

October 2012

DRAFT REPORT

Foundation Investigation and Design Proposed Culvert Extensions Stations 27+340, 27+675 and 28+037 Highway 401, Kingston, Ontario G.W.P 78-99-00

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REPORT


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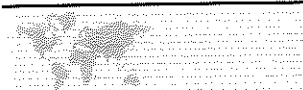
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DRAFT FOUNDATION INVESTIGATION AND DESIGN REPORT

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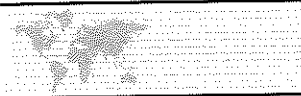
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PART A

FOUNDATION INVESTIGATION PROPOSED CULVERT EXTENSIONS AT STATIONS 27+340, 27+675 AND 28+037 HIGHWAY 401 G.W.P. 78-99-00



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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation associated with the Highway 401 expansion in Kingston, Ontario. The section of Highway 401 included in this assignment (G.W.P. 78-99-00) extends from just west of Montreal Street to about 1.8 km east of the CNR structure. This report addresses the three proposed culvert extensions at Stations 27+340, 27+675 and 28+037, as part of the Highway 401 embankment widening at the Cataraqui wetlands.

The purpose of the foundation investigation was to assess the subsurface conditions for the proposed culvert extensions by drilling 12 test holes and carrying out in situ testing and laboratory testing on selected samples. The terms of reference for the original scope of work are outlined in the MTO's Request for Proposal (RFP) dated April 2008 and a letter outlining scope changes for the project dated October 25, 2011 as requested by MTO. The work was carried out in accordance with Golder's Quality Control Plan dated November 2008.

3.0 INVESTIGATION PROCEDURES

The subsurface investigation was carried out for the culvert extensions between February 22 and 28, 2012, at which time 12 test holes (numbered C1 to C12, inclusive) were advanced at the locations shown on Drawings 1 to 3, inclusive. The boreholes were advanced to refusal or to 10 m depth, whichever was encountered first. The test holes were advanced as follows:

- Boreholes C1, C3, C5, C7 and C9 were advanced using 108 mm inside diameter (I.D.) continuous-flight hollow-stem augers on a track-mounted drill rig, supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to depths of between about 4.8 m and 10.7 m below the existing ground surface in the areas of the proposed culvert extensions.
- Boreholes C10, C11 and C12 were advanced using portable drilling equipment supplied and operated by OGS Inc. of Almonte, Ontario. The boreholes were advanced to depths of between about 2.9 m and 5.7 m below the existing ground/ice surface.
- Augerholes C2, C4 and C6 were also advanced using a track-mounted drill rig supplied and operated by Marathon Drilling, as above. The augerholes were advanced to a depth of 1.5 m.
- Manual augerhole C8 was advanced to a depth of 1.5 m using manual auger equipment.

Soil samples in the boreholes were obtained at vertical intervals ranging from 0.6 m to 1.5 m, using a 50-mm outer diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. In-situ vane testing (using an N-size or a B-size vane) was carried out within the cohesive deposits where possible. The B-size vane was only used in the boreholes that were advanced using portable drilling equipment (i.e., where the diameter of the drill casing was too narrow for the use of the N-vane). Three relatively undisturbed, 73 mm diameter thin-walled Shelby tube samples of the clay were retrieved using a fixed piston sampler.

Grab samples of the major soil strata were obtained from the augerholes.

Standpipe piezometers were installed in Borehole C1, C7 and C9 to monitor the groundwater level at the site. The standpipes consist of a 50-mm diameter rigid PVC pipe with a 1.5 m long slotted screen section, installed within silica sand backfill and sealed by a section of bentonite pellet backfill. The water levels in the standpipe piezometers were measured on March 7, April 10, and May 23, 2012.

The boreholes were backfilled with bentonite pellets, mixed with native soils, and the site conditions restored following completion of work.

The field work was supervised by members of Golder's technical staff, who located the test holes, supervised the drilling, sampling and in-situ testing operations, logged the test holes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled, and transported to Golder's laboratories in Ottawa and Mississauga for further examination. Index and classification tests consisting of grain size distribution, water content, and Atterberg limit testing were carried out on selected soil samples at the Ottawa laboratory. Three oedometer (consolidation) tests were carried out on samples of the silty clay from Boreholes C3, C7 and C9 (i.e., one consolidation test was carried out at the location of each culvert). This testing was carried out at the Mississauga laboratory. The laboratory tests were carried out to MTO and/or ASTM standards, as appropriate.



4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

The site is located in the southern portion of the physiographic region known as the Napanee Plain, and just west of the Leeds Knobs and Flats, as delineated in *The Physiography of Southern Ontario*¹.

The Napanee Plain is flat to undulating, and is characterized by relatively shallow soil deposits overlying bedrock. Geologic mapping² indicates that the bedrock within the Napanee Plain consists of grey limestone/dolostone of the Gull River Formation (of the Trenton-Black River Group), which contains some shale partings and seams.

The overburden soils within the Napanee Plain generally consist of glacial till, although alluvium is present in river and stream valleys and, in the southern portion of the Plain, low-lying areas are typically covered with deposits of stratified clay. Well records indicate that the average depth to bedrock within the Napanee Plain is approximately 2 m. However, in many areas bedrock outcrops exist at ground surface, while deeper soil deposits (on the order of 10 m) are present in the northern and southern portion of the Plain, and within and adjacent to river valleys throughout the Plain.

The Leeds Knobs and Flats are characterized by knobs of Precambrian rock surrounded by clay flats. The clay is grey in colour, and very weakly calcareous.

In particular, the study area lies within the western limits of the Cataraqui River. The Cataraqui River is characterized by a number of lakes joined by the river. This river flows southerly towards Kingston and is one of two major rivers in the area.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions as encountered in the test holes advanced during this investigation, together with the results of the in-situ and laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole, Augerhole or Manual Augerhole sheets and in Appendix A. Four relevant Record of Borehole sheets from the embankment widening investigation in the area of the culvert extension at Station 27+340 are provided in Appendix B.

Soil stratigraphy sections projected along the centrelines of the culvert extensions areas are shown on Drawings 1 to 3. The stratigraphic boundaries shown on the Record of Borehole, Augerhole and Manual Augerhole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole/augerhole locations.

In general, the subsurface conditions at the locations of the proposed culvert extensions consist of fill, topsoil and/or peat underlain by a thick deposit of stiff to very stiff silty clay. The silty clay, where fully penetrated is underlain by glacial till and/or possible bedrock.

¹ Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*. Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

² Map 2544, Ministry of Northern Development and Mines, 1991.



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The results of grain size distribution testing on several samples of silty clay and clayey silt are shown on Figure A-1 in Appendix A. The results of Atterberg limit testing on several samples of the clayey material indicate plasticity index values between 17 and 28 percent and liquid limit values between 33 and 51 percent, as shown on Figure A-2 in Appendix A, indicating a clayey silt, silty clay and clay soils of low to high plasticity. The measured natural water contents of several samples of the weathered material ranged from 23 to 36 percent.

Oedometer consolidation testing was carried out on three samples of the silty clay from Boreholes C3, C7 and C9 (i.e., one from each culvert location). The results of that testing, which are provided on Figures A-3 to A-5 in Appendix A are summarized in the table below and indicate that this material is overconsolidated, with preconsolidation pressures of 300 kPa, 315 kPa and 440 kPa and overconsolidation ratios of 5.5, 4.2 and 6.3, respectively.

