FOUNDATION INVESTIGATION AND DESIGN REPORT
W.P. SSB 041387
STORAGE BUILDING
MARYSVILLE PATROL YARD
COUNTY ROAD 24, 1 KM EAST OF COUNTY ROAD 49

MINISTRY OF TRANSPORTATION ONTARIO

PROJECT NO. ONT10785

FOUNDATION INVESTIGATION AND DESIGN REPORT

TO

MINISTRY OF TRANSPORTATION ONTARIO

ON

W.P. SSB 041387
STORAGE BUILDING
MARYSVILLE PATROL YARD
COUNTY ROAD 24, 1 KM EAST OF COUNTY ROAD 49

DISTRICT 43, BANCROFT
MINISTRY OF TRANSPORTATION ONTARIO

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FOUNDATION INVESTIGATION REPORT

for

W.P. SSB 041387
STORAGE BUILDING
MARYSVILLE PATROL YARD
COUNTY ROAD 24, 1 KM EAST OF COUNTY ROAD 49

District 43, Bancroft

1.0 INTRODUCTION

This report presents the results of a Geotechnical Foundation Investigation carried out for the proposed storage building at the Marysville Patrol Yard. The Patrol Yard is located to the north of County Road 1 approximately one kilometre east of County Road 49 in the Township of Tyendinaga in Bancroft District. The work was carried out in general accordance with our proposal of January 7, 2003.

This report has been prepared specifically and solely for the project described herein. It contains the factual information obtained from the subsurface investigation on the site and the results of the associated laboratory testing program.

2.0 SITE DESCRIPTION AND GEOLOGY

The subject site is within the limits of the MTO Marysville Patrol Yard. The Patrol Yard is located on the north side of County Road 24 approximately one kilometre east of County Road 49 which intersects with Highway 401 near Marysville Ontario. The site location is shown on the Key Plan shown on Drawing No. 10785GEO-1, provided in Appendix 1.

The proposed building is to be located in the northeastern quadrant of the Patrol Yard.

The ground surface in the area investigated sloped down from the northeast to the southwest. The northeastern limit of the investigated area was near the top of a small hill and the ground surface sloped down further to the northeast of the investigated area. The investigation area was snow covered at the time of the fieldwork, however sparse grasses and weeds were observed in the area of the boreholes on the perimeter of the investigation area. An asphalt paved driveway was located to the west of the investigated area and a gravel driveway intersecting with the paved driveway extended to the northeast from the paved driveway through the investigation area. A materials storage area was located adjacent to the northwest corner of the investigated area. A plan view and cross sections of the investigated area are shown on Drawing No. 10785GEO-1 provided in Appendix 1.

The site is near the southern limit of the physiographic region identified by Chapman and Putnam (1984) as the Napanee Plain and is characterized as a flat to undulating plain of limestone stripped of most overburden by the glaciers. Scattered drumlins are noted in the south with deposits of stratified clay in the depressions.

3.0 INVESTIGATION PROCEDURES

3.1 Field Program

The site soil conditions were investigated via a borehole drilling investigation and laboratory testing program. The drilling was carried out using a truck-mounted CME-75 drill rig and solid stem augers. The field work for this investigation was carried out on January 13 and 14, 2003.

The investigation area was cleared of underground services by MTO in advance of the investigation program. MTO had also identified the approximate locations of the building corners prior to the investigation.

A total of six (6) boreholes, designated as BH1 through BH6, were advanced during the field investigation. One borehole was advanced at the identified corners of the building and two supplementary boreholes were advanced in proximity to the location of BH3 where softer silty clay materials were encountered.

The boreholes were advanced to depths of 4.3 m to 9.2 m using solid-stem augers. Jacques Whitford personnel recorded the subsurface conditions encountered in the boreholes at the time of the drilling program. The soils were sampled by carrying out Standard Penetration Tests (SPT) in accordance with ASTM D1586. The SPT was carried out at regular intervals to a maximum spacing of 1000 mm, and the recovered soil samples were returned to our laboratory. Pocket Penetrometer testing was carried out on received samples of cohesive soils. Undrained shear strength was measured insitu by carrying out vane shear testing with an MTO type ‘N’ vane in one borehole. The subsurface conditions are described in detail in the Borehole Records provided in Appendix 2.

Water levels were recorded in the open boreholes after drilling. Boreholes BH1 and BH2 were left open overnight and groundwater was measured in the open borehole on the following day. One standpipe was installed in BH3 at a depth of 5.9 m below the existing ground surface. The lower 3 m of the standpipe was screened and the borehole caved to a depth of approximately 3 m below the ground surface immediately after installation of the standpipe. An approximate 1.8 m bentonite plug was placed above the cave material and the remainder of the borehole was backfilled with a bentonite cement and auger cutting mixture All other boreholes were backfilled with a bentonite, cement and auger cutting mixture.

All soil samples recovered were stored in moisture proof containers and were returned to our laboratory for classification and testing.

3.2 Survey

The borehole locations were established in the field by Jacques Whitford personnel by measuring from the existing infrastructure on the site.

The ground surface elevations at the borehole locations were surveyed relative to a Temporary Benchmark (TBM) on the paved area in the entrance to the existing salt/sand storage dome in the Patrol Yard southwest of the investigated area. A Geodetic Elevation of 115.621 m for the TBM was interpreted from The Patrol Facility Site Plan, Plan H-15-2-1 dated June 1993 provided by MTO.

3.3 Laboratory Testing

All samples returned to the laboratory were subjected to detailed visual classification by a geotechnical engineer. Selected samples were tested for moisture content, grain size analysis, and Atterberg limits. One representative soil sample was submitted to Phillip Analytical Services for testing of pH, soluble sulphate and conductivity to assess the potential for sulphate attack on buried concrete and the potential for corrosion of buried steel.

All soil samples will be stored for a period of one year after issuance of the final report. Unless otherwise directed, the stored samples will be disposed of at the end of this period.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix 2. An explanation of the symbols and terms used to describe the Borehole Records is also provided.

The surficial layer was sandy silt topsoil in all the boreholes except in one borehole where sand and gravel was encountered at the ground surface. The surficial materials were underlain by clayey silt fill, sand and gravel fill or silty sand fill in four boreholes. The native soils encountered ranged from varved clayey silt to silty clay till deposits.

A description of the soil stratigraphy encountered is provided in the following sections. A borehole location plan and cross-sections of the soil conditions encountered within the boreholes is shown on Drawing No. 10785GEO-1 in Appendix 1.

4.1.1 Surficial Materials

The ground surface cover at BH1 through BH5 consisted of grass with underlying topsoil. The topsoil was comprised of sandy silt with rootlets and was approximately 100 mm to 600 mm thick at the borehole locations.

The ground surface cover at BH6 was frozen sand and gravel fill and was approximately 300 mm thick.

4.1.2 Sand and Gravel Fill

A layer of sand and gravel fill was encountered below the topsoil in BH1, BH3, and BH5. In BH1 the sand and gravel fill was more sandy and was described as silty sand with gravel. In BH3 and BH4 the sand and gravel fill contained trace silt. A clayey silt pocket was observed within the stratum in BH1. Cobbles were present in BH2. The sand and gravel fill extended to depths of 0.6 m and 1.5 m below the ground surface. The SPT N-values were in the order of 14 for this deposit.

A single test conducted on a representative sample of the sand and gravel fill yielded a moisture content of 15%.

4.1.3 Clayey Silt Fill

A layer of clayey silt fill was encountered below the topsoil in BH6. The clayey silt fill contained some sand and gravel. The clayey silt fill extended to a depth of 0.8 m below the ground surface. The SPT N-value was in the order of 20 for this deposit.

