TETRA TECH EBA

OQM | Organizational Quality Management Program

2014 FORMAL ANNUAL DAM INSPECTION OF HB MINE TAILINGS STORAGE FACILITY SALMO, BC

PRESENTED TO

Central Kootenay Regional District

SEPTEMBER 15, 2014
ISSUED FOR USE
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CONSULTING ENGINEERS & SCIENTISTS · www.eba.ca

Tetra Tech EBA Inc.
150, 1715 Dickson Avenue
Kelowna, BC V1Y 9G6 CANADA
Tel 250.862.4832 Fax 250.862.2941

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ACRONYMS & ABBREVIATIONS

AMSL	Above Mean Sea Level
BC MoE	British Columbia Ministry of Environment
BCG	BGC Engineering Consultants
CDA	Canadian Dam Association
EPP	Emergency Preparedness Plan
KL	Klohn Leonoff Consulting Engineers
MEM	Ministry of Energy and Mines
OMS	Operations, Maintenance and Surveillance
RDCK	Regional District of Kootenay Boundary
SH	Sinkhole
SPT	Standard Penetration Testing
SRTM	Shuttle Radar Topography Mission

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Regional District of Central Kootenay and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the Regional District of Central Kootenay, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

1.1 General

Tetra Tech EBA Inc. (Tetra Tech EBA) was engaged by the Regional District of Central Kootenay (RDCK) to undertake the 2014 Annual Formal Inspection of the Hudson Bay Mine tailings storage facility (HB Dam) located near Salmo, BC.

Design, operation, closure, and reclamation of Mine Tailings Dams and Impoundments in British Columbia is regulated by the Health, Safety and Reclamation Code for Mines in British Columbia (2008) under the Mines Act (2003), while the BC Water Act (1996) regulates the licensing, diversion and use of water.

The Health, Safety and Reclamation Code for Mines in British Columbia (2008) requires that all major impoundments, water management facilities and dams be designed in accordance with the criteria provided in the Canadian Dam Association (CDA), Dam Safety Guidelines (2007), while the BC Water Act including all amendments up to BC Reg. 234/2013 (November 2013) requires all impoundments and dams be designed in accordance with the requirements of the BC Dam Safety Regulation including all amendments up to BC Reg. 163/2011 (November 30, 2011).

It is understood that activities at the site are conducted under Mine Permit Number M-218.

A dam safety review of the HB Dam was undertaken by Tetra Tech EBA in 2013. The results of which are presented in a report titled “Dam Safety Review of HB Mine Tailings Storage Facility, Salmo, BC” dated May 28, 2014. Based on the results of the dam safety review process, which includes a reconnaissance, analyses and assessment of the dam, a series of conclusions and recommendations were developed as summarized in the Dam Safety Review Conclusions and Recommendations Table presented as Appendix A along with priorities (Low, Medium, High or Very High) given in parentheses and current status. Low, medium, high and very high priority recommendations should be addressed within 5, 3, 1 and 0.5 year(s) respectively.

The following process was employed during the implementation of the Annual Formal Dam Inspection.

- Relevant data was reviewed by Tetra Tech EBA and a list of questions/concerns prepared.
- A meeting was held, attended by Mr. Michael J. Laws P.Eng., and Ms. Amy Wilson and Mr. Mike Morrison of RDCK (who is familiar with the operation the dam), to discuss the operation of the facility and the questions/concerns.
- A visit to the site was undertaken by Mr. Laws with Ms. Wilson.
- Preparation of this Annual Formal Inspection report, including findings, recommendations and photographs illustrating the condition of the dam at time of inspection.

A dam inspection form was completed for the dam and is included as Appendix B. As well, photographs of the dam taken at the time of the inspection are included in this report.

1.2 Site Description

HB Dam is a zoned earthfill dam that is situated approximately 7 km to the south of the Township of Salmo, and 0.5 km east of the Crowsnest Highway (BC 3) at approximately Map Grid (NAD83), Zone 11 co-ordinates 481841E, 5442021N, as shown on the attached Figure 1.2. The dam is located in a natural valley, and the water from the impoundment discharges into a creek that is a tributary of the Salmo River.

The dam, which currently impounds water and tailings, has a crest length of approximately 240 m and a maximum height of 27 m from the toe to the crest at an elevation of approximately 713 m above mean sea level (AMSL) (Based on Shuttle Radar Topography Mission (SRTM)).

1.3 Dam Design, Construction and Modification

HB Dam was initially constructed in 1955 in order to retain and store tailings produced by the HB Mine, which was in operation from 1955 to 1966 and resumed again between 1974 and 1978. The dam was raised progressively during the mine life to accommodate the influx of tailings from the mine, via downstream construction methods.

