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FOUNDATION INVESTIGATION AND DESIGN REPORT 600mm MEADOWVALE NORTH FEEDERMAIN CROSSING UNDER HWY 401 BETWEEN STA 5+820 AND STA 5+935 DERRY ROAD REGION OF PEEL PROJECT NO. 06-1377

Ref. No. G-06.1105A
June 2007

Prepared for

Region of Peel
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Distribution

5 Copies - R.V. Anderson Associates Limited
2 Copies - Geo-Canada Ltd.

CONTENTS

APPENDICES

FOUNDATION INVESTIGATION REPORT

600mm MEADOWVALE NORTH FEEDERMAIN

CROSSING UNDER HWY 401

BETWEEN STA 5+820 AND STA 5+935

DERRY ROAD

REGION OF PEEL PROJECT NO. 06-1377

1.0 INTRODUCTION

Presented in this report are the results of a geotechnical investigation carried out by Geo-Canada Ltd., a Division of Shaheen & Peaker Limited, at the request of R.V. Anderson Associates Limited (RVA). The purpose of the investigation was to provide geotechnical input and design recommendations for a 600mm dia. watermain to connect the Meadowvale North pumping station to an existing watermain on Mill Creek Dr. at Derry Rd. Along the proposed route, the watermain will pass under a bridge carrying Hwy 401 over Derry Rd. Presented in this report are the relevant geotechnical information obtained during this and a previous investigation carried out by others for MTO, and our interpretation of the results as relevant to the installation of the pipe in open cut under the Derry Rd. overpass.

2.0 METHOD OF INVESTIGATION

The subsurface conditions at the proposed crossing are shown on the log sheets of Boreholes G07-05 and G07-06 and are presented in Appendix A. The locations of the boreholes in relation to the highway are shown on the attached Drawing No. 1.

The boreholes were drilled on January 23, 2007 under full time engineering supervision using a power auger machine equipped with solid stem flight augers. The depth of the boreholes was 5.4m. To this depth, sampling of the sub-strata was at 0.75m intervals of depth by the standard penetration test (SPT) method. At the completion of the boreholes, standpipe type piezometers were installed. Details of the installation are shown on the borehole logs. Bentonite clay seals were placed within the low permeability cohesive deposits and also at ground surface. The position of the groundwater level was recorded after their installation and 3 weeks later, on February 16, 2007.

Ground surface elevations at the borehole locations were obtained by RVA and are related to the geodetic datum.

The soil and rock samples obtained from the boreholes were placed in air-tight containers and were shipped to the laboratories of Geo-Canada. Soils samples were then re-examined by a senior engineer and representative samples were selected for laboratory testing. The laboratory testing program consisted of the measurement of the natural moisture contents of each sample, two (2) grains size analyses and two (2) tests to determine the Atterberg consistency limits of cohesive soils. The results of the grain size

analyses are presented on Figures 1 and 2 and the Atterberg test results are plotted on the plasticity chart enclosed as Figure 3.

In the interpretation of the data, reference was also made to the geotechnical investigation carried out in 1994 for MTO by Fenco MacLaren for the design of the Derry Rd. overpass. The results of this investigation are enclosed as Drawing 3 titled "Borehole Location and Soil Strata", Sheet 19, WP No. 159-81-01.

3.0 REGIONAL GEOLOGY

Geologically, the site is located on a glacial till plane which extends between the Oak Ridges Moraine to the north and the old shoreline of post glacial Lake Iroquois to the south. The glacial drift (till) found in this area is typically clayey silt (Halton till) which was deposited towards the final stages of the last ice age. Drift thickness is generally shallow, generally less than 10m, and is in places interbedded with granular glacio-fluvial deposits.

Bedrock in the region is red shale of the Queenston Formation which is interbedded with bands of harder siltstone and limestone. The boundary between the overburden and the underlying shale bedrock is generally poorly defined as the base of the till is often shaley, which blends in gradually with the underlying weathered shale.

The position of the groundwater table is generally erratic and varies with local changes in the composition and permeability of the till. There are several small lakes or "cattle

ponds" in the area which were formed during the ablation of the till sheet. The macro drainage in the area is generally towards the south-east to Lake Ontario via the Credit River.

4.0 SUMMARIZED SUBSURFACE CONDITIONS

For a detailed description of the overburdens soils, bedrock and groundwater, reference should be made to the individual borehole log sheets in Appendix A. A generalized summary of the soil and bedrock conditions found in the boreholes follows.

Below the pavement structure, which at the borehole locations consisted of 150mm of asphalt and 0.3 to 0.4m granular road base, the native soil is a very stiff to hard silty clay to clayey silt till. Below this upper cohesive stratum, at a depth of 2.6m, Borehole G07-05 encountered the shale bedrock. In Borehole G07-06 at a depth of 3.7m, another very dense glacial till sheet of coarser sandy silt texture was encountered. This latter borehole was terminated at the depth of 5.5m, to which depth the shale bedrock was not encountered.

Similar conditions were encountered during the 1994 investigation for MTO.

4.1 Silty Clay to Clayey Silt Till

The native soil underlying the pavement structure at both borehole locations is a cohesive glacial till, the thickness of which ranges between 2.1 and 3.1m at the two borehole locations. Based on a grain size analysis, the tested sample consisted of 4% gravel, 22%

sand, 49% silt and 25% clay size particles (Figure 1). Two (2) Atterberg tests showed the liquid limit of the till to range between 32 and 34%, the plastic limit at 20% and corresponding plasticity indices of 12 and 14 (Figure 3). The natural moisture contents ranged from 23 to 11%, but were generally less than 20%, i.e., below the plastic limit of the soil. This consistency of the clay was also supported by the standard penetration 'N' values which ranged between 21 and greater than 50 blows/300mm, indicating a very stiff to hard but generally hard consistency. The hydraulic conductivity of this soil type is estimated to be less than 10^{-7} cm/s.

4.2 Sandy Silt Till

In Borehole G07-06, at a depth of 3.7m, the clayey silt till is underlain by a coarser grained glacial till of sandy silt texture. The surface of this till sheet is at El. 176.2m.

A grain size analysis performed on a representative sample gave 16% gravel, 34% sand, 41% silt and 9% clay size particles (Figure 2). The presence of cobbles was also inferred from the difficulty of advancing the augers below a depth of 4.25m. At a depth of 5m, a gravelly sand layer was encountered. It is believed that this sand is a coarser textured pocket or lense within the till and that its lateral extent is limited. This opinion is supported by a review of the borehole logs of the previous investigation where, with the exception of a 150mm thick sand seam in Borehole 4, no similar deposits were encountered. Natural moisture contents ranged between 8 and 10% and the SPT 'N' values were in excess of 50 indicating very dense state of compactness. The hydraulic

conductivity of the till deposit is estimated to be of the order of $5x10^{-6}$ cm/s indicating low permeability.

