Klohn Crippen Berger

Teck Resources Limited

Bullmoose Mine

2018 Dam Safety Inspection

Bullmoose Tailings Dam

CANADA'S BEST MANAGED COMPANIES Platinum member

ISO 9001
ISO 14001
OHSAS 18001

M09893A08.730

March 2019

March 26, 2019

Teck Resources Limited
Legacy Properties
601 Knighton Road
Kimberley, British Columbia
V1A 1C7

Ms. Kathleen Willman, P.Eng.
Manager Engineering and Remediation, Environmental

Dear Ms. Willman:

Bullmoose Mine
Bullmoose Tailings Dam
2018 Dam Safety Inspection

We are pleased to submit the 2018 Dam Safety Inspection Report for the Bullmoose Tailings Dam.

Please contact us if you have any questions regarding this report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Robert W. Chambers, P.Eng.
Project Manager
Senior Geotechnical Engineer, Principal

MC/OL/NG:jc

190326R-BTD DSI Report.docx
M09893A08.730

Teck Resources Limited

Bullmoose Mine

2018 Dam Safety Inspection

Bullmoose Tailings Dam

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Resources Limited (Teck) on behalf of the Bullmoose Operating Corporation to complete the 2018 Dam Safety Inspection (DSI) of the Bullmoose Tailings Dam (BTD) to comply with Section 10.5.3 of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (also referred to as the Code) (EMPR 2017). This report was prepared following:

- Ministry of Energy, Mines and Petroleum Resources (EMPR), British Columbia (BC) Section 4.2 "Annual Tailings Facility and Dam Safety Inspection Report" of the 2016 HSRC Guidance Document.
- EMPR Guidelines for Annual Dam Safety Inspection Report.
- Teck's 2014 Guideline for Tailings and Water Retaining Structures (TWRS).

The 2018 DSI was completed by the Engineer of Record (EoR), KCB representative Mr. Bob Chambers, P.Eng., on May 29, 2018. Teck have designated Mr. Bruce Donald, P.Eng., as the Tailings Storage Facility (TSF) Qualified Person, as defined by the Code, for the BTD. The 2018 event-driven and routine monthly visual inspections were completed by Facility Surveillance Officers (FSOs) Mr. Rob Muise and Mr. Ray Proulx of Teck.

The summary is provided solely for the purposes of overview. Any party who relies on this report must read the full report. The summary omits a number of details and context which are crucial to the proper application and interpretation of this report.

Summary of Facility Description

The Bullmoose Mine has been closed since 2003. The mine site is about 45 km northwest of Tumbler Ridge in northeastern BC. The BTD is classified as being under "Closure-Passive Care" based on Canadian Dam Association (CDA) (2014) guidelines. Key aspects of the facility include:

- The BTD is a horseshoe-shaped structure, with approximately 4.6 million m^3 storage capacity, situated on the south flank of the broad valley bottom, with South Bullmoose Creek to the west and West Bullmoose Creek to the north.
- The BTD is constructed of compacted coarse coal rejects (CCR) up to a final crest elevation of 1,123 masl. The dam downstream and upstream slopes are approximately 2.5H:1V and 2H:1V, respectively. The crest is approximately 1,050 m long, and 10 m to 15 m wide. The maximum dam height is 38 m from crest to downstream toe.
- Fine coal refuse tailings (approximately 4.4 million m^3), produced during operations (1983 to 2003), were placed between the BTD and the natural valley slope, forming the TSF. The TSF is reclaimed with a vegetation cover over the slopes and tailings.
- A closure spillway was constructed in 2002 at the west abutment of the BTD (inlet El. 1,122 masl). The spillway channel follows a southwesterly route from the tailings impoundment, discharging onto the natural ground at approximately El. 1,120 masl.

- The BTD impoundment has a catchment of 36 ha: 20 ha tailings impoundment and 16 ha upslope.

Summary of Key Potential Hazards and Failure Modes

The Code requires that potential hazards and failure modes described in CDA (2013) be assessed and included in the DSI report as a standard practice. The following hazards were reviewed:

Internal Erosion and Piping: The 2015 Dam Safety Review (DSR) (Golder 2016) noted that approximately one third of the available gradations of CCR are potentially internally unstable and recommended the potential for critical hydraulic gradients through the dam, which could result in internal erosion of the CCR, be assessed (DSR Recommendation PD-2015-03). KCB completed the assessment in 2018 and concluded that the likelihood of a failure due to internal instability and the potential for hydraulic gradient triggering internal erosion is considered to be "Very Rare"[1] for the following reasons:

- No visual indicators of tailings or CCR being washed through the dam have been observed during recent inspections (i.e., sinkholes, turbid seepage, etc.).
- No noted issues relating to internal erosion were referenced during construction and operations in the available documentation (Appendix IV).
- Seepage rates and piezometric gradients for the existing BTD are lower than those experienced during operations; this significantly reduces the risk of internal erosion developing under existing conditions given no such mechanisms were evidenced during operations.
- No known trigger to initiate internal erosion in the current condition, or to establish gradients above critical hydraulic gradient in the downstream shell (KCB 2018c).

This is consistent with the filter assessment completed by KCB (2015a) which concluded that there was adequate filter compatibility at interfaces between tailings and CCR, as well as between the starter dam fill and CCR (KCB 2015a).

Other Hazards: such as overtopping, slope instability, foundation failure, surface erosion, toe erosion by Bullmoose Creek floods, and earthquake deformation are not considered "key hazards" for this facility and are discussed in the main text of this report.

Summary – no present or no long-term dam safety concern indicated.

Consequence Classification of Dam

Consequence classification is not related to the likelihood of a failure, but rather the potential impact resulting from of a failure if it did occur. The BTD was classified as a "High" consequence classification structure based on CDA (2013), driven by the potential environmental impacts, and impacts to public

[1] "Very Rare" likelihood rating is defined by Teck as: for a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength/magnitude is between 1 in 1,000 years and 1 in 10,000 years. This rating is also applicable for failure modes such as instability (factor of safety (FoS) of 1.5 to 2.0) and internal erosion that are rare.

infrastructure, such as nearby pipelines, power transmission lines, and highways (KCB 2014b). There have been no significant changes to the structure, the upstream and downstream environment, or the operation of the structure that would require a revision to this classification.

Significant Changes in Instrumentation and/or Visual Monitoring Records

There are 13 functional piezometers and 7 survey monuments at the BTD. The piezometers are read annually during the DSI site visit. Instrumentation thresholds and responses for piezometers and survey monuments have been established for on-going surveillance of the BTD. No exceedances of established piezometers or survey monuments thresholds were recorded in 2018.

Piezometer data prior to 2003 and from 2014 to 2018 indicate that pore pressures have been stable, and the dam downstream shell is well drained with a low gradient. Piezometer data are not available between 2003 and 2014.

Seven survey monuments have been monitored since 2015 and no general trend or significant settlement has been observed. In 2018, the method of analysis changed, and Teck were in the process of updating historical data sets using the updated methodology.

The 2018 event-driven, routine inspections and DSI observations do not indicate any significant changes in the BTD or dam safety issues.

Significant Changes to Surface Water Control

During the 2018 site visit, no significant changes in surface water control were observed.

Operation, Maintenance, and Surveillance Manual

The Operation, Maintenance and Surveillance (OMS) manual was updated by Teck in June 2018. The document format meets Teck's 2014 TWRS requirements and the format recommended in the Mining Association of Canada (MAC) 2011 Guideline for Developing an OMS for Tailings and Water Management Facilities.

Emergency Preparedness and Response Plan

Teck indicated they have prepared a draft Mine Emergency Response Plan (MERP) which incorporates the tailings and sedimentation pond Emergency Preparedness and Response Plan (EPRP) components, as required under the Code. Teck has indicated the updated MERP document will be finalized in 2019.

Dam Safety Review

The first and most recent DSR of the BTD was completed in 2015 (Golder 2016). Teck are continuing to address and close-out on-going recommendations from the dam safety review, which are related to the MERP updates. The next DSR should be completed in 2020 (5 years from the previous), based on requirements under the Code and Teck's internal guidelines.

2018 DSI Observations and Summary of Recommendations

The BTD appears to be in good working condition with respect to stability and water management. Comparison with the available design and inspection reports indicates there have been no significant changes to the condition of the dam since 2003.

Past DSI recommendations that are outstanding are summarized in Table 1. Closed recommendations are shown in grey italics and will be removed from the table in the next DSI report. Following the 2018 DSI, KCB identified no indications of dam safety issues or new recommendations that require follow up by Teck.

Priority guidelines, specified in the Code, are assigned to each recommendation by KCB. None of the outstanding DSI recommendations are of a high priority nature and have been assigned Priority 3 or 4. Priority guidelines are as follows:

- Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
- Priority 2: If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
- Priority 3: Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
- Priority 4: Best Management Practice – further improvements are necessary to meet industry best practices or reduce potential risks.

Table E-1 DSI Recommendations

Structure	ID Number	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline / Status
Previous Recommendations Closed / Superseded						
BTD	*2017-02*	*Erosion Gully*	*OMS Manual*	*KCB to review erosion gully observed at the BTD downstream slope near the east abutment in 2018 DSI.*	*3*	*CLOSED*
	2017-03	*Piezometers and Freeboard Threshold Levels*	*HSRC Code*	*Teck to install a stake during routine visual inspection at the BTD in spring of 2018. The stake should be installed 1 m above the steady state pond level.*	*3*	*CLOSED*
Previous Recommendations Ongoing						
BTD	2017-01	Seismic Hazard Assessment for "Closure-Passive Care"	HSRC Code	Following best practices, a site specific seismic hazard assessment is recommended to support long-term performance of the dam. However, a site specific seismic hazard assessment is not considered critical for BTD dam safety and Teck may seek an exemption for this Code requirement.	4	December 2019
2018 Recommendations – No new recommendations						

List of Tables

List of Charts

List of Figures

List of Appendices

LIST OF ACRONYMS

Acronym	Definition
AEP	Annual Exceedance Probability
BC	British Columbia
BOC	Bullmoose Operating Corporation
BTD	Bullmoose Tailings Dam
CCR	Coarse Coal Rejects
CDA	Canadian Dam Association
DSI	Dam Safety Inspection
DSR	Dam Safety Review
EDGM	Earthquake Design Ground Motion
EoR	Engineer of Record
EPRP	Emergency Preparedness and Response Plan
FMEA	Failure Mode and Effect Analysis
FSO	Facility Surveillance Officer
FoS	Factor of Safety
HSRC	Health, Safety and Recreation Code for Mines in BC
IDF	Inflow Design Flood
KL	Klohn Leonoff
KCB	Klohn Crippen Berger Ltd.
MAC	Mining Association of Canada
EMPR	Ministry of Energy, Mines and Petroleum Resources (BC)
MRM	Monitoring Review Memorandum
MoE	Ministry of Environment (BC)
NBCC	National Building Code of Canada
OMS	Operational, Maintenance and Surveillance
PGA	Peak Ground Acceleration
PMF	Probable Maximum Flood
QPO	Quantifiable Performance Objectives
SaRA	Species at Risk Act
TSF	Tailings Storage Facility
TWRS	Tailings and Water Retaining Structures

1 INTRODUCTION

1.1 General

KCB was engaged by Teck Resources Limited (Teck) to complete the 2018 Dam Safety Inspection (DSI) at the Bullmoose Tailings Dam (BTD), also previously referred to as the South Fork Tailings Dam. This report was prepared following:

- Ministry of Energy, Mines and Petroleum Resources (EMPR), British Columbia (BC) Section 4.2 "Annual Tailings Facility and Dam Safety Inspection Report" of the 2016 Health, Safety and Reclamation Code (HSRC) Guidance Document (also referred to as the Code).
- EMPR Guidelines for Annual Dam Safety Inspection Report.
- Teck's 2014 Guideline for Tailings and Water Retaining Structures (TWRS).

1.2 Purpose, Scope of Work and Methodology

The following activities were undertaken by KCB as part of the DSI:

- Site visit to inspect the facility on May 29, 2018 by the Engineer of Record (EoR), KCB representative Mr. Bob Chambers, P.Eng., along with Mr. Nat Gullayanon, P.Eng., of KCB.
- Review of the site data, water management and instrumentation measurements.
- Review and update of the list of outstanding recommendations from previous annual reviews.

During the 2018 DSI site visit, KCB was accompanied by Mr. Andrew Bidwell, P.Eng., Mr. Rob Muise, and Ms. Morgan Lypka, E.I.T., of Teck.

1.3 Regulatory Requirements

This DSI addresses the performance of the BTD and associated water management infrastructure in accordance with Section 10.5.3 of the Code for Mines in BC (EMPR 2017).

1.4 Engineer of Record and Tailings Storage Facility Qualified Person

Mr. Bob Chambers, P.Eng., assumed the role of the EoR of the BTD on September 1, 2016. The responsibilities of the Tailings Storage Facility (TSF) Qualified Person, as defined in the Code (EMPR 2017), are performed for Teck by a consultant, Mr. Bruce Donald, P.Eng.

1.5 Facility Description

The Bullmoose Mine site is about 45 km northwest of Tumbler Ridge in northeastern BC. Site location is shown in Figure 1. The mine has been closed since 2003 and the BTD was reclaimed that same year.

BTD is considered to be in "Closure-Passive Care" phase (KCB 2018a) as defined by the Canadian Dam Association (CDA) Technical Bulletin Application of Dam Safety Guidelines to Mining Dam (CDA 2014).

The mine area is characterized by moderate topographic relief, with mountains several hundreds of meters above broad glacial and river formed valleys. The area is generally forested at lower elevations, with some ridgelines extending above tree line.

The BTD is a horseshoe-shaped structure situated on the south flank of the broad valley bottom, with South Bullmoose Creek to the west and West Bullmoose Creek to the north. Overview of the BTD and the impoundment is shown in Figure 2. Fine coal refuse (i.e., tailings) (approximately 4.4 Mm^3) produced during operations (1983 to 2003) were stored to an average elevation of 1,118.5 masl between the BTD and the natural valley slope which form the TSF impoundment. The design capacity of the impoundment was approximately 4.6 million m^3.

The BTD is constructed of compacted coarse coal rejects (CCR) and has a crest elevation of 1,123 masl. The dam crest varies from 10 m to 15 m wide and the embankment is approximately 1,050 m long. The dam maximum height is 38 m from crest to downstream toe. The BTD has a 15 m wide low permeability zone extending from the starter dam along the upstream face. Refer to Drawing D-108 in Appendix III for typical cross-section of the BTD.

A closure spillway was constructed in 2002 at the west abutment of the BTD with an inlet elevation of 1,122 masl. Downstream slope of the BTD was re-sloped to achieve the design 2.5H:1V slope in 2003 (BOC 2003). The spillway channel follows a southwesterly route from the tailings impoundment, discharging onto the natural ground at approximately El. 1,120 masl.

A summary of BTD key information is presented in the Facility Data Sheet in Appendix I. The ultimate dam configuration is presented in Appendix III.

2 BACKGROUND AND RECENT ACTIVITIES

2.1 Background Information

Coal production at Bullmoose began in December 1983 and produced about 1.7 million tonnes of metallurgical coal and 0.6 million tonnes of thermal coal annually. Waste from the coal preparation process included CCR and fine coal refuse (i.e., tailings). Coal production at Bullmoose ceased in 2003 and has been inactive since then. A summary of the available BTD reference documents is included in Appendix IV.

Tailings production varied considerably depending on the ratio of thermal coal to metallurgical coal. Tailings were transported as slurry, 35% solids by weight, to a single discharge point located at the southern ridge of the impoundment.

A starter embankment, about 10 m high, was constructed of borrow material to store tailings from the first year of operations which commenced in 1983 (KL 1984). Crest raises were constructed using downstream methodology to a final crest elevation of 1,122 masl. A layer of glacial till was placed on the crest for erosion protection (BOC 2003) which raised the tailings dam to El. 1,123 masl based on 2010 LiDAR. However, field observations suggest the glacial till placement was likely not consistent (in terms of thickness and coverage) across the full length and width of the crest.

Since 2003, the impoundment has been maintained as a closed facility. Reclamation work completed on the facility includes re-sloping of the downstream slope and seeding on the tailings surface and dam slopes (upstream and downstream) (BOC 2003). A closure spillway was constructed in 2002 (BOC 2004) at the left (west) abutment with an invert elevation of 1,122 masl. There has been no construction since 2003. The 2010 LiDAR survey indicates the current spillway invert and the crest elevations are 1 m higher than the post-construction as-built survey. This difference in survey does not impact this assessment as the difference in elevation between the crest and spillway invert (1 m) is the same for both surveys. During the site inspection the spillway invert appeared to be 1 m lower than the dam crest.

The foundation consists of alluvial sands and gravels with interbedded silts and glacial till. The alluvial soils are sufficiently pervious to allow pond water to seep from the impoundment. As the thickness of the deposited tailings increased, the seepage rate decreased (Teck 2013a). There are two aquifers underlying the impoundment: an upper gravelly aquifer with piezometric level approximately 4 m below the original ground surface, which is similar to the elevation of Bullmoose Creek; and a lower gravelly aquifer with piezometric level 8 m to 10 m below the original ground surface. The two aquifers are reported to be separated by a low permeability glacial till layer.

2.2 Recent Activities

The Bullmoose TSF is a closed facility and does not require operational intervention, except for routine and event-driven inspections. Maintenance is carried out on an as-required basis. The BTD performed adequately and no maintenance work was required in 2018 with the exception of

vegetation removal from the spillway and relevelling of the riprap that was disturbed when the vegetation was cleared (see Section 4.2 for more details).

The following activities were also completed as part of an on-going stewardship of the BTD by the EoR and to address previous DSIs and Dam Safety Reviews (DSRs) recommendations:

- Completed 2018 DSI at the BTD (this document);
- Reviewed event-driven and routine inspection surveillance data submitted by Teck's Facility Surveillance Officer (FSO) and documented the review in monthly Monitoring Review Memorandum (MRM);
- Reviewed Operation, Maintenance and Surveillance (OMS) manual and Emergency Preparedness and Response Plan (EPRP) document, the latter of which is now incorporated into the Mine Emergency Response Plan (MERP);
- Reviewed instrumentation data and Quantifiable Performance Objectives (QPOs);
- Reviewed 2018 climate data and updated water balance for the BTD;
- Participated in Teck's 2018 risk assessment workshop for the BTD; and
- Participated in the ITRB annual review and Teck's Internal Governance Review.

Results of these activities are discussed in the following sections of this report.

3 WATER MANAGEMENT, CLIMATE AND WATER BALANCE

3.1 Water Management

The catchment for the BTD impoundment is 36 ha: 20 ha tailings and pond surface, and 16 ha of natural upslope catchment (KCB 2015b). A pond (approximately 2 ha) is located along the northeast boundary which is approximately 400 m from the spillway inlet at the southwest corner of the impoundment (see Figure 2). Based on inspection reports since 2014, a pond has been present at that location. During that period, the pond level has ranged from approximately El. 1,116 masl to El. 1,117 masl and has an estimated volume of 26,000 m^3.

The closure spillway invert is at El. 1,122 masl with a channel width of approximately 3 m and grades ranging from 3% to 1% (KCB 2015b). The spillway is excavated within overburden and bedrock. The spillway sections excavated in overburden are armoured with riprap with D_{50} of 200 mm (KC 2004) with side slopes of 2H:1V (KC 2002). The spillway sections excavated in bedrock have side slopes of 1H:1V (KC 2002) with no erosion protection.

A diversion ditch was constructed upslope of the impoundment to divert approximately 14 ha away from the impoundment under normal conditions. However, the diversion ditch is not in suitable condition and no longer performs as designed. In 2015, KCB concluded the diversion was no longer required and did not have to be re-established for dam safety. The conclusion was based on the following findings:

- The ditch was assumed to not function for the spillway design (i.e., it does not divert upstream runoff away from the BTD impoundment).
- A steady pond elevation in the impoundment demonstrates that the diversion ditch is not required to maintain a suitable water balance for the impoundment or for dam safety.
- Hydrotechnical review (KCB 2015b) indicates that the BTD impoundment has a flood storage capacity more than 5 times the design flood volume (refer to Section 3.4 for details).

3.2 Climate

Bullmoose Mine climate data (1981-2003), based on the Bullmoose Environment Canada climate station No. 1181120 at El. 1,102 masl, is summarized in Table 3.1 and Table 3.2. No climate data is available from this station since 2003; therefore, data from Chetwynd Airport climate station No. 1181508, at El. 610 masl and 62 km north of Bullmoose, was used to estimate precipitation for water balance calculation in 2018.

Annual precipitation for the Bullmoose and Chetwynd Airport climate stations, for the period when records overlap, were used to determine an average correlation factor to apply to the Chetwynd Airport data. The Chetwynd Airport rainfall data should be multiplied by a correlation factor of 1.8 to represent the Bullmoose site. Based on this correlation factor, precipitation estimated between September 1, 2017 and August 31, 2018 was 1,250 mm for Bullmoose site.

Temperature climate normals at the Chetwynd Airport station (1981-2010) were compared against climate normal from Bullmoose (1981-2003) station. The temperature differences were then applied to the 2018 monthly temperatures measured at Chetwynd Airport to estimate the 2018 monthly temperatures at Bullmoose site.

