Klohn Crippen Berger

Teck Resources Limited

Bullmoose Mine

Bullmoose Tailings Dam

2019 Dam Safety Inspection

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April 2020

Klohn Crippen Berger

April 24, 2020

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
2019 Dam Safety Inspection

We are pleased to submit the 2019 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:jc

Klohn Crippen Berger Ltd.
500 - 2955 Virtual Way ▪ Vancouver BC V5M 4X6 ▪ Canada
t 604.669.3800 ▪ f 604.669.3835 ▪ www.klohn.com

Teck Resources Limited

Bullmoose Mine

Bullmoose Tailings Dam

2019 Dam Safety Inspection

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Resources Limited (Teck) on behalf of the Bullmoose Operating Corporation to complete the 2019 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 2019 Guideline for Tailings and Water Retaining Structures (TWRS).

The 2019 DSI was completed by the Engineer of Record (EoR), KCB representative Mr. Bob Chambers, P.Eng., on May 30, 2019. The responsibilities of the Tailings Storage Facility (TSF) Qualified Person, as defined in the Code (EMPR 2017), were performed for Teck by a consultant, Mr. Bruce Donald, P.Eng., who was formerly with Teck for 40 years and is very familiar with the facility. The role was transitioned to Mr. Mark Slater, P.Eng., of Teck in 2020. Routine and event-driven 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 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

KCB understand, and fully support, that Teck's long-term goal for all of their tailings facilities is to reach landform status with all potential failure modes ultimately being reduced to non-credible. In the context of this DSI, the term "non-credible" represents a condition where the likelihood of failure is considered negligible. Ongoing work aimed at these long-term goals will indicate over subsequent annual reporting periods if the overall landform status has been achieved along with the elimination of any credible flow failure concerns.

The Code requires that potential hazards and failure modes described in CDA (2013) be assessed and included in the DSI report. Dam safety failure modes reviewed as part of this include overtopping, slope instability, internal erosion and surface erosion. Based on 2019 conditions, failure modes that can result in an uncontrolled release of tailings are considered non-credible, under design loading, for the existing structure.

Consequence Classification of Dam

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

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 and are documented in the OMS manual.

Piezometer data is available from 1998 to 2003 and from 2014 to 2019. The data indicate pore pressures have been stable, and the dam downstream shell is well drained with a low gradient. There were no piezometer threshold exceedances noted in 2019.

Seven survey monuments have been monitored since 2015. No trends of downstream movement or significant settlement have been observed.

The 2019 routine inspections and DSI observations do not indicate any significant changes in the BTD or any dam safety issues.

Changes to Surface Water Control

During the 2019 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) Guideline for Developing an OMS for Tailings and Water Management Facilities (MAC 2011).

Emergency Preparedness and Response Plan

Teck developed a Mine Emergency Response Plan (MERP) in March, which incorporates the tailings and sedimentation pond Emergency Preparedness and Response Plan (EPRP) components (Teck 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 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.

2019 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.

DSI recommendations are summarized in Table E-1. Closed recommendations are shown in grey italics and will be removed from the table in the next DSI report.

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 Priority 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"	n/a	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	Q4 2020 (Assessment completed, reporting in progress at the time of writing)
2019 Recommendations						
BTD	2019-01	Piezometer Review and Decommissioning	n/a	Review which piezometers and wells are functioning and decommission those that are defunct. Re-label all active piezometers following the review.	4	Q4 2020 (Re-labelling complete, review and decommissioning to be completed in 2020)
BTD	2019-02	Vegetation on Spillway Channel	OMS Manual	Clear vegetation growing within the spillway channel	3	Q3 2020
BTD	2019-03	Survey Monuments	OMS Manual	Document the procedure used to survey the BTD survey monuments and include in the OMS Manual	4	Q4 2020

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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 Reclamation 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 2019 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 2019 who was formerly with Teck for 40 years and is very familiar with the facility. The role was transitioned to Mr. Mark Slater, P.Eng., of Teck in 2020.

1.2 Facility Description

The Bullmoose Mine site is about 45 km west of Tumbler Ridge in northeastern BC, as shown on 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 Dams (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 a broad valley bottom, with South Bullmoose Creek to the west and Bullmoose Creek to the north. The general site plan of the BTD and the impoundment is shown on 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 as constructed was approximately 4.6 million m^3, but there was ability to increase the size/storage potential for the impoundment had the mine continued operation.

The BTD is constructed of compacted coarse coal rejects (CCR) and has a minimum 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-sections of the BTD. The downstream slope of the BTD was re-sloped to achieve the design 2.5H:1V slope in 2003 (BOC 2003).

A closure spillway was constructed in 2002 at the west abutment of the BTD with an invert elevation of 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.

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

2 BACKGROUND AND RECENT ACTIVITIES

2.1 Background Information

A summary of the available BTD reference documents is included in Appendix IV.

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. 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 (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.

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 2019.

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

- Completed 2019 DSI at the BTD (this document);
- Reviewed routine inspection surveillance data submitted by Teck's Facility Surveillance Officer (FSO) and documented the review in monthly Monitoring Review Memorandum (MRM);
- Reviewed instrumentation data and Quantifiable Performance Objectives (QPOs);
- Reviewed 2019 climate data and updated water balance for the BTD; and
- Participated in Teck's 2019 risk assessment review for the BTD.

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 3 and 4). 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 portion excavated in overburden is armoured with riprap with D_{50} of 200 mm (KC 2004) and has side slopes of 2H:1V (KC 2002). The spillway excavated in bedrock has side slopes of 1H:1V (KC 2002) with no erosion protection.

During operations, a diversion ditch was constructed upslope of the impoundment to divert approximately 14 ha away from the impoundment under normal conditions. However, in 2015 the diversion ditch was determined to not be in suitable condition and was no longer performing as intended. 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 spillway was designed assuming the ditch was not functioning (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; the pond level is low under normal conditions.
- 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), with no diversion.

3.2 Climate

Bullmoose Mine climate data (1981 to 2003), based on the Bullmoose Environment Canada climate station No. 1181120 at El. 1,102 masl, is summarized in Table 3.1 and Figure 3.1. No climate data has been 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, has been used since 2003 to estimate precipitation for water balance calculations.

Total annual precipitation for the Bullmoose and Chetwynd Airport climate stations were compared for the periods when the records overlap, from which an average correlation factor of 1.8 was developed. This factor is applied to the Chetwynd Airport data to estimate total precipitation at Bullmoose.

Temperature climate normals at the Chetwynd Airport station (1981-2010) were compared against climate normals from Bullmoose (1981-2003) station. The temperature differences were then applied to the 2019 monthly temperatures measured at Chetwynd Airport to estimate the 2019 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, 2019 snowpack data is not available for review.

Precipitation and temperature data at Bullmoose from September 1, 2018 to August 31, 2019 are summarized in Table 3.2 and Figure 3.1. 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 Figure 3.1 and Table 3.2 for comparison.

The following observations are made based on the climate data from September 1, 2018 to August 31, 2019:

- Total annual precipitation estimated during this period was 983 mm, which is greater than the average annual precipitation of 793 mm.
- In general, monthly average daily temperatures in 2019 were similar to the average temperatures with the exception of February, where temperatures were much lower than average.

- The wettest month of the period was August 2019 where a total precipitation of 265 mm was estimated.
- Event-driven inspections are required after a 10-year rainfall event (67 mm in 24-hour duration (Teck 2018)). The largest precipitation event recorded at the Chetwynd Airport climate station was 44 mm on August 5, 2019, which is approximately 79 mm at Bullmoose using the correlation factor of 1.8. Teck completed a routine inspection on August 12, 2019 at the BTD and noted that no significant erosion had occurred.

Figure 3.1 Climate Data for Bullmoose Mine Site – 2019 and Climate Normals

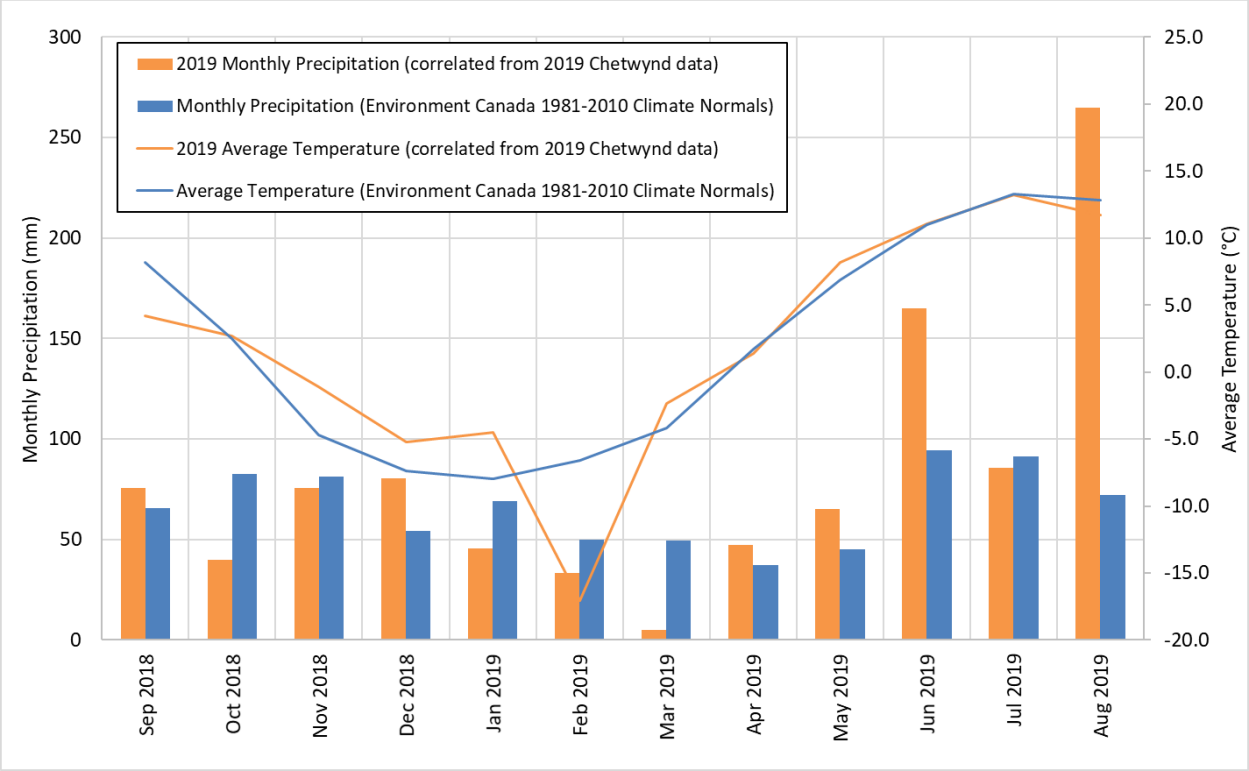

Table 3.2 Climate Data for Bullmoose Site

Month	Normals Average Monthly Precipitation[1] (mm)	2018-2019 Precipitation[2] (mm)	Normals Daily Max. Temperature[1] (°C)	Normals Daily Min. Temperature[1] (°C)	Normals Daily Average Temperature[1] (°C)	2018-2019 Daily Max. Temperature[3] (°C)	2018-2019 Daily Min. Temperature[3] (°C)	2018-2019 Daily Average Temperature[3] (°C)
September	66	75	12.9	3.4	8.2	6.9	1.4	4.2
October	83	40	6.3	-1.2	2.5	6.2	-0.7	2.7
November	82	75	-1.0	-8.5	-4.7	1.7	-3.9	-1.1
December	54	80	-3.1	-11.6	-7.4	-1.8	-8.5	-5.2
January	69	45	-3.4	-12.6	-8.0	-0.9	-8.2	-4.5
February	50	33	-2.0	-11.2	-6.6	-12.5	-21.6	-17.0
March	50	5	0.3	-8.7	-4.2	4.0	-8.8	-2.4
April	37	47	6.7	-3.4	1.7	5.8	-3.0	1.4
May	45	65	12.4	1.5	6.9	13.1	3.3	8.2
June	94	165	16.3	5.6	11.0	15.3	6.8	11.1
July	91	86	18.9	7.8	13.3	17.5	9.2	13.2
August	72	265	18.3	7.2	12.8	15.5	7.8	11.7
Total	**793**	**983**						

Notes:

1. Environment Canada Record - 1981-2010 climate normals record based on Bullmoose climate station available data from 1981 to 2003.
2. 2019 annual and monthly precipitations were estimated using 2019 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.

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, 2018 to August 31, 2019 is summarized below:

- Inflows:
  - Runoff from natural upstream catchment = 63,600 m3 (assuming a runoff coefficient of 0.4);
  - Precipitation on pond surface = 20,000 m3 (assumed pond surface on average is at El. 1,115.5 masl); and
  - Precipitation on tailings surface = 177,500 m3 (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 the Baseline Hydrology Report for the Quintette site (Teck 2013b)); and
  - Seepage losses from the impoundment = 250,900 m^3 (the remainder of inflows minus evaporation).

The estimated average seepage rate from the impoundment based on the simplified water accounting is 8 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 2014a);
- 10 L/s estimated in 2018 DSI (KCB 2019); and
- 267 L/s to 1,318 L/s measured during operations.

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

3.4 Freeboard and Flood Storage

3.4.1 Freeboard

The estimated freeboard of the BTD during the 2019 DSI site visit was approximately 8 m. There are no concerns based on the current pond level trends.

In 2018, Teck installed a permanent pond indicator approximately 1 m above the steady state pond level as Threshold Level 1 marker (location shown on Figure 3). KCB understand that the stake is to be surveyed in 2020. The pond level indicator is checked visually during routine and event-driven inspections, and is considered appropriate for on-going monitoring of the BTD pond level.

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).
- 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[1]; 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 acceptable 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.

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.

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).

[1] 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).

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 2019, 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 (notifications sent to the EoR and Tailings QP using the United States Geological Survey (USGS) Earthquake Notification System) ; or
  - flooding of Bullmoose Creek.

No significant earthquakes were recorded by the Geological Survey of Canada within 100 km of the site in 2019.

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

Figure 3 provides an overview of the facility with 2019 inspection photograph locations. Inspection photographs are included in Appendix II.

The following observations were made during the 2019 DSI site visit:

- **Dam Crest**: Good condition. No signs of lateral movement, differential settlement or cracking of the dam crest (Photos II-1, II-3 to II-5, II-7, and II-10).
- **Downstream Slope and Toe**: Good condition. No visible signs of significant erosion, displacement, or bulging (Photos II-14 to II-20). Vegetation (grasses and moss) are well established.
  - An erosion gulley was observed at the toe near the East Abutment (Photo II-15). The gulley was first observed in 2017 and dimensions appeared similar to observations to previous DSIs (approximately 0.2 m to 0.3 m wide, 0.1 m deep and 10 m to 15 m long). The likely cause was concentrated local flow during spring freshet. This feature continues to be monitored and inspected for signs of change during routine visual inspections and annual DSI site visits.