Borehole/ Sample Number	Sample Depth/Elev. (m)	Unit Weight (kN/m ³)	σ_p' (kPa)	σ_{vo}' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	Cc	Cr	e _o	OCR
C3 / 7	5.6 / 71.8	18.9	315	75	240	0.23	0.014	0.88	4.2
C7 / 8	6.4 / 69.1	18.9	300	55	245	0.26	0.014	0.92	5.5
C9 / 6	5.2 / 72.3	18.4	440	70	370	0.53	0.018	1.05	6.3

Notes:

- σ_p' - Apparent preconsolidation pressure
- σ_{vo}' - Computed existing vertical effective stress
- Cc - Compression index
- Cr - Recompression index
- e_o - Initial void ratio
- OCR - Overconsolidation ratio

4.2.4 Sand and Silt Till

The clayey deposit at Boreholes C1, C7 and C9 is underlain by glacial till. The surface of the glacial till ranges from about Elevation 66.1 to 72.7 m. The glacial till was proven to depths of about 4.8 m, 7.0 m, and 9.5 m, at Boreholes C1, C7 and C9, respectively. The till is at least 0.1 to 0.8 m thick at these locations.

The glacial till is considered to be a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sand and silt with trace clay. However, those samples were retrieved using a 50 mm external diameter sampler and therefore the test results do not reflect the cobble and boulder portions of the deposit.

The results of grain size distribution testing on two samples of the glacial till are shown on Figure A-6 in Appendix A. The measured natural water contents of two samples of the glacial till were 9 and 15 percent.

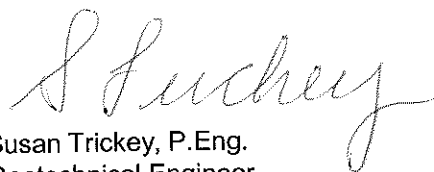
4.2.5 Sampler or Auger Refusal

Practical refusal to sampler advancement or refusal to augering was encountered at Boreholes C1, C5, C7, C9, C10 and C11. The depth to refusal and refusal elevations are summarized in the following table.

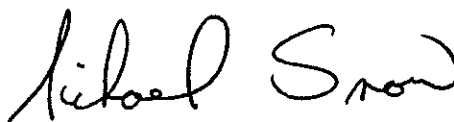
5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Susan Trickey, P.Eng. and reviewed by Mr. Michael Snow, P.Eng., a Principal and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., Golder's Designated MTO Foundations Contact for this project, conducted an independent quality review of the report.

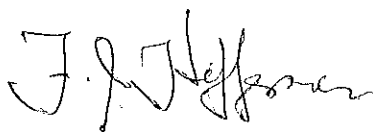
GOLDER ASSOCIATES LTD.



Susan Trickey, P.Eng.
Geotechnical Engineer



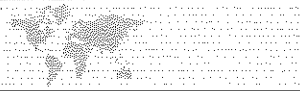
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SAT/MSS/FJH/bg

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PART B

FOUNDATION DESIGN PROPOSED CULVERT EXTENSIONS AT STATIONS 27+340, 27+675 AND 28+037 HIGHWAY 401 G.W.P. 78-99-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

① This section of the report provides foundation design recommendations for the proposed extensions of the existing culverts at Stations 27+340, 27+675 and 28+037 along Highway 401 in Kingston, Ontario. The culverts are being extended as part of the widening of Highway 401 between the CNR bridge structure (at Station 26+700) to just west of the existing Cataraqui River bridge (at Station 28+450). The recommendations are based on the interpretation of the factual data obtained from the test holes advanced during the subsurface investigation at these locations. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess the feasible foundation alternatives and to design the proposed foundations for the structures. As such, where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like. *elaborate*

6.2 Options for Culvert Extensions

The existing culverts and proposed extensions are as follows:

- Station 27+340 – A 1.85 m wide by 1.22 m high concrete rigid frame open footing (RFO) culvert approximately 38 m in length. About a 6 m extension to the north end and about a 4 m extension to the south end of the existing culvert. The proposed invert levels for the extensions are about Elevations 74.8 m and 74.7 m for the north and south ends, respectively.
- Station 27+675 – A 1.22 m wide by 1.22 m high concrete RFO footing culvert approximately 37 m in length. About a 9 m extension to both the north and south ends of the existing culvert. The proposed invert levels for the extensions are about Elevations 75.3 m and 75.1 m for the north and south ends, respectively.
- Station 28+037 – A 1.22 m wide by 1.22 m high concrete RFO footing culvert approximately 37 m in length. About a 9 m extension to both the north and the south ends of the existing culvert. The proposed invert levels for the extensions are about Elevations 76.4 m and 76.2 m for the north and south ends, respectively.

The existing culverts and proposed extensions are shown on Drawings 1 to 3. The Highway 401 embankments will be widened at the culvert locations to accommodate the additional lanes proposed for this area. The height of the new widened embankments will be up to about 3 m. However, it is understood that the grades of the existing Highway 401 eastbound and westbound lanes will remain the same.

The subsurface conditions at all of the three culvert extension locations are fairly similar, and generally consist of fill, topsoil and/or peat underlain by a clayey deposit of stiff to very stiff silty clay/clayey silt/clay. The clayey deposit, where fully penetrated is underlain by glacial till and/or possible bedrock.

From a foundation perspective either concrete box culvert extensions or rigid frame open footing concrete culvert extensions are considered acceptable at all three culvert locations. However, it is understood that the preferred foundation option is a RFO footing culvert which would match the existing culvert foundations. The open footing culvert extensions can be founded on spread footings founded below the organic soils within the layered silty clay, clayey silt and clay deposit.

② *which is preferred from a foundation perspective.*

6.4 Geotechnical Resistance

For footings founded at the elevations provided in Section 6.3 (i.e., between 1.2 m and 1.5 m depth below the existing culvert invert levels) within the very stiff silty clay, clayey silt and clay a factored geotechnical resistance at Ultimate Limit States (ULS) of 225 kPa and a geotechnical resistance at Serviceability Limit States (SLS) of 150 kPa may be used for design purposes. The SLS value corresponds to 25 mm of settlement for strip footings up to about 1.4 m in width (see Section 6.5). The recommended resistances are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the footing size or founding levels differs from that given above.

These geotechnical resistances are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.2 of the *Canadian Highway Bridge Design Code (CHBDC)*.

6.5 Settlement

It is understood that the widening of the existing Highway 401 embankments at the culvert extension locations will require the placement of about 3.0 m of new fill in order to match the existing highway grade. Provided the SLS geotechnical resistance for the culvert extensions are limited to the values provided in Section 6.4 then the total and differential culvert settlements should be minimal (i.e., less than about 25 and 15 mm, respectively). Most of this settlement will consist of recompression of the silty clay, clayey silt and clay and will occur during construction.

6.6 Resistance to Lateral Forces/Sliding Resistance

The resistance to lateral forces/sliding resistance between the concrete footings and the concrete working slab, and between the concrete working slab and the native clayey deposit, should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For this case the following parameters should be used:

Interface and Loading Condition	Parameter
Concrete footing – concrete working slab: short or long term loading	Effective friction angle = 30°
Concrete working slab – clay subgrade: short term loading	Undrained adhesion = 65 kPa
Concrete working slab – clay subgrade: long term loading	Effective interface friction angle = 25°

These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistances.