Table 3.1 Chetwynd Airport/Bullmoose Temperature Normals and Correlation Factors

Climate Normals Data	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Daily Average (°C)												
Chetwynd Station (1981-2010)	-10.2	-7.2	-2.9	4.6	9.5	13.4	15.4	14.5	9.9	4.1	-5.5	-9.1
Bullmoose Station (1981-2003)	-8.0	-6.6	-4.2	1.7	6.9	11.0	13.3	12.8	8.2	2.5	-4.7	-7.4
Temperature Difference (Bullmoose – Chetwynd)	2.2	0.6	-1.3	-2.9	-2.6	-2.4	-2.1	-1.7	-1.7	-1.6	0.8	1.7
Daily Maximum (°C)												
Chetwynd Station (1981-2010)	-5.0	-1.4	2.9	11.2	16.6	20.1	22.2	21.6	16.3	9.4	-1.1	-4.1
Bullmoose Station (1981-2003)	-3.4	-2.0	0.3	6.7	12.4	16.3	18.9	18.3	12.9	6.3	-1.0	-3.1
Temperature Difference (Bullmoose – Chetwynd)	1.6	-0.6	-2.6	-4.5	-4.2	-3.8	-3.3	-3.3	-3.4	-3.1	0.1	1.0
Daily Minimum (°C)												
Chetwynd Station (1981-2010)	-15.3	-12.9	-8.7	-2.1	2.4	6.6	8.5	7.4	3.5	-1.3	-10.0	-14.1
Bullmoose Station (1981-2003)	-12.6	-11.2	-8.7	-3.4	1.5	5.6	7.8	7.2	3.4	-1.2	-8.5	-11.6
Temperature Difference (Bullmoose – Chetwynd)	2.7	1.7	0.0	-1.3	-0.9	-1.0	-0.7	-0.2	-0.1	0.1	1.5	2.5

Snowpack depth is not measured at the Bullmoose or Chetwynd Airport stations; therefore, 2018 snowpack data is not available for review.

Precipitation and temperature data at Bullmoose from September 1, 2017 to August 31, 2018 is summarized in Chart 3.1 and Table 3.2. Climate normals between 1981 and 2003 (updated by

Environment Canada Record - 1981 to 2010) were obtained from Bullmoose climate station and are also summarized in Chart 3.1 and Table 3.2 for comparison.

Chart 3.1 Climate Data for Bullmoose Mine Site – 2018 and Climate Normals

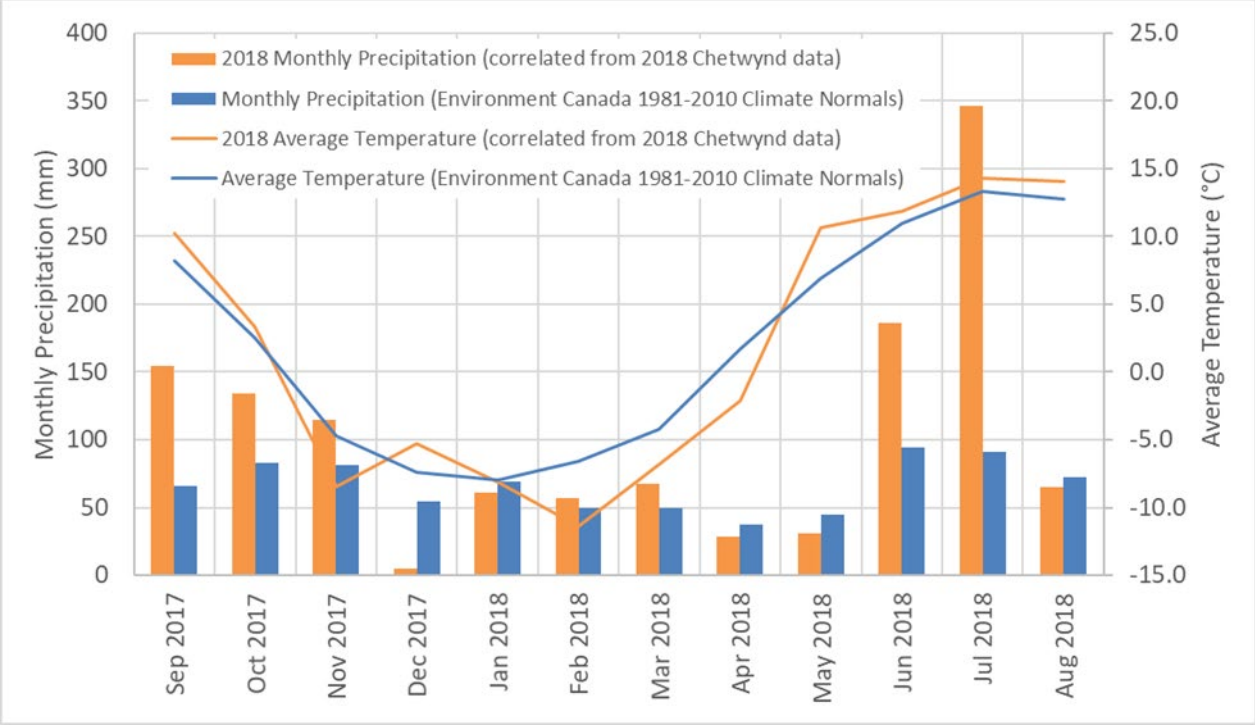


Table 3.2 Climate Data for Bullmoose Site

Month	Normals Average Monthly Precipitation[1] (mm)	2017-2018 Precipitation[2] (mm)	Normals Daily Max. Temperature[1] (°C)	Normals Daily Min. Temperature[1] (°C)	Normals Daily Average Temperature[1] (°C)	2017-2018 Daily Max. Temperature[3] (°C)	2017-2018 Daily Min. Temperature[3] (°C)	2017-2018 Daily Average Temperature[3] (°C)
September	66	155	12.9	3.4	8.2	15.2	4.4	9.9
October	83	135	6.3	-1.2	2.5	6.7	-0.2	3.0
November	82	115	-1.0	-8.5	-4.7	-4.5	-11.5	-7.9
December	54	5	-3.1	-11.6	-7.4	-2.4	-8.9	-5.7
January	69	61	-3.4	-12.6	-8.0	-4.0	-12.2	-8.1
February	50	57	-2.0	-11.2	-6.6	-10.1	-14.7	-11.0
March	50	67	0.3	-8.7	-4.2	0.0	-10.9	-8.0
April	37	28	6.7	-3.4	1.7	4.2	-8.7	0.3
May	45	31	12.4	1.5	6.9	15.4	3.6	9.6
June	94	186	16.3	5.6	11.0	16.7	6.6	11.7
July	91	346	18.9	7.8	13.3	19.2	9.4	14.2
August	72	65	18.3	7.2	12.8	19.0	8.8	13.9
Total	**793**	**1,250**						

Notes:

1. Environment Canada Record - 1981-2010 climate normals record based on Bullmoose climate station available data from 1981 to 2003.
2. 2018 annual and monthly precipitations were estimated using 2018 precipitation data from Chetwynd Airport climate station (station No. 1181508; El. 610 masl; and 62 km north of Bullmoose Mine) data and correlation factor of 1.8.
3. Bullmoose site monthly temperatures were estimated by applying temperature difference to monthly temperatures obtained from Chetwynd Airport climate station.

The following observations are made based on the climate data from September 1, 2017 to August 31, 2018:

- Total precipitation estimated during this period was 1,250 mm, which is above the precipitation normals of 793 mm.
- In general, 2018 monthly average daily temperatures were similar to the normals with the exception of February to April where temperatures were lower than the normals.
- Wettest month of the period is July 2018 where a total precipitation of 346 mm was estimated.
- Event-driven inspections are required after a 10-year rainfall event (67 mm in 24-hour duration (Teck 2018)). Review of Chetwynd Airport climate station data indicates a precipitation of 58 mm was recorded on July 19, 2018. Based on the correlation factor, a 104 mm of rain was estimated at Bullmoose site. Teck completed the event-driven inspection on July 23, 2018 at the BTD. Refer to Section 4 for further discussion of the inspection observations.

During the 2018 DSI site visit, the weather was sunny and approximately 15 ^{o}C.

3.3 Water Balance

There is no visual evidence that water has flowed through the spillway since construction and, therefore, all inflows to the impoundment are assumed to be lost through evaporation or seepage. A simplified water accounting calculation for the BTD impoundment for September 1, 2017 to August 31, 2018 is summarized below:

- Inflows:
  - Runoff from natural upstream catchment = 80,800 m^3;
  - Precipitation on pond surface = 25,400 m^3 (assumed pond surface on average is at El. 1,115.5 masl); and
  - Precipitation on tailings surface = 255,600 m^3 (average annual runoff coefficient of 0.6 assumed to account for water lost to evaporation from the beach surface and evapotranspiration).
- Outflows:
  - Evaporation from pond surface = 10,200 m^3 (evaporation rate for this site is 502 mm/year adopted from another mine site in the region); and
  - Seepage losses from the impoundment = 321,700 m^3 (the remainder of inflows minus evaporation).

The estimated average seepage rate from the impoundment based on the simplified water accounting is 10 L/s over the 12-month period. No visible flow of seepage from the BTD toe or fill was observed during the inspection. The calculated seepage rate is considered to be within the range of previously estimated/measured seepage rates:

- 3 L/s estimated in 2014 DSI (KCB 2014d);
- 10 L/s estimated in 2016 DSI (KCB 2017a); and
- 267 L/s to 1,318 L/s measured during operations.

There are no planned changes to the surface water management that would alter the water balance.

3.4 Freeboard and Flood Storage

3.4.1 Freeboard

The estimated freeboard of the BTD during the 2018 DSI site visit was approximately 6 m; the pond level was slightly higher than observed pond level in August 2017, because the site visit was completed closer to spring freshet.

Freeboard QPOs adopted for the BTD, which are based on pond level and design flood levels above spillway invert (KCB 2015b), are summarized below:

- Threshold Level 1 if the water level is 1 m above closure condition steady state pond level (i.e., maximum "normal" pond level under closure condition). In 2018, Teck installed a permanent pond indicator 1 m above the steady state pond level as Threshold Level 1 marker. The indicator will be surveyed in the spring/summer of 2019 to confirm its elevation.
- Threshold Level 2 if the water level reaches 1,000-year return period peak flood level above spillway invert: water level ≥ 1,122.3 masl, leaving 0.7 m of freeboard[2]; and
- Threshold Level 3 if the water level reaches $^2/_3$ between 1,000-year return period and probable maximum flood (PMF) peak flood level above spillway invert: water level ≥ 1,122.5 masl, leaving 0.5 m of freeboard[2].

Threshold Levels 2 and 3 are considered conservative when compared to the minimum required freeboard of 0.2 m, determined using the CDA (2013) wave setup and wave runup methodologies (KCB 2015b). Responses for the Threshold Level exceedances are summarized in Table 3.3. Teck have indicated that the thresholds will be reviewed against Teck's updated guidelines when they become available.

[2] KCB (2015b) assumed the pond elevation to be at the spillway invert (El. 1,122 masl) at the start of the design storm events (see Sections 3.4.2 and 5.6.2 for more information on flood storage and flood routing, respectively).

Table 3.3 Proposed Responses to Freeboard Thresholds Exceedances

Response Level	Exceedance Threshold	Action
1	Pond level is 1 m above steady state pond level	Notify EoR within 1 week upon verification of pond level measurement and exceedance. EoR may recommend increased monitoring of pond level and toe inspection.
2	0.7 m Freeboard	Notify EoR within 24 hours upon verification of pond level measurement and exceedance. EoR may recommend increased monitoring of pond level and toe inspection.
3	0.5 m Freeboard	Notify EoR immediately upon verification of pond level measurement and exceedance. Increased monitoring frequency as directed by the EoR. EoR may recommend mitigation measure(s) to reduce the probability of overtopping. Teck to initiate emergency response as required.

The pond level indicator is appropriate for on-going monitoring of the BTD pond level.

3.4.2 Flood Storage

The inflow design flood (IDF) for the BTD, a "High" consequence classification dam under "Closure-Passive Care" phase, is 24-hour duration $^{2}/_{3}$ between the 1,000-year return period and PMF event (CDA 2014). The IDF flood volume is 114,370 m^3 (KCB 2015b). The Bullmoose TSF has 680,000 m^3 of available flood storage, which is more than 5 times the IDF volume (see Section 5.6.2 for more details).

4 MONITORING PROGRAM AND SITE OBSERVATIONS

4.1 Visual Inspections

The BTD monitoring program includes the following visual inspections:

- Annual DSI (this report) – completed by the EoR.
- Routine – completed monthly when site is accessible by Teck FSO - Mr. Rob Muise, or Mr. Ray Proulx (alternate FSO). Inspections are documented on a standard site inspection checklist. In 2018, routine inspections were completed between April and October.
- Event-driven – completed by Teck FSO following:
  - a 24-hour rainfall event greater than the 10-year return period (67 mm total precipitation);
  - a M5 or greater earthquake recorded within 100 km of the site; or
  - flooding of Bullmoose Creek.

An event-driven inspection was completed on July 23, 2018 after an estimated 57 mm of precipitation fell over a 24 hour period. Teck communicated to KCB following the inspection that no unusual conditions were noted.

No earthquakes were recorded by the Geological Survey of Canada within 100 km of the site in 2018.

The inspection program is appropriate for the BTD, given the long performance history of the dam, adequacy of instrumentation coverage, large flood storage capacity and provision of an open channel spillway.

4.2 Dam Safety Inspection Observations and Inspection Photographs

Refer to Figure 2 for an overview of the facility with 2018 inspection photograph locations. Inspection photographs are included in Appendix II. The following observations were made during the 2018 DSI site visit:

- **Dam Crest**: Good condition. No signs of lateral movement, significant differential settlement or cracking of the dam crest (Photos II-1 and II-2).
- **Downstream Slope and Toe**: Good condition. No visible signs of significant erosion, displacement, or bulging (Photos II-14, II-15, II-17 through II-20, and II-22). Vegetation (grasses and moss) is well established and there are minor rills of the downstream slope (Photo II-16); refer to Section 5 for further discussion.

  An erosion gully on the east downstream slope, likely caused by concentrated local flow during spring freshet, was inspected in 2018 (Photo II-13 at BTD-2018-10 on Figure 2). The gully is approximately 0.2 m to 0.3 m wide, 0.08 m to 0.11 m deep and 10 m to 15 m long and appeared to be unchanged from 2017 condition. This feature should be monitored and inspected for signs of changes during the routine visual inspections and annual DSI site visits.

A small boggy area was noted at the toe of the north arm of the BTD during the DSI site visit (Photo II-21). Ponded water is likely due to snowmelt/freshet.

- **Upstream Slope**: Good condition. No signs of significant erosion or displacement (Photos II-3 to II-4, II-6, II-8, I-23 and II-25).
- **West Abutment**: Good condition. The spillway is excavated through the west abutment, no sign of erosion at the abutment (Photo II-26).
- **East Abutment**: Good condition. No signs of significant erosion or displacement of the natural slope. Vegetation is well established at the abutment and along the abutment/downstream slope contact (Photo II-9). A small channel running along BTD downstream slope contact with east abutment towards the toe had an estimated flow of 1 L/min and appeared to be unchanged from 2017 condition (Photos II-11 and II-12).
- **Tailings Impoundment and Pond**: A pond (approximately 2 ha) is located along the northeast boundary (Photos II-5 and II-8) and is approximately 400 m from the spillway inlet (see Figure 2). The impoundment is well vegetated except near the pond. Away from the pond the impoundment is well drained and supports human/animal traffic. The pond elevation was approximately 1,117 masl which appears to be slightly elevated due to spring freshet. Minimal fluctuation of the pond elevation post closure seems to suggest that seepage at the BTD is fairly constant.
- **Spillway:** Good condition (Photos II-26 to II-34). Teck cleared vegetation at the inlet and along the channel in October 2017; however, riprap was disturbed as a result of the clearing activity. Ideal riprap condition is when rocks are interlocked and tightly packed. Riprap at the BTD spillway appeared to be disturbed at the time of the 2018 DSI (i.e., not interlocked), making it potentially more susceptible to erosion if flows occur in the spillway. Teck repaired the riprap on August 15, 2018 and photographs of the repair work were submitted to KCB for review. Post-repair riprap conditions appear to be sufficient (Photo II-37). The overall spillway condition will be assessed in detail by the EoR during 2019 DSI site visit.

  Minor degradation of the riprap within the channel was observed and should be monitored during future DSI site visits and event-driven inspections following flood events.

  Previous observations suggest vegetation inside spillway channel and at the inlet requires routine monitoring and removal. Vegetation was cleared in the spring of 2018. Vegetation clearing every 2 years as specified in the OMS manual is considered adequate.

Historical Slope Failure in South Slope Above Impoundment: a historical slope failure is present in the natural slope on the south side of the impoundment (Photo II-10). The failure is also visible in photographs from previous inspection reports (Teck 2013a, KCB 2011, and KCB 2014a) indicating this has been present since at least 2010. The failed mass is overgrown with vegetation including small trees. Comparison of photographs between 2010 and 2018 does not indicate any visually identifiable changes. This feature is not a risk to the dam safety.

4.3 Instrumentation Review

4.3.1 Piezometers

A summary of the 13 functional piezometers is presented in Table 4.1. The OMS manual requires piezometers be read once per year.

In 2018, the piezometers were measured during the DSI site visit (refer to Figure 3). Four standpipe piezometers were also monitored; however, because the wells do not have proper labels, water level measurements cannot be linked to historical readings. These monitoring wells will be labeled for 2019 and are not considered critical for on-going monitoring of the BTD.

Piezometer threshold responses are summarized in Table 4.2.

- Threshold Level 1 if piezometer reaches conditions that reduce the factor of safety (FoS) of the dam equal to or below 1.5 (taken from KC (1999) Threshold Warning Level II – see Figure 3); and
- Threshold Level 2 if there are Threshold Level 1 exceedances at 2 or more piezometers on an instrumentation section.

Figures 3 and 4 summarize recent and historical piezometer readings. Figure 5 shows piezometric level across dam schematic Sections A to C.

The following observations are made based on the 2018 piezometric data:

- None of the measured piezometers exceed Threshold Level 1.
- All measured piezometers have similar water levels to those measured in 2017 (see Figure 4).
  - PA-1, PB-4, PB-5 and PC-1 appeared to be stable with no general decreasing or increasing trend.
  - PA-2 water level had dropped about 4 m between 2014 and 2015; the instrument has been relatively stable since 2015.
  - PA-4 and PA-5 water levels are relatively stable with a slight increase in 2017.
  - PB-3 and PC-3 have been registered as “dry” since 2017 indicating relatively low phreatic level across the BTD embankment.
  - PB-1 and PC-2, installed in the foundation, continue to show piezometric level below the instrument tips (i.e., they are dry). Other foundation piezometers PB-4, PB-5 and PC-1 indicate water levels are slightly below PB-1 and PC-2 tips.

Low pore pressures in the downstream shell of the dam indicate that dam drainage and foundation seepage capacity exceeds flow requirements (see Figure 5). Pore pressures have been stable, and the dam shell is drained with low gradient of approximately 0.04 to 0.05 (KCB 2018c). Operation and construction induced pore pressure responses are no longer observed. Therefore, piezometers monitoring frequency of once per year is sufficient for ongoing monitoring of the structure under “Closure-Passive Care” conditions.

KCB recommend Teck to provide new caps and labels to the standpipe piezometers to avoid labels from being switched during future readings. PA-1 top of casing appears to be broken and requires some repair work (Photo II-7).

Table 4.1 Summary of Piezometers

Piezometer ID	Tip Location	Instrument Location	Coordinates[1] (m)		Original Ground Elevation (masl)	Existing Ground Elevation (masl)	Instrument Tip Elevation (masl)
			Easting	Northing			
PA-1	Foundation	Crest	597396	6111244	1084.0	1112.5	1077.3
PA-2	Dam	Crest	597396	6111244	1084.0	1112.5	1083.4
PA-4	Foundation	Downstream Slope	597402	6111284	1081.0	1092.7	1077.3
PA-5	Dam	Downstream Slope	597402	6111284	1081.0	1092.7	1079.0
PA-3N	Dam	Crest	597364	6111174	1082.0	1123.0	1094.8
PB-1	Foundation	Crest	597126	6111148	1086.0	1123.0	1081.9
PB-3	Dam	Crest	597126	6111148	1086.0	1123.0	1099.5
PB-4	Foundation	Downstream Slope	597094	6111219	1086.0	1100.5	1080.1
PB-5	Foundation	Downstream Slope	597094	6111219	1086.0	1100.5	1081.6
PC-1	Foundation	Crest	596949	6110991	1091.0	1120.5	1083.7
PC-2	Dam	Crest	596949	6110991	1091.0	1120.5	1090.3
PC-3	Dam	Crest	596949	6110991	1091.0	1120.5	1101.8
PC-4N	Foundation	Downstream Slope	596881	6111020	1094.0	1109.5	1093.5

Notes:
1. Coordinates are from GPS readings (NAD83 UTM Zone 10N).

Table 4.2 Responses to Piezometer Thresholds Exceedances

Response Level	Exceedance Threshold	Action
1	Exceedance of established threshold in an individual piezometer	Measure again within 24 hours and increase monitoring frequency to weekly. Notify EoR within 24 hours of second reading. EoR to evaluate data for reliability, and review piezometer data within the general vicinity of the individual piezometer in question.
2	Common trend of threshold exceedances in a group of piezometers	Increase monitoring frequency of the piezometers as recommended by EoR based on assessment of common trend. EoR to assess stability, stability analysis may be initiated.

