



**FOUNDATION INVESTIGATION
AND DESIGN REPORT
OVERHEAD SIGN SUPPORT STRUCTURES
HIGHWAY 401 WIDENING FROM WEST OF
SYDENHAM ROAD TO WEST OF MONTREAL STREET
KINGSTON, ONTARIO
W.P. 77-99-01**

Submitted to:

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PART A

**FOUNDATION INVESTIGATION REPORT
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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 provide foundation engineering services for the detailed design of the Highway 401 widening from four to six lanes, from west of Sydenham Road to west of Montreal Street in the City of Kingston, Ontario. Foundation engineering services are required for the following components under W.P. 77-99-01:

- northward widening of the existing Division Street overpass structure;
- investigation of instability and settlement along a section of the Division Street W-N/S Ramp;
- widening of high fill embankments in the vicinity of Little Cataraqui Creek, between Sydenham Road and Sir John A. MacDonald Boulevard;
- overhead signs; and
- trenchless sewer installation.

This report addresses fourteen new trichord overhead or cantilever signs along Highway 401 and one new overhead sign associated with the Wolfe Island ferry crossing, located adjacent to the Kingston Harbour in the City of Kingston.

The terms of reference for the original scope of work are outlined in the MTO's Request for Proposal (RFP) dated January 2005, and in Section 6.8 of MRC's *Technical Proposal* for this project.

2.0 SITE DESCRIPTION

The proposed overhead signs are located as follows:

<i>Overhead Sign No.</i>	<i>Overhead Sign Location</i>
County Road 38	Highway 401 WBL, Station 18+015
OH-1	Highway 401 WBL, Station 20+677
OH-2	Highway 401 WBL, Station 21+100
OH-3	Highway 401 EBL, Station 21+499
OH-4	Highway 401 EBL, Station 22+059
OH-5	Highway 401 WBL, Station 22+504
OH-6	Highway 401 WBL, Station 22+944
OH-7	Highway 401 EBL, Station 23+150
OH-8	Highway 401 EBL, Station 23+536
OH-9	Highway 401 WBL, Station 23+945
OH-10	Highway 401 WBL, Station 24+975
OH-11	Highway 401 EBL, Station 25+125
OH-12	Highway 401 EBL, Station 25+568
OH-13	Sir John A. MacDonald Boulevard, Station 0+281
Wolfe Island Ferry	Wolfe Island Ferry Area, East of Ontario Street

At the proposed sign locations, Highway 401 has typically been constructed on an embankment that is typically 2 m to 4 m in height relative to the surrounding natural or rock cut grade, except at the following locations:

- OH-3, between Sydenham Road and Sir John A. MacDonald Boulevard, is located within the high fill embankment area near Little Cataraqui Creek; the embankment at this location is approximately 5 m to 6 m in height.
- OH-9, immediately west of Division Street, is located within the 6 m to 7.5 m high approach embankment for this overpass structure.
- OH-13, south of Highway 401 on Sir John A. MacDonald Boulevard, is in an area with approximately 1.2 m to 1.4 m of fill.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out in January, February and March 2007. A total of twenty-eight boreholes (Boreholes 2, 07-2, 07-3, 07-5 to 07-21, 07-23 to 07-28, 07-WIF-1 and 07-WIF-2) were advanced using a CME-75 track-mounted drill rig, supplied and operated by Marathon Drilling Company Ltd. of Ottawa, Ontario. The boreholes were advanced at the locations shown on Drawings 1 to 7.

The field work was supervised on a full-time basis by members of Golder's staff, who located the boreholes in the field, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure. In situ vane testing, using an MTO "N"-size vane, was carried out to measure the undrained shear strength where firm to stiff silty clay to clay was encountered. Where bedrock was encountered in Boreholes 2, 07-5, 07-6, 07-15 to 07-20, 07-23 to 07-28, 07-WIF-1 and 07-WIF-2, bedrock coring was completed using NQ-size coring equipment. Following completion of drilling, the boreholes were backfilled with bentonite, in accordance with the requirements of Ontario Regulation 903.

The soil and bedrock samples were identified in the field, placed in labelled containers and transported to Golder's laboratories in Mississauga and Ottawa for further examination and laboratory testing. Index and classification tests consisting of water content determinations, Atterberg limits testing and grain size distribution analyses were carried out on selected soil samples, and point load index testing was carried out on selected samples of bedrock core.

The borehole locations and ground surface elevations were determined by Golder personnel relative to survey staking provided by J.D. Barnes Surveying Ltd.; the ground surface elevations were also checked using the digital terrain model for the project. The borehole locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized in the following table and are shown on the borehole records and on Drawings 1 to 7.

<i>Borehole Number</i>	<i>MTM NAD83 Northing (m)</i>	<i>MTM NAD83 Easting (m)</i>	<i>Ground Surface Elevation (m)</i>
2	4,905,053.9	299,229.7	110.6
07-2	4,904,092.3	301,679.7	100.9
07-3	4,904,076.9	301,678.2	101.2
07-5	4,904,013.2	302,097.6	95.6
07-6	4,904,003.4	302,095.1	95.4
07-7	4,903,856.8	302,463.6	85.5
07-8	4,903,864.5	302,465.0	85.7
07-9	4,903,644.7	302,984.8	86.3
07-10	4,903,666.6	302,993.3	87.0
07-11	4,903,329.6	303,242.1	80.8

<i>Borehole Number</i>	<i>MTM NAD83 Northing (m)</i>	<i>MTM NAD83 Easting (m)</i>	<i>Ground Surface Elevation (m)</i>
07-12	4,903,322.0	303,270.6	80.6
07-13	4,903,526.0	303,416.1	88.7
07-14	4,903,513.0	303,410.4	88.8
07-15	4,903,381.4	303,828.6	90.2
07-16	4,903,368.4	303,825.7	91.2
07-17	4,903,308.3	304,024.7	92.0
07-18	4,903,318.5	304,025.6	91.8
07-19	4,903,268.0	304,401.8	90.8
07-20	4,903,282.6	304,410.2	90.9
07-21	4,903,260.3	304,822.3	87.9
07-23	4,903,478.5	305,775.2	110.5
07-24	4,903,471.6	305,780.3	110.6
07-25	4,903,545.5	305,911.3	110.0
07-26	4,903,552.2	305,906.6	111.3
07-27	4,903,802.8	306,270.6	112.5
07-28	4,903,812.5	306,263.8	113.1
07-WIF-1	4,899,164.0	306,514.4	N/A
07-WIF-2	4,899,161.4	306,510.5	N/A

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

The site is located in the southern portion of the physiographic region of Southern Ontario known as the Napanee Plain, 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.

4.2 Site Stratigraphy

Twenty-eight boreholes were advanced as part of the geotechnical investigation for the overhead sign locations. The borehole locations are shown on Drawings 1 to 7.

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records and Figures 1 to 9 following the text of this report. The stratigraphic boundaries shown on the borehole records 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 locations.

In summary, the subsoils at the site consist of variable fill materials (including rock fill) overlying deposits of clayey silt to clay and glacial till, in turn underlain by limestone bedrock. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

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.

4.2.1 Fill

Fill was encountered in all of the boreholes, immediately below the existing ground surface or a layer of asphalt. The variation in thickness and the surface and base elevations of the fill are summarized in the following table:

<i>Overhead Sign No.</i>	<i>Borehole No.</i>	<i>Elevation of Surface of Fill (m)</i>	<i>Elevation of Base of Fill (m)</i>	<i>Thickness of Fill (m)</i>
County Road 38	2	110.6	109.4	1.2
OH-1	07-2	100.9	98.3	2.6
	07-3	101.2	97.7	3.5
OH-2	07-5	95.6	94.1	1.5
	07-6	95.4	92.8	2.6
OH-3	07-7	85.5	79.6	5.9
	07-8	85.7	80.7	5.0
OH-4	07-9	86.3	82.6	3.7
	07-10	87.0	85.2	1.8
OH-5	07-13	88.7	86.6	2.1
	07-14	88.8	85.9	2.9
OH-6	07-15	90.2	88.1	2.1
	07-16	91.2	87.5	3.7
OH-7	07-17	92.0	87.7	4.3
	07-18	91.8	90.1	1.7
OH-8	07-19	90.8	86.7	4.1
	07-20	90.9	88.2	2.7
OH-9	07-21	87.9	80.4	7.5
OH-10	07-23	110.5	108.8	1.7
	07-24	110.6	108.7	2.0
OH-11	07-25	110.0	107.8	2.2
	07-26	111.3	109.3	2.0
OH-12	07-27	112.5	111.2	1.3
	07-28	113.1	111.5	1.6
OH-13	07-11	80.8	79.6	1.2
	07-12	80.6	79.2	1.4
Wolfe Island Ferry	07-WIF-1	N/A	N/A	3.0
	07-WIF-2	N/A	N/A	2.1

Typically, the upper portion of the fill is comprised of sandy gravel, to sand and gravel, to gravelly sand, to sand containing some gravel; cobbles were observed within this fill in some of the boreholes, as noted on the borehole records. The results of grain size distribution tests conducted on seven samples of sand and gravel to sand fill are shown on Figure 1. The measured SPT "N" values within the sandy gravel to sand fill ranged from 2 to 112 blows per 0.3 m of penetration, indicative of a variable, very loose to very dense relative density.

Layers of finer cohesionless fills (silty sand, sand and silt or sandy silt), approximately 0.8 m to 2.2 m in thickness, were encountered below the sandy gravel to sand fill in Boreholes 07-13, 07-14, 07-16, 07-17 and 07-25. The results of grain size distribution tests conducted on two samples of silty sand fill that contained zones of clayey silt are shown on Figure 2. The measured

SPT "N" values within the silty sand to sandy silt fill ranged from 4 to 28 blows per 0.3 m of penetration, indicative of a very loose to compact relative density.

Clayey silt to silty clay fill was encountered below the sandy gravel to sand fill in Boreholes 07-2, 07-3, 07-5, 07-7, 07-9, 07-11, 07-14, 07-15, 07-17, 07-19, 07-21, 07-23 and 07-26. The clayey silt to silty clay fill typically contains trace to some sand and trace gravel; the results of grain size distribution tests on three selected samples of the cohesive fill are shown on Figure 3. Atterberg limits testing was conducted on four samples of the cohesive fill, and measured plastic limits of 17 to 24 per cent, liquid limits of 35 to 48 per cent, and plasticity indices of 17 to 26 per cent; these results, which are plotted on a plasticity chart on Figure 4, indicate that the tested cohesive fill consists of silty clay of intermediate plasticity. The measured SPT "N" values within the cohesive fill ranged from 3 to 19 blows per 0.3 m of penetration (but typically 5 to 10 blows per 0.3 m of penetration), indicative of a soft to very stiff (but typically firm to stiff) consistency.

4.2.2 Rock Fill

Rock fill was encountered below the asphalt and sand and gravel fill in Boreholes 07-6, 07-8, 07-20, 07-21 and 07-28. The rock fill encountered in the boreholes consists of 0.7 m to 4.0 m of sandy gravel to gravel, some sand, containing cobbles and boulders. The results of grain size distribution tests on the recovered rock fill samples (excluding cobble- and boulder-sized materials) from two of the boreholes are shown on Figure 5.

The measured SPT "N" value within the rock fill ranged from 5 to 113 blows per 0.3 m of penetration, indicative of a loose to very dense relative density.

4.2.3 Clayey Silt to Clay

A deposit of silty clay to clay was encountered below the fill in Boreholes 07-2, 07-3, 07-7 to 07-14 and 07-21. Some of these boreholes were terminated within the silty clay to clay; however, where fully penetrated, the deposit varies from 0.7 m to 4.3 m in thickness.

The silty clay to clay deposit contains trace sand and gravel; silt seams and interlayers were noted within the deposit in samples recovered from Boreholes 07-10 and 07-13. The results of grain size distribution tests completed on four selected samples of the silty clay to clay are shown on Figure 6. Atterberg limits testing was completed on eleven samples of this cohesive deposit and measured plastic limits of 20 to 31 per cent, liquid limits of 43 to 76 per cent, and plasticity indices of 23 to 51 per cent; these results, which are plotted on a plasticity chart on Figure 7, confirm that the deposit varies from silty clay of intermediate plasticity to high plasticity clay.

The measured SPT "N" values within this deposit ranged from 3 to 25 blows per 0.3 m of penetration. In situ vane testing in the "softer" portions of the deposit (SPT "N" values of 3 and 4 blows per 0.3 m of penetration) measured undrained shear strengths of approximately 48 kPa to 85 kPa. These test results indicate that the silty clay to clay deposit has a firm to very stiff (but typically stiff to very stiff) consistency. The deposit is sensitive, based on measured sensitivities of 4.6 to 10.0.

4.2.4 Clayey Silt Till to Silty Sand Till

A glacial till deposit was encountered below the fill and/or silty clay to clay in Boreholes 07-2, 07-3, 07-11, 07-12, 07-15, 07-16 and 07-WIF-2. The surface of the till deposit was encountered at a depth of between 4.4 m and 5.5 m at the locations of Overhead Signs OH-1 and OH-13 (Boreholes 07-2, 07-3, 07-11 and 07-12); the boreholes at these locations were terminated within the till deposit. The surface of the till deposit was encountered at a depth of 2.1 m and 3.7 m in Boreholes 07-15 and 07-16 at the location of Overhead Sign OH-6, and at a depth of 2.1 m in Borehole 07-WIF-2 at the Wolfe Island ferry crossing site; the till is between 0.5 m and 1.5 m in thickness in these boreholes, and is underlain by bedrock.

The till deposit varies in composition from clayey silt with sand to trace sand and trace to some gravel, to silty sand or sandy silt containing trace to some gravel and trace clay. The results of grain size distribution tests completed on two selected samples of the till are shown on Figure 8. Atterberg limits testing was conducted on one selected sample of the cohesive till, and measured a plasticity index of 11 per cent, a liquid limit of 16 per cent, and a plasticity index of 5 per cent; this result, which is plotted on a plasticity chart on Figure 9, confirms that the cohesive portion of the till consists of low plasticity clayey silt.

The measured SPT "N" values within the clayey silt till ranged from 2 to greater than 30 blows per 0.3 m of penetration, indicative of a soft to hard consistency. The measured SPT "N" values within the silty sand to sandy silt till ranged from 1 to 15 blows per 0.3 m of penetration, indicative of a very loose to compact relative density.

4.2.5 Limestone Bedrock

Limestone bedrock underlies the fill and native soils at the sites for the cantilever sign at County Road 38, Overhead Signs OH-1, OH-2, OH-6 to OH-8, OH-10 to OH-12, and the Wolfe Island ferry crossing. The following table summarizes the depth to the bedrock surface and its elevation, as encountered in the boreholes; the bedrock was confirmed by coring for a length of 2.3 m to 3.3 m in all of these boreholes, except Boreholes 07-2 and 07-3 where the bedrock surface was inferred at the base of the borehole from refusal to auger and/or split-spoon sampler advance.

<i>Overhead Sign No.</i>	<i>Borehole No.</i>	<i>Ground Surface Elevation (m)</i>	<i>Depth to Bedrock (m)</i>	<i>Bedrock Surface Elevation (m)</i>
County Road 38	2	110.6	1.2	109.4
OH-1	07-2	100.9	5.6	95.3
	07-3	101.2	6.6	94.7
OH-2	07-5	95.6	1.5	94.1
	07-6	95.4	2.6	92.8
OH-6	07-15	90.2	2.6	87.6
	07-16	91.2	4.4	86.8
OH-7	07-17	92.0	4.3	87.7
	07-18	91.8	1.7	90.1
OH-8	07-19	90.8	4.1	86.7
	07-20	90.9	2.7	88.2
OH-10	07-23	110.5	1.7	108.8
	07-24	110.6	2.0	108.7
OH-11	07-25	110.0	2.2	107.8
	07-26	111.3	2.0	109.3
OH-12	07-27	112.5	1.3	111.2
	07-28	113.1	1.6	111.5
Wolfe Island Ferry	07-WIF-1	N/A	3.0	N/A
	07-WIF-2	N/A	3.6	N/A

A description of some of the terms used in the description of the bedrock samples from this site is provided on the *Lithological and Geotechnical Rock Description Terminology* sheet which precedes the Record of Borehole sheets included with this report.

The limestone bedrock at the site is a member of the Gull River Formation; it is slightly weathered to fresh, thinly-bedded, grey, and medium strong to very strong. The Rock Quality Designation (RQD) values measured on selected core samples generally ranged from about 25 to 85 per cent, indicating that the bedrock is generally of poor to good quality; however, some fracturing/broken core was observed within the upper 1.2 m of the bedrock core recovered from Borehole 2 (at the County Road 38 cantilever sign location) and in the upper 0.4 m of the bedrock from Borehole 07-19 (at OH-8), with measured RQDs of 0 per cent over these intervals. The discontinuities observed in the rock core are typically horizontal, associated with bedding planes in this thinly-bedded rock.

Point load strength tests were performed on selected samples of the bedrock core. The point load test results and the approximate unconfined compressive strength as obtained from correlation with the diametral and axial point load strength tests are summarized in Table 1 following the text of this report. The point load index test results and correlated unconfined compressive strengths confirm that the limestone is classified as a medium strong to very strong rock.

4.3 Groundwater Conditions

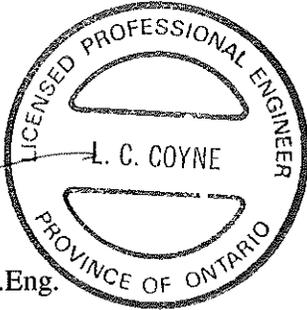
The majority of the boreholes were observed to be dry during and immediately following completion of overburden drilling and prior to rock coring. In addition, the granular fill, which ranges from in thickness from 1.5 m to 5.9 m, was dry to moist at the time of the borehole investigation. However, wet cohesionless (silty sand till) soil layers were observed at depth (3.7 m and 5.2 m) in some of the boreholes, as noted on the borehole records.

