Klohn Crippen Berger

Teck Highland Valley Copper Partnership

2019 Dam Safety Inspection Report

Bethlehem No.1 Tailings Storage Facility

FINAL

BEST MANAGED COMPANIES Platinum member

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M02341B53.730

April 2020

Klohn Crippen Berger

April 3, 2020

Teck Highland Valley Copper Partnership
PO Box 1500
Logan Lake, British Columbia
V0K 1W0

Mr. Chris Anderson
Manager, Tailings and Water

Dear Mr. Anderson:

2019 Dam Safety Inspection Report
Bethlehem No.1 Tailings Storage Facility
FINAL

We are pleased to submit the 2019 Dam Safety Inspection report for the Bethlehem No.1 Tailings Storage Facility. The inspection and this report were prepared to comply with Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code) (MEM 2017), and Section 4.2 of the Guidance Document (MEM 2016).

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Rick Friedel, P.Eng.
Engineer of Record, Designated Representative
Senior Geotechnical Engineer, Principal

RF/NS:cd

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Teck Highland Valley Copper Partnership

2019 Dam Safety Inspection Report

Bethlehem No.1 Tailings Storage Facility

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EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2019 Dam Safety Inspection (DSI) of the Bethlehem No. 1 Tailings Storage Facility (TSF) on the Highland Valley Copper (HVC) mine site in accordance with requirement of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code). The visual inspection was completed by the Engineer of Record (EoR), Mr. Rick Friedel, P.Eng., Mr. Pablo Urrutia, P.Eng., and Ms. Narges Solgi, EIT, as representatives of KCB on June 12, 2019. Mr. Chris Anderson, P. Eng., THVCP Tailings and Water Manager, is the TSF Qualified Person (as defined by the Code) for Bethlehem No. 1 TSF.

The Bethlehem No. 1 TSF was visually in good physical condition, the observed performance during the 2019 site inspections is within expected design conditions, and 2019 surveillance data is consistent with past performance.

The Bethlehem No. 1 TSF is located 4 km northeast of the operating mill. The facility was constructed in 1963 and operated from 1964 to 1989. The site has been reclaimed and is currently inactive. THVCP continues ongoing surveillance of the site including instrumentation monitoring, environmental sampling, visual inspections and maintenance activities. Under this level of site presence, Dam No. 1 and Bose Lake Dam are considered to be in the active care closure phase as defined by the Canadian Dam Association (CDA) Mining Dam Technical Bulletin (CDA 2014).

Bethlehem No.1 TSF structures are as follows:

- Dam No. 1 – comprises a glacial till starter dam which was raised by centerline method with rockfill placed to form a downstream shell and spigotted or cycloned tailings hydraulically placed on the upstream beach. A downstream rockfill buttress was later added in the valley section.
- R3 Seepage Pond Dam – located downstream from Dam No. 1, collects seepage from the Dam No. 1 underdrains (no details are available regarding construction of this dam).
- Bose Lake Dam – constructed of compacted glacial till with rockfill over the downstream slope for erosion protection, and a rockfill toe berm that includes a filter blanket and seepage collection system.
- There are two free water ponds contained within the impoundment, Bethlehem Pond No. 1 and Bethlehem Pond No. 2. The Bethlehem No. 1 TSF spillway, installed near the left abutment of Bose Lake Dam.

Dam No. 1 and Bose Lake Dam have been assigned a “Very High” and “High” consequence category, respectively, as defined by CDA (2013). R3 Seepage Pond was assigned a “Low” consequence category. There were no significant changes to the key geotechnical or hydrotechnical hazards during 2019.

The most recent dam safety review (DSR) was completed by SRK Consulting in 2018 and the report was submitted to THVCP in March 2019 (SRK 2019). The Code requires a DSR be undertaken every five years for tailings dams; therefore, the next DSR should be scheduled for 2023. SRK concluded the following (SRK 2019):

- the Bethlehem TSF is "reasonably safe"[1] with minor deficiencies and non-conformances, per CDA (2013) guidelines;
- the Bethlehem TSF is a well-managed facility with a high level of technical stewardship and appropriate operating procedures; and
- no changes to the consequence classification were recommended.

A workplan to address the recommendations (11) from the DSR report will be prepared by the end of April 2020.

The emergency preparedness and response plan (EPRP) was updated in 2016. The Operation, Maintenance and Surveillance (OMS) manual was reviewed and issued in December 2018 (THVCP 2018); emergency contacts and other minor items were updated during 2019. The OMS manual and EPRP meet the intent of the Mining Association of Canada (MAC) and CDA guidelines, are current and provide adequate coverage for existing conditions.

Routine visual inspections and instrument measurements were completed by THVCP at the OMS prescribed frequencies. There were no event-driven inspections in 2019 triggered by precipitation or earthquake events as defined in the OMS manual. 2019 instrumentation readings (e.g. piezometer, pond level, inclinometer) were consistent with recent history and do not indicate potential issues of concern.

Water quality downstream of the Bethlehem No.1 TSF during 2019 and compliance with requirements of Permit PE-376, and associated amendments is reported by THVCP in a separate report. KCB reviewed the 2019 data relevant to the facility which indicate water quality at all downstream sample sites was in compliance with permit limits.

Refer to Table 1 for status of outstanding recommendations from previous DSI reports. Recommendations that have been closed are shown in *italics*. Recommendations to address deficiencies and non-conformances identified during the 2019 DSI are summarized in Table 2.

[1] Based on APEGBC (2016) the dam is either "reasonably safe" (with or without non-conformances and / or deficiencies) or "not reasonably safe."

Table 1 Previous Deficiencies and Non-Conformance Recommendations – Status Update

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority(1)	Recommended Deadline (Status)
Bethlehem No.1Tailings Storage Facility					
BTSF-2017-01	Construction	Construction Summary	Provide a completed summary of the construction work for the Seepage Pond 1 decommissioning project to KCB.	4	Q1 2018 (Open)
Dam No. 1					
BTSF-2018-01	Flood Management	10.1.8 (the Code)	Update flood routing assessment for Bethlehem No.1 TSF and R3 Seepage Ponds based on the most recent site wide hydrology information for consistency and to confirm compliance.	3	Q2 2020 (Open)
BTSF-2018-02	*Surveillance*	*Piezometer monitoring*	*All piezometers in the Bethlehem No.1 TSF must be read in early 2019, when accessible. Prioritize reading of piezometers BP13A, BP13B, BP12A, BP12B, BP12C, BP9A, BP9B, BP9C, BP14A, BP14B, BP14C.*	*3*	*Q2 2019 (Closed)*
Bose Lake Dam					
No outstanding recommendations from previous DSIs.					
R3 Seepage Pond					
No outstanding recommendations from previous DSIs.					

Notes:
1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   - 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 2 2019 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority(1)	Recommended Deadline (Status)
Bethlehem No.1 Tailings Storage Facility					
BTSF-2019-01	DSR Recommendations	-	KCB and THVCP to develop a work plan to address 2018 DSR recommendations.	3	April, 2020
Dam No. 1 / Bose Lake Dam / R3 Seepage Pond					
No new recommendations in 2019.					

Notes:
1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   - 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.

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1 INTRODUCTION

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2019 dam safety inspection (DSI) of the Bethlehem No. 1 Tailings Storage Facility (TSF) on the Highland Valley Copper (HVC) mine site. The Bethlehem No. 1 TSF is an inactive facility constructed in 1963 and operated between 1964 and 1989. This DSI includes Bethlehem No.1 TSF retaining dams (Dam No. 1 and Bose Lake Dam) and R3 Seepage Pond for the review period between January 2019 to September 2019[2].

The Bethlehem No.1 TSF has been reclaimed. THVCP continues ongoing surveillance of the site including instrumentation monitoring, environmental sampling, visual inspections and maintenance activities. Under this level of site presence, the Bethlehem No.1 TSF is considered to be in the active care closure phase as defined by the Canadian Dam Association (CDA) Mining Dam Technical Bulletin (CDA 2014).

The DSI scope of work consisted of:

- a visual inspection of the physical conditions of the various containment facilities;
- a review of updated piezometer, inclinometer and seepage monitoring data provided by THVCP;
- a review of climate and water balance data for the site;
- a review of the Operations, Maintenance & Surveillance (OMS) manual and other relevant dam safety management documents (relevant to the DSI review period); and
- a review of any activities, other than routine, completed at the site during the DSI review period, where applicable.

The inspection and this report were prepared to comply with Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code) (MEM 2017), and Section 4.2 of the Code Guidance Document (MEM 2016).

The visual inspection was completed by the Engineer of Record (EoR), Mr. Rick Friedel, P.Eng. , Mr. Pablo Urrutia, P.Eng., and Ms. Narges Solgi, EIT, as representatives of KCB on June 12, 2019. During the inspection, the weather was sunny with cloudy periods and did not impact the inspection. Mr. Chris Anderson, P.Eng., THVCP Tailings and Water Manager, is the TSF Qualified Person (as defined by the Code) for the Bethlehem No. 1 TSF.

The Bethlehem Mine was operated under Permit M11 issued by the Ministry of Energy, Mines and Petroleum Resources (EMPR) in January 1970 and reclamation work was carried out under Permit

[2] During 2019, THVCP and KCB agreed to modify the review period for the annual DSI to October through September (was previously January to December). This change was made to allow adequate time to compile all DSIs undertaken at the HVC mine site and submit them to EMPR prior to the March 31st deadline. The change in review period shortens the review period of the 2019 DSI to 9 months as the period from October 2018 to December 2018 was captured under the 2018 DSI (KCB 2019a).

M55 issued on October 27, 1989. In July 1998, the mining permits for the Highmont Mine, the Lornex Mine, and the Bethlehem Mine were amalgamated under M11 Permit (EMPR 2019).

In addition, the Bethlehem No. 1 TSF is maintained under the following permits:

- British Columbia Ministry of Environment (MOE) Water Licences C114183 and C068389:
  - Conditional Water License 114183 authorizes the use of waters in Heustis, Jersey, and Iona (Pit) Lakes for fish cultural.
  - Conditional Water License C131299 grants the rights to water use from Trojan (Northlodge) Mann, Nicholson, Michael, Ford, and Oram Creeks for use in mining and land improvement.
- British Columbia MOE Effluent Permit PE-376 – this permit contains discharge conditions and locations of permitted discharge of surface water to the environment, including: Bethlehem area; Bose Lake Saddle Dam Seepage (active) which flows into Bose Lake; Trojan Creek at End of the Trojan Diversion (active), which flows into Witches Brook.

Dam No. 1 and Bose Lake Dam have been assigned a “Very High” and “High” consequence category, respectively, as defined by CDA (2014). The downstream R3 Seepage Pond have been assigned a “Low” consequence category as defined by CDA (2014).

The latest dam safety review (DSR) was completed by SRK Consulting in 2018 and the report was submitted in March 2019 (SRK 2019). The Code requires a DSR be undertaken every five years for tailings dams; therefore, the next DSR should be scheduled for 2023. The findings of the 2018 DSR (SRK 2019) and related recommendations are discussed further in Section 3.2.

2 FACILITY DESCRIPTION

The HVC site is located near Logan Lake, approximately 45 km south of Kamloops, in the interior of British Columbia. The Bethlehem No. 1 TSF is located 4 km northeast of the operating mill and immediately east of the Trojan TSF; refer to Figure 1 and Figure 2.

A layout of the main components of the facility are shown on Figures 3 to 5: Bethlehem Dam No. 1 (Dam No. 1); Bose Lake Dam; and R3 Seepage Pond. Dam No. 1 retains tailings on western boundary of the impoundment and Bose Lake Dam at its eastern boundary; refer to Figure 2. The R3 Seepage Pond is located downstream of Dam No. 1 approximately 200 m from the toe. Bose Lake is a natural lake approximately 60 m downstream of the Bose Lake Dam toe. There are two free water ponds in the Bethlehem No. 1 TSF that have formed in low points of the tailings surface and which are typically present year-round; Pond No. 1 located centrally in the TSF and Pond No. 2 located close to the Bose Lake Dam; refer to Figure 2.

Typical geometry and dimensions of the dams are summarized in Table 2.1. Refer to Appendix III for additional general information regarding the structures, including history, water management and select design drawings.

Bethlehem Dam No. 1

- Dam No. 1 comprises a glacial till starter dam (up to 20 m high), built in 1963. A low dyke of overburden (a few feet high) was first pushed out across the slough to displace soft peat.
- The dam foundation generally comprises competent glacial overburden up to 24 m thick overlying bedrock. Thin (~150 mm) layers of low to intermediate plasticity silt and clay are present but no distinctive laminated glaciolacustrine clay or silt have been identified.
- A rockfill toe buttress was added to the Dam No. 1 design to arrest slumping movements observed in the downstream rockfill slope. The buttress was designed (Golder 1970) to be built over on top of a layer of surficial soft material. During buttress construction, rockfill was placed over the material to provide a firm construction surface, during which the rockfill would have mixed with the soft material. Refer to Section 7.2 for further discussion regarding the influence of these deposits on stability.
- The dam was raised by centreline method with mine waste (i.e. rockfill) placed to form a downstream shell that supports an upstream beach of spigotted or cycloned tailings. The design relies on the wide tailings beach to provide separation between the tailings pond and dam rockfill. The design of the dam required the pond be kept a minimum of 122 m from the dam crest. A downstream rockfill buttress berm was later added in the valley section.
- Under existing conditions, at normal range of pond levels, the minimum beach width between Pond No. 1 and Dam No. 1 is more than 800 m and 30 m between Bose Lake Dam and Pond No. 2.

- Seepage from the underdrain system reported to two downstream seepage ponds: Seepage Pond 1; and R3 Seepage Pond. Seepage Pond 1 discharged all flow into R3 Pond. In 2016, the retaining structure at Seepage Pond 1 was breached and replaced with a weir.

Bose Lake Dam

- The dam is constructed of compacted glacial till with rockfill over a portion of the downstream slope for erosion protection, and a rockfill toe berm that includes a filter blanket and seepage collection system. Seepage from the rockfill drain is collected in concrete manholes connected by pipes which drain by gravity to a pump well at the low point along the downstream toe.
- The dam was built in four stages, the first of which was done in 1972. The final stage was completed in 1981 (KC 1994).
- In 1995, a permanent open channel spillway for the Bethlehem TSF was constructed at the left abutment of Bose Lake Dam. The channel extends to the public access road at the toe of the dam, where it is diverted through two culverts (1 x 1380 mm dia., 1 x 600 mm dia.) and discharges into Bose Lake.

R3 Seepage Pond

- The pond is located approximately 170 m downstream of the Dam No.1. A dam retains the R3 reservoir along the west side.
- A spillway channel is constructed at the right (north) abutment and discharges flow to Lower Trojan Dam downstream of the dam toe. Water is typically discharged to Lower Trojan Dam via a buried pipeline at the left abutment, but flows can also be diverted to the Highland Mill.

Table 2.1 Summary of Approximate Dam Geometry

Dam	Construction Method	Nominal Crest Elevation (m)	Maximum Dam Height (m)	Crest Length (m)	Minimum Crest Width (m)	Upstream Slope	Downstream Slope
TAILINGS DAMS							
Dam No. 1	Modified Centreline	1477 (top of sand fill) 1472 (top of rockfill)	91	2000	25	N/A	3H:1V (overall from crest of sandfill) 2.2H:1V (overall from crest of rockfill)
Bose Lake Dam	Saddle Dam Downstream	1475	31	600	9	2H:1V	2H:1V
SEEPAGE COLLECTION DAM							
R3 Seepage Pond	Unknown (believed single raise)	1371	2.6	60	6	N/A	2.3H:1V

Notes:
1. Dimensions are estimated from 2014 LiDAR data unless otherwise noted.
2. Height measured as the vertical distance between downstream toe and crest.

3 2019 ACTIVITIES

3.1 2019 Main Construction Activities

Other than routine maintenance activities, as defined in the OMS manual, (e.g., clearing weirs of vegetation), there were no major repairs or construction activities completed during 2019.

3.2 2018 Dam Safety Review

A DSR of the Bethlehem No.1 TSF and seepage collection ponds was completed by SRK Consulting (SRK) in 2018 with the final report issued in March 2019 (SRK 2019). SRK concluded the following (SRK 2019):

- The Bethlehem No.1 TSF is "reasonably safe"[3] with, in general, minor deficiencies and non-conformances, per CDA (2013) guidelines;
- The Bethlehem No.1 TSF is a well-managed facility with a high level of technical stewardship and appropriate operating procedures. The credible failure modes are understood and effectively controlled; and
- No changes to the consequence classification were recommended.

The DSR included eleven recommendations related to dam safety for the Bethlehem No.1 TSF and seepage ponds. All of the recommendation levels were assigned a Priority Level[4] of 3 or 4 which represent issues that should be resolved to meet compliance requirements or best practice but alone do not represent a dam safety concern.

THVCP and KCB have reviewed the DSR recommendations and a formal work plan with targeted timelines to address them is planned to be developed by the end of April 2019. Appendix VII includes a table of all DSR recommendations. KCB has grouped the DSR recommendations into general categories, as follows:

- (2) OMS Manual updates and/or improvements;
- (3) documentation of additional sensitivity stability analyses;
- (1) facility maintenance; and
- (5) updates to flood routing assessments and documenting minimum freeboard under "normal conditions" as per CDA (2013).

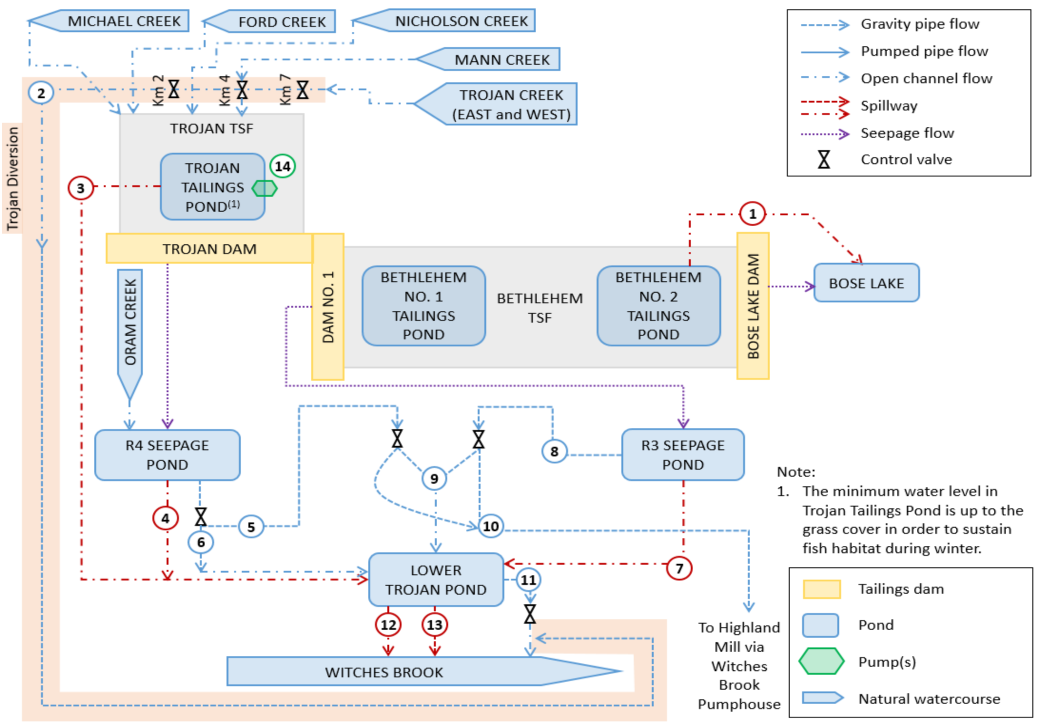
[3] Based on APEGBC (2016) the dam is either "reasonably safe" (with or without non-conformances and / or deficiencies) or "not reasonably safe."
[4] Refer to Table 8.1 for summary of Priority Levels.

4 WATER MANAGEMENT

4.1 Overview

The flow schematic for the Bethlehem No.1 TSF and nearby Trojan TSF is shown in Figure 4.1. Refer to Appendix III-A for additional information regarding water management related to the Bethlehem No.1 TSF.

Figure 4.1 Flow Schematic for Bethlehem No.1 and Trojan TSFs



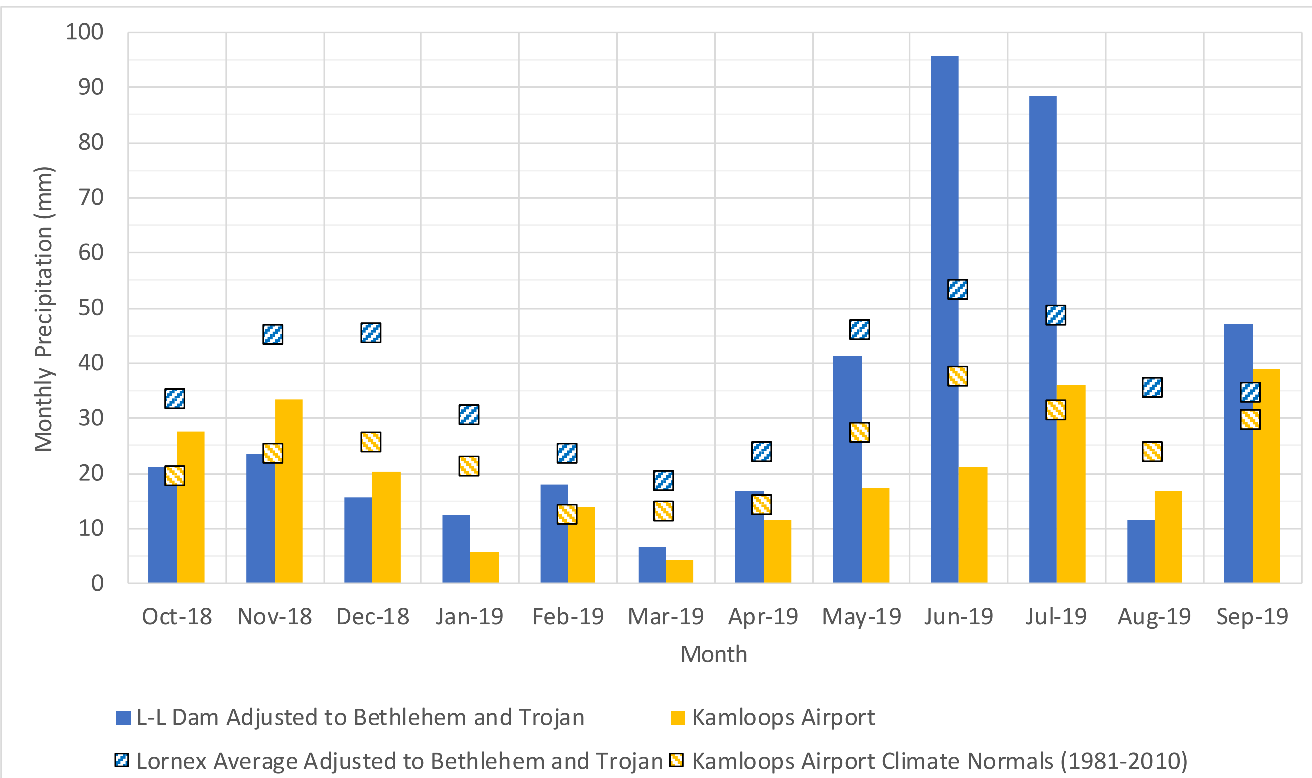
No.	Name	Description	Status
1	Bose Lake Spillway	3 m wide channel with concrete sill founded in tailings (3 m wide, vegetated) and natural ground (3 m, riprap-lined)	Operational
2	Trojan Diversion	6.5 km long series of channels, culverts, and pipelines	Operational
3	Trojan Spillway	1.3 km long open channel founded in tailings (5 m wide, vegetated), natural ground (3 m, riprap-lined) and bedrock (3 m).	Operational
4	R4 Spillway	2 m wide riprap-lined channel	Operational
5	R4 Low-Level Outlet	300 mm dia. HDPE pipe with U/S and D/S control valves and intake trash rack	Operational
6	R4 Overflow	100 mm dia. HDPE pipe with U/S control valve	Operational
7	R3 Spillway	2 m wide riprap-lined channel	Operational
8	R3 Low-Level Outlet	460 mm dia. HDPE pipeline with D/S control valve	Operational
9	Seepage to LTD	Buried pipeline	Operational
10	Northern Collection Line	Buried pipeline	Operational
11	LTD Low-Level Outlet	460 mm dia. HDPE pipe with control valve and intake trash rack	Operational
12	LTD Spillway	7 m wide channel	Operational
13	LTD Overflow	810 mm dia. HDPE pipe	Operational
14	Trojan Pump	Pump for Trojan Tailings Pond	Non-operational

4.2 Climate

THVCP provided climate data for the DSI reporting period to KCB for review. KCB applied the appropriate corrections, based on HVC site wide hydrology document (Golder 2016), and compared the climate data to typical values, refer to Appendix IV-A. The following observations were noted for the DSI reporting period (refer to Figure 4-2):

- January through April precipitation measured at Bethlehem No.1 TSF was significantly less than historic normals (based on Highland Valley Lornex adjusted to Bethlehem and Trojan Area) which, along with reduced snowpack, contributed to a less sever freshet than recent years.
- June and July 2019 were noticeably wetter than normal.
- Snowpack depths were not measured in January and February 2019. Snowpack was significantly shallower than average in April and May 2019.

Figure 4.2 Monthly Precipitation



4.3 Water Balance

THVCP manages and tracks the annual water balance for the Bethlehem No. 1 TSF. Table 4.1 is a summary of annual inflows and outflows, provided by THVCP. The water balance is based on simplified modelling results and therefore, the values should be treated as indicative only. Key assumptions regarding the water balance include:

- Assumed pond area of 97,676 m^2;
- Assumed surface area of 2,786,830 m^2;
- Modelled annual precipitation of 431 mm; and
- Runoff coefficient 0.45.

Table 4.1 Annual Water Balance for Bethlehem No.1 TSF

Item	Volume in 2019[1] (m^3)
Inflows	
Direct precipitation	42,100
Runoff	540,500
Total inflow:	582,600
Outflows	
Seepage	466,300
Evaporation[2]	52,700
Total outflow:	519,000
Balance	
Balance (inflow minus outflow)	63,600

Notes:
1. Values received from THVCP have been rounded to the closest 100 m^3.
2. Precipitation from the Shula Flats and L-L Dam weather station adjusted to the Bethlehem area was used in the water balance.
3. Evaporation assumed for Bethlehem No.1 TSF: 540 mm/year.

4.4 Flood Management

The flood management structures at Bethlehem No.1 TSF are designed for storm events with return periods greater than the minimum required by the code and thus exceeding IDF requirements, as summarized in Table 4.2. The site experienced no major storms and a less severe freshet in 2019 compared to previous years (see Section 4.2). The Bethlehem TSF flood management structures performed satisfactorily, with no discharge through their spillways, and maintained adequate freeboard throughout the year.

For consistency, the 2018 DSI (KCB 2019a) and 2018 DSR (SRK 2019) recommended that all flood routing assessments be updated based on the most appropriate current climate information.

Table 4.2 Inflow Design Flood for Bethlehem No. 1 TSF and Seepage Pond

Dam	Outfall Type	Consequence Classification	Inflow Design Flood	Spillway Design Flood (Precipitation Depth, Design Flow)		Spillway Design Reference
				Design Event	Peak Flood El.	
Dam No. 1	Open channel spillway (near Bose Lake Dam left abutment)	Very High	2/3 between 1000-year and PMF(1,3)	24-hour PMF (182.2 mm, 13.7 m^3/s)	1471.5 m	(AMEC 2014b)
Bose Lake Dam		High	1/3 between 1000-year and PMF(1,3)			
R3 Seepage Pond Dam	Open channel	Low	100-year(2)	100-year 24-hour(4) (54.3 mm, 0.16 m^3/s)	1371.2 m	(AMEC 2013a)

Notes:
1. Per the Code for tailings dams.
2. Per the Code for water dams.
3. The return period for the Bethlehem No. 1 TSF IDF is governed by the highest consequence dam (Dam No. 1).
4. Code requires for a "Low" consequence dam that the spillway be able to route an IDF equivalent to the 100-year event rather than the PMF. IDF values are presented in the table.

4.5 Freeboard

Minimum observed freeboard in 2019 for Dam No.1, Bose Lake Dam and R3 Seepage Pond exceeded Code requirements, indicating good ability to manage water within these facilities. Minimum required freeboard as per the Code, for each dam, are compared with the freeboard determined to be available during the IDF and summarized in Table 4.3. Where available, the minimum freeboard measured during 2019 based on monitoring records are also listed in Table 4.3. Key findings are as follows:

- HVC has adopted 0.5 m as the minimum freeboard for R3 Seepage Pond, which exceeds the minimum based on method proposed by the Code and CDA design requirements.
- Overtopping is not plausible at Dam No. 1 because the pond would overtop the Bose Lake Dam crest first.
- Bethlehem TSF spillway design flood assumes that the impoundment is filled to the invert of the spillway prior to the onset of the storm. This is consistent with standard approach but there is available storage in the impoundment below the spillway invert under normal operations, which provides additional flood attenuation and is not accounted for in the design.

Table 4.3 Freeboard for Bethlehem TSF and Seepage Pond

Dam	Freeboard (m) – Flood Conditions			Freeboard (m) – Normal Conditions	
	Minimum Required During IDF[1]	Minimum During IDF Based on Flood Routing[2]	2019 Minimum Freeboard (freshet/flood)	Minimum Required Under Normal Conditions	2019 Freeboard (non-freshet/non-flood)
Dam No. 1	0.5 m	5.5 m [3,4]	9.17 m[6]	Note 5	9.19 m to 9.32 m[6]
Bose Lake Dam	0.5 m	3.5 m [3]	6.19 m[9]	Note 5	6.29 m to 6.35 m[6]
R3 Seepage Pond Dam	0.5 m[7]	0.6 m [8]	1.5 m[9]	Note 5	1.5 m to 1.6 m[9]

Notes:
1. As per the Code.
2. Design Inflow Design Flood (IDF) is greater than the IDF required by the Code.
3. As per AMEC (2014b).
4. Overtopping is not plausible at Dam No. 1 because he pond would overtop the Bose Lake Dam crest first.
5. For due diligence, minimum required freeboard under normal (i.e. non-flood) conditions to be calculated as part of recommended flood routing works. Normal condition freeboard is typically greater than flood freeboard but will be less than typical non-flood freeboard at each facility.
6. Based on the 2019 pond elevation through September, and crest elevations of 1477 m and 1475 m at Dam No.1 and Bose Lake Dam respectively.
7. Minimum required freeboard to accommodate wave run-up as per CDA (2013) is 0.35 m for R3; however, minimum freeboard specified as 0.5 m to be consistent with other similar structures around the site.
8. As per KCB (2019c), freeboard during the spillway design flood, which is greater than the IDF, is 0.2 m.
9. Based on THVCP Inspection Reports.

5 REVIEW OF MONITORING RECORDS AND DOCUMENTS

5.1 Monitoring Plan

The Operation, Maintenance and Surveillance (OMS) manual, was reviewed and issued by THVCP in December 2018 (THVCP 2018). The activities undertaken for inspection and monitoring of the Bethlehem No.1 TSF are listed in Table 5.1.

Table 5.1 Monitoring Activities

TSF Monitoring	Facility	Minimum Frequency	Responsibility	OMS Compliance Met?	Documentation
Inspections					
Routine Visual Inspection[2]	Dam No.1 and Bose Lake Dam	Monthly	THVCP	Yes	THVCP Dam Safety Reports (Reviewed by KCB)
	R3 Seepage Pond	Quarterly	THVCP	Yes	THVCP Dam Safety Reports (Reviewed by KCB)
Event-Driven Inspection	All	Event Driven[1]	THVCP	none triggered in 2019	THVCP Dam Safety Reports (Reviewed by KCB)
Dam Safety Inspection (DSI)	All	Annually	KCB	Yes	Inspection Report by KCB
Instrumentation Monitoring					
Piezometers	Dam No.1 and Bose Lake Dam	Monthly[3]	THVCP	No[4]	Data reviewed by KCB as part of Annual DSI
Inclinometers	Dam No.1	Monthly[3]	THVCP	Yes	
Seepage flow instruments	R3 Seepage Pond	Monthly[3]	THVCP	Yes	THVCP Inspection Reports (Reviewed by KCB) Annual DSI
Surveys					
Dam Crest	Dam No.1 and Bose Lake Dam	Annually	THVCP	Yes	Data reviewed by KCB as part of Annual DSI
Survey monuments	Dam No.1 and Bose Lake Dam	Annually	THVCP	Yes	
Pond level	Dam No.1 and Bose Lake Dam	Twice per year	THVCP	Yes	

Notes:
1. THVCP staff are to complete an event-driven inspection in response to one of the following events:
   - Earthquake greater than magnitude 5, within 100 km of the site or any earthquake felt at site.
   - Rainfall event greater than the 10-year, 24-hour duration storm; 41 mm (Golder 2016).
2. Visual monitoring and inspection include pond level measurements and observations for any evidence of unusual condition and/or dam safety concerns (e.g. crest settlement, sinkholes, slope sloughing, erosion, seepage, piping, etc.)
3. From March to November (or when accessible).
4. Dam No. 1 impoundment piezometers were not read at prescribed frequency. This is not considered a dam safety concern and THVCP have taken steps to prevent reoccurrence, refer to Section 5.4 for further discussion.

THVCP summarizes routine inspections, or other activities at the Bethlehem No.1 TSF, in their weekly dam safety presentation which are reviewed by the THVCP site team and provided to the KCB EoR, or designate for review.

The 2018 OMS manual meets the intent of the Mining Association of Canada (MAC 2011) and CDA (2014) guidelines and provides adequate coverage for existing conditions. The OMS manual is currently being revised by THVCP. Minor updates (contacts, EPRP, etc.) were completed in 2019 and a more extensive update to reflect requirements outlined in the recent updated guidance documented by MAC (2019) is planned for 2020.

5.2 Inspections

In addition to the routine and dam safety inspections referenced in Table 5.1, the Tailings Review Board toured the Bethlehem No.1 TSF, with KCB and THVCP, during the meeting hosted at site in August 2019. This activity is not specifically listed as a requirement of the OMS Manual but is done (typically annually) for the benefit of the Review Board members.

5.3 Pond Level

The Pond No. 1 and Pond No. 2 levels were measured more frequent than prescribed in the 2018 OMS manual. The pond levels are also visually checked during routine inspections but not recorded. Pond No. 1 and Pond No. 2 level observations during 2019 are as follows:

- Pond No.1: Pond level varied seasonally consistent with historic observations which shows no long-term trend of increasing pond volume. During first quarter of 2019, the pond levels were the lowest recorded between 2012 and 2019. However due to the above average precipitation in June and July, pond level rose up to 2018 levels in the second half of the year.
- Pond No.2: Similar to Pond No. 1, pond levels have shown seasonal variation. 2019 pond levels were below 2018 for the first half of the year but rose above 2018 levels following the high precipitation months, June and July. In the later part of 2019, pond levels were similar to 2013 and within the expected operating range.

Figure 5.1 Pond No.1 Water Elevations – 2012 to 2019

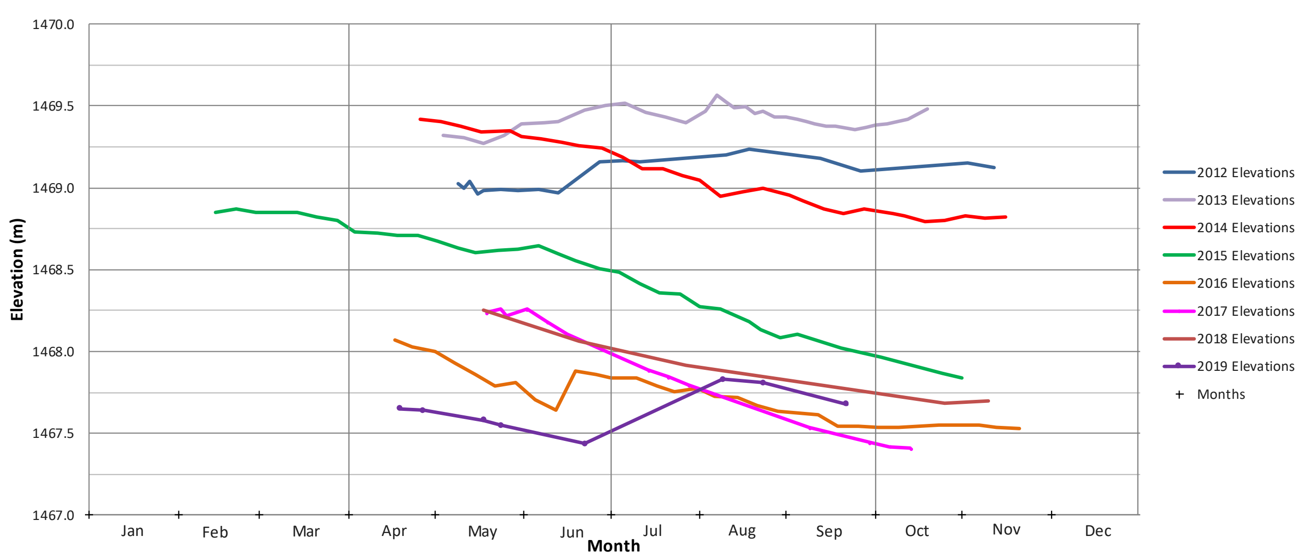
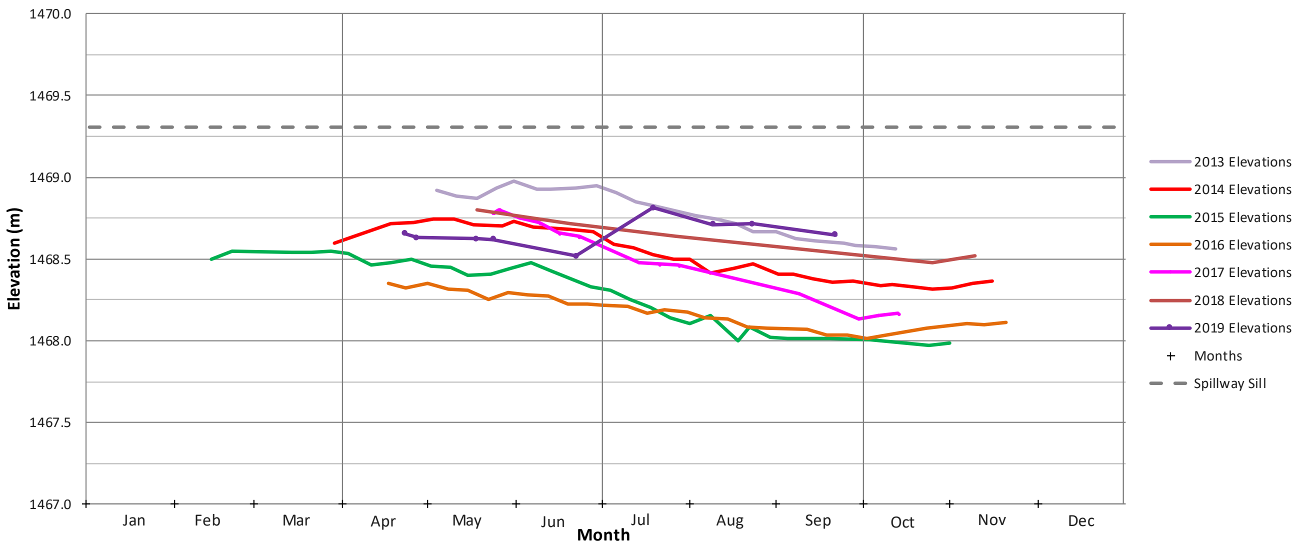


Figure 5.2 Pond No.2 Water Elevations – 2013 to 2019



5.4 Piezometers

Dam No. 1

As of end of September 2019 there are 34 piezometers being monitored at Dam No. 1 (Figure 3). Maximum and minimum piezometric levels, since 2013, instrument thresholds, as well as piezometric trends are reported in Appendix IV-B. Piezometer readings collected since 2013 from instruments which are no longer functional are also shown on the summary plots included in Appendix IV-B.

Piezometric readings at Dam No. 1 are plotted, with Pond No. 1 level, on Figure IV-B-1 to Figure IV-B-3. A summary of key observations are as follows, refer to Appendix IV-B for further discussion:

- Upstream Tailings Beach and Foundation Piezometers: except at BP14A and 14B, water elevations remained static which is consistent with previous readings:
  - Piezometric levels at BP14A and 14B rose ~0.2 m above threshold value in 2019. The threshold value was not based on a dam performance requirement or compliance criteria. The threshold is used to notify a change from recent behaviour and is set based on a previous peak reading. Revised threshold values have been set for 2020 based on the 2019 peak.
- Dam No.1 Crest Area Piezometers: P13-5 has measured a piezometric level ~El. 1410 m in the cycloned sand tailings upstream of the dam since installation. The tip of the other piezometers installed in the area are well above this elevation (~El. 1440 m to 1460 m) and are measured as dry or plugged.
- Dam No.1 Downstream Slope Area Piezometers: levels are consistent with previous years and continue to indicate a downward gradient towards the foundation.

- Piezometers along the dam crest noted as either dry or plugged were also checked monthly as summarized in Appendix IV-B.

Piezometers within the tailings beach upstream of the dam (Figure IV-B-1) were not read in 2017 and 2018. The 2018 DSI recommended (BTSF-2018-02) that readings for these piezometers be taken as soon as they were accessible in 2019. No readings were collected within the DSI review period, but THVCP collected one reading in December 2019 which have been reported in this DSI. The fact that these instruments were not read at the prescribed frequency is not a concern for the safety of the dam as monitoring is specified to identify change to established trends and not tied to a specific performance requirement. However, this does represent a non-compliance with the OMS Manual, which THVCP have taken steps to address by improving tracking of Bethlehem piezometer readings. In addition, THVCP plan to collect four readings for these piezometers in 2020.

Based on the review of the available instrumentation data, the current suite of instruments is considered sufficient for the Dam No. 1.

Bose Lake Dam

There are 11 operational piezometers at or near Bose Lake (Figure 3). Maximum and minimum piezometric levels, instruments thresholds, as well as a summary of piezometric trends are provided in Appendix IV-B.

Piezometric readings at Bose Lake Dam are plotted, with Pond No. 2 level, on Figure IV-B-7 to Figure IV-B-9. A summary of Key observations are as follows, refer to Appendix IV-B for further discussion:

- There were no piezometric threshold exceedances in 2019.
- Bose Lake Crest Area Piezometers: includes three nested instruments installed in the dam fill and foundation. General rise in piezometric level (<1 m), since 2017, is consistent with Pond No.2 level rise during that period. Instruments continue to suggest an upward gradient from the foundation (bedrock) into the dam fill.
- Bose Lake Toe Area Piezometers: levels are consistent with recent years.

Similar to Dam No. 1, the piezometers installed in the tailings beach upstream of Bose Lake Dam have not been read since 2017. The discussion related to Dam No. 1 is applicable to Bose Lake Dam piezometers.

Based on the review of the available instrumentation data, the current suite of instruments is considered sufficient for the Bose Lake Dam.

5.5 Survey Monuments

Survey monuments at Dam No. 1 and Bose Lake Dam are shown on Figure 3 and Figure 4, respectively. Monuments were surveyed in October 2019, except for the elevations of Dam No.1 monuments which were surveyed in July 2019. July 2019 elevations were compared with July 2018 elevations and used to calculate the annual settlement.

Monument surveys, horizontal displacement and settlement (vertical displacement) are plotted on Figure IV-B-4 and Figure IV-B-10. Observations based on 2019 survey are consistent with recent trends:

- There were no horizontal or vertical displacement threshold exceedances.
- The surveys indicate that downstream movements and crest settlement are negligible, which is consistent with previous years; refer to Appendix IV-B for more details.

5.6 Inclinometers

There are no significant movements and no discrete zones of movement observed in the downstream direction to date, including through the soft deposits (El. 1300 m to 1360 m) that are present in the foundation in the base of the natural valley (Section 2). This is consistent with measurements since installation. Cumulative displacements are plotted on Figure IV-B-5. Refer to Appendix IV-B for more details.

5.7 Seepage

Seepage flow measured/estimated at the weir TB-R3-FS-01 (located upstream of R3 Seepage Pond across access road at outlet of decommissioned Seepage Pond 1) was consistent throughout 2019 and similar to previous years. Refer to Appendix IV-B for more details.

5.8 Water Quality

As required by permit (PE-376), water quality downstream of the Bethlehem TSF is monitored by THVCP. A summary of data to be included in the 2019 Annual Water Quality Monitoring Report was provided to KCB by THVCP for review as part of the DSI. Select observations and findings from the monitoring data are summarized as follows:

- There are thirteen permitted surface water quality monitoring sites in the Trojan/Bethlehem area, as shown on the site monitoring plan in Appendix V.
- All sampling sites were in compliance with the permit levels, required sampling frequencies and parameters except for:
  - Sample Site #304 (End of Trojan Diversion) exceeded the permit limit for copper concentration in April, May, and July. This sample site is upstream of the Trojan TSF and therefore the exceedance is not related to facility performance.

- Sample Site #220 (Bethlehem Reclaim Pond 3) missing measurements of organic carbon (TOC) and dissolved organic carbon (DOC) in March and April.

The 2019 monitoring results were screened against applicable BC Water Quality Guidelines (WQG). Further discussion on specific WQG exceedances and water quality trends observed during 2019 are separately reported in the 2019 Annual Water Quality Monitoring Report which is submitted by THVCP to Ministry of Environment and EMPR.

6 VISUAL OBSERVATIONS AND PHOTOGRAPHS

The visual observations made during the DSI site visit and the photographs of each site are included in Appendix II. Copies of the completed field inspection forms are included in Appendix I.

No issue in terms of dam safety was observed. A summary of general observations and comments during the 2019 DSI site visit is as follows:

- R3 Seepage Pond spillway inlet is obstructed by heavy vegetation and a lock block. Obstructions should be cleared as part of THVCP routine monitoring and maintenance. THVCP noted the lock-block may be there as vehicle barrier. If so, an alternate barrier type which does not obstruct flow is required.
- R3 Seepage Pond outlet pipe trash rack was partially obstructed from vegetation; this should be cleared as part of THVCP routine monitoring and maintenance. The upstream debris fence was also obstructed which may be cleared or replaced as part of routine maintenance but not required for dam safety.
- Bose Dam spillway inlet, approach channel and initial segment of riprap channel are covered with vegetation and should be cleared as part of routine maintenance.

7 ASSESSMENT OF DAM SAFETY

7.1 Dam Classification Review

Based on the 2013 DSR (AMEC 2014a) a "Very High" consequence classification, as defined by CDA (2013), was recommended for Dam No. 1 and a "High" consequence classification was recommended for Bose Lake Dam. The R3 Seepage Pond was assigned a "Low" consequence classification as defined by CDA (2013). The consequence classifications were reviewed by KCB and THVCP, most recently, during the annual dam consequence review on January 23, 2019. The 2018 DSR (SRK 2019) concurred with current classifications and no change was recommended.

7.2 Failure Mode Review

KCB reviewed the potential failure modes identified in the Canadian Dam Safety Guidelines (CDA 2013) for Bethlehem No.1 TSF and the results are summarized in Appendix VI. An overview of the pertinent failure modes are summarized as follows:

Dam No. 1

- Slope Stability:
  - There is limited information to define the in-situ state and extent of the soft material beneath the rockfill toe buttress and portions of the dam (Section 2). It is not practical to resolve this uncertainty using conventional investigation techniques (e.g. drilling, test pits, geophysics). Inclinometer readings to date (Section 5.6) do not indicate any ongoing shear within the soft foundation unit at that location.
  - KCB reviewed the potential influence of this unit on stability assuming a reasonable worst case where the material is: continuous beneath the rockfill toe buttress; saturated; shears in an undrained manner; and susceptible to shear strength loss under the design earthquake load. Even with these reasonable worst case assumptions KCB (2019b) found that:
    - The existing condition of the dam meets design FOS criteria for global slip surfaces which would result in an uncontrolled release of tailings under static ($\geq$ 1.5) and post-earthquake ($\geq$ 1.2) loading.
    - There is a potential hazard to mine roads and downstream infrastructure (e.g. seepage ponds) related to a failure of the rockfill toe buttress if the soft layer were to fully liquefy under an extreme earthquake load and the shear strengths are as low as typical values for liquefied sands and silts, which is conservative. Such a failure of the toe buttress would not result in a flow failure and/or uncontrolled release of the contained materials. A large portion of the buttress would most likely slump to a shallower slope but would essentially remain in place. During 2020, THVCP plan to review risk of this scenario and include it in the site risk register.

Bose Lake Dam

- Overtopping: the open channel spillway is designed to safely pass a flood (PMF, 24-hour duration) significantly greater than the minimum IDF recommended under the Code (1/3 between 1000-year and PMF) and is an effective control to manage overtopping risks.

