Geotechnical Investigation-Preliminary Design Stage Relocation/Reconstruction Bolingbroke Dam

Crow Lake Road, Maberly, Ontario

CIMA + c/o Parks Canada

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1. Introduction

GHD Limited (GHD) was retained by Mr. John Konczynski of CIMA+ who have a mandate on behalf of Parks Canada to undertake a Geotechnical Investigation for the proposed relocation/reconstruction of Bolingbroke Dam located on Crow Lake Road in the Township of Tay Valley, Ontario.

The purpose of the investigation was to evaluate the subsoil and bedrock conditions by drilling boreholes at several locations. Five vertical boreholes and two boreholes at a 45° inclination were drilled at the proposed dam alignments as per CIMA's instructions. Five boreholes and probe locations were also drilled in order to assess the soil and bedrock contact depths along the proposed access road. Based upon the data, we have provided descriptions and recommendations concerning foundation and associated bearing pressures, access road pavement design, as well as comments on excavation, and construction field review.

This report has been prepared with the understanding that the design will be as described in Section 2.0 and will be carried out in accordance with all applicable codes and standards. Any changes to the project described herein will require that GHD be retained to assess the impact of the changes on the recommendations provided herein.

The scope of work for GHD consisted of the following activities:

- Drilling Fieldwork **|** The proposed scope included advancement of a total of seven boreholes including two 45° inclined boreholes plus an additional five probes. Boreholes were drilled on the shorelines, and within the upstream lake at the alternative dam locations, as directed by CIMA. Probes consisted of driving a dynamic cone and were performed along the proposed access roads.
- Packer Testing **|** Packer testing was performed in all deep boreholes at different depths to estimate the hydraulic conductivity of the bedrock.
- Acoustic TeleViewer (ATV) Logging **|** Based on the poor rock quality data collected from the boreholes drilled within the upstream lake ATV logging was performed to provide detailed 3D logging of the bedrock to assist in logging the subsurface rock condition.
- Lab Testing **|** Compression and tension test on a total of eight rock core samples; were carried out.
- Reporting **|** Preparation of this Geotechnical Report which summarizes the findings of the fieldwork programs and presents recommendations for the design and construction of the structure.

2. Site and Project Description

The Bolingbroke Dam is located near Crow Lake Road near the community of Bolingbroke in geographic Tay Valley Township, in Lanark County, Ontario. Existing Bolingbroke Dam was built on the Tay River and Bobs Lake. The Site is accessible from an abandoned farm located on 169 Crow Lake Road, in Maberly community, Ontario.

There are two options for proposed new location for relocation/reconstruction of the dam as per CIMA's instructions, both located upstream of the existing dam. The site topography is such that there are slopes on the north and south shores, with the south shore being very steep but densely wooded. The north slope is gradual with steep sections and vegetated with grass, shrubs and sporadic mature trees. North shore slopes are covered with overgrown vegetation and few trees.

It is our understanding that the proposed development will consist of relocation and reconstruction of the existing Bolingbroke Dam. It is our understanding that the project is at the preliminary stage and concept or design drawings are not available.

The location of the Site is shown on the Site Location Map attached as, Figure 1.

3. Field Investigation

3.1 Fieldwork Investigation

3.1.1 Borehole Drilling Program

The fieldwork component of this Geotechnical Investigation consisted of the advancement of a total of seven boreholes (F1 to F7) and five rock probes (P1 to P5). Two of the boreholes (F1 and F2) were drilled within the water at the two proposed alignments. The two boreholes (F3 and F6) drilled with 45° inclination; were drilled from Bobs Lake toward the south shore and borehole F6 drilled from the north shore toward Bobs Lake; boreholes F1, F2 and F3 were drilled from a barge. Boreholes F4 and F5 were drilled on the north shore. Borehole F7 and probes P1 to P5 were drilled on the proposed access road. It is noted that the boreholes locations were selected by the client.

Boreholes F1 and F2 were advanced to a depth of about 10 m below the bottom of the lake, boreholes F3 and F6 were advanced 21 m at the 45° inclination. Boreholes F4 and F5 were advanced to depths of about 18.2 m and 16.9 m, respectively. Two attempts were taken to drill the borehole F7; in first attempt refusal to auger advancement was encountered at a depth of about 0.8 m which was believed to be over a boulder therefore second attempt was carried out approximately 1.0 m away from the original location with Dynamic Cone Penetration Test (DCPT), and refusal to DCPT was encountered at a depth of about 2 m. A DCPT drives a 50 m diameter cone tip using an energy of approximately 470 joules by using a hammer. The blows of the hammer are recorded for each 0.3 m of penetration, and plotted on the logs. Probes encountered refusal to DCPT at depths varying between 1.2 m to 2.7 m below the existing surface grade. The location of the boreholes is shown in the Borehole Location Plan attached as Figure 2. A graphical representation of each borehole is presented on the Borehole Logs, Appendix A. Notes on Boreholes and Test Pit Logs are also provided as Appendix A, to assist in the interpretation of the information.

The fieldwork program was undertaken throughout August 10 to 26, 2015 with specialized diamond drilling rig adapted for soil sampling and rock coring, under the supervision of GHD field staff. Boreholes were advanced into the overburden using NW casing. Standard Penetration Tests (SPTs ASTM D1586) were performed at regular intervals using a 50 mm diameter split-spoon sampler and a 63.5 kg hammer free falling from a distance of 760 mm, to collect soil samples in boreholes F1, F2, F4, F5 and F7. The number of drops required to drive the sampler 0.3 m is recorded on the borehole logs as "N" value. Boreholes F1 to F6 were advanced into bedrock using diamond coring equipment, in order to provide rock characterization (ASTM D2113). Boreholes were sealed with cement upon drilling completion.

3.1.2 In-Situ Lugeon Test

In order to assess the permeability of the rock mass, Lugeon Tests (Packer Test) were performed at different depths in all deep boreholes.

The Lugeon Test consists of isolating a section of the borehole within the rock mass and injecting water under pressure. The investigated section of the borehole was isolated using inflatable packers. For this site double packer test was performed with one packer located at the bottom and one packer at the top of the investigated section.

Following the installation of the packers at the selected depths, water injection for five successive periods of ten minutes will be carried out. The water injection pressure was increased for the first three periods and reduced to the same pressures as the second and first periods for the two final periods respectively. The pressures were determined based on the depth of the test, the overburden pressure and the quality of the rock.

The water absorption within the selected vertical section is directly estimated from the fracturing degree of the rock mass. Based on the measured absorptions at each of the five periods the coefficient of hydraulic conductivity of the rock was determined.

The results of the Lugeon tests are provided in Appendix B and are discussed in the following sections.

3.1.3 Acoustic TeleViewer (ATV) Logging

Acoustic TeleViewer equipment was used to scan the borehole wall in boreholes F4 and F5. This method allows collecting detailed description of the joints within the massive rock, their quantity, orientation, dip, and their opening as well as detail information regarding foliations if any.

The ATV tool generates an image of the borehole wall using transmitted ultrasound pulses from a rotating sensor and records the amplitude and travel time of the reflected signals at the interface between the water and the borehole wall. This method needs the water level within the borehole to be sufficiently elevated to allow for the scanning.

The fieldwork consists of inserting the ATV tool in the centre of the borehole while controlling the descending speed. This method permits applying different parameters and filters and therefore changing the resolution of the collected data. The treatment and interpretation of the data will be completed by a geophysicist using WellCad software.

The data collected from the ATV scanning was used in bedrock description provided in Section 4.4 of this report. Graphical representations of the ATV loggings are presented on the ATV Logs, in Appendix C.

3.2 Laboratory Testing

Laboratory testing on recovered rock samples included compression (ASTM D5731), and tension strength Analysis (ASTM D3967). In total, four compression and four tension tests were performed. It is noted that none of the soil samples collected from the boreholes were of the required quantity for grain size analysis and generally consist of broken cobbles or gravels and therefore no unit weight or moisture content analyses could be performed. The results of the compression and tension testing will be discussed in Section 4.0 and on the borehole logs.

Analytical testing was carried out on a water sample collected from Bobs Lake to provide an initial assessment of corrosion potential of the water at the site at this Preliminary Design Stage. The results of the chemical analyses are discussed in Section 6.4.

The results of the compression and tension analysis are attached as Appendix D.

4. Subsurface Conditions

Detailed descriptions of the subsurface conditions are summarized in the following sections, with a graphical representation of each borehole location presented on the Borehole Logs, Appendix A. Notes on Boreholes and Test Pit Logs are also provided as Appendix A to assist in the interpretation of the information.

4.1 Lake Sediments

Lake sediments were collected from three boreholes F1, F2, and F3. The thickness of the sediments was found to be about 2 m at F1 location and 1 m at F2 location. Sediments were found to consist of silty sand with cobbles and boulders. The majority of the sediments were found to consist of large boulders.

4.2 Topsoil

A surficial covering of topsoil was observed in boreholes F4 to F7. The topsoil was observed to range in thickness from approximately 125 mm to approximately 150 mm at borehole locations. The topsoil layer was found to be a mix of organic matter within a sandy matrix. It was dark brown to black in color, and recovered in a damp condition. The topsoil descriptions, and thicknesses within this report are for planning purposes only and should not be used for quality assessments or quantity take-offs.

4.3 Silty Sand

A layer of native silty sand with cobbles and boulders were encountered from the surface in boreholes F4 and F5. The silt and sand content varies across the site and changes from silty sand to sandy silt. This material was found to be brown in colour, loose to compact in compactness condition, and was recovered in a moist condition. Large boulders are expected within this deposit.

4.4 Bedrock

Practical refusal to SPT or DCPT advancement was encountered over assumed bedrock in all boreholes probe locations at depths varying from 1.2 m in P2 to 5.4 m in F6. The type of bedrock and its quality was confirmed by retrieving bedrock core samples from boreholes F1 to F6 locations by diamond coring techniques.

Highly weathered, intensely fractured coarse grained calcite marble was encountered at the borehole locations. The colour of the marble was found to be white to pale grey becoming grey with depth. Gneiss beddings were observed in borehole F2. The Rock Quality Designation (RQD) values indicated the quality of this rock to be very poor to fair in the upper portion of the bedrock. The rock quality was found to become good to excellent at depth in F4 and F6 location. Although the rock quality was found to be very poor to fair, the recovery values suggest low probability of cavities within the rock mass.

Lugeon Test (or Packer Test) results carried out in boreholes F1 to F6 show a hydraulic conductivity of between 2 x 10^{-3} to 3.7 x 10^{-3} cm/s in the fractured zones and 1.2 x 10^{-} to 7.2 x 10^{-4} cm/s in fair to good quality bedrock zones. Generally the results show a turbulent flow within the bedrock with wash out or void filling in some of the test locations. It should be noted that the rock closer to these surface may have higher permeability.

ATV logging carried out in boreholes F4 and F5 shows dip and direction of the discontinuities; it can be seen that the upper portion of the bedrock at F4 location is intensely fractured with open/filled joints and bedrock quality increases with depth at F4 location and more close joints were recorded this also confirmed with the visual evaluation of the rock cores; at F5 location however the bedrock quality varies at different depths and the rock quality does not improve with depth; veins or change in lithology (intrusions) were recorded in this borehole as well.

Rock quality also varies at different depths in the inclined boreholes. Although rock quality is very poor in the upper 4 m of the bedrock at F6 location, rock quality improves with depth and becomes fair to good quality. At F3 location bedrock shows an increase in quality between the depths of about 9.0 m to 17 m (45° inclined) below 17 m fractured and poor quality rock is present. The Geophysical study (Seismic Refraction Survey) competed by Geophysics GPR International Inc. also shows low V_p velocities at the south shore at line No. SL-03-15.

Generally the rock quality is very poor to poor in the upper portion of the bedrock and becomes fair quality with depth (around 9 to 10 m below ground surface) at some borehole locations like F4 and F6.

Compression Strength and Tensile Strength of the rock core samples collected from the upper portion of the bedrock from boreholes F1, F2, F4 and F5. In general rock core samples collected from boreholes F2 and F4 show slightly higher strengths than the rock cores collected from F1 and F5 location. The strength analysis results are summarized in the following table.

Table 4.1 Compressive and Tensile Strength of the Rock Samples

Borehole No.	Sample No.	Depth In Meters	Uniaxial Compressive Strength (MPa)	Tensile Strength (MPa)
F1	RC2	4.5 – 6.0	58.4	--
F1	RC3	6.0 – 7.5	--	5.8
F2	RC1	3.5 – 4.5	110.4	10.1
F4	RC2	3.5 – 4.5	125.4	10.2
F5	RC2	2.5 – 3.5	93.7	9.9
Notes: (--) not tested				

5. Groundwater

No monitoring well was installed as part of this scope of work. The shallow groundwater level is considered to be at the same elevation as Lake water level.

