00	300 mm sand and gravel FILL					
234.23 0.30	FILL Brown, moist, loose to compact, consisting of silty clay with topsoil pockets, trace gravel	1	SPT	6		3 17 46 35 (81)
		2	SPT	11		
232.24 2.29	Silty CLAY TILL (CL-CI) Moist, stiff to hard, embedded sand and gravel; brown	3	SPT	10		0 4 64 32 (96)
		4	SPT	29	∇	30 31 29 10 (40)
		5	SPT	32		9 8 51 32 (83)
	grey	6	SPT	92		
		7	SPT	70		
228.74 5.79	End of Borehole					Water level measured @ 3.4m @ completion



+3, ×3: Numbers refer to Sensitivity

O 150 UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 21A-3

METRIC

W.P. GWP 57-00-00	LOCATION Northing - 4938370, Easting - 224439	ORIGINATED BY JL
DIST Owen Sound HWY 26	BOREHOLE TYPE S/S Augering, 110 mm dia	COMPILED BY JL
DATUM Geodetic	DATE 09.17.07 - 09.17.07	CHECKED BY EC

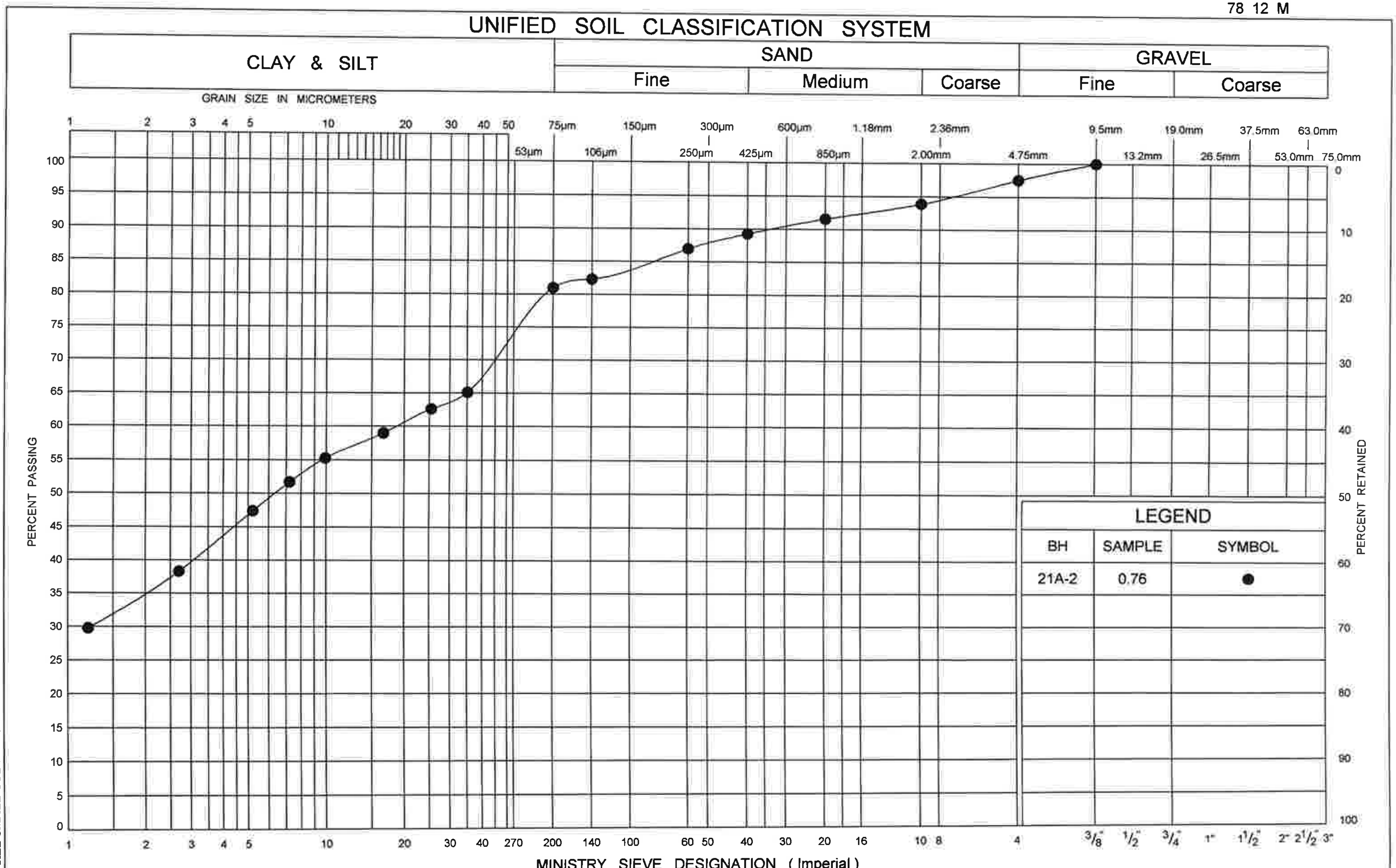
ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT / LIMITS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
232.12	Ground							
0.00	125mm TOPSOIL				232			
	brown	1	SPT	20	231			
		2	SPT	19				7 21 42 31 (73)
	Silty CLAY TILL (CL-CI) Moist, very stiff to hard, embedded sand and gravel	3	SPT	52	230		23.5	
					229			hit cobble
	grey	4	SPT	100+				
		5	SPT	25	228			hit cobble @ 4.6 m
227.40 / 4.72		6	SPT	100+				12 13 47 28 (75)
	End of Borehole							Borehole dry and open @ completion

PENETR. RESISTANCE: STANDARD ● DYN. CONE (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; WATER CONTENT (%) 10 20 30; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; GROUND WATER CONDITIONS; STRAT PLOT

$+^3, \times^3$: Numbers refer to Sensitivity

O [150] UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

78 12 M



BH	SAMPLE	SYMBOL
21A-2	0.76	●

GRAIN SIZE DISTRIBUTION

FILL

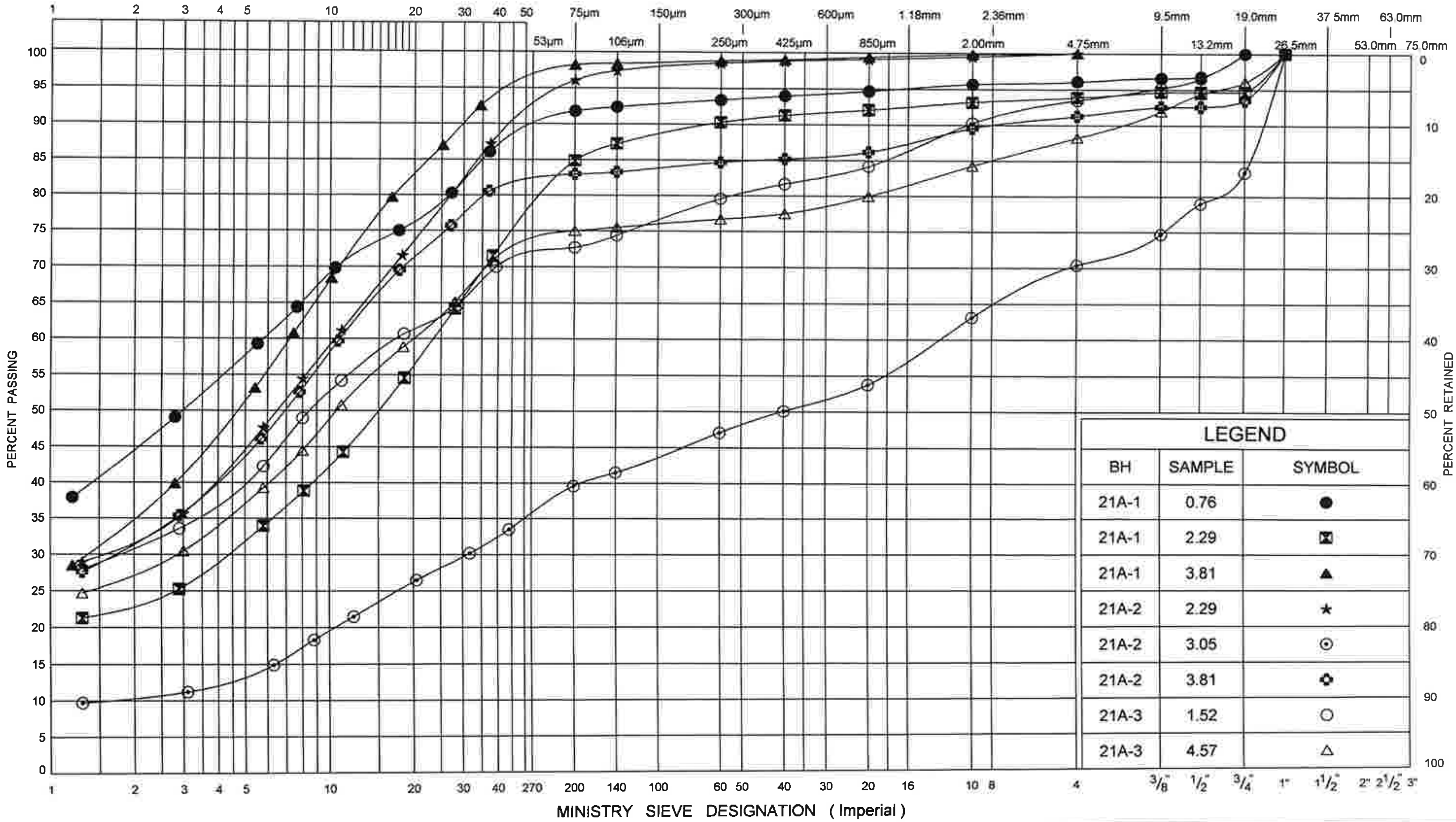
Ministry of Transportation
Ontario

FIG No C- 21A.1

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT GRAIN SIZE SMALL CULVERTS 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

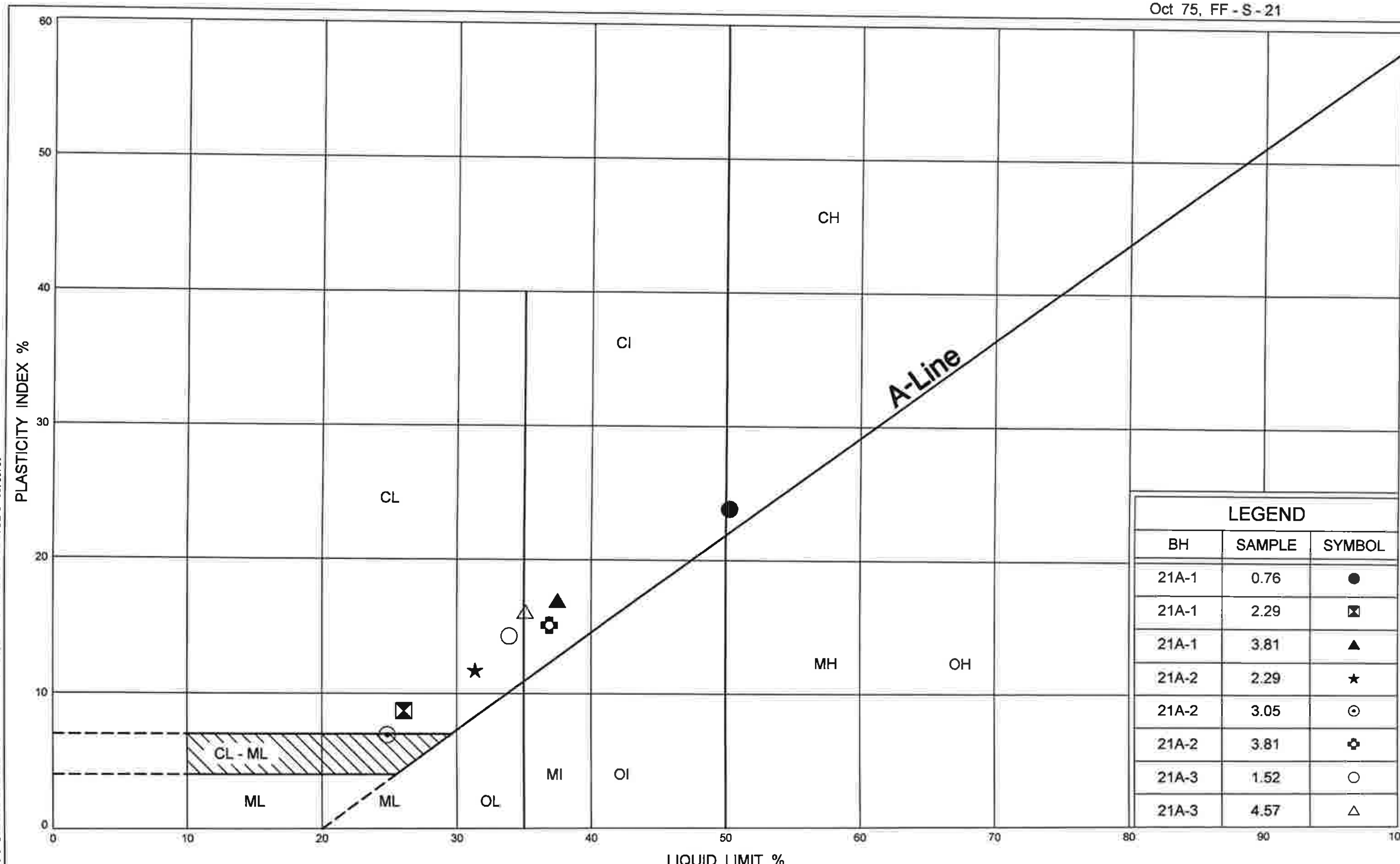
SILTY CLAY TILL, CL-CH

FIG No C- 21A.2

GWP 57-00-00

HWY 26, Thornbury to Meaford

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
21A-1	0.76	●
21A-1	2.29	⊠
21A-1	3.81	▲
21A-2	2.29	★
21A-2	3.05	⊙
21A-2	3.81	✿
21A-3	1.52	○
21A-3	4.57	△