4.3 Shale Bedrock

In Borehole G07-05, the surface of the shale bedrock was encountered at a depth of 2.6m at El. 178.3m. The rock was not cored but was penetrated with relative ease by the augers and SPTs performed indicated 50 blows/50 to 100mm of penetration. The recovered material was identified as red shale belonging to the Queenston Formation, to be highly weathered and being very weak to weak (e.g. 1 to 25 MPa). A review of the records of the previous investigation indicates similar conditions immediately below the overburden soils. They also suggest that the rock surface dips both towards the north and to the east.

4.4 Groundwater

The groundwater conditions in the boreholes were monitored in the piezometers over a period of 3 weeks. At the time of the investigation, groundwater was recorded in Borehole G07-06 at a depth of 4.3m while Borehole G07-05 was dry on completion. Three weeks later, on February 16, 2007 the position of the groundwater table was recorded at El. 179.39m in Borehole G07-05 (depth of 1.5m) and at El. 178.58m in Borehole G07-06 (1.3m). This information suggests a slight groundwater gradient towards the north-east.

Similar observations were made in 1994 during the previous investigation when the groundwater level was recorded between about El. 180 and 179.5m, showing a similar drop from south to the north.

5.0 INTERPRETATION AND DISCUSSION OF RESULTS

In this section, the subsurface conditions are briefly reviewed as relevant to the installation of the watermain in an open cut trench.

The anticipated construction conditions are described for the benefit of the design engineer in order that their impact on the design can be evaluated and constructibility established. Construction methods described in this section must not be considered as specifications or recommendations to the contractor or as the only suitable method. Prospective contractors should evaluate all the factual information and select their construction method and equipment based on their own experience.

5.1 Review of Subsurface Conditions

The boreholes put down during the present and the previous investigations indicate that below the pavement structure, the site is underlain by competent glacial deposits consisting of an upper silty clay to clayey silt till extending to between El. 178.3 and 176.2m. Below El. 178.3m at the south end of the crossing, the shale bedrock was

encountered. From here, the surface of the rock appears to dip to the north to El. 173±m in Borehole 5 of the 1994 investigation. At the north end of the crossing, sandwiched between the upper clayey till and the bedrock is a very dense sandy silt till deposit. A simplified soil profile is shown on Drawing No. 2.

The position of the stabilized groundwater levels was recorded in the piezometers between El. 178.6 and 179.4m three weeks after the completion of the boreholes.

5.2 The Proposed Watermain

The 600mm concrete pressure pipe (CPP) will be installed between the centre pier and the west abutment at a proposed invert level of El. 177.3m. The underside of the bridge pier footing is at El. 177.8m. As presently proposed, the centreline of the watermain will be 4.75m west of the west face of the centre pier and 3.85m west of the west edge of the pier footing.

5.3 Pipe Bedding

At the proposed invert levels, the pipe will be laid on the weathered shale bedrock at the south end and within the hard clayey silt till at the north end. Conditions for the support of the pipe at this level are favourable and granular bedding in accordance with current provincial standards can be used.

5.4 Excavation

To install the pipes at the proposed invert level, the trench will be about 4.1m deep at the south end and 3.1m deep at the north end. To these depths, the excavation will be through very stiff to hard cohesive clayey soils to the full depths of the excavations and will also extend about 1.4m into the weathered shale bedrock at the south end. Due to their undrained shear strength, both these cohesive deposits could theoretically stand unsupported as a vertical cut. Notwithstanding this, the work will have to comply with the Occupational Health and Safety Act (OHSA) and the trench walls would have to be either sloped or supported. Based on the soil classification system used in the Act, both the overburden clayey soils and the weathered rock can be classified as Type 1 soils. Unsupported excavations in these materials could therefore be carried out as a vertical cut to a height of 1.2m at the base of the trench, above which they will have to be cut back to an angle of 1H:1V. Because of space limitations, however, the trench will likely be excavated as a vertical cut and a trench support system will have to be installed before workers can enter the trench. Considering the limited headroom under the bridge, the shoring system will likely be a pre-fabricated system and a one which can be placed tightly against the excavated face and which can exert pressure against the trench walls (e.g. hydraulic shoring or the Slide Rail shoring system).

5.5 Dewatering

The hydraulic conductivity of the silty clay to clayey silt till and the weathered bedrock is estimated to be less than 10^{-7}cm/s. Consequently, seepage into the excavation is expected

to be nil to minimal. Any water that may seep and accumulate into the trench could be removed by pumping from sumps established at the base.

The stability of the base of a 2m wide trench against hydrostatic uplift at the interface of the sandy silt till and the gravelly sand encountered in Borehole G07-06, was checked and the factor of safety was found to be greater than 3, which is considered to be adequate.

It is therefore our opinion that external dewatering of the excavation will not be required.

5.6 Effect of the Excavation on the Foundations of the Bridge Structure

The relative position of the proposed trench to the centre pier and the west abutment is shown on Figures A and B. As shown, the trench is far removed from the west abutment and the effect of the excavation on the west abutment will not have to be examined. As proposed, the centreline of the trench is 4.75m west of the west face of the centre pier and 3.85m from the west edge of the footing. The base of the trench will extend 0.9m below the base of the centre pier footing. Shown on Figures A and B is the slope angle of the imaginary line connecting the underside of the footing with the base of the trench and as shown, this slope angle is 3.2H:1V throughout the full length of the excavation. At these angles, the excavation will have no adverse effect on the footings of the pier. In particular, there will be no need to consider the underpinning of the pier footings nor will the footing exert a lateral pressure on the trench walls, and considering the competent and cohesive nature of the ground underlying the foundations of the centre pier, we do not

expect any lateral or vertical movement (settlement) of the pier, nor is any loss of material from under the pier due to the trench excavation envisaged. It is recommended, however, that survey points be established on the pier where the movement of the pier can be monitored during construction.

As an additional precautionary measure, consideration could be given to carry out the excavation of the trench in short sections, say 5 to 6m lengths, and that each of these sections be backfilled with 'U-fill' (0.5 MPa mix) before excavating the next section. The use of 'U-fill' as backfill material will further assure that the integrity of the ground adjacent to the foundation is fully restored.

5.7 Monitoring During Construction

While we do not expect any movement of the piers, it is recommended that survey targets be established on the face of the pier where during construction, both vertical and horizontal movements can be observed and detected. The accuracy of the survey should be 3mm or less.

6.0 STATEMENT OF LIMITATIONS

The Statement of Limitations, as quoted in Appendix B, forms an integral part of this report.

GEO-CANADA LTD.
A Division of Shaheen & Peaker Limited

Ivan P. Lieszkowszky, P.Eng.

Scott M. Peaker, P.Eng.

