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FOUNDATION INVESTIGATION REPORT

Preliminary Design
Amherst Island Ferry
Docks Conversion Study
Millhaven, Ontario
G.W.P. 4067-09-00

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REPORT

Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the preliminary design for the expansion of the existing Millhaven and Stella ferry terminals in Loyalist Township, Lennox and Addington County, Ontario.

This report addresses the results of the foundation investigation carried out for the proposed expansion/reconstruction of the ferry terminals.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal (RFP) dated July 2011 and associated clarifications, and in Section 5.8 of URS's *Technical Proposal* for this assignment.

2.0 SITE DESCRIPTION

The Amherst Island ferry travels across the northeastern end of Lake Ontario between the Stella Terminal (or Amherst Island) and the Millhaven Terminal (or the mainland) located about 25 km west of Kingston, Ontario. The proposed configuration of the expanded ferry terminals are shown in plan on Drawings 1 and 3, based on the preliminary design drawings dated September 4, 2013 provided to Golder by URS.

The proposed new Amherst Island ferry terminals are to be located at the same sites as the existing terminals in Millhaven and Stella on Highway 33 and Forty Foot Road, respectively, in the general area indicated on the key plan on Drawings 1 and 3.

The elevation of the water surface of Lake Ontario ranged between about 74.2 m and 74.4 m in September 2012 when a portion of the over-water boreholes were drilled, and between about 74.9 m and 75.1 m in August 2013 when the remaining over-water boreholes were drilled. The contour lines shown on Drawings 1 and 3 represent the approximate depth from water surface to lake bottom based on a chart datum for Lake Ontario of 74.2 m as reported by Canadian Hydrographic Services, Fisheries and Oceans, Canada.

Based on the preliminary design drawings of the proposed expanded ferry terminals provided by URS, we understand that the existing on shore structures will be removed and that expanded docks, new ramps, sewage holding tanks and mechanical, storage, office and washroom facilities will be constructed. It is also understood that bulkhead walls will be constructed along the shore line as shown on Drawings 1 and 3.

In general, the terrain in the area of the proposed expanded ferry terminals is relatively flat, with the natural ground surface in the vicinity of the Millhaven terminal between about Elevation 75 m and 77 m and between about Elevation 75 m and 76 m in the vicinity of the Stella terminal.

3.0 INVESTIGATION PROCEDURES

Following the identification of the preferred ferry terminal layout alternatives to be carried forward to preliminary design, Golder and URS met with MTO Foundations on July 9, 2012 to agree on the locations for the proposed in-water foundation boreholes. As per the terms of reference for this project, four (4) in-water borehole locations

at each terminal were selected for the preliminary foundation investigation. The field work for the in-water investigation was carried out in two stages.

The first stage took place between September 12 and 27, 2012 at which time six (6) boreholes (Boreholes 12-01, 12-02, 12-02A, 12-04, 12-07 and 12-08) and one (1) dynamic cone penetration test (DCPT 12-03) were advanced at the locations shown on Drawings 1 and 3. The barge equipment employed during the first stage was comprised of a modular floating raft and tug boat supplied and operated by ODS Marine Construction, of Greely, Ontario. On September 27, 2012 after numerous days of delay and stand-by due to inclement weather, scheduling issues with the existing ferry operations and deeper than anticipated water conditions, the DFO window for in-water work closed for the fall/spring spawning season. As a result of the in-water work restriction as well as the deteriorating weather and marine conditions (which were posing health and safety risks to the workers) the field crews were demobilized from the site.

The second and remaining stage of the in-water investigation was carried out between August 12 and 15, 2013 at which time four (4) boreholes (Boreholes 13-02, 13-03, 13-05/13-05A and 13-06) were advanced at the locations shown on Drawings 1 and 3. The barge equipment employed during the second stage was comprised of a triangular “Jack-up 50” barge approximately 17 m long by 20 m wide and an “Ecosse” tug boat supplied and operated by McKeil Marine Ltd. of Hamilton, Ontario. The larger barge equipment utilized for the second stage of the in-water investigation could more readily work in deeper water with less interference with the existing ferry operations and the work was started earlier in the summer when the marine and weather conditions were more favourable.

Photographs showing the equipment used for both stages of the in-water borehole investigation are included in Appendix E.

The on-shore investigation was carried out between September 22 and 24, 2013 at which time four (4) boreholes (Boreholes 13-09, 13-10, 13-11 and 13-12) were advanced at the locations shown on Drawings 1 and 3.

Following completion of all of the field investigation, the design team, in consultation with Loyalist Township and MTO, made minor modifications to the layout of the proposed Millhaven Terminal resulting in some of the boreholes no longer being located within the footprint of the proposed Ferry Terminal expansion at this location.

The drilling investigation was carried out using a combination of CME 55 (first stage over water) and CME-75 (second stage over water) drill rigs (working from the barges) as well as a track-mounted CME 55 drill rig (for the on-land boreholes), supplied and operated by Marathon Drilling Co. Ltd. of Greely, Ontario and Canadian Soil Drilling of Springwater, Ontario. The in-water boreholes were advanced using wash rotary methods and NW-casing contained inside a 100 mm diameter outer casing or HW-casing contained inside a 140 mm diameter outer casing. The outer protective casing extended through the lake water column and was driven into the bottom of the lakebed, in accordance with Golder’s Environmental Protection Plan, dated May 11, 2012, in order to minimize sediments and drill flush water being washed into the lake. The on-shore boreholes were advanced through the overburden using 108 mm inside diameter hollow-stem augers. Soil samples were obtained at depth intervals typically ranging from about 0.75 m to 1.5 m. All soil sampling was performed, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-99). Samples of the bedrock were obtained using an ‘NQ’ or ‘HQ’ size rock core barrel.

The field work was supervised throughout by members of our engineering and technical staff, who confirmed the investigated locations, arranged for the clearance of underground services, supervised the drilling, sampling and in situ testing operations, logged the boreholes and DCPT, and examined and cared for the soil and rock samples. The samples were identified in the field, placed in appropriate containers, labeled and transported to our Mississauga or Ottawa geotechnical laboratories where the samples underwent further detailed visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing such as water content, Atterberg limits, organic contents and grain size distribution tests were carried out on selected samples of the overburden soils. Point load index testing and unconfined compression testing was carried out on specimens of the recovered rock core.

The groundwater conditions in the on-land boreholes were observed in the open boreholes during and immediately following the overburden drilling operations. All boreholes were backfilled with cement grout or bentonite upon completion, in accordance with Ontario Regulation 903 (as amended) and Golder's Environmental Protection Plan.

All of the in-water boreholes were laid out in the field by Hopkins, Cormier and Chitty, a registered Ontario land surveyor in Kingston, Ontario. The elevation of the lake water surface, to which the depths on the in-water Record of Boreholes are referred, was either measured by the surveyor at the start of the borehole drilling or determined by level survey in reference to a temporary benchmark located on each existing ferry dock, (supplied by the surveyor) at the start and completion of drilling. The on-land boreholes were located in the field relative to fixed existing features and the elevations were determined by level survey in reference to temporary benchmarks located on each existing ferry dock, as supplied by the surveyor.

The borehole locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized below and are shown on Drawings 1 and 3.

Borehole/DCPT Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground/Water Surface Elevation (m)	Borehole Depth (m)
BH 12-01	4894798.8	285574.5	74.4	9.2
BH 12-02	4894766.6	285562.3	74.4	11.1
BH 12-02A	4894778.6	285562.2	74.3	8.8
DCPT 12-03	4894703.5	285574.3	74.3	11.3
BH 12-04	4894765.9	285536.0	74.4	7.7
BH 13-02	4894766.6	285561.8	75.1	15.2
BH 13-03	4894704.9	285572.0	75.1	15.7
BH 13-09	4894833.5	285551.9	76.3	9.5
BH 13-10	4894777.0	28551.7	77.8	5.9
BH 12-07	4892480.4	288556.7	74.2	8.5
BH 12-08	4892485.0	288581.7	74.4	7.7
BH13-05/13-05A	4892500.9	288505.2	75.0	22.5
BH 13-06	4892502.8	288538.4	74.9	16.3
BH 13-11	4892471.8	288553.2	76.4	9.9
BH 13-12	4892412.9	288585.6	76.4	4.4

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site is located in the southern portion of the physiographic region known as the Napanee Plain, as delineated in The Physiography of Southern Ontario[1]. The Napanee Plain is flat to undulating, and is characterized by relatively shallow soil deposits overlying bedrock. Geologic mapping[2] indicates that the bedrock within the Napanee Plain consists of grey limestone of the Gull River Formation (of the Trenton-Black River Group), which contains some shale partings and seams.

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

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the investigation and the results of in situ and laboratory testing are shown on the Record of Boreholes and Drillholes in Appendix A (Millhaven) Appendix and C (Stella).

The stratigraphic boundaries shown on the Record of Boreholes and on the interpreted stratigraphic sections on Drawings 2 and 4 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions and top of bedrock will vary between and beyond the borehole locations.

In general, the subsurface strata encountered at the Millhaven site consist of fill and/or organics and/or silts, sands and gravels over limestone bedrock. The fills are variable in composition ranging from sand and gravel to crushed concrete to silty clay and contain varying amounts of shell fragments, organics, wood fragments and timber cribbing. At the Stella site, the subsurface strata encountered are similar, generally consisting of fill and/or organics and/or sands and gravels over limestone bedrock. The fills are variable in composition ranging from sand and gravel to clayey silt and contain concrete fragments and rootlets and timber cribbing. At both the Millhaven and Stella sites, the overburden thickness is variable ranging from as little as 0 m or less than 0.3 m up to about 6.5 m thick at the investigated locations.

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

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

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

4.2.1 Millhaven – In-Water Boreholes (Boreholes 12-01, 12-02, 12-02A, 12-04, 13-02, 13-03 and DCPT 12-03)

4.2.1.1 Lake Water

The water level in Lake Ontario at the site ranged from about Elevations 74.3 m to 74.4 m during the 2012 investigation, and was at about Elevation 75.1 m during the 2013 investigation. The depth to the lakebed varied from about 3.2 m to 8.2 m at the borehole and DCPT locations (Elevations 71.1 m and 66.9 m, respectively).

The water level elevation was surveyed to a temporary benchmark set up on each existing ferry dock at the start and end of the drilling of each borehole and the depths shown on the Records of Boreholes and Drillholes are referenced to the water surface.

4.2.1.2 Sand and Gravel to Sandy Silt and Gravel to Crushed Concrete Fill

A deposit of sand and gravel to sandy silt and gravel to crushed concrete fill was encountered at lake bottom in Boreholes 12-02 and 12-02A at depths between about 3.2 m and 4.9 m below water surface (Elevations 69.5 m to 71.1 m). This deposit was found to be about 2.4 m thick in Borehole 12-02A and greater than 6.2 m thick in Borehole 12-02 and was not fully penetrated to a depth of 11.1 m below water surface (Elevation 63.3 m) at which depth the borehole was terminated due to rough water conditions that made working conditions unsafe to continue. However, the bottom of the overburden/top of bedrock was encountered at a depth of 11.7 m (Elevation 63.4 m) in the immediately adjacent Borehole 13-02.

The measured SPT 'N' values in the sand and gravel to sandy silt and gravel fill are between 0 blows (weight of hammer) and 27 blows per 0.3 m of penetration, indicating that this deposit has a very loose to compact relative density. It was not possible to carry out SPTs in the crushed concrete fill in Borehole 12-02A and coring was required to advance the borehole through the fill at this location.

The fill varies in composition from sand and gravel trace to some silt, trace clay to sandy silt and gravel to crushed concrete, containing organics and wood fragments. The results of grain size distribution tests completed on two selected samples of the sand and gravel fill are shown on Figure B1 in Appendix B.

The measured water content of three samples of the fill ranges between about 1 per cent and 60 per cent. The organic content measured on one sample of the fill is about 12 per cent.

4.2.1.3 Clayey Organic Silt

A deposit of clayey organic silt with sand containing wood fragments and shells was encountered at lake bottom in Borehole 13-03 at a depth of about 8.2 m below water surface (Elevation 66.9 m) and was measured to be about 3.4 m thick.

A single measured SPT 'N' value in the organic silt deposit is 0 blows (weight of rods) per 0.3 m of penetration, indicating that this deposit has a very soft relative density.

The results of a grain size distribution test completed on one selected sample of the organic deposit is shown on Figure B2 in Appendix B.

The measured water content of one sample from this deposit is about 198 per cent. The measured organic content of a sample of this deposit is 18 per cent.

4.2.1.4 Sand and Gravel

A deposit of sand and gravel was encountered at lake bottom in Borehole 12-01 at a depth of about 4.3 m below water surface (Elevation 70.1 m) and a deposit of sand and gravel till was encountered underlying the organic deposit in Borehole 13-03 at a depth of about 11.6 m below surface (Elevation 63.5 m). The sand and gravel and sand and gravel till deposits were measured to be about 1.4 m and 0.3 m thick, respectively.

A single measured SPT 'N' value in the sand and gravel deposit in Borehole 12-01 is 2 blows per 0.3 m of penetration, indicating that this deposit has a very loose relative density.

The deposit is comprised of sand and gravel, some silt, trace clay to sand and gravel till, and contains organics and shell fragments in Borehole 12-01. The results of a grain size distribution test completed on one selected sample of the deposit from Borehole 12-01 is shown on Figure B3 in Appendix B.

The measured water content of one sample from near the surface of this deposit is about 44 per cent.

4.2.1.5 Bedrock

Bedrock was encountered and core samples were recovered from Boreholes 12-01, 12-02A, 12-04, 13-02 and 13-03 at depths starting between about 3.6 m and 11.9 m below water surface (Elevations 70.8 m to 63.2 m, respectively). Refusal to further penetration of DCPT 12-03 on probable bedrock was encountered at about 11.3 m below water surface (Elevation 63.0 m). Bedrock was not encountered in Borehole 12-02 to a depth of 11.1 m below water surface (Elevation 63.3 m).

Based on the recovered bedrock core samples, the bedrock at the Millhaven site consists of limestone. In general, the bedrock samples are described as fine grained, laminated to thickly bedded, slightly porous, slightly weathered to fresh, grey Limestone with shale interbeds and laminations and clay infilling within joints at some locations. The Rock Quality Designation (RQD) measured on the core samples ranges from about 0 per cent to 93 per cent, but is generally between about 60 per cent and 80 per cent, indicating a rock mass that in general is of fair to good quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 15 per cent and 100 per cent.

Unconfined Compressive Strength (UCS) tests carried out on seven samples of the Limestone bedrock from the in-water boreholes at the Millhaven site measured compressive strengths between about 9 MPa and 106 MPa. The test results which are shown on the Record of Drillhole sheets and summarised on Tables B1 to B7 in Appendix B, indicate that the bedrock is weak (R2) to very strong (R5) (but generally medium strong to strong) as per Table 3.5 of CFEM (2006) reproduced here in Table B9 in Appendix B.

Point load index tests were performed on seventeen selected samples of the rock core recovered from the in-water boreholes at the Millhaven terminal. Point load strength index values are shown on the Record of Drillhole Sheets and on Table B10 in Appendix B. The point load index (Is_{50}) results from the laboratory tests carried out on the samples of the Limestone bedrock range from approximately 2.9 MPa to 7.4 MPa. These index values correspond to UCS values ranging between about 40 MPa and 100 MPa, based on a relationship between Is_{50} and UCS which is given by a correlation factor (k), estimated to be equal to 14 for this site, and calculated as the ratio of the average laboratory UCS and average corresponding point load test index value from all of the drillholes at the Millhaven terminal. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.

Based on the laboratory UCS tests and point load testing results (refer to Table B9 in Appendix B for details on the field estimation of rock hardness and R0, R1, etc. values outlined below), the estimated intact strength of the Limestone bedrock generally ranges from medium strong (R3, 25 MPa < UCS < 50 MPa) to strong (R4, 50 MPa < UCS < 100 MPa); (CFEM, 2006).

4.2.2 Millhaven – On-Shore Boreholes (Boreholes 13-09 and 13-10)

4.2.2.1 Silty Clay Fill

A fill deposit consisting of gravelly silty clay with sand was encountered at ground surface in Borehole 13-09 (Elevation 77.8 m). The bottom of the fill deposit was encountered at a depth of 0.7 m below ground surface, corresponding to Elevation 77.1 m.

One Standard Penetration Test (SPT) "N" value measured within the cohesive fill was 23 blows per 0.3 m of penetration, suggesting a very stiff consistency.

The results of a grain size distribution test carried out on one sample of this fill deposit are shown on Figure B4 in Appendix B.

Atterberg limits testing was carried out on one sample of this cohesive fill and measured a liquid limit of 39 per cent, a plastic limit of 21 per cent and a plasticity index of 18 per cent. These test results, which are plotted on a plasticity chart on Figure B5 in Appendix B, confirm that the cohesive fill material consists of silty clay of medium plasticity.

The measured water content of one sample from this deposit is about 11 per cent.

4.2.2.2 Sandy Gravel Fill

A fill deposit consisting of sandy gravel was encountered at ground surface in Borehole 13-10 and underlying the cohesive fill at a depth of 0.7 m below ground surface (Elevation 77.1 m) in Borehole 13-09. The bottom of the fill deposit was encountered at a depth of 1.6 m to 2.9 m below ground surface (Elevation 76.2 m and 73.4 m, respectively) and the fill deposit was measured to be between 0.9 m and 2.9 m thick.

Standard Penetration Test (SPT) "N" values measured within this fill deposit were between 9 and 48 blows per 0.3 m of penetration, indicating a loose to dense relative density.

The results of grain size distribution tests carried out on two samples of this fill deposit are shown on Figure B6 in Appendix B.

The measured water content of three samples from this deposit are between about 4 per cent and 9 per cent.

4.2.2.3 Wood (Existing Cribwork)

Existing wooden cribwork from the original ferry dock structure was encountered at a depth of about 2.9 m below ground surface (Elevation 73.4 m) in Borehole 13-10 and was found to be about 1.5 m thick.

4.2.2.4 Organic Silty Sand

A deposit of dark grey organic silty sand, trace clay was encountered underlying the wooden cribwork at a depth of about 4.4 m below ground surface (Elevation 71.9 m) in Borehole 13-10. The bottom of the organic silty sand

deposit was encountered at a depth of 5.6 m below ground surface (Elevation 70.7 m) and the deposit was measured to be about 1.2 m thick.

One Standard Penetration Test (SPT) "N" value measured within this organic silty sand deposit was 1 blow per 0.3 m of penetration, indicating a very loose relative density.

The measured water content of one sample from this deposit is 58 per cent.

4.2.2.5 Sand and Gravel

A deposit of sand and gravel, trace to some silt, trace clay was encountered underlying the organic silty sand at a depth of about 5.6 m below ground surface (Elevation 70.7 m) in Borehole 13-10. The bottom of this deposit was encountered at a depth of about 6.3 m below ground surface (Elevation 70.0 m) and the deposit was measured to be 0.7 m thick.

The results of a grain size distribution test carried out on one sample of this deposit is shown on Figure B7 in Appendix B.

The measured water content of one sample from this deposit is 11 per cent.

4.2.2.6 Bedrock

Bedrock was encountered and core samples were recovered from Boreholes 13-09 and 13-10 at depths of about 1.6 m and 6.3 m below ground surface, respectively, corresponding to Elevation 76.2 m and 70.0 m.

Based on the recovered bedrock core samples, the bedrock at this location consists of Limestone inter-bedded with Shale. In general, the bedrock samples are described as fine grained, laminated, slightly porous, slightly weathered to fresh, grey Limestone with shale interbeds. The Rock Quality Designation (RQD) measured on the core samples ranges from about 0 per cent to 92 per cent, but is generally less than about 50 per cent in the upper 3 m below the bedrock surface, indicating a rock mass of very poor to excellent (but generally very poor to poor near the bedrock surface) quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 60 per cent and 100 per cent.

Unconfined Compressive Strength (UCS) tests carried out on one sample of the Limestone bedrock from Borehole 13-09 measured a compressive strength of about 71 MPa. The test result which is shown on the Record of Drillhole sheet and summarised on Table B8 in Appendix B, indicate that the bedrock is strong (R4) as per Table 3.5 of CFEM (2006) reproduced here in Table B9 in Appendix B.