It should be noted that groundwater levels are subject to seasonal fluctuations and in response to precipitation and snowmelt events, and are anticipated to be at their highest during the thaw in early spring.

6. Discussion and Recommendations

The recommendations contained within this report are based on GHD's understanding of the proposed development and are for this Preliminary Design phase and should be considered preliminary in nature, which is outlined as follows:

- The project is in preliminary stage and no design drawings are available.
- The proposed development consists of relocation and reconstruction of the existing Bolingbroke Dam.
- It is our understanding that the proposed new structure will be a gravity dam.
- Two locations are proposed as the new dam location.
- As part of this new development access roads will be constructed as well.
- Additional geotechnical investigation may be required in subsequent design stages.

If any of these assumptions are incorrect or these facts change through the design or construction phases, GHD must be retained to assess the impact on our recommendations.

Based on our understanding of the proposed structure, the subsurface conditions encountered in the boreholes, and assuming them to be representative of the subsurface conditions across the Site, the following recommendations are provided. The most important geotechnical considerations for the design of the proposed structure are the following:

- Bedrock Quality | Highly fractured and weathered marble was encountered in the boreholes. The RQD values show very poor to fair quality bedrock within the upper portion of the bedrock. The quality of the bedrock improves by depth however the good to excellent quality bedrock was encountered below a depth of about 9.0 m in F4 and below a depth of about 13 m in F5 and F6.
- Bedrock Hydraulic Conductivity | The result of the Lugeon test carried out at different depths show that generally the bedrock is highly permeable. However the permeability may be even higher in the areas, generally above 5 m to 7 m. This will have an impact on the construction of the proposed structure and rock improvement methods like grouting of the bedrock. Several grouting programs should be considered if this rock improvement method will be used. Designers should be aware that determination of the amount of required grout will be very difficult and most likely not accurate for this site.

- Preparation of Rock Subgrade | Depending on the founding depth of the proposed new structure the preparation for the foundation subgrade may consist of various procedures like cleaning and sealing, backfilling solution cavities, etc.
- Rock Improvement | Grouting of the rock foundation will be required in order to reduce the rock permeability; it is however noted that several grouting programs will be required due to high hydraulic conductivity of the bedrock and turbulent water flow to achieve desirable results. The use of fast setting grout or special use grouts may be required to overcome these issues.
- Temporary Shoring | Cofferdam construction will be required in order to provide a dry environment for construction. Contractors should have significant experience with Cofferdam design and installation. However, grouting programs may also be required to reduce water flow through the bedrock into open excavation.

6.1 Site Preparation

6.1.1 Proposed New Dam Location

Site preparation within the footprint of the proposed structure may require the construction of a cofferdam and grouting program for surface water and groundwater control during construction. Once the cofferdam has been constructed contractors may remove all sediments, topsoil, overburden soil and highly fractured and weathered rock to expose a suitable rock subgrade to the satisfaction of the geotechnical engineer and designers. The poor quality bedrock will present very difficult conditions to create adequate grout curtain.

Any exposed surface should be examined by geotechnical personnel to assess the competency. Any identified local anomalies should be excavated and replaced with concrete or be grouted.

It is noted that the bedrock was found to be highly fractured and weathered, therefore weak zones, filled joints, and solution cavities should be expected. The rock surface will require cleaning and grouting. The bedrock is highly permeable therefore contractors should allow for grout loss and multiple grouting events during any grouting and sealing operation.

The construction should ensure control of surface and groundwater; Construction dewatering techniques should be used during construction.

6.1.2 Pavement Subgrade Preparation

The preparation of the pavement subgrade at the proposed access road locations will involve the removal of any vegetation and organic soils, and any other deleterious material to expose a suitable subgrade. The exposed subgrade surface should be compacted following excavation, proof rolled and examined by geotechnical personnel to assess the competency and any identified local anomalies (over size materials) or soft spots should be subsequently excavated, replaced with suitable fill, and compacted. Field verification should be carried out by qualified geotechnical personnel during construction. Detailed recommendations regarding the pavement subgrade preparation is provided in Section 6.6 of this report.

6.2 Excavation and Dewatering

The excavations should be completed and maintained in accordance with the current Occupational Health and Safety Act (OHSA), Regulations for Construction. The following recommendations for excavations should be considered to be a supplement to, and not a replacement of the OHSA requirements.

The construction of the cofferdam will be required in order to provide a 'dry' environment for construction. Contractors will need to have significant experience with Cofferdam design and installation.

The sediments and native soils were found to consist of large boulders; contractors should be prepared to encounter occasional large boulders.

Surface water and groundwater seepage is expected in the excavated areas. Water quantities will depend on seasonal conditions, depth of excavations, and the duration that excavations are left open. Construction dewatering techniques should be taken during construction.

The groundwater inflow into the excavations was not estimated as it was not part of the mandate for this project. However, based upon permeability and rock quality a grouting program is recommended to reduce or migrate groundwater inflow into open construction excavation. It is noted that as per the Water Taking and Transfer Regulation (O. Reg. 387/04) a regulation under the Ontario Water Resources Act, Section 34, is likely required for this project.

6.3 Foundation

6.3.1 Dam Foundation

Based on the data collected during our fieldwork for this Preliminary Design Stage, it is expected that the dam foundation will be founded on the poor quality bedrock. The recommended bearing pressures for shallow foundation, founded on the poor quality marble will depend on the width of the foundation. For example, for a 5 m wide foundation the design bearing capacity is 1,500 kPa under factored ULS conditions and 750 kPa under SLS condition; the design bearing capacity for a 1 m wide foundation is 500 kPa under factored ULS conditions and 250 kPa under SLS condition. The factored ULS value includes the geotechnical resistance factor (Φ) of 0.5.

It is noted that due to the high hydraulic conductivity of the bedrock key trench combined with other foundation improvement techniques such as cut-off wall or grout curtains should be used.

The total settlement of the footings founded on bedrock using the recommended bearing pressures under SLS conditions, is estimated to be less than 25 mm.

6.3.2 Resistance to Foundation Uplift

It is anticipated that resistance to foundation uplift, would be provided by means of dead weight of footing and soil weight and by drilled and or grouted rock anchors. Dead weights calculated by the structural engineers. Grouted rock anchors may be designed based on a frictional stress between grout and the bedrock. Based upon typical published values and conservative approach, we recommend that a conservative allowable working stress value of 500 kPa be utilized to calculate the length of the required bond zone. The bond zone must be entirely within "sound bedrock" which is below the weathered zone. For this site an allowance for a weathered rock zone of 4.0 m from the surface of the bedrock in each hole should be incorporated.

Designing in accordance with the Limit State Design (LSD) method, designers may take the approach that working stress value is approximately equivalent to the SLS value. The ULS and SLS must be based upon performance and structural criteria. However, based upon typical published values, the ULS values may be approximately 1.0 MPa to more than 1.5 MPa. As per the Canadian Foundation Engineering Manual (CFEM-2012), a geotechnical resistance factor of $\Phi = 0.3$ should be applied to this empirical ULS. Higher stress values may be available; however as stated, performance load testing in the field will be required to prove the capacities. If performance testing is carried out at the outset of the project, then a resistance factor of $\Phi = 0.4$ can be applied as per CFEM-2012.

In order to mobilize the shear stress in the rock, the load at the top of the anchor zone must be properly transferred through the anchor zone to prevent progressive grout fail and ensure proper performance. Therefore, a "free length" is required through the overburden and the weathered rock zone. This free length should be a minimum of 3 m long.

The mass of rock mobilized by a rock anchor may be assumed to be based upon a 60° cone drawn up from a point located at the lower one-third point of the anchor shaft bond zone and spaced such that the theoretical cones do not overlap. Designers should review the spacing of anchors and take into account of any overlapping cones (i.e., avoid doubling-up on rock mass calculations for overlapping cones). The bulk unit weight of bedrock may be assumed to be approximately 26 kN/m^3. The corresponding buoyant unit weight would be approximately 16 kN/m^3.

GHD recommends that independent monitoring by geotechnical engineer be carried out during the installation of the anchors to monitor depths, diameters, and quality of installation as well as the grouting of the anchors. Proof testing of anchors is recommended to be carried out by the Contractor and monitored by the Geotechnical Engineer following the grouting. The testing should be completed prior to foundation elements being installed.

These types of permanent anchors should be designed with double corrosion protection by the manufacturer/installer.

6.4 Geotechnical Properties

The following soil and rock parameters can be used for designing of the dam.

Table 6.1 Soil and Rock Parameters

Soil	Density 'γ' (kN/m^3)	Angle of Internal Friction 'φ'	Cohesion 'c' (MPa)	Hydraulic Conductivity (cm/s)
Lake Sediments (Mostly boulders)	20	30	00.015	10^{-1}
Native soil(silty sand with cobbles and boulders)	18	32	00.022	10^{-2}
Marble Bedrock	24	50	17.000	10^{-3}

6.5 Corrosion Potential of Water

Analytical testing was carried out on a water sample collected from Bobs Lake borehole to determine corrosion potential of the water at the site. The selected water sample was tested for pH, resistivity, chlorides, sulphides, sulphates, and redox potential. The test results are summarized in the following table.

Table 6.2 Corrosion Potential of Water

Sample ID	Water Sample
pH	8.16
Redox Potential (mV)	190
Resistivity (ohm-cm)	7,143
Sulphide (µg/L)	<0.01
Sulphate (µg/L)	4
Chloride (µg/L)	6

The American Water Works Association (AWWA) publication 'Polyethylene Encasement for Ductile-Iron Pipe Systems' ANSI/AWWA C105/A21.5-10 dated October 1, 2010 assigns points based on the results of the above tests. The water or soil sample that has a total point score of ten or more is considered to be potentially corrosive to ductile iron pipe. Based on the results obtained for the sample submitted, the Site water is not considered to be potentially corrosive to cast iron pipe.

Table 3 of the Canadian Standards Association (CSA) document A23.1 04/A23.2 04 'Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete' divides the degree of exposure into the following three classes:

Table 6.3 Classes of Degree of Exposure

Degree (Class) of Exposure	Water Soluble (SO4) in Soil Sample (%)
Very Severe (S-1)	> 2.0
Severe (S-2)	0.20 – 2.0
Moderate (S-3)	0.10 – 0.20

A review of the analytical test results shows the sulphate content in the tested samples was found to be less than 4 x 10 - 7 percent. Based upon the test results, the degree of exposure of the subsurface concrete structures to sulphate attack is low. Therefore, normal General use (GU) hydraulic cement can be used for the below grade concrete structures.

6.6 Pavements

Access roads are expected to be constructed over the native silty sand material. In order to prepare the site for the pavement area, it is necessary that the area be stripped of any existing cover materials such as surficial topsoil and associated root-mat, or other deleterious materials deemed unsuitable by geotechnical personnel to expose a suitable subgrade. The exposed subgrade should be proof rolled in the presence of a Geotechnical Engineer. Any areas where "soft spots", rutting, local anomalies, or appreciable deflection are noted should be excavated and replaced with suitable fill, and use of geotextiles may be warranted for strength improvement. The fill should be compacted to at least 95 percent of its MPMDD.

The pavement sections described in the table below are recommended for areas subjected to access roads. Pavement materials and workmanship should conform to the appropriate Ontario Provincial Standard Specifications (OPSS).

Table 6.4 Recommended Pavement Structure

Pavement Layer	Access Road

Table 6.4 Recommended Pavement Structure

Pavement Layer	Access Road
Granular 'A' Base Course	200 mm
Granular 'B', Type II Subbase Course	300 mm

In order to accommodate the recommended thicknesses, designers will need to review grades and determine where stripping or filling is necessary.

Drainage of the pavement layers is important. The subgrade surface and each layer of the pavement section should be provided with a suitable cross fall (approximately 2 percent) to prevent water from ponding on the pavement surface and beneath the pavement layers. Surface runoff should be directed to storm sewers, or allowed to flow into ditches.

Annual or regular maintenance will be required to achieve maximum life expectancy. Generally, the asphalt pavement maintenance will involve crack sealing and repair of local distress.

It should be noted that the pavement sections described within this report represent end-use conditions only, which includes light vehicular traffic and occasional service trucks. It may be necessary that these sections be temporarily over-built during the construction phase to withstand larger construction loadings such as loaded dump trucks or concrete trucks.

