



# **MERLEX ENGINEERING LTD.**

CONSULTING GEOTECHNICAL ENGINEERS

GEOCRES No:

41I-209

**FINAL  
FOUNDATION INVESTIGATION AND  
DESIGN REPORT  
CULVERT SITE NO. 46-392 – Twp of Hagar  
GWP 372-00-00**

**Highway 17, From Highway 535 (Hagar)  
Easterly To Highway 539 (Warren), 8.4 km and  
Highway 539, From Highway 17 Northerly 0.5 km**

MEL Ref. No.: 06/11/06160      July 16, 2007

Submitted to:

Earth Tech (Canada) Inc.  
189 Wyld Street  
North Bay, Ontario  
P1B 1Z2

**Geocres No.: 41I-209**



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## **1.0 INTRODUCTION**

Merlex Engineering Ltd. (MEL) has been retained by Earth Tech (Canada) Inc., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation at Culvert Site No. 46-392 on Highway 17 (GWP 372-00-00). The limits of GWP 372-00-00 are described as: Highway 17 from Highway 535 in Hagar, Easterly 8.4 km to Highway 539 in Warren, and Highway 539 from Highway 17 northerly a distance of 0.5 km (see Enclosure No. 2, Key Plan, Appendix A). This project involves the replacement of two (2) culvert structures. Culvert Site No. 46-392 is situated outside the western limits of the above noted project some 2.8 km west of Hwy 535 in the Township of Hagar.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5005-E-0011. The terms of reference for the scope of work are outlined in MEL's proposal P-06-103R dated August 24, 2006. The purpose of the investigation was to determine the subsurface conditions in the area of the culverts. MEL investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

## **2.0 SITE DESCRIPTION**

Culvert Site No. 46-392 is located on Highway 17, some 2.8 km west of the intersection with Highway 535 in Hagar. The topography at the site is generally of low relief and the culvert flows from south to north into the Veuve River. The Veuve River meanders easterly along the north side of the highway embankment and south of the embankment for the CPR. The existing highway embankment supports two undivided lanes of highway, running in an east west direction, and the existing road embankment is some 4 to 5 m higher than the ditch level along the north side of the road.



## **2.1 Site Geology**

Bedrock in the area is late to middle Precambrian comprising of metasediment deposits of conglomerate, sand stone, silt stone, chert, and iron formation. The rock units exist as metamorphosed equivalent of the rock types (OGS Map 2440). For the project area, the surficial geology maps indicate that surficial conditions generally consist of bedrock at shallow depth and overburdened soils comprising of glaciolacustrine plain deposits of silts/clays and sands through which the Veuve River meanders in an easterly direction. Sand and gravel deposits are identified in the glaciolacustrine raised beaches north of Warren. Frequent organic deposits are encountered between the rock outcrops (OGS Map 5003).

## **3.0 INVESTIGATION PROCEDURES**

The field work for this investigation was carried out during the period of December 20 and 21, 2006, and February 8 and 9, 2007, and consisted of a total of three (3) sampled boreholes, with accompanying Dynamic Cone Penetration Test (DCPT).

The field investigation was carried out using a Bombardier mounted CME 45B drilling rig equipped with hollow stem augers and routine geotechnical sampling equipment. The boreholes were advanced using 165 mm O.D. continuous flight hollow stem augers and/or 110 mm O.D. continuous flight standard augers. Soil samples were obtained at regular intervals of depth using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures at all borehole locations. A DCPT was advanced from grade to establish a general indication of resistance characteristics of the overburden at the boring locations. In-situ field vane testing, using an MTO "N" size vane, was carried out where appropriate and possible.



Groundwater conditions in the open boreholes were observed during and immediately following completion of the individual boreholes and, if required, a temporary standpipe was installed for the duration of the drilling operation. All open boreholes were backfilled upon completion with the auger cuttings, in the general order they were removed, using reverse augering techniques. Where necessary imported bentonite (hole plug) was used to seal the hole at grade.

The field work for this investigation was under the full time direction of a senior member of our engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included routine testing for natural moisture content determination, Atterberg Limits determination, grain size analysis (sieve and/or hydrometer), and specific gravity testing. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B) with a summary of select results presented on the laboratory sheets in Appendix C (Figures L-1 to L-5).

The location of the individual boreholes were established in the field using highway chainage and offset relative to highway centerline chainage.

#### **4.0 SUBSURFACE CONDITIONS**

Details of subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix B) and on Figure No. 1 (Appendix C). Please note that stratigraphic delineation presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, and the results of SPT and DCPT, plus field observations. Typically such boundaries represent transitions from one zone



to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location.

#### **4.1 Culvert Site No. 46-392, Station 20+146.6, West of the Town of Hagar**

A plan and profile showing the borehole locations and stratigraphic sequences is shown on Figure No. 1. During the course of our exploration program, three (3) sampled boreholes (Borehole Nos. 1A, 2, and 3) were put down at this site, with Borehole No. 1A advanced through the existing highway embankment, along the south shoulder. Borehole Nos. 2 and 3 were advanced on the south and north ends of the existing culvert respectively.

At the location of Borehole No. 1A, advanced through the embankment, a layer of granular fill consisting of some 325 mm of crushed gravel was encountered. This stratum was underlain by a fine and medium sand fill with a trace of gravel and varying silt content which was penetrated to a depth of approximately 1.6 m below grade. At this point, fill consisting of predominately rockfill was penetrated between elevations  $\pm$  207.3 to 206.2 m. Below this elevation, a fill deposit consisting of silty clay and sand mixed with some rockfill was penetrated down to approximately 203.9 m (5 m depth). At this elevation, a dark grey to grey silty clay mixed with sands and a trace of gravel was penetrated to approximately elevation 202.6 m (see Grain Size Analysis, Figure L-1). This latter deposit could comprise of the natural silty clay stratum, intermixed with imported granular materials used as bedding. At approximately elevation 202.6 m, a grey fine and medium sand with some silt was penetrated down to approximately an 8.2 m depth (elevation 200.7 m). Based on the resistance to sampling, this sand deposit has a compactness of very loose. Underlying the natural sand deposits, a stratum of grey silty clay with fine seams of silty sand (generally some  $\pm$  50 mm thick) was penetrated down to elevation 196.4 m. This silty clay deposit was of a firm consistency with in-situ shear strength values



measured at 36 to 40 kPa. An atterberg limits test carried out on the silty clay portion returned a liquid limit of 37.2%, a plastic limit of 20.6%, and a natural moisture content of 41.4%. The silty clay deposit plots above the A line and is described as a plastic clay. Typical particle size analysis of this deposit is shown on Figure L-2, Appendix C. Below a depth of some 12.5 m (elevation 196.4 m), a grey gravelly sand with some silt was encountered. Based on the SPT value of 8 blows per 300 mm penetration, the compactness of this deposit is described as loose. A particle size analysis test was carried out on this deposit and indicated 36% gravel size particles, 49% sand size particles, 9% silt size particles, and 6% clay size particles (see Figure L-4, Appendix C). Sampling at the borehole was discontinued at a depth of some 14.2 m below grade and a DCPT was advanced from the bottom of the borehole. The DCPT met refusal at a short distance below the end of sampling (ie. 14.7 m below grade).

At Borehole Nos. 2 and 3, advanced at the south and north end of the culverts respectively, a thin surficial layer of black silty clay/silty sand organics some 75 to 150 mm thick was encountered. This thin surficial layer was underlain by a tan silty clay of firm consistency. This silty clay extended to approximately elevation 204.0 m, where a deposit of grey fine and medium sand with frequent silt rich seams, with a trace of clay, was penetrated. Based on the SPT values, which ranged from weight of hammer (0 blows) to 3 blows per 300 mm penetration and DCPT values which ranged from 5 to 12 blows per 300 mm penetration, the compactness of this sand deposit is described as very loose to compact, generally loose. These sands extended to a depth of some 4.7 m (elevation 200.8 m) at Borehole No. 2 and 5.9 m (elevation 199.5 m) at Borehole No. 3. Typical particle size analysis is shown on Figure L-3, Appendix C.