The water levels measured in piezometers installed by Golder for other elements of this project indicate that the stabilized groundwater level within the project limits is typically between 0 m and 2 m below the natural ground surface and the roadway fill. The groundwater level is expected to fluctuate seasonally, and is expected to rise during wet periods of the year. Cohesionless interlayers within the silty clay to clay deposit, as well as silty sand till layers, should be expected to be water-bearing; in addition, "perched" groundwater should be expected near the base of cohesionless fills, on top of the underlying, less permeable silty clay to clay deposit.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Karyn Gallant and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of the report.

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PART B

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W.P. 77-99-01**

6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical parameters and recommendations for the design and construction of foundations for the proposed overhead and cantilever signs. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation for these overhead signs. The interpretation and recommendations provided are intended to provide the designers with sufficient information to design the proposed sign foundations. Where comments are made on construction they are provided in order to highlight those aspects which could affect the planning of the project, and for which special provisions or operational constraints may be required during construction. 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.

6.2 Overhead Sign Foundations

Table 2, following the text of this report, summarizes the feasible foundation options for each sign support location, based on the soil conditions and the depth to bedrock as encountered in the borehole drilled at each proposed sign support location.

Based on the subsurface information as presented on the borehole records and summarized in Table 3 following the text of this report, the “standard” caisson design (i.e. caisson length equal to frost depth plus 5 m) is expected to apply for the foundation supports for Overhead Signs OH-1 (South Support only), OH-3, OH-4, OH-5, OH-9 and OH-13. Discussion regarding the “standard” caisson design is provided in Section 6.2.1. The standard design can be checked and optimized by a structural designer, if desired, using the recommendations provided in Section 6.2.1 and the geotechnical parameters provided in Table 3 following the text of this report. It is noted that the borehole depth at some of these sign support locations was only 6 m, in accordance with the RFP terms of reference, and there is potential for bedrock to be encountered at these locations below 6 m but above 6.5 m (i.e., within the standard caisson length). As discussed further in Section 6.2.1, a site-specific design check could be carried out for these sign support locations during design or construction (i.e., if bedrock is encountered), to determine if an overall caisson length of 6 m is sufficient or if socketting of the caisson into rock will be required.

At all other locations, the depth to the bedrock surface is less than 5 m below the design frost depth, and either caissons socketted into bedrock or foundations (caissons or footings) dowelled to bedrock will be required. Recommendations for caissons socketted into bedrock are provided in Section 6.2.2, and recommendations for foundations dowelled to bedrock are provided in Section 6.2.3.

6.2.1 Caisson Foundations in Soil

Caisson foundations for overhead sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual*. The *Sign Support Manual* includes a standard caisson foundation design (Section 4 and Standard Drawings SS118-3, SS118-4 and SS118-5), in which a 1.2 m diameter caisson is extended 5 m below the design frost depth (i.e. a total length of 6.5 m below grade for this project), except where bedrock is encountered within this depth. The standard design is based on the following minimum soil conditions:

- **Case 1 (Cohesionless Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials softer than those of Case 2 are present; for such subsurface conditions, a site-specific design is required.

As noted above, the subsurface soils at the locations for Overhead Signs OH-1, OH-3, OH-4, OH-5, OH-9 and OH-13 have friction angles and/or undrained shear strengths that exceed the input parameters used in the modeling of the standard caisson foundations. Therefore, the standard caisson foundation design (i.e., a 6.5 m long caisson) is suitable for the supports at these sign locations. However, as discussed above, there is potential for bedrock to be encountered near the base of the foundations (below a depth of about 6 m but above 6.5 m) for three of the sign supports near Sir John A. MacDonald Boulevard, as follows:

<i>Sign Support Location</i>	<i>Borehole No.</i>
OH-4, South Support	07-9
OH-4, North Support	07-10
OH-5, North Support	07-13
OH-5, South Support	07-14
OH-13, West Support	07-11
OH-13, East Support	07-12

NOTE: Although Borehole 07-8 at OH-3, North Support is only 5.9 m deep, it is not included here based on subsurface information from the surrounding high fill investigation, which shows that the bedrock is much deeper in this area.

A site-specific design check can be carried out for the above-noted sign support locations during design or construction (i.e., should bedrock be encountered during construction), to determine if an overall caisson length of 6 m is sufficient or if socketting into the bedrock (if present above a

depth of 6.5 m) will be required. The standard design can be checked and optimized by the structural designer using the recommendations provided below and the geotechnical parameters provided in Table 3 following the text of this report.

A site-specific caisson design may be determined using the following equations to calculate the unfactored passive lateral earth pressure, P_p (kPa), distributed along the depth of the caisson foundation; this earth pressure distribution is triangular with depth:

$$\begin{aligned} P_p &= K_p \gamma d_w && \text{above the groundwater table, and} \\ P_p &= K_p \gamma d_w + K_p \gamma' (d - d_w) && \text{below the groundwater table,} \end{aligned}$$

where K_p is the passive earth pressure coefficient, as given in Table 3;
 γ is the bulk unit weight (kN/m^3), as given in Table 3;
 γ' is the effective unit weight below the groundwater level (kN/m^3);
 d is the depth below the ground surface (m); and
 d_w is the depth to the groundwater level (m), as given in Table 3.

The unfactored lateral resistance should be calculated assuming an equivalent pile width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to the unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States (ULS).

The undrained capacity of the caisson should also be checked to establish whether the drained or the undrained case will govern. For the undrained case, the lateral resistance for the length of the caisson within the cohesive soil should be calculated assuming an unfactored passive lateral pressure distribution varying from $2 s_u$ (undrained shear strength) at ground surface to $9 s_u$ at and below a depth equivalent to three pile diameters, acting over the actual width of the caisson. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance at ULS.

For both the drained and undrained cases, the passive resistance in front of the caisson within the upper 1.5 m below ground surface should be neglected in the design of the foundations to account for frost action.

6.2.2 Caisson Foundations Socketted into Rock

In accordance with Standard Drawing SS118-3 of MTO's *Sign Support Manual*, where bedrock is encountered at a depth, z (in metres), of less than 5 m below the bottom of the frost layer, the required depth (in metres) of the caisson foundation below the frost layer may be taken as:

$$z + [(5 - z) / 2]$$

Based on the above, the caissons at the overhead sign support locations will be socketted between 0.5 m and 2.5 m into the limestone bedrock, as summarized in the table below. It is noted that these estimated caisson lengths and bedrock socket lengths assume that the ground surface elevation at the borehole location is identical to that at the proposed sign support location. Variations in the ground surface or bedrock surface could result in shorter socket lengths; in this case, the socket length should be that calculated using the formula above or 0.3 m, whichever is greater.

<i>Sign</i>	<i>Support</i>	<i>Borehole No.</i>	<i>Depth to Bedrock</i>	<i>Total Caisson Length</i>	<i>Bedrock Socket Length</i>
County Road 38	Single	2	1.2 m	3.7 m	2.5 m
OH-1	North	07-2	5.6 m	6.1 m	0.5 m
OH-2	North	07-5	1.5 m	4.0 m	2.5 m
	South	07-6	2.6 m	4.5 m	2.0 m
OH-6	North	07-15	2.6 m	4.5 m	2.0 m
	South	07-16	3.7 m	5.1 m	1.4 m
OH-7	North	07-18	1.7 m	4.1 m	2.4 m
	South	07-17	4.3 m	5.4 m	1.1 m
OH-8	North	07-20	2.7 m	4.6 m	1.9 m
OH-8	South	07-19	4.1 m	5.3 m	1.2 m
OH-10	North	07-23	1.7 m	4.1 m	2.4 m
	South	07-24	2.0 m	4.3 m	2.3 m
OH-11	North	07-26	2.0 m	4.3 m	2.3 m
	South	07-25	2.2 m	4.4 m	2.2 m
OH-12	North	07-28	1.6 m	4.1 m	2.5 m
	South	07-27	1.3 m	3.8 m	2.5 m
Wolfe Island Ferry	North (Left)	07-WIF-1	3.0 m	4.8 m	1.8 m
	South (Right)	07-WIF-2	3.6 m	5.1 m	1.5 m

The limestone bedrock at the site is medium strong to very strong, and coring or churn drilling will be necessary to advance the socket into the bedrock. A socket length of up to 2.5 m would be required in the rock for these sign support locations; therefore, consideration could also be given to the use of foundations dowelled/anchored to the rock, to minimize coring in the medium strong to very strong bedrock. Recommendations for the design of rock dowels are provided in the following section.

6.2.3 Foundations Dowelled to Rock

Dowelling of concrete foundations (either spread footings or caissons) to the bedrock could be considered where the depth to bedrock is less than 2 m to 3 m, to minimize the amount of bedrock coring and/or churn drilling required for larger diameter caisson sockets. Dowelled caissons may also be considered for all other locations where bedrock will be encountered within the standard foundation depth.

Where dowelled/anchored foundations are adopted, subexcavation of any loose, fractured bedrock will be required prior to construction of the foundation on the bedrock surface. MTO's

Special Provision SP902S01 should be included in the Contract Documents requiring inspection and approval of the foundation area by the Quality Verification Engineer prior to footing construction, to ensure that all loose and/or fractured rock has been removed from the foundation areas prior to construction of the footings or caissons.

The horizontal resistance of the dowels is dependent on the strength of the bedrock, grout and steel. The dowels may be designed based on a factored lateral resistance for the rock mass at ULS of 5 MPa. The rock dowels should have a minimum embedded length within the bedrock of 1 m, except for the cantilever sign at County Road 38 where rock dowels should have a minimum embedded length within the bedrock of 2 m, to extend below the zone of fractured bedrock encountered in the borehole at this location. The structural strength of the dowel and the compressive strength of the grout should not be exceeded.

For uplift of the dowels, a factored value of 700 kPa may be assumed for the grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given and it should, therefore, be verified in the field by pull-out testing. It is recommended that, if this foundation type is selected, MTO's Special Provision for supply, installation and testing of dowels be included in the Contract Documents.

6.3 Construction Considerations

It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of the following items which are expected to affect the installation of the caisson foundations for the sign supports:

- **Control of overburden soils and groundwater:** Excavations for the sign foundations will be advanced through fill materials, cohesive and cohesionless soil deposits. Cohesionless soils should be expected to be unstable below the groundwater level. Appropriate equipment and construction procedures (such as the use of a temporary liner) will be required to construct the caissons where water-bearing cohesionless soils are present.
- **Rock fill:** Rock fill was encountered at some of the sign support locations, as noted on the borehole records and discussed in Section 4.2.2. Appropriate equipment and procedures will be required to penetrate the rock fill as part of caisson installation for the overhead sign supports.
- **Bedrock strength:** Some of the sign foundations will require sockets to be formed within the bedrock, which is medium strong to very strong. Appropriate equipment and construction procedures (such as rock coring or churn drilling techniques) will be required to advance the caisson holes into the bedrock.

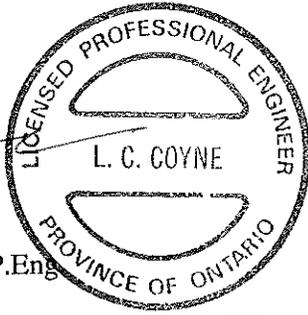
Sample NSSPs to address the control of overburden soils and groundwater, foundation construction through rock fill and bedrock strength are provided in Appendix A.

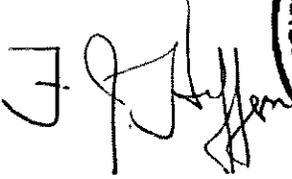
7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Karyn Gallant and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of the report.

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TABLE 1
SUMMARY OF POINT LOAD INDEX TEST RESULTS ON ROCK CORE SAMPLES

<i>Borehole Number</i>	<i>Depth (m)</i>	<i>Test Type</i>	<i>Is Axial (MPa)</i>	<i>Is Diametral (MPa)</i>	<i>Is₅₀ (MPa)</i>	<i>UCS* (MPa)</i>
07-5	3.9	Diametral		12.3	10.8	249
07-5	4.2	Diametral		7.9	7.0	161
07-6	3.8	Diametral		6.3	5.7	120
07-6	5.6	Axial	6.6		6.4	148
07-15	3.8	Diametral		7.7	6.9	158
07-15	4.9	Diametral		4.1	3.7	84
07-15	5.3	Diametral		4.0	3.6	83
07-16	4.9	Diametral		7.2	6.4	147
07-16	5.5	Diametral		8.1	7.1	164
07-16	6.5	Diametral		6.5	5.9	135
07-17	4.6	Diametral		4.7	4.4	100
07-17	4.9	Diametral		4.9	4.6	105
07-17	7.3	Diametral		3.3	3.1	71
07-18	2.3	Diametral		4.8	4.4	93
07-18	3.0	Axial	5.4		5.1	108
07-18	4.0	Diametral		6.9	6.3	132
07-19	5.1	Diametral		5.2	4.8	110
07-19	7.0	Diametral		4.6	4.3	99
07-19	7.2	Diametral		4.5	4.1	95
07-20	3.3	Diametral		4.7	4.3	90
07-20	4.8	Axial	4.7		4.6	107
07-23	2.2	Diametral		4.1	3.7	86
07-23	2.4	Diametral		4.2	3.9	89
07-23	3.6	Diametral		4.7	4.3	99
07-24	4.4	Diametral		4.9	4.5	104
07-24	4.6	Diametral		3.4	3.1	71
07-25	2.9	Diametral		5.1	4.7	107
07-25	3.1	Diametral		5.7	5.4	124
07-25	3.5	Diametral		4.3	3.9	90
07-26	3.0	Diametral		5.6	5.1	106
07-26	3.9	Axial	2.9		2.7	60
07-27	3.5	Diametral		0.5	0.4	10
07-28	2.4	Axial	3.6		3.6	83
07-28	3.6	Diametral		5.7	5.2	109
07-28	4.5	Diametral		0.6	0.5	11
07-WIF-1	3.5	Diametral		8.3	7.2	152
07-WIF-1	5.2	Axial	4.5		4.3	99
07-WIF-2	3.9	Diametral		6.9	6.3	132
07-WIF-2	4.9	Axial	9.0		8.2	181

Checked: K. GallantReviewed: L.C. Coyne

* The UCS values have been approximated using $Is_{50} \times 23$, from ISRM ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. Journal Rock Mech. Min. Sci. and Geomechanical Abstr., Vol. 22, No. 2, 1985, pp. 51-60.

TABLE 2
SUMMARY OF FEASIBLE FOUNDATION OPTIONS
OVERHEAD SIGN SUPPORT STRUCTURES
HIGHWAY 401 WIDENING FROM WEST OF SYDENHAM ROAD
TO WEST OF MONTREAL STREET, KINGSTON, ONTARIO
W.P. 77-99-01

<i>Sign</i>	<i>Support</i>	<i>Borehole No.</i>	<i>Depth to Bedrock (m)</i>	<i>Standard Caisson in Soil</i>	<i>Site-Specific Caisson in Soil</i>	<i>Caisson Socketted into Rock</i>	<i>Foundation Anchored to Rock</i>
County Rd 38	Single	2	1.2			X	X
OH-1	North	07-2	5.6			X	
	South	07-3	6.6	X			
OH-2	North	07-5	1.5			X	X
	South	07-6	2.6			X	X
OH-3	North	07-8	-	X			
	South	07-7	-	X			
OH-4	North	07-10	-	X			
	South	07-9	-	X			
OH-5	North	07-13	-	X			
	South	07-14	-	X			
OH-6	North	07-15	2.6			X	X
	South	07-16	3.7			X	X
OH-7	North	07-18	1.7			X	X
	South	07-17	4.3			X	X
OH-8	North	07-20	2.7			X	X
	South	07-19	4.1			X	X
OH-9	Single	07-21	-	X			
OH-10	North	07-23	1.7			X	X
	South	07-24	2.0			X	X
OH-11	North	07-26	2.0			X	X
	South	07-25	2.2			X	X
OH-12	North	07-28	1.6			X	X
	South	07-27	1.3			X	X
OH-13	West	07-11	-	X			
	East	07-12	-	X			
Wolfe Island Ferry	North (Left)	07-WIF-1	3.0			X	X
	South (Right)	07-WIF-2	3.6			X	X

TABLE 3
GEOTECHNICAL DESIGN PARAMETERS FOR TRICHORD OVERHEAD SIGN FOUNDATIONS
HIGHWAY 401 WIDENING FROM WEST OF SYDENHAM ROAD TO WEST OF MONTREAL STREET
KINGSTON, ONTARIO – W.P. 77-99-01

<i>Sign Support</i>	<i>Borehole No.</i>	<i>Stratum</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>	<i>Groundwater Elevation (m)</i>	s_u	ϕ'	γ	γ'	K_p
County Road 38 Single Support	2	Compact gravel fill	Above 1.2	Above 109.4	N/A	-	30	20	10	3.0
		Limestone bedrock	Below 1.2	Below 109.4		-	-	-	-	-
OH-1 North Support	07-2	Compact sand and gravel fill	Above 1.4	Above 99.5	96.5	-	30	20	10	3.0
		Firm to stiff clayey silt fill	1.4 – 3.7	99.5 – 97.2		50	28	19	9	2.8
		Very stiff silty clay	3.7 – 4.4	97.2 – 96.5		100	30	19	9	3.0
		Very stiff to hard clayey silt till	4.4 – 5.6	96.5 – 95.3		-	32	21	11	3.3
		Probable limestone bedrock	Below 5.6	Below 95.3		-	-	-	-	-
OH-1 South Support	07-3	Compact to very dense sand and gravel fill	Above 1.7	Above 99.5	96.5	-	30	20	10	3.0
		Firm to stiff silty clay fill/silty clay/clayey silt till	1.7 – 5.9	99.5 – 95.3		50	28	19	9	2.8
		Soft to firm silty clay/clayey silt till Stiff clayey silt till	Below 5.9	Below 95.3		100	30	21	11	3.0
OH-2 North Support	07-5	Loose to compact sand and gravel fill / Stiff clayey silt fill	Above 1.5	Above 94.1	92.0	-	30	20	10	3.0
		Limestone bedrock	Below 1.5	Below 94.1		-	-	-	-	-
OH-2 South Support	07-6	Very dense sand and gravel fill/rock fill	Above 2.6	Above 92.8	92.0	-	30	19	9	3.0
		Limestone bedrock	Below 2.6	Below 92.8		-	-	-	-	-
OH-3 North Support	07-8	Loose to compact sandy gravel fill	Above 5.0	Above 80.7	80.0	-	30	20	10	3.0
		Stiff silty clay to clay	Below 5.0	Below 80.7		75	28	19	9	2.8
OH-3 South Support	07-7	Loose to dense sandy gravel fill	Above 5.2	Above 80.3	80.0	-	30	20	10	3.0
		Stiff clayey silt fill/clay	Below 5.2	Below 80.3		75	28	19	9	2.8
OH-4 North Support	07-10	Compact to dense sand and gravel fill	Above 1.8	Above 85.2	81.0	-	30	20	10	3.0
		Firm to very stiff silty clay to clay	Below 1.8	Below 85.2		75	28	19	9	2.8

- NOTES:**
1. Depths are given for the borehole location; the ground surface elevation at the borehole location should be compared to the ground surface elevation at the actual sign support location, and the depths of the soil strata and depth to bedrock adjusted accordingly.
 2. Design parameters: c_u = undrained shear strength (kPa) ϕ' = effective friction angle (degrees)
 γ = bulk unit weight (kN/m³) γ' = effective unit weight below the groundwater level (kN/m³)
 K_p = passive earth pressure coefficient
 3. Although the passive resistance in the upper 1.5 m is neglected to account for frost action, c_u , ϕ' and K_p parameters are given in the event that the ground surface elevation varies significantly between the borehole and sign support locations.