Point load index tests were performed on six selected samples of the rock core recovered from the on-shore boreholes at the Millhaven terminal. Point load strength index values are shown on the Record of Drillhole Sheets and on Table B10 in Appendix B. The point load index (Is_{50}) results from the laboratory tests carried out on the samples of the Limestone bedrock range from approximately 2.3 MPa to 5.7 MPa. These index values correspond to UCS values ranging between about 30 MPa and 80 MPa, based on a relationship between Is_{50} and UCS which is given by a correlation factor (k), estimated to be equal to 14 for this site, and calculated as the ratio of the average laboratory UCS and average corresponding point load test index value from all of the drillholes at the Millhaven terminal. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.

Based on the laboratory UCS tests and point load testing results (refer to Table B9 in Appendix B for details on the field estimation of rock hardness and R0, R1, etc. values outlined below), the estimated intact strength of the Limestone bedrock generally ranges from medium strong (R3, 25 MPa < UCS < 50 MPa) to strong (R4, 50 MPa < UCS < 100 MPa); (CFEM, 2006)..

4.2.2.7 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets in Appendix A. Water was encountered at a depth of about 1.8 m below ground surface (Elevation 74.5 m) in Borehole 13-10, while Borehole 13-09 was dry upon completion of the overburden drilling to Elevation 76.2 m. It is noted that the groundwater level in Borehole 13-10 is similar to the water level in the adjacent Lake Ontario.

The water level at the site is expected to fluctuate seasonally in response to changes in the adjacent lake level, precipitation and snow melt, and is expected to be higher during the spring season and periods of precipitation.

4.2.3 Stella – In-Water Boreholes (Boreholes 12-07, 12-08, 13-05/13-05A and 13-06)

4.2.3.1 Lake Water

The water level in Lake Ontario at the site ranged from about Elevation 74.2 m to about Elevation 74.4 m during the 2012 investigation, and from elevation 74.9 m to Elevation 75.0 m Elevation during the 2013 investigation. The depth to the lakebed varied from about 2.8 m to 15.7 m at the borehole locations.

The water level elevation was surveyed to a temporary benchmark set up on each existing ferry dock at the start and end of the drilling of each borehole and the depths shown on the Records of Boreholes and Drillholes are referenced to the water surface.

4.2.3.2 Sand and Gravel to Gravel Fill

A deposit of sand and gravel to gravel fill was encountered at lake bottom in Borehole 12-07 at a depth of about 4.3 m below water surface (Elevation 69.9 m) and was found to be 1.6 m thick. The deposit is comprised of sand and gravel to gravel, trace to some sand trace silt, containing concrete fragments.

A single measured SPT ‘N’ value in the sand and gravel fill is 21 blows per 0.3 m of penetration, indicating that this deposit has a compact relative density.

The results of a grain size distribution test completed on one selected sample of the gravel fill is shown on Figure D1 in Appendix D.

The measured water content of one sample from this deposit is about 5 per cent.

4.2.3.3 Clayey Organic Silt

A deposit of clayey organic silt containing shells was encountered at lake bottom in Boreholes 13-05 and 13-06 at depths ranging from about 11.1 m to 15.7 m below water surface (Elevations 59.3 m to 63.8 m) and was measured to be between about 0.3 m and 1.8 m thick.

A single measured SPT ‘N’ value in the organic deposit is 0 blows (weight of rods) per 0.3 m of penetration, indicating that this deposit has a very soft relative density.

The results of a grain size distribution test completed on one selected sample of the organic deposit is shown on Figure D2 in Appendix D.

The measured water content of one sample from this deposit is about 173 per cent.

4.2.3.4 Sand and Gravel to Sandy Gravel

A deposit of sand and gravel to sandy gravel was encountered at lake bottom in Borehole 12-08 at a depth of about 2.8 m below water surface (Elevation 71.6 m) and underlying the organic deposits in Borehole 13-05 and 13-06 at depths ranging from about 11.4 m to 17.5 m below water surface. The deposit was measured to be between about 0.3 m and 1.1 m thick. The deposit is comprised of sand and gravel to sandy gravel, trace to some silt, trace clay, and was found to contain organics and shell fragments in the samples from Borehole 12-08.

Measured SPT 'N' values in this deposit are between 16 blows and 32 blows per 0.3 m of penetration, indicating that this deposit has a compact to dense relative density.

The results of grain size distribution tests completed on three selected samples of the deposit are shown on Figure D3 in Appendix D.

The measured water content of three samples from this deposit is between about 9 per cent and 10 per cent.

4.2.3.5 Bedrock

Bedrock was encountered and core samples were recovered from Boreholes 12-07, 12-08, 13-05A and 13-06 at depths ranging between about 3.1 m and 18.6 m below water surface (Elevations 56.4 m to 71.3 m).

Based on the recovered bedrock core samples, the bedrock at the Stella site consists of Limestone inter-bedded with Shale to shaley limestone. In general, the bedrock samples are described as fine to medium grained, laminated to medium bedded, fine to medium grained, highly weathered to fresh, grey Limestone to shaley limestone. The Rock Quality Designation (RQD) measured on the core samples is between about 0 per cent and 88 per cent, but is generally less than about 30 per cent, indicating a rock mass of very poor to poor quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 0 per cent and 100 per cent.

Unconfined Compressive Strength (UCS) tests carried out on four samples of the Limestone bedrock recovered from the in-water boreholes at the Stella terminal measured compressive strengths between about 23 MPa and 98 MPa. The test results which are plotted on the Record of Drillhole sheets and summarised on Tables D1 to D4 in Appendix D, indicate that the bedrock is weak (R2) to strong (R4) as per Table 3.5 of CFEM (2006) reproduced here in Table D6 in Appendix D.

Point load index tests were performed on nine selected samples of the rock core recovered from the in-water boreholes at the Stella terminal. Point load strength index values are shown on the Record of Drillhole Sheets and on Table D7 in Appendix D. The point load index (Is_{50}) results from the laboratory tests carried out on the samples of the Limestone bedrock range from approximately 3.7 MPa to 8.2 MPa. These index values correspond to UCS values ranging between about 45 MPa and 100 MPa, based on a relationship between Is_{50} and UCS which is given by a correlation factor (k), estimated to be equal to 12 for this site, and calculated as the ratio of the average laboratory UCS and average corresponding point load test index value from all of the

drillholes at the Stella terminal. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.

Based on the laboratory UCS tests and point load testing results (refer to Table D6 in Appendix D for details on the field estimation of rock hardness and R0, R1, etc. values outlined below), the estimated intact strength of the Limestone bedrock generally ranges from weak (R2, 5 MPa < UCS < 25 MPa) to strong (R4, 50 MPa < UCS < 100 MPa); (CFEM, 2006).

4.2.4 Stella – On-Shore Boreholes (Boreholes 13-11 and 13-12)

4.2.5 Topsoil

A 0.2 m thick surficial layer of topsoil was encountered at the ground surface in Borehole 13-12.

4.2.5.1 Clayey Silt Fill

A fill deposit consisting of clayey silt with sand and gravel, containing trace roots and rootles was encountered underlying the topsoil in Borehole 13-12 at a depth of about 0.2 m below ground surface (Elevation 76.2 m). The bottom of the clayey silt fill deposit was encountered at a depth of about 0.9 m below ground surface, corresponding to Elevation 75.5 m.

One Standard Penetration Test (SPT) “N” value measured within the cohesive fill was 20 blows per 0.3 m of penetration, suggesting a very stiff consistency.

The result of a grain size distribution test carried out on one sample of this fill deposit is shown on Figure D4 in Appendix D.

The measured water content of one sample from this deposit is about 14 per cent.

4.2.5.2 Sand and Gravel to Sandy Gravel Fill

A fill deposit consisting of sand and gravel to sandy gravel to gravel was encountered at ground surface in Borehole 13-11 and underlying the cohesive fill at a depth of about 0.9 m below ground surface (Elevation 75.5 m) in Borehole 13-12. The bottom of the fill deposit was encountered at a depth of 1.2 m to 2.7 m below ground surface (Elevations 75.2 m and 73.7 m, respectively) and the gravelly fill deposit was measured to be between about 0.3 m and 2.7 m thick.

Standard Penetration Test (SPT) “N” values measured within this fill deposit were between 7 and 25 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The results of grain size distribution tests carried out on two samples of this fill deposit are shown on Figure D5 in Appendix D.

The measured water content of two samples from this deposit are about 3 per cent and 9 per cent.

4.2.5.3 Wood (Existing Cribwork)

Wooden cribwork from the original ferry dock structure was encountered at a depth of about 2.7 m below ground surface (Elevation 73.7 m) in Borehole 13-11 and was found to be about 2.5 m thick.

4.2.5.4 Sandy Gravel to Gravel

A deposit of sandy gravel to gravel, some sand, trace to some silt, trace clay containing trace organics and crushed rock fragments was encountered underlying the timber cribwork at a depth of about 5.2 m below ground surface (Elevation 71.2 m) in Borehole 13-11. The bottom of this deposit was encountered at a depth of about 6.5 m below ground surface (Elevation 69.9 m) and the deposit was measured to be 1.3 m thick.

The result of a grain size distribution test carried out on one sample of this deposit is shown on Figure D6 in Appendix D.

The measured water content of two samples from this deposit are 11 per cent and 13 per cent.

4.2.5.5 Bedrock

Bedrock was encountered and core samples were recovered from Boreholes 13-11 and 13-12 at depths of about 6.5 m and 1.2 m below ground surface, respectively, corresponding to Elevations 69.9 m and 75.2 m.

Based on the recovered bedrock core samples, the bedrock at this location consists of Limestone inter-bedded with Shale. In general, the bedrock samples are described as laminated, fine grained, slightly porous, slightly weathered to fresh, grey Limestone. The Rock Quality Designation (RQD) measured on the core samples is between about 0 per cent and 31 per cent, indicating a rock mass of very poor to poor quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 55 per cent and 100 per cent.

An Unconfined Compressive Strength (UCS) test carried out on one sample of the Limestone bedrock measured a compressive strength of about 74 MPa. The test result which is shown on the Record of Drillhole sheet and summarised on Table D5 in Appendix D, indicate that the bedrock is strong (R4) as per Table 3.5 of CFEM (2006) reproduced here in Table D6 in Appendix D.

Point load index tests were performed on six selected samples of the rock core recovered from the on-shore boreholes at the Stella terminal. Point load strength index values are shown on the Record of Drillhole Sheets and on Table D7 in Appendix D. The point load index (Is_{50}) results from the laboratory tests carried out on the samples of the Limestone bedrock range from approximately 2.7 MPa to 9.5 MPa. These index values correspond to UCS values ranging between 30 MPa and 110 MPa, based on a relationship between Is_{50} and UCS which is given by a correlation factor (k), estimated to be equal to 12 for this site, and calculated as the ratio of the average laboratory UCS and average corresponding point load test index values from all of the drillholes at the Stella terminal. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.

Based on the laboratory UCS tests and point load testing results (refer to Table D6 in Appendix D for details on the field estimation of rock hardness and R0, R1, etc. values outlined below), the estimated intact strength of the Limestone bedrock generally ranges from medium strong (R3, 25 MPa < UCS < 50 MPa) to strong (R4, 50 MPa < UCS < 100 MPa); (CFEM, 2006).

4.2.5.6 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets in Appendix C. Water was encountered at a depth of about 1.7 m below ground surface (Elevation 74.7 m) in Borehole 13-11, while Borehole 13-12 was dry upon completion of the overburden drilling

to Elevation 75.2 m. It is noted that the groundwater level in Borehole 13-11 is similar to the water level in the adjacent Lake Ontario.

The water level at the site is expected to fluctuate seasonally in response to changes in the adjacent lake level, precipitation and snow melt, and is expected to be higher during the spring season and periods of precipitation.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Matthew Kelly, P.Eng., and reviewed by Mr. J. Paul Dittrich, P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO Foundations Contact for Golder, conducted an independent review of this report.

GOLDER ASSOCIATES LTD.

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March 24, 2014
PROVINCE OF ONTARIO

Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

MWK/JPD/FJH/jl

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Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

Ontario Geological Society, 1991. *Geology of Ontario*. Special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

MINISTRY OF TRANSPORTATION, ONTARIO

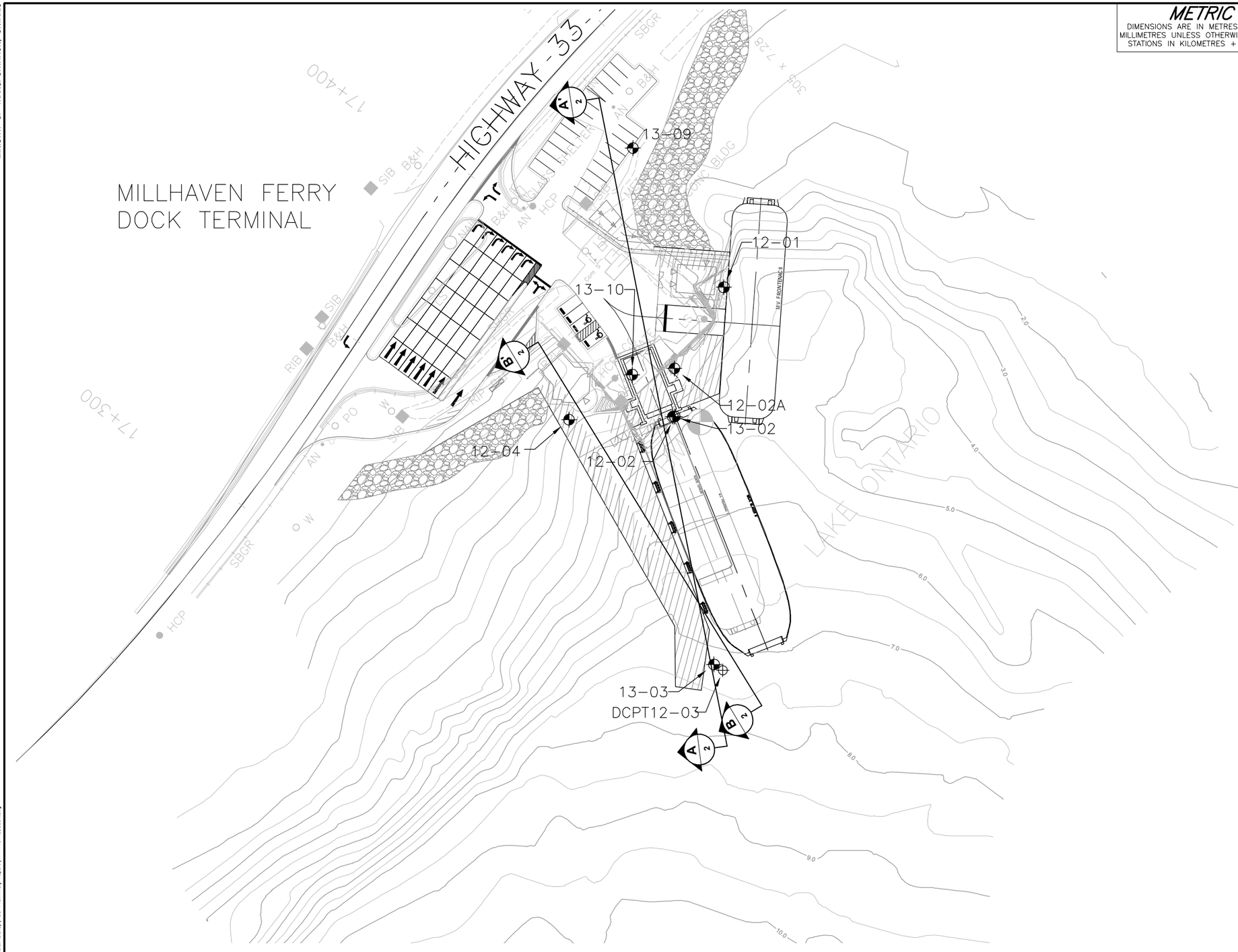
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
G.W.P. No. 4067-09-00

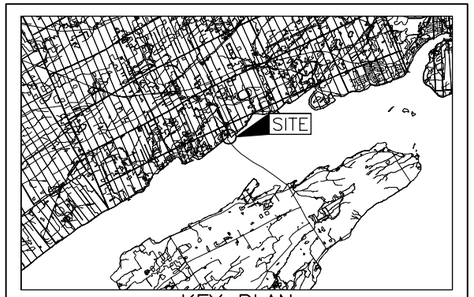
SHEET

AMHERST ISLAND
MILLHAVEN TERMINAL CONVERSION
BOREHOLE LOCATION PLAN

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
SCALE
10 0 10 20 m



KEY PLAN
SCALE
3 0 3 6 km

LEGEND

- Proposed New Ferry Dock
- 4.0 Water Depth Contours (0.5 m Interval)
- Borehole Investigation
- Dynamic Cone Penetration Test

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
12-01	74.4	4894798.8	285574.5
12-02	74.4	4894766.6	285562.3
12-02A	74.3	4894778.6	285562.2
12-04	74.4	4894765.9	285536.0
13-02	75.1	4894766.6	285561.8
13-03	75.1	4894704.9	285572.0
13-09	77.8	4894833.5	285551.9
13-10	76.3	4894777.0	285551.7

DCPT CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
DCPT12-03	74.3	4894703.5	285574.3

NOTES

Water depths shown are based on chart datum elevation of 74.2 m in Lake Ontario, as reported by the Canadian Hydrographic Services, Fisheries and Oceans Canada.

REFERENCE

Base plans provided in digital format by URS, file no. PLAN.dwg, received April 02, 2012 and CONCEPTS-TO GOLDER 10 JULY 2012.dwg, received July 10, 2012. X-Design - Millhaven.dwg and X-Design - Stella.dwg, received August 29, 2013

NO.	DATE	BY	REVISION
1	14/03/24	JFC	**Change in terminal layout and South end of proposed dock alignment by URS**

Geocres No. 31C-223

HWY.		PROJECT NO. 11-1111-0115	DIST.
SUBM'D. MWK	CHKD. MWK	DATE: Mar. 2014	SITE:
DRAWN: DD/JFC	CHKD. JPD	APPD. FJH	DWG. 1

PLOT DATE: March 24, 2014
FILENAME: I:\Projects\2011\11-1111-0115 (URS, Amherst Island)\-DC-Preliminary Report\11111101150D001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

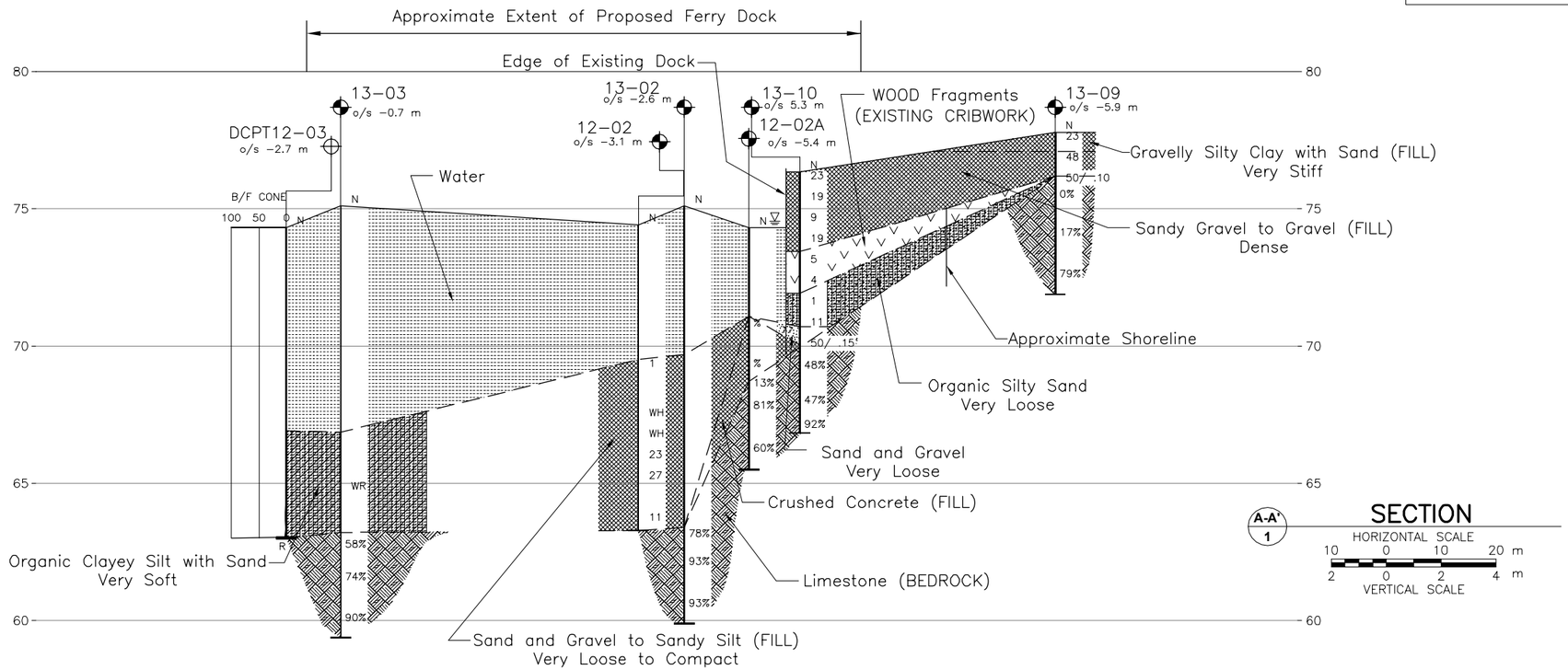
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
G.W.P. No. 4067-09-00