Underlying these sands a grey silty clay was encountered. At Borehole No. 2, this silty clay deposit exhibited a varved structure with depth and was some 3.7 m in thickness, whereas at Borehole No. 3, the silty clay deposit was only encountered over a depth of some 1.1 m. Based



on in-situ field vane tests, which returned values ranging between 32 to 38 kPa, the consistency of the clay deposit was described as firm. Underlying the clay, a deposit of grey silty sand was penetrated and based on the SPT values the compactness of the deposit is described as compact. At Borehole No. 2, cobbles and boulders were encountered in the lower reaches of the sand deposit (ie. around elevation 195.9 m) with refusal on augers and DCPT encountered at elevation 195.7 m (Borehole No. 2) and 192.8 m (DCPT refusal, Borehole No. 3).

#### **4.2 Groundwater Conditions**

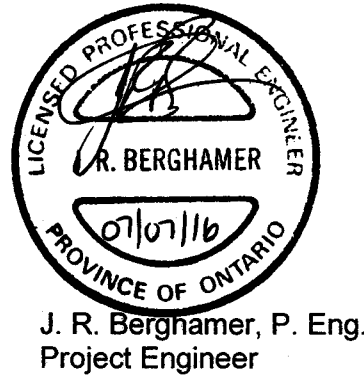
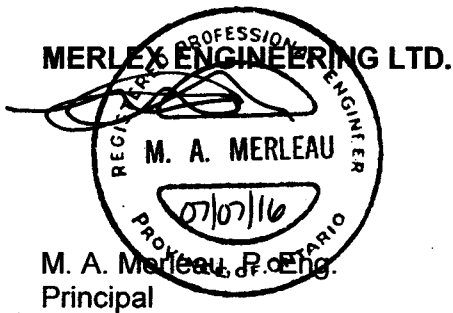
Groundwater levels in the open boreholes were taken during the advance of the individual borings and upon completion. These water levels were recorded on the individual Record of Borehole Log Sheets (Appendix B) and are considered to give an indication of the stabilized groundwater level at the time of the investigation. At Borehole No. 2 (inlet location), the groundwater level was measured at approximately elevation 204.8 m, whereas at Borehole No. 3 (outlet location), the groundwater level was measured at approximately elevation 204.7 m. During advance of the borehole (Borehole No. 1) through the embankment, the groundwater level was measured at approximately elevation 205.0 m during the field drilling operation. These groundwater levels will fluctuate seasonally.

At the time that the foundation field drilling program was carried out, the water level flowing through the culvert was at a depth of approximately 150 mm. As can be seen from the enclosed Photo No. 1, the culvert is dry at various times during the year. It was observed by others that the flow of the creek was "short cutting" through the embankment (presumed rockfill) immediately west of the existing culvert.





Upon completion of the field work, all boreholes were backfilled with the auger cuttings installed generally in the order in which they were removed using reverse augering techniques. If temporary standpipes were installed, they were removed on completion and the void grouted with a bentonite mix.





## 5.0 DESIGN COMMENTS AND RECOMMENDATIONS

### 5.1 General

The existing concrete culvert has a span of 3.05 m and rise of 2.46 m and carries two lanes of Highway 17 (undivided) in an east west direction. The culvert has a concrete bottom but it is unknown if this was poured as a structural slab connected to the walls or as a slab on grade or possible mud slab. It's thickness is unknown. The culvert carries flow from the south to north and discharges into the Veuve River, which parallels the highway embankment a short distance to the north. At the time of our field review and field drilling (November and December 2006), flow through the culvert was at a depth of some 100 to 150 mm, as can be seen in the attached Photo Nos. 2 and 3. However, as can be seen in Photo No. 1, as supplied by MTO on November 23, 2006, the culvert carries zero flow at certain times of the year. There is some 1.5 m of embankment fill on top of the culvert and a drop of some 0.5 m from the culvert invert to stream bed.

It is understood that, due to the deteriorated condition of the existing culvert, it is to be replaced. The replacements will be carried out by staging. Detours will not be required. It is further understood that precast concrete box units are being considered to replace this culvert. The units will probably not have a head wall or wing walls to allow for the use of a longer culvert length, such that the replacement could be completed using a 24 hour operation.

Based on our soils investigation program, the founding soils below the estimated culvert invert of elevation  $\pm 203.8$  m is a fine and medium sand with varying silt content at either end (Borehole Nos. 2 and 3). Borehole No. 1, advanced through the embankment, revealed a 1.2 m thick layer of silty clay mixed with sand and a trace of gravel below the estimated elevation of the culvert slab before encountering the fine and medium sand deposit as encountered at Borehole Nos. 2 and 3. The sands were underlain, below elevation 199.5 and 200.8 m, by a



firm silty clay, which in turn was underlain by sands with varying silt content and, at depth, cobble/boulder content (below elevation 198.4 to 196.4 m). These sands extended to the depths at which sampling in the boreholes was terminated (ie. elevation 194.2 to 195.7 m).

## 5.2 Foundation Consideration

The upper fluvial deposits are generally loose, variable in nature, saturated and water bearing. However, it is judged feasible to support rigid concrete box units of similar size and at similar elevations provided subgrade conditions are maintained in a stable, undisturbed condition during construction.

Groundwater control must be carried out during excavation and installation of the box units, such that an unwatered excavation is maintained during these phases of the construction operation. As can be seen from the enclosed photos, creek flows/groundwater levels will fluctuate seasonally. The excavation will have to be advanced to approximately elevation 202.6 m to remove fill material from below the new box units, as identified in Borehole No. 1A. At the time of this investigation, this elevation was some 2 m below the groundwater level. Based on information presently at hand and the nature of the construction sequences, it is our opinion that a system of sand bags or pumping from a series of strategically placed filtered sump holes and pumps may not be sufficient to divert the creek and control groundwater during installation. As such, it is our opinion that a more sophisticated dewatering system, such as vacuum well points, will be required to control the  $\pm 2$  m head of water. Ultimately, the method of dewatering will be the choice of the contractor, however the importance of maintaining the subgrade in an unwatered stable condition during excavation and foundation construction can not be stressed enough.



### **5.3 Subgrade Preparation**

The results of this investigation indicate that the native subgrade soils, below elevation  $\pm 204.0$  m, will be fine and medium sands, generally in a loose condition. However, a silty clay mixed with sands/gravels (fill) was penetrated to elevation 202.6 m. As noted previously, this fill deposit is not considered acceptable to bear the box units, as such it will have to be subexcavated where encountered and replaced with engineered fill. It is recommended that a Granular B Type I be used to raise this natural subgrade level. The engineered fill should be compacted to 100% Standard Proctor Dry Density (SPDD). A 75 mm Special Provision (SP) No. 110F13 (March 2004) Granular A top leveling course should be placed in conformance with OPSS 422.

### **5.4 Design Bearing Pressure**

Based on the above noted soil conditions and founding elevation, we have determined a factored bearing resistance value at ULS of 105 kPa. A SLS bearing resistance of 70 kPa reflects settlement considerations of the preloaded zone of soil below the existing slab, a settlement estimate of 25 mm, and the assumption that a stable subgrade is maintained during excavation and construction. A 75 mm SP No. 110F13 (March 2004) Granular A top leveling course should be placed in conformance with OPSS 422.