R3 Seepage Pond Dam

- Slope Stability: Stability analysis completed by KCB to support the 2016 DSI (KCB 2017b) indicates that the FOS under static loading, for overall slope failures through the dam fill or foundation, is greater than 1.5.

7.3 Emergency Preparedness and Response

The emergency preparedness and response plan (EPRP) for the Bethlehem No.1 TSF forms a part of the 2018 OMS manual.

Training of THVCP staff and contractors who work near the dams is provided by a PowerPoint presentation which outlines dam safety warning signs that all staff should be aware of and report if these signs are observed during their work.

In the case of an emergency, an incident command center would be established on site to coordinate with regional emergency response organizations and local authorities. The roles and responsibilities of key team members are well defined, along with reporting structures and who is responsible for declaring an emergency and starting the incident response. External emergency response groups have been provided a copy of the EPRP prepared specifically for them by THVCP. The EPRP also outlines strategies that could be implemented in the event of several types of dam emergencies. Additional systems are also being considered to further enhance the overall system.

Training and testing of the EPRP currently is done using desktop scenarios. Along with testing of the system, offsite emergency response resources are contacted regularly to ensure that contact information is still up to date. The emergency reporting contact list is also reviewed and updated as required. A tabletop exercise to review and update the EPRP for the HVC site was hosted by THVCP and attended by representatives of Communities of Interest (COIs) and KCB on site, and the EoR on the phone on November 26, 2019.

8 SUMMARY

The Bethlehem No. 1 TSF appears in good physical condition and the observed performance during the 2019 site inspections is consistent with the expected design conditions and past performance. The status of recommendations to address deficiencies and non-conformances identified during past DSIs are summarized in Table 8.1. Closed recommended actions are shown in *italics*. Recommendations to address deficiencies and non-conformances identified during the 2019 DSI are summarized in Table 8.2

Table 8.1 Previous Deficiencies and Non-Conformance Recommendations – Status Update

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[(1)]	Recommended Deadline (Status)
Bethlehem No.1Tailings Storage Facility					
BTSF-2017-01	Construction	Construction Summary	Provide a completed summary of the construction work for the Seepage Pond 1 decommissioning project to KCB.	4	Q1 2018 (Open)
Dam No. 1					
BTSF-2018-01	Flood Management	10.1.8 (the Code)	Update flood routing assessment for Bethlehem No.1 TSF and R3 Seepage Ponds based on the most recent site wide hydrology information for consistency and to confirm compliance.	3	Q2 2020 (Open)
BTSF-2018-02	*Surveillance*	*Piezometer monitoring*	*All piezometers in the Bethlehem No.1 TSF must be read in early 2019, when accessible. Prioritize reading of piezometers BP13A, BP13B, BP12A, BP12B, BP12C, BP9A, BP9B, BP9C, BP14A, BP14B, BP14C.*	*3*	*Q2 2019 (Closed)*
Bose Lake Dam					
No outstanding recommendations from previous DSIs.					
R3 Seepage Pond					
No outstanding recommendations from previous DSIs.					

Notes:
1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   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 8.2 2019 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
Bethlehem No.1 Tailings Storage Facility					
BTSF-2019-01	DSR Recommendations	-	KCB and THVCP to develop a work plan to address 2018 DSR recommendations.	3	April, 2020
Dam No. 1 / Bose Lake Dam / R3 Seepage Pond					
No new recommendations in 2019.					

Notes:
1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   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.

9 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Teck Highland Valley Copper Partnership (Client) for the specific application to the 2019 Dam Safety Inspection Project, and it may not be relied upon by any other party without KCB's written consent.

KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
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.
4. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.
5. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

KLOHN CRIPPEN BERGER LTD.

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ENGINEER
2020/04/03

Rick Friedel, P.Eng.
Engineer of Record, Designated Representative
Senior Geotechnical Engineer, Principal

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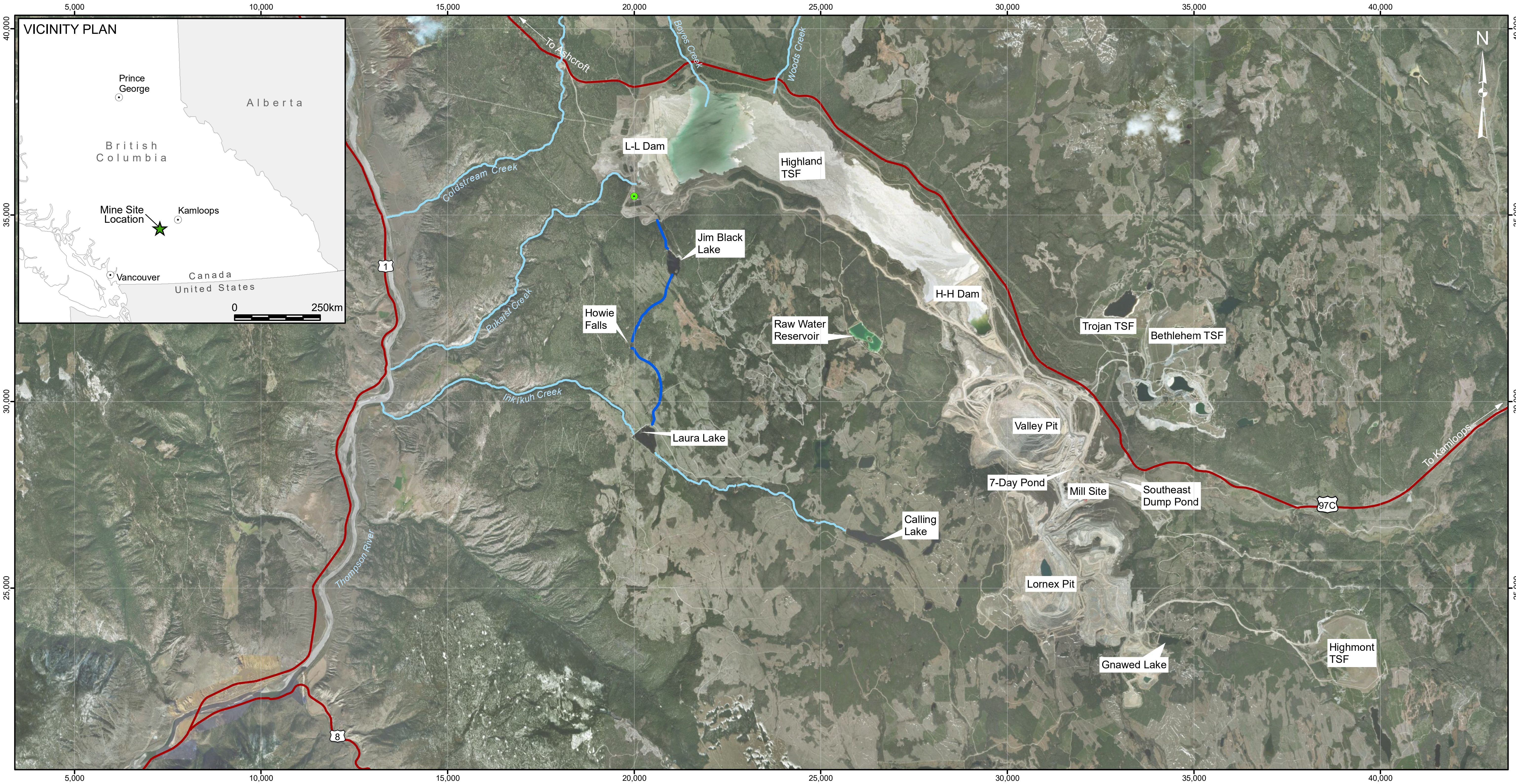
FIGURES



Legend

- L-L Dam Climate Station
- Creek / River
- Highway
- Ditch

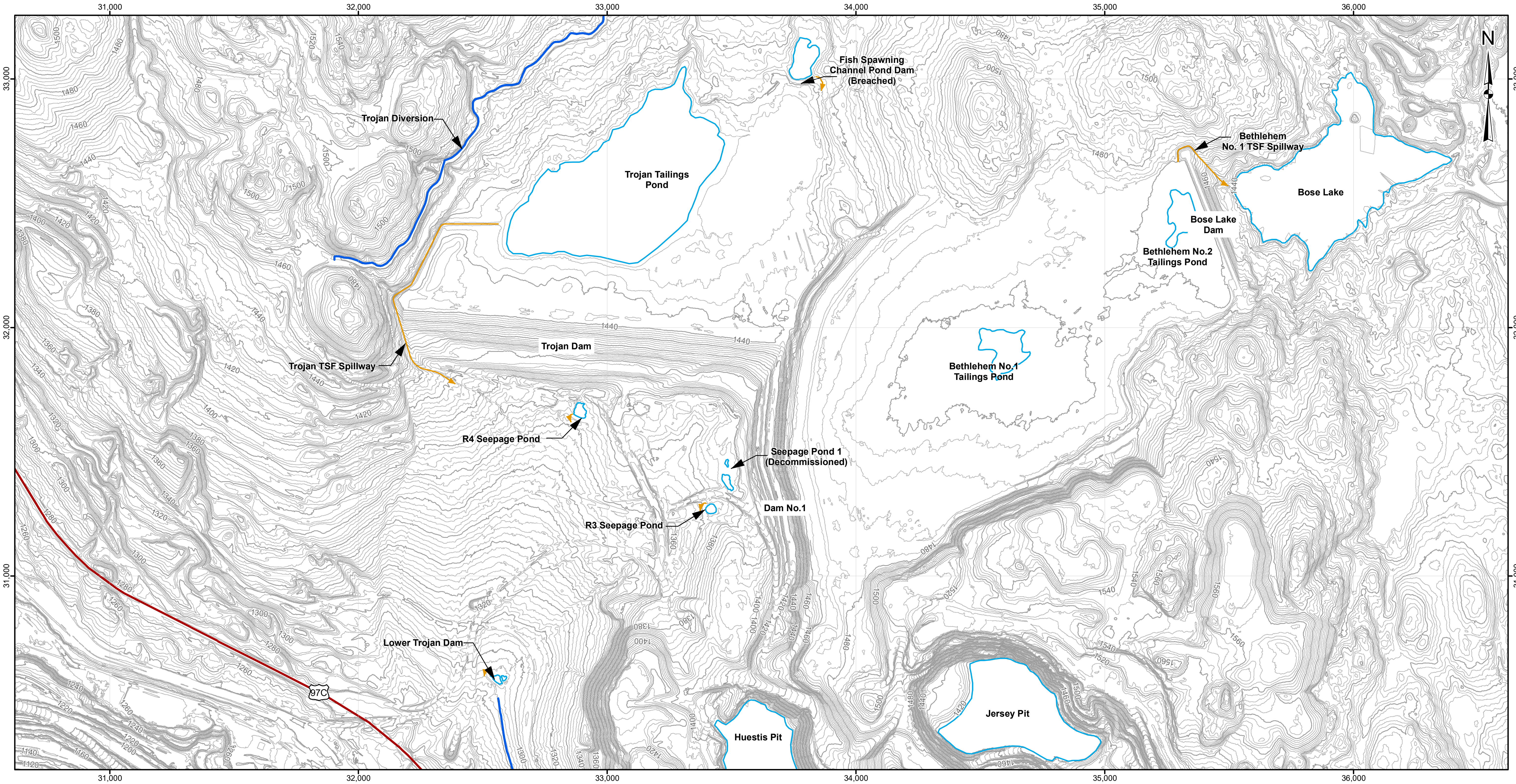
0 5km

Notes:
1. Projection: HVC Mine Grid.
2. TSF = Tailings Storage Facility.
3. Base data provided by the Government.
4. Imagery provided by ESRI.

Date: 2020-01-20
Document Path: Z:\MIV\CRIM02341B53 - HVC-2019 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Bethlehem\Fig1_Bethlehem_MineSitePlan.mxd

CLIENT	PROJECT
Highland Valley Copper / Teck	BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: MINE SITE PLAN

SCALE	PROJECT No.	FIG No.
1:100,000	M02341B53	1



Legend

- Spillway
- Highway (97C)
- Ditch
- Index Contour (10 m)
- Intermediate Contour (2 m)
- Waterbody

CLIENT	PROJECT
Highland Valley Copper / Teck	BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: BETHLEHEM OVERVIEW
	SCALE 1:15,000 — PROJECT No. M02341B53 — FIG No. 2

Notes:
1. Projection: HVC Mine Grid.
2. TSF = Tailings Storage Facility.
3. Topography from HVC, LiDAR flown on August 23rd, 2014.
4. Tailings and seepage pond extents based on imagery from September, 2016.

Date: 2020-01-20
Document Path: Z:\M\VCR\M02341B53 - HVC-2019 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Bethlehem\Fig2_Bethlehem_Overview.mxd

Legend

Instrument Type (Active)

- Standpipe Piezometer
- Vibrating Wire Piezometer
- Inclinometer
- Weir
- Survey Monument

Waypoint (BTH-2019-xx)

Instrument Type (Defunct)

- Standpipe Piezometer

Index Contour (25 m)

Intermediate Contour (5 m)

0 250m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained September, 2019
3. Topography from HVC, LiDAR flown on August 23rd, 2014.

Date: 2020-01-20
Document Path: Z:\MVCR\M02341B53 - HVC-2019 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Bethlehem\Fig3_Bethlehem_DamNo1_Plan.mxd

CLIENT: Highland Valley Copper / Teck	PROJECT: BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: DAM No.1 & SEEPAGE POND 1 PLAN
	SCALE 1:12,000 · PROJECT No. M02341B53 · FIG No. 3

Legend

Instrument Type (Active)
- Standpipe Piezometer
- Vibrating Wire Piezometer
- Survey Monument
- Waypoint (BTH-2019-xx)
- Culvert
- Spillway
- Index Contour (25 m)
- Intermediate Contour (5 m)

0 125m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained September, 2019
3. Topography from HVC, LiDAR flown on August 23rd, 2014.

Date: 2020-01-20
Document Path: Z:\MIV\CRM02341B53 - HVC-2019 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Bethlehem\Fig4_Bethlehem_BoseLakeDam_Plan.mxd

CLIENT
Highland Valley Copper
Teck

Klohn Crippen Berger

PROJECT
BETHLEHEM No. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE
BOSE LAKE DAM
PLAN

SCALE	PROJECT No.	FIG No.
1:3,500	M02341B53	4

Legend

Instrument Type (Active)
- Standpipe Piezometer
- Weir

Instrument Type (Defunct)
- Standpipe Piezometer

- Waypoint (BTH-2019-xx)
- Spillway
- Buried Pipeline
- Index Contour (5 m)
- Intermediate Contour (1 m)

0 25m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained September, 2019
3. Topography from HVC, LiDAR flown on August 23rd, 2014.
4. Location of buried pipes are approximate.

Date: 2020-01-20
Document Path: Z:\MIVCR\M02341B53 - HVC-2019 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Bethlehem\Fig5_Bethlehem_R3Seepage_Plan.mxd

CLIENT
Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT
BETHLEHEM No. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE
R3 SEEPAGE POND DAM
PLAN

SCALE	PROJECT No.	FIG No.
1:750	M02341B53	5

APPENDIX I

Dam Safety Inspection Checklist

APPENDIX I-A

Dam Safety Inspection Checklist – Dam No. 1

2019 ANNUAL DAM INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Bethlehem Dam No.1	**Inspection Date:**	June 12th, 2019
Consequence Classification:	Very High		
Weather:	Sunny	**Inspector(s):**	Rick Friedel, P.Eng. Pablo Urrutia, P.Eng. Narges Solgi, EIT
Freeboard (pond level to dam crest):	8.45 m based on the May 23rd pond survey.		

Are the following components of the facility in ***SATISFACTORY CONDITION***? (check one if applicable)

EMBANKMENT	Yes/No
U/S Slope	☒ Yes ☐ No
Crest	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No
Drains	☒ Yes ☐ No

Were any of the following ***POTENTIAL PROBLEM INDICATORS*** found?

INDICATOR	EMBANKMENT
Piping	☐ Yes ☒ No
Sinkholes	☒ Yes ☐ No
Seepage	☐ Yes ☒ No
External Erosion	☐ Yes ☒ No
Cracks	☒ Yes ☐ No
Settlement	☐ Yes ☒ No
Sloughing/Slides	☐ Yes ☒ No
Animal Activity	☐ Yes ☒ No
Excessive Growth	☐ Yes ☒ No
Excessive Debris	☐ Yes ☒ No

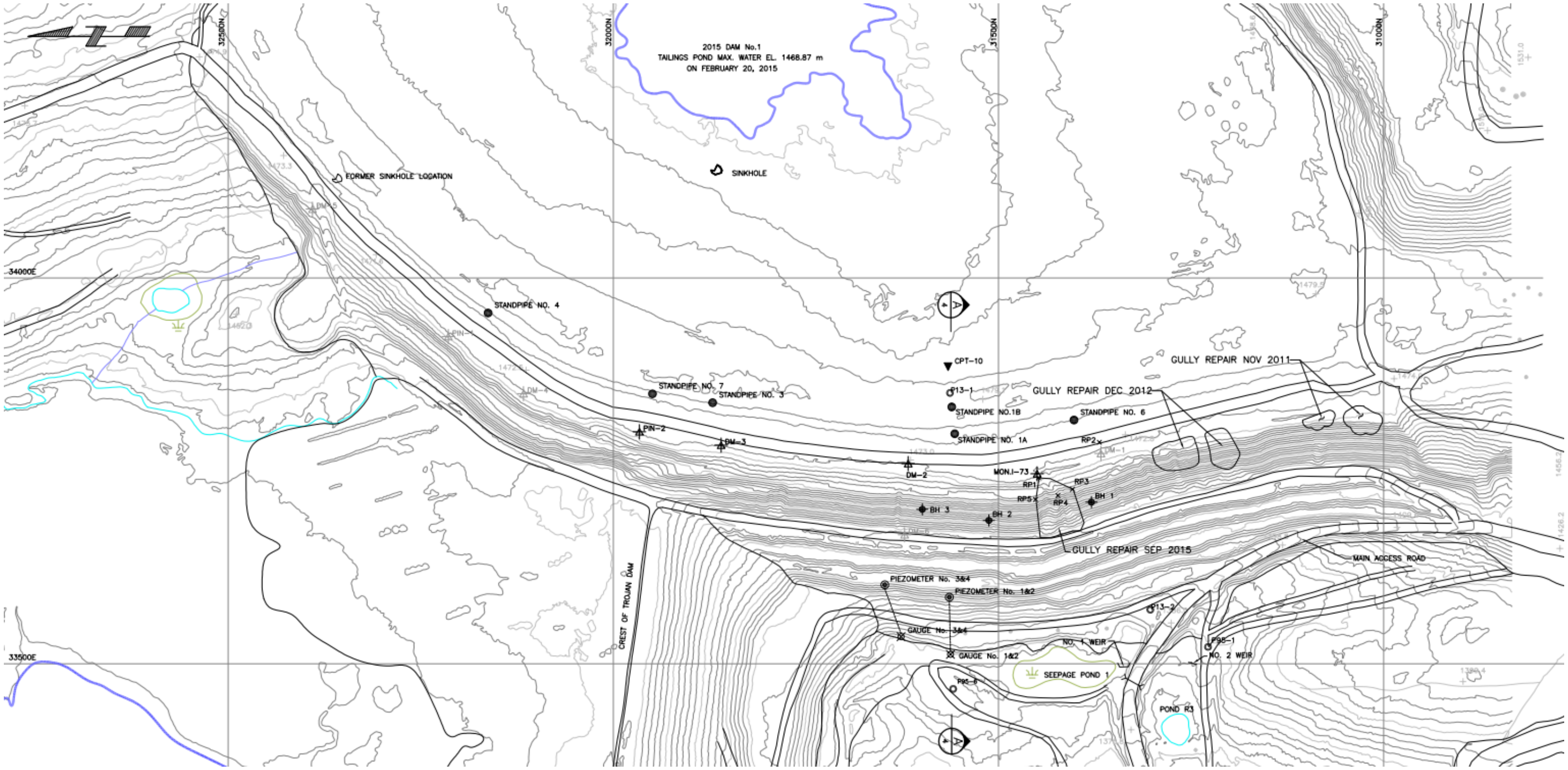
List and describe any deficiencies (all deficiencies require assessment and/or repair):

- No dam safety deficiencies observed

Comments / Notes:

- No significant visual change to sinkhole based on 2019 inspection and photos from recent DSIs. Feature is setback from the crest and present for an extended period. No indicators that is an issue of concern under existing condition but warrant ongoing visual observations.
- Cracking present along rockfill/downstream slope of Dam No.1. Known features; no significant change from previous DSIs; related to stability of shallow sloughing in rockfill and not overall structure.

SITE PLAN



2015 DAM No.1
TAILINGS POND MAX. WATER EL. 1468.87 m
ON FEBRUARY 20, 2015
FORMER SINKHOLE LOCATION
SINKHOLE
STANDPIPE NO. 4
STANDPIPE NO. 7
STANDPIPE NO. 3
STANDPIPE NO.1B
STANDPIPE NO. 1A
STANDPIPE NO. 6
CPT-10
GULLY REPAIR NOV 2011
GULLY REPAIR DEC 2012
GULLY REPAIR SEP 2015
CREST OF TROJAN DAM
PIEZOMETER No. 3&4
PIEZOMETER No. 1&2
GAUGE No. 3&4
GAUGE No. 1&2
NO. 1 WEIR
NO. 2 WEIR
SEEPAGE POND 1
POND R3
MAIN ACCESS ROAD
34000E
33500E

APPENDIX I-B

Dam Safety Inspection Checklist – Bose Lake Dam

2019 ANNUAL DAM INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Bose Lake Dam	Inspection Date:	June 12th, 2019
Consequence Classification:	Very High		
Weather:	Partly cloudy	Inspector(s):	Rick Friedel, P.Eng. Pablo Urrutia, P.Eng. Narges Solgi, EIT
Freeboard (pond level to dam crest):	6.53 m based on the May 23rd pond survey.		

Outlet Condition Survey

Description	Outlet Controls?	Was it flowing?	Flow rate
Spillway Channel	N/A	☐ Yes ☒ No	N/a

Are the following components of the facility in ***SATISFACTORY CONDITION***? (check one if applicable)

EMBANKMENT	Yes/No	SPILLWAY	Yes/No
U/S Slope	☒ Yes ☐ No	Debris Boom	☒ Yes ☐ No
Crest	☒ Yes ☐ No	Entrance	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No	Sill	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No	Road Culvert	☒ Yes ☐ No
Drains	☒ Yes ☐ No	Channel Invert	☒ Yes ☐ No
		Channel Slopes	☒ Yes ☐ No

Were any of the following ***POTENTIAL PROBLEM INDICATORS*** found?

INDICATOR	EMBANKMENT	SPILLWAY
Piping	☐ Yes ☒ No	☐ Yes ☒ No
Sinkholes	☐ Yes ☒ No	☐ Yes ☒ No
Seepage	☐ Yes ☒ No	☐ Yes ☒ No
External Erosion	☐ Yes ☒ No	☐ Yes ☒ No
Cracks	☐ Yes ☒ No	☐ Yes ☒ No
Settlement	☐ Yes ☒ No	☐ Yes ☒ No
Sloughing/Slides	☐ Yes ☒ No	☐ Yes ☒ No
Animal Activity	☐ Yes ☒ No	☐ Yes ☒ No
Excessive Growth	☐ Yes ☒ No	☐ Yes ☒ No
Excessive Debris	☐ Yes ☒ No	☐ Yes ☒ No

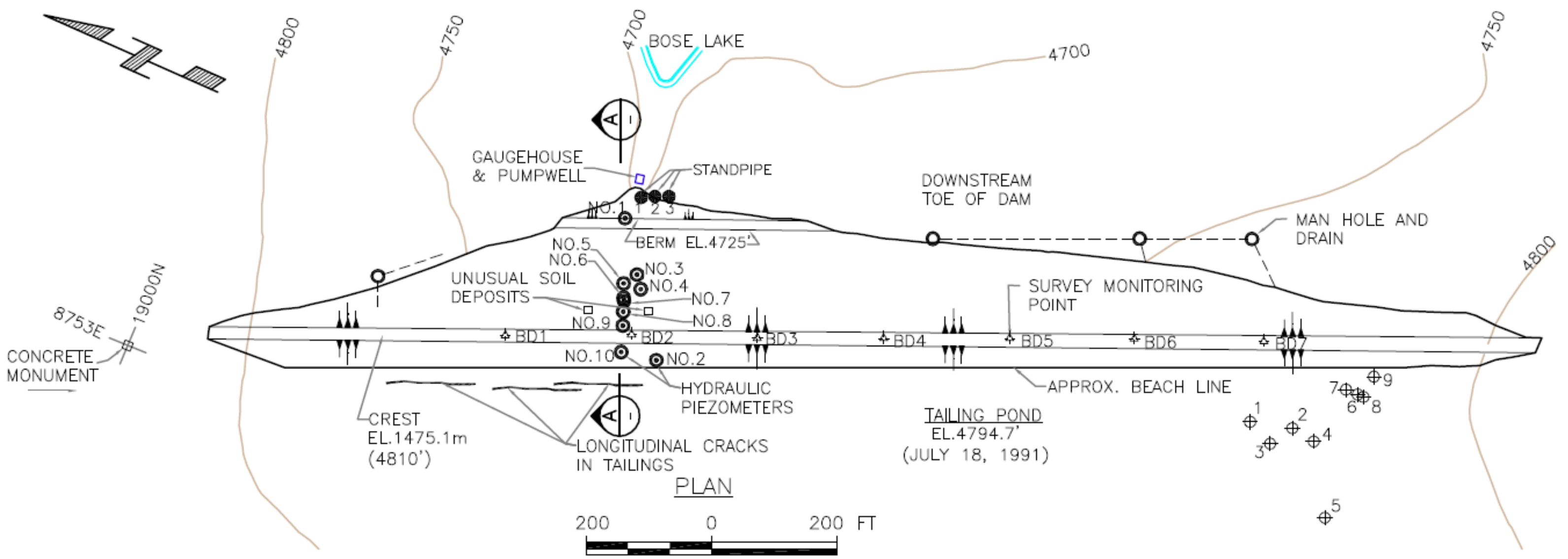
List and describe any deficiencies (all deficiencies require assessment and/or repair):

- No dam safety deficiencies observed

Comments/ Notes:

- Similar to the observation during the 2018 inspection, vegetation growth was observed at the upstream portion of the riprap lined channel section near the concrete sill. Vegetation should be monitored and removed as part of the routine maintenance.
- Bose Lake Dam sign by the road was knocked down.

SITE PLAN



4800
4750
4700
BOSE LAKE
4700
4750
GAUGEHOUSE
& PUMPWELL
STANDPIPE
DOWNSTREAM
TOE OF DAM
MAN HOLE AND
DRAIN
4800
NO.1
BERM EL.4725'
NO.5
NO.6
NO.3
NO.4
UNUSUAL SOIL
DEPOSITS
NO.7
NO.8
NO.9
SURVEY MONITORING
POINT
8753E
19000N
CONCRETE
MONUMENT
BD1
BD2
BD3
BD4
BD5
BD6
BD7
NO.10
NO.2
HYDRAULIC
PIEZOMETERS
APPROX. BEACH LINE
CREST
EL.1475.1m
(4810')
LONGITUDINAL CRACKS
IN TAILINGS
TAILING POND
EL.4794.7'
(JULY 18, 1991)
PLAN
200
0
200 FT

APPENDIX I-C

Dam Safety Inspection Checklist – R3 Seepage Pond Dam

2019 ANNUAL DAM INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	R3 Seepage Reclaim Pond Dam	**Inspection Date:**	June 12th, 2019
Weather:	Mostly Sunny	**Inspector(s):**	Rick Friedel, P.Eng. Pablo Urrutia, P.Eng. Narges Solgi, EIT
Freeboard (pond level to dam crest):	1.5 m on April 12, 2019 (as per THVCP Weekly Inspection Report of Week 15, ending April 16, 2019)		

Outlet Condition Survey

Description	Outlet Controls?	Was it Flowing?	Flow rate	Visual Review?	Testing / Detailed Inspection?
Low Level Outlet (LLO)	☒ Yes ☐ No	☒ Yes ☐ No	Not estimated	☒ Yes ☐ No	☐ Yes ☒ No
Spillway Channel	N/A	☐ Yes ☒ No	N/A	☒ Yes ☐ No	N/A

Are the following in *SATISFACTORY CONDITION*?

DAM	Yes/No	LOW LEVEL OUTLET	Yes/No	SPILLWAY CHANNEL	Yes/No
U/S Slope	☒ Yes ☐ No	Outlet Pipe	Inlet visible (clear), pipeline buried.	Invert	☒ Yes ☐ No
Crest	☒ Yes ☐ No	Outlet Controls	☒ Yes ☐ No	Side Slopes	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No			Erosion Protection	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No				

Were *POTENTIAL PROBLEM INDICATORS* found?

INDICATOR	DAM	SPILLWAY CHANNEL
Piping	☐ Yes ☒ No	☐ Yes ☒ No
Sinkholes	☐ Yes ☒ No	☐ Yes ☒ No
Seepage	☐ Yes ☒ No	☐ Yes ☒ No
Erosion	☐ Yes ☒ No	☐ Yes ☒ No
Cracks	☐ Yes ☒ No	☐ Yes ☒ No
Settlement	☐ Yes ☒ No	☐ Yes ☒ No
Sloughing/Slides	☐ Yes ☒ No	☐ Yes ☒ No
Animal Activity	☐ Yes ☒ No	☐ Yes ☒ No
Excessive Growth	☐ Yes ☒ No	☐ Yes ☒ No
Excessive Debris	☐ Yes ☒ No	☐ Yes ☒ No

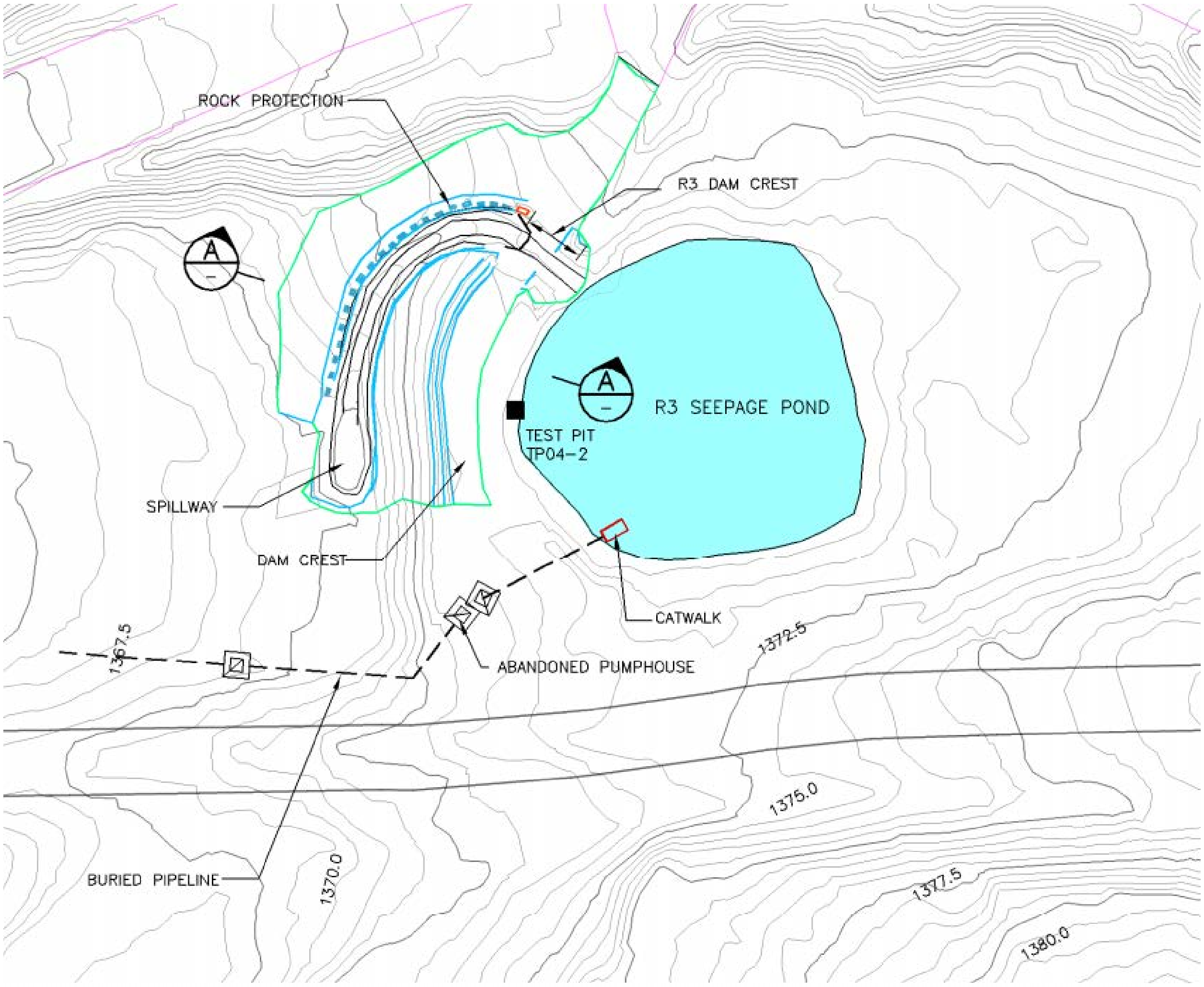
Deficiencies:

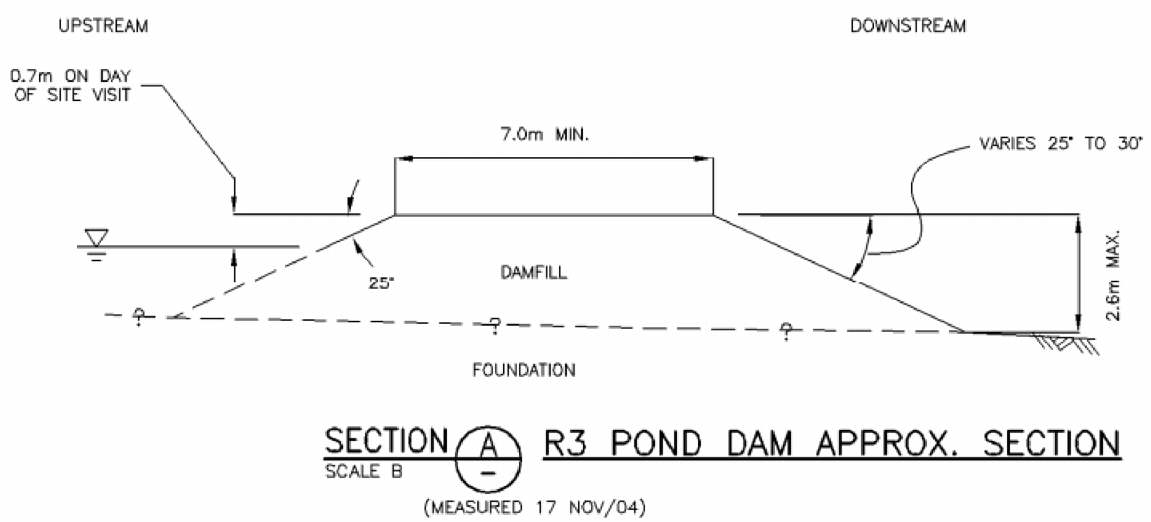
- No dam safety deficiencies observed

Comments:

- Lock block and vegetation at the spillway inlet should be cleared as part of routine maintenance
- Low Level Outlet intake trash rack is clogged and required cleaning (Not related to flood routing)

SITE PLAN


ROCK PROTECTION
R3 DAM CREST
R3 SEEPAGE POND
TEST PIT
TP04-2
SPILLWAY
DAM CREST
CATWALK
ABANDONED PUMPHOUSE
1367.5
1372.5
1375.0
1370.0
1377.5
1380.0
BURIED PIPELINE


UPSTREAM
DOWNSTREAM
0.7m ON DAY
OF SITE VISIT
7.0m MIN.
VARIES 25° TO 30°
25°
DAMFILL
2.6m MAX.
FOUNDATION
SECTION
SCALE B
R3 POND DAM APPROX. SECTION
(MEASURED 17 NOV/04)

APPENDIX II

Visual Observations and Inspection Photographs

APPENDIX II-A

Visual Observations and Inspection Photographs – Dam No. 1

Appendix II-A
Visual Observations and Inspection Photographs
Dam No. 1

VISUAL OBSERVATIONS

Crest and Tailings Beach

Good physical condition. The highpoint between the pond and the downstream slope is upstream of the slope crest. The tailings beach upstream of the downstream slope crest is well vegetated. There was no significant visual change of the sinkhole on the tailings beach (Photo II-A-2). No observations of concern were observed. (Photo II-A-1 and Photo II-A-2)

Left and Right Abutments

Good physical condition. The location of the left abutment is not visible due to the blending of dam fill and waste rock from a previously used waste dump. No signs of significant erosion, deterioration, or cracking at either abutment. (Photo II-A-3)

Downstream Slope

The remediated erosion gullies are in good physical condition and not showing signs of ongoing erosion. No significant change compared to 2018 DSI of the remediated or existing erosion features. Existing erosion features typically have vegetation growth along the base indicating ongoing erosion rate, if any, is slow. Observations of erosion and shallow slumping of the downstream slope are local features restricted to the waste rock fill benches (Photo II-A-4 and Photo II-A-5).

Pond

No visual indicators along tailings beach (i.e. change in vegetation or wave scour) of a recent high-water event.

Seepage

No signs of unexpected seepage in addition to flow from the underdrains which discharge to R3 Seepage Pond.

INSPECTION PHOTOGRAPHS

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2019-## refers to 2019 DSI waypoint shown on Figure 3.
- All photographs taken during inspection on June 12, 2019.

Photo II-A-1 Overview of impoundment (BTH-2019-01)

Photo II-A-2 Bethlehem sinkhole on tailings beach, no visual change from 2018 DSI. (BTH-2019-02)

Photo II-A-3 Overview of right abutment (BTH-2019-01)

Photo II-A-4 Overview of downstream slope of Dam No.1 from Trojan Dam (BTH-2019-03)

Photo II-A-5 Overview of downstream slope and toe from left abutment (BTH-2019-04)

APPENDIX II-B

Visual Observations and Inspection Photographs – Bose Lake Dam

Appendix II-B
Visual Observations and Inspection Photographs
Bose Lake Dam

VISUAL OBSERVATIONS

Crest

Good physical condition. No indications of major lateral movement, depressions, or cracking (Photo II-B-1).

Left and Right Abutments

Good physical condition. An access road runs along the abutments which connects the crest and toe roads. No sign of seepage, excessive scour or displacement (Photo II-B-2 through Photo II-B-4).

Downstream Slope

Good physical condition. No signs of adverse displacement or cracking. The majority of the slope is protected from erosion by coarse rockfill. The slope at the toe of the dam is well vegetated and no signs of significant animal activity (burrows) were observed (Photo II-B-2 through Photo II-B-5).

Local sand piles are present on the downstream slope of the dam. There was no sign of flow from the area which is well above nearest water level measurement. There are not interpreted as active seepage features or dam safety concern (Photo II-B-6 and Photo II-B-7).

Upstream Slope and Tailings Beach

Good physical condition. The beach immediately upstream of the dam is well vegetated with no visual issues of concern or indication of recent flooding (Photo II-B-8 and Photo II-B-9).

Pond

During inspection, the pond appears typical for the time of year. The pond remains approximately 40 m upstream of the crest in a localized depression on the tailings beach (Photo II-B-10).

Spillway Inlet

Good physical condition and consistent trapezoidal shape. Vegetation throughout channel but no major obstructions or signs of deterioration. The debris boom is secured in place with no sign of damage The vegetation at spillway inlet should be cleared as part of THVCP routine monitoring and maintenance (Photo II-B-11).

Spillway Channel and Outlet

Good physical condition. Initial segment of channel is vegetated with no or very modest grade. As the channel crosses the dam centreline, the spillway channel transitions to a riprap lined trapezoidal channel which continues downslope parallel to the dam abutment. The vegetation at approach channel and initial segment of riprap channel should be cleared as part of THVCP routine monitoring and maintenance. There was no visible sign of significant degradation of the riprap, compared to KC (2002), or blockage of the culverts (Photo II-B-12 through Photo II-B-18).

Seepage Collection System

The seepage relief wells were locked and could not be inspected. The outer casings showed no signs of damage. Water could be heard flowing within the culverts. At the gauge-house, flow was observed flowing (< 1 L/s) out of the outflow pipe and into the riprap lined basin. No surface outflow from the basin was observed; therefore, water is lost through seepage and/or evaporation (Photo II-B-19).

INSPECTION PHOTOGRAPHS

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2019-## refers to 2019 DSI waypoint shown on Figure 3.
- All photographs taken during inspection on June 12, 2019.

Photo II-B-1 Overview of dam crest looking towards right abutment (BTH-2019-05)

Photo II-B-2 Overview of downstream toe from left abutment (BTH-2019-06)

Photo II-B-3 Overview of downstream slope looking towards left abutment (BTH-2019-07)

Photo II-B-4 Overview of downstream slope looking towards right abutment (BTH-2019-07)

Photo II-B-5 Overview of downstream toe looking towards left and right abutment from middle of the toe line (BTH-2019-08)

Photo II-B-6 Pile of sand (not tailings) on upper part of starter dam slope. Appears to have been dumped there rather than resulting from seepage. Well above water level and no sign of flow in the area (BTH-2019-09)

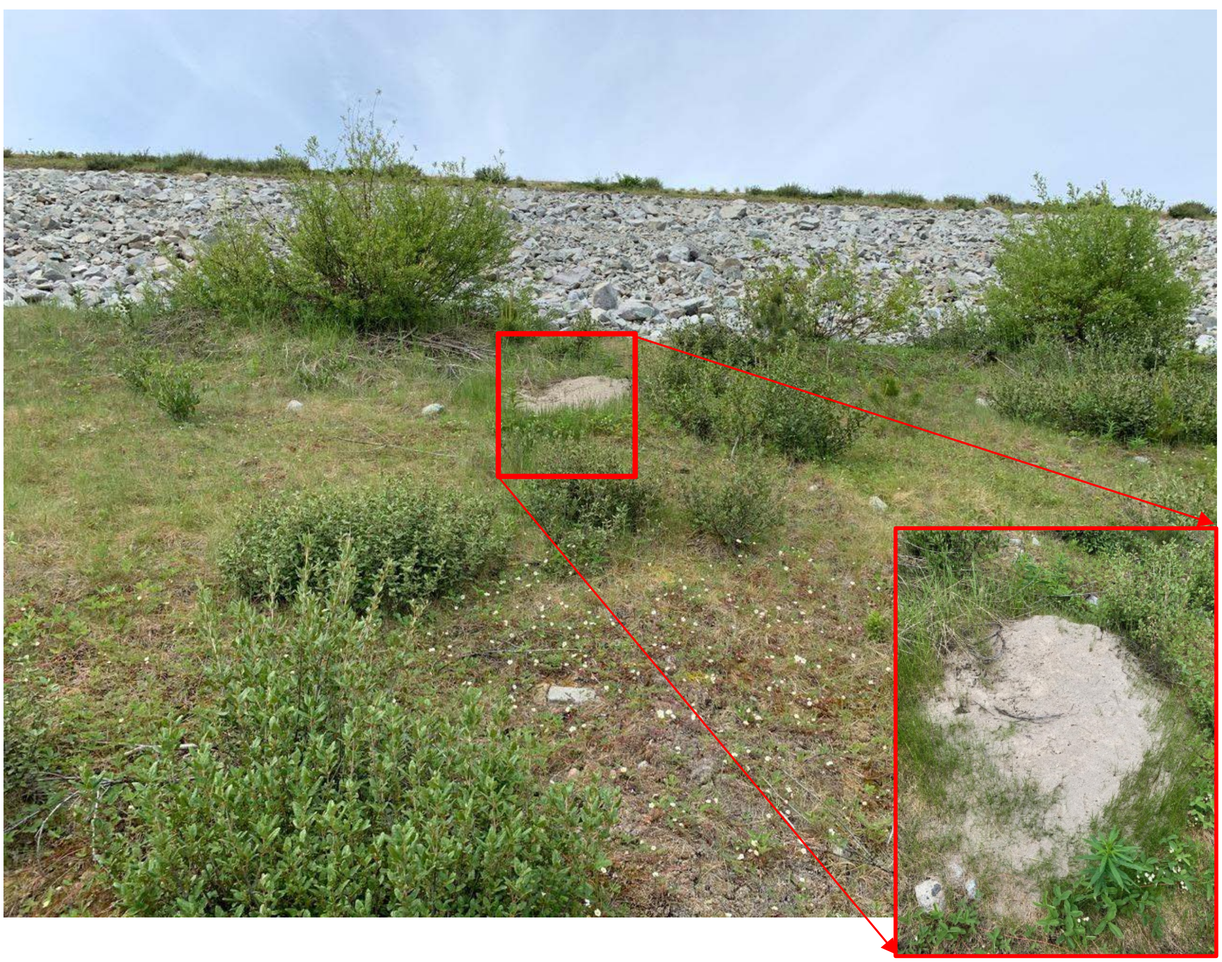


Photo II-B-7 Sand pile similar to the one observed in Photo II-B-6 and at a similar elevation (BTH-2019-10)

Photo II-B-8 Overview of crest and downstream slope from left abutment (BTH-2019-06)

Photo II-B-9 Upstream riprap, tailings beach and Pond No. 2, looking towards right abutment (BTH-2019-05)

Photo II-B-10 Overview of upstream slope and tailings pond (BTH-2019-11)

Photo II-B-11 Spillway inlet and approach channel. Vegetation to be cleared from flow channel as part of routine maintenance including approach channel and initial segment of riprap channel (BTH-2019-11)

Photo II-B-12 Spillway channel at transition point between inlet and riprap-lined segment, looking towards north. Vegetation to be cleared from flow channel as part of routine maintenance (BTH-2019-11)

Photo II-B-13 Spillway inlet and approach channel, looking southwest towards impoundment (BTH-2019-11)

Photo II-B-14 Overview of spillway channel – No vegetation around spillway bend. Riprap not degrading (BTH-2019-12)

Photo II-B-15 Spillway channel, looking southeast (downstream) towards Bose Lake (BTH-2019-12)

Photo II-B-16 Overview spillway channel (BTH-2019-13)

Photo II-B-17 Spillway channel and outlet to Bose Lake (BTH-2019-13)

Photo II-B-18 Spillway road culverts – not significantly obstructed (BTH-2019-14)

Photo II-B-19 Seepage relief well at downstream toe, looking west (upstream) – Well was locked but low flow inside could be heard (BTH-2019-15)

APPENDIX II-C

Visual Observations and Inspection Photographs – R3 Seepage Pond Dam

Appendix II-C
Visual Observations and Inspection Photographs
R3 Seepage Pond Dam

VISUAL OBSERVATIONS

Crest

Good physical condition. No indication of adverse lateral movement, depressions or cracking.

Left and Right Abutment

Good physical condition. No signs of significant erosion, deterioration, or cracking (Photo II-C-2 and Photo II-C-3).

Downstream Slope

Good physical condition. No indication of adverse displacement. No signs of erosion, deterioration, or seepage.

Pond

At the time of inspection was more than 1 m below the spillway invert (Photo II-C-1).

Low-level Outlet

The outlet pipe trash rack was partially obstructed from vegetation; this should be cleared as part of THVCP routine monitoring and maintenance. The upstream debris fence was also obstructed which may be cleared or replaced as part of routine maintenance but not required for dam safety (Photo II-C-4).

Spillway

Good physical condition. No indicators of recent flow through the channel. No visual signs of riprap degradation.

Heavy vegetation and a lock block are obstructing spillway inlet and should be cleared as part of THVCP routine monitoring and maintenance. THVCP noted the lock-block may be there as vehicle barrier. If so, an alternate barrier type which does not obstruct flow is required (Photo II-C-2).

Seepage

None observed.

INSPECTION PHOTOGRAPHS

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2019-## refers to 2019 DSI waypoint shown on Figure 5.
- All photographs taken during inspection on June 12, 2019.