SHEET

AMHERST ISLAND
MILLHAVEN TERMINAL CONVERSION
SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



A-A'
1

SECTION
HORIZONTAL SCALE
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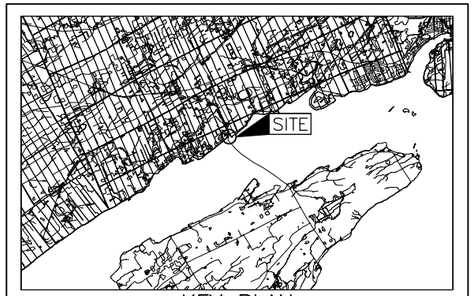
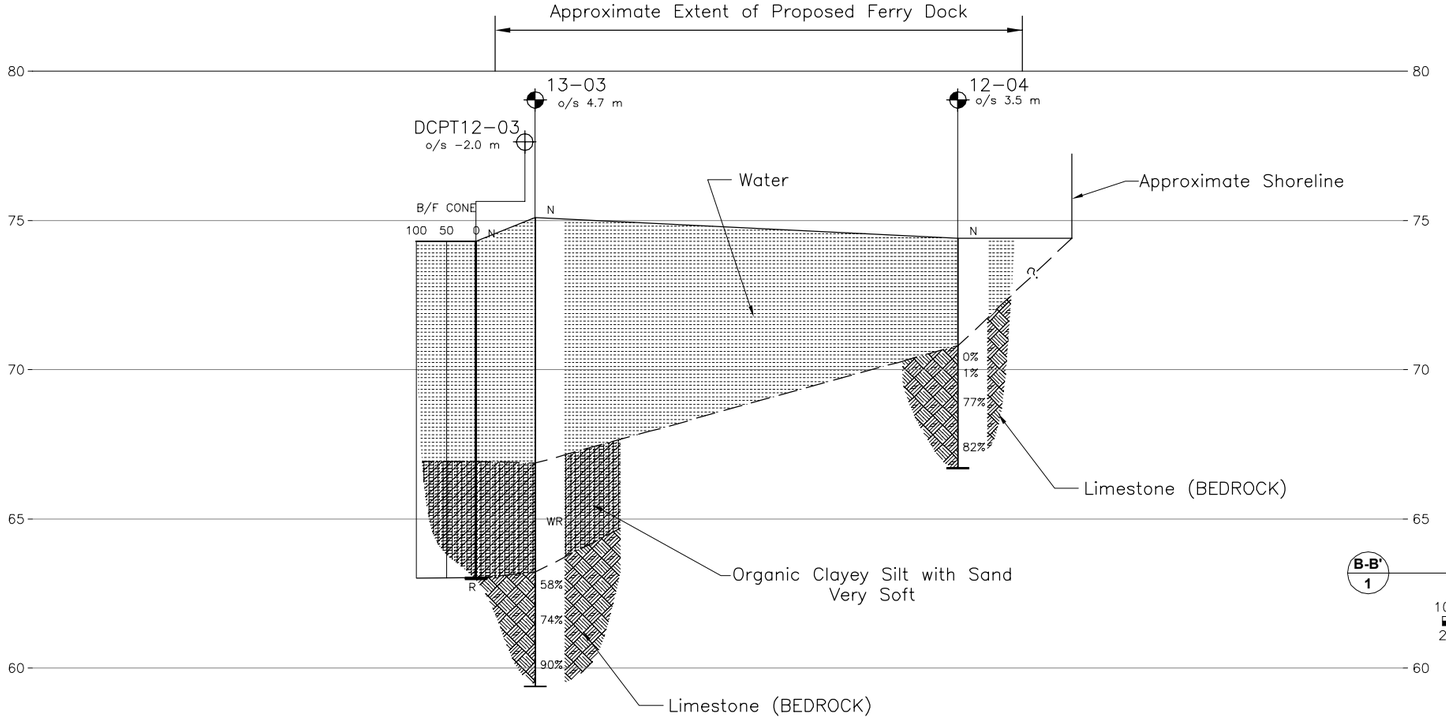
VERTICAL SCALE
2 0 2 4 m



KEY PLAN
SCALE
3 0 3 6 km

LEGEND

⊕	Borehole Investigation
⊕	Dynamic Cone Penetration Test
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
R	Refusal on inferred Bedrock



B-B'
1

SECTION
HORIZONTAL SCALE
10 0 10 20 m
VERTICAL SCALE
2 0 2 4 m

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
12-01	74.4	4894798.8	285574.5
12-02	74.4	4894766.6	285562.3
12-02A	74.3	4894778.6	285562.2
12-04	74.4	4894765.9	285536.0
13-02	75.1	4894766.6	285561.8
13-03	75.1	4894704.9	285572.0
13-09	77.8	4894833.5	285551.9
13-10	76.3	4894777.0	285551.7

DCPT CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
DCPT12-03	74.3	4894703.5	285574.3

REFERENCE

Base plans provided in digital format by URS, file no. PLAN.dwg, received April 02, 2012 and CONCEPTS-TO GOLDER 10 JULY 2012.dwg, received July 10, 2012.

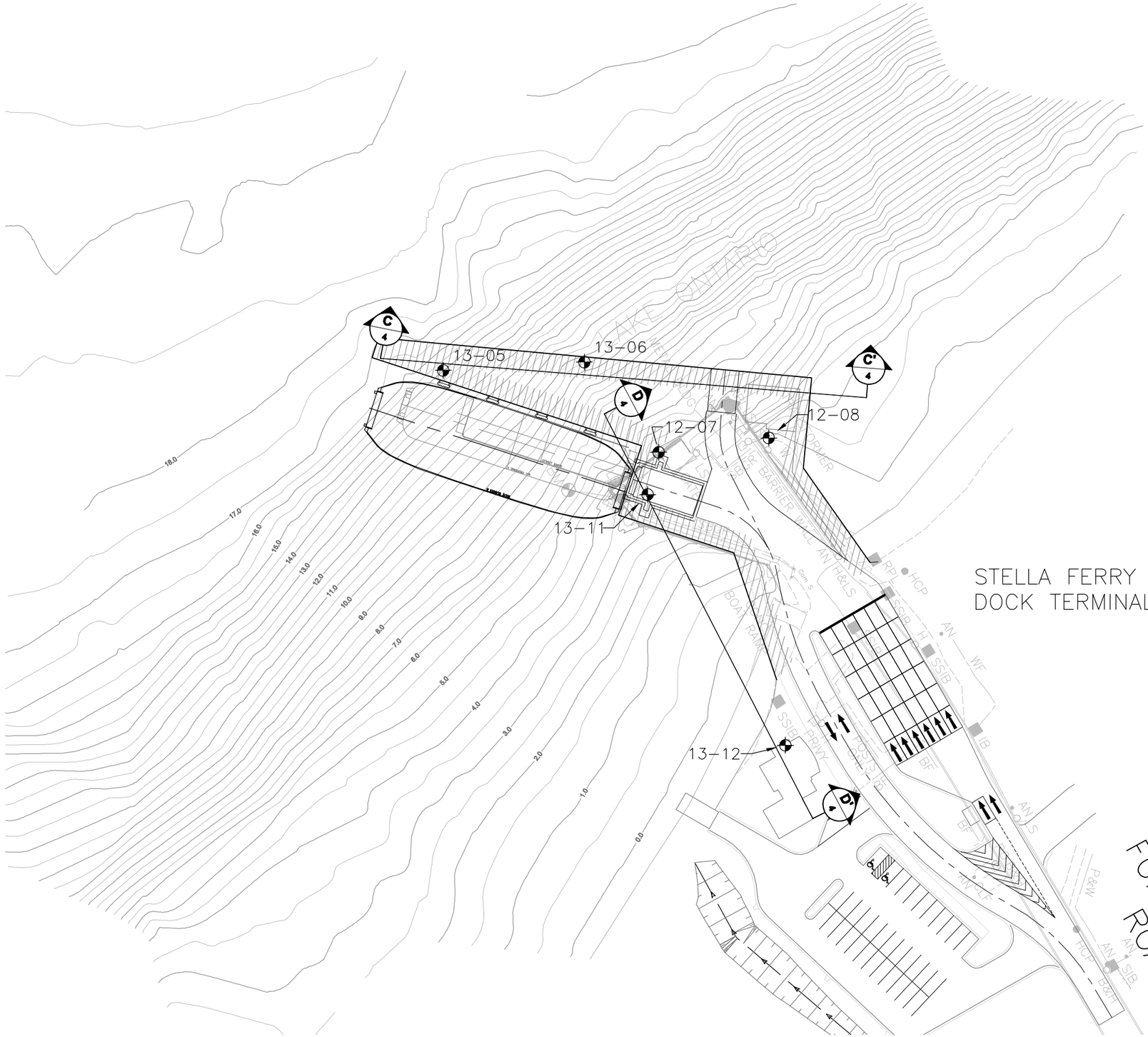
NO.	DATE	BY	REVISION

Geocres No. 31C-223

HWY.		PROJECT NO. 11-1111-0115	DIST.
SUBM'D. MWK	CHKD. MWK	DATE: Nov. 2013	SITE:
DRAWN: DD/JFC	CHKD. JPD	APPD. FJH	DWG. 2

PLOT DATE: January 10, 2014
FILENAME: I:\Projects\2011\11-1111-0115 (URS, Amherst Island)\-DC-Preliminary Report\1111110115DC002.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
10 0 10 20 m

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

CONT No.
G.W.P. No. 4067-09-00

SHEET

AMHERST ISLAND
STELLA TERMINAL CONVERSION
BOREHOLE LOCATION PLAN

Golder Associates Ltd.
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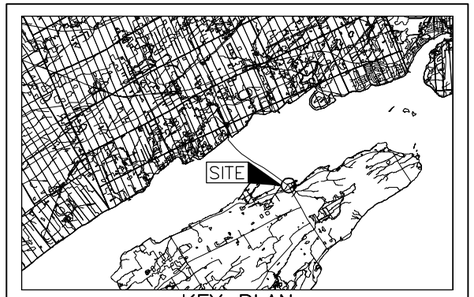


KEY PLAN
SCALE
3 0 3 6 km

LEGEND

- Proposed New Ferry Dock
- 4.0 Water Depth Contours (0.5 m Interval)
- Borehole Investigation
- Dynamic Cone Penetration Test

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
12-07	74.2	4892481.7	288555.8
12-08	74.4	4892485.0	288581.7
13-05_13-05A	75.0	4892500.9	288505.2
13-06	74.9	4892502.8	288538.4
13-11	76.4	4892471.8	288553.2
13-12	76.4	4892412.9	288585.6

NOTES

Water depths shown are based on chart datum elevation of 74.2 m in Lake Ontario, as reported by the Canadian Hydrographic Services, Fisheries and Oceans Canada.

REFERENCE

Base plans provided in digital format by URS, file no. PLAN.dwg, received April 02, 2012 and CONCEPTS-TO GOLDER 10 JULY 2012.dwg, received July 10, 2012. X-Design - Millhaven.dwg and X-Design - Stella.dwg, received August 29, 2013

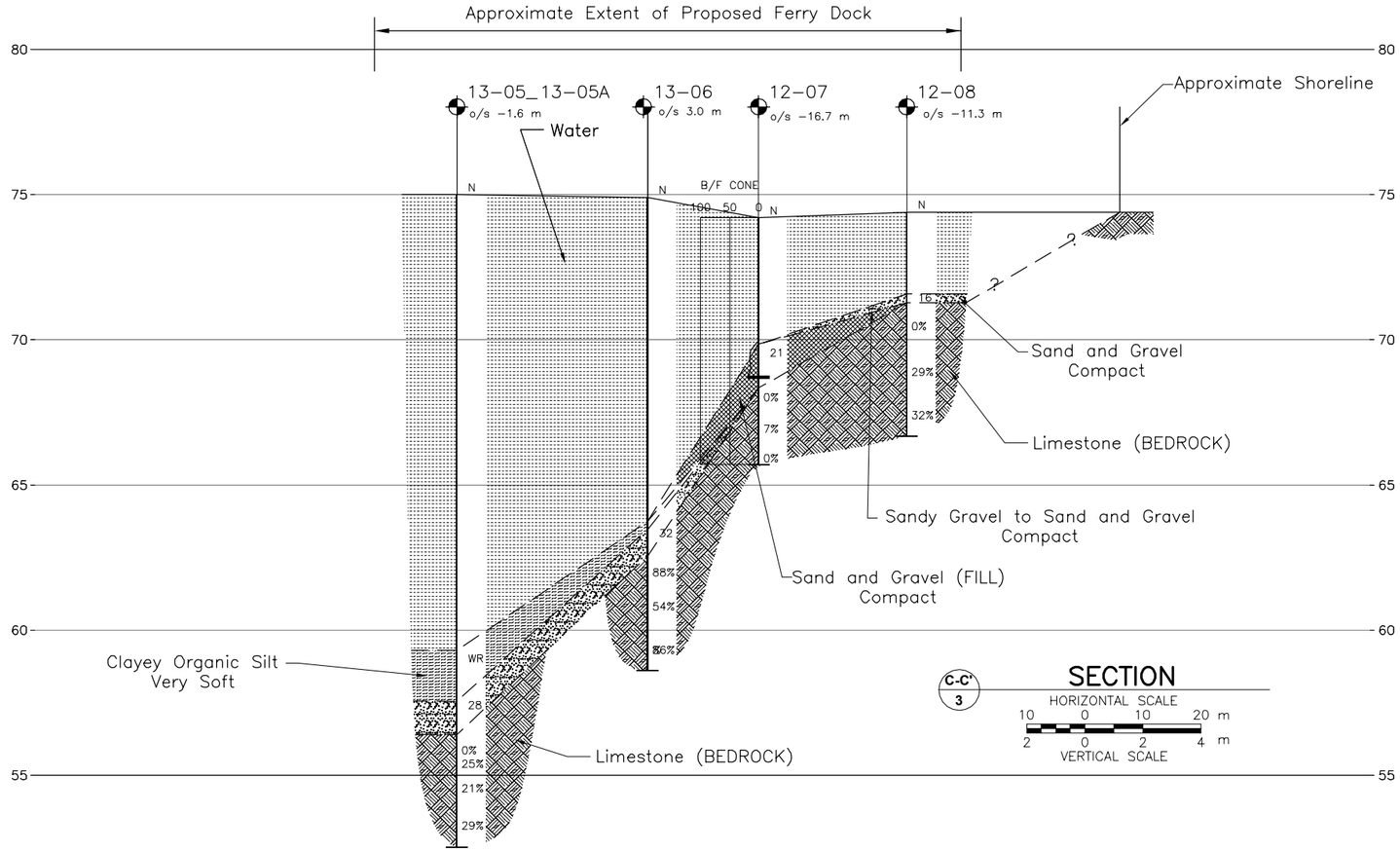
NO.	DATE	BY	REVISION

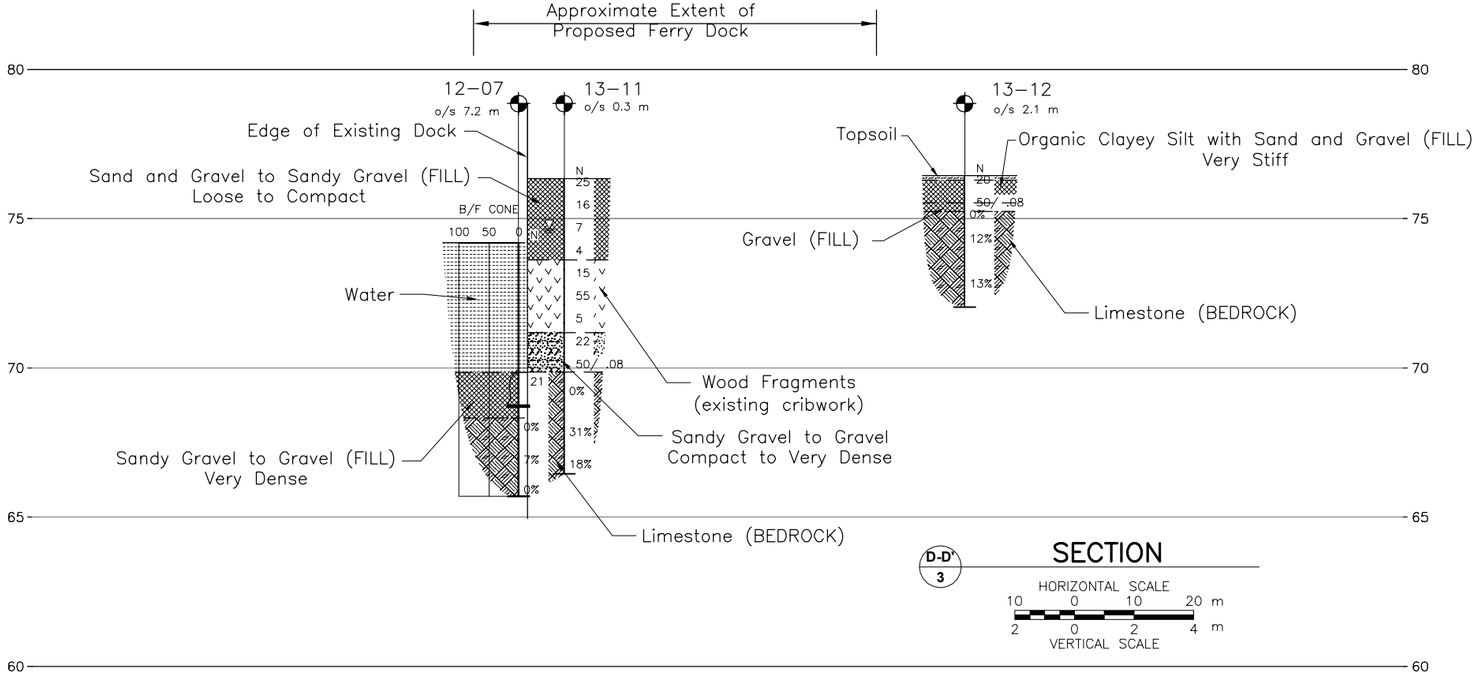
Geocres No. 31C-223

HWY.	PROJECT NO. 11-1111-0115		DIST.
SUBM'D. MWK	CHKD. MWK	DATE: Nov. 2013	SITE:
DRAWN: DD/JFC	CHKD. JPD	APPD. FJH	DWG. 3

PLOT DATE: January 10, 2014
FILENAME: T:\Projects\2011\11-1111-0115 (URS, Amherst Island)\-02-Preliminary Report\1111110115D003.dwg

MINISTRY OF TRANSPORTATION, ONTARIO





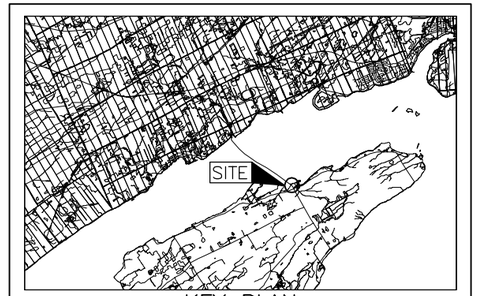
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
G.W.P. No. 4067-09-00

SHEET

AMHERST ISLAND
STELLA TERMINAL CONVERSION
SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole Investigation
- Dynamic Cone Penetration Test
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- R — Refusal on inferred Bedrock

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
12-07	74.2	4892481.7	288555.8
12-08	74.4	4892485.0	288581.7
13-05_13-05A	77.2	4892500.9	288505.2
13-06	77.1	4892502.8	288538.4
13-11	76.4	4892471.8	288553.2
13-12	76.4	4892412.9	288585.6

NO.	DATE	BY	REVISION

Geocres No. 31C-223

HWY.	PROJECT NO. 11-1111-0115		DIST.
SUBM'D. MWK	CHKD. MWK	DATE: 12/18/2012	SITE:
DRAWN: MR/DD	CHKD. JPD	APPD. FJH	DWG. 4