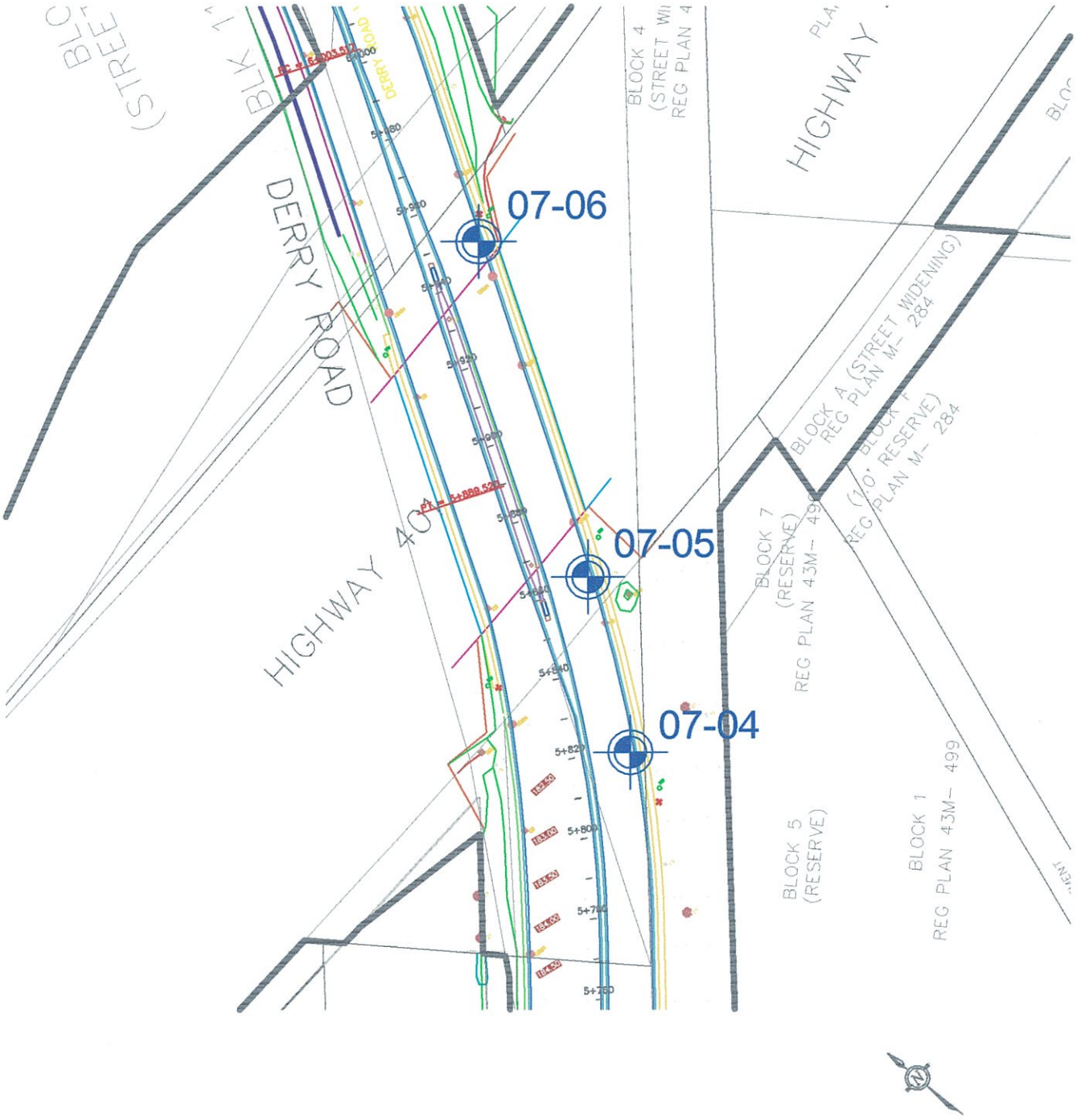
Zuhtu Ozden, P.Eng.
Designated MTO Contact

IPL/SMP/ZO:sf

Encl.

