GEOTECHNICAL/MATERIALS EVALUATION
PROPOSED DEH CHO BRIDGE
FORT PROVIDENCE, NT

Project No. 1700063

February, 2004

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FORT PROVIDENCE, NT

Submitted To:

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1.0 INTRODUCTION

1.1 General

This report presents the results of a geotechnical and materials evaluation completed by EBA Engineering Consultants Ltd. (EBA) for the foundation and earthworks for the Deh Cho Bridge proposed for construction at the existing Mackenzie River ferry crossing near Fort Providence, NT. The primary objective of the investigation was to provide the bridge designers with the soil engineering parameters needed to design the bridge foundation and approaches.

1.2 Project Details

The construction of a highway bridge across the Mackenzie River, near Fort Providence, NT, is proposed. The location being considered for the bridge is at the current location of the ferry crossing. The bridge is expected to be approximately 1 km in length. The foundation concept includes two abutments and eight piers. At the time of the site investigation it was anticipated that the abutments would be founded on driven H-piles and the piers would be founded on cast-in-place concrete caissons. The foundation concept has been revised, based on the findings from this investigation, to replace the caissons with spread footings at the pier locations.

Northwest Hydraulic Consultants (1975) completed a hydrologic study of the area of the proposed crossing. That report reproduced some earlier geotechnical information collected by Public Works Canada, about 1 km downstream from the presently proposed crossing. Clay till was the prevalent soil type encountered. It was described as being fairly hard to very hard.

1.3 Scope of Work

EBA's scope of work evolved through the completion of the project and discussions with Jivko Engineering. The scope of work documented in this report is summarized as follows:

- Arrange for the drilling of geotechnical boreholes at locations selected by the client;
- Complete field and laboratory testing in order to determine the following soil properties:
  - Unit weight;
  - Elastic modulus;
  - Poisson's ratio (optional);
  - Effective angle of internal friction;
  - Effective cohesion; and
  - Unconfined compressive strength;
- Prepare a data report that describes the site investigation and presents the findings;
- Provide geotechnical recommendations for footing bearing capacity and excavation over sand;
- Evaluate the suitability of local gravel for concrete aggregate;
- Prepare pavements designs for bridge approaches; and
- Respond to enquiries received during the permit application process, specifically
  - Provide and estimate of sediment liberated by soil excavation;
  - Determine the geochemistry of proposed quarry rock; and
  - Consider ammonia concentrations from quarry blasting.

2.0 METHODS OF INVESTIGATION

2.1 Initial Site Investigation

The initial site investigation was completed from April 8 to April 19, 2003, using a truck-mounted air-rotary drill rig, operated by Midnight Sun Drilling Co. Limited, of Whitehorse, Yukon. The drill was equipped with an ODEX drilling system. Mr. Ryan Lyle, M.I.T. of EBA, monitored the drilling. Selected photographs of the site investigation are presented in Appendix B.

Eight boreholes were drilled to depths ranging from 8.4 m to 21.2 m below ice surface. Borehole locations were selected and located in the field by Jivko Engineering. Mechanical breakdown prevented the completion of the borehole at location P-2. Therefore an additional borehole (identified as P-2A) was drilled approximately one metre away from Borehole P-2 and completed to the desired depth. Borehole locations are indicated on Figure 1. The elevation of the ice surface was approximately 151 m above sea level at the time of drilling.

The soils encountered were visually classified at the time of drilling. Representative, disturbed samples of soil were collected from the drill cuttings and a split spoon sampler and retained for laboratory testing. Several relatively undisturbed, Shelby tube samples were collected for strength and bulk density testing. Borehole logs are presented in Appendix C.

Penetration tests were completed to assess the consistency of the soil using a 75 mm outside diameter split spoon sampler. The 75 mm sampler has a larger diameter than a Standard Penetration Test (SPT) sampler (50.8 mm). The hammer size and drop height used were the same as used in Standard Penetration Testing (623 N and 76.2 cm respectively). Blow counts were recorded using the same methodology as for Standard Penetration Testing, that is, blow counts were recorded for 300 mm of penetration. The large diameter penetrometer test is referred to as "LPT" on the borehole logs and later in this report. Further discussion on the interpretation of LPT results is provided later in this report.

The LPT did not give representative results in sand as the sand was carried up into the casing under hydrostatic pressure. Therefore, a dynamic cone penetration test was conducted in Borehole 2A in an attempt to assess the consistency of the undisturbed sand beyond the end of the borehole.

Pocket penetrometer measurements were also taken on the soil to assist with the determination of the consistency. These are shown on the borehole logs.

It had been intended to drill a borehole at each of the two abutment and eight proposed pier locations. The Department of Transportation would not permit work on the ice after the nearby public ice crossing was closed for the season. Therefore work was halted after seven of the desired ten locations were investigated. Pier locations P6, P8 and the north abutment were not drilled at the time of the initial investigation.

2.2 Additional Drilling

Additional drilling was completed on October 28, 2003 using a MARL-10 solid stem auger drill operated by Mobile Augers and Research Ltd. of Edmonton, AB. EBA's field representative was Mr. Kevin Dragon, M.I.T.

Two boreholes were advanced to depths of 10 and 12 metres at the A-2 and P-8 locations respectively. Jivko Engineering laid out borehole locations by measuring from a survey control point. Approximate borehole locations are shown on Figure 1. The actual location for Borehole P-8 was shifted on to the edge of the jetty.

The soils encountered were logged. Standard Penetration Tests (SPT's) were undertaken at regular intervals to obtain soil consistency information and disturbed samples. Additional disturbed soil samples were also obtained from the auger flights. Relatively undisturbed, Shelby tube samples were also obtained at depths below the riverbed. Samples were retained for laboratory testing. Borehole logs that indicate the field observations are presented in Appendix C.

Boreholes were backfilled with cuttings upon completion.

2.3 Borrow Sources

Borrow sources were not investigated by EBA, but by representatives of Jivko Engineering. Samples of potential quarry rock, concrete aggregate and approach construction materials were delivered to EBA's Yellowknife office throughout the summer and fall.

2.4 Laboratory Testing

The natural moisture contents of selected samples from the geotechnical programs were determined in order to get an indication of the moisture content variation with depth. Sieve and hydrometer analyses were performed on selected samples in order to determine gradations. The Atterberg Limits of selected samples were determined for the purpose of soil classification. The soluble sulphate contents of selected samples were also determined. These laboratory test results are presented on the borehole logs in Appendix C, as well as separately where applicable in Appendix D. Table D-1 summarizes all laboratory test results from the geotechnical site investigations.

Two multi-stage, consolidated, undrained, triaxial tests were completed to determine the drained strength behaviour of the clay till. The Elastic modulus was calculated from these test results. Six unconfined compression tests were completed to determine the

undrained soil strengths of the clay till. Test results are summarized on the borehole logs in Appendix C and more details are provided in Appendix D.

The bulk densities of the samples submitted for strength testing were determined. The bulk densities of three additional clay samples were also determined. These results are presented on the borehole logs in Appendix C and summarized in Appendix D.

The drilling process disturbed the sand, so it was not possible to obtain undisturbed samples for bulk density testing. However, one of the split spoon penetrometer samples was considered to yield reasonably representative moisture content. The specific gravity of the sand at this location was determined in order to permit the approximate bulk density to be calculated.

The test results from samples of potential concrete aggregate are presented in Appendix E. This includes gradation and petrographic analysis.

The test results from samples of the various materials being considered for bridge approach construction are presented in Appendix F. This includes gradation, Atterberg Limits, Standard Proctor, California Bearing Ratio and some durability testing (L.A. Abrasion and unconfined compressive strength). Table F-1 summarizes these test results.

The propensity of the clay till to liberate sediment and the geochemistry of potential quarry rock were evaluated. These test results are presented in Appendix G.

3.0 SITE DESCRIPTION

3.1 Surface Conditions

During the initial investigation the site included the frozen river surface and two jetties extending into the river that were previously constructed for the ferry operation. Photographs attached in Appendix A show the site conditions during the initial investigation.

The area investigated spanned about 1,050 m. Borehole A-1 at the south abutment location was drilled at the south ferry landing, from a mixture of snow and soil fill.

Borehole P-2, 3, 4, 5 and 7 were drilled from the ice. Water/ice depths were about 4 m to 5 m at the time of the site investigation.

Boreholes P-8 and A-2 were drilled from land at the north jetty, which has gravel and sand fill at surface.

3.2 Subsurface Stratigraphy

The following paragraphs summarize the soil stratigraphy encountered in both investigations. The details at borehole locations are described in Appendix C.

Gravel: There is a layer of gravel/cobbles/boulders on the riverbed. The thickness of this layer ranged from 0.1 m at Borehole P-1 to 0.7 m at Boreholes P-2/2A, and averaged 0.4 m. The drilling technique pulerverized the rock, so that particle sizes could not be determined. While the soil was logged as gravel, boulders can be anticipated, based on other work EBA has completed in the area.

Clay (Till): The prevalent soil below the river and abutment areas is hard clay till. Till is naturally a variable material, so that the soil was occasionally also logged as gravel, silt, or sand till, or combinations thereof. This is treated as one unit for the purpose of this discussion. The soil has the following characteristics, based on the lab testing:

- The bulk density is quite consistent, ranging from 2279 kg/m^3 to 2361 kg/m^3 and averaging 2331 kg/m^3;
- The unconfined compressive strength ranged from 792 kPa to 1409 kPa. Below the river, the two samples from shallower depth (about 6 m below ice surface) had higher strengths than the two samples from deeper (9 m to 12 m below the ice surface). This may reflect increased disturbance of the samples from greater depth, due to stress release. The unconfined compressive strengths from the holes drilled at the north jetty were 792 kPa and 869 kPa, which is at the low end of the observed range;
- The effective stress parameters were ϕ' of about 25° and c' of about 20 to 40 kPa;
- The elastic modulus ranged from 2 to 5 MPa at in situ confining stress and increased up to about 10 to 40 MPa at 16 times the in situ stress;
- The clay is low to medium plastic;

- Moisture contents in the clay till ranged from 8% to 13% and averaged 10%. The moisture content of the till is generally below the plastic limit; and
- Samples of the till generally contained a trace of gravel. It is anticipated that cobbles and boulders are also present in the till, but the drill would have pulverized these and they would not have been collected in the split spoon or Shelby tube samplers.

Sand: A layer of sand is present within the till near the south side of the river. Figure 2 illustrates the interpreted extent of the sand, encountered in Boreholes A-1 to P-2. The sand is generally fine-grained and contains a trace of gravel and a trace to some fines (silt and clay). The sand tended to flow up into the casing when the drill bit was extracted, so it was difficult to assess its consistency with the LPT. However, a dynamic cone penetration test in Borehole P-2A demonstrated that the sand is very dense. Moisture contents of samples from this unit were measured to range from 10% to 19% and average 15%, however these results may be somewhat higher than actual as a result of sample disturbance.

Fill: About 2 m of clay fill was encountered in Borehole A-1 above the natural soil. The fill has similar characteristics to and is likely derived from the local clay till. The consistency ranged from stiff to very stiff at the borehole location.

EBA's (2000) investigation was predominantly on the existing jetty at the proposed location of the south abutment, so further description on the nature of the clay fill can be found in that report. The log of Borehole 1 from that previous investigation is included in Appendix C, for information, together with a copy of the site plan indicating the borehole's location. This borehole log also provides some additional information on the characteristics of the clay till in that area.

Granular fill was encountered at the north ferry landing over the locally derived, fine-grained silt/clay fill. The consistency of the granular fill is compact. The thickness of this layer ranged from 0.3 m in Borehole A-2 to 2.1 m in Borehole P-8 (Boreholes P-8 and A-2). The consistency of the silt/clay fill ranged from firm to stiff. This fill extended to about 4.5 m below grade at both borehole locations.

3.3 Permafrost

The Fort Providence area is in the zone of widespread discontinuous permafrost. Permafrost was not encountered in any of the boreholes drilled at the site. Permafrost is not expected to underlie the site because of the warming influence of the river.

4.0 INTERPRETATION OF FINDINGS

4.1 Large Diameter Penetrometer

During the initial site investigation, penetration tests were completed in the boreholes ahead of the casing using a 75 mm diameter split spoon driven with an SPT hammer (623 N weight and 76.2 cm drop). SPT's are typically correlated to consistency: unconfined compressive strength for cohesive soils and density for cohesionless soils. There is presently no correlation to assist with interpreting LPT results obtained with the combination of equipment used during this investigation, to EBA's knowledge. Therefore, an attempt was made to correlate the LPT results to unconfined compressive strengths from this project. Of the four unconfined compressive strength tests completed, three were associated with what are considered reliable LPT tests. The relationship from this data is plotted in Figure 3. It can be seen that there is no obvious correlation with the limited available data, however, a trend line was applied. This trend line can be used to obtain a crude approximation of strength or consistency of the clay till.

The conventional correlation for an SPT test is also illustrated on Figure 3. It can be seen that the trend line for the LPT falls below the line for the SPT. This is as expected, because the LPT is conducted with a larger diameter split spoon. At a given soil strength, it should take more energy to drive a larger diameter penetrometer. Further information on correlating LPT results to SPT results can be found in Daniel, et al (2003).

The relationship between SPT blow counts and the unconfined compressive strengths measured from the supplementary investigation are also plotted on Figure 3. These points suggest that the conventional correlation can be extrapolated for the hard tills encountered at this site.

4.2 Sand Density

The sand became highly disturbed during drilling, so it was not possible to collect undisturbed samples for bulk density determination. However, the LPT at a depth of 12 m in Borehole A-1 penetrated the upper boundary of the sand layer. The natural moisture content from this sample is considered to be reasonably representative. The specific gravity of this sand sample was determined to be 2.57. Since the soil is known to be saturated, a bulk density can be calculated. Assuming that natural moisture content of 14.7 percent is correct, the bulk density of the sand at the sample location is 2140 kg/m^3.

4.3 Bearing Capacity

Bearing capacity is estimated for short-term or end of construction conditions. These conditions provide the critical design case with lowest factor of safety against bearing capacity failure. Undrained Mohr-Columb (total stress) parameters determined from the results of consolidated-undrained triaxial tests are cohesion intercept, c, of 20 kPa and angle of internal friction, ϕ, of 22 ^{o}.

Ultimate bearing pressure (q_u) for a rectangular or square bearing surface can be calculated from the following relationship:

$$q_u = cN_cS_c + \gamma D_f N_q S_q + 0.5\gamma BN_\gamma S_\gamma \quad [1]$$

where: c denotes the cohesion intercept;
S_c, S_q and S_γ are shape factors;
γ is the buoyant unit weight of soil;
D_f is the embedement depth of footing (3 m in this study); and
N_c, N_q and N_γ are bearing capacity factors.

S_q is approximately equal to S_c for most soils and a value of 0.8 is frequently used for S_γ:

$$S_c = \left(1 + 0.2\frac{B}{L}\right) \quad [2]$$

where: B denotes the width of the footing; and
L denotes the length of a rectangular footing.

Based on the available data and knowledge, the ultimate bearing capacity of the clay till for a rectangular footing (9.2 m x 33 m) is approximately 810 kPa. The same value of ultimate bearing capacity can be used for a footing 8.2 m wide by 24 m long on the clay till. Because the value above is considered to be conservative, we recommend that a Factor of Safety of 2 be applied to the ultimate bearing pressure to obtain an allowable bearing pressure. That is, the recommended allowable bearing pressure for short-term loading is 405 kPa.

4.4 Poisson's Ratio and Settlement

For an elastic material deformed at constant volume (e.g. undrained triaxial test) it can be shown that the Poisson's ratio (ν) is equal to 0.5. Consequently, immediate settlement of foundation is calculated using this value of ν for a saturated material. Settlement computed from above procedure is before consolidation when settlement occurs after dissipation of pore water pressure.

The appropriate elastic modulus, E, and ν are not generally known for deformations due to consolidation. Considering results from the consolidated undrained triaxial test (CU-2) and assuming plain strain conditions for simplicity, the Poisson's ratios after Stage 1, 2, and 3 of consolidation are 0.48, 0.45 and 0.39 respectively. The decreasing trend in ν indicates increased stiffness with increased effective chamber pressure. These values are in agreement with previous studies, which show decrease in ν when material stiffness increases (e.g. Bowles, 1982). Poisson's ratio calculated from plane strain conditions is twice than that obtained from a triaxial test (e.g. Das, 1997). Estimated values of ν determined from the triaxial test results, range from 0.19 to 0.24 for the hard clay till.

4.5 Footing Excavation Over Sand

At the proposed locations of Piers 1 and 2, the upper boundary of the sand lies about 3.7 m below the riverbed. It is understood that the footings will be founded about 3 m below the riverbed. If an additional 0.2 m is allowed for a mud slab, it means that there would be about 0.5 m of clay till between the base of the excavation and the top of the sand. If footing excavations were undertaken "in the dry" at these locations, there would be about 8 m of excess pore-pressure below the base of the excavation.

A relatively simple static analysis, considering only the mass of overlying soil and the adhesion of the clay to the sheet-pile cofferdam wall, indicates that the base of the excavation will not be stable in the configuration described above. This analysis suggests that the overall Factor of Safety drops below 2 once the excavation is about 1.7 m deep, or 2 m above the sand.

The foregoing comments are based on statics and the assumption of overall failure, which is likely an oversimplification of the processes that will occur during excavation. It is understood that the sheet-piles will be installed by drilling pilot holes prior to driving. These pilot holes will provide a path for seepage and piping of sand along the inner face of the sheet-piles, regardless of the thickness of clay over sand. Furthermore unacceptable deformations would likely occur before failure. A more rigorous seepage and stress analysis should be completed if excavation in the dry is to be considered further.

Because the currently proposed configuration is not expected to provide adequate resistance to failure for excavation in the dry, three responses could be considered:

- Excavation and footing construction can be taken underwater;
- Well-points can be installed into the sand to lower the pore-pressure during foundation construction; or
- The sheet-piles can be driven through the sand and seated in the underlying clay till.

Even if sheet-piles are driven through the sand, well-points in the sand may be required to control build up of pore pressures.

5.0 CONCRETE AGGREGATES AND MIX

5.1 Aggregate Assessment

A sample of sandy gravel was delivered to EBA on June 30, 2003. This material is being considered as concrete aggregate for the construction of the bridge foundation. EBA was requested to evaluate the suitability of the sample for concrete aggregate.

The sample was collected from a pit along NWT Highway No. 3 at km 86. The information with the sample indicated that it was collected from Southwest of the Tower. The sample was a 50 mm minus product. It is not known if this was representative of the deposit, or if there is oversize present that was not included in the sample. EBA completed a sieve analysis on the pit run material, then crushed the sample to a nominal 20 mm minus size and completed another sieve analysis. A petrographic analysis was completed on a subsample of the crush. The results of these tests are presented in Appendix E.

The petrographic analysis indicated that the 20 mm to 5 mm fraction is composed primarily of hard rock types. A petrographic number of 120 was determined for the sample, which is within the maximum limit of 130 specified by Alberta Transportation for coarse aggregates used in bridge decks or other high abrasion applications. Therefore, the petrographic analysis indicates that the physical properties of the 20 mm to 5 mm aggregate are suitable for use as aggregate in the production of structural, flatwork and foundation concrete.

The chemical stability of concrete aggregate with cement paste cannot be assessed by petrographic analysis. The coarse aggregate contains a number of rock types high in silica. It would normally be recommended that concrete prism testing (CSA A23.2-14A) be undertaken to evaluate the potential for alkali aggregate reactivity (AAR). However, this test takes at least a year to complete, which could not be accommodated within the schedule proposed for this project. Alternatively, the rapid mortar bar test (CSA A23.2-25A) could be completed to give a preliminary indication of the potential for AAR. This test takes a few weeks to complete, but may provide false positive results. In the absence of laboratory test data, this coarse aggregate should be presumed to be moderately alkali-silica reactive.

From the sieve results, it can be seen that the fine aggregate fraction (5 mm minus) represents about 35% by mass of the sample as received. This is about the right proportion of sand to gravel for concrete aggregate. It can also be seen that through crushing the sand (5 mm minus) fraction increases to about 40%, which could be somewhat high. Regardless of the aggregate top-size for the mix produced, it is recommended that the aggregate be separated on a 5 mm screen to allow control of the coarse and fine fractions in the mix.

The fines content (percent passing a 0.08 mm sieve) of the sample received was determined to be 2.8 percent. Assuming a theoretical split of the material on a 5 mm screen, the fines content of the fine fraction would be 8 percent. This significantly exceeds the specified maximum of 3 percent (5 percent in the case of manufactured fines; CSA A23.1-00). Therefore, EBA would normally recommend that the fine aggregate be washed. Washing concrete aggregates has not become standard practice in the Northwest Territories. Local experience suggests that it should also be possible to address this deviation from CSA specifications in the mix design and through the use of appropriate admixtures. A trial batch was recommended to verify this.

5.2 Concrete Trial Batch

5.2.1 Aggregate Properties

Four additional samples from Hwy No. 3, km 86 were received on December 1, 2003 to use in a trial mix. EBA completed sieve analyses on the pit run material. The results are presented in Appendix E. The aggregate was combined and then crushed to a nominal 20 mm minus size. Following crushing, the sample was divided into coarse and fine fractions by separating the crushed sample through a 5 mm screen. Subsequently, sieve analyses were completed for both the coarse and fine fractions. The sieve results are presented in Appendix E.

The grading of the nominal 20 mm coarse concrete aggregate is presented in the following table. The grading has been compared to the CSA A23.1-00 20-5 mm coarse aggregate grading requirements.

Table 1: 20-5 mm COARSE AGGREGATE GRADING

Aggregate	Sieve Size (mm; Percents Passing by Mass)						
	28	**20**	**14**	**10**	**5**	**2.5**	**0.080**
20-5 mm Coarse Agg.	100	99	94	70	0	0	0.0
CSA 20-5 mm Min.	100	85	60	25	0	0	0
CSA 20-5 mm Max.	100	100	90	60	10	5	1.0
Pass/Fail	Pass	Pass	Fail	Fail	Pass	Pass	Pass

The coarse fraction fails to comply with the CSA 20-5 mm coarse aggregate grading requirements being finer on the 14 mm and 10 mm sieves. However, the trial mix will take this into account. In general, the presence finer material requires an increase in water demand resulting in an increase in cement content.

The grading of the concrete sand (5 mm minus fraction) is shown in the following table. The grading has been compared to the CSA A23.1-00 5-0 mm fine aggregate grading requirements.

Table 2: CONCRETE SAND, FINE AGGREGATE GRADING

Aggregate	Sieve Size (mm; Percents Passing by Mass)								
	10	**5**	**2.5**	**1.25**	**0.630**	**0.315**	**0.160**	**0.080**	**FM**
Sand	100	100	82	67	54	29	9	4.0	2.6
Specified Min.	100	95	80	50	25	10	2	0	2.3
Specified Max.	100	100	100	90	65	35	10	3	3.1
Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass

As can be seen from this table, the fine aggregate grading almost complies with the specified CSA fine aggregate grading requirements. The fines content is one percent over the recommended maximum.

The fineness modulus (FM) of 2.60 for the fine aggregate is within the CSA limits of 2.3 to 3.1.

The relative density and absorption of the fine and coarse aggregate were determined. The coarse aggregate was tested to determine dry rodded density. The fine aggregate was tested for organic impurities (colour plate). The results are presented in Table 3.

Table 3: AGGREGATE PHYSICAL PROPERTIES

Physical Property	20-5 mm Fraction	5 mm Minus Fraction
Bulk Specific Gravity (SSD)	2.64	2.65
Absorption (%)	1.1	1.3
Dry Rod Density, kg/m3	1605	--
Colour Plate	--	2

The colour plate of value of 2 is within the CSA limit of a colour no darker than the standard value of 3. This indicates excessive organic material is not present in the fine fraction.

5.2.2 Theoretical Mix Design

It is understood that the specified compressive strength for the foundation concrete will be on the order of 25 MPa or 30 MPa. A target compressive strength of 30 MPa was selected for the trial batches. In the design, a safety factor of 15% has been applied to the

desired compressive strength. Given the proposed size of the footings, we recommend that the use of a mix of cement and fly ash be considered. Therefore, two mixes were prepared, one with only Type 10 cement, and the other with 35 percent (by mass of cementing materials) fly ash. Air entrainment would normally be Category 2 (4 to 7 percent for nominal 20 mm aggretgate), however, we elected to target slightly above this range to allow for improved durability.

Batch quantities for one cubic metre of fresh concrete produced with aggregates in SSD are summarized in Table 4.

Table 4: 30 MPa STRUCTURAL CONCRETE TRIAL BRACH PROMOTIONS

Material/Property	Type 10 Cement Only		Cement with 35% Fly Ash	
	Theoretical	As-Batched	Theoretical	As-Batched
Water (kg/m^3)	166	159	166	153
Cement (kg/m^3)	380	380	247	247
Fly Ash (kg/m^3)	0	0	133	133
20-5 mm Crush (kg/m^3)	1030	1030	1030	1054
5-0 mm Sand (kg/m^3)	607	607	607	640
Slump (mm)	80-110	80	80-120	80
Air Content (%)	7.0-9.0	8.0	7.0-9.0	7.0
Yield (kg/m^3)	2182	2176	2182	2203

Compressive strength test results to-date are summarized in Table 5. Additional information is provided in Appendix E.

Table 5: TRAIL BATCH COMPRESSIVE STRENGTH SUMMARY

Age	Compressive Strength (MPa)	
	Type 10 Cement Only	Cement with 35% Fly Ash
7-day	27.4	27.4
7-day	26.3	24.7
Average 7-day	**26.9**	**26.1**
28-day	42.8	31.3
28-day	43.3	30.2
Average 28-day	**43.1**	**30.8**

Because concrete incorporating fly ash exhibits slower strength gain than “conventional” concrete, cylinders were also cast for compressive strength testing at 56 days. These results will be reported separately, when available.

The results to-date indicate that concrete with adequate compressive strengths can be produced with the aggregate from the Hwy. 3, km 86 pit. Considering all of the results together, the 5 mm minus fraction represents about 50 percent of the material by mass. Based on the trial batch, about 40 percent of the available fine fraction is not required. So, overall, about 20 percent of the aggregate extracted will not be required for the production of concrete.

Because of the volume of the concrete pours, aggregate with larger top-size than 20 mm could be considered. However, the advantage of using a larger top-size could be offset by the requirement to split the aggregate into three stockpiles in order to control segregation. Crushing the aggregate to 20 mm top-size, should improve the angularity and bond in the concrete, hence producing higher compressive strengths. Therefore, a nominal 20 mm coarse aggregate is recommended.

The AAR issue has not been entirely resolved. The use of a preblended cement and fly ash would tend to provide mitigation against AAR, so this may permit the use of moderately reactive aggregates. Also, increased air entrainment tends to provide some mitigation against AAR. Therefore, the trial batch program was geared towards demonstrating the viability of using a moderately reactive aggregate.

5.3 Cement Type

Two tests were conducted to determine the water soluble sulphate content on samples of clay till recovered from the site. The tests indicated soluble sulphate concentrations of 0.58 and 0.61 percent.

The potential degree of sulphate attack on concrete may be considered to be ‘severe’, corresponding to an S-2 class of exposure. Accordingly the use of Type 50 cement with a maximum water/cementing materials ratio by mass of 0.45 and a minimum specified 28-day compressive strength of 32 MPa is recommended.

It should be noted that Type 10 was used for the trial batch, because of it’s availability and because the objective of the testing was only to demonstrate the suitability of the aggregate. However, aside from the cement type, the mix proportions and compressive strength test results will conform to the foregoing recommendations.

6.0 PAVEMENT DESIGN

This section describes the materials being considered for the construction of the bridge approaches and presents the associated pavement structure designs.

Traffic volumes were discussed with Jivko Engineering at the outset of this assignment. The following has been assumed for design:

- Present commercial traffic is estimated at 25,000 trucks per year;
- Future traffic, for a 20 year design life, is 50,000 trucks per year;
- Estimated truck factor of 2.0;
- This gives a design volume of 7.5×10^5 equivalent single axle loads (ESAL's);
- Surfacing is asphaltic surface treatment (chip seal)

Samples of possible construction materials were delivered on June 30, 2003. Table F-1 provides a list of the samples received, together with their source, proposed application and basic composition.

The proposed structural aggregates (subbase and base) were tested for gradation and durability. Potential base course samples were crushed to 20 mm minus. Proposed embankment materials were tested for classification purposes and their California Bearing Ratios (CBR) were determined. Laboratory tests results are summarized on Table F-1. More detailed test report sheets are also presented in Appendix F.

The pavement design was based on an AASHTO methodology. Typical moduli, correlations and coefficients were selected based on the materials tested, roadway geometry and anticipated environmental influences. Because different materials are being considered for each approach, two design cases were developed. Structurally, the proposed base and subbase materials proposed for each approach are quite similar. The primary difference is the embankment material used for each approach; a silty clay embankment is proposed for the north approach and a gravelly sand is proposed for the south approach. The design criteria for each case are outlined in Table 6.

Table 6: PAVEMENT DESIGN SUMMARY

Parameter	Design Case 1 – North Side	Design Case 2 – South Side
Subgrade CBR (85%)	4 (clay embankment material)	25 (1 m minimum sand embankment)
Reliability, R	75%	75%
Standard Deviation, S_o	0.45	0.45
Pavement Serviceability Indices		
p_I	4.2	4.2
p_t	2.5	2.5
Structural Coefficients		
Asphalt Pavement	0.40	0.40
Crushed Base	0.14	0.14
Subbase	0.10	0.10
Drainage Coefficients		
Asphalt Pavement	1.00	1.00
Crushed Base	0.95	0.95
Subbase	0.80	0.80
Structural Number	84	40
Required Conventional Pavement		
Asphalt Pavement (mm)	100	75
Crushed Base (mm)	150	100
Subbase (mm)	300	none required
Equivalent for Surface Treatment		
Crushed Base (mm)	**200**	**250**
Subbase (mm)	**500**	**none required**

It should be noted in the foregoing that a minimum thickness of 1 m has been assumed for the sand embankment fill at the south approach. If less fill is going over the existing clay jetty at the south ferry landing, then a structure between the two given above would be recommended. Conversely, for the north approach, the use of select fill for the upper portion of the embankment could be considered to reduce the granular structure requirement.

Six additional samples were received in the fall of 2003 for gradation analysis. Table F-2 summarizes all the testing completed on the potential embankment or common fill materials.

The primary objective for the additional samples from the north side of the river was to assess if a better embankment fill material could be identified. The combined sand and gravel fraction for the two samples received this fall (Samples TP 7-1 and TP 9) runs around 35 percent, compared to about 25 percent from this summer's sample (Sample 3243-5). While there is more granular material in the more recently received samples, the silt/clay is still dominant and behaves almost exactly the same as before. Therefore, there is not expected to be a large difference in the CBR values between the

sample received this summer and the samples received this fall. There would be some improvement, but it is not expected to make a significant difference to the pavement design for the north side.

The primary objective for the additional samples from the south side of the river was to assess the extent of the previously identified granular deposit. Sample TP 2-1 was comparable to and coarser than this summer's sample (Sample 3243-6). The other three samples were clayey and possibly even worse for a construction material than the clay on the north side. It is recommend that if clay must be used for embankment fill on the south side of the river, it be used in the bottom of the embankment. The pavement design presented in Table 6 is based on at least 1 m of the granular material.

7.0 PERMITTING ASSISTANCE

7.1 Sediment Liberation

Preliminary designs assumed that footing construction would occur during the winter, so that soil excavated during footing construction could be disposed of over the ice. However it is understood that some contractors have expressed a preference for completing foundation construction during the summer. This would entail excavating soil from within a cofferdam, loading it on barges and transporting it to shore for unloading and disposal. As wet soil is loaded on to the barges the soil will drain to some extent and water can be expected to discharge into the river. This has caused the regulators to question how much sediment might be discharged into the river.

There is no established procedure to assess the potential for the liberation of sediment, to EBA's knowledge. Therefore, we have employed what we shall refer to as a "shake test" to assess how much sediment might be liberated from the soil during the excavation process. Six samples of the clay till that prevails below the riverbed were tested as follows:

- Approximately 1 kg sample of soil was placed in a vessel and submerged in about 4 litres of water;

- A lid was placed on the vessel and the sample was subjected to "moderate" agitation, by hand. The frequency was about 1 cycle per second and the amplitude was about 0.5 m;
- Three samples were shaken for 1 minute and three samples were shaken for 30 seconds;
- The dirty water was decanted from the vessel. Coarse pieces that had broken from the sample would have remained in the vessel, as they would in the cofferdam or barge;
- The dirty water was placed in an oven, so that the water was evaporated;
- The weight of fine-grained sediment that was liberated was recorded;
- The gradation of the sediment liberated was recorded with a conventional hydrometer analysis.

Test results are summarized and are presented in Appendix G. After ½ minute of shaking, an average of 1.2% of the sample mass was liberated. After 1 minute of shaking, an average of 2.7% of the sample mass was liberated.

EBA has attempted to determine how these findings might relate to construction. Our rationale and assumptions were as follows:

- From Northwest Hydraulic Consultants (1975) we determined that the mean annual river flow is 160,000 cubic feet per second (cfs). This likely represents a lower bound for summer flow.
- We assumed that each pier would impact about 10 percent of the river cross-section or flow. This would be about 450 m^3/s (16,000 cfs).
- It is understood that most footings will be founded at 3 m, and be 8.2 m by 24 m, giving a minimum excavation volume of about 600 m^3. However, realistically, there will be over-excavation. We have assumed that the excavation would be 2 m larger in each dimension and 0.2 m deeper, giving an estimated volume of about 1,100 m^3, or about 2,600,000 kg of soil.
- We assumed, based on the shake test results, that about 3% of the soil mass is liberated as sediment. This amounts to about 77,000 kg.
- We assumed that footing excavation would take place over 3 days, during which time about 11,800,000 m^3 of water would be impacted. The larger piers would take proportionally longer to excavate.

- If we assume that the sediment is discharged somewhat uniformly (gradually) over this interval, it suggests that the sediment would add less than 1 mg/l to the suspended solids in the river.

The foregoing comments are presented for illustrative purposes. EBA shall leave it to others to assess the validity of this approach and the significance of the conclusion.

7.2 Limestone Geochemistry

Three samples of limestone bedrock were collected by Jivko Engineering from the Fort Providence area and submitted to EBA. The three samples are described in Table 7. EBA was requested to arrange for the determination of the rocks' geochemistry. It is understood that the rock is being considered for fill around the bridge abutments, and that the regulators have requested an assessment of the geochemistry of this proposed fill.

Table 7: POTENTIAL QUARRIED ROCK SOURCES

Sample No.	EBA Lab No.	Source	Description
1	3243-2	Hwy. No. 1, km 192	Limestone – moderately to highly weathered, brown
2	3501-1	Hwy. No. 3, km 165	Limestone – fresh to slightly weathered, grey
3	3501-2	Hwy. No. 1, km 196	Limestone – moderately to highly weathered, brown

The samples were crushed down to 10 mm minus in EBA's Yellowknife laboratory. The samples were then sent to ALS Environmental in Vancouver for analysis. Metals scans were completed by ALS Environmental. Subsamples were forwarded to ALS Chemex for acid base accounting. Complete test results are presented in Appendix G.

Through discussions with Indian and Northern Affairs Canada, it was confirmed that the applicable regulatory criteria are the Canadian Interim Sediment Quality Guidelines for the Protection of Aquatic Life, prepared by the Canadian Council of Ministers of the Environment (CCME), 2002 update. The test results are compared to the regulatory guidelines in Table 8.

Table 8: QUARRY ROCKMETALS ANALYSIS

Metal	Hwy. No. 1, km 192	Hwy. No. 3, km 165	Hwy. No. 1, km 196	CCME Guideline
Arsenic	0.9	0.3	1.8	5.9
Cadmium	<0.10	<0.10	<0.10	0.6
Chromium	<8.0	<8.0	<8.0	37.3
Copper	<4.0	<4.0	<4.0	35.7
Lead	4.5	<2.0	3.7	35
Zinc	49.2	42.8	10.5	123

Note: All results are expressed as milligrams per dry kilogram

It can be seen from the foregoing that none of the regulated parameters tested exceed the applicable guidelines.

The acid base accounting results confirm that the rock is basic, as is expected for limestone.

7.3 Ammonia Control

The regulators requested that attention be given to the control of ammonia residues in the quarried rock. In order to attempt to gauge the significance of this issue, EBA attempted to come up with an estimate of the levels that could be anticipated. We did not locate any ammonia monitoring data from rock quarries along the highway system. The closest analogy we could identify was mine waste rock.

Millard (2003) provided some useful data from Ekati™. Quarried waste rock is used for road construction around the mine site. The roads are watered for dust suppression and runoff down-gradient of roads is monitored for ammonia. Monitoring data from nine measurements was provided, and total ammonia, N, ranged from 0.02 mg/L to 0.31 mg/L, and averaged 0.18 mg/L. The CCME guideline for total ammonia, N, in freshwater equates to 5.58 mg/L. All recorded values were an over an order of magnitude below this level. While this data is not conclusive and may not be directly applicable, it does suggest that the levels of residual ammonia could be anticipated to be low.

A monitoring program should be implemented in any case.

Measures can be employed to reduce blasting residues. It is in the contractor's interest to optimize the efficiency of the blast, and this will also result in less residue. Misfires typically are the largest contributor, so that contractor should have a protocol on how these will be handled. If the blast holes are wet, ammonium nitrate may not combust properly and the use of emulsions should be considered.

In general, blasting more competent rock will result in less residues than blasting poor quality rock. Therefore deeper blasts are preferable to shallow blasts.

8.0 LIMITATIONS

Information presented herein is based on the findings in ten boreholes at discrete locations on the proposed project site and other information as described. The conditions encountered during the geotechnical investigations are considered to be reasonably representative. However, it should be recognized that conditions can vary between borehole locations. If conditions other than those reported are noted during subsequent phases of the project, EBA should be notified and given the opportunity to review the current recommendations in light of the new findings. This report has been prepared for the exclusive use of Jivko Engineering and their agents, for specific application as described in Section 1.0 of this report. It has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty is made, either expressed or implied.

Reference should be made to the General Conditions in Appendix A of this report for further limitations.

9.0 CLOSURE

We trust that this report satisfies your present requirements. EBA would be pleased to provide any further information that may be needed during the design and to advise on the geotechnical aspects of the specifications. Please contact our Yellowknife Office if you have any questions or comments.

Respectfully submitted,

EBA Engineering Consultants Ltd.

Compiled by:

Reviewed by:

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FEB 5/04
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PERMIT NUMBER
P 018
EBA ENGINEERING CONSULTANTS LTD.

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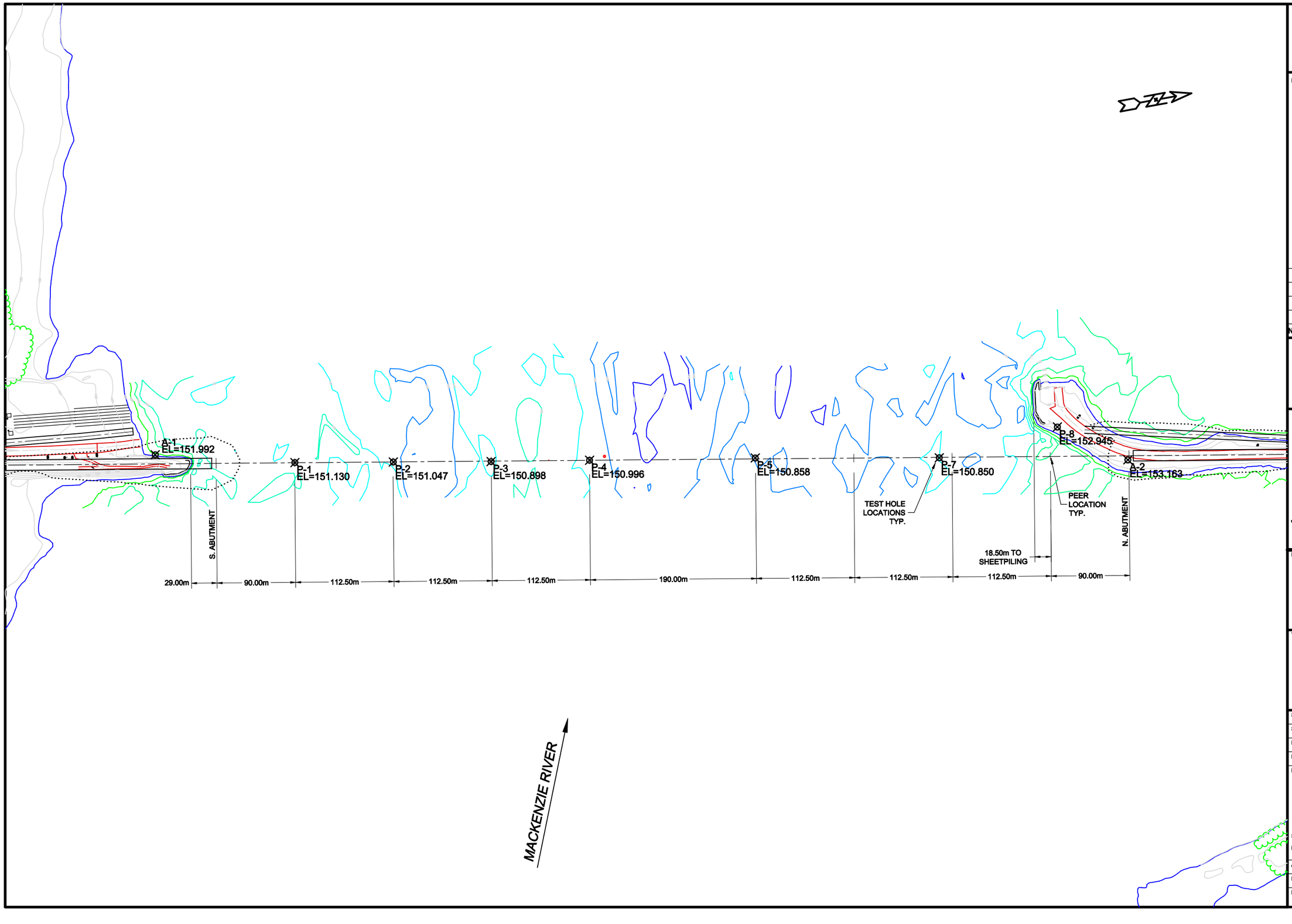
FIGURES



Deh Cho Bridge Corporation

Notes:

No.	Date	Revision Description	Initials

A. detail number
B. location drawing number
C. drawing number

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Project
YELLOWKNIFE HWY#3 Km 23
DEH CHO BRIDGE
ON MACKENZIE RIVER
PRELIMINARY DESIGN

Title
GEOTECHNICAL
INVESTIGATION
DRILL HOLE LOCATIONS

Scale	1 : 4 000	
Surveyed by	K. Jivkov	
Drawn by	K. Jivkov	Feb 9, 2004
Designed by		Checked by
Insignia		Insignia
Signature		Signature
Date		Date
Approved by		
Project No.		Page of
Drawing No.		