The dam is an earthfill embankment that was constructed utilizing materials borrowed from beyond its east and west abutments. The material from the east and west abutment vary slightly, with the materials from the east typically comprising silty fine to medium sand, while the materials from the west is typically a well graded till (silt, sand, gravel, cobbles, and boulders).

The initial dam crest was at 759 m (2492 ft.), and was constructed with an earthfilled timber crib wall at the base of the downstream toe. In 1964 the timber crib failed and deformed 3.0 to 4.6 m downstream. After this failure, concrete pipe drains were added to the downstream toe of the dam, and an earthfill berm was constructed to stabilize the crib structure. In 1967 the dam crest was at a height of 762 m (2500 ft.) from progressive raises during the mine life.

The flow of water from the upstream to the downstream was controlled via two timber decant towers and two 600 mm (24 inch) diameter steel pipes discharging into the outlet creek.

In 1973, prior to the resumption of mining activities, Cominco retained Golder Associates Ltd. (Golder) to perform stability analyses on the tailings dam. An investigation comprising of three boreholes, was conducted to determine the geotechnical characteristics of the dam and its foundation. One borehole was located on the dam's crest and two were drilled on the downstream slope of the dam, with standpipe piezometers installed in all three boreholes. Standard penetration testing (SPT) was performed during the drilling program with an average SPT N value of 10 blows/ft. established for the dam material. The depth to bedrock was established to be 20.72 m below the existing dam crest. The Golder borehole logs and associated laboratory testing data can be found in the 2013 Dam Safety Review Report.

In their 1974 report, Golder recommended that a downstream filter blanket be constructed and that the dam should be raised by the downstream method. Based on this recommendation, the dam was raised 3.05 m (10 ft.) and the downstream filter blanket was constructed between 1974 and 1975. In 1976 Cominco retained Golder to perform an assessment of the area surrounding the dam to assess potential borrow materials, as well as to assess the dam stability for future dam extensions. Based on this study, the dam was raised 4.57 m (15 ft.) in 1977. In addition to the raising of the dam in 1977, the decant towers were filled with concrete and replaced with a new spillway and manhole, the manhole structure comprised a 915 mm (36 inch) diameter steel pipe designed to pass a maximum flow of 2.26 m^3/second.

In 1981 David Minerals retained Klohn Leonoff Consulting Engineers (KL) to investigate the feasibility of using the HB Dam to retain one million tonnes of tailings. This report concluded that the existing structure had an available storage capacity for 790,000 tonnes of tailings. Based on anecdotal evidence, it is believed that these additional tailings were placed in the HB Dam impoundment.

In 2000, RDCK commissioned BGC Engineering Consultants (BGC) to prepare a decommissioning plan for HB Dam. BGC undertook a geotechnical site investigation that comprised two boreholes and eight testpits, which can be found in that attached Appendix B2 as well as a site survey. A pond sounding was conducted in the fall of

2000, which indicated that the maximum available storage to the dam crest was 200,000 m³. The primary source of water recharge to the tailings pond is surface runoff. Based on the study, BGC recommended:

- Construction of an open channel spillway and decommissioning of the 1977 spillway.
- Construction of a 10 m wide toe berm to meet the dam stability requirements.
- Construction of a 1.5 m thick rockfill blanket to provide adequate drainage.
- The addition of rip-rap to upstream slopes.

The 'decommissioning' of the dam was undertaken in 2005 by RDCK in accordance with the recommendations provided by BGC in their 2000 report. In addition to this work, the crest of the dam was re-graded with a camber. The dimensions of the dam post 'decommissioning' were:

- 240 m long.
- 25 m high, with a crest elevation of approximately 713 m AMSL.
- Crest width of between 6 and 7 m.
- Overall upstream slope of 1.5H:1V and Downstream slope of 2H:1V.

The toe berm dimensions were:

- 12 m wide.
- 12 m high.
- Downstream slope of 2.5H:1V.

The new spillway consisted of a 90 m long side channel excavated into bedrock at the right abutment and a rip-rap lined outlet channel approximately 120 m long.

During the early summer of 2012, an embankment slough occurred sometime between routine inspections that were conducted on June 25, 2012 and July 2, 2012. On July 6, 2012 the presence of a sinkhole (SH-1) was identified at the toe of the upstream face of the embankment and on July 18, 2012 a second sinkhole (SH-2) was discovered approximately 12 m west of the first identified sinkhole. These sinkholes were only detected once the water level of the pond was sufficiently reduced to expose the features completely. A 50 mm diameter standpipe was found at the location of SH-1, which had not been recorded in previous reports and had also not been properly decommissioned. It was confirmed that a continuous seepage path existed between SH-1 and SH-2. The standpipe was removed to a depth of 4 m and core material was placed in 300 mm lifts to the crest and upstream slope elevations.