TABLE 3 (Continued)
GEOTECHNICAL DESIGN PARAMETERS FOR TRICHORD OVERHEAD SIGN FOUNDATIONS
HIGHWAY 401 WIDENING FROM WEST OF SYDENHAM ROAD TO WEST OF MONTREAL STREET
KINGSTON, ONTARIO – W.P. 77-99-01

<i>Sign Support</i>	<i>Borehole No.</i>	<i>Stratum</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>	<i>Groundwater Elevation (m)</i>	s_u	ϕ'	γ	γ'	K_p
OH-12 North Support	07-28	Dense to very dense sand and gravel/ rock fill	Above 1.6	Above 111.5	110.0	-	30	20	10	3.0
		Limestone bedrock	Below 1.6	Below 111.5		-	-	-	-	-
OH-12 South Support	07-27	Compact sand and gravel fill	Above 1.3	Above 111.2	110.0	-	30	20	10	3.0
		Limestone bedrock	Below 1.3	Below 111.2		-	-	-	-	-
OH-13 West Support	07-11	Stiff silty clay fill/silty clay to clay	Above 3.8	Above 77.0	77.0	75	28	19	9	2.8
		Firm to stiff silty clay to clay	3.8 – 5.5	77.0 – 75.3		50	28	19	9	2.8
		Very loose silty sand till	Below 5.5	Below 75.3		-	28	21	11	2.8
OH-13 East Support	07-12	Loose sand and gravel fill	Above 1.4	Above 79.2	77.0	-	28	20	10	2.8
		Very stiff silty clay to clay	1.4 – 4.1	79.2 – 76.5		-	30	19	9	3.0
		Stiff silty clay to clay	4.1 – 5.3	76.5 – 75.3		65	28	19	9	2.8
		Loose sandy silt	Below 5.3	Below 75.3		-	28	21	11	2.8
Wolfe Island Ferry North (Left) Support	07-WIF-1	Compact to very loose sand and gravel fill	Above 3.0	To be confirmed	To be confirmed	-	28	20	10	2.8
		Limestone bedrock	Below 3.0			-	-	-	-	-
Wolfe Island Ferry South (Right) Support	07-WIF-2	Compact to dense sand and gravel fill	Above 2.1	To be confirmed	To be confirmed	-	30	20	10	3.0
		Loose to compact silty sand till	2.1 – 3.6			-	30	21	11	3.0
		Limestone bedrock	Below 3.6			-	-	-	-	-

- NOTES:**
1. Depths are given for the borehole location; the ground surface elevation at the borehole location should be compared to the ground surface elevation at the actual sign support location, and the depths of the soil strata and depth to bedrock adjusted accordingly.
 2. Design parameters: c_u = undrained shear strength (kPa); ϕ' = effective friction angle (degrees);
 γ = bulk unit weight (kN/m³); γ' = effective unit weight below the groundwater level (kN/m³); and
 K_p = passive earth pressure coefficient.
 3. Although the passive resistance in the upper 1.5 m is neglected to account for frost action, c_u , ϕ' and K_p parameters are given in the event that the ground surface elevation varies significantly between the borehole and sign support locations.

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
SS	Split-spoon
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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

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.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.)

Consistency

	kPa	c_u, s_u	psf
Very soft	0 to 12		0 to 250
Soft	12 to 25		250 to 500
Firm	25 to 50		500 to 1,000
Stiff	50 to 100		1,000 to 2,000
Very stiff	100 to 200		2,000 to 4,000
Hard	over 200		over 4,000

Dynamic Cone 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

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project 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.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (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 (LV-laboratory vane test)
γ	unit weight

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

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LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. General

π	3.1416
$\ln x$	natural logarithm of x
$\log_{10} x$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_i	sensitivity

- Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 Shear strength = (Compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: * Grains > 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	



PROJECT <u>021-1142</u>	RECORD OF BOREHOLE No 2	1 OF 1 METRIC
W.P. <u>76-99-01</u>	LOCATION <u>N 4905053.9 ; E 289229.7</u>	ORIGINATED BY <u>PKS</u>
DIST <u>41</u> HWY <u>401</u>	BOREHOLE TYPE <u>108mm ID Hollow Stem Auger</u>	COMPILED BY <u>JFC</u>
DATUM <u>Geodetic</u>	DATE <u>September 27, 2002</u>	CHECKED BY <u>LCC</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
110.6	GROUND SURFACE													
0.9	Silty Sand, trace clay to clayey silt with sand, some gravel, some styrofoam pieces (FILL) Compact/Stiff		1	SS	13									
109.4	Crushed limestone gravel (FILL) Compact		2	SS	24									
1.2	Limestone/Dolostone (BEDROCK) For bedrock coring details, refer to Record of Drillhole 2.													
106.3	NOTE: Borehole dry on completion of overburden drilling.													
4.3														

MIS-MTO 001 021-1142.GPJ GAL-MISS.GDT 5/26/08

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 021-1142

RECORD OF DRILLHOLE: 2

SHEET 1 OF 1

LOCATION: N 4905053.9 ; E 239229.7

DRILLING DATE: September 27, 2002

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-55 Bombardier

DRILLING CONTRACTOR: Marathon

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN NO.	PENETRATION RATE (m/min)	FLUSH	COLOUR	FR/FX-FRACTURE F-FAULT			SM-SMOOTH			FL-FLEXURED			BC-BROKEN CORE			NOTES WATER LEVELS INSTRUMENTATION	
									CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH. BREAK	RECOVERY	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY K, cm/sec				
									SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	B-BEDDING						TOTAL CORE %	SOLID CORE %		DIP W/L CORE AXIS
		Refer to Previous Page		1.24																		
2	CME-55 BOMBARDIER 128mm ID HOLLOW STEM AUGER	Limestone/Dolostone (Bedrock) with shale seams Slightly weathered to fresh Medium strong to strong Grey			1	0.1	50															
3																						
4					2	0.1	100															
5		END OF BOREHOLE		4.30																		
6																						
7																						
8																						
9																						
10																						
11																						

MIS-ROCK 001 1142-ROCK.GPJ GAL-MISS.GDT 5/28/08 JFC

DEPTH SCALE
1:50



LOGGED: PKS
CHECKED: LCC

RECORD OF BOREHOLE No 07-2 1 OF 1 **METRIC**

PROJECT 05-1111-031 LOCATION N 4904092.3 ; E 301679.7 ORIGINATED BY DM

W.P. 77-99-01 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG

DATUM Geodetic DATE January 23, 2007 CHECKED BY LCC

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								
						20	40	60	80	100						
100.9	GROUND SURFACE															
0.0	Sand and gravel (FILL) Compact Grey Moist		1	SS	18											
99.5																
1.4	Clayey silt, trace sand and gravel (FILL) Firm to stiff Brown Moist		2	SS	4											
98.3																
2.7	TOPSOIL Clayey silt, containing sand seams (Possible FILL) Firm Brown Moist		4	SS	7											
97.2																
3.7	SILTY CLAY, trace sand Very stiff Brown Moist		5	SS	15											
96.5																
4.4	CLAYEY SILT with sand, some gravel (TILL) Very stiff to hard Brown Wet		6	SS	20											27 42 19 12
95.3																
5.6	End of Borehole Auger Refusal Notes: 1. Water encountered at 5.2 m depth during drilling.		7	SS	300.13											

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE



RECORD OF BOREHOLE No 07-5

1 OF 1 **METRIC**

PROJECT 05-1111-031 LOCATION N 4904013.2 ; E 302097.6 ORIGINATED BY DM
 W.P. 77-99-01 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE January 29, 2007 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
95.6	GROUND SURFACE																
0.0	Sand and gravel (FILL) Loose to compact Grey Moist																
94.7			1	SS	8												
0.9	Clayey silt, trace sand and gravel (FILL) Stiff Brown Moist																
94.1			2	SS	5/0.15												
1.5	LIMESTONE (BEDROCK) containing shale seams Fresh Grey Medium strong to very strong Thinly bedded																RQD = 23%
	Bedrock cored from 1.5 m to 4.2 m depth. For bedrock coring details, refer to Record of Drillhole 07-5																
			3	RC	REC 35%												
			4	RC	REC 98%												
91.4																	
4.2	End of Borehole																
	Notes: 1. Borehole dry prior to start of rock coring operations.																

MIS-MTO-001_051111031.GPJ GAL-MISS.GDT 2/6/08

+3, X3, Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-5

SHEET 1 OF 1

LOCATION: N 4904013.2 ; E 302097.6

DRILLING DATE: January 29, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/hr)	FLUSH	COLOUR	% RETURN	RECOVERY			R.O.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY			Diameter of Test Load (MPa)	RWC % AVG.	NOTES WATER LEVELS INSTRUMENTATION	
										JN - Joint	BD - Bedding	PL - Planar			PG - Polished	BR - Broken Rock							
										FLT - Fault	FO - Foliation	CU - Curved			K - Slickensided	NOTE: For additional abbreviations refer to list of abbreviations & symbols							
		Continued from Record of Borehole 07-5		94.08																			
2	NG Rotary Coring, Uncased	LIMESTONE (BEDROCK) containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		1.52																			
3																							
4					4																		
4		End of Drillhole		91.36																			
4.24				4.24																			
5																							
6																							
7																							
8																							
9																							
10																							
11																							

MIS-RCK 004_051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1 : 50



LOGGED: DM
CHECKED: LCC

PROJECT <u>05-1111-031</u>	RECORD OF BOREHOLE No 07-6	1 OF 1 METRIC
W.P. <u>77-99-01</u>	LOCATION <u>N 4904003.4 :E 302095.1</u>	ORIGINATED BY <u>DM</u>
DIST <u>Eastern HWY 401</u>	BOREHOLE TYPE <u>Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers</u>	COMPILED BY <u>KG</u>
DATUM <u>Geodetic</u>	DATE <u>February 27, 2007</u>	CHECKED BY <u>LCC</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20 40 60 80 100	20 40 60 80 100	25 50 75					GR SA SI CL	
95.4 0.0	GROUND SURFACE ASPHALT														
0.3 94.5 0.9	Sand and gravel, trace silt and clay, containing cobbles (FILL) Very dense Grey Moist Gravel and cobbles, some sand (ROCK FILL) Very dense Grey Dry	█	1	SS	50/0.15										
		█	2	SS	113									39 52 7 2	
		█	3	SS	51/0.15										
92.8 2.6	LIMESTONE (BEDROCK) containing shale seams Fresh Grey Medium strong to very strong Thinly bedded Bedrock cored from 2.6 m to 5.8 m depth. For bedrock coring details, refer to Record of Drillhole 07-6	█	4	RC	REC 100%									RQD = 37%	
		█	5	RC	REC 100%									RQD = 84%	
		█	6	RC	REC 100%									RQD = 62%	
89.6 5.8	End of Borehole Notes: 1. Borehole dry prior to start of rock coring operations.														

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-6

SHEET 1 OF 1

LOCATION: N 4904003.4 ; E 302095.1

DRILLING DATE: February 27, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: --

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. (m)	RUN NO.	PENETRATION RATE mm/(m)	FLUSH	RECOVERY		R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY		Diameter of Point Load Index (MPa)	R.M.C. - Q AVG.	NOTES WATER LEVELS INSTRUMENTATION	
								TOTAL CORE %	SOLID CORE %			B Angle	DIP #1 CORE AXIS	Type and Surface Description	K, cm/sec	10'				
								FLY	SHR			UN	SM	10'	10'					
		Continued from Record of Borehole 07-6		92.78																
3		LIMESTONE (BEDROCK) containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		2.62	4		100	100	100											
4					5		100													
5					6		100													
6		End of Drillhole		89.59																
				5.81																
7																				
8																				
9																				
10																				
11																				
12																				

MIS-RCK 004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1 : 50



LOGGED: DM
CHECKED: LCC

RECORD OF BOREHOLE No 07-7

1 OF 1 **METRIC**

PROJECT 05-1111-031 LOCATION N 4903856.8 :E 302463.6 ORIGINATED BY DM
 W.P. 77-99-01 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE January 11, 2007 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
							20 40 60 80 100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	25 50 75				
85.5	GROUND SURFACE															
0.0	Sand and gravel (FILL) Grey															
85.0																
0.5	Clayey silt (FILL) Very stiff						85									
84.6	Grey-brown Moist		1	SS	28											
0.9	Sandy gravel, trace silt, containing cobbles (FILL) Loose to dense Grey-brown Moist		2	SS	13		84									
			3	SS	16		83								68 27 (5)	
			4	SS	6		82									
			5	SS	5		81									
			6	SS	30		80									
80.3	Clayey silt, trace sand and gravel (FILL) Stiff		7	SS	8		80									
79.6	Brown Moist															
5.9	CLAY, trace sand Stiff		8	SS	12		79									
79.0	Brown Moist															
6.6	End of Borehole															
	Notes: 1. Borehole dry upon completion of drilling.															

MIS-MTO 001_051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-8

 1 OF 1 **METRIC**

PROJECT 05-1111-031 LOCATION N 4903864.5 , E 302465.0 ORIGINATED BY DM
 W.P. 77-99-01 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE February 28, 2007 CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
85.7	GROUND SURFACE													
0.0	ASPHALT													
85.3														
0.4	Sand and gravel (FILL) Brown Dry													
84.7														
1.0	Sandy gravel, trace silt, containing cobbles/boulders (ROCK FILL) Grey-brown Loose to compact Dry		1	SS	9									
			2	SS	17									
			3	SS	5									
			4	SS	8									
			5	SS	8									
80.7														
5.0	SILTY CLAY to CLAY, trace sand Stiff Brown Moist		6	SS	11									
79.8														
5.9	End of Borehole Notes: 1. Borehole dry upon completion of drilling.													

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08



PROJECT 05-1111-031 **RECORD OF BOREHOLE No 07-9** 1 OF 1 **METRIC**
 W.P. 77-99-01 LOCATION N 4903644.7 E 302984.8 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE January 29, 2007 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
86.3 0.0	GROUND SURFACE Sand and gravel (FILL) Compact Grey Moist																
85.2 1.1	Silty clay, trace to some sand, trace gravel, containing organics (FILL) Stiff to very stiff Brown to grey-brown Moist		1	SS	25												
			2	SS	19												
			3	SS	10												0 14 44 42
			4	SS	9												
82.6 3.7	SILTY CLAY, trace sand and gravel Stiff to very stiff Brown to grey-brown Moist		5	SS	13												
			6	SS	16												
		7	SS	10													
80.2 6.1	End of Borehole Notes: 1. Borehole dry upon completion of drilling.																

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○³ STRAIN AT FAILURE

PROJECT <u>05-1111-031</u>	RECORD OF BOREHOLE No 07-10	1 OF 1 METRIC
W.P. <u>77-99-01</u>	LOCATION <u>N 4903666.6 ; E 302993.3</u>	ORIGINATED BY <u>DM</u>
DIST <u>Eastern HWY 401</u>	BOREHOLE TYPE <u>Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers</u>	COMPILED BY <u>KG</u>
DATUM <u>Geodetic</u>	DATE <u>March 1, 2007</u>	CHECKED BY <u>LCC</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
87.0	GROUND SURFACE																
0.0	ASPHALT																
86.6																	
0.4	Sand and gravel, containing clayey silt pockets (FILL) Compact to dense Brown Moist		1	SS	38		86										
85.2			2	SS	9												
1.8	SILTY CLAY to CLAY, trace to some sand, trace gravel, containing silt seams and layers Firm to very stiff Grey-brown Moist		3	SS	5		85										0 8 39 53
			4	SS	12		84										
			5	SS	17		83										
			6	SS	9		82										
81.1			7	SS	8												
5.9	End of Borehole																
	Notes: 1. Borehole dry upon completion of drilling.																

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

PROJECT 05-1111-031 **RECORD OF BOREHOLE No 07-11** 1 OF 1 **METRIC**

W.P. 77-99-01 LOCATION N 4903329.6 ; E 303242.1 ORIGINATED BY DM

DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG

DATUM Geodetic DATE January 16, 2007 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			20	40					
80.8	GROUND SURFACE													
80.0	ASPHALT													
80.0	Gravel, trace to some sand (FILL) Compact Grey Moist		1	SS	10									
79.6	Silly clay, trace sand (FILL) Stiff Brown Moist		2	SS	8									
79.6	SILTY CLAY to CLAY, trace sand Stiff Brown Moist		3	SS	3									
77.0	SILTY CLAY to CLAY Firm to stiff Grey Moist to wet		4	SS	PM	▽							0 0 44 56	
75.3	SILTY SAND, trace to some gravel, trace clay (TILL) Very loose Grey Wet End of Borehole		5	SS	1									

Notes:
1. Water encountered at 3.7 m depth during drilling.