### **5.5 Lateral Earth Pressure**

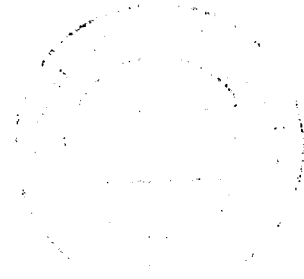
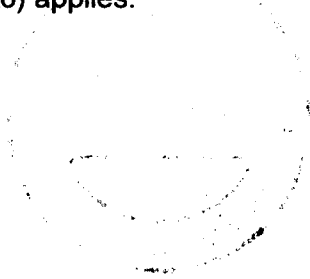
A free draining granular material, such as SP No. 110F13 (March 2004) Granular B Type I, is recommended as appropriate backfill to the culvert in order to insure the prevention of hydrostatic pressure build-up. The embankment fill should be placed in a balanced manner on the outer sides of the box units.



Lateral earth pressures should be computed in accordance with the CHBDC. The design parameters are as follows:

	<u>Granular A</u>	<u>Granular B Type I</u>	<u>Rock Fill</u>
Angle of Internal Friction (degrees)	35	30	43
Unit weight (KN/m <sup>3</sup> )	22	20	18.5
Active earth pressure (Ka)	0.27	0.33	0.19
At-rest earth pressure (Ko)	0.43	0.50	0.32

For rigid structures, such as rigid box units, deflection cannot occur, as such the "at-rest" condition (Ko) applies.





## 6.0 CLOSURE

Information provided in this report is valid only at the locations described above. Any assumptions of continuity of soil stratigraphy between boreholes, as shown on the enclosed cross-sections, is intended as an aid for design purposes only and does not constitute a statement of existing conditions for contractual or construction purposes.

Details of the investigation, the material analysis and recommendation in this report are considered to be complete. However, should any questions arise, please do not hesitate to contact the undersigned.

**MERLEX ENGINEERING LTD.**



M. A. Merleau, P. Eng.  
Principal



J. R. Berghamer, P. Eng.

## **APPENDIX A**

Enclosure No. 1: List of Abbreviations and Symbols

Enclosure No. 2: Key Plan



## LIST OF ABBREVIATIONS & DESCRIPTION OF TERMS

The abbreviations and terms, used to describe retrieved samples and commonly employed on the borehole logs, on the figures and in the report are as follows:

### 1. ABBREVIATIONS

AS	Auger Sample
CS	Chunk Sample
DS	Denison type sample
FS	Foil Sample
HB	Hammer Bouncing
NFP	No Further Progress
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
RC	Rock core with size & percentage of recovery
SS	Split Spoon
ST	Slotted Tube
TO	Thin-walled, open
TP	Thin-walled, piston
WH	Sampler Advanced by static weight (weight of hammer and/or rods)
WS	Wash Sample

### 2. PENETRATION RESISTANCE/"N"

*Dynamic Cone Penetration Test (DCPT):*

A continuous profile showing the number of blows for each 300 mm of penetration of a 50 mm diameter 90° point cone driven by a 63 kg hammer falling 760 mm.

Plotted as 

*Standard Penetration Test (SPT) or "N" Values*

The number of blows of a 63 kg hammer falling 760 mm required to advance a 50 mm O.D. drive open sampler 300 mm.

### 3. SOIL DESCRIPTION

a) *Cohesionless Soils:*

"N" (blows/0.3 m)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

### 3. SOIL DESCRIPTION (Cont'd)

b) *Cohesive Soils:*

Undrained Shear Strength (kPa)	Consistency
Less than 12	very soft
12 to 25	soft
25 to 50	firm
50 to 100	stiff
100 to 200	very stiff
over 200	hard

c) *Method of Determination of Undrained Shear Strength of Cohesive Soils:*

- + 3.2 - Field Vane test in borehole.  
The number denotes the sensitivity to remoulding.
- D - Laboratory Vane Test
- " - Compression test in laboratory

For a saturated cohesive soil the undrained shear strength is taken as one-half of the undrained compressive strength.

### 4. TERMINOLOGY

Terminology used for describing soil strata is based on the proportion of individual particle sizes present in the samples (please note that, with the exception of those samples subject to a grain-size analysis, all samples were classified visually and the accuracy of visual examination is not sufficient to determine exact grain sizing):

Trace, or occasional	Less than 10%
Some	10 to 20%
With	20 to 30%
Adjective (i.e. silty or sandy)	30 to 40%
And (i.e. sand and gravel)	40 to 60%

### 5. LABORATORY TESTS

- P Standard Proctor Test
- A Atterberg Limit Test
- GS Grain Size Analysis
- H Hydrometer Analysis
- C Consolidation

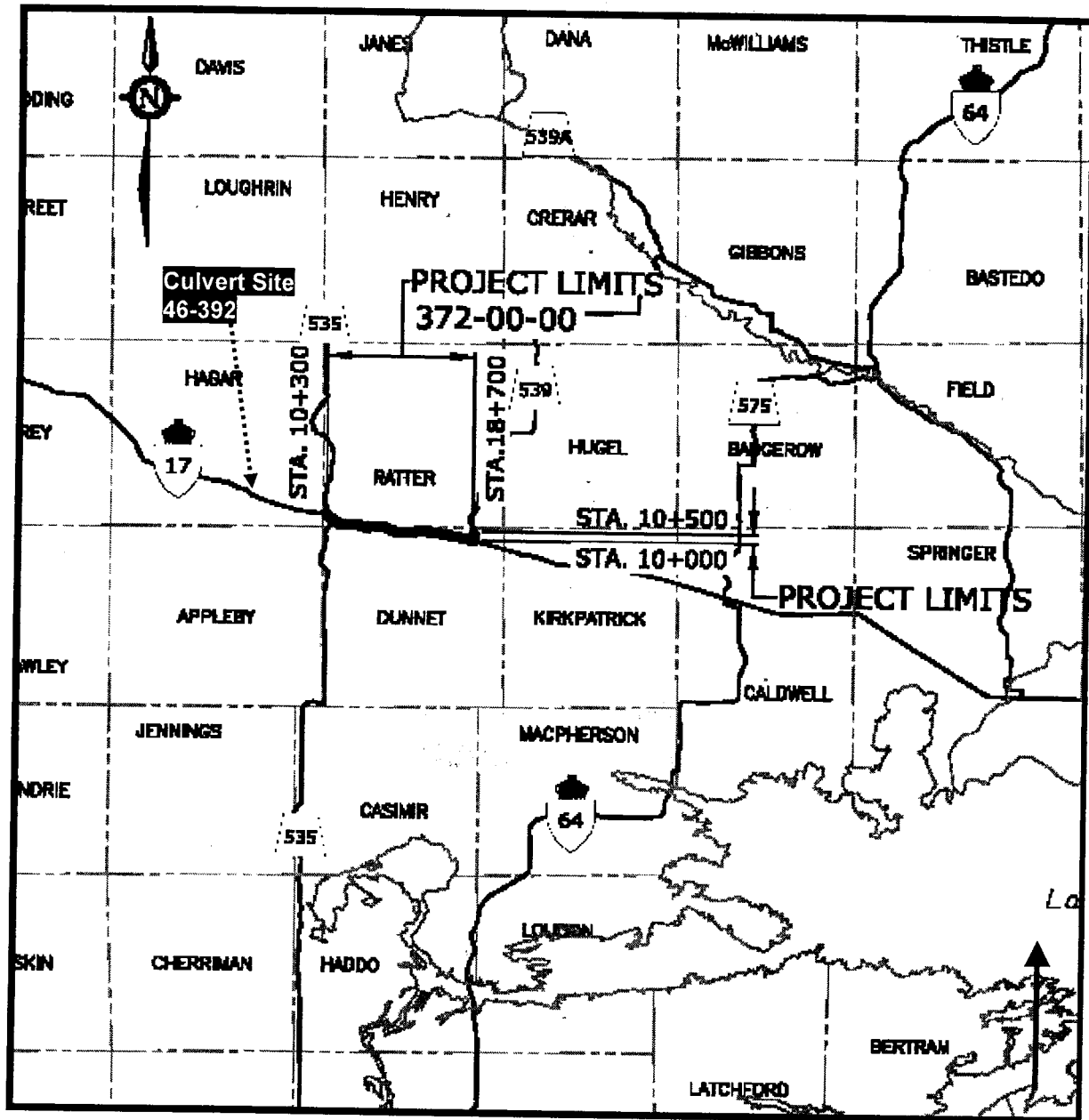


**SAMPLE DESCRIPTION NOTES:**

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.
2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.
3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.
4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