4.1.4 Sand and Gravel Till

Native, sand and gravel till soil was encountered below the topsoil in BH2 and BH4 and below the fill materials in BH1 and BH3. The sand and gravel till varied from a sand and gravel containing some silt in BH2 and BH4 to a sand containing trace silt and gravel in BH3. The sand and gravel till, where encountered, extended to depths varying from 2.0 m to 3.8 m below the ground surface as measured in the boreholes. The SPT N-values ranged from 11 to 40 indicating that the sand and gravel till was compact to very dense.

Grain size distribution testing was completed on one representative sample from BH1 at an approximate depth of 1.8 m below the ground surface. The results yielded 29 % gravel, 39 % sand and 32 % silt and clay size particles. The results of the test are illustrated on Figure No. 1 in **Appendix 3**.

Four tests conducted on representative samples of the native sand and gravel soil yielded moisture contents ranging from 8 % to 17 %.

4.1.5 Varved Clayey Silt

Varved clayey silt soil was encountered below the sand and gravel in BH3 and BH5. The varved clayey silt was interbedded with sandy silt and contained a few sand seams. The varved clayey silt soil extended to a depth of 4.6 m below the ground surface in BH3 and to the termination depth of BH5.

The SPT N-values ranged from 9 to 17. The insitu undrained shear strength was measured to be 70 kPa in BH3 at an approximate depth of 4.1 m. A remoulded strength of approximately 13 kPa was measured with a resulting sensitivity in the order of 5.5. The insitu testing and Pocket Penetrometer testing indicated the consistency of the varved clayey silt varied from stiff to very stiff.

Atterberg Limits tests were completed on two samples from BH5. For samples SS3 and SS4 the liquid limit was determined to be 18% and 34% and the plastic limit was 12 % and 16 % for resulting plasticity indices of 6 % and 18 % for the respective samples. This material can be classified as clayey silt of low plasticity, (CL) according to the Unified Soil Classification System. The results of the analysis are presented in Figure 2 in **Appendix 3**.

Two tests conducted on representative samples of the native varved clayey silt soil yielded moisture contents ranging from 15 % to 27 %.

4.1.6 Clayey Silt Till

Native, clayey silt soil was encountered below the sand and gravel till in BH1, BH2, and BH4, and below the varved clayey silt in BH3 and clayey silt fill in BH6. The clayey silt till contained some sand trace gravel. The clayey silt extended to depths of 4.3 m to 9.1 m below the ground surface as measured in the respective boreholes. The SPT N-values ranged from 11 to 96. Pocket Penetrometer testing indicated the consistency of the clayey silt varied from stiff to hard.

Atterberg Limits tests were completed on four representative samples from BH1 BH3 and BH5. The liquid limit was determined to vary from 15 % to 16 % and the plastic limit was determined to vary from 11 % to 13 % for resulting plasticity indices of 3 % to 4 %. In accordance with the Unified Soil Classification System this material lies within the borderline region of materials classified as clayey silt of low plasticity, (CL) or silts of low plasticity (ML). Based on the medium to high strength (crushing characteristics) of dried samples the stratum is described as clayey silt in this report. The results of the analysis are presented in Figure 3 in **Appendix 3**.

One grain size distribution testing was completed on a representative sample. The result yielded 14 % gravel, 38 % sand and 48 % silt and clay size particles. The results of the test are illustrated on Figure No. 4 in **Appendix 3**.

Eight tests conducted on representative samples of the native clayey silt till soil yielded moisture contents ranging from 5 % to 18 %, with an average of 8 %.

4.1.7 Bedrock

Auger refusal was encountered on inferred bedrock at all borehole locations at depths from 4.3 m to 9.1 m below ground surface.

4.2 Groundwater

Groundwater was encountered in the open boreholes in BH1 through BH3 and BH5 on completion of drilling. Prior to backfilling the boreholes, the depth to groundwater was recorded in all the boreholes and BH1 and BH2 were left open overnight and the water levels were measured the next day. A standpipe was installed in BH3 and the water level was measured on January 14, 2003. The water levels measured are provided below in Table 1.

Table 1
Groundwater Level Measurements

Borehole No.	Open Borehole on completion of drilling		Open Borehole one day after drilling		Standpipe one day after installation	
	Depth (m)	Elevation	Depth (m)	Elevation	Depth (m)	Elevation
BH1	4.4	114.9	2.5	116.8	N/I	-
BH2	5.2	113.3	4.0	114.5	N/I	-
BH3	3.9	112.3	N/A		2.6	113.6
BH4	Dry		N/A		N/I	-
BH5	3.4	112.4	N/A		N/I	-
BH6	Dry		N/A		N/I	

Notes: *Depth is recorded as depth below ground surface
N/I - Standpipe not installed
N/A- Not Applicable

4.3 Chemical Testing

Analytical chemical testing was completed on one soil sample to assess the potential for degradation of the foundation concrete in the presence of soluble sulphates, and the potential for the corrosion of exposed steel construction materials used in buried components. The results of the tests are summarized in Table 2.

Table 2
Analytical Chemistry Results

Borehole/Sample No.	Median Depth (m)	pH	Soluble Sulphate (ppm)	Resistivity* (Ohm-cm)
BH4 – Sample 2	1.0	7.55	36	4 310

Notes: *The result of the conductivity test has been used to provide an indication of the resistivity of the soil.

5.0 CLOSURE

This report has been prepared for the sole benefit of the MTO and its agents, and may not be used by any third party without the express consent of Jacques Whitford Associates Limited and the MTO. Any use that a third party makes of this report is the responsibility of the third party.

A subsurface investigation is a limited sampling of a site. The subsurface conditions reported herein are based on information gathered at the specific borehole locations and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions as influenced by geologic processes, as well as the history of the site reflecting natural conditions, construction activity and site use.

Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

We trust the information provided herein meets your present requirements. Should you have any questions or require additional information or clarification, please do not hesitate to contact us.

Yours truly,

JACQUES, WHITFORD AND ASSOCIATES LIMITED

Harry Sturm, P.Eng.
Senior Engineer

Fred J. Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact

FOUNDATION DESIGN REPORT

For

W.P. SSB 041387
PROPOSED STORAGE BUILDING

MARYSVILLE PATROL YARD
COUNTY ROAD 1, 1 KM EAST OF COUNTY ROAD 49

6.0 PROPOSED DEVELOPMENT

The Ontario Ministry of Transportation (MTO) has proposed to construct a building for the storage of salt and sand at the Marysville Patrol Yard. The MTO indicated that the proposed building is to be approximately 24.4 m wide by 48.8 m long and have 2.4 m high above grade concrete perimeter walls with a metal frame roof structure to be covered in fabric. The concrete walls are to retain the salt and sand stored in the building. It is anticipated that the Finished Floor Elevation (FFE) of the building will be similar to the existing grades in the paved driveway to the southwest of the investigated area and that the floor of the building will consist of a concrete slab-on-grade.

The approximate location of the proposed building was provided in the field and a plan view of the identified location is provided on Drawing No. 10785GEO-1 in Appendix 1.

7.0 GEOTECHNICAL DESIGN

7.1 Building Foundation

The surficial soils encountered in the boreholes consisted of topsoil or sand and gravel at the ground surface. The surficial materials were underlain by clayey silt fill, sand and gravel fill or silty sand fill in four boreholes. Native soils were encountered below the fill material or the topsoil and ranged from varved clayey silt to clayey silt till deposits. Groundwater was encountered in the open boreholes upon completion of drilling except in BH4 and BH6 which remained dry on completion of the drilling. Water was measured at elevations varying from 112.3 to 116.8.

Based on the conditions encountered in the boreholes, the proposed building may be supported on conventional strip and spread footings founded at or below elevation 114.2 m in the stiff varved clayey silt soil or the stiff to hard clayey silt till.

7.1.1 Bearing Resistance

Spread footings placed a minimum of 1.5 m below final grade in the stiff varved clayey silt soil or the stiff to hard clayey silt till may be designed for a factored bearing resistance at ULS of 200 kPa. The value provided is for vertical concentric loads only and includes a factor of 0.5. Effects of load inclination and eccentricity need to be taken into account in accordance with Clause 6.7.4 of the CHBDC, CAN/CSA-S6-00 using the curve for “cohesive soil” for footings placed on clayey silt deposits.

