GEOTECHNICAL INVESTIGATION AND CONCRETE CONDITION ASSESSMENT DAM AT LOCK 38 TRENT SEVERN WATERWAY ONTARIO

For:
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Professional and Technical Programs
Real Property Services
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TABLE OF CONTENTS

APPENDIX J
ENVIRONMENTAL TEST RESULTS

APPENDIX K
GEOPHYSICAL TEST RESULTS

APPENDIX L
CLASSIFICATION OF CONCRETE DISTRESSES

1.0 INTRODUCTION

Downunder Geotechnical Limited was retained by Public Works and Government Services Canada (PWGSC) to conduct a geotechnical investigation for the proposed Dam at Lock 38, 6km west of Bolsover, Ontario. The dam straddles the Talbot River as part of the Trent Severn Waterway (44^0 30’ 35” N, 79^0 06’ 24” W). The site is presented in Figure No.1.

The objective of the site investigation includes:
- Assess the quality and strength of the existing concrete structures;
- Define the bedrock surface and determine the quality of the bedrock beneath the dam structures;
- Determine the depth of groundwater and flow regime at the project site;
- Assess overall feasibility of the proposed project layout and cofferdam schemes from a geotechnical perspective; and,
- Assess in-situ sediments for potential contaminants prior to commencing construction efforts.

Authorization to proceed with this investigation was provided by PWGSC under Call-up No. EQ754-131106/002/PWL, dated January 30, 2017. The work carried out for this investigation was completed in general accordance with Downunder Geotechnical’s proposal dated January 23, 2017(revised) and the PWGSC Project Brief dated December 15, 2016.

The recommendations provided are for the designers only and not to be relied upon by contractors bidding on this project. It is recommended that contractors bidding on this project review the factual data with a qualified geotechnical engineer and develop their own opinion of the subsurface soil and groundwater conditions at the site as well as the constructability concerns and details of the project. This report was prepared with the assumption that the design will be in accordance with all applicable standards and codes, regulations, and good engineering practice will be exercised. Further, the recommendations and opinions in this report are applicable only to the proposed project as described above.

Any questions concerning the geotechnical aspects of the proposed project should be directed to Downunder Geotechnical Limited for further elaboration and/or clarification.

2.0 REGIONAL GEOLOGY

Based on published geological mapping and papers, the regional geology in this area was laid down during the advance and retreat of the last continental ice sheet. Silty sand to sandy silt glacial till were laid down on the existing bedrock. The glacial till was then overlaid by glaciolacustrine nearshore and beach deposits of sands and gravels.

The bedrock in the area consists of a Paleozoic grey limestone of the Middle Ordovician Simcoe Group. The limestone consists of medium to thick bedded limestone, shaly limestone and bioclastic limestone.

3.0 EXISTING SITE CONDITION

The Dam at Lock 38 is a regulating concrete gravity dam and is operated to maintain the navigation water levels on the Trent Severn Waterway, and to provide water control of the watershed. We understand that the dam was built in 1908 and has two 7.6m wide sluices with stoplogs and two 6.1m wide weirs north of the north sluice and one 6.1m wide overflow weir south of the south sluice. At the south end of the south overflow weir and north end of the north overflow weir is a 20.4m and 11.9m wide concrete bulkhead, respectively. The south bulkhead is tied into the river bank and the north bulkhead is tied to the lock wall through the earth embankment between the dam and the lock. The dam has a total length of about 75m. The dam height is about 8.1m retaining a reservoir depth of about 7m.

Photographs of the site are included in Figure Nos. 5 and 6.

4.0 HISTORICAL INVESTIGATION

A geotechnical investigation at the site was carried out in 2013 for PWGSC by KGS Group (Ref. No. 12-0006-028, dated October 2014). Four boreholes were advanced at the site (Boreholes TH 13-01 to 13-04). The Record of Boreholes and relevant geotechnical laboratory test results are included in Appendix B for reference.

The boreholes were advanced along the crest of the embankments to the underlying bedrock/competent native soils to depths of 6.1 to 9.5m below grade. The subsurface conditions consisted of the following:

- Sandy silt to clayey silt/silty clay fill mixed with topsoil (soft to firm) to a depth of 5.5 to 5.9m below grade.
- A discontinuous loose to dense sandy silt underlies the fill.
- A compact to very dense sandy silt glacial till underlies the fill and sandy silt.
- Inferred limestone bedrock was encountered at a depth of 8.7 and 9.5m below grade in Boreholes TH 13-01 and 13-02.

5.0 INVESTIGATION PROCEDURES

The fieldwork for the current investigation was carried out from February 21 to June 27, 2017. The fieldwork consisted of advancing twenty-three (23) boreholes (Boreholes DC-1 to DC-7, DS-1 to DS-5, SP-1, US-1 to US-5 and V-1 to V-5) to depths of 4.4 to 12.2m, and six piezocone penetration tests (CPT-DC-2, CPT-DC-5, CPT-DC-6, CPT-DS-5, CPT-SP-1 and CPT-US-5) to depths of 2.7 to 5.2m below existing ground surface. The approximate borehole and piezocone penetration test (CPT) locations are presented on Figure No. 1.

Boreholes DC-1 to DC-7 were advanced with a truck mounded drill rig and the remaining boreholes were advanced with restricted access manual soil sampling and coring equipment owned and operated by Ohlmann Geotechnical Services Inc. of Almonte, Ontario, under the full-time supervision of geotechnical staff from Downunder Geotechnical Limited. Soil samples were obtained by employing the Standard Penetration Test (SPT), in accordance with ASTM D1586. The SPT consists of freely dropping a 63.5 kilogram hammer a vertical distance of 0.76m to drive a 51 mm outside diameter split-barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m was recorded and is denoted as ‘N’-values. These recorded ‘N’-values give an indication of the consistency or compactness of the soil and are recorded on the Record of Borehole sheets in Appendix A. In some of the boreholes the manual soil sampling equipment used a modified version of the SPT by using a 21.2 kilogram hammer and correcting the measured ‘N’-values to the SPT standard. The ‘N’-values provided on the Record of Borehole sheets are corrected ‘N’-values.

In-situ shear vane tests were carried out within the cohesive soils to obtain an indication of the undrained shear strength of the soil. Pocket penetrometer measurements were taken on SPT samples. The results of the in-situ shear vane and pocket penetrometer tests are on the Record of Borehole sheets in Appendix A.

Concrete and bedrock coring was carried out within Boreholes V-1 to V-5, DS-1 to DS-5, SP-1 and US-1 to US-5. Boreholes DS-1 to DS-5, SP-1 and US-1 to US-5 were cored with a single tube NQ size core barrel. The concrete and bedrock coring within Boreholes V-1 to V-5 was carried out with a single tube 75mm diameter core barrel for the first run in order to accommodate the dual tube NQ size core barrel below this depth. The cores were logged for structural/geological features and retained for laboratory testing. The descriptions are included on the Record of Borehole sheets in Appendix A and photographs of the cores are presented in Appendix G.

Dynamic cone penetration testing (DCPT) was carried out adjacent to Borehole DC-4. The DCPT consists of fixing a 60^0 apex cone to the bottom of the drill rods and freely dropping a 63.5 kilogram hammer a vertical distance of 0.76m on the drill rods. The number of blows of the hammer to drive the cone into the relatively undisturbed ground by a vertical distance of 0.30m was recorded. These measurements give a general indication on the compactness or consistency of the soil deposits and are recorded on the Record of Borehole Sheets in Appendix A.

Piezocone Penetration Testing

CPTs were carried out in general accordance with ASTM standards (D 5778). CPT-SP-1, CPT-DS-5 and CPT-US-5 were carried out with portable push equipment by ConeTec Investigation Inc. while CPT-DC-2, CPT-DC-5 and CPT-DC-6 were carried out with an anchored direct push rig by Strata Drilling Group. All work was carried out under the supervision of geotechnical staff from Downunder Geotechnical Limited.

At the CPT locations a 32mm diameter instrumented cone and friction sleeve assembly was hydraulically thrust into the soil at a rate of about 2 cm/s to refusal depths of 2.7 to 5.2m below grade. The soundings were conducted using a 10 tonne capacity Conetec or GEOTECH AB cone with a tip area of 10 cm^2, a friction sleeve area of 150 cm^2 and a u_2 filter location. The pore pressure filters were saturated overnight with glycerine under pressure. Measurements were taken at 2 to 2.5 cm depth intervals during penetration. The CPT soundings are included graphically in Appendix A.

Injection Lugeon Testing

Injection packer (lugeon) tests were performed in Boreholes V-2 to V-5, DS-1 to DS-5 and US-1 to US-5 within the bedrock in order to estimate the hydraulic conductivity of the bedrock. The tests were performed using a double packer system to isolate sections of the bedrock for testing.

Prior to each test, the borehole was flushed with clean water to remove core cuttings. The packer assembly was then lowered into the borehole and the rubber packers expanded. During the test, water was pumped into the test interval at injection pressures generally less than the estimated overburden pressure. The tests were carried out in three ascending and two descending stages. The injection rate of water was recorded at each pressure interval for several minutes. The hydraulic conductivity of the rock was calculated based on the results, which are presented in Appendix H.

Groundwater Level Measurements

Monitoring wells were installed in Boreholes DC-2, DC-7, V-1, V-3, V-5, US-5 and SP-1 within the bedrock. The monitoring wells consisted of 19 to 38mm PVC outside diameter casing. Solinst Leveloggers were installed in all monitoring wells to measure water levels every six hours. The levelogger readings were corrected for atmospheric pressure from the barologger installed at the site. Manual groundwater levels within the wells were measured about every two weeks. The groundwater levels are presented in Appendix I.

A standard vibrating wire piezometer (VWP), manufactured by Durham Geo Slope Indicator, was installed in Borehole US-5 at a depth of about 4.6m below grade within the overburden along with a monitoring well installed within the bedrock. The VWP was saturated and installed as per the manufacturer's instructions using the grout-in method. Readings were taken with a VW Mini-logger every hour. The calibration sheet and readings are included in Appendix I.

Laboratory Testing

The soil and bedrock samples were stored in air tight containers to minimize moisture loss and transported to our office for further examination and classification. The samples were visually inspected and logged for classification purposes and for evidence of environmental impacts. A laboratory testing program was carried out consisting of the following:

- Natural moisture contents – 98 tests
- Atterberg Limits – 23 tests
- Grain size analyses – 19 tests
- Unconsolidated undrained triaxial compression tests – 5 tests
- Consolidated drained Direct shear tests on soil samples– 6 tests
- Unconfined compressive strength tests on soil samples – 2 tests
- Consolidation tests on soil samples – 5 tests
- Concrete unconfined compressive strength – 6 tests
- Rock unconfined compressive strength – 10 tests
- Direct shear on rock joints – 5 tests
- Alkali silica reaction – 2 tests

The results of the laboratory testing are presented on the Record of Borehole sheets attached in Appendix A and in Appendices C to F.

Environmental Soil Sampling

Soil samples were obtained by employing the SPT, in accordance with ASTM D1586. The samplers were cleaned with an alconox solution and rinsed with potable water prior to sample collection. Soil sampling was carried out under the direction of an experienced geotechnical technician from Downunder Geotechnical.

Downunder Geotechnical staff followed strict sample handling practices, including the changing of disposable nitrile gloves between samples to ensure the integrity of the samples collected. All soil samples selected for analytical analyses were placed in laboratory prepared containers and stored within a cooler packed with ice packs. The samples were delivered and submitted to Caduceon Environmental Laboratories in Richmond Hill, Ontario, which is an accredited laboratory from the Canadian Association for Laboratory Accreditation.

Selected soil samples were submitted for the following analysis:

- Petroleum hydrocarbon fractions (PHC F1 – F4);
- Volatile Organic Compounds (VOCs);
- O. Reg. 153/04 Inorganics and Metals;
- Polycyclic Aromatic Hydrocarbons;
- Organochlorine Pesticides; and,
- Poly-Chlorinated Biphenyls.

Three soil samples were submitted for testing in accordance with Ontario Regulation 347 (as amended by 558/00) Schedule 4 waste classification protocol, which includes leachate concentrations for 88 parameters.

The results are presented in Appendix J.

Groundwater Sampling

One monitoring well was developed on April 22, 2017, by purging the well using a bailer. The well was developed in this manner in order to restore the natural hydraulic conductivity and obtain representative water quality of the formation groundwater. A minimum of three well volumes were removed prior to sampling and until measured groundwater quality indicators (pH, temperature, conductivity) were relatively stable using an Horiba Water Quality meter.

Water samples were placed directly into laboratory prepared containers for Provincial Water Quality Objectives (PWQO) parameters. The samples were stored in a cooler with ice packs and delivered to Caduceon Environmental Laboratories in Richmond Hill, Ontario. The results are presented in Appendix J.

Elevations

Local benchmarks were established at the site by DM Wills Associates Limited. The benchmark geodetic elevations were derived from GPS observations on the Cansel Network. Borehole elevations were taken by Downunder Geotechnical staff based on these local benchmarks.

Geophysical Profiling

Seismic refraction, multi-channel analysis of surface waves, georadar and sub-bottom profiling was carried out at the site by Geophysics GPR International Inc. to assess the bedrock profile. The results are presented in Appendix K.

6.0 SUBSURFACE CONDITIONS

Descriptions of the sub-surface conditions encountered in the boreholes advanced by Downunder Geotechnical Limited are presented on the Record of Borehole sheets in Appendix A. The following paragraphs are intended to supplement and complement these data.

6.1 Diversion Channel

Boreholes DC-1 to DC-7 were advanced in the area of the proposed diversion channel. Figure No. 2 presents the inferred subsurface cross-section at the proposed diversion channel. We understand that the diversion channel has been cancelled, however the results are presented below.

6.1.1 Fill

Topsoil was encountered at ground surface at Boreholes DC-1, DC-2 and DC-4 to DC-7, and ranged in thickness from 17cm to 2.1m. Occasional wood chips were found in the topsoil at Borehole DC-1. Measured ‘N’-values within the topsoil range from 2 to 4 blows per 0.3m indicating a very loose compactness. Measured moisture contents range from 17 to 30%.

At the ground surface of Borehole DC-3 about 1.2m of sand with gravel to silty sand fill was encountered as part of the gravel parking lot. A measured ‘N’-value of 43 blows per 0.3m was obtained within the fill indicating a compact to dense compactness. Measured moisture of 17% was obtained within the fill.

Below the topsoil in Boreholes DC-1 and DC-2, a brown to grey to black silty sand, sandy silt, silty clay and topsoil fill was encountered to a depth of about 2.1 and 6.1m below grade. Measured ‘N’-values range from 1 to 28 blows per 0.3m indicating a very loose to compact compactness. Measure moisture contents range from 8 to 30%. A buried topsoil layer was encountered in these boreholes at depths of about 1.1 and 3.4m below grade.

An Atterberg Limits determination on a representative sample of the silty clay fill indicates a liquid limit of 25%, plastic limit of 16% and plasticity index of 9%. The results are presented on the plasticity chart in Appendix C and on the Record of Borehole sheets in Appendix A.

One grain size analysis was carried out on a representative sample of the silty sand fill. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

Gravel	1%
Sand	52%

Silt	33%
Clay	14%

6.1.2 Silts and Sands

Below the fill in Borehole DC-1 a grey silty sand deposit with trace shell fragments and clay was encountered at a depth of about 6.1 to the termination depth of 7.0m below grade. A measured ‘N’-value of 6 blows per 0.3m was obtained indicating a loose compactness. A measured moisture content of 23% was obtained. One grain size analysis was carried out on a representative sample of the silty sand. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

Gravel	0%
Sand	52%
Silt	39%
Clay	9%

Layers of silty sand to sandy silt to sand were encountered within the glacial till in Boreholes DC-3, DC-5, and DC-7. Measured ‘N’-values within these sands and silts range from 13 to 41 blows per 0.3m indicating a compact to dense compactness. Measured moisture contents range from 12 to 24%. Three grain size analyses were carried out on representative samples of the sands and silts. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

	Silty Sand	Sand	Sandy Silt
Gravel	3%	6%	0%
Sand	71%	90%	45%
Silt	23%	3%	55%
Clay	3%	1%	0%

6.1.3 Silty Clay to Clayey Silt

Below the fill and topsoil in Boreholes DC-2 to DC-7, a brown to grey silty clay to clayey silt deposit was encountered to depths of 2.5 to 6.7m below grade.

Measured ‘N’-values range from 2 to 4 blows per 0.3m. In situ shear vane tests, pocket penetrometer tests and unconsolidated undrained triaxial compression tests indicate the following ranges in undrained shear strength.

In Situ Shear Vane Tests	54 to 94 kPa
	Sensitivities of 2.2 to 13
Pocket Penetrometer Tests	13 to 50 kPa
UU Triaxial Tests	45 to 70 kPa

The above results indicate a consistency of very soft to very stiff, but typically firm to stiff.

Moisture contents, twelve Atterberg Limits, four grain size distribution analyses, six consolidated drained Direct shear tests and two consolidation tests were carried out on samples of the silty clay to clayey silt. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are further summarized below.

Moisture Contents	11 to 31%
Atterberg Limits	
Liquid Limit	23 to 30%
Plastic Limit	8 to 19%
Plasticity Index	7 to 19%
Grain Size Distribution	
Gravel	0 to 1%
Sand	2 to 5%
Silt	61 to 68%
Clay	27 to 36%
Bulk Unit Weight	18.6 to 19.5 kN/m^3
Compression Ratio	0.09 and 0.13
Recompression Ratio	0.01
Constrained Modulus at σ_v’	6.0 and 12.1 MPa
OCR	2.6 and 4.6
Initial Void Ratio	0.848 and 0.896
Mean Effective Friction Angle	
Peak	31.1^0
Residual	32.5^0
Mean Apparent Cohesion	
Peak	8.7 kPa
Residual	4.7 kPa

CPT testing was carried out adjacent to Boreholes DC-2, DC-5 and DC-6. The results are presented in Appendix A and summarized below.

Inferred Parameter	Mean Value		
	CPT-DC-2	CPT-DC-5	CPT-DC-6
Undrained Shear Strength	51 kPa	56 kPa	90 kPa
OCR	3.0	8.2	17
Constrained Modulus	3.9 MPa	4.3 MPa	6.1 MPa

The above results indicate an overconsolidated low plasticity clay of moderate compressibility.

6.1.4 Glacial Till

The silty clay to clayey silt and silts and sands are underlain by a brown to grey silty sand to sandy silt glacial till deposit in Boreholes DC-2 to DC-7. These boreholes were terminated within the glacial till at depths of about 5.8 to 10.1m below grade. The glacial till is a heterogeneous mixture of a silty sand to sandy silt matrix, with varying amounts of gravel and trace clay. In Boreholes DC-6 and DC-7 a silty clay to clayey silt glacial till deposit was encountered. Cobbles and boulders are anticipated within the glacial till.

Measured 'N'-values range from 11 to greater than 50 blows per 0.3m indicating a compact to generally very dense compactness. Measured moisture contents range from 6 to 12%. Two Atterberg Limits were carried out within the sandy silt to silty clay glacial till indicating a liquid limit of 15 and 29%, plastic limit of 10 and 19% and plasticity index of 4 and 11%.

Eight grain size analyses were carried out on representative samples of the glacial till. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

	Silty Sand to Sandy Silt Glacial Till	Silty Clay Glacial Till
Gravel	6 to 19%	0%
Sand	30 to 58%	48%
Silt	21 to 45%	34%
Clay	8 to 17%	18%

6.1.5 Limestone Bedrock

Auger refusal on inferred bedrock was obtained in all boreholes at depths ranging from 5.8 to 10.1 m below grade, or Elevation 224.2 to 229.1 m. The bedrock in the area consists of grey limestone bedrock. The profile of the bedrock surface was confirmed by the seismic geophysical survey as outlined in Appendix K.

6.1.6 Groundwater Conditions

Monitoring wells were installed in Boreholes DC-2 and DC-7. Each monitoring well consisted of 37mm diameter PVC riser pipe and screen. The screens consisted of 3m long No. 10 slotted PVC screen. Threaded points are installed at the bottom of each well, and all pipe sections were threaded. The annular space of the borehole around the screen was packed with clean silica sand. The upper section of the wells were completed with solid riser casing, with the annular space above the screen sealed with bentonite chips. Manual water levels were taken about every two weeks. Results are presented graphically and summarized in Appendix I. The water levels are summarized in the table below.

Borehole No.	**Ground Surface Elevation (m)**	**Depth to Groundwater Table below existing grade (m) [Groundwater Elevation (m)]**				
		February 22, 2017	March 11, 20107	March 24, 2017	April 2, 2017	April 8, 2017
DC-2	235.8	2.1 [233.7]	1.7 [234.1]	1.5 [234.3]	1.4 [234.4]	1.2 [234.6]
DC-7	234.1	-	4.5 [229.6]	4.5 [229.6]	4.4 [229.7]	4.5 [229.6]
TH13-02	235.6	-	1.4 [234.2]	1.4 [234.2]	1.5 [234.1]	1.4 [234.2]

The groundwater levels will fluctuate seasonally, in response to precipitation events and river levels.

6.2 Sediment Pond

Borehole SP-1 was advanced in the area of the proposed sediment pond.

6.2.1 Silty Clay to Clayey Silt

About 17cm of topsoil was encountered at ground surface. Underlying the topsoil is a mottled brown silty clay to clayey silt deposit to a depth of about 3.8m below grade. CPT-SP-1 indicates the silty clay to clayey silt deposit extends to about 4.5m below grade.

Measured 'N'-values range from 4 to 8 blows per 0.3m. An in situ shear vane test within this deposit indicates an undrained shear strength of 51 kPa and sensitivity of 3.3. The inferred undrained shear strength from CPT-SP-1 ranges from 34 to 192 kPa, with an average of about 76 kPa. These indicate a consistency of firm to very stiff, but typically stiff.

Moisture contents, two Atterberg Limits and one consolidation test were carried out on samples of the silty clay to clayey silt. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are further summarized below.

Moisture Contents	22 to 41%
Atterberg Limits Liquid Limit Plastic Limit Plasticity Index	 22 and 26% 16 and 19% 6 and 7%
Bulk Unit Weight	19.1 kN/m^3
Compression Ratio Recompression Ratio Constrained Modulus at σ_v' OCR Initial Void Ratio	0.12 0.01 3.9 MPa 8.5 1.014

CPT testing was carried out adjacent to Borehole SP-1. The results are presented in Appendix A and summarized below.

Inferred Parameter	Mean Value
Undrained Shear Strength	76 kPa
OCR	12.6
Constrained Modulus	6.9 MPa

The above results indicate an overconsolidated low plasticity clay of moderate compressibility.

6.2.3 Glacial Till

Below the silty clay to clayey silt the borehole encountered a grey sandy silt glacial till to a depth of about 8.1m below grade. The glacial till is a heterogeneous mixture of sandy silt matrix, with varying amounts of gravel and trace clay. Cobbles and boulders are anticipated within the glacial till.

Measured 'N'-values range from 32 to greater than 50 blows per 0.3m indicating a dense to very dense compactness. Measured moisture contents range from 9 to 11%.

Two grain size analyses were carried out on representative samples of the glacial till. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

Gravel	2 and 14%
Sand	36 and 37%
Silt	40 and 50%
Clay	10 and 11%

6.2.4 Limestone Bedrock

Fresh, grey limestone bedrock was encountered in the borehole at a depth of 8.1m below grade or Elevation 226.7m. The borehole was terminated within the bedrock at a depth of 9.3m below grade, or Elevation 225.5m. The limestone bedrock contains occasional fossils and about 10% shale interbeds.

Rock coring was carried out to about 1.2m below the bedrock surface. Rock cores of NQ size were obtained using a single tube core barrel.

The rock cores were logged and photographs of the cores are presented in Appendix G. Details of the core logging are included in the Record of Borehole sheets in Appendix A.

The rock core logging is further summarized below. Logging of the cores was carried out using ASTM and ISRM procedures and naming conventions. An explanation of these terms is included in Appendix A.

Borehole	Run	Depth (m)	Recovery	Rock Quality Designation (RQD)	Fracture Frequency (fractures per 0.3m)
SP-1	1	8.1 to 9.3	100%	77%	0 to 3

Based on the rock core logging, bedrock can be described as having good rock quality, and thinly to medium joint spacing. Based on the ISRM strength convention, the bedrock can be described as medium strong to very strong.

6.2.5 Groundwater Conditions

A monitoring well was installed in Borehole SP-1. The monitoring well consisted of a 37mm diameter PVC riser pipe and screen. The screen consisted of 1.5m long No. 10 slotted PVC screen. Threaded points are installed at the bottom of the well, and all pipe sections were threaded. The annular space of the borehole around the screen was packed with clean silica sand. The upper section of the well was completed with solid riser casing, with the annular space above the screen sealed with bentonite chips. A water level of 2.0m below grade, or Elevation 232.8m, was measured after installation. The groundwater level will fluctuate seasonally and in response to precipitation events.

A rising head slug test was carried out within the monitoring well which is screened within the glacial till. The results are presented in Appendix I and indicate a hydraulic conductivity of 3.0×10^{-8} m/s.

6.3 Downstream Cofferdam

Boreholes DS-1 to DS-5 were advanced in the area of the downstream cofferdam. Figure No. 4 presents the inferred subsurface cross-section at the downstream cofferdam.

6.3.1 Fill

Borehole DS-1 was advanced at low water level on the edge of the river and encountered about 0.3m of sand fill with cobbles.

6.3.2 Silty Clay to Clayey Silt

Borehole DS-5 was advanced on the south side of the river and encountered 15cm of topsoil at ground surface. Below the topsoil is a brown silty sand to about 1.1m below grade. A measured 'N'-value of 4 blows per 0.3m indicates a loose compactness. A measured moisture content of 21% was obtained within the silty sand.

Underlying the silty sand is a mottled brown silty clay to clayey silt deposit to about 4.0m below grade or about Elevation 235.0m.

Measured 'N'-values range from 8 to 14 blow per 0.3m and an unconfined compressive strength of 42kPa was obtained, indicating a firm to stiff consistency. Moisture contents, two Atterberg Limits and one consolidation test were carried out on samples of the silty clay to clayey silt. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are further summarized below.

Moisture Contents	26 to 31%
Atterberg Limits	
Liquid Limit	22 and 26%
Plastic Limit	16%
Plasticity Index	6 and 10%
Bulk Unit Weight	18.2 kN/m^3
Compression Ratio	0.10
Recompression Ratio	0.01
Constrained Modulus at σ_v'	4.0 MPa
OCR	2.0
Initial Void Ratio	0.971

CPT testing was carried out adjacent to Borehole DS-5. The results are presented in Appendix A and summarized below.

Inferred Parameter	Mean Value
Undrained Shear Strength	71 kPa
OCR	6.2
Constrained Modulus	6.7 MPa

The above results indicate an overconsolidated low plasticity clay of moderate compressibility.

6.3.3 Glacial Till

Below the silty clay to clayey silt in Borehole DS-5, below the fill in Borehole DS-1 and below the river water in Boreholes DS-2 and DS-4, a grey silty sand to sandy silt glacial till was encountered to depths of 1.3 to 7.4m below grade, or Elevation 226.9 to 227.6m. The glacial till is a heterogeneous mixture of silty sand to sandy silt matrix, with varying amounts of gravel and trace clay. Cobbles and boulders are anticipated within the glacial till.

Measured 'N'-values range from 12 to 40 blows per 0.3m indicating a compact to dense compactness. Measured moisture contents of 8 and 15% were obtained.

One grain size analysis was carried out on a representative sample of the glacial till. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

Gravel	20%
Sand	35%
Silt	33%
Clay	12%

6.3.5 Limestone Bedrock

Underlying the glacial till in Boreholes DS-1, DS-2, DS-4 and DS-5, and below the riverbed sediment (less than 5cm thick) in Borehole DS-3, a grey limestone bedrock was encountered and cored. Fresh, grey limestone bedrock was encountered at a depth of 1.2 to 1.9m below river level (and 7.4m below the south riverbank), or about Elevation 226.9 to 227.6m. The boreholes were terminated within the bedrock at depths of 2.7 to 3.5m below the top of the bedrock. The limestone bedrock contains occasional fossils and about 10% shale interbeds. Rock cores of NQ size were obtained using a single tube core barrel.

The rock cores were logged and photographed, with selected samples submitted for testing. Photographs of the cores are presented in Appendix G. Details of the core logging are included in the Record of Borehole sheets in Appendix A.

An unconfined compressive strength test was carried out on a representative sample of the bedrock. The results are presented in Appendix E and summarized below.

Unconfined Compressive Strength 77.0 MPa
Density 2,689 kg/m^3

The rock core logging is further summarized below. Logging of the cores was carried out using ASTM and ISRM procedures and naming conventions. An explanation of these terms is included in Appendix A.

Borehole	Run	Depth (m)	Recovery	Rock Quality Designation (RQD)	Fracture Frequency (fractures per 0.3m)
DS-1	1	2.0 to 2.9	100%	92%	1 to 3
	2	2.9 to 4.0	81%	68%	0 to 3
	3	4.0 to 4.6	100%	95%	1 to 2
	4	4.6 to 5.4	99%	93%	2
DS-2	1	1.3 to 2.2	100%	85%	2 to 4
	2	2.2 to 3.4	97%	97%	1 to 2
	3	3.4 to 4.4	97%	97%	0 to 2
DS-3	1	1.2 to 2.6	99%	90%	0 to 3
	2	2.6 to 3.5	100%	100%	1 to 2
	3	3.5 to 4.7	99%	87%	0 to 3
DS-4	1	1.6 to 2.9	97%	83%	0 to 2
	2	2.9 to 4.1	99%	99%	0 to 1
		4.1 to 5.1	100%	90%	0to 3
DS-5	1	7.4 to 8.3	97%	46%	3 to 4
	2	8.3 to 9.3	100%	98%	1 to 4
		9.3 to 10.1	100%	100%	1 to 2

Based on the rock core logging, bedrock can be described as having good to excellent rock quality, but typically excellent rock quality, and typically thinly to medium joint spacing. Based on the ISRM strength convention, the bedrock can be described as medium strong to very strong.

6.3.6 Groundwater Conditions

Boreholes DS-1 to DS-4 were advanced within the river course and water levels within the overburden will fluctuate with the riverlevel. Artesian water levels were encountered within the bedrock at depths of about 2.3 and 4.0m below grade during rock coring at Boreholes DS-1 and DS-3. At Borehole DS-1 casing was used to estimate the water head in the bedrock, which stabilized at about 1.6m above the water surface, or about Elevation 230.5m.

At Borehole DS-5 the groundwater is estimated at a depth of about 2.0m below grade, or about Elevation 233.0m, based on the change in moisture condition of the silty clay to clayey silt deposit. Water levels will fluctuate seasonally and in response to weather events.

Injection lugeon tests were carried out within the bedrock. The results are presented in Appendix H and summarized below.

Borehole No.	Depth	Classification	Condition of Rock Mass Discontinuties	Flow Type	Lugeons	Hydraulic Conductivity (cm/s)
DS-1	2.3-3.8m	Low	Tight	Laminar	3.6	3.46×10^{-5}
DS-2	1.6-3.1m	Very High	Open Closely Spaced or Voids	Dilation	106.2	1.03×10^{-3}
DS-3	1.8-2.7m	Very High	Open Closely Spaced or Voids	Turbulent	242.2	2.02×10^{-3}
DS-4	2.0-2.9m	Very High	Open Closely Spaced or Voids	Wash-out	173.2	1.44×10^{-3}
DS-5	7.6-9.1m	Very Low	Very Tight	n/a	0.0	$<1.0 \times 10^{-5}$

The packer assembly was lost in the cored hole at DS-3 and may be encountered during cofferdam construction.

6.4 Upstream Cofferdam

Boreholes US-1 to US-5 were advanced in the area of the upstream cofferdam. Figure No. 3 presents the inferred subsurface cross-section at the upstream cofferdam.

6.4.1 Fill

Borehole US-4 was advanced through 1.2m of rip rap protection on the south riverbank.

Borehole US-1 and US-5 encountered about 5 to 30cm of topsoil at ground surface on the north riverbank embankment. The topsoil was underlain by a sandy silt, clayey silt to silty clay, silt, silty sand and peat fill deposit to a depth of about 5.8 and 6.0m below grade, or about Elevation 229.2 and 229.5m. The fill contains frequent topsoil inclusions, rootlets, trace decaying wood, organics, red brick fragments and sand.

Measured 'N'-values range from 3 to 11 blows per 0.3m. In situ shear vane tests within the fill indicate an undrained shear strength of 18 to 51 kPa, and a sensitivity of 1.9 to 4.0.

Measured moisture contents range from 19 to 40%. Atterberg Limits determination on representative samples of the fill indicates a liquid limit of 23%, plastic limit of 6 and 9% and plasticity index of 14 and 17%. One bulk unit weight determination of 18.6 kN/m^3 was obtained from a sample of the fill. The results are presented on the plasticity chart in Appendix C and on the Record of Borehole sheets in Appendix A.

CPT testing was carried out adjacent to Borehole US-5. The results are presented in Appendix A and summarized below.

Inferred Parameter	Mean Value
Undrained Shear Strength	36 kPa
OCR	6.7
Constrained Modulus	3.6 MPa

6.4.2 Silty Sand to Sandy Silt

Below the fill in Boreholes US-1 and US-5, a silty sand with trace gravel and shell fragments was encountered to a depth of about 6.7 and 6.8m, or Elevation 228.4 and 228.6m. Measured 'N'-values of 5 and 14 blows per 0.3m were obtained indicating a loose to compact compactness. Moisture contents of 20 and 24% were obtained.

One grain size analysis was carried out on a representative sample of the silty sand. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

Gravel	0%
Sand	66%
Silt	29%
Clay	5%

Below the river water in Borehole US-2 a 0.8m thick dark grey sandy silt with decaying wood was encountered to a depth of 6.2m, or Elevation 228.4m. At Borehole US-3 a silty sand layer less than 5cm thick was encountered. A measured ‘N’-value within the sandy silt of 3 blows per 0.3m was obtained indicating a very loose compactness. A moisture content of 37% was obtained.

One grain size analysis was carried out on a representative sample of the sandy silt. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are summarized below.

Gravel	0%
Sand	48%
Silt	45%
Clay	7%

6.4.3 Silty Clay to Clayey Silt

Below the rip rap at Borehole US-4, a grey varved silty clay to clayey silt deposit was encountered to about 3.6m below grade.

Measured ‘N’-values of 7 and 9 blows per 0.3m were obtained. An unconfined compressive strength tests from a representative sample of the silty clay to clayey silt indicates an undrained shear strength of 44kPa. An in situ shear vane test within this deposit indicates an undrained shear strength of 112 kPa. These tests indicate a consistency of firm to very stiff.

Three moisture contents, two Atterberg Limits and one consolidation test were carried out on samples of the silty clay to clayey silt. The results are presented in Appendix C and on the Record of Borehole sheets in Appendix A. The results are further summarized below.

Moisture Contents	25 to 28%
Atterberg Limits	
Liquid Limit	20 and 26%
Plastic Limit	8 and 14%
Plasticity Index	6 and 18%
Bulk Unit Weight	20.0 kN/m^3
Compression Ratio	0.14
Recompression Ratio	0.01
Constrained Modulus at σ_v'	3.0 to 14.3 MPa
OCR	5.3
Initial Void Ratio	0.785

The above results indicate an overconsolidated low plasticity clay of moderate compressibility.

6.4.4 Glacial Till

Underlying the silty clay to clayey silt in Borehole US-4, a grey silty sand glacial till was encountered to a depth of 5.2m below grade, or Elevation 228.6m. The glacial till is a heterogeneous mixture of silty sand matrix, with varying amounts of gravel and trace clay. Cobbles and boulders are anticipated within the glacial till.

A measured ‘N’-value greater than 50 blows per 0.3m was obtained indicating a very dense compactness. A measured moisture content of 9% was obtained within the till.

6.4.5 Limestone Bedrock

Underlying the silty sand, sandy silt and glacial till in Boreholes US-1 to US-5, a grey limestone bedrock was encountered and cored. Fresh, grey limestone bedrock was encountered at a depth of 6.7 and 6.8m, or Elevation 228.4 and 228.6m, below the north fill embankment at Boreholes US-1 and US-5, at a depth of 5.2m below grade, or Elevation 228.6m, below the south riverbed at Borehole US-4, and at the riverbed surface to 0.8m below the riverbed, or Elevation 228.4m, at Boreholes US-2 and US-3.

The boreholes were terminated within the bedrock at depths of 1.9 to 3.8m below the top of the bedrock. The limestone bedrock contains occasional fossils and about 10 to 20% shale interbeds. At Boreholes US-1, US-3 and US-4, sand and clay joint infilling was observed. The surface to upper 0.7m of the bedrock at Boreholes US-2, US-3 and US-5 was slightly weathered. Rock cores of NQ size were obtained using a single tube core barrel.

The rock cores were logged and photographed, with selected samples submitted for testing. Photographs of the cores are presented in Appendix G. Details of the core logging are included in the Record of Borehole sheets in Appendix A.

Two unconfined compressive strength tests were carried out on representative samples of the bedrock. The results are presented in Appendix E and summarized below.

Unconfined Compressive Strength 68.3 and 110.7 MPa
Density 2,683 and 2,696 kg/m^3

The rock core logging is further summarized below. Logging of the cores was carried out using ASTM and ISRM procedures and naming conventions. An explanation of these terms is included in Appendix A.

Borehole	Run	Depth (m)	Recovery	Rock Quality Designation (RQD)	Fracture Frequency (fractures per 0.3m)
US-1	1	6.8 to 8.2	96%	82%	0 to 3
	2	8.2 to 9.3	100%	100%	0 to 2
	3	9.3 to 10.6	98%	95%	0 to 2
US-2	1	6.2 to 7.1	98%	0%	3 to 9
	2	7.1 to 8.4	92%	47%	2 to 5
	3	8.4 to 9.6	100%	69%	2 to 3
US-3	1	6.2 to 7.6	80%	29%	2 to 5
	2	7.6 to 8.0	100%	32%	9
	3	8.0 to 8.1	50%	0%	1
US-4	1	5.2 to 6.5	100%	100%	1 to 2
	2	6.5 to 7.6	99%	81%	0 to 1
	3	7.6 to 8.6	100%	94%	0 to 1
US-5	1	6.7 to 7.8	98%	83%	0 to 3
	2	7.8 to 8.9	92%	71%	0 to 3
	3	8.9 to 10.0	100%	79%	1 to 3

Based on the rock core logging, bedrock can be described as having very poor to excellent rock quality, but typically very poor rock quality below the river course and good to excellent below the embankments, and typically thinly to medium joint spacing. Based on the ISRM strength convention, the bedrock can be described as medium strong to very strong.

6.4.6 Groundwater Conditions

Boreholes US-2 to US-4 were advanced within the river course and water levels within the overburden will fluctuate with the riverlevel. At Borehole US-3 casing was lost within the borehole and may be encountered during cofferdam construction at the base of the riverbed.

A monitoring well was installed within the bedrock at Borehole US-5. The monitoring well consisted of 37mm diameter PVC riser pipe and screen. The screen consisted of 1.5m long No. 10 slotted PVC screen. Threaded points are installed at the bottom of the well, and all pipe sections were threaded. The annular space of the borehole around the screen was packed with clean silica sand. The upper section of the well was completed with solid riser casing, with the annular space above the screen sealed with bentonite chips. Manual water levels were taken about every two weeks. Results are presented graphically and summarized in Appendix I.

At Borehole US-5 a fully grouted VWP was installed within the earthfill embankment at a depth of about 4.6m below grade. The VWP consisted of a 3.5 bar capacity VWP from Durham Geo Slope Indicator. The calibration sheet is included in Appendix I. The VWP was saturated as per the manufacturer's instructions and attached to the well riser. The cable was connected to a datalogger at surface with readings recorded every hour. Results are presented graphically and summarized in Appendix I. The results are summarized in the table below.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater Table below existing grade (m) [Groundwater Elevation (m)]							
		April 2, 2017	April 8, 2017	April 22, 2017	May 7, 2017	May 20, 2017	May 27, 2017	June 10, 2017	June 24, 2017
US-5	235.3	2.5 [232.8]	3.2 [232.1]	2.5 [232.8]	2.1 [233.2]	2.5 [232.8]	2.7 [232.6]	2.7 [232.6]	2.7 [232.6]
VWP at US-5	235.3	1.8 [234.5]	1.7 [234.6]	1.3 [234.0]	1.2 [234.1]	1.1 [234.2]	0.8 [234.5]	0.9 [234.4]	0.9 [234.4]

Water levels will fluctuate seasonally, in response to weather events and river water levels.

Injection lugeon tests were carried out within the bedrock. The results are presented in Appendix H and summarized below.

Borehole No.	Depth	Classification	Condition of Rock Mass Discontinuties	Flow Type	Lugeons	Hydraulic Conductivity (cm/s)
US-1	6.9-8.4m	Very Low	Very Tight	n/a	0.0	$<1.0 \times 10^{-5}$
US-2	5.7-7.3m	Very High	Open Closely Spaced or Voids	Turbulent	143.4	1.38×10^{-3}
US-3*	6.4-7.9m	-	-	-	-	-
US-4	5.7-6.6m	Very Low	Very Tight	Dilation	0.9	7.67×10^{-6}
US-5	7.2-8.7m	Moderate	Few Partly Open	Dilation	6.8	6.59×10^{-5}

*testing could not be carried out due to excessive leaking of the casing.

6.5 Lock 38 Dam

Borehole V-1 was advanced through the upstream Lock 38 wall and Boreholes V-2 to V-5 were advanced through the concrete dam.

6.5.1 Concrete

The upstream Lock 38 wall was cored at Borehole V-1. The base of the concrete wall was encountered at a depth of 6.4m, or Elevation 229.1m. The upper 0.4m consists of newer concrete with steel reinforcement and angular aggregate. The older concrete below the bonded interface contains rounded aggregate. Core recoveries range from 90 to 100%. The concrete-bedrock interface is horizontal and bonded. At a depth of 4.5m a 1.2m thick sand layer was encountered embedded within the wall. A measured ‘N’-value within the sand of greater than 50 blows per 0.3m indicates a very dense compactness. This sand layer likely represents an infilled void within the wall.

Boreholes V-2 to V-5 were advanced from the top of the dam. The base of the concrete was encountered at a depth of 8.3 to 9.0 m below the top of the dam, or Elevation 226.9 to 227.9m. The concrete contains rounded to angular aggregate and based on the high air void content of the concrete, evidence of segregation was observed within the concrete. Black and yellow staining and calcium carbonate staining was observed at several locations, as well as broken zones of concrete and wood fragments. Core recoveries range from 76 to 100%. The concrete-bedrock interface is horizontal to slightly inclined and generally unbonded.

Unconfined compressive strength tests were carried out on six (6) representative concrete samples. The results are attached and summarized below.

> Unconfined Compressive Strength 6.3 to 41.0 MPa (average 20.9 MPa)
> Density 2,226 to 2,423 kg/m^3

Two cores were submitted to Amec Foster Wheeler for alkali aggregate reaction assessment by petrographic examinations and damage rating index interpretation. The results are presented in Appendix F. Examination of the horizontal cores from the upstream central pier and downstream weir wall indicate the following information on the concrete and distresses within the cores:

- Concrete composed of gravel coarse aggregate and natural fine aggregate of similar grading and lithology.
- Air void content about 9 to 11%.
- Poor consolidated and high permeability.
- Trace Alkali Silica Reaction is occurring within the cores.

6.5.2 Limestone Bedrock

Fresh, grey limestone bedrock was encountered in the boreholes at depths of 6.4 to 9.0m below grade, or Elevation 226.9 to 229.1m. The upper 0.6 to 0.9m of the bedrock at Boreholes V-4 and V-5 was slightly weathered. The boreholes were terminated within the bedrock at depths of 9.9 to 12.2m. The limestone bedrock contains occasional fossils and about 5 to 20% shale interbeds. Rock joints are typically rough and horizontal, with some inclined joints observed. Clay infilling was observed in some joints in Boreholes V-1 and V-3.

Rock coring was carried out to about 3.1 to 4.0m below the bedrock surface. Rock cores of NQ size were obtained using a single tube core barrel in Borehole V-1 and a dual tube core barrel of NQ size in Boreholes V-2 to V-5.

The rock cores were logged and photographed, with selected samples submitted for testing. Photographs of the cores are presented in Appendix G. Details of the core logging are included in the Record of Borehole sheets in Appendix A.

Unconfined compressive strength tests were carried out on 7 representative bedrock samples. The results are presented in Appendix E and summarized below.

Unconfined Compressive Strength 42.7 to 143.7 MPa
Density 2,677 to 2,693 kg/m^3

Direct shear tests were carried out on five (5) representative rock joints from Boreholes V-2, V-3 and V-5. The results are presented in Appendix E and summarized below.

Borehole No.	**Depth (m)**	**Peak**		**Residual**	
		Φ’	**c’**	**Φ’**	**c’**
V-2	8.4	36.4^0	723 kPa	32.2^0	362 kPa
V-3	8.4	32.7^0	75 kPa	33.1^0	362 kPa
V-3	8.5	30.7^0	508 kPa	29.1^0	0 kPa
V-3	10.0	39.7^0	376 kPa	40.7^0	136kPa
V-5	9.4	36.8^0	272 kPa	36.5^0	57 kPa

The rock core logging is further summarized below. Logging of the cores was carried out using ASTM and ISRM procedures and naming conventions. An explanation of these terms is included in Appendix A.

Borehole	Run	Depth (m)	Recovery	Rock Quality Designation (RQD)	Fracture Frequency (fractures per 0.3m)
V-1	1	6.4 to 6.5	100%	-	-
	2	6.5 to 7.5	100%	57%	2 to 3
	3	7.5 to 8.0	90%	80%	0 to 1
	4	8.0 to 8.4	100%	81%	1
	5	8.4 to 8.9	100%	100%	0 to 1
	6	8.9 to 9.9	85%	83%	1 to 2
V-2	1	8.4 to 8.9	93%	53%	1 to 2
	2	8.9 to 10.3	100%	85%	0 to 3
	3	10.3 to 11.7	99%	95%	0 to 2
V-3	1	8.3 to 9.8	98%	90%	1 to 5
	2	9.8 to 11.5	96%	96%	0 to 1
V-4	1	9.0 to 9.5	83%	81%	1 to 2
	2	9.5 to 10.0	95%	69%	2
	3	10.0 to 11.5	98%	93%	0 to 2
	4	11.5 to 12.2	100%	71%	1 to 3
V-5	1	9.2 to 9.8	87%	59%	3 to 4
	2	9.8 to 11.3	100%	92%	0 to 3
	3	11.3 to 11.9	90%	90%	1 to 2

Based on the rock core logging, bedrock can be described as having fair to excellent rock quality, and typically thinly to medium joint spacing. Based on the ISRM strength convention, the bedrock can be described as medium strong to very strong.

6.5.3 Groundwater Conditions

A total of three (3) monitoring wells were installed within the bedrock at the site (Boreholes V-1, V-3 and V-5). Each monitoring well consisted of 19 to 37mm diameter PVC riser pipe and screen. The screens consisted of 1.5m long No. 10 slotted PVC screen. Threaded points are installed at the bottom of each well, and all pipe sections were threaded. The annular space of the borehole around the screen was packed with clean silica sand. The upper section of the wells were completed with solid riser casing, with the annular space above the screen sealed with bentonite chips. Manual water levels were taken about every two weeks. Results are presented graphically and summarized in Appendix I.

The results are summarized in the following table.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater Table below existing grade (m) [Groundwater Elevation (m)]							
		April 2, 2017	April 8, 2017	April 22, 2017	May 7, 2017	May 20, 2017	May 27, 2017	June 10, 2017	June 24, 2017
V-1	235.5	2.7 [232.8]	3.6 [231.9]	2.8 [232.7]	2.3 [233.2]	2.6 [232.9]	2.5 [233.0]	2.7 [232.8]	2.6 [232.9]
V-3	235.9	4.0 [231.9]	4.4 [231.5]	4.4 [231.5]	3.6 [232.3]	4.1 [231.8]	4.4 [231.5]	4.4 [231.5]	4.5 [231.4]
V-5	236.3	4.2 [232.1]	4.3 [232.0]	4.4 [231.9]	3.8 [232.5]	4.2 [232.1]	4.5 [231.8]	4.5 [231.8]	4.6 [231.7]

Water levels will fluctuate seasonally and in response to weather events and river levels.

Injection lugeon tests were carried out within the bedrock. The results are presented in Appendix H and summarized below.

Borehole No.	Depth	Classification	Condition of Rock Mass Discontinuties	Flow Type	Lugeons	Hydraulic Conductivity (cm/s)
V-2	8.8-10.3m	Very Low	Very Tight	Dilation	0.6	6.00×10^{-6}
V-3	8.8-10.3m	High	Many Open	Laminar	51.1	4.93×10^{-4}
V-4	9.5-11.0m	Very Low	Very Tight	n/a	0.0	$<1.0 \times 10^{-5}$
V-5	9.2-10.7m	Moderate	Few Partly Open	Dilation	10.0	9.70×10^{-5}

7.0 DISCUSSION AND RECOMMENDATIONS

The recommendations and comments are based on factual information and are intended only for use by the design engineers. The number of boreholes and cores may not be sufficient to determine all the factors that may affect construction methods and costs. Concrete and subsurface soil, rock and groundwater conditions between and beyond the boreholes/cores may differ from those encountered at the borehole/core locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The anticipated construction conditions are also discussed, but only to the extent that they may influence design decisions. Construction methods discussed express our opinion only and are not intended to direct the contractors on how to carry out the construction. Contractors should also be aware that the data and the interpretation presented in this report may not be sufficient to assess all the factors that may have an effect on the construction.

7.1 Concrete Condition Assessment

The dam structure is composed of four distinct structural units:

- North Weir Wall and Abutment
- North Pier
- Central Pier
- South Pier
- South Weir Wall and Abutment

Visual Distresses
Each unit was inspected on April 29, 2017 in accordance with the Ontario Structure Inspection Manual (2008) and photographed. A description of the classification of the concrete distresses and photographs of the concrete distresses are attached. The concrete distresses at each structural unit are described below.

North Weir Wall and Abutment
East Face
- Severe to very severe alkali aggregate reaction
- Wide and very severe spalling at waterline

West Face
- Very severe alkali aggregate reaction
- Wide cracks

- Very severe spalling
- Very severe disintegration
- Very severe erosion at waterline
- Tree growing out of face of gravity wall
- Water running through horizontal cracks in gravity wall

North Pier
East Face
- Severe to very severe alkali aggregate reaction
- Wide and very severe spalling at waterline

West Face
- Upper new concrete capping
- Wide cracks
- Very severe spalling
- Grass growing in cracks on pier steps

Central Pier
East Face
- Severe alkali aggregate reaction

West Face
- Upper new concrete capping
- Severe alkali aggregate reaction
- Severe spalling
- Moss growing on pier steps

South Pier
East Face
- Severe to very severe alkali aggregate reaction
- Moss growing on face

West Face
- Upper new concrete capping
- Severe to very severe alkali aggregate reaction
- Moss growing on upper pier steps

South Weir Wall and Abutment
East Face
- Medium to very severe alkali aggregate reaction
- Very severe scaling at waterline

West Face
- Severe to very severe alkali aggregate reaction
- Wide cracks
- Light scaling
- Very severe spalling
- Very severe disintegration
- Severe erosion at waterline
- Tree growing out of face of gravity wall
- Water running through horizontal cracks in gravity wall

Concrete Core Laboratory Testing
Vertical and horizontal concrete cores were extracted from the structure. Locations and description of the concrete cores are presented in Section 6.5.1. The concrete contains generally rounded aggregate with evidence of segregation observed within the concrete. The concrete also contains weathered and stained joints and wood inclusions at depth.

Unconfined compressive strength tests were carried out on 6 representative concrete samples with an average strength of 20.9MPa and density of 2315 kg/m^3.

Two cores were submitted for alkali aggregate reaction assessment by petrographic examinations and damage rating index interpretation. Examination of the horizontal cores from the upstream central pier and the downstream gravity wall indicate the following information on the concrete and distresses within the cores:

- Concrete composed of gravel coarse aggregate and natural fine aggregate of similar grading and lithology.
- Air void content about 9 to 11%.
- Poor consolidation and high permeability.
- Trace Alkali Silica Reaction is occurring within the cores.

Assessment
Based on the visual concrete distresses observed at the surface of the structure the downstream face is in very poor condition, while the upstream face is considered to be in fair condition. The concrete cores obtained and the results of the laboratory testing indicate the concrete mass is in poor condition with wood present within the concrete mass. The downstream face concrete distresses indicate an advanced state of alkali-aggregate reaction and deterioration. Alkali aggregate reaction is a reaction which occurs over time in concrete between the highly alkaline cement paste and non-crystalline silicon dioxide, which is found in many common aggregates. Rehabilitation methods cannot stop this alkali aggregate reaction, only delay its progress as the chemical reaction produces more gel, resulting in cracking and deterioration of the concrete. Based on the advanced state of the concrete distresses we recommend that replacement of the dam be undertaken as opposed to rehabilitation.

7.2 Cofferdam Construction

7.2.1 Shoring

Upstream Cofferdam
Based on the upstream boreholes, the upstream cofferdam will be extended through the following stratigraphy:

River Course
- 5 to 6m of water
- 0 to 0.8m of very loose sandy silt with decaying wood
- fresh medium strong to very strong limestone bedrock

North Riverbank

- 5 to 6m of firm to stiff sandy silt to clayey silt/silty clay, silt, peat and silty sand fill with topsoil
- ~1m of loose to very dense silty sand
- fresh medium strong to very strong limestone bedrock

South Riverbank

- ~1m of rip rap
- 2.4m of firm to stiff silty clay to clayey silt
- 1.6m of very dense silty sand glacial till
- fresh medium strong to very strong limestone bedrock

Typical cofferdam consisting of sheet pile shoring is not feasible within the river course due to the lack of overburden for embedment. Within the river course, due to the thin overburden, a braced cofferdam will likely be required due to the depth of water to be retained. This typically consists of sheet piles braced laterally with wooden cribs and washed coarse aggregate. Sheet pile shoring is feasible at the north riverbank location, supplemented by rock anchors where required. Sheet pile shoring at the south riverbank location will encounter hard driving through the glacial till due to the possible presence of cobbles and boulders. Rock anchors will be required for lateral support.

The bedrock is slightly weathered to fresh at the upstream cofferdam location, however frequent sand and clay joint infilling may be found and the bedrock within the river course has a high hydraulic conductivity due to open joints within the bedrock and will require grouting to minimize water flow. The cofferdam bottom will need to be sealed by grouting methods to cut of water flow before commencement of dewatering.

Based on the geophysics carried out at the site the bedrock profile is generally flat below the river and compares well with the findings of the boreholes.

Downstream Cofferdam

Based on the downstream boreholes, the downstream cofferdam will be extended through the following stratigraphy:

River Course

- up to 1.5m of water
- 0 to 2m of sand with cobbles and compact to very dense silty sand glacial till
- fresh medium strong to very strong limestone bedrock

South Riverbank

- ~1m of loose silty sand
- 3m of stiff silty clay to clayey silt
- 3.4m of dense sandy silt glacial till
- fresh medium strong to very strong limestone bedrock

Typical cofferdam consisting of sheet pile shoring is not feasible within the river course due to the lack of overburden for embedment. Within the river course, due to the thin overburden and low water levels, a rockfill cofferdam is feasible. The rockfill cofferdam will require an internal impervious membrane to minimize seepage.

Sheet pile shoring is feasible at the south riverbank location, supplemented by rock anchors where required. Sheet pile shoring at the south riverbank location will encounter hard driving through the glacial till due to the possible presence of cobbles and boulders. Rock anchors will be required for lateral support.

The bedrock is slightly weathered to fresh at the downstream cofferdam location, however the bedrock within the river course has a high hydraulic conductivity due to open joints within the bedrock and will require grouting to minimize water flow. The cofferdam bottom will need to be sealed by grouting methods to cut of water flow before commencement of dewatering. The groundwater within the bedrock likely has an artesian head in the order of 4 to 5m above the bedrock surface.

Based on the geophysics carried out at the site the bedrock profile is generally flat below the river and compares well with the findings of the boreholes.

Rock Anchors

For horizontal restraint the use of rock anchors may be considered. A specialist contractor would be required to install the rock anchors. An unfactored grout-rock bond strength of 1,000 kPa can be used for the limestone bedrock. Factored geotechnical resistance at Ultimate Limits State (ULS) should be derived using a geotechnical resistance factor of 0.3 in tension. The Structural Engineer must consider the elastic elongation of the anchors.

In order to check for rock mass stability, due to the variable joint spacing in the rock, a shearing angle of 60^0 should be used to determine the weight of the rock above the mid-point of the bonded anchor length. For any soil above the rock, the weight of the soil should be determined by a cylinder equal in diameter to the cone diameter calculated at the rock surface. Rock cohesion/shear strength should be neglected in determining the rock mass stability. Potential for failure should also be analyzed for the base, mid-point and top of the socket. Group effects will need to be considered for closely spaced anchors.

Rock anchors filled with cement grout with a suitable number of reinforcement bars should be installed in the center of the grout hole. The minimum anchor spacing is three times the anchor diameter. A reduction in resistance due to spacing must be taken into consideration for closer spacing. The anchor stability and reinforcement bar details should be designed and checked by an experienced Structural Engineer. Corrosion protection is recommended for all rock anchors.

7.2.2 Soil and Rock Parameters

The following parameters can be used for shoring design.

Soil Type	Compactness or Consistency	Bulk Unit Weight (kN/m^3)	Undrained Shear Strength (kPa)	Drained Friction Angle (degrees)	Apparent Cohesion (kPa)
Earthfill Embankment Sandy Silt to Clayey Silt to Silty Clay with Topsoil	Soft to Stiff	18.5	20	26^0	0
Silty Clay to Clayey Silt	Firm to Stiff	19.0	50	30^0	4
Upstream Sandy Silt	Very Loose	17.0		26^0	0
Silty Sand to Sandy Silt Glacial Till	Compact to Very Dense	21.0	-	38^0	0
Limestone Bedrock					
Rock Mass	-	26.0	-	40^0	400
Joints	-	-	-	32^0	0
Rock-Concrete Interface	-	-	-	32^0	0

The groundwater table within the bedrock should be assumed to be at about Elevation 233.5m at the upstream cofferdam and Elevation 232.5 m at the dam structure and downstream cofferdam.

Surcharge loading will need to be taken into account. A minimum of 12kPa surcharge load should be used for construction equipment. The design of vertical shoring should use a lateral earth pressure diagram from the Canadian Foundation Engineering Manual (latest edition), based on the above noted parameters.

7.2.3 Excavation and Dewatering

The proposed cofferdam construction will require excavation in the overburden soils and potentially into the limestone bedrock. Excavations must be carried out as per the Occupational Health and Safety Act and Regulations for Construction Projects. Minimum support system requirements for steeper excavations are indicated in Sections 235 through 238 and 241 of the Act and Regulations. Based on the Act the soils can be classified as follows.

Soil Type	Soil Description	Temporary Stable Excavation Side Slopes
3	Fills and soils above the groundwater table	1H to 1V
4	All fills and soils below the groundwater table or river level	3H to 1V

Slopes should be inspected regularly, especially in the fill, for signs of instability, erosion and water seepage. Where instability is observed, the slope should be flattened or temporary shoring may be required.

Normal excavation equipment will be suitable for excavation purposes within the overburden. The limestone bedrock will require use of line drilling and/or hoe ramming to excavate the rock. Chemical fracturing may also be considered as an alternative. Blasting is not recommended due to the potential for fracturing the rock.

Groundwater is anticipated to be encountered within all excavations. Dewatering within the overburden soils will require the use of wellpoints, except within the silty clay to clayey silts where pumping from temporary pumps should suffice. Grouting of the bedrock will be required due to the high groundwater inflows expected from the anticipated artesian water levels.

7.2.4 Safety Boom Anchors

Safety boom anchors may be required upstream of the dam. These structures typically consist of cast-in-place augered concrete piles (caissons). The geotechnical reaction at Serviceability Limits State (SLS) and factored geotechnical resistance at ULS will vary depending on the depth and diameter of the caissons. The following table provides the SLS and ULS values for a 600mm, 900mm and 1200mm diameter caisson.

Caisson Foundation Depth	Caisson Diameter	SLS (kN) in Compression	Factored ULS (kN) in Compression	Factored ULS (kN) in Tension
1m into bedrock	600mm	**	750	560
1m into bedrock	900mm	**	1130	850
1m into bedrock	1200mm	**	1500	1130

** SLS does not govern as the footing will not settle more than 25mm before the factored ULS value is achieved.

The above ULS value incorporates a geotechnical resistance factor of 0.4 in compression and 0.3 in tension. The SLS values are not provided as the ULS will govern the design. Higher values are available for larger diameter caissons.

An unfactored grout-rock bond strength of 1,000 kPa can be used for the limestone bedrock.

The caisson installation must be carried out by an experienced specialist contractor using temporary liners within the overburden. The temporary liner should be removed gradually during construction as the concrete is being poured, a minimum 2m overlap between the steel liner and concrete should be maintained to prevent “necking”. Rock core barrels will be required to penetrate into the limestone bedrock.

Minimum caisson sizes, thickness and other caisson requirements should be designed in accordance to the latest sections of the National Building Code.

The caisson installations should be inspected and evaluated by a Geotechnical Engineer prior to concreting to ensure that they are founded on competent undisturbed subgrade capable of supporting the recommended geotechnical resistances and reactions.

Lateral Resistance

Pile foundations have slender shafts that offer limited resistance to lateral loads for vertically installed shafts. The ultimate lateral capacity of vertical piles can be determined using Broms' Method. The soil parameters noted in Section 7.2.2 can be assumed for the soils and rock below the site. This method should be considered approximate and will only provide a rough estimation of lateral resistance.

A geotechnical resistance of 0.5 should be applied to the above analysis to obtain the factored lateral pile geotechnical resistance at ULS.

The following equation may be used to estimate the coefficient of horizontal subgrade reaction for deflection calculations in non-cohesive soils:

$$k_s = n_h\, z/d$$

where:
k_s = coefficient of horizontal subgrade reaction
n_h = coefficient related to soil density (see below)
z = depth below grade (m)
d = pile diameter (m)

Based on the borehole findings the following n_h values can be used for design.

Soil Type	**n_h (kN/m^3)**
Very Loose Silts and Sands	1,300

In order to provide a more accurate estimate of the horizontal deformation of the pole foundations finite element software using p-y curves, such as LPILE, is recommended. Site specific p-y curves can be developed if in situ pressuremeter testing is carried out at the site to further refine the analysis.

7.3 Soil and Groundwater Disposal

7.3.1 Soil Disposal

Samples from the upstream sandy silts, downstream fill and diversion channel fill deposits were submitted for the following analysis:

- Petroleum hydrocarbon fractions (PHC F1 – F4);
- Volatile Organic Compounds (VOCs);
- O. Reg. 153/04 Inorganics and Metals;
- Polycyclic Aromatic Hydrocarbons;
- Organochlorine Pesticides; and,
- Poly-Chlorinated Biphenyls.

The results have been compared to the Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (MOECC Standards, 2011) for residential/parkland/institutional/industrial/commercial/community property use (Table 8). Table 8 has been used as the site is within 30m from a water body and the area is in a potable groundwater condition.

The results meet Table 8 MOECC Standards and are presented in Appendix J.

Samples from the upstream sandy silts, downstream fill and diversion channel fill deposits were also submitted for with Ontario Regulation 347 (as amended by 558/00) Schedule 4 waste classification protocol, which includes leachate concentrations for 88 parameters. The results meet Schedule 4 criteria and are presented in Appendix J.

Based on the test results obtained excess soil may be disposed off-site at a licensed MOECC landfill as non-impacted, non-hazardous waste.

7.3.2 PWQO Groundwater Testing

Groundwater samples were obtained from the monitoring well at Borehole V-3 for testing PWQO parameters. The results are presented in Appendix J. The following parameters exceed the PWQO criteria:

- Iron
- Phosphorous

There are several parameters where the laboratory method detection limit could not meet the Interim PWQO or PWQO criteria as these limits are below detectable laboratory limits. These are included in Appendix J.

8.0 CLOSURE

The attached Report Limitations are an integral part of this report.

Sincerely,

LICENSED PROFESSIONAL ENGINEER
15 July 2018
A.R. DREVININKAS
90502154
PROVINCE OF ONTARIO

Andrew Drevininkas, P. Eng.

Geoffrey Creer, P.Eng.

Michael Nkemitag, Ph.D., P.Eng.

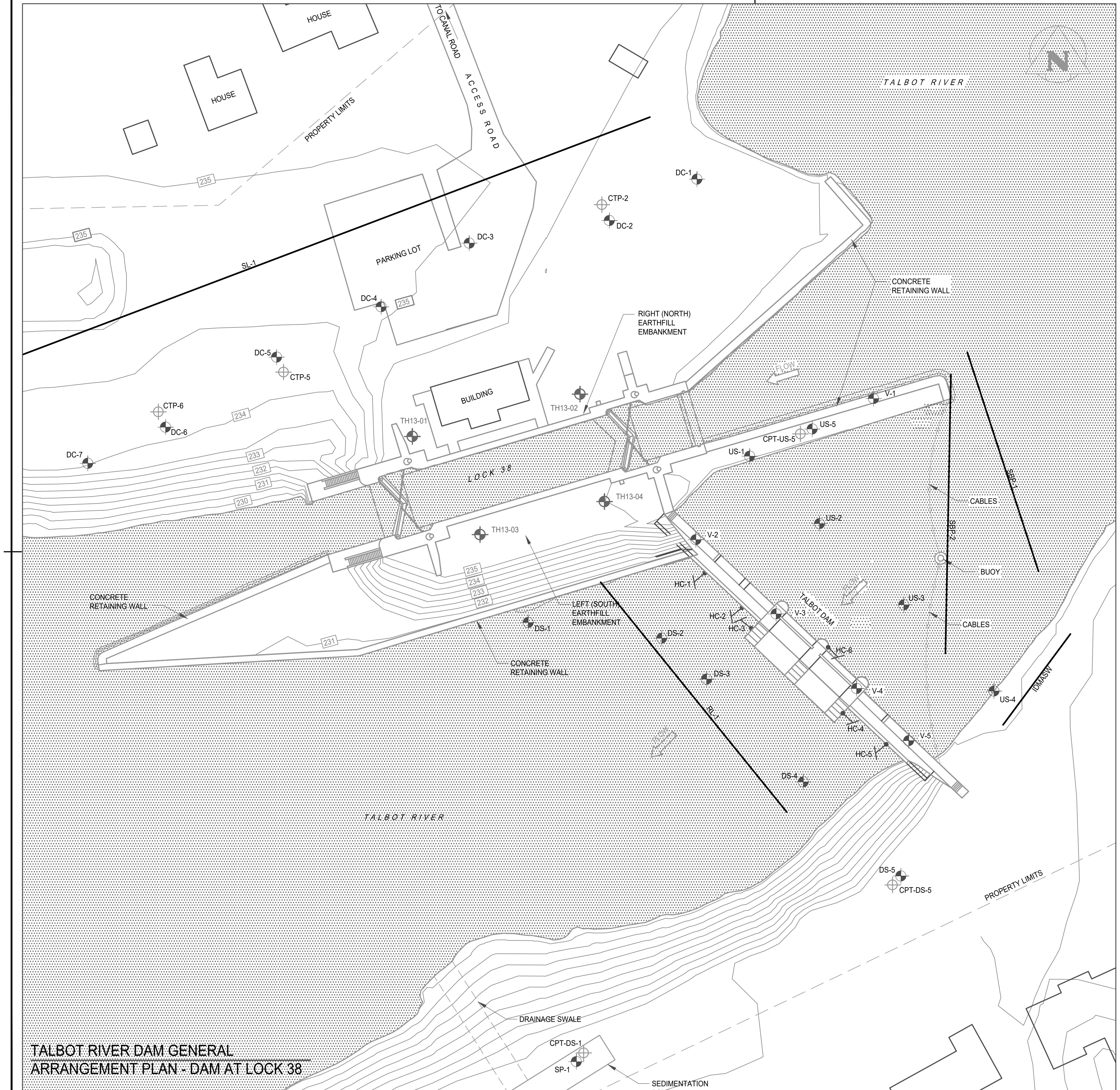
REPORT LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information herein in no way reflects on the environmental aspects of the project. Subsurface and groundwater conditions beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the testholes.

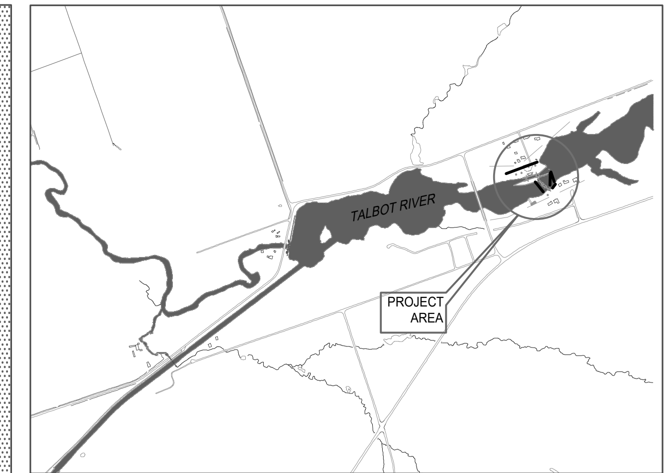
The design recommendations in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report relating to potential construction problems and possible methods of construction are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of fill may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

This report was prepared for PWGSC and its agents. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Downunder Geotechnical Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.



TALBOT RIVER DAM GENERAL ARRANGEMENT PLAN - DAM AT LOCK 38



VICINITY MAP

SCALE N.T.S.

NOTES:

1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.
2. SITE LAYOUT BASED ON SURVEYS AND FIELD MEASUREMENTS CONDUCTED AT SITE IN NOVEMBER 2012 AND BACKGROUND INFORMATION.

REFERENCES:

EXISTING DRAWINGS FROM PARKS CANADA

DRAWING No.	TITLE
T-20-200.6	TRENT CANAL SIMCOE BALSAM LAKE DIVISION PRPOSED CHANGE IN LOCATION OF LOCK & DAM NO. 2. SECTION NO. 3
T-22-118A17	TRENT CANAL SECTION NO. 3 SIMCOE BALSAM LAKE DIVISION LOCK NO. 2
T-22-118A65	TRENT CANAL SECTION NO. 3 SIMCOE BALSAM LAKE DIVISION DAM AT LOCK NO. 2

LEGEND

DS-#	DOWNSTREAM COFFERDAM BOREHOLE
US-#	UPSTREAM COFFERDAM BOREHOLES
V-#	VERTICAL CONCRETE CORE HOLES INTO BEDROCK
DC-#	DIVERSION CHANNEL BOREHOLE
HC-#	HORIZONTAL CONCRETE CORING
TH13-#	EXISTING TESTHOLES
CTP-6	PIEZOCONE PENETRATION TESTS
SL-1	SEISMIC REFRACTION AND 2D MASW PROFILE LINE
RL-1	GEORADAR PROFILE LINE
SBP-1	ACOUSTIC SUB-BOTTOM PROFILER LINE 1
SBP-2	ACOUSTIC SUB-BOTTOM PROFILER LINE 2
IDMASW	ID MULTI-CHANNEL ANALYSIS OF SURFACE WAVES PROFILE LINE

1:800 0 5 10 15 20m

1:800 METRIC 11"X17"

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C drawing no. — where detailed / dessin no. — où détaillé

project title / titre du projet
TRENT—SEVERN WATERWAY INFRASTRUCTURE
TALBON DAMS REHABILITATION
KIRKFIELD BUNDLE

drawing title / titre du dessin
DAM AT LOCK 38 — TALBOT GEOTECHNICAL INVESTIGATION PLAN

drawn by / dessine par: BRUNO BIEBEL

designed by / conc par: ANDREW DREVININKAS

approved by / approuve par: ANDREW DREVININKAS

tender / soumission

project manager / administrateur de projets

project date / date du projet: 2017/07/12

project no. / no. du projet: D17105A

drawing no. / dessine no.: FIG.01

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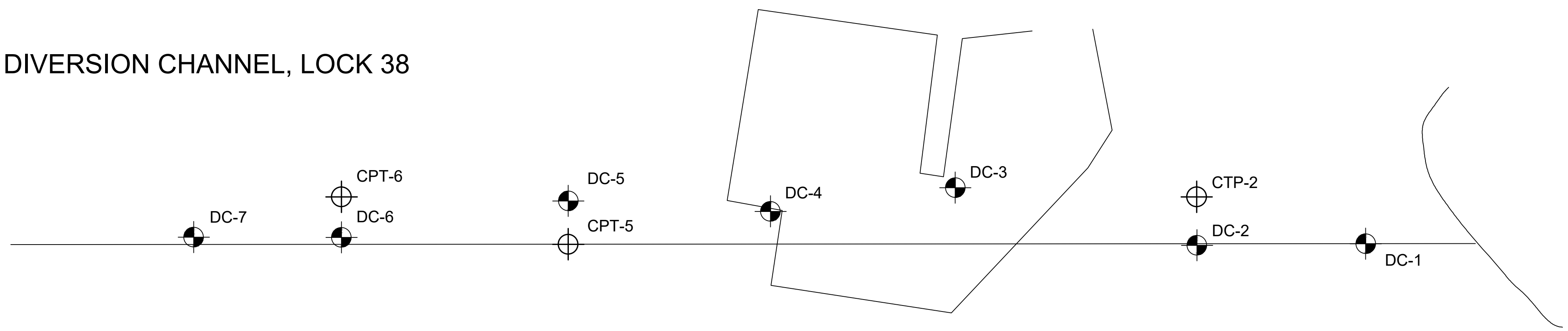
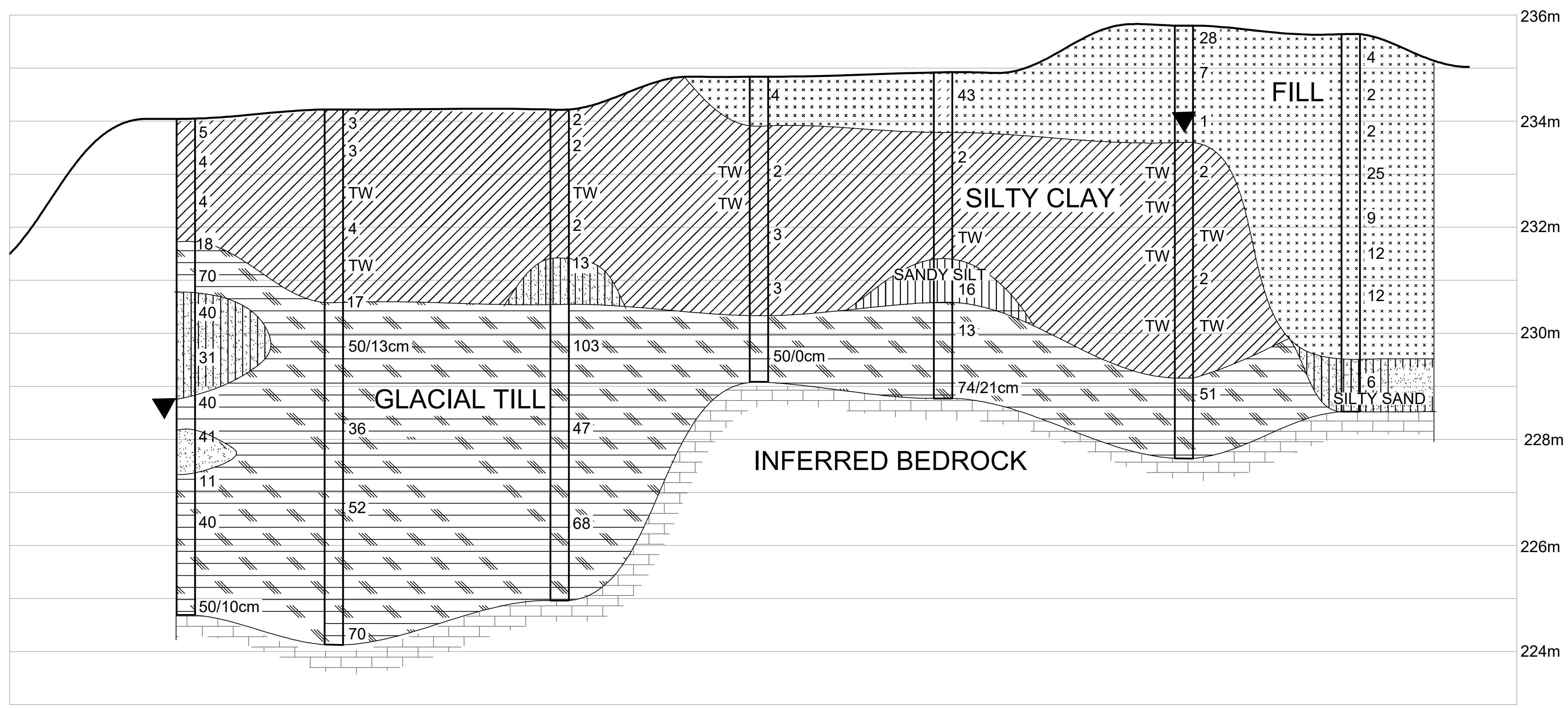
DIVERSION CHANNEL, LOCK 38





INFERRED CROSS-SECTION - LOCK 38

LEGEND

- FILL
- SILTY CLAY
- GLACIAL TILL
- SILTY SAND
- SANDY SILT
- TW — SHELBY TUBE
- ## — N-VALUE

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TALBON DAMS REHABILITATION
KIRKFIELD BUNDLE

drawing title / titre du dessin
DIVERSION CHANNEL, LOCK 38
INFERRED CROSS–SECTION

drawn by / dessine par: BRUNO BIEBEL

designed by / conc par: ANDREW DREVININKAS

approved by / approuve par: ANDREW DREVININKAS

tender / soumission

project manager / administrateur de projets

project date / date du projet: 2017/02/10

project no. / no. du projet: D17105A

drawing no. / dessine no.: FIG.02

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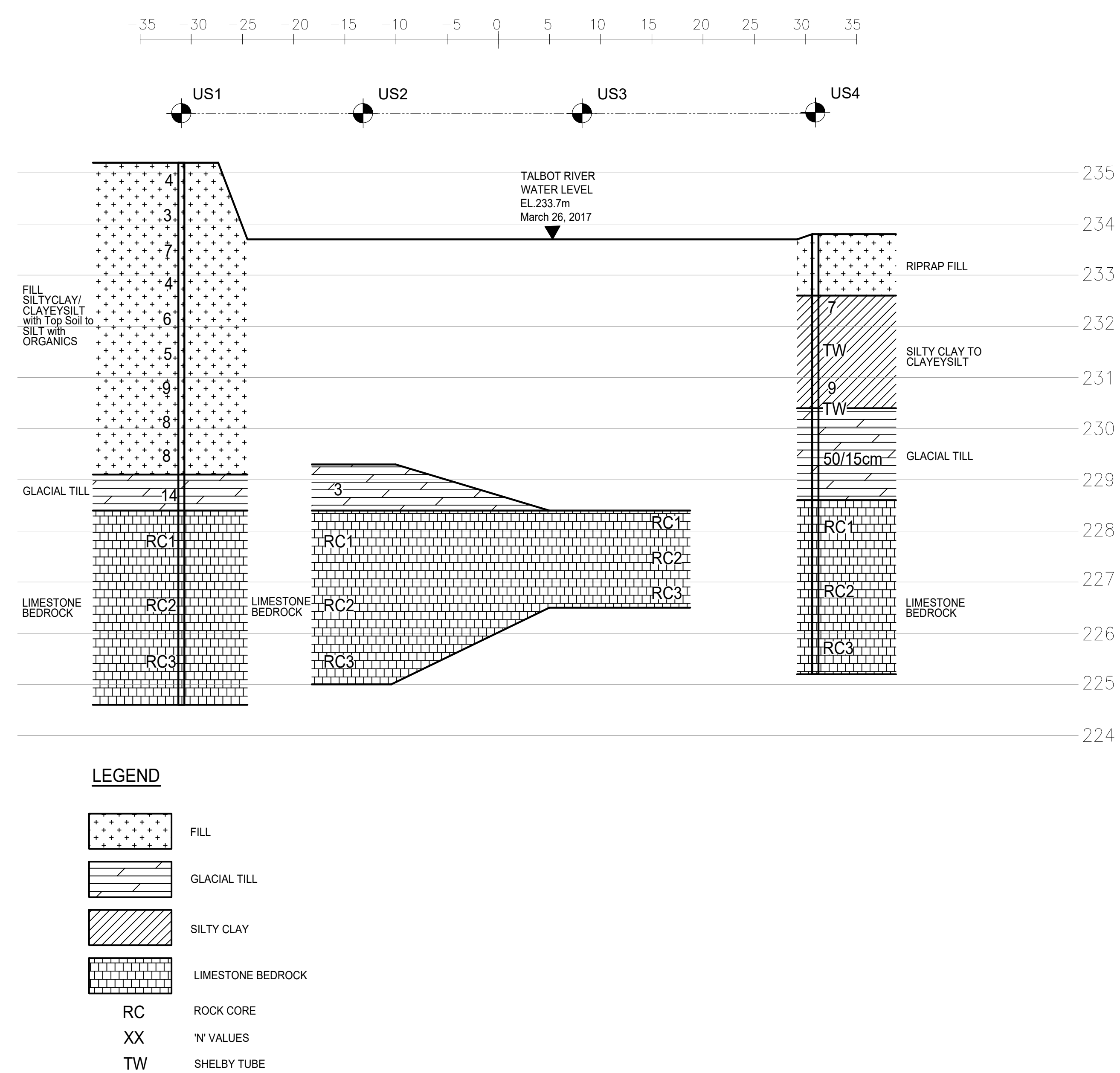

INFERRED CROSS-SECTION AT UPSTREAM COFFERDAM - TALBOT DAM

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B drawing no. – where detail required / dessin no. – où détail exigé
C drawing no. – where detailed / dessin no. – où détaillé

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TALBON DAMS REHABILITATION
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drawing title / titre du dessin
UPSTREAM COFFERDAM, LOCK 38
INFERRED CROSS–SECTION

drawn by / dessine par: BRUNO BIEBEL

designed by / conc par: ANDREW DREVININKAS

approved by / approuve par: ANDREW DREVININKAS

tender / soumission — project manager / administrateur de projets

project date / date du projet: 2017/06/15

project no. / no. du projet: D17105A

drawing no. / dessine no.: FIG.03

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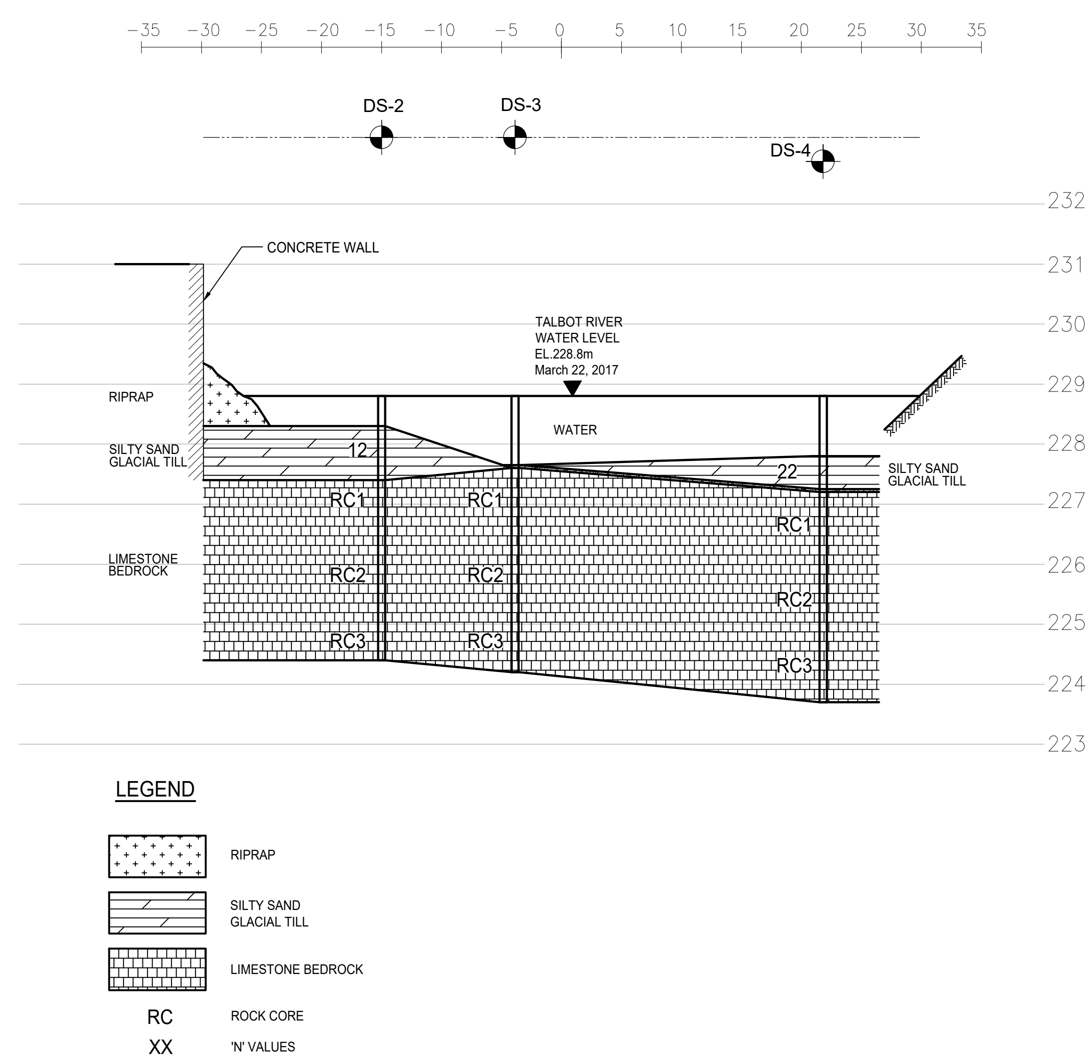

INFERRED CROSS-SECTION AT DOWNSTREAM COFFERDAM - TALBOT DAM

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DOWNSTREAM COFFERDAM, LOCK 38
INFERRED CROSS–SECTION

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designed by / conc par: ANDREW DREVININKAS

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project no. / no. du projet: D17105A

drawing no. / dessine no.: FIG.04

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SITE PHOTOGRAPHS

Aerial photo of Dam at Lock 38.

Looking east at downstream face of Dam at Lock 38.

Looking west at upstream face of Dam at Lock 38.

FIGURE No. 5

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SITE PHOTOGRAPHS

Packer equipment.

Conetec portable CPT rig.

Horizontal coring of downstream pier.

Portable coring on raft.

Truck mount drill rig at Diversion Channel.

Portable coring on raft.

FIGURE No. 6

APPENDIX A

Explanation of Terms Used in the Record of Borehole Sheets

Classification of Soils

As per Unified Soil Classification System ASTM D2487

Consistency (Cohesive Soils)

Consistency	Undrained Shear Strength (kPa)	N-value
Very soft	<12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very stiff	100-200	15-30
hard	>200	>30

Compactness (Cohesionless Soils)

Compactness	N-value
Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Sample Types

GS **Grab Sample**
DP **Direct Push soil core sample**
RC **Rock core**
CC **Concrete core**
SS **Split Spoon sample**
TW **Thin walled sample**

Recovery

■ **Sample recovery**

□ **No sample recovery**

Soil Boundaries
The boundaries of the soil strata encountered are presented on the borehole logs as dashed and solid lines. Dashed lines represent an assumed boundary between soil strata, while a solid line represents an observed transition between soil strata within the recovered soil samples.

Cobbles and Boulders
Cobbles and boulders may be encountered within the soil deposits, which cannot be sampled in their boreholes. Glacial till is known to contain cobbles and boulders due to the nature of their formation/deposition and should be expected in any excavations within the soil.

Fill
It should be noted that fill is heterogeneous in nature and has a variable compactness, consistency, or degree of compaction. The fill description is based solely on the soil sample retrieved and may not be representative of the entire layer. All fills should be expected to contain variable materials, including possible obstructions, such as wood, concrete, etc. which may not have been encountered within the boreholes. The depth of fill may also be variable and cannot be detected solely on the results of the boreholes. Testpits are recommended to confirm the variability of the material and depth of the fill.

Explanation of Terms Used in the Record of Borehole Sheets

Recovery (REC)

Rock core recovery indicates the total length of rock core recovered, expressed as a percentage of the actual length of core run.

Rock Quality Designation (RQD)

Rock quality designation, as per ASTM D6032-08, is obtained by measuring the length of recovered rock core pieces that are longer than 100mm and expressed as their sum length as a percentage of the length of core run. RQD is a function of the frequency of joints, bedding plane partings, and fractures in the rock cores. Mechanical breaks due to the rock coring process are not included, however determination of which breaks are natural and which have been induced is subjective. As per ASTM, RQD is an approximate indication of rock quality classification as follows.

RQD	Rock Quality Classifications
0 to 25%	Very Poor
25 to 50%	Poor
50 to 75%	Fair
75 to 90%	Good
90 to 100%	Excellent

Fracture Index (FI)

Fracture index is based on a visual examination of the rock core. The number of fractures per 0.3m length of core is recorded and averaged over the core run.

