

**FOUNDATION INVESTIGATION REPORT
MELGUND RIVER BRIDGE REPLACEMENT
HIGHWAY 17
BETWEEN DRYDEN AND IGNACE ONTARIO
DISTRICT OF KENORA, ONTARIO**

W.P. 6145-04-00, Site No. 41S-66

Geocres Number: 52F-37

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed replacement of the existing bridge structure which carries Highway 17 over Melgund River located west of Borups Corners in the District of Kenora, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile and cross-sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to Hatch Mott MacDonald, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0010.

2 SITE DESCRIPTION

The Melgund River Bridge is located on Highway 17 approximately 2.5 km west of Borups Corners, Ontario (between Dryden and Ignace) in the District of Kenora.

At present, the highway crosses the Melgund River on a four-span structure supported on timber piles. Each span length is approximately 5.0 m. The total length of the bridge is 20.1 m and the width is 11.2 m. The Melgund River flows to the south.

The area surrounding the bridge site is relatively flat. The areas to south and northwest of the site consist of open fields while the area to the northeast is treed.

Photographs in Appendix C show the general nature of the site.

The site lies within the physiographic region known as the Wabigoon Subprovince of the Superior Province of the Canadian Shield, which is underlain by Archean rocks. The region is characterized by mafic to intermediate metavolcanic rocks consisting of basaltic and andesitic flows, tuffs and breccias, chert, iron formation, minor metasedimentary and intrusive rocks and related migmatites. Locally, the bedrock is mantled by glaciolacustrine varved silt and clay deposits.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out during the period of July 27 to August 12, 2011 and consisted of drilling and sampling six boreholes (numbered MEL-01 to MEL-06) through the highway embankment in the area of the existing west and east approaches and abutments. Boreholes MEL-01 and MEL-06 were drilled at the west and east approaches, respectively, and were both terminated at a depth of 11.3 m (elevations 361.8 and 361.7). Boreholes MEL-02 and MEL-03 were drilled at the west abutment to depths of 39.3 m and 42.2 m, respectively (elevations 333.7 and 330.9). Boreholes MEL-04 and MEL-05 were drilled at the east abutment to depths of 48.1 m and 42.1 m, respectively (elevations 324.9 and 330.9). Bedrock was proved in Boreholes MEL-03 and MEL-04 by NQ size diamond coring.

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

The drilling was carried out from the highway grade using CME 75 and truck-mounted drill rig. NW casing was used to advance the boreholes through the overburden deposits and NQ coring methods were used to advance selected boreholes through the bedrock. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was carried out to assess the undrained shear strength of soft to firm cohesive deposits.

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

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

One standpipe piezometer consisting of 19 mm PVC pipe with slotted screen and enclosed in filter sand was installed at this site to permit longer term groundwater level monitoring. The boreholes were backfilled with bentonite holeplug in general accordance with O.Reg. 903 upon completion. The location and completion details of the piezometer and boreholes are presented in Table 3.1.

Table 3.1 – Borehole Abandonment Details

Location	Borehole	Piezometer Tip Depth/ Elevation (m)	Abandonment Details
West Approach	MEL-01	None installed	Borehole backfilled with bentonite holeplug to 0.3 m, concrete from 0.3 m to 0.1 m, and asphalt to surface.
West Abutment	MEL-02	38.8 / 334.2	Sand from 38.8 m to 32.2 m, bentonite holeplug from 32.2 m to 0.3 m, sand from 0.3 m to 0.15 m, then asphalt to surface.
	MEL-03	None installed	Borehole backfilled with clay cuttings to 6.4 m, bentonite from 6.4 m to 0.1 m, then asphalt to surface.
East Abutment	MEL-04	None installed	Borehole backfilled with bentonite to 0.4 m, sand from 0.4 m to 0.1 m, then asphalt to surface.
	MEL-05	None installed	Borehole backfilled with bentonite holeplug to 37.7 m, clay cuttings from 37.7 m to 5.4 m, bentonite from 5.4 m to 0.1 m, then asphalt to surface.
East Approach	MEL-06	None installed	Borehole backfilled with bentonite holeplug to 0.3 m, concrete from 0.3 m to 0.1 m, then asphalt to surface.

The piezometers will be decommissioned in accordance with O. Reg. 903 prior to the end of 2012.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing, where appropriate. The results of this testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures contained in Appendix B.

Point load tests were carried out on selected samples of intact bedrock to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the rock core samples are included in Appendix B and on the Record of Borehole sheets in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any

interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

In general terms, the stratigraphy encountered at this site consists of pavement structure overlying granular fill and cohesive fill. Peat was encountered below the fill in the four boreholes drilled at the abutments. Layers of native silt and silty clay were encountered below the fill and peat. In two boreholes, a layer of sand to silty sand with organics was also encountered below the fill. Slightly weathered to fresh, grey, mafic to intermediate metavolcanic bedrock was contacted below the native silt and silty clay layers at depths ranging from 39.2 m to 45.0 m.

More detailed descriptions of the individual strata are presented below.

5.1 Pavement Structure

Pavement structure was encountered in all the boreholes drilled at this site. Boreholes MEL-01 and MEL-06 were drilled through the existing Highway 17 shoulders and consisted of 75 mm and 90 mm of asphalt overlying granular fill.

Boreholes MEL-02 to MEL-05 were drilled through the Highway 17 lanes and revealed 50 mm to 75 mm of asphalt over 280 mm to 450 mm of approach slab concrete. Granular fill was encountered below the concrete. A thin layer (100 mm) of sand fill was encountered between the asphalt and concrete in Borehole MEL-03.

5.2 Sand to Gravelly Sand Fill

Granular fill consisting of brown sand containing trace gravel to gravelly, trace silt and occasional cobbles and boulders was encountered directly below the pavement structure in all the boreholes. Coring through cobbles and boulders was required to advance Borehole MEL-02.

The thickness of the granular fill ranged from 1.0 m to 1.5 m with a lower boundary at 1.4 m to 1.9 m depth (elevations 371.6 to 371.1).

SPT 'N' values recorded in the granular fill ranged from 23 blows for 0.3 m penetration to 50 blows for 0.025 m penetration, indicating a compact to very dense relative density. High 'N' values may be indicative of the presence of cobbles. Highway embankment fills are heterogeneous in nature and besides cobbles and boulders, may contain rockfill.

The moisture content of samples of the sand to gravelly sand fill generally ranged from 15% to 18%. Lower moisture contents of 6% and 2% were measured in Boreholes MEL-01 and MEL-03.

Grain size distribution curve for a sand fill sample is presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of the laboratory tests are summarized as follows

Soil Particles	Percentage (%)
Gravel	33
Sand	64
Silt and Clay	3

5.3 Silty Clay Fill

Silty clay fill was encountered below the granular fill in all the boreholes. The silty clay fill is brown and contains trace gravel and trace to some sand. The thickness of the silty clay fill ranged from 0.6 m to 1.6 m.

The depth to the base of the silty clay fill ranges from 2.1 m to 3.4 m (elevations 370.9 to 369.6).

SPT 'N' values recorded in the cohesive fill typically ranged from 8 to 25 blows for 0.3 m penetration, indicating a stiff to very stiff consistency. Lower 'N' values of 0 and 5 blows for 0.3 m penetration, indicating a very soft to stiff consistency, were recorded in Boreholes MEL-02 and MEL-04 near the lower boundary.

The moisture content of samples of the silty clay fill ranged from 24% to 36%.

Two samples of the cohesive fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and on Figure B2 of Appendix B.

Soil Particles	Percentage (%)
Gravel	0 to 9
Sand	0 to 12
Silt	18 to 27
Clay	62 to 73

A 1.1 m thick layer of brown silt fill was encountered below the silty clay fill in Borehole MEL-05. This isolated layer of silt fill contains trace sand and trace organics/rootlets. The silt fill layer had a lower boundary at a depth of 4.1 m (elevation 368.9). An SPT 'N' value of 4 blows for 0.3 m was recorded in the silt fill, indicating a loose relative density. The moisture content of the silt fill sample was 36%.

5.4 Peat/Organics

Dark brown to grey peat/organics containing some roots, rootlets and wood fibres was encountered below the silty clay fill in Boreholes MEL-02 to MEL-04 and below the layer of silt fill in Borehole MEL-05.

The thickness of the peat/organics ranged from 0.1 m to 0.9 m with a lower boundary at a depth of 3.0 to 5.0 m (elevations 370.1 to 368.1).

An SPT 'N' value of 2 blows for 0.3 m penetration, indicating a very loose condition, was recorded in the peat/organics layer Borehole MEL-05.

The moisture content of samples of the peat/organics ranged from 32% to 78%.

5.5 Sand to Silty Sand

A layer of native grey sand to silty sand mixed with organics/peat was encountered at depths of 3.5 m and 4.6 m in Boreholes MEL-04 and MEL-06, respectively. The sand to silt sand contains trace clay, wood fibres, roots and rootlets.

The thickness of this layer was 1.6 m and 1.5 m in Boreholes MEL-04 and MEL-06, respectively.

The depth to the base of this layer was 5.1 m and 6.1 m (elevations 367.9 and 366.9), in Boreholes MEL-04 and MEL-06, respectively.

SPT 'N' values recorded in the sand/silty sand layers were 4 and 8 blows for 0.3 m penetration, indicating a loose relative density.

The moisture contents of samples of this layer were 42% and 100%. The moisture content of 100% can be attributed to the presence of organics in the sample.

One sample of the sand/silty sand was selected for gradation analysis and the results are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and on Figure B3 of Appendix B.

Soil Particles	Percentage (%)
Gravel	0
Sand	52
Silt	42
Clay	5

5.6 Silt

Layers of native grey silt were encountered at various depths in all the boreholes drilled at this site. The silt generally contains some sand and trace to some clay. Two samples of the silt were found to be clayey. The layers of silt were interbedded with layers of silty clay. The depths, elevations and thicknesses of the silt layers encountered in each borehole are listed in Table 5.1. The thickness of the individual layers of silt ranged from 1.0 m to 17.4 m. Some of the boreholes were terminated in the silt deposit.

Table 5.1 – Depths, Elevations and Thickness of Silt Layers

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
MEL-01	2.1 to 4.6 7.6 to 11.3 (borehole termination depth)	370.9 to 368.5 365.4 to 361.8	2.5 > 3.7
MEL-02	3.1 to 4.1 6.7 to 17.0 23.1 to 25.6 27.8 to 35.1 36.6 to 39.3 (borehole termination depth)	369.9 to 368.9 366.4 to 356.0 350.0 to 347.5 345.2 to 338.0 336.5 to 333.7	1.0 10.3 2.5 7.3 > 2.7
MEL-03	3.0 to 4.1 6.7 to 16.9 21.3 to 38.7	370.1 to 368.9 366.4 to 356.2 351.8 to 334.3	1.1 10.2 17.4
MEL-04	7.6 to 16.9 22.9 to 24.4 35.1 to 45.0	365.4 to 356.1 350.1 to 348.6 338.0 to 328.0	9.3 1.5 9.9
MEL-05	7.2 to 16.5 27.7 to 42.1 (borehole termination depth)	365.9 to 356.5 345.3 to 330.9	9.3 > 14.4
MEL-06	3.0 to 4.6 7.5 to 11.3 (borehole termination depth)	370.0 to 368.4 365.5 to 361.7	1.6 > 3.8

Cobbles were encountered in the silt near elevations 342.4 and 333.5 in Boreholes MEL-02 and MEL-04, respectively. In Borehole MEL-03, cobbles were contacted near elevations 360.0 and 342.5.

SPT ‘N’ values recorded in the native silt layers ranged from 3 to 30 blows for 0.3 m penetration, indicating a very loose to compact relative density.

The moisture contents of samples of the silt typically range from 20% and 48%. Higher moisture contents, ranging from 57% to 72%, were measured in four samples of the silt.