  - A small wet area was noted near the toe of the north arm of the BTD during the DSI site visit (Photo II-18). There were no signs of seepage emerging from the downstream slope, and the wet area is believed to be due to ponding from snowmelt from the slopes.
- **Upstream Slope**: Good condition. No signs of significant erosion or displacement (Photos II-9 and II-10).
- **West Abutment**: Good condition. The spillway is excavated through the west abutment, no signs of erosion at the abutment (Photo II-20).
- **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-12 and II-13). There is a small channel running along the east abutment towards the toe which is unchanged from the 2018 condition.
- **Tailings Impoundment and Pond**: A pond (approximately 2 ha) is located on the east side of the impoundment (Photos II-9 and II-10) and is approximately 400 m from the spillway inlet. The impoundment is well vegetated except near the pond. Away from the pond the tailings surface is well drained and supports human/animal traffic. The pond was below the pond level threshold stake at the time of the inspection.
- **Spillway:** Good condition (Photos II-21 to II-24). There was some minor vegetation growth in the spillway where the riprap entered the forested area. KCB have included a recommendation to clear this vegetation in this DSI report. Riprap at the BTD spillway was noted to have a “disturbed” appearance (i.e., not interlocked) in 2018. The riprap was repaired and the post-repair riprap conditions observed during the 2019 DSI site visit appeared to be adequate (Photo II-21 and II-22).
- **Historical Slope Failure On Natural Slope South Of Impoundment:** A historical slope failure is present in the natural slope on the south side of the impoundment (Photo II-11). 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 slide mass is overgrown with vegetation including small trees. Comparison of photographs between 2010 and 2019 does not indicate any visually identifiable changes. This feature is not a risk to the dam safety.

4.3 Piezometers

There are 13 functional piezometers at the BTD (11 standpipe piezometers and 2 pneumatic piezometers) as summarized on Figure 5. The piezometers are shown in plan view on Figure 3. The OMS manual requires piezometers be read once per year. The piezometers were measured during the 2019 DSI site visit. The labels on several piezometers were noted to be in poor condition during the DSI site visit. The June, 2019 inspection report by the Teck FSO indicated that the piezometers had been re-labelled.

Piezometer threshold responses are summarized in Table 4.1:

- 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 5); and
- Threshold Level 2 if there are Threshold Level 1 exceedances at 2 or more piezometers on an instrumentation section.

Four monitoring wells were also measured during the site visit; however, because the wells did not have proper labels, water level measurements cannot be linked to readings from the operations period. The wells are not considered critical for on-going monitoring of the BTD. Piezometer labels should be refreshed and caps replaced as needed, as described in the OMS.

Figure 6 summarizes recent and historical piezometer readings. Figure 7 shows piezometric level across dam schematic Sections A to C. Piezometer details and threshold levels are summarized on Figure 5.

The following observations are made based on the 2019 piezometric data:

- None of the measured piezometers exceed Threshold Level 1.
- All measured piezometers have similar water levels to those measured in 2018 (see Figures 5 and 6):
  - PA-1, PA-4, PA-5, PB-4, PB-5 and PC-1 appeared to be stable with no general decreasing or increasing trend.
  - PA-2 water level dropped about 4 m between 2014 and 2015; the instrument has been relatively stable since 2015.
  - PB-3 and PC-3, installed in the dam, 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 a 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.

The piezometer measurements show that 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.

Table 4.1 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.

4.4 Survey Monument Pins

In July 2015, seven survey monuments were installed on the BTD. The survey monuments are measured by WSP annually and are summarized on Figure 8. Survey measurements up to 2019 are shown on Figures 8 through 11. Survey monument QPOs are as follow:

- Threshold Level 1 was 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 on Figures 9 to 11.
- 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 4.2.

Table 4.2 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.

In 2018, WSP indicated that there was an error in the method used to process the survey data, and that the historical data would need to be reprocessed. The reprocessed data was provided to KCB in December, 2018, however the method used to reprocess the data was not provided. The reprocessed data showed that readings from February, 2016 to February, 2017 had exceeded the horizontal threshold at M1 and M2, before reverting back to below the threshold value. These instruments have been relatively stable since February, 2017, and there have been no signs of cracking or slumping noted, so no changes to the survey monument thresholds are considered necessary at this time. KCB recommend that the survey method be formally documented and included in the OMS manual.

Overall, the survey monuments are generally within their threshold values, and are not exhibiting any trends that would indicate a dam safety concern. Overall trends can be more confidently interpreted as the number of survey readings increase.

4.5 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 have indicated that there have been no water quality exceedances and that the monitoring frequency meets their permit requirements. 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][2]
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 Figure 7)	2H:1V

Notes:
1. The HSRC Code (EMPR 2017) does not specify IDF or EDGM for "Closure-Passive Care" phase.
2. Clause 10.1.19 (2) of the Code (EMPR 2017) states that "*Sections 10.1.8 [Seismic and Flood Design Criteria], 10.1.9 [Design Slopes], and 10.1.10 [Minimum Static Factor of Safety] of this code do not apply to mines with respect to which the chief inspector has received an application for a permit before the date on which this subsection comes into force.*"

5.2 Dam Safety Review

The first and most recent DSR of the BTD was completed in 2015 (Golder 2016). Teck have addressed the recommendations from the DSR.

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 2019).

5.3 Failure Modes Review

KCB understand, and fully support, that Teck's long-term goal for all of their tailings facilities is to reach landform status with all potential failure modes ultimately being reduced to non-credible. In the context of this DSI, the term "non-credible" represents a condition where the likelihood of failure is considered negligible. Ongoing work aimed at these long-term goals will indicate over subsequent annual reporting periods if the overall landform status has been achieved along with the elimination of any credible flow failure concerns.

The Code requires identification of potential hazards and failure modes described in CDA (2013) be assessed based on the DSI observations and a review of available documents regarding the BTD, including the 2019 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, an overtopping failure was considered to be non-credible,.
- **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. No trigger to initiate internal erosion under current conditions has been identified. Hydraulic gradients in the dam shell have been consistent over the past several years (approximately 0.04) and are well below the average critical gradient required to erode the dam fill (0.11) (KCB 2018c). Based on these observations, and previous assessments (KCB 2018c), internal erosion is considered non-credible under current conditions.
- **Slope Instability - Static:** 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. This analysis and the long performance history with no visible or documented signs of instability indicates that the current condition of the structure is stable under normal loading, and that a slope failure resulting in a release of tailings is non-credible.
- **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-35) 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 2019 spring freshet runoff.

  Shallow rills were observed on the downstream slope. The rills appear to be stable based on comparison with previous DSI photographs.

  The existing rills and gulley do not represent a dam safety concern, and a failure that releases tailings as a result of these features is non-credible under current conditions. On-going surface erosion represents a maintenance issue as part of long-term closure.
- **Toe Erosion During Bullmoose Creek Flood:** The maximum flood level in Bullmoose Creek near the BTD during the IDF[2] 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)

[2] $^2/_3$ between 1,000-year and PMF event

from the BTD toe (KCB 2018b). The study indicates that the potential for sufficient toe erosion to occur, during the IDF, that causes a release of tailings from BTD is non-credible.

- **Slope Stability - Earthquakes:** The peak ground acceleration (PGA) for the EDGM is 0.18g based on a simplified seismic hazard assessment using the National Building Code of Canada (NBCC) (2015) hazard values and a log-log extrapolation method (KCB 2017c). KCB completed a pseudo-static stability assessment of the BTD in 2018 to assess deformations under seismic loading; the assessment 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. Based on the above, the BTD meets slope stability criteria under seismic loading and is capable of accommodating potential seismic deformations, which indicates that a release of tailings resulting from the design earthquake is non-credible.

The recommended site specific seismic hazard assessment (Table 6.1) is in progress and scheduled to be completed in 2020. The outcomes are not expected to impact the above conclusions.

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 (Figure 3). A tailings runout analysis completed by KCB (2014b) indicates that the sub-station is located within the 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 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.

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.

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

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 2019 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. The IDF flood volume is 114,370 m^3 (KCB 2015b).

The TSF has approximately 680,000 m^3 of available storage before discharging through the spillway; this is more than 5 times the IDF flood volume. There is an additional 187,600 m^3 of flood storage between the spillway invert and the BTD crest.

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[3] (or that the pond can store the IDF while maintaining 0.4 m of freeboard assuming a fully blocked spillway). A minimum required freeboard of 0.2 m was determined in the KCB (2015b) assessment using the wave setup and wave runup methodologies described in CDA (2013).

Historical observations show the pond varies 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 “Not Credible” as discussed in Section 5.3.

5.7 Operational Performance

The BTD has been closed since 2003 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

The BTD EPRP was incorporated into the Bullmoose Mine Emergency Response Plan (MERP) dated March 27, 2019. The status of open recommendations from the DSR (Golder 2016) are updated below:

[3] 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.

- Recommendation No. ONC-2015-09: Flood management due to flooding of Bullmoose Creek should be included in the EPRP – flood studies were completed by KCB (2018b). The 2019 MERP includes response actions for extreme weather events such as flooding, landslides, and earthquakes, and so this recommendation has been closed.
- Recommendation No. ONC-2015-10: Include records of personnel training in emergency procedures. The 2019 MERP includes a summary of past MERP tabletop exercises, and indicates that further details are available on Teck's internal servers.

BTD management and incident command organization charts are up to date in the MERP document. The MERP requires the documents be reviewed and, if necessary, updated on an annual basis.

6 SUMMARY AND RECOMMENDATIONS

The BTD appears to be in good condition and the observed performance is consistent with the expected design conditions. There are no indications of present or long-term dam safety 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 conditions. The water balance assessment estimated seepage rates are within the expected range.

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. The procedure for reading the survey monuments should be documented and included in the OMS manual during the next update.

The BTD is a "High" consequence classification dam under existing conditions 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. The MERP was updated in March, 2019.

DSI recommendations 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.

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"	n/a	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	Q4 2020 (Assessment completed, reporting in progress at the time of writing)
2019 Recommendations						
BTD	2019-01	Piezometer Review and Decommissioning	n/a	Review which piezometers and wells are functioning and decommission those that are defunct. Re-label all active piezometers following the review.	4	Q4 2020 (Re-labelling complete, review and decommissioning to be completed in 2020)
BTD	2019-02	Vegetation on Spillway Channel	OMS Manual	Clear vegetation growing within the spillway channel	3	Q3 2020
BTD	2019-03	Survey Monuments	OMS Manual	Document the procedure used to survey the BTD survey monuments and include in the OMS Manual	4	Q4 2020

7 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Teck Resources Limited (Client) and the applicable regulatory authorities for the specific application to the 2019 Dam Safety Inspections, and it may not be relied upon by any other party without KCB's written consent.

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2. The Executive Summary is a selection of key elements of the report. It does not include details needed for the proper application of the findings and recommendations in the report.
3. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
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5. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Max Cronk, P.Eng.
Project Engineer
Geotechnical Engineer

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

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
R. W. CHAMBERS
24 APR 2020

MC:jc

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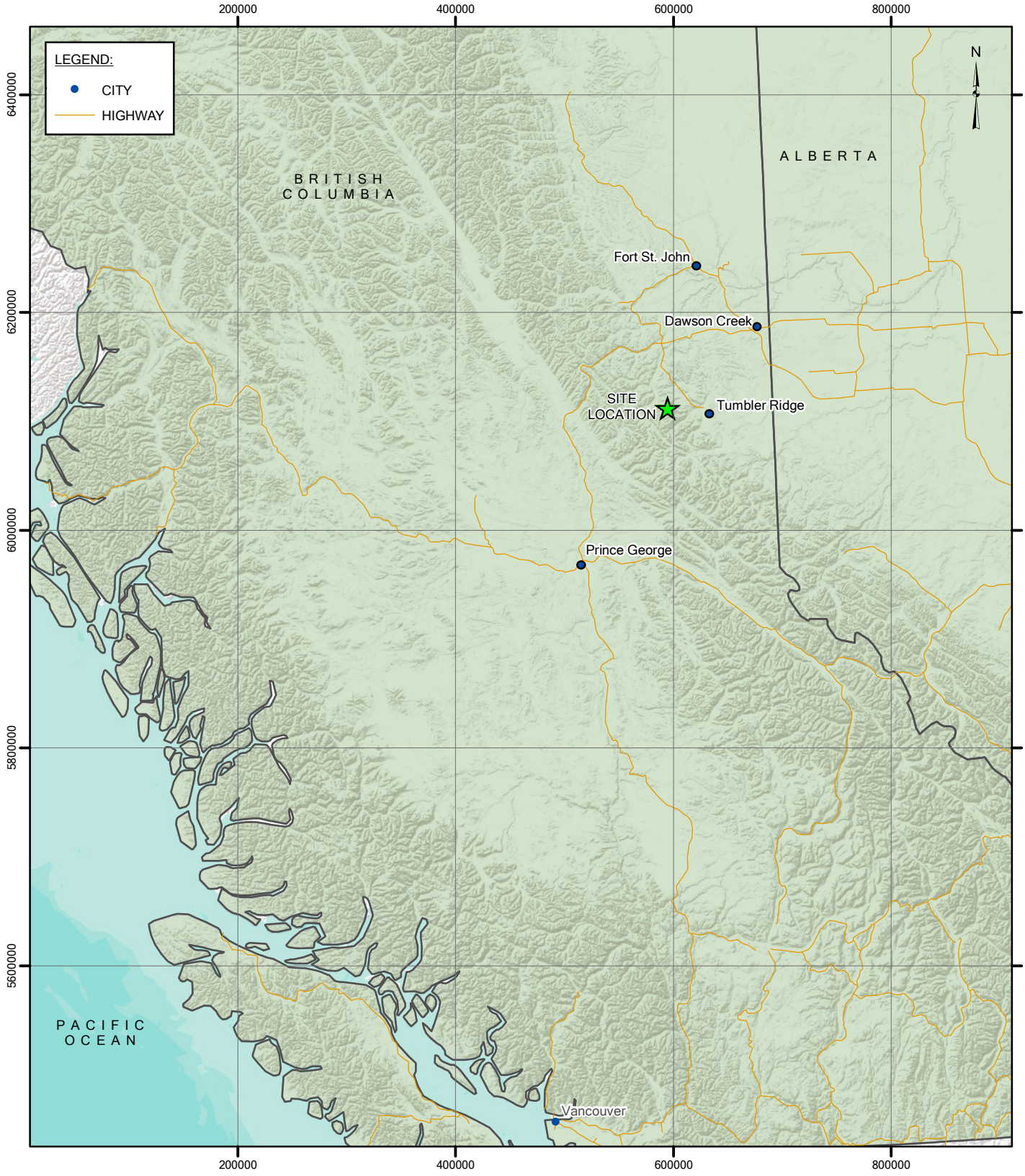
FIGURES