Ministry of Transportation
Ontario

PLASTICITY CHART
SILTY CLAY TILL, CL-CH

FIG No C- 21A.3

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT PLASTICITY CHART SMALL CULVE 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

RECORD OF BOREHOLE No 24A-1

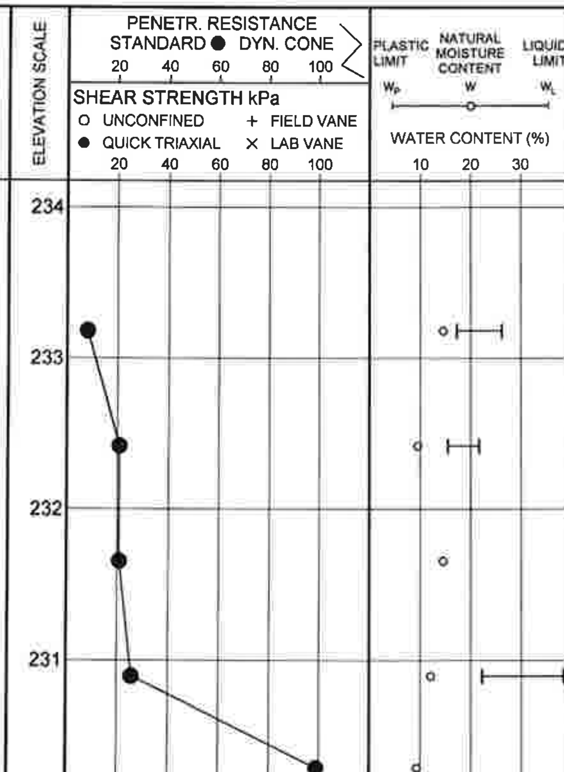
METRIC

W.P. GWP 57-00-00 LOCATION Northing - 4937949, Easting - 225064 ORIGINATED BY JL

DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY JL

DATUM Geodetic DATE 07 24 07 - 07 24 07 CHECKED BY EC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	UNIT WEIGHT γ (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.17	Ground						
0.00	150mm TOPSOIL						
	Clayey Silty Gravelly SAND (SC-SM-SW) Brown, moist, loose to compact, some gravel	1	SPT	8			11 42 30 16 (46)
		2	SPT	21			26 45 21 7 (28)
231.88 / 2.29	Silty CLAY TILL (CI) Grey, moist, very stiff to hard, embedded sand and gravel	3	SPT	21		22.0	
		4	SPT	26			4 4 59 33 (92)
230.21 / 3.96		5	SPT	100+			
	End of Borehole						Borehole dry and open @ completion



+3, ×3: Numbers refer to Sensitivity O 150 UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 24A-2

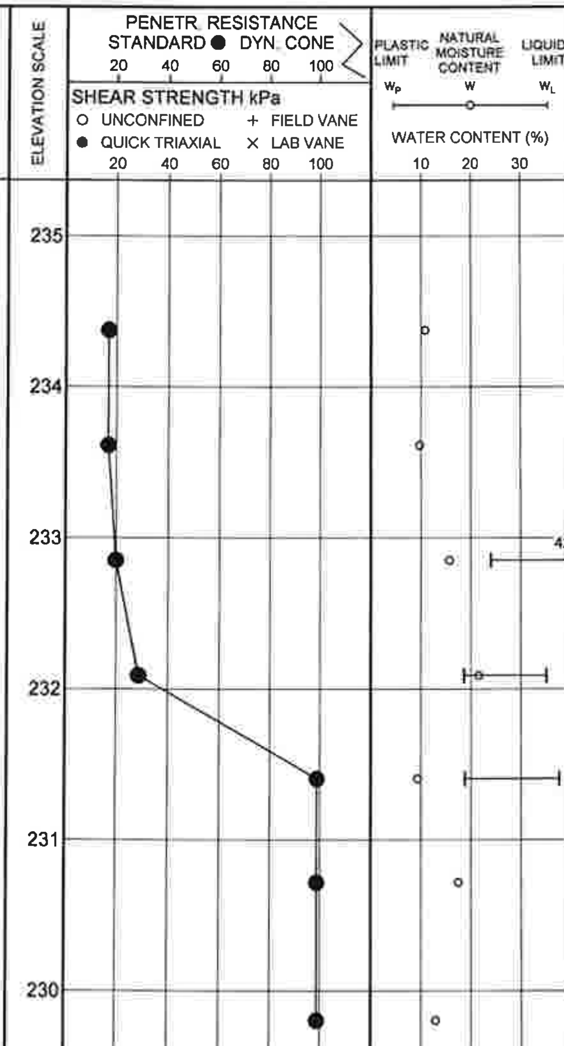
METRIC

W.P. GWP 57-00-00 LOCATION Northing - 4937962, Easting - 225075 ORIGINATED BY JL

DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY JL

DATUM Geodetic DATE 07.24.07 - 07.24.07 CHECKED BY EC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.37	Ground						
0.00	100 mm Recycled ASPHALT						
235.07 / 0.30	200 mm sand and gravel FILL						
	FILL Brown, moist, very stiff, consisting of silty clay, some gravel	1	SPT	17			19 11 35 34 (70)
		2	SPT	17			
233.08 / 2.29	Brown Silty CLAY TILL (CI) Grey, moist, very stiff, embedded sand and gravel. Grey	3	SPT	20	▽	22.9	1 6 54 39 (93) Water level measured @ 2.6 m @ completion
		4	SPT	29			0 4 64 32 (96)
231.71 / 3.66	SHALE BEDROCK Grey, weathered, weak, close to moderately close bedding, fair quality, occ. limestone layers (10 to 20mm thick).	5	SPT	100+			3 10 54 33 (87)
		6	SPT	100+			
		7	SPT	100+			
229.58 / 5.79	End of Borehole						



+ ³, × ³: Numbers refer to Sensitivity O ¹⁵⁰ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 24A-3

1 OF 1 **METRIC**

W.P. GWP 57-00-00 LOCATION Northing - 4937980, Easting - 225077 ORIGINATED BY JL

DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia COMPILED BY JL

DATUM Geodetic DATE 07.24.07 - 07.24.07 CHECKED BY EC

Soil Profile

ELEV / DEPTH	DESCRIPTION
234.07	Ground
0.00	100 mm TOPSOIL
	Brown Silty CLAY TILL (CI) Grey, moist, very stiff to hard, embedded sand and gravel Grey
230.87 / 3.20	SHALE BEDROCK Grey, weathered, weak, close to moderately close bedding, fair quality, occ. limestone layers (10 to 20mm thick)
230.11 / 3.96	End of Borehole

Samples

NUMBER	TYPE	"N" VALUES	Water content (%)	Liquid limit W_L	GR	SA	SI	CL	Remarks
1	SPT	23		42	11	4	45	39 (85)	
2	SPT	35		40	1	5	54	40 (94)	
3	SPT	58							
4	SPT	100+							
5	SPT	100+							

Ground water conditions: Borehole dry and open @ completion

Elevation scale: 234, 233, 232, 231

PENETR. RESISTANCE: STANDARD ● DYN. CONE; 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

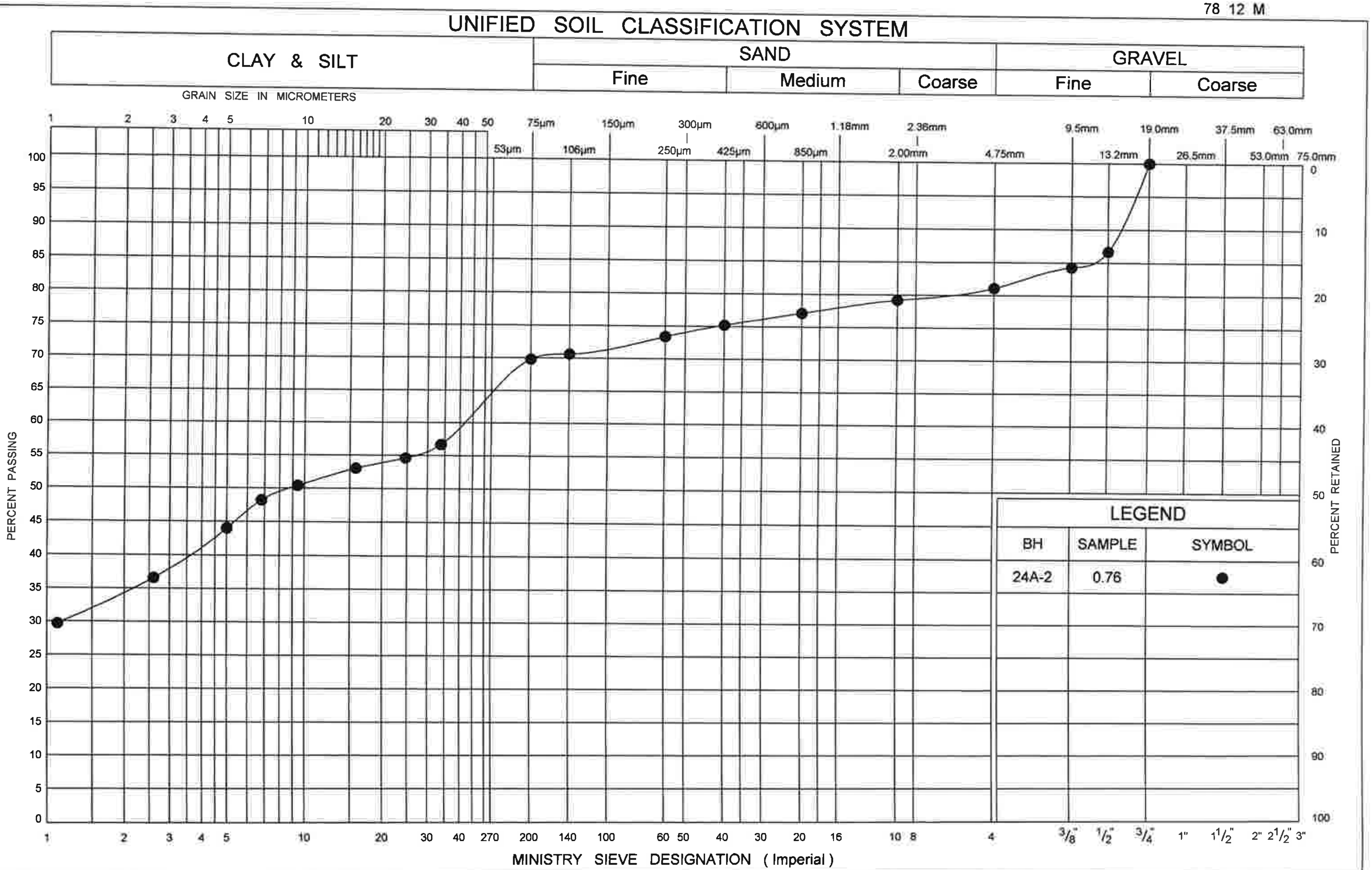
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

+³, ×³: Numbers refer to Sensitivity   O¹⁵⁰ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

