

REPORT

**FOUNDATION INVESTIGATION
AND DESIGN REPORT
SEWER CROSSINGS
HIGHWAY 400 SBL
BETWEEN HIGHWAY 11 AND HIGHWAY 93
SIMCOE COUNTY
G.W.P. 2168-06-00**

Submitted to:

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PART A

FOUNDATION INVESTIGATION REPORT

**SEWER CROSSINGS
HIGHWAY 400 SBL
BETWEEN HIGHWAY 11 AND HIGHWAY 93
SIMCOE COUNTY
G.W.P. 2168-06-00**

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Genivar on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the rehabilitation of Highway 400 southbound lanes (SBL) between the Highway 400-93 interchange and Highway 11 (Forbes Road) in Simcoe County, Ontario.

This report addresses the replacement of sixteen existing storm sewers located in Flos and Vespra Townships within the project limits, at the following locations:

<i>Township</i>	<i>Catchment ID Number</i>	<i>Sewer Crossing Station (m)</i>
Vespra	24	20+823
	36A	23+806
	37	23+927
	39A	24+157
	42	24+955
	43	25+175
	53	26+032
	56	26+536
	60	27+216
	63	27+989
	68	28+746
	72	29+349
Flos	97	10+659
	100	11+269
	102	11+757
	109	13+274

It is noted that originally the sewer crossing at Station 20+823 was planned to be at Station 20+764 m, however when the sewer alignment was lowered and there was a conflict with a utility and it had to be relocated to Station 20+823. The terms of reference and scope of work for the foundation investigation are outlined in MTO's Terms of Reference dated March 20, 2008, and in Golder's Proposal No. 06-1111-011 entitled "Proposal for Additional Foundation Engineering Services, Installation of Sewer Crossings by Trenchless Methods, Highway 400 Between Highways 11 and 93, G.W.P. 176-99-00", dated April 25, 2008.

2.0 SITE DESCRIPTION

The sixteen sewer crossing sites addressed in this report are located along Highway 400 southbound lanes between Highway 93 and Highway 11 (Forbes Road), in Simcoe County, Ontario. The location, dimensions, existing embankment height, and invert elevation for the existing CSP sewer crossing are summarized in the following table.

<i>Catchment ID Number</i>	<i>Approximate Station (m)</i>	<i>Existing Sewer Dimensions (mm)</i>	<i>Length (m)</i>	<i>Approximate Embankment Height (m)</i>	<i>Invert Elevation at Shoulder (m)</i>
24	20+823	450	60	1.6	262.290 (inlet) 262.146 (outlet)
36A	23+806	525	60	1.4	284.800 (inlet) 284.653 (outlet)
37	23+927	500	59	1.4	281.330 (inlet) 281.177 (outlet)
39A	24+157	450	90	2.8	277.979 (inlet) 277.386 (outlet)
42	24+955	450	62	2.0	278.362 (inlet) 278.193 (outlet)
43	25+175	400	49	1.4	275.270 (inlet) 275.118 (outlet)
53	26+032	450	50	1.0	266.760 (inlet) 266.605 (outlet)
56	26+536	450	43	2.6	256.298 (inlet) 255.083 (outlet)
60	27+216	600	36	3.5	263.364 (inlet) 260.949 (outlet)
63	27+989	600	37	2.9	270.040 (inlet) 269.505 (outlet)
68	28+746	600	39	4.5	264.970 (inlet) 261.640 (outlet)
72	29+349	600	32	2.1	268.250 (inlet) 266.54 (outlet)
97	10+659	600	36	2.5	241.571 (inlet) 240.960 (outlet)
100	11+269	600	35	2.4	241.620 (inlet) 241.350 (outlet)
102	11+757	600	35	2.4	241.713 (inlet) 241.540 (outlet)
109	13+274	300	44	1.5	244.760 (inlet) 244.558 (outlet)

In general, the terrain in the vicinity of each of the sewer crossing sites is relatively flat and poorly drained. Overall, the natural ground surface within the area addressed by this report is undulating. From Highway 93 (Penetanguishene Road) to Horseshoe Valley Road (County Road 22) the ground surface slopes toward the south from approximately Elevation 246 m to Elevation 244 m. The next sewer crossing is approximately 2.2 km south of Horseshoe Valley Road (County Rd 22) and the ground surface is at about Elevation 270 m and slopes downward towards

the south to Elevation 257 m just north of Forbes Road. The ground surface then gradually rises to Elevation 290 south of Forbes Road then slopes down towards the south to about Elevation 263 at the most southerly sewer crossing. The Highway 400 embankment varies from approximately 2 m to 4.5 m in height relative to the natural ground surface at the sewer crossing sites.

3.0 INVESTIGATION PROCEDURES

A borehole investigation was carried out between July 2nd and 15th, 2008, during which time thirty-two boreholes (Boreholes 08-1 to 08-32) were advanced to investigate the subsurface conditions at the storm sewer locations. In accordance with the Terms of Reference, two boreholes were advanced at each of the sewer crossings. The borehole locations are shown on Drawings 1 through 5. In addition, relevant boreholes that were drilled as part of the geotechnical investigation for culverts along Highway 400 southbound lanes between Highway 11 (Forbes Road) and Highway 93, Simcoe County, are shown on Drawings 1 and 2. The relevant Record of Borehole logs and laboratory data are presented in Appendix A.

The boreholes were drilled using truck-mounted, track-mounted and portable drill rigs, supplied and operated by Walker Drilling of Utopia, Ontario. The boreholes were advanced using hollow stem augers to depths ranging from 4.9 m to 9.8 m, to extend at least three tunnel diameters below the proposed sewer invert level. 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.

The groundwater conditions in the open boreholes were observed during the drilling operations. The boreholes were backfilled to ground surface using bentonite pellets in accordance with Ontario Regulation 128 (amendment to Ontario Regulation 903).

The field work was supervised throughout by a member of Golder's technical staff, who located the boreholes in the field, arranged for the clearance of underground services, supervised the drilling, sampling and in situ testing operations, and logged the boreholes. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's geotechnical laboratory in Mississauga, where the samples underwent further visual examination and geotechnical classification testing (water content, Atterberg limits, grain size distribution and organic content). All of the laboratory tests were carried out to MTO and/or ASTM standards as appropriate.

The borehole locations were measured in the field by a member of Golder's technical staff, relative to the existing sewers, and the ground surface elevations at the borehole locations were interpolated from the digital terrain model for the project. The borehole locations (MTM NAD83 coordinates) and ground surface elevations (referenced to geodetic datum) are summarized in the following table. The stations given are approximate. It should be noted that a sewer crossing was proposed at Station 20+764, however it was relocated to Station 20+823.

<i>Catchment ID Number</i>	<i>Station (m)</i>	<i>Borehole Designation</i>	<i>Borehole Location</i>	<i>MTM NAD83 Northing (m)</i>	<i>MTM NAD83 Easting (m)</i>	<i>Ground Surface Elevation(m)</i>	<i>Borehole Depth (m)</i>
24	20+823	08-29	West shoulder	4 922 409.3	291 649.0	262.4	5.2
		08-30	Centre median	4 922 431.2	291 648.2	262.9	5.2
36A	23+806	08-27	West shoulder	4 925 023.7	290 044.7	287.1	5.2
		08-28	Centre median	4 925 013.1	290 064.8	287.7	5.2
37	23+927	08-25	West shoulder	4 925 124.1	289 979.6	283.7	5.2
		08-26	Centre median	4 925 114.2	289 999.2	284.1	5.2
39A	24+157	08-31	West shoulder	4 925 292.4	289 869.5	280.4	6.7
		08-32	Centre median	4 925 319.6	289 863.7	280.4	5.2
42	24+955	08-23	West shoulder	4 925 959.3	289 432.8	280.6	6.7
		08-24	Centre median	4 925 980.6	289 431.6	280.3	5.2
43	25+175	08-21	West shoulder	4 926 162.3	289 295.0	277.4	6.7
		08-22	Centre median	4 926 152.0	289 322.6	277.4	5.2
53	26+032	08-19	West shoulder	4 926 884.7	288 821.7	268.5	5.2
		08-20	Centre median	4 926 874.5	288 849.2	269.0	4.9
56	26+536	08-17	West shoulder	4 927 291.6	288 555.9	258.0	6.7
		08-18	Centre median	4 927 314.9	288 561.4	257.5	5.2
60	27+216	08-15	West shoulder	4 927 855.4	288 173.4	265.8	9.8
		08-16	Centre median	4 927 866.3	288 189.0	265.2	5.2
63	27+989	08-13	West shoulder	4 928 499.5	287 735.1	272.7	8.2
		08-14	Centre median	4 928 506.3	287 754.4	272.3	5.2
68	28+746	08-11	West shoulder	4 929 123.9	287 310.7	267.9	9.8
		08-12	Centre median	4 929 135.0	287 326.8	267.4	5.2
72	29+349	08-9	West shoulder	4 929 618.6	286 971.6	270.1	6.7
		08-10	Centre median	4 929 629.9	286 988.7	270.0	5.2
97	10+659	08-7	West shoulder	4 932 039.2	285 326.1	244.0	6.7
		08-8	Centre median	4 932 050.6	285 346.5	243.2	5.2
100	11+269	08-5	West shoulder	4 932 624.9	285 152.5	243.9	6.7
		08-6	Centre median	4 932 629.8	285 172.3	243.6	5.2
102	11+757	08-3	West shoulder	4 933 098.7	285 036.7	243.9	6.7
		08-4	Centre median	4 933 103.5	285 056.1	243.6	5.2
109	13+274	08-1	West shoulder	4 934 537.5	285 137.0	246.3	5.2
		08-2	Centre median	4 934 533.2	285 156.9	246.5	5.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 400 is located within the physiographic region known as the Simcoe Uplands, according to *The Physiography of Southern Ontario*¹. The general topography within the Simcoe Uplands consists of sloping till (moraine) plains. The surficial soils in this region consist of sandy silt to sand and gravel, representing shoreline deposits of a former glacial lake that once flooded the area, overlying a glacial till deposit. Surficial deposits of clayey silt to silty clay are also present adjacent to current and former streams.

4.2 Subsurface Conditions

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 following the text of this report; the results of laboratory testing are also presented on Figures 1 to 16. For the purpose of assessing the soil types at each sewer crossing location the results of the grain size distribution test analysis for each sewer crossing are presented on one figure each and are shown on Figures 17 to 32. The stratigraphic boundaries shown on the borehole records, and on the interpreted stratigraphic sections on Drawings 6 to 10, 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.

Most boreholes encountered fill soils immediately below ground surface and the extent and nature of the fill soils are described in Section 4.2.2. A brief overview of the native soil conditions at each of the sixteen sewer crossing sites is provided in the following table:

<i>Catchment ID Number</i>	<i>Approximate Station (m)</i>	<i>Borehole Designation</i>	<i>General Subsurface Conditions</i>
24	20+823	08-29 08-30	The native soils at this sewer crossing site consist of loose/dense silty sand underlain by a till deposit consisting of compact to very dense sand and silt.
36A	23+806	08-27 08-28	The native soils at the borehole drilled along the ditch line consist of till deposit of firm to stiff clayey silt underlain by dense sand and gravel, which in turn is underlain by very stiff to hard clayey silt. At the borehole drilled within the median, the native soils consist of compact to dense gravelly sand underlain by compact to very dense sand.

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.

<i>Catchment ID Number</i>	<i>Approximate Station (m)</i>	<i>Borehole Designation</i>	<i>General Subsurface Conditions</i>
37	23+927	08-25 08-26	The native soils at this sewer crossing site consist of compact to very dense sand with a thin layer of dense silty sand within the sand deposit.
39A	24+157	08-31 08-32	The native soils at this location consist of a surficial till deposit of stiff to very stiff clayey silt underlain by stiff to hard silty clay to clayey silt.
42	24+955	08-23 08-24	The native soils at the borehole drilled along the ditch line consist of till deposit of stiff to very stiff silty clay to clayey silt with a 2.7 m thick layer of compact sand within the till deposit. At the borehole drilled within the median. The native soils consist of a till deposit of very stiff clayey silt with sand, underlain by compact sand which is in turn underlain by dense sand and gravel.
43	25+175	08-21 08-22	The native soils at the borehole drilled along the ditch line consist of compact sand and silt underlain by a till deposit consisting of very dense sandy silt. Alternating layers of compact to dense sand and dense sand and silt were encountered at the borehole drilled within the median.
53	26+032	08-19 08-20	The native soils at this sewer crossing site consist of alternating layers of compact to dense sand and compact silty sand to dense to very dense sand and silt.
56	26+536	08-17 08-18	The native soils at this site consist of compact silty sand underlain by compact to dense sand. The borehole drilled along the ditch line encountered a till deposit consisting of compact sand and silt.
60	27+216	08-15 08-16	The native soils at this sewer crossing site consist of loose silty sand underlain by loose to very dense sand.
63	27+989	08-13 08-14	The native soils at this site consist of compact to dense sand to silty sand to sand and silt. At the borehole drilled along the ditch line the silty sand was underlain by till deposit consisting of compact silty sand.
68	28+746	08-11 08-12	The native soils at this sewer crossing site consist of compact to very dense silty sand. The silty sand in the borehole located in the ditch line is underlain by very dense gravelly sand which in turn is underlain by compact sand.
72	29+349	08-9 08-10	The native soils at this site consist of loose to dense sand and silt underlain by dense sand at the centre median borehole.
97	10+659	08-7 08-8	The native soils at this sewer crossing site consist of compact sand and compact silty sand underlain by either compact silt at the ditch line borehole location and stiff silty clay at the centre median borehole location. The silty clay is underlain by compact silty sand.
100	11+269	08-5 08-6	The native soils at this site consist of compact sand and compact to dense silty sand. The sand in the ditch line borehole location is underlain by compact sandy silt
102	11+757	08-3 08-4	The native soils at this site consist of loose to compact sand to silty sand.

<i>Catchment ID Number</i>	<i>Approximate Station (m)</i>	<i>Borehole Designation</i>	<i>General Subsurface Conditions</i>
109	13+274	08-1 08-2	The native soils at this sewer crossing site consist of compact sands that range in composition from sand, trace silt to sand and silt.

A more detailed description of the soil deposits encountered in the boreholes is provided below.

4.2.1 Topsoil

Approximately 100 mm to 200 mm of topsoil was encountered immediately below the existing ground surface in the boreholes drilled along the centre median. Also a 400 mm thick layer of sandy silt topsoil was encountered underlying the fill in Borehole 08-15 at a depth of 4.6 m (Elevation 261.2 m).

4.2.2 Fill

Approximately 0.8 m to 6.1 m of moist sand and gravel fill to sand and silt fill was encountered immediately below the ground surface at all boreholes. Within the cohesionless fill, layers of clayey silt to clayey silt with sand were noted as well as decayed organic matter. Cohesive fill was encountered in Boreholes 08-10, 08-15, 08-16, 08-21 to 08-24. The cohesive fill contains some to with sand, trace gravel and decayed organic matter. The thickness of the cohesive fill varies from 0.4 m to generally 1.5 m, however at Borehole 08-15 it was found to be 3.8 m thick.

Standard Penetration test (SPT) 'N' values measured within the cohesionless fill were variable and ranged from 4 to 54 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The results of grain size distribution tests carried out on samples of the gravelly sand to sand and gravel fill are shown on Figure 1. The results of grain size distribution tests carried out on selected samples of the sand to silty sand fill are shown on Figures 2A and 2B. The results of grain size distribution tests carried out on selected samples of the sand and silt fill are shown on Figure 3. Atterberg limits testing was completed on one sample of the sand and silt fill; the result, which are plotted on a plasticity chart on Figure 4, confirm that this fill consists of sand and silt of low plasticity.

SPT 'N' values measured within the cohesive fill ranged from 4 to 26 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. Figure 5 presents the results of a grain size distribution test carried out on one sample of the clayey silt with sand fill. Atterberg limits testing was completed on six samples of the cohesive fill; the results, which are plotted on a plasticity chart on Figure 6, confirm that this fill consists of clayey silt of low plasticity. Fill thicknesses and the elevation of the base of the fill at each borehole location are provided in the table that follows:

<i>Catchment ID Number</i>	<i>Sewer Crossing Station (m)</i>	<i>Borehole Designation</i>	<i>Approximate Depth of Base of Fill (m)</i>	<i>Approximate Elevation of Base of Fill (m)</i>
24	20+823 ⁽¹⁾	08-29	0.8	261.6
		08-30	0.8	262.1
36A	23+806	08-27	0.8	286.3
		08-28	0.8	286.9
37	23+927	08-25	0.8	282.9
		08-26	0.8	283.3
39A	24+157	08-31	2.3	278.1
		08-32	0.8	279.6
42	24+955	08-23	2.3	278.3
		08-24	2.3	278.0
43	25+175	08-21	3.1	274.4
		08-22	2.3	275.1
53	26+032	08-19	0.8	267.7
		08-20	0.8	268.2
56	26+536	08-17	2.3	255.7
		08-18	1.5	256.0
60	27+216	08-15	5.0	260.8
		08-16	4.6	260.6
63	27+989	08-13	2.3	270.4
		08-14	1.1	271.2
68	28+746	08-11	6.1	261.8
		08-12	4.6	262.8
72	29+349	08-9	1.0	269.1
		08-10	1.5	268.5
97	10+659	08-7	2.7	241.3
		08-8	1.7	241.5
100	11+269	08-5	2.0	241.9
		08-6	1.5	242.1
102	11+757	08-3	0.8	243.1
		08-4	1.2	242.4
109	13+274	08-1	0.8	245.5
		08-2	2.3	244.2

¹ Boreholes for this Catchment drilled at Station 20+764 as per the initial planning.

4.2.3 Sand and Gravel to Silt

Interlayered cohesionless soils were encountered at the boreholes drilled for all sewer crossing sites with the exception of Boreholes 08-31 and 08-32 which were drilled in vicinity of the sewer crossing at Station 24+157 m. All boreholes with the exception of Boreholes 08-13, 08-17, 08-21, 08-23, 08-27 and 08-29 to 08-32 terminated within the interlayered cohesionless soil deposits at depths of between 4.9 m and 9.8 m below the ground surface.

The interlayered cohesionless soils vary in composition from sand and gravel, to sand containing trace to some gravel, trace to some silt, to silty sand containing trace silt, to sand and silt containing trace to some gravel. The sand and silty sand directly underlying the fill at Boreholes 08-2 and 08-7, respectively, contained decayed organic matter. Finer cohesionless soils were

encountered at two boreholes only; Borehole 08-5 terminated in a 0.6 m thick layer of sandy silt and Borehole 08-7 terminated within a 3.0 m thick layer of silt. The results of grain size distribution tests completed on forty-five selected samples of these interlayered cohesionless soils are presented on Figures 7 to 11. The table below summarizes the Figure numbers and the soil groups.

Figure Number	Soil Group
7	Gravelly Sand to Sand and Gravel
8A, 8B and 8C	Sand
9A and 9B	Silty Sand
10A and 10B	Sand and Silt
11	Silt

The natural water content measured on selected samples of the cohesionless soil ranged from 2 percent to 12 percent. The measured SPT 'N' values ranged from 4 to 88 blows per 0.3 m of penetration, indicative of a loose to very dense relative density; however, the average of all measured values was 25 blows per 0.3 m of penetration indicating that the median relative density of the deposit is compact.

4.2.4 Clayey Silt to Silty Clay

A deposit of clayey silt to silty clay, between 0.8 m and greater than 3.0 m in thickness, was encountered immediately below the fill in Borehole 08-31, below the cohesionless soil in Boreholes 08-8 and 08-27 and below a till deposit consisting of clayey silt at Borehole 08-32. Boreholes 08-27, 08-31 and 08-32 terminated in this deposit at depths of between 5.2 m and 6.7 m below the ground surface. The surface of the clayey silt to silty clay deposit was encountered at the following depths, and elevations:

<i>Sewer Crossing Station (m)</i>	<i>Borehole Designation</i>	<i>Depth to Surface of Clayey Silt to Silty Clay (m)</i>	<i>Elevation of Surface of Clayey Silt to Silty Clay (m)</i>	<i>Thickness of deposit (m)</i>
10+659	08-8	2.3	240.9	2.2
24+157	08-31	2.3	278.1	0.3
		4.5	275.9	>2.2
	08-32	3.0	277.4	>2.2
23+806	08-27	3.1	284.1	>2.1

This cohesive deposit contains trace to some sand and trace to some gravel. The results of grain size distribution tests carried out on three samples of the clayey silt to silty clay deposit are shown on Figure 12. Atterberg limits testing was conducted on four selected samples of the clayey silt to silty clay deposit and measured plastic limits of 16 to 19 per cent, liquid limits of 26 to 46 per cent, and plasticity indices of 10 to 26 per cent. These test results, which are plotted on a plasticity chart on Figure 13, confirm that the clayey silt to silty clay is of low to medium

plasticity. The natural water content measured on selected samples of the cohesive soil ranged from 16 percent to 26 percent.

The measured SPT 'N' values within the clayey silt to silty clay deposit ranged from 10 to 61 blows per 0.3 m of penetration, indicative of a stiff to hard consistency.

4.2.5 Silty Clay Till to Clayey Silt Till

A till deposit was encountered below the fill or clayey silt and the sand deposits in Boreholes 08-23 and 08-24, 08-31 and 08-32. The thickness of the till deposit varied from 0.8 m and 2.2 m. Borehole 08-23, which was drilled to a depth of 6.7 m, was terminated within the till deposit and had only penetrated 0.6 m into the deposit. The surface of the till deposit was encountered at the following depths and elevations in the boreholes:

<i>Sewer Crossing Station (m)</i>	<i>Borehole Designation</i>	<i>Depth to Surface of Clayey Silt to Silty Clay Till (m)</i>	<i>Elevation of Surface of Clayey Silt to Silty Clay Till (m)</i>	<i>Thickness of Clayey Silt to Silty Clay Till deposit (m)</i>
24+955	08-23	2.3	278.3	1.5
		6.1	274.5	>0.6
24+157	08-24	2.3	278.0	0.8
	08-31	2.6	277.8	1.9
	08-32	0.8	279.6	2.2

The till deposit generally consists of silty clay to clayey silt containing trace to some sand and trace gravel. In addition, during drilling, grinding of the augers was noted and is recorded and such observations are noted on the borehole records. The grinding of augers during drilling is indicative of the presence of cobbles or boulders. The measured SPT 'N' values within the silty clay to clayey silt till deposit ranged from 9 to 35 blows per 0.3 m of penetration, indicative of a stiff to hard consistency.

The result of a grain size distribution test on three selected samples of the clayey silt till deposit, is shown on Figure 14. Atterberg limits testing was carried out on five selected samples of the till deposit, and measured plastic limits of 13 to 17 per cent, liquid limits of 19 to 39 per cent, and plasticity indices of 6 to 22 per cent; these test results, which are plotted on a plasticity chart on Figure 15, confirm that the clayey silt till generally has a low plasticity and the silty clay till has a medium plasticity. The natural water content measured on selected samples of the cohesive till ranged from 13 percent to 22 percent.

4.2.6 Silty Sand Till to Sandy Silt Till

A till deposit was encountered below the cohesionless deposits in Boreholes 08-13, 08-17, 08-21 and 08-29 and 08-30. Where encountered the boreholes were terminated within the till deposit. At some locations the borehole only penetrated 0.6 m to 3.7 m into the till deposit. The surface of the till deposit was encountered at the following depths and elevations in the boreholes:

<i>Sewer Crossing Station (m)</i>	<i>Borehole Designation</i>	<i>Depth to Surface of Silty Sand to Sandy Silt Till (m)</i>	<i>Elevation of Surface of Silty Sand to Sandy Silt Till (m)</i>	<i>Thickness of Silty Sand to Sandy Silt Till deposit (m)</i>
27+989	08-13	7.6	265.1	>0.6
26+536	08-17	3.8	254.2	>2.9
25+175	08-21	6.1	271.3	>0.6
20+823	08-29	2.3	260.1	>2.9
	08-30	1.5	261.4	>3.7

The till deposit generally consists of silty sand to sandy silt containing trace to some gravel and trace to some clay. While not specifically encountered in the boreholes as part of this investigation, cobbles and boulders should also be expected within the till deposit. The measured SPT 'N' values within the silty sand to sandy silt till deposit ranged from 10 to greater than 100 blows per 0.3 m of penetration, indicative of a compact to very dense relative density. The results of a grain size distribution tests on three selected samples of the sandy silt to sand and silt till deposit, are shown on Figure 16. The natural water content measured on selected samples of the cohesionless till ranged from 7 percent to 10 percent.

4.2.7 Groundwater Conditions

Based on the observed soil moisture conditions, changes in colour from brown to grey, the observed water levels in the open boreholes following completion of drilling and the measured water level in the piezometers on September 25, November 20 and 21, 2008, the estimated groundwater depths and elevations at the sewer crossing sites are summarized as follows:

<i>Sewer Crossing Station</i>	<i>Borehole Designation</i>	<i>Depth to Groundwater (m)</i>		<i>Groundwater Elevation (m)</i>	
		<i>Sep 25, 2008</i>	<i>Nov 20/21, 2008</i>	<i>Sep 25, 2008</i>	<i>Nov 20/21, 2008</i>
20+764	08-30	Dry during drilling ¹		Dry during drilling ¹	
23+806	08-28	Dry during drilling ¹		Dry during drilling ¹	
23+927	08-26	Dry during drilling ¹		Dry during drilling ¹	
24+157	08-32	Dry during drilling ¹		Dry during drilling ¹	
24+955	08-24	3.0, during drilling ¹		277.2, during drilling ¹	
25+175	08-22	3.3	Not accessible	274.1	Not accessible
26+032	08-20	Dry	Dry	Dry	Dry
26+536	08-18	Dry	Dry	Dry	Dry
27+216	08-16	Dry	Dry	Dry	Dry
27+989	08-14	Dry	Dry	Dry	Dry
28+746	08-12	4.1	3.9	263.3	263.5
29+349	08-10	Dry	Dry	Dry	Dry
10+659	08-8	1.2	1.0	242.0	242.2
11+269	08-6	2.6	2.0	241.0	241.6
11+757	08-4	2.7	2.2	240.9	241.4
13+274	08-2	1.2	1.1	245.3	245.4

1. Piezometer was found to be destroyed when inspected on September 25, 2008.

The groundwater level at the sewer crossing locations will be subject to seasonal fluctuations, and will be higher during wet periods of the year (i.e. during spring conditions). Comparison of the depth to groundwater measurements between September 25 and November 20/21, 2008 illustrates the increase in water level as a result of the increased precipitation during the fall. The water level in the piezometers in Boreholes 08-4 and 08-6 were 0.5 and 0.6 m higher, respectively. At Boreholes 08-2 and 08-8 the groundwater level increased only 0.1 m and 0.2 m, respectively.


5.0 CLOSURE

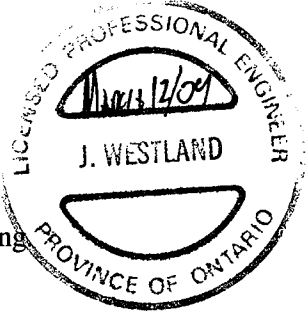
This Foundation Investigation Report was prepared by Ms. Sandra McGaghran, P.Eng., and reviewed by Mr. John Westland, P.Eng., an Principal and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent quality control review of the report.

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PART B

FOUNDATION DESIGN REPORT

**SEWER CROSSINGS
HIGHWAY 400 SBL
BETWEEN HIGHWAY 11 AND HIGHWAY 93
SIMCOE COUNTY
G.W.P. 2168-06-00**

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical/foundation design recommendations for the proposed replacement of sixteen sewer crossings located along the Highway 400 southbound lanes between Highways 11 and 93. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation for these sewer crossing sites. The interpretation and recommendations are intended to provide the designers with sufficient information to assess the feasible trenchless installation methods/open cut excavations and to design the sewer crossings. Where comments are made on construction, they are provided in order to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the Contract Documents. 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 Pipe Material Options

Installation of the sewer by either the jack and bore method or pipe ramming will require that a steel casing be installed during boring or ramming. The steel casing would remain in place with a smaller diameter sewer pipe installed within the casing. It is recommended that grout be injected in the annular space between the sewer pipe and the steel casing. To accommodate pipe installation and potential misalignment during casing advance it is understood that the steel casing will be about 1.5 times the diameter of the sewer pipe; therefore for a 300 mm diameter sewer a 450 mm diameter steel casing would be installed and for a 600 mm diameter sewer a 900 mm diameter steel casing would be installed.

The pipe must be selected to support overburden and highway loads, hydrostatic pressures (if present) and to withstand the grouting pressure and installation forces. Overburden pressure may be calculated using an unit weight of soil of 21 kN/m³. Groundwater pressures are not applicable, except at Stations 10+659 m, 11+269 and 13+274 m where the design groundwater pressure may be taken as 15 kPa.

6.3 Tunnel Alignment

Table 1 (following the text of this report) provides a summary of the invert of the steel casing, proposed storm sewer dimensions, the range of cover at the highway shoulder(s) and the corresponding range of overburden cover expressed as a function of the tunnel diameter (the number of tunnel diameters between the crown of the tunnel and the ground surface). Table 1 also provides a summary of the subsurface conditions encountered in the boreholes at the depth

zone where the sewers are to be advanced. As previously discussed, the sewer for Catchment 24 had to be relocated after the investigation was completed. Therefore there is greater uncertainty in the subsurface conditions at that crossing location. Plan and stratigraphic sections at the proposed sewer crossing locations are shown on Drawings 1 to 10.

The soil cover below the Highway 400 southbound lane pavement/shoulder grade and above the proposed obvert elevation of the steel casing at the storm sewer crossings varies from about 1.5 m to 2.8 m, with the exception of two locations where the maximum cover is 4.5 m (Station 27+216 m) and 5.9 m (Station 28+746 m). The minimum overburden cover below the Highway 400 southbound lane pavement/shoulder grade varies from 1.5 tunnel diameters to 2.9 tunnel diameters, and the maximum overburden cover varies from 2.2 tunnel diameters to 6.5 tunnel diameters. The MTO states in their Terms of Reference that “the minimum overburden cover shall not be less than two tunnel diameters or 1.5 m, whichever is greater, at any point along the entire length of the crossing.” The proposed storm sewer crossings meet the minimum cover requirements at all stations.

6.4 Pipe Material Options

The pipe must be selected to support overburden and highway loads, hydrostatic pressures (if present) and to withstand the grouting pressure and installation forces. Overburden pressures may be calculated using a unit weight of soil of 21 kN/m³. Groundwater pressures are not applicable, except at Stations 10+659 m, 11+269 m and 13+274 m where the design groundwater pressure may be taken as 15 kPa.

6.5 Pipe Installation Methods

It is understood that the Contractor will be responsible for choosing the method and equipment for sewer installation. Ground behaviour will be, in part, dependent on the installation method adopted and this report provides guidance on the influence of ground behaviour on some possible sewer installation methods. It should not be construed that the Contractor is restricted to the particular methods considered herein, and in the event of alternative methods, the Contractor must make his own interpretation of the anticipated ground behaviour, based on the factual information provided in Part A, Foundation Investigation Report, of this report.

Based on a cross section submitted by email from Genivar (dated October 16, 2008) it is understood that it is preferable that the sewers be installed using trenchless methods under the Highway 400 southbound lanes (i.e. between the west and east shoulders); both trenchless and open-cut installation methods are under consideration outside of this area (i.e. in the centre median and west ditch areas).

Possible trenchless methods include, jacking and boring, pipe ramming, using a micro-tunnel boring machine (MTBM) and horizontal directional drilling (HDD).

HDD uses drilling fluid under pressure to create the pilot hole, and typically for diameters of 375 mm to 600 mm, the recommended minimum cover is about 3.0 m. For the overburden cover depths presented in Table 1, the HDD method would not be suitable for any of the storm sewer crossings. Therefore this alternative is not considered further.

The following section of the report will present and address the geotechnical design recommendations and construction issues for the two main types of construction: the tunnelled section (jack and bore, MTBM and pipe ramming) and the conventional open cut section.

6.5.1 Open Cut Excavation

Open cut trenching across the active highway includes pavement structure demolition and restoration; trench excavation and excavation sidewall support; pipe installation; and trench backfilling. The open cut method offers the best control of gradient and alignment of the sewers, reduced potential for delays resulting from encountering obstructions and least risk of unanticipated damage to the active highway. The major disadvantages with open cut installation of the sewer pipes are the requirement for lane closures resulting in traffic disruption, large excavations for deep installations, pavement reconstruction and the potential for post construction settlement of the backfill materials. Post construction settlement may be minimized by using unshrinkable fill to backfill the trench. The open cut excavation method is feasible at all sewer crossing locations.

Further discussion on open cut excavations are provided in Section 6.5.1.

6.5.2 Jack and Bore

Jack and bore is a method of forming a near horizontal bore from a jacking/drive pit; the boring is undertaken with a rotating cutter head and a continuous welded casing is jacked through reaction against a thrust block located within the jacking pit. Spoil from the tunnel excavation is transported to the jacking pit along helical wound auger flights, and the new pipe is then installed within the casing. The casing may be lubricated to reduce the frictional forces between casing and the surrounding soil. Jack and bore is generally suitable for penetrating cohesive soils and cohesionless soils that are well-graded (i.e. broadly graded), however if boulders and cobbles are encountered, their removal may result in loss of ground at the face and ground settlement at the ground surface, depending on the soil conditions. Difficulties may also be encountered in maintaining alignment control of the tunnel as it advances due to the presence of stiffer or more compact/dense soils ahead of the face, cobbles or boulders at the face or due to mixed face conditions.

The size of the jacking pit is controlled by the equipment size and the length of the casing sections which are being installed. Typically, a work area of about 10 m long by about 3 m to 5 m wide is required to accommodate the jacking/drive pit for jack and bore operations. The receiving pit is typically about 3 m square.

6.5.3 Pipe Ramming

Pipe ramming involves the use of a percussive hammer to advance a steel casing with a cutting shoe attached at the front end of the casing. The casing is generally advanced open-ended and the soil within the casing is typically removed after the casing has been driven the entire length of the installation, thereby reducing the potential for ground loss into the casing during driving. As each casing length is installed the rammer is removed, the next casing is welded in place and the rammer replaced and restarted. On completion of the bore, compressed air or water, pressure jetting or augering is used to remove the spoils from within the casing.

Pipe ramming is best suited for soft to firm clays and very loose to compact sands above the water table. Pipe ramming methods are also better suited for penetrating through/displacing potential obstructions such as cobbles and boulders in comparison to jack and bore installation method. However, difficulties in maintaining alignment control of the tunnel as it advances can still occur if cobbles and boulders are encountered. Vibrations from the pipe ramming operations may result in settlement of loose materials in the immediate vicinity of the installation. Furthermore, a “plug” of soil may form at the head of the casing inducing surficial heave as the pipe is advanced. This can be controlled by stopping the operation and removing spoil from within the pipe before advancing further. Compared to the jack and bore method an advantage of pipe ramming is there is no need for a thrust block in the entrance pit, therefore a smaller pit size is required for pipe ramming.

6.5.4 Micro – Tunnel Boring Machine (MTBM)

These machines utilize pressurized bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face. The excavated soil is withdrawn in a controlled manner to prevent loss of ground during tunnel advance. The slurry is circulated back through the tunnel to transport cuttings to a settling tank. The MTBM can also be specified to have the capability to crush boulders which are anticipated along the proposed tunnel alignment. Given the machines ability to control soil and water pressures at the face, dewatering prior to advancing the tunnel would not be necessary with this tunnelling method.

Although this method would typically be considered to be the method that minimizes the risk of loss of ground and ground surface settlement, this risk would be greater for most of the proposed crossings because of the relatively shallow cover. In addition it is relatively expensive to

mobilize this type of machine and the availability of machines with the suitable diameter bore and the mobilization costs for such equipment may constrain their use on this project.

6.5.5 Anticipated Soil Behaviour and Feasibility of Tunnelling Methods

The anticipated soil and groundwater conditions within the proposed tunnel horizons are presented on Table 1. As discussed in Part A Foundation Investigation Report, Section 4.2.7 the groundwater level measured in the piezometers is generally below the sewer invert at all sewer crossing locations, with the exception of the sewer crossing at Station 10+659 m, 11+269 m and 13+274 m where the groundwater level is anticipated to be 0.6 m above the invert, 0.3 m above the invert and 0.8 m above the invert of the steel casing, respectively. Also at Station 11+757 m the groundwater level measured on September 25, 2008 (after a dry summer) was 0.6 m below the proposed sewer invert. Subsequent water level reading, on November 20, 2008, at Station 11+757 m indicate that the groundwater level is 0.1 m below the invert. This increase in groundwater level is likely due to seasonal fluctuations, and it is recommended that the groundwater conditions be verified immediately prior to the start of construction.

Based on the fines content, the coefficient of uniformity (which indicates whether the soil is well graded, and is expressed as the ratio of the particle size at which 60 percent of the particles are finer than over the particle size at which 10 percent are finer than) and the SPT 'N' values, the soil has been classified according to the Tunnelman's Ground Classification System (Terzaghi, 1950). This system is commonly used to describe the potential behaviour of an unsupported tunnel face during excavation and uses qualitative "stand-up time" criteria to classify the ground at and above the tunnel face into the following principal categories: firm, slowly ravelling, rapidly ravelling, cohesive running and running.

The soil conditions within the tunnel horizon have been classified on Table 2 (following the text of this report) and generally they range from "firm" to "running." Soils that are classified as "cohesive running" or "running" are not considered suitable for the jack and bore method because of the risk for uncontrolled inflows into the casing that would lead to increased settlement at the ground surface. In general, sand and gravel and poorly graded silty sand with a coefficient of uniformity of less than 3 are classified as "cohesive running" or "running." Pipe ramming is suitable in most soil conditions, above the water table, with the exception of very stiff to hard clays, as friction along the circumference of the pipe can build up and result in difficulty in advancing the pipe. Where such conditions are present the feasibility of pipe ramming has been categorized as questionable.

The feasibility for installing the sewer using the jack and bore method or pipe ramming are presented on the attached Table 2. To summarize, the soil conditions at ten of the sixteen sewer crossings are not considered suitable for installation using jack and bore methods. With the exception of three sewer crossing, where the feasibility is questionable, all the sites are

considered suitable for pipe ramming. Due to the recommended minimum cover of 2.5 m, only one site (Station 28+746) is considered feasible for MTBM, five sites are considered questionable as the depth of cover is between 2.0 m and 2.5 m and ten sites are not considered feasible as the cover above the obvert of the sewer is less than 2.0 m. A summary comparison of the advantages, disadvantages, relative costs and risks associated with the sewer installation methods is presented in Table 3, following the text of this report.

6.5.5.1 Jack and Bore Considerations

Typically in cohesionless soil the specifications should require that a plug of spoil material remain in the casing at all times. This can be achieved by maintaining the cutting head at the appropriate distance behind the leading edge of the casing or retracting it into the casing during the jacking operations. The objective being to balance the potential inflow of material into the casing, with a plug of soils at the front of the casing to minimize ground loss and consequent settlement. Once started the jack and bore operation should continue without stoppage until complete.

If obstructions, such as a boulder or a nest of cobbles, are encountered, it would be necessary to remove the augers and soil plug. Depending on the soil conditions this may result in loss of ground at the face and ground settlement at the ground surface. Typically the till deposits and native cohesive deposits will have a greater “stand-up time” compared to the cohesionless soil and fill. For cohesionless soil above the water table, the greater the fines content and the more broadly graded the soil is the greater the stand-up time will be.

Difficulties may also be encountered in maintaining alignment control of the tunnel as it advances due to the presence of cobbles/boulders, stiffer or more compact/dense soils ahead of the face or mixed face conditions. By extending the tunnel beyond the east shoulder of the southbound lanes into the median there is an increased risk of difficulty with tunnel alignment owing to the greater installation length.

Ground movements should be monitored during pipeline installation to confirm permissible ground surface movement (i.e. settlement/heave) tolerances are not exceeded (see Section 6.5.5). Construction specifications for the installation of the sewer by jacking and boring and pipe ramming are given in Special Provision, “Draft Specification for Sewer Installation via Trenchless Technology” (see Appendix B).

6.5.5.2 Pipe Ramming Considerations

In Table 2, pipe ramming was considered questionable at the sewer crossing locations where very stiff to hard cohesive soils and cohesive tills were encountered within the tunnel horizon as friction can build up along the outside of the pipe as it is advanced, making it more difficult to

advance the pipe. Also, when the next casing is being welded, the stresses around the circumference of the pipe may increase which will further increase the friction around the pipe, making it more difficult to advance the pipe. The casing may be lubricated to reduce the frictional forces between casing and the surrounding soil and/or the Contractor may utilize a higher energy hammer in such conditions.

As with the jack and bore method, tunnel alignment may be difficult to control due to the presence of cobbles/boulders, or mixed face conditions. Also, there is an increased risk of difficulty with alignment control for the option where the tunnelled portion is extended beyond the east shoulder of the southbound lanes into the median, owing to the increased installation length. If cobbles and boulders are encountered, the casing may be cleaned out, allowing access for equipment to break up the obstructions. Cleaning out the spoils from inside the casing may result in the loss of ground at the face of the casing. As discussed in Section 6.4.4.1 the till and cohesive soils will have a longer “stand-up time”, compared to the cohesionless soil and fills.

Ground movements should be monitored during pipeline installation to confirm permissible ground surface movement (i.e. settlement/heave) tolerances are not exceeded (see Section 6.5.5). Construction specifications for the installation of the sewer by jacking and boring and pipe ramming are given in Special Provision, “Draft Specification for Sewer Installation via Trenchless Technology” (see Appendix B).

6.5.5.3 MTBM Considerations

Considering the MTBM method uses bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face there is the possibility for the bentonite slurry to migrate up to the surface causing hydraulic fracture (typically referred to as “frac-out”) of the overlying soils. If this occurs during tunnelling the pressurized bentonite slurry is reduced at the face of the tunnel and therefore the face may become unstable, depending on the soil and groundwater conditions at the face. It is recommended that MTBM method is unsuitable for those sewer crossing locations with cover of less than 2.5 m. An advantage of the MTBM is lowering of the groundwater is not required. Another advantage is the MTBM can also be specified to have the capability to crush boulders which are anticipated along the proposed tunnel alignment. Ground movements should be monitored during pipeline installation to confirm permissible ground surface movement (i.e. settlement/heave) tolerances are not exceeded (see Section 6.5.5). Construction specifications for the installation of the sewer by jacking and boring and pipe ramming are given in Special Provision, “Draft Specification for Sewer Installation via Trenchless Technology” (see Appendix B).

6.6 Design and Construction Considerations

6.6.1 Excavation and Groundwater/Surface Water Control

Excavations will be required for the jacking and receiving pits for trenchless installation methods, and for any installations carried out using open cut methods. The excavations are anticipated to be extended through variable fill materials, and native soils consisting of sand and gravel to sand and silt to silt and silty clay to clayey silt, and cohesive and cohesionless till deposits.

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Projects. The fill materials, any firm to stiff and loose to compact native soils are classified as Type 3 soil, according to the OHSA. Very stiff to hard and dense to very dense portions of the native soils would be classified as Type 1 or 2 soil. Temporary excavations (i.e. those which are only open for a relatively short period) within these overburden soils should be made with side slopes not steeper than 1 horizontal to 1 vertical (1H:1V) assuming that appropriate groundwater control, if required, is carried out.

In most intact piezometers, the groundwater elevation was found to be below the proposed sewer outlet invert elevation (see Table 1), with the exception of the piezometers installed in Boreholes 08-2, 08-6 and 08-8 for the sewer crossings at about Stations 10+659 m, 11+269, and 13+274, where the groundwater levels were 0.6 m, 0.3 m and 0.8 m above the outlet invert elevation of the steel casing, respectively. The groundwater level in the piezometer installed for the sewer crossing at Station 11+757 was 0.1 m below the invert. At these locations a dewatering system will be required at the entrance and receiving pits to maintain base stability. It is noted that the groundwater level in the piezometers installed for sewer crossing at Station 11+269 m and 11+757 m was 0.3 m and 0.6 m below the invert of the sewer during dry months, respectively; however after a wet period in the fall the groundwater level had risen to 0.3 m above the invert and 0.1 m below the invert, respectively. This increase is due to seasonal fluctuations and it is recommended to verify the groundwater conditions immediately prior to the start of construction (tunnelling or open cut excavation). With the exception of the excavations at Stations 10+659 m, 11+269, 11+757 and 13+274 m, it is anticipated that any water entering the base of the excavation can be handled by pumping from properly filtered sumps located in the base of the excavation.

Seepage from zones of perched water within the fill materials should be expected particularly where granular zones are intercepted in the excavation. Where the overburden materials at the crossing locations are predominantly fine-grained in nature, the seepage through these deposits is expected to be minor and pumping from properly filtered sumps located at the base of the excavation should provide sufficient control of surface water and any “perched” groundwater.

Shallower side slopes may be required to minimize surficial sloughing if the construction is carried out at times of high “perched” water levels.

The entry and exit pits for jack and bore, pipe ramming installation methods are anticipated to be located in the area of existing median ditches or in low-lying areas. All surface water, including water within existing ditches, should be directed away from the open excavations.

6.6.1.1 Permit to Take Water Requirements for Dewatering

The potential daily pumping rate to dewater the excavations associated with the installation of the sewer crossings has been assessed, to determine whether a Permit to Take Water (PTTW) will be required for dewatering at individual sewer crossings. The Ministry of Environment requires a PTTW for any site for which the dewatering volume exceeds 50,000 litres (50 cubic metres) per day.

The assessment of potential dewatering volumes was completed based on the borehole information (soil type and thickness, and groundwater elevation) and geotechnical laboratory testing (grain size distribution test results), together with the proposed sewer invert elevations as given in Table 1 following the text of this report. The following table summarizes the groundwater conditions and requirements for a PTTW for each individual sewer site:

<i>Sewer Crossing Station (m)</i>	<i>Borehole Designation</i>	<i>Proposed Sewer Invert Elevation (m)</i>	<i>Groundwater Elevation (m)</i>	<i>PTTW Required?</i>
20+823	08-30	262.1 – 262.3	Dry based on drilling observations ¹	Not Required
23+806	08-28	284.6 – 284.8	Dry based on drilling observations ¹	Not Required
23+927	08-26	281.1 - 281.3	Dry based on drilling observations ¹	Not Required
24+157	08-32	277.4 – 277.9	Dry based on drilling observations ¹	Not Required
24+955	08-24	278.2 – 278.4	277.2 (based on drilling observations)	Not Required
25+175	08-22	275.1 – 275.3	274.1	Not Required
26+032	08-20	266.6 – 266.7	Dry	Not Required
26+536	08-18	255.1 – 256.3	Dry	Not Required
27+216	08-16	260.9 – 263.3	Dry	Not Required
27+989	08-14	269.5 – 270.0	Dry	Not Required
28+746	08-12	261.6 - 265.0	263.5 ⁺	Not Required
29+349	08-10	266.54 – 268.2	Dry	Not Required
10+659	08-8	240.9 – 241.6	242.2 ⁺	Not Required
11+269	08-6	241.3 – 241.6	241.6 ⁺	Not Required
11+757	08-4	241.5 - 241.7	241.4 ⁺	Not Required
13+274	08-2	244.5 – 244.8	245.4 ⁺	Not Required

Notes:

1. Piezometer was found to be destroyed when inspected on September 25, 2008.
2. ‘+’ indicates that the groundwater was measured on November 20 or 21, 2008.

6.6.2 Temporary Excavation Support

Temporary roadway protection may be required at the entry and exit pit work areas at the crossing locations if sufficient space is not available to permit open cut excavations. Based on the subsurface conditions at the crossing locations and the likely excavation geometry, it is anticipated that a soldier pile and lagging system using internal bracing (struts), anchors or rakers to provide lateral support would be suitable. The internal bracing (struts), anchors or rakers support should be designed to accommodate the loads applied from pressures and surcharge pressures from area, line or point loads as well as the impact of sloping ground behind the system. The lagging should be backed with filter cloth to prevent loss of fines in areas where the temporary shoring intercepts zones of perched water conditions.