Bedding

Term	Bed Thickness
Very thickly bedded	>2m
Thickly bedded	600mm to 2m
Medium bedded	200 to 600mm
Thinly bedded	60 to 200mm
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly laminated	<6mm

Rock Strength – ISRM

Term	Description	Unconfined Compressive Strength (MPa)
Extremely weak	Indented by thumbnail	0.25 to 1.0
Very weak	Can be peeled by a pocket knife	1.0 to 5.0
Weak	Can be peeled by a pocket knife with difficulty	5.0 to 25
Medium strong	Cannot be scraped or peeled with a pocket knife	25 to 50
Strong	Requires more than one blow of a geological hammer to fracture it	50 to 100
Very Strong	Requires many blows of a geological hammer to fracture it	100 to 250
Extremely Strong	Can only be chipped with a geological hammer	>250

Rock Weathering – ISRM

Term	Description
Fresh	No visible sign of rock material weathering
Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surface. May be somewhat weaker than in its fresh condition
Moderately weathered	Less than half of the rock is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a corestone or continuous framework
Highly weathered	More than half of the rock is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a corestone or continuous framework
Completely weathered	All rock is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported

RECORD OF BOREHOLE No DC-1

Project No.:D17105A
Drilling Date:2/21/2017
Project: Dam at Lock 38
Drilling Method: Hollow Stem Augering
Location: Proposed Diversion Channel at Lock 38
Hole Diameter: 200mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane □ UU Triaxial ▲ Pocket Penetrometer: 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30 40

GROUND SURFACE ELEVATION 235.6m

Sample Number	Type	"N" Values	Natural Moisture Content (%)
1	SS	4	26
2	SS	2	20
3	SS	2	30
4	SS	25	8
5	SS	9	13, 25
6	SS	12	15
7	SS	12	17, 24
8	SS	6	23

Soil Description	Approx. Depth (m)	Remarks & Grain Size Distribution (%) GR SA SI CL
very loose, brown to black Topsoil FILL, occasional Wood chips, moist	0 – 2.1	
compact, grey Silty Sand to Sandy Silt FILL, trace Gravel, Clay, moist (wet below ~3.0m)	2.1 – 3.4	
loose, black Topsoil FILL, moist	3.4 – 3.7	
compact, grey Silty Sand FILL, trace Gravel, Topsoil, Clay, moist	3.7 – 6.2	1 52 33 14
loose, grey SILTY SAND, trace shell fragments, Clay, wet	6.2 – 7.0	0 52 39 9

ELEVATION SCALE: 235, 234, 233, 232, 231, 230, 229
DEPTH (m): 1, 2, 3, 4, 5, 6, 7
GROUND WATER CONDITIONS: ∇ at approx. 2.7m

AUGER REFUSAL AT 7.0m
SPOON BOUNCING ON INFERRED BEDROCK
GROUNDWATER IN OPEN BORE ON COMPLETION: 2.7m

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RECORD OF BOREHOLE No DC-2

Project No.:D17105A
Drilling Date:2/21/2017
Project: Dam at Lock 38
Drilling Method: Hollow Stem Augering
Location: Proposed Diversion Channel at Lock 38
Hole Diameter: 200mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: 50 100 150 200 (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer)
UNIT WEIGHT γ kN/m^3
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 10 20 30 40

GROUND SURFACE ELEVATION 235.8m

NUMBER	TYPE	"N" VALUES
1	SS	28
2	SS	7
3	SS	1
4	SS	2
5	TW	
6	SS	2
7	TW	
8	SS	51

SOIL DESCRIPTION		
	17cm TOPSOIL	
compact	brown Silty Sand FILL with Gravel	damp
firm	brown Silty Clay FILL trace Topsoil	moist
loose	brown Topsoil FILL	moist
very loose	brown Sandy Silt FILL trace Topsoil	wet
stiff	brown SILTY CLAY to CLAYEY SILT	wet
very dense	grey SANDY SILT GLACIAL TILL trace Gravel, Clay occasional Silty Sand seams	wet

Water content values (%): 16, 18, 25; 24; 30; 27; 24; 16, 23; 25; 10
Field vane: 85 / 5.1; 80 / 5.7; 75 / 4.6; 71 / 4.3
Unit weight: 19.4; 19.0; 19.3; 18.6; 19.3

ELEVATION SCALE: 235, 234, 233, 232, 231, 230, 229, 228
DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
1	4	68	27
6	33	45	16

AUGER REFUSAL AT 8.1m
SPOON BOUNCING ON INFERRED BEDROCK
GROUNDWATER IN MONITORING WELL
Feb 22, 2017: 2.1m
March 11, 2017: 1.7m

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RECORD OF BOREHOLE No DC-3

Project No.:D17105A
Drilling Date:2/22/2017
Project: Dam at Lock 38
Drilling Method: Hollow Stem Augering
Location: Proposed Diversion Channel at Lock 38
Hole Diameter: 200mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40

GROUND SURFACE ELEVATION 234.9m

Shear strength	Unit weight	Water content (%)	Sample No.	Type	"N" Values	Soil description	Elevation	Depth (m)	Remarks & grain size distribution (%) GR SA SI CL
		17	1	SS	43	brown Sand FILL with Gravel			
						compact, dark brown Silty Sand FILL, damp	234	1	
▲		11	2	SS	2	stiff, brown SILTY CLAY to CLAYEY SILT, wet	233	2	
● 13 / 78							232	3	
□	19.5		3	TW					
		22	4	SS	16	compact, brown SANDY SILT, wet	231	4	0 45 55 0
		10 11 15	5	SS	13	compact, grey SANDY SILT GLACIAL TILL with Gravel, trace Clay, wet	230	5	
		8	6	SS	74/ 21cm		229	6	19 30 34 17

AUGER REFUSAL AT 5.9m IN GLACIAL TILL
SPOON BOUNCING ON INFERRED BEDROCK AT 6.2m
GROUNDWATER IN OPEN BORE ON COMPLETION: 1.2m

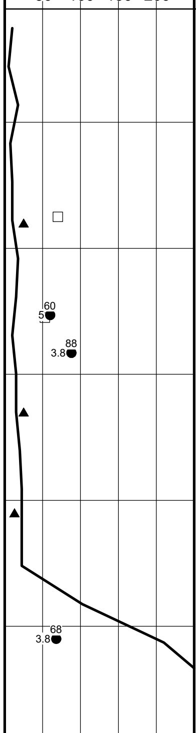
RECORD OF BOREHOLE No DC-4

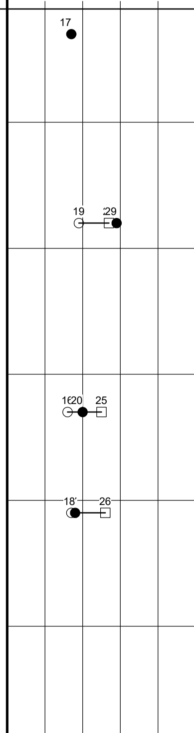
Project No.:D17105A
Drilling Date:2/22/2017
Project: Dam at Lock 38
Drilling Method: Hollow Stem Augering
Location: Proposed Diversion Channel at Lock 38
Hole Diameter: 200mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 0 20 40 60 80 100
SHEAR STRENGTH kPa — ● Field Vane ☐ UU Triaxial ▲ Pocket Penetrometer — 50 100 150 200

UNIT WEIGHT γ kN/m³

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%) 10 20 30 40





GROUND SURFACE ELEVATION 234.9m

Sample Number	Type	"N" Values	Unit Weight γ (kN/m³)	Soil Description	Elevation	Depth (m)	Remarks & Grain Size Distribution (%) GR SA SI CL
1	SS	4		loose Topsoil FILL damp			
					234	1	
2	SS	2	19.5	stiff brown SILTY CLAY to CLAYEY SILT wet			0 5 61 34; TW1 taken at 1.5m
			19.5		233	2	TW2 taken at 2.3m
					232	3	Unable to push TW at 3.0m
3	SS	3					
4	SS	3			231	4	
				grey SILTY SAND GLACIAL TILL trace Gravel, Clay	230	5	
5	SS	50/ 0cm					

Ground water conditions: ∇ at approx. 1.0m

AUGER REFUSAL AT 5.8m
SPOON BOUNCING ON INFERRED BEDROCK
Moved borehole 2m west and 2m north, auger refusal at 5.8m
GROUNDWATER IN OPEN BORE ON COMPLETION: 1.0m

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RECORD OF BOREHOLE No DC-5

Project No.:D17105A
Drilling Date:3/10/2017
Project: Dam at Lock 38
Drilling Method: Hollow Stem Augering
Location: Proposed Diversion Channel at Lock 38
Hole Diameter: 200mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT (0 20 40 60 80 100); SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200) | UNIT WEIGHT γ kN/m³ | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40 | SAMPLES | SOIL PROFILE | ELEVATION SCALE | DEPTH (m) | GROUND WATER CONDITIONS | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

GROUND SURFACE ELEVATION 234.3m

Sample NUMBER	TYPE	"N" VALUES	Shear strength (Field Vane)	Unit weight (kN/m³)	Water content (W_P / W / W_L)	GR	SA	SI	CL
1	SS	2							
2	SS	2			20 / 31 / 27				
3	TW			19.3					
4	SS	2	5.5, 78		18 / 31 / 23	0	3	67	30
5	SS	13			30, 24				
6	SS	53/ 28cm			9	15	31	40	14
7	SS	47			11	7	58	27	8
8	SS	68			7	16	53	22	9

SOIL DESCRIPTION

Elevation / Depth	Consistency	Description	Moisture
234.3–234.0 m		30cm TOPSOIL	
to approx. 231.1 m (3.2 m)	stiff	brown SILTY CLAY to CLAYEY SILT	wet
to approx. 230.3 m (4.0 m)	compact	brown SILTY SAND trace Gravel	wet
to approx. 228.4 m (5.9 m)	very dense	brown / -------------------- / grey SANDY SILT GLACIAL TILL trace Gravel, Clay	wet
to 225.0 m (9.3 m)	dense / very dense	grey SILTY SAND GLACIAL TILL trace Gravel, Clay	wet

Elevation scale: 234, 233, 232, 231, 230, 229, 228, 227, 226, 225
Depth (m): 1, 2, 3, 4, 5, 6, 7, 8, 9

END OF BOREHOLE AT 9.3m
AUGER REFUSAL ON INFERRED BEDROCK

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RECORD OF BOREHOLE No DC-6

Project: Dam at Lock 38	Project No.:D17105A
Location: Proposed Diversion Channel at Lock 38	Drilling Date:3/10/2017
Client: Public Works and Government Services Canada	Drilling Method: Hollow Stem Augering
	Hole Diameter: 200mm
	DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer): 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30 40

SAMPLES

NUMBER	TYPE	"N" VALUES	Shear strength	Unit weight (kN/m³)	Water content	Remarks & Grain size distribution (%) GR SA SI CL
1	SS	3			30	
2	SS	3	▲		18 266	
3	TW		54 / 3.8	19.3		
4	SS	4	▲ 94 / 8.0		19 300	
5	TW		61 / 3.7	19.4	1316	
6	SS	17	▲ 85 / 7.2; >>		26; 9	
7	SS	70/ 28cm			8	0 48 34 18
8	SS	36			8	7 53 31 9
9	SS	52			6	
10	SS	59			8	

SOIL PROFILE

GROUND SURFACE ELEVATION 234.3m

Elevation (m)	Soil description
234.3	51cm TOPSOIL
	SILTY CLAY to CLAYEY SILT, brown, stiff, moist; grey below ~233 m, wet
230.2	CLAYEY SILT GLACIAL TILL, grey, trace Sand, Gravel, hard, moist
229	SILTY SAND TO SANDY SILT GLACIAL TILL, grey, trace Gravel, Clay, occasional wet Sand seams, dense to very dense, moist

END OF BOREHOLE AT 10.1m
AUGER REFUSAL ON INFERRED BEDROCK

ELEVATION SCALE: 234, 233, 232, 231, 230, 229, 228, 227, 226, 225
DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

GROUND WATER CONDITIONS

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RECORD OF BOREHOLE No DC-7

Project No.:D17105A
Drilling Date:3/10/2017

Project: Dam at Lock 38
Drilling Method: Hollow Stem Augering

Location: Proposed Diversion Channel at Lock 38
Hole Diameter: 200mm

Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane □ UU Triaxial ▲ Pocket Penetrometer: 50 100 150 200
UNIT WEIGHT γ kN/m^3
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30 40

GROUND SURFACE ELEVATION 234.1m

NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	SHEAR STRENGTH
1	SS	5	15	57, 2.2
2	SS	4	8, 26, 27	
3	SS	4	30	
4	SS	18	25	57, 4
5	SS	70	9	>>
6	SS	40	12	
7	SS	31	21	
8	SS	40	8, 18, 29	
9	SS	41	14	
10	SS	11	7	
11	SS	40	6	
12	SS	50/10cm	12	

SOIL PROFILE — SOIL DESCRIPTION

17cm TOPSOIL

stiff — brown SILTY CLAY to CLAYEY SILT — moist

compact — brown SANDY SILT — wet

hard — brown SILTY CLAY GLACIAL TILL trace Gravel, Sand — moist

dense — brown SILTY SAND — wet

hard — grey SILTY CLAY GLACIAL TILL trace Gravel, Sand pockets of Silty Clay and Silty Sand — moist

dense — grey SAND trace Gravel — wet

compact / dense — grey SILTY SAND GLACIAL TILL trace Gravel, Clay — wet

END OF BOREHOLE AT 9.4m
AUGER REFUSAL ON INFERRED BEDROCK
GROUNDWATER IN MONITORING WELL
March 11, 2017: 4.5m

ELEVATION SCALE: 234, 233, 232, 231, 230, 229, 228, 227, 226, 225
DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9

GROUND WATER CONDITIONS

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
0	2	62	36
3	71	23	3
6	90	3	1
16	54	21	9

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RECORD OF BOREHOLE No DS-1

Project: Dam at Lock 38	Project No.:D17105A
Location: Lock 38, Trent Severn Waterway, Ontario	Drilling Date:3/12/2017
Client: Public Works and Government Services Canada	Drilling Method: Portable Drilling
	Hole Diameter: 75mm
	DATUM: Geodetic

GROUND SURFACE ELEVATION 228.9m

Water Content (%)	Sample Number	Type	"N" Values	Soil Description	Elevation	Depth (m)	Remarks & Grain Size Distribution (%) GR SA SI CL
				brown Sand FILL with Cobbles			
6	1	SS	30	grey SILTY SAND GLACIAL TILL trace Gravel, Clay; dense; wet	228	1	20 35 33 12
	2	RC			227	2	
	1	RC		grey LIMESTONE BEDROCK fresh occasional fossils occasional black Shale interbeds (~10%) thinly to medium jointing medium strong to very strong good to excellent rock quality			RC1 REC=100% RQD=92%
	2	RC		Joints at 2.1m horizontal, rough; 2.3m horizontal, rough; 2.6m horizontal, rough; 2.7m horizontal, rough; 2.8m horizontal, rough; 2.8m horizontal, rough	226	3	RC2 REC=81% RQD=68%
	3	RC		3.0 to 3.1m, 45 degrees, rough; 3.3m horizontal, rough; 3.4m horizontal, rough; 3.4m horizontal, rough	225	4	RC3 REC=100% RQD=95%
	4	RC		4.2m horizontal, rough; 4.5m horizontal, rough; 4.6m horizontal, rough; 4.7m horizontal, rough; 5.2m horizontal, rough; 5.2m horizontal, rough	224	5	RC4 REC=99% RQD=93
				END OF BOREHOLE AT 5.4m			Artesian water level at 2.3m depth stabilized about 1.6m above grade.

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (0 20 40 60 80 100); SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200); UNIT WEIGHT γ kN/m³; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40; SAMPLES: NUMBER, TYPE, "N" VALUES, RECOVERY; SOIL PROFILE: STRAT PLOT, SOIL DESCRIPTION; ELEVATION SCALE; DEPTH (m); GROUND WATER CONDITIONS; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

RECORD OF BOREHOLE No DS-2

Project: Dam at Lock 38	Project No.:D17105A
Location: Lock 38, Trent Severn Waterway, Ontario	Drilling Date:3/22/2017
Client: Public Works and Government Services Canada	Drilling Method: Portable Drilling
	Hole Diameter: 75mm
	DATUM: Geodetic

WATER SURFACE ELEVATION 228.8m

Water Content (%)	Sample Number	Type	"N" Values	Soil Description	Elevation Scale	Depth (m)	Remarks & Grain Size Distribution (%)
				WATER			
9	1	SS	12	compact grey SILTY SAND GLACIAL TILL trace Gravel, Clay wet	228	1	
	1	RC		grey LIMESTONE BEDROCK slightly weathered to 1.4m fresh occasional fossils occasional black Shale interbeds (~20%) thinly to medium jointing medium strong to very strong good to excellent rock quality Joints at 1.3 to 1.4m 85 degrees, rough 1.5m 85m degrees, rough 1.5m horizontal, rough 1.6m horizontal, rough 1.7m horizontal, rough 1.8m horizontal, rough 2.1, horizontal, rough 2.2m horizontal, rough 2.6m horizontal, rough 2.8m horizontal, rough 3.0m horizontal, rough 3.2m horizontal, rough 3.6m horizontal, rough 3.7m horizontal, rough 3.9m 30 degrees, rough	227	2	RC1 REC=100% RQD=85%
	2	RC			226	3	RC2 REC=97% RQD=97%
	3	RC			225	4	RC3 REC=97% RQD=97%

END OF BOREHOLE AT 4.4m

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (0 20 40 60 80 100); SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200); UNIT WEIGHT γ kN/m³; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30 40; SAMPLES: NUMBER, TYPE, "N" VALUES, RECOVERY; SOIL PROFILE: STRAT PLOT, SOIL DESCRIPTION; ELEVATION SCALE; DEPTH (m); GROUND WATER CONDITIONS; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

RECORD OF BOREHOLE No DS-3

Project No.:D17105A

Drilling Date:3/25/2017

Project: Dam at Lock 38

Drilling Method: Portable Drilling

Location: Lock 38, Trent Severn Waterway, Ontario

Hole Diameter: 75mm

Client: Public Works and Government Services Canada

DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT (0 20 40 60 80 100) / SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200)	UNIT WEIGHT γ kN/m³	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40	SAMPLES: NUMBER	TYPE	"N" VALUES	RECOVERY	STRAT PLOT	SOIL PROFILE: SOIL DESCRIPTION (WATER SURFACE ELEVATION 228.8m)	ELEVATION SCALE	DEPTH (m)	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
									228	1		
			1	RC				<5cm of sediment at bottom of river grey LIMESTONE BEDROCK fresh occasional fossils occasional black Shale interbeds (~10%) thinly to medium jointing medium strong to very strong good to excellent rock quality Joints at 1.2m horizontal, rough 1.4m horizontal, rough 1.5m horizontal, rough 2.0m horizontal, rough 2.3m 20 degrees, rough 2.7m horizontal, rough 2.9m horizontal, rough 3.1m horizontal, rough 3.4m horizontal, rough 3.8m horizontal, rough 3.9m horizontal, rough 4.2m horizontal, rough 4.3m horizontal, rough 4.4m horizontal, rough END OF BOREHOLE AT 4.7m	227	2		RC1 REC=99% RQD=90%
			2	RC					226	3		RC2 REC=100% RQD=100%
			3	RC					225	4		RC3 REC=99% RQD=87% Artesian water condition at 4.0m

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RECORD OF BOREHOLE No DS-4

Project No.:D17105A
Drilling Date:3/26/2017

Project: Dam at Lock 38 | Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario | Hole Diameter: 75mm
Client: Public Works and Government Services Canada | DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane ☐ UU Triaxial ▲ Pocket Penetrometer; 50 100 150 200
UNIT WEIGHT γ kN/m^3
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40

WATER SURFACE ELEVATION 228.8m

Water content (%)	SAMPLES NUMBER	TYPE	"N" VALUES	SOIL DESCRIPTION	ELEVATION SCALE	DEPTH (m)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
				WATER	228	1	
15	1	SS	22	grey SILTY SAND GLACIAL TILL trace Gravel, Clay			
	1	RC		grey LIMESTONE BEDROCK fresh occasional fossils occasional black Shale interbeds (~10%) thinly to medium jointing medium strong to very strong good to excellent rock quality	227	2	RC1 REC=97% RQD=83% Water loss during coring at 2.3m. Regain water at 4.4m
	2	RC		Joints at 1.8m horizontal, rough 1.8m horizontal, rough 2.1m horizontal, rough 2.2m horizontal, rough 2.5m horizontal, rough	226 / 225	3 / 4	RC2 REC=99% RQD=99%
	3	RC		3.1m horizontal, rough 3.5m 20 degrees, rough 3.8m horizontal, rough 4.2m horizontal, rough 4.2m 25 degrees, rough 4.3m 30 degrees, rough 5.0m horizontal, rough	224	5	RC3 REC=100% RQD=90%
				END OF BOREHOLE AT 5.1m			

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RECORD OF BOREHOLE No DS-5

Project No.:D17105A
Drilling Date:6/13/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane □ UU Triaxial ▲ Pocket Penetrometer: 50 100 150 200

UNIT WEIGHT γ kN/m³

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30 40

GROUND SURFACE ELEVATION 235.0m

SAMPLES NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	UNIT WEIGHT (kN/m³)	REMARKS
1	SS	4	21		
2	SS	14	31		
3	SS	14			
4	SS	8	16 (Wp), 26		
5	TW		16 (Wp), 22 (WL), 31	18.2	
			11		
6	SS	35			
			8		
7	SS	40			
1	RC				RC1 REC=97% RQD=46%
2	RC				RC2 REC=100% RQD=98%
3	RC				RC3 REC=100% RQD=100%

SOIL PROFILE / SOIL DESCRIPTION

15cm TOPSOIL

loose — brown SILTY SAND — damp

(to 1.0m, El. 234)

stiff — mottled brown SILTY CLAY to CLAYEY SILT — damp / moist

(to 4.0m, El. 231)

dense — grey SANDY SILT GLACIAL TILL trace Gravel, Clay — wet

(to 7.4m)

grey
LIMESTONE BEDROCK
slightly weathered to 7.5m
fresh
occasional fossils
occasional black Shale interbeds
(~10%)
thinly to medium jointing
medium strong to very strong
good to excellent rock quality
Joints at
7.4m, horizontal, rough
7.5m, horizontal, rough
7.6m, horizontal, rough
7.6m, horizontal, rough
7.8m, horizontal, rough
7.9m, horizontal, rough
8.0m, horizontal, rough
8.1m, horizontal, rough
8.1m, horizontal, rough
8.2m, horizontal, rough
8.5m, horizontal, rough
8.6m, horizontal, rough
8.6m, horizontal, rough
8.7m, horizontal, rough
9.0m, horizontal, rough
9.1m, horizontal, rough
9.2m, horizontal, rough
9.2m, horizontal, rough
9.4m, horizontal, rough
9.6m, horizontal, rough
9.8m, horizontal, rough
END OF BOREHOLE AT 10.1m

ELEVATION SCALE	DEPTH (m)
234	1
233	2
232	3
231	4
230	5
229	6
228	7
227	8
226	9
225	10

GROUND WATER CONDITIONS

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

RECORD OF BOREHOLE No SP-1

Project No.:D17105A
Drilling Date:6/15/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

GROUND SURFACE ELEVATION 234.8m

Sample No.	Type	"N" Values	Depth / Elevation	Soil Description	Lab Data	Remarks & Grain Size (GR SA SI CL)
			0	17cm TOPSOIL		
1	SS	5		mottled brown SILTY CLAY to CLAYEY SILT, firm to stiff, moist		
2	SS	8			w = 22	
3	SS	4			w = 41	
4	SS	5			wP = 19, wL = 28	
5	TW				γ = 19.1 kN/m³; wP = 16, w = 31, wL = 22	
					Field Vane 51 kPa (3.3)	
			~3.8m (231m)	grey SANDY SILT GLACIAL TILL, trace Gravel, Clay, dense, moist		
6	SS	43			w = 11	2 37 50 11
				wet		
7	SS	32			w = 11	14 36 40 10
8	SS	90/15cm		very dense	w = 9	
1	RC		~8.1m	grey LIMESTONE BEDROCK, fresh, occasional fossils, occasional black Shale interbeds (~20%), thinly to medium jointing, medium strong to very strong, good rock quality		RC1 REC=100% RQD=77%

Joints at
8.2m, horizontal, rough
8.4m, horizontal, rough
8.5m, horizontal, rough
8.6m, horizontal, rough
8.7m, horizontal, rough
8.8m, horizontal, rough
8.9m, horizontal, rough
8.9m, horizontal, rough

END OF BOREHOLE AT 9.3m
GROUNDWATER IN MONITORING WELL June 24/17:2.0m

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (0 20 40 60 80 100); SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200); UNIT WEIGHT γ kN/m³; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40; ELEVATION SCALE 234–226; DEPTH (m) 1–9; GROUND WATER CONDITIONS.

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RECORD OF BOREHOLE No US-1

Project No.:D17105A
Drilling Date:3/23/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

GROUND SURFACE ELEVATION 235.2m

Sample No.	Type	"N" Values	Water Content (%)	Soil Description	Remarks
1	SS	4	24	5cm TOPSOIL; loose brown Sandy Silt FILL, trace red brick fragments, trace Topsoil, Rootlets, moist	
2	SS	3	19	very loose	
3	SS	7	24	loose	
4	SS	4	26	grey to black Clayey Silt FILL with Topsoil, trace Sand; firm to stiff, wet	
				Shear strength: Field Vane 51 / 1.9	
5	SS	6	30		
6	SS	5	29		
7	SS	9	29	dark grey Silt FILL with Organics; stiff, wet	
8	SS	8	30		
9	SS	8	19		
10	SS	14	20	loose / very dense, brown SILTY SAND, trace Gravel, Shell fragments, wet	
1	RC			grey LIMESTONE BEDROCK	RC1 REC=96% RQD=82%
2	RC				RC2 REC=100% RQD=100%
3	RC				RC3 REC=98% RQD=95%

grey
LIMESTONE BEDROCK
fresh
occasional fossils
occasional black Shale interbeds
(~10%)
thinly to medium jointing
medium strong to very strong
good to excellent rock quality
Joints at
6.8m horizontal, rough
6.9m horizontal, rough
7.0m horizontal, rough
7.2m horizontal, rough
7.3m horizontal, rough
7.5m horizontal, rough
7.8, horizontal, rough
7.9m horizontal, rough
8.0m horizontal, rough
8.4m horizontal, rough
8.5m horizontal, rough
9.1m horizontal, rough
9.3m horizontal, rough
9.4m horizontal, rough
9.8m horizontal, rough
10.4m horizontal, smooth
10.5m horizontal, rough, clay infilling
END OF BOREHOLE AT 10.6m

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (0 20 40 60 80 100); SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200); UNIT WEIGHT γ kN/m³; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40; SAMPLES: NUMBER, TYPE, "N" VALUES, RECOVERY; STRAT PLOT; SOIL PROFILE: SOIL DESCRIPTION; ELEVATION SCALE (235–225); DEPTH (m) (1–10); GROUND WATER CONDITIONS; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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RECORD OF BOREHOLE No US-2

Project No.:D17105A
Drilling Date:5/25/2017
Drilling Method: Portable Drilling
Hole Diameter: 75mm
DATUM: Geodetic

Project: Dam at Lock 38
Location: Lock 38, Trent Severn Waterway, Ontario
Client: Public Works and Government Services Canada

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer: 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30 40

WATER SURFACE ELEVATION 234.6m

Depth / Elevation	Water Content (%)	Sample Number	Type	"N" Values	Soil Description	Remarks & Grain Size Distribution (%) GR SA SI CL
0 – ~5.4 m					WATER	
~5.4 – 6.2 m (elev. ~229)	37	1	SS	3	very loose, dark grey SANDY SILT with decaying wood, wet	0 48 45 7
6.2 – 9.6 m (elev. ~228 – 225)		1	RC		grey LIMESTONE BEDROCK, fresh, slightly weathered surface, occasional fossils, occasional black Shale interbeds (~10%), thinly to medium jointing, medium strong to very strong, good to excellent rock quality	RC1 REC=98% RQD=0%
		2	RC			RC2 REC=92% RQD=47%
		3	RC			RC3 REC=100% RQD=69%

Joints at
6.2m horizontal, rough
6.2m horizontal, rough
6.2m horizontal, rough
6.3m horizontal, rough
6.3m horizontal, rough
6.4m horizontal, rough
6.4m, 20 degrees, rough
6.5m horizontal, rough
6.5m horizontal, rough
6.6m horizontal, rough
6.7m, 20 degrees, rough
6.8m horizontal, rough
6.9m horizontal, rough
7.0m horizontal, rough
7.1m horizontal, rough
7.2m horizontal, rough
7.5m horizontal, rough
7.6m, horizontal, rough
7.6m, horizontal, rough
7.7m, horizontal, rough
7.7m, 20 degrees, rough
7.8m, horizontal, rough
7.8m, 30 degrees, rough
7.9m, horizontal, rough
8.0m, horizontal, rough
8.1m, 20 degrees, rough
8.5m, horizontal, rough
8.6m, horizontal, rough
8.8m, horizontal, rough
9.0m, horizontal, rough
9.0m, horizontal, rough
9.1m, horizontal, rough
9.2m, horizontal, rough
9.4m, horizontal, rough
9.4m, horizontal, rough

END OF BOREHOLE AT 9.6m

Elevation scale: 234, 233, 232, 231, 230, 229, 228, 227, 226
Depth (m): 1, 2, 3, 4, 5, 6, 7, 8, 9

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RECORD OF BOREHOLE No US-3

Project No.:D17105A
Drilling Date:5/24/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT 0 20 40 60 80 100 / SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer) 50 100 150 200	UNIT WEIGHT γ kN/m³	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30 40	SAMPLES NUMBER	TYPE	"N" VALUES	RECOVERY	STRAT PLOT	SOIL PROFILE — SOIL DESCRIPTION (WATER SURFACE ELEVATION 234.6m)	ELEVATION SCALE	DEPTH (m)	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
								WATER	234 233 232 231 230 229	1 2 3 4 5 6		
								less than 5cm of SILTY SAND				
			1	RC				grey LIMESTONE BEDROCK slightly weathered to 6.9m fresh occasional fossils occasional black Shale interbeds (~10%) thinly to medium jointing medium strong to very strong very poor rock quality	228	7		RC1 REC=80% RQD=29%
			2	RC					227			RC2 REC=100% RQD=32%
			3	RC						8		RC3 REC=50% RQD=0%

Joints at
6.2m horizontal, rough
6.3m horizontal, rough
6.7 to 6.8m, vertical, rough
6.8m horizontal, rough
6.8m horizontal, rough
6.9m, horizontal, rough
7.0m horizontal, rough
7.1m horizontal, rough
7.2m horizontal, rough
7.2m horizontal, rough
7.3m horizontal, rough
7.4m horizontal, rough
7.5m horizontal, rough
7.6m horizontal, rough
7.6m horizontal, rough
7.7m horizontal, rough
7.8m, horizontal, rough
7.9m, horizontal, rough
7.9m, horizontal, rough, 10mm clay infilling
8.0m, horizontal, rough, 15mm sand infilling
8.0m, horizontal, rough, 25mm sand infilling
8.0m, horizontal, rough, 25mm clay infilling
8.1m, horizontal, rough, clay infilling
END OF BOREHOLE AT 8.1m

RECORD OF BOREHOLE No US-4

Project No.:D17105A
Drilling Date:3/20/2017
Drilling Method: Portable Drilling
Hole Diameter: 75mm
DATUM: Geodetic

Project: Dam at Lock 38
Location: Lock 38, Trent Severn Waterway, Ontario
Client: Public Works and Government Services Canada

GROUND SURFACE ELEVATION 233.8m

Depth (m)	Elevation (m)	Soil Description	Sample No.	Type	"N" Values	Unit Weight γ (kN/m³)	Water Content (%)	Shear Strength (kPa)	Remarks & Grain Size Distribution (%)
0–1.2	233.8–232.6	RIP RAP							
1.2–3.6	232.6–230.2	firm to very stiff, grey SILTY CLAY to CLAYEY SILT, varved, moist to wet	1	SS	7		w_P=14, w_L=20, w=28		
			2	TW		19.9	27		
			3	SS	9		w_P=8, w=25, w_L=26; 11	Field Vane 112	
			4	TW			10		
3.6–5.2	230.2–228.6	very dense, grey SILTY SAND GLACIAL TILL, trace Gravel, Clay, wet	5	SS	50/15cm		9	Pocket Penetrometer	
5.2–8.6	228.6–225.2	grey LIMESTONE BEDROCK, fresh, occasional fossils, occasional black Shale interbeds (~20%), thinly to medium jointing, medium strong to very strong, good to excellent rock quality. Joints at 5.3m horizontal, rough; 5.3m 45 degress, rough; 5.6m horizontal, rough; 6.1m horizontal, rough; 6.4m horizontal, rough; 7.0m horizontal, rough; 7.3m horizontal, rough; 8.2m horizontal, rough; 8.5m, horizontal, rough, clay infilling	1	RC					RC1 REC=100% RQD=100%
			2	RC					RC2 REC=99% RQD=81%
			3	RC					RC3 REC=100% RQD=94%

END OF BOREHOLE AT 8.6m

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RECORD OF BOREHOLE No US-5

Project No.:D17105A
Drilling Date:3/13/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

GROUND SURFACE ELEVATION 235.3m

Sample No.	Type	"N" Values	Soil Description	Remarks
			30cm TOPSOIL	
1	SS	4	loose, brown Silty Sand FILL with Topsoil inclusions, Rootlets, trace decaying Wood, wet	
2	SS	6		
3	SS	5		TW taken at 1.5m
4	SS	5	soft to stiff, dark brown to dark grey Silty Clay to Clayey Silt FILL, trace decaying Wood, Rootlets, wet	
5	SS	7		
6	SS	8		
7	SS	8		
8	SS	11		TW taken at 4.6m; Vibrating Wire Piezometer at 4.6m
			firm, black PEAT, wet	
9	SS	5	loose, grey Silty Sand FILL with Topsoil inclusions, trace decaying wood, wet	GR 0, SA 66, SI 29, CL 5
			loose, dary grey SILTY SAND trace Shell fragments, wet	
1	RC		grey LIMESTONE BEDROCK	RC1 REC=98% RQD=83%
2	RC			RC2 REC=92% RQD=71%; Water loss during coring at 8.2m to 9.4m
3	RC			RC3 REC=100% RQD=79%

grey
LIMESTONE BEDROCK
slightly weathered to 6.9m
fresh
occasional fossils
occasional black Shale interbeds
(~20%)
thinly to medium jointing
medium strong to very strong
good to excellent rock quality
Joints at
6.9m horizontal, rough
6.9m 45 degress, rough
7.0m horizontal, rough
7.1m horizontal, rough
7.1m horizontal, rough
7.7m horizontal, rough
8.0m horizontal, rough
8.0m 20 degrees, rough
8.1m, horizontal, rough
8.2m horizontal, rough
8.2m horizontal, rough
8.9m horizontal, rough
9.0m 20 degrees, rough
9.1m horizontal, rough
9.2m horizontal, rough
9.3m 30 degrees, rough
9.6m 20 degrees, rough
9.9m horizontal, rough
END OF BOREHOLE AT 10.0m

Unit weight: 18.6 kN/m³ (at sample 3)

Water content (%): 24, 25, 27, 28 (Wp 6, WL 23), 26, 29 (Wp 9, WL 23), 27, 29, 27, 40, 24

Field vane shear strength: 24 kPa (3.1) at ~2.0m; 18 kPa (4.0) at ~5.0m

Elevation scale: 235, 234, 233, 232, 231, 230, 229, 228, 227, 226
Depth (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DYNAMIC CONE PENETRATION RESISTANCE PLOT 0 20 40 60 80 100
SHEAR STRENGTH kPa ● Field Vane □ UU Triaxial ▲ Pocket Penetrometer 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT, NATURAL MOISTURE CONTENT, LIQUID LIMIT (w_P, w, w_L) WATER CONTENT (%) 10 20 30 40
SAMPLES: NUMBER, TYPE, "N" VALUES, RECOVERY
SOIL PROFILE: STRAT PLOT, SOIL DESCRIPTION
ELEVATION SCALE, DEPTH (m), GROUND WATER CONDITIONS, REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

RECORD OF BOREHOLE No V-1

Project No.:D17105A
Drilling Date:3/12/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane □ UU Triaxial ▲ Pocket Penetrometer: 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%): 10 20 30 40

WALL SURFACE ELEVATION 235.5m

Number	Type	"N" Values	Soil Description	Elevation (m)	Depth (m)	Remarks (GR SA SI CL)
1	CC		CONCRETE Angular aggregate steel reinforcement at 0.1m inclinded bonded joint at 0.3m	235		CC1 REC=98%
2	CC		CONCRETE Rounded aggregate	234	1	CC2 REC=100%
3	CC			233	2	CC3 REC=90%
4	CC			232	3 / 4	CC4 REC=95%
5	SS	57/ 15cm	SAND	231 / 230	5	
6	CC		CONCRETE Rounded aggregate		6	CC6 REC=100%
1	RC		grey LIMESTONE BEDROCK fresh occasional fossils occasional black Shale interbeds (~20%) thinly to medium jointing medium strong to very strong fair to excellent rock quality Joints at 6.6m horizontal, rough 6.6m horizontal, rough 6.8m horizontal, rough 6.9m horizontal, rough 7.0m horizontal, rough 7.1m horizontal, rough 7.1m horizontal, rough 7.5m 45 degrees, rough 7.8m horizontal, rough, clay infilling 8.3m horizontal, rough 8.5m 20 degrees, rough 9.1m horizontal, rough 9.2m horizontal, rough 9.4m horizontal, rough 9.8m horizontal, rough	229		RC1 REC=100%
2	RC				7	RC2 REC=100% RQD=57%
3	RC			228	8	RC3 REC=90% RQD=80%
4	RC			227		RC4 REC=100% RQD=81%
5	RC				9	RC5 REC=100% RQD=100%
6	RC			226		RC6 REC=85% RQD=83%

END OF BOREHOLE AT 9.9m

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RECORD OF BOREHOLE No V-2

Project No.:D17105A
Drilling Date:4/9/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane ☐ UU Triaxial ▲ Pocket Penetrometer: 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30 40

PIER SURFACE ELEVATION 236.3m

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%)
1	CC		CC1 REC=98%
2	CC		CC2 REC=94%
3	CC		CC3 REC=89%
4	CC		CC4 REC=99%
5	CC		CC5 REC=100%
6	CC		Water loss during coreing at 6.7m; CC6 REC=83%
7	CC		CC7 REC=100%
1	RC		RC1 REC=93% RQD=53%
2	RC		RC2 REC=100% RQD=85%
3	RC		RC3 REC=99% RQD=95%

SOIL DESCRIPTION

cold joint at 1.7m

Cold joint at 2.4m

CONCRETE
rounded aggregate
high air void ratio

Calcium carbonate staining at 5.1m

Yellow staining at 5.4m

Yellow and black staining at:
6.0m
6.3m
6.4m

Broken concrete at 7.4 to 7.7m
Wood piece at 7.7m

Bonded concrete-rock interface

grey
LIMESTONE BEDROCK
fresh
occasional fossils
occasional black Shale interbeds (~20%)
thinly to medium jointing
medium strong to very strong
fair to excellent rock quality
Joints at
8.5m horizontal, rough
8.8m horizontal, rough
8.8m horizontal, rough
9.0m horizontal, rough
9.2m 20 degrees, rough
9.5m horizontal, rough
9.8m 30 degrees, rough
9.8m horizontal, rough
9.9m horizontal, rough
9.9m horizontal, rough
10.1m 10 degrees, rough
10.7m horizontal, rough
11.2m horizontal, rough
11.2m horizontal, rough
END OF BOREHOLE AT 11.7m

ELEVATION SCALE: 236, 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225
DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

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RECORD OF BOREHOLE No V-3

Project No.:D17105A
Drilling Date:4/6/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane ☐ UU Triaxial ▲ Pocket Penetrometer: 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%): 10 20 30 40

SAMPLES NUMBER	TYPE	"N" VALUES	RECOVERY	SOIL DESCRIPTION	REMARKS & GRAIN SIZE DISTRIBUTION (%)
				PIER SURFACE ELEVATION 235.9m	GR SA SI CL
1	CC			CONCRETE rounded aggregate high air void ratio	CC1 REC=100%
2	CC				CC2 REC=100%
3	CC				CC3 REC=92%
4	CC				CC4 REC=77%
5	CC				CC5 REC=100%
6	CC			Broken concrete at 5m Yellow staining Broken concrete zone 5.5 to 5.7m Yellow staining	CC6 REC=77%
7	CC			Broken concrete zone 6.2 to 6.3m Yellow staining	CC7 REC=95%
8	CC				CC8 REC=99%
9	CC				CC9 REC=100%
10	CC			inclined bonded concrete-bedrock interface	CC10 REC=100%
1	RC			grey LIMESTONE BEDROCK fresh occasional fossils occasional black Shale interbeds (~10%) thinly to medium jointing medium strong to very strong fair to excellent rock quality Joints at 8.3m horizontal, rough, trace clay infill 8.4m horizontal, rough, trace clay infill 8.4m 30 degrees, rough, stained brown 8.5m horizontal, rough 8.6m horizontal, rough 8.6m horizontal, rough 8.8m horizontal, rough 8.9m horizontal, smooth, trace clay infill 9.0m horizontal, rough, yellow staining 9.0m horizontal, rough 9.3m horizontal, rough 9.9m horizontal, rough 10.0m horizontal, smooth 10.2m horizontal, rough 10.7m horizontal, rough 11.0m horizontal, rough	RC1 REC=98% RQD=90%
2	RC				RC2 REC=96% RQD=96%
				END OF BOREHOLE AT 11.5m	

ELEVATION SCALE: 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225
DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
GROUND WATER CONDITIONS

RECORD OF BOREHOLE No V-4

Project No.:D17105A
Drilling Date:4/5/2017
Project: Dam at Lock 38
Drilling Method: Portable Drilling
Location: Lock 38, Trent Severn Waterway, Ontario
Hole Diameter: 75mm
Client: Public Works and Government Services Canada
DATUM: Geodetic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 0 20 40 60 80 100
SHEAR STRENGTH kPa: ● Field Vane □ UU Triaxial ▲ Pocket Penetrometer: 50 100 150 200
UNIT WEIGHT γ kN/m³
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30 40

PIER SURFACE ELEVATION 235.9m

SAMPLE NUMBER	TYPE	"N" VALUES	SOIL DESCRIPTION	ELEVATION SCALE	DEPTH (m)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	CC		Cold joint at 0.8m Vertical crack from 1.2 to 1.8m	235	1	CC1 REC=99%
2	CC		CONCRETE rounded aggregate high air void ratio	234	2	CC2 REC=99%
3	CC		Piece of wood cored at 3.2m	233	3	CC3 REC=100%
4	CC		Yellow staining at 4.3m, 5m, 6.1m, 7.0m Brown staining at 7.3m	232 / 231	4 / 5	CC4 REC=100%
5	CC			230	6	CC5 REC=100%
6	CC		Broken concrete at 7.9 to 8.4m	229 / 228	7 / 8	CC6 REC=80%
7	CC		unbonded concrete-rock interface	227	9	CC7 REC=100%
1	RC		grey LIMESTONE BEDROCK slightly weathered to 9.6m fresh occasional fossils occasional black Shale interbeds (~10%) thinly to medium jointing medium strong to very strong fair to excellent rock quality Joints at 9.1m horizontal, rough 9.3m horizontal, rough, yellow staining 9.4m horizontal, rough, yellow staining 9.6m horizontal, rough 9.8m horizontal, rough 9.8m 30 degrees, rough 9.9m horizontal, rough 10.4m 45 degrees, rough 11.0m horizontal, rough 11.1m horizontal, rough 11.4m horizontal, rough 11.7m horizontal, rough 11.7m horizontal, rough 11.8m horizontal, rough 11.9m horizontal, rough 12.2m 30 degrees, rough END OF BOREHOLE AT 12.2m			RC1 REC=83% RQD=81%
2	RC			226	10	RC2 REC=95% RQD=69%
3	RC			225	11	RC3 REC=98% RQD=93%
4	RC			224	12	RC4 REC=100% RQD=71%

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RECORD OF BOREHOLE No V-5

Project No.:D17105A
Drilling Date:4/10/2017
Drilling Method: Portable Drilling
Hole Diameter: 75mm
DATUM: Geodetic

Project: Dam at Lock 38
Location: Lock 38, Trent Severn Waterway, Ontario
Client: Public Works and Government Services Canada

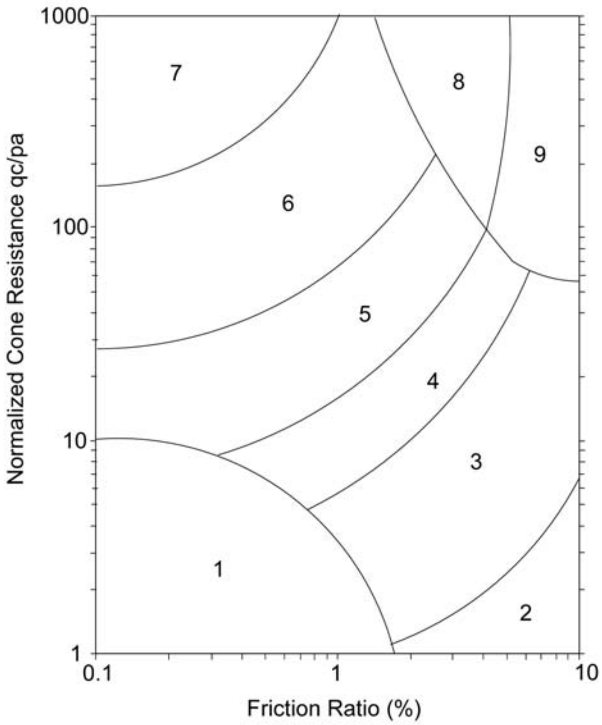
SAMPLE NUMBER	TYPE	"N" VALUES	SOIL DESCRIPTION	ELEVATION SCALE	DEPTH (m)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			PIER SURFACE ELEVATION 236.3m	236		
1	CC		CONCRETE rounded aggregate high air void ratio	235	1	CC1 REC=92%
2	CC			234	2	CC2 REC=100%
3	CC			233	3	CC3 REC=78%
4	CC		Poor Recovery from 5.5 to 6.0m	232, 231	4, 5	CC4 REC=81%
5	CC		5cm thick Wood piece at 6.0m Broken concrete from 6.0 to 6.8m	230, 229	6, 7, 8	CC5 REC=76%
6	CC		unbonded concrete-rock interface	228	9	CC6 REC=100%
1	RC		grey LIMESTONE BEDROCK slightly weathered to 9.6m fresh occasional fossils occasional black Shale interbeds (~5%) thinly to medium jointing medium strong to very strong fair to excellent rock quality	227		RC1 REC=87% RQD=59%
2	RC		Joints at 9.3m horizontal, rough 9.3m horizontal, rough 9.4m horizontal, rough 9.4m horizontal, rough 9.5m horizontal, rough 9.6m horizontal, rough 9.6m horizontal, rough 9.9m 20 degrees, rough 10.0m horizontal, rough 10.1m 20 degrees, rough 10.3m horizontal, rough 10.4m 45 degrees, rough 10.4m horizontal, rough 10.5m horizontal, rough 10.6m horizontal, rough 11.4m horizontal, rough 11.5m horizontal, rough 11.7m horizontal, rough	226	10	RC2 REC=100% RQD=92%
3	RC			225	11	RC3 REC=90% RQD=90%
			END OF BOREHOLE AT 11.9m			

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (0 20 40 60 80 100); SHEAR STRENGTH kPa (● Field Vane, □ UU Triaxial, ▲ Pocket Penetrometer; 50 100 150 200); UNIT WEIGHT γ kN/m³; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 40; SAMPLES: NUMBER, TYPE, "N" VALUES, RECOVERY; SOIL PROFILE: STRAT PLOT, SOIL DESCRIPTION; ELEVATION SCALE; DEPTH (m); GROUND WATER CONDITIONS; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

CPT Interpretation

The data collected from the CPTu tests are presented graphically. The Soil Behaviour Type (SBT) interpretation is based on charts described by Robertson (1990). The inferred CPTu geotechnical parameters and interpretations made in this report are presented as a guide only.

1. **Soil Behaviour Type:** SBT is based on the following chart from Robertson (1990).



NORMALIZED SOIL BEHAVIOUR TYPE (after Robertson 1990)

ZONE		SBT
1		Sensitive, fine grained
2		Organic materials
3		Clay
4		Silty Clay to Clay
5		Silty Sand to Sandy Silt
6		Sand to Silty Sand
7		Sand
8		Very dense/stiff soil*
9		Very dense/stiff soil*

* heavily overconsolidated and/or cemented

2. **Tip Resistance:** The CPTu provides a continuous measurement of the cone resistance, q_c. The measured cone resistance is corrected to total cone resistance, q_t, using the following equation,

$$q_t = q_c + u_2\,(1\text{-}a)$$

where u_2 = pore pressure acting behind the cone
a = cone area ratio = A_n/A_c
= 0.57 for GEOTECH AB 10 tonne cone
= 0.80 for Conetec 10 tonne cone
A_n=cross-sectional area of the load cell or shaft
A_c = projected area of the cone

3. **Friction Ratio:** The friction along the cone sleeve, f_s, is continuously measured during cone penetration. Friction Ratio is a commonly used parameter for determination of soil profiling and classification. Friction ratio is determined by the following equation.

$$FR\ (\%) = \frac{f_s}{q_t}$$

4. **Pore Pressure:** Continuous measurements of porewater pressure are taken during penetration. Due to the dynamic nature of the cone penetration, the porewater pressure measurements within fine grained soils are not representative due to undrained conditions and may even be negative in overconsolidated soils or dilatant silts.

5. **Undrained Shear Strength:** The relationship between cone resistance and undrained shear strength can be empirically represented by the following equation.

$$S_u = \frac{(q_T - \sigma_V)}{N_{kt}}$$

where S_u = undrained shear strength (kPa)
σ_V= vertical stress (kPa)
N_{kt}= dimensionless constant

Typically N_{kt} varies from 10 to 30. Undrained shear strengths were determined for SBTs 1 to 5. In order to correlate to the in situ shear vane test results a N_{kt} of 15 was used.

6. **Equivalent N_{60} SPT Value:** Based on Jefferies and Davies (1993) the following empirical equation is used to correlate to equivalent Standard Penetration Test results.

$$N_{60} = \frac{q_C}{0.85 \times (1 - I_C/4.6)}$$

where q_C = tip resistance (MPa)
I_C = Soil Classification Index

Jefferies and Davies (1993) proposed a CPT Soil Index I_C, which is used in SPT correlation.

$$I_C = [\ (3.47\text{-}\log(Q))^2 + (1.22 + (\log F))^2]^{0.5}$$

where Q = normalized tip resistance = $(q_T - \sigma_{V0})/\ \sigma_{V0}'$
F = normalized sleeve friction = $f_s /\ (q_T - \sigma_{V0})$
B_q= normalized excess porewater pressure reading=$(u_2\text{-}u_0)/(q_T\text{-}\sigma_{V0})$

7. **OCR:** The estimate of the overconsolidation ratio, OCR, in clays is based on the following equation,

$$OCR = \frac{k\,(q_t - \sigma_v)}{\sigma'_v}$$

Where k is constant typically ranging from 0.2 to 0.5 for clays. A 'k' value of 0.22 was used for SBTs 1 to 5 to correlate with the oedometer test results.

8. **Constrained Modulus:** The constrained modulus, M, represents the deformation characteristics of the clay soils for preconsolidation stresses, and is a function of the stress history, drainage condition and the stress path direction of the soil. The estimate of M for clays and sands is based on Robertson (2009) and Senneset (1982):

$$M = \alpha_m\,(q_t - \sigma_{vo})$$

For I_c <2.2 (Sands):

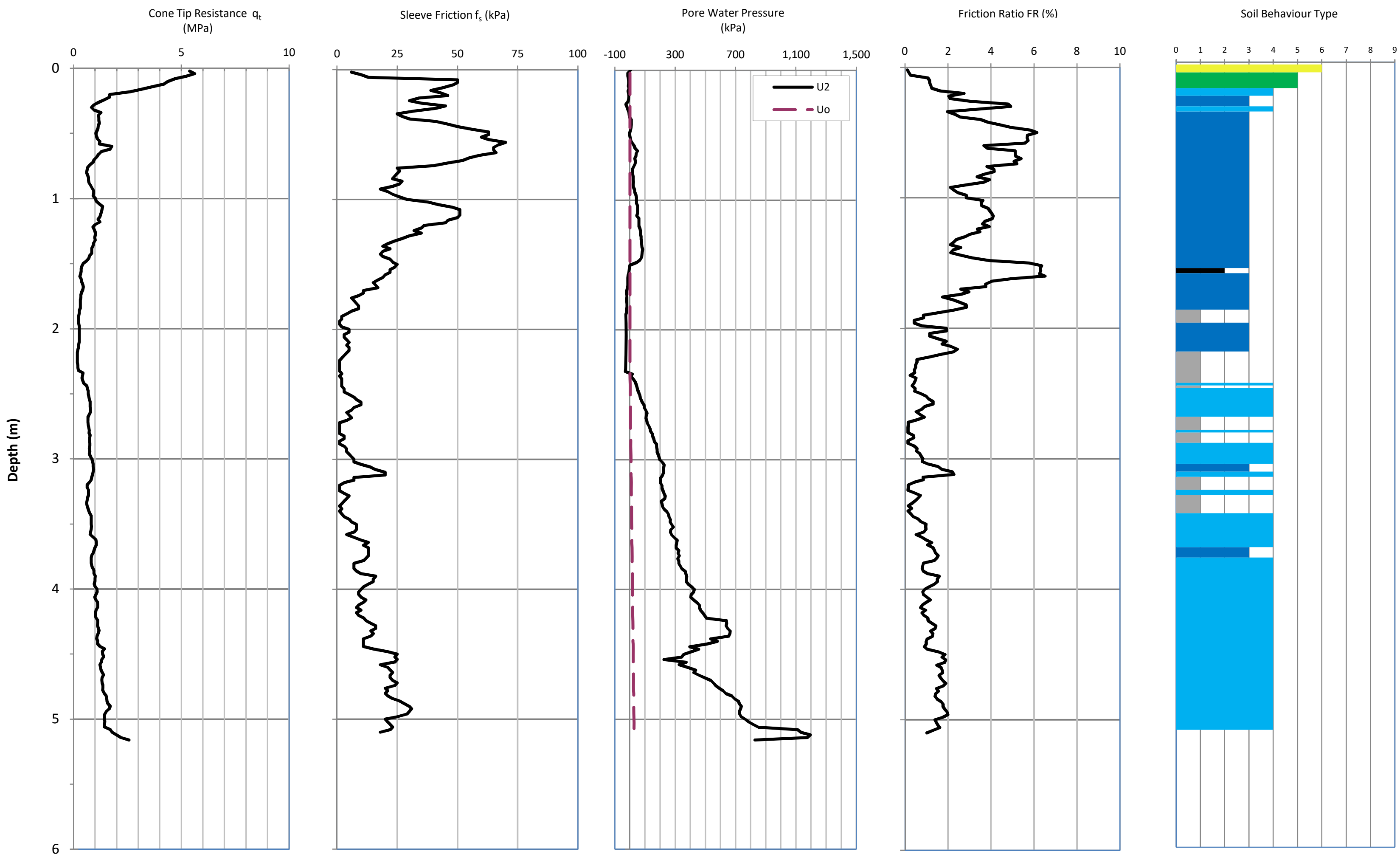
$$\alpha_m = 0.0188\,[\,10^{(0.55\,Ic\,+\,1.68)}]$$

For I_c >2.2 (Clays):

If q_t<0.7MPa $\alpha_m = 6$
If 0.7MPa < q_t<2.0MPa $\alpha_m = 5$
If q_t>2.0MPa $\alpha_m = 3$

The above results compare well with the oedometer results.

PiezoCone Penetration Test



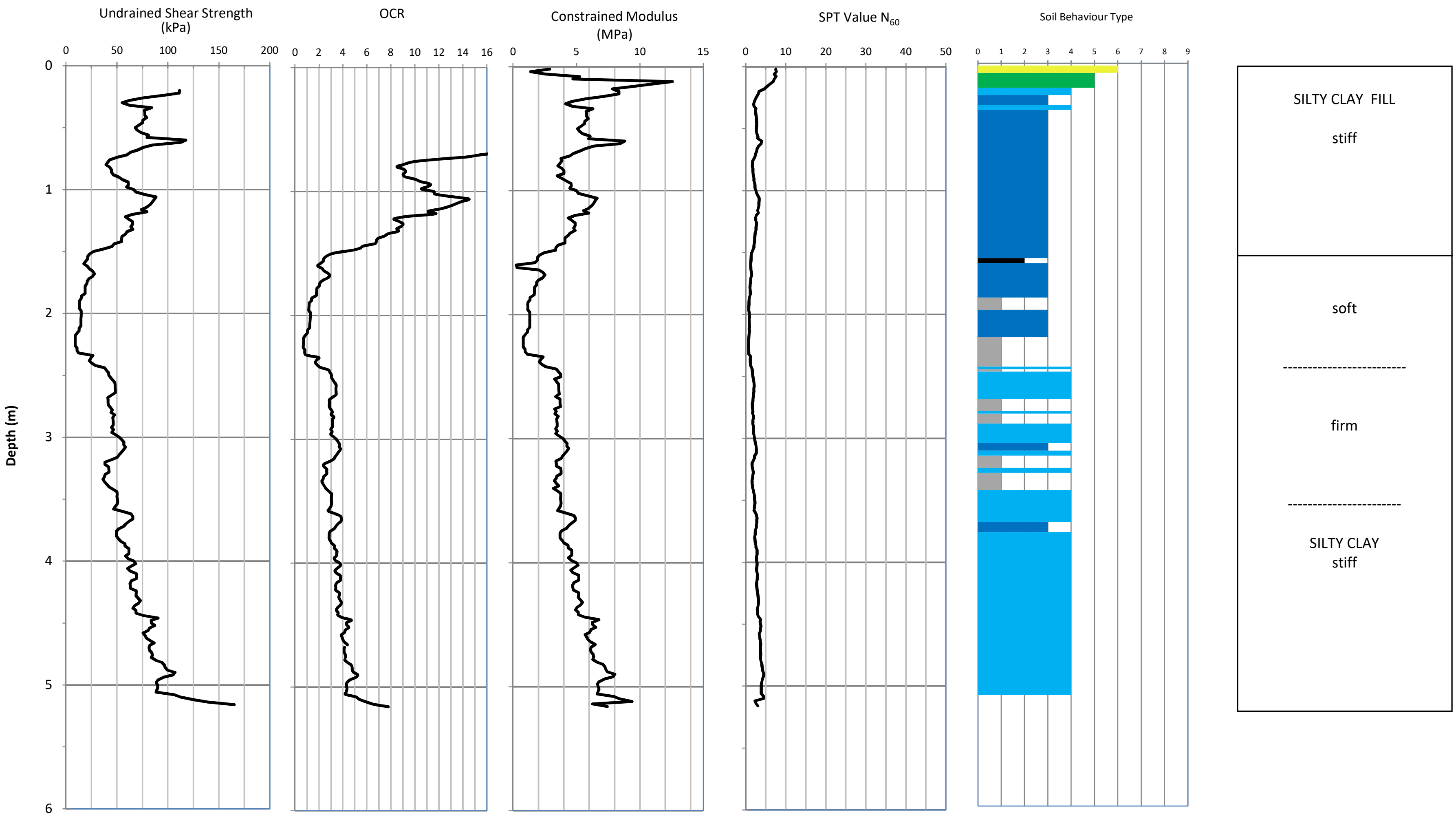
Date: March 20, 2017
Location: Dam at Lock 38, Brechin, Ontario
Engineer: A.Drevininkas
Cone: GEOTECH AB 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-DC-2

CPT Probe 4143

DownUnder Geotechnical Limited

PiezoCone Penetration Test



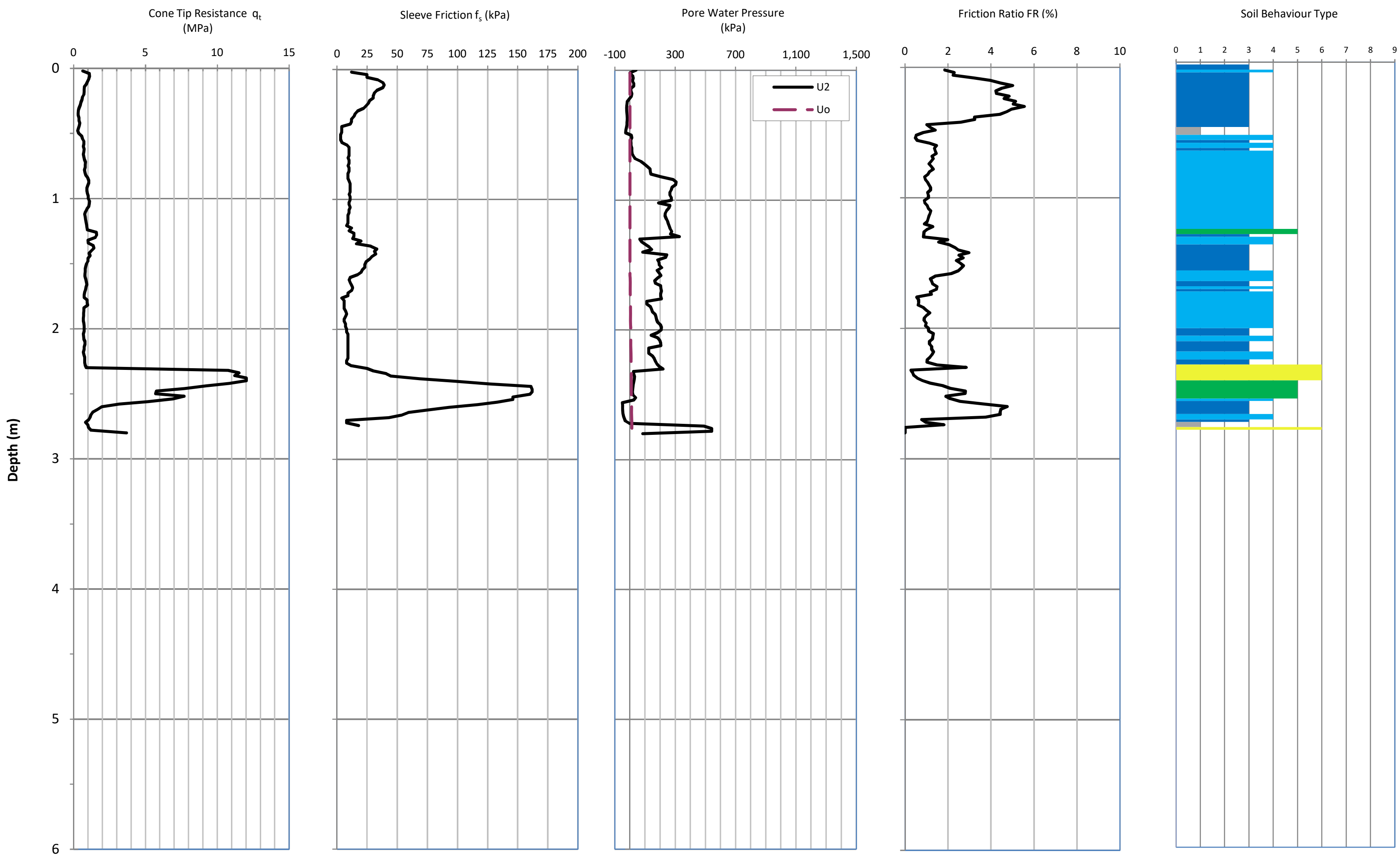
Date: March 20, 2017
Location: Dam at Lock 38, Brechin, Ontario
Engineer: A.Drevininkas
Cone: GEOTECH AB 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-DC-2

CPT Probe 4143

DownUnder Geotechnical Limited

PiezoCone Penetration Test



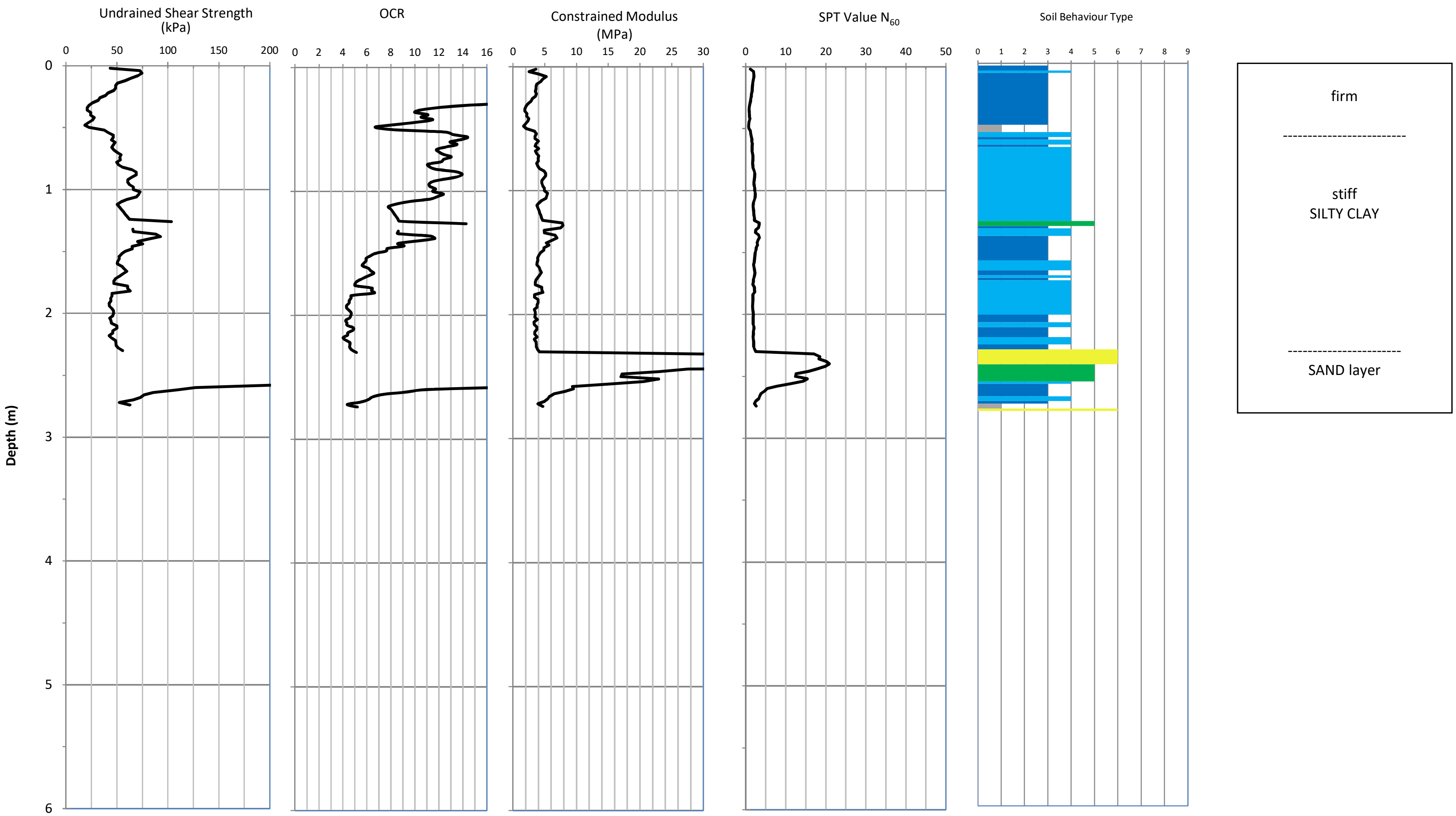
CPT-DC-5

Date: March 20, 2017
Location: Dam at Lock 38, Brechin, Ontario
Engineer: A.Drevininkas
Cone: GEOTECH AB 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT Probe 4143

DownUnder Geotechnical Limited

PiezoCone Penetration Test



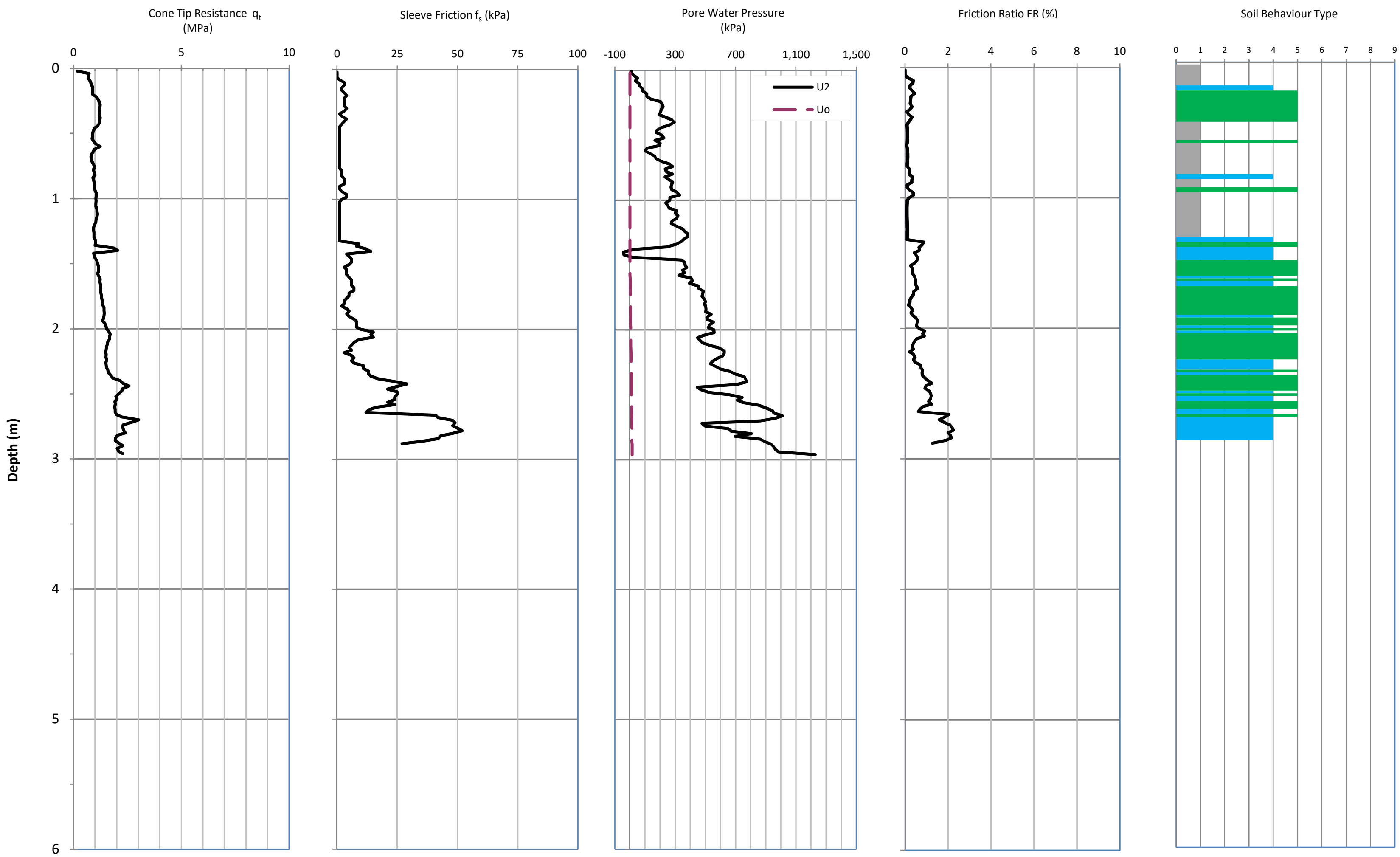
Date: March 20, 2017
Location: Dam at Lock 38, Brechin, Ontario
Engineer: A.Drevininkas
Cone: GEOTECH AB 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-DC-5

CPT Probe 4143

DownUnder Geotechnical Limited

PiezoCone Penetration Test



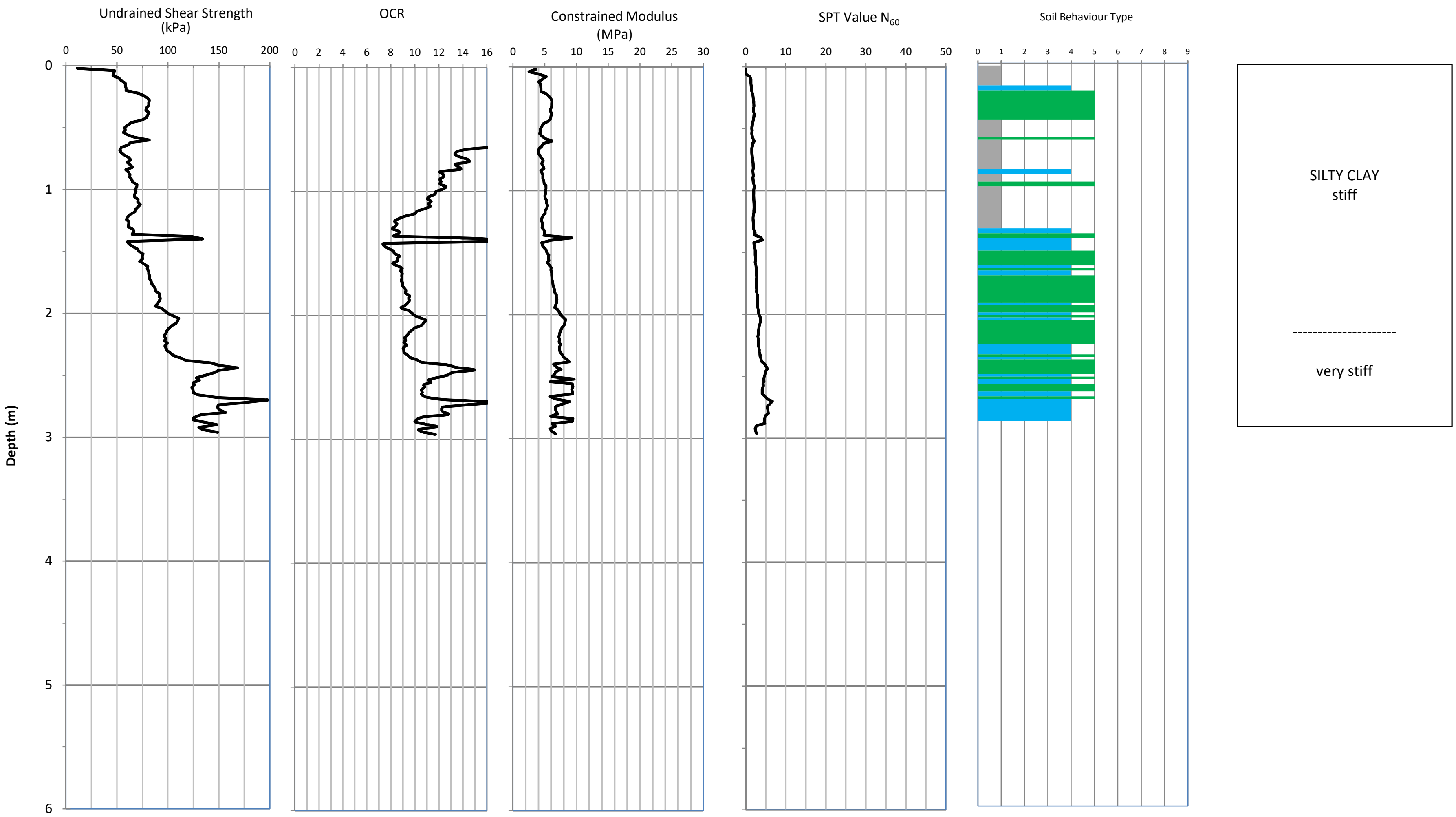
Date: March 20, 2017
Location: Dam at Lock 38, Brechin, Ontario
Engineer: A.Drevininkas
Cone: GEOTECH AB 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-DC-6

CPT Probe 4143

DownUnder Geotechnical Limited

PiezoCone Penetration Test



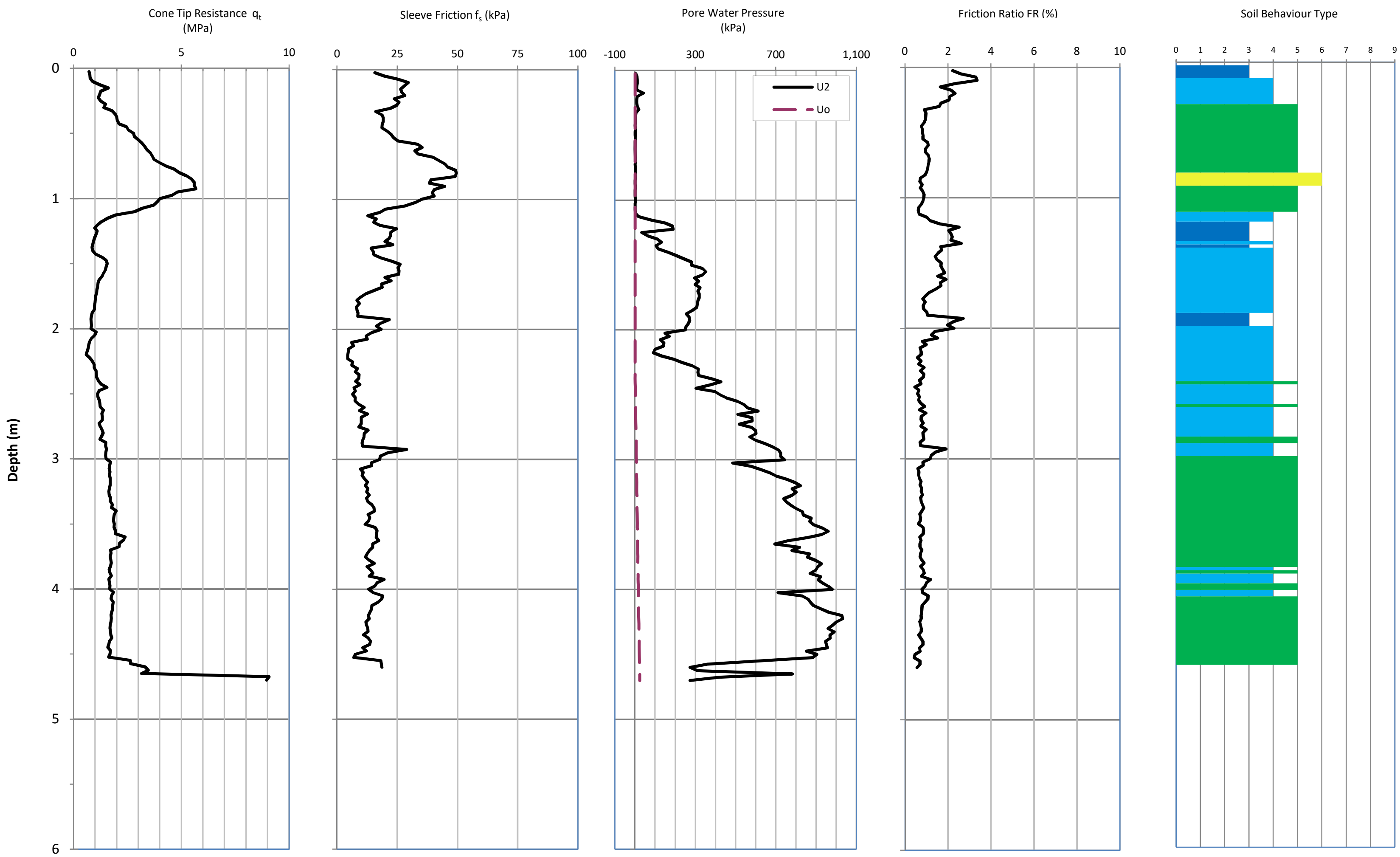
Date: March 20, 2017
Location: Dam at Lock 38, Brechin, Ontario
Engineer: A.Drevininkas
Cone: GEOTECH AB 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-DC-6

CPT Probe 4143

DownUnder Geotechnical Limited

PiezoCone Penetration Test



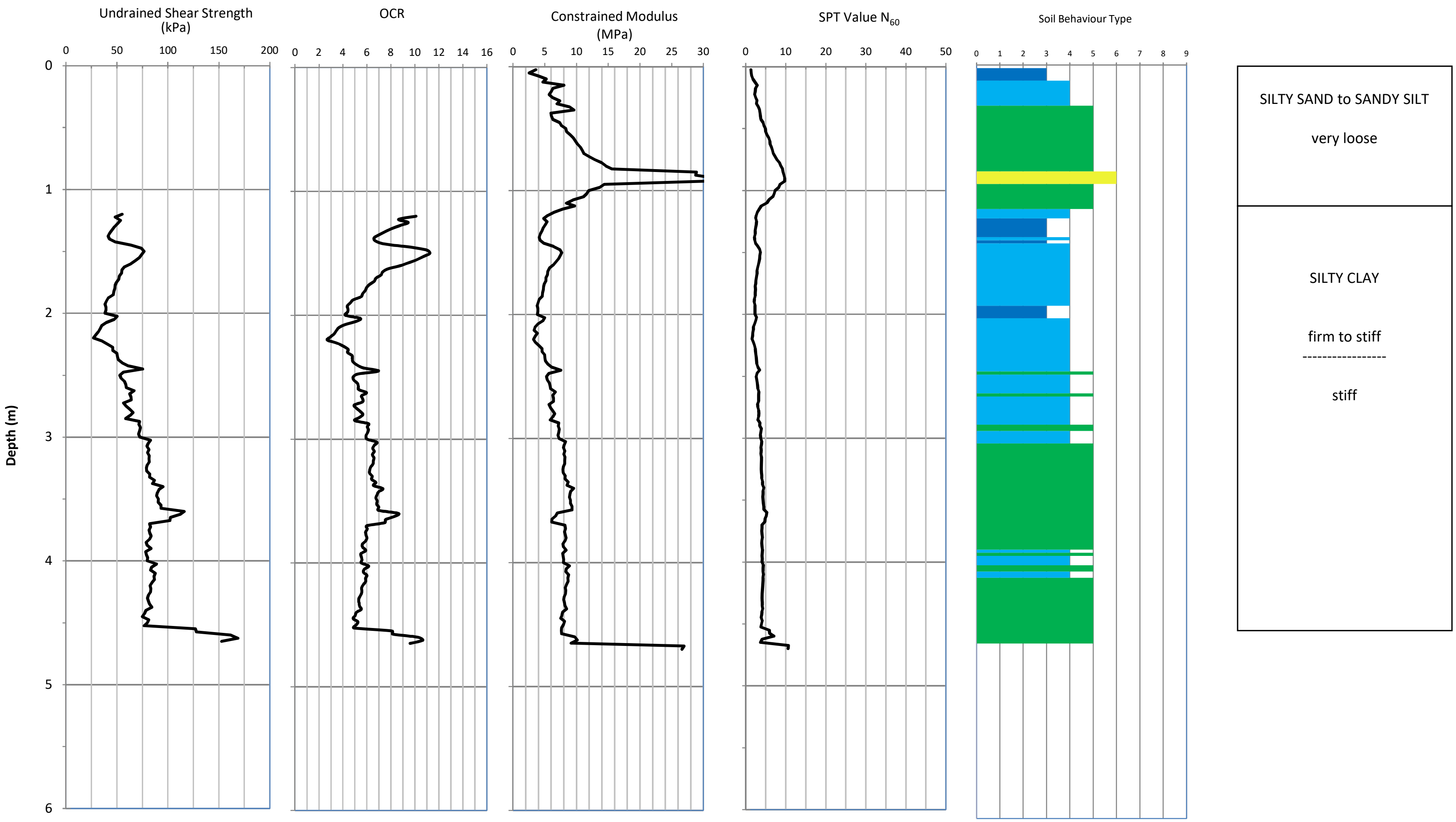
Date: June 27, 2017
Location: Dam at Lock 38, Brechin, Ontario
ConeTec Investigations
Cone: CONETEC 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-DS-5

CPT Probe 355:T1000F10U500

DownUnder Geotechnical Limited

PiezoCone Penetration Test



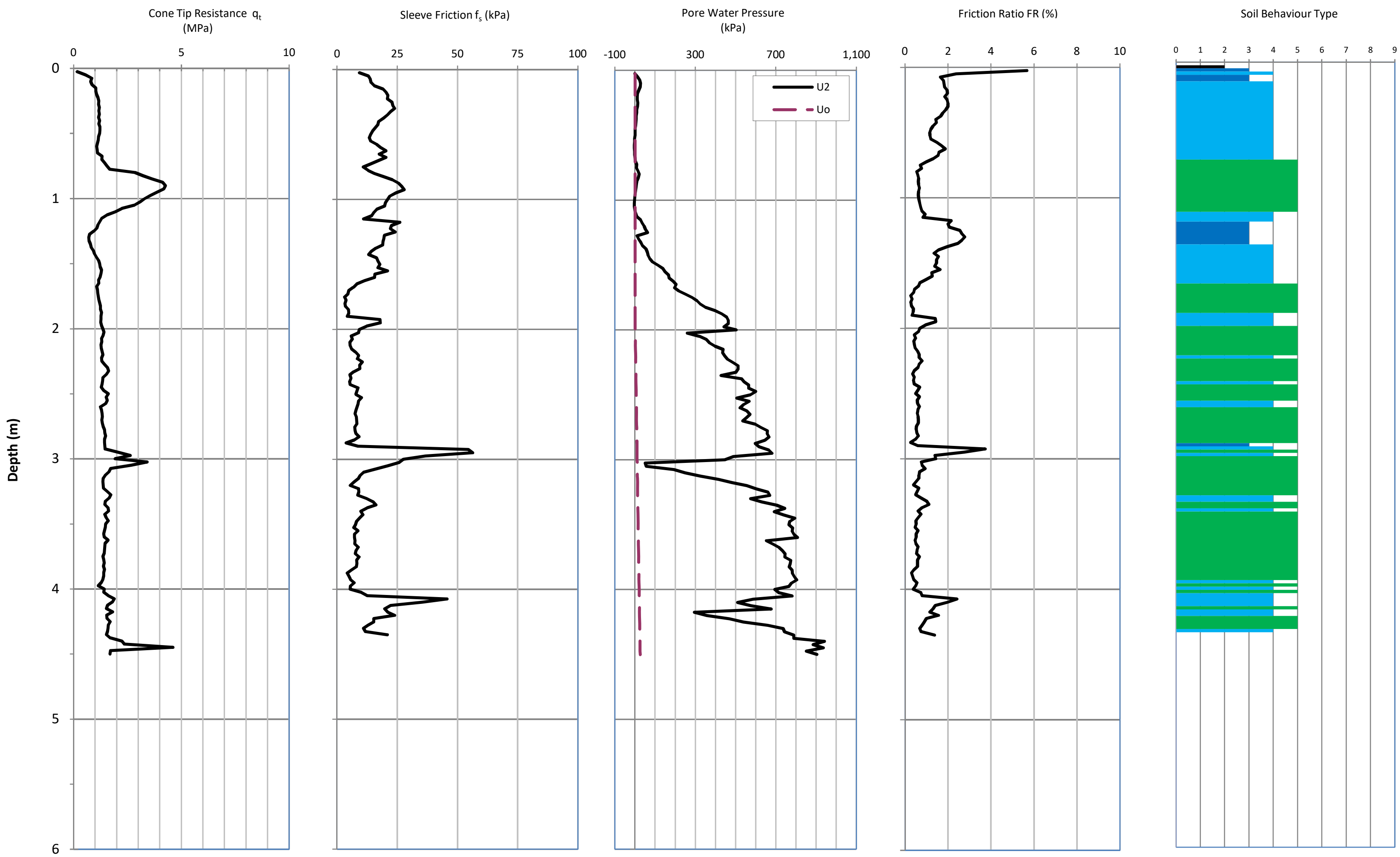
Date: June 27, 2017
Location: Dam at Lock 38, Brechin, Ontario
ConeTec Investigations
Cone: CONETEC 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-DS-5

CPT Probe 355:T1000F10U500

DownUnder Geotechnical Limited

PiezoCone Penetration Test



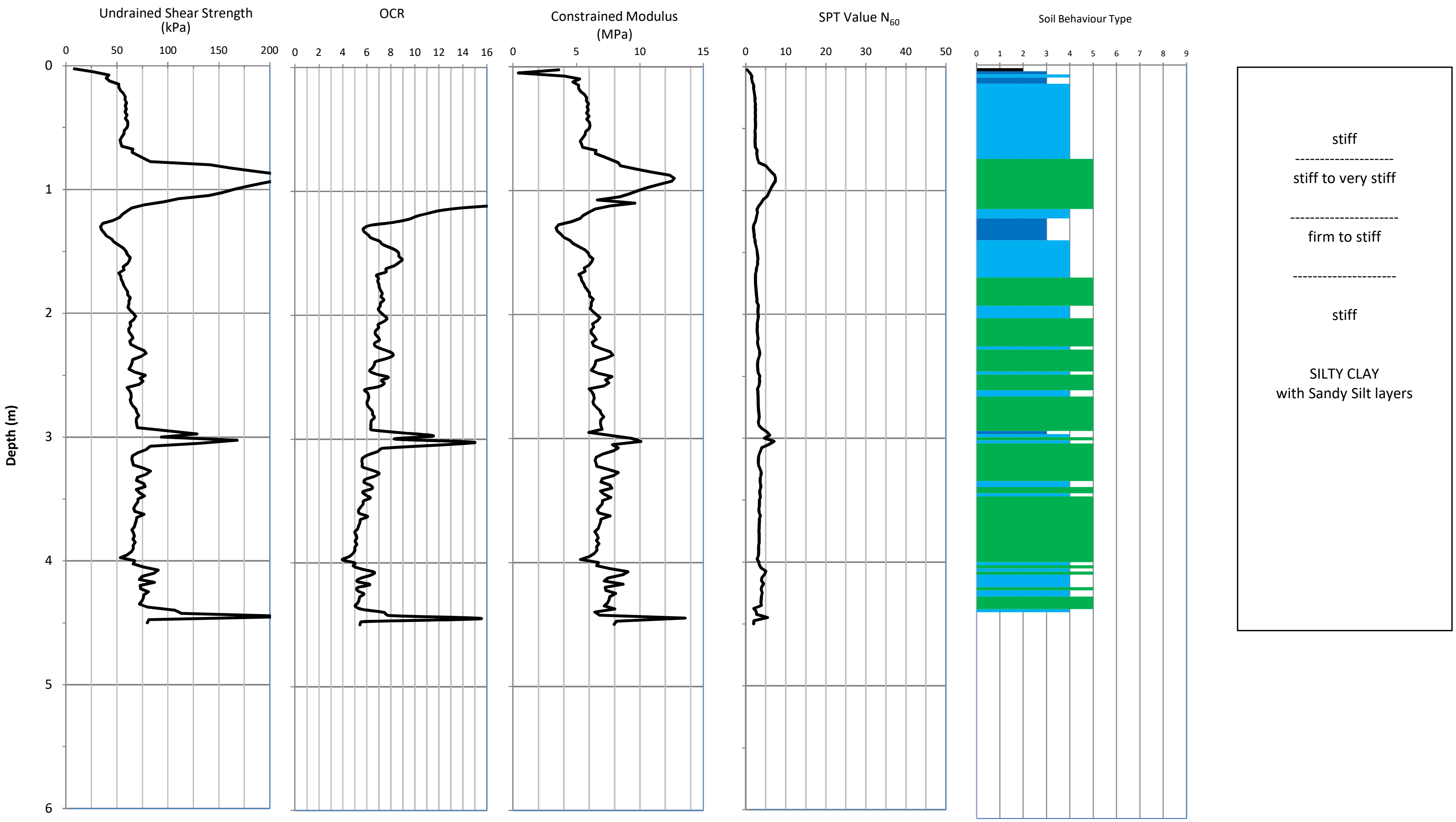
Date: June 27, 2017
Location: Dam at Lock 38, Brechin, Ontario
ConeTec Investigations
Cone: CONETEC 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-SP-1

CPT Probe 355:T1000F10U500

DownUnder Geotechnical Limited

PiezoCone Penetration Test



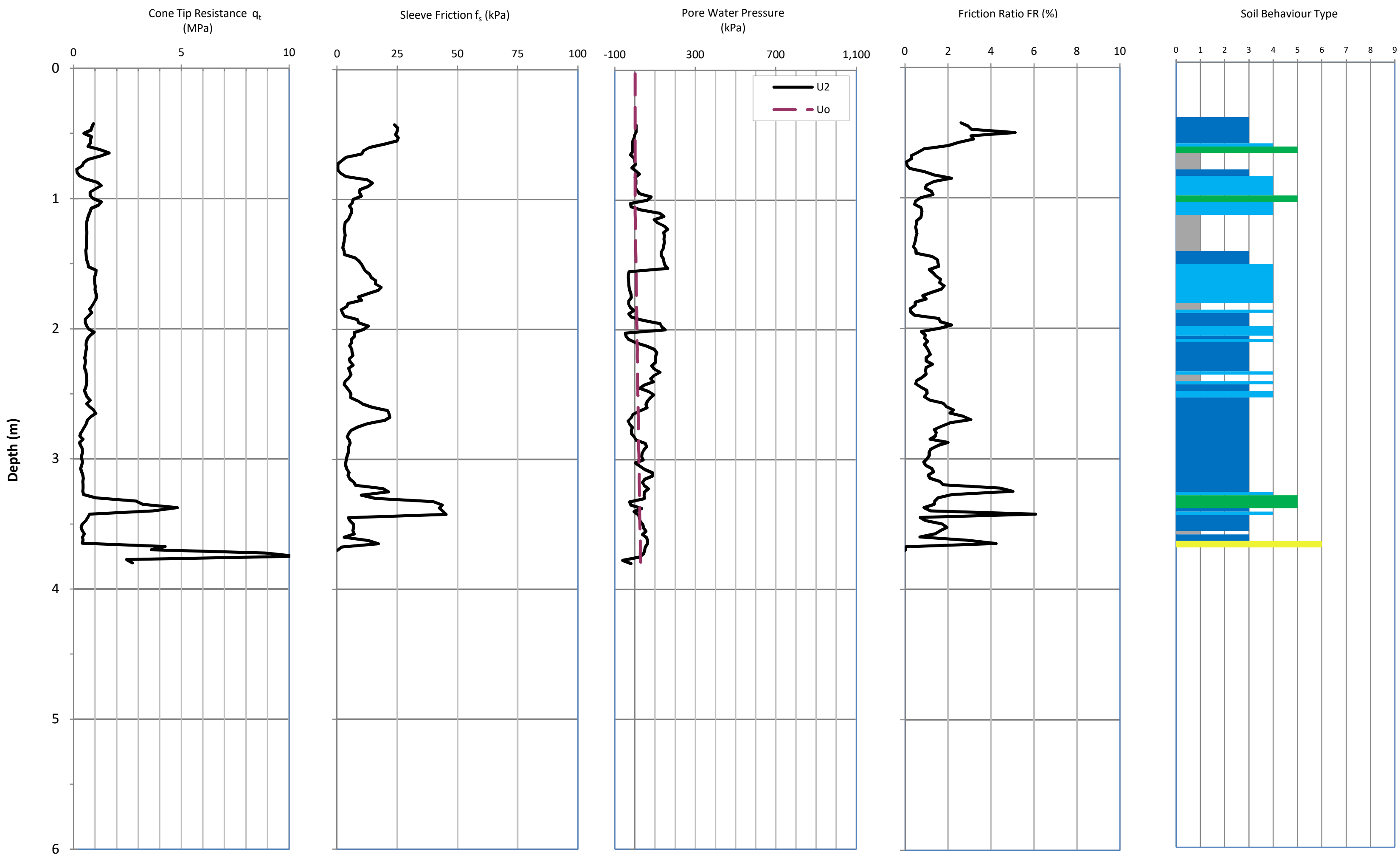
Date: June 27, 2017
Location: Dam at Lock 38, Brechin, Ontario
ConeTec Investigations
Cone: CONETEC 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-SP-1

CPT Probe 355:T1000F10U500

DownUnder Geotechnical Limited

PiezoCone Penetration Test



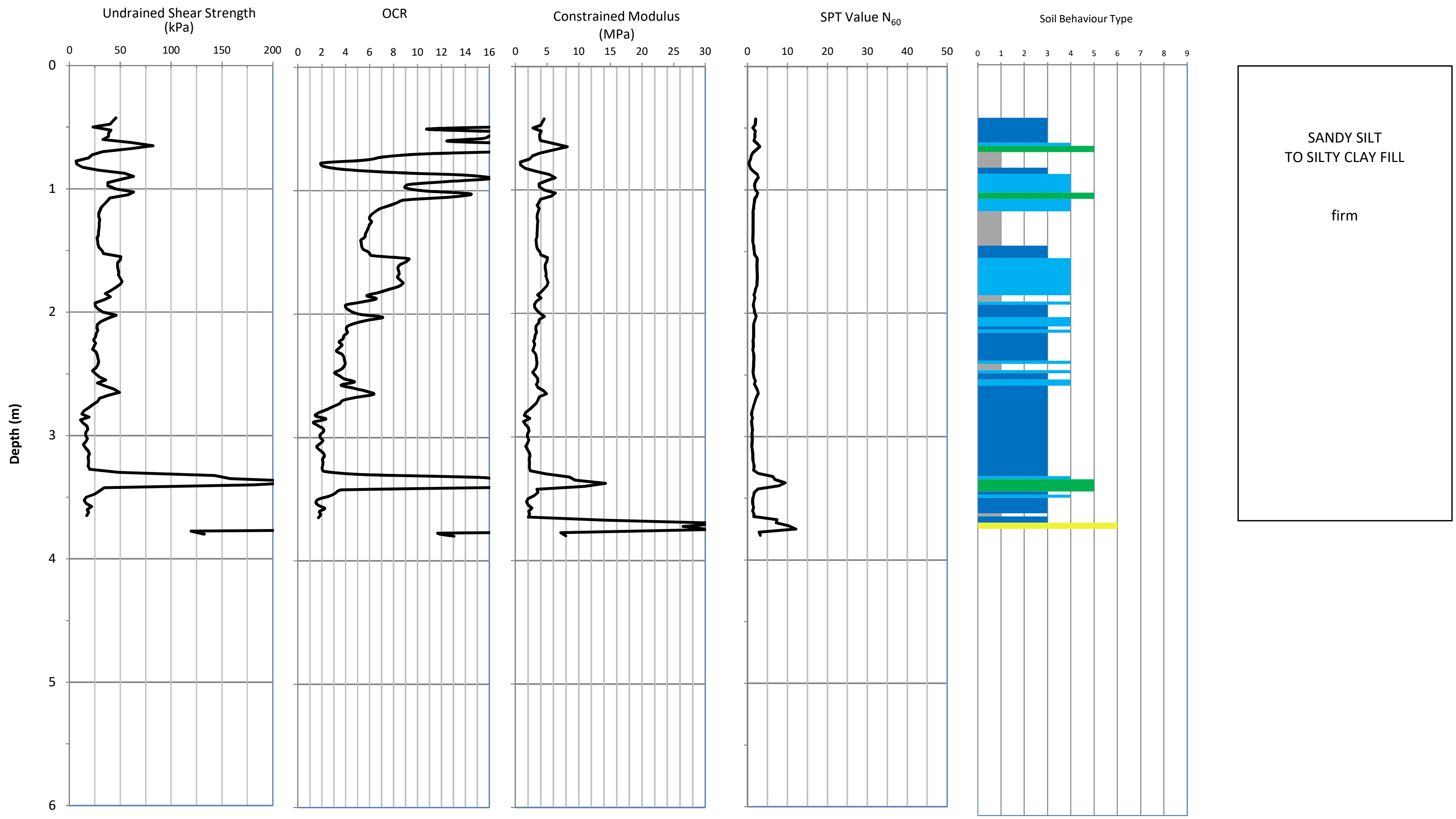
Date: June 27, 2017
Location: Dam at Lock 38, Brechin, Ontario
ConeTec Investigations
Cone: CONETEC 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-US-5

CPT Probe 355:T1000F10U500

DownUnder Geotechnical Limited

PiezoCone Penetration Test



Date: June 27, 2017
Location: Dam at Lock 38, Brechin, Ontario
ConeTec Investigations
Cone: CONETEC 10 tonne
Tip Area: 10 cm^2
Friction Sleeve Area: 150 cm^2
Filter Location: U_2

CPT-US-5

CPT Probe 355:T1000F10U500

DownUnder Geotechnical Limited

APPENDIX B

KGS GROUP | **SUMMARY LOG** | REFERENCE NO. | HOLE NO. **TH13-01** | SHEET 1 of 1

CLIENT	PWGSC	JOB NO.	12-0006-28
PROJECT	TALBOT DAM AND LOCK 38	GROUND ELEV.	235.65 m
		TOP OF PVC ELEV.	
SITE	Lock 38	WATER ELEV.	
LOCATION	NW corner of Lock 38 (right earthfill embankment)	DATE DRILLED	04/06/2013
DRILLING METHOD	200 mm ø Hollow Stem Auger, CME 75 (Automatic Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m	MC
235.6	0.0	**TOPSOIL**- Black, moist.				
		EMBANKMENT FILL (0.0 - 5.60 m)				
		Sandy Silt Fill (0.0-2.28 m) - Brown, moist, firm, trace topsoil inclusions.	S1	67	3, 4, 3	
		- Some topsoil, trace clay below 1.52 m.	S2	78	3, 4, 4	
		Topsoil Mixed Clayey Silt Fill (2.28-4.72 m) - Grey/brown, firm, low plasticity, trace sand.	S3	100	2, 3, 3	
		- Grey/Brown, some sand below 3.05 m.	S4	100	1, 2, 2	●
		- Grain Size Distribution: Gravel (0.0%), Sand (45.0%), Silt (47.2 %), and Clay (7.8%) at +/- 3.5 m.				
		- Trace sand below 3.81 m.	S5	100	1, 2, 2	●
		Clayey Silt to Silty Clay Fill (4.72 - 5.60 m) - Grey/brown, very moist, soft, low plasticity.	S6	100	0, 1, 1	●
		- Moist, stiff below 5.33 m.	S7	100	3, 5, 6	
230.0	5.60	**SANDY SILT TILL**- Grey, moist, dense, low plasticity to non plastic.				
		- Varying sand content.	S8	100	12, 20, 28	●
		- Compact below 7.62 m.	S9	100	18, 13, 15	●
		- Grain Size Distribution: Gravel (28.2%), Sand (45.1%), Silt (14.9 %), and Clay (11.8%) at +/- 8.1 m.				
		- Compact to dense below 8.83 m.	S10	100	15, 15, 15	
226.2	9.45	**AUGER REFUSAL PRESUMABLY ON BEDROCK at +/- 9.45 m**	S11		50 (No penetration)	

Notes:
1. Groundwater level at 2.44 m below grade immediately after drilling.
2. Borehole caved in at 2.74 m.
3. Borehole completed on June 4, 2013.
4. Backfilled with bentonite chips.