CDSR/07/G-06.1105A RVA

APPENDIX A



LEGEND

GEO-CANADA (2007) BOREHOLE WITH STANDPIPE

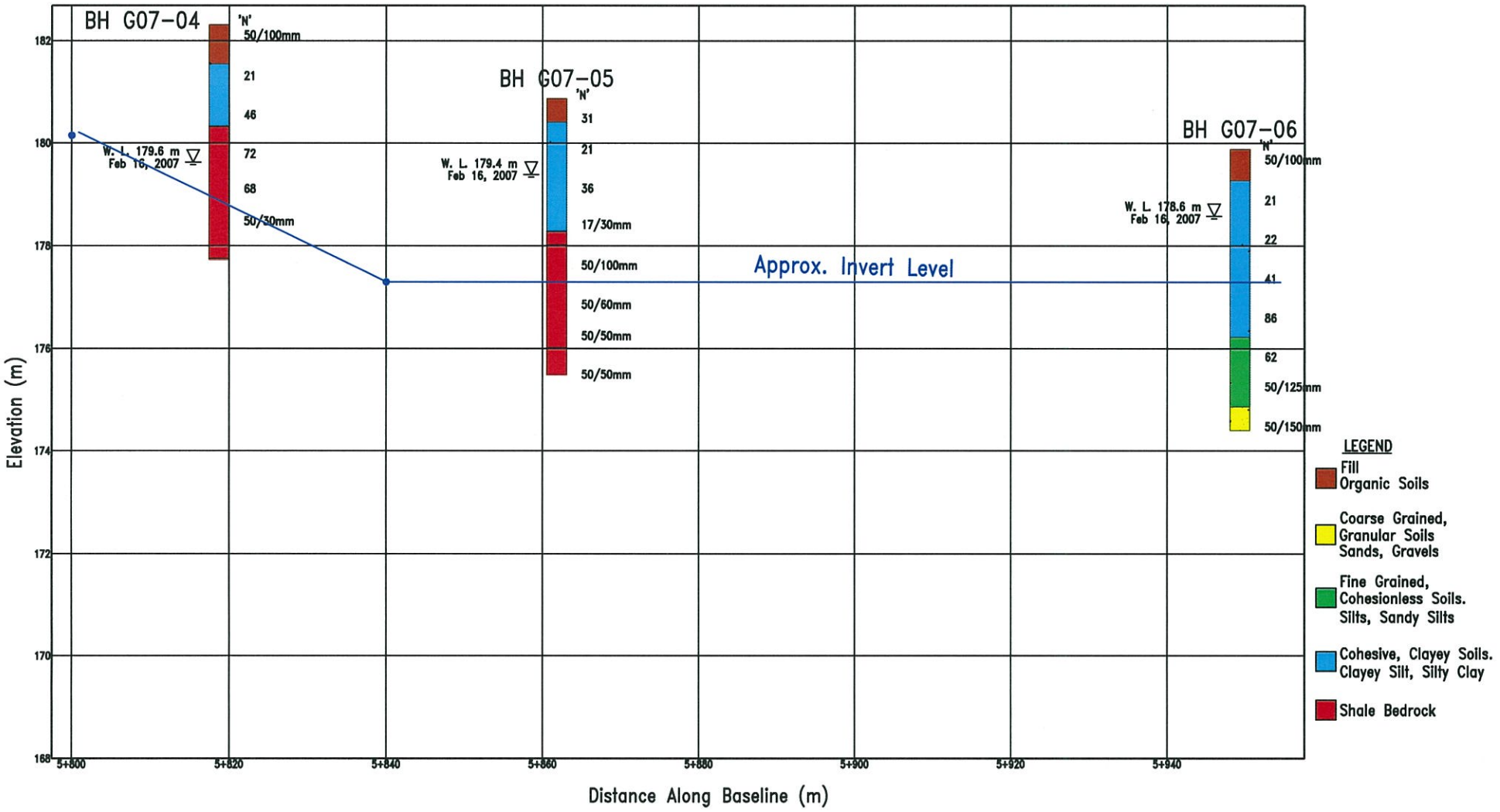
07-05

SCALE 1:1500

0 15 30 45 60 75m

Notes: Base plan, CAD file 061244-Design provided by R.V. Anderson

GEO-CANADA LTD.	MEADOWVALE FEEDER MAIN BOREHOLE LOCATION PLAN HIGHWAY 401 CROSSING	Project No.: G-06.1105A Drawing No.: 1 Date: June 2007



GEO-CANADA LTD.

MEADOWVALE FEEDER MAIN
SUBSURFACE PROFILE
DERRY ROAD, CROSSING UNDER HWY 401 (Sta 5+820 to Sta 5+960)

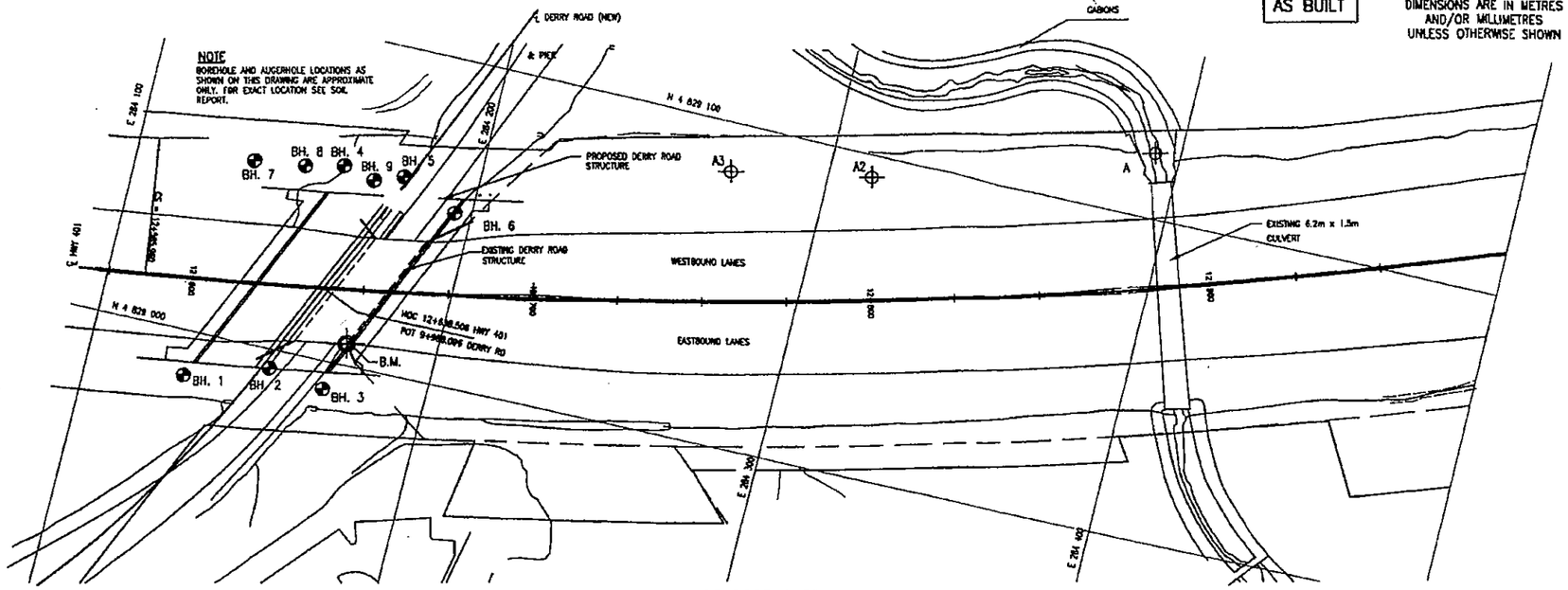
Project No.: G-06.1105A
Drawing No.: 2
Date: June 2007

AS BUILT

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

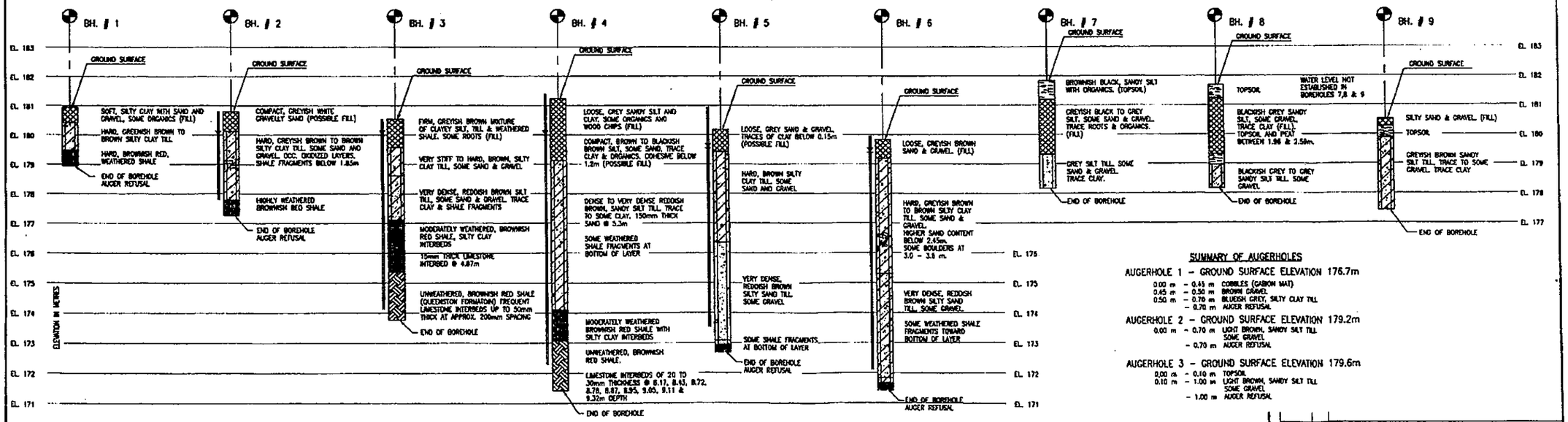
CONT. No.	
WP. No. 159-81-01	
DERRY ROAD OVERPASS	SHEET
BOREHOLE LOCATION & SOIL STRATA	119
Fenco MacLaren	

NOTE
BOREHOLE AND AUGERHOLE LOCATIONS AS SHOWN ON THIS DRAWING ARE APPROXIMATE ONLY. FOR EXACT LOCATION SEE SOIL REPORT.