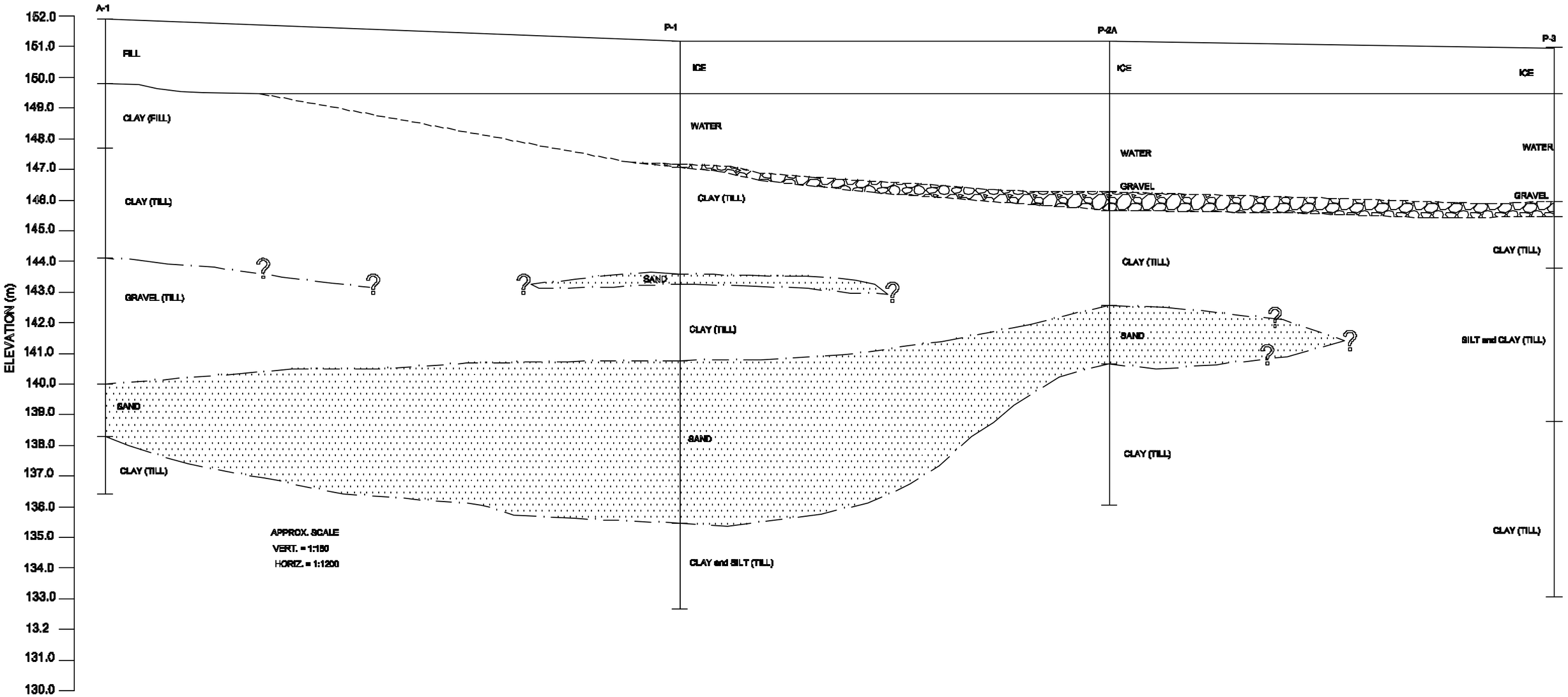


Figure 2
South Side Cross-Section

1700D63fig02.dwg

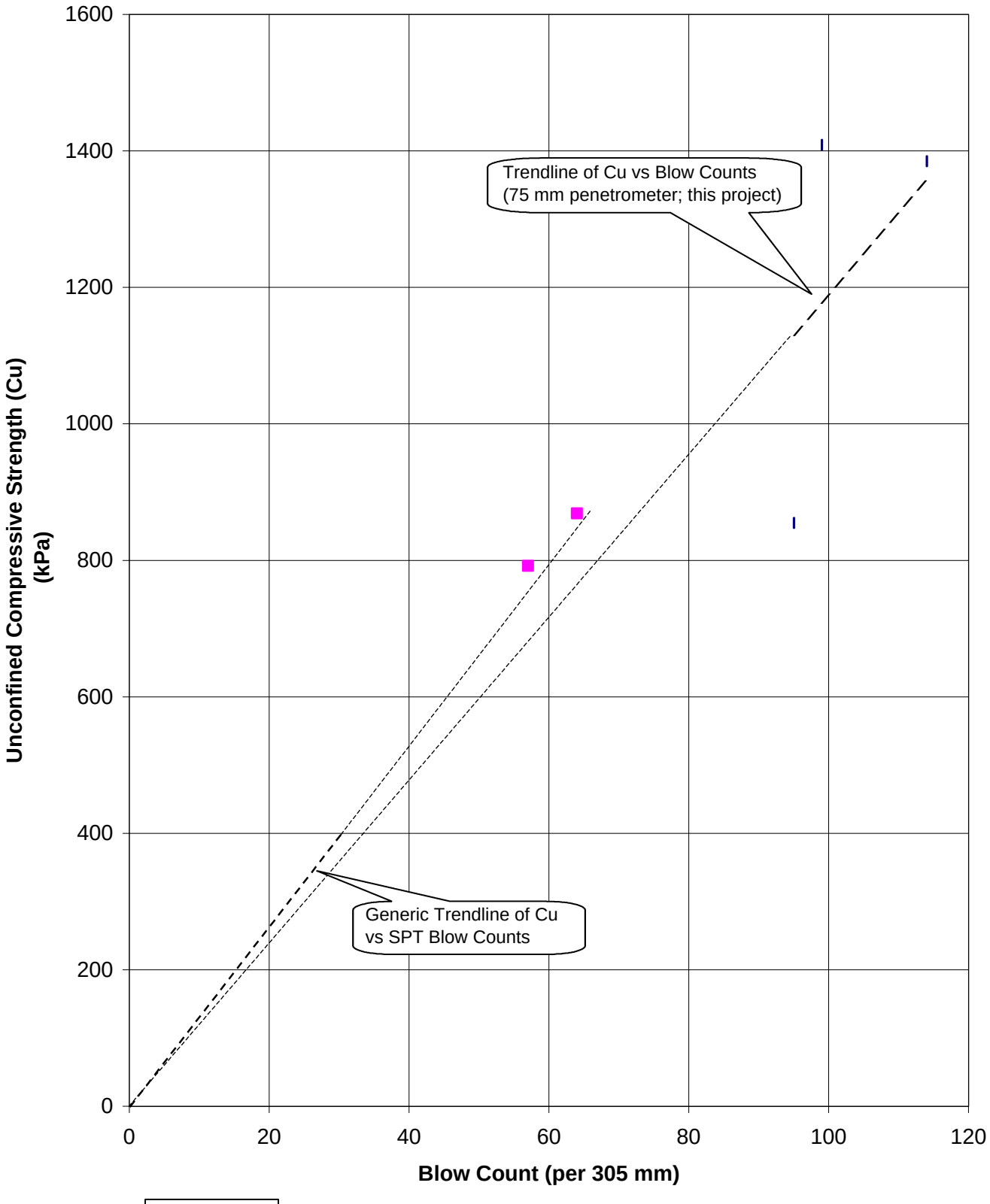


Figure 3
Strength Versus Blow Count

APPENDIX A
GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

A.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

A.2 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

A.3 LOGS OF TEST HOLES

The test hole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

A.4 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

A.5 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

A.6 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

A.7 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

A.8 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

A.9 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

A.10 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

A.11 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

A.12 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

A.13 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

A.14 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

A.15 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

APPENDIX B
PHOTOS

Photo 1: April 13, 2003 – Set-up at P-7, looking south

Photo 2: April 8, 2003 – Drill Set-up at P-1

Photo 3: April 18, 2003 – Drilling at A-1, looking south to Merv Hardie Ferry

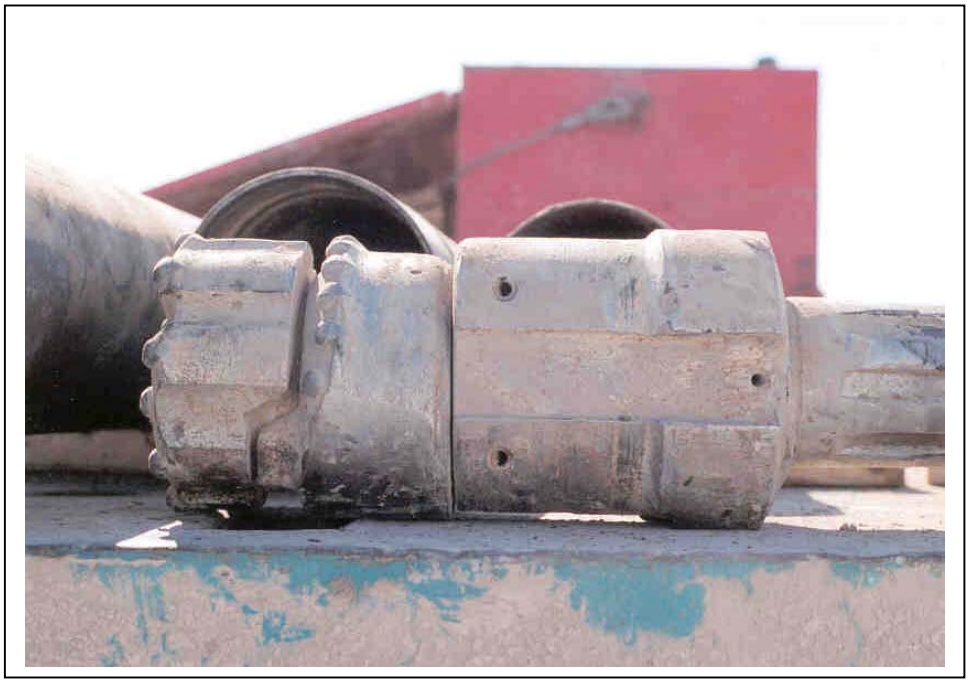


Photo 4: April 17, 2003 – ODEX Drill Bit

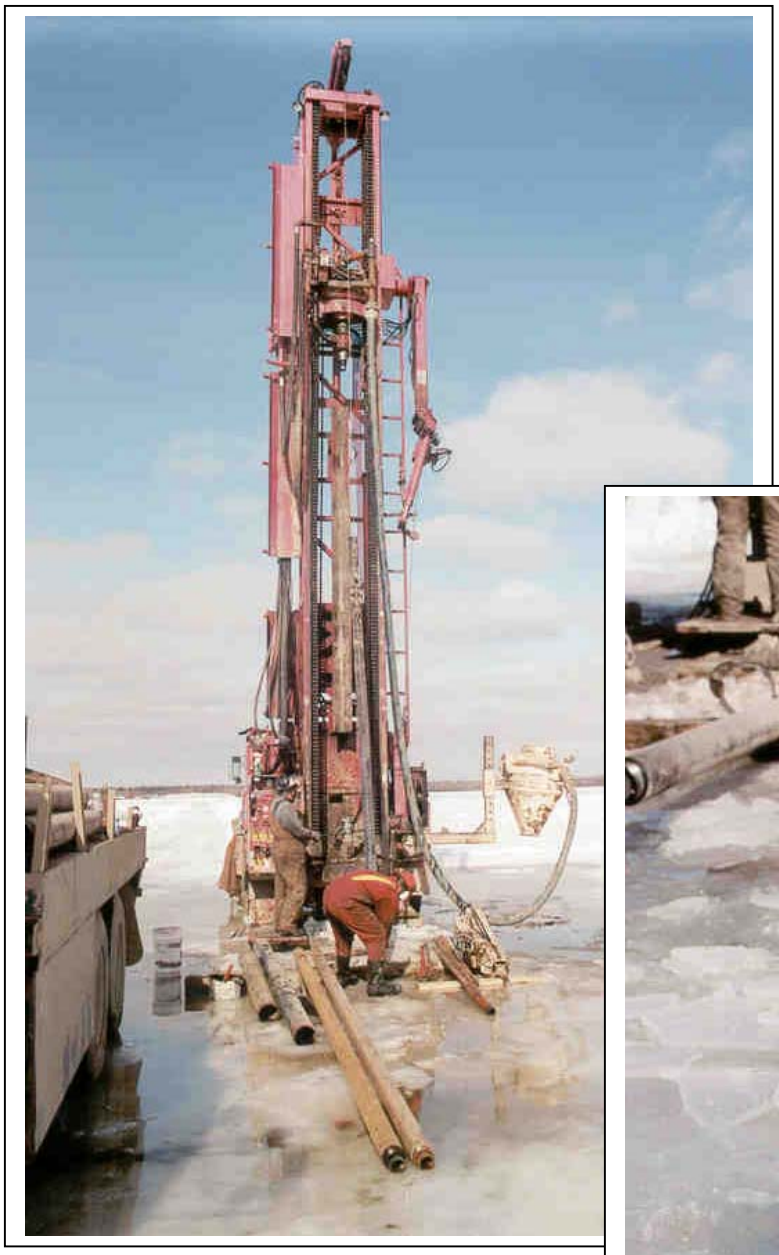


Photo 5: April 8, 2003
- Putting on steel at P-1

Photo 6: Aptil 17, 2003
- Shelby Tube on left and LPT Split Spoon on right

APPENDIX C
BOREHOLE LOGS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm sieve): includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N (blows per 0.3m)
Very Loose	0 to 20%	0 to 4
Loose	20 to 40%	4 to 10
Compact	40 to 75%	10 to 30
Dense	75 to 90%	30 to 50
Very Dense	90 to 100%	greater than 50

The number of blows, N, on a 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH (kPa)
Very Soft	Less Than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater Than 400

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

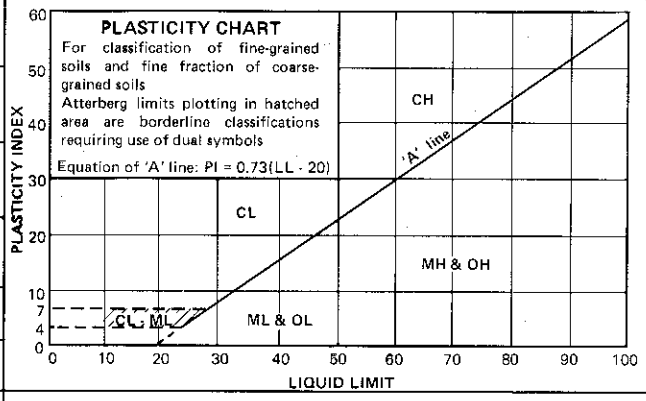
GENERAL DESCRIPTIVE TERMS

Slickensided	- having inclined planes of weakness that are slick and glossy in appearance.
Fissured	- containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated	- composed of thin layers of varying colour and texture.
Interbedded	- composed of alternate layers of different soil types.
Calcareous	- containing appreciable quantities of calcium carbonate.
Well Graded	- having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded	- predominantly of one grain size, or having a range of sizes with some intermediate size missing.

eba

UNIFIED SOIL CLASSIFICATION†

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass No. 200 sieve GW, GP, SW, SP More than 12% pass No. 200 sieve GM, GC, SM, SC 5% to 12% pass No. 200 sieve Borderline classification requiring use of dual symbols	$C_U = D_{60}/D_{10}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below 'A' line or plasticity index less than 4
			GC	Clayey gravels, gravel-sand clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines		$C_U = D_{60}/D_{10}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly-graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		Atterberg limits plot below 'A' line or plasticity index less than 4
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7
FINE-GRAINED SOILS 50% or more passes No. 200 sieve*	SILTS AND CLAYS Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands		Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	SILTS AND CLAYS Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
			CH	Inorganic clay of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity		
HIGHLY ORGANIC SOILS			PT	Peat, muck and other highly organic soils		



*Based on the material passing the 3 in. (75 mm) sieve
†ASTM Designation D 2487, for identification procedure see D 2488

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOLS	SYMBOLS	SUBGROUP DESCRIPTION	
N	Nf	Poorly-bonded or friable	
	Nbn	No excess ice, well-bonded	
	Nbe	Excess ice, well-bonded	

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOLS	SYMBOLS	SUBGROUP DESCRIPTION	
V	Vx	Individual ice crystals or inclusions	
	Vc	Ice coatings on particles	
	Vr	Random or irregularly oriented ice formations	
	Vs	Stratified or distinctly oriented ice formations	

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + Soil Type	Ice with soil inclusions	
	ICE	Ice without soil inclusions (greater than 25 mm (1 in.) thick)	

NOTE:

1. *Dual symbols are used to indicate borderline or mixed ice classifications*
2. *Visual estimates of ice contents indicated on borehole logs ± 5%*
3. *This system of ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes*

LEGEND
Soil ☐ Ice ■

PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: A–1
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6791796 E471689	ELEVATION: 151.99 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A–CASING | CORE

Depth(m)	Sample Type	Sample No	SPT(N)	SOIL DESCRIPTION	Pocket Pen. qu (kPa) 100 200 300 400 / Penetrat.(blows/300 mm) 30 60 90 120 / Plastic – M.C. – Liquid 20 40 60 80	LABORATORY TEST RESULTS	Elevation(m)
0.0				FILL – drill pad consisting of snow, ice, till and sand			151.99
1.0							151.0
2.0							150.0
		1	48	CLAY (FILL) – some silt, some gravel, trace sand, moist, firm, medium plastic, grey with brown staining			
3.0							149.0
		2	150	– LPT hit practical refusal on a rock		105 blows for 120 mm	
4.0		3					148.0
		4		CLAY (TILL) – silty, some sand, some gravel, trace sand, dry, stiff, low plastic, gravel is limestone and sandstone, olive grey			
5.0		5	90				147.0
6.0		6					146.0
		7				Bulk Density = 2359 kg/m3	
7.0							145.0
		8					
8.0		9		GRAVEL (TILL) – sandy, silty, trace clay, moist, low plastic matrix, brown, gravel up to 2 cm			144.0
9.0		10	150	– LPT hit practical refusal on a rock		100 blows for 100 mm	143.0
10.0							142.0
11.0							141.0
12.0		11	150	SAND – trace gravel, trace fines, wet, very dense, brown, grading from coarse to fine grained with depth		140 blows for 300 mm 10% gravel, 83% sand, 7% fines(silt/clay) Specific Gravity = 2.57	140.0
13.0							139.0
14.0				CLAY (TILL) – silty, trace sand, some			138.0

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LOGGED BY: RRL	COMPLETION DEPTH: 15.6 m
REVIEWED BY: TEH	COMPLETE: 04/19/03
Fig. No: A–1	Page 1 of 2

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: A-1
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6791796 E471689	ELEVATION: 151.99 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400 / ■ PENETRAT.(blows/300 mm) ■ 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
14.0		12		gravel, dry, stiff, low plastic, olive grey			137.0
15.0		13	102				136.0
16.0				END OF HOLE (15.6 m) – at desired depth PENETRATION TESTING USED 75 mm SAMPLER			135.0
17.0							134.0
18.0							133.0
19.0							132.0
20.0							131.0
21.0							130.0
22.0							129.0
23.0							128.0
24.0							127.0
25.0							126.0
26.0							125.0
27.0							124.0
28.0							

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LOGGED BY: RRL	COMPLETION DEPTH: 15.6 m
REVIEWED BY: TEH	COMPLETE: 04/19/03
Fig. No: A-1	Page 2 of 2

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-1
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6791952 E471727	ELEVATION: 151.13 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				ICE		151.0
1.0						150.0
				WATER		
2.0						149.0
3.0						148.0
4.0				GRAVEL - sandy, river bottom sediments		147.0
		1		CLAY (TILL) - some sand, some silt,		
		2		trace gravel, damp to wet, low plastic, grey		
5.0						146.0
6.0		3				145.0
		4	125	CLAY and GRAVEL (TILL) - some silt, trace sand, dry to damp, very stiff, low to medium plastic, gravel is limestone and sandstone, olive grey clay		
7.0		5		- becomes more coarse		144.0
8.0		6	35	SAND - gravelly, trace silt, sand is		143.0
		7		medium grained, very wet		
		8		CLAY (TILL) - silty, some sand and gravel, damp, stiff, low plastic, grey		
9.0						142.0
		9				
10.0						141.0
		10		SAND - some gravel, trace silt, medium		
		11		grained, damp to wet, brown		
11.0				- difficult drilling due to sand welling		140.0
		12		up the casing		
		13		- wet	89% sand, 11% fines(silt/clay)	
12.0						139.0
13.0						138.0
				- becoming fine grained, poorly graded,		
14.0						

POCKET PEN. qu (kPa): 100 200 300 400
PENETRAT.(blows/300 mm): 30 60 90 120
PLASTIC M.C. LIQUID: 20 40 60 80

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	REVIEWED BY: TEH
	Fig. No: B-1
	COMPLETION DEPTH: 18.5 m
	COMPLETE: 04/09/03
	Page 1 of 2

04/02/13 08:34AM (1700063)

PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-1
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6791952 E471727	ELEVATION: 151.13 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400 / ■ PENETRAT.(blows/300 mm) ■ 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
14.0		14		no gravel, trace to some silt			137.0
15.0				– silty, moist			136.0
16.0		15		CLAY AND SILT (TILL) – trace sand, trace gravel, dry, very stiff, low plastic, olive grey to tan, gravel is mostly subangular and limestone			135.0
17.0		16					134.0
18.0		17					
		18	122			122 blows for 100 mm	133.0
19.0				END OF HOLE (18.5 m) – LPT hit practical refusal prior to its completion. PENETRATION TESTING USED 75 mm SAMPLER			132.0
20.0							131.0
21.0							130.0
22.0							129.0
23.0							128.0
24.0							127.0
25.0							126.0
26.0							125.0
27.0							124.0
28.0							

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LOGGED BY: RRL	COMPLETION DEPTH: 18.5 m
REVIEWED BY: TEH	COMPLETE: 04/09/03
Fig. No: B-1	Page 2 of 2

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-2
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792060 E471747	ELEVATION: 151.05 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				ICE		151.0
1.0						150.0
2.0				WATER		149.0
3.0						148.0
4.0						147.0
5.0				GRAVEL - sandy, river bottom sediments		146.0
6.0		1		CLAY (TILL) - silty, some gravel, trace sand, wet, stiff, low plastic, olive grey		145.0
		2		- dry		
		3	114	- very stiff, gravel is subrounded to subangular and consists of sedimentary rock fragments	Qu = 1385 kPa Bulk Density = 2353 kg/m3 6% gravel, 33% sand, 39% silt, 22% clay	
7.0		4				144.0
8.0		5				143.0
9.0				END OF HOLE (8.4m) - hole abandoned as pilot bit broke at bottom of hole. Hole P-2A was drilled approximately 0.75 m to the south of hole P-2. PENETRATION TESTING USED 75 mm SAMPLER		142.0
10.0						141.0
11.0						140.0
12.0						139.0
13.0						138.0
14.0						

▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400

■ PENETRAT.(blows/300 mm) ■ 30 60 90 120

PLASTIC M.C. LIQUID 20 40 60 80

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LOGGED BY: RRL	COMPLETION DEPTH: 8.38 m
REVIEWED BY: TEH	COMPLETE: 04/17/03
Fig. No: B-2	Page 1 of 1

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-2A
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792060 E471747	ELEVATION: 151.05 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	POCKET PEN. qu (kPa) 100 200 300 400 / PENETRAT.(blows/300 mm) 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				ICE			151.0
1.0							150.0
				WATER			
2.0							149.0
3.0							148.0
4.0							147.0
5.0				GRAVEL - sandy, river bottom sediments			146.0
6.0				CLAY (TILL) - silty, some gravel, trace sand, wet, stiff, low plastic, olive grey - dry - very stiff, gravel is subrounded to subangular and consists of sedimentary rock fragments			145.0
7.0							144.0
8.0							143.0
9.0		6		SAND - gravelly, silty, moist, brown			142.0
		7	30	- gravel and sand, some silt, wet, brown sand, grey fines - difficult drilling as sand/gravel welled up the casing, no recovery in split spoon - used SPT hammer with dynamic cone from 9 to 10 metres, sand/gravel shown to be very dense (>100 blows per 300 mm)			
10.0							141.0
11.0				CLAY (TILL) - silty, some gravel, some sand, wet cutting (till assumed to be dry), grey			140.0
12.0		8	150	- gravelly, some sand, dry, very stiff, low plastic, olive grey		100 blows for 100 mm	139.0
13.0							138.0
14.0							

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LOGGED BY: RRL	COMPLETION DEPTH: 15.1 m
REVIEWED BY: TEH	COMPLETE: 04/17/03
Fig. No: B-2A	Page 1 of 2

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-2A
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792060 E471747	ELEVATION: 151.05 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400 / ■ PENETRAT.(blows/300 mm) ■ 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
14.0							137.0
15.0	☒	9	150	END OF HOLE (15.1m) – at desired depth		155 blows for 290 mm	136.0
16.0				PENETRATION TESTING USED 75 mm SAMPLER			135.0
17.0							134.0
18.0							133.0
19.0							132.0
20.0							131.0
21.0							130.0
22.0							129.0
23.0							128.0
24.0							127.0
25.0							126.0
26.0							125.0
27.0							124.0
28.0							

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LOGGED BY: RRL	COMPLETION DEPTH: 15.1 m
REVIEWED BY: TEH	COMPLETE: 04/17/03
Fig. No: B-2A	Page 2 of 2

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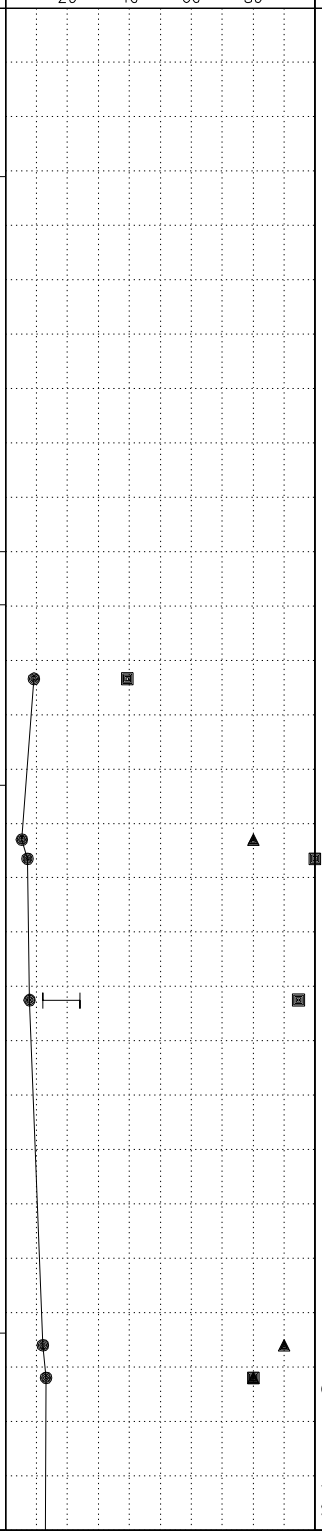
PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-3
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792173 E471766	ELEVATION: 150.9 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				ICE		150.0
1.0						
2.0				WATER		149.0
3.0						148.0
4.0						147.0
5.0				GRAVEL - sandy, river bottom sediments		146.0
6.0		1		CLAY (TILL) - silty, some sand, some gravel, trace sand, dry to damp, very stiff, low to medium plastic, gravel is limestone and sandstone, olive grey clay		145.0
		2	59			
7.0		3		- trace sand		144.0
		4		SILT and CLAY (TILL) - light brown		
8.0		5				143.0
		6	150		149 blows for 200 mm	
				- LPT stopped on a dark fine-grained rock (probable dolomite)		
9.0		7	142	- becoming sandy - less sandy, more silt, very stiff, low plastic, olive grey, gravel pieces up to 2 cm, gravel is of sedimentary origin		142.0
10.0		8				141.0
11.0		9				140.0
12.0		10				139.0
		11		CLAY (TILL) - silty, trace sand, some gravel, dry very stiff, low plastic, olive grey	Phi' = 24.6 deg. c' = 40.0 kPa E (in situ) = 5 MPa Bulk Density = 2295 kg/m3 2% gravel, 16% sand, 45% silt, 37% clay	
		12	120			
13.0						138.0
14.0						137.0



EBA Engineering Consultants Ltd. Yellowknife, N.W.T.	LOGGED BY: RRL	COMPLETION DEPTH: 17.9 m
	REVIEWED BY: TEH	COMPLETE: 04/11/03
	Fig. No: B-3	Page 1 of 2

PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-3
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792173 E471766	ELEVATION: 150.9 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400 / ■ PENETRAT.(blows/300 mm) ■ 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
14.0		13					136.0
15.0		14	156			156 blows for 300 mm	135.0
16.0		15					134.0
17.0		16					133.0
18.0		17	146	END OF HOLE (17.9 m) - at desired depth PENETRATION TESTING USED 75 mm SAMPLER			132.0
19.0							131.0
20.0							130.0
21.0							129.0
22.0							128.0
23.0							127.0
24.0							126.0
25.0							125.0
26.0							124.0
27.0							123.0
28.0							

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LOGGED BY: RRL	COMPLETION DEPTH: 17.9 m
REVIEWED BY: TEH	COMPLETE: 04/11/03
Fig. No: B-3	Page 2 of 2

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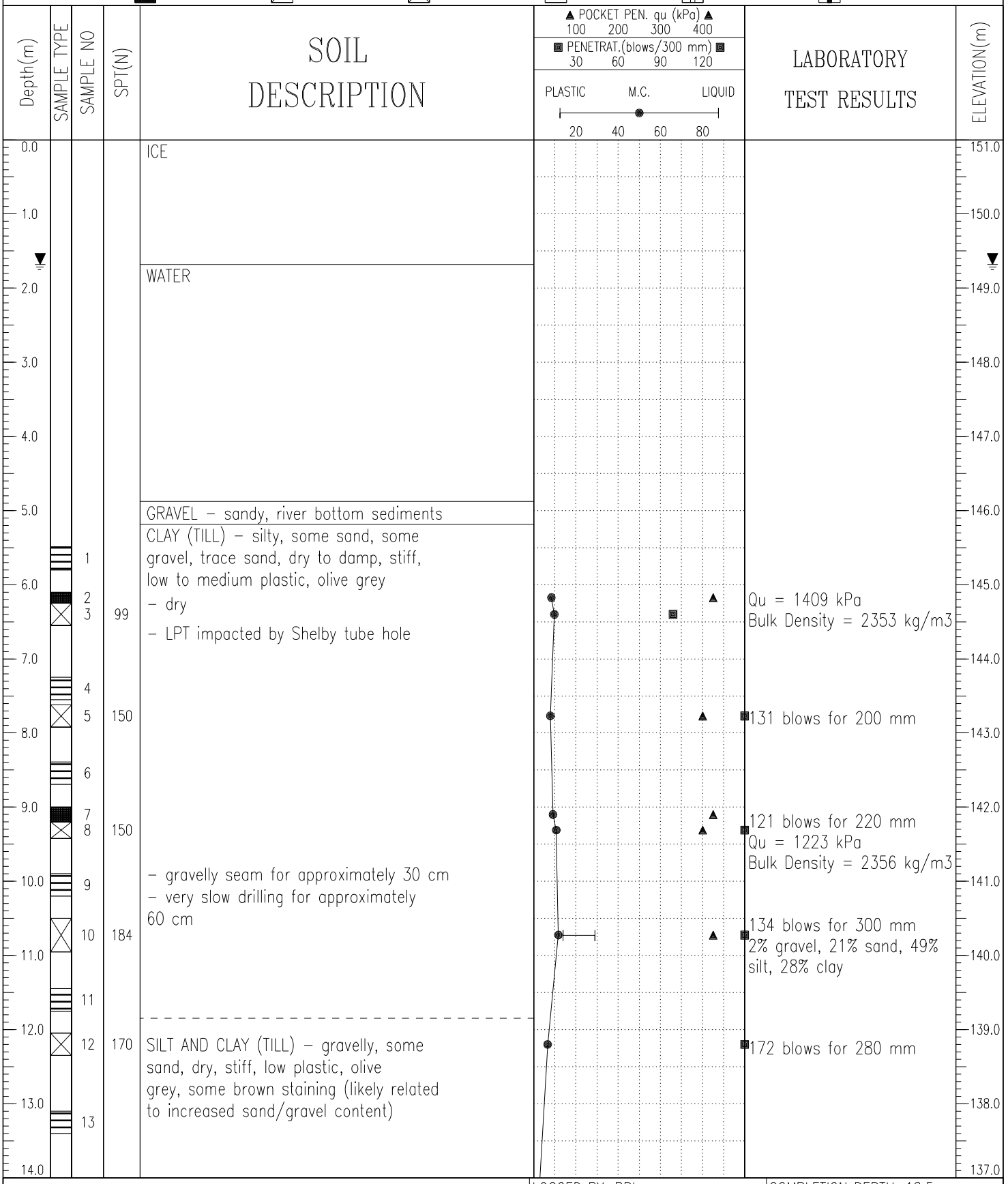
PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-4
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792284 E471784	ELEVATION: 151 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE



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LOGGED BY: RRL	COMPLETION DEPTH: 18.5 m
REVIEWED BY: TEH	COMPLETE: 04/16/03
Fig. No: B-4	Page 1 of 2

PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-4
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792284 E471784	ELEVATION: 151 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	POCKET PEN. qu (kPa) 100 200 300 400 / PENETRAT.(blows/300 mm) 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
14.0		14		- some gravel			137.0
15.0		15	159	CLAY (TILL) - silty, some sand, some gravel, dry, stiff, low plastic, olive grey with brown sand		159 blows for 300 mm	136.0
16.0		16		- trace sand			135.0
17.0		17					134.0
18.0		18	174			174 blows for 300 mm	133.0
19.0				END OF HOLE (18.5 m) - at desired depth PENETRATION TESTING USED 75 mm SAMPLER			132.0
20.0							131.0
21.0							130.0
22.0							129.0
23.0							128.0
24.0							127.0
25.0							126.0
26.0							125.0
27.0							124.0
28.0							123.0

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LOGGED BY: RRL	COMPLETION DEPTH: 18.5 m
REVIEWED BY: TEH	COMPLETE: 04/16/03
Fig. No: B-4	Page 2 of 2

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-5
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792470 E471817	ELEVATION: 150.86 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				ICE		150.0
1.0						
				WATER		149.0
2.0						
3.0						148.0
4.0						147.0
5.0						146.0
6.0		1		GRAVEL - sandy, river bottom sediments		145.0
		2		CLAY (TILL) - silty, trace sand, some gravel, wet, stiff, medium plastic, olive grey		144.0
7.0		3	53	- dry	5% gravel, 20% sand, 44% silt, 31% clay	
		4		- less silty, moist		143.0
8.0		5		SILT and SAND (TILL), trace clay, trace gravel, dry, low plastic, tan		
9.0		6				142.0
		7	141	- sand seam, gravelly, trace fines, brown, well-graded, wet	Bulk Density = 2357 kg/m3	
		8		CLAY (TILL) - silty, gravelly, trace sand, dry , very stiff, low plastic, grey		
10.0				- some gravel		141.0
11.0		9	93			140.0
		10				
12.0		11				139.0
		12				
		13	95		Qu = 855 kPa Bulk Density = 2361 kg/m3	
13.0		14				138.0
14.0						137.0

▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400

■ PENETRAT.(blows/300 mm) ■ 30 60 90 120

PLASTIC M.C. LIQUID 20 40 60 80

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LOGGED BY: RRL	COMPLETION DEPTH: 21.2 m
REVIEWED BY: TEH	COMPLETE: 04/13/03
Fig. No: B-4	Page 1 of 2

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-5
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792470 E471817	ELEVATION: 150.86 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400 / ■ PENETRAT.(blows/300 mm) ■ 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
14.0		15					
15.0							136.0
		16	106	– olive grey			
16.0							135.0
		17					
17.0							134.0
		18					
18.0							133.0
		19	140				
19.0							132.0
		20		SILT (TILL) – sandy, some clay, some gravel, dry, very stiff, low plastic, light brown			
20.0							131.0
		21					
21.0		22	164	CLAY (TILL) – silty, trace sand, some gravel, dry, very stiff, low plastic light brown, gravel clasts up to 3 cm		164 blows for 300 mm	130.0
22.0				END OF HOLE (21.2 m) – at desired depth PENETRATION TESTING USED 75 mm SAMPLER			129.0
23.0							128.0
24.0							127.0
25.0							126.0
26.0							125.0
27.0							124.0
28.0							123.0

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LOGGED BY: RRL	COMPLETION DEPTH: 21.2 m
REVIEWED BY: TEH	COMPLETE: 04/13/03
Fig. No: B-4	Page 2 of 2

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PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-7
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792677 E471852	ELEVATION: 150.85 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				ICE		150.0
1.0						
				WATER		149.0
2.0						
3.0						148.0
4.0						147.0
				GRAVEL - sandy, river bottom sediments		
5.0						146.0
				CLAY (TILL) - silty, some sand, some gravel, trace sand, dry to damp, stiff,		
6.0	X	1	69	medium plastic, grey		145.0
7.0		2				144.0
		3			Phi' = 25.2 deg.	
8.0	X	4	82	- LPT influenced by void created by Shelby tube	c' = 18.3 kPa E (in situ) = 2 MPa Bulk Density = 2328 kg/m3	143.0
		5				
9.0	X	6	88	- becoming olive grey, dry		142.0
10.0						141.0
11.0						140.0
12.0						139.0
		7				
13.0	X	8	150	- becoming sandy, sand is brown, silty clay remains olive grey	116 blows for 150 mm Bulk Density = 2338 kg/m3	138.0
		9				
14.0						137.0

▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400

■ PENETRAT.(blows/300 mm) ■ 30 60 90 120

PLASTIC M.C. LIQUID 20 40 60 80

EBA Engineering Consultants Ltd. Yellowknife, N.W.T.	LOGGED BY: RRL	COMPLETION DEPTH: 15.4 m
	REVIEWED BY: TEH	COMPLETE: 04/15/03
	Fig. No: B-7	Page 1 of 2

PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-7
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: AIR ROTARY (ODEX)	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792677 E471852	ELEVATION: 150.85 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400 / ■ PENETRAT.(blows/300 mm) ■ 30 60 90 120 / PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
14.0							136.0
15.0	⊠	10	172		▲ ■	172 blows for 300 mm	135.0
				END OF HOLE (15.4 m) – at desired depth PENETRATION TESTING USED 75 mm SAMPLER			
16.0							134.0
17.0							133.0
18.0							132.0
19.0							131.0
20.0							130.0
21.0							129.0
22.0							128.0
23.0							127.0
24.0							126.0
25.0							125.0
26.0							124.0
27.0							123.0
28.0							

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LOGGED BY: RRL	COMPLETION DEPTH: 15.4 m
REVIEWED BY: TEH	COMPLETE: 04/15/03
Fig. No: B-7	Page 2 of 2

04/02/13 08:35AM (1700063)

PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: P-8
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: MARL 10 SOLID STEM	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792814 E471847	ELEVATION: 152.95 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				GRAVEL and SAND (FILL) - some silt, medium to fine-grained, sub-angular, brown, compact		152.95
1.0		S1				152.0
		S2	14			
2.0		S3		SILT (FILL) - sandy, some gravel, brown, damp, stiff, cobbles		151.0
		S4	12			
3.0						150.0
		S5				
4.0		S6	16			149.0
				CLAY (TILL) - silty, some sand, fine-grained, gravelly, stiff, wet, grey		
5.0		S7		- becomes dry		148.0
		S8				
6.0		S9	48	- becomes hard		147.0
		S10				
7.0		S11			Qu = 792 kPa Bulk Density = 2279 kg/m3	146.0
		S12	57	Soluble Sulphate = 0.01%		
8.0						145.0
9.0				- becomes difficult to drill		144.0
		S13				
10.0		S14	74			143.0
11.0						142.0
		S15				
		S16	95/250			
12.0				END OF BOREHOLE (11.9 m) - at target depth - borehole dry upon completion		141.0
13.0						140.0
14.0						139.0

▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400

■ SPT "N" (blows/300 mm) ■ 20 40 60 80

PLASTIC M.C. LIQUID 20 40 60 80

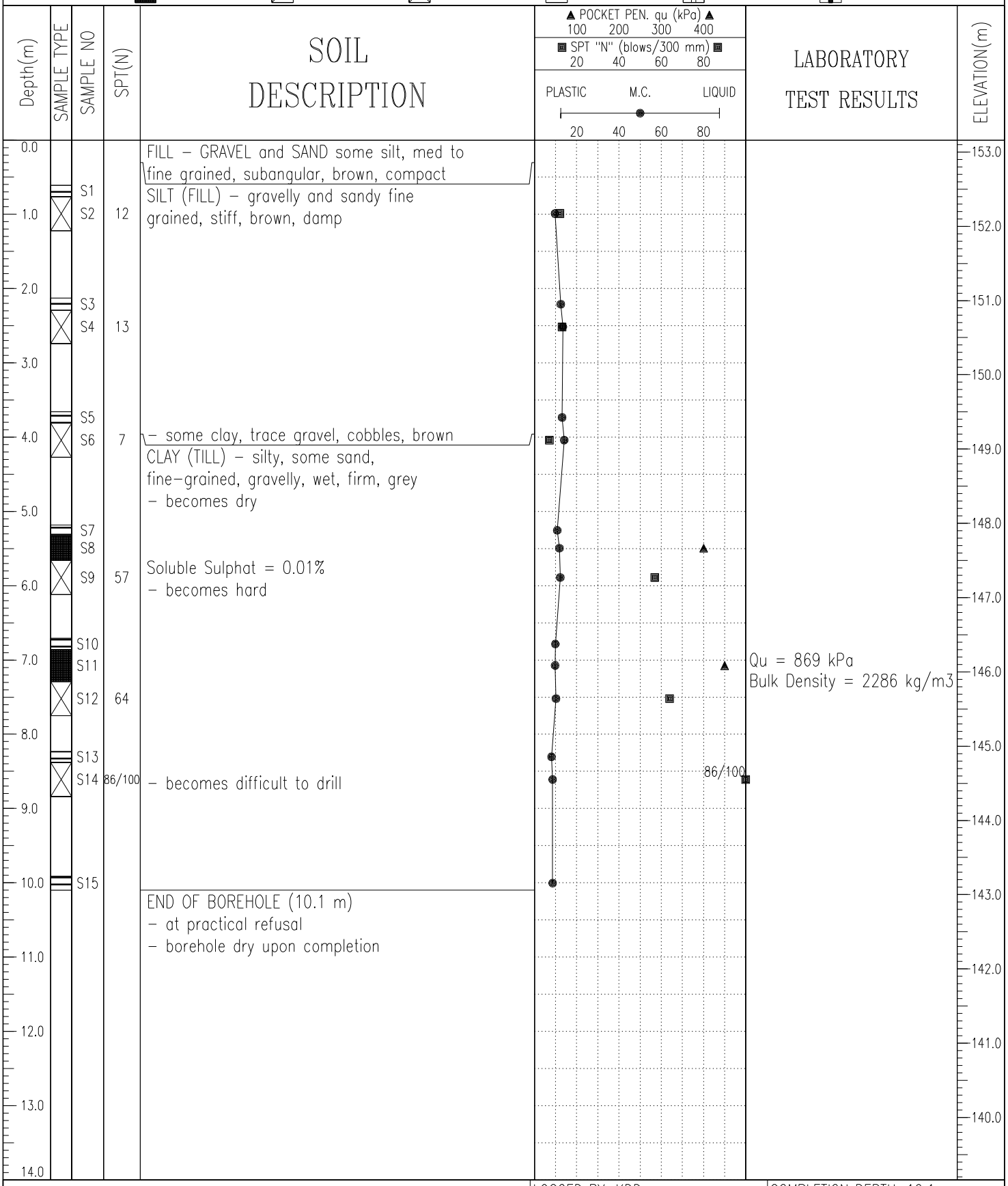
95/250

EBA Engineering Consultants Ltd. Yellowknife, N.W.T.	LOGGED BY: KDD
	REVIEWED BY: TEH
	Fig. No: P-8
	COMPLETION DEPTH: 11.9 m
	COMPLETE: 10/28/03
	Page 1 of 1

04/02/13 08:35AM (17000631)

PROJECT: DEH CHO BRIDGE	CLIENT: JIVKO ENGINEERING	BOREHOLE NO: A-2
MACKENZIE RIVER NEAR FORT PROVIDENCE, NT	DRILL: MARL 10 SOLID STEM	PROJECT NO: 1700063
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6792890 E471895	ELEVATION: 153.16 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE



EBA Engineering Consultants Ltd. Yellowknife, N.W.T.	LOGGED BY: KDD	COMPLETION DEPTH: 10.1 m
	REVIEWED BY: TEH	COMPLETE: 10/28/03
	Fig. No: A-2	Page 1 of 1

04/02/13 08:33AM (17000631)

PROJECT: DORY POINT SOUTH FERRY LANDING	CLIENT: GNWT – DOT, STRUCTURES	BOREHOLE NO: 13997-01
FORT PROVIDENCE, N.W.T.	DRILL: SOLID STEM AUGER (MARL 10)	PROJECT NO: 0701-99-13997
LOCATION: SEE FIGURE 1	UTM ZONE: 11 N6791513 E471726	ELEVATION: 150.54 m

SAMPLE TYPE: SHELBY TUBE | NO RECOVERY | 75 mm SPOON | BULK SAMPLE | A-CASING | CORE

Depth(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	SOIL DESCRIPTION	▲ POCKET PEN. qu (kPa) ▲ 100 200 300 400 SPT "N" (blows/300 mm) 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	LABORATORY TEST RESULTS	ELEVATION(m)
0.0				SAND and GRAVEL (FILL)– trace silt, well graded CLAY (TILL)– stiff, silty, trace gravel, trace sand, low plastic			150.0
1.0			9				
				– CU: phi = 26.0 deg., c = 13.2 kPa – Bulk Density = 2211 kg/m3			149.0
2.0			15	–very stiff, medium plastic			148.0
3.0				– trace coal – becomes hard, wet			
			87				147.0
				– dry, grey			
4.0							146.0
			100	– hard, low plastic			
5.0				END OF HOLE (5.0 m) – at desired depth – slight seepage at completion – no slough			145.0
6.0							144.0
7.0							143.0
8.0							

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LOGGED BY: TEH	COMPLETION DEPTH: 5 m
REVIEWED BY: TEH	COMPLETE: 99/06/21
Fig. No: B-1	Page 1 of 1

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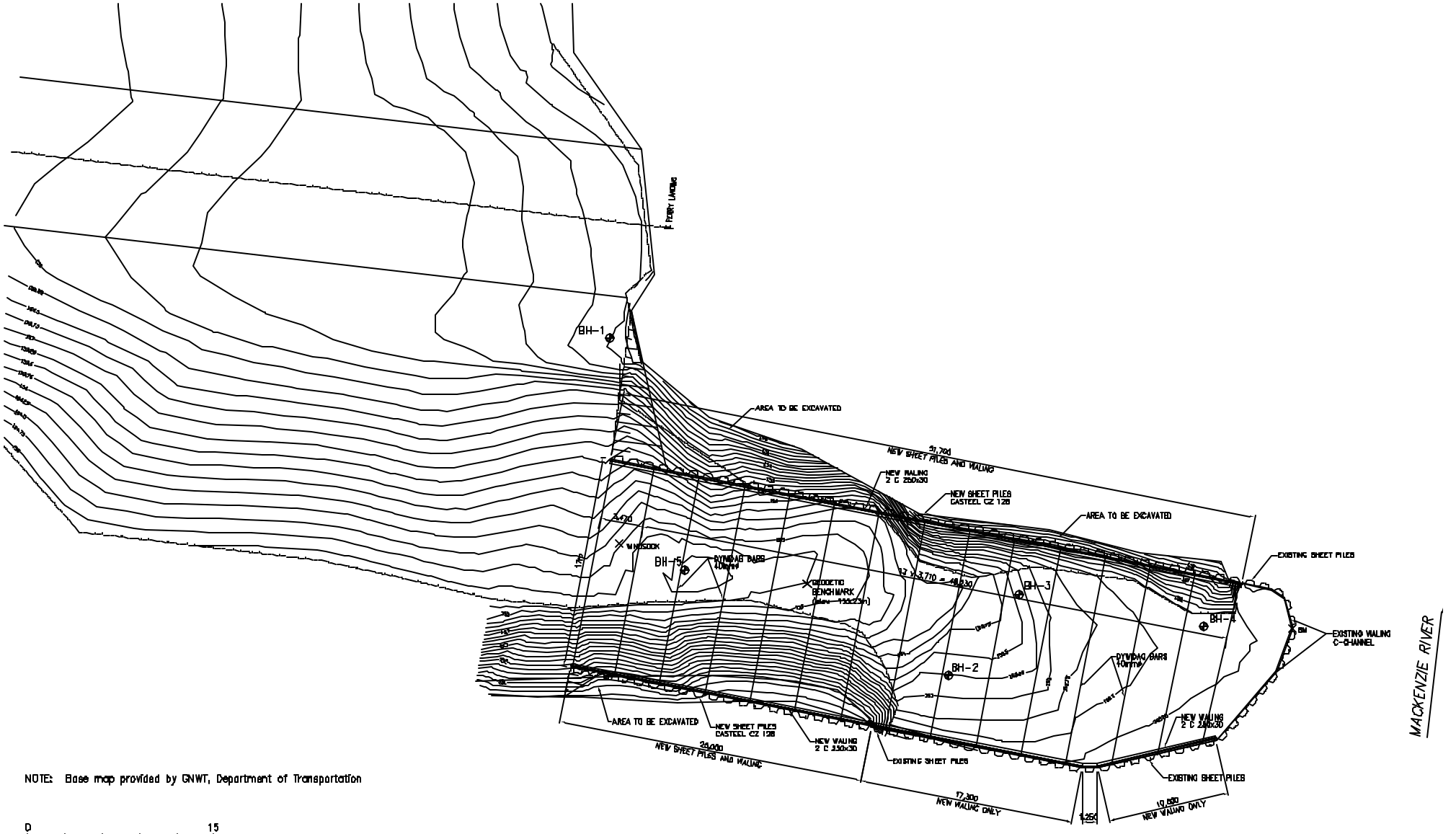

NOTE: Base map provided by GNWT, Department of Transportation

0 15
metres
(1:450)

Figure 1
Borehole Location Plan & Proposed Reconstruction

13997g02a.dwg

eba

APPENDIX D
GEOTECHNICAL INVESTIGATION LABORATORY TEST RESULTS

TABLE D-1

DEH CHO BRIDGE SITE INVESTIGATION
LABORATORY TEST RESULT SUMMARY

Borehole	Below Ice		Below Grade		Soil	Moisture	Gravel	Sand	Silt	Clay	Liquid	Plastic	Bulk	Qu	Phi'	c'	Elastic	Specific
	Top	Bot.	Top	Bot.	Type	Content			(or Fines)		Limit	Limit	Density				Modulus[1]	Gravity
	(m)	(m)	(m)	(m)		(%)	(%)	(%)	(%)	(%)			(kg/m3)	(kPa)	(deg.)	(kPa)	(MPa)	
A-1	2.3	2.7	0.2	0.6	Clay (Fill)	18.1												
A-1	3.7	3.8	1.6	1.7	Clay (Fill)	13.8												
A-1	5.0	5.5	2.9	3.4	Clay (Till)	7.5												
A-1	6.2	6.6	4.1	4.5	Clay (Till)	9.8							2359					
A-1	9.1	9.3	7.0	7.2	Gravel (Till)	6.3												
A-1	12.0	12.5	9.9	10.4	Sand	14.7	10	83	7	n.d.[2]			2140	(calculated)				2.57
A-1	15.1	15.5	13.0	13.4	Clay (Till)	11.0												
P-1	6.2	6.7	2.2	2.7	Clay and Gravel (Till)	11.2												
P-1	7.8	7.9	3.8	3.9	Sand	14.2												
P-1	8.1	8.2	4.1	4.2	Clay (Till)	10.9												
P-1	10.5	11.0	6.5	7.0	Sand	15.6												
P-1	11.6	12.0	7.6	8.0	Sand	18.9	0	89	11	n.d.								
P-1	18.1	18.4	14.1	14.4	Clay and Silt (Till)	14.3												
P-2	6.2	6.4	1.3	1.5	Clay (Till)	8.3							2353	1385				
P-2	6.4	6.7	1.5	1.8	Clay (Till)	8.7	6	33	39	22								
P-2A	12.2	12.3	7.3	7.4	Clay (Till)	9.2												
P-2A	14.8	15.1	9.9	10.2	Clay (Till)	11.0												
P-3	5.9	6.4	0.9	1.4	Clay (Till)	9.2												
P-3	7.6	7.7	2.6	2.7	Silt and Clay (Till)	5.3												
P-3	7.7	7.9	2.7	2.9	Silt and Clay (Till)	7.1												
P-3	8.9	9.4	3.9	4.4	Silt and Clay (Till)	7.8					24	12						
P-3	12.2	12.4	7.2	7.4	Clay (Till)	12.1							2295		24.6	40	5	
P-3	12.4	12.7	7.4	7.7	Clay (Till)	13.1	2	16	45	37								
P-3	14.6	15.1	9.6	10.1	Clay (Till)	12.6												
P-3	17.4	17.8	12.4	12.8	Clay (Till)	10.6												

Note: 1 - Elastic Modulus at in situ stress; see full results for other values

2 - n.d. denotes silt and clay contents not determined; fines refers to combined silt and clay content

TABLE D-1

DEH CHO BRIDGE SITE INVESTIGATION
LABORATORY TEST RESULT SUMMARY

Borehole	Below Ice		Below Grade		Soil	Moisture	Gravel	Sand	Silt	Clay	Liquid	Plastic	Bulk	Qu	Phi'	c'	Elastic	Specific
	Top	Bot.	Top	Bot.	Type	Content			(or Fines)		Limit	Limit	Density				Modulus[1]	Gravity
	(m)	(m)	(m)	(m)		(%)	(%)	(%)	(%)	(%)			(kg/m3)	(kPa)	(deg.)	(kPa)	(MPa)	
P-4	6.1	6.2	1.2	1.3	Clay (Till)	8.4							2353	1409				
P-4	6.2	6.6	1.3	1.7	Clay (Till)	9.8												
P-4	7.6	7.9	2.7	3.0	Clay (Till)	7.9												
P-4	9.0	9.2	4.1	4.3	Clay (Till)	9.1							2356	1223				
P-4	9.2	9.4	4.3	4.5	Clay (Till)	10.7												
P-4	10.5	11.0	5.6	6.1	Clay (Till)	11.7	2	21	49	28	29	14						
P-4	12.0	12.3	7.1	7.4	Silt and Clay (Till)	6.6												
P-4	14.2	14.5	9.3	9.6	Silt and Clay (Till)	2.1												
P-4	18.0	18.4	13.1	13.5	Clay (Till)	11.0												
P-5	7.2	7.6	1.2	1.6	Clay (Till)	12.5	5	20	44	31	32	14						
P-5	9.0	9.1	3.0	3.1	Silt and Sand (Till)	9.6							2357					
P-5	9.1	9.3	3.1	3.3	Sand	10.5												
P-5	9.3	9.6	3.3	3.6	Clay (Till)	9.7												
P-5	10.7	11.1	4.7	5.1	Clay (Till)	10.2												
P-5	12.2	12.4	6.2	6.4	Clay (Till)	10.4							2361	855				
P-5	12.4	12.7	6.4	6.7	Clay (Till)	9.2												
P-5	15.1	15.5	9.1	9.5	Clay (Till)	10.6												
P-5	18.0	18.4	12.0	12.4	Clay (Till)	9.3												
P-5	20.7	21.2	14.7	15.2	Clay (Till)	8.1												
P-7	6.1	6.6	1.5	2.0	Clay (Till)	8.5												
P-7	7.6	7.8	3.0	3.2	Clay (Till)	10.2							2328		25.2	18.3	2	
P-7	7.8	8.1	3.2	3.5	Clay (Till)	12.9												
P-7	8.8	9.3	4.2	4.7	Clay (Till)	10.6					30	15						
P-7	12.2	12.4	7.6	7.8	Clay (Till)	10.7							2338					
P-7	12.4	12.5	7.8	7.9	Clay (Till)	10.4												
P-7	14.9	15.4	10.3	10.8	Clay (Till)	9.5												

Note: 1 - Elastic Modulus at in situ stress; see full results for other values

2 - n.d. denotes silt and clay contents not determined; fines refers to combined silt and clay content

TABLE D-1

DEH CHO BRIDGE SITE INVESTIGATION
LABORATORY TEST RESULT SUMMARY

Borehole	Below Ice		Below Grade		Soil	Moisture	Gravel	Sand	Silt	Clay	Liquid	Plastic	Bulk	Qu	Phi'	c'	Elastic	Specific
	Top	Bot.	Top	Bot.	Type	Content			(or Fines)		Limit	Limit	Density				Modulus[1]	Gravity
	(m)	(m)	(m)	(m)		(%)	(%)	(%)	(%)	(%)			(kg/m3)	(kPa)	(deg.)	(kPa)	(MPa)	
P-8			0.6	0.8	Gravel & Sand (Fill)	8.3												
P-8			0.8	1.2	Gravel & Sand (Fill)	6.4												
P-8			2.1	2.3	Silt (Fill)	11.2												
P-8			2.3	2.7	Silt (Fill)	12.7												
P-8			3.7	3.8	Silt (Fill)	12.1												
P-8			3.8	4.3	Silt (Fill)	11.4												
P-8			5.2	5.3	Clay (Till)	9.1												
P-8			5.3	5.7	Clay (Till)	8.3												
P-8			5.7	6.1	Clay (Till)	8.3												
P-8			6.7	6.9	Clay (Till)	8.9												
P-8			6.9	7.4	Clay (Till)	9.3							2279	792				
P-8			7.4	7.9	Clay (Till)	8.4												
P-8			9.8	9.9	Clay (Till)	9.1												
P-8			9.9	10.4	Clay (Till)	9.6												
P-8			11.3	11.4	Clay (Till)	8.9												
P-8			11.4	11.9	Clay (Till)	8.9												
A-2			0.6	0.8	Silt (Fill)	9.1												
A-2			0.8	1.2	Silt (Fill)	9.7												
A-2			2.1	2.3	Silt (Fill)	12.5												
A-2			2.3	2.7	Silt (Fill)	13.4												
A-2			3.7	3.8	Silt (Fill)	13.1												
A-2			3.8	4.3	Silt (Fill)	14.1												
A-2			5.2	5.3	Clay (Till)	10.8												
A-2			5.3	5.7	Clay (Till)	11.8												
A-2			5.7	6.1	Clay (Till)	12.2												
A-2			6.7	6.9	Clay (Till)	9.9												
A-2			6.9	7.3	Clay (Till)	9.8							2286	869				
A-2			7.3	7.8	Clay (Till)	10.2												
A-2			8.2	8.4	Clay (Till)	8.1												
A-2			8.4	8.8	Clay (Till)	8.6												
A-2			9.9	10.1	Clay (Till)	8.6												

Note: 1 - Elastic Modulus at in situ stress; see full results for other values

2 - n.d. denotes silt and clay contents not determined; fines refers to combined silt and clay content

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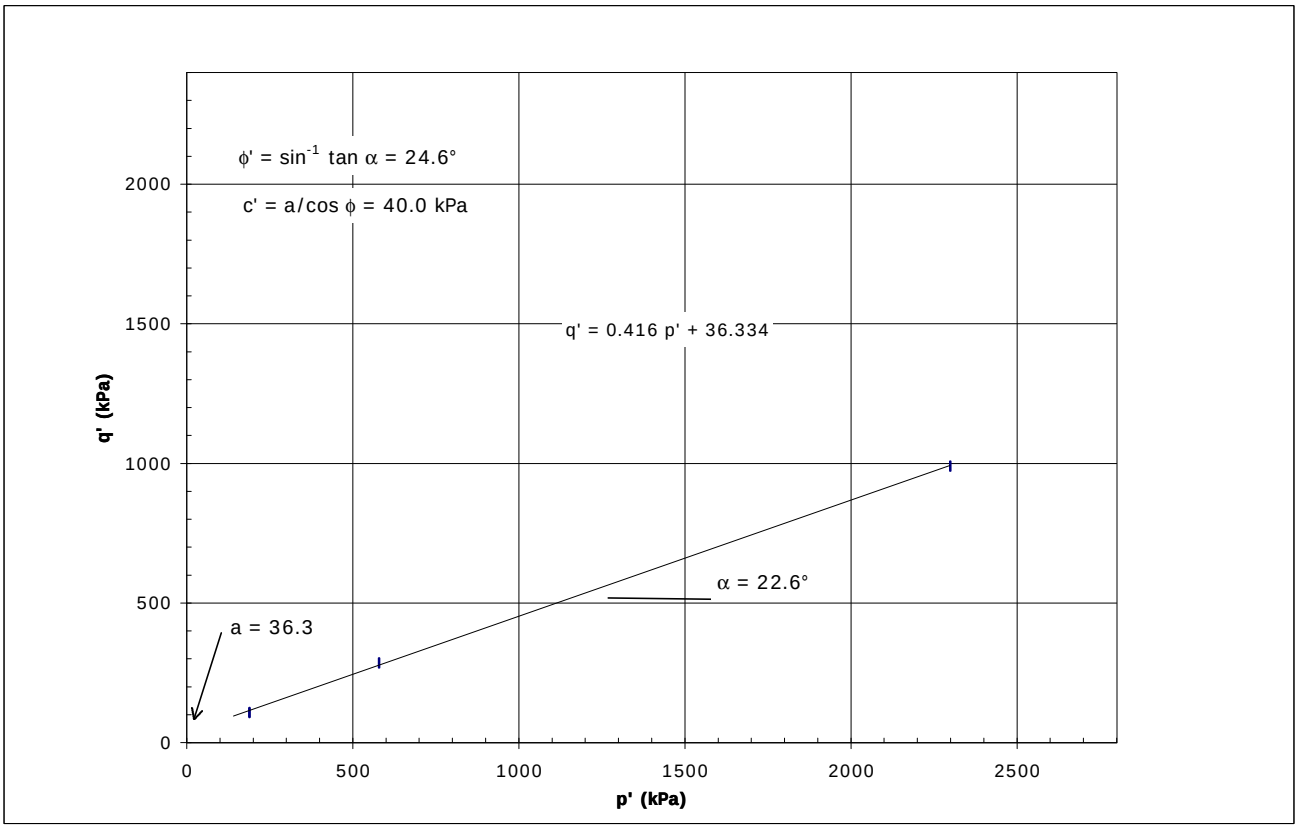
Modified Mohr (p'-q') Plot

Project No. 1700063

Borehole No. P-3
Depth (ft): 40-41
Test No. CU-1

σ'_3 (kPa)	$p' = (\sigma'_1+\sigma'_2)/2$ (kPa)	$q' = (\sigma'_1-\sigma'_2)/2$ (kPa)
100	188.0	107.5
400	577.9	285.4
1600	2297.6	990.6



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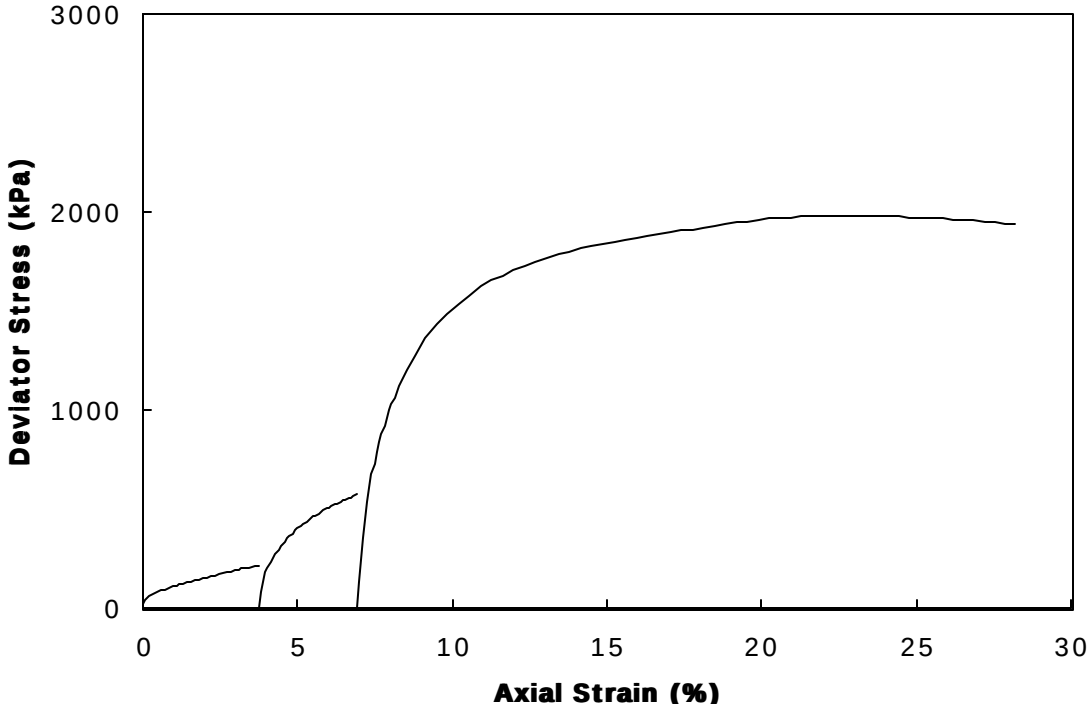
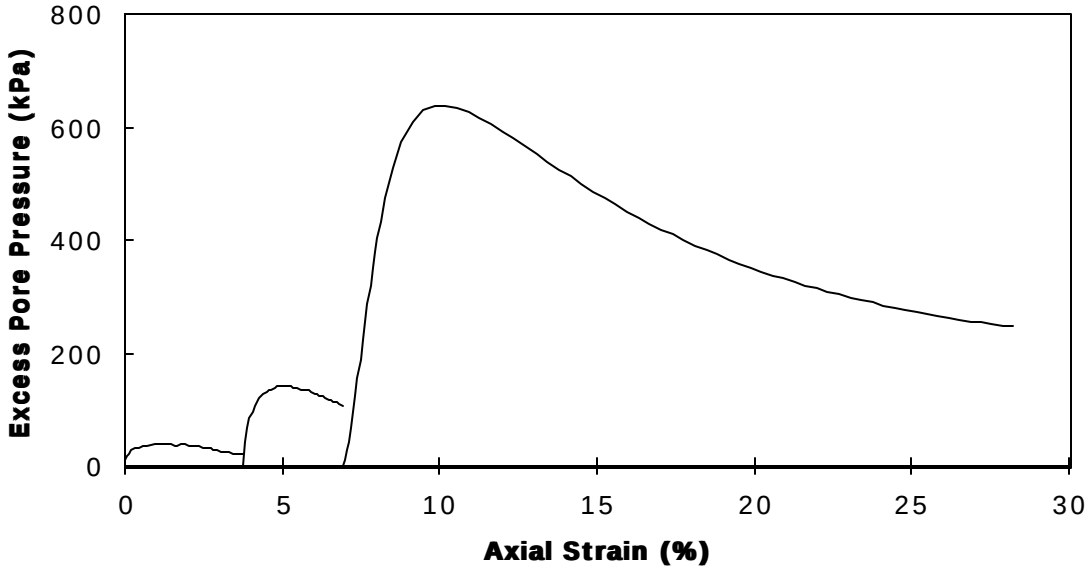
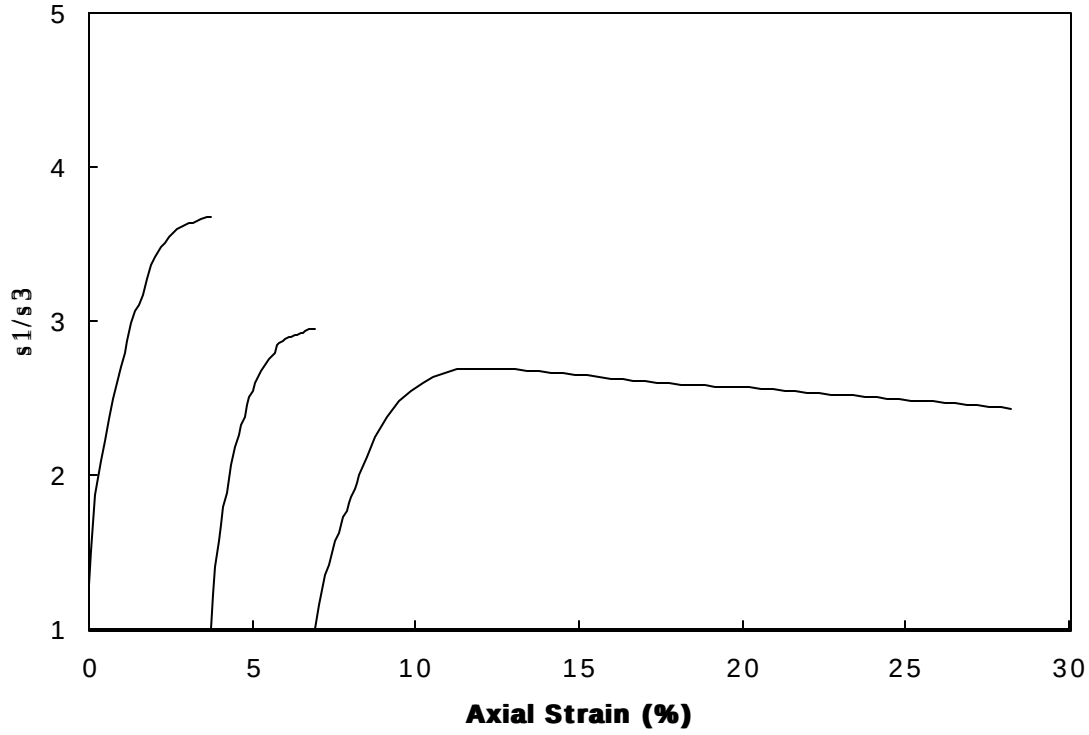
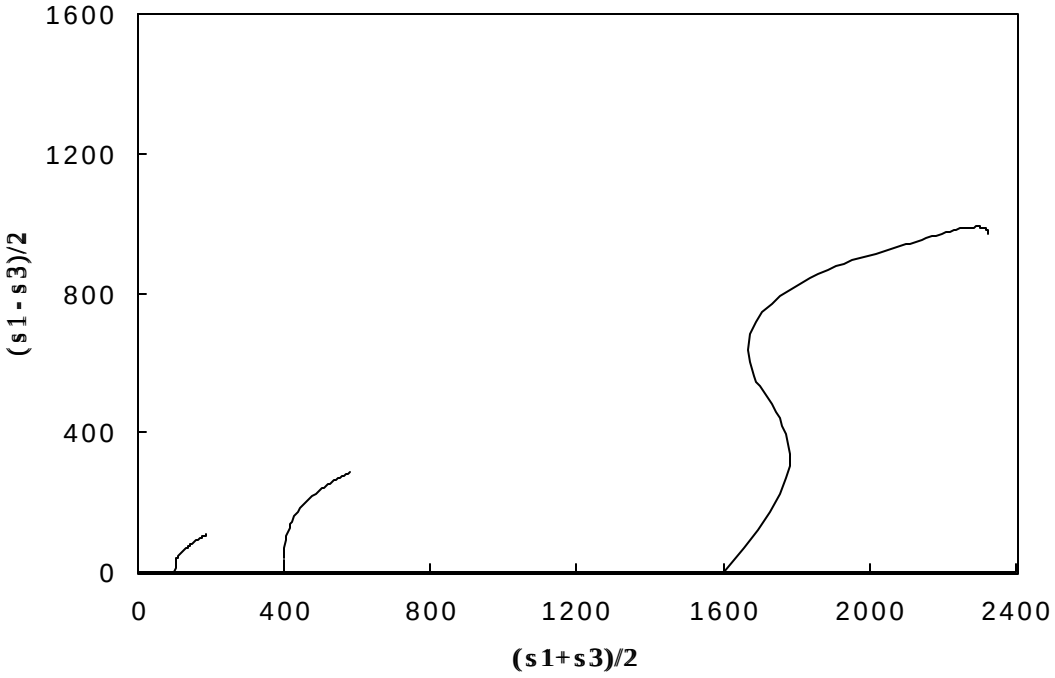




Test Hole: P-3
Effective Stress: 100/400/1600 kPa
Strain Rate: 0.014 %/min.
Test No.: CU-1

EBA Engineering Consultants Ltd.





Test Number: CU-1

EBA Engineering Consultants Ltd.

Multi-Stage Consolidated Undrained Triaxial Test

STAGE 1

Project No.: 1700063
Date Tested: 03-05-20

Test Hole No.: P-3
Depth (ft): 40-41
Test Number: CU-1

	Initial	Final
Moisture Content (%):	12.1	11.5
Wet Density (Mg/m3):	2.295	2.500
Dry Density (Mg/m3):	2.048	2.242

Strain (%)	$\sigma1-\sigma3$ (kPa)	Excess PP (kPa)	Parameter a	$\sigma1/\sigma3$	$(\sigma1-\sigma3)/2$ (kPa)	$(\sigma1+\sigma3)/2$ (kPa)
0.00	0.0	0.0	0.00	1.00	0.0	100.0
0.03	25.2	10.5	0.42	1.28	12.6	102.1
0.06	42.9	16.4	0.38	1.51	21.4	105.0
0.10	53.3	22.5	0.42	1.69	26.6	104.2
0.18	64.0	26.7	0.42	1.87	32.0	105.3
0.34	75.1	31.3	0.42	2.09	37.5	106.3
0.47	82.3	32.5	0.39	2.22	41.1	108.7
0.59	88.7	34.7	0.39	2.36	44.4	109.7
0.71	95.1	36.4	0.38	2.49	47.5	111.1
0.95	106.3	37.6	0.35	2.70	53.1	115.6
1.07	111.6	37.6	0.34	2.79	55.8	118.2
1.19	117.0	37.6	0.32	2.87	58.5	120.9
1.31	122.6	38.1	0.31	2.98	61.3	123.2
1.43	127.7	38.0	0.30	3.06	63.8	125.8
1.56	132.7	37.1	0.28	3.11	66.4	129.3
1.68	137.8	36.4	0.26	3.17	68.9	132.5
1.80	142.6	37.2	0.26	3.27	71.3	134.1
1.91	148.0	37.5	0.25	3.37	74.0	136.5
2.04	153.0	36.7	0.24	3.42	76.5	139.8
2.21	159.7	35.5	0.22	3.48	79.8	144.4
2.34	164.5	34.4	0.21	3.51	82.2	147.8
2.46	169.6	33.3	0.20	3.54	84.8	151.6
2.70	179.8	30.9	0.17	3.60	89.9	159.0
2.83	184.1	29.6	0.16	3.61	92.1	162.5
2.95	188.9	28.0	0.15	3.62	94.4	166.4
3.08	193.7	26.4	0.14	3.63	96.9	170.5
3.20	197.8	25.1	0.13	3.64	98.9	173.8
3.32	202.6	23.7	0.12	3.65	101.3	177.6
3.45	206.9	22.3	0.11	3.66	103.5	181.1
3.61	211.2	20.9	0.10	3.67	105.6	184.7
3.73	215.1	19.5	0.09	3.67	107.5	188.0

Test Hole No.: P-3 Test Number: CU-1 STAGE 2
Depth (ft): 40-41

Strain (%)	$\sigma1-\sigma3$ (kPa)	Excess PP (kPa)	Parameter a	$\sigma1/\sigma3$	$(\sigma1-\sigma3)/2$ (kPa)	$(\sigma1+\sigma3)/2$ (kPa)
3.73	0.0	0.0	0.00	1.00	0.0	400.0
3.81	79.8	40.7	0.51	1.22	39.9	399.2
3.89	136.1	67.3	0.49	1.41	68.1	400.8
3.96	178.5	84.8	0.48	1.57	89.2	404.5
4.04	206.6	96.5	0.47	1.68	103.3	406.8
4.12	232.0	105.1	0.45	1.79	116.0	410.9
4.20	252.8	112.9	0.45	1.88	126.4	413.5
4.28	273.5	120.4	0.44	1.98	136.7	416.3
4.37	291.4	125.9	0.43	2.06	145.7	419.8
4.49	318.1	131.8	0.41	2.19	159.1	427.2
4.57	333.6	134.3	0.40	2.26	166.8	432.5
4.66	349.6	135.9	0.39	2.32	174.8	438.9
4.75	363.5	137.1	0.38	2.38	181.7	444.7
4.83	377.6	140.2	0.37	2.45	188.8	448.6
4.92	390.4	141.0	0.36	2.51	195.2	454.2
5.01	402.9	140.2	0.35	2.55	201.5	461.2
5.10	414.0	141.6	0.34	2.60	207.0	465.5
5.18	425.6	141.2	0.33	2.64	212.8	471.6
5.27	435.4	140.1	0.32	2.68	217.7	477.6
5.36	446.9	139.2	0.31	2.71	223.4	484.2
5.49	460.2	137.0	0.30	2.75	230.1	493.1
5.58	468.5	135.5	0.29	2.77	234.3	498.7
5.67	477.3	133.7	0.28	2.79	238.6	505.0
5.76	487.1	135.8	0.28	2.84	243.6	507.8
5.84	494.2	133.4	0.27	2.85	247.1	513.7
5.93	501.7	131.3	0.26	2.87	250.8	519.5
6.02	508.7	129.1	0.25	2.88	254.3	525.3
6.11	516.7	127.2	0.25	2.89	258.4	531.1
6.19	522.8	124.9	0.24	2.90	261.4	536.5
6.28	529.6	122.4	0.23	2.91	264.8	542.4
6.37	535.7	119.5	0.22	2.91	267.9	548.4
6.46	542.2	117.6	0.22	2.92	271.1	553.5
6.55	547.3	116.1	0.21	2.93	273.6	557.6
6.64	554.0	113.6	0.20	2.93	277.0	563.5
6.73	560.0	112.0	0.20	2.94	280.0	568.0
6.82	565.1	110.3	0.20	2.95	282.6	572.3
6.91	570.8	107.5	0.19	2.95	285.4	577.9

Test Hole No.: P-3 Test Number: CU-1 STAGE 3
Depth (ft): 40-41

Strain (%)	$\sigma1-\sigma3$ (kPa)	Excess PP (kPa)	Parameter a	$\sigma1/\sigma3$	$(\sigma1-\sigma3)/2$ (kPa)	$(\sigma1+\sigma3)/2$ (kPa)
6.91	0.0	0.0	0.00	1.00	0.0	1600.0
6.97	132.2	11.1	0.08	1.08	66.1	1655.0
7.04	244.2	26.9	0.11	1.16	122.1	1695.1
7.10	348.8	44.2	0.13	1.22	174.4	1730.2
7.17	447.1	67.6	0.15	1.29	223.5	1755.9
7.25	534.6	95.1	0.18	1.36	267.3	1772.2
7.32	609.1	124.3	0.20	1.41	304.5	1780.2
7.40	674.8	156.0	0.23	1.47	337.4	1781.4
7.47	732.0	188.6	0.26	1.52	366.0	1777.4
7.55	786.1	222.1	0.28	1.57	393.0	1770.9
7.64	836.9	255.4	0.31	1.62	418.5	1763.1
7.72	882.3	287.8	0.33	1.67	441.2	1753.3
7.80	922.9	319.7	0.35	1.72	461.5	1741.8
7.88	960.6	349.3	0.36	1.77	480.3	1730.9
7.96	996.2	377.8	0.38	1.82	498.1	1720.3
8.04	1030.2	405.2	0.39	1.86	515.1	1709.9
8.11	1062.2	430.7	0.41	1.91	531.1	1700.4
8.19	1092.5	454.5	0.42	1.95	546.2	1691.7
8.27	1121.0	474.2	0.42	2.00	560.5	1686.3
8.51	1200.7	527.7	0.44	2.12	600.4	1672.7
8.78	1276.2	572.5	0.45	2.24	638.1	1665.5
9.13	1361.3	608.4	0.45	2.37	680.6	1672.2
9.48	1431.5	628.8	0.44	2.47	715.8	1686.9
9.84	1488.9	637.3	0.43	2.55	744.5	1707.2
10.20	1537.9	638.3	0.42	2.60	769.0	1730.7
10.56	1580.8	634.2	0.40	2.64	790.4	1756.1
10.91	1622.5	626.4	0.39	2.67	811.3	1784.8
11.28	1654.4	617.2	0.37	2.68	827.2	1810.0
11.63	1681.4	604.2	0.36	2.69	840.7	1836.5
11.99	1706.1	591.8	0.35	2.69	853.1	1861.3
12.34	1728.5	579.1	0.34	2.69	864.2	1885.1
12.70	1749.6	565.7	0.32	2.69	874.8	1909.1
13.06	1768.0	551.7	0.31	2.69	884.0	1932.3
13.42	1784.7	538.7	0.30	2.68	892.3	1953.6
13.78	1801.6	525.5	0.29	2.68	900.8	1975.3
14.15	1815.5	512.0	0.28	2.67	907.7	1995.7
14.51	1828.9	498.4	0.27	2.66	914.4	2016.0
14.87	1839.9	485.6	0.26	2.65	919.9	2034.3
15.24	1850.4	474.6	0.26	2.64	925.2	2050.6
15.60	1859.4	462.3	0.25	2.63	929.7	2067.4
15.96	1869.2	449.7	0.24	2.63	934.6	2084.9

Test Hole No.: P-3 Test Number: CU-1 STAGE 3
Depth (ft): 40-41

Strain (%)	$\sigma1-\sigma3$ (kPa)	Excess PP (kPa)	Parameter a	$\sigma1/\sigma3$	$(\sigma1-\sigma3)/2$ (kPa)	$(\sigma1+\sigma3)/2$ (kPa)
16.32	1878.2	439.5	0.23	2.62	939.1	2099.6
16.68	1886.0	430.1	0.23	2.61	943.0	2112.9
17.04	1895.1	418.7	0.22	2.60	947.5	2128.8
17.40	1904.4	409.8	0.22	2.60	952.2	2142.3
17.76	1913.3	400.0	0.21	2.59	956.7	2156.6
18.12	1921.5	390.6	0.20	2.59	960.8	2170.1
18.48	1930.5	381.8	0.20	2.58	965.2	2183.4
18.84	1940.2	374.0	0.19	2.58	970.1	2196.1
19.19	1947.1	366.0	0.19	2.58	973.5	2207.5
19.54	1952.4	357.9	0.18	2.57	976.2	2218.2
19.88	1959.5	351.7	0.18	2.57	979.7	2228.0
20.23	1965.7	345.1	0.18	2.57	982.8	2237.7
20.58	1969.3	337.7	0.17	2.56	984.7	2246.9
20.93	1972.5	331.3	0.17	2.55	986.2	2254.9
21.28	1975.0	325.7	0.16	2.55	987.5	2261.8
21.63	1976.9	319.3	0.16	2.54	988.5	2269.2
21.99	1978.0	313.7	0.16	2.54	989.0	2275.3
22.34	1976.4	308.5	0.16	2.53	988.2	2279.7
22.69	1978.4	303.2	0.15	2.53	989.2	2285.9
23.04	1979.8	297.4	0.15	2.52	989.9	2292.4
23.40	1981.3	293.0	0.15	2.52	990.6	2297.6
23.75	1981.1	289.2	0.15	2.51	990.5	2301.3
24.10	1976.7	284.4	0.14	2.50	988.3	2303.9
24.44	1977.2	280.0	0.14	2.50	988.6	2308.6
24.79	1973.9	276.4	0.14	2.49	986.9	2310.5
25.14	1972.9	272.8	0.14	2.49	986.5	2313.6
25.49	1970.1	268.8	0.14	2.48	985.1	2316.3
25.83	1967.3	265.6	0.13	2.47	983.7	2318.1
26.18	1963.6	262.8	0.13	2.47	981.8	2319.0
26.52	1960.6	259.2	0.13	2.46	980.3	2321.1
26.86	1958.1	256.6	0.13	2.46	979.1	2322.5
27.20	1953.7	254.2	0.13	2.45	976.8	2322.6
27.55	1948.4	251.4	0.13	2.44	974.2	2322.8
27.89	1942.9	248.3	0.13	2.44	971.5	2323.1
28.20	1938.4	246.5	0.13	2.43	969.2	2322.6

SAMPLE INFORMATION

Project: Proposed Deh Cho Bridge
Address: Fort Providence, NWT.