6.7 Culvert Bedding, Backfill and Erosion Protection

Backfill, cover and construction of the frost taper (backfill transition) for concrete culverts should be completed in accordance with OPSS 422 (*Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut*) and/or OPSD 803.010 (*Backfill and Cover for Concrete Culverts*).

Backfill to culvert walls should consist of granular fill meeting the requirements of OPSS 1010 Granular A or Granular B Type II, but with less than 5 per cent passing the No. 200 sieve. The backfill should be placed and compacted in accordance with MTO's Special Provision SP105S21 (Amendment to OPSS 501). The fill depth

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- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the culvert walls, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with MTO's Special Provision SP105S10 (*Amendment to OPSS 501*). Other surcharge loadings should be accounted for in the design as required.
- The granular fill may be placed either in a zone with the width equal to at least 1.5 m behind the back of the walls (see Case (a) in Figure C6.20(a) of the *Commentary* to the CHBDC), or within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (see Case (b) in Figure C6.20(b) of the *Commentary* to the CHBDC).
- For Case (a), the pressures are based on the existing embankment fill materials and the existing overburden soils and the following parameters (unfactored) may be used:

	Existing Fill
Soil unit weight	20 kN/m ³
Coefficients of static lateral earth pressure: At rest, K_o	0.50

- For Case (b), where the pressures are based on OPSS Granular A or Granular B Type II fill behind the wall, the following parameters (unfactored) may be assumed:

	Granular A	Granular B Type II
Soil unit weight:	22 kN/m ³	21 kN/m ³
Coefficients of static lateral earth pressure: At rest, K_o	0.43	0.43

Because the culvert walls do not allow lateral yielding, at-rest earth pressures should be assumed for the geotechnical design.

6.8.1 Seismic Considerations

Seismic (earthquake) loading should be assessed in the design in accordance with Section 4.6.4 of CHBDC, as significant seismic loading would result in increased lateral earth pressures acting on the culvert walls. The walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given above, plus the applicable earthquake-induced dynamic earth pressure. The earthquake-induced dynamic pressure distribution is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e., an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:

$$P = K_o \gamma d + (K_{AE} - K_o) \gamma (H - d)$$

Where:

- K_o is the static at-rest earth pressure coefficient (K_o);
- K_{AE} is the seismic active earth pressure coefficient;
- γ is the unit weight of the backfill soil (kN/m³) as given previously;

6.9.2 Excavations and Temporary Roadway Protection

Temporary excavations for the culvert extensions will be made through the existing fill, organic material, silty clay with organic matter and into the very stiff silty clay, clayey silt and clay deposit. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The existing fill above the water table would be classified as Type 3 soil, based on the OHSA. According to OHSA excavations in excavations that extend to, or into, Type 3 soils should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V). The fill material, organic material, silty clay with organic matter and very stiff silty clay below the water table would be classified as Type 4 soil, based on OSHA and excavations in these materials should be sloped no steeper than 3H:1V.

6.9.3 Subgrade Protection

All fill, topsoil, organics and soft or loose soils should be removed from below the proposed founding elevations and wasted or reused as landscaping fill, as required. Subgrade preparation should be performed and monitored in accordance with OPSS. The cleaned excavation base should be inspected by a QVE qualified in geotechnical engineering prior to placing a concrete working slab.

Where the subgrade is formed in the native clayey soils, this soil will be susceptible to softening and disturbance due to construction activities and ponded water. It is therefore recommended that the footings be constructed on a 75 mm thick concrete working slab consisting of 20 MPa lean concrete; the Contract Documents should include the appropriate Special Provision for the concrete working slab item.

Based on the footing founding levels and subsurface conditions as encountered in the boreholes advanced at this site, no subexcavation requirements have been identified at this time. However, in the event that subexcavation is required, the width of the required subexcavation should be defined by lines extending from 0.3 m beyond the outside edges of the proposed culvert extension footings outward and downward at 1H:1V. The subexcavated area should be backfilled with granular material meeting OPSS 1010 Granular A or Granular B Type II placed and compacted in accordance with the requirements of MTO's Special Provision SP105S10.

A sample NSSP for subgrade protection is provided in Appendix C.



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Table 1
Comparison of Foundation Alternatives
G.W.P. 78-99-00

Foundation Option	Feasibility	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Rigid Frame Open Footing	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Matches existing foundation type Desirable option for culvert flow 	<ul style="list-style-type: none"> Would require excavation below the water table 	<ul style="list-style-type: none"> Moderate cost 	<ul style="list-style-type: none"> Low risk option
Box Culvert	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Would require minimum excavation below the water table 	<ul style="list-style-type: none"> Does not match existing foundation type 	<ul style="list-style-type: none"> Moderate cost 	<ul style="list-style-type: none"> Moderate risk option
Deep Foundations	<ul style="list-style-type: none"> Feasible but not required/practical 	<ul style="list-style-type: none"> Would not result in settlement 	<ul style="list-style-type: none"> Would require piles 	<ul style="list-style-type: none"> Expensive option 	<ul style="list-style-type: none"> Low risk option

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample
DT	Dual Tube sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open Sampler for a distance of 300 mm (12 in.)

Dynamic Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive Uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Peizo-Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded Electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a)

Cohesionless Soils

Density Index (Relative Density)

Very loose
Loose
Compact
Dense
Very dense

N
Blows/300 mm
Or Blows/ft.

0 to 4
4 to 10
10 to 30
30 to 50
over 50

(b)

Consistency

Cohesive Soils

C_u or S_u

Kpa

Psf

Very soft
Soft
Firm
Stiff
Very stiff
Hard

0 to 12
12 to 25
25 to 50
50 to 100
100 to 200
Over 200

0 to 250
250 to 500
500 to 1,000
1,000 to 2,000
2,000 to 4,000
Over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limited
w_l	liquid limit
C	consolidaiton (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	modified Proctor compaction test
SPC	standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:

1. Tests which are anisotropically consolidated prior shear are shown as CAD, CAU.

RECORD OF BOREHOLE No C1

1 OF 1 **METRIC**

PROJECT 08-1111-0044

G.W.P. 78-99-00

LOCATION N 4904750.0 ; E 308530.7

ORIGINATED BY DG

DIST HWY 401

BOREHOLE TYPE Power Auger, 108mm Diam. Hollow Stem

COMPILED BY JM

DATUM Geodetic

DATE February 23, 2012

CHECKED BY SAT

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 ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED						
76.7	GROUND SURFACE							20 40 60 80 100							
76.0	TOPSOIL														
0.1	SILTY CLAY Very stiff Grey-brown Moist		1	SS	16										
			2	SS	11										
74.4															
2.3	SILTY CLAY and CLAYEY SILT, with sandy silt layers Very stiff Grey-brown to grey Moist		3	SS	9										
			4	SS	6										
72.7															
4.0	SAND, some silt and gravel, trace clay (TILL) Compact Grey Wet		5	SS	15									16 48 29 7	
71.9			6	SS	>50										
4.8	End of Borehole Auger Refusal														
	Note: 1. Water level in well screen at 0.5 m (Elev. 77.2 m) above ground surface on Mar. 7, Apr. 10, and May 23, 2012.														