PLOT DATE: January 10, 2014
FILENAME: I:\Projects\2011\11-1111-0115 (URS, Amherst Island)\-DC-Preliminary Report\11111101150004.dwg

APPENDIX A

Record of Boreholes and Drillholes – Millhaven Terminal

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
FoS	factor of safety

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	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_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (compressive strength)/2

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
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic 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, 60º 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 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (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

(b) Cohesive Soils

Consistency

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

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.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel / Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

JN Joint
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

Golder Associates

RECORD OF BOREHOLE No 12-01

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4894798.8 ;E 285574.5 ORIGINATED BY MS/DM
DIST HWY 33 BOREHOLE TYPE CME-55 Barge Mounted, NW Casing COMPILED BY MWK
DATUM Geodetic DATE September 12, 2012 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
74.4	WATER SURFACE										
0.0	Water						74				
							73				
							72				
							71				
70.1											
4.3	SAND and GRAVEL, some silt, trace clay, containing organics and shell fragments Very loose Brown Wet		1	SS	2		70		43.5 ○		47 35 16 2
68.7							69				
5.7	LIMESTONE (BEDROCK) Bedrock cored from 5.7 m to 9.2 m depth. Refer to Record of Drillhole for bedrock coring details.		1	NQ	REC 79%						RQD = 0%
			2	NQ	REC 100%		68				RQD = 58%
							67				
			3	NQ	REC 83%		66				RQD = 22%
65.2											
9.2	END OF BOREHOLE										

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

GTA-MTO 001 11-1111-0115.GPJ GAL-GTA.GDT 1/10/14

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 12-01

SHEET 1 OF 1

LOCATION: N 4894798.8 ;E 285574.5

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		68.67																		
6	NQ Rock Core / NW Casing	LIMESTONE, fine grained, laminated, slightly porous Slightly weathered to fresh Grey Strong to very strong		5.73	1																	
7					2																	(Axial)
8					3																	UCS = 103 MPa (Axial)
9				65.21																		
		END OF DRILLHOLE		9.19																		
10																						
11																						
12																						
13																						
14																						
15																						

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate
BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage
PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular
PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE
1 : 50

LOGGED: MS/DM

CHECKED: JPD

Golder Associates

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 12-02

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4894766.6 ;E 285562.3 ORIGINATED BY MS
DIST HWY 33 BOREHOLE TYPE CME-55 Barge Mounted, NW Casing COMPILED BY MWK
DATUM Geodetic DATE September 15, 2012 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
74.4	WATER SURFACE										
0.0	Water						74				
69.5							73				
							72				
							71				
							70				
4.9	Sand and gravel, some silt, containing wood fragments and organics (FILL) Very loose Brown Wet		1	SS	1		69				
			2	SS	WH		68		60 ○		44 40 16 0
66.2			3	SS	WH		67			OC = 12.0%	
8.2	Sandy silt and gravel (FILL) Compact Brown Wet		4	SS	23		66		○		
65.5											
8.9	Sand and gravel, trace silt, trace clay (FILL) Compact Grey Wet		5	SS	27		65				52 41 5 2
			6	SS	11		64		○		
63.3											
11.1	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 11-1111-0115.GPJ GAL-GTA.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 12-02A

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4894778.6 ;E 285562.2 ORIGINATED BY MS/DM
DIST HWY 33 BOREHOLE TYPE CME-55 Barge Mounted, NW Casing COMPILED BY MWK
DATUM Geodetic DATE September 26 to 27, 2012 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
74.3	WATER SURFACE										
0.0	Water						74				
71.1							73				
3.2	Crushed concrete (FILL)			NQ	REC 39%		72				
70.6							71				
3.7	No recovery										
70.1							70				
4.2	Crushed concrete (FILL)			NQ	REC 13%		69				
68.7											
5.6	LIMESTONE (Bedrock)		2	NQ	REC 100%						RQD = 13%
	Bedrock cored from 5.6 m to 8.8 m depth		3	NQ	REC 100%		68				RQD = 81%
	Refer to Record of Drillhole for bedrock coring details		4	NQ	REC 82%		67				RQD = 60%
65.5							66				
8.8	END OF DRILLHOLE										

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

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 12-02A

SHEET 1 OF 1

LOCATION: N 4894778.6 ;E 285562.2

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		68.71																	
6	NQ Rock Core / NW Casing	LIMESTONE, thinly to medium bedded, fine grained, slightly porous Slightly weathered to fresh Grey Strong		5.59	2		100														
					3		0														(Axial)
7				67.09																	(Axial)
		LIMESTONE, thinly bedded, fine grained, Fresh to slightly weathered Grey Strong Clay infilling in joints		7.21																	UCS = 53.5 MPa
8					4		0														(Axial)
				65.49																	
9		END OF DRILLHOLE		8.81																	
10																					
11																					
12																					
13																					
14																					
15																					

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MS/DM
CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF DCPT No DCPT12-03

SHEET 1 OF 1

METRIC

PROJECT 11-1111-0115

G.W.P. 4067-09-00 LOCATION N 4894703.5 ;E 285574.3 ORIGINATED BY MS

DIST HWY 33 BOREHOLE TYPE CME-55 Barge Mounted COMPILED BY MWK

DATUM Geodetic DATE September 21, 2012 CHECKED BY JPD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	w_P w w_L	γ kN/m³	GR SA SI CL
74.3 WATER SURFACE								20 40 60 80 100	10 20 30		
0.0	Water						74				
							73				
							72				
							71				
							70				
							69				
							68				
66.9							67				
7.4	Very loose Overburden						66				
							65				
							64				
63.0							63				
11.3	END OF DCPT DCPT BOUNCING REFUSAL ON INFERRED BEDROCK										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 12-04

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00
DIST HWY 33
DATUM Geodetic

LOCATION N 4894765.9 ;E 285536.0
BOREHOLE TYPE CME-55 Barge Mounted, NW Casing
DATE September 13, 2012

ORIGINATED BY MS/DM
COMPILED BY MWK
CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
74.4	WATER SURFACE										
0.0	Water						74				
							73				
							72				
70.8							71				
3.6	LIMESTONE (Bedrock) Bedrock cored from 3.6 m to 7.7 m depth. Refer to Record of Drillhole for bedrock coring details.		1	NQ	REC 68%						RQD = 0%
			2	NQ	REC 78%		70				RQD = 1%
			3	NQ	REC 100%		69				RQD = 77%
			4	NQ	REC 100%		68				RQD = 82%
66.7							67				
7.7	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 12-04

SHEET 1 OF 1

LOCATION: N 4894765.9 ;E 285536.0

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		70.80																	
4	NQ Rock Core / NW Casing	LIMESTONE, fine grained, laminated, slightly porous Slightly weathered to fresh Grey Medium strong to strong		3.60	1		100														
					2		100												•		
5					3		100												•		UCS = 41.3 MPa (Axial)
6																					
7				66.70	4		0												•		(Axial)
		END OF DRILLHOLE		7.70																	
8																					
9																					
10																					
11																					
12																					
13																					

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MS/DM
CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-02

SHEET 1 OF 2

METRIC

PROJECT 11-1111-0115
G.W.P. 4067-09-00
DIST HWY 33
DATUM Geodetic

LOCATION N 4894766.6 ;E 285561.8
BOREHOLE TYPE CME-75 Barge Mounted, NW Casing
DATE August 12 and 13, 2013

ORIGINATED BY PH
COMPILED BY MWK
CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
75.1	WATER SURFACE						75				
0.0	Water										
69.7							70				
5.4	Overburden Refer to Record of Borehole 12-02 for details of overburden stratigraphy						69				
63.4							64				
11.7	LIMESTONE (BEDROCK) Bedrock cored from 11.6 m to 15.2 m depth. Refer to Record of Drillhole 13-02 for bedrock coring details.		1	HQ	REC 100%		63				RQD = 78%
			2	HQ	REC 99%		62				RQD = 93%
			3	HQ	REC 97%		61				RQD = 93%

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

PROJECT 11-1111-0115

RECORD OF BOREHOLE No 13-02

SHEET 2 OF 2

METRIC

G.W.P. 4067-09-00 LOCATION N 4894766.6 ;E 285561.8 ORIGINATED BY PH

DIST HWY 33 BOREHOLE TYPE CME-75 Barge Mounted, NW Casing COMPILED BY MWK

DATUM Geodetic DATE August 12 and 13, 2013 CHECKED BY JPD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
59.9			3	HQ			60				
15.2	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-02

SHEET 1 OF 1

LOCATION: N 4894766.6 ;E 285561.8

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Canadian Soil Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate; BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage; PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular; PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break; BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		63.44																	
12	HQ Rock Core / NQ Casing	LIMESTONE, fine grained slightly porous Fresh Medium to thickly bedded Grey Weak to very strong		11.66	1		100							JN,PL,RO JN,PL,RO							(Axial) UCS=64.2 MPa
13					2		50							25 mm clay seam							(Axial)
14					3		0							JN,W,SM JN,W,SM JN,W,RO							UCS=8.6 MPa
15				59.89																	(Axial)
		END OF DRILLHOLE		15.21																	
16																					
17																					
18																					
19																					
20																					
21																					

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-03

SHEET 1 OF 2

METRIC

PROJECT 11-1111-0115
G.W.P. 4067-09-00
DIST _____ HWY 33
DATUM Geodetic

LOCATION N 4894704.9 ;E 285572.0
BOREHOLE TYPE CME-75 Barge Mounted, NW Casing
DATE August 13, 2013

ORIGINATED BY PH
COMPILED BY MWK
CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
75.1	WATER SURFACE										
0.0	Water						75				
							74				
							73				
							72				
							71				
							70				
							69				
							68				
66.9							67				
8.2	CLAYEY ORGANIC SILT with SAND, containing wood fragments and shells Very soft Dark brown						66				
			1	SS	WR		65		197.8 ○		O. C. = 17.9% 0 31 46 23
63.5							64				
63.2	Sand and gravel (TILL)										
11.9	LIMESTONE (BEDROCK) Bedrock cored from 11.9 m to 15.7 m depth. Refer to Record of Drillhole 13-03 for bedrock coring details.		1	HQ	REC 98%		63				RQD = 58%
			2	HQ	REC 98%		62				RQD = 74%
			3	HQ	REC 64%		61				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 13-03

SHEET 2 OF 2 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4894704.9 ;E 285572.0 ORIGINATED BY PH
DIST HWY 33 BOREHOLE TYPE CME-75 Barge Mounted, NW Casing COMPILED BY MWK
DATUM Geodetic DATE August 13, 2013 CHECKED BY JPD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
59.4			3	HQ	REC 64%		60				RQD = 90%
15.7	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-03

SHEET 1 OF 1

LOCATION: N 4894704.9 ;E 285572.0

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Canadian Soil Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		63.21																		
12	HQ Rock Core / HW Casing	LIMESTONE, fine grained slightly porous Fresh Medium to thickly bedded Grey Medium strong to very strong Thin laminations of black shale		11.89	1										JN,PL,Ro JN,PL,SM							UCS=55.0 MPa
13															,, ,,							(Axial)
					2										JN,W,Ro							
14															JN,PL,Ro							(Axial)
					3										JN,N,Ro JN,PL,Ro							(Axial)
15															JN,PL,Ro							UCS=106.1 MPa
				59.38																		
		END OF DRILLHOLE		15.72																		
16																						
17																						
18																						
19																						
20																						
21																						

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-09

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4894833.5 ;E 285551.9 ORIGINATED BY TWB
DIST HWY 33 BOREHOLE TYPE CME-55 Track Mounted COMPILED BY MWK
DATUM Geodetic DATE October 22 and 23, 2013 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
77.8	GROUND SURFACE										
0.0	Gravelly Silty Clay with Sand (FILL) Very stiff		1	SS	23				○		21 47 19 13
77.1	Dark brown Moist						77				
0.7	Sandy gravel to gravel containing crushed rock, trace silt (FILL) Dense		2	SS	48				○		
76.2	Grey to brown Moist		3	SS	50/ .10						
1.6	LIMESTONE (BEDROCK) Bedrock cored from 1.6 m to 5.9 m depth. Refer to Record of Drillhole 13-09 for bedrock coring details.		1	RC	REC 69%		76				RQD = 0%
							75				
			2	RC	REC 45%						RQD = 17%
							74				
			3	RC	REC 100%		73				RQD = 79%
71.9							72				
5.9	END OF BOREHOLE										

NOTE:

1. Borehole dry upon completion of overburden driling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-09

SHEET 1 OF 1

LOCATION: N 4894833.5 ;E 285551.9

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		76.18																		
2	NQ ROCK CORING	LIMESTONE with shale interbeds Slightly weathered to fresh Laminated Grey Fine grained, slightly porous Medium strong to strong		1.60	1		0								JN,UN,VRO							
3					2		0								JN,UN,RO BD,UN,RO JN,UN,VRO JN,UN,VRO JN,UN,VRO							
4																						
5					3		0								BD,UN,RO BD,UN,RO BD,UN,RO							UCS=70.9 MPa (axial) (axial) (axial)
6				71.88											BD,UN,RO JN,UN,VRO JN,UN,VRO							
		END OF BOREHOLE		5.90																		
7																						
8																						
9																						
10																						
11																						

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TWB
CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-10

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4894777.0 ;E 285551.7 ORIGINATED BY TWB
DIST HWY 33 BOREHOLE TYPE CME-55 Track Mounted COMPILED BY MWK
DATUM Geodetic DATE October 22, 2013 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
76.3	GROUND SURFACE										
0.0	Sandy gravel, trace silt, trace clay (FILL) Loose to compact Grey Moist		1	SS	23		76	○	○		
			2	SS	19						65 29 4 2
			3	SS	9	▽	75		○		76 20 3 1
73.4			4	SS	19		74				
2.9	WOOD fragments (EXISTING CRIBWORK)		5	SS	5		73				
71.9			6	SS	4						
4.4	Organic SILTY SAND, trace clay Very loose Dark grey Wet		7	SS	1		72			58 ○	
70.7			8	SS	11		71				
5.6	SAND and GRAVEL, trace to some silt, trace clay Compact Dark grey Wet		9	SS	50/ .15				○		59 32 6 3
70.0							70				
6.3	LIMESTONE (BEDROCK) Bedrock cored from 6.3 m to 9.5 m depth. Refer to Record of Drillhole 13-10 for bedrock coring details.		1	RC	REC 100%						RQD = 48%
			2	RC	REC 98%		69				RQD = 47%
66.8			3	RC	REC 100%		68				RQD = 92%
9.5	END OF BOREHOLE NOTE: 1. Water encountered during drilling at a depth of 1.8 m (Elev. 74.5 m) below ground surface.						67				

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

GTA-MTO 001 11-1111-0115.GPJ GAL-GTA.GDT 1/10/14

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-10

SHEET 1 OF 1

LOCATION: N 4894777.0 ;E 285551.7

DRILLING DATE: October 22, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		70.04																	
7	NQ ROCK CORING	LIMESTONE with shale interbeds Slightly weathered to fresh Laminated Grey Fine grained, slightly porous Medium strong to strong		6.30	1		100							JN,UN,VRO JN,UN,VRO JN,UN,RO JN,UN,RO JN,UN,RO							(axial)
8					2		0							JN,UN,VRO JN,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO JN,UN,RO							(axial)
		~ 3 mm dark grey clayey silt seam at 8.6 m depth												BD,UN,RO							
9					3		0							JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO							(axial)
				66.84																	
		END OF BOREHOLE		9.50																	

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TWB
CHECKED: JPD

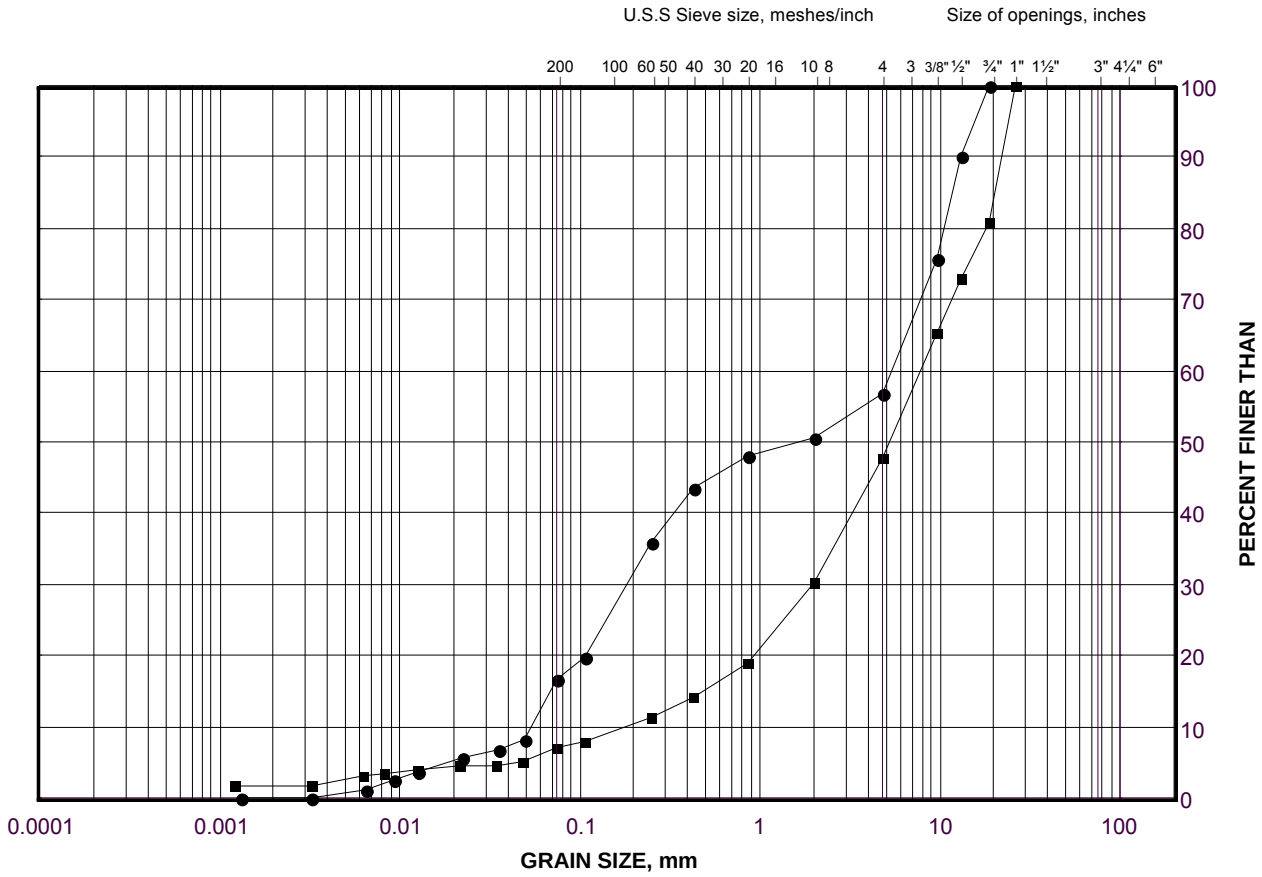
APPENDIX B

Laboratory Test Results – Millhaven Terminal

GRAIN SIZE DISTRIBUTION

Sand and Gravel (FILL)

FIGURE B1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-02	2	67.4
■	12-02	5	65.1