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-12

1 OF 1 **METRIC**

PROJECT 05-1111-031 LOCATION N 4903322.0 ; E 303270.6 ORIGINATED BY DM
 W.P. 77-99-01 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE January 16, 2007 CHECKED BY LCC

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								WATER CONTENT (%)					
						20	40	60	80	100	20	40	60	80	100	25	50	75		GR SA SI CL	
80.6	GROUND SURFACE																				
0.0	Sand and gravel, some silt, trace clay (FILL) Loose Brown Moist		1	SS	6																
79.2																					
1.4	SILTY CLAY to CLAY, trace sand and gravel Stiff to very stiff Brown Moist		2	SS	14																
	Becoming grey-brown at 3.8 m depth		3	SS	13																
			4	SS	8																
			5	SS	4				+												0 0 45 55
75.3	Becoming grey at 5.2 m depth																				
5.3	SANDY SILT, trace gravel and clay (TILL)		6	SS	3																
74.8	Loose Grey Wet																				
5.8	End of Borehole																				
	Notes: 1. Borehole dry upon completion of drilling.																				

MIS-MTO 001_051111031.GPJ GAL-MISS.GDT 2/8/08

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-13

1 OF 1 **METRIC**

PROJECT 05-1111-031
 W.P. 77-99-01 LOCATION N 4903526.0 ; E 303416.1 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE January 18, 2007 CHECKED BY LCC

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					
88.7 0.0	GROUND SURFACE Sand and gravel (FILL) Compact Grey Moist		1	SS	19										
87.4 1.3	Silly sand, trace gravel, containing clayey silt zones (FILL) Loose Brown Moist		2	SS	5									3 53 22 22	
86.6 2.1	SILTY CLAY to CLAY, trace to some sand Stiff to very stiff Brown Moist		3	SS	10										
			4	SS	13										
			5	SS	20										
			6	SS	17										
82.9 82.6 6.1	SILTY CLAY, trace sand, containing silt seams Firm Grey Moist End of Borehole Notes: 1. Borehole dry upon completion of drilling.		7	SS	6										

MIS-MTO 001_051111031.GPJ_GAL-MISS.GDT_2/8/08

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE



RECORD OF BOREHOLE No 07-15

1 OF 1 **METRIC**

PROJECT 05-1111-031 W.P. 77-99-01 LOCATION N 4903381.4 ; E 303828.6 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE January 22, 2007 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
90.2	GROUND SURFACE																
0.0	Sand and gravel (FILL) Grey																
89.6	Silty clay, trace sand and gravel (FILL)		1	SS	25												
0.8	Sand and gravel, some silt (FILL)																
88.8	Compact Grey Moist		2	SS	15												
1.4	Clayey silt, some sand and gravel (FILL)																
88.1	Very stiff Brown Moist		3	SS	15												
2.1																	
87.6																	
2.6	SILTY SAND, some gravel, trace clay (TILL) Compact Brown Moist		4	RC	REC 89%												RQD = 35%
	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		5	RC	REC 100%												RQD = 82%
	Bedrock cored from 2.6 m to 5.4 m depth. For bedrock coring details, refer to Record of Drillhole 07-15		6	RC	REC 83%												RQD = 27%
84.8																	
5.4	End of Borehole Notes: 1. Borehole dry prior to start of rock coring operations.																

MIS-MTC 001 051111031.GPJ GAL-MISS.GDT 2/8/08

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-15

SHEET 1 OF 1

LOCATION: N 4903381.4 ; E 303828.6

DRILLING DATE: January 22, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	RECOVERY			FRACT INDEX PER 0.3 m	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter (mm)	Q (kg)	AVG.	NOTES WATER LEVELS INSTRUMENTATION			
								TOTAL CORE %	SOLID CORE %	R.Q.D. %		Dip	Angle	W	Jr	Ja	Jh					K _v	K _t	K _h
								0-30	30-60	60-90		0-30	30-60	60-90	0-30	30-60	60-90					0	1	2
		Continued from Record of Borehole 07-15		87.61																				
3		LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded - Soil infilling at 3.65 m - Weathered rock and vertical fracture from 4.60 m to 4.90 m		2.59																				
4																								
5																								
6		End of Drillhole		84.84																				
6				5.36																				
7																								
8																								
9																								
10																								
11																								
12																								

MIS-RCK.04_051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE

1 : 50



LOGGED: DM

CHECKED: LCC



RECORD OF BOREHOLE No 07-16

1 OF 1 **METRIC**

PROJECT 05-1111-031 LOCATION N 4903368.4 ; E 303825.7 ORIGINATED BY DM
 W.P. 77-99-01 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DIST Eastern HWY 401 DATE January 31, 2007 CHECKED BY LCC
 DATUM Geodetic

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	"N" VALUES			20	40	60					
91.2	GROUND SURFACE														
0.0	ASPHALT						91								
0.2	Sand and gravel, trace silt (FILL) Compact Grey-brown to grey Moist	[Pattern]	1	SS	29		90								
89.0	Sand and silt to sandy silt, some gravel, containing organics (FILL) Compact to loose Grey-brown Moist	[Pattern]	2	SS	17		89								
		[Pattern]	3	SS	9		88								
87.5	Silty SAND, trace gravel and clay (TILL) Compact Brown Moist	[Pattern]	4	SS	11		87							9 63 (28)	
86.8	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded	[Pattern]	5	RC	REC 100%		86							RQD = 64%	
	Bedrock cored from 4.4 m to 7.4 m depth. For bedrock coring details, refer to Record of Drillhole 07-16	[Pattern]	6	RC	REC 95%		85							RQD = 65%	
83.8	End of Borehole						84								
7.4	Notes: 1. Borehole dry prior to start of rock coring operations.														

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+ 3, X 3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-16

SHEET 1 OF 1

LOCATION: N 4903368.4 ;E 303825.7

DRILLING DATE: January 31, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: --

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. (m)	RUN NO.	PENETRATION RATE (mm/min)	FLUSH	COLOUR	% RETURN	JN - Joint		BD - Bedding		PL - Planar		PO - Polished		BR - Broken Rock		NOTES: For additional abbreviations refer to list of abbreviations & symbols.	WATER LEVELS INSTRUMENTATION	
										RECOVERY		FRACT INDEX		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY		Diameter				
										TOTAL CORE %	SOLID CORE %	R.Q.D. %	INDEX PER 0.3 m	B Angle	DIP W/1 CORE AXIS	K, cm/sec	Point Load Index (MPa)	1" DIA	1/2" DIA			
		Continued from Record of Borehole 07-16		86.78																		
5	NG Rotary Coring, Uncased	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded - Fractured zone at 4.72 m		4.42																		
6																						
7																						
8		End of Drillhole		83.76																		
9				7.44																		
10																						
11																						
12																						
13																						
14																						

MIS-RCK 004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE

1 : 50



LOGGED: DM

CHECKED: LCC

RECORD OF BOREHOLE No 07-17

1 OF 1 **METRIC**

PROJECT 05-1111-031 LOCATION N 4903308.3 E 304024.7 ORIGINATED BY DM
 W.P. 77-99-01 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DIST Eastern HWY 401 DATE January 24, 2007 CHECKED BY LCC
 DATUM Geodetic

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					
92.0 0.0	GROUND SURFACE Sand and gravel (FILL) Compact Grey Moist		1	SS	22											
90.6 1.4	Clayey silt, some sand, trace gravel (FILL) Stiff Grey-brown Moist		2	SS	8											
89.9 2.1	Sandy silt, trace gravel and clay, containing clayey silt zones and organics (FILL) Compact Brown to grey Moist		3	SS	19										1 21 59 19	
			4	SS	13											
			5	SS	19											
87.7 4.3	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded Bedrock cored from 4.3 m to 7.5 m depth. For bedrock coring details, refer to Record of Drillhole 07-17		6	RC	REC 100%										RQD = 63%	
			7	RC	REC 78%										RQD = 43%	
			8	RC	REC 100%										RQD = 59%	
84.5 7.5	End of Borehole Note: 1. Borehole dry prior to start of rock coring operations.															

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-17

SHEET 1 OF 1

LOCATION: N 4903308.3 ;E 304024.7

DRILLING DATE: January 24, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		PENETRATION RATE min/m	FLUSH % RETURN	RECOVERY		R.O.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY K, cm/sec			Diameter Load Index (MPa)	RVC AVG	NOTES WATER LEVELS INSTRUMENTATION		
				DEPTH (m)	RUN NO.			TOTAL CORE %	SOLID CORE %			θ Angle	DIP w/rl CORE AXIS	J	Ja	Jn	10 ⁻²				10 ⁻¹	10 ⁰
		Continued from Record of Borehole 07-17		87.73																		
5	NG Rotary Casing, Uncased	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded - Weathered and broken zone from 6.0 m to 6.6 m		4.27																		
6																						
7																						
8		End of Drillhole		84.53																		
				7.47																		
9																						
10																						
11																						
12																						
13																						
14																						

MIS-RCK 004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1: 50



LOGGED: DM
CHECKED: LCC

PROJECT 05-1111-031

RECORD OF BOREHOLE No 07-18

1 OF 1 **METRIC**

W.P. 77-99-01

LOCATION N 4903318.5 ; E 304025.6

ORIGINATED BY DM

DIST Eastern HWY 401

BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers

COMPILED BY KG

DATUM Geodetic

DATE March 27, 2007

CHECKED BY LCC

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 (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20	40	60	80
91.8	GROUND SURFACE																				
0.0	ASPHALT																				
	Sand and gravel (FILL)																				
0.4	ASPHALT																				
	Sand and gravel, trace to some silt (FILL)																				
	Compact Brown Moist		1	SS	26																
90.1			2	SS	14/0.15																
1.7	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		3	RC	REC 76%															39 40 14 7	
	Bedrock cored between 1.7 and 4.6 m depth. For bedrock coring details, refer to Record of Drillhole 07-18.		4	RC	REC 86%																RQD = 44%
			5	RC	REC 100%																RQD = 50%
87.2																					RQD = 76%
4.6	End of Borehole																				
	Note: 1. Borehole dry prior to start of rock coring operations.																				

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+3, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031
 LOCATION: N 4903318.5 ; E 304025.6
 INCLINATION: -90° AZIMUTH: --

RECORD OF DRILLHOLE: 07-18

DRILLING DATE: March 27, 2007
 DRILL RIG: CME-75
 DRILLING CONTRACTOR: Marathon Drilling Ltd.

SHEET 1 OF 1
 DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PENETRATION RATE (m/min)	RUN No.	F LUSH	R.O.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA				HYDRALLIC CONDUCTIVITY		Diameter Point Load Index (MPa)	RQD %	NOTES WATER LEVELS INSTRUMENTATION
										RECOVERY		DISCONTINUITY DATA		K, cm/sec				
										TOTAL CORE %	SOLID CORE %	Type and Surface Description	Angle	Dip w/rl Core Axis	Jr			
		Continued from Record of Borehole 07-18		90.13														
2		LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded -Fractured between 1.7 m to 2.0 m -Thin soil infills at 2.1 m to 2.5 m - Vertical fractures, slightly weathered at 3.1 m and 3.3 m		1.67														
3																		
4																		
5		End of Drillhole		87.20 4.60														
6																		
7																		
8																		
9																		
10																		
11																		

MIS-RCK 004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1 : 50



LOGGED: DM
CHECKED: LCC

PROJECT 05-1111-031 **RECORD OF BOREHOLE No 07-19** 1 OF 1 **METRIC**

W.P. 77-99-01 LOCATION N 4903268.0 E 304401.8 ORIGINATED BY DM

DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG

DATUM Geodetic DATE January 24, 2007 CHECKED BY LCC

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			20	40	60					
90.8 0.0	GROUND SURFACE Sand and gravel to gravel, some sand, containing cobbles (FILL) Compact Grey Moist		1	SS	20										
			2	SS	42										
88.7 2.1	Clayey silt with sand, trace gravel, containing organics (FILL) Stiff Dark brown to grey Moist		3	SS	9										
			4	SS	8										
			5	SS	8										
86.7 4.1	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded Bedrock cored from 4.1 m to 7.4 m depth. For bedrock coring details, refer to Record of Drillhole 07-19	7	RC	REC 75%										RQD = 0%	
		8	RC	REC 93%										RQD = 31%	
		9	RC	REC 100%										RQD = 69%	
83.4 7.4	End of Borehole Note: 1. Borehole dry prior to start of rock coring operations.														

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 05-1111-031
RECORD OF BOREHOLE No 07-20

 1 OF 1 **METRIC**

 W.P. 77-99-01

 LOCATION N 4903282.6 ; E 304410.2

 ORIGINATED BY DM

 DIST Eastern HWY 401

 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers

 COMPILED BY KG

 DATUM Geodetic

 DATE March 27, 2007

 CHECKED BY LCC

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						25
90.9	GROUND SURFACE																	
0.0	ASPHALT																	
0.3	Sand, some gravel and silt, trace clay (FILL) Dense Grey Moist		1	SS	38													
89.7																		
1.2	Gravel and cobbles, some sand, trace silt (ROCK FILL) Compact Grey Dry		2	SS	26													
89																		
88.2			3	SS	13													
2.7	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		4	RC	REC 100%													
88																		
87	Bedrock cored between 2.7 and 5.2 m depth. For bedrock coring details, refer to Record of Drillhole 07-20.		5	RC	REC 67%													RQD = 42%
86																		
85.7			6	RC	REC 96%													RQD = 42%
5.2	End of Borehole																	
	Note: 1. Borehole dry prior to start of rock coring operations.																	

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

 +³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-20

SHEET 1 OF 1

LOCATION: N 4903282.6 ; E 304410.2

DRILLING DATE: March 27, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PENETRATION RATE (mm/min)	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY		Cemental Point Load Index (MPa)	RVC % AVG.	NOTES WATER LEVELS INSTRUMENTATION	
							TOTAL CORE %	SOLID CORE %			B Angle	DIP/VERT CORE AXIS	K ₁	K ₂				
							JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate	BD - Bedding FD - Foliation CO - Contact OR - Orthogonal CL - Cleavage			PL - Planar CU - Curved LIJ - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth Ro - Rough NB - Mechanical Break	BR - Broken Rock					
		Continued from Record of Borehole 07-20		89.16														
3		LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		2.74														
4																		
5																		
6		End of Drillhole		85.72														
7																		
8																		
9																		
10																		
11																		
12																		

MIS-ROK-004_051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1 : 50



LOGGED: DM
CHECKED: LCC

PROJECT <u>05-1111-031</u>	RECORD OF BOREHOLE No 07-21	1 OF 1 METRIC
W.P. <u>77-99-01</u>	LOCATION <u>N 4903260.3 ; E 304822.3</u>	ORIGINATED BY <u>DM</u>
DIST <u>Eastern</u> HWY <u>401</u>	BOREHOLE TYPE <u>Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers</u>	COMPILED BY <u>KG</u>
DATUM <u>Geodetic</u>	DATE <u>January 22, 2007</u>	CHECKED BY <u>LCC</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100	20 40 60 80 100	25 50 75					
87.9	GROUND SURFACE														
0.0	ASPHALT														
0.3	Sand and gravel to sand, trace gravel (FILL) Compact Brown to grey Moist		1	SS	26										
			2	SS	20										
85.8	Clayey silt, trace sand and gravel (FILL) Very stiff to hard Brown Moist		3	SS	47										
2.3	Gravel and cobbles, some sand (ROCK FILL) Loose to dense Grey Moist		4	SS	12										
			5	SS	5										
			6	SS	8										
			7	SS	24										
82.0	TOPSOIL Clayey silt with sand to some sand, trace gravel (FILL) Stiff to very stiff Grey-brown Moist		8	SS	10										
6.0			9	SS	16									4 23 41 32	
80.4	SILTY CLAY, trace gravel Stiff Brown Moist		10	SS	14										
79.8															
8.1	End of Borehole Note: 1. Borehole dry upon completion of drilling.														

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-23

SHEET 1 OF 1

LOCATION: N 4903478.5 ; E 305775.2

DRILLING DATE: January 22, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLOR	% RETURN	RECOVERY		R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter Point Load Index (MPa)	RWC % AVG.	NOTES WATER LEVELS INSTRUMENTATION			
										TOTAL CORE %	SOLID CORE %			B Angle	DIP w/1 CORE AXIS	Jr	Jv	Jh	K, cm/sec				10 ⁻⁸	10 ⁻⁷	10 ⁻⁶
										UN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Congregate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage			PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break	BR - Broken Rock									
		Continued from Record of Borehole 07-23		108.83																					
2		LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		1.67																					
3		-Vertical and horizontal seams from 2.21 m to 4.06 m infilled with calcite																							
4		End of Drillhole		106.44 4.06																					
5																									
6																									
7																									
8																									
9																									
10																									
11																									

MIS-RCK.004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1 : 50



LOGGED: DM
CHECKED: LCC

PROJECT <u>05-1111-031</u>	RECORD OF BOREHOLE No 07-24	1 OF 1 METRIC
W.P. <u>77-99-01</u>	LOCATION <u>N 4903471.6, E 305780.3</u>	ORIGINATED BY <u>DM</u>
DIST <u>Eastern HWY 401</u>	BOREHOLE TYPE <u>Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers</u>	COMPILED BY <u>KG</u>
DATUM <u>Geodetic</u>	DATE <u>January 29, 2007</u>	CHECKED BY <u>LCC</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
		NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					PLASTIC LIMIT	W _p	LIQUID LIMIT			W _L	WATER CONTENT (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT					20	40	60	80	100	20	40	60	80	100	25	50	75	γ	GR SA SI CL	
110.6	GROUND SURFACE																					
0.0	ASPHALT																					
0.1	Gravelly sand, trace silt (FILL) Dense Brown Moist																					
109.5			1	SS	35																	25 67 (8)
1.1	Sand and gravel, containing cobbles (FILL) Very loose Grey Moist																					
108.7			2	SS	2																	
2.0	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded																					
	Bedrock cored from 2.0 m to 4.6 m depth. For bedrock coring details, refer to Record of Drillhole 07-24																					
			3	RC	REC 96%																	RQD = 73%
			4	RC	REC 98%																	RQD = 46%
106.0	End of Borehole																					
4.6	Note: 1. Borehole dry prior to start of rock coring operations.																					