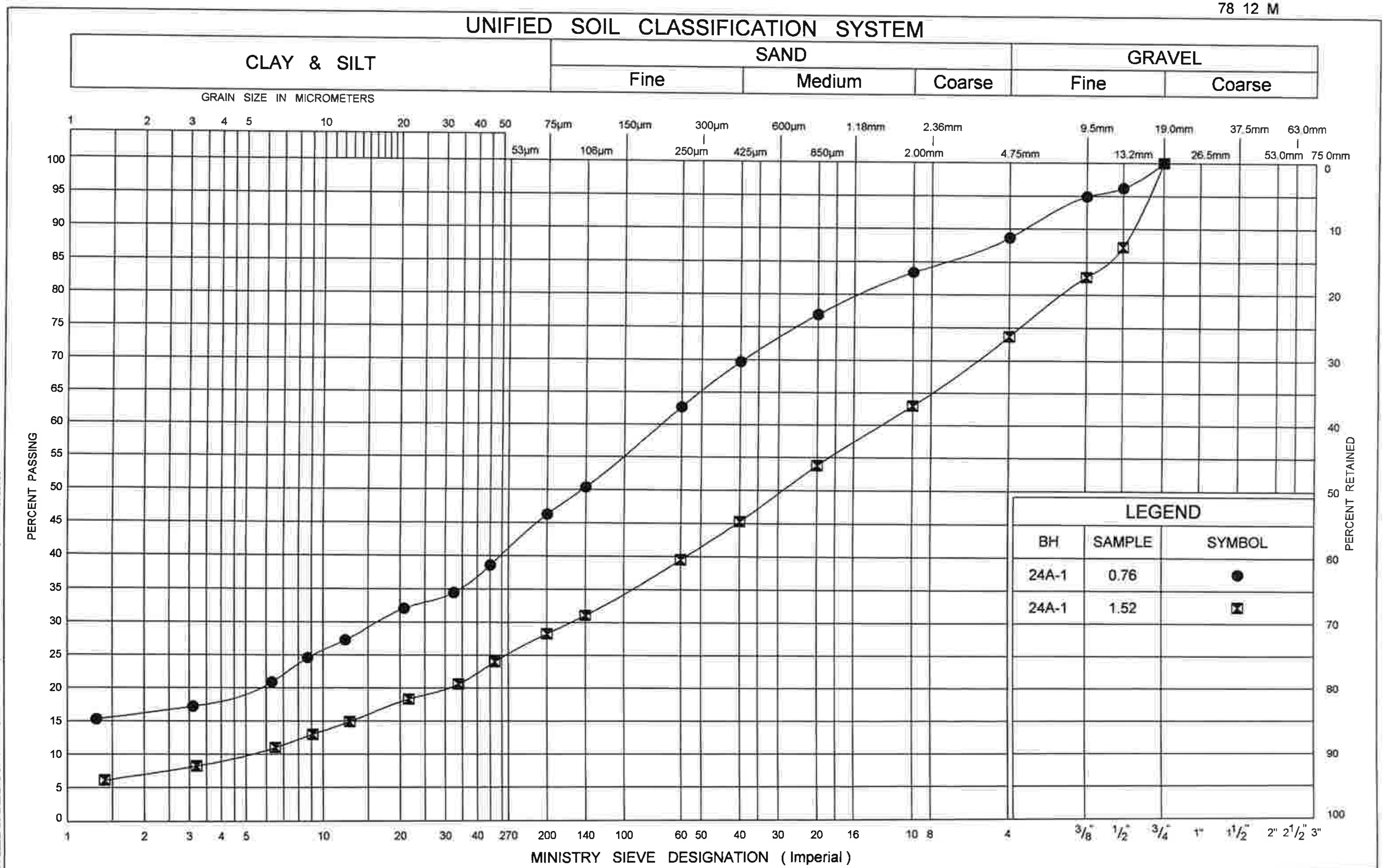
78 12 M



Ministry of Transportation Ontario	GRAIN SIZE DISTRIBUTION FILL	FIG No C- 24A.1 GWP 57-00-00 HWY 26, Thornbury to Meaford

ONTARIO MOT GRAIN SIZE SMALL CULVERTS 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

78 12 M



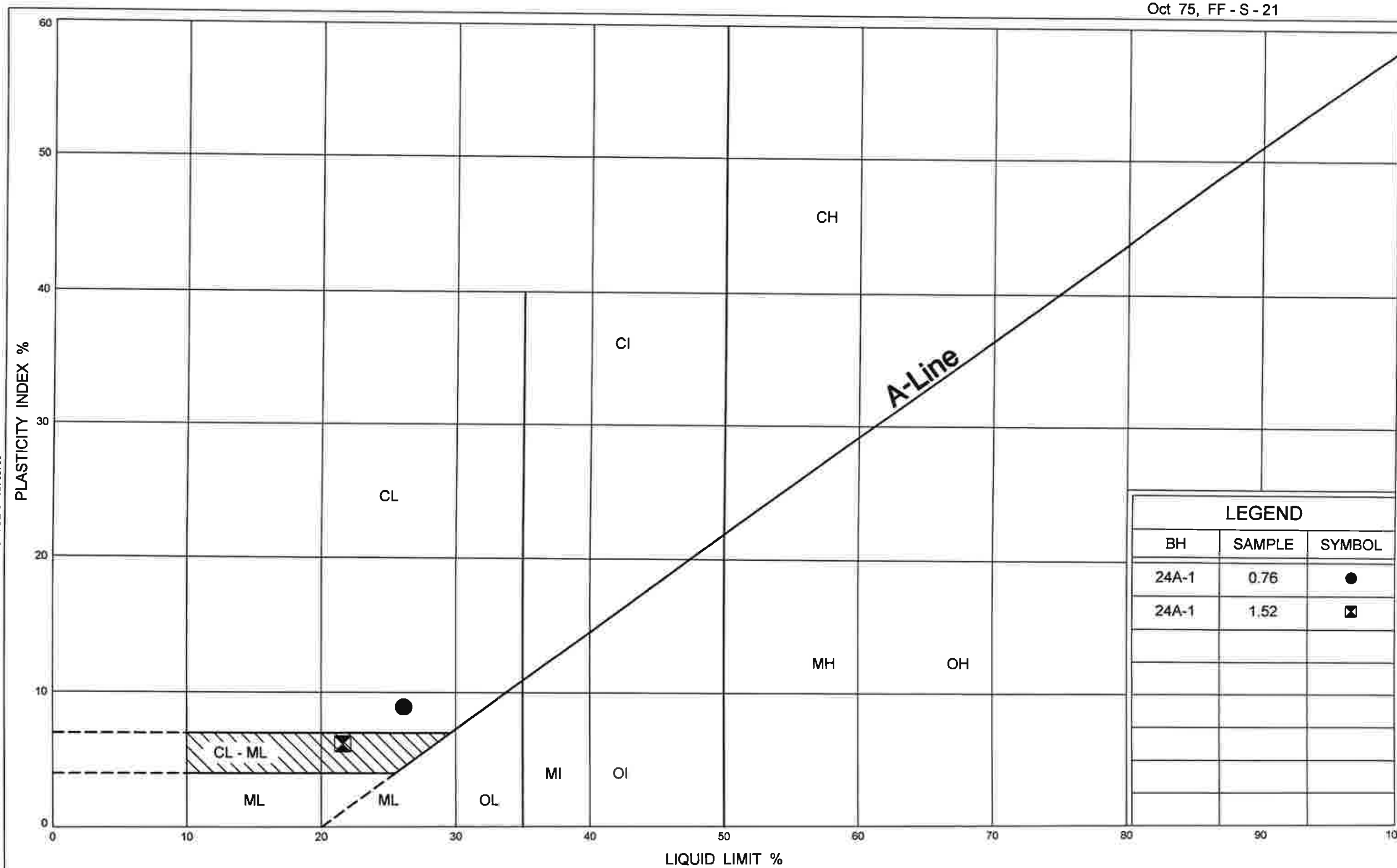
BH	SAMPLE	SYMBOL
24A-1	0.76	●
24A-1	1.52	⊠

Ministry of Transportation Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILTY GRAVELLY SAND, SC-SM-SW

FIG No C- 24A.2
GWP 57-00-00
HWY 26, Thornbury to Meaford

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
24A-1	0.76	●
24A-1	1.52	⊠

Ministry of Transportation
Ontario

PLASTICITY CHART

CLAYEY SILTY GRAVELLY SAND, SC-SM-SW

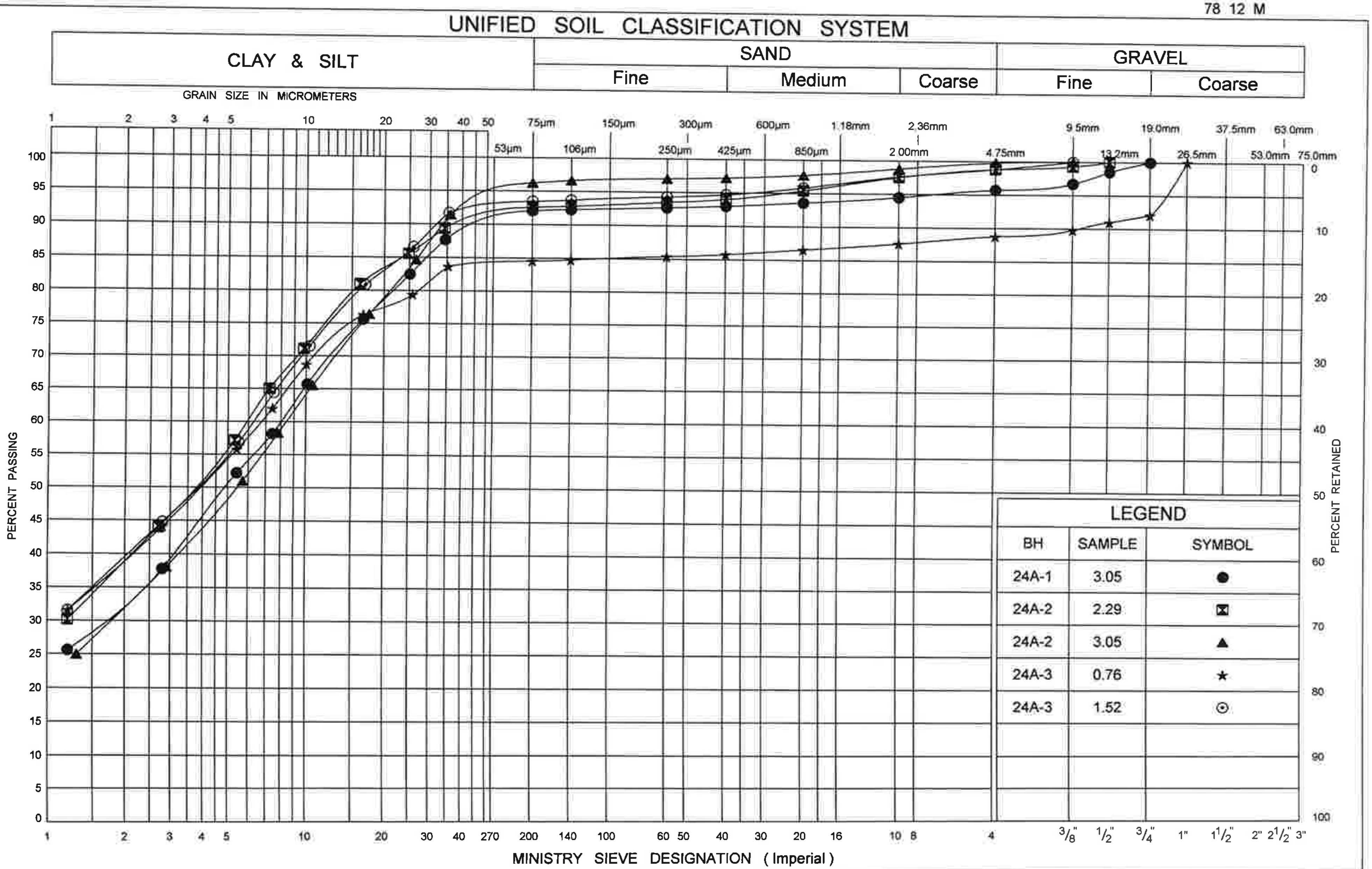
FIG No C- 24A.3

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT PLASTICITY CHART SMALL CULVE 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