The SLS capacities are governed by the size of the footings and should be reviewed once the footing size has been determined. For preliminary purposes a bearing resistance at SLS of 150 kPa is appropriate for a footing width of 1.5 m assuming that 25 mm of settlement is acceptable. This settlement is in addition to that induced by the stockpile.

Should these bearing resistance values be insufficient for the proposed construction it is suggested that the building be moved to the north outside the area where varved clayey silt was encountered. It is anticipated that if the southern building wall was moved approximately 10 m north, to the area of BH6 the foundations would be founded on clayey silt till in their entirety. Should the foundations be founded on the very stiff to hard clayey silt till a factored bearing resistance at ULS of 250 kPa and a bearing resistance at SLS of 175 kPa is suggested for a footing width of 1.5 m assuming a factor of 0.5 and an acceptable settlement of 25 mm.

7.1.2 Horizontal Resistance

It is understood that the salt and sand within the proposed building may piled against the 2.4 m high concrete walls which would then function as retaining structures. For rigidly tied structures, the at-rest pressure should be used for design, however due to the proposed building wall length and height it is anticipated that wall movement will occur and active earth pressures will apply to the design.

The following information is provided for the calculation of lateral pressures on the proposed walls due to the sand or salt. This information is based on previous work with salt storage facilities.

Parameter	Sand	Salt
Bulk Unit Weight	19 kN/m^3	11 kN/m^3
Internal Friction Angle	30º	40º
Active Earth Pressure Coefficient*	0.75	0.59

Notes: * The material is assumed to be piled at its angle of repose from the top of the wall.

Resistance to lateral forces/sliding resistance between the concrete footings and the subsoils should be calculated in accordance with Clause 6.7.5 of the CHBDC, CAN/CSA-S6-00. A coefficient of friction of 0.35 may be assumed between mass concrete for the footing and the undisturbed, clean surface of the varved clayey silt soil. . A coefficient of friction of 0.45 may be assumed between mass concrete for the footing and the undisturbed, clean soil should the footings be placed on undisturbed native sand and gravel or clayey silt till.

Additional horizontal resistance could be achieved by lowering the foundations and utilizing passive resistance from beneath the frost depth. Lateral earth pressures may be calculated based on the following.

Parameter	Native Clayey Silt
Bulk Unit Weight	18 kN/m^3
Effective Friction Angle	27°
Active Earth Pressure Coefficient	0.37
Passive Earth Pressure Coefficient	2.7

The use of a shear key to increase horizontal resistance could be considered.

7.1.3 Frost Protection

It is anticipated that the foundations for the building will be shallow spread footing foundations founded on the native clayey silt soils and that the building will be unheated. Concrete footings should be provided with a minimum of 1.5 m of soil cover for adequate frost protection.

7.2 Concrete and Exposed Steel

Analytical chemical testing completed on one sample of the sand and gravel indicates that there is a low potential for sulphate attack on concrete. Therefore, in accordance with the Canadian Standards Association (CSA) A23.1 M90, normal Type 10, Portland Cement may be used in buried concrete.

The resistivity test result indicated that there is a moderate potential for corrosion of buried and exposed reinforcing steel when compared to literature references (J.D. Palmer, Soil Resistivity Measurement and Analysis, Materials Performance, Volume 13, 1974). Given the proposed use of the site, special precautions should be considered to protect steel from corrosion.

7.3 Slab On Grade

It is anticipated that the floor slab on the interior of the proposed building will be constructed of concrete and will be subjected to heavy truck and loader traffic. It is recommended that the concrete floor slab be constructed with the following structure:

- 250 mm of plain concrete
- 150 mm OPSS Granular A
- 300 mm OPSS Granular B or Select Subgrade Material for frost buffering

The concrete slab should be constructed with a maximum joint spacing of 4.5 m. The free edges of the concrete slab that are trafficed by heavy vehicles should be thickened a minimum of 20% and the thickened edge should be transitioned over a minimum length of 1.5 m. The floor slab should be isolated from all building walls.

A perimeter drainage system will not be required, provided that the proposed floor is a minimum of 150 mm above the exterior grade and the ground surface around the perimeter of the building slopes down away from the building walls. A drainage swale is recommended between the building and the anticipated earth cut slopes on the south east and west sides of the building.

Underfloor drains will not be required for the proposed structure.

Settlement calculations indicate that the floor slab loaded with up to 6 m of sand in a conical shape is anticipated to experience less than 25 mm of settlement.

7.4 Pavement Design

It is anticipated that a new asphalt pavement is to be constructed on the perimeter of the new storage building and that it will be subject to truck and loader traffic. Based on the information from other patrol yard sites the following pavement structure is recommended for use at this site.

- 40 mm HL3 Surface Course
- 90 mm HL8 Binder Course, placed in two lifts
- 150 mm OPSS Granular A
- 450 mm OPSS Granular B Type I

Where the new asphalt pavement abuts the existing asphalt pavement the subgrade should be graded to ensure that the water drains away from the existing pavement.

Where asphalt pavements abut concrete pavements some cracking and distortion of the asphalt should be anticipated due the differences in thermal and strength characteristics of the asphalt and the concrete.

8.0 GENERAL CONSTRUCTION RECOMMENDATIONS

8.1 Site Preparation

It is anticipated that a cut and fill earthworks program will be implemented to establish the final sub-grade elevations for the proposed building. In order to establish the assumed FFE it is anticipated that cuts of up to 3 m in height will be required at the eastern building wall transitioning to zero at the western building wall.

It will be necessary to remove all the topsoil from within the area of proposed development including the areas to be paved. The topsoil thickness at the borehole locations was measured to vary from 100 mm to 600 mm.

Prior to initiating the placement of the fill material in areas requiring fill, the surface of the exposed, subgrade after topsoil removal should be proof rolled and compacted. Areas that do not require a change in grade should also be proof rolled at this time. The proof rolling program should consist of a minimum of 4 passes per unit area using a large, vibratory compactor (minimum static weight of 5 tonnes). The proof rolling program will provide a uniform surface for construction and will minimize the infiltration of precipitation and ground surface runoff.

Where structural fill is required for site levelling, or to backfill localized excavations, the material should be OPSS Granular B - Type 1, Select Sub-Grade Material, or other approved fill.

The structural fill should be placed in 200 mm thick, loose lifts. The material should be compacted to a minimum of 100% of the materials Standard Proctor Maximum Dry Density (SPMDD) in the areas of planned buildings and interior slab on grade and to a minimum of 98% of the materials SPMDD in the areas of planned pavements.

8.2 Temporary Excavations and Backfill

Temporary excavations for the construction of foundations or installation of buried services must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA).

All soils within the anticipated excavations depths for this site; including the fill materials, the stiff clayey silt and the compact, sand and gravel encountered in the boreholes can be classified as Type 3 soils. The minimum excavation side slope for Type 3 soil is 1:1 (Horizontal:Vertical) in accordance with the OHSA.

Should excavations extend into the hard clayey silt till this material can be classified as Type 2 soils. The minimum excavation side slope for Type 2 soil is 1:1 (Horizontal:Vertical) with a maximum 1.2 m vertical excavation in accordance with the OHSA.

Water was recorded at depths of 2.5 m to 5.2 m below the existing ground surface.

If localized instability is noted during excavation or if wet conditions are encountered, the side slopes should be flattened.

8.3 Dewatering

Groundwater was encountered at depths in the order 2.5 m to 5.2 below the existing ground surface in four boreholes and the remaining boreholes were dry upon completion of drilling. Based on the anticipated construction and the foundation recommendations it is anticipated that the groundwater table may be intersected in the shallow excavations required for the construction of the footings.