# KEY PLAN

Enclosure No. 2



Not to Scale

## FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT GWP 372-00-00

Culvert Site No. 46-392 – Twp. of Hagar  
Highway 17, From Highway 535 (Hagar)  
Easterly To Highway 539 (Warren), 8.4 km and  
Highway 539, From Highway 17 Northerly 0.5 km



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MEL Reference No. 06/11/06160

July 2007

## **APPENDIX B**

Enclosure Nos. 3 to 5: Record of Borehole Sheets

## METRIC

## RECORD OF BOREHOLE No. 1A - Culvert 46-392



REFERENCE 06/11/06160 DATUM Geodetic LOCATION 4.2 m West of C/L of Culvert - 5.1 m South of C/L of Road. ORIGINATED BY ELS  
 PROJECT Hwy 17 - Township of Hagar - Site 46-392 BOREHOLE TYPE Hollow Stem Augers & Dynamic Cone Penetration Test COMPILED BY DVL  
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 12/21/06 - 12/20/06 TIME 9:53:00 AM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								20 40 60 80 100							
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%)				
						20 40 60 80 100					20 40 60				
208.9	Ground Surface														
0.0	±325 mm Crushed Gravel		1a	AS											
	FILL														
	Fine and Medium Sand, Trace of Gravel, Trace to Some Silt with Depth		2a	AS											
207.3															

## COMMENTS

1) Initially borehole located 3.0 m West of Culvert C/L, South Shoulder, refusal on DCPT and Auger at 1.6 m depth. Relocated borehole to 4.2 m West of culvert C/L, South Shoulder.

The stratification lines represent approximate boundaries. The transition may be gradual.

+ 3, X<sup>3</sup>: Numbers on right refer to  
Sensitivity  
Numbers on left refer to  
values greater than 120 kPa  
○ 3% STRAIN AT FAILURE

## WATER LEVEL RECORDS

Date (dd/mm/yyyy)/Time	Water Depth (m)	Cave In (m)
1) 12/21/06	3.9	▽
2)	-	▽
3)	-	▽

See Fig. L-1  
0 36 31 33  
SG = 2.65

1 87 (12)


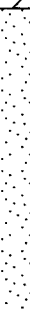
## MERLEX ENGINEERING LTD.

120 Progress Court, P1B 8G4 Phone: 705 476 2550 Fax: 705 476 8882 Email: merlex@merlex.ca

MEL-GEO 06160 - HWY 17 HAGAR 46-392.GPJ MEL-GEO.GDT 7/16/07

**METRIC****RECORD OF BOREHOLE No. 1A - Culvert 46-392**

REFERENCE 06/11/06160 DATUM Geodetic LOCATION 4.2 m West of C/L of Culvert - 5.1 m South of C/L of Road. ORIGINATED BY ELS  
 PROJECT Hwy 17 - Township of Hagar - Site 46-392 BOREHOLE TYPE Hollow Stem Augers & Dynamic Cone Penetration Test COMPILED BY DVL  
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 12/21/06 - 12/20/06 TIME 9:53:00 AM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
Continued from Previous Page								20 40 60 80 100	20 40 60						
200.7 8.2	CLAY  Grey Silty Clay with Occasional 50 mm Thick Silty Sand and Sand Layers  (Firm)														
			6	SS	6										
			7	SS	PM										
196.4 12.5	SANDS  Grey Gravelly Sand, some Silt  (Loose)		8	SS	PM										

MEL-GEO 06160 - HWY 17 HAGAR 46-392.GPJ MEL-GEO.GDT 7/16/07

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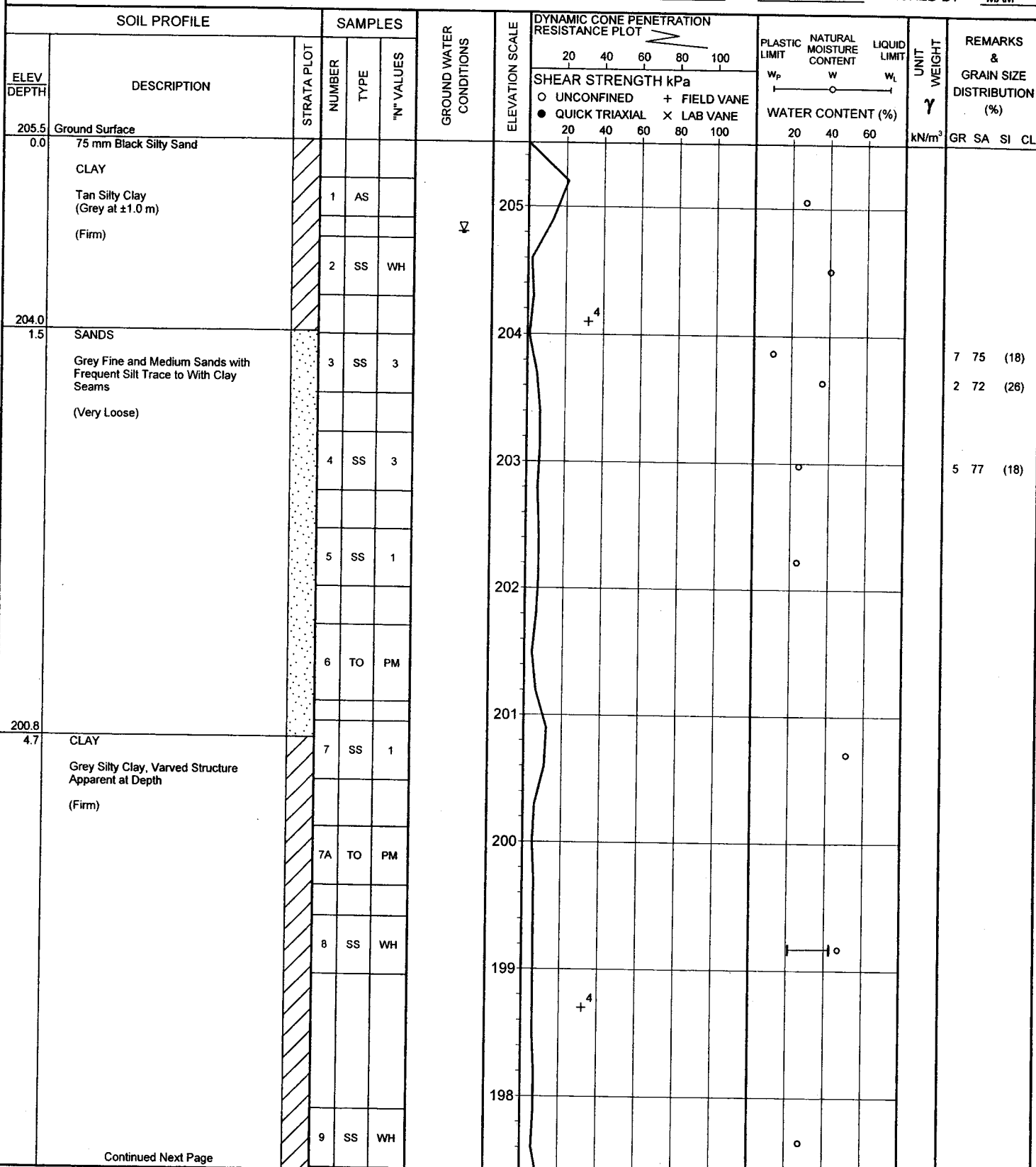
120 Progress Court, P1B 8G4 Phone: 705 476 2550 Fax: 705 476 8882 Email: merlex@merlex.ca