The embankment slough was repaired by reconstructing the core material to its original height and width using locally sourced glacial till. A shear key was built at the toe of the sloughed area and a coarse rock blanket was placed over on the downstream face of the reconstructed core material, a v-notch weir was also installed at the toe of the dam (Tetra Tech EBA 2012).

2.0 BACKGROUND REVIEW

Given that the HB Dam had very recently undergone a formal Dam Safety Review in accordance with CDA Guidelines by Tetra Tech EBA, only documentation produced since the dam safety review was conducted or utilized in the continual operation of the facility were reviewed. The following documentation relating to the HB Dam was briefly reviewed as part of the Formal Annual Inspection:

- Routine Inspections Reports by RDCK for 2013/14 including piezometer readings.
- Emergency Preparedness Plane (EPP), HB Mine Tailings Storage Facility, Salmo, British Columbia, April 2011, Conestoga-Rovers & Associates.
- Operation, Maintenance & Surveillance Manual, HB Mine Tailings Storage Facility, Salmo, British Columbia, April 2011, Conestoga-Rovers & Associates.

3.0 SITE RECONNAISSANCE

3.1 General

A site reconnaissance of the HB Dam was undertaken by Tetra Tech EBA on the morning of May 15, 2014, Tetra Tech EBA's site representative was Mr. Michael Laws who was accompanied by Ms. Amy Wilson of RDCK. The weather at the time of the site inspection was fine and clear.

EBA inspected the crest, upstream slope, downstream slope, downstream toe area, abutments and spillway structure of the dam. Key observations are as follows:

- An emergency draw down pump is positioned at the left abutment of the dam. From conversations with RDCK staff it is understood that it is tested twice a year (Photo 1).
- The dam has been recrested since the 2013 Dam Safety Review (Photo's 2 and 7).
- Brush vegetation that was growing on the upstream slope of the dam has been removed (Photo 2).
- The existing reservoir staff gauge is in imperial units and is proposed to be replaced by RDCK with a metric gauge (Photo 4).
- The rip-rap on the upstream slope of the dam has moved exposing the underlying filter fabric (Photo 5).
- A log boom is in place at the spillway channel entrance (Photo 6).
- Warnings signs have been placed at both the left and right abutments of the dam (Photo 7).
- Some rip-rap used in the 2012 dam repair has been replaced in the spillway outlet channel and some check dams constructed (Photo's 9 and 11).
- The top of the toe berm, in proximity to Piezometer P3, is dry.
- Seepage observed at the left abutment toe is clear.
- A minor surface slough occurred during the 2014 freshet above the right abutment toe berm. No active seepage was observed in the area at the time of the dam inspection (Photo 13).
- Water is pooling (assumed to be due to condensation) in the P5/P6 piezometer casing (Photo 14).

3.2 Piezometers

As part of the site reconnaissance the four functioning standpipe piezometers in the dam were read.

The location of the four piezometers is shown on the attached Figure 3.2a.

The readings recorded during the site inspection, along with those undertaken by RDCK over the past 12 months are presented on the attached Figure 3.2b.

Based on the review of current and historical piezometer readings, no significant changes were noted, and therefore, it is assumed that the interior drainage of the dam is still functioning as intended.

4.0 CONSEQUENCE CLASSIFICATION REVIEW

The dam is currently classified as a “Low” consequence dam based on application of the CDA 1999 Dam Safety Guidelines by BCG during the last dam safety review in 2002. This rating now equates to a “Significant” consequence dam rating in terms of the newer CDA 2007 Dam Safety Guidelines. A “Significant” classification (CDA 2007) suggests that in the event of a dam failure, no fatalities to the permanent population are anticipated and only limited socioeconomic, financial and environmental damages are expected.

A review of the consequence classification of the dam conducted by Tetra Tech EBA as part of the 2013 dam safety review, recommended that the consequence classification of the HB Dam be increased to “Very High” based on the estimated economic and environmental loses that would occur due to a breach of the dam.

5.0 DAM SAFETY MANAGEMENT REVIEW

5.1 Operations, Maintenance And Surveillance Manual

An Operations, Maintenance and Surveillance (OMS) Manual is a means to provide both experienced and new staff with the information they need to support the safe operation of a dam (CDA, 2007).

EBA has undertaken a review of the OMS prepared by Conestoga-Rovers & Associates dated April 2011. The OMS also includes a customized inspection form for the facility. In general the existing OMS plan meets the current BC MoE Dam Safety requirements for an OMS plan.

EBA has noted the following general areas for improvement in the OMS Manual dated April 2011:

- If the dam consequence classification rating is increased, the OMS Manual will require revision to reflect the updated classification.
- The OMS Manual should include a plan indicating the location of all instrumentation and areas of seepage to be monitored during inspections.
- The OMS Manual should include the most updated drawings of the dam reflecting the modifications made to the dam in 2012.