PROJECT 08-1111-0044				RECORD OF BOREHOLE No C3				1 OF 1 METRIC							
G.W.P. 78-99-00				LOCATION N 4904709.7 :E 308539.9				ORIGINATED BY DG							
DIST HWY 401				BOREHOLE TYPE Power Auger, 108mm Diam. Hollow Stem				COMPILED BY JM							
DATUM Geodetic				DATE February 22, 2012				CHECKED BY SAT							
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
77.4	GROUND SURFACE														
0.0	Silty clay (FILL) Grey-brown Moist														
76.3	PEAT		1	SS	3										
75.9	SILTY CLAY, with organic matter Stiff to very stiff Grey-black Moist		2	SS	4										
75.1	SILTY CLAY Very stiff Grey-brown Moist		3	SS	5										
72.1	SILTY CLAY and CLAYEY SILT, trace sand Stiff to very stiff Grey Wet		4	SS	4										
5.3			5	SS	5										
			6	SS	4										
			7	TP	PH										
			8	SS	3										
			9	SS	3										
			10	SS	6										
			11	SS	14										
66.7	End of Borehole														
10.7	Note: 1. Open borehole dry on Feb. 23, 2012.														

MIS-MTO 001 08-1111-0044.GPJ GAL-MISS.GDT 07/16/12 DD

RECORD OF BOREHOLE No C5

1 OF 1 **METRIC**

PROJECT 08-1111-0044

G.W.P. 78-99-00

LOCATION N 4904637.1 ; E 308188.3

ORIGINATED BY JD

DIST HWY 401

BOREHOLE TYPE Power Auger, 108mm Diam. Hollow Stem

COMPILED BY JM

DATUM Geodetic

DATE February 27, 2012

CHECKED BY SAT

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 ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED						
76.1 0.0	GROUND SURFACE SILTY CLAY, trace sand Very stiff Grey-brown Moist		1	SS	7										
			2	SS	17										
			3	SS	17										
			4	SS	15										
72.3 3.8	SILTY CLAY Very stiff Grey		5	SS	5										
			6	SS	5										
			7	SS	3										
69.2 6.9	End of Borehole Sampler Refusal		8	SS	>50										

PROJECT 08-1111-0044

RECORD OF BOREHOLE No C7

1 OF 1 **METRIC**

G.W.P. 78-99-00

LOCATION N 4904597.4 ; E 308202.5

ORIGINATED BY DG

DIST HWY 401

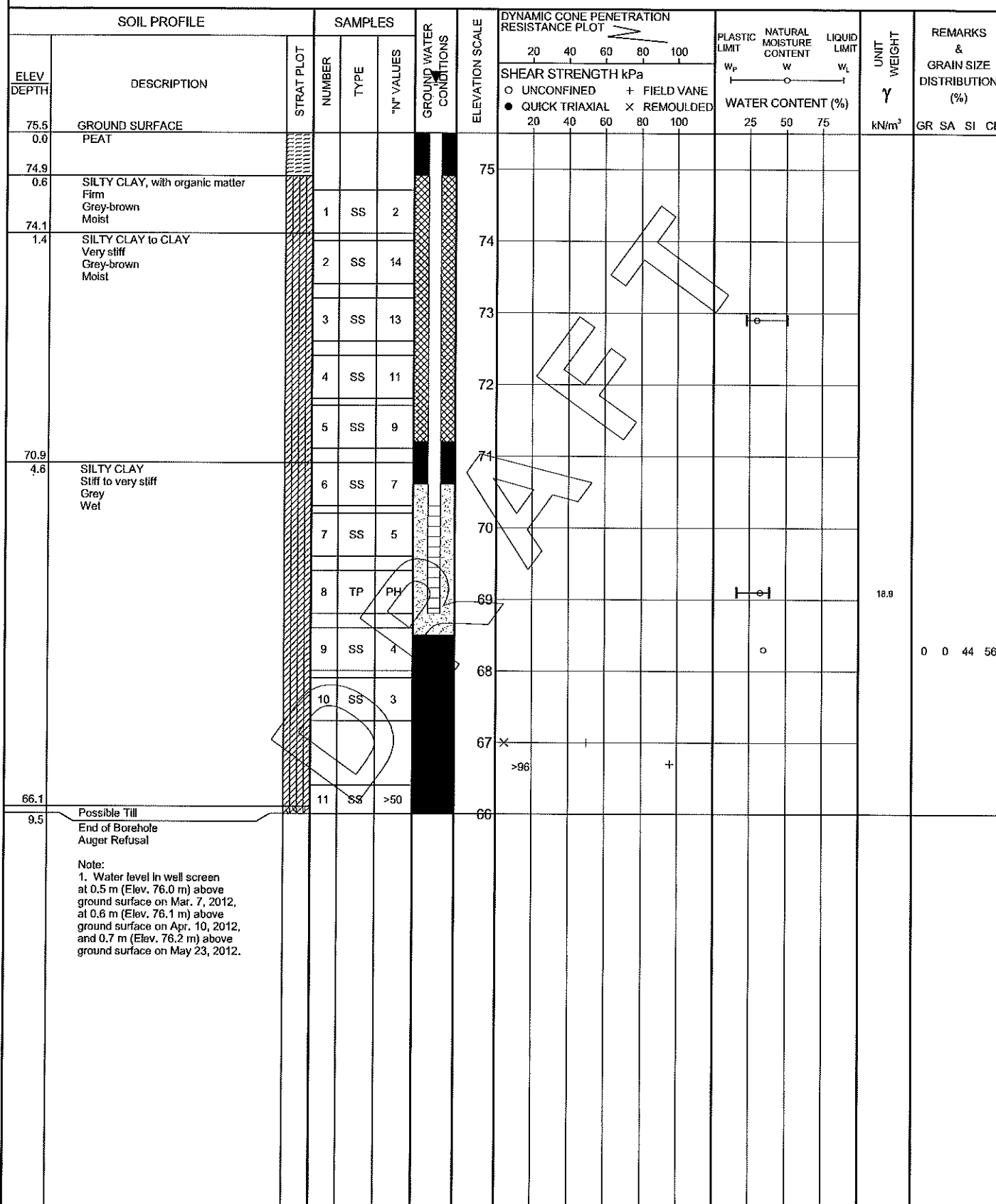
BOREHOLE TYPE Power Auger, 108mm Diam. Hollow Stem