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

SCALE 0 100,000 m

CLIENT: Teck

Klohn Crippen Berger

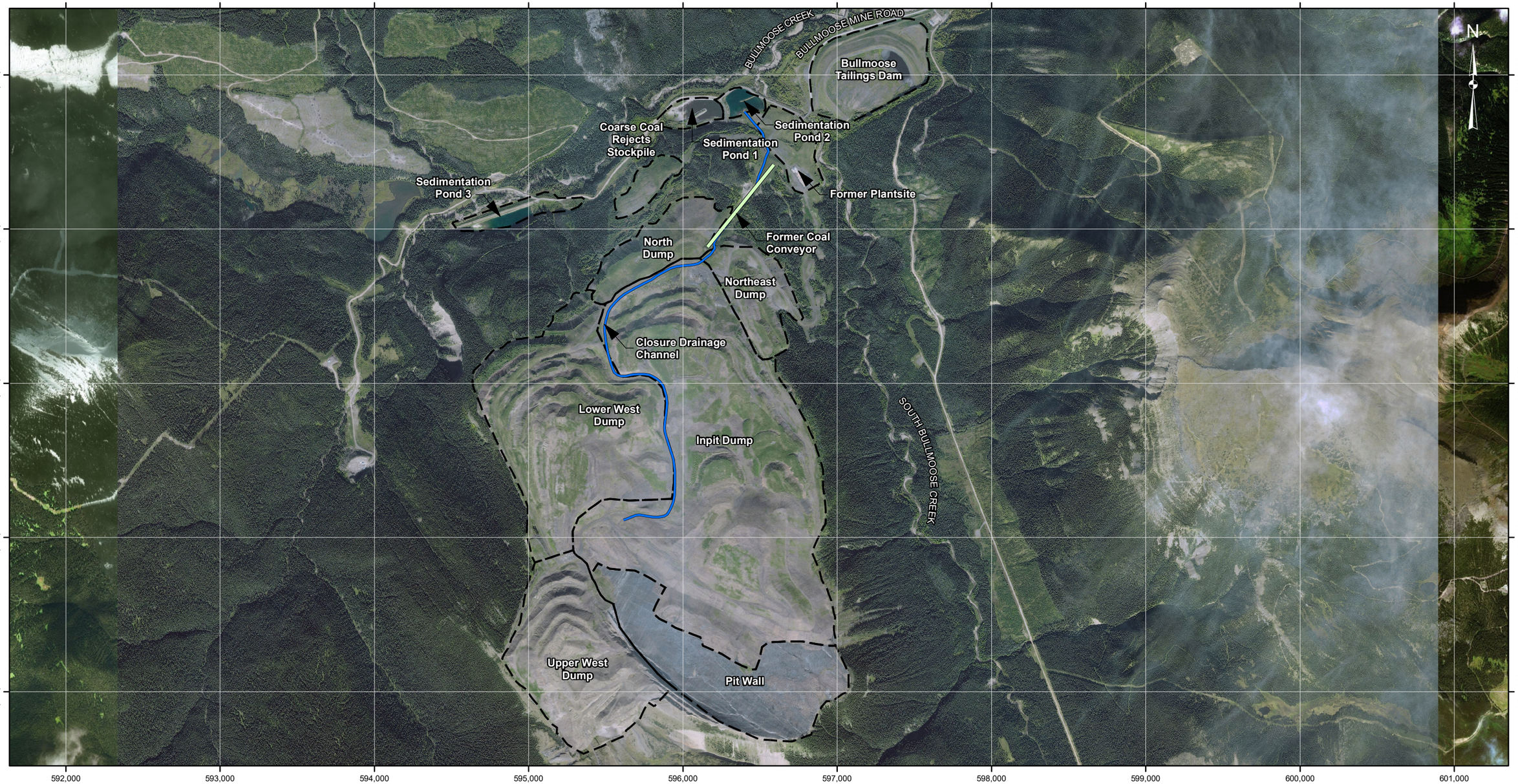
PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

TITLE: SITE LOCATION

PROJECT No. M09893A09

FIG No. 1

Path: Z:\MVCR\M09893A09-TML-Bullmoose 2019 Consulting\400 Drawings\GIS\02 Maps\Reports\DSI 2019\BTD\Site Location.mxd afischer



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

LEGEND:

- FORMER COAL CONVEYOR
- CLOSURE DRAINAGE CHANNEL
- STRUCTURE BOUNDARY

SCALE 0 1,000 m

CLIENT: Teck

Klohn Crippen Berger

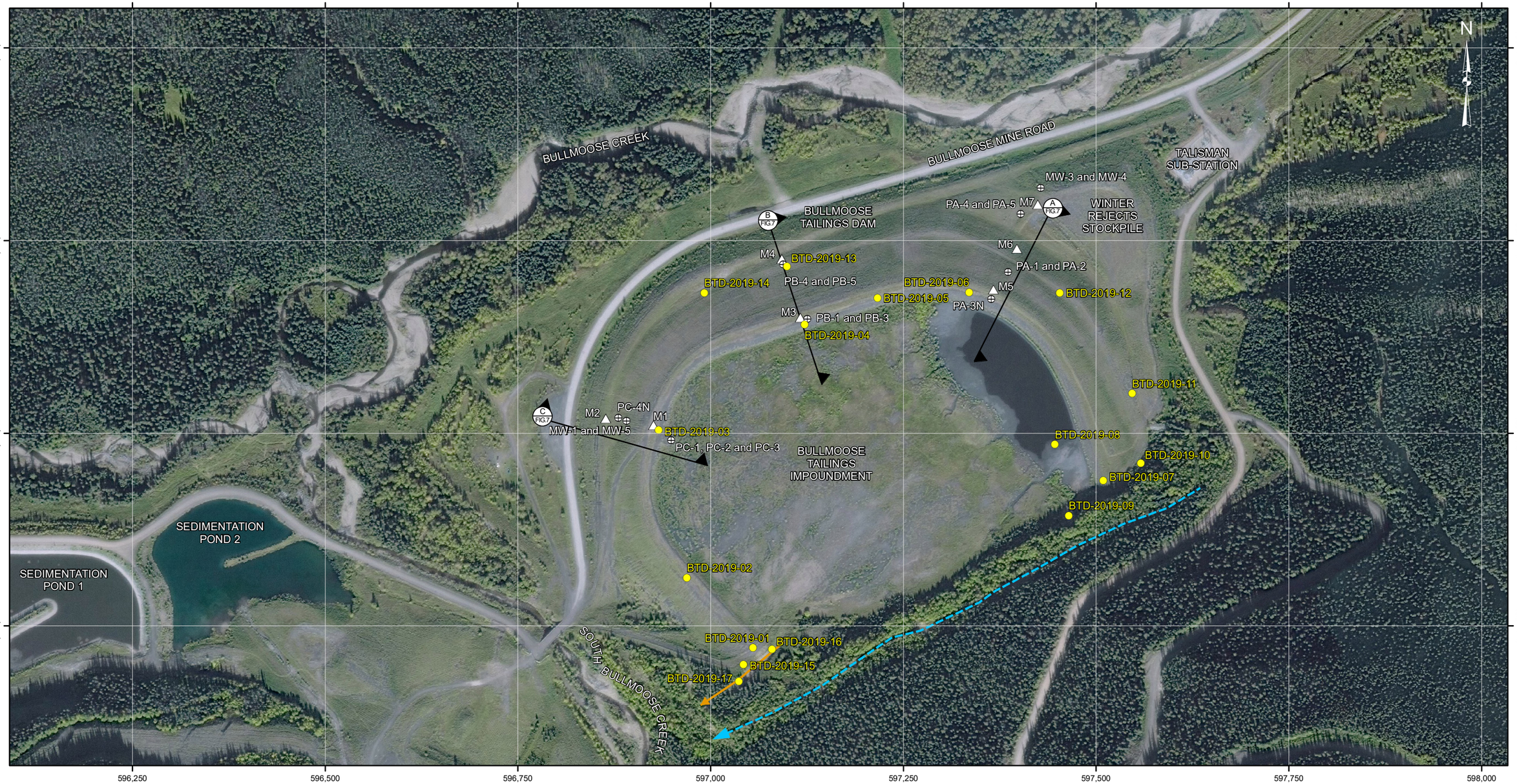
PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

TITLE: GENERAL SITE PLAN

PROJECT No. M09893A09

FIG No. 2

Path: Z:\MV\CRM\09893\A09-TML-Bullmoose 2019 Consulting\400 Drawings\GIS\02_Maps\Reports\DSI_2019\BTD\BTD_General_Site_Plan.mxd



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

LEGEND:

- BTD-2019-23 — 2019 DSI PHOTOGRAPH LOCATION
- M1 — SURVEY MONUMENT
- PC-4N — PIEZOMETER
- SPILLWAY
- DIVERSION CHANNEL (OVERGROWN)

SCALE 0 150 m

CLIENT: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

TITLE: BULLMOOSE TAILINGS DAM
GENERAL ARRANGEMENT

PROJECT No. M09893A09

FIG No. 3

Path: \\int.klohn.com\Proj\Data\MVCR\M09893A09-TML-Bullmoose 2019 Consulting\400 Drawings\GIS\02_Maps\Reports\DSI_2019\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

N

BULLMOOSE CREEK

BULLMOOSE MINE ROAD

TALISMAN SUB-STATION

BULLMOOSE TAILINGS DAM

WINTER REJECTS STOCKPILE

BULLMOOSE TAILINGS IMPOUNDMENT

36 ha

WEST BULLMOOSE CREEK

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: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

TITLE: BULLMOOSE TAILINGS DAM CATCHMENT

PROJECT No. M09893A09

FIG No. 4

Path: \\int.klohn.com\Proj\Data\MV\CR\M09893A09-TML-Bullmoose 2019 Consulting\400 Drawings\GIS\02_Maps\Reports\DSI_2019\BTD\BTD_Catchment.mxd

SECTION	PIEZOMETER	COORDINATES (m)		ORIGINAL GROUND (masl)	EXISTING GROUND ELEVATION (masl)	PIEZO. SCREEN / TIP ELEVATION (masl)	MEASURED STICKUP (m)	2019 PNEUMATIC READING (PSI)	2019 STANDPIPE READING (m)	2019 DSI WATER ELEVATION (masl)	WATER ELEVATION LOWER THAN (IF DRY)	THRESHOLD LEVEL 1 (masl)	WATER LEVEL ABOVE ORG. GROUND (m)	2018 DSI WATER ELEVATION (masl)	CHANGE FROM 2018 (m)	PIEZOMETER LOCATION	
		EASTING	NORTHING													LOCATION	UNIT
SECTION A	PA-1 (RELABELLED IN 2017)	597396	6111244	1084.0	1112.5	1077.3	0.76	-	35.0	1078.3	-	≥1100.0	-5.7	1078.5	-0.16	DOWNSTREAM SLOPE	FOUNDATION
	PA-2 (RELABELLED IN 2017)	597396	6111244	1084.0	1112.5	1083.4	0.71	-	29.7	1083.5	-	≥1100.0	-0.5	1085.1	-1.63	DOWNSTREAM SLOPE	DAM
	PA-4	597402	6111284	1081.0	1092.7	1077.3	1.74	-	12.1	1082.4	-	≥1088.0	1.4	1082.5	-0.17	DOWNSTREAM SLOPE	FOUNDATION
	PA-5	597402	6111284	1081.0	1092.7	1079.0	1.83	-	12.3	1082.2	-	≥1088.0	1.2	1082.4	-0.16	DOWNSTREAM SLOPE	DAM
	PA-3N	597364	6111174	1082.0	1123.0	1094.8	-	0.4	-	1095.0	-	≥1107.0	13.0	1096.1	-1.05	CREST	DAM
	NO LABEL (MW-3)	597428	6111318	1076.7	1090.0	1053.7	1.30	-	20.7	1070.6	-	≥1095.0	-6.1	1070.3	0.33	DOWNSTREAM SLOPE	FOUNDATION
	NO LABEL (MW-4)	597428	6111318	1076.7	1090.0	1068.3	1.23	-	14.8	1076.5	-	≥1095.0	-0.2	1076.1	0.35	DOWNSTREAM SLOPE	FOUNDATION
SECTION B	NO LABEL (LIKELY PB-1)	597126	6111148	1086.0	1123.0	1081.9	0.20	-	40.6	DRY	1082.6	≥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	-	20.1	1081.8	-	≥1095.0	-4.2	1081.9	-0.13	DOWNSTREAM SLOPE	FOUNDATION
	PB-5	597094	6111219	1086.0	1100.5	1081.6	1.36	-	20.0	1081.9	-	≥1095.0	-4.1	1082.01	-0.13	DOWNSTREAM SLOPE	FOUNDATION
SECTION C	PC-1	596949	6110991	1091.0	1120.5	1083.7	1.04	-	36.1	1085.5	-	≥1110.0	-5.5	1085.7	-0.23	CREST	FOUNDATION
	PC-2	596949	6110991	1091.0	1120.5	1090.3	1.74	-	30.4	DRY	1091.8	≥1110.0	N/A	DRY	N/A	CREST	DAM
	PC-3	596949	6110991	1091.0	1120.5	1101.8	1.38	-	19.6	DRY	1102.3	≥1110.0	N/A	DRY	N/A	CREST	DAM
	NO LABEL (MW-1/MW-5)	596891	6111015	1093.5	1111.5	UNKNOWN	0.68	-	22.9	1089.3	-	-	-4.2	1089.7	-0.41	DOWNSTREAM SLOPE	FOUNDATION
	NO LABEL (MW-1/MW-5)	596891	6111015	1093.5	1111.5	UNKNOWN	1.04	-	17.7	1094.8	-	-	1.3	1094.69	0.14	DOWNSTREAM SLOPE	FOUNDATION
	PC-4N	596881	6111020	1094.0	1109.5	1093.5	-	1.3	-	1094.4	-	≥1100.0	0.4	1094.6	-0.14	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

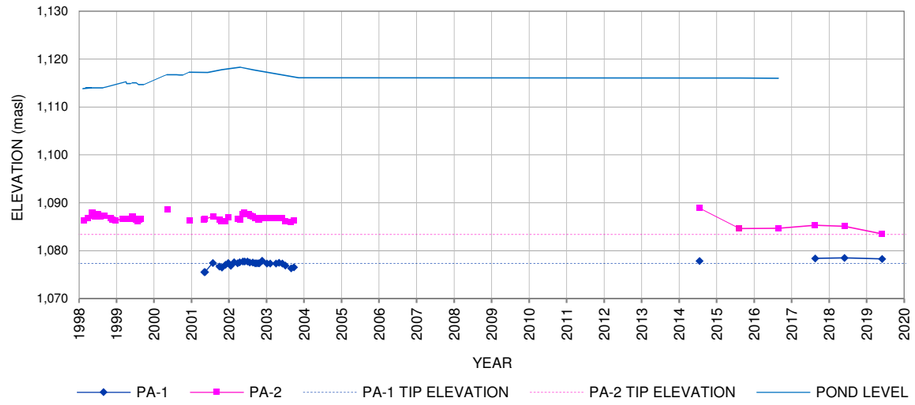
PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

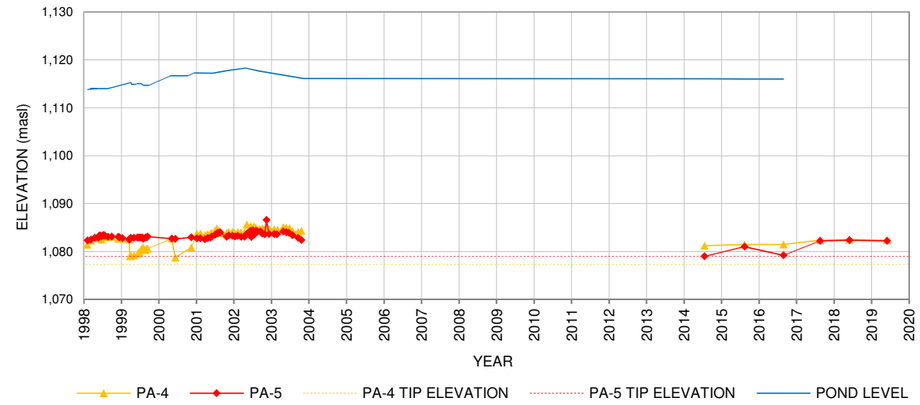
TITLE: BULLMOOSE TAILINGS DAM
2019 PIEZOMETER READINGS