MIS-MTC 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-24

SHEET 1 OF 1

LOCATION: N 4903471.6 E 305780.3

DRILLING DATE: January 29, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		PENETRATION RATE (min/m)	FLUSH	RECOVERY			R.O.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter of Point Load Index (RPS)	RMC - Q AVG.	
				DEPTH (m)	RUN NO.			TOTAL CORE %	SOLID CORE %	BD			FO	PL	PO	BR	K _v cm/sec	K _h cm/sec			K _z cm/sec
										UN - Joint			BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock					
2		Continued from Record of Borehole 07-24		108.65																	
		LIMESTONE (BEDROCK), containing shale seams		1.95																	
		Fresh Grey Medium strong to very strong Thinly bedded		3																	
		- Fractured zones between 1.95 m to 2.06 m and 3.58 m to 3.74 m																			
		- Horizontal infilled seams, occasional calcite inclusions																			
				4																	
		End of Drillhole		105.98																	
				4.62																	
5																					
6																					
7																					
8																					
9																					
10																					
11																					

MIS-RCK.004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1:50



LOGGED: DM
CHECKED: LCC

PROJECT 05-1111-031 **RECORD OF BOREHOLE No 07-25** 1 OF 1 **METRIC**
 W.P. 77-99-01 LOCATION N 4903545.5 ; E 305911.3 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE January 24, 2007 CHECKED BY LCC

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						25
110.0	GROUND SURFACE																	
0.0	Sand, trace gravel to sand and gravel, containing cobbles (FILL) Compact to dense Grey Moist		1	SS	32													
108.6																		
1.4	Sandy silt, trace gravel, containing organics (FILL) Loose to very dense Brown to grey-brown Moist		2	SS	4													
107.8																		
2.2	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		3	SS	36/0.05													RQD = 37%
	Bedrock cored from 2.2 m to 5.4 m depth. For bedrock coring details, refer to Record of Drillhole 07-25		4	RC	REC 94%													RQD = 72%
			5	RC	REC 99%													
			6	RC	REC 100%													RQD = 85%
104.6	End of Borehole																	
5.4	Note: 1. Borehole dry prior to start of rock coring operations.																	

MIS-MTO 001_051111031.GPJ GAL-MISS.GDT 2/8/08

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-25

SHEET 1 OF 1

LOCATION: N 4903545.5 ; E 305911.3

DRILLING DATE: January 24, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: --

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. (m)	RUN NO.	PENETRATION RATE (mm/min)	FLUSH	RECOVERY		R.O.D. (%)	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter (mm)	R.I.C. (°) AVG.			
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	K, cm/sec	T	C						
								FLUSH	FLUSH			FLUSH	FLUSH	FLUSH	FLUSH	FLUSH						
		Continued from Record of Borehole 07-25		107.80																		
3	NO Rotary Coring, Uncased	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		2.20																		
4																						
5																						
6																						
		End of Drillhole		104.59 5.41																		
8																						
9																						
10																						
11																						
12																						

MIS-RCK 004_051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1 : 50



LOGGED: DM
CHECKED: LCC

PROJECT 05-1111-031 **RECORD OF BOREHOLE No 07-26** 1 OF 1 **METRIC**
 W.P. 77-99-01 LOCATION N 4903552.2 ; E 305906.6 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE March 8, 2007 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
							20 40 60 80 100									
							20 40 60 80 100									
111.3	GROUND SURFACE															
0.0	ASPHALT															
0.2	Sand and gravel to gravel, some sand, trace silt, containing cobbles (FILL) Dense to very dense Brown to grey Moist		1	SS	36/0.28											
109.9	Clayey silt, some sand, trace gravel (FILL) Stiff Grey-brown Moist		2	SS	8											
109.3	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		3	RC	REC 99%											RQD = 31%
2.0	Bedrock cored from 2.0 m to 4.5 m depth. For bedrock coring details, refer to Record of Drillhole 07-26		4	RC	REC 87%											RQD = 65%
106.8	End of Borehole															
4.5	Note: 1. Borehole dry prior to start of rock coring operations.															

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 05-1111-031	RECORD OF BOREHOLE No 07-27	1 OF 1 METRIC
W.P. 77-99-01	LOCATION N 4903802.8 ; E 306270.6	ORIGINATED BY DM
DIST Eastern HWY 401	BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers	COMPILED BY KG
DATUM Geodetic	DATE January 24, 2007	CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							PLASTIC LIMIT w_p
							20 40 60 80 100								
112.5	GROUND SURFACE														
0.0	Sand and gravel (FILL) Compact Brown Moist														
111.7			1	SS	25/0.15		112								
111.2	Clayey silt, some sand (FILL) Sand and gravel, containing cobble (FILL) Compact Brown Moist														RQD = 27%
1.3			2	RC	REC 63%		111								
	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded														RQD = 28%
			3	RC	REC 68%		110								
109.0	Bedrock cored from 1.3 m to 3.6 m depth. For bedrock coring details, refer to Record of Drillhole 07-27														RQD = 21%
3.6	End of Borehole		4	RC	REC 76%		109								
	Note: 1. Borehole dry prior to start of rock coring operations.														

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-27

SHEET 1 OF 1

LOCATION: N 4903802.8 ; E 306270.6

DRILLING DATE: January 24, 2007

DATUM: Geodetic

INCLINATION: -90° AZMUTH: --

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.														NOTES WATER LEVELS INSTRUMENTATION									
				DEPTH (m)	RUN NO.	PENETRATION RATE min/m	FLUSH % RETURN	RECOVERY		R.O.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec			Diameter Point Load Index (MPa)	RQC AVG.							
								TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION	Jr	Jv	Jh	TO ₁	TO ₂				TO ₃						
		Continued from Record of Borehole 07-27		111.21																							
2	N.Q. Rotary Coring, Unceased	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		1.29																							
3																											
4																											
4																											
4		End of Drillhole		108.95																							
3.55																											

MIS-RCK 004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE
1:50



LOGGED: DM
CHECKED: LCC

PROJECT 05-1111-031 **RECORD OF BOREHOLE No 07-28** 1 OF 1 **METRIC**
 W.P. 77-99-01 LOCATION N 4903812.5 ; E 306263.8 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE March 12, 2007 CHECKED BY LCC

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									WATER CONTENT (%)	
						20	40	60	80	100								
113.1	GROUND SURFACE																	
0.0	ASPHALT																	
0.2	Sand and gravel, some silt, trace clay (FILL)																	
112.2	Dense to very dense Brown Moist		1	SS	87										41	46	10	3
0.9	Gravel and cobbles (ROCK FILL)																	
111.5	Very dense Grey Dry		2	SS	56/0.10													
1.6	LIMESTONE (BEDROCK), containing shale seams																	
	Fresh Grey Medium strong to very strong Thinly bedded		3	RC	REC 92%													RQD = 19%
	Bedrock cored from 1.6 m to 4.7 m depth. For bedrock coring details, refer to Record of Drillhole 07-28																	
			4	RC	REC 100%													RQD = 73%
108.5	End of Borehole																	
4.7	Note: 1. Borehole dry prior to start of rock coring operations.																	

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-28

SHEET 1 OF 1

LOCATION: N 4903812.5 E 306263.8

DRILLING DATE: March 12, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE	FLUSH	RECOVERY		R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY			Diameter of Core (mm)	RVC %	NOTES WATER LEVELS INSTRUMENTATION	
								TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION		K, cm/sec		Point Load Index (MPa)						
								100	100			1	2	1	2		1	2				
		Continued from Record of Borehole 07-28		111.48																		
2		LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		1.62																		
3		- Moderately weathered and fractured between 1.58 m and 1.91 m - Fractured between 2.59 m and 2.66 m - Fractured between 3.09 m and 3.32 m																				
4																						
5		End of Drillhole		108.45																		
6				4.65																		
7																						
8																						
9																						
10																						
11																						

MIS-RCK-004 051111031.GPJ GAL-MISS.GDT 2/8/08

DEPTH SCALE

1 : 50



LOGGED: DM

CHECKED: LCC

PROJECT 05-1111-031 **RECORD OF BOREHOLE No 07-WIF-1** 1 OF 1 **METRIC**
 W.P. 77-99-01 LOCATION N 4899164.0 E 306514.4 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE March 26, 2007 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)		
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)	
								20	40	60	80	100	25	50	75	GR	SA	SI	CL
0.0	GROUND SURFACE																		
0.1	ASPHALT																		
	Sand and gravel, some silt, trace clay, containing asphalt and brick fragments (FILL) Compact to very loose Brown to grey Moist		1	SS	28								○						38 41 15 6
			2	SS	4														
			3	SS	8								○						
3.0	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		5	RC	REC 100%														RQD = 72%
	Bedrock cored between 3.0 and 5.4 m depth. For bedrock coring details, refer to Record of Drillhole 07-WIF-1.		6	RC	REC 95%														RQD = 51%
			7	RC	REC 100%														RQD = 62%
5.4	End of Borehole Note: 1. Borehole dry prior to start of rock coring operations.																		

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+³, X³: Numbers refer to Sensitivity ○³ STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-WIF-2

1 OF 1 **METRIC**

PROJECT 05-1111-031 W.P. 77-99-01 LOCATION N 4899161.4 ; E 306510.5 ORIGINATED BY DM
 DIST Eastern HWY 401 BOREHOLE TYPE Track-Mounted C.M.E. 75, 200mm O.D. Hollow Stem Augers COMPILED BY KG
 DATUM Geodetic DATE March 26, 2007 CHECKED BY LCC

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								
							20	40	60	80	100					
0.0	GROUND SURFACE															
0.1	ASPHALT															
	Sand and gravel, trace silt and clay, containing cobbles, asphalt and brick fragments (FILL) Dense to compact Brown to grey Moist		1	SS	40											41 45 9 5
			2	SS	12											
2.1	Silty SAND, some gravel, trace clay (TILL) Loose to compact Brown Moist		3	SS	8											
			4	SS	10											
3.6	LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		5	RC	REC 93%											RQD = 27%
	Bedrock cored between 3.6 and 6.1 m depth. For bedrock coring details, refer to Record of Drillhole 07-WIF-2.		6	RC	REC 95%											RQD = 70%
6.1	End of Borehole Note: 1. Borehole dry prior to start of rock coring operations.															

MIS-MTO 001 051111031.GPJ GAL-MISS.GDT 2/8/08

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 05-1111-031

RECORD OF DRILLHOLE: 07-WIF-2

SHEET 1 OF 1

LOCATION: N 4899161.4 ; E 306510.5

DRILLING DATE: March 26, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-75

DRILLING CONTRACTOR: Marathon Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLOUR	% RETURN	RECOVERY				R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter of Point Load Factor (MPa)	RVC %	NOTES WATER LEVELS INSTRUMENTATION
										JN - Joint	BD - Bedding	PL - Planar	PO - Polished			BR - Broken Rock								
										FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided			NOTE: For additional abbreviations refer to list of abbreviations & symbols.								
		Continued from Record of Borehole 07-WIF-2		3.55																				
4		LIMESTONE (BEDROCK), containing shale seams Fresh Grey Medium strong to very strong Thinly bedded		5																				
5				6																				
6		End of Drillhole		8.10																				
7																								
8																								
9																								
10																								
11																								
12																								
13																								

MIS-RCK.004_051111031.GPJ GAL-MISS.GDT_2/8/08

DEPTH SCALE

1 : 50



LOGGED: DM

CHECKED: LCC

METRIC
 DIMENSIONS ARE IN METRES AND/OR
 MILLIMETRES UNLESS OTHERWISE SHOWN.
 STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 77-99-01

HIGHWAY 401, STATION 18+015
 Cantilever Sign at County Road 38

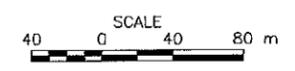
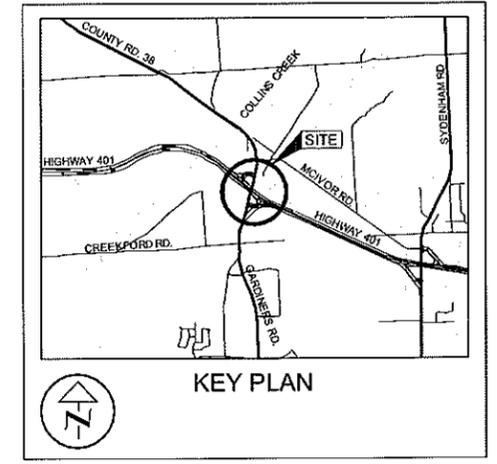
BOREHOLE LOCATION



SHEET



Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



LEGEND

● Borehole - Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
2	110.6	4905053.9	299229.7

NOTES

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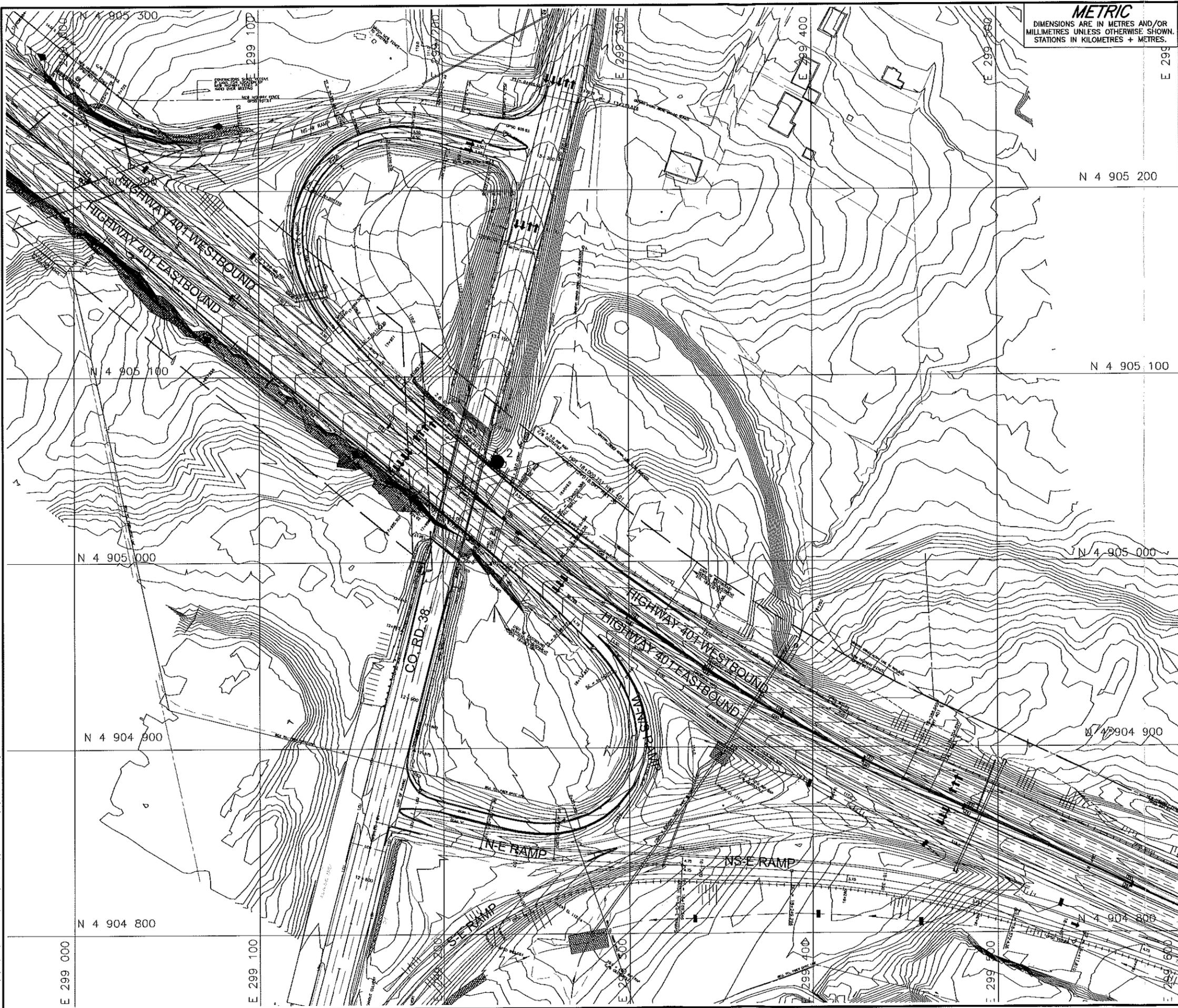
REFERENCE

This drawing was prepared using a base plan supplied in digital format by MTO Eastern Region

NO.	DATE	BY	REVISION

Geocres No.

HWY. 401	PROJECT NO. 05-1111-031	DIST.
SUBM'D. LCC	CHKD. LCC	DATE: May, 26, 08
DRAWN: MMZ	CHKD. LCC	APPD. ASP
		DWG. 1



METRIC
 DIMENSIONS ARE IN METRES AND/OR
 MILLIMETRES UNLESS OTHERWISE SHOWN.
 STATIONS IN KILOMETRES + METRES.