Project Number: 11-1111-0115

Checked By: MWK

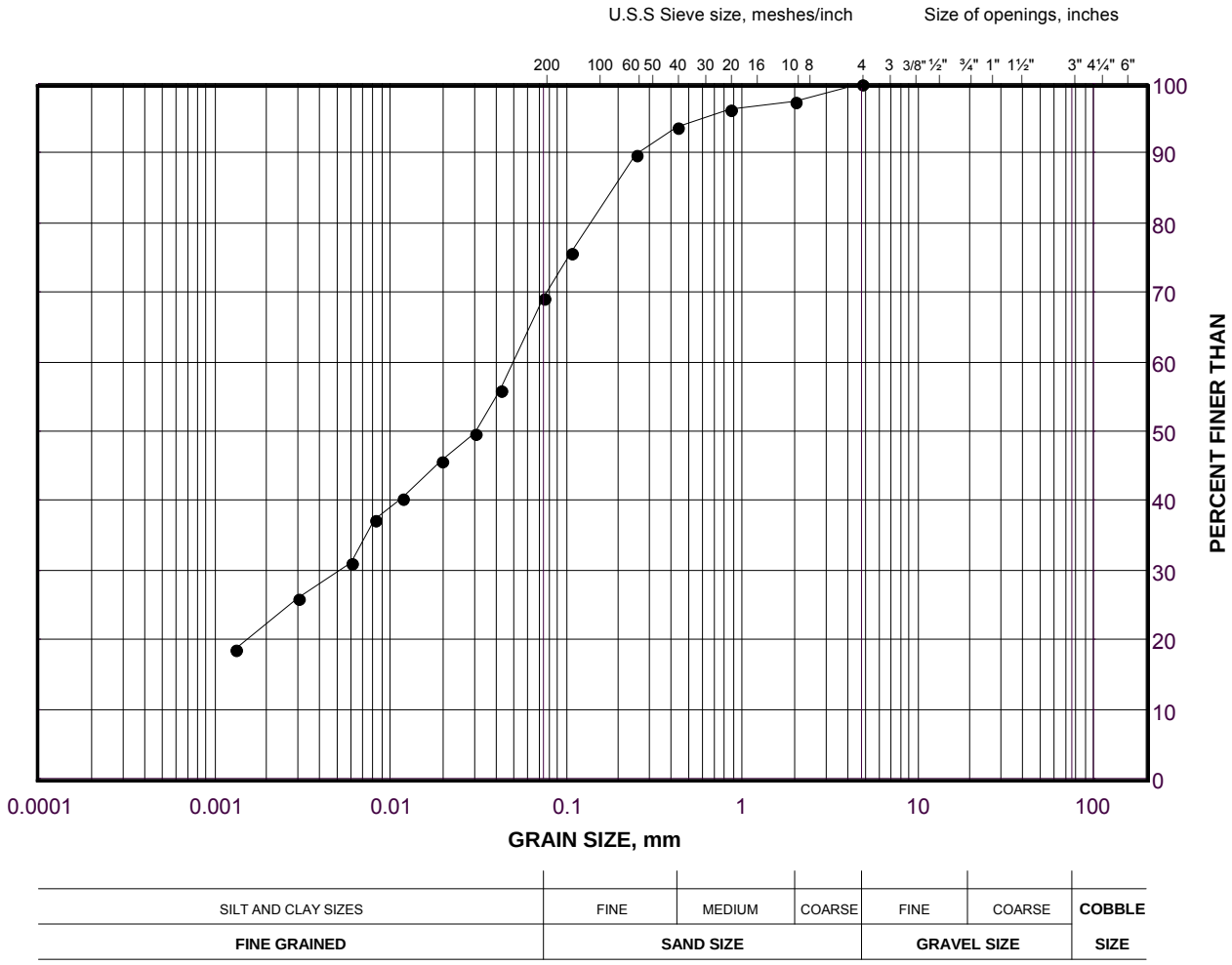
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Clayey Organic Silt with Sand

FIGURE B2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-03	1	64.8

Project Number: 11-1111-0115

Checked By: MWK

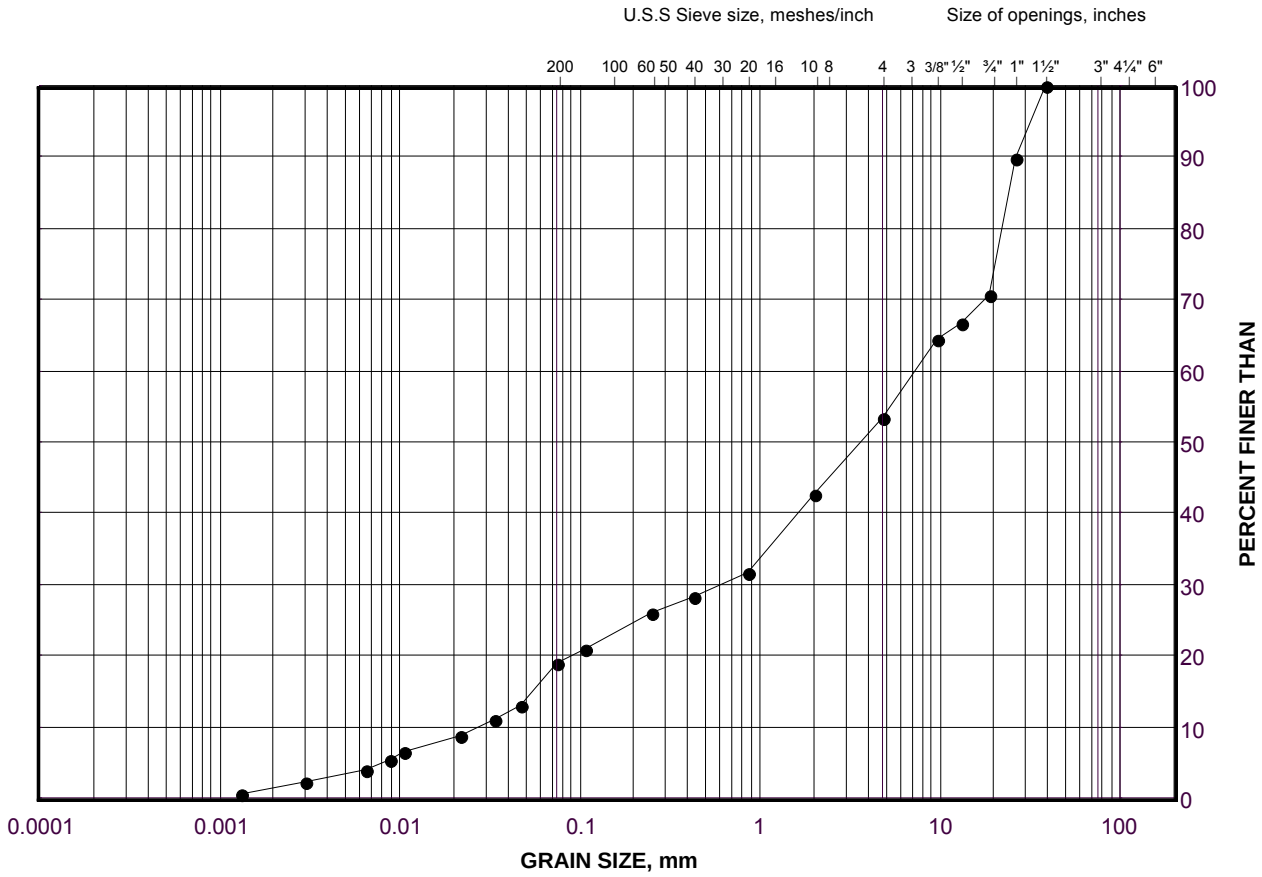
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-01	1	69.8

Project Number: 11-1111-0115

Checked By: MWK

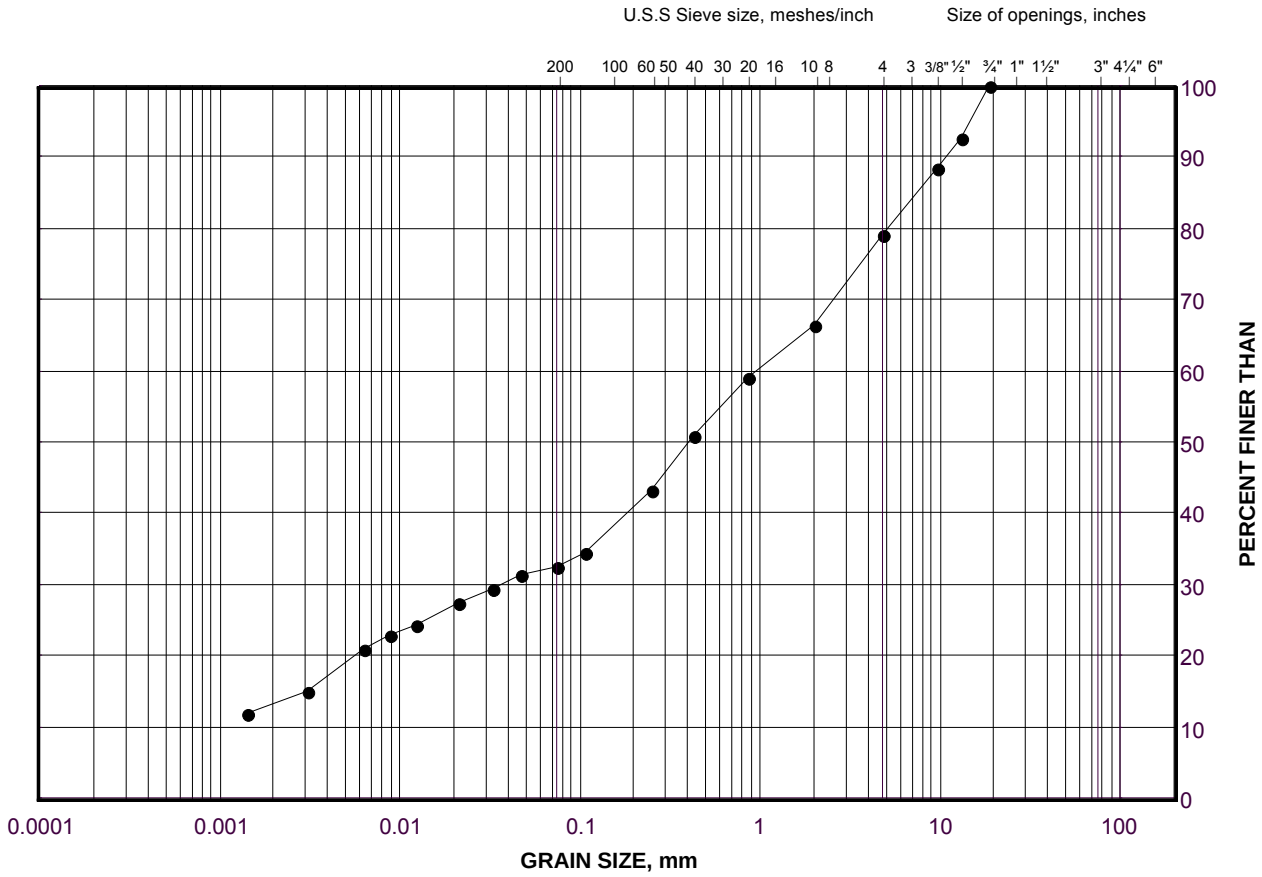
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Gravelly Silty Clay with Sand (FILL)

FIGURE B4



LEGEND

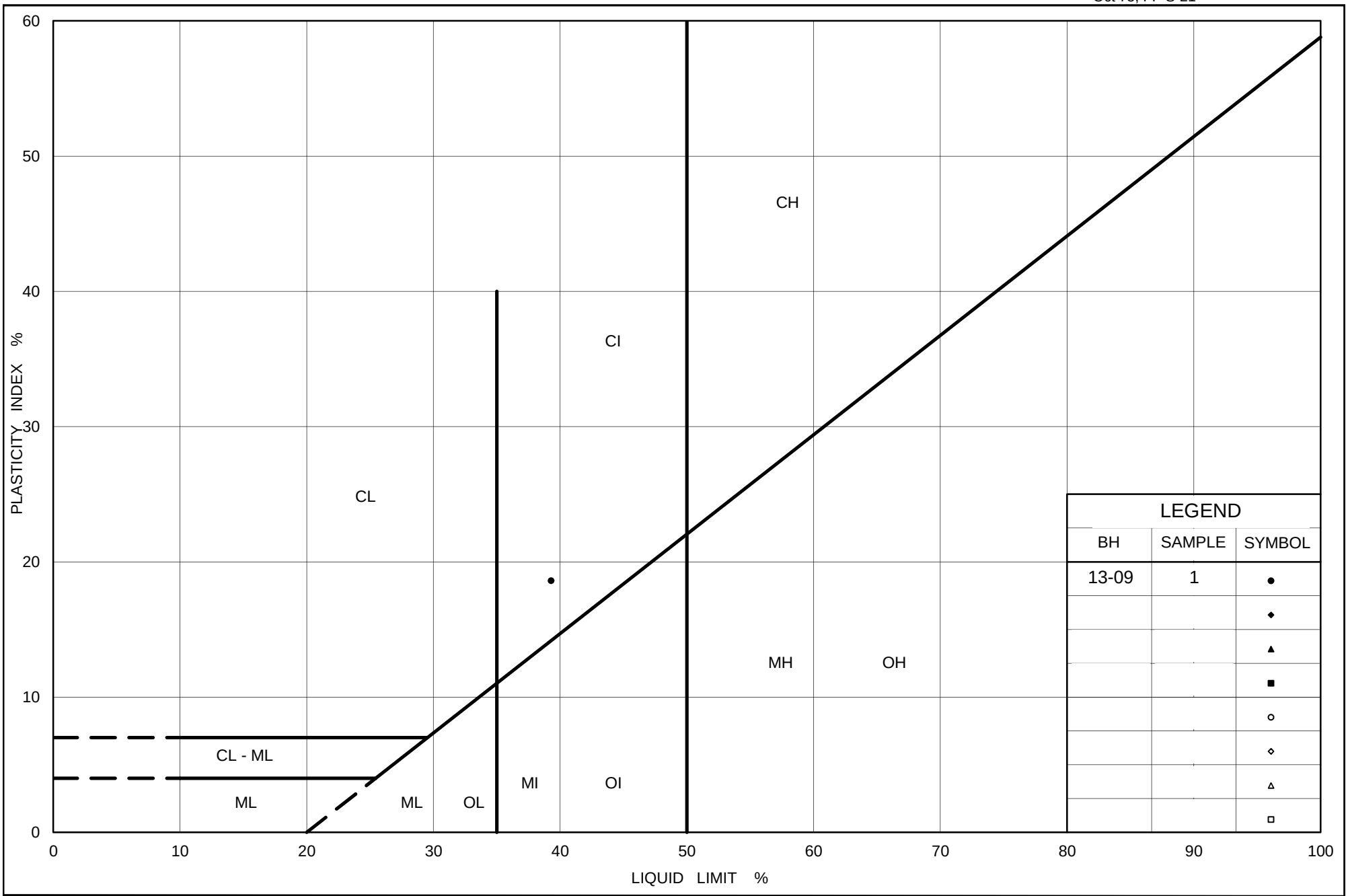
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-09	1	77.5

Project Number: 11-1111-0115

Checked By: MWK

Golder Associates

Date: 19-Nov-13



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay (FILL)

Figure No. B5

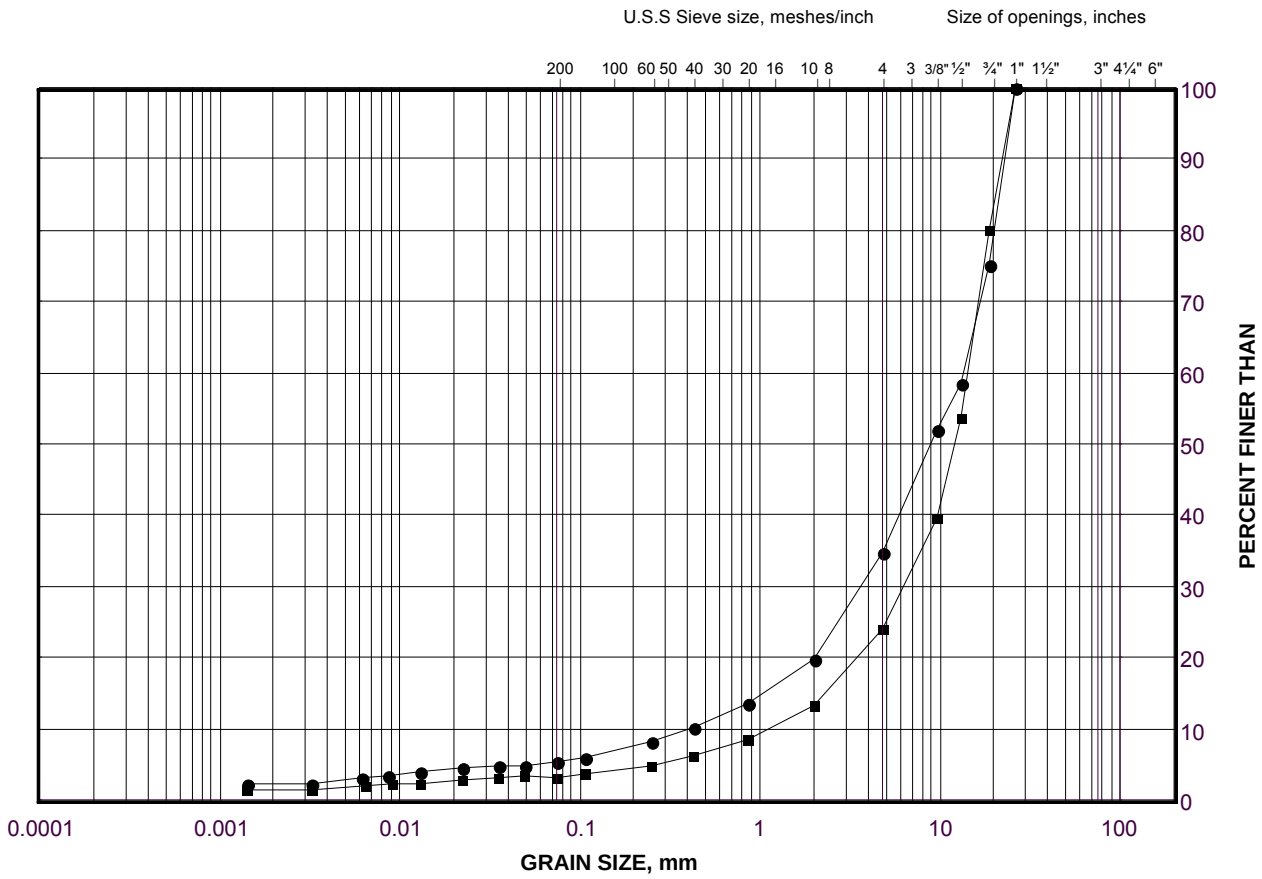
Project No. 11-1111-0115

Checked By: MWK

GRAIN SIZE DISTRIBUTION

Sandy Gravel (FILL)

FIGURE B6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-10	2	75.3
■	13-10	3	74.5

Project Number: 11-1111-0115

Checked By: MWK

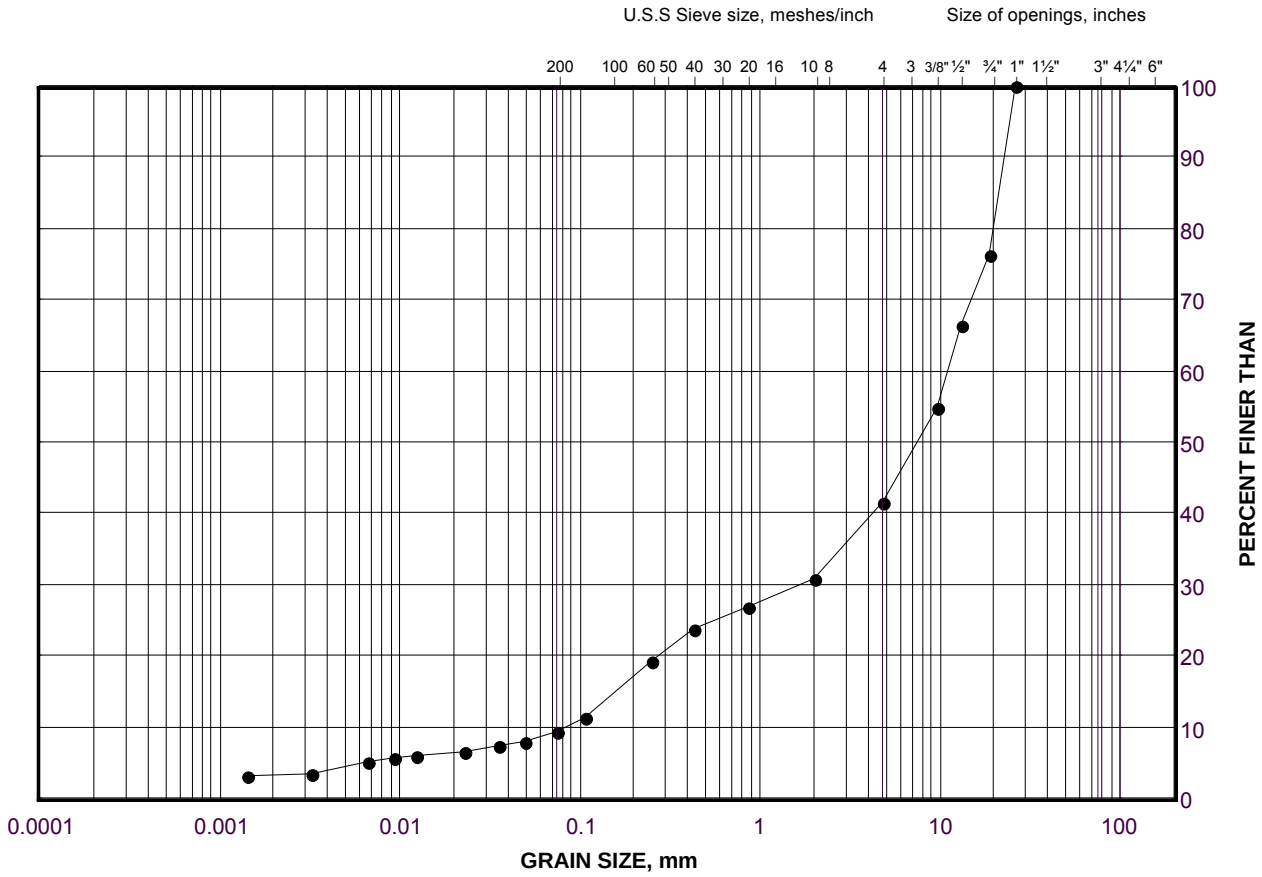
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-10	8	70.5