The temporary excavation support system should be designed and constructed in accordance with MTO's Special Provision (SSP)105S19. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in SSP105S19.

6.6.3 Pipe Bedding

In areas where the sewer is installed in an open cut excavation at least 150 mm of Granular "A" meeting Ontario Provincial Standard Specification (OPSS) 1010 should be used as pipe bedding for the sewer. The bedding material should extend to the spring line of the pipe and should be compacted to at least 95 percent of the materials Standard Proctor Maximum Dry Density (SPMDD) using suitable vibratory compaction equipment. Sand cover material should be used from the spring line of the pipe to at least 300 millimetres above the top of the pipe. Clear stone should not be used as bedding material unless a complete, stitched geotextile surround is provided. All bedding and cover material should be placed in 150 mm loose lifts and uniformly compacted to at least 95 percent of materials SPMDD.

6.6.4 Trench Backfill

Where open cut excavations across Highway 400 are used to install the sewer, it is recommended to backfill the trench with unshrinkable fill to minimize post construction settlement. Beyond the shoulder of Highway 400 the majority of native site soils may be used for trench backfill provided they are free of significant amounts of topsoil, organic material or other deleterious material. Care should be taken to minimize the potential for over-wetting of the soils during the construction operations. Difficulties with compaction and/or backfill performance should be anticipated for soils where the water content is above the optimum for compaction purposes. Soils that are significantly above their optimum water content for compaction are not considered suitable for re-use as trench backfill. Therefore, these soils would require drying or mixing with drier materials prior to re-use as trench backfill.

All trench backfill materials should be placed in maximum 300 mm loose lifts and uniformly compacted to at least 95 percent of SPMDD in the pavement areas. Backfilling operations during cold weather should be carried out so that no inclusions of frozen lumps of soil, snow or ice are incorporated into the backfill. Backfill placed and compacted under such conditions must be carried out so that the fill temperature is above 0° C throughout the placement and compaction process.

Normal post-construction settlement of the compacted trench backfill should be anticipated with the majority of such settlement taking place within about six months following the completion of trench backfilling operations.

6.6.5 Instrumentation and Monitoring

An instrumentation and monitoring program is recommended at sewer crossing locations in order to:

- Document the effects of the sewer installation on the overlying roadways, adjacent structures or services lines/pipes;
- Obtain prior warning of ground movements that could occur due to the construction methods and equipment or unforeseen ground condition;
- Verify the Contractor's compliance with the settlement limits imposed in the Contract; and
- Allow adjustments to be made to the sewer installation methods such that the settlement limits established are not exceeded.

Monitoring of settlement instruments on this project is constrained by the continuous and high traffic volume and the limited periods during which access to the highway can be obtained. By necessity, settlement points on the road must be read remotely and the use of electromagnetic distance measuring (EDM) equipment reading reflectors installed on the highway is recommended. A specialist surveying firm should be retained to confirm the set-up and to carry out the settlement monitoring during construction; their equipment and procedures must be capable of surveying the settlement point elevation to within ± 2 mm of the actual elevation.

In addition, the installation of in-ground settlement points, consisting of a sleeved iron bars, set 0.3 m above the tunnel invert elevation at each crossing at accessible locations (e.g. highway shoulders) should be also considered. The elevation of the top of the bar would be read using conventional precision levelling equipment. The in-ground monitoring points provide the best measure of the ground settlement affects of tunnelling, as they are unaffected by frost heave, thaw settlement or the bridging action of the pavement structure.

All monitoring points should be read at least three times (on separate days) before the start of sewer installation to establish a pre-construction baseline. All points behind the face of the excavation and those within 10 m of the front of the face should be read every 4 hours over the duration of the tunnel drives. The effectiveness of this monitoring method could be impacted by weather conditions if the work is undertaken during the winter months.

A settlement monitoring plan consistent with the requirements in the “Appendix: Settlement Monitoring Guideline – Tunnelling” of MTO’s “Guideline for Foundation Engineering – Tunnelling Speciality for Corridor Encroachment Permit Application”, should be established as part of the Contract Administration for construction. A copy of the “Guideline for Foundation Engineering – Tunnelling Speciality for Corridor Encroachment Permit Application” is provided in Appendix C of this report.


6.6.6 Grouting


After the permanent sewer pipe is installed within the jacked or rammed casing, post installation grout to fill the annular space between the pipes should be carried out. Refer to the Specification for sewer installation via trenchless technology presented in Appendix B. For any installations at which the settlement monitoring indicates that pavement settlement has occurred, or where signs of ground loss have been noted, provision should be made for a program of compensation grouting above the pipe.


7.0 CLOSURE


This Foundation Design Report was prepared by Ms. Sandra McGaghran, P.Eng., and reviewed by Mr. John Westland, P.Eng., a Principal and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent quality control review of the report.

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SMM/LCC/JW/FJH/jl

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TABLE 1
SUMMARY OF ANTICIPATED SUBSURFACE CONDITIONS AT SEWER CROSSINGS
HIGHWAY 400 SOUTHBOUND LANES
BETWEEN HIGHWAY 11 AND HIGHWAY 93, SIMCOE COUNTY

Sewer Crossing Station (m)	Approximate Sewer Pipe Invert Elevation (m)	Proposed Sewer Pipe Diameter (mm)	Approximate Depth of Cover to obvert of steel casing (m)	Overburden Cover to obvert of steel casing (tunnel diameters)	Anticipated Subsurface Conditions at Design Sewer Pipe Level	Distance between Groundwater and Invert of Steel Casing at Outlet (m)	
20+823	262.1 – 262.3	450	1.50 – 1.66	2.2 – 2.4	Loose to dense silty sand, compact to very dense sand and silt till ⁽³⁾	>3.5 below	
23+806	284.6 – 284.8	525	1.57 – 1.72	2.0 - 2.2	Dense gravelly sand to sand and gravel, firm to stiff clayey silt till	>2.8 below	
23+927	281.2 – 281.3	500	1.5 – 1.65	2.0 - 2.2	Compact to dense sand	>2.7 below	
24+157	277.4 – 277.9	450	1.97 – 2.57	2.9 – 3.8	Hard clayey silt, stiff to very stiff clayey silt till	>3.7 below	
24+955	278.2 – 278.4	450	1.84 – 2.01	2.7 – 3.0	Firm to stiff clayey silt fill, stiff to very stiff silty clay till	1.0 below	
25+175	275.1 – 275.3	450	1.50 – 1.65	2.2 – 2.4	Firm to very stiff clayey silt fill	1.0 below+	
26+032	266.6 – 266.8	450	1.50 – 1.65	2.2 – 2.4	Compact sand to silty sand, dense to very dense sand and silt	>2.2 below	
26+536	255.1 – 256.3	450	1.47 – 2.69	2.2 – 4.0	Compact sand, compact silty sand fill	>2.1 below	
27+216	260.9 – 263.3	600	2.13 – 4.55	2.4 – 5.1	Loose to compact silty sand fill, compact silty sand topsoil, stiff to very stiff clayey silt fill	>4.8* below	
27+989	269.5 – 270.0	600	2.30 – 2.84	2.6 – 3.2	Compact sand, compact to dense silty sand	>1.8 below	
28+746	261.6 - 265.0	600	2.55 – 5.88	2.8 – 6.5	Compact silty sand, compact to very dense sand and silt fill	1.3 below	1.1 m below+
29+349	266.54 - 268.25	600	1.80 – 3.5	2.0 – 3.9	Compact to dense sand and silt, very stiff clayey silt fill, compact silty sand fill	>1.1 below	
10+659	240.9 – 241.6	600	2.02 – 2.63	2.2 – 2.9	Stiff clayey silt fill, compact silty sand to sand, compact sand fill	0.4 above	0.6 above+
11+269	241.3 – 241.6	600	2.04 – 2.31	2.3 – 2.6	Compact silty sand, compact sand, compact silty sand fill	0.3 below	0.3 above+
11+757	241.5 - 241.7	600	2.05 – 2.23	2.3 – 2.5	Loose to compact sand, loose to compact sand fill	0.6 below	0.1 below+
13+274	244.5 – 244.8	300	1.47 – 1.67	3.3 – 3.7	Compact sand fill, compact sand	0.7 above	0.8 above+

Notes:

1. ‘*’ indicates groundwater conditions based on observations during drilling in adjacent deeper borehole
2. All groundwater level measurements taken on September 25, 2008 with the exception of those marked with a ‘+’, which were measured on November 20 or 21, 2008.
3. Boreholes at this sewer crossing were drilled at Station 20+764 as per initial planning.

Feasibility of Jack and Bore and Pipe Ramming
Highway 400 Southbound Lane
Between Highway 11 and Highway 93, Simcoe County

Sewer Crossing Station (m)	Proposed Sewer Dimensions (mm)	Approximate Depth of Cover (at shoulder) (m)	Borehole Designation	Soil Conditions ¹ (ground surface to invert)	Fines Content ² (%)	SPT 'N' Values (ground surface to invert) (per 0.3 m)	Coefficient of Uniformity	Behaviour	Feasibility of Jack and Bore	Feasibility of Pipe Ramming	Feasibility of MTBM
20+823	450	1.5 – 1.65	08-29	Sand and gravel Fill ^{*a} , Silty Sand^{*b}	22 ^{*a} , 22 ^{*b}	6, 31, 42	4	Rapid Ravelling	Yes	Yes	No
			08-30	Silty sand Fill, Silty Sand, Sand and Silt Till	54	9, 8, 20	50	Rapid Ravelling / Firm			
23+806	525	1.57 – 1.72	08-27	Sand and gravel Fill, Clayey Silt Till, Sand and Gravel	-	28, 5, 14, 50	-	Firm	No	Yes	No
			08-28	Sand Fill, Sand, Gravelly Sand*, Sand	8	9, 16, 33, 32	10	Running			
23+927	500	1.5 – 1.65	08-25	Sand and gravel Fill, Sand*	4*	12, 29, 24	4.6	Rapidly Ravelling / Cohesive Running	No	Yes	No
			08-26	Silty sand Fill, Sand*	5*, 8*	12, 23, 32	3.1	Rapidly Ravelling / Cohesive Running			
24+157	450	1.97 – 2.57	08-31	Sand Fill*, Clayey Silt, Clayey Silt Till	28*	8, 12, 23, 35	-	Slowly Ravelling	Yes	Questionable	No
			08-32	Silty sand Fill, Clayey Silt Till	92	6, 13, 9, 21	-	Firm			
24+955	450	1.84 – 2.01	08-23	Sand and gravel Fill, Clayey silt Fill, Silty Clay Till*	83*	25, 6, 10, 12	-	Slowly Ravelling	Yes	Questionable	No
			08-24	Silty sand Fill, Clayey silt Fill	-	13, 9, 9, 15	-	Slowly Ravelling			
25+175	450	1.5 – 1.65	08-21	Sand and gravel Fill, Clayey silt Fill	-	12, 4, 7	-	Slowly Ravelling	Yes	Questionable	No
			08-22	Clayey silt Fill	-	9, 20, 26	-	Slowly Ravelling			
26+032	450	1.5 – 1.65	08-19	Sand and gravel Fill, Sand*, Silty Sand	15*	9, 19, 26	6.4	Cohesive Running	No	Yes	No
			08-20	Silty sand Fill, Sand and Silt*	63*	14, 56, 37	3.5	Rapidly Ravelling			
26+536	450	1.47 – 2.69	08-17	Sand and gravel to sand and silt Fill, Sand*	9*	15, 6, 43, 19, 20	1.4	Cohesive Running	No	Yes	No
			08-18	Silty Fill, Silty sand Fill, Silty Sand*	32*	13, 28, 20	22	Cohesive Running / Rapidly Ravelling			
27+216	600	2.13 – 4.55	08-15	Clayey silt with sand Fill^{*a}, silty sand topsoil^{*b}	63 ^{*a} , 23 ^{*b}	16, 8, 8, 12, 15, 13, 12	5.5	Slowly Ravelling	Yes	Yes	Questionable
			08-16	Clayey silt Fill, silty sand Fill*	35*	9, 16 27	2.8	Slowly Ravelling / Cohesive Running			
27+989	600	2.3 – 2.84	08-13	Sand to silty sand* Fill, Sand, Silty Sand	24*	4, 22, 46, 29, 19	-	Cohesive Running / Rapidly Ravelling	No	Yes	Questionable
			08-14	Silty sand Fill, Silty sand^{*a} to Sand^{*b}	25 ^{*a} , 18 ^{*b}	13, 38, 31, 25	5	Cohesive Running / Rapidly Ravelling			
28+746	600	2.55 – 5.88	08-11	Sand and silt Fill^{*a}, Silty Sand^{*b}	43 ^{*a} , 29 ^{*b}	6, 14, 23, 26, 25, 37, 54, 15	6, 2.3	Cohesive Running / Rapidly Ravelling	No	Yes	Yes
			08-12	Sand and silt Fill	55, 33	14, 28, 30, 60	4.6, 4.3	Rapidly Ravelling			
29+349	600	1.8 – 3.5	08-9	Sand and gravel to silty sand Fill, Sand and Silt*	42*, 45*	11, 25, 29, 37, 31	2.5	Rapidly Ravelling	Yes	Yes	No
			08-10	Silty sand Fill, Clayey silt Fill	-	16, 26, 27		Slowly Ravelling			
10+659	600	2.02 – 2.63	08-7	Sand and gravel to sand Fill ^{*a} , Clayey silt Fill, Silty Sand^{*b}	22 ^{*a} , 25 ^{*b}	17, 25, 26, 10, 10	9	Cohesive Running	No Requires dewatering	Yes	Questionable
			08-8	Sand Fill, Sand*	16*	10, 17, 16	4.2	Cohesive Running			
11+269	600	2.04 – 2.31	08-5	Sand and gravel Fill, Silty sand Fill^{*a}, Sand^{*b}	25 ^{*a} , 17 ^{*b}	9, 17, 8, 14	3.3	Rapidly Ravelling / Cohesive Running	No Requires dewatering	Yes	Questionable
			08-6	Silty sand Fill, Silty Sand*	23*, 28*	29, 15, 23, 18	14, 4	Rapidly Ravelling			
11+757	600	2.05 – 2.23	08-3	Sand and gravel Fill, Sand	9, 19	20, 14, 12, 10	4.8	Cohesive Running	No	Yes	Questionable
			08-4	Sand Fill, Sand	18, 25	11, 9, 11	4.0	Cohesive Running			
13+274	300	1.47 – 1.67	08-1	Silty sand Fill, Sand	14	17, 13 13	3.2	Cohesive Running	No Requires dewatering	Yes	No
			08-2	Sand Fill	14	20, 19, 24	2.6	Cohesive Running			

Notes:

1. Soil conditions from ground surface to invert, bold soil condition indicates soil conditions at tunnel horizon. Please note that Boreholes BH 08-29 and 08-30 were drilled at approximate Station 20+764 as per initial planning.

2. Fines content is the percentage by weight passing the number 200 sieve.

^{*a} and ^{*b} Fines content marked with ^{*a} coincide with soil material marked with an ^{*a} and Fines content marked with ^{*b} coincide with soil material marked with an ^{*b}

TABLE 3
EVALUATION OF SEWER INSTALLATION METHODS
HIGHWAY 400 SOUTHBOUND LANES
BETWEEN HIGHWAY 11 AND HIGHWAY 93, SIMCOE COUNTY

<i>Installation Method</i>	<i>NS¹</i>	<i>Advantages</i>	<i>Disadvantages</i>	<i>Estimated Costs/m of Sewer Installation</i>	<i>Risk/Consequences</i>
Open Cut Installations (OPSS 410)		Best control of gradient and alignment of sewers. Reduced potential for delays resulting from encountering obstructions. Least risk of damage to active highway unanticipated	Requires lane closures and pavement reconstruction. Large excavations required for deep installations.	\$250.00/m	Increased traffic disruption.
Jack and Bore Installation (OPSS 416)	NS ¹ at Station 23+806, 23+927, 26+032, 26+536, 27+989, 28+746, 10+659, 11+269, 11+757 and 13+274.	Sewer can be installed without lane closures resulting in minimal traffic disruption.	Large work area required for jacking pit. Obstructions (e.g. cobbles, boulders and rockfill) may deflect and/or halt bore. Greatest risk of ground subsidence of highway particularly if obstructions that slow installation procedures or if unanticipated granular soils encountered.	\$900 ² /m to \$1,800 ³ /m	Risk of encountering refusal on obstructions within fill particularly where man entry to remove obstructions is not possible. Obstructions can result in deflection of the casing resulting in misalignment of sewer. Potential for loss of ground into casing particularly if cohesionless materials are encountered. Risk of ground surface subsidence increases with decreasing cover.
Pipe Ramming Installation	Questionable at Station 24+157, 24+955 and 25+175	Minimal traffic disruption. Less risk of subsidence above pipe alignment than jack and bore installation methods. Better suited for penetrating through potential obstructions such as cobbles and boulders than jack and bore methods.	Large obstructions can deflect casing. Potential for heaving at ground surface.	\$1,800 ² /m to \$3,600 ³ /m	Obstructions can cause deflection of casing resulting in misalignment of sewer. Nests of cobbles and/or boulders can stop penetration of casing requiring hand mining. Vibration from pipe ramming may be experienced by the users of the highway.
MTBM	NS ¹ at Station 20+823, 23+806, 23+927,	Does not require groundwater lowering. Machine is able to counterbalance earth and water pressures in a	Lack of availability of machines with the suitable diameter bore. Relatively expensive. High mobilization cost for short	\$8,000/m	Time delay in obtaining a suitable diameter machine is likely. Hydraulic fracture (frac-out) is possible at sewer crossing locations with cover

	24+157, 24+955, 25+175, 26+032, 26+536, 29+349 and 13+274 Questionable at Station 27+216, 27+989, 10+659, 11+269 and 11+757	controlled manner, thereby reducing the risk of ground losses during tunnelling. Machine can also be specified to have the capability to crush boulders.	crossings. Susceptible to hydraulic fracture.		less than 2.5 m, resulting in a unsupported face.
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Notes:

1. NS¹: Not considered a suitable installation alternative for certain crossings.
2. Costs based on 300 mm diameter sewer.
3. Costs based on 600 mm diameter sewer.

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.) drive open sampler for a distance of 300 mm (12 in.)

Consistency

	c_u, s_u	kPa	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.

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 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

(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 $= \sigma'_p / \sigma'_{vo}$

(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_t	sensitivity

- Notes:**
- 1 $\tau = c' + \sigma' \tan \phi'$
 - 2 shear strength $= (\text{compressive strength})/2$
 - * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

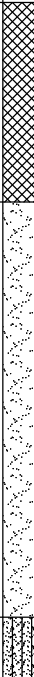

PROJECT 06-1111-011				RECORD OF BOREHOLE No 08-01				1 OF 1 METRIC									
W.P. 2168-06-00				LOCATION N 4934537.5 ; E 285137.0				ORIGINATED BY PKS									
DIST Central HWY 400				BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB									
DATUM Geodetic				DATE July 11, 2008				CHECKED BY LCC/SMM									
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									
246.3	GROUND SURFACE							20	40	60	80	100					
0.0	Silty sand, trace gravel (FILL) Compact Brown Moist		1	SS	17		246										
245.5	SAND, some silt Compact Brown Moist		2	SS	13		245										
			3	SS	13												
244.1	SAND and SILT, containing clay seams Loose to compact Grey Wet		4	SS	16		244										
			5	SS	4		243										
			6	SS	15		242										
241.7	Silty SAND, trace gravel, containing clayey silt seams Compact Grey Wet		7	SS	17												
241.1	END OF BOREHOLE																
5.2	NOTE: 1. Water level in open borehole at 3.0 m depth (Elev. 243.3 m) upon completion of drilling.																

PROJECT 06-1111-011				RECORD OF BOREHOLE No 08-02				1 OF 1 METRIC									
W.P. 2168-06-00				LOCATION N 4934533.2 ; E 285156.9				ORIGINATED BY PKS									
DIST Central HWY 400				BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB									
DATUM Geodetic				DATE July 10, 2008				CHECKED BY LCC/SMM									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
246.5	GROUND SURFACE						20	40	60	80	100						
0.0	Sandy silt (TOPSOIL)		1	SS	20												
0.1	Sand, trace to some silt, trace to some gravel (FILL)		2	SS	19												
	Compact Brown/grey Moist		3	SS	24												
244.2																	
2.3	SAND, some silt, containing decayed organic matter		4	SS	11												
243.5	Compact Grey Wet																
3.1	SAND and SILT, trace clay		5	SS	4												
	Loose to compact Grey Wet		6	SS	14												
241.9																	
4.6	SAND, trace to some silt, containing clay seams		7	SS	21												
241.3	Compact Grey Wet																
5.2	END OF BOREHOLE																
NOTE: 1. Water level in open borehole at 2.7 m depth (Elev. 243.8 m) upon completion of drilling. 2. Water level in piezometer measured at a depth of 1.4 m (Elev. 245.1 m) on September 25, 2008. 3. Water level in piezometer measured at a depth of 1.1 m (Elev. 245.4 m) on November 20, 2008.																	


+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

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PROJECT 06-1111-011			RECORD OF BOREHOLE No 08-04			1 OF 1 METRIC											
W.P. 2168-06-00			LOCATION N 4933103.5 ; E 285056.1			ORIGINATED BY PKS											
DIST Central HWY 400			BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers			COMPILED BY TB											
DATUM Geodetic			DATE July 10, 2008			CHECKED BY LCC/SMM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	10 20 30					
243.6	GROUND SURFACE																
0.0	Sandy silt (TOPSOIL)																
0.2	Sand, some silt, containing topsoil (FILL) Loose to compact Brown Moist		1	SS	11		243										0 82 17 1
242.4			2	SS	9		242										
1.2	SAND to Silty SAND, some silt Loose to compact Brown Moist																
	Wet below 2.1 m depth		3	SS	11		241										0 75 24 1
			4	SS	8		240										
			5	SS	13		239										
			6	SS	13												
			7	SS	10												
238.4	END OF BOREHOLE																
5.2	NOTE: 1. Water level in open borehole at 4.0 m depth (Elev. 239.7 m) upon completion of drilling. 2. Water level in piezometer measured at a depth of 2.7 m (Elev. 240.9 m) on September 25, 2008. 3. Water level in piezometer measured at a depth of 2.2 m (Elev. 241.4 m) on November 20, 2008.																

PROJECT 06-1111-011			RECORD OF BOREHOLE No 08-05			1 OF 1 METRIC													
W.P. 2168-06-00			LOCATION N 4932624.9 ; E 285152.5			ORIGINATED BY PKS													
DIST Central HWY 400			BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers			COMPILED BY TB													
DATUM Geodetic			DATE July 2, 2008			CHECKED BY LCC/SMM													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)			γ kN/m³	GR SA SI CL		
							20 40 60 80 100	20 40 60 80 100	Wp	W	WL	10 20 30							
243.9 0.0	GROUND SURFACE Silty sand, trace to some gravel (FILL) Loose to compact Brown Moist		1	SS	9		243												
			2	SS	17		242												3 72 23 2
241.9 2.0	SAND, some silt Compact Brown to grey Moist Wet below 2.7 m depth		3	SS	8		241												0 83 17 0
			4	SS	14		240												
			5	SS	16		239												
			6	SS	17		238												
			7	SS	18														
237.8 6.1	Sandy SILT Compact Grey Wet		8	SS	19														
237.2 6.7	END OF BOREHOLE NOTE: 1. Water level in open borehole at 5.2 m depth (Elev. 238.7 m) upon completion of drilling.																		

PROJECT 06-1111-011			RECORD OF BOREHOLE No 08-06			1 OF 1 METRIC												
W.P. 2168-06-00			LOCATION N 4932629.8 ;E 285172.3			ORIGINATED BY PKS												
DIST Central HWY 400			BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers			COMPILED BY TB												
DATUM Geodetic			DATE July 10, 2008			CHECKED BY LCC/SMM												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
								20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p	W	W _L	10 20 30				
243.6	0.0	GROUND SURFACE																
	0.2	Sandy silt (TOPSOIL) Silty sand, trace gravel, containing decayed organic matter (FILL) Compact Dark brown Moist		1	SS	29		243										
				2	SS	15												
242.1	1.5	Silty SAND Compact to dense Brown Moist Wet below 2.3 m depth		3	SS	23		242									0 77 20 3	
				4	SS	18		241										
				5	SS	12		240										
				6	SS	17											0 72 25 3	
				7	SS	32		239										
238.4	5.2	END OF BOREHOLE																
		NOTE: 1. Water level in piezometer measured at a depth of 2.6 m (Elev. 241.0 m) on September 25, 2008. 2. Water level in piezometer measured at a depth of 2.0 m (Elev. 241.6 m) on November 20, 2008.																

PROJECT 06-1111-011			RECORD OF BOREHOLE No 08-07			1 OF 1 METRIC											
W.P. 2168-06-00			LOCATION N 4932039.2 ; E 285326.1			ORIGINATED BY PKS											
DIST Central HWY 400			BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers			COMPILED BY TB											
DATUM Geodetic			DATE July 2, 2008			CHECKED BY LCC/SMM											
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 (%)
244.0	GROUND SURFACE							20	40	60	80	100					
0.0	Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	17												
243.2	Sand, some silt, containing silty clay pockets (FILL) Compact Brown Moist		2	SS	25	243											0 78 15 7
0.8			3	SS	26	242											
241.7	Clayey silt, some sand, trace gravel (FILL) Stiff Brown Moist		4	SS	10	241											
2.3																	
241.3	Silty SAND, containing rootlets and decayed organic matter (30 mm thick) Compact Black Moist		5	SS	10	240											0 75 22 3
2.7																	
240.2	SILT, trace sand, containing clayey silt lenses Compact Grey Wet		6	SS	20	239											0 3 90 7
3.8			7	SS	14	238											
237.3	END OF BOREHOLE		8	SS	18												
6.7	NOTE: 1. Water level in open borehole at 5.5 m depth (Elev. 238.5 m) upon completion of drilling.																

PROJECT 06-1111-011				RECORD OF BOREHOLE No 08-08				1 OF 1 METRIC									
W.P. 2168-06-00				LOCATION N 4932050.6 ; E 285346.5				ORIGINATED BY PKS									
DIST Central HWY 400				BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB									
DATUM Geodetic				DATE July 10, 2008				CHECKED BY LCC/SMM									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
243.2	GROUND SURFACE						20	40	60	80	100						
0.9	Sandy silt (TOPSOIL) Sand, some silt, trace clay, trace gravel, containing clay layers (FILL) Compact Brown to grey Moist		1	SS	10												
			2	SS	17												
241.5	SAND, some silt, trace gravel Compact Grey Moist		3	SS	16								o			2 82 14 2	
240.9	SILTY CLAY, trace sand Stiff Grey Moist		4	SS	10												
2.3			5	SS	14										46	0 2 38 60	
			6	SS	13												
238.7	Silty SAND, containing clayey silt seams Compact Brown Wet		7	SS	18												
4.5	END OF BOREHOLE																
238.0	NOTE: 1. Water level in open borehole at 4.0 m depth (Elev. 239.2 m) upon completion of drilling. 2. Water level in piezometer measured at a depth of 1.2 m (Elev. 242.0 m) on September 25, 2008. 3. Water level in piezometer measured at a depth of 1.0 m (Elev. 242.2 m) on November 20, 2008.																
5.2																	

PROJECT <u>06-1111-011</u>			RECORD OF BOREHOLE No 08-09			1 OF 1 METRIC										
W.P. <u>2168-06-00</u>			LOCATION <u>N 4929618.6 ; E 286971.6</u>			ORIGINATED BY <u>PKS</u>										
DIST <u>Central</u> HWY <u>400</u>			BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>			COMPILED BY <u>TB</u>										
DATUM <u>Geodetic</u>			DATE <u>July 2, 2008</u>			CHECKED BY <u>LCC/SMM</u>										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
270.1	GROUND SURFACE						20	40	60	80	100	W _p	W	W _L		
0.0	Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	11											
269.3	Silty sand, trace gravel (FILL) Compact Brown Moist		2	SS	25											
1.0	SAND and SILT, trace gravel Loose to dense Brown Moist		3	SS	29											
			4	SS	37											
			5	SS	31											
			6	SS	12											
			7	SS	9											
			8	SS	20											
263.4	END OF BOREHOLE															
6.7	NOTE: 1. Borehole dry upon completion of drilling.															



PROJECT <u>06-1111-011</u>				RECORD OF BOREHOLE No 08-10				1 OF 1 METRIC									
W.P. <u>2168-06-00</u>				LOCATION <u>N 4929629.9 ; E 286988.7</u>				ORIGINATED BY <u>PKS</u>									
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>									
DATUM <u>Geodetic</u>				DATE <u>July 11, 2008</u>				CHECKED BY <u>LCC/SMM</u>									
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			SHEAR STRENGTH kPa									
270.0	GROUND SURFACE																
0.0	Sandy silt (TOPSOIL)		1	SS	16												
269.2	Silty sand, trace clay, trace gravel (FILL)																
0.8	Compact Brown Moist		2	SS	26												
268.5	Clayey silt, trace sand, containing sand seams (FILL)																
1.5	Very stiff Brown Moist		3	SS	27												
267.0	SAND and SILT, containing cobbles and boulders between 2.2 m and 3.0 m depth																
3.0	Compact to dense Brown Moist		4	SS	21												0 48 50 2
267.0	SAND, some silt, trace gravel																
266.0	Dense Brown Moist		5	SS	34												
266.0			6	SS	32												2 84 13 1
264.8			7	SS	33												
5.2	END OF BOREHOLE																
NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was dry on September 25, 2008. 3. Piezometer was dry on November 21, 2008.																	


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+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

PROJECT <u>06-1111-011</u>		RECORD OF BOREHOLE No 08-12				1 OF 1 METRIC						
W.P. <u>2168-06-00</u>		LOCATION <u>N 4929135.0 ; E 287326.8</u>				ORIGINATED BY <u>PKS</u>						
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>						
DATUM <u>Geodetic</u>		DATE <u>July 14, 2008</u>				CHECKED BY <u>LCC/SMM</u>						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa				W _p — W — W _L
267.4	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30		
0.7	Sandy silt (TOPSOIL)		1	SS	14		267					
	Sand and silt, trace clay, trace gravel, containing clayey silt seams (POSSIBLY FILL)		2	SS	28		266					
	Compact to very dense		3	SS	30		265					
	Brown		4	SS	60		264					
	Moist		5	SS	33		263					
263.6	Silty sand, containing decayed organic matter (FILL)		6	SS	46							
3.8	Dense											
262.8	Brown											
4.6	Wet		7	SS	28							
262.2	Silty SAND, trace gravel, containing topsoil and rootlets											
5.2	Compact											
	Dark grey											
	Moist											
	END OF BOREHOLE											
NOTE: 1. Water level in piezometer measured at a depth of 4.1 m (Elev. 263.3 m) on September 25, 2008. 2. Water level in piezometer measured at a depth of 3.9 m (Elev. 263.5 m) on November 21, 2008.												



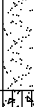
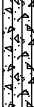
PROJECT		06-1111-011		RECORD OF BOREHOLE No 08-13				1 OF 1 METRIC									
W.P.		2168-06-00		LOCATION		N 4928499.5 ; E 287735.1		ORIGINATED BY									
DIST		Central HWY 400		BOREHOLE TYPE		210 mm Diameter Hollow Stem Augers		COMPILED BY									
DATUM		Geodetic		DATE		July 7, 2008		CHECKED BY									
								LCC/SMM									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
272.7	GROUND SURFACE																
0.0	Sand, trace to some gravel (FILL) Loose Brown Moist		1	SS	4												
271.9																	
0.8	Silty sand, trace gravel (FILL) Compact to dense Brown Moist		2	SS	22												4 72 23 1
			3	SS	46												
270.4																	
2.3	SAND, trace silt, containing cobbles and boulders Compact Brown Moist		4	SS	29												
269.7																	
3.1	Silty SAND, trace gravel Compact Brown Moist		5	SS	19												
268.9																	
3.8	SAND and SILT, trace gravel, trace clay Compact Brown Moist		6	SS	23												4 35 53 8
			7	SS	16												
266.6																	
6.1	Silty SAND, trace gravel, trace clay Compact Brown Moist		8	SS	28												1 72 24 3
265.1																	
7.6	Silty SAND, trace gravel (TILL) Compact Brown Wet		9	SS	18												
264.5																	
8.2	END OF BOREHOLE																
	NOTE: 1. Borehole dry upon completion of drilling.																

PROJECT <u>06-1111-011</u>			RECORD OF BOREHOLE No 08-14			1 OF 1 METRIC														
W.P. <u>2168-06-00</u>			LOCATION <u>N 4928506.3 ; E 287754.4</u>			ORIGINATED BY <u>PKS</u>														
DIST <u>Central</u> HWY <u>400</u>			BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>			COMPILED BY <u>TB</u>														
DATUM <u>Geodetic</u>			DATE <u>July 14, 2008</u>			CHECKED BY <u>LCC/SMM</u>														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p — W — W _L WATER CONTENT (%)			γ kN/m ³	GR SA SI CL			
								20 40 60 80 100					10 20 30							
272.3 0.7	GROUND SURFACE Sandy silt (TOPSOIL) Silty sand, trace gravel (FILL) Compact Brown Moist		1	SS	13		272													
271.2 1.1	Silty SAND to SAND, some silt Compact to dense Brown Moist		2	SS	38		271													
			3	SS	31		270													
			4	SS	25		270													
			5	SS	31		269													
			6	SS	30		268													
			7	SS	41															
267.1 5.2	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was dry on September 25, 2008.																			

PROJECT <u>06-1111-011</u>		RECORD OF BOREHOLE No 08-15				1 OF 1 METRIC										
W.P. <u>2168-06-00</u>		LOCATION <u>N 4927855.4 ; E 288173.4</u>				ORIGINATED BY <u>PKS</u>										
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>										
DATUM <u>Geodetic</u>		DATE <u>July 7, 2008</u>				CHECKED BY <u>LCC/SMM</u>										
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								
265.8	GROUND SURFACE															
0.0	Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	16											
265.0	Clayey silt with sand, trace gravel, containing decayed organic matter (FILL) Stiff to very stiff Brown Moist		2	SS	8											
0.8			3	SS	8											
			4	SS	12											
			5	SS	15											
			6	SS	13											
261.2	Silty sand, trace to some gravel, trace clay (TOPSOIL) Compact Black Moist		7	SS	12											
260.8	Silty SAND Loose Brown Moist															
5.0																
259.7	SAND, some gravel, trace silt Loose to very dense Brown Moist		8	SS	6											
6.1																
	Trace gravel below 4.6 m depth		9	SS	23											
			10	SS	66											
256.1	END OF BOREHOLE															
9.8	NOTE: 1. Borehole dry upon completion of drilling.															

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PROJECT 06-1111-011				RECORD OF BOREHOLE No 08-16				1 OF 1 METRIC									
W.P. 2168-06-00				LOCATION N 4927866.3 ; E 288189.0				ORIGINATED BY PKS									
DIST Central HWY 400				BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB									
DATUM Geodetic				DATE July 14, 2008				CHECKED BY LCC/SMM									
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									
265.2	GROUND SURFACE							20	40	60	80	100					
0.7	Sandy silt (TOPSOIL)		1	SS	9												
	Clayey silt, some sand, trace gravel (FILL)		2	SS	16												
	Stiff to very stiff																
	Brown																
	Moist																
	Trace rootlets to 0.6 m depth																
263.7																	
1.5	Silty sand, trace to some gravel, containing clay seams (FILL)		3	SS	27												
	Loose to compact																
	Brown/black																
	Moist																
	Containing topsoil and rootlets below 3.1 m depth		4	SS	22												
			5	SS	11												
			6	SS	8												
260.6																	
4.6	SAND, some gravel, trace to some silt		7	SS	21												
	Compact																
	Brown																
	Moist																
260.0																	
5.2	END OF BOREHOLE																
	NOTE:																
	1. Borehole dry upon completion of drilling.																
	2. Piezometer was dry on September 25, 2008.																
	3. Piezometer was dry on November 21, 2008.																



PROJECT 06-1111-011			RECORD OF BOREHOLE No 08-17			1 OF 1 METRIC											
W.P. 2168-06-00			LOCATION N 4927291.6 ; E 288555.9			ORIGINATED BY PKS											
DIST Central HWY 400			BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers			COMPILED BY TB											
DATUM Geodetic			DATE July 7, 2008			CHECKED BY LCC/SMM											
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									
258.0	GROUND SURFACE							20	40	60	80	100					
0.0	Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	15												
257.2			2	SS	6												
0.8	Sand and silt, some clay, trace gravel (FILL) Loose Brown Moist																
256.5			3	SS	43												
1.5	Silty sand, trace gravel (FILL) Dense Brown Moist																
255.7			4	SS	19												
2.3	SAND, some gravel, trace to some silt Compact Brown Moist		5	SS	20												
254.2			6	SS	10												
3.8	SAND and SILT, trace gravel, trace clay (TILL) Compact Brown Moist																
251.3			7	SS	25												
			8	SS	21												
252																	
6.7	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.																



PROJECT <u>06-1111-011</u>				RECORD OF BOREHOLE No 08-18				1 OF 1 METRIC									
W.P. <u>2168-06-00</u>				LOCATION <u>N 4927314.9 ; E 288561.4</u>				ORIGINATED BY <u>PKS</u>									
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>									
DATUM <u>Geodetic</u>				DATE <u>July 14, 2008</u>				CHECKED BY <u>LCC/SMM</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
257.5	GROUND SURFACE																
0.0	Sandy silt (TOPSOIL)		1	SS	13												
0.1	Sand, trace to some silt, trace gravel (FILL)																
256.7	Compact Brown Moist		2	SS	28												
0.8	Silty sand (FILL)																
256.0	Compact Brown Moist																
1.5	Silty SAND, some gravel		3	SS	20												15 53 28 4
	Compact Brown Moist																
			4	SS	18												
			5	SS	29												0 71 26 3
253.7	SAND, some silt																
3.8	Dense Brown Moist		6	SS	31												0 83 17 0
			7	SS	35												
252.3	END OF BOREHOLE																
5.2	NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was dry on September 25, 2008. 3. Piezometer was dry on November 21, 2008.																


+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

MIS-MTO 001 06-1111-011.GPJ GAL-MISS.GDT 3/9/09 DD/SAC





PROJECT		RECORD OF BOREHOLE No 08-20				1 OF 1 METRIC								
W.P. 06-1111-011		LOCATION N 4926874.5 ; E 288849.2				ORIGINATED BY PKS								
DIST Central HWY 400		BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB								
DATUM Geodetic		DATE July 14, 2008				CHECKED BY LCC/SMM								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
269.0	GROUND SURFACE							20 40 60 80 100						
0.7	Sandy silt (TOPSOIL)		1	SS	14									
268.2	Silty sand, trace gravel (FILL) Compact Brown Moist													
0.8	SAND and SILT, trace gravel, containing clayey silt seams to 1.4 m depth Dense to very dense Brown Moist		2	SS	56									
			3	SS	37									
266.7														
2.3	SAND, trace to some silt Dense Brown Moist		4	SS	33									
266.0														
3.1	SAND and SILT, trace gravel, trace to some clay Very dense Brown Moist		5	SS	75									
265.2														
3.8	SAND, trace to some silt Dense Brown Moist		6	SS	47									
264.4														
264.1	SAND and SILT, trace gravel Very dense Brown Moist		7	SS	88									
4.9	END OF BOREHOLE													
NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was dry on September 25, 2008. 3. Piezometer was dry on November 21, 2008.														

PROJECT		06-1111-011		RECORD OF BOREHOLE No 08-21		1 OF 1 METRIC											
W.P.		2168-06-00		LOCATION		N 4926162.3 ; E 289295.0											
DIST		Central HWY 400		BOREHOLE TYPE		210 mm Diameter Hollow Stem Augers											
DATUM		Geodetic		DATE		July 3, 2008											
				ORIGINATED BY		PKS											
				COMPILED BY		TB											
				CHECKED BY		LCC/SMM											
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									
277.4	GROUND SURFACE							20	40	60	80	100					
0.0	Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	12		277										28 45 26 1
276.6	Clayey silt, some sand, trace gravel, containing decayed organic matter (FILL) Firm Grey Moist		2	SS	4		276										
275.1	Gravelly sand, some silt (FILL) Compact Brown Moist to wet		3	SS	7		275										
274.4	SAND and SILT Compact Brown Wet		4	SS	25		274										
3.1		5	SS	17	273												
		6	SS	29	272												
		7	SS	23	271												
271.3	Sandy SILT, some gravel, trace clay (TILL) Very dense Brown Moist	8	SS	84											0 57 42 1		
270.7	END OF BOREHOLE														18 28 50 6		
6.7	NOTE: 1. Water level in open borehole at 5.8 m depth (Elev. 271.6 m) upon completion of drilling.																

PROJECT <u>06-1111-011</u>				RECORD OF BOREHOLE No 08-22				1 OF 1 METRIC									
W.P. <u>2168-06-00</u>				LOCATION <u>N 4926152.0 ; E 289322.6</u>				ORIGINATED BY <u>PKS</u>									
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>									
DATUM <u>Geodetic</u>				DATE <u>July 15, 2008</u>				CHECKED BY <u>LCC/SMM</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
277.4 0.0	GROUND SURFACE Clayey silt, some sand, trace gravel, containing topsoil (FILL) Stiff to very stiff Brown Moist		1	SS	9		277									8 33 56 3	
			2	SS	20		276										
			3	SS	26												
275.1 2.3	SAND, trace to some silt Compact Brown Wet		4	SS	14		275										
274.4 3.0	SAND and SILT, trace to some gravel Dense Brown Wet		5	SS	33		274										
273.6 3.8	SAND, trace to some silt Compact to dense Brown Wet		6	SS	35												
			7	SS	24		273										
272.2 5.2	END OF BOREHOLE NOTE: 1. Water level in open borehole at 3.7 m depth (Elev. 273.7 m) upon completion of drilling. 2. Water level in piezometer measured at a depth of 3.3 m (Elev. 274.1 m) on September 25, 2008.																

PROJECT 06-1111-011				RECORD OF BOREHOLE No 08-23				1 OF 1 METRIC									
W.P. 2168-06-00				LOCATION N 4925959.3 ; E 289432.8				ORIGINATED BY PKS									
DIST Central HWY 400				BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB									
DATUM Geodetic				DATE July 7, 2008				CHECKED BY LCC/SMM									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
280.6 0.0	GROUND SURFACE Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	25	280											1 16 40 43
279.8 0.8	Clayey silt, some sand, trace gravel (FILL) Firm to stiff Brown Moist		2	SS	6		279										
			3	SS	10												
278.3 2.3	SILTY CLAY, some sand, trace gravel (TILL) Stiff to very stiff Brown/Grey Moist		4	SS	12		278										
			5	SS	17												
276.8 3.8	SAND, trace to some silt, trace gravel (TILL) Compact Brown Wet		6	SS	11		277										
			7	SS	17												
274.5 6.1	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff Grey Wet		8	SS	27		276										
273.9 6.7	END OF BOREHOLE NOTE: 1. Water level in open borehole at 4.9 m depth (Elev. 275.7 m) upon completion of drilling.				275												
						274											

PROJECT <u>06-1111-011</u>				RECORD OF BOREHOLE No 08-24				1 OF 1 METRIC									
W.P. <u>2168-06-00</u>				LOCATION <u>N 4925980.6 ; E 289431.6</u>				ORIGINATED BY <u>PKS</u>									
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>									
DATUM <u>Geodetic</u>				DATE <u>July 15, 2008</u>				CHECKED BY <u>LCC/SMM</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
280.3	GROUND SURFACE																
0.0	Sandy silt (TOPSOIL)																
0.2	Silty sand, trace gravel, containing clay seams (FILL) Loose to compact		1	SS	13												
279.2	Brown Moist																
1.1	Clayey silt, trace to some sand, containing decayed organic matter, trace gravel (FILL) Firm		2	SS	9												
	Grey Moist																
	Brown below 1.5 m depth																
278.0	CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff		4	SS	15												7 25 48 20
277.3	Brown Moist																
3.1	SAND, trace to some silt Compact		5	SS	21												
276.5	Moist to wet																
3.8	SAND and GRAVEL, trace silt Dense		6	SS	30												46 48 4 2
	Brown Wet																
			7	SS	42												
275.1	END OF BOREHOLE																
5.2	NOTE: 1. Water level in open borehole at 3.0 m depth (Elev. 277.2 m) upon completion of drilling. 2. Piezometer was found to have been destroyed when inspected on September 25, 2008.																







PROJECT		RECORD OF BOREHOLE No 08-25				1 OF 1 METRIC												
W.P. 2168-06-00		LOCATION N 4925124.1 ; E 289979.6				ORIGINATED BY PKS												
DIST Central HWY 400		BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB												
DATUM Geodetic		DATE July 3, 2008				CHECKED BY LCC/SMM												
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 (%)
283.7	GROUND SURFACE							20	40	60	80	100						
0.0	Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	12													
282.9	SAND, trace silt, trace to some gravel Compact Brown Moist		2	SS	29													
0.8																		
			3	SS	24													
			4	SS	14													
			5	SS	19													
279.9	SAND and GRAVEL, trace silt Compact Brown Moist		6	SS	29													
3.8																		
279.3	SAND, trace silt, trace gravel Compact Brown Moist																	
4.4																		
			7	SS	22													
278.5	END OF BOREHOLE																	
5.2	NOTE: 1. Borehole dry upon completion of drilling.																	

PROJECT <u>06-1111-011</u>				RECORD OF BOREHOLE No 08-26				1 OF 1 METRIC									
W.P. <u>2168-06-00</u>				LOCATION <u>N 4925114.2 ; E 289999.2</u>				ORIGINATED BY <u>PKS</u>									
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>									
DATUM <u>Geodetic</u>				DATE <u>July 15, 2008</u>				CHECKED BY <u>LCC/SMM</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
284.1	GROUND SURFACE							20	40	60	80	100					
0.0	Sandy silt (TOPSOIL)		1	SS	12												
283.3	Silty sand, trace gravel (FILL) Compact Brown Moist		2	SS	23												13 79 7 1
0.8	SAND, trace to some gravel, trace to some silt Compact to dense Brown Moist		3	SS	32												
			4	SS	29												5 90 4 1
			5	SS	50												
280.3	Silty SAND, trace gravel, containing gravelly seams Dense Brown Moist		6	SS	49												
279.5	SAND, trace silt, trace gravel Very dense Brown Moist		7	SS	67												
278.9	END OF BOREHOLE																
5.2	NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was found to have been destroyed when inspected on September 25, 2008.																


PROJECT 06-1111-011				RECORD OF BOREHOLE No 08-27				1 OF 1 METRIC									
W.P. 2168-06-00				LOCATION N 4925023.7 ; E 290044.7				ORIGINATED BY PKS									
DIST Central HWY 400				BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB									
DATUM Geodetic				DATE July 3, 2008				CHECKED BY LCC/SMM									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
287.1	GROUND SURFACE						20	40	60	80	100						
0.0	Sand and gravel, trace to some silt (FILL) Compact Brown Moist		1	SS	28												
286.3	CLAYEY SILT, some sand, trace gravel (TILL) Firm to stiff Brown Moist		2	SS	5												
0.8			3	SS	14												
284.8																	
2.3	SAND and GRAVEL, trace to some silt Dense Brown Moist		4	SS	50												
284.1	CLAYEY SILT, trace sand Very stiff to hard Brown Moist		5	SS	29												
3.1			6	SS	39												
			7	SS	42												
281.9	END OF BOREHOLE																
5.2	NOTE: 1. Borehole dry upon completion of drilling.																