Photo II-C-1 Overview of R3 Pond (BTH-2019-16)

Photo II-C-2 overview of spillway inlet and right abutment. Lock-block and vegetation to be cleared from inlet (BTH-2019-16 and BTH-2019-17)

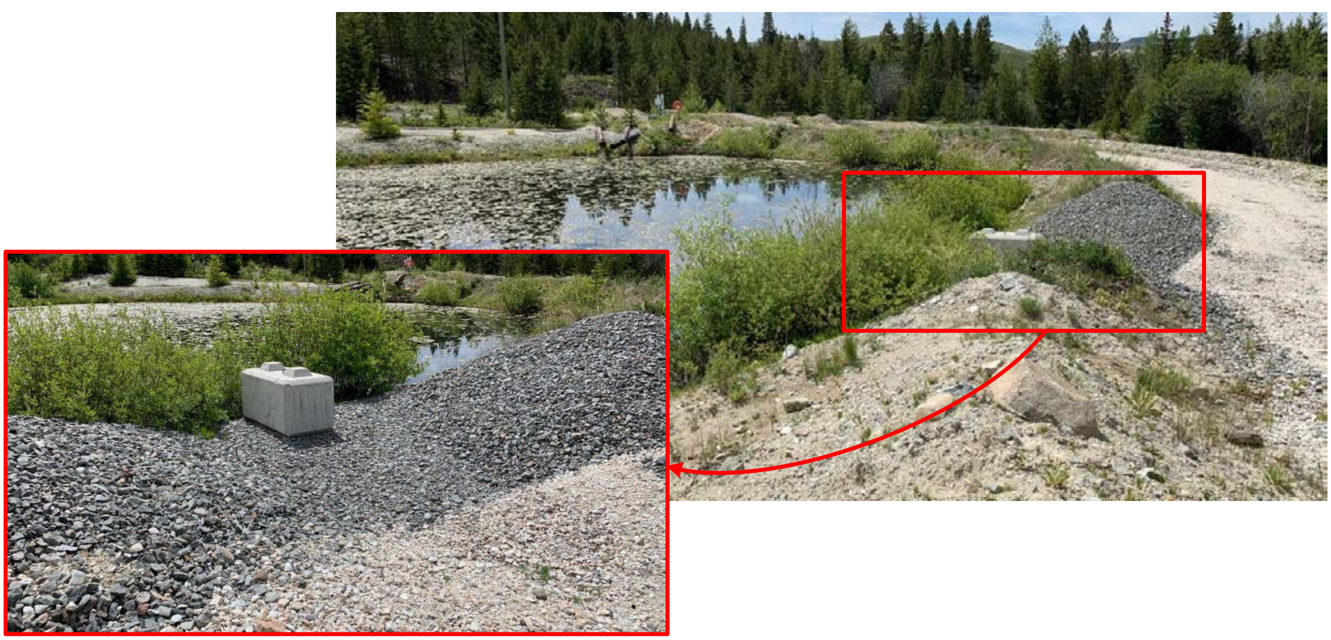


Photo II-C-3 Spillway channel and road crossing at right abutment, looking downstream (BTH-2019-17)

Photo II-C-4 Pond and trash rack for Low-Level Outlet (LLO) (BTH-2019-18)

APPENDIX III

APPENDIX III-A

Overview, History, and Water Management

Appendix III-A
Overview, History, and Water Management

OVERVIEW

Dam No. 1 and Seepage Ponds

A layout of Dam No. 1 and R3 Seepage Pond are shown on Figure 3 and Figure 5, with typical geometry and dimensions summarized in Table III-A-1. Refer to Appendix III-B for relevant design drawings.

General information regarding Dam No. 1 and its seepage structures are as follows:

- Construction record drawings were not available except for the R3 Seepage Pond spillway (AMEC 2013b). Issued for construction drawings were found for the downstream berm of Dam No. 1 (Gepac 1971a and 1971b). Additional design drawing details were found in a long-term stability assessment report (KC 1996).
- The dam foundation generally comprises of the following:
  - Well-graded sand near surface, underlain by dense glacial till up to 24 m thick overlying bedrock.
  - There may be soft swamp deposits as well as tailings deposits from a minor dam breach in 1965 in the valley section remaining in the low-lying area in the valley section, under the upstream portion of the rockfill dam (AMEC 2014a).
  - No distinctive laminated glaciolacustrine clay or silt was intersected by the DHB16-1 which was drilled in 2016 (KCB 2017a); however, thin (~150 mm) layers of low to intermediate plasticity silt and clay was intersected within a Stratified Glacial Till unit. Based on DHB16-1 and other available drilling the unit may be continuous beneath the dam.
  - Abutments of the dam were founded on overburden consisting of dense till-like material (Ingledow 1966).
- Dam No. 1 began as a 20 ft high starter dam constructed of glacial till. A low dyke of overburden (a few feet high) was first pushed out across the slough to displace soft peat. Cycloned tailings were placed over this dyke to form the dam base.
- The dam was raised by centreline method with rockfill placed to form a downstream shell and spigotted or cycloned tailings placed on the upstream beach. The design relies on the large cycloned sand zone and long tailings beach to provide separation between the tailings pond and dam rockfill. The design of the dam required the pond to be kept at a minimum offset of 122 m from the dam crest. A downstream rockfill buttress berm was later added in the valley section.

- Downstream of Dam No. 1, the seepage collection system consists of two structures connected in series:
  - Seepage Pond 1, a pond in a natural depression of apparent glacial till. The structure was decommissioned as a dam in 2016 by breaching the retaining berm, removing the ability to retain water. Flow from the finger drains in Dam No. 1 passes through the breached pond before reaching the R3 Seepage Pond.
  - R3 Seepage Pond, located 120 m downstream of Seepage Pond 1 on the opposite side of the main haul road, collects flows from Seepage Pond 1 and from local catchments. The pond is contained by a dam on its west side. A spillway channel is constructed through the northern portion of the dam and discharges flow into Lower Trojan Dam downstream of the dam toe. Water is typically discharged to Lower Trojan Dam via a buried pipeline at the left abutment, but flows can also be diverted to the Highland Mill. Outflows are not measured.
- Outflow from breached Seepage Pond 1 is measured at weir TB-R3-FS-01.

Bose Lake Dam

A layout of Bose Lake Dam is shown in Figure 4. The dam is located in a saddle at the east end of the TSF. The typical geometry and dimensions of the dam are summarized in Table III-A-1. Refer to Appendix III-B for relevant design drawings.

General information regarding the dam are as follows:

- Construction record drawings of the dams were not available with the exception of the Bose Lake Dam spillway. Design drawings from the ultimate Bose Lake Dam raise (Fellhauer 1980) and a subsequent long-term stability assessment report (KC 1996) were used as reference.
- Historical reports (Gepac 1972, KC 1996) indicate that the dam is located on a bedrock saddle overlain by a glacial till blanket. There is no evidence of glaciolacustrine or lacustrine soils beneath Bose Lake Dam based on available reference reports and investigations (KCB 2015).
- The dam is constructed of compacted glacial till with rockfill over the downstream slope for erosion protection, and a rockfill toe berm that includes a filter blanket and seepage collection system. The dam abuts into glacial till at both ends.
- Seepage from the rockfill drain is collected in concrete manholes connected by pipes which drain by gravity to a pump well at the low point along the downstream toe.
- A permanent open channel spillway for the Bethlehem No. 1 TSF was constructed at the left abutment of Bose Lake Dam. The invert of the inlet channel is set at El. 1469.3 m at the flow control sill, which is about 5.7 m below that crest of the dam. The channel extends to the public access road at the toe of the dam, where it is diverted through two culverts (1 x 1380 mm dia., 1 x 600 mm dia.) and discharges into Bose Lake.

Table III-A-1 Summary of Approximate Dam Geometry

Dam	Construction Method	Nominal Crest Elevation (m)	Maximum Dam Height (m)	Crest Length (m)	Minimum Crest Width (m)	Upstream Slope	Downstream Slope
TAILINGS DAMS							
Dam No. 1	Modified Centreline	1477 (top of sand fill) 1472 (top of rockfill)	91	2000	25	N/A	3H:1V (overall from crest of sandfill) 2.2H:1V (overall from crest of rockfill)
Bose Lake Dam	Saddle Dam Downstream	1475	31	600	9	2H:1V	2H:1V
SEEPAGE COLLECTION DAM							
R3 Seepage Pond	Unknown (believed single raise)	1371	2.6	60	6	N/A	2.3H:1V

Notes:
1. Dimensions are estimated from 2014 LiDAR data unless otherwise noted.
2. Height measured as the vertical distance between downstream toe and crest.

HISTORY

A brief history of the construction and operations of the Bethlehem No. 1 TSF, prior to 2019, is summarized as follows:

Dam No. 1

- Construction began in 1963 with the starter dam, originally designed by Ingledow and Associates, with additional design in later years by Gepac and Fellhauer Consultants.
- From 1966 to 1972, the dam was raised by modified centreline method, placing rockfill downstream and spigotted or cycloned tailings upstream. The rockfill crest was raised to its final elevation of 4,800 ft (1472 m) in 1972 (KC 1994).
- From 1970 to 1971, a rockfill toe berm was added as a response to observed cracking on the dam crest, that was likely associated with the presence of soft foundation deposits which were left in place beneath a portion of rockfill shell (Golder 1970).
- In 1977, during construction of the upstream tailings zone, a washout of sand occurred on the left abutment with sinkhole-like depressions forming upstream of the rockfill. The holes were backfilled with cycloned sand. Remedial measures included placement of a low permeability glacial till blanket in the area of the depressions. Three similar incidents near the right abutment occurred between 1978 and 1981 (KC 1994).
- In 1983, the dam was completed to its ultimate crest elevation of 1476.9 m (KC 1994).

- Since tailings disposal ended in 1989, gully erosion of the downstream rockfill slope has been an ongoing maintenance issue:
  - Since 2011, five gullies have been repaired, two in 2011, two in 2012, one in 2015, and a number along a 150 m long stretch south of the midpoint Dam No. 1. Repairs as part of regular maintenance by THVCP were done by cleaning out loose debris and infilling with sand and gravel.
  - In 2014, the southernmost gully, previously backfilled, was re-sloped.
- A drill hole was completed in April 2016 to supplement foundation information and collect samples of potential glaciolacustrine layers in the foundation, if present (KCB 2017a).
  - Low to intermediate plasticity silt and clay was found as thin layers stratified within the glacial till. No distinctive laminated glaciolacustrine clay or silt was intersected by the drill hole.
  - Two vibrating wire piezometers and an inclinometer were installed in the foundation at DHB16-1 at the toe of Bethlehem Dam No.1.

R3 Seepage Pond

- In 1964, the R3 Seepage Pond system was installed. Upgrades were made in 1970, 1979 and 1984.
- In 2012, the dam was overtopped when the outlet pipe became plugged during maintenance work.
- In 2013 in response to the overtopping event of 2012, a spillway, designed by AMEC, was constructed on the right abutment of the dam (AMEC 2013a).
- In 2015, THVCP placed riprap on the downstream dam slope for erosion control.

Bose Lake Dam

- In 1972, the first of four stages of the Bose Lake Dam construction began. The last stage ended in 1981 to the final crest elevation of 1475.1 m (KC 1994).
- In 1995, a permanent spillway was constructed at the north abutment of the Bose Lake Dam (AMEC 2014a).

Impoundment

- In 1989, tailings disposal at Bethlehem No. 1 TSF ended (AMEC 2014a).
- In 1993, a sinkhole (4 m to 5 m wide on the surface and 4 m deep) was discovered in the tailings beach at Dam No. 1; about 400 m upstream of the dam crest:
  - In 1994, the sinkhole was backfilled with waste rock. In 1996, it was backfilled again due to continued settlement.

  - On October 11, 1997, KCB examined the sinkhole and recommended no further action other than ongoing monitoring. In recent years, there has been no significant change in the sinkhole.
- In 2014, THVCP constructed and instrumented a test fill pad in the mid-portion of the south side of the impoundment to characterize the response of the tailings under load.

WATER MANAGEMENT

There are no water management diversions upstream of the impoundment. Therefore, all inflow from the upstream catchments reports to the impoundment. Impoundment and downstream water management is summarized below and shown on Figure III-A-1. Figure references for key operating water management structures are summarized in Table III-A-2.

Bethlehem Pond No. 1

- Inflows pond in a low point of the tailings surface near the center of the impoundment, referred to as the Bethlehem Pond No. 1, as shown on Figure 2.
- Inflows include precipitation on the western impoundment and surface runoff from upstream catchments (approx. 230 ha).
- The pond level fluctuates seasonally with up to 1 m variance based on historic records, refer to Figure IV-B-1. Since 2014, there has been an overall downward trend in the pond level attributed to a water balance deficit. This trend is not evident in 2017 or 2018. The deviation from the downward trend is believed to be due to larger freshet flows during that period.

Bethlehem Pond No. 2

- Inflows pond in a second low point of the tailings surface upstream of Bose Lake Dam on the west side of the impoundment, referred to as the Bethlehem Pond No. 2, as shown on Figure 2.
- Inflows include precipitation on the eastern impoundment and surface runoff from upstream catchments (approx. 85 ha).
- The pond level varies seasonally up to 1 m based on historic records; refer to Figure IV-B-7. Since 2015, there has been a long-term downward trend in the pond level. This trend is not evident in 2017 or 2018, mainly due to increased inflows during freshet.
- Outflows are similar to Bethlehem No. 1 tailings pond. Seepage through the Bose Lake Dam is collected by a series of four seepage collection concrete manholes and pipelines connected via a rockfill drain buried along the downstream toe. The collected water discharges to an outfall adjacent to the spillway channel and a decommissioned pumphouse, after which it seeps through access road fill and reports to Bose Lake.

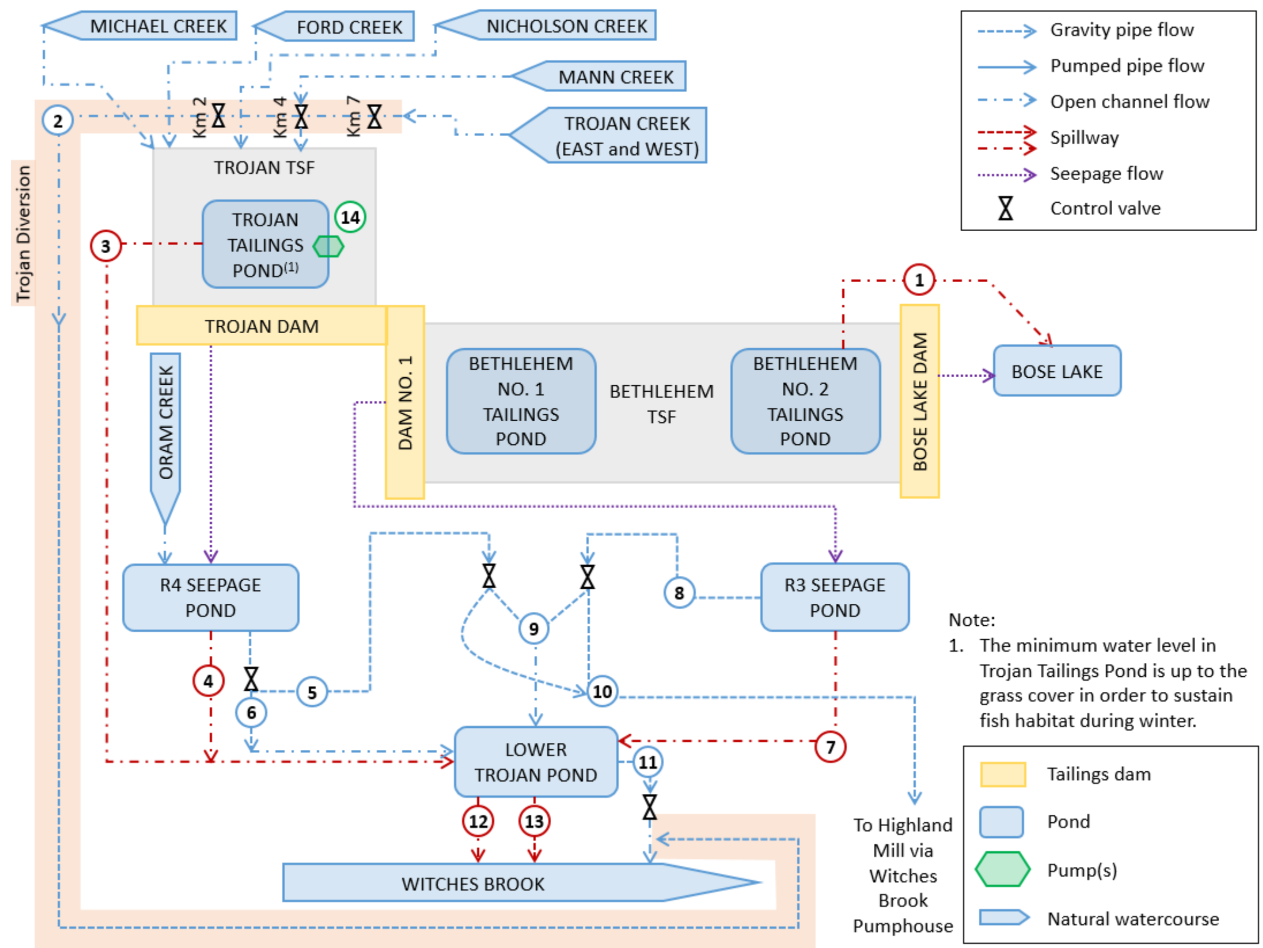
Bethlehem No. 1 TSF Spillway

- The 3 m wide open channel spillway is excavated near the left abutment of Bose Lake Dam and discharges into Bose Lake via 2 corrugated steel pipe (CSP) culverts (1 x 1380 mm dia., 1 x 600 mm dia.) under a public road.
- The upper 60 m of the spillway channel, starting where the channel crosses the dam centerline and past the 70 m approach channel, has a grade of 0.5% and is lined by riprap with a maximum size of between 125 mm and 160 mm. The lower reach of the channel has segments with steeper grades (as steep as 25.6%) and lined by riprap with a maximum size of between 1050 mm to 1340 mm.
- There are no outlets for surface water discharge from the impoundment except through the Bethlehem No. 1 spillway located at the left abutment of Bose Lake Dam. There has been no flow through the spillway since it was constructed in 2014. Therefore, outflows are primarily evapotranspiration and seepage. Seepage that discharges near the dam toe is collected by R3 Seepage Pond.

R3 Seepage Pond

- Inflows include seepage from Dam No. 1 (routed through Seepage Pond 1, not shown on Figure III-A-1), precipitation on the pond, and surface runoff from upstream catchments.
- The water level in the pond is not regularly surveyed by THVCP; however, visual estimates of available freeboard are included in the quarterly inspections by THVCP.
- Outflows are primarily through a 460 mm diameter (18”) buried gravity pipeline which leads to Lower Trojan Dam and eventually discharges to Witches Brook. Other minor losses include seepage, evaporation, and diversion to the Highland Mill when needed. During flood events, water could also discharge through the riprap lined spillway near the right abutment. There is a stilling basin at the outlet of the spillway, after which flow continues downslope towards Lower Trojan Dam, after which it reports to Witches Brook.

Figure III-A-1 Flow Schematic for Bethlehem and Trojan TSFs



No.	Name	Description	Status
1	Bose Lake Spillway	3 m wide channel with concrete sill founded in tailings (3 m wide, vegetated) and natural ground (3 m, riprap-lined)	Operational
2	Trojan Diversion	6.5 km long series of channels, culverts, and pipelines	Operational
3	Trojan Spillway	1.3 km long open channel founded in tailings (5 m wide, vegetated), natural ground (3 m, riprap-lined) and bedrock (3 m).	Operational
4	R4 Spillway	2 m wide riprap-lined channel	Operational
5	R4 Low-Level Outlet	300 mm dia. HDPE pipe with U/S and D/S control valves and intake trash rack	Operational
6	R4 Overflow	100 mm dia. HDPE pipe with U/S control valve	Operational
7	R3 Spillway	2 m wide riprap-lined channel	Operational
8	R3 Low-Level Outlet	460 mm dia. HDPE pipeline with D/S control valve	Operational
9	Seepage to LTD	Buried pipeline	Operational
10	Northern Collection Line	Buried pipeline	Operational
11	LTD Low-Level Outlet	460 mm dia. HDPE pipe with control valve and intake trash rack	Operational
12	LTD Spillway	7 m wide channel	Operational
13	LTD Overflow	810 mm dia. HDPE pipe	Operational
14	Trojan Pump	Pump for Trojan Tailings Pond	Non-operational

Table III-A-2 Operational Water Management Structure Reference Drawings

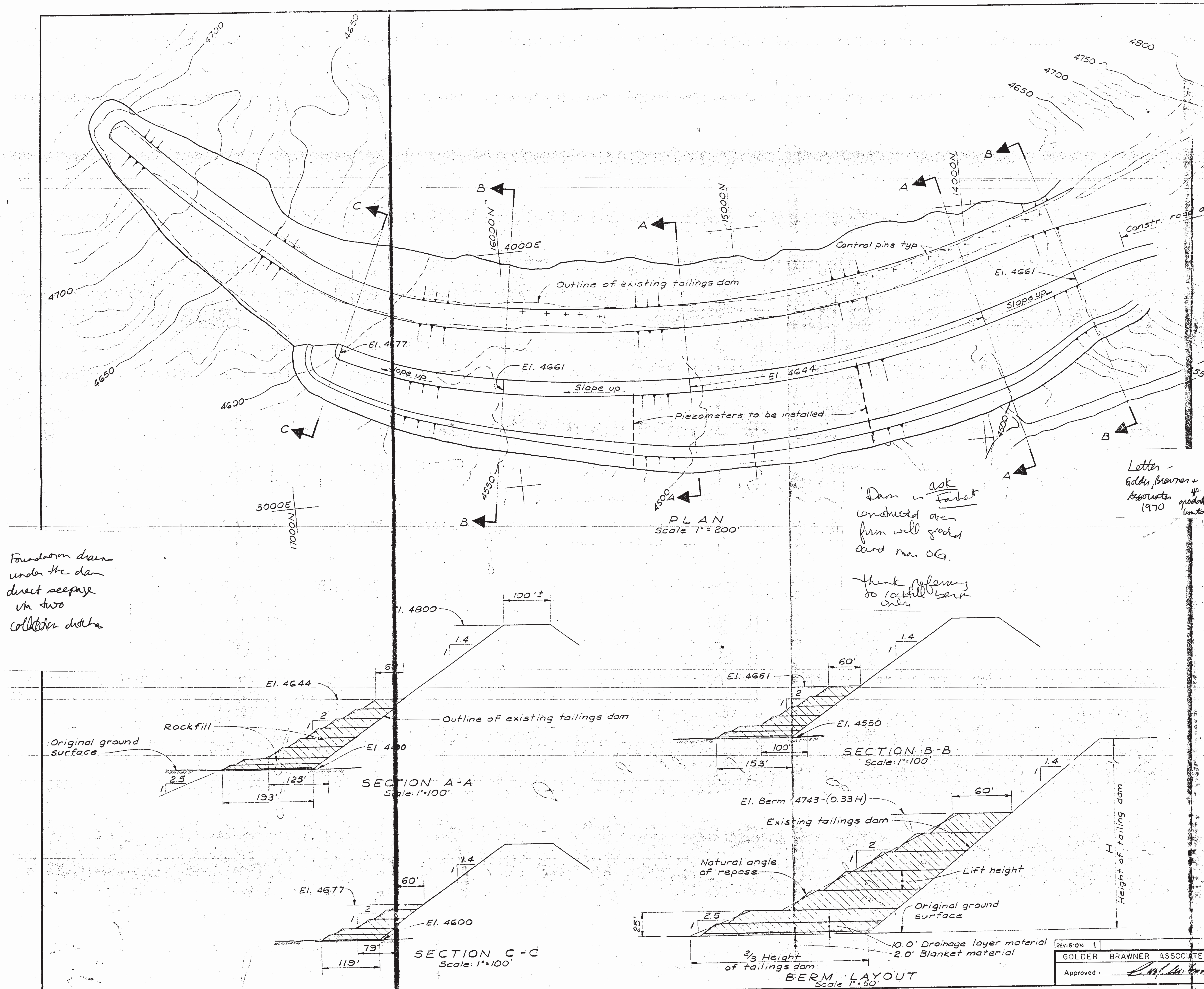
Structure Name	Drawing or Figure Reference (Appendix IV)
Spillway	114-808-201-1
R3 Seepage Pond Outlet pipeline	B-002
R3 Seepage Pond Spillway	AB-002, AB-003
Bose Lake Seepage collection system	B-23012 A fourth seepage relief well was installed between the right abutment and the eastern well shown on this drawing.

APPENDIX III-B

Reference Dam Design Drawings

APPENDIX III-B-1

Reference Dam Design Drawings – Dam No. 1



Materials

1. 'Blanket material' shall be any reasonable non-organic material such as sand, gravel, or rock.
2. 'Drainage Layer material' shall be an approved free draining material having a permeability not less than 2×10^{-1}. Material shall have a minimum 10 percent particle size of 0.4 mm. The applicable gradation limits are shown in Fig. 1, by Golder, Brawner and Associates, attached to TBAL letter of Sept. 8, 1970.
3. 'Rock Fill material' shall be any durable and strong rock material obtained from waste excavation, providing that the silt content shall not exceed 30% by weight.

Construction

1. Existing ground surfaces shall be in un-frozen condition when blanket material and drainage layer material placed.
2. The initial blanket material shall be placed approximately 2 feet thick, as required, to prevent contamination of subsequent drainage layer by existing surface deposits.
3. Drainage layer material shall be end dumped to provide a 10 feet thick finished layer. Mechanical compaction is not required.
4. Rock fill shall be placed in lifts 10 to 20 feet high.
5. Significant amounts of snow shall be removed prior to dumping rock.

Scheduling

As far as is possible, consistent with reasonable convenience of placing, the berm construction should be scheduled to expedite the work in the areas where maximum movement of the present slope is occurring.

CONSTRUCTION ISSUE

REV. NO.	DATE	MADE	CHKD.	INSP.	SUBD.	RECD.	APPD.	
1	Nov 3/70	H.C.					H.R.	General Revision

REVISION 1

GOLDER BRAWNER ASSOCIATES

Approved:

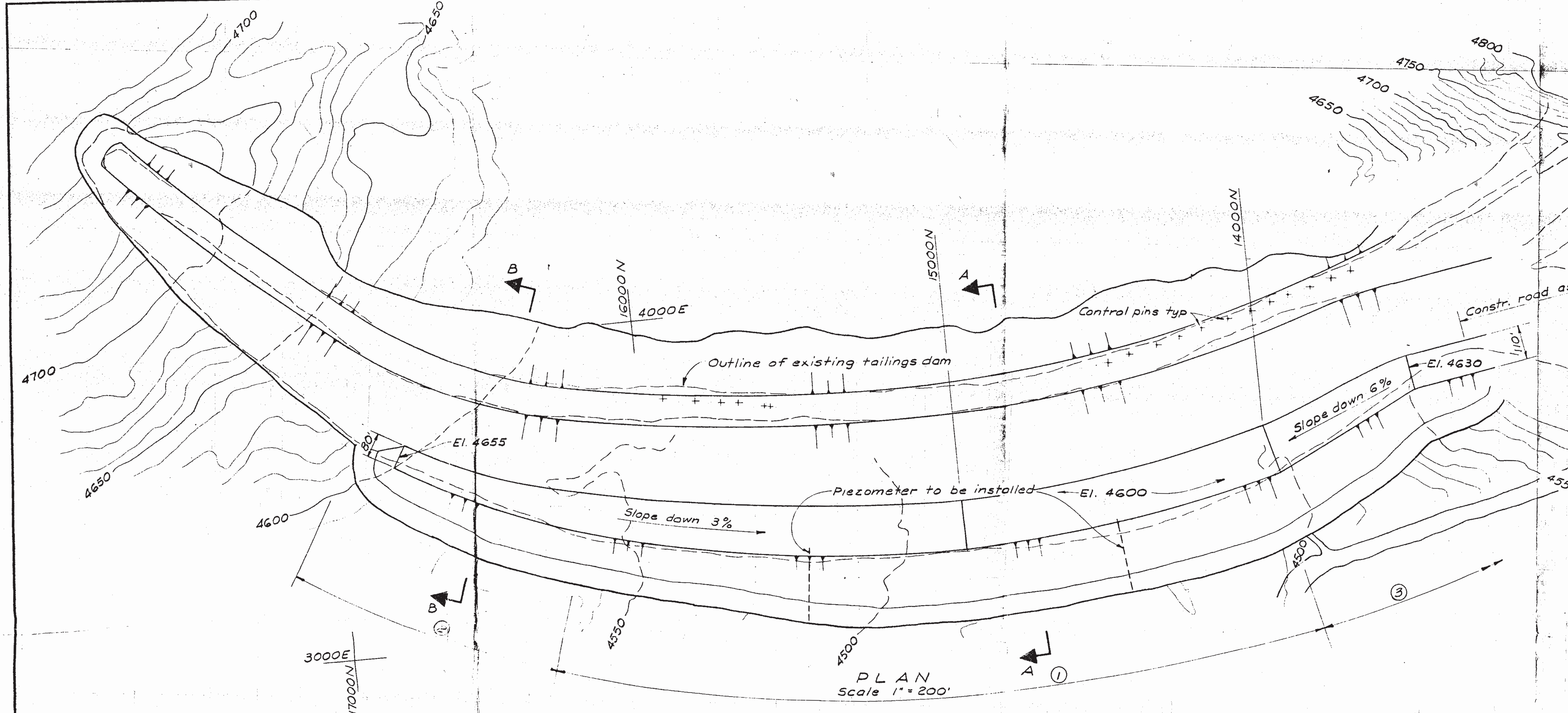
BETHLEHEM COPPER CORPORATION LTD.

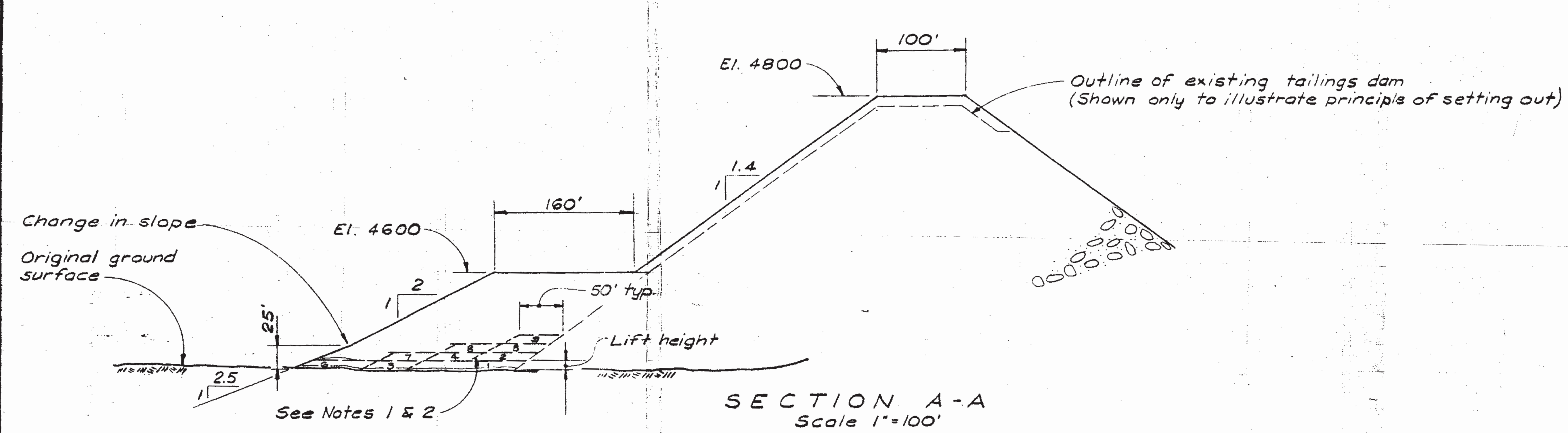
HIGHLAND VALLEY TAILINGS DAM

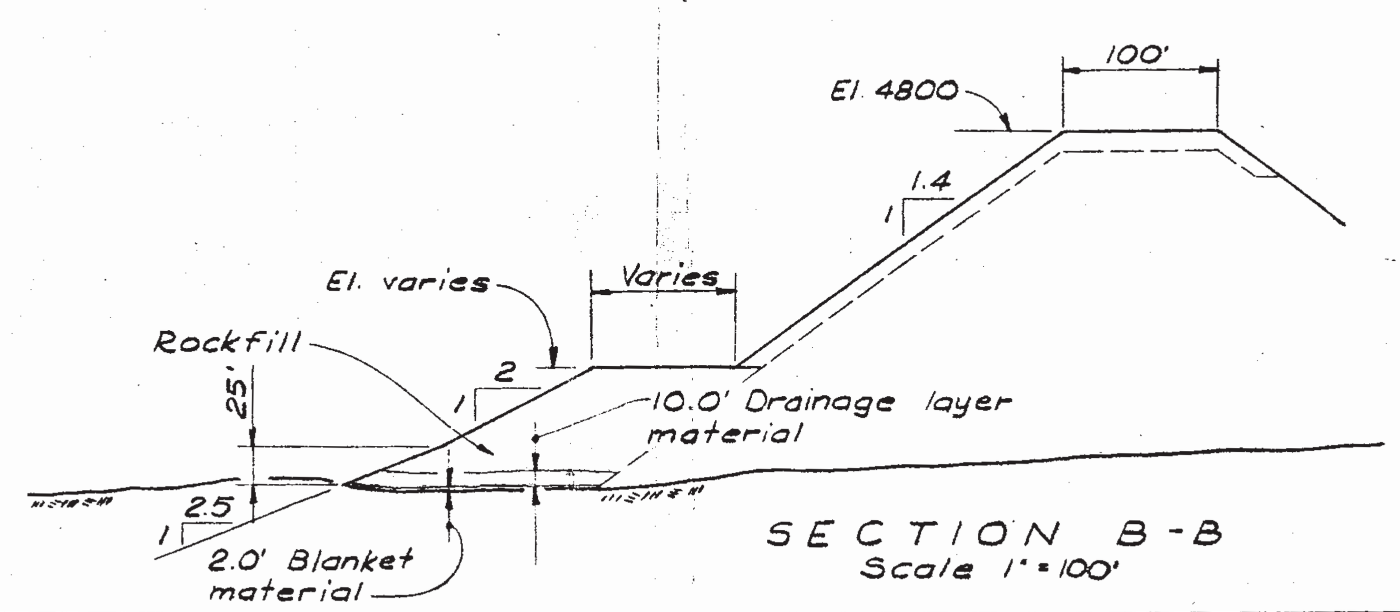
DETAILS OF DOWNSTREAM BERM

T. INGLEDOW & ASSOCIATES LIMITED
CONSULTING ENGINEERS — VANCOUVER, CANADA

DESIGNED	
DRAWN	H.C.
CHECKED	
INSPECTED	
SUBMITTED	
RECOMMENDED	SRB
APPROVED	
SCALE	AS SHOWN
DATE	SEPT. 9, 1970
	221 - 02 - 102 R1







Materials

1. 'Blanket material' shall be any reasonable non-organic material such as sand, gravel, or rock.

2. 'Drainage Layer material' shall be an approved free draining material having a permeability not less than 2×10^{-1}. Material shall have a minimum 10 percent particle size of 0.4 mm. The applicable gradation limits are shown in Fig. 1, by Golder, Brawner and Associates, attached to TIAL letter of Sept. 8, 1970.

3. 'Rock Fill material' shall be any durable and strong rock material obtained from waste excavation, providing that the silt content shall not exceed 30% by weight.

Construction

1. Existing ground surfaces shall be in un-frozen condition when blanket material and drainage layer material placed.

2. The initial blanket material shall be placed approximately 2 feet thick, as required, to prevent contamination of subsequent drainage layer by existing surface deposits.

3. Drainage layer material shall be end dumped to provide a 10 feet thick finished layer. Mechanical compaction is not required.

4. Rock fill shall be placed in lifts 10 to 20 feet high.

5. Significant amounts of snow shall be removed prior to dumping rock.

Scheduling

As far as is possible, consistent with reasonable convenience of placing, the berm construction should be scheduled to expedite the work in the areas where maximum movement of the present slope is occurring. The recommended general principle of scheduling is indicated on the drawing.

NOTES:

1. Numbers on Plan and Section indicate recommended order of construction.
2. In Section A-A the sequence of lifts after No. 9 shall continue in the sequence of lifts 6, 7, 8, and 9.

CONSTRUCTION ISSUE

GOLDER BRAWNER ASSOCIATES
Approved : [signature]

REV. NO.	DATE	MADE	CHKD.	INSP.	SUBD.	RECD.	APPD.
1							
2							
3							
4							
5							

BETHLEHEM COPPER CORPORATION LTD.

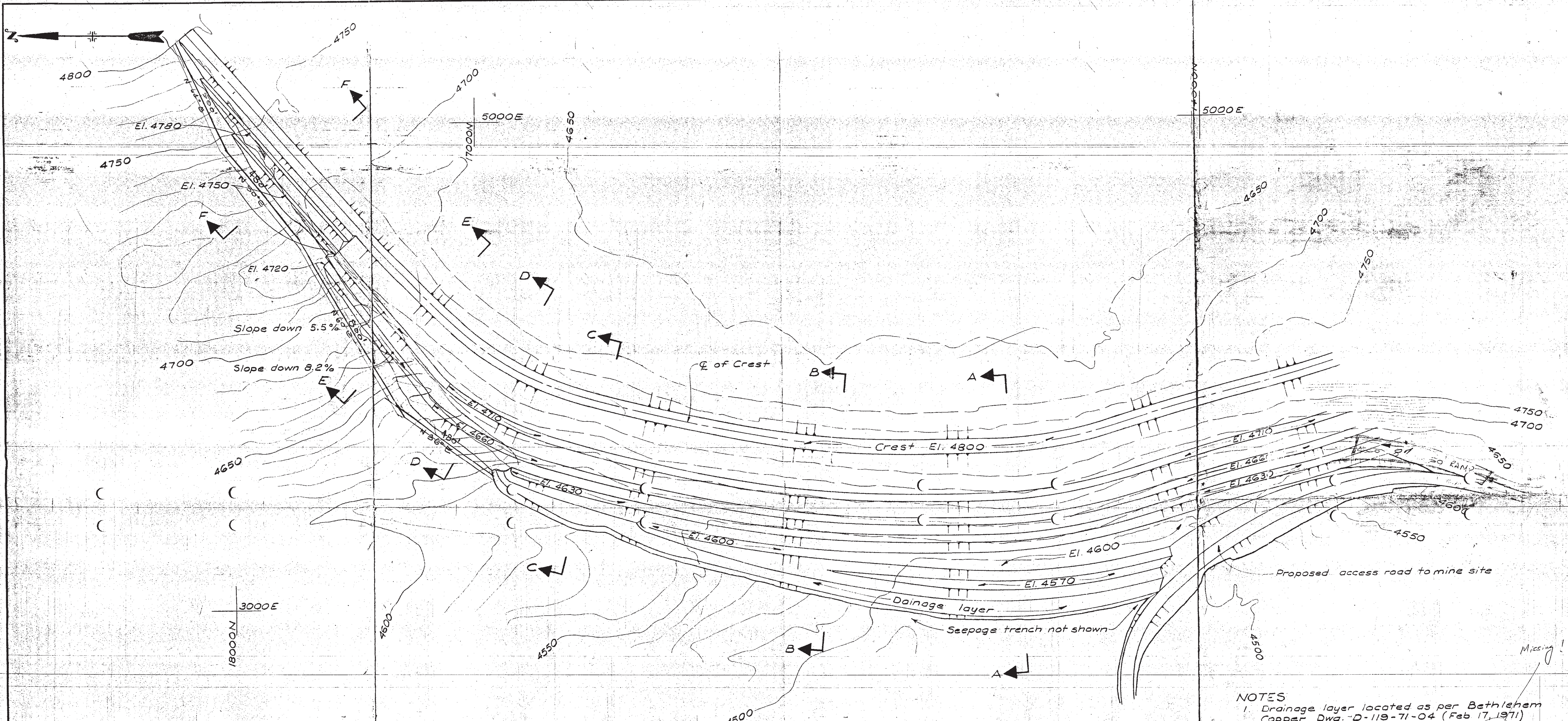
HIGHLAND VALLEY TAILINGS DAM

DETAILS OF DOWNSTREAM BERM

T. INGLEDOW & ASSOCIATES LIMITED
CONSULTING ENGINEERS — VANCOUVER, CANADA

DESIGNED
DRAWN H.C.
CHECKED
INSPECTED
SUBMITTED
RECOMMENDED S.B.B.
APPROVED [signature]

SCALE AS SHOWN
DATE SEPT. 9, 1970
221-02-102



NOTES
1. Drainage layer located as per Bethlehem Copper Dwg. D-119-71-04 (Feb 17, 1971)
2. For Sections see Dwgs 221-02-1103 & 221-02-1104
3. This Drawing supersedes Dwg 221-02-1100
4. Contours taken from Bethlehem Copper Dwg. D119-71-03

Missing!

REFERENCES
Bethlehem Copper Corporation Ltd. Drawings

D119-71-03 Tailings Dam
D119-71-04 Tailings Dam Cross Sections A-A & B-B
D119-71-05 Toe Drain Sections

CONSTRUCTION ISSUE

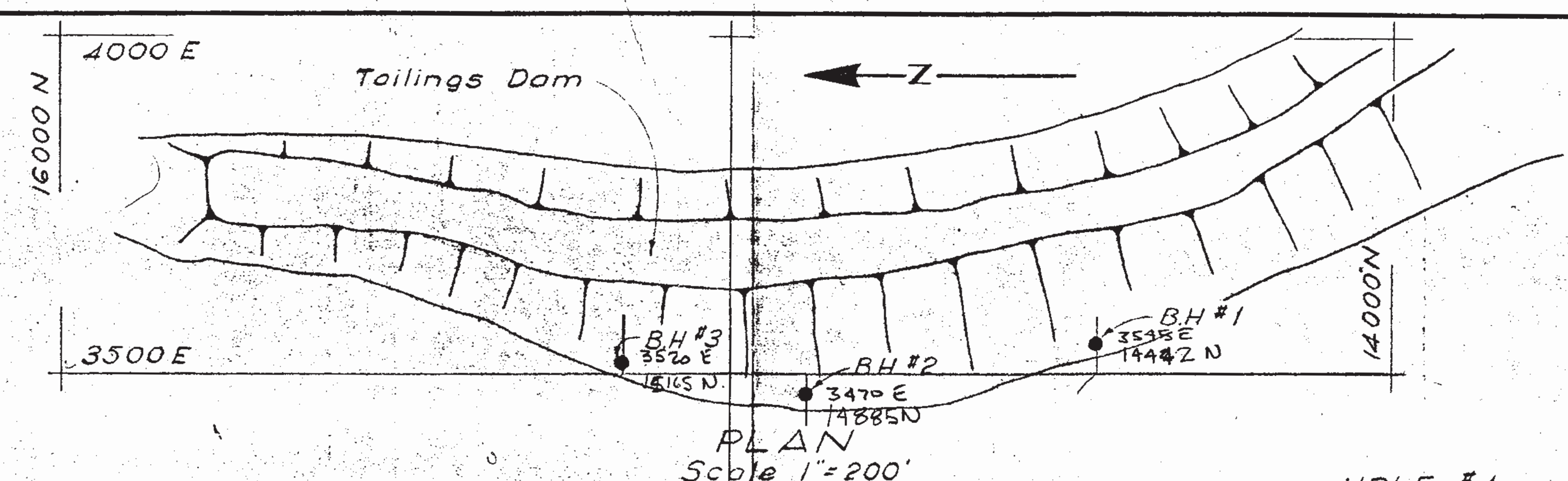
BETHLEHEM COPPER CORPORATION LIMITED

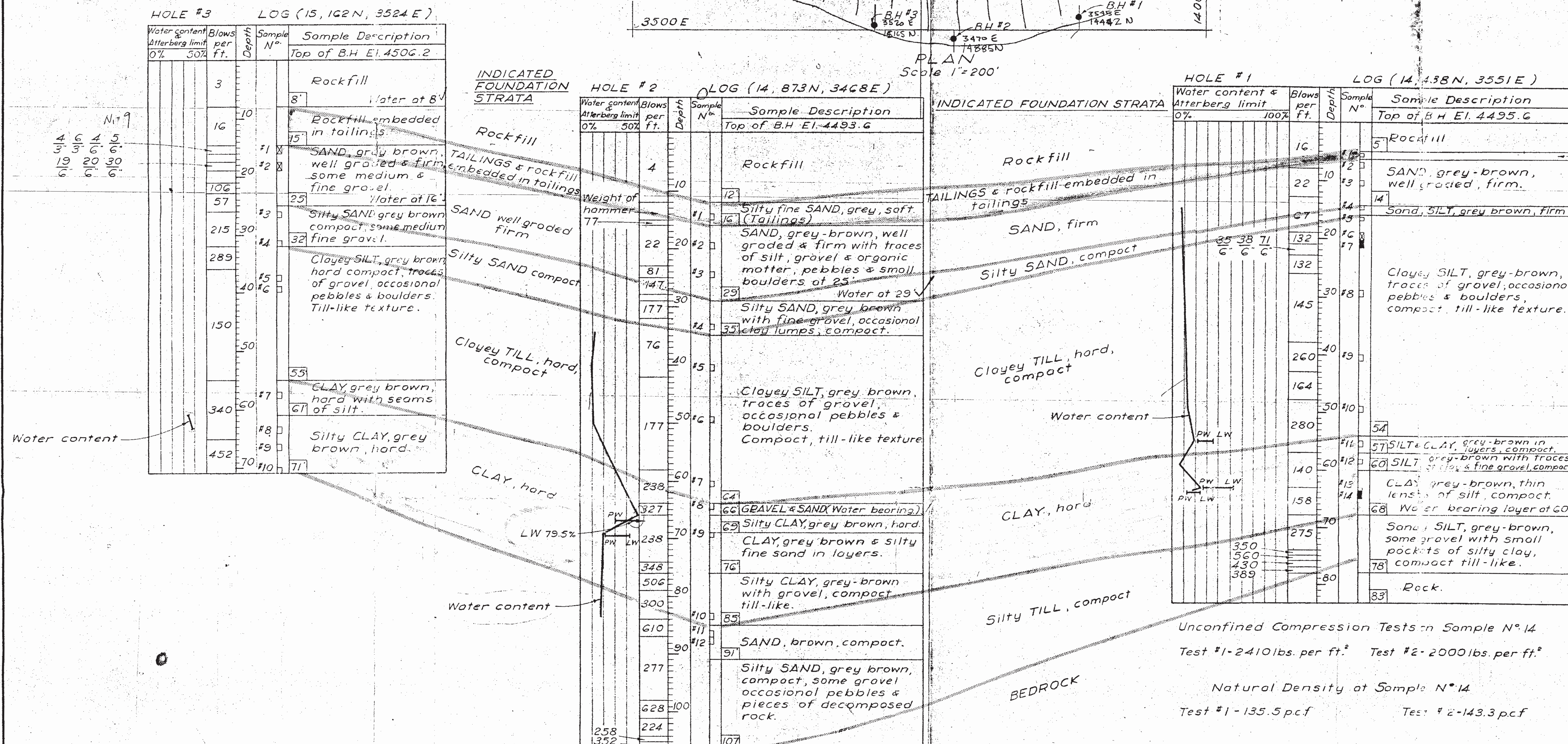
TAILINGS DAM NUMBER ONE
REDESIGN JULY 1971
PLAN

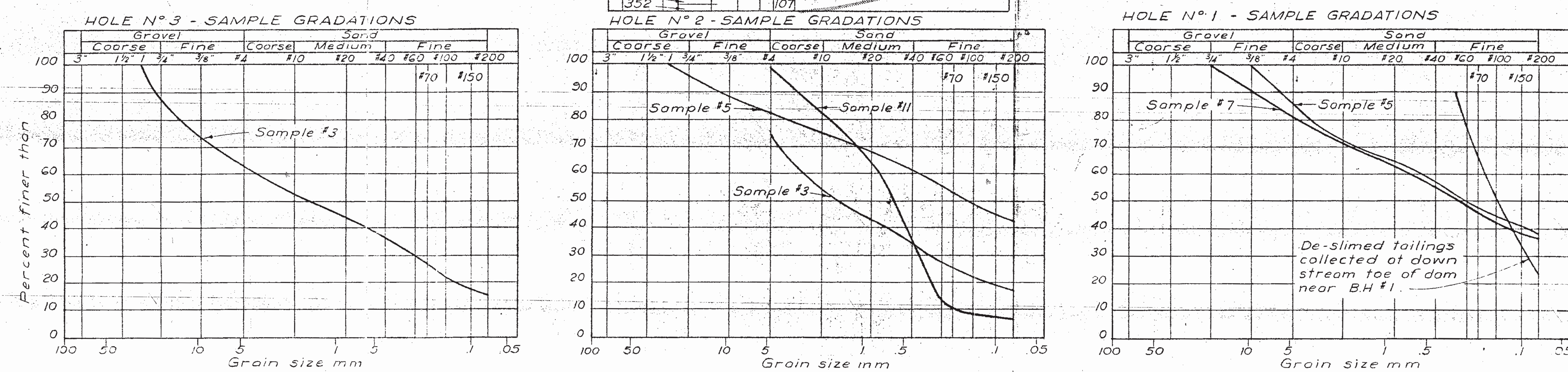
GEPAC CONSULTANTS LTD.
CONSULTING ENGINEERS VANCOUVER, CANADA

DESIGNED	
DRAWN H. Coulter	SCALE 1" = 200'
CHECKED J. A. Knowles	DATE
INSPECTED	
SUBMITTED [signature]	221
RECOMMENDED [signature]	02-1102
APPROVED	

REV. NO.	DATE	MADE	CHKD.	INSP.	SUBD.	R.-CD.	APPD.
1							
2							
3							
4							
5							







NOTES

1. Blow counts shown are averages for the indicated hole section required to drive a 5½" O.D casing with a diesel hammer developing 8000 ft. lb.
2. Standard penetration resistance referred to sections in inches shown thus "20/6" and indicating the number of blows of a 140 lb. weight falling 30" required to drive a 2" O.D. split-barrel spoon.
3. Drilling & sampling performed by Becker Drilling (Alberta) Ltd. with Hammer Drill Unit, Aug. 16 to 24, 1966
4. Laboratory testing of soil samples performed by R.A. Spence Ltd.