Plot scales: Cu POCKET PEN (kPa) ★; Cu TORVANE (kPa) ◆ (20, 40, 60, 80); SPT (N) blows/0.15 m ▲; DYNAMIC CONE (N) blows/ft △ (20, 40, 60); PL, MC, LL % (20, 40, 60, 80)

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	C.H./S.G.	DRAFT	5/12/13

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-02**

CLIENT PWGSC
PROJECT TALBOT DAM AND LOCK 38
SITE Lock 38
LOCATION NE corner of Lock 38 (right earthfill embankment)
DRILLING METHOD 200 mm ø Hollow Stem Auger, CME 75 (Automatic Hammer)

JOB NO. 12-0006-28
GROUND ELEV. 235.55 m
TOP OF PVC ELEV. 236.21 m
WATER ELEV.
DATE DRILLED 04/06/2013
UTM (m) N
E

ELEVATION (m)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m
235.3	**TOPSOIL** - Black, moist.				
	EMBANKMENT FILL (0.0 - 5.49 m) **Sandy Silt Fill (0.3-4.57 m)** - Brown, moist, firm, some clay, some topsoil.		S1		3, 3, 4
	- Grain Size Distribution: Gravel (1.3%), Sand (29.1%), Silt (57.5 %), and Clay (12.1%) at +/- 2.0 m. - Topsoil layer 0.25 mm thick at +/- 1.65 m.		S2		2, 3, 3
	- Brown/grey, topsoil mixed from 3.05 to 4.57 m.		S3		3, 3, 8
	Clayey Silt Fill (4.57-5.49 m) - Grey, very moist, soft, low plasticity, some sand.		S4		1, 2, 1
230.1	**SANDY SILT TILL** - Grey, moist, compact, low plasticity to non plastic, trace clay.				
	- Varying sand content.		S5		9, 14, 14
	- Very dense below +/- 7.9 m.	7.9	S6	100	18, 32, 50
226.9		8.5 8.7			
	AUGER REFUSAL PRESUMABLY ON BEDROCK +/- 8.69 m.				

Column headings: ELEVATION (m); DEPTH (m) (ft); GRAPHICS; DESCRIPTION AND CLASSIFICATION; PIEZ. LOG; DEPTH (m); SAMPLE TYPE; NUMBER; RECOVERY %; SPT (N) blows/0.15 m ▲; DYNAMIC CONE (N) blows/ft △; 20 40 60; Cu POCKET PEN (kPa) ★; Cu TORVANE (kPa) ◆; 20 40 60 80; PL MC LL %; 20 40 60 80

Notes:
1. Water level at 2.85 m immediately after drilling.
2. Borehole completed on June 5, 2013.
3. Installed standpipe piezometer to a depth of 8.53 m with a 0.66 m stickup.

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	C.H./S.G.	DRAFT	5/12/13

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-03**

CLIENT	PWGSC	JOB NO.	12-0006-28
PROJECT	TALBOT DAM AND LOCK 38	GROUND ELEV.	235.55 m
		TOP OF PVC ELEV.	
SITE	Lock 38	WATER ELEV.	
LOCATION	SW corner of Lock 38 (right earthfill embankment)	DATE DRILLED	04/06/2013
DRILLING METHOD	Casing and Washboring - Portable Rig (Manual Hammer)	UTM (m)	N
			E

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION
235.2	0.00–0.30	**TOPSOIL** - Black, moist,
	0.30–5.49	**EMBANKMENT FILL (0.30-5.49 m)**
		Sandy Silt (0.30-3.05 m) - Brown, moist, firm, trace clay.
		- Trace gravel, topsoil inclusions, rootlets below 0.61 m.
		- No sample recovery from 1.22 to 2.44 m.
		- Some subangular gravel and rock pieces below 2.44 m.
		- SPT blow count high (presence of gravel and rock pieces) from 2.44 to 3.05 m.
		Topsoil Mixed Sandy Silt Fill (3.05-5.49 m) - Brown/grey, compact, trace clay.
		- Trace subangular gravel below 4.88 m.
230.1	5.49–6.10	**SANDY SILT** - Brown/grey, very moist to wet, loose to compact, sand layers.
		- Grain Size Distribution: Gravel (0.0%), Sand (32.4%), Silt (61.3 %), and Clay (6.3%) at +/- 6.1 m.
229.5	6.10	**END OF BOREHOLE AT 6.10 m.**

Notes:
1. Sand backing up into the casing, boring terminated at +/- 6.10 m.
2. Borehole completed on June 5, 2013.
3. Borehole backfilled with bentonite chip.

SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %
Split Spoon	S1	50
Split Spoon	S2	75
Split Spoon	S3	0
Split Spoon	S4	0
Split Spoon	S5	17
Split Spoon	S6	17
Split Spoon	S7	44
Split Spoon	S8	42
Split Spoon	S9	63
Split Spoon	S10	50

SPT (N) blows/0.15 m ▲: 2, 6, 6, 4, 3, 3, 5, 7, 12, 8, 5, 6, 7, 6, 7, 8, 14, 27, 21, 16, 16, 14, 15, 13, 14, 16, 16, 15, 10, 10, 12, 14, 15, 15, 17, 15, 2, 6, 12, 12

DYNAMIC CONE (N) blows/ft △

Cu POCKET PEN (kPa) ★ Cu TORVANE (kPa) ◆

PL MC LL %

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	C.H./S.G.	DRAFT	5/12/13

KGS GROUP

SUMMARY LOG

REFERENCE NO.

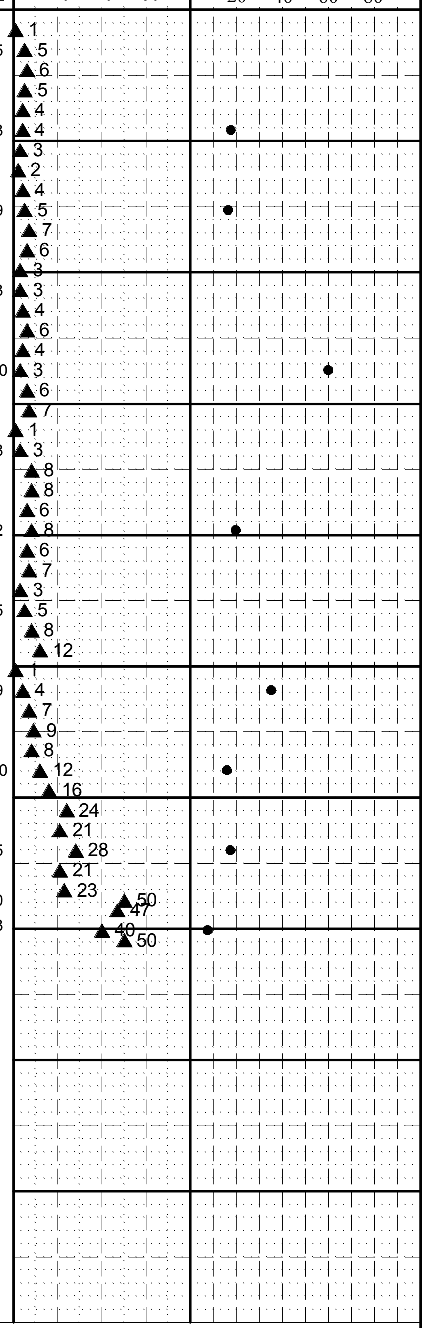
HOLE NO. **TH13-04**

CLIENT	PWGSC	JOB NO.	12-0006-28
PROJECT	TALBOT DAM AND LOCK 38	GROUND ELEV.	235.55 m
		TOP OF PVC ELEV.	
SITE	Lock 38	WATER ELEV.	
LOCATION	SE corner of Lock 38 (right earthfill embankment)	DATE DRILLED	04/06/2013
DRILLING METHOD	Casing and Washboring - Portable Rig (Manual Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)
235.55	0.00	**TOPSOIL** - Black, moist.		
235.2	0.30	**EMBANKMENT FILL(0.30-5.94 M)** **Sandy Silt Fill (0.30-2.44 m)** - Brown, moist. - Some topsoil below 0.61 m. - Grain Size Distribution: Gravel (0.0%), Sand (10.0%), Silt (73.0 %), and Clay (17.0%) at +/- 1.2 m. - Trace gravel at 1.22 m. - 0.20 m thick black topsoil layer at 1.63 m. **Sandy Silt and Topsoil Fill (2.44-5.94 m)** - Black/brown, moist, trace clay. - Topsoil layers at 3.05 m. - Some fine grained sand, some topsoil at 3.66 m. - Brown and black, organic topsoil layers, wood pieces at 4.27 m. - Some silty sand at 4.88 m. - Topsoil organic content 9.1% at +/- 5.0 m.		
229.6	5.94	**SANDY SILT** - Brown/grey, very moist, dense.		
228.8	6.71	**SANDY SILT TILL** - Grey, moist, very dense.	VW	7.1
228.5	7.09	**END OF BOREHOLE AT 7.09 m.**		

SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %
Split Spoon	S1	75
Split Spoon	S2	83
Split Spoon	S3	79
Split Spoon	S4	83
Split Spoon	S5	100
Split Spoon	S6	68
Split Spoon	S7	92
Split Spoon	S8	75
Split Spoon	S9	79
Split Spoon	S10	100
Split Spoon	S11	75
Split Spoon	S12	50
Split Spoon	S13	63

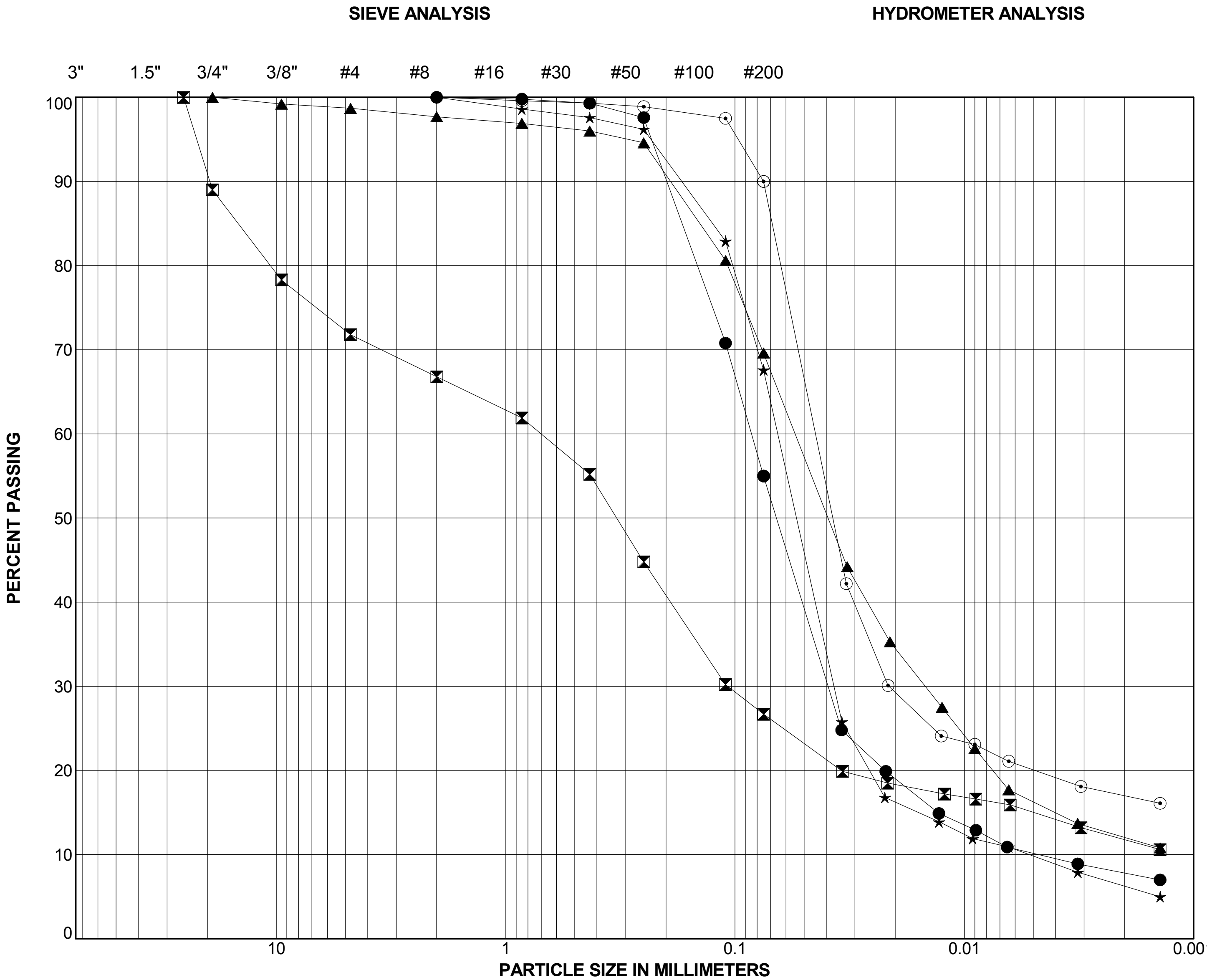
SPT (N) blows/0.15 m ▲ — DYNAMIC CONE (N) blows/ft △ — Cu POCKET PEN (kPa) ★ — Cu TORVANE (kPa) ◆ — PL MC LL %



Notes:
1. Installed a vibrating wired (Serial No. 12-9208) at a depth of 7.05 m below grade.
2. Borehole completed on June 5, 2013.

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	C.H./S.G.	DRAFT	5/12/13



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

SYMBOL	HOLE	DEPTH (m)	SAMPLE #	% GRAVEL	% SAND	% SILT	% CLAY	% SILT & CLAY	Cu	Cc	CLASSIFICATION
●	*TH13-01*	*3.0*	*S4*	*0.0*	*45.0*	*47.2*	*7.8*	*55.0*	*17.9*	*3.9*	
⧗	*TH13-01*	*7.6*	*S9*	*28.2*	*45.1*	*14.9*	*11.8*	*26.7*			
▲	*TH13-02*	*1.5*	*S2*	*1.3*	*29.1*	*57.5*	*12.1*	*69.6*			
★	*TH13-03*	*5.5*	*S10*	*0.0*	*32.4*	*61.3*	*6.3*	*67.6*	*12.5*	*4.1*	
⊙	*TH13-04*	*0.6*	*S2*	*0.0*	*10.0*	*73.0*	*17.0*	*90.0*			

KGS GROUP

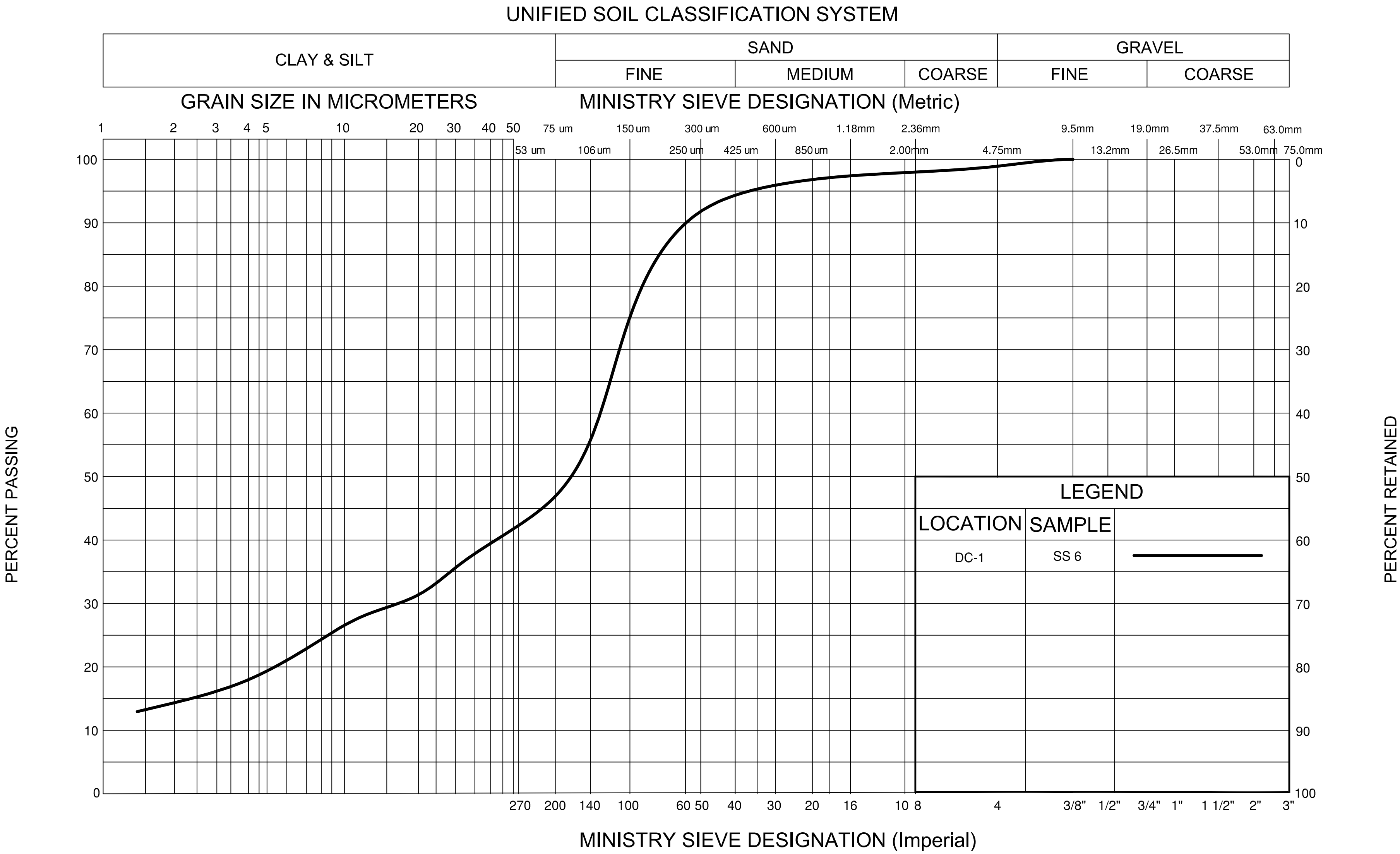
TALBOT DAM AND LOCK 38

GRAIN SIZE ANALYSES

July 2013	Figure 1	Page 1 of 1

SIEVE ANALYSIS P:\PROJECTS\2012\12-0006-028\DESIGN\GEO\LOGS\LOCK 38 LOGS.GPJ

APPENDIX C



GRAIN SIZE DISTRIBUTION

SILTY SAND FILL, trace Clay

Project No. D17105A

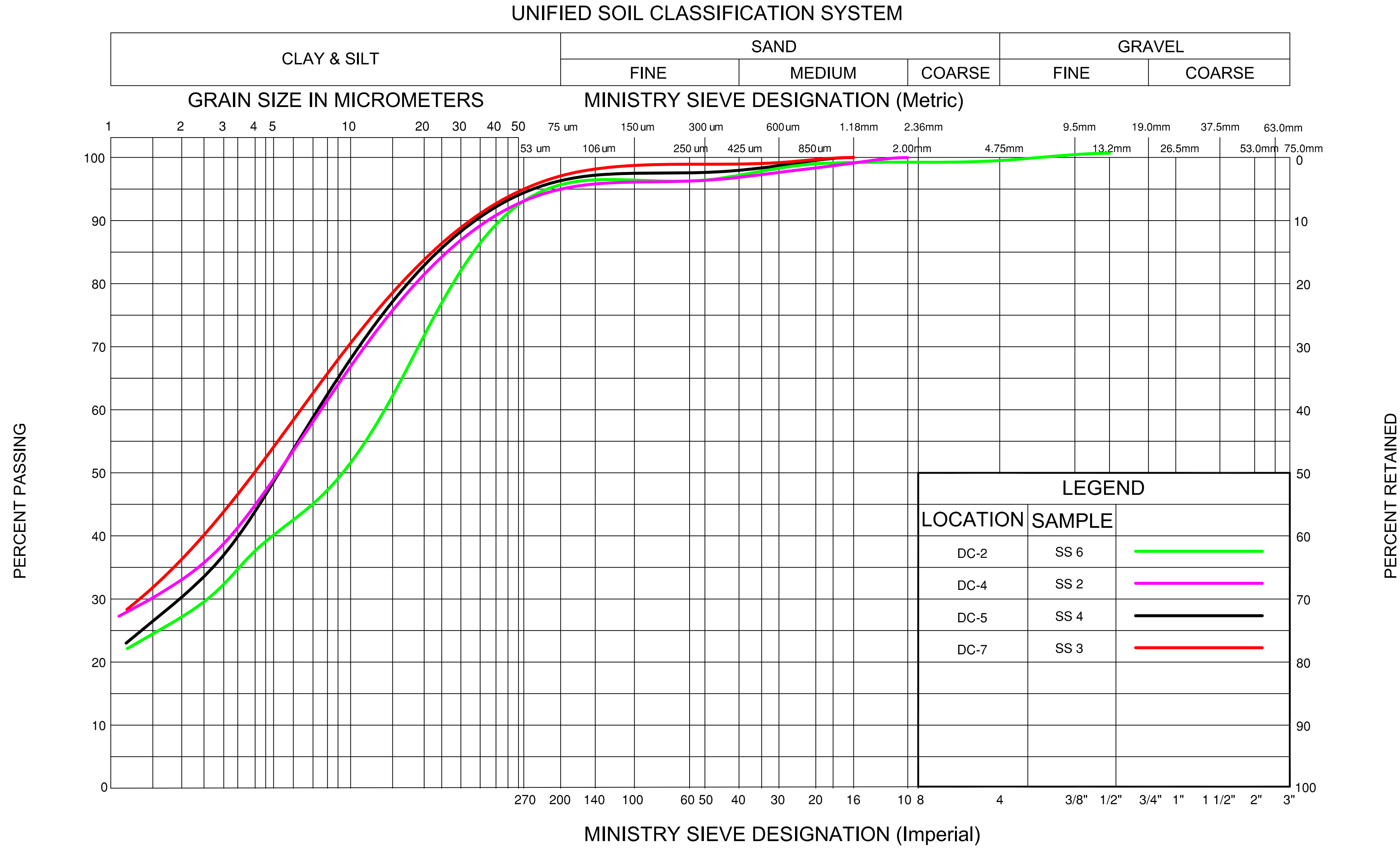
Project: Diversion Channel, Lock 38

Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: March 2017



GRAIN SIZE DISTRIBUTION

SILTY CLAY

Project No. D17105A

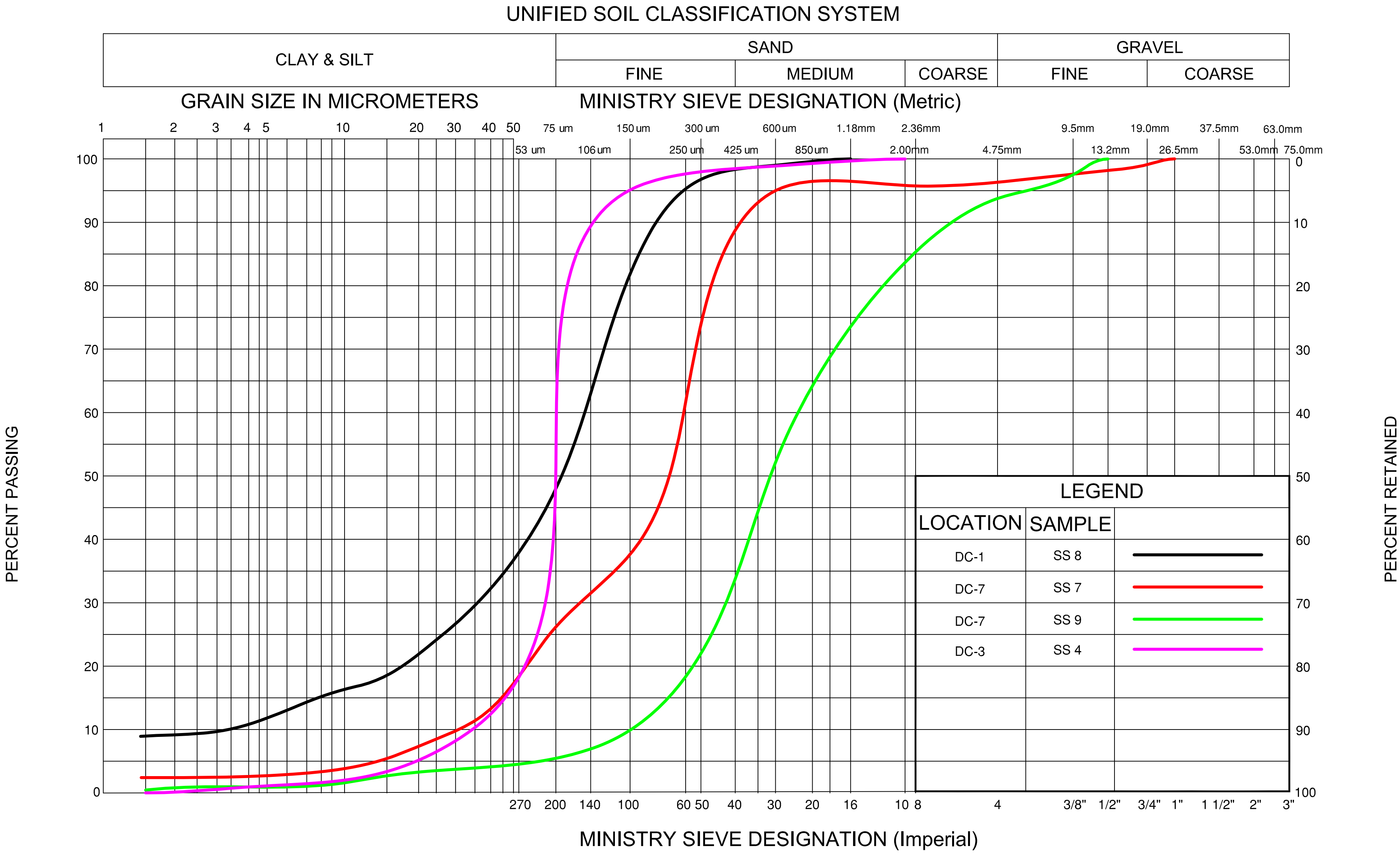
Project: Diversion Channel, Lock 38

Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: March 2017



GRAIN SIZE DISTRIBUTION

SILTY SAND to SAND

Project No. D17105A

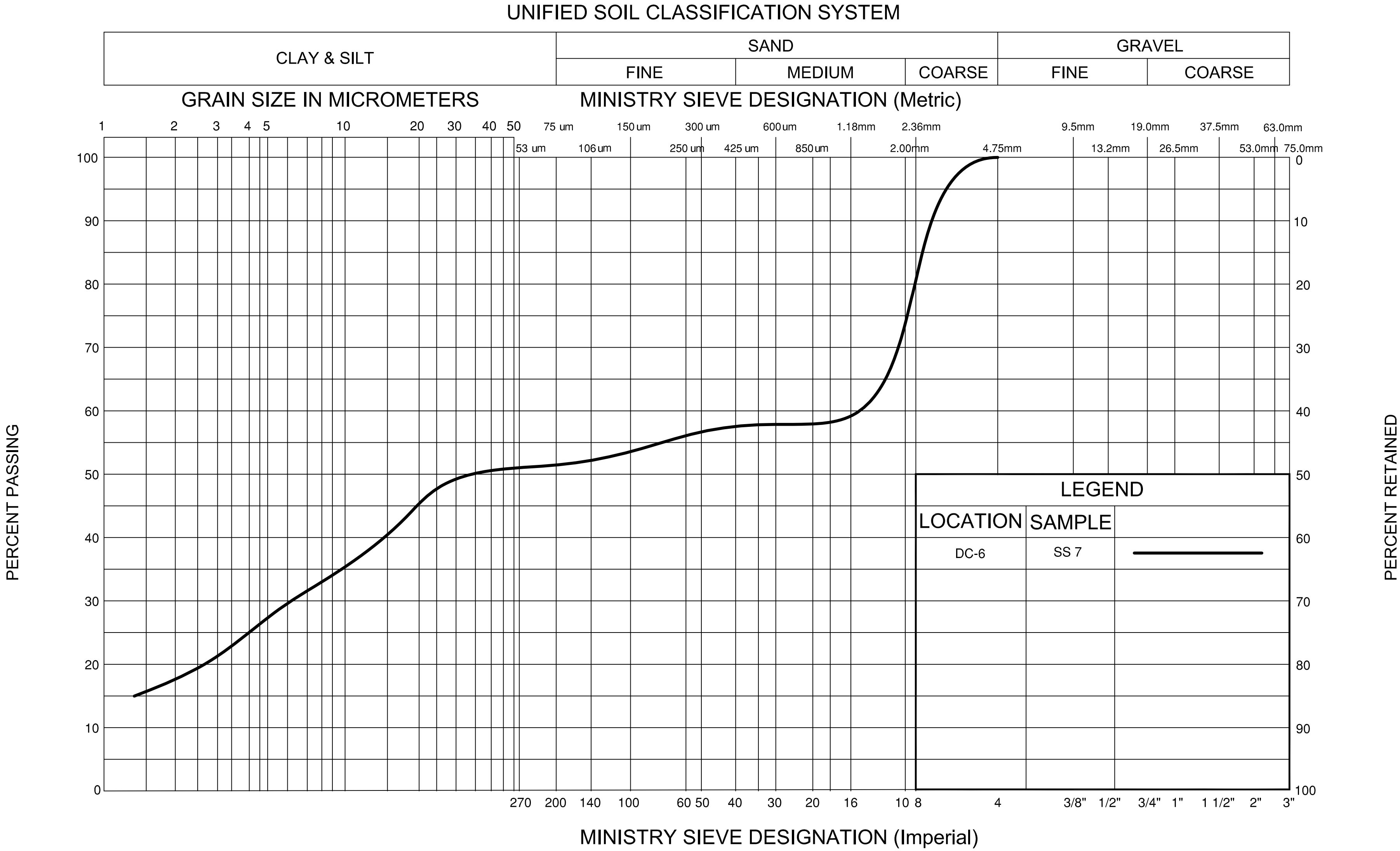
Project: Diversion Channel, Lock 38

Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: March 2017



GRAIN SIZE DISTRIBUTION

SILTY CLAY GLACIAL TILL

Project No. D17105A

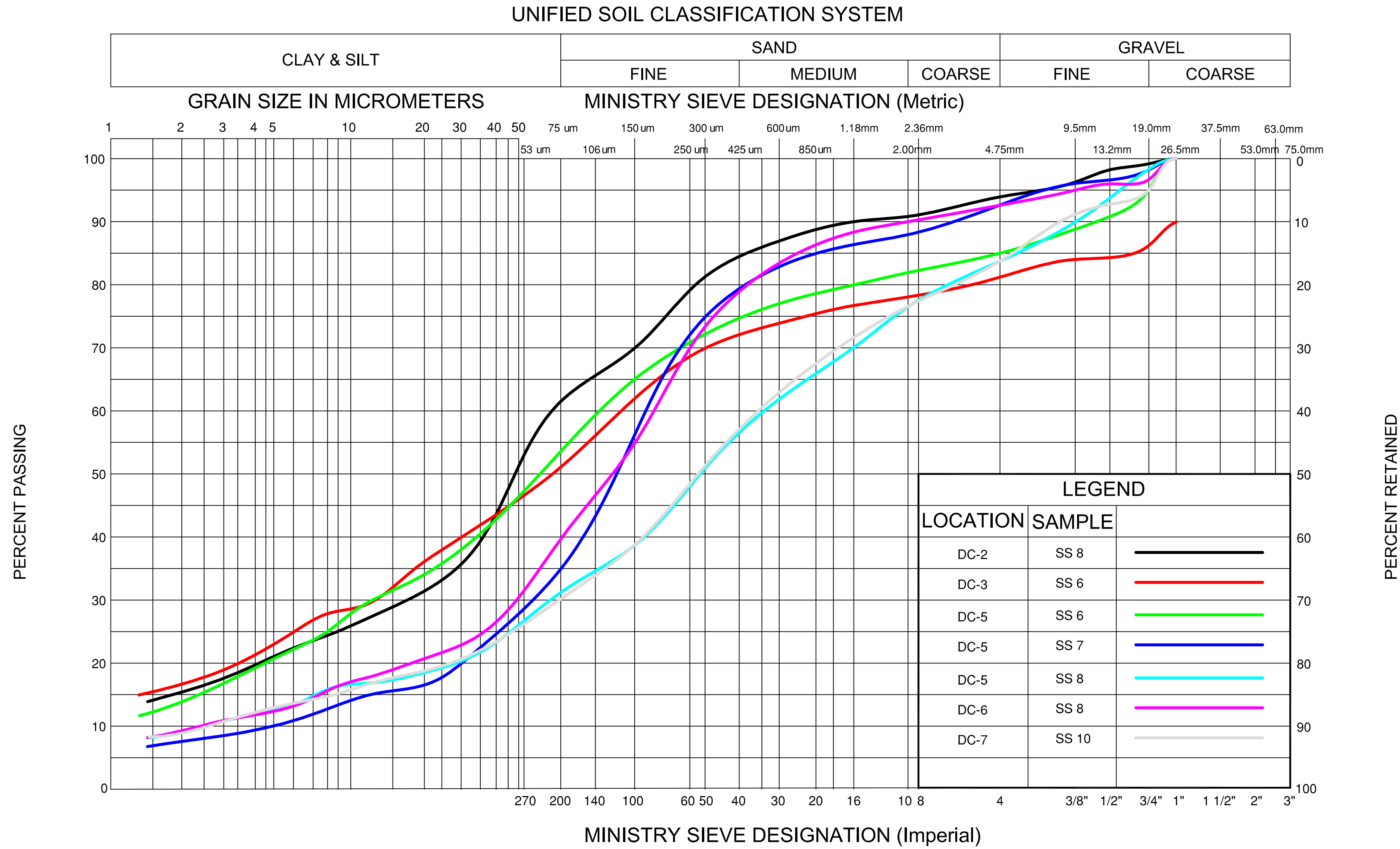
Project: Diversion Channel, Lock 38

Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: March 2017



GRAIN SIZE DISTRIBUTION

SILTY SAND to SANDY SILT GLACIAL TILL, trace to with Gravel, trace Clay

Project No. D17105A

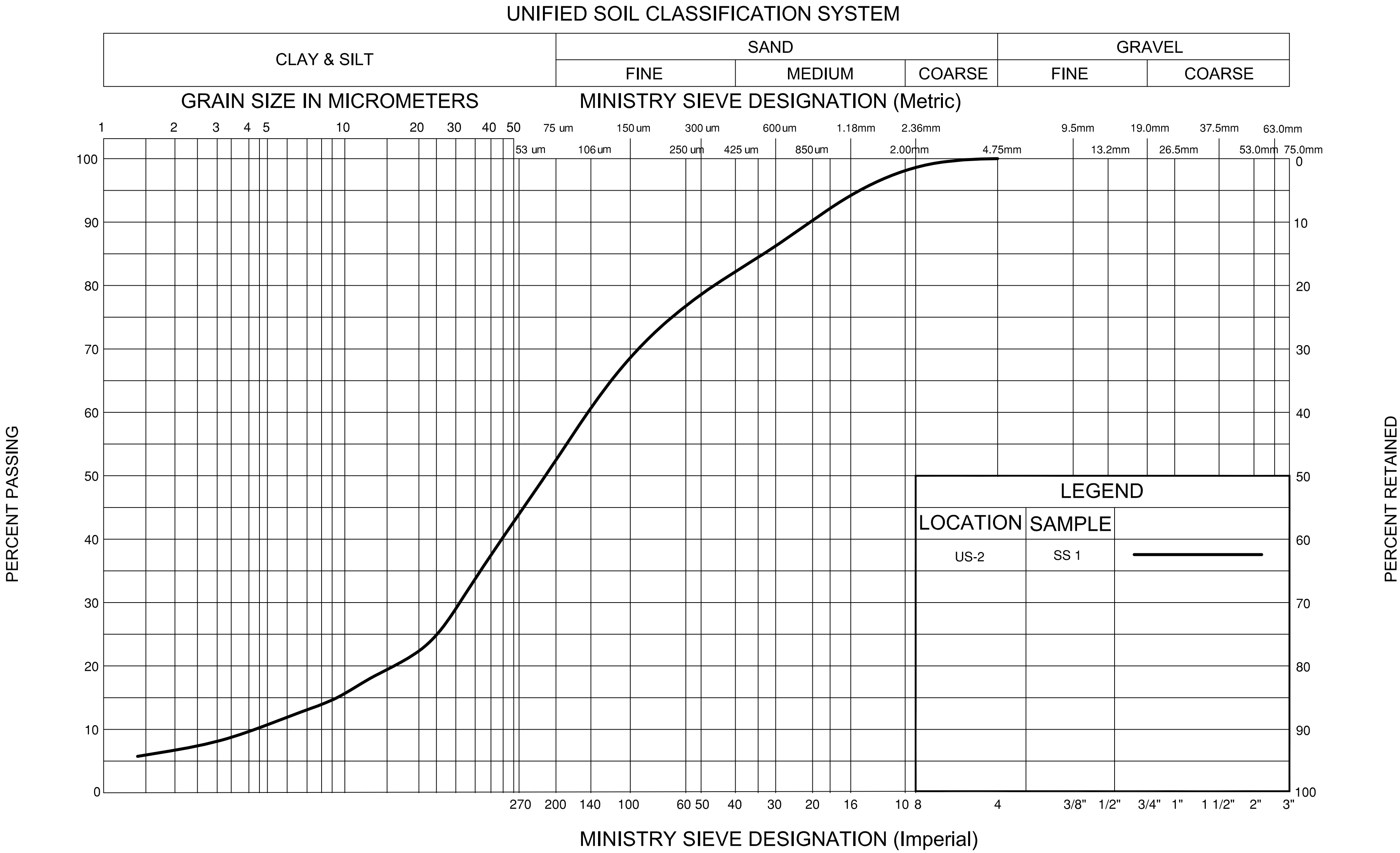
Project: Diversion Channel, Lock 38

Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

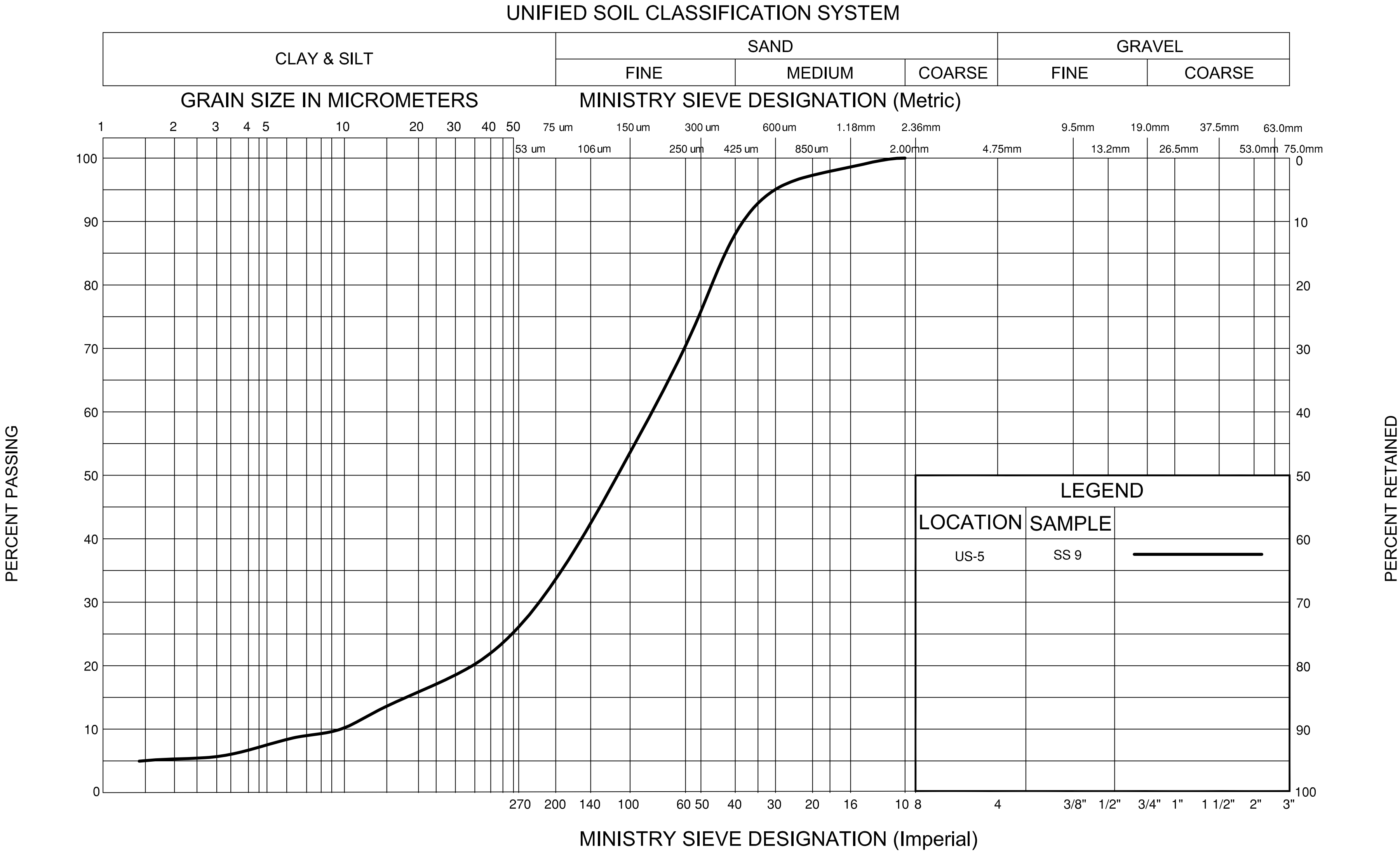
Date: March 2017



GRAIN SIZE DISTRIBUTION

SANDY SILT with decaying Wood

Project No. D17105A	
Project:	Dam at Lock 38 Trent Severn Waterway
Checked: AD	**DownUnder Geotechnical Limited**
Date: July 2017	



GRAIN SIZE DISTRIBUTION

SILTY SAND

Project No. D17105A

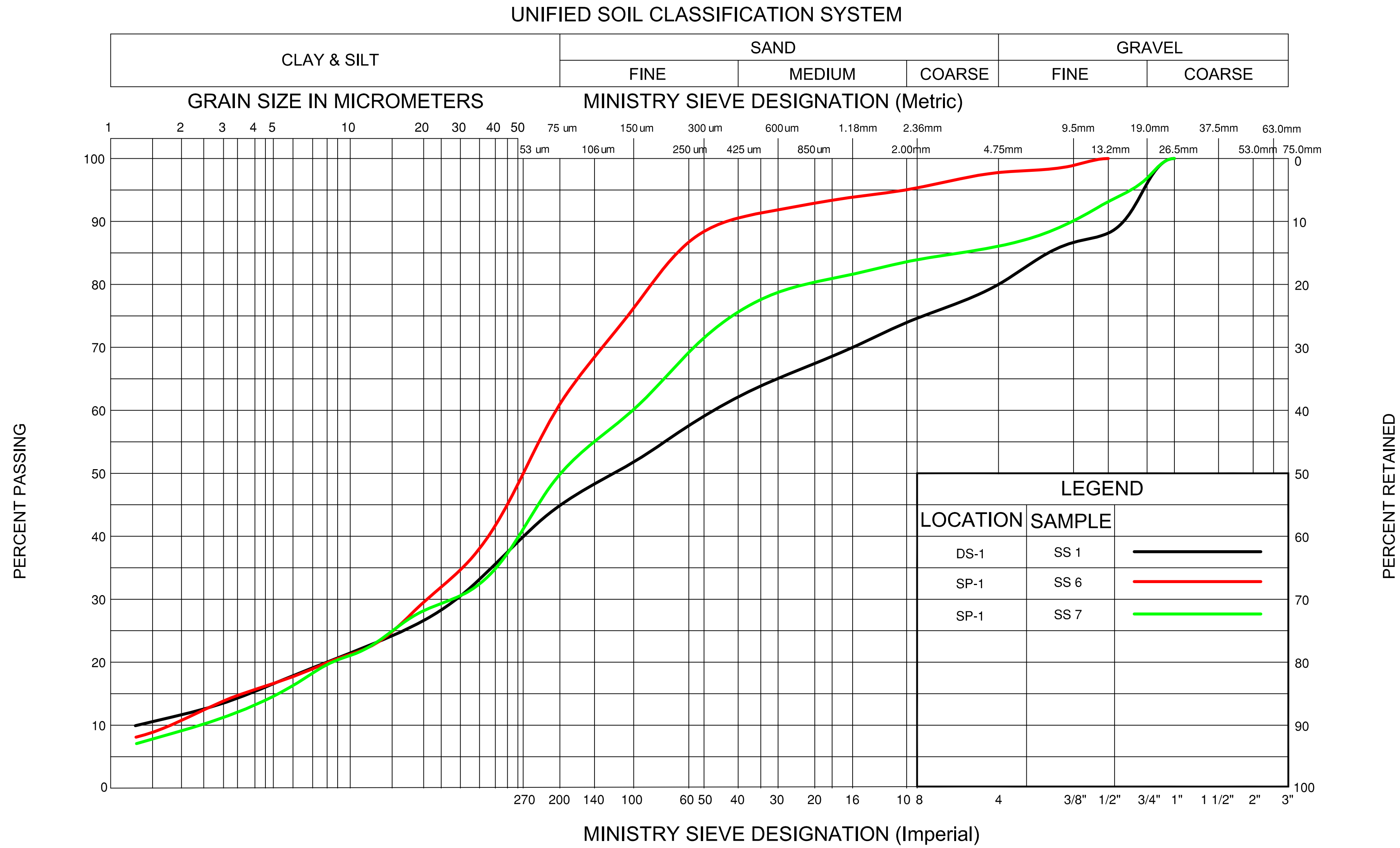
Project: Dam at Lock 38

Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: July 2017



GRAIN SIZE DISTRIBUTION

SILTY SAND to SANDY SILT GLACIAL TILL, trace to with Gravel, trace Clay

Project No. D17105A

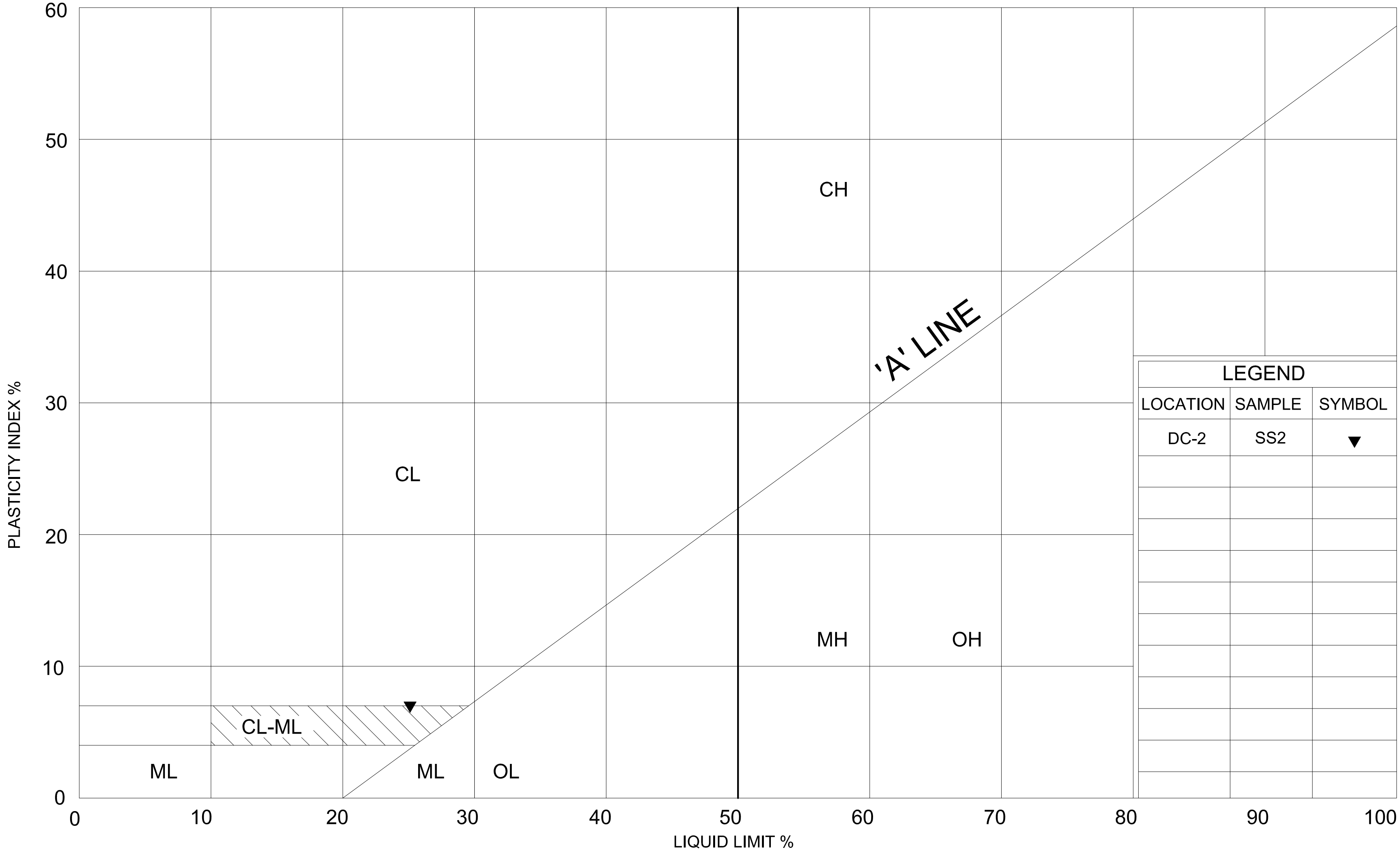
Project: Dam at Lock 38

Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: July 2017



PLASTICITY CHART
SILTY CLAY FILL

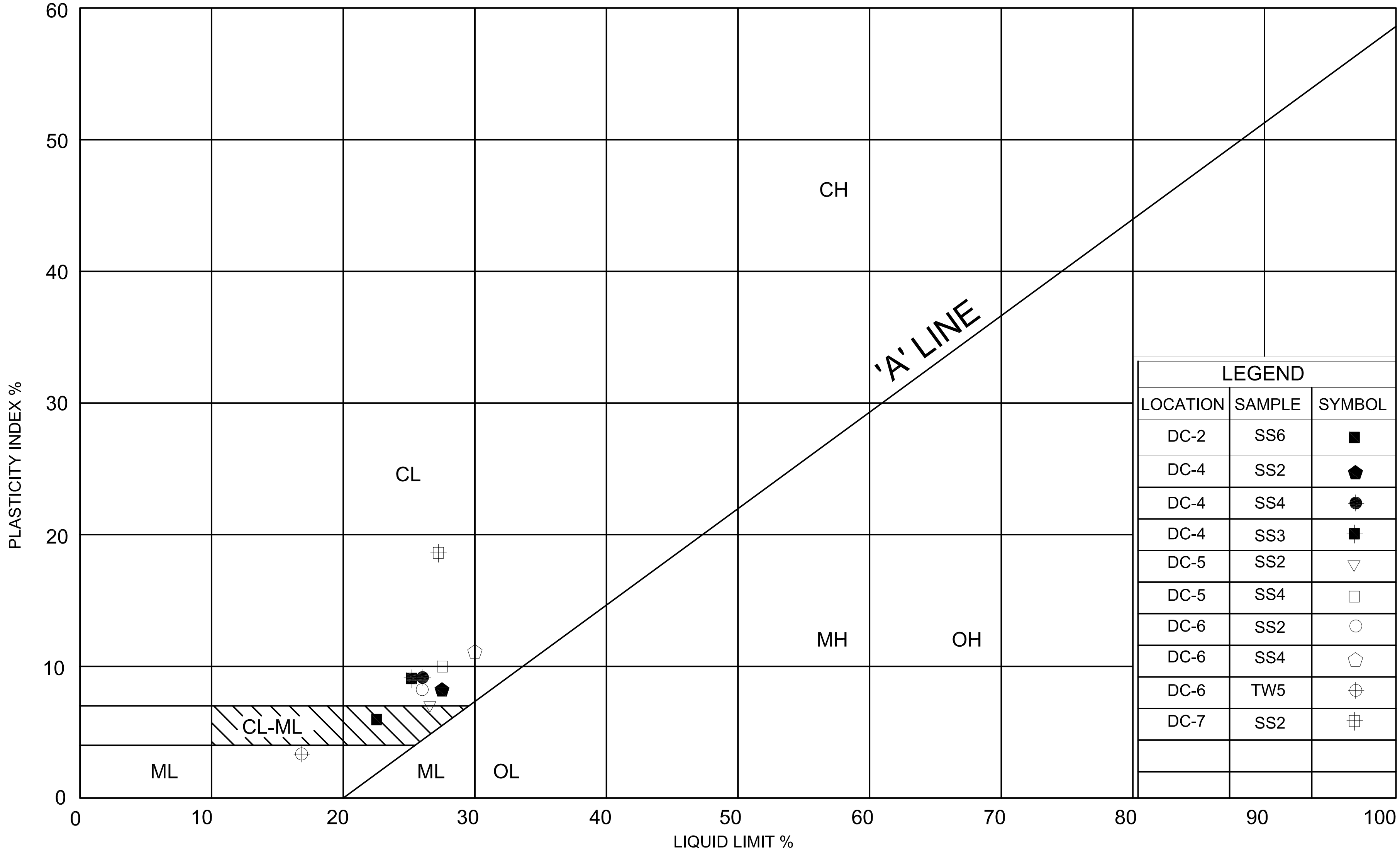
Project No. D17105A

Project:
Diversion Channel, Lock 38, TSW

Checked: AD

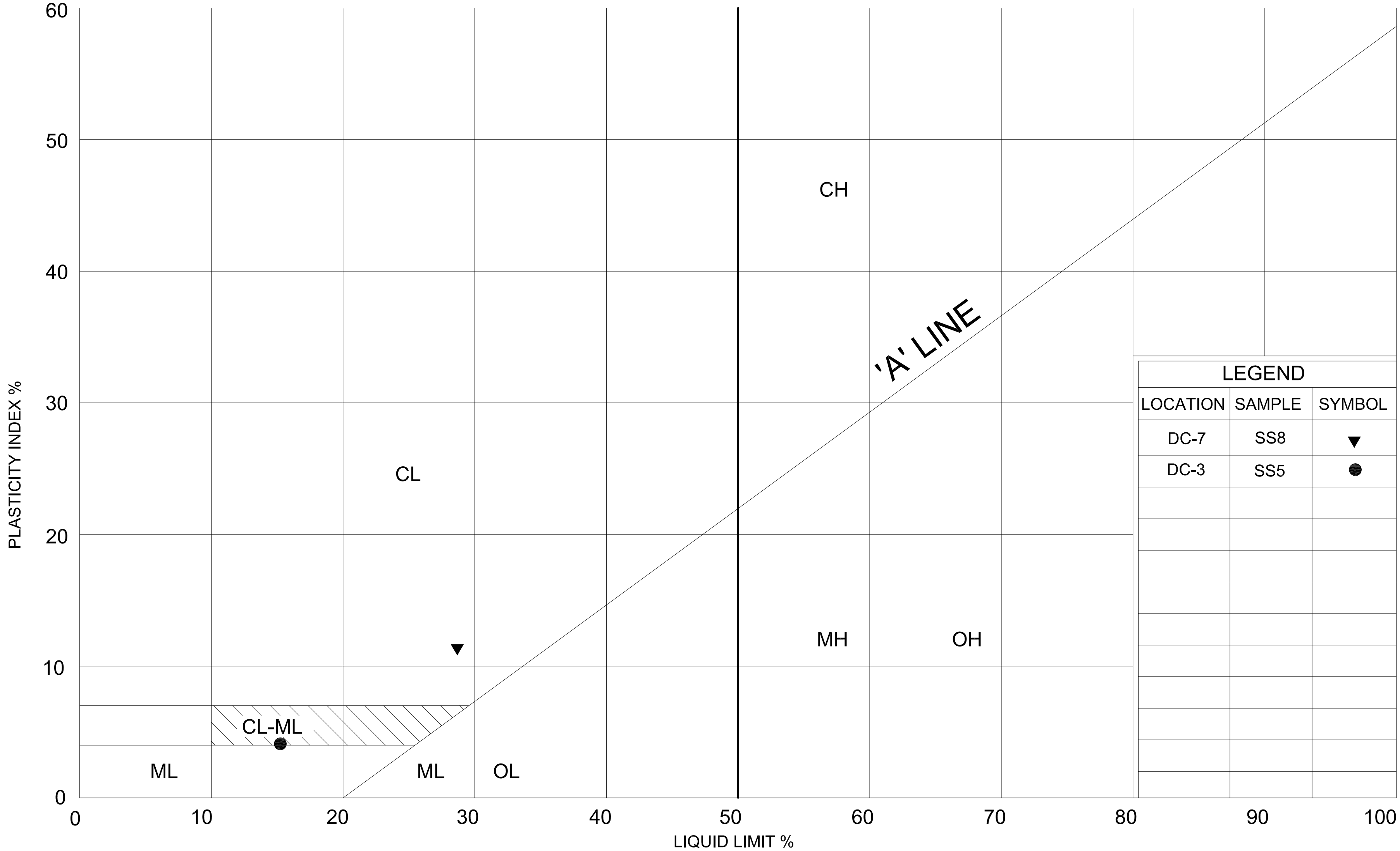
DownUnder Geotechnical Limited

Date: July 2017



LEGEND		
LOCATION	SAMPLE	SYMBOL
DC-2	SS6	■
DC-4	SS2	⬟
DC-4	SS4	●
DC-4	SS3	■
DC-5	SS2	▽
DC-5	SS4	□
DC-6	SS2	○
DC-6	SS4	⬠
DC-6	TW5	⊕
DC-7	SS2	⊞

PLASTICITY CHART SILTY CLAY to CLAYEY SILT		Project No. D17105A Project: Diversion Channel, Lock 38, TSW
Checked: AD	**DownUnder Geotechnical Limited**	Date: July 2017



PLASTICITY CHART
GLACIAL TILL

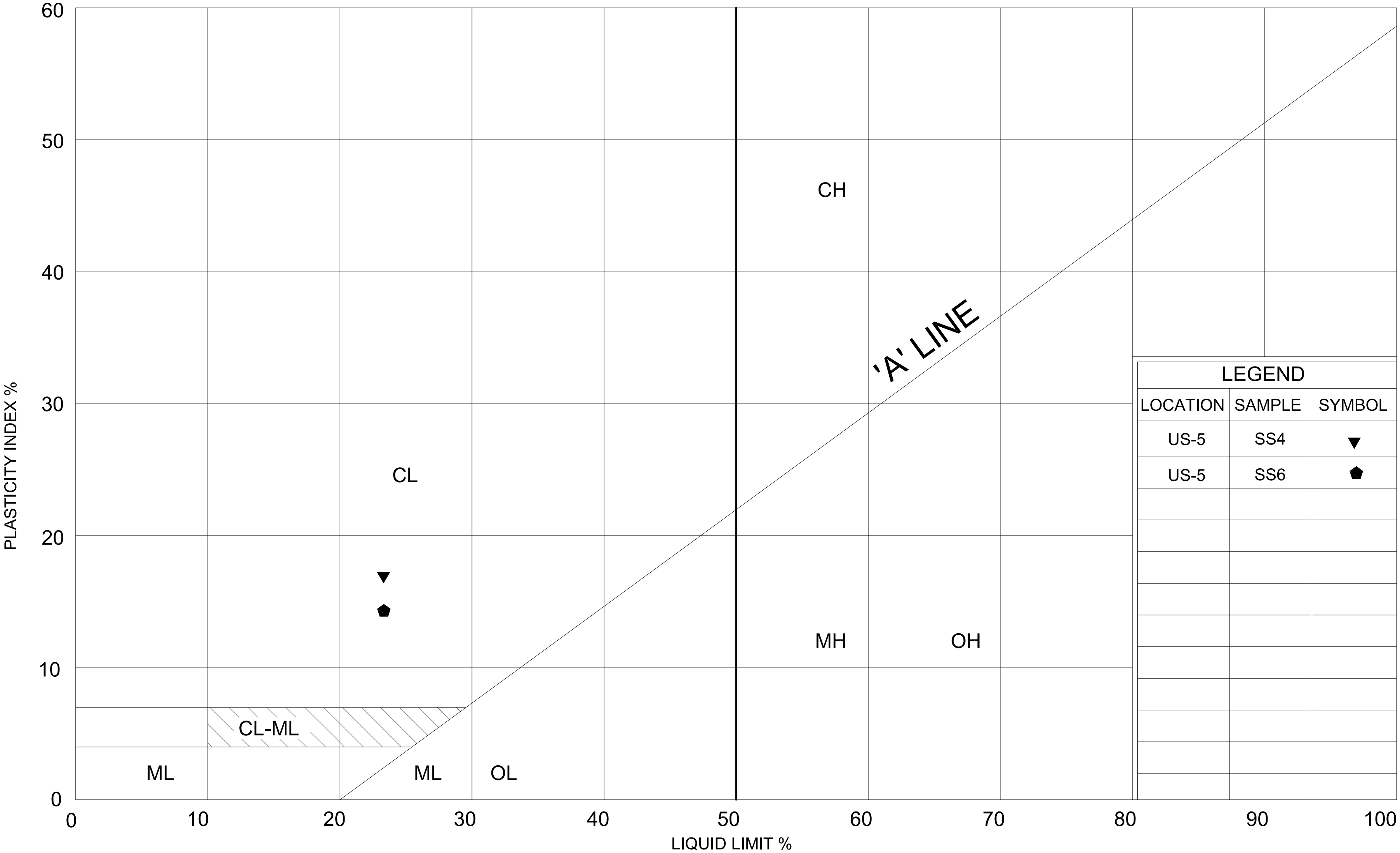
Project No. D17105A

Project:
Diversion Channel, Lock 38, TSW

Checked: AD

DownUnder Geotechnical Limited

Date: July 2017



PLASTICITY CHART
SILTY CLAY FILL

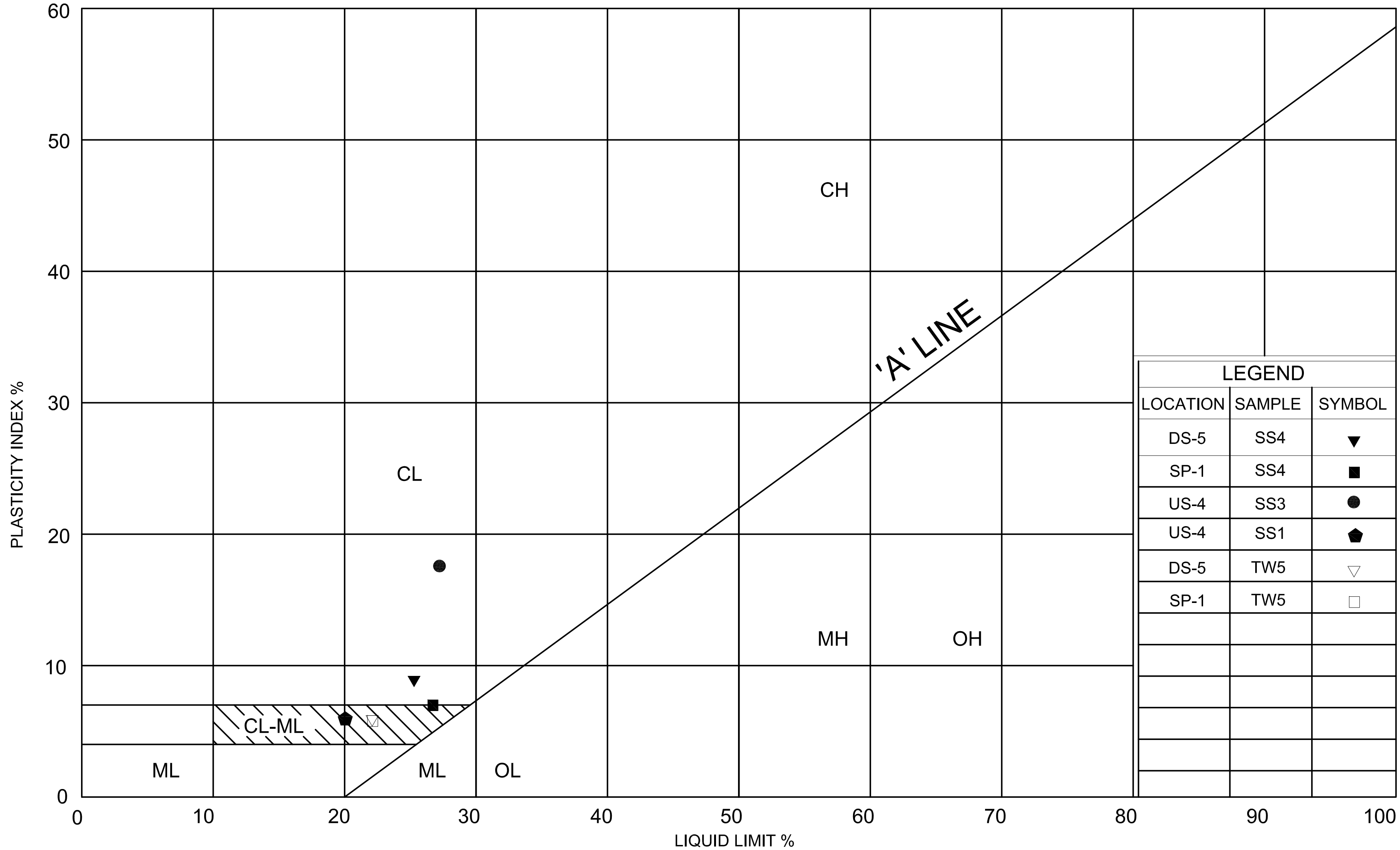
Project No. D17105A

Project:
Dam at Lock 38, Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: July 2017



PLASTICITY CHART

SILTY CLAY to CLAYEY SILT

Project No. D17105A

Project:
Dam at Lock 38, Trent Severn Waterway

Checked: AD

DownUnder Geotechnical Limited

Date: July 2017

Unconfined Compression Test Results for Cohesive Soils

ASTM D-2166

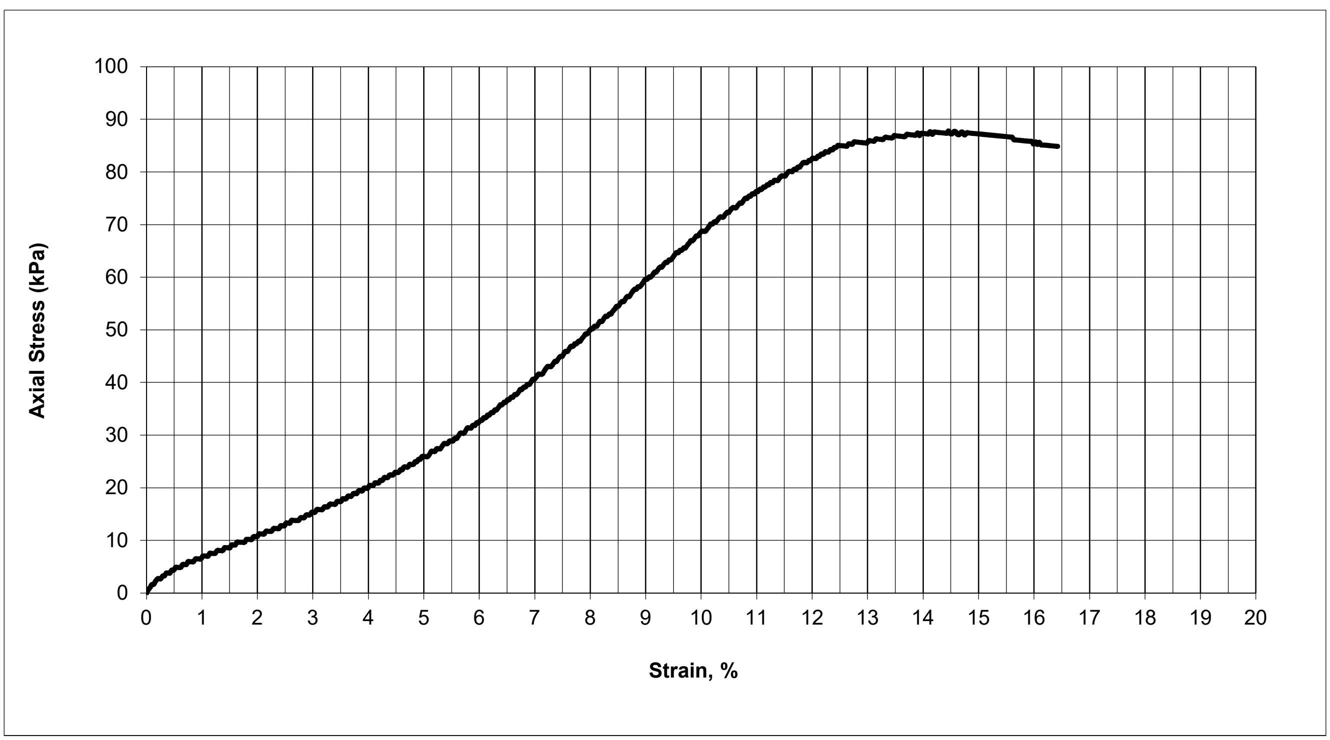
Borehole No.	US-4
Depth	2.4m

Project No.	D17105A
Site	Dam at Lock 38

Sample Conditions	
Diameter (D)	4.8cm
Length (H)	10.2cm
Volume	187 cm^3
H:D	2.1
Wet Mass	379.0g
Bulk Density	19.9 kN/m^3
Water Content	27%

Sample Description
Silty Clay

Loading Rate	1mm/min
Average Rate of Strain	0.98%/min
Strain at Failure	14.2%
Failure Type	Shear
Unconfined Compressive Strength	**88 kPa**
Undrained Shear Strength	**44 kPa**



DownUnder Geotechnical Limited

Unconfined Compression Test Results for Cohesive Soils

ASTM D-2166

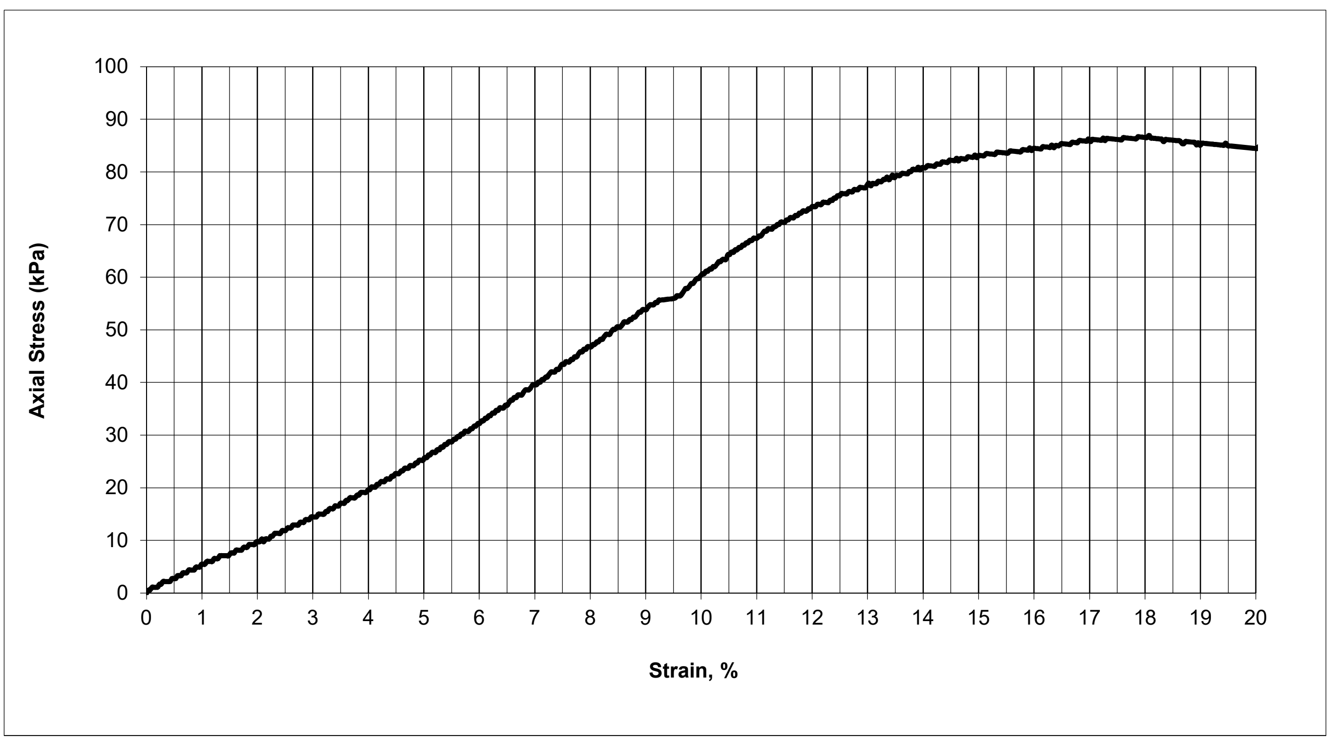
Borehole No.	DS-5
Depth	3.8m

Project No.	D17105A
Site	Dam at Lock 38

Sample Conditions	
Diameter (D)	4.8cm
Length (H)	10.1cm
Volume	183 cm^3
H:D	2.1
Wet Mass	386.2g
Bulk Density	20.7 kN/m^3
Water Content	26%

Sample Description
Silty Clay

Loading Rate	1mm/min
Average Rate of Strain	0.98%/min
Strain at Failure	15.0%
Failure Type	Bulging
Unconfined Compressive Strength	**83 kPa**
Undrained Shear Strength	**42 kPa**



DownUnder Geotechnical Limited

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

ASTM D 2850

SAMPLE IDENTIFICATION

PROJECT NUMBER	1775914	SAMPLE NUMBER	TW5
BOREHOLE NUMBER	DC-2	SAMPLE DEPTH, m	3.8

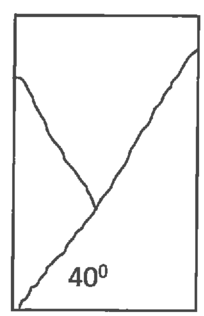
TEST CONDITIONS

MACHINE SPEED, mm/min	0.50	TYPE OF SPECIMEN	Intact
RATE OF AXIAL STRAIN, %/min	0.49	L/D	2.02
CELL PRESSURE, kPa	60		

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.11	WATER CONTENT, (specimen) %	29.25
SAMPLE DIAMETER, cm	5.00	UNIT WEIGHT, kN/m^3	19.33
SAMPLE AREA, cm^2	19.63	DRY UNIT WT., kN/m^3	14.96
SAMPLE VOLUME, cm^3	198.51	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	391.46	VOID RATIO	0.77
DRY WEIGHT, g	302.87		

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	14.8	COMPRESSIVE STRENGTH, kPa	108

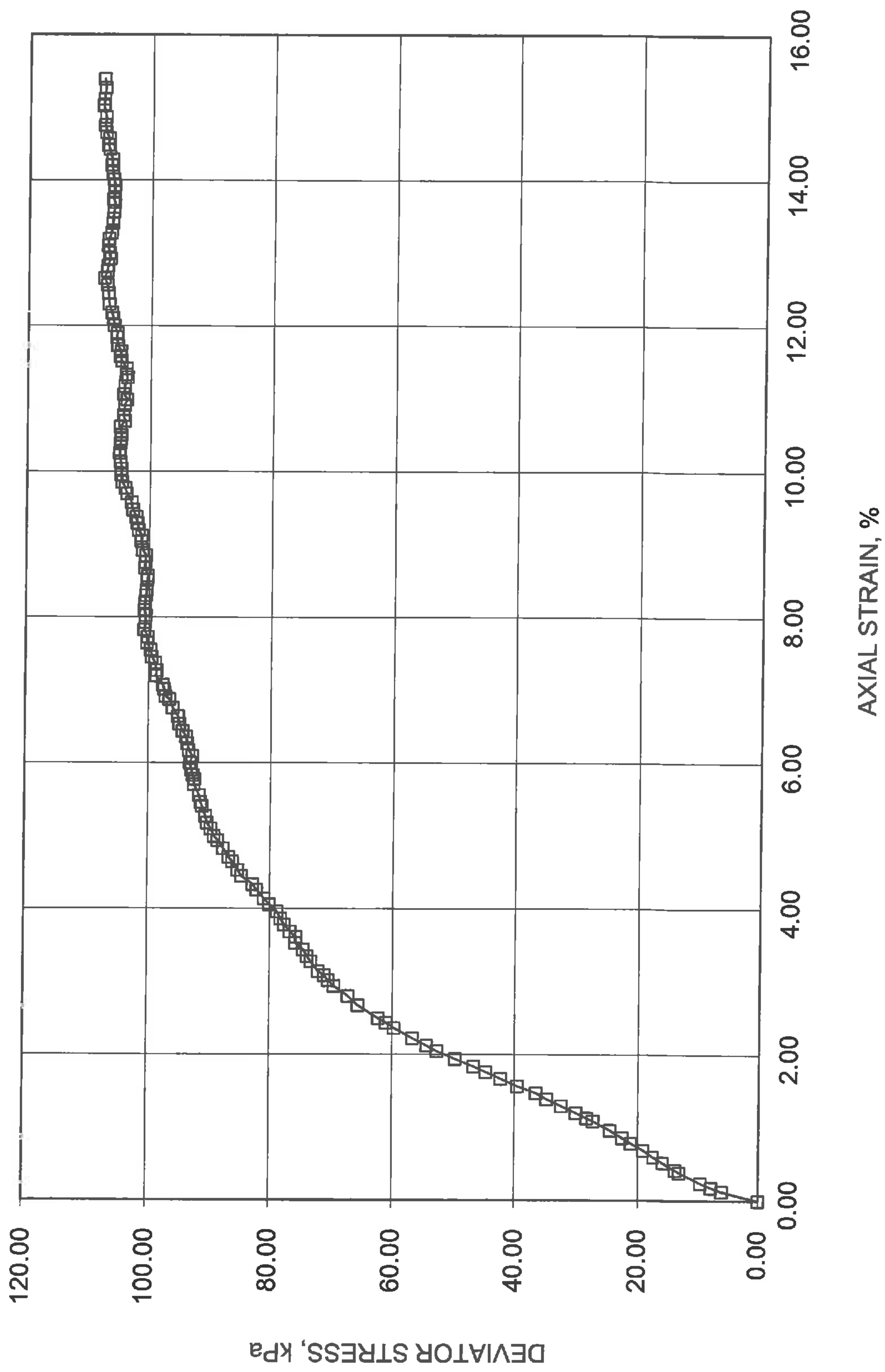
REMARKS: Specimen taken 13.5-27.5cm from top of the tı DATE: March 14, 2017

Checked By: [signature]

Golder Associates

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)	FIGURE

BOREHOLE NUMBER DC-2 SAMPLE NUMBER TW5 SAMPLE DEPTH, m 3.8



Project No.1775914

Checked By: bb

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

ASTM D 2850

SAMPLE IDENTIFICATION

PROJECT NUMBER	1775914	SAMPLE NUMBER	TW2
BOREHOLE NUMBER	DC-4A	SAMPLE DEPTH, m	2.3

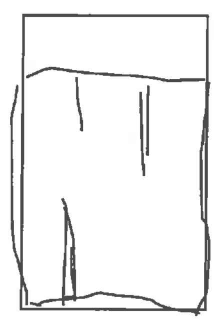
TEST CONDITIONS

MACHINE SPEED, mm/min	0.50	TYPE OF SPECIMEN	Intact
RATE OF AXIAL STRAIN, %/min	0.36	L/D	2.02
CELL PRESSURE, kPa	40		

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	14.02	WATER CONTENT, (specimen) %	28.34
SAMPLE DIAMETER, cm	6.93	UNIT WEIGHT, kN/m^3	19.46
SAMPLE AREA, cm^2	37.73	DRY UNIT WT., kN/m^3	15.17
SAMPLE VOLUME, cm^3	528.78	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	1049.85	VOID RATIO	0.75
DRY WEIGHT, g	818.02		

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	6.4	COMPRESSIVE STRENGTH, kPa	105

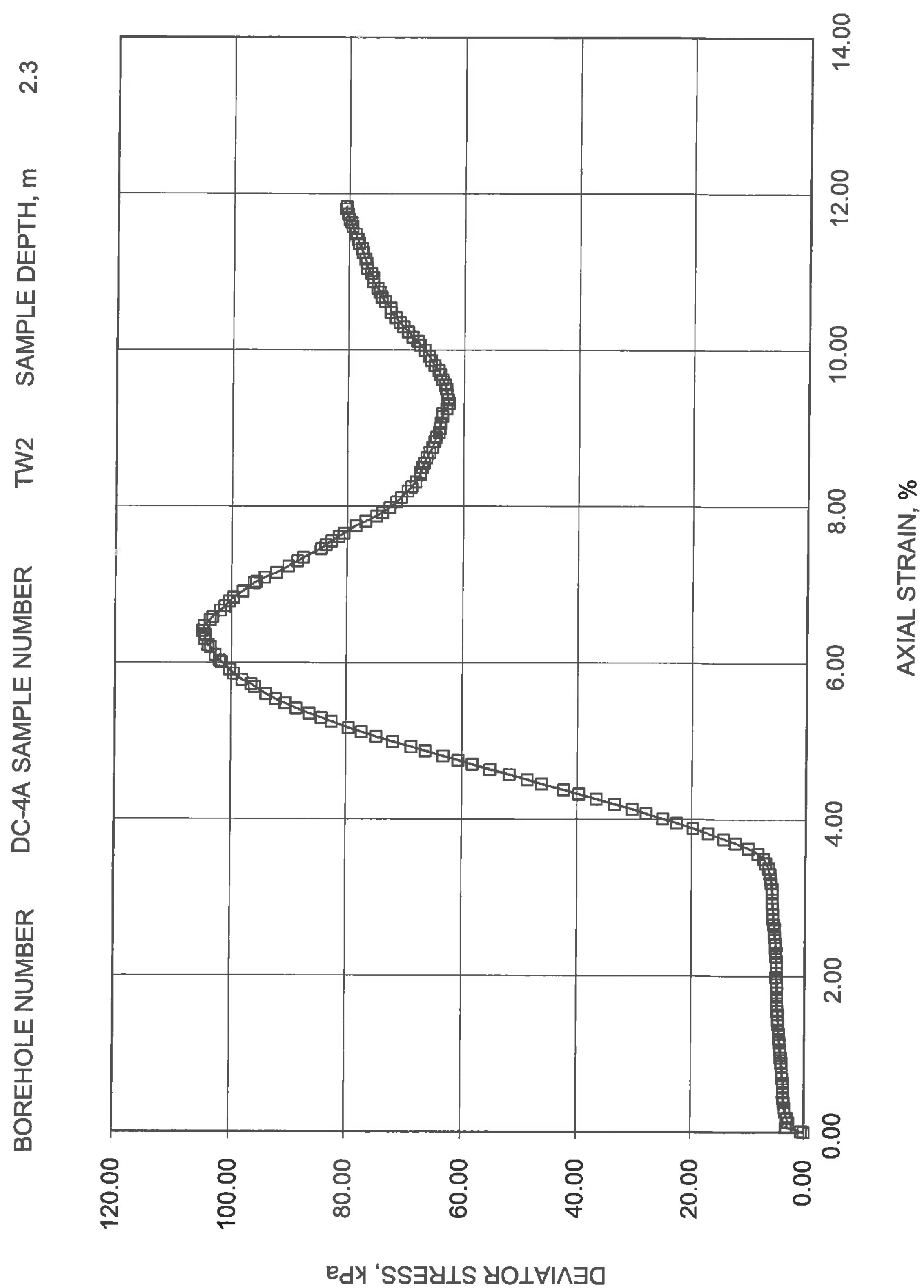
REMARKS: Specimen taken 6-23cm from top of the tube DATE: March 8, 2017

Checked By: [signature]

Golder Associates

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

FIGURE



Project No.1775914

Checked By:

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

ASTM D 2850

SAMPLE IDENTIFICATION

PROJECT NUMBER	1775914	SAMPLE NUMBER	TW1
BOREHOLE NUMBER	DC-4A	SAMPLE DEPTH, m	1.5

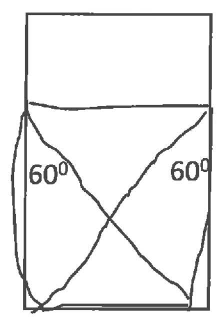
TEST CONDITIONS

MACHINE SPEED, mm/min	0.50	TYPE OF SPECIMEN	Intact
RATE OF AXIAL STRAIN, %/min	0.36	L/D	2.03
CELL PRESSURE, kPa	30		

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	14.01	WATER CONTENT, (specimen) %	28.18
SAMPLE DIAMETER, cm	6.90	UNIT WEIGHT, kN/m^3	19.50
SAMPLE AREA, cm^2	37.40	DRY UNIT WT., kN/m^3	15.21
SAMPLE VOLUME, cm^3	524.03	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	1042.34	VOID RATIO	0.74
DRY WEIGHT, g	813.18		

FAILURE SKETCH



TEST RESULTS

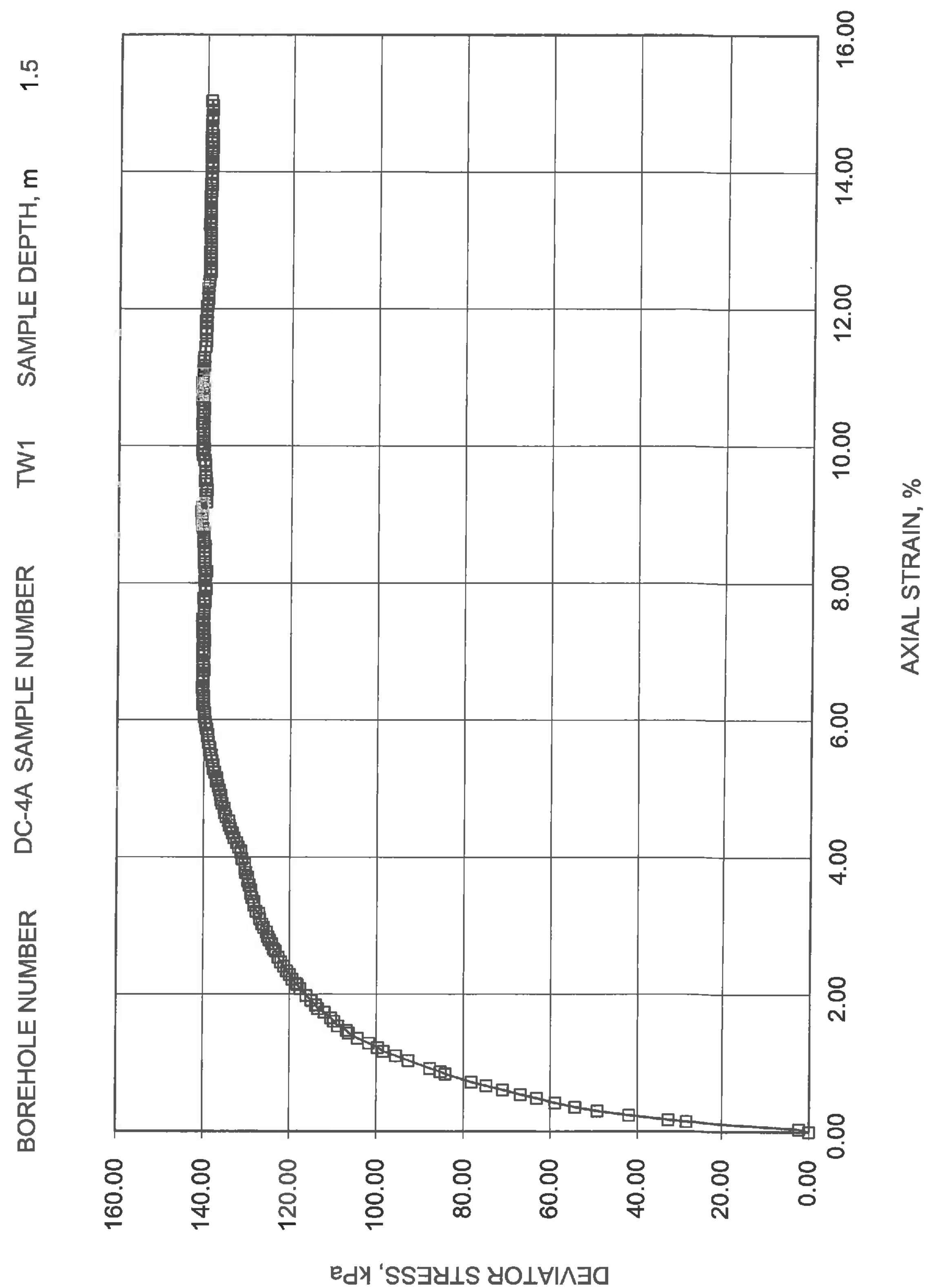
STRAIN AT FAILURE, %	10.9	COMPRESSIVE STRENGTH, kPa	141