5.2 Emergency Preparedness Plan

The objective of an Emergency Preparedness Plan (EPP) is to provide the basic information that allows for the planning and coordination by municipalities, Royal Canadian Mounted Police, local police, provincial agencies, utility owners and transportation companies and other parties that would be affected by a major flood (CDA, 2007).

EBA has undertaken a brief review of the final draft EPP prepared by Conestoga-Rovers & Associates dated April 2011. In general the draft EPP meets the current BC MoE Dam Safety requirements for an EPP.

EBA has noted the following general areas for improvement in the final draft EPP dated April 2011:

- If the dam consequence classification rating is increased, the EPP will require revision to reflect the updated classification.
- The EPP should include the inundation plan developed during the 2013 Dam Safety Review.

6.0 MINIMUM FREQUENCY OF SAFETY ACTIVITIES

The most recent (September 12, 2011) amendment (BC Reg. 163/2011) to the BC Dam Safety Regulation provides recommended minimum frequency of dam safety activities as provided in Table 1 below.

In general the RDCK is meeting or exceeding the minimum recommended frequency of dam safety activities as specified in the BC Dam Safety Regulation, however it is unknown when the contact information was last updated in the EPP.

Table 1: Comparison of Dam Consequence Classifications

Item	Activity	Frequency of Activity			
		Extreme Classification	**Very High and High Classification**	**Significant Classification**	**Low Classification**
1	Site surveillance	Weekly[1]	Weekly[1]	Monthly[1]	Quarterly
2	Formal inspection	Semi-annually	Annually	Annually	Annually
3	Monitor instrumentation	Annually unless otherwise specified in the OMS manual	Annually unless otherwise specified in the OMS manual	Annually unless otherwise specified in the OMS manual	If and when required by a dam safety officer
4	Test operation of outlet facilities, spillway gates and other mechanical components	Annually unless otherwise specified in the OMS manual	Annually unless otherwise specified in the OMS manual	Annually unless otherwise specified in the OMS manual	Annually
5	Update the emergency contact information in the EPP	Annually	Annually	Annually	Not applicable
6	Review, and revise if necessary, the OMS manual and the EPP	Every 7 years	Every 10 years	Every 10 years	Not applicable
7	Conduct dam safety review and submit dam safety report	Every 7 years	Every 10 years	Not applicable	Not applicable
8	Review downstream conditions, as set out in Section 6.1, and notify a dam safety officer of any change in classification	Annually	Annually	Annually	Annually

1 The frequency of visual inspections may be reduced if provided for in the OMS manual.

7.0 RECOMMENDATIONS

A summary of the recommendations resulting from the 2014 Formal Annual Dam Inspection and their priority (Low, Medium, High or Very High) are given in parentheses is provided below. Low, medium, high and very high priority recommendations should be addressed within 5, 3, 1 and 0.5 year(s) respectively.

7.1 Background Review

- There are no recommendations from this area of review.

7.2 Consequence Classification

- As recommended in the 2013 Dam Safety Review, due to the estimated economic loses that would occur due to a breach of the dam it is recommended that the consequence classification of the HB Dam be increased to "Very High". Any decision to modify the consequence classification rating must be confirmed by the Ministry of Energy and Mines (Very High).

7.3 Site Reconnaissance

- A snow shed should be built over the emergency draw down pump and it should be protected with a tarpaulin to facilitate easy access and in the event of an emergency in the freshet. (High).
- A drainage hole should be drilled in the side of the P5/P6 piezometer casing (High).
- The area where the shallow slump occurred above the right toe berm should be continued to be monitored. Should any further slope movement occur during the 2015 freshet the area should be armoured with riprap (High).
- The geotextile exposed along the upstream face of the dam should be secured with the placement of additional riprap (High).

7.4 Dam Safety Management Review

- If the dam consequence classification rating is increased, the OMS Manual will require revision to reflect the updated classification (High).
- The OMS Manual should include a plan indicating the location of all instrumentation and areas of seepage to be monitored during inspections (High).
- The OMS Manual should include the most updated drawings of the dam reflecting the modifications made to the dam in 2012 (High).
- If the dam consequence classification rating is increased, the EPP will require revision to reflect the updated classification (High).
- The EPP should include the inundation plan developed during the 2013 Dam Safety Review (High).

8.0 CLOSURE

The recommendations and comments presented herein are based on observations made on-site, communications with RDCK personnel, and Tetra Tech EBA's on-site knowledge of the site. We trust that these comments and recommendations meet your present requirements. Please contact the undersigned should you have questions or comments.

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

Prepared by:
Michael J. Laws, P.Eng.
Geotechnical & Dam Safety Engineer
Engineering Practice
Direct Line: 250.862.3026 x230
michael.laws@tetratech.com

Reviewed by:
Scott Martin, P. Eng.
Vice President
Engineering Practice
Direct Line: 250.862.3026 x260
scott.martin@tetratech.com

/bi

REFERENCES

British Columbia Dam Safety Regulation, BC Reg. 44/2000, including amendments up to BC Reg. 163/2011, September 12, 2011.