PROJECT No. M09893A09

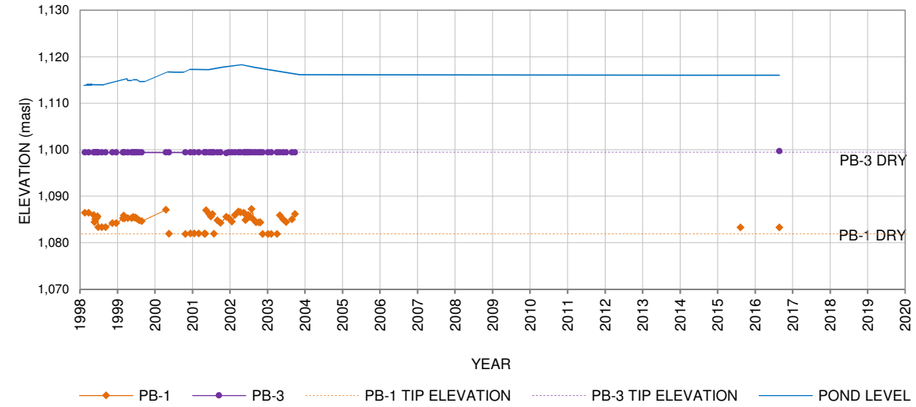
FIG. No. 5

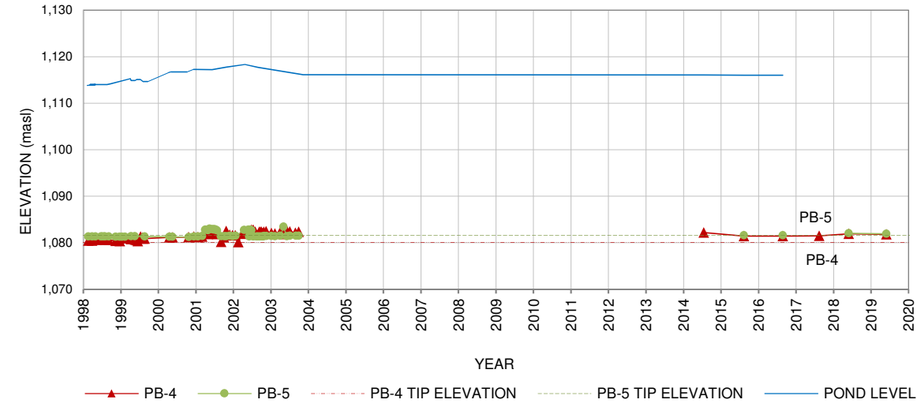
Date & Time: 2019-10-03 13:28
Figure File: C:\Users\mcronk\Desktop\Work\DSI Reports\BTD DSI\[191003 Bullmoose Piezometer.xlsx]Figure A



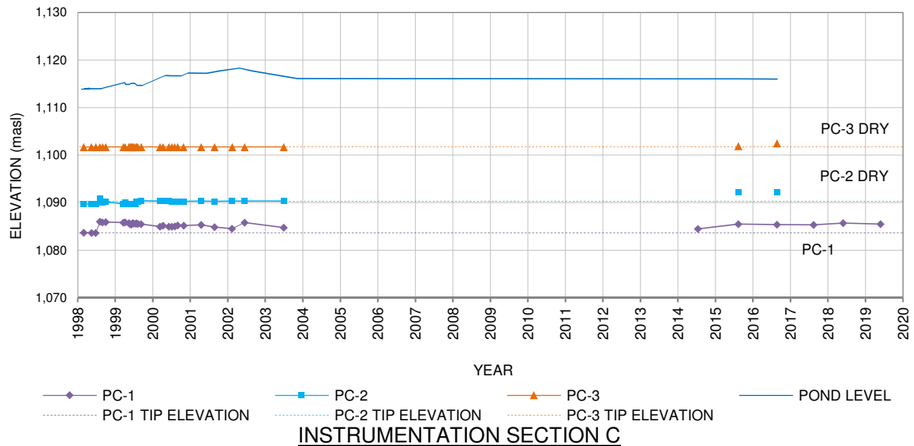


INSTRUMENTATION SECTION A





INSTRUMENTATION SECTION B



INSTRUMENTATION SECTION C

CLIENT: Teck

Klohn Crippen Berger

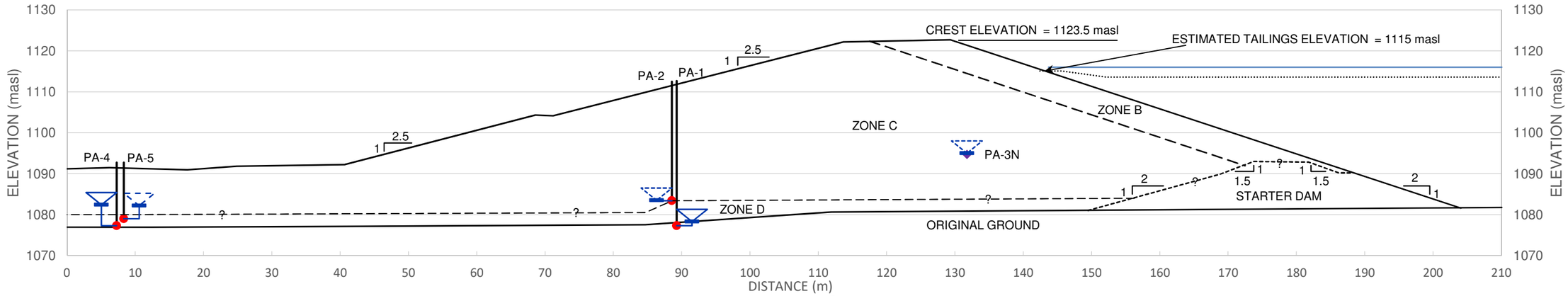
PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

TITLE: BULLMOOSE TAILINGS DAM
HISTORICAL PIEZOMETER READINGS

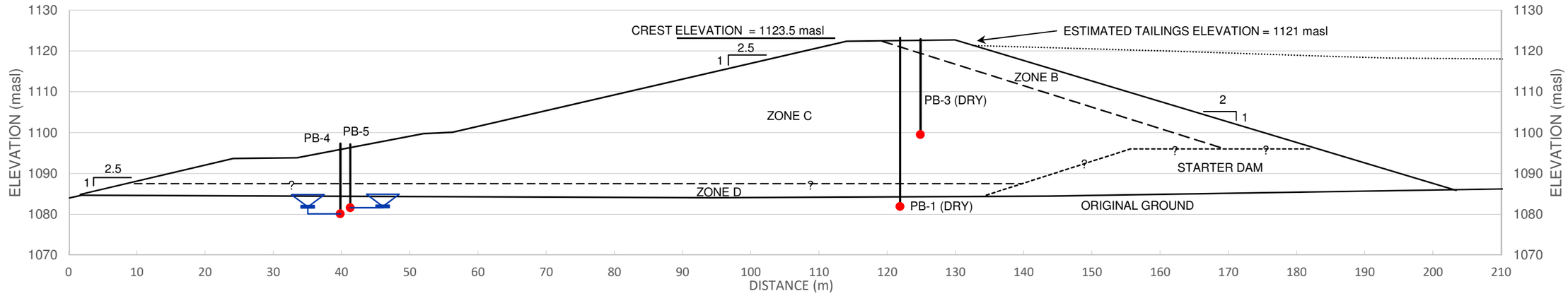
PROJECT No. M09893A09

FIG. No. 6

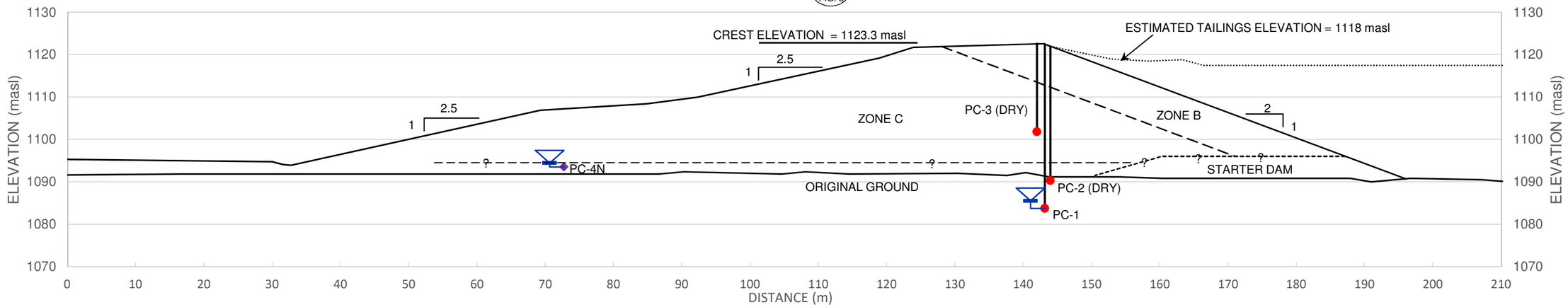
Date & Time: 2019-10-25 14:21
Figure File: Z:\M\VCR\M09893A09-TML-Bullmoose 2019 Consulting\300 Design\303 Instrumentation\BTD Piezometer\[191003 Bullmoose Piezometer.xlsx]Figure C



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 P.B.2 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
2019 DAM SAFETY INSPECTION

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

PROJECT No. M09893A09

FIG. No. 7

Date & Time: 2019-10-25 11:54
Figure File: Z:\MVCR\M09893A09-TML-Bullmoose 2019 Consulting\300 Design\303 Instrumentation\BTD Piezometer\[191003 Bullmoose Piezometer.xlsx]Figure B

MONUMENT	NORTHING (m)							
	October 15, 2015	December 14, 2015	February 22, 2016	September 6, 2016	February 21, 2017	May 21, 2017	October 4, 2018	July 2, 2019
M1	5082.830	5082.822	5082.849	5082.857	5082.853	5082.845	5082.853	5082.843
M2	5100.194	5100.186	5100.212	5100.220	5100.220	5100.208	5100.216	5100.205
M3	5231.547	5231.543	5231.560	5231.565	5231.551	5231.559	5231.563	5231.558
M4	5307.344	5307.335	5307.356	5307.357	5307.357	5307.355	5307.357	5307.355
M5	5257.995	5257.994	5258.012	5258.013	5258.012	5258.008	5258.012	5258.011
M6	5320.391	5320.390	5320.407	5320.409	5320.403	5320.405	5320.407	5320.406
M7	5371.856	5371.852	5371.865	5371.869	5371.869	5371.868	5371.869	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	July 2, 2019
M1	5239.400	5239.394	5239.434	5239.422	5239.407	5239.408	5239.410	5239.408
M2	5181.277	5181.269	5181.313	5181.301	5181.279	5181.286	5181.288	5181.285
M3	5438.104	5438.101	5438.120	5438.113	5438.113	5438.106	5438.108	5438.106
M4	5408.275	5408.271	5408.292	5408.289	5408.281	5408.281	5408.282	5408.280
M5	5687.275	5687.268	5687.275	5687.269	5687.274	5687.271	5687.272	5687.271
M6	5715.759	5715.756	5715.760	5715.757	5715.764	5715.760	5715.758	5715.760
M7	5739.531	5739.534	5739.532	5739.527	5739.531	5739.529	5739.530	5739.529

MONUMENT	ELEVATION (m)							
	October 15, 2015	December 14, 2015	February 22, 2016	September 6, 2016	February 21, 2017	May 21, 2017	October 4, 2018	July 2, 2019
M1	125.512	125.524	125.505	125.502	125.511	125.496	125.500	125.498
M2	109.830	109.845	109.827	109.823	109.835	109.817	109.818	109.825
M3	125.762	125.773	125.751	125.753	125.748	125.754	125.746	125.745
M4	100.020	100.020	100.018	100.014	100.018	100.013	100.008	100.008
M5	125.863	125.860	125.846	125.849	125.857	125.846	125.845	125.850
M6	100.320	100.322	100.315	100.312	100.313	100.307	100.313	100.310
M7	95.748	95.753	95.755	95.747	95.750	95.749	95.755	95.762

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 NOV 5, 2019.
2. BASE READING: OCTOBER 2015
3. SURVEY COORDINATES ARE MEASURED USING LOCALLY ESTABLISHED DATUM.

CLIENT: Teck

Klohn Crippen Berger

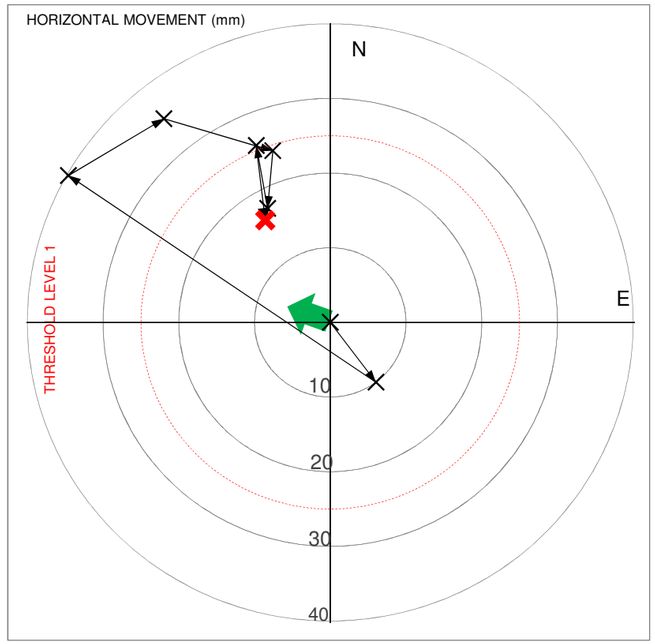
PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