Selected samples of the silt underwent laboratory grain size analysis testing. The grain size distribution curves for the silt samples tested are presented in Figures B4 to B6 in Appendix B. A clayey sample of the silt also underwent Atterberg Limits testing. The results of this test are shown on Figure B9, Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	Percentage (%)
Gravel	0
Sand	0 and 19
Silt	73 to 92
Clay	8 to 24

Index Property	Percentage (%)
Liquid Limit	27
Plastic Limit	20

The above result indicates that the silt, where clayey, is of low plasticity with group symbols of CL-ML.

5.7 Silty Clay

Native reddish brown to grey silty clay was encountered at various depths in all the boreholes. The silty clay is described as varved in some boreholes. The depths, elevations and thicknesses of the silty clay layers encountered in each borehole are list in Table 5.2. The thickness of the individual layers of silty clay ranges from 1.4 m to 11.2 m.

Table 5.2 – Depths, Elevations and Thicknesses of Silty Clay Layers

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
MEL-01	4.6 to 7.6	368.5 to 365.4	3.0
MEL-02	4.1 to 6.7	368.9 to 366.4	2.6
	17.0 to 23.1	356.0 to 350.0	6.1
	25.6 to 27.8	347.5 to 345.2	2.2
	35.1 to 36.6	338.0 to 336.5	1.5
MEL-03	4.1 to 6.7	368.9 to 366.4	2.6
	16.9 to 21.3	356.2 to 351.8	4.4
MEL-04	5.1 to 7.6	367.9 to 365.4	2.5
	16.9 to 22.9	356.1 to 350.1	6.0
	24.4 to 35.1	348.6 to 338.0	10.7
MEL-05	5.0 to 7.2	368.1 to 365.9	2.2
	16.5 to 27.7	356.5 to 345.3	11.2
MEL-06	6.1 to 7.5	366.9 to 365.5	1.4

Standard Penetration tests performed in the silty clay layers gave SPT ‘N’ values ranging from 0 to 8 blows per 0.3 m of penetration, indicating a very soft to firm consistency. Higher SPT ‘N’ values of 12 and 13 blows for 0.3 m penetration were recorded in Borehole MEL-04 between 29 m and 33 m depth, indicating a stiff consistency.

In-situ vane shear tests were carried out in Boreholes MEL-01 and MEL-06 to assess the undrained shear strength of the soft to firm cohesive deposits. Shear strengths results were 20 kPa and 32 kPa.

The moisture contents of samples of the silty clay layers typically ranged from 25% to 84%.

Selected samples of the silty clay underwent laboratory grain size analysis testing and Atterberg Limits tests. The grain size distribution curves for tested samples of silty clay are presented in Appendix B, Figures B7 and B8. The results of the Atterberg Limits tests are presented in Figures B10 and B11, Appendix B. The results are also summarized on the Record of Borehole sheets included in Appendix A. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	0
Sand	0
Silt	22 to 66
Clay	34 to 78

Index Property	Percentage (%)
Liquid Limit	34 to 69
Plastic Limit	21 to 24

The above results indicate that the silty clay is typically of medium to high plasticity with group symbols of CI-CH. Only was sample had a low plasticity and a group symbol of CL.

5.8 Cobbles and Boulders

A layer of cobbles and boulders was encountered at 38.7 m (elevation 334.3) below the silt layer and overlying bedrock in borehole MEL-03. The layer of cobbles and was 0.5 m thick with a lower boundary at a depth of 39.2 m (elevation 333.8).

5.9 Bedrock

The overburden soils described above are underlain by grey mafic to intermediate metavolcanic bedrock. The bedrock was slightly weathered to fresh and contained frequent 25 mm to 50 mm quartz interbeds. Occasional mechanical breaks and sub-vertical fractures were noted throughout the bedrock cores.

Bedrock was proved by coring in Boreholes MEL-03 and MEL-04. Table 5.3 summarizes depths and elevations to the top of bedrock.

Table 5.3 – Depths and Elevations of Top of Bedrock

Borehole	Top of Bedrock	
	Depth (m)	Elevation (m)
MEL-03	39.2	333.8
MEL-04	45.0	328.0

Core recovery in the bedrock ranged from 83 to 100%. The RQD values ranged from 67% to 100%, indicating fair to excellent rock quality.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was generally less than 2.

The estimated unconfined compressive strength of the rock cores (average per Run) generally ranged from 25 MPa to 60 MPa, indicating a medium strong to strong rock. In Borehole MEL-03 Run1 an unconfined compressive strength was 201 MPa, indicating a very strong rock. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results are presented in Appendix B.

5.10 Water Levels

Water levels were monitored in the open boreholes during and upon completion of drilling. One standpipe piezometer was installed in Borehole MEL-02 to monitor water levels after completion of drilling. The water levels measured in the piezometer and open boreholes are summarized in Table 5.4.

Table 5.4 – Water Level Measurements

Foundation Unit	Borehole	Date	Water Level (m)		Comments
			Depth	Elevation	
West Approach	MEL-01	July 28, 2011	3.3	369.7	Open borehole
West Abutment	MEL-02	August 17, 2011	1.8	371.2	In piezometer
		September 15, 2011	1.4	371.6	
East Approach	MEL-06	July 28, 2011	3.6	369.4	Open borehole

Piezometric readings indicate that the water level is near elevation 371.6.

Preliminary GA drawing indicates that water level in the Melgund River was near Elevation 370.2 on May 12, 2011.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. Hatch Mott MacDonald surveyed the borehole locations and provided the co-ordinates and the ground surface elevations.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied truck mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Ms. Eckie Siu and Mr. George Azzopardi, from Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall planning and supervision of the field program was conducted by Mr. Mark Farrant, P. Eng.

Interpretation of the data and preparation of the report were carried out by Ms. Lindsey Blaine, E.I.T.

The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
	WH Sampler Advanced by Self Static Weight		RC Rock Core
			SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


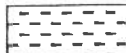



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
	HIGHLY ORGANIC SOILS		Pt
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION		SYMBOLS	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No MEL-01

1 OF 2

METRIC

W.P. 6145-04-00 LOCATION N 5 494 379.0 E 351 294.7 Melgund River Bridge ORIGINATED BY GA
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.07.28 - 2011.07.28 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
373.0												
0.0	ASPHALT: (90mm)						373					
0.1	SAND Compact to Dense Brown Wet (FILL) Trace gravel, occasional cobbles		1	SS	26							
			2	SS	36		372					
371.5												
1.5	Silty CLAY, trace gravel Very Stiff Brown (FILL)		3	SS	25		371					
370.9												
2.1	SILT, some clay Loose Grey Wet		4	SS	8		370					
			5	SS	9		369					0 0 86 14
368.5												
4.6	Silty CLAY, varved Soft to Firm Grey		6	SS	2		368					0 0 29 71
			7	SS	5		367					
365.4							366					
7.6	SILT, trace clay Compact Grey Wet		8	SS	15		365					
			9	SS	14		364					0 0 91 9

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15
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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-01

2 OF 2

METRIC

W.P. 6145-04-00 LOCATION N 5 494 379.0 E 351 294.7 Melgund River Bridge ORIGINATED BY GA
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2011.07.28 - 2011.07.28 CHECKED BY RPR

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20			40	60	80	100	PLASTIC LIMIT w _p		NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	GR	SA
	Continued From Previous Page																	
361.8	SILT Compact Grey Wet		10	SS	22													
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND WATER LEVEL AT 3.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 11.3m TO 0.3m, CONCRETE FROM 0.3m TO 0.1m, THEN ASPHALT TO SURFACE.																	

+³ x³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-02

1 OF 5

METRIC

W.P. 6936-10-00 LOCATION N 5 494 377.5 E 351 301.4 Melgund River Bridge ORIGINATED BY ES
HWY 17 BOREHOLE TYPE Casing COMPILED BY AN
DATUM Geodetic DATE 2011.08.08 - 2011.08.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
373.0	ASPHALT: (75mm)						373					
0.0 0.1	CONCRETE											
372.7												
0.4	Gravelly SAND, occasional cobbles and boulders Very Dense Brown (FILL) Coring required (spoon bouncing)		1	SS	50/ 0.025		372					
371.2			2	SS	11		371					
1.9	Silty CLAY, trace sand Soft to Stiff Brown (FILL)											
370.4			3	SS	5		370					
2.6	PEAT/ORGANICS, clayey, occasional roots and rootlets Firm Dark Brown (500mm)		4	SS	13		369					
369.9												
3.1	SILT, trace clay, some sand, occasional sand pockets, occasional oxide staining Compact Brown to Grey Moist						368					
368.9			5	SS	0		367					
4.1	Silty CLAY Very Soft Grey											
366.4	Occasional silt layers		6	SS	2		365					
6.7	SILT, some sand, trace clay Loose Grey Wet		7	SS	8		364					
	Compact		8	SS	13							

Continued Next Page

+ 3, x 3, Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

METRIC

ELEV. DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	20 40 60 80 100	W _P	W	W _L		
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						

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+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No MEL-02

4 OF 5

METRIC

W.P. 6936-10-00 LOCATION N 5 494 377.5 E 351 301.4 Melgund River Bridge ORIGINATED BY ES
HWY 17 BOREHOLE TYPE Casing COMPILED BY AN
DATUM Geodetic DATE 2011.08.08 - 2011.08.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT		
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	W P W W L	WATER CONTENT (%) 20 40 60		
	SILT, some sand Compact Grey Wet Cobbles from 30.6m to 31.0m						343					
							342					
			19	SS	14		341			C		
							340					
							339					
338.0							338					
35.1	Silty CLAY, varved with silt layers Firm Grey		20	SS	5		337					0 0 58 42
336.5							336					
36.6	SILT, some sand Compact Grey						335					
			21	SS	13		334					
333.7												
39.3	END OF BOREHOLE AT 39.3m Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.											

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+ 3 × 3

Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

METRIC

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(%) STRAIN AT FAILURE

METRIC

[illegible]

+ 3, X 3: Numbers refer to Sensitivity

METRIC

[illegible]

+ 3, × 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No MEL-03

3 OF 5

METRIC

W.P. 6145-04-00 LOCATION N 5 494 382.4 E 351 302.9 Melgund River Bridge ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.08.03 - 2011.08.05 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
351.8	Silty CLAY, varved, with silt layers Soft to Stiff Grey		15	SS	3		353							
21.3	SILT, some sand, some clay to clayey Compact Grey Wet						352							
							351							
			16	SS	10		350							0 0 79 21
							349							
							348							
			17	SS	8		347							
							346							
							345							
			18	SS	19		344							

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+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-03

4 OF 5

METRIC

W.P. 6936-10-00 LOCATION N 5 494 382.4 E 351 302.9 Meigund River Bridge ORIGINATED BY ES
HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2011.08.03 - 2011.08.05 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100	
	Continued From Previous Page											
	SILT, some clay to clayey Compact Grey Wet Cobbles from 30.5m to 31.2m											
			19	SS	14							0 0 76 24
			20	SS	21							
			21	SS	30							
334.3 38.7	Cored through BOULDERS and COBBLES		1	RUN								
333.8 39.2	BEDROCK , mafic to intermediate metavolcanic, slightly weathered to fresh, grey, occasional white bands, occasional mechanical breaks Coring started at 38.7m		2	RUN								RUN #1 TCR=83% SCR=67% RQD=67%

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

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15
10

(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE						SAMPLES								DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)														
								DYNAMIC CONE PENETRATION RESISTANCE PLOT ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT 														
	Continued From Previous Page																										
	BEDROCK, mafic to intermediate metavolvanic, slightly weathered to fresh, grey, occasional white bands																										
	Sub-horizontal fractures (25mm to 50mm) at 39.1m, 40.0m and 40.3m																										
	Sub-vertical fractures at 40.0m 100mm at 40.3m		3	RUN																							
330.9							333																				
							332																				
							331																				
42.2	END OF BOREHOLE AT 42.2m. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 6.4m, BENTONITE TO 0.1m, THEN ASPHALT TO SURFACE.																										