British Columbia Ministry of Environment, 2010. Dam Safety Review Guidelines – Version 2.

Canadian Dam Association, 2007. Dam Safety Guidelines.

Canadian Dam Association, 2007. Technical Bulletin – Hydrotechnical Considerations for Dam Safety

Canadian Dam Association, 2007. Technical Bulletin – Seismic Hazard Considerations for Dam Safety

Conestoga-Rovers & Associates. April 2011. Emergency Preparedness Plane (EPP), HB Mine Tailings Storage Facility, Salmo, British Columbia.

Conestoga-Rovers & Associates. April 2011. Operation, Maintenance & Surveillance Manual, HB Mine Tailings Storage Facility, Salmo, British Columbia.

Tetra Tech EBA Inc., May 28, 2014. Dam Safety Review of HB Mine Tailings Storage Facility, Salmo, BC.

FIGURES

LEGEND

- Regional District Boundary

NOTES
Base data source:
Imagery (date unknown) provided by Bing.
Regional District boundary downloaded from GeoBC.

STATUS
ISSUED FOR USE

HB DAM - 2013 DAM SAFETY REVIEW

Site Location

PROJECTION UTM Zone 11N	**DATUM** NAD83	**CLIENT** Central Kootenay Regional District	
Scale: 1:15,000 200 100 0 200 400 Meters			
FILE NO. Figure 1.2 - Site Location.mxd		TETRA TECH EBA	
PROJECT NO. K13103109-01	**DWN** SB / **CKD** SP / **APVD** MJL / **REV** 0		**Figure 1.2**
OFFICE Tt EBA-KELOWNA	**DATE** January 28, 2014		

Q:\Kelowna\GIS\ENGINEERING\K131\K13103109_HB Dam\Maps\ISSUED FOR REVIEW\Figure 1.2-1 - Site Location.mxd modified 1/28/2014 by sarah.blair

LEGEND

- Borehole - Golder (1973)
- Borehole - BGC (2000)
- Testpit - BGC (2000)
- Piezometer
- New Water Level Gauge

NOTES
Base data source:
Imagery (date unknown) provided by Bing.
Locations of Piezometers, and Water Level Gauge should be considered approximate as they have been digitized from a PDF of a site survey by Ward Engineering and Land Surveying Ltd. (file # 12-069, dated June 7, 2013).

Locations of the testpits and boreholes should be considered approximate as they have been digitized from a PDF of a site survey by Sproulers Enterprises Ltd., dated Oct. - Nov. 2000.

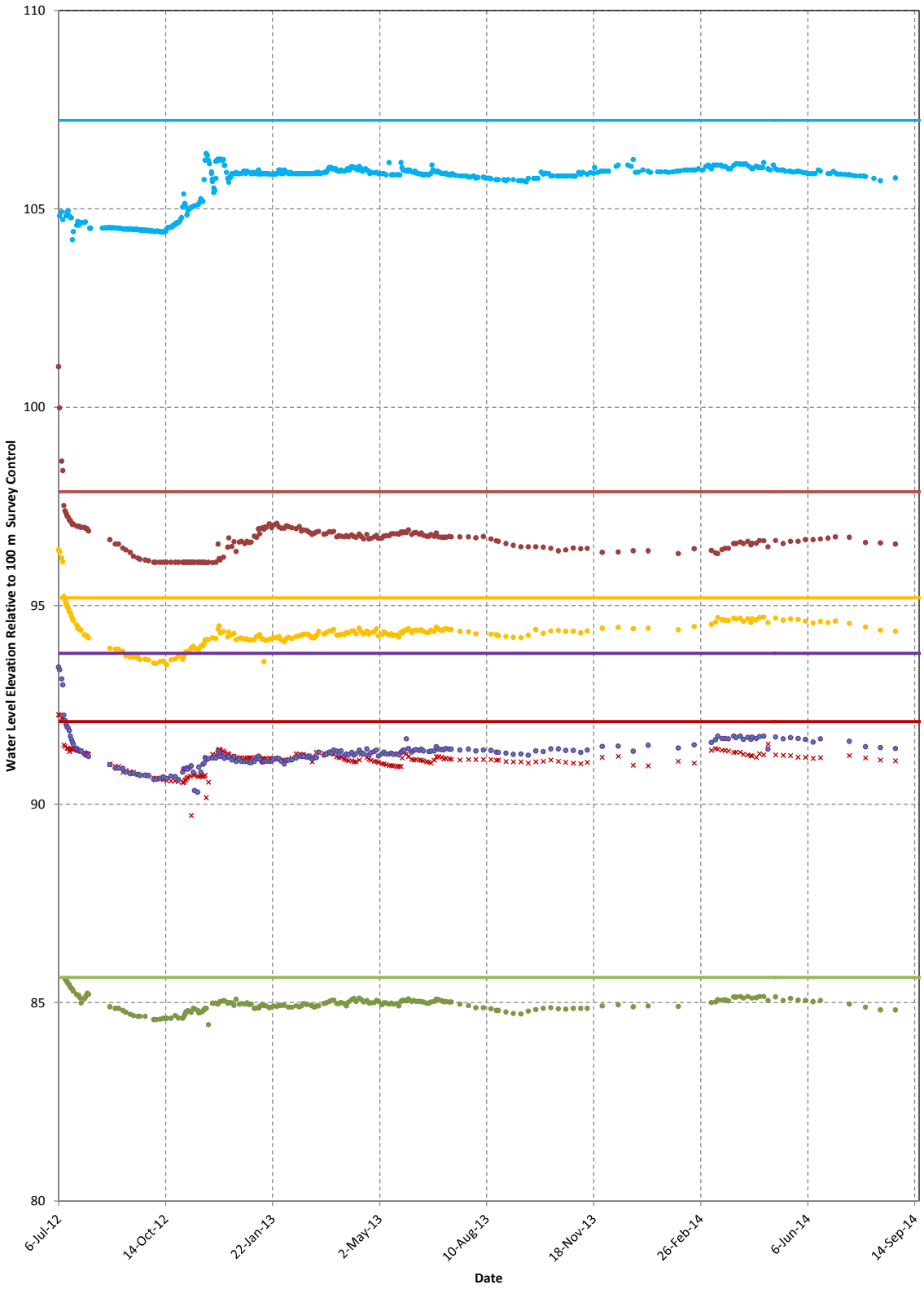
STATUS
ISSUED FOR USE

HB DAM - 2013 DAM SAFETY REVIEW

Instrumentation and Historical Geotechnical Investigation Testing Locations

PROJECTION UTM Zone 11N		**DATUM** NAD83	**CLIENT** Central Kootenay Regional District
Scale: 1:1,000 20 10 0 20 Meters			TETRA TECH EBA
FILE NO. Figure 3.7a- Site Instrumentation.mxd			
PROJECT NO. K13103109-01	**DWN** SB / **CKD** LM / **APVD** MJL / **REV** 1		**Figure 3.2a**
OFFICE KELOWNA	**DATE** March 28, 2014		

Q:\Kelowna\GIS\ENGINEERING\K13\K13103109_HB Dam\Maps\ISSUED FOR REVIEW\Figure 3.6-1 - Site Instrumentation.mxd modified 3/28/2014 by sarah.blair



LEGEND

- Reservoir Level
- P1
- P2
- P3
- P5
- P6
- Reservoir Level (Historical)
- P1 (Historical)
- P2 (Historical)
- P3 (Historical)
- P5 (Historical)
- P6 (Historical)

NOTES

STATUS
ISSUED FOR USE

CLIENT

Regional District Central Kootenay

TETRA TECH EBA

2014 FORMAL ANNUAL INSPECTION OF HB DAM, SALMO, BC

Piezometer Readings from P1, P2, P3, P5, and P6

PROJECT NO.	DWN	CKD	APVD	REV
K13103109-03	MJL	SM	SM	0

OFFICE	DATE
KELOWNA	September 13, 2014

Figure 3.2b

PHOTOGRAPHS

Photo 1	Emergency draw down pump at left abutment of the dam.
Photo 2	Dam crest and upstream slope from left abutment. Note recrested since 2013 Dam Safety Review, and vegetation removed from upstream slope.
Photo 3	Downstream slope from left abutment.
Photo 4:	Reservoir level gauge.
Photo 5:	Rip-rap moving on upstream slope, exposing geotextile.
Photo 6:	Log boom in place.
Photo 7:	Dam crest from right abutment. Note warning sign in place.
Photo 8:	Spillway channel at right abutment.
Photo 9:	Spillway outlet channel.
Photo 10:	Downstream slope of dam from right abutment.
Photo 11:	Spillway outlet channel.
Photo 12:	V-Notch weir located at left abutment toe of dam.
Photo 13:	Shallow slump above right toe berm.
Photo 14:	Water ponded in P5/P6 piezometer casing.
Photo 15:	Emergency drawdown pump hose.

Photo 1: Emergency draw down pump at left abutment of the dam.

Photo 2: Dam crest and upstream slope from left abutment. Note recrested since 2013 Dam Safety Review, and vegetation removed from upstream slope.

Photo 3: Downstream slope from left abutment.

Photo 4: Reservoir level gauge.

Photo 5: Rip-rap moving on upstream slope, exposing geotextile.