Project Number: 1700063
Date Tested: 03·05·20 By: S.K.
Test Apparatus: Tx (cu), multistage
Machine Number: 1
Rate of Strain: 0.02 mm/minute
Normal Stress: _____ kPa
Cell Pressure: 500, 800, 2000 kPa
Back Pressure: 400 kPa
Head Differential: 100, 400, 1600 kPa
Swelling Pressure: _____ kPa

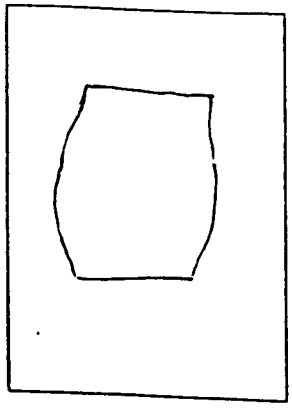
Borehole Number: P-3
Depth: 40 - 41'
Test Number: CU-1
Sample Description: CLAY, silty, trc. sand & gravel (25 mm), dark grayish brown

Sample Description	Diameter (mm)	Height (mm)
1	72.24	142.72
2	72.64	143.28
3	71.56	143.04
4		
Mean	72.15	143.01

$V = 584.7\ cm^3$

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1342.1	1346.0
Mass of Dry Soil & Tare g			1208.4
Mass of Tare g			10.7
Mass of Dry Soil g		1197.7	1197.7
Mass of Moisture g			
Moisture Content %		12.1	11.5
Wet Density Mg/m^3		2.295	2.500
Dry Density Mg/m^3		2.048	2.242

Sketch and Remarks:



Initial Stickup = 115.82 mm
Stickup after 1st cons. = 115.26 mm
Stickup after 2nd cons. = 111.26 mm
Stickup after 3rd cons. = 107.90 mm

Angle of Shear: _____

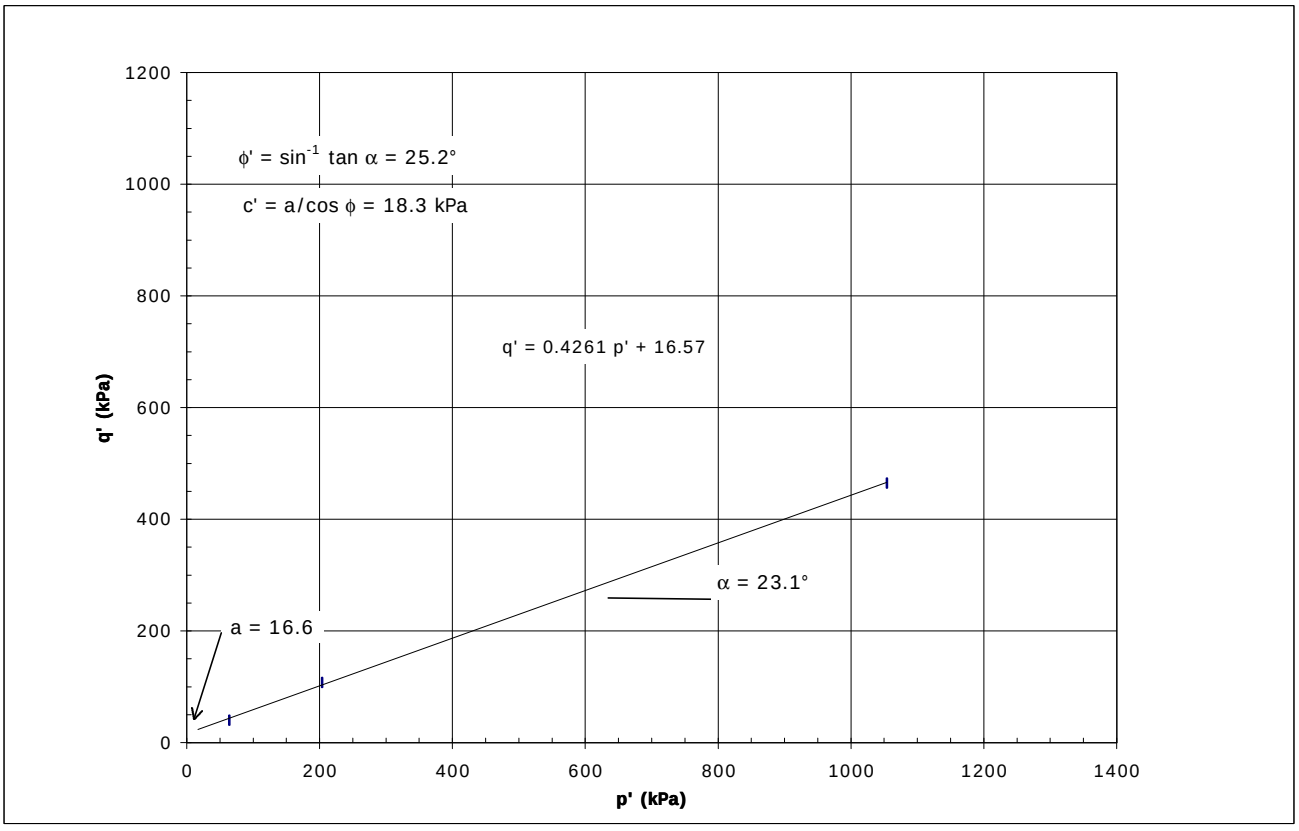
EBA Engineering Consultants Ltd.

Modified Mohr (p'-q') Plot

Project No. 1700063

Borehole No. P-7
Depth (ft): 24.0-25.75
Test No. CU-2

σ'_3 (kPa)	$p' = (\sigma'_1+\sigma'_2)/2$ (kPa)	$q' = (\sigma'_1-\sigma'_2)/2$ (kPa)
30	63.7	39.9
120	203.2	107.6
480	1053.8	465.0



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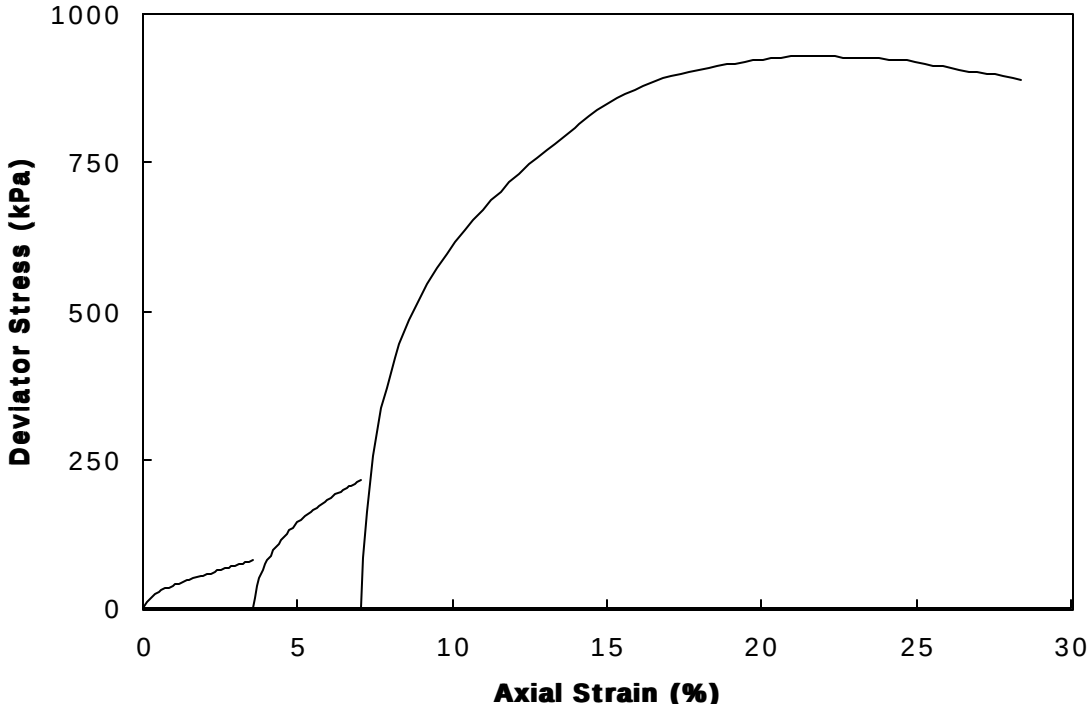
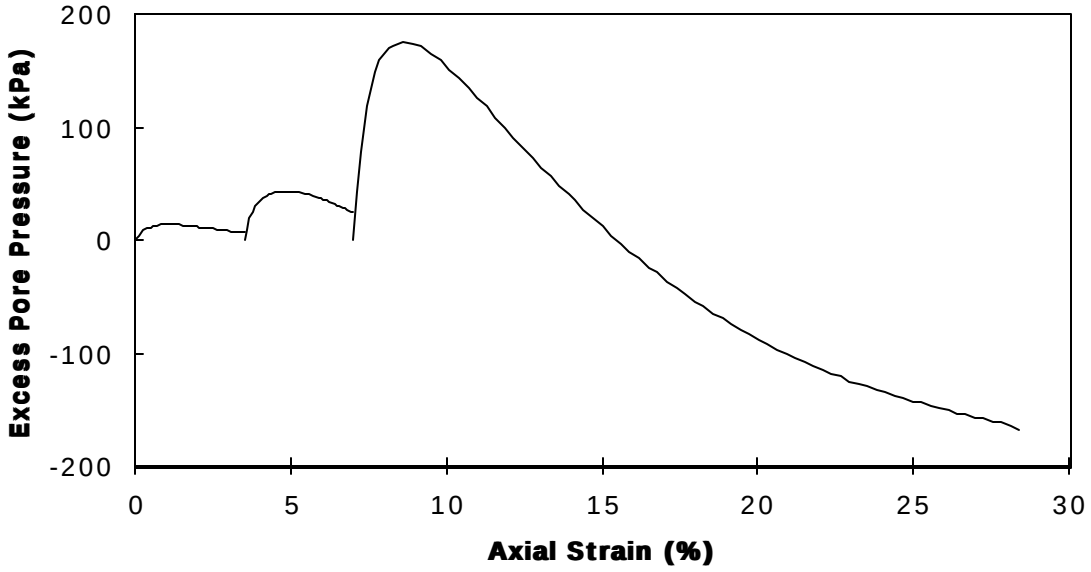
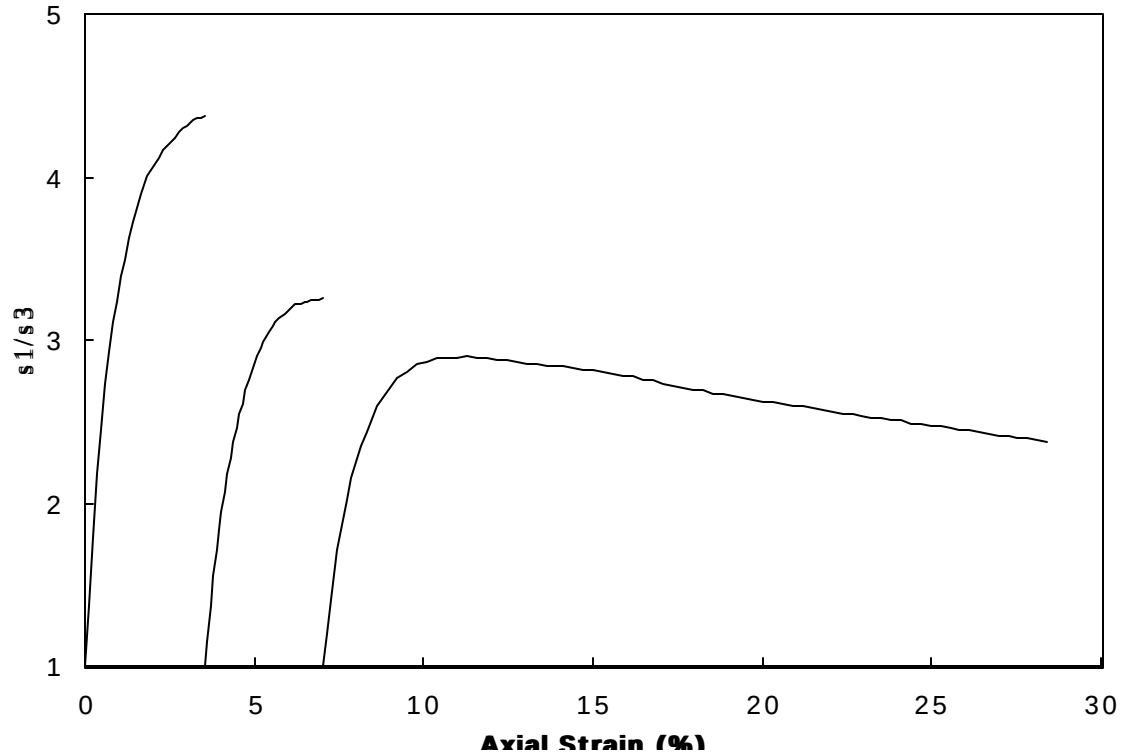
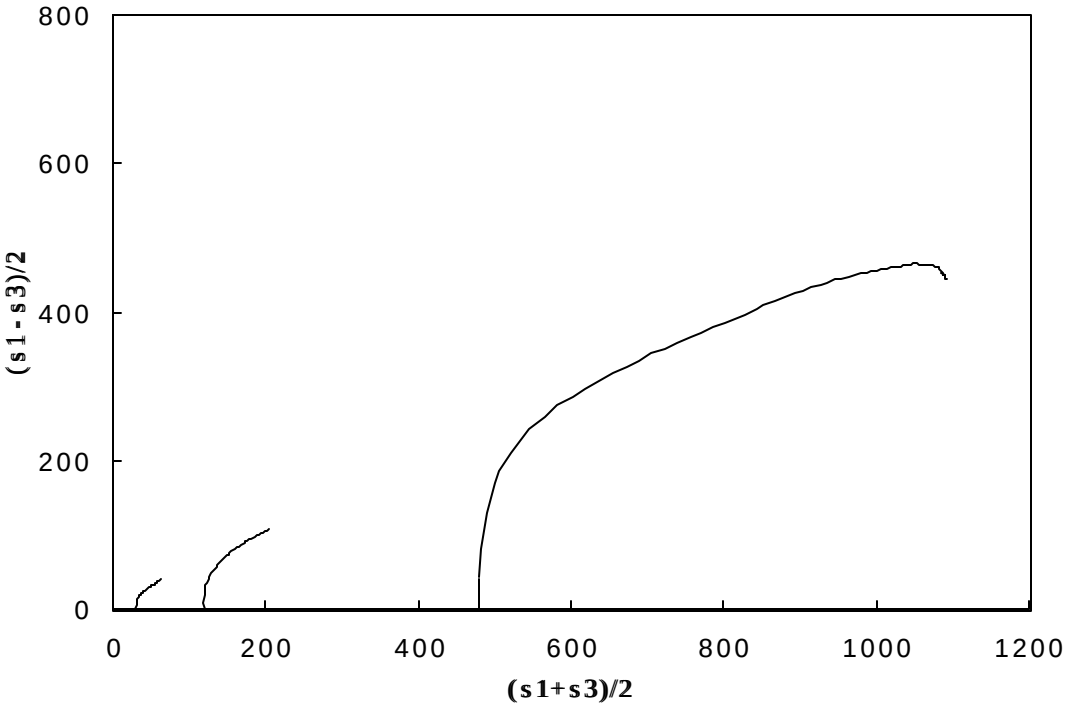




Test Hole: P-7
Effective Stress: 30/120/480 kPa
Strain Rate: 0.015 %/min.
Test No.: CU-2





Test Number: CU-2

EBA Engineering Consultants Ltd.

Multi-Stage Consolidated Undrained Triaxial Test

STAGE 1

Project No.: 1700063
Date Tested: 03-05-27

Test Hole No.: P-7
Depth (ft): 25-25.75
Test Number: CU-2

	Initial	Final
Moisture Content (%):	10.2	10.8
Wet Density (Mg/m3):	2.328	2.501
Dry Density (Mg/m3):	2.113	2.256

Strain (%)	$\sigma1-\sigma3$ (kPa)	Excess PP (kPa)	Parameter a	$\sigma1/\sigma3$	$(\sigma1-\sigma3)/2$ (kPa)	$(\sigma1+\sigma3)/2$ (kPa)
0.00	0.0	0.0	0.00	1.00	0.0	30.0
0.14	9.8	3.4	0.35	1.37	4.9	31.5
0.26	17.3	8.0	0.46	1.79	8.7	30.6
0.37	23.5	10.1	0.43	2.18	11.7	31.6
0.49	27.0	11.3	0.42	2.45	13.5	32.2
0.61	30.4	12.4	0.41	2.72	15.2	32.9
0.72	32.7	13.0	0.40	2.92	16.3	33.3
0.84	35.2	13.3	0.38	3.11	17.6	34.3
0.95	37.1	13.4	0.36	3.24	18.6	35.2
1.06	39.4	13.5	0.34	3.39	19.7	36.1
1.18	41.4	13.4	0.32	3.50	20.7	37.3
1.29	43.5	13.4	0.31	3.62	21.7	38.3
1.40	45.5	13.3	0.29	3.72	22.8	39.5
1.52	47.4	13.1	0.28	3.81	23.7	40.6
1.63	49.6	12.9	0.26	3.90	24.8	41.9
1.85	53.3	12.2	0.23	4.00	26.7	44.5
1.97	55.2	11.8	0.21	4.04	27.6	45.8
2.08	57.1	11.5	0.20	4.08	28.5	47.0
2.19	58.8	11.2	0.19	4.12	29.4	48.2
2.30	60.8	10.8	0.18	4.16	30.4	49.6
2.41	62.6	10.4	0.17	4.19	31.3	50.9
2.53	64.8	9.9	0.15	4.22	32.4	52.5
2.65	66.6	9.5	0.14	4.24	33.3	53.8
2.76	68.5	9.1	0.13	4.27	34.2	55.2
2.87	70.3	8.7	0.12	4.30	35.1	56.5
2.98	72.0	8.3	0.12	4.31	36.0	57.7
3.09	73.6	7.9	0.11	4.33	36.8	58.9
3.21	75.3	7.5	0.10	4.34	37.6	60.1
3.33	76.9	7.1	0.09	4.36	38.5	61.4
3.44	78.4	6.7	0.09	4.37	39.2	62.5
3.55	79.9	6.3	0.08	4.37	39.9	63.7

Test Hole No.: P-7 Test Number: CU-2 STAGE 2
Depth (ft): 25-25.75

Strain (%)	σ1–σ3 (kPa)	Excess PP (kPa)	Parameter a	σ1/σ3	(σ1–σ3)/2 (kPa)	(σ1+σ3)/2 (kPa)
3.55	0.0	0.0	0.00	1.00	0.0	120.0
3.61	16.3	9.5	0.58	1.15	8.1	118.7
3.69	37.4	18.9	0.51	1.37	18.7	119.8
3.78	52.0	25.0	0.48	1.55	26.0	121.0
3.87	64.2	30.4	0.47	1.72	32.1	121.7
3.95	72.5	32.6	0.45	1.83	36.2	123.6
4.04	80.8	35.0	0.43	1.95	40.4	125.4
4.13	88.1	37.2	0.42	2.06	44.0	126.8
4.22	96.0	38.8	0.40	2.18	48.0	129.2
4.30	102.0	40.1	0.39	2.28	51.0	130.9
4.39	108.3	41.1	0.38	2.37	54.2	133.0
4.48	114.2	41.8	0.37	2.46	57.1	135.3
4.56	119.8	42.5	0.35	2.55	59.9	137.5
4.65	124.6	42.7	0.34	2.61	62.3	139.6
4.73	129.9	43.1	0.33	2.69	65.0	141.8
4.82	135.1	43.0	0.32	2.75	67.5	144.6
5.00	143.7	43.0	0.30	2.87	71.9	148.9
5.09	147.3	42.5	0.29	2.90	73.7	151.2
5.18	151.2	42.7	0.28	2.96	75.6	152.9
5.26	154.8	41.9	0.27	2.98	77.4	155.5
5.44	162.2	40.9	0.25	3.05	81.1	160.2
5.53	165.5	40.5	0.24	3.08	82.7	162.3
5.61	169.1	40.0	0.24	3.11	84.5	164.6
5.70	172.4	39.4	0.23	3.14	86.2	166.8
5.88	178.4	37.3	0.21	3.16	89.2	171.9
5.97	181.2	36.7	0.20	3.17	90.6	173.9
6.05	184.3	35.9	0.19	3.19	92.1	176.2
6.14	187.5	35.0	0.19	3.20	93.7	178.8
6.23	190.5	34.0	0.18	3.22	95.3	181.2
6.40	196.1	31.8	0.16	3.22	98.1	186.2
6.49	198.9	30.8	0.15	3.23	99.4	188.6
6.58	201.3	30.0	0.15	3.24	100.6	190.7
6.67	204.6	28.7	0.14	3.24	102.3	193.6
6.75	207.0	27.7	0.13	3.24	103.5	195.8
6.84	210.3	26.4	0.13	3.25	105.2	198.7
6.93	212.7	25.5	0.12	3.25	106.4	200.9
7.02	215.3	24.4	0.11	3.25	107.6	203.2

Test Hole No.: P-7 Test Number: CU-2 STAGE 3
Depth (ft): 25-25.75

Strain (%)	$\sigma1-\sigma3$ (kPa)	Excess PP (kPa)	Parameter a	$\sigma1/\sigma3$	$(\sigma1-\sigma3)/2$ (kPa)	$(\sigma1+\sigma3)/2$ (kPa)
7.02	0.0	0.0	0.00	1.00	0.0	480.0
7.14	85.0	42.5	0.50	1.19	42.5	480.0
7.26	161.5	77.5	0.48	1.40	80.8	483.2
7.42	256.8	118.0	0.46	1.71	128.4	490.3
7.71	337.7	149.3	0.44	2.02	168.8	499.5
7.86	369.3	158.9	0.43	2.15	184.6	505.7
8.15	420.9	169.4	0.40	2.36	210.4	521.0
8.30	443.2	172.4	0.39	2.44	221.6	529.1
8.60	483.9	175.9	0.36	2.59	242.0	546.1
8.91	517.6	173.1	0.33	2.69	258.8	565.7
9.21	546.8	171.1	0.31	2.77	273.4	582.3
9.51	572.1	163.8	0.29	2.81	286.1	602.3
9.81	595.1	158.9	0.27	2.85	297.5	618.6
10.11	615.9	150.1	0.24	2.87	308.0	637.9
10.40	634.9	143.1	0.23	2.88	317.4	654.3
10.70	653.2	133.8	0.20	2.89	326.6	672.8
10.99	670.6	125.9	0.19	2.89	335.3	689.4
11.28	687.3	118.8	0.17	2.90	343.7	704.8
11.57	701.8	108.6	0.15	2.89	350.9	722.4
11.86	718.3	99.1	0.14	2.89	359.1	740.0
12.17	731.5	89.5	0.12	2.87	365.7	756.2
12.46	745.8	81.6	0.11	2.87	372.9	771.3
12.76	758.0	72.9	0.10	2.86	379.0	786.1
13.05	770.9	64.3	0.08	2.85	385.5	801.2
13.35	782.5	57.2	0.07	2.85	391.2	814.1
13.65	793.8	48.2	0.06	2.84	396.9	828.7
13.94	808.2	40.9	0.05	2.84	404.1	843.2
14.12	816.4	35.9	0.04	2.84	408.2	852.3
14.42	827.9	26.3	0.03	2.82	414.0	867.7
14.71	839.5	18.8	0.02	2.82	419.8	881.0
15.00	849.0	11.6	0.01	2.81	424.5	892.9
15.29	857.0	3.8	0.00	2.80	428.5	904.7
15.59	864.7	-2.8	0.00	2.79	432.3	915.1
15.89	872.4	-10.6	-0.01	2.78	436.2	926.8
16.18	879.5	-15.9	-0.02	2.77	439.7	935.6
16.48	886.4	-23.9	-0.03	2.76	443.2	947.1
16.78	890.6	-28.8	-0.03	2.75	445.3	954.1
17.09	895.1	-37.1	-0.04	2.73	447.5	964.6
17.38	898.8	-41.9	-0.05	2.72	449.4	971.3
17.68	902.6	-48.2	-0.05	2.71	451.3	979.5
17.98	906.3	-54.3	-0.06	2.70	453.1	987.4

Test Hole No.: P-7 Test Number: CU-2 STAGE 3
Depth (ft): 25-25.75

Strain (%)	σ1–σ3 (kPa)	Excess PP (kPa)	Parameter a	σ1/σ3	(σ1–σ3)/2 (kPa)	(σ1+σ3)/2 (kPa)
18.27	909.1	-58.5	-0.06	2.69	454.5	993.0
18.56	911.9	-65.5	-0.07	2.67	456.0	1001.4
18.86	915.7	-69.0	-0.08	2.67	457.8	1006.8
19.15	917.4	-74.9	-0.08	2.65	458.7	1013.6
19.45	918.5	-79.3	-0.09	2.64	459.3	1018.5
19.74	921.2	-83.2	-0.09	2.64	460.6	1023.8
20.03	923.7	-89.2	-0.10	2.62	461.9	1031.1
20.33	925.4	-91.9	-0.10	2.62	462.7	1034.6
20.63	926.9	-97.3	-0.10	2.61	463.5	1040.7
20.92	928.9	-100.5	-0.11	2.60	464.5	1045.0
21.21	929.6	-103.6	-0.11	2.59	464.8	1048.4
21.50	930.0	-108.8	-0.12	2.58	465.0	1053.8
21.79	929.1	-111.2	-0.12	2.57	464.6	1055.8
22.08	928.6	-114.7	-0.12	2.56	464.3	1059.1
22.36	928.2	-118.0	-0.13	2.55	464.1	1062.1
22.65	927.6	-120.5	-0.13	2.54	463.8	1064.3
22.93	926.2	-124.9	-0.13	2.53	463.1	1068.0
23.23	925.3	-126.7	-0.14	2.53	462.7	1069.4
23.52	926.2	-130.0	-0.14	2.52	463.1	1073.1
23.81	924.6	-132.6	-0.14	2.51	462.3	1074.9
24.10	923.4	-134.3	-0.15	2.50	461.7	1076.0
24.39	922.1	-138.7	-0.15	2.49	461.0	1079.7
24.68	921.0	-139.6	-0.15	2.49	460.5	1080.1
24.97	918.9	-142.9	-0.16	2.48	459.4	1082.3
25.26	916.9	-144.1	-0.16	2.47	458.5	1082.5
25.55	913.8	-146.0	-0.16	2.46	456.9	1082.9
25.83	912.5	-149.0	-0.16	2.45	456.2	1085.3
26.12	910.0	-149.8	-0.16	2.44	455.0	1084.8
26.40	906.9	-153.6	-0.17	2.43	453.5	1087.1
26.68	903.9	-153.9	-0.17	2.43	452.0	1085.9
26.97	902.1	-157.7	-0.17	2.41	451.1	1088.8
27.25	900.5	-157.9	-0.18	2.41	450.2	1088.1
27.54	898.2	-160.6	-0.18	2.40	449.1	1089.7
27.83	894.8	-161.7	-0.18	2.39	447.4	1089.1
28.11	891.6	-164.7	-0.18	2.38	445.8	1090.5
28.39	890.1	-167.7	-0.19	2.37	445.0	1092.7

SAMPLE INFORMATION

Project: Proposed Deh Cho Bridge
Address: Fort Providence, NWT.

Project Number: 1700063
Date Tested: 03.05.27 By: S.K.
Test Apparatus: Tx (CU), multistage
Machine Number: 1
Rate of Strain: 0.02 mm/minute
Normal Stress: ____ kPa
Cell Pressure: 430, 520, 880 kPa
Back Pressure: 400 kPa
Head Differential: 30, 120, 480 kPa
Swelling Pressure: ____ kPa

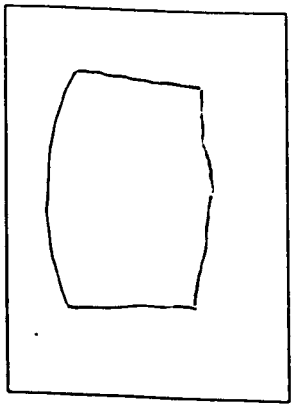
Borehole Number: P-7
Depth: 25'-25'9"
Test Number: CU-2
Sample Description: CLAY, silty, trc. sand & gravel (15 mm), dark grayish brown

Sample Description	Diameter (mm)	Height (mm)
1	73.20	138.20
2	70.16	139.38
3	71.32	138.84
4	72.54	
Mean	71.81	138.47

V = 560.81 cm³

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1305.5	1323.7
Mass of Dry Soil & Tare g			1195.4
Mass of Tare g			10.6
Mass of Dry Soil g		1184.8	1184.8
Mass of Moisture g			
Moisture Content %		10.2	10.8
Wet Density Mg/m³		2.328	2.501
Dry Density Mg/m³		2.113	2.256

Sketch and Remarks:



Initial stickup = 114.08 mm
Stickup after 1st cons. = 112.38 mm
Stickup after 2nd cons. = 109.12 mm
Stickup after 3rd cons. = 106.14 mm

Angle of Shear: ____

EBA Engineering Consultants Ltd.

Stress-Strain Parameters

CU-1

Young's undrained tangent modulus (E) is calculated at 50% of peak deviatoric stress.
n is the reading at 50% of peak deviatoric stress
(n+1) and (n-1) are the values at one reading above and below the 50% reading
For undrained tests, the Poisson's ratio (υ_u) is theoretically equal to 0.5

Stage	At n		At n-1		At n+1		
	Strain (%)	Deviatoric Stress (kPa)	Strain (%)	Deviatoric Stress (kPa)	Strain (%)	Deviatoric Stress (kPa)	E (MPa)
1	0.95	106	0.71	95	1.07	112	5
2	4.37	291	4.28	274	4.49	318	21
3	7.96	996	7.88	961	8.04	1030	44

CU-2

Young's undrained tangent modulus (E) is calculated at 50% of peak deviatoric stress.
n is the reading at 50% of peak deviatoric stress
(n+1) and (n-1) are the values at one reading above and below the 50% reading
For undrained tests, the Poisson's ratio (υ_u) is theoretically equal to 0.5

Stage	At n		At n-1		At n+1		
	Strain (%)	Deviatoric Stress (kPa)	Strain (%)	Deviatoric Stress (kPa)	Strain (%)	Deviatoric Stress (kPa)	E (MPa)
1	1.06	39	0.95	37	1.18	41	2
2	4.39	108	4.3	102	4.48	114	7
3	8.60	484	8.3	443	8.91	518	12

EBA Engineering Consultants Ltd.

Unconfined Compression Test

Project No.: 1700063
Date Tested: 03-11-19

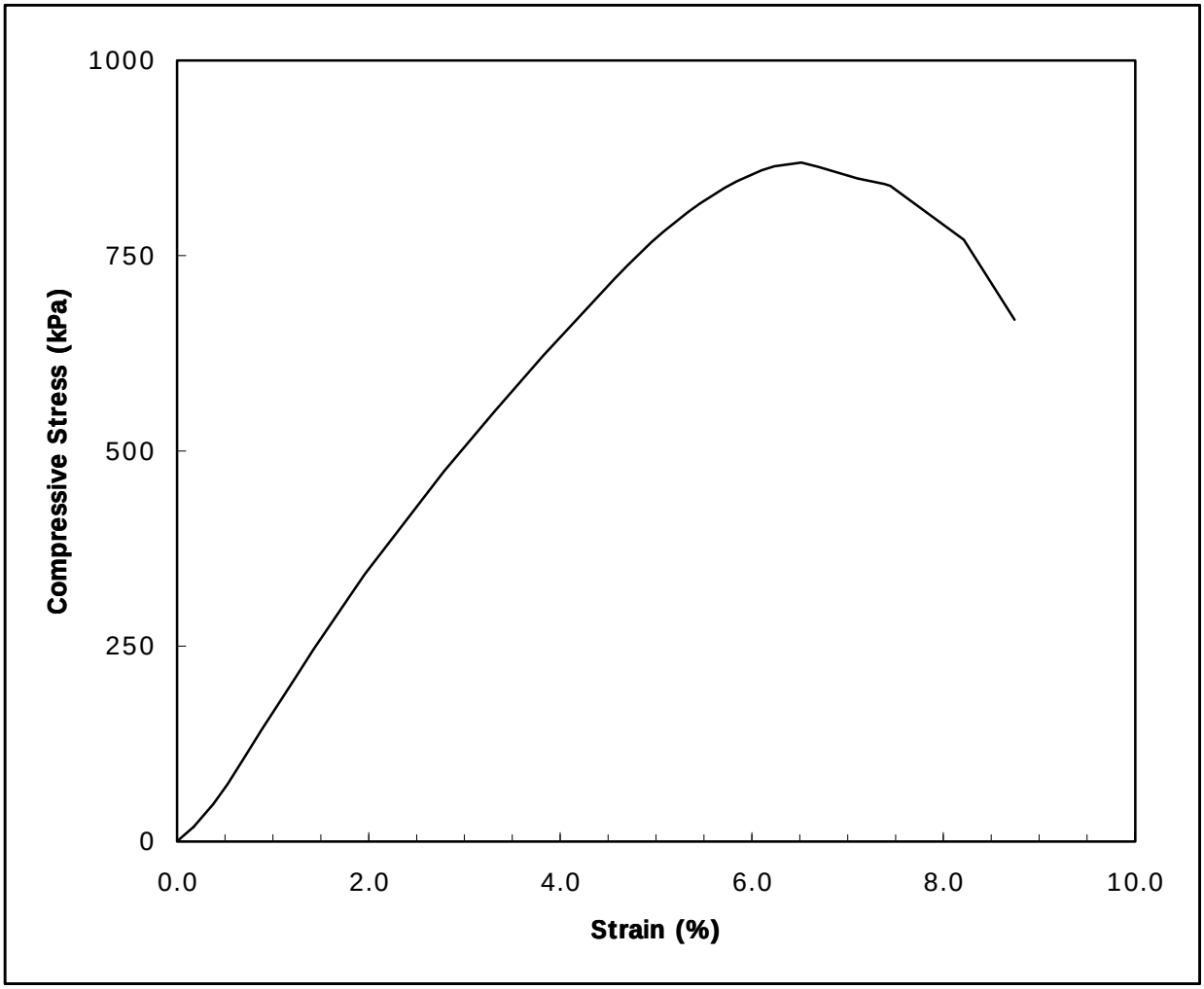
Test Hole No.: A-2
Depth : 22.5 ft
Test Number: QU-1

Initial Sample Conditions

Moisture Content (%):	9.8
Wet Density (Mg/m3):	2.286
Dry Density (Mg/m3):	2.083

Rate of Strain (%/min): 0.5

Peak Stress (kPa) 869



SAMPLE INFORMATION

Project: DEH CHO BRIDGE
Address:
Project Number: 1700063
Date Tested: 03.11.19 By: M.T. & S.K.
Test Apparatus: Tx (Qu)
Machine Number: 1
Rate of Strain: ____ mm% / minute
Normal Stress: ____ kPa
Cell Pressure: ____ kPa
Back Pressure: ____ kPa
Head Differential: ____ kPa
Swelling Pressure: ____ kPa

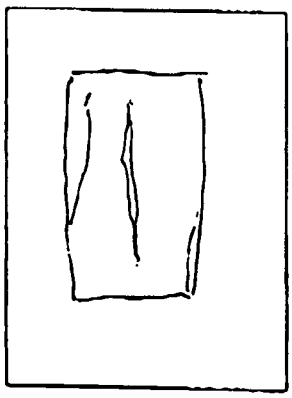
Borehole Number: 1 (S11)
Depth: 22.5'
Test Number: QU-1
Sample Description: CLAY (till) silty, sandy, trc. gravel, dark grayish brown

Sample Description	Diameter (mm)	Height (mm)
1	74.0	140.3
2	72.2	139.8
3	73.6	140.3
4		
Mean	73.3	140.1

V = 591.20

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1351.5	701.6
Mass of Dry Soil & Tare g			640.1
Mass of Tare g			10.7
Mass of Dry Soil g			629.4
Mass of Moisture g			61.5
Moisture Content %			9.8
Wet Density Mg/m^3		2.286	
Dry Density Mg/m^3		2.083	

Sketch and Remarks:



PP = 4.5+

Angle of Shear: 90°

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Unconfined Compression Test

Project No.: 1700063
Date Tested: 03-06-04

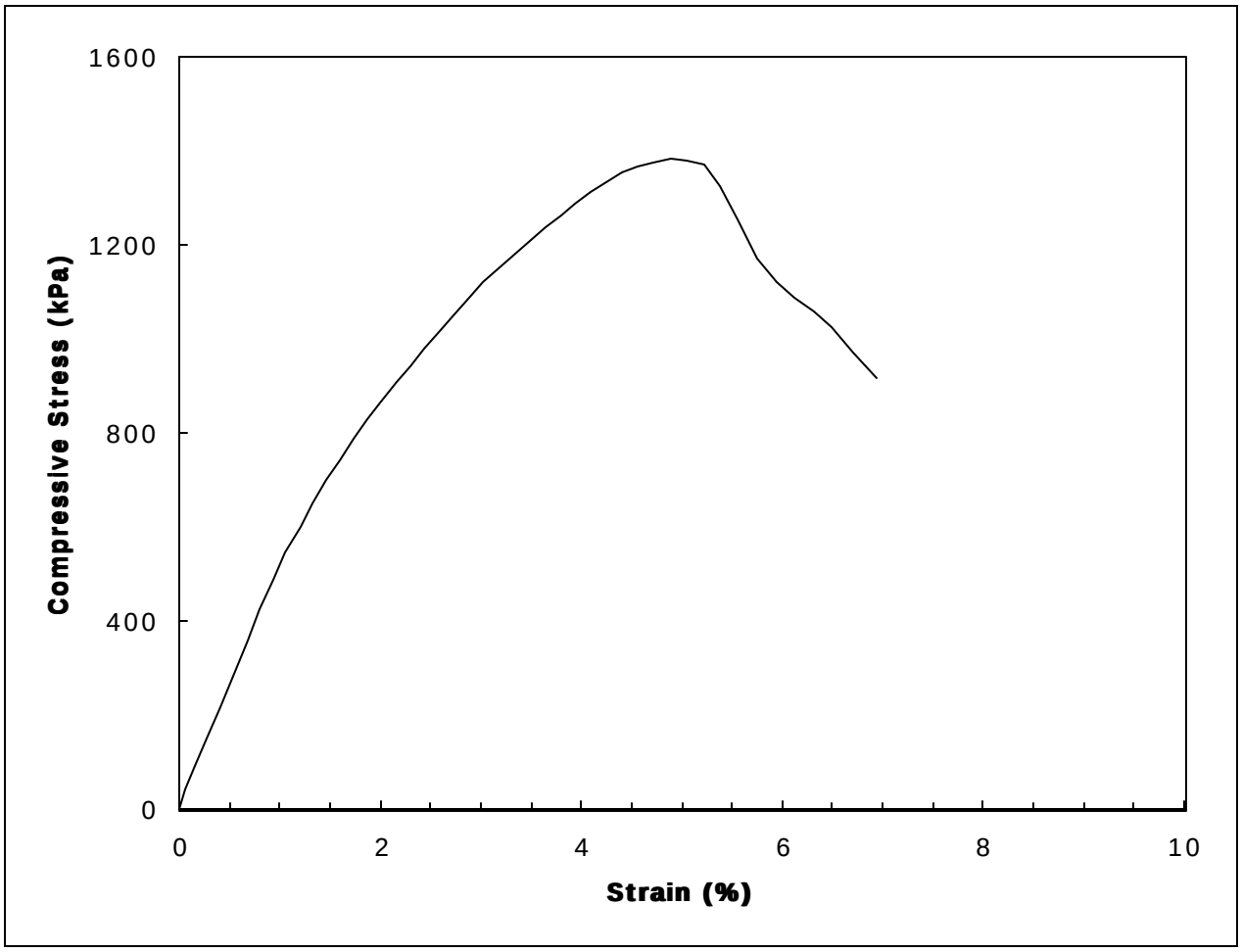
Test Hole No.: P-2
Depth (ft): 20.5-21.2
Test Number: QU-1

Initial Sample Conditions

Moisture Content (%):	8.3
Wet Density (Mg/m3):	2.353
Dry Density (Mg/m3):	2.171

Rate of Strain (%/min): 0.5

Peak Stress (kPa): 1385



SAMPLE INFORMATION

Project: Proposed Deh Cho Bridge
Address: _____
_____
Project Number: 1700063
Date Tested: 03.06.04 By: S.K.
Test Apparatus: Tx (Qu)
Machine Number: 1
Rate of Strain: 0.5 ~~mm~~% / minute
Normal Stress: _____ kPa
Cell Pressure: _____ kPa
Back Pressure: _____ kPa
Head Differential: _____ kPa
Swelling Pressure: _____ kPa

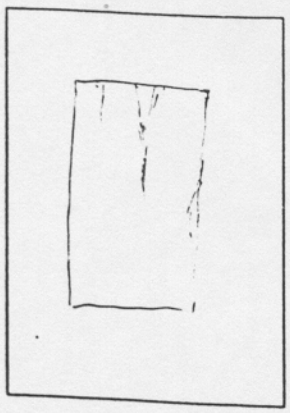
Borehole Number: P-2
Depth: 20'6" - 21'2"
Test Number: QU-1
Sample Description: CLAY (till), silty, some sand, trc. gravel (25 mm), coal specks, dark grayish brown.