78 12 M



Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL, CL-CI

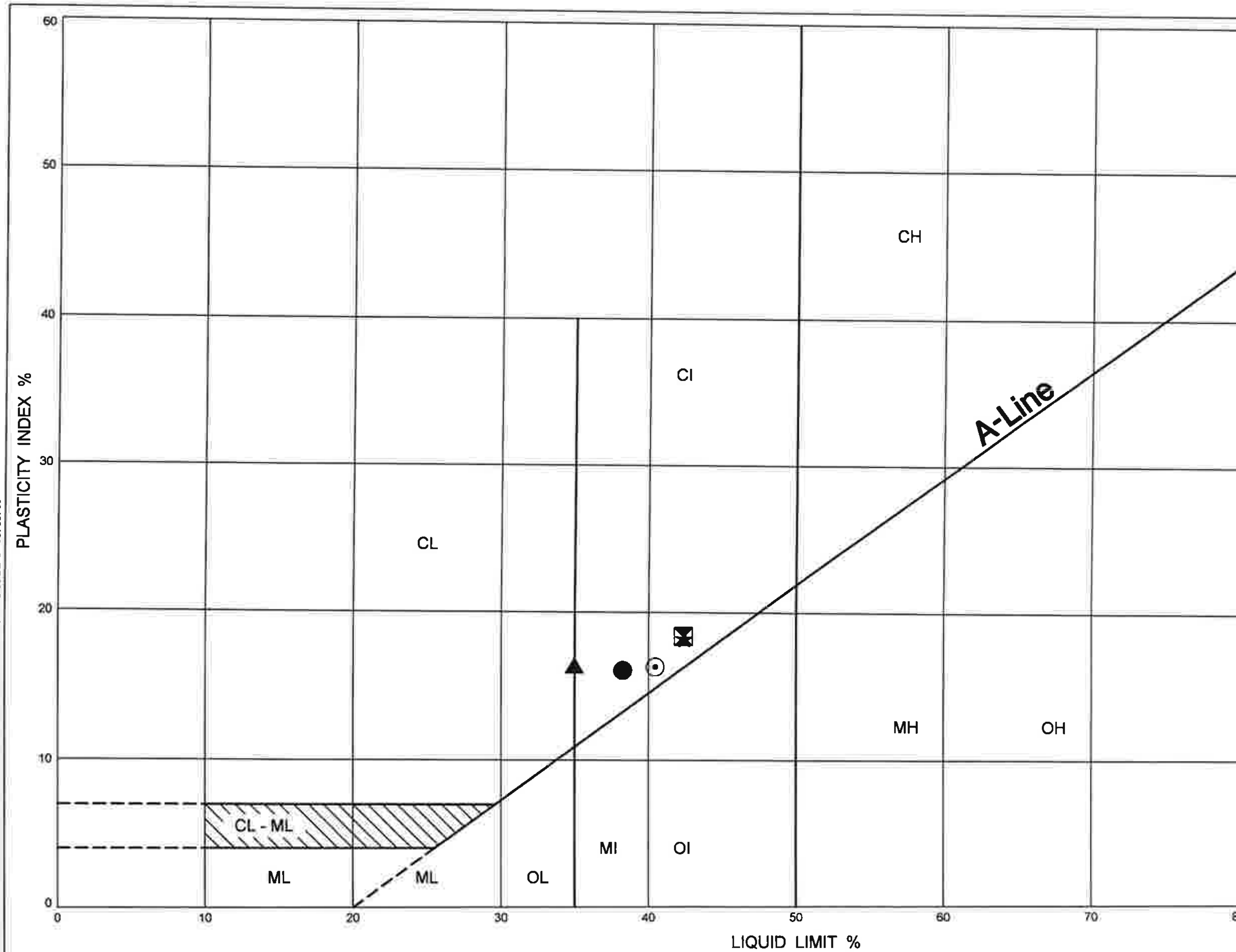
FIG No C- 24A.4

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT GRAIN SIZE SMALL CULVERTS 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
24A-1	3.05	●
24A-2	2.29	⊠
24A-2	3.05	▲
24A-3	0.76	★
24A-3	1.52	⊙

ONTARIO MOT PLASTICITY CHART SMALL CULVE 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

Ministry of Transportation
Ontario

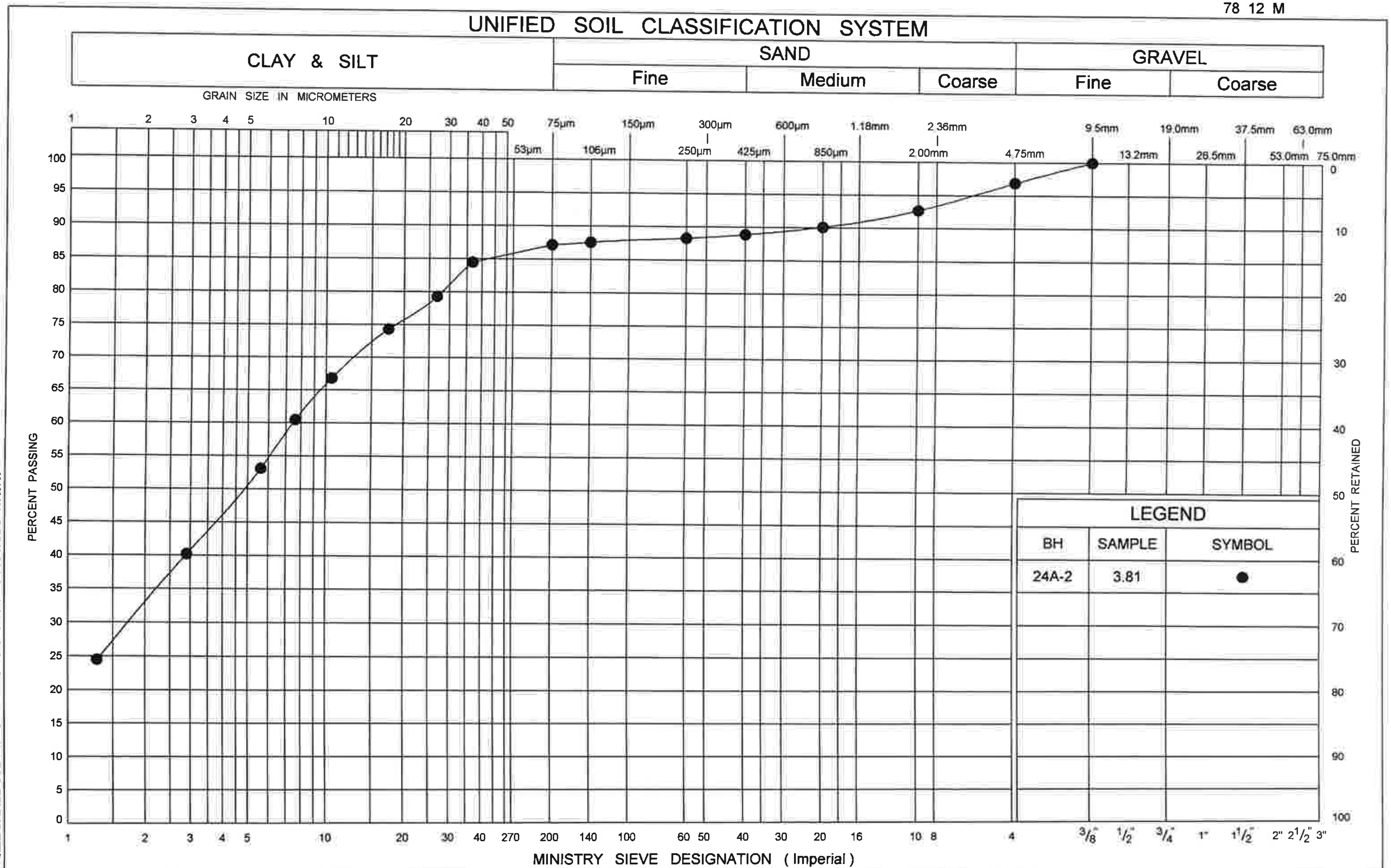
PLASTICITY CHART

SILTY CLAY TILL, CL-CI

FIG No C- 24A.5

GWP 57-00-00

HWY 26, Thornbury to Meaford



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
WEATHERED SHALE BEDROCK

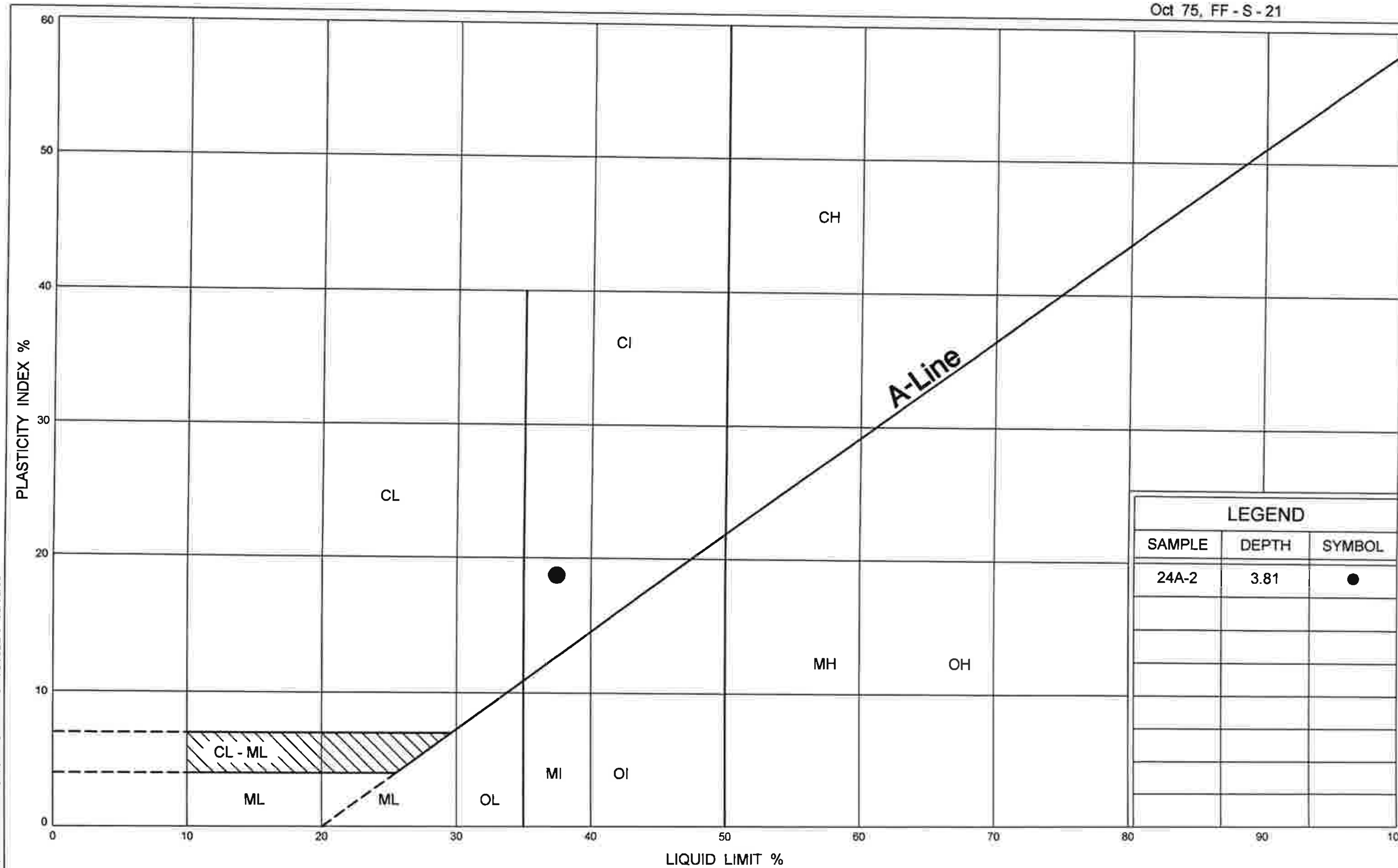
FIG No C- 24A.6

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT GRAIN SIZE SMALL CULVERTS 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

Oct 75, FF - S - 21



LEGEND		
SAMPLE	DEPTH	SYMBOL
24A-2	3.81	●

Ministry of Transportation
Ontario

PLASTICITY CHART

SHALE/Silty CLAY TILL complex

FIG No C24A.7

GWP 57-00-00

HWY 26, Thornbury to Meaford

RECORD OF BOREHOLE No 25A-1

METRIC

W.P. GWP 57-00-00 LOCATION Northing - 4937665, Easting - 225891 ORIGINATED BY JL

DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY JL

DATUM Geodetic DATE 09.18.07 - 09.18.07 CHECKED BY EC

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.23	Ground						
0.00	75mm TOPSOIL						Hand drilling with 31.75 kg (70 lb.) hammer. N-values are corrected values.
	Silty SAND and GRAVEL (SM-GM) Brown, moist, compact, slight plasticity.	1	SPT	10		223	
		2	SPT	20			35 34 25 7 (32)
		3	SPT	38		222	
221.40 / 1.83	End of Borehole						Borehole terminated due to difficult retrieval of sampler. Borehole dry and open at completion.