COMPILED BY JM

DATUM Geodetic

DATE February 22, 2012

CHECKED BY SAT



PROJECT 08-1111-0044

RECORD OF BOREHOLE No C9

1 OF 1 **METRIC**

G.W.P. 78-99-00

LOCATION N 4904532.3, E 307877.4

ORIGINATED BY JD

DIST HWY 401

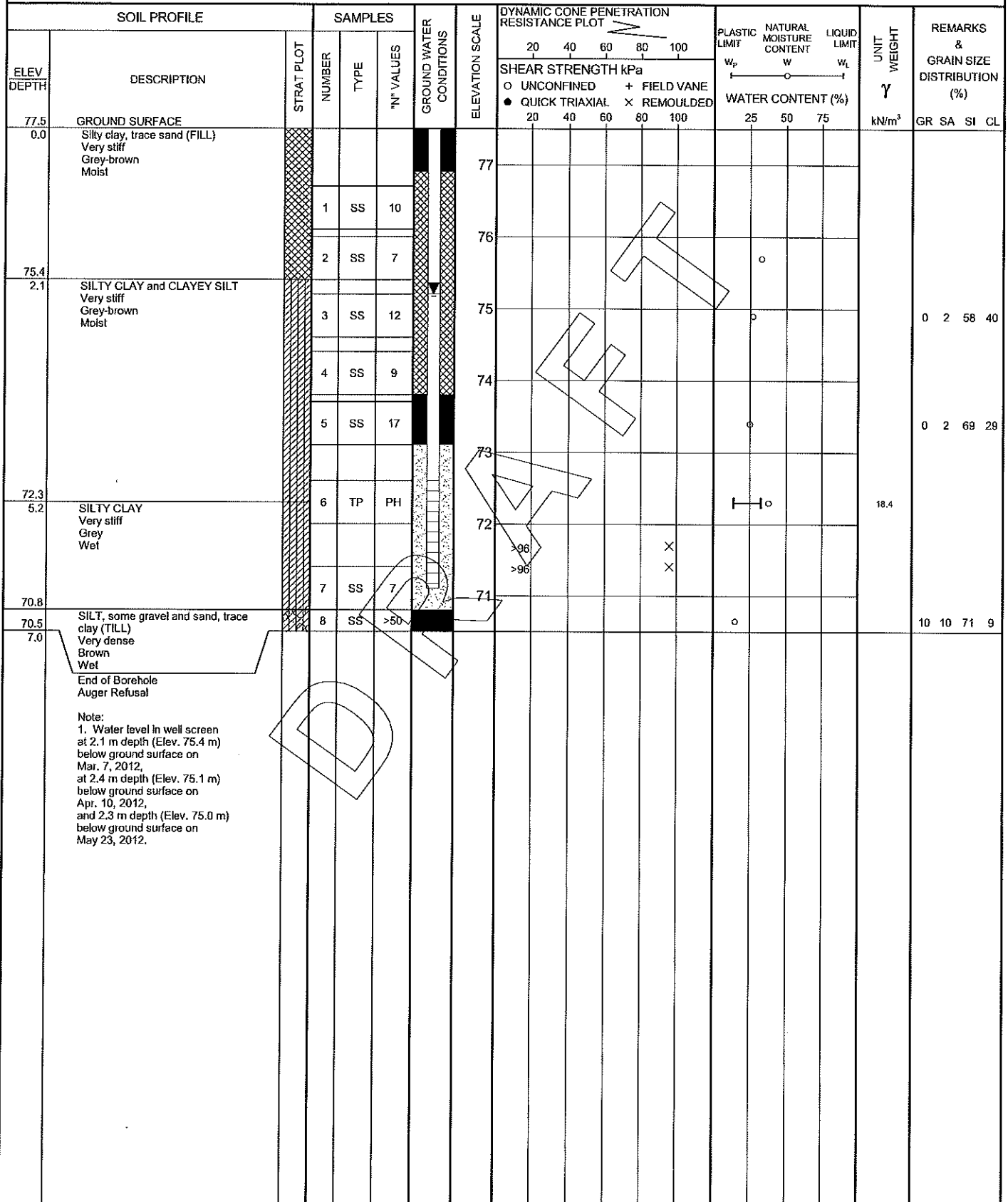
BOREHOLE TYPE Power Auger, 108mm Diam. Hollow Stem

COMPILED BY JM

DATUM Geodetic

DATE February 27, 2012

CHECKED BY SAT

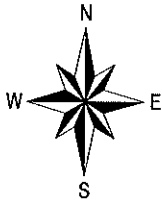
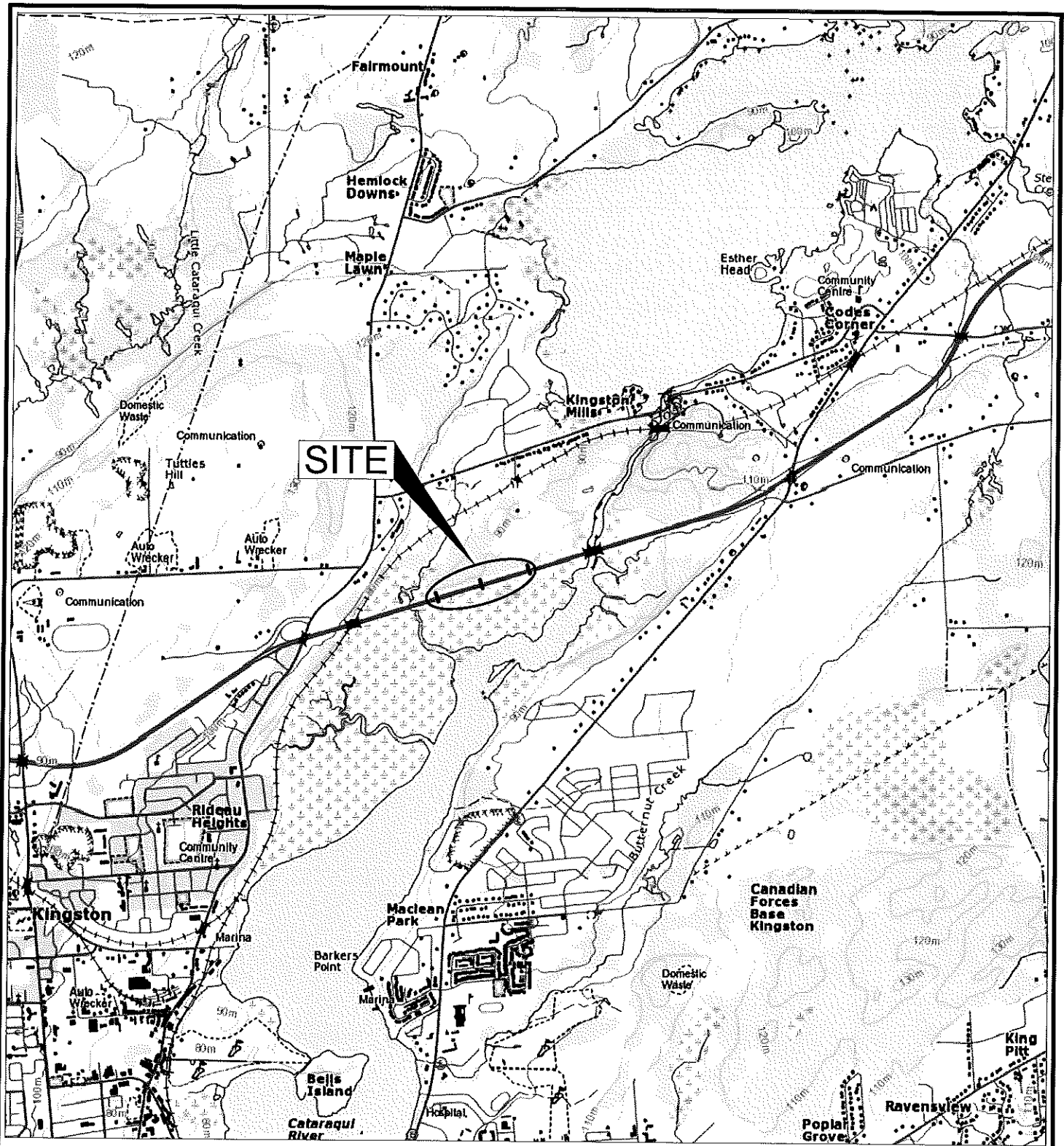