Sample Description	Diameter (mm)	Height (mm)
1	71.0	143.7
2	71.8	144.6
3	72.5	143.8
4		
Mean	71.8	144.0

$V = 583.0\ cm^3$

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1371.7	1335.9
Mass of Dry Soil & Tare g			1233.8
Mass of Tare g			10.6
Mass of Dry Soil g			1223.2
Mass of Moisture g			
Moisture Content %			8.3
Wet Density Mg/m^3		2.353	
Dry Density Mg/m^3		2.171	

Sketch and Remarks:



Angle of Shear: 90°

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Unconfined Compression Test

Project No.: 1700063
Date Tested: 03-06-04

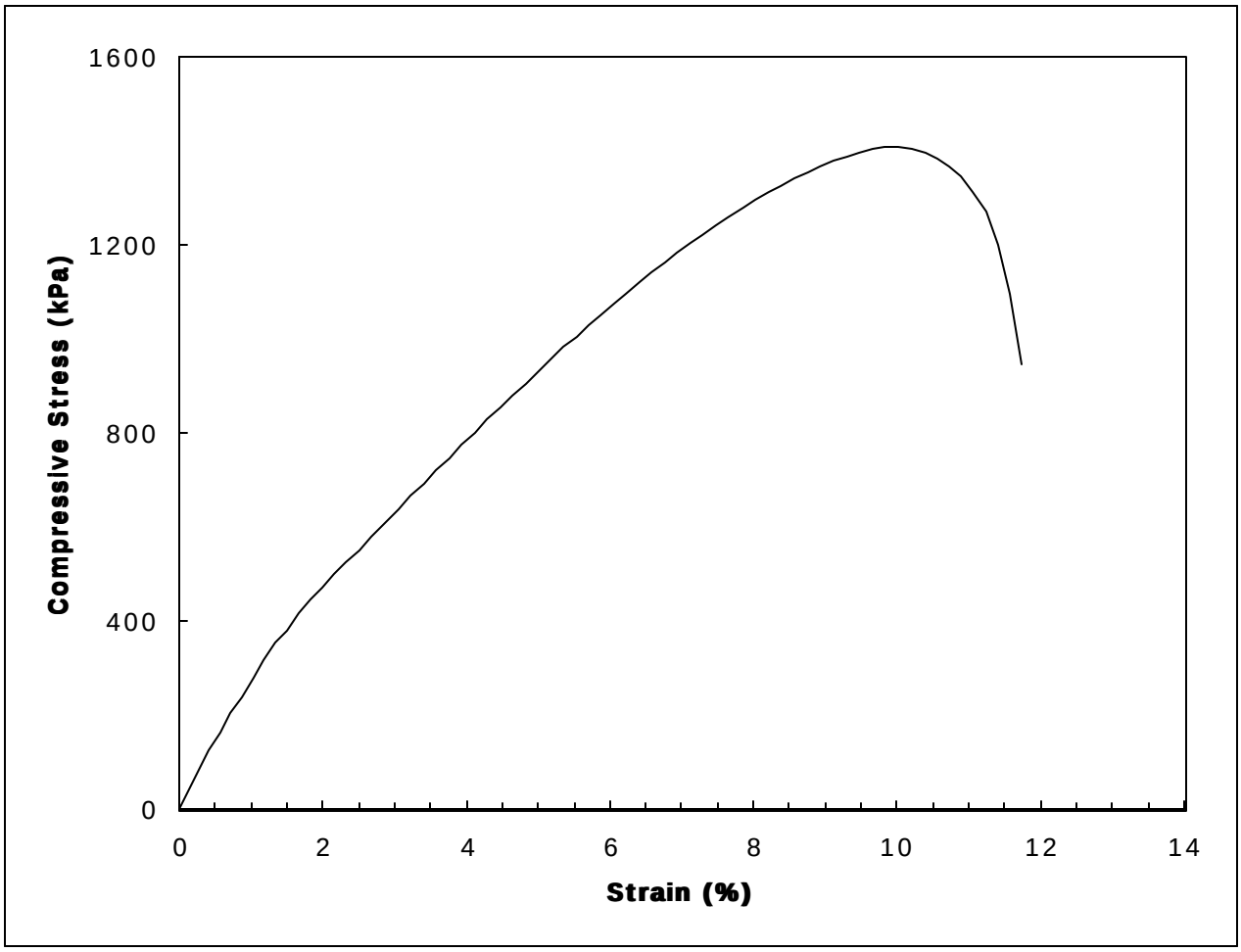
Test Hole No.: P-4
Depth (ft): 20-20.5
Test Number: QU-2

Initial Sample Conditions

Moisture Content (%):	8.4
Wet Density (Mg/m3):	2.353
Dry Density (Mg/m3):	2.170

Rate of Strain (%/min): 0.5

Peak Stress (kPa): 1409



SAMPLE INFORMATION

Project: Proposed Deh Cho Bridge
Address:
Project Number: 1700063
Date Tested: 03.06.04 By: S.K.
Test Apparatus: Tx (Qu)
Machine Number: 1
Rate of Strain: 0.5 %/minute
Normal Stress: kPa
Cell Pressure: kPa
Back Pressure: kPa
Head Differential: kPa
Swelling Pressure: kPa

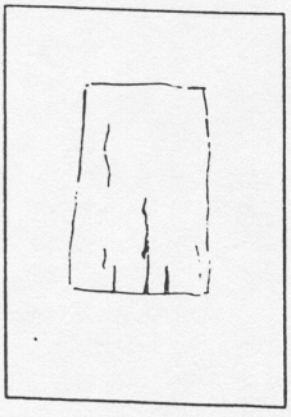
Borehole Number: P-4
Depth: 20' - 20.5'
Test Number: QU-2
Sample Description: CLAY (till), silty, some sand, trc. gravel (20 mm), dark grayish brown

Sample Description	Diameter (mm)	Height (mm)
1	72.7	136.3
2	71.8	136.2
3	72.6	136.8
4		
Mean	72.4	136.4

$V = 561.5\ cm^3$

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1321.5	1323.7
Mass of Dry Soil & Tare g			1221.6
Mass of Tare g			10.6
Mass of Dry Soil g			1211.0
Mass of Moisture g			
Moisture Content %			8.4
Wet Density Mg/m^3		2.353	
Dry Density Mg/m^3		2.170	

Sketch and Remarks:



Angle of Shear: 90°

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Unconfined Compression Test

Project No.: 1700063
Date Tested: 03-06-11

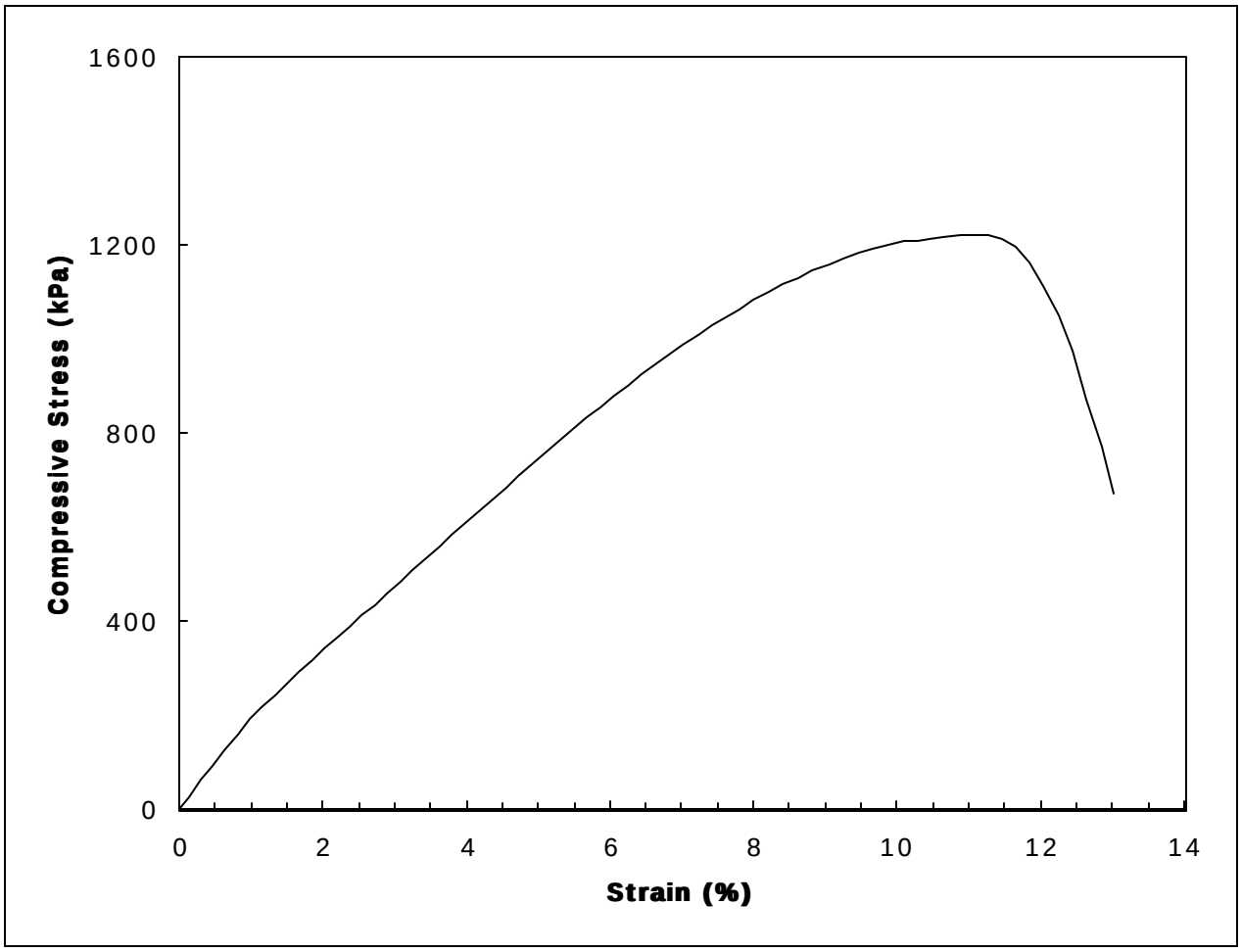
Test Hole No.: P-4
Depth (ft): 29.5-30.1
Test Number: QU-3

Initial Sample Conditions

Moisture Content (%):	9.1
Wet Density (Mg/m3):	2.356
Dry Density (Mg/m3):	2.159

Rate of Strain (%/min): 0.5

Peak Stress (kPa): 1223



SAMPLE INFORMATION

Project: Proposed Deh Cho Bridge

Address: _____

_____

Project Number: 1700063

Date Tested: 03·06·11 By: S.K.

Test Apparatus: Tx(Qu)

Machine Number: 1

Rate of Strain: 0.5 ~~mm~~% / minute

Normal Stress: _____ kPa

Cell Pressure: _____ kPa

Back Pressure: _____ kPa

Head Differential: _____ kPa

Swelling Pressure: _____ kPa

Borehole Number: P-4

Depth: 29.5' - 30'1"

Test Number: QU-3

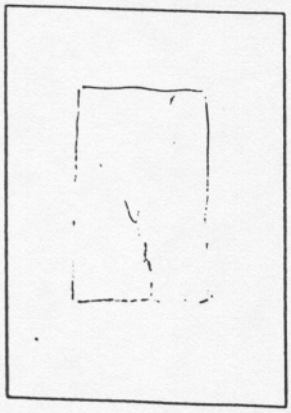
Sample Description: CLAY (till), silty, some sand, coal specks, trc. gravel (20 mm), dk. grayish brown.

Sample Description	Diameter (mm)	Height (mm)
1	72.0	135.8
2	72.1	135.5
3	72.3	135.6
4		
Mean	72.1	135.6

$V = 554.2\ cm^3$

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1305.9	1292.5
Mass of Dry Soil & Tare g			1185.1
Mass of Tare g			10.7
Mass of Dry Soil g			1174.4
Mass of Moisture g			
Moisture Content %			9.1
Wet Density Mg/m^3		2.356	
Dry Density Mg/m^3		2.159	

Sketch and Remarks:



Angle of Shear: 90°

EBA Engineering Consultants Ltd.

Unconfined Compression Test

Project No.: 1700063
Date Tested: 03-06-11

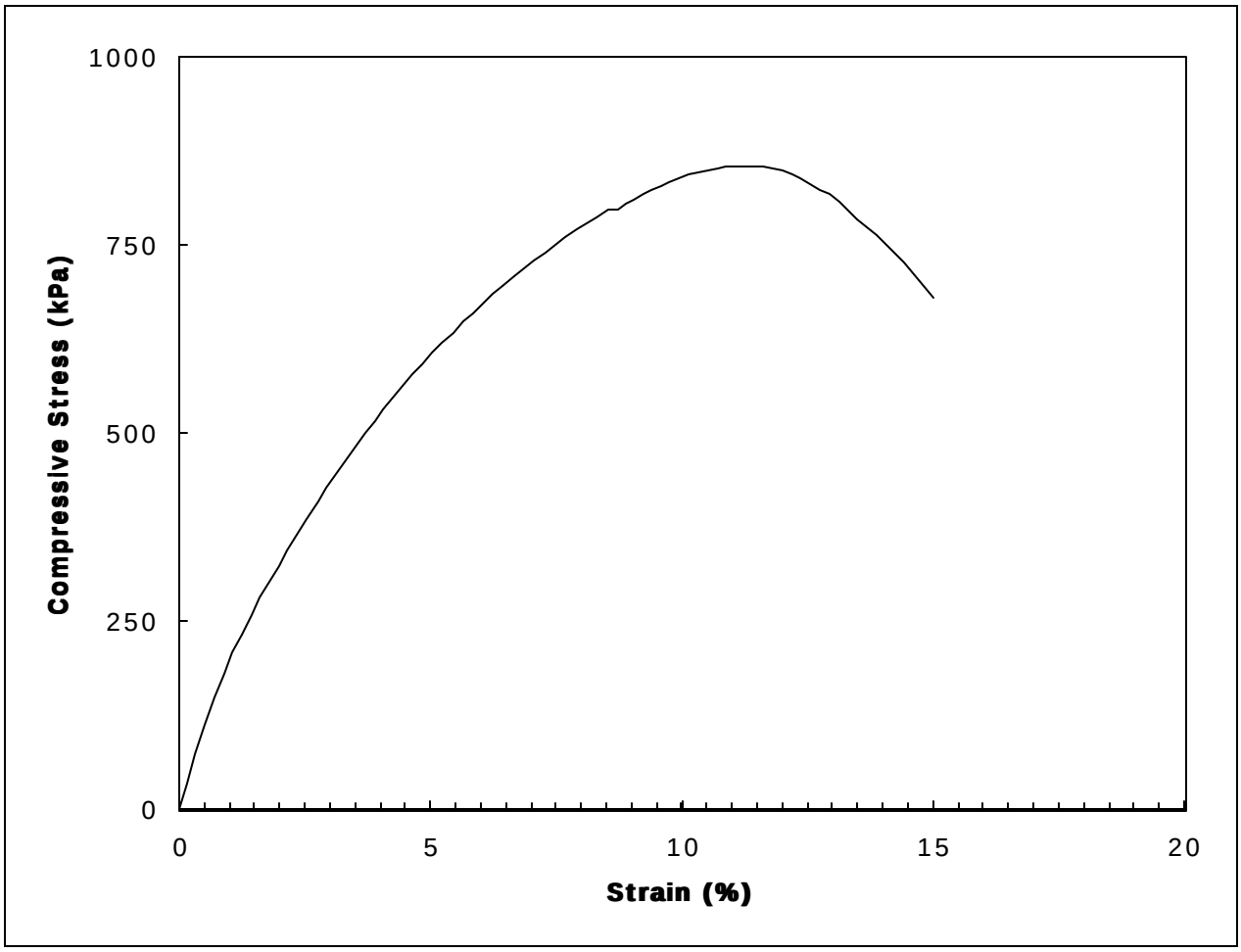
Test Hole No.: P-5
Depth (ft): 40-40.8
Test Number: QU-4

Initial Sample Conditions

Moisture Content (%):	10.4
Wet Density (Mg/m3):	2.361
Dry Density (Mg/m3):	2.139

Rate of Strain (%/min): 0.5

Peak Stress (kPa): 855



SAMPLE INFORMATION

Project: Proposed Deh Cho Bridge
Address: _____
_____
Project Number: 1700063
Date Tested: 03.06.11 By: S.K.
Test Apparatus: Tx (Qu)
Machine Number: 1.
Rate of Strain: 0.5 ~~%~~ % / minute
Normal Stress: _____ kPa
Cell Pressure: _____ kPa
Back Pressure: _____ kPa
Head Differential: _____ kPa
Swelling Pressure: _____ kPa

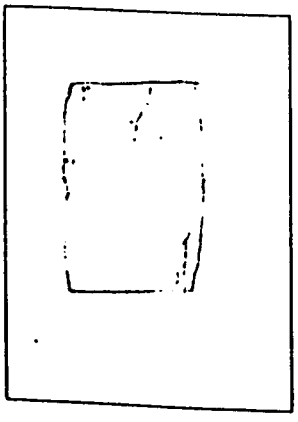
Borehole Number: P-5
Depth: 40'-40'10"
Test Number: QU-4
Sample Description: CLAY (Till), silty, some sand, trc. gravel (20 mm), dark grayish brown

Sample Description	Diameter (mm)	Height (mm)
1	71.9	137.1
2	72.8	137.3
3	71.7	137.5
4		
Mean	72.1	137.3

$V = 561.0\ cm^3$

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1324.7	1334.9
Mass of Dry Soil & Tare g			1210.5
Mass of Tare g			10.5
Mass of Dry Soil g			1200.0
Mass of Moisture g			
Moisture Content %			10.4
Wet Density Mg/m^3		2.361	
Dry Density Mg/m^3		2.139	

Sketch and Remarks:



Angle of Shear: 90°

EBA Engineering Consultants Ltd.

Unconfined Compression Test

Project No.: 1700063
Date Tested: 03-11-19

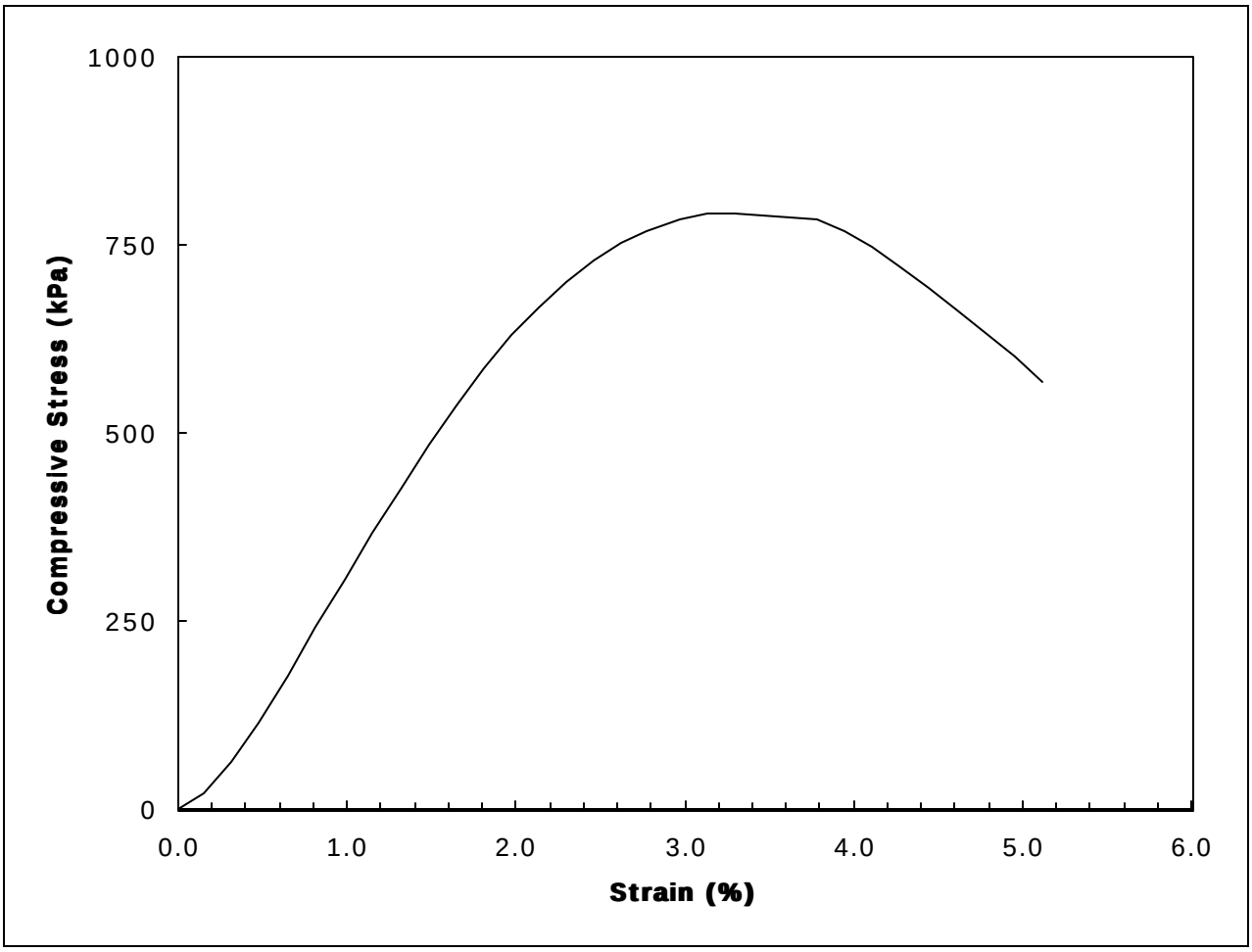
Test Hole No.: P-8
Depth: 22.5 ft.
Test Number: QU-2

Initial Sample Conditions

Moisture Content (%):	9.3
Wet Density (Mg/m3):	2.279
Dry Density (Mg/m3):	2.085

Rate of Strain (%/min): 0.5

Peak Stress (kPa): 792



SAMPLE INFORMATION

Project: DEH CHO BRIDGE
Address:
Project Number: 1700063
Date Tested: NOV 19 '03 By: MM
Test Apparatus: TX (QU)
Machine Number: 1
Rate of Strain: 0.5 % / minute
Normal Stress: kPa
Cell Pressure: kPa
Back Pressure: kPa
Head Differential: kPa
Swelling Pressure: kPa

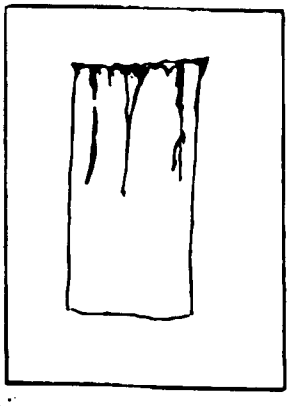
Borehole Number: 2 (SU)
Depth: 22.5'
Test Number: QU-2
Sample Description: CLAY, SILTY, TR SAND - DARK GREY - BROWN

Sample Description	Diameter (mm)	Height (mm)
1	73.4	143.2
2	73.5	143.4
3	73.1	143.0
4		
Mean	73.3	143.2

$V = 604.28\ cm^3$

	Trimmings	Initial	Final
Tare Number			
Mass of Wet Soil & Tare g		1377.3	655.2
Mass of Dry Soil & Tare g			600.3
Mass of Tare g			10.6
Mass of Dry Soil g			589.7
Mass of Moisture g			54.9
Moisture Content %			9.3
Wet Density Mg/m^3		2.279	
Dry Density Mg/m^3		2.085	

Sketch and Remarks:



P.P = 4.5+

Angle of Shear: 90°

eba

EBA Engineering Consultants Ltd.

BULK DENSITIES

Project: Proposed Deh Cho Bridge Project Number: 1700063

Address: _____ Date Tested: 03·06·11 By: S.K.

Borehole Number	A-1		P-7		P-3	
Depth	20.5'-21.5'		40'-40'7"		25'-25.3'	
Test Number						
Initial Wet Sample Wt.	1321.9		930.8			
	Sample Description		Sample Description		Sample Description	
	Diameter	Height	Diameter	Height	Diameter	Height
	72.1	136.7	72.2	97.3		
	72.2	136.5	72.3	97.4		
	72.5	136.0	72.1	97.0		
Average	72.3	136.5	72.2	97.2		

Tare Number	V = 560.4 cm³	V = 396.1 cm³	
Mass of Wet Soil & Tare	1330.7	937.1	322.9
Mass of Dry Soil & Tare	1213.3	847.6	307.1
Mass of Tare	10.5	10.6	6.5
Mass of Dry Soil	1202.8	837.0	300.6
Mass of Moisture	117.4	89.5	15.8
Moisture Content	9.8	10.7	5.3
Wet Density	2.359	2.338	
Dry Density	2.149	2.112	

Soil Description			
	CLAY (till), silty, sandy, trc. grav. (30 mm), dk. grayish brown	CLAY (till), silty, sandy, trc. grav. (15 mm), dark grayish brown	CLAY (till), silty, sandy, trc. gravel (20 mm), dk. grayish brown
			Note: Sample too irregular for density and is somewhat dessicated.

EBA Engineering Consultants Ltd.

BULK DENSITIES

Project: Proposed Deh Cho Bridge Project Number: 1700063

Address: _____ Date Tested: 03.05.27 By: S.K.

Borehole Number	P-5					
Depth	29.5 – 30'					
Test Number						
Initial Wet Sample Wt.	658.7					
	Sample Description		Sample Description		Sample Description	
	Diameter	Height	Diameter	Height	Diameter	Height
	72.44	68.60				
	71.68	68.66				
	72.00	68.48				
Average	72.04	68.59				

Tare Number	V = 279.5 cm³		
Mass of Wet Soil & Tare	663.2		
Mass of Dry Soil & Tare	605.6		
Mass of Tare	6.7		
Mass of Dry Soil	598.9		
Mass of Moisture	57.6		
Moisture Content	9.6		
Wet Density	2.357		
Dry Density	2.150		

Soil Description	CLAY (till),		
	silty, sandy,		
	tr. gravel,		
	dk. grayish brown		
	Note: Sample too		
	short for CU		
	triaxial.		

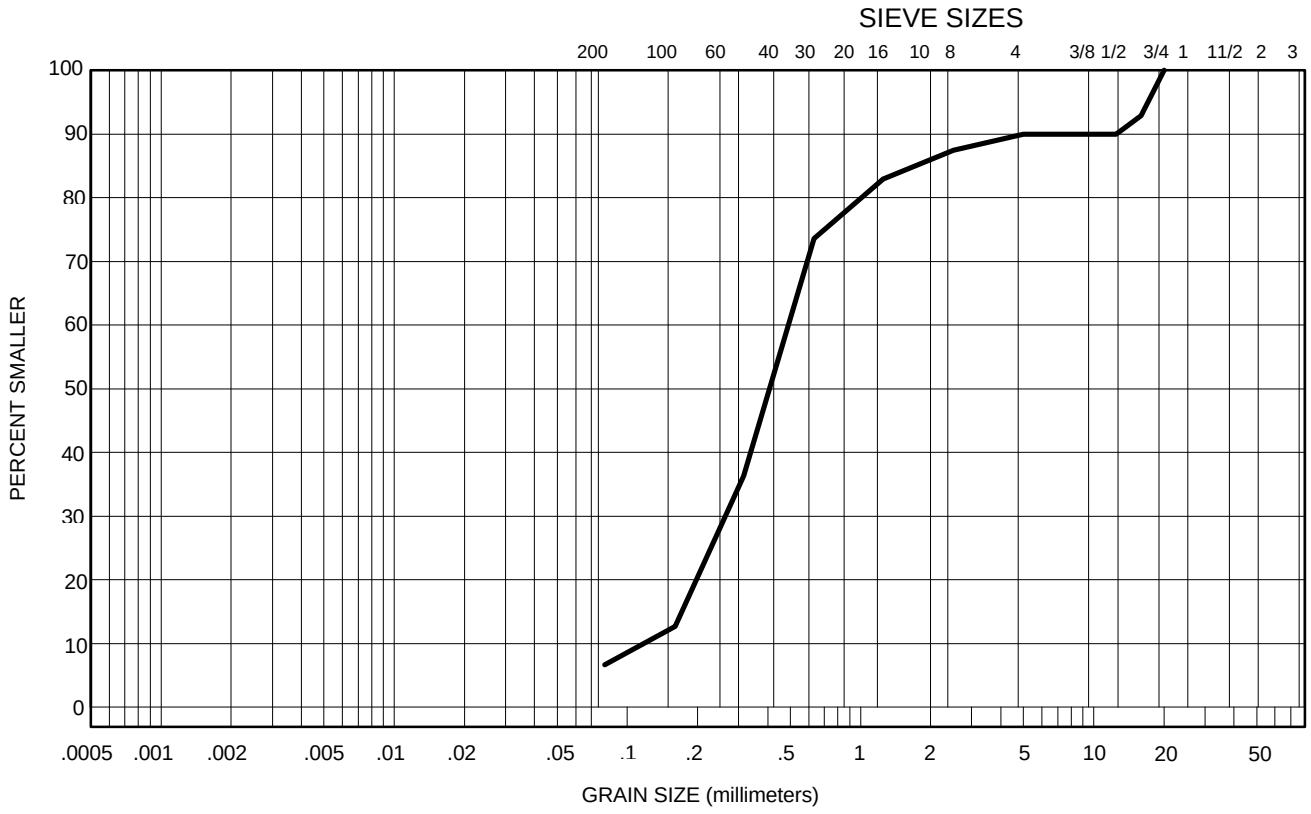
EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge
Project Number: 1700063
Client: Jivko Engineering
Attention: Mr.Jivko Jivkov, P.Eng.
Date Tested: May 27, 2003
Borehole Number: A-1
Depth: 12.0-12.5 m
Sample Number: n/a
Lab Number: 3168-5
Soil Description: SAND, some gravel, trace silt.
Natural Moisture Content: 14.7%
Remarks:

SIEVE	PERCENTAGE PASSING
40	
25	
20	100
16	93
12.5	90
10	90
5	90
2.5	87
1.25	83
0.63	74
0.315	36
0.16	13
0.08	6.7

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge

Project Number: 1700063

Client: Jivko Engineering

Attention: Mr.Jivko Jivkov, P.Eng.

Date Tested: May 27, 2003

Borehole Number: P-1

Depth: 11.6-12.0 m

Sample Number: n/a

Lab Number: 3168-41

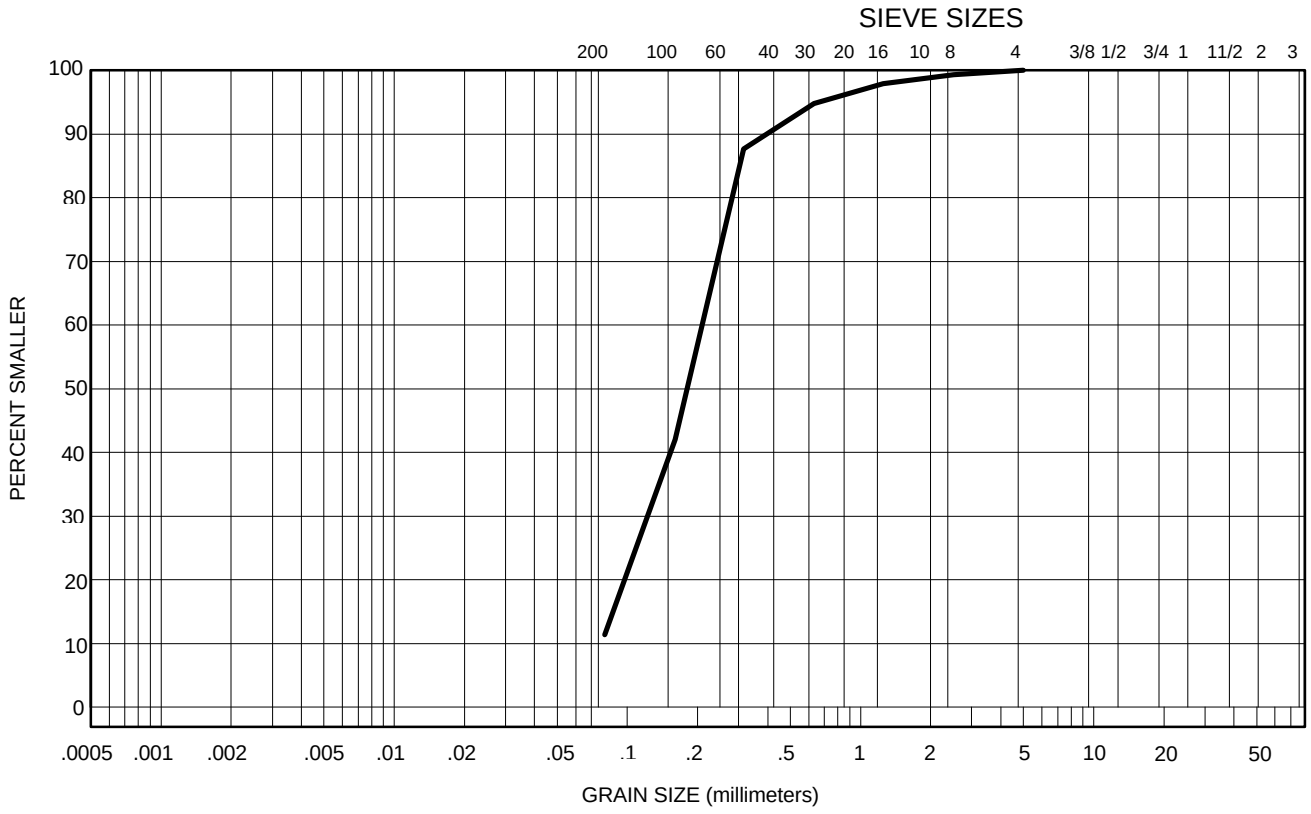
Soil Description: SAND, some silt.

Natural Moisture Content: 18.9%

Remarks:

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	
12.5	
10	
5	100
2.5	99
1.25	98
0.63	95
0.315	88
0.16	42
0.08	11.4

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge

Project Number: 1700063

Client: Jivko Engineering

Attention: Mr.Jivko Jivkov, P.Eng.

Date Tested: May 26-28, 2003

Borehole Number: P-2

Depth: 6.25-6.7 m

Sample Number: n/a

Lab Number: 3168-33

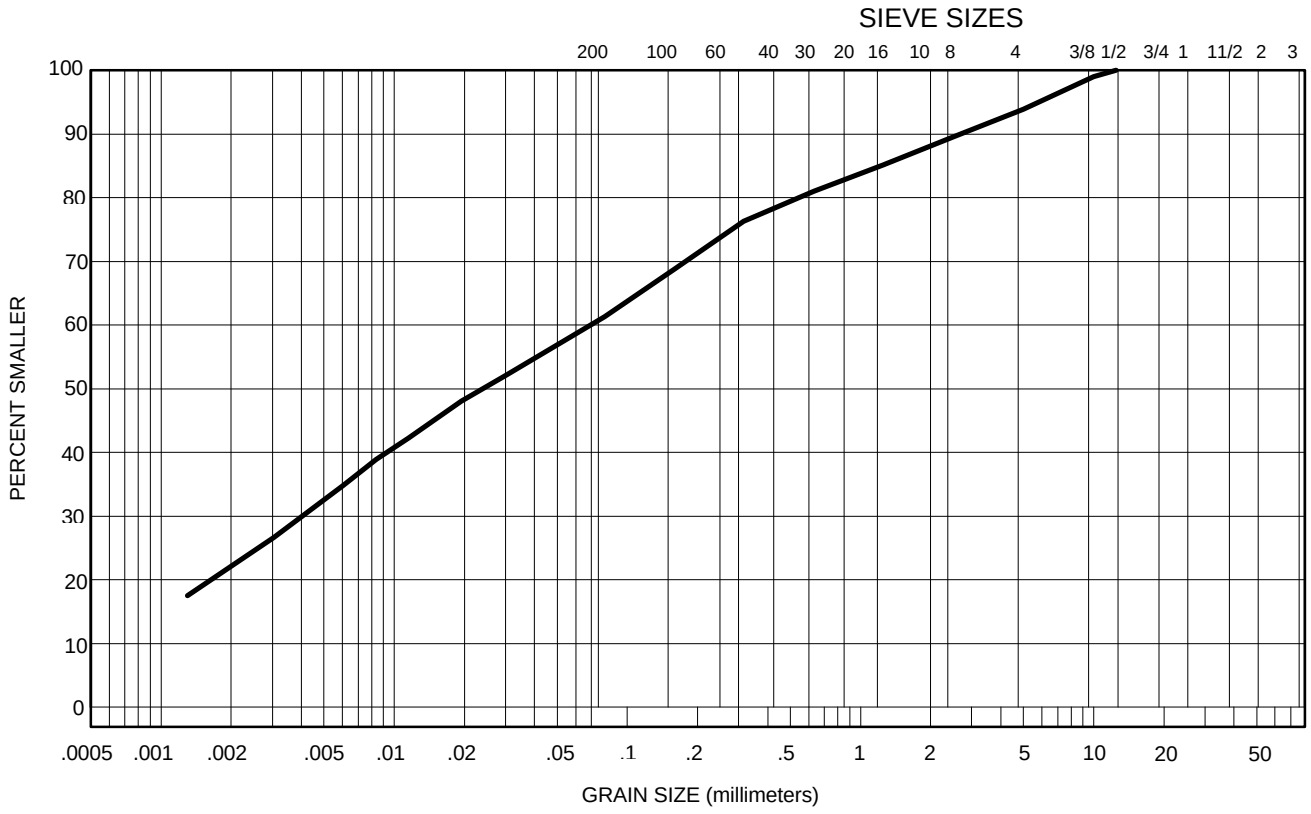
Soil Description: Sandy, clayey SILT, trace gravel

Natural Moisture Content: 8.7%

Remarks:

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	
12.5	100
10	99
5	94
2.5	90
1.25	85
0.63	81
0.315	76
0.16	69
0.08	61

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge

Project Number: 1700063

Client: Jivko Engineering

Attention: Mr.Jivko Jivkov, P.Eng.

