TLA'AMIN
CAPITAL ASSETS
INC.

# Sliammon Development Corp.

Sliammon Creek Hydroelectric Project

Powell River, BC

Technical Report

## Initial Geotechnical and Dam Assessment

**BBA Document No. / Rev.** 3774001-000000-41-ERA-0001 / RAA
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## FOR INFORMATION

Do not use for construction

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# 1. INTRODUCTION

## 1.1 Scope of specification

Tla'amin Capital Assets Inc. (TCAI or the Proponent) proposes to build the Sliammon Creek Hydroelectric Project (the Project) on existing lands within its traditional territory and held under its newly ratified Treaty, effective April 5, 2016 within the Province of British Columbia (BC or the Province). A water licence (WL) application has been submitted to Front Counter BC (FCBC) for review by the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) Water Stewardship Division (WSD) under the *Water Sustainability Act* (formerly the *Water Act*). The Proponent has been offered an Investigative Licence (IL) by the MFLNRO to complete the investigative phase that supports the clean energy Development Plan Information Requirements (DPIR).

Tla'amin Nation holds two water licences including drinking water treatment plant and Salmon hatchery. Fisheries & Oceans Canada (DFO) holds the third water licence for the concrete weir dam (1984) with stop logs for active storage to maintain instream flow requirements (IFR) during summer base flow period to support downstream fish habitat. Based on existing communication and our discussions with Tla'amin Nation and TCAI, it is our understanding that DFO have had some concerns regarding condition of the weir dam and intend to remove the dam in 2016. There is no previous formal dam safety review and inspection or geotechnical assessment report for the dam condition.

On February 24$^{rd}$ to 26$^{th}$ representatives from BBA Engineering Ltd. (BBA) conducted the field review and geotechnical assessment. The weather was partly cloudy with a mild rainfall on the last day. The main purpose of the site visit was to inspect the existing dam structure condition and review its foundation with geotechnical assessment.

The detailed terms of reference for the work undertaken by BBA included the following:

- Perform a literature survey of the surficial and bedrock geology and seismicity of the dam location.
- Undertake a site reconnaissance for initial geotechnical foundation assessment and terrain hazard assessment in the general vicinity of the dam location.
- Review existing dam structural condition
- Prepare the preliminary site reconnaissance findings report and provide recommendations for dam repair and mitigation measures to operate the existing dam for another year.

# 2. BACKGROUND INFORMATION

## 2.1 Topography and geomorphology

Sliammon Creek Watershed is located about 4.5 km northwest of Powell River within the Sunshine Coast Forest District. Sliammon Creek flows into the Straight of Georgia at the community of Sliammon. The project is located in the Georgia Depression area between Vancouver Island Ranges and Pacific Ranges of British Columbia. Most of the features visible today were formed during the last ice age, which ended in this area about 10.4 thousand years ago.

The Sliammon Lake area is about 1.8 $km^2$ and located on the west side of Powell Lake. The Sliammon Lake watershed area is about 44 $km^2$ at the existing dam's location. Sliammon Creek flows in a side valley to the Georgia depression. The study area spans between two major physiography regions including the Georgia Lowlands and the Pacific Ranges of the Coast Mountains as a transition zone. Local relief in the study area is about 1000 meters, with elevations ranging from about 120 meters above sea level at the Sliammon Lake to 1110 meters at the peak level.

## 2.2 Bedrock geology

Based on the British Columbia Surficial Geology (BCSG) map NTS 1:250,000 sheets 092F, the study area is primary underlain primary by quartz diorite and granodiorite (Roddick and Hutchinson, 1972). This formation had outcropped at the weir dam location and creek bed in the downstream areas. Also, the bedrock had occasionally outcropped along or near the proposed penstock alignment as shown in Figure 1 and Figure 2.

Figure 1 – Bedrock outcrop at the weir dam location

Figure 2 – Bedrock outcrop in the downstream area of the weir dam

## 2.3 Surficial geology

The surficial geology of the study area is dominated by various types of glacial, glaciofluvial, colluvial, and fluvial deposits. Bedrock outcrops are present at the weir dam location and locally along the proposed penstock alignment. Fluvial and glaciofluvial deposits comprising gravelly sand to sandy gravel with trace silt and some cobbles and boulders were observed on the lake side and in both abutments at the weir dam and intake locations as shown in Figure 3. These deposits are covered locally by a thin layer of colluvial material comprising mostly cobbles and boulders with some sand and gravel and little silt on the slopes.