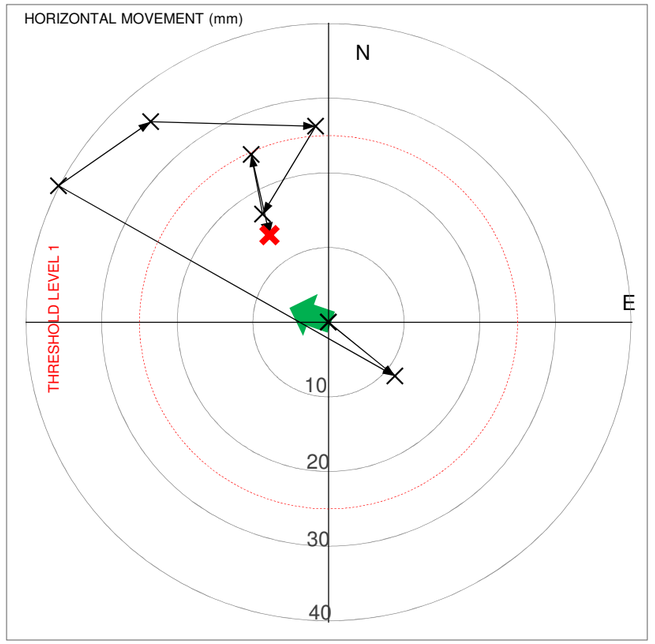
TITLE: BULLMOOSE TAILINGS DAM
2019 SURVEY MONUMENTS READINGS

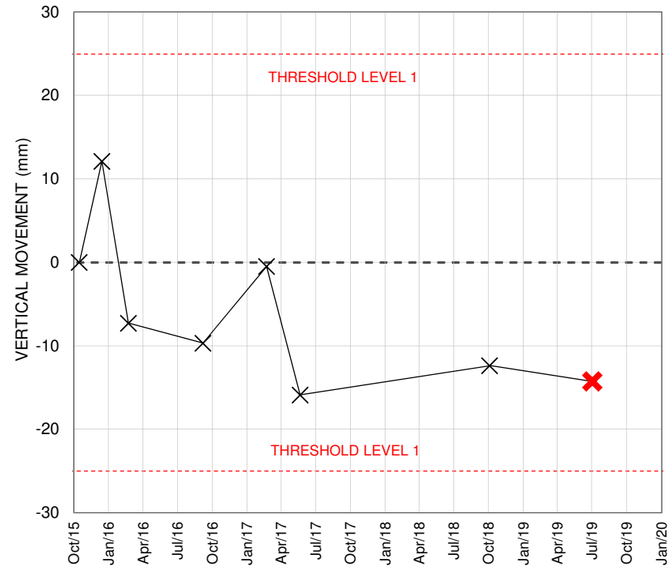
PROJECT No. M09893A09

FIG. No. 8

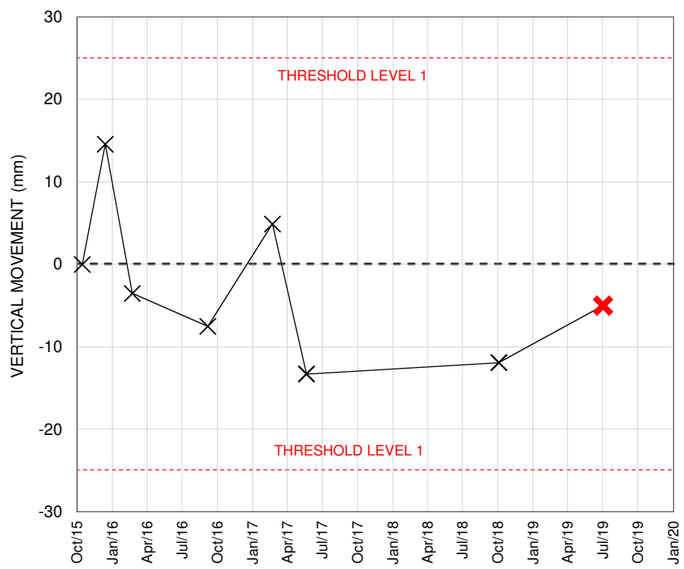
Date & Time: 2020-03-23 16:39
Figure File: Z:\MVCR\M09893A09-TML-Bullmoose 2019 Consulting\300 Design\303 Instrumentation\BTD Survey\[191106 Bullmoose Survey.xlsx]Figure D







M1 SURVEY RECORDS



M2 SURVEY RECORDS

NOTES:

1. SURVEY DATA PROVIDED BY TECK RESOURCES LTD. LATEST READINGS RECEIVED ON NOV 5, 2019.
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

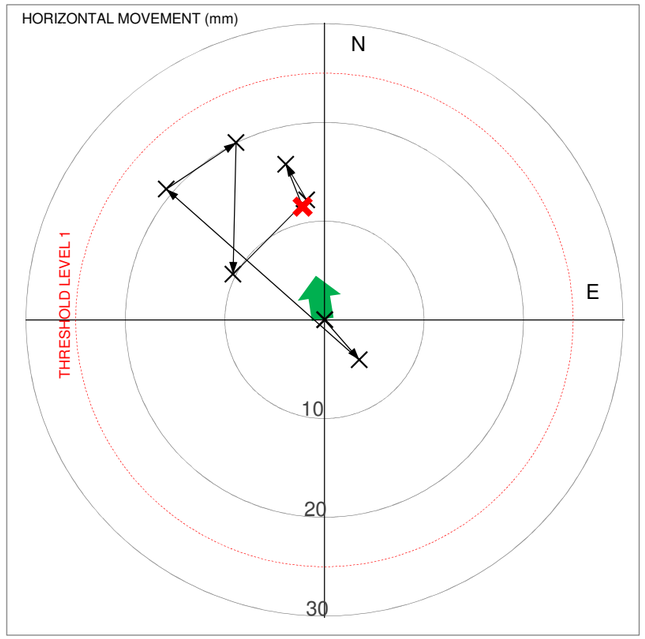
PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

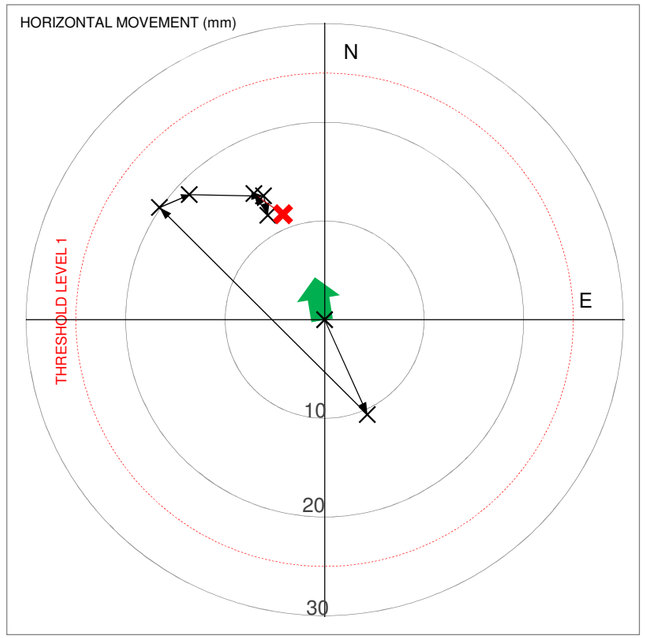
TITLE: BULLMOOSE TAILINGS DAM
SURVEY MONUMENTS (M1 AND M2) AND
THRESHOLD LEVELS

PROJECT No. M09893A09

FIG. No. 9

Date & Time: 2020-03-23 16:39
Figure File: Z:\M\VCR\M09893A09-TML-Bullmoose 2019 Consulting\300 Design\303 Instrumentation\BTD Survey\[191106 Bullmoose Survey.xlsx]Figure D





M3 SURVEY RECORDS

M4 SURVEY RECORDS

NOTES:

1. SURVEY DATA PROVIDED BY TECK RESOURCES LTD. LATEST READINGS RECEIVED ON NOV 5, 2019.
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

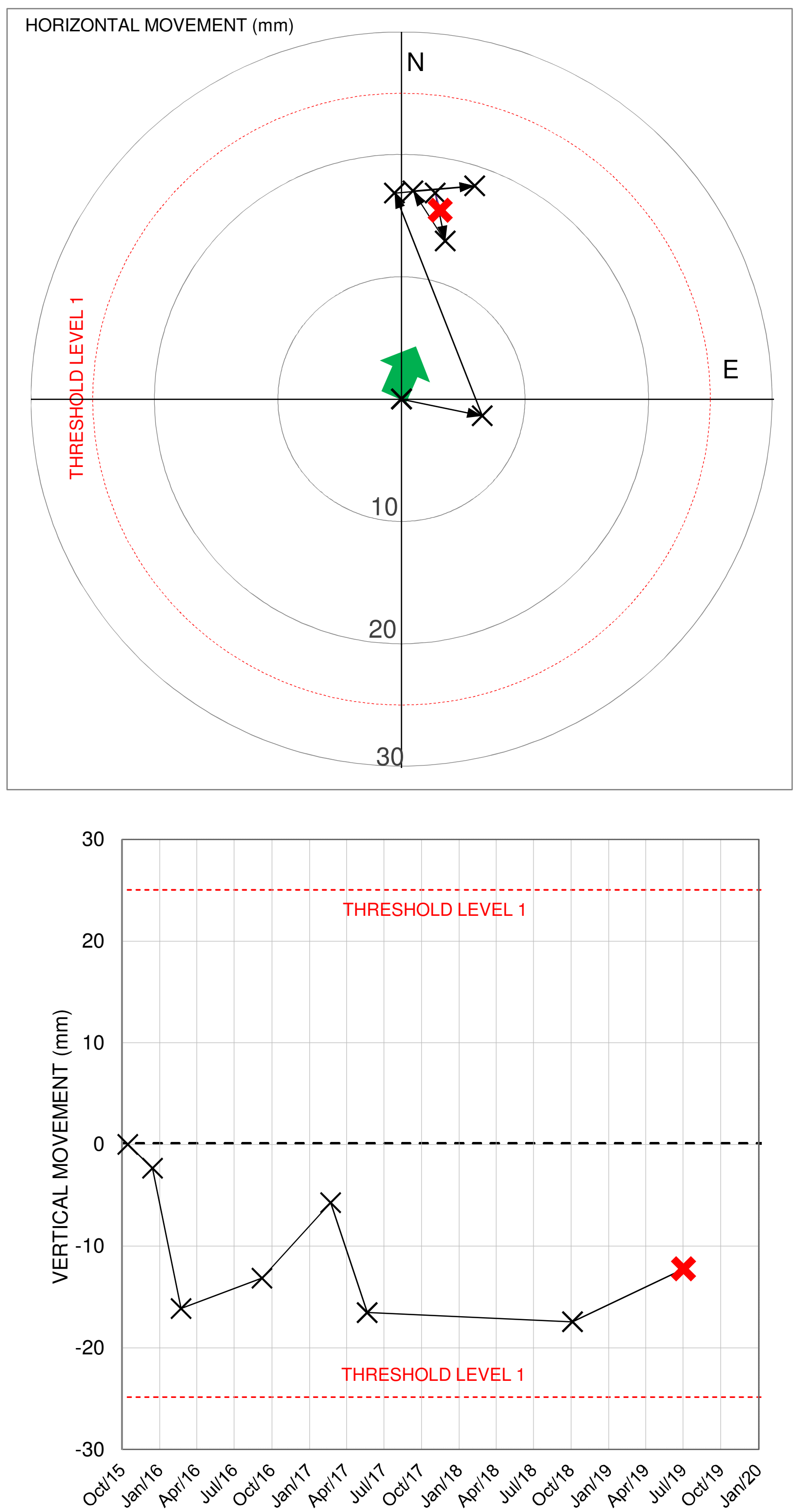
PROJECT: BULLMOOSE MINE
2019 DAM SAFETY INSPECTION