Date Tested: May 26-28, 2003

Borehole Number: P-3

Depth: 12.25-12.7 m

Sample Number: n/a

Lab Number: 3168-30

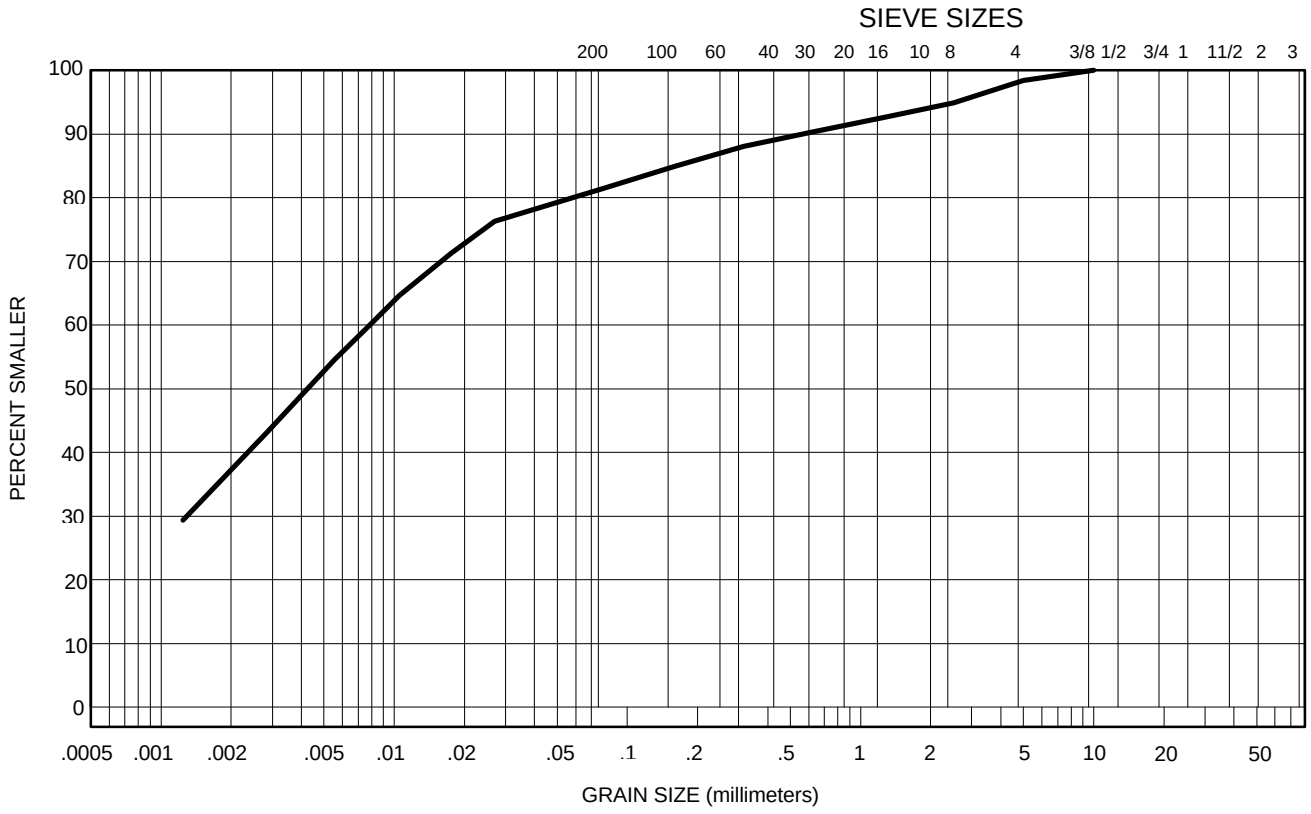
Soil Description: SILT and CLAY, some sand, trace gravel.

Natural Moisture Content: 13.1%

Remarks:

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	
12.5	
10	100
5	98
2.5	95
1.25	93
0.63	90
0.315	88
0.16	85
0.08	82

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge

Project Number: 1700063

Client: Jivko Engineering.

Attention: Mr. Jivko Jivkov, P.Eng.

Date Tested: May 26-28, 2003

Borehole Number: P-4

Depth: 10.5 - 11.0 m

Sample Number: n/a

Lab Number: 3168-23

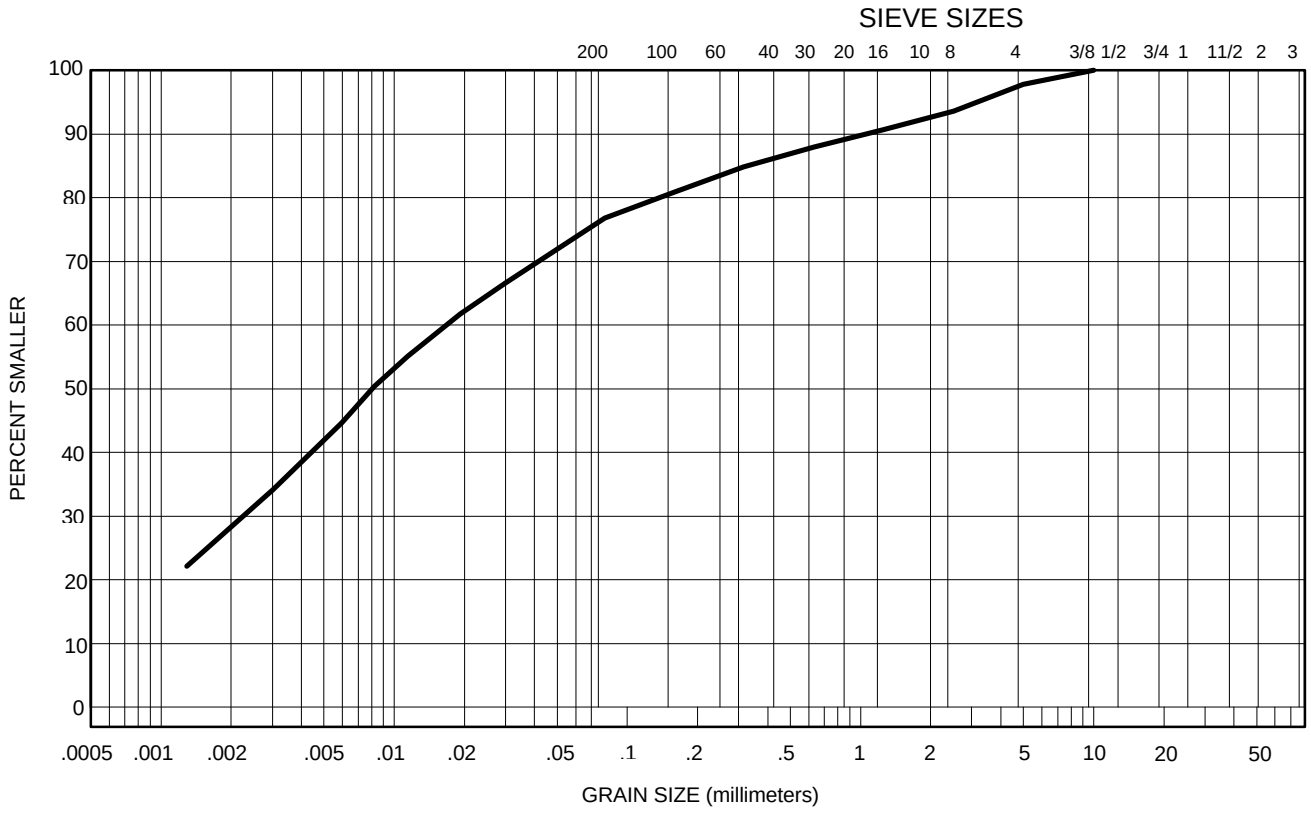
Soil Description: Clayey, sandy SILT, trace gravel.

Natural Moisture Content: 11.7%

Remarks: LL=29%, PL=14%, PI=15%

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	
12.5	
10	100
5	98
2.5	94
1.25	91
0.63	88
0.315	85
0.16	81
0.08	77

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge

Project Number: 1700063

Client: Jivko Engineering.

Attention: Mr. Jivko Jivkov, P.Eng.

Date Tested: May 26-28, 2003

Borehole Number: P-5

Depth: 7.2-7.6 m

Sample Number: n/a

Lab Number: 3168-12

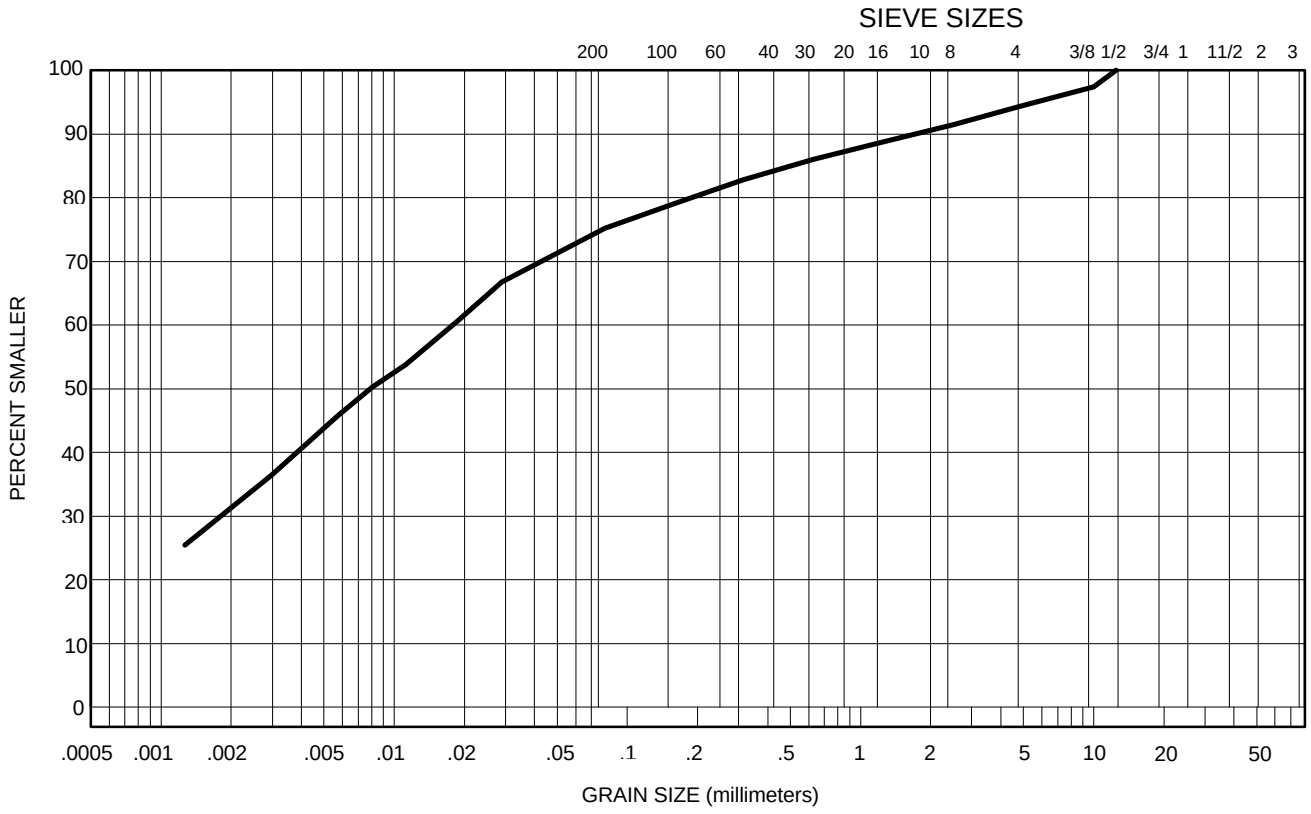
Soil Description: Clayey SILT, some sand, trace gravel

Natural Moisture Content: 12.5%

Remarks: LL=32%, PL=14%, PI=18%

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	
12.5	100
10	97
5	95
2.5	91
1.25	89
0.63	86
0.315	83
0.16	79
0.08	75

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

APPENDIX E
CONCRETE AGGREGATE LABORATORY TEST RESULTS

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

Project: Pavement Design for Mackenzie River Bridge
Address: Fort Providence
Project Number: 1700063.001
Date Tested: July 4, 2003
Client: Jivko Engineering

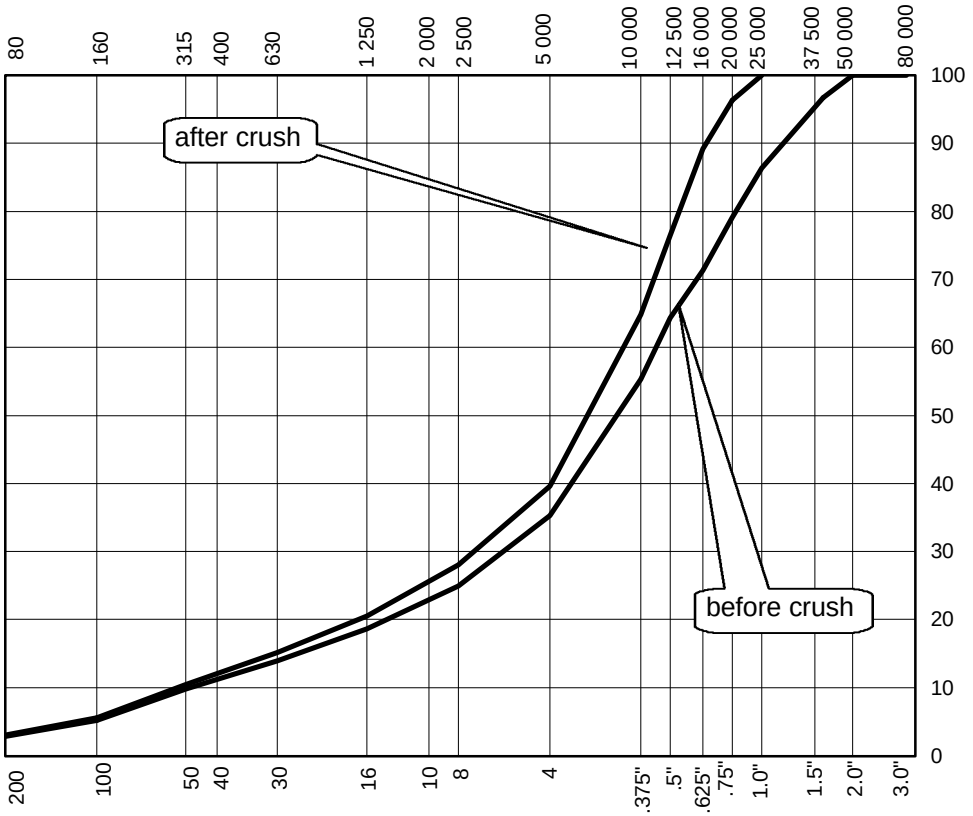
Attention: Jivko Jivkov, P.Eng.

Lab Number: 3243-1
Sample Description: Sandy GRAVEL, trace fines.

Sample Number: n/a
Natural Moisture Content: 1.7%
Depth, m n/a
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	
2"	50 000	100
1.5"	37 500	97
1"	25 000	86
.75"	20 000	79
.625"	16 000	71
.5"	12 500	64
.375"	10 000	55
No. 4	5 000	35
No. 8	2 500	25
16	1250	19
30	630	14
50	315	10
100	160	5
200	80	2.8

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Sample collected from Hwy 3, km 86, SW of Tower; for concrete aggregate.

Reviewed By: _____ P.Eng.

TABLE 1

SUMMARY OF PETROGRAPHIC ANALYSIS OF COARSE AGGREGATE

Jivko Engineering
Project # 1700063.001
20 mm Coarse Aggregate (Laboratory Crush)
Sample # 3243-1LC (km 86, Hwy No. 3)

ROCK TYPE	Size Fraction				Weighted Percent by Mass
	28 - 20 mm	20 - 14 mm	14 - 10 mm	10 - 5 mm	
GOOD multiplier: 1					
BASALT - hard		12.0	3.0	2.7	5.0
GRANITE/GNIESS - hard		28.4	29.7	24.1	26.9
QUARTZITE/SANDSTONE - hard		38.9	13.6	15.8	20.7
CHERT - hard		0.0	0.0	0.0	0.0
CARBONATE - hard		11.1	46.7	51.9	40.4
Subtotal, Good Rock Types:		**90.3**	**93.0**	**94.4**	**93.0**
FAIR multiplier: 3					
BASALT-fair		0.0	0.0	0.0	0.0
GRANITE/GNIESS - weathered		0.9	1.0	0.4	0.7
QUARTZITE/SANDSTONE - medium		0.7	0.7	2.1	1.3
CHERT - weathered		0.0	0.0	0.0	0.0
CARBONATES-weathered		0.0	0.8	1.2	0.8
SHALE - Hard		0.9	1.5	1.0	1.2
MICA SCHIST		3.9	0.0	0.8	1.3
Subtotal, Fair Rock Types:		**6.5**	**4.0**	**5.6**	**5.3**
POOR multiplier: 6					
SILTSTONE - soft		0.0	2.0	0.0	0.6
MICA SCHIST - weathered		3.2	1.0	0.0	1.1
Subtotal, Poor Rock Types:		**3.2**	**3.0**	**0.0**	**1.7**
DELETERIOUS multiplier: 10					
CHERT-porous		0.00	0.00	0.00	0.00
IRONSTONE - soft		0.00	0.00	0.00	0.00
Subtotal, Deleterious Rock Types:		**0.00**	**0.00**	**0.00**	**0.00**
		100.0%	100.0%	100.0%	100.0%
PERCENT OF FRACTION IN SAMPLE	4.0%	13.5%	17.5%	25.0%	60.0%
PETROGRAPHIC NUMBER	Not Tested	129	123	111	**120**
WEIGHTED CHERT CONTENT					**0.00%**
WEIGHTED IRONSTONE CONTENT					**0.00%**

NOTES:

1) The Petrographic Number is not intended to identify any potential for alkali-aggregat reactivity (AAR). The chemical stability of this aggregate in Portland cement concre must be assessed by other test methods.
2) 470 g sample analyzed for 20-14 mm size fraction, approximately 1000 g specified by LS 609.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

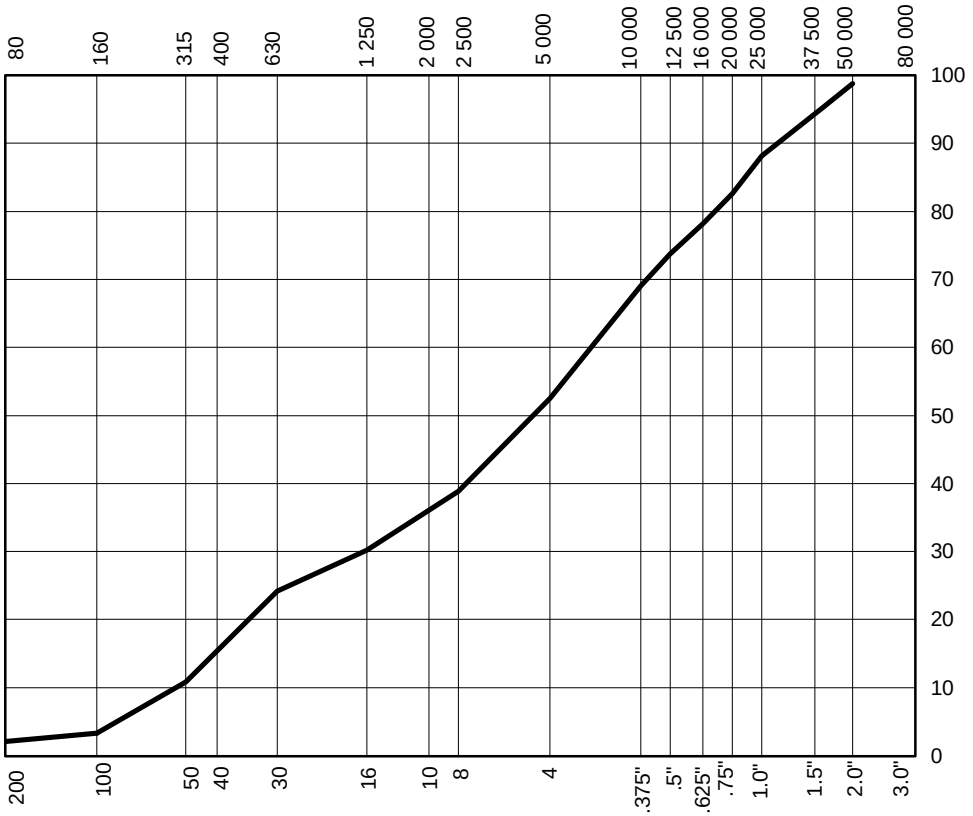
Project: Pavement Design for Mackenzie River Bridge
Address: Ft. Providence, NT
Project Number: 1780063.001
Date Tested: December 9, 2003
Client: Jivko Engineering

Attention: Mr. Jivko Jivkov, P.Eng.

Lab Number: 3537-86-2
Sample Description: SAND and gravel, trace silt.
Sample Location: Hwy. #3, km 86
Depth: 2.2 m
Natural Moisture Content: 2.2%
Colour Plate No.: n/d
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	100
2"	50 000	99
1.5"	37 500	95
1"	25 000	88
.75"	20 000	83
.625"	16 000	78
.5"	12 500	74
.375"	10 000	69
No. 4	5 000	53
No. 8	2 500	39
16	1250	30
30	630	24
50	315	11
100	160	3
200	80	2.0

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks:

Reviewed By: P.Eng.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

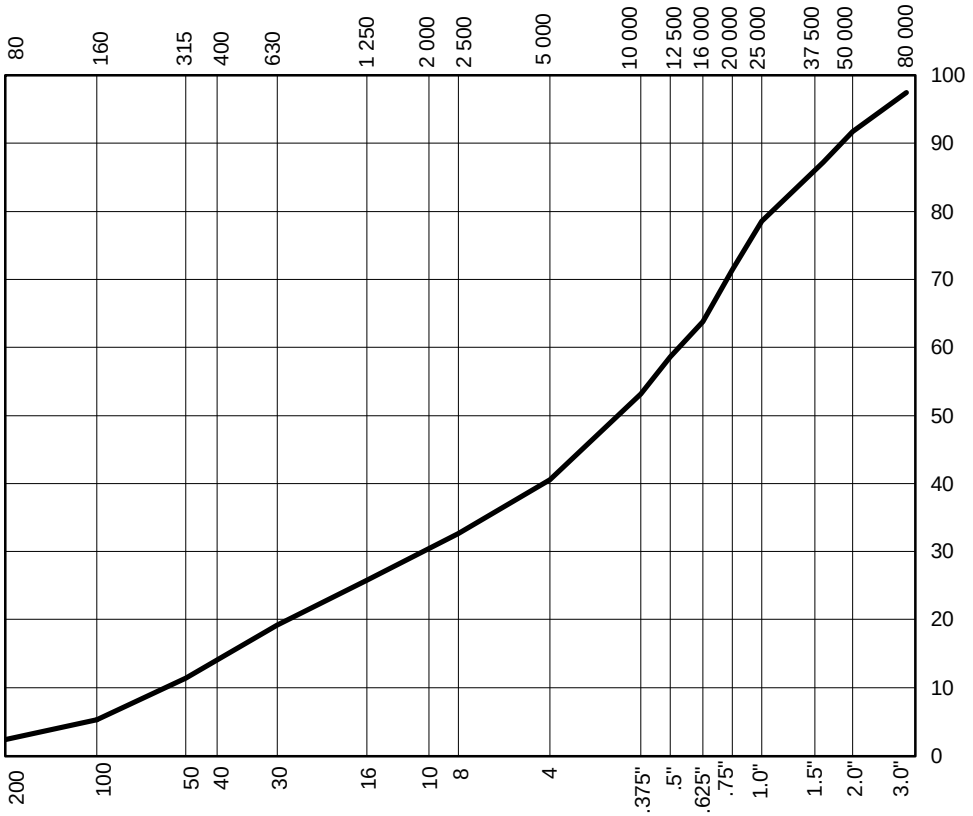
Project: Pavement Design for Mackenzie River Bridge
Address: Ft. Providence, NT
Project Number: 1780063.001
Date Tested: December 9, 2003
Client: Jivko Engineering

Attention: Mr. Jivko Jivkov, P.Eng.

Lab Number: 3537-86-3
Sample Description: GRAVEL and sand, trace sil.
Sample Location: Hwy. #3, km 86
Depth: 1.5 m
Natural Moisture Content: 5.0%
Colour Plate No.: n/d
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	97
2"	50 000	92
1.5"	37 500	87
1"	25 000	79
.75"	20 000	71
.625"	16 000	64
.5"	12 500	59
.375"	10 000	53
No. 4	5 000	41
No. 8	2 500	33
16	1250	26
30	630	19
50	315	11
100	160	5
200	80	2.3

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Presence of the fragile shale in the sample.

Reviewed By: _____ P.Eng.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

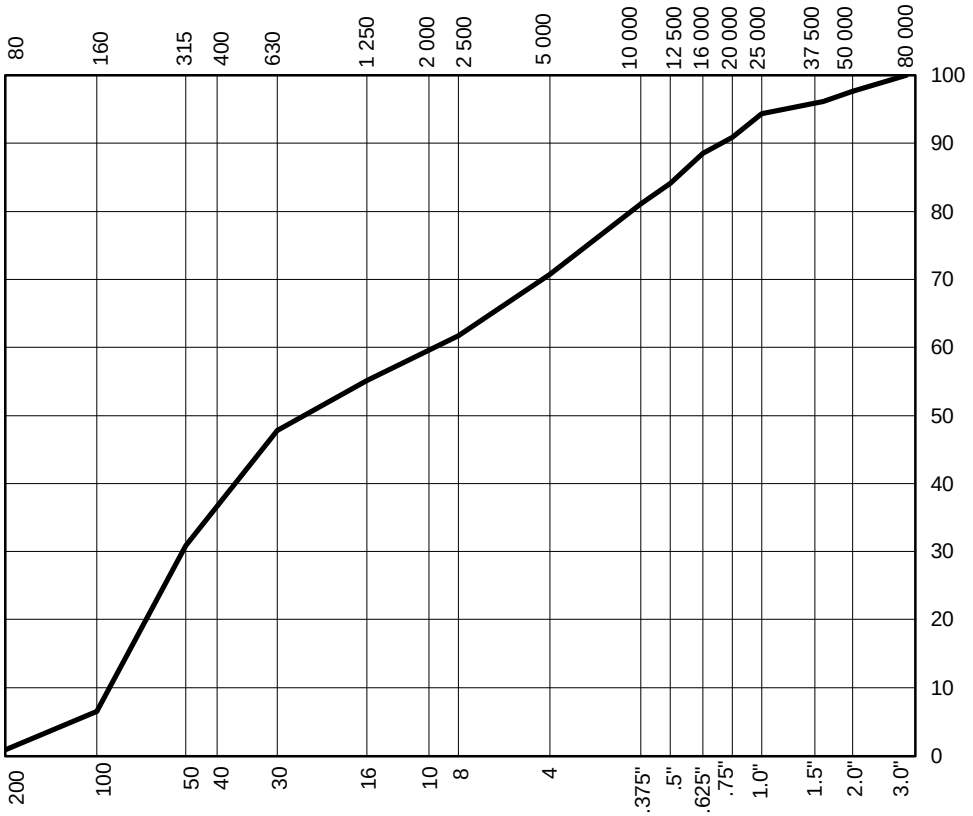
Project: Pavement Design for Mackenzie River Bridge
Address: Ft. Providence, NT
Project Number: 1780063.001
Date Tested: December 9, 2003
Client: Jivko Engineering

Attention: Mr. Jivko Jivkov, P.Eng.

Lab Number: 3537-86-4
Sample Description: Gravelly SAND, trace silt.
Sample Location: Hwy. #3, km 86
Depth: 1.5 m
Natural Moisture Content: 2.7%
Colour Plate No.: n/d
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	100
2"	50 000	98
1.5"	37 500	96
1"	25 000	94
.75"	20 000	91
.625"	16 000	89
.5"	12 500	84
.375"	10 000	81
No. 4	5 000	71
No. 8	2 500	62
16	1250	55
30	630	48
50	315	31
100	160	6
200	80	0.9

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks:

Reviewed By: P.Eng.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

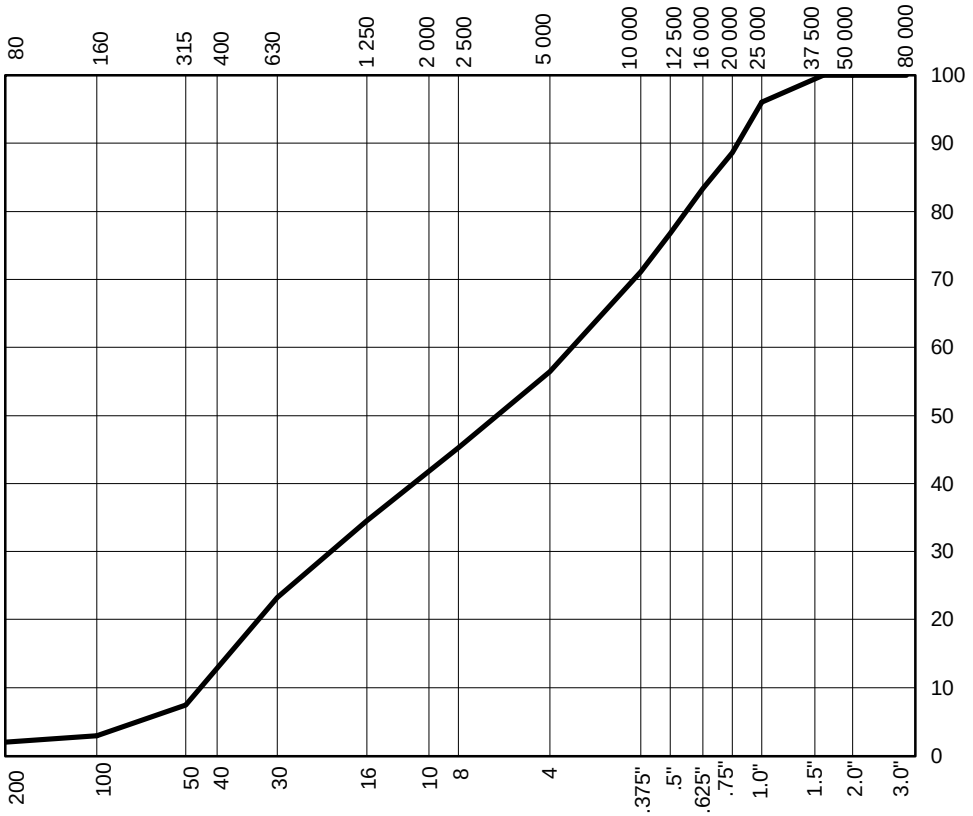
Project: Pavement Design for Mackenzie River Bridge
Address: Ft. Providence, NT
Project Number: 1780063.001
Date Tested: December 9, 2003
Client: Jivko Engineering

Attention: Mr. Jivko Jivkov, P.Eng.

Lab Number: 3537-86-5
Sample Description: SAND and gravel, trace sil.
Sample Location: Hwy. #3, km 86
Depth: 2.0 m
Natural Moisture Content: 5.2%
Colour Plate No.: n/d
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	
2"	50 000	
1.5"	37 500	100
1"	25 000	96
.75"	20 000	89
.625"	16 000	83
.5"	12 500	77
.375"	10 000	71
No. 4	5 000	56
No. 8	2 500	45
16	1250	35
30	630	23
50	315	7
100	160	3
200	80	2.0

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Presence of the fragile shale in the sample.

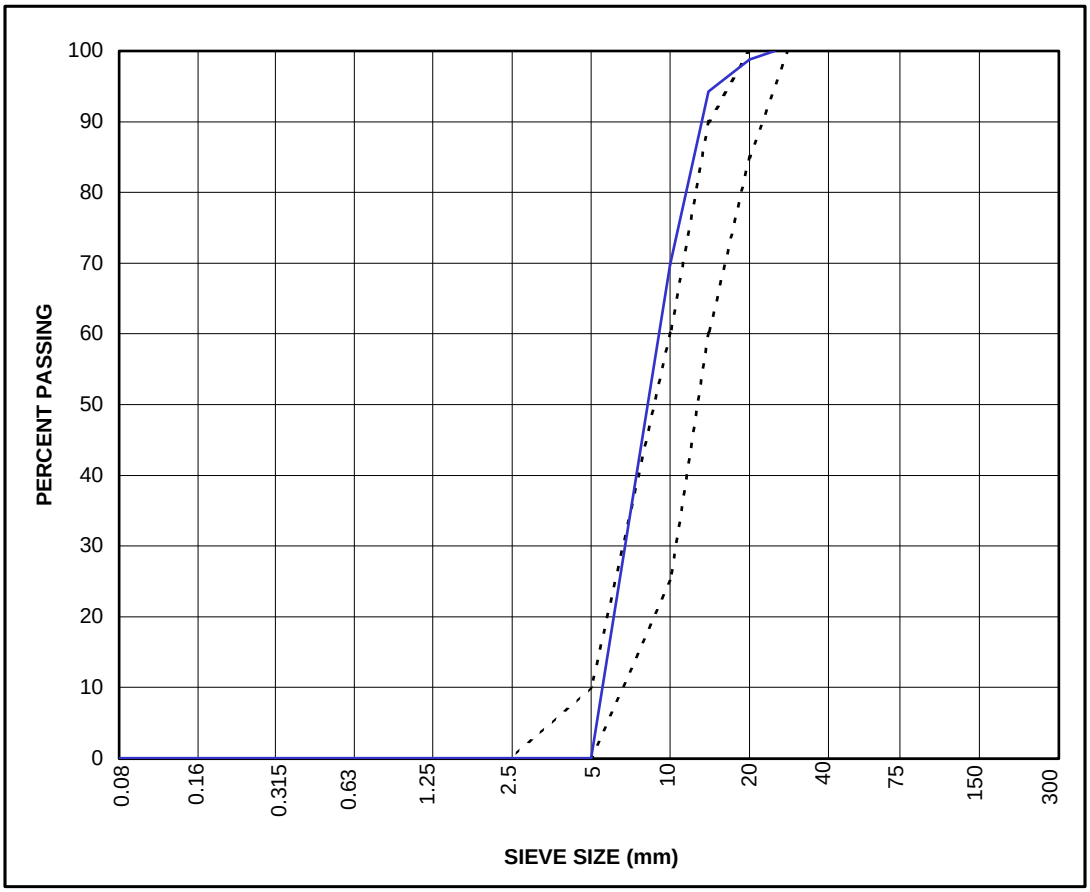
Reviewed By: _____ P.Eng.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

PROJECT:	Jivko Jivkov, P.Eng.	**SAMPLE NO:**	3537-86-C
ADDRESS:	Yellowknife, NT	**SAMPLE DESCRIPTION:**	
PROJECT NO:	1700063.001	20-5 mm Concrete Aggregate	
Date Tested:	Dec 22/03 **By:** RSG		
CLIENT:	Jivko Engineering	**NAT. MOISTURE CONT.:**	0.0%
	#504-999 Canada Place	**DRY ROD DENSITY:**	1605
	Yellowknife NT	**BULK REL DENSITY:**	2.61
ATTENTION:	Jivko Jivkov, P.Eng.	**BULK REL. DENSITY (SSD):**	2.64
		APPARENT REL. DENSITY:	2.69
		ABSORPTION:	1.1%

SIEVE SIZE	PERCENT PASSING
25	100
20	99
14	94
10	70
5	0
2.5	0
1.25	0
0.63	0
0.315	0
0.16	0
0.08	0.0



Remarks:

Grading Limits: CSA A23.1-00 20-5 mm coarse aggregate

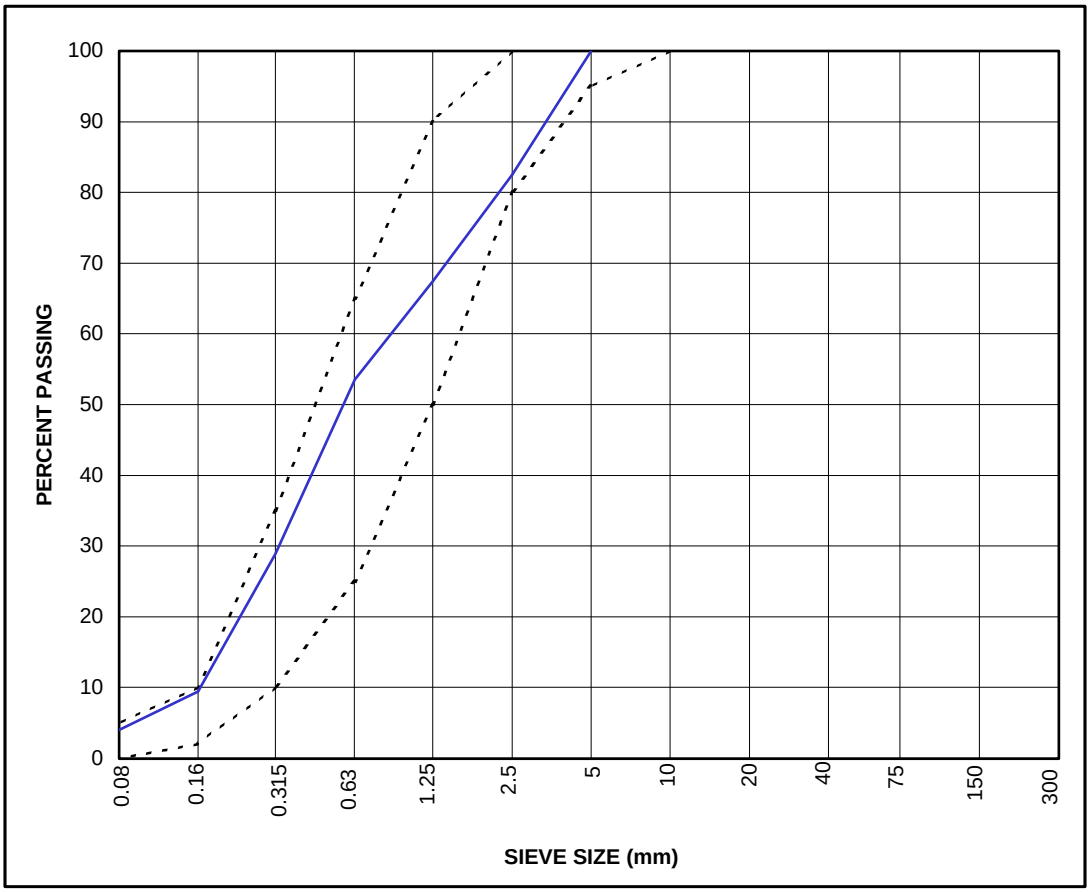
Reviewed by: _____ P.Eng.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

PROJECT:	Deh Cho Bridge	**SAMPLE NO:**	3537-86-F
ADDRESS:	Yellowknife, NT	**SAMPLE DESCRIPTION:**	
PROJECT NO:	1700063.001		Concrete Sand
Date Tested:	Dec 22/03 **By:** RSG		
CLIENT:	Jivko Engineering	**NAT. MOISTURE CONT.:**	2.1%
		COLOR PLATE	2
		BULK REL DENSITY:	2.62
ATTENTION:	Jivko Jivkov, P.Eng.	**BULK REL. DENSITY (SSD):**	2.65
		APPARENT REL. DENSITY:	2.71
		ABSORPTION:	1.3%

SIEVE SIZE	PERCENT PASSING
5	100
2.5	82
1.25	67
0.63	54
0.315	29
0.16	9
0.08	4.0
PAN	2.6
FM	2.58



Remarks:

Grading Limits: CSA FA1 fine aggregate

Reviewed by: _____ P.Eng.

EBA Engineering Consultants Ltd.

CONCRETE STRENGTH TEST RESULTS

CSA Specification CAN3 - A23.2

Project No: 1700063.001

Project: Deh Cho Bridge

Ft. Providence, NT

Client: Jivko Engineering

Yellowknife, NT

Attention: Mr. Jivko Jivkov, P. Eng.

Test Location: EBA Lab, Yellowknife, NT

Placing Method:

Test No: 3689

INFORMATION FROM DELIVERY SLIP

Supplier: Laboratory Trial

Truck No: Plant Dep:

Ticket No: Mix No.

Load Amount: 0.015 m3 Cumulative: m3

Admixture: Air X CaCl2 Other Polyheed 997

Specified Strength: 30 MPa Spec Air: 8 %

Cement Type: 10 Spec Slump: 100 mm

Max Aggregate Size: 20 mm

Test Time: 9:30 Unit Weight 2330 kg/m^3

Temperature: Air 17 °C Concrete 16 °C

Concrete Setting Limits: (15 - 25C) Temperature Yes ☐ No ☐ Within Specification If No see remarks

Slump: 80 mm Air Content: 8.0%

Date Cast: 04 01 07 By: MB

Date Received: 04 01 07 By: MB

Cylinder Number	Age Days	Test Date	Test By	Comp. Strength MPa	Type of Failure	Comments
3689-1	7	04 01 14	MB	27.4	C	
3689-2	7	04 01 14	MB	26.3	C	
3689-3	28	04 02 04	MB	42.8	C	
3689-4	28	04 02 04	MB	43.3	C	
3689-5	56	04 03 03				
3689-6	56	04 03 03				

Type of Failure

C Conical, D Diagonal, V Vertical, E End, O Other

Remarks: No Fly Ash

cc

Reviewed By: P.Eng.

file

EBA Engineering Consultants Ltd.