6.7 Construction Field Review

The recommendations provided in this report are based on an adequate level of construction monitoring being conducted during construction phase of the proposed dam. GHD requests to be retained to review the drawings and specifications, once complete, to verify that the recommendations within this report have been adhered to, and to look for other geotechnical problems. Due to the nature of the proposed development, an adequate level of construction monitoring is considered to be as follows:

- Prior to construction of foundation, the exposed foundation subgrade should be examined by a Geotechnical Engineer or a qualified Technologist acting under the supervision of a Geotechnical Engineer, to assess whether the subgrade conditions correspond to those encountered in the boreholes, and the recommendations provided in this report have been implemented.
- Placement of concrete should be periodically tested to ensure that job specifications are being achieved.
- Rock anchor installation should be monitored by a qualified technologist on a full-time basis to ensure that holes remain clean, and to verify that specified bond lengths are achieved.
- A program of proof and performance testing should be carried out on all anchors to ensure that they achieve the specified design capacity.

7. Limitation of the Investigation

This report is intended solely for CIMA+ or other party explicitly identified in this report, and is prohibited for use by others without GHD's prior written consent. This report is considered GHD's professional work product and shall remain the sole property of GHD. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient's sole risk, without liability to GHD. Client shall defend, indemnify and hold GHD harmless from any liability arising from or related to Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The recommendations made in this report are in accordance with our present understanding of the project, the current site use, ground surface elevations and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of Geotechnical Engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. 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.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in the study report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. We should be retained to review our recommendations when the drawings and specifications are complete. Without this review, GHD will not be liable for any misunderstanding of our recommendations or their application and adaptation into the final design.

By issuing this report, GHD is the Geotechnical Engineer of record. It is recommended that GHD be retained during construction of all foundations and during earthwork operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the seven boreholes and five rock probe locations only. The subsurface conditions confirmed at these test locations may vary at other locations. Soil and groundwater conditions between and beyond the 12 test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction, which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations.

If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD is completed.

All of Which is Respectfully Submitted,

GHD Limited

Bahareh Vazhbakht

Bahareh Vazhbakht, M.A.Sc.

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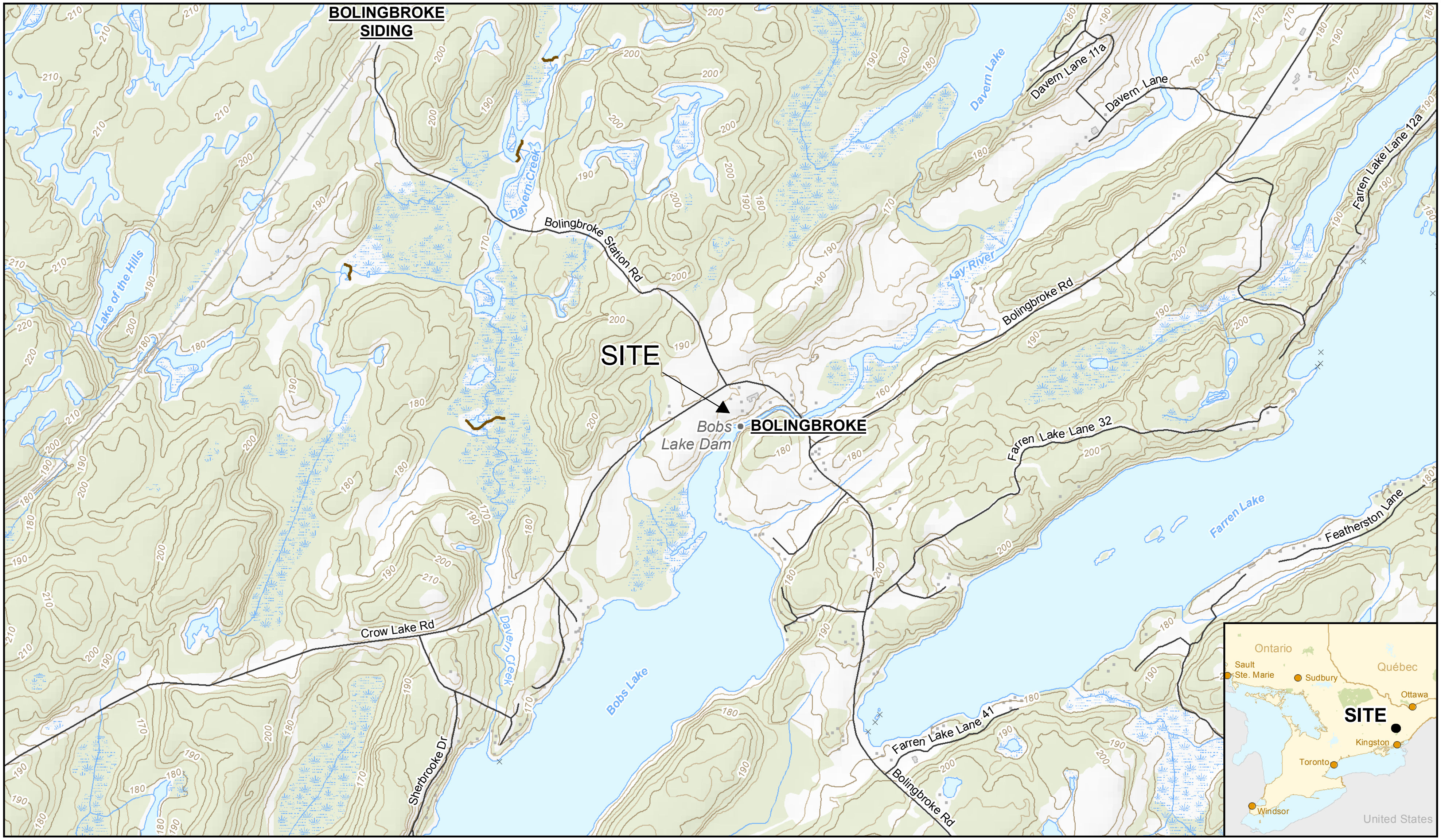

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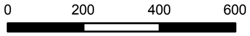
Inset Map: ESRI Data & Maps 2008 Data Distribution Application (DDA)



Coordinate System:
NAD 1983 UTM Zone 18N

CIMA + C/O PARKS CANADA
BOB'S LAKE DAM, 169 CROW LAKE ROAD, MABERLY, ON

11103700
Sep 21, 2015

SITE LOCATION MAP

FIGURE 1

GIS File: Q:\GIS\PROJECTS\11103000s\11103700\Layouts\KONC001\11103700-00(KONC001)GIS-OT001.mxd

LABEL	LAT	LONG	X_COORD	Y_COORD	COORD_TYPE
F1	44.75926	-76.52279	379479.556	4957335.701	UTM Zone 18 NAD 83
F2	44.75936	-76.52271	379485.462	4957346.454	UTM Zone 18 NAD 83
F3	44.75919	-76.52261	379493.640	4957327.674	UTM Zone 18 NAD 83
F4	44.75940	-76.52304	379460.019	4957351.300	UTM Zone 18 NAD 83
F5	44.75948	-76.52289	379471.378	4957360.690	UTM Zone 18 NAD 83
F6	44.75934	-76.52310	379454.943	4957344.798	UTM Zone 18 NAD 83
F7	44.75960	-76.52293	379468.579	4957378.493	UTM Zone 18 NAD 83
PROBE1	44.76011	-76.52390	379393.445	4957432.118	UTM Zone 18 NAD 83
PROBE2	44.75986	-76.52359	379417.305	4957403.701	UTM Zone 18 NAD 83
PROBE3	44.75976	-76.52316	379451.085	4957391.369	UTM Zone 18 NAD 83
PROBE4	44.76021	-76.52274	379485.132	4957440.965	UTM Zone 18 NAD 83
PROBE5	44.75990	-76.52284	379476.553	4957406.650	UTM Zone 18 NAD 83

Source: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation, June 2012

0 10 20 30
Meters

Coordinate System:
NAD 1983 UTM Zone 18N

N

CIMA + C/O PARKS CANADA
BOB'S LAKE DAM, 169 CROW LAKE ROAD, MABERLY, ON

11103700
Feb 5, 2016

BOREHOLE LOCATION PLAN

FIGURE 2

GIS File: Q:\GIS\PROJECTS\11103000s\11103700\Layouts\001\11103700-A1(001)GIS-OT001.mxd

Appendices

Appendix A
Borehole Logs and Notes on Boreholes and Test Pits

REFERENCE No.: 11103700-A1

ENCLOSURE No.: 1

GHD

BOREHOLE No.: F1

ELEVATION: 162.30 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

DESCRIBED BY: J. Poisson

CHECKED BY: B. Vazhbakht

DATE (START): August 11, 2015

DATE (FINISH): August 13, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
├─┤		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa 10 20 30 40 50 60 70 80 90
meters	162.30		GROUND SURFACE			%	ppm	N	
			WATER						
2.0									
	159.7		**SEDIMENTS** - silty sand, cobbles and boulders	☒	SS1	13		12	●
				☒	SS2	100		R	
4.0					RC1	100			
	157.7		**MARBLE** - highly fractured, coarse grained calcite marble, moderately weathered, close irregular discontinuity, white to pale grey, massive, poor quality		RC2	70		37	
6.0									
					RC3	100		38	
					RC4	100		71	
8.0					RC5	100		31	
10.0	152.3		Becoming slightly weathered and pink		RC6	100		24	
	151.4		Fresh to faint weathering, very close to close discontinuity, pale grey		RC7	100		48	
12.0					RC8	100		67	
	149.6		Borehole terminated within bedrock at 12.7m						
14.0									
16.0									
18.0									
20.0									
22.0									
24.0									

NOTES:

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 2

BOREHOLE No.: **F2**
ELEVATION: 162.30 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada
PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction
LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario
DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht
DATE (START): August 14, 2015 DATE (FINISH): August 14, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
⊢⊣		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	162.30		GROUND SURFACE			%	ppm	N
2.0			**WATER**					
	159.9		**SEDIMENTS** - silty sand, cobbles and boulders	☒	SS1	100		R
4.0	158.9		**MARBLE** - highly fractured, coarse grained calcite marble, very close discontinuity, faint weathering, grey, massive, fair to poor quality		RC1	91		58
	157.8		**GNEISS** - coarse grained calcite, weakly bonded, highly weathered, unknown discontinuity, dark grey, poor quality		RC2	100		33
6.0	156.9		**MARBLE** - medium grained with trace pyrite, slightly weathered, extreme close discontinuity, pale grey, massive, very poor to fair quality		RC3	100		55
8.0					RC4	78		22
10.0					RC5	100		63
					RC6	100		60
12.0	150.2		**GNEISS** - coarse grained, slightly weathered on fractures, extremely close discontinuity, massive		RC7	100		23
	149.8		**GNEISS** - medium to fine grained, faintly weathered, extreme close to close discontinuity, pale grey, massive, very poor quality					
14.0	148.9		Borehole terminated within bedrock at 13.4m					
16.0								
18.0								
20.0								
22.0								
24.0								

SCALE FOR TEST RESULTS
50kPa 100kPa 150kPa 200kPa
10 20 30 40 50 60 70 80 90

NOTES:

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 3

BOREHOLE No.: F3

ELEVATION:

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht

DATE (START): August 17, 2015 DATE (FINISH): August 17, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
⊢⊣		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa 10 20 30 40 50 60 70 80 90
meters			GROUND SURFACE			%	ppm	N	
			WATER						
			SEDIMENTS - silty sand, cobbles and boulders						
2.0					RC1	76		16	
			MARBLE - highly fractured, coarse grained calcite marble, faintly weathered, becoming slightly weathered, very close to close discontinuity, very poor quality, becoming fair quality between 9 to 17 m						
					RC2	100		33	
4.0									
					RC3	48		0	
6.0									
					RC4	100		7	
8.0					RC5	100		37	
					RC6	100		60	
10.0									
					RC7	100		63	
12.0									
					RC8	100		73	
14.0					RC9	100		72	
					RC10	100		68	
16.0									
					RC11	100		38	
18.0									
					RC12	77		17	
20.0					RC13	100		55	
					RC14	100		29	
22.0									
			Borehole terminated within bedrock at 22.0m						
24.0									