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

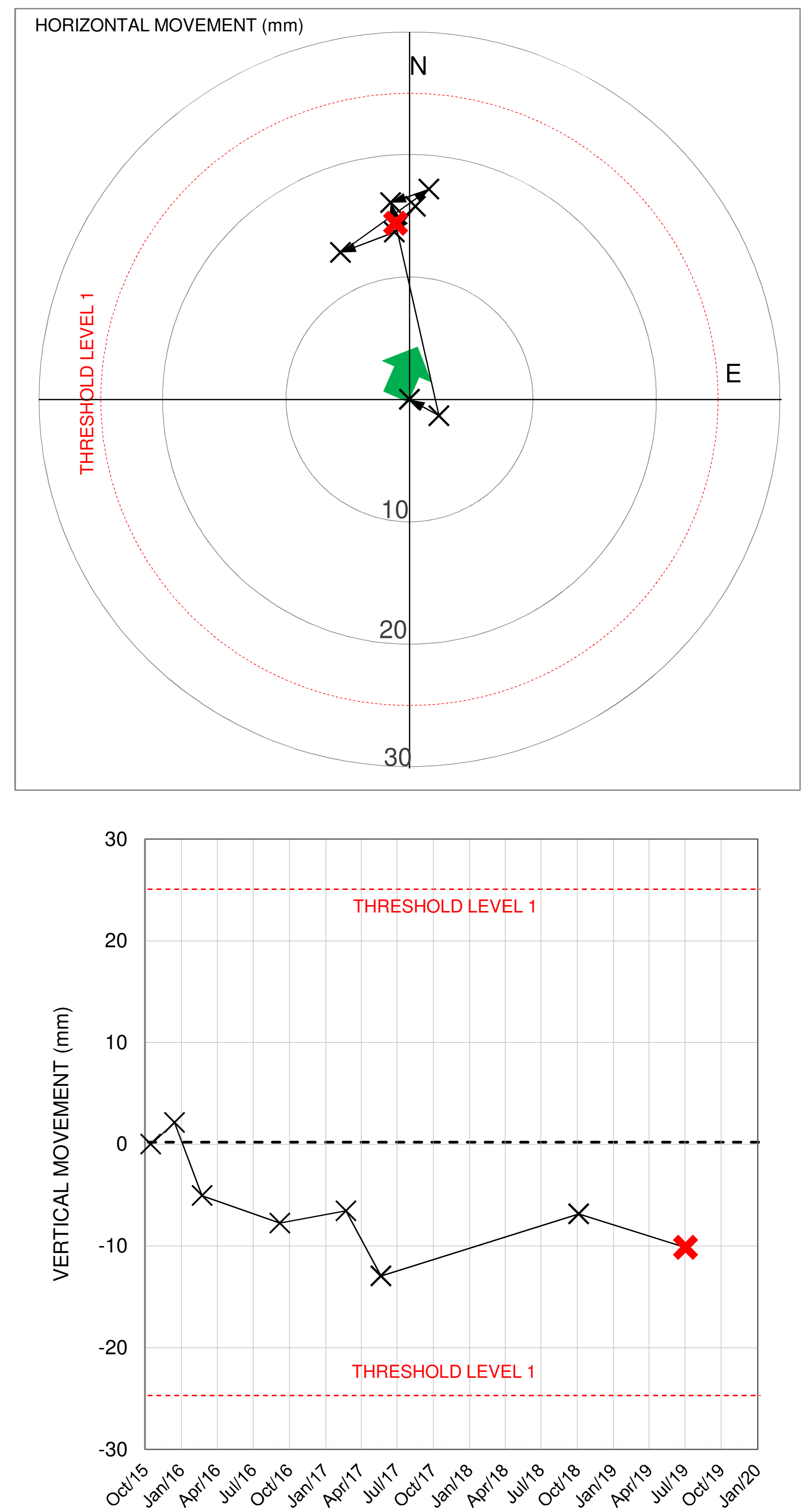
PROJECT No. M09893A09

FIG. No. 10

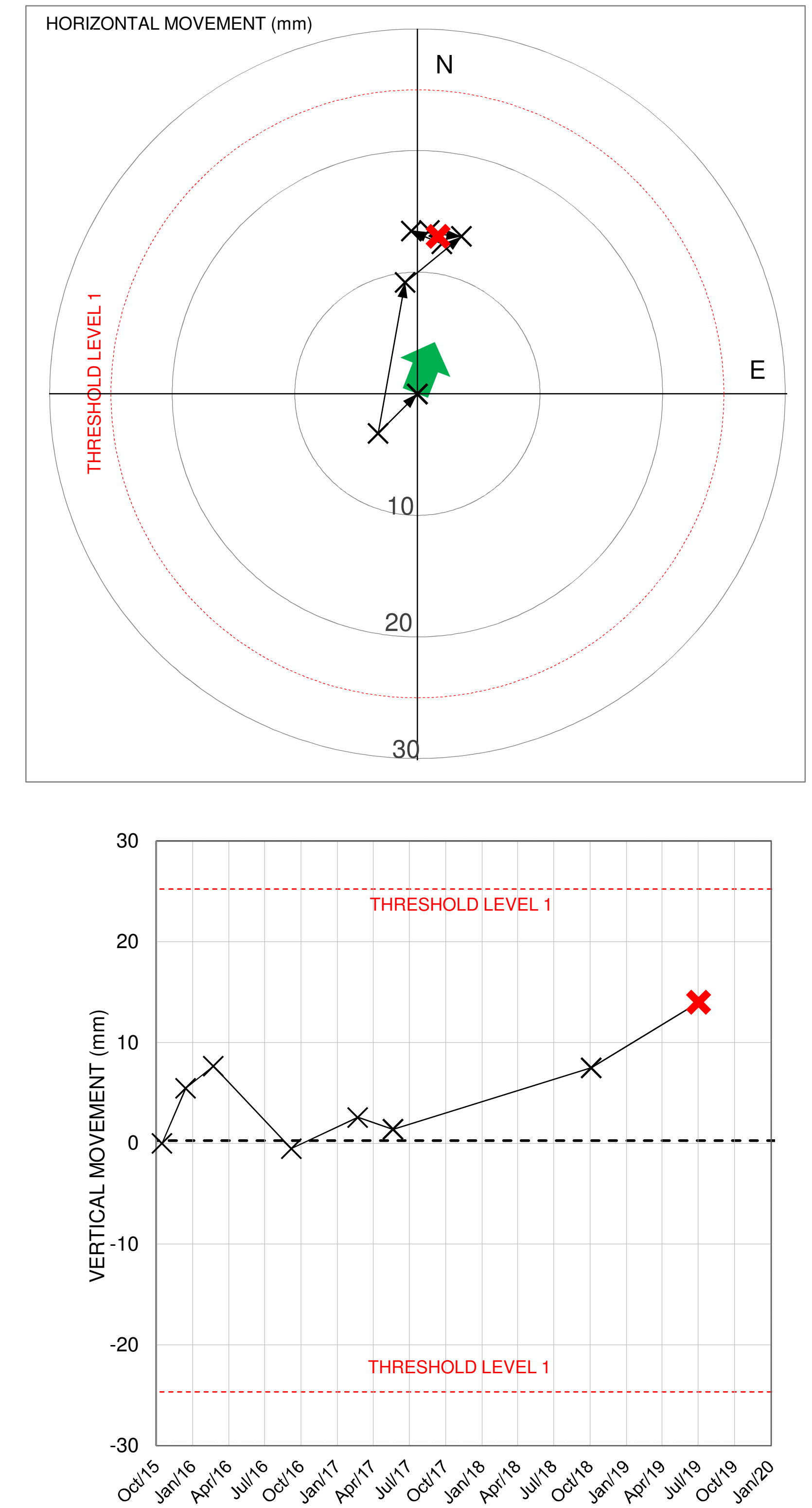
Date & Time: 2020-03-23 16:39
Figure File: Z:\M\VCR\M09893A09-TML-Bullmoose 2019 Consulting\300 Design\303 Instrumentation\BTD Survey\[191106 Bullmoose Survey.xlsx]Figure D



M5 SURVEY RECORDS



M6 SURVEY RECORDS



M7 SURVEY RECORDS

NOTES:

1. SURVEY DATA PROVIDED BY TECK RESOURCES LTD. LATEST READINGS RECEIVED ON NOV 5, 2019.
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
2019 DAM SAFETY INSPECTION

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

PROJECT No. M09893A09

FIG. No. 11

Date & Time: 2020-03-23 16:39
Figure File: Z:\MVCR\M09893A09-TML-Bullmoose 2019 Consulting\300 Design\303 Instrumentation\BTD Survey\[191106 Bullmoose Survey.xlsx]Figure D

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 Stored	4.4 million m^3
Design 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	Invert 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-2019-## refers to the 2019 DSI photograph location, as shown on Figure 3

Photographs were taken during site inspection on May 30, 2019.

Photo II-1 BTD Crest – looking north (BTD-2019-01)

Photo II-2 BTD Impoundment – looking northeast (BTD-2019-01)

Photo II-3 BTD Crest – looking north (BTD-2019-02)

Photo II-4 BTD Crest – looking east (BTD-2019-03)

Photo II-5 BTD Crest – looking west (BTD-2019-03)

Photo II-6 BTD Impoundment – looking southeast (BTD-2019-03)

Photo II-7 BTD Crest – looking east (BTD-2019-04)

Photo II-8 BTD Crest – looking east (BTD-2019-05)

Photo II-9 BTD Pond – looking south (BTD-2019-06)

Photo II-10 BTD Crest and Pond – looking north (BTD-2019-07)

Photo II-11 Historic slide from the natural slope. Mostly overgrown with small trees. No signs of change from previous inspections – looking south (BTD-2019-09)

Photo II-12 BTD East Abutment – looking west (BTD-2019-10)

Photo II-13 BTD East Abutment – looking east (BTD-2019-10)

Photo II-14 BTD East Abutment – looking north (BTD-2019-10)

Photo II-15 BTD Toe. Erosion gulley observed during previous inspections. No obvious signs of change – looking north (BTD-2019-11)

Photo II-16 BTD Downstream Slope – looking north (BTD-2019-12)

Photo II-17 BTD Downstream Slope – looking west (BTD-2019-13)

Photo II-18 BTD Downstream Toe. Wet area along the toe. Noted in previous DSI reports as being an area where snowmelt water collects. No signs of seepage emerging from the slope – looking east (BTD-2019-14)

Photo II-19 BTD Downstream Slope – looking east (BTD-2019-14)

Photo II-20 BTD Downstream Slope and West Abutment – looking north (BTD-2019-15)

Photo II-21 BTD Spillway. Riprap armoured portion of the spillway – looking upstream (BTD-2019-16)

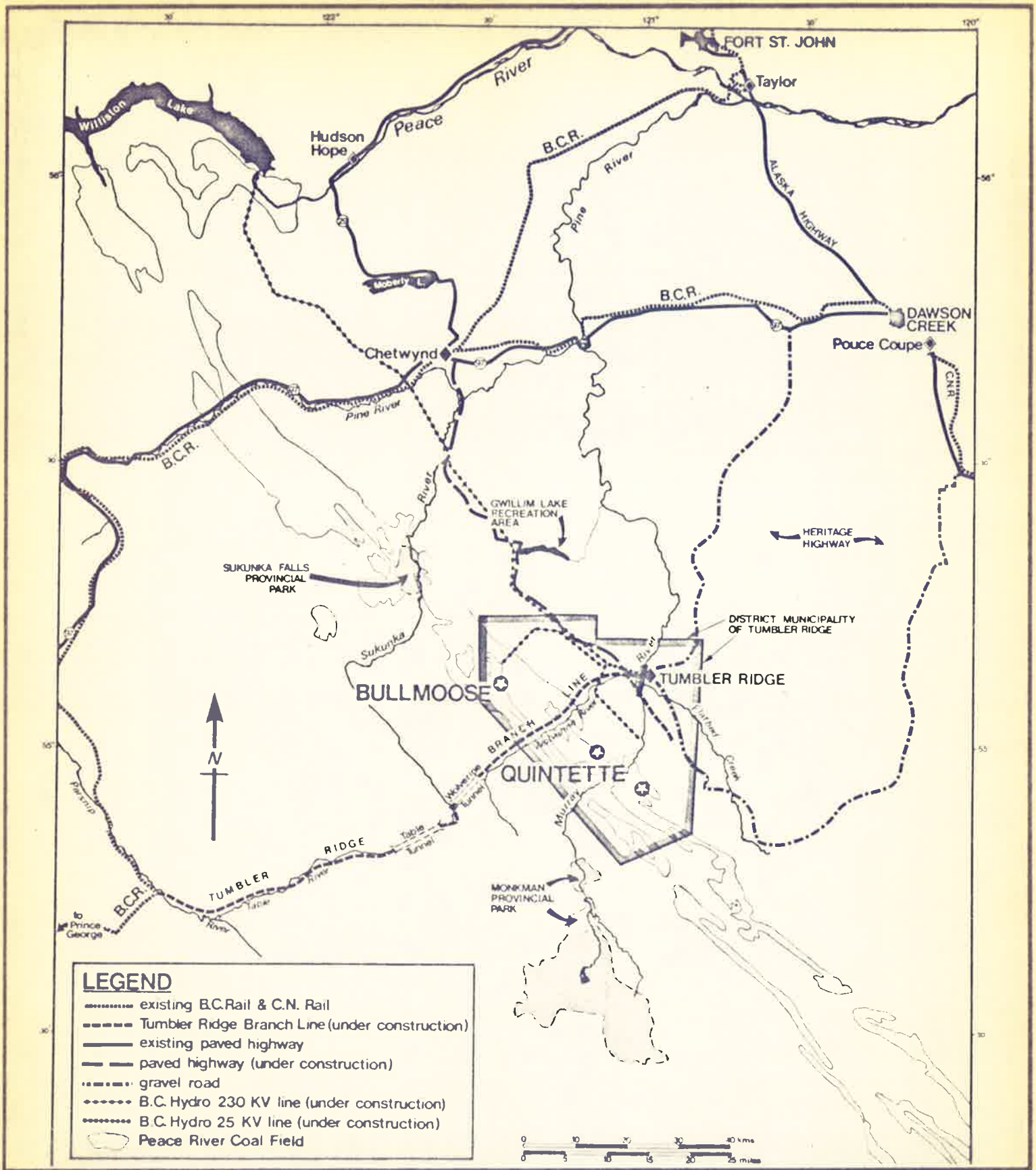
Photo II-22 BTD Spillway Riprap. D_{50} of approximately 300 mm – looking upstream (BTD-2019-16)

Photo II-23 BTD Spillway. Unarmoured portion of the spillway (left bank comprised of bedrock) – looking downstream (BTD-2019-16)

Photo II-24 BTD Spillway Outlet. Riprap D_{50} of approximately 300 mm – looking downstream (BTD-2019-17)

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

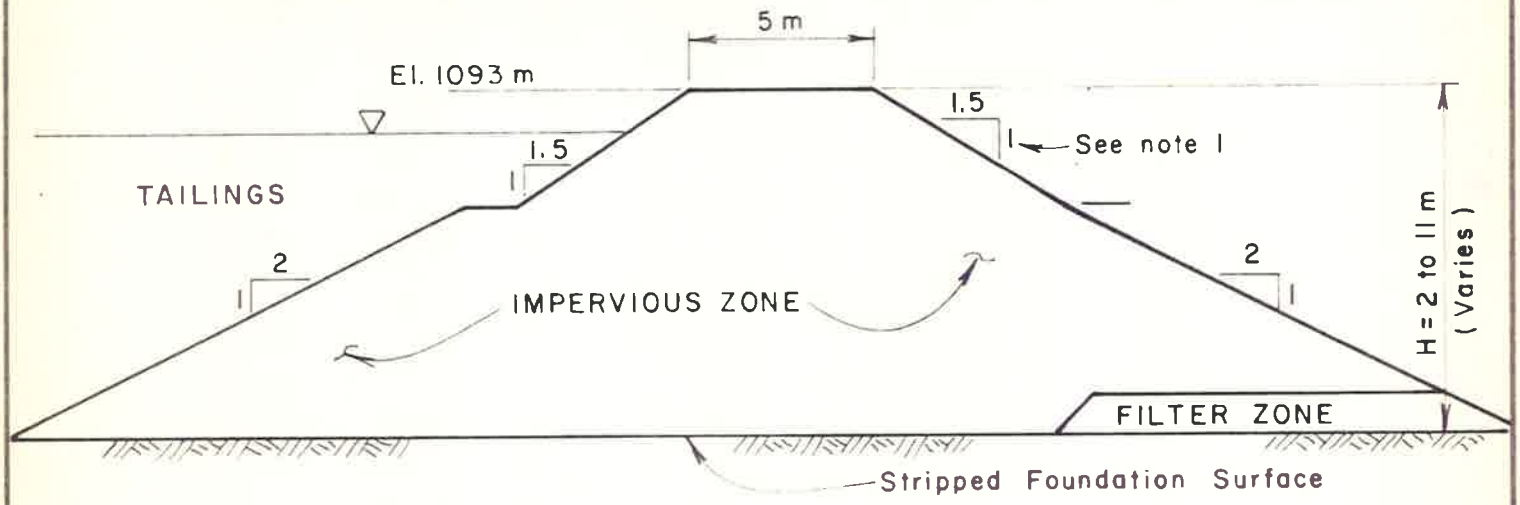
APPROVED: H. N. McLEOD

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

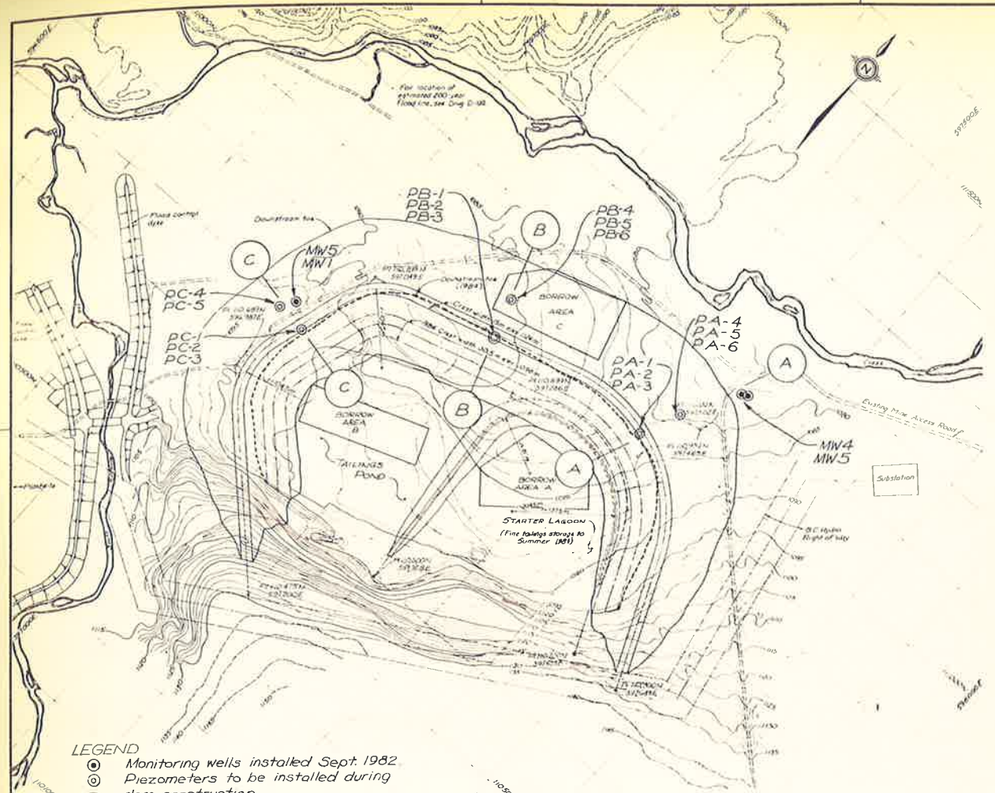
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