PROJECT <u>08-1111-0044</u>		RECORD OF BOREHOLE No C11			1 OF 1 METRIC	
G.W.P. <u>78-99-00</u>		LOCATION <u>N 4904491.8 ; E 307882.4</u>			ORIGINATED BY <u>PAH</u>	
DIST <u>HWY 401</u>		BOREHOLE TYPE <u>Wash Boring, NW Casing / Manual Auger, Open Hole</u>			COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>February 27, 2012</u>			CHECKED BY <u>SAT</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	25 50 75			
75.0	GROUND SURFACE													
0.0	ICE													
0.3	WATER													
74.2	Rockfill, with peat (FILL) Wet													
0.8	SILTY CLAY, with organic matter Firm		1	SS	PM									
73.6	Dark grey Wet													
1.4	SILTY CLAY and CLAYEY SILT, with silty sand layers Very stiff Grey-brown Wet		2	SS	23									
			3	SS	33									
			4	SS	18									
			5	SS	35									
70.7	SILTY CLAY, with sand layers Very stiff Grey Wet		6	SS	15									
4.3			7	SS	14									
69.3			8	SS	11									
5.7	End of Borehole Sampler Refusal													

MIS-UTO 001 08-1111-0044.GPJ GAL-MISS.GDT 07/16/12 DD

PLOT DATE: July 16, 2012
 FILENAME: N:\Active\2005\1111\08-1111-0044 MRC Hwy 401\ACAD\Phase 4800\0811110044-4800-01.dwg



DRAFT

NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH
 THE ACCOMPANYING GOLDER ASSOCIATES LTD.
 REPORT No. 08-1111-0044-4800



SCALE	1:40,000
DATE	12 APR. 2012
DESIGN	
CAD	J.M.
CHECK	gaf
REVIEW	

TITLE

KEY PLAN

FILE No. 0811110044-4800-01.dwg

PROJECT No. 08-1111-0044

REV.