RECORD OF BOREHOLE No MEL-04

1 OF 5

METRIC

W.P. 6936-10-00 LOCATION N 5 494 370.6 E 351 325.4 Melgund River Bridge ORIGINATED BY ES
HWY 61 BOREHOLE TYPE Casing COMPILED BY AN
DATUM DATE 2011.08.11 - 2011.08.12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
373.0	ASPHALT: (75mm)						373					
0.0												
0.1	CONCRETE: (280mm)											
372.7												
0.4	Gravelly SAND, trace silt and clay, occasional cobbles Very Dense to Compact Brown Wet (FILL)		1	SS	50/ 0.100		372					33 64 3 (SI+CL)
371.1			2	SS	13		371					
1.9	Silty CLAY, trace to some sand, trace gravel Stiff Brown (FILL)		3	SS	8		370					
369.6			4	SS	0		369					
369.4	Very Soft											
3.5	PEAT/ORGANICS, trace clay Dark Brown Damp (100mm)											
	SAND, some silt Very Loose to Loose Grey Moist		5	SS	8		368					
367.9	Mixed with peat/organics, wood fibres, trace roots and rootlets											
5.1	Silty CLAY, varved with silt layers Very Soft Grey		6	SS	1		367					0 0 62 38
365.4							366					
7.6	SILT, trace to some clay Compact Grey Moist		7	SS	12		365					
			8	SS	12		364					

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+ 3, x 3: Numbers refer to
Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

2 OF 5

METRIC

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+³, ×³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

ONTMT4S 5121.GPJ 10/27/11

RECORD OF BOREHOLE No MEL-04

3 OF 5

METRIC

W.P. 6145-04-00 LOCATION N 5 494 370.6 E 351 325.4 Melgund River Bridge ORIGINATED BY ES
HWY 17 BOREHOLE TYPE Casing COMPILED BY AN
DATUM Geodetic DATE 2011.08.11 - 2011.08.12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 20 40 60			GR SA SI CL
20.0	Silty CLAY Very Soft Reddish Brown		15	SS	0		353					
350.1							352					
22.9	SILT, some sand Very Loose Grey Wet		16	SS	3		350					
348.6							349					
24.4	Silty CLAY, occasional silt seams Soft Grey		17	SS	2		347					
							346					
							345					
							344					
	Stiff		18	SS	12							0 0 66 34

Continued Next Page

+³, x³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

4 OF 5

W.P.	6936-10-00	LOCATION	N 5 494 370.6 E 351 325.4 Melgund River Bridge	ORIGINATED BY	ES
HWY	17	BOREHOLE TYPE	Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2011.08.11 - 2011.08.12	CHECKED BY	RPR

[illegible]

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Numbers refer to
Sensitivity

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15 5
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-04

5 OF 5

METRIC

W.P. 6145-04-00 LOCATION N 5 494 370.6 E 351 325.4 Melgund River Bridge ORIGINATED BY ES
HWY 17 BOREHOLE TYPE Casing COMPILED BY AN
DATUM Geodetic DATE 2011.08.11 - 2011.08.12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
Continued From Previous Page																		
328.0	SILT, trace clay Loose Grey Wet						333											
							332											
							331											
							330											
							329											
45.0	BEDROCK, mafic to intermediate metavolvanic, slightly weathered to fresh, grey, occasional white bands, occasional mechanical breaks Coring started at 45.0m Quartz interbeds (25mm to 50mm) at 42.2m, 42.5m 100mm at 42.4m Sub-vertical fractures (125mm) at 42.2m Quartz interbeds (25mm) at 43.0m, 43.3m, 43.7m, 43.8m, 44.0m, 44.1m, 44.2m, 47.4m, 47.7m, 47.9m 325mm at 43.2m 100mm at 47.5m 50mm at 47.8m 50mm at 47.9m Sub-vertical fractures (25mm to 100mm) at 42.8m, 43.9m and 48.1m		1	RUN			328							FI				
327																		
324.9			2	RUN			326											
							3	RUN										
48.1			END OF BOREHOLE AT 48.1m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.4m, SAND TO 0.1m, THEN ASPHALT TO SURFACE.						325									1

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-05

1 OF 5

METRIC

W.P. 6936-10-00 LOCATION N 5 494 375.5 E 351 326.7 Melgund River Bridge ORIGINATED BY ES
HWY 61 BOREHOLE TYPE Casing COMPILED BY AN
DATUM DATE 2011.08.06 - 2011.08.07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	FLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
373.0	ASPHALT: (50mm)						373						
372.7	CONCRETE: (300mm)												
0.4	SAND, some gravel, occasional cobbles Very Dense Brown (FILL)			SS	50/								
					0.050								
371.6	Silty CLAY Very Stiff to Stiff Brown (FILL)		2	SS	17		372						
1.4													
			3	SS	11		371						
370.0	SILT, trace sand, trace organics, occasional rootlets Loose Brown Moist (FILL)		4	SS	4		370						
368.9	PEAT/ORGANICS, wood fibres Very Loose Dark Brown Wet (900mm)		5	SS	2		369						
368.1	Silty CLAY Very Soft Grey						368						
5.0			6	SS	2		367						
365.9	SILT, some clay Loose Grey Wet		7	SS	9		366						
7.2													
			8	SS	12		365						
							364						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-05

4 OF 5

METRIC

W.P. 6145-04-00 LOCATION N 5 494 375.5 E 351 326.7 Melgund River Bridge ORIGINATED BY ES
HWY 17 BOREHOLE TYPE Casing COMPILED BY AN
DATUM Geodetic DATE 2011.08.06 - 2011.08.07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE								
								● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page							20 40 60 80 100		20 40 60						
	SILT, trace clay Compact to Loose Grey 															

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+ ³, × ³: Numbers refer to
Sensitivity

20
15-5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-05

5 OF 5

METRIC

W.P. 6145-04-00 LOCATION N 5 494 375.5 E 351 326.7 Melgund River Bridge ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.08.06 - 2011.08.07 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100		
	Continued From Previous Page												
	SILT, trace clay Loose Grey Wet					333							
			22	SS	5	332							0 0 91 9
330.8 42.1	END OF BOREHOLE AT 42.1m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO 37.7m, AUGER CUTTINGS TO 5.4m, HOLEPLUG TO 0.1m, THEN ASPHALT TO SURFACE.												

RECORD OF BOREHOLE No MEL-06

1 OF 2

METRIC

W.P. 6145-04-00 LOCATION N 5 494 373.6 E 351 334.6 Melgund River Bridge ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.07.28 - 2011.07.28 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)								
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL			× LAB VANE	w _p	w	w _L					
373.0							20	40	60	80	100	20	40	60	GR	SA	SI	CL			
0.0 0.1	ASPHALT: (75mm)						373														
	SAND, trace gravel, occasional cobbles Dense Brown Wet (FILL)		1	SS	35																
			2	SS	35		372														
371.4																					
1.6	CLAY, some silt, some sand, trace gravel Very Stiff to Stiff Brown (FILL)		3	SS	21		371														
			4	SS	12												9	12	18	62	
370.0							370														
3.0	SILT, trace clay Loose Grey Wet		5	SS	6																
							369														
368.4																					
4.6	Silty SAND and organics, trace clay, occasional wood fibres Loose Grey Wet		6	SS	4		368										0	52	42	5	
366.9							367														
6.1	Silty CLAY, varved Soft Grey		7	SS	3																
							366														
365.5																					
7.5	SILT, some clay Compact Grey Wet		8	SS	12		365														
			9	SS	21		364											0	0	89	11

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+³, x³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MEL-06

2 OF 2

METRIC

W.P. 6145-04-00 LOCATION N 5 494 373.6 E 351 334.6 Melgund River Bridge ORIGINATED BY ES
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2011.07.28 - 2011.07.28 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
	Continued From Previous Page							20 40 60 80 100							
361.7	SILT, some clay Compact Grey Wet		11	SS	12		363								
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND WATER LEVEL AT 3.6m. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.						362								

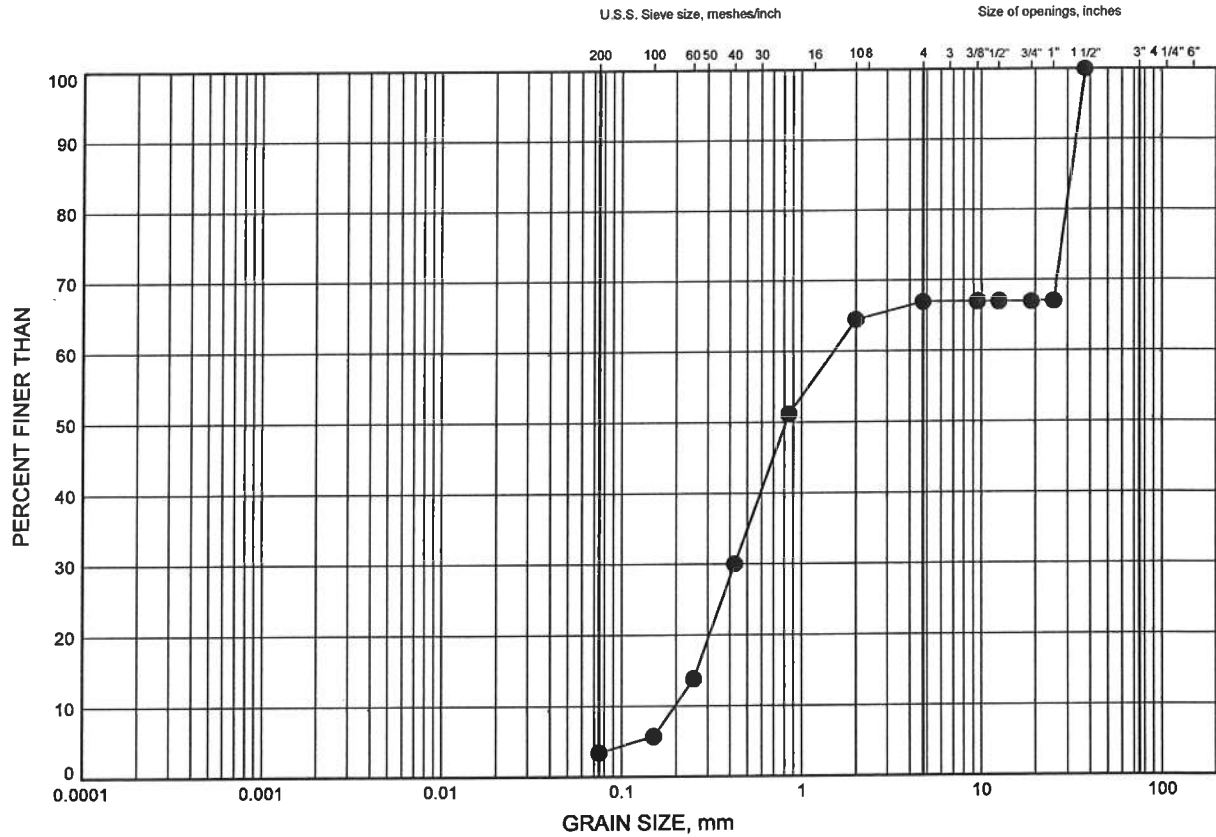
Appendix B

Laboratory Test Results

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly Sand Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-04	1.07	371.94