LEGEND

- □ Sample from recovered cuttings
- ☒ Split spoon sample
- ▮ Shelby tube sample, 3" O.D.
- LW Liquid limit water content.
- PW Plastic limit water content.

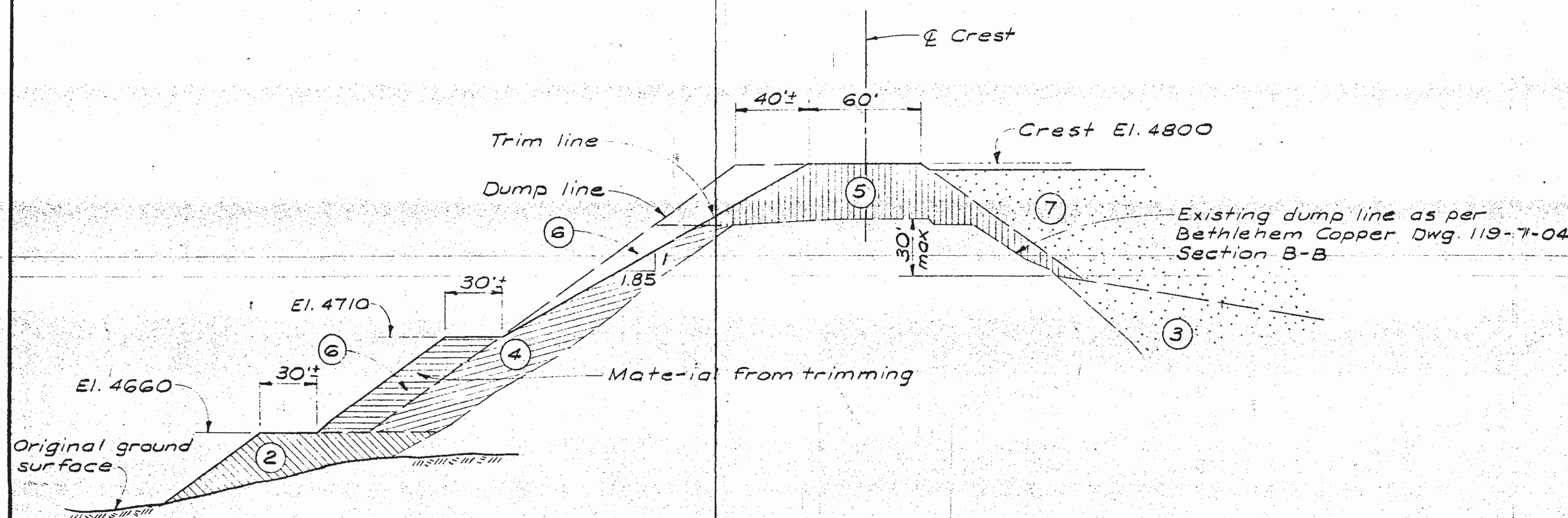
BETHLEHEM COPPER CORPORATION

HIGHLAND VALLEY MINE TAILINGS DAM FOUNDATION SOIL CHARACTERISTICS

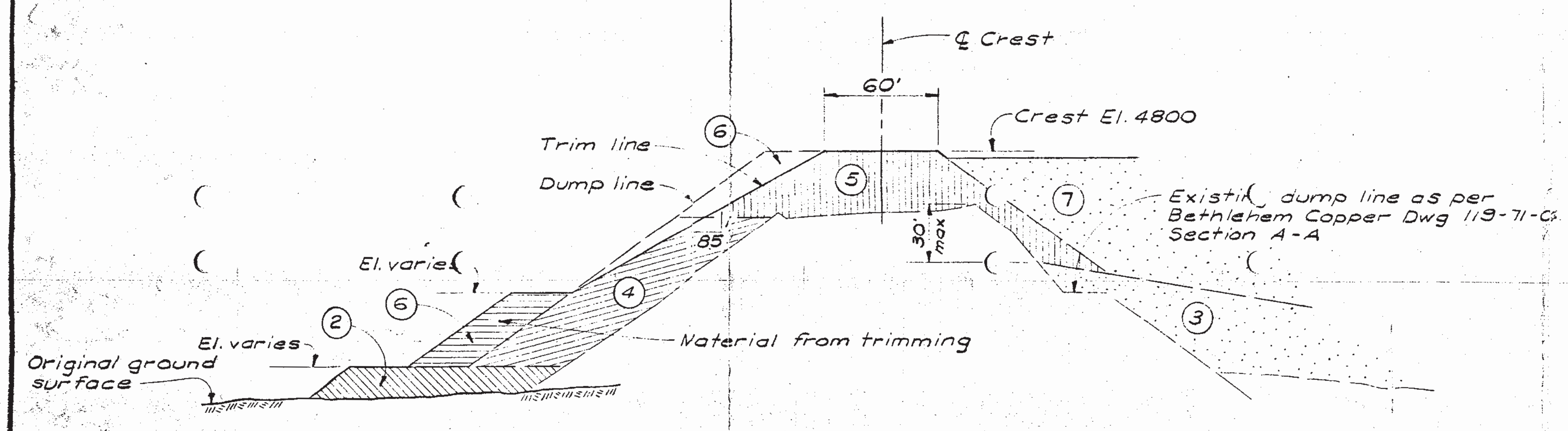
T. INGLEDOW & ASSOCIATES LIMITED
CONSULTING ENGINEERS — VANCOUVER, CANADA

DESIGNED	P.C.	SCALE	As shown
DRAWN	W.J.	DATE	OCT 10, 1966
CHECKED			221
INSPECTED			02-1004
SUBMITTED			
RECOMMENDED			
APPROVED			

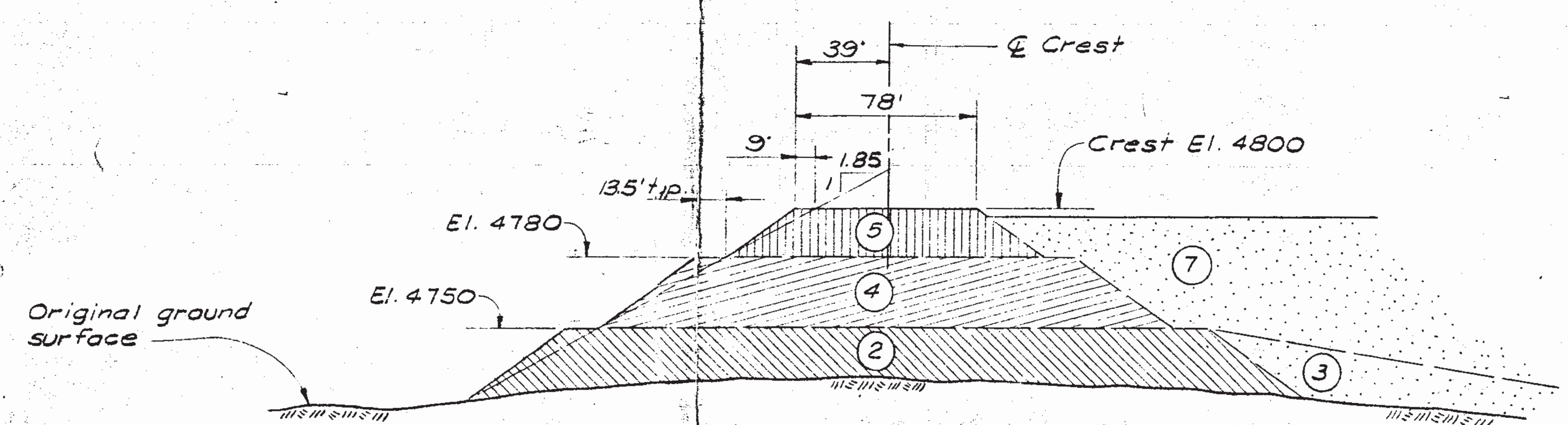
REV. NO.	DATE	MADE	CHKD.	INSP.	SUBD.	RECD.	APPD.
1							
2							
3							
4							
5							



SECTION D - D
(Approx. 16,800N)



SECTION E - E
(Approx. 17,180N)



SECTION F - F
(Approx. 17,720N)

LEGEND

(1) Sequence of construction

NOTES

1. For General Notes and References see Dwg 221-02-1102
2. For location of Sections see Dwg 221-02-1102
3. This Drawing supersedes Dwg. 221-02-1101
4. Rock fill material for construction sequences (1), (2), (4), and (5) to be any durable and strong rock material obtained from waste excavation providing that the silt (fines - #200 sieve) shall not exceed 30 percent by weight.
5. Material for sequences (3) and (7) to be deslimed tailings sands.

CONSTRUCTION ISSUE

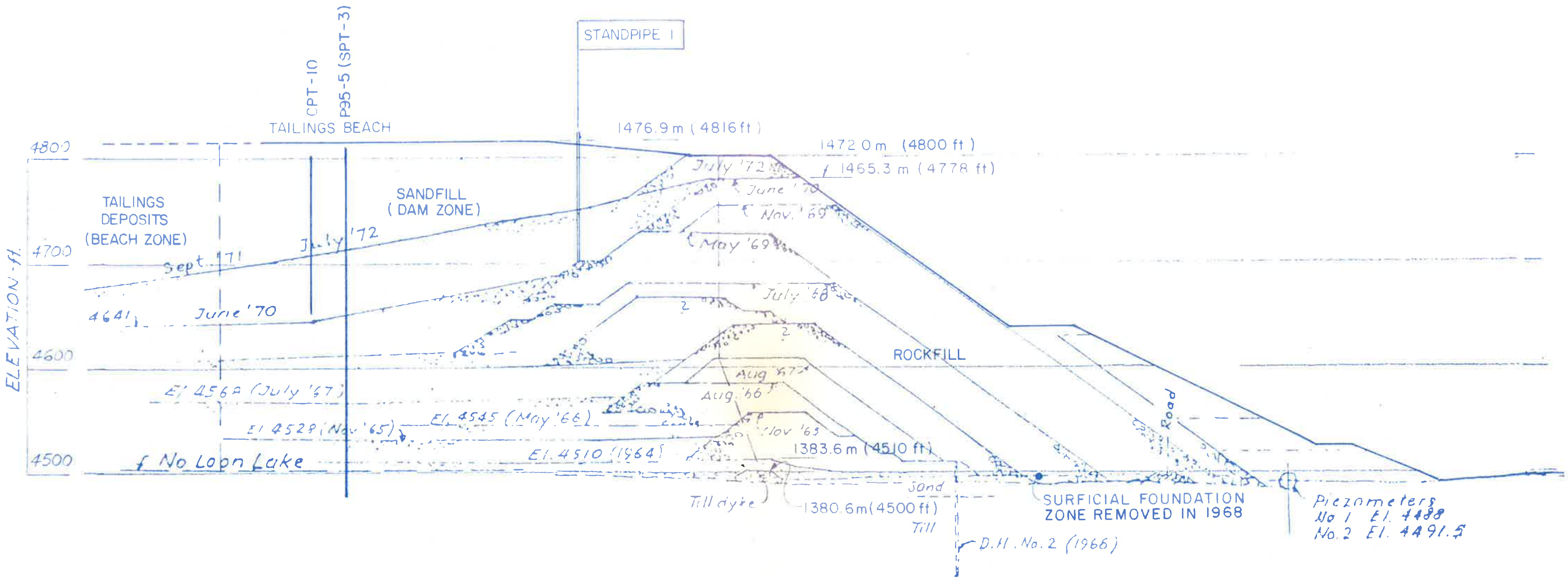
BETHLEHEM COPPER CORPORATION LIMITED

TAILINGS DAM NUMBER ONE
REDESIGN JULY 1971
SECTIONS - SHEET 2 OF 2

GEPAC CONSULTANTS LTD.
CONSULTING ENGINEERS — VANCOUVER, CANADA

DESIGNED	
DRAWN	H. Coulter
CHECKED	J. A. Knowles
INSPECTED	
SUBMITTED	[signature]
RECOMMENDED	
APPROVED	[signature]
SCALE	1" = 50'
DATE	
DWG. NO.	221 02-1104

REV. NO.	DATE	MADE	CHKD.	INSP.	SUBD.	RECD.	APPD.
1							
2							
3							
4							
5							



SECTION (A) AT STA. 6 (15 000 N)

SCALE 1" = 100' 23005/6

SOURCE

BETHLEHEM AS-BUILT DAM CONSTRUCTION SECTION.

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED DEC. 9, 1996

KLOHN-CRIPPEN		DATE
DESIGNED		
DRAWN		
CHECKED		
RECOMMENDED		
APPROVED		

KLOHN-CRIPPEN

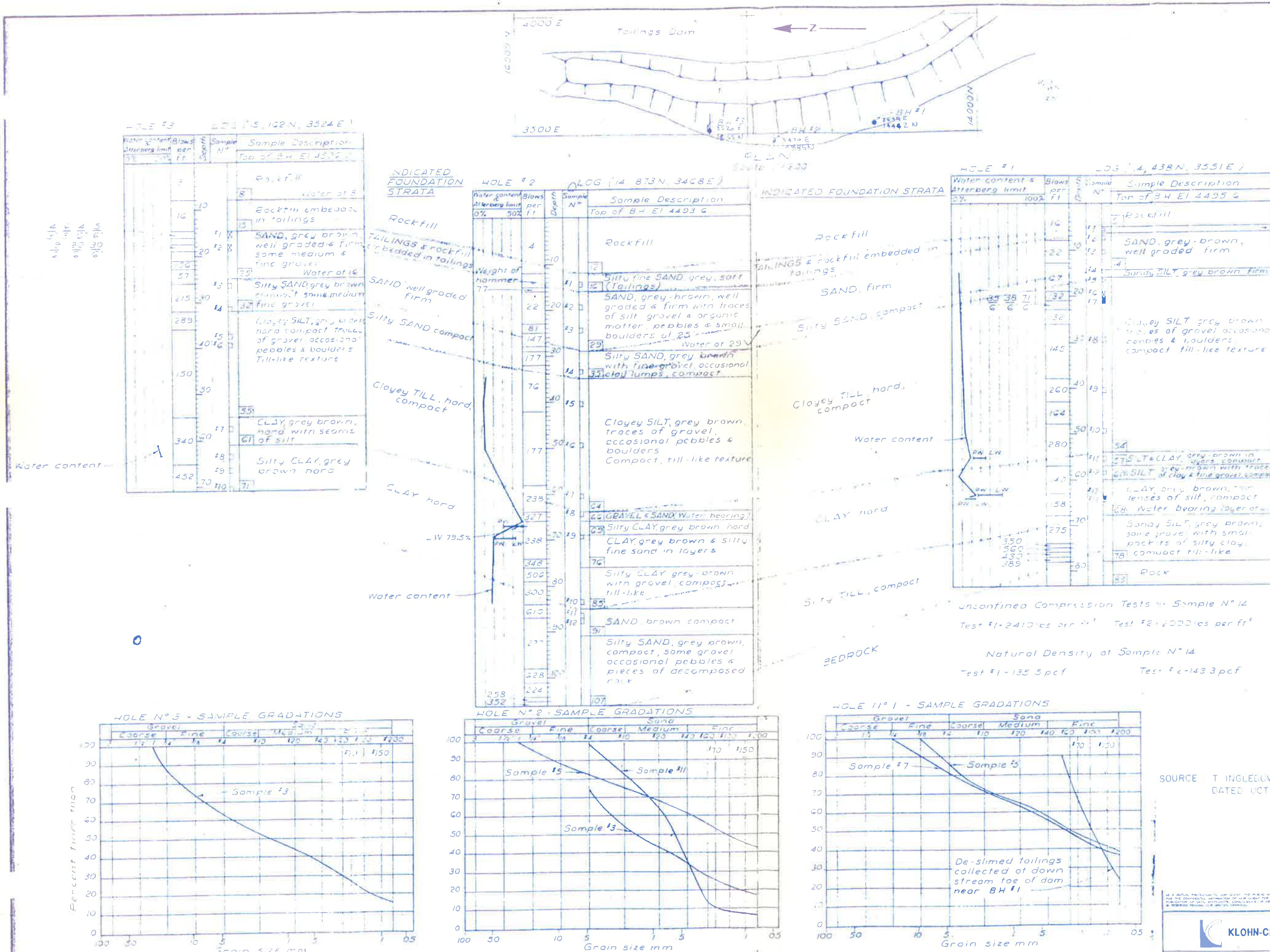
CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: TYPICAL SECTION DAM No. 1

SCALE

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
DEC. 9, 1996	PM2916 23	B-23C07	



NOTES

1. Blow counts shown are averages for the indicated hole section required to drive a 5½" OD casing with a diesel hammer developing 8000 ft lb
2. Standard penetration resistance referred to sections in inches shown thus 20/6 and indicating the number of blows of a 140 lb weight falling 30" required to drive a 2" OD split-barrel spoon
3. Drilling & sampling performed by Becker Drilling (Alberta) Ltd. with Hammer Drill Unit, Aug 16 to 24, 1966
4. Laboratory testing of soil samples performed by R A Spence Ltd

LEGEND

□	Sample from recovered cuttings
⊠	Split spoon sample
■	Shelby tube sample, 3" OD
LW	Liquid limit water content
PW	Plastic limit water content

SOURCE: T. INGLEDOW & ASSOCIATES LIMITED DWG. No. 221-02-1004, DATED OCT 10, 1966

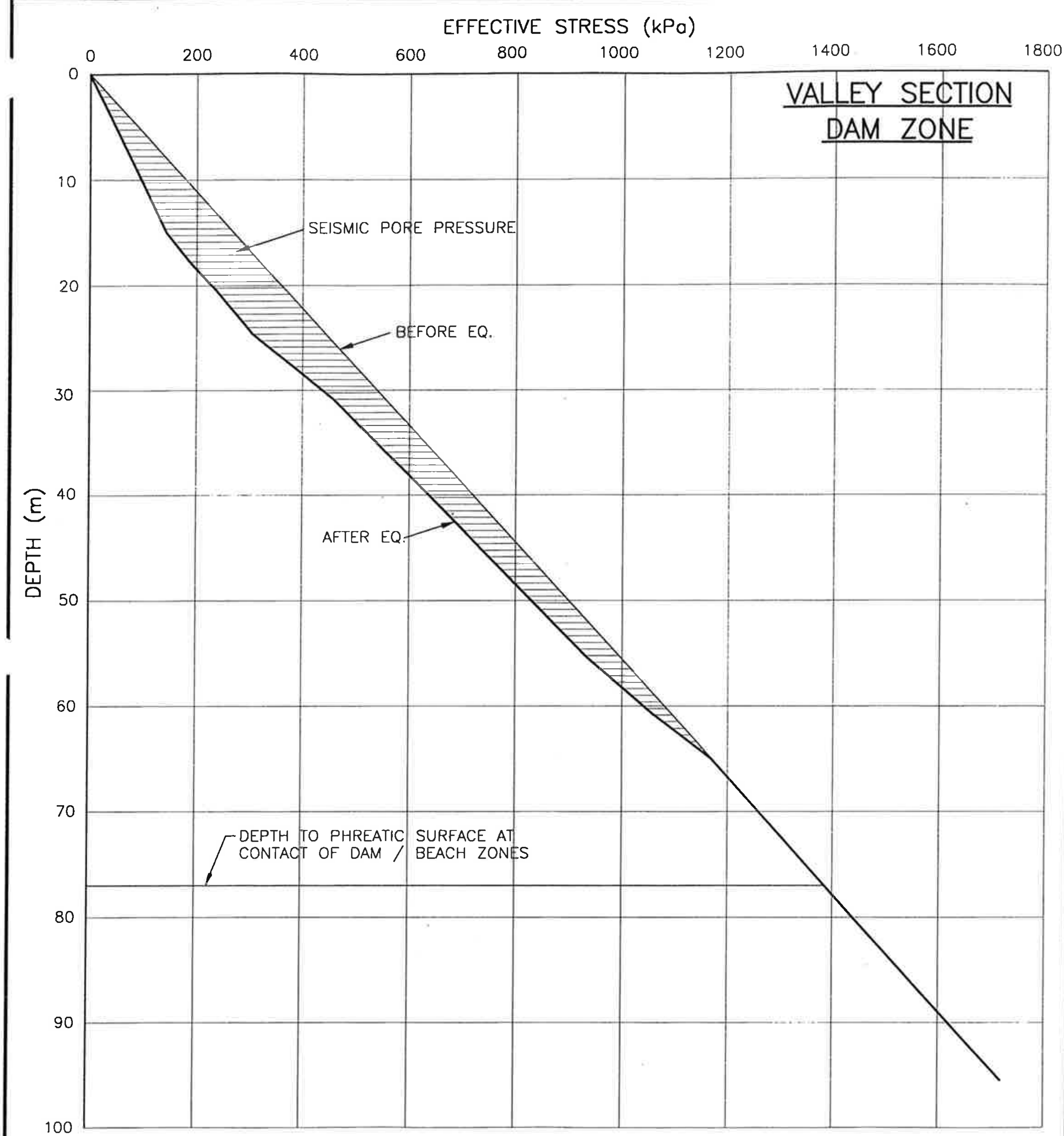
KLOHN-CRIPPEN

HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: SUBSOIL DATA - DAM No 1

DATE OF ISSUE	PROJECT No	DWG No	REV
DEC 9, 1996	PM296 23	B-23008	



SCALE

KLOHN-CRIPPEN

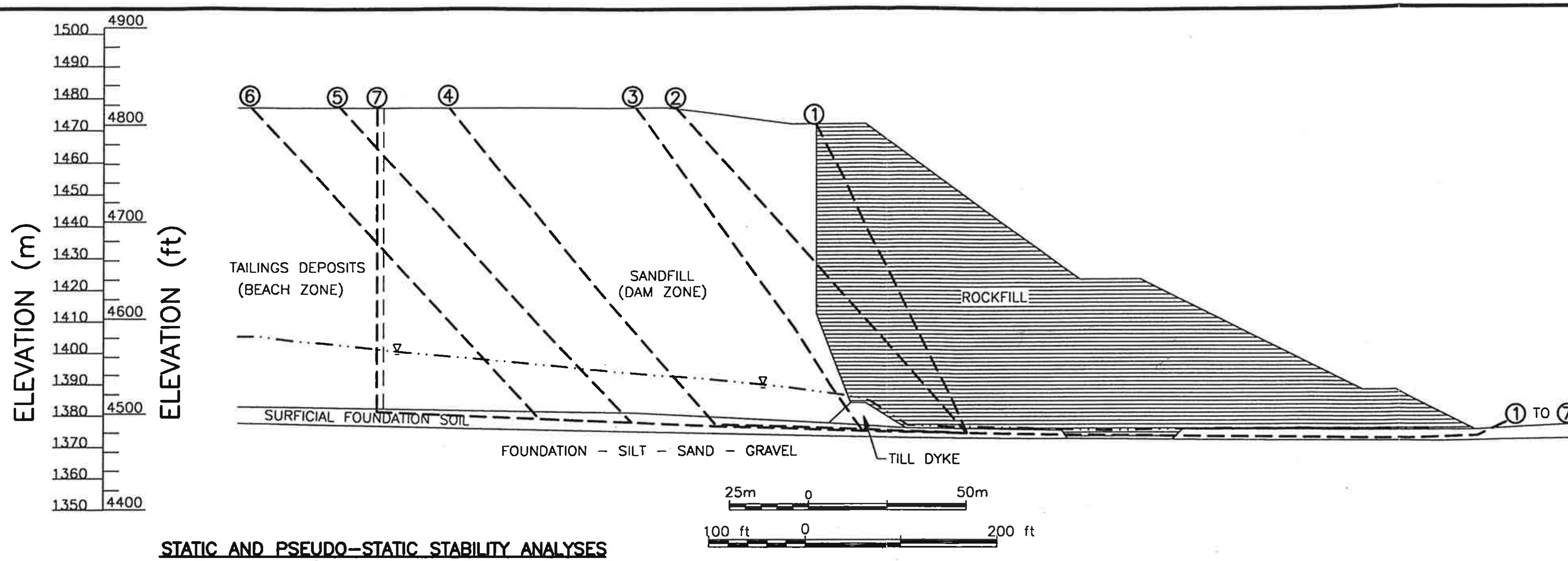
PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: EFFECTIVE STRESS CHANGE DUE TO EARTHQUAKE DAM No.1

CLIENT: HIGHLAND VALLEY COPPER

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
DEC. 9, 1996	PM2916 23	A-23009	

APPROVED



STATIC AND PSEUDO-STATIC STABILITY ANALYSES
SUMMARY OF SAFETY FACTOR AND YIELD ACCELERATION

FAILURE SURFACE NUMBER	FACTOR OF SAFETY (1)		YIELD ACCELERATION (g)
	STATIC	PSEUDO-STATIC (a=0.1g)	
③	1.71	1.31	0.22

(1) FACTOR OF SAFETY OBTAINED FROM SIMPLIFIED JANBU METHOD OF SLICES WITH NO CORRECTION FOR SIDE FORCES BETWEEN SLICES, USING SLOPE-W COMPUTER PROGRAM.

MATERIAL PROPERTIES

TYPE OF MATERIAL	UNIT WEIGHT		EFFECTIVE SHEAR STRENGTH(1) FRICTION ANGLE ϕ' (degree)
	γ_{moist} (kN/m³)	γ_{sat} (kN/m³)	
ROCKFILL	18.9	–	37
SAND FILL (DAM ZONE)	18	–	30
TAILINGS DEPOSITS (BEACH ZONE)	–	19	25
TILL DYKE	–	22.8	35
SURFICIAL SOIL ZONE	–	15.7	25/15 (2)
SILT/SAND/GRAVEL (FOUNDATION)	–	18.9	30

(1) EFFECTIVE SHEAR STRENGTH – COHESION C' = 0 kN/m²

(2) SURFICIAL SOIL ZONE – ϕ = 15% WAS SELECTED BY GOLDER (1970) THIS SELECTED STRENGTH APPEARS TO HAVE INCORPORATED ESTIMATED STRENGTH LOSS DUE TO EARTHQUAKE SHAKING. FOR STATIC CONDITION, ϕ = 25° IS USED.

POST-EARTHQUAKE STABILITY ANALYSIS
SUMMARY OF SAFETY FACTOR

FAILURE SURFACE NUMBER	FACTOR OF SAFETY (1)
①	1.42
②	1.31
③	1.27
④	1.49
⑤	1.61
⑥	1.50
⑦	1.28

(1) FACTOR OF SAFETY OBTAINED FROM SIMPLIFIED JANBU METHOD OF SLICES WITH NO CORRECTION FOR SIDE FORCES BETWEEN SLICES, USING SLOPE-W COMPUTER PROGRAM.

LEGEND

④– – – –④ FAILURE SURFACE No.4

– · · ∇ · · – PIEZOMETRIC SURFACE

NOTES

1. ELEVATION IN METRES REFERS TO HIGHLAND VALLEY COPPER DATUM.
2. ELEVATION IN FEET REFERS TO BETHLEHEM COPPER DATUM.

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED DEC. 9, 1996

SCALE

KLOHN-CRIPPEN		DATE
DESIGNED	PH	JUNE 96
DRAWN	CYW	
CHECKED		
RECOMMENDED		
APPROVED	[signature]	DEC.96

KLOHN-CRIPPEN

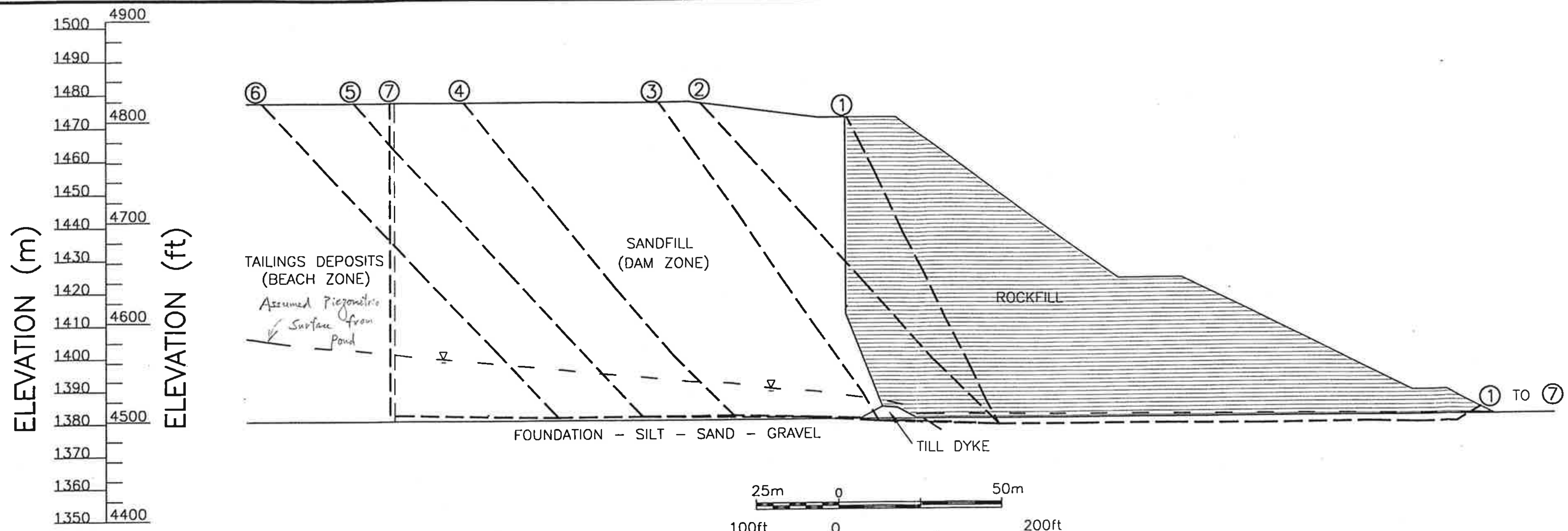
CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: STABILITY ANALYSES DAM No.1 SECTION A-A – VALLEY SECTION OVER SURFICIAL FOUNDATION ZONE

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
DEC. 9, 1996	PM2916 23	B-23010	

N:\M\M2916\CADD\23\23010.DWG
10/08/96 TIME: 2:15



STATIC AND PSEUDO-STATIC STABILITY ANALYSES SUMMARY OF SAFETY FOACTOR AND YIELD ACCELERATION

FAILURE SURFACE NUMBER	FACTOR OF SAFETY (1)		YIELD ACCELERATION (g)
	STATIC	PSEUDO-STATIC (a=0.1g)	
③	1.89	1.46	0.29

(1) FACTOR OF SAFETY OBTAINED FROM SIMPLIFIED JANBU METHOD OF SLICES WITH NO CORRECTION FOR SIDE FORCES BETWEEN SLICES, USING SLOPE-W COMPUTER PROGRAM.

MATERIAL PROPERTIES

TYPE OF MATERIAL	UNIT WEIGHT		EFFECTIVE SHEAR STRENGTH (1) FRICTION ANGLE
	γ_{moist} (kN/m³)	γ_{sat} (kN/m³)	ø' (degree)
ROCKFILL	18.9	–	37
SANDFILL (DAM ZONE)	18	–	30
TAILINGS DEPOSITS (BEACH ZONE)	–	19	25
TILL DYKE	–	22.8	35
SILT/SAND/GRAVEL FOUNDATION	–	18.9	30

(1) EFFECTIVE SHEAR STRENGTH – COHESION C' = 0 kN/m^2

POST-EARTHQUAKE STABILITY ANALYSIS SUMMARY OF SAFETY FACTOR

FAILURE SURFACE NUMBER	FACTOR OF SAFETY (1)
①	1.76
②	1.58
③	1.76
④	2.26
⑤	2.54
⑥	2.68
⑦	2.49

(1) FACTOR OF SAFETY OBTAINED FROM SIMPLIFIED JANBU METHOD OF SLICES WITH NO CORRECTION FOR SIDE FORCES BETWEEN SLICES, USING SLOPE-W COMPUTER PROGRAM.

LEGEND

④– – – –④ FAILURE SURFACE No.4

– ▽ – PIEZOMETRIC SURFACE

NOTES

1. ELEVATION IN METRES REFERS TO HIGHLAND VALLEY COPPER DATUM.
2. ELEVATION IN FEET REFERS TO BETHLEHEM COPPER DATUM.

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED DEC. 9, 1996

KLOHN-CRIPPEN		DATE
DESIGNED	PH	JUNE 96
DRAWN	CYW	
CHECKED		
RECOMMENDED		
APPROVED	(signature)	DEC-96

KLOHN-CRIPPEN

CLIENT: HIGHLAND COPPER VALLEY

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: STABILITY ANALYSES DAM No.1 SECTION B-B – TYPICAL VALLEY SECTION

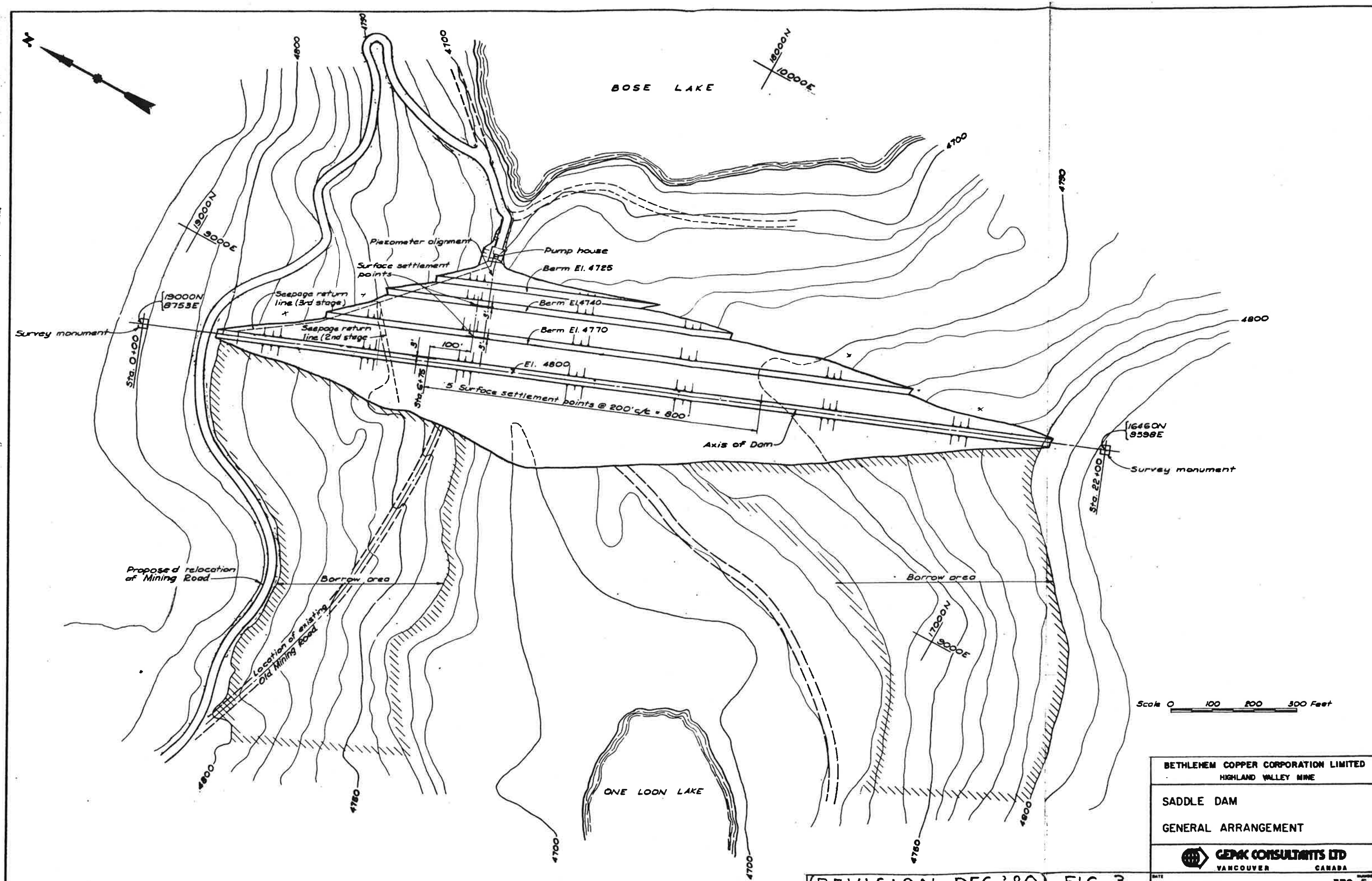
SCALE

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
DEC. 9, 1996	PM2916 23	B-23011	

N:\M\M2916\CADD\23\B-23011.DWG 10/08/96 TIME: 2.30

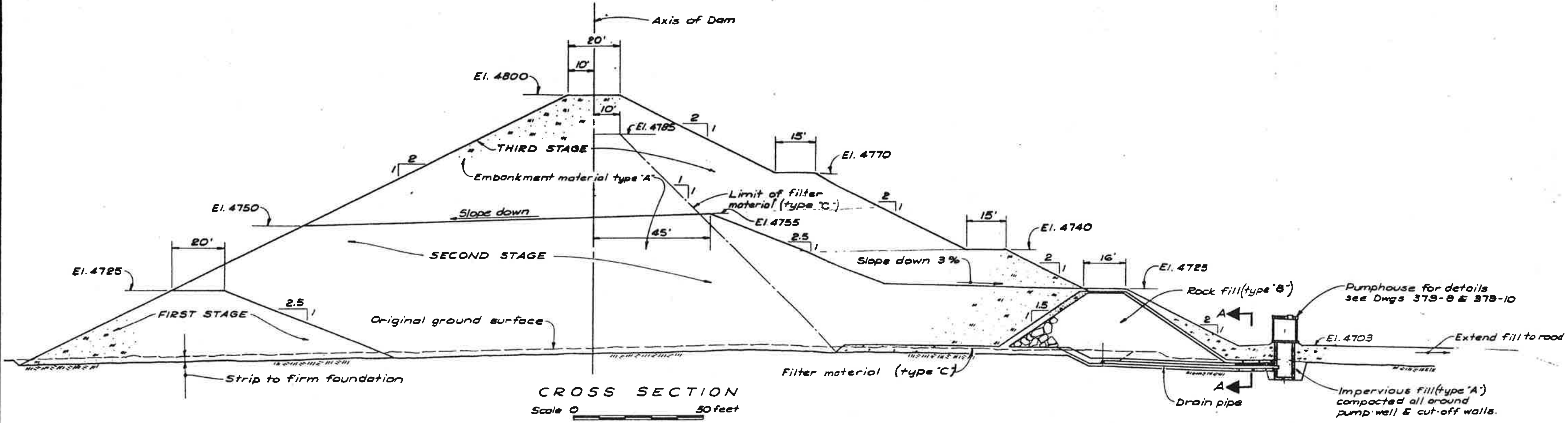
APPENDIX III-B-2

Reference Dam Design Drawings – Bose Lake Dam



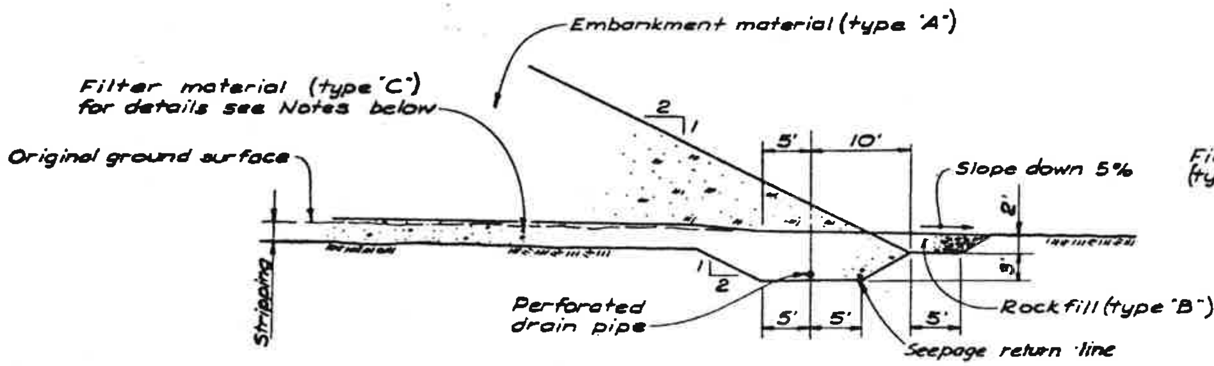
BETHLEHEM COPPER CORPORATION LIMITED HIGHLAND VALLEY MINE
SADDLE DAM GENERAL ARRANGEMENT
GEPAC CONSULTANTS LTD VANCOUVER CANADA
JANUARY, 1972 379-5

(REVISION DEC.'80) FIG. 3



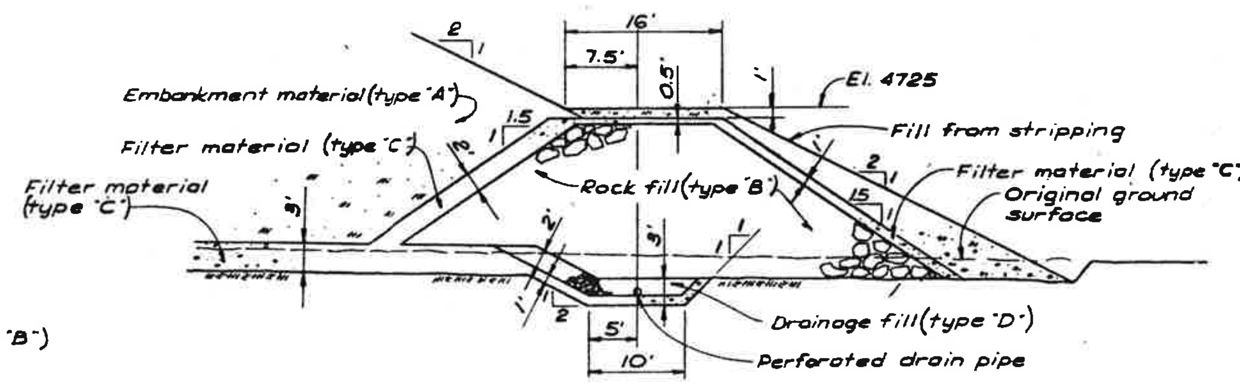
CROSS SECTION

Scale 0 50 feet



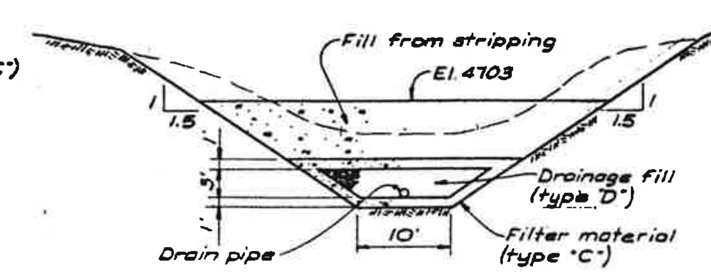
DOWNSTREAM TOE ABOVE EL. 4725

Scale 0 10 20 30 feet



DOWNSTREAM TOE BELOW EL. 4725

Scale 0 10 20 30 feet



SECTION A-A

Scale 0 10 20 30 feet

NOTES

1. Thickness of drainage blanket to be 36" from El. 4700 to El. 4725, 30" from El. 4725 to El. 4750, and 24" from El. 4750 to El. 4785. Elevations refer to stripped foundation surface. No blanket above El. 4785
2. The perforated drain pipe to be 8" from bottom to El. 4725 and 6" above El. 4725 and terminate at El. 4785. Elevations are at invert of pipe.

CONSTRUCTION MATERIAL

TYPE 'A'
Impervious fill — Silty sand and gravel, max. size 6", well graded, more than 10% finer than #200 sieve.

TYPE 'B'
Rock fill — Rock and sandy gravel reasonably sound, max. size 24", less than 30% finer than #4 sieve.

TYPE 'C'
Filter material — Medium to coarse sandy gravel, sound and durable, max. size 3", less than 10% finer than #20 sieve.

TYPE 'D'
Drainage fill — Free draining gravel max size 3", less than 20% finer than #4 sieve.