## METRIC

## RECORD OF BOREHOLE No. 2 - Culvert 46-392



REFERENCE 06/11/06160 DATUM Geodetic LOCATION 5.4 m West of C/L of Culvert - 16.5 m South of C/L of Hwy 17 ORIGINATED BY ELS  
 PROJECT Hwy 17 - Township of Hagar - Site 46-392 BOREHOLE TYPE Hollow Stem Augers & Dynamic Cone Penetration Test COMPILED BY DVL  
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 2/8/07 - 2/8/07 TIME 3:00:00 PM CHECKED BY MAM



## COMMENTS

1) DCPT advanced 1.1 m East of Borehole.

The stratification lines represent approximate boundaries. The transition may be gradual.

+ 3, × 3 : Numbers on right refer to Sensitivity  
 Numbers on left refer to values greater than 120 kPa  
 ○ 3% STRAIN AT FAILURE

## WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 2/9/07	0.7	✓
2)	-	✓
3)	-	✓

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MEL-GEO 06160 - HWY 17 HAGAR 46-392.GPJ MEL-GEO.GDT 7/16/07

**METRIC****RECORD OF BOREHOLE No. 2 - Culvert 46-392**

REFERENCE 06/11/06160 DATUM Geodetic LOCATION 5.4 m West of C/L of Culvert - 16.5 m South of C/L of Hwy 17 ORIGINATED BY ELS  
 PROJECT Hwy 17 - Township of Hagar - Site 46-392 BOREHOLE TYPE Hollow Stem Augers & Dynamic Cone Penetration Test COMPILED BY DVL  
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 2/8/07 - 2/8/07 TIME 3:00:00 PM CHECKED BY MAM

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80
	Continued from Previous Page															
197.1																
8.4	SANDS					197										
	Grey Silty Sands															
	(Compact)															
	Cobbles and Boulders		10	SS	15/275mm 50/25mm											
195.7						196										
9.8	Auger Refusal Probably Boulders/Possible Bedrock End of Borehole															

MEL-GEO 06160 - HWY 17 HAGAR 46-392.GPJ MEL-GEO.GDT 7/16/07

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## METRIC

## RECORD OF BOREHOLE No. 3 - Culvert 46-392



REFERENCE 06/11/06160 DATUM Geodetic LOCATION 4.0 m East of C/L of Culvert - 19.2 m North of C/L of Hwy 17 ORIGINATED BY ELS  
 PROJECT Hwy 17 - Township of Hagar - Site 46-392 BOREHOLE TYPE Hollow Stem Augers & Dynamic Cone Penetration Test COMPILED BY DVL  
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 2/9/07 - 2/9/07 TIME 1:40:00 PM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
205.4	Ground Surface												
0.0	150 mm Black Silty Clay with Organics		1	AS									
	CLAY												
	Tan Silty Clay (Firm)		2	SS	4								
204.0													
1.4	SANDS												
	Grey Fine and Medium Sands with Occasional Silty Seams (Very Loose)		3	SS	2								3 76 (21)
			4	SS	WH								1 89 (10)
			5	SS	WH								
			6	SS	WH								
199.5													
5.9	CLAY		7	TO	PM								
	Grey Silty Clay (Firm)												
198.4													
7.0	SANDS		8	SS	29								
	Grey Silty Sand (Compact)												
Continued Next Page													
COMMENTS							+ 3, X 3: Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE						
							WATER LEVEL RECORDS Date (dd/mm/yyyy)/Time Water Depth (m) Cave In (m) 1) 2/9/07 0.7 2) - 3) -						

The stratification lines represent approximate boundaries. The transition may be gradual.

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MEL-GEO 06160 - HWY 17 HAGAR 46-392.GPJ MEL-GEO.GDT 7/16/07



**METRIC****RECORD OF BOREHOLE No. 3 - Culvert 46-392**

REFERENCE 06/11/06160 DATUM Geodetic LOCATION 4.0 m East of C/L of Culvert - 19.2 m North of C/L of Hwy 17 ORIGINATED BY ELS  
 PROJECT Hwy 17 - Township of Hagar - Site 46-392 BOREHOLE TYPE Hollow Stem Augers & Dynamic Cone Penetration Test COMPILED BY DVL  
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 2/9/07 - 2/9/07 TIME 1:40:00 PM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
	Continued from Previous Page												
	SANDS Grey Sands, some Silty to Silty (Compact)												
195.7			9	SS	26								
9.7	Auger Refusal End of Sampling  Probably Sands with Cobbles/Boulders												
192.6													
12.8	End of DCPT End of Borehole												

MEL-GEO 06160 - HWY 17 HAGAR 46-392.GPJ MEL-GEO.GDT 7/16/07

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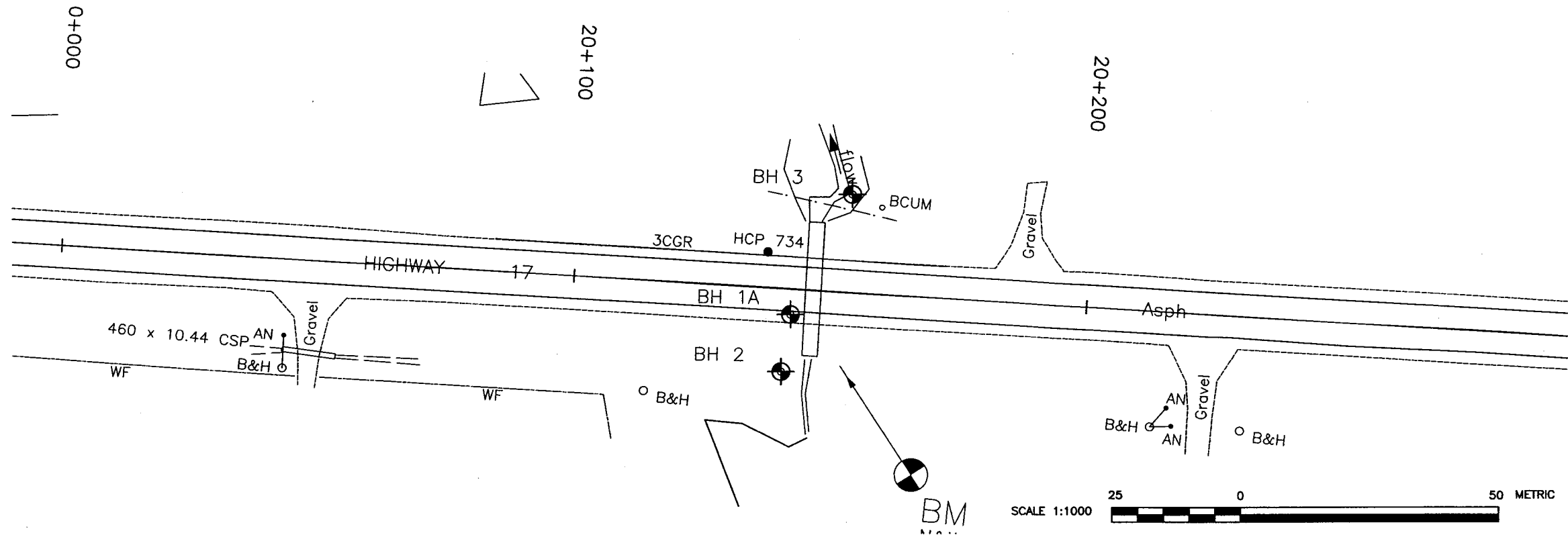
120 Progress Court, P1B 8G4 Phone: 705 476 2550 Fax: 705 476 8882 Email: merlex@merlex.ca