REMARKS: Specimen taken 43-61cm from top of the tube DATE: March 5, 2017

Checked By: MJM

Golder Associates

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)	FIGURE



Project No.1775914

Checked By:

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

ASTM D 2850

SAMPLE IDENTIFICATION

PROJECT NUMBER	1775914	SAMPLE NUMBER	TW3
BOREHOLE NUMBER	DC-3	SAMPLE DEPTH, m	3.0

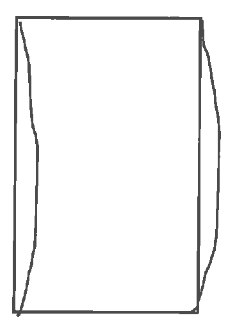
TEST CONDITIONS

MACHINE SPEED, mm/min	0.50	TYPE OF SPECIMEN	Intact
RATE OF AXIAL STRAIN, %/min	0.50	L/D	2.01
CELL PRESSURE, kPa	50		

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.08	WATER CONTENT, (specimen) %	27.56
SAMPLE DIAMETER, cm	5.02	UNIT WEIGHT, kN/m^3	19.49
SAMPLE AREA, cm^2	19.77	DRY UNIT WT., kN/m^3	15.28
SAMPLE VOLUME, cm^3	199.27	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	396.23	VOID RATIO	0.73
DRY WEIGHT, g	310.63		

FAILURE SKETCH



TEST RESULTS

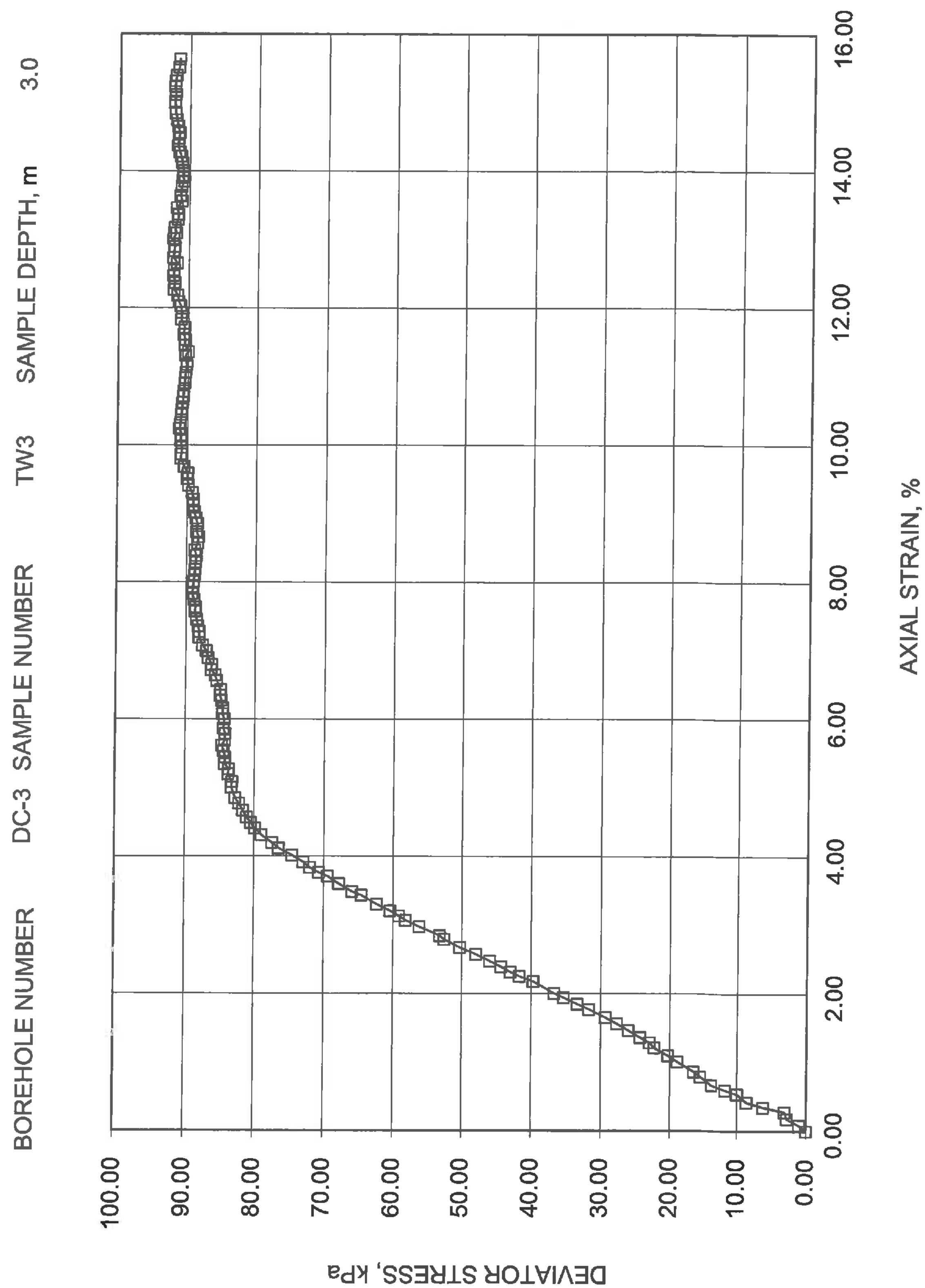
STRAIN AT FAILURE, %	13.0	COMPRESSIVE STRENGTH, kPa	92

REMARKS: Specimen taken 24-40cm from bottom of the tı DATE: March 14, 2017

Checked By: [signature]

Golder Associates

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)	FIGURE



Project No.1775914

Checked By:

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

ASTM D 2850

SAMPLE IDENTIFICATION

PROJECT NUMBER	1775914	SAMPLE NUMBER	TW7
BOREHOLE NUMBER	DC-2	SAMPLE DEPTH, m	5.3

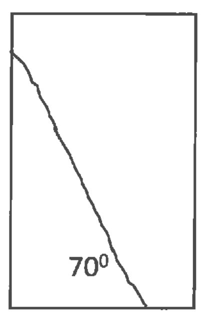
TEST CONDITIONS

MACHINE SPEED, mm/min	0.50	TYPE OF SPECIMEN	Intact
RATE OF AXIAL STRAIN, %/min	0.49	L/D	2.02
CELL PRESSURE, kPa	75		

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.11	WATER CONTENT, (specimen) %	28.38
SAMPLE DIAMETER, cm	5.01	UNIT WEIGHT, kN/m^3	19.30
SAMPLE AREA, cm^2	19.71	DRY UNIT WT., kN/m^3	15.03
SAMPLE VOLUME, cm^3	199.30	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	392.35	VOID RATIO	0.76
DRY WEIGHT, g	305.61		

FAILURE SKETCH



TEST RESULTS

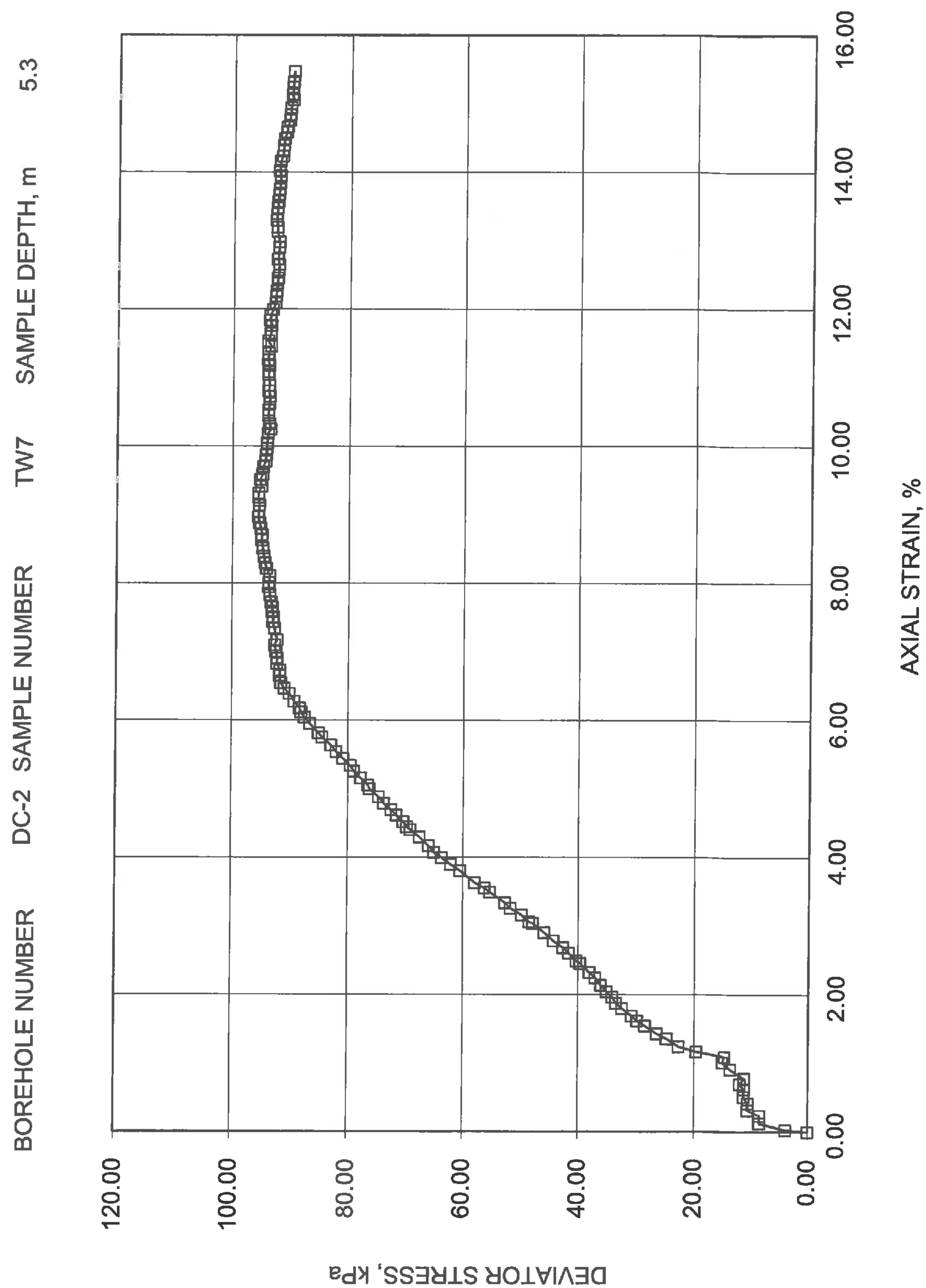
STRAIN AT FAILURE, %	9.3	COMPRESSIVE STRENGTH, kPa	96

REMARKS: Specimen taken 20-34cm from bottom of the tı DATE: March 14, 2017

Checked By: [signature]

Golder Associates

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)	FIGURE



Project No.1775914

Checked By: MU

Consolidated Drained Direct Shear Compression Test Results

Borehole #	Sample #	Depth (m)	Density (Mg/m^3)	Peak Strength		Residual Strength	
				Φ’	c’	Φ	c
DC-4A	TW2	2.3	1.89 to 1.91	31.9^0	5.1 kPa	31.5^0	4.6 kPa
DC-5	TW3	1.5	1.89 to 1.98	34.2^0	4.7 kPa	32.6^0	4.4 kPa
DC-6	TW3	1.5	1.92 to 1.94	25.4^0	15.5 kPa	28.6^0	8.7 kPa
DC-2A	TW2	3.1	1.90 to 2.01	30.9^0	6.7 kPa	30.5^0	3.1 kPa
DC-4A	TW1	1.5	1.85 to 1.89	30.1^0	9.2 kPa	35.2^0	4.0 kPa
DC-6	TW5	3.1	1.89 to 2.02	34.0^0	10.8 kPa	36.3^0	3.3 kPa

Φ Friction Angle
c Apparent Cohesion

CONSOLIDATED DRAINED DIRECT SHEAR TEST ASTM D3080 SHEET 1 OF 3			FIGURE
TEST STAGE	A	B	C
BOREHOLE NUMBER		DC-4A	
SAMPLE		TW2	
SAMPLE DEPTH, (m)		2.3	
SAMPLE HEIGHT, (mm)	25.79	25.44	25.29
SAMPLE LENGTH, (mm)	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	27.0	27.8	28.5
NORMAL (CONSOLIDATION) STRESS, (kPa)	20	40	80
WATER CONTENT, AFTER TEST, (%)	26.8	29.0	28.2
DISPLACEMENT RATE, mm/min	0.0048	0.0048	0.0048
TIME TO FAILURE, hours	5	20	19
PEAK SHEAR STRESS[1], (kPa)	18.0	29.6	55.4
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.6	5.8	5.5
RESIDUAL SHEAR STRESS, (kPa)	16.9	28.9	53.6
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	11.9	11.6	11.6
DRY DENSITY, initial, Mg/m^3	1.50	1.49	1.47
WET DENSITY, initial, Mg/m^3	1.91	1.91	1.89

TEST NOTES:

[1] In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement(ASTM D3080).

Date: 03/14/2017

Project No. 1775914

Golder Associates

Prepared By: LH

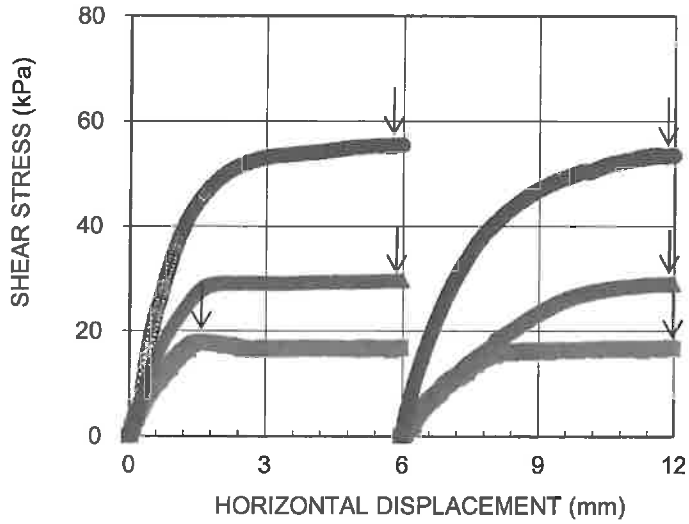
Checked By: [signature]

CONSOLIDATED DRAINED DIRECT SHEAR TEST
SHEET 2 OF 3

FIGURE

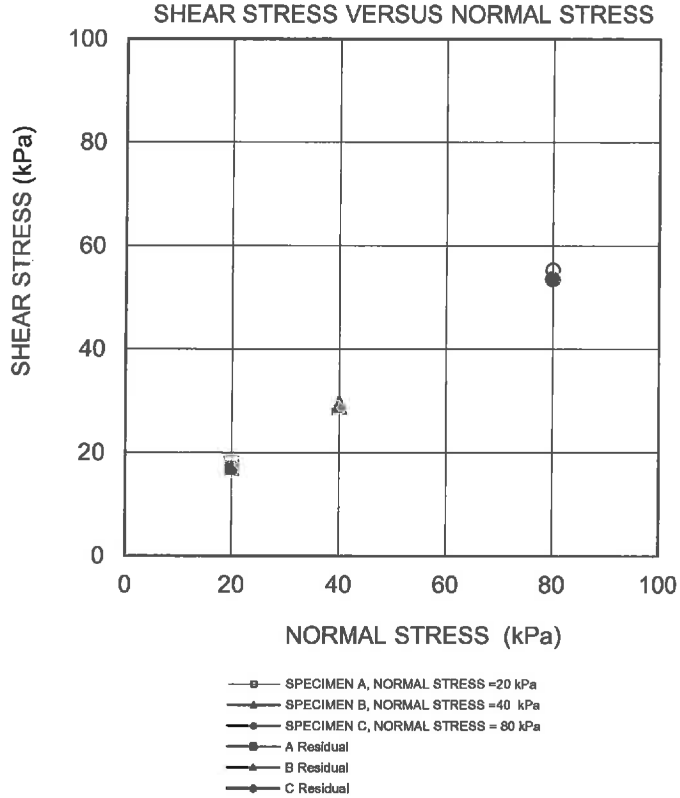
BH DC-4A SA TW2

SHEAR STRESS VERSUS HORIZONTAL DISPLACEMENT



BH DC-4A SA TW2

SHEAR STRESS VERSUS NORMAL STRESS



Date: 03/14/2017

Project No. 1775914

Golder Associates

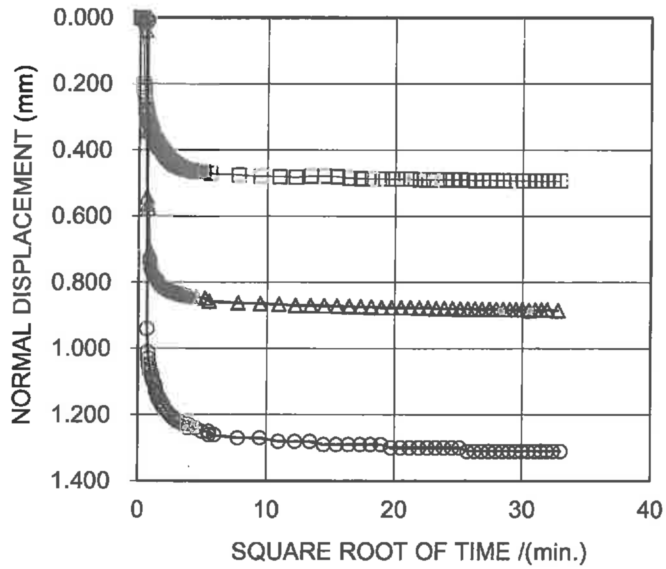
Prepared By LH

Checked By:

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE

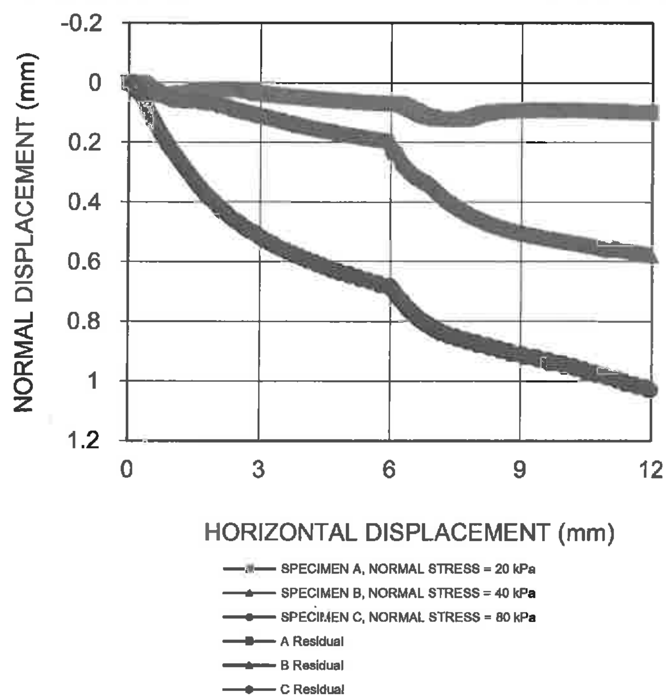
BH DC-4A SA TW2

NORMAL DISPLACEMENT VERSUS SQUARE ROOT OF TIME



BH DC-4A SA TW2

NORMAL DISPLACEMENT VERSUS HORIZONTAL DISPLACEMENT



Date: 03/14/2017

Project No. 1775914

Golder Associates

Prepared By LH

Checked By: [signature]

CONSOLIDATED DRAINED DIRECT SHEAR TEST ASTM D3080 SHEET 1 OF 3	FIGURE		
TEST STAGE	A	B	C
BOREHOLE NUMBER		DC-5	
SAMPLE		TW3	
SAMPLE DEPTH, (m)		1.50	
SAMPLE HEIGHT, (mm)	25.17	25.01	25.23
SAMPLE LENGTH, (mm)	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	27.8	27.8	27.8
NORMAL (CONSOLIDATION) STRESS, (kPa)	15	30	60
WATER CONTENT, AFTER TEST, (%)	27.9	26.5	29.8
DISPLACEMENT RATE, mm/min	0.0048	0.0048	0.0048
TIME TO FAILURE, hours	5	7	10
PEAK SHEAR STRESS[1], (kPa)	14.4	25.5	45.0
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.6	2.1	3.0
RESIDUAL SHEAR STRESS, (kPa)	13.5	24.0	42.3
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	11.1	11.7	9.4
DRY DENSITY, initial, Mg/m^3	1.50	1.55	1.48
WET DENSITY, initial, Mg/m^3	1.91	1.98	1.89

TEST NOTES:

[1] In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement(ASTM D3080).

[2] Specimen A taken 44-50cm from top of the tube
Specimen B taken 37-44cm from top of the tube
Specimen C taken 50-57cm from top of the tube

Date: 04/03/2017

Project No. 1775914

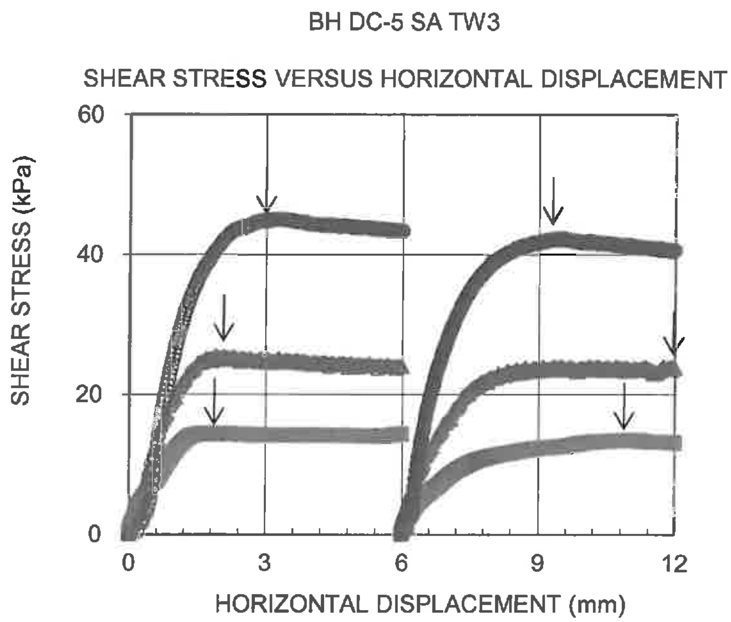
Golder Associates

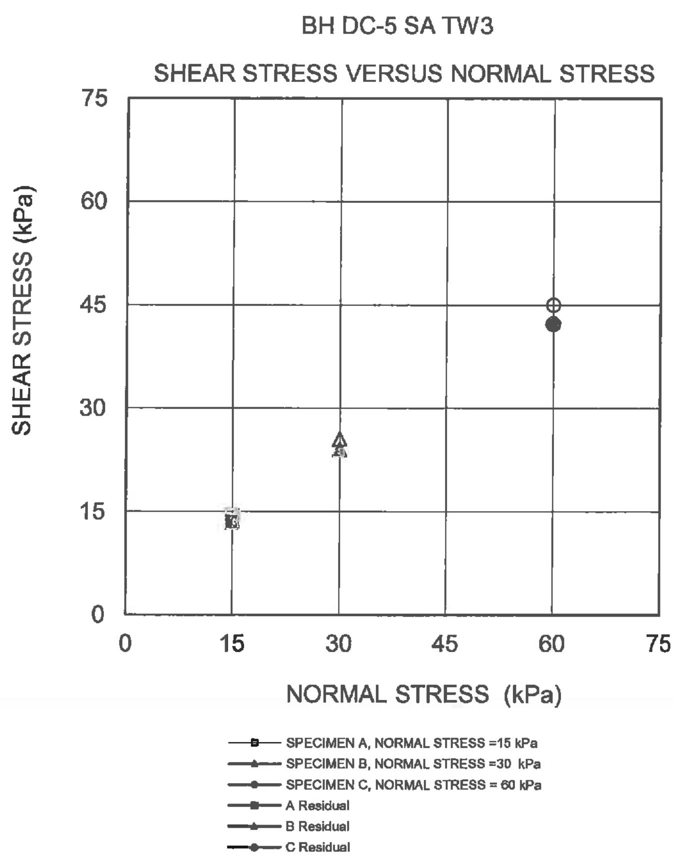
Prepared By: LH

Checked By: [signature]

CONSOLIDATED DRAINED DIRECT SHEAR TEST
SHEET 2 OF 3

FIGURE





Date: 04/03/2017

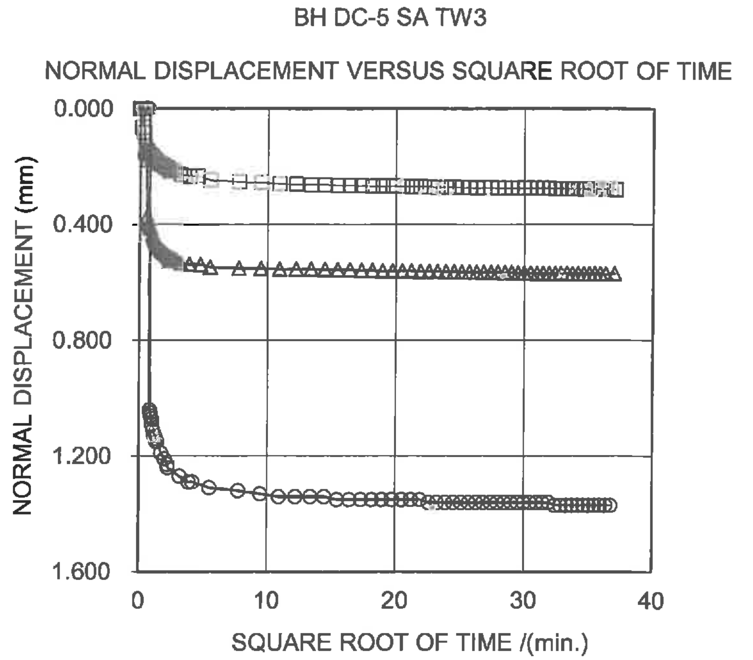
Project No. 1775914

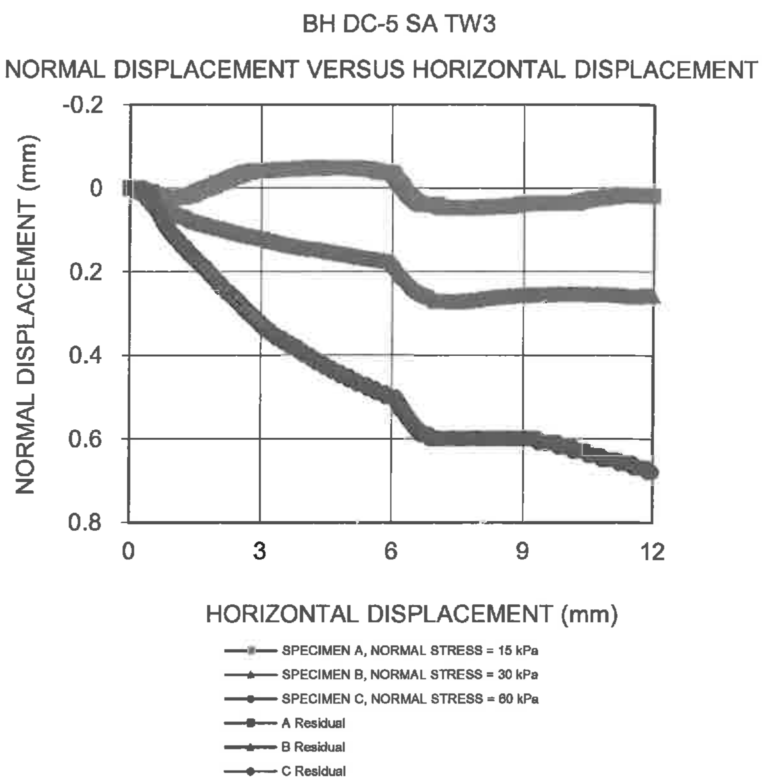
Golder Associates

Prepared By LH

Checked By:

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE





Date: 04/03/2017

Project No. 1775914

Golder Associates

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CONSOLIDATED DRAINED DIRECT SHEAR TEST
ASTM D3080
SHEET 1 OF 3

FIGURE

TEST STAGE	A	B	C
BOREHOLE NUMBER		DC-6	
SAMPLE		TW3	
SAMPLE DEPTH, (m)		1.52-2.13	
SAMPLE HEIGHT, (mm)	24.86	25.21	25.29
SAMPLE LENGTH, (mm)	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	26.7	26.7	26.7
NORMAL (CONSOLIDATION) STRESS, (kPa)	15	30	60
WATER CONTENT, AFTER TEST, (%)	30.3	29.7	26.8
DISPLACEMENT RATE, mm/min	0.0048	0.0048	0.0048
TIME TO FAILURE, hours	8	8	11
PEAK SHEAR STRESS[1], (kPa)	22.5	29.8	43.9
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	2.2	2.2	3.0
RESIDUAL SHEAR STRESS, (kPa)	15.7	26.1	40.2
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	11.7	12.0	10.2
DRY DENSITY, initial, Mg/m^3	1.53	1.52	1.53
WET DENSITY, initial, Mg/m^3	1.94	1.92	1.93

TEST NOTES:

[1] In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement(ASTM D3080).

[2] Specimen A taken 38-44cm from top of the tube
Specimen B taken 44-50cm from top of the tube
Specimen C taken 50-56cm from top of the tube

Date: 03/29/2017
Project No. 1775914

Golder Associates

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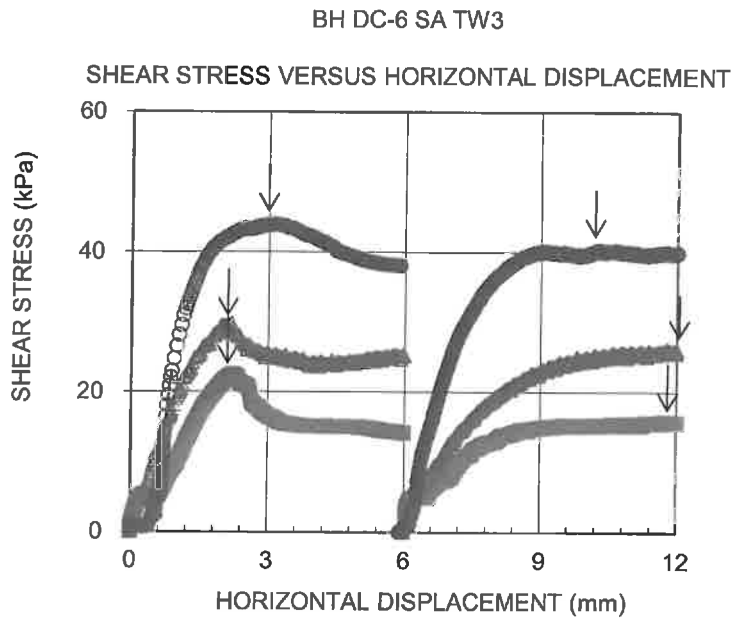
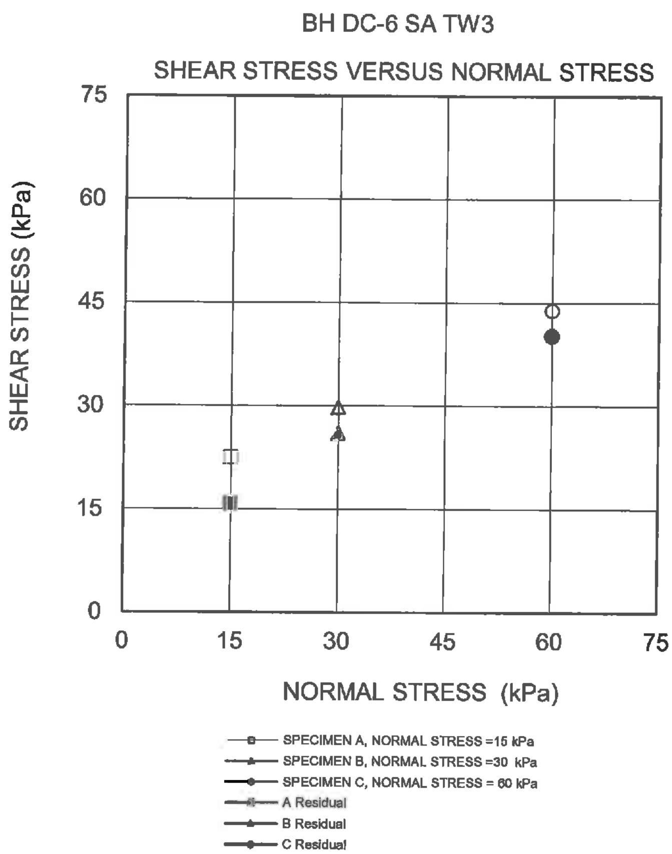
Checked By: [signature]

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 2 OF 3	FIGURE





Date: 03/29/2017
Project No. 1775914

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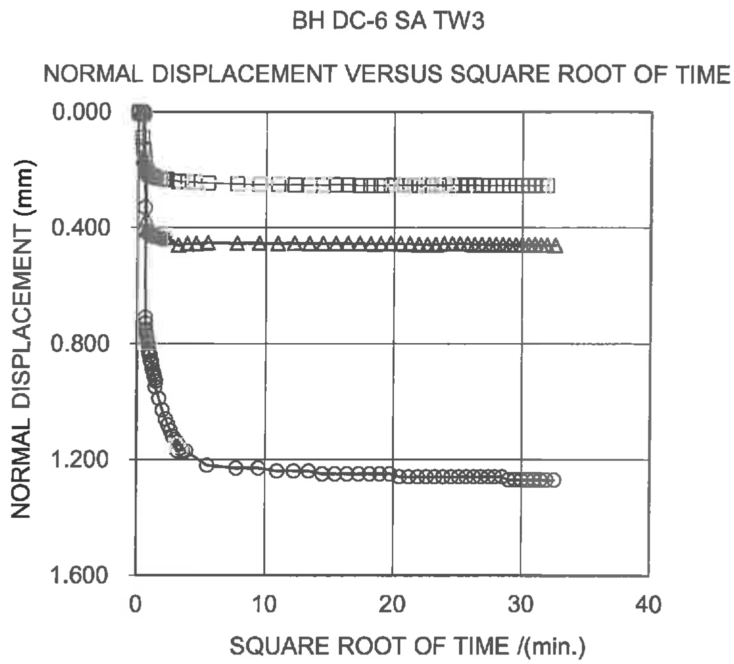
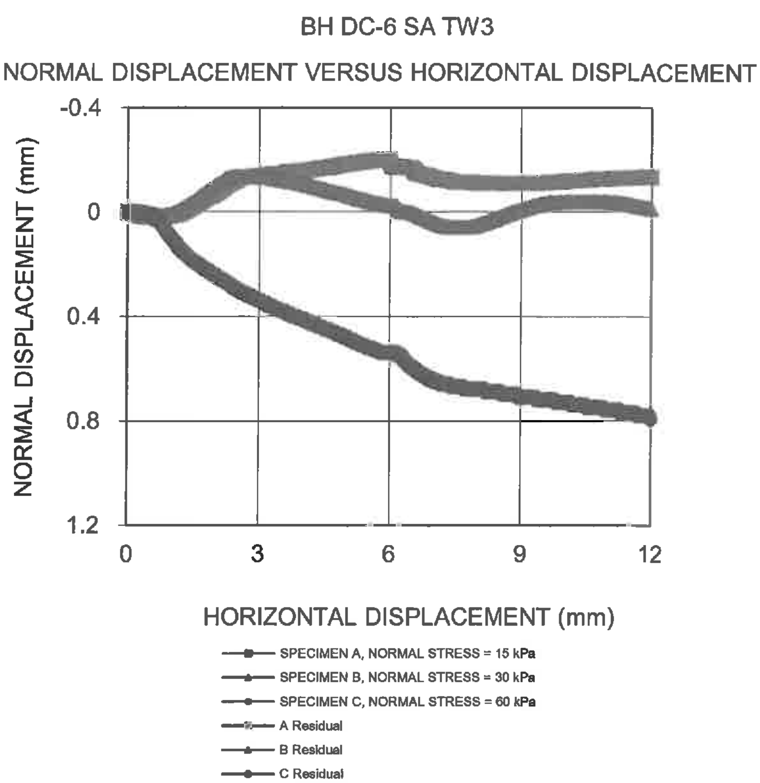
CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE





Date: 03/29/2017

Project No. 1775914

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CONSOLIDATED DRAINED DIRECT SHEAR TEST ASTM D3080 SHEET 1 OF 3	FIGURE		
TEST STAGE	A	B	C
BOREHOLE NUMBER		DC-2A	
SAMPLE		TW2	
SAMPLE DEPTH, (m)		3.05	
SAMPLE HEIGHT, (mm)	25.53	24.86	24.57
SAMPLE LENGTH, (mm)	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	29.2	29.2	29.2
NORMAL (CONSOLIDATION) STRESS, (kPa)	25	50	100
WATER CONTENT, AFTER TEST, (%)	23.8	22.0	21.0
DISPLACEMENT RATE, mm/min	0.0048	0.0048	0.0048
TIME TO FAILURE, hours	12	7	20
PEAK SHEAR STRESS[1], (kPa)	20.9	37.2	65.7
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	3.3	1.9	5.7
RESIDUAL SHEAR STRESS, (kPa)	20.4	30.0	64.6
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	10.8	12.0	10.4
DRY DENSITY, initial, Mg/m^3	1.49	1.47	1.56
WET DENSITY, initial, Mg/m^3	1.92	1.90	2.01

TEST NOTES:

1 In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement(ASTM D3080).

2 Specimen A taken 36-43cm from top of the tube
Specimen B taken 43-50cm from top of the tube
Specimen C taken 50-57cm from top of the tube

Date: 03/27/2017

Project No. 1775914

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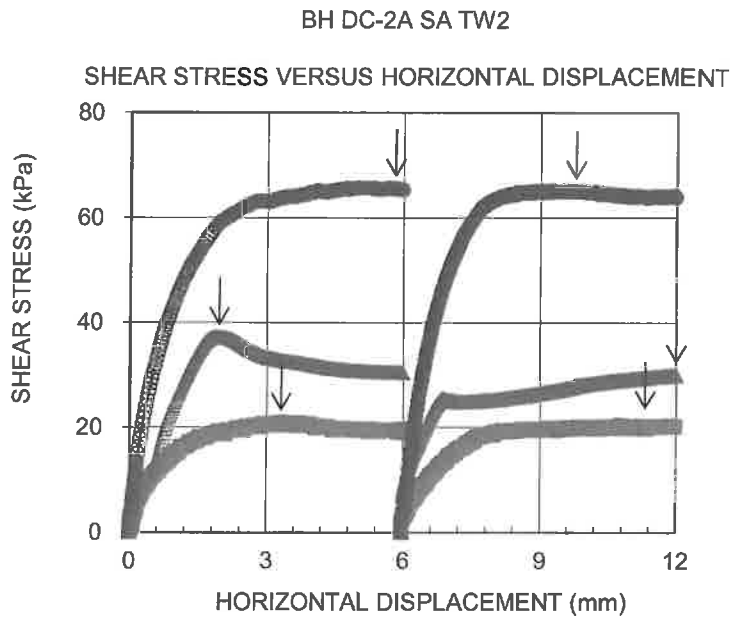
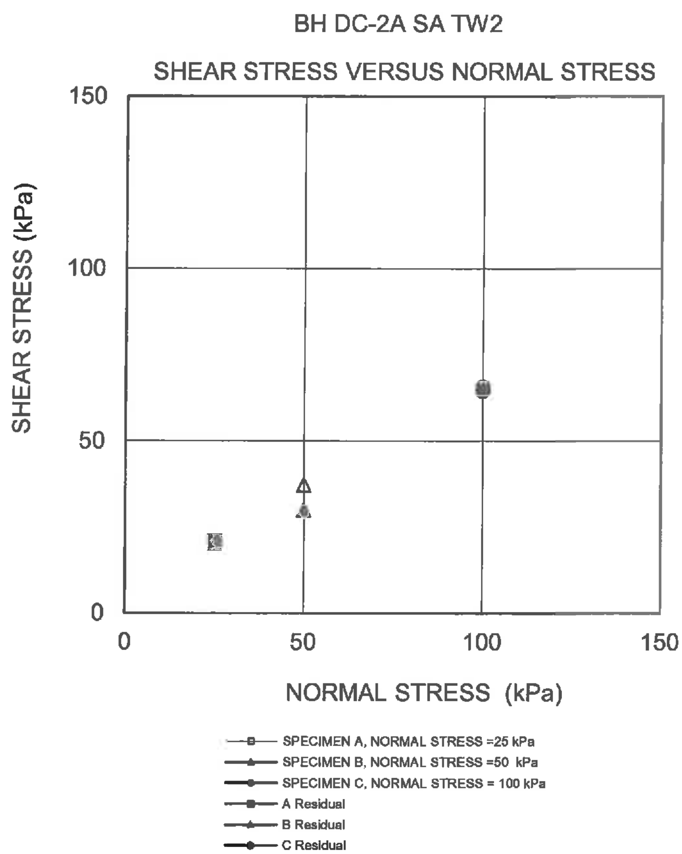
CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 2 OF 3	FIGURE





Date: 03/27/2017

Project No. 1775914

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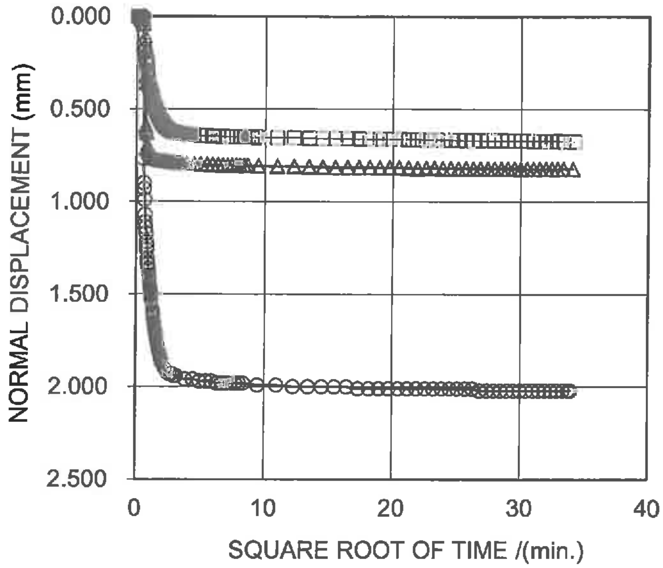
Checked By: [signature]

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE

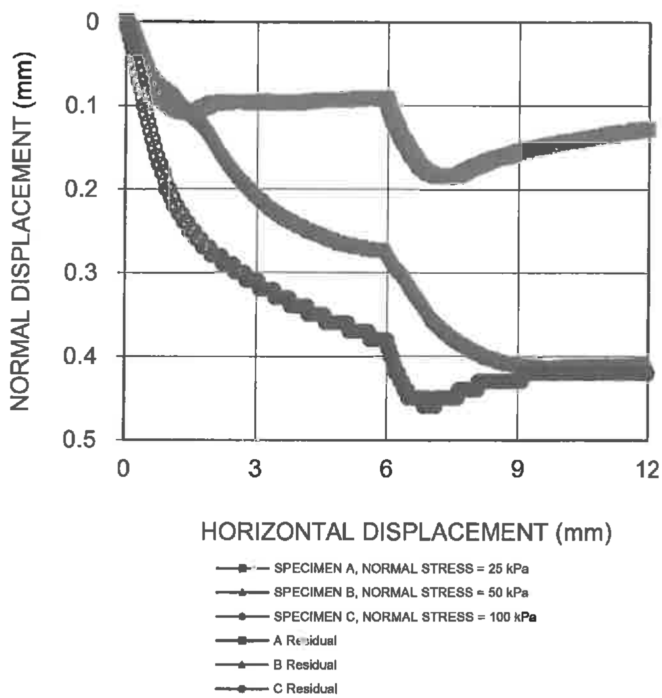
BH DC-2A SA TW2

NORMAL DISPLACEMENT VERSUS SQUARE ROOT OF TIME



BH DC-2A SA TW2

NORMAL DISPLACEMENT VERSUS HORIZONTAL DISPLACEMENT



Date: 03/27/2017

Project No. 1775914

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Checked By:

CONSOLIDATED DRAINED DIRECT SHEAR TEST ASTM D3080 SHEET 1 OF 3	FIGURE

TEST STAGE	A	B	C
BOREHOLE NUMBER		DC-4A	
SAMPLE		TW1	
SAMPLE DEPTH, (m)		1.5	
SAMPLE HEIGHT, (mm)	25.67	25.76	25.42
SAMPLE LENGTH, (mm)	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	26.1	26.1	28.2
NORMAL (CONSOLIDATION) STRESS, (kPa)	15	30	60
WATER CONTENT, AFTER TEST, (%)	28.3	31.2	28.5
DISPLACEMENT RATE, mm/min	0.0048	0.0048	0.0048
TIME TO FAILURE, hours	5	6	20
PEAK SHEAR STRESS[1], (kPa)	18.8	27.8	47.0
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.5	1.8	5.9
RESIDUAL SHEAR STRESS, (kPa)	15.1	24.6	46.8
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	12.0	11.4	11.9
DRY DENSITY, initial, Mg/m^3	1.50	1.47	1.44
WET DENSITY, initial, Mg/m^3	1.89	1.85	1.85

TEST NOTES:

[1] In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement(ASTM D3080).

Date: 03/08/2017

Project No. 1775914

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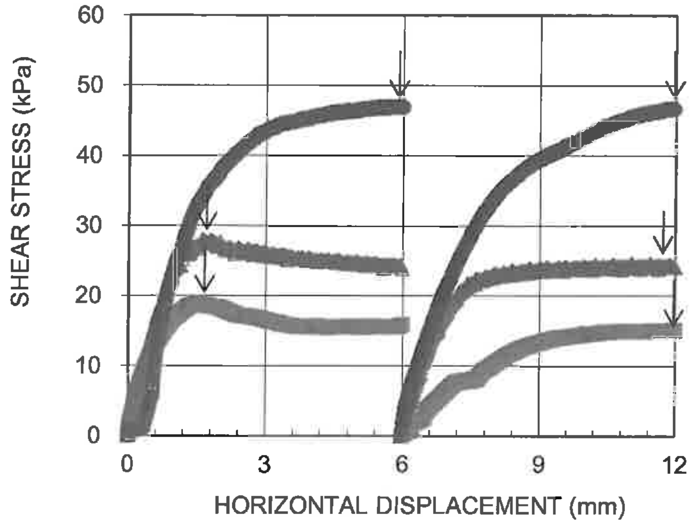
CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 2 OF 3	FIGURE

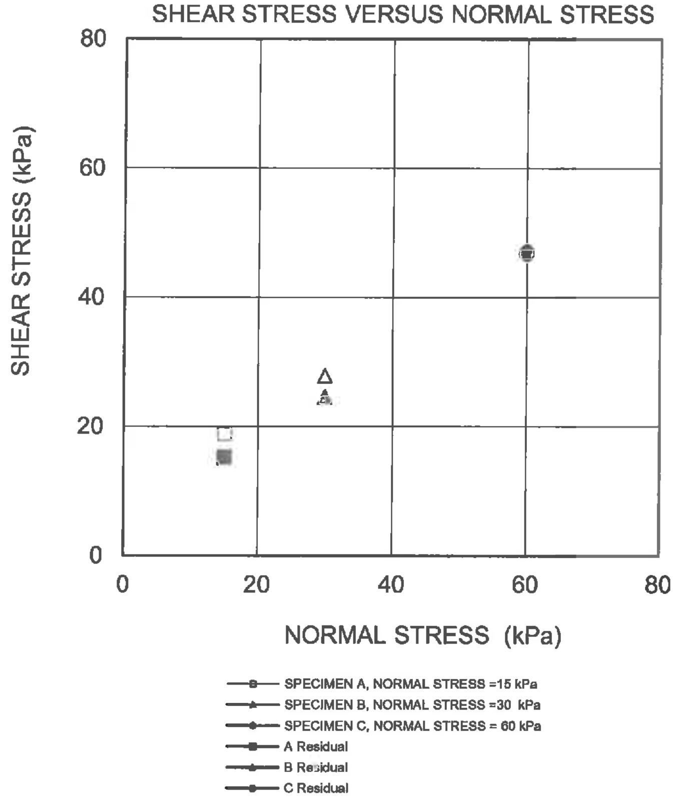
BHDC-4A SA TW1

SHEAR STRESS VERSUS HORIZONTAL DISPLACEMENT



BHDC-4A SA TW1

SHEAR STRESS VERSUS NORMAL STRESS



Date: 03/08/2017

Project No. 1775914

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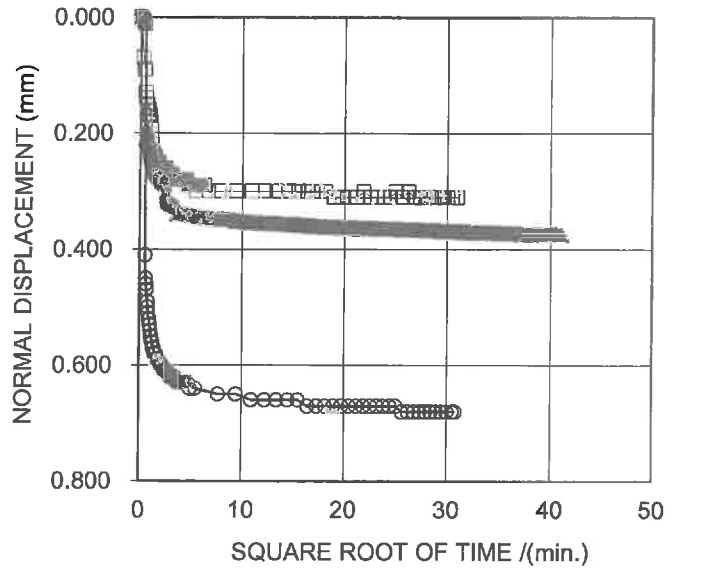
CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE

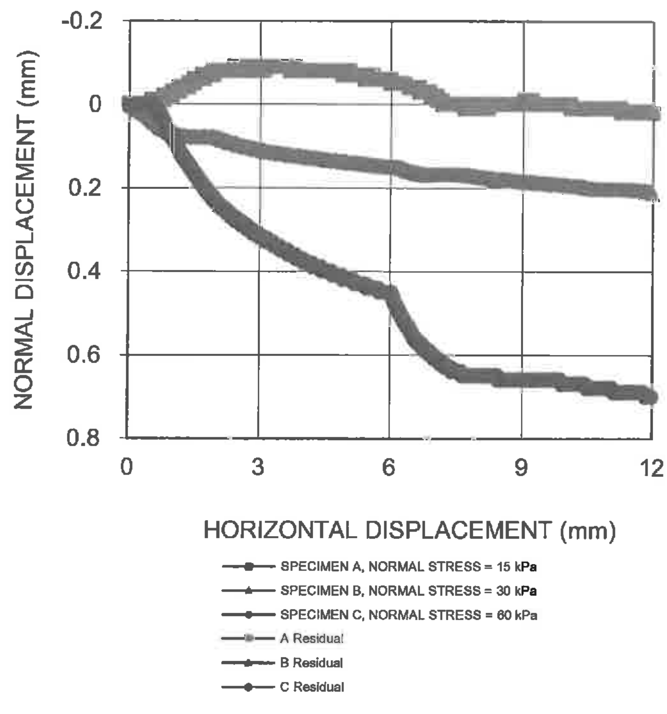
BHDC-4A SA TW1

NORMAL DISPLACEMENT VERSUS SQUARE ROOT OF TIME



BHDC-4A SA TW1

NORMAL DISPLACEMENT VERSUS HORIZONTAL DISPLACEMENT



Date: 03/08/2017

Project No. 1775914

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CONSOLIDATED DRAINED DIRECT SHEAR TEST ASTM D3080 SHEET 1 OF 3	FIGURE	

TEST STAGE	A	B	C
BOREHOLE NUMBER		DC-6	
SAMPLE		TW5	
SAMPLE DEPTH, (m)		3.05	
SAMPLE HEIGHT, (mm)	25.55	25.34	24.58
SAMPLE LENGTH, (mm)	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	28.1	28.1	28.1
NORMAL (CONSOLIDATION) STRESS, (kPa)	25	50	100
WATER CONTENT, AFTER TEST, (%)	29.7	29.3	27.2
DISPLACEMENT RATE, mm/min	0.0048	0.0048	0.0048
TIME TO FAILURE, hours	6	9	18
PEAK SHEAR STRESS[1], (kPa)	28.0	44.1	78.6
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.7	2.5	5.3
RESIDUAL SHEAR STRESS, (kPa)	23.5	38.0	78.5
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	11.9	12.0	12.0
DRY DENSITY, initial, Mg/m^3	1.48	1.50	1.58
WET DENSITY, initial, Mg/m^3	1.89	1.92	2.02

TEST NOTES:

[1] In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement(ASTM D3080).

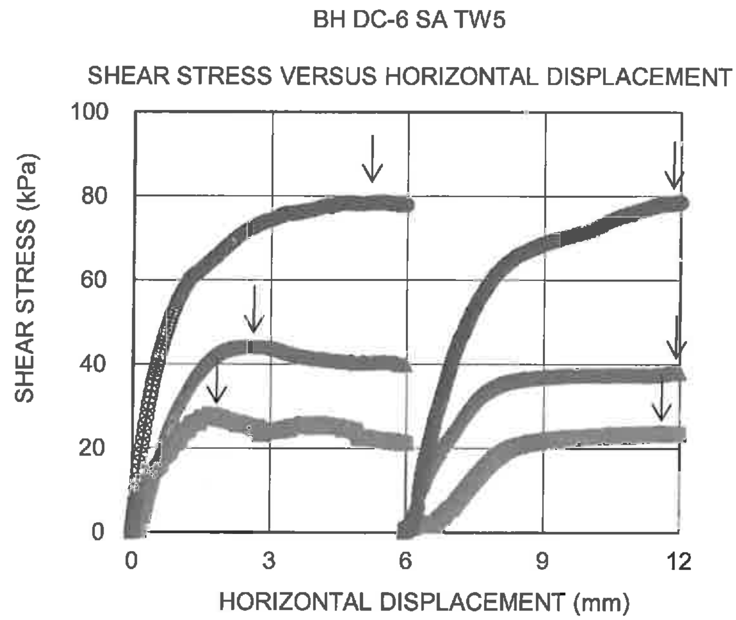
[2] Specimen A taken 38-45cm from top of the tube
Specimen B taken 45-52cm from top of the tube
Specimen C taken 52-59cm from top of the tube

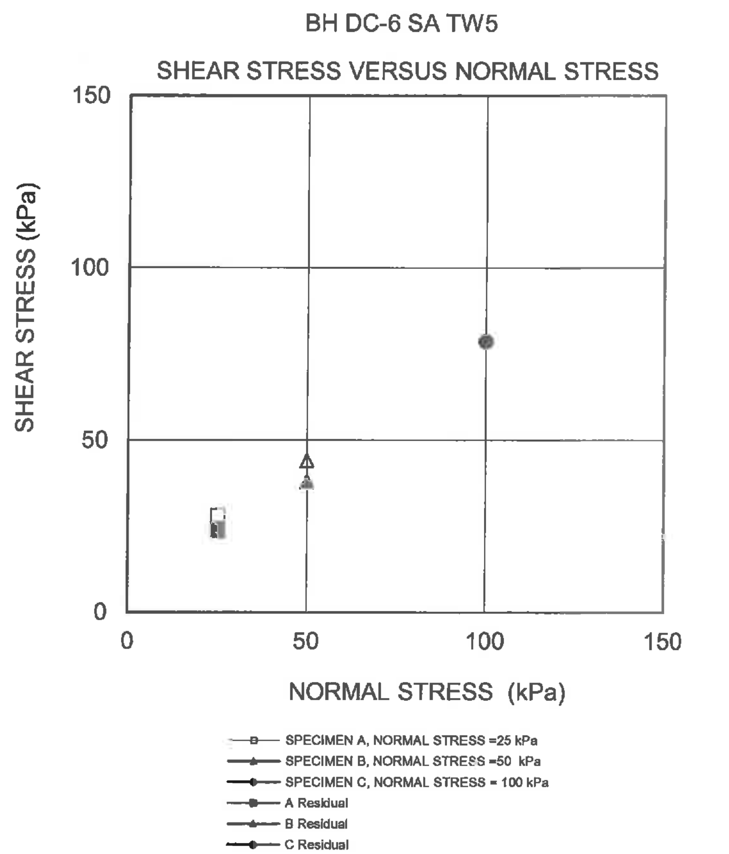
Date: 03/29/2017
Project No. 1775914

Golder Associates

Prepared By: LH
Checked By: [signature]

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 2 OF 3	FIGURE





Date: 03/29/2017

Project No. 1775914

Golder Associates

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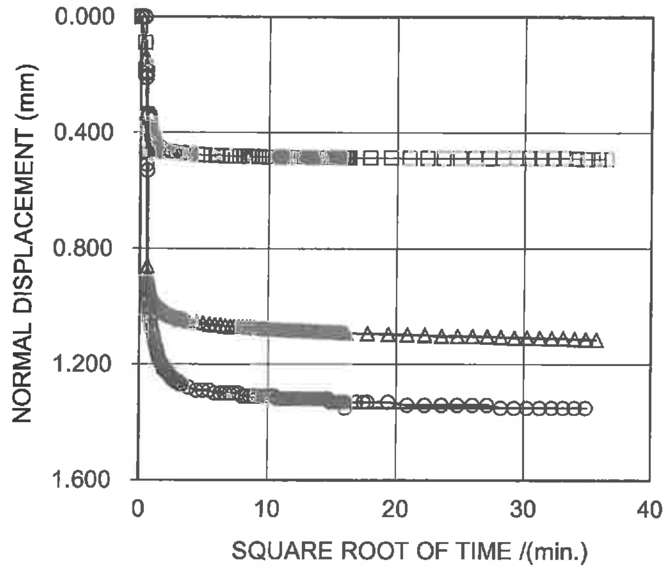
Checked By:

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE

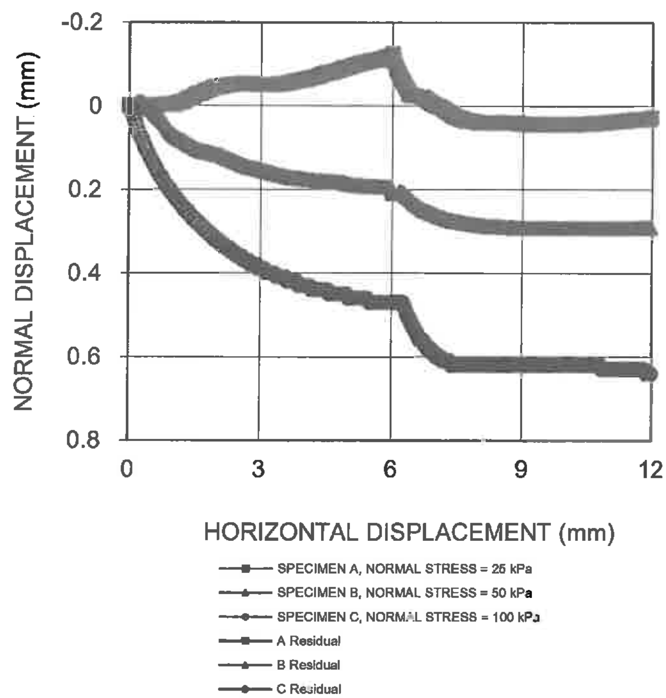
BH DC-6 SA TW5

NORMAL DISPLACEMENT VERSUS SQUARE ROOT OF TIME



BH DC-6 SA TW5

NORMAL DISPLACEMENT VERSUS HORIZONTAL DISPLACEMENT



Date: 03/29/2017

Project No. 1775914

Golder Associates

Prepared By LH

Checked By: [signature]

One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. DC-2A
Depth: 3.8m

Test Date: April 2017
Sample Description
brown SILTY CLAY

Sample Parameters:

	Units	Initial	Final
Sample Diameter:	mm	50.0	50.0
Height of Sample:	mm	19.5	17.5
Wet Mass	g	74.1	71.8
Water Content	%	24.0	23.0
Bulk Density	kN/m^3	19.0	20.5
Dry Density	kN/m^3	14.4	15.8
Assumed Specific Gravity	-	2.72	2.72
Void Ratio	-	0.848	0.654
Degree of Saturation	-	77.0	95.6

Test Results

Load	∑ΔH	∑Δ H/H_0	$H=(H_0-\Delta H)$	Void Ratio	Cv
kPa	mm	%	mm	-	m^2/day
0	0	-	19.50		
12.5	0.03	0.1%	19.47	0.845	0.226
25	0.14	0.7%	19.36	0.835	0.221
50	0.24	1.2%	19.26	0.825	0.356
100	0.32	1.6%	19.18	0.818	0.349
200	0.59	3.0%	18.91	0.792	0.039
400	0.95	4.9%	18.55	0.758	0.032
800	1.42	7.3%	18.09	0.714	0.030
1600	1.88	9.7%	17.62	0.670	0.033
3200	2.27	11.6%	17.23	0.633	0.061
800	2.20	11.3%	17.30	0.640	
200	2.17	11.1%	17.34	0.643	
50	2.12	10.9%	17.38	0.647	
12.5	2.05	10.5%	17.46	0.654	

Load	Constrained Modulus, M'
kPa	MPa
25-50	5.0
50-100	12.1
100-200	7.0
200-400	10.4
400-800	15.7
800-1600	30.2
1600-3200	72.3

C_C= 0.13
C_R= 0.01
OCR= 2.6
σ'_p= 130 kPa
σ'_v= 50 kPa

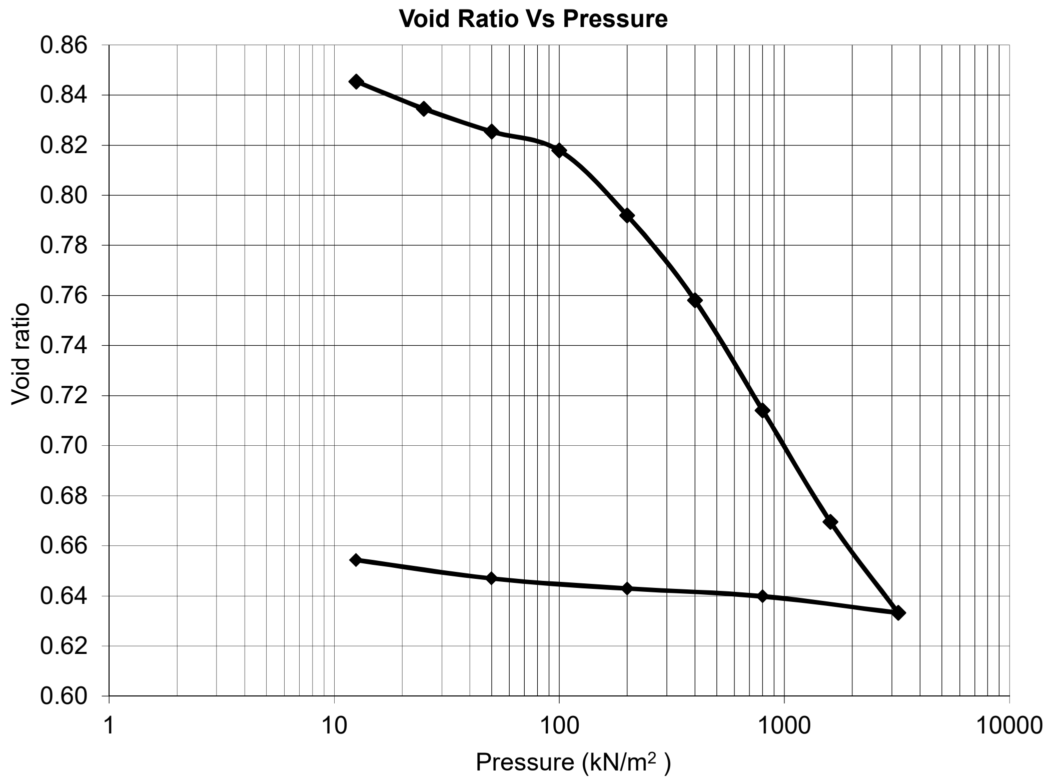
DownUnder Geotechnical Limited

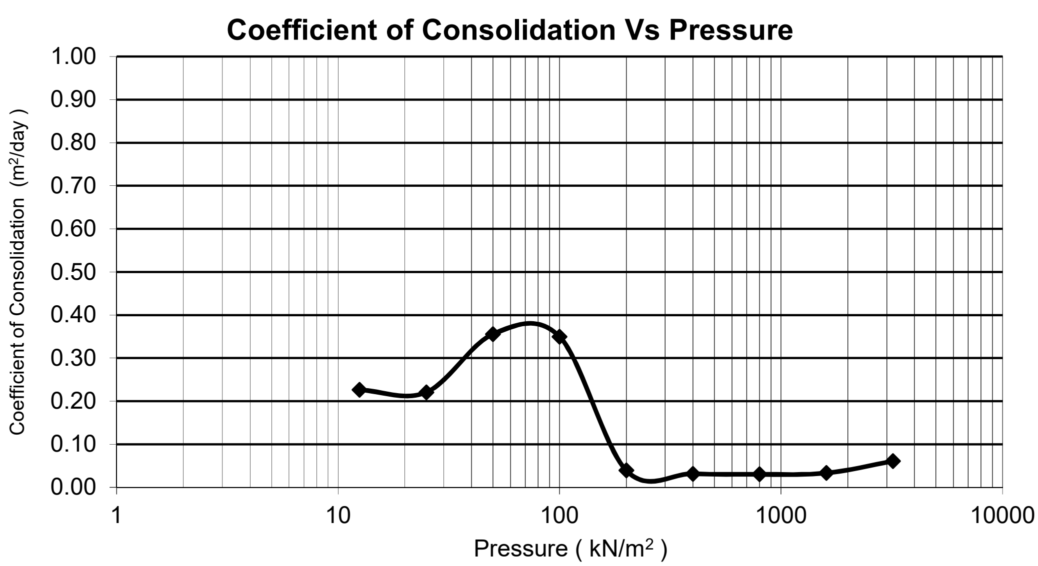
One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. DC-2A
Depth: 3.8m

Test Date: April 2017
Sample Description
brown SILTY CLAY





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One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. DC-2A
Depth: 5.3m

Test Date: April 2017
Sample Description
brown SILTY CLAY

Sample Parameters:

	Units	Initial	Final
Sample Diameter:	mm	50.0	50.0
Height of Sample:	mm	19.5	18.0
Wet Mass	g	72.7	68.2
Water Content	%	24.5	20.7
Bulk Density	kN/m^3	18.6	18.9
Dry Density	kN/m^3	14.1	15.0
Assumed Specific Gravity	-	2.72	2.72
Void Ratio	-	0.896	0.735
Degree of Saturation	-	74.3	76.6

Test Results

Load	$\sum\Delta H$	$\sum\Delta H/H_0$	$H=(H_0-\Delta H)$	Void Ratio	Cv
kPa	mm	%	mm	-	m^2/day
0	0	-	19.50		
12.5	0.11	0.6%	19.39	0.886	0.286
25	0.26	1.3%	19.24	0.871	0.314
50	0.43	2.2%	19.07	0.854	0.266
100	0.59	3.0%	18.91	0.839	0.348
200	0.74	3.8%	18.76	0.824	0.316
400	0.93	4.8%	18.57	0.806	0.127
800	1.23	6.3%	18.27	0.777	0.084
1600	1.50	7.7%	18.00	0.750	0.146
3200	1.79	9.2%	17.71	0.722	0.157
800	1.76	9.0%	17.74	0.725	
200	1.72	8.8%	17.78	0.729	
50	1.65	8.5%	17.85	0.735	
12.5	1.47	7.6%	18.03	0.753	

Load	Constrained Modulus, M'
kPa	MPa
25-50	2.7
50-100	6.0
100-200	12.4
200-400	20.1
400-800	24.6
800-1600	53.4
1600-3200	98.9

C_C= 0.09
C_R= 0.01
OCR= 4.6
σ'_p= 275 kPa
σ'_v= 60 kPa

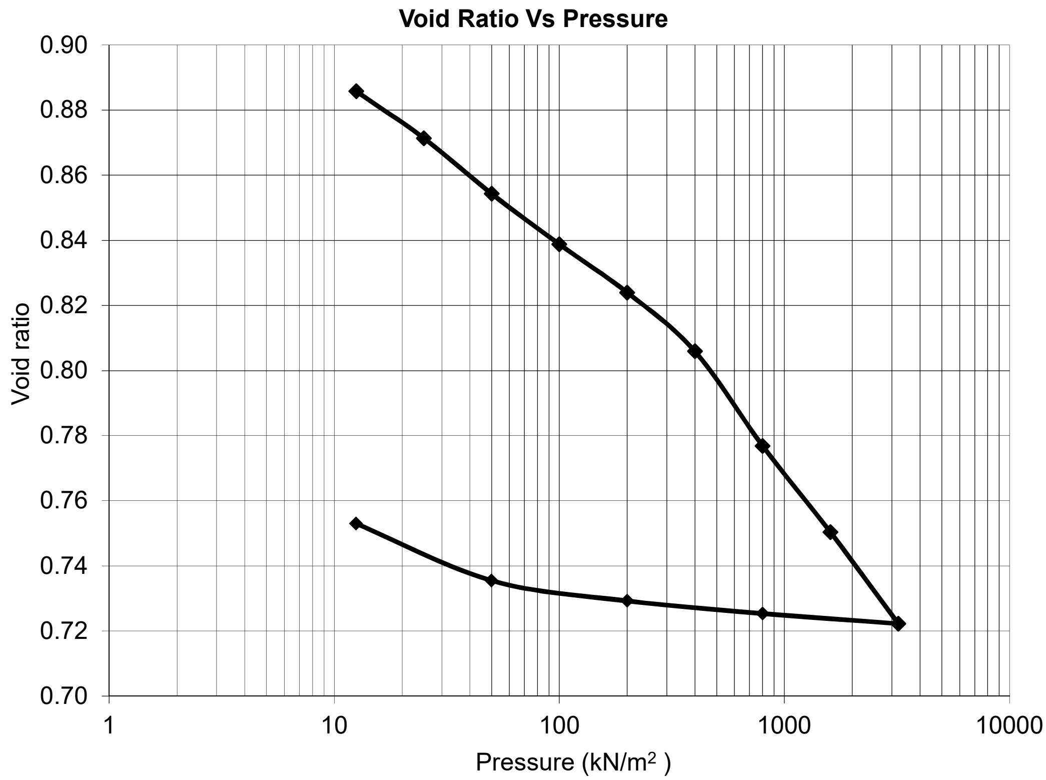
DownUnder Geotechnical Limited

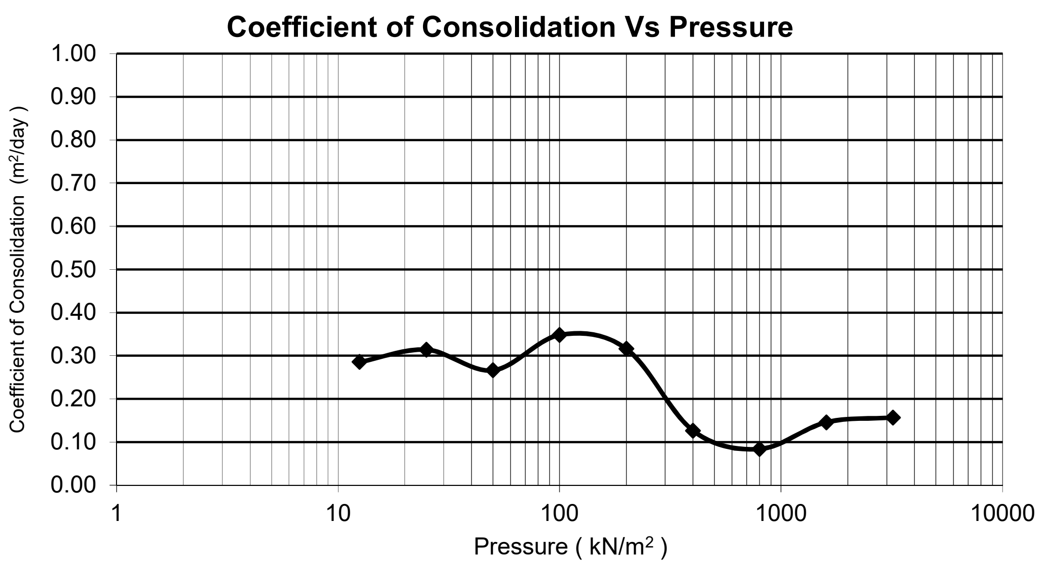
One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. DC-2A
Depth: 5.3m

Test Date: April 2017
Sample Description
brown SILTY CLAY





DownUnder Geotechnical Limited

One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. DS-5
Depth: 3.8m

Test Date: July 2017
Sample Description
brown SILTY CLAY, trace Gravel

Sample Parameters:

	Units	Initial	Final
Sample Diameter:	mm	50.0	50.0
Height of Sample:	mm	19.5	17.7
Wet Mass	g	71.0	68.6
Water Content	%	25.6	24.7
Bulk Density	kN/m^3	18.2	19.4
Dry Density	kN/m^3	13.5	14.6
Assumed Specific Gravity	-	2.72	2.72
Void Ratio	-	0.971	0.784
Degree of Saturation	-	71.7	85.7

Test Results

Load	$\sum\Delta H$	$\sum\Delta H/H_0$	$H=(H_0-\Delta H)$	Void Ratio	Cv
kPa	mm	%	mm	-	m^2/day
0	0	-	19.50		
12.5	0.01	0.0%	19.50	0.970	0.428
25	0.19	1.0%	19.31	0.952	0.345
50	0.38	2.0%	19.12	0.932	0.396
100	0.62	3.2%	18.88	0.908	0.376
200	0.94	4.8%	18.57	0.876	0.351
400	1.20	6.1%	18.30	0.849	0.330
800	1.51	7.7%	17.99	0.818	0.183
1600	1.78	9.1%	17.73	0.791	0.213
3200	2.07	10.6%	17.43	0.761	0.198
800	2.01	10.3%	17.49	0.767	
200	1.95	10.0%	17.55	0.774	
50	1.89	9.7%	17.61	0.780	
12.5	1.84	9.4%	17.66	0.784	

Load	Constrained Modulus, M'
kPa	MPa
25-50	2.5
50-100	4.0
100-200	6.0
200-400	14.0
400-800	23.4
800-1600	53.9
1600-3200	94.9

C_C= 0.10
C_R= 0.01
OCR= 2.0
σ'_p= 100 kPa
σ'_v= 50 kPa

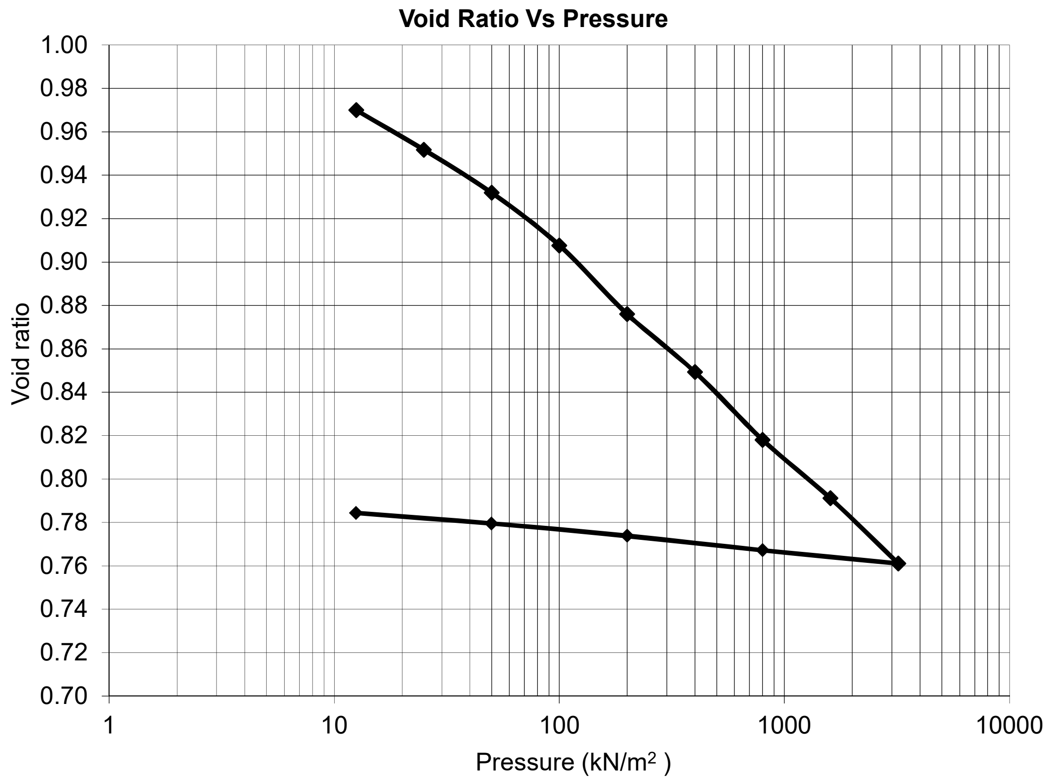
DownUnder Geotechnical Limited

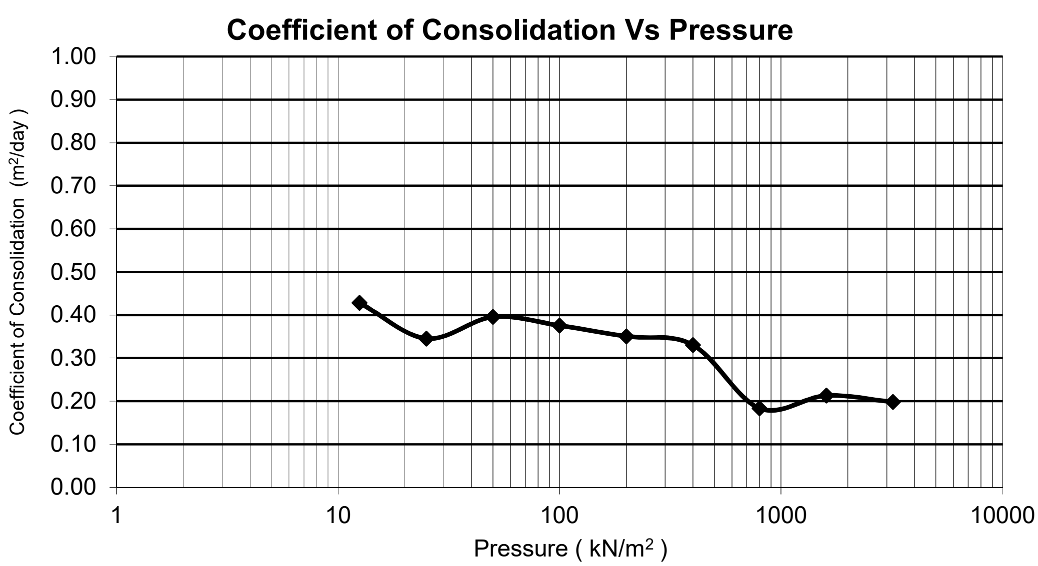
One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. DS-5
Depth: 3.8m

Test Date: July 2017
Sample Description
brown SILTY CLAY, trace Gravel





DownUnder Geotechnical Limited

One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. SP-1
Depth: 2.4m

Test Date: July 2017
Sample Description
brown SILTY CLAY

Sample Parameters:

	Units	Initial	Final
Sample Diameter:	mm	50.0	50.0
Height of Sample:	mm	19.5	18.1
Wet Mass	g	74.9	71.2
Water Content	%	31.0	21.8
Bulk Density	kN/m^3	19.2	19.7
Dry Density	kN/m^3	13.2	15.4
Assumed Specific Gravity	-	2.72	2.72
Void Ratio	-	1.014	0.866
Degree of Saturation	-	83.1	68.4

Test Results

Load	$\sum\Delta H$	$\sum\Delta H/H_0$	$H=(H_0-\Delta H)$	Void Ratio	Cv
kPa	mm	%	mm	-	m^2/day
0	0	-	19.50		
12.5	0.01	0.0%	19.49	1.013	0.447
25	0.09	0.5%	19.41	1.005	0.440
50	0.22	1.1%	19.29	0.992	0.428
100	0.31	1.6%	19.19	0.982	0.420
200	0.46	2.3%	19.04	0.967	0.407
400	0.63	3.2%	18.87	0.949	0.290
800	0.96	4.9%	18.54	0.915	0.189
1600	1.29	6.6%	18.21	0.881	0.133
3200	1.65	8.5%	17.85	0.844	0.230
800	1.58	8.1%	17.92	0.851	
200	1.50	7.7%	18.00	0.859	
50	1.46	7.5%	18.04	0.863	
12.5	1.43	7.3%	18.07	0.866	

Load	Constrained Modulus, M'
kPa	MPa
25-50	3.9
50-100	10.3
100-200	12.9
200-400	22.2
400-800	22.6
800-1600	44.2
1600-3200	79.3

C_C= 0.12
C_R= 0.01
OCR= 8.5
σ'_p= 340 kPa
σ'_v= 40 kPa

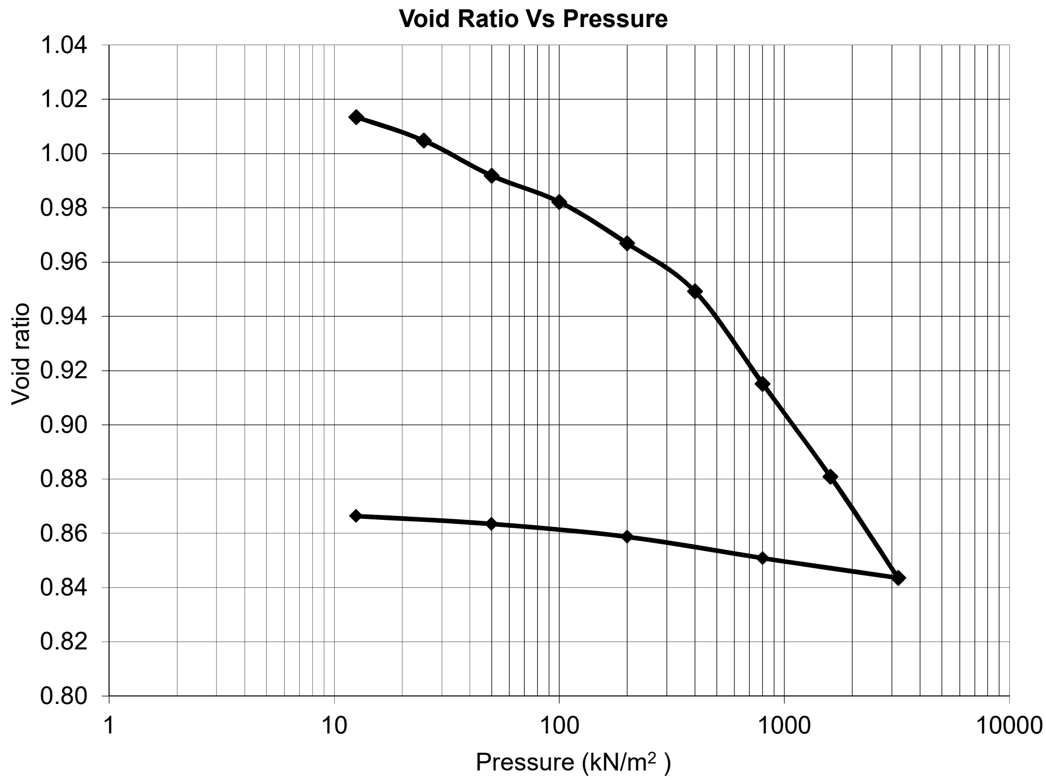
DownUnder Geotechnical Limited

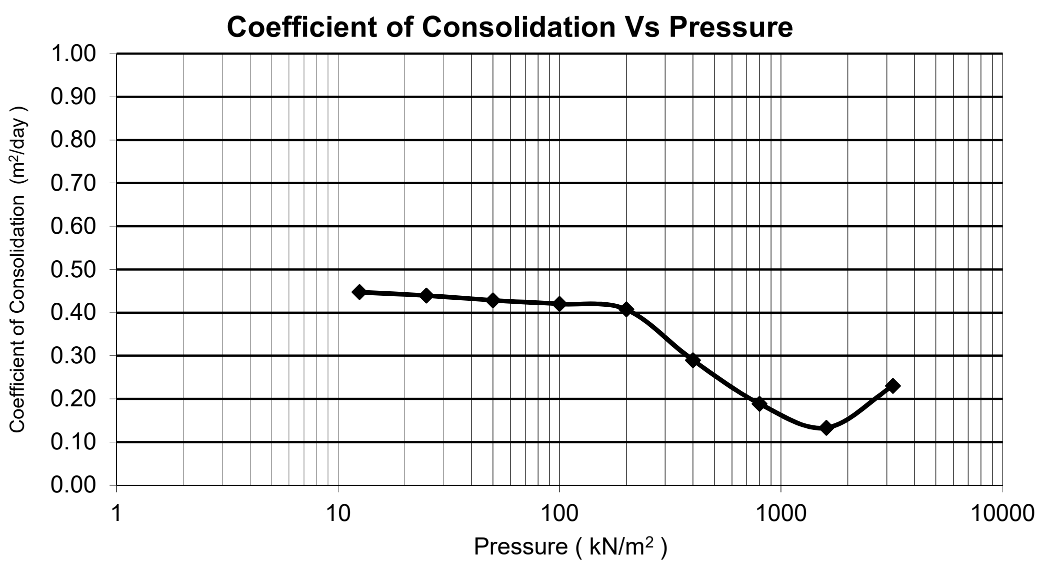
One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. SP-1
Depth: 2.4m

Test Date: July 2017
Sample Description
brown SILTY CLAY





DownUnder Geotechnical Limited

One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. US-4
Depth: 2.4m

Test Date: April 2017
Sample Description
brown SILTY CLAY

Sample Parameters:

	Units	Initial	Final
Sample Diameter:	mm	50.0	50.0
Height of Sample:	mm	19.5	17.5
Wet Mass	g	80.3	87.1
Water Content	%	27.4	18.6
Bulk Density	kN/m^3	20.6	24.9
Dry Density	kN/m^3	14.9	20.2
Assumed Specific Gravity	-	2.72	2.72
Void Ratio	-	0.785	0.603
Degree of Saturation	-	94.9	83.9

Test Results

Load	$\sum\Delta H$	$\sum\Delta H/H_0$	$H=(H_0-\Delta H)$	Void Ratio	Cv
kPa	mm	%	mm	-	m^2/day
0	0	-	19.50		
12.5	0.02	0.1%	19.48	0.784	0.428
25	0.21	1.1%	19.29	0.766	0.380
50	0.37	1.9%	19.13	0.752	0.396
100	0.43	2.2%	19.07	0.746	0.287
200	0.53	2.7%	18.97	0.737	0.143
400	0.79	4.0%	18.71	0.713	0.028
800	1.32	6.8%	18.18	0.665	0.024
1600	1.73	8.9%	17.77	0.627	0.032
3200	2.15	11.0%	17.35	0.589	0.028
800	2.13	10.9%	17.37	0.590	
200	2.11	10.8%	17.39	0.592	
50	2.03	10.4%	17.47	0.599	
12.5	1.99	10.2%	17.51	0.603	

Load	Constrained Modulus, M'
kPa	MPa
25-50	3.0
50-100	14.4
100-200	20.4
200-400	14.4
400-800	13.9
800-1600	34.6
1600-3200	68.0

C_C= 0.14
C_R= 0.01
OCR= 5.3
σ'_p= 210 kPa
σ'_v= 40 kPa

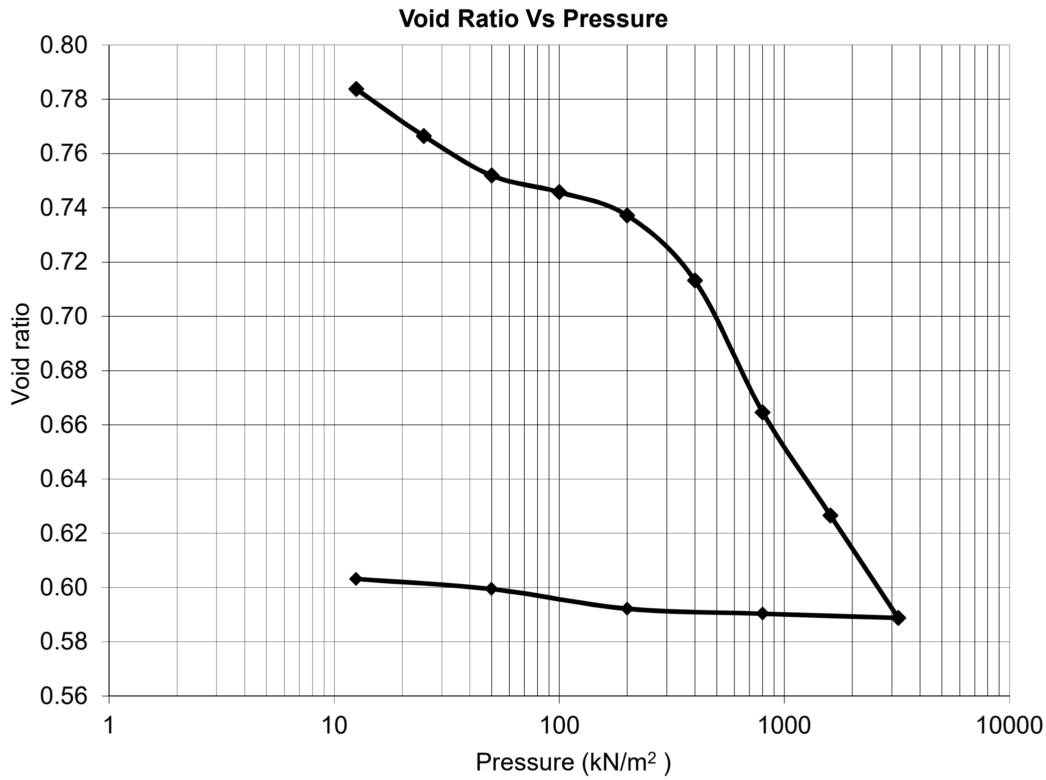
DownUnder Geotechnical Limited

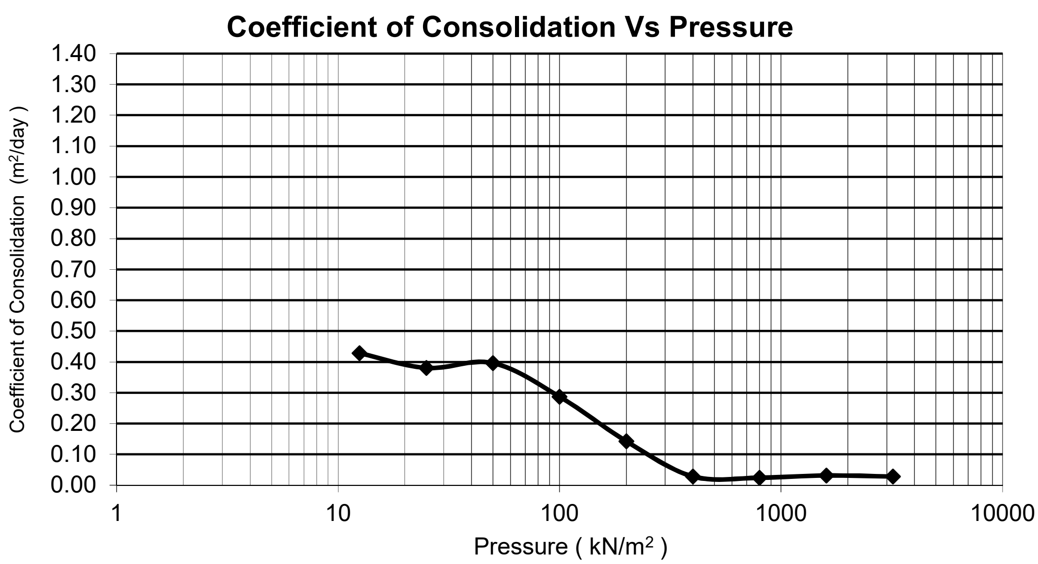
One Dimensional Consolidation Test
ASTM 2435-11

Downunder Geotechnical Project No:D17105A
Project: Dam at Lock 38, Trent Severn Waterway

Borehole No. US-4
Depth: 2.4m

Test Date: April 2017
Sample Description
brown SILTY CLAY





DownUnder Geotechnical Limited

APPENDIX D

OBTAINING AND TESTING DRILLED CORES FOR COMPRESSIVE STRENGTH TEST
(CSA A23.2-14C)

May 8, 2017

Golder Project Number: 1775914-1000

DownUnder Geotechnical Limited
P.O. Box 96737, Jane/Major Mackenzie Drive
Maple, ON L6A 0A2

ATTENTION: Mr. Andrew Drevininkas, P.Eng

Project:	**Dam at Lock 38, Trent Severn Waterway, Ref No. D17105A**

Date Cast: Not Available
Date Tested: May 8, 2017

Date Received: May 2, 2017
Tested By: J. Allen

Core ID:	**Borehole V-3**	**Borehole V-4**
Depth:	5.2 to 5.3m	6.4 to 6.5 m
Golder Lab Number:	C-17-0353	C-17-0354
Moisture Condition at Time of Test	Moist	Moist
Capping Material	Grinder	Grinder
Average Diameter, (mm)	47	47
Average Length (mm)	94	94
Density, (Mg/m^3)	2.345	2.423
Load, (kN)	45.76	41.67
Compressive Strength, (MPa)	26.4	24.0
Corrected Compressive Strength, (MPa)	**26.4**	**24.0**
Type of Fracture	1	1
Remarks:		

Reviewed by: ______________________
Jeremy Rose, Laboratory Manager

CCIL
The Voice Of Independent Canadian Laboratories
La voix des laboratoires indépendants canadiens

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

OBTAINING AND TESTING DRILLED CORES FOR COMPRESSIVE STRENGTH TEST
(CSA A23.2-14C)

May 8, 2017

Golder Project Number: 1775914-1000

DownUnder Geotechnical Limited
P.O. Box 96737, Jane/Major Mackenzie Drive
Maple, ON L6A 0A2

ATTENTION: Mr. Andrew Drevininkas, P.Eng

Project:	**Dam at Lock 38, Trent Severn Waterway, Ref No. D17105A**

Date Cast: Not Available
Date Tested: May 8, 2017

Date Received: May 2, 2017
Tested By: J. Allen

Core ID:	**Borehole V-2**	**Borehole V-5**
Depth:	6.3 to 6.4m	2.5 to 2.7m
Golder Lab Number:	C-17-0355	C-17-0356
Moisture Condition at Time of Test	Moist	Moist
Capping Material	Grinder	Grinder
Average Diameter, (mm)	47	47
Average Length (mm)	94	94
Density, (Mg/m^3)	2.227	2.353
Load, (kN)	10.94	71.16
Compressive Strength, (MPa)	6.3	41.0
Corrected Compressive Strength, (MPa)	**6.3**	**41.0**
Type of Fracture	1	1
Remarks:		

Reviewed by: ______________________
Jeremy Rose, Laboratory Manager

OBTAINING AND TESTING DRILLED CORES FOR COMPRESSIVE STRENGTH TEST
(CSA A23.2-14C)

May 8, 2017

Golder Project Number: 1775914-1000

DownUnder Geotechnical Limited
P.O. Box 96737, Jane/Major Mackenzie Drive
Maple, ON L6A 0A2

ATTENTION: Mr. Andrew Drevininkas, P.Eng

Project:	**Dam at Lock 38, Trent Severn Waterway, Ref No. D17105A**

Date Cast: Not Available
Date Tested: May 8, 2017

Date Received: May 2, 2017
Tested By: J. Allen

Core ID:	**Borehole V-2**	**Borehole V-2**
Depth:	5.2 to 5.4m	7.7 to 7.9m
Golder Lab Number:	C-17-0357	C-17-0358
Moisture Condition at Time of Test	Moist	Moist
Capping Material	Grinder	Grinder
Average Diameter, (mm)	47	48
Average Length (mm)	94	96
Density, (Mg/m^3)	2.226	2.318
Load, (kN)	30.13	18.95
Compressive Strength, (MPa)	17.4	10.5
Corrected Compressive Strength, (MPa)	**17.4**	**10.5**
Type of Fracture	1	1
Remarks:		

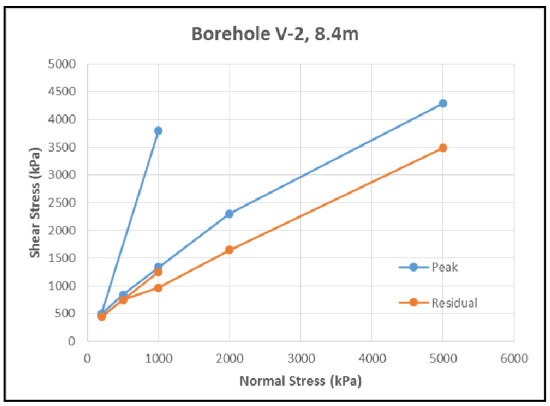
Reviewed by: ______________________
Jeremy Rose, Laboratory Manager

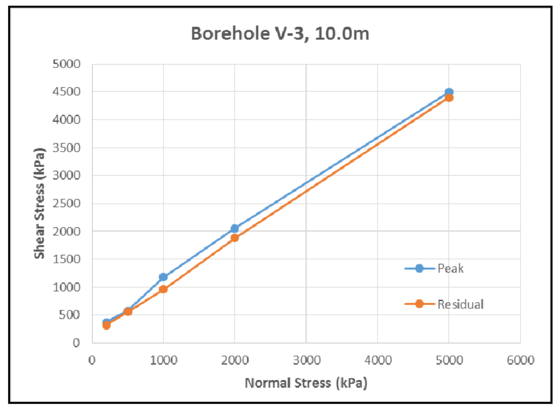
Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

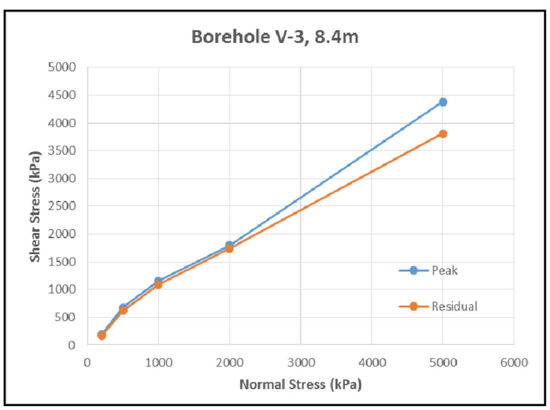
APPENDIX E

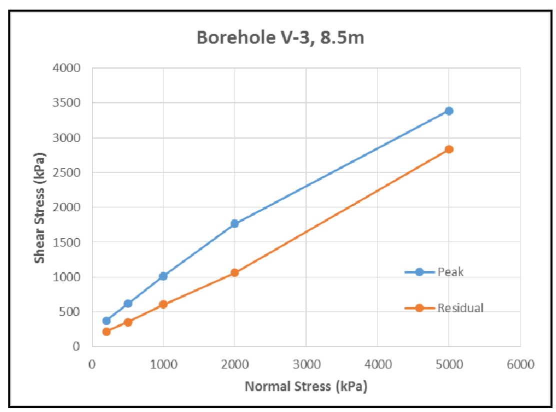
DIRECT SHEAR TEST RESULTS SUMMARY

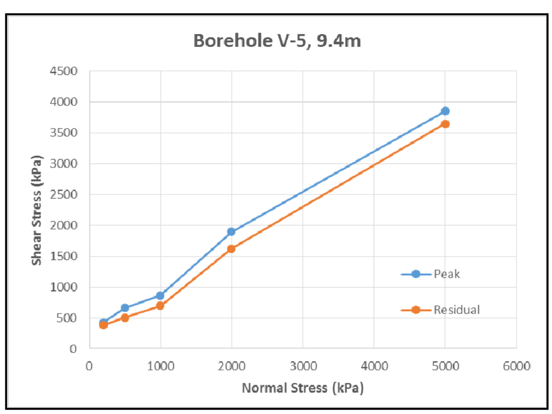
Borehole No.	Depth (m)	Peak		Residual	
		Φ’	c’	Φ’	c’
V-2	8.4	36.4^{0}	723 kPa	32.2^{0}	362 kPa
V-3	8.4	32.7^{0}	75 kPa	33.1^{0}	362 kPa
V-3	8.5	30.7^{0}	508 kPa	29.1^{0}	0 kPa
V-3	10.0	39.7^{0}	376 kPa	40.7^{0}	136kPa
V-5	9.4	36.8^{0}	272 kPa	36.5^{0}	57 kPa











UNCONFINED COMPRESSIVE STRENGTH

ROCK CORES

Borehole #	Depth (m)	Diameter (mm)	Density (kg/m^3)	UCS (MPa)	Comments
V-2	9.1 to 9.2	47	2690	94.0	Brittle failure partially along shaley plane.
V-2	10.0 to 10.1	47	2660	42.7	Broke partially along shaley plane.
V-3	9.0 to 9.1	47	2677	60.6	Broke partially along shaley plane.
V-4	9.2 to 9.3	47	2687	82.0	Broke through intact rock.
V-4	9.6 to 9.7	47	2687	112.8	Broke through intact rock.
V-4	10.6 to 10.7	47	2693	143.7	Brittle failure through intact rock.
V-5	9.7 to 9.8	47	2681	58.3	Broke partially along shaley plane.
DS-2	1.7 to 1.8	49	2689	77..0	Broke partially along shaley plane.
US-1	7.0 to 7.1	50	2696	110.7	Brittle failure through intact rock.
US-4	5.4 to 5.5	49	2683	68.3	Broke partially along shaley plane.