TITLE: TAILINGS STARTER DAM
TYPICAL AS-BUILT SECTION

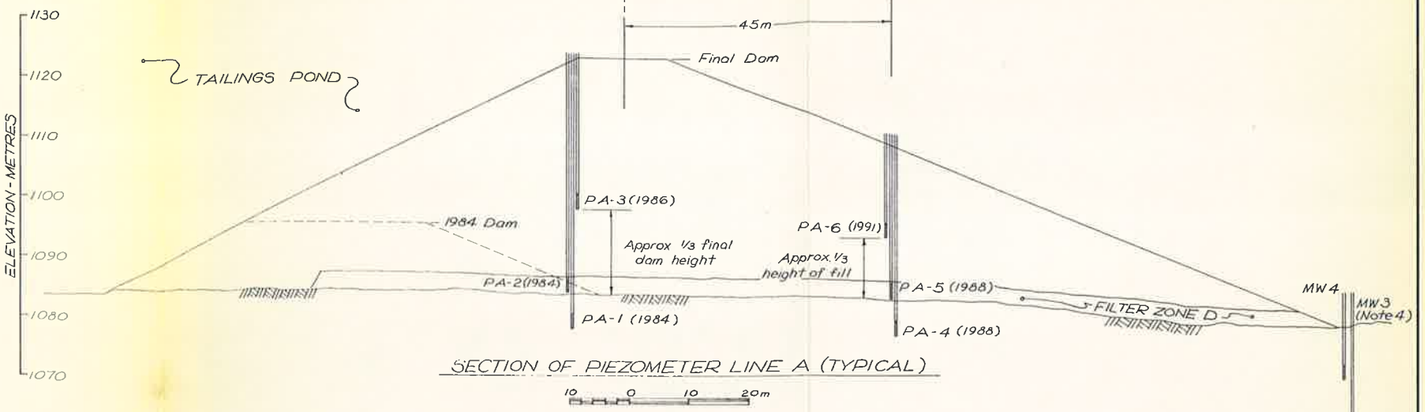
CLIENT: BULLMOOSE OPERATING CORPORATION

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

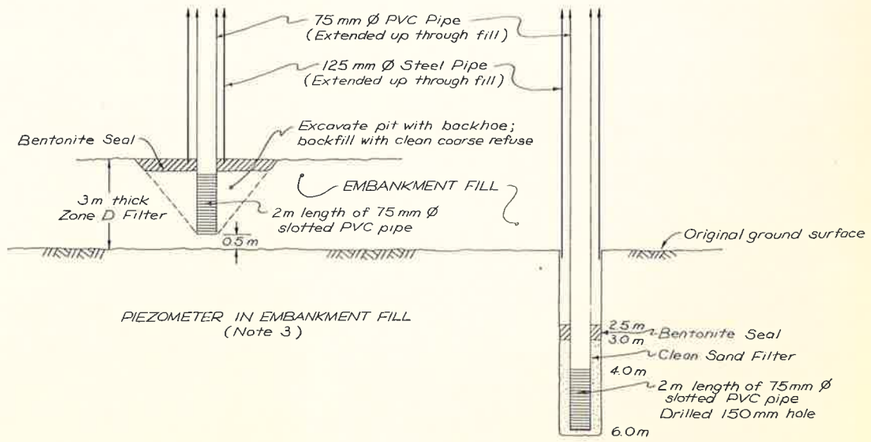


LEGEND
- ◉ Monitoring wells installed Sept 1982
- ◎ Piezometers to be installed during dam construction.
- (A) Piezometer Lines

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

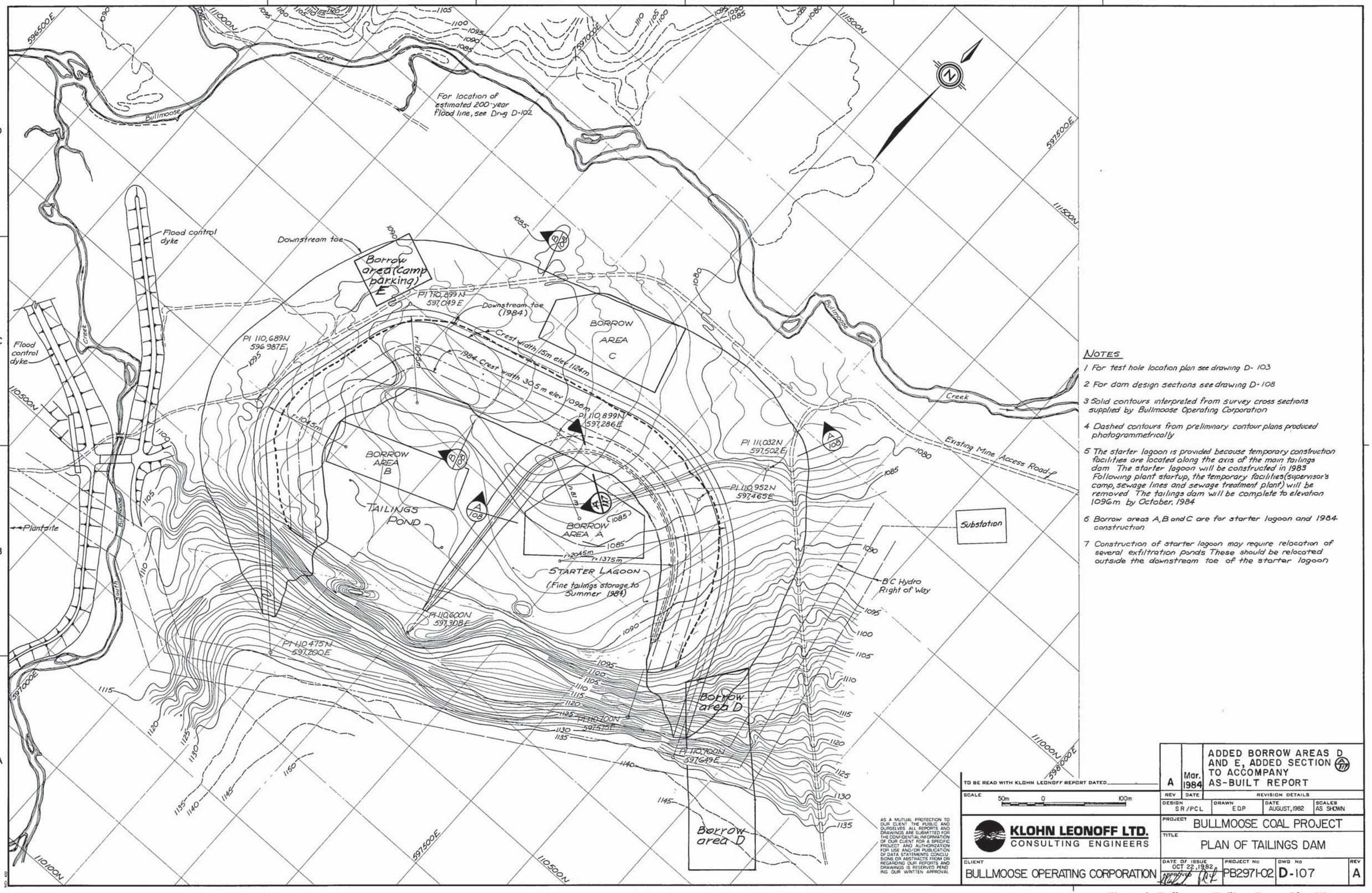
TITLE: PLAN, SECTION & DETAILS OF TAILINGS DAM PIEZOMETERS