**GEOTECHNICAL INVESTIGATION
 HIGHWAY 401 CULVERTS**

FIGURE

1

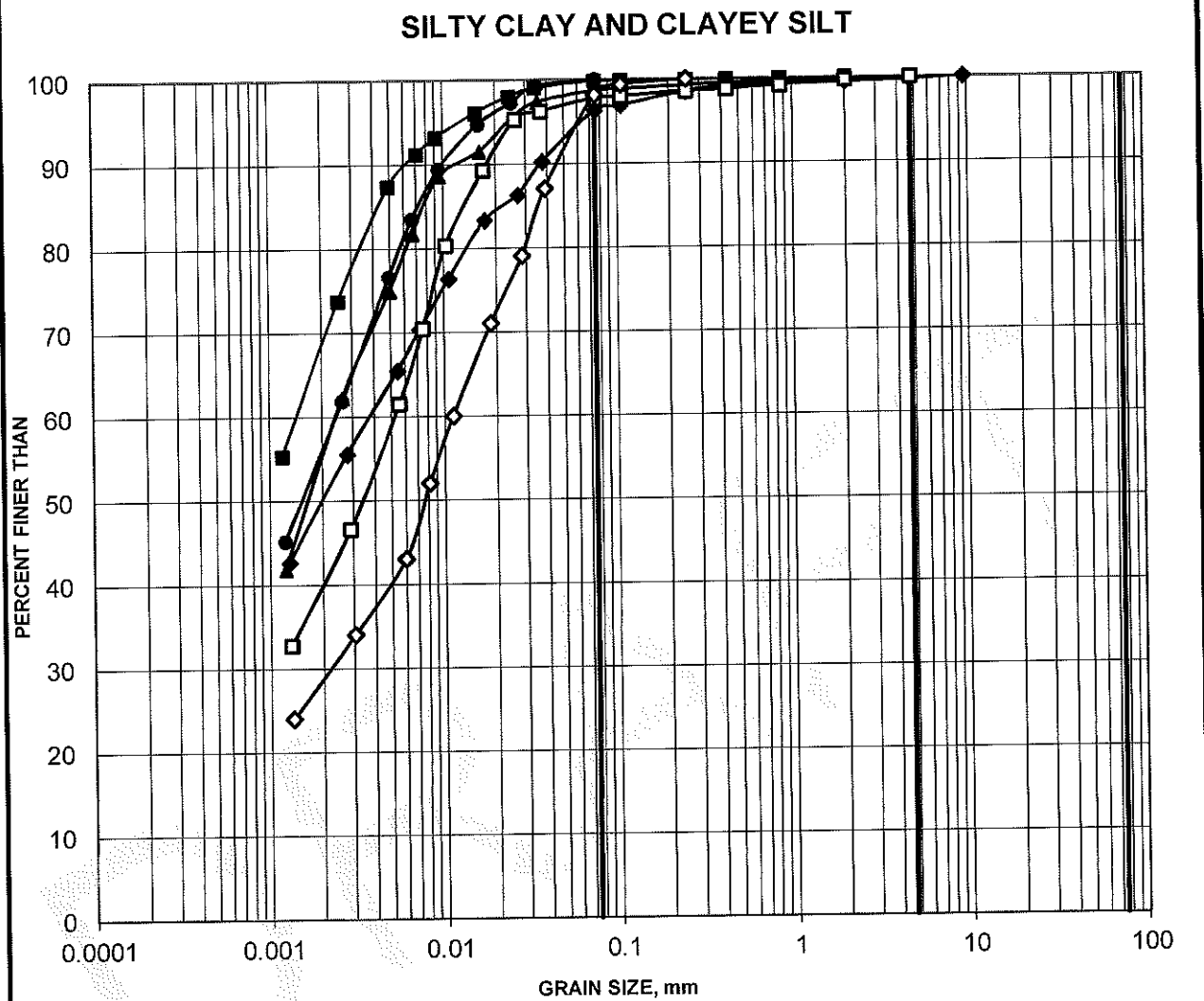
INSERT
MAPS

APPENDIX A

Laboratory Test Data – Soil

GRAIN SIZE DISTRIBUTION

FIGURE A-1



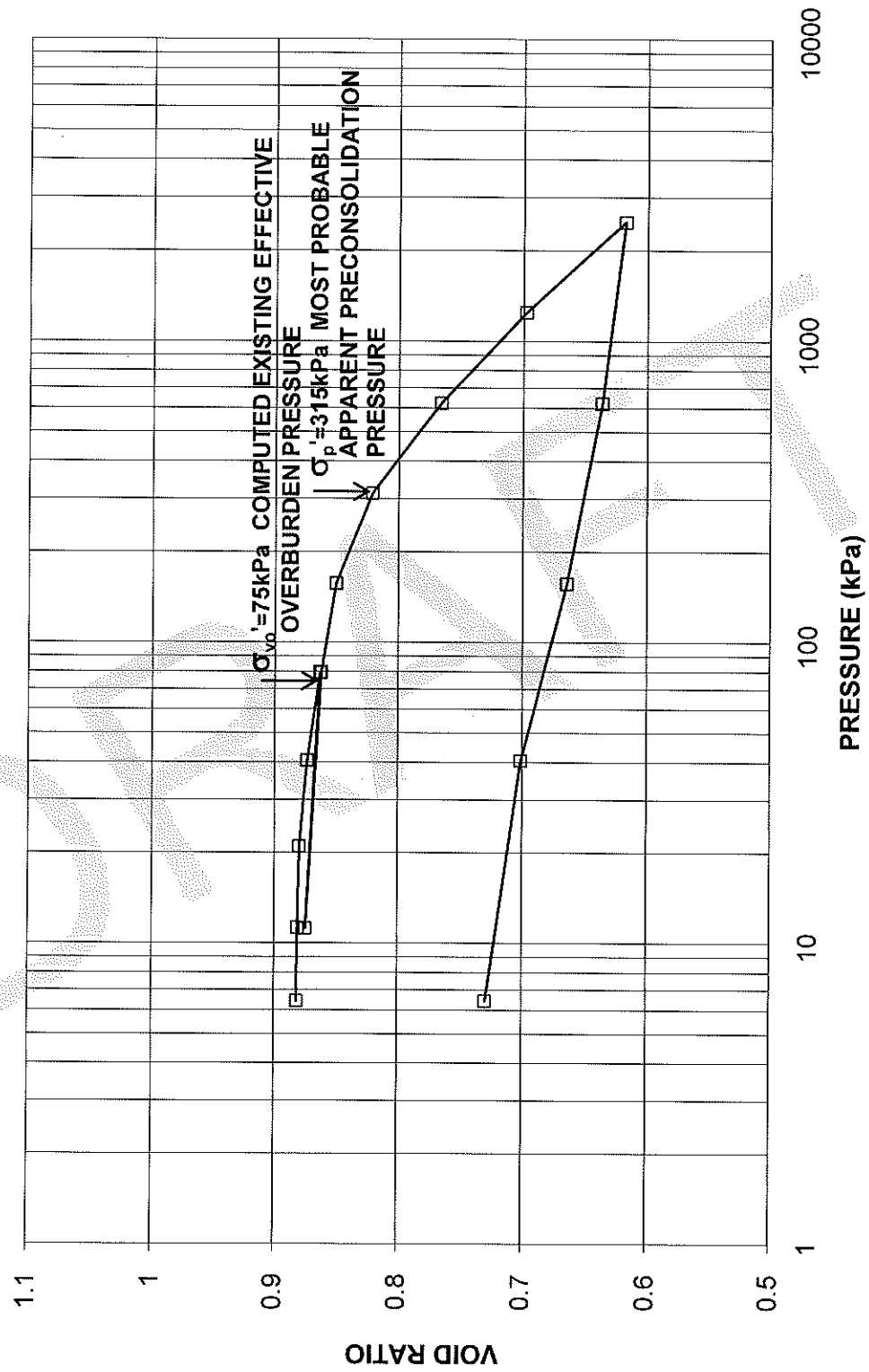
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
—■—	C-3	4
—◆—	C-3	11
—▲—	C-5	2
—●—	C-7	9
—□—	C-9	3
—◇—	C-9	5

CONSOLIDATION TEST VOID RATIO VS LOG PRESSURE

FIGURE A-3

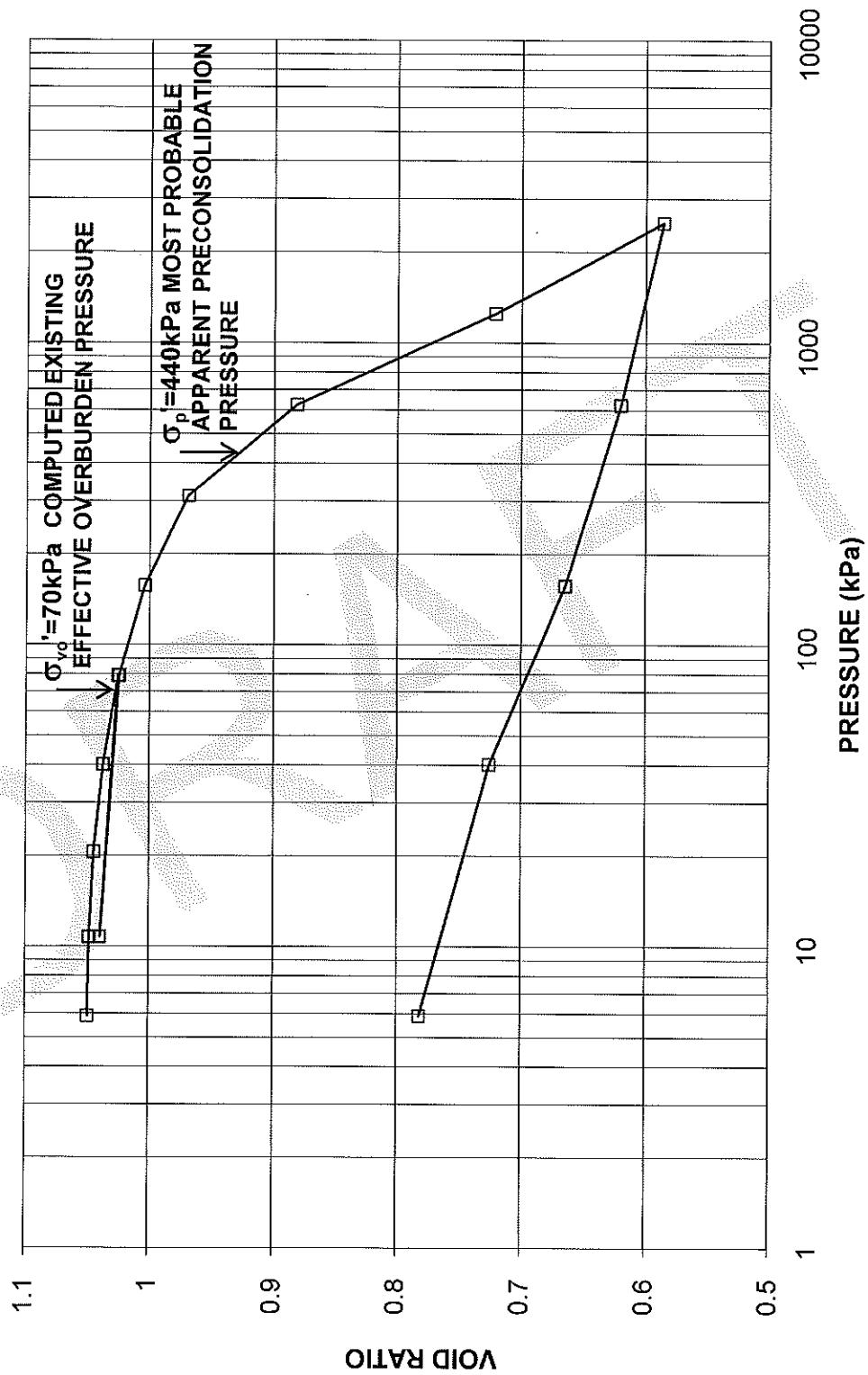
CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH C-3 SA 7