PLAN OF BOREHOLES
1 : 750

LEGEND
- BOREHOLE
- AUGERHOLE
- B.M.=T.T.B.M. 833 LOCATED AT SOUTH END OF EAST ABUTMENT OF EXISTING HWY 401 AND DERRY ROAD BRIDGE EL. 181.006m



SUMMARY OF AUGERHOLES

AUGERHOLE 1 - GROUND SURFACE ELEVATION 176.7m
- 0.00 m - 0.45 m COBBLES (GABION MAT)
- 0.45 m - 0.50 m BROWN GRAVEL
- 0.50 m - 0.70 m BLUEISH GREY, SILTY CLAY TILL
- 0.70 m AUGER REFUSAL

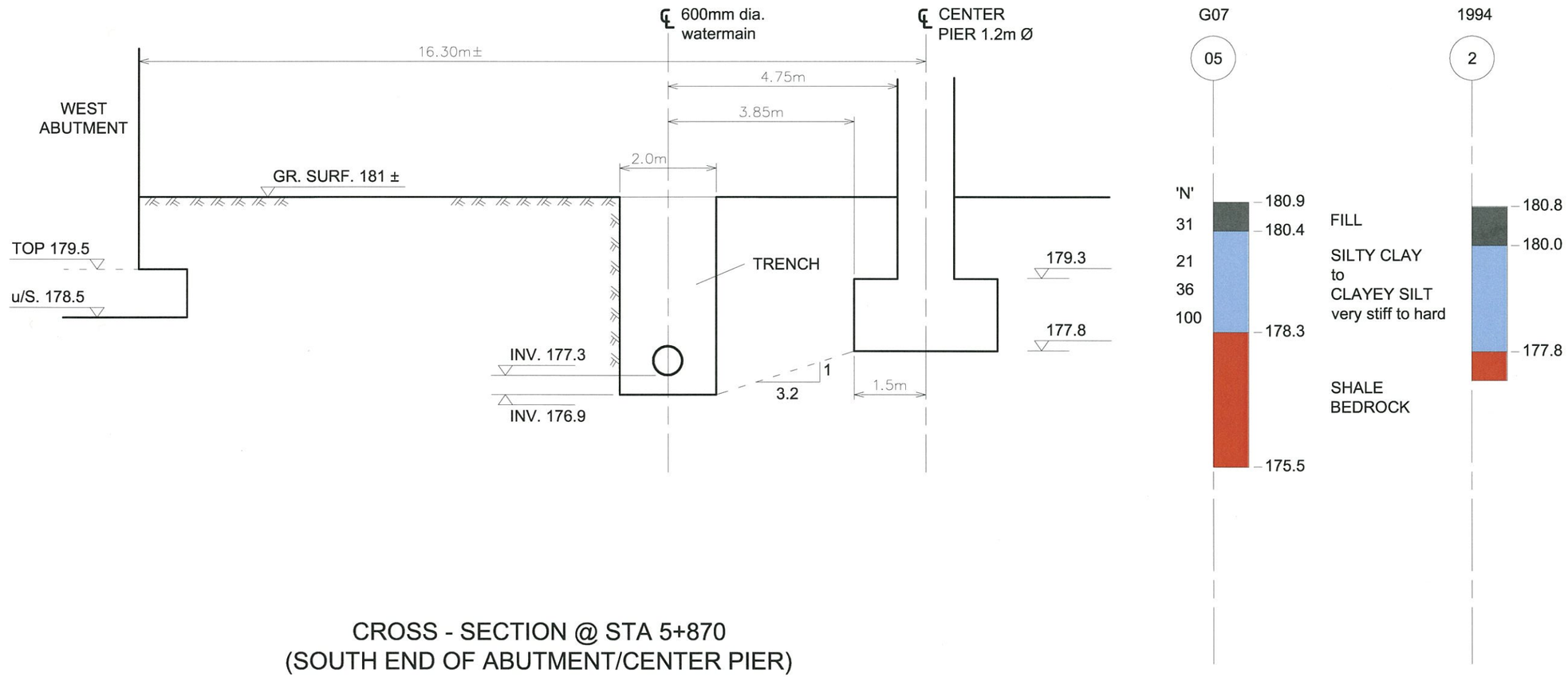
AUGERHOLE 2 - GROUND SURFACE ELEVATION 179.2m
- 0.00 m - 0.70 m LIGHT BROWN, SANDY SILT TILL SOME GRAVEL
- 0.70 m AUGER REFUSAL

AUGERHOLE 3 - GROUND SURFACE ELEVATION 179.6m
- 0.00 m - 0.10 m TOPSOIL
- 0.10 m - 1.00 m LIGHT BROWN, SANDY SILT TILL SOME GRAVEL
- 1.00 m AUGER REFUSAL

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION					
DESIGN IC	CHK. IC	CODE CHBDC-3 E0	LOAD CLASS "A"	DATE 19/94				
DRAWN DW	CHK. LSH	SITE 24-124	STRUCT.	SCHEME	DWG. 2			