BETHLEHEM COPPER CORPORATION LIMITED
HIGHLAND VALLEY MINE

SADDLE DAM

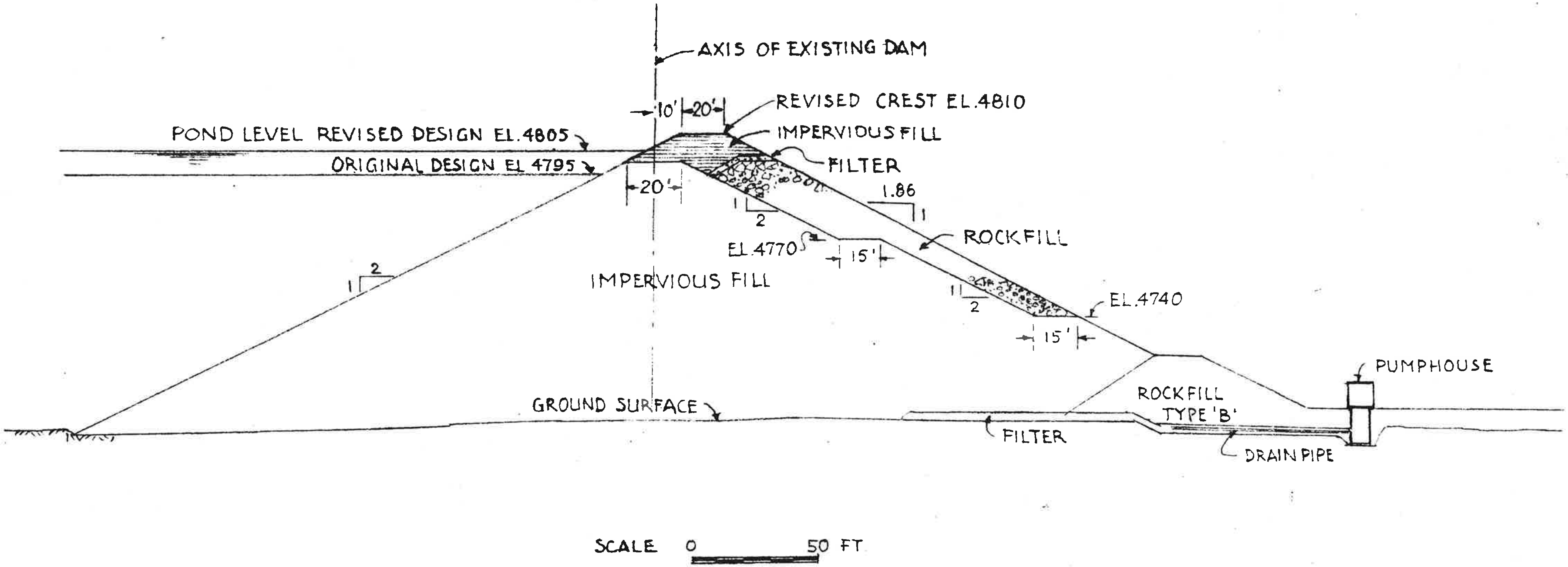
SECTIONS AND DETAILS

GEPAC CONSULTANTS LTD
VANCOUVER CANADA

(REVISION DEC. '80) FIG. 4

DATE JANUARY, 1972

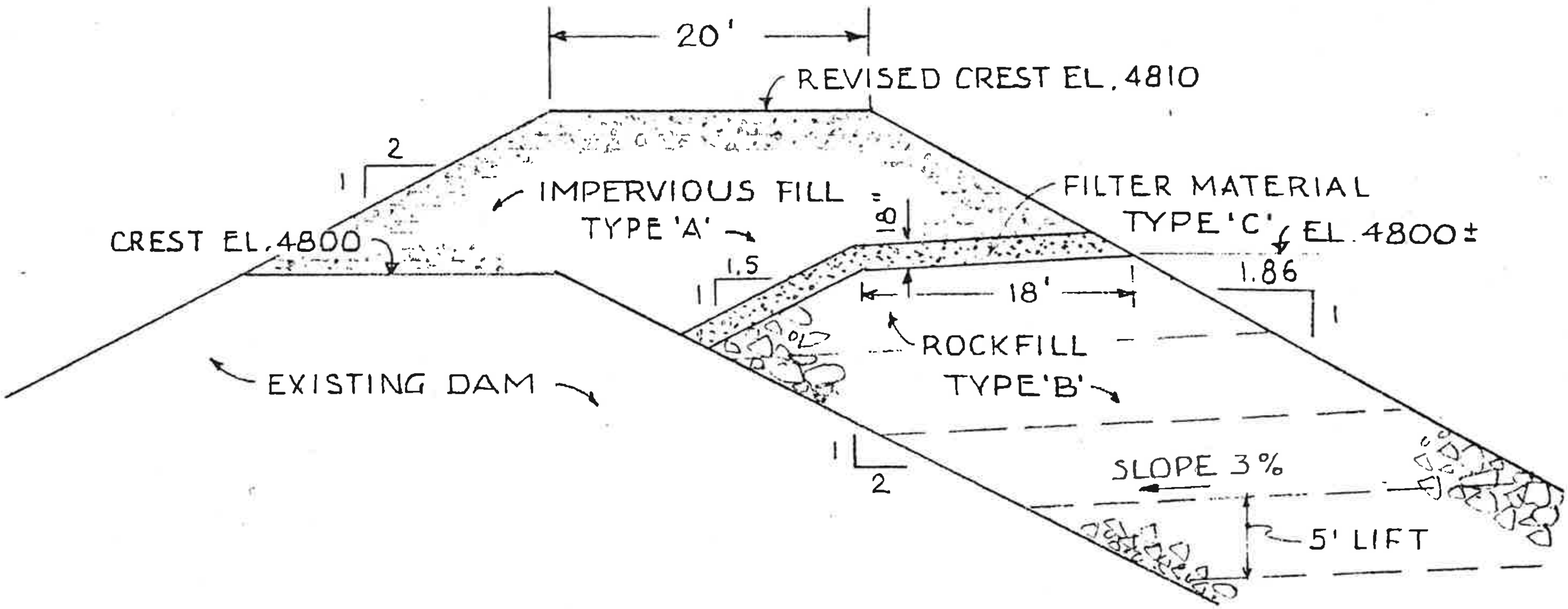
NUMBER 379-6



BOSE LAKE DAM
REVISED CROSS-SECTION

DEC.1980

FIGURE 5



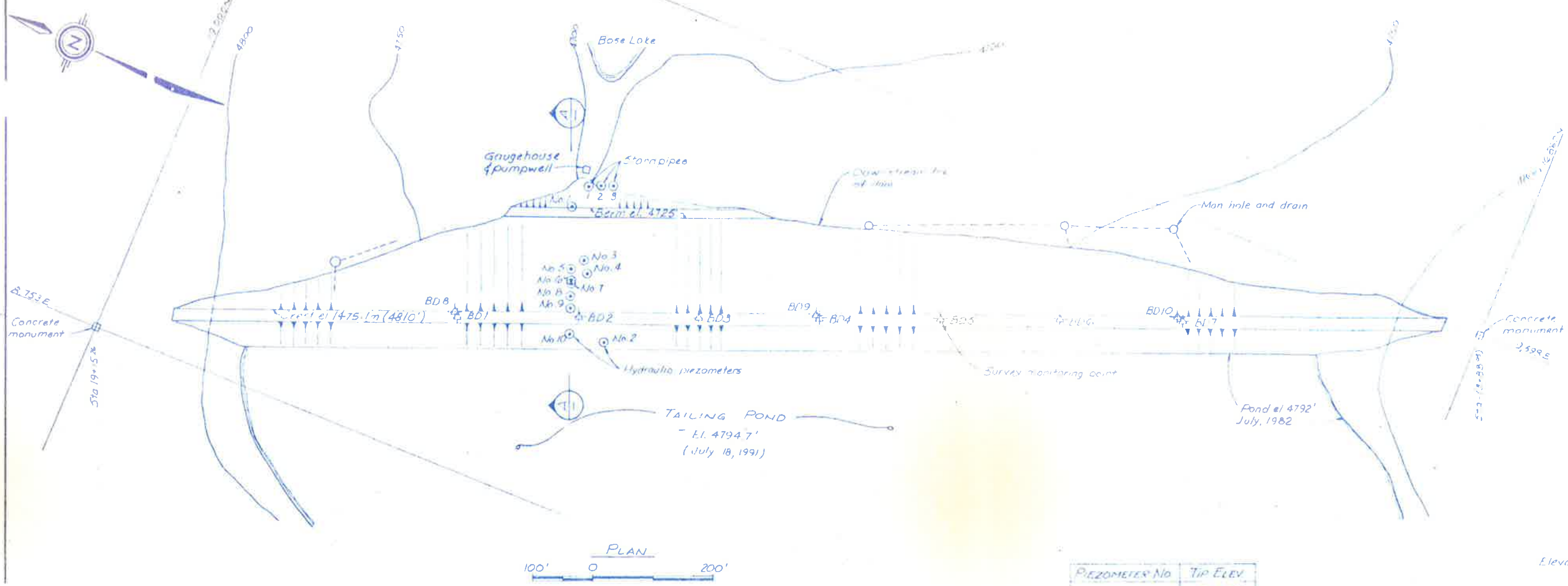
SCALE 1" = 10'

FIG. 6

BOSE LAKE DAM

REVISED CREST DETAIL

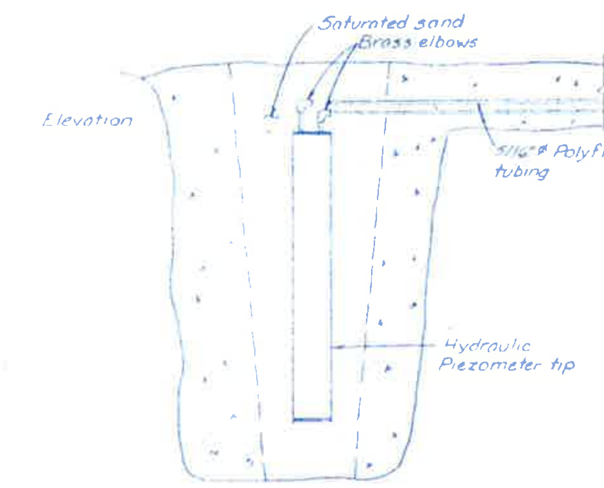
DEC. 1980 FIGURE 6



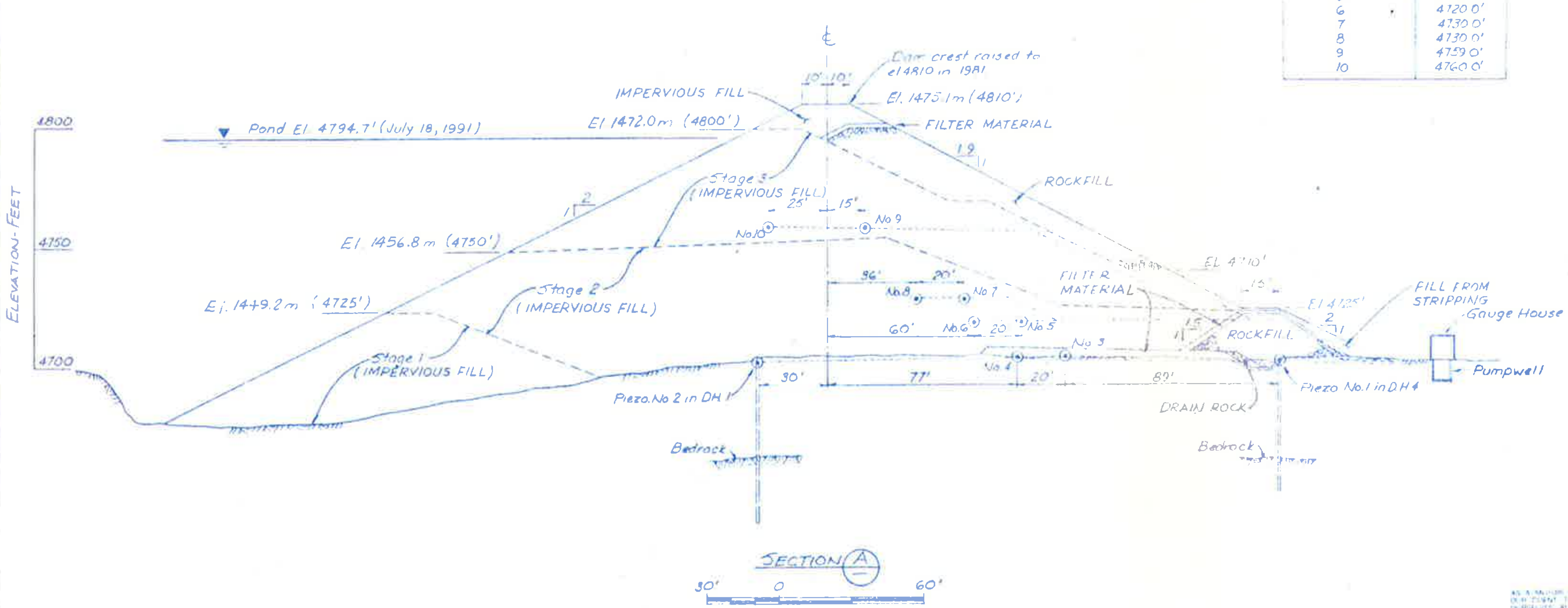
Piezometer No	Tip Elev
1	4704.63'
2	4703.56'
3	4705.0'
4	4720.0'
5	4720.0'
6	4720.0'
7	4730.0'
8	4730.0'
9	4759.0'
10	4760.0'

CONSTRUCTION MATERIAL SPECIFICATIONS (Note 3)

- Impervious Fill - Well-graded silty sand and gravel, max. size 6", with >10% finer than No. 200 sieve.
- Rockfill - Rock and sandy gravel, reasonably sound, max size 24", less than 30% finer than No. 4 seive.
- Filter Material - Medium to coarse sandy gravel, sound and durable, max size 3", less than 10% finer than No. 200 sieve.
- Drain Rock - Free-draining gravel, max size 3", less than 20% finer than No. 4 sieve.



PIEZOMETER DETAIL
NTS



SECTION A

NOTES

1. Based on drawing D-211 83-01 supplied by Cominco Copper Division.
2. Outlines of construction stages are approximate.
3. Construction material specifications as outlined in December 31, 1980 design report by H. Fellhauser, P. Eng.
4. Only survey monitoring points BD8, BD9 and BD10 remain as of August, 1991.
5. Elevations based on Bethlehem datum.

SOURCE: KLOHN LEONOFF PROJECT No. PB2916 18, DWG. No. D-2026 REV C, DATED NOV 13, 1992.

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED DEC 9, 1995

KLOHN-CRIPPEN

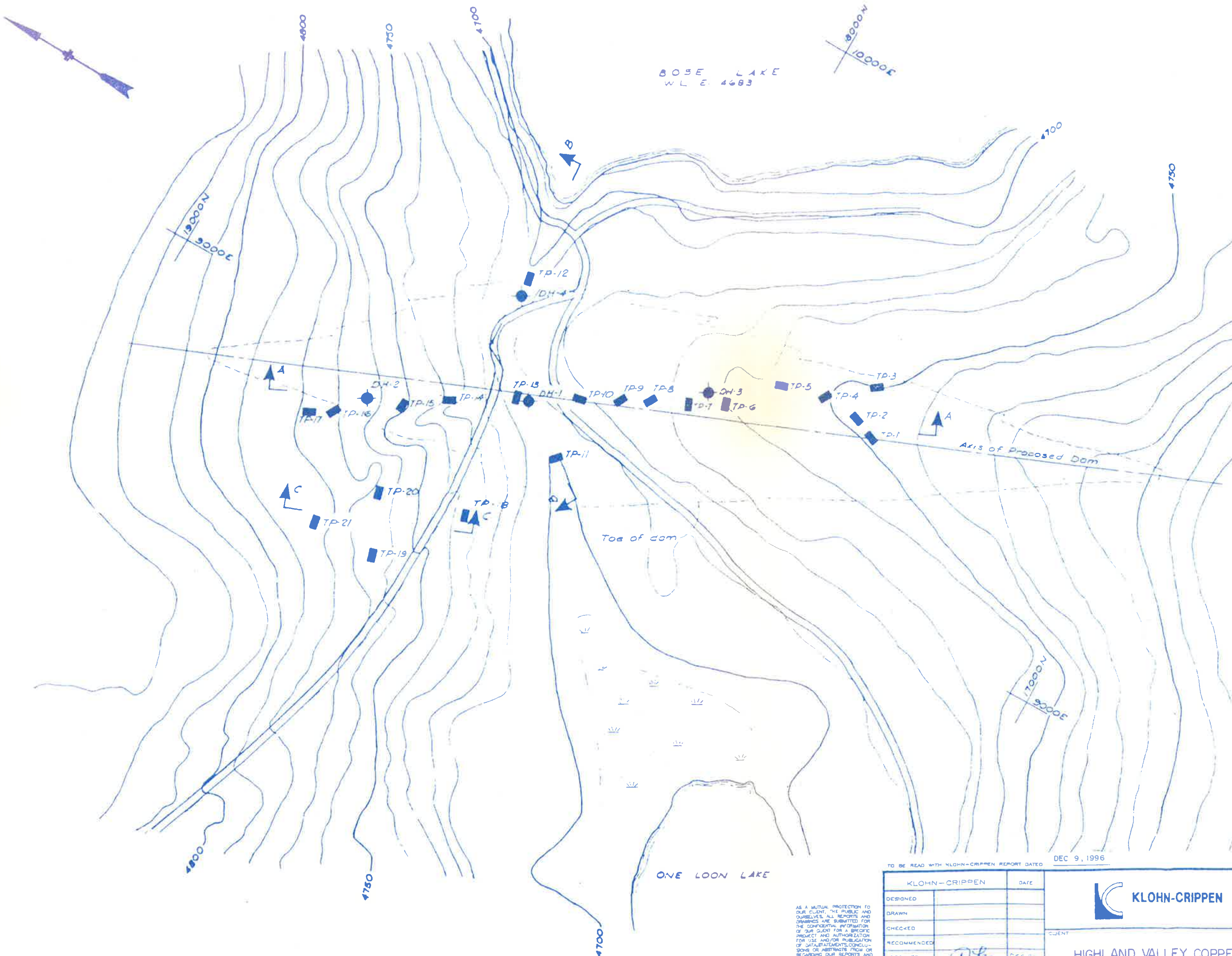
CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: PLAN AND TYPICAL SECTION BOSE LAKE DAM

DRAWN: EDP | DATE: MARCH, 1983 | SCALES: AS SHOWN

DATE OF ISSUE: DEC 9, 1995 | PROJECT No: PM2916 23 | DWG No: B-23012



NOTES

1 Coordinates shown on drawings refer to the grid system used by Bethlehem Copper Corporation Ltd.

2 Topography is based on aerial mapping correlated by ground survey.

3 The location and elevation of drill holes are as follows.

Drill Hole	Coordinates	Ground Elev
DH-1	18225 N 9050 E	4704
DH-2	18520 N 8895 E	4765
DH-3	17905 N 9245 E	4736
DH-4	18345 N 9232 E	4703

4 Sections are shown on Dwg 379-4

LEGEND

Drill Holes

Test Pits

SOURCE :
GEPAC CONSULTANTS LTD, DWG No. 379-3, DATED JANUARY, 1972.

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED DEC 9, 1996

SCALE

KLOHN-CRIPPEN		DATE
DESIGNED		
DRAWN		
CHECKED		
RECOMMENDED		
APPROVED	R.Fo	DEC 96

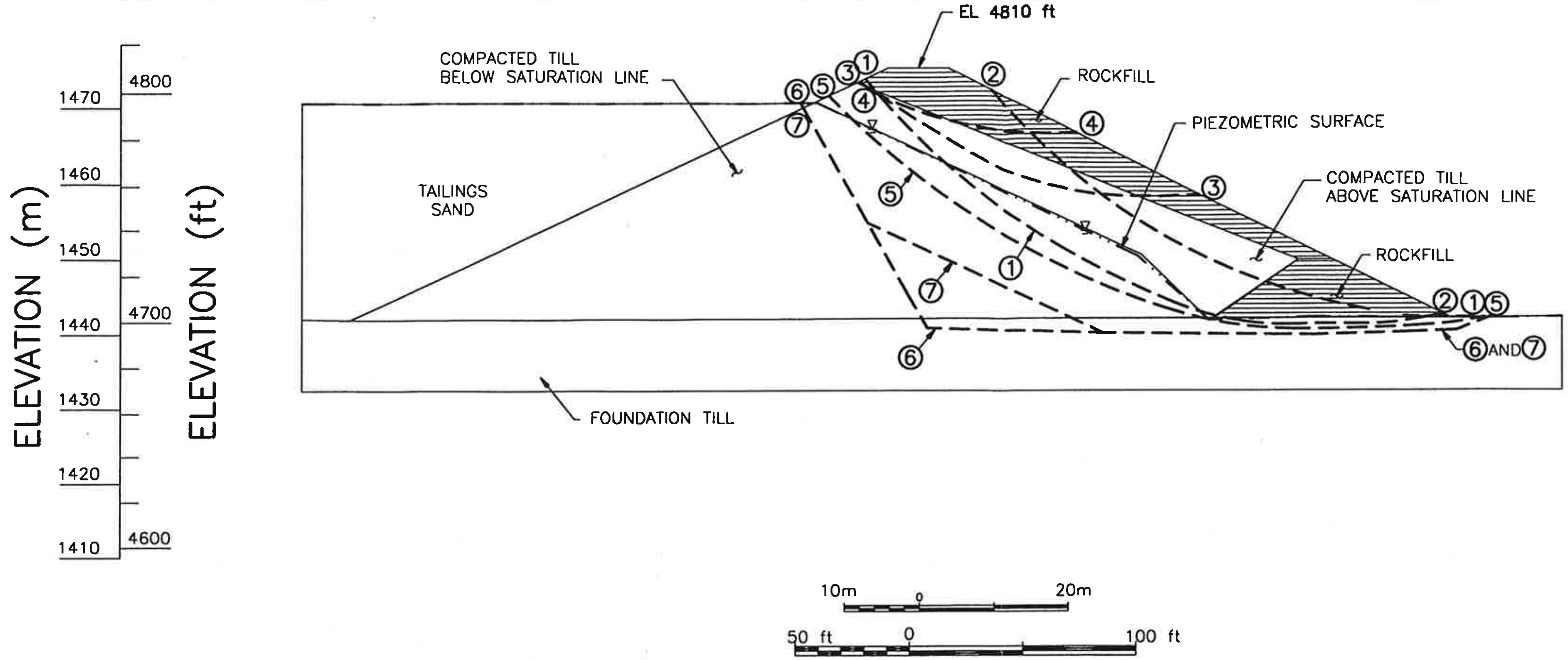
KLOHN-CRIPPEN

CLIENT
HIGHLAND VALLEY COPPER

PROJECT
LONG-TERM STABILITY ASSESSMENT

TITLE
LOCATION PLAN OF TEST HOLES
AND TEST PITS
BOSE LAKE DAM

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
DEC 9, 1996	PM2916 23	B-23013	



STATIC AND PSEUDO-STATIC STABILITY ANALYSES SUMMARY OF SAFETY FACTOR AND YIELD ACCELERATION

FAILURE SURFACE NUMBER	FACTOR OF SAFETY (1)		YIELD ACCELERATION (g)
	STATIC	PSEUDO-STATIC (a=0.1g)	
①	1.56	1.23	0.2
②	1.50	1.19	0.2
③	1.88	1.45	0.3
④	3.00	2.09	0.45
⑤	1.60	1.23	0.2
⑥	1.98	1.47	0.25
⑦	1.73	1.30	0.2

(1) FACTOR OF SAFETY OBTAINED FROM SIMPLIFIED JANBU METHOD OF SLICES WITH NO CORRECTION FOR SIDE FORCES BETWEEN SLICES, USING SLOPE-W COMPUTER PROGRAM.

MATERIAL PROPERTIES

TYPE OF MATERIAL	UNIT WEIGHT		EFFECTIVE SHEAR STRENGTH(1) FRICTION ANGLE ø' (degree)
	γ_{moist} (kN/m^3)	γ_{sat} (kN/m^3)	
ROCKFILL	18.9	–	37
COMPACTED TILL (ABOVE SATURATION LINE)	21.5	–	35
COMPACTED TILL (BELOW SATURATION LINE)	–	22.0	35
FOUNDATION TILL	–	22.8	35

(1) EFFECTIVE SHEAR STRENGTH – COHESION C' = 0 kN/m^2

LEGEND

④- - - -④ FAILURE SURFACE No.4

–··▽··– PIEZOMETRIC SURFACE

NOTES

1. ELEVATION IN METRES REFERS TO HIGHLAND VALLEY COPPER DATUM.
2. ELEVATION IN FEET REFERS TO BETHLEHEM COPPER DATUM.

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED DEC. 9, 1996

KLOHN-CRIPPEN		DATE
DESIGNED	PH	JUNE 96
DRAWN	CYW	
CHECKED		
RECOMMENDED		
APPROVED	(signature)	DEC.96

KLOHN-CRIPPEN

CLIENT: HIGHLAND COPPER VALLEY

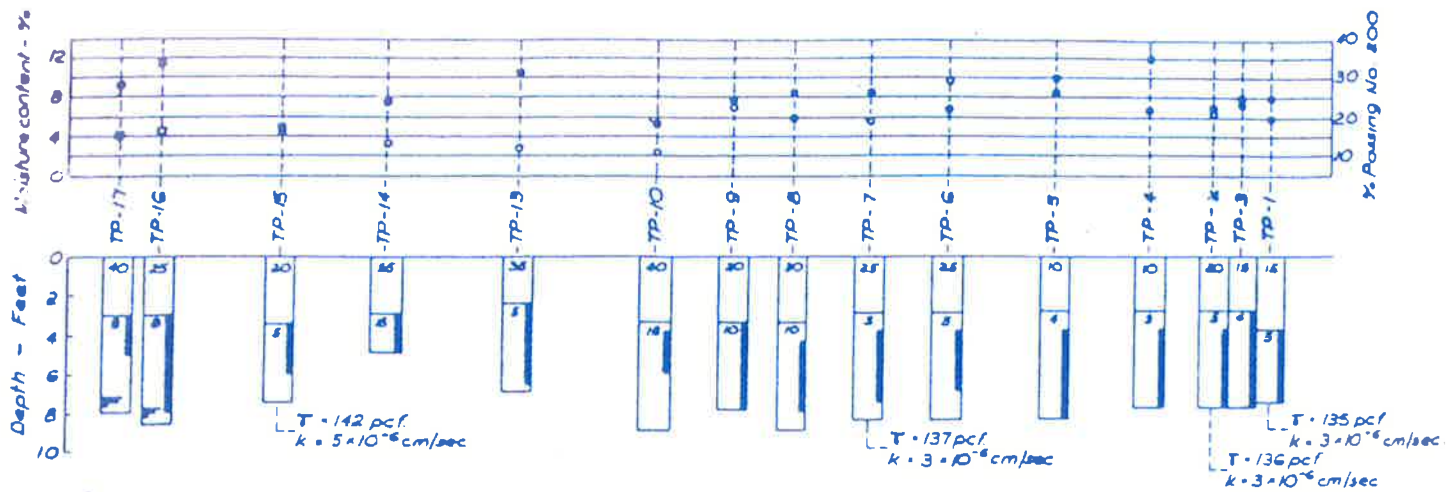
PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: STABILITY ANALYSES BOSE LAKE DAM

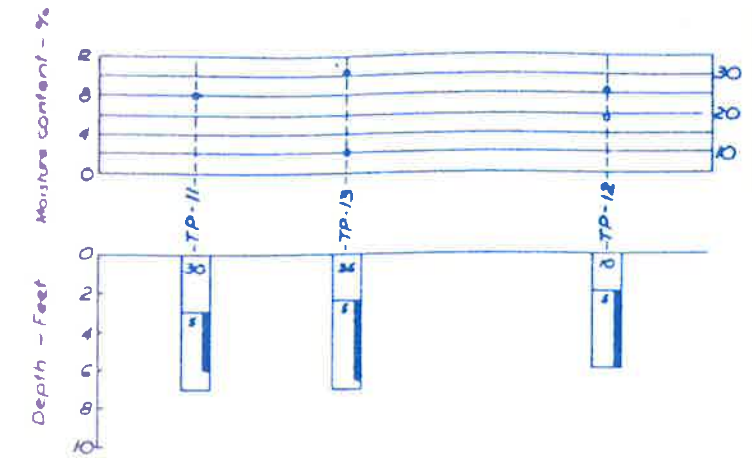
SCALE

DATE OF ISSUE: DEC. 9, 1996 | PROJECT No.: PM2916 23 | DWG. No.: B-23015 | REV

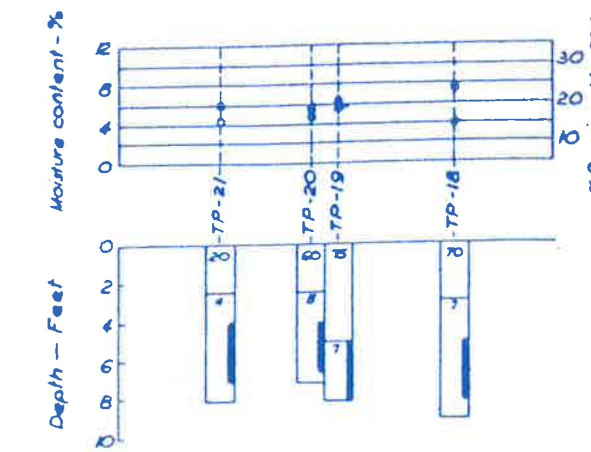
N:\M\M2916\CADD\23\B-23015.DWG 08/23/96 time 4:30



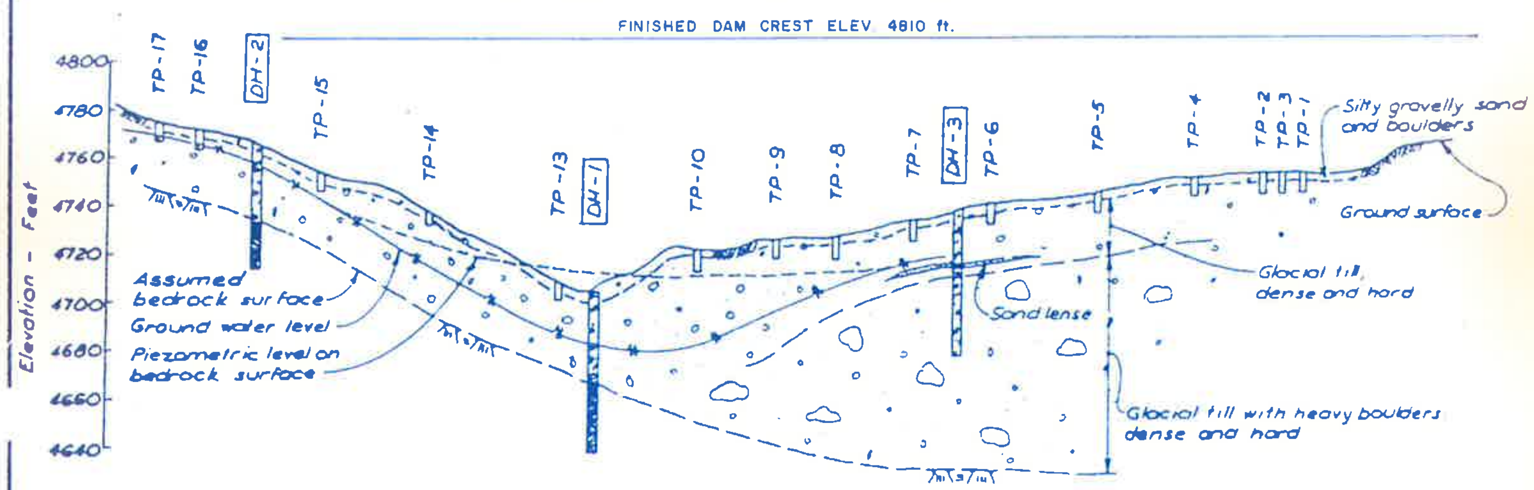
LOG OF TEST PITS ALONG SECTION A - A



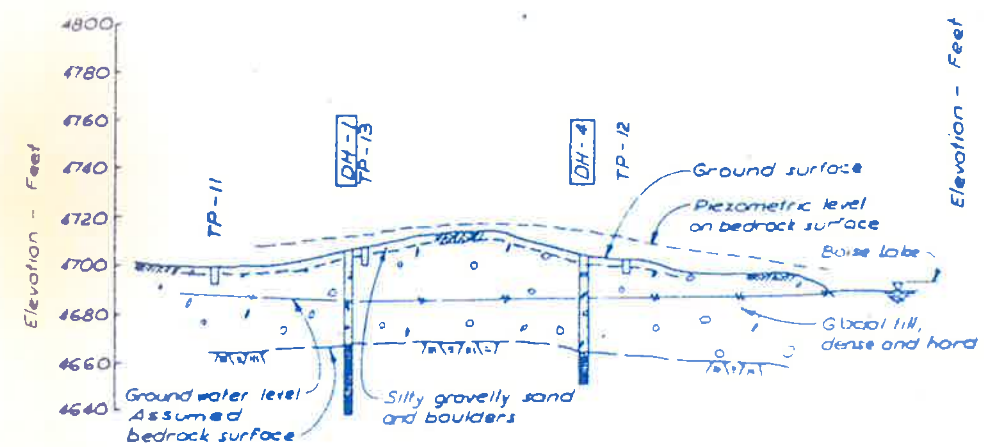
LOG OF TEST PITS ALONG SECTION B - B



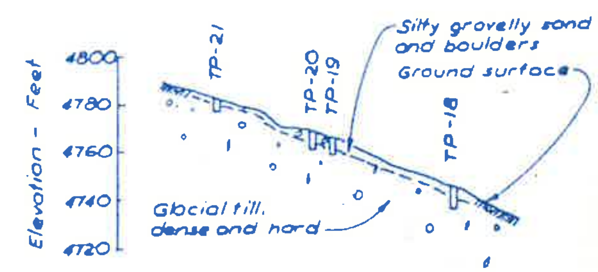
LOG OF TEST PITS ALONG SECTION C-C



SECTION A - A



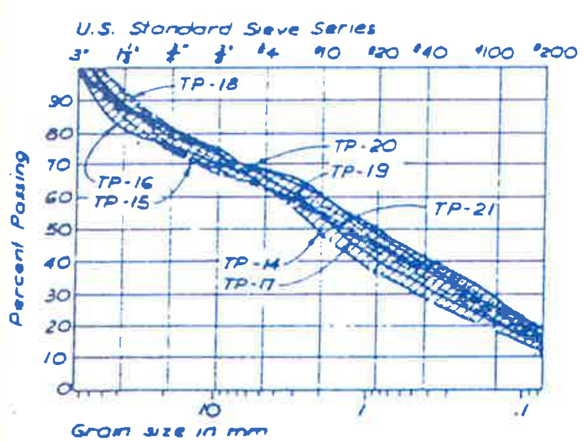
SECTION B - B



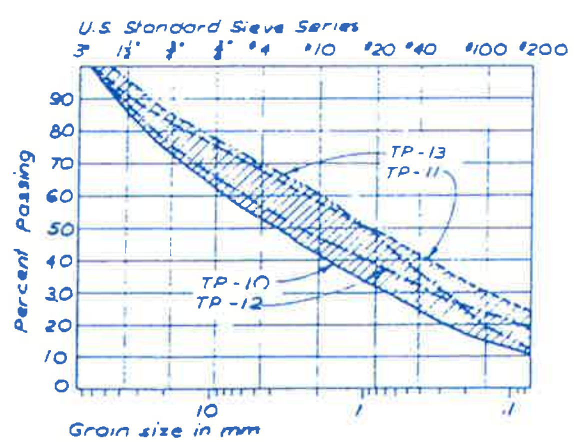
SECTION C-C

NOTES

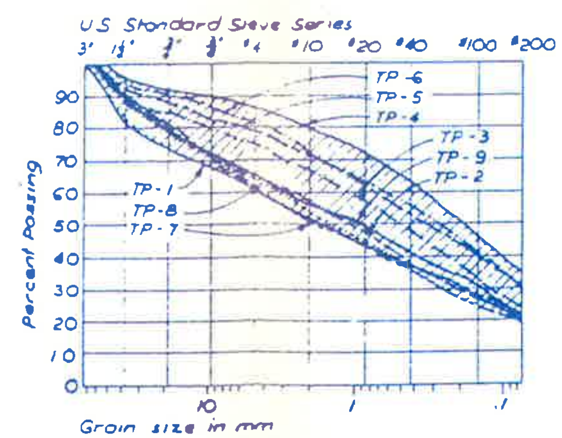
1. Location of sections shown on Dwg. 379-3
2. Bedrock surface, ground water and piezometric levels shown on sections between drill holes (DH) are inferred and approximate only



Left Abutment (TP-14 to TP-21)

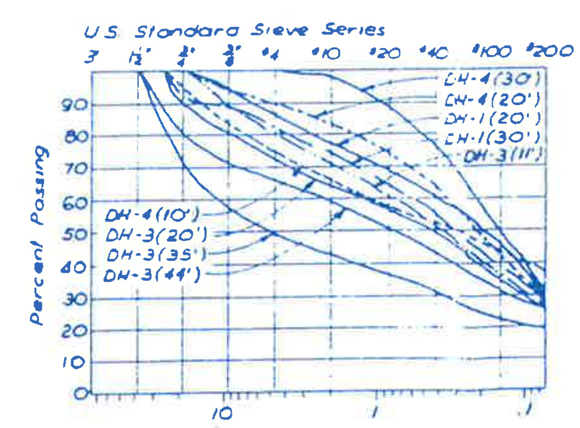


Centre (TP-10 to TP-13)



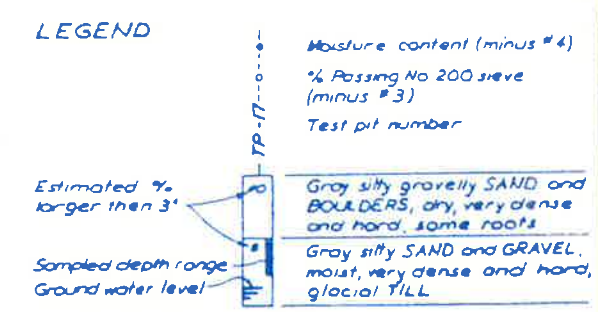
Right Abutment (TP-1 to TP-9)

GRAIN SIZE DISTRIBUTION — TEST PIT SAMPLES



GRAIN SIZE DISTRIBUTION - DRILL HOLE SAMPLES

LEGEND



T = in-situ dry density (minus #3)
k = coefficient of permeability

SOURCE:
GEPAC CONSULTANTS LTD. DWG. No. 379-4, DATED JANUARY, 1972.

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED DEC. 9, 1996

KLOHN-CRIPPEN		DATE
DESIGNED		
DRAWN		
CHECKED		
RECOMMENDED		
APPROVED	[signature]	DEC.96

KLOHN-CRIPPEN

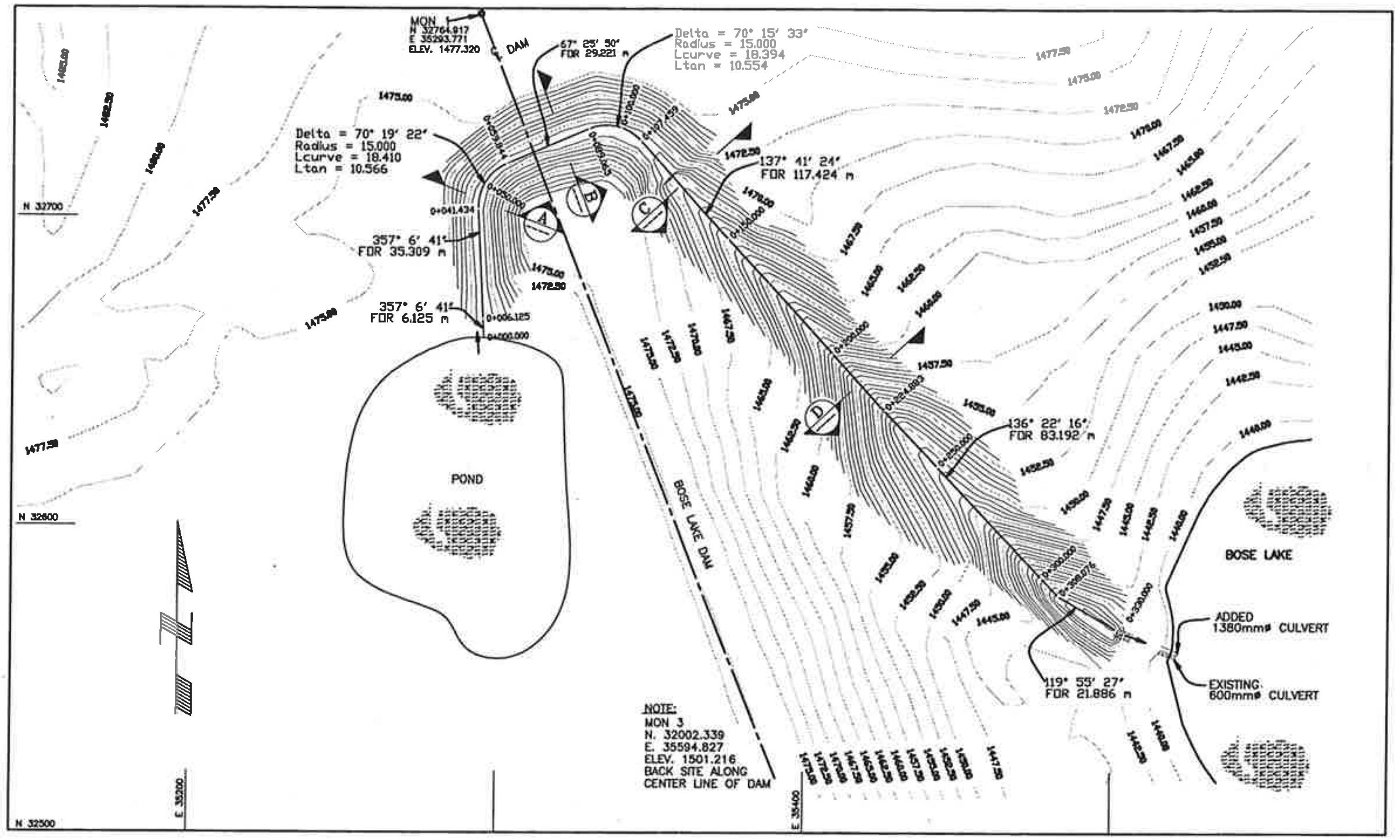
CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

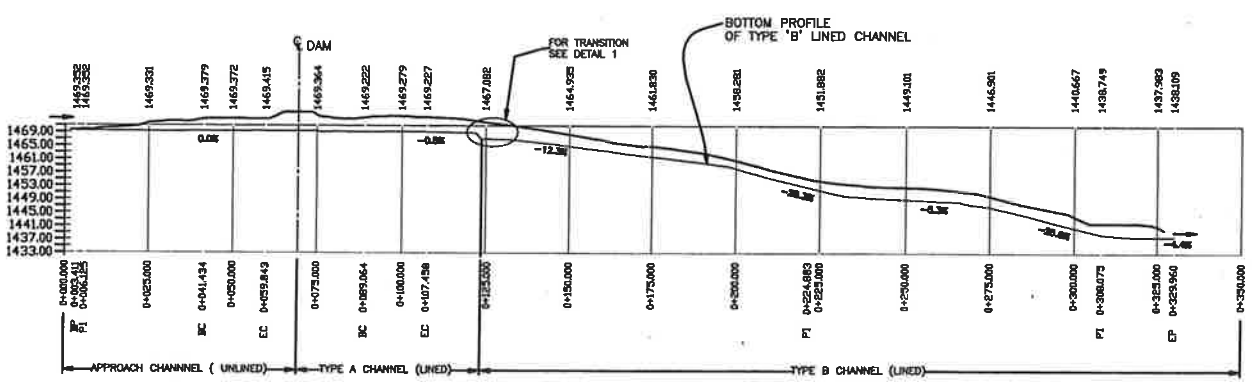
TITLE: SUBSOIL DATA - BOSE LAKE DAM

SCALE

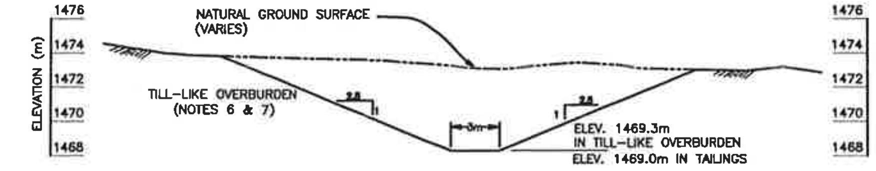
DATE OF ISSUE	PROJECT No.	DWG No.	REV.
DEC. 9, 1996	PM2916 23	B-23014	



GENERAL ARRANGEMENT – PLAN

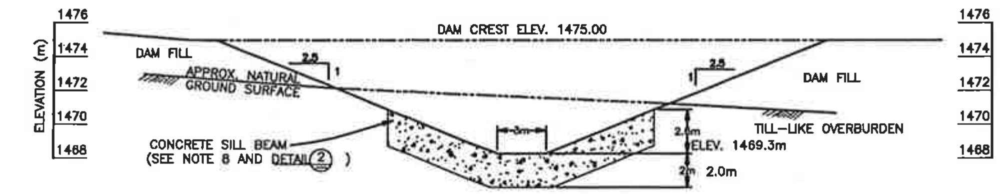


PROFILE ALONG SPILLWAY CHANNEL



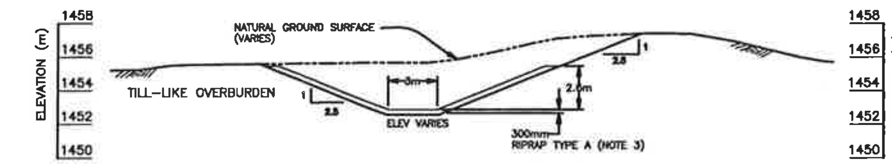
TYPICAL UNLINED CHANNEL

SECTION A
1:200



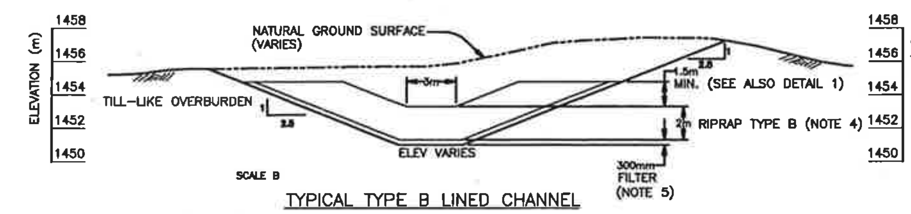
CONCRETE SILL BEAM

SECTION B
1:200



TYPICAL TYPE A LINED CHANNEL

SECTION C
1:200



TYPICAL TYPE B LINED CHANNEL

SECTION D
1:200

NOTES

1. BASE TOPOGRAPHY AND AS-BUILT SURVEY WERE SUPPLIED BY HIGHLAND VALLEY COPPER.
2. APPROACH CHANNEL IS HORIZONTAL FROM TAILINGS TO CONCRETE SILL AT DAM CENTRELINE WITH AN ELEV. OF 1469.3m IN TILL AND 1469.0m IN TAILINGS.
3. TYPE A RIPRAP TO CONSIST OF A 300mm THICK LAYER OF HARD DURABLE ROCK WEIGHING NOT LESS THAN 2400 kg/m^3. NO DIMENSION OF AN INDIVIDUAL ROCK SHOULD BE LESS THAN 1/3 OF LARGEST DIMENSION. THE RIPRAP SHOULD BE WELL GRADED AND CONFORM TO THE FOLLOWING:

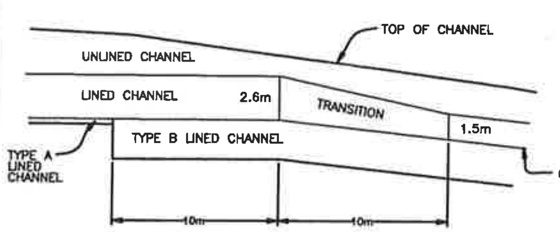
% LESS THAN BY WEIGHT	WEIGHT (kg)	DIA. (mm)
100	2.5 TO 5.0	125 TO 160
50	1.3 TO 2.1	100 TO 120
15	0.3 TO 1.1	60 TO 95
5	0.3	60

NO FILTER LAYER WAS REQUIRED.

4. TYPE B RIPRAP TO CONSIST OF A 2000mm THICK LAYER OF HARD DURABLE ROCK WEIGHING NOT LESS THAN 2400 kg/m^3. NO DIMENSION OF AN INDIVIDUAL ROCK SHOULD BE LESS THAN 1/3 OF LARGEST DIMENSION. THE RIPRAP SHOULD BE WELL GRADED AND CONFORM TO THE FOLLOWING:

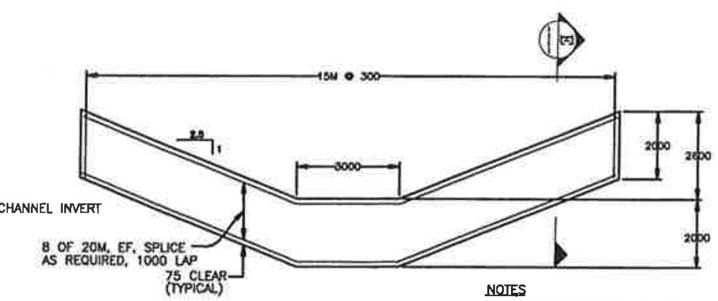
% LESS THAN BY WEIGHT	WEIGHT (kg)	DIA. (mm)
100	1500 TO 3000	1050 TO 1340
50	750 TO 1270	840 TO 1000
15	190 TO 630	530 TO 800
5	160	500

5. FILTER MATERIAL SHOULD BE WELL GRADED AND CONFORM TO THE FOLLOWING:
   MAXIMUM PARTICLE SIZE = 400mm
   D_{85}= 150mm TO 300mm
   D_{50}= 40mm TO 100mm
   D_{15}= 10mm TO 30mm
6. WHERE EXCAVATION WAS THROUGH TAILINGS, SIDE SLOPES WERE 10H:1V.
7. WHERE EXCAVATION WAS THROUGH TILL-LIKE OVERBURDEN, OR WEATHERED BEDROCK ENCOUNTERED BETWEEN STA. 0+050m AND STA. 0+062m AND BETWEEN STA. 0+076m AND STA. 0+101m, SIDE SLOPES WERE 2.5H:1V.
8. SEE DETAIL 2 FOR CONCRETE SILL BEAM CROSS SECTION AND STEEL REINFORCEMENT. FOUNDATION PREPARATION FOR AND BACKFILL AROUND THE SILL BEAM WERE INSPECTED BY THE FIELD ENGINEER. THE BACKFILL UPSTREAM OF THE SILL BEAM WAS COMPACTED TO A MINIMUM DENSITY OF 97% STANDARD PROCTOR OPTIMUM DENSITY, WHILE THE RIPRAP DOWNSTREAM OF THE SILL BEAM WAS PLACED TO MINIMIZE SEGREGATION BUT WITHOUT COMPACTION. BACKFILL ON BOTH SIDES OF THE CONCRETE SILL BEAM WERE PLACED CONCURRENTLY WITH MINIMUM DIFFERENTIAL IN ELEVATION TO PREVENT TILTING THE BEAM.
9. AT THE EXISTING PUBLIC ACCESS ROAD NEAR STA. 0+330 A 1380mm ø CULVERT WAS INSTALLED TO SUPPLEMENT THE EXISTING 600mm ø CULVERT.
10. ROAD WAS RIPRAP LINED ON UPSTREAM SIDE IN CHANNEL AREA.
11. ALL DIMENSIONS, AND ELEVATIONS IN METRES.
12. RIPRAP AND FILTER MATERIALS WERE PLACED IN A MANNER TO PREVENT SEGREGATION OF THE PLACED MATERIALS.
13. CONSTRUCTION ADJUSTMENTS AND MODIFICATIONS WERE BASED ON THE ACTUAL GROUND CONDITIONS ENCOUNTERED.
14. MODIFICATIONS TO THE SPILLWAY AND CONSTRUCTION MATERIALS FOR RIPRAP AND FILTERS REQUIRED FOR LINING THE SPILLWAY CHANNELS WERE CHECKED BY FIELD ENGINEER AND DESIGNERS FOR COMPLIANCE WITH THE DESIGN INTENT.