4.3.2 Survey Monument Pins

In July 2015, 7 survey monuments were installed on the BTD. Survey readings are summarized in Figure 6. Survey measurements up to 2018 are also shown in Figures 9 through 11. Survey monument QPOs are as follow:

- Thresholds Level 1 were developed based on the maximum observed survey measurement to date plus approximately 20%. The threshold is exceeded if:
  - Horizontal movement ≥ 25 mm from the initial reading.
  - Vertical movement ≥ 25 mm from the initial reading.
  - Vertical movement ≥ 15 mm between successive readings.
  - Threshold Level 1 values are illustrated in Figures 7 to 9.
- Threshold Level 2:
  - If there are Threshold Level 1 exceedances at 2 or more monuments on a section.

Threshold Level 2 was developed such that responses are based on a trend of instruments exceeding Threshold Level 1 rather than an individual monument exceeding a threshold in a single occurrence, which may have been caused by reading error or faulty instrument, leading to unnecessary increase in monitoring of the instrument.

Survey monument threshold responses are summarized in Table 4.3.

Table 4.3 Responses to Survey Monument Thresholds Exceedances

Response Level	Exceedance Threshold	Action
1	Exceedance of established threshold in one survey monument	Notify EoR within 24 hours upon verification of reading exceedance. EoR to evaluate data for reliability, and review survey data within the general vicinity of the individual survey monument in question. EoR may recommend repeat measurement and increased on-going monitoring frequency.
2	Common trend of threshold exceedances in a group of survey monuments (2 or more adjacent monuments)	Notify EoR within 24 hours upon verification of reading exceedance. Repeat reading within 1 week. EoR to assess dam integrity and may recommend analyses, site visit or other action.

From a review of the data taken between 2015 and 2018, there appears to be no general trend or significant settlement and the observed movement appears to be within the survey accuracy. Overall trends can be more confidently interpreted as the number of survey readings increase.

In KCB's opinion, survey monument reading frequency once per year is appropriate based on the following:

- The dam has been inactive for 15 years and the water level within the impoundment is significantly below the spillway invert.
- There are no noted issues of slope instability.
- No general trend in the downstream direction based on available survey data since installation in October 2015.
- No significant settlement was observed, and recorded settlements can be accommodated without reducing the minimum required freeboard.
- Reading the survey monuments annually is consistent with the current piezometer reading frequency.

4.4 Discharge Water Quality

Inflows and outflows at the Bullmoose TSF are summarized in Section 3.3. Groundwater sampling wells are installed downstream of the tailings dam, with samples collected for water quality analyses. Teck reports the results to the Ministry of Environment (MoE) as specified in Permit No. PE-06757.

5 DAM SAFETY ASSESSMENT

5.1 Design Basis Review

The relevant criteria from CDA (2014) and the Code (EMPR 2017) are compared in Table 5.1. The BTD is considered to be under "Closure-Passive Care" phase as sufficient time has passed since the closure work was completed in 2003 and instrumentation data has indicated the dam has reached a steady state condition (KCB 2018a). The dam was reviewed with respect to these design criteria as described in Sections 5.3 and 5.6.

Table 5.1 Comparison of CDA and HSRC Design Criteria for Tailings Dams Classified as "High"

Parameter	CDA (2014) "High" Consequence Classification	HSRC (EMPR 2017)[1]
IDF Annual Exceedance Probability (AEP)	$^2/_3$ Between 1,000-Year and PMF	$^1/_3$ Between 975-Year and PMF
Earthquake Design Ground Motion (EDGM) AEP	½ Between 2,475-Year and 10,000-Year	2,475-Year
FoS for Slope Stability: 1) Static – Long-term 2) Pseudo-Static 3) Post-Earthquake	 1.5 1.0 1.2	 1.5 Not Specified Not Specified
Steepest Allowable Downstream Slope	Not Specified (BTD steepest overall slope is 2.5H:1V at Section A – see Figures 2 and 5)	2H:1V

Notes:
1. The HSRC Code (EMPR 2017) does not specify IDF or EDGM for "Closure-Passive Care" phase.

5.2 Dam Safety Review

The first and most recent DSR of the BTD was completed in 2015 (Golder 2016). Teck are continuing to address outstanding recommendations from the DSR, and have indicated these will be closed out as part of the annual OMS and MERP/EPRP updates. Outstanding recommendations are summarized below:

- DSR Recommendation (ONC-2015-08): Procedures regarding instrumentation readings, frequency and data management should be documented within the OMS as well as the threshold values and procedures relating to the triggering of thresholds.
- DSR Recommendation (ONC-2015-09): Flood management due to flooding of West Bullmoose Creek should be included in the EPRP.
- DSR Recommendation (ONC-2015-10): Include records of personnel emergency training in emergency procedures.
- DSR Recommendation (ONC-2015-11): Document the frequency of the revisions to the EPRP in the EPRP.
- DSR Recommendation (ONC-2015-12): Develop a chain-of-command and organization chart and include within the EPRP.

The next DSR should be completed in 2020 (in 5 years from the previous), based on requirements under the Code and Teck's internal policy (Teck 2014).

5.3 Failure Modes Review

The Code requires identification of potential hazards and failure modes described in CDA (2013) be assessed and included in the DSI report as a standard practice. Teck likelihood definitions from 2018 Failure Mode and Effect Analysis (FMEA) were adopted for this assessment and are defined in footnote for reference. Based on the DSI observations, review of available documents regarding the BTD (Appendix IV), and review of the 2018 risk register, the following potential failure modes were reviewed:

- **Overtopping:** The pond level (visually estimated) is 7 m to 8 m below spillway invert level. At this level, the available flood storage before spilling is more than 5 times the IDF volume (KCB 2015b) (see Sections 3.4.2and 5.6.2 for more details). In the extreme event where the pond is at the spillway invert level at the start of the IDF, the spillway would have sufficient capacity to pass the peak flow (KCB 2015b). If the spillway was completely blocked and the pond was at the spillway invert at the start of the IDF event, the IDF can be contained with 0.4 m freeboard. Based on these factors, the likelihood of an overtopping failure is considered to be "Not Credible"]as noted in the 2018 risk register completed by Teck. .
- **Internal Erosion and Piping:** The dam is a semi-pervious design (i.e., no compacted core or seepage barrier) which allows seepage flow through the dam fill. The 2015 DSR noted that approximately one third of the available gradations of CCR are potentially internally unstable (Golder 2016). They recommended the potential for critical hydraulic gradients through the dam, which could result in internal erosion of the CCR, be assessed (Golder 2016). KCB reviewed this issue and concluded:
  - No visual indicators of tailings or CCR being washed through the dam have been observed during recent inspections (i.e., sinkholes, turbid seepage, etc.);
  - No noted issues relating to internal erosion were referenced during construction and operations in the available documentation (Appendix IV);
  - Seepage rates and piezometric gradients for the existing BTD are lower than those experienced during operations; this significantly reduces the risk of internal erosion developing under existing conditions;
  - No known trigger to initiate internal erosion in the current condition, or to establish gradients above critical hydraulic gradient in the downstream shell (KCB 2018c); and
  - Even if the compelling items above were not present, the KCB 2015 filter assessment indicates adequate filter compatibility at interfaces between tailings and CCR, as well as between the starter dam fill and CCR (KCB 2015a).

  The current OMS manual includes surveillance parameters for internal erosion to help the FSO recognize the initiation and progression mechanisms of internal erosion (Teck 2018) if it develops.

Based on performance to date, surveillance measures and KCB (2018c) internal stability assessment, the likelihood of a failure due to internal erosion and piping is considered to be "Very Rare"[3].

- **Slope Instability:** The dam is composed of compacted fill with a free draining downstream shell and drainage layers. The downstream slope of the dam is 2.5H:1V (KL 1982). The FoS reported in design was greater than 1.7 (KC 1996), which exceeds the Code requirements. 2018 piezometer readings indicate that the pore pressures in the dam are similar to mine closure levels and are all below Threshold Level 1. This analysis and the long performance history with no visible or documented displacements indicates the likelihood of a failure due to slope instability is "Very Rare".
- **Foundation Failure:** The dam is constructed on a competent foundation with no known weak layers identified in the available design documents (refer to Section 5.6.1 for more information). The likelihood of a failure due to foundation irregularities is considered to be "Very Rare".
- **Surface Erosion:** Both upstream and downstream slopes of the dam have a vegetation cover to protect against surface erosion. The erosion gully at the east downstream toe (Photo II-13) appeared to be well vegetated, indicating the erosion has not progressed since its formation. In addition, the vegetation appeared to be protecting the gully from 2018 spring freshet runoff. The gully poses no immediate dam safety and stability concern.

  Some minor rills of the downstream slope were observed. They appear to be stable based on comparison with previous DSI photographs; therefore, they are not considered a dam safety concern.

  The likelihood of failure due to surface erosion is considered to be "Close to Non-Credible"[4].
- **Erosion During Bullmoose Creek Flood:** Maximum flood level in West Bullmoose Creek near the BTD corresponding to the $^2/_3$ between 1,000-year and PMF event is 2 m below Bullmoose Mine Road (see Figure 2 for Bullmoose Mine road location) and the flood inundation extent is at least 40 m (horizontal) from the BTD toe (KCB 2018b). The studies indicate the likelihood of erosion at the BTD toe due to the design flood events in both South and West Bullmoose Creeks is considered to be "Not Credible".
- **Earthquakes:** CDA (2014) recommend a ½ way between 2,475-year and 10,000-year return period earthquake for the design of a "High" consequence classification dam under "Closure-Passive Care". The peak ground acceleration (PGA) for the design return period is 0.18g based on a simplified seismic hazard assessment using an updated National Building Code of Canada (NBCC) (2015) hazard values and a log-log extrapolation methodology (KCB 2017c).

[3] "Very Rare" likelihood rating is defined by Teck as: for a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength/magnitude is between 1 in 1,000 years and 1 in 10,000 years. This rating is also applicable for failure modes such as instability (factor of safety (FoS) of 1.5 to 2.0) and internal erosion that are very rare.

[4] "Close to Non-Credible" likelihood rating is defined by Teck as for a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength/magnitude is greater than 1 in 10,000 years; this rating is also applicable for failure modes such as instability (FoS of 2.0 or greater) and internal erosion that are close to non-credible.

KCB completed a pseudo-static stability assessment of the BTD in 2018 and determined that the yield ground acceleration that would cause FoS < 1 is 0.16g. Based on Hynes-Griffin and Franklin (1984), the BTD would have to experience a PGA of approximately 0.32g before deformation greater than 1 m can be expected. The BTD has approximately 6 m to 7 m of freeboard which is much greater than anticipated vertical settlements. Under the design earthquake, the seismic deformations would not be sufficient to release tailings into the environment.

The BTD pseudo-static stability exceeds the CDA (2014) recommended design criteria, indicating the likelihood of a failure caused by deformation during the design earthquake is "Not Credible".

To comply with the Code, a site specific seismic hazard assessment is recommended to support long-term performance of the dam. However, the site specific seismic hazard assessment is not considered critical for BTD dam safety and Teck may seek exemption from this requirement.

5.4 Upstream and Downstream Conditions Review

5.4.1 Upstream

There have been no significant changes in the upstream condition since mine closure in 2003. No mine infrastructure is located upstream of the BTD impoundment with the exception of forestry service/recreational roads, and a diversion ditch described in Section 3.1.

5.4.2 Downstream

There have been no significant changes in the downstream condition since mine closure in 2003. KCB (2014b) flood inundation study indicates the flood route downstream of the tailings storage facility is generally unpopulated. The town of Tumbler Ridge is the only populated center within the study area. There are recreation sites including walking, hiking and all-terrain vehicle trails throughout the downstream drainage route, as well as industrial sites and other infrastructures. No loss of life is expected from the permanent population within the studied flood zone.

The most significant industrial site, due to its proximity to the dam, is the Talisman Gas Plant and supporting infrastructures (i.e., powerlines and pipelines). The gas plant is located approximately 2 km downstream of the TSF. An electric sub-station is less than 200 m from the dam. A tailings runout analysis completed by KCB (2014b) indicates that the sub-station is located within an inundation extent of a hypothetical "Sunny Day" tailings runout failure.

5.5 Dam Classification Review

Consequence classification is not related to the likelihood of a failure, but rather related to the potential impact resulting from of a failure if it did occur. Design basis for dams are then selected based on their consequence rating. The BTD was classified as a "High" consequence classification structure based on CDA (2013), the inundation study findings and consequence classification review completed by KCB (2014b), which concluded that a failure could increase suspended solids levels

within Bullmoose Creek and impact downstream infrastructure including pipelines, transmission lines, and highways. The factors considered in the classification of the BTD are listed in Table 5.2.

Table 5.2 Classification of BTD Based on Consequence Category

Population at Risk	Loss of Life	Economic and Social Loss	Environmental and Cultural Losses
No Permanent Population	Significant	High	High

There have been no significant changes to the TSF, upstream or the downstream condition since last consequence classification review (KCB 2014b) that would require a revision to this classification.

5.6 Physical Performance

5.6.1 Geotechnical

The dam has performed adequately for over 30 years without any records of slumping or instability. The closure work in 2003 included re-sloping of the downstream slope to approximately 2.5H:1V (BOC 2003, Teck Cominco 2003).

The dam is composed of compacted fill with a free draining downstream shell and drainage layers (refer to Drawing D-108 in Appendix III). Review of piezometer data prior to 2003 and from 2014 to 2018 indicates pore pressures have been stable and the dam shell is drained with a low gradient (i.e., dam drainage and foundation seepage capacity exceeds flow requirements).

The dam is constructed on dense to very dense, non-liquefiable surficial silty sand and gravel, glacial till consisting of a silt-sand-gravel mixture and alluvial silty granular soils (KCB 2015a). No weak layers were identified in the available design documents, and organics and surficial unsuitable materials were reported to be excavated prior to fill placement. Stability analysis indicate that the dam meets the static and seismic stability criteria as described in Section 5.3.

5.6.2 Hydrotechnical

The BTD spillway was designed for an IDF equivalent to the 1,000-year return period (KC 2001). This complied with dam safety guidelines at the time (CDA 1999). However, under CDA (2014), the recommended IDF for the BTD, a “High” consequence classification dam, is the $^2/_3$ between the 1,000-year return period and PMF, which is considered appropriate under the Code.

A hydrotechnical review of the spillway undertaken in 2015 by KCB (2015b) concluded the spillway can safely route the IDF recommended by CDA (2014) while maintaining 0.5 m of freeboard[5] (or 0.4 m of freeboard assuming a fully blocked spillway). The minimum required freeboard of 0.2 m was

[5] KCB (2015b) conservatively assumed the pond elevation to be at the spillway invert (El. 1,122 masl) at the start of the design storm events.

determined in the KCB (2015b) assessment using the wave setup and wave runup methodologies described in CDA (2013).

The TSF has approximately 680,000 m^3 of available storage before discharging through the spillway. There is an additional 187,600 m^3 of flood storage between the spillway invert and the BTD crest.

Historical observations show the pond vary between El. 1,116 masl to El. 1,117 masl and is approximately 400 m from the spillway. Discharge through the spillway has not been observed in the past.

Based on these factors, the likelihood of an overtopping failure is considered to be "Close to Non-Credible" as discussed in Section 5.3.

5.7 Operational Performance

The BTD has been closed for about 15 years and, as indicated in Section 2, there are no operational requirements.

5.8 Documentation Review

5.8.1 Operation, Maintenance and Surveillance Manual

The OMS manual for the BTD was updated by Teck in June 2018 and is considered adequate for on-going monitoring of the BTD. Survey monument reading procedures still need to be included in the OMS manual. Teck plans to include the survey reading procedures in the next revision of the OMS manual.

Guidance on visual inspections and thresholds (i.e., QPOs) for piezometers and survey monuments, which are used to indicate compliance with stability assessment assumptions, are included in the OMS manual. If a threshold is exceeded, the OMS manual includes a corresponding response action and timeline to complete.

Surveillance parameters have been updated to include visual indicators for internal erosion initiation and progression mechanisms.

In general, the OMS document meets the CDA (2013) and Teck (2014) TWRS requirements and the document follows the format recommended in MAC (2011).

5.8.2 Emergency Preparedness and Response Plan

An EPRP was updated and issued in draft version in January 2017; however, the following DSR (Golder 2016) recommendations are remaining to be addressed:

- Recommendation No. ONC-2015-09: Flood management due to flooding of West Bullmoose Creek should be included in the EPRP – flood studies were completed by KCB (2018b).
- Recommendation No. ONC-2015-10: Include records of personnel training in emergency procedures.

BTD management and incident command organization charts are up to date in the EPRP document. The EPRP requires the documents be reviewed and, if necessary, updated on an annual basis. Teck indicated they have prepared a draft Mine Emergency Response Plan (MERP) which incorporates the tailings and sedimentation pond EPRP components, as required under the Code. Teck has indicated the updated MERP document will be finalized in 2019.

6 SUMMARY AND RECOMMENDATIONS

The BTD appears to be in good working condition and the observed performance is consistent with the expected design conditions. There are no indications of present or long-term concerns.

Comparison of the observed condition of the dam with the referenced design and inspection reports indicates there have been no significant changes to the condition of the structure since the site was closed in 2003. Review of the instrumentation data indicates that the BTD has reached steady state condition. The water balance assessment estimated seepage rates to be within the expected range.

No maintenance work was required in 2018 except the spillway repair as discussed in Section 4.2. Event-driven and routine visual inspections, instrumentation readings, and the DSI were completed as per the Code, OMS and Teck's internal requirements. Visual inspections and instrumentation data indicate no dam safety issues.

Total precipitation measured in 2018 was higher than the climate normals. Exceedance in precipitation threshold occurred on July 19, 2018, which triggered an event-driven inspection by Teck. No unusual conditions were noted by the FSO.

The BTD is a "High" consequence classification dam as per CDA (2013). The facility is considered to be under "Closure-Passive Care" as per CDA (2014) (KCB 2018a). There have been no significant changes to the upstream and downstream conditions since the last consequence classification review (KCB 2014b); therefore, no change in the dam consequence classification is required.

The OMS manual was updated in June 2018 and is considered current and adequate for on-going monitoring and maintenance of the BTD. Teck plans to update the EPRP by the end of Q1 2019.

Past recommendations regarding the dam that are still outstanding are summarized in Table 6.1. Closed recommendations are shown in grey italics and will be removed from the table in the next DSI report. Following the 2018 DSI, KCB identified no indications of dam safety issues or new recommendations that require follow up by Teck.

Priority guidelines, specified in the Code, are assigned to each recommendation by KCB. Priority guidelines are as follow:

- Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
- Priority 2: If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
- Priority 3: Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
- Priority 4: Best Management Practice – further improvements are necessary to meet industry best practices or reduce potential risks.

Table 6.1 DSI Recommendations

Structure	ID Number	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline / Status
Previous Recommendations Closed / Superseded						
BTD	*2017-02*	*Erosion Gully*	*OMS Manual*	*KCB to review erosion gully observed at the BTD downstream slope near the east abutment in 2018 DSI.*	*3*	*CLOSED*
	2017-03	*Piezometers and Freeboard Threshold Levels*	*HSRC Code*	*Teck to install a stake during routine visual inspection at the BTD in spring of 2018. The stake should be installed 1 m above the steady state pond level.*	*3*	*CLOSED*
Previous Recommendations Ongoing						
BTD	2017-01	Seismic Hazard Assessment for "Closure-Passive Care"	HSRC Code	Following best practices, a site specific seismic hazard assessment is recommended to support long-term performance of the dam. However, a site specific seismic hazard assessment is not considered critical for BTD dam safety and Teck may seek an exemption for this Code requirement.	4	December 2019
2018 Recommendations – No new recommendations						

7 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Teck Resources Limited (Client) for the specific application to the 2018 Dam Safety Inspection. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Nat Gullayanon, P.Eng.
Project Engineer
Geotechnical Engineer

Robert W. Chambers, P.Eng.
Project Manager
Senior Geotechnical Engineer, Principal

MC/OL/NG:jc

REFERENCES

Bullmoose Operating Corporation (BOC). 2003. “Tailings Dam Annual Review of Operations”, November.

Bullmoose Operating Corporation (BOC). 2004. ““Tailings Dam Annual Review of Operations”, November.

Canadian Dam Association (CDA). 1999. “Dam Safety Guidelines 1999”, January.

Canadian Dam Association (CDA). 2013. “Dam Safety Guidelines 2007 – Revised 2013”.

Canadian Dam Association (CDA). 2014. “Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams”.

Golder Associates (Golder). 2016. “Bullmoose Mine Tailings Storage Dam 2015 Dam Safety Review”, May 10.

Hynes-Griffin M. E. and Franklin A. G. 1984. “Rationalizing the Seismic Coefficient Method”. US Army Corps of Engineers, July.

Klohn Leonoff (KL). 1982. “Bullmoose Coal Project Design Tailings Dam Design Report”, October.

Klohn Leonoff (KL). 1984. “Bullmoose Tailings Disposal 1983 Starter Dam Construction”, March.

Klohn Crippen Consultants Ltd. (KC). 1996. “South Fork Tailings Dam - Seepage and Stability Review”, October.

Klohn Crippen Consultants Ltd. (KC). 1999. “Bullmoose Tailings Facility Establishment of Threshold Warning Levels for Piezometers”, October.

Klohn Crippen Consultants Ltd. (KC). 2001. “Tailings Impoundment Closure Spillway Design”, December.