## **APPENDIX C**

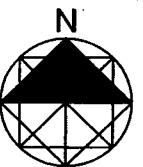
Figure 1: Borehole Locations and Soil Strata Plan

Figures L-1 to L-4: Summary Grain Size Analysis Graph

Figure L-5: Atterberg Limits



CONT No 0  
WP No 372-00-00  
Geocres No.: 41I-209



HWY 17 Twp. Hagar  
Culvert Site No. 46-392  
Section 20+146.6  
BOREHOLE LOCATIONS & SOIL STRATA

Figure  
1

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Consulting Geotechnical Engineers

#### STRATIGRAPHY LEGEND

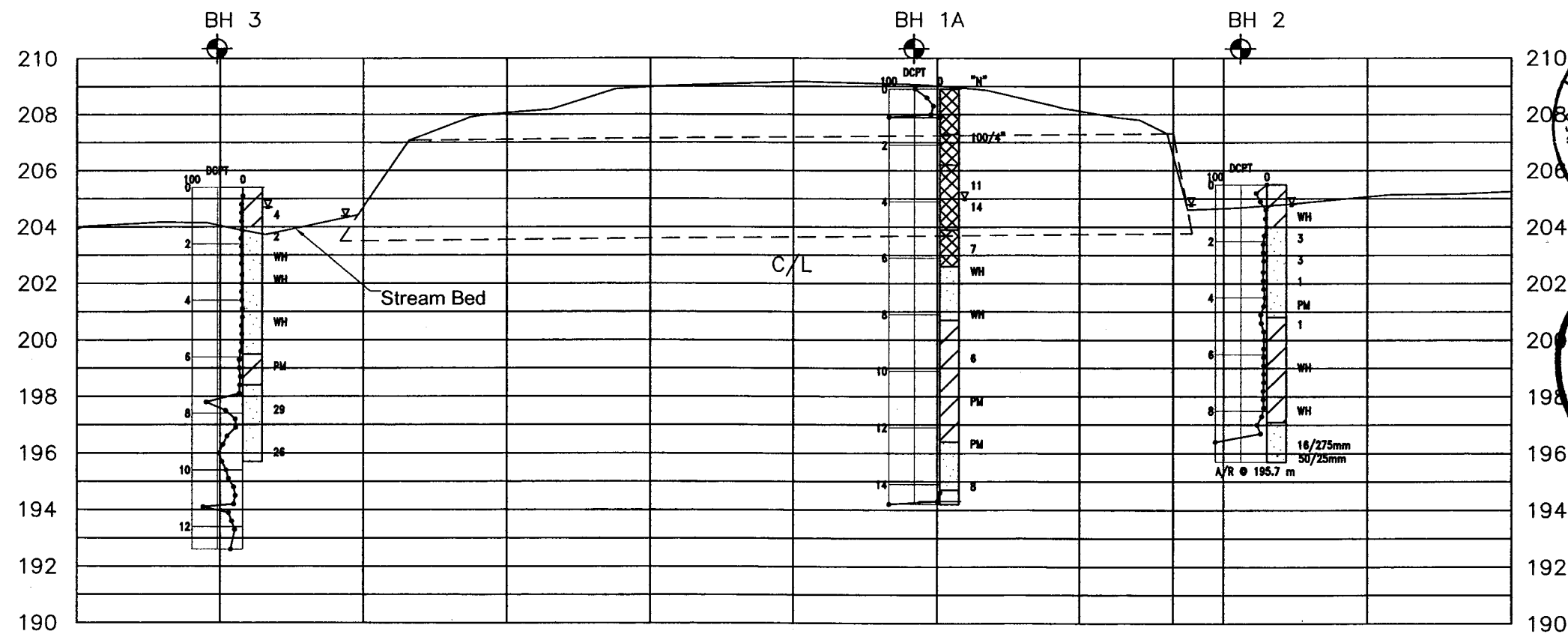
	TOPSOIL		SAND		SILTY SAND/ SANDY SILT
	PEAT		SAND & GRAVEL		SILT
	VARVED/ INTERLAYERED CLAYS & SILTS		CLAY		SILTY CLAY
	FILL		TILL		CRUSHED GRAVEL
	ASPHALT COATED		ORGANIC SILTS		

#### LEGEND

- 
- 
- 
- 
- 
- 
- 

Borehole No.	Co-ordinates		Elevation
	Station	Offset	
Borehole No.1A	20+143.5	5.0 m Rt	208.9
Borehole No.2	20+142	16.0 m Rt	205.5
Borehole No.3	20+151	19.0 m Lt	205.4

**NOTE 1:**  
The boundaries between soil strata have been established at the borehole locations only. The boundaries between boreholes are assumed based on borehole data.



CULVERT SECTION AT 20+146.6

SCALE 1:200

REVISIONS	DATE	BY	DESCRIPTION
	00/00/03	DVL	REV 0 -
	00/00/03	DVL	REV 1-
	00/00/03	DVL	REV 3 -
	00/00/03	DVL	REV 4-

HWY No. 17 Culvert 46-392 - MEL Reference No. 06160	DIST
SUBM'D	DATE 07/05/01
DRAWN DVL	CHK MAM
DATE 07/04/30	SITE
FIG 1	