NOTES:
Inclined Borehole (45°) - Elevation 162.3m

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 4

BOREHOLE No.: F4

ELEVATION: 163.30 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht

DATE (START): August 19, 2015 DATE (FINISH): August 20, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
├─┤		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa 10 20 30 40 50 60 70 80 90
meters	163.30		GROUND SURFACE			%	ppm	N	
	163.2		**TOPSOIL**						
			SILTY SAND - brown, loose, moist	☒	SS1	4		5	●
				☒	SS2	43		R	
2.0			Possible cobbles and boulders						
	160.6		**MARBLE** - highly to moderately fractured coarse grained calcite marble, slightly weathered, extremely close to close discontinuity, massive, very poor to fair quality	▮	RC1	91		26	
4.0				▮	RC2	77		40	
				▮	RC3	83		0	
6.0				▮	RC4	68		15	
8.0				▮	RC5	90		42	
	154.2		Some stylolites at 15.2m, increasing quartz content, becoming fair to excellent quality						
10.0				▮	RC6	88		62	
				▮	RC7	100		90	
12.0				▮	RC8	100		96	
14.0				▮	RC9	100		95	
16.0				▮	RC10	97		85	
				▮	RC11	100		96	
18.0	145.1		Borehole terminated within bedrock at 18.2m						
20.0									
22.0									
24.0									

NOTES:

REFERENCE No.: 11103700-A1

ENCLOSURE No.: 5

BOREHOLE No.: F5

ELEVATION: 166.20 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

DESCRIBED BY: J. Poisson

CHECKED BY: B. Vazhbakht

DATE (START): August 20, 2015

DATE (FINISH): August 20, 2015

LEGEND

- ☒ SS Split Spoon
- ▮ GS Auger Sample
- ▨ ST Shelby Tube
- ▼ Water Level
- ○ Water content (%)
- ├─┤ Atterberg limits (%)
- ● N Penetration Index based on Split Spoon sample
- • N Penetration Index based on Dynamic Cone sample
- △ Cu Shear Strength based on Field Vane
- □ Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- ▲ Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	166.20		GROUND SURFACE			%	ppm	N
	166.1		**TOPSOIL**					
			SILTY SAND - with cobbles, brown, compact, moist	☒	SS1	100		R
	164.8		**MARBLE** - moderately fractured, coarse to medium grained calcite marble, slightly weathered to fresh, extremely close discontinuity, pale grey to grey, generally massive with gneissic banding and foliation, poor to fair quality	▮	RC1	100		39
2.0								
				▮	RC2	100		58
4.0				▮	RC3	100		49
	161.3		Mineralization at 4.9m and high weathering					
				▮	RC4	97		37
6.0								
				▮	RC5	100		52
8.0								
				▮	RC6	95		67
10.0				▮	RC7	98		61
				▮	RC8	100		23
12.0	154.3		Highly fractured layer					
				▮	RC9	92		70
14.0								
				▮	RC10	97		80
16.0				▮	RC11	100		95
	149.3		Borehole terminated within bedrock at 16.9m					
18.0								
20.0								
22.0								
24.0								

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

NOTES:

REFERENCE No.: 11103700-A1

ENCLOSURE No.: 6

BOREHOLE No.: **F6**

ELEVATION:

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

DESCRIBED BY: J. Poisson

CHECKED BY: B. Vazhbakht

DATE (START): August 21, 2015

DATE (FINISH): August 21, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
⊢⊣		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters			GROUND SURFACE			%	ppm	N
			OVERBURDEN SOIL - Topsoil and silty sand with cobbles - No soil samples collected.					
2.0								
4.0								
6.0								
8.0			**MARBLE** - highly fractured, coarse to medium grained marble, highly weathered, grey brown, very poor quality		RC1	63		10
					RC2	82		0
10.0								
			Large veins of feldspar, foliation/shist		RC3	40		0
12.0			Moderately fractured, fine to medium grained, fresh to slightly weathered, extreme to very close fractures, pale grey, some mineralization on joints, notable around 15.8m, fair becoming excellent quality		RC4	100		55
14.0					RC5	95		77
					RC6	97		85
16.0								
					RC7	97		83
18.0					RC8	98		77
20.0					RC9	100		95
			Borehole terminated within bedrock at 21.2m					
22.0								
24.0								

SCALE FOR TEST RESULTS

50kPa 100kPa 150kPa 200kPa

10 20 30 40 50 60 70 80 90

NOTES:
Inclined Borehole (45°) - Elevation 163.3m

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 7

BOREHOLE No.: F7

ELEVATION: 174.90 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

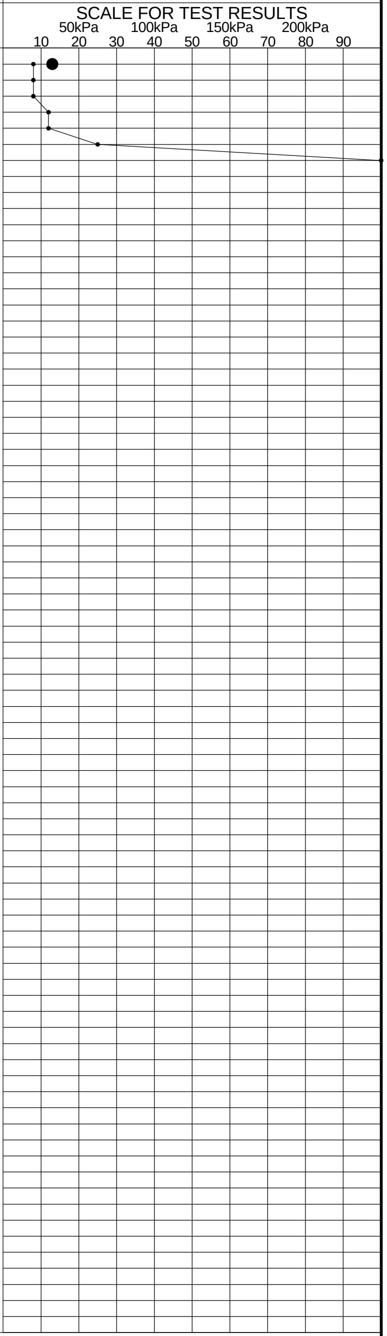
DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht

DATE (START): August 26, 2015 DATE (FINISH): August 26, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
⊢⊣		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	174.90		GROUND SURFACE			%	ppm	N
	174.7		**TOPSOIL**	☒	SS1	58		13
	174.1		**SILTY SAND** - possible cobbles and boulders, brown, compact, moist	☒	SS2	100		R
			Refusal to SPT at 0.8m					
2.0								
4.0								
6.0								
8.0								
10.0								
12.0								
14.0								
16.0								
18.0								
20.0								
22.0								
24.0								



NOTES:

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 8

BOREHOLE No.: **P1**

ELEVATION: 177.80 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

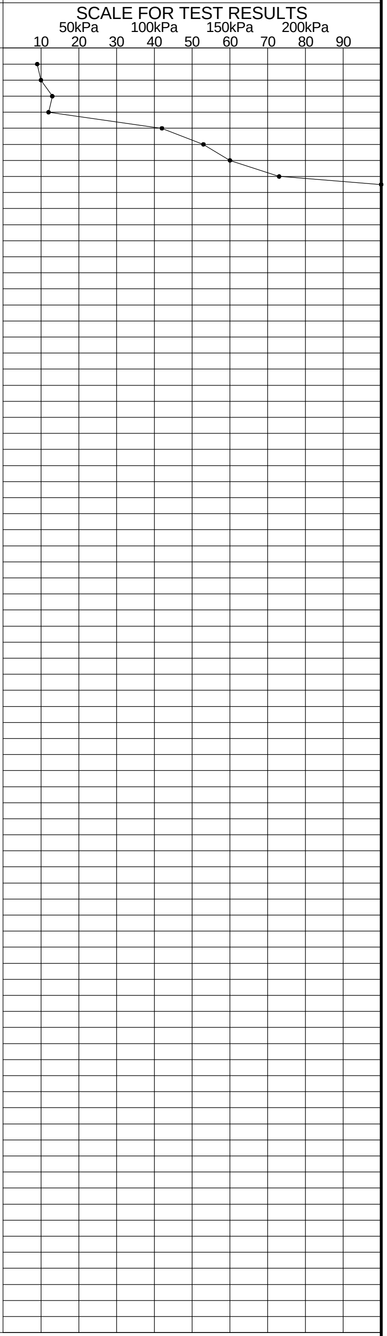
DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht

DATE (START): August 26, 2015 DATE (FINISH): August 26, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
├─┤		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	177.80		GROUND SURFACE			%	ppm	N
2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0			Refusal to DCPT at 2.6m					



NOTES:

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 9

BOREHOLE No.: P2

ELEVATION: 175.50 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht

DATE (START): August 26, 2015 DATE (FINISH): August 26, 2015

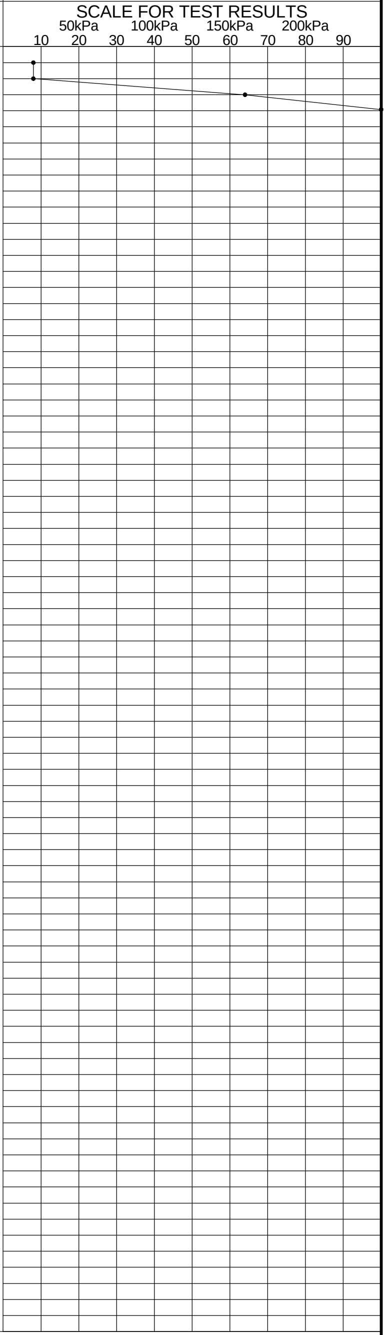
LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
├─┤		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	175.50		GROUND SURFACE			%	ppm	N
			Refusal to DCPT at 1.2m					

Depth scale: 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0

SCALE FOR TEST RESULTS



NOTES:

BOREHOLE LOG 11103700-A1-BOREHOLE LOGS.GPJ INSPEC_SOL.GDT 2/5/16

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 10

BOREHOLE No.: P3

ELEVATION: 173.30 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

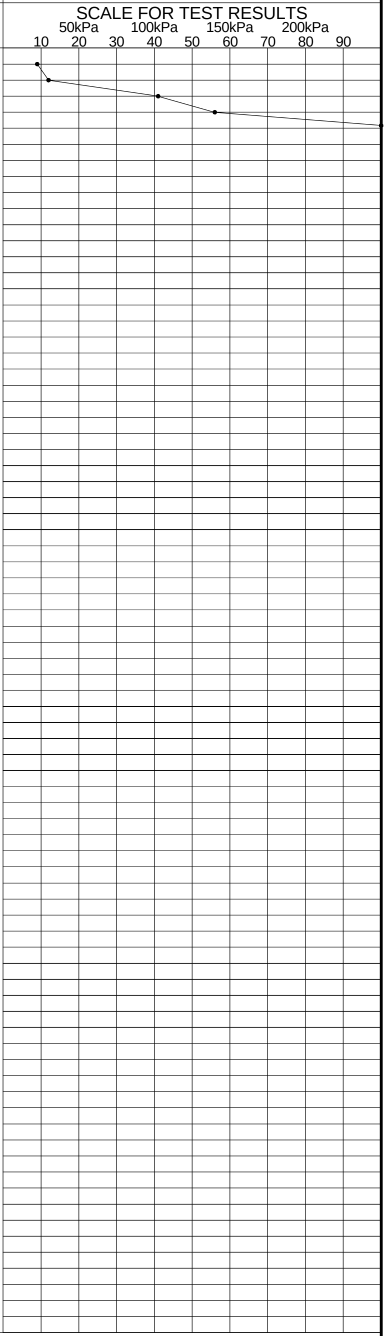
DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht

DATE (START): August 26, 2015 DATE (FINISH): August 26, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
⊢⊣		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	173.30		GROUND SURFACE			%	ppm	N
			Refusal to DCPT at 1.5m					
2.0								
4.0								
6.0								
8.0								
10.0								
12.0								
14.0								
16.0								
18.0								
20.0								
22.0								
24.0								