09 May 2017
File: TB172011

DownUnder Geotechnical Limited
P.O. Box 96737, Jane/Major Mackenzie P.O.
2943 Major Mackenzie Drive
Maple, Ontario
L6A 0A2

Attention: Mr. Andrew Drevininkas, P.Eng.

Re: LABORATORY TESTING OF ROCK AND CONCRETE CORE – D17105A

This report summarizes laboratory testing conducted by Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler), on rock and concrete core samples received in Amec Foster Wheeler's Hamilton, Ontario rock mechanics laboratory. The test results reported here include unconfined compressive strength and direct shear strength.

A total of fifteen (15) test specimens were prepared and tested from fifteen (15) core samples received in the Amec Foster Wheeler laboratory. Core samples were NQ and NQ2 drill sizes, nominally 47.6mm and 50.5mm diameter, respectively. Testing was conducted in accordance with ASTM D5607, "Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force" and ASTM D7012, "Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures". Summary tables of the test results are attached as are the pre-test and post-test photographs.

In the results of some direct shear samples, a well-defined peak and residual shear stress was difficult to determine as the peak and residual stresses tended to rise and fall throughout the test. This could be caused by factors such as a build-up of joint material, undulations within the joint plane and inconsistencies in the nature of joint face asperities at various displacements. As such, the selection of the peak and residual shear stress is subject to interpretation. The displacement/shear stress plots are included in the report attachments and all raw data will be provided to aid in analysis should alternative peak and residual stress values be selected.

When performing the direct shear tests, the normal load was maintained at a constant value for the first 1mm of shear displacement. As maintenance of the normal load at a constant value at high displacement will result in an increase in normal pressure due to decreasing contact area in the joint, the normal force was reduced gradually as a function of shear displacement to maintain a constant normal pressure throughout the remaining shear displacement. This procedure acts to prevent unnecessary joint plane damage at increased shear displacement that would be unrepresentative of typical joint plane damage at the designated normal pressure.

Amec Foster Wheeler Environment & Infrastructure
A Division of Amec Foster Wheeler Americas
505 Woodward Avenue, Unit #1
Hamilton, Ontario L8H 6N6
Tel +1 905 312-0700
Fax +1 905 312-0771
www.amecfw.com

The attached core data summary spreadsheet contains a comments column with a description of the failure mode for each specimen. A mention of "brittle failure" indicates that the specimen failed suddenly and completely with a rapid release of stored energy while "broke" means that the failure was gradual or occurred as a staged event. The phrase "through intact rock" indicates that no portion of the main failure plane contained any pre-existing planes of weakness (veins, healed joints, foliation planes, etc.), "partially along healed joint" or "partially along foliation plane" indicates that at least a portion of the dominant failure plane formed along a pre-existing plane of weakness and any description that mentions "along healed joint" or "along foliation plane" indicates that the dominant failure plane fell mostly or exclusively along a pre-existing plane of weakness.

It should be noted that the deviation of edge straightness for UCS specimens R7609 and R7611 exceeded the maximum allowable by the test method of 0.5mm due to defects in the core introduced during coring operations. Additionally, UCS specimen R7605 failed along a shale layer during cutting and was tested with a length to diameter ratio of 1.98, slightly less than the minimum guideline of 2.00.

Direct shear specimen R7616 was comprised of an intact rock/concrete interface. To prevent failure through flexion or torsion when shear force was applied, specimen R7616 required a normal pressure of 1000kPa to initiate shear failure without associated flexion or torsion. R7616 failed through the concrete mass rather than along the rock/concrete interface, however the induced shear plane was observed to be suitable for additional shearing and was tested at all normal pressures. All direct shear specimens for this project had a joint surface area smaller than the minimum of 1900mm^2 recommended in ASTM D5607.

We trust that this information meets your current requirements. If you would like to discuss any portion of the above, please contact this office at your convenience.

Respectfully Submitted,

AMEC FOSTER WHEELER ENVIRONMENT & INFRASTRUCTURE
A DIVISION OF AMEC FOSTER WHEELER AMERICAS LIMITED

Kellen Shenton, P.Geo.
Project Geoscientist

Reviewed by,

Barry Shenton

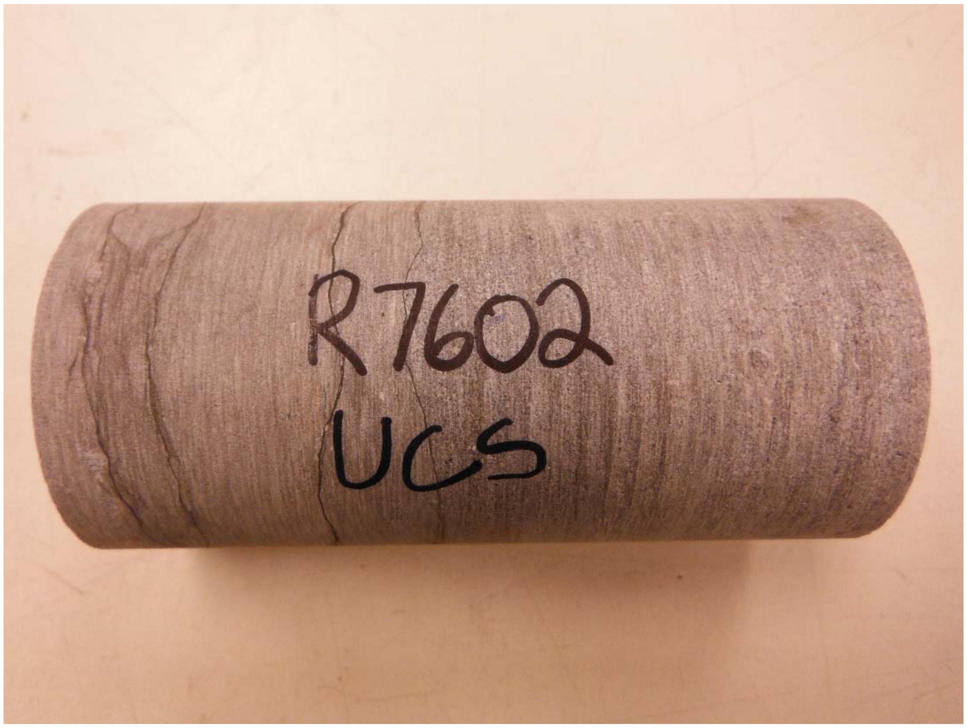
Barry Shenton
Senior Materials Technologist

Sample #	Test	Borehole #	Depth from	Depth to	Length	Diameter	L/D	Mass	**Density**	load	**Sigma 1**	Comments
			(m)	(m)	(mm)	(mm)		(g)	**(kg/m^3)**	(kN)	**(MPa)**	
R7602	UCS	V-4	10.61	10.71	99.48	47.24	2.11	469.5	**2693**	251.9	**143.7**	Brittle failure through intact rock.
R7603	UCS	V-4	9.19	9.29	99.15	47.18	2.10	465.7	**2687**	143.3	**82.0**	Broke through intact rock.
R7604	UCS	V-2	9.09	9.19	99.48	47.23	2.11	468.9	**2690**	164.7	**94.0**	Brittle failure partially along shaley plane.
R7605	UCS	V-3	9.00	9.10	93.35	47.21	1.98	437.5	**2677**	106.1	**60.6**	Broke partially along shaley plane.
R7606	UCS	V-4	9.61	9.71	99.28	47.23	2.10	467.4	**2687**	197.7	**112.8**	Broke through intact rock.
R7607	UCS	V-5	9.71	9.81	99.53	47.11	2.11	465.2	**2681**	101.7	**58.3**	Broke partially along shaley plane.
R7608	UCS	V-2	10.00	10.10	99.41	47.24	2.10	463.5	**2660**	74.9	**42.7**	Broke partially along shaley plane.
R7609	UCS	DS-2	1.70	1.80	100.30	49.11	2.04	510.9	**2689**	145.8	**77.0**	Broke partially along shaley plane.
R7610	UCS	US-4	5.42	5.52	99.76	49.15	2.03	507.9	**2683**	129.5	**68.3**	Broke partially along shaley plane.
R7611	UCS	US-1	7.04	7.14	99.94	49.71	2.01	522.9	**2696**	214.9	**110.7**	Brittle failure through intact rock.
R7612	DS	V-3	10.00									
R7613	DS	V-3	8.50									
R7614	DS	V-5	9.40									
R7615	DS	V-3	8.40									
R7616	DS	V-2	8.40									

TB172011 - DownUnder Geotechnical Limited						
Laboratory ID	R7612	Area (mm^2)	1743			
Borehole ID	V-3	Stage	Normal stress (kPa)	Initial Normal Load (kN)	Peak Shear Stress (kPa)	Residual Shear Stress (kPa)
Depth (m)	10.00	1	200	0.35	373	323
Major Axis (mm)	47.23	2	500	0.87	582	561
Minor Axis (mm)	46.98	3	1000	1.74	1178	962
		4	2000	3.49	2058	1882
		5	5000	8.71	4495	4397
Laboratory ID	R7613	Area (mm^2)	1811			
Borehole ID	V-3	Stage	Normal stress (kPa)	Initial Normal Load (kN)	Peak Shear Stress (kPa)	Residual Shear Stress (kPa)
Depth (m)	8.50	1	200	0.36	374	216
Major Axis (mm)	48.77	2	500	0.91	617	353
Minor Axis (mm)	47.27	3	1000	1.81	1018	605
		4	2000	3.62	1765	1060
		5	5000	9.05	3389	2833
Laboratory ID	R7614	Area (mm^2)	1659			
Borehole ID	V-5	Stage	Normal stress (kPa)	Initial Normal Load (kN)	Peak Shear Stress (kPa)	Residual Shear Stress (kPa)
Depth (m)	9.40	1	200	0.33	423	384
Major Axis (mm)	46.37	2	500	0.83	662	502
Minor Axis (mm)	45.56	3	1000	1.66	864	696
		4	2000	3.32	1899	1620
		5	5000	8.30	3853	3651
Laboratory ID	R7615	Area (mm^2)	1740			
Borehole ID	V-3	Stage	Normal stress (kPa)	Initial Normal Load (kN)	Peak Shear Stress (kPa)	Residual Shear Stress (kPa)
Depth (m)	8.40	1	200	0.35	188	168
Major Axis (mm)	47.05	2	500	0.87	679	617
Minor Axis (mm)	47.10	3	1000	1.74	1154	1089
		4	2000	3.48	1796	1741
		5	5000	8.70	4378	3809

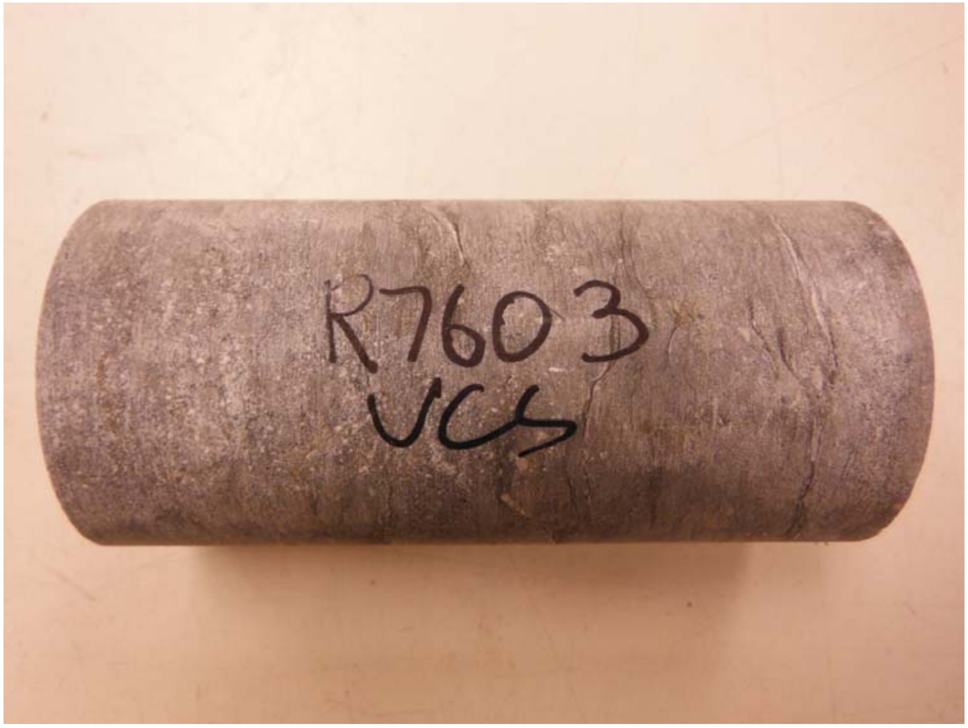
TB172011 - DownUnder Geotechnical Limited						
Laboratory ID	R7616	Area (mm^2)	1762			
Borehole ID	V-2	Stage	Normal stress (kPa)	Initial Normal Load (kN)	Peak Shear Stress (kPa)	Residual Shear Stress (kPa)
Depth (m)	8.40	1	1000	1.76	3801	1250
Major Axis (mm)	47.59	2	200	0.35	496	445
Minor Axis (mm)	47.13	3	500	0.88	839	746
		4	1000	1.76	1339	965
		5	2000	3.52	2301	1647
		6	5000	8.81	4288	3487

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-4	**Ref. No.:** D17105A
Depth: 10.61m – 10.71m	**Lab #:** R7602

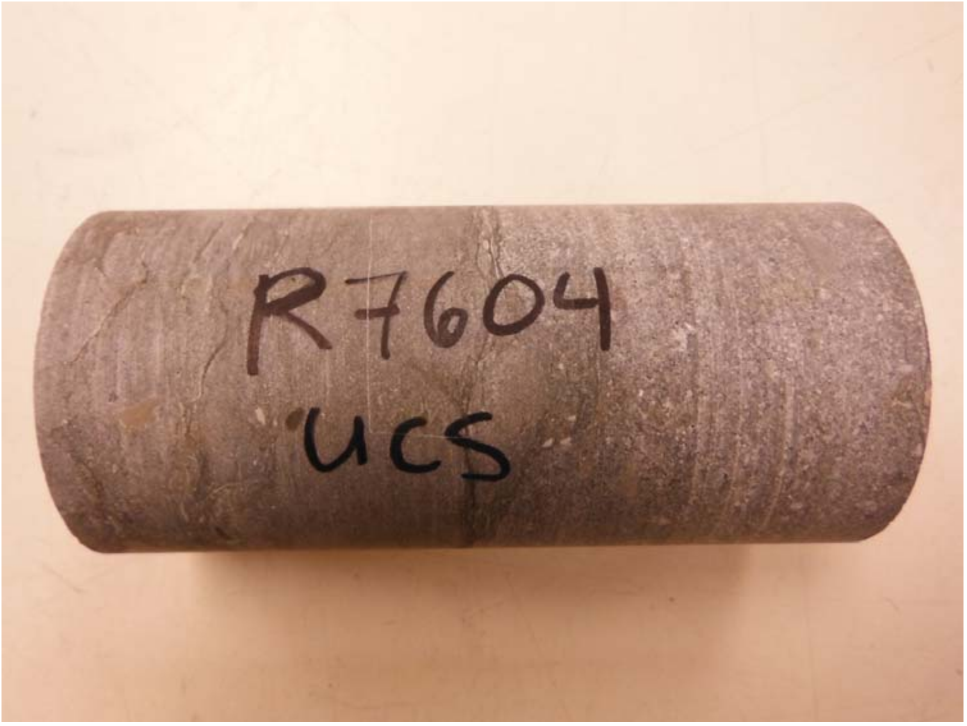


Amec Foster Wheeler Environment & Infrastructure
Hamilton Rock Mechanics Laboratory

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-4	**Ref. No.:** D17105A
Depth: 9.19m – 9.29m	**Lab #:** R7603



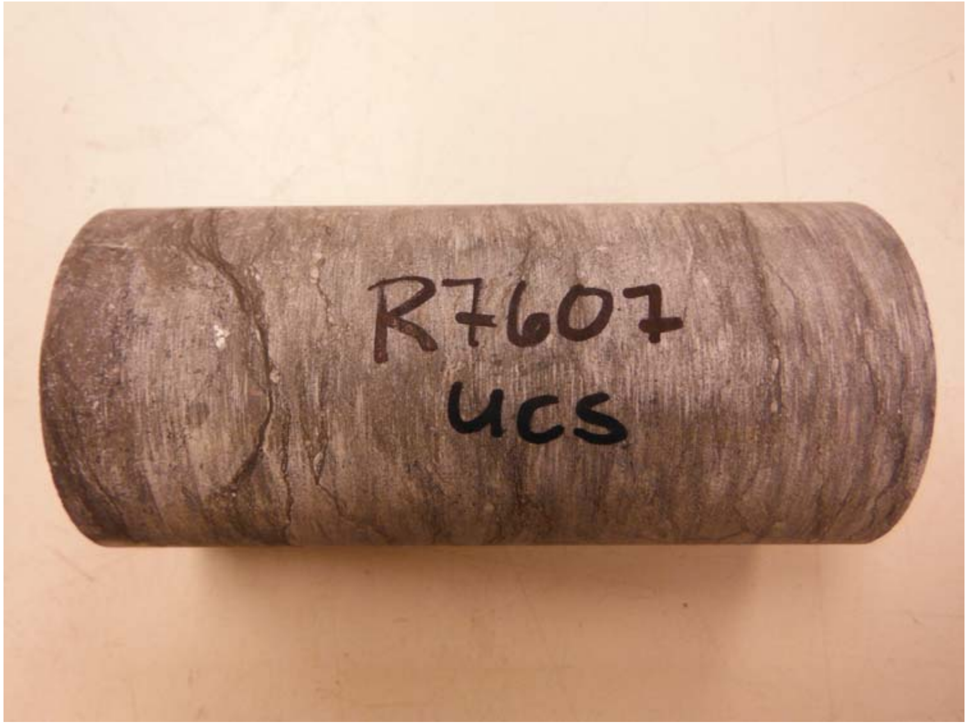
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-2	**Ref. No.:** D17105A
Depth: 9.09m – 9.19m	**Lab #:** R7604



Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 9.00m – 9.10m	**Lab #:** R7605

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-4	**Ref. No.:** D17105A
Depth: 9.61m – 9.71m	**Lab #:** R7606

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-5	**Ref. No.:** D17105A
Depth: 9.71m – 9.81m	**Lab #:** R7607



Amec Foster Wheeler Environment & Infrastructure
Hamilton Rock Mechanics Laboratory

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-2	**Ref. No.:** D17105A
Depth: 10.00m – 10.10m	**Lab #:** R7608

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Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: DS-2	**Ref. No.:** D17105A
Depth: 1.70m – 1.80m	**Lab #:** R7609

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: US-4	**Ref. No.:** D17105A
Depth: 5.42m – 5.52m	**Lab #:** R7610

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: US-1	**Ref. No.:** D17105A
Depth: 7.04m – 7.14m	**Lab #:** R7611

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Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 10.00m	**Lab #:** R7612

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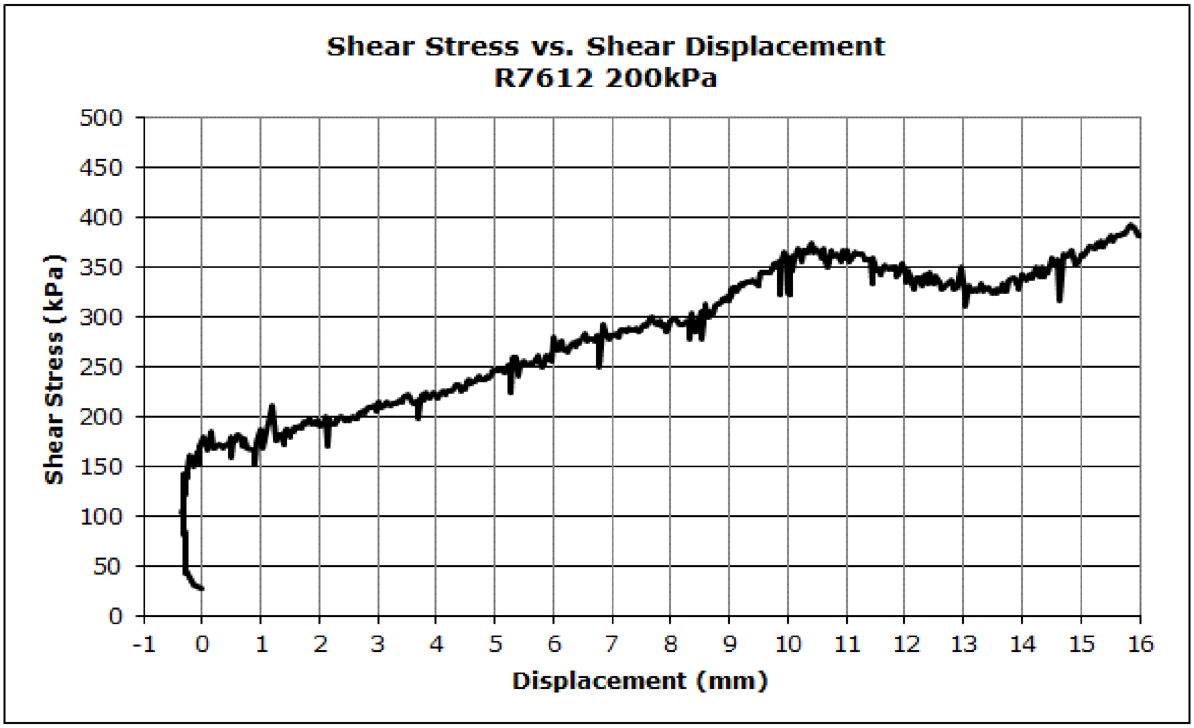
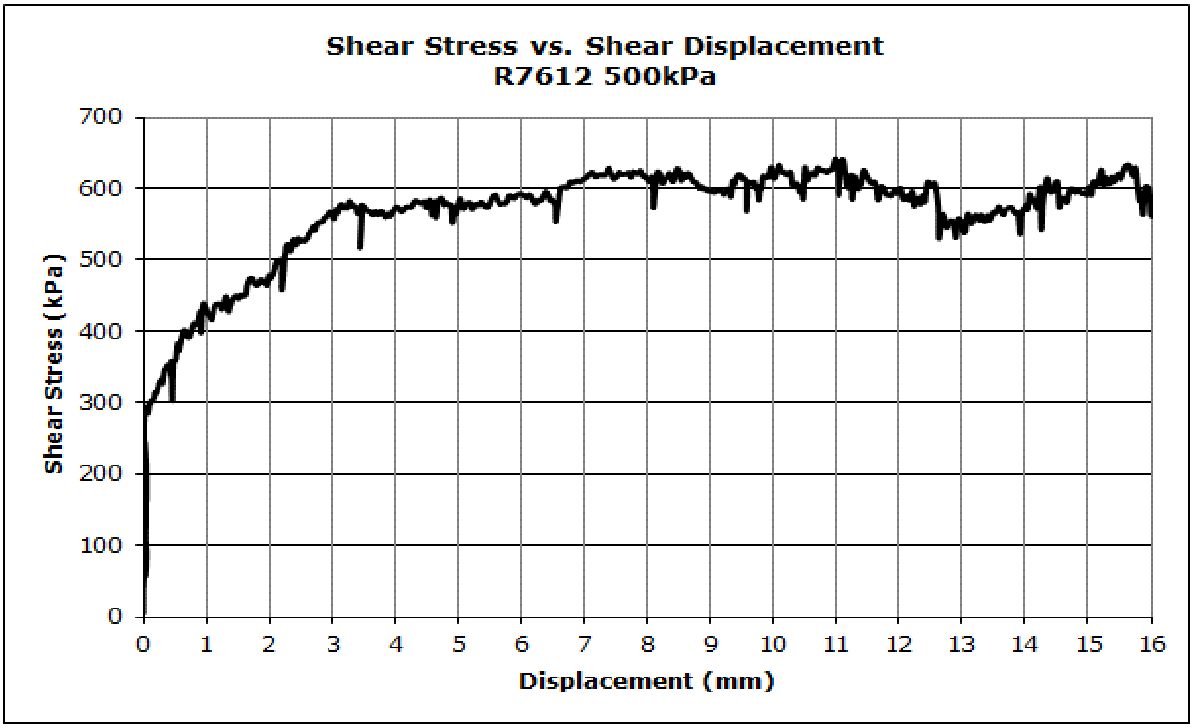
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 10.00m	**Lab #:** R7612

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 10.00m	**Lab #:** R7612





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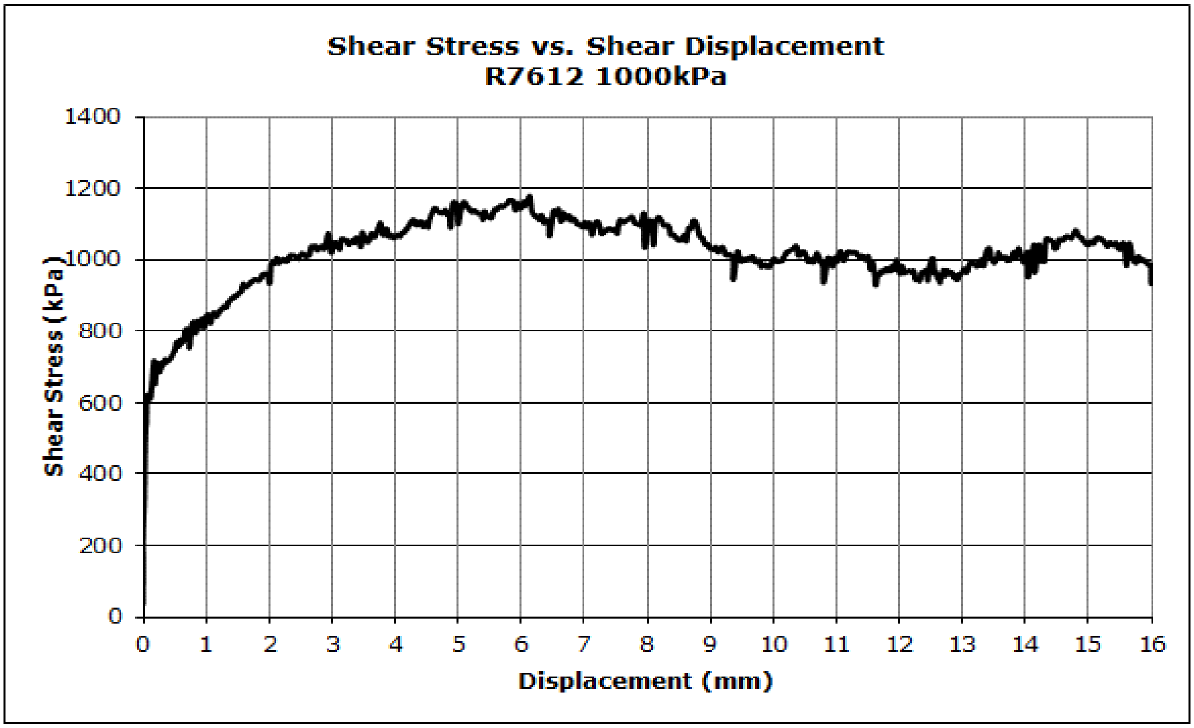
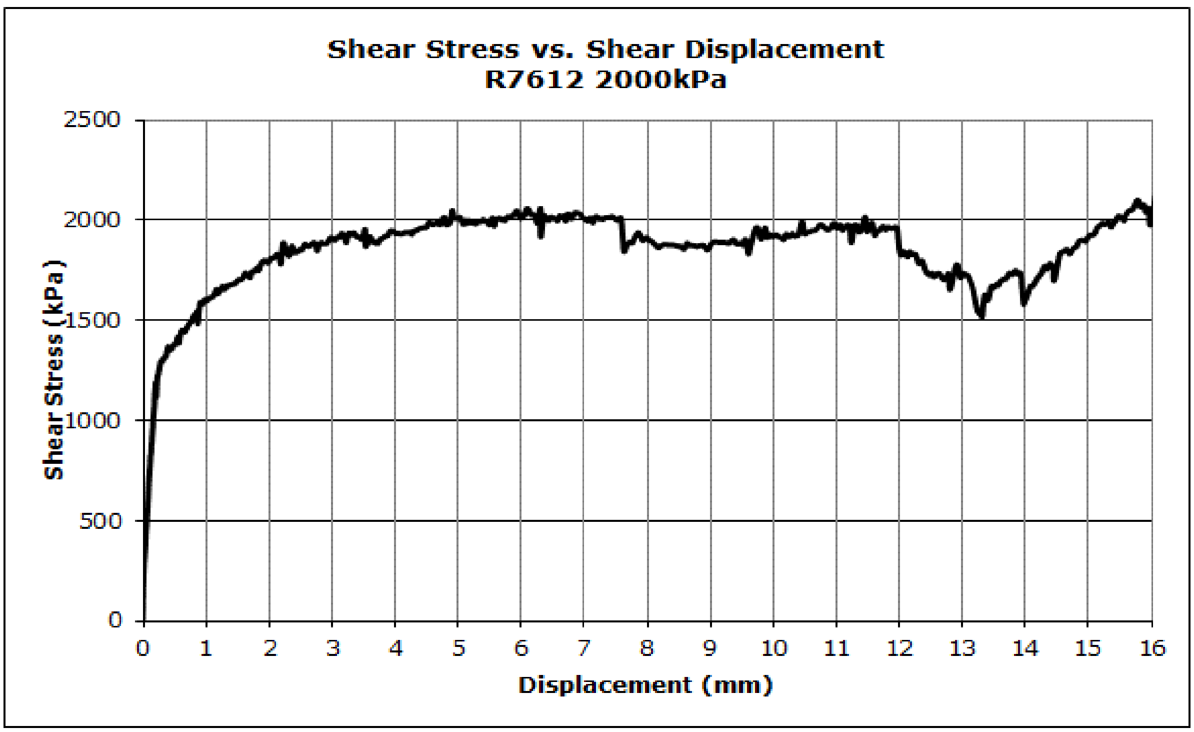
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 10.00m	**Lab #:** R7612





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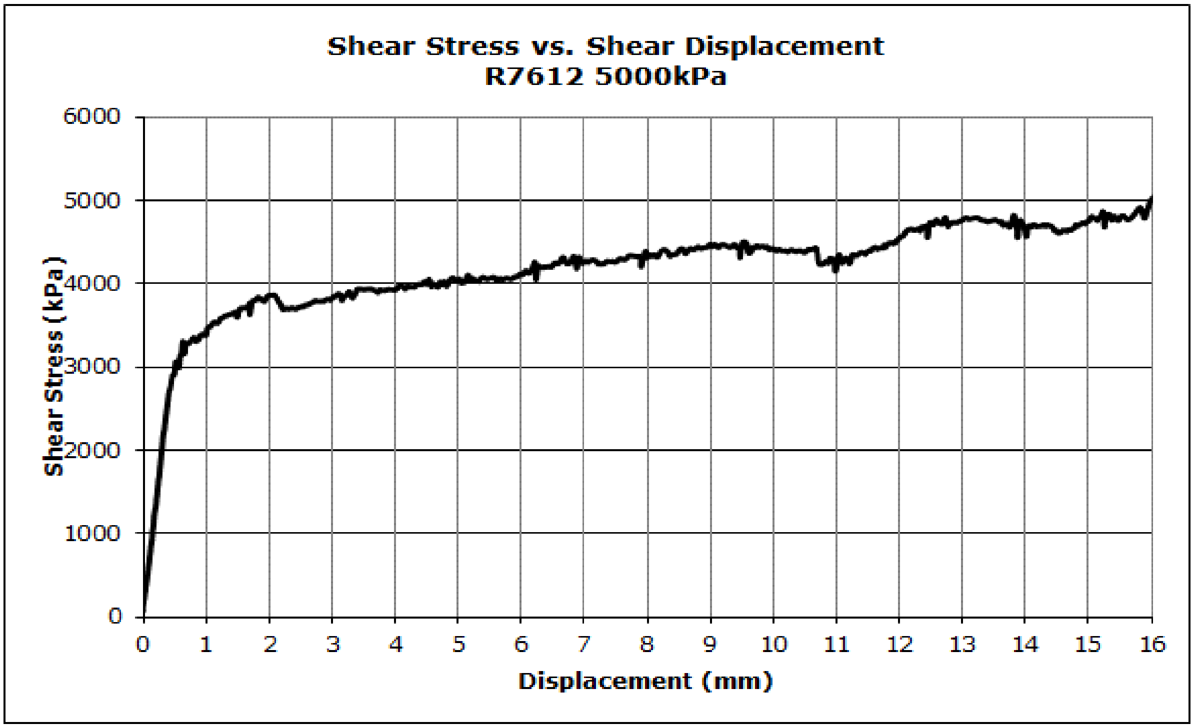
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 10.00m	**Lab #:** R7612



Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.50m	**Lab #:** R7613

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Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.50m	**Lab #:** R7613

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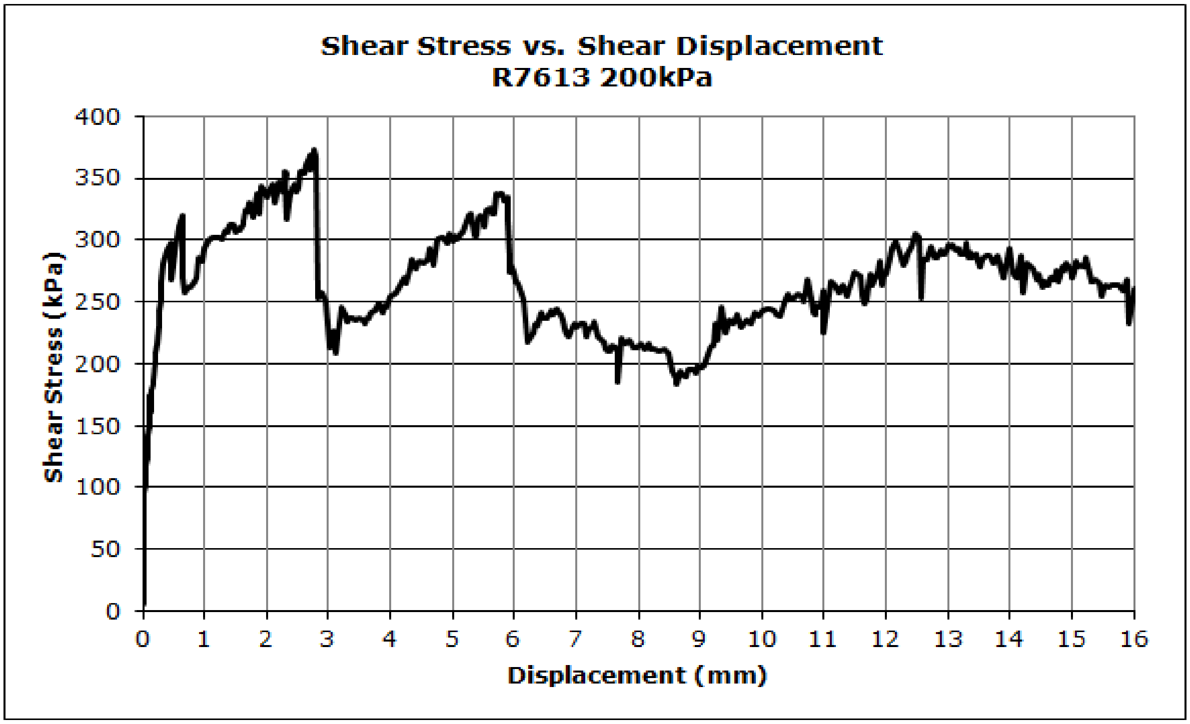
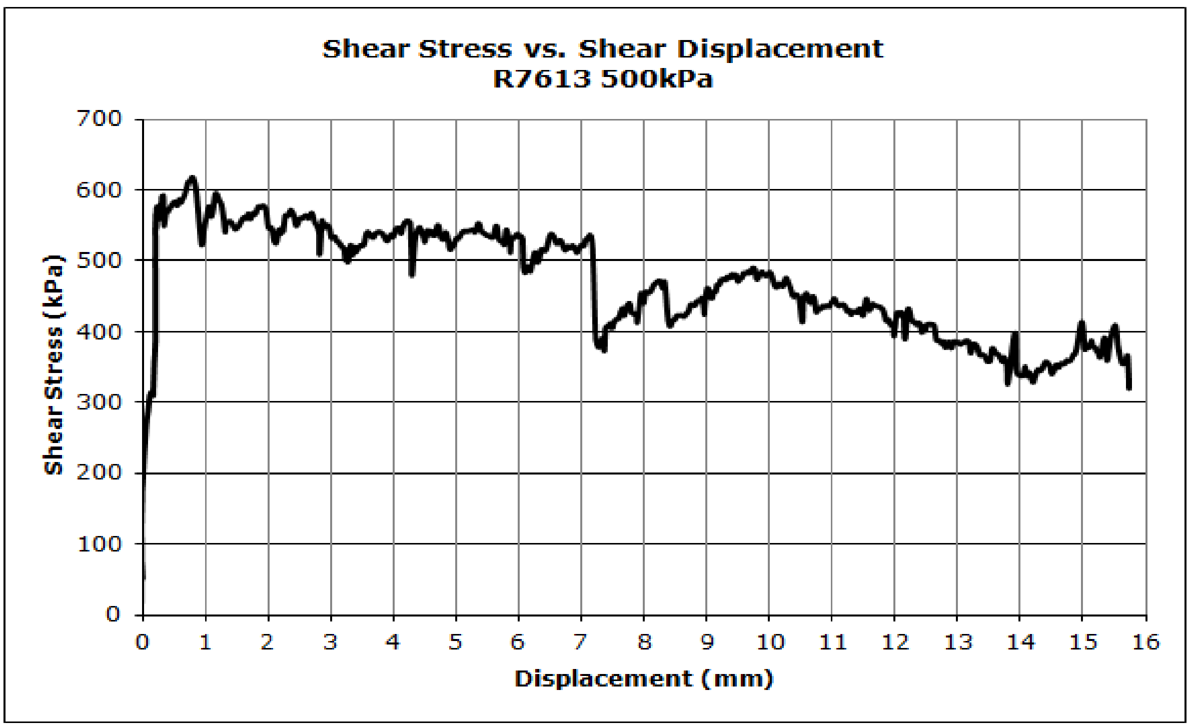
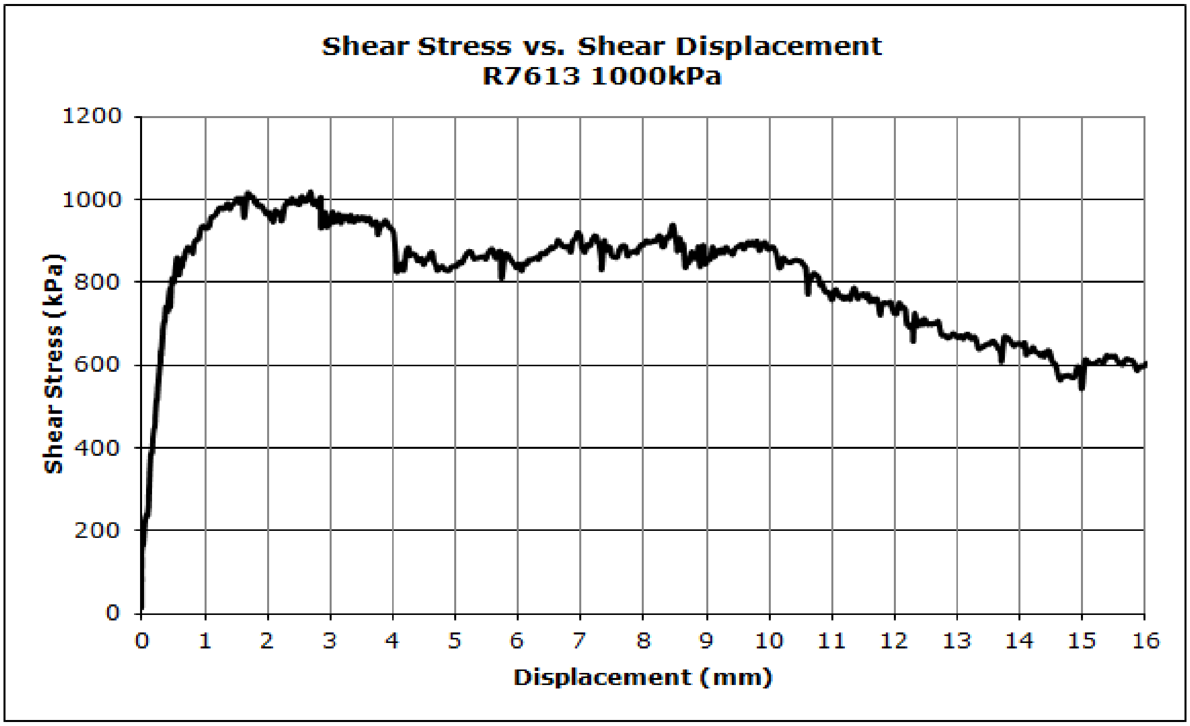
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.50m	**Lab #:** R7613

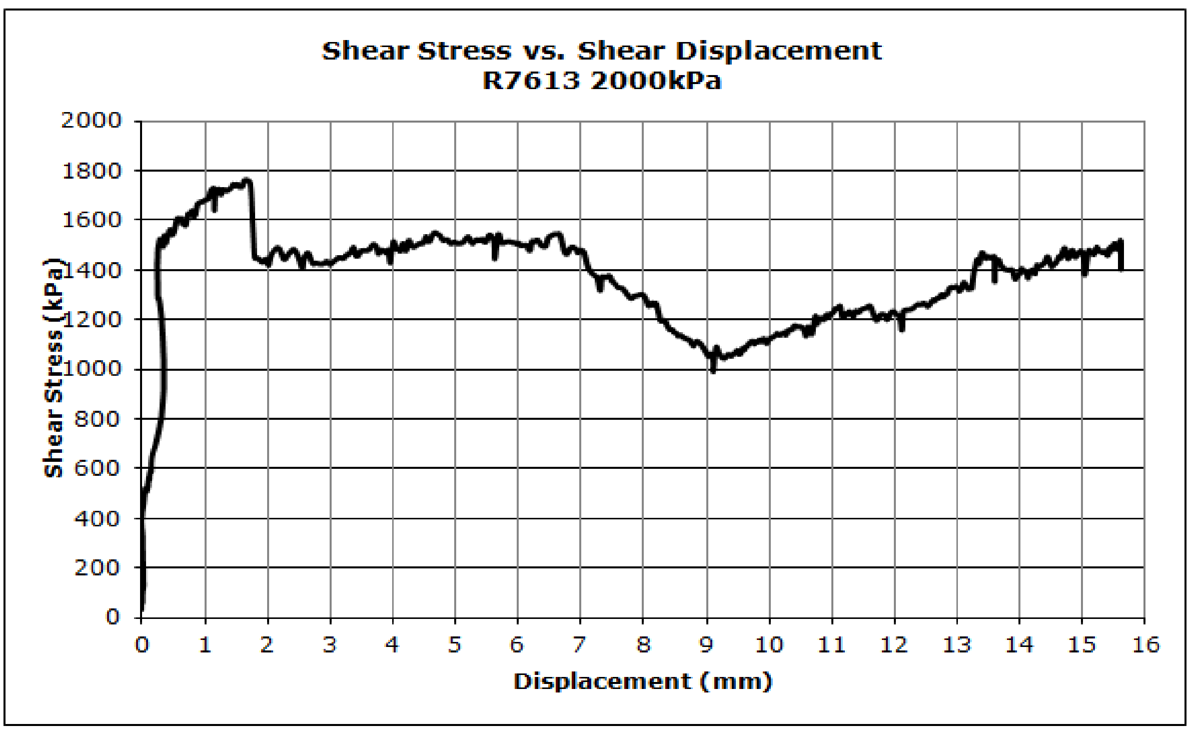




Amec Foster Wheeler Environment & Infrastructure
Hamilton Rock Mechanics Laboratory

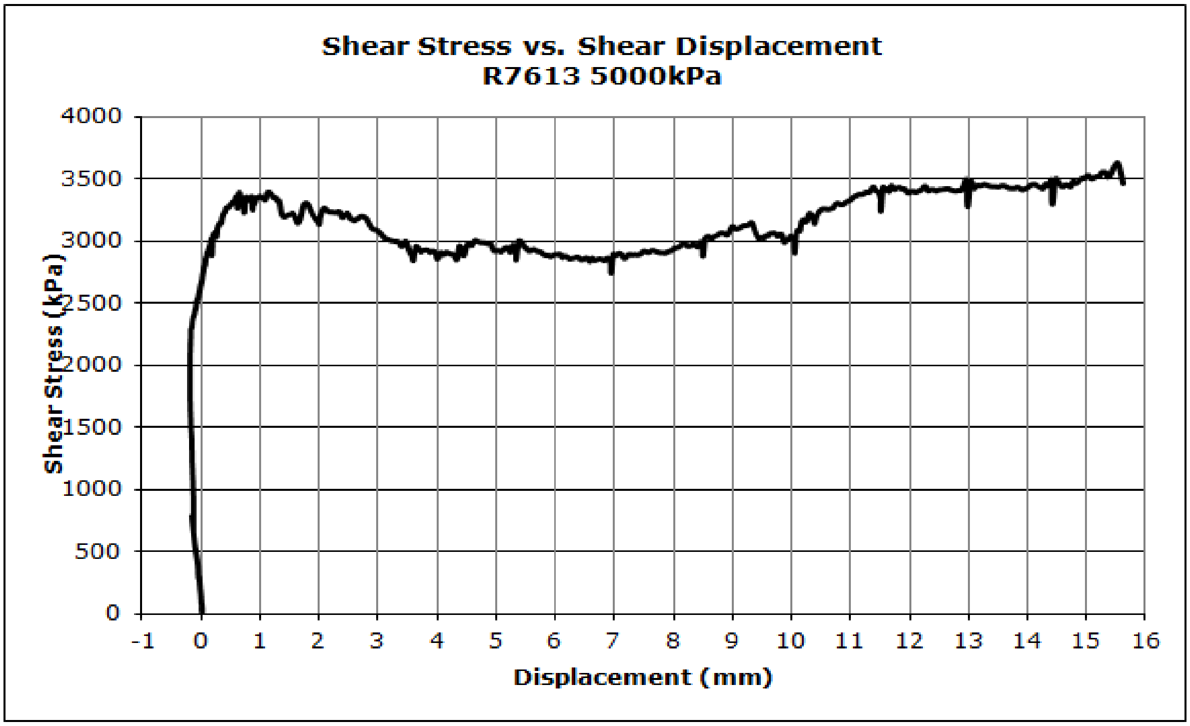
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.50m	**Lab #:** R7613





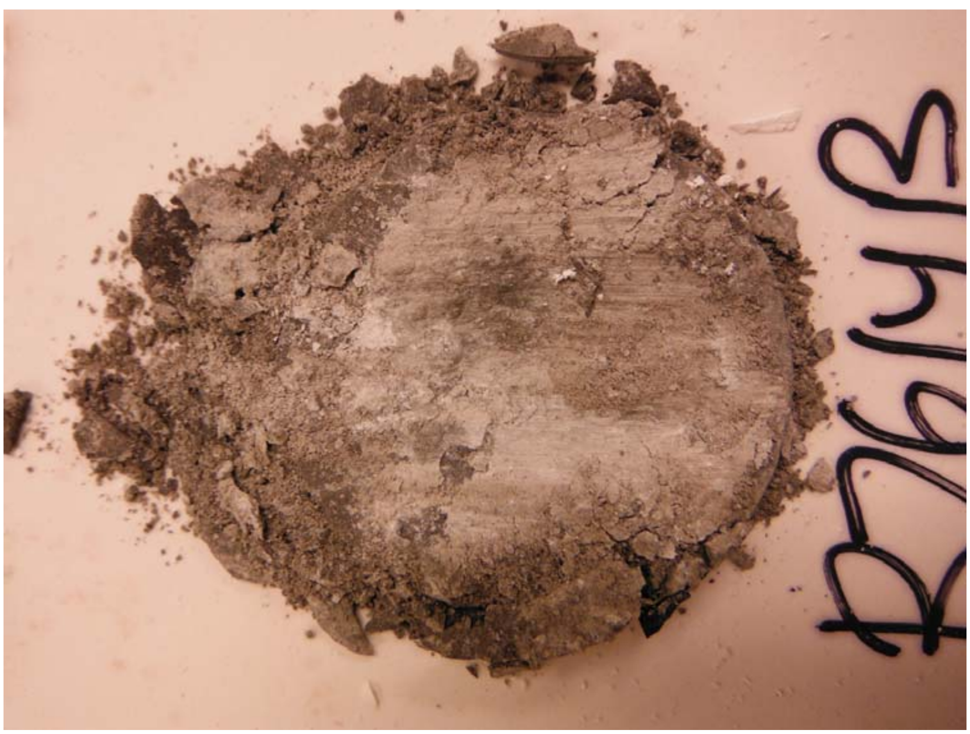
Amec Foster Wheeler Environment & Infrastructure
Hamilton Rock Mechanics Laboratory

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.50m	**Lab #:** R7613



Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-5	**Ref. No.:** D17105A
Depth: 9.40m	**Lab #:** R7614

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-5	**Ref. No.:** D17105A
Depth: 9.40m	**Lab #:** R7614



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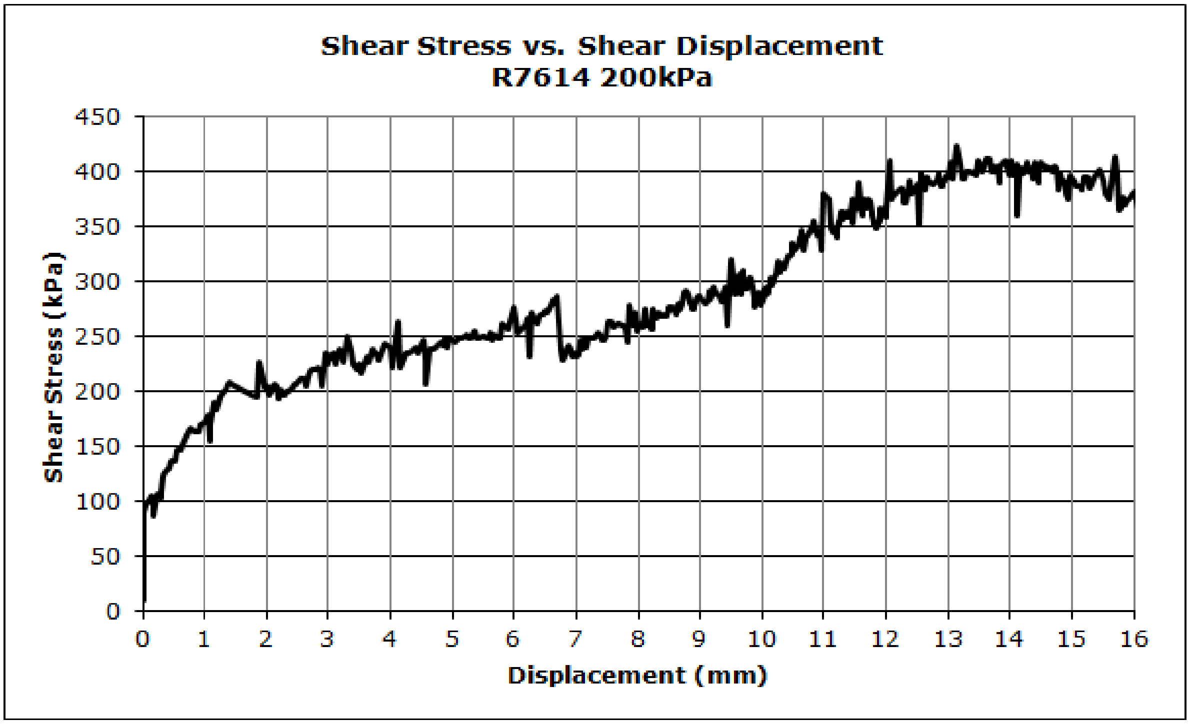
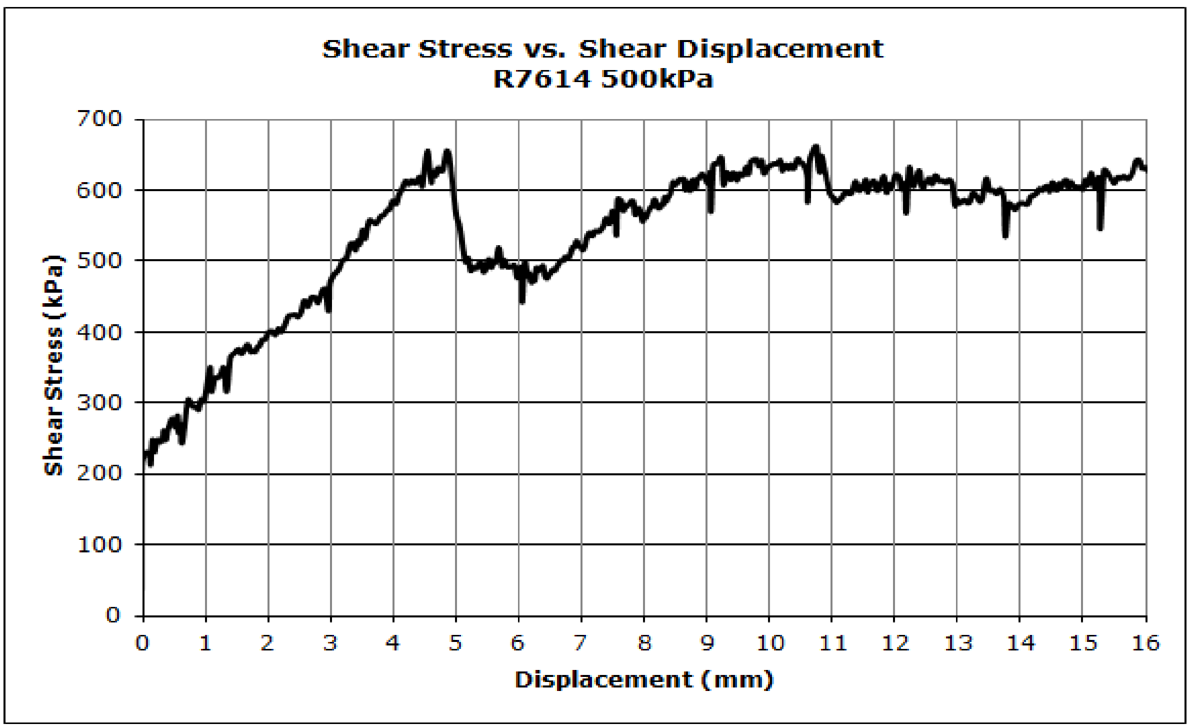
Hamilton Rock Mechanics Laboratory

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-5	**Ref. No.:** D17105A
Depth: 9.40m	**Lab #:** R7614





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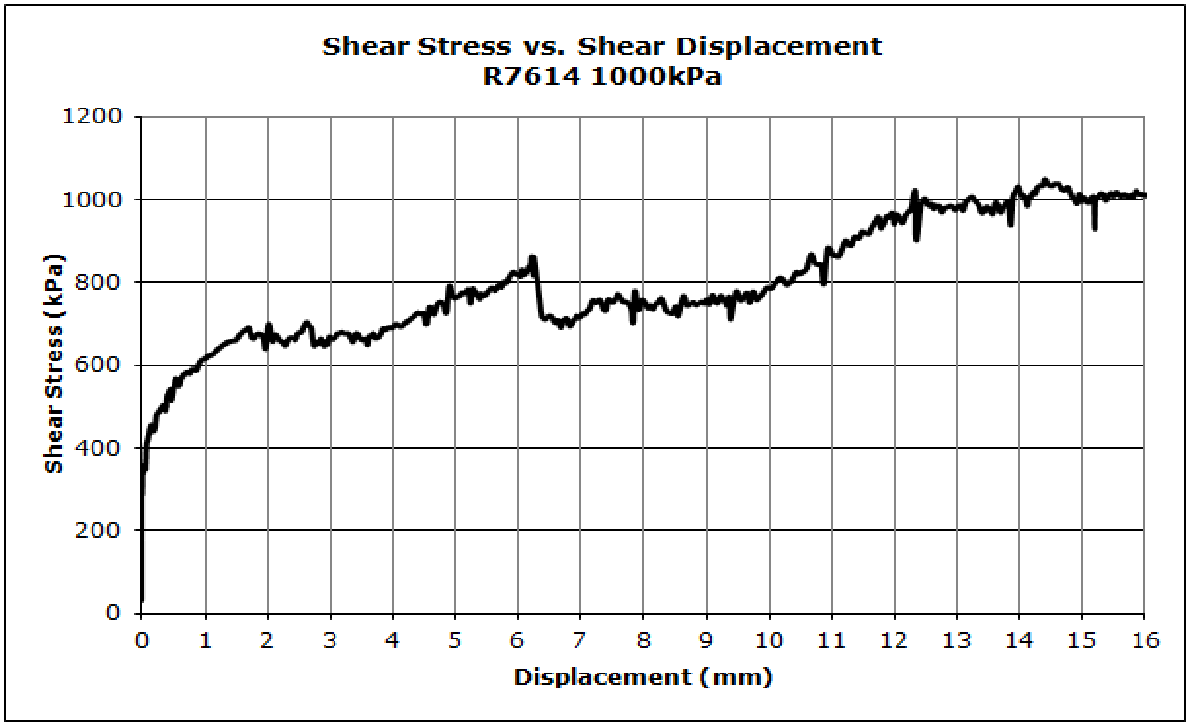
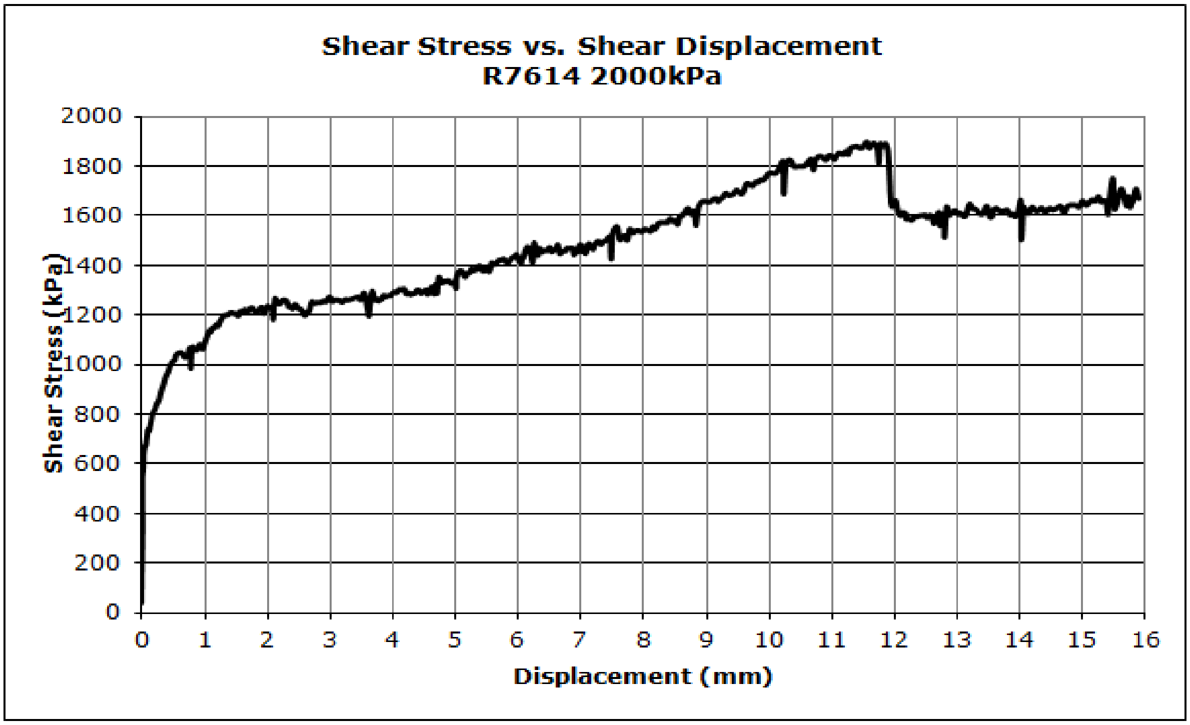
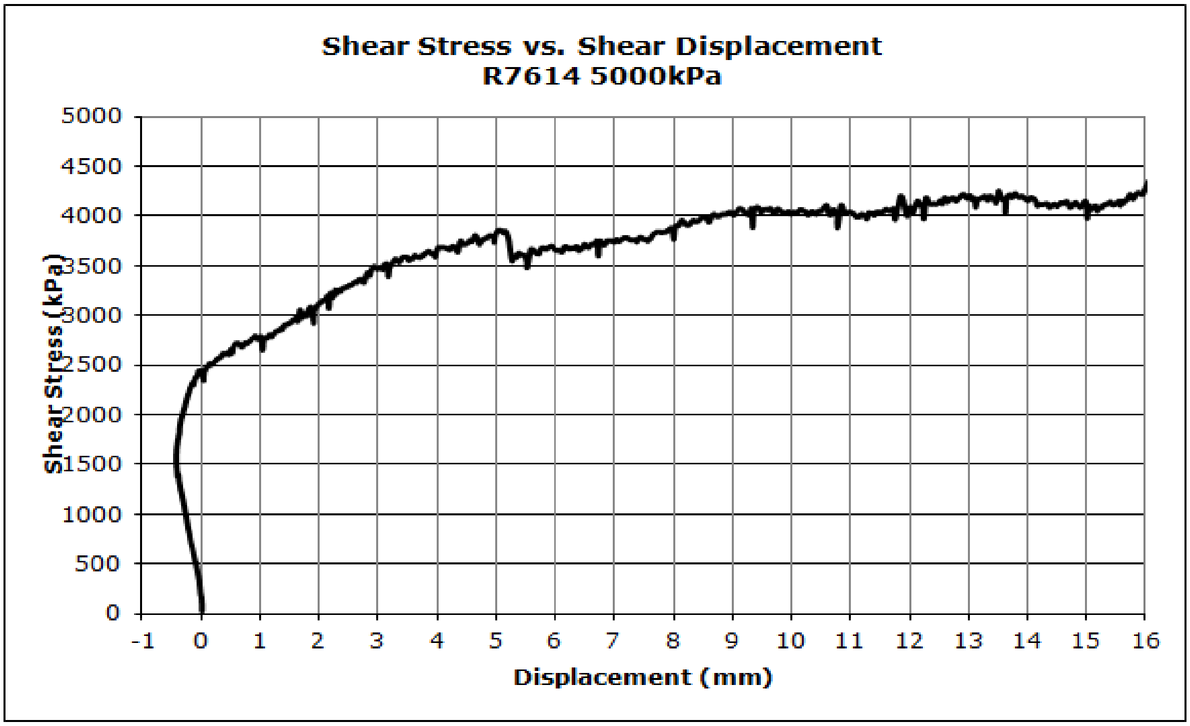
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-5	**Ref. No.:** D17105A
Depth: 9.40m	**Lab #:** R7614





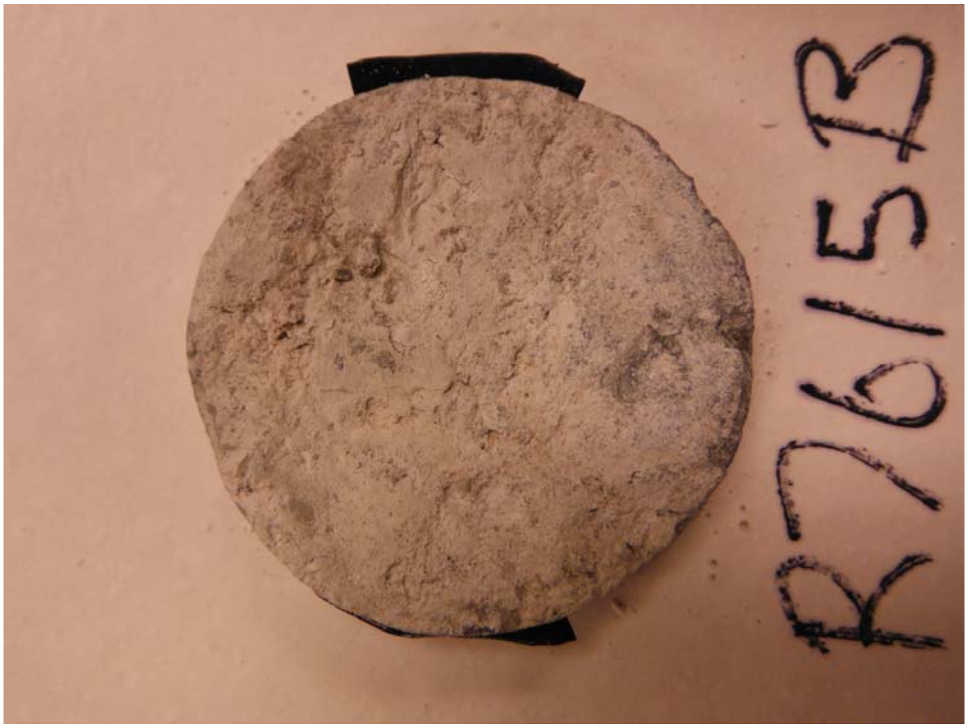
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-5	**Ref. No.:** D17105A
Depth: 9.40m	**Lab #:** R7614



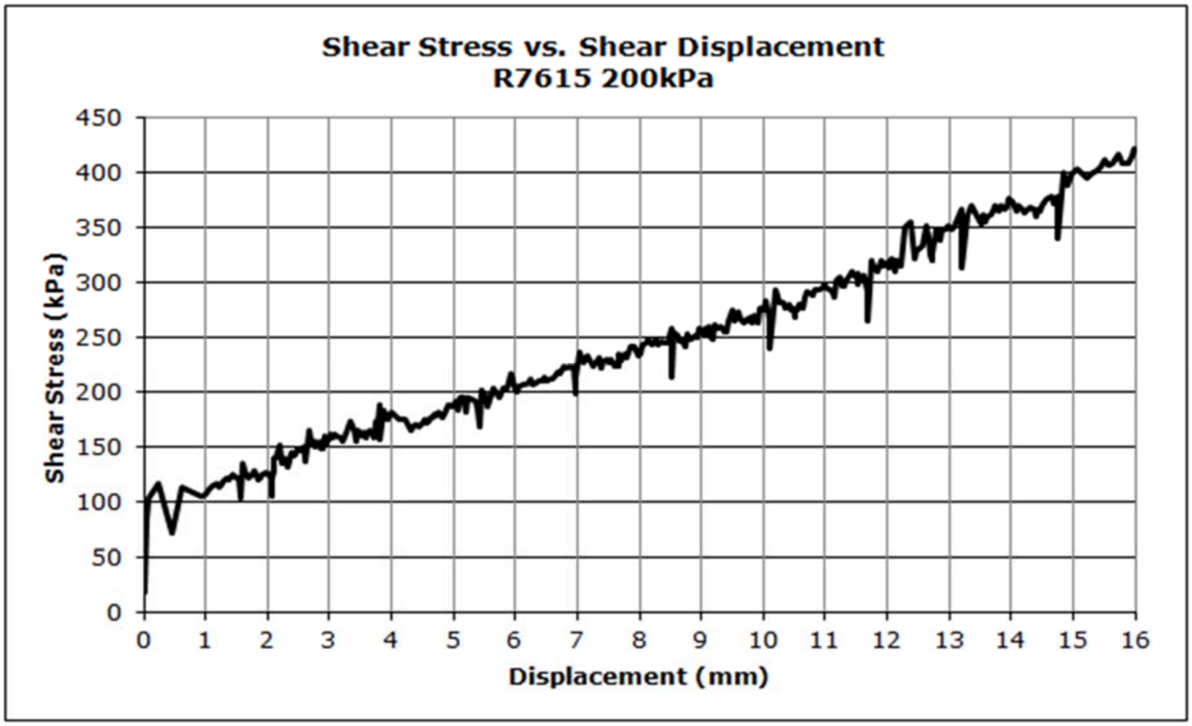
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7615

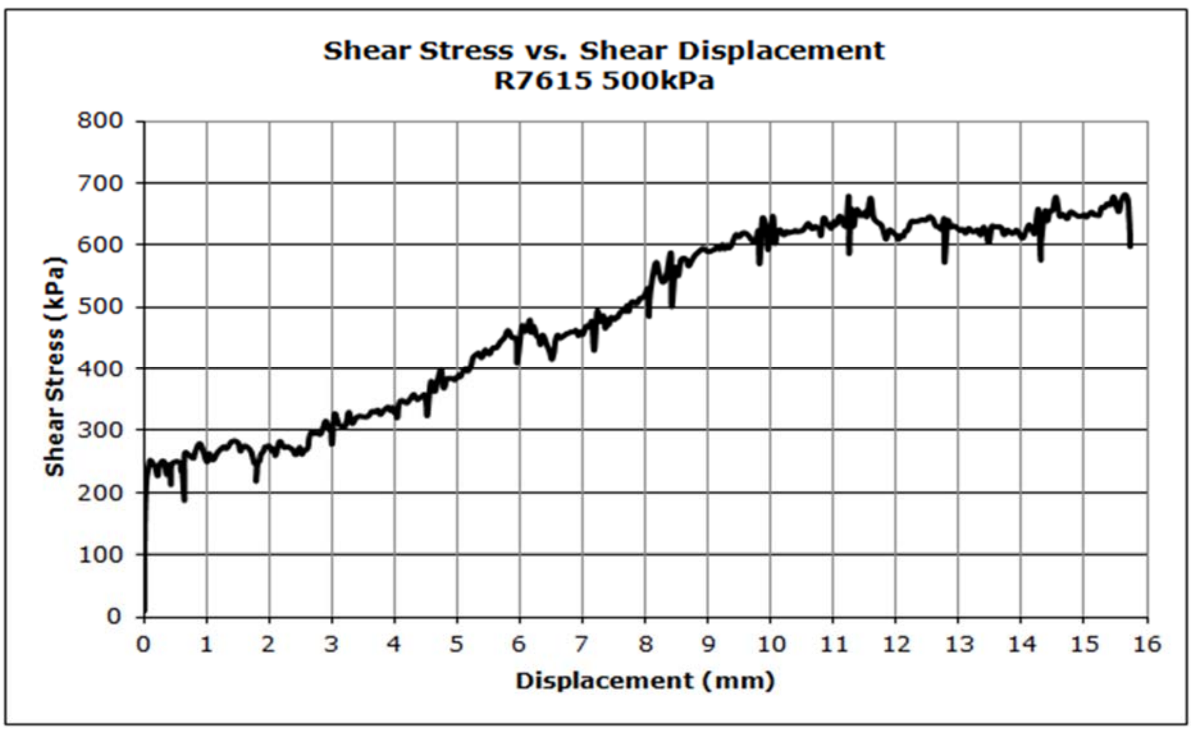
Amec Foster Wheeler Environment & Infrastructure
Hamilton Rock Mechanics Laboratory

Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7615

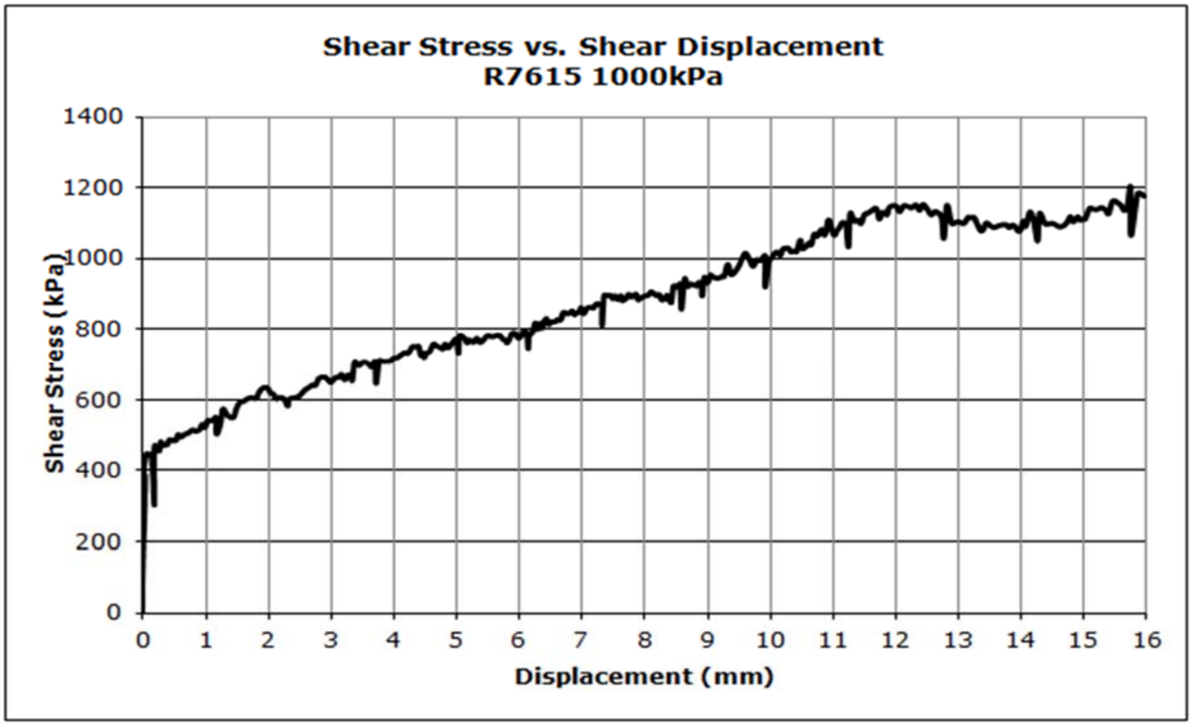


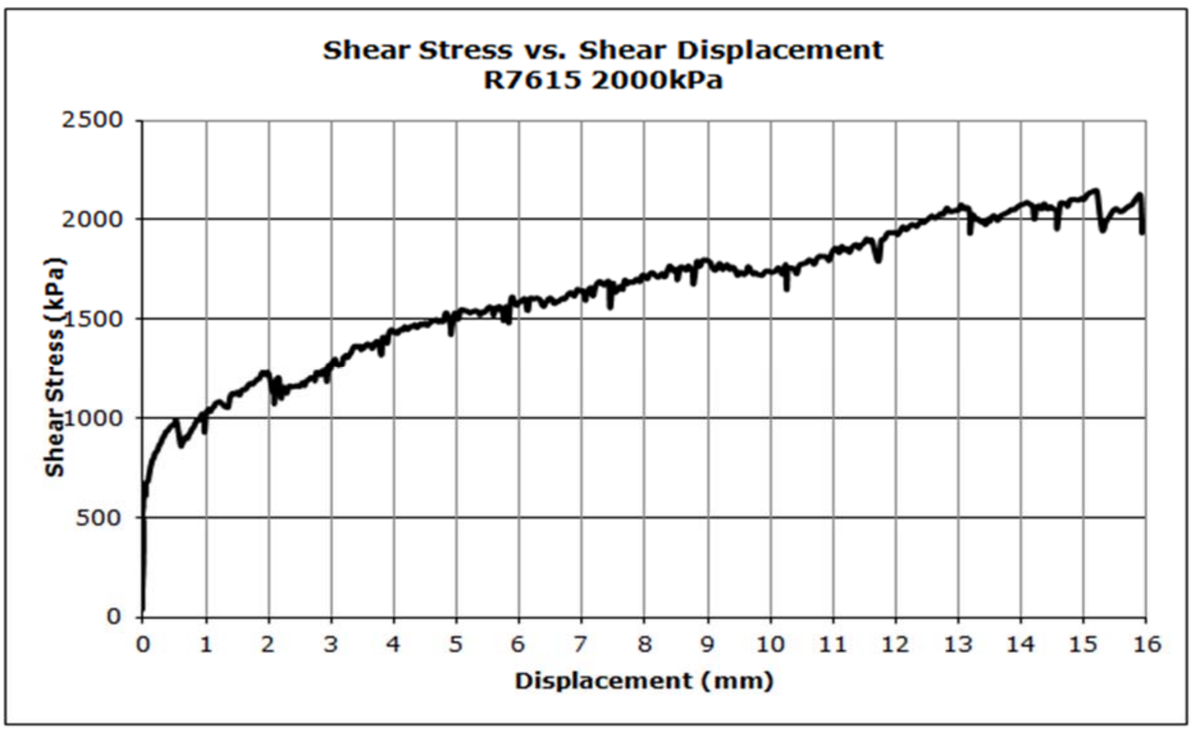
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7615





Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7615





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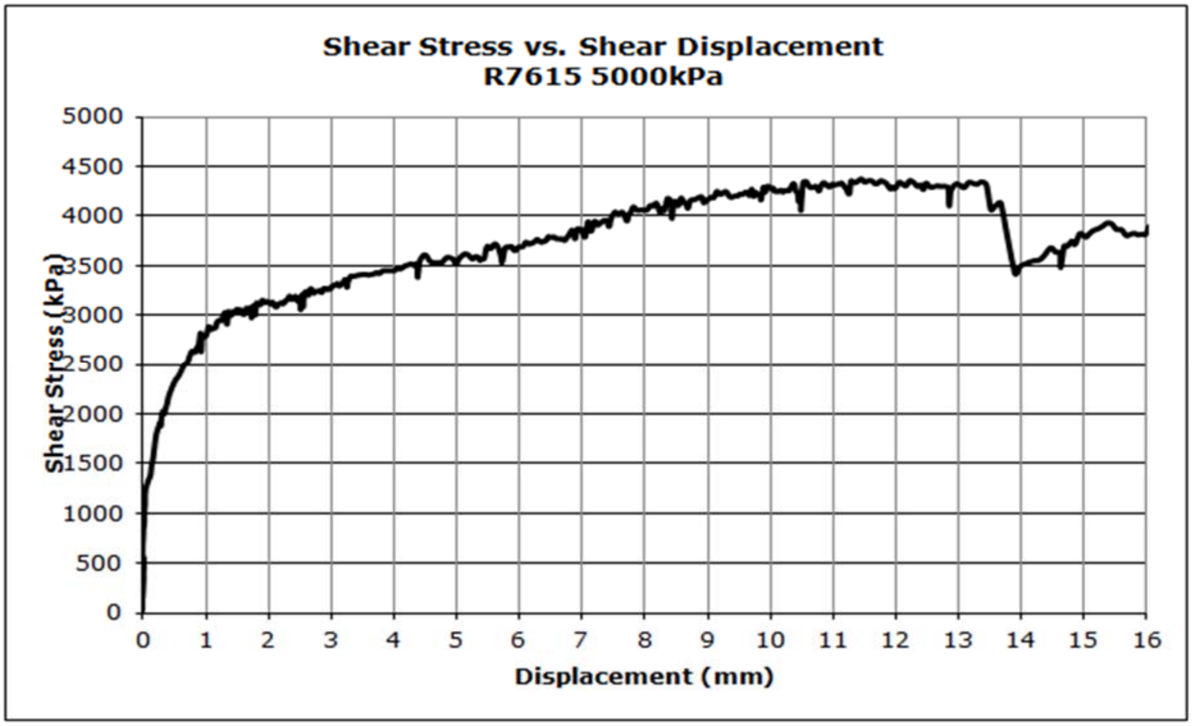
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-3	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7615



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Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-2	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7616

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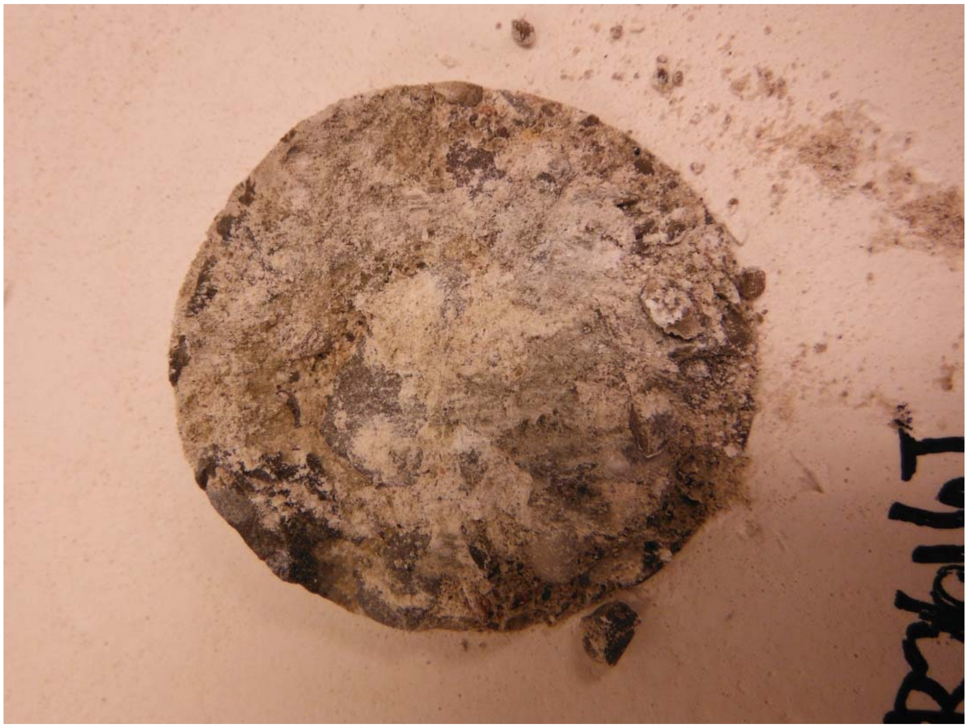
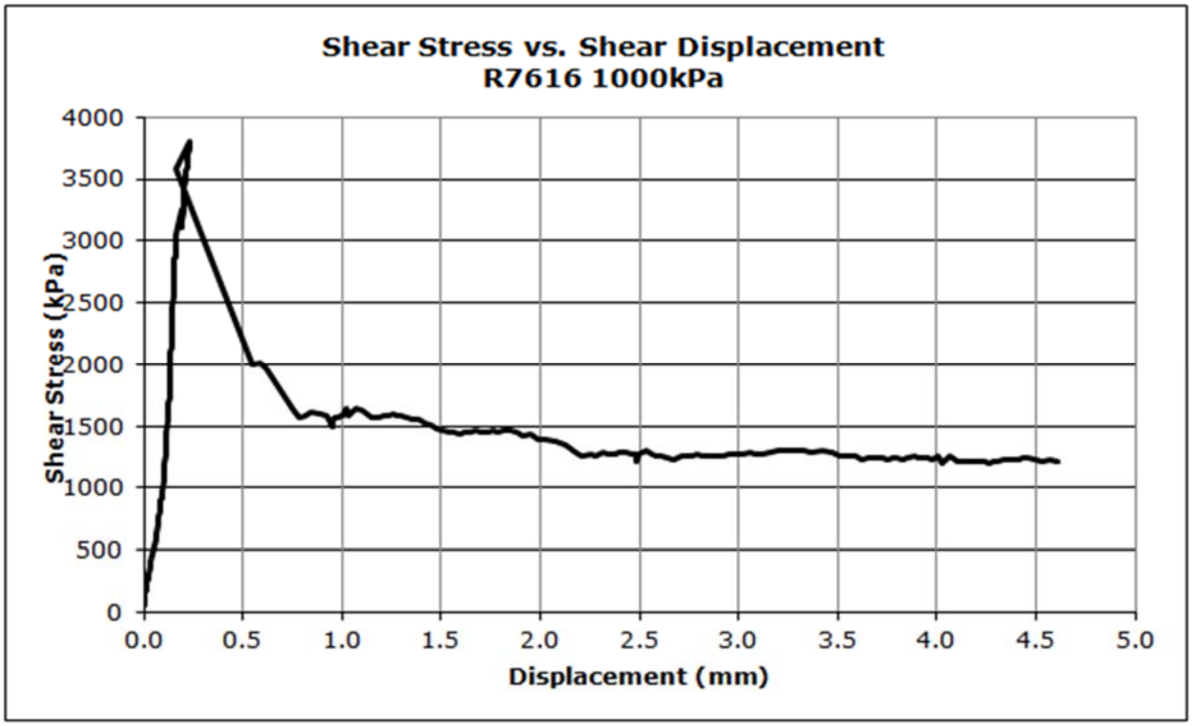
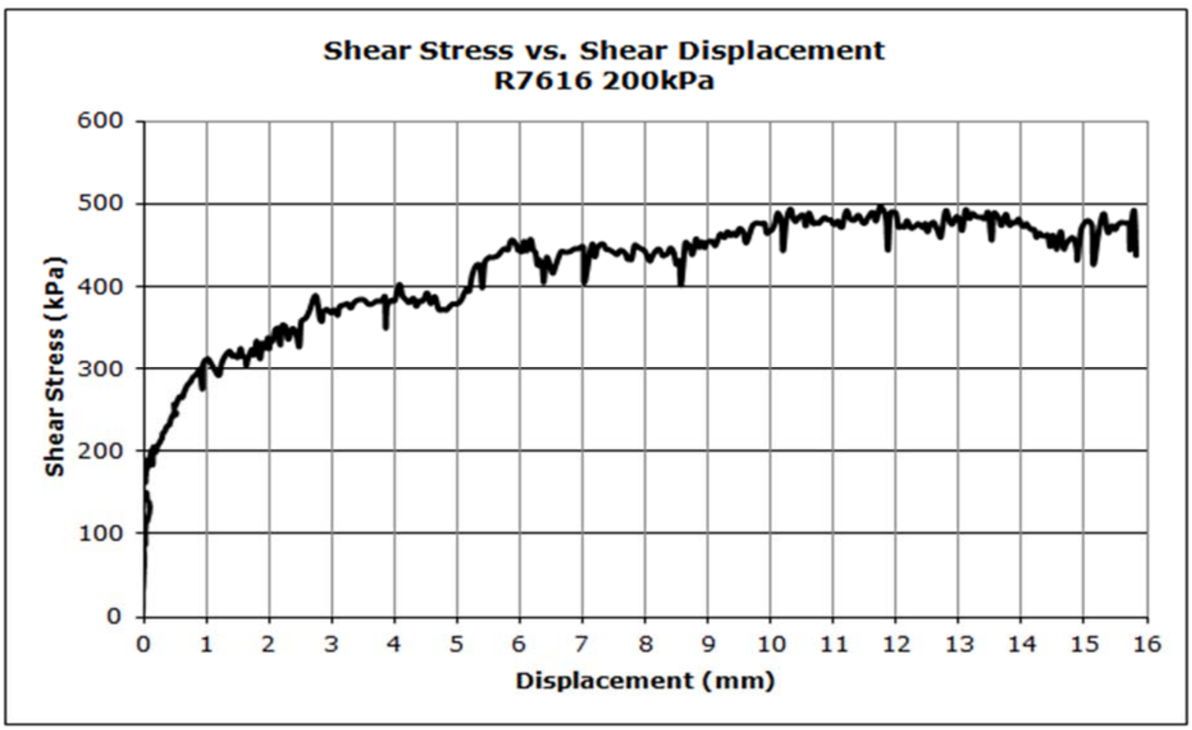
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-2	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7616