Klohn Crippen Consultants Ltd. (KC). 2002. “Tailings Impoundment Closure Spillway – Review of Proposed Layout”, March 18.

Klohn Crippen Consultants Ltd. (KC). 2004. “Bullmoose Tailings Facility Closure Spillway Inspection on September 22, 2004”, October 6.

Klohn Crippen Berger Ltd. (KCB). 2011. “Bullmoose 2010 Dam Safety Inspection and Consequence Classification”, March.

Klohn Crippen Berger Ltd. (KCB). 2014a. “Bullmoose Mine 2013 Dam Safety Inspection”, March.

Klohn Crippen Berger Ltd. (KCB). 2014b. “Bullmoose Mine Tailings Storage Facility – Dam Breach and Inundation Study”, June.

Klohn Crippen Berger Ltd. (KCB). 2015a. “Bullmoose Mine Tailings Storage Facility Response to February 3, 2015 MEM Memorandum”, June.

Klohn Crippen Berger Ltd. (KCB). 2015b. “Bullmoose Mine 2015 Consulting – Tailings Storage Facility Hydrotechnical Review”, December.

Klohn Crippen Berger Ltd. (KCB). 2017a. “Bullmoose Mine Tailings Storage Dam – 2016 Dam Safety Inspection”, March 1.

Klohn Crippen Berger Ltd. (KCB). 2017b. “Bullmoose 2017 Consulting – Survey Monuments Quantifiable Performance Objectives”, October 13.

Klohn Crippen Berger Ltd. (KCB). 2017c. “Bullmoose Mine Tailings Storage Facility – Review of Seismic Hazard Assessment”, October 13.

Klohn Crippen Berger Ltd. (KCB). 2018a. “Bullmoose Tailings Dam – Closure Passive Care - Draft”, February 26.

Klohn Crippen Berger Ltd. (KCB). 2018b. “Bullmoose Creek Flood Study”, June 22.

Klohn Crippen Berger Ltd. (KCB). 2018c. “Bullmoose Tailings Dam - Internal Stability Assessment”, December 3.

Mining Association of Canada (MAC). 2011. “Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities”.

Ministry of Energy, Mines and Petroleum Resources of British Columbia (EMPR). 2016. “Health, Safety and Reclamation Code for Mines in British Columbia Guidance Document”, July.

Ministry of Energy, Mines and Petroleum Resources of British Columbia (EMPR). 2017. “Health, Safety and Reclamation Code for Mines in British Columbia”, June.

National Building Code of Canada (NBCC). 2015. National Research Council of Canada.

Teck Cominco. (2003). “Bullmoose Mine – Closure Report Reclamation Permit No. C-158”, January.

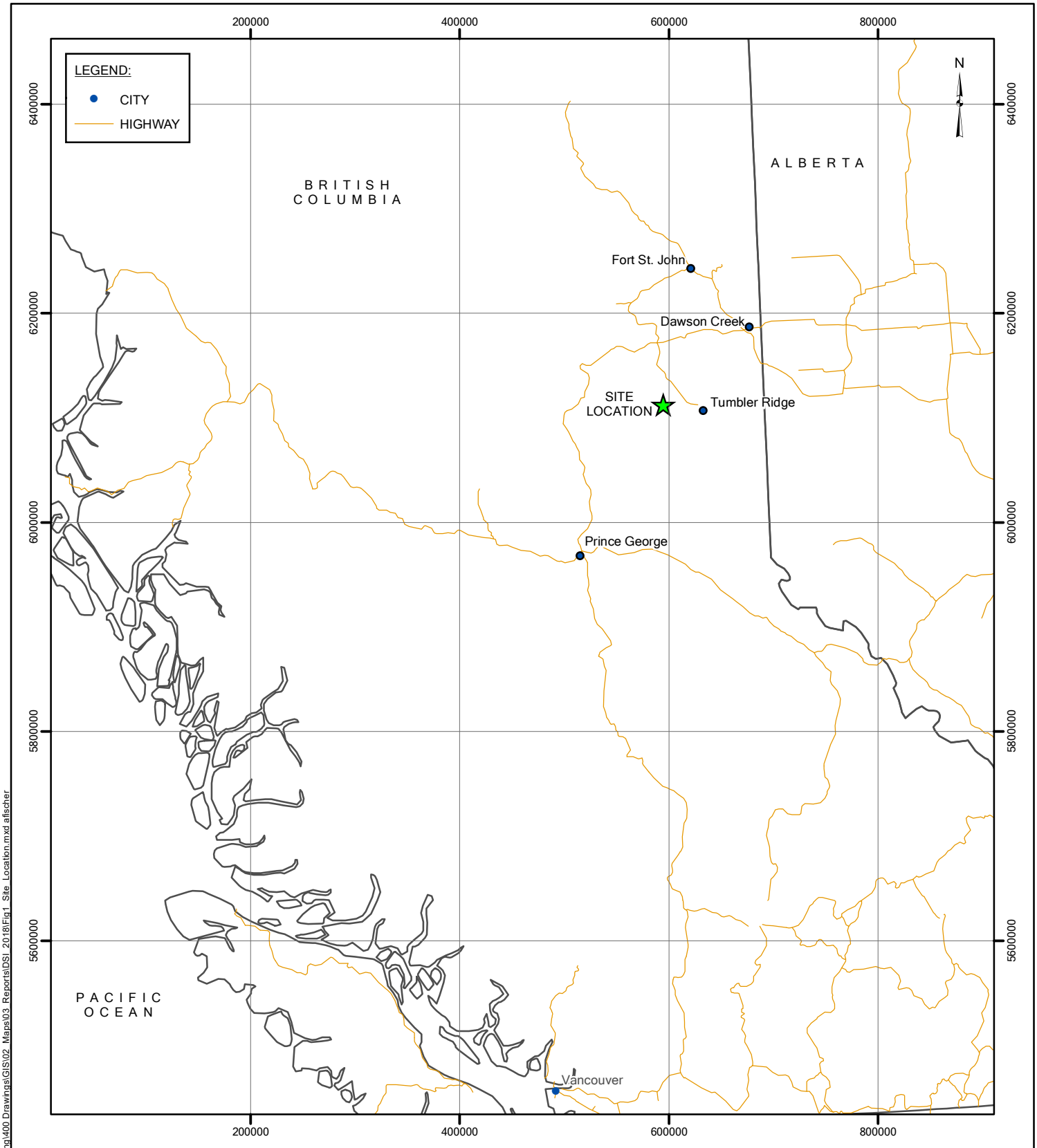
Teck Resources Limited. (Teck). 2013a. “Bullmoose Tailings Impoundment 2012 Dam Safety Inspection”, August.

Teck Resources Limited. (Teck). 2013b. “Baseline Hydrology and Design Basis”, January.

Teck Resources Limited (Teck). 2014. “Guideline for Tailings and Water Retaining Structures”, November.

Teck Resources Limited. (Teck). 2018. “Tailings Storage Facility Operations, Maintenance and Surveillance Manual”.

FIGURES



NOTES:
1. PROJECTION: UTM ZONE 10N, NAD83.
2. BASE DATA: ESRI.

SCALE 0 100 km

CLIENT [redacted]

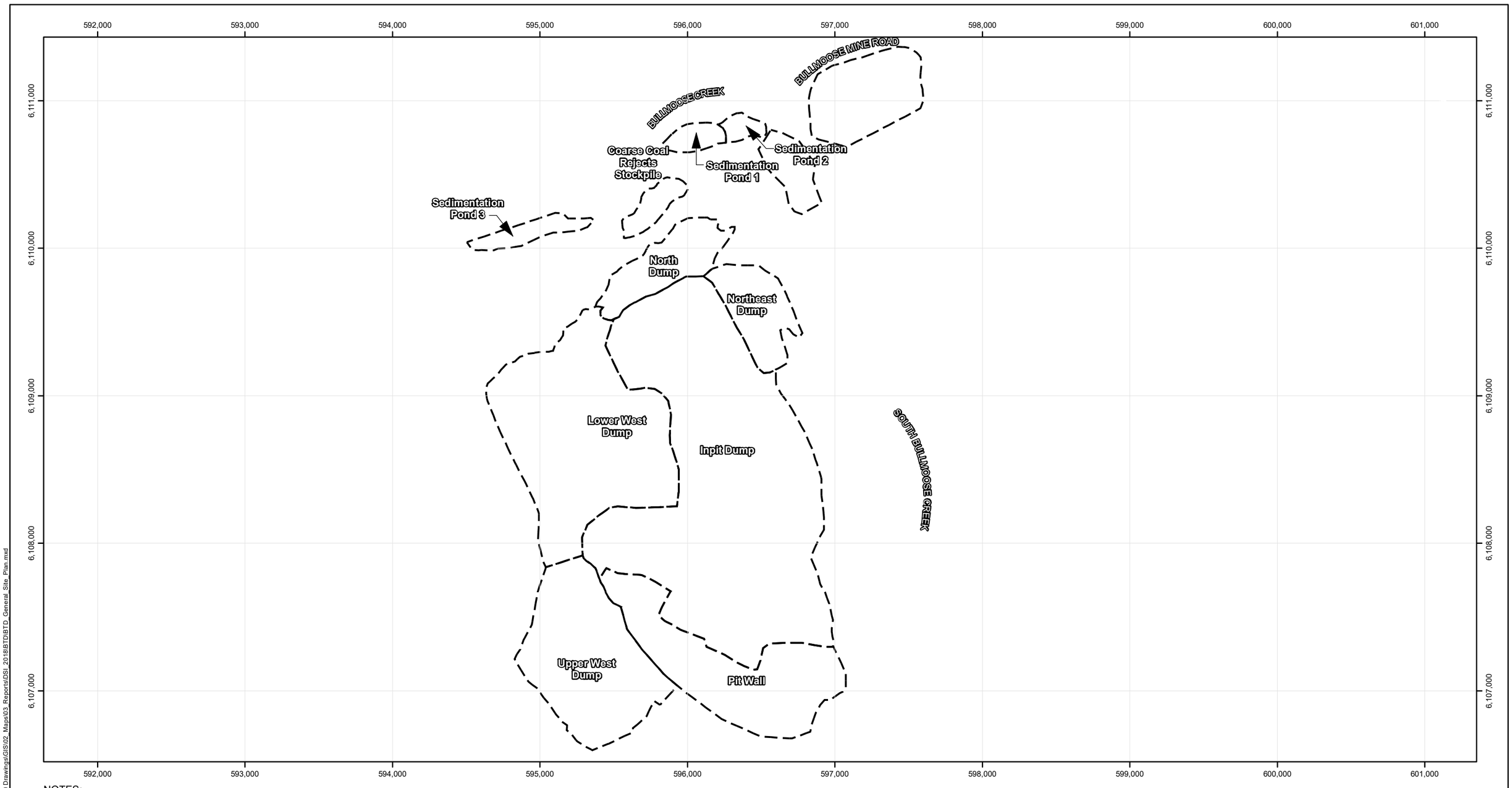
PROJECT
BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

TITLE
SITE LOCATION

PROJECT No. M09893A08

FIG No. 1

Path: Z:\M\VCR\M09893A08-TML-Bullmoose 2018 Consulting\400 Drawings\GIS\02 Maps\03 Reports\DSI 2018\Fig1 Site Location.mxd afischer



NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. BASE DATA: ESRI.
3. SEPTEMBER 2013 IMAGERY FROM TECK.

LEGEND:

STRUCTURE BOUNDARY

SCALE 0 1,000 m

CLIENT [redacted]

PROJECT
BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

TITLE
GENERAL SITE PLAN

PROJECT No. M09893A08

FIG No. 2

Path: Z:\M\VCR\M09893A08-TML-Bullmoose 2018 Consulting\400 Drawings\GIS\02_Maps\03_Reports\DSI_2018\BTD\BTD_General_Site_Plan.mxd

596,250 596,500 596,750 597,000 597,250 597,500 597,750 598,000

6,111,500 6,111,250 6,111,000 6,110,750

BULLMOOSE CREEK

BULLMOOSE MINE ROAD

TALISMAN SUB-STATION

MW-3 and MW-4

BTD-2018-13

PA-4 and PA-5

M7

A FIG.7

WINTER REJECTS STOCKPILE

B FIG.7

BULLMOOSE TAILINGS DAM

BTD-2018-14

M6

M4

BTD-2018-15

PB-4 and PB-5

BTD-2018-16

BTD-2018-04

PA-1 and PA-2

BTD-2018-12

PA-3N

M5

M3

PB-1 and PB-3

BTD-2018-03

BTD-2018-02

BTD-2018-17

BTD-2018-11

BTD-2018-10

C FIG.7

M2

PC-4N

M1

BTD-2018-05

BTD-2018-09

MW-1 and MW-5

BTD-2018-01

PC-1, PC-2 and PC-3

BULLMOOSE TAILINGS IMPOUNDMENT

BTD-2018-08

BTD-2018-06

BTD-2018-07

SEDIMENTATION POND 2

BTD-2018-18

BTD-2018-19

SEDIMENTATION POND 1

BTD-2018-20

BTD-2018-21

BTD-2018-28

BTD-2018-22

BTD-2018-23

BTD-2018-27

BTD-2018-24

BTD-2018-25

BTD-2018-26

NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. BASE DATA: TRIM, DATE: 1996.
3. SEPTEMBER 2013 IMAGERY FROM TECK.

LEGEND:

BTD-2018-23 2018 DSI PHOTOGRAPH LOCATION

M1 SURVEY MONUMENT

PC-4N PIEZOMETER

SPILLWAY

DIVERSION CHANNEL (OVERGROWN)

SCALE 0 150 m

CLIENT [redacted]

[redacted]

PROJECT
BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

TITLE
BULLMOOSE TAILINGS DAM
GENERAL ARRANGEMENT

PROJECT No. M09893A08

FIG No. 3

Path: Z:\M\VCR\M09893A08-TML-Bullmoose 2018 Consulting\400 Drawings\GIS\02_Maps\03_Reports\DSI_2018\BTD\BTD_General_Arrangement.mxd

595,500 596,000 596,500 597,000 597,500 598,000 598,500 599,000

6,111,500

6,111,000

6,110,500

6,110,000

BULLMOOSE CREEK

BULLMOOSE MINE ROAD

TALISMAN SUB-STATION

BULLMOOSE TAILINGS DAM

WINTER REJECTS STOCKPILE

WEST BULLMOOSE CREEK

BULLMOOSE TAILINGS IMPOUNDMENT

36 ha

SEDIMENTATION POND 2

SEDIMENTATION POND 1

SOUTH BULLMOOSE CREEK

NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. BASE DATA: TRIM, DATE: 1996.
3. SEPTEMBER 2013 IMAGERY FROM TECK.

LEGEND:

- SPILLWAY
- DIVERSION CHANNEL (OVERGROWN)
- CATCHMENT AREA

SCALE 0 250 m

CLIENT [redacted]

[redacted]

PROJECT
BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

TITLE
BULLMOOSE TAILINGS DAM CATCHMENT

PROJECT No. M09893A08

FIG No. 4

Path: Z:\M\VCR\M09893A08-TML-Bullmoose 2018\Consulting\400 Drawings\GIS\02_Maps\03_Reports\DSI_2018\BTD\BTD_Catchment.mxd

SECTION	PIEZOMETER	COORDINATES (m)		ORIGINAL GROUND (masl)	EXISTING GROUND ELEVATION (masl)	PIEZO. SCREEN / TIP ELEVATION (masl)	MEASURED STICKUP (m)	PNEUMATIC READING (PSI)	2018 STANDPIPE READING (m)	2018 DSI WATER ELEVATION (masl)	WATER ELEVATION LOWER THAN (IF DRY)	THRESHOLD LEVEL 1 (masl)	WATER LEVEL ABOVE ORG. GROUND (m)	2017 DSI WATER ELEVATION (masl)	CHANGE FROM 2017 (m)	PIEZOMETER LOCATION	
		EASTING	NORTHING													LOCATION	UNIT
SECTION A	PA-1 (RELABELLED IN 2017)	597396	6111244	1084.0	1112.5	1077.3	0.76	-	34.8	1078.5	-	≥1100.0	-5.5	1078.4	0.09	DOWNSTREAM SLOPE	FOUNDATION
	PA-2 (RELABELLED IN 2017)	597396	6111244	1084.0	1112.5	1083.4	0.71	-	28.1	1085.1	-	≥1100.0	1.1	1085.3	-0.18	DOWNSTREAM SLOPE	DAM
	PA-4	597402	6111284	1081.0	1092.7	1077.3	1.74	-	11.9	1082.5	-	≥1088.0	1.5	1082.4	0.16	DOWNSTREAM SLOPE	FOUNDATION
	PA-5	597402	6111284	1081.0	1092.7	1079.0	1.83	-	12.2	1082.4	-	≥1088.0	1.4	1082.2	0.15	DOWNSTREAM SLOPE	DAM
	PA-3N	597364	6111174	1082.0	1123.0	1094.8	-	1.9	-	1096.1	-	≥1107.0	14.1	1095.0	1.12	CREST	DAM
	NO LABEL (MW-3)	597428	6111318	1076.7	1090.0	1053.7	1.30	-	21.1	1070.3	-	≥1095.0	-6.5	1067.7	2.60	DOWNSTREAM SLOPE	FOUNDATION
	NO LABEL (MW-4)	597428	6111318	1076.7	1090.0	1068.3	1.23	-	15.1	1076.1	-	≥1095.0	-0.6	1074.9	1.25	DOWNSTREAM SLOPE	FOUNDATION
SECTION B	NO LABEL (LIKELY PB-1)	597126	6111148	1086.0	1123.0	1081.9	0.20	-	40.6	DRY	1082.7	≥1107.0	N/A	DRY	N/A	CREST	FOUNDATION
	PB-3	597126	6111148	1086.0	1123.0	1099.5	1.06	-	24.2	DRY	1099.9	≥1107.0	N/A	DRY	N/A	CREST	DAM
	PB-4	597094	6111219	1086.0	1100.5	1080.1	1.33	-	19.9	1081.9	-	≥1095.0	-4.1	1081.5	0.47	DOWNSTREAM SLOPE	FOUNDATION
	PB-5	597094	6111219	1086.0	1100.5	1081.6	1.36	-	19.9	1082.0	-	≥1095.0	-4.0	DRY	N/A	DOWNSTREAM SLOPE	FOUNDATION
SECTION C	PC-1	596949	6110991	1091.0	1120.5	1083.7	1.04	-	35.8	1085.7	-	≥1110.0	-5.3	1085.3	0.38	CREST	FOUNDATION
	PC-2	596949	6110991	1091.0	1120.5	1090.3	1.74	-	30.0	DRY	1092.2	≥1110.0	N/A	DRY	N/A	CREST	DAM
	PC-3	596949	6110991	1091.0	1120.5	1101.8	1.38	-	17.7	DRY	1104.2	≥1110.0	N/A	DRY	N/A	CREST	DAM
	NO LABEL (MW-1/MW-5)	596891	6111015	1093.5	1111.5	UNKNOWN	0.68	-	22.5	1089.7	-	-	-3.8	1089.5	0.16	DOWNSTREAM SLOPE	FOUNDATION
	NO LABEL (MW-1/MW-5)	596891	6111015	1093.5	1111.5	UNKNOWN	1.04	-	17.9	1094.7	-	-	1.2	DRY	N/A	DOWNSTREAM SLOPE	FOUNDATION
	PC-4N	596881	6111020	1094.0	1109.5	1093.5	-	1.5	-	1094.6	-	≥1100.0	0.6	1094.1	0.49	DOWNSTREAM SLOPE	FOUNDTATION

NOTES:

1. COORDINATES LOCATIONS ARE FROM GPS READINGS (NAD83 UTM ZONE 10N). ORIGINAL GROUND ELEVATION IN TABLE ARE FROM KL (1982). EXISTING GROUND ELEVATIONS WERE PROVIDED BY TECK.