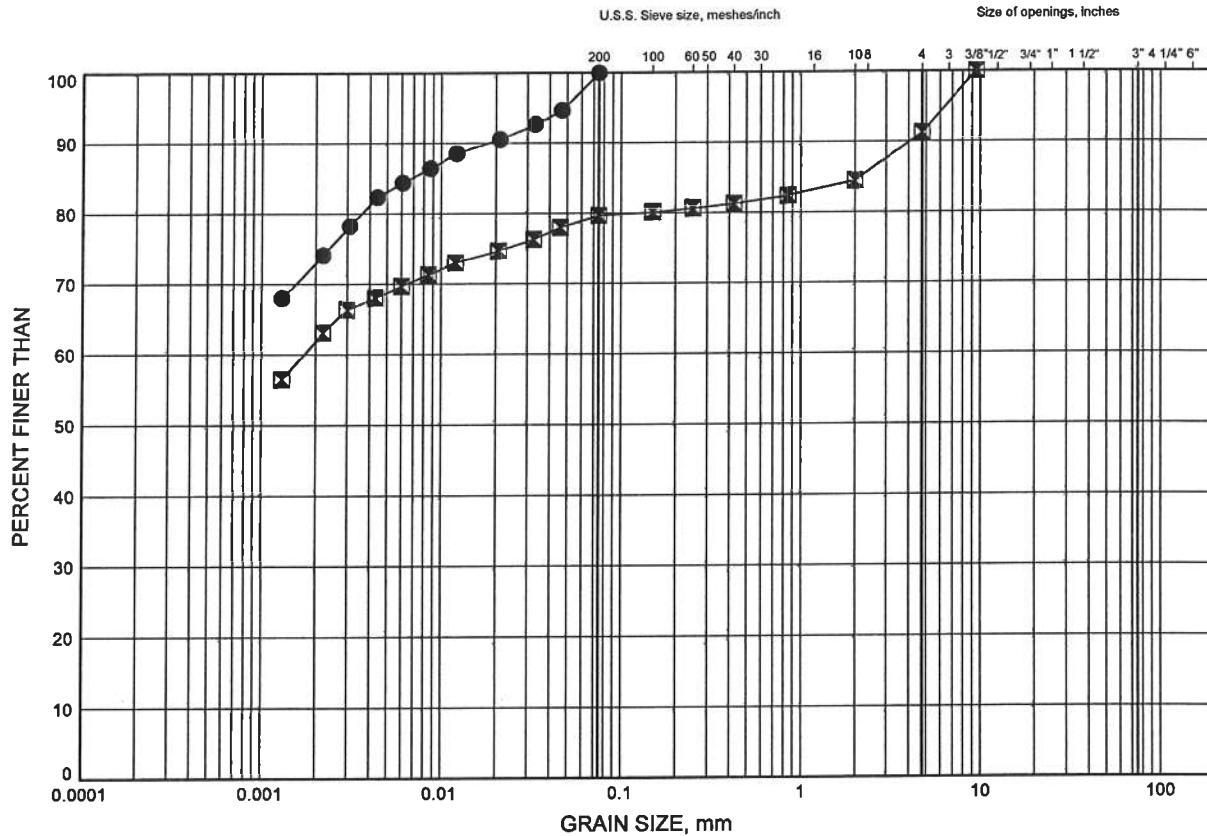


W.P.# .6145-04-00.....
Prepared By .AN.....
Checked By .LRB.....

6010-E-0010 Bridge and Culvert Rehabs NWR GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty Clay Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

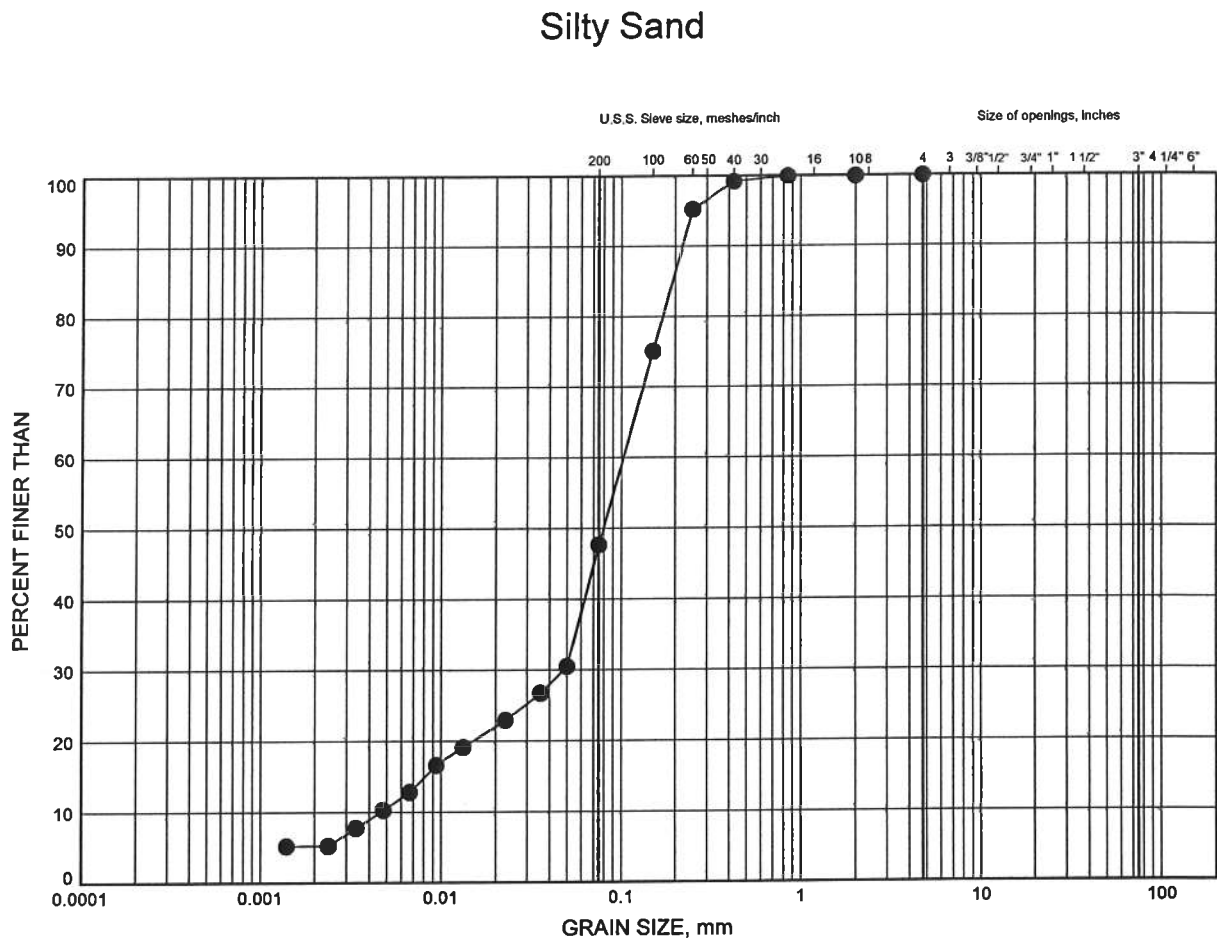
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-05	2.59	370.44
■	MEL-06	2.59	370.43



W.P.# 6145-04-00.....
Prepared By AN.....
Checked By LRB.....

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B3



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

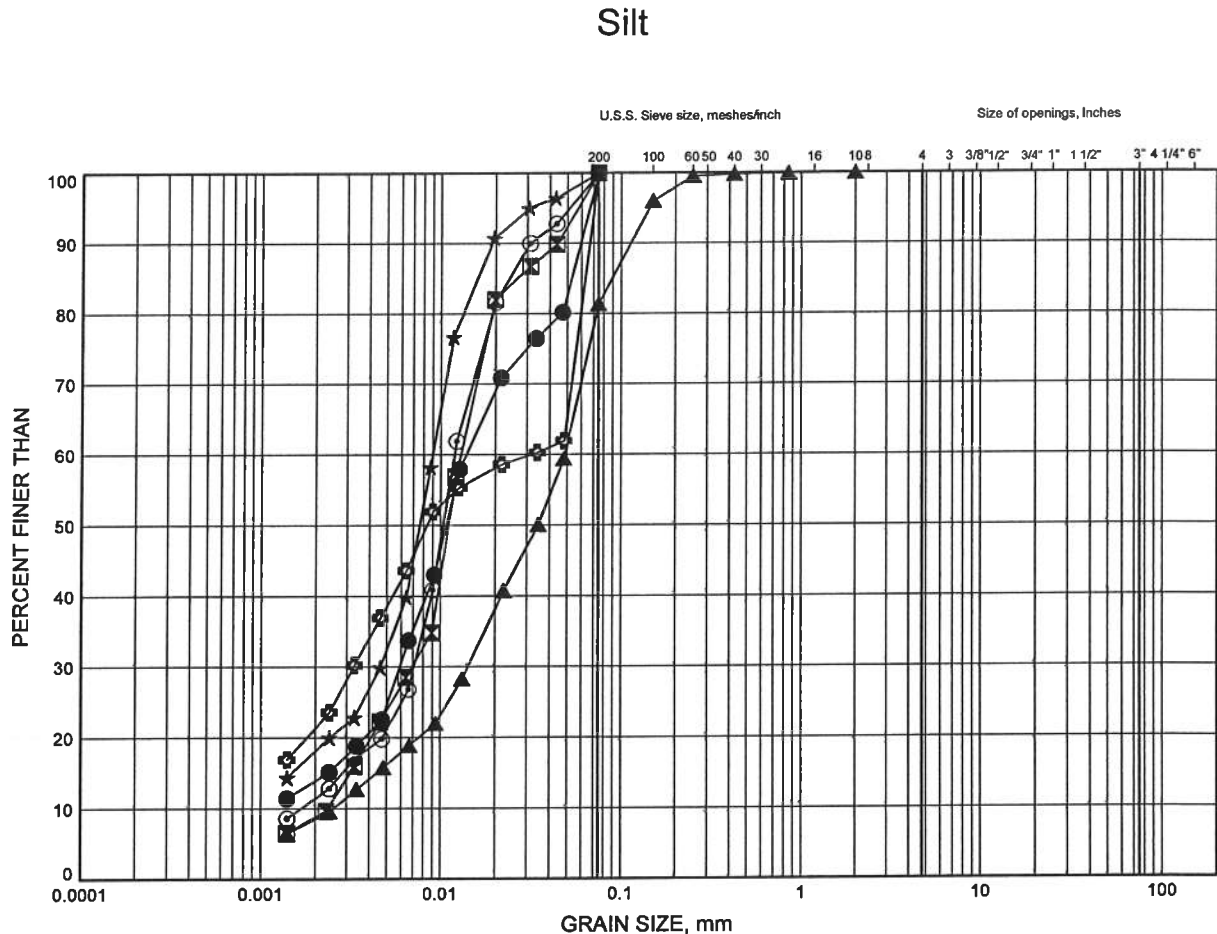
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-06	4.88	368.14



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Prepared By AN
Checked By LRB