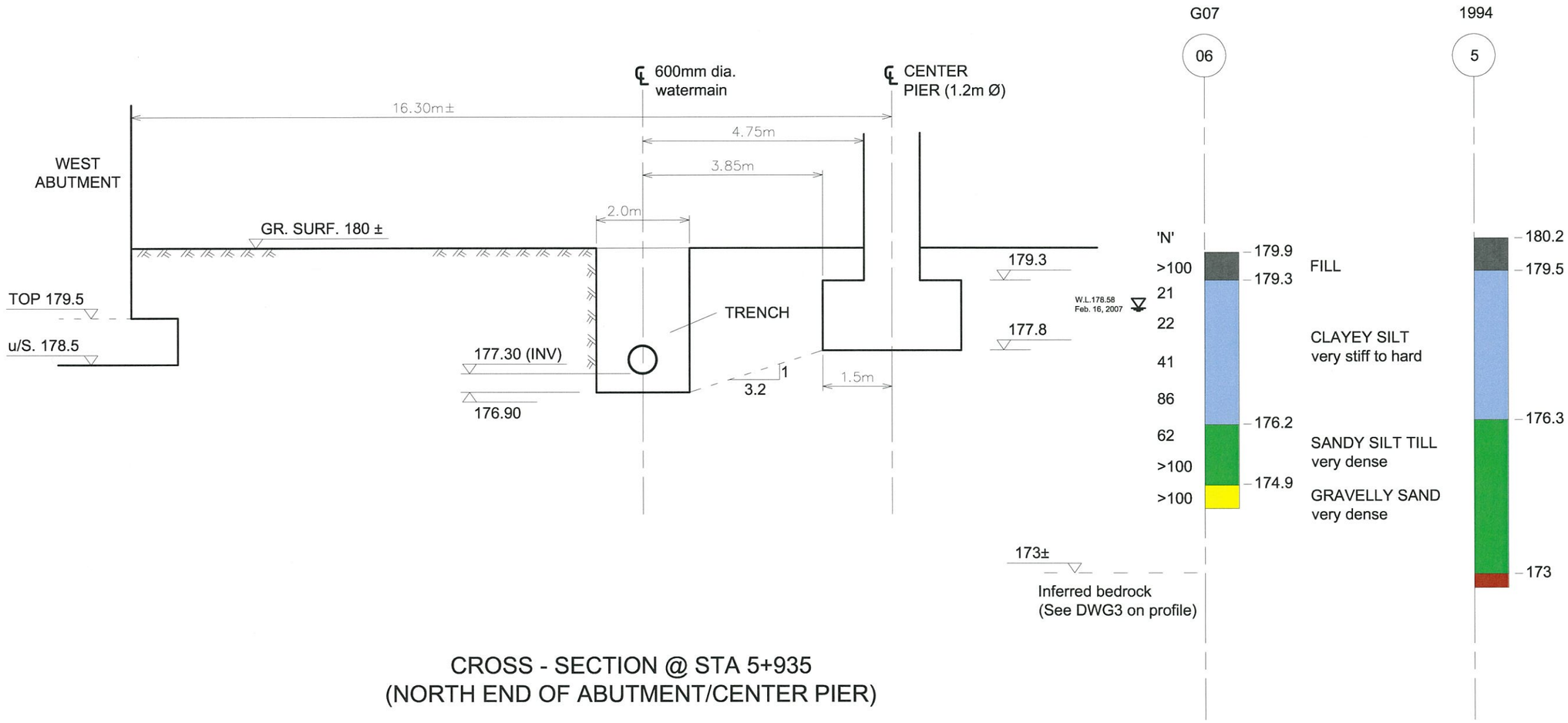
G-06.1105A
Drawing No.3
June 2007



CROSS - SECTION @ STA 5+870
(SOUTH END OF ABUTMENT/CENTER PIER)

SCALE 1:100

GEO-CANADA LTD.	DERRY ROAD WEST PROPOSED 600mm WATERMAIN AT HIGHWAY 401	Project No.: G-06.1105A Figure No.: A Date: June 06, 2007



CROSS - SECTION @ STA 5+935
(NORTH END OF ABUTMENT/CENTER PIER)

SCALE 1:100

GEO-CANADA LTD.

DERRY ROAD WEST
PROPOSED 600mm WATERMAIN
AT HIGHWAY 401

Project No.: G-06.1105A
Figure No.: B
Date: June 06, 2007

GEO-CANADA

LOG OF BOREHOLE G07-05

PROJECT: 600mm Meadowvale North Feedermain
CLIENT: R.V Anderson Assoc.
LOCATION:
DATUM ELEVATION: Geodetic
BOREHOLE LOCATION: Refer to Drawing 4

DRILLING DATA
Method: Solid Flight Augers
Diameter: 120mm
Date: 23 January 2007

REF. NO.: G-06.1105
ENCL NO.: 5

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	ELEVATION
180.9	Ground Surface				
0.0 / 180.7	**ASPHALT:** 150mm				
0.2 / 180.4	**FILL: SANDY GRAVEL:** fine to medium grained, sand is fine to coarse grained, light brown and dark grey (Road Base Material)	1	SS	31	
0.5	**SILTY CLAY:** low plasticity, with some fine to medium grained gravel, light grey, orange mottled, very stiff (TILL)	2	SS	21	180
179.5					
1.4	**CLAYEY SILT:** low plasticity, some fine grained sand, trcae fine to medium grained gravel, dark grey, faint brown mottles, hard (TILL)	3	SS	36	
	with reduced clay content	4	SS	17/ 30mm	179
178.3					
2.6	**SHALE:** weathered, red, very low to low strength (Extremely weathered material as SILT)	5	SS	50/ 100mm	178
		6	SS	50/ 60mm	177
		7	SS	50/ 60mm	
		8	AS		176
175.5		9	SS	50/ 60mm	
5.4	END OF BOREHOLE Target depth achieved				

GROUND WATER CONDITIONS: W. L. 179.39 m Feb 16, 2007

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 25 50 75 100 125

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

- auger grinding intermittently between 1.8m and 2.3m
- SPT blows 24,15, 17 for 30mm - hammer double bouncing after 10 blows little resistance to auger (resistance scale 1/5)
- increased drilling resistance (resistance scale 3/5) drill cuttings are moist

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ $^{\varepsilon}$=3% Strain at Failure

GEO-CANADA

LOG OF BOREHOLE G07-06

PROJECT: 600mm Meadowvale North Feedermain
CLIENT: R.V Anderson Assoc.
LOCATION:
DATUM ELEVATION: Geodetic
BOREHOLE LOCATION: Refer to Drawing 4