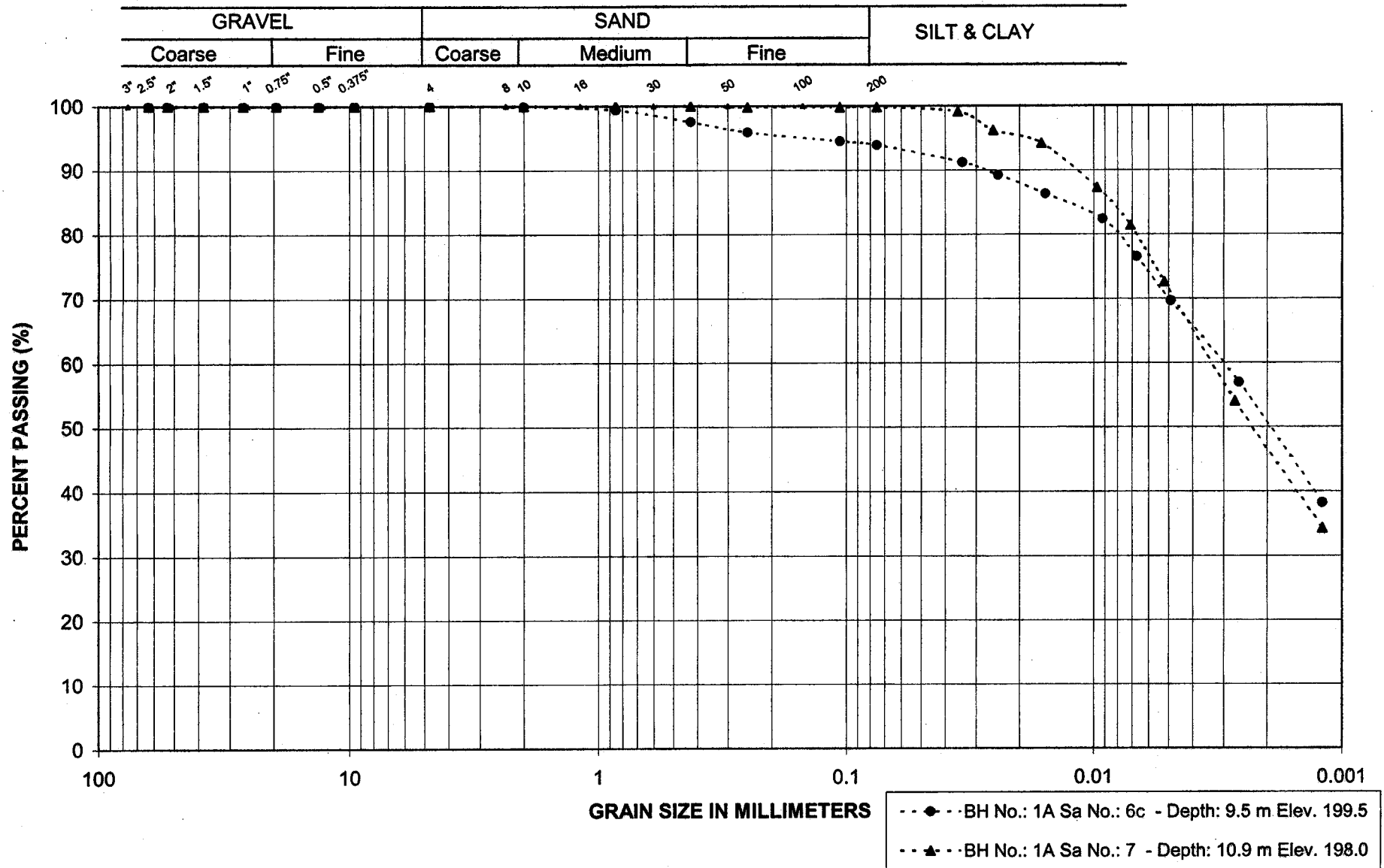
**Date:** May 2007



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FIGURE L-1

## GRAIN SIZE ANALYSIS



PROJECT: Hwy 17 - Culvert 46-392  
LOCATION: Hagar Twp.

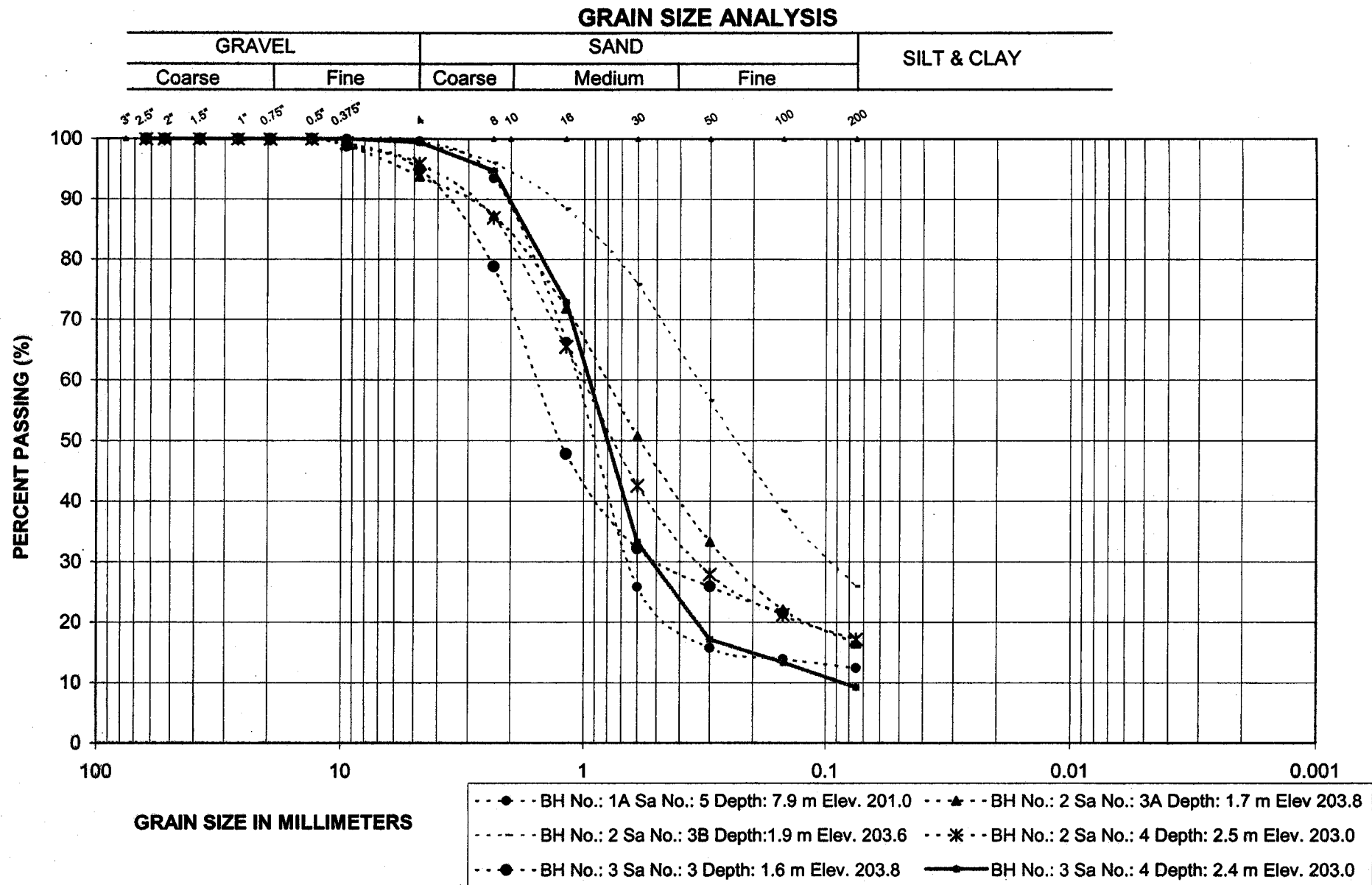
CLAY

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FIGURE L-2

Reference No.: 06160

Date: May 2007



PROJECT: Hwy 17 - Culvert 46-392  
LOCATION: Hagar Twp.