NOTES:

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 11

BOREHOLE No.: **P4**

ELEVATION: 174.20 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: Cima + c/o Parks Canada

PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction

LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario

DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht

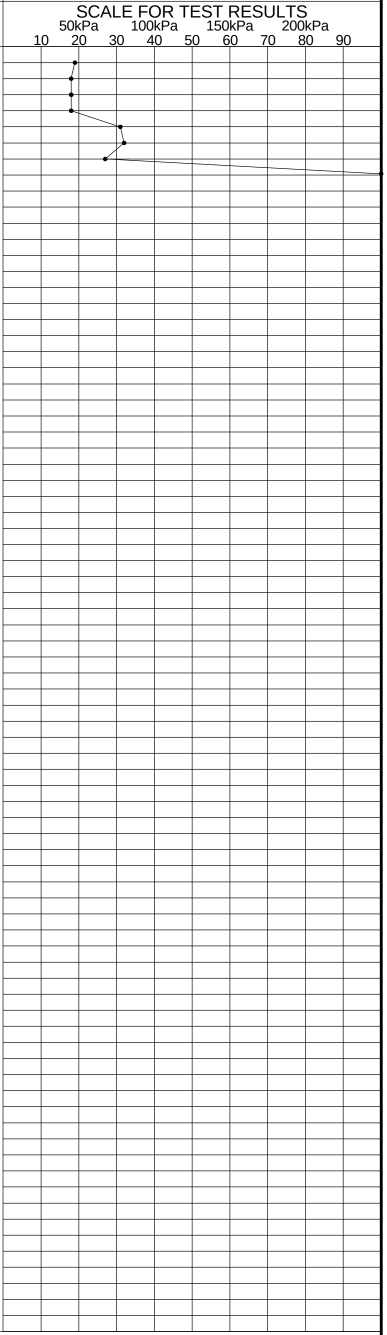
DATE (START): August 26, 2015 DATE (FINISH): August 26, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
├─┤		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	174.20		GROUND SURFACE			%	ppm	N
2.0								
			Refusal to DCPT at 2.4m					
4.0								
6.0								
8.0								
10.0								
12.0								
14.0								
16.0								
18.0								
20.0								
22.0								
24.0								

SCALE FOR TEST RESULTS



NOTES:

REFERENCE No.: 11103700-A1 ENCLOSURE No.: 12

BOREHOLE No.: P5

ELEVATION: 175.10 m

BOREHOLE LOG

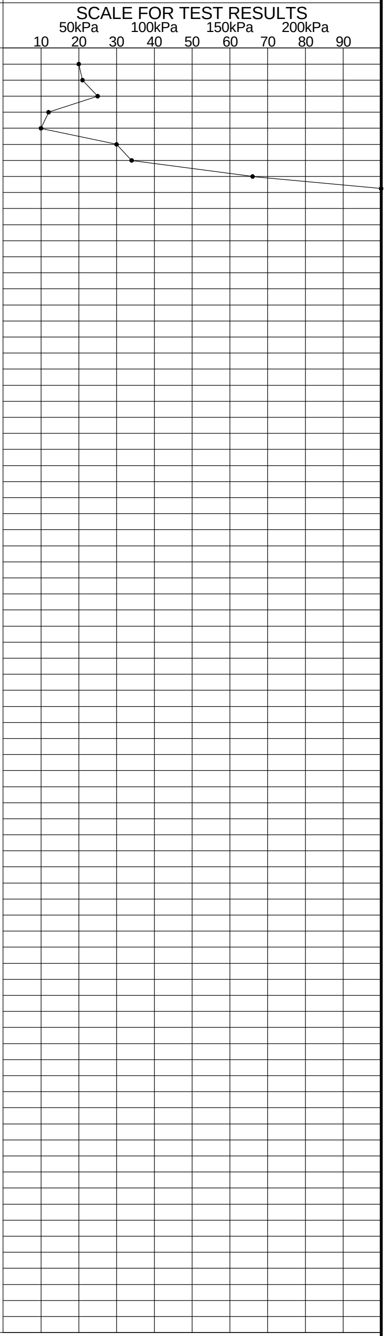
Page: 1 of 1

CLIENT: Cima + c/o Parks Canada
PROJECT: Geotechnical Investigation - Proposed Dam Relocation/Reconstruction
LOCATION: Bob's Lake Dam, 169 Crow Lake Road, Bolingbroke, Ontario
DESCRIBED BY: J. Poisson CHECKED BY: B. Vazhbakht
DATE (START): August 26, 2015 DATE (FINISH): August 26, 2015

LEGEND

☒	SS	Split Spoon
▮	GS	Auger Sample
▨	ST	Shelby Tube
▼		Water Level
○		Water content (%)
├─┤		Atterberg limits (%)
●	N	Penetration Index based on Split Spoon sample
•	N	Penetration Index based on Dynamic Cone sample
△	Cu	Shear Strength based on Field Vane
□	Cu	Shear Strength based on Lab Vane
S		Sensitivity Value of Soil
▲		Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA				
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD
meters	175.10		GROUND SURFACE			%	ppm	N
2.0								
			Refusal to DCPT at 2.7m					
4.0								
6.0								
8.0								
10.0								
12.0								
14.0								
16.0								
18.0								
20.0								
22.0								
24.0								



NOTES:

Notes on Borehole and Test Pit Reports

Soil description :

Each subsurface stratum is described using the following terminology. The relative density of granular soils is determined by the Standard Penetration Index ("N" value), while the consistency of clayey sols is measured by the value of undrained shear strength (Cu).

Classification (Unified system)

Clay	< 0.002 mm		
Silt	0.002 to 0.075 mm		
Sand	0.075 to 4.75 mm	fine	0.075 to 4.25 mm
		medium	0.425 to 2.0 mm
		coarse	2.0 to 4.75 mm
Gravel	4.75 to 75 mm	fine	4.75 to 19 mm
		coarse	19 to 75 mm
Cobbles	75 to 300 mm		
Boulders	>300 mm		

Terminology

"trace"	1-10%
"some"	10-20%
adjective (silty, sandy)	20-35%
"and"	35-50%

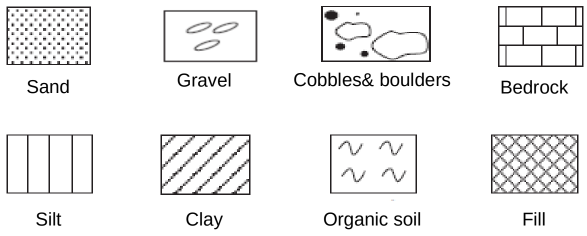
Relative density of granular soils	**Standard penetration index "N" value** (BLOWS/ft – 300 mm)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Consistency of cohesive soils	**Undrained shear strength (Cu)**	
	(P.S.F)	(kPa)
Very soft	<250	<12
Soft	250-500	12-25
Firm	500-1000	25-50
Stiff	1000-2000	50-100
Very stiff	2000-4000	100-200
Hard	>4000	>200

Rock quality designation

"RQD" (%) Value	Quality
<25	Very poor
25-50	Poor
50-75	Fair
75-90	Good
>90	Excellent

STRATIGRAPHIC LEGEND



Samples:

Type and Number

The type of sample recovered is shown on the log by the abbreviation listed hereafter. The numbering of samples is sequential for each type of sample.

SS: Split spoon
SSE, GSE, AGE: Environmental sampling
ST: Shelby tube
PS: Piston sample (Osterberg)
AG: Auger
RC: Rock core
GS: Grab sample

Recovery

The recovery, shown as a percentage, is the ratio of length of the sample obtained to the distance the sampler was driven/pushed into the soil

RQD

The "Rock Quality Designation" or "RQD" value, expressed as percentage, is the ratio of the total length of all core fragments of 4 inches (10 cm) or more to the total length of the run.

IN-SITU TESTS:

N: Standard penetration index
R: Refusal to penetration
N_c: Dynamic cone penetration index
Cu: Undrained shear strength
Pr: Pressure meter
k: Permeability
ABS: Absorption (Packer test)

LABORATORY TESTS:

I_p: Plasticity index
W_l: Liquid limit
Wp: Plastic limit
H: Hydrometer analysis
GSA: Grain size analysis
A: Atterberg limits
w: Water content
γ: Unit weight
C: Consolidation
CS: Swedish fall cone
CHEM: Chemical analysis
O.V.: Organic vapor

Appendix B

Lugeon Test (Packer Tests) Results

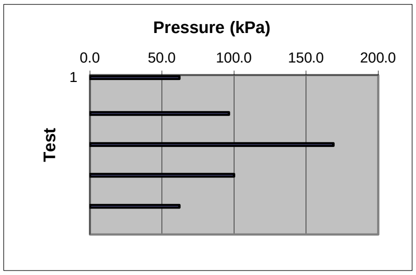
ROCK PERMEABILITY TEST RESULTS
LUGEON (PACKER) TEST METHOD

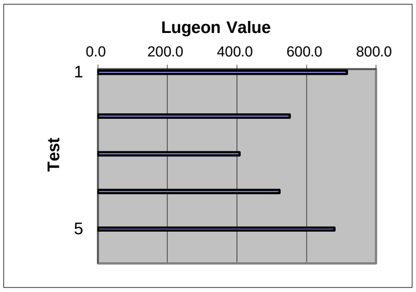
Borehole NO.:	F1
Project NO.:	11103700-A1
Test NO.:	1

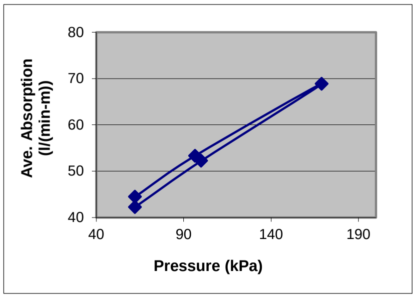
Test Depth:

Z (H) = 7.4 m (Top)
Z = 8.7 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu =	407.5
Corresponding Pressure	169.1

Equivalent Permeability Coefficient

Equation

k = q / (2 x Pi x L x h) x Log_e (L / r)

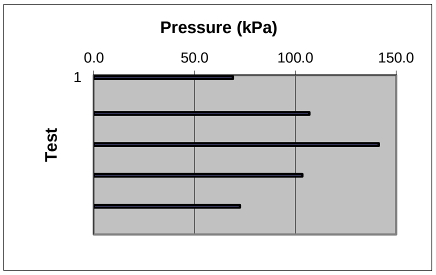
***k* = 3.342E-03 cm/s**

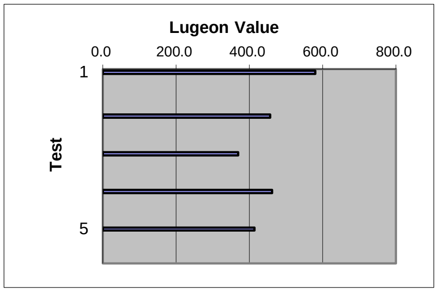
Borehole NO.:	F1
Project NO.:	11103700-A1
Test NO.:	2

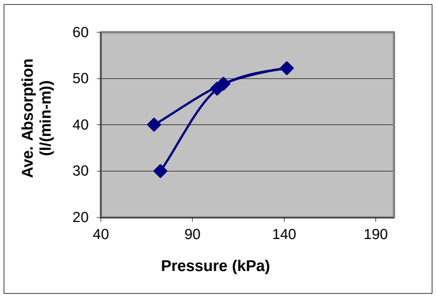
Test Depth:

Z (H) = 5.8 m (Top)
Z = 7.0 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu =	369.2
Corresponding Pressure	141.5

Equivalent Permeability Coefficient

Equation

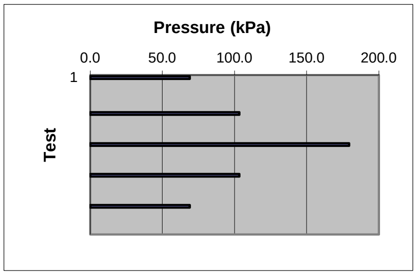
k = q / (2 x Pi x L x h) x Log_e (L / r)