PROJECT <u>06-1111-011</u>		RECORD OF BOREHOLE No 08-28		1 OF 1 METRIC	
W.P. <u>2168-06-00</u>		LOCATION <u>N 4925013.1 ; E 290064.8</u>		ORIGINATED BY <u>PKS</u>	
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>		COMPILED BY <u>TB</u>	
DATUM <u>Geodetic</u>		DATE <u>July 15, 2008</u>		CHECKED BY <u>LCC/SMM</u>	

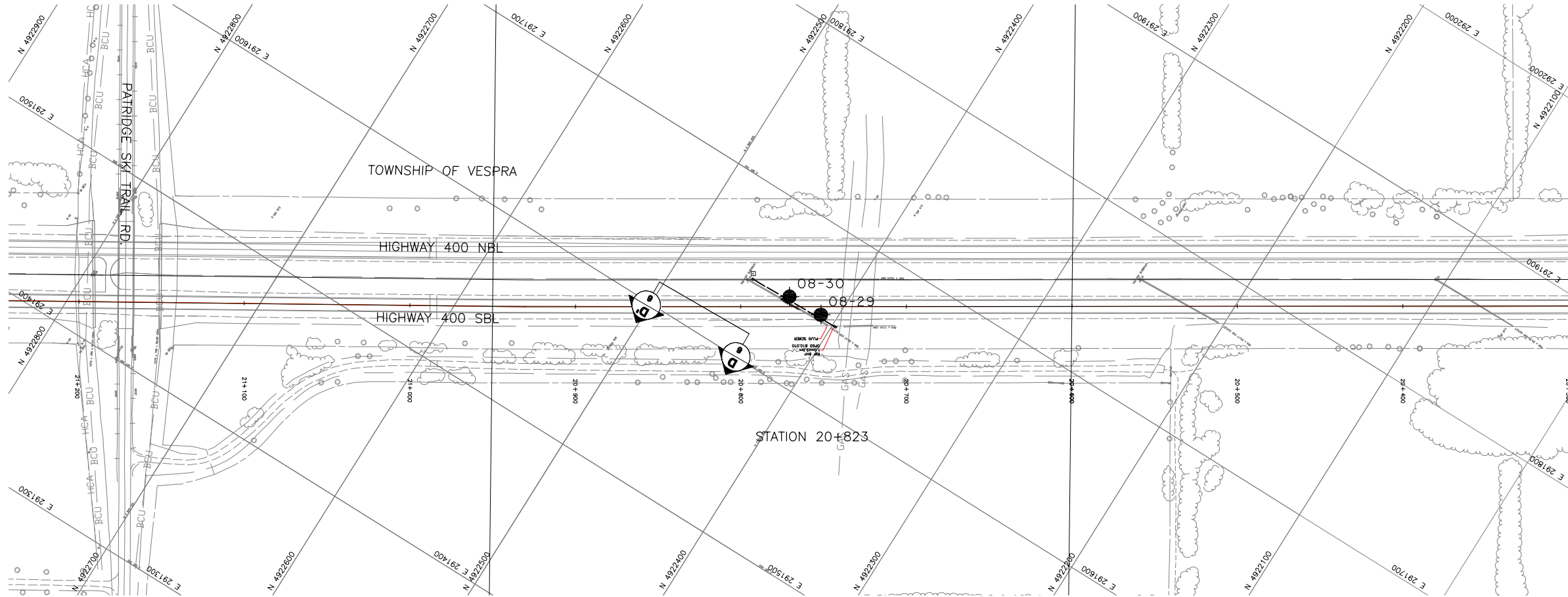
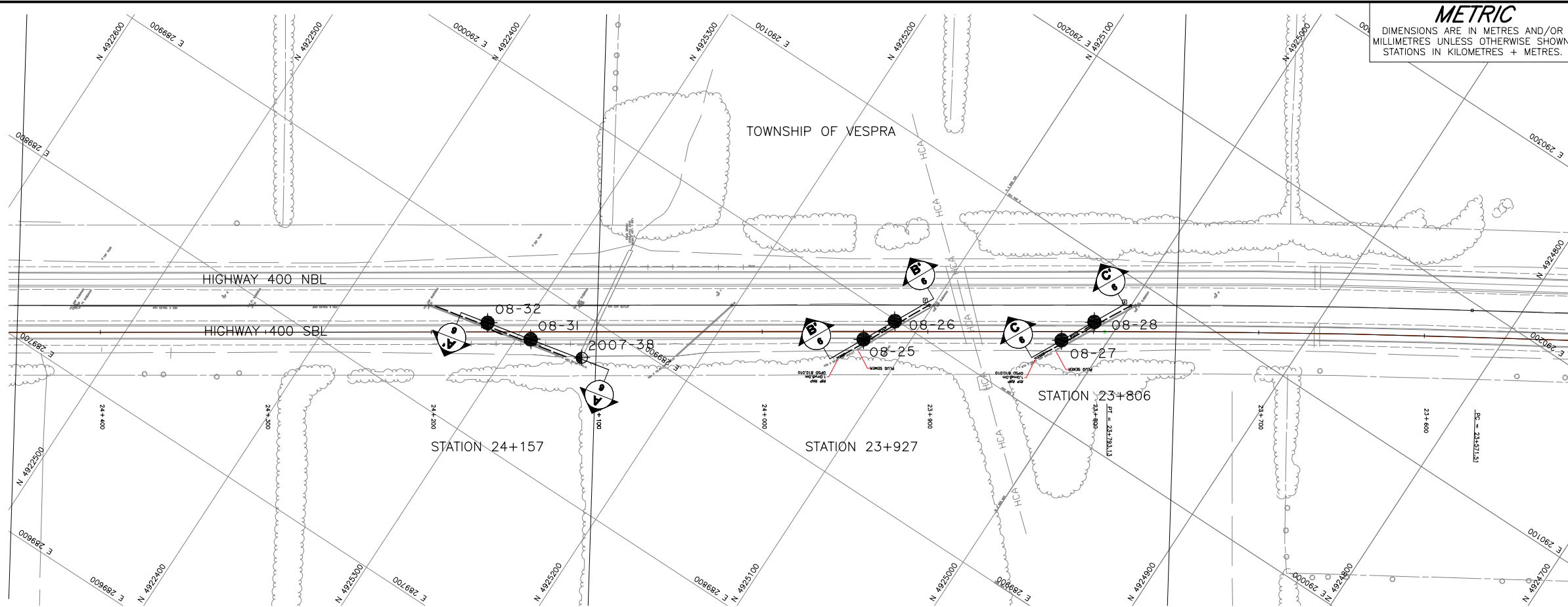
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED				W _p W W _L				
287.7	GROUND SURFACE															
0.0	Sandy silt (TOPSOIL)		1	SS	9											
0.1	Sand, trace gravel, trace silt, trace clay (FILL)															
286.9	Loose Brown Moist		2	SS	16											
0.8	SAND, trace silt															
286.2	Compact Brown Moist		3	SS	33											
1.5	Gravelly SAND, trace to some silt														21 71 6 2	
285.4	Dense Brown Moist		4	SS	32											
2.3	SAND, trace silt, containing gravelly layers (80 mm thick)															
	Compact to very dense		5	SS	66										45 50 4 1	
	Brown Moist															
			6	SS	28											
			7	SS	20											
282.5	END OF BOREHOLE															
5.2	NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was found to have been destroyed when inspected on September 25, 2008.															

PROJECT <u>06-1111-011</u>				RECORD OF BOREHOLE No 08-29				1 OF 1 METRIC											
W.P. <u>2168-06-00</u>				LOCATION <u>N 4922409.3 ; E 291649.0</u>				ORIGINATED BY <u>PKS</u>											
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>											
DATUM <u>Geodetic</u>				DATE <u>July 4, 2008</u>				CHECKED BY <u>LCC/SMM</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										WATER CONTENT (%) 10 20 30	
262.4 0.0	GROUND SURFACE Sand and gravel, some silt, trace clay (FILL) Loose Brown Moist		1	SS	6		262							○					38 40 20 2
261.6 0.8	Silty SAND, trace to some gravel Dense Brown Moist Wet below 1.5 m depth		2	SS	31		261												8 70 21 1
260.1 2.3	SAND and SILT, trace gravel, trace to some clay (TILL) Dense to very dense Brown Moist		4	SS	53		260												
			5	SS	49		259												
			6	SS	62		258							○					2 56 35 7
257.2 5.2	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.		7	SS	74														

PROJECT <u>06-1111-011</u>				RECORD OF BOREHOLE No 08-30				1 OF 1 METRIC									
W.P. <u>2168-06-00</u>				LOCATION <u>N 4922431.2 ; E 291648.2</u>				ORIGINATED BY <u>PKS</u>									
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>TB</u>									
DATUM <u>Geodetic</u>				DATE <u>July 15, 2008</u>				CHECKED BY <u>LCC/SMM</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
262.9	GROUND SURFACE																
0.0	Sandy silt (TOPSOIL)																
0.2	Silty sand, trace gravel (FILL)		1	SS	9												
262.1	Loose Brown Moist																
0.8	Silty SAND, trace gravel		2	SS	8												
261.4	Loose Brown Moist																
1.5	SAND and SILT, trace gravel, trace to some clay (TILL)		3	SS	20												
	Compact to very dense Grey Moist																
			4	SS	64												
			5	SS	96												
			6	SS	50/0.10												
			7	SS	77												
257.7	END OF BOREHOLE																
5.2	NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was found to have been destroyed when inspected on September 25, 2008.																

PROJECT <u>06-1111-011</u>		RECORD OF BOREHOLE No 08-31		1 OF 1 METRIC															
W.P. <u>2168-06-00</u>		LOCATION <u>N 4925292.4 ;E 289869.5</u>		ORIGINATED BY <u>PKS</u>															
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Augers</u>		COMPILED BY <u>TB</u>															
DATUM <u>Geodetic</u>		DATE <u>July 7, 2008</u>		CHECKED BY <u>LCC/SMM</u>															
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										WATER CONTENT (%) 10 20 30	
280.4 0.0	GROUND SURFACE Sand and gravel, trace to some silt (FILL) Loose Brown Moist		1	SS	8		280												
279.6 0.8	Sand, some silt, trace gravel, trace clay (FILL) Compact Brown Moist		2	SS	12		279												
			3	SS	23														
278.1							278												
277.8 2.6	CLAYEY SILT, trace sand, containing rootlets and decayed organic matter Hard Grey/Black Moist		4	SS	35														
	CLAYEY SILT, trace sand, trace gravel, containing cobbles and boulders between 2.2 m and 3.0 m depth (TILL) Stiff Brown Moist		5	SS	13		277												
275.9 4.5	CLAYEY SILT, trace sand, trace gravel Stiff to very stiff Brown Moist		6	SS	20														
			7	SS	12		276												
					275														
273.7 6.7	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.		8	SS	12		274												

PROJECT 06-1111-011				RECORD OF BOREHOLE No 08-32				1 OF 1 METRIC									
W.P. 2168-06-00				LOCATION N 4925319.6 ; E 289863.7				ORIGINATED BY PKS									
DIST Central HWY 400				BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY TB									
DATUM Geodetic				DATE July 15, 2008				CHECKED BY LCC/SMM									
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									
280.4	GROUND SURFACE																
0.0	Silty sand, some gravel, containing clayey silt seams (FILL) Loose Brown Moist		1	SS	6												
279.6	CLAYEY SILT, trace to some sand, trace gravel (TILL) Stiff to very stiff Brown Moist		2	SS	13												
0.8			3	SS	9												
			4	SS	21												
277.4	SILTY CLAY, trace sand, trace gravel Hard Brown Moist		5	SS	61												
3.0			6	SS	37												
			7	SS	51												
275.2	END OF BOREHOLE																
5.2	NOTE: 1. Borehole dry upon completion of drilling. 2. Piezometer was found to have been destroyed when inspected on September 25, 2008.																



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

CONT No.
WP No. 2168-06-00



Highway 400 SBL
Sewer Crossings
Station 20+300 to 24+600
Borehole Locations

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE

4 0 4 8 km

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation ("Foundation Investigation and Design Report, Culverts, Highway 400 SBL Between Highway 11 and County Road 11 (Forbes Road), Simcoe County" G.W.P. 167-99-00, Dated April 2008)

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-32	280.4	4925319.6	289863.7
08-31	280.4	4925292.4	289869.5
08-30	262.9	4922431.2	291648.2
08-29	262.4	4922409.3	291649.0
08-28	287.7	4925013.1	290064.8
08-27	287.1	4925023.7	290044.7
08-26	284.1	4925114.2	289999.2
08-25	283.7	4925124.1	289979.6
2007-38	277.0	4925260.4	289877.1

NOTES

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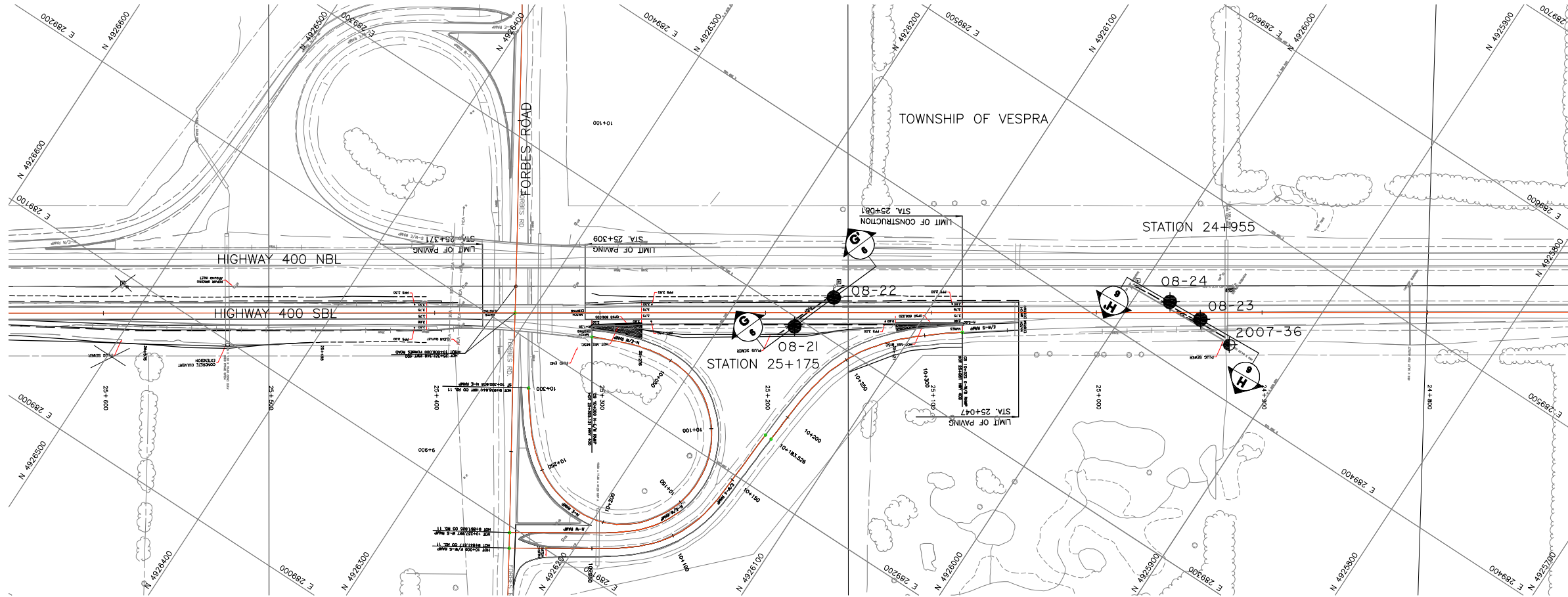
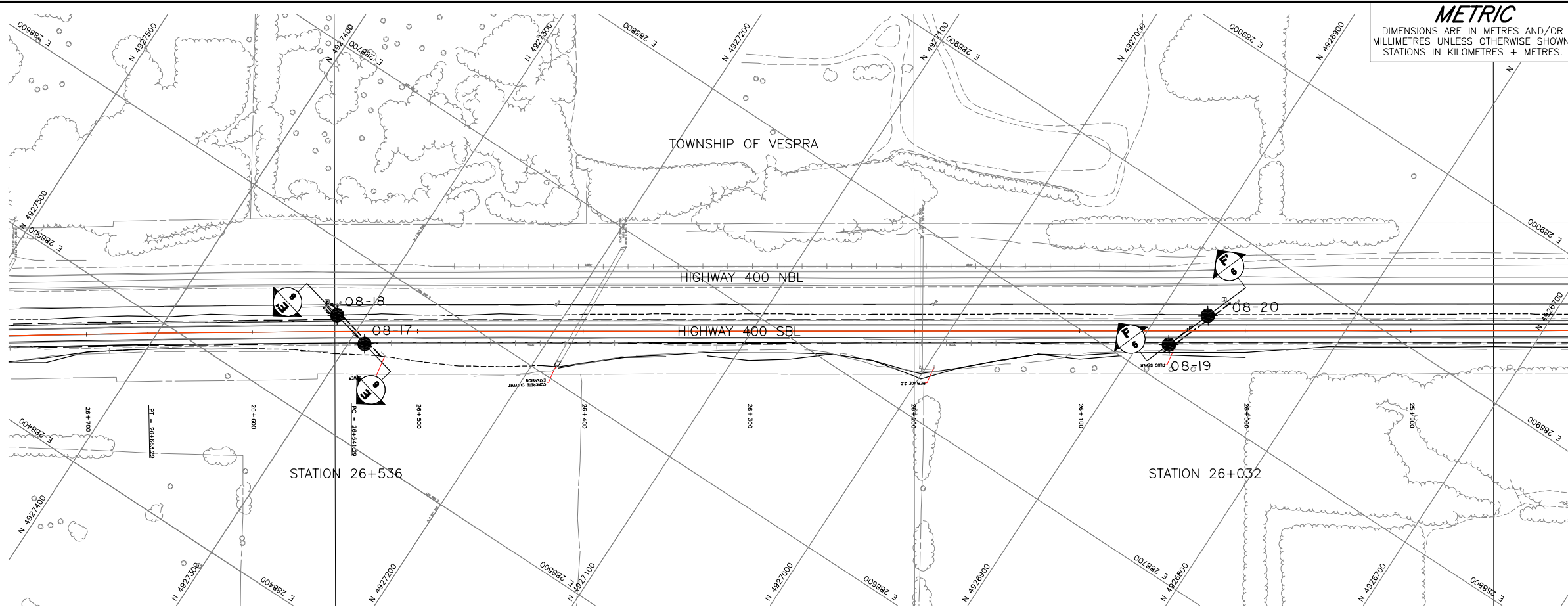
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The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Transenco Limited ("Hwy 400 Base Plan_1.dwg", and "Hwy 400 Base Plan_3.dwg" received on December 4, 2007).

NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011-6	
SUBM'D. SMM		DATE: 12-Mar-2009	SITE:
DRAWN: DD		CHKD. SMM	APPD. LCC
		DWG. 1	



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

CONT No.
WP No. 2168-06-00



Highway 400 SBL
Sewer Crossings
Station 24+720 to 26+750
Borehole Locations

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE

4 0 4 8 km

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation ("Foundation Investigation and Design Report, Culverts, Highway 400 SBL Between Highway 11 and County Road 11 (Forbes Road), Simcoe County" G.W.P. 167-99-00, Dated April 2008)

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-24	280.3	4925980.6	289431.6
08-23	280.6	4925959.3	289432.8
08-22	277.4	4926152.0	289322.6
08-21	277.4	4926162.3	289295.0
08-20	269.0	4926874.5	288849.2
08-19	268.5	4926884.7	288821.7
08-18	257.5	4927314.9	288561.4
08-17	258.0	4927291.6	288555.9
2007-36	278.2	4925953.0	289457.4

NOTES

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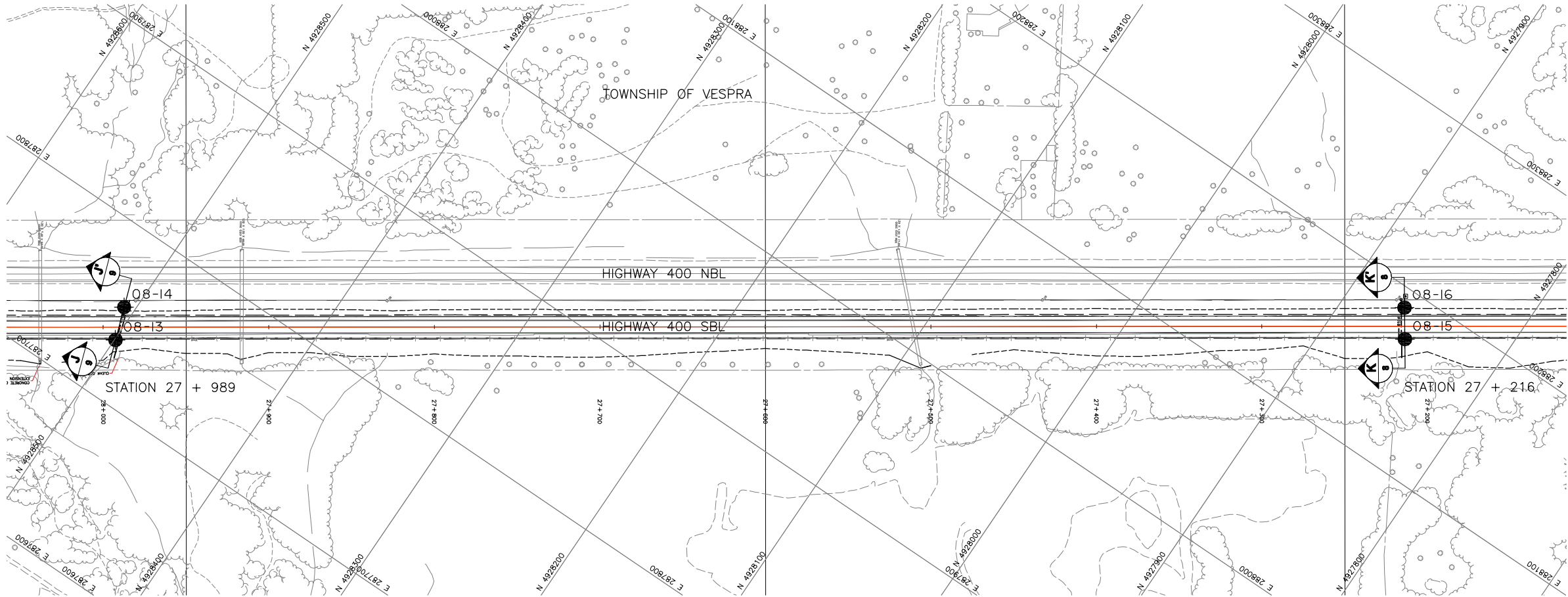
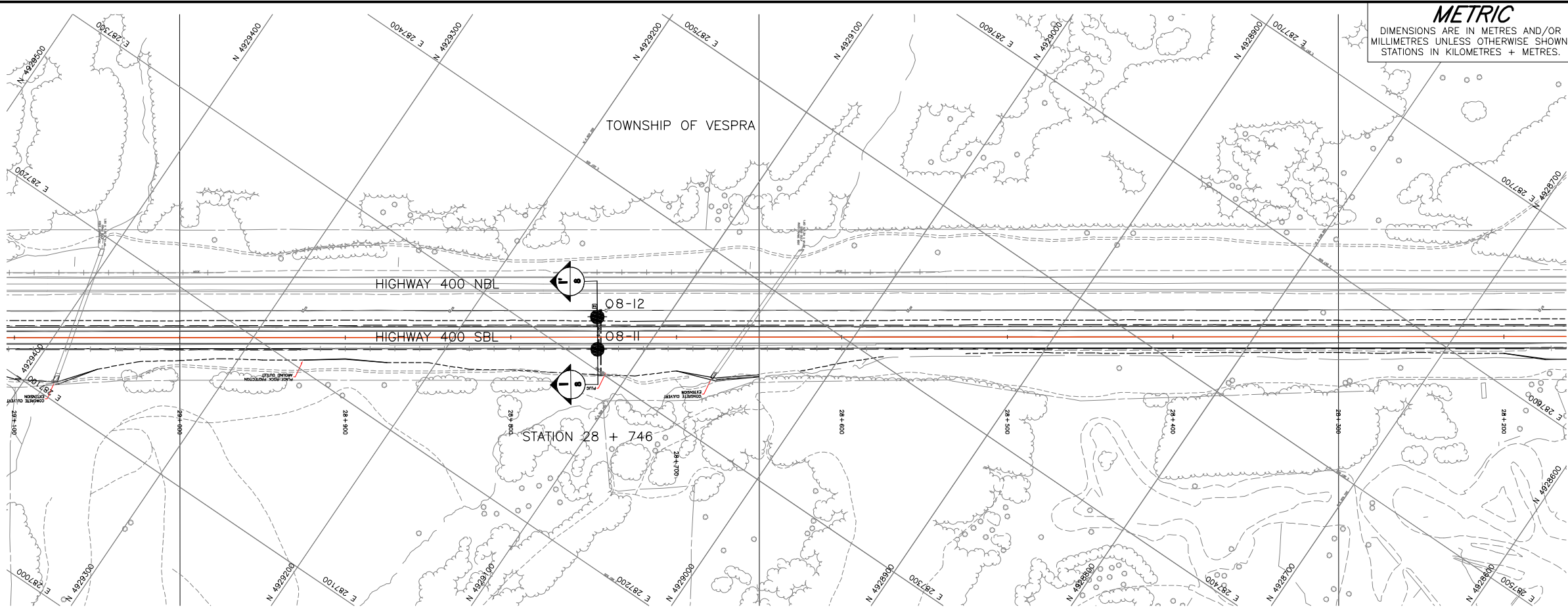
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NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011-6	
SUBM'D. SMM		DATE: 12-Mar-2009	SITE:
DRAWN: DD/RJ		CHKD. SMM	APPD. LCC
		DWG. 2	



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

CONT No.
WP No. 2168-06-00

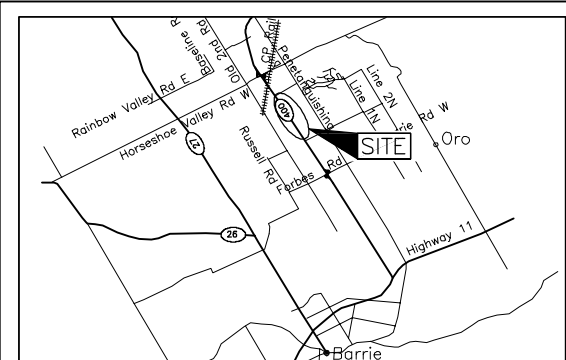


Highway 400 SBL
Sewer Crossings
Station 27+100 to 29+000
Borehole Locations

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE

4 0 4 8 km

LEGEND

● Borehole - Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-16	265.2	4927866.3	288189.0
08-15	265.8	4927855.4	288173.4
08-14	272.3	4928506.3	287754.4
08-13	272.7	4928499.5	287735.1
08-12	267.4	4929135.0	287326.8
08-11	267.9	4929123.9	287310.7

NOTES

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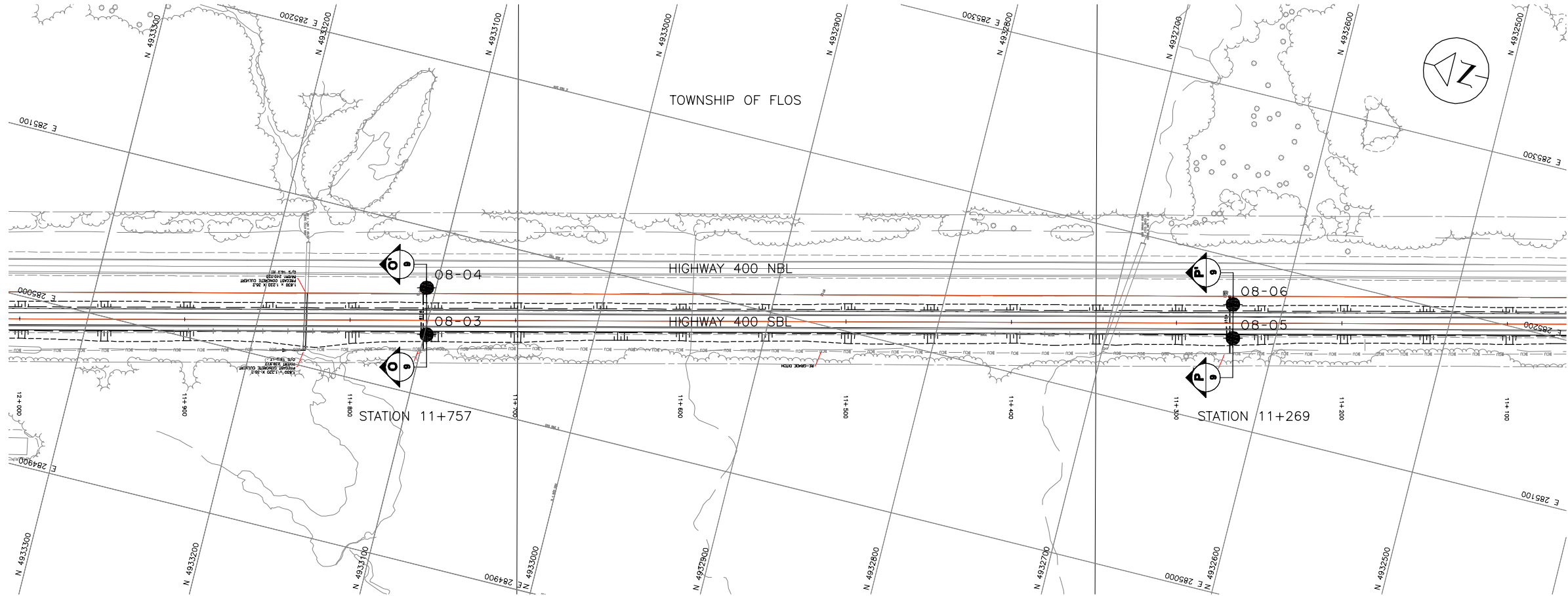
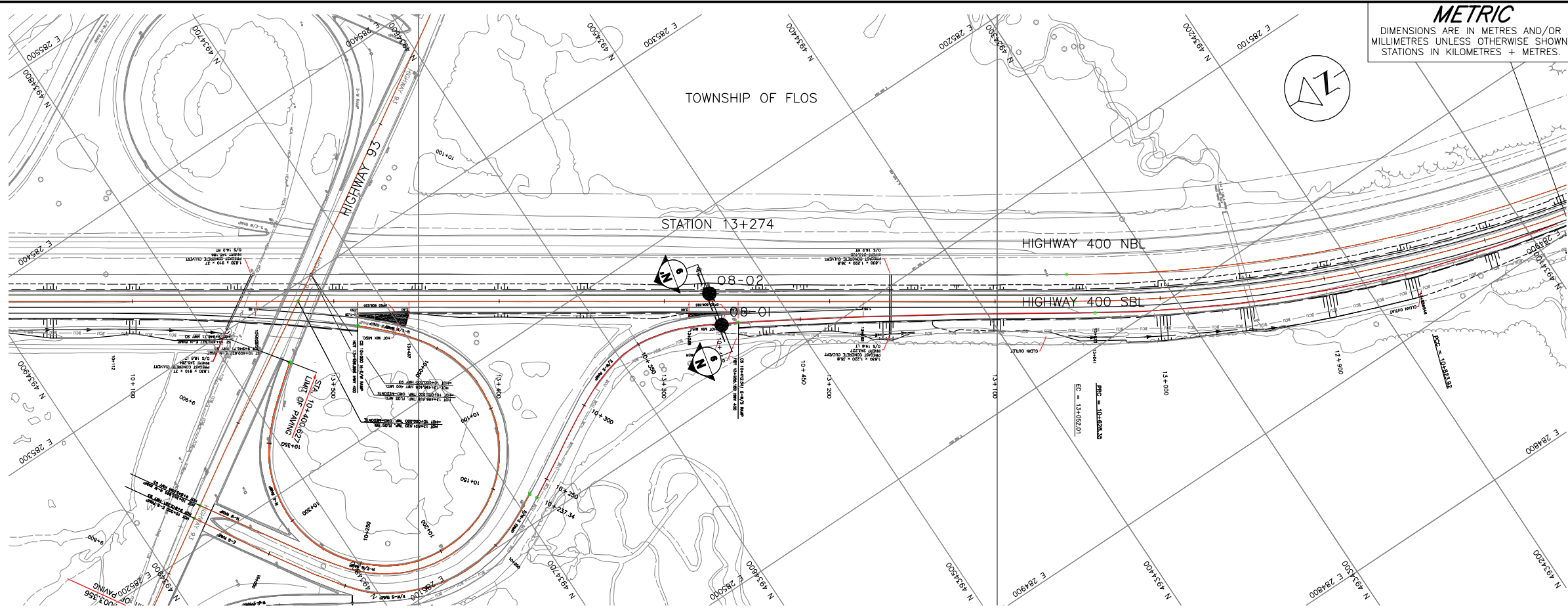
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REFERENCE

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NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011-6	
SUBM'D. SMM	CHKD. PKS	DATE: 12-Mar-2009	SITE:
DRAWN: DD/RJ	CHKD. SMM	APPD. LCC	DWG. 3



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

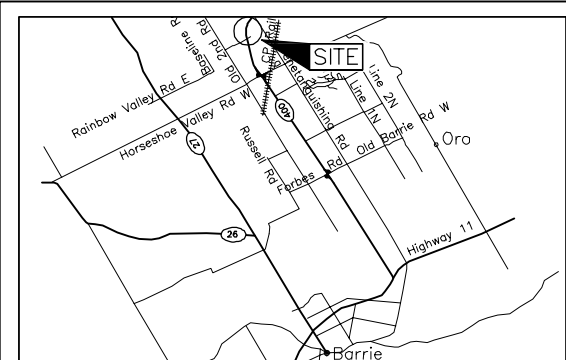
CONT No.
WP No. 2168-06-00

Highway 400 SBL
Sewer Crossings
Station 11+100 to 13+500
Borehole Locations

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
4 0 4 8 km

LEGEND

● Borehole - Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-6	243.6	4932629.8	285172.3
08-5	243.9	4932624.9	285152.5
08-4	243.6	4933103.5	285056.1
08-3	243.9	4933098.7	285036.7
08-2	246.5	4934533.2	285156.9
08-1	246.3	4934537.5	285137.0

NOTES

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REFERENCE

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NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011-6	
SUBM'D. SMM	CHKD. PKS	DATE: 12-Mar-2009	SITE:
DRAWN: DD/RJ	CHKD. SMM	APPD. LCC	DWG. 5

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

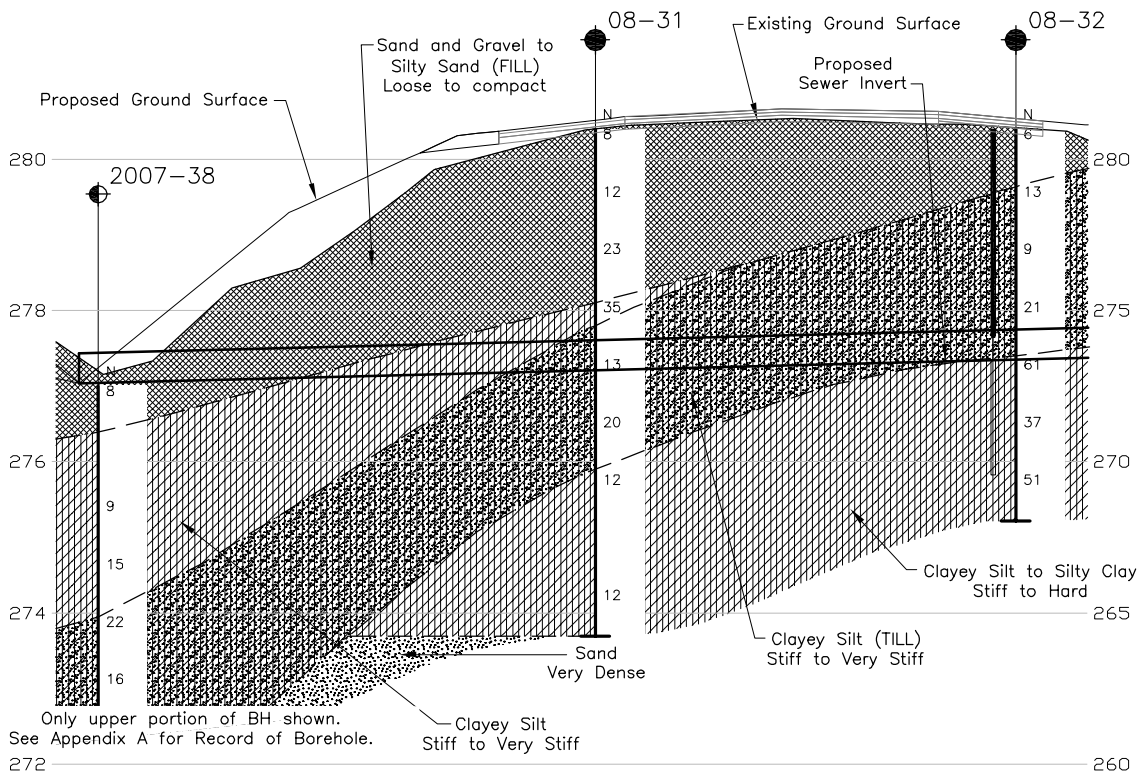
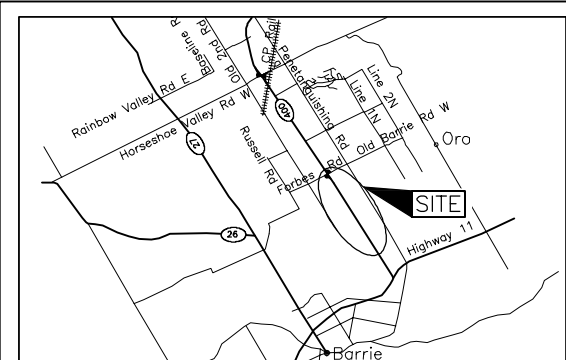
CONT No.
WP No. 2168-06-00

HIGHWAY 400 SBL
Sewer Crossings
SOIL STRATA

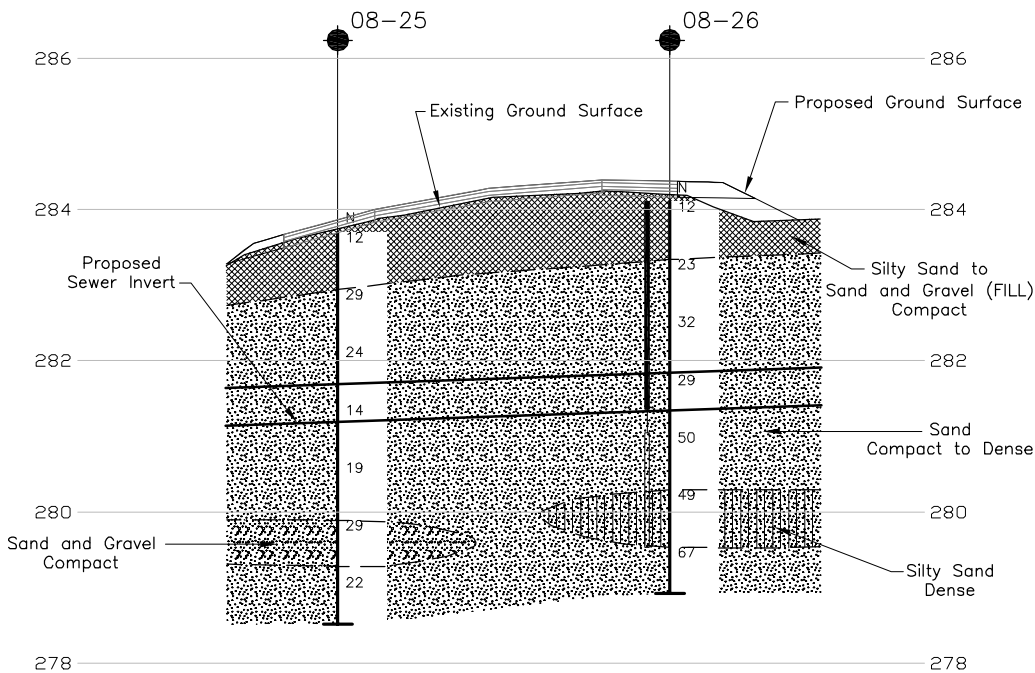
SHEET



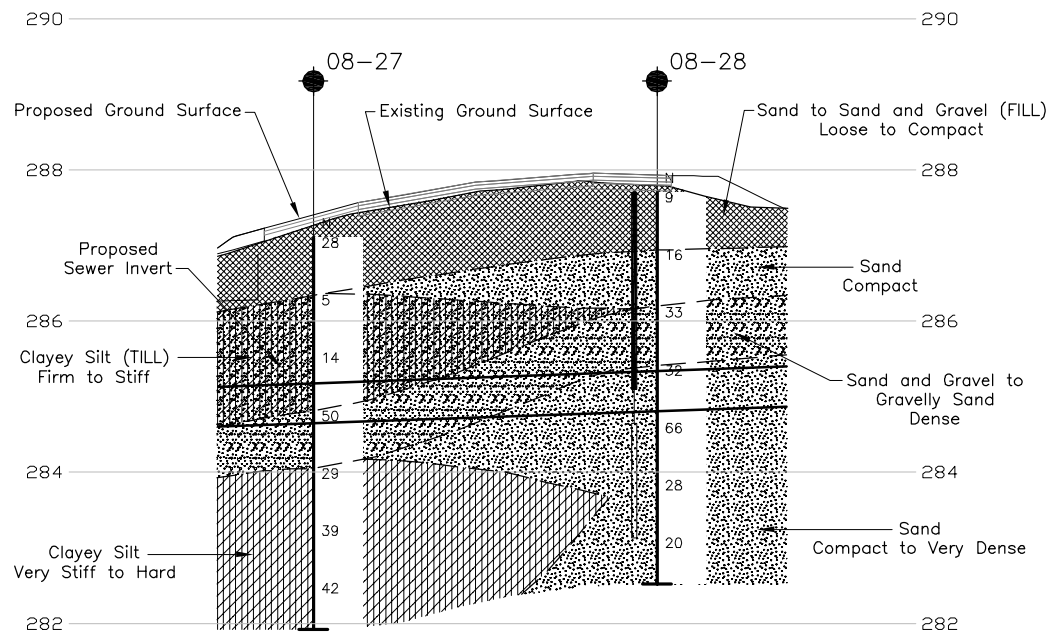
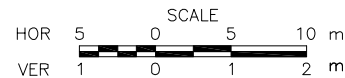
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



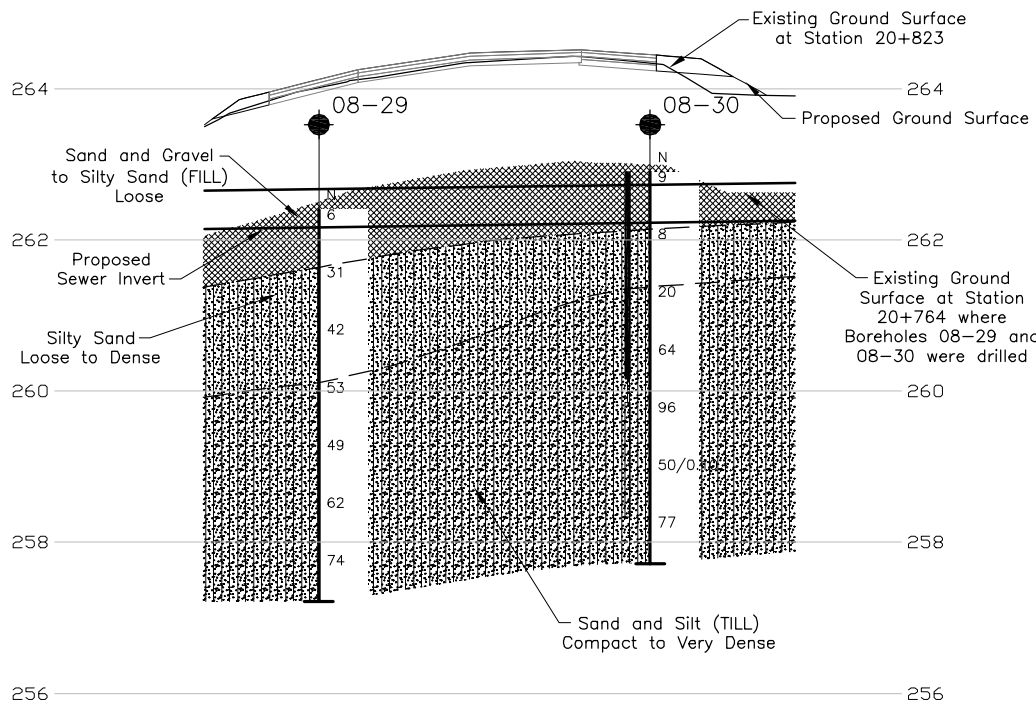
CROSS-SECTION A-A'
SEWER CROSSING AT STATION 24+157



CROSS-SECTION B-B'
SEWER CROSSING AT STATION 23+927



CROSS-SECTION C-C'
SEWER CROSSING AT STATION 23+806



CROSS-SECTION D-D'
SEWER CROSSING AT STATION 20+823



LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation ("Foundation Investigation and Design Report, Culverts, Highway 400 SBL Between Highway 11 and County Road 11 (Forbes Road) Simcoe County" G.W.P. 167-99-00, Dated April 2008)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- WL in piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-32	280.4	4925319.6	289863.7
08-31	280.4	4925292.4	289869.5
08-30	262.9	4922431.2	291648.2
08-29	262.4	4922409.3	291649.0
08-28	287.7	4925013.1	290064.8
08-27	287.1	4925023.7	290044.7
08-26	284.1	4925114.2	289999.2
08-25	283.7	4925124.1	289979.6
2007-38	277.0	4925260.4	289877.1

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REFERENCE

Existing ground surface and proposed ground surface provided in digital format by Genivar (drawing file "Golder Sewers Contract 2.dwg" received on November 07, 2008).

NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011	
SUBM'D. SMM		CHKD. PKS	DATE: 13-Mar-2009
DRAWN: DD		CHKD. SMM	APPD. LCC
		DIST.	
		SITE:	
		DWG. 6	

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

CONT No.
 WP No. 2168-06-00

HIGHWAY 400 SBL
 Sewer Crossings
 SOIL STRATA

SHEET



Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
 SCALE
 0 4 8 km

LEGEND

- Borehole - Current Investigation
- ⊕ Borehole - Previous Investigation ("Foundation Investigation and Design Report, Culverts, Highway 400 SBL Between Highway 11 and County Road 11 (Forbes Road) Simcoe County" G.W.P. 167-99-00, Dated April 2008)
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling
- ≡ WL in piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-24	280.3	4925980.6	289431.6
08-23	280.6	4925959.3	289432.8
08-22	277.4	4926152.0	289322.6
08-21	277.4	4926162.3	289295.0
08-20	269.0	4926874.5	288849.2
08-19	268.5	4926884.7	288821.7
08-18	257.5	4927314.9	288561.4
08-17	258.0	4927291.6	288555.9
2007-36	278.2	4925936.4	289429.5

NOTES

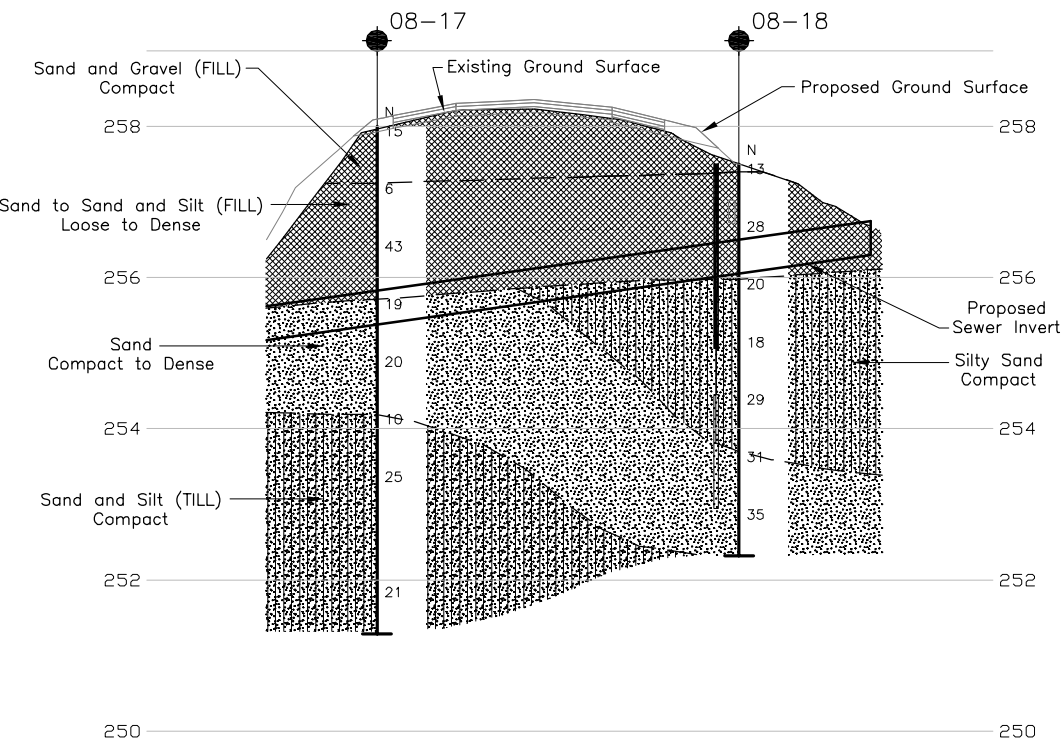
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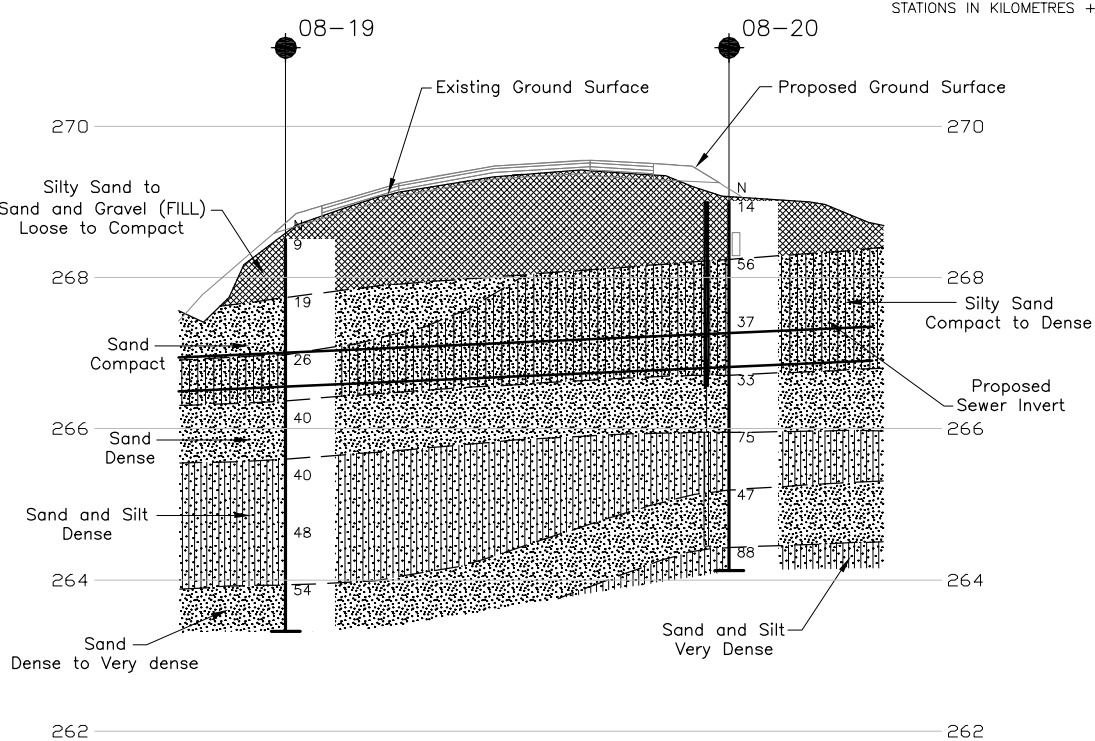
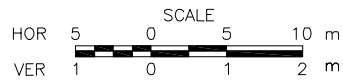
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REFERENCE

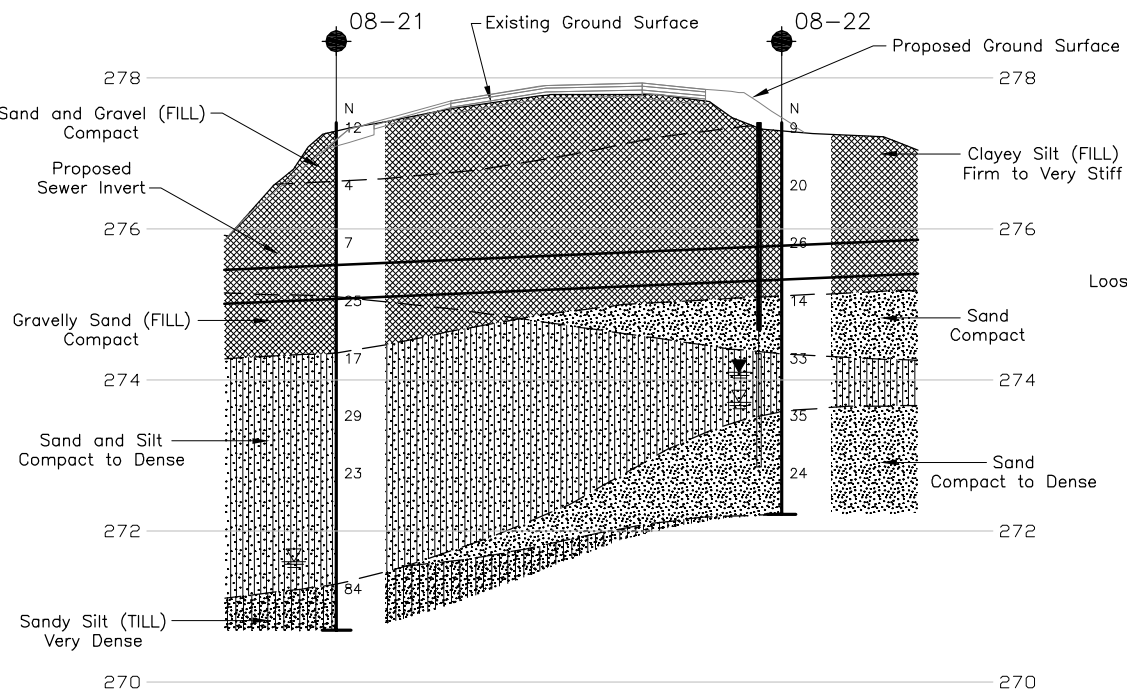
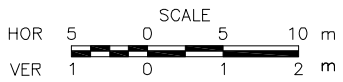
Existing ground surface and proposed ground surface provided in digital format by Genivar (drawing file "Golder Sewers Contract 2.dwg" received on November 07, 2008).



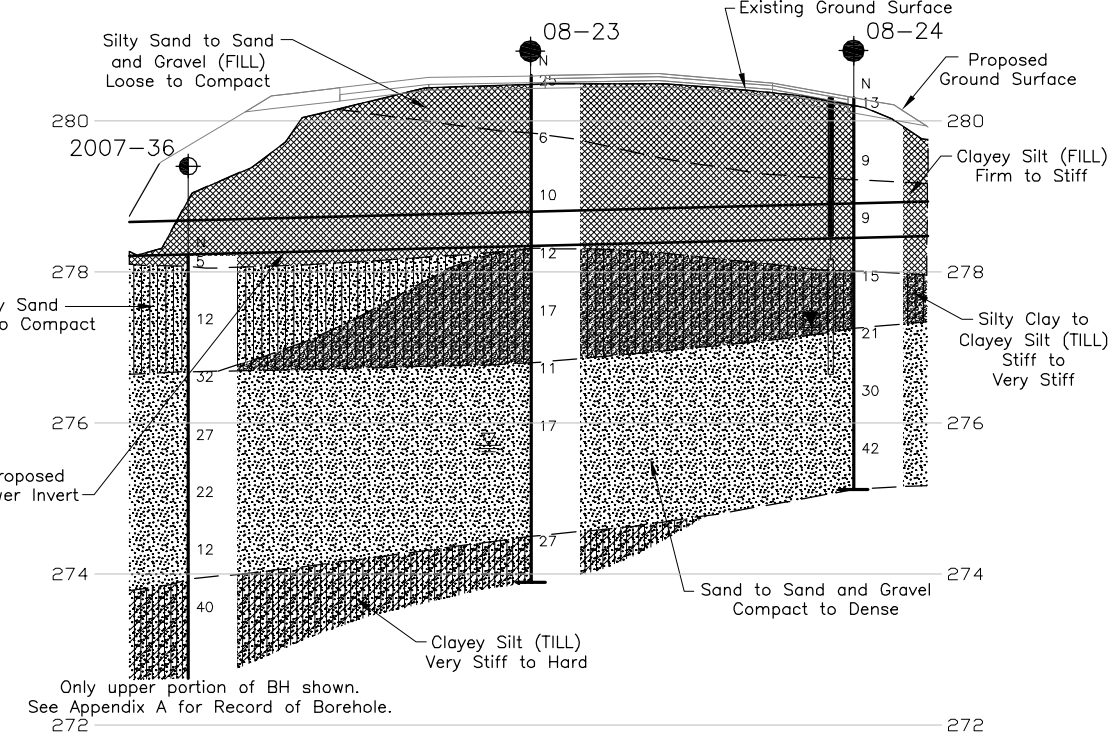
CROSS-SECTION E-E'
 SEWER CROSSING AT STATION 26+536



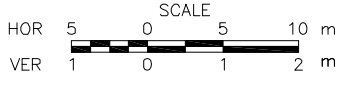
CROSS-SECTION F-F'
 SEWER CROSSING AT STATION 26+032



CROSS-SECTION G-G'
 SEWER CROSSING AT STATION 25+175



CROSS-SECTION H-H'
 SEWER CROSSING AT STATION 24+955



NO.	DATE	BY	REVISION

Geocres No.	PROJECT NO. 06-1111-011	DIST.
HWY. 400	DATE: 12-Mar-2009	SITE:
SUBM'D. SMM	CHKD. SMM	APPD. LCC
DRAWN: DD/RJ		DWG. 7

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

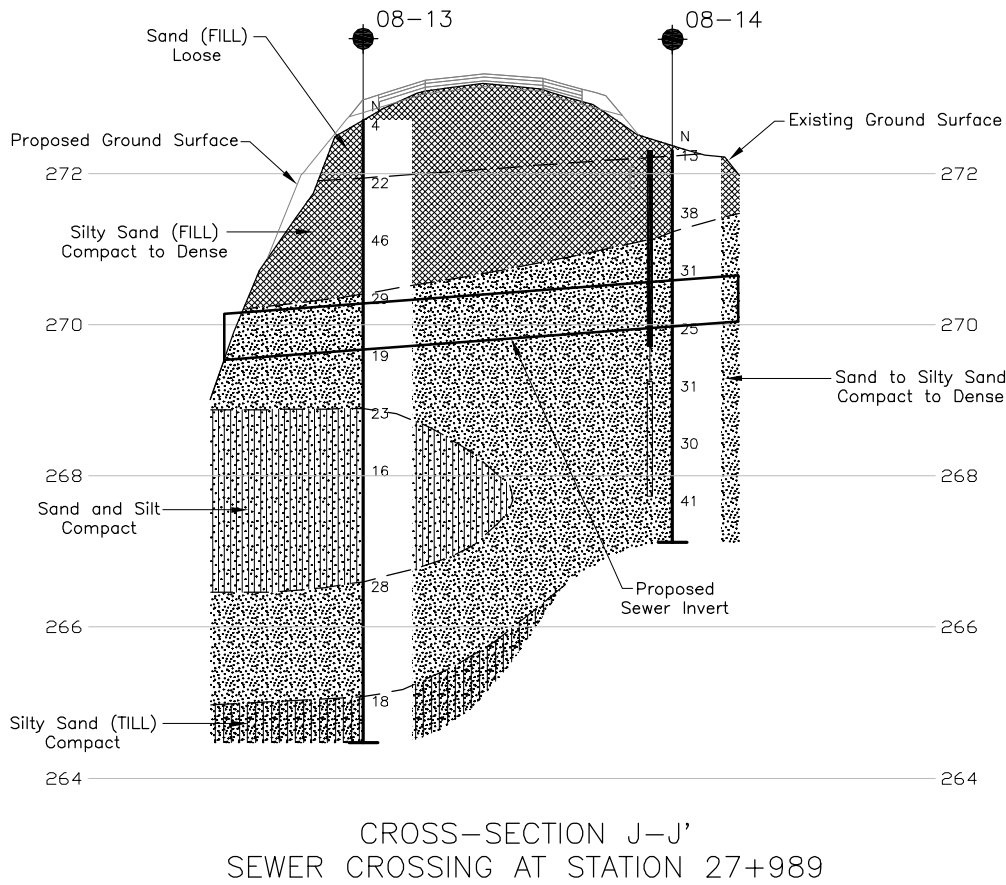
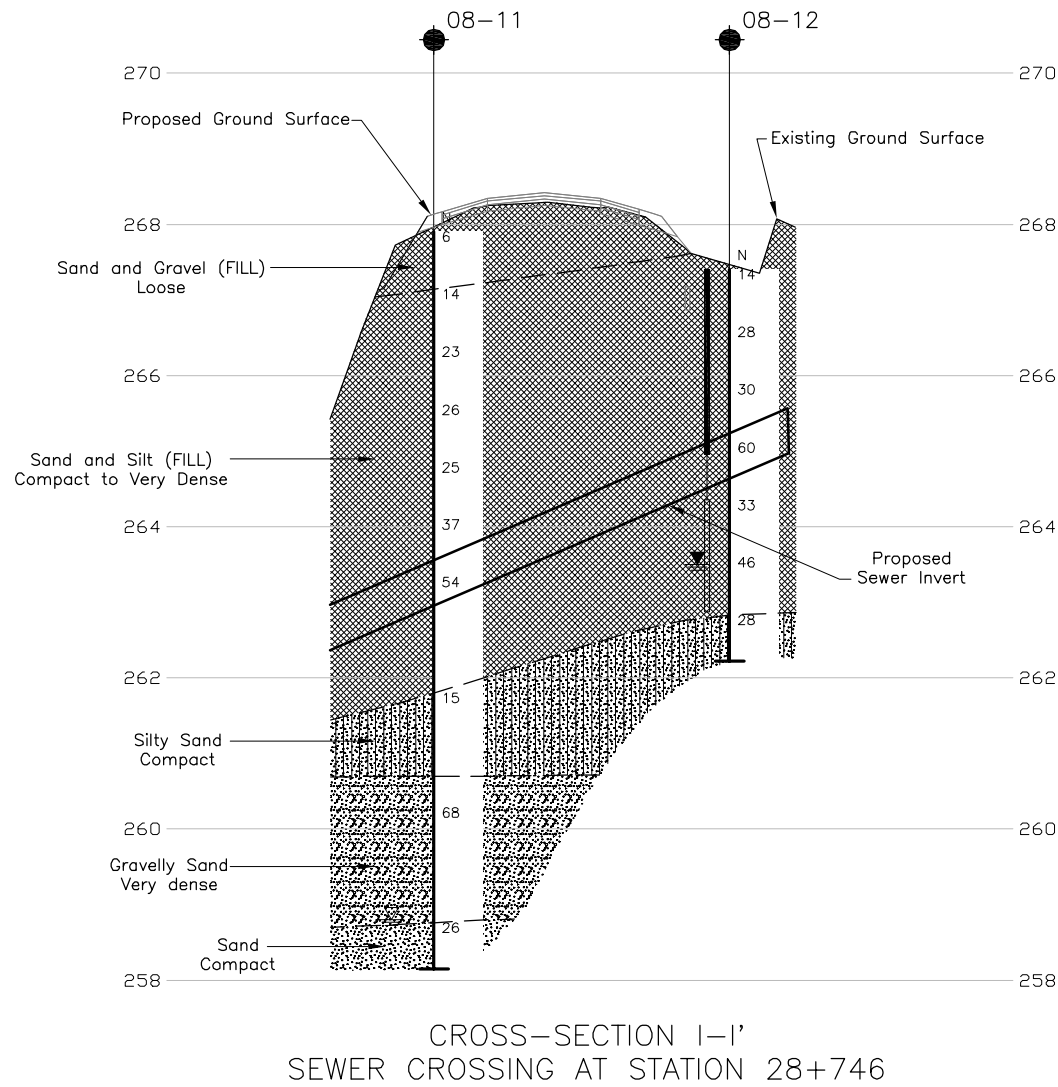
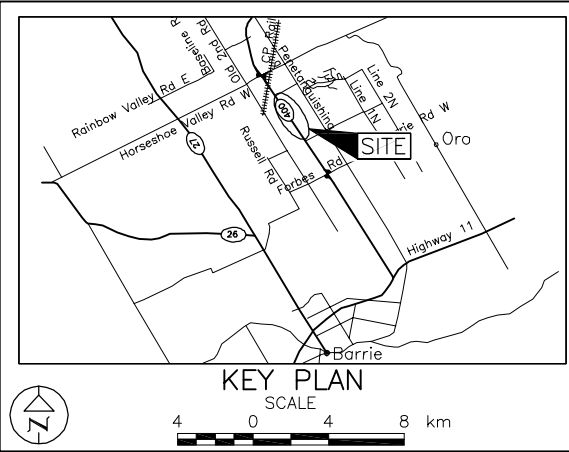
CONT No.
WP No. 2168-06-00

HIGHWAY 400 SBL
Sewer Crossings
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- WL in piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-14	272.3	4928506.3	287754.4
08-13	272.7	4928499.5	287735.1
08-12	267.4	4929135.0	287326.8
08-11	267.9	4929123.9	287310.7

NOTES

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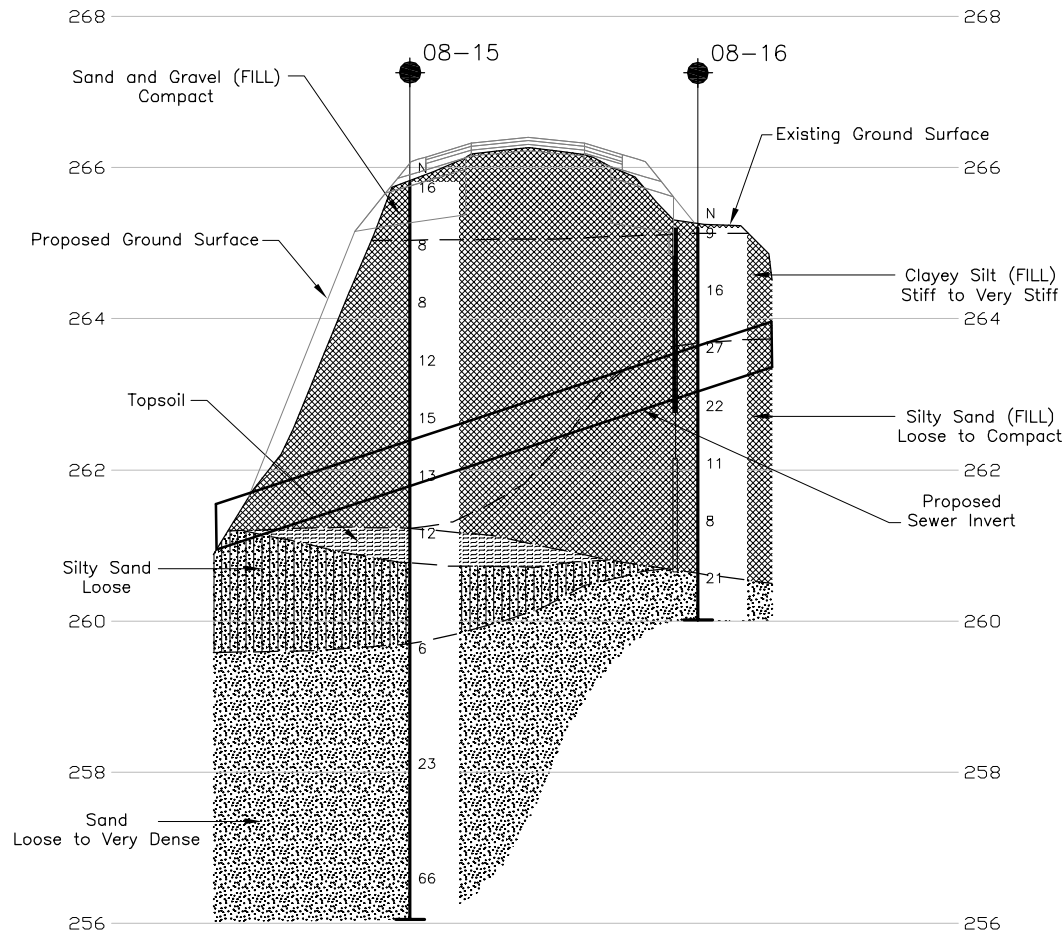
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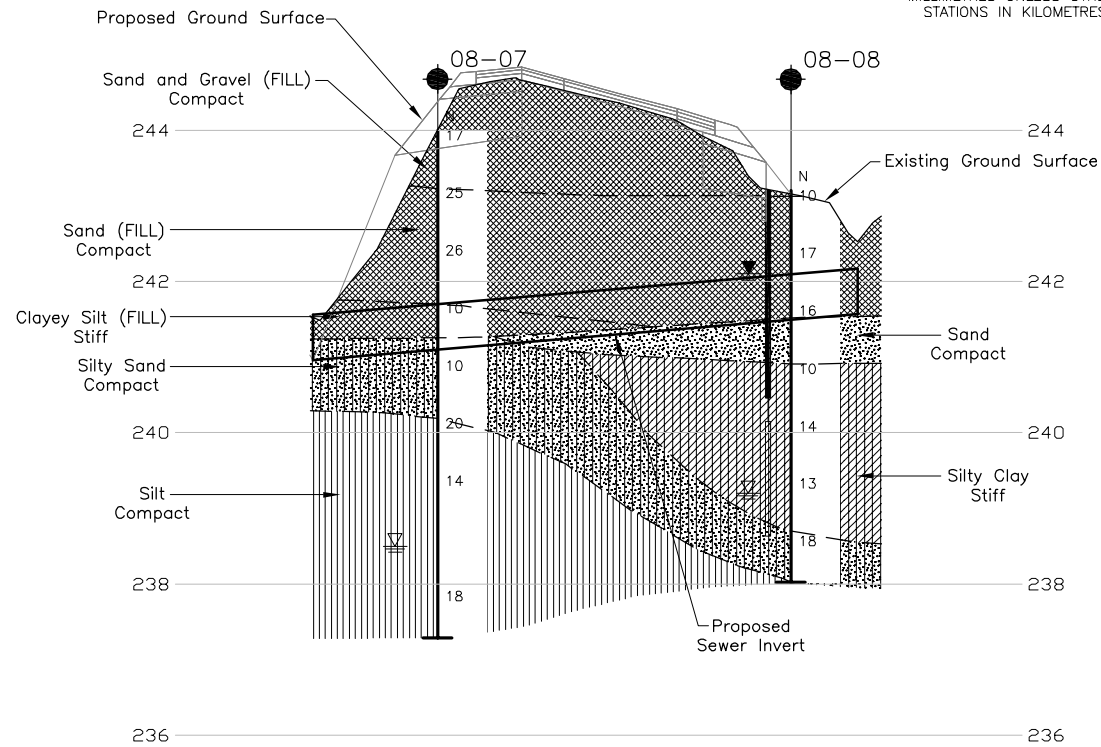
REFERENCE

Existing ground surface and proposed ground surface provided in digital format by Genivar (drawing file "Golder Sewers Contract 2.dwg" received on November 07, 2008).

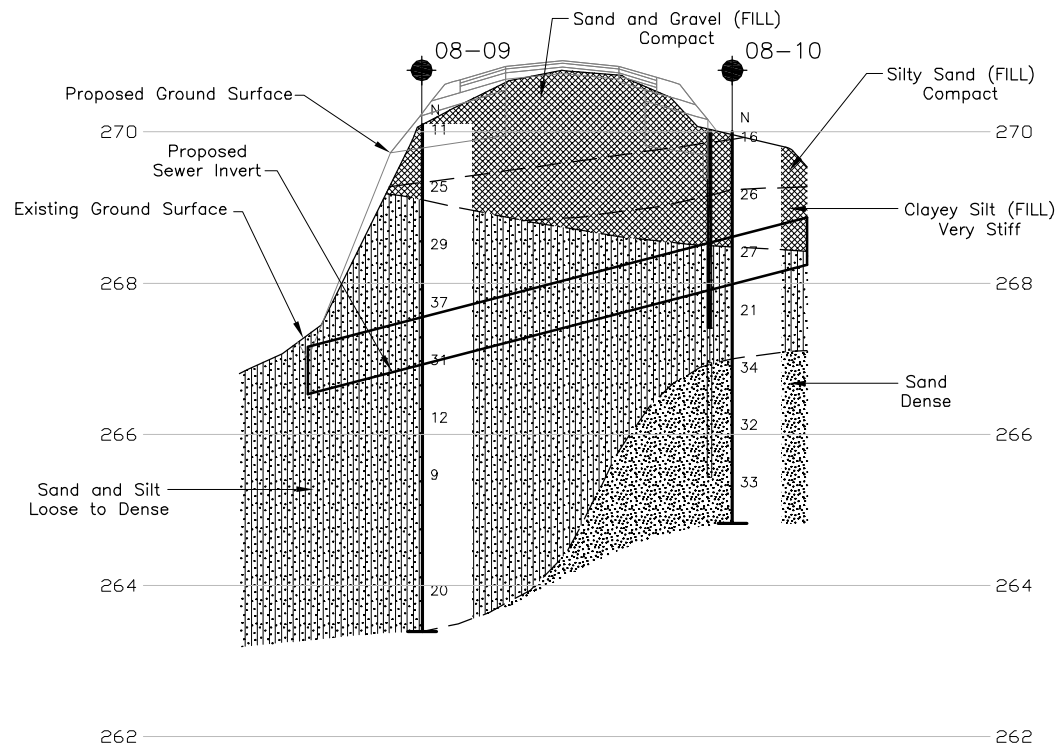
NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011	
SUBM'D. SMM		CHKD. PKS	DATE: 13-Mar-2009
DRAWN: DD/RJ		CHKD. SMM	APPD. LCC
		DIST.	
		SITE:	
		DWG. 8	



CROSS SECTION K-K'
SEWER CROSSING AT STATION 27+216



CROSS-SECTION L-L'
SEWER CROSSING AT STATION 10+659



CROSS-SECTION M-M'
SEWER CROSSING AT STATION 29+349



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

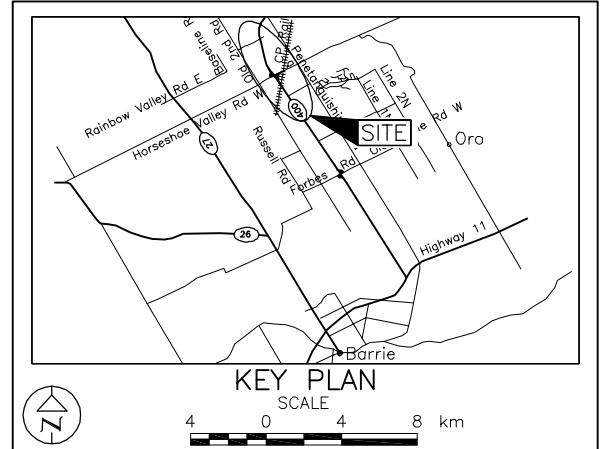
CONT No.
WP No. 2168-06-00

HIGHWAY 400 SBL
Sewer Crossings
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling
- ≡ WL in piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-16	265.2	4927866.3	288189.0
08-15	265.8	4927855.4	288173.4
08-10	270.0	4929629.9	286988.7
08-9	270.1	4929618.6	286971.6
08-8	243.2	4932050.6	285346.5
08-7	244.0	4932039.2	285326.1

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

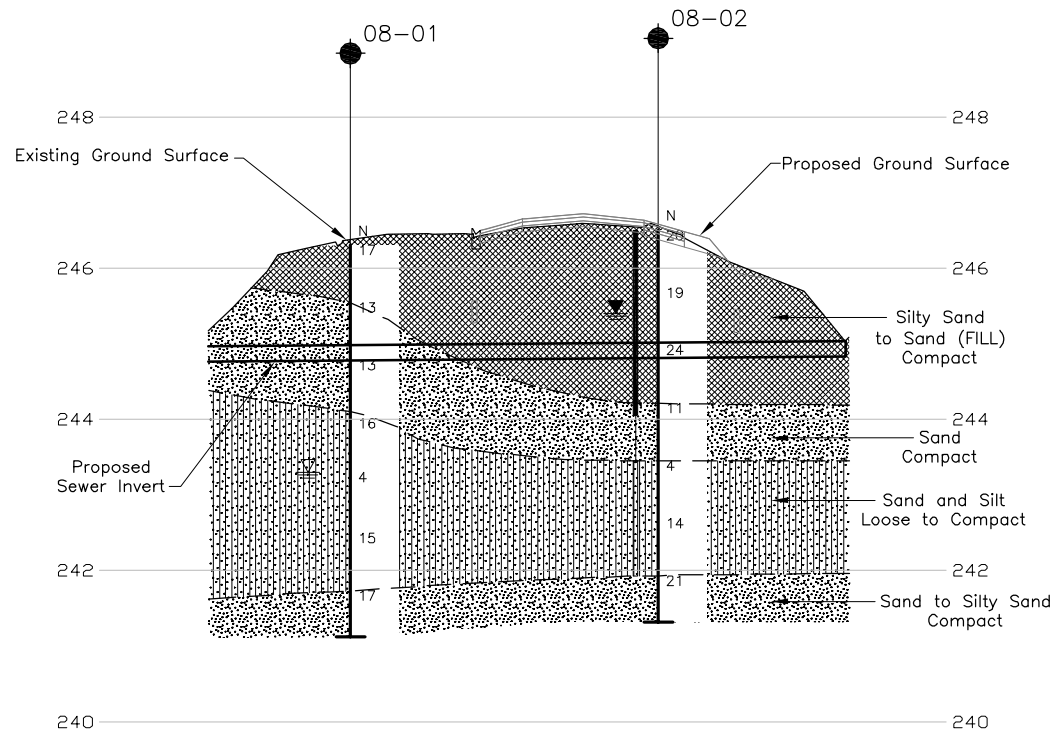
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

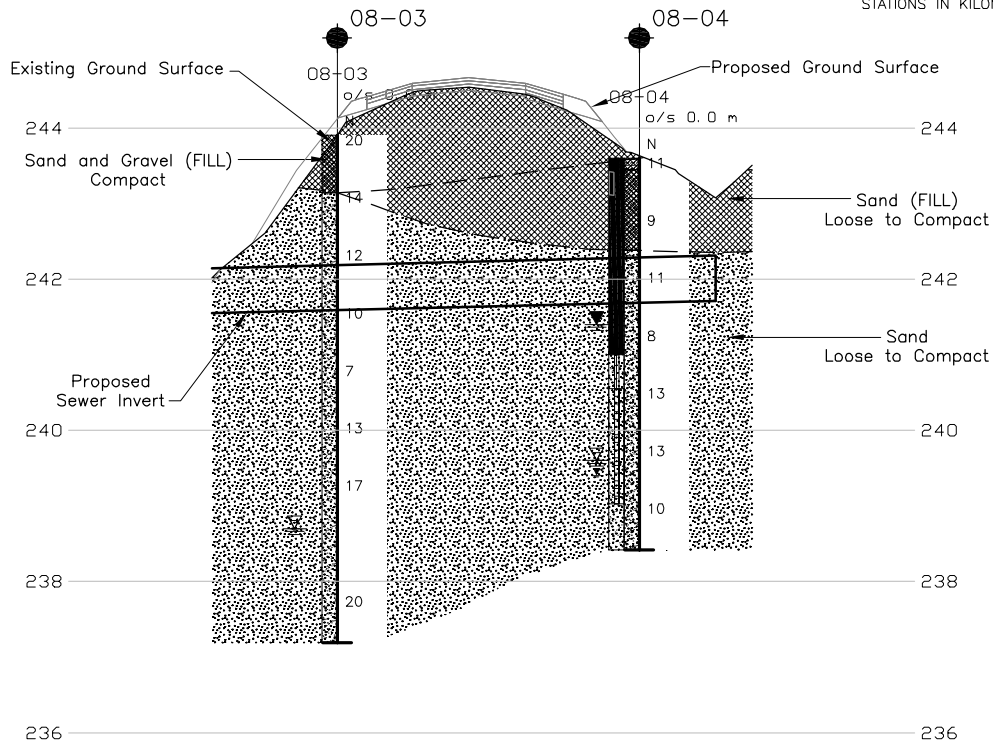
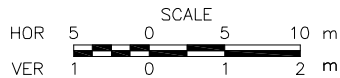
REFERENCE

Existing ground surface and proposed ground surface provided in digital format by Genivar (drawing file "Golder Sewers Contract 2.dwg" received on November 07, 2008).

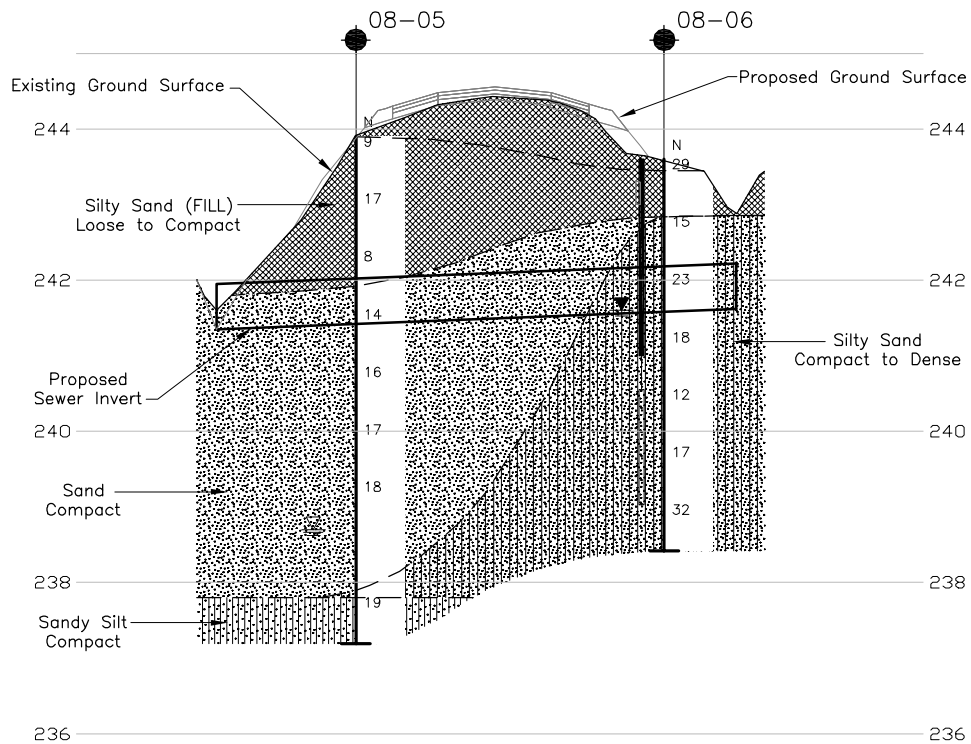
NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011	
SUBM'D. SMM		CHKD. PKS	DATE: 13-Mar-2009
DRAWN: DD		CHKD. SMM	APPD. LCC
		DIST.	
		SITE:	
		DWG. 9	



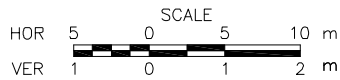
CROSS-SECTION N-N'
SEWER CROSSING AT STATION 13+274



CROSS-SECTION O-O'
SEWER CROSSING AT STATION 11+757



CROSS-SECTION P-P'
SEWER CROSSING AT STATION 11+269



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

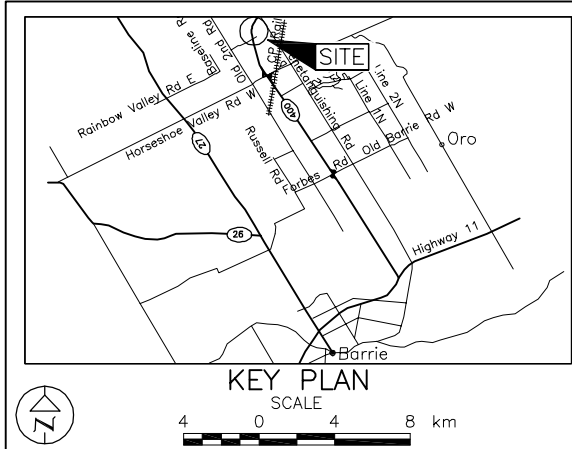
CONT No.
WP No. 2168-06-00

HIGHWAY 400 SBL
Sewer Crossings
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- ⬮ Seal
- ⬮ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling
- ≡ WL in piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-6	243.6	4932629.8	285172.3
08-5	243.9	4932624.9	285152.5
08-4	243.6	4933103.5	285056.1
08-3	243.9	4933098.7	285036.7
08-2	246.5	4934533.2	285156.9
08-1	246.3	4934537.5	285137.0

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

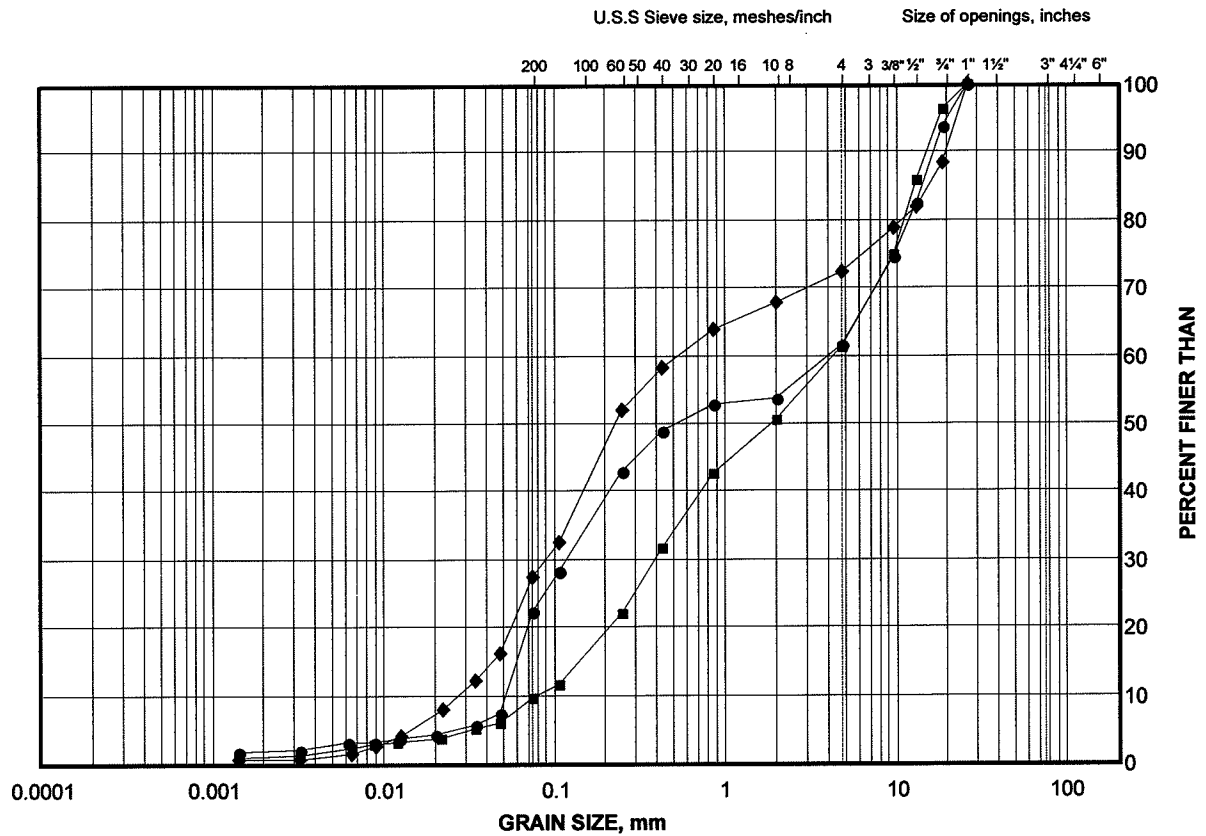
Existing ground surface and proposed ground surface provided in digital format by Genivar (drawing file "Golder Sewers Contract 2.dwg" received on November 07, 2008).

NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 06-1111-011	DIST.
SUBM'D. SMM	CHKD. PKS	DATE: 12-Mar-2009	SITE:
DRAWN: DD/RJ	CHKD. SMM	APPD. LCC	DWG. 10

GRAIN SIZE DISTRIBUTION TEST RESULTS

Gravelly 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)
●	08-29	1	262.1
■	08-3	1	243.6
◆	08-21	4	274.8

Project Number: 06-1111-011

Checked By:

SM

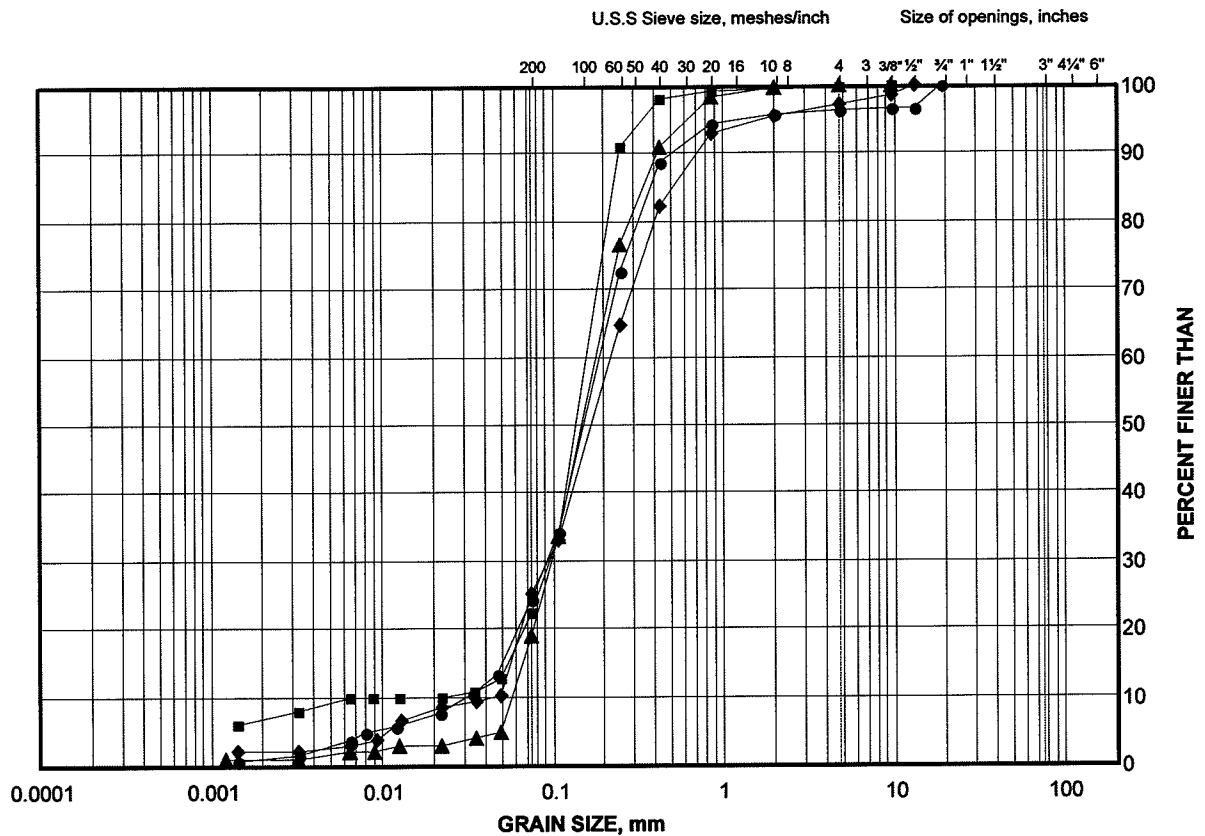
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand to Silty Sand Fill

FIGURE 2A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	08-13	2	271.6
■	08-7	2	242.9
◆	08-5	2	242.8
▲	08-4	2	242.5

Project Number: 06-1111-011

Checked By: *SM*

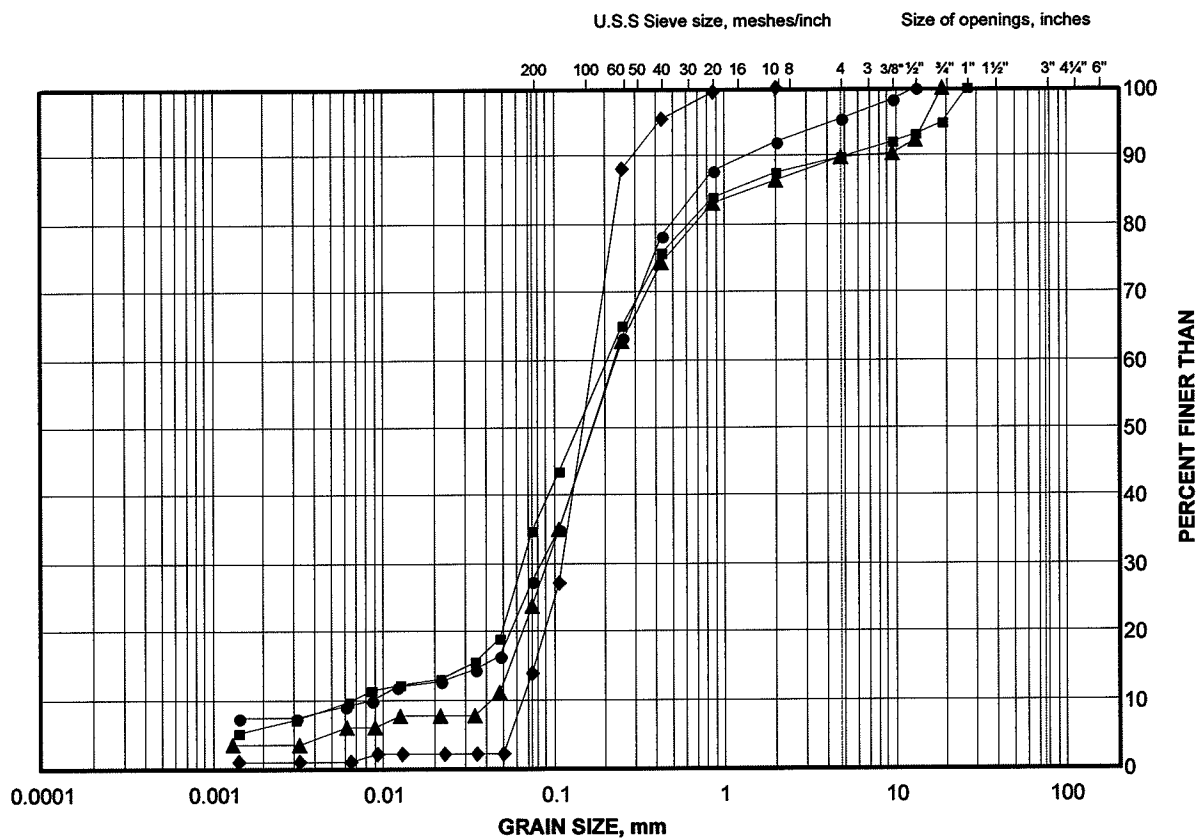
Golder Associates

Date: 18-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand to Silty Sand Fill

FIGURE 2B



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-31	3	278.6
■	08-16	3	263.4
◆	08-2	3	244.7
▲	08-15	7	260.9