Glacial deposits and till material comprising grey hard silty sand to sandy silt material with some rounded to sub-rounded cobbles and boulders were locally observed on the cut slopes along the forestry access road to Sliammon Lake that are covered by a thin layer of colluvial material.

Figure 3 – Glaciofluvial deposits comprising gravelly sand with some rounded cobbles

Figure 4 – Glacial till material observed along the forestry access road to the dam

## 2.4 Seismicity

The Sliammon Creek Hydro Project is located on the North American Plate, and about 230 km east of the Cascadia subduction zone that marks the boundary with the adjacent Juan de Fuca plate. Relatively large earthquakes may affect the project area; all project components shall be designed to meet CDA and NBCC requirements. Based on Natural Resources Canada and 2015 National Building Code of Canada, the 2% in 50 year seismic spectral acceleration (S(0.2)) in this area is about 0.566 of gravity and according to Peak Ground Acceleration (PGA) of 0.262g as shown in Table 1 and Figure 5.

Project structures should be designed to resist the site specific design earthquake events. This typically is the 1:2500 year event for the dam, which is classified as high hazard dam. The potential for liquefaction of foundations of major structures like the proposed powerhouse shall be considered.

**Table 1: Seismic Design Data Parameters**

| Return Period | Peak Ground Acceleration | Spectral Acceleration | | | |
|---|---|---|---|---|---|
| (Years) | PGA(g) | Sa(0.2) | Sa(0.5) | Sa(1.0) | Sa(2.0) |
| 1:2,475 | 0.262 | 0.566 | 0.527 | 0.360 | 0.236 |
| 1:1,000 | 0.176 | 0.384 | 0.352 | 0.231 | 0.146 |
| 1:475 | 0.121 | 0.269 | 0.241 | 0.150 | 0.091 |

Source: 2015 National Building Code Seismic Hazard Calculation

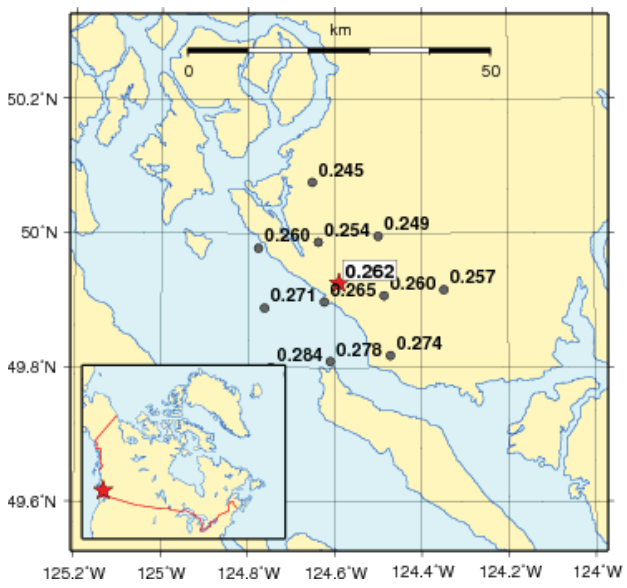



Figure 5 – Peak Ground Acceleration (PGA) for 2% in 50 years in the Sliammon Creek dam location

# 3. DAM INSPECTION ASPECTS

The preliminary geotechnical assessment and dam condition review is broken down into two main components: geotechnical and structural assessment. A general arrangement of the Sliammon dam and intake infrastructures is presented on Drawing SL-1010 in Appendix A.

## 3.1 Geotechnical assessment of the weir dam area

The concrete weir dam is located at the outlet mouth of the Sliammon Lake about 1.8 $km^2$in area. Bedrock has outcropped at the creek bed along the concrete weir dam and the dam structure is found on the massive quartz diorite with widely-spaced vertical and horizontal fractures. These kind of rocks are relatively resistant to weathering and erosion and have a relatively stable rock slopes. Bedrock has outcropped along the Sliammon Creek in downstream area of the dam to some distance or is covered by colluvial material.

Bedrock outcrop was observed on the right and left abutments of the dam up to about 1 m above the lake level, then covered by fluvial material and colluvial materials on upper slope area. Both dam abutments have a gentle slope with %15-40 and low terrain hazard but right abutment slopes will get steeper in downstream area of the dam. The upstream area of the dam axis is covered by rockfill and riprap material in cobbles to boulder sizes as shown in Figure 6.