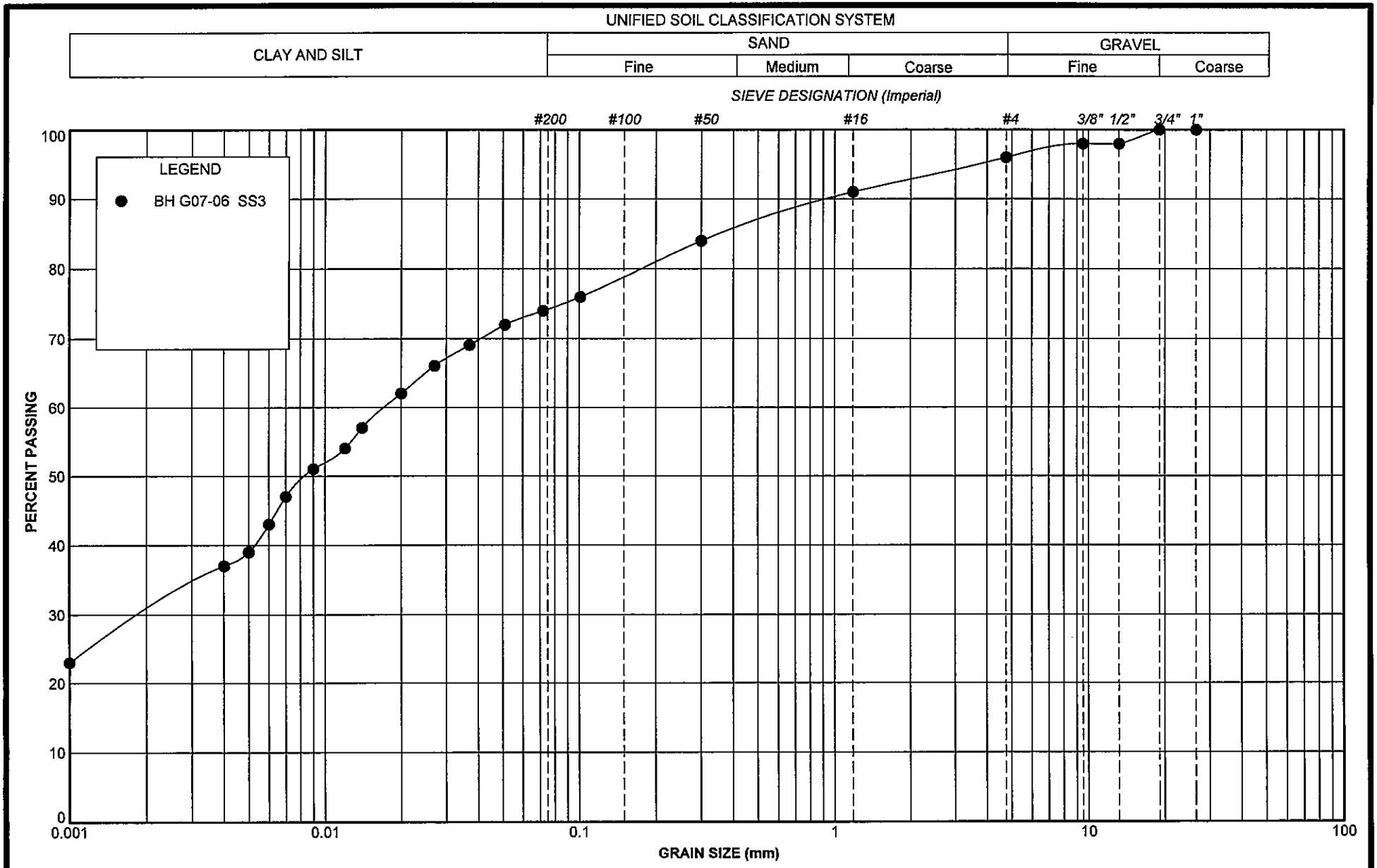
DRILLING DATA
Method: Solid Flight Augers
Diameter: 120mm
Date: 23 January 2007

REF. NO.: G-06.1105
ENCL NO.: 6

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) (25 50 75 100 125) O UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.9	Ground Surface									
0.0 / 179.7	**ASPHALT:** 150mm									
0.2 / 179.3	**FILL: GRAVELLY SAND:** fine to coarse grained, gravel is fine grained, brown (Road Base Material)		1	SS	50/100mm					
0.6	**CLAYEY SILT:** low plasticity, dark grey and black, very stiff to hard		2	SS	21		179			
	with some fine grained sand, trace fine grained gravel, becoming light brown-grey, faint orange mottled (TILL)		3	SS	22	▽ vw. L. 178.58 m Feb 16, 2007	178			4 22 49 25
			4	SS	41		177			
			5	SS	86					
176.2							176			
3.7	**SANDY SILT:** fine grained, some fine to coarse grained gravel, brown, very dense (TILL)		6	SS	62					16 34 41 9
	with cobbles		7	SS	50/125mm					augers grinding below 4.25m
174.9							175			
5.0	**GRAVELLY SAND:** fine to coarse grained, gravel is fine grained, wet, very dense									water inflow
174.4			8	SS	50/150mm					
5.5	END OF BOREHOLE Borehole open at completion of drilling. Water level at 4.3m below ground surface at completion of drilling									

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; O $^{\varepsilon=3\%}$ Strain at Failure

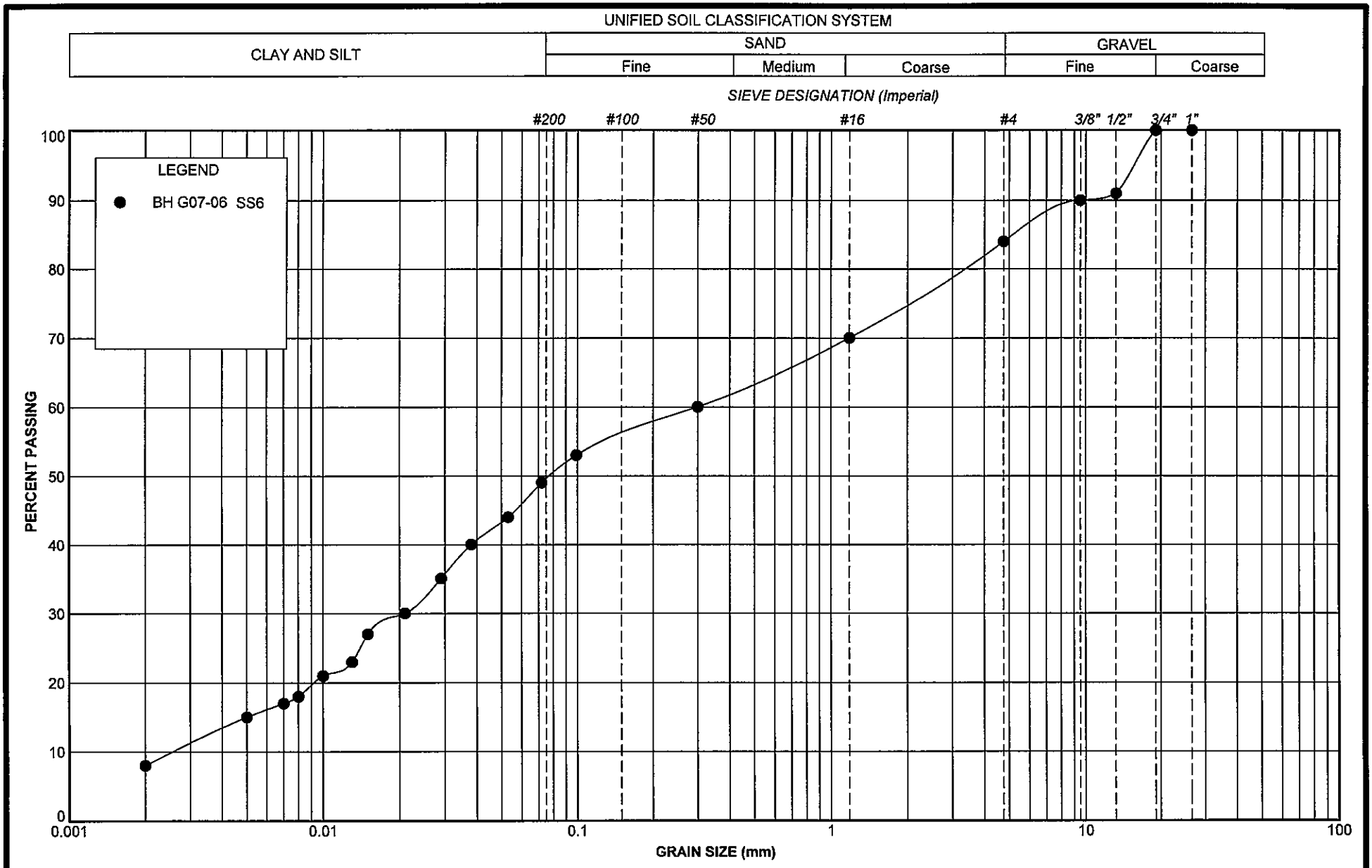
GEO-CANADA SOIL LOG DK G06.1105BHLOGS.GPJ GEO-CAN TEMPLATE1.GDT 3/12/07