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

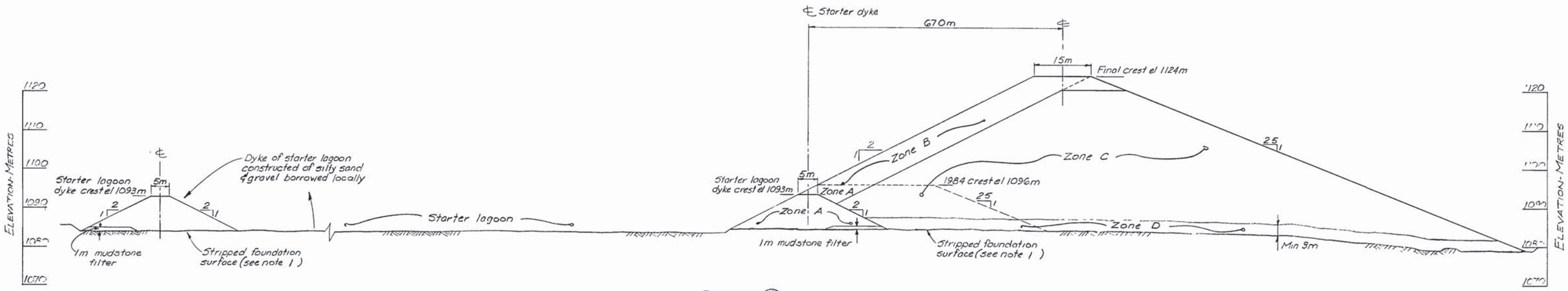
TITLE PLAN OF TAILINGS DAM

CLIENT BULLMOOSE OPERATING CORPORATION

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

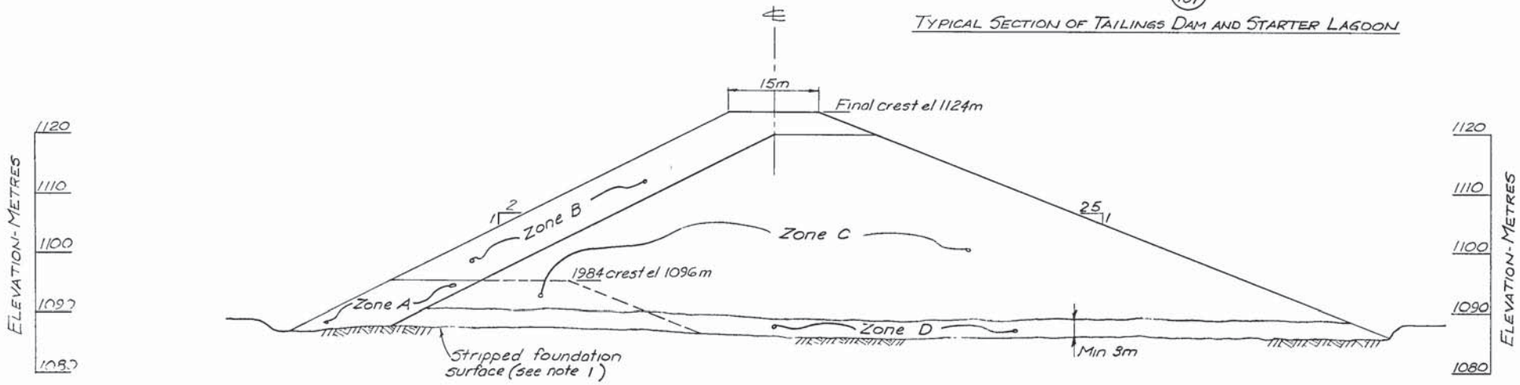
APPROVED

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

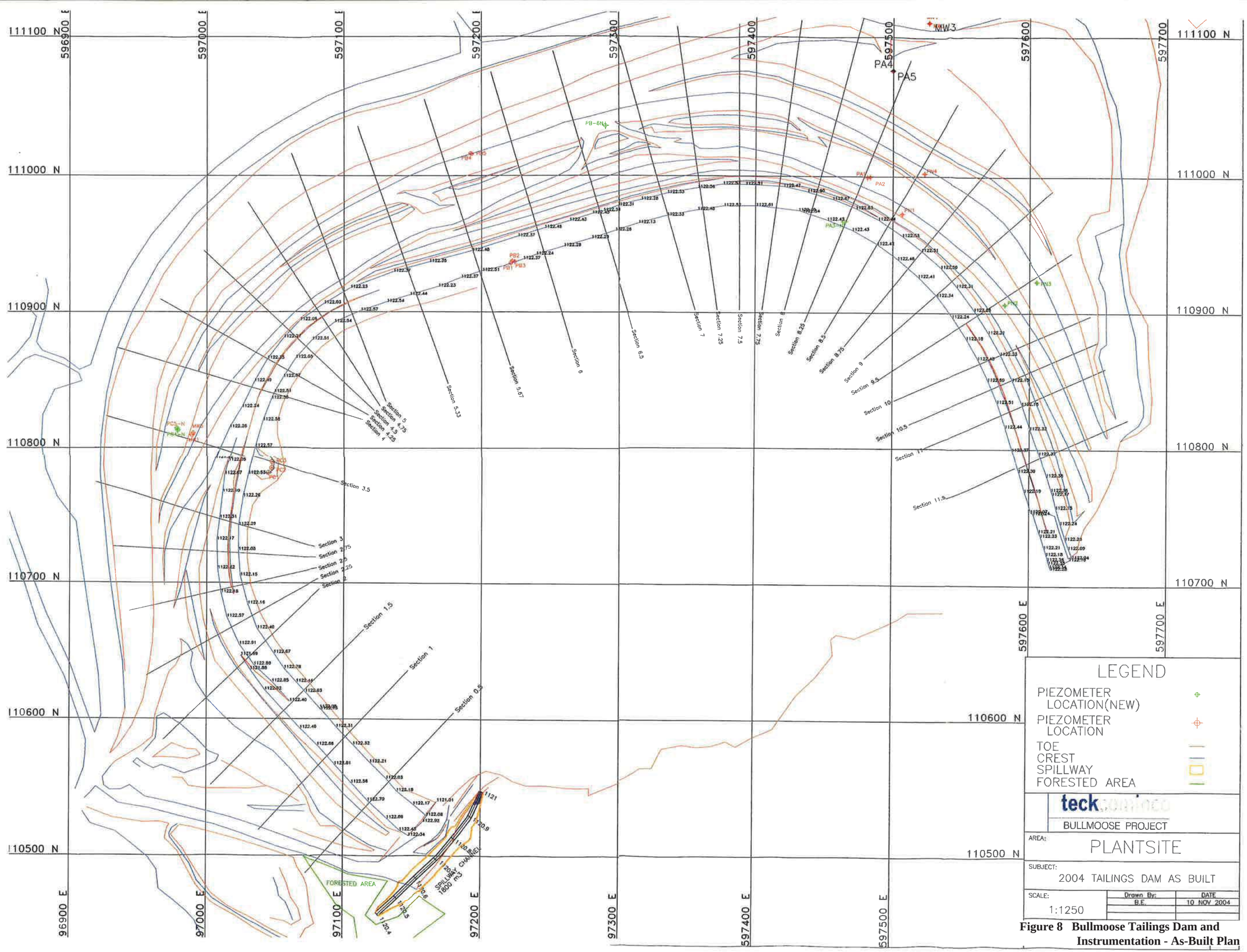
TITLE: TYPICAL SECTIONS OF TAILINGS DAM

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

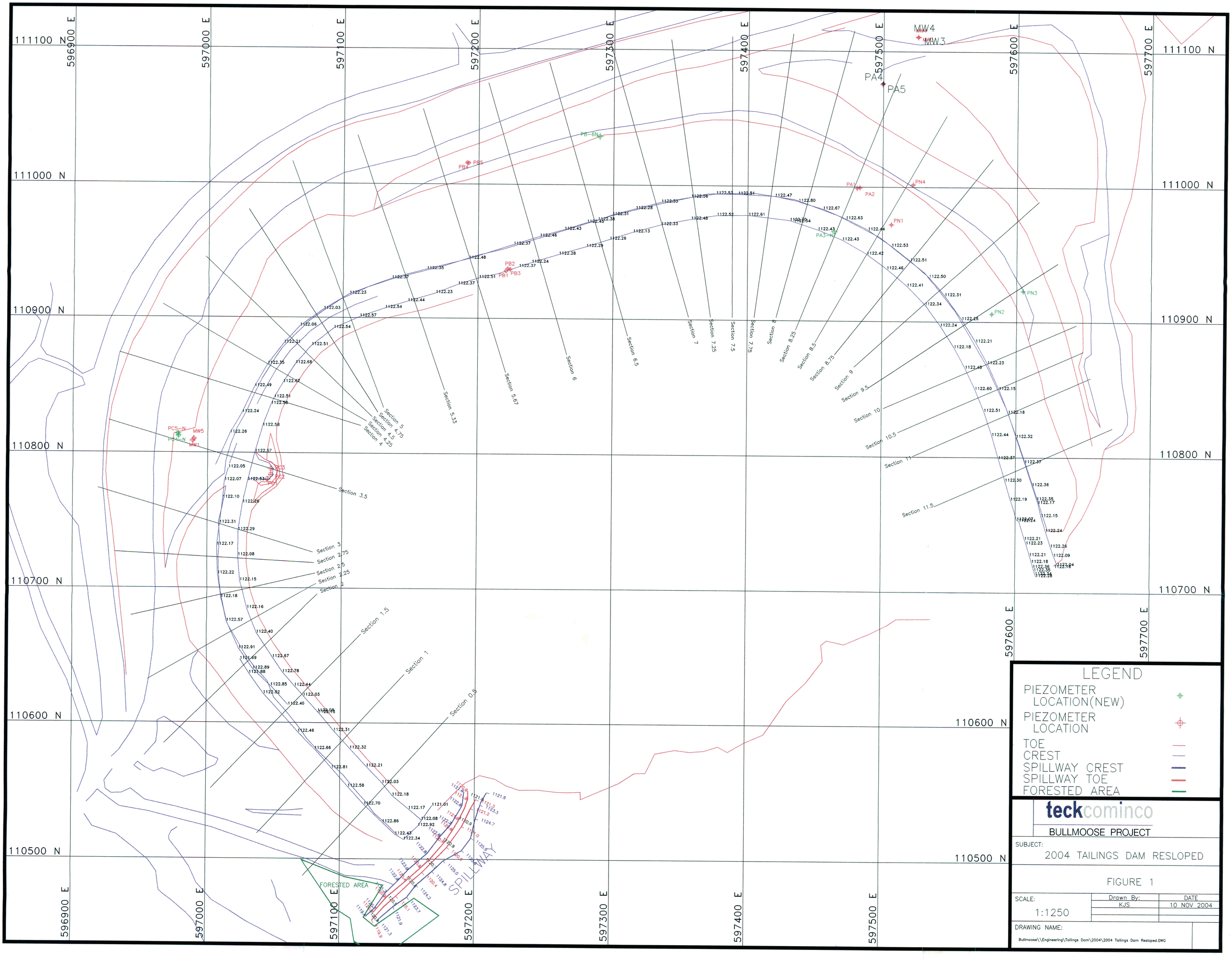
BULLMOOSE PROJECT

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:

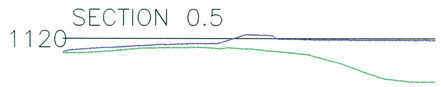
2004 TAILINGS DAM RESLOPED

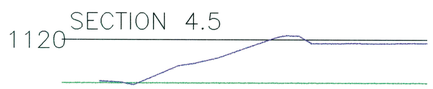
FIGURE 1

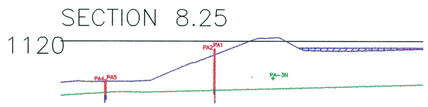
SCALE:	Drawn By:	DATE
1:1250	KJS	10 NOV 2004

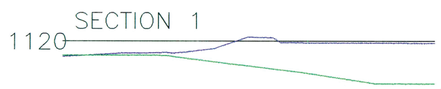
DRAWING NAME:

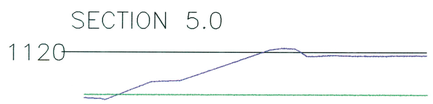
Bullmoose\\Engineering\Tailings Dam\2004\2004 Tailings Dam Resloped.DWG

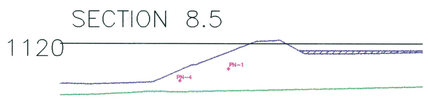


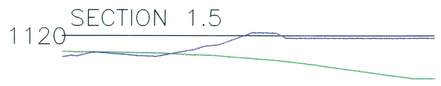


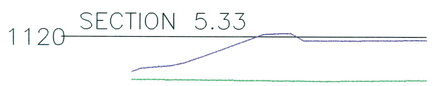


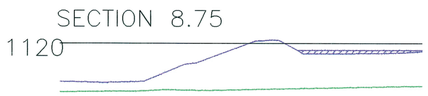


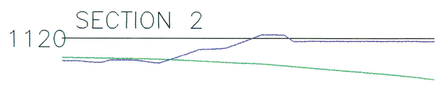


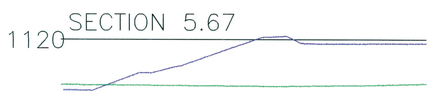


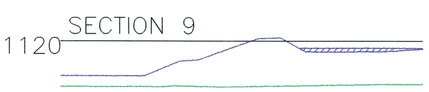


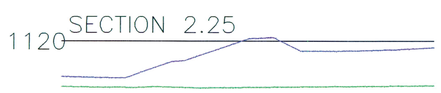


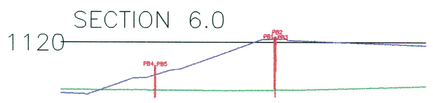


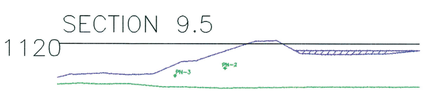


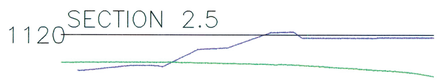


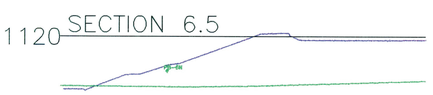


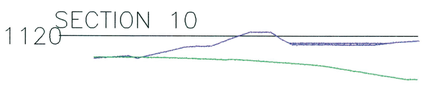


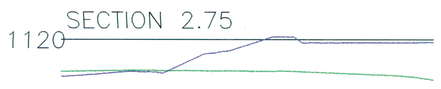


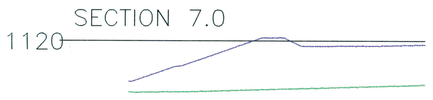


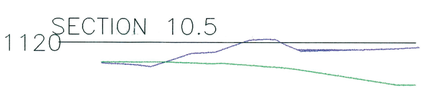


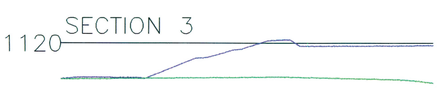


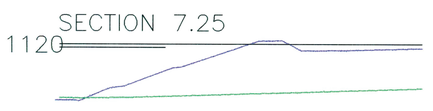


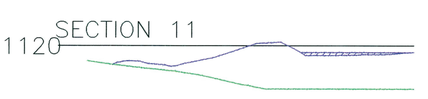


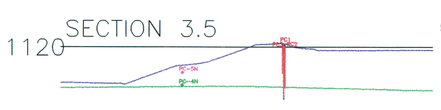


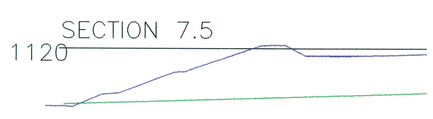


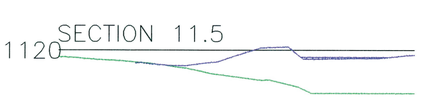


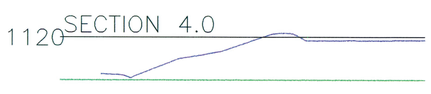


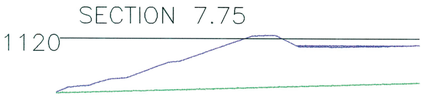


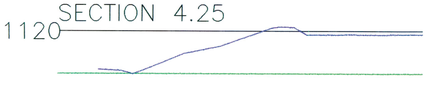


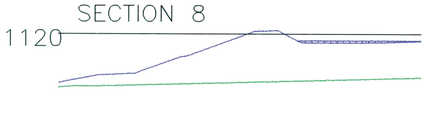












LEGEND

- 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

APPENDIX IV

Register of Reference Documents

Appendix IV
Register of Reference Documents

Document Title	Author	Date of Issue
Bullmoose Coal Project - Phase II - Geotechnical, Hydrogeological and Water Management Study - Report II - Project Description, Geologic Setting and Phase II Field Investigation	Hardy Associates Ltd.	08-Jan-82
Bullmoose Coal Project - Phase II - Geotechnical, Hydrogeological and Water Management Study - Report VI - Tailings Disposal Facility Geotechnical Study	Hardy Associates Ltd.	23-Feb-82
Bullmoose Coal Project - Phase II - Geotechnical, Hydrogeological and Water Management Study - Report X - Construction Materials	Hardy Associates Ltd.	30-Mar-82
Sedimentation Ponds No. 1 and No. 2 Bullmoose Coal Project - Geotechnical Design Report	Klohn Leonoff	25-Jun-82
Bullmoose Coal Project - Tailings Dam Design Report	Klohn Leonoff	Oct-82
Bullmoose Coal Project - DESIGN: Sedimentation Pond No. 3	Klohn Leonoff	25-Feb-83
Bullmoose Tailings Disposal 1983 Starter Dam Construction	Klohn Leonoff	14-Mar-1984
Annual Review of Tailings Dam - 1984/85	Bullmoose Operating Corporation	Aug-85
Annual Review of Tailings Dam 1986/87	Klohn Leonoff	11-Aug-87
Report on Site Visit July 24, 1987 and Annual Review of Tailings Dam 1986/87	Klohn Leonoff	11-Aug-87
Bullmoose Coal Project Hydrogeology Study	Klohn Leonoff	Nov-87
Annual Review of Tailings Dams for 1987/88	Klohn Leonoff	09-Sep-88
Annual Review of Operations - 1987/88	Bullmoose Operating Corporation	Aug-88
Annual Review of Tailings Dams for 1988/1989	Klohn Leonoff	28-Aug-89
Annual Review of Operations - 1988/89	Bullmoose Operating Corporation	Aug-89
1989-90 Annual Review of Tailings Dam	Klohn Leonoff	30-Aug-90
Tailings Pond Annual Review of Operations - 1989/90	Bullmoose Operating Corporation	Aug-90
1990-91 Annual Review of Tailings Dam	Klohn Leonoff	29-Aug-91
Annual Review of Operations - 1990/91	Bullmoose Operating Corporation	Jul-91
1991-92 Annual Review of Tailings Dam	Klohn Leonoff	26-Aug-92
Annual Review of Operations 1991/92	Bullmoose Operating Corporation	Jul-92
1992-93 Annual Review of Tailings Dam	Klohn Crippen	30-Aug-93
Annual Review of Operations 1992/93	Bullmoose Operating Corporation	Jul-93
Annual Review of Operations 1993/94	Bullmoose Operating Corporation	Jul-94
May Site Visit: Tailings Dam Recommendations	Klohn Crippen	01-Jun-95
South Fork Tailings Dam - Seepage and Stability Review	Klohn Crippen	Oct. 1996
1996 Annual Review of Tailings Facility	Klohn Crippen	17-Dec-96
Density Comparison, Tailings Dam Construction - Bullmoose Mine, Tumbler Ridge, BC	Peace Country Materials Testing Ltd.	04-Jun-97
1997 Annual Review of Tailings Facility	Klohn Crippen	17-Dec-97
Annual Review of Operations 1997/98 Tailings Pond	Bullmoose Operating Corporation	Dec-98
1998 Annual Review of Tailings Facility	Klohn Crippen	13-Jan-99
Bullmoose Tailings Facility Establishment of Threshold Warning Levels of Piezometers	Klohn Crippen	Oct-99
Summary of Site Visit on September 23, 1999	Klohn Crippen	19-Nov-99
Annual Review of Operations 1998/99 Tailings Pond	Bullmoose Operating Corporation	Nov-99
Tailings Impoundment Closure Report - Draft	Bullmoose Operating Corporation	Jan-00
1999 Annual Review	Klohn Crippen	07-Feb-00
Annual Review of Operations	Bullmoose Operating Corporation	Nov-00
Review of 2000 Tailings Operations Report	Klohn Crippen	Dec-00
Annual Review of Operations	Bullmoose Operating Corporation	Nov-01
Tailings Impoundment Closure Spillway Design	Klohn Crippen	Dec-01
Review of 2001 Tailings Operations Report	Klohn Crippen	18-Dec-01
Tailings Impoundment Closure Spillway - Review of Proposed Layout	Klohn Crippen	Oct-02
Bullmoose Mine Review of 2002 Tailings Operations Report	Klohn Crippen	18-Dec-02
Annual Review of Operations	Bullmoose Operating Corporation	Nov-2003
Bullmoose Mine Review of 2003 Tailings Operations Report	Klohn Crippen	18-Dec-2003
Bullmoose Tailings Facility Closure Spillway Inspection on September 22, 2004	Klohn Crippen	Oct-2004
Tailings Dam Annual Review of Operations	Bullmoose Operating Corporation	01-Nov-04
Bullmoose Mine Review of 2004 Tailings Operations Report	Klohn Crippen	Dec. 2004
Bullmoose 2010 Dam Safety Inspection and Consequence Classification	Klohn Crippen Berger	01-Mar-11
Bullmoose Tailings Impoundment 2012 Dam Safety Inspection	Teck	Aug-13
Bullmoose Mine 2013 Dam Safety Inspection	Klohn Crippen Berger	25-Mar-14
Bullmoose Mine Tailings Dam Design Review	Klohn Crippen Berger	15-Aug-14
Bullmoose Mine Tailings Storage Dam 2014 Dam Safety Inspection Revision 1	Klohn Crippen Berger	26-Nov-14
Bullmoose Mine Tailings Storage Facility - Dam Breach and Inundation Study	Klohn Crippen Berger	27-Nov-14
Bullmoose Mine Tailings Storage Facility - Response to February 3, 2015 MEM Memorandum	Klohn Crippen Berger	29-Jun-15
Bullmoose Mine 2015 Consulting - Tailings Storage Facility Hydrotechnical Review	Klohn Crippen Berger	22-Dec-15
Bullmoose Mine Tailings Storage Dam – 2015 Dam Safety Inspection	Klohn Crippen Berger	22-Mar-16
Bullmoose Tailings Storage Facility Engineer of Record	Klohn Crippen Berger	23-Sep-16
Bullmoose Mine Tailings Dam - Water Management, Water Balance and Quantifiable Performance Objectives	Klohn Crippen Berger	22-Dec-16
Bullmoose Mine Tailings Storage Dam – 2016 Dam Safety Inspection	Klohn Crippen Berger	01-Mar-17
Bullmoose Tailings Dam - Review of Monument Survey Data - May, 2017	Klohn Crippen Berger	09-Jun-17
Survey Monuments Quantifiable Performance Objectives	Klohn Crippen Berger	25-Aug-17
Review of Seismic Hazard Assessment	Klohn Crippen Berger	13-Oct-17
Bullmoose Mine Tailings Storage Dam – 2017 Dam Safety Inspection - Revision 1	Klohn Crippen Berger	16-Mar-18
Bullmoose Tailings Dam – Closure Passive Care - Draft	Klohn Crippen Berger	26-Feb-18
Bullmoose Creek Flood Study	Klohn Crippen Berger	22-Jun-18
Bullmoose Tailings Dam - Internal Stability Assessment	Klohn Crippen Berger	03-Dec-18