PENETR. RESISTANCE: STANDARD ● DYN. CONE (20, 40, 60, 80, 100)

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20, 40, 60, 80, 100)

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity O^{150} UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 25A-2

METRIC

W.P. GWP 57-00-00	LOCATION Northing - 4937670, Easting - 225892		ORIGINATED BY JL
DIST Owen Sound HWY 26	BOREHOLE TYPE S/S Augering, 110 mm dia		COMPILED BY JL
DATUM Geodetic	DATE 07.23.07 - 07.23.07		CHECKED BY EC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
224.29	Ground					
0.00	300mm sand and gravel FILL					
223.99 / 0.30	FILL Brown, moist, compact, consisting of silty sand, some gravel and rock fragments, trace clay	1	SPT	18		
		2	SPT	19		19 47 27 7 (35)
222.00 / 2.29	Sandy SILT TILL (ML) Brown, moist, very dense, some gravel	3	SPT	52	25.4	
		4	SPT	100		15 34 39 12 (51) non-plastic
220.48 / 3.81	SHALE BEDROCK Grey, weathered, weak, close to moderately close bedding, fair quality, occ. limestone layers (10 to 20mm thick)	5	SPT	100+		
		6	SPT	100+		
		7	SPT	100+		
218.80 / 5.49	End of Borehole					Borehole dry & open @ completion

Elevation scale: 224, 223, 222, 221, 220, 219

Column headings: PENETR. RESISTANCE – STANDARD ● DYN. CONE (20, 40, 60, 80, 100); SHEAR STRENGTH kPa – O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L – WATER CONTENT (%) (10, 20, 30); GROUND WATER CONDITIONS; STRAT PLOT

+³, ×³: Numbers refer to Sensitivity

O¹⁵⁰ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 25A-3

METRIC

W.P. GWP 57-00-00 | LOCATION Northing - 4937695, Easting - 225899 | ORIGINATED BY JL

DIST Owen Sound HWY 26 | BOREHOLE TYPE S/S Augering, 110 mm dia | COMPILED BY JL

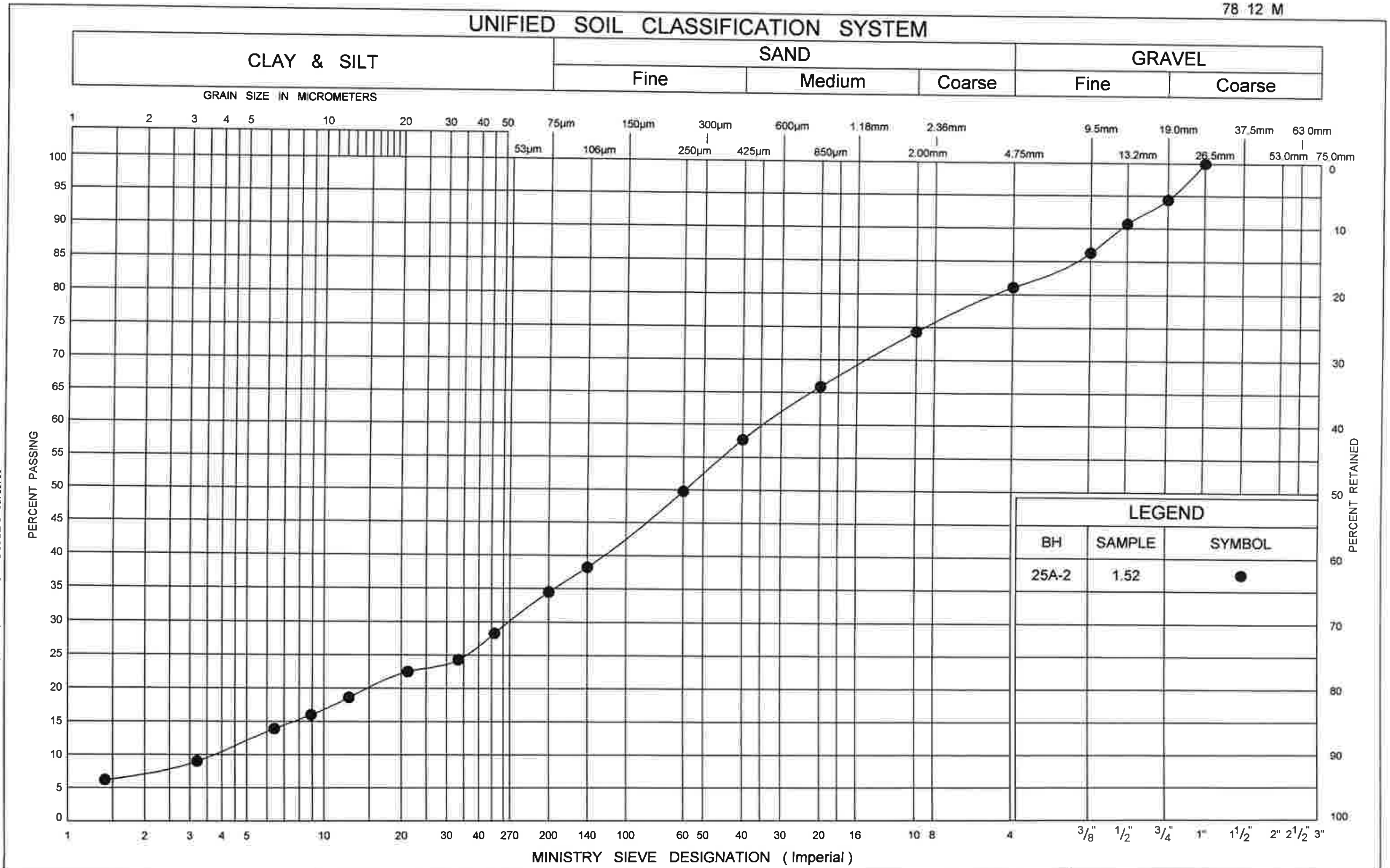
DATUM Geodetic | DATE 07.24.07 - 07.24.07 | CHECKED BY EC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.05	Ground				223			
0.00	Trace organics							
	Silty SAND (SM) Brown, moist, very dense, some gravel, slight plasticity	1	SPT	69	222	o		15 54 24 7 non-plastic (31)
221.53 / 1.52	SANDY SILT TILL (ML to CL-ML) Brown, moist, dense to very dense, some gravel and clay	2	SPT	36	221	o		
		3	SPT	100+		o (Wp–WL shown)		12 30 40 18 (58)
220.00 / 3.05	SHALE BEDROCK Grey, weathered, weak, close to moderately close bedding, fair quality, occ. limestone layers (10 to 20mm thick).	4	SPT	100+	220	o	24.8	
		5	SPT	100+	219	o		
		6	SPT	100+		o	21.9	
218.02 / 5.03	End of Borehole							Borehole dry & open @ completion.

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; PENETR. RESISTANCE STANDARD ● DYN. CONE (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30.

+3, ×3: Numbers refer to Sensitivity

○150 UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS



Ministry of Transportation
Ontario

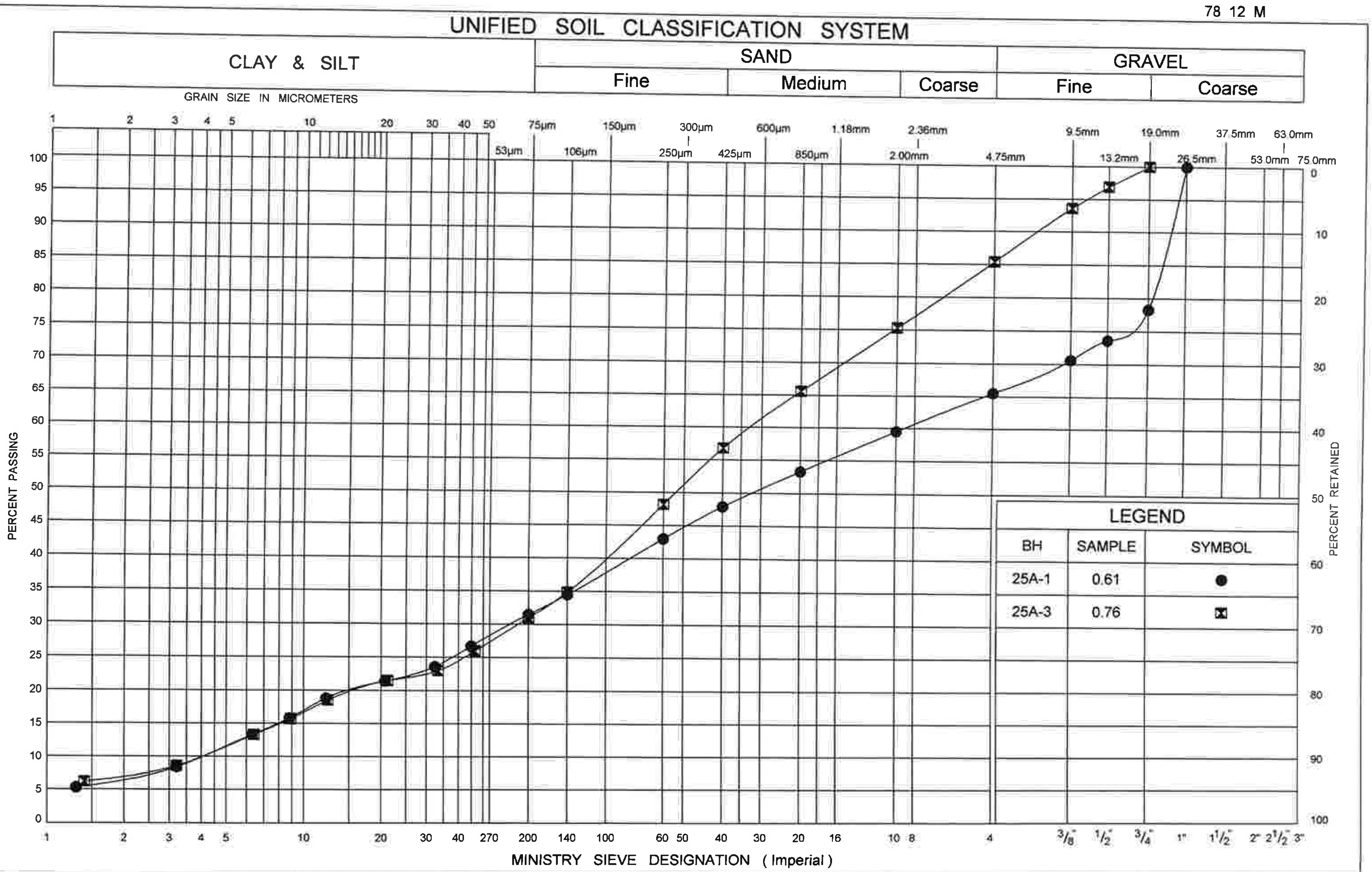
GRAIN SIZE DISTRIBUTION

FILL

FIG No C- 25A.1

GWP 57-00-00

HWY 26, Thornbury to Meaford



ONTARIO MOT GRAIN SIZE SMALL CULVERTS 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