TRANSITION DETAIL

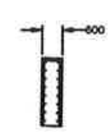
DETAIL 1
1:200



CONCRETE SILL BEAM DETAIL

DETAIL 2
1:100

NOTES
1. REINFORCING STEEL TO BE GRADE 400.
2. CONCRETE TO BE 30 MPa, 5% AIR.



SECTION E
1:100

TO BE READ WITH KLOHN CRIPPEN REPORT DATED JANUARY 18, 2002

NO.	DATE	ISSUE / REVISION	DRAWN	APPROVED
	JANUARY 18, 2002	ISSUED WITH REPORT	CYW	

CAD File: 114-808-201-1

No.	Revision	Date	By	Ch'd	App'd	No.	Reference Drawings
1	ADDED KLOHN-CRIPPEN SECTIONS & NOTES		R.B.				

KLOHN CRIPPEN

PROJECT No. PM 2916 29 — DWG. No. D-29001

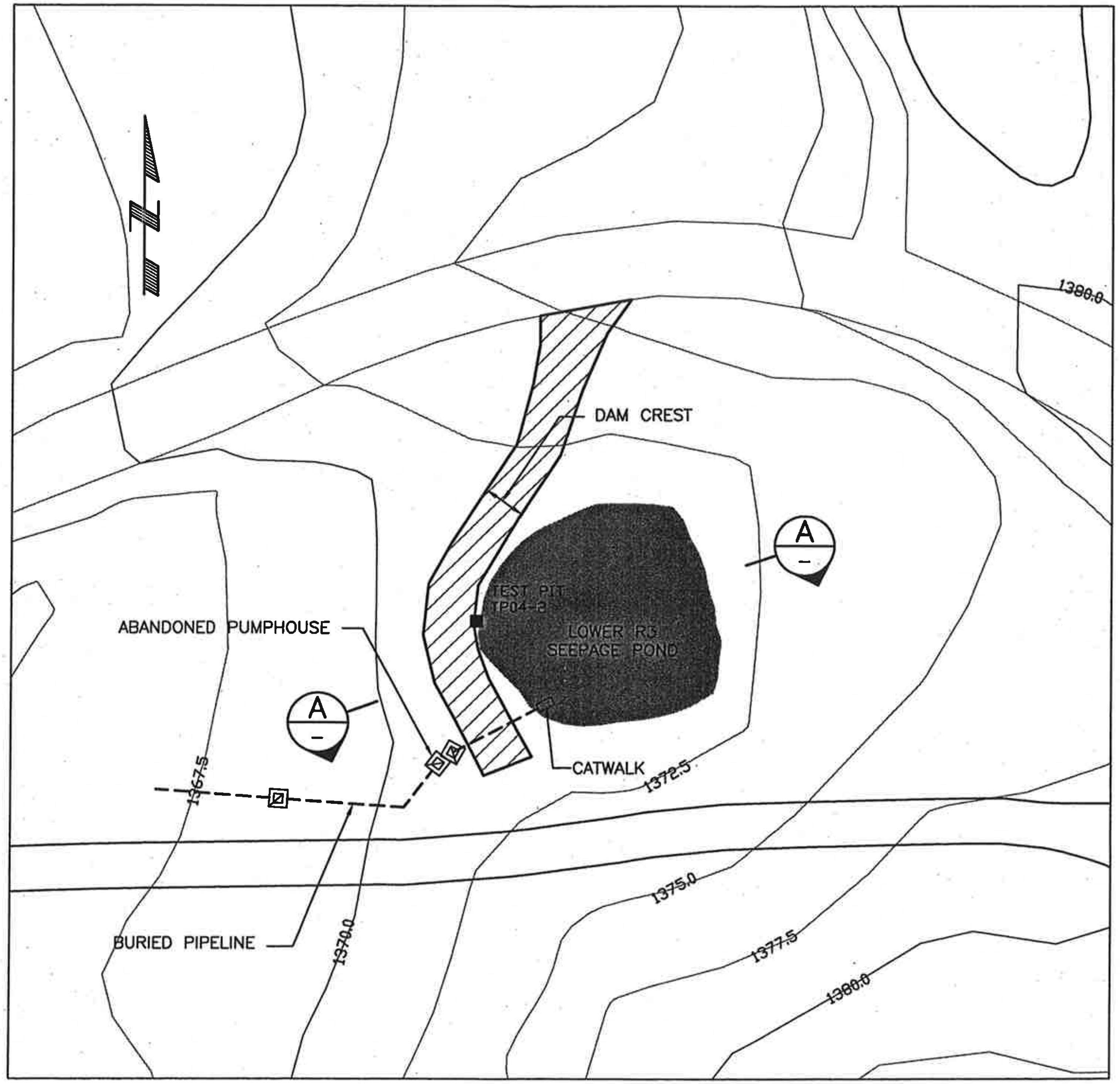
Highland Valley Copper

AS-BUILT BOSE LAKE DAM SPILLWAY
PLAN, PROFILE & SECTIONS

DRAWN H. P. — CHECKED
DATE 98 11 27 — SCALE 1:1000
DWG No. 114-808-201-1 — REV. 1

APPENDIX III-B-3

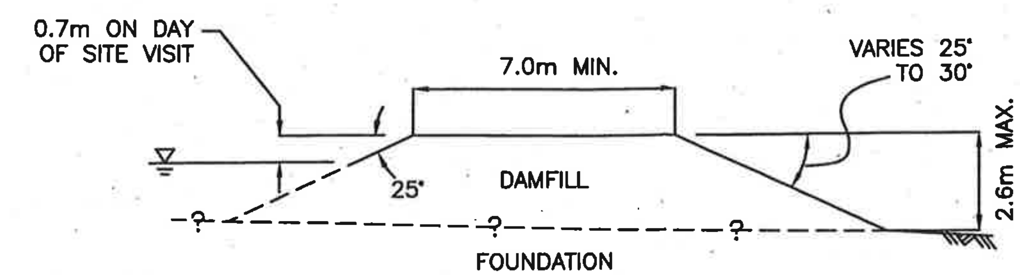
Reference Dam Design Drawings – R3 Seepage Pond Dam



PLAN
SCALE A

UPSTREAM

DOWNSTREAM



R3 POND DAM APPROX. SECTION
(MEASURED 17 NOV/04)
SCALE B

NOTES:

1. CROSS SECTION SHOWN IS TAKEN AT THE HIGHEST POINT IN THE DAM. DAM CREST WIDTH INCREASES TO ABOUT 9.5m IN SOME SHALLOWER AREAS.
2. FOR LOCATION OF POND SEE FIGURE B-001.
3. LOCATION OF BURIED PIPES ARE APPROXIMATE.

SCALE B 0 10m

SCALE A 0 50m

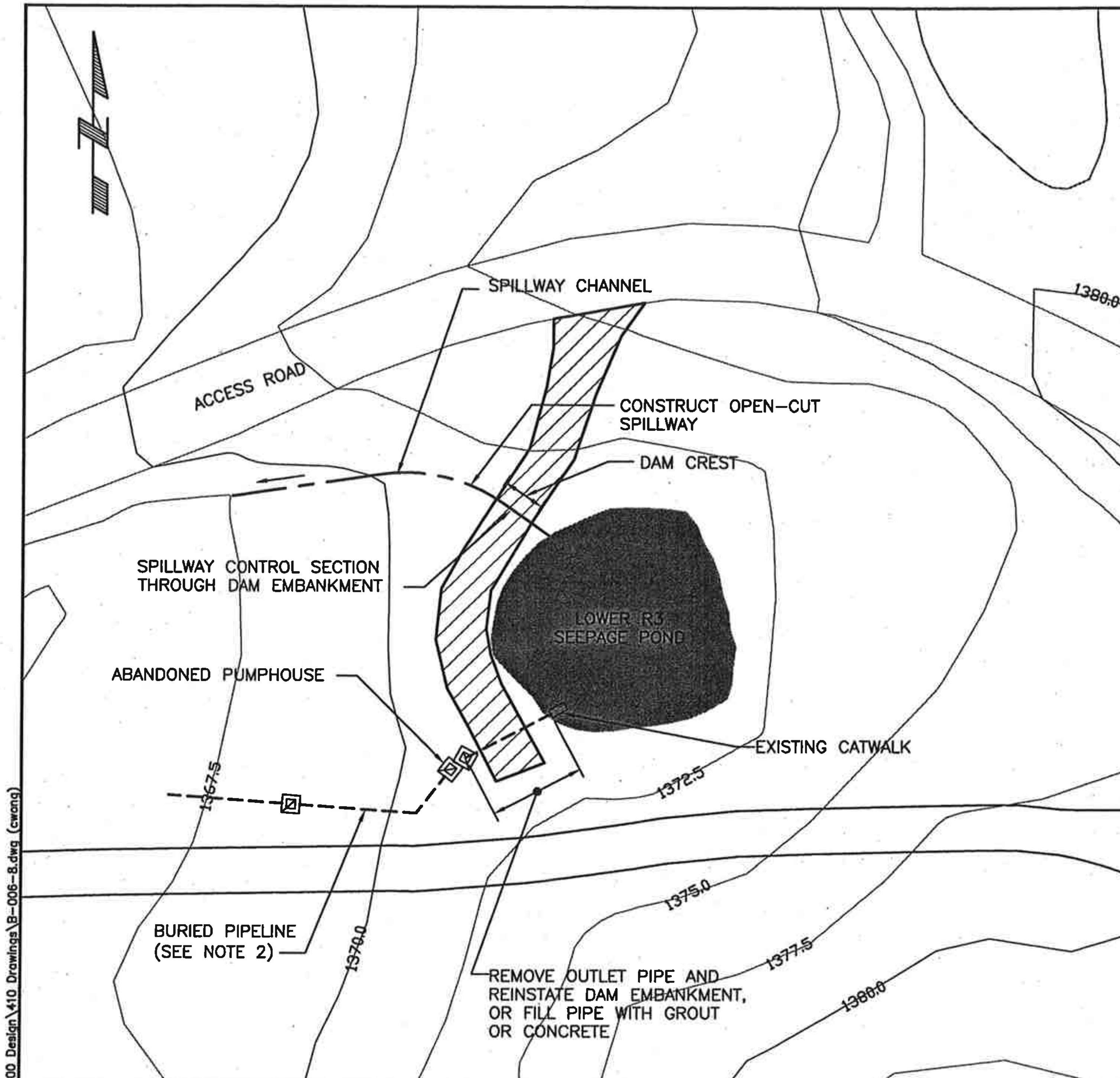
NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN REPORT DATED JUNE 10, 2005

CLIENT	HIGHLAND VALLEY COPPER
PROJECT	TROJAN CREEK PONDS
TITLE	LOWER R3 SEEPAGE POND PLAN AND DAM SECTION
PROJECT No.	M 02341 A3105
FIG. No.	B-002

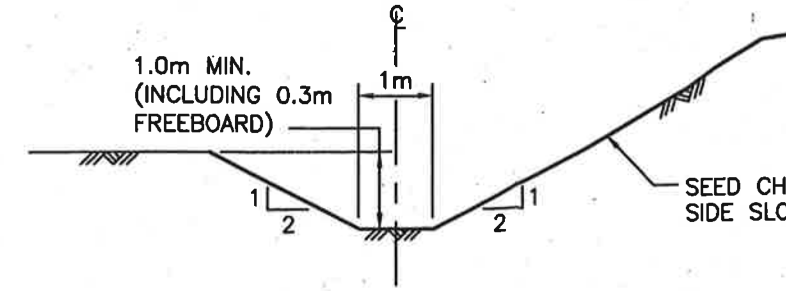
KLOHN CRIPPEN

Time: 13:27:53
Date: 3/9/2005
Scale: 1=5(PS)
Drawing File: M\M02341A3105 - Trojan Creek Ponds\400 Design\410 Drawings\B-001-5.dwg (cwong)
Xrefs: FIG-BASE



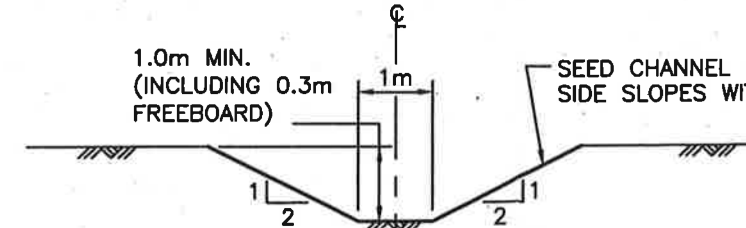
PLAN

SCALE A



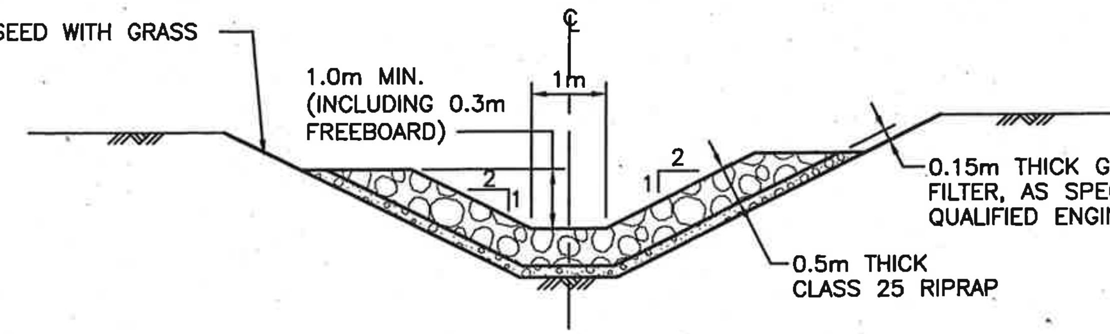
SPILLWAY CONTROL SECTION THROUGH DAM

SCALE B



SPILLWAY CHANNEL SECTION FOR 0.5% OR FLATTER BED SLOPE

SCALE B



SPILLWAY CHANNEL SECTION FOR 0.6% TO 10% BED SLOPE

SCALE B

CLASS 25 RIPRAP GRADATION

PERCENT LIGHTER THAN	MASS (kg)	APPROX. AVERAGE DIMENSION OF ANGULAR ROCK (mm)
85	75	400
50	25	300
15	2.5	150

NOTES:

1. FOR LOCATION OF POND SEE FIGURE B-001.
2. LOCATION SHOWN FOR BURIED PIPELNE IS APPROXIMATE.

SCALE B 0 5m

SCALE A 0 50m

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN REPORT DATED JUNE 10, 2005

CLIENT: HIGHLAND VALLEY COPPER

KLOHN CRIPPEN

PROJECT: TROJAN CREEK PONDS

TITLE: LOWER R3 SEEPAGE POND PROPOSED DECOMMISSIONING WORK PLAN AND SECTIONS

PROJECT No. M 02341 A3105

FIG. No. B-006

Time: 9:8:18
Date: 6/10/2005
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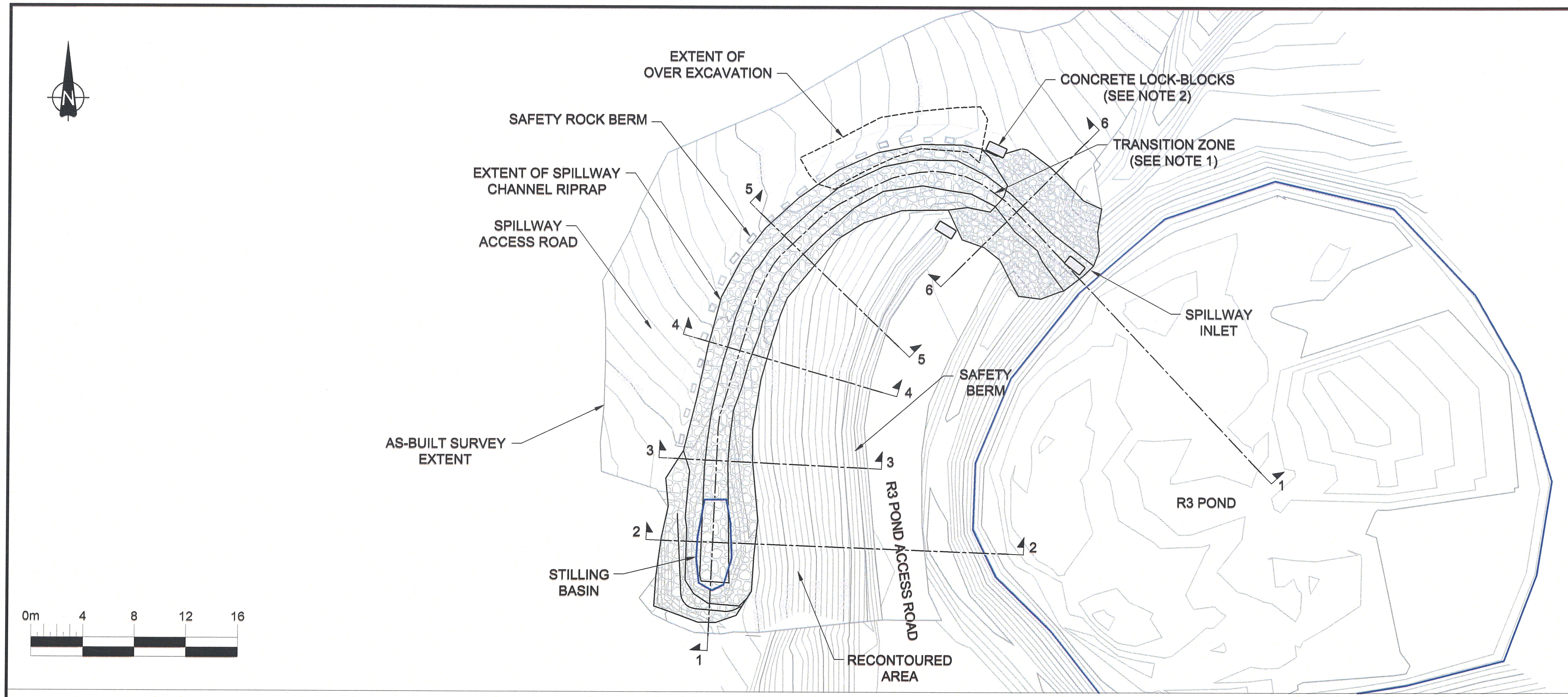
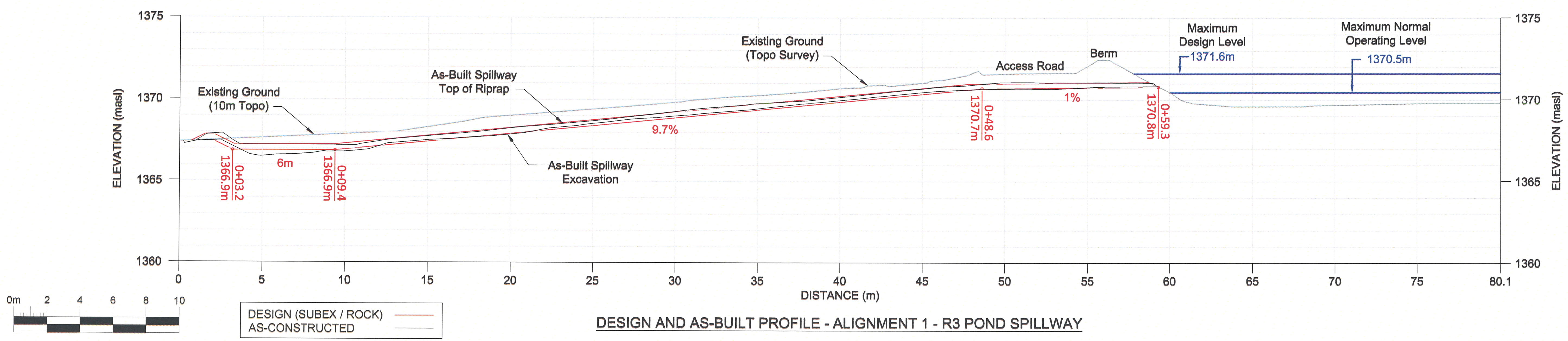


NOTES:

1. THE D_{50} = 240mm RIPRAP WAS EXTENDED FOR A DISTANCE OF 2.0 m AS A TRANSITION ZONE OVER THE 1% SLOPE.
2. CONCRETE LOCK-BLOKS WERE INSTALLED AT THE INLET PORTION OF THE CHANNEL AS WELL AS THE SIDES OF THE ACCESS ROAD CROSSING THE SPILLWAY FOR SAFETY REASONS.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC ENVIRONMENT & INFRASTRUCTURE LETTER DATED 17 DECEMBER 2013.
4. AS-BUILT SURVEY DATA PROVIDED BY HIGHLAND VALLEY COPPER SURVEYORS.

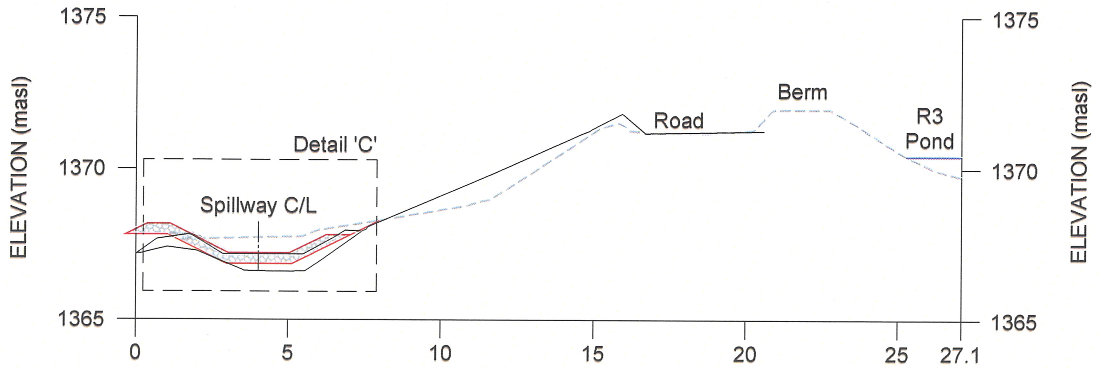


DESIGN AND AS-BUILT PROFILE - ALIGNMENT 1 - R3 POND SPILLWAY

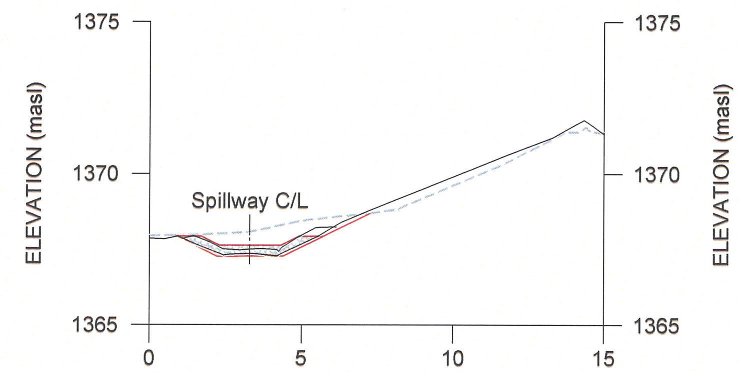
AS-BUILT DRAWINGS

CLIENT:	Highland Valley Copper Teck
	AMEC Environment & Infrastructure, Suite 600 - 4445 Lougheed Highway, Burnaby, BC V5C 0E4, Tel. 604-294-3811 Fax 604-294-4664
DWN BY:	TH
CHK'D BY:	HY/AF
DATUM:	MINE
PROJECTION:	MINE
SCALE:	AS SHOWN
PROJECT:	CONSTRUCTED SPILLWAY - TROJAN - BETHLEHEM RECLAIM 3
TITLE:	AS CONSTRUCTED PLAN AND PROFILE
DATE:	DECEMBER 2013
PROJECT NO:	VW1031
REV. NO:	A
FIGURE NO:	AB-002

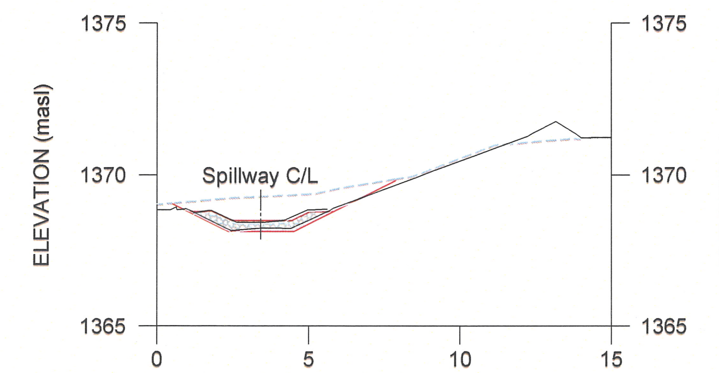
W:\Projects\VW1031 - Tech Highland Valley Copper\Drawings\As-Built Drawings\VW1026-R3-Pond-Berm-Spillway-AsBuilt.Dec.6.dwg - Plan and Profile - Dec. 17, 2013 11:43am - hamid.yousefbeigi



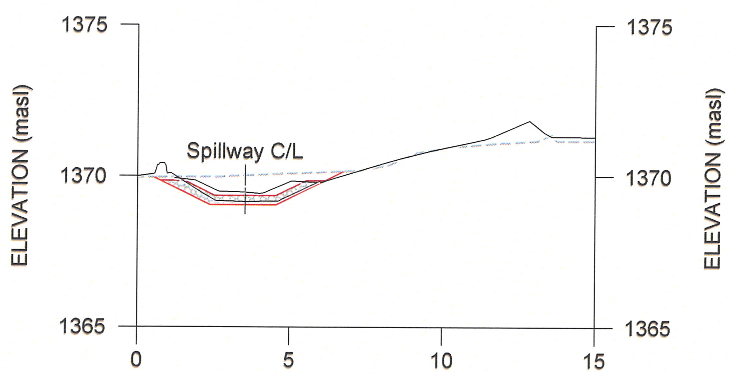
SECTION - ALIGNMENT 2
STILLING BASIN
(See Detail 'C')



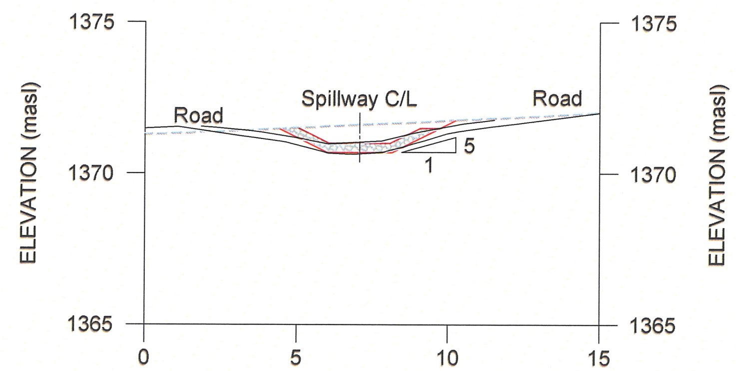
SECTION - ALIGNMENT 3
SPILLWAY
(See Detail 'B')



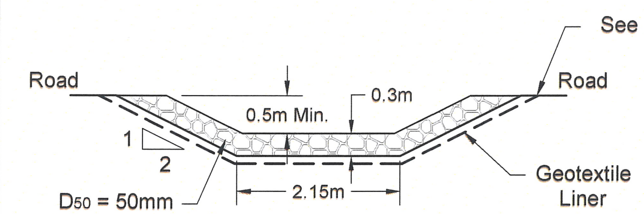
SECTION - ALIGNMENT 4
SPILLWAY
(See Detail 'B')



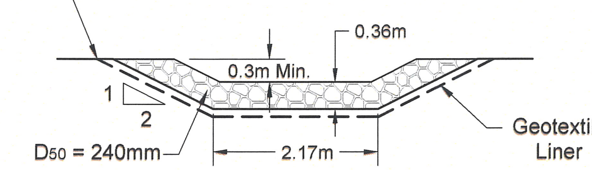
SECTION - ALIGNMENT 5
SPILLWAY
(See Detail 'B')



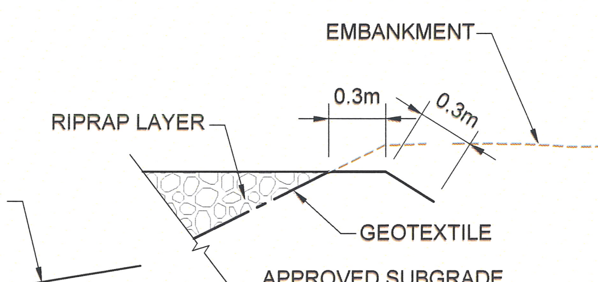
SECTION - ALIGNMENT 6
R3 POND BERM / ACCESS ROAD
(See Detail 'A')



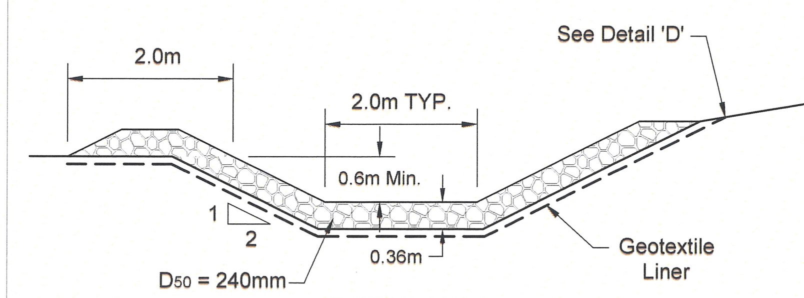
DETAIL 'A'
TYPICAL SECTION - SPILLWAY
CHANNEL 1% GRADE



DETAIL 'B'
TYPICAL SECTION - SPILLWAY
CHANNEL 9.7% GRADE



DETAIL 'D'
TYPICAL SECTION - ANCHORE
DETAIL



DETAIL 'C'
TYPICAL SECTION - STILLING
BASIN

DESIGN (SUBEX / ROCK)
AS-CONSTRUCTED

0m 4 8 12 16

0m 1 2 3 4

NOTES:

1. SECTION - ALIGNMENT 6 WAS MODIFIED IN THE FIELD
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC ENVIRONMENT & INFRASTRUCTURE LETTER DATED 17 DECEMBER 2013.
3. AS-BUILT SURVEY DATA PROVIDED BY HIGHLAND VALLEY COPPER SURVEYORS.

AS-BUILT DRAWINGS

CLIENT: Highland Valley Copper
Teck

AMEC Environment & Infrastructure
Suite 600 - 4445 Lougheed Highway
Burnaby, BC V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664
amec

DWN BY:	TH
CHK'D BY:	AF
DATUM:	MINE
PROJECTION:	MINE
SCALE:	AS SHOWN

PROJECT: CONSTRUCTED SPILLWAY - TROJAN - BETHLEHEM RECLAIM 3

TITLE: AS CONSTRUCTED CHANNEL SECTIONS AND TYPICAL DETAILS

DATE:	DECEMBER 2013
PROJECT NO:	VW1031
REV. NO:	A
FIGURE NO:	AB-003

W:\Projects\VW1031 - Tech Highland Valley Copper\Drawings\As-Built Drawings\VW1026-R3-Pond-Berm-Spillway-AsBuilt.Dec.6.dwg - Sections - Dec. 17, 2013 11:43am - hamid.yousefbeigi

APPENDIX IV

APPENDIX IV-A

Climate Data

Appendix IV-A
Climate Data

THVCP provided weather data from the L-L Dam climate station (El. 1186 m) which is the nearest climate station to the site but is at a lower elevation than Bethlehem No.1 TSF catchment (>El. 1477 m, i.e. dam crest). Climate data was adjusted for elevation, using the recommended adjustment factor from L-L Dam to Bethlehem and Trojan Area (El. 1,400 m to 1,570 m), from Golder (2016). To support key precipitation trends and impacts on observed dam performance, data from Kamloops Airport (Environment Canada Station No. 1163781, El. 345 m) was reviewed for comparison. Precipitation records from L-L Dam (adjusted) and Kamloops Airport between October 2018 and September 2019 are tabulated and plotted with average monthly values or climate normals in and Figure IV-A-1, respectively. Normal precipitation data, reported in Table IV-A-1, is based on the Highland Valley Lornex climate station, adjusted for elevation to Bethlehem and Trojan Area using Golder (2016).

Seasonal snowpack depth is not measured at the L-L Dam weather station. Instead, monthly measurements at the Highland Valley snow survey station (Station No. 1C09A) near the Trojan TSF are used by THVCP to monitor snowpack. The measurements are sorted by survey period (the first of January through May) to compare snowpack depths, in snow-water equivalent (SWE), for the same period each year. Historical average and 2019 snowpack depths based on available records are summarized in Table IV-A-2.

The following observations were noted for 2019:

- January through April precipitation measured at Bethlehem No.1 TSF was significantly less than historic normals (based on Highland Valley Lornex adjusted to Bethlehem and Trojan Area) which, along with reduced snowpack, contributed to a less sever freshet than recent years.
- June and July 2019 were noticeably wetter than normal.
- Snowpack depths were not measured in January and February 2019. Snowpack was significantly shallower than average in April and May 2019.

Table IV-A-1 Monthly Precipitation

Month	Precipitation (mm)			
	L-L Dam Weather Station Data Adjusted to Bethlehem and Trojan Area[(1)]	1976-2011 Highland Valley Lornex Normals Adjusted to Bethlehem and Trojan Area[(2)]	Kamloops Airport Weather Station[(3)]	1981-2010 Kamloops Airport Weather Station Normals[(4)]
Oct 2018[(5)]	21.3	33.3	27.5	19.4
Nov 2018[(5)]	23.4	44.8	33.5	23.3
Dec 2018[(5)]	15.6	45.3	20.2	25.4
Jan 2019	12.3	30.5	5.7	21.1
Feb 2019	18.0	23.3	13.8	12.4
Mar 2019	6.8	18.5	4.3	12.8
Apr 2019	16.8	23.6	11.5	14.2
May 2019	41.4	45.8	17.4	27.3
Jun 2019	95.7	53.2	21.2	37.4
Jul 2019	88.3	48.3	36.0	31.4
Aug 2019	11.6	35.2	16.7	23.7
Sep 2019	47.2	34.6	39.1	29.4
Annual Total	**398.4**	**436.4**	**246.9**	**277.6**

Notes:
1. Available data from L-L Dam climate station was adjusted by a L-L Dam-to-Bethlehem and Trojan adjustment factor of 1.05 (Golder 2016).
2. Estimated by Golder (2016) using appropriate adjustment factors and average precipitation measured at Highland Valley Lornex climate station (Environment Canada ID No. 1123469 at El. 1268 m).
3. 2019 data from Kamloops Airport station with ID No. 1163781. Kamloops Airport Climate Station was relocated 500 m in 2013 from station ID No. 1163780.
4. Climate normals from data collected at previous Kamloops Airport station location (ID No. 1163780).
5. October to December 2018 were reported in 2018 DSI and outside of 2019 DSI reporting period but are included for reference.

Figure IV-A-1 Monthly Precipitation

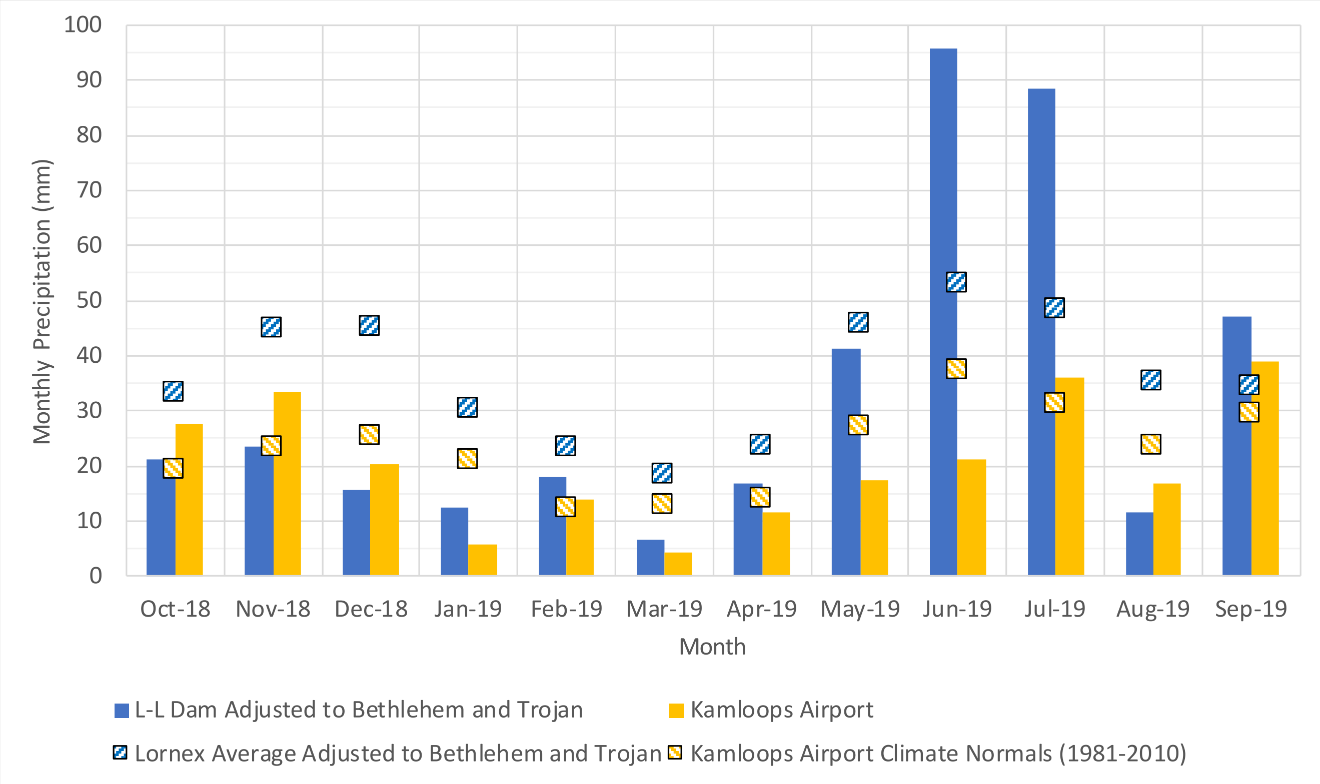


Table IV-A-2 Historical Average and 2019 Snowpack Depths

Survey Period	Years of Record[1]	Historic Average Snowpack Depth[2] (mm SWE[3])	2019 Snowpack Depth (mm SWE[3])	Percent Change Relative to Historic Average
January 1st	11	50.2	Not surveyed	N/A
February 1st	25	83.5	Not surveyed	N/A
March 1st	53	90.8	90	-1%
April 1st	52	100.8	54	-46%
May 1st	52	28.6	Trace	-100%
May 15th	25	2.4	Not surveyed (assumed to be 0)	-
June 1st	8	0.0	Not surveyed (assumed to be 0)	-

Notes:

1. At the Highland Valley snow survey station (Station No. 1C09A) near the Bethlehem TSF. Data prior to 1966 was not included as the station was moved to its current location in 1965.
2. Calculated based on available period on record. 2019 surveys were completed within 48-hours of the Survey Period date.
3. SWE = snow water equivalent.

APPENDIX IV-B

Instrumentation Summary and Plots

Appendix IV-B
Instrumentation Summary and Plots

IV-B-1 PIEZOMETERS

Piezometric readings at Dam No. 1 and Bose Lake Dam are plotted on Figure IV-B-1 to Figure IV-B-3 and Figure IV-B-7 to Figure IV-B-9, respectively. Key observations are as follows:

Dam No. 1

- Piezometers in the impounded tailings historically remained static. No readings were taken in 2017 and 2018 from these piezometers. The 2018 DSI recommended (BTSF-2018-02) that readings for these piezometers be taken as soon as they were accessible in 2019. No readings were collected within the DSI review period, but THVCP collected one reading in December 2019 which have been reported in this DSI. Monitoring of these instruments is required under the OMS Manual (THVCP 2018) as confirmation that there are no unexpected changes in established trends which may indicate a change to the facility. The fact that these instruments were not read at the prescribed frequency is not a dam safety concern but is a non-compliance with the OMS Manual. In late 2019, THVCP took steps to improve tracking of the Bethlehem impoundment piezometer readings so this does not reoccur and plan to collect four readings for these piezometers in 2020
  - Upstream Tailings Beach and Foundation Piezometers: water elevations remained static which is consistent with previous readings. Except at BP14A and 14B which rose ~0.2 m above threshold value which was based on previous peak reading as an indicator of change, not a dam safety concern. Piezometric levels at these instruments have rose ~0.7 m over the past 3 years. Revised thresholds values have been set for 2020.
- Most of the instruments located parallel to the crest in the upstream dam fill (screened between about El. 1440 m and 1450 m), were plugged or dry based on the available readings in 2019.
- Both VWP piezometers installed at Dam No. 1 within Glacial Till unit reached equilibrium in May 2018. VWP16-1A water level remain steady since then. Piezometric levels at VWP16-1B show negative pressures.
- Instruments in the foundation, downstream of the dam, show steady seasonal fluctuations.

Bose Lake Dam

- There were no piezometric threshold exceedances in 2019.
- Historically, piezometers in the impounded tailings remained consistent and indicated a downward gradient through the tailings and into the Glacial Till foundation. No readings were taken since October 2017 from these piezometers. Based on seepage readings, pond elevation or data from other piezometers further downstream, no sign that indicates an increase in piezometric levels was observed. However, similar to the Dam No. 1 piezometers, these are to

be measured, as per the OMS Manual, to confirm no change in established behaviour has occurred. Similar to the piezometers that were not read from the impoundment near Dam No. 1, these do not represent a dam safety concern and THVCP initiated effort to comply with OMS Manual and plan to collect four readings for these piezometers in 2020.

- Along the dam crest, a nested set of instruments installed in the dam fill and foundation (BD-VWP14-1A, BD-VWP14-1B, and BD-VWP14-1C) have historically shown an upward gradient from the bedrock into the Glacial Till which extends into the dam fill with seasonal fluctuations.
- Measurements from piezometers downstream of the dam also remained consistent with previous years. These piezometers show a slight upward trend (which is consistent with pond level rise) with seasonal fluctuations.

Thresholds for piezometers were updated and reported in the 2016 DSI (KCB 2017b). The thresholds were set at 0.5 m above the maximum elevation head to identify any deviations from established trends. Questionable readings (e.g., where there was a spike that has not been repeated) were not used when defining thresholds. 2019 maximum and minimum water levels and instrument thresholds were reviewed as part of 2019 DSI. Six piezometer threshold revisions are proposed for 2020 (Refer to Table 1).

Table IV-B-1 2019 Piezometric Levels and 2020 Thresholds

Instrument ID	Dam Zone or Foundation Unit	Status of Piezometer	2019 Piezometric Levels (m)		Proposed 2020 Threshold Value(1) (m)
			Maximum	Minimum	
Dam No. 1					
STANDPIPE No. 1B	Dam Fill	Plugged	Reported plugged in 2019		1440.4
STANDPIPE No. 1A	Dam Fill	Plugged	Reported plugged in 2019		1457.9
STANDPIPE No. 3	Dam Fill	Plugged	Reported dry in 2019		1441.6
STANDPIPE No. 4	Dam Fill	Plugged	Reported dry in 2019		1453.6
STANDPIPE No. 6	Upstream Dam Fill	Defunct	n/a		n/a
STANDPIPE No. 7	Dam Fill	Plugged	Reported dry in 2019		1440.5
P95-1	Downstream Foundation	Active	1378.1	1376.7	1379.0
P95-2	Downstream Foundation	Destroyed	n/a		n/a
P95-5	Dam Foundation	Destroyed	n/a		n/a
P95-6	Downstream Foundation	Active	1372.0	1371.4	1373.6
13-SRK-09/P13-5	Tailings	Active	1410.3	1410.1	***1411.0***
13-SRK-12B/P13-6	Glacial Till	Active	1377.3	1377.2	1377.9
VWPB16 - 1A	Glacial Till	Active	1350.3	1350.2	1351.7
VWPB16 - 1B	Glacial Till	Active	1357.2	1356.9	1369.8
BP3A	Glacial Till	Active	1452.6 (2)		1454.8
BP3B	Tailings	Active	1453.9 (2)		1455.9
BP3C	Tailings	Active	1461.0 (2)		1466.6
BP4A	Glacial Till	Active	1465.0 (2)		1466.7
BP4B	Tailings	Active	1450.8 (2)		1454.6

Instrument ID	Dam Zone or Foundation Unit	Status of Piezometer	2019 Piezometric Levels (m)		Proposed 2020 Threshold Value[1] (m)
			Maximum	Minimum	
BP5A	Glacial Till	Active	1461.0 [2]		1461.6
BP5B	Tailings	Active	1463.7 [2]		1465.3
BP9A	Tailings	Active	1402.7 [2]		1403.4
BP9B	Tailings	Active	1424.3 [2]		1424.9
BP9C	Tailings	Active	1449.1 [2]		***1449.6***
BP10A	Tailings	Active	1463.9 [2]		1465.2
BP10B	Tailings	Active	-[3]		1466.8
BP12A	Tailings	Active	-[4]		1420.8
BP12B	Tailings	Active	-[4]		1441.8
BP12C	Tailings	Active	-[4]		1463.9
BP13A	Glacial Till	Active	1440.1 [2]		1441.5
BP13B	Tailings	Active	1445.3 [2]		1446.0
BP14A	Glacial Till	Active	1424.5 [2]		***1425.0***
BP-14B	Tailings	Active	1425.2 [2]		***1425.7***
BP14C	Tailings	Active	1446.9 [2]		1447.9
BP15A	Glacial Till	Active	-[4]		1447.7
BP15B	Tailings	Active	-[4]		1451.0
BP15C	Tailings	Active	-[4]		1458.6
Bose Lake Dam					
No.1	Overburden / Bedrock Contact	Active	1444.8	1444.7	1445.3
No.2	Overburden / Bedrock Contact	Active	1444.6	1444.4	1445.2
BD-VWP14-1A	Bedrock	Active	1451.4	1451.0	***1452.0***
BD-VWP14-1B	Overburden	Active	1451.2	1450.8	***1451.7***
BD-VWP14-1C	Dam Fill	Active	1448.8	1448.6	1449.9
BP6A	Glacial Till	Active	-[4]		1462.8
BP6B	Tailings	Active	-[4]		1466.0
BP6C	Tailings	Active	-[4]		1467.3
BP7A	Glacial Till	Active	-[4]		1469.1
BP7B	Tailings	Active	-[4]		1469.1
BP7C	Tailings	Active	-[4]		1468.3

Notes:
1. ***Bold Italics*** indicate revised threshold for 2020.
2. Based on single reading taken in December 2019 (outside the review period of this DSI)
3. BP10B wire is cut and no reading was taken for this piezometer in December 2019.
4. No readings were taken in 2019.

Based on the review of the available instrumentation data, the current suite of instruments is considered sufficient for the Bethlehem TSF.

IV-B-2 SURVEY MONUMENTS

Monument surveys, horizontal displacement and settlement (vertical displacement) are plotted on Figure IV-B-4 and Figure IV-B-10. In 2019:

- There were no horizontal or vertical displacement threshold exceedances.
- The surveys do not indicate trend of significant movements in the downstream direction or significant crest settlement which is consistent with previous years; refer to Table IV-B-2.

Since 2014, THVCP surveys use a total station with an estimated accuracy of 25 mm for horizontal measurements, and a high precision digital level with an estimated accuracy of 10 mm for vertical measurements.

Table IV-B-2 2019 Survey Monument Displacement Summary

Monument ID	Incremental		Change from Initial Survey(3)	
	Vector Horizontal Displacement(1) (mm)	Vertical Displacement(2) (mm)	Vector Horizontal Displacement (mm)	Vertical Displacement (mm)
Dam No. 1				
MON 1-73	1.5, parallel to dam centreline (toward south)	-4.4	52.0, downstream	-199.5
DM-2	7.4, upstream (toward south)	-2.7	36.6, downstream	-146.3
DM-3	5.7, downstream (toward north)	-3.8	19.8, downstream	-90.6
PIN-2	7.3, parallel to dam centerline (toward north)	-2.8	36.2, downstream	-79.0
Bethlehem Sinkhole	Note 4	-8.0	N/A	-147
Bose Lake Dam				
BD-1	5.5, upstream (toward north)	-0.3	66.5, upstream and parallel to dam crest	-23.2
BD-2	11.1, upstream	-0.2	3.5, downstream	-12
BD-3	27.3, upstream	-0.2	27.6, downstream	+3.1
BD-4	16.0, upstream	+0.3	5.8, upstream	-5.7
BD-5	10.5, upstream	+0.7	12.3, upstream	-2.0
BD-6	2.6, upstream	+1.2	7.3, downstream	+3.1
BD-7	5.5, downstream	+1.7	28.6, downstream	+2.8

Notes:

1. Incremental horizontal displacements are calculated between the Nov 2018 and October 2019 surveys.
2. Incremental vertical displacements are calculated between the Nov 2018 and October 2019 surveys for Bose Lake Dam. Dam No.1 monument elevations were not surveyed in October 2019, therefore the vertical displacements are calculated between July 2018 and July 2019 surveys.
3. Calculated between July/October 2019 surveys and earliest historic readings:
   - 2008 for BD-7;
   - 2013 for BD-3 (shift pre- and post-2013 possibly attributed to damage or change to datum; no observations this was an indicator of dam safety issue);
   - 2014 for Bethlehem sinkhole;
   - 1983 for all other monuments.
4. Horizonal displacement not required to be surveyed.