CLIENT: Teck

Klohn Crippen Berger

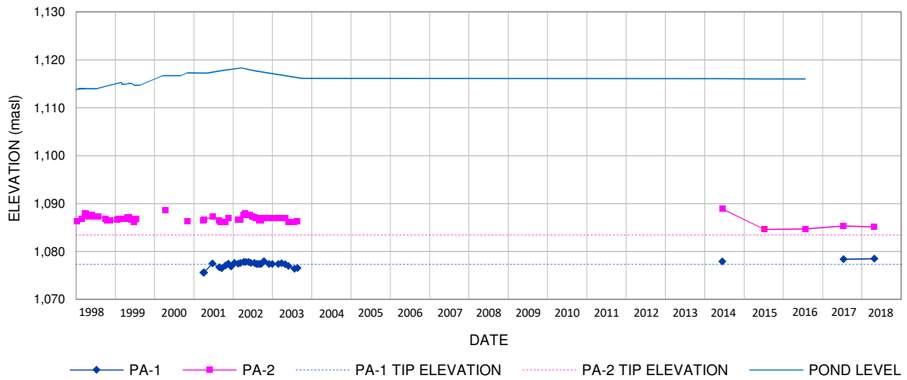
PROJECT: BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

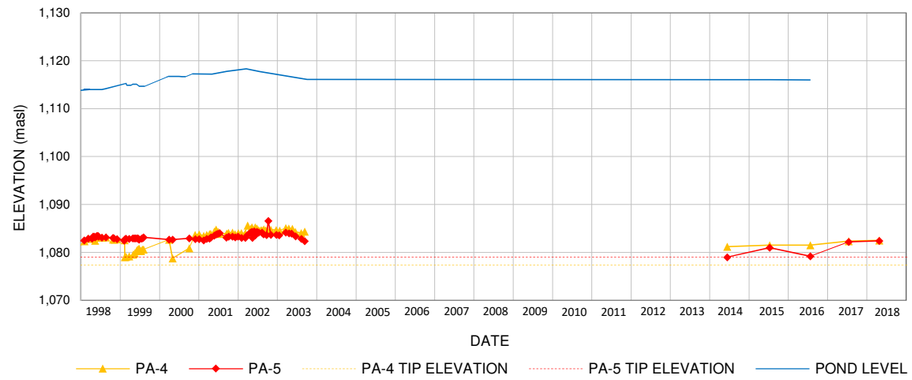
TITLE: BULLMOOSE TAILINGS DAM
2018 PIEZOMETER READINGS

PROJECT No. M09893A08

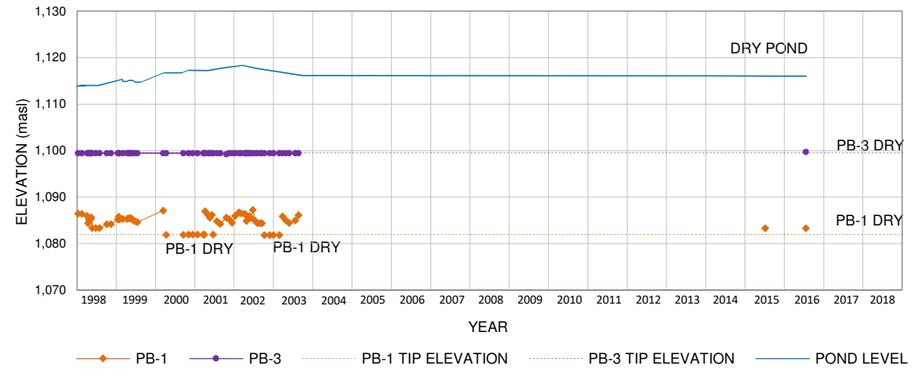
FIG. No. 5

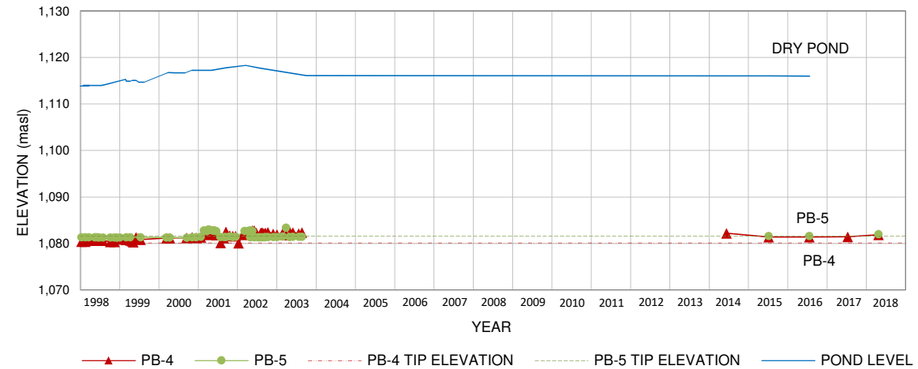
Date & Time: 2019-02-13 16:41
Figure File: Z:\M\VCR\M09893A08-TML-Bullmoose 2018 Consulting\300 Design\301 Instrumentation\BTD Piezometer\[180611 Bullmoose Piezometer.xlsx]Figure C



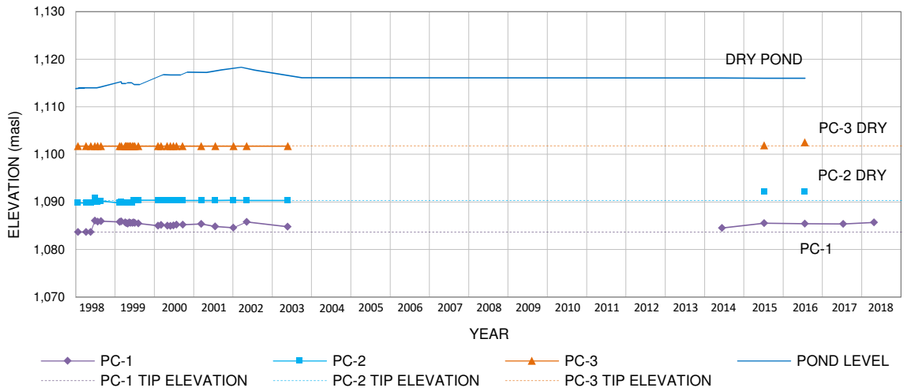


INSTRUMENTATION SECTION A





INSTRUMENTATION SECTION B



INSTRUMENTATION SECTION C

CLIENT: Teck

Klohn Crippen Berger

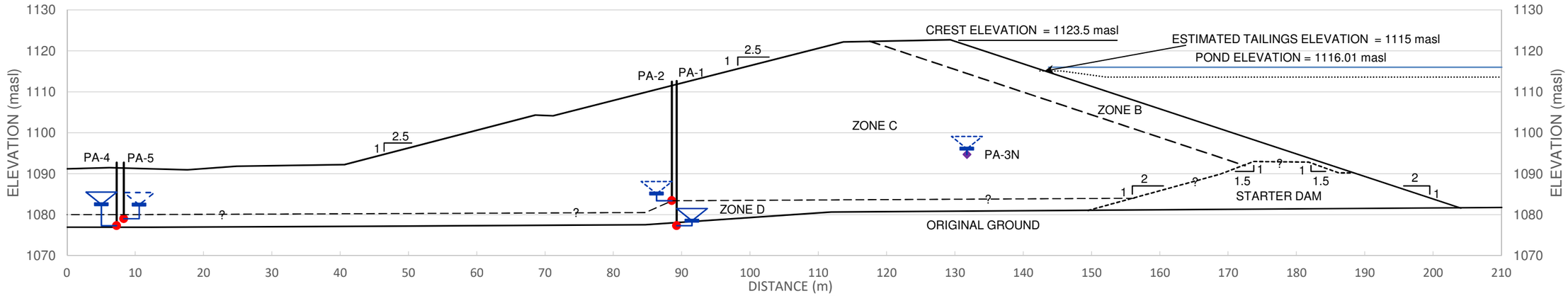
PROJECT: BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

TITLE: BULLMOOSE TAILINGS DAM
HISTORICAL PIEZOMETER READINGS

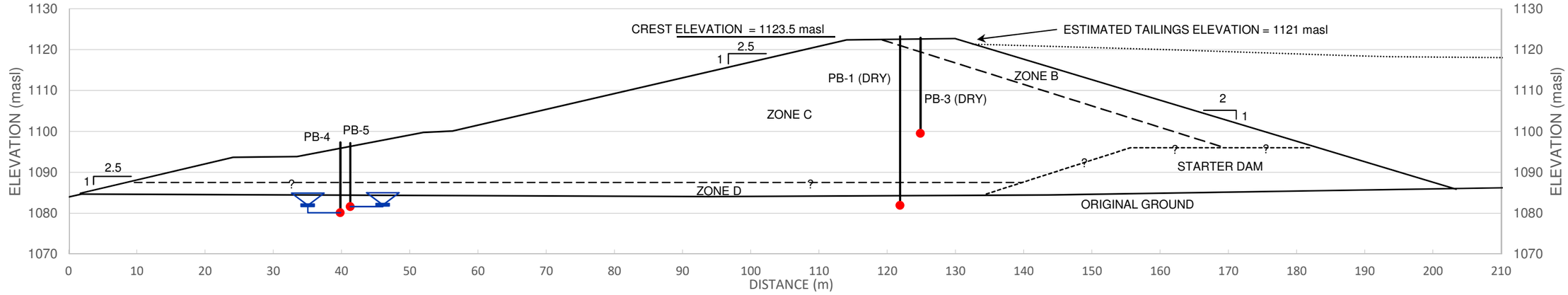
PROJECT No. M09893A08

FIG. No. 6

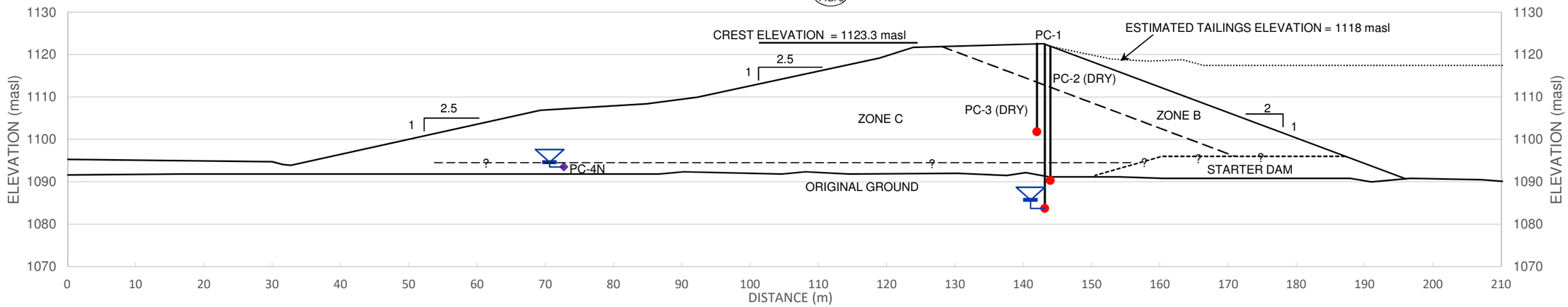
Date & Time: 2019-02-13 16:41
Figure File: Z:\MVCR\M09893A08-TML-Bullmoose 2018 Consulting\300 Design\301 Instrumentation\BTD Piezometer\[180611 Bullmoose Piezometer.xlsx]Figure C



SECTION A (FIG. 3)



SECTION B (FIG. 3)



SECTION C (FIG. 3)

NOTES:

1. SECTION DRAWINGS PRODUCED BY TECK (2004).
2. STARTER DAM SECTION OBTAINED FROM KLOHN LEONOFF (1984).
3. ZONE B AS-BUILT PRODUCED BY TECK (2000).

LEGEND:

- STANDPIPE PIEZOMETER TIP
- PNEUMATIC PIEZOMETER TIP
- EMBANKMENT PIEZOMETER WATER LEVEL
- FOUNDATION PIEZOMETER WATER LEVEL

Klohn Leonoff (1982 Design Report:

ZONE	MATERIAL	LIFT THICKNESS	COMPACTION* %Standard proctor
A Impervious	Silty sand & gravel (borrow)	0.3m	98%
B low permeability	Coarse refuse	0.15m	98%
C General Fill	Coarse refuse	0.5m	98%
D Drainage	Coarse refuse	1.0m	95%

* 98% standard proctor should be achieved with 4 passes with a large vibratory roller and 95% with about 2 passes

CLIENT: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

TITLE: BULLMOOSE TAILINGS DAM
INSTRUMENTATION SCHEMATIC
SECTIONS A, B AND C

PROJECT No. M09893A08

FIG. No. 7

Date & Time: 2019-02-13 16:41
Figure File: Z:\MVCR\M09893A08-TML-Bullmoose 2018 Consulting\300 Design\301 Instrumentation\BTD Piezometer\[180611 Bullmoose Piezometer.xlsx]Figure C

MONUMENT	NORTHING (m)						
	October 15, 2015	December 14, 2015	February 22, 2016	September 6, 2016	February 21, 2017	May 21, 2017	October 4, 2018
M1	5082.830	5082.822	5082.849	5082.857	5082.853	5082.845	5082.853
M2	5100.194	5100.186	5100.212	5100.220	5100.220	5100.208	5100.216
M3	5231.547	5231.543	5231.560	5231.565	5231.551	5231.559	5231.563
M4	5307.344	5307.335	5307.356	5307.357	5307.357	5307.355	5307.357
M5	5257.995	5257.994	5258.012	5258.013	5258.012	5258.008	5258.012
M6	5320.391	5320.390	5320.407	5320.409	5320.403	5320.405	5320.407
M7	5371.856	5371.852	5371.865	5371.869	5371.869	5371.868	5371.869

MONUMENT	EASTING (m)						
	October 15, 2015	December 14, 2015	February 22, 2016	September 6, 2016	February 21, 2017	May 21, 2017	October 4, 2018
M1	5239.400	5239.394	5239.434	5239.422	5239.407	5239.408	5239.410
M2	5181.277	5181.269	5181.313	5181.301	5181.279	5181.286	5181.288
M3	5438.104	5438.101	5438.120	5438.113	5438.113	5438.106	5438.108
M4	5408.275	5408.271	5408.292	5408.289	5408.281	5408.281	5408.282
M5	5687.275	5687.268	5687.275	5687.269	5687.274	5687.271	5687.272
M6	5715.759	5715.756	5715.760	5715.757	5715.764	5715.760	5715.758
M7	5739.531	5739.534	5739.532	5739.527	5739.531	5739.529	5739.530

MONUMENT	ELEVATION (m)						
	October 15, 2015	December 14, 2015	February 22, 2016	September 6, 2016	February 21, 2017	May 21, 2017	October 4, 2018
M1	125.512	125.524	125.505	125.502	125.511	125.496	125.500
M2	109.830	109.845	109.827	109.823	109.835	109.817	109.818
M3	125.762	125.773	125.751	125.753	125.748	125.754	125.746
M4	100.020	100.020	100.018	100.014	100.018	100.013	100.008
M5	125.863	125.860	125.846	125.849	125.857	125.846	125.845
M6	100.320	100.322	100.315	100.312	100.313	100.307	100.313
M7	95.748	95.753	95.755	95.747	95.750	95.749	95.755

SURVEY ACCURACY:
HORIZONTAL: +/- 5 mm to 10 mm
VERTICAL: +/- 5 mm to 10 mm

NOTES:

1. SURVEY DATA PROVIDED BY TECK RESOURCES LTD. LATEST READINGS RECEIVED ON DECEMBER 24, 2018.
2. BASE READING: OCTOBER 2015
3. SURVEY COORDINATES ARE MEASURED USING LOCALLY ESTABLISHED DATUM.

CLIENT: Teck

Klohn Crippen Berger

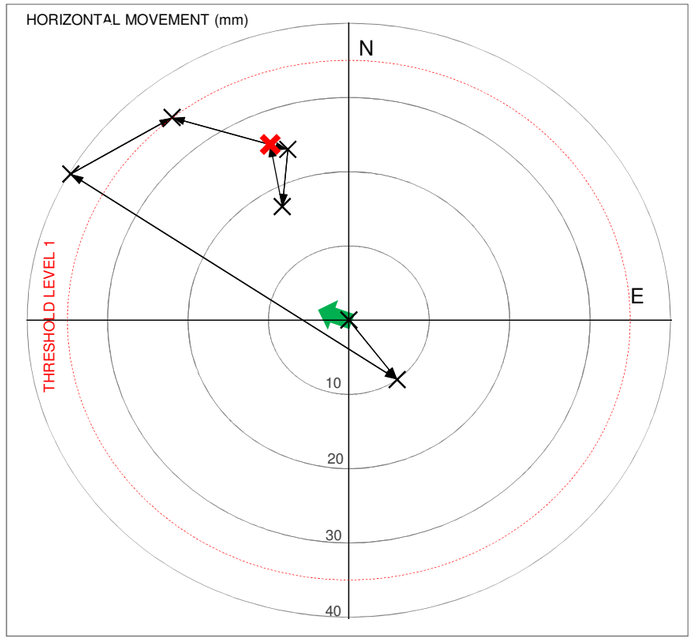
PROJECT: BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

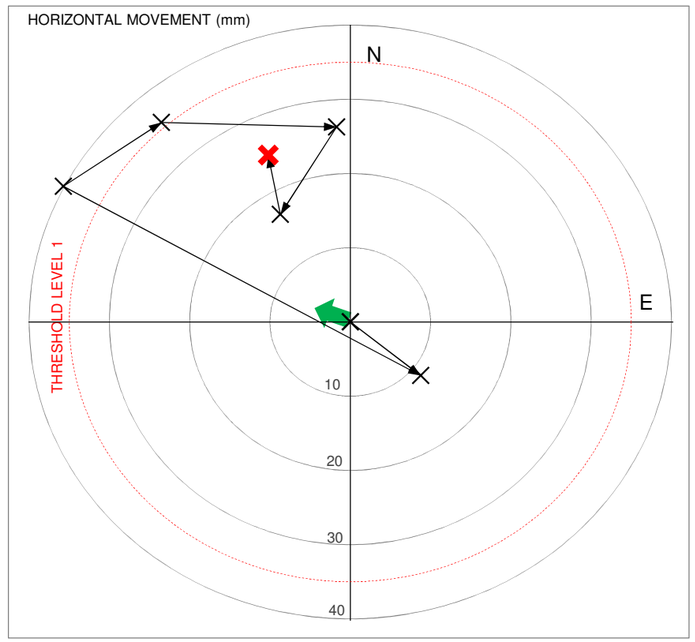
TITLE: BULLMOOSE TAILINGS DAM
2018 SURVEY MONUMENTS READINGS

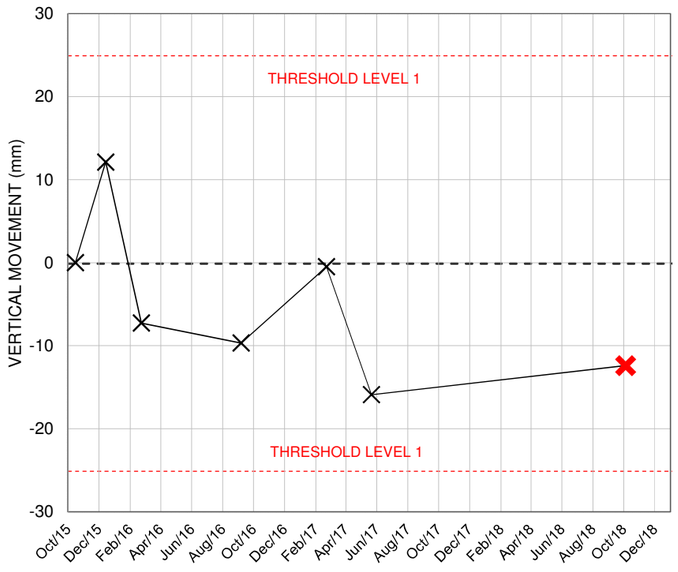
PROJECT No. M09893A08

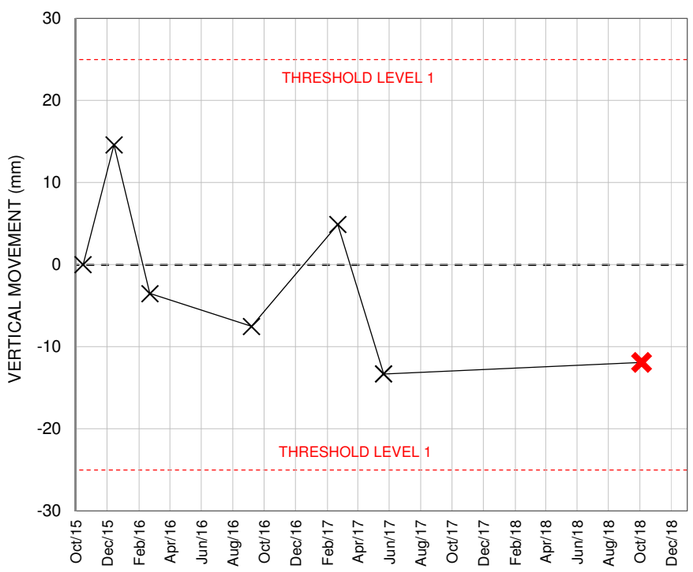
FIG. No. 8

Date & Time: 2019-02-13 17:04
Figure File: Z:\M\VCR\M09893A08-TML-Bullmoose 2018 Consulting\300 Design\301 Instrumentation\BTD Survey\[190104 Bullmoose Survey.xlsx]Project & Figure Info.









M1 SURVEY RECORDS

M2 SURVEY RECORDS

NOTES:

1. SURVEY DATA PROVIDED BY TECK RESOURCES LTD. LATEST READINGS RECEIVED ON DECEMBER 24, 2018.
2. SURVEY COORDINATES ARE MEASURED USING LOCALLY ESTABLISHED DATUM.

LEGEND:

- DOWNSTREAM DIRECTION
- LATEST SURVEY READING

THRESHOLD VALUES:

THRESHOLD LEVEL 1: ≥ 35 mm OF HORIZONTAL MOVEMENT FROM INITIAL READING;
≥ 35 mm OF VERTICAL MOVEMENT FROM INITIAL READING; OR
IF VERTICAL MOVEMENT ≥ 15 mm BETWEEN SUCCESSIVE READINGS.
THRESHOLD LEVEL 2: IF THERE IS A TREND OF THRESHOLD EXEEDANCE IN THE MONITORING MONUMENTS.