Project Number: 11-1111-0115

Checked By: MWK

Golder Associates

Date: 19-Nov-13

TABLE B1 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 3
BOREHOLE NUMBER	12-01	SAMPLE DEPTH, m	7.8

TEST CONDITIONS

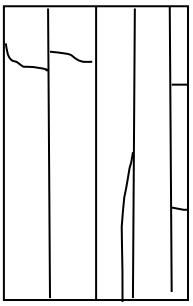
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.32

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.93	WATER CONTENT, (specimen) %	0.09
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m^3	26.44
SAMPLE AREA, cm^2	17.50	DRY UNIT WT., kN/m^3	26.42
SAMPLE VOLUME, cm^3	191.28	SPECIFIC GRAVITY	-
WET WEIGHT, g	515.95	VOID RATIO	-
DRY WEIGHT, g	515.49		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	103.0

REMARKS:

DATE: 11/12/2012

Checked By: MWK

Golder Associates

TABLE B2 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 4
BOREHOLE NUMBER	12-02A	SAMPLE DEPTH, m	7.62-7.76

TEST CONDITIONS

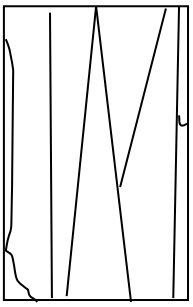
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.26

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.65	WATER CONTENT, (specimen) %	0.12
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m^3	26.23
SAMPLE AREA, cm^2	17.47	DRY UNIT WT., kN/m^3	26.20
SAMPLE VOLUME, cm^3	186.03	SPECIFIC GRAVITY	-
WET WEIGHT, g	497.76	VOID RATIO	-
DRY WEIGHT, g	497.16		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	53.5

REMARKS:

DATE: 11/15/2012

Checked By: MWK

Golder Associates

TABLE B3 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 3
BOREHOLE NUMBER	12-04	SAMPLE DEPTH, m	5.0

TEST CONDITIONS

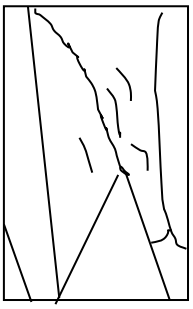
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.27

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.64	WATER CONTENT, (specimen) %	0.22
SAMPLE DIAMETER, cm	4.68	UNIT WEIGHT, kN/m^3	26.09
SAMPLE AREA, cm^2	17.23	DRY UNIT WT., kN/m^3	26.04
SAMPLE VOLUME, cm^3	183.34	SPECIFIC GRAVITY	-
WET WEIGHT, g	488.04	VOID RATIO	-
DRY WEIGHT, g	486.97		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	41.3

REMARKS:

DATE: 11/12/2012

Checked By: MWK

Golder Associates

TABLE B4 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 1
BOREHOLE NUMBER	13-02	SAMPLE DEPTH, m	12.0-12.2

TEST CONDITIONS

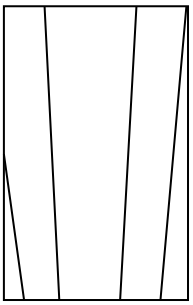
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.19

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.34	WATER CONTENT, (specimen) %	0.19
SAMPLE DIAMETER, cm	6.09	UNIT WEIGHT, kN/m^3	26.37
SAMPLE AREA, cm^2	29.08	DRY UNIT WT., kN/m^3	26.32
SAMPLE VOLUME, cm^3	387.88	SPECIFIC GRAVITY	-
WET WEIGHT, g	1043.50	VOID RATIO	-
DRY WEIGHT, g	1041.52		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	64.2

REMARKS:

DATE: 9/26/2013

Checked By: MWK

Golder Associates

TABLE B5 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 3
BOREHOLE NUMBER	13-02	SAMPLE DEPTH, m	13.8-14.0

TEST CONDITIONS

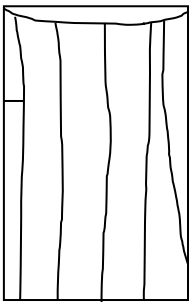
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.13

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	12.97	WATER CONTENT, (specimen) %	0.41
SAMPLE DIAMETER, cm	6.08	UNIT WEIGHT, kN/m^3	26.16
SAMPLE AREA, cm^2	29.04	DRY UNIT WT., kN/m^3	26.06
SAMPLE VOLUME, cm^3	376.66	SPECIFIC GRAVITY	-
WET WEIGHT, g	1005.30	VOID RATIO	-
DRY WEIGHT, g	1001.20		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	8.6

REMARKS:

DATE: 9/26/2013

Checked By: MWK

Golder Associates

TABLE B6 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 1
BOREHOLE NUMBER	13-03	SAMPLE DEPTH, m	12.5-12.7

TEST CONDITIONS

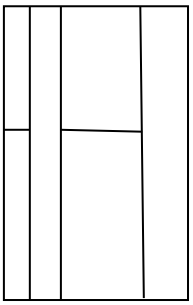
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.16

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.16	WATER CONTENT, (specimen) %	0.12
SAMPLE DIAMETER, cm	6.09	UNIT WEIGHT, kN/m^3	26.33
SAMPLE AREA, cm^2	29.13	DRY UNIT WT., kN/m^3	26.30
SAMPLE VOLUME, cm^3	383.19	SPECIFIC GRAVITY	-
WET WEIGHT, g	1029.10	VOID RATIO	-
DRY WEIGHT, g	1027.87		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	55.0

REMARKS:

DATE: 9/26/2013

Checked By: MWK

Golder Associates

TABLE B7 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 3
BOREHOLE NUMBER	13-03	SAMPLE DEPTH, m	15.0-15.2

TEST CONDITIONS

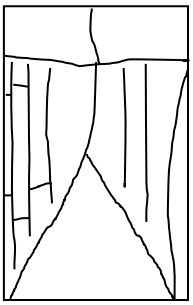
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.18

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.29	WATER CONTENT, (specimen) %	0.15
SAMPLE DIAMETER, cm	6.09	UNIT WEIGHT, kN/m^3	26.52
SAMPLE AREA, cm^2	29.13	DRY UNIT WT., kN/m^3	26.48
SAMPLE VOLUME, cm^3	387.15	SPECIFIC GRAVITY	-
WET WEIGHT, g	1047.30	VOID RATIO	-
DRY WEIGHT, g	1045.73		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	106.1

REMARKS:

DATE: 9/26/2013

Checked By: MWK

Golder Associates

TABLE B8 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 3
BOREHOLE NUMBER	13-09	SAMPLE DEPTH, m	4.63-4.83

TEST CONDITIONS

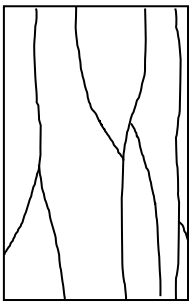
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.27

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.75	WATER CONTENT, (specimen) %	0.23
SAMPLE DIAMETER, cm	4.73	UNIT WEIGHT, kN/m^3	26.42
SAMPLE AREA, cm^2	17.57	DRY UNIT WT., kN/m^3	26.36
SAMPLE VOLUME, cm^3	188.90	SPECIFIC GRAVITY	-
WET WEIGHT, g	509.05	VOID RATIO	-
DRY WEIGHT, g	507.88		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	70.9

REMARKS:

DATE: 10/28/2013

Checked By: MWK

Golder Associates

TABLE B9
Field Estimation of Rock Hardness
(Representation of Intact Rock Strength)

Grade	Description	Field Identification	Approx. Range of UCS (MPa)
R0	Extremely weak rock	Indented by thumbnail.	0.25 – 1
R1	Very weak rock	Material can be shaped with a pocket knife or can be peeled by a pocket knife. Crumbles under firm blows of pick (or point) of geological hammer.	1.0 – 5.0
R2	Weak rock	Knife cuts material but too hard to shape into triaxial specimens or material can be peeled by a pocket knife with difficulty. Shallow indentations (< 5 mm) made by firm blow with pick (or point) of geological hammer.	5.0 – 25
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife. Hand held specimens can be fractured with *single* firm blow of geological hammer.	25 – 50
R4	Strong rock	Hand held a specimen requires *more than one* blow of geological hammer to fracture it.	50 – 100
R5	Very strong rock	Specimen requires many blows of geological hammer to break intact rock specimens (or to fracture it).	100 – 250
R6	Extremely strong rock	Specimen can only be chipped under repeated hammer blows, rings when hit.	> 250

NOTES:

1. Hand held specimens should have height ≅ 2 times the diameter.
2. Materials having a uniaxial compressive strength (UCS) of less than about 0.5 MPa and cohesionless materials should be classified using soil classification systems.
3. Rocks with a uniaxial compressive strength below 25 MPa (i.e., below R2) are likely to yield highly ambiguous results under point load testing.

REFERENCES:

1. Brown (1981). “Suggested Methods for Rock Characterization Testing and Monitoring”, International Society for Rock Mechanics.

2. Hoek, E., Kaiser, P.K., Bawden, W.F. (1995). “Support of Underground Excavations in Hard Rock”, Balkema, Rotterdam.

TABEL B10 - POINT LOAD TEST RESULTS ON ROCK SAMPLES

PROJECT NO.	11-1111-0115
TITLE	URS / Ferry Terminals / Amhearst Island
DATE	November, 2012

Borehole Number	Sample Number	Sample Depth (m)	Test Type	Core Length (mm)	Core [2] Diameter (mm)	Equivalent Diameter (mm)	Ram Pressure (kPa)	Load (P) (kN)	Is Axial (MPa)	Is Diametral (MPa)	**Is (50mm)** (MPa)	**Approx. [1] UCS** (MPa)
12-01	Run 2	6.3	A	25.18	47.22	38.91	7,080	6.71	4.434	-	3.960	55
12-01	Run 2	7.0	D	106.31	39.75	-	11,760	11.15	-	7.056	6.364	89
12-01	Run 3	8.2	A	21.68	47.16	36.08	6,420	6.09	4.675	-	4.037	57
12-02A	Run 3	6.1	A	24.74	47.13	38.53	7,080	6.71	4.521	-	4.021	56
12-02A	Run 3	7.1	D	100.58	39.87	-	11,960	11.34	-	7.133	6.442	90
12-02A	Run 4	8.4	A	25.29	47.20	38.99	12,420	11.77	7.747	-	6.926	97
12-04	Run 2	4.5	D	92.88	42.44	-	11,960	11.34	-	6.295	5.847	82
12-04	Run 3	5.2	A	22.68	46.91	36.81	8,940	8.48	6.257	-	5.451	76
12-04	Run 4	7.1	A	24.45	46.93	38.22	9,760	9.25	6.333	-	5.612	79
13-02	Run 1	11.8	A	23.84	60.83	42.97	15,500	14.69	7.958	-	7.434	104
13-02	Run 2	13.1	A	29.51	60.78	47.79	14,900	14.13	6.185	-	6.061	85
13-02	Run 3	15.1	A	28.11	60.83	46.66	6,760	6.41	2.944	-	2.853	40
13-03	Run 2	12.9	A	27.23	60.84	45.93	11,160	10.58	5.016	-	4.828	68
13-03	Run 2	13.8	A	25.58	60.85	44.52	11,520	10.92	5.511	-	5.230	73
13-03	Run 3	14.6	A	27.03	60.91	45.78	7,940	7.53	3.591	-	3.451	48
13-09	Run 3	4.9	A	20.14	47.44	34.88	4,300	4.08	3.351	-	2.850	40
13-09	Run 3	5.5	A	15.86	47.46	30.96	7,100	6.73	7.023	-	5.660	79
13-09	Run 3	5.2	A	21.65	47.28	36.10	4,980	4.72	3.622	-	3.129	44
13-10	Run 1	6.4	A	20.08	47.45	34.83	4,540	4.30	3.548	-	3.015	42
13-10	Run 2	8.2	A	23.05	47.38	37.29	3,900	3.70	2.659	-	2.330	33
13-10	Run 3	9.0	A	23.18	47.40	37.40	9,420	8.93	6.384	-	5.602	78

(1) Is_{50} x C, from ISRM "Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.
C=14, calculated from Is_{50} average (8 tests) equal to 4.4 MPa on axial orientation and UCS average equal to 62.9 MPa (8 tests)
(2) Actual distance between point load cones at time of failure.

APPENDIX C

Record of Boreholes and Drillholes – Stella Terminal

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
FoS	factor of safety

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	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_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (compressive strength)/2

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
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic 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, 60º 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 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (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

(b) Cohesive Soils

Consistency

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

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.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel / Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

JN Joint
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

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RECORD OF BOREHOLE No 12-07

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4892481.7 ;E 288555.8 ORIGINATED BY MS/DM
DIST HWY 33 BOREHOLE TYPE CME-55 Track Mounted COMPILED BY MWK
DATUM Geodetic DATE September 14, 2012 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
74.2	WATER SURFACE										
0.0	Water						74				
							73				
							72				
							71				
69.9							70				
4.3	Sand and gravel to gravel, trace to some sand, trace silt, containing concrete fragments (FILL) Compact Grey		1	SS	21				○		82 17 (1)
68.3							69				
5.9	LIMESTONE (BEDROCK) Bedrock cored from 5.9 m to 8.5 m depth. Refer to Record of Drillhole 12-07 for bedrock coring details.		1	RC	REC 71%		68				RQD = 0%
			2	RC	REC 37%		67				RQD = 7%
65.7			3	RC	REC 13%		66				RQD = 0%
8.5	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 11-1111-0115.GPJ GAL-GTA.GDT 1/10/14

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 12-07

SHEET 1 OF 1

LOCATION: N 4892481.7 ;E 288555.8

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		68.33																	
6	NQ Rock Core / NW Casing	LIMESTONE, thinly bedded, fine grained, laminated Slightly to moderately weathered Grey Weak to medium strong		5.87	1		100														
				67.72																	
7		LIMESTONE, thinly bedded, fine grained, laminated, highly fractured Slightly to highly weathered Grey Strong		6.48	2		0												•		(Axial)
8																			•		(Axial)
					3		0														
				65.70																	
		END OF DRILLHOLE		8.50																	
9																					
10																					
11																					
12																					
13																					
14																					
15																					

DEPTH SCALE
1 : 50

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LOGGED: MS/DM

CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 12-08

SHEET 1 OF 1

METRIC

PROJECT 11-1111-0115
G.W.P. 4067-09-00
LOCATION N 4892485.0 ;E 288581.7
ORIGINATED BY MS/DM
DIST HWY 33
BOREHOLE TYPE CME-55 Barge Mounted, NW Casing
COMPILED BY MWK
DATUM Geodetic
DATE September 14, 2012
CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
74.4	WATER SURFACE										
0.0	Water						74				
							73				
							72				
71.6											
71.3	Sand and Gravel, some silt, trace clay, containing organics and shell fragments Compact Grey Wet		1	SS	16				○		46 36 16 2
3.1	SHALEY LIMESTONE (BEDROCK) Bedrock cored from 3.1 m to 7.7 m depth. Refer to Record of Drillhole 12-08 for bedrock coring details.		1	NQ	REC 100%		71				RQD = 0%
			2	NQ	REC 100%		70				RQD = 29%
			3	NQ	REC 98%		69				RQD = 32%
							68				
66.7							67				
7.7	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 12-08

SHEET 1 OF 1

LOCATION: N 4892485.0 ;E 288581.7

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		71.28																		
4	NQ Rock Core / NW Casing	SHALEY LIMESTONE, fine grained, laminated, slightly porous Slightly weathered to fresh Grey Medium strong to strong		3.12	1																	(Axial)
5					2																8.113	
6																						
7				66.68	3																	UCS = 44.5 MPa
		END OF DRILLHOLE		7.72																		
8																						
9																						
10																						
11																						
12																						
13																						

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE

1 : 50

LOGGED: MS/DM

CHECKED: JPD

Golder Associates

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-05

SHEET 1 OF 2

METRIC

PROJECT 11-1111-0115

G.W.P. 4067-09-00 LOCATION N 4892500.9 ;E 288505.2 ORIGINATED BY PH

DIST HWY 33 BOREHOLE TYPE CME-75 Barge Mounted, NW Casing COMPILED BY MWK

DATUM Geodetic DATE August 14, 2013 CHECKED BY JPD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
75.0	WATER SURFACE										
0.0	Water										
							74				
							73				
							72				
							71				
							70				
							69				
							68				
							67				
							66				
							65				
							64				
							63				
							62				
							61				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 13-05

SHEET 2 OF 2 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4892500.9 ;E 288505.2 ORIGINATED BY PH
DIST HWY 33 BOREHOLE TYPE CME-75 Barge Mounted, NW Casing COMPILED BY MWK
DATUM Geodetic DATE August 14, 2013 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
59.3	Water										
15.7	CLAYEY ORGANIC SILT, gravelly, trace to some sand, containing shells Very soft		1	SS	WR		59		172.8		23 10 31 36
57.6							58				
17.5	Sandy gravel to SAND and GRAVEL, some silt Compact Grey		2	SS	28		57				64 25 9 2
56.4											
18.6	LIMESTONE (BEDROCK) Bedrock cored from 18.6 m to 22.5 m depth. Refer to Record of Drillhole 13-05A for bedrock coring details.		1	HQ	REC 85%		56				RQD = 0%
			2	HQ	REC 75%						RQD = 25%
			3	HQ	REC 62%		55				RQD = 21%
			4	HQ	REC 92%		54				RQD = 29%
52.5							53				
22.5	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 11-1111-0115.GPJ GAL-GTA.GDT 1/10/14

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-05A

SHEET 1 OF 1

LOCATION: N 4892500.9 ;E 288505.2

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Canadian Soil Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH / COLOUR / % RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		56.29																	
19	HQ Rock Core / HW Casing	LIMESTONE, with thin interbeds of weak to very black shale Fresh Very thinly bedded to laminated Dark grey Fine to medium grained Weak to strong Moderately fossiliferous		18.71	1		100														
20					2		100														
					3		100							BD,W,Ro JN,W,Ro JN,W,SM JN,W,Ro JN,W,Ro BD,W,SM JN,W,SM D,W,Ro							
21																			4		(Axial)
																				8.209	(Axial)
					4		100							JN,W,Ro JN,W,Ro							
22														BD,W,Ro BD,W,SM BD,W,SM							UCS=22.8 MPa
				52.52																	
		END OF DRILLHOLE NOTE: Drillhole 13-05A advanced immediately adjacent to borehole 13-05 due to difficulties in advancing drillhole 13-05		22.48																	
23																					
24																					
25																					
26																					
27																					
28																					

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PH
CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-06

SHEET 1 OF 2

METRIC

PROJECT 11-1111-0115

G.W.P. 4067-09-00 LOCATION N 4892502.8 ;E 288538.4 ORIGINATED BY PH

DIST HWY 33 BOREHOLE TYPE CME-75 Barge Mounted, NW Casing COMPILED BY MWK

DATUM Geodetic DATE August 15, 2013 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
74.9	WATER SURFACE										
0.0	Water						74				
							73				
							72				
							71				
							70				
							69				
							68				
							67				
							66				
							65				
63.8							64				
63.5	CLAYEY ORGANIC SILT, containing shells										
11.4	Sandy gravel, trace to some silt, trace clay Dense Grey Wet		1	SS	32		63		○		67 23 8 2
62.6											
12.3	LIMESTONE (BEDROCK) Bedrock cored from 12.5 m to 16.3 m depth. Refer to Record of Drillhole 13-06 for bedrock coring details.		1	HQ	REC 100%		62				RQD = 88%
			2	HQ	REC 97%		61				RQD = 54%
				RC			60				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 13-06