Project Number: 06-1111-011

Checked By: SMU

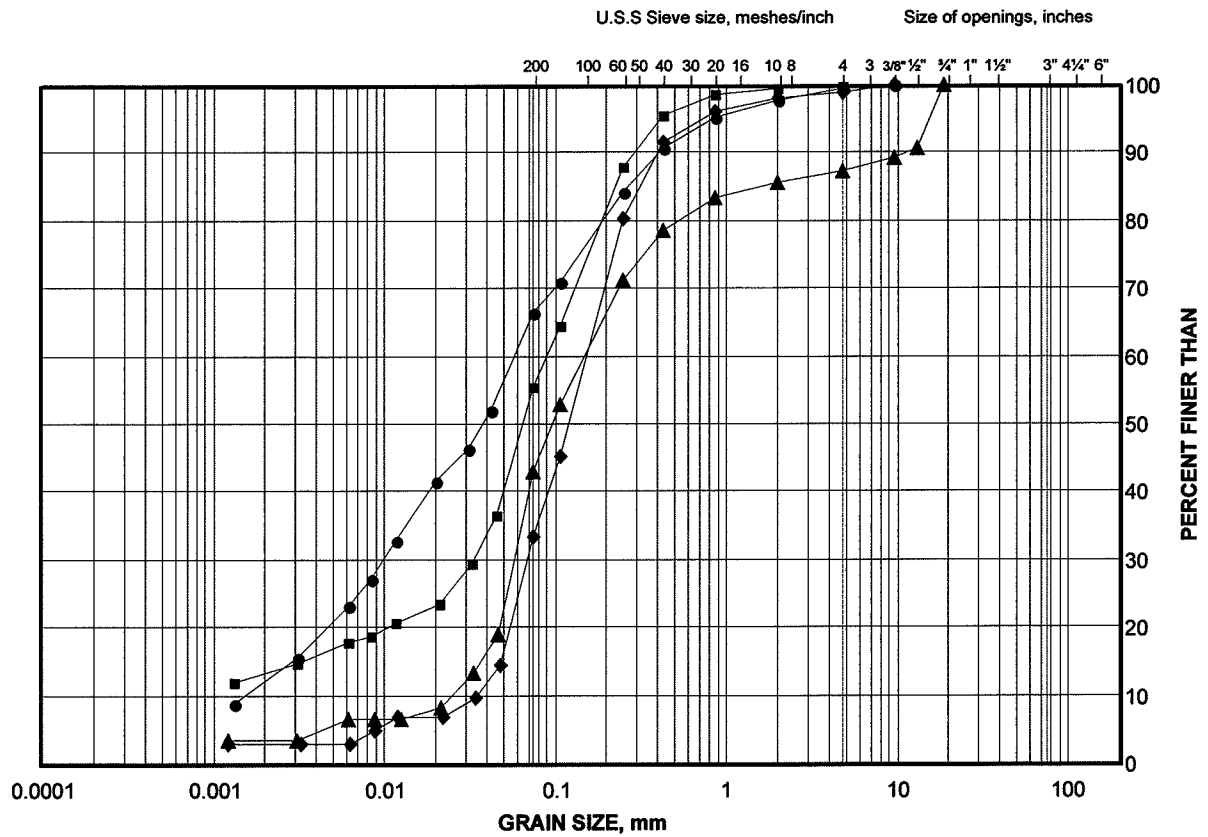
Golder Associates

Date: 18-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Silt Fill

FIGURE 3



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

LEGEND

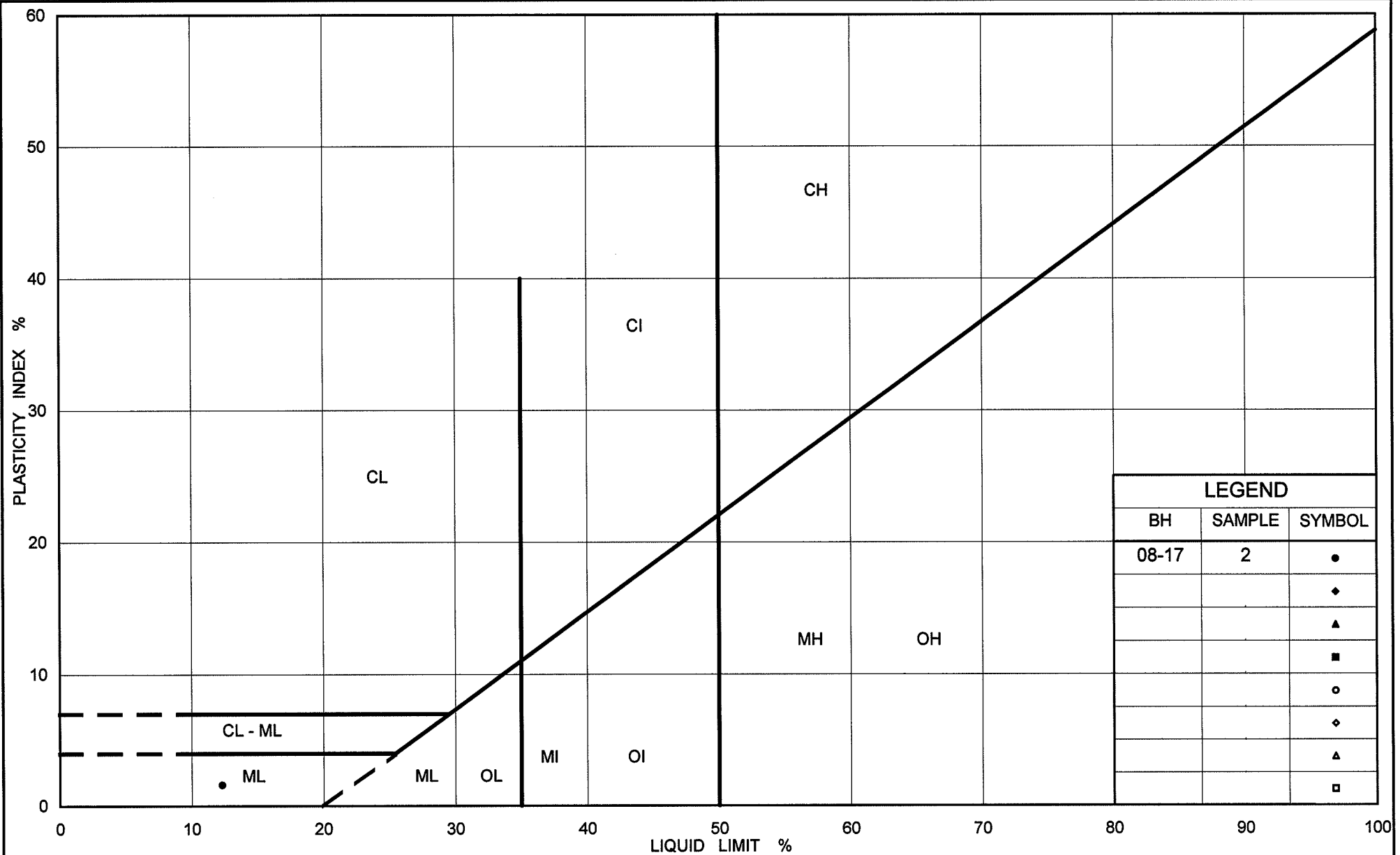
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-17	2	256.9
■	08-12	2	266.3
◆	08-12	5	264.0
▲	08-11	7	263.0

Project Number: 06-1111-011

Checked By: SMU

Golder Associates

Date: 17-Nov-08



Ministry of Transportation

Ontario

PLASTICITY CHART Sand and Silt Fill

FIG No. 4

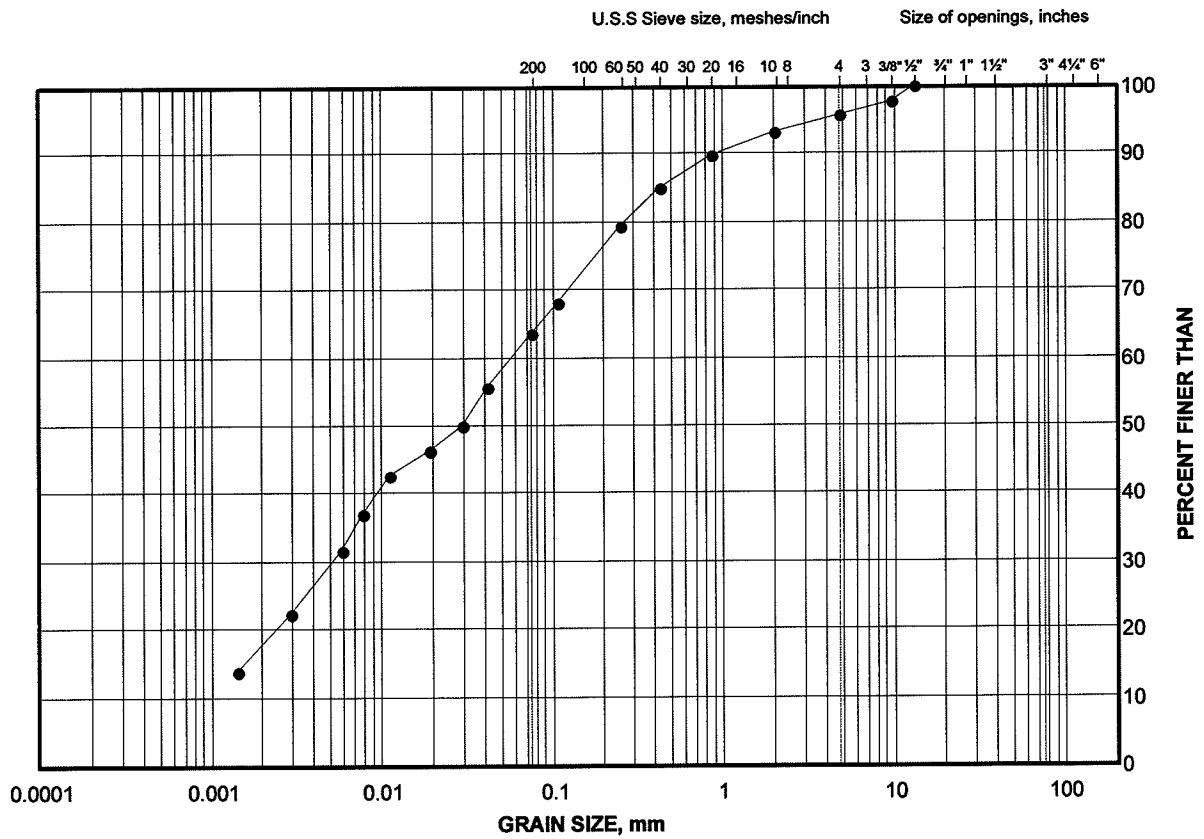
Project No. 06-1111-011

Checked By: *SM*

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt with Sand 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)
•	08-15	5	262.4

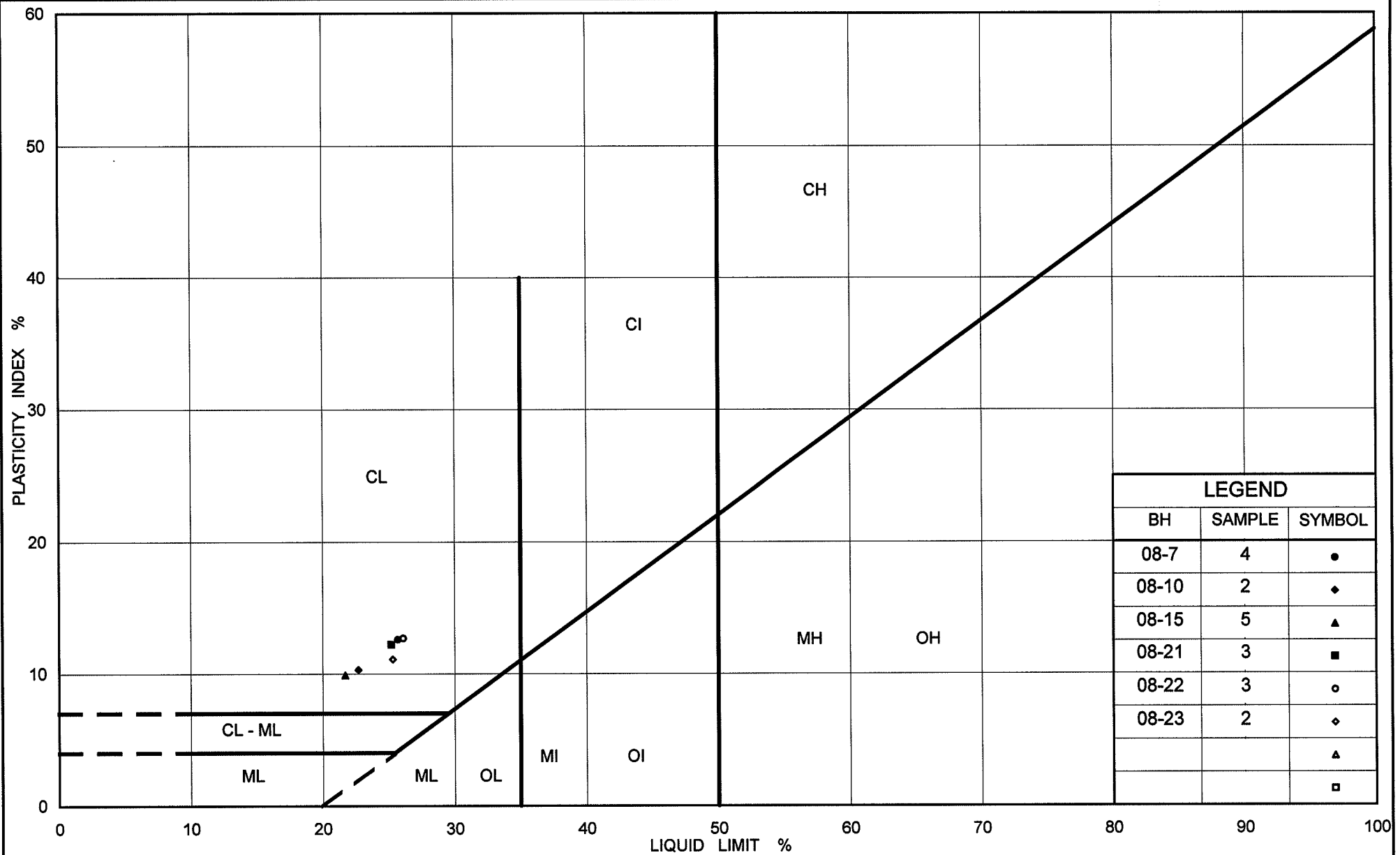
Project Number: 06-1111-011

Checked By:

SMV

Golder Associates

Date: 17-Nov-08



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt Fill to Clayey Silt with Sand Fill

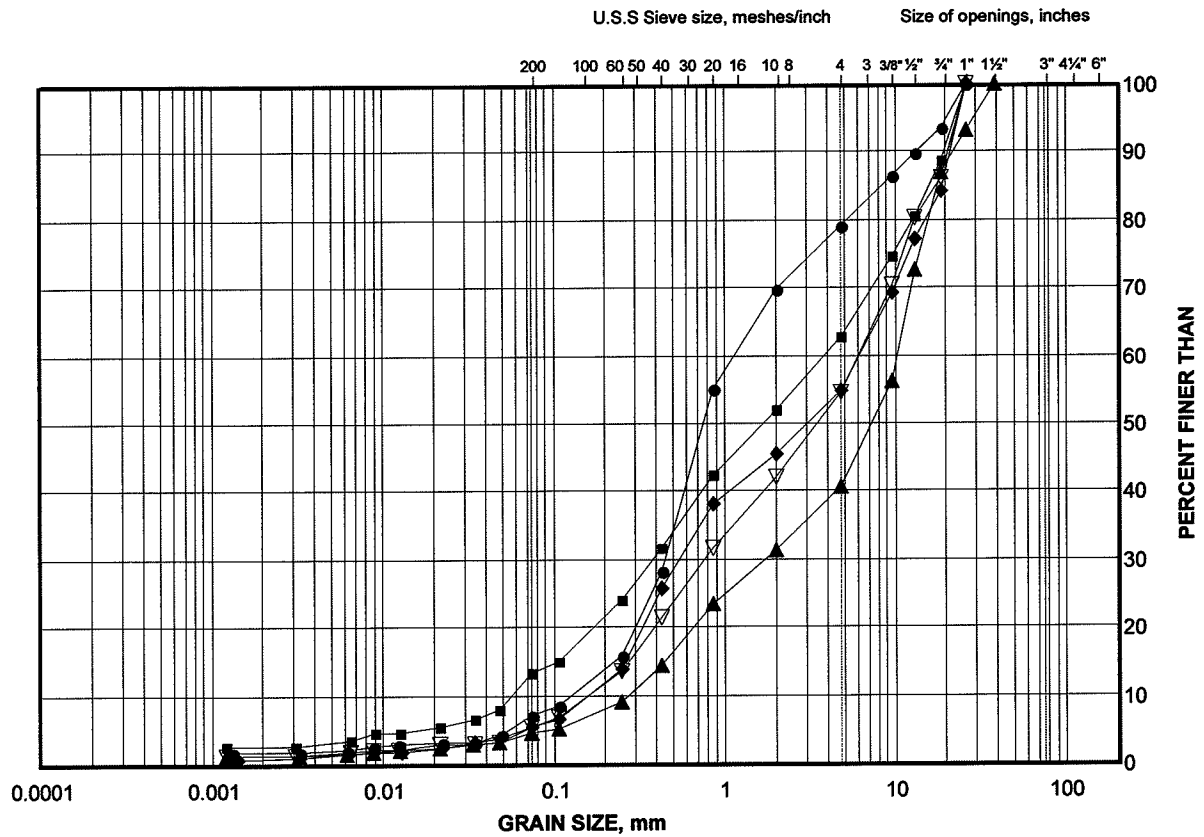
FIG No. 6

Project No. 06-1111-011

Checked By:

Gravelly Sand to Sand and Gravel

FIGURE 7



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-28	3	285.9
■	08-27	4	284.5
◆	08-28	5	284.3
▲	08-25	6	279.6
▽	08-24	6	276.2

Project Number: 06-1111-011

Checked By:

8mm

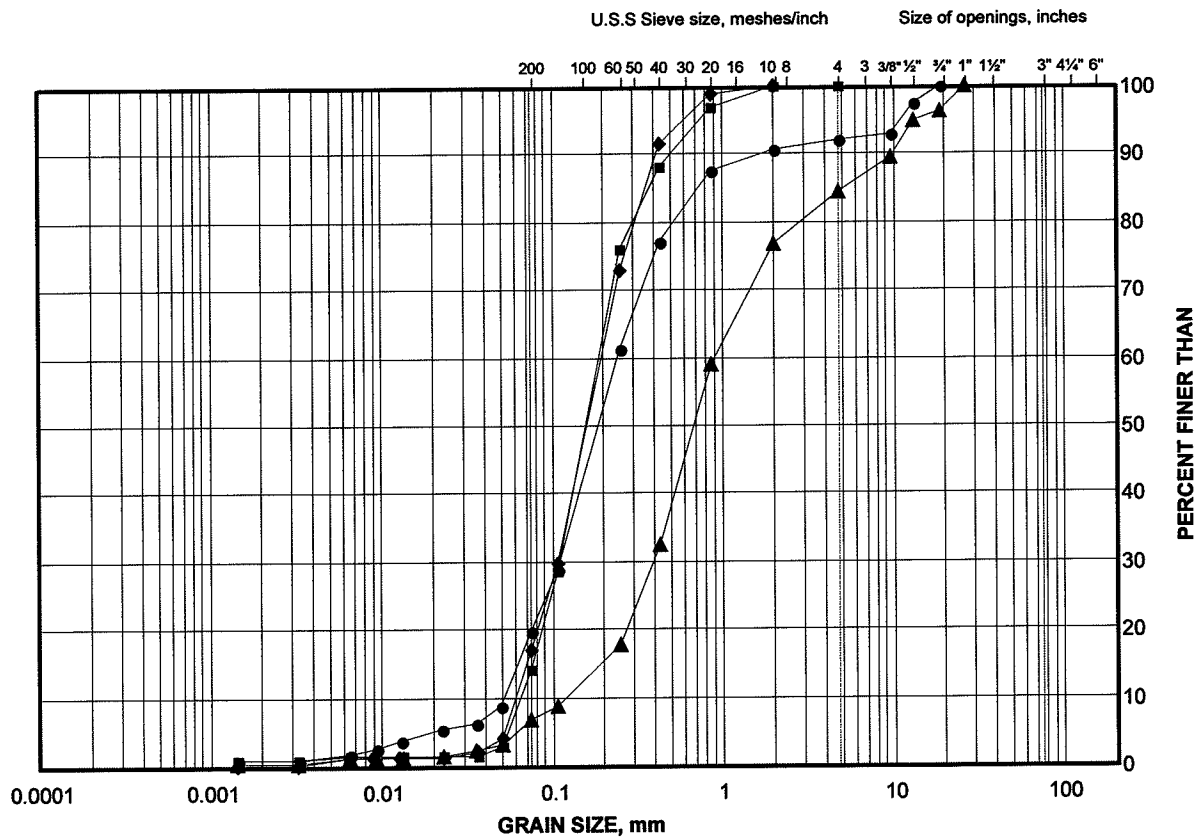
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand

FIGURE 8A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-3	3	242.1
■	08-1	3	244.5
◆	08-5	4	241.3
▲	08-15	9	257.9

Project Number: 06-1111-011

Checked By: 8mm

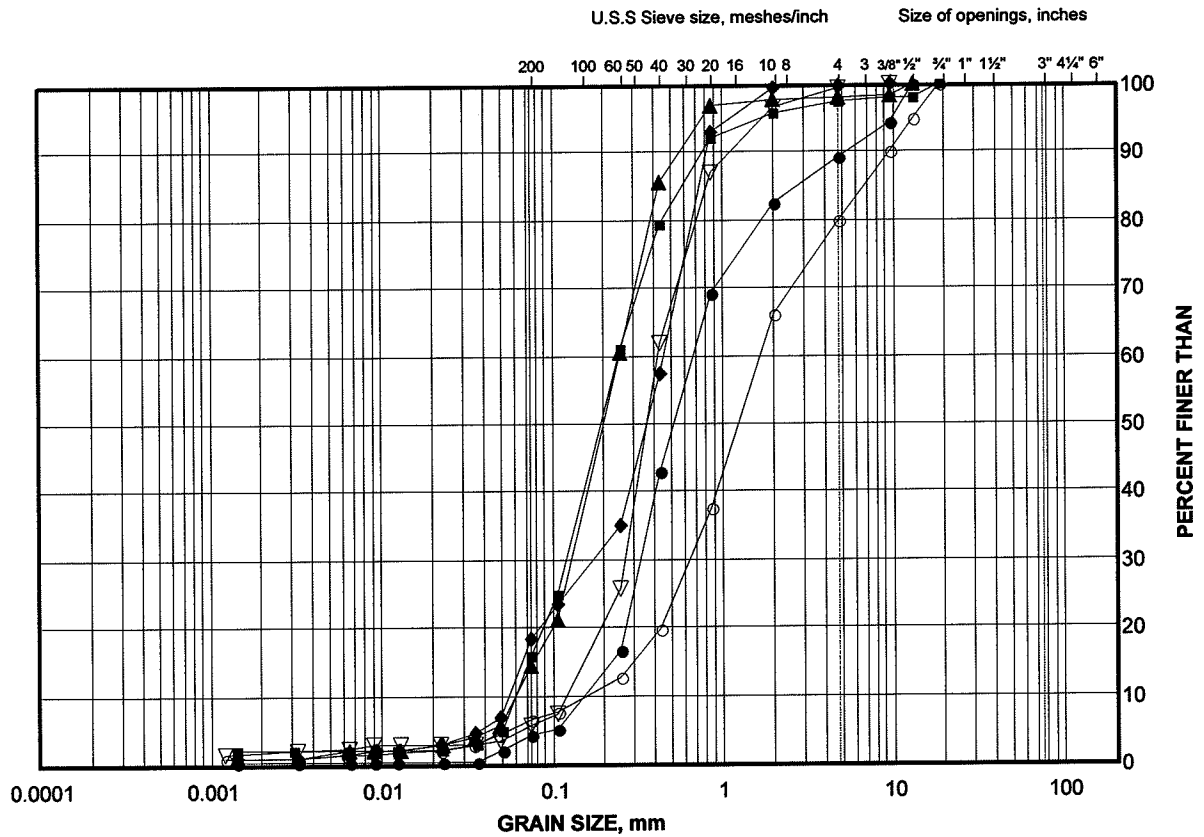
Golder Associates

Date: 18-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand

FIGURE 8B



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-25	3	281.9
■	08-8	3	241.4
◆	08-14	5	268.9
▲	08-10	6	265.9
▽	08-23	7	275.7
○	08-16	7	260.3

Project Number: 06-1111-011

Checked By:

8m

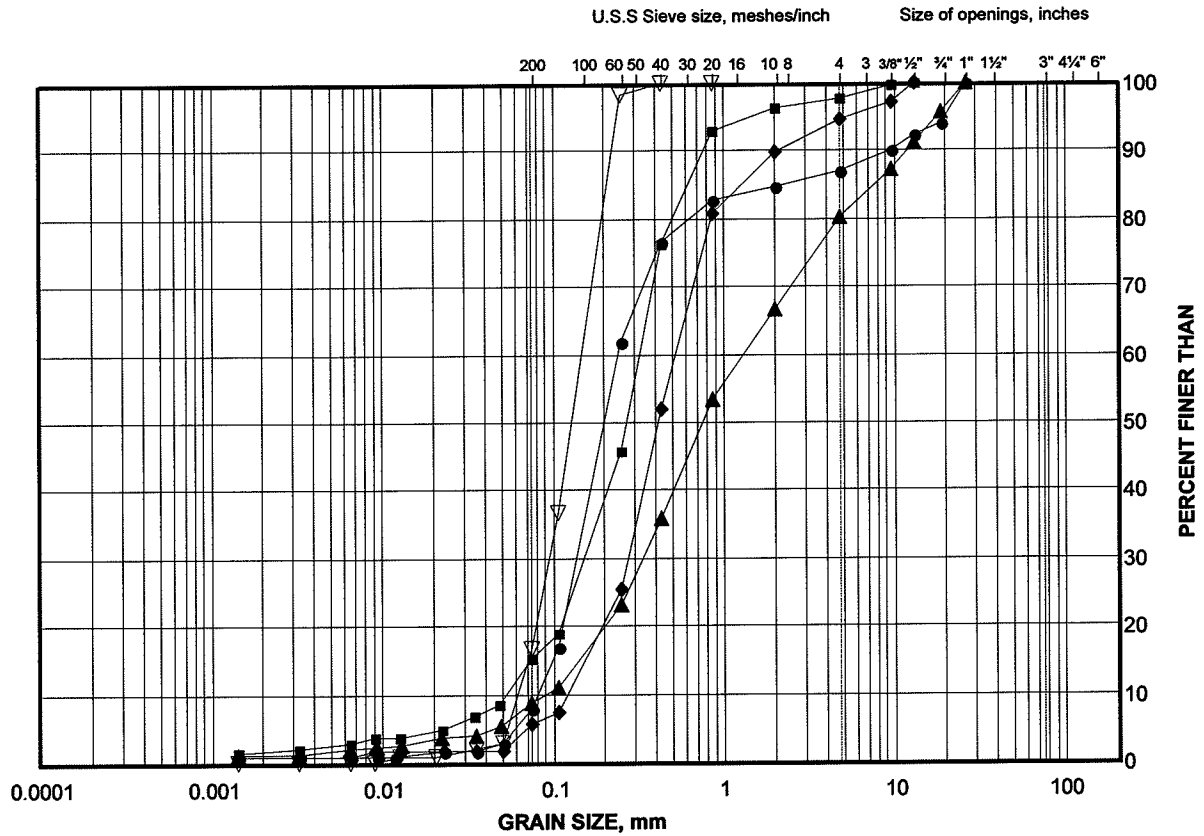
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand

FIGURE 8C



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-26	2	283.0
■	08-19	2	267.4
◆	08-26	4	281.5
▲	08-17	4	255.4
▽	08-18	6	253.4

Project Number: 06-1111-011

Checked By: SMU

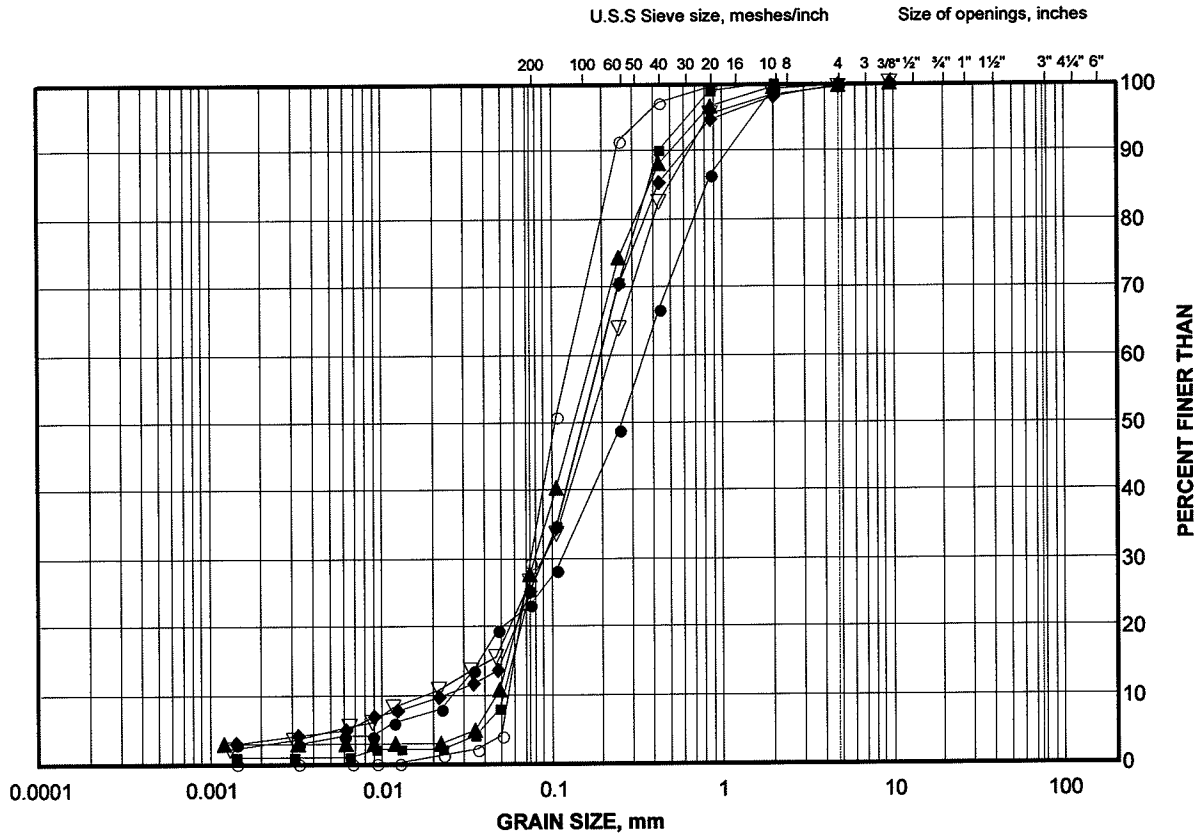
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Sand

FIGURE 9A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-6	3	241.8
■	08-4	4	241.0
◆	08-7	5	240.6
▲	08-6	6	239.5
▽	08-13	8	266.3
○	08-11	8	261.5

Project Number: 06-1111-011

Checked By: 8mm

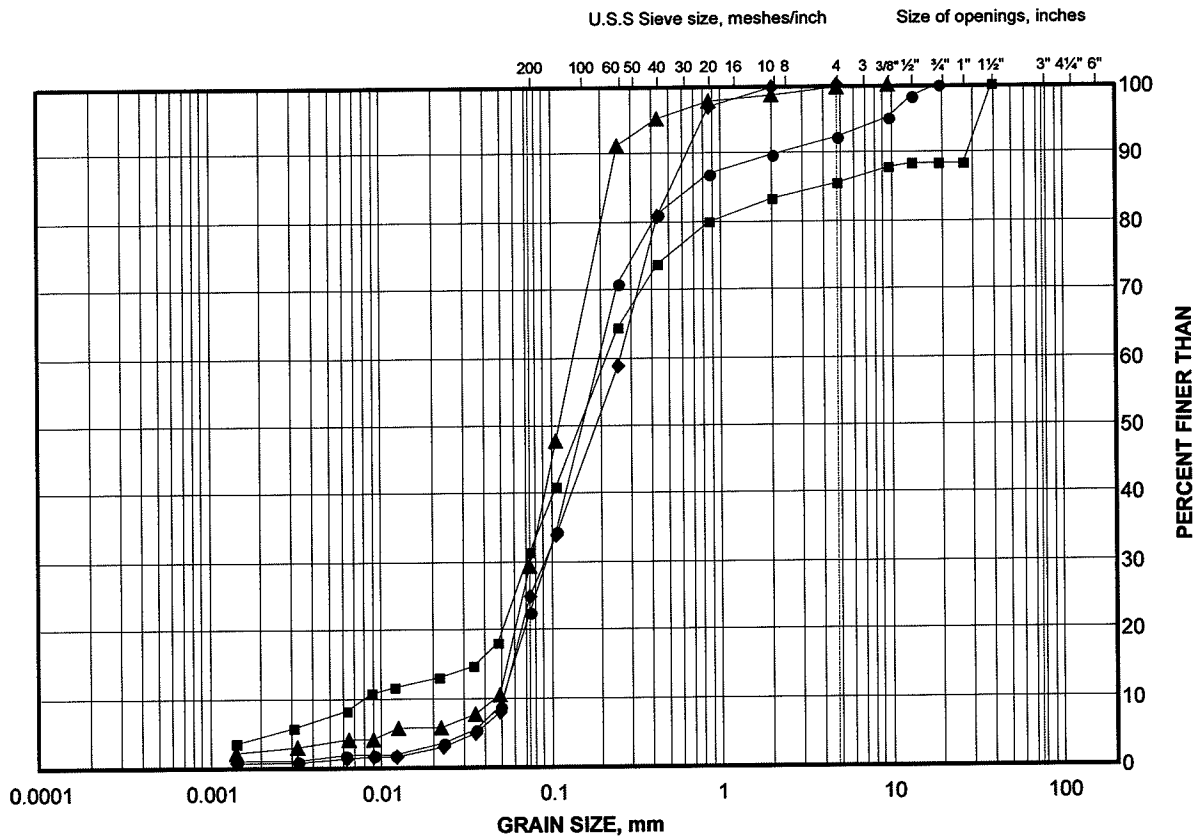
Golder Associates

Date: 18-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Sand

FIGURE 9B



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-29	3	260.6
■	08-18	3	255.7
◆	08-14	3	270.5
▲	08-18	5	254.1

Project Number: 06-1111-011

Checked By: SMU

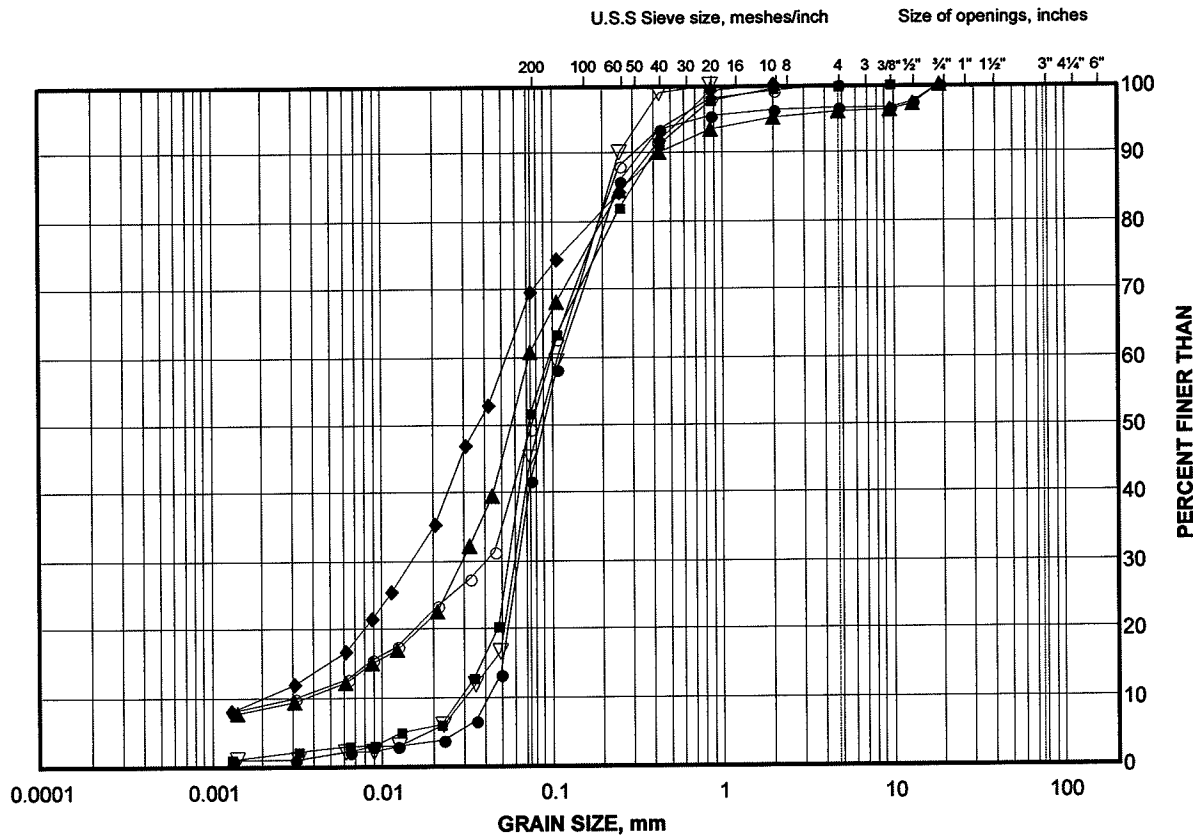
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Silt

FIGURE 10A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-9	3	268.3
■	08-10	4	267.4
◆	08-2	5	243.1
▲	08-13	6	268.8
▽	08-9	6	266.0
○	08-1	6	242.2

Project Number: 06-1111-011

Checked By: SMU

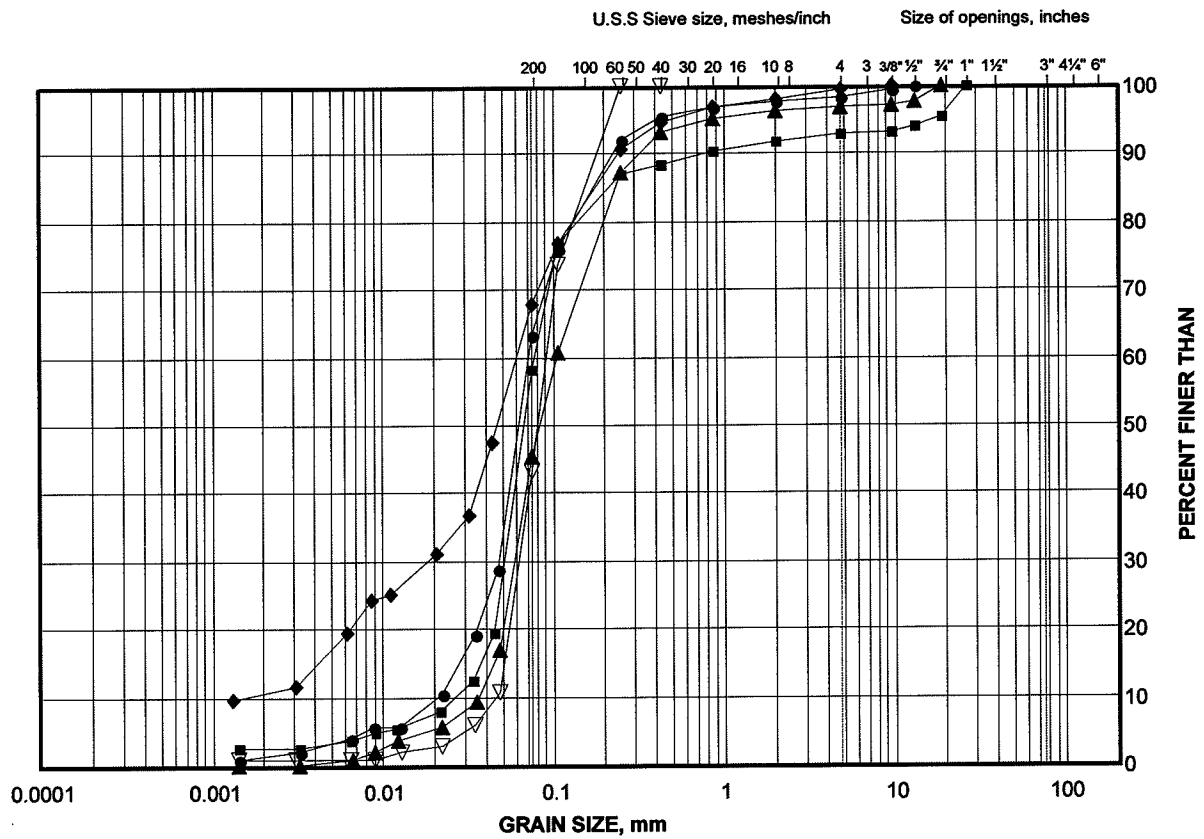
Golder Associates

Date: 18-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Silt

FIGURE 10B



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-20	3	267.2
■	08-22	5	274.0
◆	08-20	5	265.6
▲	08-19	5	265.1
▽	08-21	6	273.3

Project Number: 06-1111-011

Checked By: SMU

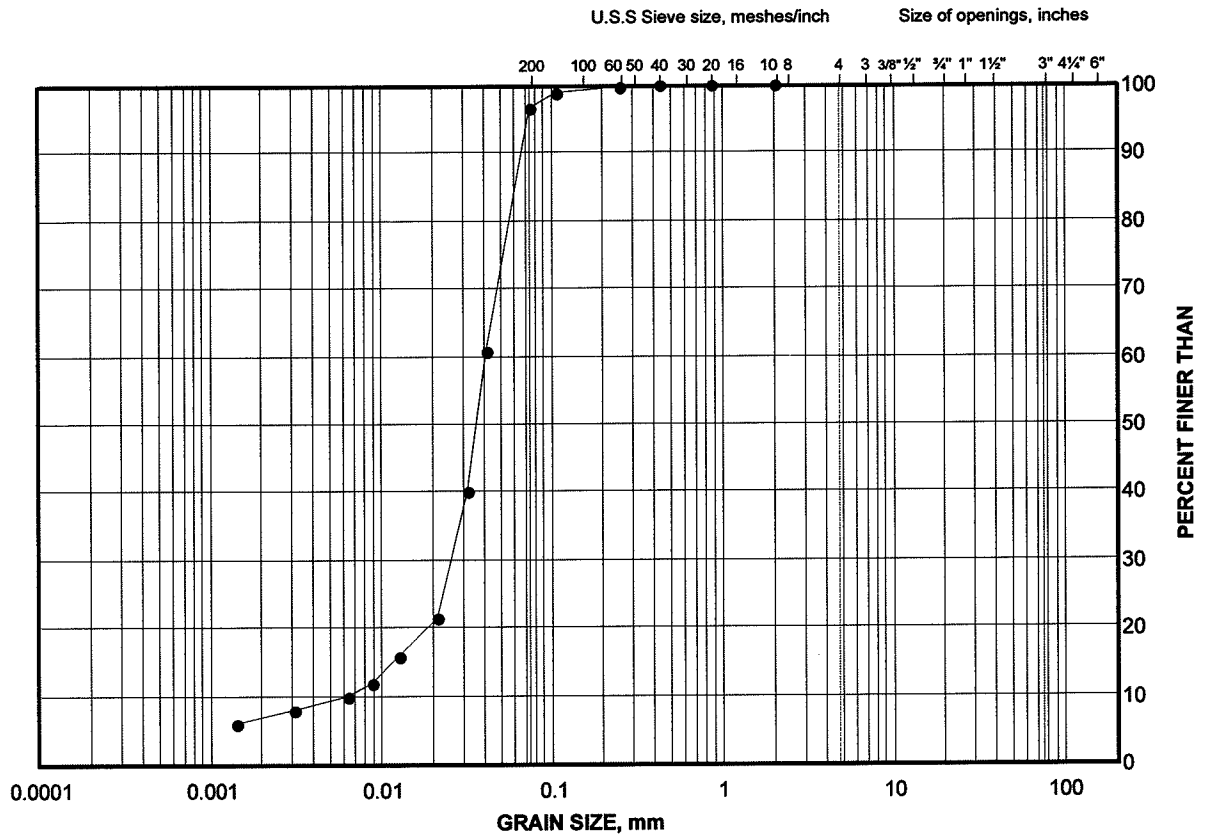
Golder Associates

Date: 19-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silt

FIGURE 11



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	08-7	7	239.1

Project Number: 06-1111-011

Checked By: 8m

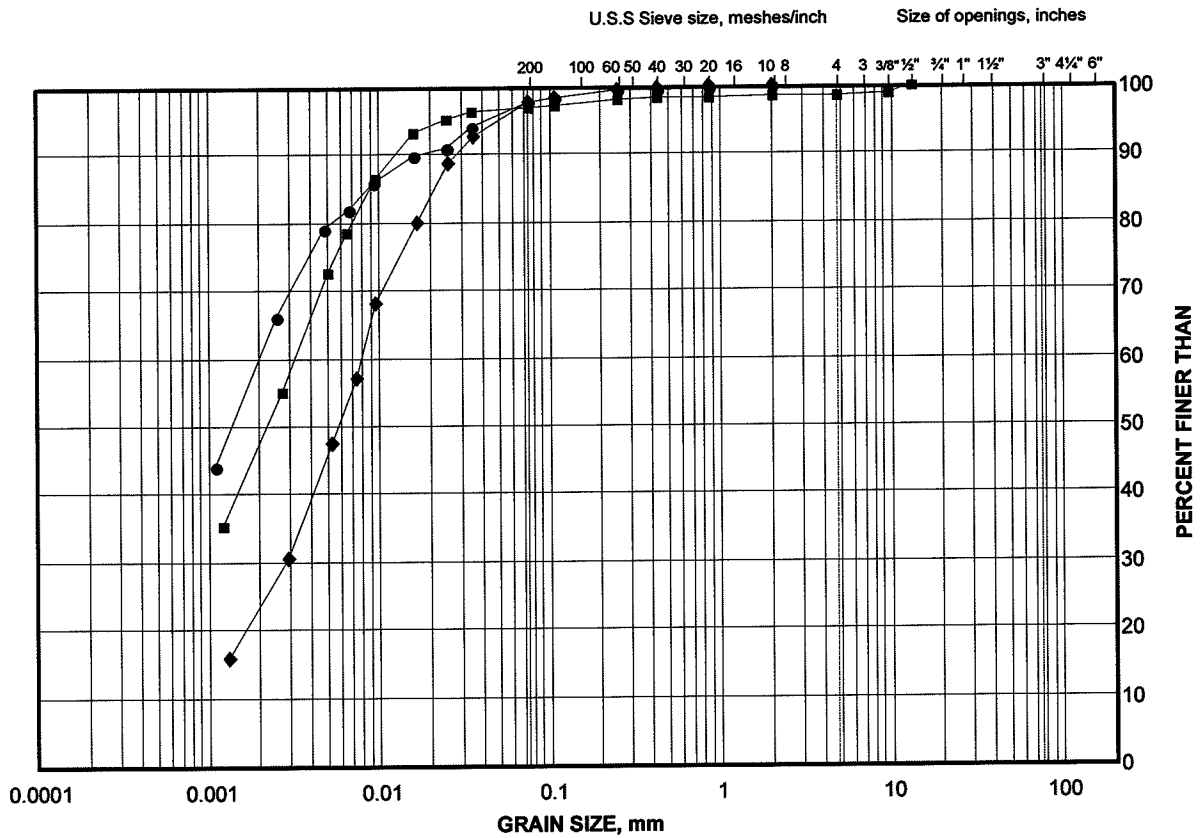
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt to Silty Clay