Ministry of Transportation
Ontario

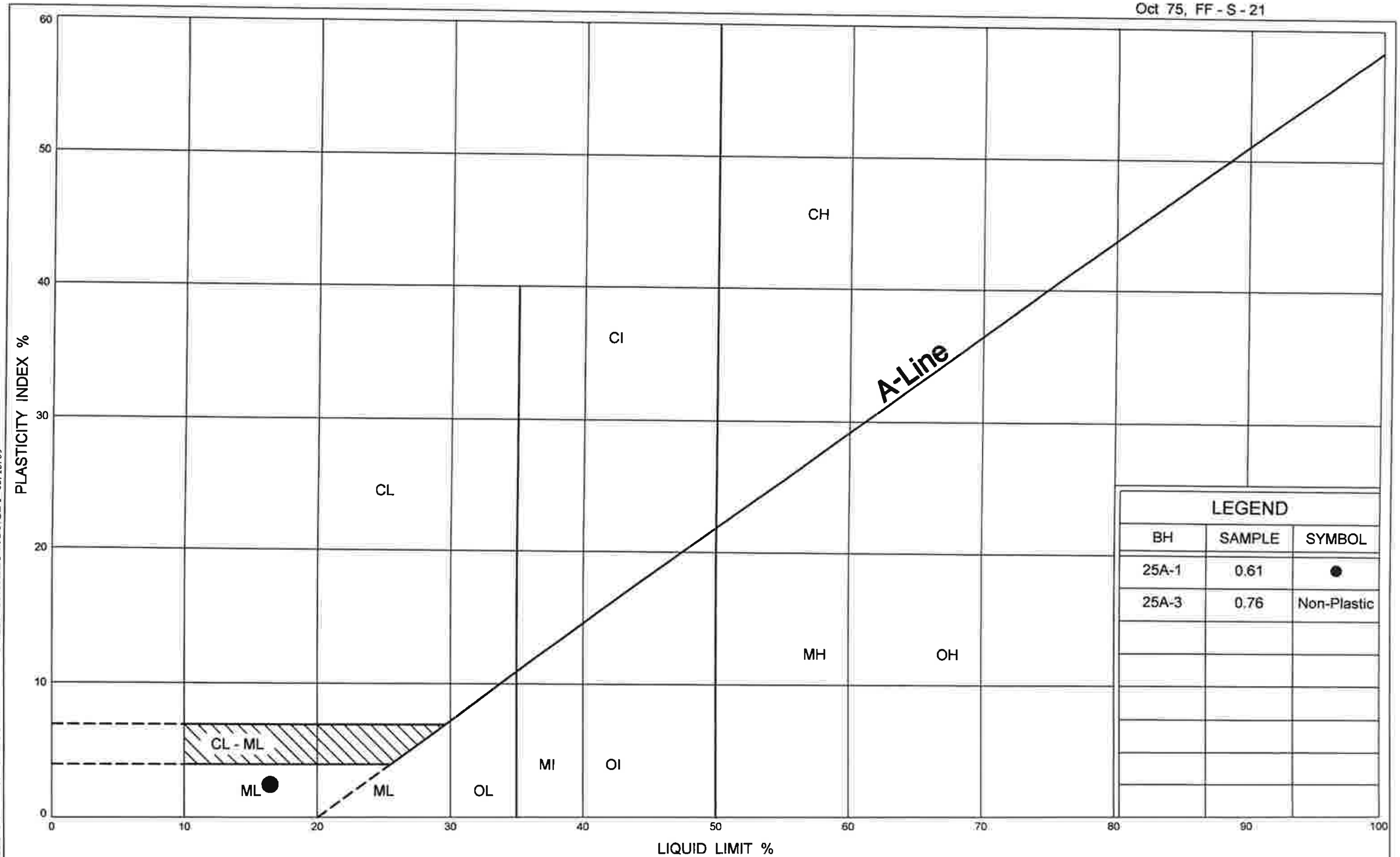
GRAIN SIZE DISTRIBUTION
SILTY SAND TO SILTY SAND AND GRAVEL, SM-GM

FIG No C- 25A.2

GWP 57-00-00

HWY 26, Thornbury to Meaford

Oct 75, FF - S - 21



LEGEND

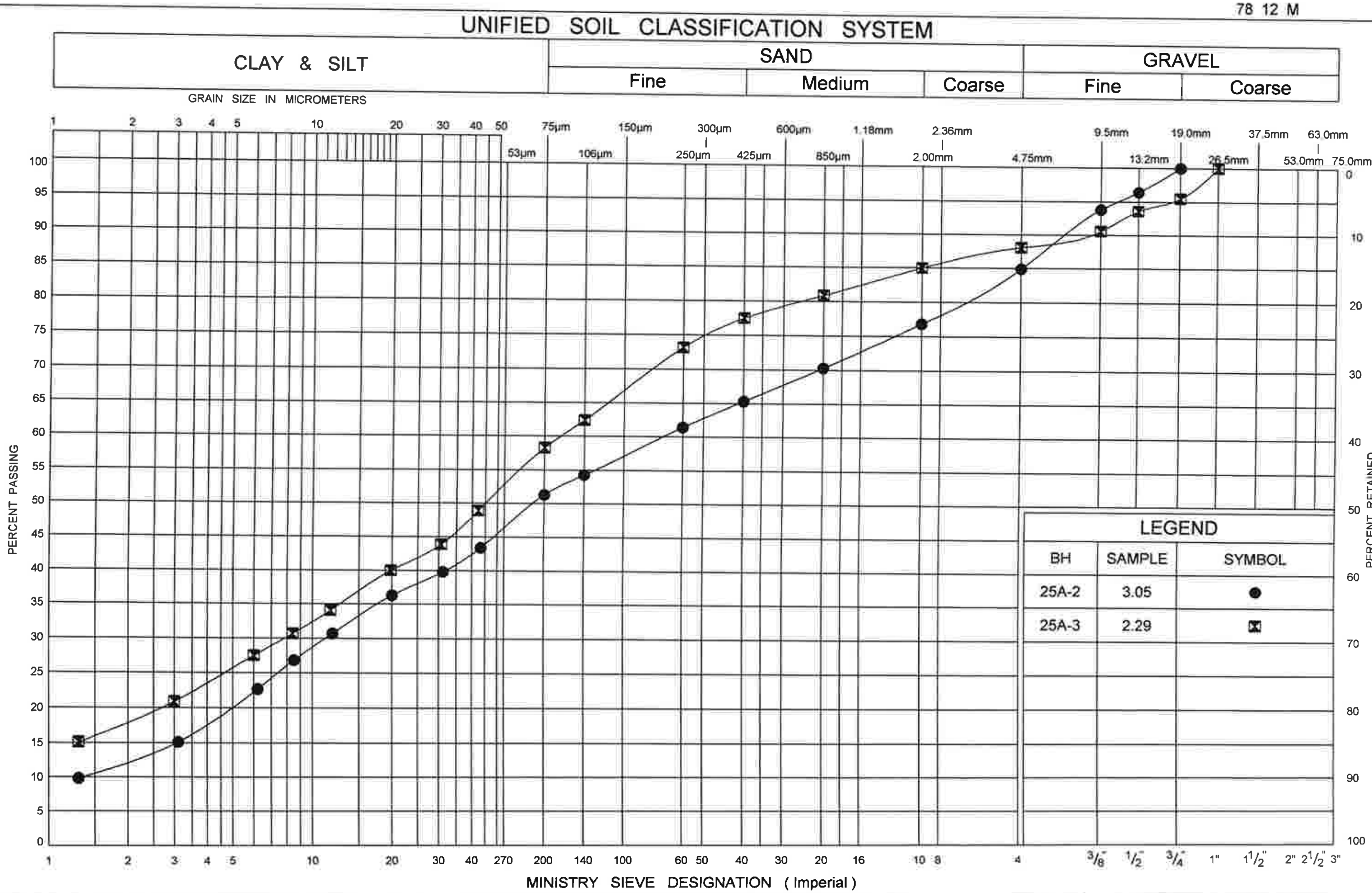
BH	SAMPLE	SYMBOL
25A-1	0.61	●
25A-3	0.76	Non-Plastic

ONTARIO MOT PLASTICITY CHART SMALL CULVE 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

Ministry of Transportation
Ontario

PLASTICITY CHART
SILTY SAND TO SILTY SAND AND GRAVEL, SM-GM

FIG No C- 25A.3
GWP 57-00-00
HWY 26, Thornbury to Meaford



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

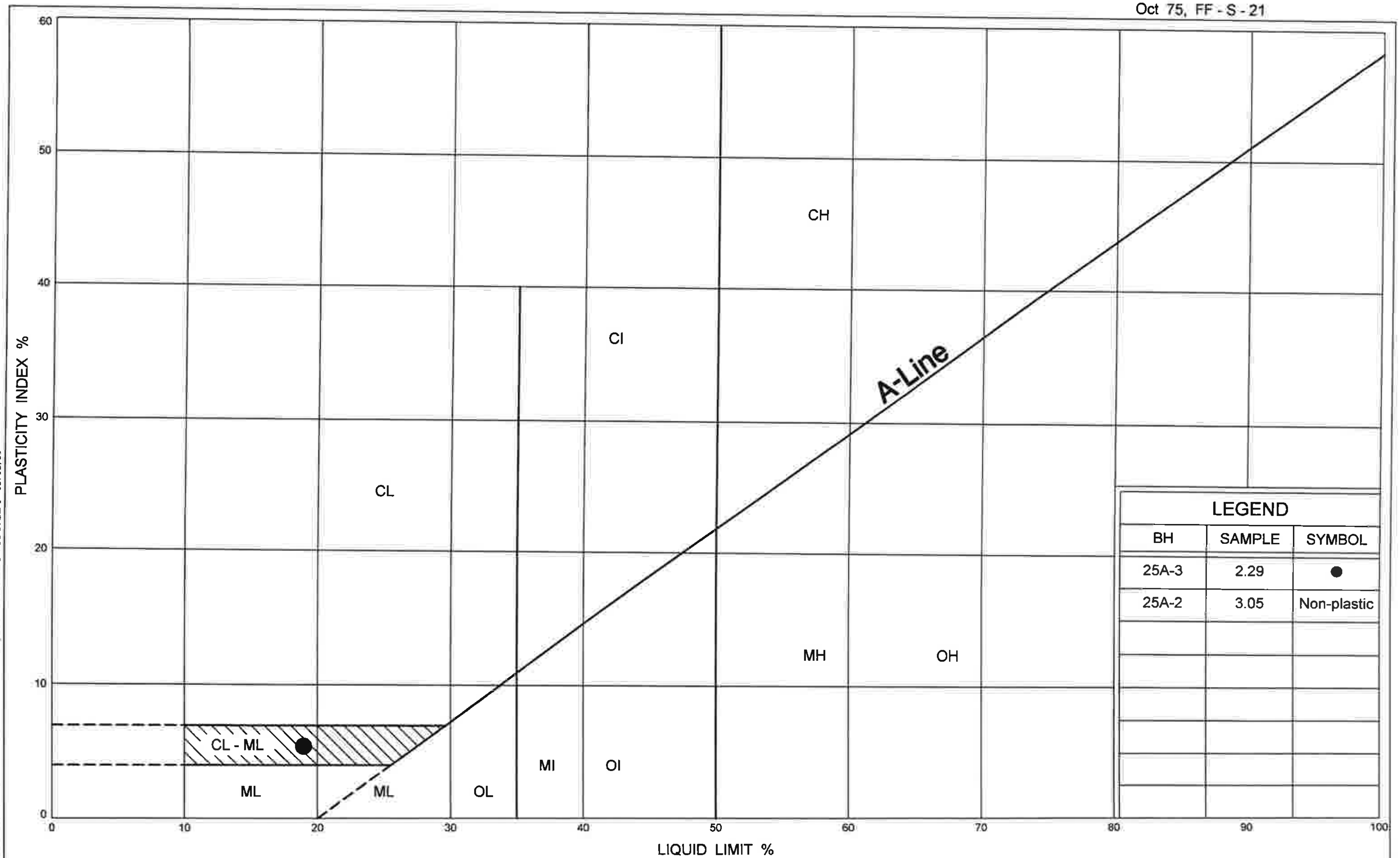
SANDY TO CLAYEY SILT TILL, ML TO CL-ML

FIG No C- 25A.4

GWP 57-00-00

HWY 26, Thornbury to Meaford

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
25A-3	2.29	●
25A-2	3.05	Non-plastic

Ministry of Transportation
Ontario

PLASTICITY CHART

SANDY TO CLAYEY SILT TILL, ML TO CL-ML

FIG No C- 25A.5

GWP 57-00-00

HWY 26, Thornbury to Meaford

RECORD OF BOREHOLE No 27A-1

1 OF 1 **METRIC**

W.P. GWP 57-00-00	LOCATION Northing - 4937035, Easting - 227795		ORIGINATED BY JL
DIST Owen Sound HWY 26	BOREHOLE TYPE S/S Augering, 110 mm dia		COMPILED BY JL
DATUM Geodetic	DATE 09.18.07 - 09.18.07		CHECKED BY EC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.96	Ground						
0.00	75 mm TOPSOIL						Hand drilling with 31.75 kg (70 lb.) hammer N-values are corrected values.
	SAND and SILT TILL, (SM-ML) Brown, wet to moist, very loose to very dense	1	SPT	4	∇		
		2	SPT	5		194	4 35 49 11 (60)
193.44		3	SPT	42+			
1.52	End of Borehole						sampler refusal, no further penetration Water level measured @ 0.35 m @ completion.

PENETR. RESISTANCE: STANDARD ● DYN. CONE (20, 40, 60, 80, 100)

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20, 40, 60, 80, 100)

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

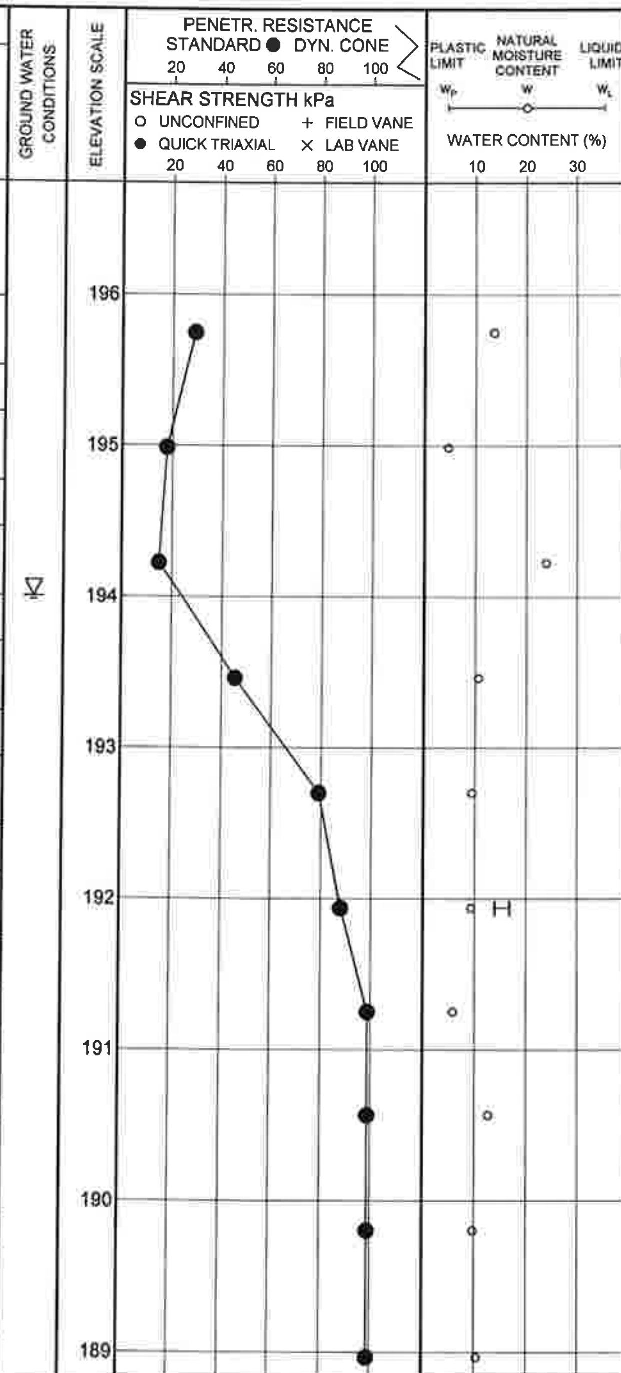
$+^3, \times^3$: Numbers refer to Sensitivity O [150] UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 27A-2

METRIC

W.P. GWP 57-00-00 LOCATION Northing - 4937051, Easting - 227812 ORIGINATED BY JL
DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia COMPILED BY JL
DATUM Geodetic DATE 07.22.07 - 07.23.07 CHECKED BY EC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.74	Ground					
0.00	FILL Brown, moist, consisting of sand and gravel.					
	FILL Dark brown, moist, compact, consisting of clayey silt	1	SPT	29		7 47 32 13 (45)
		2	SPT	18		
194.30 2.44	buried topsoil layer	3	SPT	15	23.4	Water level measured @ 2.7 m @completion
193.69 3.05	Sandy SILT to SAND and SILT TILL, (SM-ML) Grey, moist, dense to very dense, trace to some gravel, slight plasticity.	4	SPT	46	24.5	10 46 37 7 (44)
		5	SPT	80		16 26 49 9 (57)
		6	SPT	89		17 29 44 11 (55)
		7	SPT	100+		
		8	SPT	100+		spoon bouncing on cobbles
		9	SPT	100+	24.5	spoon bouncing on cobbles
188.82		10	SPT	100+		
7.92	End of Borehole					



$+^3, \times^3$: Numbers refer to Sensitivity

O [150] UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 27A-3

METRIC

W.P. GWP 57-00-00 LOCATION Northing - 4937052, Easting - 227831 ORIGINATED BY JL

DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia COMPILED BY JL

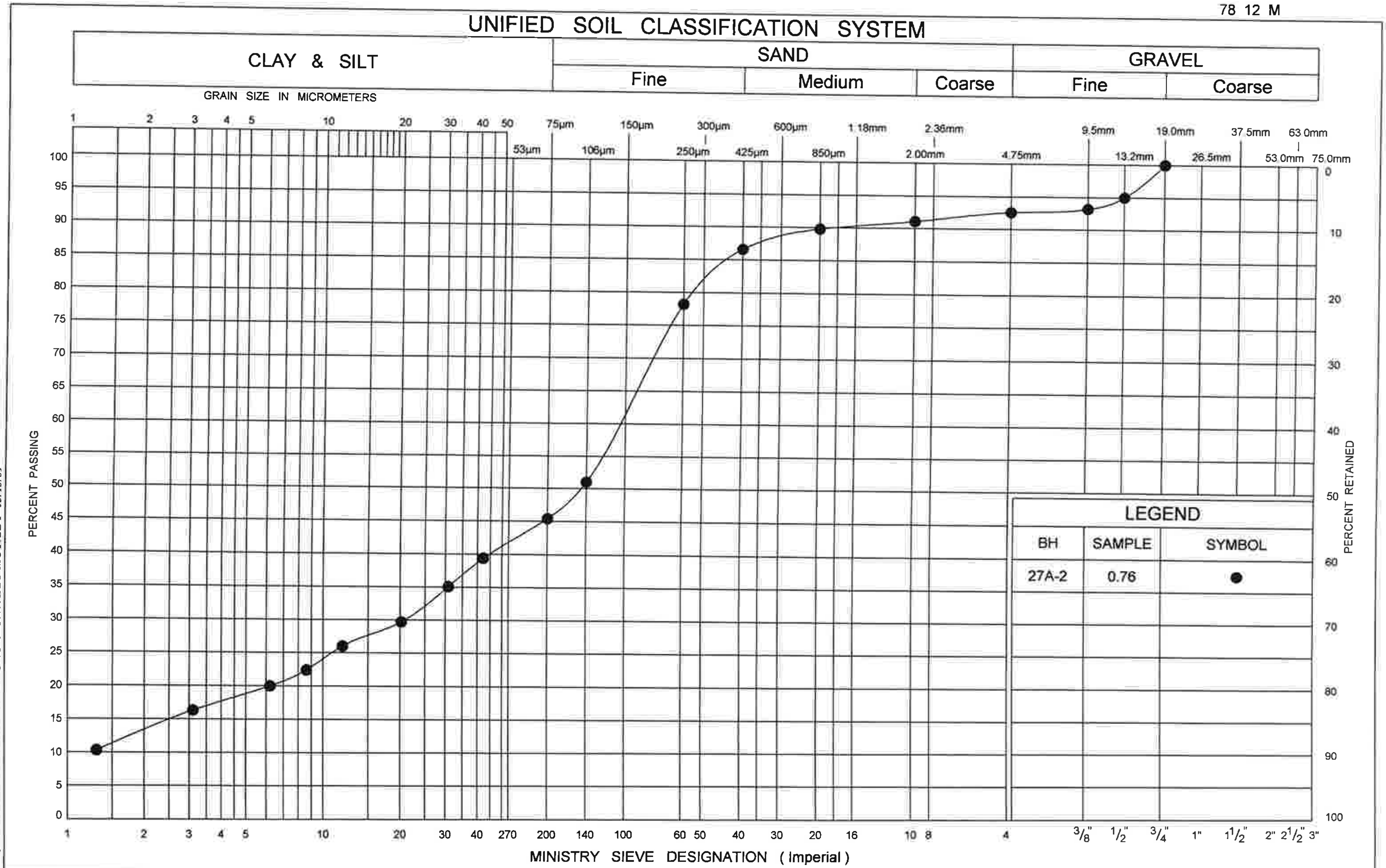
DATUM Geodetic DATE 07.23.07 - 07.23.07 CHECKED BY EC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.96	Ground						
0.00	510 mm TOPSOIL						
194.45 / 0.51	Sandy SILT TILL, (ML) Moist, dense to very dense, embedded gravel, occasional silty clay layers. Brown				∇		
		1	SPT	39		194	6 29 50 15 (65)
		2	SPT	100+			
						193	
		3	SPT	100+			
						192	
	Grey	4	SPT	100+			
	silty clay layer	5	SPT	100+		191	5 22 50 23 (73)
190.69 / 4.27							
190.16 / 4.80	End of Borehole	6	SPT	100+			Water level measured @ 0.75 m @ completion.

Legend: PENETR. RESISTANCE STANDARD ● DYN. CONE; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%); UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity

O 150 UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS



Ministry of Transportation
Ontario

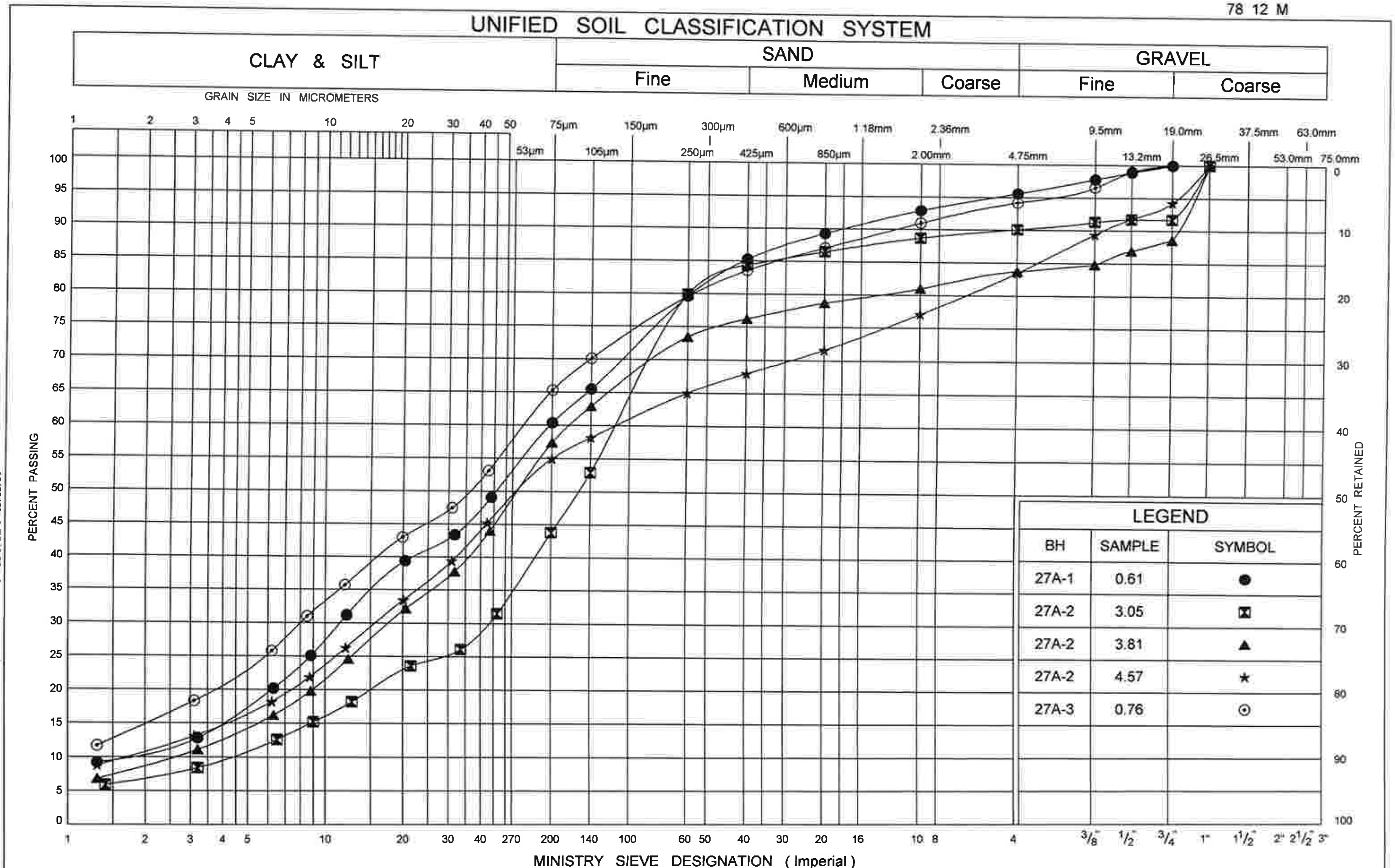
GRAIN SIZE DISTRIBUTION

FILL

FIG No C- 27A.1

GWP 57-00-00

HWY 26, Thornbury to Meaford



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Ontario

GRAIN SIZE DISTRIBUTION

SANDY SILT TO SAND AND SILT TILL, SM-ML

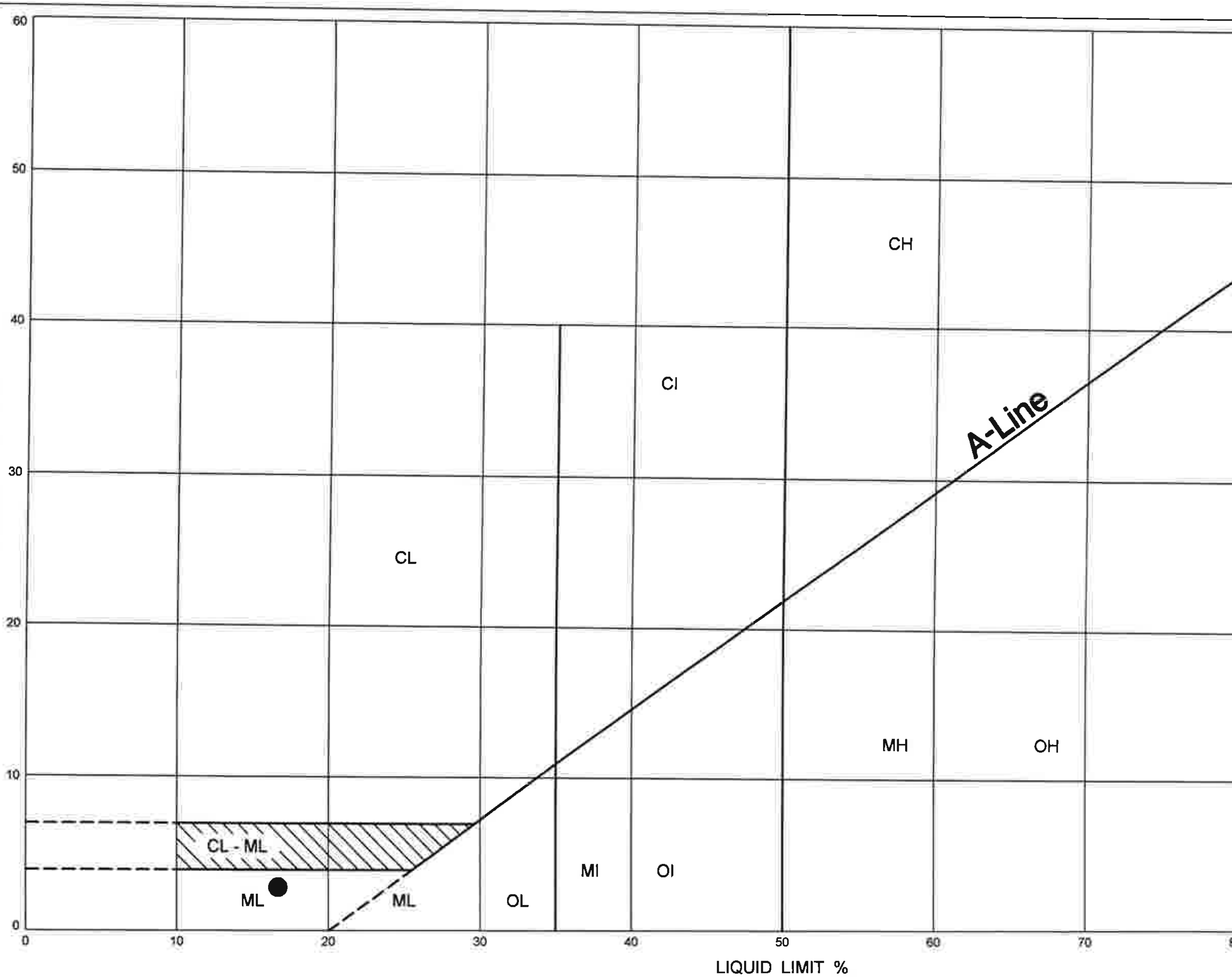
FIG No C- 27A.2

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT GRAIN SIZE SMALL CULVERTS 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
27A-2	4.57	●

Ministry of Transportation
Ontario

PLASTICITY CHART

SANDY SILT TO SAND AND SILT TILL, SM-ML

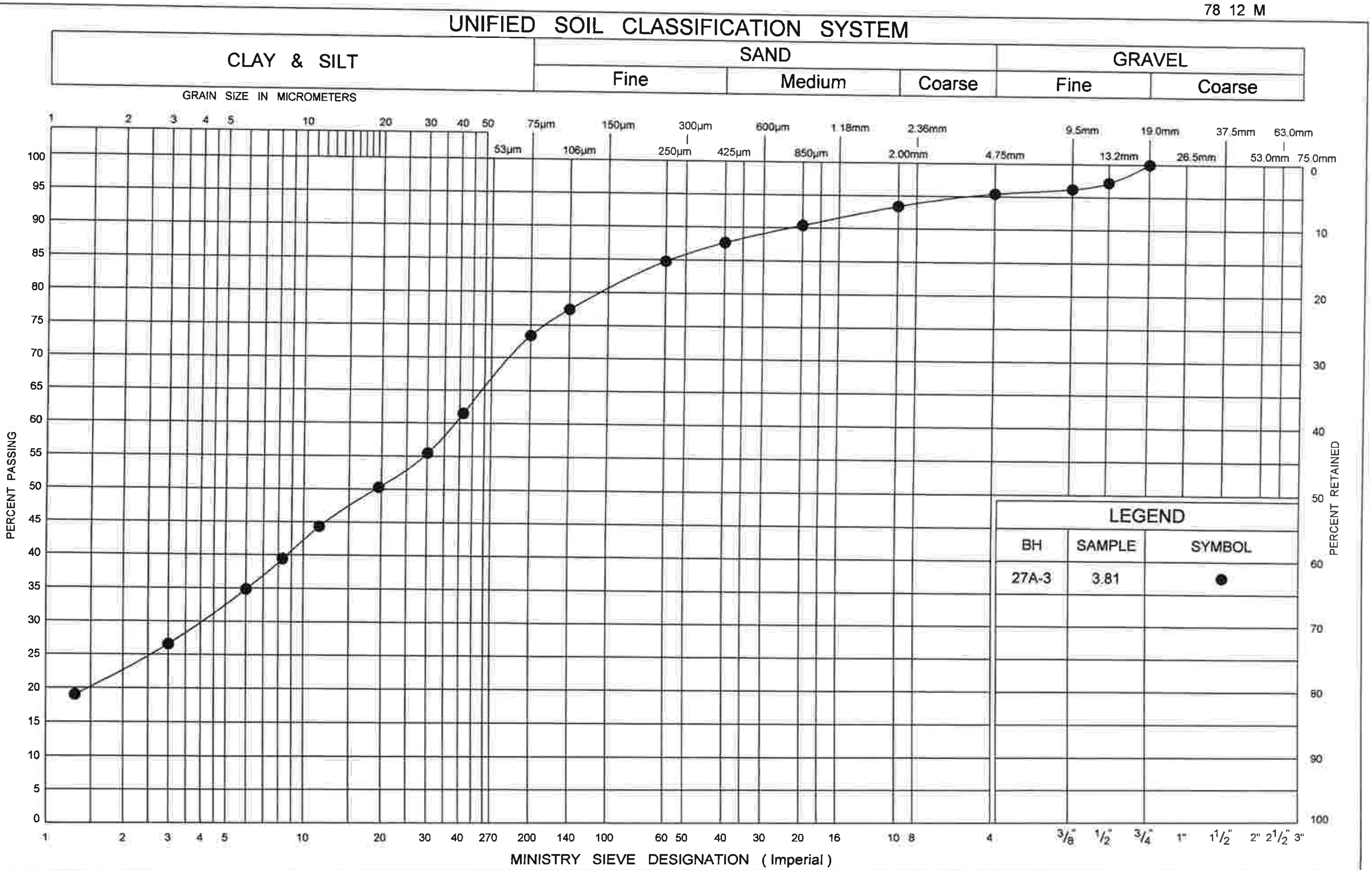
FIG No C- 27A.3

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT PLASTICITY CHART SMALL CULVE 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

78 12 M



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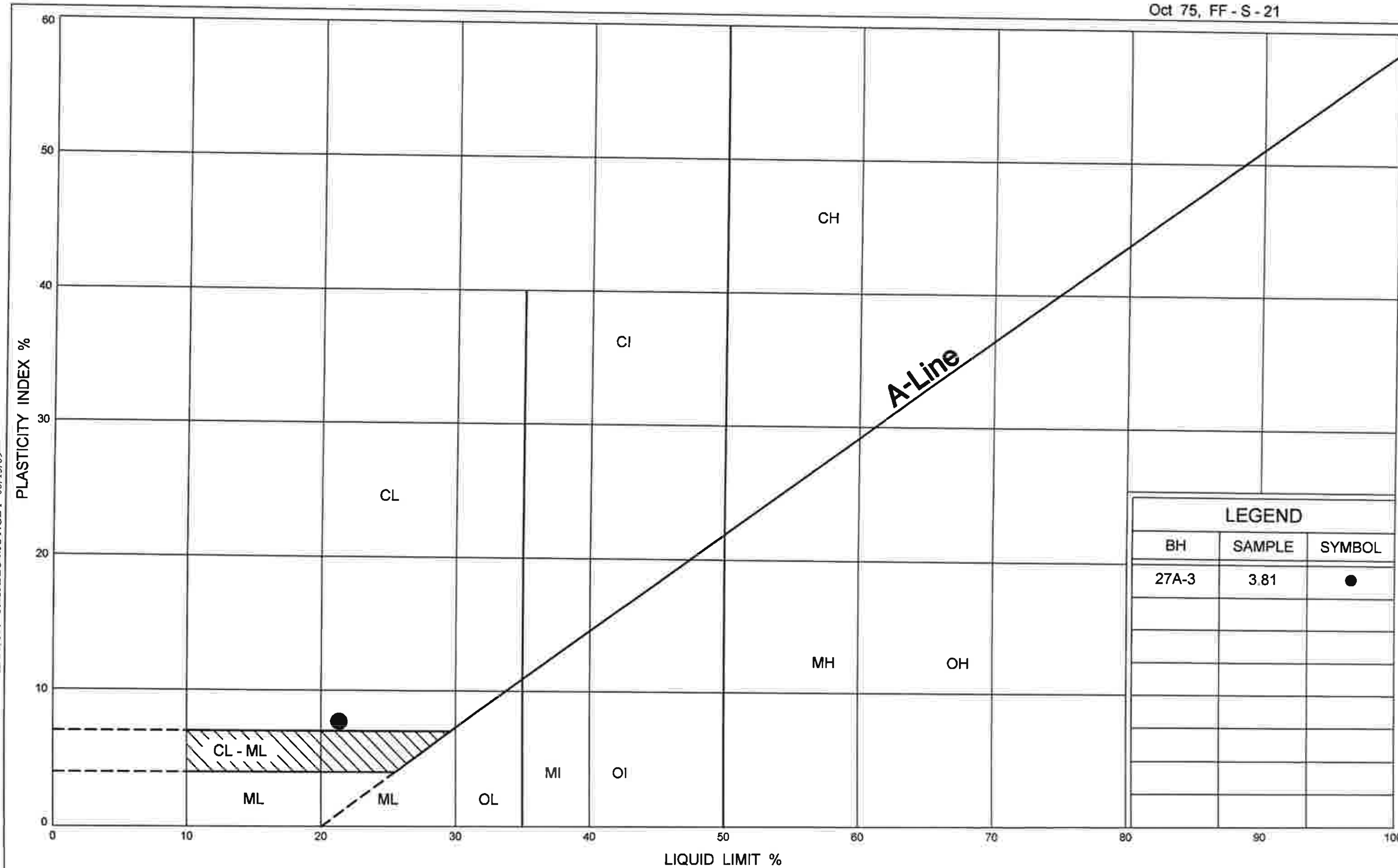
GRAIN SIZE DISTRIBUTION
SILTY CLAY LAYER

FIG No C- 27A.4
GWP 57-00-00
HWY 26, Thornbury to Meaford

ONTARIO MOT GRAIN SIZE SMALL CULVERTS 07-6-IEG1.GPJ ONTARIO MOT.GDT 03/13/09

Oct 75, FF - S - 21



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PLASTICITY CHART
SILTY CLAY LAYER

FIG No C- 27A.5

GWP 57-00-00

HWY 26, Thornbury to Meaford

Appendix C

Site Photographs

Station 10+025 – Looking downstream (north)

Station 10+025 – Downstream end (north)

Station 10+ 025 – Looking upstream (south)

Station 10+025 – Upstream end (south)

Station 10+765 – Looking downstream (north)

Station 10+765 – Downstream end (north)

Station 10+765 – Looking upstream (south)

Station 10+765 – Upstream end (south)

Station 11+638 – Looking downstream (north)

Station 11+638 – Downstream end (north)

Station 11+638 – Looking upstream (south)

Station 11+638 – Upstream end (south)

Station 13+656 – Looking downstream (north)

Station 13+656 – Downstream end (north)

Station 13+656 – Looking upstream (south)

Station 13+656 – Upstream end (south)

Appendix D

Limitations of Report

APPENDIX D

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Infrastructure Engineering Group Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, IEG recommends that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.