Groundwater was observed at elevations between 112.3 m and 116.8 m. The proposed foundation elevation of 114.2 m suggests the shallow excavations may extend below the groundwater elevation and inflow of groundwater should be anticipated. Groundwater inflow should be minimal as the native soils below the groundwater table were generally cohesive. It should be noted that wet sand was encountered in BH1 at an approximate elevation of 116.6. It is anticipated that groundwater inflows into excavations below the groundwater table will be handled by pumping from sumps.

8.4 Slopes and Erosion Control

Permanent cut slope should be constructed with slopes no steeper than 2.75:1 (Horizontal:Vertical). The cut materials are anticipated to vary from silty sand to sand and gravel based on the information from BH1 and BH2. The erodability of these materials is assessed to be slight to moderate.

The cuts slopes should be protected from erosion by the placement of seed and mulch over topsoil. It should be noted that the groundwater level measured in BH1 on January 14th was above the proposed level of the potential cut grade at that location and soil samples recovered at elevation 116.5 m were wet. Groundwater seepage from the cut slope may occur over an extended period of one or two years in the area of BH1. Should seepage be observed at the time of construction slope protection including gravel sheeting with underlying non woven geotextile should be considered for the areas exhibiting seepage.

9.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The recommendations given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours truly,

JACQUES, WHITFORD AND ASSOCIATES LIMITED

REGISTERED PROFESSIONAL ENGINEER
H.J. STURM
PROVINCE OF ONTARIO

Harry Sturm, P.Eng
Senior Engineer

LICENSED PROFESSIONAL ENGINEER
F.J. GRIFFITHS
PROVINCE OF ONTARIO

Fred J. Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact

APPENDIX 1

- **Borehole Location Plan and Soil Sections**

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

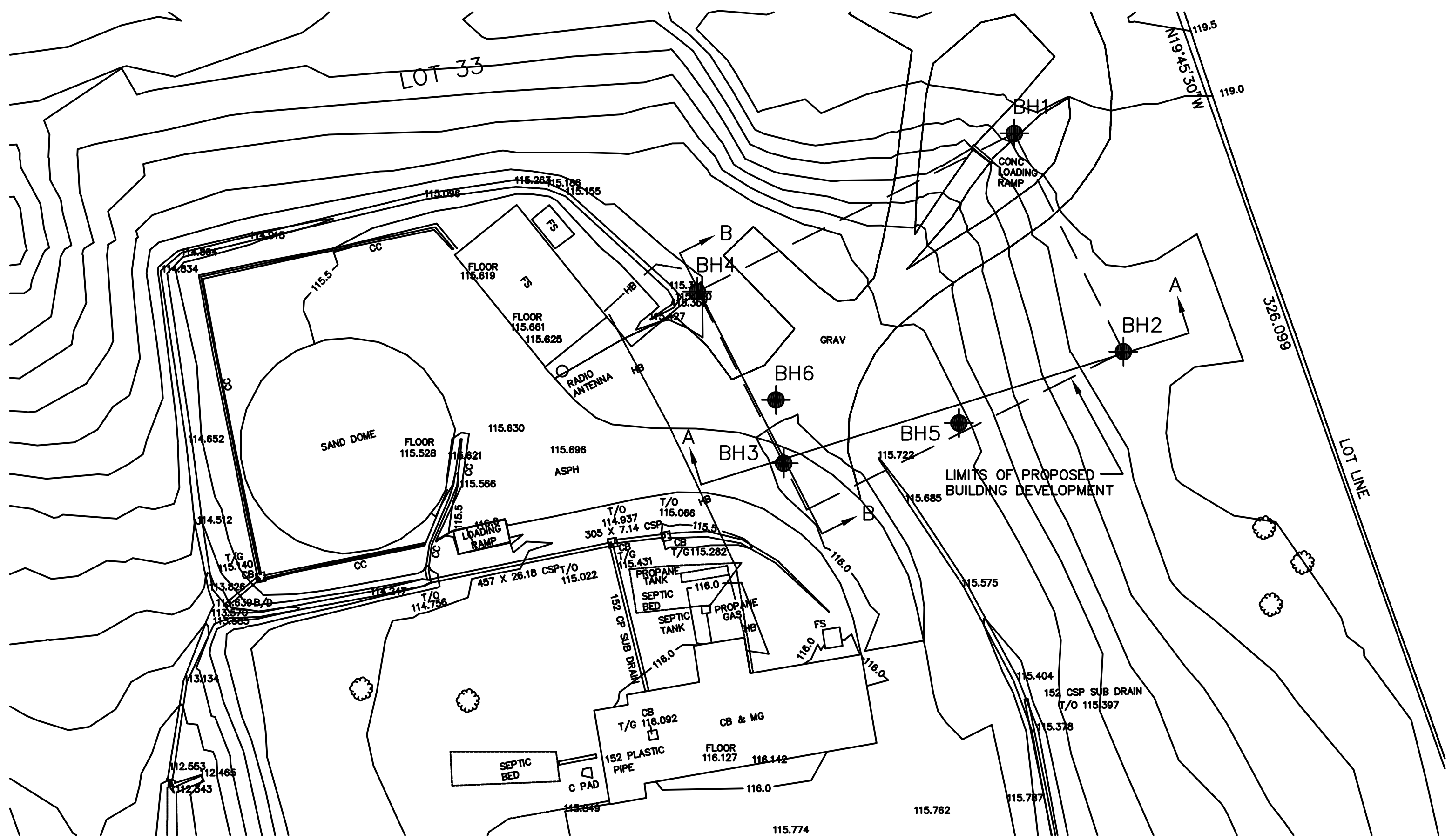
CONT No
WP No 4001–X–002595

MARYSVILLE PATROL YARD
PROPOSED STORAGE FACILITY

BOREHOLE LOCATIONS

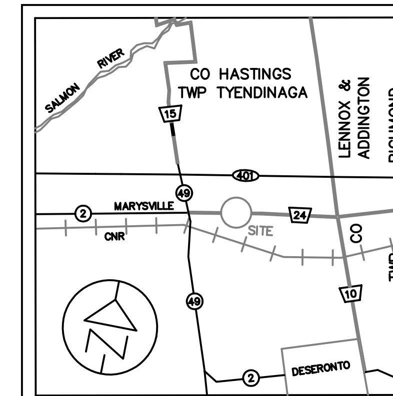
SHEET
1

JACQUES, WHITFORD LIMITED



PLAN

SCALE
10m 0 10m



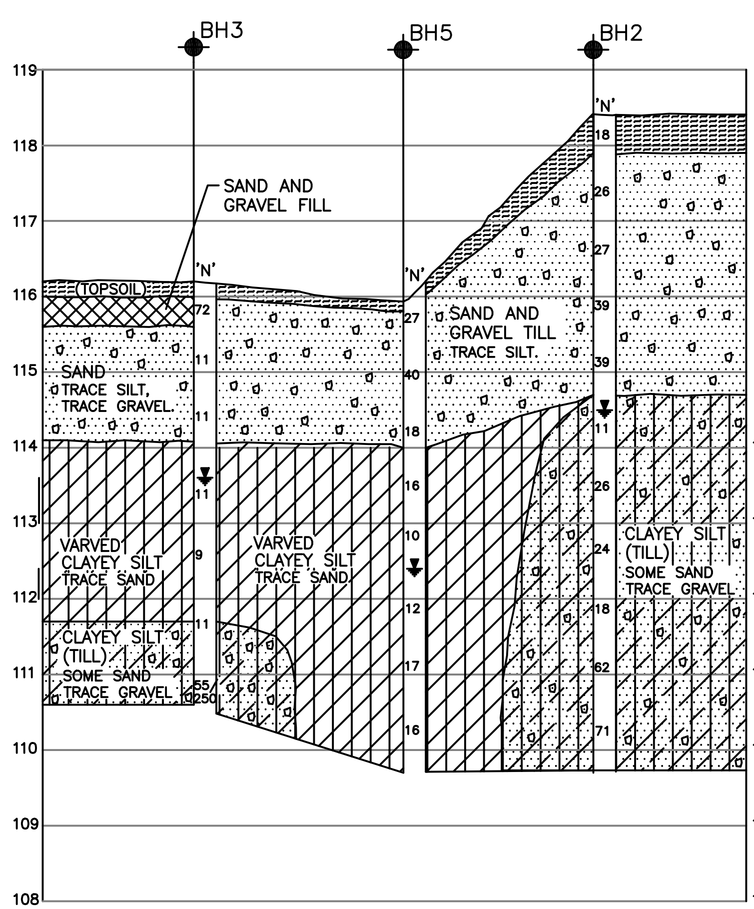
KEY PLAN
1km 0 1 2km

LEGEND

- Bore Hole
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- WL at time of investigation 99 03

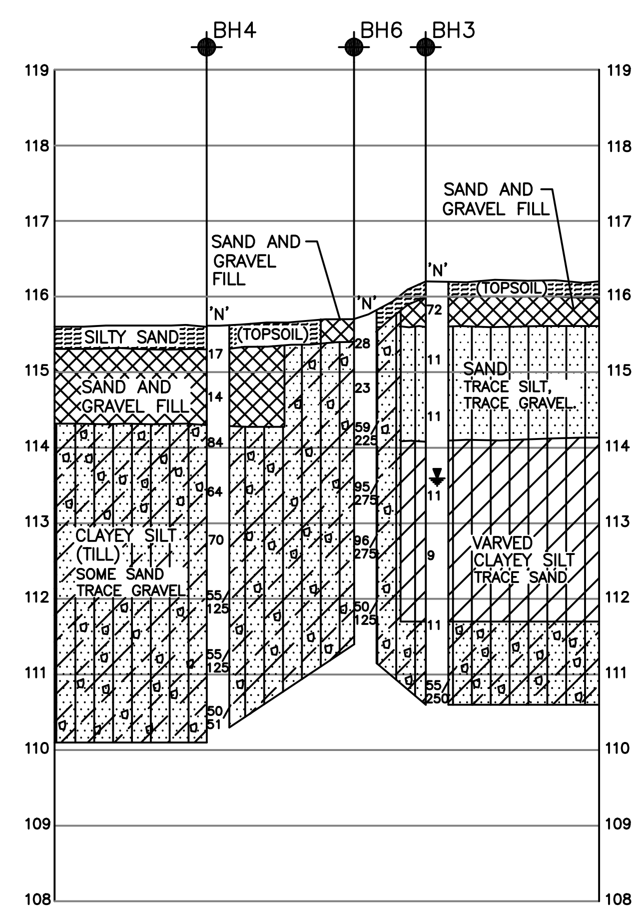
No	ELEVATION	COORDINATES NORTH	COORDINATES EAST
BH1	119.3	4 899 164	257 220
BH2	118.5	4 899 133	257 236
BH3	116.3	4 899 117	257 188
BH4	115.6	4 899 141	257 176
BH5	115.9	4 899 123	257 213
BH6	115.7	4 899 126	257 187

NOTE
Area of Planned Building and Boreholes



SECTION A–A

SCALE
10m 0 10m Horizontal
1m 0 1m Vertical



SECTION B–B

Rev.	DATE	BY	DESCRIPTION
–			–

GEOCRES No

COUNTY ROAD 24, MARYSVILLE			DIST 43
SUBM'D HS	CHECKED	DATE JAN 20, 2003	SITE
DRAWN LMV	CHECKED	APPROVED	DWG 10785GEO–1

10785GEO–1A

APPENDIX 2

- **Explanation of Terms Used in Report**
- **Borehole Records**

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT 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
Till	-	unstratified and unsorted glacial deposit which may include particle sizes from clay to boulders
Fill	-	materials not identified as deposited by natural geological processes

Terminology describing soil structure:

Desiccated	-	having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	-	material breaks along plane of fracture
Varved	-	composed of regular alternating layers of silt and clay
Stratified	-	alternating layers or beds greater than 6mm (3”) thick
Laminated	-	alternating layers or beds less than 6mm (3”) thick
Blocky	-	material can be broken into small and hard angular lumps
Lensed	-	irregular shaped pockets of soil with differing textures
Seam	-	a thin, confined layer of soil having different particle size, texture, or color from materials above and below
Well Graded	-	having wide range in grain sizes and substantial amounts of all intermediate particles sizes
Uniformly Graded	-	predominantly one grain size

Soil descriptions and classification are based on the Unified Soil Classification System (USCS) (ASTM D-2488), which classifies soils on the basis of engineering properties. 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. This 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.

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 the standard of the Ministry of Transportation of Ontario:

Trace or occasional	Less than 10%
Some	10-20%
With	20-30%

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test ‘N’-value*.

Compactness	‘N’-value
Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Continued Next Page

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

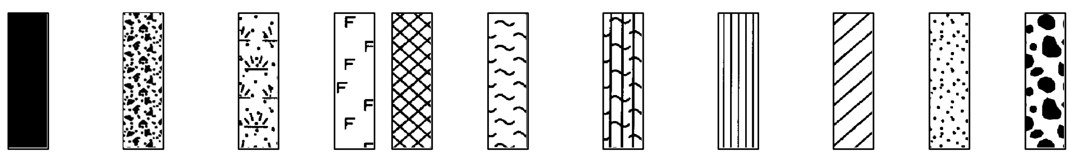
The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis. Standard Penetration Test 'N'-values* can also be used to provide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

Consistency	Undrained Shear Strength (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

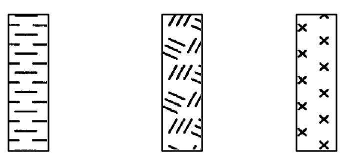
Note: *'N'-VALUE- The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in millimeters (e.g. 50/75).

STRATA PLOT

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



Asphalt *Concrete* *Topsoil* *Fill* *Peat* *Organic Silt* *Silt* *Clay* *Sand* *Gravel*



Sedimentary Rock *Metamorphic Rock* *Igneous Rock*

WATER LEVEL MEASUREMENT

Open Borehole or Test Pit

Monitoring Well, Piezometer or Standpipe

SAMPLE TYPE

SS	Split spoon sample (obtained from the Standard Penetration Test)
TW	Thin Wall Sample or Shelby Tube
PS	Piston sample
GS	Grab sample
AS	Auger sample

BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ,etc.	Rock core samples obtained with the use of standard size diamond drilling bits.

RECORD OF BOREHOLE No BH1

METRIC

W.P. SSB 041387 | LOCATION N 4899164 E 257221 | ORIGINATED BY NK

DIST 43 HWY Marysville Patrol | BOREHOLE TYPE Solid Stem Augers, Split Spoon | COMPILED BY NB

DATUM Geo | DATE 03.01.13 | CHECKED BY HS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
119.3						
0.0	Black, Silty SAND (Topsoil), with rootlets, moist	1	SS	9	119	
118.7 / 0.6	Brown, compact, Silty SAND (Fill), with gravel, moist	2	SS	14	118	
117.7 / 1.5	Brown, compact, Silty SAND (Till), with gravel, trace clay, moist	3	SS	30		29 39 (32)
	-150 mm Clayey SILT pocket, some sand, moist - wet	4	SS	13	117	
116.4 / 2.9	Brown, hard, Clayey SILT (Till), with sand, some gravel, moist	5	SS	73	116	14 38 28 20
		6	SS	50/ 125	115	
		7	SS	50/ 125	114	
113.9 / 5.3	-Grey	8	SS	50/ 125		
		9	SS	50/ 100	113	
					112	
		10	SS	92/ 250	111	
110.1 / 9.1	End of Borehole Auger Refusal on Inferred Bedrock					