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B4



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

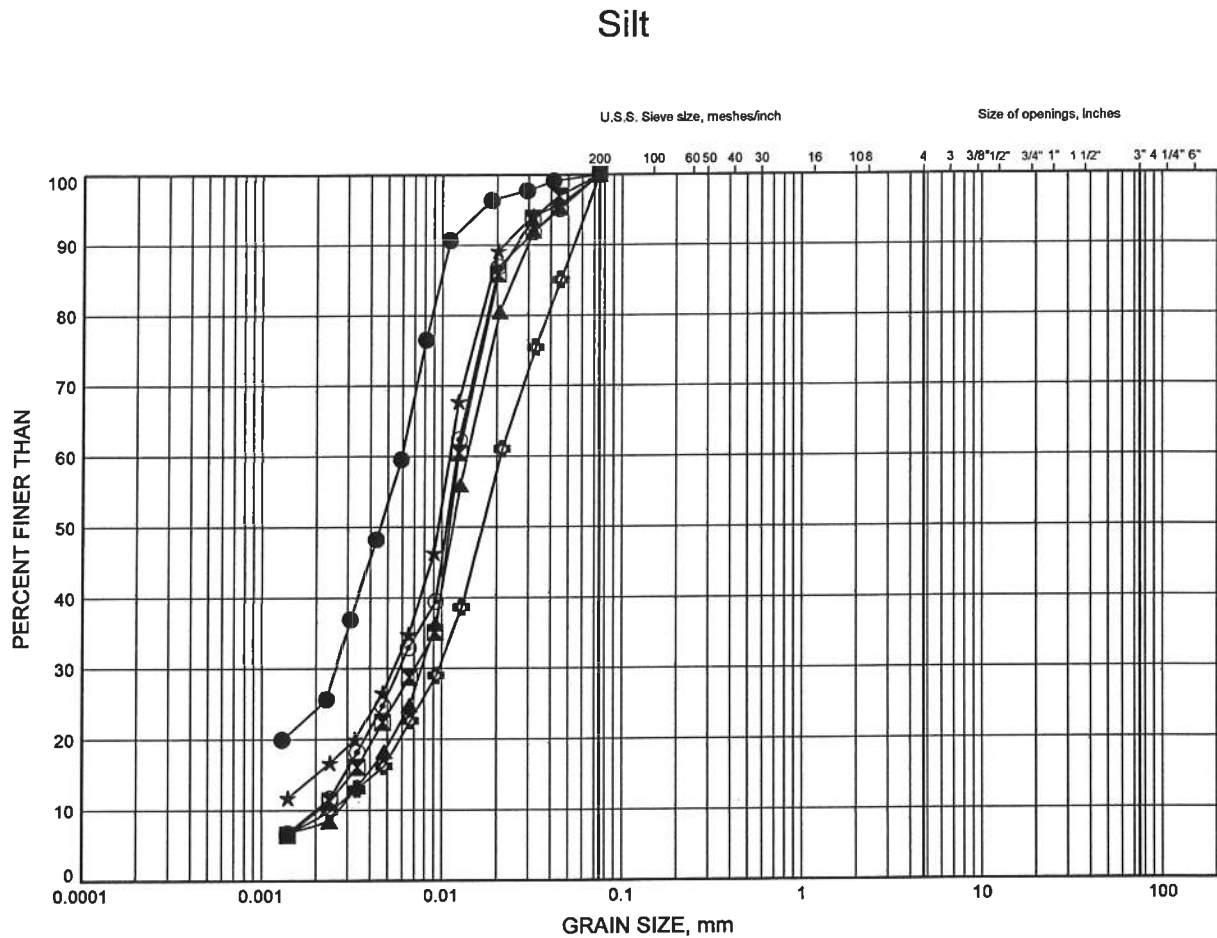
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-01	3.35	369.69
⊠	MEL-01	9.45	363.60
▲	MEL-02	3.35	369.69
★	MEL-02	14.02	359.02
⊙	MEL-03	10.97	362.05
⊕	MEL-03	23.16	349.86



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Prepared By AN.....
Checked By LRB.....

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B5



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

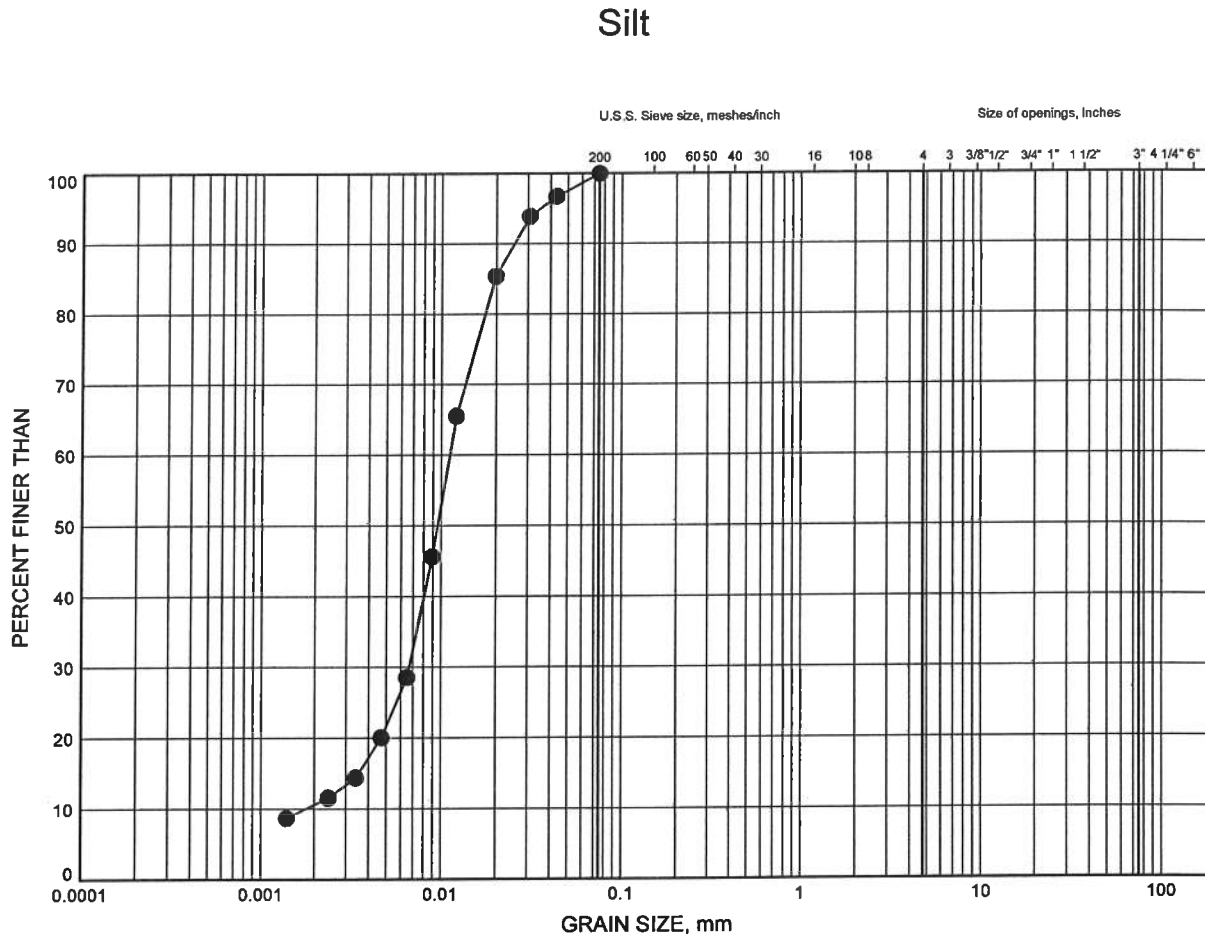
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-03	32.31	340.72
⊠	MEL-04	12.50	360.51
▲	MEL-04	38.40	334.60
★	MEL-05	7.92	365.10
⊙	MEL-05	15.54	357.48
⊕	MEL-05	41.45	331.58



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Prepared By .AN.....
Checked By .LRB.....

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B6



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

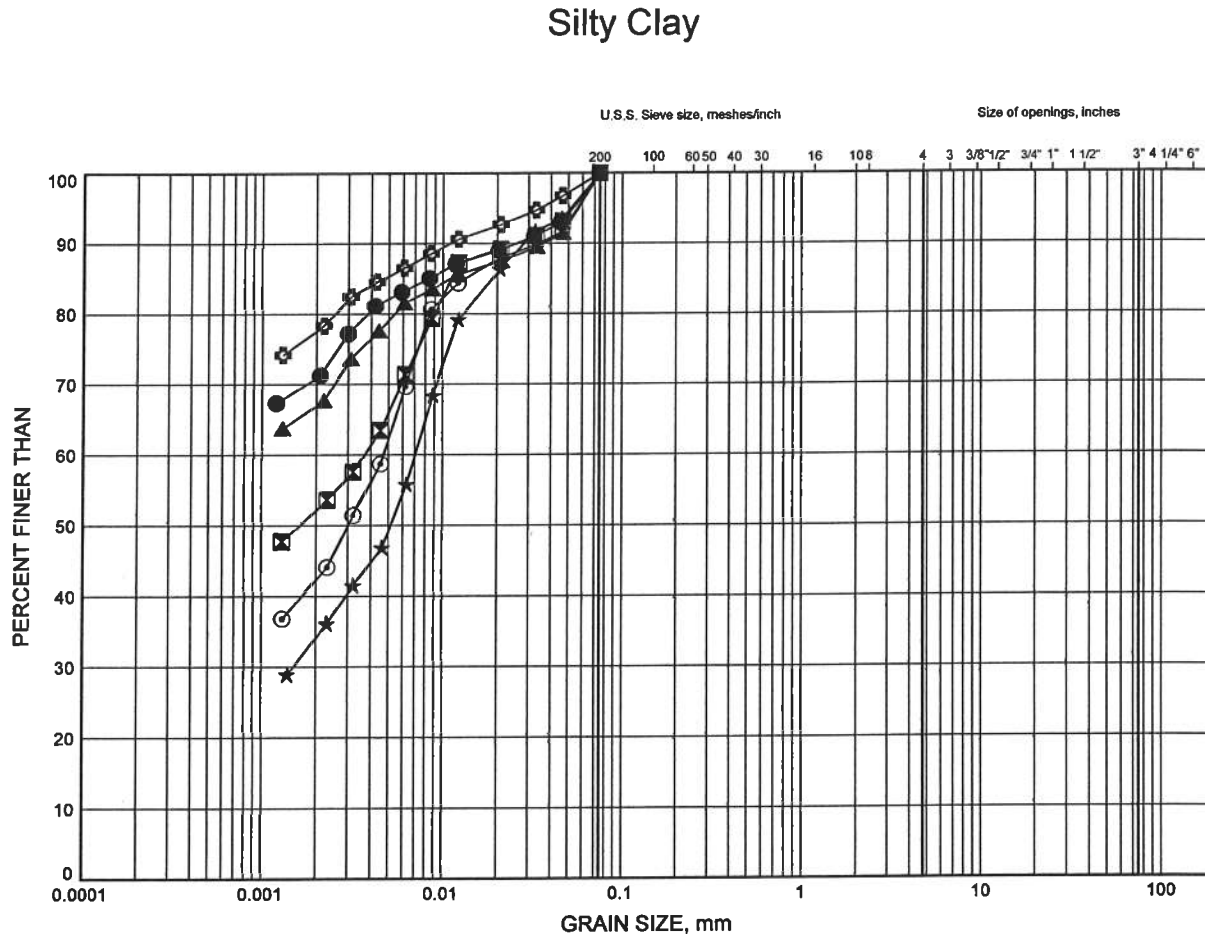
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-06	9.45	363.57



W.P.# 6145-04-00.....
Prepared By .AN.....
Checked By .LRB.....