Figure 6 – Upstream area of the weir dam

Debris material and jammed logs were observed at downstream of the weir dam and on both right and left banks of the dam as shown in Figure 7. There is evidence of debris flow erosion and impact to the weir dam and its abutments during storm events. The log boom was not installed in the upstream area of the weir to protect the dam structure from debris and log impact during storm events.

Figure 7 – Jammed debris material and logs downstream of the weir dam

Figure 8 – Debris and erosion evidence on the right abutment of the weir dam

## 3.2 Structural condition of the weir dam

The dam structure has been built as a concrete weir dam with W-shaped steel columns and angle supports used to install stop logs. A sluice way has been built in the middle of the weir dam to as a gate for flow control. The purpose of the weir dam is to store water in Sliammon Lake during summer using stop log installation to store and release surplus water gradually throughout the summer according to the WL conditions for DFO to maintain fish habitat. It is BBA's understanding that there are no engineering records regarding the weir dam design and construction records.

Based on the site visit and observations, BBA concludes that the dam was built on the exposed bedrock using a reinforced concrete weir structure with about 20-30 cm thickness. The weir dam has five openings to install stop logs on each sides of the central concrete sluice way, which equates to ten openings in total. There is no information regarding foundation preparation and dowel installation in the bedrock foundation to review how the weir dam connected to the foundation. This information is important to review the stability of the weir dam during normal operation and extreme conditions. BBA expects that DFO can supply this information.

Foundation concrete cracks were observed on downstream areas between the W-shape steel columns and support angles as shown in the Figure 9. These foundation concrete cracks have been generated by upstream forces pushing against the support angles on the downstream side, probably during storm events by impact forces from passing logs and debris over the weir. Given

the presence of these concrete foundation cracks in the downstream area due to debris impact forces, several mitigation measures are recommended to protect and maintain the stability of the weir dam.


Figure 9 – Concrete cracks were observed between W-shape columns and angles supports foundation

## 4. CONCLUSION AND RECOMMENDATIONS

Based on the site reconnaissance and dam inspection results, as well as discussions in the meeting dated February 26, 2016, BBA concludes that the concrete weir dam condition is general not bad. Some mitigation measures and repairs are required to maintain operation of the weir dam with stop logs installation for another year. Our findings and required dam mitigation measures were previously provided in an email to TCAI by BBA dated April 11, 2016 as presented in Appendix B. Foundation concrete cracks between W-shape steel columns and support angles are a result of upstream forces putting excessive pressure against the downstream support angles during storm events. Impact forces include the passing of logs over the weir. The following mitigation measures and repairs are recommended to maintain the dam operation with stop logs installation for another year:

- Stabilize the W-shaped weir columns and provide additional reinforcement support with an additional plate welded to each existing W steel column and steel angle support, as shown in the Figure 9.
- Install a protective log boom on the upstream area of the weir dam location to protect the weir from logs and debris flow impact as shown in Drawing SL-1010 (Appendix A).
- The existing ground elevation in the general vicinity of the intake structure location and lake access road, which sits at about 123 masl. Risk for wave run-up overflow and erosion could potentially cause debris flow and flooding to the access road and surrounding terrain. Mitigation is required by building a berm up to an elevation of 124m in this area, as shown in Drawing SL-1010 (Appendix A).
- Regular dam safety inspections will be carried out on a weekly basis by Tla'amin Nation staff with monthly inspections completed by BBA staff during the period of water storage to maintain IFRs for fish habitat under the current WL. Based on observations made during dam safety inspections, all jammed debris material collected on the upstream side of the protective log boom shall be removed. BBA is required to review and approve specific inspection forms currently used for dam safety inspection.

## 5. LIMITATIONS AND CLOSURE

The recommendations presented in this report are based on BBA's interpretation and understanding of the site conditions and the information provided by TCAI for the Sliammon Lake weir dam and intake. To properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the report in its entirety. BBA cannot be responsible for use, by any party, of portions of the report without reference to the whole report. In addition, any variations in structure locations or anticipated loading from those utilized in this report should be brought to our attention immediately. As such, changes may affect our conclusions. This report is an initial geotechnical assessment and dam inspection obtained from a site visit.

It must be stressed that an initial terrain and geotechnical assessment cannot guarantee that all slope hazards that might affect the Project will be recognized, or that failures will not occur in the future. More detailed terrain hazard assessment may be required in the future. BBA is not responsible for global stability around the dam location and Sliammon Lake and its impact on the weir dam. The risk analysis shall be undertaken within the framework of a terrain stability assessment as outlined in APEGBC (2003). The risk analysis should consider the likelihood of a fatality in the event of an incident as well as the likely economic consequences.