FIGURE 12



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

LEGEND

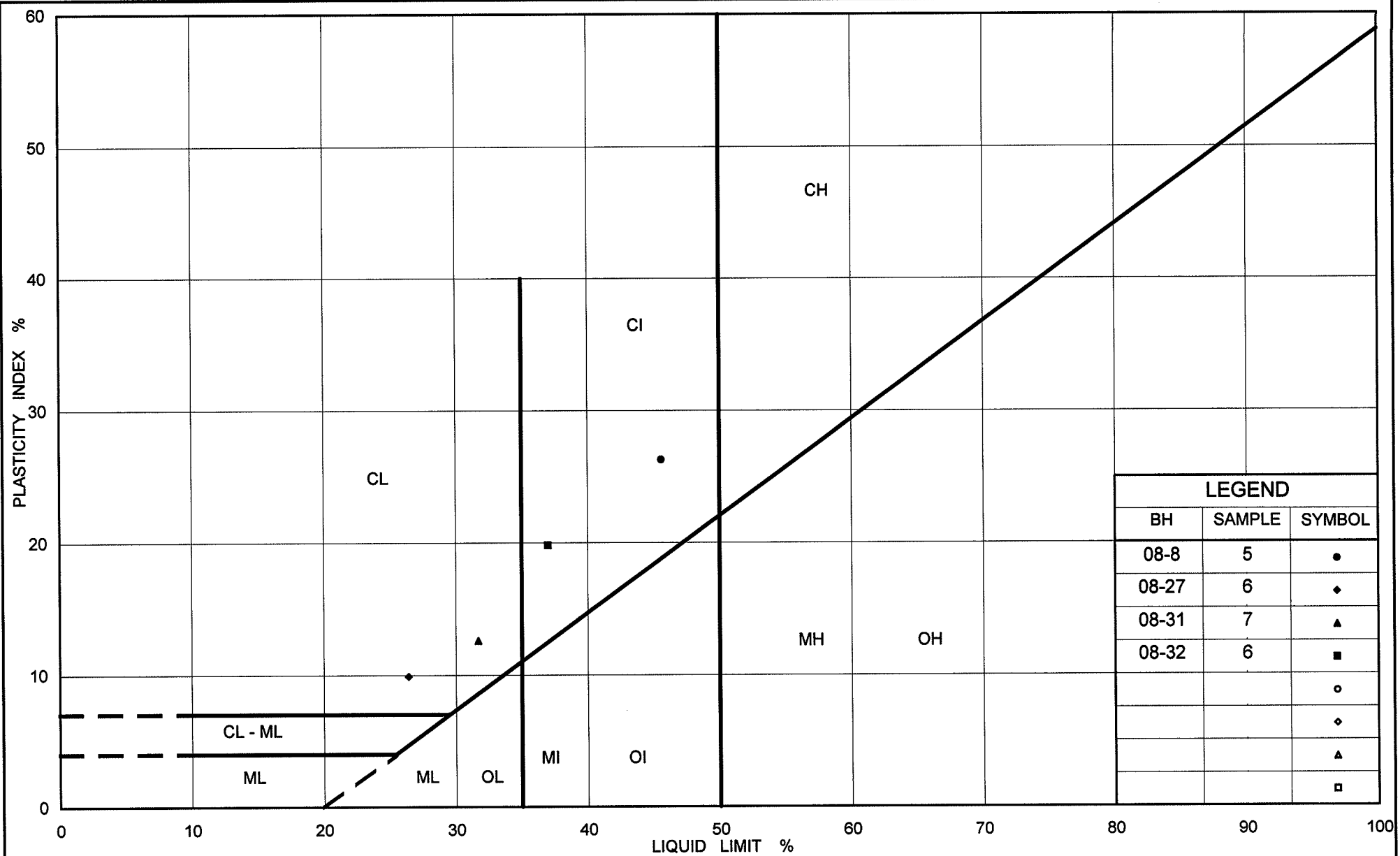
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-8	5	239.8
■	08-32	6	276.0
◆	08-27	6	283.0

Project Number: 06-1111-011

Checked By: 8mm

Golder Associates

Date: 17-Nov-08



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt with Sand to Silty Clay

FIG No. 13

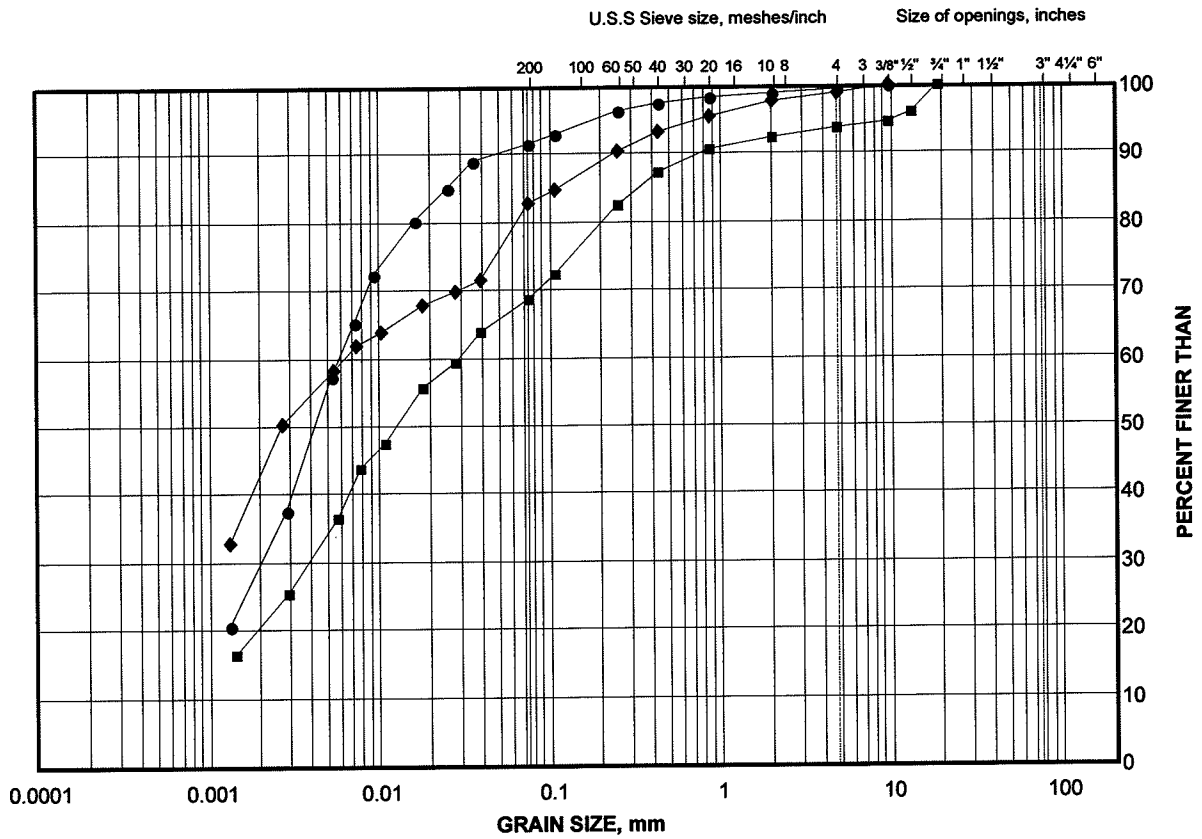
Project No. 06-1111-011

Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Clay to Clayey Silt with Sand Till

FIGURE 14



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-32	3	278.6
■	08-24	4	277.7
◆	08-23	4	278.0

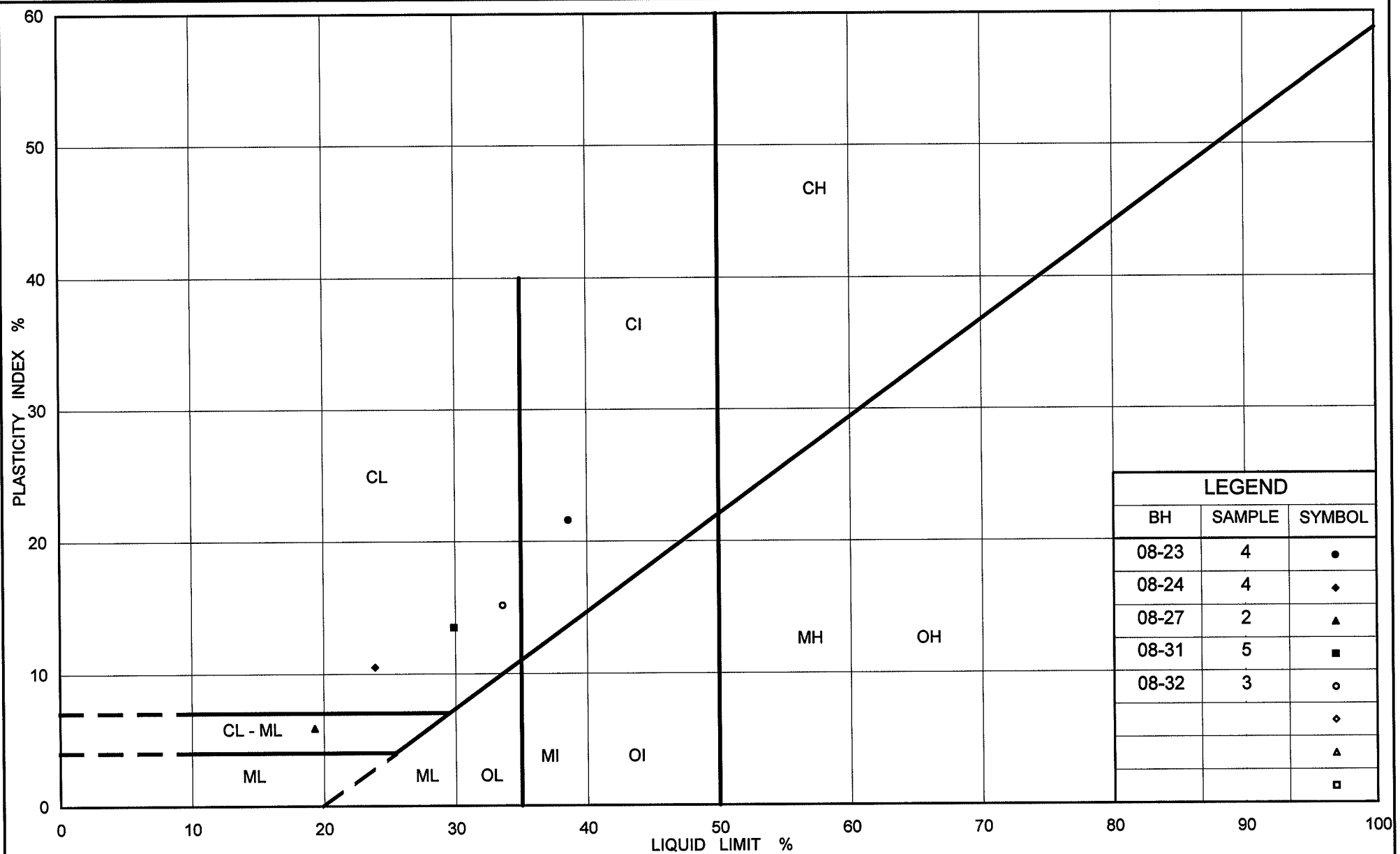
Project Number: 06-1111-011

Checked By:

SM

Golder Associates

Date: 17-Nov-08



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt Till to Silty Clay Till

FIG No. 15

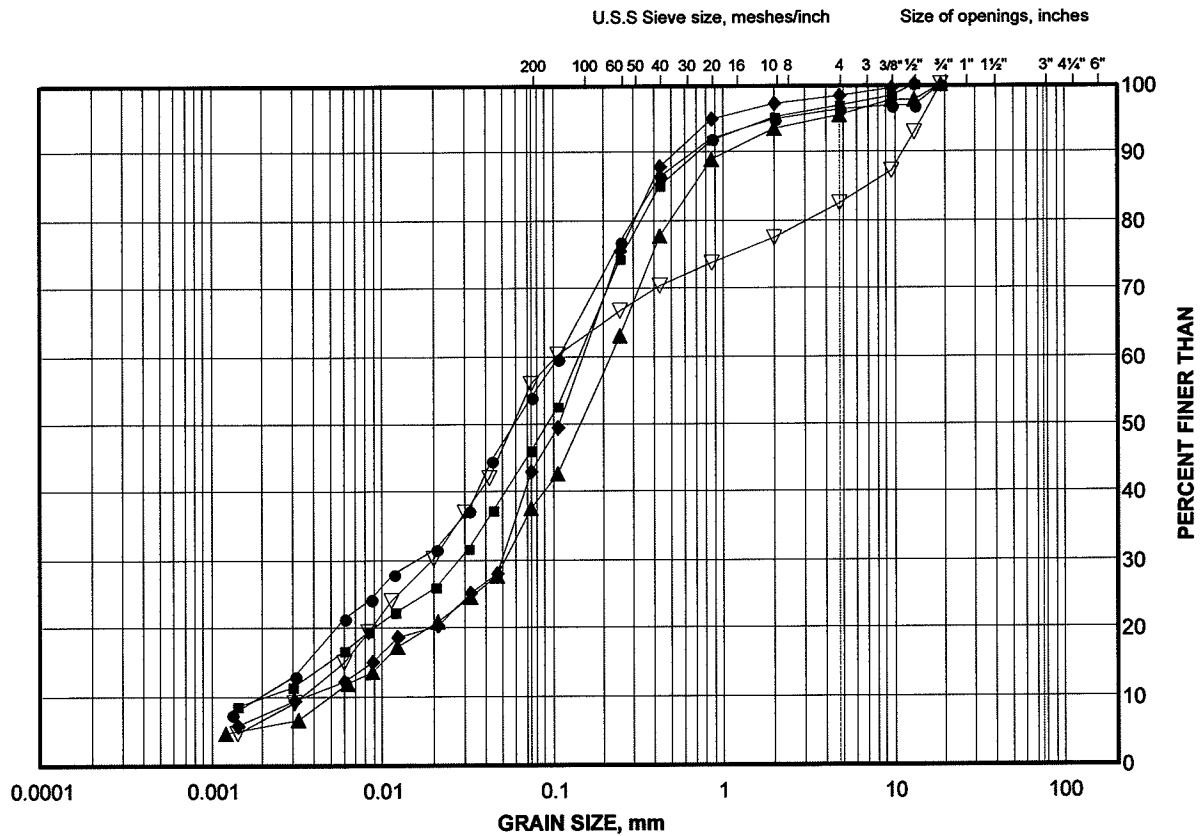
Project No. 06-1111-011

Checked By: *SM*

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sandy Silt to Sand and Silt Till

FIGURE 16



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-30	3	261.1
■	08-30	5	259.5
◆	08-29	6	258.3
▲	08-17	7	253.1
▽	08-21	8	271.0

Project Number: 06-1111-011

Checked By: SM

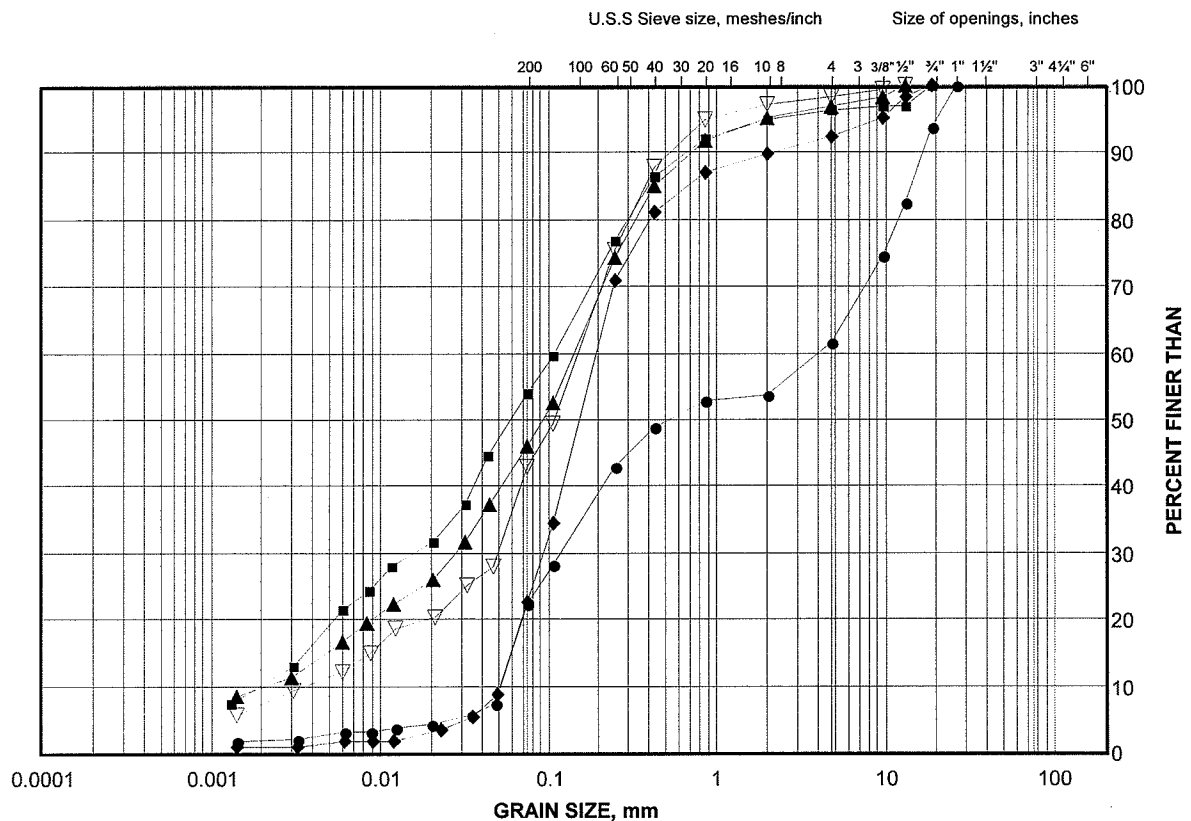
Golder Associates

Date: 19-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 20+823 m

FIGURE 17



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-29	1	262.1
■	08-30	3	261.1*
◆	08-29	3	260.6*
▲	08-30	5	259.5
▽	08-29	6	258.3

NOTES: SEWER INVERT ELEV. 262.29m (INLET) TO 262.15m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

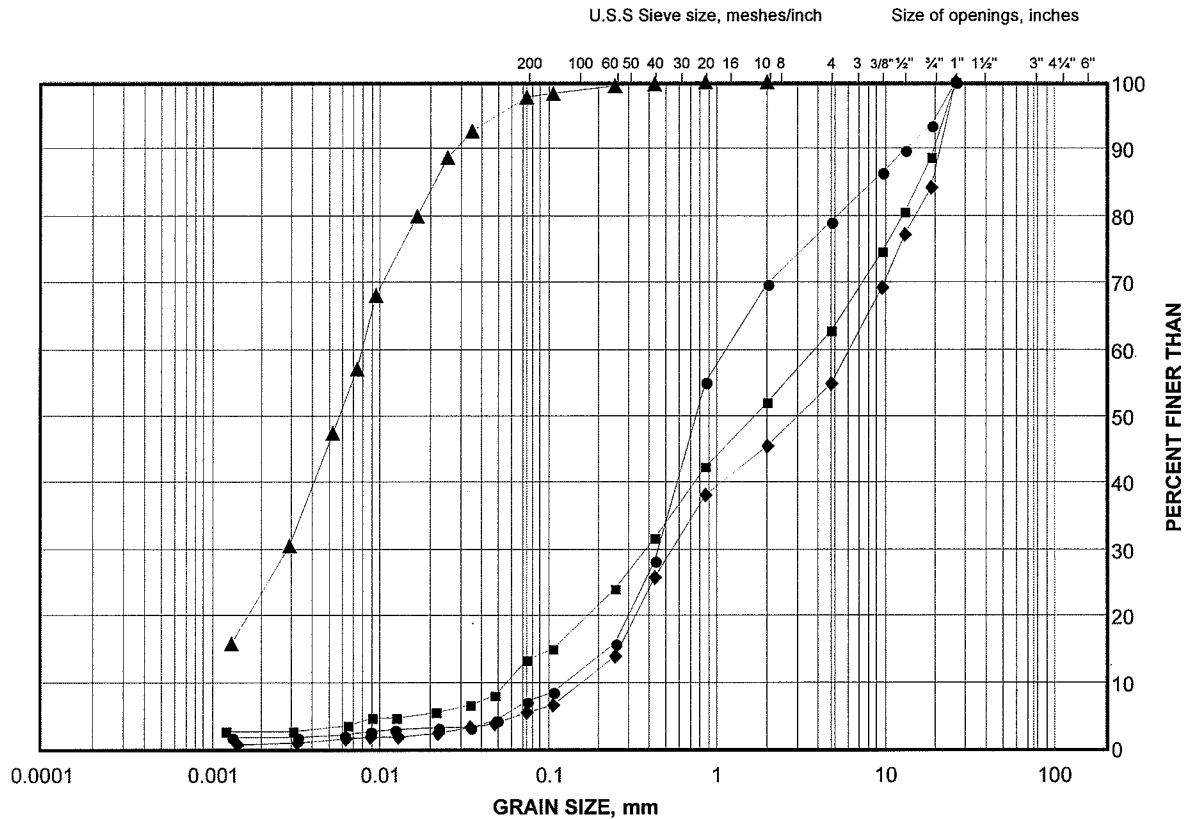
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 23+806 m

FIGURE 18



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-28	3	285.9*
■	08-27	4	284.5
◆	08-28	5	284.3
▲	08-27	6	283.0

NOTES: SEWER INVERT ELEV. 284.8m (INLET) TO 284.65m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

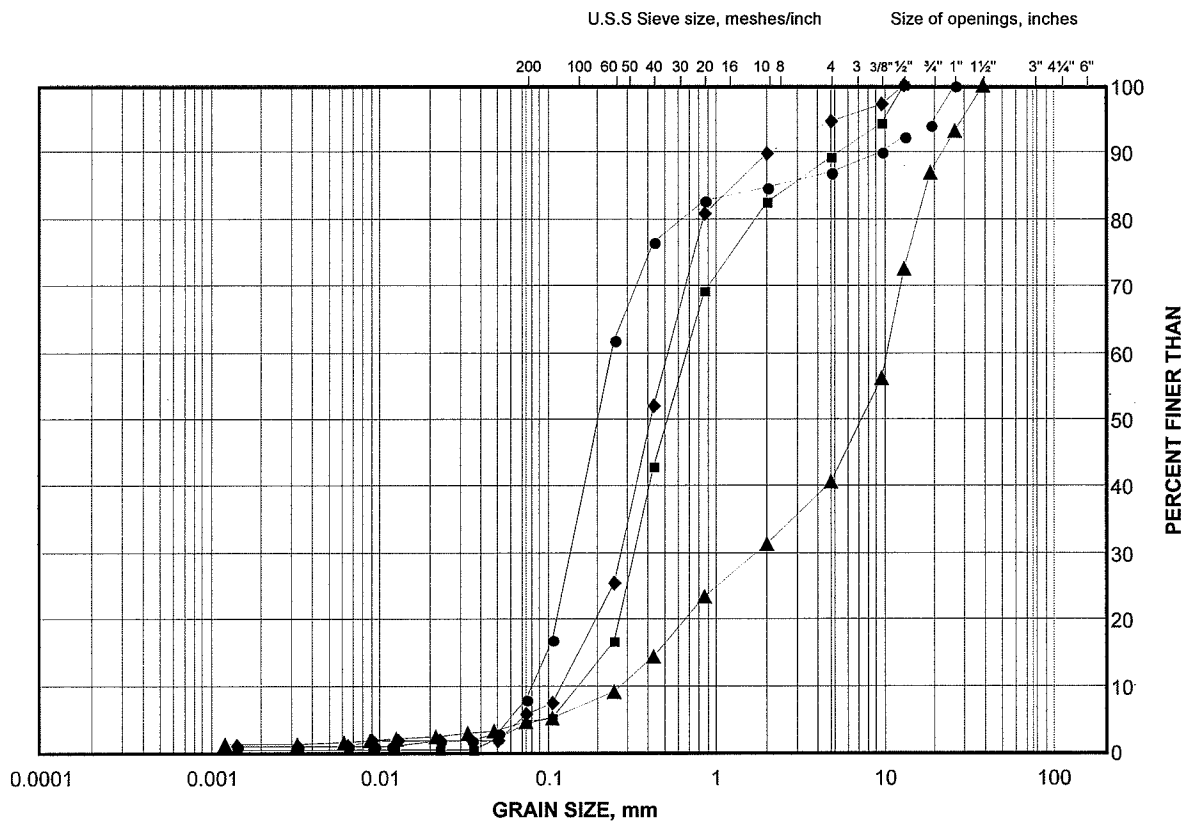
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 23+927 m

FIGURE 19



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-26	2	283.0*
■	08-25	3	281.9*
◆	08-26	4	281.5*
▲	08-25	6	279.6

NOTES: SEWER INVERT ELEV. 281.33m (INLET) TO 281.18m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

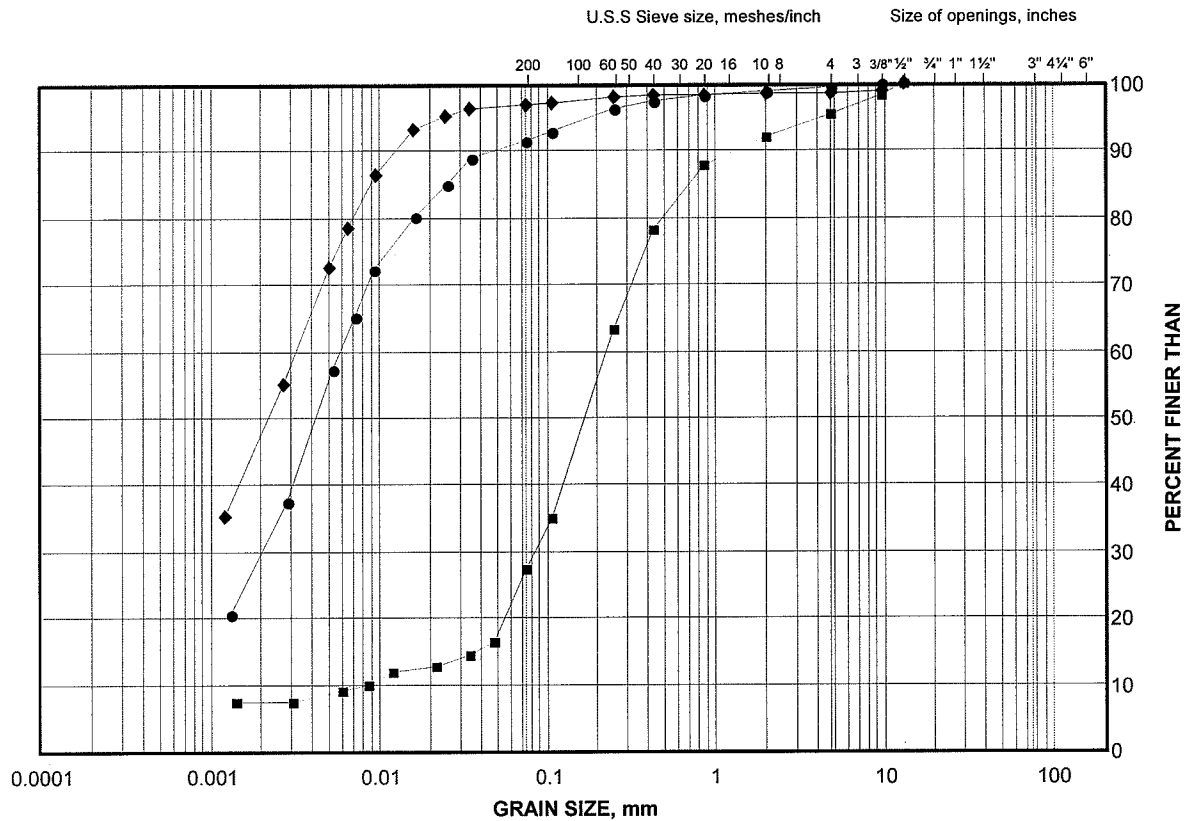
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 24+157 m

FIGURE 20



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	08-32	3	278.6*
■	08-31	3	278.6
◆	08-32	6	276.0

NOTES: SEWER INVERT ELEV. 277.98m (INLET) TO 277.39m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

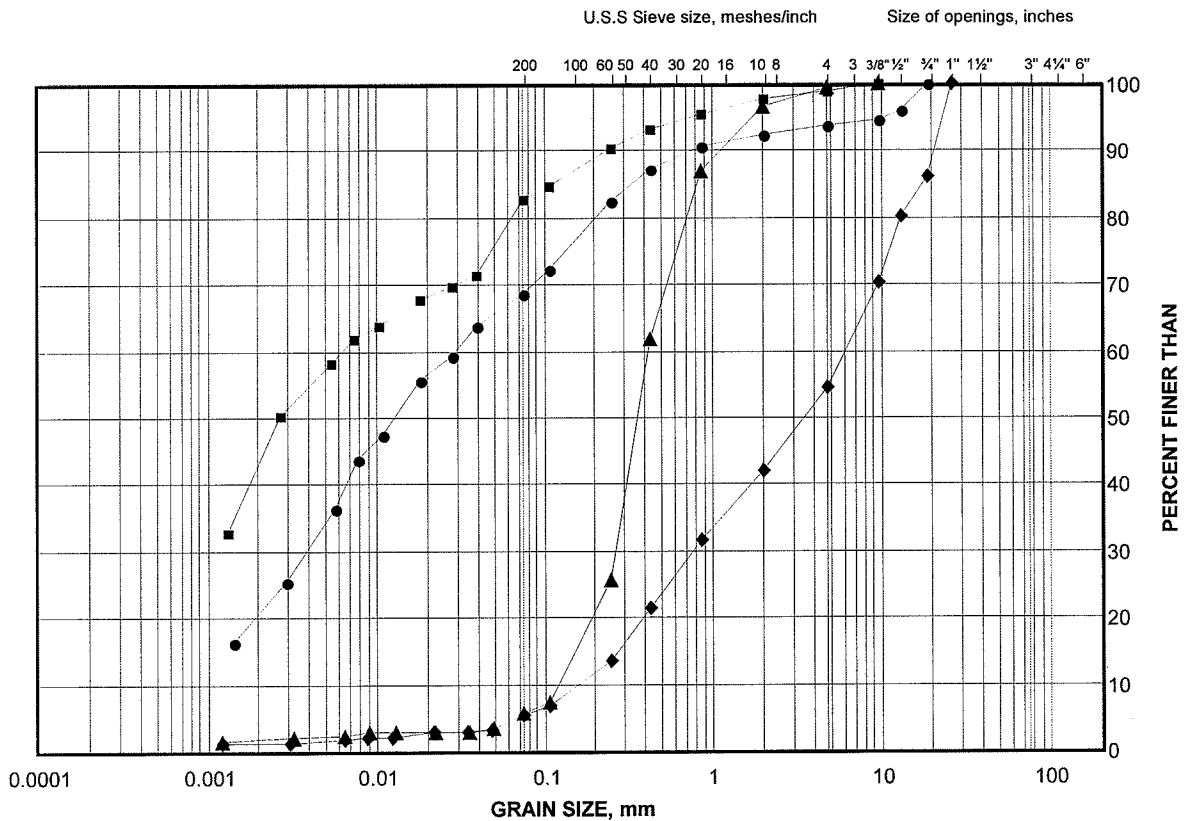
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 24+955 m

FIGURE 21



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-24	4	277.7
■	08-23	4	278.0*
◆	08-24	6	276.2
▲	08-23	7	275.7

NOTES: SEWER INVERT ELEV. 278.36m (INLET) TO 278.19m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *87m*

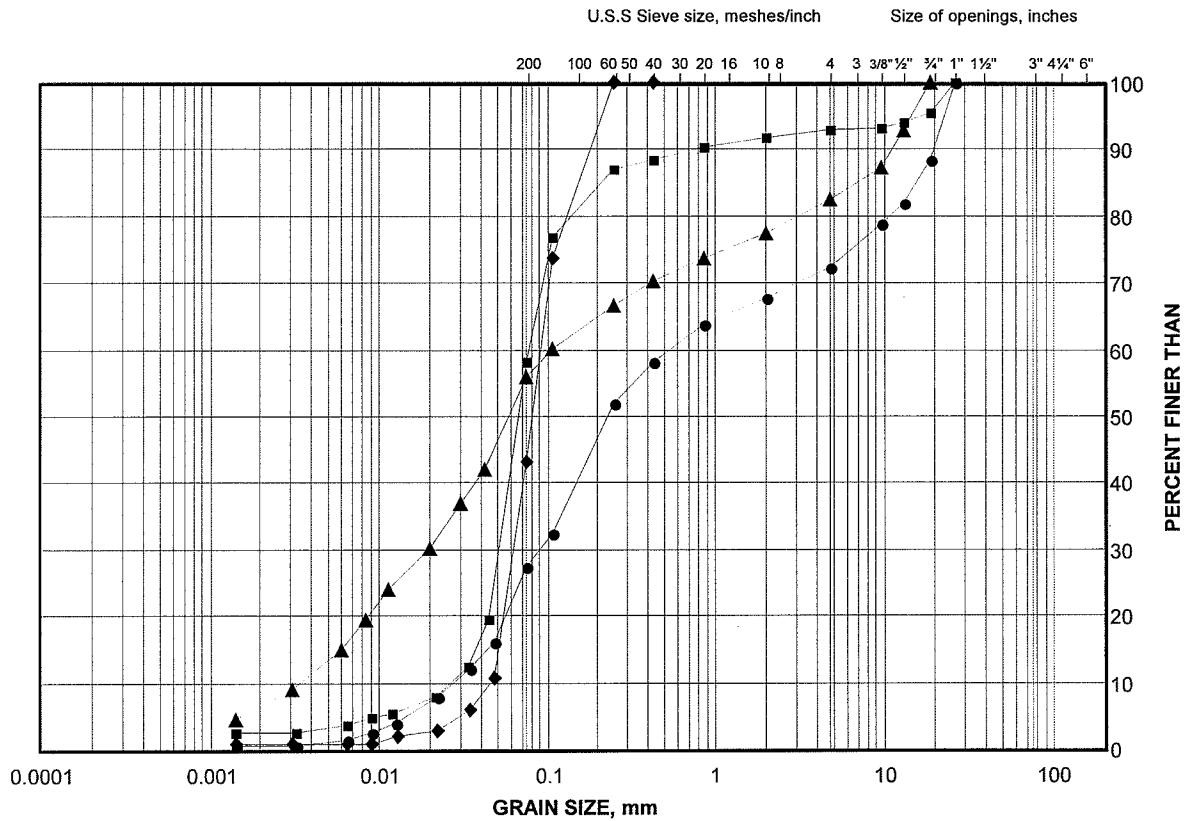
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 25+175 m

FIGURE 22



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-21	4	274.8
■	08-22	5	274.0
◆	08-21	6	273.3
▲	08-21	8	271.0

NOTES: SEWER INVERT ELEV. 275.23m (INLET) TO 275.12m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

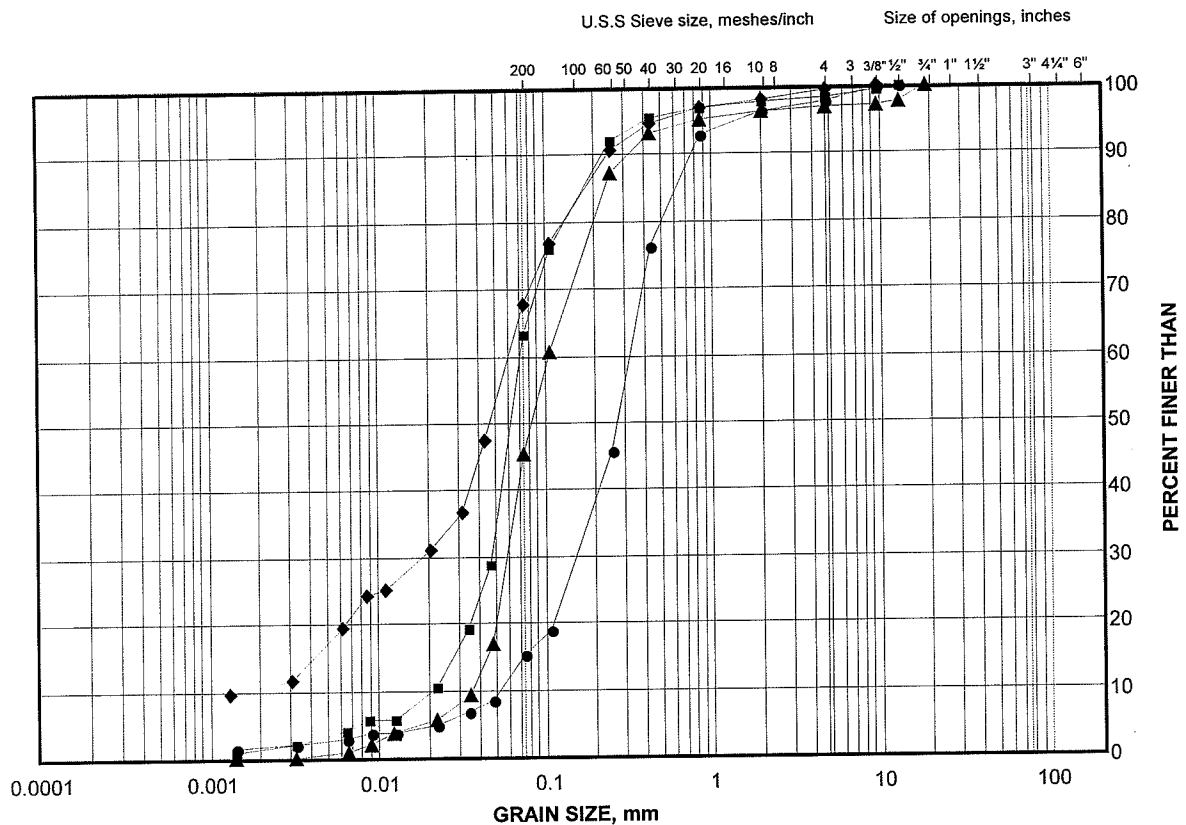
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 26+032 m

FIGURE 23



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-19	2	267.4*
■	08-20	3	267.2*
◆	08-20	5	265.6
▲	08-19	5	265.1

NOTES: SEWER INVERT ELEV. 266.75m (INLET) TO 266.6m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

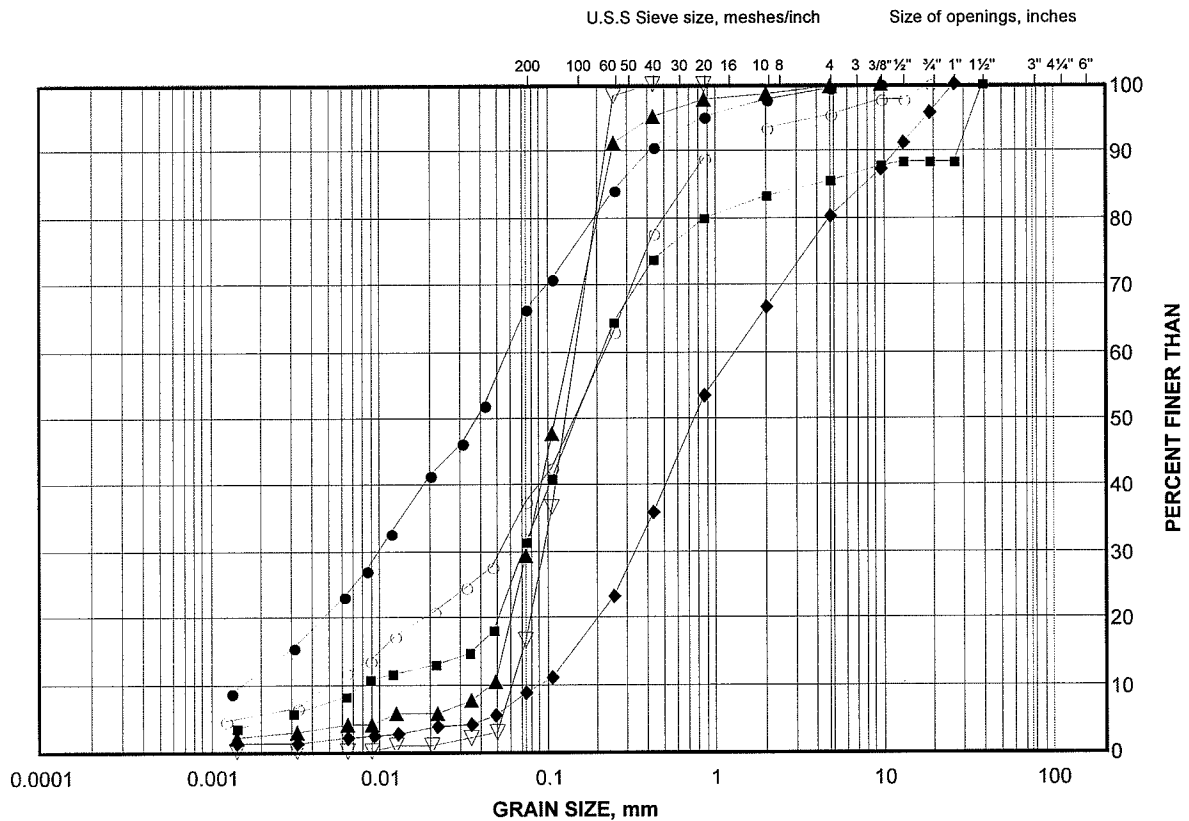
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 26+536 m

FIGURE 24



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-17	2	256.9
■	08-18	3	255.7
◆	08-17	4	255.4*
▲	08-18	5	254.1
▽	08-18	6	253.4
○	08-17	7	253.1

NOTES: SEWER INVERT ELEV. 256.30m (INLET) TO 255.08m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

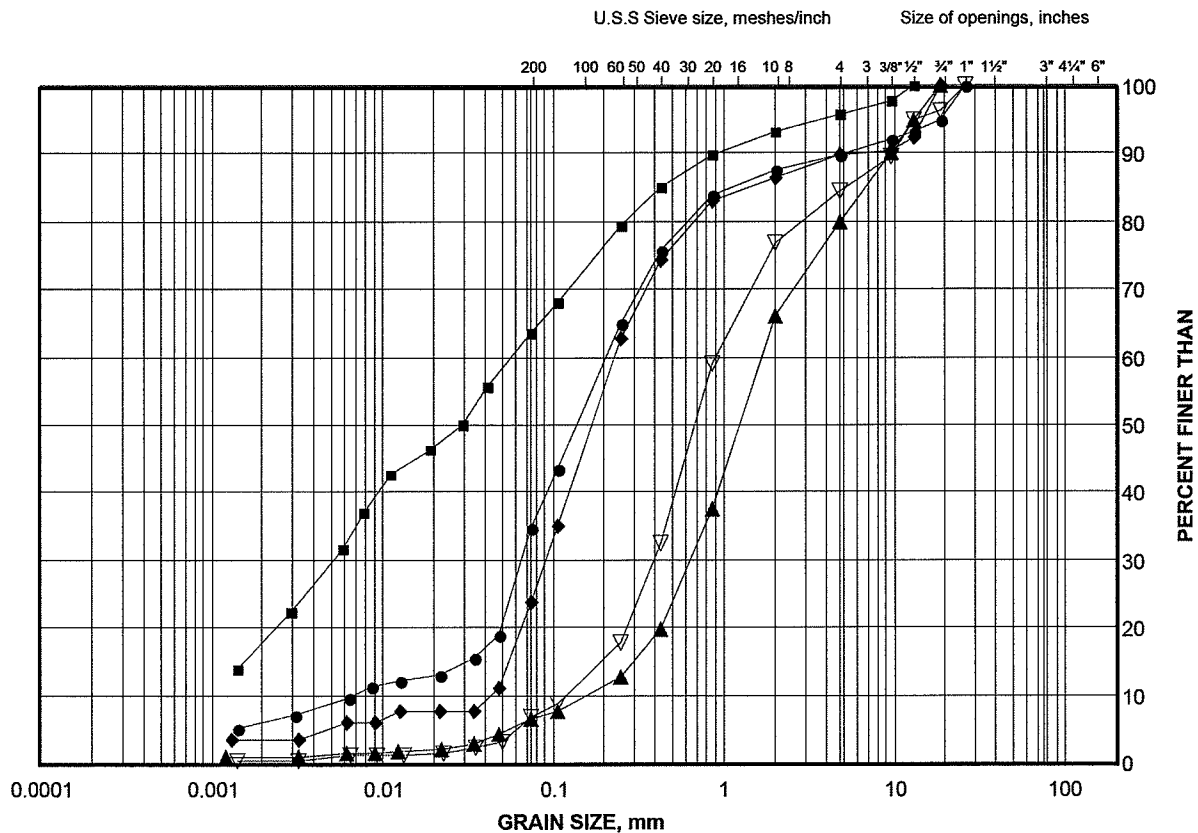
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 27+216 m

FIGURE 25



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-16	3	263.4*
■	08-15	5	262.4*
◆	08-15	7	260.9*
▲	08-16	7	260.3
▽	08-15	9	257.9

Project Number: 06-1111-011

Checked By: *SM*

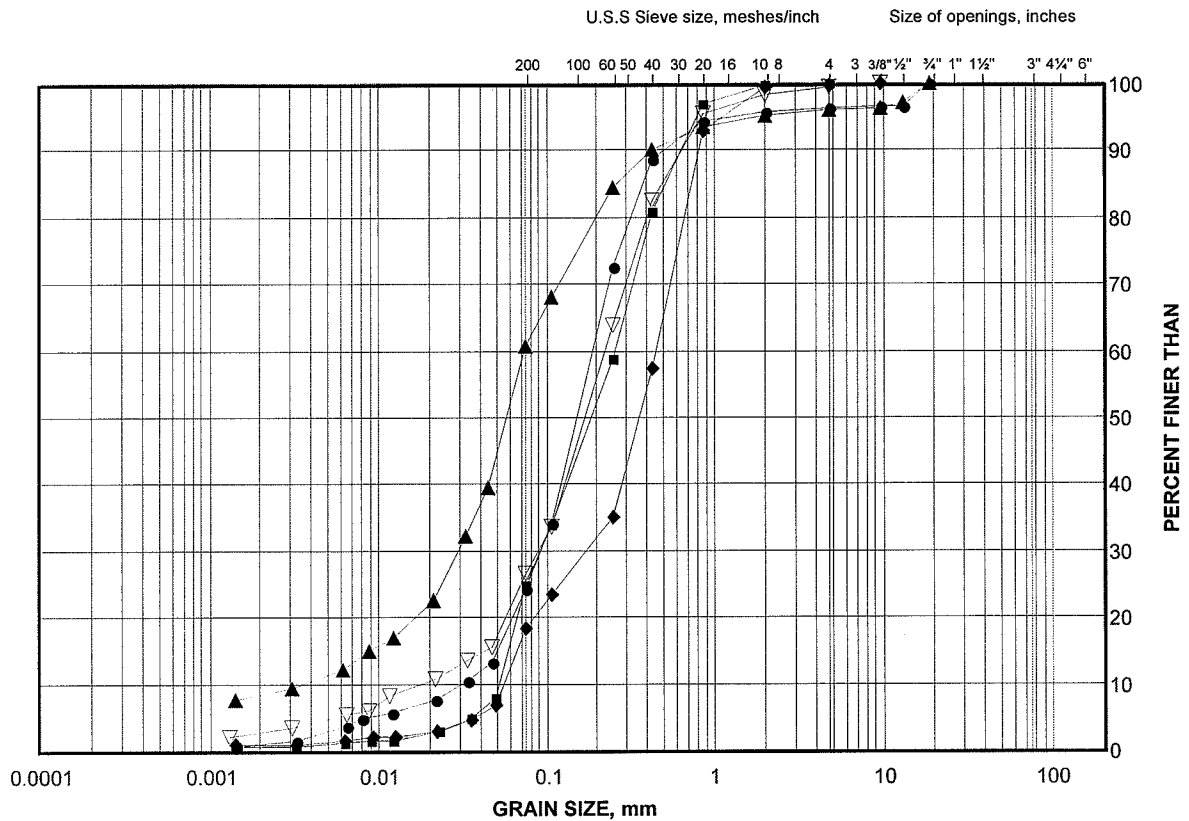
Golder Associates

Date: 28-Oct-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 27+989 m

FIGURE 26



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-13	2	271.6
■	08-14	3	270.5*
◆	08-14	5	268.9
▲	08-13	6	268.8
▽	08-13	8	266.3