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B7



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-01	4.88	368.17
⊠	MEL-02	6.40	366.64
▲	MEL-02	18.59	354.45
★	MEL-02	26.21	346.83
⊙	MEL-02	35.36	337.68
⊕	MEL-03	4.88	368.15

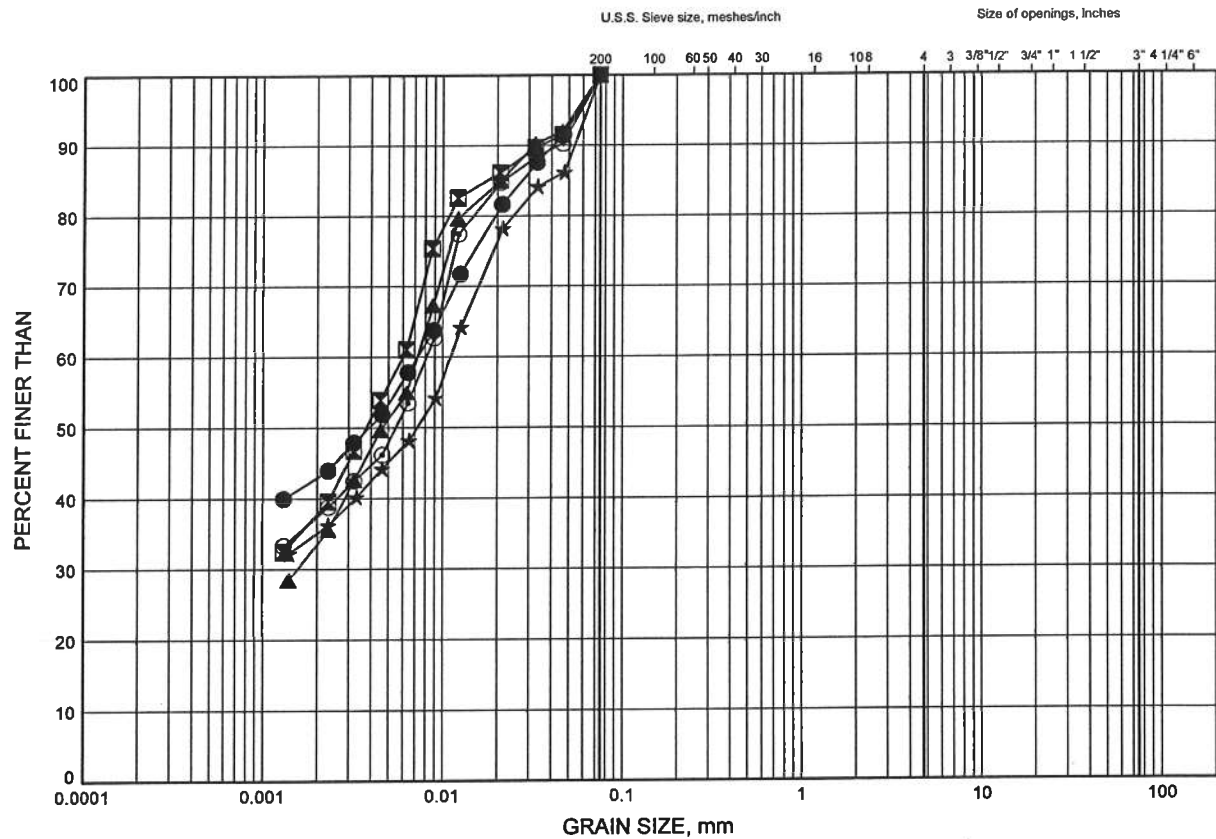


W.P.# 6145-04-00.....
Prepared By AN.....
Checked By LRB.....

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B8

Silty Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MEL-03	18.59	354.43
⊠	MEL-04	6.40	366.61
▲	MEL-04	29.26	343.75
★	MEL-05	20.12	352.91
⊙	MEL-05	26.21	346.82