Movement thresholds (horizontal and settlement) were established during the 2016 DSI for the survey monuments; refer to Table IV-B-3. No changes are proposed for 2020. The thresholds were set based on the following criteria:

- Horizontal vector displacement threshold was set at 80 mm from the original location, based on the typical scatter in the available data which is most likely related to a survey or datum issue rather than movements.
- Incremental settlement between readings was set at 20 mm based on a review of the typical variation between readings (regardless of period between readings).
- Total settlement was set at approximately 50 mm below the most recent reading (except for the sinkhole), based on the observed settlement trends.

Table IV-B-3 2020 Survey Monument Displacement Thresholds

Instrument ID	Instrument Threshold (mm)		
	Total Horizontal Vector Displacement from Original Position (1)	Incremental Vertical Displacement Between Readings(2)	Total Vertical Displacement(3)
DAM NO. 1			
MON 1-73	80	20	240
DM-2			170
DM-3			125
PIN-2			125
Bethlehem Sinkhole			250
BOSE LAKE DAM			
BD-1	80	20	75
BD-2			50
BD-3			75
BD-4			50
BD-5			50
BD-6			50
BD-7			50

Notes:
1. Horizontal vector displacement threshold was set at 80 mm from the original location, based on the typical scatter in the available data which is most likely related to a survey or datum issue rather than movements.
2. Incremental settlement between readings was set at 20 mm based on a review of the typical variation between readings (regardless of period between readings).
3. Total settlement was set at approximately 50 mm below the most recent reading (except for the sinkhole), based on the observed settlement trends.

IV-B-3 INCLINOMETERS

No additional inclinometers were installed in 2019. Required monitoring frequency (monthly, when accessible) for the single inclinometer at Dam No. 1 (IB16-1) are defined in the 2018 OMS manual (THVCP 2018).

Cumulative displacements are plotted on Figure IV-B-5. There are no significant movements in the downstream direction in the readings and no discrete zones of movement to date.

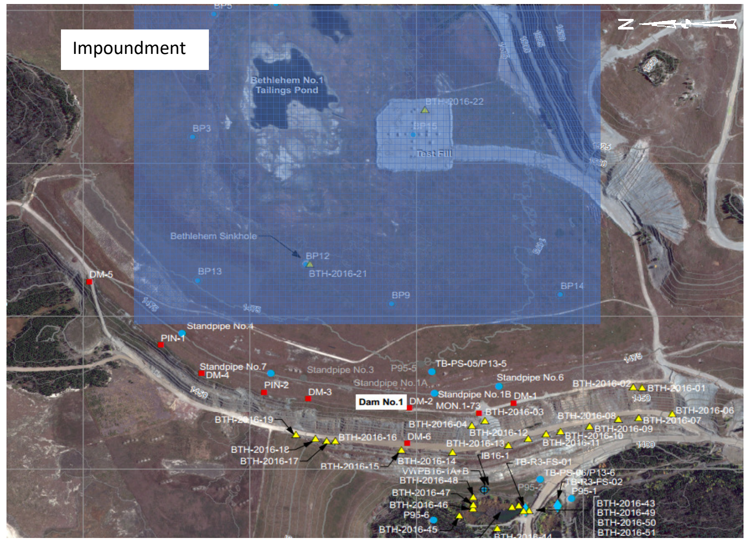
There is no planned construction at or significant change to the existing condition of the facility planned. Therefore, the development of significant movements in the foundation at this time are not expected. Based on measurements to date, KCB proposes the following thresholds for ongoing monitoring: 1 mm/month over any 3 m vertical section.

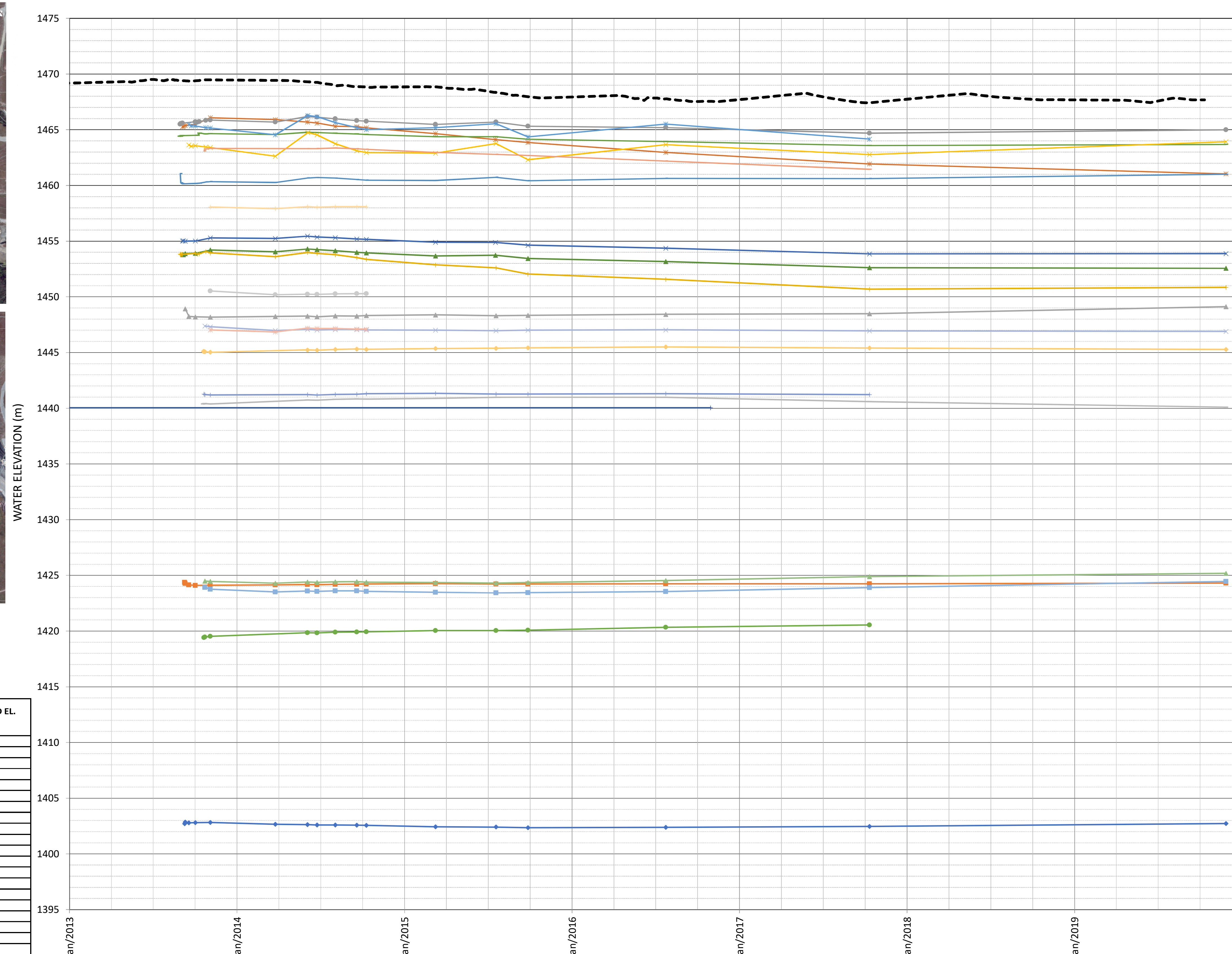
IV-B-4 SEEPAGE

Historically, seepage is recorded at two weirs upstream of R3 Seepage Pond: TB-R3-FS-01 (across access road at outlet of decommissioned Seepage Pond 1) and TB-R3-FS-02 (approx. 50 m upstream of pond). The latter, which collected the majority of inflows to R3 Seepage Pond, was decommissioned in 2016 along with Seepage Pond 1.

In 2019, TB-R3-FS-01 flow was measured/estimated monthly (data was reviewed up to end of September 2019). This is consistent with the monitoring frequency in the 2018 OMS manual. The weir was reported frozen between November 2018 and March 2019. The peak seepage flow was recorded in May and July 2019.

INSTRUMENTATION PLOTS





LEGEND:

- STANDPIPE NO. 7 (Tip El. 1439.8706 m, Upstream Dam Fill, dry elevation)
- BP3A (Tip El. 1439.4 m, Glacial Till)
- BP3B (Tip El. 1444 m, Tailings)
- BP3C (Tip El. 1457.7 m, Tailings)
- BP4A (Tip El. 1421.9 m, Glacial Till)
- BP4B (Tip El. 1449.4 m, Tailings)
- BP5A (Tip El. 1450 m, Glacial Till)
- BP5B (Tip El. 1459.1 m, Tailings)
- BP9A (Tip El. 1371.8 m, Tailings)
- BP9B (Tip El. 1411.5 m, Tailings)
- BP9C (Tip El. 1441.9 m, Tailings)
- BP10A (Tip El. 1452.8 m, Tailings)
- BP10B (Tip El. 1462 m, Tailings)
- BP12A (Tip El. 1404 m, Tailings)
- BP12B (Tip El. 1426.1 m, Tailings)
- BP12C (Tip El. 1456.6 m, Tailings)
- BP13A (Tip El. 1431.6 m, Glacial Till)
- BP13B (Tip El. 1442.9 m, Tailings)
- BP14A (Tip El. 1417.8 m, Glacial Till)
- BP-14B (Tip El. 1423.9 m, Tailings)
- BP14C (Tip El. 1447 m, Tailings)
- BP15A (Tip El. 1394.9 m, Glacial Till)
- BP15B (Tip El. 1411.7 m, Tailings)
- BP15C (Tip El. 1440.6 m, Tailings)
- Bethlehem No.1 Pond Level

PIEZOMETER ID	2019 THRESHOLD EL. (m)
BP3A	1454.8
BP3B	1455.9
BP3C	1466.6
BP4A	1466.7
BP4B	1454.6
BP5A	1461.6
BP5B	1465.3
BP9A	1403.4
BP9B	1424.9
BP9C	1449.4
BP10A	1465.2
BP10B	1466.8
BP12A	1420.8
BP12B	1441.8
BP12C	1463.9
BP13A	1441.5
BP13B	1446.0
BP14A	1424.4
BP-14B	1425.0
BP14C	1447.9
BP15A	1447.7
BP15B	1451.0
BP15C	1458.6

NOTES:

1. One reading was taken for each piezometer in December 2019.
2. No reading was taken in December 2019 for BP10B as the wire was cut.
3. No readings were collected for BP12 or B15 series in December 2019.

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

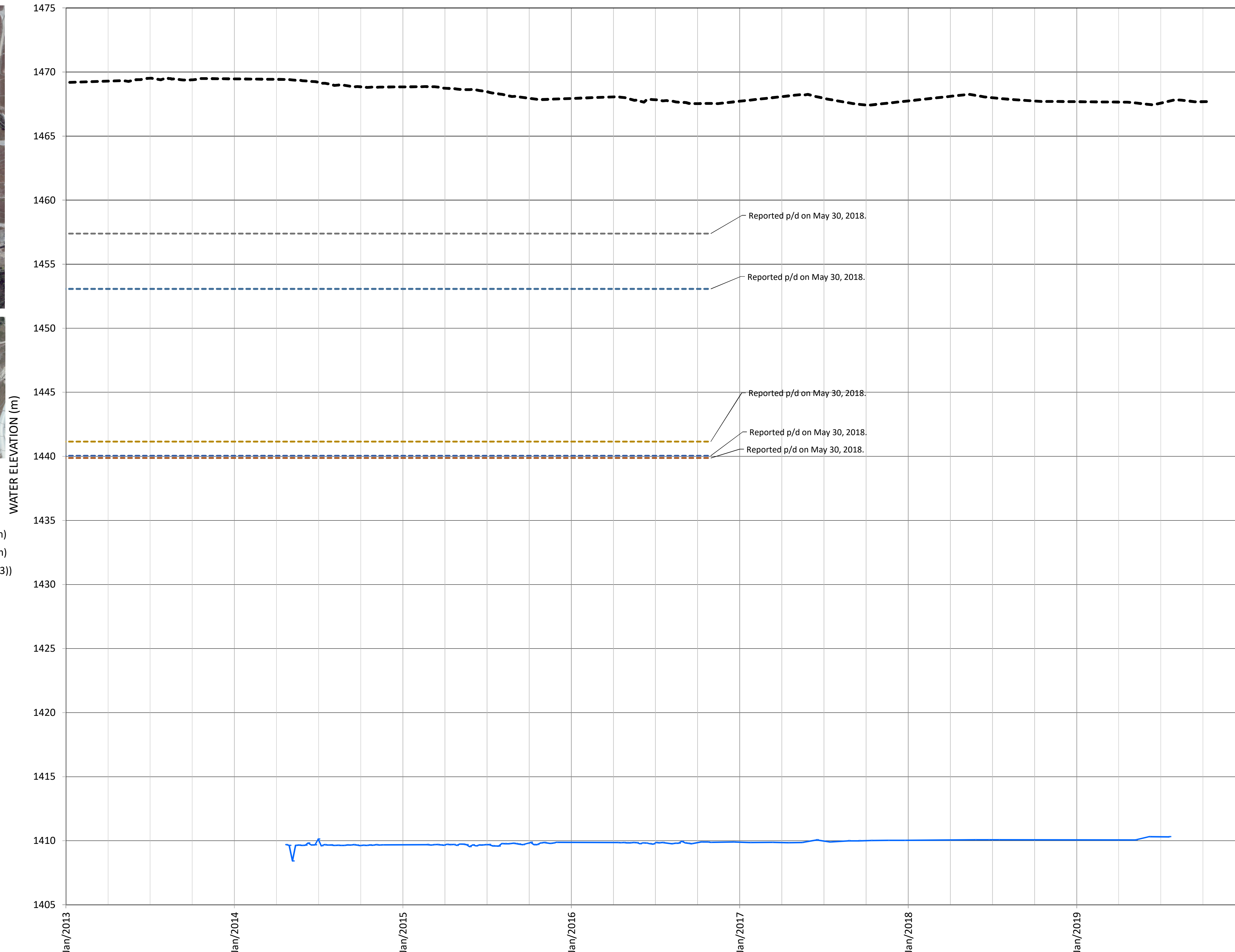
TITLE: DAM No. 1 PIEZOMETRIC DATA
2013-2019

IMPOUNDMENT

PROJECT No. M02341B53

FIG No. IV-B-1

January 13, 2020
Z:\M\VCR\M02341B53 - HVC-2019 Dam Safety Support\300 Design\330 Piezometer Data\Bethlehem\[200113 Bethlehem Piezo.xlsx]IV-B-9 BLD DOWNSTREAM TOE



LEGEND:

- STANDPIPE NO. 1B (Tip El. 1440.26684 m, Upstream Dam Fill, plugged elevation)
- STANDPIPE NO. 1A (Tip El. 1446.60668 m, Upstream Dam Fill, plugged elevation)
- STANDPIPE NO. 3 (Tip El. 1442.7662 m, Upstream Dam Fill, dry elevation (note 3))
- STANDPIPE NO. 4 (Tip El. 1451.7578 m, Upstream Dam Fill, dry elevation)
- STANDPIPE NO. 7 (Tip El. 1439.8706 m, Upstream Dam Fill, dry elevation)
- 13-SRK-09/P13-5 (Tip El. 1391.2 m, Tailings)
- Bethlehem No.1 Pond Level

PIEZOMETER ID	2019 THRESHOLD EL. (m)
STANDPIPE No. 1A	1457.9
STANDPIPE No. 1B	1440.4
STANDPIPE No. 3	1441.6
STANDPIPE No. 4	1453.6
STANDPIPE No. 7	1440.5
13-SRK-09/P13-5	1410.6

NOTES:

1. STANDPIPE NO. 3 HAS BEEN NOTED AS DRY/PLUGGED IN THE RECORDS AND LIKELY EXPLAINS THE ERRATIC JUMPS IN MEASUREMENTS. HOWEVER A FALLING HEAD TEST CONDUCTED IN 2015 INDICATED THE PIEZOMETER WAS STILL RESPONDING.
2. STANDPIPE NO. 6 WAS TESTED IN 2015 AND FOUND TO BE DEFUNCT.
3. TIP ELEVATION FROM ORIGINAL LOGS. THE INSTRUMENT WAS SOUNDED IN 2015 AND THE TIP ELEVATION WAS FOUND TO BE EL. 1441.05 m WHICH WAS USED TO SET THE ALERT THRESHOLD.

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: DAM No. 1 PIEZOMETRIC DATA
2013-2019

CREST

PROJECT No. M02341B53

FIG No. IV-B-2

January 13, 2020
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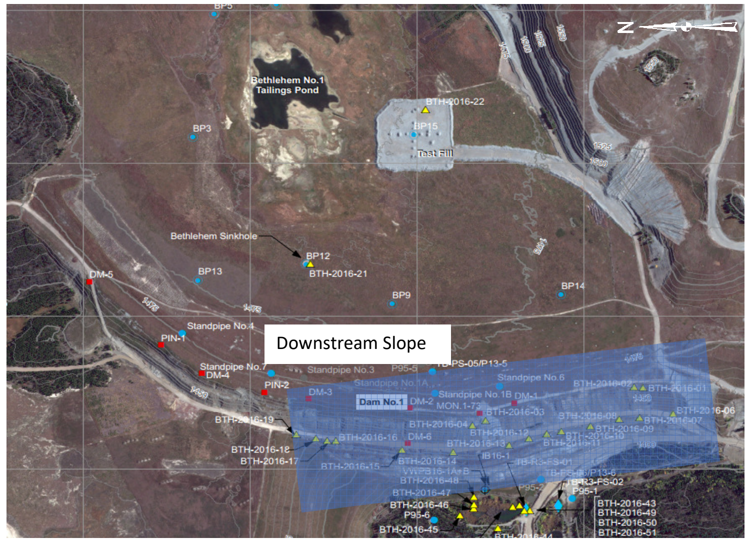
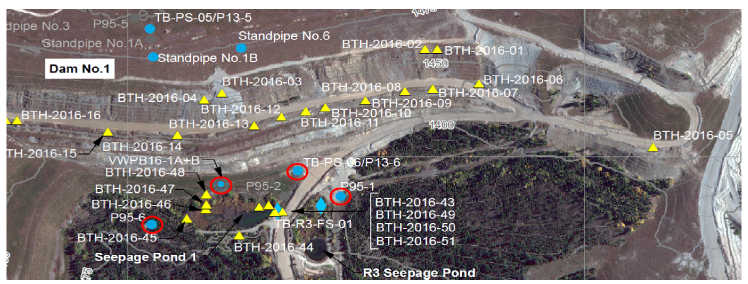
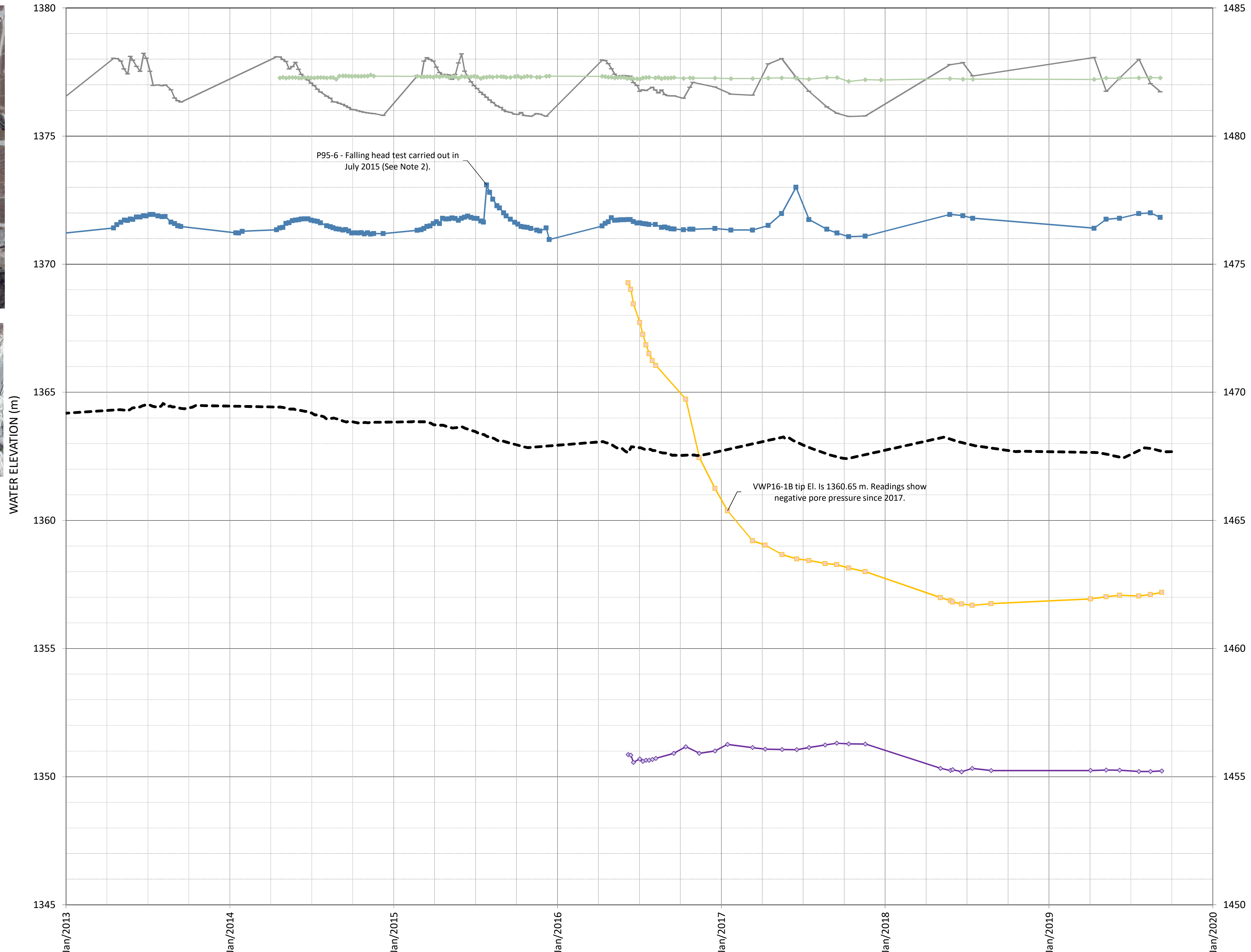




LEGEND:

- VWP16-1B (Tip El. 1360.65 m, Glacial Till)
- P95-1 (Tip El. 1373.7 m, Downstream Foundation)
- P95-6 (Tip El. 1368.190784 m, Downstream Foundation)
- 13-SRK-12B/P13-6 (Tip El. 1357.2 m, Glacial Till)
- VWP16-1A (Tip El. 1346.15 m, Glacial Till)
- Bethlehem No.1 Pond Level

PIEZOMETER ID	2019 THRESHOLD EL. (m)
P95-1	1379.0
P95-6	1373.6
13-SRK-12B/P13-6	1377.9
VWP16-1A	1351.7
VWP16-1B	1369.8



NOTES:

1. PIEZOMETER WATER ELEVATIONS PLOTTED ON PRIMARY (LEFT) AXIS, POND ELEVATION PLOTTED ON SECONDARY (RIGHT) AXIS.
2. FALLING HEAD TEST CARRIED OUT ON P95-6 DURING JULY 2015 - CAUSE OF SPIKE IN PIEZOMETRIC LEVELS

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION

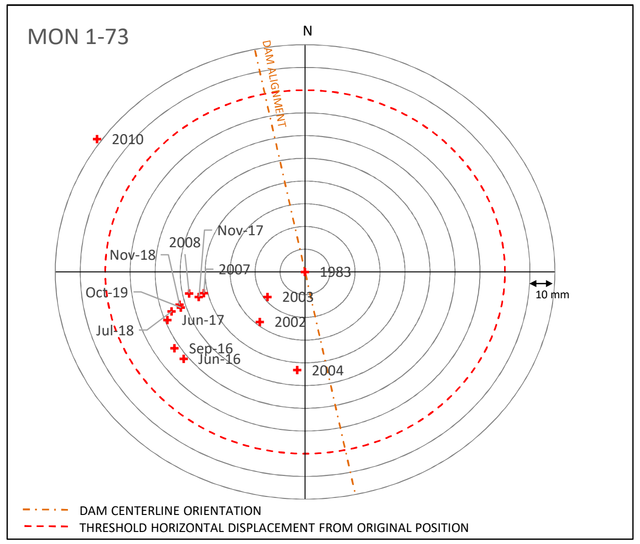
TITLE: DAM No. 1 PIEZOMETRIC DATA 2013-2019

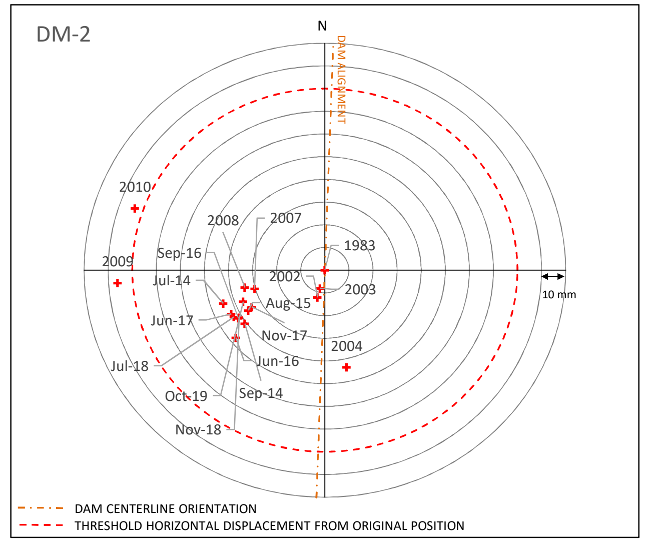
DOWNSTREAM SLOPE

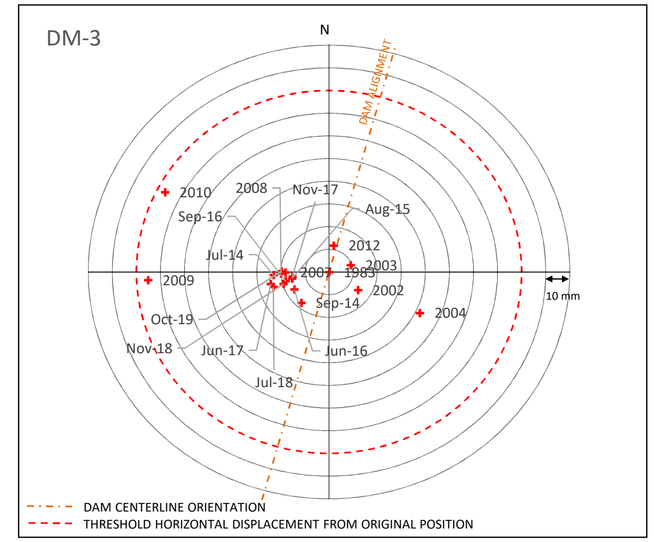
PROJECT No. M02341B53

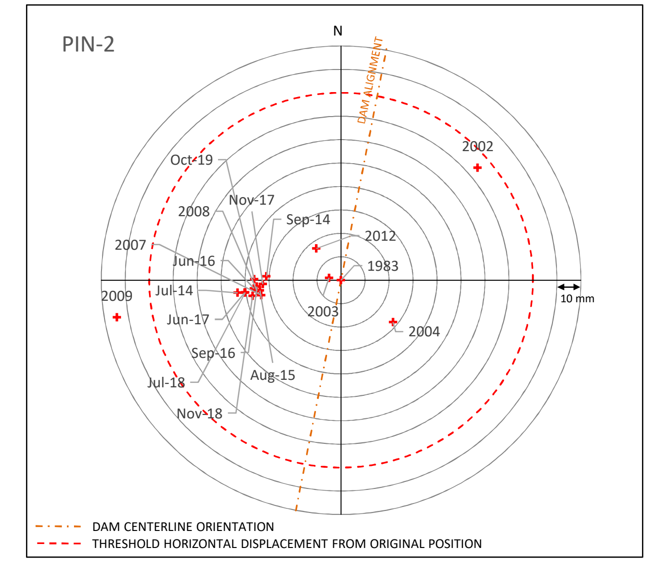
FIG No. IV-B-3

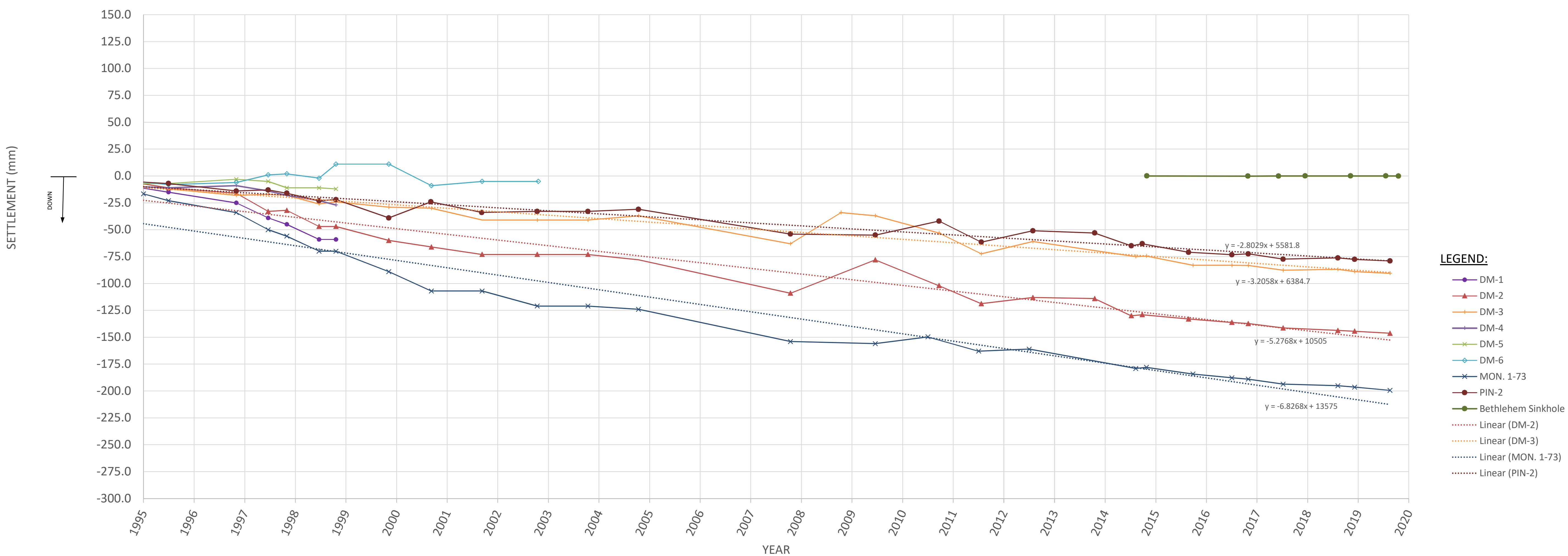
January 13, 2020
Z:\M\VCR\M02341B53 - HVC\2019 Dam Safety Support\300 Design\330 Piezometer Data\Bethlehem\[200113 Bethlehem Piezo.xlsx]IV-B-9 BLD DOWNSTREAM TOE











MONUMENT ID	2019 THRESHOLDS		
	HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION (mm)	INCREMENTAL SETTLEMENT BETWEEN READINGS (mm)	TOTAL SETTLEMENT (mm)
MON 1-73	80	20	240
DM-2			170
DM-3			125
PIN-2			125
Bethlehem Sinkhole			250

NOTES:

1. DAM No. 1 MOVEMENT MONITORING DATA PRIOR TO 1995 NOT SHOWN.
2. REFER TO FIGURE 3 FOR MONUMENT LOCATIONS IN PLAN VIEW.
3. DM-1, DM-4 AND DM-5 DESTROYED IN 1999.
4. DM-6 DESTROYED IN 2002.
5. 2008 SETTLEMENT DATA OF DM-2, MON. 1-73, AND PIN-2 WERE OUTLIERS AND NOT PLOTTED.

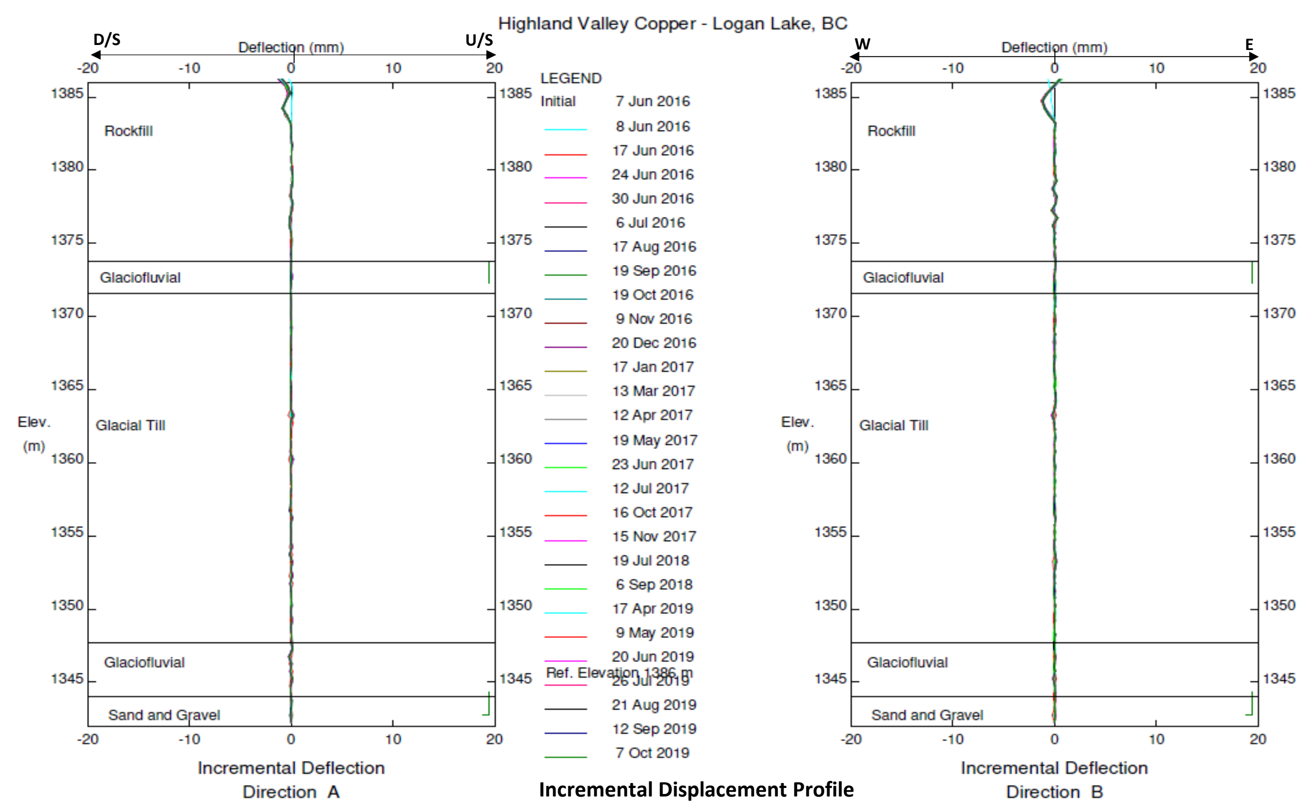
CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

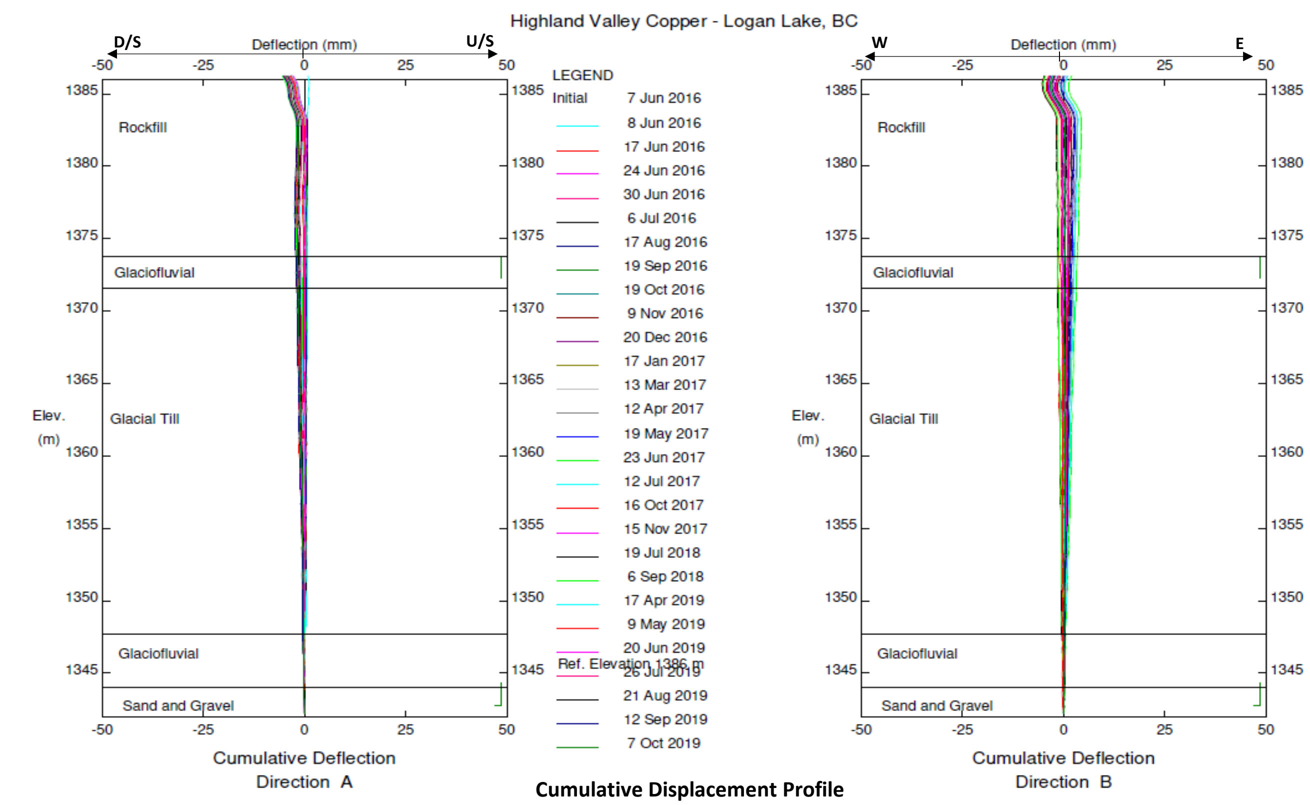
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION

TITLE: DAM NO. 1 SURVEY MONUMENT READINGS

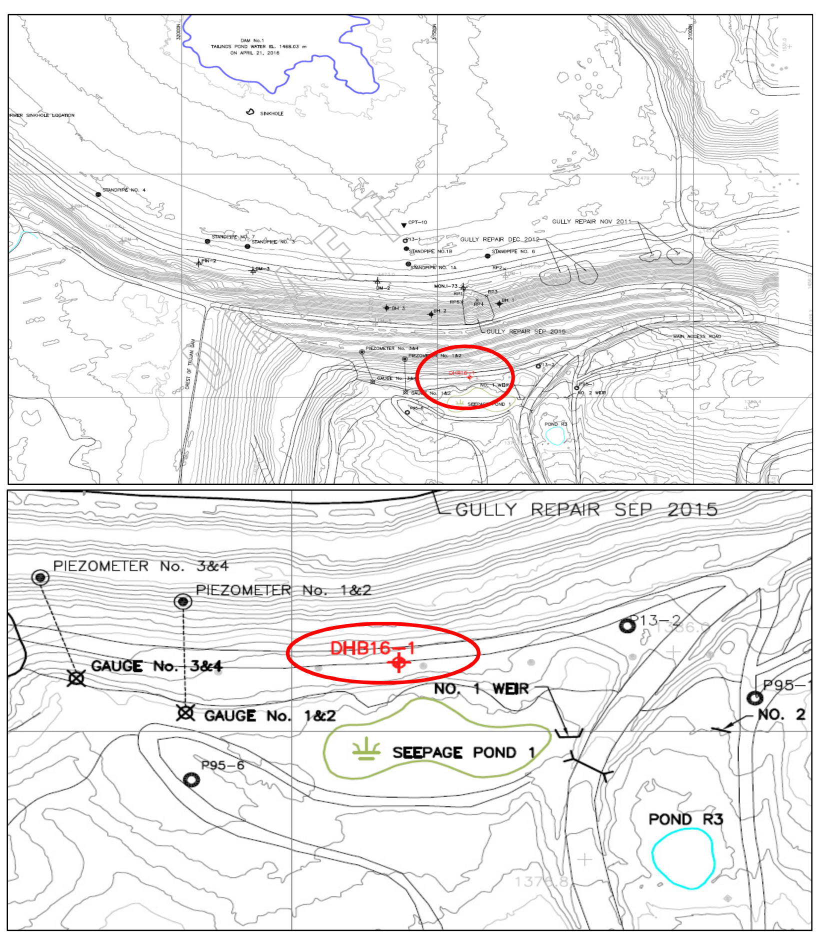
PROJECT No. M02341B53 | FIG No. IV-B-4

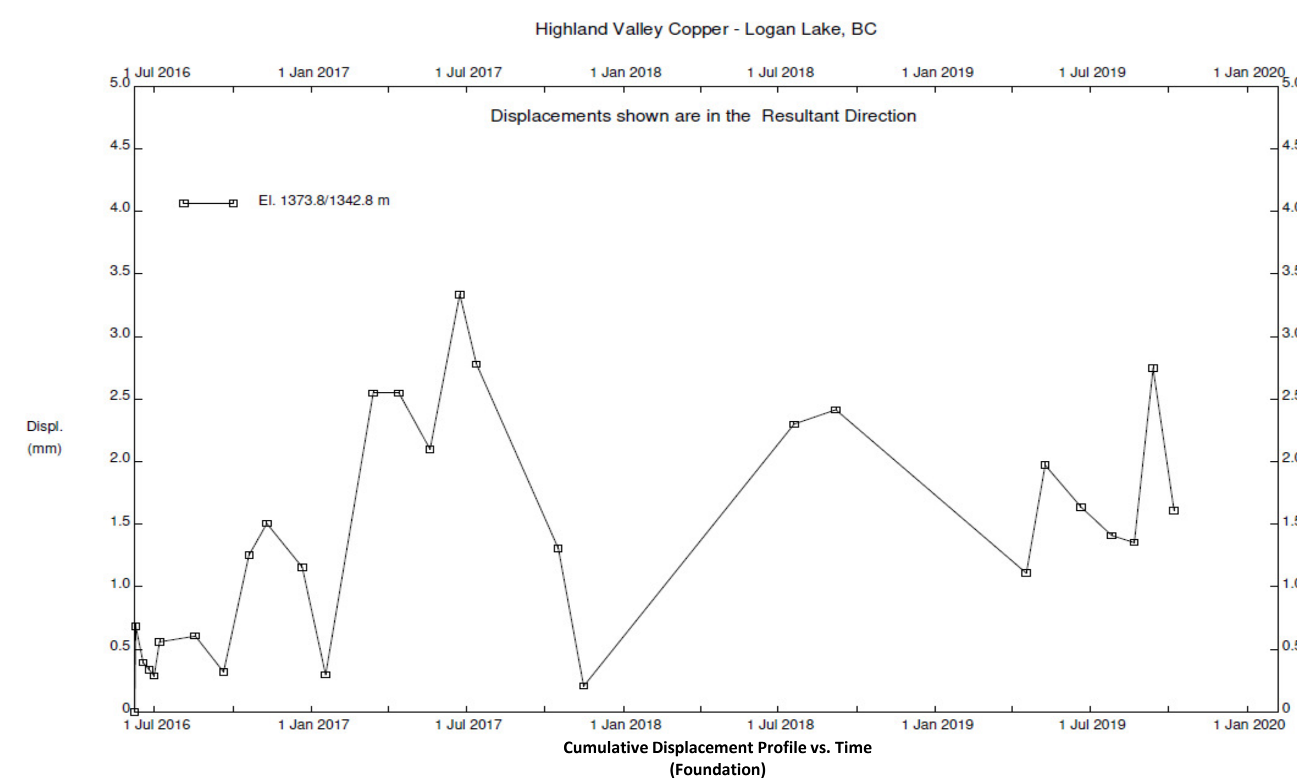


Incremental Displacement Profile



Cumulative Displacement Profile





Cumulative Displacement Profile vs. Time (Foundation)

NOTES:
1) IB16-1 was installed on April 20, 2016.
2) IB16-1 was initialized on June 07, 2016.
3) Reel/Probe Serial Number for the initial reading: DR15020000/DP06580000.

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

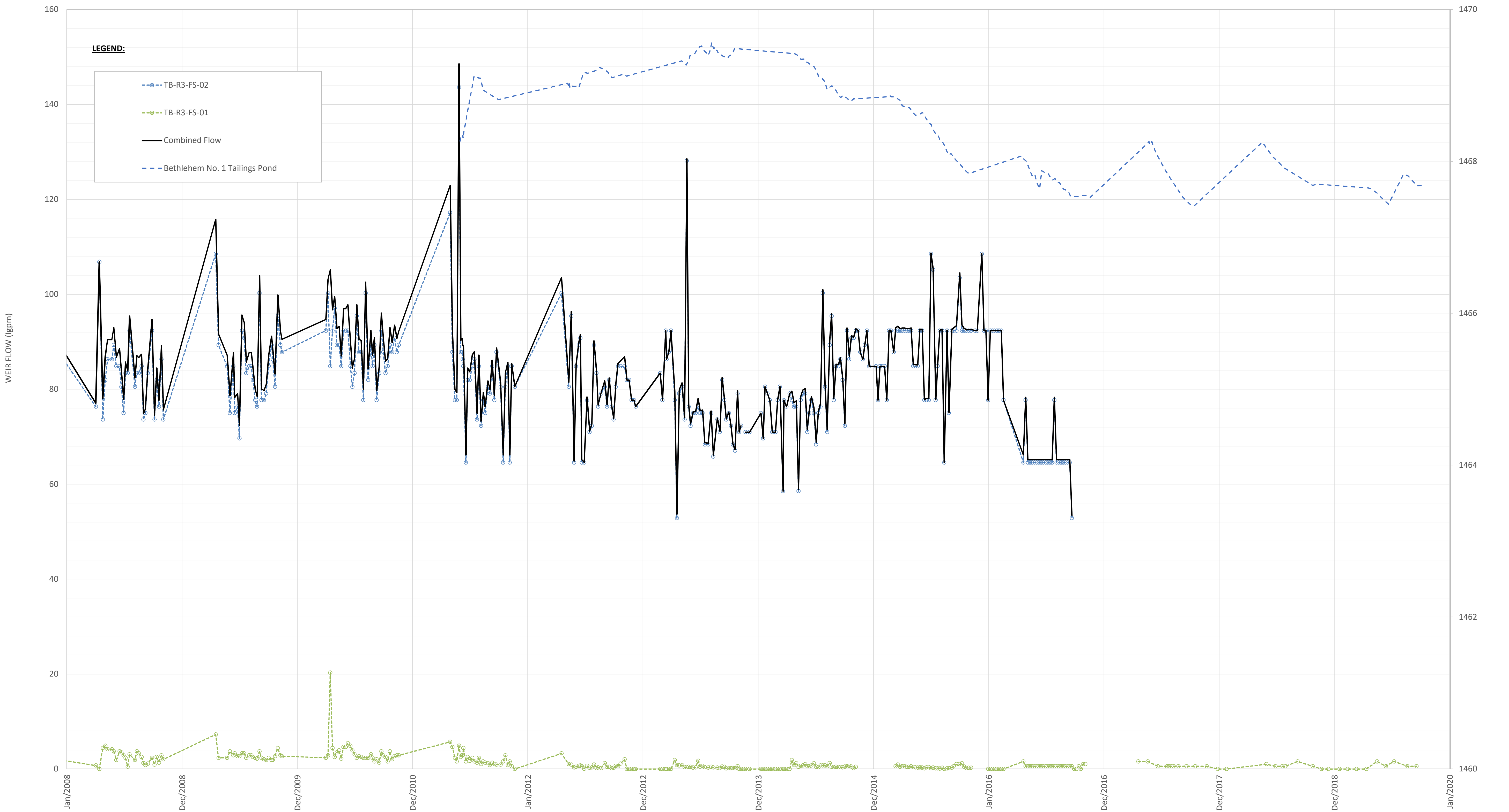
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY

TITLE: INCLINOMETER DISPLACEMENT PROFILE IB16-1

PROJECT No. M02341B53

FIG No. IV-B-5

January 13, 2020



NOTES:
1. WEIR FLOW PLOTTED ON PRIMARY (LEFT) AXIS, BETHLEHEM NO. 1 TAILINGS POND ELEVATION PLOTTED ON SECONDARY (RIGHT) AXIS.
2. TB-R3-FS-02 (WEIR 1) REMVOED OCTOBER 2016, COMBINDED FLOW ONLY PLOTTED UNTIL THAT DATE.