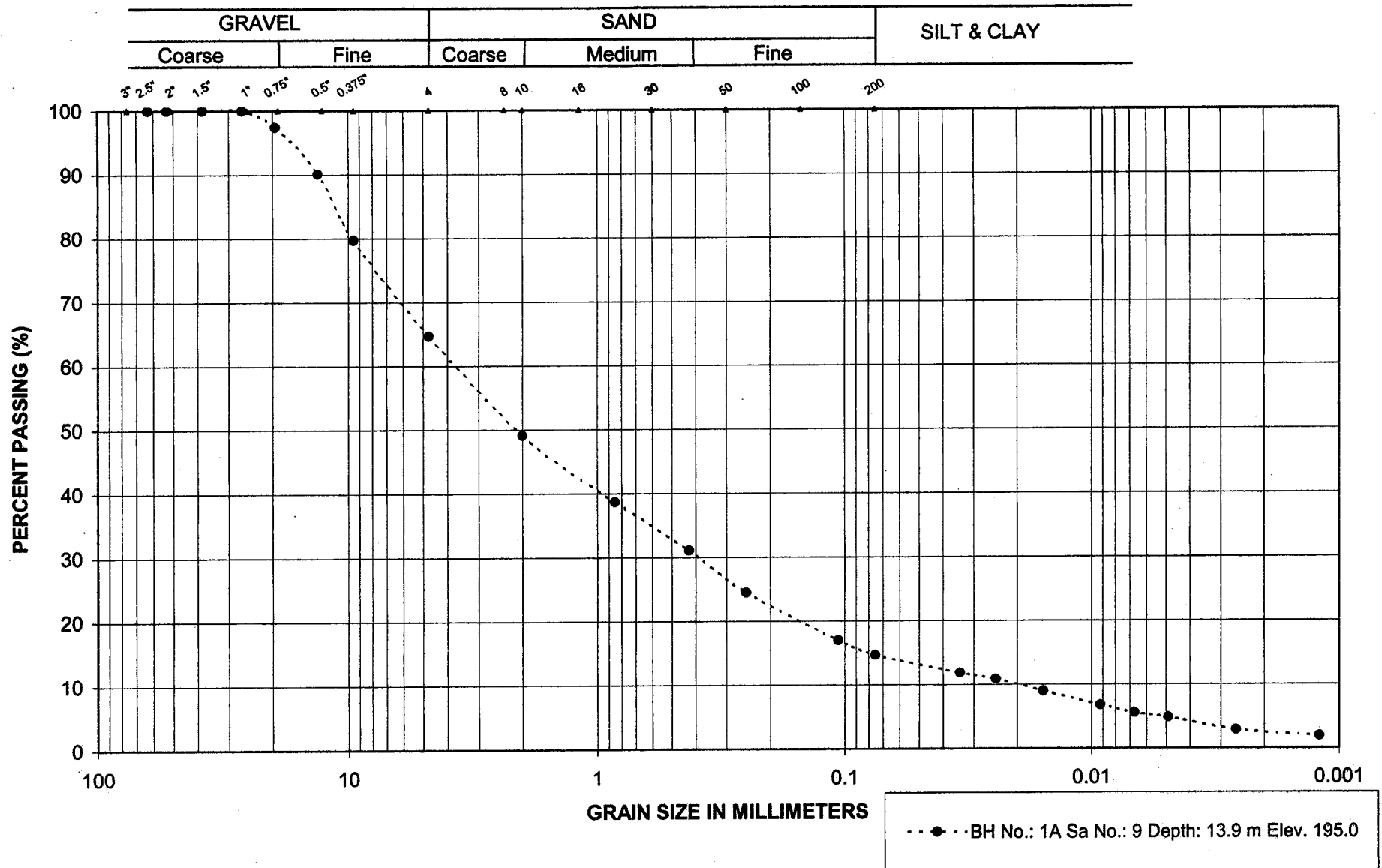
SANDS some SILT  
MERLEX ENGINEERING LTD.

FIGURE L-3

Reference No.: 06160

Date: May 2007

# GRAIN SIZE ANALYSIS



PROJECT: Hwy 17 - Culvert 46-392  
LOCATION: Hagar Twp.

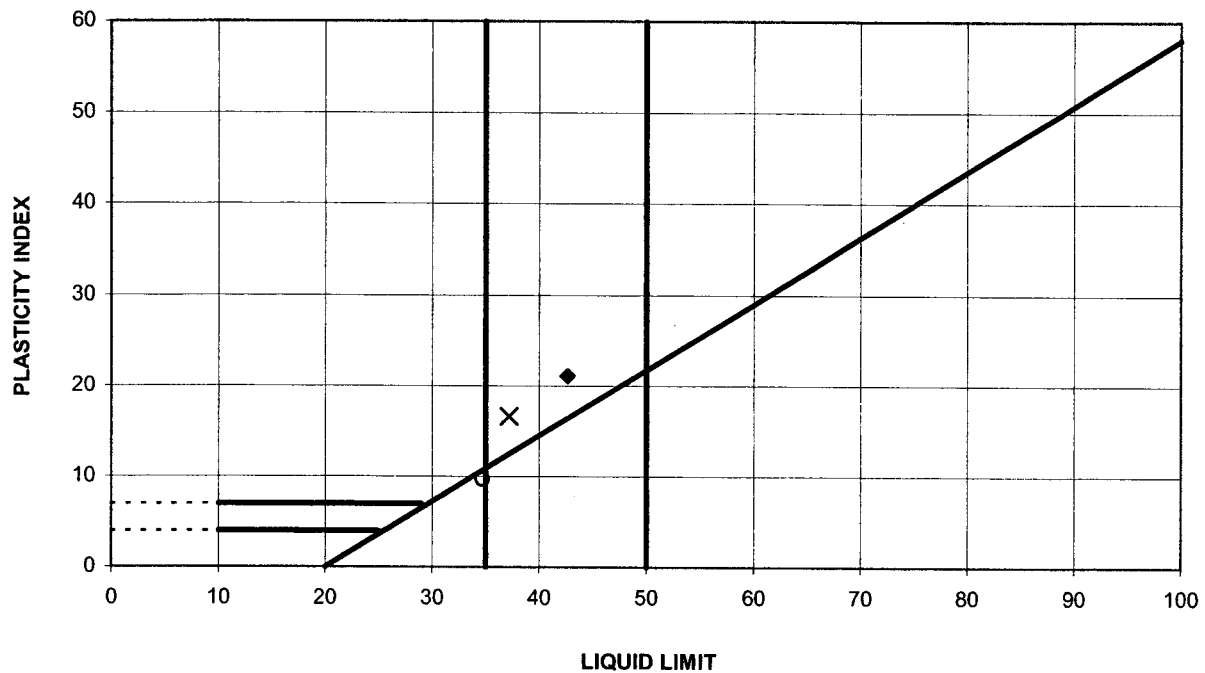
GRAVELLY SANDS  
MERLEX ENGINEERING LTD.

FIGURE L-4

# ATTERBERG LIMITS TEST RESULTS

FIGURE L-5

## ATTERBERG INDICES



SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plasticity Index
o	1A	3	5.5	203.4	34.7	9.7
x	1A	7	10.9	198.0	37.2	16.6
◆	2	8	6.4	199.1	42.6	21.1

Date: May-07  
 Project: Hwy 17 - Culvert 46-392

Prep'd: DVL  
 Chkd: MAM

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## **APPENDIX D**

Enclosure No. 6: Photo Essay

Enclosure No. 7: List of OPSS Referenced in Report



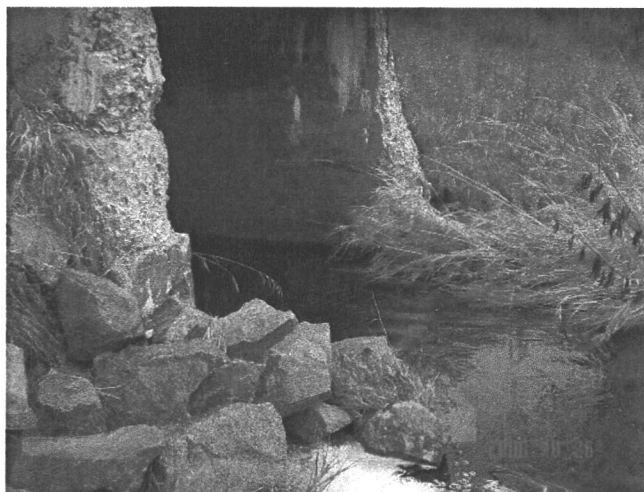
Photo: 1 and 2



Left: Photo showing no flow along culvert, north (outlet) end (photo received from MTO on November 23, 2006).  
 Right: Flow through the north end of the culvert was at a depth of some 100 to 150 mm (photo taken on October 26, 2006).

MEL Ref. No.: 06/11/06160

Photo: 3 and 4



Left: Flow through the culvert (inlet) was at a depth of some 100 to 150 mm (photo taken on October 26, 2006).  
 Right: Wetland pond south of inlet (photo taken December 2006).

MEL Ref. No.: 06/11/06160



**Ontario Provincial Standard Specifications (OPSS)  
Referenced in Report**

**Specification**

**Title**

SP No. 110F13  
(March 2004)

Amendment to OPSS 1010, November 2003  
Aggregates for Granular O, A, B, M, and SSM

OPSS 422  
(April 2004)

Construction Specification For Precast Reinforced  
Concrete Box Culverts and Box Servers in Open Cut