Photo 6: Log boom in place.

Photo 7: Dam crest from right abutment. Note warning sign in place.

Photo 8: Spillway channel at right abutment.

Photo 9: Spillway outlet channel.

Photo 10: Downstream slope of dam from right abutment.

Photo 11: Spillway outlet channel.

Photo 12: V-Notch weir located at left abutment toe of dam.

Photo 13: Shallow slump above right toe berm.

Photo 14: Water ponded in P5/P6 piezometer casing.

Photo 15: Emergency drawdown pump hose.

APPENDIX A

DAM SAFETY REVIEW OBSERVATIONS CONCLUSIONS AND RECOMMENDATIONS

Dam Safety Review of HB Mine Tailings Storage Facility – Observations, Conclusions and Recommendations

Task	Observations and Conclusions	Recommendations	Completed/Outstanding
Background Review	▪ The original dam design drawings were prepared using different assumed datums. ▪ Seepage at the toe of the dam has been noted throughout the life of the dam. ▪ The dam filter zone does not extended to above the maximum pond operating level. ▪ Burrowing from animal activity has been noted on the downstream slope of the dam has been noted throughout the life of the dam. ▪ No obvious signs of historical or current slope instability of the reservoir sides slopes were observed in the review of the available aerial photography.	▪ An updated drawing of the 2012 topographical survey of the dam should be prepared, utilizing mean sea level as the elevation datum, to avoid confusion with previous surveys and enable better correlation with historical data (High).	Outstanding
Site Reconnaissance	▪ Some brush vegetation is growing in the upstream slope of the dam. ▪ Minor rutting from vehicle traffic noted on the dam crest. ▪ Minor animal activity (tracks) was noted on the dam crest. ▪ The spillway channel inlet has no log boom. ▪ Noted rip-rap protection missing in spillway outlet channel.	▪ The brushy vegetation of the upstream slope of the dam should be removed (High). ▪ The rip-rap protection missing in spillway outlet channel should be replaced (Very High). ▪ A log boom should be installed across the spillway inlet channel entrance (Very High).	Completed Outstanding Completed
Consequence Classification	▪ The dam breach inundation mapping indicates that a total area of approximately 0.73 km² would be impacted in the event of a dam breach, including the Crowsnest Highway (BC 3) depositing approximately 714,000 m³ of tailings. ▪ One permanent residence and the Crowsnest Highway where there is likely to be a temporary population are situated in the immediate downstream flood inundation zone where flood levels are expected to reach several metres, where an estimated potential loss of life of three people would occur in the event of a dam breach assuming a warning of less than 15 minutes. ▪ Economic consequences resulting from an failure of the embankment including, cleanup of deposited tailings, restoration of contaminated land and reconstruction of the HB Dam have estimated to be in the range of $45.7 M to $83.4 M.	▪ Based on the estimated economic loses that would occur due to a breach of the dam it is recommended that the consequence classification of the HB Dam is increased to "Very High". However any decision to modify the consequence classification rating must be confirmed by the Ministry of Energy and Mines (Very High).	Outstanding
Failure Mode Assessment	▪ The plausible failure modes of the dam are; overtopping, post seismic upstream and downstream slope instability and internal erosion through the embankment.	▪ There are no recommendations in this area of review.	n/a
Geotechnical Assessment	▪ Liquefaction induced vertical settlements of no greater than 225 mm would occur assuming that all of the 1955 embankment fill layer could liquefy. ▪ Results of the static stability analysis indicated that the embankment meets CDA criteria for normal static and seismic loading conditions. ▪ The dam is assumed to be Zoning Category 3 and therefore vulnerable to internal erosion based on zoning with the embankment materials likely to comprise silty sands and gravels with less than 30% fines that are extremely erodible. Based on the results of the internal erosion screening assessment potential failure modes could include; backward erosion and suffusion of the core; a crack or concentrated leak could form due to, desiccation by drying in the crest, due to freezing in the crest, and the presences of conduits through the embankment and poorly compacted fills.	▪ A feasibility engineering study should be undertaken to assess various modifications that could be made to the embankment to reduce its vulnerability to internal erosion. Depending on the outcome of this study it is possible that a geotechnical investigation would be required during detailed design to confirm the geotechnical properties of the existing dam filter and core materials (Medium).	Outstanding
Hydrotechnical Assessment	▪ Dam breach analysis results indicate that the HB Dam should have a "Very High" consequence classification. The CDA guidelines recommend an Inflow Design Flood (IDF) for a "Very High" consequence dam of ⅔ of the way between a 1,000-year flood and the Probable Maximum Flood (PMF). The peak inflow to the HB Dam during the IDF was determined to be 39.3 m³/s, which would be safely passed by the spillway. ▪ The dam should have freeboard such that 95% of the waves do not overtop the dam crest during a 1,000-year wind event under maximum normal reservoir conditions or during a 2-year wind event under design flood conditions (IDF). These values were calculated at 1.09 m and 0.38 m, respectively. ▪ The HB Dam does have enough available freeboard to meet the minimum requirement for the design flood considered ("Very High") and would not be overtopped by waves from a 1,000-year wind event under normal reservoir conditions.	▪ There are no recommendations in this area of review.	n/a
Dam Safety Management	▪ The existing EPP and OMS Manual have not been updated since they were put together in 2011. Multiple changes have occurred since these documents were put together, including, changes of personnel, modification of the embankment and spillway, addition of extra instrumentation and changes to design criteria.	▪ The existing EPP and OMS Manual should be updated to reflect changes that have occurred since these documents were put together, incorporate additional information developed and any changes of personnel that may have occurred (Very High).	Outstanding

APPENDIX B
DAM INSPECTION FORM

INSPECTION FORM

HB MINE TAILINGS STORAGE FACILITY

PERMIT M-218

Date: _____ **Name/Company:** M. Laws (Tetra Tech EBA) & A. Wilson (RDCK)

Inspection Type (circle one): Routine Visual (Formal) **Weather:** Fine

Supplies: Inspection form, clip board, tape measure, camera, pencils, flashlight, and water level

Facility Component	***Satisfactory Condition?*** ***Yes***	***No***	***Observation*** (Picture # & description, measurement, sketch, location, comments on deficiencies)
Tailings Pond			
Shoreline	☒	☐	
Erosion	☒	☐	
Reservoir	☒	☐	Note any obstruction or excessive debris in reservoir.
Crest			
Vegetation	☒	☐	
Animal Activity	☒	☐	
Rutting/Grading/ Surface Drainage	☒	☐	
Slide/Slump	☒	☐	
U/S Slope			vegetation removed from upstream slope
Vegetation	☒	☐	
Animal Activity	☒	☐	
Erosion/ Erosion Control	☒	☐	
Slide/Slump/Cracks/ Settlement	☒	☐	
D/S Slope			
Vegetation	☒	☐	
Animal Activity	☒	☐	some elk/deer tracks
Erosion/Erosion Control	☒	☐	
Slide/Slump/Cracks/ Settlement	☒	☐	shallow slump above right toe berm, appears to be superficial no obvious signs of seepage
Seepage/Drainage	☒	☐	
Toe Berm	☒	☐	surface of toe berm dry
Unnamed Creek	☒	☐	
Abutements			
Vegetation	☒	☐	
Animal Activity	☒	☐	
Erosion/Erosion Control	☒	☐	
Slide/Slump/Cracks/ Settlement	☒	☐	
Seepage/Drainage	☒	☐	seepage at left abutment toe clear

INSPECTION FORM

HB MINE TAILINGS STORAGE FACILITY

PERMIT M-218

Facility Component	*Satisfactory Condition?* Yes	No	*Observation* (Picture # & description, Measurement, Sketch, Location, Comments on Deficiencies found)
Spillway Entrance	☒	☐	
Erosion/Erosion Control	☒	☐	
Channel Walls/Stilling Basin	☒	☐	Note any obstruction or excessive debris in spillway entrance/channel.
Flow?	☐yes → Flow Rate: 0.5 - 1.0 m3/s		
	☐no → Reservoir drawdown below spillway sill level: _____		
Flume Line (min. annually) North of Emerald Mine Rd.	☐	☐	
Tailings Deposition Area	☐	☐	Note any signs of erosion.

Instrumentation

Meters Below Top of Riser (mBTOR) or Below Ground Surface (BGS)

P1 15.63	mBTOR / ~~mBGS~~	
P2 13.73	mBTOR / ~~mBGS~~	Survey Markers:
P3 4.29	mBTOR / ~~mBGS~~	
P4 _____	mBTOR / ~~mBGS~~	v-notch weir: 5.1 cm
P5 3.69	mBTOR / ~~mBGS~~	Water Level Gauge: _____ m below reference point
P6 3.31	mBTOR / ~~mBGS~~	

Performance

☒ normal → File with RDCK records.

☐ abnormal → Advise Services & Waste Management Supervisor and evaluate. Notify Dam Safety Officer if unsafe dam conditions.

Notes:

Signature: _____

APPENDIX C

TETRA TECH EBA'S GENERAL CONDITIONS - GEOTECHNICAL REPORT

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 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 Tetra Tech EBA’s Client. Tetra Tech 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 Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech 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.

4.0 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. Tetra Tech 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.

5.0 LOGS OF TESTHOLES

The testhole 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.

6.0 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. Tetra Tech 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.

7.0 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.

8.0 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.

9.0 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.

10.0 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.

11.0 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.

12.0 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.

13.0 SAMPLES

Tetra Tech 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.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.