CLIENT: Highland Valley Copper / Teck

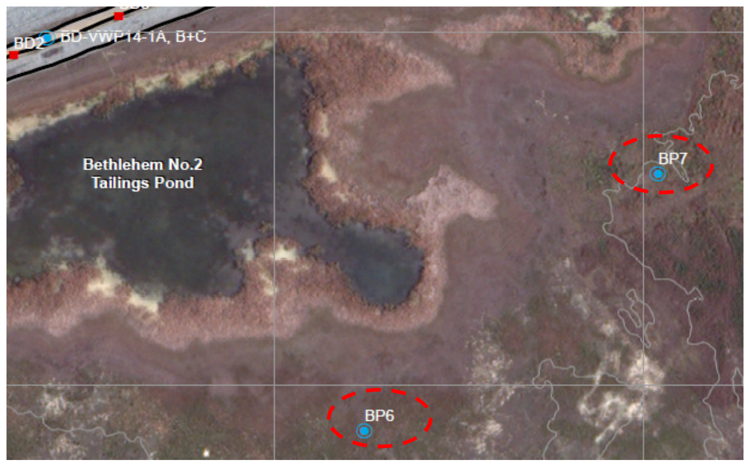
Klohn Crippen Berger

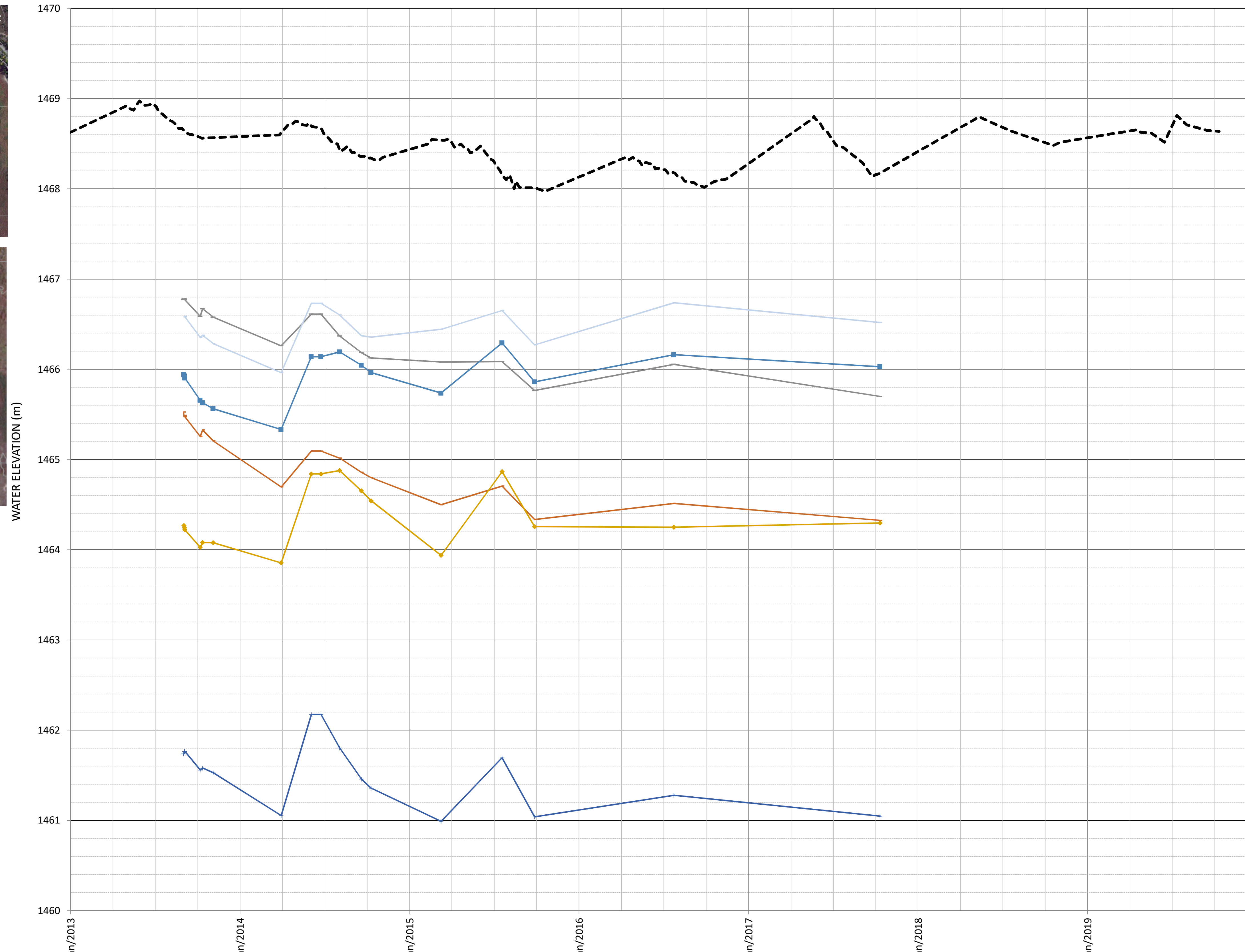
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: DAM NO. 1
WEIR FLOWS

PROJECT No. M02341B53 | FIG No. IV-B-6

January 13, 2020
Z:\M\VCR\M02341B53 - HVC-2019 Dam Safety Support\300 Design\360 Seepage Data\Bethlehem\[200113 Beth Weir.xlsx]IV-B-6 Seepage





LEGEND:

- BP6A (Tip El. 1431.1 m, Glacial Till)
- BP6B (Tip El. 1441.8 m, Tailings)
- BP6C (Tip El. 1455.5 m, Tailings)
- BP7A (Tip El. 1439.6 m, Glacial Till)
- BP7B (Tip El. 1448.7 m, Tailings)
- BP7C (Tip El. 1459.4 m, Tailings)
- Bethlehem No.2 Pond Level

PIEZOMETER ID	2019 THRESHOLD EL. (m)
BP6A	1462.8
BP6B	1466.0
BP6C	1467.3
BP7A	1469.1
BP7B	1469.1
BP7C	1468.3

NOTES:

1. NO READINGS WERE TAKEN IN 2019.

January 13, 2020
Z:\M\VCR\M02341B53 - HVC-2019 Dam Safety Support\300 Design\330 Piezometer Data\Bethlehem\[200113 Bethlehem Piezo.xlsx]IV-B-9 BLD DOWNSTREAM TOE

CLIENT: Highland Valley Copper / Teck

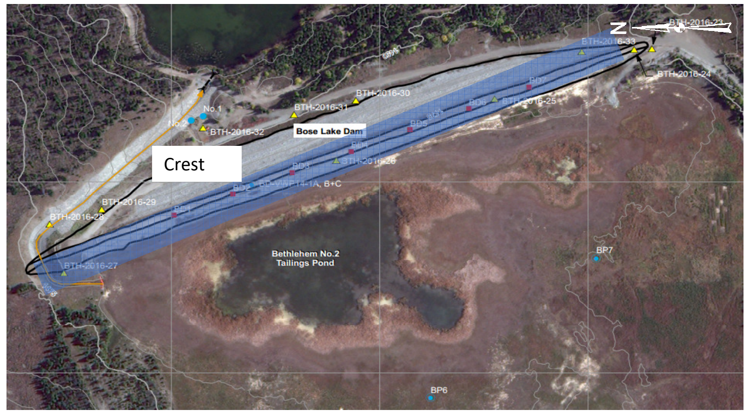
Klohn Crippen Berger

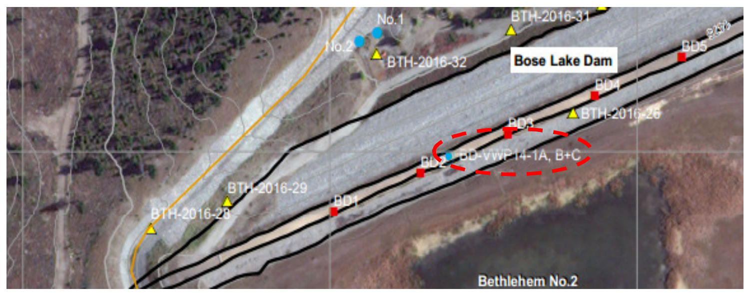
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

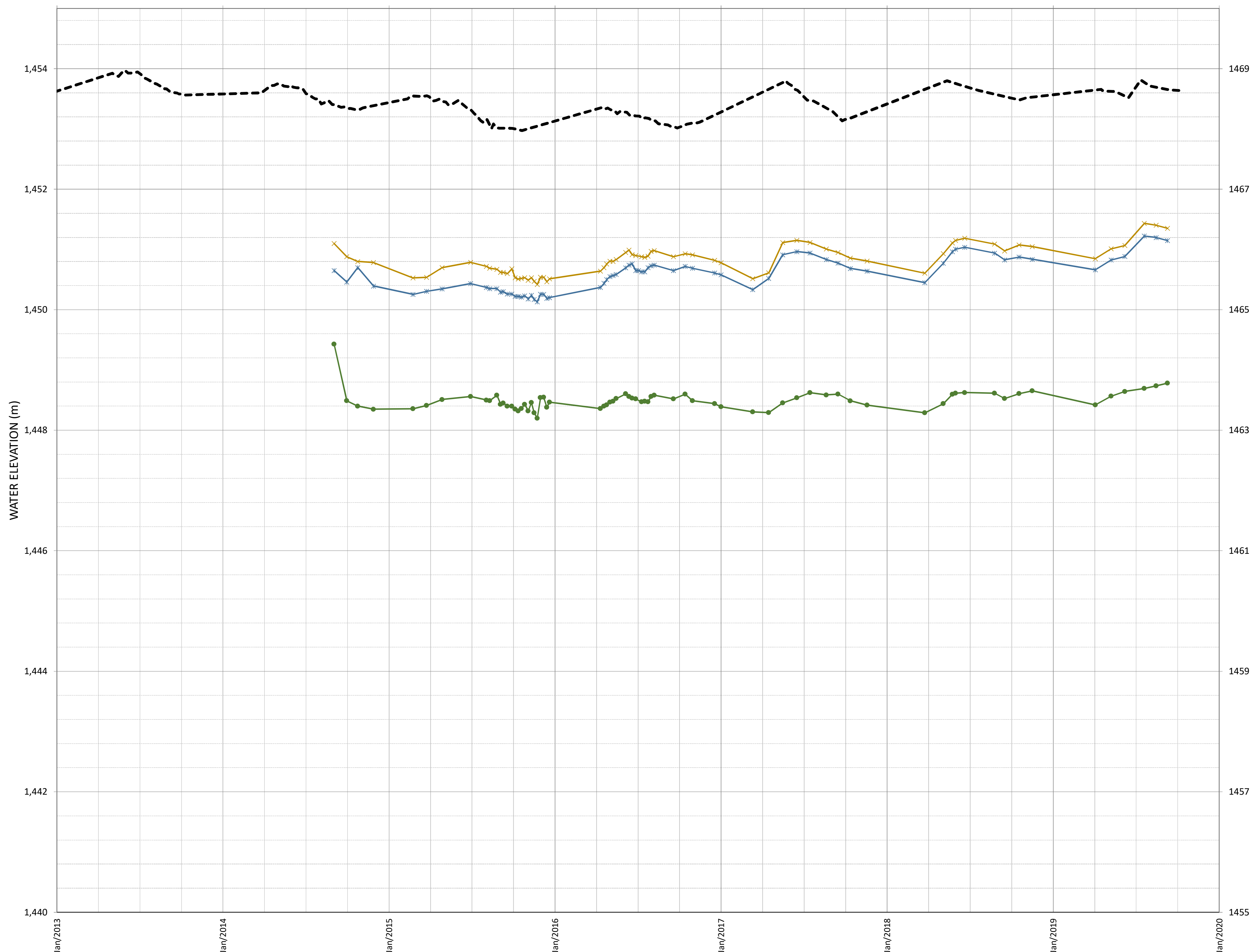
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA
2013-2019

IMPOUNDMENT

PROJECT No.	FIG No.
M02341B53	IV-B-7







LEGEND:

- Bethlehem No.2 Pond Level
- BD-VWP14-1A (Tip El. 1425.1 m, Bedrock)
- BD-VWP14-1B (Tip El. 1435.1 m, Overburden)
- BD-VWP14-1C (Tip El. 1448.1 m, Dam Fill)

PIEZOMETER ID	2019 THRESHOLD EL. (m)
BD-VWP14-1A	1451.6
BD-VWP14-1B	1451.3
BD-VWP14-1C	1449.9

NOTES:

1. PIEZOMETER WATER ELEVATIONS PLOTTED ON PRIMARY (LEFT) AXIS, POND ELEVATION PLOTTED ON SECONDARY (RIGHT) AXIS.

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: BOSE LAKE DAM PIEZOMETRIC DATA
2013-2019

CREST

PROJECT No. M02341B53

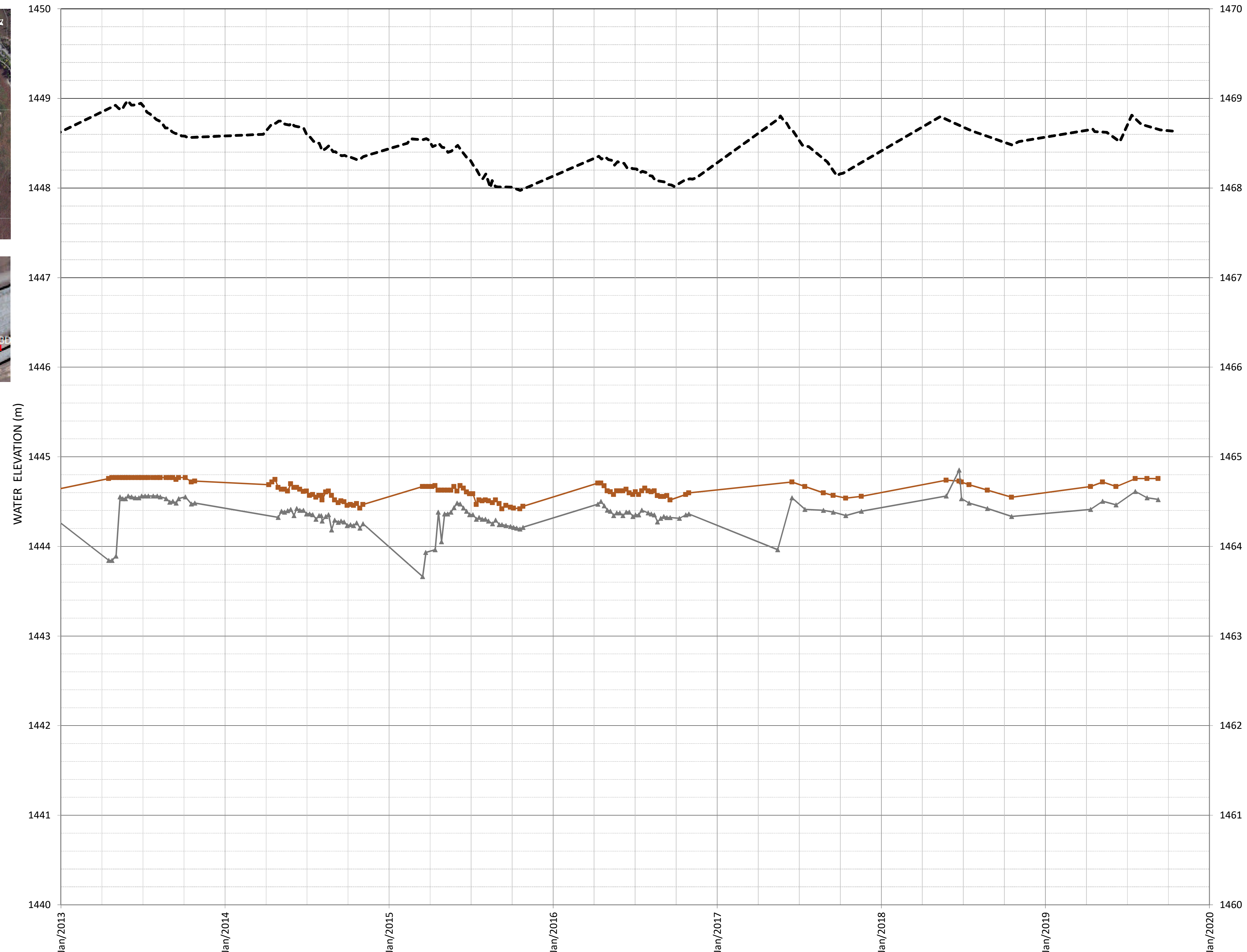
FIG No. IV-B-8

January 13, 2020
Z:\M\VCR\M02341B53 - HVC-2019 Dam Safety Support\300 Design\330 Piezometer Data\Bethlehem\[200113 Bethlehem Piezo.xlsx]IV-B-9 BLD DOWNSTREAM TOE

LEGEND:

- No. 1 (Tip El. 1433.0126 m, Overburden / Bedrock)
- No. 2 (Tip El. 1434.2318 m, Overburden / Bedrock)
- Bethlehem No.2 Pond Level

PIEZOMETER ID	2019 THRESHOLD EL. (m)
No. 1	1445.3
No. 2	1445.2



NOTES:

1. PIEZOMETER WATER ELEVATIONS PLOTTED ON PRIMARY (LEFT) AXIS, POND ELEVATION PLOTTED ON SECONDARY (RIGHT) AXIS.

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

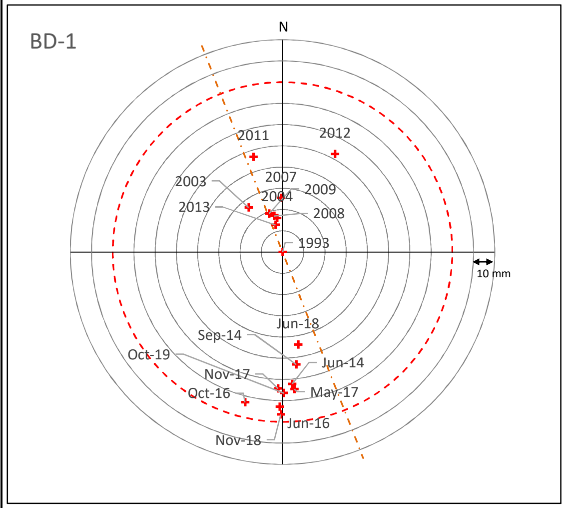
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

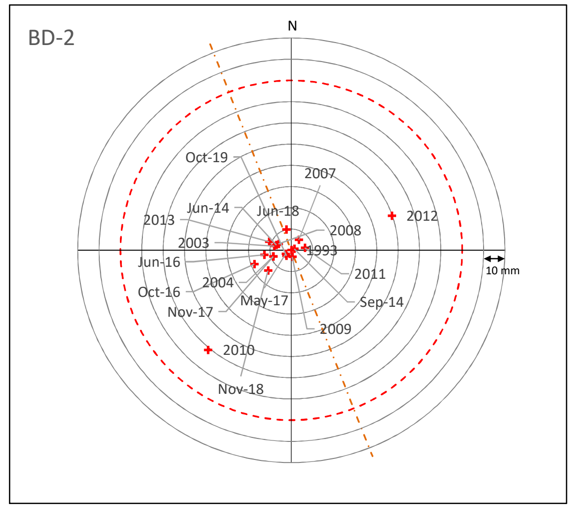
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA
2013-2018

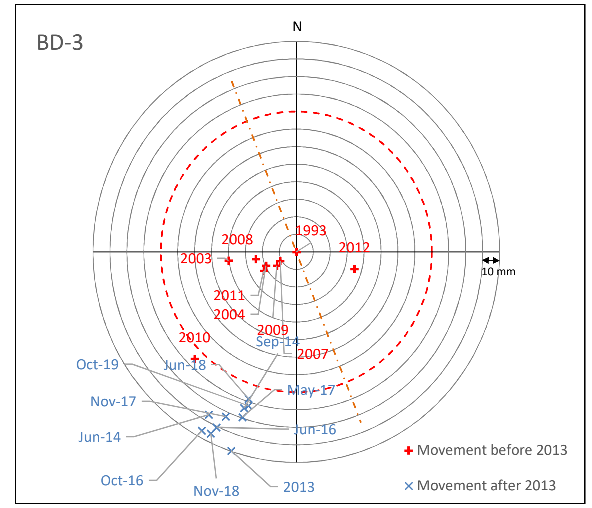
DOWNSTREAM TOE

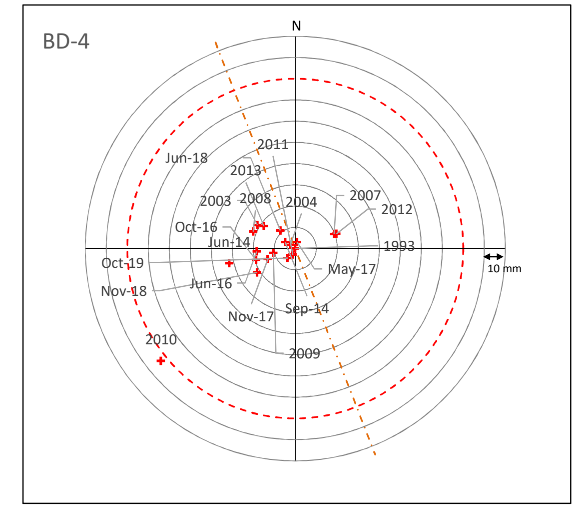
PROJECT No. M02341B53 | FIG No. IV-B-9

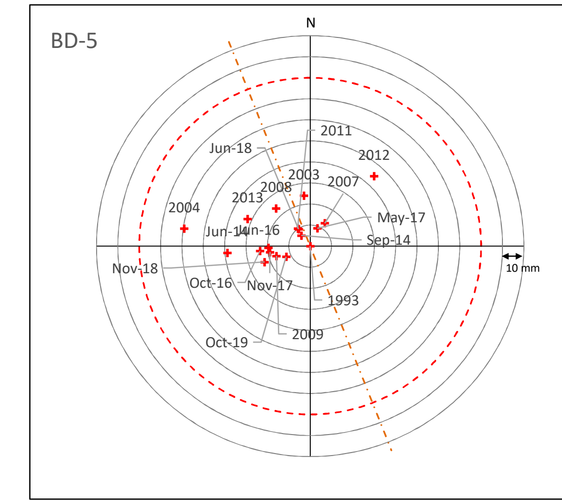
January 13, 2020
Z:\M\VCR\M02341B53 - HVC-2019 Dam Safety Support\300 Design\330 Piezometer Data\Bethlehem\[200113 Bethlehem Piezo.xlsx]IV-B-9 BLD DOWNSTREAM TOE

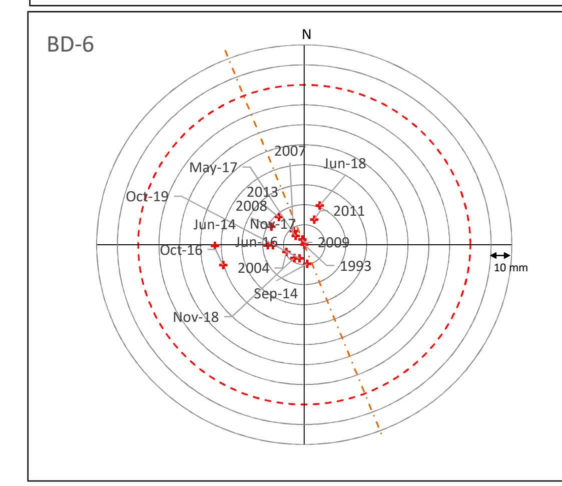


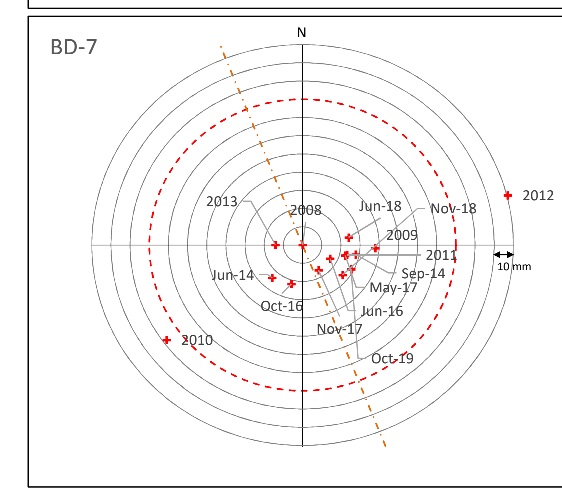








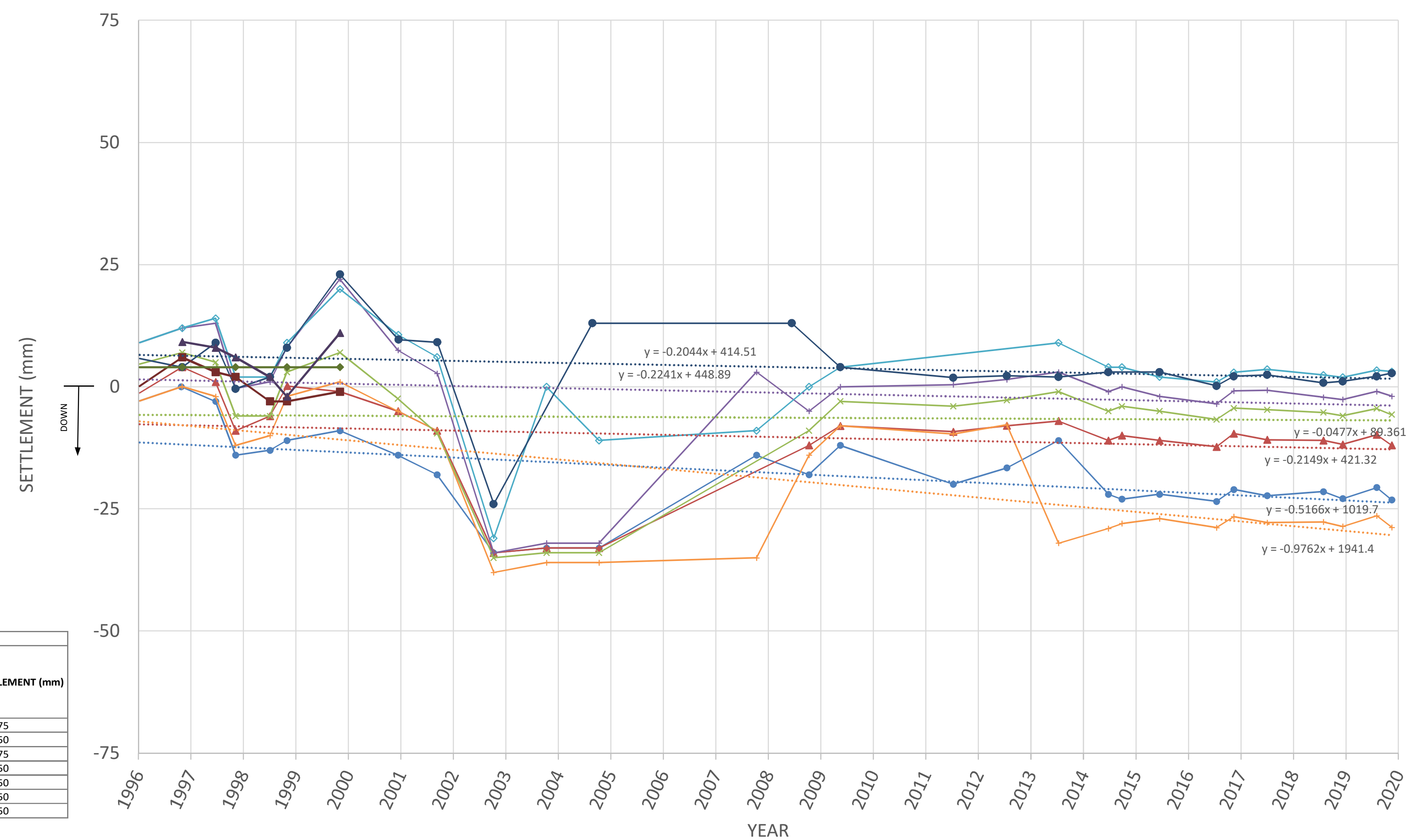




- - · DAM CENTERLINE ORIENTATION
- - - THRESHOLD HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION

LEGEND:

BD-1, BD-2, BD-3, BD-4, BD-5, BD-6, BD-7, BD-8, BD-9, BD-10



MONUMENT ID	2019 THRESHOLDS: HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION (mm)	INCREMENTAL SETTLEMENT BETWEEN READINGS (mm)	TOTAL SETTLEMENT (mm)
BD-1			75
BD-2			50
BD-3			75
BD-4	80	20	50
BD-5			50
BD-6			50
BD-7			50

NOTES:

1. BOSE LAKE DAM CREST MOVEMENT MONITORING DATA PRIOR TO 1996 NOT SHOWN.
2. REFER TO FIGURE 3 FOR MONUMENT LOCATIONS IN PLAN VIEW.
3. BD-8, BD-9 AND BD-10 DESTROYED IN 1999 OR 2000.
4. BD-1 2010 READING (NOT SHOWN IN PLAN PLOT) LOCATED 1505 mm FROM INITIAL 1993 READING. READING WAS REVIEWED AND FOUND MORE LIKELY RELATED TO SURVEY ERROR THAN DISPLACEMENT.
5. BD-5 2010 READING (NOT SHOWN IN PLAN PLOT) LOCATED 294 mm FROM INITIAL 1993 READING. READING WAS REVIEWED AND FOUND MORE LIKELY RELATED TO SURVEY ERROR THAN DISPLACEMENT.
6. BD-3 SHIFT BETWEEN PRE AND POST 2013 SURVEYS WHICH COULD BE THE RESULT OF DAMAGE OR SURVEY DATUM. NOT AN INDICATOR OF DAM SAFETY ISSUE.
7. BD-7 2003 SETTLEMENT DATA WAS OUTLIER AND NOT PLOTTED.
8. 2007 SETTLEMENT DATA OF BD-4, AND BD-2 WERE OUTLIERS AND NOT PLOTTED.

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

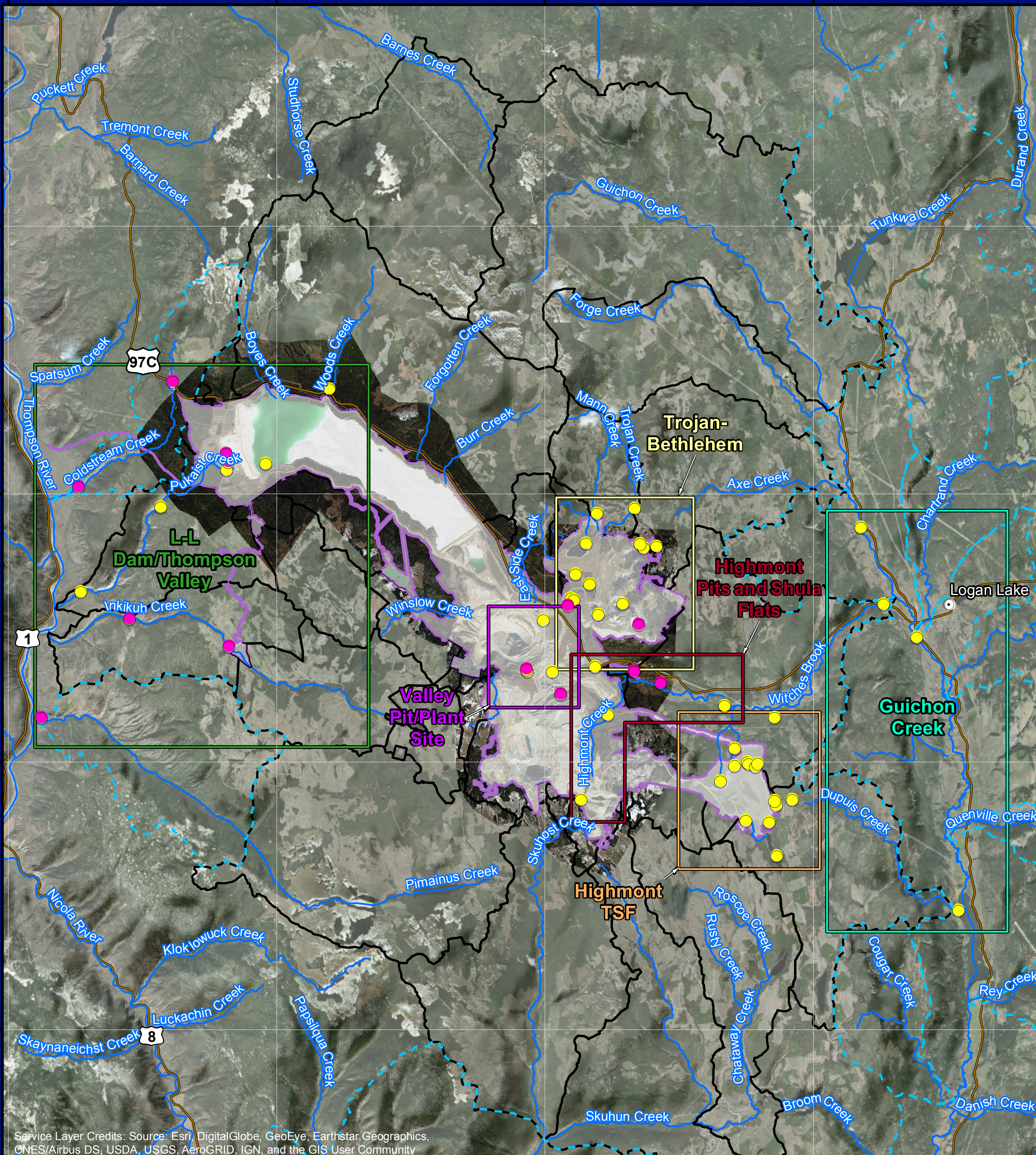
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION

TITLE: BOSE LAKE DAM SURVEY MONUMENT READINGS

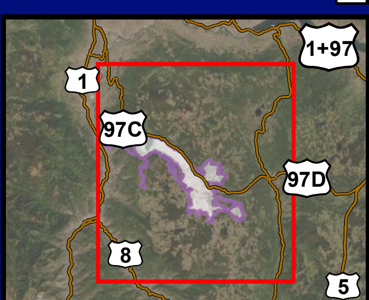
PROJECT No. M02341B53 | FIG No. IV--B10

APPENDIX V

Map of Water Quality Monitoring Points



0 2,000 4,000 8,000 12,000 16,000 20,000 Metres



Guichon Creek
Highmont Pits and Shula Flats
Highmont TSF
L-L Dam/Thompson Valley
Trojan-Bethlehem
Valley Pit/Plant Site
Community
Highway

Permitted Mine Area

Sampling Site

Permitted
Voluntary

Watersheds

Freshwater Atlas
HVC Updated

Highland Valley Copper / Teck

Teck Resources Limited
PO Box 1500
Logan Lake, BC, Canada

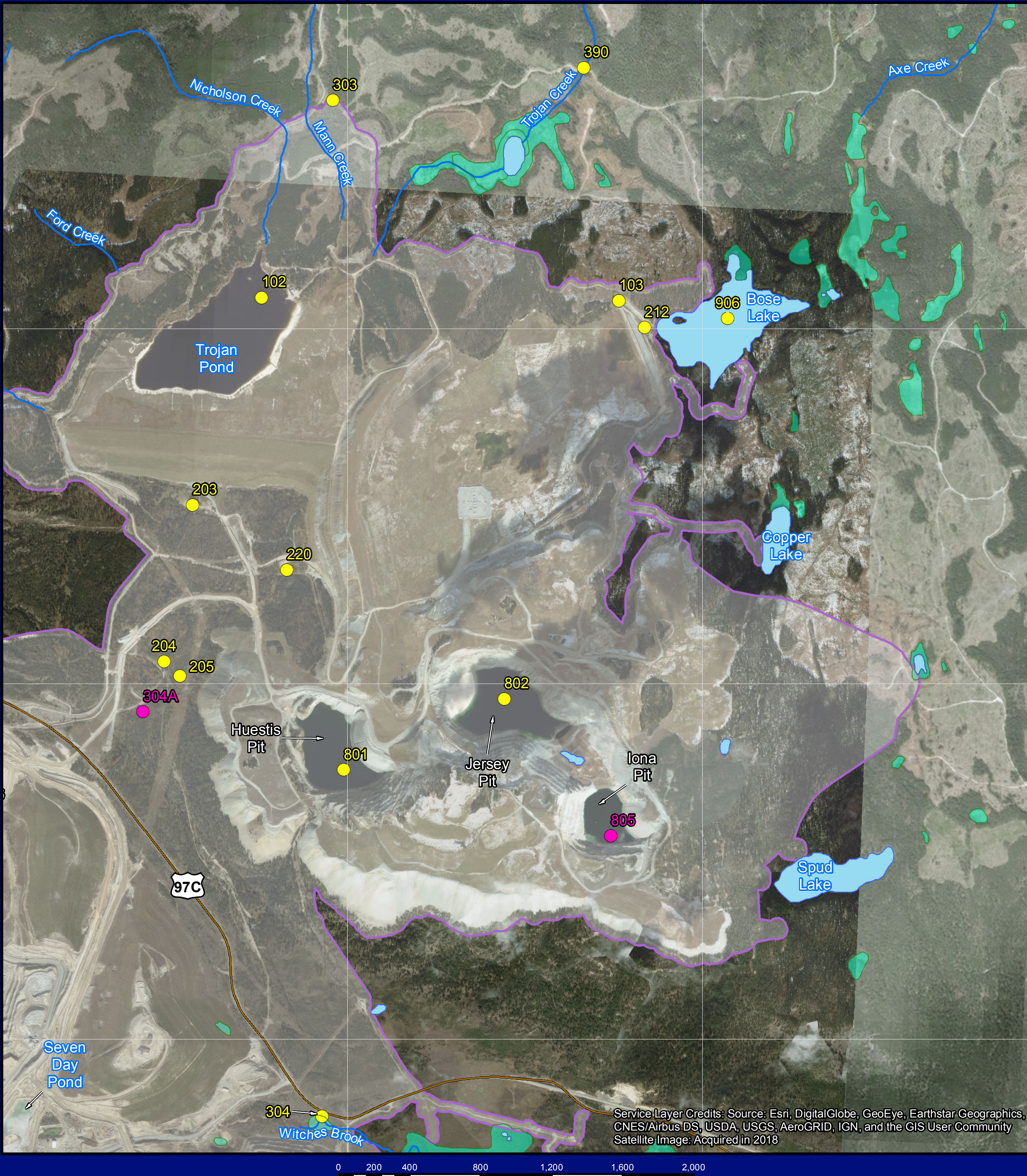
N

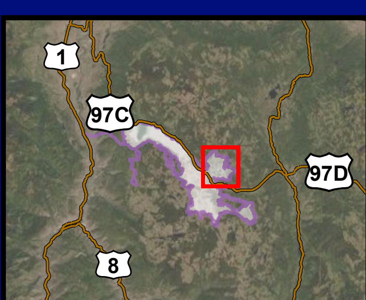
Figure E-1
Water Quality Monitoring Sites, Highland Valley Copper, 2019

1:200,000

PROJECTION: NAD 1983 UTM Zone 10N

DATE: 3/19/2020 | GIS No.:HVCE-01-004a





Sampling Site

- Permitted
- Voluntary
- Permitted Mine Area
- Wetland
- Highway

Highland Valley Copper / Teck

Teck Resources Limited
PO Box 1500
Logan Lake, BC, Canada

Figure 3.2-26
Water Quality Monitoring Sites in the Trojan-Bethlehem Area, Highland Valley Copper, 2019
1:30,000

N

PROJECTION: NAD 1983 UTM Zone 10N

DATE: 2/7/2020

GIS No.:HVCE-01-004d

APPENDIX VI

Failure Mode Review

Appendix VI
Failure Mode Review

VI-1 OVERVIEW

Based on the DSI and review of available documents regarding Bethlehem No. 1 TSF, the potential failure modes included in the Canadian Dam Safety Guidelines (CDA 2013) were reviewed:

VI-2 DAM NO. 1

Overtopping

Overtopping of the Dam No. 1 is not a plausible failure mode in the current configuration because the crest is 2 m higher than the Bose Lake Dam crest on the far side of the impoundment. Therefore, the Bose Lake Dam would be overtopped before the pond reached the Dam No. 1 crest.

Internal Erosion and Piping

Based on a 2015 review of filter adequacy (KCB 2015), the likelihood of piping related failure through the dam developing at this stage is very low.

Slope Stability: Static and Seismic Loading

- There is limited information to define the in-situ state and extent of the soft material beneath the rockfill toe buttress and portions of the dam (Section 2). It is not practical to resolve this uncertainty using conventional investigation techniques (e.g. drilling, test pits, geophysics). Inclinometer readings to date (Section 5.6) do not indicate any ongoing shear within the soft foundation unit at that location.
- KCB reviewed the potential influence of this unit on stability assuming a reasonable worst case where the material is: continuous beneath the rockfill toe buttress; saturated; shears in an undrained manner; and susceptible to shear strength loss under the design earthquake load. Even with these reasonable worst case assumptions KCB (2019b) found that:
  - The existing condition of the dam meets design FOS criteria for global slip surfaces which would result in an uncontrolled release of tailings under static ($\geq$ 1.5) and post-earthquake ($\geq$ 1.2) loading.
  - There is a potential hazard to mine roads and downstream infrastructure (e.g. seepage ponds) related to a failure of the rockfill toe buttress if the soft layer were to fully liquefy under an extreme earthquake load and the shear strengths are as low as typical values for liquefied sands and silts, which is conservative given the variability and presence of rockfill in the unit. Such a failure of the toe buttress would not result in a flow failure and/or uncontrolled release of the contained materials. A large portion of the buttress would most likely slump to a shallower slope than existing but would essentially remain in place. During 2020, THVCP plan to review risk of this and include in the site risk register.

Surface Erosion

The downstream slope has some significant erosion features noted in prior DSI reports. Although relatively large in size, they have not been observed to progress into larger slope failures and are setback from the tailings beach that could lead to overtopping. Progressive erosion that develops over time or multiple events are managed through routine and event-driven monitoring and maintenance. The likelihood of surface erosion over the downstream slope resulting in a failure from a single event is very low with the diligent inspection and maintenance program prescribed in the OMS manual.

VI-3 BOSE LAKE DAM

Overtopping

The Bethlehem No.1 TSF has an open channel spillway designed (AMEC 2014a) near the left abutment of the Bose Lake Dam to safely pass the PMF which is greater than the minimum IDF recommended under the Code. The spillway and freeboard are effective controls to manage overtopping risks.

Internal Erosion and Piping

Bose Lake Dam is a glacial till embankment with a downstream filter zone, drain and rockfill zone. Based on historic performance, low flow gradients, seepage water quality, and the 2015 review of filter adequacy (KCB 2015), the likelihood of piping related failure through the dam, developing at this stage, is very low.

Slope Stability – Static and Earthquake Loading

The structural integrity of the dam is based on a competent Glacial Till foundation and compacted fill (Glacial Till and rockfill). Each of these units have relatively high shear strength and not subject to significant strength loss during earthquake loading. Based on previous slope stability analyses (KC 1996), the factor of safety (FOS) of slip surfaces through the fill or foundation is greater than the minimum required by the Code.

Surface Erosion

The majority of the downstream slope is covered with rockfill armouring; remaining areas are well vegetated with grasses. Progressive erosion that develops over time or multiple events are managed through routine and event-driven monitoring and maintenance. With this program in place, the likelihood of surface erosion over the downstream slope resulting in a failure from a single event is considered negligible.

VI-4 R3 SEEPAGE POND DAM

Overtopping

The R3 Seepage Pond has an open channel spillway designed to safely pass the PMF (PMP, 24-hour duration event), which is greater than the minimum IDF recommended under the Code (100-year flood). The spillway and freeboard are effective controls to manage overtopping risks.

Internal Erosion and Piping

The absence of suspended solids noted in observed seepage water during routine inspections over the service life of the dam suggests failure by internal erosion under existing conditions is low.

Slope Stability – Static Loading

Stability analysis completed by KCB to support the 2016 DSI (KCB 2017b) indicates that the FOS of a more deeply seated failure through the dam fill or foundation is greater than 1.5.

Slope Stability – Earthquake Loading

The seismic coefficient used in previous stability analysis, which indicated satisfactory FOS, corresponds to seismic load that is greater than the minimum EDGM required by the Code, 100-year.

Surface Erosion

The downstream slopes have some coarse rock and are lightly vegetated. Therefore, combined with the short slope lengths and the small catchment areas (i.e. restricted to primarily the slope area itself), the likelihood of surface erosion resulting in a failure is considered very low.

APPENDIX VII

2018 DSR Recommendations

Appendix VII
Dam Safety Review Recommendations

Table VII-1 2018 Bethlehem No.1 TSF Dam Safety Review Recommendations

ID	Priority[1]	2018 DSR Comment	Topic
SRK19-BD-01	4	THVCP have installed public safety signs as recommended by AMEC in the previous DSR (AMEC 2014a). However, these signs do not identify hazards specifically. Include identification and description of hazards in the public safety signs near the Bose Lake Dam.	Safety / Bose Lake Dam
SRK19-BD-02	3	The factor of safety for a static failure obtained in 1996 (KCC 1996) is exactly at the minimum required (1.50). The phreatic surface is estimated to be currently lower than the assumed depth in 1996, but no sensitivities were included in the stability assessments to verify how sensitive dam stability is to phreatic levels. Update stability analyses to include sensitivities to the phreatic surface. If phreatic levels are shown to be critical to stability, re-define thresholds based on the results of stability and/or other appropriate engineering analyses.	Stability / Bose Lake Dam
SRK19-BD-03	3	The earthquake used in the 1996 stability assessment (KCC 1996) does not meet the current criterion for annual exceedance probability. Utilize the appropriate earthquake in the stability assessment (it is understood it is being incorporated into KCB (2019))	Stability / Dam No. 1
SRK19-BD-04	3	The PMF design flood was not evaluated in accordance with CDA (2013) Evaluate the spring and summer/autumn PMF as per CDA (2013) and update the flood routing analysis.	Hydrotechnical / Bethlehem TSF
SRK19-BD-05	3	The required normal freeboard as per CDA (2013) was not evaluated. Determine normal operating water level if different than spillway invert and evaluate the required normal freeboard as per CDA (2013).	Hydrotechnical / Bethlehem TSF
SRK19-BD-06	3	The OMS manual should include a maintenance protocol for the log boom at the inlet of the Bose Lake Dam spillway channel. Include maintenance requirements for the log boom in the OMS manual.	OMS / Log Boom
SRK19-R3-01	4	The dam crest elevation is reported as 1371 m in the current OMS manual (THVCP 2016) and the latest DSI (KCB 2018). It is reported as 1371.8 m in the latest freeboard evaluation report (KCB 2018b). Reconcile the dam crest elevation and include in the final OMS currently being finalised.	Survey / R3
SRK19-R3-02	4	The 100-year inflow design flood is not based on the most recent hydrology. Update the inflow design flood and flood routing with the most recent hydrology.	Hydrotechnical / R3
SRK19-R3-03	3	The required normal freeboard as per CDA (2013) was not evaluated. Determine maximum normal operating water level if different than spillway invert and evaluate the required normal freeboard as per CDA (2013).	Hydrotechnical / R3
SRK19-R3-04	3	The emergency spillway channel has a large concrete block in the inlet which would affect flood capacity. Remove the concrete block in the spillway channel.	Hydrotechnical / R3

ID	Priority[1]	2018 DSR Comment	Topic
SRK19-R3-05	3	KCB (2017) reports that a stability analysis carried out to support the DSI indicated that the FOS for a deep-seated failure was compliant with the Code (MEM, 2017), but there is no reference for such analysis. Include the references for the stability assessments of R3 Reclaim Pond in the OMS manual.	Stability / R3

Notes:

1- Priority guidelines are defined as follows (MEM 2016):

- 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.

2- Deficiency: an inadequacy, or uncertainty in the adequacy, of the dam system to meet its performance goals in accordance with good dam safety practices.

3- Non-Conformance: an inadequacy in the nonphysical controls (procedures, processes and management systems) necessary to maintain the safety of the dam.