SURVEY ACCURACY:

HORIZONTAL: +/- 5 mm to 10 mm
VERTICAL: +/- 5 mm to 10 mm

CLIENT: Teck

Klohn Crippen Berger

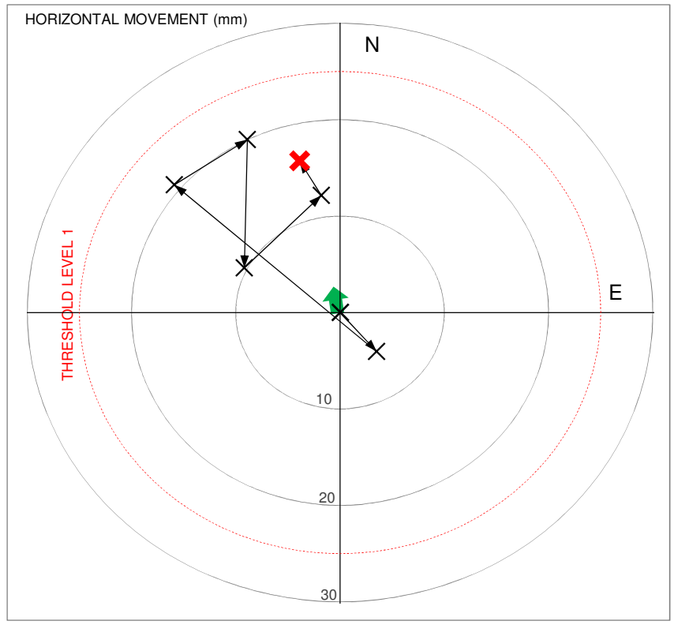
PROJECT: BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

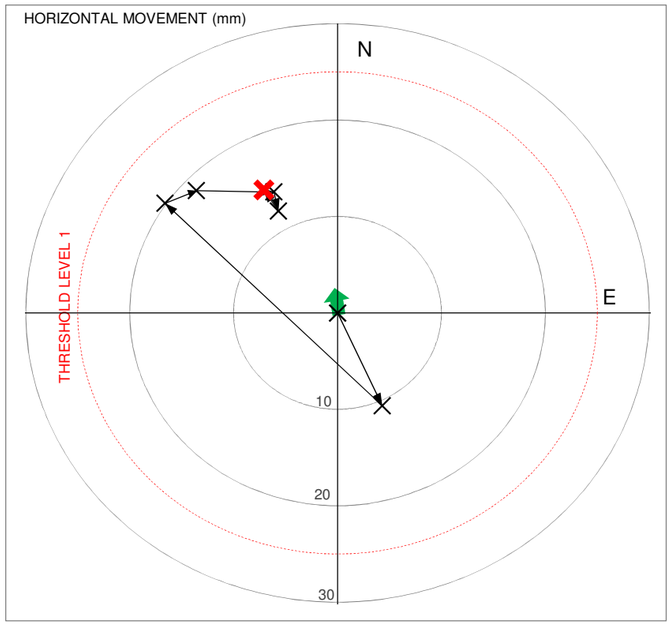
TITLE: BULLMOOSE TAILINGS DAM
SURVEY MONUMENTS (M1 AND M2) AND
THRESHOLD LEVELS

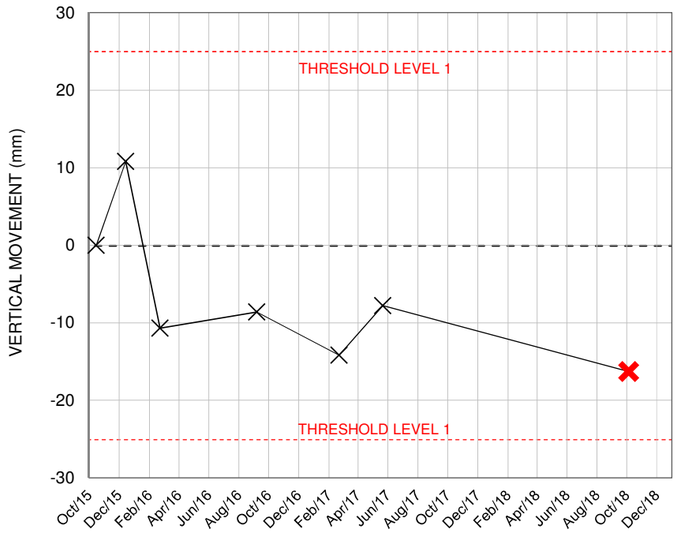
PROJECT No. M09893A08

FIG. No. 9

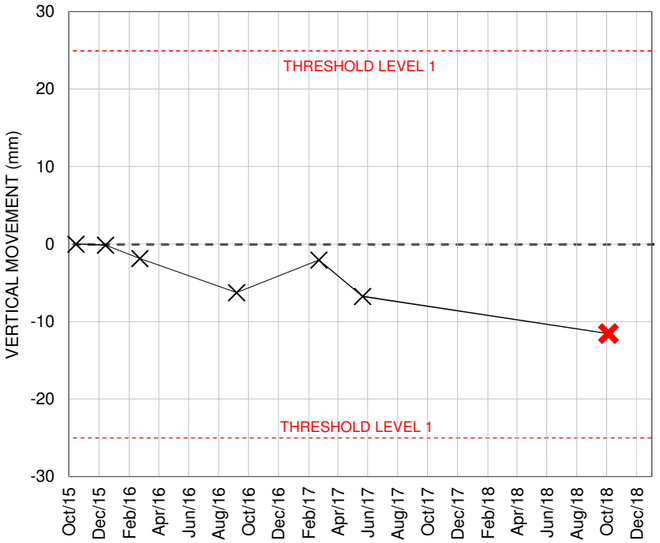
Date & Time: 2019-02-13 17:04
Figure File: Z:\M\VCR\M09893A08-TML-Bullmoose 2018 Consulting\300 Design\301 Instrumentation\BTD Survey\[190104 Bullmoose Survey.xlsx]Project & Figure Info.







M3 SURVEY RECORDS



M4 SURVEY RECORDS

NOTES:

1. SURVEY DATA PROVIDED BY TECK RESOURCES LTD. LATEST READINGS RECEIVED ON DECEMBER 24, 2018.
2. SURVEY COORDINATES ARE MEASURED USING LOCALLY ESTABLISHED DATUM.

LEGEND:

DOWNSTREAM DIRECTION

LATEST SURVEY READING

THRESHOLD VALUES:

THRESHOLD LEVEL 1: ≥ 25 mm OF HORIZONTAL MOVEMENT FROM INITIAL READING;
≥ 25 mm OF VERTICAL MOVEMENT FROM INITIAL READING; OR
IF VERTICAL MOVEMENT ≥ 15 mm BETWEEN SUCCESSIVE READINGS.
THRESHOLD LEVEL 2: IF THERE IS A TREND OF THRESHOLD EXEEDANCE IN THE MONITORING MONUMENTS.

SURVEY ACCURACY:

HORIZONTAL: +/- 5 mm to 10 mm
VERTICAL: +/- 5 mm to 10 mm

CLIENT: Teck

Klohn Crippen Berger

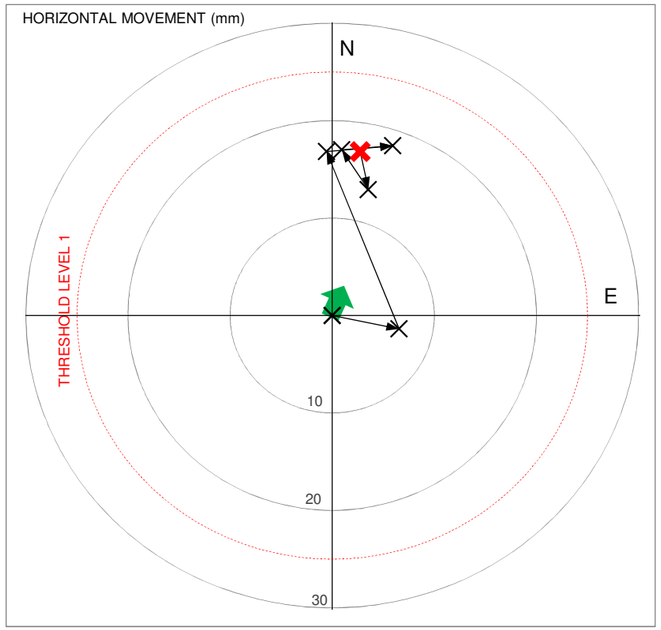
PROJECT: BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

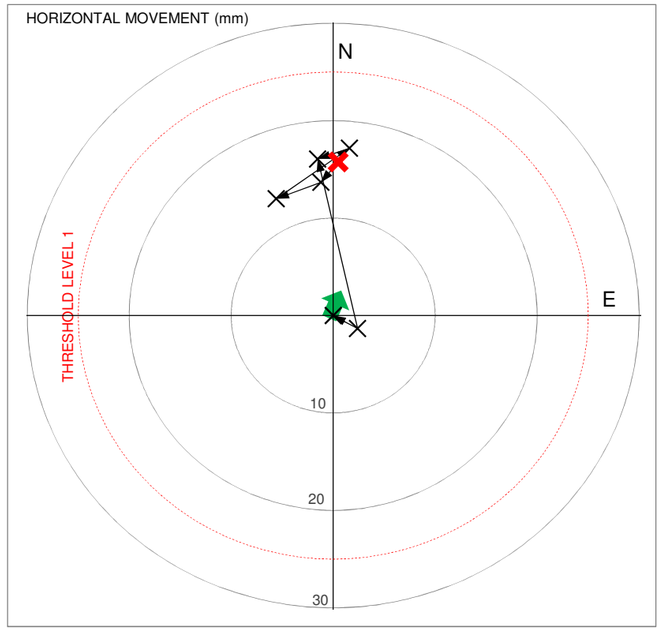
TITLE: BULLMOOSE TAILINGS DAM
SURVEY MONUMENTS (M3 AND M4) AND
THRESHOLD LEVELS

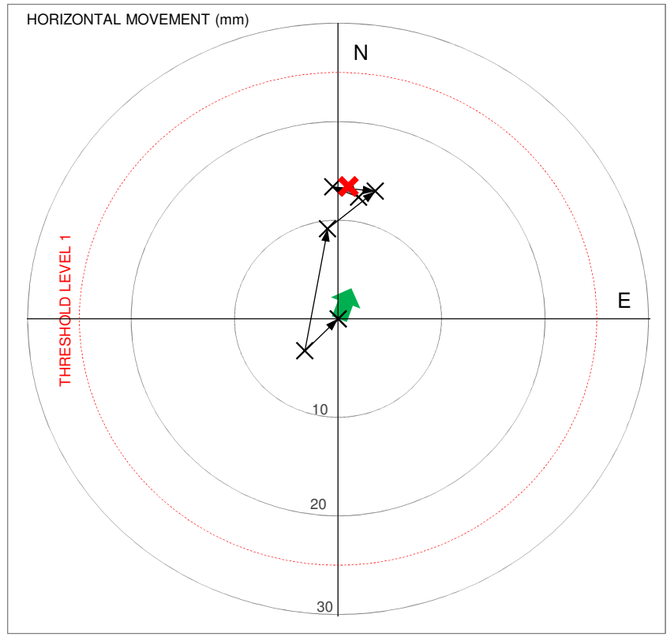
PROJECT No. M09893A08

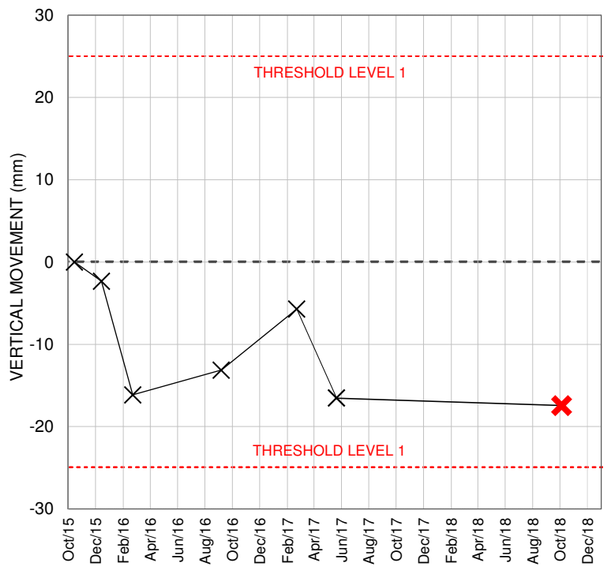
FIG. No. 10

Date & Time: 2019-02-13 17:04
Figure File: Z:\M\VCR\M09893A08-TML-Bullmoose 2018 Consulting\300 Design\301 Instrumentation\BTD Survey\[190104 Bullmoose Survey.xlsx]Project & Figure Info.

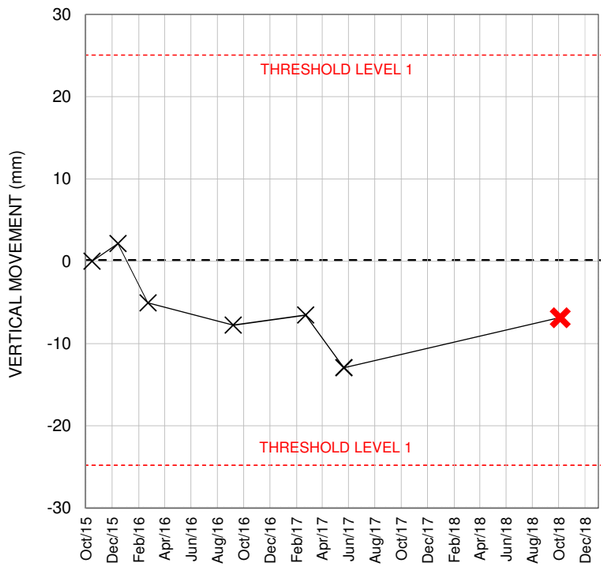




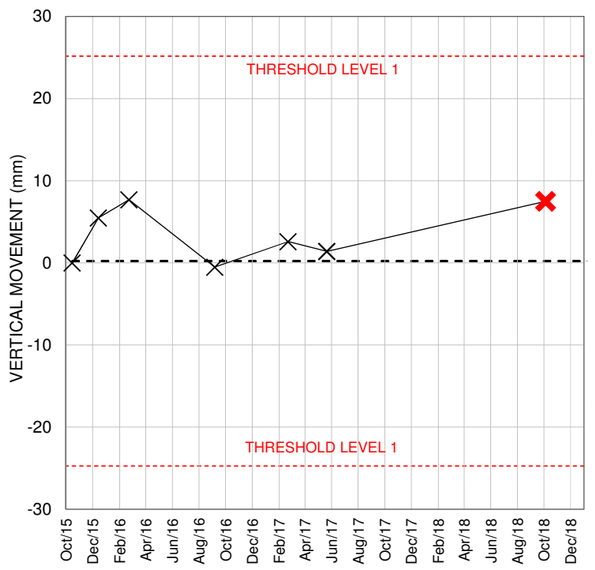




M5 SURVEY RECORDS



M6 SURVEY RECORDS



M7 SURVEY RECORDS

NOTES:

1. SURVEY DATA PROVIDED BY TECK RESOURCES LTD. LATEST READINGS RECEIVED ON DECEMBER 24, 2018.
2. SURVEY COORDINATES ARE MEASURED USING LOCALLY ESTABLISHED DATUM.

LEGEND:

DOWNSTREAM DIRECTION

LATEST SURVEY READING

THRESHOLD VALUES:

THRESHOLD LEVEL 1: ≥ 25 mm OF HORIZONTAL MOVEMENT FROM INITIAL READING;
≥ 25 mm OF VERTICAL MOVEMENT FROM INITIAL READING; OR
IF VERTICAL MOVEMENT ≥ 15 mm BETWEEN SUCCESSIVE READINGS.
THRESHOLD LEVEL 2: IF THERE IS A TREND OF THRESHOLD EXEEDANCESIN THE MONITORING MONUMENTS.

SURVEY ACCURACY:

HORIZONTAL: +/- 5 mm to 10 mm
VERTICAL: +/- 5 mm to 10 mm

CLIENT: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2018 DAM SAFETY INSPECTION

TITLE: BULLMOOSE TAILINGS DAM
SURVEY MONUMENTS (M5 TO M7) AND
THRESHOLD LEVELS

PROJECT No. M09893A08

FIG. No. 11

Date & Time: 2019-02-13 17:04
Figure File: Z:\MVCR\M09893A08-TML-Bullmoose 2018 Consulting\300 Design\301 Instrumentation\BTD Survey\[190104 Bullmoose Survey.xlsx]Project & Figure Info.

APPENDIX I

Facility Data Sheet

Appendix I
Facility Data Sheet

Item	Information
Dam Type	Zoned Earthfill comprises of Coarse Coal Refuse - CCR
Foundation	Competent Silty Sand and Gravel, Glacial Till and Alluvial Soils
Construction Methodologies	Downstream Raises
Operation	1983 to 2003
Maximum Dam Height	38 m (crest to downstream toe)
Crest Elevation	1,123 masl
Dam Length	1,050 m
Dam Crest Width	10 m to 15 m
Slopes	Upstream 2H:1V; Downstream 2.5H:1V
Impoundment Area	20 ha (surface area of covered tailings plus 2 ha of pond)
Pond Volume	26,000 m^3 (approximate)
Volume of Tailings	4.4 million m^3
Storage Capacity	4.6 million m^3
Consequence Classification	"High"
Phase	"Closure-Passive Care" based on CDA (2014)
Inflow Design Flood (IDF)	$^2/_3$ between 1,000-year return period and PMF (based on "High" consequence classification)
Design Earthquake	½ between 2,475-year and 10,000-year return period earthquake (based on "High" consequence classification)
Spillway Capacity	Inlet El. 1,122 masl. Spillway has the capacity to route IDF while leaving 0.5 m of freeboard.
Minimum Required Freeboard	0.2 m based on CDA (2013) wave setup + wave runup methodologies
Catchment Area	36 ha (16 ha upslope; 20 ha impoundment)
Access to Dam	Vehicle access to the mine from Tumbler Ridge, BC, is 27 km northwest along BC Highway 29, and then 18 km southwest along Bullmoose Road.

APPENDIX II

Inspection Photographs

Appendix II
Inspection Photographs

LEGEND:

- BTD = Bullmoose Tailings Dam
- BTD-2018-## refers to the 2018 DSI photograph location, as shown on Figure 3

Photographs were taken during site inspection on May 29, 2018.

Photo II-1 Overview of BTD crest – looking east. Slope is in good condition and no signs of erosion, settlement or cracking (BTD-2018-01)

Photo II-2 Overview of BTD crest - looking south. No signs of distress (BTD-2018-01)

Photo II-3 Overview of upstream slope - looking south. Slope is in good condition and no sign of distress (BTD-2018-01)

Photo II-4 **Overview of upstream slope - looking southwest. Slope is in good condition and no sign of distress (BTD-2018-02)**

Photo II-5 **Overview of ponded area. Pond level appears to be elevated due to spring freshet - higher than previous year observation (not a dam safety concern) (BTD-2018-03)**

Photo II-6 Overview of upstream slope - looking north. Slope is in good condition and no signs of distress (BTD-2018-03)

Photo II-7 Standpipe piezometer PA-1 – top of casing requires trimming (BTD-2018-04)

Photo II-8 **Overview of upstream slope adjacent to the ponded area - looking northwest. Slope is in good condition and no signs of distress (BTD-2018-05)**

Photo II-9 **Over view of BTD east abutment – looking south. No changes were observed since 2016 (BTD-2018-06)**

Photo II-10 Historical slide area on a natural slope south of the impoundment – looking south. No significant changes since 2015 observation (BTD-2018-07)

Photo II-11 Side channel which runs downslope from the east abutment – looking northeast. Flow was approximately 1 L/min (BTD-2018-08)

Photo II-12 **Ponded area downstream of the east abutment – looking north. Water level appears to be elevated due to freshet when compared to 2017 observation (BTD-2018-09)**

Photo II-13 **Rain/snowmelt erosion feature – looking north. The gully is approximately 0.2 m to 0.3 m wide, and 0.8 m to 1.1 m deep, and approximately 10 m to 15 m long. No significant changes from 2017 observation (BTD-2018-10)**

Photo II-14 Overview of the lower downstream slope – looking north. Photo was taken standing on the mid-slope bench. No signs of distress (BTD-2018-11)

Photo II-15 Overview of the upper downstream slope – looking northwest. Photo was taken standing on the mid-slope bench. No signs of distress (BTD-2018-12)

Photo II-16 **Overview of the upper portion of the downstream slope – looking southwest. Possible slope break observed likely due to normal soil erosion and rilling (BTD-2018-12)**

Photo II-17 **Upper portion of the downstream slope – looking north. Slope is in good condition with no signs of erosion or movement (BTD-2018-13)**

Photo II-18 Lower portion of the downstream slope – looking west. Slope is in good condition with no signs of erosion or movement (BTD-2018-14)

Photo II-19 Overview of the downstream slope – looking east. Slope is in good condition with no signs of erosion or movement (BTD-2018-14)

Photo II-20 Overview of the downstream slope – looking west. Slope is in good condition with no signs of erosion or movement (BTD-2018-15)

Photo II-21 Boggy area observed at the toe – looking west. Ponded water likely due to recent freshet (BTD-2018-16)

Photo II-22 Downstream slope – looking east. Slope is in good condition with no signs of erosion or movement (BTD-2018-17)

Photo II-23 Upstream slope – looking north. Slope is in good condition with no signs of erosion or movement (BTD-2018-18)

Photo II-24 Downstream slope – looking west. Slope is in good condition with no signs of erosion or movement (BTD-2018-19)

Photo II-25 Upstream slope – looking southeast. Tailings surface elevation is approximately 1.5 m lower than the crest elevation (BTD-2018-20)

Photo II-26 Spillway inlet – looking southwest. Vegetation was removed in 2017; no major obstruction (BTD-2018-21