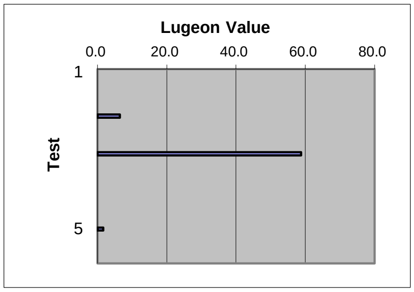
***k* = 3.028E-03 cm/s**

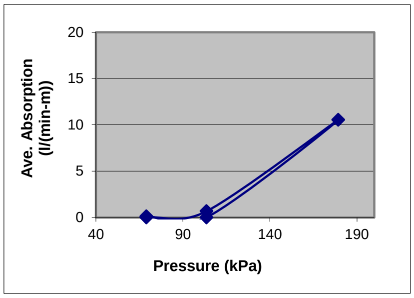
ROCK PERMEABILITY TEST RESULTS
LUGEON (PACKER) TEST METHOD

Borehole NO.: F2
Project NO.: 11103700-A1
Test NO.: 1
Test Depth:
Z (H) = 8.2 m (Top)
Z = 9.4 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 58.8
Corresponding Pressure 179.4

Equivalent Permeability Coefficient

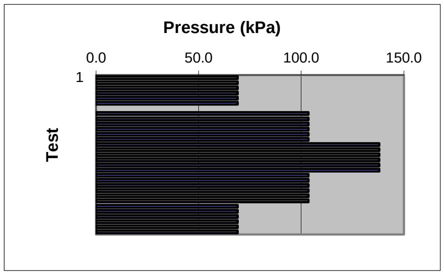
Equation

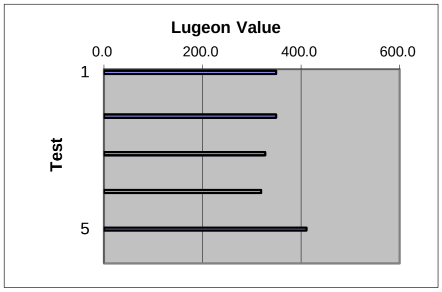
k = q / (2 x Pi x L x h) x Log_e (L / r)

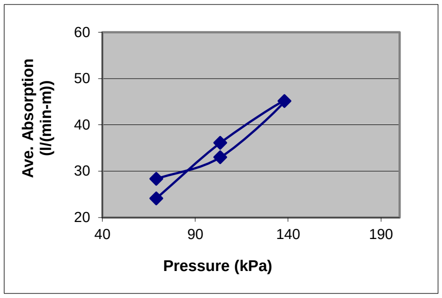
k* = 4.825E-04 *cm/s

Borehole NO.: F2
Project NO.: 11103700-A1
Test NO.: 2
Test Depth:
Z (H) = 6.7 m (Top)
Z = 7.9 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 326.9
Corresponding Pressure 138.0

Equivalent Permeability Coefficient

Equation

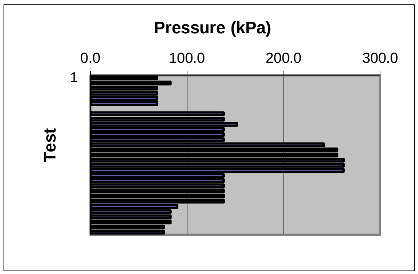
k = q / (2 x Pi x L x h) x Log_e (L / r)

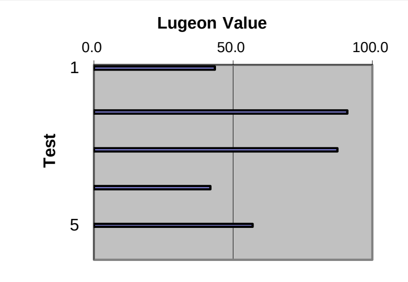
k* = 2.681E-03 *cm/s

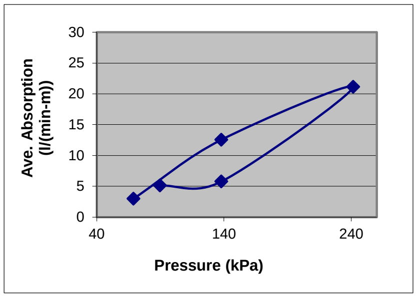
ROCK PERMEABILITY TEST RESULTS
LUGEON (PACKER) TEST METHOD

Borehole NO.: F3
Project NO.: 11103700-A1
Test NO.: 1
Test Depth:
Z (H) = 18.5 m (Top)
Z = 19.8 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 87.4
Corresponding Pressure 241.5

Equivalent Permeability Coefficient

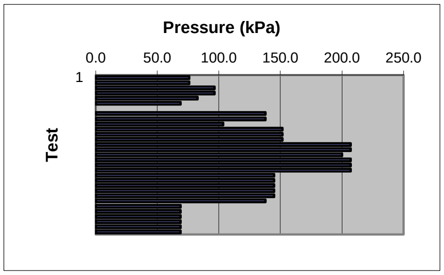
Equation

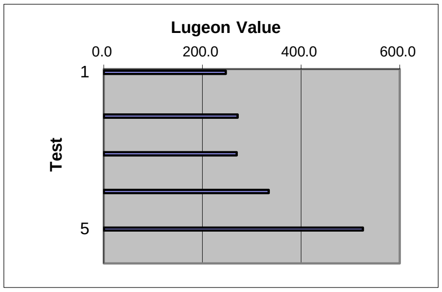
k = q / (2 x Pi x L x h) x Log_e (L / r)

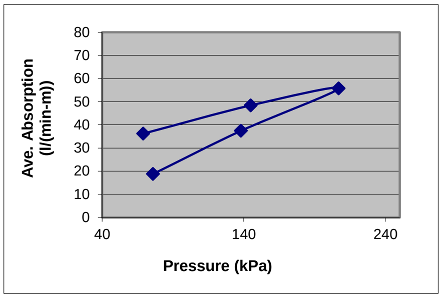
k = 7.169E-04 cm/s

Borehole NO.: F3
Project NO.: 11103700-A1
Test NO.: 2
Test Depth:
Z (H) = 17.0 m (Top)
Z = 18.2 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 269.5
Corresponding Pressure 207.0

Equivalent Permeability Coefficient

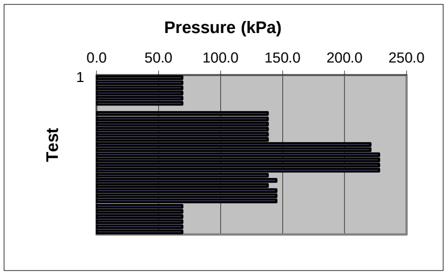
Equation

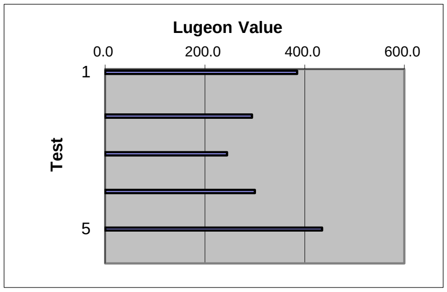
k = q / (2 x Pi x L x h) x Log_e (L / r)

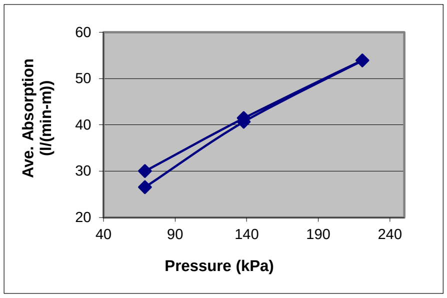
k = 2.210E-03 cm/s

Borehole NO.: F3
Project NO.: 11103700-A1
Test NO.: 3
Test Depth:
Z (H) = 15.5 m (Top)
Z = 16.7 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 244.1
Corresponding Pressure 220.8

Equivalent Permeability Coefficient

Equation

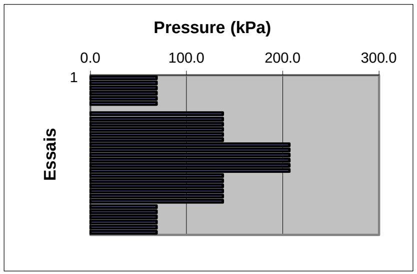
k = q / (2 x Pi x L x h) x Log_e (L / r)

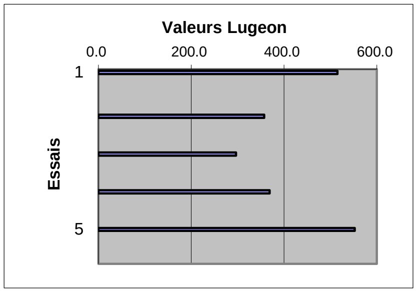
k = 2.002E-03 cm/s

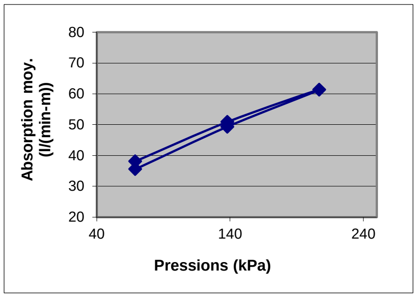
ROCK PERMEABILITY TEST RESULTS
LUGEON (PACKER) TEST METHOD

Borehole NO.: F4
Project NO.: 11103700-A1
Test NO.: 1
Test Depth:
Z (H) = 15.5 m (Top)
Z = 16.7 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 296.3
Corresponding Pressure 207.0

Equivalent Permeability Coefficient

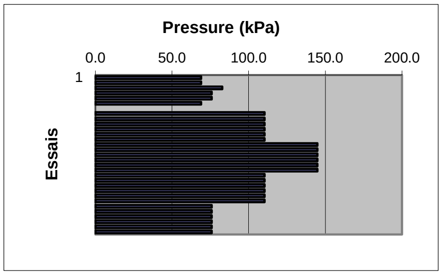
Equation

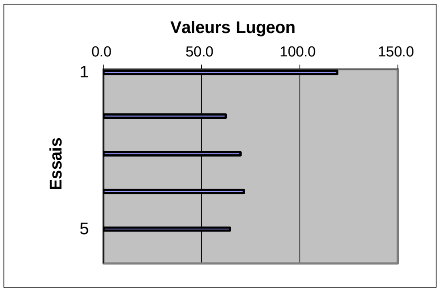
k = q / (2 x Pi x L x h) x Log$_e$ (L / r)

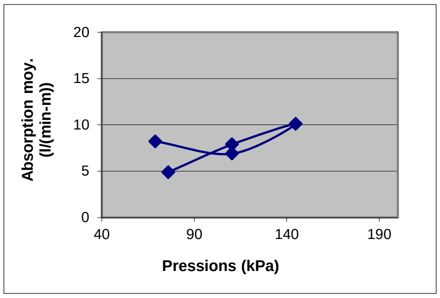
k = 2.430E-03 cm/s

Borehole NO.: F4
Project NO.: 11103700-A1
Test NO.: 2
Test Depth:
Z (H) = 10.9 m (Top)
Z = 12.1 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 69.8
Corresponding Pressure 144.9

Equivalent Permeability Coefficient

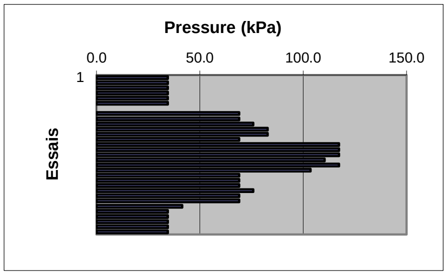
Equation

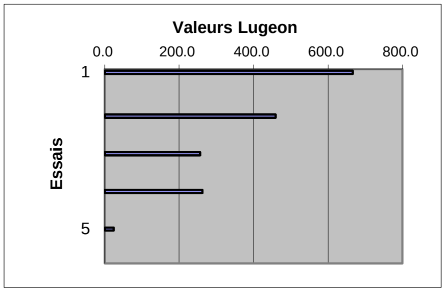
k = q / (2 x Pi x L x h) x Log$_e$ (L / r)

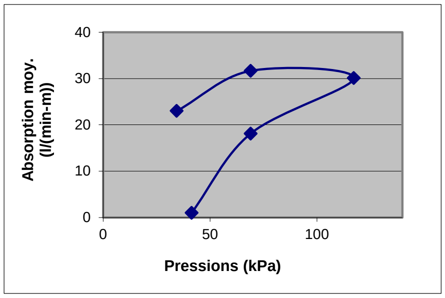
k = 5.723E-04 cm/s

Borehole NO.: F4
Project NO.: 11103700-A1
Test NO.: 3
Test Depth:
Z (H) = 7.9 m (Top)
Z = 9.1 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9
Q = del B / del t
A = Q / Zbas - Zhaut
Lu = (moy. A x 1000) / P