GEO-CANADA

GRAIN SIZE DISTRIBUTION
SILTY CLAY

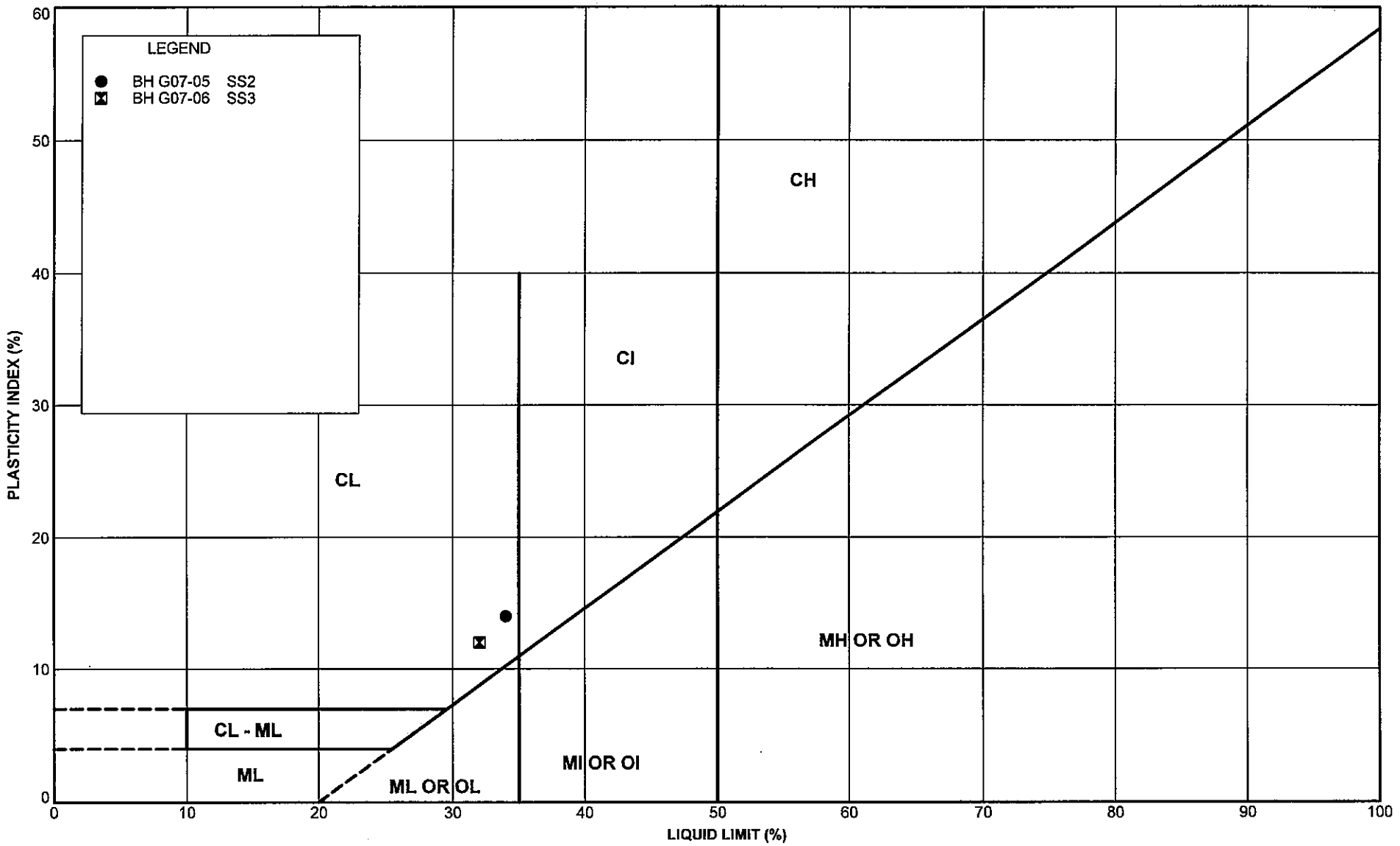
FIGURE NO.	1
Job No.	G-06.1105A
DATE	JUNE 2007



GEO-CANADA

GRAIN SIZE DISTRIBUTION
SANDY SILT TILL

FIGURE NO.	2
Job No.	G-06.1105A
DATE	JUNE 2007



GEO-CANADA

PLASTICITY CHART

FIGURE NO.	3
JOB NO.	G-06.1105A
DATE	JUNE 2007

APPENDIX B

Statement of Limitations

The conclusions and recommendations in this report are based on information determined at the borehole locations. Soil, bedrock and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the geotechnical investigation.

The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain assumptions had to be made. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

We recommend, therefore, that we be retained during the final design stage to review the specifications and design drawings, to verify that they are consistent with our recommendations and the assumptions made in our analysis. We recommend also that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the boreholes and to ensure that our recommendations are properly instituted. In cases where these recommendations are not followed, the company's responsibility is limited to interpreting accurately the information encountered within the individual boreholes.

The comments given in this report on potential construction problems and possible construction methods are intended only for the guidance of the design engineer. They are not intended as specifications or as instructions to contractors. The number of boreholes, the sampling interval and laboratory testing conducted may not be sufficient to determine all of the factors that may affect construction methods, sequencing, equipment and costs. Prospective contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented, obtain additional subsurface data as required and draw their own conclusions as to how the subsurface conditions may affect them.

Geo-Canada Ltd. accepts no responsibility for loss, delay, damage or other problems suffered by contractors who fail to heed the foregoing limitation.

The testing and evaluation of the environmental quality of soil, rock and groundwater with respect to its reuse or disposal is excluded from the scope of Geo-Canada's work unless stated otherwise in this report.