The report has been prepared following generally accepted geotechnical engineering principles and practices. The main purpose of this report was to describe subsurface soil, bedrock and groundwater conditions and provide an Initial Geotechnical Assessment for the Sliammon Project.

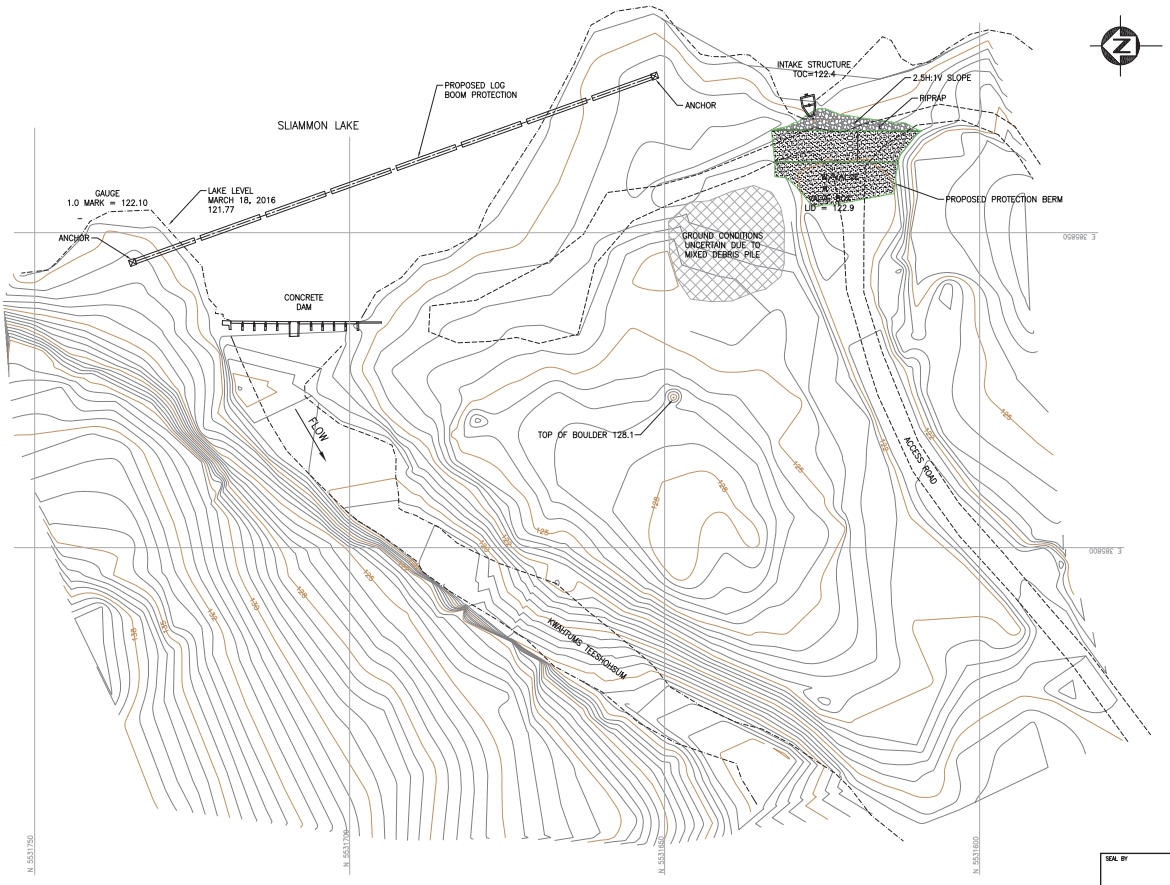
This report has been completed for the exclusive use of TCAI and other parties involved in the design and construction of the Project. Any use of the information contained in this report by third parties or for other than the intended purpose must first be approved in writing by BBA.

BBA trusts that this report satisfies the current requirements; however, questions that arise or further information requirements can be addressed by contacting the undersigned.

## 6. REFERENCES


- Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). 2003. Guidelines For Terrain Stability Assessments in the Forest Sector. Burnaby, BC. October 2003.
- British Columbia Dam Safety Regulation. 2000. B.C. Reg 44/2000. Water Act.
- Canadian Dam Association. 2007. Dam Safety Guidelines and Technical Bulletins.
- Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual
- US Bureau of Reclamation (USBR). 1987. Design of Small Dams.
- Natural Resources Canada (1994-2008). National Air Photo Library, Sliammon Lake Area.
- BCGC. (1976). Surficial Geology Map, NTS 1:250,000, Sheet 092F15.
- Digital Geology Map of British Columbia, (2005), Map Place.