NOTES: SEWER INVERT ELEV. 270.04m (INLET) TO 269.51m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

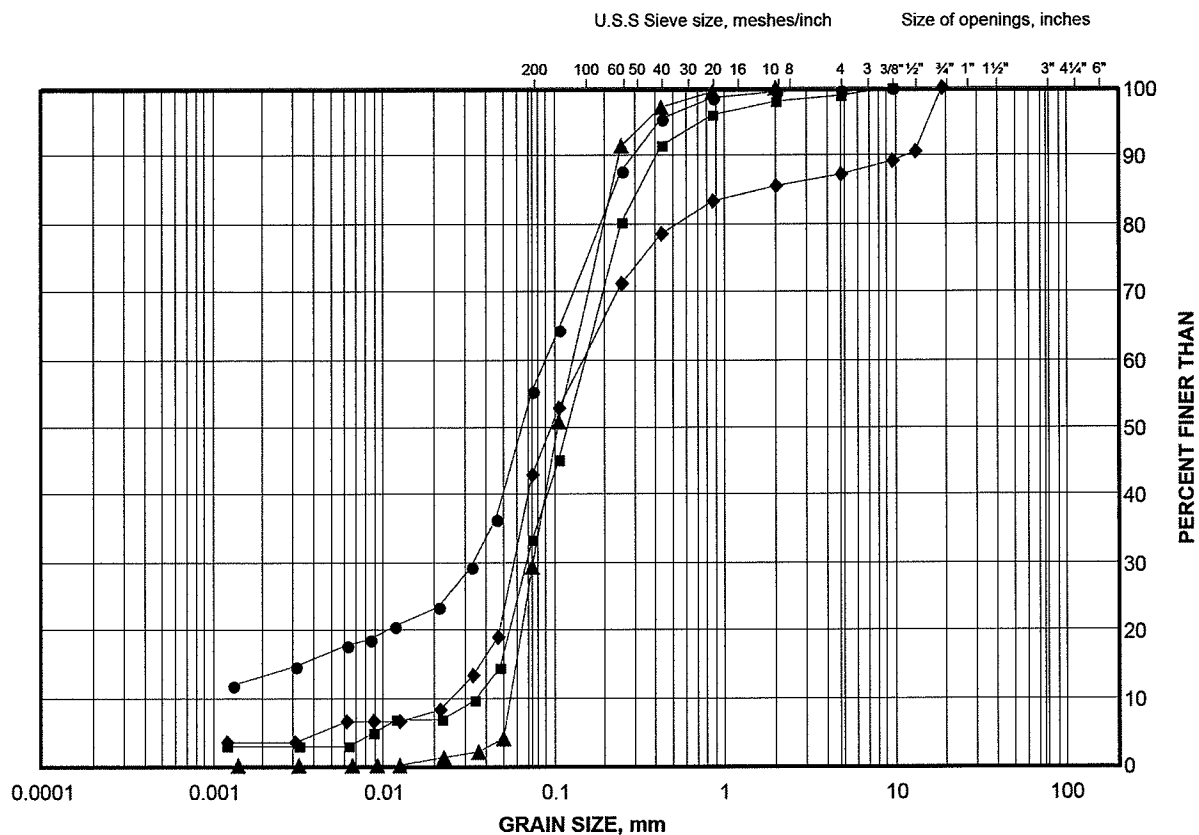
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 28+746 m

FIGURE 27



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	08-12	2	266.3*
■	08-12	5	264.0*
◆	08-11	7	263.0
▲	08-11	8	261.5*

Project Number: 06-1111-011

Checked By: *SM*

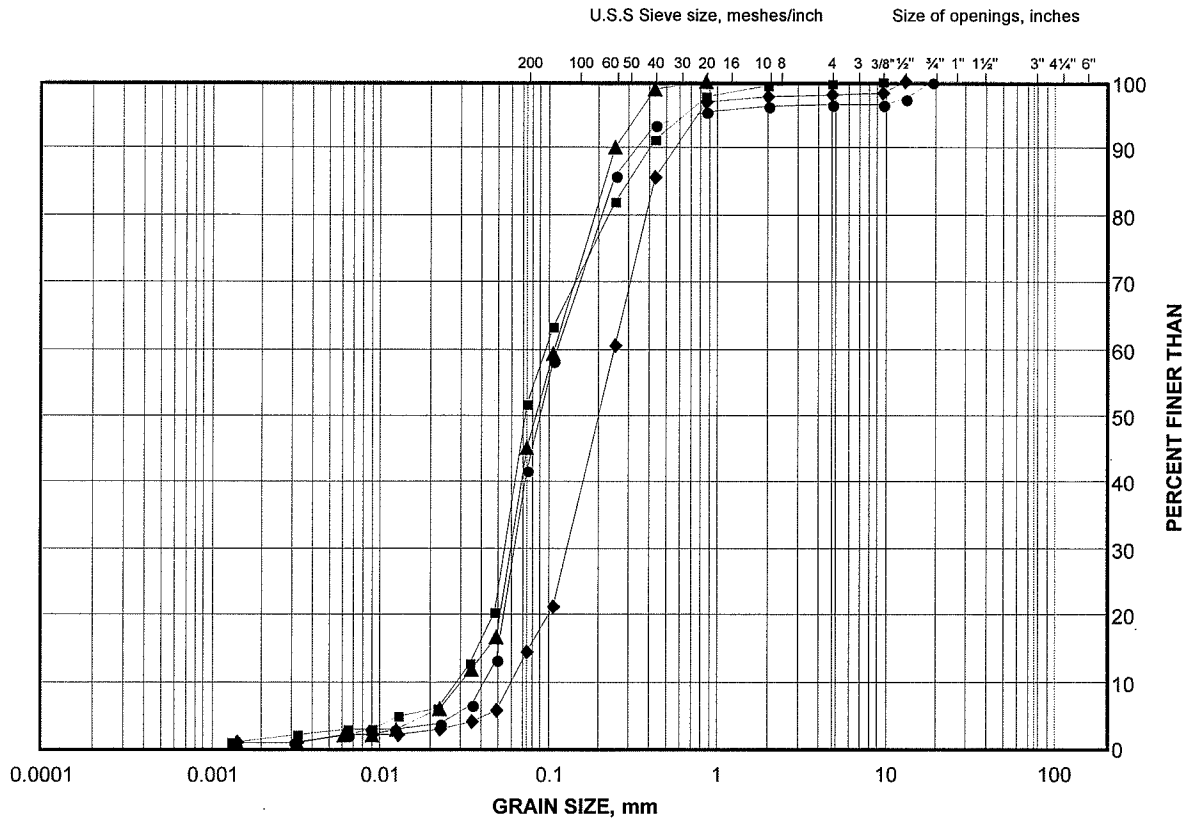
Golder Associates

Date: 28-Oct-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 29+349 m

FIGURE 28



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-9	3	268.3*
■	08-10	4	267.4
◆	08-10	6	265.9
▲	08-9	6	266.0*

NOTES: SEWER INVERT ELEV. 268.24m (INLET) TO 266.54m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

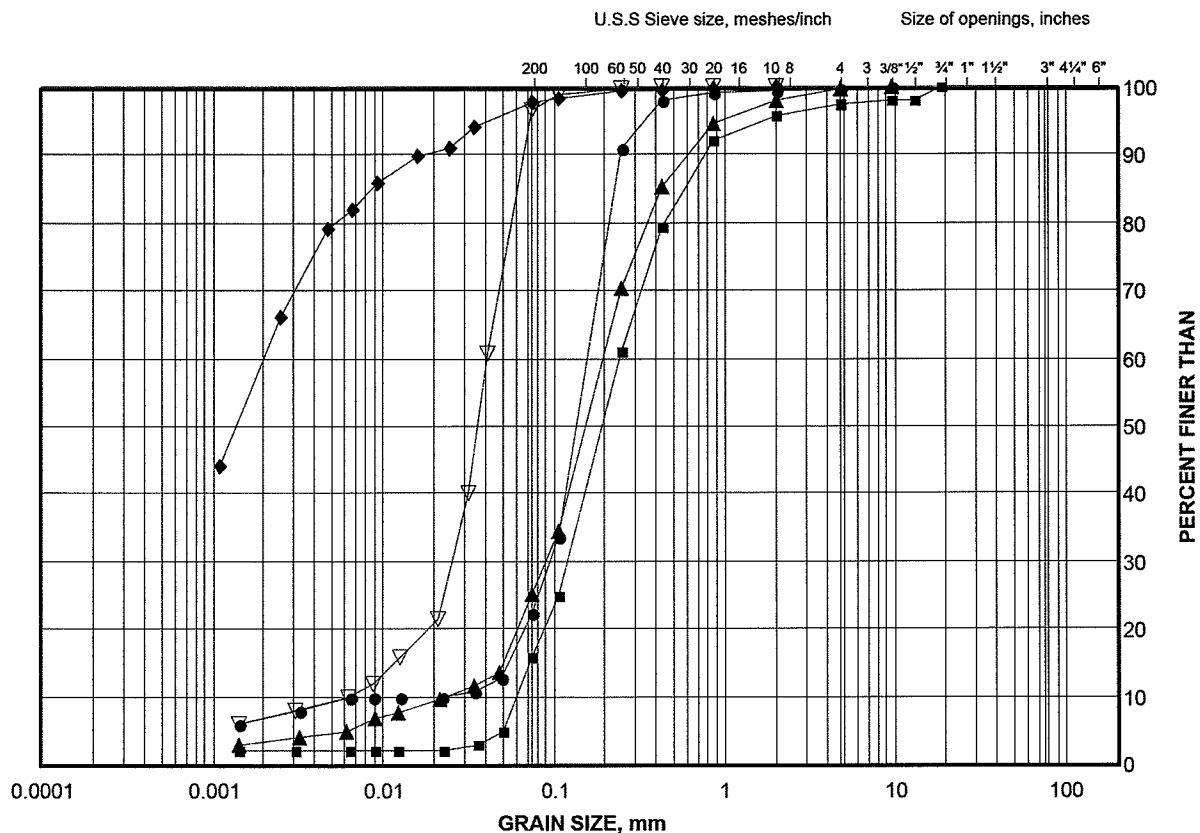
Golder Associates

Date: 28-Oct-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 10+659 m

FIGURE 29



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-7	2	242.9
■	08-8	3	241.4*
◆	08-8	5	239.8
▲	08-7	5	240.6*
▽	08-7	7	239.1

Project Number: 06-1111-011

Checked By: *SN*

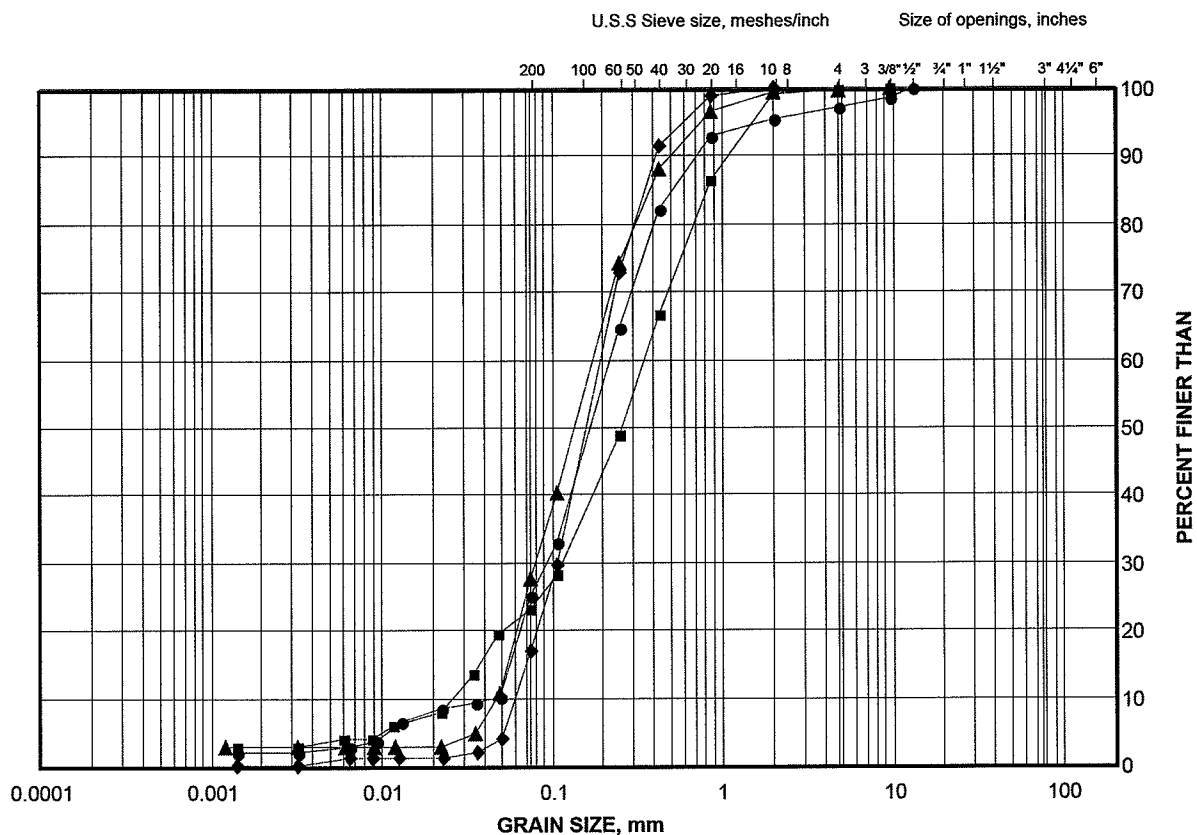
Golder Associates

Date: 28-Oct-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 11+269 m

FIGURE 30



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-5	2	242.8
■	08-6	3	241.8*
◆	08-5	4	241.3*
▲	08-6	6	239.5

Project Number: 06-1111-011

Checked By: *SM*

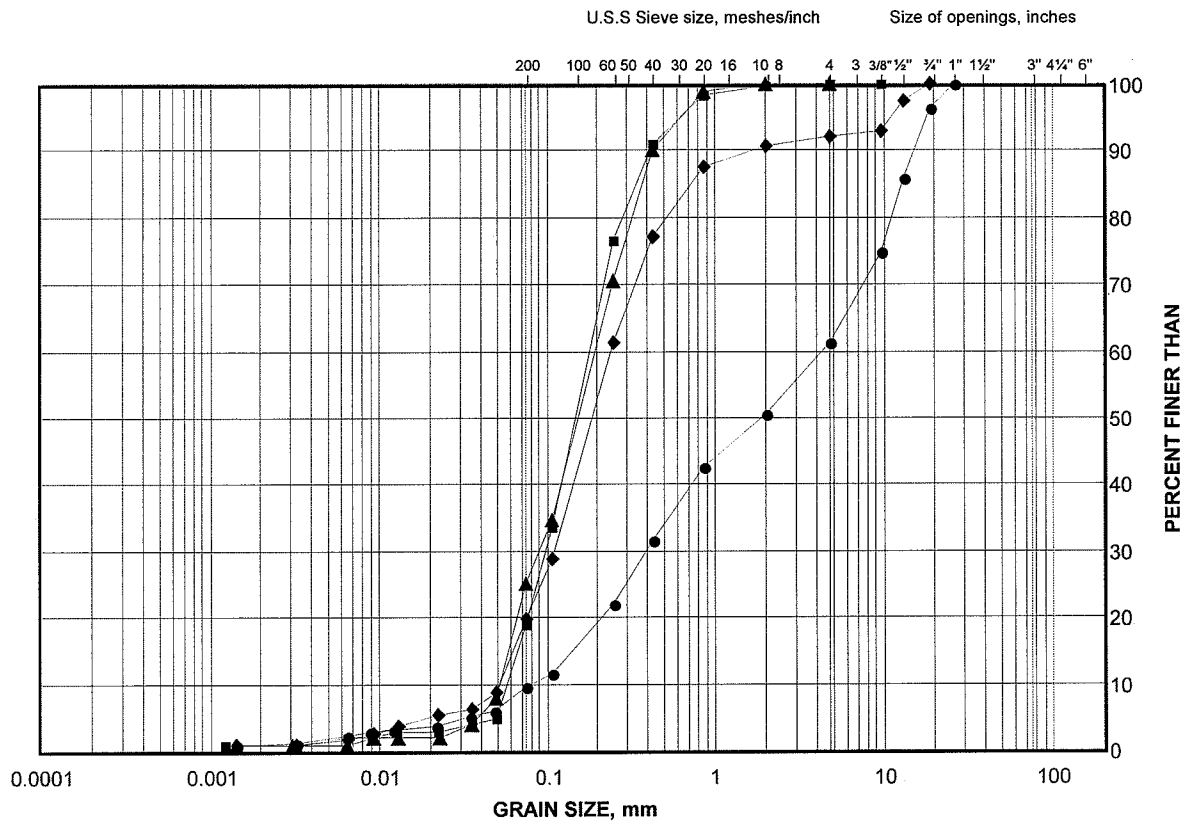
Golder Associates

Date: 28-Oct-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 11+757 m

FIGURE 31



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-3	1	243.6
■	08-4	2	242.5*
◆	08-3	3	242.1*
▲	08-4	4	241.0*

NOTES: SEWER INVERT ELEV. 241.71m (INLET) TO 241.54m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

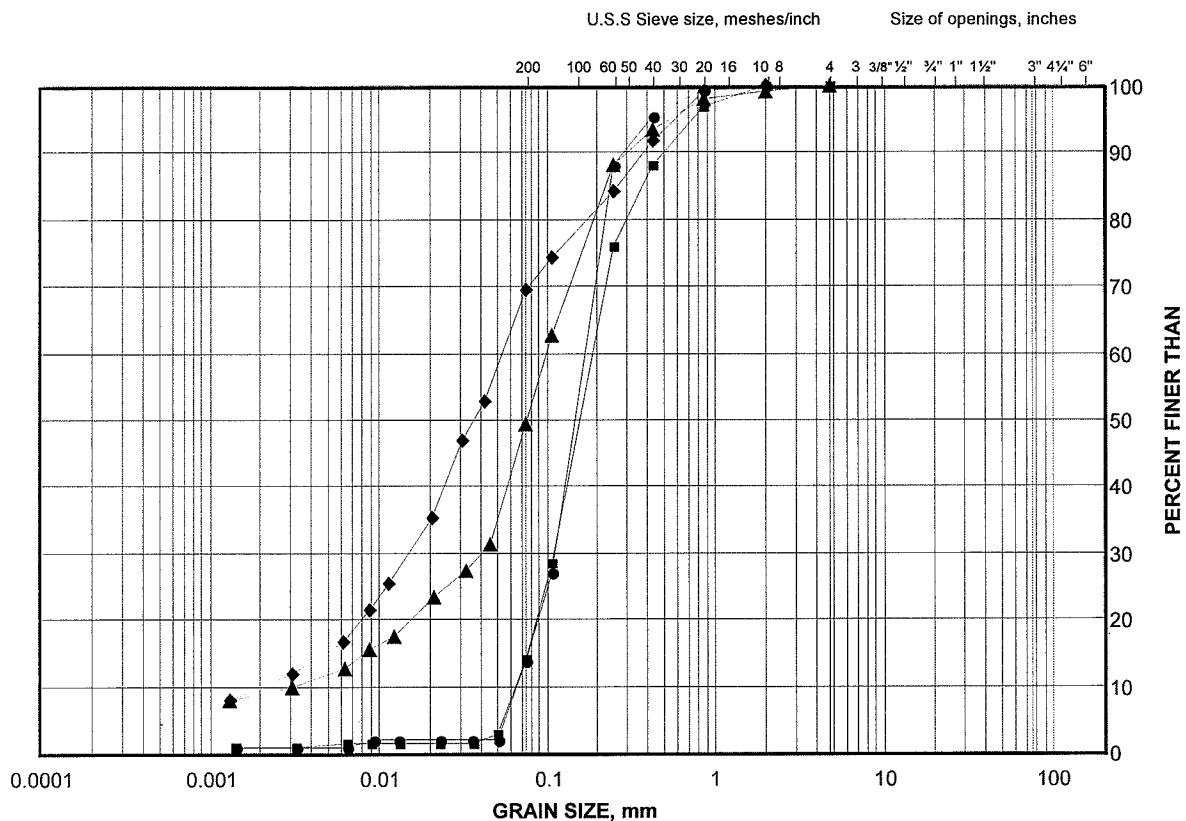
Golder Associates

Date: 11-Mar-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sewer Crossing Station 13+274 m

FIGURE 32



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-2	3	244.7*
■	08-1	3	244.5*
◆	08-2	5	243.1
▲	08-1	6	242.2

NOTES: SEWER INVERT ELEV. 244.76m (INLET) TO 244.56m (OUTLET)

* SAMPLE IN TUNNEL HORIZON.

THE SAMPLES USED IN THE GEOTECHNICAL INVESTIGATIONS LIMIT THE MAXIMUM PARTICLE SIZE THAT CAN BE SAMPLED AND TESTED TO ABOUT 40mm. LARGER PARTICLE SIZES, INCLUDING COBBLES AND BOULDERS, ARE KNOWN TO BE PRESENT IN THE DEPOSIT, AS DISCUSSED IN THE TEXT OF THE REPORT.

Project Number: 06-1111-011

Checked By: *SM*

Golder Associates

Date: 11-Mar-09

APPENDIX A
Relevant Borehole Logs and Laboratory Data from “Foundation
Investigation and Design Report, Culverts, Highway 400 SBL Between
Highway 11 and County Road 11 (Forbes Road), Simcoe County, G.W.P.
167-99-00

PROJECT 06-1111-011		RECORD OF BOREHOLE No 2007-36				1 OF 1 METRIC										
W.P. 2168-06-00		LOCATION N 4925936.4 :E 289429.5				ORIGINATED BY PKS										
DIST Central HWY 400		BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers				COMPILED BY VO										
DATUM Geodetic		DATE November 20, 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 (%)	
278.2	GROUND SURFACE						20	40	60	80	100					
0.0	TOPSOIL															
0.1	Silty SAND, trace gravel, containing 75 mm thick clayey silt seam and rootlets Loose to compact Brown Moist		1	SS	5											
			2	SS	12											
276.7																
1.5	SAND and GRAVEL, trace silt Compact to dense Brown Wet		3	SS	32											
			4	SS	27											
			5	SS	22											
			6	SS	12											
273.9																
4.3	CLAYEY SILT, some sand, trace gravel (TILL) Hard Grey Moist		7	SS	40											
			8	SS	92											
			9	SS	54											
			10	SS	150											
			11	SS	100/0.25											
			12	SS	100/0.15											
265.8	END OF BOREHOLE															
12.4	NOTE: 1. Water level in open borehole at 7.6 m depth (Elevation 270.6 m) upon completion of drilling.															

MIS-MTO 001 06-1111-011.GPJ GAL-MISS.GDT 3/12/09 DD/SAC

PROJECT 06-1111-011

RECORD OF BOREHOLE No 2007-38

1 OF 1 **METRIC**

W.P. 2168-06-00

LOCATION N 4925260.4 :E 289877.1

ORIGINATED BY PKS

DIST Central HWY 400




BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers

COMPILED BY VO

DATUM Geodetic

DATE November 20 and 21, 2007

CHECKED BY LCC

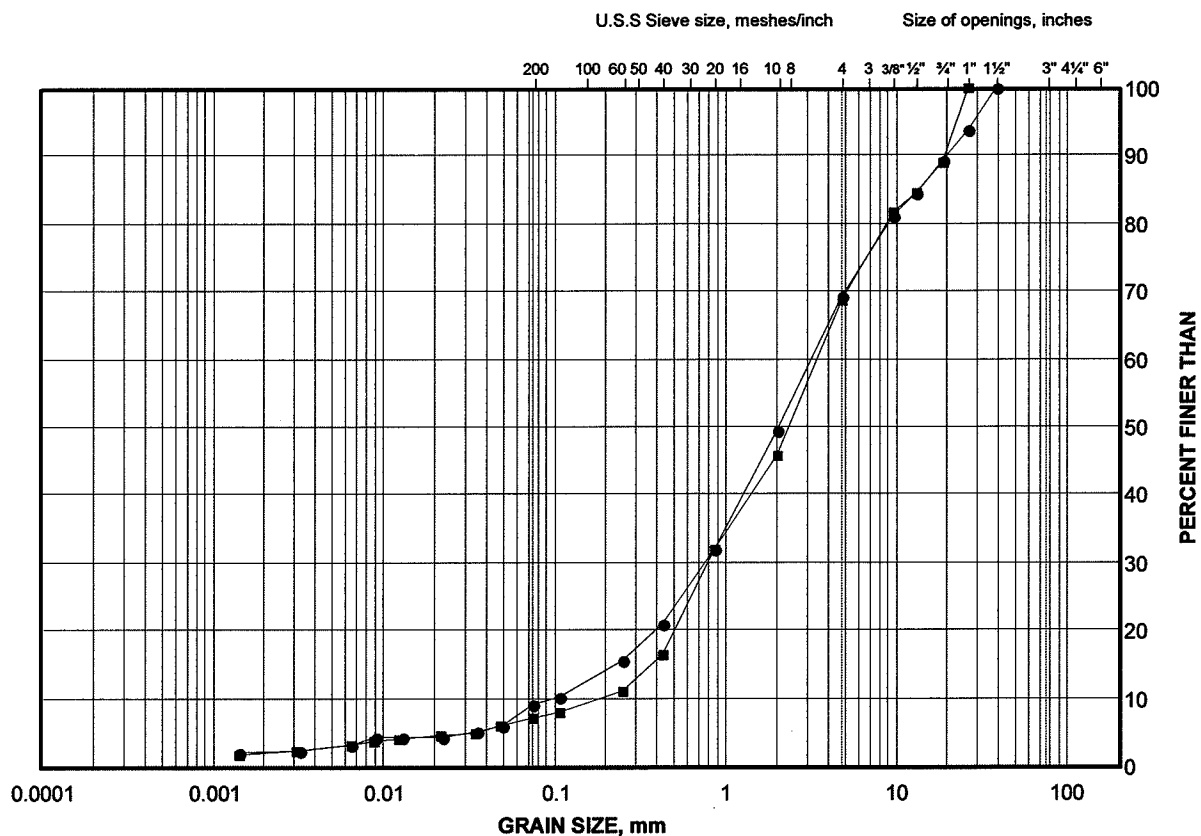
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20 40 60 80 100										
277.0	GROUND SURFACE																	
0.0	Sand, some silt, trace clay and gravel, containing organics and rootlets (FILL)		1	SS	8													
276.4	Loose Brown Moist		2	SS	18													
0.6	CLAYEY SILT, some sand, trace gravel Stiff to very stiff Brown Moist		3	SS	9													
			4	SS	15													
274.0																		
3.1	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff Brown Moist		5	SS	22													
			6	SS	16													
			7	SS	24													
270.9																		
6.1	SAND, trace silt, clay and gravel Very dense Brown Moist		8	SS	00/0.15													
			9	SS	00/0.25													
			10	SS	00/0.15													
			11	SS	00/0.15													
264.6																		
12.5	END OF BOREHOLE		12	SS	00/0.25													
	NOTE: 1. Borehole dry on completion of drilling operations.																	

MIS-MTO 001 06-1111-011.GPJ GAL-MISS.GDT 3/12/09 DD/SAC

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Gravel

FIGURE A1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	2007-36	4	275.6
■	2007-36	6	274.1

Project Number: 06-1111-011

Checked By: SM

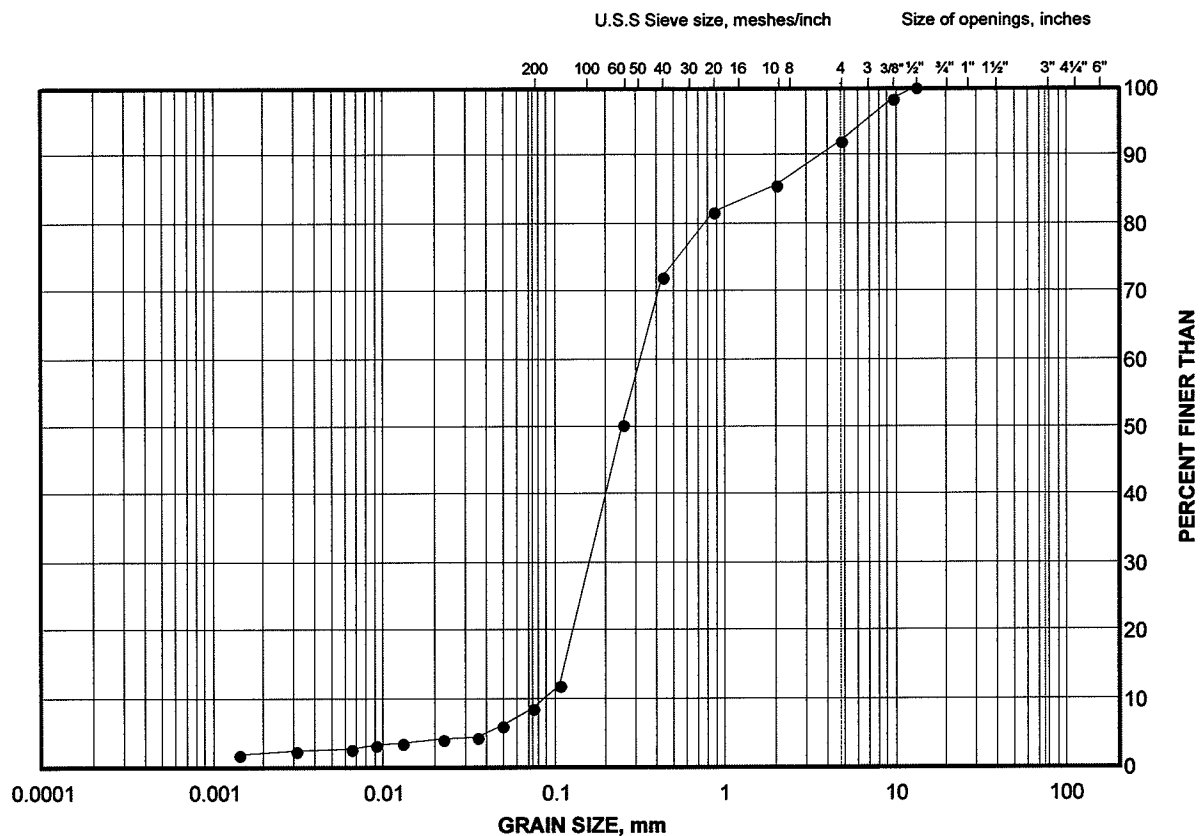
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULT

Sand

FIGURE A2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	2007-38	8	270.7

Project Number: 06-1111-011

Checked By: *SM*

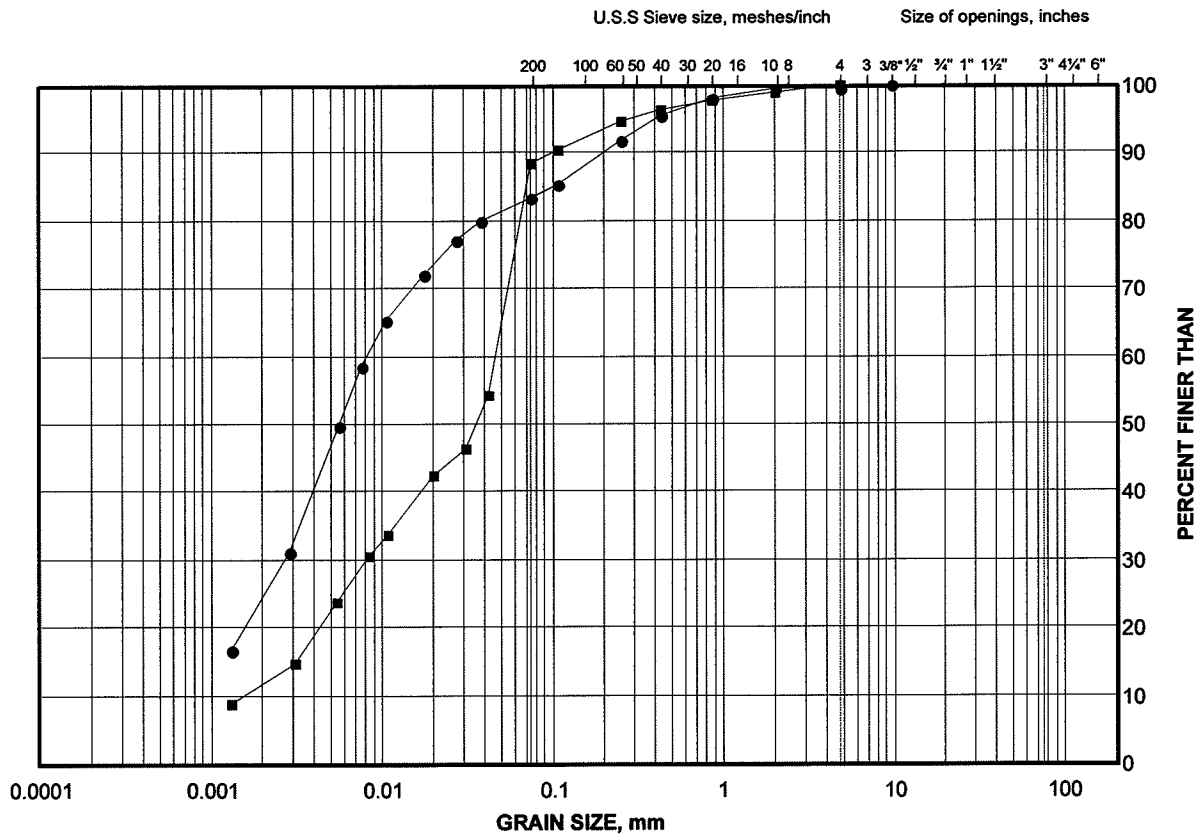
Golder Associates

Date: 17-Nov-08

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt

FIGURE A3



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

LEGEND

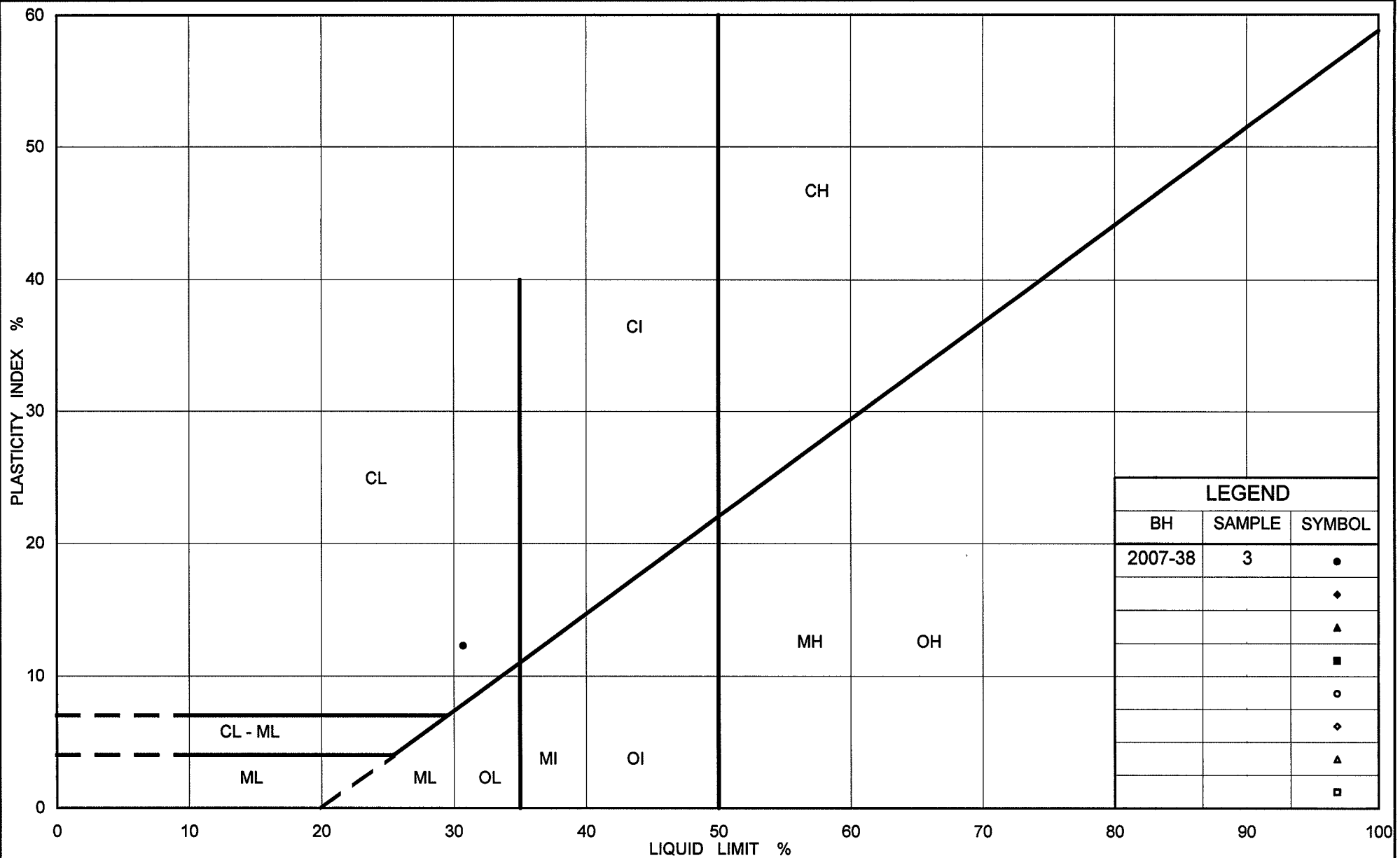
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	2007-38	2	275.9
■	2007-38	4	274.4

Project Number: 06-1111-011

Checked By: *STM*

Golder Associates

Date: 17-Nov-08



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt

FIG No. A4

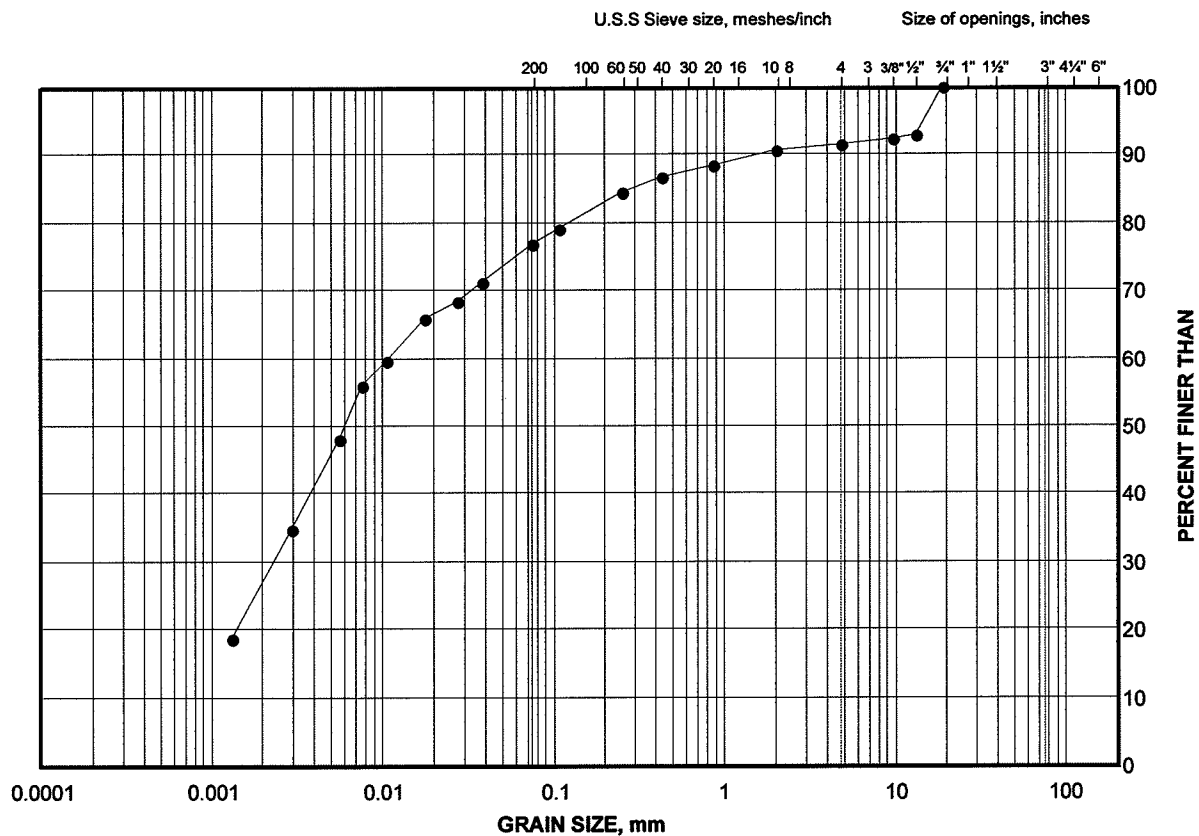
Project No. 06-1111-011

Checked By: *SM*

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

FIGURE A5



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

LEGEND

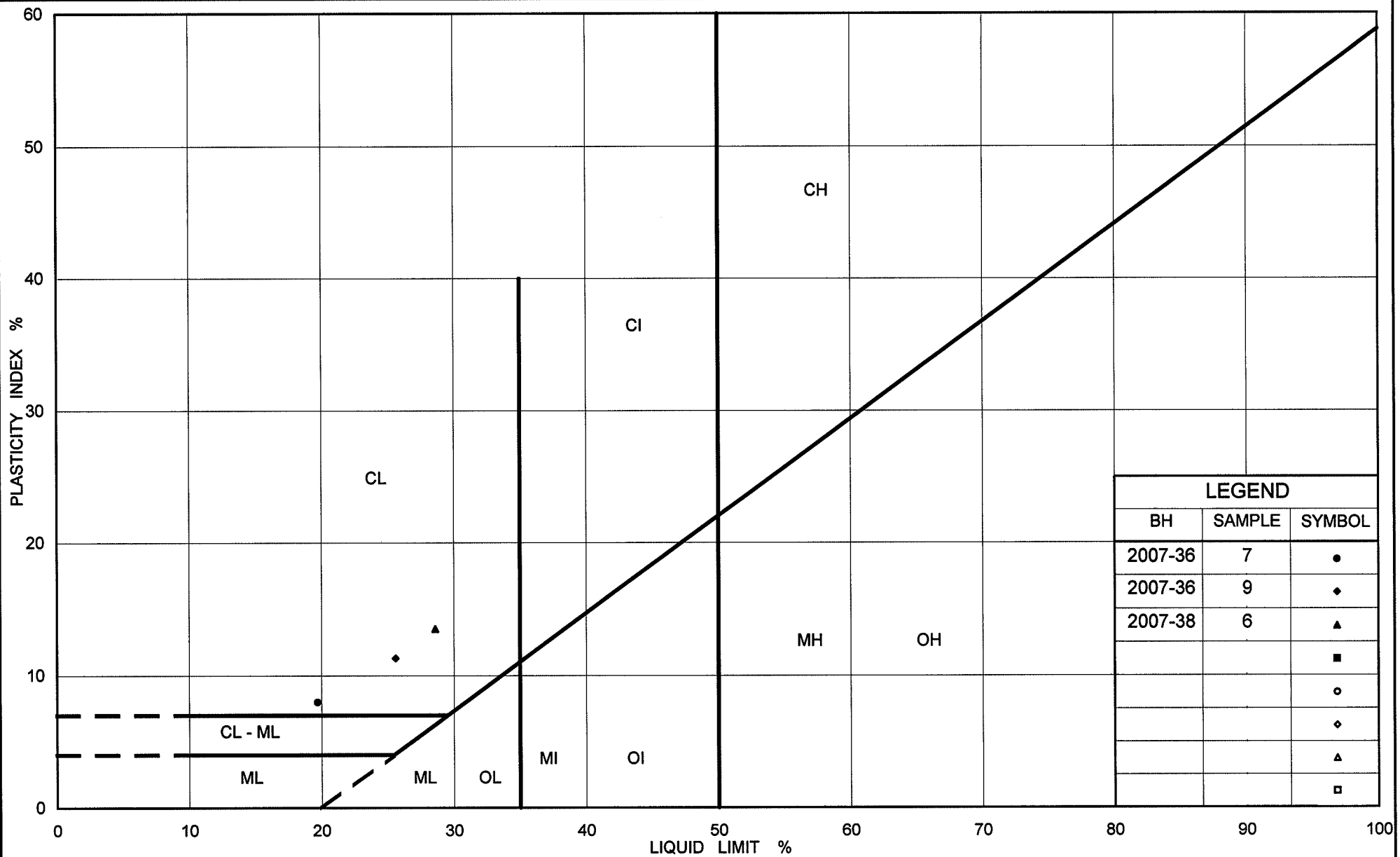
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	2007-36	9	270.3

Project Number: 06-1111-011

Checked By: *SM*

Golder Associates

Date: 17-Nov-08



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt Till

FIG No. A6

Project No. 06-1111-011

Checked By: *SM*

APPENDIX B
Special Provision
Draft Specification for Sewer Installation via Trenchless Technology

DRAFT SPECIFICATION FOR SEWER INSTALLATION VIA TRENCHLESS TECHNOLOGY

Special Provision

OPSS 415 (Construction Specification for Pipeline and Utility Installation by Tunnelling), OPSS 416 (Construction Specification for Pipeline and Utility Installation by Jacking and Boring) and OPSS 450 (Construction Specification for Pipeline and Utility Installation in Soil by Horizontal Directional Drilling) are deleted and replaced with the following:

1. Scope

This specification covers the general requirements for the installation of sewers by trenchless methods.

The Contractor shall determine the most appropriate method of installation. Specifications for Jack & Bore, Pipe Ramming, Directional Drilling, and Tunnelling are provided herein, and shall be applied to the installation method considered feasible by the Contractor.

2. REFERENCES

This specification refers to the following standards, specifications, or publications:

“Foundation Investigation Report, Sewer Crossings, Highway 400 SBL Between Highway 11 (Forbes Road) and Highway 93, Simcoe County, Ontario, G.W.P. 2168-06-00, by Golder Associates Ltd. Reference No. 06-1111-011-6.

Ontario Provincial Standard Specifications, General

OPSS 180 Management and Disposal of Excess Material

Ontario Provincial Standard Specifications, Construction

OPSS 504 Preservation, Protection, and Reconstruction of Existing Facilities
 OPSS 507 Site Restoration Following Installation of Pipelines, Utilities and
 Associated Structures in Open Cut
 OPSS 514 Trenching, Backfilling, and Compaction
 OPSS 517 Dewatering of Pipeline, Utility, and Associated Structure Excavation
 OPSS 538 Support Systems
 OPSS 539 Protection Schemes

Ontario Provincial Standard Specifications, Material

OPSS 1004 Aggregates - Miscellaneous
 OPSS 1350 Concrete - Materials and Production
 OPSS 1440 Steel Reinforcement for Concrete
 OPSS 1802 Smooth Walled Steel Pipe

MTO Specifications

Form 1820 Concrete Pipe
 Form 1840 Polyethylene Pipe
 SP 105S19 Construction Specification for Protection Systems

American Society for Testing and Materials (ASTM) International Standards

ASTM A252-93	Welding and Seamless Steel Pipe Piles
ASTM D2657-03	Standard Practice for Heat Fusion Joining of Polyelofin Pipe and Fittings
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM F894	Polyethylene Large Diameter Profile Wall Sewer and Drain Pipe

Canadian Standards Association Standards:

CSA B182.6	Profile Polyethylene Sewer Pipe and Fittings.
CAN/CSA A5-93	Portland Cement
CSA W59	Welded Steel Construction (Metal Arc Welding)

3. DEFINITIONS

For the purpose of this specification, the following definitions apply:

Auger Jack & Bore: a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead and rotating a cutter head, followed by removal of material from inside the bore by using an auger.

Backreamer: a cutting head suitably designed for the subsurface conditions that is attached to the end of a drill string to enlarge the pilot bore during a pullback operation.

Bore Path: a drilled path according to the grade and alignment tolerances specified in the Contract Documents.