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS (water level symbol at approx. elev. 116.8); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, FIELD VANE, X 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, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2

METRIC

W.P. SSB 041387 | LOCATION N 4899133 E 257236 | ORIGINATED BY NK

DIST 43 HWY Marysville Patrol | BOREHOLE TYPE Solid Stem Augers, Split Spoon | COMPILED BY NB

DATUM Geo | DATE 03.01.13 | CHECKED BY HS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
118.5						
0.0	Dark brown, Silty SAND (Topsoil), with rootlets	1	SS	18		118
117.9 / 0.6	Dark brown, compact, SAND and GRAVEL (Till), trace silt, moist	2	SS	26		
	-cobbles	3	SS	27		117
	-dense	4	SS	39		116
		5	SS	39		115
114.7 / 3.8	Brown, stiff, Clayey SILT(Till), some sand, trace gravel, moist	6	SS	11	▽	
	very stiff	7	SS	26		114
113.1 / 5.3	-51 mm sand seam - Grey	8	SS	24		113
		9	SS	18		112
	- hard, damp	10	SS	62		111
		11	SS	71		110
109.7 / 8.7	End of Borehole Auger Refusal on Inferred Bedrock					

Column headings (no data plotted): DYNAMIC CONE PENETRATION RESISTANCE PLOT (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); UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

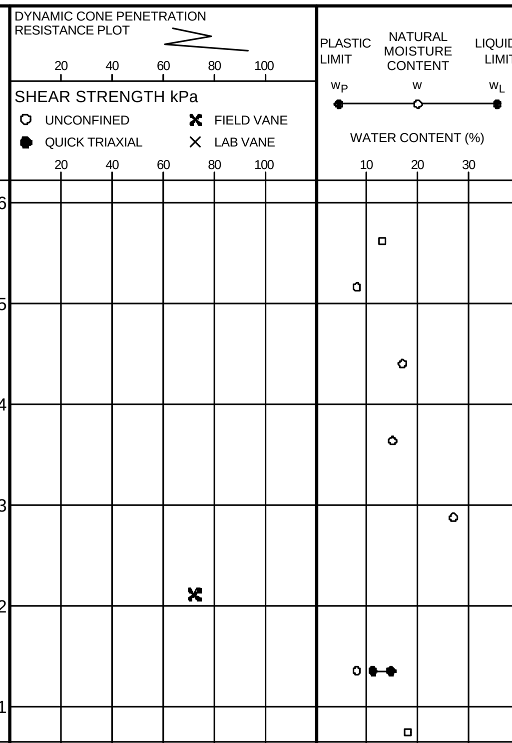
RECORD OF BOREHOLE No BH3

METRIC

W.P.	SSB 041387	LOCATION	N 4899117 E 257188	ORIGINATED BY	NK
DIST	43 HWY Marysville Patrol	BOREHOLE TYPE	Solid Stem Augers, Split Spoon	COMPILED BY	NB
DATUM	Geo	DATE	03.01.13	CHECKED BY	HS

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES
116.2 / 0.0	Black, Silty SAND (Topsoil), trace rootlets, moist	1	SS	72
0.2	Brown, compact, SAND and GRAVEL (Fill), moist			
115.6 / 0.6	Brown, compact, SAND (Till), trace silt and gravel, moist	2	SS	11
		3	SS	11
114.1 / 2.1	Brown, stiff, varved, Clayey SILT, some sand, trace gravel, moist	4	SS	11
113.2 / 3.0	-Grey	5	SS	9
111.7 / 4.6	Grey, stiff, Clayey SILT (Till), some sand, trace gravel, moist	7	SS	11
	-25 mm sand seam	8	SS	55/250
110.6 / 5.6	End of borehole Auger Refusal on Inferred Bedrock			

ELEVATION SCALE: 116, 115, 114, 113, 112, 111



UNIT WEIGHT γ kN/m³

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

Numbers refer to Sensitivity (field vane 3, lab vane 3)

3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH4

METRIC

W.P. SSB 041387 | LOCATION N 4899142 E 257176 | ORIGINATED BY NK

DIST 43 HWY Marysville Patrol | BOREHOLE TYPE Solid Stem Augers, Split Spoon | COMPILED BY NB

DATUM Geo | DATE 03.01.13 | CHECKED BY HS

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT
115.6					
0.0	Black, Silty SAND (Topsoil), moist				
115.3 / 0.3	Brown, compact, SAND and GRAVEL (Fill), moist	1	SS	17	
	-dark brown, moist	2	SS	14	
114.3 / 1.4	Brown, hard, Clayey SILT (Till), some sand and gravel, moist	3	SS	84	plotted
		4	SS	64	plotted
		5	SS	70	
		6	SS	50/125	
		7	SS	50/125	
110.1 / 5.6		8	SS	50/51	

End of Borehole

Auger Refusal on Inferred Bedrock

Borehole dry on completion of drilling

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (115, 114, 113, 112, 111); DYNAMIC CONE PENETRATION RESISTANCE PLOT (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); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

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

RECORD OF BOREHOLE No BH5

METRIC

W.P. SSB 041387 | LOCATION N 4899124 E 257214 | ORIGINATED BY NK

DIST 43 | HWY Marysville Patrol | BOREHOLE TYPE Solid Stem Augers, Split Spoon | COMPILED BY NB

DATUM Geo | DATE 03.01.14 | CHECKED BY HS

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
115.9						
115.8 / 0.0	Black, Silty SAND (Topsoil), some rootlets					
0.1	Brown, dense, SAND and GRAVEL (Till), trace silt, damp to moist	1	SS	27		
	-dark brown, moist	2	SS	40		115
	-wet	3	SS	18		114
113.9 / 2.0	Brown, very stiff, varved Clayey SILT, trace sand, moist					
113.6 / 2.3	-Grey	4	SS	16		113
	-70 mm sand seam	5	SS	10	∇	112
		6	SS	12		111
	-25 mm sand seam	7	SS	17		
		8	SS	16		110
109.7 / 6.2	End of Borehole Auger Refusal on Inferred Bedrock					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 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   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH6

METRIC

W.P. SSB 041387 LOCATION N 4899127 E 257187 ORIGINATED BY NK

DIST 43 HWY Marysville Patrol BOREHOLE TYPE Solid Stem Augers, Split Spoon COMPILED BY NB

DATUM Geo DATE 03.01.14 CHECKED BY HS

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
115.7					
0.0	SAND and GRAVEL (Frozen)				
115.4 0.3	Brown, very stiff, Clayey SILT (Fill), some sand and gravel, damp	1	SS	28	
114.9 0.8	Brown, very stiff, Clayey SILT (Till), some sand, trace gravel, moist	2	SS	23	115
	-300 mm cobbles, hard	3	SS	69/ 225	114
	-damp	4	SS	95/ 275	113
112.6 3.0	-Grey	5	SS	96/ 275	112
		6	SS	50/ 125	
111.4 4.3	End of Borehole Auger Refusal on Inferred Bedrock Borehole dry on completion of drilling				

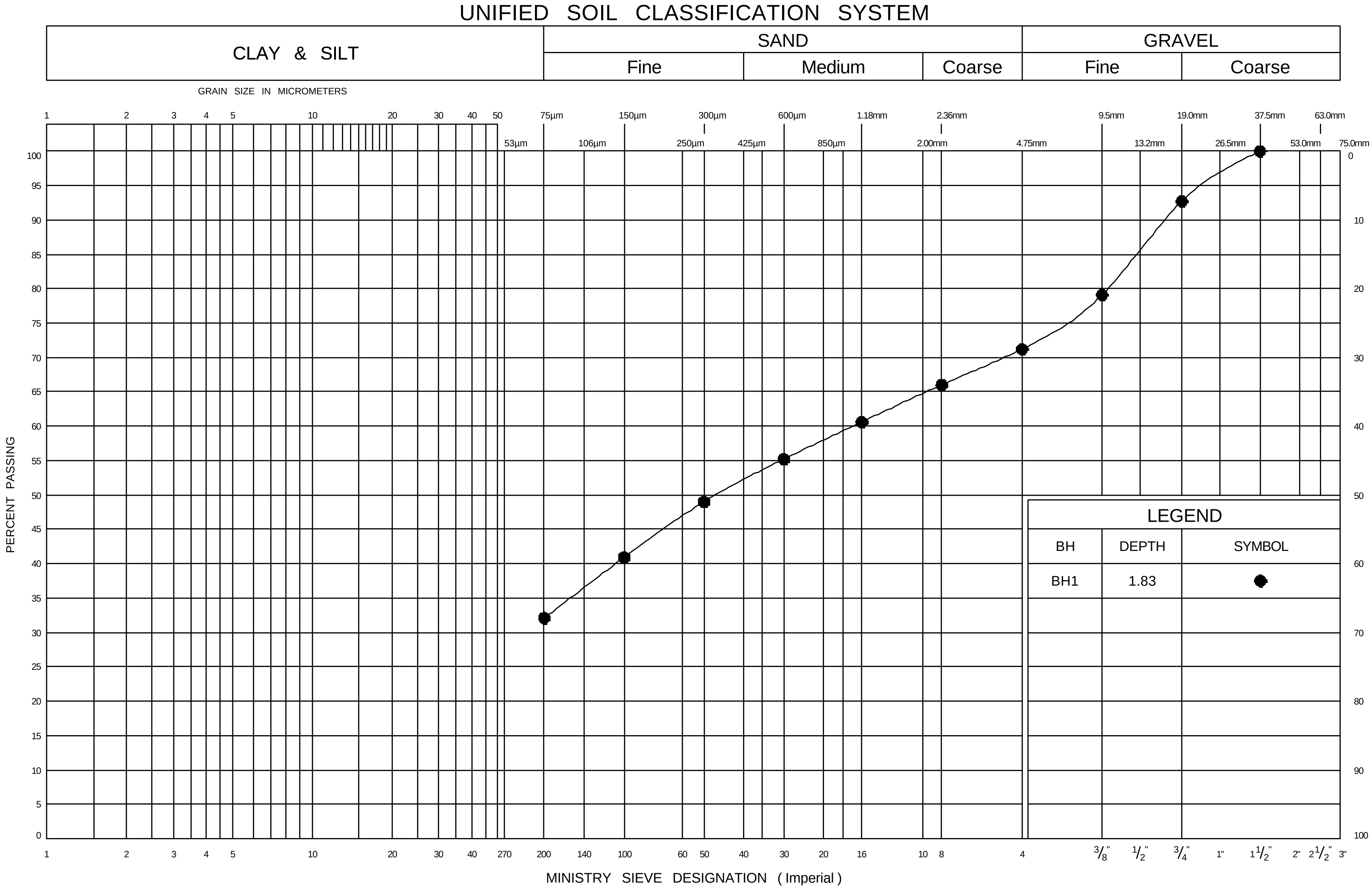
Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, ✖ FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR, SA, SI, CL)

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

APPENDIX 3

- **Atterberg Limits Tests**
- **Grain Size Distribution Curves**

78 12 M



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GRAIN SIZE DISTRIBUTION

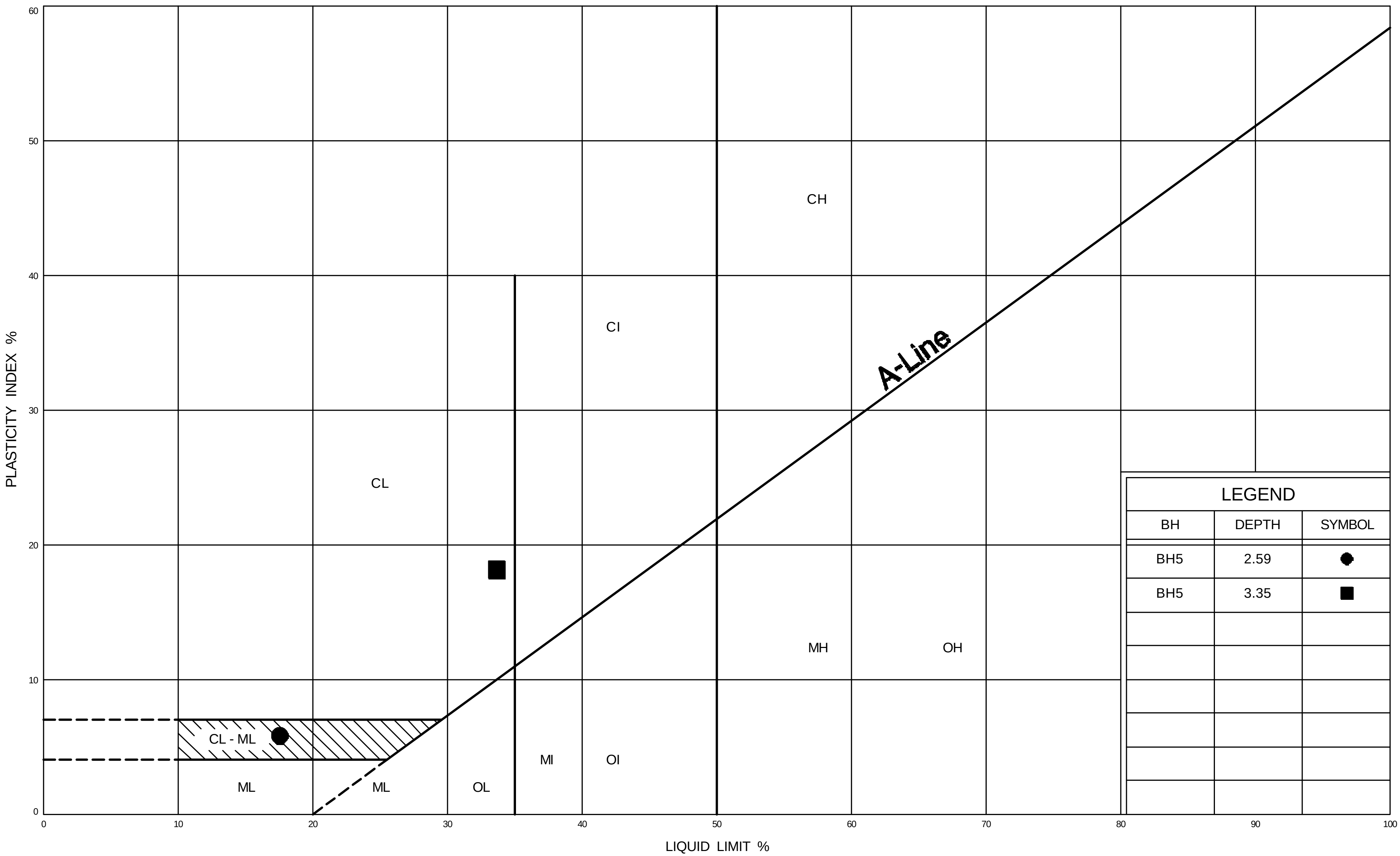
Sand and Gravel Till

FIG No 1

W P SSB 041387

MTO

Oct 75, FF - S - 21



BH	DEPTH	SYMBOL
BH5	2.59	●
BH5	3.35	■

ONTARIO MOT PLASTICITY CHART 10785.GPJ ONTARIO MOT.GDT 03/02/05

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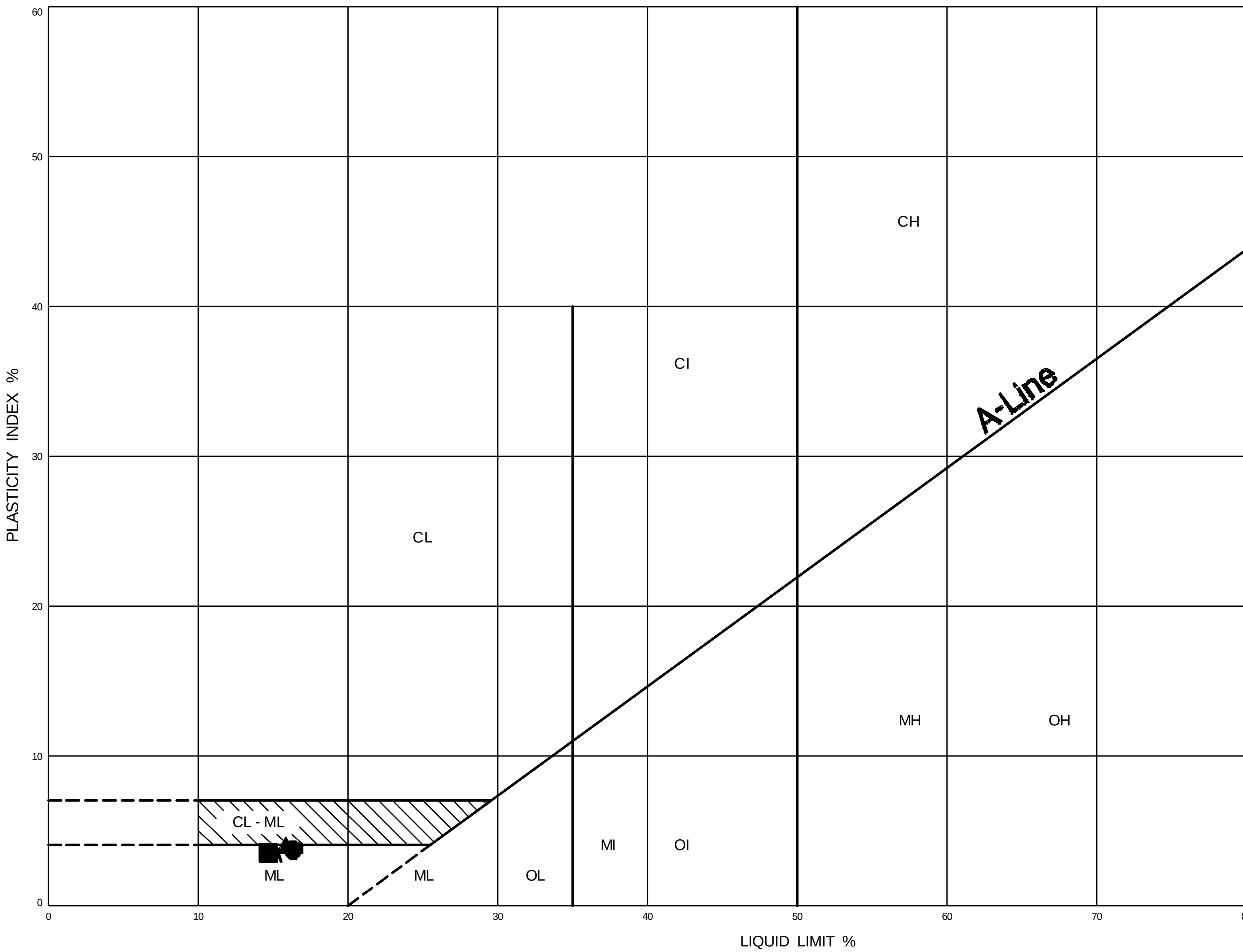
PLASTICITY CHART
Varved Clayey Silt

FIG No 2
W P SSB 041387
MTO

Oct 75, FF - S - 21



LEGEND		
BH	DEPTH	SYMBOL
BH1	3.35	●
BH3	4.88	■
BH4	1.83	▲
BH4	2.59	★

ONTARIO MOT PLASTICITY CHART 10785.GPJ ONTARIO MOT.GDT 03/02/05

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PLASTICITY CHART

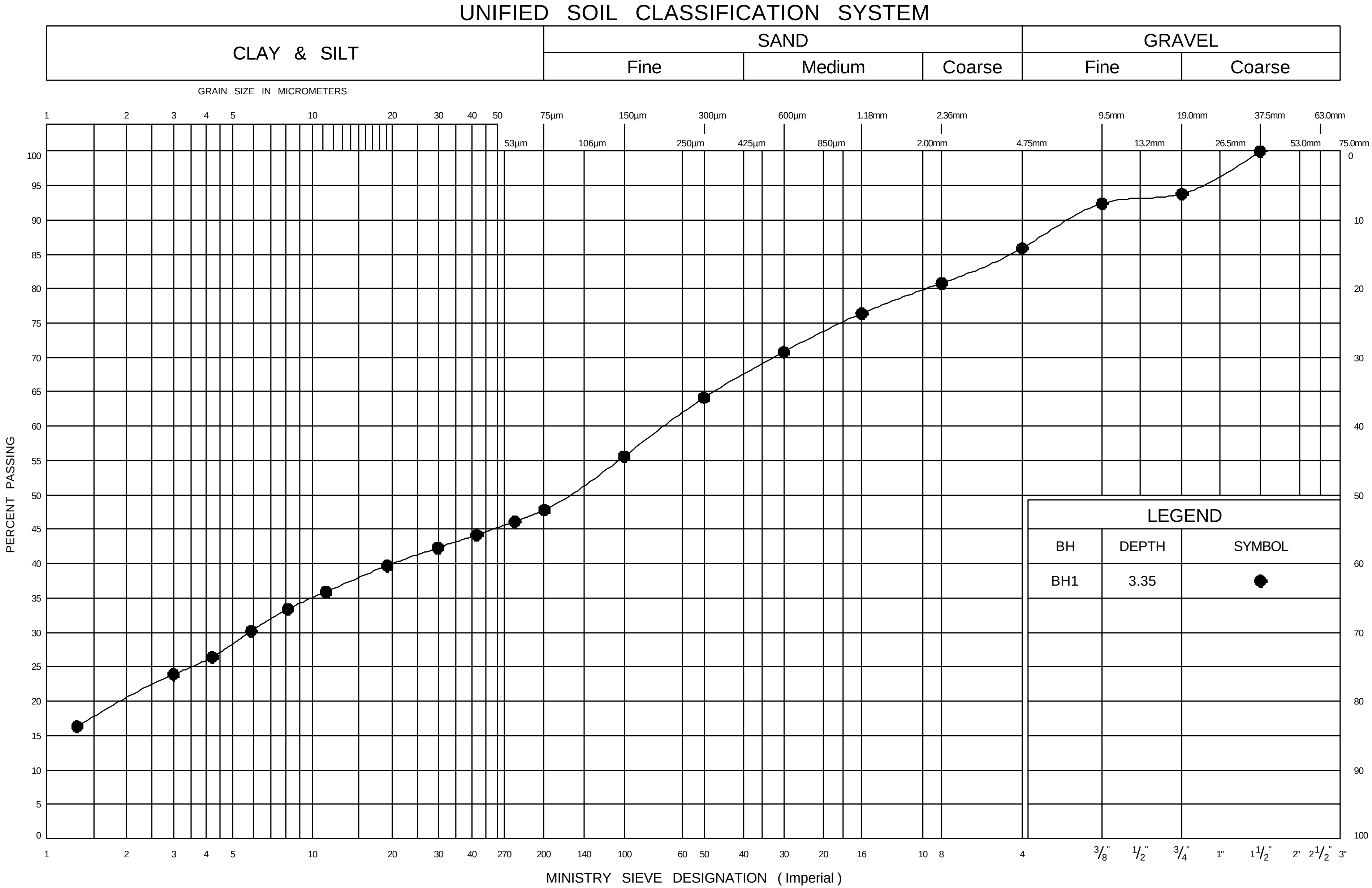
Clayey Silt Till

FIG No 3

W P SSB 041387

MTO

78 12 M



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GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIG No 4

W P SSB 041387

MTO