CONCRETE STRENGTH TEST RESULTS

CSA Specification CAN3 - A23.2

Project No: 1700063.001

Project: Deh Cho Bridge

Ft. Providence, NT

Client: Jivko Engineering

Yellowknife, NT

Attention: Mr. Jivko Jivkov, P. Eng.

Test Location: EBA Lab, Yellowknife, NT

Placing Method:

Test No: 3690

INFORMATION FROM DELIVERY SLIP

Supplier: Laboratory Trial

Truck No: Plant Dep:

Ticket No: Mix No.

Load Amount: 0.015 m3 Cumulative: m3

Admixture: Air X CaCl2 Other Polyheed 997

Specified Strength: 30 MPa Spec Air: 8 %

Cement Type: 10 Spec Slump: 100 mm

Max Aggregate Size: 20 mm

Test Time: 11:30 Unit Weight 2280 kg/m^3

Temperature: Air 17 °C Concrete 16 °C

Concrete Setting Limits: (15 - 25C) Temperature Yes [ ] No [ ] Within Specification If No see remarks

Slump: 80 mm Air Content: 7.0%

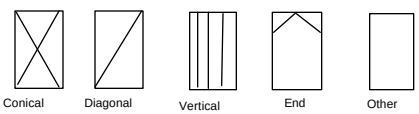
Date Cast: 04 01 07 By: MB

Date Received: 04 01 07 By: MB

Cylinder Number	Age Days	Test Date	Test By	Comp. Strength MPa	Type of Failure	Comments
3690-1	7	04 01 14	MB	27.4	C	
3690-2	8	04 01 15	MB	24.7	C	
3690-3	28	04 02 04	MB	31.3	C	
3690-4	28	04 02 04	MB	30.2	C	
3690-5	56	04 03 03				
3690-6	56	04 03 03				

Type of Failure

C Conical, D Diagonal, V Vertical, E End, O Other



Remarks: 35% Fly Ash

cc

Reviewed By: P.Eng.

file

APPENDIX F
PAVEMENT DESIGN LABORATORY TEST RESULTS

DEH CHO BRIDGE APPROACH PAVEMENT DESIGN
LABORATORY TEST RESULT SUMMARY

EBA Sample Number	Sample Source/Purpose (from Client)	Soil Type	Gravel (%)	Sand (%)	Silt (or Fines[1]) (%)	Clay (%)	LL	PL	Comp. Str. (MPa)	Fractured Face Count (%)	L.A. Abrasion (%)	Standard Proctor MDD (kg/m^3)	Standard Proctor Optimum (%)	California Bearing Ratio (lb. @ 0.1") Unsoaked	California Bearing Ratio (lb. @ 0.1") Soaked
3243-2	Hwy. #1, km 192; near the end of the access road by the Forestry tower; for submerged part of embankment	COBBLES - grey brown (limestone)							40-60						
		20 mm minus crush	80	18	2	n/d				99	27				
3243-3	Hwy. #3, km 44A, 500 - 700 m west of highway; gravel to base course and crush on north side	GRAVEL - some cobbles, some sand, well graded, brown	67	27	6	n/d									
		20 mm minus crush	60	34	6	n/d				93	25				
3243-4	Hwy. #3, km 44B: west of highway: sand for base course, for winter haul: might have to be ripped	SAND - trace silt, uniform, grey-brown	0	96	4	n/d									
3243-5	Hwy. #3, km 23: north bank on north side of the highway, for common fill on north	CLAY - silty, trace gravel, grey-brown	6	20	49	25	29	16				1970	11.5	11.7	2.2
3243-6	Hwy. #3, km 22; south of bridge, south of road to federal dock (near the gate), for common fill on south side	SAND - trace gravel, med. grained, brown	31	59	10	n/d						2130	8.5	19.0	23.9
3243-7	Hwy. #1, km 196; sample from bank on south side of pit; for base course & crush on south side; also for chips	GRAVEL - some cobble, some sand, well graded, brown	65	32	3	n/d									
		20 mm minus crush	60	37	3	n/d				64	20				

Note: 1 - n.d. denotes silt and clay contents not determined; fines refers to combined silt and clay content

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

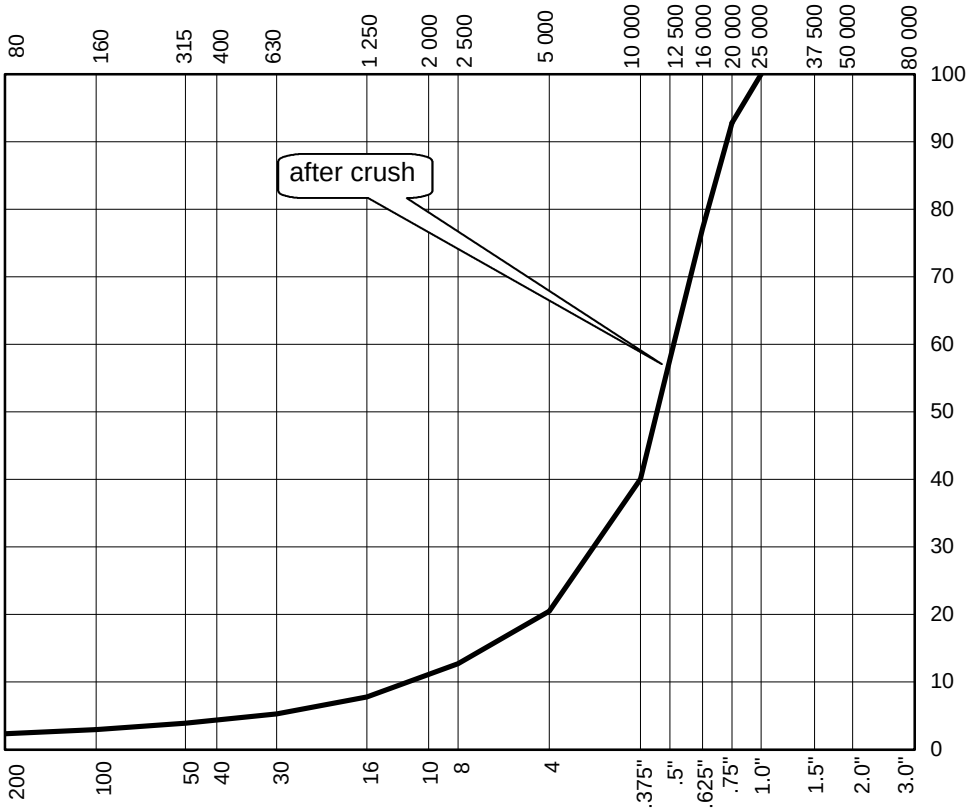
Project: Pavement Design for Mackenzie River Bridge
Address: Fort Providence
Project Number: 1700063.001
Date Tested: July 11, 2003
Client: Jivko Engineering

Attention: Jivko Jivkov, P.Eng.

Lab Number: 3243-2LC
Sample Description: -20 mm (Lab. Crush) Limestone
Fractured Face Count: 99%
L. A. Abrasion Loss: 27%
Sample Number: n/a
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	
2"	50 000	
1.5"	37 500	
1"	25 000	100
.75"	20 000	93
.625"	16 000	77
.5"	12 500	58
.375"	10 000	40
No. 4	5 000	20
No. 8	2 500	13
16	1250	8
30	630	5
50	315	4
100	160	3
200	80	2.3

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Unconfined compressive strength = 40 Mpa to 60 MPa

Reviewed By: _____ P.Eng.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

Project: Pavement Design for Mackenzie River Bridge
Address: Fort Providence
Project Number: 1700063.001
Date Tested: July 7, 2003
Client: Jivko Engineering

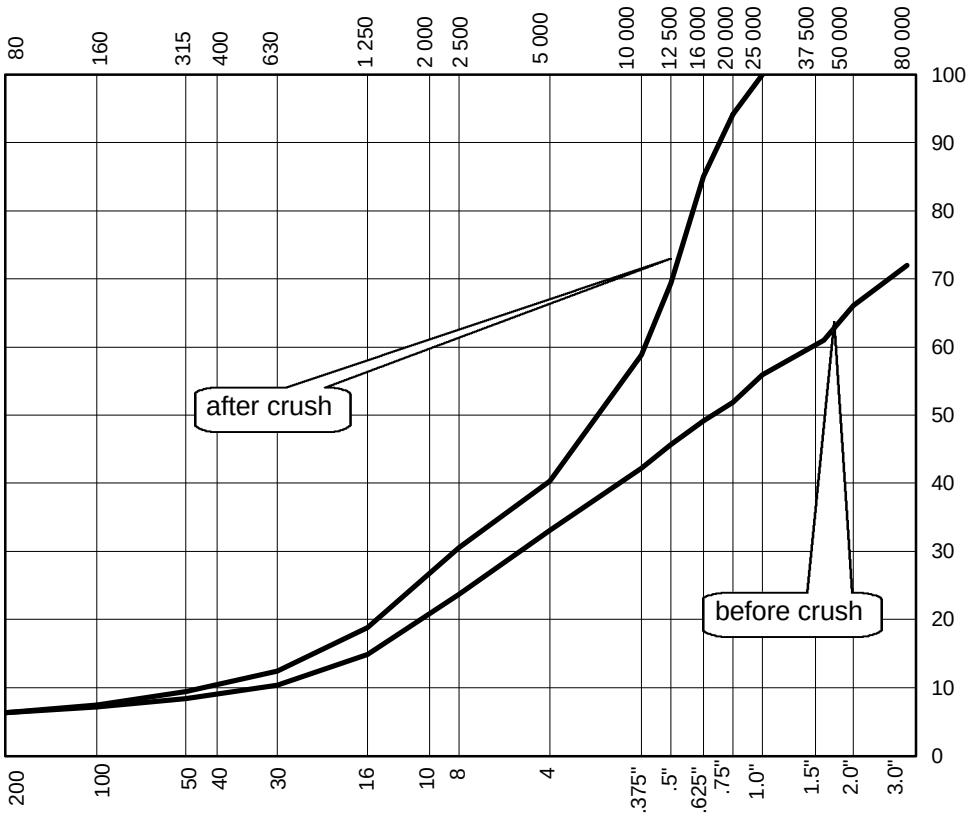
Attention: Jivko Jivkov, P.Eng.

Lab Number: 3243-3
Sample Description: Sandy GRAVEL, trace fines.

Fractured Face Count 93%
L. A. Abrasion Loss 25%
Sample Number n/a
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	72
2"	50 000	66
1.5"	37 500	61
1"	25 000	56
.75"	20 000	52
.625"	16 000	49
.5"	12 500	46
.375"	10 000	42
No. 4	5 000	33
No. 8	2 500	24
16	1250	15
30	630	10
50	315	8
100	160	7
200	80	6.3

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Sample collected from Hwy 3, km 44A, 500-700 m W of Hwy; gravel for base course and crush on north side.

Reviewed By: _____ P.Eng.

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

Project: Pavement Design for Mackenzie River Bridge
Address: Fort Providence
Project Number: 1700063.001
Date Tested: July 8, 2003
Client: Jivko Engineering

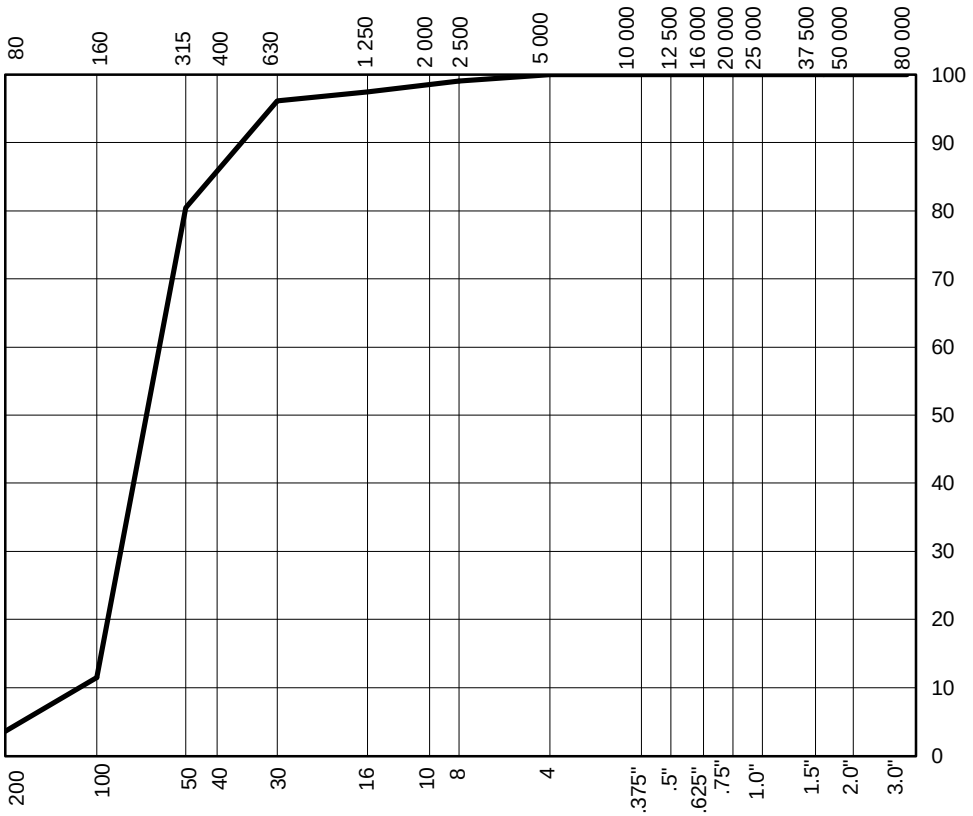
Attention: Jivko Jivkov, P.Eng.

Lab Number: 3243-4
Sample Description: SAND, trace fines.

Fractured Face Count: n/a
L. A. Abrasion Loss: n/a
Sample Number: n/a
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	
2"	50 000	
1.5"	37 500	
1"	25 000	
.75"	20 000	
.625"	16 000	
.5"	12 500	
.375"	10 000	
No. 4	5 000	100
No. 8	2 500	99
16	1250	97
30	630	96
50	315	80
100	160	11
200	80	3.6

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Sample collected from Hwy 3, km 44B, W of Hwy; sand for base course, . for winter haul; might have to be ripped.

Reviewed By: _____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Pavement Design for Mackenzie River Bridge

Project Number: 1700063.001

Client: Jivko Engineering

Attention: Mr.Jivko Jivkov, P.Eng.

Date Tested: July 9-11,2003.

Borehole Number: n/a

Depth: n/a

Sample Number: n/a

Lab Number: 3243-5

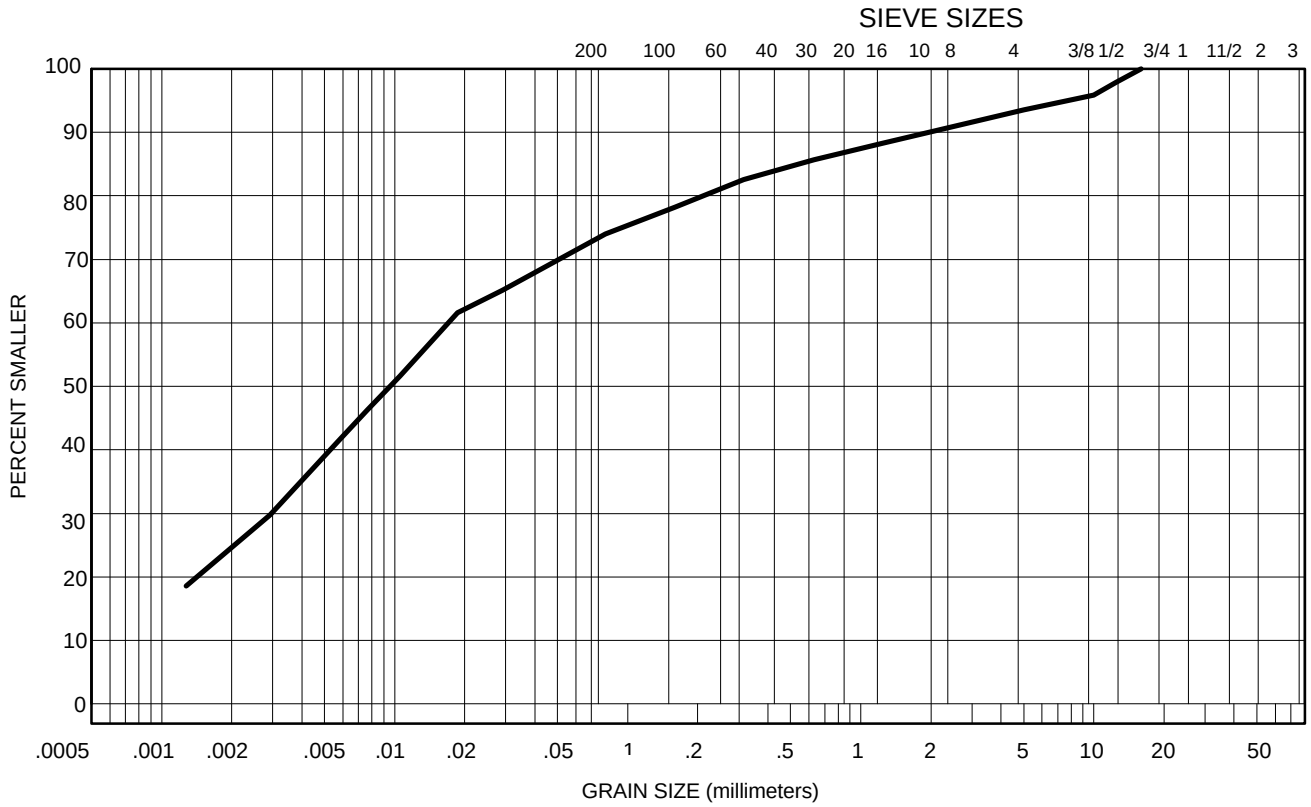
Soil Description: Sandy, clayey SILT, trace gravel.

Natural Moisture Content: 1.4%

Remarks: LL=29%, PL=16%, PI=13%

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	100
12.5	98
10	96
5	94
2.5	91
1.25	88
0.63	86
0.315	83
0.16	78
0.08	74

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

MOISTURE - DENSITY RELATIONSHIP

ASTM D698, D1557, or D2049

PROJECT: Mackenzie Bridge

PROJECT NO.: 701-1700063.001

CLIENT:

DESCRIPTION: CLAY, silty, tr. sand, 25mm gravel - olive brown

SAMPLE LOCATION:

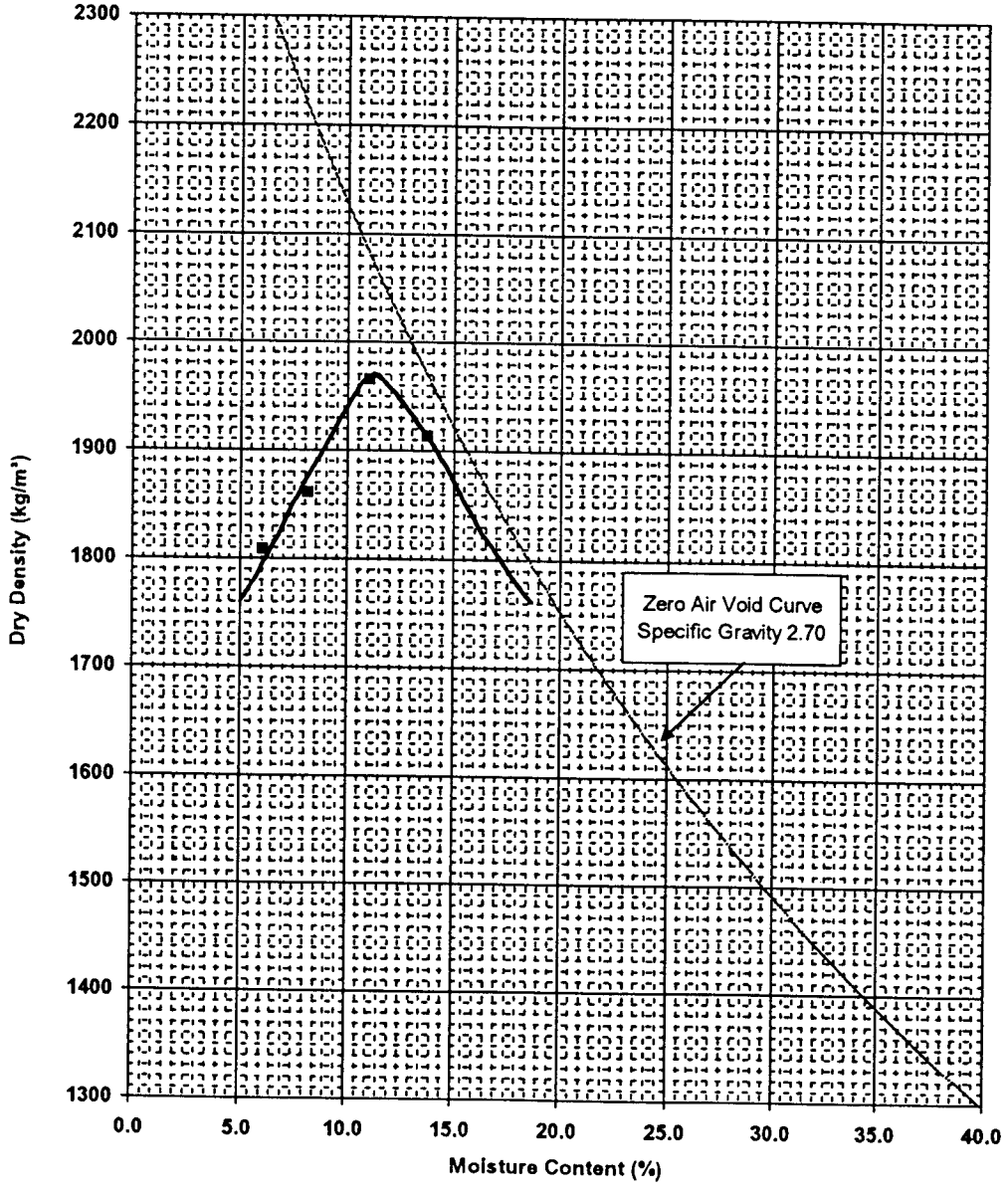
SAMPLE NUMBER: 3243-5

DATE TESTED: 03/07/23

MOISTURE CONTENT (as received): 6.0%

MAXIMUM DRY DENSITY: 1970 kg/m^3

OPTIMUM MOISTURE CONTENT: 11.5%



STANDARD PROCTOR

ASTM D698

Hammer Mass: 2.494 kg

Hammer Drop: 304.8 mm

Number of Layers: 3

Number of Blows/Layer: 56

Diameter of Mould: 152.3 mm

Height of Mould: 116.5 mm

Mould Volume: 0.00212 m3

Compactive Effort: 590.3 kJ/m3

REVIEWED BY:

P.Eng.

REMARKS:

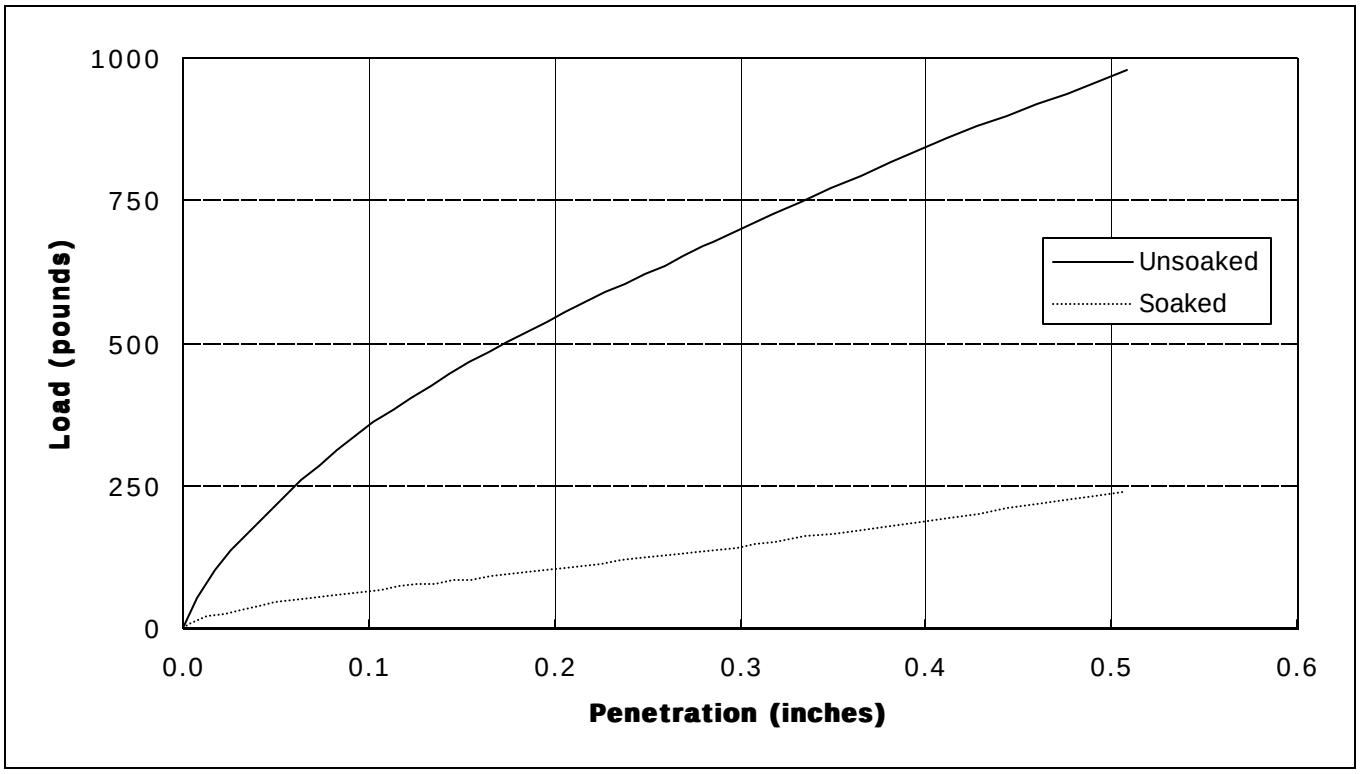
Rock correction - 5.3%+20mm

EBA Engineering Consultants Ltd.

CBR Test

Project Number: 1700063.001
Date (Unsoaked): 03-07-26
Date (Soaked): 03-07-30

Sample Designation: 3243.5



	CBR Values (%)	
	Unsoaked	Soaked
0.1"=	11.7	2.2
0.2"=	12.1	2.3

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

Project: Pavement Design for Mackenzie River Bridge
Address: Fort Providence
Project Number: 1700063.001
Date Tested: July 8, 2003
Client: Jivko Engineering

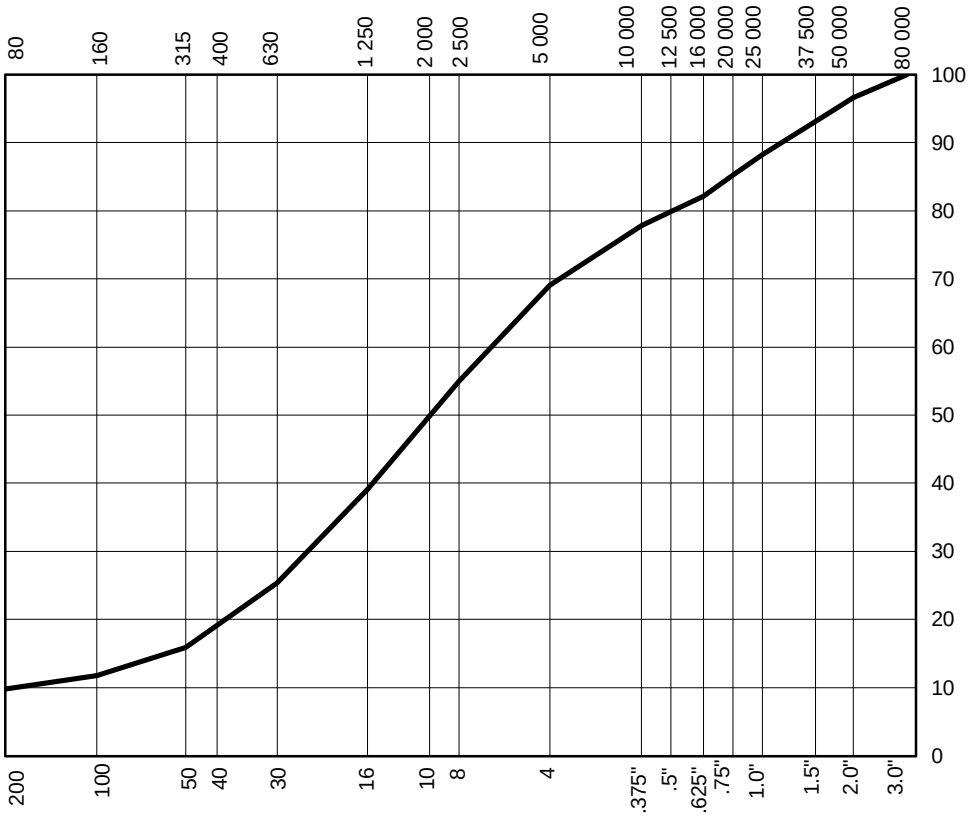
Attention: Jivko Jivkov, P.Eng.

Lab Number: 3243-6
Sample Description: Gravelly SAND, some fines.

Fractured Face Count: n/a
L. A. Abrasion Loss: n/a
Sample Number: n/a
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	100
2"	50 000	97
1.5"	37 500	94
1"	25 000	88
.75"	20 000	85
.625"	16 000	82
.5"	12 500	80
.375"	10 000	78
No. 4	5 000	69
No. 8	2 500	55
16	1250	39
30	630	25
50	315	16
100	160	12
200	80	9.8

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Sample collected from Hwy 3, km 22, S of road to Federal dock (near the gate), for common fill on South side.

Reviewed By: _____ P.Eng.

EBA Engineering Consultants Ltd.

MOISTURE - DENSITY RELATIONSHIP

ASTM D698, D1557, or D2049

PROJECT: Mackenzie Bridge

SAMPLE NUMBER: 3243-6 ~~Pail #2~~

PROJECT NO.: 701-1700063.001

DATE TESTED: 03/07/22

CLIENT:

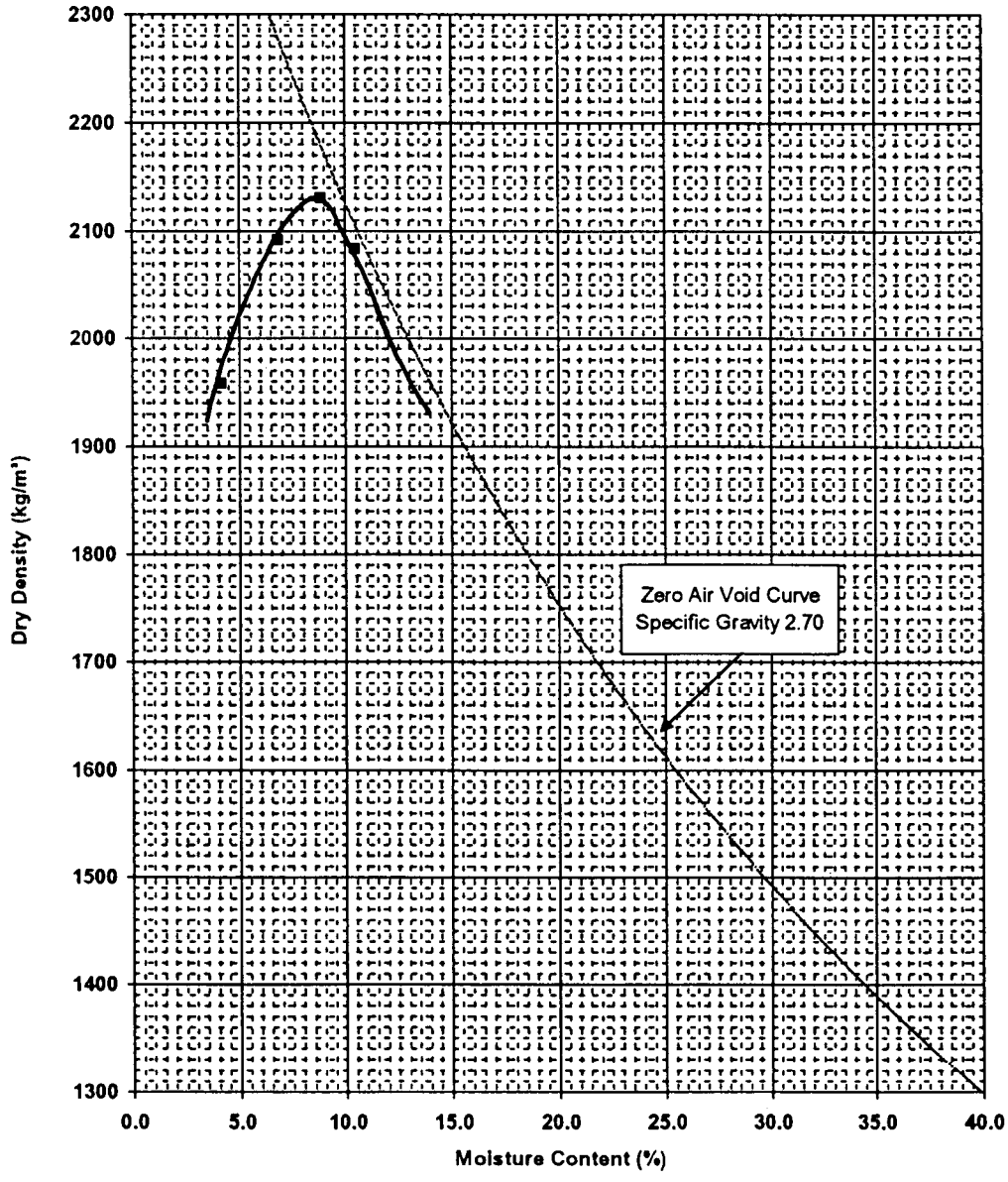
MOISTURE CONTENT (as received): 2.5%

DESCRIPTION: SAND & GRAVEL (40mm max), tr. silt - brown

MAXIMUM DRY DENSITY: 2130 kg/m^3

SAMPLE LOCATION: Hwy #1

OPTIMUM MOISTURE CONTENT: 8.5%



STANDARD PROCTOR

ASTM D698

Hammer Mass: 2.494 kg

Hammer Drop: 304.8 mm

Number of Layers: 3

Number of Blows/Layer: 56

Diameter of Mould: 152.3 mm

Height of Mould: 116.5 mm

Mould Volume: 0.00212 m3

Compactive Effort: 590.3 kJ/m3

REVIEWED BY:

P.Eng.

REMARKS:

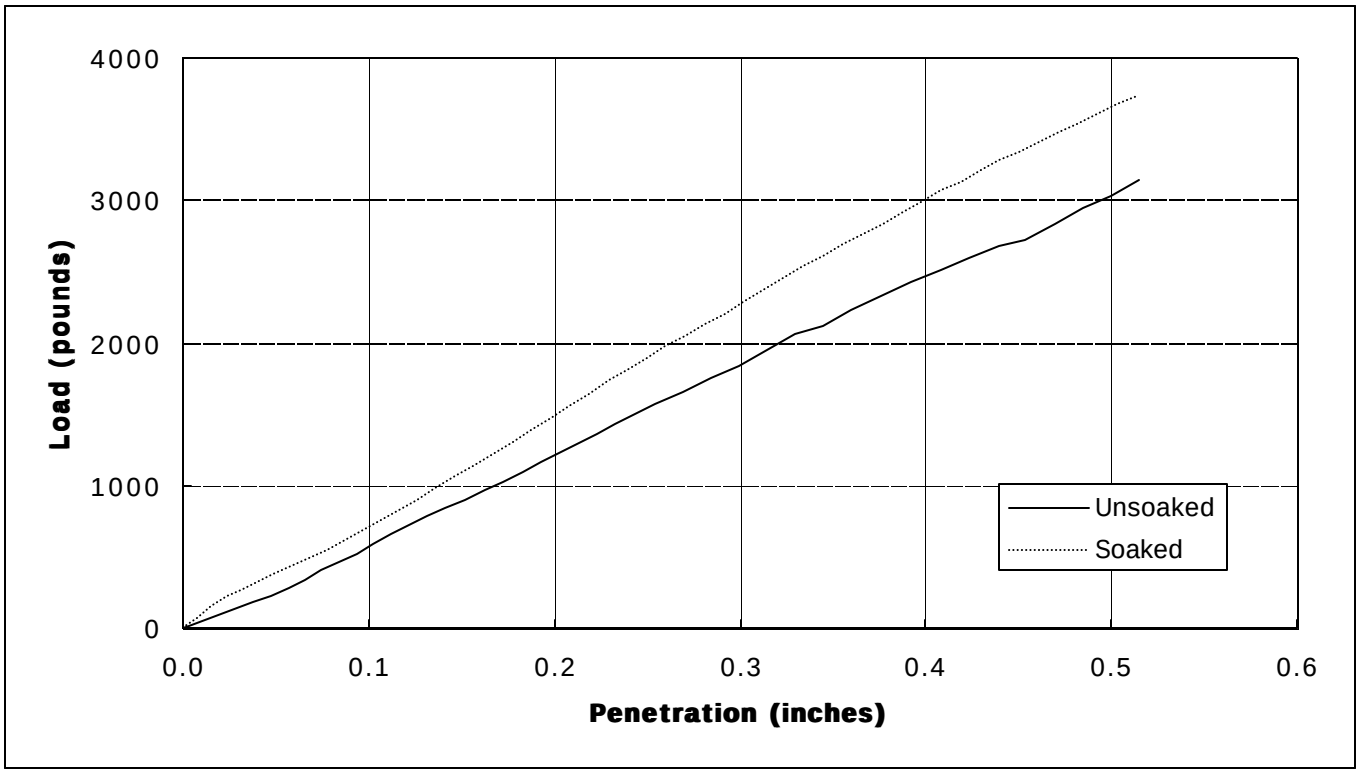
Rock correction-18.8%+20mm

EBA Engineering Consultants Ltd.

CBR Test

Project Number: 1700063.001
Date (Unsoaked): 03-07-26
Date (Soaked): 03-07-30

Sample Designation: 3243.6



	CBR Values (%)	
	Unsoaked	Soaked
0.1"=	19.0	23.9
0.2"=	27.0	33.0

EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS REPORT

Project: Pavement Design for Mackenzie River Bridge
Address: Fort Providence
Project Number: 1700063.001
Date Tested: July 7, 2003
Client: Jivko Engineering

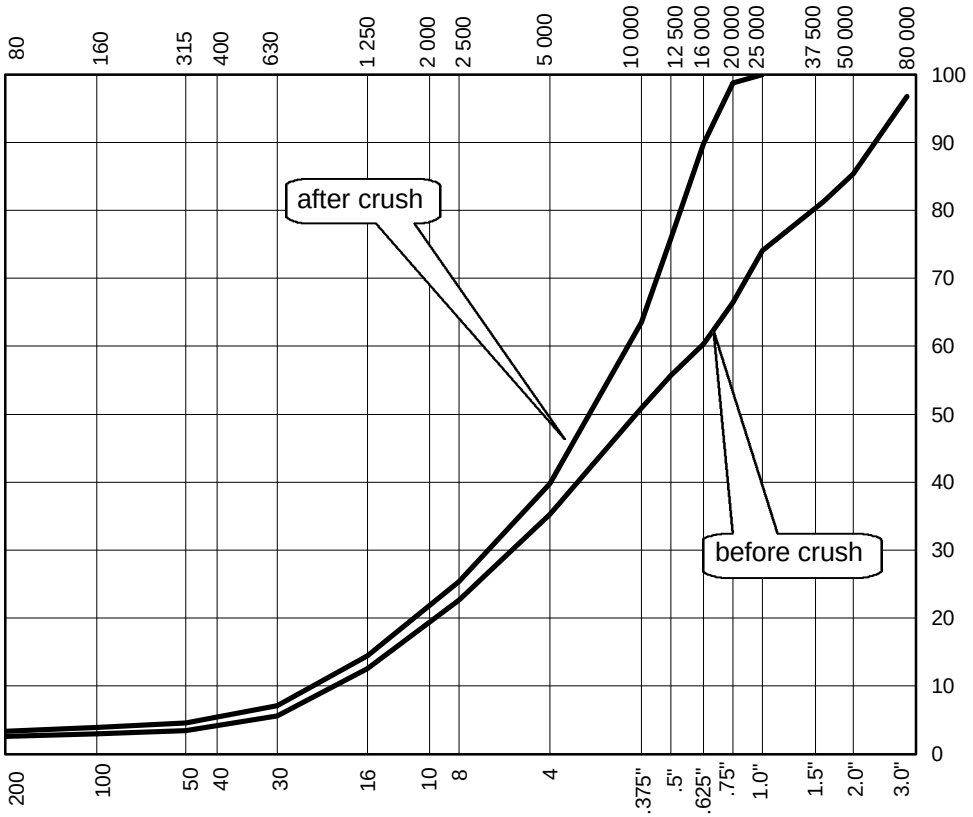
Attention: Jivko Jivkov, P.Eng.