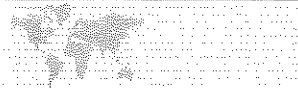


CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE

FIGURE A-5

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH C-9 SA 6





APPENDIX B

**Record of Borehole Sheets – Embankment Widening Investigation,
Boreholes E14, E15, W13 and W14**

PROJECT 08-1111-0044

RECORD OF BOREHOLE No E14

1 OF 1 **METRIC**

G.W.P. 78-99-01

LOCATION N 4904473.4 E 307848.6

ORIGINATED BY JEB

DIST HWY 401

BOREHOLE TYPE Portable Equipment, Continuous Sampling

COMPILED BY AT

DATUM Geodetic

DATE February 19, 2009

CHECKED BY KSL

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
75.1	GROUND SURFACE													
0.0	PEAT (Fibrous), trace sand Very soft Black Wet		1	SS	10		75							
			2	SS	WH		74							
			3	SS	WH									
73.1	Organic CLAY, trace sand, containing rootlets Stiff		4	SS	11		73							OC = 7.7%
72.6	Grey Moist		5	SS	60/0.10									0 3 45 42
72.3	SILTY CLAY, trace sand Hard Black Moist													
2.7	END OF BOREHOLE SPOON REFUSAL													
NOTES: 1. Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 74.8 m) upon completion of drilling. 2. Two Dynamic Cone Penetration Test were advanced 2 m South and 2.8 m Southwest of Borehole E14, refusal encountered at a depth of 2.9 m and 3.1 m below ground surface (Elev. 72.2 m and 72.0 m) upon completion of drilling. See Record of DCPT E14C1 and E14C2 for further details.														

PROJECT 08-1111-0044		RECORD OF PENETRATION TEST No E14C2				1 OF 1 METRIC							
G.W.P. 78-99-01		LOCATION N 4904470.9 ; E 307847.3				ORIGINATED BY JEB/DM							
DIST _____ HWY 401		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test				COMPILED BY AT							
DATUM Geodetic		DATE February 23, 2009				CHECKED BY KSL							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		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 (%)		γ	
75.1 0.0	GROUND SURFACE Start of Dynamic Cone Penetration Test (DCPT)						75	20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	25 50 75			GR SA SI CL
72.2 2.9	END OF DCPT Refusal to further penetration (45 blows/0.15 m) NOTE: 1. The Dynamic Cone Penetration Test is located 2.8 m Southwest of Borehole E14.						74 73						

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PROJECT 08-1111-0044

RECORD OF BOREHOLE No W13

1 OF 1 **METRIC**

G.W.P. 78-99-01

LOCATION N 4904522.7 ; E 307834.5

ORIGINATED BY DM

DIST HWY 401

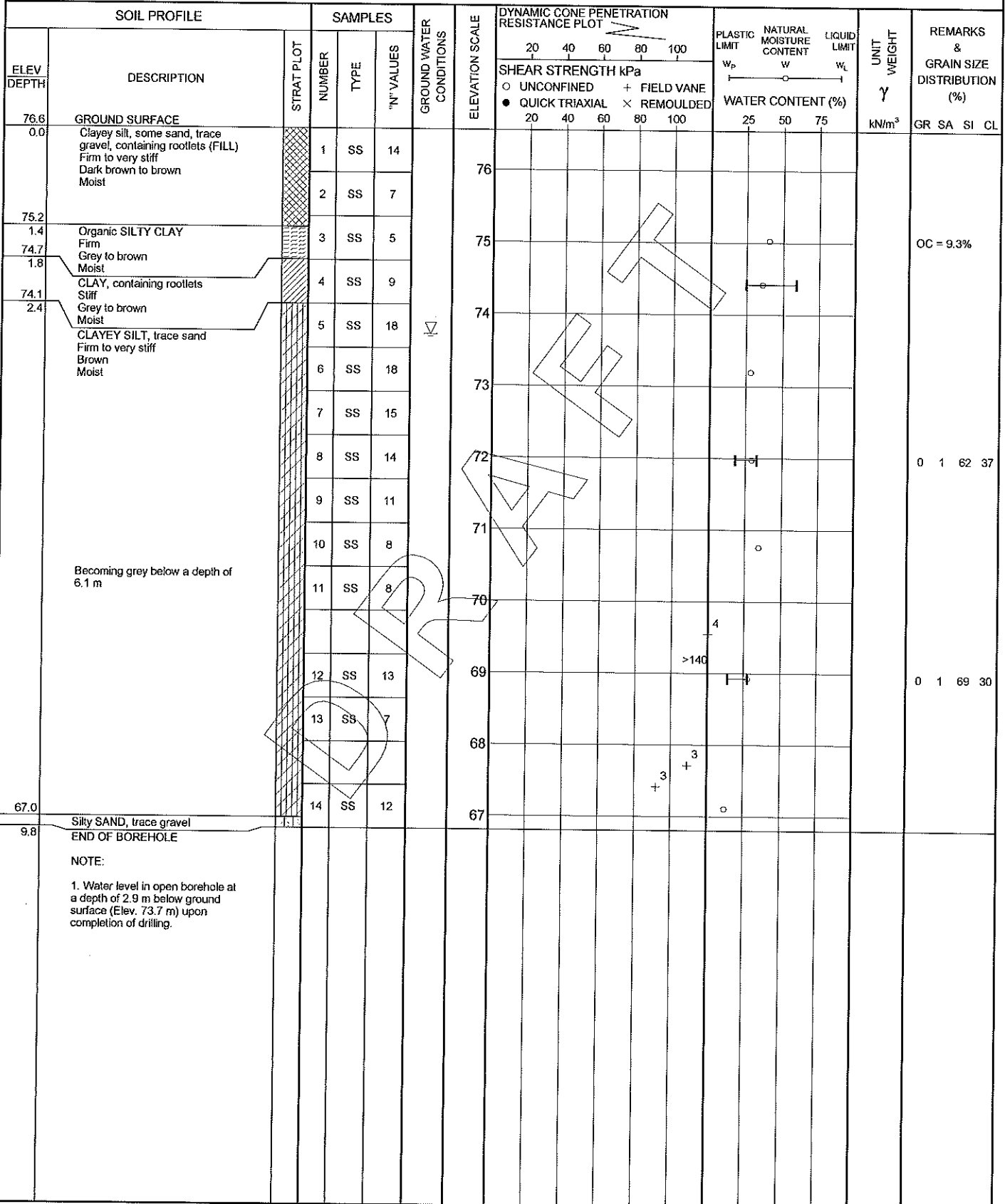
BOREHOLE TYPE Portable Equipment, Continuous Sampling

COMPILED BY AT

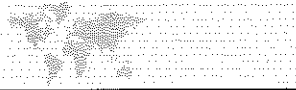
DATUM Geodetic

DATE February 3, 2009

CHECKED BY KSL



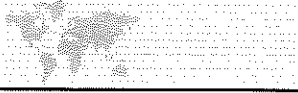
MIS-MTO 001 08-1111-0044.GPJ GAL-MISS.GDT 07/16/12 DD



APPENDIX C

Non-Standard Special Provisions





DRAFT FOUNDATION INVESTIGATION AND DESIGN REPORT

GROUND WATER AND SURFACE WATER CONTROL – Item No.

Non-Standard Special Provision

Control of the surface water and groundwater will be necessary for the construction of the culvert extensions, to allow excavation and foundation construction to be carried out in dry conditions.

The surface water flow could be passed through the culvert extension area by means of a temporary pipe, or diverted by pumping from behind a temporary cofferdam to the adjacent culvert crossing. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the clay subgrade soils.

Basis of Payment

Payment at the contract price for the above tender item shall include full compensation for all labour and materials to complete the work.

END OF SECTION