Design Engineer: means the Engineer retained by the Contractor who produces the original design and working drawings. The design engineer shall be licensed to practice in the Province of Ontario.

Design Checking Engineer: means the Engineer retained by the Contractor who checks the original design and working drawings. The design checking engineer shall be licensed to practice in the Province of Ontario.

Digger Shield/Hand Mining: a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead while tunnelling advances using hand-mining (man-entry operation or “Jack and Mine) or a “digger” type shield with a hydraulic excavator arm to remove materials from inside the liner pipe.

Drilling Fluids: a mixture of water and additives, such as bentonite, polymers, surfactants, and soda ash, designed to block the pore space on a bore wall, reduce friction in the bore, and to suspend and carry cuttings to the surface.

Drilling Fluid Fracture or Frac Out: a condition where the drilling fluid’s pressure in the bore is sufficient to overcome the in situ confining stress, thereby fracturing the soil and/or rock materials and allowing the drilling fluids to migrate to the surface at an unplanned location.

Engineer: a Professional Engineer licensed by the Professional Engineers of Ontario to practice in the Province of Ontario.

Excavation: includes all materials encountered regardless of type and extent. Excavation shall include removal of natural soil, large boulders, cobbles, wood and fill regardless of means necessary to break consolidated materials for removal.

Environmentally Sensitive Area (ESA): areas adjacent to construction that are off limits to the Contractor as specified elsewhere in the Contract.

Fill: man-made mixture of previously placed/handled materials such as sand, clay, silt, gravel, broken rock, sometimes containing organic and/or deleterious materials, placed in an excavation or other area to raise the surface elevation.

Grouting: injection of grout into voids.

Guidance System: an electronic system capable of locating the position, depth and orientation of the drill head during the directional drilling process.

Directional Drilling (DD): directional boring or guided boring.

HDPE: high density polyethylene.

Inadvertent Returns: the flow of unexpected fluids, saturated materials (or running soil) towards the drilling rig that typically originated from an artesian aquifer encountered during the drilling process.

Loss of Circulation: the discontinuation of the flow of drilling fluid in the bore back to the entry or exit point or other planned recovery points.

Pilot Bore: the initial bore to set directional controlled horizontal and vertical alignment between the connecting points.

Pipe Jacking: a method for installing steel casing or concrete pipe in the subsurface utilizing hydraulically operated jacks of adequate number and capacity to ensure smooth and uniform advancement without overstressing the liner/pipe.

Pipe Ramming: a method for installing steel casings utilizing the energy from a percussion hammer to advance a steel casing with a cutting shoe attached at the front end of the casing.

Primary Liner (Support): system installed prior to or concurrent with excavation, to maintain stability of an excavation and to support earth or rock and any structure utilities or other facilities in or on the supported earth or rock mass, until the excavation is completed.

Product: pipelines, conduits, cable, or ducts.

Pullback: that part of the DD method in which the drill string is pulled back through the bore path to the entry point.

Quality Verification Engineer (QVE): an Engineer who has a minimum of five (5) years experience in the field of pipe installation using trenchless methods or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the contract. The Quality Verification Engineer

shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificate(s) of Conformance.

Reaming: a process for pulling a tool attached to the end of the drill string through the bore path to enlarge the bore and mix the cuttings with the drilling fluid. This typically includes multiple passes.

Rock: natural beds or massive fragments, or the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin, which may or may not be weathered and includes boulders having a size equivalent to 0.3 m in diameter or greater.

Secondary Liner: concrete pipe, HDPE pipe or un-reinforced cast-in-place concrete, installed subsequent to tunnel excavation.

Shaft: vertically sided excavation used as entry and/or exit points from which the trenchless method is initiated or directed for the installation of product.

Strike Alert: a system that is intended to alert and protect the operator in the case of inadvertent drilling into an electrical utility cable. The strike alert system consists of a sensor and an alarm connected to the drill rig and a grounding stake. The alarm may be audio or visual or both.

Slurry: a mixture of soil and/or rock cuttings, and drilling fluid.

Soil: all materials except those defined as rock, and excludes stone masonry, concrete, and other manufactured materials; includes rock fragments having an equivalent size less than 0.3 m in diameter.

Tunnelling: an underground method of constructing a passage open at both ends that involves installing a pipe. For the purpose of this specification, the pipe may be installed by any of the various methods defined above such as Auger Jack & Boring, Pipe Ramming, Directional Drilling or using hand mining methods

4. DESIGN AND SUBMISSION REQUIREMENTS

4.01 General

The Contractor's documentation, submission requirements and installation methods shall specifically consider and address the subsurface conditions at each sewer crossing as identified in the geotechnical information. The subsurface conditions at/along the various sewer crossing alignments are presented in "Foundation Investigation Report, Sewer Crossings, Highway 400 SBL Between Highway 11 (Forbes Road) and Highway 93, Simcoe County, Ontario, G.W.P. 2168-06-00, by Golder Associates Ltd. Reference No. 06-1111-011-6.

4.02 Working Drawings

Three copies of stamped working drawings for portal or shaft construction, primary liner, excavation, secondary lining, dewatering and groundwater control and grouting shall be submitted to the Contract Administrator (CA) at least one (1) week prior to the commencement of the work for information purposes. All submissions shall bear the seal and signature of the Design Engineer and Design Checking Engineer. The Contractor shall have a copy of the stamped working drawings at the site during construction.

As a minimum, working drawings/details pertaining to the tunnel design and construction shall include the following (as appropriate):

a) Plans, Elevations and Details:

- A work plan outlining the materials, procedures, methods and schedule to be used to execute the work;
- A list of personnel, including backup personnel, and their qualifications and experience;
- A safety plan including the company safety manual and emergency procedures;
- The work area layout;
- An erosion and sediment control plan that includes a contingency plan in the event the erosion and sediment control measures fail;
- A drilling fluid management plan, if applicable, that addresses control of frac-out pressures, any potential environmental impacts and includes a contingency plan detailing emergency procedures in the event that the fluid management plan fails;
- Lighting, ventilation and fire safety details as may be required by applicable occupational health and safety regulations; and
- Excavated materials disposal plan.

b) Design Criteria:

- Primary liner design details, if applicable; and
- Design assumption and material data when materials other than those specified are proposed for use.
- Drill path design, details of alignment and alignment control, maximum curvature and reaming stages;

c) Materials:

- Certification from the manufacturer that the product furnished on the contract meets the specifications cited in the manufacturer's product specification and that the materials supplied are suitable for the application; and
- Material mixture for filling voids and installation procedures.

d) Upstream/Downstream Portal Installation Procedure:

- The access shaft or entry/exit pit details designed and stamped/signed by the Design Engineer, as applicable; and
- Face support and other temporary support details, if applicable.

e) Primary Liner/Secondary Liner Installation and Grouting Procedure:

- Excavation and pipe jacking procedures, including methodology to handle obstructions and preventing soil cave-in.; and
- Details of tunnelling equipment/methods to be used for the works.

f) Excavation and Dewatering:

- Ground control/dewatering details, as applicable, describing the proposed method for control, handling, treatment, and disposal of water.

g) Monitoring Method

- The methods to be employed to monitor and maintain the alignment of the installation;

4.02 Site Survey

Prior to commencing the work, the Contractor shall, at each sewer pipe location, layout the alignment and install settlement monitoring points.

4.03 Certificate of Conformance

The Contractor shall submit details of the sequence and method of construction to the Quality Verification Engineer for review, prepared and stamped by the Design Engineer. The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate shall state that the construction procedures are in conformance with the requirements and specifications of the contract documents.

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer upon completion of each of the following operations and prior to commencement of each subsequent operation for each sewer installation:

- Site Surveying (as noted in Section 4.02)
- Excavation for pits including dewatering of excavation
- Jacking/Ramming/Directional Drilling of Casing/Liner
- Excavation and Dewatering
- Installation of Sewer
- Grouting Operations

Each Certificate of Conformance shall state that the work has been carried out in general conformance with the contract documents, specifications and/or stamped working drawings.

In addition, upon completion of the installation of the sewer pipe at each location, the Contractor shall submit to the Contract Administrator a **final** Certificate of Conformance sealed and signed by the Quality Verification Engineer. The Certificate shall state that the sewer pipe has been installed in general conformance with the Contractor's Submission and Design Requirements, stamped working drawings and contract documents.

The Design Engineer will not be permitted to carry out the work of the Quality Verification Engineer.

5. MATERIALS

5.01 Sewer Pipe

The sewer pipes shall be concrete pipe or high density polyethylene pipe as specified.

5.02 Concrete

Concrete shall be according to OPSS 1350. The concrete strength shall be as specified in the Contractor's design submission.

5.03 Concrete Reinforcement

Steel reinforcing for concrete work shall be according to OPSS 1440.

5.04 Timber

Timber shall be sound, straight, and free from cracks, shakes and large or loose knots.

5.05 Grout

The Contractor shall submit the proposed grout mix design for grouts to be used for lubricating jacking pipe and for filling of voids and annular spaces. Parging grout shall consist of a mixture of one part Portland cement conforming to the requirements of CAN/CSA A5-93 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.

5.06 Auger Jack & Bore Materials

5.06.01 Pipe Materials

Steel pipe shall conform with ASTM A252-95 welded joints suitable for jacking operations. The Contractor shall select pipe class for pipe jacking.

Concrete pipe as per MTO Form 1820.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

5.07 Pipe Ramming Materials

5.07.01 Pipe Materials

Steel pipe shall conform with ASTM A 252-93 welded joints.

New steel casing when specified shall be smooth wall carbon steel pipe according to ASTM A252-93 Grade 2.

Used steel casing can be used provided that the steel casing can resist the applicable static and dynamic loadings.

Pipe wall thickness shall be determined by the Contractor based on static and dynamic loads from traffic loading and anticipated ramming forces for selected pipe and driven pipe lengths. The wall thickness shall be increased as required to ensure the casing is not damaged during handling and installation. A minimum wall thickness of 50 mm and minimum yield strength of 240 MPa is required.

Pipe segments shall be determined by the Contractor.

Steel pipe joints shall be pressure fit type or welded.

All steel casing pipe shall be square cut.

Steel casing pipe shall have roundness such that the difference between the major and minor outside diameters shall not exceed 1% of the specified nominal outside diameter or 6 mm, whichever is less.

Steel casing pipe shall have a minimum allowable straightness of 1.5 mm maximum per metre of length.

5.07.02 Mill Certificates

For permanent casing, the Contractor shall submit to the Contract Administrator at the time of delivery one copy of the mill certificate, indicating that the steel meets the requirements for the appropriate standards for casings.

Where mill test certificates originate from a mill outside Canada or the United States of America the Contractor shall have the information on the mill certificate verified by testing by a Canadian laboratory. The laboratory shall be accredited by a Canadian National Accreditation Body to comply with the requirements of ISO/IEC Guide 25 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date and the signature of an authorized officer of the Canadian testing laboratory.

5.08 Directional Drilling Materials

5.08.01 Drilling Fluids

The drilling fluids shall be mixed according to the manufacturer's recommendations and be appropriate for the anticipated subsurface conditions.

5.08.02 Pipe Materials

High Density Polyethylene (HDPE) pipe as per MTO Form 1840 shall be used in accordance with ASTM D3350.

The requirements for fittings shall be suitable for and compatible with the class and type of pipe with which they will be used and in according to CAN/CSA-B182.6 or ASTM F894.

The Contractor shall determine the required dimensional ratio (DR) of the HDPE pipe to support all subsurface conditions and hydrostatic pressures, and to withstand the grouting pressure and installation forces. The Contractor shall identify these forces in his submission requirements.

The Contractor's submission shall demonstrate, in conjunction with the manufacturer's specifications, that the heat resistance of the pipe material is sufficient to tolerate without damage the heat of hydration generated by grout curing.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

Jointing of HDPE piping shall be completed by thermal butt fusion in accordance with manufacturer's recommended procedures and as outlined in the latest revision of ASTM D2657. All manufacturer's recommendations and procedures shall be followed during the jointing process.

Jointing of HDPE piping to other piping materials or appurtenances shall be completed using flanged connections.

5.09 Tunnelling Materials

5.09.01 Primary Liner

Tunnelling methods will require installation of a primary liner. The primary liner shall be designed by the Contractor and the design/drawings shall be stamped/signed by the Design Engineer. The design shall be submitted to the Contract Administrator as specified herein.

5.09.02 Secondary Liner

Concrete or High Density Polyethylene Pipe shall be used according to the following requirements.

5.09.02.01 Concrete Pipe

Concrete pipe as per MTO Form 1820 shall be used. The Contractor shall select the pipe class to withstand grouting pressure and installation forces. The Contractor shall identify these forces in his submission requirements.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

5.09.02.02 High Density Polyethylene (HDPE)

High Density Polyethylene (HDPE) pipe as per MTO Form 1840 shall be used in accordance with ASTM D3350.

The requirements for fittings shall be according to CAN/CSA-B182.6 or ASTM F894.

The Contractor shall determine the required dimensional ratio (DR) to withstand the grouting pressure and installation forces. The Contractor shall identify these forces in his submission requirements.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

Joining of HDPE piping shall be completed by thermal butt fusion in accordance with manufacturer's recommended procedures and as outlined in the latest revision of ASTM D2657. All manufacturer's recommendations and procedures shall be followed during the joining process.

Joining of HDPE piping to other piping materials shall be completed using flanged connections.

6. EQUIPMENT

6.01 Auger Jack & Bore Equipment

Pipe auger jack & bore equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.02 Pipe Ramming Equipment

Pipe ramming equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

The pipe ramming hammer(s) shall be capable of driving the pipe casing from the drive pit through the existing subsurface conditions at the site.

Specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the pipe shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.03 Directional Drilling Equipment

6.03.01 General

The directional drilling equipment shall consist of a directional drilling rig and a drilling fluid mixing and delivery system of sufficient capacity to successfully complete the product installation without exceeding the maximum tensile strength of the product being installed.

6.03.02 Drilling Rig

The directional drilling rig shall:

- consist of a leak free hydraulically powered boring system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head;
- contain a guidance system to accurately guide boring operations;
- be anchored to the ground to withstand the rotating, pushing, and pulling forces required to complete the product installation; and
- be grounded during all operations unless otherwise specified by the drilling rig manufacturer.

6.03.03 Drill Head

The drill head shall be steerable by changing its rotation, be equipped with the necessary cutting surfaces and drilling fluid jets, and be of the type for the anticipated subsurface conditions,

6.03.04 Guidance System

The guidance system shall be setup, installed, and operated by trained and experienced personnel. The operator shall be aware of any magnetic or electromagnetic anomalies and shall consider such influences in the operation of the guidance system when a magnetic or electromagnetic system is used.

6.03.05 Drilling Fluid Mixing System

The drilling fluid mixing system shall be of sufficient size to thoroughly and uniformly mix the required drilling fluid.

6.03.06 Drilling Fluid Delivery System

The delivery system shall have a means of measuring and controlling fluid pressures and be of sufficient flow capacity to ensure that all slurry volumes are adequate for the length and diameter of the final bore and the anticipated subsurface conditions. Connections between the delivery pump and drill pipe shall be leak-free.

6.04 Tunnelling Equipment

Tunnelling equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the tunnel face shall be submitted to the Contract Administrator information purposes. Use of explosives or rock fracturing chemicals shall only be considered subject to a field demonstration satisfactory to the Ministry prior to its use.

7. CONSTRUCTION

7.01 General

The Contractor shall notify the Contract Administrator at least 48 hours in advance of starting work. The proposed method of sewer pipe installation to be used by the Contractor shall be submitted to the Contract Administrator for information purposes prior to commencing the work and shall be subject to the limitations presented in the following subsections.

7.01.01 Layout, Alignment and Depth Control

The location of the installation shall be established from the lines, elevations and tolerances specified in the Contract Documents. The sewer pipe installation shall be to the horizontal and vertical alignments specified in the Contract Drawings. Deviations from location, alignment, grades and/or invert levels shall be corrected by the Contractor at no cost to the Ministry.

All reference points necessary to construct the sewer pipe installation and appurtenances shall be laid out.

The Contractor shall calibrate tracking and locating equipment at the beginning of each work day, and shall monitor and record the alignment and depth readings provided by the tracking system at every 5 m in normal conditions and every 2 m where precise alignment control is necessary;

The Contract Administrator shall be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

All excavations shall be carried out in accordance with the Occupational Health and Safety Act (OHSA) of Ontario.

For directional drilling, the contractor shall ensure that during pilot hole drilling the maximum degree of deviation or “dog-leg” shall be 2.5 degrees per 9m drill pipe length. Any deviation exceeding 2.5 degrees will necessitate a pull-back and straightening of the alignment at the Contractor’s sole expense. The pilot hole exit location shall be within 0.5m of the target location.

7.01.02 Construction Shafts

Construction shafts shall be specified in the Contractor's submission. The boundaries and protection of these shall be as required to contain all disturbances to areas outside of the ESA limits.

Shafts shall be maintained in a drained condition.

A minimum 2.4 m high secure fence shall be installed around the perimeter of the construction shaft area with gates and truck entrances. The fence shall be removed on completion of the work.

7.01.03 Protection Schemes

The construction of all protection schemes shall be according to OPSS 539. Where the stability, safety, or function of an existing roadway, watercourse, other works, proposed works or ESA's may be impaired due to the method of operation, protection shall be provided. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works.

7.01.04 Settlement or Heave

Any disturbance to the ground surface (settlement or heave) as a result of the pipe installation shall be immediately corrected by the Contractor, at no additional cost to the Ministry.

7.01.05 Stability of Excavation

The construction methods, plant, procedures, and precautions employed shall ensure that excavations are stable, free from disturbance, and maintained in a drained condition.

The construction methods, plant, and materials employed shall prevent the migration of soil and/or rock material into the excavation from adjacent ground.

7.01.06 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 504.

Minimum horizontal and vertical clearances to existing facilities as specified in the Contract Documents shall be maintained. Clearances shall be measured from the nearest edge of the largest cut diameter required to the nearest edge of the facility being paralleled or crossed.

Existing underground facilities shall be exposed to verify its horizontal and vertical locations when the outlet sewer pipe path comes within 1.0 m horizontally or vertically of the existing facility. Existing facilities shall be exposed by non-destructive methods. The number of exposures required to monitor work progress shall be as specified in the Contract Documents.

7.01.07 Transporting, Unloading, Storing and Handling Materials

Manufacturer's handling and storage recommendations shall be followed.

7.01.08 Trenching, Backfilling and Compacting

Trenching, backfilling, and compacting for entry and exit points or other locations along the sewer pipe path shall be according to OPSS 514.

7.01.09 Support Systems

Support systems shall be according to OPSS 538.

If any open excavation will encroach into the highway embankment the protection system shall satisfy the requirements for Performance Level 2 as specified in SP105S19.

7.01.10 Dewatering

The work of this Section includes control, handling, treatment, and disposal of groundwater. The Contractor shall review the foundation investigation report for reference to soil and groundwater conditions on the project site and plan a dewatering scheme accordingly.

The Contractor shall control groundwater inflows to excavations to maintain stability of surrounding ground, to prevent erosion of soil, to prevent softening of ground exposed in the excavation, and to avoid interfering with execution of the work.

The Contractor shall maintain excavations free of standing water at all times during excavation, including while concrete is curing.

Should water enter the excavation in amounts that could adversely affect the performance of the work or could cause loss of ground, the Contractor shall take immediate steps to control the inflow.

The Contractor is alerted that seepage zones of perched water within the fill materials should be expected, particularly where granular materials are excavated.

Dewatering shall be according to OPSS 517.

7.01.11 Removal of Boulders

The Contractor is alerted that cobbles and boulders should be anticipated in the soil deposits at the site. Accordingly, the Contractor shall address the removal of cobbles and boulders in the proposed method of construction. The Contractor shall immediately inform the Contract Administrator of any obstruction encountered.

7.01.12 Record Keeping

Verification record requirements of the alignment and depth of the installation shall be as specified in the Contract Documents. A copy of the verification records shall be given to the Contract Administrator at the completion of the installation.

7.01.13 Testing

Testing of the product installation shall consist of verifying the specified grade between the two ends of the sewer pipe and passing of water from the median end of the pipe to the outlet end to confirm gravity flow conditions.

7.01.14 Management and Disposal of Excess Material

Management and disposal of excess material shall be according to OPSS 180. Satisfactory re-usable excavated material required for backfill shall be separated from unsuitable excavated material.

7.01.15 Site Restoration

Site restoration shall be according to OPSS 507.

7.01.16 Supervision

A qualified individual, who is experienced in the construction of sewer pipe installation by trenchless methods shall supervise the work at all times.

7.02 Auger Jack & Bore Installation

7.02.01 Method of Installation Procedure

The installation procedure to be used shall be subject to the following limitations:

- Hydraulically operated jacks of adequate number and capacity shall be provided to ensure smooth and uniform advancement without over-stressing of the pipe.
- A suitably padded jacking head or collar shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.
- The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.
- Selection of the excavation method and jacking equipment shall take into consideration the conditions at each sewer crossing.

7.02.02 Pipe Installation

Concrete pipe joints shall be water tight and according to OPSS 1820 and must withstand jacking forces, determined by the Contractor.

During the jacking of the liner the space between the liner and the wall of the excavation shall be kept filled with bentonite slurry. Upon completion of jacking, the space between the liner and the wall of the excavation shall be filled with grout.

The annular space between the liner and the product shall be fully grouted with a water tight, expandable and stable grout.

7.03 Pipe Ramming Installation

For pipe ramming installation the following requirements apply:

Only smooth walled steel pipe shall be used. But welding of pipe joints shall conform to CAS W59.

Ramming equipment of adequate capacity shall be provided to ensure smooth and uniform advancement without overstressing of the pipe. Delays shall be avoided between ramming operations.

A ramming head shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.

Two or more lubricated guide rails or sills shall be provided of sufficient length to fully support the pipe at the specified line and grade in the ramming pit. Pipe shall be installed to the line and grade specified.

Following installation of the pipe, all material shall be removed from the pipe to the satisfaction of the Contract Administrator. Any voids remaining between the pipe and the excavation wall shall be grouted as soon as the pipe is rammed. The annular space between the liner pipe and the product shall be fully grouted with a water tight, expandable and stable grout.

7.04 Directional Drilling Installation

7.04.01 General

When strike alerts are provided on a drilling rig, they shall be activated during drilling and maintained at all times.

7.04.02 Site Preparation

The work site shall be graded or filled to provide a level working area for the drilling rig. No alterations beyond what is required for DD operations are to be made. All activities shall be confined to designated work areas.

7.04.03 Pilot Bore

The pilot bore shall be drilled along the bore path in accordance with the grade, alignment, and tolerances as indicated on the Contractor's submitted drilling plan to ensure that the product is installed to the line and grade shown on the Contract Drawings. The Contractor's methods shall take into consideration the conditions at each sewer crossing within the pipe alignment and shall be suitable to advance through such obstructions such as cobbles and boulders and address the potential for deflection off these obstruction and/or soil conditions.

In the event the pilot bore deviates from the submitted path, the Contract Administrator shall be notified. The Contract Administrator may require the Contractor to pullback and re-drill from the location along the bore path before the deviation.

In the event that a drilling fluid fracture, inadvertent returns, or loss of circulation occurs during pilot bore drilling operations, the Contract Administrator shall be advised of the event and action shall be taken in accordance with the Contractor's submitted contingency plan.

At the entry and exit points, there is potential for ravelling of the existing soil, fill and or weathered rock areas along the alignment. This is conventionally addressed by the use of drilling fluid. However, casing may be required. The Contractor's methods shall take into consideration the potential need to install sections of casing to manage ravelling at or near ground surface.

If a drill hole beneath the highway must be abandoned, the hole shall be backfilled with grout or bentonite to prevent future subsidence.

The Contractor shall maintain drilling fluid pressure and circulation throughout the DD process, including during the initial pilot bore and during the reaming process.

The Contractor shall at all times and for the entire length of the installation alignment be able to demonstrate the horizontal and vertical position of the alignment, the fluid volume used, return rates and pressures.

7.04.04 Drilling Fluid Fracture (Frac-Out)

In order to reduce the potential for hydraulic fracturing of the hole during directional drilling, a minimum depth of cover of 5m is normally maintained between the pipe and the ground surface. Sections of the pipe close to the exit pit with less than 5m cover shall be cased. The Contractor shall ensure that drilling fluid pressures are properly set and controlled to prevent frac-out, for the depth of cover available between the bottom of the pavement structure (bottom of the subbase material) and the top of the bore.

Since fluid loss normally occurs in fault zones, fracture zones, or seams of coarse material, fluid migration does not always gravitate to the surface, thus making detection difficult. Once a fluid loss is detected, the Contractor shall halt operations immediately and conduct a detailed examination of the drill path and implement measures to mitigate fluid loss. If no surface migration is evident, resume operation while paying particular attention to fluid monitoring.

In the event of a fluid migration to the surface occurring, the Contractor shall halt all operations immediately, isolate the migration site, and recover fluids. Once the fracture is controlled, continue drilling operations with the operator paying particular attention to the fracture points

7.04.05 Reaming

The bore shall be reamed using the appropriate tools to a diameter at least 50% greater than the outside diameter of the product.

7.04.06 Product Installation

7.04.06.01 General

The product shall be jointed according to manufacturer's recommendations. The length of the product to be pulled shall be jointed as one length before commencement of the continuous pulling operation.

The product shall be protected from damage during the pullback operation.

The minimum allowable bending radius for the product shall not be exceeded.

Product shall be allowed to recover before connections to new or existing facility are made. Product recovery time shall be according to manufacturers recommendations.

7.04.06.02 Pullback and Grouting

After successfully reaming the bore to the required diameter, the product shall be pulled through the bore path. Once the pullback operation has commenced, it shall continue without interruption until the product is completely pulled into bore unless otherwise approved by the Contract Administrator.

A swivel shall be used between the reamer and the product being installed to prevent rotational forces from being transferred to the product. When specified in the Contract Documents, a weak link or breakaway connector shall be used to prevent excess pulling force from damaging the product.

The product shall be inspected for damage where visible at excavation pits and where it exits the bore. Any damage noted shall be rectified to the satisfaction of the Contract Administrator,

The pull back and reaming operations shall not exceed the fluid circulation rate capabilities. Reaming and back pulling operations shall be planned to insure that, once started, all reaming and back pulling operations are completed without stopping and within the permitted work hours.

The space between the pipe and the excavation walls shall be filled with grout.

7.05 Tunnelling Installation

7.05.01 General

The method of tunnelling shall be selected by the Contractor and shall be submitted to the Contract Administrator prior to commencement of the work for information purposes.

Excavation of native soil and fill shall be done in a manner to control groundwater inflow to the excavation and to prevent loss of ground into the excavation.

Methods of excavating the tunnel shall be capable of fully supporting the face and shall accommodate the removal of boulders and other oversize objects from the face. Continuous ground support shall be maintained during excavation.

As the excavation progresses, the Contractor shall continuously monitor (every 2m) indications of support distress, such as cracking, deflection or failure of support system and subsidence of ground near the excavation.

The Contractor shall advance the ventilation system as a regular part of the normal excavation cycle.

The Contractor shall provide lighting in accordance with OSHA requirements for the entire length of the tunnel.

The tunnel is to be kept sufficiently dry at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor shall maintain clean working conditions at all times in tunnels.

In the event that excavation threatens to endanger personnel, the Work, or adjacent property, the Contractor shall cease excavation. The Contractor shall then evaluate methods of construction and revise as necessary to ensure the safe continuation of the work.

The Contractor shall maintain tunnel excavation line and grade to provide for construction of final lining within specified tolerances.

7.05.01 Tunnelling Method

The tunnelling method shall be suitable to provide face support in changing ground conditions that may be encountered during the progress of the work. The selection of the tunnelling method should consider the soil conditions at each sewer crossing and the presence of obstructions, such as cobbles and boulders, with respect to the tunnel alignment.

7.05.02 Primary Liner (Support System)

Primary support systems shall prevent deterioration, loosening, or unravelling of ground surfaces exposed by excavation.

The primary liner support system shall be designed and installed to achieve the intended performance requirements.

Primary liner support system shall maintain the safety of personnel, minimize ground movement into the excavation, ensure stability and maintain strength of ground surrounding the excavation.

The primary liner shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting, and shall ensure that no ground loading or other loading will be placed on the new work until after design strength has been reached.

The primary liner shall be installed so that the exterior is as tight as possible to the excavated surface of the tunnel and allows the placement of the full design thickness of the secondary lining.

Primary support systems shall be compatible with the encountered ground conditions, with the method of excavation, with methods for control of water, and with placement of the permanent lining.

All voids between the primary lining and the surface of the excavation shall be filled with cement grout. If an unexpanded liner is used, the space outside the liner plates shall be grouted at least daily.

7.05.03 Secondary Liner

7.05.03.01 Placing of Grout

The void outside the finished secondary liner shall be filled with cement grout according to the Contractor's submission.

Grout shall not be placed until the lining has achieved 85% of its specified strength or 30 MPa. Grouting shall be limited to such sequences and programs as are necessary to avoid damaging any part of the works or any other structure or property.

7.06 Instrumentation Monitoring

The work specified in this Section includes furnishing and installing instruments for monitoring of settlement and ground stability.

Surface settlement markers for monitoring ground stability shall be installed at the pavement/ground surface level on the shoulder, side slope and pavement at not greater than 5 m intervals along the tunnel alignment and as an array of three in ground (1.5 m depth) measurement points on the shoulder of the highway perpendicular to the alignment. The equipment and procedures used for settlement monitoring during construction must be capable of surveying the settlement point elevations to within ± 1 mm of the actual elevation.

Surface settlement markers shall be hardened steel markers treated or coated to resist corrosion, with an exposed convex head having a minimum diameter of 12 mm and similar to surveyor's PK nails. Markers shall be rigidly affixed so as not to move relative to the surface to which it is attached. Traffic shall be

managed by the contractor using short term lane closures in accordance with the Ontario Traffic Manual (OTM).

In general, settlement monitoring points shall be 12-18 mm rebar encased in a 50-70 mm, SCH40 PVC pipe, set to a depth of 1.5 m below ground surface. The assembly shall be placed in a drill hole and backfilled with uniform sand as shown on the Contract Drawings.

The Contractor shall install all surface settlement instruments a minimum of one week prior to the start of works.

The surface settlement instruments shall be clearly labelled for easy identification.

The Contractor shall submit to the Contract Administrator a site plan showing the locations of the monitoring points, a geodetic survey of the settlement monitoring points including station, offset and elevation recorded at the following time intervals:

- Three consecutive readings at least one week prior to commencement of the work (Baseline Reading);
- Two times per shift during tunnelling operations period; and
- Weekly after completion of the work for one month, or until such time at which all parties agree that further movement has stopped.

All readings shall be submitted to the Contract Administrative for information purposes on a weekly basis. Each report shall include all survey data collected in tabular and graphical format as plots of time versus settlement in comparison to survey data collected prior to commencement of the work.

7.07 Criteria for Assessment of Roadway Subsidence/Heave

Based on the monitoring of ground movement as specified in Subsection 4.02, the following represents trigger levels that define magnitude of movement and corresponding action:

- Review Level: If a maximum value of 10 mm relative to the baseline readings is reached, the Contractor shall review or modify the method, rate of sequence of construction or ground stabilization measures to mitigate further ground displacement.

If the Review Level is exceeded, the Contractor shall immediately notify the CA and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert Levels from being reached. All construction work shall be continued such that the Alert Level is not reached.

- Alert Level: If a maximum value of 15 mm relative to the baseline readings is reached, the Contractor shall cease construction operations, inform the Contract Administrator and execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public and maintain traffic.

No construction shall take place until all the following conditions are satisfied:

- The cause of the settlement has been identified.
- The Contractor submits a corrective/preventive plan.

- Any corrective and/or preventive measure deemed necessary by the Contractor is implemented.
- The CA deems it is safe to proceed.

The Contractor shall avoid damaging instrumentation during construction. Instrumentation that is damaged as a result of the Contractor's operation shall be repaired or replaced by the Contractor within one business day. The costs for replacement/repair shall be borne by the Contractor.

At the completion of the job, the Contractor shall abandon all instrumentations installed during the course of the Work.

9. MEASUREMENT FOR PAYMENT

Measurement shall be by Plan Quantity Payment as may be revised by Adjusted Plan Quantity Payment in metres, following along the centre line of the sewer pipes from centre to centre of maintenance holes or chambers (catch basins) or from/to the end of the pipe where no maintenance hole or chamber is installed, of the actual length of sewer installed by trenchless methods.

10. BASIS OF PAYMENT

Payment at the contract price shall be full compensation for providing all labour, equipment and materials required for excavation (regardless of material encountered), dewatering, sheathing and shoring, supply and installation of primary liners, supply and installation of the sewers, site restoration and for all other work necessary to complete the sewer as specified.

Where a protection system is made necessary because of the Contractor's operations (e.g. choice of trenchless installation method), the cost shall be included in this item and shall be full compensation for all labour, equipment and materials required to carry out the work including subsequently removing the temporary protection system and performing any necessary restoration work.

Payment for connecting intercepted drains and service connections into the sewer system shall be made on the following basis:

- (a) Where such drains and service connections are shown on the contract drawings the cost of connections shall be included in the contract price for installation of sewers.
- (b) Where such drains and service connections are not shown on the contract drawings, the cost of connections will be considered an allowable extra to the contract.

Payment for removal of boulders/obstructions greater than an equivalent 0.3 m in diameter shall be on a time and materials basis. The Contractor shall inform the Contract Administrator when boulders/obstructions are encountered and prior to removal to allow for proper and accurate tracking of time and material charges.

APPENDIX C
Guidelines for Foundation Engineering - Tunelling
Speciality for Corridor Encroachment Permit Application

Guidelines For Foundation Engineering – Tunnelling Specialty For Corridor Encroachment Permit Application

These guidelines specify MTO's minimum requirements for the Foundation Engineering – Tunnelling Specialty component of submissions from proponents of development within the Ministry of Transportation's (MTO) corridor permit control area. The Foundation Engineering – Tunnelling Specialty component of submissions is a requirement for the permit application only and do not cover all the design requirements.

The complexity ratings of Foundations Engineering services are defined in Table 1.

Table 1: Complexity ratings for tunnelling specialty services

Highway Classification	Tunnel Excavation Diameter (ϕ)					
	≤ 1 m		>1 m & ≤ 2 m		>2 m	
	Minimum Overburden Cover * (m)					
	≥ 3 ϕ (or 1.5 m whichever is greater)	< 3 ϕ (or 1.5 m whichever is greater)	≥ 3 ϕ	< 3 ϕ (or 1.5 m whichever is greater)	≥ 3 ϕ	< 3 ϕ (or 1.5 m whichever is greater)
Kings Highway	Low	Medium	Medium	High	High	High
400 Series Freeway	Medium	High	High	High	High	High

*Minimum overburden cover is the vertical distance measured from the lowest ground elevation to the crown of the tunnel.

Foundations Engineering consultants that are registered in the MTO consultant acquisition system (RAQS) at complexity ratings identified in Table 1 are eligible to provide Foundations Engineering services for this project. Alternatively, the proponents may propose a Foundations Engineering consultant that is not registered in RAQS, in which case, the proponent must submit sufficient documentation to demonstrate that the consultant's qualifications meet or exceed the RAQS complexity requirements.

For Engineering Materials Testing and Evaluation, the consultant shall be qualified for Soil and Rock testing of complexity level at least equal to that identified for this project.

Consultant services shall be provided in accordance with the most recent editions of the Canadian Highway Bridge Design Code (CHBDC), and the 'Guideline for Professional Engineers Providing Geotechnical Engineering Services' published by the Professional Engineers of Ontario.

The designated principal contact identified for Foundations Engineering services by MTO shall sign, and where required, seal, all submissions and correspondence that are submitted to MTO.

Services include, but are not restricted to, conducting a site investigation that shall be of sufficient scope to verify design assumptions and to provide the contractor with adequate subsurface information for design and construction planning.

Sufficient subsurface (factual) information is required to determine the vertical and horizontal extent of subsurface materials (including both soil and rock) and their pertinent engineering properties and groundwater conditions.

Subsurface information is usually acquired by advancing boreholes, laboratory testing of soil samples and rock core samples, performing in-situ tests such as standard penetration tests, dynamic cone tests, and piezocone tests (CPTU) and test pits.

Minimum requirements for Subsurface Investigation and Recommendations

A minimum of one borehole shall be advanced at each end of tunnel crossing. The boreholes shall be located outside but within 2 m of the tunnel's excavated footprint.

Spacing between the boreholes shall not exceed 50 m. In case of larger spacing between the boreholes, additional boreholes shall be advanced except where significant traffic disruptions might occur and where consistent conditions are evident.

Boreholes shall be advanced to 3 tunnel diameters (excavated diameters) below invert. If bedrock is encountered earlier, the borehole shall advance to at least 3 m below the invert of tunnel into the bedrock.

The investigations, if required, shall be supplemented with additional and deeper boreholes to verify consistent conditions and existence of boulders within critical foundation zones.

Sampling and testing, consisting of Standard Penetration Test, thin wall tube sample, rock cores, and MTO Field Vane Test where appropriate, shall be conducted to develop a comprehensive subsurface model. Semi-continuous sampling at 0.75m (2.5ft) intervals is required within overburden; whereas, sampling interval of 1.5m (5.0ft) is required below the tunnel invert.

Where encountered, the bedrock-soil interface shall be determined by geological definition and not the by the material properties.

All aspects of implementation of means of subsurface investigations including, but not limited to, planning, licensing, construction, maintenance, abandonment, and reporting, shall be in accordance with Ministry of the Environment Regulation 903 and its amendments (the water well regulation under the OWRA).

Boreholes and piezometer tubes shall be backfilled with a suitable bentonite/cement mixture. Test pits shall be backfilled with suitable material and either re-vegetated or otherwise protected from erosion. Temporary open holes shall be adequately covered.

Holes in roads shall be backfilled as required to prevent future settlement and acceptably patched where pavement surfaces have been damaged. Backfilling requirements shall be described in the Foundation Investigation and Design Report.

Where encountered, artesian groundwater conditions shall be sealed. Details of the artesian condition and the sealing operation shall be included in the Foundation Investigation Report.

Fieldwork shall be carried out in accordance with the Occupational Health and Safety Act.

Traffic protection in accordance with MTO requirements shall be provided during the course of any field investigations. However, where significant traffic disruptions might occur, boreholes may be relocated or numbers reduced with MTO's approval.

The locations and ground surface elevations of all boreholes, test pits and soundings shall be surveyed and referred to fixed reference points and data. Locations are to be identified by co-ordinates (Northing and Easting). The vertical accuracy of survey readings shall be within 0.1m; whereas, horizontal accuracy shall be within 0.5m.

Minimum Laboratory Testing Requirements:

Laboratory testing shall consist of routine testing of 25% of samples. One routine lab test is defined as natural water content plus Atterberg Limit plus grain size distribution tests. Complex laboratory testing is defined by all other tests including compressive strength, shear strength, consolidation, permeability and triaxial testing. Laboratory testing requirements shall be supplemented with additional routine and complex tests if required to verify strata boundaries and properties and behaviour of critical subsurface zones.

Borehole Log Preparation and Foundation Drawing:

Borehole log sheets, figures and drawings shall be prepared in accordance with MTO standards. The Foundation Drawing shall consist of a plan showing the locations of all borings, test pits and soundings and various stratigraphical longitudinal profiles and stratigraphical cross-sections at each tunnel structure foundation element and groundwater levels.

Minimum Requirements for the Foundation Investigation and Design Report:

A Foundation Investigation and Design Report shall consist of the factual subsurface information (including the field and laboratory test information) and the recommendations required for foundation design.

The report shall be signed and sealed by two professional engineers, registered with the Professional Engineers of Ontario, representing the consulting firm; one of them shall be the firm's designated principal contact for MTO's Foundations Engineering projects.

- The Foundation Investigation component of the report shall contain:
- Site Description - including topography, vegetation, drainage, existing land use, and structures.
- Investigation Procedures - including site investigation and lab testing procedures.
- Description of Subsurface Conditions - including soil, boulders, rock and groundwater conditions.
- Miscellaneous Section - that identifies the name of the drilling company, the laboratory where testing was performed, the persons who carried out the field supervision, and those who wrote and reviewed the report.

The Foundation Design component of the report shall present discussion and recommendations for design. The consultant shall analyse field data and test results and make comprehensive and practical recommendations pertaining to temporary, interim and permanent conditions at the Project.

The consultant shall identify and evaluate all reasonable and appropriate alternatives for the proposed tunnel crossing. Alternatives may include, but not limited to, jack & bore, pipe jacking using TBM, pipe ramming, micro-tunnelling (if economically feasible), utility tunnelling using TBM (two pass system), Horizontal Directional Drilling (HDD) and cut and cover methods.

The consultant shall identify and present overview assessments of the advantages, disadvantages, costs and risks/consequences of alternative tunnelling methods in a table. The report should conclude a preferred alternative from foundation engineering and cost effectiveness perspective.

In the development and design of the preferred alternative, the Consultant shall, as applicable, address:

- impacts on the land use and property, traffic and transportation, and environment,
- length and diameter constraints
- control of face stability
- capability of boulder excavation
- evaluation of temporary and permanent support
- alignment control
- estimated settlements and heave and management of these deformations
- special access and egress requirements for TBM's and other similar equipment such as those used for the Jack & Bore method including recommendations for vertical shafts and jacking pits;
- shored and un-shored alternatives for open-cut excavation;
- groundwater control & dewatering;
- the long-term stability of the tunnel;

- relative costs; and
- traffic management and contractor access for each alternative.

If borehole logs available from previous projects are included to meet the requirements of field investigations then the accuracy of subsurface information from these boreholes remains the responsibility of consultant except in situations where MTO specify the use of previous boreholes. Borehole logs from previous studies that are appended to the report shall be reformatted to meet the MTO's requirements.

The final foundation recommendations shall detail the geometric, material and strength properties of the new tunnel crossing plus the liner, bedding and backfill requirements, and slope and embankment restoration requirements. The invert elevation should be assessed in view of the subsurface conditions and the anticipated open face stability control.

The consultant is responsible for developing contract documents sufficient to implement the design. This typically includes:

- Contract specifications for materials and specialized construction activities, and
- Recommendations for methods of overcoming anticipated construction problems, in particular, those relating to dewatering, boulder excavation, alignment control and the stability of excavations and embankments.

The consultant shall develop a detailed instrumentation and monitoring program that meets the requirements of these guidelines. (see Appendix for typical settlement monitoring guidelines).

The consultant is responsible for preparing Traffic Control Plans and to obtain approvals and an Encroachment Permit from the Ministry, which are required for lane closures necessary to install the settlement monitoring points.

The tunnelling consultant shall ensure that the foundations engineering component of the project is adequately reflected in the design drawings, specifications and related contract documents.

Written confirmation is required from the Proponent and the tunnelling consultant that the design package submitted to MTO have been reviewed by the tunnelling consultant and that all recommendations have been satisfactorily incorporated in the contract package.

APPENDIX: SETTLEMENT MONITORING GUIDELINES - TUNNELING

The purpose of settlement monitoring is to prevent damage to existing utilities and highway structures along the tunnel alignment. Ground settlement include settlement due to lost ground and dewatering/drainage.

Instrumentation Arrays

All measurement points shall be installed and surveyed before the start of excavation to establish benchmarks/baseline.

Surface Monitoring Points

Surface monitoring points will be installed to cover the whole length of the tunnel with in the right of way under the jurisdiction of MTO (Figure 1).

Surface monitoring points will be located at not greater than 5m intervals along the tunnel alignment. The surface monitoring will be identified using paint marks on the pavement. Surface monitoring points installed on the unpaved right of way shall be founded below frost penetration depths. The interval and/or marking of the points should be changed with MTO's approval where traffic disruptions might occur.

The final instrumentation plan should be finalised when Contractor's proposed construction method is available.

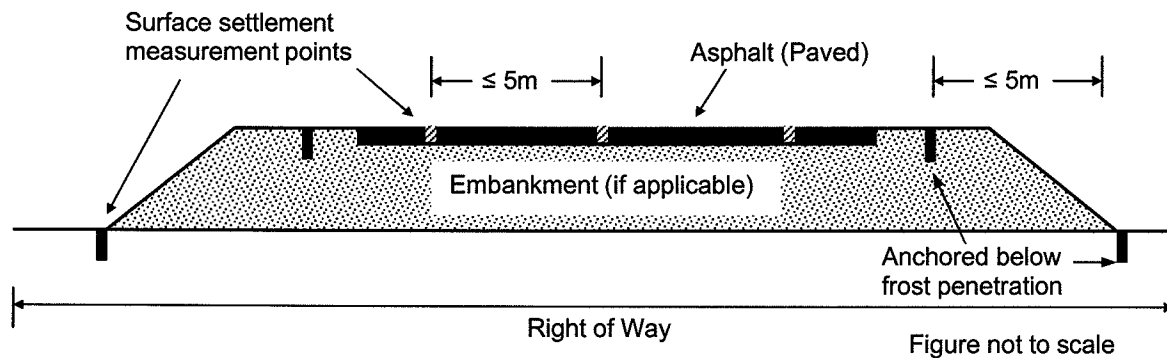


Figure 1: Typical configuration of surface settlement monitoring points along the tunnel alignment.

Condition Survey

A condition survey for the pavement will be carried out prior to commencement of construction and documented for the purpose of requirement of restoration. The condition survey shall document visible flaws such as cracks, distortions and deviations, heaves, and depressions. This surface survey will be completed during the installation of the monitors and again once the tunnel has been completed.

Reading Frequency

An average of at least two readings shall be taken to establish the initial conditions.

The reading and collection of data from the surface monitoring points shall be read and recorded by the Contractor during the construction period and after construction for period of at least 2 weeks provided that further settlement has stopped.

A minimum of three (3) sets of reading be taken daily, provided that movements are within anticipated limits. Otherwise, the frequencies should increase according to a pre-planned interval.

Monitoring of movements is required during work stoppages, such as during non-operation period (off-shifts) or weekends. A minimum of three (3) sets of readings should be taken daily.

Measurements of the monitoring points shall be reported promptly to MTO for review.

Data Collection and Data Transfer

A procedure is required to be established in consultation with MTO so that the monitoring data and the interpreted data will reach all parties as soon as necessary. The contract administrator/consultant and the Contractor should interpret monitoring data as needed for the purpose of on-going construction. The Foundation Engineer should be contacted for technical support to the prime Consultant in the interpretation of ground movements and review of the Contractor's response when Review and Alert Levels are reached.

Criteria for Assessment

The acceptable surface settlement (or heave) will be according to criteria as specified below.

Baseline Reading – A baseline reading of the instrumentation shall be taken prior to commencement of the work. An average of at least two initial readings shall be recorded as baseline reading.

Review Level – A maximum value of 10 mm relative to the baseline readings is suggested for this project. If this level is reached, the method, rate or sequence of construction, or ground stabilization measures should be reviewed or modified to mitigate further ground displacements.

Alert Level – A maximum value of 15mm relative to the baseline readings is suggested for this project. If this level is reached, the Contractor shall cease construction operations and to execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public and maintain traffic.

Review of Contractor's Proposed Method

MTO, the Proponent's prime consultant and Foundation Engineer should review the Contractor's proposed method of construction. The proposed method should include a description of the potential loss of ground, and calculation of the maximum settlement in relation to the Contractor's procedure and equipment, alternative/remedial measures when review level of measurement is reached; and contingency/remedial measures when alert level of measurement is reached.

Contractor's Responsibility For Restoration and Warranty Provision

In addition to the monitoring program to assess the adequacy of the construction method to control potential ground movements and groundwater, the Contractor is responsible for reinstatement (such as surface paving) should movements or other surface distress occur, and provide a reasonable warranty period acceptable to MTO. Remedial measures shall be approved by MTO; however, MTO maintains the right to perform the maintenance at the proponent's expense.

Construction Monitoring

The Proponent shall retain a qualified Geotechnical Consultant to supervise the installation of surface settlement points on site and to provide direction, technical input and field inspection on this project.