Lugeon Value Lu = 256.7
Corresponding Pressure 117.3

Equivalent Permeability Coefficient

Equation

k = q / (2 x Pi x L x h) x Log$_e$ (L / r)

k = 2.105E-03 cm/s

ROCK PERMEABILITY TEST RESULTS
LUGEON (PACKER) TEST METHOD

Borehole NO.: F5

Project NO.: 11103700-A1

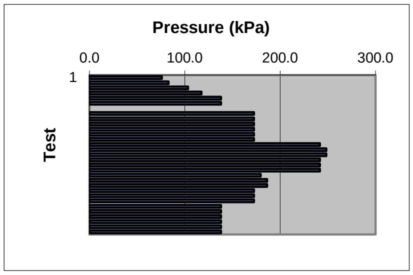
Test NO.: 1

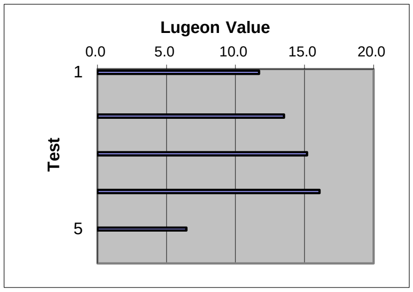
Test Depth:

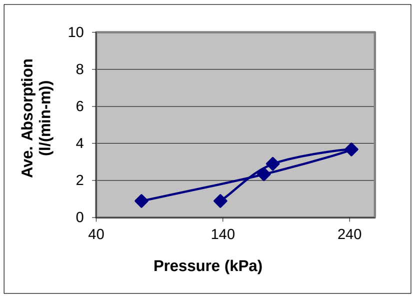
Z (H) = 14.1 m (Top)

Z = 15.5 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure

Pmax = 25H (kPa)

kPa to psi multiply by 0.14

psi to kPa,multiply by 6.9

Q = del B / del t

A = Q / Zbas - Zhaut

Lu = (moy. A x 1000) / P

Lugeon Value Lu = 15.2

Corresponding Pressure 241.5

Equivalent Permeability Coefficient

Equation

$k = q / (2 \times Pi \times L \times h) \times Log_e (L / r)$

k = *1.245E-04* ***cm/s***

Borehole NO.: F5

Project NO.: 11103700-A1

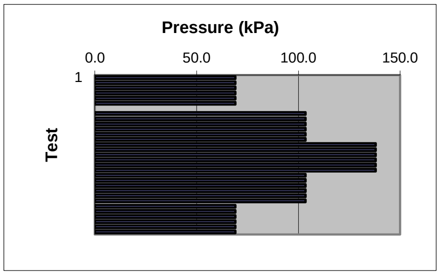
Test NO.: 2

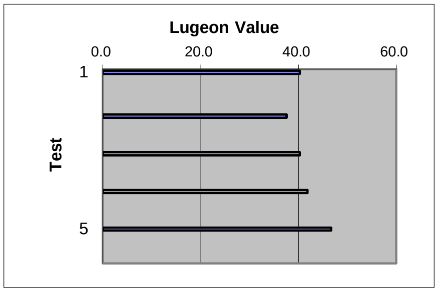
Test Depth:

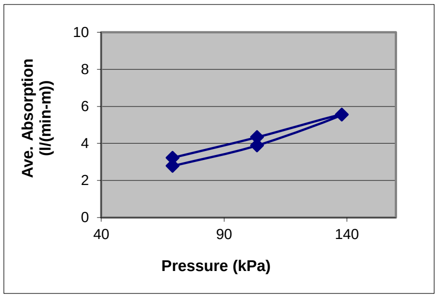
Z (H) = 11.1 m (Top)

Z = 12.3 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure

Pmax = 25H (kPa)

kPa to psi multiply by 0.14

psi to kPa,multiply by 6.9

Q = del B / del t

A = Q / Zbas - Zhaut

Lu = (moy. A x 1000) / P

Lugeon Value Lu = 40.3

Corresponding Pressure 138.0

Equivalent Permeability Coefficient

Equation

$k = q / (2 \times Pi \times L \times h) \times Log_e (L / r)$

k = *3.301E-04* ***cm/s***

Borehole NO.: F5

Project NO.: 11103700-A1

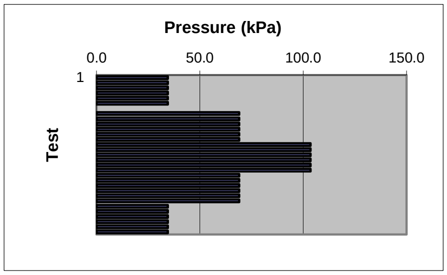
Test NO.: 3

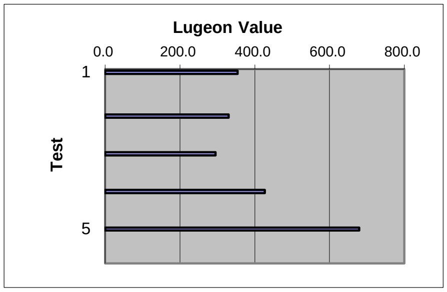
Test Depth:

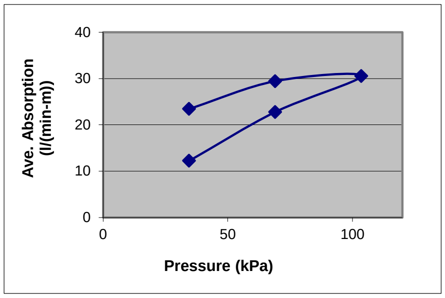
Z (H) = 8.0 m (Top)

Z = 4.2 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure

Pmax = 25H (kPa)

kPa to psi multiply by 0.14

psi to kPa,multiply by 6.9

Q = del B / del t

A = Q / Zbas - Zhaut

Lu = (moy. A x 1000) / P

Lugeon Value Lu = 295.2

Corresponding Pressure 103.5

Equivalent Permeability Coefficient

Equation

$k = q / (2 \times Pi \times L \times h) \times Log_e (L / r)$

k = *2.421E-03* ***cm/s***

ROCK PERMEABILITY TEST RESULTS
LUGEON (PACKER) TEST METHOD

Borehole NO.: F6

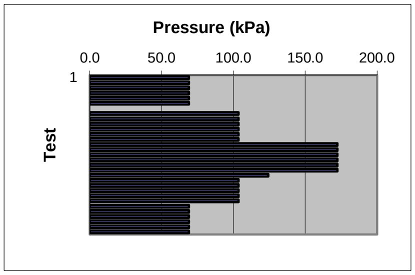
Project NO.: 11103700-A1

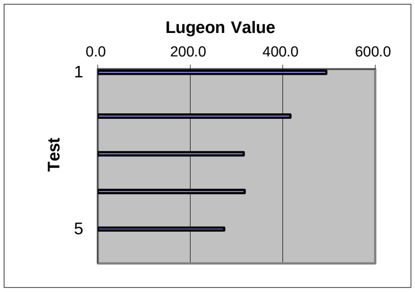
Test NO.: 1

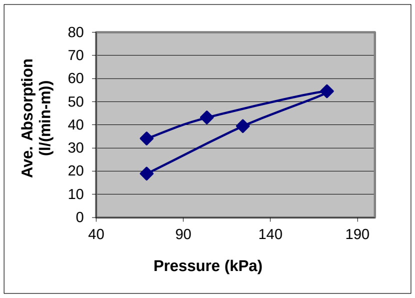
Test Depth:

Z (H) = 18.6 m (Top)
Z = 19.8 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9

Q = del B / del t

A = Q / Zbas - Zhaut

Lu = (moy. A x 1000) / P

Lugeon Value Lu = 315.6

Corresponding Pressure 172.5

Equivalent Permeability Coefficient

Equation

k = q / (2 x Pi x L x h) x Log_e (L / r)

***k* = 2.588E-03 cm/s**

Borehole NO.: F6

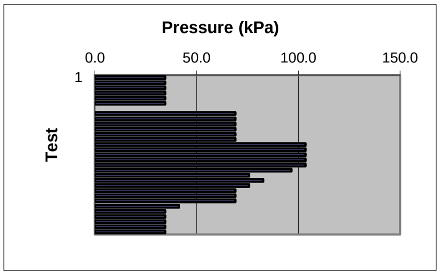
Project NO.: 11103700-A1

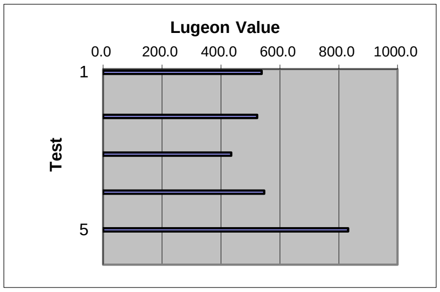
Test NO.: 2

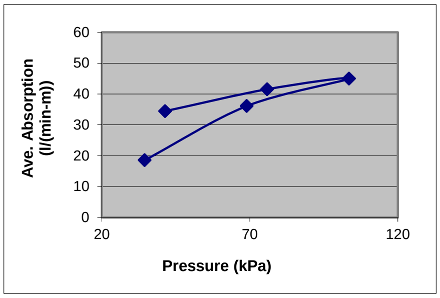
Test Depth:

Z (H) = 14.0 m (Top)
Z = 15.2 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9

Q = del B / del t

A = Q / Zbas - Zhaut

Lu = (moy. A x 1000) / P

Lugeon Value Lu = 434.8

Corresponding Pressure 103.5

Equivalent Permeability Coefficient

Equation

k = q / (2 x Pi x L x h) x Log_e (L / r)

***k* = 3.566E-03 cm/s**

Borehole NO.: F6

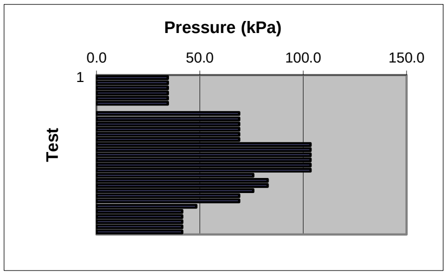
Project NO.: 11103700-A1

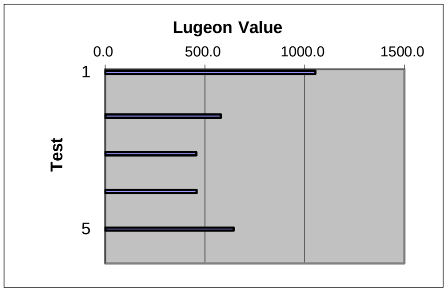
Test NO.: 3

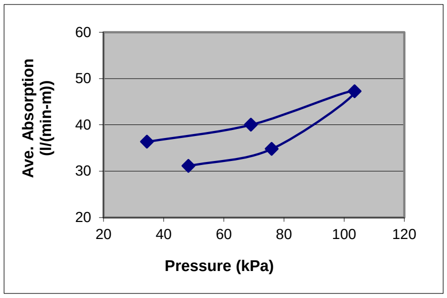
Test Depth:

Z (H) = 12.5 m (Top)
Z = 13.7 m (Bottom)

Figures







Calculations

Maxiumum Test Pressure
Pmax = 25H (kPa)
kPa to psi multiply by 0.14
psi to kPa,multiply by 6.9

Q = del B / del t

A = Q / Zbas - Zhaut

Lu = (moy. A x 1000) / P

Lugeon Value Lu = 456.3

Corresponding Pressure 103.5

Equivalent Permeability Coefficient

Equation

k = q / (2 x Pi x L x h) x Log_e (L / r)

***k* = 3.742E-03 cm/s**

Appendix C

Acoustic TeleViewer (ATV) Logs

JOB NUMBER	11103700-A1
CLIENT	Cima+ c/o Parks Canada
PROJECT	Bob's Lake Dam Relocation/Reconstruction
LOCATION	169 Crow Lake Road, Bolingbroke, Ontario
Plot Date:	2015/9/27

GHD
179 Colonnade Road South Suite 400
Ottawa Ontario K2E 7J4 Canada
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W www.ghd.com

ACOUSTIC BOREHOLE IMAGER LOG

BORE HOLE NO.	F04	**EASTING**	379462
DRILLING METHOD	DDH CORING	**NORTHING**	4957351
HOLE DIAMETER	NQ (76 mm)	**SURFACE ELEV'N**	
DRILLED DEPTH	17.98 M	**HORIZONTAL DATUM:**	NAD 1983
LOGGED FROM TO	2.11 - 17.92 M	**HEIGHT DATUM:**	CGVD2013
LOGGED BY	N Lolom	**HOLE INCLINATION**	90
DATE LOGGED	21/08/2015	**RUN NO.**	1