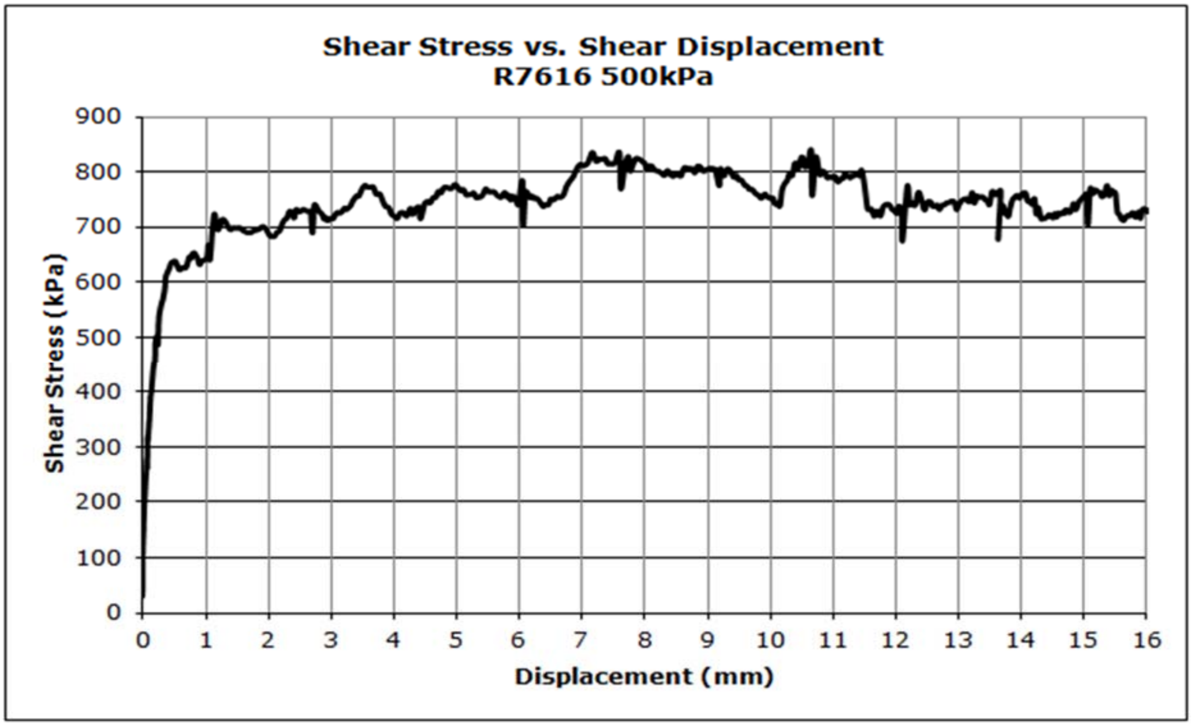
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-2	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7616

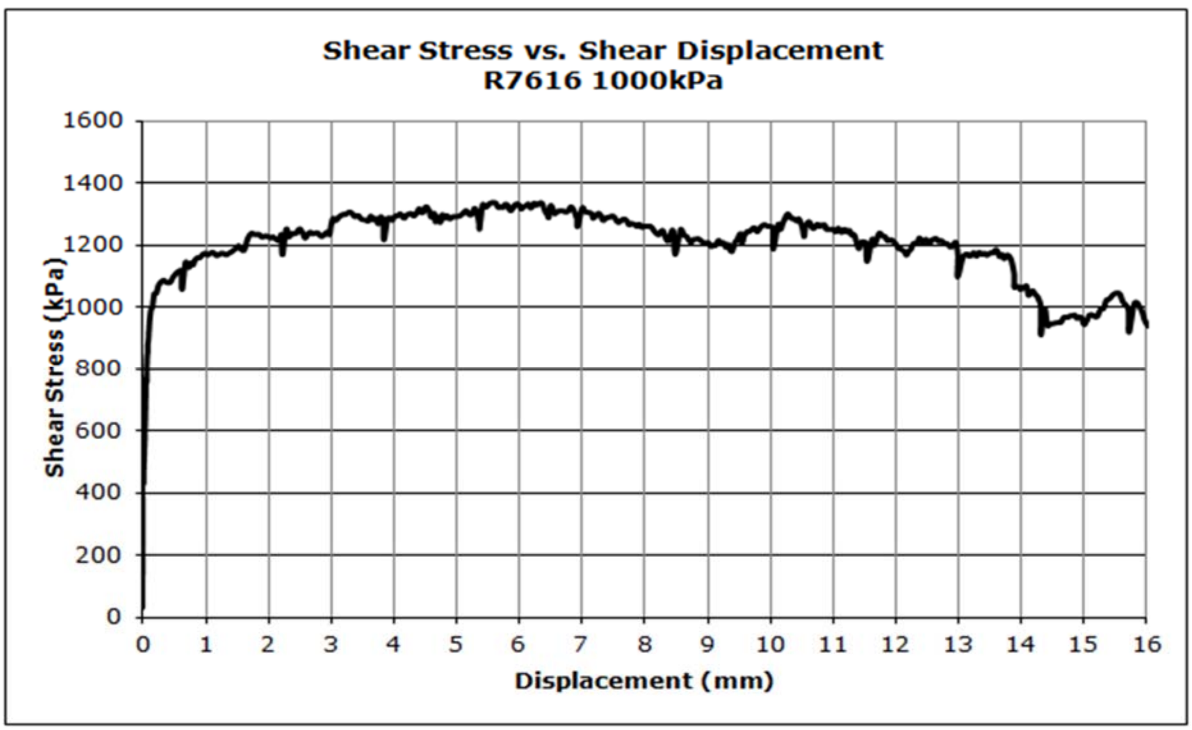




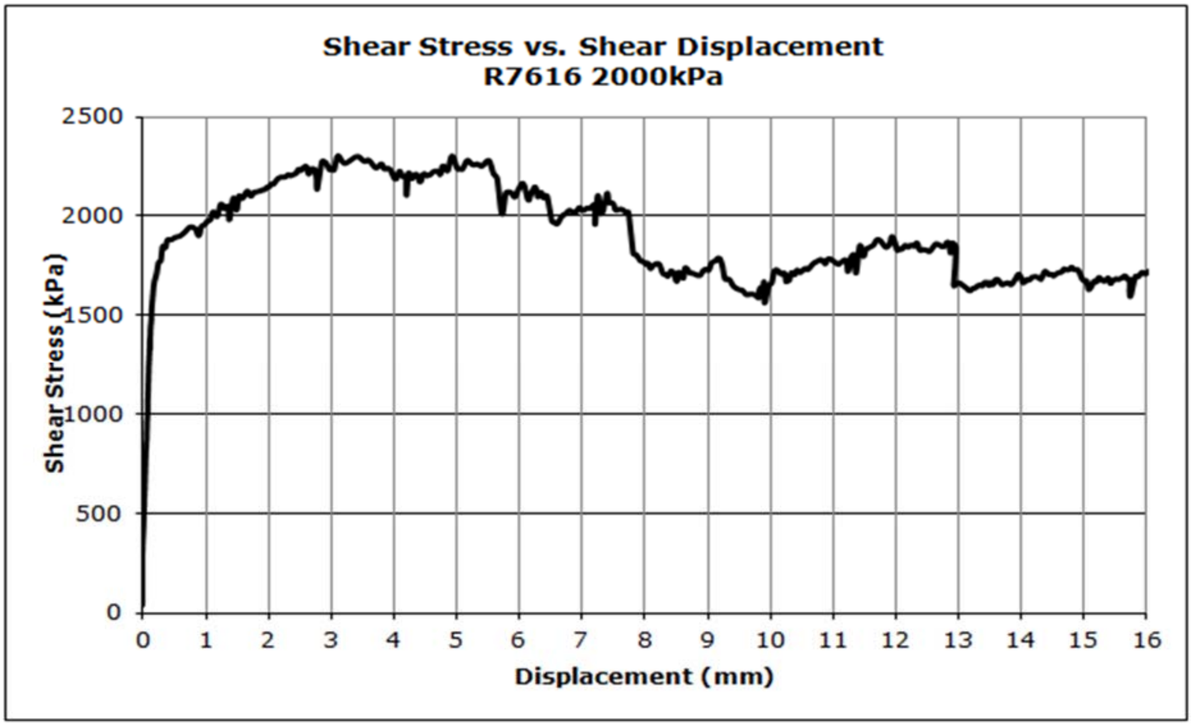
Amec Foster Wheeler Environment & Infrastructure
Hamilton Rock Mechanics Laboratory

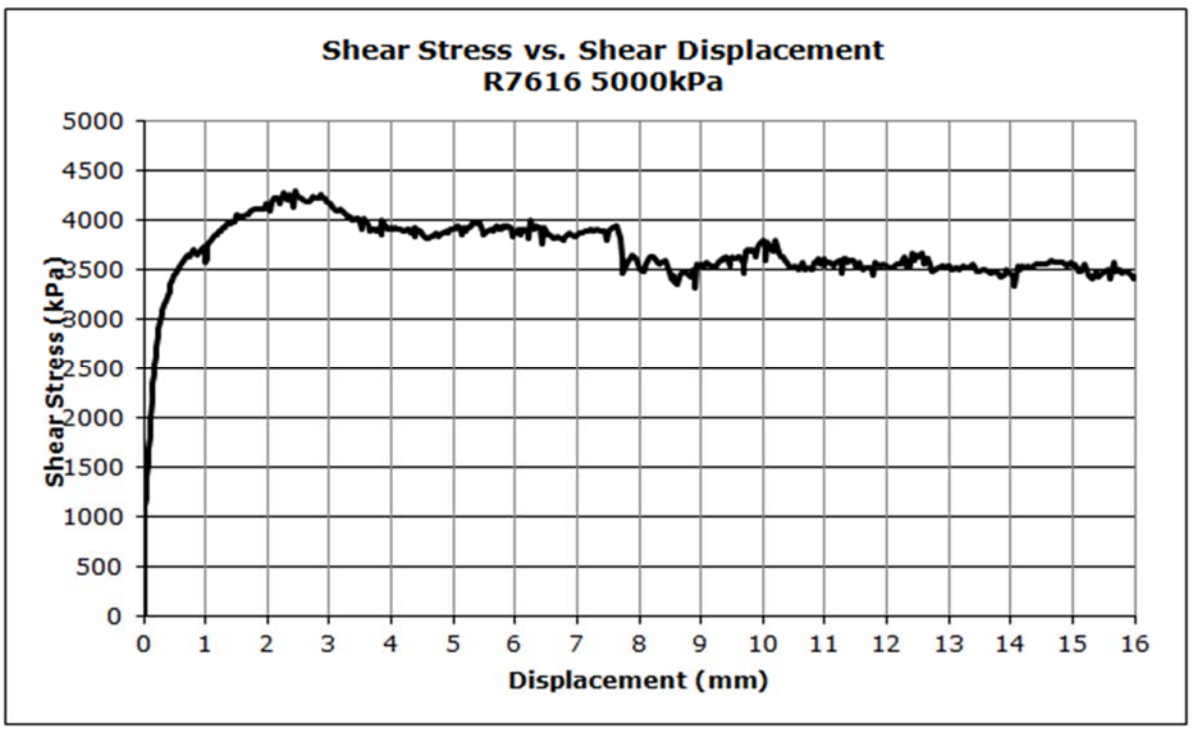
Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-2	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7616





Client: DownUnder Geotechnical Limited	**Project No.:** TB172011
Borehole #: V-2	**Ref. No.:** D17105A
Depth: 8.40m	**Lab #:** R7616





APPENDIX F

16 June 2017

File: TB172011

DownUnder Geotechnical Limited
P.O. Box 96737
2943 Major Mackenzie Drive
Maple, Ontario
L6A 0A2

Attn: Andrew Drevininkas, P.Eng.
President

Re: PETROGRAPHIC EXAMINATION AND DAMAGE RATING INDEX
TALBOT DAM AT LOCK 38 (D17105A)
GAMEBRIDGE, CITY OF KAWARTHA LAKES, ONTARIO

1.0 INTRODUCTION

Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler), is pleased to present this report summarizing results of the petrographic examinations and damage rating index determination conducted on two (2) concrete cores removed from structures of the Talbot Dam at Lock 38 located along the Talbot Canal, part of the Trent-Severn Waterway, in Gamebridge, City of Kawartha Lakes, Ontario.

It is understood that as a part of an historic investment into Trent-Severn Waterway infrastructure major concrete repair work is taking place on the Talbot Canal between Lock 39 and Lock 41, built between 1895 and 1907. As part of this repair DownUnder Geotechnical Limited (DownUnder Geotech) has provided concrete cores removed from the Talbot Dam at Lock 38 in order to identify the presence or absence of Alkali-Silica Reactivity (ASR) and determination the severity of concrete distress.

2.0 METHODOLOGY

Upon receipt, the two concrete cores identified as HC-3 and HC-6 were logged and photographed prior to preparation for laboratory testing. Parameters considered during logging included the general condition of the concrete, identification of any distress such as alkali silica reactivity (ASR) or freeze-thaw damage, core dimensions, coarse aggregate lithologies, constituent proportions (sand, stone, cement paste, voids), and general features and / or signs of any other obvious distress. When possible, freshly exposed surfaces of the cores were tested with phenolphthalein indicator to determine the presence of pervasive carbonation of the cement paste.

Petrographic Examination of the polished faces was conducted based on *ASTM C856, Standard Practice for Petrographic Examination of Hardened Concrete* in addition to the determination of

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Damage Rating Index (DRI) based on the procedure outlined in Fournier et al., 2015. Examination of petrographic thin sections prepared at specific locations from each of the two concrete cores provides detailed insight into the overall quality of the concrete and in particular any micro-features associated with ASR. These results will be presented under a separate cover when results are available.

3.0 RESULTS

Detailed petrographic examination reports for each core are presented in Enclosures 1 and 2. Coarse and fine aggregate lithologies and associated distress found within core HC-3 and core HC-6 were common among chert, carbonate containing silicified fossil fragments, gneiss and sandstone particles (Table 1).

Table 1 Summary of Coarse and Fine Aggregate Lithologies and ASR Distress Features

Lithological Types	ASR Distress Features
Carbonate (Siliceous) (containing silicified fossil fragments)	Reaction Rims/Alteration Rims Crack within coarse aggregate filled or partly filled with secondary mineralization +/-Alkali-Silica Gel, +/- Ettringite, +/- Calcium Hydroxide Open and fine network cracks in coarse aggregate
Gneiss	Reaction Rims/Alteration Rims Crack within coarse aggregate filled or partly filled with secondary mineralization of +/-Alkali-Silica Gel, +/- Ettringite, +/- Calcium Hydroxide Open and fine network cracks in coarse aggregate
Sandstone (fine grained)	Reaction Rims/Alteration Rims Debonding
Chert	Reaction Rims/Alteration Rims

As defined by Fournier et al:

> Reaction rim - a Dark layer inside the periphery of an aggregate particle; it corresponds to either a "reaction" rim (due to alkali-silica reaction) or an "alteration" rim (~ essentially observed around natural gravel aggregate due to weathering under natural environmental conditions).
>
> Debonded aggregate - Loss of paste-aggregate bond due to the presence of a crack (either opened or partially/totally filled with reaction products) that appears along a significant portion of the interfacial zone between the aggregate particle and the cement paste.
>
> Reacted aggregate - Aggregate particle that shows signs of desagragation, overall disintegration (loose rock grains) or loss in integrity.

Damage features commonly associated with alkali-silica reaction include reaction rims, debonding, and internal cracking of aggregate particles extending into the adjacent cement paste that are either open or contain silica gel. Trace silica gel in core HC-3 and HC-6 was limited to macro-cracks within a small number of siliceous carbonate and gneiss particles as well as rare entrapped voids adjacent to these particles.

Enclosures 3 to 7 present the core logging and petrographic features identified during examination. Core Logging and petrographic examination of the polished surface of HC-3 and HC-6 confirmed that the concrete cores were composed of gravel coarse aggregate and natural fine aggregate of similar grading and lithology. Overall the concrete displayed an uneven distribution of coarse aggregate and smaller, rounded voids near the external exposed formed surface. The concrete was poorly consolidated as evidenced by the high percentage of irregular shaped, elongate and interconnected voids with orientation strongly associated with cement paste-aggregate particles.

The Damage Rating Index (DRI) is a semi-quantitative damage assessment determined by petrographic analysis of concrete specimen that is particularly applicable to concrete durability concerns resulting from rebar corrosion, sulphate attack, cyclic freezing and thawing and ASR in the aggregate and in the coarser portions of the fine aggregate (>2mm). Results of the DRI determinations for concrete cores HC-3 (DRI value of 195) and HC-6 (DRI value of 91) are presented in Figure 1.

Typically concrete with DRI values less than 200/250 appear to be in good condition when examined with the naked eye (macroscopic), but with limited signs (trace) of deterioration when viewed under a stereomicroscope. Concrete with DRI values between 200/250 to 400 generally appears to be in good to fair condition macroscopically; however fair to moderate deterioration is evident when viewed under a stereomicroscope. Concrete with DRI values between 400 and 700/750 shows moderate deterioration macroscopically, but moderate to severe damage when viewed microscopically. Concrete with DRI values greater than 700/750 appears severely damaged macroscopically and microscopically.

Petrographic examination of concrete cores HC-3 and HC-6 indicates trace ASR is occurring within the concrete. The DRI value seen in HC-3 is due primarily to a single large particle (approximately 30 mm wide) of gneiss exhibiting a high frequency of open cracks and a single large particle of fine sandstone (approximately 50 mm wide) exhibiting debonding. The presence of reaction products coating large number of interconnected entrapped voids in concrete cores HC-3 and HC-6 indicate poor consolidation and high permeability of the concrete which may affect durability.

If you have any questions with regards to this report please do not hesitate to contact the undersigned at your convenience.

Yours truly,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited

Reviewed by,

Martin Little, P.Geo.
Senior Geoscientist

John Balinski, P.Geo.
Senior Associate Materials Consultant

ml:JB
Enclosure(s) (5)
Figure(s) (1)

Amec Foster Wheeler Environment & Infrastructure
505 Woodward Avenue, Unit #1
Hamilton, Ontario, Canada
L8H 6N6

Petrographic Examination of Hardened Concrete - ASTM C856

ENCLOSURE 1

Job No	TB172011	Exam Date	8 June 2017
Lab No	C510-17	Analyzed by	Martin Little
Sample No	HC-3	Received	01-May-17
Location	Talbot Dam, Trent Severn Waterway		

Details of Structure

Year of Construction	n/a	Description of Structure	Dam at Lock 38
Description of Deterioration / Problem	Alkali-Aggregate Reactivity		

Total Concrete

Hit with Hammer	Ring	Unusually Wet / Dry Areas	Yes
Strength	Strong	Cement / Coarse Aggregate Bond	Weak
Breaks with Fingers	Other - See Below	Cement / Fine Aggregate Bond	Weak

Observations Diameter: 98 mm; Length: 627 mm (length of petrographic segment - 370 mm to 627 mm)

Exposed Exterior of Core : Planar, smooth over 40% of surface, delamination of outer 2 mm of concrete core was easily gouged with metal probe. Approximately 40% of the external surface broken away; approximately 10% of external remaining surface irregular, rough and displaying orange-yellow efflorescence and dark ?biologic? staining under delamination.

Phenolphthalein Indicator - Patchy carbonation 32 mm below the exposed exterior surface along the core length to base

Core Length: Macro-cracks that measure up to 45 mm wide noted 68 mm, 230 mm, and 370 mm from the exposed external surface, white reaction products in voids, in addition to orange-yellow efflorescence lining cracks; Segregation (uneven distribution of coarse aggregate and smaller, rounded voids) was prominent above the first macro-crack occurring 32 mm to 68 mm from the external surface of the core. High percentage of irregular shaped, elongate, interconnected voids lined with reaction product are systemic throughout core length. Cement paste in body of concrete was easily gouged with very weak cement paste noted 310 mm to 490 mm below the exposed exterior surface, associated with wide macro-crack.

Base of core : Poorly consolidated concrete characterized by large irregular shaped, elongate interconnected voids and occasional exposure of rounded particle perimeters.

Coarse Aggregate

Percent of Total	25-30 % by volume of concrete				
Preferred Orientation	Not Observed	Distribution	Uneven	Grading	Even
Material Type	Gravel	Maximum Size	57 mm	Shape	Rounded

Observations Coarse aggregate displayed infrequent features associated with ASR including Reaction Products (RP) within internal cracks that measured 0.8 mm wide; closed or line crack measured less than 0.02 mm wide. Severe distress seen in gneiss (reacted)

Reaction products microscopically identified as alkali-silica gel, ettringite or combination. Debonding rare, seen in weak sandstone particle

Majority of Reaction Rims/Alteration Rims (RR/AR) observed on rounded particle perimeters likely due to in-situ weathering of gravel prior to use in Portland cement concrete.

Lithological Types	Percentage of Coarse Aggregate	Reaction Rims / Reaction Products / Fractures	Remarks
Carbonate (crystalline LMST)	58	RR/AR, RP and Fractures	Open and fine network cracks 0.1 mm wide
Carbonate (Siliceous)	30	RR/AR, RP and Open Fractures	Open and fine network cracks 0.08 mm wide
Gneiss	2	RR/AR, RP and Open Fractures	Open and fine network cracks 0.8 mm wide
Granite	4	-	-
Sandstone (very fine grained)	4	Debonding	Weak, soft matrix
Chert	2	-	Leached

Fine Aggregate

Percent of Total	30-35 % by volume of concrete		
Preferred Orientation	Not Observed	Distribution	Even
Material Type	Natural	Shape	Rounded
		Grading	Even

Observations: Majority of Reaction Rims/Alteration Rims (RR/AR) observed on rounded particle perimeters likely due to in-situ weathering of gravel prior to use in Portland cement concrete.

Lithological Types	Percentage of Fine Aggregate	Reaction Rims / Reaction Products / Fractures	Remarks
Carbonate (crystalline LMST)	29	RR/AR	-
Carbonate (Siliceous)	8	RR/AR	-
Quartzite	2	-	-
Quartz Sandstone	4	-	-
Diorite	1	-	-
Chert	1	RR/AR	-
Quartz (individual grains)	40	-	-
Feldspar (individual grains)	10	-	-
Amphibole (individual grains)	4	-	-
Mica	1	-	-

Cement Paste

Percent of Total	25-30 % by volume of concrete		
Bleeding	Not Observed	Colour	Light Grey / -
Slag	Not Observed / Fly Ash: Not Observed	Colour Distribution	Even
Strength	Strong	Appearance in Broken Concrete	Not Broken
Retempering	Not Observed	Carbonation	Outer Skin

Observations: The cement paste within the concrete core showed patchy carbonation along its length and was generally weak, able to be easily gouged with a metal probe. The bond between the cement paste and coarse aggregate weak and aggregate could be plucked in some locations as mentioned previously. Analysis of thin section from core HC-3 will provide further comment on the overall quality of the cement paste.

Voids

Percent of Total	10-11 % by volume of concrete		
Percent with Mineralization	>90%	Mineralization	Reaction Products
Interior Luster	Dull	Interior Condition	Filled and Partly Lined
Grading	Non air-entrained	Shape	Irregular
		Average	1 mm

Observations: Entrapped voids characterized by irregular shaped, elongate and interconnected voids with orientation strongly associated with cement paste-aggregate particle perimeters. Occasional reaction products observed within voids were microscopically identified as alkali silica gel, ettringite or combination. Majority of reaction products within air voids were identified as ettringite needles or rosettes.

Cracks

Continuity, Distribution & Location	Within Aggregate Particle		
Maximum Width-micro-crack (mm)	0.8	Amount	Occasional
Minimum Width-micro-crack (mm)	0.08	Filling	Reaction Products
Associated with Embedded Items	No	Describe	-

Observations: Occasional open and fine network cracks restricted to inner portion of coarse aggregate particles of gneiss that measured up to 0.8 mm; Rare open and fine network cracks that measured up to 0.03 mm were infilled or intermittently filled with reaction products microscopically identified as alkali silica gel, ettringite, calcium hydroxide or combination of reaction products was restricted to inner coarse aggregate particles of cherty carbonate and gneiss.

Embedded Items

NOT OBSERVED

Description	-		
Location	-		
Size (mm)	-	Condition	-
		Associated Features	-

Observations: -

Conclusions

Core HC-3 displays trace ASR damage features limited to a small number of coarse aggregate cherty carbonate and gneiss including the presence of small amounts of silica gel. The presence of weak cement paste, efflorescence lining large macro-cracks and reaction product coating large number of interconnected entrapped voids indicate poor consolidation and high permeability of the concrete which may affect durability.

Amec Foster Wheeler Environment & Infrastructure
505 Woodward Avenue, Unit #1
Hamilton, Ontario, Canada
L8H 6N6

Petrographic Examination of Hardened Concrete - ASTM C856

ENCLOSURE 2

Job No	TB172011	Exam Date	8 June 2017
Lab No	C509-17	Analyzed by	Martin Little
Sample No	HC-6	Received	01-May-17
Location	Talbot Dam, Trent Severn Waterway		

Details of Structure

Year of Construction	n/a	Description of Structure	Dam at Lock 38
Description of Deterioration / Problem	Alkali-Aggregate Reactivity		

Total Concrete

Hit with Hammer	Ring	Unusually Wet / Dry Areas	Yes
Strength	Strong	Cement / Coarse Aggregate Bond	Weak
Breaks with Fingers	Other - See Below	Cement / Fine Aggregate Bond	Weak

Observations: Diameter: 97 mm; Length: 709 mm (length of petrographic segment - 509 mm to 709 mm)
Exposed Exterior of Core : Planar, slightly rough impression of formwork, cement paste at surface difficult to scratch with metal probe.
Phenolphthalein Indicator - Patchy carbonation 55 mm below the exposed exterior surface along the core length to base

Core Length: Oblique macro-cracks that measure 7 mm to 30 mm wide noted 90 mm - 95 mm, 135 mm - 140 mm and 551 mm - 517 mm to 540 mm - 543 mm from the exposed exterior surface of the core. These macro-cracks were infilled with and stained with efflorescence and displayed a high number of entrapped voids along with smooth, rounded sockets and rounded aggregate particle perimeters. Segregation (uneven distribution of coarse aggregate and smaller, rounded voids) was prominent above the first macro-crack occurring 55 mm to 65 mm from the external surface of the core. High percentage of irregular shaped, elongate and interconnected voids lined with reaction product are systemic throughout core length. Cement paste in body of concrete was easily gouged with very weak cement paste noted 100 mm to 265 mm below the exposed exterior surface, associated with gouging and oblique macro-crack noted at 135 mm - 140 mm and 551 mm - 517 mm to

Base of core : Poor consolidation, smooth rounded sockets and rounded particle perimeters displaying reaction product indicate poor cement paste-aggregate bonds occurs at localized areas similar to oblique macro-cracks
551 mm - 517 mm to 540 mm - 543 mm from the exposed exterior surface of the core.

Coarse Aggregate

Percent of Total	30-35 % by volume of concrete				
Preferred Orientation	Not Observed	Distribution	Even	Grading	Even
Material Type	Gravel	Maximum Size	35 mm	Shape	Rounded

Observations: Coarse aggregate displayed occasional features associated with ASR including Reaction Products (RP) within internal cracks that measured 0.1 mm wide; closed or line crack measures 0.02 mm wide. Severe distress seen in gneiss (reacted)
Reaction products microscopically identified as alkali-silica gel, ettringite or combination.
Majority of Reaction Rims/Alteration Rims (RR/AR) observed on rounded particle perimeters likely due to in-situ weathering of gravel prior to use in Portland cement concrete.

Lithological Types	Percentage of Coarse Aggregate	Reaction Rims / Reaction Products / Fractures	Remarks
Carbonate (crystalline LMST)	66	RR/AR and Fractures	Fractures <0.02 mm wide
Carbonate (Siliceous)	25	RR/AR, RP and Open Fractures	Open and fine network cracks 0.06 mm wide
Gneiss	2	RR/AR, RP and Open Fractures	Open and fine network cracks 0.2 mm wide
Granite	7	-	-

Fine Aggregate

Percent of Total	30-35	% by volume of concrete			
Preferred Orientation	Not Observed	Distribution	Even	Grading	Even
Material Type	Natural	Shape	Rounded		

Observations: Majority of Reaction Rims/Alteration Rims (RR/AR) observed on rounded particle perimeters likely due to in-situ weathering of gravel prior to use in Portland cement concrete.

Lithological Types	Percentage of Fine Aggregate	Reaction Rims / Reaction Products / Fractures	Remarks
Carbonate (crystalline LMST)	35	RR/AR	-
Carbonate (Siliceous)	5	RR/AR	-
Quartzite	2	-	-
Quartz Sandstone	2	RR/AR and Fractures	Fractures <0.02 mm wide
Diorite	4	RR/AR and Fractures	Fractures <0.02 mm wide
Chert	2	RR/AR	-
Quartz (individual grains)	41	-	-
Feldspar (individual grains)	5	-	-
Amphibole (individual grains)	3	-	-
Mica	1	-	-

Cement Paste

Percent of Total	25-30	% by volume of concrete			
Bleeding	Not Observed		Colour	Grey	Light and Dark
Slag	Not Observed	Fly Ash: Observed	Colour Distribution		Mottled
Strength	Strong		Appearance in Broken Concrete		Not Broken
Retempering	Not Observed		Carbonation		Outer Skin

Observations: The cement paste within the concrete core showed patchy carbonation along its length and was generally weak, able to be easily gouged with a metal probe. The bond between the cement paste and coarse aggregate weak and aggregate could be plucked in some locations as mentioned previously. Analysis of thin section from core HC-6 will provide further comment on the overall quality of the cement paste.

Voids

Percent of Total	9-10	% by volume of concrete			
Percent with Mineralization	>90%	Mineralization	Reaction Products		
Interior Luster	Dull	Interior Condition	Filled and Partly Lined		
Grading	Non air-entrained	Shape	Irregular	Average	0.6 mm

Observations: Entrapped voids characterized by irregular shaped, elongate and interconnected voids with orientation strongly associated with cement paste-aggregate particle perimeters. Occasional reaction products observed within voids were microscopically identified as alkali silica gel, ettringite or combination. Majority of reaction products within air voids were identified as ettringite needles or rosettes.

Cracks

Continuity, Distribution & Location	Within Aggregate Particle				
Maximum Width-micro-crack (mm)	0.1			Amount	Occasional
Minimum Width-micro-crack (mm)	0.06			Filling	Reaction Products
Associated with Embedded Items	No	Describe	-		

Observations: Occasional open and fine network cracks restricted to inner coarse aggregate particles of gneiss that measured up to 0.2 mm; Rare open and fine network cracks that measured up to 0.06 mm were infilled or intermittently filled with reaction products microscopically identified as alkali silica gel, ettringite, calcium hydroxide or combination of reaction products was restricted to inner coarse aggregate particles of cherty carbonate and gneiss.

Embedded Items

NOT OBSERVED

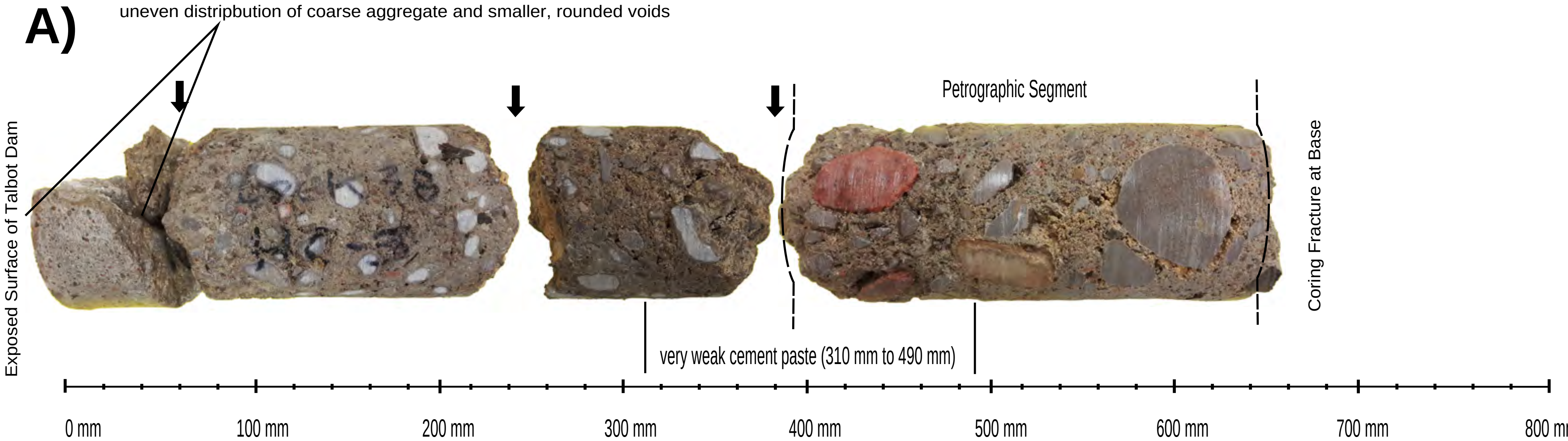
Description	-				
Location	-				
Size (mm)	-	Condition	-	Associated Features	-

Observations: -

Conclusions

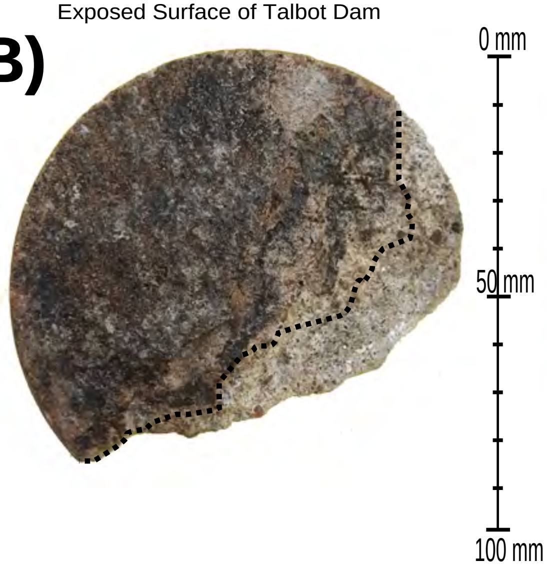
Core HC-6 displays trace ASR damage features limited to a small number of coarse aggregate cherty carbonate and gneiss including the presence of small amounts of silica gel. The presence of weak cement paste, efflorescence lining large macro-cracks and reaction product coating large number of interconnected entrapped voids indicate poor consolidation and high permeability of the concrete which may affect durability.

A)



Exposed Surface of Talbot Dam

B)



Coring Fracture at base

C)

Core Dimensions

Length (mm) Min.	612
Length (mm) Max.	627
Diameter (mm)	98

Coarse Aggregate

Material Type	Gravel
Max. Size (mm)	57
Percentage (by volume of concrete)	25-30
Preferred Orientation	Not Observed
Grading	Well Graded
Distribution	Uneven
Segregation	Uneven distribution of coarse aggregate near formed surface

Fine Aggregate

Material Type	Natural
Percentage (by volume of concrete)	30-35
Grading	Even

Air Content

Percentage (by volume of concrete)	10-11
Percentage Total Voids (Lined and Filled)	>90
Secondary Mineralization	Observed

Cement Paste

Percentage (by volume of concrete)	25-30
Depth of carbonation (mm) (by Phenolphthalein Indicator)	Patchy Full Length

Photographs and core logging results of as-received concrete core HC-3 showing the full core length A) macro-cracks at 32 mm to 68 mm, 230 mm, and 370 mm have expanded up to 45 mm wide (black arrows). Segregation (uneven distribution of coarse aggregate and smaller, rounded voids) was prominent above the first macro-crack occurring 32 mm to 68 mm from the external surface of the core. Cement paste in body of concrete was easily gouged with very weak cement paste noted 310 mm to 490 mm below the exposed exterior surface, associated with wide macro-crack in cement paste. The exposed external formed surface of the core B) was planar,smooth over 40% of surface, delamination of outer 2 mm of concrete core was easily gouged with metal probe. Approximately 40% of the external surface broken away; approximately 10% of external remaining surface irregular, rough and displaying orange-yellow efflorescence and dark ?biologic? staining under delamination (black dashed line). At the base of the core C) poorly consolidated concrete characterized by large irregular shaped, elongate interconnected voids and occasional exposure or rounded particle perimeters at localized areas.

PETROGRAPHIC EXAMINATION AND DAMAGE RATING INDEX
TALBOT DAM AT LOCK 38
GAMEBRIDGE, CITY OF KAWARTHA LAKES, ONTARIO

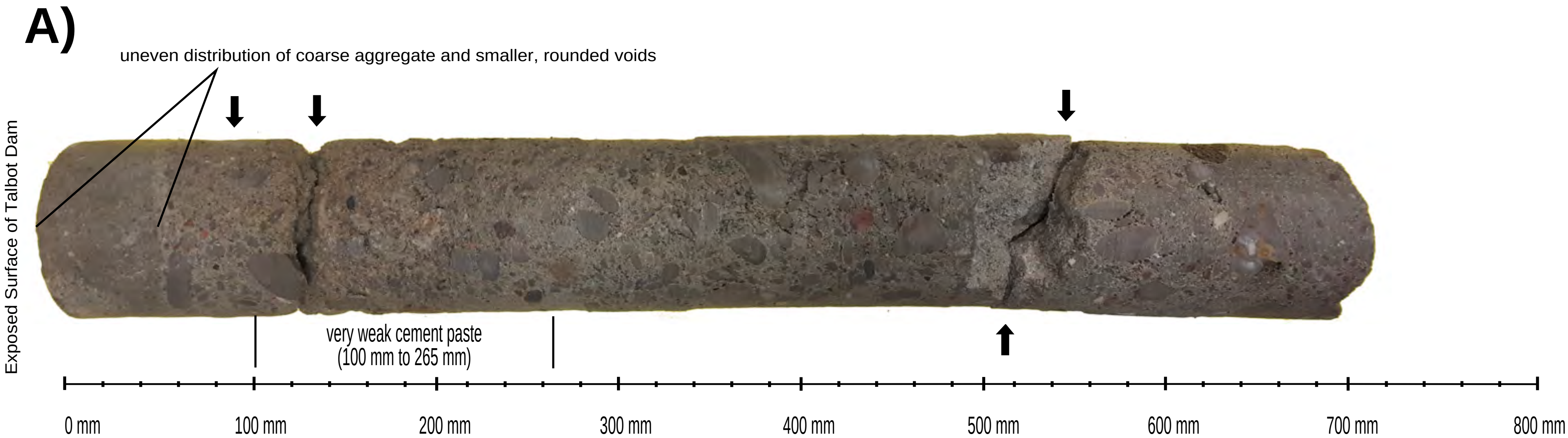
ENCLOSURE 3

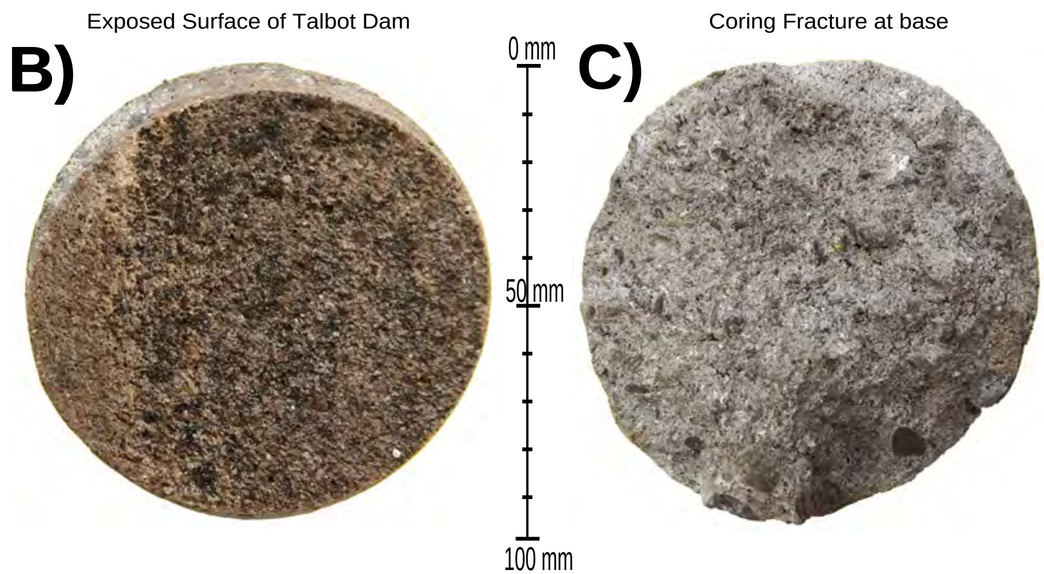
amec foster wheeler

PROJECT No: TB172011

SCALE: As Indicated

DATE : June 2017





Core Dimensions

Length (mm) Min.	688
Length (mm) Max.	709
Diameter (mm)	98

Coarse Aggregate

Material Type	Gravel
Max. Size (mm)	35
Percentage (by volume of concrete)	30-35
Preferred Orientation	Not Observed
Grading	Well Graded
Distribution	Even
Segregation	Ueven distribution of coarse aggregate near formed surface

Fine Aggregate

Material Type	Natural
Percentage (by volume of concrete)	30-35
Grading	Even

Air Content

Percentage (by volume of concrete)	9-10
Percentage Total Voids (Lined and Filled)	>90
Secondary Mineralization	Observed

Cement Paste

Percentage (by volume of concrete)	25-30
Depth of carbonation (mm) (by Phenolphthalein Indicator)	Patchy Full Length

Photographs and core logging results of as-received of concrete core HC-6 showing the full core length with A) several macro-cracks at 90 mm to 95 mm, 130 mm to 140 mm, and 551 mm to 517 mm have expanded up to 30 mm wide (black arrows). Segregation (uneven distribution of coarse aggregate and smaller, rounded voids) was prominent above the first macro-crack occurring 55 mm to 66 mm from the external surface of the core. Cement paste in body of concrete was easily gouged with very weak cement paste noted 100 mm to 265 mm below the exposed exterior surface, associated with wide macro-crack in cement paste. The exposed external surface of the core B) was planar, slightly rough impression of formwork. The cement paste at surface was difficult to scratch with metal probe. At the base of the core C) poorly consolidated concrete characterized by large irregular shaped, elongate interconnected voids and occasional exposure or rounded particle perimeters at localized areas.

PETROGRAPHIC EXAMINATION AND DAMAGE RATING INDEX
TALBOT DAM AT LOCK 38
GAMEBRIDGE, CITY OF KAWARTHA LAKES, ONTARIO

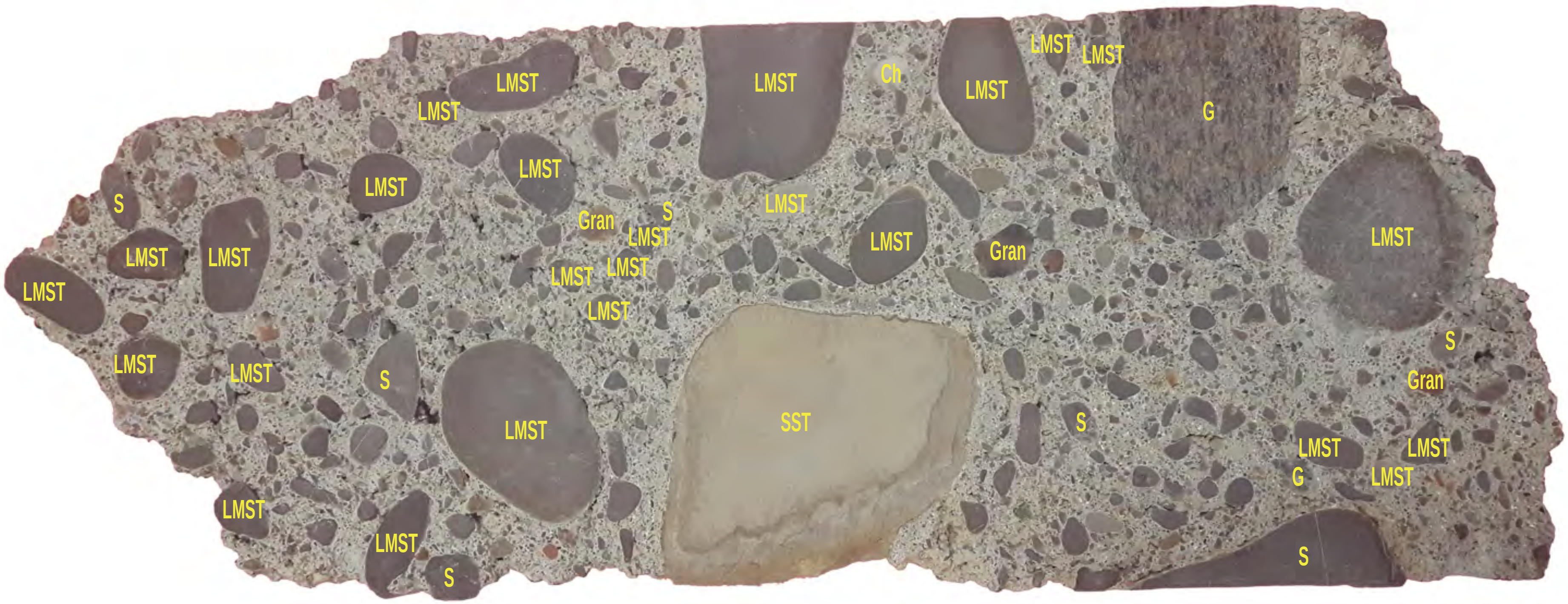
ENCLOSURE 4

amec foster wheeler

PROJECT No: TB172011

SCALE: As Indicated

DATE : June 2017



Segement Length

0 mm — 100 mm — 200 mm — 275 mm

Distance from exposed exterior surface of the core

370 mm — 470 mm — 570 mm — 645 mm

Photograph of polished face of core HC-3 between 370 mm and 627 mm from the exposed exterior surface of the core and measuring 257 mm long. Coarse aggregate is composed of Carbonate (crystalline LMST) - 58%, Carbonate (Siliceous S) - 30%, Gneiss (G) - 2%, Granite (Gran) - 4%, Sandstone (very fine grained SST) - 4% and Chert (Ch) - 2%. Coarse and fine aggregate lithologies and associated distress found within core HC-3 and core HC-6 were common among chert, carbonate containing silicified fossil fragments and gneiss particles. High percentage of irregular shaped, elongate and interconnected entrapped voids are seen with orientation strongly associated with cement paste-aggregate particle perimeters. Generally, the concrete of HC-3 appears in good condition with limited signs of deterioration attributed to ASR such as cracking and silica gel observed in several macro-cracks and entrapped voids within this Talbot Dam core.

PETROGRAPHIC EXAMINATION AND DAMAGE RATING INDEX
TALBOT DAM AT LOCK 38
GAMEBRIDGE, CITY OF KAWARTHA LAKES, ONTARIO

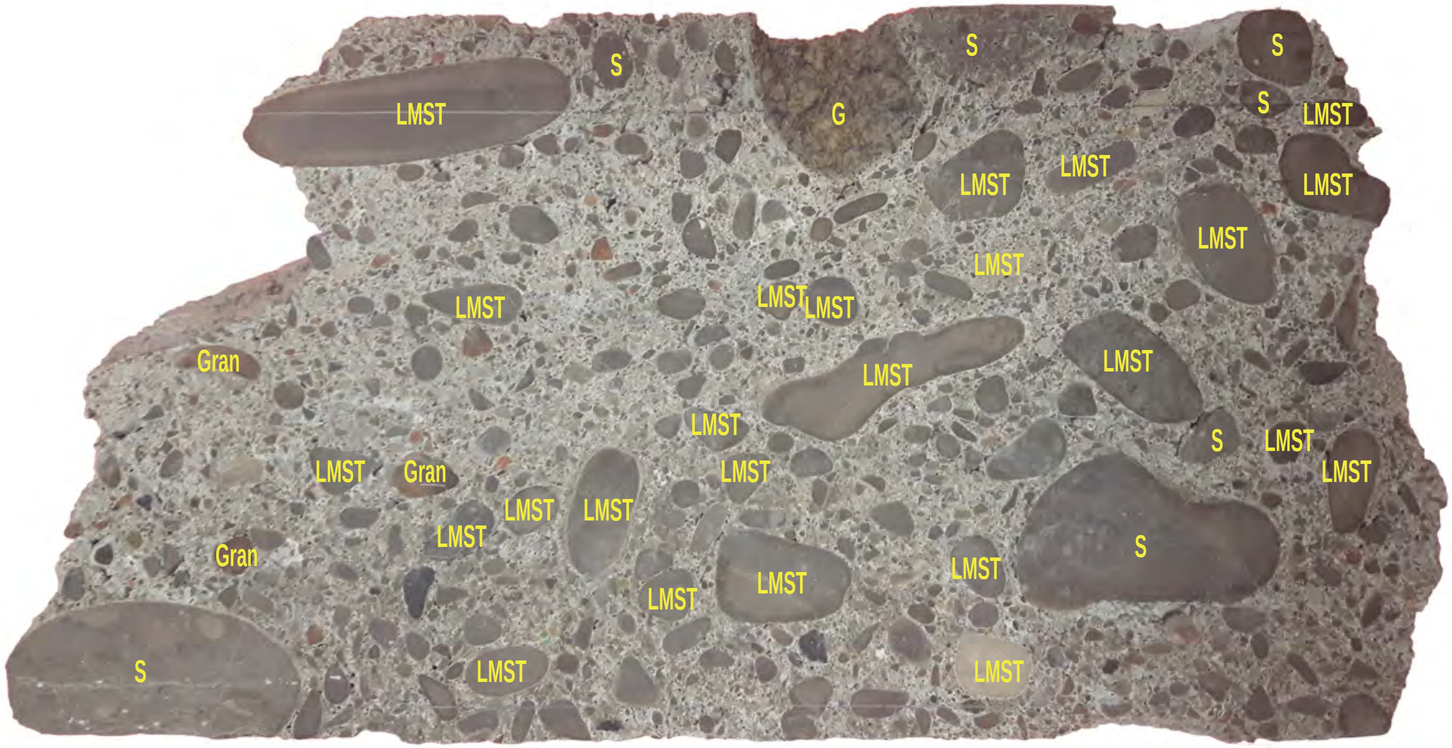
ENCLOSURE 5

amec foster wheeler

PROJECT No: TB172011

SCALE: As Indicated

DATE : June 2017



Segement Length

0 mm | 100 mm | 200 mm | 275 mm

Distance from exposed exterior surface of the core

509 mm | 609 mm | 709 mm | 774 mm

Photograph of polished face of core HC-6 located between 509 mm and 709 mm from the exposed exterior surface of the core and measuring 200 mm long. Coarse aggregate is composed of Carbonate (crystalline LMST) - 66%, Carbonate (Siliceous S) - 25%, Gneiss (G) - 2%, and Granite (Gran) - 7%. Coarse and fine aggregate lithologies and associated distress found within core HC-3 and core HC-6 were common among chert, carbonate containing silicified fossil fragments and gneiss particles. High percentage of irregular shaped, elongate and interconnected entrapped voids are seen with orientation strongly associated with cement paste-aggregate particle perimeters. Generally, the concrete of HC-6 appears in good condition with trace signs of deterioration attributed to ASR such as cracking and silica gel observed in several macro-cracks and entrapped voids within this Talbot Dam core.

PETROGRAPHIC EXAMINATION AND DAMAGE RATING INDEX
TALBOT DAM AT LOCK 38
GAMEBRIDGE, CITY OF KAWARTHA LAKES, ONTARIO

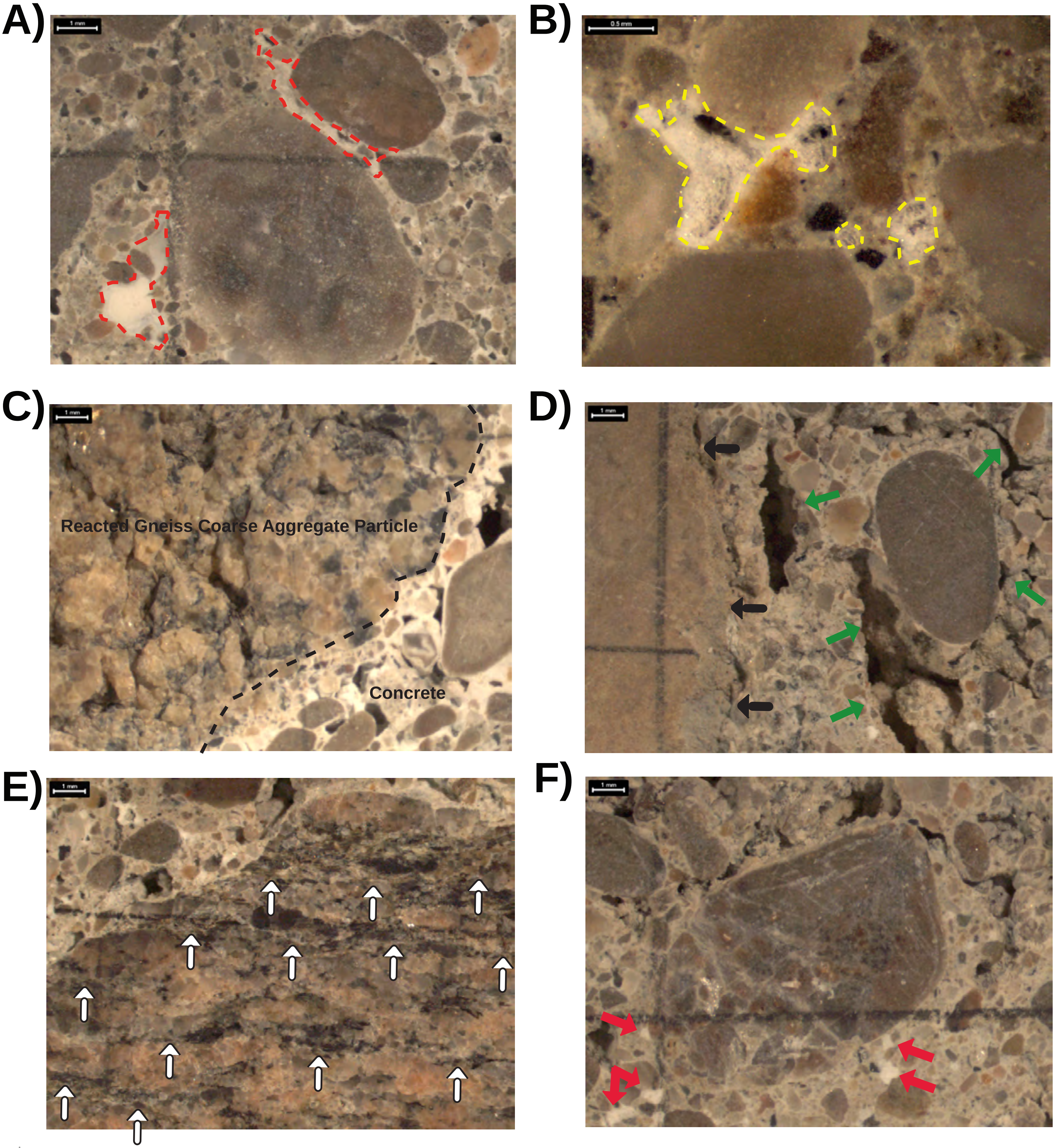
ENCLOSURE 6

amec foster wheeler

PROJECT No: TB172011

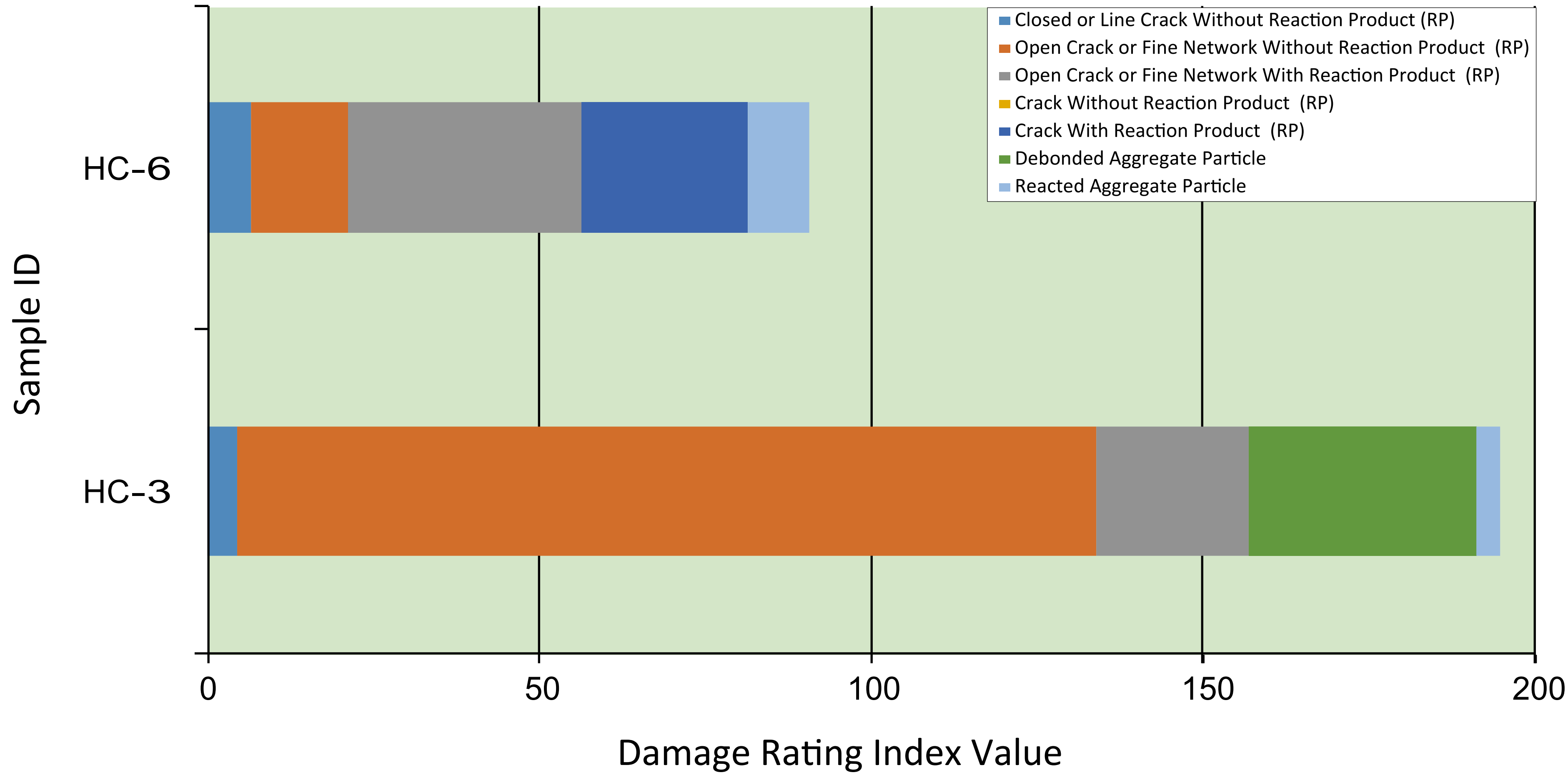
SCALE: As Indicated

DATE : June 2017



Photomicrographs of polished face of Talbot Dam cores HC-3 and HC-6, showing A) alkali silica gel within cement paste - aggregate interface adjacent to Carbonate (crystalline) denoted by red dashed lines. Secondary mineralization was observed within HC-3 confirmed by B) white ettringite needles within the body of the cement paste and along the cement paste - aggregate interface (yellow dashed lines). Photograph C) displays a reactive gneiss coarse aggregate particle with boundery with concrete denoted by dashed black line. Photograph D) shows debonding of very fine grained sandstone coarse aggregate that measured approximately 50 mm wide (black arrows) and elongate entrapped voids (green arrows). Gneiss particle E) approximately 30 mm wide exhibiting a high frequency of open cracks (white arrows). Photograph F) shows the presence of silica gel (red arrows) within cracks of a siliceous carbonate particle that extend from the partilce into the cement paste.

PETROGRAPHIC EXAMINATION AND DAMAGE RATING INDEX TALBOT DAM AT LOCK 38 GAMEBRIDGE, CITY OF KAWARTHA LAKES, ONTARIO		
ENCLOSURE 7		amec foster wheeler
PROJECT No.: TB172011		
SCALE: As indicated	DATE: June 2017	



Sample ID	Cracks in Aggregate Partilces			Cracks in Cement Paste				Observations			Total
	Closed or Line Crack Without RP	Open Crack or Fine Network Without RP	Open Crack or Fine Network With RP	Crack Without RP	Crack With RP	Debonded Aggregate Particle	Reacted Aggregate Particle	Reaction Rim	Air Void With RP	RP Impregnated Cement Paste	
HC-3	5	130	23	0	0	34	4				195
HC-6	6	15	35	0	25	0	9				91

Results of determination of the damage rating index based on Fournier, B., Fecteau, P-L., Villeneuve, V., Tremblay, S., and L. Sanchez. 2015. “Description of Petrographic Features of Damage in Concrete used in the Determination of the Damage Rating Index (DRI)”, Universite Laval.

Limited Signs of Deterioration
DRI values up to 200/250

Moderate Signs of Deterioration
DRI values between 400 and 700/750

Fair to Moderate Signs of Deterioration
DRI values between 200/250 to 400

Severe Signs of Deterioration
DRI values between greater than 700/750

PETROGRAPHIC EXAMINATION AND DAMAGE RATING INDEX
TALBOT DAM - LOCK 38
GAMEBRIDGE, CITY OF KAWARTHA LAKES, ONTARIO

FIGURE 1

amec foster wheeler

PROJECT No: TB172011

SCALE: As Indicated | **DATE : June 2017**

APPENDIX G

PHOTOGRAPHS OF CONCRETE HORIZONTAL CORE SAMPLES

TOP

BOTTOM

Photo of Horizontal Core 1. Recovery 52cm. New concrete capping (angular aggregate) to 37cm depth. Broken concrete below with rounded aggregate and high air void content.

TOP

BOTTOM

Photo of Horizontal Core 2. Recovery 27cm. Newer concrete to 27cm. Double rebar at 12cm depth. Broken concrete, sand and wood fragments at bottom of core.

TOP

BOTTOM

Photo of Horizontal Core 3. Recovery 62cm. Evidence of segregation, rounded aggregate, high air void content and yellow staining on fractures.

DownUnder Geotechnical Limited

PHOTOGRAPHS OF CONCRETE HORIZONTAL CORE SAMPLES

TOP

BOTTOM

Photo of Horizontal Core 4. Recovery 64cm. Fine aggregate to 6cm. Rounded aggregate.

TOP

BOTTOM

Photo of Horizontal Core 5. Recovery 64cm. Broken concrete, rounded aggregate, high air void content.

TOP

BOTTOM

Photo of Horizontal Core 6. Recovery 70cm. Fine aggregate to 6cm. Rounded aggregate and high air void content.

DownUnder Geotechnical Limited

PHOTOGRAPHS OF ROCK AND CONCRETE CORE SAMPLES

TOP

Photo of Concrete and Rock Cores from Borehole V-1.

DownUnder Geotechnical Limited

PHOTOGRAPHS OF ROCK AND CONCRETE CORE SAMPLES

Photo of Concrete and Rock Cores from Borehole V-2.

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PHOTOGRAPHS OF ROCK AND CONCRETE CORE SAMPLES

Weak concrete matrix.

Bonded Concrete-Rock Interface.

Wood encountered in concrete in Run 7.

Evidence of segregation.

White and black staining at concrete joint.

Photo of Concrete and Rock Cores from Borehole V-2.

DownUnder Geotechnical Limited

PHOTOGRAPHS OF ROCK AND CONCRETE CORE SAMPLES

Photo of Concrete and Rock Cores from Borehole V-3.

Evidence of segregation.

DownUnder Geotechnical Limited

PHOTOGRAPHS OF ROCK AND CONCRETE CORE SAMPLES

TOP

Photo of Concrete and Rock Cores from Borehole V-4.

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PHOTOGRAPHS OF ROCK AND CONCRETE CORE SAMPLES

TOP

Photo of Concrete and Rock Cores from Borehole V-5.

Wood encountered in concrete at top of Run 5.

DownUnder Geotechnical Limited

PHOTOGRAPHS OF ROCK CORE SAMPLES

TOP
RUN1
RUN2
RUN3

Photo of Rock Cores from Borehole DS-1.

TOP
RUN1
RUN3

Photo of Rock Cores from Borehole DS-2.

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PHOTOGRAPHS OF ROCK CORE SAMPLES

TOP

RUN1

RUN2

RUN3

Photo of Rock Cores from Borehole DS-3.

TOP

RUN1

RUN2

RUN3

Photo of Rock Cores from Borehole DS-4.

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PHOTOGRAPHS OF ROCK CORE SAMPLES

TOP

Photo of Rock Cores from Borehole DS-5.

TOP

Photo of Rock Cores from Borehole SP-1.

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PHOTOGRAPHS OF ROCK CORE SAMPLES

TOP
RUN1
RUN2
RUN3

Photo of Rock Cores from Borehole US-1.

TOP
RUN1
RUN2
RUN3

Photo of Rock Cores from Borehole US-2.

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PHOTOGRAPHS OF ROCK CORE SAMPLES

TOP

RUN1

RUN2 RUN3

Photo of Rock Cores from Borehole US-3.

TOP

RUN1

RUN2

RUN3

Photo of Rock Cores from Borehole US-4.

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PHOTOGRAPHS OF ROCK CORE SAMPLES

TOP

RUN3

Photo of Rock Cores from Borehole US-5.

APPENDIX H

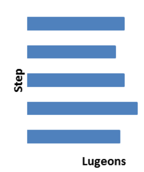
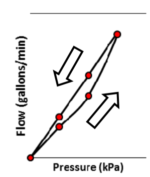
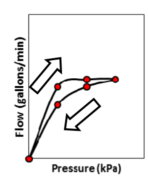
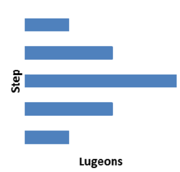
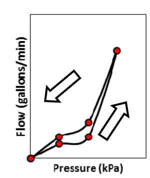
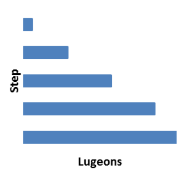
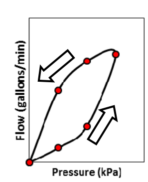
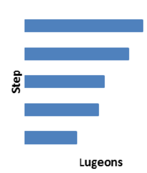
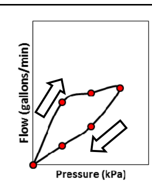
SUMMARY OF PACKER TEST RESULTS

Borehole No.	Depth	Classification	Condition of Rock Mass Discontinuties	Flow Type	Lugeons	Hydraulic Conductivity (cm/s)
V-2	8.8-10.3m	Very Low	Very Tight	Dilation	0.6	6.00×10^{-6}
V-3	8.8-10.3m	High	Many Open	Laminar	51.1	4.93×10^{-4}
V-4	9.5-11.0m	Very Low	Very Tight	n/a	0.0	$<1.0 \times 10^{-5}$
V-5	9.2-10.7m	Moderate	Few Partly Open	Dilation	10.0	9.70×10^{-5}
DS-1	2.3-3.8m	Low	Tight	Laminar	3.6	3.46×10^{-5}
DS-2	1.6-3.1m	Very High	Open Closely Spaced or Voids	Dilation	106.2	1.03×10^{-3}
DS-3	1.8-2.7m	Very High	Open Closely Spaced or Voids	Turbulent	242.2	2.02×10^{-3}
DS-4	2.0-2.9m	Very High	Open Closely Spaced or Voids	Wash-out	173.2	1.44×10^{-3}
DS-5	7.6-9.1m	Very Low	Very Tight	n/a	0.0	$<1.0 \times 10^{-5}$
US-1	6.9-8.4m	Very Low	Very Tight	n/a	0.0	$<1.0 \times 10^{-5}$
US-2	5.7-7.3m	Very High	Open Closely Spaced or Voids	Turbulent	143.4	1.38×10^{-3}
US-3	6.4-7.9m	-	-	-	-	-
US-4	5.7-6.6m	Very Low	Very Tight	Dilation	0.9	7.67×10^{-6}
US-5	7.2-8.7m	Moderate	Few Partly Open	Dilation	6.8	6.59×10^{-5}

PACKER TEST RESULTS CLASSIFICATIONS

Lugeon Range	Classification	Hydraulic Conductivity Range (cm/s)	Condition of Rock Mass Discontinuities	Reporting Precision (Lugeons)
<1	Very Low	$<1 \times 10^{-5}$	Very Tight	<1
1 to 5	Low	1×10^{-5} to 6×10^{-5}	Tight	± 0
5 to 15	Moderate	6×10^{-5} to 2×10^{-4}	Few Partly Open	± 1
15 to 50	Medium	2×10^{-4} to 6×10^{-4}	Some Open	± 5
50 to 100	High	6×10^{-4} to 1×10^{-3}	Many Open	± 10
>100	Very High	$> 1 \times 10^{-3}$	Open closely spaced or voids	>100

(Quiňones-Rozo, 2010)

Behaviour	Lugeon Pattern	Flow vs Pressure Pattern	Representative Lugeon Value
Laminar			Average of Lugeon values for all steps
Turbulent			Lugeon value corresponding to the highest water pressure
Dilation			Lowest Lugeon value recorded, corresponding either to low or medium water pressure
Wash-out			Highest Lugeon value recorded
Void Filling			Final Lugeon value

(Houlsby, 1976)

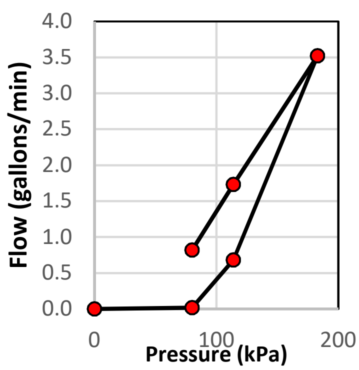
Lugeon Test Analysis Report

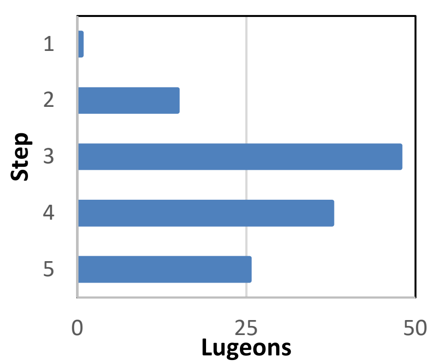
Project: Dam at Lock 38, Trent Severn Waterway

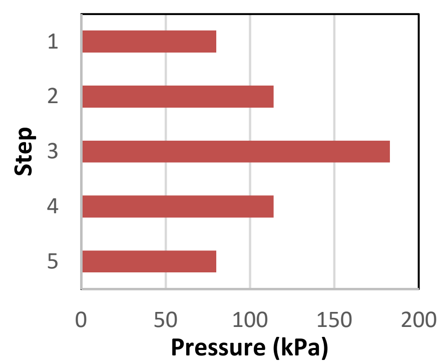
Ref. No.: D17105A

Borehole No. V-2	Field Testing by: Rory Watson
Depth Test Interval: 8.8 to 10.3m	Length of Test Interval: 1.52m
Elevation of Test Interval: 226.0 to 227.5m	Depth to Bedrock: 8.4m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 4.0m
Test Date: April 17, 2017	Height of Gauge above grade: 0.6m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	80	0.02	6.00E-06	0.6
2	114	0.68	1.43E-04	14.8
3	183	3.52	4.61E-04	47.8
4	114	1.73	3.64E-04	37.7
5	80	0.82	2.46E-04	25.5







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.10	0.07	0.05	0.03	0.03	0.01	0.03	0.01	0.01
2	0.67	0.59	0.71	0.66	0.70	0.73			
3	3.50	3.47	3.53	3.49	3.55	3.60	3.53		
4	1.90	1.80	1.98	1.71	1.74	1.71	1.75		
5	0.69	0.84	0.85	0.81	0.83	0.81	0.83	0.83	0.82

Classification	Very Low
Condition of Rock Mass Discontinuties	Very Tight
Flow Type	Dilation
Lugeons	0.6
Hydraulic Conductivity	6.00 E-06 cm/s

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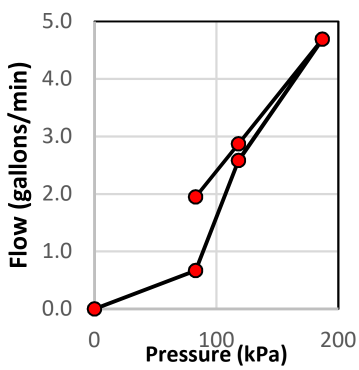
Lugeon Test Analysis Report

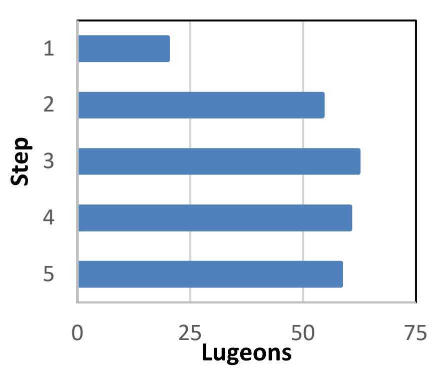
Project: Dam at Lock 38, Trent Severn Waterway

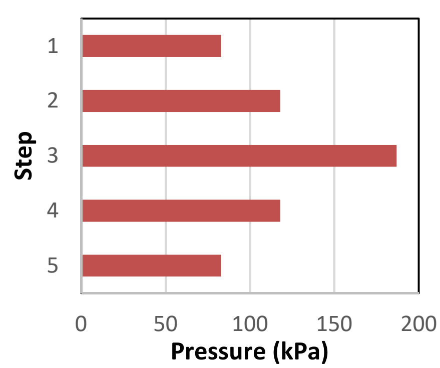
Ref. No.: D17105A

Borehole No. V-3	Field Testing by: Rory Watson
Depth Test Interval: 8.8 to 10.3m	Length of Test Interval: 1.52m
Elevation of Test Interval: 225.6 to 227.1m	Depth to Bedrock: 8.3m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 4.1m
Test Date: April 18, 2017	Height of Gauge above grade: 0.9m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	83	0.67	1.94E-04	20.0
2	118	2.58	5.25E-04	54.3
3	187	4.69	6.02E-04	62.3
4	118	2.87	5.83E-04	60.4
5	83	1.95	5.64E-04	58.3







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.79	0.67	0.65	0.67	0.66	0.66	0.59		
2	2.49	2.43	2.48	2.57	2.50	2.67	2.46	2.93	2.67
3	5.02	4.61	4.68	4.65	4.80	4.75	4.60	4.71	
4	3.04	2.77	2.93	2.86	2.91	2.87	2.82	2.91	
5	1.04	1.92	1.98	1.97	1.91				

Classification	High
Condition of Rock Mass Discontinuties	Many Open
Flow Type	Laminar
Lugeons	51.1
Hydraulic Conductivity	4.93 E-04 cm/s

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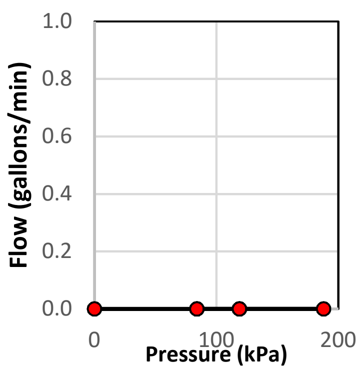
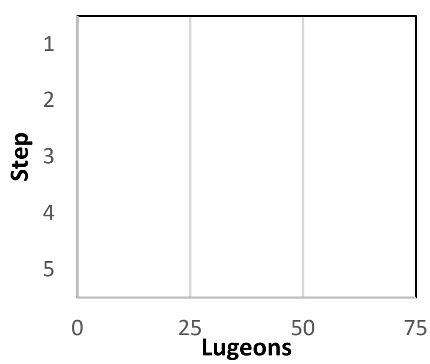
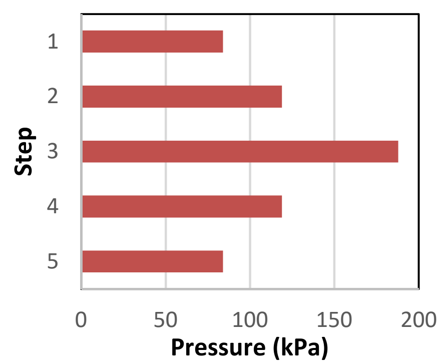
Lugeon Test Analysis Report

Lugeon Test Analysis Report	
Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. V-4	Field Testing by: Rory Watson
Depth Test Interval: 9.5 to 11.0m	Length of Test Interval: 1.52m
Elevation of Test Interval: 225.6 to 227.1m	Depth to Bedrock: 9.0m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 4.2m
Test Date: April 17, 2017	Height of Gauge above grade: 0.9m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	84	0.00	n/a	0.0
2	119	0.00	n/a	0.0
3	188	0.00	n/a	0.0
4	119	0.00	n/a	0.0
5	84	0.00	n/a	0.0







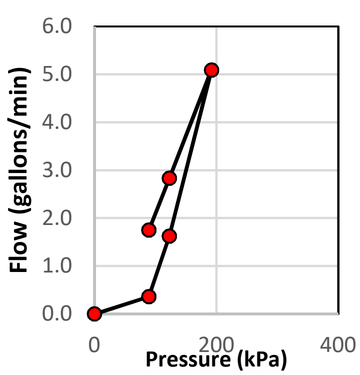
Flow Rate Readings (gallons/minute)

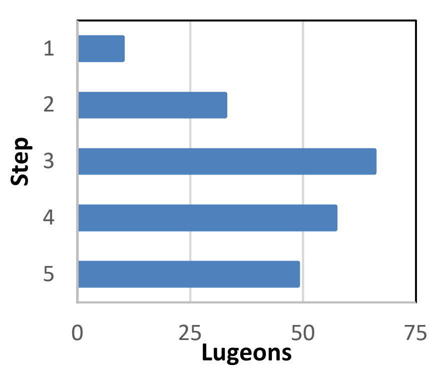
Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.00	0.00	0.00	0.00					
2	0.00	0.00	0.00	0.00	0.00				
3	0.00	0.00	0.00	0.00	0.00				
4	0.00	0.00	0.00	0.00	0.00				
5	0.00	0.00	0.00	0.00	0.00				

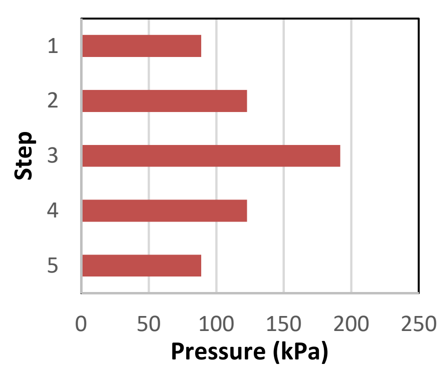
Classification	Very Low
Condition of Rock Mass Discontinuties	Very Tight
Flow Type	n/a
Lugeons	0
Hydraulic Conductivity	<1.0 E-05 cm/s

Lugeon Test Analysis Report	
Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. V-5	Field Testing by: Rory Watson
Depth Test Interval: 9.2 to 10.7m	Length of Test Interval: 1.52m
Elevation of Test Interval: 225.6 to 227.1m	Depth to Bedrock: 8.8m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 4.1m
Test Date: April 18, 2017	Height of Gauge above grade: 1.4m

Step	Pressure (kPa)	Average Flow Readings (gallons/min)	Hydraulic Conductivity K (cm/s)	Hydraulic Conductivity Lugeon
1	89	0.36	9.70E-05	10.0
2	123	1.62	3.16E-04	32.7
3	192	5.09	6.36E-04	65.8
4	123	2.83	5.52E-04	57.1
5	89	1.75	4.72E-04	48.8







Flow Rate Readings (gallons/minute)

Step	Minutes 1	2	3	4	5	6	7	8	9
1	0.46	0.44	0.33	0.38	0.37	0.36			
2	1.64	1.60	1.72	1.50	1.66	1.59			
3	5.44	4.87	5.10	5.00	5.09	5.03	5.09		
4	3.89	2.89	2.79	2.81	2.83	2.81			
5	1.50	1.66	1.80	1.76	1.75	1.74	1.73		

Classification	Moderate
Condition of Rock Mass Discontinuties	Few Partly Open
Flow Type	Dilation
Lugeons	10.0
Hydraulic Conductivity	9.70 E-05 cm/s

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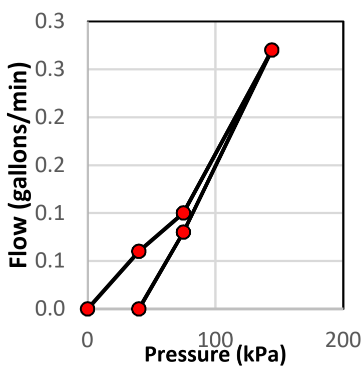
Lugeon Test Analysis Report

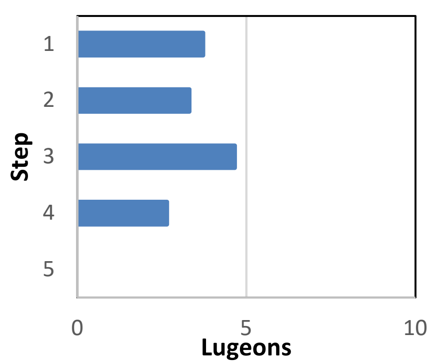
Project: Dam at Lock 38, Trent Severn Waterway

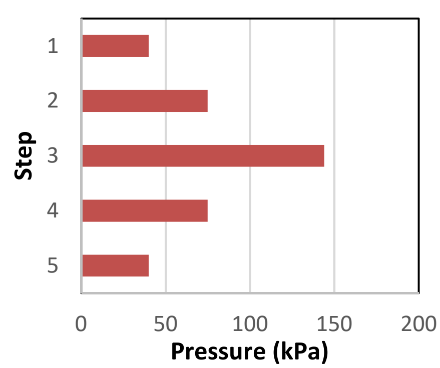
Ref. No.: D17105A

Borehole No. DS-1	Field Testing by: Rory Watson
Depth Test Interval: 2.3 to 3.8m	Length of Test Interval: 1.52m
Elevation of Test Interval: 225.1 to 226.6m	Depth to Bedrock: 2.0m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 0.1m
Test Date: March 20, 2017	Height of Gauge above grade: 0.5m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	40	0.06	3.60E-05	3.7
2	75	0.10	3.20E-05	3.3
3	144	0.27	4.50E-05	4.7
4	75	0.08	2.56E-05	2.6
5	40	0.00	n/a	n/a







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.05	0.06	0.07	0.07					
2	0.12	0.08	0.09	0.09					
3	0.23	0.28	0.28	0.27					
4	0.11	0.08	0.06	0.07					
5	0.00	0.00	0.00	0.00	0.00				

Classification	Low
Condition of Rock Mass Discontinuties	Tight
Flow Type	Laminar
Lugeons	3.6
Hydraulic Conductivity	3.46 E-05 cm/s

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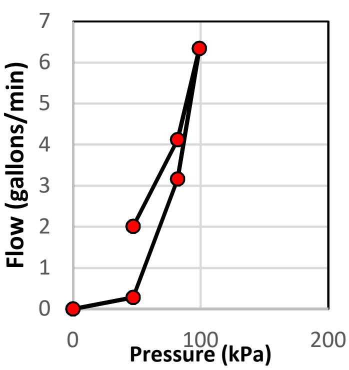
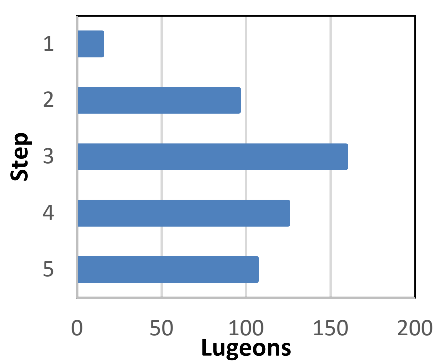
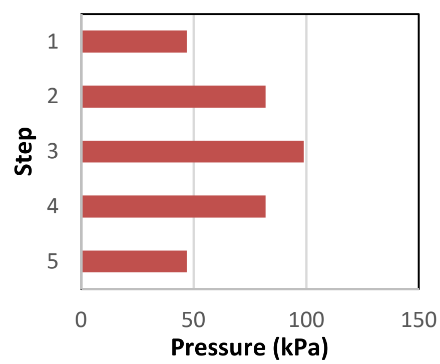
Lugeon Test Analysis Report	
Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. DS-2	Field Testing by: Andrew Loong
Depth Test Interval: 1.6 to 3.1m	Length of Test Interval: 1.52m
Elevation of Test Interval: 225.7 to 227.2m	Depth to Bedrock: 1.3m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 0m
Test Date: March 25, 2017	Height of Gauge above grade: 1.3m

Step	**Pressure**	**Average Flow**	**Hydraulic Conductivity**	
	(kPa)	**Readings (gallons/min)**	**K (cm/s)**	**Lugeon**
1	47	0.28	1.43E-04	14.8
2	82	3.16	9.24E-04	95.7
3	99	6.34	1.54E-03	159.0
4	82	4.12	1.21E-03	124.8
5	47	2.01	1.03E-03	106.2







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.44	0.25	0.26	0.22	0.24	0.24			
2	1.86	2.68	3.07	3.04	3.29	3.45	3.47	3.76	3.79
3	5.28	8.91	4.84						
4	7.20	3.77	3.68	3.85	3.83	3.64	3.92	3.84	3.35
5	1.84	2.03	2.08	1.94	2.09	2.05			

Classification	Very High
Condition of Rock Mass Discontinuties	Open Closely Spaced or Voids
Flow Type	Dilation
Lugeons	106.2
Hydraulic Conductivity	1.03 E-03 cm/s

Comment: Pressure could not be increased above 12.5 psi during testing.