# Appendix A: Sliammon Dam and Intake Infrastructure




NOTES:

1. CONTOURS GENERATED FROM EMERY AND RAE LAND SURVEYING Ltd. FILE No: 10436-02.
2. SURVEY GRID SHOWN IS UTM ZONE 10 NAD83.
3. COORDINATE STATIONS AND ELEVATIONS ARE IN METERS UNLESS OTHERWISE NOTED.
4. DAM REPAIR DETAILS ARE PROVIDED BY GEOTECHNICAL ENGINEER VIA EMAIL DATED APRIL 11, 2016.
5. GEOTECHNICAL ENGINEER IS REQUIRED TO REVIEW DAM REPAIR AND REQUIRED MITIGATION DURING AND AFTER CONSTRUCTION.

**FOR INFORMATION ONLY**

SCALE A 5 0 10 20 30 m

| DWG. NO. | DESCRIPTION | Rev. | REVISION DESCRIPTION | Date | Design | Drawn | Chk'd | App'd |
|---|---|---|---|---|---|---|---|---|
| REFERENCE DRAWINGS | | A | ISSUED FOR DISCUSSION | APR 11, 16 | AA | EZ | | |

DRAWN BY: EZ
DESIGN BY: AA
CHK'D BY: AT
APP'D BY: CW
DATE: APR 11, 2016
SCALE: AS SHOWN

CLIENT
TLA'AMIN NATION
SLIAMMON FIRST NATION

BBA

SEAL BY

SLIAMMON CREEK HYDROELECTRIC PROJECT
CONCRETE DAM & INTAKE GENERAL PLAN
DAM REPAIR AND REQUIRED MITIGATION

| PROJECT NO. | DRAWING NO. | REVISION |
|---|---|---|
| 80553 | SL-1010 | A |

File: Z:\03 Projects\80553-SL\05 Cad_GIS\Drawings\1000 - Diversion Weir and Intake Structure\SL-1010; Plotted: 4/11/2016 2:18 PM by EMMA ZENG; Saved: 4/11/2016 1:38 PM by EZENG

# Appendix B: Email to TCAI by BBA dated April 11, 2016 (Findings and required dam mitigation measures)

## Aboutalebi, Alireza

**From:** Aboutalebi, Alireza
**Sent:** April 11, 2016 4:34 PM
**To:** 'kelly.rankin@sliammondevcorp.com'
**Cc:** Taleb, Ali; Wilkinson, Chad; 'clint.williams@sliammon.bc.ca'
**Subject:** Sliamon Dam Inspection and Required Repairs and Mitigation
**Attachments:** SL-1010_RA.pdf; Figure 1 - Slimaon Dam Repair.png

Hi Kelly,

Thanks for the dam area survey and other information. As discussed in the meeting dated February 26, 2016, based on our dam inspection the concrete weir dam condition in general is not bad but some mitigation measures and repairs are required to maintain operation of the dam with stop logs installation for another year. Foundation concrete cracks were observed on downstream areas between W shape steel columns and support angles. These foundation concrete cracks generated by pushing the support angles to the downstream probably during storm events by impact forces from passing logs over the weir. The following mitigation measures and repairs are required to maintain dam operation with stop logs installation for another year:

- For the stability of the W-shaped weir columns and to provide additional reinforcement support, an additional horizontal steel angle and plate shall be welded to each existing W steel column and angle as shown in the Figure 1.
- The log boom protection shall be installed and placed on the upstream area of the weir dam location to protect the weir from logs and debris flow impact as shown in attached drawing.
- The existing ground elevation in the general vicinity of the intake structure location and access road area is about 123m and there is a risk for wave run-up overflow and erosion that cause debris flow to the downstream. Mitigation measure is required in this area by building a berm up to an elevation of 124m as shown in the attached drawing.
- Dam safety inspections will be carried out on a weekly basis by Tla'amin Nation staff and monthly by BBA staff during dam operation with stop logs as suggested by DFO. Based on dam safety inspection observation, all collected and jammed debris material and logs shall be removed on the upstream side of the log boom protection. Can you please send over any specific inspection forms that Tla'amin staff are currently using for dam safety inspection (if provided by DFO)?

Regards,
Alireza

**Alireza Aboutalebi, MSc., P.Eng.**
**Senior Geotechnical Engineer, Project Manager**

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