Parks Canada Parcs Canada

PROCESSED BY	G Pettifer
CHECKED BY	J Rothfischer
APPROVED BY	B Vazhbakht
APPROVED DATE	2015/9/28
REVISION NO.	1

JOB NUMBER 11103700-A1
CLIENT Cima+ c/o Parks Canada
PROJECT Bob's Lake Dam Relocation/Reconstruction
LOCATION 169 Crow Lake Road, Bolingbroke, Ontario
Plot Date: 2015/9/27

GHD
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Ottawa Ontario K2E 7J4 Canada
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ACOUSTIC BOREHOLE IMAGER LOG

BORE HOLE NO.	F05	EASTING	379466
DRILLING METHOD	DDH CORING	NORTHING	4957362
HOLE DIAMETER	NQ (76 mm)	SURFACE ELEV'N	
DRILLED DEPTH	16.87 M	HORIZONTAL DATUM:	NAD 1983
LOGGED FROM TO	3.90 - 16.34 M	HEIGHT DATUM:	CGVD2013
LOGGED BY	N Lolom	HOLE INCLINATION	90
DATE LOGGED	21/08/2015	RUN NO.	1

Parks Canada Parcs Canada

PROCESSED BY G Pettifer
CHECKED BY J Rothfischer
APPROVED BY B Vazhbakht
APPROVED DATE 2015/9/28
REVISION NO. 1

Appendix D
Laboratory Analytical Results

POINT LOAD STRENGTH OF ROCK
(ASTM D5731)

CLIENT: CIMA & c/o Parks Canada **LAB No.:** WLA 577-1

PROJECT/ SITE: Bobs Lake Dam - Bolinbroke, ON **PROJECT No.:** 11103700-A1

Borehole No.: F-1 Sample No.: RC-2

Depth, m: 4.5-6.0 Sample Description: Rock Core

Trial #	Specimen Width W	Distance Between Platens D	Pressure Applied	Breaking Load P	Equivalent Core Diameter D_e	Point Load Strength Index I_s	Corrected Point Load Strength Index I_{s50}	Uniaxial Compressive Strength (predicted)
	mm	mm	MPa	kN	mm	MPa	MPa	MPa
1	47.0	47.0	11.6	11.0	53.0	3.9	4.0	84.3
2	47.0	47.0	6.3	6.0	53.0	2.1	2.2	52.1
3	47.0	47.0	3.7	3.5	53.0	1.2	1.3	36.1
4	47.0	30.0	5.6	5.3	42.4	2.9	2.7	61.2
5	47.0	26.5	4.8	4.5	39.8	2.8	2.5	58.0
Average	**47.0**	**39.5**	**6.4**	**6.0**	**48.3**	**2.6**	**2.5**	**58.4**

REMARKS:

PERFORMED BY: Setareh Memarian **DATE:** October 2, 2015

VERIFIED BY: Michael Braverman **DATE:** October 3, 2015

POINT LOAD STRENGTH OF ROCK
(ASTM D5731)

CLIENT: CIMA & c/o Parks Canada

LAB No.: WLA 577-2

PROJECT/ SITE: Bobs Lake Dam - Bolinbroke, ON

PROJECT No.: 11103700-A1

Borehole No.: F-2

Sample No.: RC-1

Depth, m: 3.5-4.5

Sample Description: Rock Core

Trial #	Specimen Width W	Distance Between Platens D	Pressure Applied	Breaking Load P	Equivalent Core Diameter D_e	Point Load Strength Index I_s	Corrected Point Load Strength Index I_{s50}	Uniaxial Compressive Strength (predicted)
	mm	mm	MPa	kN	mm	MPa	MPa	MPa
1	47.4	47.4	13.5	12.8	53.5	4.5	4.6	94.8
2	47.4	32.4	12.4	11.7	44.2	6.0	5.6	112.9
3	47.4	31.4	15.3	14.5	43.5	7.6	7.1	138.8
4	47.4	23.4	12.6	11.9	37.6	8.4	7.3	141.8
5	47.4	22.4	10.1	9.5	36.8	7.0	6.0	119.5
6	47.4	28.4	5.9	5.6	41.4	3.3	3.0	65.7
7	47.4	19.4	7.3	6.9	34.2	5.9	4.9	99.0
Average	**47.4**	**29.3**	**11.0**	**10.4**	**41.6**	**6.1**	**5.5**	**110.4**

REMARKS:

PERFORMED BY: Setareh Memarian

DATE: October 2, 2015

VERIFIED BY: Michael Braverman

DATE: October 3, 2015

POINT LOAD STRENGTH OF ROCK
(ASTM D5731)

CLIENT:	CIMA & c/o Parks Canada	**LAB No.:**	WLA 577-3
PROJECT/ SITE:	Bobs Lake Dam - Bolinbroke, ON	**PROJECT No.:**	11103700-A1
Borehole No.:	F-4	Sample No.:	RC-2
Depth, m:	3.5-4.5	Sample Description:	Rock Core

Trial #	Specimen Width W	Distance Between Platens D	Pressure Applied	Breaking Load P	Equivalent Core Diameter D_e	Point Load Strength Index I_s	Corrected Point Load Strength Index I_{s50}	Uniaxial Compressive Strength (predicted)
	mm	mm	MPa	kN	mm	MPa	MPa	MPa
1	47.3	47.3	13.5	12.8	53.4	4.5	4.6	95.1
2	47.3	27.8	12.4	11.7	40.9	7.0	6.3	125.1
3	47.3	21.8	15.3	14.5	36.2	11.0	9.4	178.5
4	47.3	29.8	12.6	11.9	42.4	6.6	6.1	120.7
5	47.3	26.3	10.1	9.5	39.8	6.0	5.3	107.6
Average	**47.3**	**30.6**	**12.8**	**12.1**	**42.5**	**7.0**	**6.4**	**125.4**

REMARKS:

PERFORMED BY:	Setareh Memarian	**DATE:**	October 2, 2015
VERIFIED BY:	Michael Braverman	**DATE:**	October 3, 2015

POINT LOAD STRENGTH OF ROCK
(ASTM D5731)

CLIENT:	CIMA & c/o Parks Canada	**LAB No.:**	WLA 577-4
PROJECT/ SITE:	Bobs Lake Dam - Bolinbroke, ON	**PROJECT No.:**	11103700-A1
Borehole No.:	F-5	Sample No.:	RC-2
Depth, m:	2.5-3.5	Sample Description:	Rock Core

Trial #	Specimen Width W	Distance Between Platens D	Pressure Applied	Breaking Load P	Equivalent Core Diameter D_e	Point Load Strength Index I_s	Corrected Point Load Strength Index I_{s50}	Uniaxial Compressive Strength (predicted)
	mm	mm	MPa	kN	mm	MPa	MPa	MPa
1	47.7	47.7	14.8	14.0	53.8	4.8	5.0	101.7
2	47.7	41.7	12.3	11.6	50.3	4.6	4.6	94.7
3	47.7	30.7	11.1	10.5	43.1	5.6	5.2	105.4
4	47.7	27.7	6.4	6.1	41.0	3.6	3.3	71.1
5	47.7	35.7	11.1	10.5	46.5	4.8	4.7	95.6
Average	**47.7**	**36.7**	**11.1**	**10.5**	**46.9**	**4.7**	**4.6**	**93.7**

REMARKS:

PERFORMED BY:	Setareh Memarian	**DATE:**	October 2, 2015
VERIFIED BY:	Michael Braverman	**DATE:**	October 3, 2015

Résistance à la traction par écrasement latéral sur échantillon de roc intact
ASTM D3967-05

Client : Cima+ c/o Parks Canada

Projet : Bobs Lake Dam, Bolingbroke, Ontario

N° de projet : 11103700-A1

N° d'échantillon : BH-1 / RC-3

Profondeur :

Appareils de mesure utilisés : Presse N° 500QCP9804 Vernier N° 8160

Données techniques

Diamètre (D):	47.4	47.4	(mm)
Longueur (L):	23.9	23.7	(mm)
Ratio L/D	0.50	Entre 0.20 et 0.75	
Condition d'humidité:	Dry		
Taux de chargement:	-	▨	(MPa/min)
Type de fracture:	Shear	▨	
Durée de l'essai	37sec	Entre 1 et 10 minutes	

Résistance en tension (Essai Brésilien) 5.8 (MPa)

Vue de l'échantillon

Avant essai

Après essai

Description macroscopique

Pinkish white medium grained quartzitic marble

Remarques :

Effectué par : F. Adenot. **Date :** October 30th, 2015

Vérifié par : B. Cyr. B. Sc. Géologie. **Date :** October 30th, 2015

Résistance à la traction par écrasement latéral sur échantillon de roc intact
ASTM D3967-05

Client : Cima+ c/o Parks Canada

Projet : Bobs Lake Dam, Bolingbroke, Ontario

N° de projet : 11103700-A1

N° d'échantillon : BH-2 / RC-1

Profondeur :

Appareils de mesure utilisés : Presse N° 500QCP9804 Vernier N° 8160

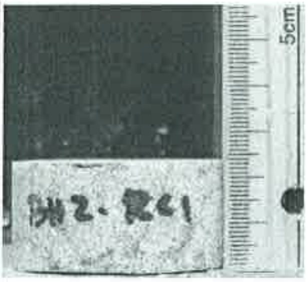
Données techniques

Diamètre (D):	47.3	47.3	(mm)
Longueur (L):	24.1	23.9	(mm)
Ratio L/D	0.51	Entre 0.20 et 0.75	
Condition d'humidité:	Dry		
Taux de chargement:	15187.2		(N/min)
Type de fracture:	Shear		
Durée de l'essai	1min 7sec	Entre 1 et 10 minutes	

Résistance en tension Brésilien) **(Essai** 10.1 (MPa)

Vue de l'échantillon

Avant essai



Après essai

Description macroscopique

Greenish white medium grained quartzitic marble

Remarques :

Effectué par : F. Adenot. **Date :** October 30th, 2015

Vérifié par : B. Cyr. B. Sc. Géologie. **Date :** October 30th, 2015

Résistance à la traction par écrasement latéral sur échantillon de roc intact
ASTM D3967-05

Client : Cima+ c/o Parks Canada

Projet : Bobs Lake Dam, Bolingbroke, Ontario

N° de projet : 11103700-A1

N° d'échantillon : BH-5 / RC-2

Profondeur :

Appareils de mesure utilisés : Presse N° 500QCP9804 Vernier N° 8160

Données techniques

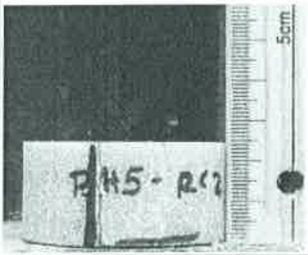
Diamètre (D):	47.4	47.4	(mm)
Longueur (L):	24.4	24.8	(mm)
Ratio L/D	0.52	Entre 0.20 et 0.75	
Condition d'humidité:	Dry		
Taux de chargement:	15271.8		(N/min)
Type de fracture:	Shear		
Durée de l'essai	1min 5sec	Entre 1 et 10 minutes	

Résistance en tension (Essai Brésilien) 9.9 (MPa)

Vue de l'échantillon

Avant essai

Après essai



Description macroscopique

White medium grained marble

Remarques :

Effectué par : F. Adenot. **Date :** October 30th, 2015

Vérifié par : B. Cyr. B. Sc. Géologie. **Date :** October 30th, 2015

Résistance à la traction par écrasement latéral sur échantillon de roc intact
ASTM D3967-05

Client : Cima+ c/o Parks Canada

Projet : Bobs Lake Dam, Bolingbroke, Ontario

N° de projet : 11103700-A1

N° d'échantillon : F-4 / RC-2

Profondeur :

Appareils de mesure utilisés : Presse N° 500QCP9804 Vernier N° 8160

Données techniques

Diamètre (D):	47.3	47.3	(mm)
Longueur (L):	22.4	22.8	(mm)
Ratio L/D	0.48	Entre 0.20 et 0.75	
Condition d'humidité:	Dry		
Taux de chargement:	-		(N/min)
Type de fracture:	Shear		
Durée de l'essai	1min 2sec	Entre 1 et 10 minutes	

Résistance en tension (Essai Brésilien) 10.2 (MPa)

Vue de l'échantillon

Avant essai

Après essai

Description macroscopique

Greenish grey medium grained quartzite

Remarques :

Effectué par : F. Adenot. **Date :** October 30th, 2015

Vérifié par : B. Cyr. B. Sc. Géologie. **Date :** October 30th, 2015

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