SHEET 2 OF 2 **METRIC**

PROJECT 11-1111-0115
G.W.P. 4067-09-00 LOCATION N 4892502.8 ;E 288538.4 ORIGINATED BY PH
DIST HWY 33 BOREHOLE TYPE CME-75 Barge Mounted, NW Casing COMPILED BY MWK
DATUM Geodetic DATE August 15, 2013 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	LIMESTONE (BEDROCK) Bedrock cored from 12.5 m to 16.3 m depth. Refer to Record of Drillhole 13-06 for bedrock coring details.		3	HQ RC	REC 98% REC %		59				RQD = 86%
58.6 16.3	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-06

SHEET 1 OF 1

LOCATION: N 4892502.8 ;E 288538.4

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-75

DRILLING CONTRACTOR: Canadian Soil Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		62.40																	
13	HQ Rock Core / HW Casing	LIMESTONE with laminated to very thinly bedded black shale Fresh Thin to medium beds Grey Fine to medium grain Strong Moderately fossiliferous		12.50	1		100							JN,PL,SM BR,, JN,W,Ro BD,PL,SM JN,W,Ro ,,							
14					2		100							BD,W,Ro BD,PL,SM ,, BD,PL,SM BD,PL,SM ,, JN,W,Ro ,, JN,W,Ro JN,W,SM JN,W,Ro JN,W,Ro ,, BR,, JN,,							(Axial) UCS=98.1 MPa (Axial)
15					3		100							,, ,W,SM ,, ,W,SM							UCS=72.5 MPa
16				58.60										,W,SM ,,							(Axial)
		END OF DRILLHOLE		16.30																	
17																					
18																					
19																					
20																					
21																					
22																					

DEPTH SCALE
1 : 50

LOGGED: PH
CHECKED: JPD

Golder Associates

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-11

SHEET 1 OF 1

METRIC

PROJECT 11-1111-0115

G.W.P. 4067-09-00 LOCATION N 4892471.8 ;E 288553.2 ORIGINATED BY TWB

DIST HWY 33 BOREHOLE TYPE CME-55 Track Mounted COMPILED BY MWK

DATUM Geodetic DATE October 23, 2013 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
76.4	GROUND SURFACE										
0.0	Sand and gravel, trace to some sand, trace Clay, containing pockets of clayey silt (FILL) Compact Brown Moist		1	SS	25		76		○		
			2	SS	16						57 31 8 4
74.7							75				
1.7	Sandy gravel, trace silt, trace clay (FILL) Loose Brown Wet		3	SS	7	▽			○		
73.7			4A 4B	SS	4		74				69 28 1 2
2.7	WOOD fragments (EXISTING CRIBWORK)		5	SS	15		73				
			6	SS	55						
71.2			7	SS	5		72				
5.2	Sandy gravel, trace to some silt, trace clay, trace organics Compact Dark grey Wet		8	SS	22		71		○		65 25 7 3
70.5											
5.9	GRAVEL, some sand, some silt, trace clay, containing rock fragments Very dense Dark grey Wet		9	SS	50/ .08				○		
69.9							70				
6.5	LIMESTONE (BEDROCK) Bedrock cored from 6.5 m to 9.9 m depth. Refer to Record of Drillhole 13-11 for bedrock coring details.		1	RC	REC 100%						RQD = 0%
			2	RC	REC 100%		69				RQD = 31%
							68				
66.5			3	RC	REC 100%		67				RQD = 18%
9.9	END OF BOREHOLE NOTE: 1. Water encountered during drilling at a depth of 1.7 m (Elev. 74.7 m) below ground surface.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 11-1111-0115.GPJ GAL-GTA.GDT 1/10/14

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-11

SHEET 1 OF 1

LOCATION: N 4892471.8 ;E 288553.2

DRILLING DATE: October 23, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		69.86																		
7	NQ ROCK CORING October 23, 2013	LIMESTONE with shale interbeds Slightly weathered to fresh Laminated Grey Fine grained, slightly porous Medium strong to strong		6.50	1			100							BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO							8.142(axial)
8					2			100							JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,SM BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO							(axial)
9					3			100							JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO							(axial)
				66.46																		
10		END OF BOREHOLE		9.90											BD,UN,SM BD,UN,RO BD,UN,RO JN,UN,RO JN,UN,RO BD,UN,RO							
11																						
12																						
13																						
14																						
15																						
16																						

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TWB
CHECKED: JPD

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

Golder Associates

RECORD OF BOREHOLE No 13-12

SHEET 1 OF 1

METRIC

PROJECT 11-1111-0115

G.W.P. 4067-09-00 LOCATION N 4892412.9 ;E 288585.6 ORIGINATED BY TWB

DIST HWY 33 BOREHOLE TYPE CME-55 Track Mounted COMPILED BY MWK

DATUM Geodetic DATE October 23, 2013 CHECKED BY JPD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
76.4	GROUND SURFACE										
0.0	TOPSOIL										
0.2	Clayey silt with sand and gravel, trace roots and rootlets (FILL) Very stiff Brown Moist		1	SS	20		76		○		40 31 19 10
75.5			2	SS	50/ .08						
75.2	Gravel, some sand to sandy, some silt, trace clay, trace rootlets (FILL) Brown Moist		1	RC	REC 100%						RQD = 0%
1.2	LIMESTONE (BEDROCK) Bedrock cored from 1.2 m to 4.4 m depth. Refer to Record of Drillhole 13-12 for bedrock coring details.		2	RC	REC 100%		75				RQD = 12%
							74				
			3	RC	REC 100%		73				RQD = 13%
72.0											
4.4	END OF BOREHOLE										

NOTES:

1. Borehole dry upon completion of overburden drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 11-1111-0115

RECORD OF DRILLHOLE: 13-12

SHEET 1 OF 1

LOCATION: N 4892412.9 ;E 288585.6

DRILLING DATE: October 24, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		75.24																	
2	NQ ROCK CORING October 24, 2013	LIMESTONE with shale interbeds Slightly weathered to fresh Laminated Grey Fine grained, slightly porous Strong to very strong Highly weathered shale seam at 2.3 m depth		1.20	1		100							JN,UN,RO JN,UN,RO JN,UN,RO JN,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO JN,UN,RO JN,UN,RO JN,UN,RO						UCS=73.8MPa (axial)
					2		100														
3					3		100														(axial) 9.512(axial)
4				72.04																	
		END OF BOREHOLE		4.40										BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO JN,UN,VRO BD,UN,RO JN,UN,RO JN,UN,RO BD,UN,RO JN,UN,RO BD,UN,RO						
5																					
6																					
7																					
8																					
9																					
10																					
11																					

GTA-RCK 004 11-1111-0115.GPJ GAL-MISS.GDT 1/10/14

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TWB
CHECKED: JPD

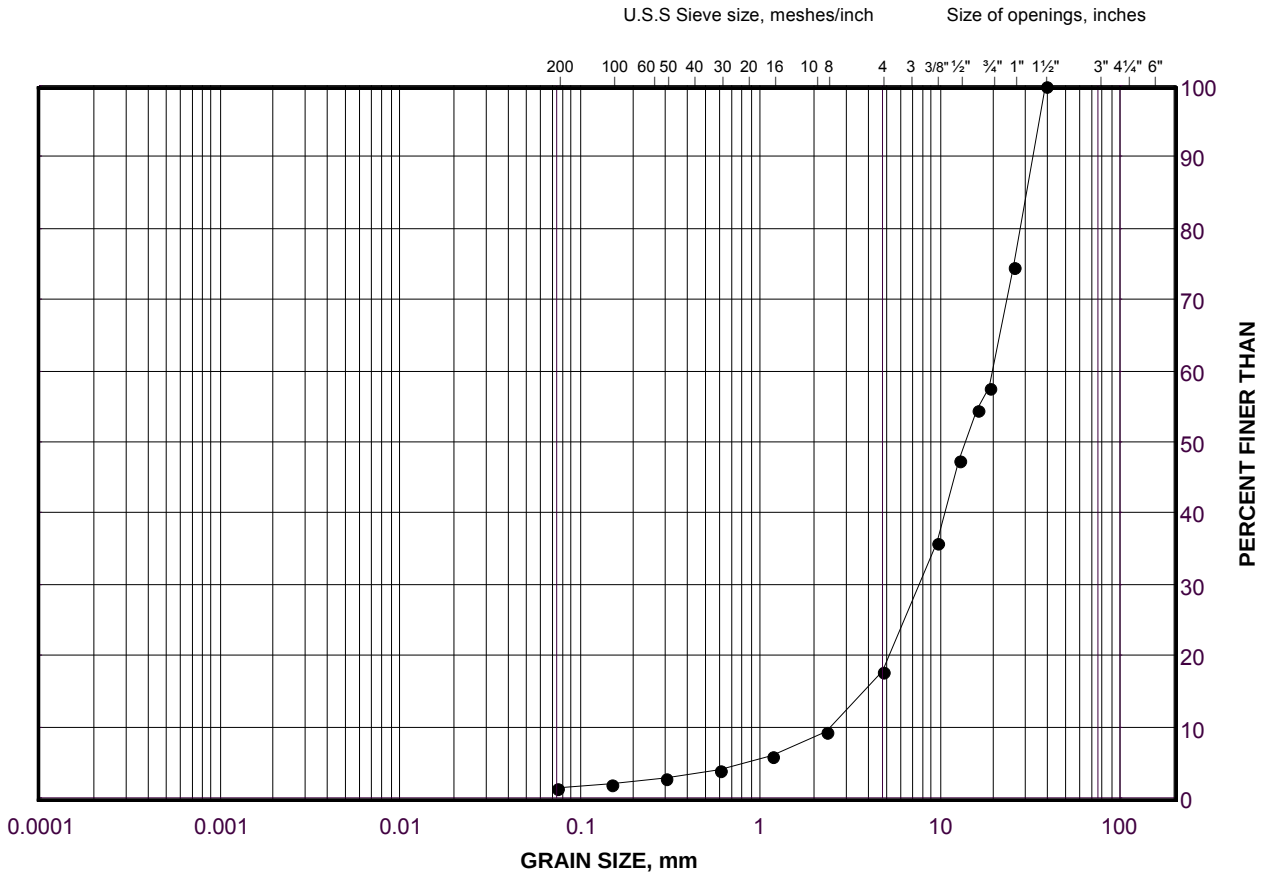
APPENDIX D

Laboratory Test Results – Stella Terminal

GRAIN SIZE DISTRIBUTION

Gravel (FILL)

FIGURE D1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-07	1	69.4

Project Number: 11-1111-0115

Checked By: MWK

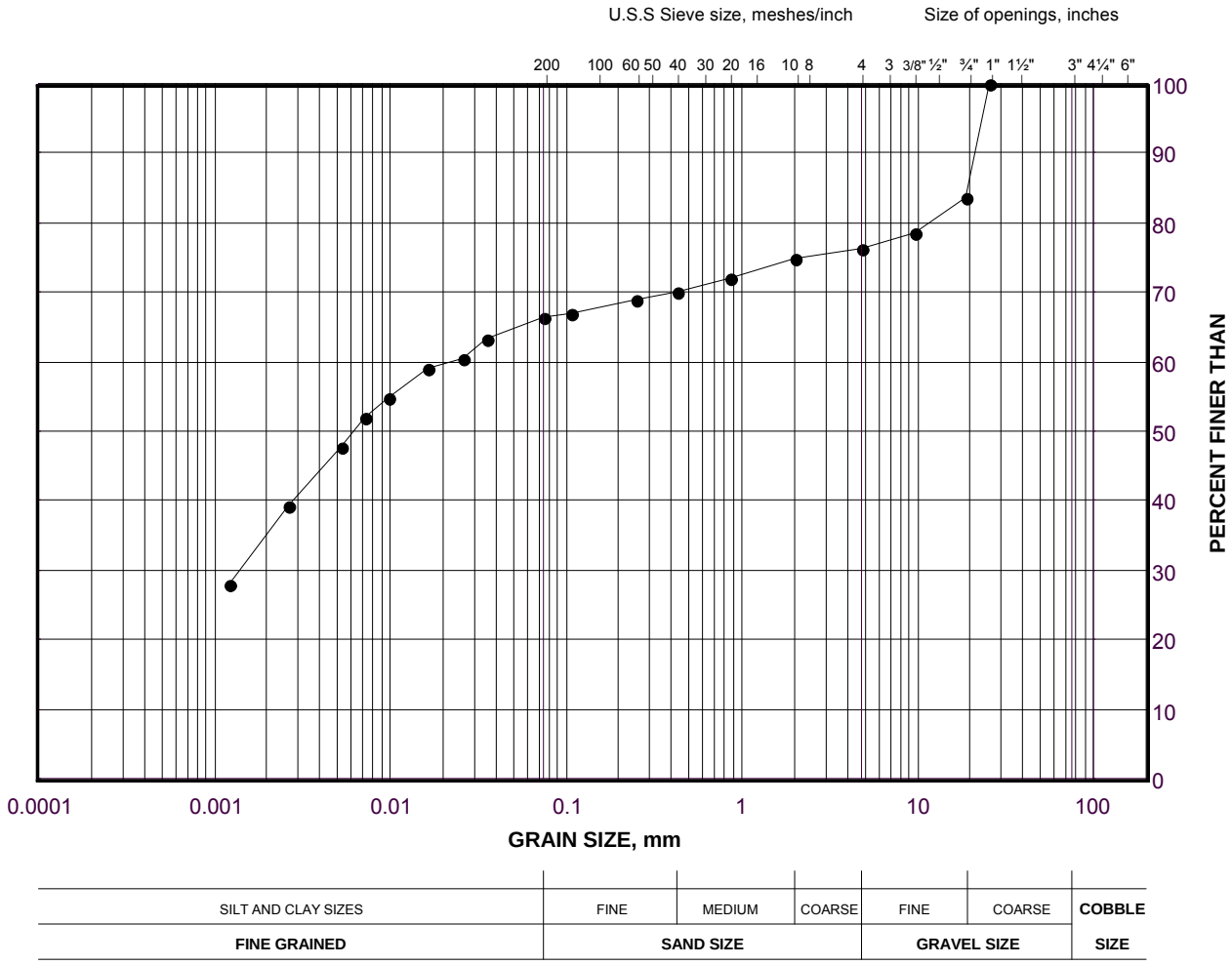
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Clayey Organic Silt

FIGURE D2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-05	1	58.9

Project Number: 11-1111-0115

Checked By: MWK

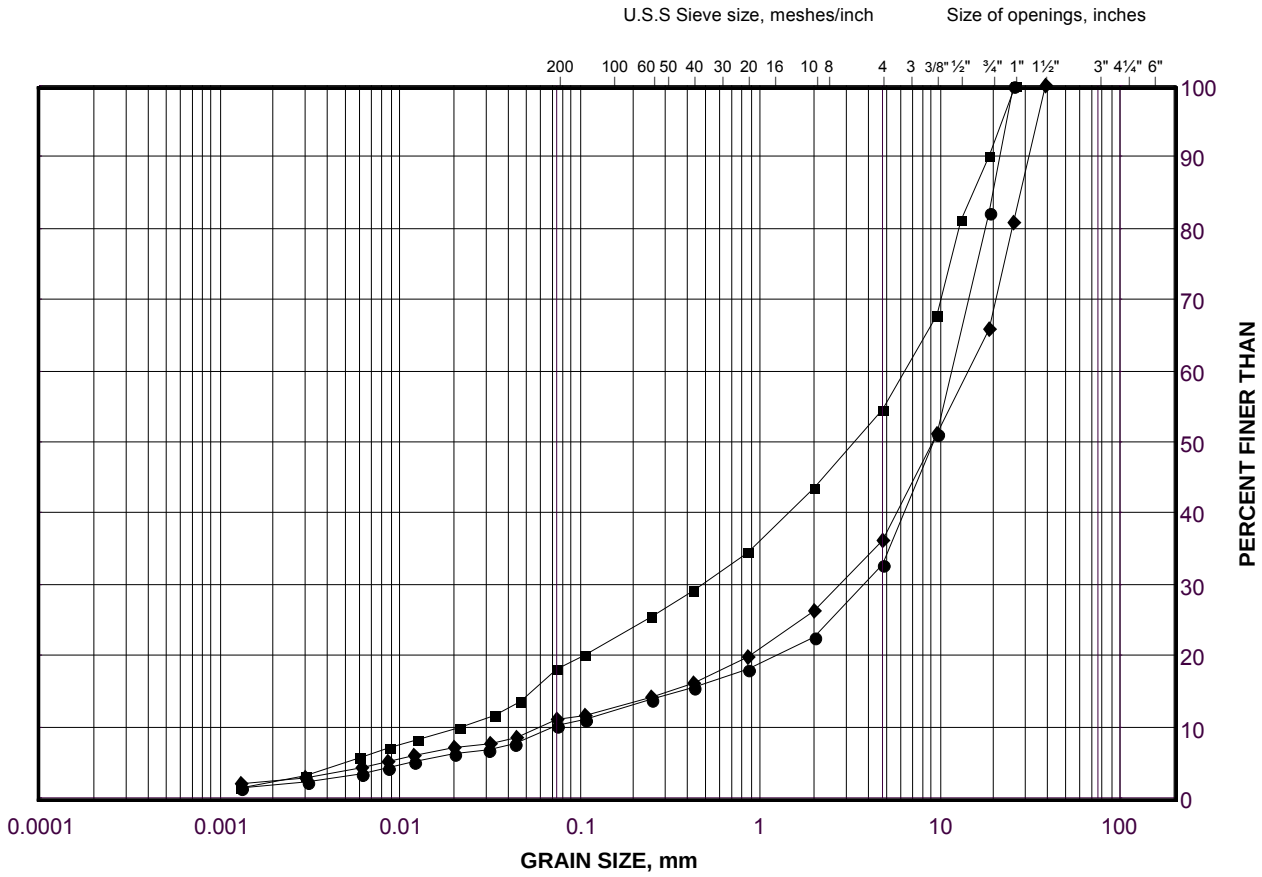
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Sand and Gravel to Sandy Gravel

FIGURE D3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-06	1	63.3
■	12-08	1	71.4
◆	13-05	2	57.2

Project Number: 11-1111-0115

Checked By: MWK

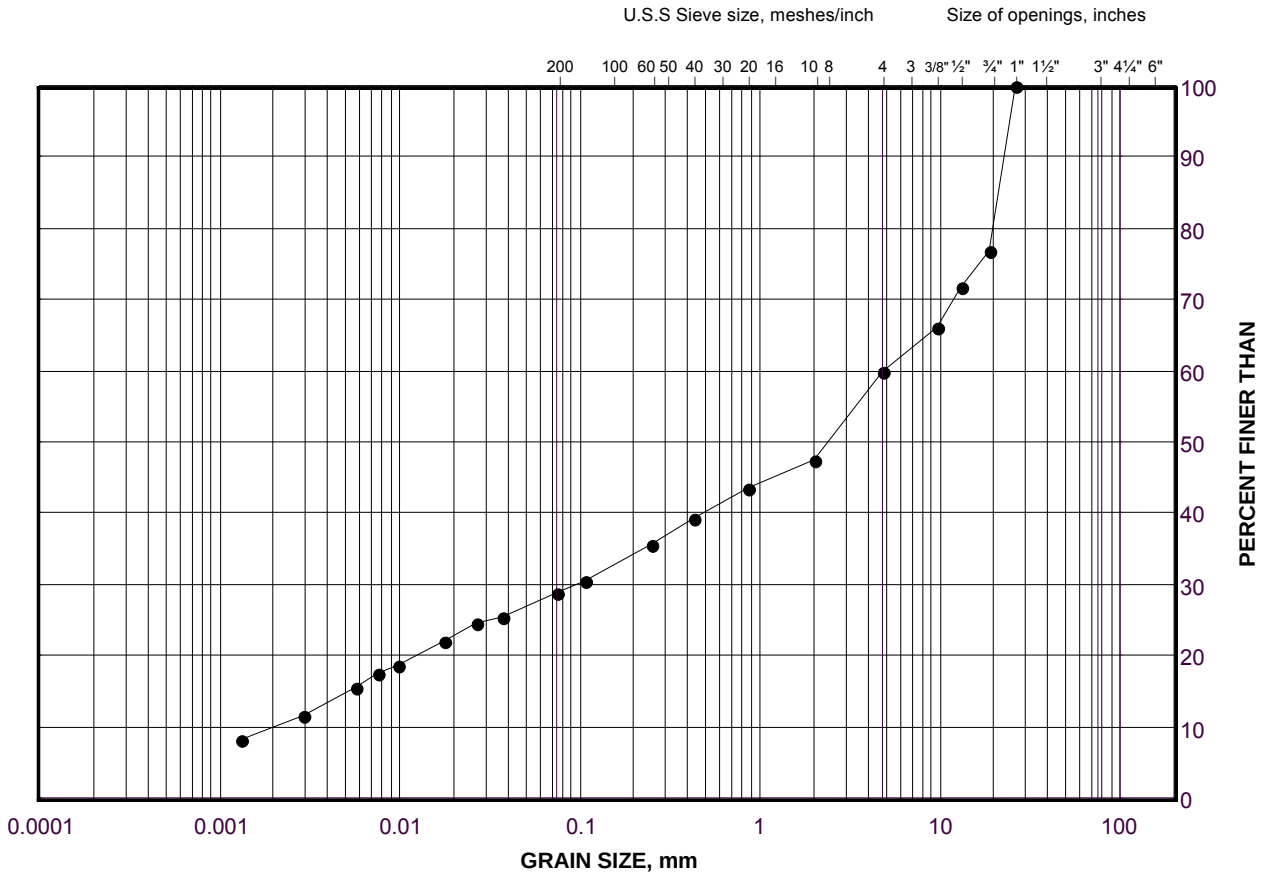
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Clayey Silt (FILL)