Lab Number: 3243-7
Sample Description: Sandy GRAVEL, trace fines.

Fractured Face Count: 64%
L. A. Abrasion Loss: 20%
Sample Number: n/a
Bulk Relative Density: n/d
Apparent Relative Density (SSD): n/d
Aparent Relative Density: n/d
Absorption: n/d

Sieve Sizes		%
U.S.	Metric	Passing
3"	80 000	97
2"	50 000	85
1.5"	37 500	81
1"	25 000	74
.75"	20 000	66
.625"	16 000	60
.5"	12 500	56
.375"	10 000	51
No. 4	5 000	35
No. 8	2 500	23
16	1250	13
30	630	6
50	315	3
100	160	3
200	80	2.6

Metric Sieve Size (C.G.S.B. Spec. 8-GP-2M)



U.S. Standard Sieve Size - approximate (A.S.T.M. Des. E 11)

Remarks: Sample collected from Hwy 1, km 196; sample from bank on South side of pit; for base course & crush on South side; also for chips.

Reviewed By: _____ P.Eng.

DEH CHO BRIDGE APPROACHES - POSSIBLE EMBANKMENT FILL MATERIALS
LABORATORY TEST RESULT SUMMARY

Sample Number	Sample Source/Purpose (from Client)	Visual Description	Gravel (%)	Sand (%)	Silt (or Fines[1]) (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Standard Proctor MDD (kg/m^3)	Standard Proctor Optimum (%)	California Bearing Ratio (lb. @ 0.2") Unsoaked	California Bearing Ratio (lb. @ 0.2") Soaked
North Side												
EBA # 3243-5	Hwy. #3, km 23: north bank on north side of the highway, for common fill on north	CLAY - silty, trace gravel, grey-brown	6	20	49	25	29	16	1970	11.5	12.1	2.3
TP 7-1	Hwy. #3, km 23: north side	CLAY - silty, trace cobbles, some sand	13	23	40	24	30	17				
TP 9	Hwy. #3, km 23: north side	SILT - clayey, some sand, some gravel	19	16	45	20	30	17				
South Side												
EBA # 3243-6	Hwy. #3, km 22; south of bridge, south of road to federal dock (near the gate), for common fill on south side	SAND - trace gravel, med. grained, brown	31	59	10	n/d			2130	8.5	27.0	33.0
TP 2-1	Hwy. #3, km 22; south side; 1 m deep - Option 1	SAND - some gravel	56	41	3	n/d						
TP-2-2	Hwy. #3, km 22; south side; 2 m deep - Option 1	CLAY - silty, trace gravel, hard (blocky)	5	17	46	32	34	18				
TP 3-1	Hwy. #3, km 22; south side - Option 2	CLAY - silty, trace gravel, hard (blocky)	8	18	39	35	40	16				
TP 4-1	Hwy. #3, km 22; south side - Option 2	CLAY - silty, trace gravel, trace roots	5	18	45	32	38	17				

Note: 1 - n.d. denotes silt and clay contents not determined; fines refers to combined silt and clay content

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Pavement Design for Mackenzie River Bridge

Project Number: 1700063.001

Client: Jivko Engineering

Attention: Jivko Jivkov, P.Eng.

Date Tested: December 1, 2003

Borehole Number: 2

Depth: 1 m

Location Hwy. #3, km 22; South Side - Option 1

Lab Number: 3536-2-1

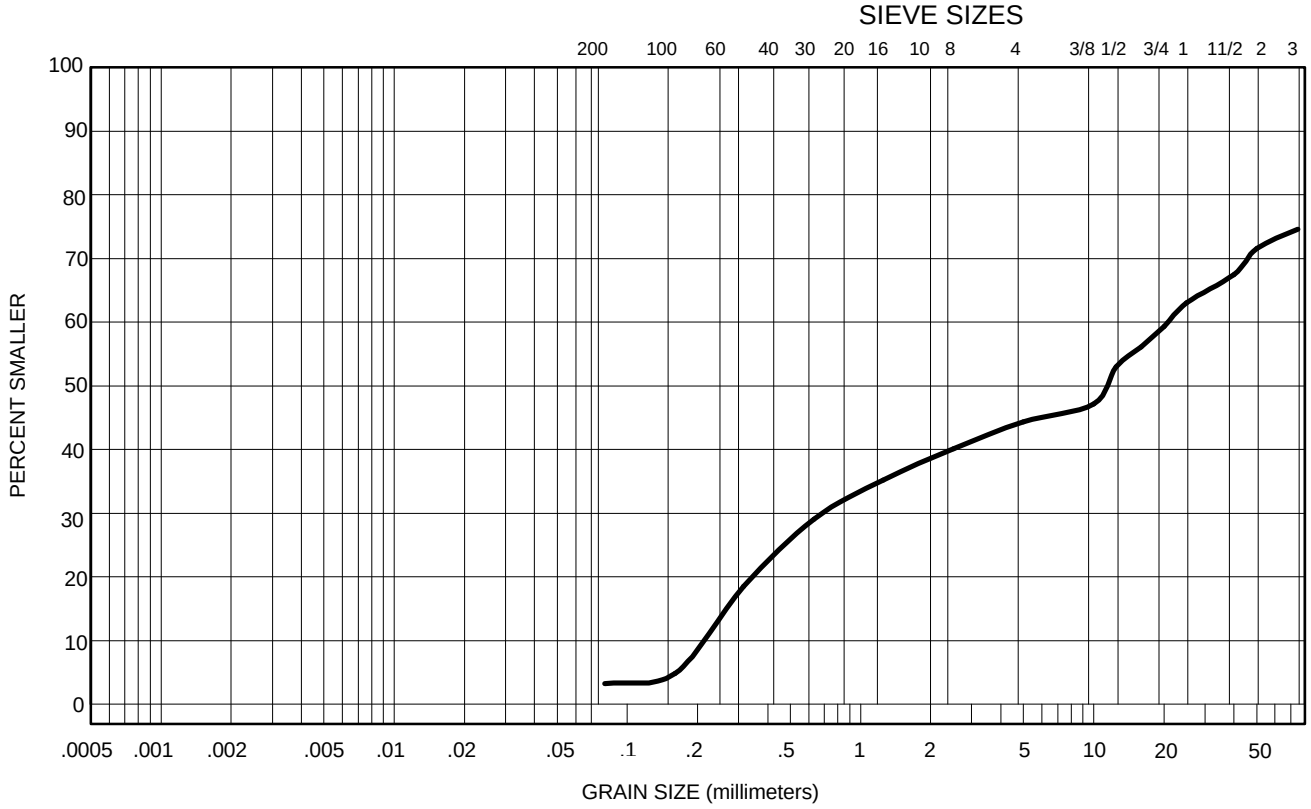
Soil Description: GRAVEL and sand, trace silt.

Natural Moisture Content: 8.4%

Remarks:

SIEVE	PERCENTAGE PASSING
75	75
50	72
40	67
25	63
20	59
16	56
12.5	53
10	47
5	44
2.5	40
1.25	35
0.63	29
0.315	18
0.16	5
0.08	3.3

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Pavement Design for Mackenzie River Bridge

Project Number: 1700063.001

Client: Jivko Engineering

Attention: Jivko Jivkov, P.Eng.

Date Tested: December 1, 2003

Borehole Number: 2

Depth: 2 m

Location Hwy. #3, km 22: South Side - Option 1

Lab Number: 3536-2-2

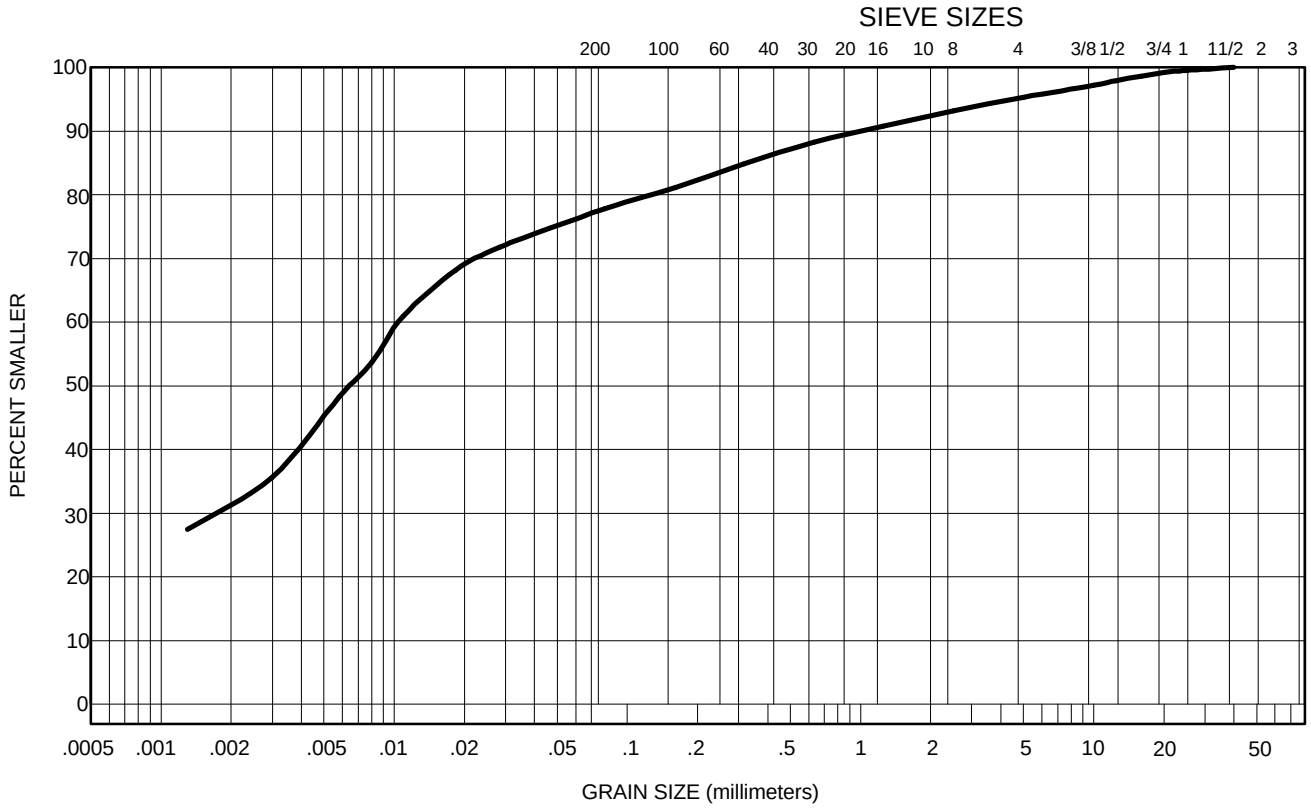
Soil Description: Clayey SILT, some sand, trace gravel.

Natural Moisture Content: 11.9%

Remarks: LL=34%, PL=18%, IP=18%

SIEVE	PERCENTAGE PASSING
75	
50	
40	100
25	99
20	99
16	99
12.5	98
10	97
5	95
2.5	93
1.25	91
0.63	88
0.315	85
0.16	81
0.08	78

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Pavement Design for Mackenzie River Bridge

Project Number: 1700063.001

Client: Jivko Engineering

Attention: Jivko Jivkov, P.Eng.

Date Tested: December 1, 2003

Test Pit Number: 3-1

Depth: n/a

Location Hwy. #3, km 22; South Side - Option 2

Lab Number: 3536-3-1

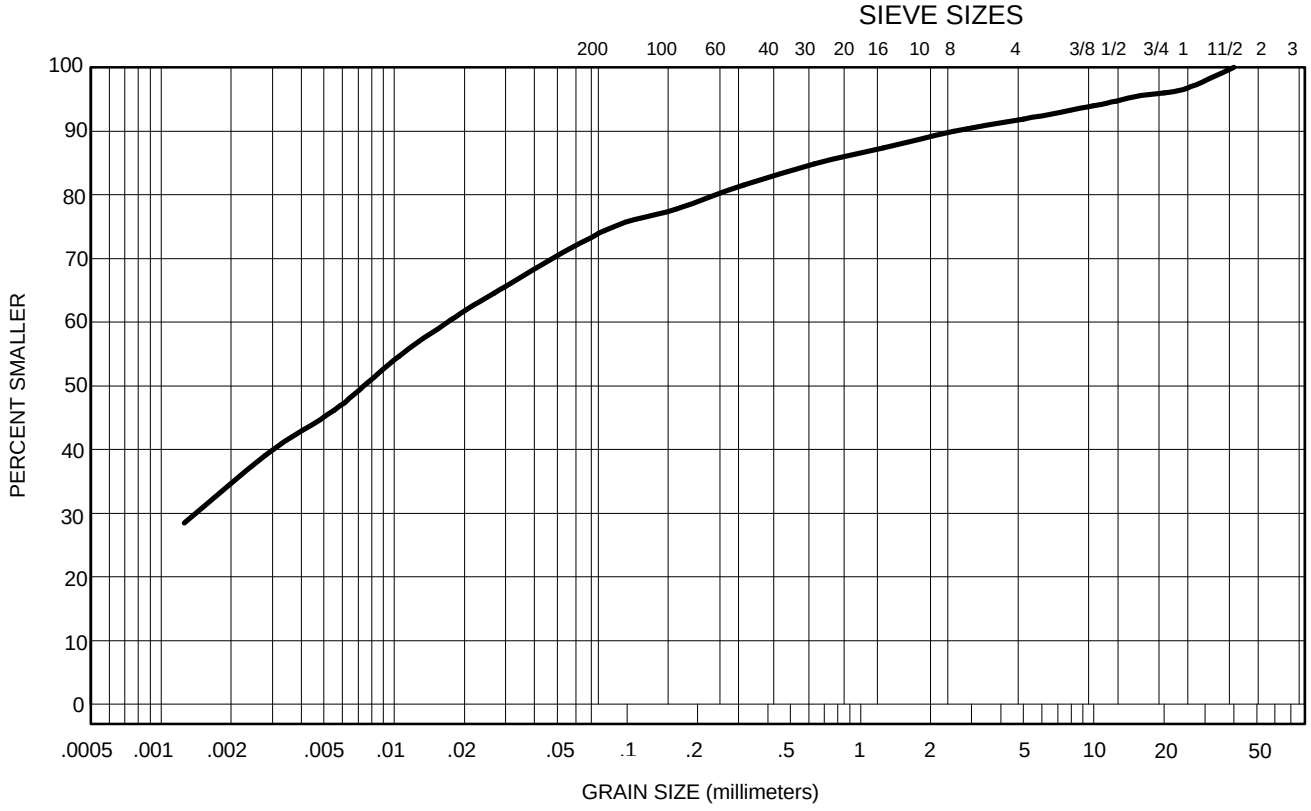
Soil Description: SILT and clay, some sand, trace gravel.

Natural Moisture Content: 16.2%

Remarks: LL=40%, PL=16%, IP=24%

SIEVE	PERCENTAGE PASSING
75	#N/A
50	#N/A
40	100
25	97
20	96
16	96
12.5	95
10	94
5	92
2.5	90
1.25	87
0.63	85
0.315	82
0.16	78
0.08	74

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

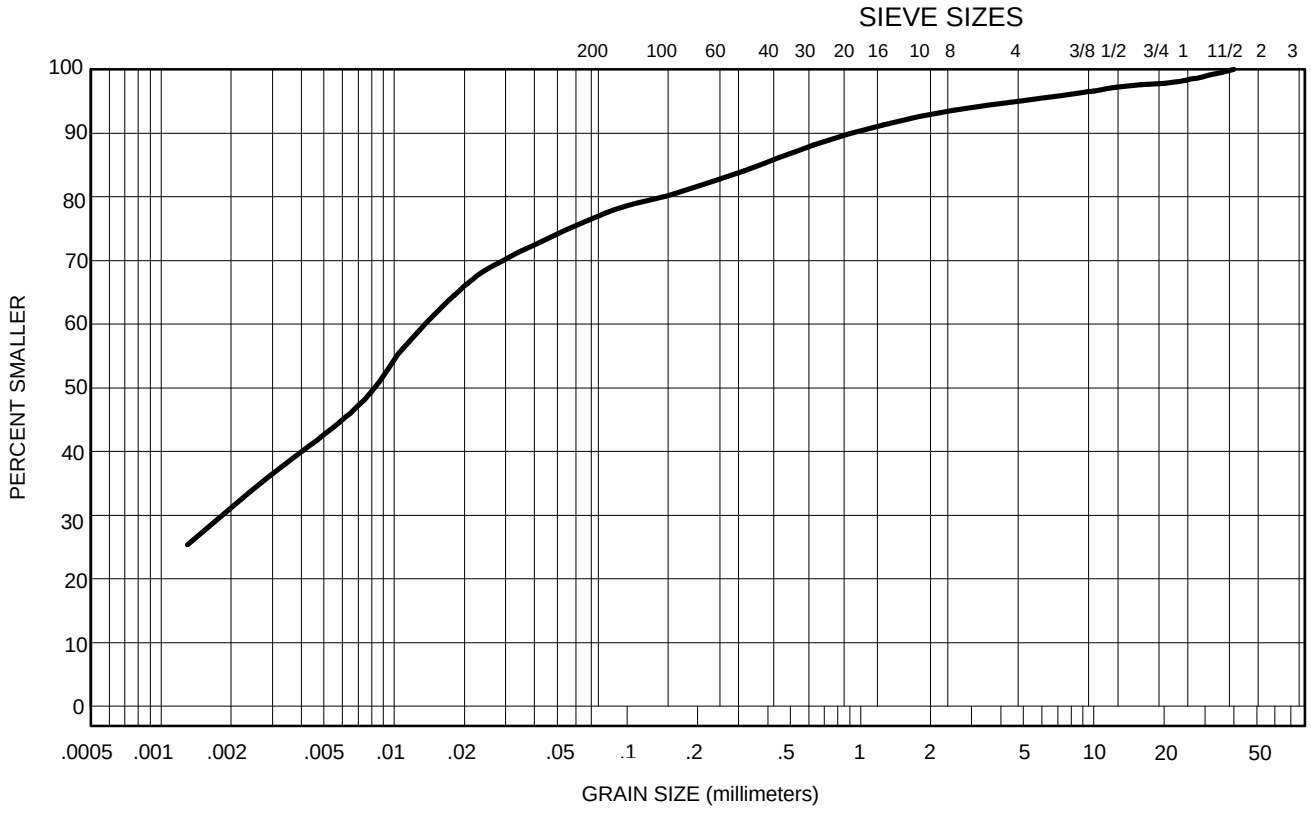
EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Pavement Design for Mackenzie River Bridge
Project Number: 1700063.001
Client: Jivko Engineering
Attention: Jivko Jivkov, P.Eng.
Date Tested: December 1, 2003
Test Pit Number: 4-1
Depth: n/a
Location Hwy. #3, km 22; South Side - Option 2
Lab Number: 3536-4-1
Soil Description: Clayey, sandy SILT, trace gravel.
Natural Moisture Content: 13.0%
Remarks: LL=38%, PL=17%, IP=21%

SIEVE	PERCENTAGE PASSING
75	#N/A
50	#N/A
40	100
25	98
20	98
16	98
12.5	97
10	97
5	95
2.5	94
1.25	91
0.63	88
0.315	84
0.16	80
0.08	77

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Pavement Design for Mackenzie River Bridge

Project Number: 1700063.001

Client: Jivko Engineering

Attention: Jivko Jivkov, P.Eng.

Date Tested: December 1, 2003

Test Pit Number: 7-1

Depth: n/a

Location Hwy. #3, km 23; North Side

Lab Number: 3536-7-1

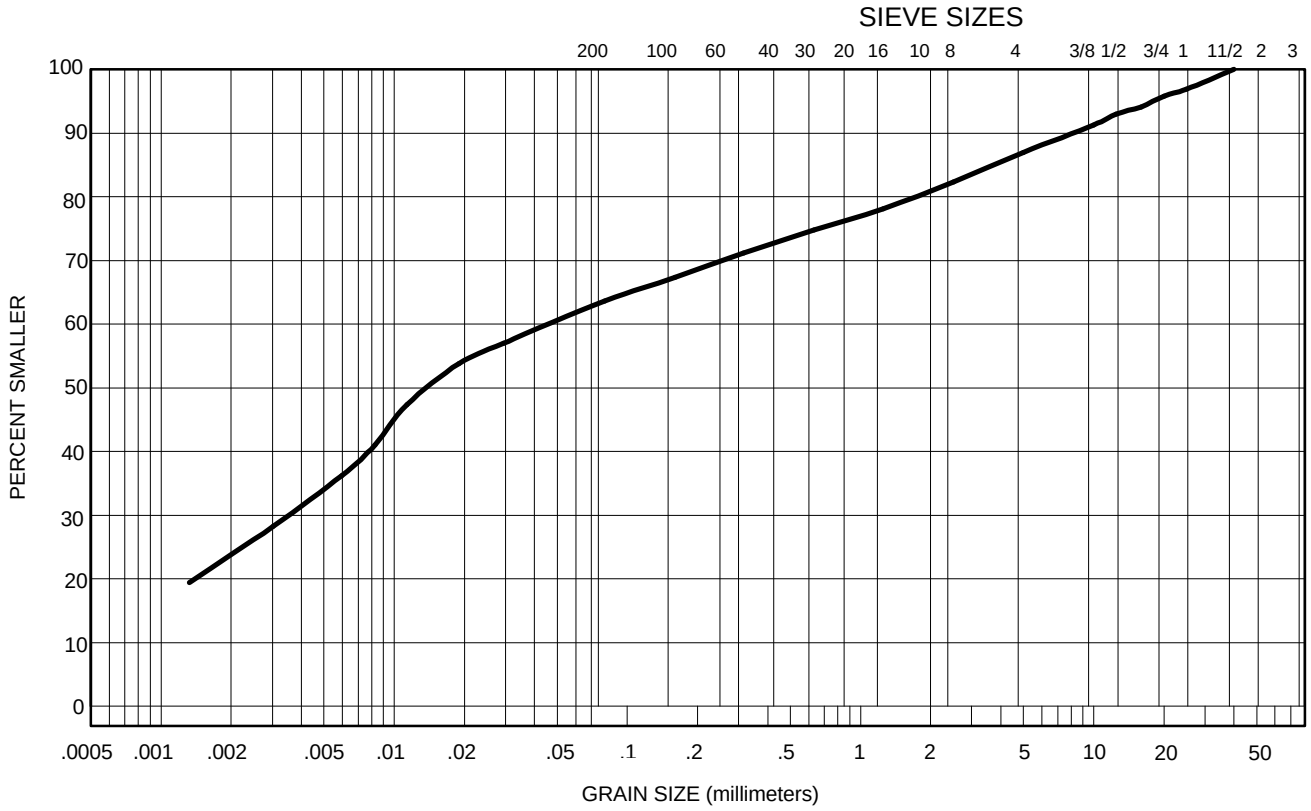
Soil Description: Clayey, sandy SILT, some gravel.

Natural Moisture Content: 17.7%

Remarks: LL=30%, PL=17%, IP=13%

SIEVE	PERCENTAGE PASSING
75	
50	
40	100
25	97
20	96
16	94
12.5	93
10	91
5	87
2.5	82
1.25	78
0.63	75
0.315	71
0.16	67
0.08	64

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Pavement Design for Mackenzie River Bridge

Project Number: 1700063.001

Client: Jivko Engineering

Attention: Jivko Jivkov, P.Eng.

Date Tested: December 12, 2003

Test Pit Number: 9

Depth: 1.2 m

Location n/a

Lab Number: 3537-9-1.2

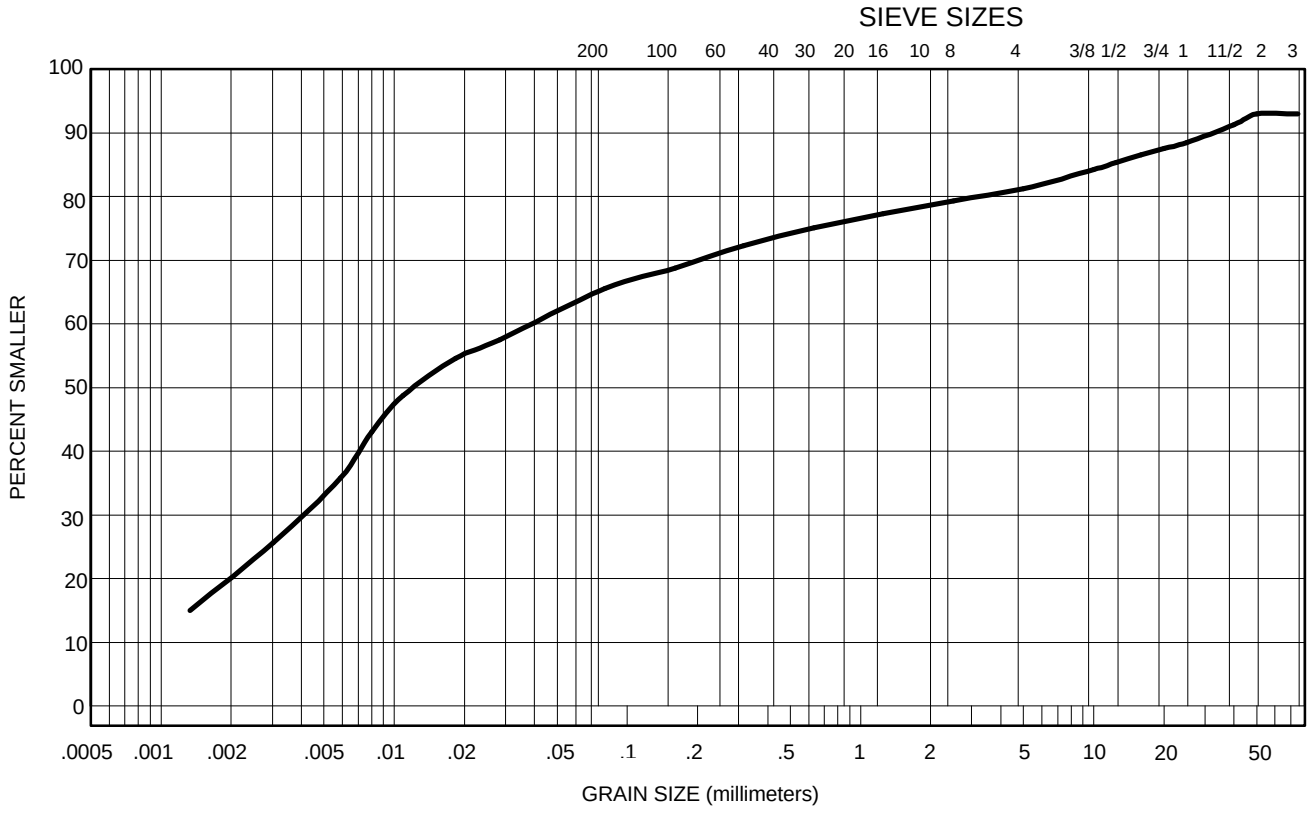
Soil Description: Clayey SILT, some gravel, some sand.

Natural Moisture Content: 10.4%

Remarks: LL=30%, PL=17%, IP=13%

SIEVE, mm	PERCENTAGE PASSING
100	100
75	93
50	93
40	91
25	88
20	88
16	86
12.5	85
10	84
5	81
2.5	79
1.25	77
0.63	75
0.315	72
0.16	69
0.08	66

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

APPENDIX G
PERMITTING ASSISTANCE LABORATORY TEST RESULTS

EBA Engineering Consultants Ltd.

SEDIMENT LIBERATION TEST RESULTS

Project:	Proposed Deh Cho Bridge	BH No:	BH-4
Project No.:	1700063	Date Tested:	22-Oct-03
Location:	Mackenzie River near Ft. Providence, NT	By:	MB
Client:	Jivko Engineering		

BH No.	Depth (feet)	Initial moisture content, %	Sediment Liberated, %	Final moisture content, %
0.5 minute shake				
4	20-21.5	6.8	0.5	8.3
4	49.5-51	8.3	1.9	9.3
4	50.9-60.5	9.5	1.1	11.5
	Averages	8.2	1.2	9.7
1.0 minute shake				
4	34.5-36	10.7	0.8	11.8
4	39.5-40.5	5.8	2.1	11.4
4	49.5-51	8.3	5.1	9.5
	Averages	8.3	2.7	10.9

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge.

Project Number: 1700063

Client: Jivko Engineering

Attention: Mr. Jivko Jivkov, P.Eng.

Date Tested: October 23-24,2003.

Borehole Number: 4

Depth: combined sample

Sample Number: n/a

Lab Number: 3168 SL 1

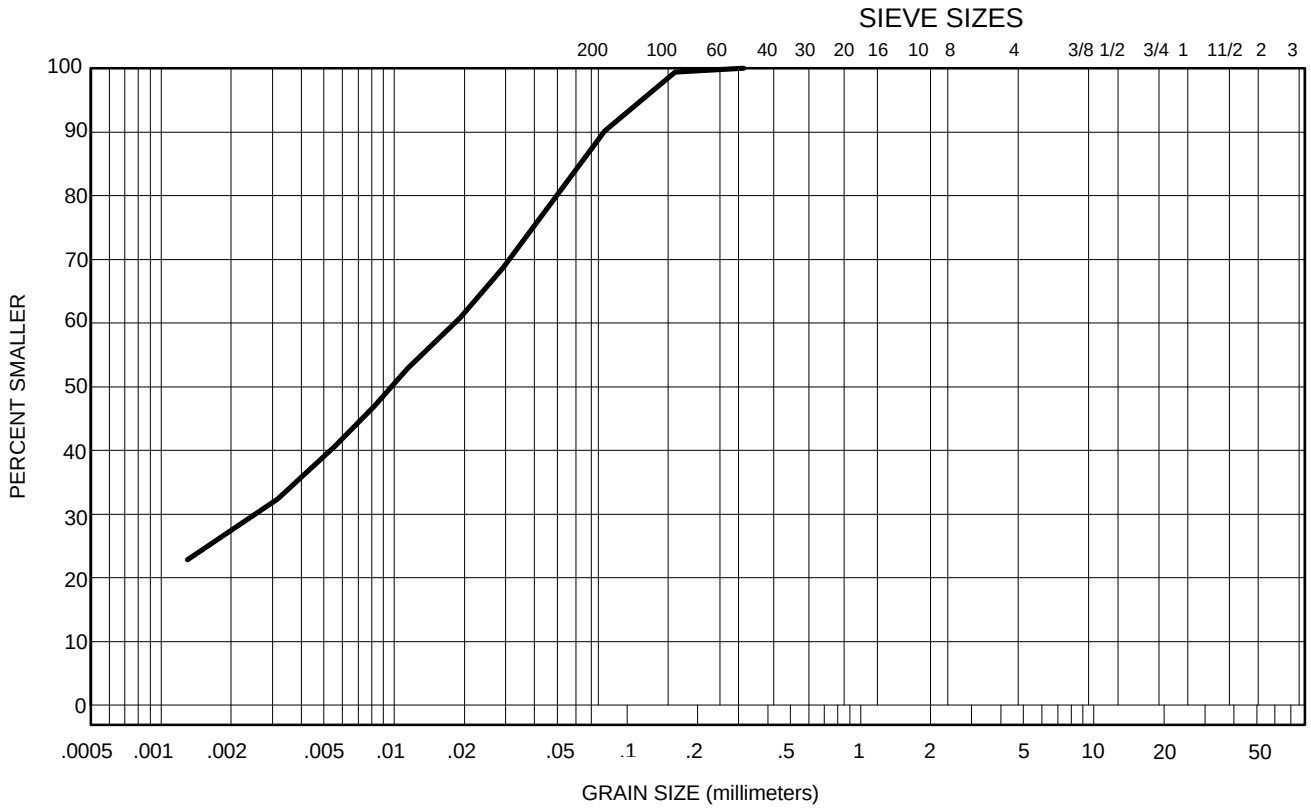
Soil Description: Clayey SILT

Natural Moisture Content: n/a

Remarks: sediment liberated after 1 minute of shaking

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	
12.5	
10	
5	
2.5	
1.25	
0.63	
0.315	100
0.16	99
0.08	90

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

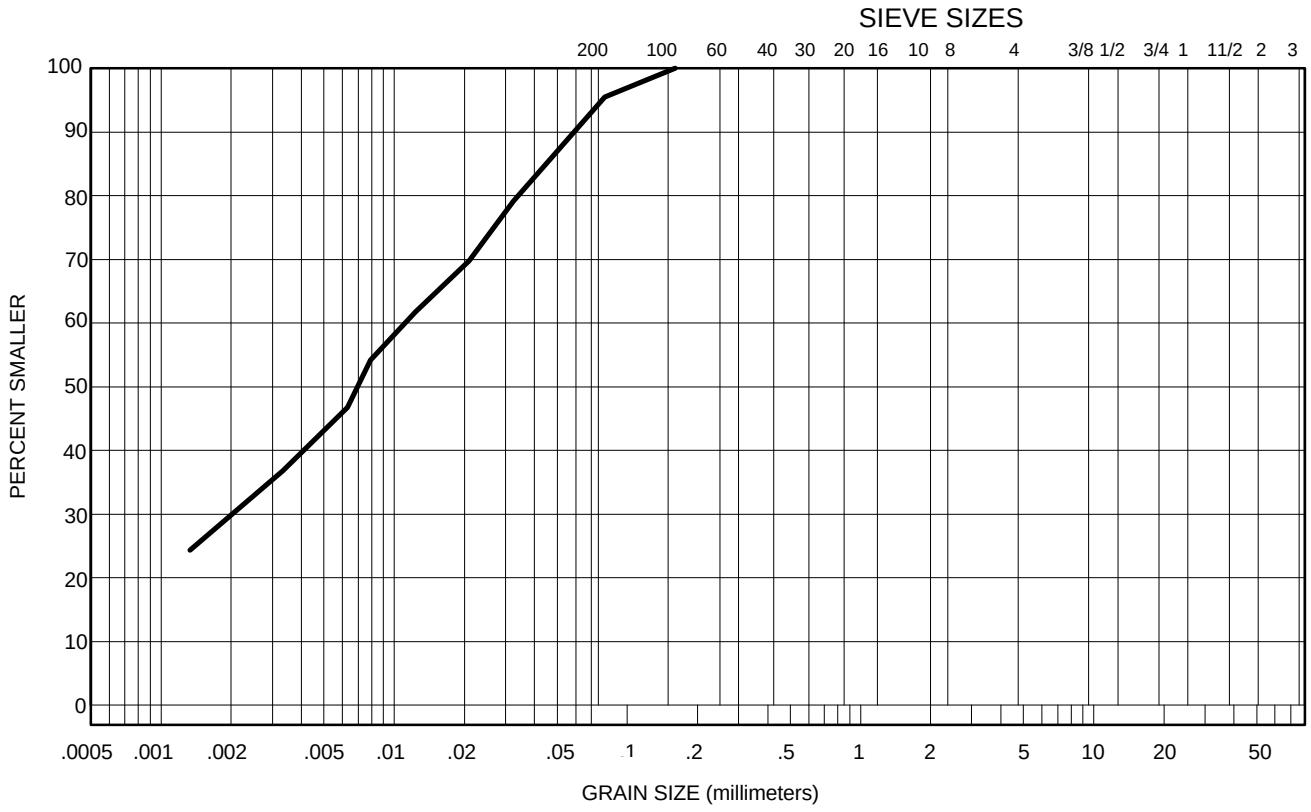
EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: Geotechnical Investigation for Proposed Deh Cho Bridge.
Project Number: 1700063
Client: Jivko Engineering
Attention: Mr. Jivko Jivkov, P.Eng.
Date Tested: October 23-24,2003.
Borehole Number: 4
Depth: combined sample
Sample Number: n/a
Lab Number: 3168 SL 2
Soil Description: Clayey SILT
Natural Moisture Content: n/a
Remarks: sediment liberated after 0.5 minutes of shaking

SIEVE	PERCENTAGE PASSING
40	
25	
20	
16	
12.5	
10	
5	
2.5	
1.25	
0.63	
0.315	
0.16	100
0.08	95

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Reviewed By:_____ P.Eng.

ALS Environmental

1700063
Rec'd Dec 17/03

CHEMICAL ANALYSIS REPORT

Date:	November 27, 2003
ALS File No.	T5791
Report On:	1700063 Soil Analysis Mackenzie River Bridge
Report To:	**EBA Engineering Consultants Ltd.** PO Box 2244 #201 - 4916 - 49 Street Yellowknife, NT X1A 2P7
Attention:	**Mr. Ed Hoeve**
Received:	October 27, 2003

ALS ENVIRONMENTAL
per:

Can Dang, B.Sc. - Project Chemist
Natasha Markovic-Mirovic, B.Sc. - Project Chemist

ALS CANADA LTD.
1988 Triumph Street, Vancouver, BC Canada V5L 1K5
Phone: 604-253-4188 Fax: 604-253-6700 Website: www.alsenviro.com

File No. T5791

REMARKS

The Acid Base Accounting analysis was subcontracted to Chemex Labs Ltd. of North Vancouver. Refer to the appendix for detail.

The detection limits for the total metals were increased due to elevated Calcium concentration found in the samples.

File No. T5791

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		3243-2 Hwy #1 km 192	3501-1 Hwy#3 km 165	3501-2 Hwy #1 km 196
ALS ID		*1*	*2*	*3*
Physical Tests				
Moisture	%	3.89	0.13	0.62
Total Metals				
Aluminum	T-Al	960	<200	890
Antimony	T-Sb	<80	<80	<80
Arsenic	T-As	0.910	0.269	1.84
Barium	T-Ba	9.6	10.7	11.9
Beryllium	T-Be	<2.0	<2.0	<2.0
Bismuth	T-Bi	<80	<80	<80
Cadmium	T-Cd	<0.10	<0.10	<0.10
Calcium	T-Ca	424000	380000	404000
Chromium	T-Cr	<8.0	<8.0	<8.0
Cobalt	T-Co	<8.0	<8.0	<8.0
Copper	T-Cu	<4.0	<4.0	<4.0
Iron	T-Fe	4090	890	3100
Lead	T-Pb	4.5	<2.0	3.7
Lithium	T-Li	<8.0	<8.0	<8.0
Magnesium	T-Mg	3510	4560	3570
Manganese	T-Mn	313	163	260
Molybdenum	T-Mo	<16	<16	<16
Nickel	T-Ni	<20	<20	<20
Phosphorus	T-P	<200	<200	<200
Potassium	T-K	<800	<800	<800
Selenium	T-Se	<200	<200	<200
Silver	T-Ag	<8.0	<8.0	<8.0
Strontium	T-Sr	512	281	698
Thallium	T-Tl	<200	<200	<200
Tin	T-Sn	<40	<40	<40
Titanium	T-Ti	<4.0	<4.0	<4.0
Vanadium	T-V	<8.0	<8.0	<8.0
Zinc	T-Zn	49.2	42.8	10.5
Miscellaneous				
Acid Base Accounting		Appendix	Appendix	Appendix

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

File No. T5791

Appendix 1 - Methodology

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:	
Sample:	14 days
Reference:	Puget
For more detail see	ALS Environmental "Collection & Sampling Guide"

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption/emission/fluorescence spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:	
Sample/Extract:	6 months (Mercury = 28 days)
Reference:	EPA
For more detail see	ALS Environmental "Collection & Sampling Guide"

End of Report

ALS Chemex
EXCELLENCE IN ANALYTICAL CHEMISTRY
ALS Canada Ltd
212 Brooksbank Avenue
North Vancouver BC V7J 2C1 Canada
Phone: 604 984 0221 Fax: 604 984 0218

To: ALS ENVIRONMENTAL
1988 TRIUMPH ST
VANCOUVER BC V5L 1K5

Page # : 1
Date : 13-Nov-2003
Account: APN

CERTIFICATE VA03044466

Project : T5791
P.O. No:
This report is for 3 ROCK CHIP samples submitted to our lab in North Vancouver, BC, Canada on 28-Oct-2003.
The following have access to data associated with this certificate:
CAN DANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
OA-VOL08	Basic Acid Base Accounting	

To: **ALS ENVIRONMENTAL**
ATTN: CAN DANG
1988 TRIUMPH ST
VANCOUVER BC V5L 1K5

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature:

ALS Chemex
EXCELLENCE IN ANALYTICAL CHEMISTRY
ALS Canada Ltd
212 Brooksbank Avenue
North Vancouver BC V7J 2C1 Canada
Phone: 604 984 0221 Fax: 604 984 0218

To: **ALS ENVIRONMENTAL**
1988 TRIUMPH ST
VANCOUVER BC V5L 1K5

Date : 13-Nov-2003
Account: APN

Project : T5791

CERTIFICATE OF ANALYSIS VA03044466

mple Description	Method Analyte Units LOR	WEI-21 Recvd Wt kg 0.02	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP t CaCO3/ 1	OA-VOL08 NP t CaCO3/ 1	OA-ELE07 pH Unity 0.1	OA-VOL08 MPA t CaCO3/ 0.5	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01
T5791-1		0.60	4.0	915	915	8.0	<0.5	2928	0.01
T5791-2		0.56	4.0	957	960	8.1	3.4	279.3	0.11
T5791-3		0.54	4.0	897	897	8.2	<0.5	2870	0.01