Photo II-27 Spillway channel – looking southwest. Vegetation clearing activity disturbed riprap materials. Photo was taken before repair work was completed (BTD-2018-22)

Photo II-28 Disturbed riprap overview – photo was taken during the DSI site visit (BTD-2018-22)

Photo II-29 Blue PVC pipe fragment found in the BTD spillway channel – no information on the PVC pipe is available for review (BTD-2018-23)

Photo II-30 Spillway channel section founded on bedrock – looking upstream. No obstruction was observed (BTD-2018-24)

Photo II-31 Typical cut in bedrock on left bank of spillway channel (BTD-2018-24)

Photo II-32 Spillway channel - looking downstream where channel transitions from riprap lined (invert and right bank) and bedrock (left bank) to channel being entirely in bedrock (BTD-2018-24)

Photo II-33 Spillway channel looking downstream after transition from bedrock to riprap. Channel is armoured with riprap on the invert and side slopes (BTD-2018-25)

Photo II-34 End of riprap along channel at spillway outfall – looking downstream. Spillway discharges over a natural steep slope (BTD-2018-26)

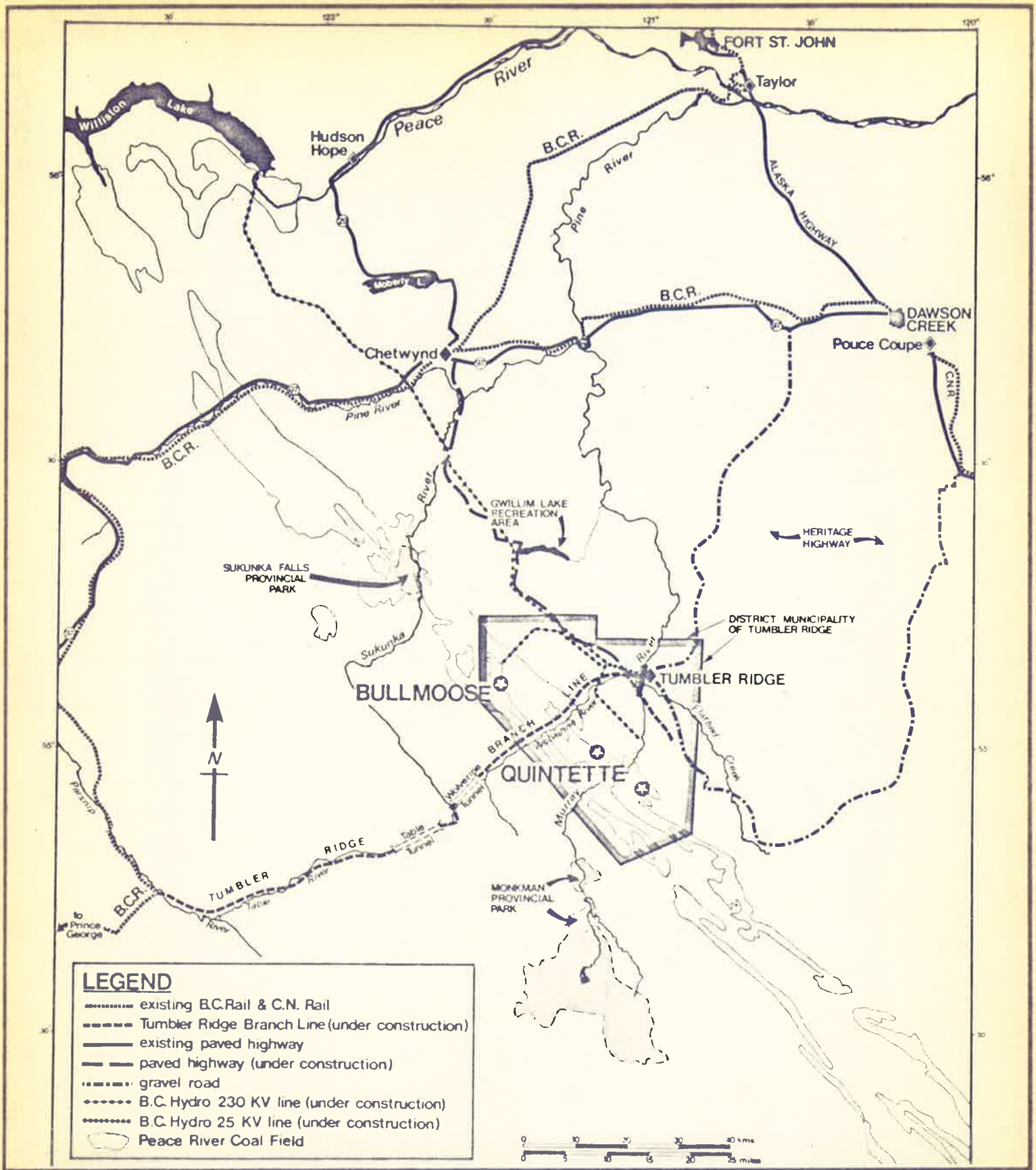
Photo II-35 Downstream slope near the west abutment – looking north. No signs of distress (BTD-2018-27)

Photo II-36 Toe of the dam along west slope is approximately 1.5H:1V – looking north. The slope appears to be stable with no significant sign of erosion or movement (BTD-2018-28)

Photo II-37 Teck repaired disturbed riprap on August 15, 2018 – looking northeast

APPENDIX III

Dam Design Drawings



KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

TITLE: LOCATION PLAN

CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE: OCT. 22, 1982

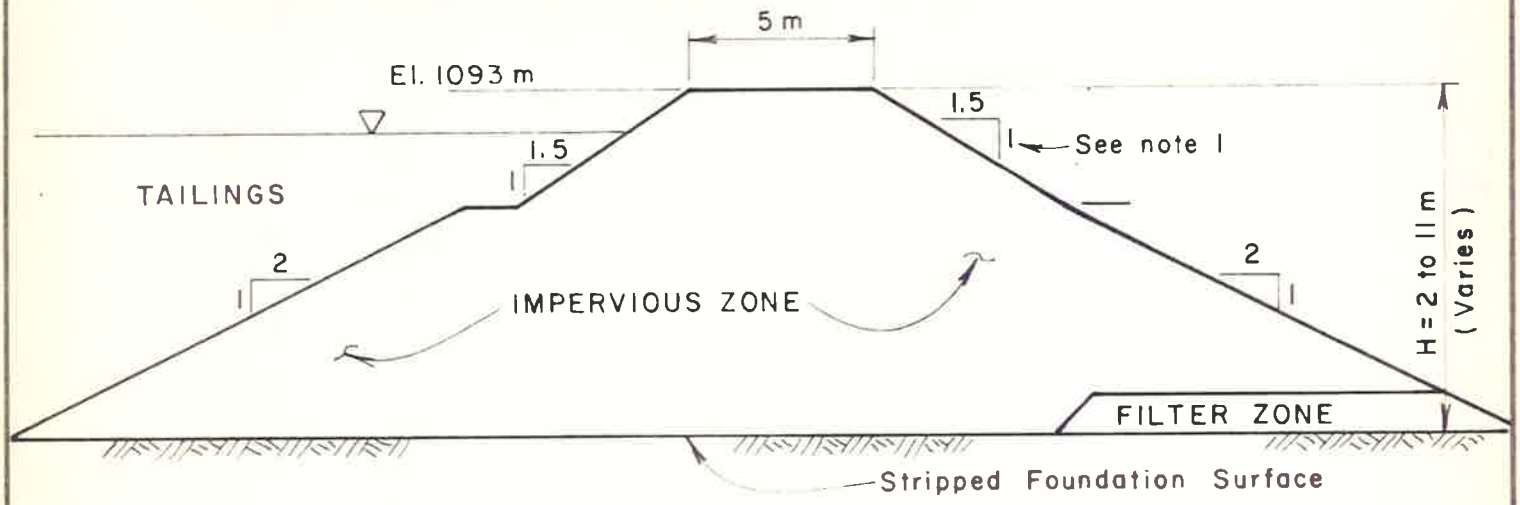
APPROVED: H. N. McLEOD

PROJECT No: PB2971-02

DWG No: A-101

REV:

PROFESSIONAL ENGINEER — BRITISH COLUMBIA



FOUNDATION SOILS

(Vary from medium dense sand and gravel to silty sands and sandy silts)

NOTES

1. Dam slope revised to 1.5 : 1, H:V over maximum top 5.0 metres of dam in October, 1984.
2. Impervious zone consists of silty sand and gravel compacted to 98 % of the Standard Proctor Density.
3. Filter zone consists of blasted mudstone and sandstone, moderately well graded; 15 percent greater than 150 mm.

SCALE 1:200

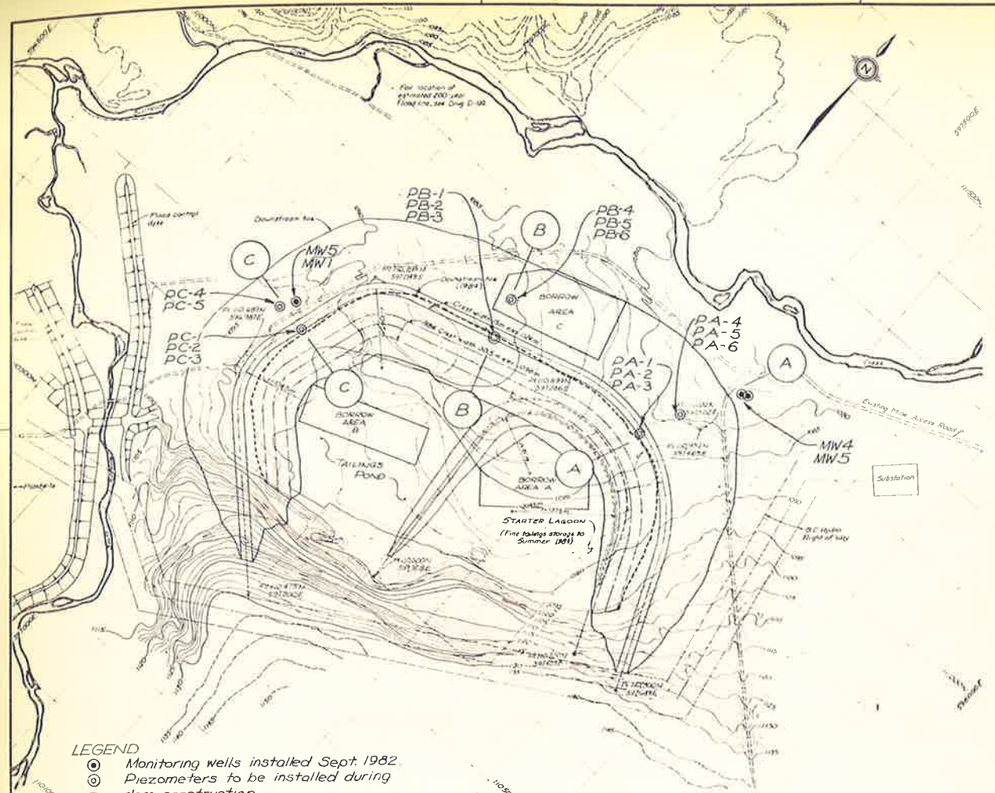
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

TITLE: TAILINGS STARTER DAM
TYPICAL AS-BUILT SECTION

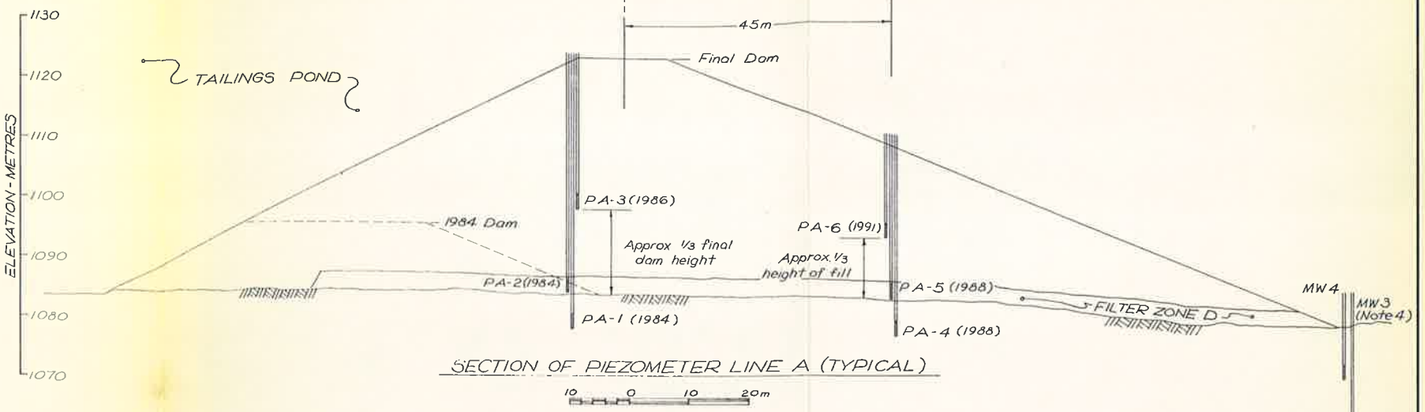
CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No	DWG No	REV
MARCH 15, 1984	PB2971-02	A-117	
APPROVED			

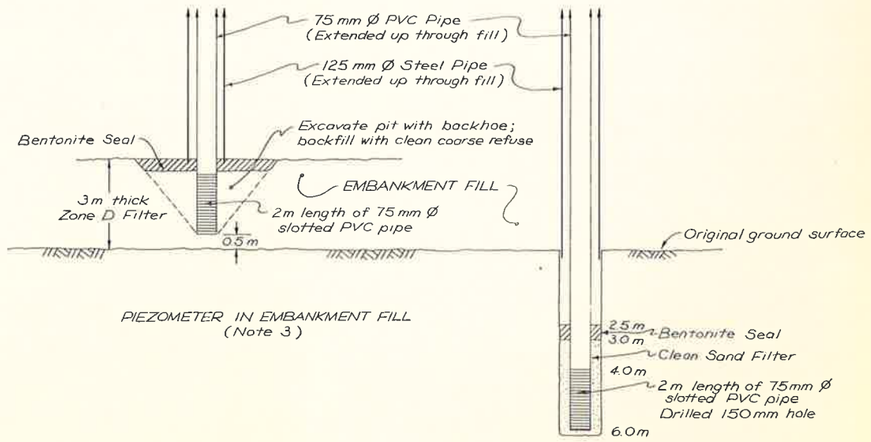


LEGEND
- ◉ Monitoring wells installed Sept 1982
- ◎ Piezometers to be installed during dam construction.
- (A) Piezometer Lines

LOCATION PLAN
50 0 50 100m



SECTION OF PIEZOMETER LINE A (TYPICAL)
10 0 10 20m



PIEZOMETER IN EMBANKMENT FILL (Note 3)

FOUNDATION PIEZOMETER (Note 1)

TYPICAL PIEZOMETER INSTALLATION DETAILS

N.T.S.

NOTES:

1. Standpipe piezometers will be installed during construction of the dam and will be extended up through the embankment fill. PA-1, PA-2 and PB-1, PB-2 and PC-1, PC-2 to be installed in 1984. Additional piezometers to be installed as shown during later construction.
2. Foundation piezometers to be installed with a drilling rig.
3. Piezometers in embankment fill to be installed with a backhoe.
4. Monitoring wells installed by Klohn Leonoff Ltd. in Sept. 1982.

TO BE READ WITH KLOHN LEONOFF REPORT DATED OCT. 22, 1982

SCALE: AS SHOWN

REV.	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
H.M.	D.T.	OCT. 1982	AS SHOWN

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

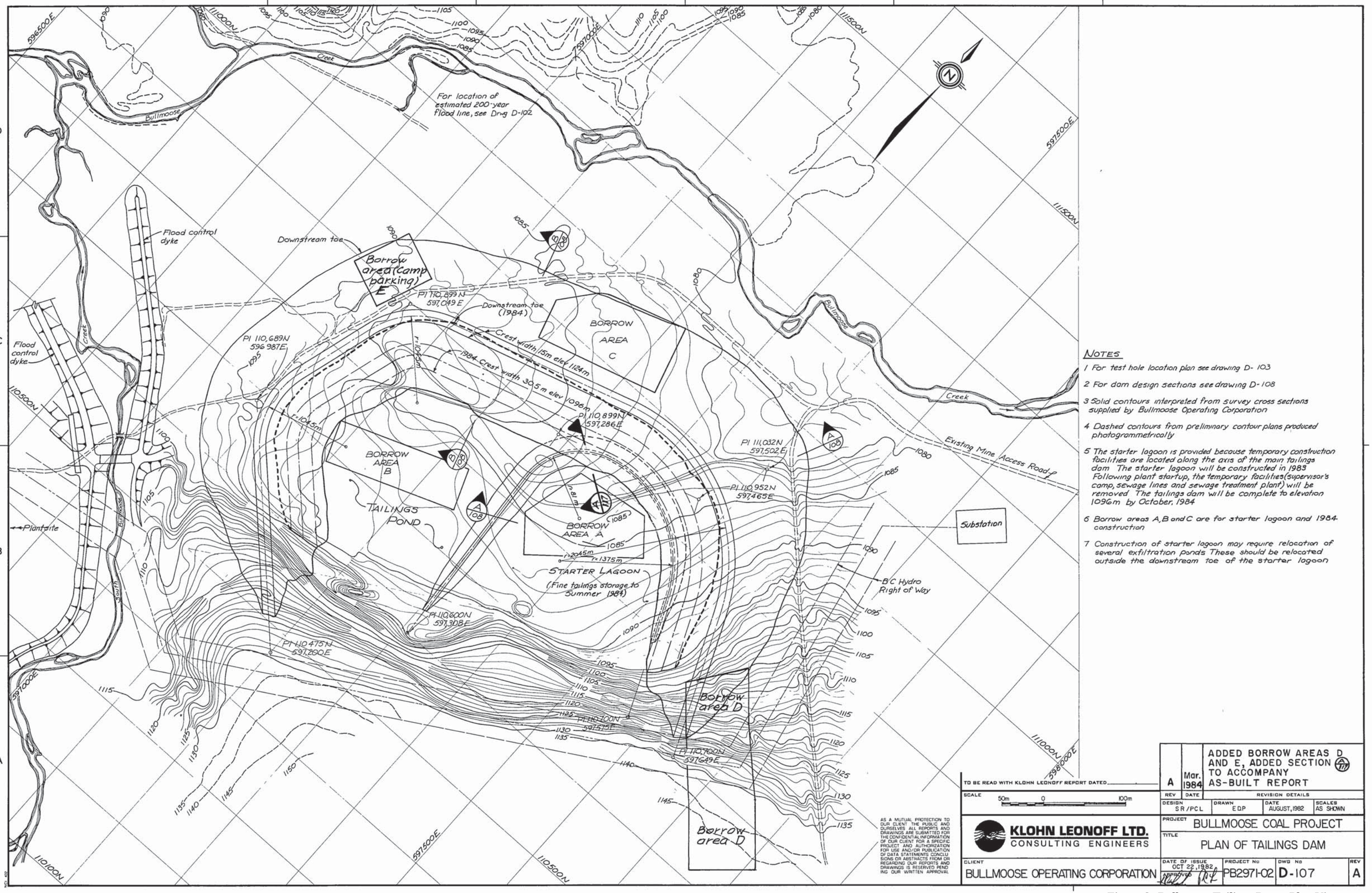
TITLE: PLAN, SECTION & DETAILS OF TAILINGS DAM PIEZOMETERS

CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. 22, 1982	PB2971-02	D-112	

APPROVED

P. C. LIGHTHALL
PROFESSIONAL ENGINEER
BRITISH COLUMBIA



NOTES

1 For test hole location plan see drawing D-103

2 For dam design sections see drawing D-108

3 Solid contours interpreted from survey cross sections supplied by Bullmoose Operating Corporation

4 Dashed contours from preliminary contour plans produced photogrammetrically

5 The starter lagoon is provided because temporary construction facilities are located along the axis of the main tailings dam The starter lagoon will be constructed in 1983 Following plant startup, the temporary facilities (supervisor's camp, sewage lines and sewage treatment plant) will be removed The tailings dam will be complete to elevation 1096m by October, 1984

6 Borrow areas A, B and C are for starter lagoon and 1984 construction

7 Construction of starter lagoon may require relocation of several exfiltration ponds These should be relocated outside the downstream toe of the starter lagoon

TO BE READ WITH KLOHN LEONOFF REPORT DATED

REV	DATE	REVISION DETAILS
A	Mar. 1984	ADDED BORROW AREAS D AND E, ADDED SECTION (A-111) TO ACCOMPANY AS-BUILT REPORT

SCALE 50m 0 100m

DESIGN	DRAWN	DATE	SCALES
SR/PCL	EDP	AUGUST, 1982	AS SHOWN

KLOHN LEONOFF LTD. CONSULTING ENGINEERS

PROJECT BULLMOOSE COAL PROJECT

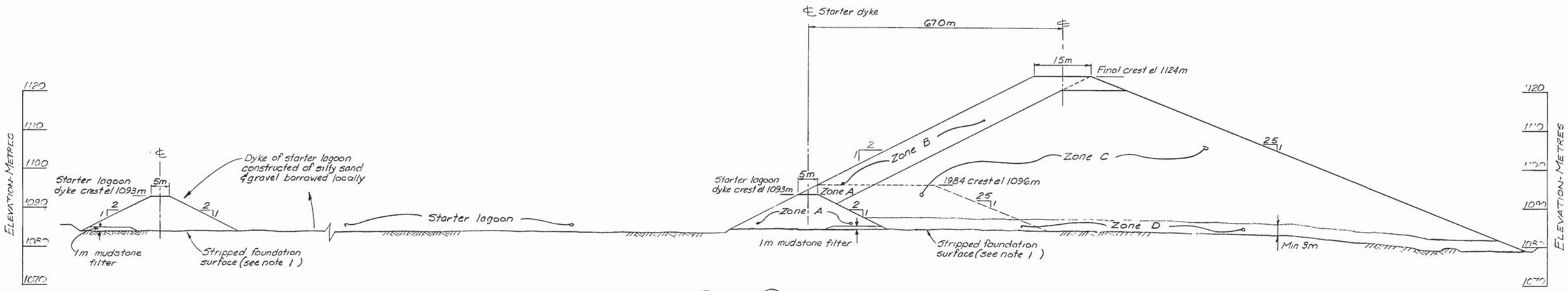
TITLE PLAN OF TAILINGS DAM

CLIENT BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No	DWG No	REV
OCT 22, 1982	PB2971-02	D-107	A

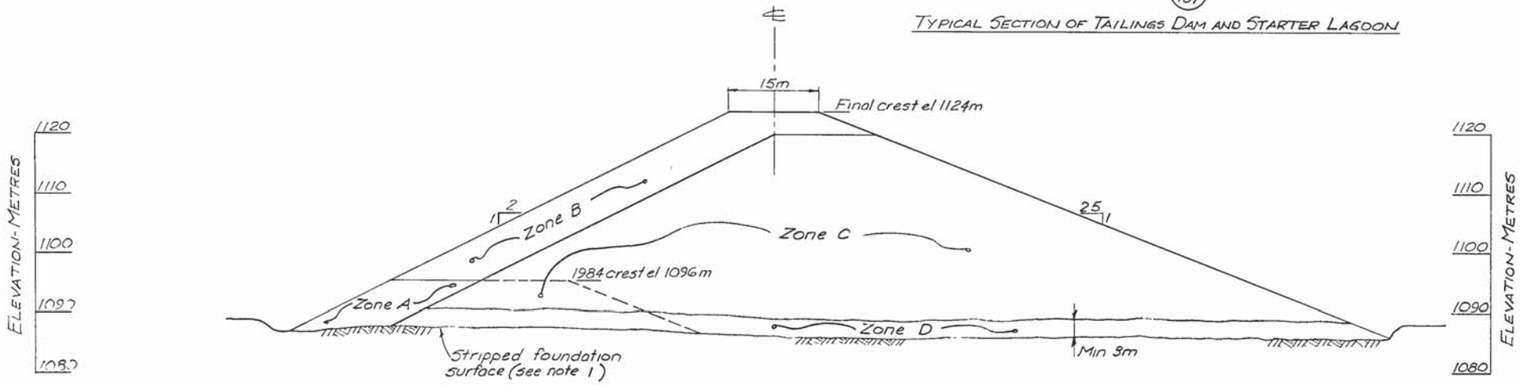
APPROVED

Figure 6 Bullmoose Tailings Dam - Plan View



SECTION A/107

TYPICAL SECTION OF TAILINGS DAM AND STARTER LAGOON



SECTION B/107

TYPICAL SECTION OF TAILINGS DAM

ZONE	MATERIAL	LIFT THICKNESS	COMPACTION* %Standard proctor
A Impervious	Silty sand & gravel (borrow)	0.3m	98 %
B Low permeability	Coarse refuse	0.15m	98 %
C General fill	Coarse refuse	0.5m	98 %
D Drainage	Coarse refuse	1.0m	95 %

* 98% standard proctor should be achieved with 4 passes with a large vibratory roller and 95 % with about 2 passes

CONSTRUCTION NOTES

1 FOUNDATION PREPARATION

All vegetation, organics and soft material shall be removed from the dam foundation area to expose silty sand and gravel soils Loose materials include areas where waste from the plantsite and construction camp excavation were placed during the 1982 site development The foundation surface should be heavily compacted prior to fill placement

2 CONSTRUCTION MATERIALS, PLACEMENT COMPACTION

GENERAL

Fill placement should be carried out during warmer parts of the year so that no frozen materials or lenses of ice or snow are incorporated in the fill

Where a vibratory roller is specified for compaction in following sections, the compactor should have a minimum static weight of 8 tonnes

ZONE A

Zone A material will be used for the starter dyke and for the upstream zone of the tailings dam for 1984 construction The material should consist of silty sand and gravel borrowed from the alluvial deposits within the tailings dam reservoir Zone A is intended to be a zone of low permeability and should have a minimum of 15 percent by weight passing the 0 075 mm sieve size

Zone A material should be placed in maximum loose lift thicknesses of 0 3 m and compacted to a minimum density equivalent to 98 percent of the maximum Standard Proctor density (ASTM D-698 Method D) This density should be achieved by compacting with at least four passes of a vibratory roller, provided the water content of the fill material is near optimum

ZONE B

Zone B is a 15 m wide zone of coarse refuse on the upstream side of the tailings dam which will be heavily compacted to provide a zone of low permeability The coarse refuse should be placed in maximum loose lift thicknesses of 0 15 m and compacted with at least 4 complete passes of a vibratory roller

ZONE C

Zone C is the general fill portion of the dam, constructed of compacted coarse refuse The coarser refuse should be placed in maximum loose lift thicknesses of 0 5 m and compacted with a minimum of 4 complete passes of a vibratory roller The fill surface should be scarified between lifts

ZONE D

Zone D is a drainage zone, constructed of loosely compacted, select coarse refuse

The coarse refuse used in Zone D should be selected to have the minimum amount of fines There should be a maximum of 5 percent, by weight, passing the 0 075 mm sieve size Coarse refuse should be placed in lifts 1 m thick Compaction should consist of 2 complete passes of a vibratory roller The fill surface should be scarified between lifts

3 QUALITY CONTROL AND TESTING

COMPACTION CONTROL

Standard Proctor compaction tests conforming to ASTM D-698 Method D should be carried out a minimum of once per week during construction or at any time when the material quality changes Compaction control should consist of frequent inspection of placement and compaction procedures, augmented by field density tests One field density test for every 1500 m^3 of fill placed should be performed Zones A, B and C should be compacted to 98% Standard Proctor density and the filter Zone D to 95% Standard Proctor

GRAIN SIZE ANALYSES

For Zone A, grain size analyses of the fill material should be performed at a minimum frequency of twice weekly For the coarse refuse, grain size analyses should be performed weekly on samples from the stockpile and the fill after compaction

4 TAILINGS DISCHARGE

Tailings may be deposited to the pond by a single point discharge, with the discharge point located at intervals along the dam crest Discharge should be adjusted so as to form a beach adjacent to the dam and to maintain the ponded water at the back of the pond adjacent to the hillside During freezing weather, tailings should be discharged near or beneath the surface of the water pond so as to minimize ice formation on the beaches.

TO BE READ WITH KLOHN LEONOFF REPORT DATED OCT 22, 1982

SCALE 10m 0 30m

REV	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
SR/PCL	EDP	SEPT, 1982	AS SHOWN

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

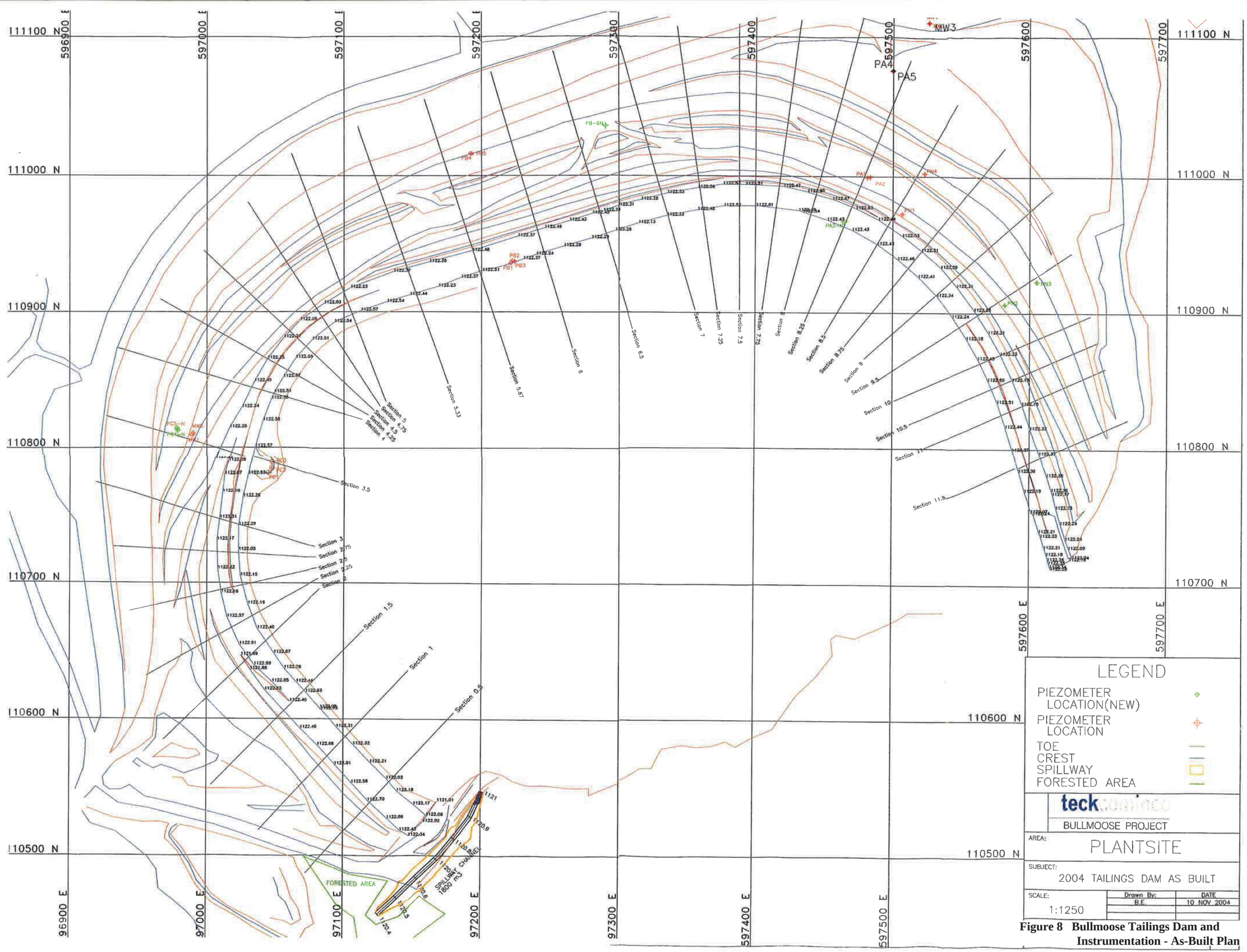
TITLE: TYPICAL SECTIONS OF TAILINGS DAM

CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No	DWG No	REV
OCT 22, 1982	PB297-02	D-108	

APPROVED

Figure 7 Bullmoose Tailings Dam - Typical Sections



LEGEND

- PIEZOMETER LOCATION(NEW)
- PIEZOMETER LOCATION
- TOE
- CREST
- SPILLWAY
- FORESTED AREA

teck COMINCO

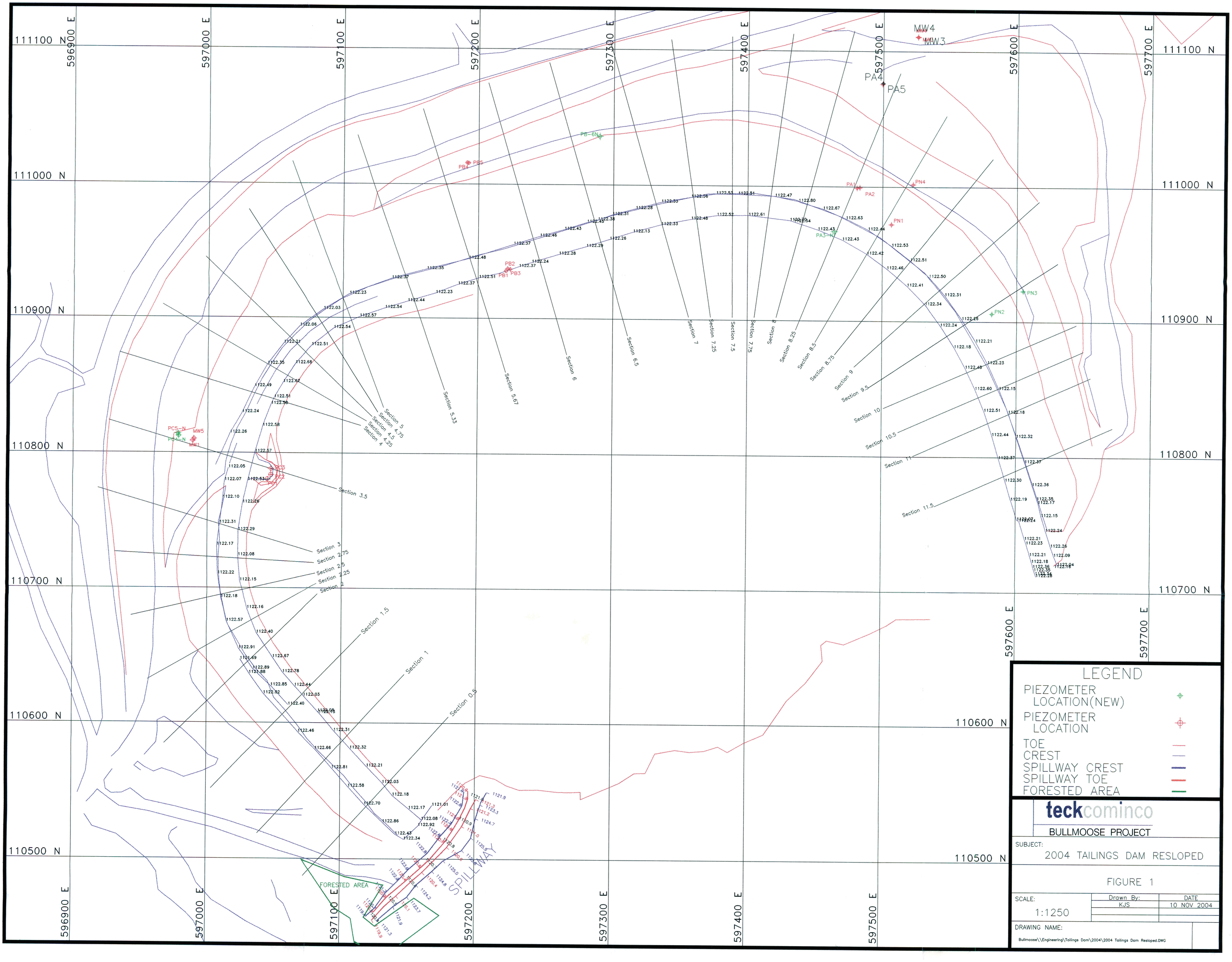
BULLMOOSE PROJECT

AREA: PLANTSITE

SUBJECT: 2004 TAILINGS DAM AS BUILT

SCALE:	Drawn By:	DATE
1:1250	B.E.	10 NOV 2004

Figure 8 Bullmoose Tailings Dam and Instrumentation - As-Built Plan



LEGEND

- PIEZOMETER LOCATION(NEW)
- PIEZOMETER LOCATION
- TOE
- CREST
- SPILLWAY CREST
- SPILLWAY TOE
- FORESTED AREA

teckcominco

BULLMOOSE PROJECT

SUBJECT:

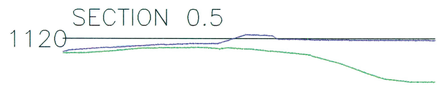
2004 TAILINGS DAM RESLOPED

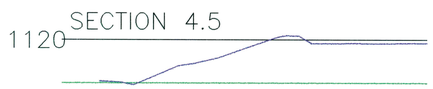
FIGURE 1

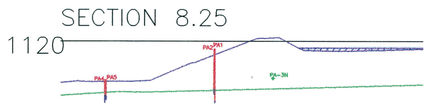
SCALE:	Drawn By:	DATE
1:1250	KJS	10 NOV 2004

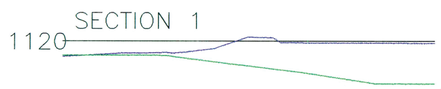
DRAWING NAME:

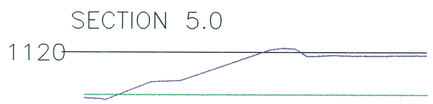
Bullmoose\\Engineering\Tailings Dam\2004\2004 Tailings Dam Resloped.DWG

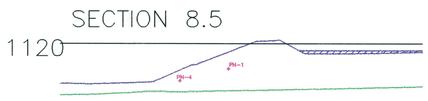


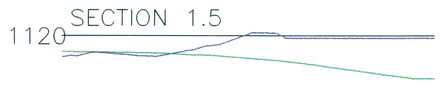


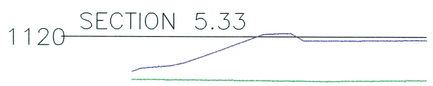


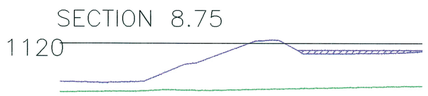


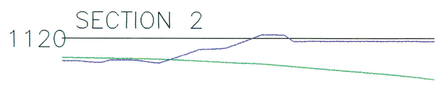


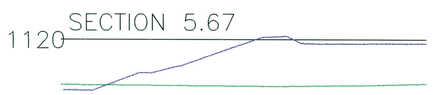


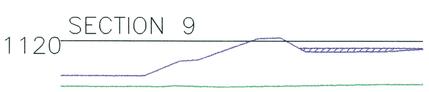


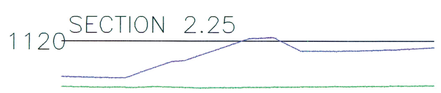


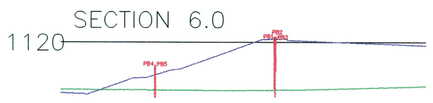


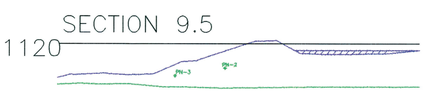


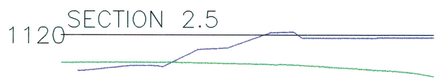


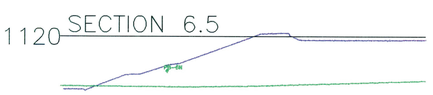


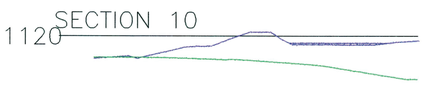


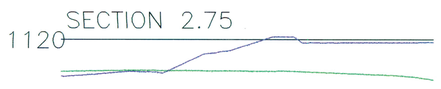


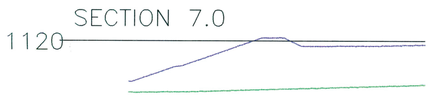


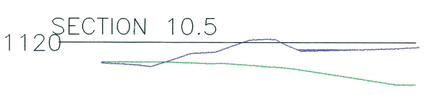


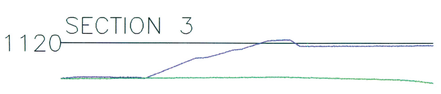


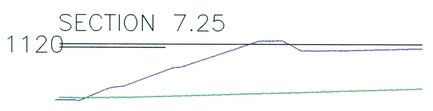


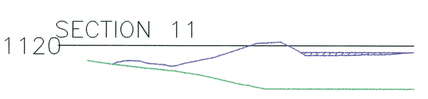


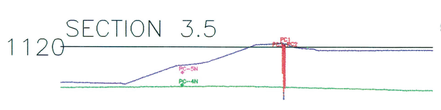


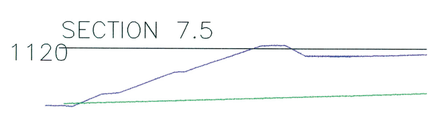


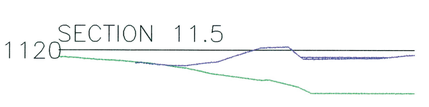


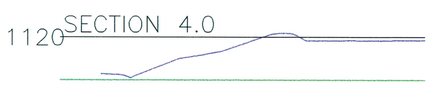


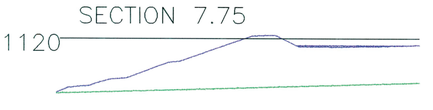


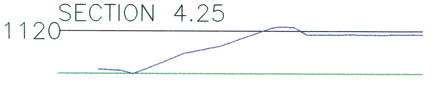


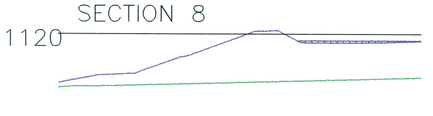












LEGEND

- Final Crest EOS 2003
- Original Ground
- PN–1 New Piezometer
- PB–6N Piezometer Location
- PB3 Standpipe
- Water Elev. Sep. 2004 Elev. 1115.2 m

0 125 m

1:2,500

teckcominco

BULLMOOSE PROJECT

SECTIONS OF TAILINGS DAM

DATE: NOVEMBER 10, 2004

Bullmoose:\\Engineering\TailingsDam\2004\Sections 2004.DWG