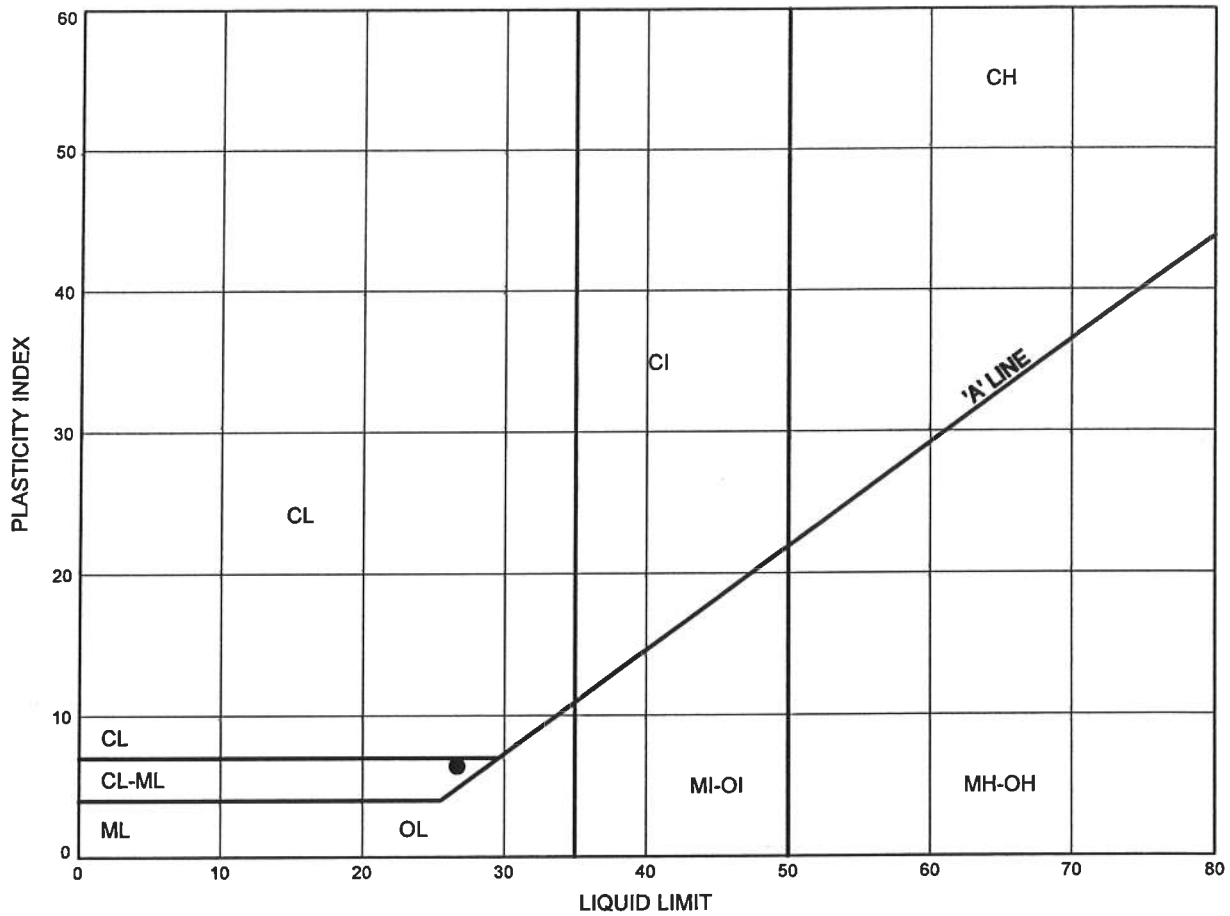


W.P.# 6145-04-00
Prepared By AN
Checked By LRB

6010-E-0010 Bridge and Culvert Rehabs NWR
ATTERBERG LIMITS TEST RESULTS

FIGURE B9

Clayey Silt



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	MEL-03	23.16	349.86

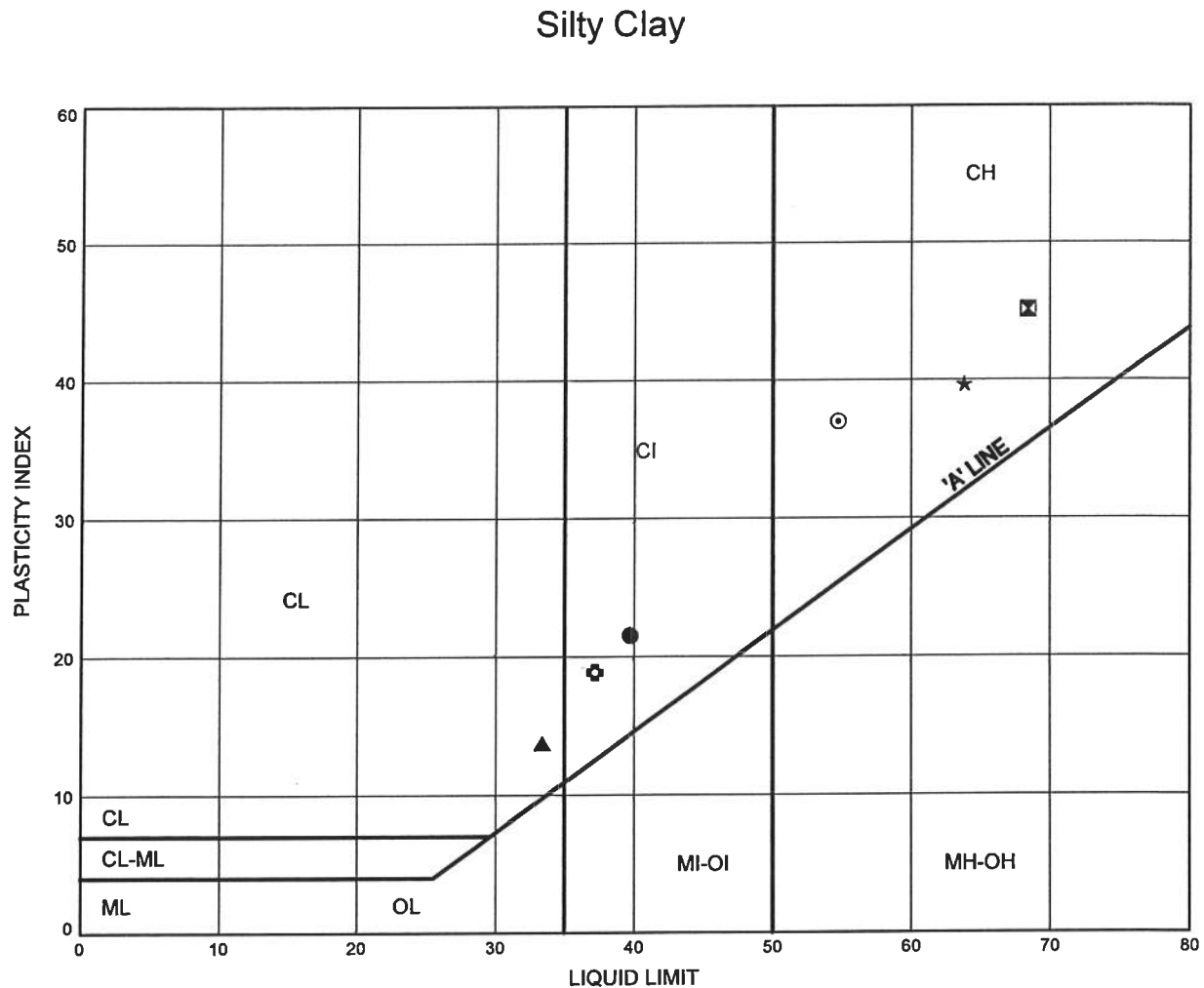
Date October 2011
 Project 6145-04-00



Prep'd AN
 Chkd. LRB

6010-E-0010 Bridge and Culvert Rehabs NWR
ATTERBERG LIMITS TEST RESULTS

FIGURE B10

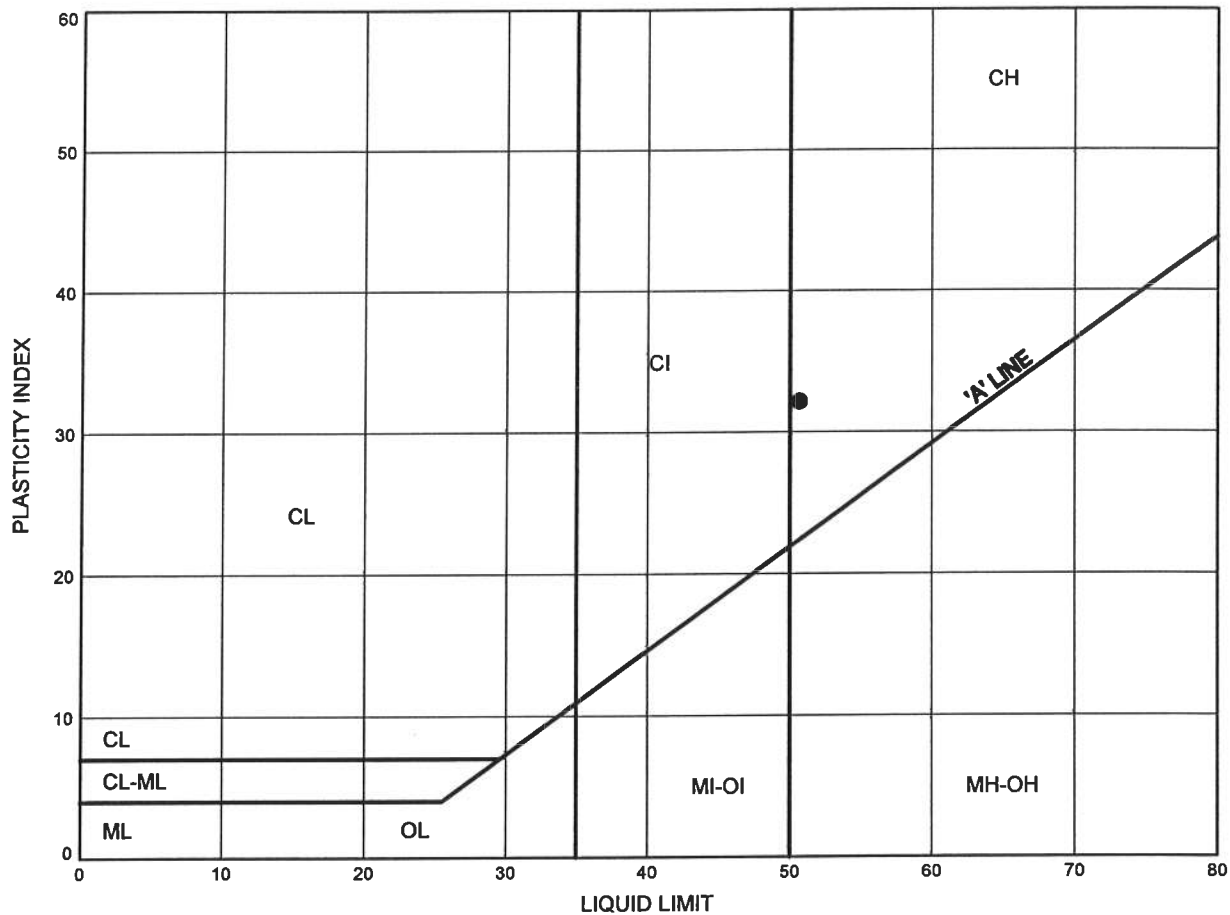


SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	MEL-02	6.40	366.64
⊠	MEL-02	18.59	354.45
▲	MEL-02	35.36	337.68
★	MEL-03	4.88	368.15
⊙	MEL-03	18.59	354.43
⊕	MEL-04	6.40	366.61

6010-E-0010 Bridge and Culvert Rehabs NWR
ATTERBERG LIMITS TEST RESULTS

FIGURE B11

Silty Clay



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	MEL-05	20.12	352.91



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POINT LOAD TEST SHEET

Job No : 19-1605-121 Client : Hatch Mott MacDonald
Date Drilled : August 05, 2011
Project Name : Melgund River Bridge Date Tested : September 06, 2011
Core Size : NQ BH No : MEL-03 Tester : DB

Test No.	Run No.	Depth (m)	Axial or Diametral	Force (kN)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	38.8	A	27.3	47.0	55.3	210.9	Mafic	Very Strong
2	1	39.1	D	2.5	47.3	54.8	26.4	Mafic	Medium Strong
3	2	39.4	A	7.8	47.2	61.1	55.7	Mafic	Strong
4	2	39.8	A	3.0	47.0	54.3	23.3	Mafic	Weak
5	2	40.6	A	6.4	47.1	64.3	43.6	Mafic	Medium Strong
6	3	40.9	A	7.4	47.2	60.4	53.4	Mafic	Strong
7	3	41.5	A	4.3	47.2	61.9	30.6	Mafic	Medium Strong
8	3	42.1	A	8.9	47.3	64.9	60.3	Mafic	Strong
9									
10									
11									
12									
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30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

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

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



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

POINT LOAD TEST SHEET

Job No : 19-1605-121 Client : Hatch Mott MacDonald
Date Drilled : August 12, 2011
Project Name : Melgund River Bridge Date Tested : September 06, 2011
Core Size : NQ BH No : MEL-04 Tester : DB

Test No.	Run No.	Depth (m)	Axial or Diametral	Force (kN)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	45.2	D	3.2	47.1	63.8	34.2	Mafic	Medium Strong
2	1	45.7	A	2.7	47.1	54.7	21.3	Mafic	Weak
3	2	46.2	A	3.8	47.1	63.9	26.3	Mafic	Medium Strong
4	2	46.7	A	4.3	47.3	64.7	29.4	Mafic	Medium Strong
5	2	47.2	D	3.8	47.3	63.1	39.3	Mafic	Medium Strong
6	3	47.7	A	3.8	47.3	69.8	24.4	Mafic	Weak
7	3	47.9	A	6.4	47.4	64.3	43.9	Mafic	Medium Strong
8									
9									
10									
11									
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13									
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29									
30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

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

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

Appendix C

Site Photographs



Photograph 1– Melgund River Bridge - Looking West



Photograph 2 – Melgund River, Looking North from Bridge



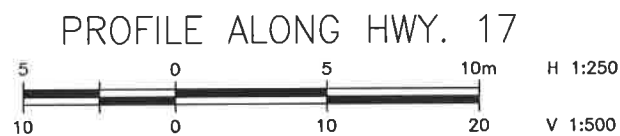
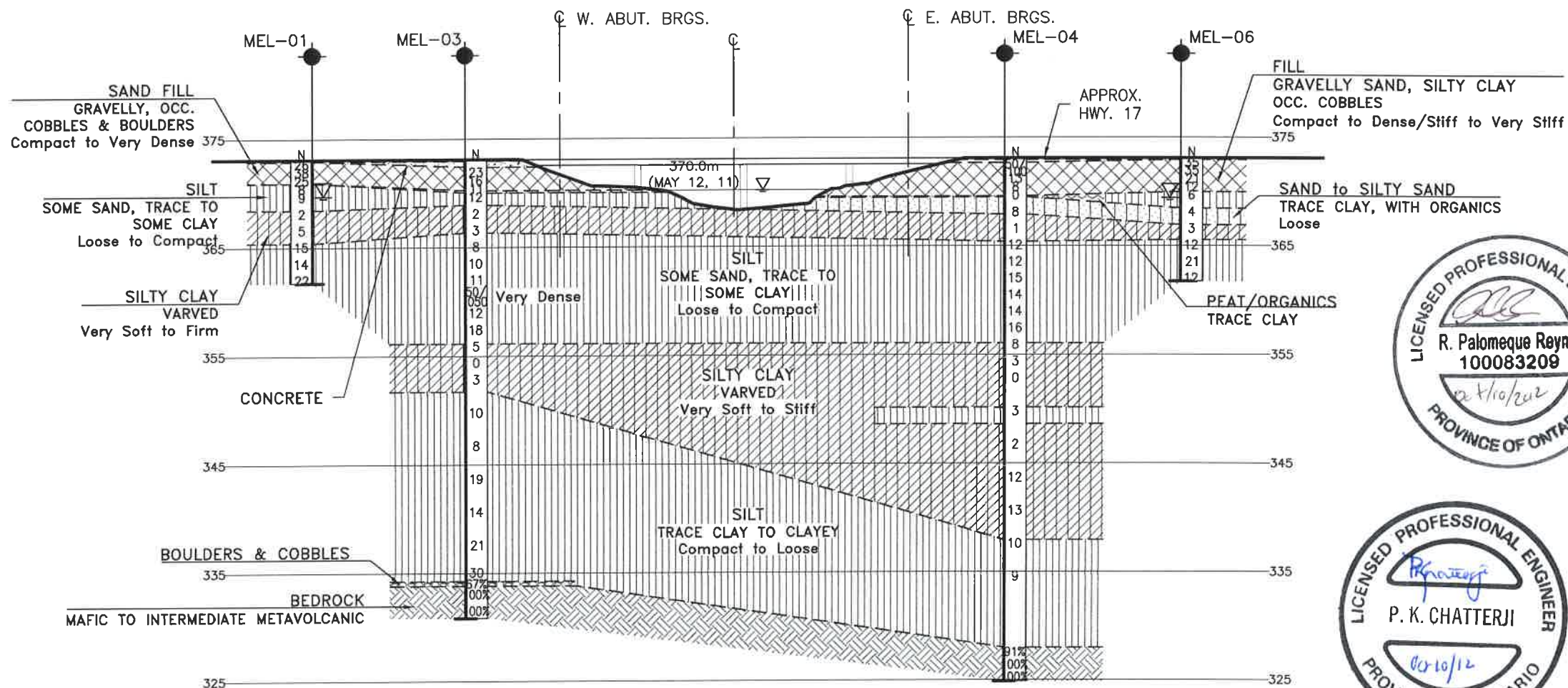
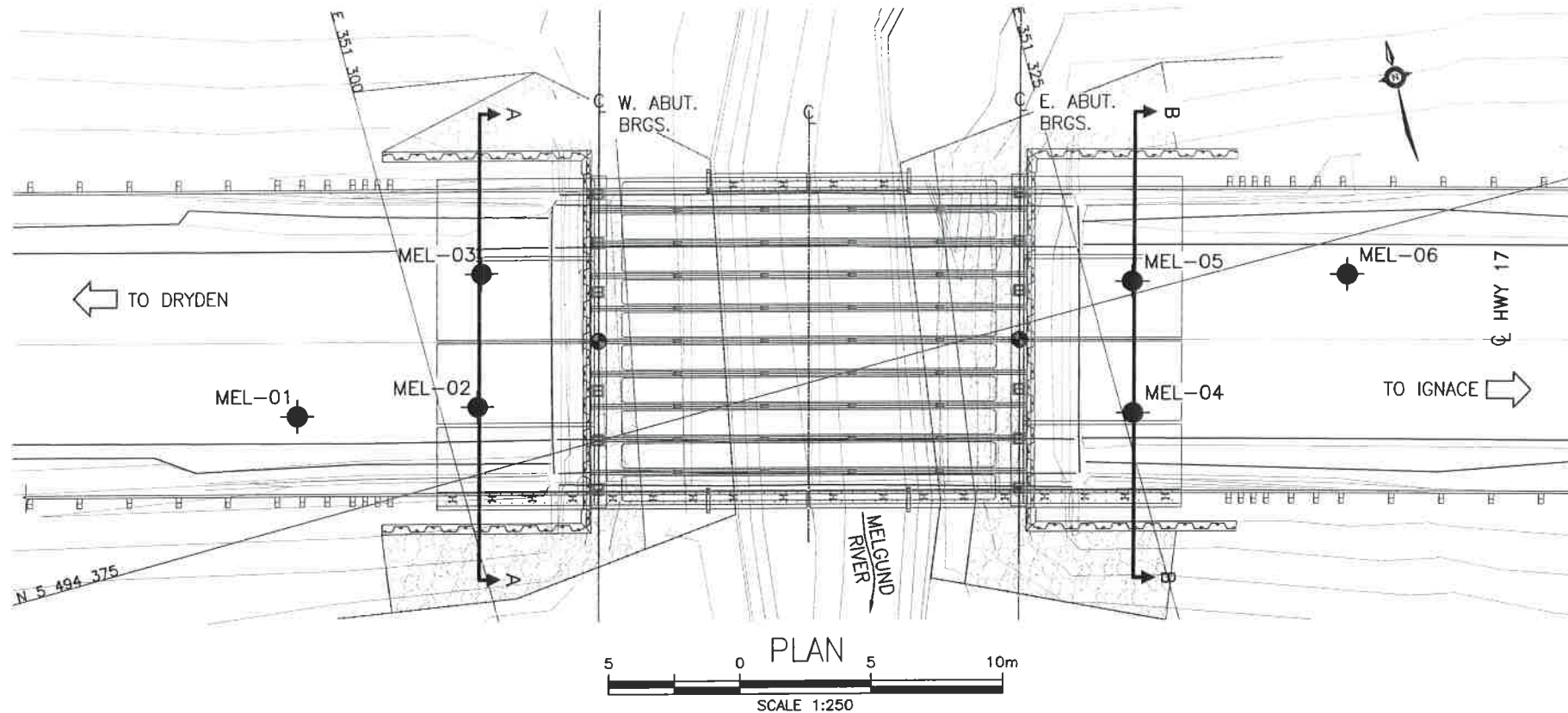
Photograph 3 – Melgund River Bridge, Looking South



Photograph 4 – Melgund River, Looking South from Bridge

Appendix D

Drawing titled “Borehole Locations and Soil Strata”



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

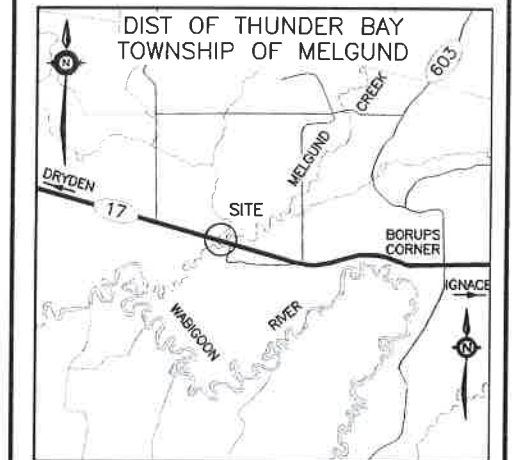
CONT No 2012-6013
WP No 6145-04-01

HIGHWAY 17
MELGUND RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

Hatch Mott MacDonald

THURBER ENGINEERING LTD.

SHEET
8



KEYPLAN
LEGEND

- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
MEL-01	373.0	5 494 379.0	351 294.7
MEL-02	373.0	5 494 377.5	351 301.4
MEL-03	373.0	5 494 382.4	351 302.9
MEL-04	373.0	5 494 370.6	351 325.4
MEL-05	373.0	5 494 375.5	351 326.7
MEL-06	373.0	5 494 373.6	351 334.6

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCREs No. 52F-37



REVISIONS	DATE	BY	DESCRIPTION
DESIGN LRB	CHK LRB	CODE CAN/CSA S6-06/LOAD G1-825-0MT/DATE OCT. 2012	
DRAWN AN	CHK RPR	SITE 415-66	STRUCT DWG 2

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

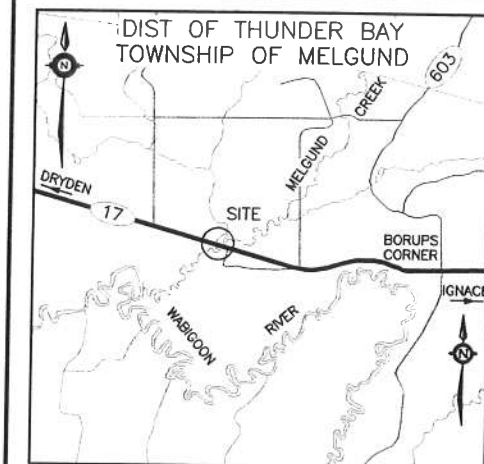
CONT No 2012-6013
WP No 6145-04-01

HIGHWAY 17
MELGUND RVR
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
9

**Hatch Mott
MacDonald**

THURBER ENGINEERING LTD.



**KEYPLAN
LEGEND**

- ◆ Borehole
- ◆ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

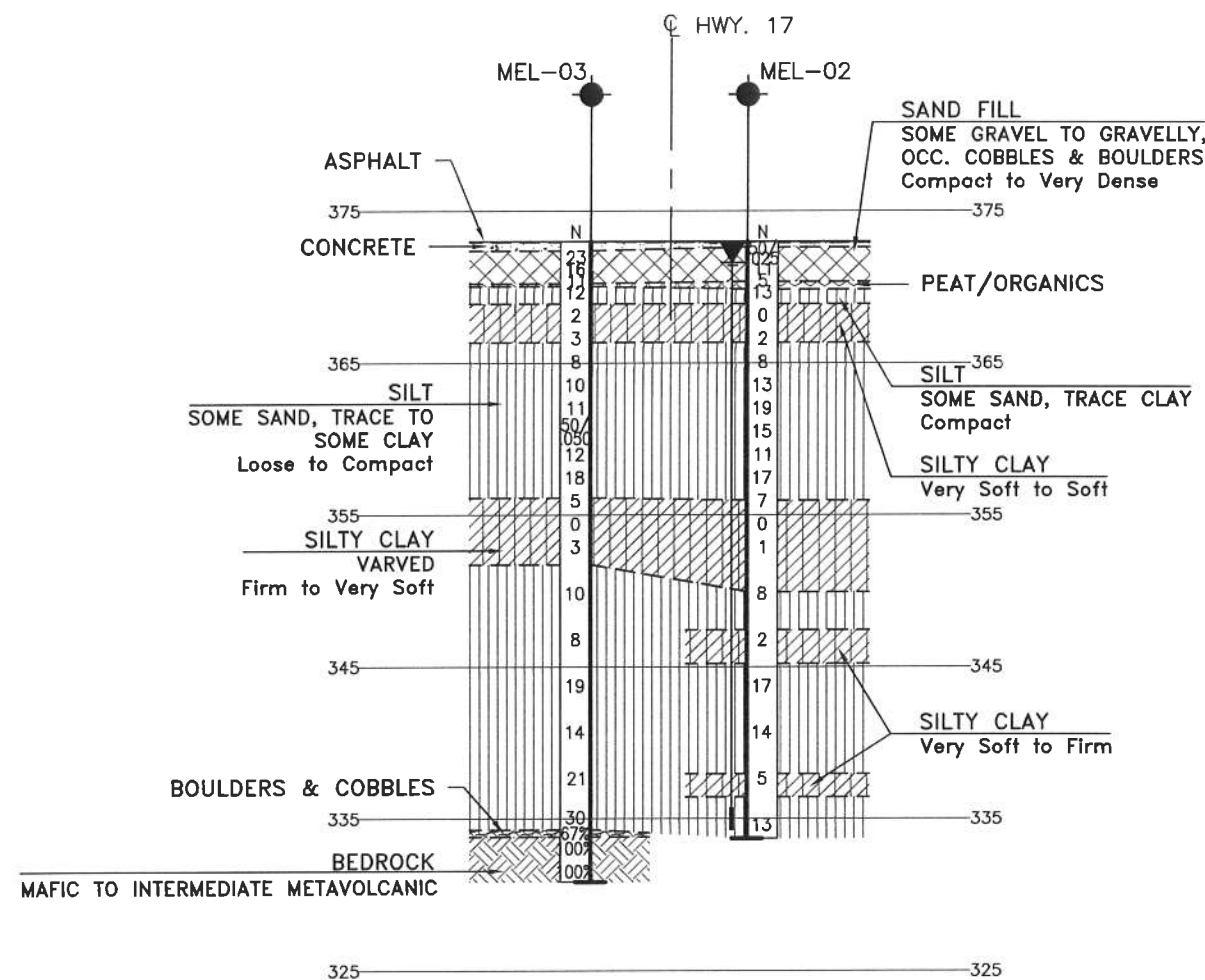
NO	ELEVATION	NORTHING	EASTING
MEL-01	373.0	5 494 379.0	351 294.7
MEL-02	373.0	5 494 377.5	351 301.4
MEL-03	373.0	5 494 382.4	351 302.9
MEL-04	373.0	5 494 370.6	351 325.4
MEL-05	373.0	5 494 375.5	351 326.7
MEL-06	373.0	5 494 373.6	351 334.6

-NOTES-

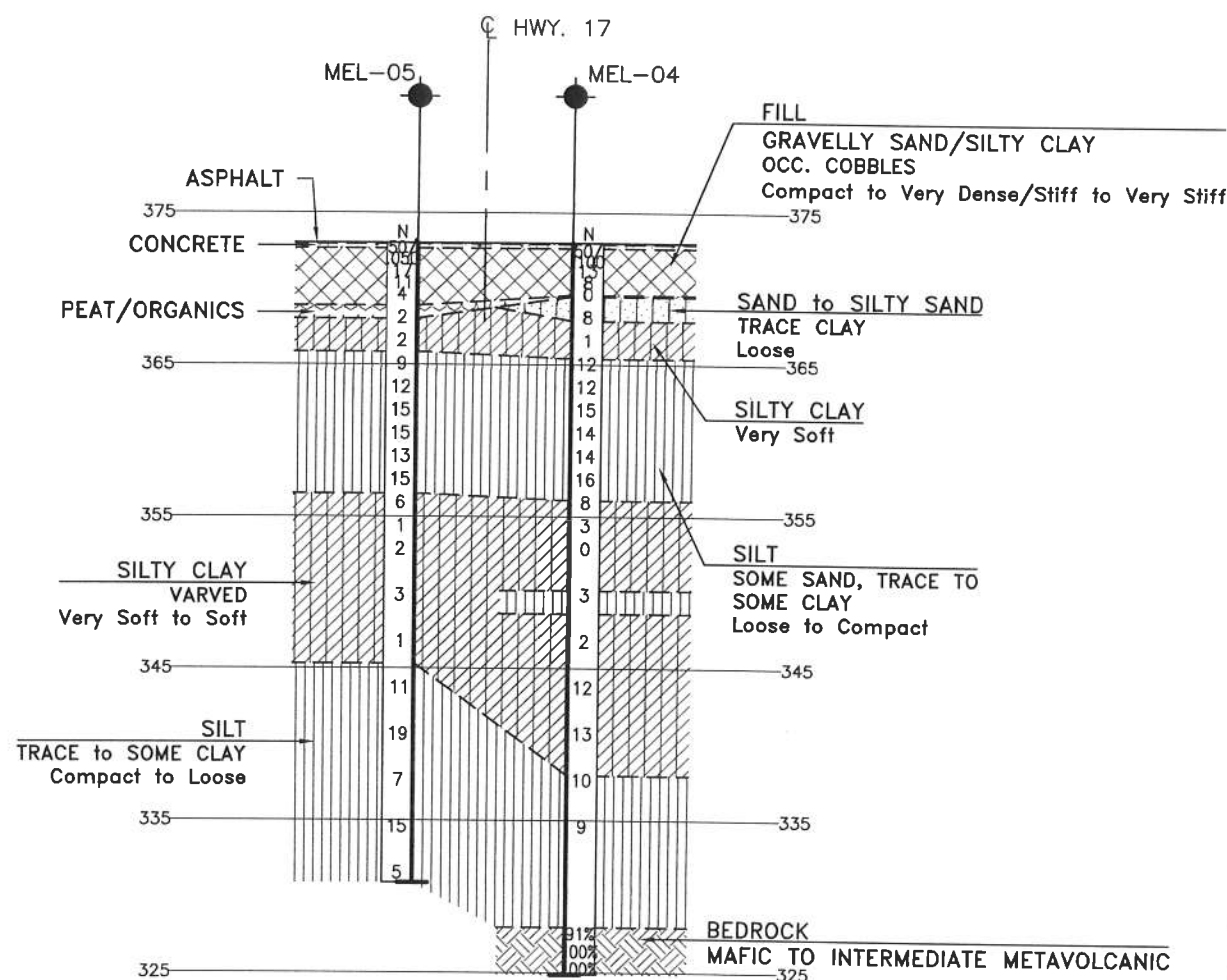
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRE No. 52F-37

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LRB	CHK	LRB
DRAWN	AN	CHK	RPR
DATE	OCT. 2012		
CODE	CAN/CSA S6-06	LOAD	CI-825-ONT
SITE	415-86	STRUCT	DWG 3



SECTION A-A



SECTION B-B