FIGURE D4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-12	1	76.1

Project Number: 11-1111-0115

Checked By: MWK

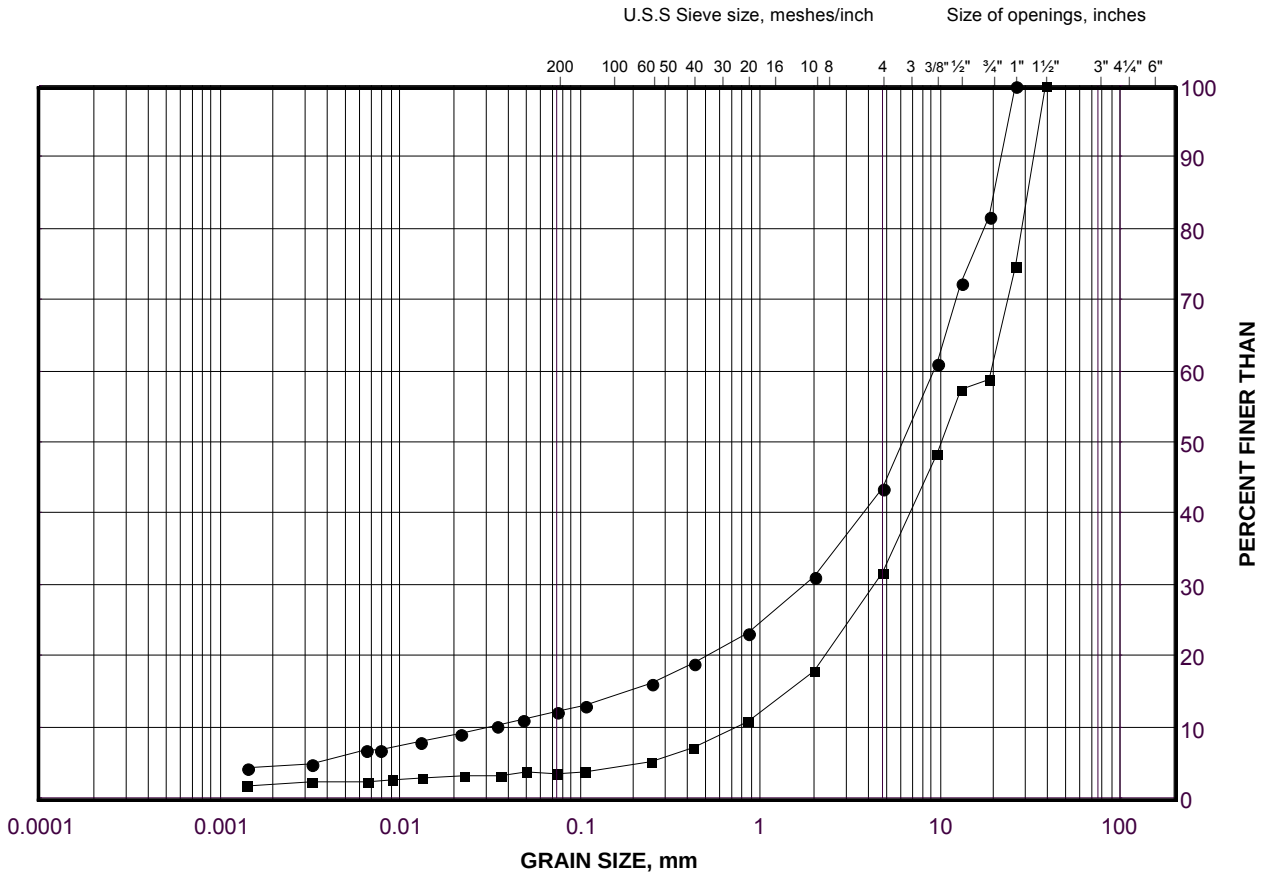
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Sand and Gravel to Sandy Gravel (FILL)

FIGURE D5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-11	2	75.3
■	13-11	4A	73.9

Project Number: 11-1111-0115

Checked By: MWK

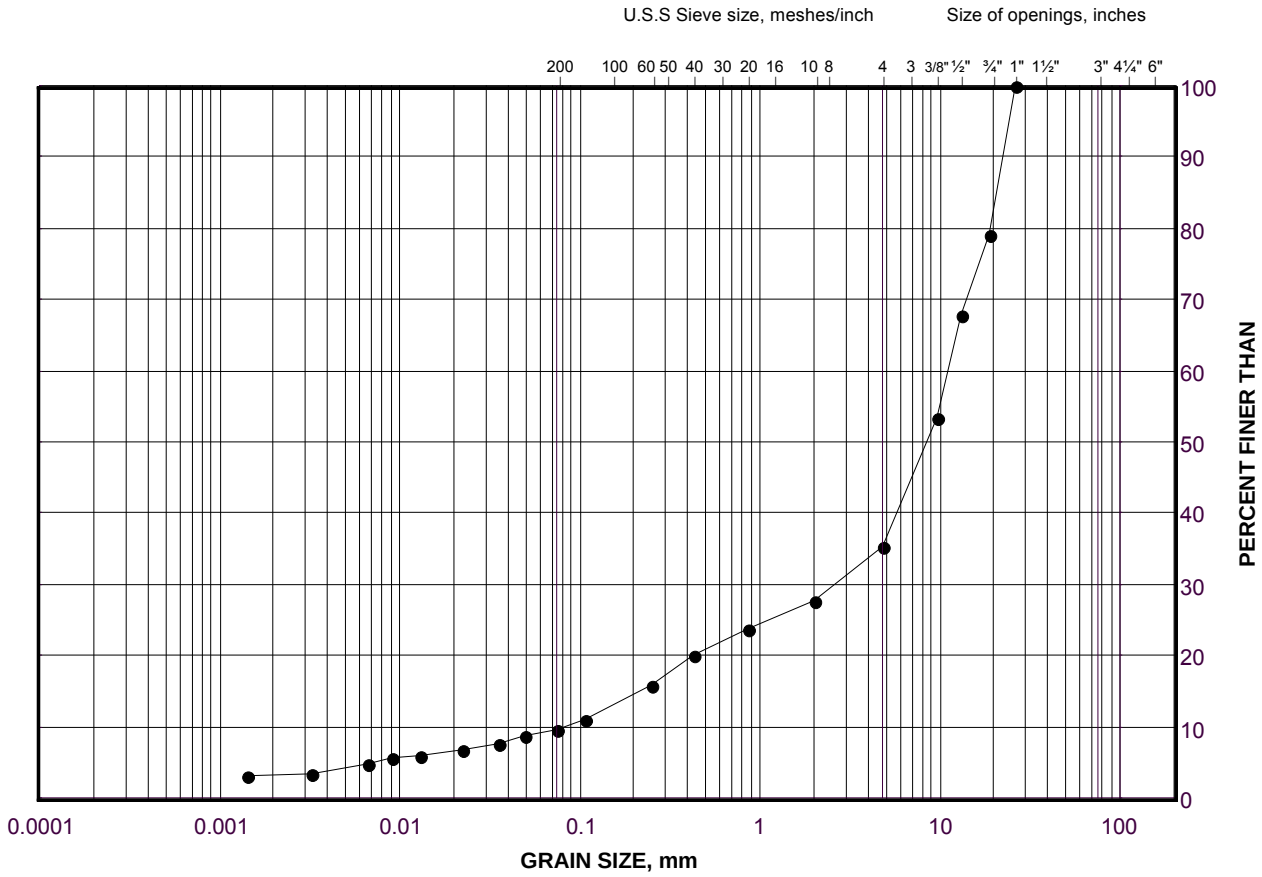
Golder Associates

Date: 19-Nov-13

GRAIN SIZE DISTRIBUTION

Sandy Gravel

FIGURE D6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-11	8	70.8

Project Number: 11-1111-0115

Checked By: MWK

Golder Associates

Date: 19-Nov-13

TABLE D1 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 3
BOREHOLE NUMBER	12-08	SAMPLE DEPTH, m	7.5

TEST CONDITIONS

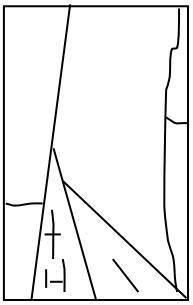
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.24

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.59	WATER CONTENT, (specimen) %	0.20
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m^3	25.91
SAMPLE AREA, cm^2	17.50	DRY UNIT WT., kN/m^3	25.86
SAMPLE VOLUME, cm^3	185.33	SPECIFIC GRAVITY	-
WET WEIGHT, g	489.89	VOID RATIO	-
DRY WEIGHT, g	488.91		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	44.5

REMARKS:

DATE: 11/12/2012

Checked By: MWK

Golder Associates

TABLE D2 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 4
BOREHOLE NUMBER	13-05A	SAMPLE DEPTH, m	22.2-22.4

TEST CONDITIONS

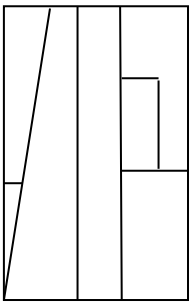
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.13

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.43	WATER CONTENT, (specimen) %	0.33
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m^3	26.09
SAMPLE AREA, cm^2	31.27	DRY UNIT WT., kN/m^3	26.01
SAMPLE VOLUME, cm^3	419.85	SPECIFIC GRAVITY	-
WET WEIGHT, g	1117.60	VOID RATIO	-
DRY WEIGHT, g	1113.92		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	22.8

REMARKS:

DATE: 9/26/2013

Checked By: MWK

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TABLE D3 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 2
BOREHOLE NUMBER	13-06	SAMPLE DEPTH, m	14.1-14.3

TEST CONDITIONS

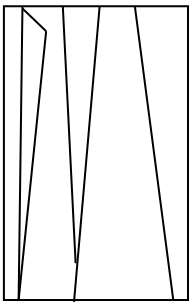
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	1.71

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.81	WATER CONTENT, (specimen) %	0.14
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m^3	26.47
SAMPLE AREA, cm^2	31.29	DRY UNIT WT., kN/m^3	26.43
SAMPLE VOLUME, cm^3	338.10	SPECIFIC GRAVITY	-
WET WEIGHT, g	912.90	VOID RATIO	-
DRY WEIGHT, g	911.62		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	98.1

REMARKS: L/D Ratio not in accordance with ASTM Standa DATE: 9/26/2013

Checked By: MWK

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TABLE D4 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 3
BOREHOLE NUMBER	13-06	SAMPLE DEPTH, m	15.3-15.6

TEST CONDITIONS

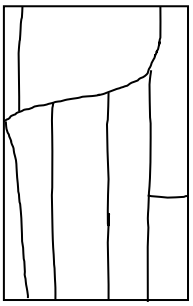
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.16

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.63	WATER CONTENT, (specimen) %	0.05
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m^3	26.47
SAMPLE AREA, cm^2	31.27	DRY UNIT WT., kN/m^3	26.45
SAMPLE VOLUME, cm^3	426.14	SPECIFIC GRAVITY	-
WET WEIGHT, g	1150.50	VOID RATIO	-
DRY WEIGHT, g	1149.93		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	72.5

REMARKS:

DATE: 9/26/2013

Checked By: MWK

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TABLE D5 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1111-0115	SAMPLE NUMBER	Run 2
BOREHOLE NUMBER	13-12	SAMPLE DEPTH, m	1.51-1.87

TEST CONDITIONS

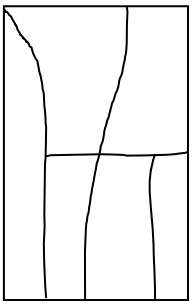
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.23

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.53	WATER CONTENT, (specimen) %	0.10
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m^3	26.38
SAMPLE AREA, cm^2	17.48	DRY UNIT WT., kN/m^3	26.35
SAMPLE VOLUME, cm^3	184.13	SPECIFIC GRAVITY	-
WET WEIGHT, g	495.50	VOID RATIO	-
DRY WEIGHT, g	495.00		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	73.8

REMARKS:

DATE: 10/28/2013

Checked By: MWK

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TABLE D6
Field Estimation of Rock Hardness
(Representation of Intact Rock Strength)

Grade	Description	Field Identification	Approx. Range of UCS (MPa)
R0	Extremely weak rock	Indented by thumbnail.	0.25 – 1
R1	Very weak rock	Material can be shaped with a pocket knife or can be peeled by a pocket knife. Crumbles under firm blows of pick (or point) of geological hammer.	1.0 – 5.0
R2	Weak rock	Knife cuts material but too hard to shape into triaxial specimens or material can be peeled by a pocket knife with difficulty. Shallow indentations (< 5 mm) made by firm blow with pick (or point) of geological hammer.	5.0 – 25
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife. Hand held specimens can be fractured with *single* firm blow of geological hammer.	25 – 50
R4	Strong rock	Hand held a specimen requires *more than one* blow of geological hammer to fracture it.	50 – 100
R5	Very strong rock	Specimen requires many blows of geological hammer to break intact rock specimens (or to fracture it).	100 – 250
R6	Extremely strong rock	Specimen can only be chipped under repeated hammer blows, rings when hit.	> 250

NOTES:

1. Hand held specimens should have height ≅ 2 times the diameter.
2. Materials having a uniaxial compressive strength (UCS) of less than about 0.5 MPa and cohesionless materials should be classified using soil classification systems.
3. Rocks with a uniaxial compressive strength below 25 MPa (i.e., below R2) are likely to yield highly ambiguous results under point load testing.

REFERENCES:

1. Brown (1981). “Suggested Methods for Rock Characterization Testing and Monitoring”, International Society for Rock Mechanics.

2. Hoek, E., Kaiser, P.K., Bawden, W.F. (1995). “Support of Underground Excavations in Hard Rock”, Balkema, Rotterdam.

TABEL D7 - POINT LOAD TEST RESULTS ON ROCK SAMPLES

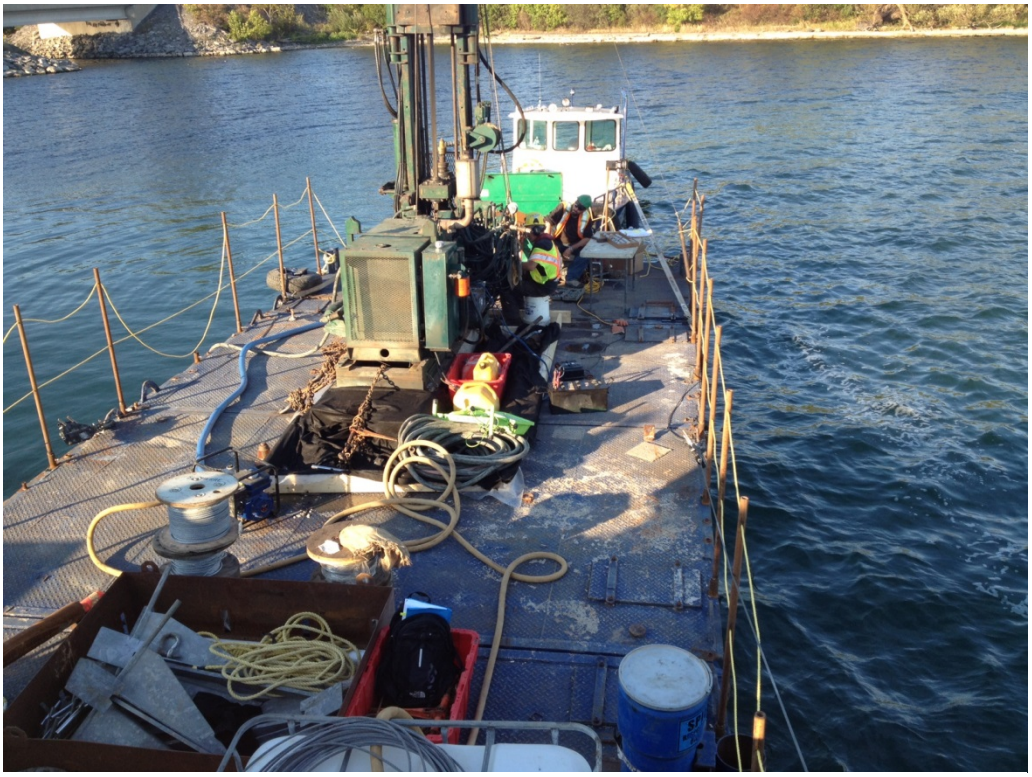
PROJECT NO. 11-1111-0115
TITLE URS / Ferry Terminals / Amhearst Island
DATE November, 2012

Borehole Number	Sample Number	Sample Depth (m)	Test Type	Core Length (mm)	Core [2] Diameter (mm)	Equivalent Diameter (mm)	Ram Pressure (kPa)	Load (P) (kN)	Is Axial (MPa)	Is Diametral (MPa)	**Is (50mm)** (MPa)	**Approx. [1] UCS** (MPa)
12-07	Run 2	7.8	A	23.09	46.95	37.15	10,500	9.95	7.212	-	6.310	76
12-07	Run 2	6.8	A	31.63	47.10	43.55	13,060	12.38	6.527	-	6.134	74
12-08	Run 1	4.0	A	36.36	46.97	46.63	15,320	14.52	6.679	-	6.473	78
12-08	Run 2	5.5	D	100.87	38.10	-	14,040	13.31	-	9.169	8.113	97
12-08	Run 3	7.0	D	60.01	40.68	-	9,780	9.27	-	5.603	5.106	61
13-05A	Run 3	20.9	A	27.72	63.07	47.18	8,800	8.34	3.748	-	3.651	44
13-05A	Run 4	21.4	A	25.57	63.05	45.31	18,580	17.61	8.581	-	8.209	99
13-06	Run 2	13.6	A	25.25	63.19	45.07	17,560	16.65	8.195	-	7.821	94
13-06	Run 2	14.6	A	26.76	63.17	46.39	12,420	11.77	5.471	-	5.289	63
13-06	Run 3	15.8	A	24.32	63.13	44.21	11,400	10.81	5.529	-	5.231	63
13-11	Run 1	7.1	A	19.46	47.42	34.28	11,960	11.34	9.650	-	8.142	98
13-11	Run 2	8.6	A	19.47	47.35	34.26	3,900	3.70	3.150	-	2.657	32
13-11	Run 2	9.2	A	19.63	47.41	34.42	6,600	6.26	5.280	-	4.464	54
13-12	Run 2	1.9	A	19.94	47.44	34.70	8,820	8.36	6.942	-	5.890	71
13-12	Run 3	3.3	A	22.09	47.41	36.52	7,880	7.47	5.602	-	4.864	58
13-12	Run 3	3.5	A	23.05	47.38	37.29	15,920	15.09	10.854	-	9.512	114

(1) Is_{50} x C, from ISRM "Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.
C=12, calculated from Is_{50} average (4 tests) equal to 6.0 MPa on axial orientation and UCS average equal to 72.2 MPa (4 tests)
(2) Actual distance between point load cones at time of failure.

APPENDIX E

Foundation Investigation Photographs



Modular Barge at Borehole 12-01 (09/12/2012)

Modular barge tug boat at Borehole 12-01 (09/12/2012)

Modular barge and tug boat between Millhaven and Stella (09/13/2012)

Jack-Up Barge at Borehole 13-03 (08/14/2013)

Jack-Up Barge and tug boat at Borehole 13-03 (08/14/2013)

Tug boat docked at Stella dock from Borehole 13-05 (08/14/2013)

Jack-Up Barge at Borehole 13-06 (08/15/2013)

Jack-Up Barge at Borehole 13-06 (08/15/2013)

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