CONT No.
 WP No. 77-99-01

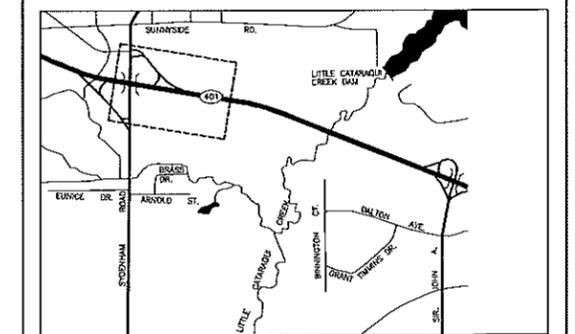


HIGHWAY 401, 20+200 - 20+850
 Overhead Sign OH-1
 BOREHOLE LOCATIONS

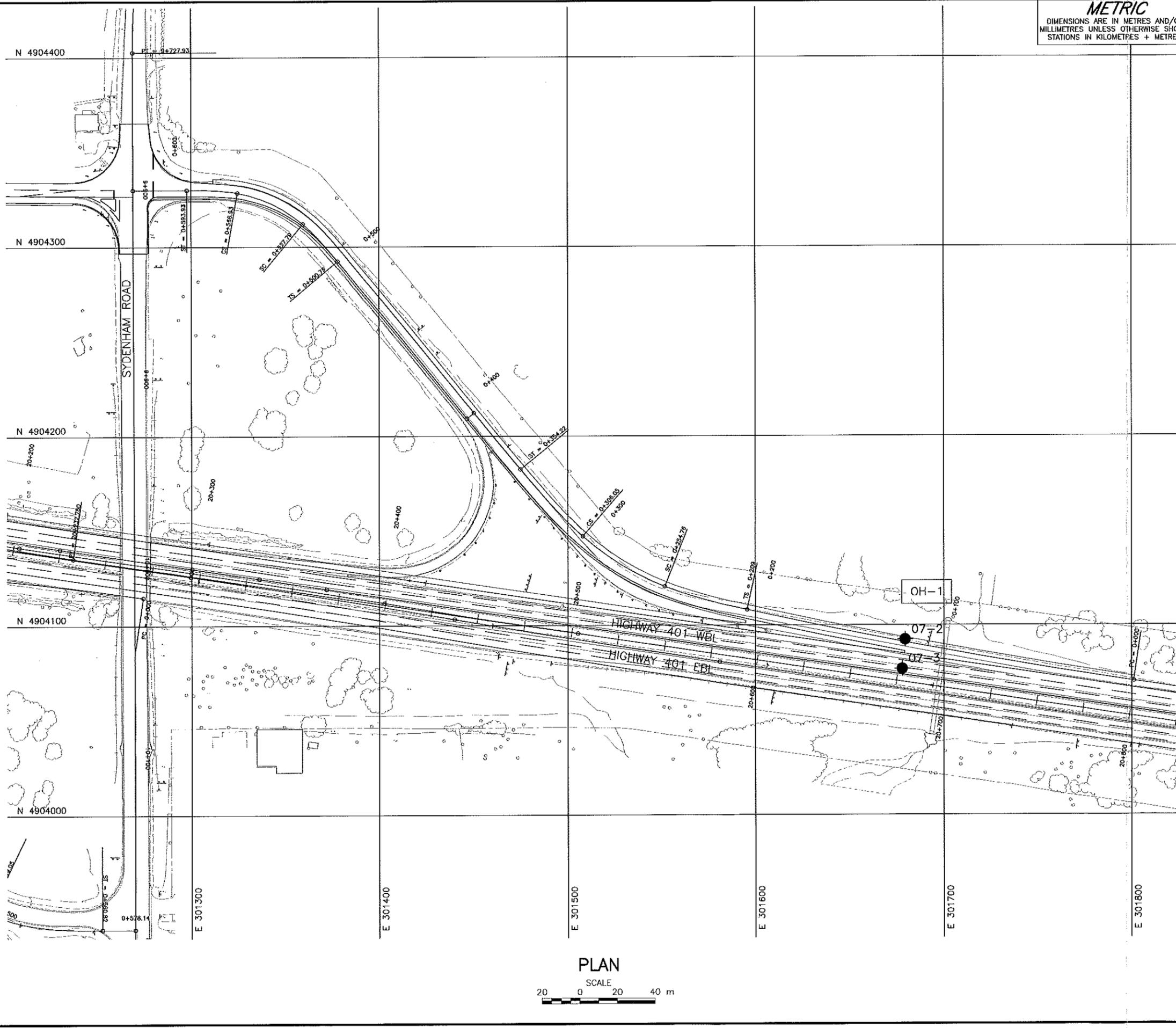
SHEET



Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



KEY PLAN



PLAN



LEGEND			
	Borehole - Current Investigation		
No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
07-2	100.9	4904092.3	301679.7
07-3	101.2	4904076.9	301678.2

NOTES

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REFERENCE

Base plans provided in digital format by MRC, drawing files no. "Align 6230 bp Division W-NS Ramp Settlement 06-04-27.dwg" received February 16, 2007, "Align H6230XM01.dwg", "H6230XB01.dwg" and "H6230XB02.dwg" received January 10, 2006, and "OHS.dwg" received January 09, 2006.

NO.	DATE	BY	REVISION

Geocres No.			
HWY. 401	PROJECT NO. 05-1111-031	DIST.	
SUBM'D. KG	CHKD. LCC	DATE: May. 26, 08	SITE:
DRAWN: DD	CHKD. KG	APPD. LCC	DWG. 2

METRIC
 DIMENSIONS ARE IN METRES AND/OR
 MILLIMETRES UNLESS OTHERWISE SHOWN.
 STATIONS IN KILOMETRES + METRES.

CONT No.
 WP No. 77-99-01

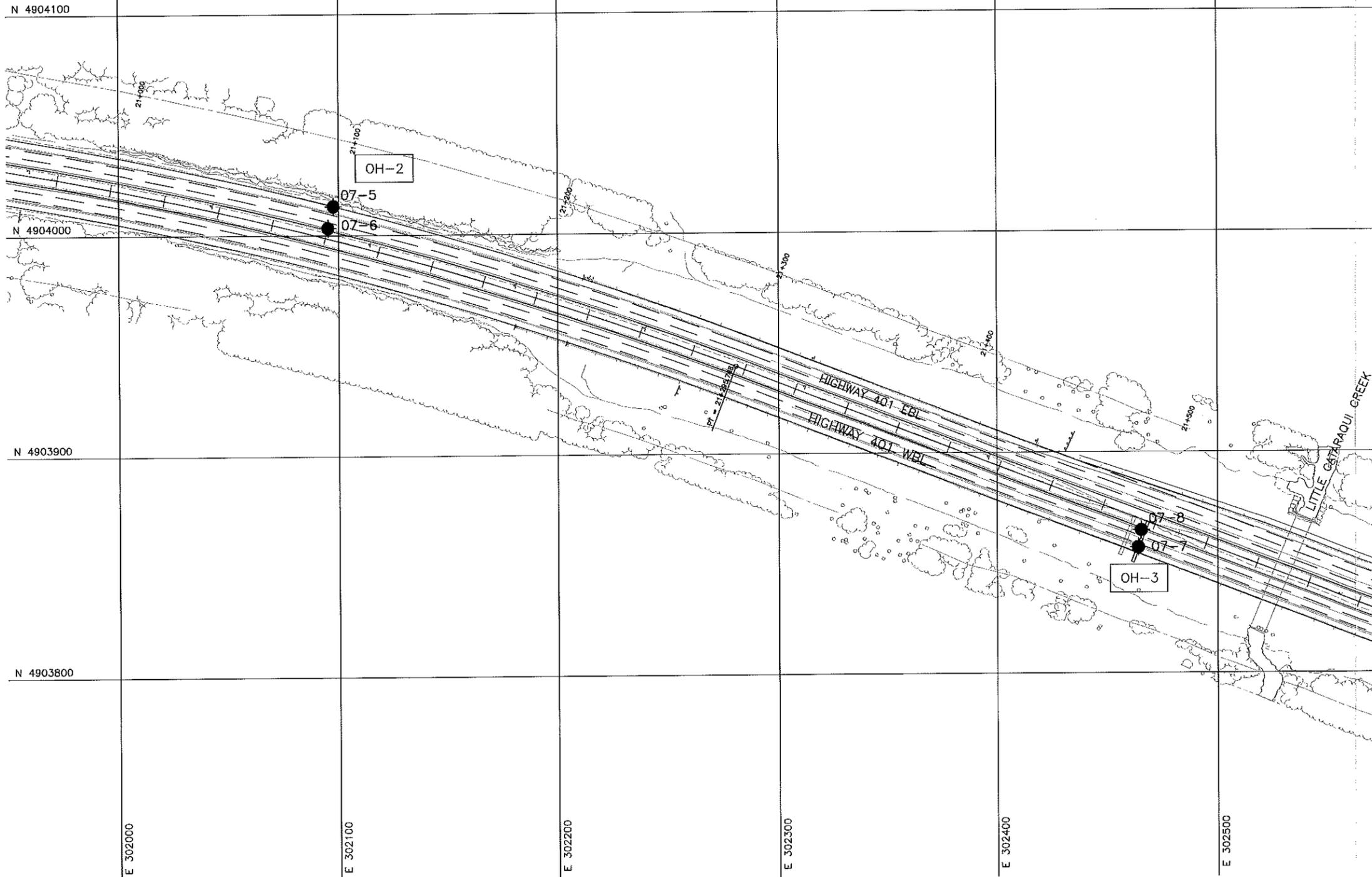
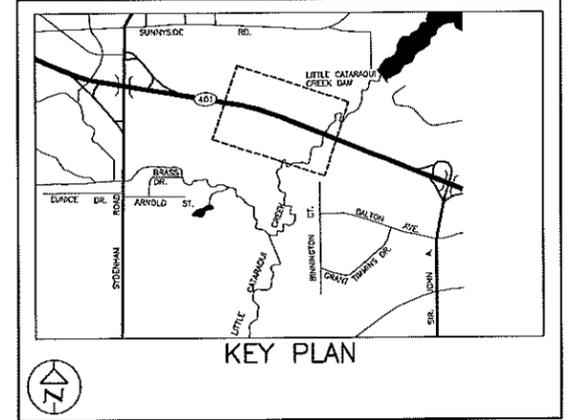


HIGHWAY 401, 20+900 - 21+600
 Overhead Signs OH-2 and OH-3
 BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



LEGEND			
	Borehole - Current Investigation		
No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
07-5	95.6	4904013.2	302097.6
07-6	95.4	4904003.4	302095.1
07-7	85.5	4903856.8	302463.6
07-8	85.7	4903864.5	302465.0

NOTES

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REFERENCE

Base plans provided in digital format by MRC, drawing files no "Align 6230 bp Division W-NS Ramp Settlement 06-04-27.dwg" received February 16, 2007, "Align H6230XM01.dwg", "H6230XB01.dwg" and "H6230XB02.dwg" received January 10, 2008, and "OHS.dwg" received January 09, 2008.



NO.	DATE	BY	REVISION

Geocres No. _____

HWY. 401	PROJECT NO. 05-1111-031	DIST.
SUBM'D. KG	CHKD. LCC	DATE: May, 26, 08
DRAWN: DD	CHKD. KG	APPD. LCC
		DWG. 3

METRIC
 DIMENSIONS ARE IN METRES AND/OR
 MILLIMETRES UNLESS OTHERWISE SHOWN.
 STATIONS IN KILOMETRES + METRES.

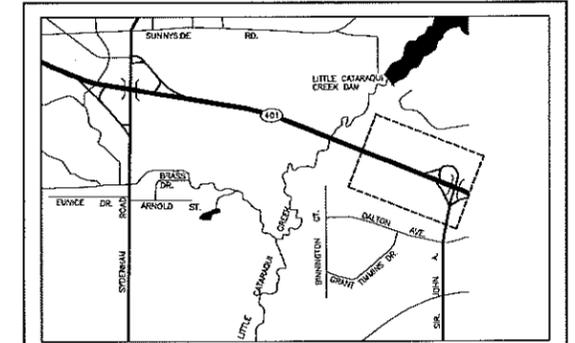
CONT No.
 WP No. 77-99-01



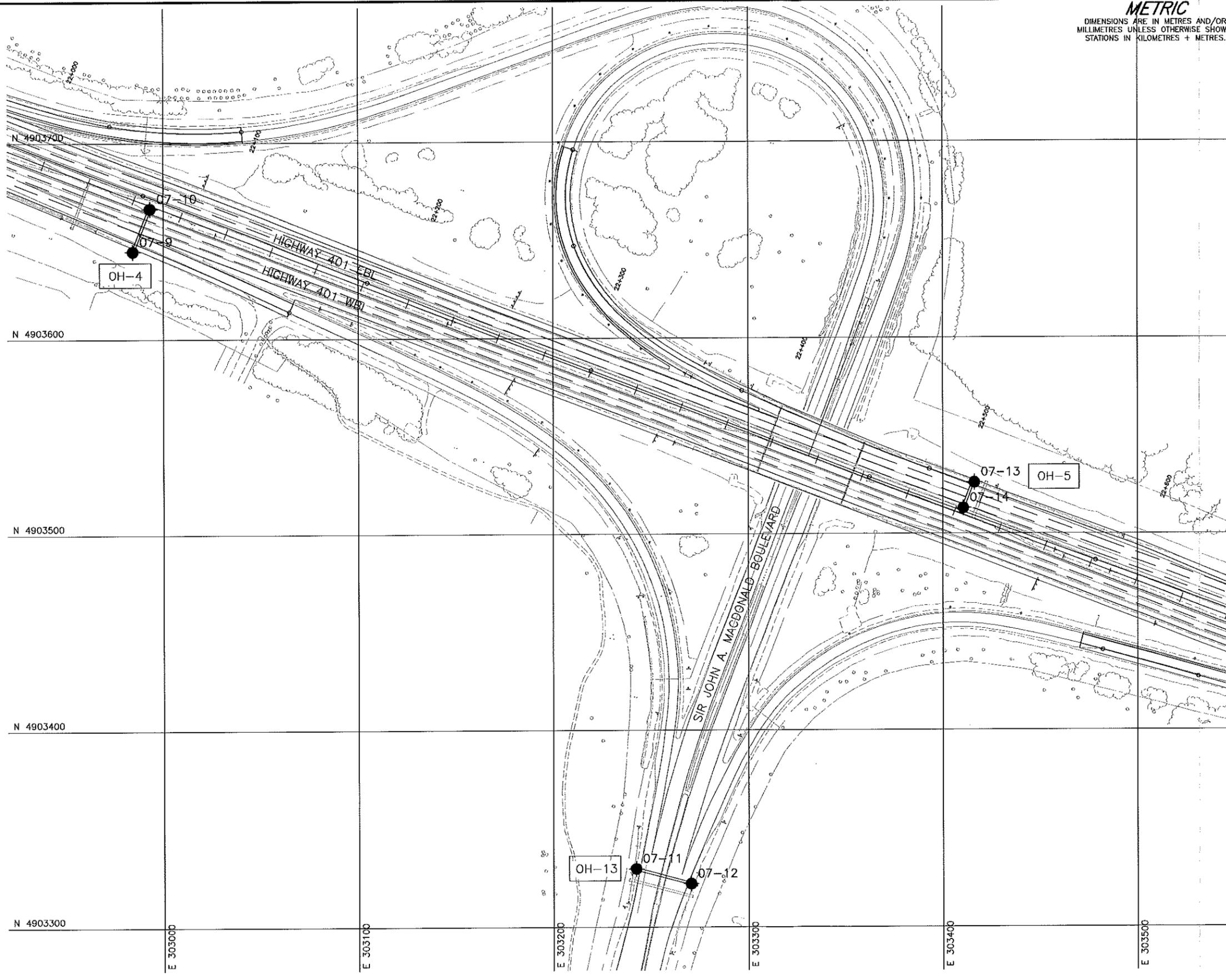
HIGHWAY 401, 22+000 - 22+650
 Overhead Signs OH-4, OH-5 and OH-13
BOREHOLE LOCATIONS



Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



KEY PLAN



LEGEND

● Borehole - Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
07-9	86.3	4903644.7	302984.8
07-10	87.0	4903666.6	302993.3
07-11	80.8	4903329.6	303242.1
07-12	80.6	4903322.0	303270.6
07-13	88.7	4903526.0	303416.1
07-14	88.8	4903513.0	303410.4

NOTES

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REFERENCE

Base plans provided in digital format by MRC, drawing files no "Align 6230 bp Division W-NS Ramp Settlement 06-04-27.dwg" received February 16, 2007, "Align H6230XM01.dwg", "H6230XB01.dwg" and "H6230XB02.dwg" received January 10, 2006, and "OHS.dwg" received January 09, 2006.



NO.	DATE	BY	REVISION

Geocres No.

HWY. 401	PROJECT NO. 05-1111-031	DIST.
SUBM'D. KG	CHKD. LCC	DATE: May. 26, 08
DRAWN: DD	CHKD. KG	APPD. LCC
		DWG. 4

METRIC
 DIMENSIONS ARE IN METRES AND/OR
 MILLIMETRES UNLESS OTHERWISE SHOWN.
 STATIONS IN KILOMETRES + METRES.