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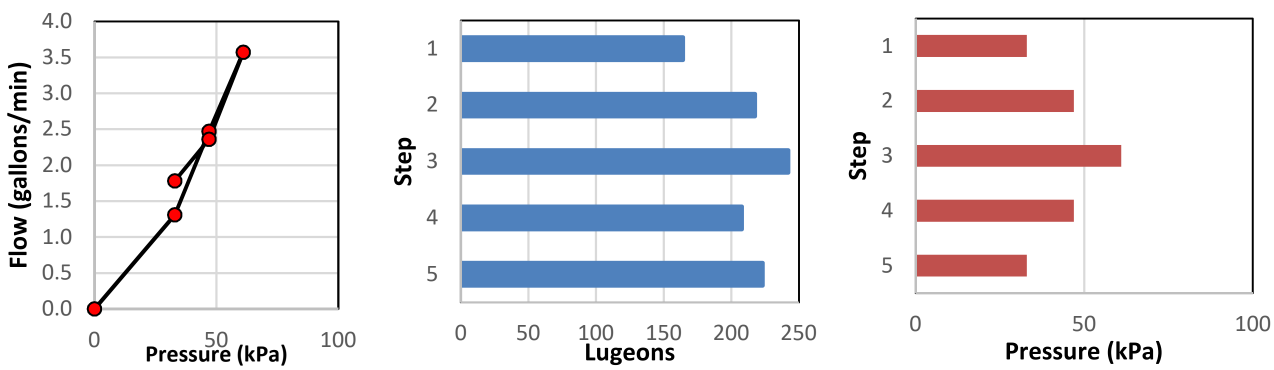
Lugeon Test Analysis Report

Project: Dam at Lock 38, Trent Severn Waterway

Ref. No.: D17105A

Borehole No. DS-3	Field Testing by: Rory Watson
Depth Test Interval: 1.8 to 2.7m	Length of Test Interval: 0.91m
Elevation of Test Interval: 226.1 to 227.0m	Depth to Bedrock: 1.2m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 0m
Test Date: March 26, 2017	Height of Gauge above grade: 1.3m

Step	Pressure (kPa)	Average Flow Readings (gallons/min)	Hydraulic Conductivity K (cm/s)	Hydraulic Conductivity Lugeon
1	33	1.31	1.37E-03	164.3
2	47	2.47	1.81E-03	217.5
3	61	3.57	2.02E-03	242.2
4	47	2.36	1.73E-03	207.8
5	33	1.78	1.86E-03	223.3



Flow Rate Readings (gallons/minute)

Step	Minutes 1	2	3	4	5	6	7	8	9
1	1.31	1.23	1.26	1.30	1.34	1.43			
2	2.39	2.46	2.39	2.59	2.51				
3	3.81	3.48	3.61	3.48	3.47				
4	1.62	2.46	2.55	2.46	2.71				
5	0.83	1.64	1.68	1.71	2.21	2.64	1.75		

Classification	Very High
Condition of Rock Mass Discontinuties	Open Closely Spaced or Voids
Flow Type	Turbulent
Lugeons	242.2
Hydraulic Conductivity	2.02 E-03 cm/s

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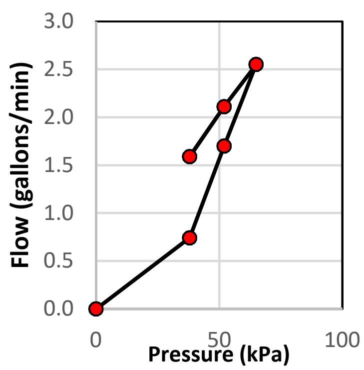
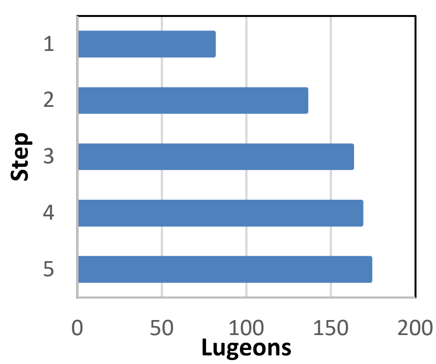
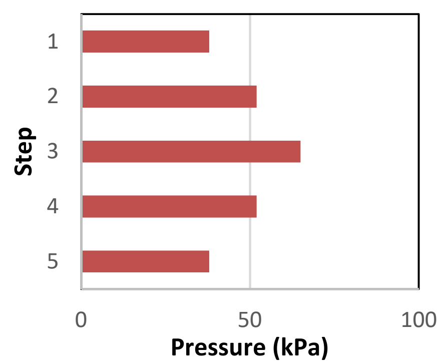
Lugeon Test Analysis Report

Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. DS-4	Field Testing by: Rory Watson
Depth Test Interval: 2.0 to 2.9m	Length of Test Interval: 0.91m
Elevation of Test Interval: 225.9 to 226.8m	Depth to Bedrock: 1.6m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 0m
Test Date: March 27, 2017	Height of Gauge above grade: 1.8m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	38	0.74	6.72E-04	80.6
2	52	1.70	1.13E-03	135.3
3	65	2.55	1.35E-03	162.4
4	52	2.11	1.40E-03	167.9
5	38	1.59	1.44E-03	173.2







Flow Rate Readings (gallons/minute)

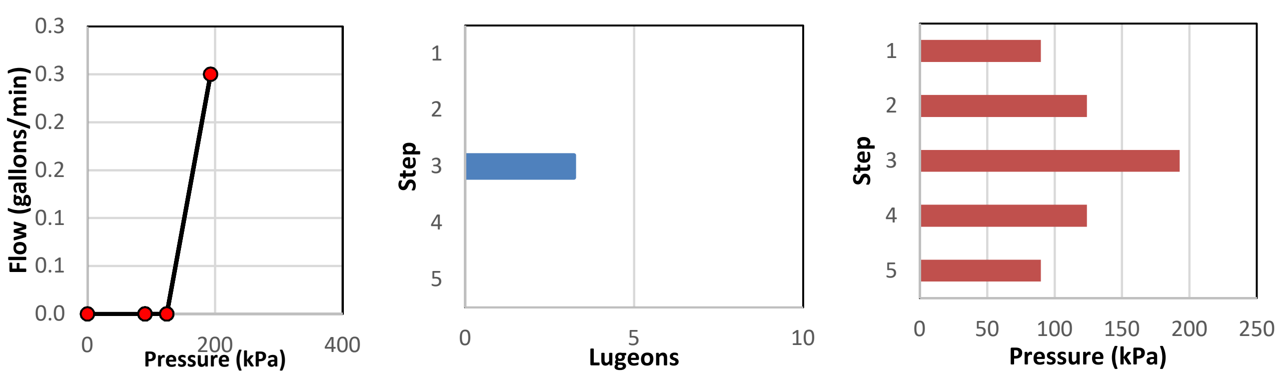
Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.71	0.72	0.72	0.84	0.70	0.76			
2	1.66	1.57	1.76	1.70	1.79				
3	2.77	2.50	2.51	2.51	2.60	2.52	2.42	2.53	
4	2.12	2.15	2.05	2.10	2.13				
5	1.64	1.54	1.62	1.58	1.65	1.48	1.62		

Classification	Very High
Condition of Rock Mass Discontinuties	Open Closely Spaced or Voids
Flow Type	Wash-out
Lugeons	173.2
Hydraulic Conductivity	1.44 E-03 cm/s

DownUnder Geotechnical Limited

Lugeon Test Analysis Report	
Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. DS-5	Field Testing by: Rory Watson
Depth Test Interval: 7.6 to 9.1m	Length of Test Interval: 1.52m
Elevation of Test Interval: 225.9 to 227.4m	Depth to Bedrock: 7.4m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 4.4m
Test Date: June 15, 2017	Height of Gauge above grade: 1.2m

Step	**Pressure**	**Average Flow**	**Hydraulic Conductivity**	
	(kPa)	**Readings (gallons/min)**	**K (cm/s)**	**Lugeon**
1	90	0.00	<1.0E-05	0.0
2	124	0.00	<1.0E-05	0.0
3	193	0.25	3.11E-05	3.2
4	124	0.00	<1.0E-05	0.0
5	90	0.00	<1.0E-05	0.0



Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.00	0.00	0.00	0.00					
2	0.00	0.00	0.00	0.00					
3	2.00	1.50	0.50	0.50	0.50	0.25	0.25	0.25	0.25
4	0.00	0.00	0.00	0.00	0.00				
5	0.00	0.00	0.00	0.00					

Classification	Very Low
Condition of Rock Mass Discontinuties	Very Tight
Flow Type	n/a
Lugeons	0
Hydraulic Conductivity	<1.0 E-05 cm/s

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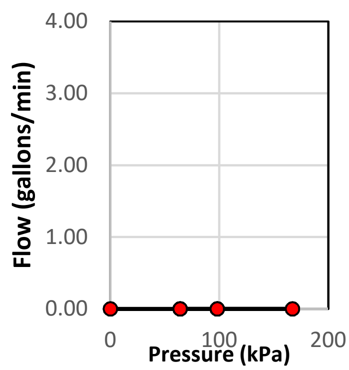
Lugeon Test Analysis Report

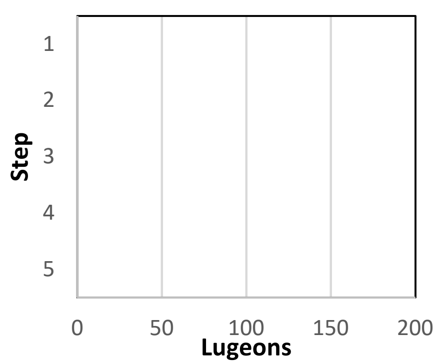
Project: Dam at Lock 38, Trent Severn Waterway

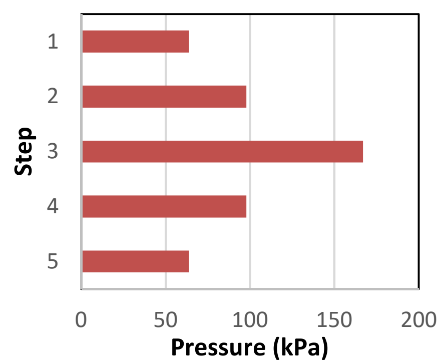
Ref. No.: D17105A

Borehole No. US-1	Field Testing by: Rory Watson
Depth Test Interval: 6.9 to 8.4m	Length of Test Interval: 1.52m
Elevation of Test Interval: 226.8 to 228.3m	Depth to Bedrock: 6.8m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 1.8m
Test Date: April 7, 2017	Height of Gauge above grade: 1.2m

Step	**Pressure**	**Average Flow**	**Hydraulic Conductivity**	
	(kPa)	**Readings (gallons/min)**	**K (cm/s)**	**Lugeon**
1	64	0.00	n/a	0.0
2	98	0.00	n/a	0.0
3	167	0.00	n/a	0.0
4	98	0.00	n/a	0.0
5	64	0.00	n/a	0.0







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.00	0.00	0.00	0.00					
2	0.00	0.00	0.00	0.00					
3	0.00	0.00	0.00	0.00					
4	0.00	0.00	0.00	0.00					
5	0.00	0.00	0.00	0.00					

Classification	Very Low
Condition of Rock Mass Discontinuties	Very Tight
Flow Type	n/a
Lugeons	0
Hydraulic Conductivity	<1.0 E-05 cm/s

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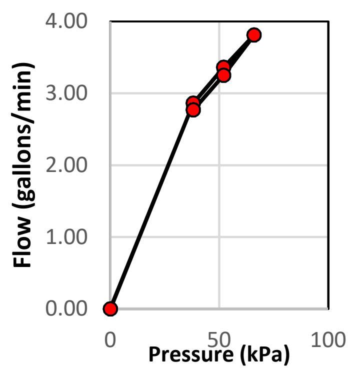
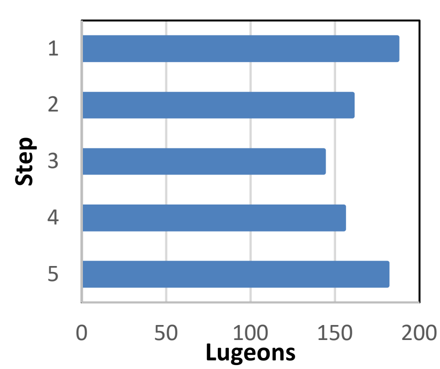
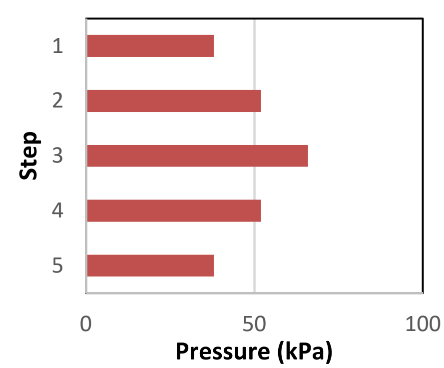
Lugeon Test Analysis Report	
Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. US-2	Field Testing by: Rory Watson
Depth Test Interval: 5.7 to 7.3m	Length of Test Interval: 1.52m
Elevation of Test Interval: 227.2 to 228.1m	Depth to Bedrock: 6.5m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 0m
Test Date: May 24, 2017	Height of Gauge above grade: 1.8m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	38	2.86	1.81E-03	186.9
2	52	3.36	1.55E-03	160.5
3	66	3.81	1.38E-03	143.4
4	52	3.25	1.50E-03	155.2
5	38	2.77	1.75E-03	181.0







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	3.25	2.77	2.99	2.70	2.73	2.82	2.78		
2	3.46	3.38	3.38	3.33	3.18	3.42			
3	4.10	3.79	3.91	3.81	3.81				
4	3.37	3.17	3.23	3.21					
5	2.85	2.71	2.84	3.08	2.48	2.71	2.73	2.79	

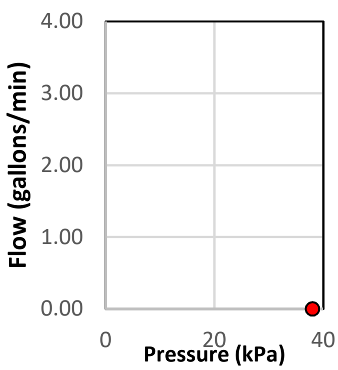
Classification	Very High
Condition of Rock Mass Discontinuties	Open Closely Spaced or Voids
Flow Type	Turbluent
Lugeons	143.4
Hydraulic Conductivity	1.38 E-03 cm/s

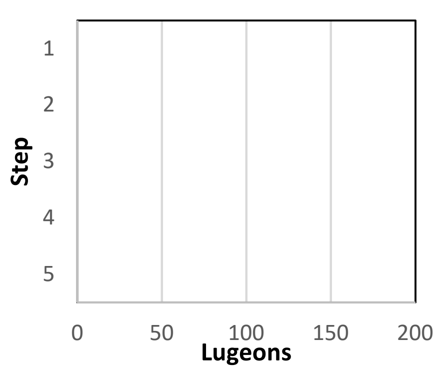
Comment: Water leakage from casing at 38 and 52 kPa pressures during testing.

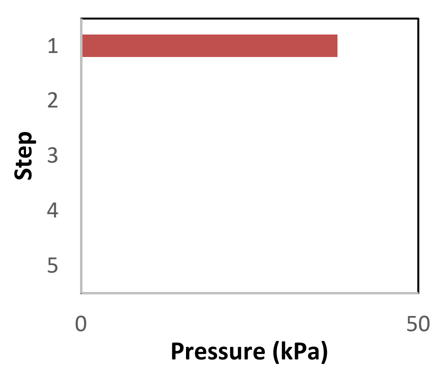
DownUnder Geotechnical Limited

Lugeon Test Analysis Report	
Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. US-3	Field Testing by: Rory Watson
Depth Test Interval: 6.4 to 7.9m	Length of Test Interval: 1.52m
Elevation of Test Interval: 226.7 to 228.2m	Depth to Bedrock: 6.2m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 0m
Test Date: May 25, 2017	Height of Gauge above grade: 1.8m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	38	n/a	n/a	n/a
2	n/a	n/a	n/a	n/a
3	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	n/a	n/a	n/a	n/a					
2	n/a	n/a	n/a	n/a					
3	n/a	n/a	n/a	n/a					
4	n/a	n/a	n/a	n/a					
5	n/a	n/a	n/a	n/a					

Classification	-
Condition of Rock Mass Discontinuties	-
Flow Type	-
Lugeons	-
Hydraulic Conductivity	-

Comment: Excessive leakage during testing from casing. Could not seal casing.

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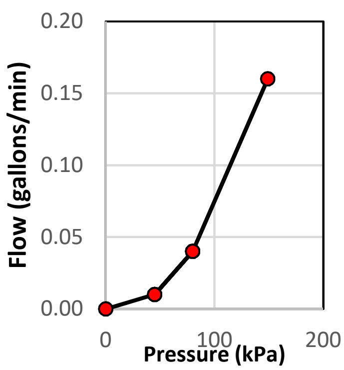
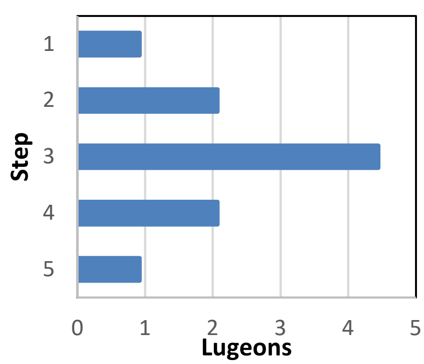
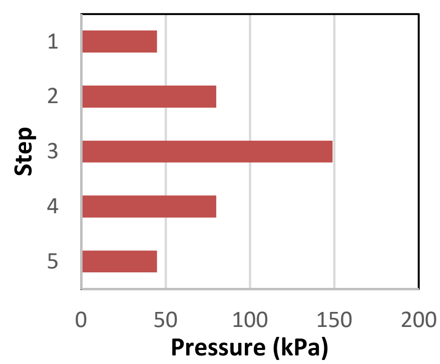
Lugeon Test Analysis Report

Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. US-4	Field Testing by: Rory Watson
Depth Test Interval: 5.7 to 6.6m	Length of Test Interval: 0.91m
Elevation of Test Interval: 227.2 to 228.1m	Depth to Bedrock: 5.2m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 0m
Test Date: April 3, 2017	Height of Gauge above grade: 1.1m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	45	0.01	7.67E-06	0.9
2	80	0.04	1.73E-05	2.1
3	149	0.16	3.71E-05	4.4
4	80	0.04	1.73E-05	2.1
5	45	0.01	7.67E-06	0.9







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.00	0.01	0.00	0.01	0.01	0.01			
2	0.17	0.06	0.06	0.03	0.04	0.02	0.02	0.02	
3	0.17	0.16	0.17	0.16	0.14	0.14			
4	0.05	0.04	0.03	0.03	0.04				
5	0.01	0.01	0.01	0.01					

Classification	Very Low
Condition of Rock Mass Discontinuties	Very Tight
Flow Type	Dilation
Lugeons	0.9
Hydraulic Conductivity	7.67 E-06 cm/s

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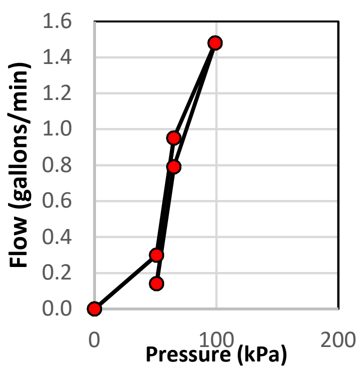
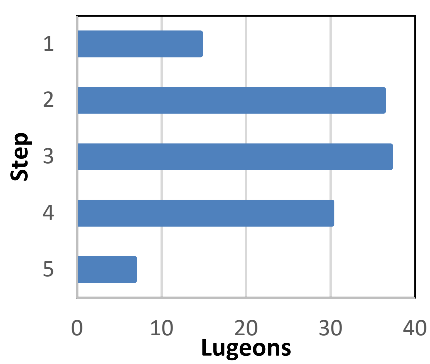
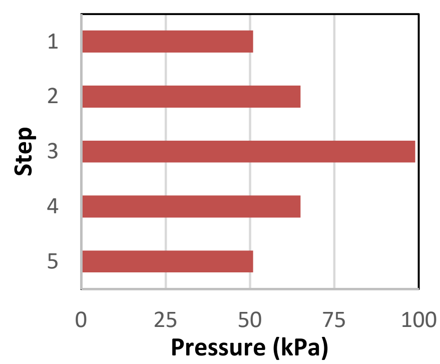
Lugeon Test Analysis Report

Project: Dam at Lock 38, Trent Severn Waterway	
Ref. No.: D17105A	
Borehole No. US-5	Field Testing by: Andrew Loong
Depth Test Interval: 7.2 to 8.7m	Length of Test Interval: 1.52m
Elevation of Test Interval: 226.6 to 228.1m	Depth to Bedrock: 6.7m
Diameter of Testhole: 7.5cm	Depth to Groundwater: 2.0m
Test Date: March 22, 2017	Height of Gauge above grade: 1.1m

Step	Pressure	Average Flow	Hydraulic Conductivity	
	(kPa)	Readings (gallons/min)	K (cm/s)	Lugeon
1	51	0.30	1.41E-04	14.6
2	65	0.95	3.51E-04	36.3
3	99	1.48	3.59E-04	37.1
4	65	0.79	2.92E-04	30.2
5	51	0.14	6.59E-05	6.8







Flow Rate Readings (gallons/minute)

Step	Minutes								
	1	2	3	4	5	6	7	8	9
1	0.26	0.33	0.35	0.32	0.31	0.31	0.28	0.30	0.28
2	0.86	0.99	0.96	1.04	0.96	0.98	0.96	0.86	0.90
3	1.29	1.42	1.34	1.44	1.39	1.50	1.70	1.78	
4	0.75	0.64	0.67	0.69	0.77	0.88	0.88	0.94	0.85
5	0.02	0.08	0.17	0.28					

Classification	Moderate
Condition of Rock Mass Discontinuties	Few Partly Open
Flow Type	Dilation
Lugeons	6.8
Hydraulic Conductivity	6.59 E-05 cm/s

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APPENDIX I

Groundwater Monitoring Summary

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater Table below existing grade (m) [Groundwater Elevation (m)]							
		April 2, 2017	April 8, 2017	April 22, 2017	May 7, 2017	May 20, 2017	May 27, 2017	June 10, 2017	June 24, 2017
V-1	235.5	2.7 [232.8]	3.6 [231.9]	2.8 [232.7]	2.3 [233.2]	2.6 [232.9]	2.5 [233.0]	2.7 [232.8]	2.6 [232.9]
V-3	235.9	4.0 [231.9]	4.4 [231.5]	4.4 [231.5]	3.6 [232.3]	4.1 [231.8]	4.4 [231.5]	4.4 [231.5]	4.5 [231.4]
V-5	236.3	4.2 [232.1]	4.3 [232.0]	4.4 [231.9]	3.8 [232.5]	4.2 [232.1]	4.5 [231.8]	4.5 [231.8]	4.6 [231.7]
SP-1	234.8	-	-	-	-	-	-	-	2.0 [232.8]
US-5	235.3	2.5 [232.8]	3.2 [232.1]	2.5 [232.8]	2.1 [233.2]	2.5 [232.8]	2.7 [232.6]	2.7 [232.6]	2.7 [232.6]
Vibrating Wire Piezometer at US-5	235.3	1.8 [234.5]	1.7 [234.6]	1.3 [234.0]	1.2 [234.1]	1.1 [234.2]	0.8 [234.5]	0.9 [234.4]	0.9 [234.4]

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater Table below existing grade (m) [Groundwater Elevation (m)]				
		February 22, 2017	March 11, 20107	March 24, 2017	April 2, 2017	April 8, 2017
DC-2	235.8	2.1 [233.7]	1.7 [234.1]	1.5 [234.3]	1.4 [234.4]	1.2 [234.6]
DC-7	234.1	-	4.5 [229.6]	4.5 [229.6]	4.4 [229.7]	4.5 [229.6]
TH13-02	235.6	-	1.4 [234.2]	1.4 [234.2]	1.5 [234.1]	1.4 [234.2]

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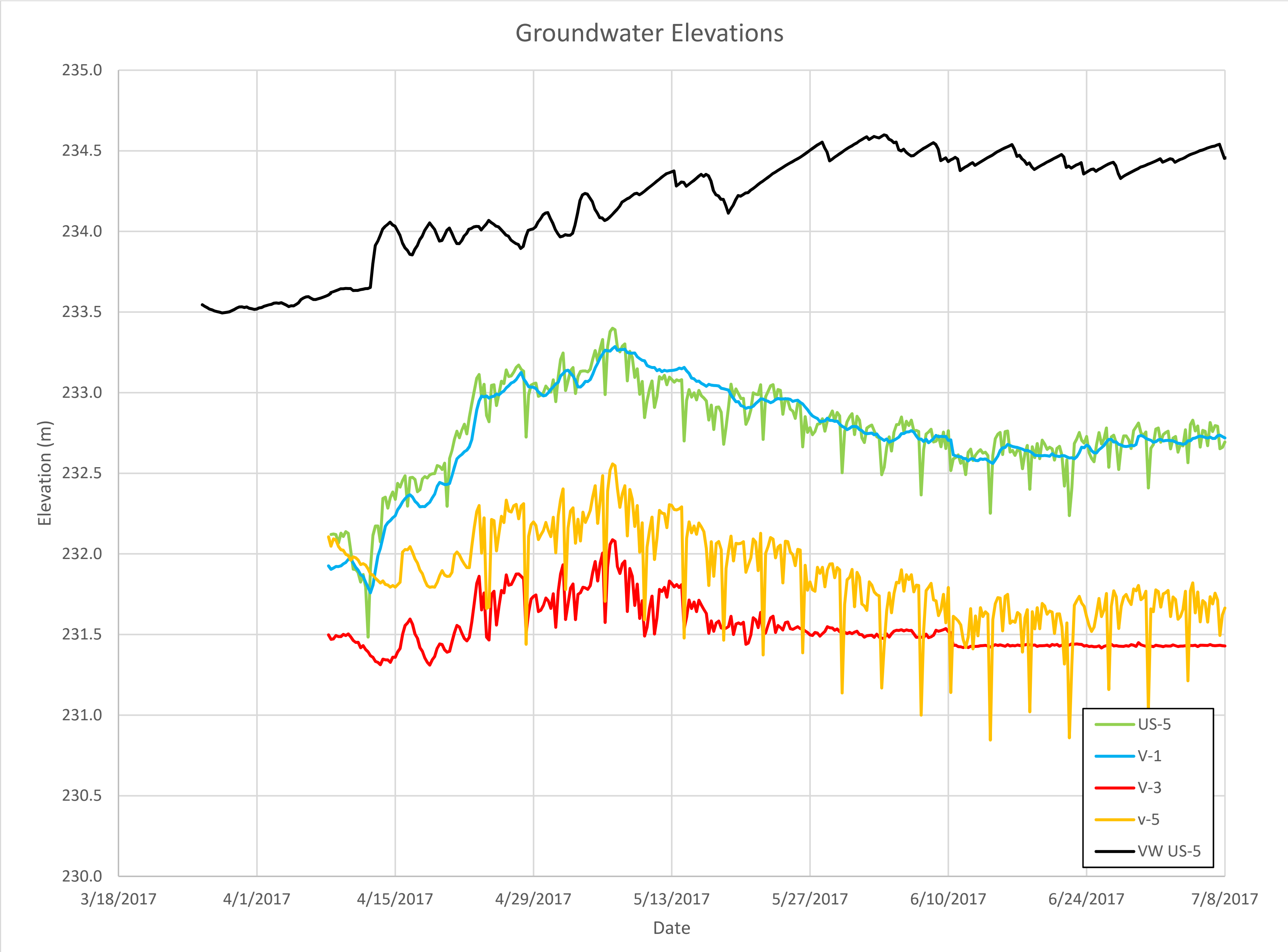
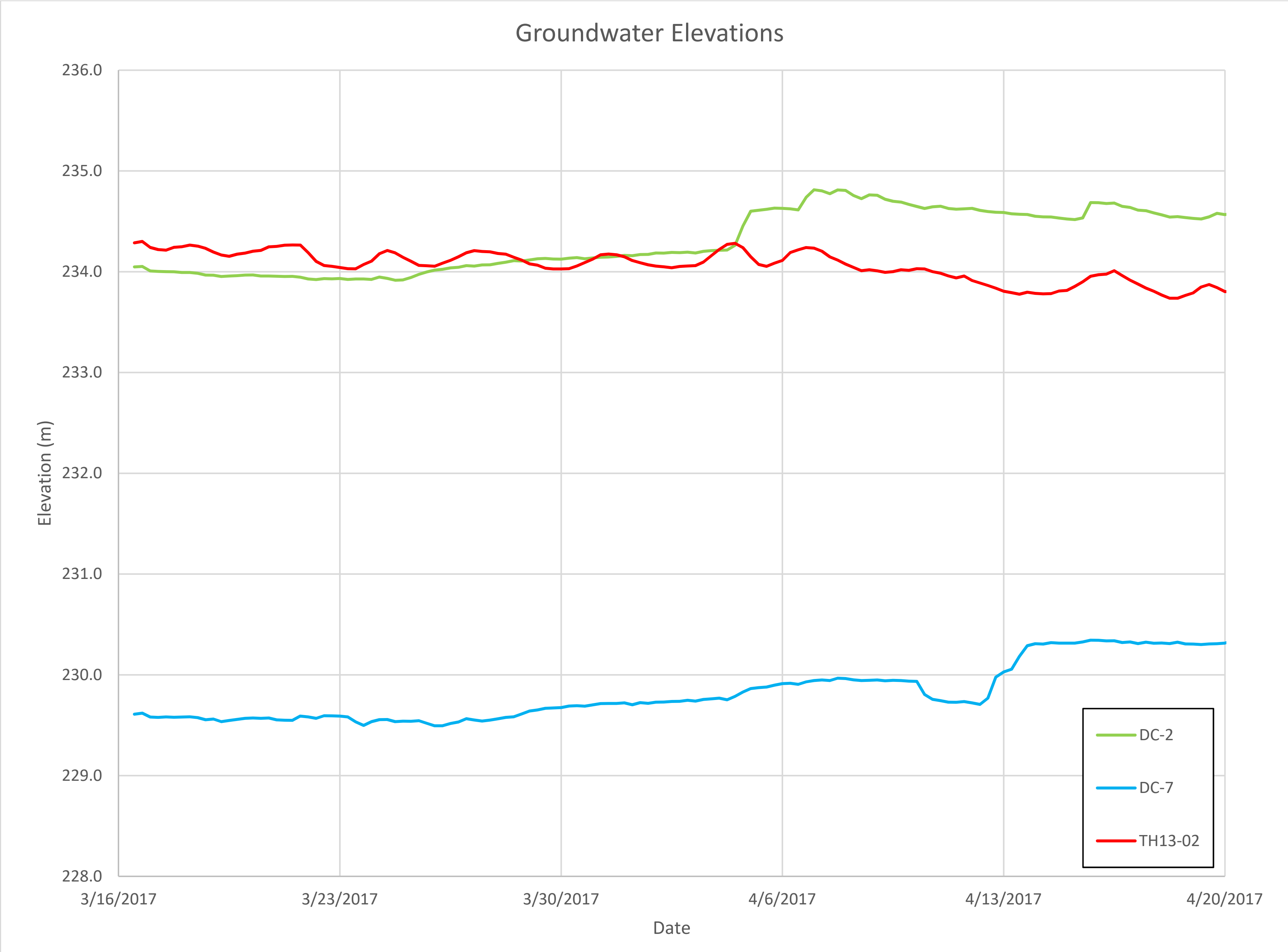


Groundwater Elevations
235.0
234.5
234.0
233.5
233.0
232.5
232.0
231.5
231.0
230.5
230.0
Elevation (m)
3/18/2017
4/1/2017
4/15/2017
4/29/2017
5/13/2017
5/27/2017
6/10/2017
6/24/2017
7/8/2017
Date
US-5
V-1
V-3
v-5
VW US-5

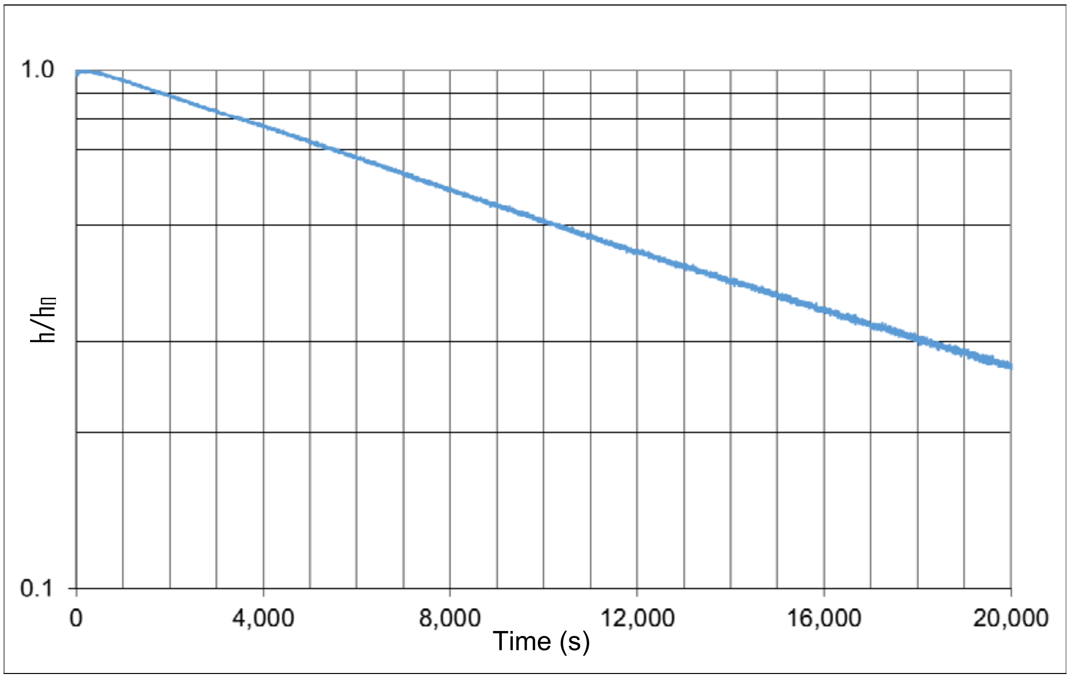

Groundwater Elevations
236.0
235.0
234.0
233.0
232.0
231.0
230.0
229.0
228.0
Elevation (m)
3/16/2017
3/23/2017
3/30/2017
4/6/2017
4/13/2017
4/20/2017
Date
DC-2
DC-7
TH13-02

RISING HEAD TEST RESULTS

Monitoring Well No. SP-1 Date: June 24, 2017

Transducer Model: Solinst 3001 Junior Levellogger

Initial Displacement: 0.72m



The hydraulic conductivity, k (m/s), was evaluated using the following expression (Hvorslev's Method).

$$k = \frac{R^2}{2LT_0} \; Ln \; \frac{L}{R}$$

Where k = hydraulic conductivity (cm/s) = **3.0 x 10^{-8} m/s**
L = saturated length of well screen = 152cm
r = well radius = 3.8 cm
T_o = basic time lag (37% recovery) = 14,650 s

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VW Piezometer Calibration Certificate

Serial #: 1603791	Part #: 52611028
Range : 350 kPa	Cable Part # : 50613524
Cable Length: 15 m	Calibrated by: AM
Date of Calibration: 11/30/2016	Note:

ABC Calibration Factors

	A	B	C
kPa	-1.076686E-4	6.833971E-3	8.697111E+2
psi	-1.561601E-5	9.911837E-4	1.261409E+2

Pressure in kPa/psi $= (A \times Hz^2) + (B \times Hz) + C$, where Hz is frequency in Hertz.

TI Calibration Factors

	C0	C1	C2	C3	C4	C5
kPa	8.691989E+2	5.068276E-3	1.805446E-1	-1.073836E-4	2.211832E-5	-1.707885E-3
psi	1.260622E+2	7.350654E-4	2.618486E-2	-1.557413E-5	3.207878E-6	-2.476991E-4

Pressure in kPa/psi $= C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + (C4 \times Hz \times T) + (C5 \times T^2)$

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
Applied pressure and temperature are NIST traceable.

Summary of Test Results at 15°C

Thermistor reading is 14.9 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

Applied (kPa)	Equivalent (psi)	Frequency (Hz)	Calculated (kPa)	Calculated (psi)	Error (%FS)
0.0	0.00	2874.0	0.0	0.00	-0.01
35.0	5.08	2816.3	35.0	5.07	0.01
70.0	10.15	2757.4	69.9	10.14	0.02
105.0	15.23	2697.1	104.9	15.22	0.02
140.0	20.31	2635.3	140.0	20.30	0.00
175.0	25.38	2572.0	175.0	25.39	-0.01
210.0	30.46	2507.2	210.0	30.46	-0.01
245.0	35.53	2440.6	245.1	35.54	-0.02
280.0	40.61	2372.3	280.0	40.61	0.00
315.0	45.69	2301.8	315.0	45.68	0.00
350.0	50.76	2229.0	350.0	50.76	0.00

Vibrating Wire Piezometers

Applications

VW piezometers are used to monitor pore-water pressure. They can also be used to monitor water levels. Typical applications include:

- Monitoring pore water pressures to determine safe rates of fill or excavation.
- Monitoring pore water pressures to determine slope stability.
- Monitoring the effects of dewatering systems used for excavations.
- Monitoring the effects of ground improvement systems such as vertical drains and sand drains.
- Monitoring pore pressures to check the performance of earth fill dams and embankments.
- Monitoring pore pressures to check containment systems at land fills and tailings dams.
- Monitoring water levels in stilling basins and weirs.

VW Piezometers: Standard, Low-Pressure, and Push-In (bottom)

Operation

The VW piezometer converts water pressure to a frequency signal via a diaphragm, a tensioned steel wire, and an electromagnetic coil.

The piezometer is designed so that a change in pressure on the diaphragm causes a change in tension of the wire. An electro-magnetic coil is used to excite the wire, which then vibrates at its natural frequency. The vibration of the wire in the proximity of the coil generates a frequency signal that is transmitted to the readout device.

The readout or data logger stores the reading in Hz. Calibration factors are then applied to the reading to arrive at a pressure in engineering units.

Types of VW Piezometers

Standard: The standard piezometer is suitable for most applications. It operates equally well in fully-grouted boreholes or sand-filter zones.

Heavy-Duty: The heavy-duty model has a strong, double-wall housing and is supplied with armored cable.

Push-In: The push-in piezometer has can be pushed a short distance into soft soils using an EW drill rod.

Multi-Level: Uses multiple sensors in a single borehole. See separate datasheet.

Low-Pressure: This piezometer is designed to monitor very small changes in pore-water pressure.

Vented: This piezometer is used to monitor water levels in open standpipes and wells. See separate datasheet.

Corrosion Resistant: A titanium body protects against corrosive environments.

Advantages

Groutable: VW piezometers can be installed in fully-grouted boreholes and do not require sand filter zones. This greatly simplifies the installation of multiple sensors in the same borehole. It also makes it possible to install piezometers with inclinometer casing within the same borehole.

High Resolution: VW piezometers provide a resolution of 0.025% FS.

High Accuracy: Slope Indicator's automated, precision calibration system ensures that these sensors meet or exceed specifications.

Rapid Response: VW piezometers respond very quickly to changes in pore-water pressure.

Reliable Signal Transmission: With properly shielded cable, signals from the VW piezometer can be transmitted long distances.

STANDARD VW PIEZOMETERS CE

3.5 bar (50 psi) Piezometer 52611020
7 bar (100 psi) Piezometer 52611030
10 bar (150 psi) Piezometer 52611060
17 bar (250 psi) Piezometer 52611040
35 bar (500 psi) Piezometer 52611050
Signal Cable 50613824

The standard VW piezometer is suitable for most applications. The piezometer can be installed without a sand filter when the borehole is backfilled with bentonite-cement grout.

VW PIEZOMETERS WITH CABLE CE

Standard VW Piezometers, 3.5 bar (50 psi)
with 15 m (50') cable 52611028
with 30 m (100') cable 52611024
with 45 m (150') cable 52611027
with 60 m (200') cable 52611026

Standard VW Piezometers, 7 bar (100 psi)
with 30 m (100') cable 52611033
with 45 m (150') cable 52611034
with 60 m (200') cable 52611035
with 90 m (300') cable 52611036

PUSH-IN VW PIEZOMETERS CE

3.5 bar (50 psi) Piezometer 52621020
7 bar (100 psi) Piezometer 52621030
10 bar (150 psi) Piezometer 52621060
17 bar (250 psi) Piezometer 52621040
35 bar (500 psi) Piezometer 52621050
Signal Cable 50613824
Adapter for EW Drill Rod. 50718042
EW Coupling 50718010

The push-in piezometer is a variant of the standard VW piezometer. It has a special housing that allows it to be pushed a short distance into soft, cohesive soils.

HEAVY-DUTY VW PIEZOMETERS

3.5 bar (50 psi) Piezometer 52610520
7 bar (100 psi) Piezometer. 52610530
10 bar (150 psi) Piezometer. 52610560
17 bar (250 psi) Piezometer. 52610540
35 bar (500 psi) Piezometer. 52610550
Signal Cable, Armored. 50613586

This piezometer features a strong double wall housing and is normally supplied with armored signal cable.

LOW-PRESSURE VW PIEZOMETERS

0.7 bar (10 psi) Piezometer 52611610
1.8 bar (25 psi) Piezometer 52611625
Signal Cable. 50613824

The low-pressure piezometer is designed to monitor very small changes in pore-water pressure. It can also be used to monitor water levels.

CORROSION-RESISTANT VW PIEZOMETERS

7 bar (100 psi) Piezometer. 52621230
17 bar (250 psi) Piezometer. 52621240
Signal Cable. 50613824

The body of the corrosion-resistant VW piezometer is manufactured of titanium while the filter and diaphragm are protected by a heat-bonded PTFE coating and a PVC housing.

VW PIEZOMETER SPECIFICATIONS

Sensor Type: Pluck-type vibrating wire sensor with built-in thermistor.

Range: Standard ranges are listed at left. Custom calibration ranges are available.

Resolution: 0.025%FS.

Accuracy: ±0.1% FS for 0.7 - 7 bar sensors, ±0.3% FS for 17 and 35 bar sensors.

Maximum Pressure: 1.5 x rated range.

Filter: 50-micron, sintered stainless steel. A ceramic 1-bar high-air entry filter can be ordered for standard and heavy-duty piezometers by specifying part number 60101240 in addition to the piezometer part number.

Temperature Coefficient: < 0.04% FS per °C).

Materials: Stainless steel.

Size: Standard: 19 x 195 mm (0.75 x 7.75")
Low-Pressure: 29 x 191 mm (1.125 x 7.5").
Heavy-Duty: 29 x 191 mm (1.125 x 7.5").
Push-In: 35 x 270 mm (1.385 x 10.5").

Weight: Standard: 0.16 kg (0.3 lb).
Low-pressure: 0.45 kg (1 lb).
Heavy-Duty: 0.8 kg (1.75 lb).
Push-in: 1.2 kg (2.75 lb).

SIGNAL CABLE SPECIFICATIONS

Signal Cable 50613824

Shielded cable with four 22-gauge tinned-copper conductors and polyvinyl chloride (PVC) jacket.

Armored Signal Cable 50613586

Shield cable with four 22-gauge tinned-copper conductors, inner polyurethane jacket, steel braid armor, and outer high-density, polyethylene jacket. For heavy duty piezometer only.

READOUT & TERMINAL BOXES

VW Data Recorder. 52613500
Jumper Cable for Terminal Box. . .52613557
Terminal Box for 6 sensors 57711606
Terminal Box for 12 Sensors 57711600
Terminal Box for 24 Sensors 97711624

See separate datasheet for VW Data Recorder. Terminal boxes provide terminals for 6, 12, or 24 sensors. Sensors are selected by rotary switch. 6-sensor box is 240 x 190 x 120 mm (9.5 x 7.5 x 4.75"). 12 and 24-sensor boxes are 290 x 345 x 135 mm (11.5 x 13.5 x 5.25").

DATA LOGGERS

VW MiniLogger for 1 Sensor 52613310
4-Channel V-Logger 52615140
Campbell Scientific Data Loggers

VW piezometers connect directly to the VW MIniLogger and V-Logger. The CR1000 requires an AVW200 vibrating wire adaptor.

www.slopeindicator.com
solutions@slope.com
Slope Indicator East 2175 West Park Court, Stone Mountain, GA USA 30087 Tel: +1-770-465-7557
Slope Indicator West 12123 Harbour Reach Drive, Mukilteo, WA, USA 98275 Tel: +1-425-493-6200

APPENDIX J

Caduceon Environmental Laboratories

Certificate of Analysis

Final Report

C.O.C:

Report No.: B17-04603

Report To:
Downunder Geotechnical
2943 Major MacKenzie Drive PO Box 96737
Maple, ON L6A 0A2
Attention: Andrew Dreivinkas
Date Received: 23 Feb, 2017
Date Reported: 1 Mar, 2017
Sample Matrix: Soil

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel.: 289-475-5442
Fax: 289-562-1963
Job/Project No.: Lock 38, Talbot ON
P.O. Number: D17105A
Waterworks No.: -

Parameter	Reference Method	Date/Site Analyzed	Table 1	Table 8	M.D.L.	Units	Diversion Channel B17-04603-1 21 Feb 2017
pH @25°C	MOEE 3137	24-Feb-17/R			-	pH Units	7.70
Conductivity @25°C	MOEE3138	24-Feb-17/R	0.57 mS/cm	0.7 mS/cm	0.07	mS/cm	0.14
Cyanide (Free)	SM4500CN	28-Feb-17/R	0.051 µg/g	0.051 µg/g	0.05	µg/g	< 0.05
Sodium Adsorption Ratio	SM 3120	27-Feb-17/O	2.4 µg/g	5 units	-	units	0.148
Antimony	EPA 200.8	28-Feb-17/R	1.3 µg/g	1.3 µg/g	0.4	µg/g	< 0.4
Arsenic	EPA 200.8	28-Feb-17/R	18 µg/g	18 µg/g	0.5	µg/g	0.7
Barium	EPA 200.8	28-Feb-17/R	220 µg/g	220 µg/g	0.4	µg/g	82.8
Beryllium	EPA 200.8	28-Feb-17/R	2.5 µg/g	2.5 µg/g	0.05	µg/g	0.71
Boron	EPA 200.8	28-Feb-17/R	36 µg/g	36 µg/g	0.5	µg/g	8.5
Cadmium	EPA 200.8	28-Feb-17/R	1.2 µg/g	1.2 µg/g	0.03	µg/g	0.09
Chromium	EPA 200.8	28-Feb-17/R	70 µg/g	70 µg/g	0.4	µg/g	24.2
Chromium (VI)	EPA3060A	27-Feb-17/R	0.66 µg/g	0.66 µg/g	0.5	µg/g	< 0.5
Cobalt	EPA 200.8	28-Feb-17/R	21 µg/g	22 µg/g	0.2	µg/g	7.3
Copper	EPA 200.8	28-Feb-17/R	92 µg/g	92 µg/g	0.4	µg/g	19.5
Lead	EPA 200.8	28-Feb-17/R	120 µg/g	120 µg/g	0.1	µg/g	5.4
Mercury	EPA7471A	23-Feb-17/R	0.27 µg/g	0.27 µg/g	0.005	µg/g	0.021
Molybdenum	EPA 200.8	28-Feb-17/R	2 µg/g	2 µg/g	0.1	µg/g	0.4
Nickel	EPA 200.8	28-Feb-17/R	82 µg/g	82 µg/g	0.4	µg/g	14.7
Selenium	EPA 200.8	28-Feb-17/R	1.5 µg/g	1.5 µg/g	0.1	µg/g	0.6
Silver	EPA 200.8	28-Feb-17/R	0.5 µg/g	0.5 µg/g	0.01	µg/g	0.06
Thallium	EPA 200.8	28-Feb-17/R	1 µg/g	1 µg/g	0.02	µg/g	0.12
Uranium	EPA 200.8	28-Feb-17/R	2.5 µg/g	2.5 µg/g	0.02	µg/g	0.49
Vanadium	EPA 200.8	28-Feb-17/R	86 µg/g	86 µg/g	0.8	µg/g	50.0
Zinc	EPA 200.8	28-Feb-17/R	290 µg/g	290 µg/g	30	µg/g	40
Acetone	EPA 8260	23-Feb-17/R	0.5 µg/g	0.5 µg/g	0.5	µg/g	< 0.5
Benzene	EPA 8260	23-Feb-17/R	0.02 µg/g	0.02 µg/g	0.02	µg/g	< 0.02
Bromodichloromethane	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Bromoform	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Bromomethane	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Carbon Tetrachloride	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Monochlorobenzene (Chlorobenzene)	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Chloroform	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dibromochloromethane	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichlorobenzene,1,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichlorobenzene,1,3-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichlorobenzene,1,4-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichlorodifluoromethane	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichloroethane,1,1-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethane,1,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethylene,1,1-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethene, cis-1,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethene, trans-1,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloropropane,1,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloropropene, cis-1,3-	EPA 8260	23-Feb-17/R			0.02	µg/g	< 0.02
Dichloropropene, trans-1,3-	EPA 8260	23-Feb-17/R			0.02	µg/g	< 0.02
Dichloropropene 1,3- cis+trans	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Ethylbenzene	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dibromoethane,1,2- (Ethylene Dibromide)	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Hexane	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Methyl Ethyl Ketone	EPA 8260	23-Feb-17/R	0.5 µg/g	0.5 µg/g	0.5	µg/g	< 0.5
Methyl Isobutyl Ketone	EPA 8260	23-Feb-17/R	0.5 µg/g	0.5 µg/g	0.5	µg/g	< 0.5
Methyl-t-butyl Ether	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichloromethane (Methylene Chloride)	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Styrene	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Tetrachloroethane,1,1,1,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Tetrachloroethane,1,1,2,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Tetrachloroethylene	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Toluene	EPA 8260	23-Feb-17/R	0.2 µg/g	0.2 µg/g	0.2	µg/g	< 0.2
Trichloroethane,1,1,1-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Trichloroethane,1,1,2-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Trichloroethylene	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Trichlorofluoromethane	EPA 8260	23-Feb-17/R	0.25 µg/g	0.25 µg/g	0.02	µg/g	< 0.02

Vinyl Chloride	EPA 8260	23-Feb-17/R	0.02 µg/g	0.02 µg/g	0.02	µg/g	< 0.02
Xylene, m,p-	EPA 8260	23-Feb-17/R			0.03	µg/g	< 0.03
Xylene, o-	EPA 8260	23-Feb-17/R			0.03	µg/g	< 0.03
Xylene, m,p,o-	EPA 8260	23-Feb-17/R	0.05 µg/g	0.05 µg/g	0.03	µg/g	< 0.03
PHC F1 (C6-C10)	CWS Tier 1	23-Feb-17/R	25 µg/g	25 µg/g	10	µg/g	< 10
PHC F2 (>C10-C16)	CWS Tier 1	28-Feb-17/R	10 µg/g	10 µg/g	5	µg/g	< 5
PHC F3 (>C16-C34)	CWS Tier 1	28-Feb-17/R	240 µg/g	240 µg/g	10	µg/g	< 10
PHC F4 (>C34-C50)	CWS Tier 1	28-Feb-17/R	120 µg/g	120 µg/g	10	µg/g	< 10
% moisture	-	23-Feb-17/R			-	%	19.0
Acenaphthene	EPA 8270	28-Feb-17/K	0.072 µg/g	0.072 µg/g	0.05	µg/g	< 0.05
Acenaphthylene	EPA 8270	28-Feb-17/K	0.093 µg/g	0.093 µg/g	0.05	µg/g	< 0.05
Anthracene	EPA 8270	28-Feb-17/K	0.16 µg/g	0.22 µg/g	0.05	µg/g	< 0.05
Benzo(a)anthracene	EPA 8270	28-Feb-17/K	0.36 µg/g	0.36 µg/g	0.05	µg/g	< 0.05
Benzo(a)pyrene	EPA 8270	28-Feb-17/K	0.3 µg/g	0.3 µg/g	0.05	µg/g	< 0.05
Benzo(b)fluoranthene	EPA 8270	28-Feb-17/K	0.47 µg/g	0.47 µg/g	0.05	µg/g	< 0.05
Benzo(k)fluoranthene	EPA 8270	28-Feb-17/K	0.48 µg/g	0.48 µg/g	0.05	µg/g	< 0.05
Benzo(g,h,i)perylene	EPA 8270	28-Feb-17/K	0.68 µg/g	0.68 µg/g	0.05	µg/g	< 0.05
Biphenyl, 1, 1-	EPA 8270	28-Feb-17/K	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Bis(2-Chloroethyl)ether	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Bis(2-Chloroisopropyl)ether	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Bis(2-ethylhexyl) Phthalate	EPA 8270	28-Feb-17/K	5 µg/g	5 µg/g	0.5	µg/g	< 0.5
Chloroaniline, 4-	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Chlorophenol, 2-	EPA 8270	28-Feb-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Chrysene	EPA 8270	28-Feb-17/K	2.8 µg/g	2.8 µg/g	0.05	µg/g	< 0.05
Dibenzo(a,h)anthracene	EPA 8270	28-Feb-17/K	0.1 µg/g	0.1 µg/g	0.05	µg/g	< 0.05
Dichlorobenzidine, 3,3'-	EPA 8270	28-Feb-17/K	1 µg/g	1 µg/g	0.05	µg/g	< 0.05
Dichlorophenol, 2,4-	EPA 8270	28-Feb-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Diethyl Phthalate	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.1	µg/g	< 0.1
Dimethyl Phthalate	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.1	µg/g	< 0.1
Dimethylphenol, 2,4-	EPA 8270	28-Feb-17/K	0.2 µg/g	0.2 µg/g	0.1	µg/g	< 0.1
Dinitrophenol, 2,4-	EPA 8270	28-Feb-17/K	2 µg/g	2 µg/g	0.1	µg/g	< 0.1
Dinitrotoluene, 2,4-	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Dinitrotoluene, 2,6-	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Fluoranthene	EPA 8270	28-Feb-17/K	0.56 µg/g	0.69 µg/g	0.05	µg/g	< 0.05
Fluorene	EPA 8270	28-Feb-17/K	0.12 µg/g	0.19 µg/g	0.05	µg/g	< 0.05
Indeno(1,2,3,-cd)pyrene	EPA 8270	28-Feb-17/K	0.23 µg/g	0.23 µg/g	0.05	µg/g	< 0.05
Methylnaphthalene,1-	EPA 8270	28-Feb-17/K	0.59 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Methylnaphthalene,2-	EPA 8270	28-Feb-17/K	0.59 µg/g	0.59 µg/g	0.05	µg/g	< 0.05
Methylnaphthalene 2-(1-)	EPA 8270	28-Feb-17/K	0.59 µg/g	0.59 µg/g	0.05	µg/g	< 0.05
Naphthalene	EPA 8270	28-Feb-17/K	0.09 µg/g	0.09 µg/g	0.05	µg/g	< 0.05
Pentachlorophenol	EPA 8270	28-Feb-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Phenanthrene	EPA 8270	28-Feb-17/K	0.69 µg/g	0.69 µg/g	0.05	µg/g	< 0.05
Phenol	EPA 8270	28-Feb-17/K	0.5 µg/g	0.5 µg/g	0.01	µg/g	< 0.01
Pyrene	EPA 8270	28-Feb-17/K	1 µg/g	1 µg/g	0.05	µg/g	< 0.05
Trichlorobenzene,1,2,4-	EPA 8270	28-Feb-17/K	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Trichlorophenol, 2,4,5-	EPA 8270	28-Feb-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Trichlorophenol 2,4,6-	EPA 8270	28-Feb-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Aldrin	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Chlordane (alpha)	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
Chlordane (Gamma)	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
Chlordane Total (alpha+gamma)	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
DDD, 2,4-	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
DDD, 4,4-	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
DDD Total	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
DDE, 2,4-	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
DDE, 4,4-	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
DDE Total	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
DDT, 2,4-	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
DDT, 4,4-	EPA 8080	1-Mar-17/K			0.05	µg/g	< 0.05
DDT Total	EPA 8080	1-Mar-17/K	1.4 µg/g	1.4 µg/g	0.05	µg/g	< 0.05
Dieldrin	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Lindane (Hexachlorocyclohexane, Gamma)	EPA 8080	1-Mar-17/K	0.01 µg/g	0.01 µg/g	0.01	µg/g	< 0.01
Endosulfan I	EPA 8080	1-Mar-17/K			0.04	µg/g	< 0.04
Endosulfan II	EPA 8080	1-Mar-17/K			0.04	µg/g	< 0.04
Endosulfan I/II	EPA 8080	1-Mar-17/K	0.04 µg/g	0.04 µg/g	0.04	µg/g	< 0.04
Endrin	EPA 8080	1-Mar-17/K	0.04 µg/g	0.04 µg/g	0.04	µg/g	< 0.04
Heptachlor	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Heptachlor Epoxide	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Hexachlorobenzene	EPA 8080	1-Mar-17/K	0.01 µg/g	0.02 µg/g	0.01	µg/g	< 0.01
Hexachlorobutadiene	EPA 8080	1-Mar-17/K	0.01 µg/g	0.01 µg/g	0.01	µg/g	< 0.01
Hexachloroethane	EPA 8080	1-Mar-17/K	0.01 µg/g	0.01 µg/g	0.01	µg/g	< 0.01
Methoxychlor	EPA 8080	1-Mar-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Poly-Chlorinated Biphenyls (PCB's)	EPA 8080	1-Mar-17/K	0.3 µg/g	0.3 µg/g	0.3	µg/g	< 0.3

M.D.L. = Method Detection Limit

Caduceon Environmental Laboratories

Certificate of Analysis
Final Report

C.O.C:

Report No.: B17-09132

Report To:
Downunder Geotechnical

2943 Major MacKenzie Drive PO Box 96737
Maple, ON L6A 0A2

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14

Richmond Hill ON L4B 1J9
Tel.: 289-475-5442

Fax: 289-562-1963

Attention: Andrew Drevininkas

Date Received: 12 Apr, 2017
Date Reported: 24 Apr, 2017

Sample Matrix: Soil

Job/Project No.: Dam at Lock 38
P.O. Number: D17105A

Waterworks No.: -

Parameter	Reference Method	Date/Site Analyzed	Table 1	Table 8	M.D.L.	Units	Downstream Cofferdam at Lock 38 B17-09132-1 06 Apr 2017
pH @25°C	MOEE 3137	17-Apr-17/R			-	pH Units	7.73
Conductivity @25°C	MOEE3138	17-Apr-17/R	0.57 mS/cm	0.7 mS/cm	0.07	mS/cm	0.13
Cyanide (Free)	SM4500CN	18-Apr-17/R	0.051 µg/g	0.051 µg/g	0.05	µg/g	< 0.05
Sodium Adsorption Ratio	SM 3120	20-Apr-17/O	2.4 µg/g	5 units	-	units	0.118
Antimony	EPA 200.8	17-Apr-17/R	1.3 µg/g	1.3 µg/g	0.4	µg/g	< 0.4
Arsenic	EPA 200.8	17-Apr-17/R	18 µg/g	18 µg/g	0.5	µg/g	< 0.5
Barium	EPA 200.8	17-Apr-17/R	220 µg/g	220 µg/g	0.4	µg/g	37.7
Beryllium	EPA 200.8	17-Apr-17/R	2.5 µg/g	2.5 µg/g	0.05	µg/g	0.29
Boron	EPA 200.8	17-Apr-17/R	36 µg/g	36 µg/g	0.5	µg/g	3.7
Cadmium	EPA 200.8	17-Apr-17/R	1.2 µg/g	1.2 µg/g	0.03	µg/g	0.07
Chromium	EPA 200.8	17-Apr-17/R	70 µg/g	70 µg/g	0.4	µg/g	12.2
Chromium (VI)	EPA3060A	18-Apr-17/R	0.66 µg/g	0.66 µg/g	0.5	µg/g	< 0.5
Cobalt	EPA 200.8	17-Apr-17/R	21 µg/g	22 µg/g	0.2	µg/g	3.0
Copper	EPA 200.8	17-Apr-17/R	92 µg/g	92 µg/g	0.4	µg/g	7.1
Lead	EPA 200.8	17-Apr-17/R	120 µg/g	120 µg/g	0.1	µg/g	2.7
Mercury	EPA7471A	18-Apr-17/R	0.27 µg/g	0.27 µg/g	0.005	µg/g	0.015
Molybdenum	EPA 200.8	17-Apr-17/R	2 µg/g	2 µg/g	0.1	µg/g	0.2
Nickel	EPA 200.8	17-Apr-17/R	82 µg/g	82 µg/g	0.4	µg/g	6.0
Selenium	EPA 200.8	17-Apr-17/R	1.5 µg/g	1.5 µg/g	0.1	µg/g	0.2
Silver	EPA 200.8	17-Apr-17/R	0.5 µg/g	0.5 µg/g	0.01	µg/g	0.02
Thallium	EPA 200.8	17-Apr-17/R	1 µg/g	1 µg/g	0.02	µg/g	< 0.02
Uranium	EPA 200.8	17-Apr-17/R	2.5 µg/g	2.5 µg/g	0.02	µg/g	0.41
Vanadium	EPA 200.8	17-Apr-17/R	86 µg/g	86 µg/g	0.8	µg/g	27.3
Zinc	EPA 200.8	17-Apr-17/R	290 µg/g	290 µg/g	30	µg/g	< 30
Acetone	EPA 8260	12-Apr-17/R	0.5 µg/g	0.5 µg/g	0.5	µg/g	< 0.5
Benzene	EPA 8260	12-Apr-17/R	0.02 µg/g	0.02 µg/g	0.02	µg/g	< 0.02
Bromodichloromethane	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Bromoform	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Bromomethane	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Carbon Tetrachloride	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Monochlorobenzene (Chlorobenzene)	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Chloroform	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dibromochloromethane	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichlorobenzene,1,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichlorobenzene,1,3-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichlorobenzene,1,4-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichlorodifluoromethane	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichloroethane,1,1-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethane,1,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethylene,1,1-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethene, cis-1,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloroethene, trans-1,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloropropane,1,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Dichloropropene, cis-1,3-	EPA 8260	12-Apr-17/R			0.02	µg/g	< 0.02
Dichloropropene, trans-1,3-	EPA 8260	12-Apr-17/R			0.02	µg/g	< 0.02
Dichloropropene 1,3- cis+trans	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Ethylbenzene	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dibromoethane,1,2- (Ethylene Dibromide)	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Hexane	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Methyl Ethyl Ketone	EPA 8260	12-Apr-17/R	0.5 µg/g	0.5 µg/g	0.5	µg/g	< 0.5
Methyl Isobutyl Ketone	EPA 8260	12-Apr-17/R	0.5 µg/g	0.5 µg/g	0.5	µg/g	< 0.5
Methyl-t-butyl Ether	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Dichloromethane (Methylene Chloride)	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Styrene	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Tetrachloroethane,1,1,1,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02

Tetrachloroethane,1,1,2,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Tetrachloroethylene	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Toluene	EPA 8260	12-Apr-17/R	0.2 µg/g	0.2 µg/g	0.2	µg/g	< 0.2
Trichloroethane,1,1,1-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Trichloroethane,1,1,2-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Trichloroethylene	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Trichlorofluoromethane	EPA 8260	12-Apr-17/R	0.25 µg/g	0.25 µg/g	0.02	µg/g	< 0.02
Vinyl Chloride	EPA 8260	12-Apr-17/R	0.02 µg/g	0.02 µg/g	0.02	µg/g	< 0.02
Xylene, m,p-	EPA 8260	12-Apr-17/R			0.03	µg/g	< 0.03
Xylene, o-	EPA 8260	12-Apr-17/R			0.03	µg/g	< 0.03
Xylene, m,p,o-	EPA 8260	12-Apr-17/R	0.05 µg/g	0.05 µg/g	0.03	µg/g	< 0.03
PHC F1 (C6-C10)	CWS Tier 1	12-Apr-17/R	25 µg/g	25 µg/g	10	µg/g	< 10
PHC F2 (>C10-C16)	CWS Tier 1	17-Apr-17/K	10 µg/g	10 µg/g	5	µg/g	< 5
PHC F3 (>C16-C34)	CWS Tier 1	17-Apr-17/K	240 µg/g	240 µg/g	10	µg/g	< 10
PHC F4 (>C34-C50)	CWS Tier 1	17-Apr-17/K	120 µg/g	120 µg/g	10	µg/g	< 10
% moisture	-	12-Apr-17/R			-	%	20.6
Acenaphthene	EPA 8270	18-Apr-17/K	0.072 µg/g	0.072 µg/g	0.05	µg/g	< 0.05
Acenaphthylene	EPA 8270	18-Apr-17/K	0.093 µg/g	0.093 µg/g	0.05	µg/g	< 0.05
Anthracene	EPA 8270	18-Apr-17/K	0.16 µg/g	0.22 µg/g	0.05	µg/g	< 0.05
Benzo(a)anthracene	EPA 8270	18-Apr-17/K	0.36 µg/g	0.36 µg/g	0.05	µg/g	< 0.05
Benzo(a)pyrene	EPA 8270	18-Apr-17/K	0.3 µg/g	0.3 µg/g	0.05	µg/g	< 0.05
Benzo(b)fluoranthene	EPA 8270	18-Apr-17/K	0.47 µg/g	0.47 µg/g	0.05	µg/g	< 0.05
Benzo(k)fluoranthene	EPA 8270	18-Apr-17/K	0.48 µg/g	0.48 µg/g	0.05	µg/g	< 0.05
Benzo(g,h,i)perylene	EPA 8270	18-Apr-17/K	0.68 µg/g	0.68 µg/g	0.05	µg/g	< 0.05
Biphenyl, 1, 1-	EPA 8270	18-Apr-17/K	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Bis(2-Chloroethyl)ether	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Bis(2-Chloroisopropyl)ether	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Bis(2-ethylhexyl) Phthalate	EPA 8270	18-Apr-17/K	5 µg/g	5 µg/g	0.5	µg/g	< 0.5
Chloroaniline, 4-	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Chlorophenol, 2-	EPA 8270	18-Apr-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Chrysene	EPA 8270	18-Apr-17/K	2.8 µg/g	2.8 µg/g	0.05	µg/g	< 0.05
Dibenzo(a,h)anthracene	EPA 8270	18-Apr-17/K	0.1 µg/g	0.1 µg/g	0.05	µg/g	< 0.05
Dichlorobenzidine, 3,3'-	EPA 8270	18-Apr-17/K	1 µg/g	1 µg/g	0.05	µg/g	< 0.05
Dichlorophenol, 2,4-	EPA 8270	18-Apr-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Diethyl Phthalate	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.1	µg/g	< 0.1
Dimethyl Phthalate	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.1	µg/g	< 0.1
Dimethylphenol, 2,4-	EPA 8270	18-Apr-17/K	0.2 µg/g	0.2 µg/g	0.1	µg/g	< 0.1
Dinitrophenol, 2,4-	EPA 8270	18-Apr-17/K	2 µg/g	2 µg/g	0.1	µg/g	< 0.1
Dinitrotoluene, 2,4-	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Dinitrotoluene, 2,6-	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.02	µg/g	< 0.02
Fluoranthene	EPA 8270	18-Apr-17/K	0.56 µg/g	0.69 µg/g	0.05	µg/g	< 0.05
Fluorene	EPA 8270	18-Apr-17/K	0.12 µg/g	0.19 µg/g	0.05	µg/g	< 0.05
Indeno(1,2,3,-cd)pyrene	EPA 8270	18-Apr-17/K	0.23 µg/g	0.23 µg/g	0.05	µg/g	< 0.05
Methylnaphthalene,1-	EPA 8270	18-Apr-17/K	0.59 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Methylnaphthalene,2-	EPA 8270	18-Apr-17/K	0.59 µg/g	0.59 µg/g	0.05	µg/g	< 0.05
Methylnaphthalene 2-(1-)	EPA 8270	18-Apr-17/K	0.59 µg/g	0.59 µg/g	0.05	µg/g	< 0.05
Naphthalene	EPA 8270	18-Apr-17/K	0.09 µg/g	0.09 µg/g	0.05	µg/g	< 0.05
Pentachlorophenol	EPA 8270	18-Apr-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Phenanthrene	EPA 8270	18-Apr-17/K	0.69 µg/g	0.69 µg/g	0.05	µg/g	< 0.05
Phenol	EPA 8270	18-Apr-17/K	0.5 µg/g	0.5 µg/g	0.01	µg/g	< 0.01
Pyrene	EPA 8270	18-Apr-17/K	1 µg/g	1 µg/g	0.05	µg/g	< 0.05
Trichlorobenzene,1,2,4-	EPA 8270	18-Apr-17/K	0.05 µg/g	0.05 µg/g	0.02	µg/g	< 0.02
Trichlorophenol, 2,4,5-	EPA 8270	18-Apr-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Trichlorophenol 2,4,6-	EPA 8270	18-Apr-17/K	0.1 µg/g	0.1 µg/g	0.02	µg/g	< 0.02
Aldrin	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Chlordane (alpha)	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
Chlordane (Gamma)	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
Chlordane Total (alpha+gamma)	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
DDD, 2,4-	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
DDD, 4,4-	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
DDD Total	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
DDE, 2,4-	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
DDE, 4,4-	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
DDE Total	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
DDT, 2,4-	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
DDT, 4,4-	EPA 8080	20-Apr-17/K			0.05	µg/g	< 0.05
DDT Total	EPA 8080	20-Apr-17/K	1.4 µg/g	1.4 µg/g	0.05	µg/g	< 0.05
Dieldrin	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Lindane (Hexachlorocyclohexane, Gamma)	EPA 8080	20-Apr-17/K	0.01 µg/g	0.01 µg/g	0.01	µg/g	< 0.01
Endosulfan I	EPA 8080	20-Apr-17/K			0.04	µg/g	< 0.04
Endosulfan II	EPA 8080	20-Apr-17/K			0.04	µg/g	< 0.04
Endosulfan I/II	EPA 8080	20-Apr-17/K	0.04 µg/g	0.04 µg/g	0.04	µg/g	< 0.04
Endrin	EPA 8080	20-Apr-17/K	0.04 µg/g	0.04 µg/g	0.04	µg/g	< 0.04
Heptachlor	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Heptachlor Epoxide	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Hexachlorobenzene	EPA 8080	20-Apr-17/K	0.01 µg/g	0.02 µg/g	0.01	µg/g	< 0.01
Hexachlorobutadiene	EPA 8080	20-Apr-17/K	0.01 µg/g	0.01 µg/g	0.01	µg/g	< 0.01
Hexachloroethane	EPA 8080	20-Apr-17/K	0.01 µg/g	0.01 µg/g	0.01	µg/g	< 0.01
Methoxychlor	EPA 8080	20-Apr-17/K	0.05 µg/g	0.05 µg/g	0.05	µg/g	< 0.05
Poly-Chlorinated Biphenyls (PCB's)	EPA 8080	20-Apr-17/K	0.3 µg/g	0.3 µg/g	0.3	µg/g	< 0.3

M.D.L. = Method Detection Limit

Provincial Water Quality Objective Parameters

Parameter	PWQO criteria	V-3 Results
Aldrin/Dieldrin	0.001 µg/L	<0.01µg/L
Alkalinity	Alkalinity should not be decreased by more than 25% of the natural concentration.	196 mg/L
Aluminum	Interim PWQO[4]: • *At pH >6.5 to 9.0, the Interim PWQO is 75 µg/L based on total aluminum measured in clay-free samples. * If natural background aluminum concentrations in water bodies unaffected by manmade inputs are greater than the numerical Interim PWQO (above), no condition is permitted that would increase the aluminum concentration in clay-free samples by more than 10% of the natural background level.	40 µg/L
Ammonia (un-ionized)	20 µg/L	<0.01 mg/L
Anthracene	0.0008 µg/L (Interim PWQO)	<0.05 µg/L
Antimony	20 µg/L	<0.5 µg/L
Arsenic	100 µg/L	4.0 µg/L
Benz[a]anthracene	0.0004 µg/L (Interim PWQO)	<0.05 µg/L
Benzene	100 µg/L	<0.5 µg/L
Benzo[g,h,i]perylene	0.00002 µg/L (Interim PWQO)	<0.05 µg/L
Benzo[k]fluoranthene	0.0002 µg/L (Interim PWQO)	<0.05 µg/L
Beryllium	**Hardness as $CaCO_3$ (mg/L)** — **PWQO (µg/L)** <75 — 11 >75 — 1100	<2 µg/L
Biphenyl	0.2 µg/L	<0.2 µg/L
Bis(2-chloroethyl) ether	200 µg/L	<0.2 µg/L
Boron	200 µg/L	49 µg/L
Bromodichloromethane	200 µg/L	<0.1 µg/L
Bromoform	60 µg/L	<0.1 µg/L
Bromomethane	0.9 µg/L	<0.3 µg/L
Cadmium	0.2 µg/L (PWQO)	<0.070 µg/L
Chlordane	0.06 µg/L	<0.05µg/L

Provincial Water Quality Objective Parameters

Chlorobenzene	15 µg/L	<0.2 µg/L
Chlorpyrifos	0.001µg/L (PWQO)	<0.5µg/L
Chromium (VI)	1 µg/L	<0.001 mg/L
Chrysene	0.0001 µg/L (Interim PWQO)	<0.05 µg/L
Cobalt	0.9 µg/L	<0.5 µg/L
Copper	5 µg/L	<0.5 µg/L
DDT & metabolites	0.003 µg/L	<1 µg/L
Diazinon	0.08 µg/L	<1µg/L
Dibenz[a,h]anthracene	0.002 µg/L (Interim PWQO)	<0.05 µg/L
Dicamba	200 µg/L	<5µg/L
Dichlorobenzene, 1,2-	2.5 µg/L	<0.1 µg/L
Dichlorobenzene, 1,3-	2.5 µg/L	<0.1 µg/L
Dichlorobenzene, 1,4-	4 µg/L	<0.2 µg/L
Dichlorobenzidine, 3,3'-	0.6 µg/L	<0.5 µg/L
Dichloroethane, 1,1-	200 µg/L	<0.1 µg/L
Dichloroethane, 1,2-	100 µg/L	<0.1 µg/L
Dichlorophenols	0.2 µg/L	<0.2 µg/L
Dichloropropane, 1,2-	0.7 µg/L	<0.1 µg/L
Dichloropropylene, trans-1,3	7 µg/L	<0.1 µg/L
Diethylene glycol	11000 µg/L	<3 mg/L
Dinitrotoluene, 2,4-	4 µg/L	<0.2 µg/L
Dinitrotoluene, 2,6-	6 µg/L	<0.2 µg/L
Diquat	0.5 µg/L	<5µg/L
Diuron	1.6 µg/L	<5µg/L
Endosulfan	0.003 µg/L (Interim PWQO)	<0.05µg/L
Endrin	0.002 µg/L (Interim PWQO)	<0.05µg/L
Escherichia coli	100 *E. coli* per 100 mL	<10 per 100mL
Ethylbenzene	8 µg/L	<0.5 µg/L
Ethylene dibromide	5 µg/L	<0.1 µg/L
Ethylene glycol	2000 µg/L (Interim PWQO)	<3 mg/L
Fluoranthene	0.0008 µg/L (Interim PWQO)	<0.05 µg/L
Fluorene	0.2 µg/L	<0.05 µg/L

Provincial Water Quality Objective Parameters

Heptachlor	0.001 µg/L	<0.01µg/L
Hexachlorobenzene	0.0065 µg/L	<0.01µg/L
Iron	300 µg/L	3,110 µg/L
Lead	**Alkalinity as $CaCO_3$ (mg/L) — PWQO (µg/L)** <20 — 5 20 to 40 — 10 40 to 80 — 20 >80 — 25	0.5 µg/L
Lindane	0.01 µg/L	<0.01µg/L
Malathion	0.1 µg/L	<5µg/L
Mercury	0.2 µg/L	<0.02 µg/L
Methoxychlor	0.04 µg/L	<0.05µg/L
Methyl ethyl ketone	400 µg/L	<1 µg/L
Methylene chloride	100 µg/L	<0.3 µg/L
Methylnaphthalene, 1-	2 µg/L	<0.05 µg/L
Methylnaphthalene, 2-	2 µg/L	<0.05 µg/L
Methyl-t-butyl ether (MTBE)	200 µg/L	<1 µg/L
Molybdenum	40 µg/L	<10 µg/L
Naphthalene	7 µg/L	<0.05 µg/L
Nickel	25 µg/L	2 µg/L
Oil & Grease	Oil or petrochemicals should not be present in concentrations that: • can be detected as a visible film, sheen, or discolouration on the surface; • can be detected by odour; • can cause tainting of edible aquatic organisms; • can form deposits on shorelines and bottom sediments that are detectable by sight or odour, or are deleterious to resident aquatic organisms.	<1.0 mg/L
Parathion	0.008 µg/L	<3µg/L
Pentachlorophenol	0.5 µg/L	<0.2 µg/L
pH CAS No. NA	6.5 - 8.5	7.75

Provincial Water Quality Objective Parameters

Phenanthrene	0.03 µg/L (Interim PWQO)	<0.05 µg/L
Phenol	5 µg/L	<0.1 µg/L
Phosphorus, total	• To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L; • A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value; • Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.	0.76mg/L
Polychlorinated biphenyls (Total PCBs)	0.001 µg/L	<0.05µg/L
Propylene glycol, 1,2-	44000 µg/L (Interim PWQO)	<3 mg/L Propylene Glycol
Propylene glycol, 1,3-	10000 µg/L (Interim PWQO)	
Selenium	100 µg/L	<5 µg/L
Silver	0.1 µg/L	<0.1 µg/L
Simazine	10 µg/L	<0.5µg/L
Styrene	4 µg/L	<0.5 µg/L
Temperature	-	10^0
Tetrachloroethane, 1,1,1,2-	20 µg/L	<0.1 µg/L
Tetrachloroethane, 1,1,2,2-	70 µg/L	<0.4 µg/L
Tetrachloroethylene	50 µg/L	<0.2 µg/L
Thallium	0.3 µg/L	<0.3 µg/L
Toluene	0.8 µg/L	<0.5 µg/L
Trichlorobenzene, 1,2,3-	0.9 µg/L	<0.2 µg/L
Trichlorobenzene, 1,2,4-	0.5 µg/L	<0.2 µg/L
Trichloroethane, 1,1,1-	10 µg/L	<0.1 µg/L
Trichloroethane, 1,1,2-	800 µg/L	<0.1 µg/L
Trichloroethylene	20 µg/L	<0.1 µg/L
Trichlorophenols	18 µg/L	<0.2 µg/L

Provincial Water Quality Objective Parameters

Trimethylbenzenes	3 µg/L	<2 µg/L
Tungsten	30 µg/L	10 µg/L
Turbidity	-	30.7
Uranium	5 µg/L	<0.3 µg/L
Vanadium	6 µg/L	<5 µg/L
Vinyl chloride	600 µg/L	<0.2 µg/L
Xylene, m-	2 µg/L	<0.4 µg/L
Xylene, o-	40 µg/	<0.1 µg/L
Xylene, p-	30 µg/L	<0.4 µg/L
Zinc	30 µg/L	6 µg/L
Zirconium	4 µg/L	<3 µg/L

CERTIFICATE OF ANALYSIS

Final Report

CADUCEON ENVIRONMENTAL LABORATORIES — Client committed. Quality assured.

C.O.C.: --- **REPORT No. B17-04603 (i)**

Report To:

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DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
pH @25°C	pH Units		MOEE 3137	24-Feb-17/R	7.70			
Conductivity @25°C	mS/cm	0.07	MOEE3138	24-Feb-17/R	0.14			
Cyanide (Free)	µg/g	0.05	SM4500CN	28-Feb-17/R	< 0.05			
Sodium Adsorption Ratio	units		SM 3120	27-Feb-17/O	0.148			
Antimony	µg/g	0.4	EPA 200.8	28-Feb-17/R	< 0.4			
Arsenic	µg/g	0.5	EPA 200.8	28-Feb-17/R	0.7			
Barium	µg/g	0.4	EPA 200.8	28-Feb-17/R	82.8			
Beryllium	µg/g	0.05	EPA 200.8	28-Feb-17/R	0.71			
Boron	µg/g	0.5	EPA 200.8	28-Feb-17/R	8.5			
Cadmium	µg/g	0.03	EPA 200.8	28-Feb-17/R	0.09			
Chromium	µg/g	0.4	EPA 200.8	28-Feb-17/R	24.2			
Chromium (VI)	µg/g	0.5	EPA3060A	27-Feb-17/R	< 0.5			
Cobalt	µg/g	0.2	EPA 200.8	28-Feb-17/R	7.3			
Copper	µg/g	0.4	EPA 200.8	28-Feb-17/R	19.5			
Lead	µg/g	0.1	EPA 200.8	28-Feb-17/R	5.4			

CBurke
Christine Burke
Lab Manager

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04603 (i)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Mercury	µg/g	0.005	EPA7471A	23-Feb-17/R	0.021			
Molybdenum	µg/g	0.1	EPA 200.8	28-Feb-17/R	0.4			
Nickel	µg/g	0.4	EPA 200.8	28-Feb-17/R	14.7			
Selenium	µg/g	0.1	EPA 200.8	28-Feb-17/R	0.6			
Silver	µg/g	0.01	EPA 200.8	28-Feb-17/R	0.06			
Thallium	µg/g	0.02	EPA 200.8	28-Feb-17/R	0.12			
Uranium	µg/g	0.02	EPA 200.8	28-Feb-17/R	0.49			
Vanadium	µg/g	0.8	EPA 200.8	28-Feb-17/R	50.0			
Zinc	µg/g	30	EPA 200.8	28-Feb-17/R	40			

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

CBurke
Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04603 (ii)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Acetone	µg/g	0.5	EPA 8260	23-Feb-17/R	< 0.5			
Benzene	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Bromodichloromethane	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Bromoform	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Bromomethane	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Carbon Tetrachloride	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Monochlorobenzene (Chlorobenzene)	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Chloroform	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dibromochloromethane	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichlorobenzene,1,2-	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Dichlorobenzene,1,3-	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Dichlorobenzene,1,4-	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Dichlorodifluoromethane	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Dichloroethane,1,1-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			

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Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
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CBurke
Christine Burke
Lab Manager

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WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Dichloroethane,1,2-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichloroethylene,1,1-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichloroethene, cis-1,2-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichloroethene, trans-1,2-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichloropropane,1,2-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichloropropene, cis-1,3-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichloropropene, trans-1,3-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Dichloropropene 1,3- cis+trans	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Ethylbenzene	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Dibromoethane,1,2- (Ethylene Dibromide)	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Hexane	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Methyl Ethyl Ketone	µg/g	0.5	EPA 8260	23-Feb-17/R	< 0.5			
Methyl Isobutyl Ketone	µg/g	0.5	EPA 8260	23-Feb-17/R	< 0.5			
Methyl-t-butyl Ether	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			

Christine Burke
Lab Manager

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Final Report

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P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Dichloromethane (Methylene Chloride)	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Styrene	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Tetrachloroethane,1,1,1,2-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Tetrachloroethane,1,1,2,2-	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Tetrachloroethylene	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Toluene	µg/g	0.2	EPA 8260	23-Feb-17/R	< 0.2			
Trichloroethane,1,1,1-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Trichloroethane,1,1,2-	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Trichloroethylene	µg/g	0.05	EPA 8260	23-Feb-17/R	< 0.05			
Trichlorofluoromethane	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Vinyl Chloride	µg/g	0.02	EPA 8260	23-Feb-17/R	< 0.02			
Xylene, m,p-	µg/g	0.03	EPA 8260	23-Feb-17/R	< 0.03			
Xylene, o-	µg/g	0.03	EPA 8260	23-Feb-17/R	< 0.03			
Xylene, m,p,o-	µg/g	0.03	EPA 8260	23-Feb-17/R	< 0.03			

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JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
PHC F1 (C6-C10)	µg/g	10	CWS Tier 1	23-Feb-17/R	< 10			
PHC F2 (>C10-C16)	µg/g	5	CWS Tier 1	28-Feb-17/R	< 5			
PHC F3 (>C16-C34)	µg/g	10	CWS Tier 1	28-Feb-17/R	< 10			
PHC F4 (>C34-C50)	µg/g	10	CWS Tier 1	28-Feb-17/R	< 10			
% moisture	%			23-Feb-17/R	19.0			

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

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Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
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CBurke
Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04603 (iii)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Acenaphthene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Acenaphthylene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Anthracene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Benzo(a)anthracene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Benzo(a)pyrene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Benzo(b)fluoranthene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Benzo(k)fluoranthene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Benzo(g,h,i)perylene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Biphenyl, 1, 1-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Bis(2-Chloroethyl)ether	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Bis(2-Chloroisopropyl)ether	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Bis(2-ethylhexyl) Phthalate	µg/g	0.5	EPA 8270	28-Feb-17/K	< 0.5			
Chloroaniline, 4-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Chlorophenol, 2-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Chrysene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			

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Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04603 (iii)**

Report To:

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2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Dibenzo(a,h)anthracene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Dichlorobenzidine, 3,3'-	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Dichlorophenol, 2,4-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Diethyl Phthalate	µg/g	0.1	EPA 8270	28-Feb-17/K	< 0.1			
Dimethyl Phthalate	µg/g	0.1	EPA 8270	28-Feb-17/K	< 0.1			
Dimethylphenol, 2,4-	µg/g	0.1	EPA 8270	28-Feb-17/K	< 0.1			
Dinitrophenol, 2,4-	µg/g	0.1	EPA 8270	28-Feb-17/K	< 0.1			
Dinitrotoluene, 2,4-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Dinitrotoluene, 2,6-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Fluoranthene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Fluorene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Indeno(1,2,3,-cd)pyrene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Methylnaphthalene,1-	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Methylnaphthalene,2-	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Methylnaphthalene 2-(1-)	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			

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Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B17-04603 (iii)

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DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Naphthalene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Pentachlorophenol	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Phenanthrene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Phenol	µg/g	0.01	EPA 8270	28-Feb-17/K	< 0.01			
Pyrene	µg/g	0.05	EPA 8270	28-Feb-17/K	< 0.05			
Trichlorobenzene,1,2,4-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Trichlorophenol, 2,4,5-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			
Trichlorophenol 2,4,6-	µg/g	0.02	EPA 8270	28-Feb-17/K	< 0.02			

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

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R.L. = Reporting Limit
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Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

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C.O.C.: --- **REPORT No. B17-04603 (iv)**

Report To:

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Attention: Andrew Drevininkas

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DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Aldrin	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
Chlordane (alpha)	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
Chlordane (Gamma)	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
Chlordane Total (alpha+gamma)	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDD, 2,4-	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDD, 4,4-	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDD Total	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDE, 2,4-	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDE, 4,4-	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDE Total	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDT, 2,4-	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDT, 4,4-	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
DDT Total	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
Dieldrin	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			

CBurke
Christine Burke
Lab Manager

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04603 (iv)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Lindane (Hexachlorocyclohexane, Gamma)	µg/g	0.01	EPA 8080	01-Mar-17/K	< 0.01			
Endosulfan I	µg/g	0.04	EPA 8080	01-Mar-17/K	< 0.04			
Endosulfan II	µg/g	0.04	EPA 8080	01-Mar-17/K	< 0.04			
Endosulfan I/II	µg/g	0.04	EPA 8080	01-Mar-17/K	< 0.04			
Endrin	µg/g	0.04	EPA 8080	01-Mar-17/K	< 0.04			
Heptachlor	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
Heptachlor Epoxide	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
Hexachlorobenzene	µg/g	0.01	EPA 8080	01-Mar-17/K	< 0.01			
Hexachlorobutadiene	µg/g	0.01	EPA 8080	01-Mar-17/K	< 0.01			
Hexachloroethane	µg/g	0.01	EPA 8080	01-Mar-17/K	< 0.01			
Methoxychlor	µg/g	0.05	EPA 8080	01-Mar-17/K	< 0.05			
Poly-Chlorinated Biphenyls (PCB's)	µg/g	0.3	EPA 8080	01-Mar-17/K	< 0.3			

Christine Burke
Lab Manager

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04603 (iv)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 01-Mar-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04603-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B17-04625 (i)

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 12-Apr-17
SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Flashpoint	°C	20.0	ASTM D93	24-Feb-17/O	> 65.0			
Cyanide (Free)	mg/L	0.005	SM 4500CN	28-Feb-17/K	< 0.005			
Fluoride	mg/L	0.1	SM 4500FD	28-Feb-17/K	< 0.1			
Nitrite (N)	mg/L	0.1	SM4110C	27-Feb-17/O	< 1			
Nitrate (N)	mg/L	0.1	SM4110C	27-Feb-17/O	< 1			
Nitrate + Nitrite (N)	mg/L	0.1	SM4110C	27-Feb-17/O	< 1			
Arsenic	mg/L	0.02	EPA 1311	28-Feb-17/R	< 0.02			
Barium	mg/L	0.05	EPA 1311	28-Feb-17/R	0.49			
Boron	mg/L	0.03	EPA 1311	28-Feb-17/R	< 0.03			
Cadmium	mg/L	0.01	EPA 1311	28-Feb-17/R	< 0.01			
Chromium	mg/L	0.04	EPA 1311	28-Feb-17/R	< 0.04			
Lead	mg/L	0.02	EPA 1311	28-Feb-17/R	< 0.02			
Mercury	mg/L	0.0005	EPA1311	02-Mar-17/R	< 0.0005			
Selenium	mg/L	0.03	EPA 1311	28-Feb-17/R	< 0.03			
Silver	mg/L	0.01	EPA 1311	28-Feb-17/R	< 0.01			
Uranium	mg/L	0.02	EPA 1311	28-Feb-17/R	< 0.02			

1 . Elevated RL due to matrix interference

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

CADUCEON ENVIRONMENTAL LABORATORIES
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C.O.C.: --- **REPORT No. B17-04625 (ii)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 12-Apr-17
SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Benzene	mg/L	0.0005	EPA 8260	27-Feb-17/O	< 0.005			
Carbon Tetrachloride	mg/L	0.0002	EPA 8260	27-Feb-17/O	< 0.002			
Monochlorobenzene (Chlorobenzene)	mg/L	0.0002	EPA 8260	27-Feb-17/O	< 0.002			
Chloroform	mg/L	0.0003	EPA 8260	27-Feb-17/O	< 0.003			
Dichlorobenzene,1,2-	mg/L	0.0001	EPA 8260	27-Feb-17/O	< 0.001			
Dichlorobenzene,1,4-	mg/L	0.0002	EPA 8260	27-Feb-17/O	< 0.002			
Dichloroethane,1,2-	mg/L	0.0001	EPA 8260	27-Feb-17/O	< 0.001			
Dichloroethene, 1,1-	mg/L	0.0001	EPA 8260	27-Feb-17/O	< 0.001			
Dichloromethane (Methylene Chloride)	mg/L	0.0003	EPA 8260	27-Feb-17/O	< 0.003			
Methyl Ethyl Ketone	mg/L	0.001	EPA 8260	27-Feb-17/O	< 0.01			
Tetrachloroethylene	mg/L	0.0002	EPA 8260	27-Feb-17/O	< 0.002			
Trichloroethylene	mg/L	0.0001	EPA 8260	27-Feb-17/O	< 0.001			
Vinyl Chloride	mg/L	0.0002	EPA 8260	27-Feb-17/O	< 0.002			

1 Elevated RL due to matrix interference

Christine Burke
Lab Manager

R.L. = Reporting Limit
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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B17-04625 (iii)

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 12-Apr-17
SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Benzo(a)pyrene	mg/L	0.0005	EPA 8270	01-Mar-17/K	< 0.0005			
Cresol, m,p,o-	mg/L	0.01	EPA 8270	01-Mar-17/K	< 0.01			
Dichlorophenol, 2,4-	mg/L	0.002	EPA 8270	01-Mar-17/K	< 0.002			
Dinitrotoluene, 2,4-	mg/L	0.002	EPA 8270	01-Mar-17/K	< 0.002			
Hexachlorobenzene	mg/L	0.001	EPA 8270	01-Mar-17/K	< 0.001			
Hexachlorobutadiene	mg/L	0.001	EPA 8270	01-Mar-17/K	< 0.001			
Hexachloroethane	mg/L	0.001	EPA 8270	01-Mar-17/K	< 0.001			
Nitrobenzene	mg/L	0.01	EPA 8270	01-Mar-17/K	< 0.01			
Pentachlorophenol	mg/L	0.002	EPA 8270	01-Mar-17/K	< 0.002			
Tetrachlorophenol, 2,3,4,6-	mg/L	0.002	EPA 8270	01-Mar-17/K	< 0.002			
Trichlorophenol, 2,4,5-	mg/L	0.002	EPA 8270	01-Mar-17/K	< 0.002			
Trichlorophenol 2,4,6-	mg/L	0.002	EPA 8270	01-Mar-17/K	< 0.002			
Poly-Chlorinated Biphenyls (PCB's)	mg/L	0.00005	EPA 8082A	27-Feb-17/R	< 0.00005			
Aroclor	-		-	27-Feb-17	-			

CBurke

Christine Burke
Lab Manager

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

CADUCEON ENVIRONMENTAL LABORATORIES

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04625 (iv)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 12-Apr-17
SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Aldrin	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Atrazine	µg/L	0.3	subcontract	03-Mar-17	< 0.3			
Atrazine (Desethyl)	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Azinphos-methyl	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
BHC (alpha)	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
BHC (beta)	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
BHC (delta)	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Bromoxynil	µg/L	10	subcontract	03-Mar-17	< 10			
Chlordane (alpha)	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Chlordane (Gamma)	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Chlorpyrifos	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Cyanazine	µg/L	0.4	subcontract	03-Mar-17	< 0.4			
Dichlorophenoxy acetic acid, 2,4- (2,4-D)	µg/L	10	subcontract	03-Mar-17	< 10			
DDD, 4,4-	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
DDE, 4,4-	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
DDT, 2,4-	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
DDT, 4,4-	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Diazinon	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Dicamba	µg/L	10	subcontract	03-Mar-17	< 10			
Dieldrin	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Dimethoate	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Dinoseb	µg/L	10	subcontract	03-Mar-17	< 10			
Diquat	µg/L	7	subcontract	03-Mar-17	< 7			

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Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B17-04625 (iv)

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 12-Apr-17
SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Endrin	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Glyphosate	µg/L	20	subcontract	03-Mar-17	< 20			
Heptachlor Epoxide	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Heptachlor	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Lindane (Hexachlorocyclohexane, Gamma)	µg/L	0.01	subcontract	03-Mar-17	< 0.01			
Malathion	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Metolachlor	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Methoxychlor	µg/L	0.06	subcontract	03-Mar-17	< 0.06			
Methyl Parathion	µg/L	0.4	subcontract	03-Mar-17	< 0.4			
Metribuzin	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Nitrosodimethylamine (NDMA)	µg/L	0.5	subcontract	03-Mar-17	< 0.5			
Nitrilotriacetic acid (NTA)	mg/L	0.5	subcontract	03-Mar-17	< 0.5			
Paraquat	µg/L	1	subcontract	03-Mar-17	< 1			
Parathion	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Phorate	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Picloram	µg/L	60	subcontract	03-Mar-17	< 60			
Simazine	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Terbufos	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Triallate	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Trifluralin	µg/L	0.2	subcontract	03-Mar-17	< 0.2			
Trichlorophenoxy acetic acid, 2,4,5-	µg/L	10	subcontract	03-Mar-17	< 10			

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES

Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04625 (iv)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 12-Apr-17
SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Trichlorophenoxypropionic acid, 2,4,5-	µg/L	10	subcontract	03-Mar-17	< 10			

1 . All analyses subcontracted to Testmark Labs

Christine Burke
Lab Manager

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B17-04625 (v)

Report To:

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2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
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Tel: 289-475-5442
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DATE RECEIVED: 23-Feb-17
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SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
2378-Tcdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total TCDFs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
12378-Pecdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
23478-Pecdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total PeCDFs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
123478-Hxcdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
123678-Hxcdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
234678-Hxcdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
123789-Hxcdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total HxCDFs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
1234678-Hpcdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
1234789-Hpcdf	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total HpCDFs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Christine Burke
Lab Manager

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DATE RECEIVED: 23-Feb-17
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SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Octachlorodibenzofuran	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
2378-Tcdd	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total TCDDs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
12378-Pecdd	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total PeCDDs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
123478-Hxcdd	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
123678-Hxcdd	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
123789-Hxcdd	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total HxCDDs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
1234678-Hpcdd	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Total HpCDDs	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Octachlorodibenzodioxin	ppq	1	E.C. 1/RM/19	12-Apr-17	< 1			
Dioxin & Furan (TEQ)	ppt		E.C. 1/RM/19	12-Apr-17	0			

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-04625 (v)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 23-Feb-17
DATE REPORTED: 12-Apr-17
SAMPLE MATRIX: Soil/Leachate

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Diversion Channel			
			Sample I.D.		B17-04625-1			
			Date Collected		21-Feb-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				

1 . All analyses subcontracted to Wellington Labs

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-09132 (i)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
pH @25°C	pH Units		MOEE 3137	17-Apr-17/R	7.73			
Conductivity @25°C	mS/cm	0.07	MOEE3138	17-Apr-17/R	0.13			
Cyanide (Free)	µg/g	0.05	SM4500CN	18-Apr-17/R	< 0.05			
Sodium Adsorption Ratio	units		SM 3120	20-Apr-17/O	0.118			
Antimony	µg/g	0.4	EPA 200.8	17-Apr-17/R	< 0.4			
Arsenic	µg/g	0.5	EPA 200.8	17-Apr-17/R	< 0.5			
Barium	µg/g	0.4	EPA 200.8	17-Apr-17/R	37.7			
Beryllium	µg/g	0.05	EPA 200.8	17-Apr-17/R	0.29			
Boron	µg/g	0.5	EPA 200.8	17-Apr-17/R	3.7			
Cadmium	µg/g	0.03	EPA 200.8	17-Apr-17/R	0.07			
Chromium	µg/g	0.4	EPA 200.8	17-Apr-17/R	12.2			
Chromium (VI)	µg/g	0.5	EPA3060A	18-Apr-17/R	< 0.5			
Cobalt	µg/g	0.2	EPA 200.8	17-Apr-17/R	3.0			
Copper	µg/g	0.4	EPA 200.8	17-Apr-17/R	7.1			
Lead	µg/g	0.1	EPA 200.8	17-Apr-17/R	2.7			

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

CBurke
Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-09132 (i)**

Report To:

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Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Mercury	µg/g	0.005	EPA7471A	18-Apr-17/R	0.015			
Molybdenum	µg/g	0.1	EPA 200.8	17-Apr-17/R	0.2			
Nickel	µg/g	0.4	EPA 200.8	17-Apr-17/R	6.0			
Selenium	µg/g	0.1	EPA 200.8	17-Apr-17/R	0.2			
Silver	µg/g	0.01	EPA 200.8	17-Apr-17/R	0.02			
Thallium	µg/g	0.02	EPA 200.8	17-Apr-17/R	< 0.02			
Uranium	µg/g	0.02	EPA 200.8	17-Apr-17/R	0.41			
Vanadium	µg/g	0.8	EPA 200.8	17-Apr-17/R	27.3			
Zinc	µg/g	30	EPA 200.8	17-Apr-17/R	< 30			

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-09132 (ii)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Acetone	µg/g	0.5	EPA 8260	12-Apr-17/R	< 0.5			
Benzene	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Bromodichloromethane	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Bromoform	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Bromomethane	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Carbon Tetrachloride	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Monochlorobenzene (Chlorobenzene)	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Chloroform	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dibromochloromethane	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichlorobenzene,1,2-	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Dichlorobenzene,1,3-	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Dichlorobenzene,1,4-	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Dichlorodifluoromethane	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Dichloroethane,1,1-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
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CBurke
Christine Burke
Lab Manager

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110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Dichloroethane,1,2-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichloroethylene,1,1-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichloroethene, cis-1,2-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichloroethene, trans-1,2-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichloropropane,1,2-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichloropropene, cis-1,3-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichloropropene, trans-1,3-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Dichloropropene 1,3- cis+trans	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Ethylbenzene	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Dibromoethane,1,2- (Ethylene Dibromide)	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Hexane	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Methyl Ethyl Ketone	µg/g	0.5	EPA 8260	12-Apr-17/R	< 0.5			
Methyl Isobutyl Ketone	µg/g	0.5	EPA 8260	12-Apr-17/R	< 0.5			

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Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
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Christine Burke
Lab Manager

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DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Methyl-t-butyl Ether	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Dichloromethane (Methylene Chloride)	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Styrene	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Tetrachloroethane,1,1,1,2-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Tetrachloroethane,1,1,2,2-	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Tetrachloroethylene	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Toluene	µg/g	0.2	EPA 8260	12-Apr-17/R	< 0.2			
Trichloroethane,1,1,1-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Trichloroethane,1,1,2-	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Trichloroethylene	µg/g	0.05	EPA 8260	12-Apr-17/R	< 0.05			
Trichlorofluoromethane	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Vinyl Chloride	µg/g	0.02	EPA 8260	12-Apr-17/R	< 0.02			
Xylene, m,p-	µg/g	0.03	EPA 8260	12-Apr-17/R	< 0.03			
Xylene, o-	µg/g	0.03	EPA 8260	12-Apr-17/R	< 0.03			

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-09132 (ii)**

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Attention: Andrew Drevininkas

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110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Xylene, m,p,o-	µg/g	0.03	EPA 8260	12-Apr-17/R	< 0.03			
PHC F1 (C6-C10)	µg/g	10	CWS Tier 1	12-Apr-17/R	< 10			
PHC F2 (>C10-C16)	µg/g	5	CWS Tier 1	17-Apr-17/K	< 5			
PHC F3 (>C16-C34)	µg/g	10	CWS Tier 1	17-Apr-17/K	< 10			
PHC F4 (>C34-C50)	µg/g	10	CWS Tier 1	17-Apr-17/K	< 10			
% moisture	%			12-Apr-17/R	20.6			

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-09132 (iii)**

Report To:

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2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Acenaphthene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Acenaphthylene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Anthracene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Benzo(a)anthracene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Benzo(a)pyrene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Benzo(b)fluoranthene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Benzo(k)fluoranthene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Benzo(g,h,i)perylene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Biphenyl, 1, 1-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Bis(2-Chloroethyl)ether	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Bis(2-Chloroisopropyl)ether	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Bis(2-ethylhexyl) Phthalate	µg/g	0.5	EPA 8270	18-Apr-17/K	< 0.5			
Chloroaniline, 4-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Chlorophenol, 2-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Chrysene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			

Christine Burke
Lab Manager

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

CERTIFICATE OF ANALYSIS

Final Report

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

C.O.C.: --- **REPORT No. B17-09132 (iii)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Dibenzo(a,h)anthracene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Dichlorobenzidine, 3,3'-	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Dichlorophenol, 2,4-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Diethyl Phthalate	µg/g	0.1	EPA 8270	18-Apr-17/K	< 0.1			
Dimethyl Phthalate	µg/g	0.1	EPA 8270	18-Apr-17/K	< 0.1			
Dimethylphenol, 2,4-	µg/g	0.1	EPA 8270	18-Apr-17/K	< 0.1			
Dinitrophenol, 2,4-	µg/g	0.1	EPA 8270	18-Apr-17/K	< 0.1			
Dinitrotoluene, 2,4-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Dinitrotoluene, 2,6-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Fluoranthene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Fluorene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Indeno(1,2,3,-cd)pyrene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Methylnaphthalene,1-	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Methylnaphthalene,2-	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Methylnaphthalene 2-(1-)	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

CBurke
Christine Burke
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
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REPORT No. B17-09132 (iii)

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Attention: Andrew Drevininkas

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Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Naphthalene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Pentachlorophenol	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Phenanthrene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Phenol	µg/g	0.01	EPA 8270	18-Apr-17/K	< 0.01			
Pyrene	µg/g	0.05	EPA 8270	18-Apr-17/K	< 0.05			
Trichlorobenzene,1,2,4-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Trichlorophenol, 2,4,5-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			
Trichlorophenol 2,4,6-	µg/g	0.02	EPA 8270	18-Apr-17/K	< 0.02			

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill
Uncertainty values available upon request

CBurke
Christine Burke
Lab Manager

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-09132 (iv)**

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Apr-17
DATE REPORTED: 24-Apr-17
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Aldrin	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
Chlordane (alpha)	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
Chlordane (Gamma)	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
Chlordane Total (alpha+gamma)	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDD, 2,4-	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDD, 4,4-	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDD Total	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDE, 2,4-	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDE, 4,4-	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDE Total	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDT, 2,4-	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDT, 4,4-	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
DDT Total	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
Dieldrin	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			

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SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Lindane (Hexachlorocyclohexane, Gamma)	µg/g	0.01	EPA 8080	20-Apr-17/K	< 0.01			
Endosulfan I	µg/g	0.04	EPA 8080	20-Apr-17/K	< 0.04			
Endosulfan II	µg/g	0.04	EPA 8080	20-Apr-17/K	< 0.04			
Endosulfan I/II	µg/g	0.04	EPA 8080	20-Apr-17/K	< 0.04			
Endrin	µg/g	0.04	EPA 8080	20-Apr-17/K	< 0.04			
Heptachlor	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
Heptachlor Epoxide	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
Hexachlorobenzene	µg/g	0.01	EPA 8080	20-Apr-17/K	< 0.01			
Hexachlorobutadiene	µg/g	0.01	EPA 8080	20-Apr-17/K	< 0.01			
Hexachloroethane	µg/g	0.01	EPA 8080	20-Apr-17/K	< 0.01			
Methoxychlor	µg/g	0.05	EPA 8080	20-Apr-17/K	< 0.05			
Poly-Chlorinated Biphenyls (PCB's)	µg/g	0.3	EPA 8080	20-Apr-17/K	< 0.3			

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SAMPLE MATRIX: Soil

JOB/PROJECT NO.: Dam at Lock 38
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Downstream Cofferdam at Lock 38			
			Sample I.D.		B17-09132-1			
			Date Collected		06-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
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nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
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Final Report

C.O.C.: ---

REPORT No. B17-10303 (i)

Report To:

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2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 24-Apr-17
DATE REPORTED: 09-May-17
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
E coli	cfu/100mL	1	SM9222B	24-Apr-17/R	< 10			
Alkalinity(CaCO3) to pH4.5	mg/L	3	SM 2320	26-Apr-17/K	196			
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	28-Apr-17/K	3.74			
Ammonia (N)-unionized	mg/L	0.01	CALC	28-Apr-17/K	< 0.01			
BOD(5 day)	mg/L	2	SM 5210B	26-Apr-17/K	< 2			
Conductivity @25°C	µmho/cm	1	SM2510B	26-Apr-17/K	403			
Cyanide (Free)	µg/L	5	SM4500CN	27-Apr-17/R	< 5			
Phenolics	mg/L	0.001	MOEE 3179	25-Apr-17/O	< 0.001			
pH @25°C	pH Units		SM4500H+	26-Apr-17/K	7.75			
Phosphorus-Total	mg/L	0.01	E3199A.1	27-Apr-17/K	0.76			
Total Kjeldahl Nitrogen	mg/L	0.1	E3199A.1	27-Apr-17/K	4.0			
Turbidity	NTU	0.1	SM 2130	25-Apr-17/O	30.7			
Total Suspended Solids	mg/L	3	SM2540D	25-Apr-17/K	30			
Hardness (as CaCO3)	mg/L	1	SM 3120	27-Apr-17/O	184			
Aluminum	µg/L	10	SM 3120	28-Apr-17/O	40			
Antimony	µg/L	0.5	EPA 200.8	27-Apr-17/O	< 0.5			
Arsenic	µg/L	0.5	EPA 200.8	27-Apr-17/O	4.0			
Barium	µg/L	1	SM 3120	27-Apr-17/O	19			
Beryllium	µg/L	2	SM 3120	27-Apr-17/O	< 2			
Boron	µg/L	5	SM 3120	27-Apr-17/O	49			
Cadmium	µg/L	0.07	EPA 200.8	27-Apr-17/O	< 0.070			
Cobalt	µg/L	0.5	EPA 200.8	27-Apr-17/O	< 0.5			
Chromium	µg/L	2	SM 3120	27-Apr-17/O	5			
Chromium (VI)	mg/L	0.001	MOE E3056	08-May-17/O	< 0.001			
Copper	µg/L	0.5	EPA 200.8	27-Apr-17/O	< 0.5			

Steve Garrett
Director of Laboratory Services

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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Final Report

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DATE RECEIVED: 24-Apr-17
DATE REPORTED: 09-May-17
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Iron	µg/L	5	SM 3120	27-Apr-17/O	3110			
Lead	µg/L	0.1	EPA 200.8	27-Apr-17/O	0.5			
Mercury	µg/L	0.02	SM 3112B	27-Apr-17/R	< 0.02			
Molybdenum	µg/L	10	SM 3120	27-Apr-17/O	< 10			
Nickel	µg/L	1	EPA 200.8	27-Apr-17/O	2			
Selenium	µg/L	5	EPA 200.8	27-Apr-17/O	< 5			
Silver	µg/L	0.1	EPA 200.8	27-Apr-17/O	< 0.1			
Thallium	µg/L	0.3	EPA 200.8	27-Apr-17/O	< 0.3			
Tungsten	µg/L	10	SM 3120	27-Apr-17/O	10			
Uranium	µg/L	0.3	EPA 200.8	27-Apr-17/O	< 0.3			
Vanadium	µg/L	5	SM 3120	27-Apr-17/O	< 5			
Zinc	µg/L	5	SM 3120	27-Apr-17/O	6			
Zirconium	µg/L	3	SM 3120	27-Apr-17/O	< 3			

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Steve Garrett
Director of Laboratory Services

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B17-10303 (ii)**

Report To:

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2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 24-Apr-17
DATE REPORTED: 09-May-17
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Acetone	µg/L	2	EPA 8260	26-Apr-17/O	< 2			
Benzene	µg/L	0.5	EPA 8260	26-Apr-17/O	< 0.5			
Bromodichloromethane	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Bromoform	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Bromomethane	µg/L	0.3	EPA 8260	26-Apr-17/O	< 0.3			
Carbon Tetrachloride	µg/L	0.2	EPA 8260	26-Apr-17/O	< 0.2			
Monochlorobenzene (Chlorobenzene)	µg/L	0.2	EPA 8260	26-Apr-17/O	< 0.2			
Chloroform	µg/L	0.3	EPA 8260	26-Apr-17/O	< 0.3			
Dibromochloromethane	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dibromoethane,1,2- (Ethylene Dibromide)	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichlorobenzene,1,2-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichlorobenzene,1,3-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichlorobenzene,1,4-	µg/L	0.2	EPA 8260	26-Apr-17/O	< 0.2			
Dichlorodifluoromethane	µg/L	1	EPA 8260	26-Apr-17/O	< 1			
Dichloroethane,1,1-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloroethane,1,2-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloroethene, 1,1-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloroethene, cis-1,2-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloroethene, trans-1,2-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloropropane,1,2-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloropropene, cis-1,3-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloropropene, trans-1,3-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Dichloropropene 1,3- cis+trans	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			

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Steve Garrett
Director of Laboratory Services

CADUCEON ENVIRONMENTAL LABORATORIES
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P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Ethylbenzene	µg/L	0.5	EPA 8260	26-Apr-17/O	< 0.5			
Hexane	µg/L	1	EPA 8260	26-Apr-17/O	< 1			
Dichloromethane (Methylene Chloride)	µg/L	0.3	EPA 8260	26-Apr-17/O	< 0.3			
Methyl Ethyl Ketone	µg/L	1	EPA 8260	26-Apr-17/O	< 1			
Methyl Isobutyl Ketone	µg/L	1	EPA 8260	26-Apr-17/O	< 1			
Methyl-t-butyl Ether	µg/L	1	EPA 8260	26-Apr-17/O	< 1			
Styrene	µg/L	0.5	EPA 8260	26-Apr-17/O	< 0.5			
Tetrachloroethane,1,1,1,2-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Tetrachloroethane,1,1,2,2-	µg/L	0.4	EPA 8260	26-Apr-17/O	< 0.4			
Tetrachloroethylene	µg/L	0.2	EPA 8260	26-Apr-17/O	< 0.2			
Toluene	µg/L	0.5	EPA 8260	26-Apr-17/O	< 0.5			
Trichloroethane,1,1,1-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Trichloroethane,1,1,2-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Trichloroethylene	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Trichlorofluoromethane	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Vinyl Chloride	µg/L	0.2	EPA 8260	26-Apr-17/O	< 0.2			
Xylene, m,p-	µg/L	0.4	EPA 8260	26-Apr-17/O	< 0.4			
Xylene, o-	µg/L	0.1	EPA 8260	26-Apr-17/O	< 0.1			
Xylene, m,p,o-	µg/L	0.4	EPA 8260	26-Apr-17/O	< 0.4			
Dichloroethane-d4,1,2-(SS)	%		EPA 8260	26-Apr-17/O	101			
Toluene-d8 (SS)	%		EPA 8260	26-Apr-17/O	105			
Bromofluorobenzene,4(SS)	%		EPA 8260	26-Apr-17/O	95.0			
Chloromethane	µg/L	0.3	EPA 8260	26-Apr-17/O	< 0.3			
Trichlorobenzene,1,2,3-	µg/L	0.2	EPA 8260	26-Apr-17/O	< 0.2			
Trichlorobenzene,1,2,4-	µg/L	0.2	EPA 8260	26-Apr-17/O	< 0.2			

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DATE RECEIVED: 24-Apr-17
DATE REPORTED: 09-May-17
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Trimethylbenzene,1,2,4-	µg/L	2	EPA 8260	26-Apr-17/O	< 2			

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DATE RECEIVED: 24-Apr-17
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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Oil and Grease-Anim/Veg.	mg/L	1.0	SM 5520	26-Apr-17/K	< 1.0			
Oil and Grease-Mineral	mg/L	1.0	SM 5520	26-Apr-17/K	< 1.0			
Oil & Grease-Total	mg/L	1.0	SM 5520	26-Apr-17/K	< 1.0			
Chlorophenol, 2-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Dinitrophenol, 2,4-	µg/L	1	EPA 8270	01-May-17/K	< 1			
Acenaphthene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Acenaphthylene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Anthracene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Benzo(a)anthracene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Benzo(a)pyrene	µg/L	0.01	EPA 8270	01-May-17/K	< 0.01			
Benzo(b)fluoranthene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Benzo(k)fluoranthene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Benzo(g,h,i)perylene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Biphenyl, 1, 1-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Bis(2-Chloroethyl)ether	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Bis(2-Chloroisopropyl)ether	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Bis(2-ethylhexyl) Phthalate	µg/L	5	EPA 8270	01-May-17/K	< 5			
Chloroaniline, 4-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Chrysene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Dibenzo(a,h)anthracene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Dichlorobenzidine, 3,3'-	µg/L	0.5	EPA 8270	01-May-17/K	< 0.5			
Dichlorophenol, 2,4-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Diethyl Phthalate	µg/L	1	EPA 8270	01-May-17/K	< 1			
Dimethyl Phthalate	µg/L	1	EPA 8270	01-May-17/K	< 1			
Dimethylphenol, 2,4-	µg/L	1	EPA 8270	01-May-17/K	< 1			
Dinitrotoluene, 2,4-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Steve Garrett
Director of Laboratory Services

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B17-10303 (iii)

Report To:

Downunder Geotechnical
2943 Major MacKenzie Drive, PO Box 96737
Maple ON L6A 0A2
Attention: Andrew Drevininkas

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 24-Apr-17
DATE REPORTED: 09-May-17
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Lock 38, Talbot ON
P.O. NUMBER: D17105A
WATERWORKS NO.

			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Dinitrotoluene, 2,6-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Fluoranthene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Fluorene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
2-Fluorobiphenyl (SS)	% rec.	10	EPA 8270	01-May-17/K	54.0			
Indeno(1,2,3,-cd)pyrene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Methylnaphthalene,1-	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Methylnaphthalene,2-	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Methylnaphthalene 2-(1-)	µg/L	0.07	EPA 8270	01-May-17/K	< 0.07			
Naphthalene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Nitrobenzene-d5 (SS)	% rec.	10	EPA 8270	01-May-17/K	56.0			
Pentachlorophenol	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Phenanthrene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Phenol	µg/L	0.1	EPA 8270	01-May-17/K	< 0.1			
Phenol-d5 (SS)	% rec.	10	EPA 8270	01-May-17/K	29.0			
Pyrene	µg/L	0.05	EPA 8270	01-May-17/K	< 0.05			
Trichlorobenzene,1,2,4-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Trichlorophenol, 2,4,5-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Trichlorophenol 2,4,6-	µg/L	0.2	EPA 8270	01-May-17/K	< 0.2			
Tribromophenol, 2,4,6- (SS)	% rec.	10	EPA 8270	01-May-17/K	82.0			
Terphenyl-d14 (SS)	% rec.	10	EPA 8270	01-May-17/K	78.0			
Propylene Glycol	mg/L	3	EPA 8015	27-Apr-17/O	< 3			
Ethylene Glycol	mg/L	3	EPA 8015	27-Apr-17/O	< 3			
Diethylene Glycol	mg/L	3	EPA 8015	27-Apr-17/O	< 3			

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			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Dichlorophenoxy acetic acid, 2,4- (2,4-D)	µg/L	5	EPA 8270	03-May-17/K	< 5			
Carbaryl	µg/L	3	EPA 8270	03-May-17/K	< 3			
Chlorpyrifos	µg/L	0.5	EPA 8270	03-May-17/K	< 0.5			
Diazinon	µg/L	1	EPA 8270	03-May-17/K	< 1			
Dicamba	µg/L	5	EPA 8270	03-May-17/K	< 5			
Diuron	µg/L	5	EPA 8270	03-May-17/K	< 5			
2-Fluorobiphenyl (SS)	% rec.	10	EPA 8270	03-May-17/K	50.0			
Malathion	µg/L	5	EPA 8270	03-May-17/K	< 5			
Metolachlor	µg/L	3	EPA 8270	03-May-17/K	< 3			
Nitrobenzene-d5 (SS)	% rec.	10	EPA 8270	03-May-17/K	75.0			
Parathion	µg/L	3	EPA 8270	03-May-17/K	< 3			
Phenol-d5 (SS)	% rec.	10	EPA 8270	03-May-17/K	30.0			
Simazine	µg/L	0.5	EPA 8270	03-May-17/K	< 0.5			
Terphenyl-d14 (SS)	% rec.	10	EPA 8270	03-May-17/K	81.0			
Tribromophenol, 2,4,6- (SS)	% rec.	10	EPA 8270	03-May-17/K	61.0			
Aldrin	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			
Chlordane (alpha)	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Chlordane (Gamma)	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Chlordane Total (alpha+gamma)	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
DDD, 2,4-	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
DDD, 4,4-	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
DDD Total Water	µg/L	0.07	EPA 8080	27-Apr-17/K	< 0.07			
DDE, 2,4-	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			
DDE, 4,4-	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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			Client I.D.		Dam at Lock 38 - Borehole V-3			
			Sample I.D.		B17-10303-1			
			Date Collected		22-Apr-17			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
DDE Total water	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			
DDT, 2,4-	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
DDT, 4,4-	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
DDT Total water	µg/L	1	EPA 8080	27-Apr-17/K	< 1			
Dieldrin	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Lindane (Hexachlorocyclohexane, Gamma)	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			
Endosulfan I	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Endosulfan II	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Endosulfan I/II	µg/L	0.07	EPA 8080	27-Apr-17/K	< 0.07			
Endrin	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Heptachlor	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			
Heptachlor Epoxide	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			
Hexachlorobenzene	µg/L	0.01	EPA 8080	27-Apr-17/K	< 0.01			
Methoxychlor	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Poly-Chlorinated Biphenyls (PCB's)	µg/L	0.05	EPA 8080	27-Apr-17/K	< 0.05			
Diquat	µg/L	5	EPA 549.1	05-May-17/K	< 5			

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Steve Garrett
Director of Laboratory Services

APPENDIX K

GEOPHYSICS GPR INTERNATIONAL INC.

GEOPHYSICAL SURVEY AT THE LOCK 38 DAM, TALBOT RIVER, ONTARIO

Presented to :

DownUnder Geotechnical Limited

2943 Major Mackenzie Drive
Maple, Ontario
L6A 0A2

Geophysics GPR International Inc.
6741 Columbus Road, Unit 14
Mississauga (Ontario) L5T 2G9
Tel. : +1 905.696.0656
info@geophysicsgpr.com
May 2017 T-17997

TABLE OF CONTENT

TABLE OF FIGURES

APPENDICES

1 INTRODUCTION

Geophysics GPR International Inc. has been requested by the Downunder Geotechnical Ltd. to carry out a geophysical survey for the purpose of mapping geology along a proposed diversion channel and upstream and downstream of the Dam at Lock 38, on the Talbot River, Ontario.

The surveys were performed on April 5-6, 2017.

The investigations involved a combination of seismic and ground penetrating radar (georadar) methods.

The following paragraphs describe the survey design, the principles of the test methods, the methodology for interpreting the data, and provide a culmination of the results in profile view.

2 METHODOLOGY

2.1 GPR Personnel

The GPR Personnel and their respective dates on site are outlined in Table 1.

Personnel	Role	Dates on site
Ilia Gusakov	Project Geophysicist	April 5-6, 2017
Tomas Westerblom	Technician	April 5-6, 2017
Rick Hall	Technician	April 6, 2017
Anthony Situm	Helper	April 6, 2017

2.2 Positioning

Positioning was logged in real-time with a Hemisphere Crescent GPS with Omnistar differential corrections. The accuracy of the X,Y positioning are typically on the order of +/- 0.6 to 1.0 m.

The coordinate system is NAD83.

The water surface elevation is based on averaged DGPS readings taking over the course of the surveying. The vertical accuracy of the elevation data is typically on the order of +/- 1.0 to 2.0 m. The averaged water level was 229.9 m (ITRF2008) with a standard deviation of 0.5 m for the downstream survey and 234.5 m with a standard deviation of 0.25 m for the upstream portion.

All geophysical measurements are in SI units.

2.3 Georadar

Basic Theory

Georadar utilises radar technology to obtain a near-continuous profile of the subsurface. The basic principle is to emit an electromagnetic impulse into the ground at a predetermined frequency rate (typically 10 to 80 scans/second). This pulse will travel through the sub-surface and reflect off boundaries of differing dielectric constants (contrasts of EM impedances). The reflected pulse returns to the surface and is recorded by a receiver and displayed in real-time as a cross-sectional image. Only by moving the antennas along a profile directly over the targets can the locations and depths be determined. Examples of radar reflecting boundaries included air/water (water table); water/earth (bathymetry); earth/metal, PVC, or concrete (pipe locating); and differing earth materials (stratigraphic profiles, including bedrock profiles).

The depth of investigation is controlled by the frequency and power of the antenna limited by attenuation and diffraction of the radar signal. Lower frequency antennas provide greater depth penetration at the expense of resolution. The radar signal is attenuated by conductive ground materials (e.g. clays, dissolved salts etc.). The radar signal is diffracted by irregular shaped material (e.g. boulders, debris) that prevents the clear return of the reflected pulse.

More information on the georadar operating principle and equipment can be found in Appendix A.

Survey Design
The georadar data were collected with a GSSI SIR-3000 system with a 270 MHz antenna.

Interpretation Method
Processing of the radar images involved basic filtering and signal enhancements.

The vertical scale on all radar images is a two-way time scale representing the time taken for a radar pulse to transmit to a reflector and back to the receiver. In order to convert the time scale to a depth scale a signal velocity must be applied. The velocity with which the pulse travels through the given material is determined by the dielectric constant. This dielectric will vary with the type of material.

Calculating a velocity can be done in many ways but the most reliable method is with a test pit or borehole as the real rock contact can be exposed. Baring in-situ measurements or borehole data, the dielectric value can be approximated based on the expect material type. Appendix A contains a table of relative dielectric values for commonly encountered materials. For this site a dielectric of 81 was used for the water column and a dielectrics of 20 was used for the bottom sediments respectively. The dielectric for the bottom sediments was based on the borehole data provided by the client. The dielectric value will likely vary to some degree across the survey area depending on type and compaction of the sediments.

An underestimate of the dielectric will result in an over estimate of the signal velocity and in turn an over estimate of the depths.

Interpretation of the data is based primarily on the qualitative analysis of three characteristics of radar reflections: continuity, amplitude and shape. The interpreter then identifies reflectors and textures within the radar records that represent subsurface contacts, objects or zones. The true nature of the interpreted features can only be assumed without corroborating evidence.

The scale bar in georadar data is in time (nanoseconds). As discussed above, the material velocity/dielectric is used to convert the time scale to a depth scale (as in Figure 4).

2.4 Seismic Refraction

Basic Theory

The seismic refraction method relies on measuring the transit time of the wave that takes the shortest time to travel from the shot-point to each geophone. The fastest seismic waves are the compressional (P) or acoustic waves, where displaced particles oscillate in the direction of wave propagation. The energy that follows this first arrival, such as reflected waves and transverse (S) waves, is not considered under routine seismic refraction interpretation. Figure 1 illustrates the basic operating principle for refraction surveys on land.

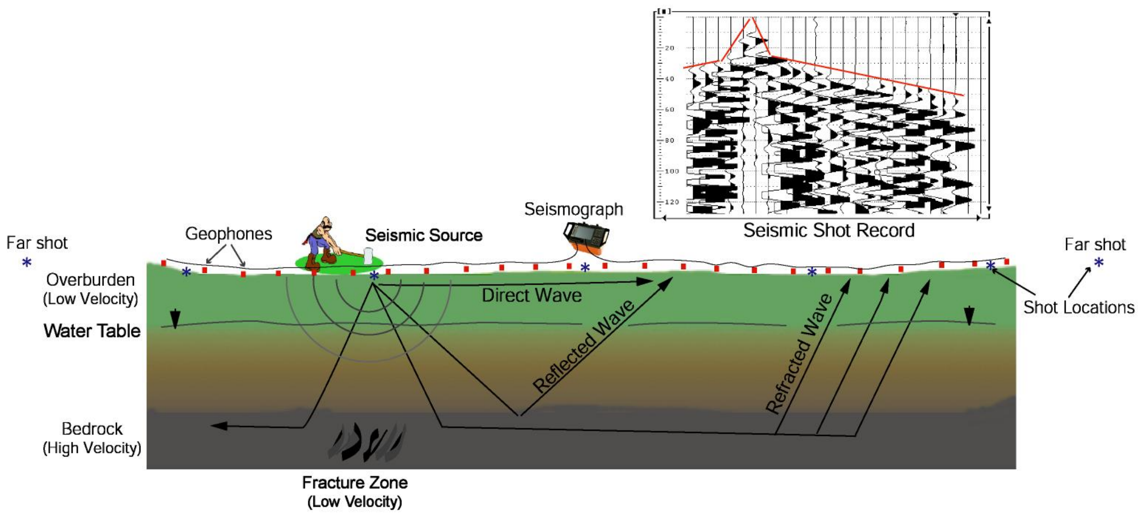


Figure 1: Seismic refraction operating principle

Survey Design

A seismic spread typically consists of 24 vibration monitoring devices (geophones/hydrophones) connected in line (spread) to a seismograph (ABEM Terraloc MK6) by 24 connector cables. Seismic pulses (shots) are then generated at various locations with respect to the spread using a sledge hammer source. The seismic survey used a geophone spacing of 3.0 m. Typically, five shots were executed: one shot at the centre of the profile, two shots at the ends and two far shots on either external side of the spread to provide the true velocity of the rock surface.

Interpretation Method and Accuracy of Results

Interpretation of the refraction seismic data was performed using the refraction tomography method. The method uses a computer inversion procedure to calculate a best-fit model for the refraction arrival time data. The result of the inversion is 2D velocity model for a given seismic line. The main processing sequence involved plotting, picking, and 2D inversion of the seismic shot records using the SeisimagerSW software package.

The seismic refraction method typically allows the determination of the bedrock profile with a precision of 10% or better for depths greater than 10 m and a precision of 1 m for depths less than 10 m. The precision in the determination of rock velocities is plus or minus 3%. The vertical contacts (lateral velocity change), usually associated with faults and deep valleys, are generally accurate to within 5 m in width; although, this is somewhat site specific.

The two most significant problem areas for refraction mapping are the “hidden” layer and the effect of velocity inversions.

A “hidden” layer or “blind zone” is a stratigraphic layer that is not possible to discern from the arrival time data due to insufficient velocity variation or thickness. The unknown presence of a hidden layer has the effect of making the interpreted bedrock depth too shallow. The presence of a “hidden” layer is typically revealed through borehole data and calculations can be made to compensate for the presence of such a layer.

Velocity inversions occur when the velocity does not increase with depth. The velocity inversion can result from the presence of a low or high velocity layer. Refractions from low-velocity layers cannot be determined from the arrival time data. The unknown presence of a low velocity layer has the effect of making the interpreted depths deeper than actual depths. At this particular site there was no evidence of velocity inversions.

2.5 Sub-bottom Profiling (SBP)

Basic Theory

Sub-bottom profiling (SBP) consists of emitting a seismic wave into the water and recording the echo generated by the reflection of the emitted wave on geological contacts of different impedance (different density). The survey was carried using the EDGETECH 3100P sub-bottom profiler system coupled with a SB-424 tow fish. The system utilized EDGETECH’s Full Spectrum CHIRP technology to send and record a seismic sweep from 4 KHz to 24 kHz, which according to the manufacturer specifications enables imagery of the sub-bottom structures with a high resolution to a depth of up to 40 m in clays and up to 2 m in sands. The 3100 system’s vertical resolution is 4-8 cm.

A more information can be found in Appendix A.

Survey Design

During data acquisition, the vessel speed was kept between 2 and 4 knots, while the tow fish was kept 0.2 metres beneath the surface. The high resolution imagery of the sub structure was recorded in an EdgeTech's proprietary JSF format. Figure 2is a graphic representation of the path of a single channel reflection pulse with the exception that the source and receiver are contained within the same device.

Interpretation Method

Processing of the sub-bottom profiler images involved basic filtering and signal enhancements.
The vertical scale on the sub-bottom image is a two-way time scale representing the time taken for an acoustic pulse to transmit to a reflector and back to the receiver. In order to convert the

time scale to a depth scale a signal velocity must be applied. The velocity with which the pulse travels through the given material was measured with a sound velocity probe.

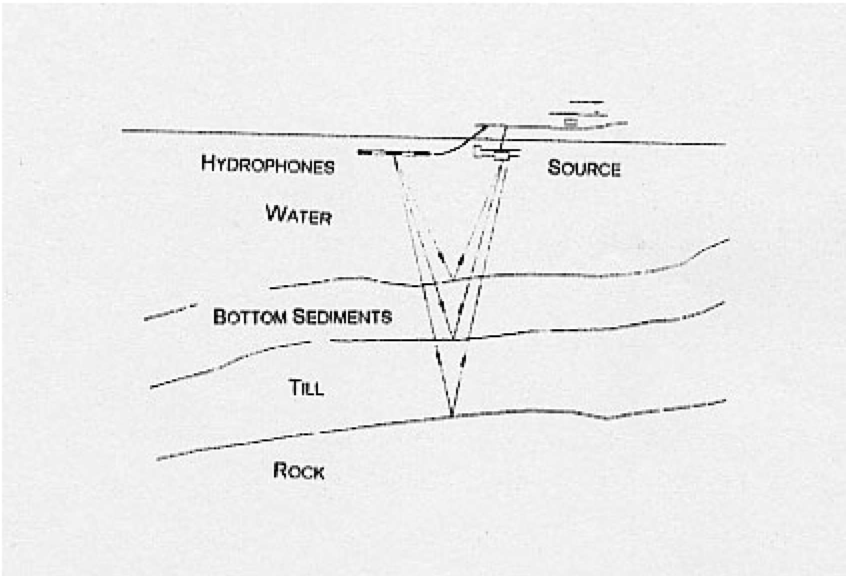


Figure 2: Seismic reflection operating principle

2.6 1D Multi-channel Analysis of Surface Waves (1D MASW)

Basic Theory

The Multi-channel Analysis of Surface Waves (MASW) and the Micro-tremor Array Measurements (MAM) are seismic methods used to evaluate the shear-wave velocities of subsurface materials through the analysis of the dispersion properties of Rayleigh surface waves ("ground roll"). The dispersion properties are measured as a change in phase velocity with frequency. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. Inversion of the Rayleigh wave dispersion curve yields a shear-wave (Vs) velocity depth profile (sounding). A more detailed description of the method can be found in the paper Multi-channel Analysis of Surface Waves, Park, C.B., Miller, R.D. and Xia, J. Geophysics, Vol. 64, No. 3 (May-June 1999); P. 800–808.

Survey Design

The geometry of an MASW survey is similar to that of a seismic refraction investigation (i.e. 12 to 24 geophones in a linear array). The fundamental principle involves intentionally generating an acoustic wave at the surface and digitally recording the surface waves from the moment of source impact with a linear series of geophones on the surface. This is referred to as an "active source" method. A sledgehammer was used as the primary energy source.

Unlike the refraction method, which produces a data point beneath each geophone, the shear-wave depth profile is the average of the bulk area within the middle third of the geophone spread.

The theoretical maximum depth of penetration is half of the maximum seismic array length, in practice the maximum depth of penetration is often influenced by the geology.

Interpretation Method and Accuracy of Results

The main processing sequence involved plotting, picking, and 1-D inversion of the MASW shot records using the SeisimagerSW™ software package. The results of the inversion process are inherently non-unique and the final model must be judged to be geologically realistic. The inversion modelling also assumes that all layering is flat/horizontal and laterally uniform.

The 1D MASW sounding is presented as a shear-wave velocity versus depth chart representative of a bulk area/volume of material beneath the seismic spread.

A table of typical shear-wave (S-wave) velocities for various overburden materials is enclosed in Appendix A.

Typically the accuracy of the shear-wave velocities modelled from the MASW method is on the order of +/- 10 to 15% for overburden material. The estimated error is typically higher (and underestimated) for shear-wave velocities within rock formations.

The depth to bedrock as measured from the MASW method is typically accurate to +/- 10 to 15%; however, weathered layers and/or dense tills overlying bedrock can increase this error.

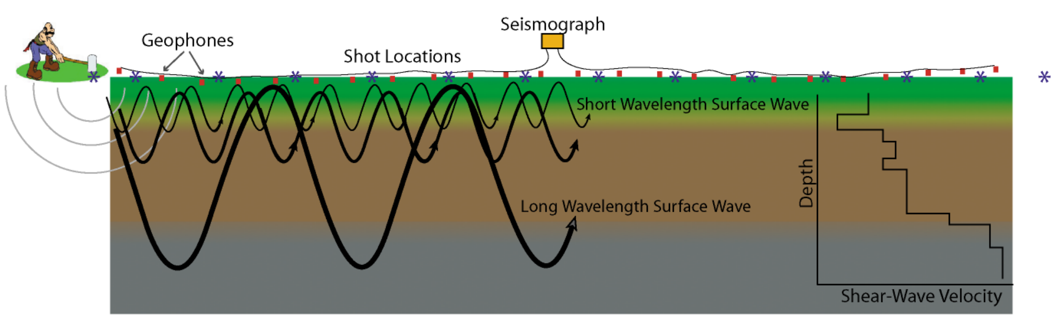


Figure 3: MASW Operating Principle

2.7 2D Multi-channel Analysis of Surface Waves (2D MASW)

Basic Theory

The two dimensional Multi-channel Analysis of Surface Waves (2D-MASW) is an extension of the 1D analysis and the basic theory behind the method is similar. The 2D method involves collecting multiple shot records along a profile. The shot records are compared and combined based on shot/receiver geometry (common-mid-point (CMP)). A multi-channel analysis is then performed on the CMP gathers to generate a phase dispersion curve for calculating the surface wave phase velocities. A non-linear least-squares inversion is run to generate a 2D shear wave velocity model. A more detailed description of the method can be found in the paper CMP Cross-Correlation Analysis of Multi-Channel Surface-Wave Data, Hayashi, K., and Suzuki, H. Exploration Geophysics, (2004) 35, 7-13.

A table of typical shear-wave (S-wave) velocities for various overburden materials is enclosed in Appendix A.

Survey Design

The 2D MASW data analysis used stationary spreads of geophones with spacings between geophones of 3 m. The energy source was a sledge hammer.

Interpretation Method and Accuracy of Results

The main processing sequence involved the use of the SeisimagerSW-2D software package for compiling the common-mid-point gathers, picking of the dispersion curves and 2D inversion of the MASW shot records.

The 2D MASW profile is presented as a colour contour cross-sectional plot of shear wave velocities.

The main sources of error are generally related to the identification of the fundamental mode of the dispersion curve. Typically the fundamental mode is the dominant mode; however, it some cases, higher modes can be dominant. An additional source of error is in the modelling/inversion process. As with most inversion problems, the solution is non-unique and must be judged to be geologically realistic.

Typically the accuracy of the shear-wave velocities modelled from the MASW method is on the order of +/- 10 to 15% for overburden material. The estimated error is typically higher (and underestimated) for shear-wave velocities within rock formations.

The depth to bedrock as measured from the MASW method is typically accurate to +/- 10 to 15%; however, weathered layers and/or dense tills overlying bedrock can increase this error.

3 RESULTS

3.1 Georadar

The shallow water and strong current prevented profiles being collected parallel with the downstream side of the dam. Alternatively, a series of profiles were collected perpendicular to the dam from which the perpendicular profile was extracted. The current with the central portion was not navigable.

Upstream of the dam, the water depth was too great for the radar signal to reach the bottom.

The interpolated georadar profile is presented in Drawing T-17997_B1.

Water level elevations are based on DGPS data and should be considered approximate.

Figure 4 presents an example radar image.

The following is a description of the key features of the radar images:

Bottom: The first signal reflection is from the water bottom. In general a higher amplitude reflection will occur from a material with a higher dielectric contrast from the water (e.g. rock or boulders versus saturated sands). An irregular surface (e.g. boulders) will diffract the radar signal resulting in hyperbola shaped reflectors.

*Sub-bottom reflectors***:** A percentage of the radar signal will pass through the water/bottom contact and reflect off material below the bottom contact (e.g. within the sediments or underlying material). This is the signal that is typically of interest in marine radar surveys. The true nature/source of the bottom reflector can only be inferred from the georadar image without secondary data.

Coarser Sub-bottom material: clusters of stronger reflectors with increased hyperbolas/mottled image "texture" can indicate the presence of increased coarse material (cobbles). Larger hyperbolic targets can indicate boulder material.

The largest source of error for the interpreted georadar images is in the assumption that the interpreted reflectors represent the geologic descriptors. As is evident from the georadar images, the interpreted bedrock contact is near the limit of the radar signal penetration thus decreasing the confidence level.

3.2 Sub-bottom Profiler (SBP)

Acoustic sub-bottom profiles were collected in the area upstream of the dam. The safety buoy line prevented access to the proposed seismic line.

Two of the sub-bottom profiles are presented as interpreted cross-sections in Drawing T-17997_B1.

Water level elevations are based on DGPS data and should be considered approximate.

Figure 4 presents an example sub-bottom profile image collected running north to south along the buoy line and then south to north.

3.3 Marine Seismic Refraction

The strong currents prevented marine seismic refraction data from being collected along the proposed river crossing alignments.

3.4 1D MASW

A 1D MASW sounding was collected on the south-east shoreline upstream of the dam. The shear-wave velocity model has been constrained based on refracted seismic bedrock depths of 5.5 m to 6.5 m below grade.

The 1D shear-wave velocity model is presented in Drawing T-17997_B1.

The shear-wave velocities within the overburden ranged from approximately 100 m/s to 320 m/s. Indicating very soft/loose to stiff/compact overburden material.

3.5 Diversion Channel Seismic Profile

Seismic refraction and 2D MASW data were collected along the proposed diversion channel.

The quality of the seismic wave arrivals was very good. The refraction tomography compressional (P) wave velocity model and the 2D MASW shear (S) wave velocity model are presented in Drawing T-17997_B1 along with an interpreted geologic model based on the combined refraction and 2D MASW data sets.

The topography and thus elevation data are based on borehole and contour line elevations provided by the client.

The general compressional (P) wave velocity model consists of four layers.

The upper layer, with a velocity range of 330 m/s to 600 m/s, is interpreted as uncompacted overburden material and/or fill. This layer extends from surface to a maximum depth of approximately 2.5 m below grade.

The second layer, with an average velocity range of 1200 m/s to 1500 m/s, is interpreted as partially to fully saturated, overburden and/or fill material. This layer extends down to a depth of approximately 5 m below grade.

The third layer, with an average velocity range of 1500 m/s to 2500 m/s, is interpreted as dense till.

The fourth layer, with a velocity of greater than 2500 m/s is interpreted as bedrock. True bedrock P-wave velocities ranged from 3500 to 4950 m/s. Based on the refraction tomography model, the bedrock depth ranged from approximately 6 to 10 m below grade. The lower bedrock velocities (3500 m/s) detected at the east end of the profile could indicate a more weathered or moderately fractured bedrock.

The general shear (S) wave velocity model consists of four zones

Zone 1 has low to very low shear-wave velocities (< 200 m/s). Low shear-wave velocities can be indicate low shear strength soils. This zone is thickest at the east end of the profile.

Zone 2 has shear-wave velocities between 200 m/s and approximately 360 m/s. This velocity range is typical for stiff to compact overburden.

Zone 3 has shear-wave velocities between 360 m/s and approximately 760 m/s. This velocity range is typical for hard/dense to very hard/dense overburden (till). This zone is thickest at the west end of the profile.

Zone 4 is interpreted has bedrock with shear-wave velocities greater than 760 m/s (typically 1400 m/s). This velocity range is typical for competent rock. The shear-wave velocity of bedrock is poorly constrained. The inversion modelling process, which is inherently non-unique, tends to underestimate the true shear-wave. The top of bedrock generally corresponds to the maximum gradient (steepest increase) in velocities. The bedrock contact is typically interpreted as the point of maximum gradient (steepest increase) in velocities.

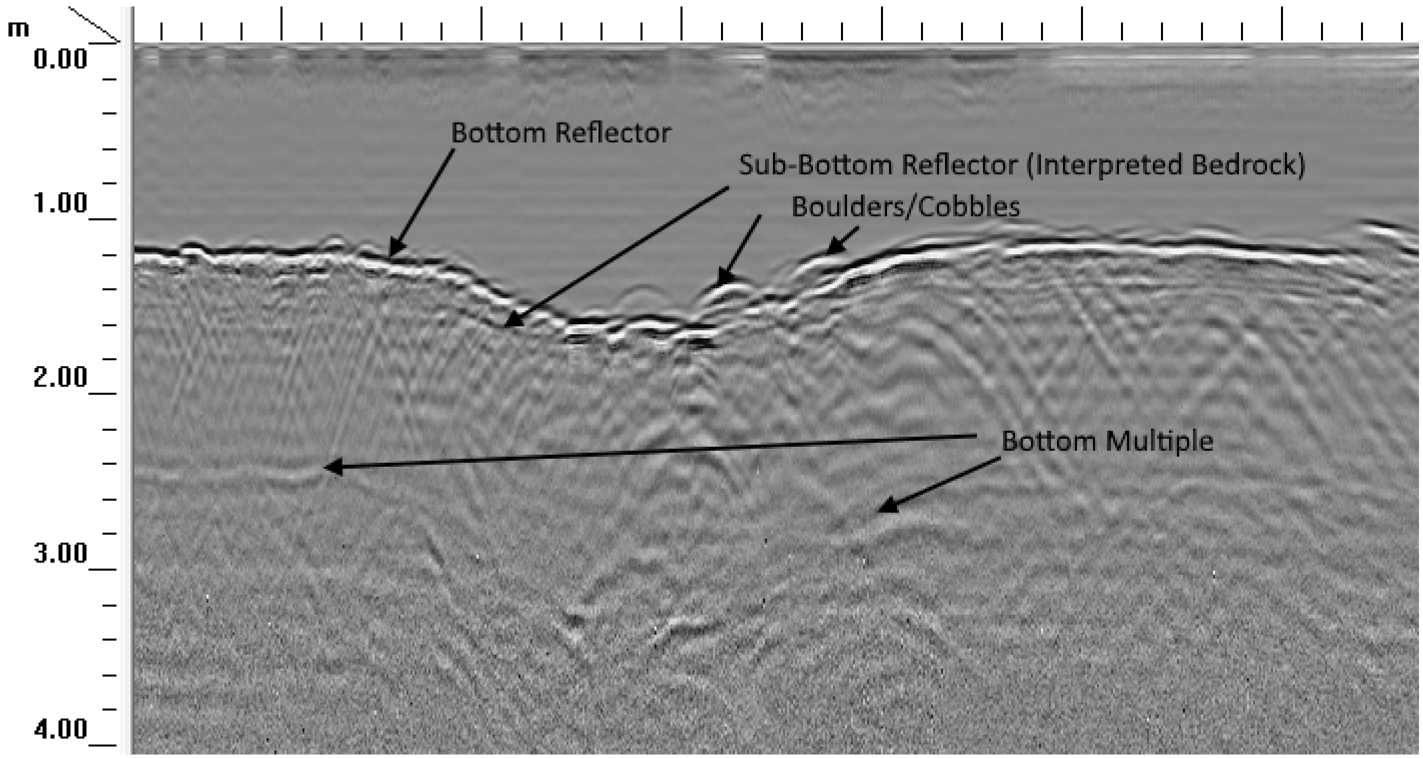


Figure 4: Example Georadar image collected on the downstream dam side

4 CONCLUSIONS & RECOMMENDATIONS

At the request of Downunder Geotechnical, Geophysics GPR collected geophysical data along a proposed diversion channel alignment and on the downstream and upstream sides of the dam at Lock 38 on the Talbot River, Ontario. The purpose of the investigation was to map sub-surface geology.

The results of the investigation are presented in Drawing T-17997_B1.

The preferred methodology for accurately mapping the depth to competent bedrock is the seismic refraction method. Unfortunately strong water currents prevented the seismic cable from being installed safely along the proposed river crossings. Ideally, seismic refraction data would be collected with the dam closed thus allowing the seismic cable to be installed at the proposed locations. Alternatively, a technique called 'reverse shooting' can obtain a seismic refraction profile closer to the dam; however, this is a substantially larger level of effort. It should be noted that the application of refraction in this instance is moot because the borehole results suggest a thin cover on the bedrock both upstream and downstream of the dam. The method is neither precise or accurate enough to measure thicknesses less than a meter.

As alternative techniques to the seismic refraction method, georadar data were collected downstream and acoustic sub-bottom profile data were collected upstream of the dam. The limitation of both of these methods is that the results are essentially cross-sectional 'pictures' with various reflectors. The true nature of these reflections can only be assumed based on additional information (e.g., boreholes).

Upstream of the dam, the quality of acoustic sub-bottom profile data were good; however, the safety buoy line could not be crossed with the boat preventing sub-bottom profile data from being collected at the proposed locations.

Downstream of the dam, the water depth and strong current prevent the georadar data from being safely collected fully along the proposed alignment. Again, data could be collected with the dam closed.

Seismic refraction data and 2D MASW were collected along the proposed diversion channel. The interpreted profile is presented in Drawing T-17997_B1. The results are in very good agreement with the borehole data provided by the client.

This report has been prepared by Ben McClement, P.Eng. and reviewed by Milan Situm, P.Geo.

Ben McClement, P.Eng.

LICENSED PROFESSIONAL ENGINEER
R.B. McCLEMENT
PROVINCE OF ONTARIO

Milan Situm, P.Geo.

PROFESSIONAL GEOSCIENTISTS
MILAN SITUM
PRACTISING MEMBER
0237
ONTARIO

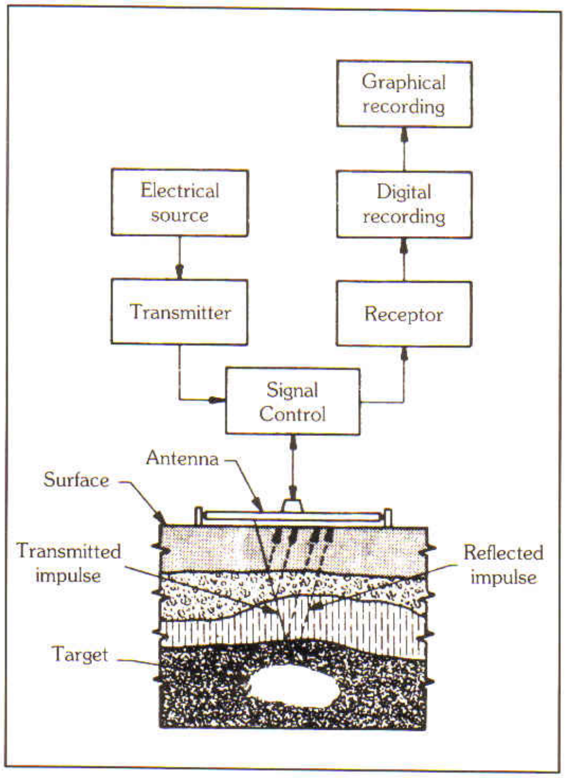
Appendix A

Equipment and Methodology Fact Sheets

GEOPHYSICS G P R INTERNATIONAL INC.

GEORADAR

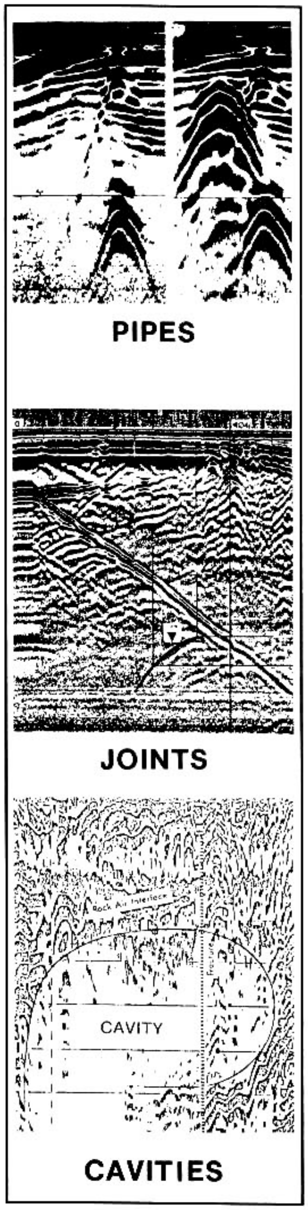
As indicated by its name, georadar combines high resolution radar with geology. The underlying principle is based on the propagation of electromagnetic wave impulses (VHF) that are reflected by anomalies in the terrain (joints, irregularities, interfaces, etc.) at different depths, and then captured by the antenna. The georadar records the time taken by each transmitted signal to complete the cycle in order to calculate the depth of the anomaly. The result is similar to a seismic reflection profile where all the reflections are displayed graphically. This technique is used to solve problems for which there had previously been no practical solution.



PRINCIPLES OF GEORADAR

FEATURES

- Penetration of more than 20 metres in certain materials (penetration being inversely proportional to conductivity).
- Surveying in continuous mode.
- Identification of objects measuring only a few centimeters.
- Light and manoeuvrable equipment.
- Detection of conductivity, open spaces and/or holes (cavities).
- Detection of breaks: faults, fractures, joints, cavities.
- Results similar to seismic reflection: continuous underground profile.
- Results available immediately.
- Can be used in land, sea or airborne surveys.



FIELDS OF APPLICATION

Civil Engineering / Mining Exploration-Exploitation / Research / Archaeology / Environment

- Geotechnology: investigation of soils and surface deposits.
- Optimal selection of anchor bolts in mines and quarries.
- Detection of buried pipes before beginning excavation.
- Detection of liquid or gas leakage in soils.
- Detection of cracks in concrete structures.
- Checking material homogeneity.
- Detection of cavities beneath road pavement.
- Determination of water saturation level.
- Detection of girders in reinforced concrete.
- Detection of pollutant leakage in water bodies.
- Inspection of buried disposal sites and or dangerous deposits.
- Continuous measurement of ice thickness.
- Archaeological research: ancient foundations, artifacts.
- Non-destructive method for measuring road pavement thickness.
- Localization and measurement of soil's thickness (swamps, peat bogs).
- Determination of rock beddings (location and thickness).
- Bathymetric studies (depth sounding).
- Calculation of the thickness of permafrost and ice.
- Geotechnical studies for the installation of aqueducts.

SPECIAL FEATURES

The equipment is practical, easy to manoeuvre, and multi-faceted. The field of application of georadar continues to expand in various sectors, particularly in geotechnology (aqueducts), civil engineering (excavation, structures) and mining (structures).

GEOPHYSICS G P R INTERNATIONAL INC.

3100

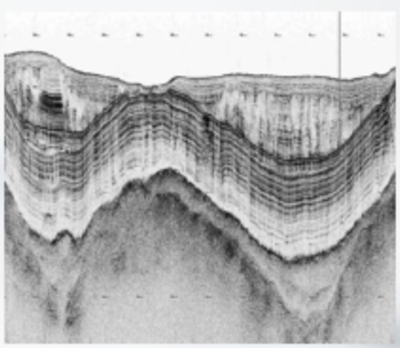
PORTABLE SUB-BOTTOM PROFILING SYSTEM

FEATURES

- Portable
- Low power requirement (runs on AC or DC)
- Choice of towfish depending on the application
- Pole mount option for shallow water surveys
- Easy to setup and operate

APPLICATIONS

- Geological Surveys
- Geohazard Surveys
- Buried Object Location
- Mining/Dredging Surveys
- Bridge/Shoreline Scour Surveys
- Pipeline and Cable Location



The 3100 is EdgeTech's portable version of their highly successful sub-bottom profiler product line. The system utilizes EdgeTech's Full Spectrum CHIRP technology which provides higher resolution imagery of the sub-bottom structure and greater penetration.

The 3100 is ideally suited for use in rivers, lakes, ponds and shallow water ocean applications up to 300m max depth. The system was designed for customers that require a portable system that can be used from smaller boats while not wanting to sacrifice image quality.

A 3100 system comes with a choice of two towfish; either the SB-424 or SB-216S. These towfish operate at different frequency ranges and selection between the two depends on the type of application. The 424 operates at 4-24 kHz and will provide slightly higher resolution but less penetration. The 216S operates at 2-16 kHz and provides slightly less resolution but greater penetration. Along with a towfish, the 3100 system comes with a portable splash-proof topside processor with laptop computer running EdgeTech's DISCOVER software for display of the sonar data. The system comes standard with a 35m tow cable with customer-specified lengths also available.

EdgeTech

3100

PORTABLE SUB-BOTTOM PROFILING SYSTEM

KEY SPECIFICATIONS

TOWFISH	SB- 216S	SB- 424
Frequency Range	2-16 kHz	4-24 kHz
Vertical Resolution (depends on pulse selected)	6-10 cm	4-8 cm
Penetration		
In coarse calcareous sand	6m	2m
In clay	80m	40m
Length	105 cm (41")	77 cm (30")
Width	67 cm (26")	50 cm (20")
Height	40 cm (16")	34 cm (13")
Weight in Air	76 kg (167 lbs.)	45 kg (100 lbs.)
Weight in Water	32 kg (70 lbs.)	18 kg (40 lbs.)
Max Depth Rating of Towfish	300 meters	
TOPSIDE PROCESSOR		
Hardware	Rugged, portable splashproof enclosure	
Operating System	Windows 7	
Display	Splashproof semi-rugged laptop	
Archive	DVD-R/W	
File Format	JSF, SEG-Y & XTF	
I/O	Ethernet	

SB-216S TOWFISH

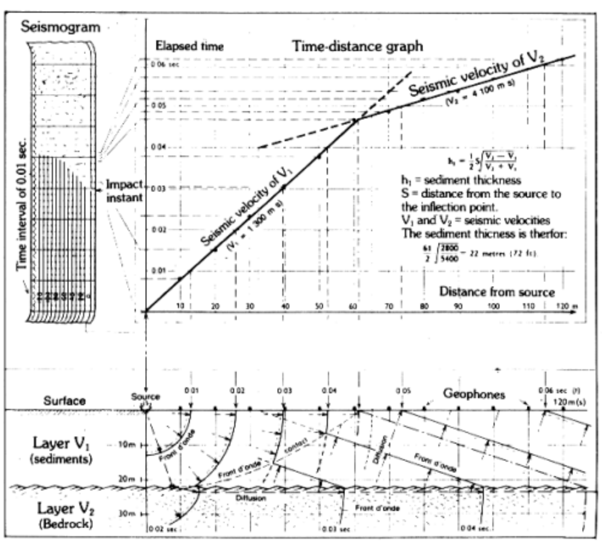
SB-424 TOWFISH

GEOPHYSICS G P R INTERNATIONAL INC.

SEISMIC REFRACTION

Seismic refraction consists of recording the length of time taken for an artificially provoked surface vibration to propagate through the earth. By processing the data, the seismic velocities and depths of the underlying rock layers can be determined. These velocities are characteristic of the nature and quality of the bedrock; a fissured, fractured or sheared rock will be characterized by reduced seismic velocities.

The method is generally used to obtain a better geological analysis of the sub-surface and to determine the following characteristics: the quality, profile and depth of bedrock, its nature, degree of alteration and any other physical contrasts. Seismic refraction ensures that maximum information may be gained from geological field work, and that direct investment costs (drilling, excavation), will be reduced.



PRINCIPLE OF SEISMIC REFRACTION

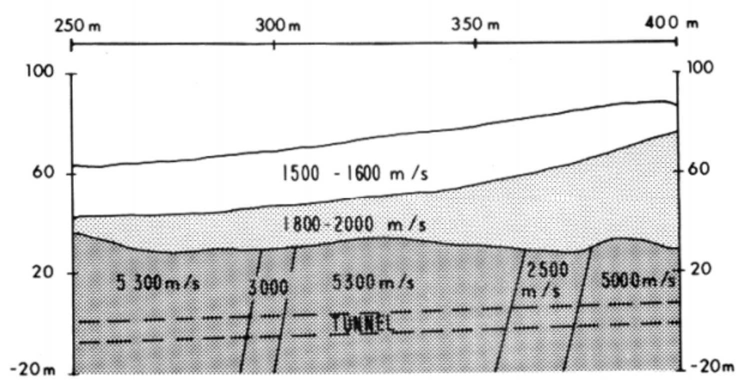
FEATURES

- Precise determination of soil thickness .
- Precise determination of the seismic velocities (rock type and quality).
- Localization and identification of geological units.
- Detailed analysis of soil.
- Year-round use.
- Sea and land surveys (above and below ground).
- Great accessibility possible to rough terrain and remote regions.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

- Identification of faults, fractures, shear zones.
- Detection of rock differences (veins, dykes, cavities, etc.).
- Determination of rock topography.
- Evaluation of volume of soil present or to be excavated.
- Excellent complement to geological mapping.
- Recognition of geophysical anomalies such as VLF, gravimetry, etc.
- Drill site selection, better target identification.
- Evaluation of the size, thickness and condition of surface shafts (mining exploitation).
- Mass Rock Quality Determination (MRQD).
- Detection of rock irregularities and breaks.
- Hydrogeology (detection of water tables, veins, reservoirs).
- Excellent complement to any geological analysis.

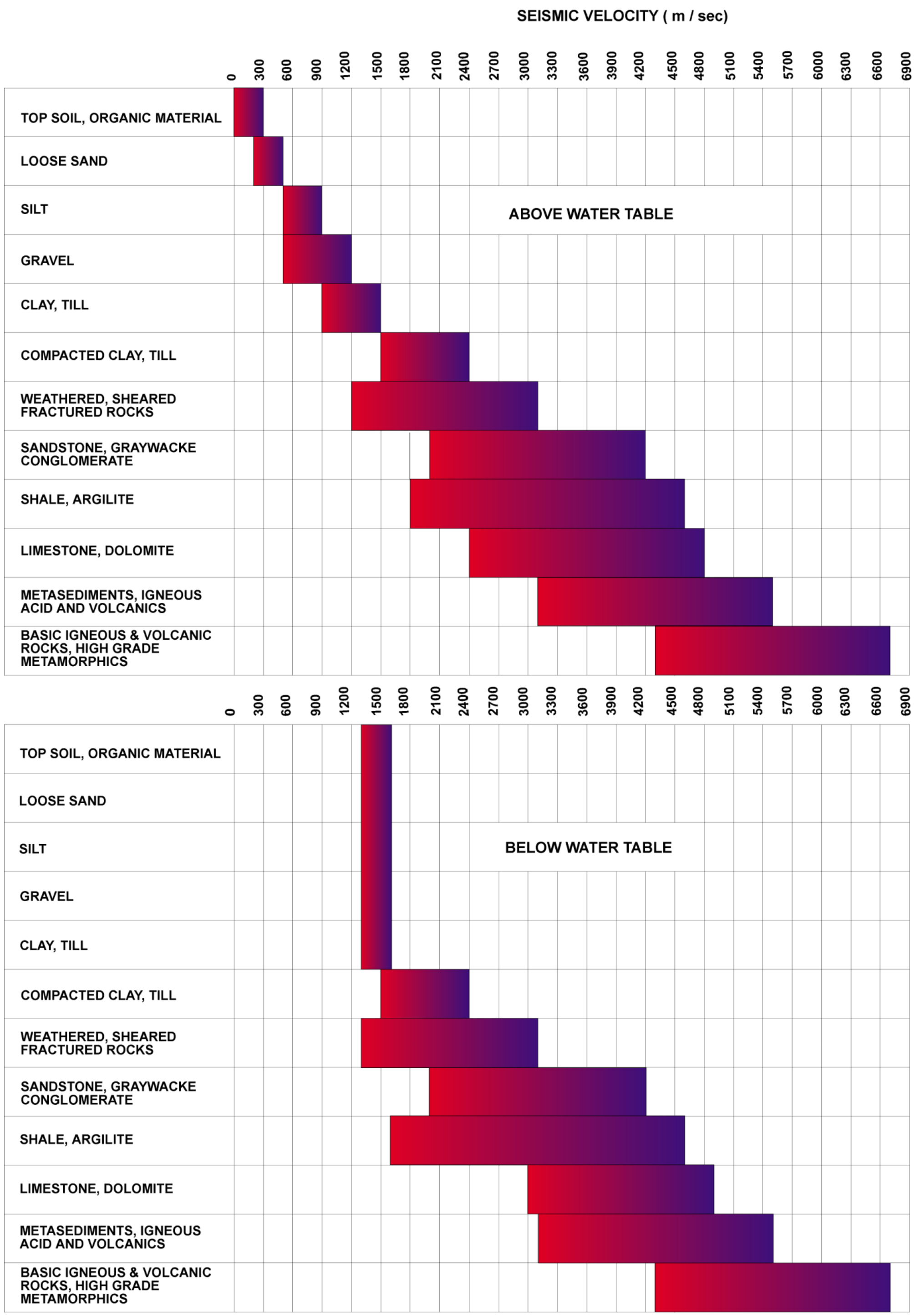


Interpretation results of a seismic profile

ADDITIONAL REMARKS

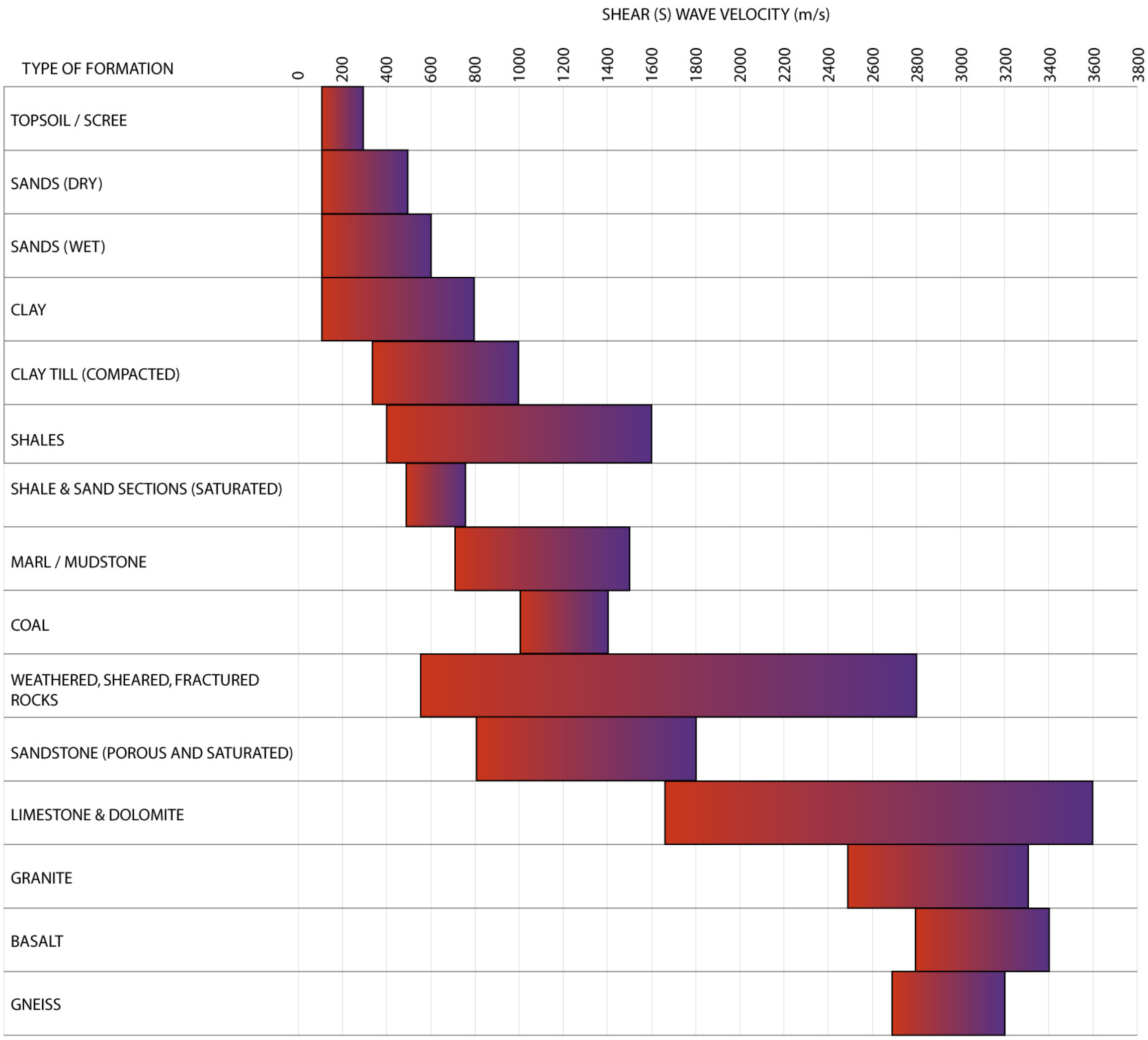
Geophysics GPR International Inc. has been recognized for the past fifteen years as a leader in both the application and the development of seismic methods. Seismic refraction is currently used in both civil and mining engineering; the use of lighter high-performance equipment and better tomographical interpretation of the results have contributed to its growing popularity.

GEOPHYSICS G P R INTERNATIONAL INC.



SOIL AND ROCK CLASSIFICATION
BASED ON SEISMIC VELOCITIES

Compressional (P) Wave Velocities

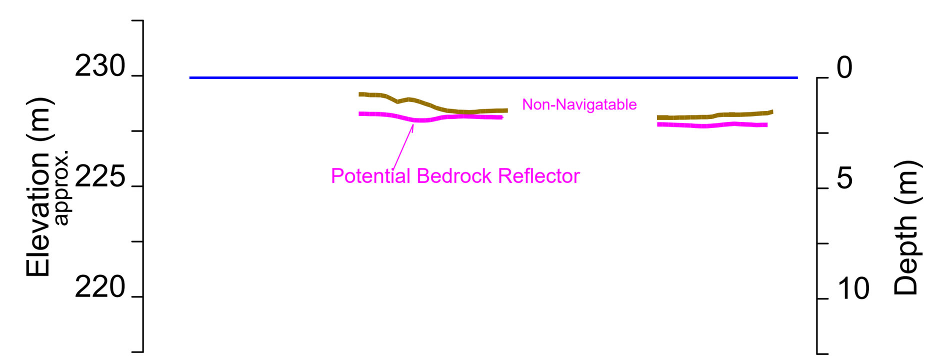


Typical rock velocities, Based on Bourbie, Coussy and Zinszner, Acoustics of Porous Media, 1987
with modifications by Geophysics GPR. Rev A.1 July 2011

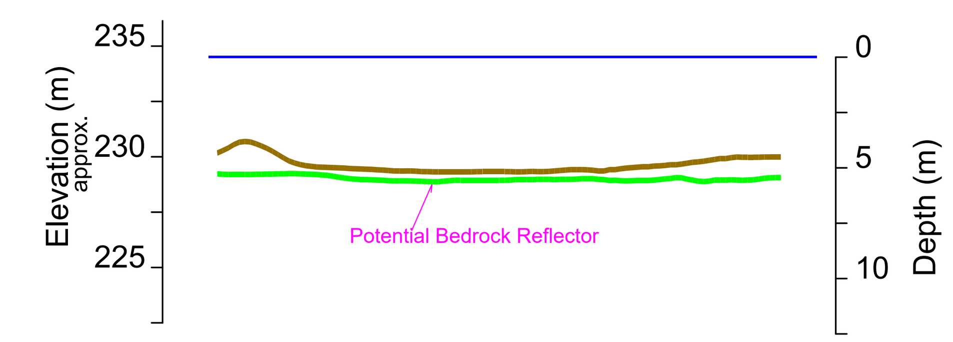
Shear (S) Wave Velocities

Appendix B

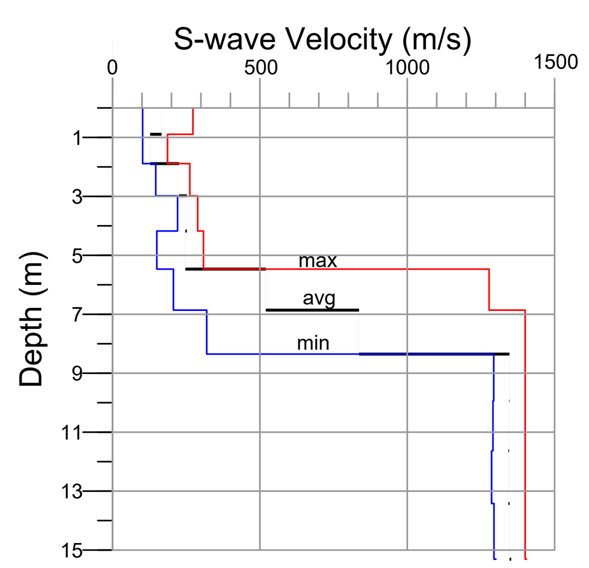
Drawing T-17997_B1



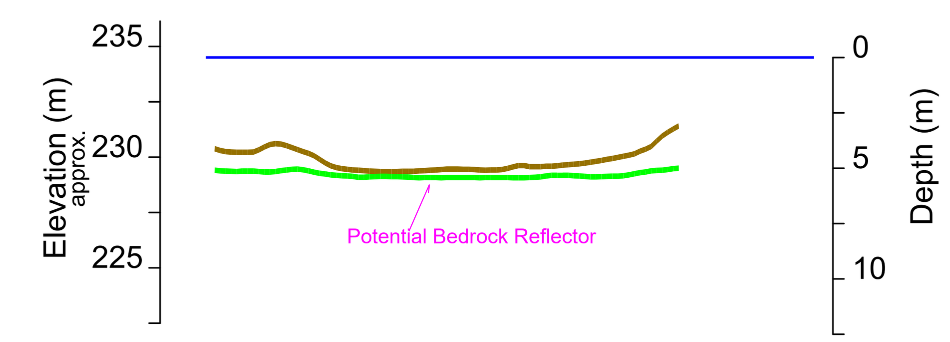
RL-1 - Interpretation



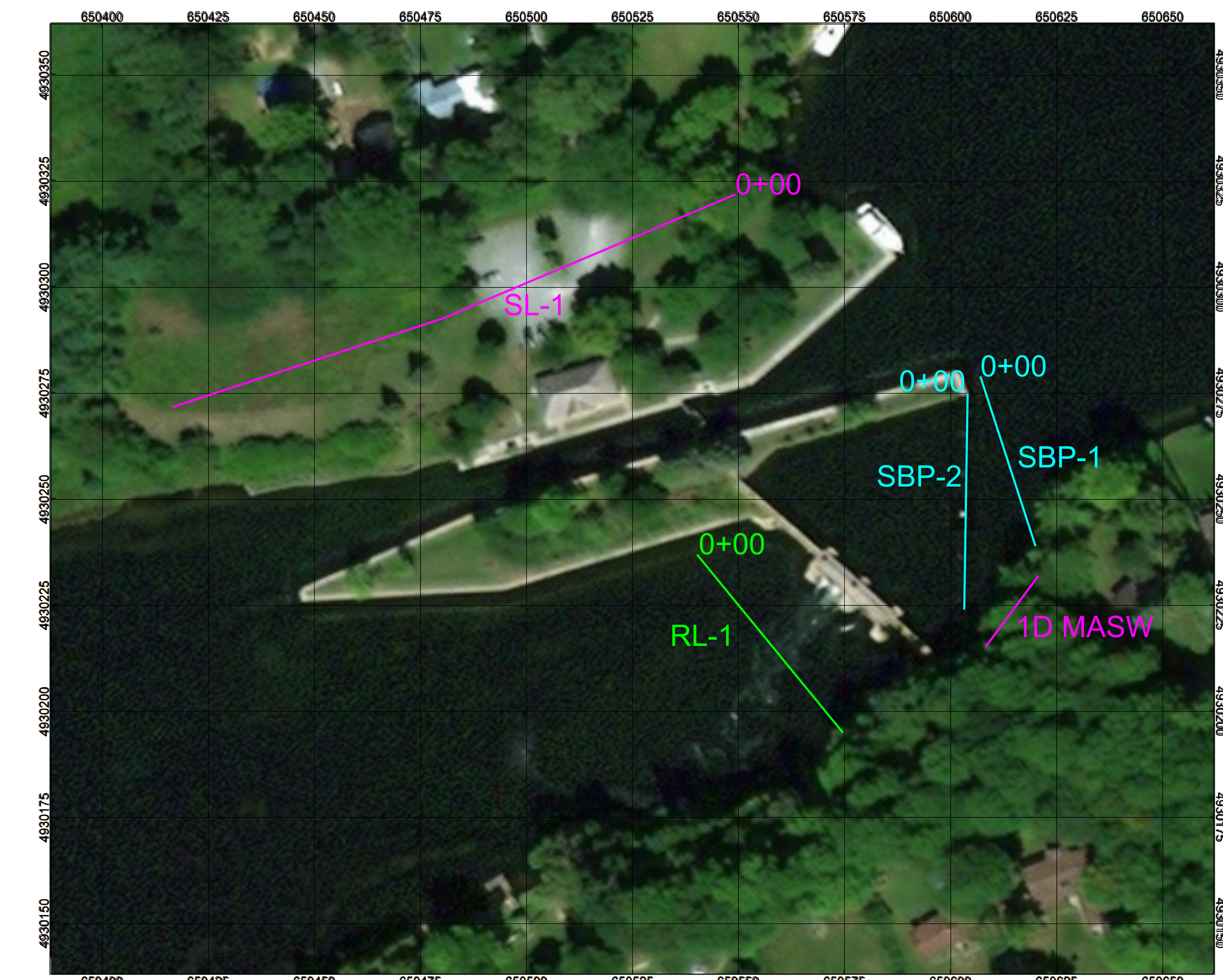
SBP-1 - Interpretation

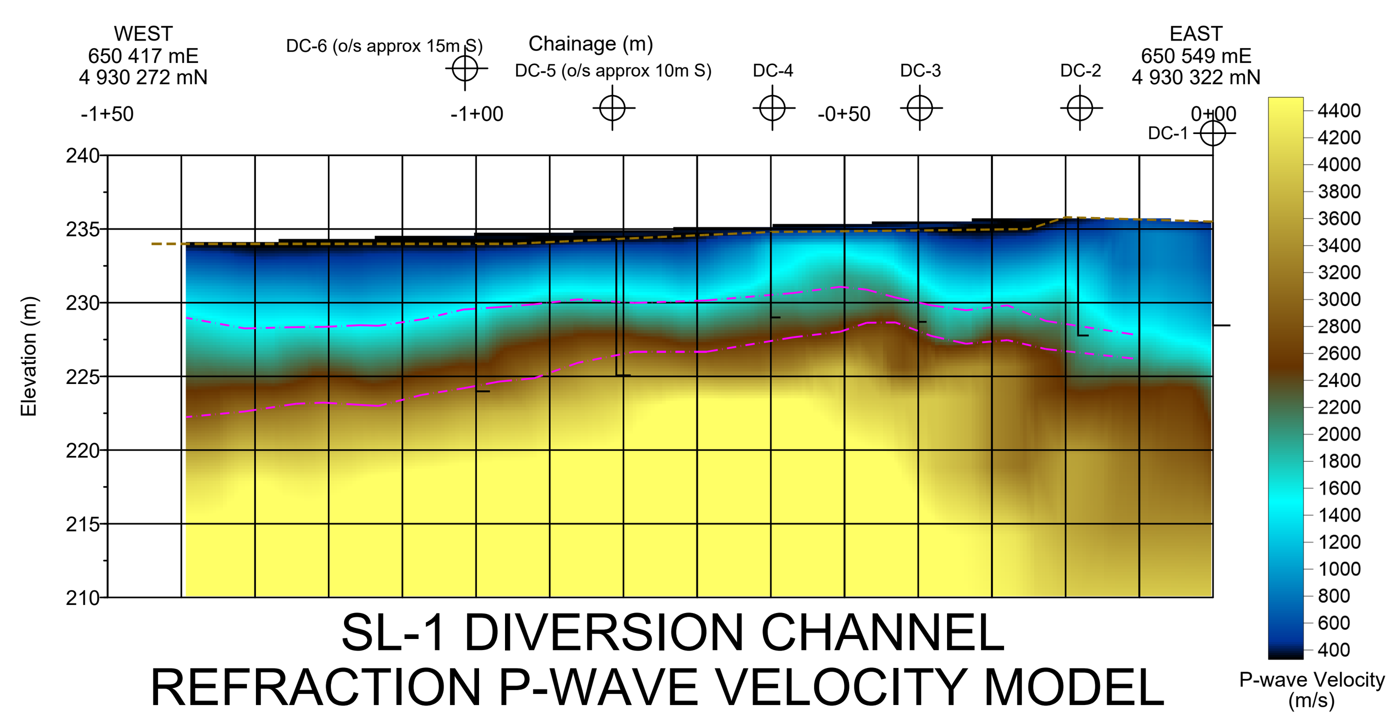


1D MASW Sounding

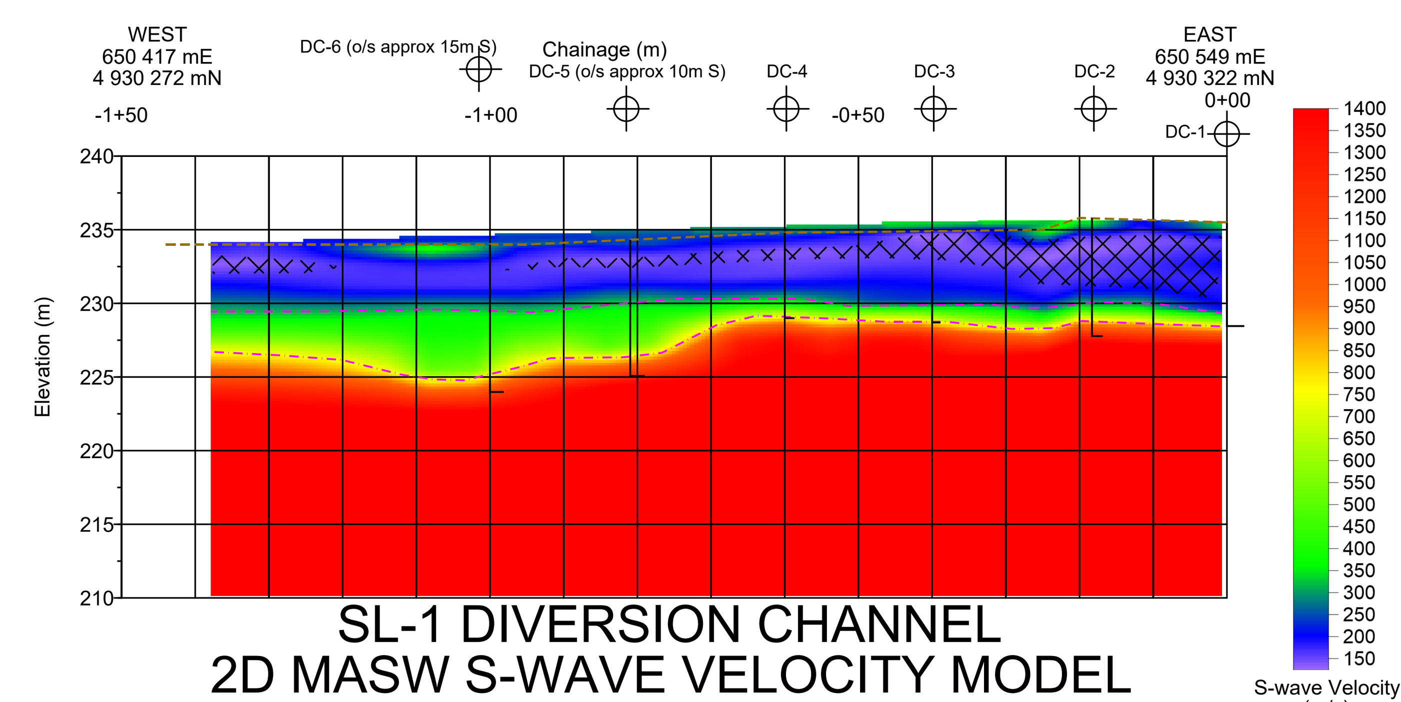


SBP-2 - Interpretation





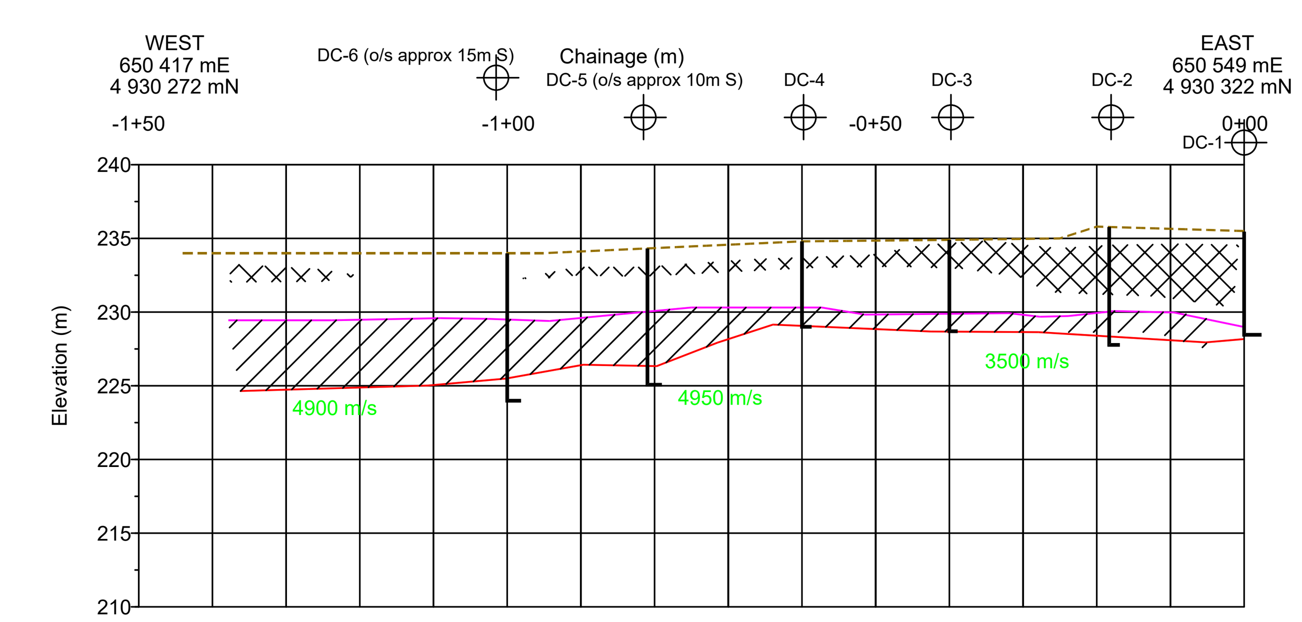
SL-1 DIVERSION CHANNEL
REFRACTION P-WAVE VELOCITY MODEL



SL-1 DIVERSION CHANNEL
2D MASW S-WAVE VELOCITY MODEL

P-wave Velocity (m/s)	General Interpreted Lithology
300 to 400	Soft/Loose Overburden
400 to 1200	Stiff/Compact Overburden
1200 to 1500	Water Saturated Overburden
1500 to 2500	Hard/Dense Overburden
> 2500	Bedrock (Potentially Very Hard/Dense Overburden)

S-wave Velocity (m/s)	General Interpreted Lithology
< 200	Soft/Loose Overburden
200 to 400	Stiff/Compact Overburden
400 to 600	Hard/Dense Overburden
600 to 760	Very Hard/Dense Overburden
> 760	Bedrock (Potentially Very Hard/Dense Overburden)



SL-1 DIVERSION CHANNEL
COMBINED INTERPRETED MODEL

Not valid for construction

No.	NOTES
1	THE SEISMIC SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2017
2	THE WATER ELEVATION AT THE TIME OF THE SURVEY IS BASED ON AVERAGED DGPS READINGS
3	THE COORDINATE SYSTEM IS UTM NAD83 ZONE 17.
4	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, INTERPRETATION AND LIMITATIONS
5	BOREHOLE DATA PROVIDED BY THE CLIENT AND PRESENTED FOR REFERENCE PURPOSES ONLY

LEGEND

- Sub-bottom Contact (Radar)
- Sub-bottom Contact (Acoustic SBP)
- Interpreted Bedrock (Seismic)
- Water Surface
- Bathymetry Profile
- Interpreted Seismic Contact
- 4500 m/s P-Wave Velocity
- Interpreted Dense/Hard Soils
- Interpreted Soft/Loose Soils
- Topography

No	DATE	MODIFICATIONS	GPR	APP.
1				

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	RBM
REVU PAR / REVIEWED BY	B.McClement, P.Eng.
APPROUVÉ PAR / APPROVED BY	M. Situm, P.Geo.
# CONTRAT / CONTRACT #	T-17997
DATE	MAY 2017
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17997_B1

CLIENT: *DownUnder Geotechnical*

PROJET / PROJECT: LOCK 38 DAM, TALBOT RIVER, ONTARIO

TITRE / TITLE: Geophysical Survey

APPENDIX L

Classification of Concrete Distresses

(modified from Ontario Structure Inspection Manual, 2008)

Scaling

Severity	Description
Light	Loss of surface mortar to a depth of up to 5mm without exposure to coarse aggregate.
Medium	Loss of surface mortar to a depth of 6 to 10mm with exposure of some coarse aggregate.
Severe	Loss of surface mortar to a depth of 11 to 20mm with aggregate particles standing out from the concrete and a few completely lost.
Very Severe	Loss of surface mortar and aggregate particles to a depth greater than 20mm.

Disintegration

Severity	Description
Light	Loss of section up to 25mm in depth with some loss of coarse aggregate.
Medium	Loss of section between 25 and 50mm deep with considerable loss of coarse aggregate.
Severe	Loss of section between 50 and 100mm deep with substantial loss of coarse aggregate over a large area.
Very Severe	Loss of section in excess of 100mm deep and extending over a large area.

Erosion

Severity	Description
Light	Loss of section up to 25mm in depth with some loss of coarse aggregate.
Medium	Loss of section between 25 and 50mm deep with considerable loss of coarse aggregate.
Severe	Loss of section between 50 and 100mm deep with substantial loss of coarse aggregate over a large area.
Very Severe	Loss of section in excess of 100mm deep and extending over a large area.

Spalling

Severity	Description
Light	Spalled area measuring less than 150mm in any direction or less than 25mm in depth.
Medium	Spalled area measuring between 150 to 300mm in any direction or between 25 and 50mm in depth.
Severe	Spalled area measuring between 300 to 600mm in any direction or between 50 and 100mm in depth.
Very Severe	Spalled area measuring more than 600mm in any direction or greater than 100mm in depth.

Cracking

Severity	Description
Hairline cracks	Less than 0.1mm wide.
Narrow cracks	0.1 to 0.3mm wide.
Medium cracks	0.3 to 1.0mm wide.
Wide cracks	Greater than 1.0mm wide.

Alkali-Aggregate Reaction

Severity	Description
Light	Hairline pattern cracks, widely spaced, with no visible expansion of concrete mass.
Medium	Narrow pattern cracks, closely spaced, with visible expansion of the concrete mass.
Severe	Medium to wide pattern cracks, closely spaced, with visible expansion and deterioration of concrete.
Very Severe	Wide pattern cracks, closely spaced, with extensive expansion and deterioration of concrete.

Surface Defects

- Stratification
- Segregation
- Cold Joints
- Deposits
    - Efflorescence
    - Exudation
    - Incrustation
    - Stalactite
- Honeycombing
- Pop-outs
- Abrasion
- Wear
- Slippery Concrete Surfaces

CONCRETE DISTRESS PHOTOGRAPHS
SOUTH WEIR AND ABUTMENT

Alkali-aggregate reaction at South Abutment.

Upstream face of South Abutment.

Upstream face of South Abutment showing alkali-aggregate reaction.

Tree growing out of downstream face of South Weir and water stains from seepage through wall.

Tree growing out of downstream face of South Weir and water stains from seepage through wall.

CONCRETE DISTRESS PHOTOGRAPHS
SOUTH PIER

Downstream face of south pier.

View of top of Downstream south pier.

Upstream face of south pier.

Upstream face of south pier.

CONCRETE DISTRESS PHOTOGRAPHS
CENTRAL PIER

Upstream face of middle pier.

Upstream face of middle pier.

Downstream middle pier showing alkali-aggregate reaction.

Downstream middle pier showing alkali-aggregate reaction.

CONCRETE DISTRESS PHOTOGRAPHS
NORTH PIER

Severe alkali-aggregate reaction.

Severe alkali-aggregate reaction.

Wide grass filled crack at top of downstream face.

Looking south at north pier.

Upstream face of north pier with cracking and spalling at waterline.

CONCRETE DISTRESS PHOTOGRAPHS
NORTH WEIR WALL AND ABUTMENT

Alkali-aggregate downstream face of north weir wall and tree growing out of wall.

Downstream face of north weir wall.

Upstream face of north abutment.

Alkali-aggregate reaction on north abutment.

Vegetation growing in wall, very severe spalling, and alkali-aggregate reaction on north downstream weir wall.

Water seepage, very severe spalling, wide cracks and alkali-aggregate reaction on north downstream weir wall.

DownUnder Geotechnical Limited