CONT No.
 WP No. 77-99-01

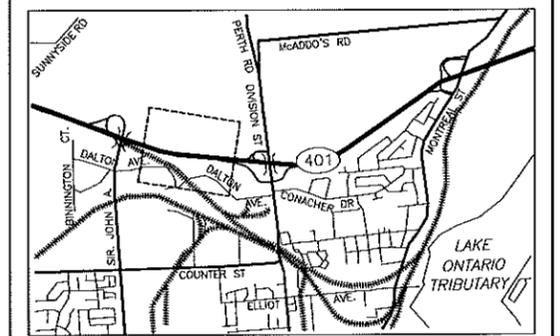


HIGHWAY 401, 22+900 - 23+550
 Overhead Signs OH-6, OH-7 and OH-8
BOREHOLE LOCATIONS

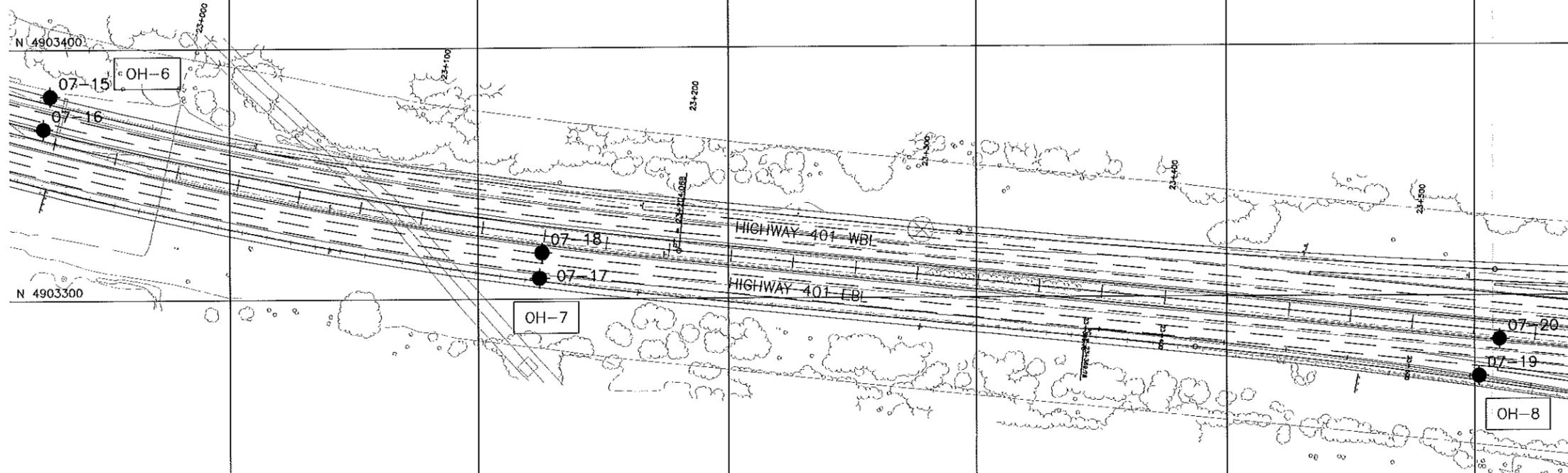
SHEET



Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



KEY PLAN



N 4903500

N 4903400

N 4903300

N 4903200

N 4903100

E 303900

E 304000

E 304100

E 304200

E 304300

E 304400

LEGEND

● Borehole - Current Investigation			
No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
07-15	90.2	4903381.4	303828.6
07-16	91.2	4903368.4	303825.7
07-17	92.0	4903308.3	304024.7
07-18	91.8	4903318.5	304025.6
07-19	90.8	4903268.0	304401.8
07-20	90.9	4903282.6	304410.2

NOTES

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PLAN



NO.	DATE	BY	REVISION

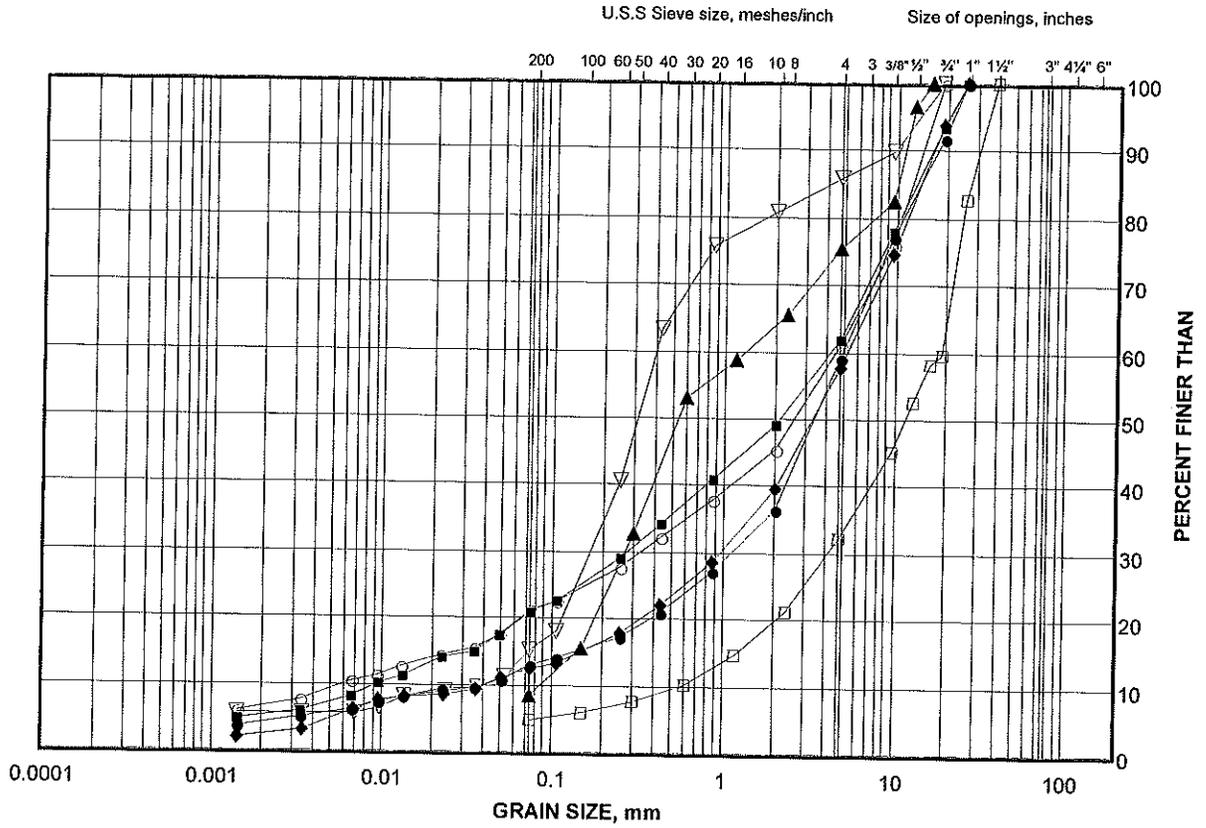
Geocres No.

HWY. 401	PROJECT NO. 05-1111-031	DIST.
SUBM'D. KG	CHKD. LCC	DATE: May. 26, 08
DRAWN: DD	CHKD. KG	APPD. LCC
		DWG. 5

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand to Sand and Gravel Fill

FIGURE 1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-WIF-02	1	
■	07-WIF-01	1	
◆	07-28	1	112.4
▲	07-24	1	109.7
▽	07-20	1	90.0
○	07-18	2	90.4
□	07-7	3	83.1

Project Number: 05-1111-031

Checked By: *Ullrey*

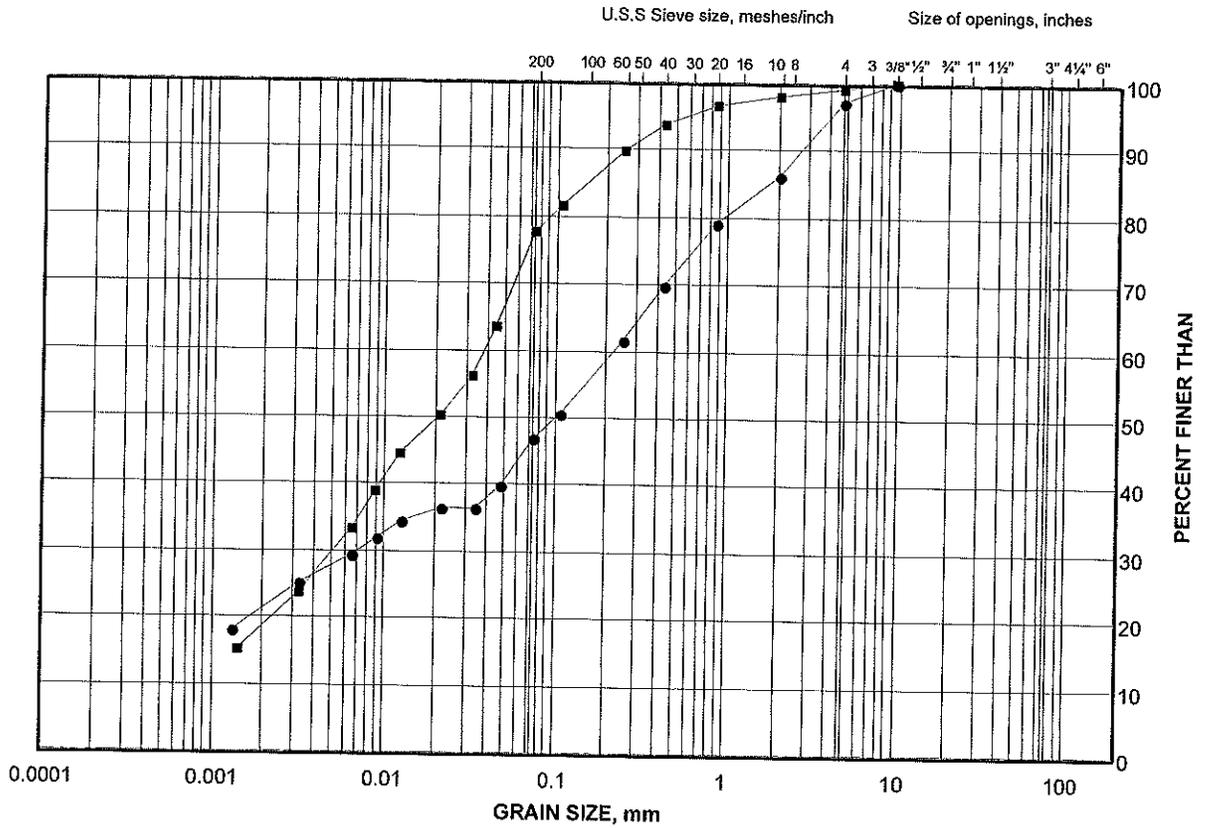
Golder Associates

Date: 04-Feb-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Sand Fill Containing Clayey Silt Zones

FIGURE 2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-13	2	87.0
■	07-17	3	89.6

Project Number: 05-1111-031

Checked By: *[Signature]*

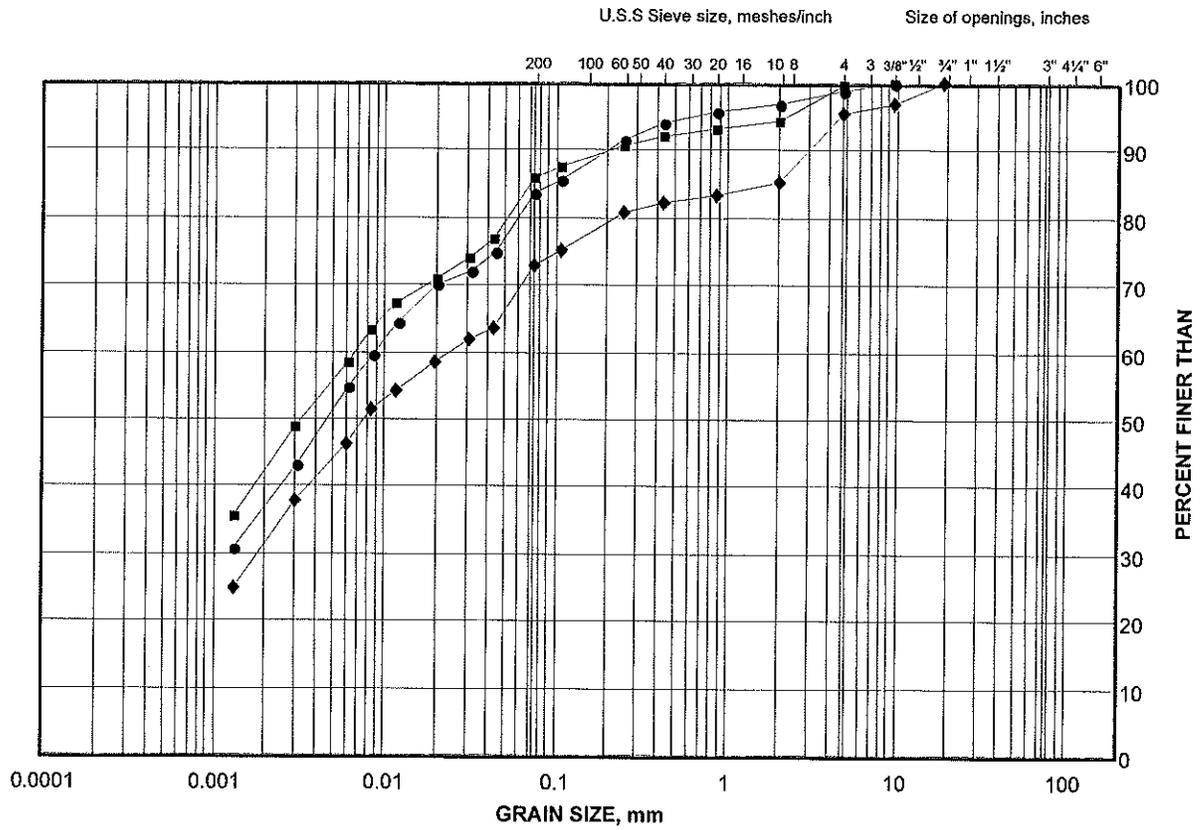
Golder Associates

Date: 04-Feb-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt to Silty Clay Fill

FIGURE 3



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

LEGEND

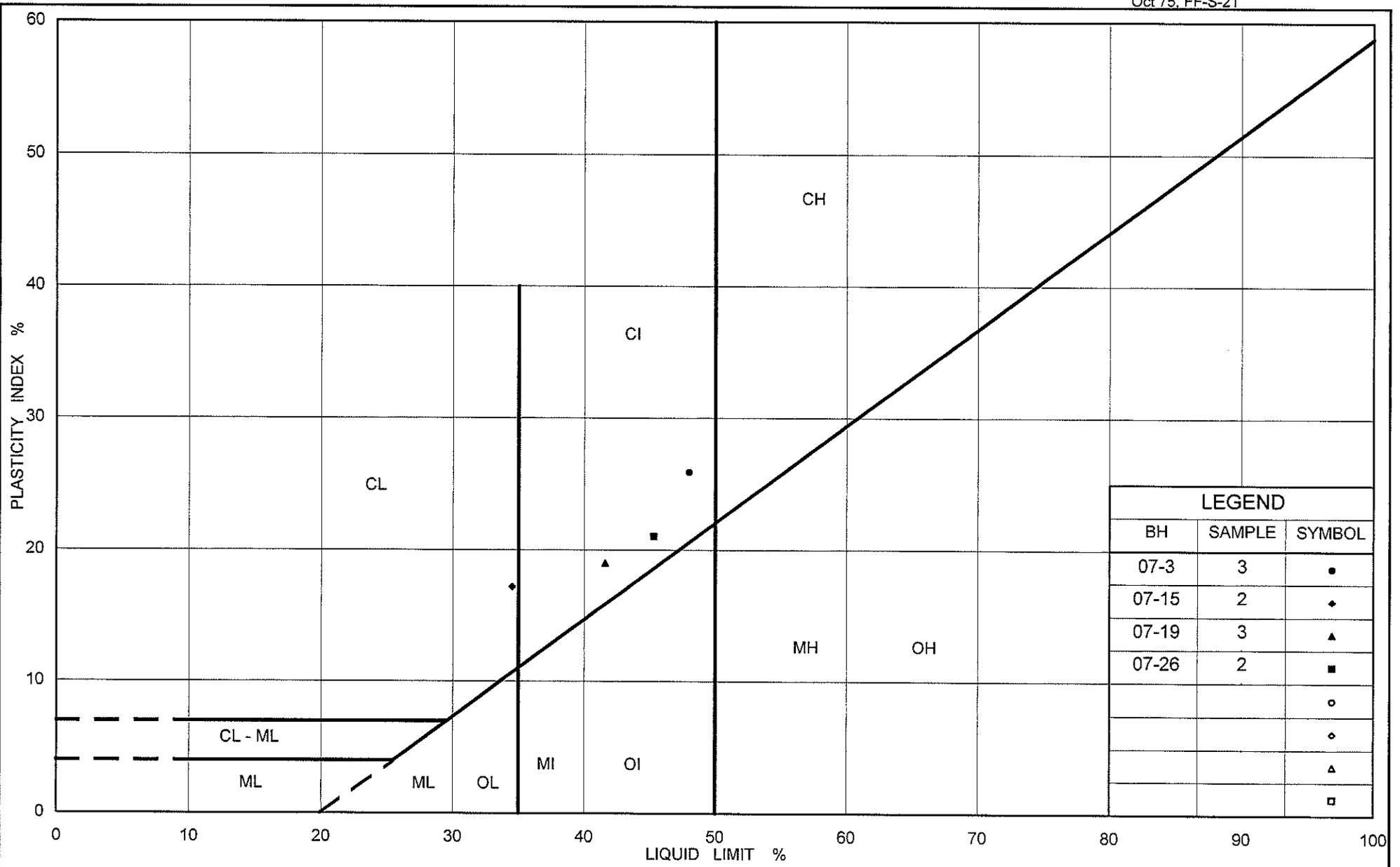
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-14	3	86.4
■	07-9	3	83.9
◆	07-21	9	80.9

Project Number: 05-1111-031

Checked By: *[Signature]*

Golder Associates

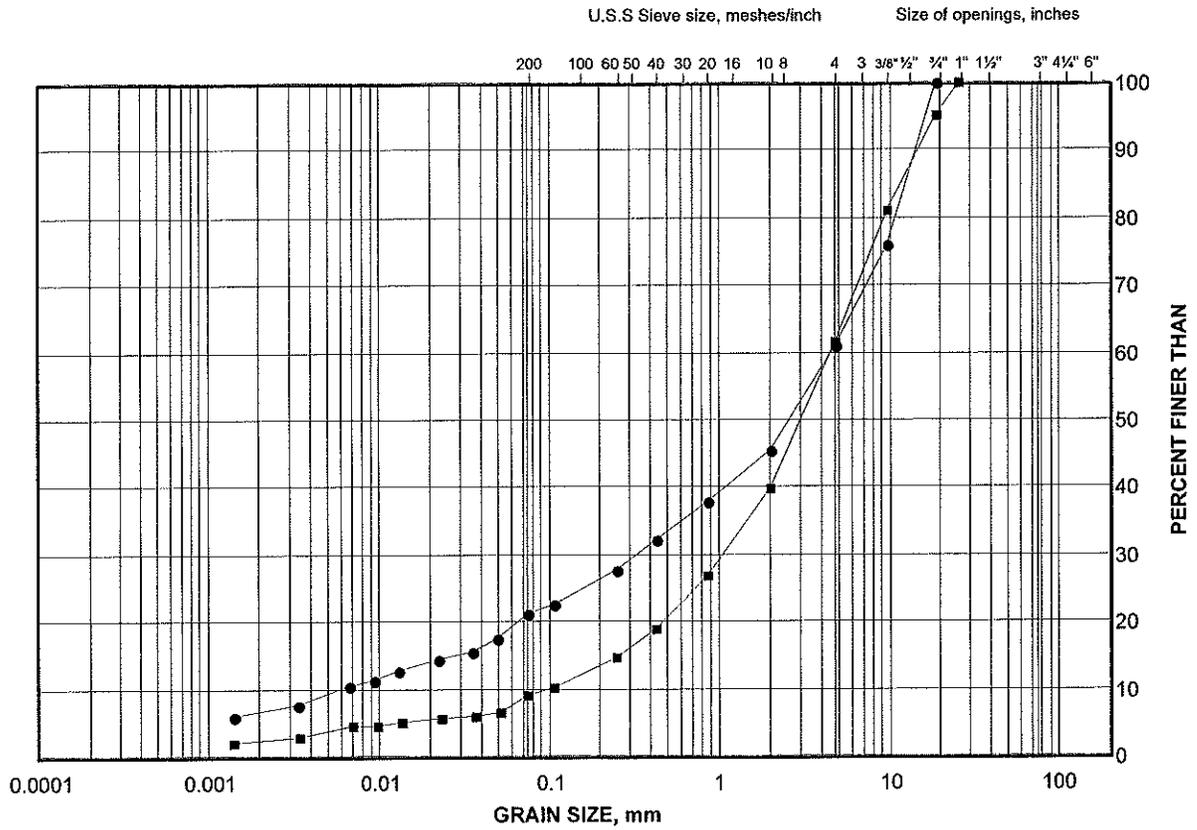
Date: 04-Feb-08



GRAIN SIZE DISTRIBUTION TEST RESULTS

Rock Fill

FIGURE 5



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-8	2	83.1
■	07-6	2	93.7

Project Number: 05-1111-031

Checked By: *W. H. [Signature]*

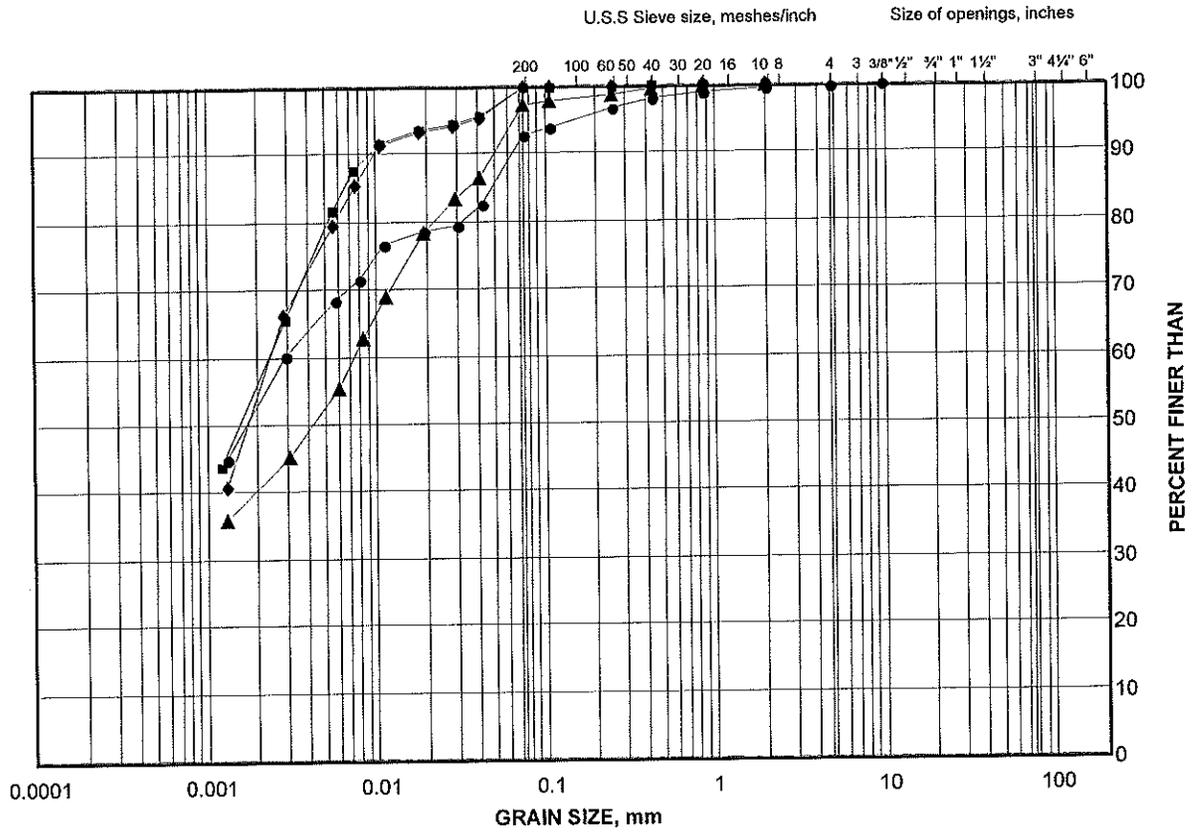
Golder Associates

Date: 04-Feb-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Clay to Clay

FIGURE 6



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

LEGEND

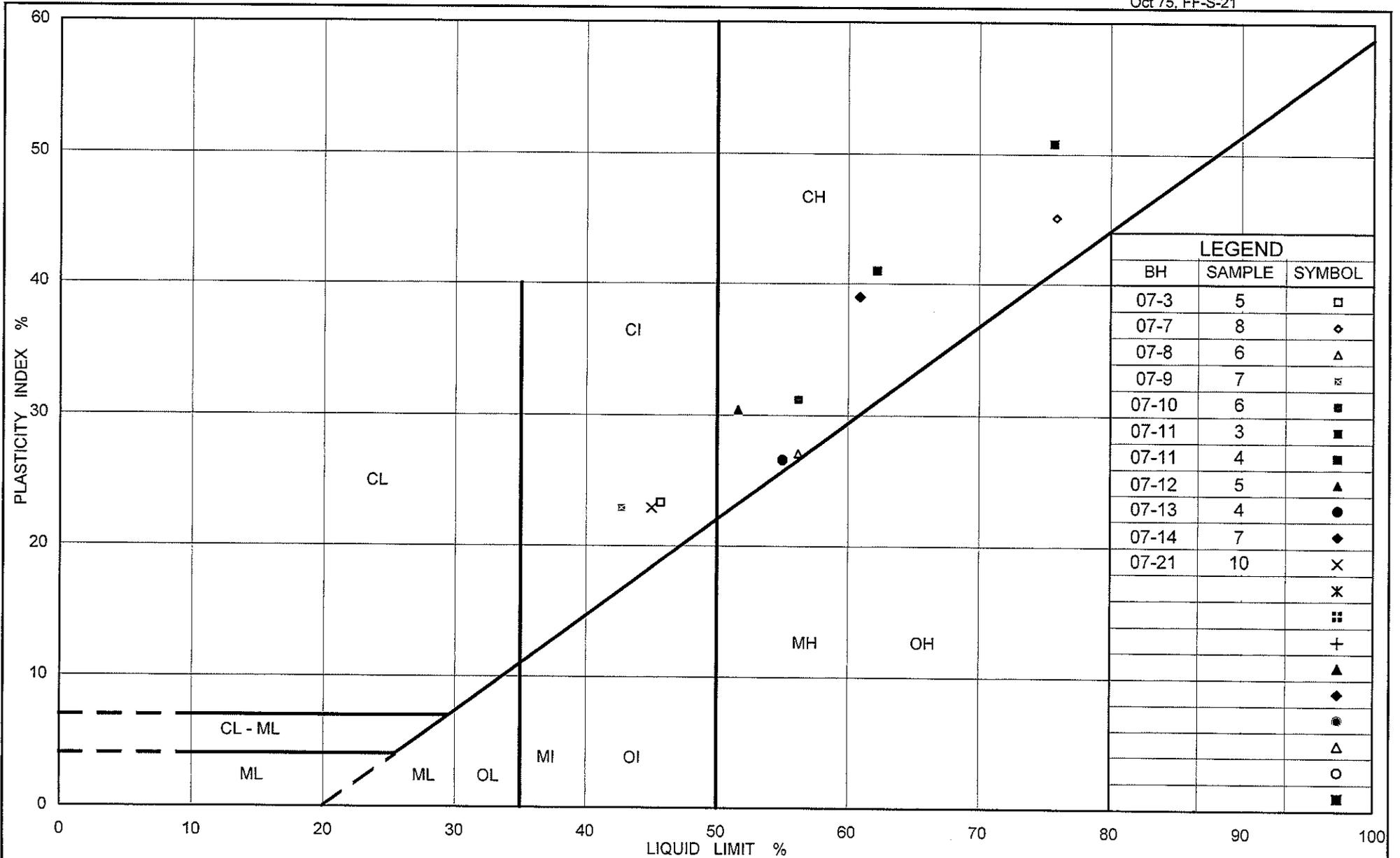
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-10	2	85.1
■	07-11	4	76.7
◆	07-12	5	76.5
▲	07-3	5	97.1

Project Number: 05-1111-031

Checked By: *W. Lopez*

Golder Associates

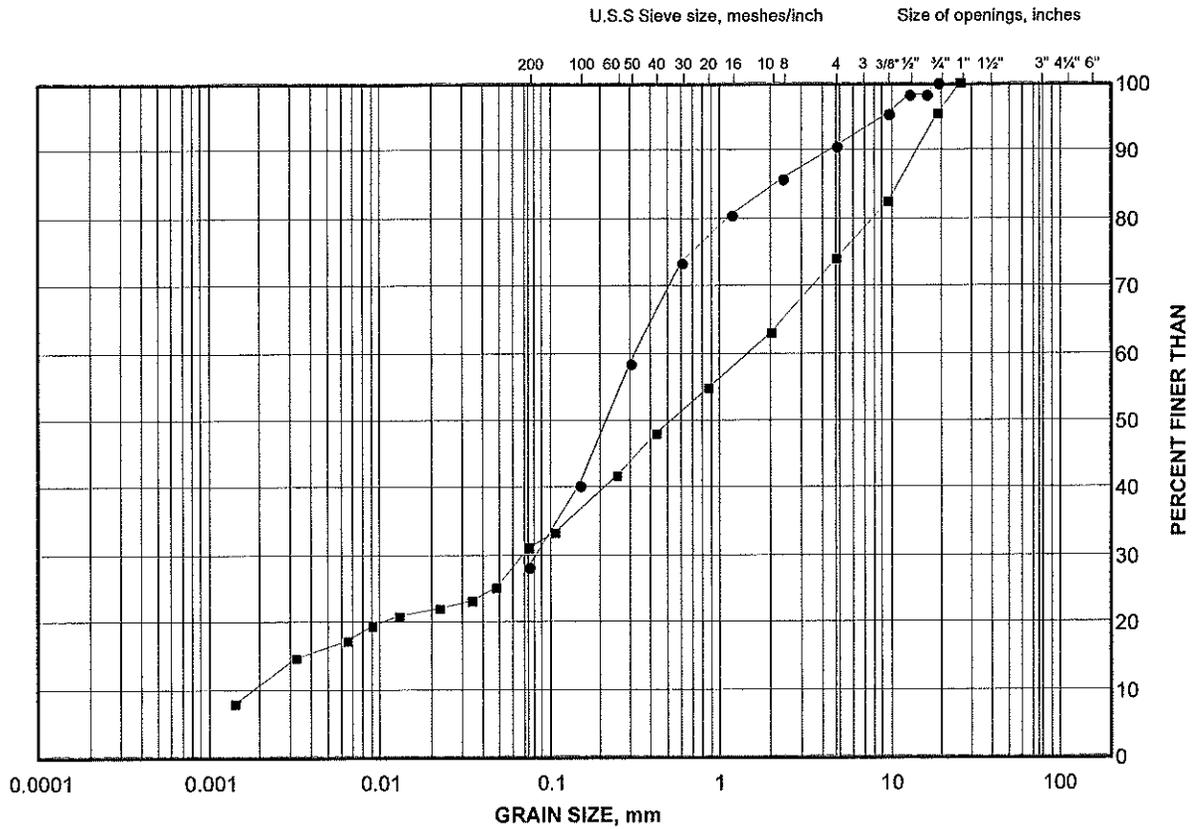
Date: 04-Feb-08



GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Sand Till to Clayey Silt Till

FIGURE 8



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

LEGEND

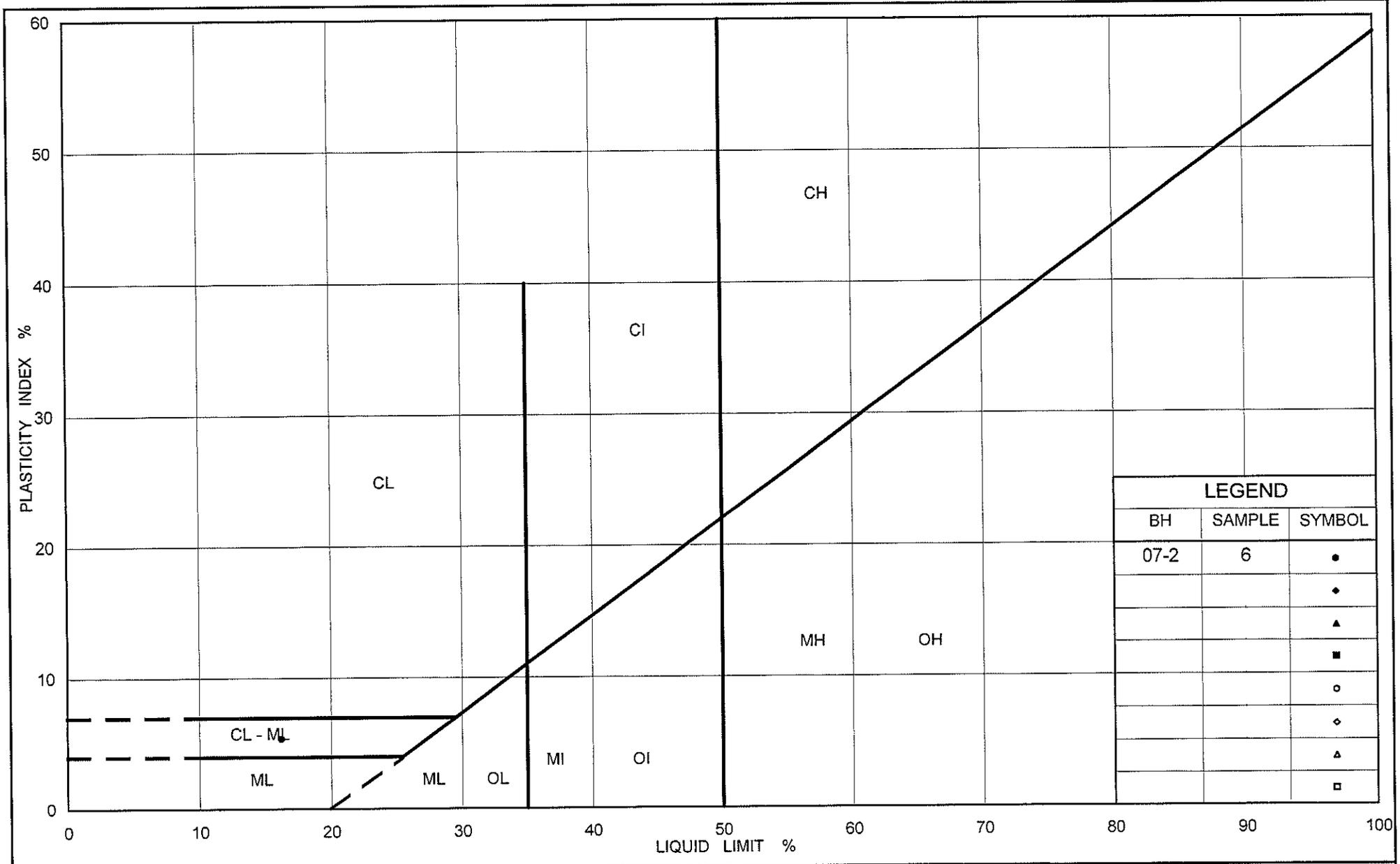
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-16	4	87.1
■	07-2	6	96.2

Project Number: 05-1111-031

Checked By: *W. [Signature]*

Golder Associates

Date: 04-Feb-08



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt Till

Figure No. 9

Project No. 05-1111-031

Checked By: *W. J. [Signature]*

August 2008

05-1111-031-4

APPENDIX A

**SPECIAL PROVISIONS AND
NON-STANDARD SPECIAL PROVISIONS**

CAISSON SOCKETS IN BEDROCK - Item No.

Special Provision

The limestone bedrock at this site varies from medium strong to very strong. Appropriate construction equipment and procedures will be required for construction of caisson foundation sockets within the bedrock.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

**CONTROL OF OVERBURDEN SOILS AND GROUNDWATER DURING CAISSON
INSTALLATION - Item No.**

Special Provision

Caisson excavations will be advanced through cohesionless fill and cohesionless soil interlayers within cohesive soil deposits, which may be water-bearing; these soils should be expected to slough/flow into unsupported caisson holes. Appropriate construction procedures and equipment will be required to control sloughing and flowing during drilling and concrete placement for caisson foundations.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

**BOULDERS/OBSTRUCTIONS IN ROCK FILL DURING CAISSON INSTALLATION
FOR OVERHEAD SIGNS - Item No.**

Special Provision

Rock fill was encountered at some of the sign support locations, as noted on the borehole records. Appropriate equipment and procedures will be required to penetrate the rock fill as part of caisson installation for the overhead sign supports.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION