Klohn Crippen Berger

Teck Highland Valley Copper Partnership

2018 Dam Safety Inspection Report

Bethlehem No. 1 Tailings Storage Facility

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M02341B43.730

March 2019

March 26, 2019

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

Mr. Chris Anderson
Manager, Tailings and Water

Dear Mr. Anderson:

2018 Dam Safety Inspection Report
Bethlehem No.1 Tailings Storage Facility

We are pleased to submit the 2018 Dam Safety Inspection report for the Bethlehem 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), Section 4.2 “Annual Tailings Facility and Dam Safety Inspection Report” of the Code Guidance Document.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

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

RF/PU:cd

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Teck Highland Valley Copper Partnership

2018 Dam Safety Inspection Report

Bethlehem No. 1 Tailings Storage Facility

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) were engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2018 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. and Mr. Tyler Lappin, P.Eng., as representatives of KCB on August 7, 2018. Mr. Chris Anderson, P. Eng., THVCP Manager, Tailings and Water, is the TSF Qualified Person (as defined by the Code) for Bethlehem No. 1 TSF.

This DSI includes the following dams: Dam No. 1 and Bose Lake Dam, which form the tailings impoundment; and R3 Seepage Pond, located downstream of Dam No. 1. Seepage Pond 1, downstream of Dam No. 1, was breached in a controlled manner by THVCP in 2016 and is no longer capable of retaining water.

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. The facility was constructed in 1963 and operated from 1964 to 1989. The site has been reclaimed and is currently inactive. THVCP continue ongoing surveillance of the site including 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).

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 placed on the upstream beach. A downstream rockfill buttress was later added in the valley section. The R3 Seepage Pond Dam, located downstream from Dam No. 1, collects seepage from the Dam No. 1 underdrains.

Bose Lake 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.

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 2018. A dam safety review (DSR) was completed by AMEC in 2013 (AMEC 2014a). The Code requires a DSR be undertaken every five years for tailings dams. THVCP Commissioned DSR in 2018 which is currently underway and is expected to be completed in 2019.

There are two free water ponds, located in the impoundment: Bethlehem Pond No. 1; and Bethlehem Pond No. 2. In 2017, both ponds varied seasonally consistent with historic observations showing no long-term trend of increasing pond volume. The Bethlehem No. 1 TSF spillway, installed near the left abutment of Bose Lake Dam, is designed for 24-hour PMF event, which is greater than the IDF required for a "Very High" consequence facility under the Code.

The Emergency Preparedness and Response Plan (EPRP) was updated in 2016. The Operation, Maintenance and Surveillance (OMS) manual was also reviewed and issued as in December 2018

(THVCP 2018). The OMS manual and EPRP meet the intent of the Mining Association of Canada (MAC) and CDA guidelines, are current and provides adequate coverage for existing conditions.

Visual inspections and instrument measurements were completed by THVCP but not all were done at the prescribed frequency in the OMS. KCB recommended some of the piezometers which were not read in 2018 should be read early in 2019, when accessible. The frequency of routine visual inspections was increased during freshet by THVCP as a proactive measure. There were no event-driven inspections in 2018 triggered by precipitation or earthquake event as defined in the OMS manual. There were no threshold exceedances during 2018.

Piezometric and movement thresholds which monitor deviation from the established trend, were reviewed, no revisions are proposed for 2019. A threshold has been set for inclinometer IB16-1.

Water quality downstream of the Bethlehem TSF is monitored by HVC monthly to assess the effectiveness of the tailings facility in protecting the downstream receiving environment (ERM 2019). All permit sampling requirements and frequency were met in 2018, except for two instances when a subset of the required water quality parameters was not measured for specific samples. These parameters were tested in the previous and subsequent months.

The Bethlehem No. 1 TSF appeared to be in good physical condition and the observed performance during the 2018 site inspections is consistent with the expected design conditions and past performance. 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 2018 DSI are summarized in Table 2.

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 Tailings 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 (deferred to 2019)
Dam No. 1					
BTSF-2017-04	*Surveillance*	*Inclinometer Monitoring*	*Establish a 2018 threshold limit for inclinometer IB16-1.*	*4*	*Q4, 2018 (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 2018 DSI Recommendations

ID No.	Deficiency or Non-Conformance	Applicable Reg. or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline
Bethlehem Tailings Storage Facility					
BTSF-2018-01	Flood Management	10.1.8 (the Code)	Update flood routing assessment for Bethlehem TSF and R3 Seepage Ponds based on the most recent site wide hydrology information for consistency and to confirm compliance.	3	Q2, 2020
BTSF-2018-02	Surveillance	Piezometer monitoring	All piezometers in the Bethlehem 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
Dam No. 1					
No new recommendations from 2018					
Bose Lake Dam					
No new recommendations from 2018					
R3 Seepage Pond					
No new recommendations from 2018					

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 2018 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. No tailings have been discharged into the impoundment since 1989. The site has been reclaimed since tailings discharge ceased and THVCP continue ongoing surveillance and maintenance. This DSI includes the following dams: Dam No. 1 and Bose Lake Dam, which form the TSF; and R3 Seepage Pond, located downstream of Dam No. 1.

The reclaimed site is monitored by THVCP staff who are onsite to support the ongoing operations at the site. Monthly THVCP staff visit the Bethlehem No. 1 TSF for environmental sampling, inspections and maintenance activities. Under this level of site presence, the facility is considered to be in the active care closure phase as defined by the Canadian Dam Association (CDA 2014).

The 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 other relevant dam safety management documents (e.g. Operations, Maintenance & Surveillance (OMS) manual); and
- a review of the past year's construction records, 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), Section 4.2 "Annual Tailings Facility and Dam Safety Inspection Report" of the Code Guidance Document (MEM 2016).

The visual inspection was completed by the Engineer of Record (EoR), Mr. Rick Friedel, P.Eng. and Mr. Tyler Lappin, P.Eng., as representatives of KCB on August 7, 2018. During the inspection, the weather was sunny with cloudy periods and did not impact the inspection. Mr. Chris Anderson, P.Eng., THVCP Manager, Tailings and Water, 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 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 Permit M11.

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

- British Columbia Ministry of Environment (MOE) Water Licences C114183 and C068389 – these licenses allow diversion and storage of water from Pukaist Creek on Crown Land.
- 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 (2013) based on the latest dam consequence review hosted by THVCP on January 23, 2019, which the EoR (Mr. Rick Friedel, P.Eng. of KCB) participated in via teleconference.

A dam safety review (DSR) was completed by AMEC in 2013 (AMEC 2014a). The Code requires a DSR be undertaken every five years for tailings dams. THVCP Commissioned a DSR in 2018 which is currently underway and is expected to be completed in 2019.

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; refer to Figure 1.

Bethlehem No. 1 TSF is retained by Dam No. 1 on its western boundary 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.

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 2.1. Refer to Appendix III 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:
  - 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; and
  - 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 was placed over this dyke to form the dam base.

- The dam was raised by centerline 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 be kept a minimum 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 2.1. Refer to Appendix III 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 2.1 Summary of Approximate Dam Geometry

Dam	Nominal Crest Elevation (m)	Maximum Dam Height (m)	Crest Length (m)	Minimum Crest Width (m)	Upstream Slope	Downstream Slope
TAILINGS DAMS						
Dam No. 1	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	1475	31	600	9	2H:1V	2H:1V
SEEPAGE COLLECTION DAM						
R3 Seepage Pond	1371	3	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 HISTORY AND RECENT ACTIVITY

3.1 History

A brief history of the construction and operations of the Bethlehem No. 1 TSF, prior to 2018, 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.

3.2 2018 Activities

In addition to routine maintenance activities, as defined in the OMS manual, (e.g., clearing weirs of vegetation) no repairs or construction activities were completed during 2018. THVCP has planned to complete routine maintenance on any erosion gullies in the rockfill slope during 2019.

4 WATER MANAGEMENT

4.1 Overview

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 4.1. Figure references for key operating water management structures are summarized in Table 4.1.

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-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; discussed further in Sections 4.2 and 5.3.

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-7. Since 2015, there has been a long-term downward trend in the pond level. This trend is not evident in 2017 or 2018, largely due to increased inflows during freshet; discussed further in Sections 4.2 and 5.3.
- 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

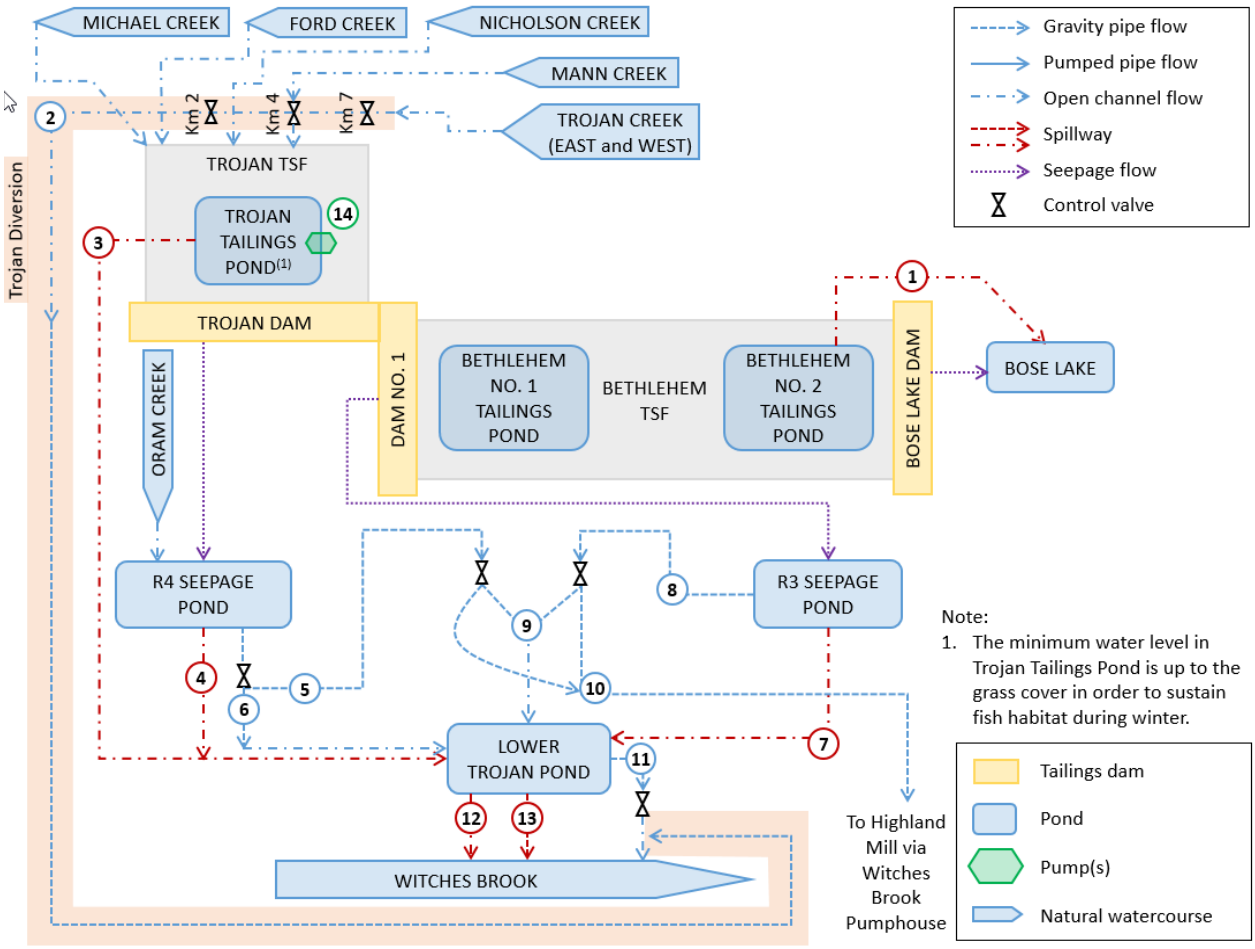
- The 3 m wide open channel spillway is excavated near the left abutment of Bose Lake Dam and discharges into Bose Lake via 2 corrugated steel pipe (CSP) culverts (1 x 1380 mm dia., 1 x 600 mm dia.) under a public road.

- 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 4.1), 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. These visual estimates of available freeboard ranged from 1.2 m to 1.8 m in 2018. The vertical distance between the pond and dam crest was 1.5 m based on a visual estimate during the 2018 DSI site visit.
- 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 4.1 Process Flow Diagram 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 4.1 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.

4.2 Climate

THVCP provided weather data from the L-L Dam climate station (El. 1186 m) which has historically been selected as most representative for the mine site. In 2018, some data logger issues in June, September and November led to some short data gaps as noted in Table 4.2. To support key precipitation trends and impacts on observed dam performance in 2018 data from Kamloops Airport (Environment Canada Station No. 1163781, El. 345 m) was reviewed for comparison that no major events were missed and general trends were consistent. Precipitation records at L-L Dam and Kamloops Airport are tabulated and plotted with average monthly values or climate normals in Table 4.2 and Figure 4.2, respectively.

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 to track the changes in snowpack. The measurements are sorted by survey period (the first of January through May) to compare snowpack depths (in snow-water equivalent (SWE)) around the same time each year. Historical average and 2018 snowpack depths based on available records are summarized in Table 4.3.

The following observations were noted for 2018:

- April was noticeably wetter than normal which appears to coincide with the peak pond level recorded in 2018; see Section 5.3.
- September was also wetter than normal which appears to coincide with the peak seepage rate recorded in 2018; see Section 5.7.
- Snowpack depths measured from March 1st to May 1st were significantly (up to +520%) deeper than average. The drier than normal month may have offset a portion of the melt-induced flows during freshet; however, impact of freshet could have also been less due to improvements made by THVCP following 2017 freshet.

Table 4.2 Monthly Precipitation

Month	Precipitation (mm)			
	2018 at Bethlehem TSF[1]	Average Monthly at Bethlehem TSF[2]	2018 at Kamloops Airport[3]	1981-2010 Climate Normals at Kamloops Airport[3]
January	20.8	30.5	23.7	21.1
February	28.2	23.3	51.9	12.4
March	17.5	18.5	19.6	12.8
April	84.5	23.6	42.8	14.2
May	13.6	45.8	2.4	27.3
June	51.0[4]	53.2	36.8	37.4
July	38.8	48.3	35.7	31.4
August	43.7	35.2	19.2	23.7
September	56.9[5]	34.6	50.5	29.4
October	21.3	33.3	27.5	19.4
November	23.4	44.8	33.5	23.3
December	15.6	45.3	20.2	25.4
Annual Total	415.3	436.4	363.8	277.6

Notes:
1. Available data from L-L Dam climate station was adjusted by a L-L Dam-to-Bethlehem/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. 2018 data from relocated station (ID No. 1163781); climate normals from data collected at previous station location (ID No. 1163780).
4. Data missing from June 6 to June 24 and June 26 to June 31, inclusive.
5. Data missing from September 21 to September 30, inclusive.

Figure 4.2 Monthly Precipitation

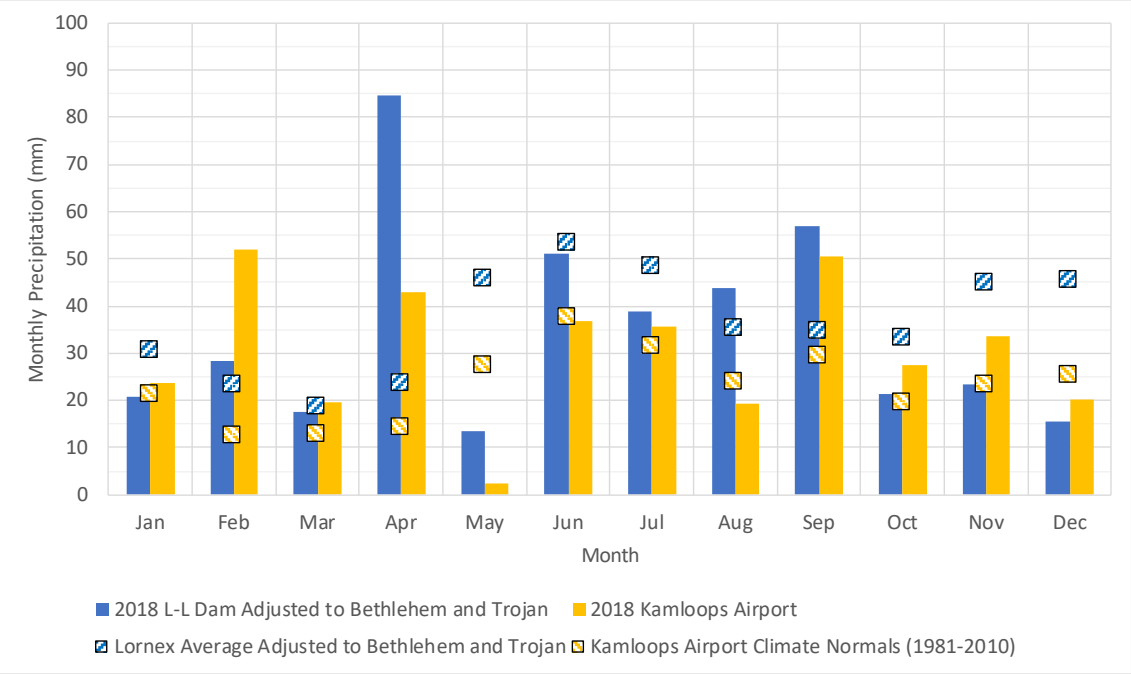


Table 4.3 Historical Average and 2018 Snowpack Depths

Survey Period	Years of Record[1]	Historic Average Snowpack Depth[2] (mm SWE[3])	2018 Snowpack Depth (mm SWE[3])	Percent Difference
January 1st	11	50.2	Not surveyed	N/A
February 1st	25	83.5	Not surveyed	N/A
March 1st	52	90.8	156	+72%
April 1st	51	101.7	166	+63%
May 1st	51	29.2	181	+520%
May 15th	25	2.4	Not surveyed	N/A

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.
3. SWE = snow water equivalent.
4. The March 1st survey was conducted on March 5, 2018. The April 1st survey was conducted on March 27, 2018. The May 1st survey was conducted on April 24, 2018.

4.3 Water Balance

THVCP manages and tracks the annual water balance for the Bethlehem No. 1 TSF. Table 4.4 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 m²;
- Assumed surface area of 2,786,830 m²;
- Modelled annual precipitation of 446 mm; and
- Runoff coefficient 0.45.

Table 4.4 Annual Water Balance for Bethlehem TSF

Item	Volume in 2018[1] (m³)
Inflows	
Direct precipitation	43,500
Runoff	538,500
Total inflow:	582,000
Outflows	
Seepage	466,300
Evaporation[2]	52,700
Total outflow:	519,000
Balance	
Balance (inflow minus outflow)	63,000

Notes:
1. Values received from THVCP have been rounded to the closest 100 m³.
2. Precipitation from the Shula Flats weather station adjusted to the Bethlehem area was used in the water balance.
3. Evaporation assumed for Bethlehem TSF: 540 mm/year.

4.4 Flood Management

The summary of flood management structures and the applicable design criteria and details for the four dams are given in Table 4.5 below with the following discussion points noted:

- The structures are designed for storm events with return periods greater than those required by the Code.
- Flood routing assessments, including hydrologic modelling to estimate flood volumes and peak flow rates, for the Bethlehem impoundment, R3 Seepage Pond and other legacy tailings facilities have been completed at various time periods, during which climate data has changed. For completeness, KCB recommends all flood routing assessments be updated based on the most appropriate climate information.

Table 4.5 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 Level	
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

The Code specifies that an evaluation of available freeboard[1] in excess of the design flood (i.e., account for wave setup and wave run-up) is required but defers to CDA (2013) for freeboard design standards. Consideration should be given to the mining dam specific factors highlighted in the CDA (2014). Minimum required freeboard, as per the Code, for each dam and the freeboard during the IDF are summarized in Table 4.6. Where available, the minimum freeboard measured during 2018 based on monitoring records are also listed in Table 4.6.

[1] The vertical distance between the peak flood level during a flood event and the low point of the dam crest.

In summary:

- The freeboard for R3 Seepage Pond was reviewed and updated in 2018 (KCB 2019); minimum freeboard required under the Code is met for the IDF. Minimum freeboard under the spillway design event which is larger than the IDF (Table 4.5), is 0.2 m.
- Both Dam No. 1 and Bose Lake Dam meet the minimum freeboard requirement, during the IDF. In addition, the 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 the available storage in the impoundment below the spillway invert under normal operations, provides additional flood attenuation not accounted for in the design.

Table 4.6 Minimum Required Freeboard

Dam	Required Freeboard During Inflow Design Flood [1]	Minimum Freeboard During Inflow Design Flood	2018 Freeboard	2018 Freeboard Surveyed
Dam No. 1	0.5 m	5.5 m [3]	7.7 m	Annual minimum from surveys, refer to App IV
Bose Lake Dam	0.5 m	3.5 m [3]	6.3 m	Annual minimum from surveys, refer to App IV
R3 Seepage Pond Dam	0.5 m [2]	0.6 m [4]	1.2 m	Quarterly minimum from Dam Inspector surveillance

Notes:
1. As per the Code.
2. 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.
3. As per AMEC (2014b).
4. As per KCB (2019).

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 2018 update supersedes the versions submitted to EMPR in December 2016 and was adopted on site.

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. A 2019 update to the OMS manual is planned to include additions referenced throughout this report and meet the recently updated guidance document by MAC (2019).

5.2 Inspections

The 2018 Bethlehem No. 1 TSF monitoring program includes the following inspections:

- Annual DSI (this report) – completed by the EoR to comply with Section 10.5.3 of the Code and submitted to EMPR.
- Routine – monthly inspections of Dam No. 1, Bose Lake Dam, and quarterly inspections of R3 Seepage Pond are to be completed by THVCP staff when safely accessible. This frequency was met in 2018 with the exception of a gap for Dam No. 1 and Bose Lake Dam from August to September, inclusive. Summaries of dam inspection observations have been reviewed as part of this DSI:
  - As this system has reached an equilibrium or steady condition, reduced frequency of routine monitoring is considered appropriate. Event-driven inspections are of more value to confirm that the changed condition (i.e. flood, earthquake) did not have a significant impact on the structures. This change will be reflected in the next OMS manual update.
- Event-driven – should be completed by THVCP staff in response to any event that may have resulted in damage to the facility. The event-driven monitoring procedures are triggered by the events below (included in the 2018 OMS manual). EoR participation is determined on a case-by-case basis:
  - Piezometric and dam movement instrumentation thresholds as discussed in Section 5.4 to Section 5.6.
  - 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).

The frequency of routine visual inspections was increased during freshet by THVCP as a proactive measure. There were no event-driven inspections in 2018 triggered by precipitation or earthquake events as defined in the OMS manual.

5.3 Reservoir Level

The Pond No. 1 and Pond No. 2 levels were measured five (5) times in 2018, which is more frequent than prescribed in the 2018 OMS manual (twice per year). The pond level is also visually checked during routine inspections but not recorded. Of the five measurements, there were three in May, June, and July which are typical high flow periods during and following freshet.

R3 Seepage Pond levels were measured at the frequency prescribed in the 2018 OMS manual (quarterly). Quarterly dam inspection records provided by THVCP include visual estimates of available freeboard.

Reservoir levels are shown in conjunction with piezometric levels and seepage rates in Appendix IV:

- Figure IV-1 to Figure IV-3 plots measured Pond No. 1 levels and Dam No. 1 piezometric levels.
- Figure IV-7 to Figure IV-9 plots measured Pond No. 2 levels and Bose Lake Dam piezometric levels.
- Figure IV-6 plots pond levels with measured weir flows at TB-R3-FS-01 (collects seepage flows from the northern half of Bethlehem No. 1).

Between 2014 and 2016, the levels at Pond No. 1 and Pond No. 2 were trending downwards (with the exception of seasonal rise during freshet) at an overall rate of about 0.8 m/year and 0.6 m/year, respectively. This trend apparently ceased in 2017, when pond levels appear to have stabilized and the only changes in pond level are due to seasonal fluctuations. The 2017 and 2018 freshet events were more pronounced than previous years. As was the case in 2017, 2018 pond levels have steadily decreased since a peak in May.

5.4 Piezometers

There are 48 piezometers at the Bethlehem No. 1 TSF, 45 of which are operational and being monitored, while 3 are inoperative (Figure 3) as they have been either buried or damaged.

Piezometers were typically read between March and August (Dam No. 1 piezometers) or between March and October (Bose Dam piezometers) on a monthly basis, with the exception of the BP-series standpipe piezometers located in the interior of the TSF, which were not read in 2018. The standpipes in the upstream dam fill (historically dry) were only read once in 2018. These frequencies are non-compliant with those identified in the 2018 OMS manual: monthly for all other piezometers (when accessible, typically between March and November, inclusive). Note that KCB has recommended THVCP that monitoring frequency for piezometers within the impoundment (BP-series) could be reduced to quarterly (2016 DSI recommendation).

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

Dam No. 1

- There were no piezometric threshold exceedances in 2018.
- Piezometers in the impounded tailings historically remained static. No readings were taken in 2018 from these piezometers but there are not indications based on seepage readings, pond elevation or data from other piezometers further downstream that indicate an increase in piezometric levels. Nevertheless, to demonstrate this and meet compliance, KCB recommend THVCP to read piezometers within the impoundment (prioritizing the ones closer to the dam: BP9, BP12, BP13, and BP14) as soon as the instruments become accessible in 2019.
- 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 one available reading in 2018. In these piezometers, the dry reading is consistent with previous years, piezometers have read dry since 1984 (KL 1992). One piezometer, 13-SRK-09/P13-5 screened at about El. 1400 m, show piezometric levels in 2018 consistent with previous years.
- The piezometric levels measured at VWP16-1A (screened in Glacial Till, located under the downstream slope) seem to have equalized since installation in April 2016. Piezometric levels at VWP16-1B which is screened in Glacial Till foundation under the downstream slope, have been dropping since installation. This instrument may still in the process of equilibrating after installation. Readings beyond August were not available.
- Instruments in the foundation, downstream of the dam, show steady seasonal fluctuations. Readings beyond August were not available.

Bose Lake Dam

- There were no piezometric threshold exceedances in 2018.
- 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 in 2018 from these piezometers. There are not indications based on seepage readings, pond elevation or data from other piezometers further downstream indicate an increase in piezometric levels. However, similar to the Dam No. 1 piezometers KCB recommend THVCP read the instruments as soon as the instruments become accessible in 2019.
- Along the dam crest, a nested set of instruments installed in the dam fill and foundation (BD-VWP14-1A, -1B, and -1C) have historically shown an upward gradient from the bedrock into the Glacial Till which extends into the dam fill. VWP14-1C showed an unusual drop in readings (~8 m) starting in September 2018. This is likely attributed to a data entry or instrumentation error as a similar response was not observed at other locations. KCB recommend THVCP to review and resolve and instrumentation errors, if none are found, the instrument should be read as soon as it becomes accessible in 2019.
- Measurements from piezometers downstream of the dam also remained consistent with previous years. A larger spike than typical (~0.2 m) was measured at Standpipe 2 during freshet but it dropped to normal levels at the next reading and did not exceed its threshold.

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; refer to Table 5.1, 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.

Piezometric level thresholds for the Bethlehem TSF reference a Notification Level (NL) response under the Trigger-Action-Response-Plan established on site and exceedance of this value is intended to notify THVCP of a change in behaviour, not a short-term dam safety concern. No changes are proposed for 2019, refer to Table 5.1.

Table 5.1 2018 Piezometric Levels and 2019 Thresholds

Instrument ID	Foundation Unit	2018 Piezometric Levels (m)		Proposed 2019 Notification Level [1] (m)
		Maximum	Minimum	
Dam No. 1				
STANDPIPE No. 1B	Dam Fill	Reported plugged in 2018		1440.4
STANDPIPE No. 1A	Dam Fill	Reported plugged in 2018		1457.9
STANDPIPE No. 3	Dam Fill	Reported dry in 2018		1441.6
STANDPIPE No. 4	Dam Fill	Reported dry in 2018		1453.6
STANDPIPE No. 7	Dam Fill	Reported dry in 2018		1440.5
P95-1	Downstream Foundation	1377.9	1377.3	1379.0
P95-6	Downstream Foundation	1371.9	1371.8	1373.6
13-SRK-09/P13-5	Tailings	1410.1	1410.1	1410.6
13-SRK-12B/P13-6	Glacial Till	1377.2	1377.2	1377.9
VWPB16 - 1A	Glacial Till	1350.3	1350.2	1351.7
VWPB16 - 1B	Glacial Till	1357.0	1356.7	1369.8
BP3A	Glacial Till	-[2]		1454.8
BP3B	Tailings	-[2]		1455.9
BP3C	Tailings	-[2]		1466.6
BP4A	Glacial Till	-[2]		1466.7
BP4B	Tailings	-[2]		1454.6
BP5A	Glacial Till	-[2]		1461.6
BP5B	Tailings	-[2]		1465.3
BP9A	Tailings	-[2]		1403.4
BP9B	Tailings	-[2]		1424.9
BP9C	Tailings	-[2]		1449.4
BP10A	Tailings	-[2]		1465.2
BP10B	Tailings	-[2]		1466.8
BP12A	Tailings	-[2]		1420.8
BP12B	Tailings	-[2]		1441.8
BP12C	Tailings	-[2]		1463.9
BP13A	Glacial Till	-[2]		1441.5
BP13B	Tailings	-[2]		1446.0
BP14A	Glacial Till	-[2]		1424.4
BP-14B	Tailings	-[2]		1425.0
BP14C	Tailings	-[2]		1447.9

Instrument ID	Foundation Unit	2018 Piezometric Levels (m)		Proposed 2019 Notification Level [1] (m)
		Maximum	Minimum	
BP15A	Glacial Till	-[2]		1447.7
BP15B	Tailings	-[2]		1451.0
BP15C	Tailings	-[2]		1458.6
Bose Lake Dam				
No.1	Overburden / Bedrock Contact	1444.7	1444.5	1445.3
No.2	Overburden / Bedrock Contact	1444.9	1444.3	1445.2
BD-VWP14-1A	Bedrock	1451.2	1450.6	1451.6
BD-VWP14-1B	Overburden	1451.0	1450.4	1451.3
BD-VWP14-1C	Dam Fill	1448.6	1448.3	1449.9
BP6A	Glacial Till	-[2]		1462.8
BP6B	Tailings	-[2]		1466.0
BP6C	Tailings	-[2]		1467.3
BP7A	Glacial Till	-[2]		1469.1
BP7B	Tailings	-[2]		1469.1
BP7C	Tailings	-[2]		1468.3

Notes:
1. No threshold changes are proposed for 2019.
2. No readings were taken in 2018.

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

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 once in 2018: June for Bose Lake Dam and July for Dam No. 1. This meets the required frequency prescribed in the 2018 OMS manual (annual).

Monument surveys, horizontal displacement and settlement (vertical displacement) are plotted on Figure IV-4 and Figure IV-10. In 2018:

- 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; refer to Table 5.2. This is consistent with previous years.

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 5.2 2018 Survey Monument Displacement Summary

Monument ID	Incremental[1]		Cumulative[2]	
	Vector Horizontal Displacement (mm)	Vertical Displacement (mm)	Vector Horizontal Displacement (mm)	Vertical Displacement (mm)
Dam No. 1				
MON 1-73	4.1, upstream	-1.4	56.1, downstream	-195.1
DM-2	1.7, upstream	-2.3	43.1, downstream	-143.6
DM-3	1.7, upstream	0.9	24.0, downstream	-86.8
PIN-2	0.4, parallel to dam centerline	1.2	40.2, downstream	-76.2
Bethlehem Sinkhole	Note 3	-2.0	N/A	-139.0
Bose Lake Dam				
BD-1	21.0, downstream	+0.8	44.3, upstream and parallel to dam crest	-21.5
BD-2	11.5, downstream	-0.1	10.0, downstream	-11.0
BD-3	11.1, downstream	+0.1	31.4, downstream	+4.2
BD-4	9.7, upstream	-0.6	11.1, upstream	-5.3
BD-5	8.8, upstream	-1.4	9.7, upstream	-2.1
BD-6	19.2, downstream	-1.2	20.8, downstream	+2.4
BD-7	10.0, downstream	-1.6	24.4, downstream	+0.8

Notes:
1. Displacements are calculated between the June/July 2018 surveys and the May/June 2017 surveys.
2. Calculated between June/July 2018 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.
3. 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 5.3. No changes are proposed for 2019. 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 5.3 Proposed 2019 Survey Monument Displacement Thresholds

Instrument ID	Notification Level (NL) / T1 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.

5.6 Inclinometers

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

Cumulative displacements are plotted on Figure IV-5. There are no significant movements in the downstream direction in the readings and no discrete zones of movement to date. There appears to be a slight rotation error (in the upstream direction) in readings starting around November 2017. KCB suggests THVCP to, as the instrument is monitored in 2019, evaluate if data should be corrected for a potential rotation error.

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 propose the following thresholds for ongoing monitoring:

- Notification Level: 1 mm/month over any 3 m vertical section.

5.7 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 2018, TB-R3-FS-01 was read once in January (frozen) then monthly from May to November. This is consistent with the monitoring frequency in the 2018 OMS manual. Historically, readings were taken earlier, e.g. March or April, to capture lead-up to freshet; however, there were no observations of indicators of dam safety issues accompanying the missed April reading.

The peak seepage flow was recorded in September, a month which experienced higher than normal rates of precipitation in 2018; see Section 4.2. This peak rate is comparable to those historically recorded during freshet.

5.8 Water Quality

Water quality downstream of the Bethlehem TSF is monitored by THVCP monthly to assess the effectiveness of the tailings facility in protecting the downstream receiving environment. A copy of the 2018 Annual Water Quality Monitoring Report (ERM 2019) was provided to KCB for review as part of the DSI. Select observations and findings from the monitoring report are summarized as follows:

- There are twelve permitted surface water quality monitoring sites in the Trojan/Bethlehem area, as shown on the site monitoring plan in Appendix V.
- All permit sampling requirements and frequency were met in 2018, except for two instances when a subset of the required water quality parameters was not measured for specific samples. These parameters were tested in the previous and subsequent months.

The 2018 monitoring results were screened against applicable BC Water Quality Guidelines (WQG). Further discussion on specific WQG exceedances and water quality trends observed during 2018 can be found in the 2018 Annual Water Quality Monitoring Report (ERM 2019).

6 VISUAL OBSERVATIONS AND PHOTOGRAPHS

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

Dam No. 1

- **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 change noted in the dimensions of the sinkhole on the tailings beach. No other areas of differential settlement or cracking of concern was observed. (Photo II-A-1 through Photo II-A-3)
- **Left and Right Abutments**: Good physical condition. The precise 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.
- **Downstream Slope**:
  - Covered by erosion features formed by precipitation and snowmelt that extend from slope crest to toe. These features cause some shallow sloughing of the downstream slope in some areas but there are no indicators that they are significantly impacting deep seated failures that would extend upstream into the tailings beach. Survey monument monitoring support this observation. The erosion features are remediated on an as needed basis. (Photo II-A-4 through Photo II-A-6)
  - A 35-mm wide crack was observed on top of rockfill placed in September 2015 to repair one of the erosion features. There was no visible change from during the 2017 DSI (KCB 2018). The progression of the crack is being monitored by THVCP. (Photo II-A-7)
- **Pond**: No visual indicators along tailings beach 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.

Bose Lake Dam

- **Crest**: Good physical condition. No indications of major lateral movement, depressions, or cracking. (Photo II-B-1 and Photo II-B-2)
- **Left and Right Abutments**: Good physical condition. An access road runs along the abutments which connects the crest and toe roads. No sign of excessive scour or displacement. (Photo II-B-1 and Photo II-B-3)
- **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-3 through Photo II-B-6 and Photo II-B-12)
- **Tailings Beach**: Good physical condition. The beach immediately upstream of the dam is well vegetated with no issues of concern or indication of recent flooding. (Photo II-B-3)

- **Pond**: During inspection, the pond appears unchanged from the 2017 DSI (KCB 2018). The pond remains approximately 40 m upstream of the crest in a localized depression. (Photo II-B-3)
- **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. (Photo II-B-7)
- **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. At the base of the natural slope, approximately 100 m downstream of the dam toe, the flow passes below the access road via two CSP culverts. There was no visible sign of significant degradation of the riprap, compared to KC (2002), or blockage of the culverts. (Photo II-B-8 through Photo II-B-12)
- **Seepage Collection System**: The seepage relief wells were locked and could not be inspected. The outer casings showed no signs of damage. At the gauge-house, flow was observed flowing (approximately 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-13 through Photo II-B-15)

R3 Seepage Pond Dam

- **Crest**: Good physical condition. No indication of adverse lateral movement, depressions or cracking. (Photo II-C-1)
- **Left and Right Abutment**: Good physical condition. No signs of significant erosion, deterioration, or cracking. (Photo II-C-1 and Photo II-C-2)
- **Downstream Slope**: Good physical condition. No indication of adverse displacement. No signs of erosion, deterioration, or seepage. (Photo II-C-3)
- **Pond**: At the time of inspection pond was observed to be approximately 1.0 m below the invert of the spillway. (Photo II-C-1 and Photo II-C-4)
- **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 unobstructed. (Photo II-C-4)
- **Spillway**: Good physical condition. No indicators of recent flow through the channel. No visual signs of riprap degradation.
  - Heavy vegetation at spillway inlet and wood debris on the north (right bank) slope as well as in the energy dissipater were observed and should be cleared as part of THVCP routine monitoring and maintenance. (Photo II-C-5 and Photo II-C-6)
  - Minor rill erosion due to runoff from the norther access road may affect the right bank of the spillway. The existing rock “fence” should be reinforced to protect against potential erosive flows. (Photo II-C-2)
- **Seepage**: None observed.

7 ASSESSMENT OF DAM SAFETY

7.1 Dam Classification Review

The most recent 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). A new DSR is currently underway and is expected to be completed in 2019.

Based on the latest dam consequence review hosted by THVCP on January 23, 2019, no change in consequence classification was recommended for either of the three dam sites.

7.2 Failure Mode Review

7.2.1 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:

7.2.2 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.

Stability: Static and Seismic 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 (1.5). KCB (2019) completed a stability analyses assuming the layer of Stratified Glacial Till conservatively had the geotechnical parameters equivalent to the normally consolidated glaciolacustrine and appropriately conservative undrained strength parameters for the soft foundation deposits; the FOS criteria were still met for global slip surfaces through the crest.

For the static and post-earthquake undrained conditions, the results for some local failure surfaces near the toe and through the soft foundation are below FOS criteria. However, these local failure surfaces near the toe are constrained by the rockfill buttress and would not result in an uncontrolled release of the contained materials. Moreover, even if such a local failure would occur, the proportion of liquefied material represented by the soft sediments is very small compared to the majority of the

failure mass comprising mainly rockfill. If this failure were to occur the buttress would deform but would essentially remain in place.

Based on these assessments and the dam performance to date, the likelihood of a slope instability failure developing is considered low under static and post-earthquake loading. It should be noted that the most recent stability review (KCB 2019) was provided to the DSR reviewers for consideration in their assessment.

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 provided diligent inspection and maintenance as prescribed in the OMS.

7.2.3 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. Given the presence and design of the spillway, the likelihood of overtopping due to a flood event are considered very low.

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.

Stability

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 (1.5). Therefore, the likelihood of a slope instability failure developing is considered very low.

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.

Earthquake

Based on the stability analysis (KC 1996) using a seismic coefficient corresponding to a higher load than the minimum earthquake design ground motion (EDGM) required under the Code, the likelihood of a seismic-related failure during the EDGM is considered low.

7.2.4 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). Given the presence and design of the spillway, the likelihood of overtopping during the IDF is considered very low.

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.

Stability

An infinite slope stability analysis was conducted in 2005 to assess the FOS of a surficial sloughing failure along the downstream slope (KC 2005). The static FOS for a shallow sloughing failure of the downstream slope, based on infinite slope analysis, was stated as greater than 1.1 to 1.4 (slope angle varies along dam) which is below the minimum FOS (1.5) required by the Code. However, a shallow sloughing failure would not result in release of the pond, especially given that the crest of the dam is wider that the height of the downstream slope and that a regular inspection and maintenance program is in place. 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.

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.

Earthquake

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. Therefore, the likelihood of seismic related failure during the EDGM is considered low.

7.3 Emergency Preparedness and Response

The emergency preparedness and response plan (EPRP) for the Bethlehem TSF was updated in 2016 and forms a part of the OMS manual.

Training of THVCP staff and contractors who work near the dams is provided by a video presentation which outlines dam safety warning signs that all staff should be aware of and report if any 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 table top exercise to review and update the EPRP for the HVC site was hosted by THVCP and attended by representatives of the KCB on site and the EoR on the phone on November 22, 2018.

8 SUMMARY

The Bethlehem No. 1 TSF appears in good physical condition and the observed performance during the 2018 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 recommendations actions are shown in *italics*. Recommendations to address deficiencies and non-conformances identified during the 2018 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	Recommended Deadline (Status)
Bethlehem Tailings 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 (deferred to 2019)
Dam No. 1					
BTSF-2017-04	*Surveillance*	*Inclinometer Monitoring*	*Establish a 2018 threshold limit for inclinometer IB16-1.*	*4*	*Q4, 2018 (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 2018 DSI Recommendations

ID No.	Deficiency or Non-Conformance	Applicable Reg. or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline
Bethlehem Tailings Storage Facility					
BTSF-2018-01	Flood Management	10.1.8 (the Code)	Update flood routing assessment for Bethlehem TSF and R3 Seepage Ponds based on the most recent site wide hydrology information for consistency and to confirm compliance.	3	Q2, 2020
BTSF-2018-02	Surveillance	Piezometer monitoring	All piezometers in the Bethlehem 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
Dam No. 1					
No new recommendations from 2018					
Bose Lake Dam					
No new recommendations from 2018					
R3 Seepage Pond					
No new recommendations from 2018					

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 Ltd. The report has been prepared for the exclusive use of Teck Highland Valley Copper Partnership (Client). The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

KLOHN CRIPPEN BERGER LTD.

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Engineer of Record
Senior Geotechnical Engineer, Principal

Pablo Urrutia, P.Eng.
Senior Geotechnical Engineer

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FIGURES

VICINITY PLAN

Legend

- 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.

CLIENT	TECK HIGHLAND VALLEY COPPER PARTNERSHIP
	Klohn Crippen Berger
PROJECT	BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2018 DAM SAFETY INSPECTION
TITLE	MINE SITE PLAN
SCALE	1:100,000
PROJECT No.	M02341B43
FIG No.	1

Date: 2019-03-01
Document Path: \\int.klohn.com\ProjData\MVCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\GIS\02. Maps\Reports\DSI\Bethlehem\Fig1_Bethlehem_MineSitePlan.mxd

Trojan Diversion
Trojan Tailings Pond
Fish Spawning Channel Pond Dam (Breached)
Bethlehem No. 1 TSF Spillway
Bose Lake
Bose Lake Dam
Bethlehem No.2 Tailings Pond
Trojan Dam
Trojan TSF Spillway
Bethlehem No.1 Tailings Pond
R4 Seepage Pond
Seepage Pond 1 (Decommissioned)
Dam No.1
R3 Seepage Pond
Lower Trojan Dam
97C
Huestis Pit
Jersey Pit

N

Legend

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

0 0.5km

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.

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
BETHLEHEM No. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
BETHLEHEM OVERVIEW

SCALE	PROJECT No.	FIG No.
1:15,000	M02341B43	2

Date: 2019-02-01
Drawn: SH
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Bethlehem No.1 Tailings Pond
Test Fill
Jersey Pit
Bethlehem Sinkhole
Huestis Pit
Trojan Tailings Pond
Trojan Dam
Dam No.1
R3 Seepage Pond
Seepage Pond 1 (Decommissioned)

BP5
BP4
BP3
BP15
BP12
BP13
BP9
BP14
DM-5
DM-4
DM-3
DM-2
DM-1
DM-6
PIN-1
PIN-2
Standpipe No.4
Standpipe No.3
Standpipe No.7
Standpipe No.1A
Standpipe No.1B
Standpipe No.6
P95-5
P95-6
P95-1
TB-PS-05/P13-5
TB-PS-08/P13-6
TB-R3-FS-01
TB-R3-FS-02
VWPB16-1A+B
IB16-1
MON.1-73
BTH-2018-01
BTH-2018-02
BTH-2018-03
BTH-2018-04
BTH-2018-05
BTH-2018-06
BTH-2018-07
BTH-2018-15
BTH-2018-18
BTH-2018-19
BTH-2018-20
BTH-2018-21
BTH-2018-22

33,600 33,200 32,800 32,400 32,000 31,600 31,200 30,800 30,400 30,000 29,600 29,200
34,800 34,400 34,000 33,600 33,200 32,800

Legend

Instrument Type (Active)
- Standpipe Piezometer
- Vibrating Wire Piezometer
- Inclinometer
- Weir
- Survey Monument
- Waypoint (BTH-2018-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 October, 2018
3. Topography from HVC, LiDAR flown on August 23rd, 2014.

CLIENT
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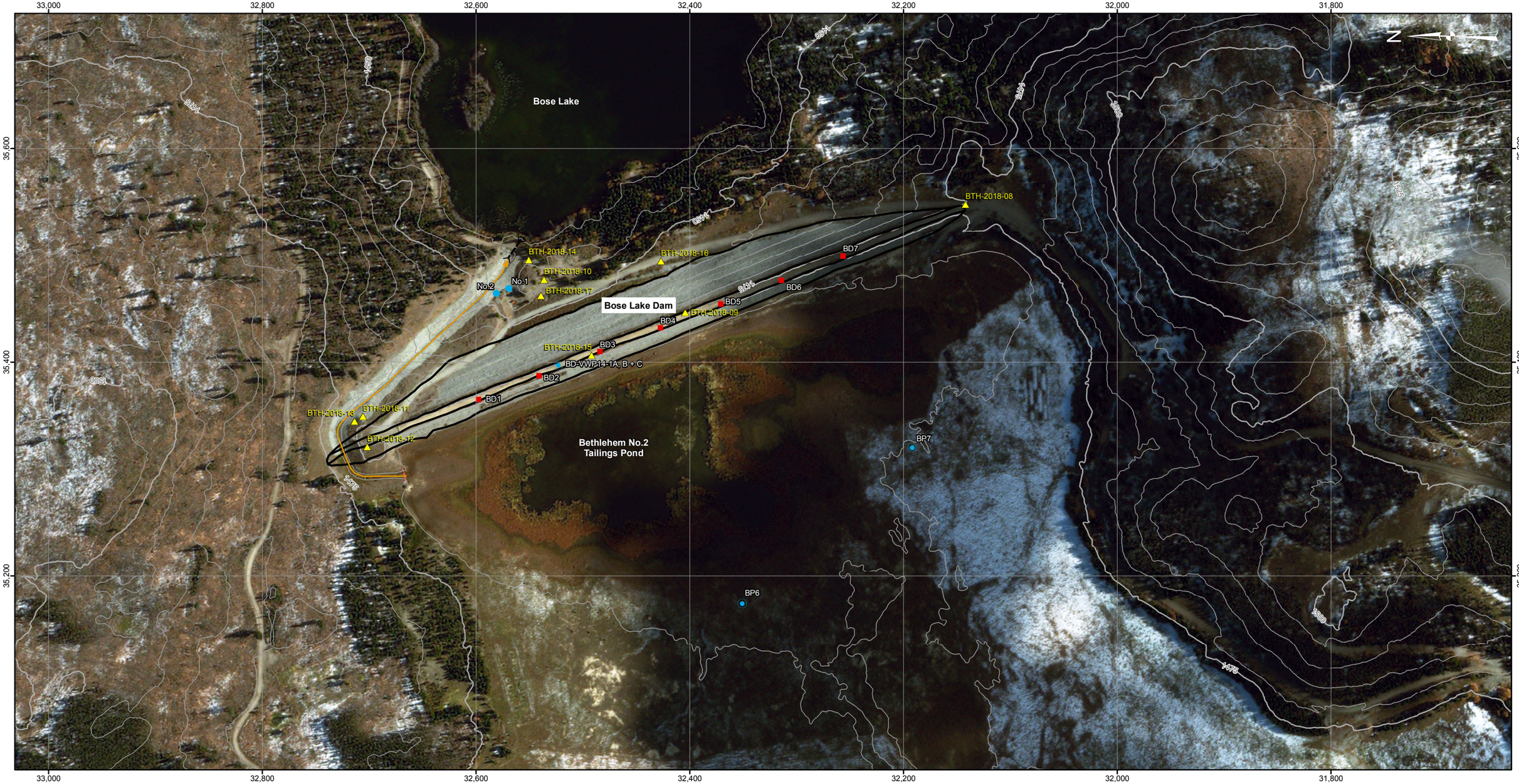
PROJECT
BETHLEHEM No. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
DAM No.1 & SEEPAGE POND 1 PLAN

SCALE	PROJECT No.	FIG No.
1:12,000	M02341B43	3

Date: 2019-02-26
Document Path: \\nt.klohn.com\ProjData\MVCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\BethlehemFig3_Bethlehem_DamNo1_Plan.mxd



Legend

Instrument Type (Active)
- Standpipe Piezometer
- Vibrating Wire Piezometer

- Waypoint (BTH-2018-xx)
- Survey Monument

- Culvert
- Spillway
- Index Contour (25 m)
- Intermediate Contour (5 m)

0 125m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained October, 2018
3. Topography from HVC, LiDAR flown on August 23rd, 2014.

CLIENT	TECK HIGHLAND VALLEY COPPER PARTNERSHIP
	Klohn Crippen Berger
PROJECT	BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2018 DAM SAFETY INSPECTION
TITLE	BOSE LAKE DAM PLAN
SCALE	1:3,500
PROJECT No.	M02341B43
FIG No.	4

Date: 2019-02-26
Document Path: \\int.klohn.com\ProjData\MVCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Bethlehem\Fig4_Bethlehem_BoseLakeDam_Plan.mxd

33,300 33,350 33,400 33,450 33,500 33,550

31,300 31,250 31,200

TB-R3-FS-01

P95-2

BTH-2018-19

BTH-2018-05

BTH-2018-22

BTH-2018-18

BTH-2018-20

R3 Seepage Pond

R3 Seepage Pond Dam

TB-R3-FS-02

BTH-2018-21

460 mm Dia. Buried Pipeline

Abandoned Pumphouse

P95-1

N

1560 1570 1580 1590 1600 1610

Legend

Instrument Type (Active)
- Standpipe Piezometer
- Weir

Instrument Type (Defunct)
- Standpipe Piezometer

- Waypoint (BTH-2018-xx)
- Spillway
- Buried Pipeline
- Index Contour (5 m)
- Intermediate Contour (1 m)

0 25m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained October, 2018
3. Topography from HVC, LiDAR flown on August 23rd, 2014.
4. Location of buried pipes are approximate.

CLIENT	TECK HIGHLAND VALLEY COPPER PARTNERSHIP
	Klohn Crippen Berger
PROJECT	BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2018 DAM SAFETY INSPECTION
TITLE	R3 SEEPAGE POND DAM PLAN
SCALE	1:750
PROJECT No.	M02341B43
FIG No.	5

Date: 2019-02-26
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APPENDIX I

Dam Safety Inspection Checklist

APPENDIX I-A

Dam Safety Inspection Checklist – Dam No. 1

2018 ANNUAL DAM INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Bethlehem Dam No.1	**Inspection Date:**	7-Aug-18
Consequence Classification:	Very High		
Weather:	Sunny, partial cloud cover	**Inspector(s):**	Rick Friedel, Tyler Lappin
Freeboard (pond level to dam crest):	8.1 m (based on pond survey completed 26-Jul-18)		

Are the following components of your dam 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?

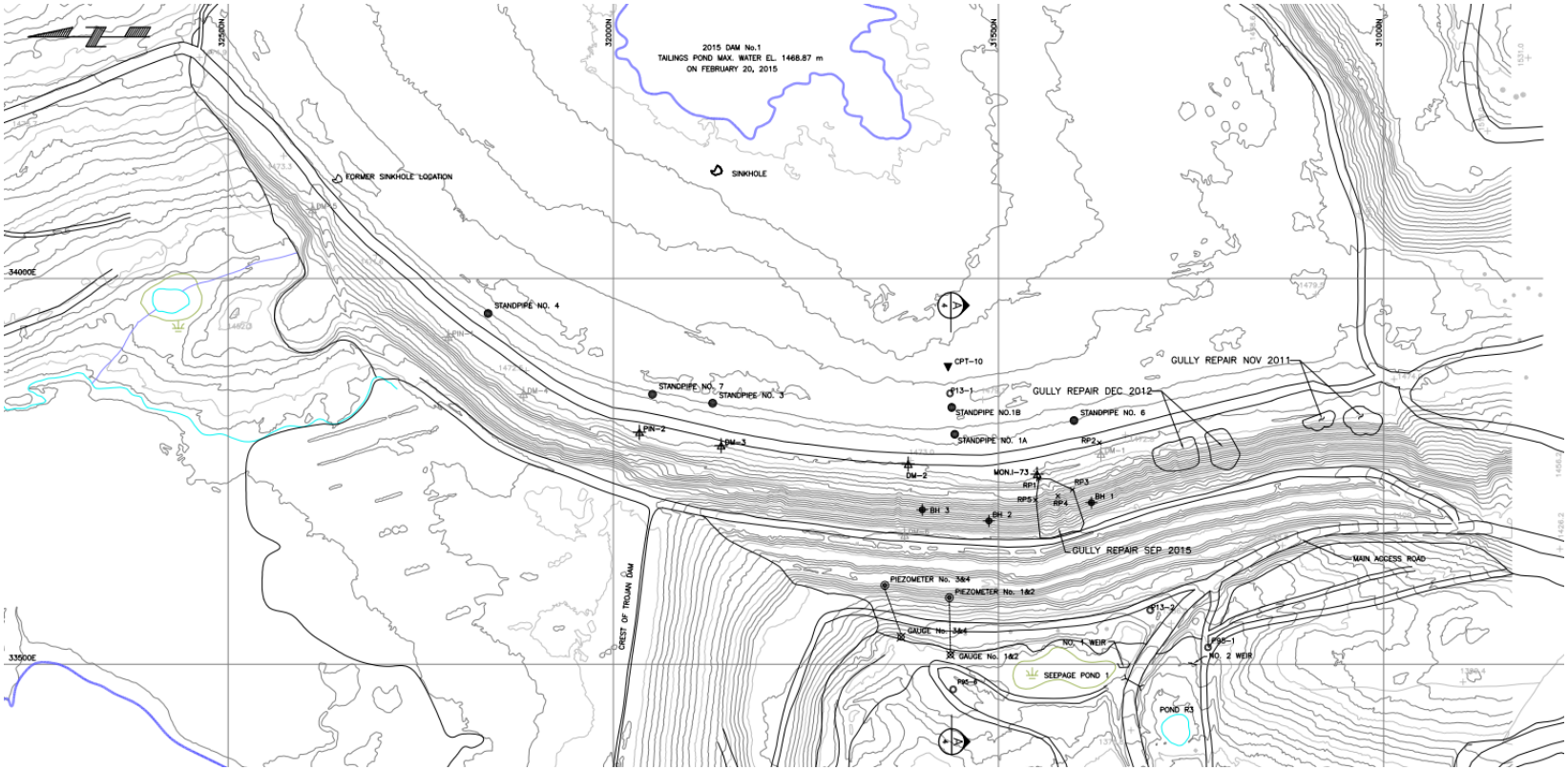
INDICATOR	EMBANKMENT
Piping	☐ Yes ☒ No
Sinkholes	☒ Yes ☐ No
Seepage	☐ Yes ☒ No
External Erosion	☐ Yes ☒ No
Cracks	☒ Yes ☐ No
Settlement	☐ Yes ☒ No
Sloughing/Slides	☐ Yes ☒ No
Animal Activity	☐ Yes ☒ No
Excessive Growth	☐ Yes ☒ No
Excessive Debris	☐ Yes ☒ No

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

None.

Comments / Notes:

1. The cracking, which formed during the September 2015 repair of an erosion gully, was observed. Crack width was observed to be approximately 3 cm which is consistent with previous inspections. These cracks should continue to be monitored.
2. The sinkhole on the tailings beach did not appear to have changed from the 2017 inspection. Survey monitoring should continue.
3. Rill erosion features from previous inspections appears to have been repaired.


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
CPT-10
GULLY REPAIR NOV 2011
GULLY REPAIR DEC 2012
STANDPIPE NO.1B
STANDPIPE NO. 6
STANDPIPE NO. 1A
PPN-2
DM-3
DM-2
MON.I-73
RP1
RP2
RP3
RP4
RP5
BH 1
BH 2
BH 3
GULLY REPAIR SEP 2015
MAIN ACCESS ROAD
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
CREST OF TROJAN DAM
34000E
33500E
32000N
31500N
31000N

APPENDIX I-B

Dam Safety Inspection Checklist – Bose Lake Dam

2018 ANNUAL DAM INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Bose Lake Dam	**Inspection Date:**	7-Aug-18
Consequence Classification:	Very High		
Weather:	Sunny, partial cloud cover	**Inspector(s):**	Rick Friedel, Tyler Lappin
Freeboard (pond level to spillway invert):	6.5 m (based on pond survey completed 26-Jul-18)		

Outlet Condition

Description	Was it flowing?	Flow rate
	☐ Yes ☒ No	

Are the following components of your dam 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

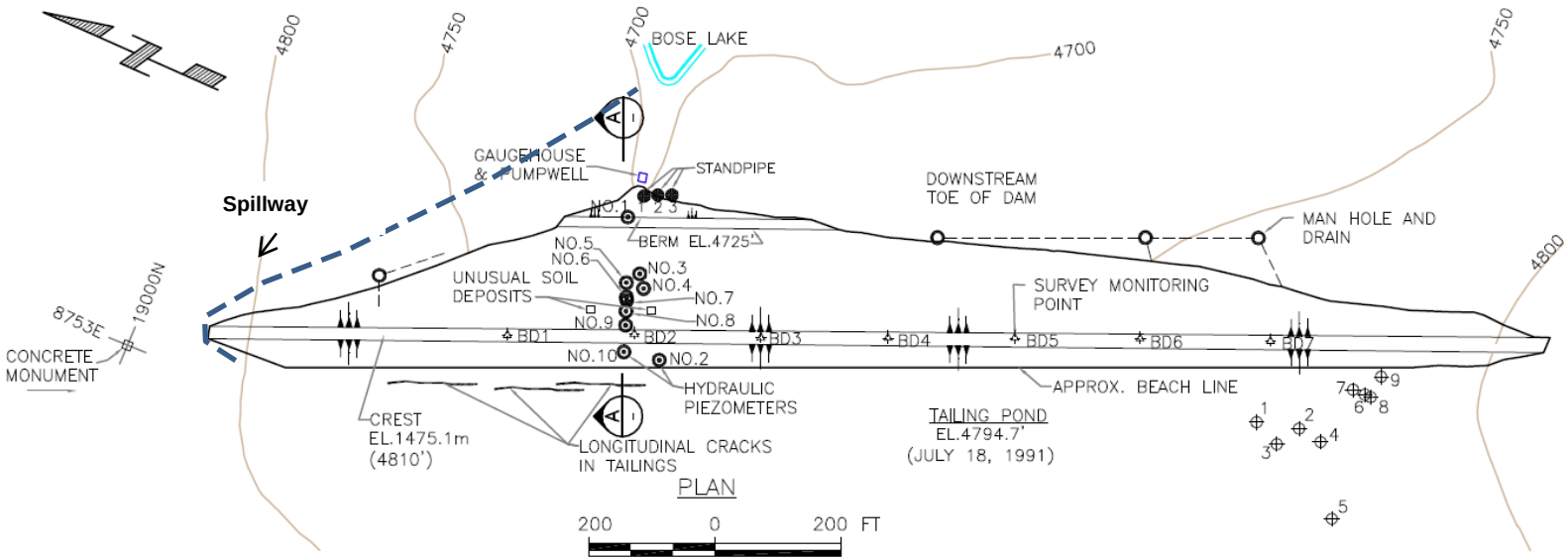
List and describe any deficiencies (all deficiencies require assessment and/or repair):

None.

Comments/ Notes:

1. Similar to the observation during the 2017 inspection, vegetation growth was observed at the upstream portion of the riprap lined channel section near the concrete sill. This growth should be monitored and removed if deemed to be impacting the spillway capacity or riprap integrity.
2. Seepage collection system outlet flowing at approximately 1 L/s.
3. The animal burrowing and minor downstream slope erosion features, noted in the 2017 inspection, were not observed during the 2018 site inspection.

SITE PLAN


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

APPENDIX I-C

Dam Safety Inspection Checklist – R3 Seepage Pond Dam

2018 ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	R3 Seepage Reclaim Pond Dam	**Inspection Date:**	7-Aug-18
Weather:	Sunny, partial cloud cover	**Inspector(s):**	Rick Friedel, Tyler Lappin
Freeboard (pond level to dam crest):	1.5 m (visually estimated)		

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	

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	Buried, no visual check	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

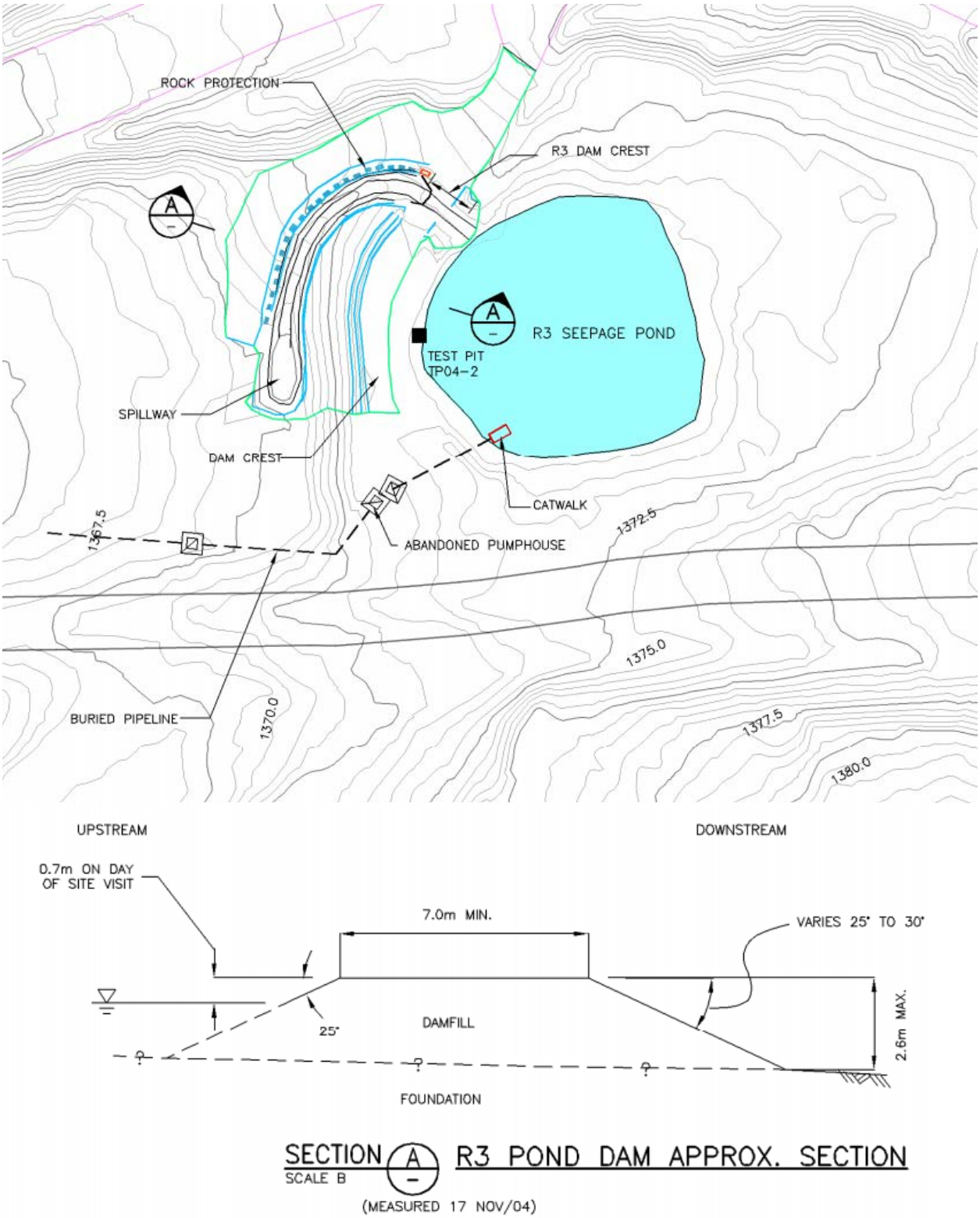
Deficiencies:

None.

Comments:

1. Minor erosion observed along the road at the right abutment (to the right of the spillway). Should be monitored and regraded to prevent concentrated flow.
2. Some wood debris was observed at the end of the spillway in the riprap outlet basin, which should be removed as part of THVCP regular maintenance.

SITE PLAN


ROCK PROTECTION
R3 DAM CREST
A
R3 SEEPAGE POND
TEST PIT
TP04-2
SPILLWAY
DAM CREST
CATWALK
ABANDONED PUMPHOUSE
BURIED PIPELINE
1367.5
1370.0
1372.5
1375.0
1377.5
1380.0
UPSTREAM
DOWNSTREAM
0.7m ON DAY
OF SITE VISIT
7.0m MIN.
VARIES 25° TO 30°
25°
DAMFILL
2.6m MAX.
FOUNDATION
SECTION A
SCALE B
R3 POND DAM APPROX. SECTION
(MEASURED 17 NOV/04)

APPENDIX II

Inspection Photographs

APPENDIX II-A

Inspection Photographs – Dam No. 1

Appendix II-A
Inspection Photographs - Dam No. 1

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2018-## refers to 2018 DSI waypoint shown on Figure 3.
- All photographs taken during inspection on August 7, 2018.

Photo II-A-1 Overview of tailings impoundment, looking north at Pond No. 1 and test fill pad. (BTH-2018-01)

Photo II-A-2 Rockfill bench immediately downstream of crest (to right), looking north towards Trojan Dam. (BTH-2018-02)

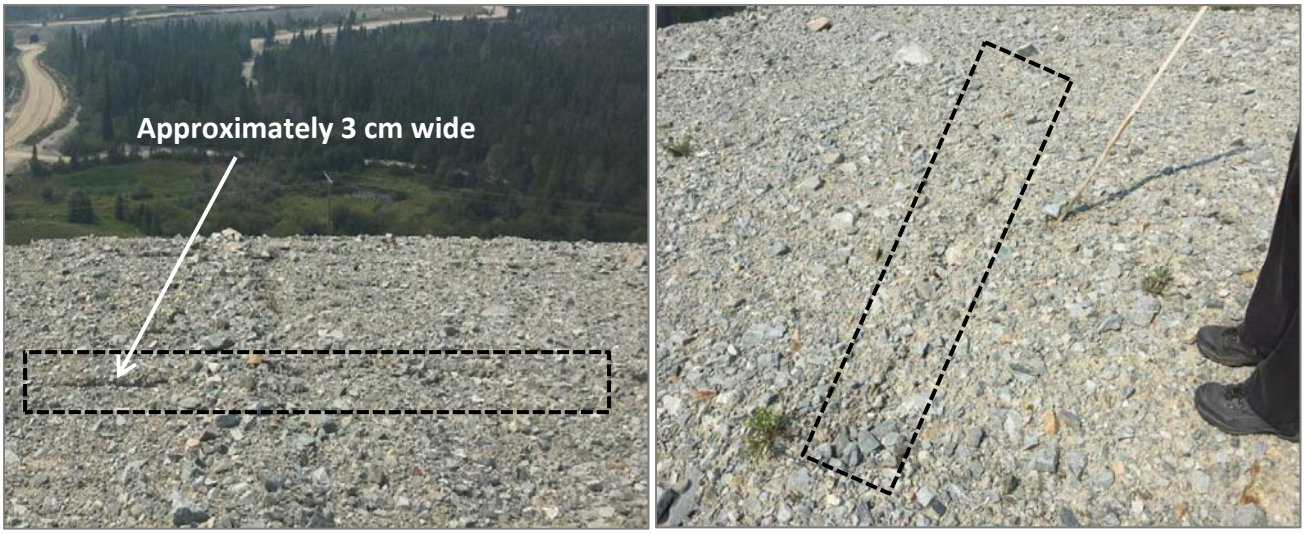
Photo II-A-3 Bethlehem sinkhole on tailings beach. (BTH-2018-03)

Photo II-A-4 Downstream slope of Dam No. 1, looking northeast. (BTH-2018-04)

Photo II-A-5 Downstream slope of Dam No. 1, looking west from R3 Seepage Pond. (BTH-2018-05)

Photo II-A-6 Downstream slope of Dam No. 1, looking (from left to right) south, west, north. (BTH-2018-06)

Photo II-A-7 Cracks (two separate instances shown in pictures below) on crest of rockfill placed in September 2015 as part of erosion gully repair. (BTH-2018-07)



APPENDIX II-B

Inspection Photographs – Bose Lake Dam

Appendix II-B
Inspection Photographs - Bose Lake Dam

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2018-## refers to 2018 DSI waypoint shown on Figure 3.
- All photographs taken during inspection on August 7, 2018.

Photo II-B-1 Dam crest at right abutment [left] and downstream slope [right], looking towards left abutment (BTH-2018-08)

Photo II-B-2 Dam crest at mid-point of dam, looking towards left abutment (BTH-2018-09)

Photo II-B-3 Upstream riprap, tailings beach and Pond No. 2, looking at right abutment [left] and towards left abutment [right] (BTH-2018-09)

Photo II-B-4 Downstream slope, standing at bank of Bose Lake looking west. (BTH-2018-10)

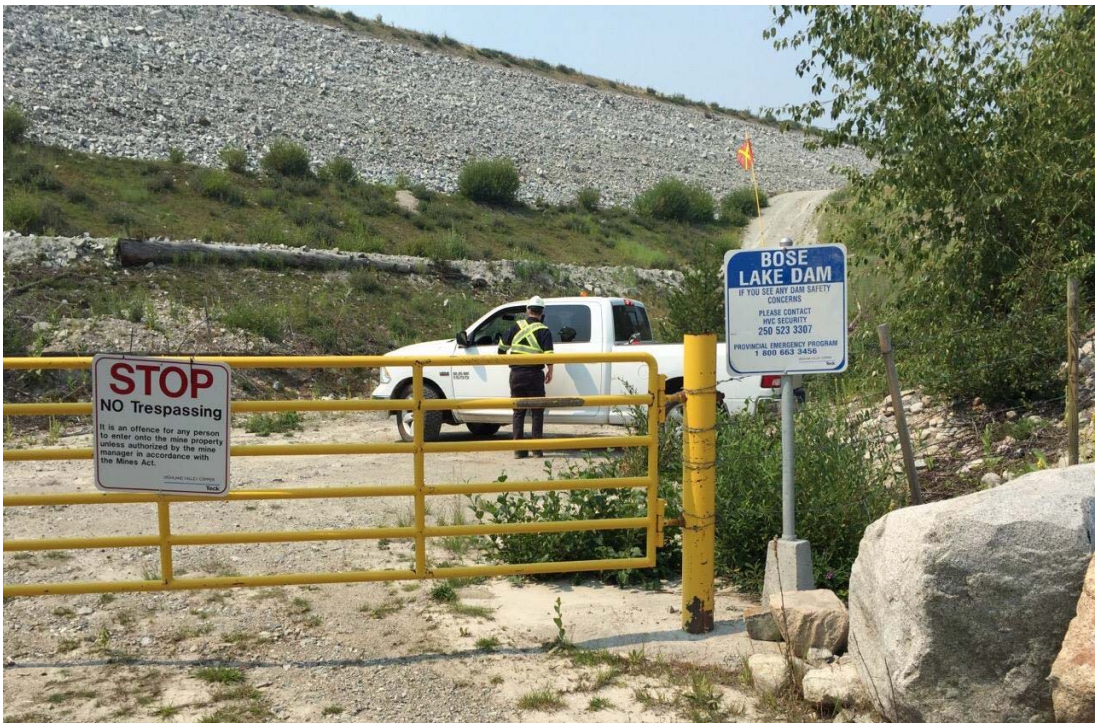


Photo II-B-5 Downstream slope at mid-point of dam, looking east at Bose Lake (BTH-2018-09)

Photo II-B-6 Downstream slope at left abutment, looking southeast at Bose Lake (BTH-2018-11)

Photo II-B-7 Spillway inlet, looking northwest towards impoundment (BTH-2018-12)

Photo II-B-8 Spillway channel at transition point between inlet and riprap-lined segment, looking southeast (downstream) towards Bose Lake (BTH-2018-12)

Photo II-B-9 Spillway channel, looking southeast (downstream) towards Bose Lake (BTH-2018-13)

Photo II-B-10 Spillway channel, looking northwest (upstream) at Bose Lake Dam (BTH-2018-14)

Photo II-B-11 Spillway culverts (BTH-2018-14)

Photo II-B-12 Spillway overview (BTH-2018-15)

Photo II-B-13 Seepage relief well at downstream toe, looking west (upstream) (BTH-2018-16)

Photo II-B-14 Old gauge-house and decommissioned pump-well (BTH-2018-17)

Photo II-B-15 Seepage outflow to riprap lined infiltration basin (BTH-2018-17)

APPENDIX II-C

Inspection Photographs – R3 Seepage Pond Dam

Appendix II-C
Inspection Photographs - R3 Seepage Pond Dam

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2018-## refers to 2018 DSI waypoint shown on Figure 5.
- All photographs taken during inspection on August 7, 2018.

Photo II-C-1 Overview of pond and dam looking southeast (BTH-2018-18)

Photo II-C-2 Erosion near right abutment, looking south towards spillway [left] and north towards access road [right] (BTH-2018-19)

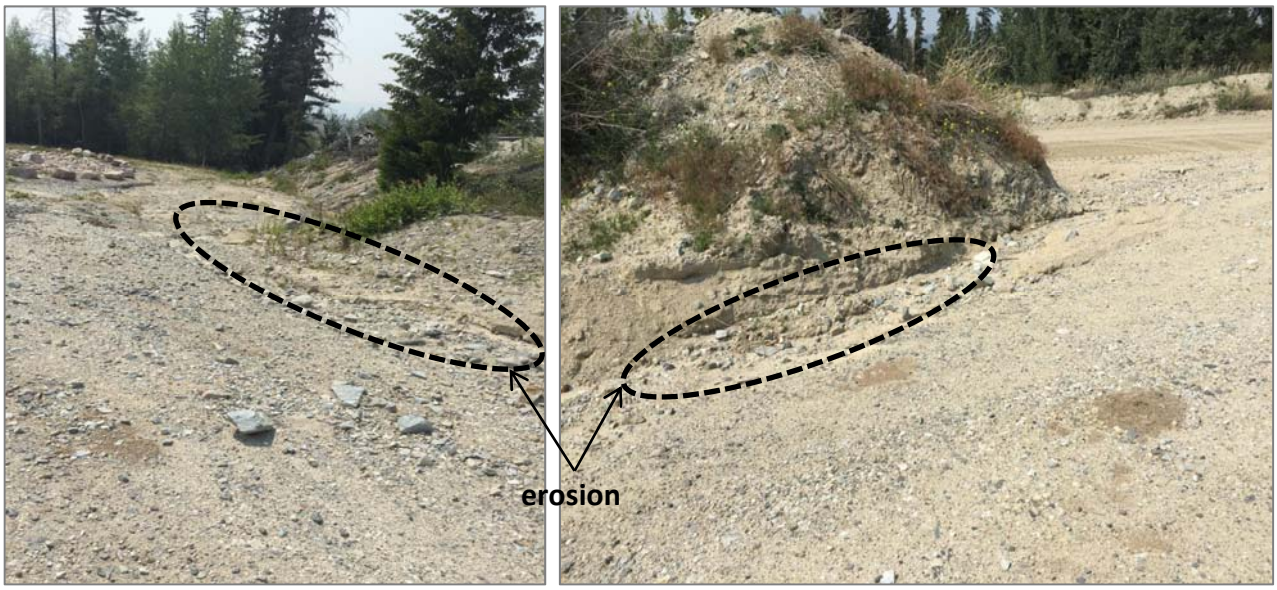


Photo II-C-3 Downstream slope and spillway, looking south [left] and north [right] (BTH-2018-20)

Photo II-C-4 Pond and debris fence for low-level outlet (BTH-2018-21)

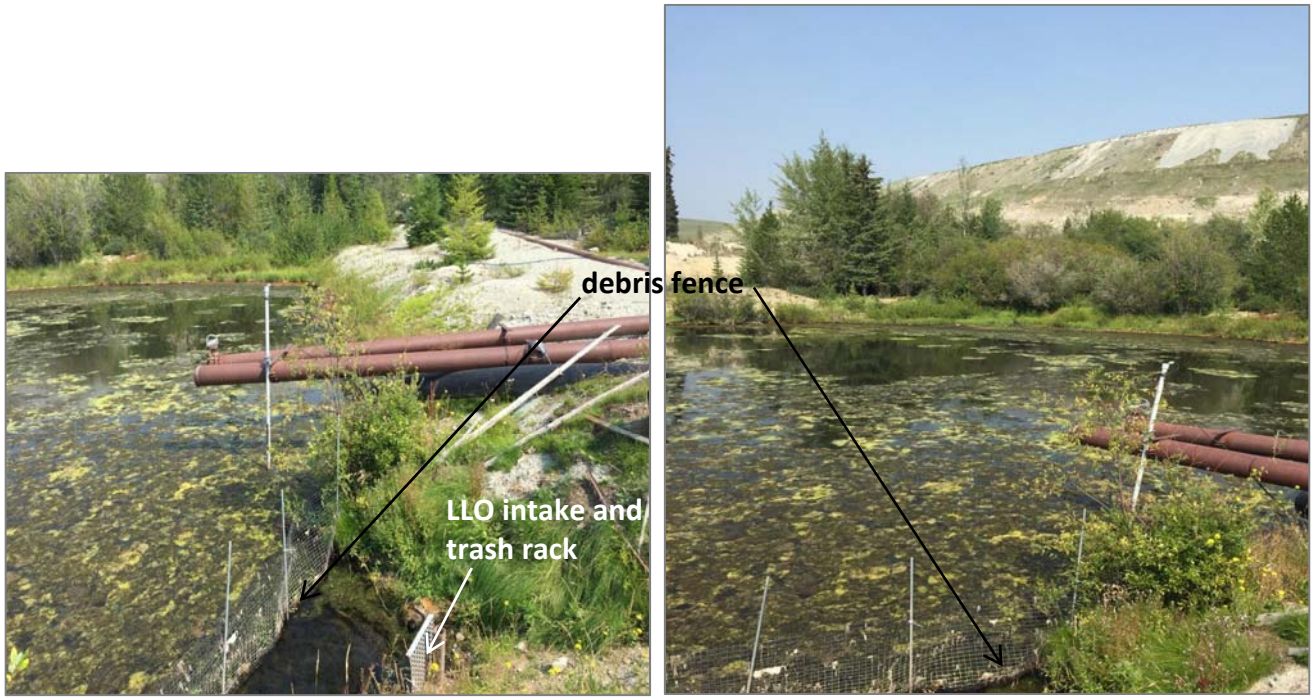


Photo II-C-5 Spillway inlet, looking upstream toward pond (BTH-2018-22)

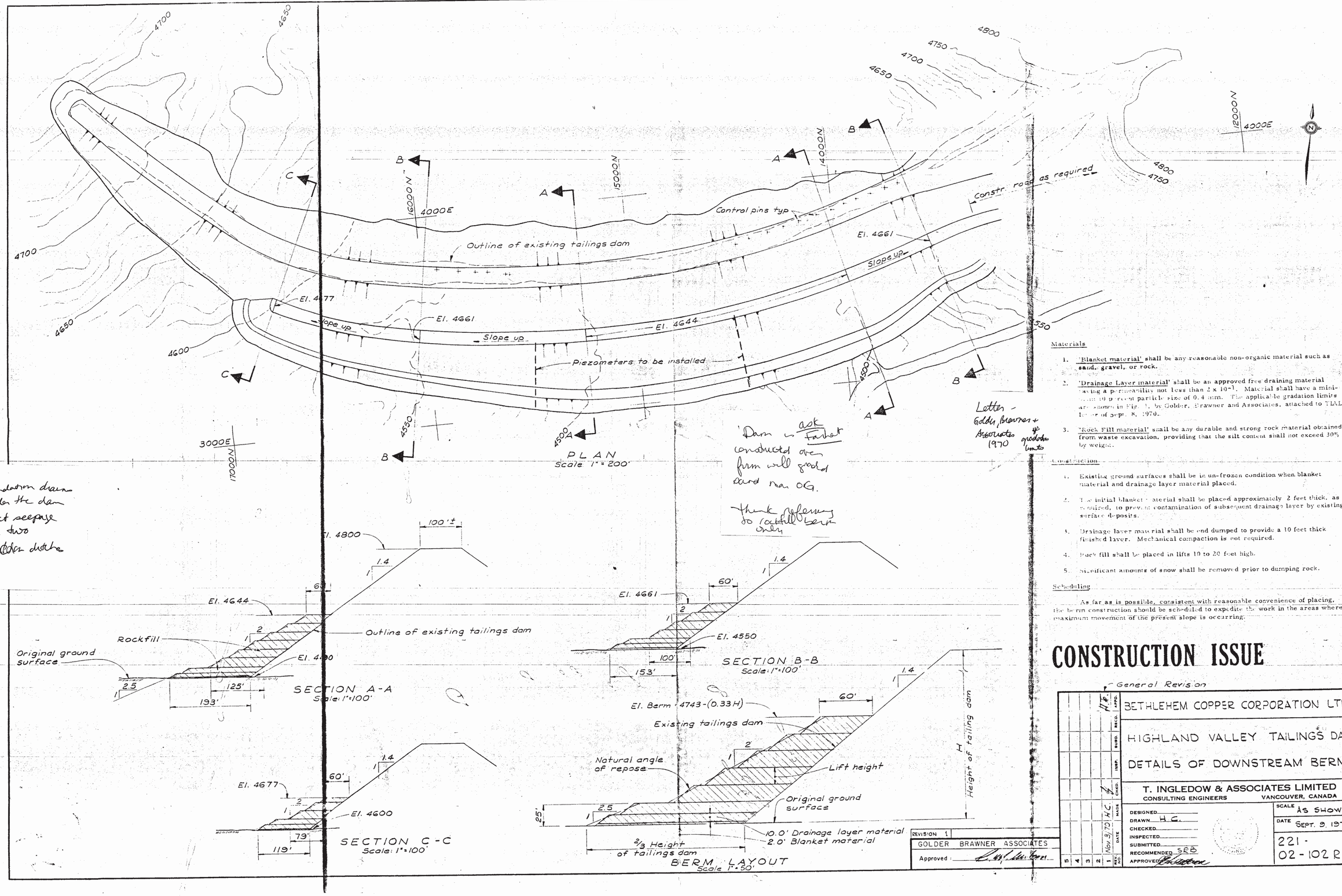
Photo II-C-6 Spillway crossing at right abutment, looking downstream (BTH-2018-22)

APPENDIX III

Reference Dam Design Drawings

APPENDIX III-A

Reference Dam Design Drawings – Dam No. 1



Foundation drain under the dam direct seepage via two collection ditches

'Dam is constructed of ask Farhat from well graded sand max 0G.

Think referring to rockfill berm only

Letter - Golder, Brawner + Associates 1970 re gradation limits

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.

CONSTRUCTION ISSUE

General Revision

REVISION 1

GOLDER BRAWNER ASSOCIATES

Approved

REV.	DATE	MADE	CHKD.	INSP.	SUBD.	RECD.	APPD.
5							
4							
3							
2							
1	Nov. 3, 70	H.C.					H.E.

BETHLEHEM COPPER CORPORATION LTD.

HIGHLAND VALLEY TAILINGS DAM

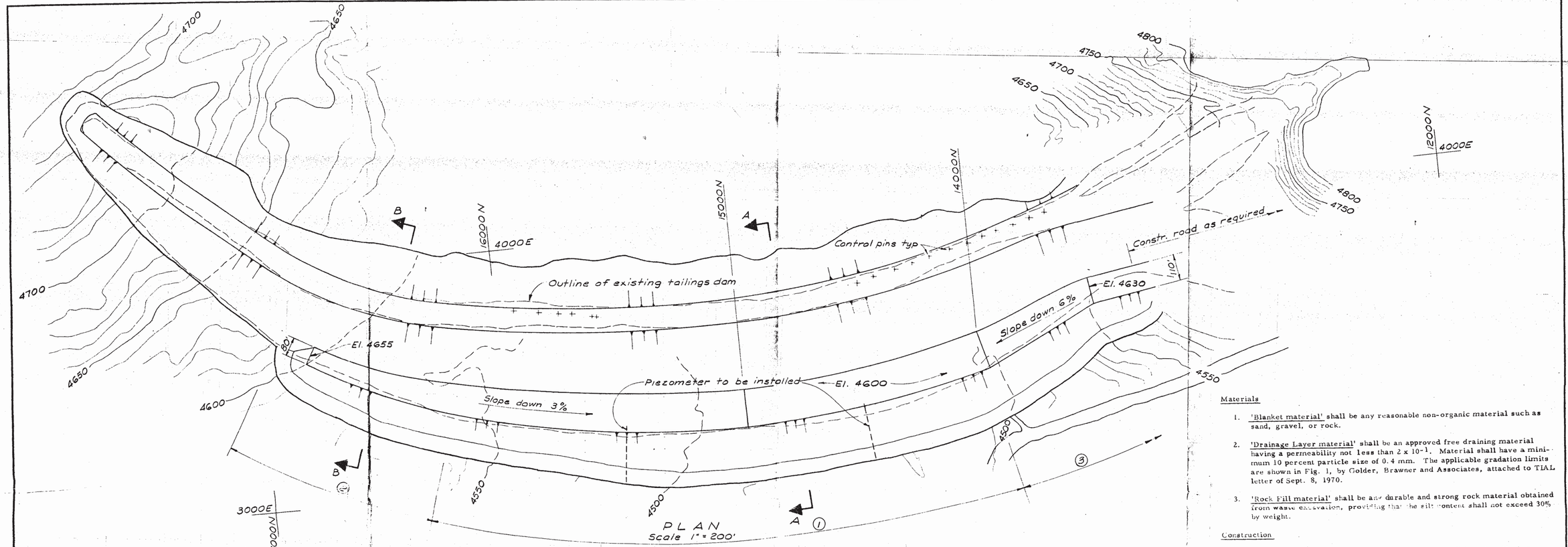
DETAILS OF DOWNSTREAM BERM

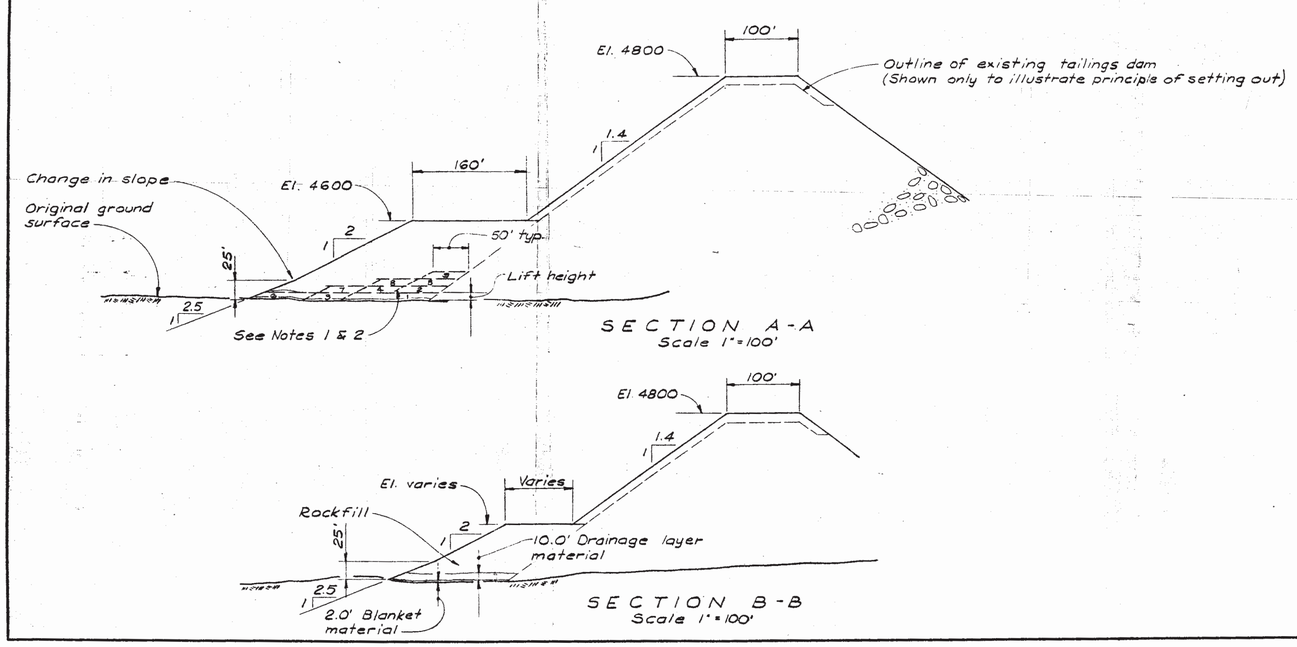
T. INGLEDOW & ASSOCIATES LIMITED
CONSULTING ENGINEERS VANCOUVER, CANADA

DESIGNED
DRAWN H.C.
CHECKED
INSPECTED
SUBMITTED
RECOMMENDED SEB
APPROVED

SCALE AS SHOWN
DATE SEPT. 9, 1970

221 - 02 - 102 R1





CONSTRUCTION ISSUE

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.

GOLDER BRAWNER ASSOCIATES
Approved: E.W.M. Grieve

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

BETHLEHEM COPPER CORPORATION LTD.

HIGHLAND VALLEY TAILINGS DAM

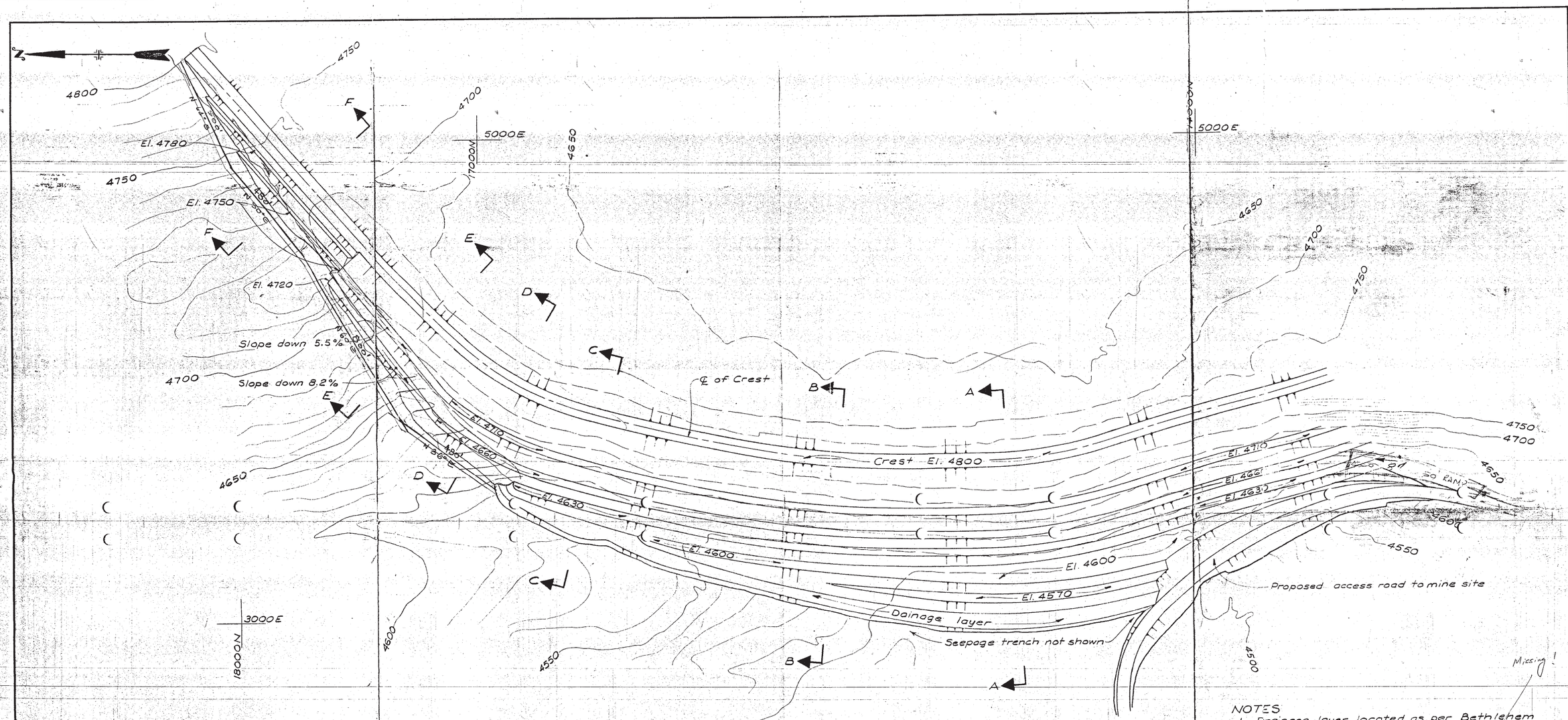
DETAILS OF DOWNSTREAM BERM

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



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

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

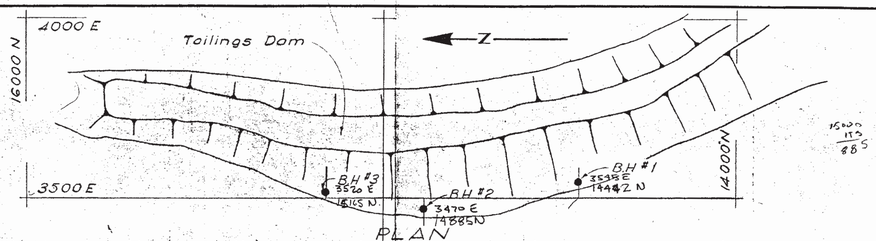
TAILINGS DAM NUMBER ONE
REDESIGN JULY 1971
PLAN

GEPAC CONSULTANTS LTD.
CONSULTING ENGINEERS VANCOUVER, CANADA

DESIGNED
DRAWN H. Coulter
CHECKED J. A. Knowles
INSPECTED
SUBMITTED
RECOMMENDED
APPROVED

SCALE 1" = 200'
DATE
221
02-1102

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



PLAN
Scale 1"=200'

HOLE #3 LOG (15, 162 N, 3524 E)

Water content & Atterberg limit 0% 50%	Blows per ft.	Depth	Sample N°	Sample Description
				Top of B.H El. 4506.2
	3			Rockfill
			8'	Water at 8'
	16	10		Rockfill embedded in tailings
N=9 4/9 6/3 4/6 5/6 19/6 20/6 30/6			15'	
			#1	SAND, grey brown, well graded & firm some medium & fine gravel.
	106	20	#2	
	57		25'	Water at 16'
	215	30	#3	Silty SAND grey brown compact some medium fine gravel.
			32'	
	289		#4	Clayey SILT, grey brown hard compact, traces of gravel occasional pebbles & boulders. Till-like texture.
		40	#5	
	150		#6	
		50		
			55'	
	340	60	#7	CLAY grey brown, hard with seams of silt.
			61'	
			#8	Silty CLAY, grey brown, hard.
	452		#9	
		70	#10	
			71'	

Water content

INDICATED FOUNDATION STRATA

Rockfill
TAILINGS & rockfill embedded in tailings
SAND well graded firm
Silty SAND compact
Clayey TILL, hard, compact
CLAY, hard
Silty TILL, compact
BEDROCK

HOLE #2 LOG (14, 873 N, 3468 E)

Water content Atterberg limit 0% 50%	Blows per ft.	Depth	Sample N°	Sample Description
				Top of B.H El. 4493.6
	4			Rockfill
Weight of hammer 77		10	12'	
	22		#1	Silty fine SAND, grey, soft. (Tailings)
		20	#2	SAND, grey-brown, well graded & firm with traces of silt, gravel & organic matter, pebbles & small boulders at 25'
	81		#3	
	147		29'	Water at 29'
	177	30	#4	Silty SAND, grey brown with fine gravel, occasional clay lumps, compact.
	76		35'	
		40	#5	Clayey SILT, grey brown, traces of gravel, occasional pebbles & boulders. Compact, till-like texture
	177	50	#6	
			#7	
	238	60	C4	
	327		G6	GRAVEL & SAND (Water bearing)
PW LW 79.5% PW LW	238	70	G5	Silty CLAY, grey brown, hard. CLAY, grey brown & silty fine sand in layers.
	348		76'	
	506	80	#9	Silty CLAY, grey-brown with gravel, compact till-like.
	300		#10	
	610		85'	
		90	#11	
	277		#12	SAND, brown, compact.
	628	100	91'	Silty SAND, grey brown, compact, some gravel occasional pebbles & pieces of decomposed rock.
	224			
258 352			107'	

Water content

INDICATED FOUNDATION STRATA

Rockfill
TAILINGS & rockfill embedded in tailings
SAND, firm
Silty SAND, compact
Clayey TILL, hard, compact
Water content
CLAY, hard
Silty TILL, compact
BEDROCK

HOLE #1 LOG (14, 438 N, 3551 E)

Water content & Atterberg limit 0% 100%	Blows per ft.	Depth	Sample N°	Sample Description
				Top of B.H El. 4495.6
	16		5'	Rockfill
			#2	Water table of El. 4492.6
	22	10	#3	Sandy SILT, grey-brown with traces of organic matter.
			14'	
	67		#4	SAND, grey-brown, well graded, firm.
			#5	
35 38 71 C C C	132	20	#6	Sand, SILT, grey brown, firm
	132		#7	
	145	30	#8	Clayey SILT, grey-brown, traces of gravel, occasional pebbles & boulders, compact, till-like texture.
	260	40	#9	
	164		#10	
	280	50	54'	
			#11	SILT & CLAY, grey-brown in layers, compact.
PW LW PW LW	140	60	#12	SILT, grey-brown with traces of clay & fine gravel, compact
	158		#13	CLAY, grey-brown, thin lenses of silt, compact.
		70	#14	
	275		68'	Water bearing layer at 68'
350 560 480 389				Sand, SILT, grey-brown, some gravel with small pockets of silty clay, compact till-like.
		80	78'	
				Rock.
			83'	

Water content

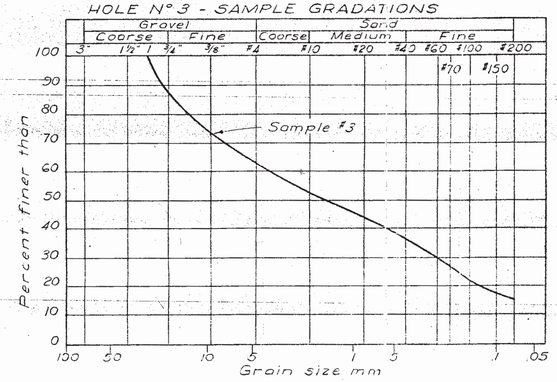
Unconfined Compression Tests on Sample N° 14

Test #1 - 2410 lbs. per ft.² Test #2 - 2000 lbs. per ft.²

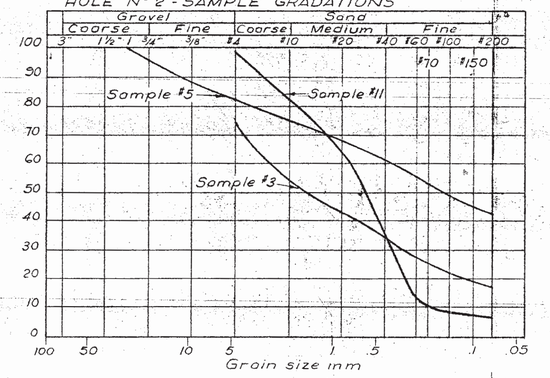
Natural Density of Sample N° 14

Test #1 - 135.5 p.c.f Test #2 - 143.3 p.c.f

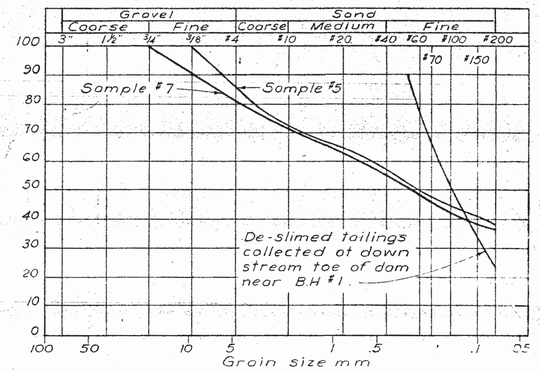
HOLE N° 3 - SAMPLE GRADATIONS



HOLE N° 2 - SAMPLE GRADATIONS



HOLE N° 1 - SAMPLE GRADATIONS



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/C" 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

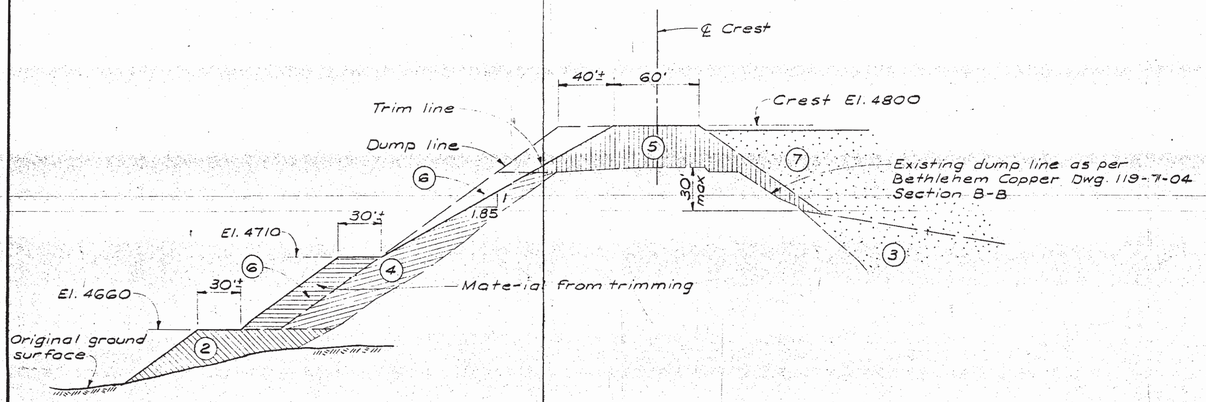
T. INGLEDOW & ASSOCIATES LIMITED
CONSULTING ENGINEERS VANCOUVER, CANADA

DESIGNED D.C.
DRAWN W.J
CHECKED G.E.
INSPECTED
SUBMITTED
RECOMMENDED
APPROVED H.H.

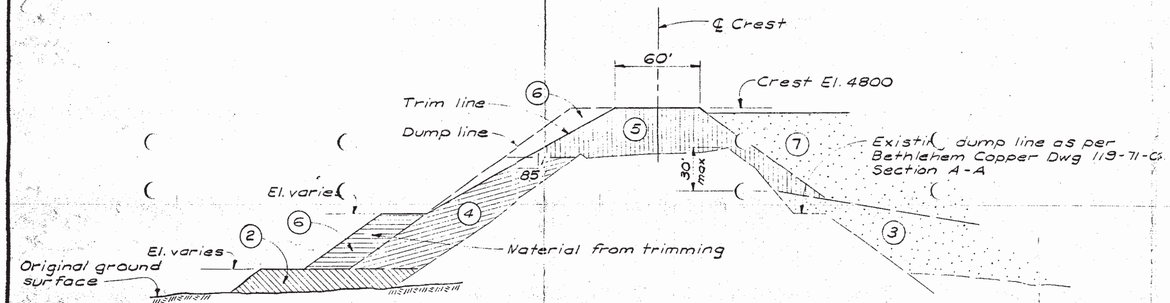
SCALE As shown
DATE OCT 10, 1966

221
02-1004

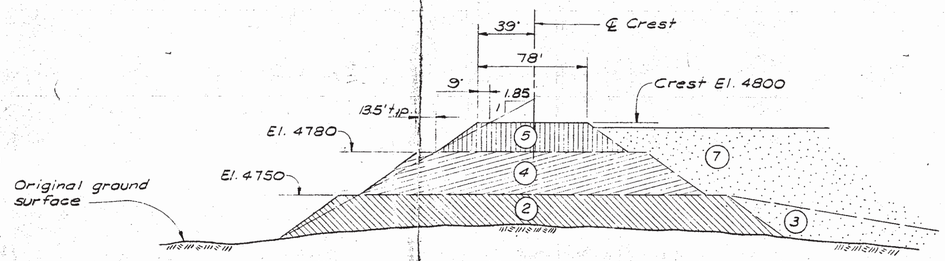
REV. NO. 5 4 3 2 1 — DATE — MADE — CHKD. — INSP. — SUBMD. — RECD. — APPD.



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

REV. NO.	DATE	BASIS	CHKD.	INSP.	SURD.	RECD.	APPD.
5							
4							
3							
2							
1							

BETHLEHEM COPPER CORPORATION LIMITED

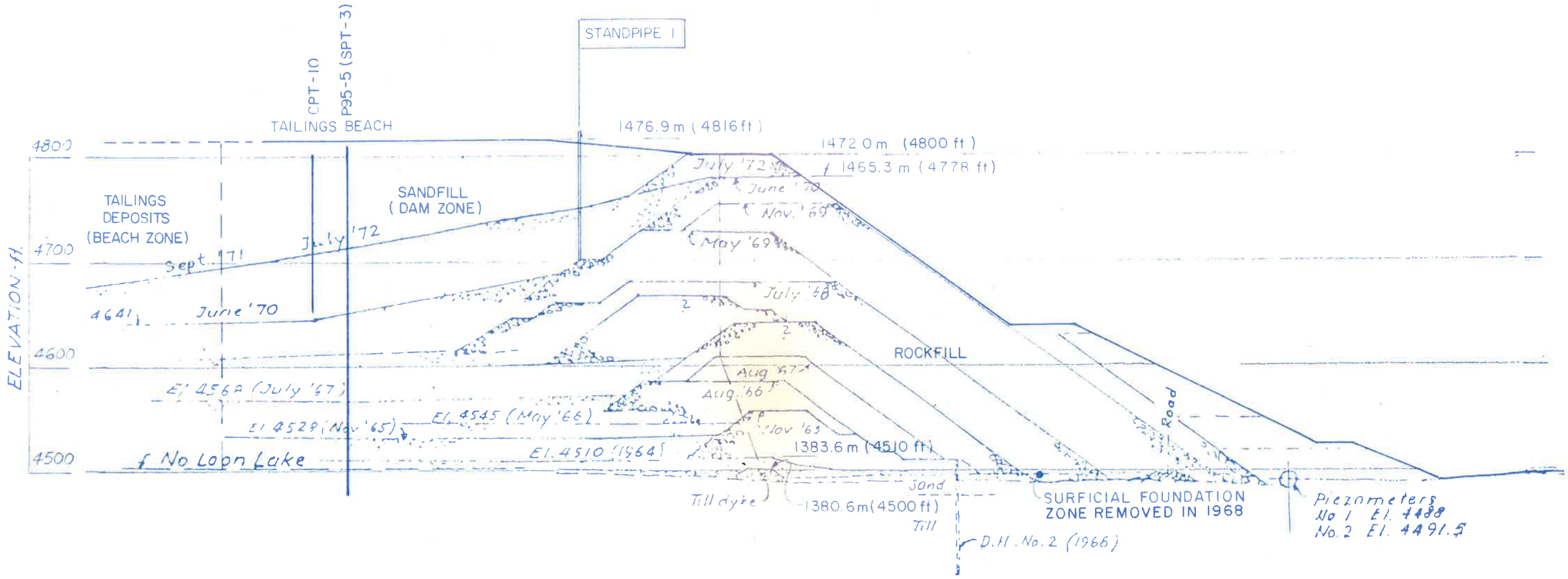
TAILINGS DAM NUMBER ONE
REDESIGN JULY 1971
SECTIONS - SHEET 2 OF 2

GEPAC CONSULTANTS LTD.
CONSULTING ENGINEERS VANCOUVER, CANADA

DESIGNED
DRAWN H. COULTER
CHECKED J. A. Knowles
INSPECTED
SUBMITTED
RECOMMENDED
APPROVED

SCALE 1" = 50'
DATE

221
02-1104



SECTION A AT STA. 6 (15000N)

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

SCALE

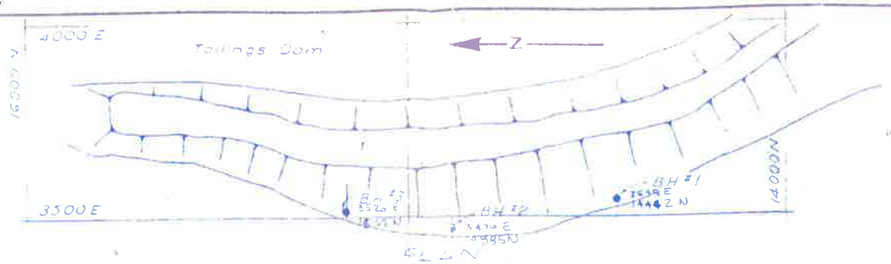
PROJECT

LONG-TERM STABILITY ASSESSMENT

TITLE

TYPICAL SECTION
DAM No.1

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
DEC. 9, 1996	PM2916 23	B-23007	



HOLE #3 — LOG (15,162N, 3524E)

Water content & Atterberg limit 0% 50%	Blows per ft	Depth	Sample N°	Sample Description
	3			Top of B.H. El 4502 G
				Rockfill
	16	10		Water at 8
				Rockfill embedded in tailings
		20	#1	SAND, grey brown, well graded & firm, some medium & fine gravel
	36		#2	
	57		55	Water at 16
	215	30	#3	Silty SAND, grey brown, almost same medium & fine gravel
	289		14	
		40	#4	Clayey SILT, grey brown, hard compact, traces of gravel, occasional pebbles & boulders, Till-like texture
	150		#5	
		50	#6	
			55	
	340	60	#7	CLAY, grey brown, hard with seams of silt
			61	
			#8	Silty CLAY, grey brown hard
	452	70	#9	
			#10	
			71	

Water content — 1

INDICATED FOUNDATION STRATA

Rockfill

TAILINGS & rockfill embedded in tailings

SAND well graded firm

Silty SAND compact

Clayey TILL, hard, compact

CLAY hard

LW 79.5%

Water content

HOLE #2 — LOG (14,873N, 3468E)

Water content & Atterberg limit 0% 50%	Blows per ft	Depth	Sample N°	Sample Description
	4			Top of B.H. El 4493 G
		10		Rockfill
			2	
Weight of hammer 77	11		16	Silty fine SAND, grey, soft (Tailings)
	22	20	#2	SAND, grey-brown, well graded & firm with traces of silt, gravel & organic matter, pebbles & small boulders of 25
	81		#3	
	147		29	Water at 29
	177	30		Silty SAND, grey brown with fine gravel, occasional clay lumps, compact
			14	
	76	40	33	
			#4	
			#5	Clayey SILT, grey brown, traces of gravel, occasional pebbles & boulders, Compact, till-like texture
	177	50	#6	
			50	
	239	60	#7	
			41	
	327		#8	
			24	
			62	GRAVEL & SAND, Water bearing
			65	Silty CLAY, grey brown hard
	238	70	#9	CLAY, grey brown & silty fine sand in layers
			76	
	348			Silty CLAY grey brown with gravel, compact till-like
	506	80		
	600			
			#10	
	610		#11	
			#12	
		90		
			55	
				SAND, brown compact
			91	
				Silty SAND, grey brown, compact, some gravel occasional pebbles & pieces of decomposed rock
	328	100		
	224			
			107	
	258			
	352			

Water content

INDICATED FOUNDATION STRATA

Rockfill

TAILINGS & Rockfill embedded in tailings

SAND, firm

Silty SAND, compact

Clayey TILL, hard, compact

Water content

PW LW

CLAY hard

Silty TILL, compact

BEDROCK

HOLE #1 — LOG (14,438N, 3551E)

Water content & Atterberg limit 0% 100%	Blows per ft	Depth	Sample N°	Sample Description
				Top of B.H. El 4495 G
	16			Rockfill
		10	1	
	22		2	SAND, grey-brown, well graded firm
			4	
	67			Sandy SILT, grey brown firm
35 38 71 6" 6" 6"		20	16	
	32		17	
	36			Clayey SILT grey brown, traces of gravel occasional cobbles & boulders, compact till-like texture
	145	30	18	
	260	40	19	
	164			
		50	1,0	
	280		54	
			51	SILT & CLAY, grey brown with traces of gravel, compact
		60	60	SILT, grey brown with traces of clay & fine gravel, compact
	43		2	
			3	CLAY, grey brown, thin lenses of silt, compact
	58	70		
			68	Water Bearing layer of silt
	275			Sandy SILT, grey brown, some gravel with small pockets of silty clay
	350			
	560		78	compact till-like
	430			
	389	80		
			83	Rock

PW LW

Uncontined Compression Tests on Sample N° 14

Test #1 - 2410 lbs per ft² Test #2 - 2000 lbs per ft²

Natural Density of Sample N° 14

Test #1 - 135 5 pcf Test #2 - 143 3 pcf

Water table at El 4492 G

Sandy SILT, grey-brown with traces of organic matter.

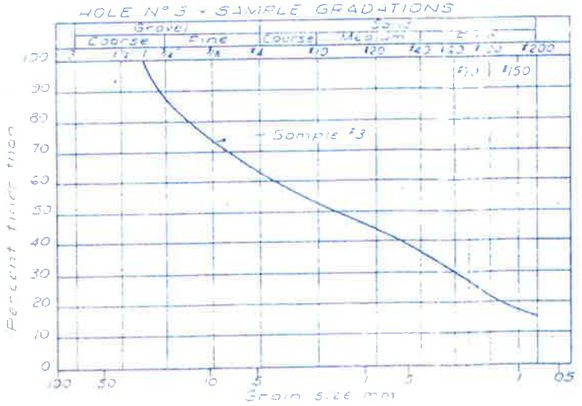
NOTES

1. Blow counts shown are averages for the indicated hole section required to drive a 5½" OD casing with a 4" 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.

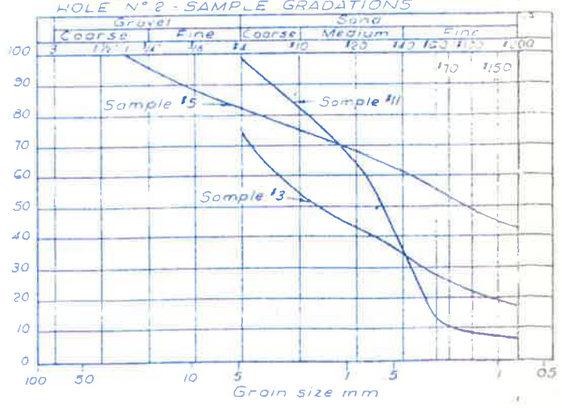
LEGEND

- Sample from recovered cuttings
- Split spoon sample
- Shelby tube sample, 3.00
- LW Liquid limit water content
- PW Plastic limit water content.

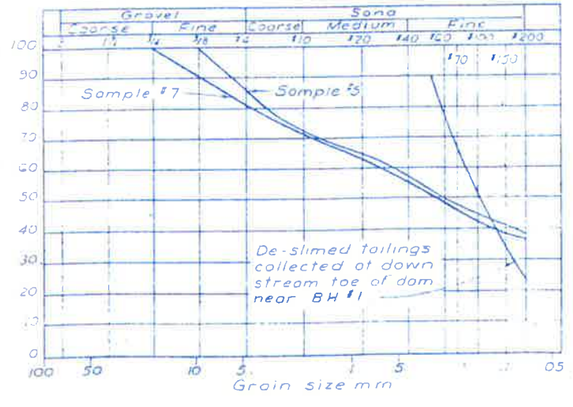
HOLE N° 3 - SAMPLE GRADATIONS



HOLE N° 2 - SAMPLE GRADATIONS



HOLE #1 - SAMPLE GRADATIONS



SOURCE T. INGLEDOW & ASSOCIATES LIMITED DWG. No. 281-02-1004, DATED OCT 10, 1966

KLOHN-CRIPPEN

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: SUBSOIL DATA - DAM "A" I

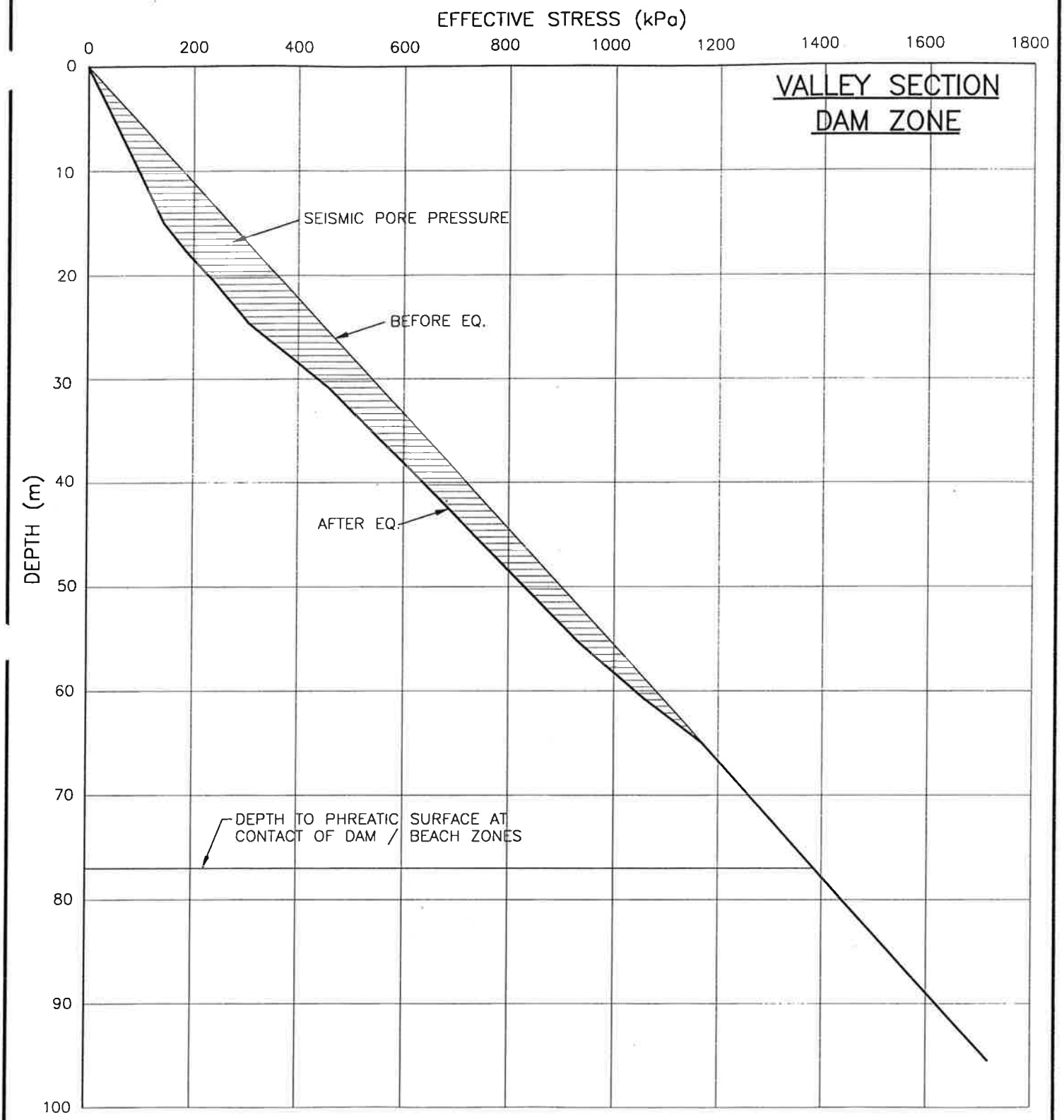
CLIENT: HIGHLAND VALLEY COPPER

DATE OF ISSUE: DEC 9 1966 APPROVED: R.F.

PROJECT No.: PM2916 23

DWG. No.: A-33008

REV.



SCALE

KLOHN-CRIPPEN

PROJECT: LONG–TERM STABILITY ASSESSMENT

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

CLIENT: HIGHLAND VALLEY COPPER

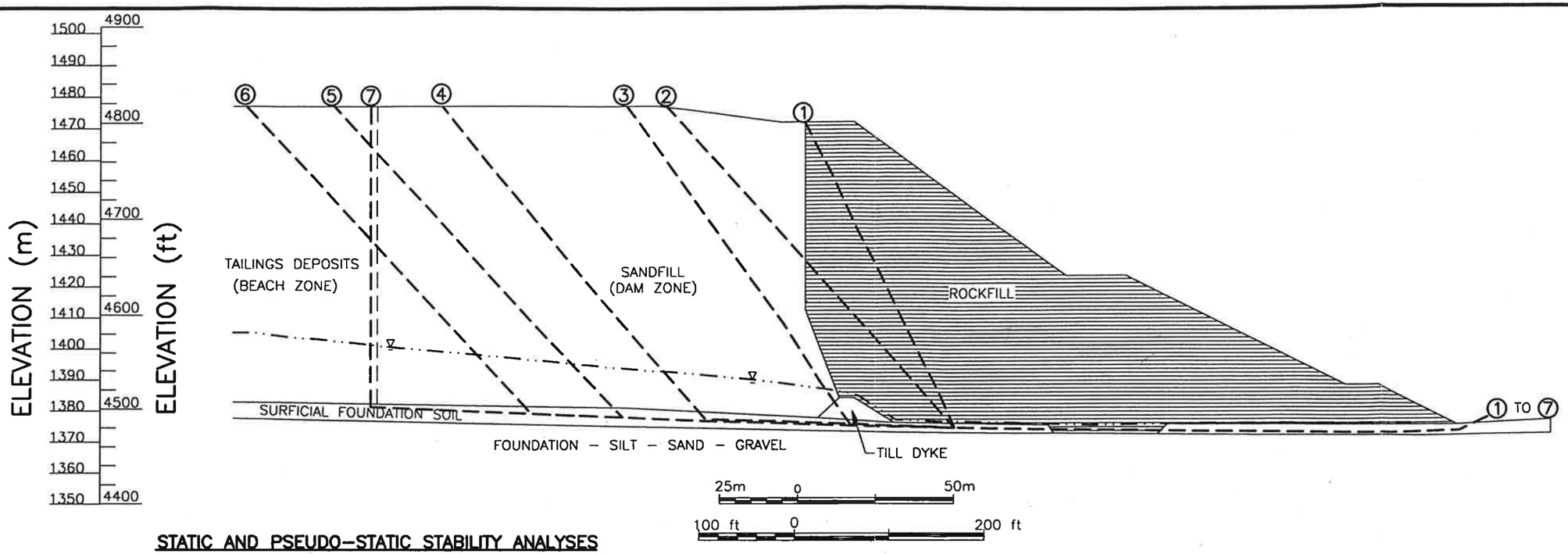
DATE OF ISSUE: DEC. 9, 1996

APPROVED

PROJECT No.: PM2916 23

DWG. No.: A–23009

REV.



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 ø' (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 – ø = 15% WAS SELECTED BY GOLDER (1970) THIS SELECTED STRENGTH APPEARS TO HAVE INCORPORATED ESTIMATED STRENGTH LOSS DUE TO EARTHQUAKE SHAKING. FOR STATIC CONDITION, ø = 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	RFG	DEC.96

KLOHN-CRIPPEN

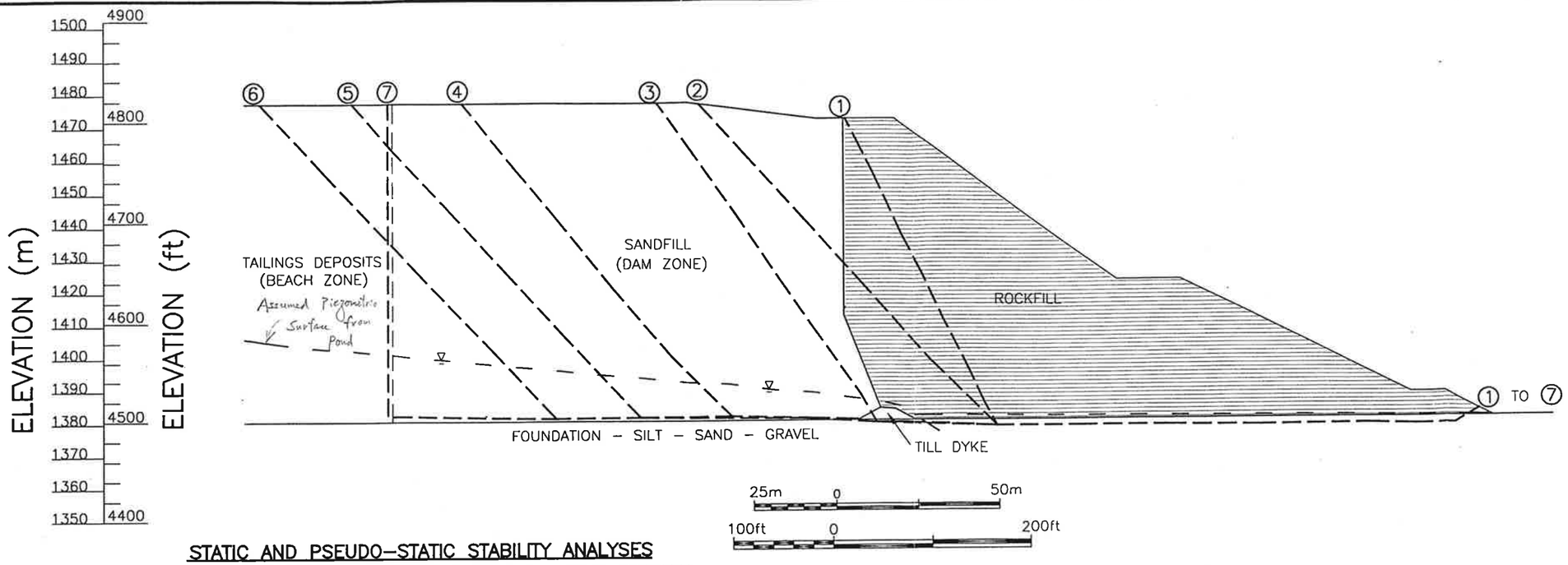
CLIENT: HIGHLAND VALLEY COPPER

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 ø' (degree)
	γ_{moist} (kN/m³)	γ_{sat} (kN/m³)	
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/m²

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

SCALE

KLOHN–CRIPPEN		DATE
DESIGNED	PH	JUNE 96
DRAWN	CYW	
CHECKED		
RECOMMENDED		
APPROVED		DEC.96

KLOHN–CRIPPEN

CLIENT

HIGHLAND COPPER VALLEY

PROJECT

LONG–TERM STABILITY ASSESSMENT

TITLE

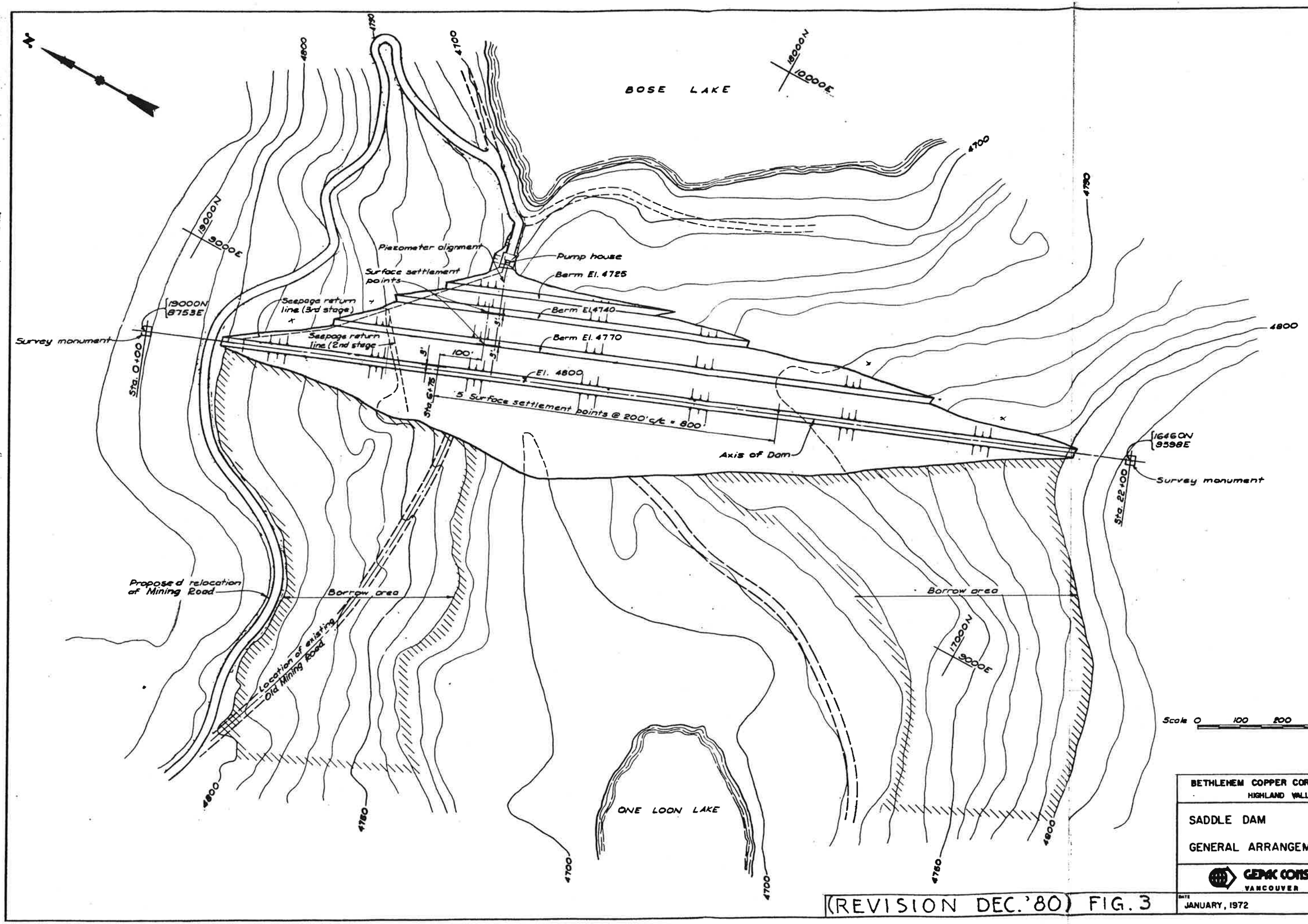
STABILITY ANALYSES
DAM No.1 SECTION B–B
– TYPICAL VALLEY SECTION

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

Reference Dam Design Drawings – Bose Lake Dam



BETHLEHEM COPPER CORPORATION LIMITED
HIGHLAND VALLEY MINE

SADDLE DAM

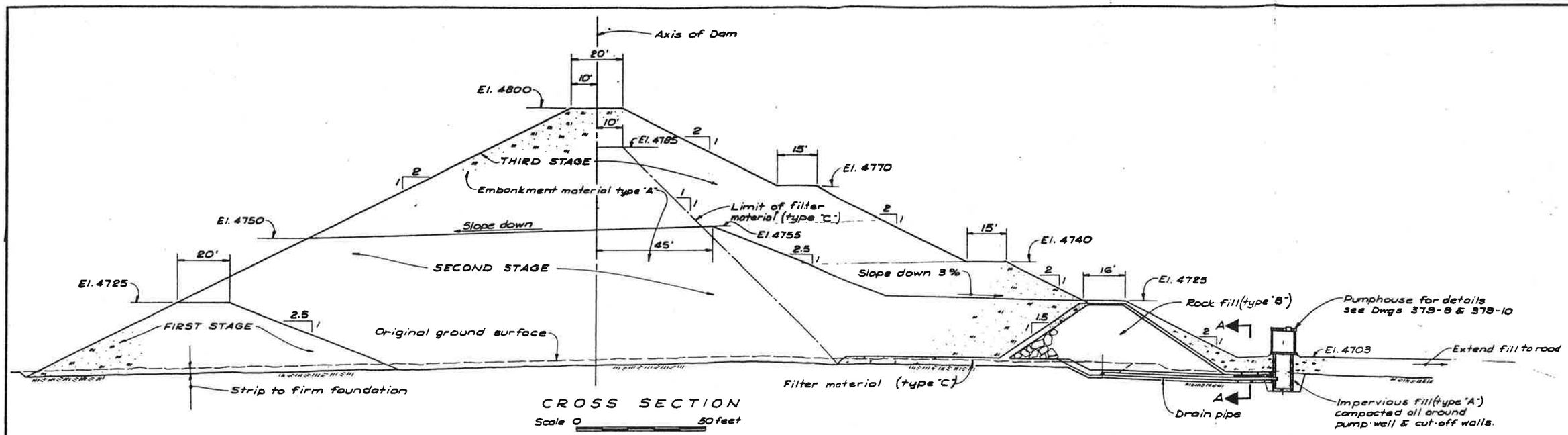
GENERAL ARRANGEMENT

GEMK CONSULTANTS LTD
VANCOUVER CANADA

(REVISION DEC.'80) FIG. 3

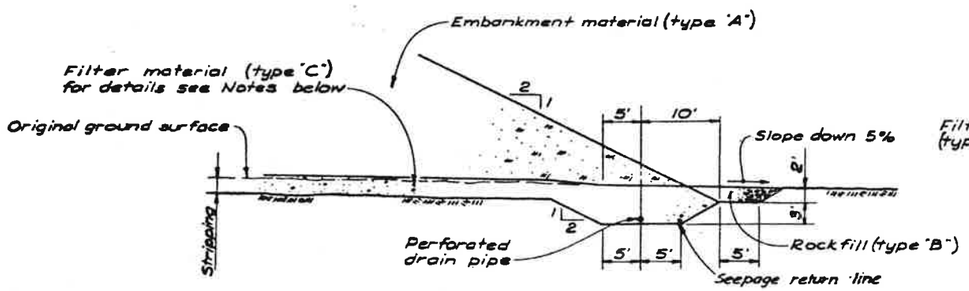
DATE JANUARY, 1972

379-5



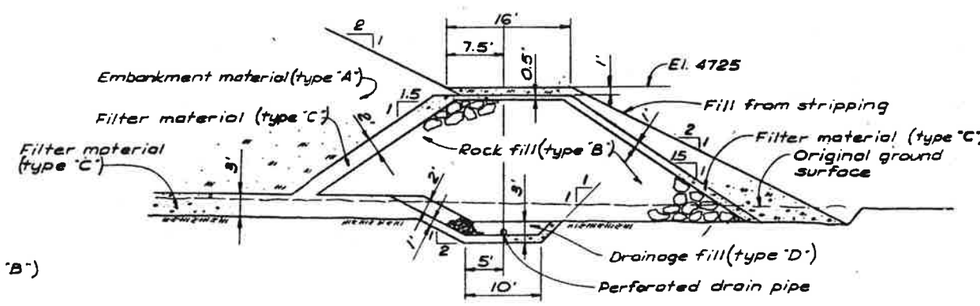
CROSS SECTION

Scale 0 50 feet



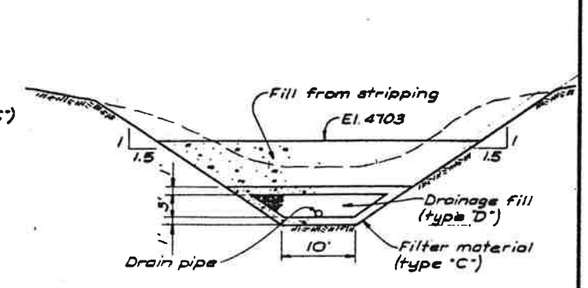
DOWNSTREAM TOE ABOVE EL. 4725

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

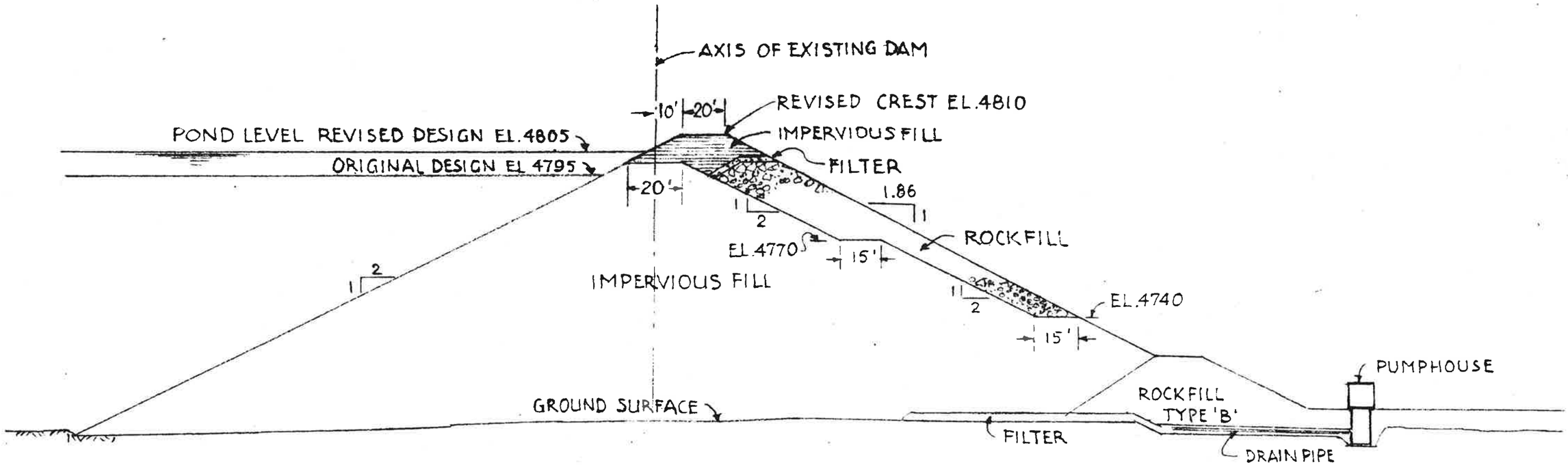
SECTIONS AND DETAILS

GEMC CONSULTANTS LTD
VANCOUVER CANADA

DATE JANUARY, 1972

NUMBER 379-6

(REVISION DEC. '80) FIG. 4



SCALE 0 50 FT

BOSE LAKE DAM
REVISED CROSS-SECTION

DEC.1980 FIGURE 5

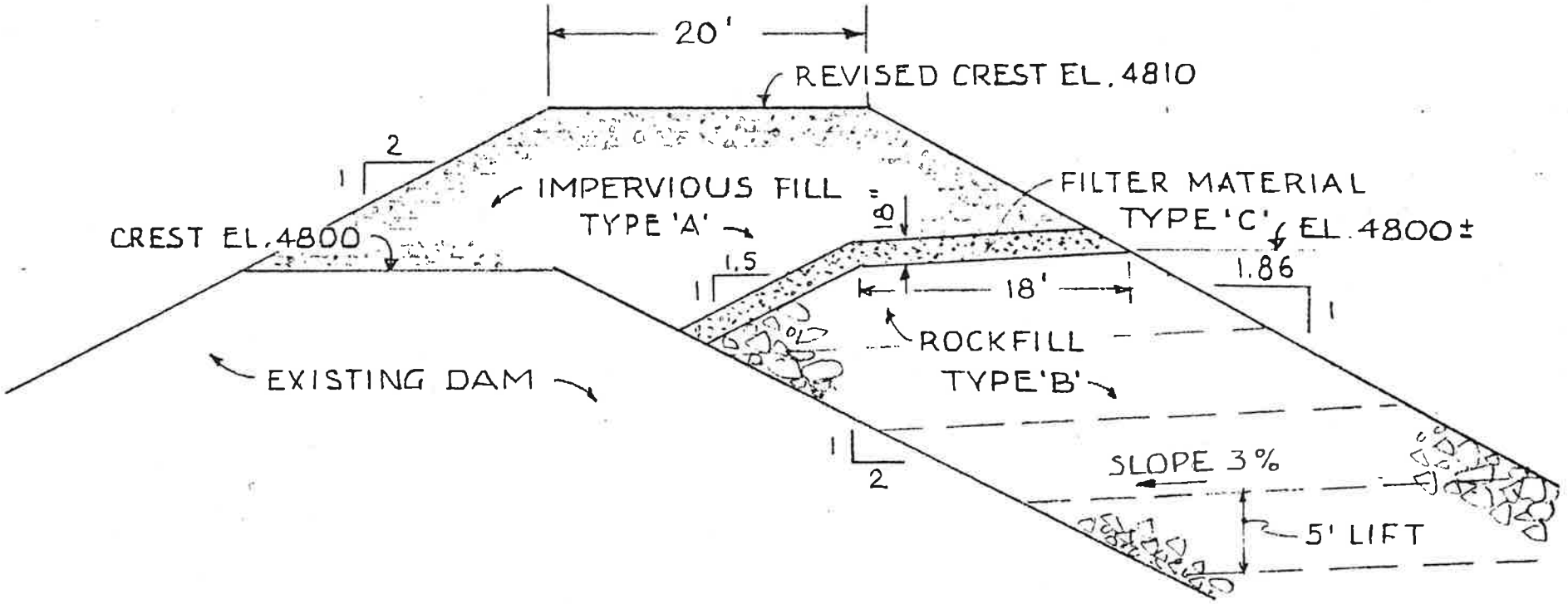
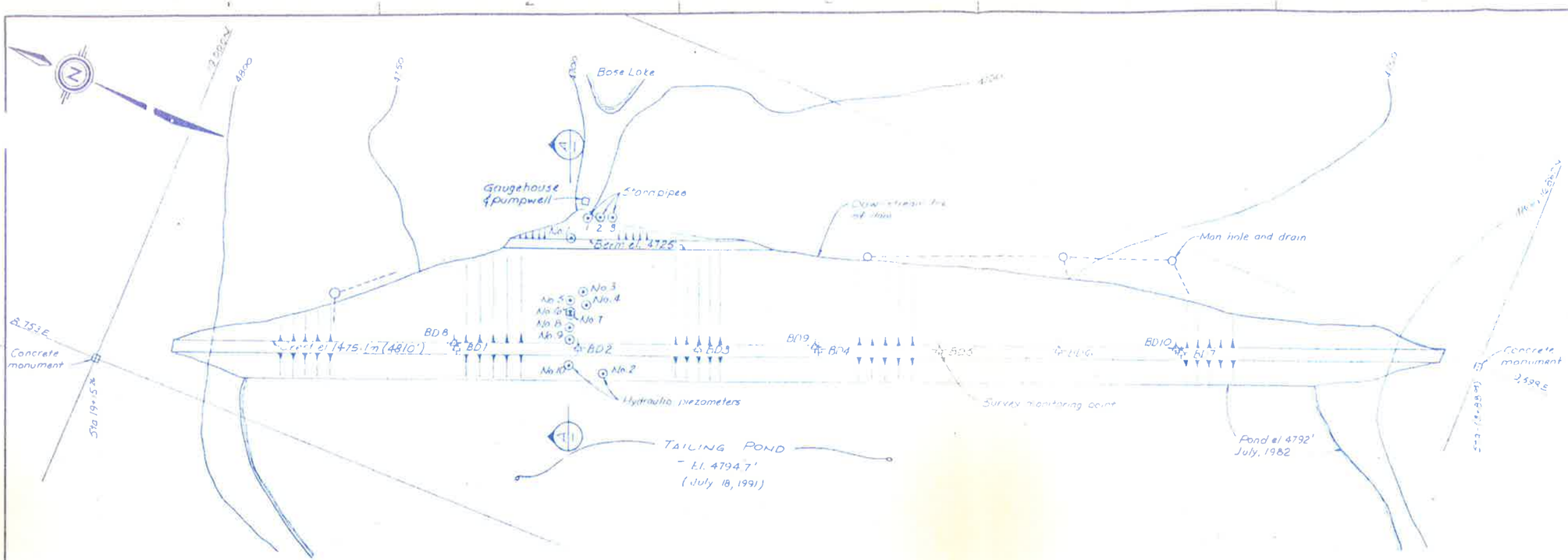


FIG. 6

BOSE LAKE DAM

REVISED CREST DETAIL

DEC. 1980 FIGURE 6

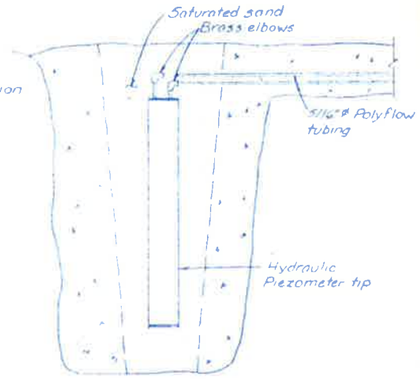


PLAN

100' 0 200'

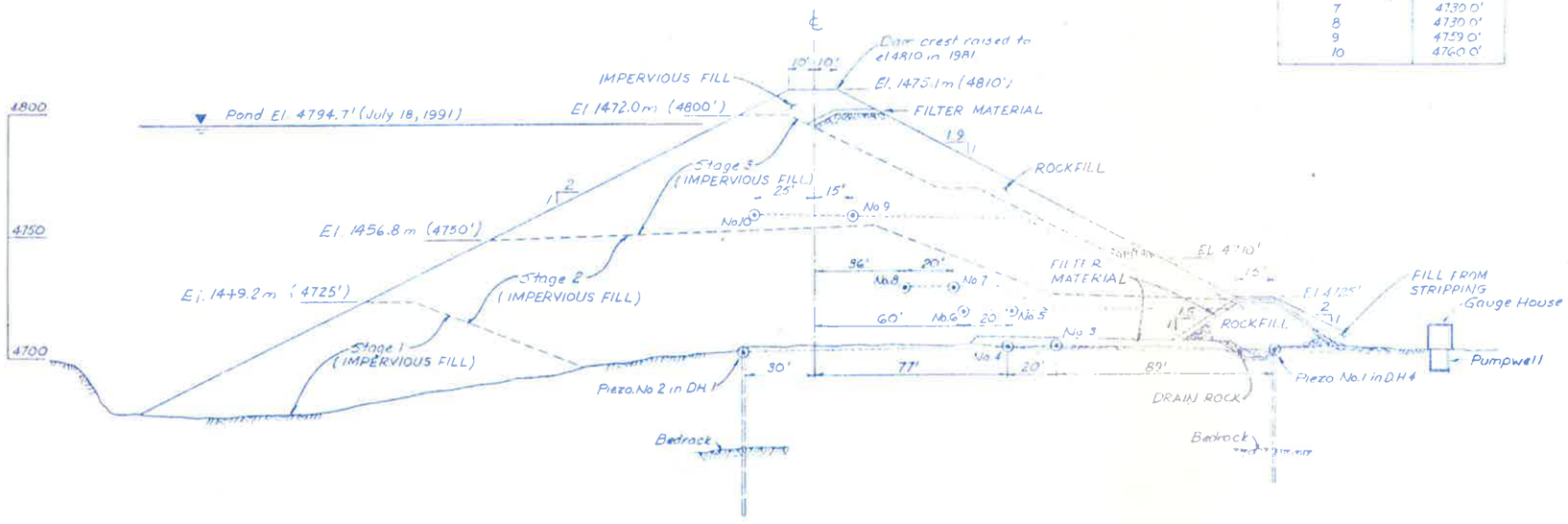
CONSTRUCTION MATERIAL SPECIFICATIONS (Note 4)	
Impervious Fill	- Well-graded silty sand and gravel, max. size 6", with >10% finer than No. 200 sieve.
Rockfill	- Rock and sandy gravel, reasonably sound, max. size 24", less than 30% finer than No. 4 sieve.
Filter Material	- Medium to coarse sandy gravel, 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 No.	TIP ELEV.
1	4704.63'
2	4705.36'
3	4705.0'
4	4720.0'
5	4720.0'
6	4720.0'
7	4730.0'
8	4730.0'
9	4759.0'
10	4760.0'



PIEZOMETER DETAIL

NTS



SECTION (A)

30' 0 60'

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

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

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

SCALE:

REV	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALE
	EDP	MARCH, 1983	AS SHOWN

KLOHN-CRIPPEN

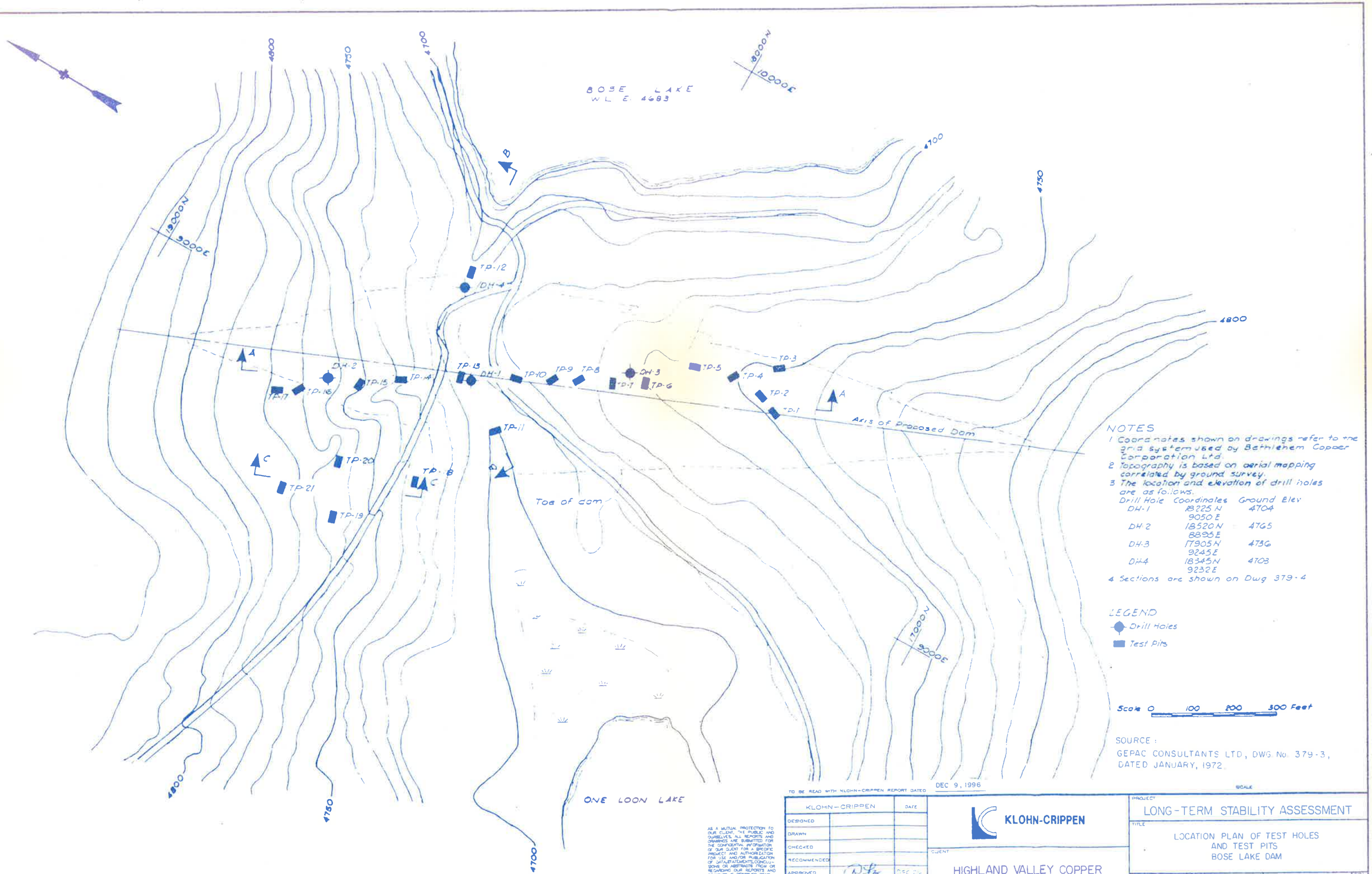
CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: PLAN AND TYPICAL SECTION BOSE LAKE DAM

DATE OF ISSUE	PROJECT No.	DWG. No.
DEC. 9, 1996	PM2916 23	B-23012

APPROVED



NOTES

1. Coord nates 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	4708

4. Sections are shown on Dwg 379-4

LEGEND

- Drill Holes
- Test Pits

Scale 0 100 200 300 Feet

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		DEC 9/96

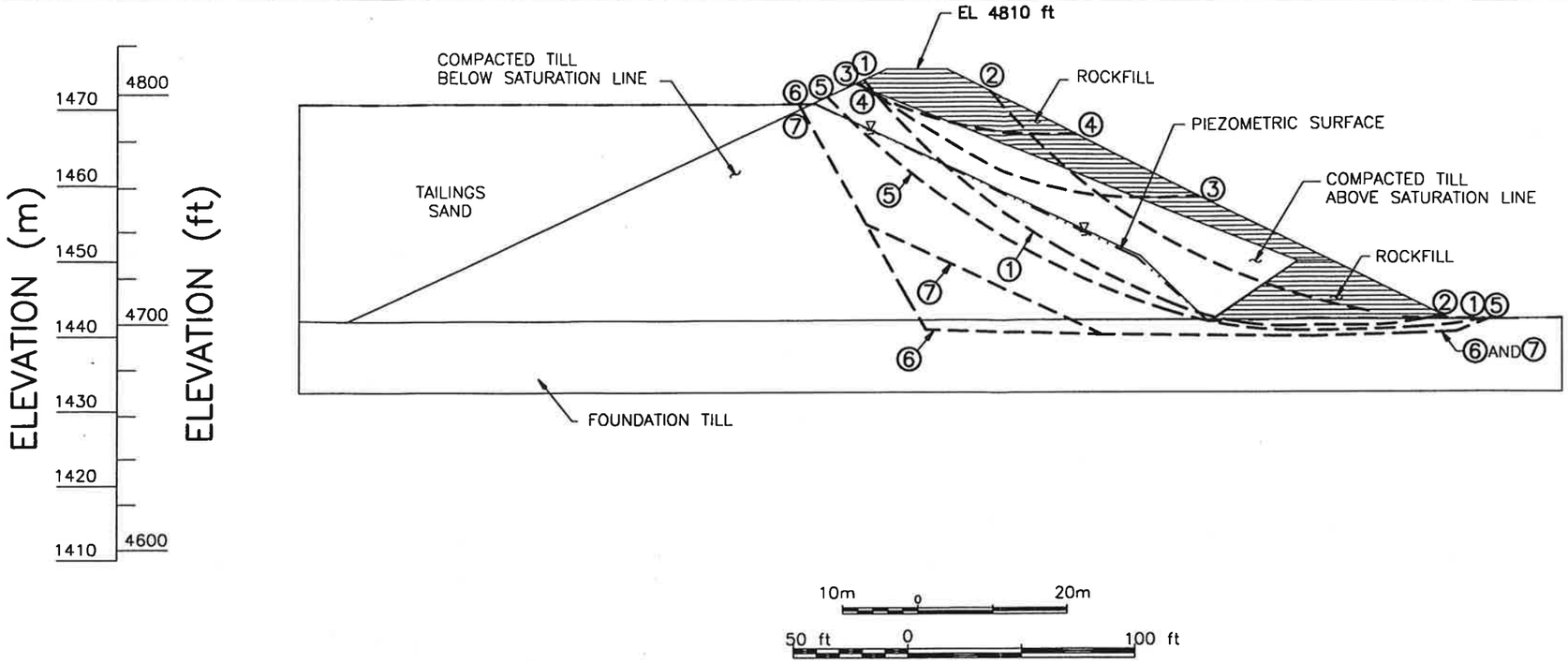
KLOHN-CRIPPEN

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)
	γmoist (kN/m³)	γsat (kN/m³)	
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/m²

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		DEC.96

KLOHN-CRIPPEN

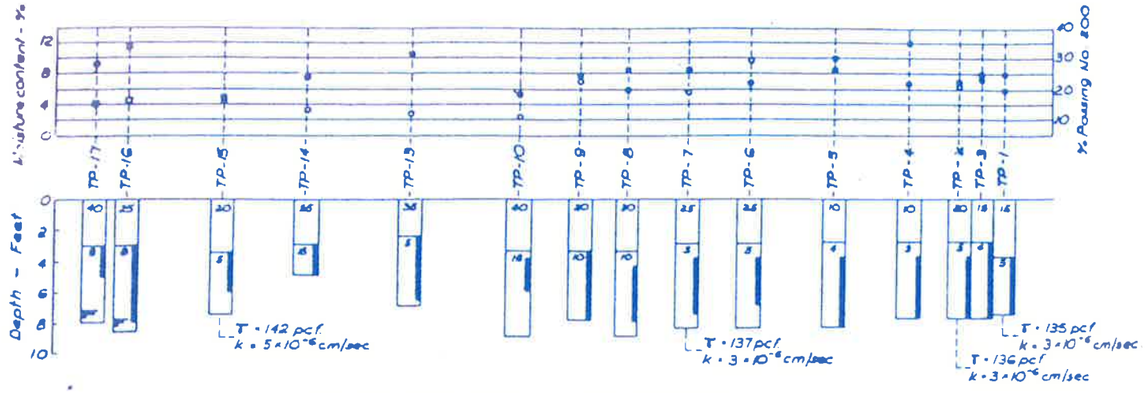
CLIENT: HIGHLAND COPPER VALLEY

PROJECT: LONG-TERM STABILITY ASSESSMENT

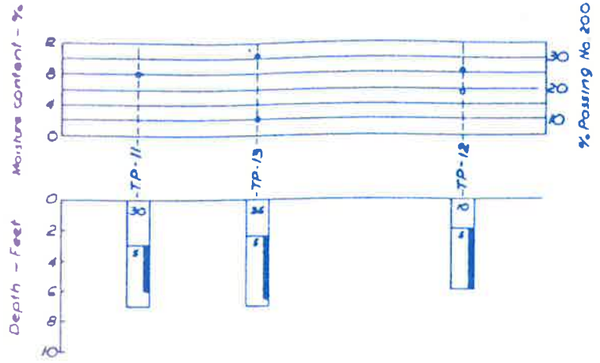
TITLE: STABILITY ANALYSES
BOSE LAKE DAM

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

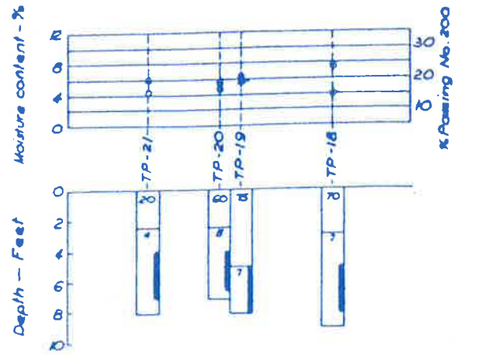
N:\M\M2916\CADD\23\B-23015.DWG
08/23/96 time 4:30



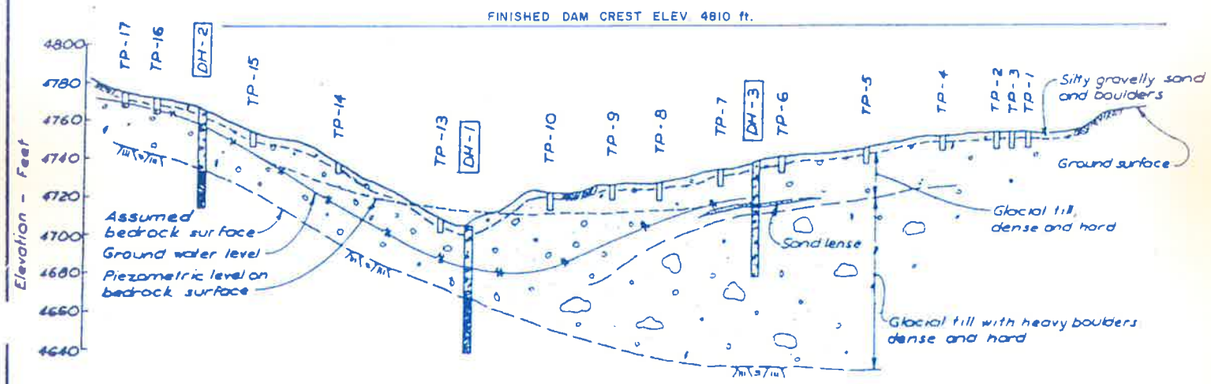
LOG OF TEST PITS ALONG SECTION A - A



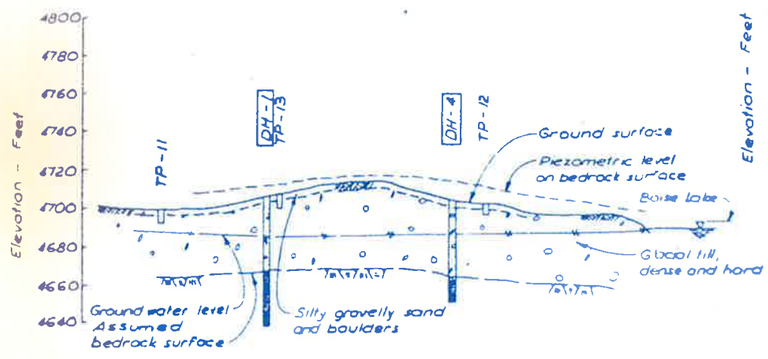
LOG OF TEST PITS ALONG SECTION B - B



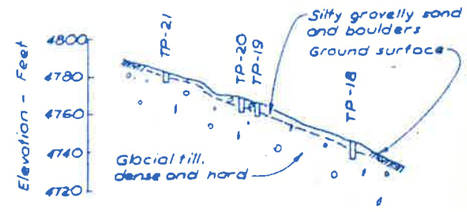
LOG OF TEST PITS ALONG SECTION C-C



SECTION A - A

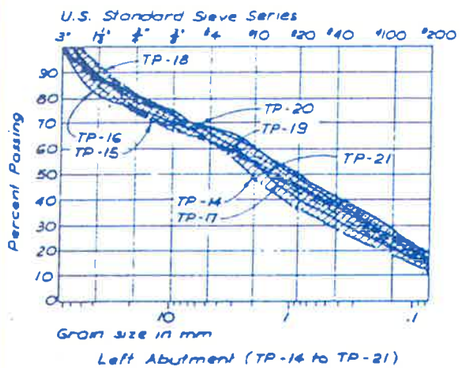


SECTION B - B

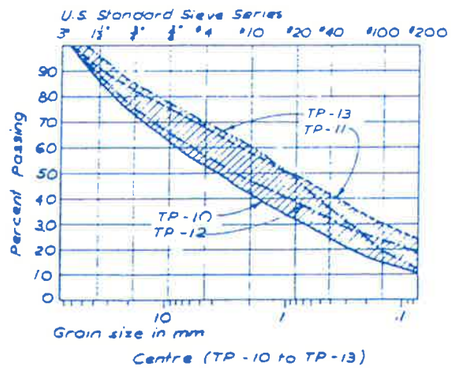


SECTION C-C

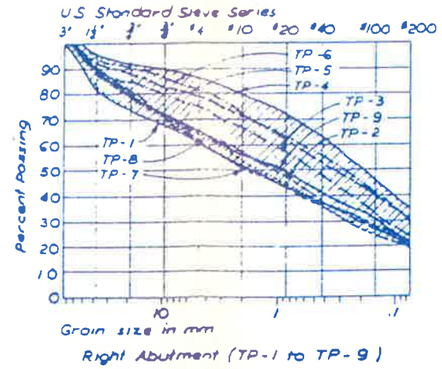
NOTES
1. Location of sections shown on Dwg. 379-3
2. Bedrock surface, ground water and piezometric levels shown on sections between drill holes (DH, are inferred and approximate only



Left Abutment (TP-14 to TP-21)

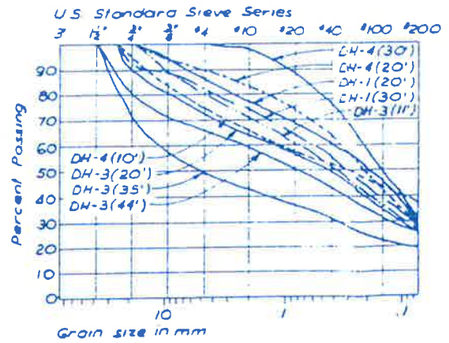


Centre (TP-10 to TP-13)



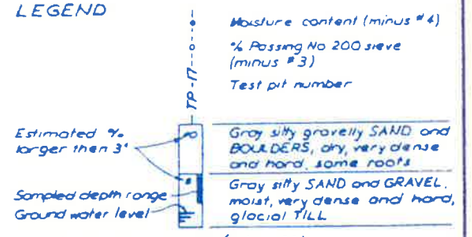
Right Abutment (TP-1 to TP-9)

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		DEC.96

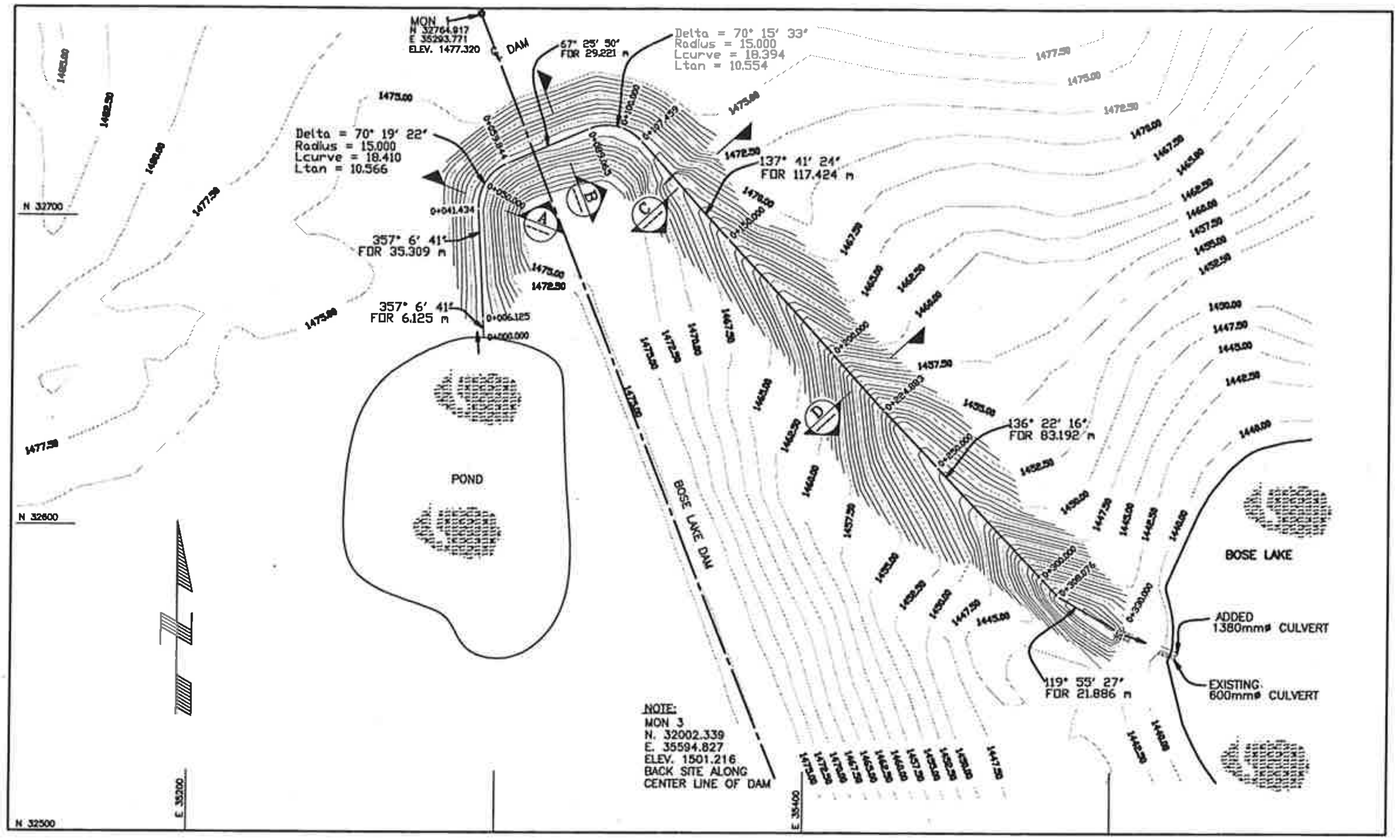
KLOHN-CRIPPEN

CLIENT: HIGHLAND VALLEY COPPER

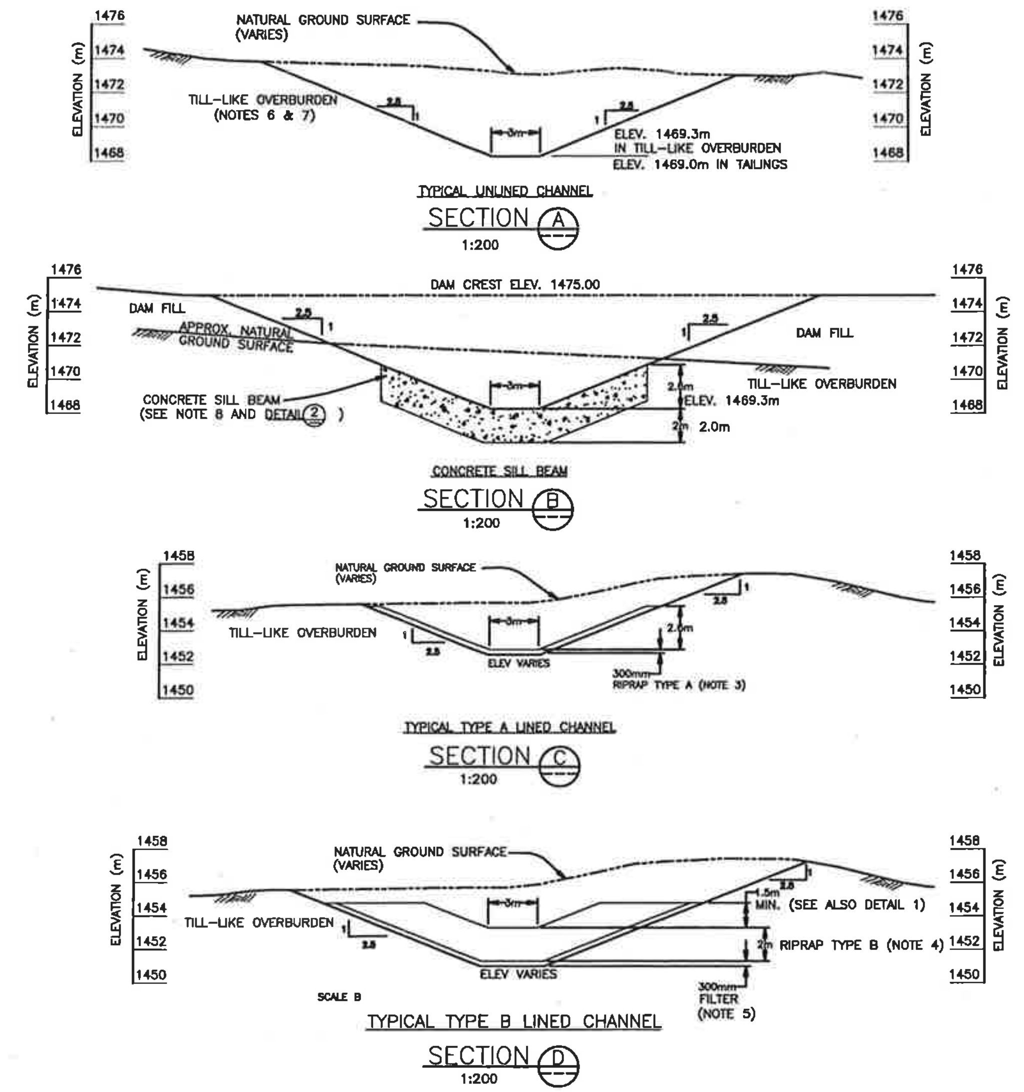
PROJECT: LONG-TERM STABILITY ASSESSMENT

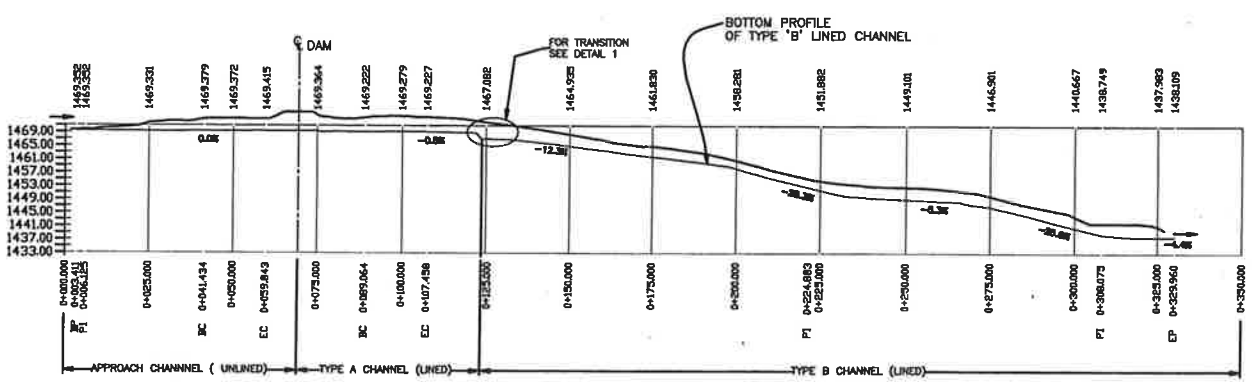
TITLE: SUBSOIL DATA - BOSE LAKE DAM

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

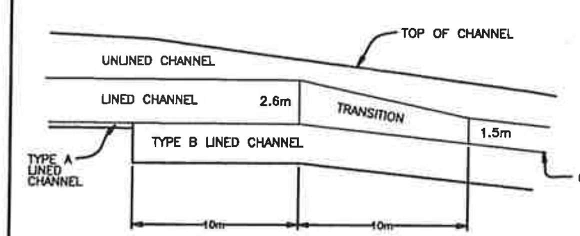


GENERAL ARRANGEMENT – PLAN



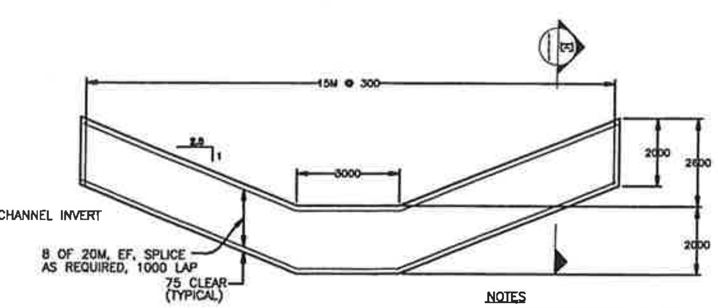


PROFILE ALONG SPILLWAY CHANNEL



TRANSITION DETAIL

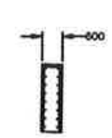
DETAIL 1
1:200



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

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.

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

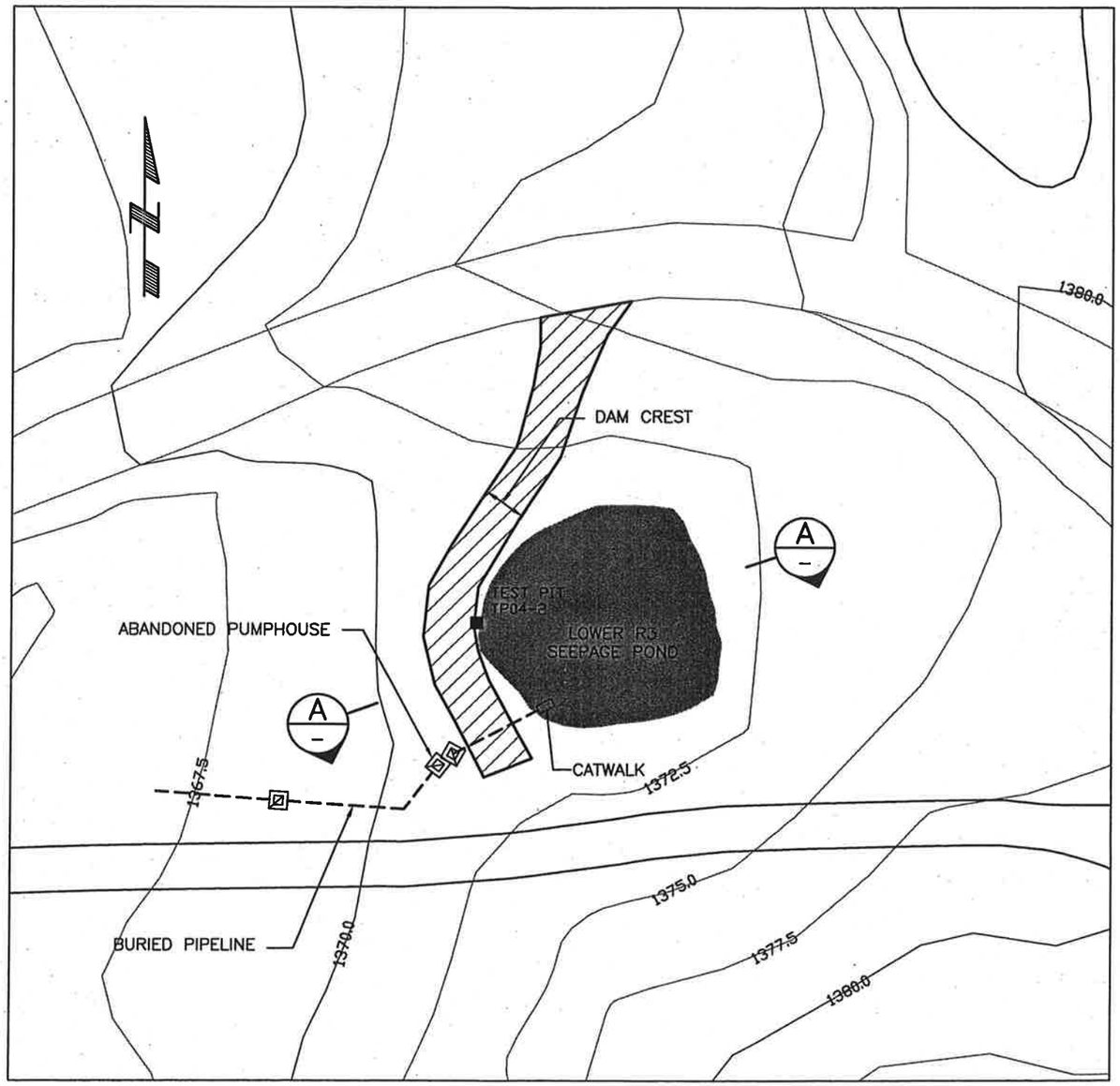
Highland Valley Copper

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

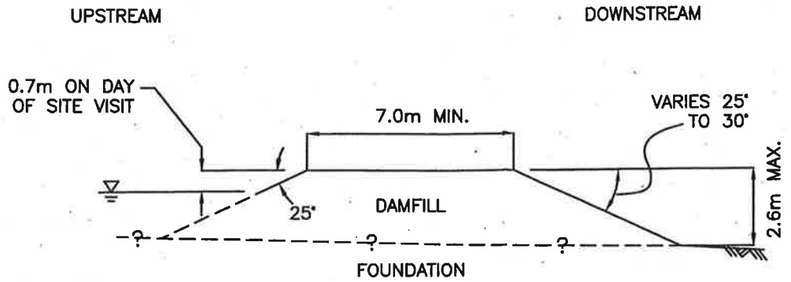
DRAWN H. P. — CHECKED
DATE 98 11 27 — SCALE 1:1000
DWG No. 114-808-201-1 — REV. 1

APPENDIX III-C

Reference Dam Design Drawings – R3 Seepage Pond Dam



PLAN
SCALE A



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
SCALE

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 PLAN AND DAM SECTION

PROJECT No. M 02341 A3105

FIG. No. B-002

Time: 13:27:53
Date: 3/9/2005
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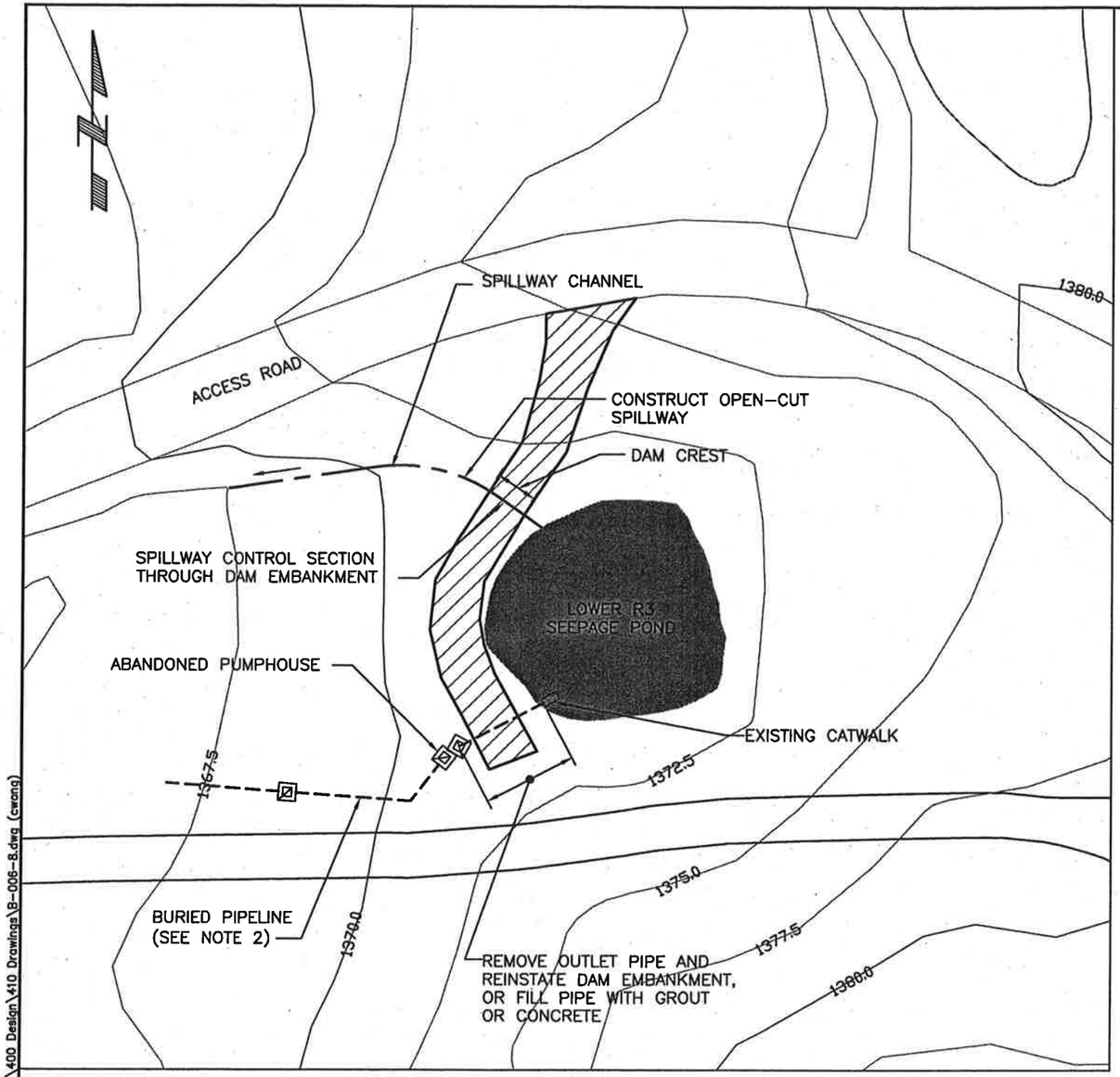
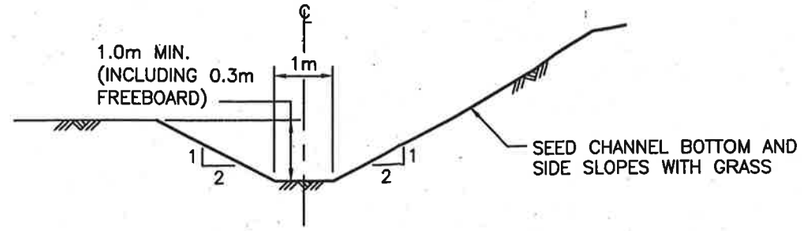
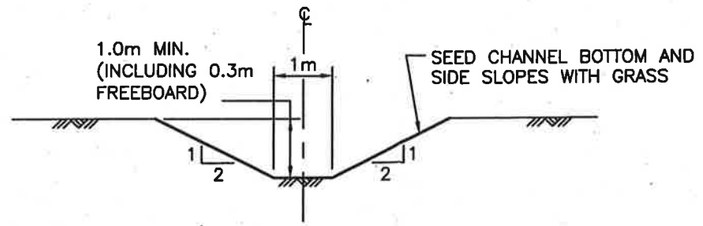
Xrefs: FIG-BASE



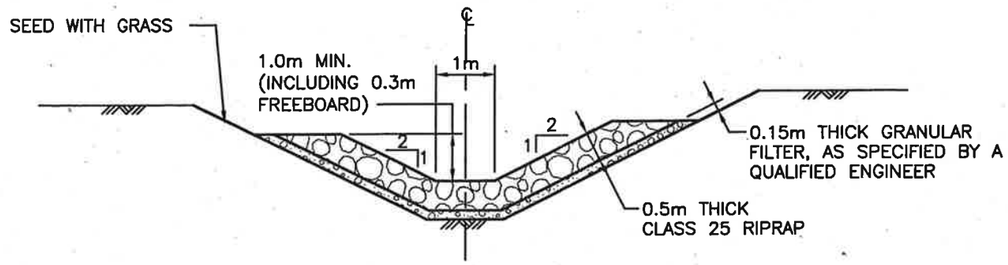
PLAN
SCALE A



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

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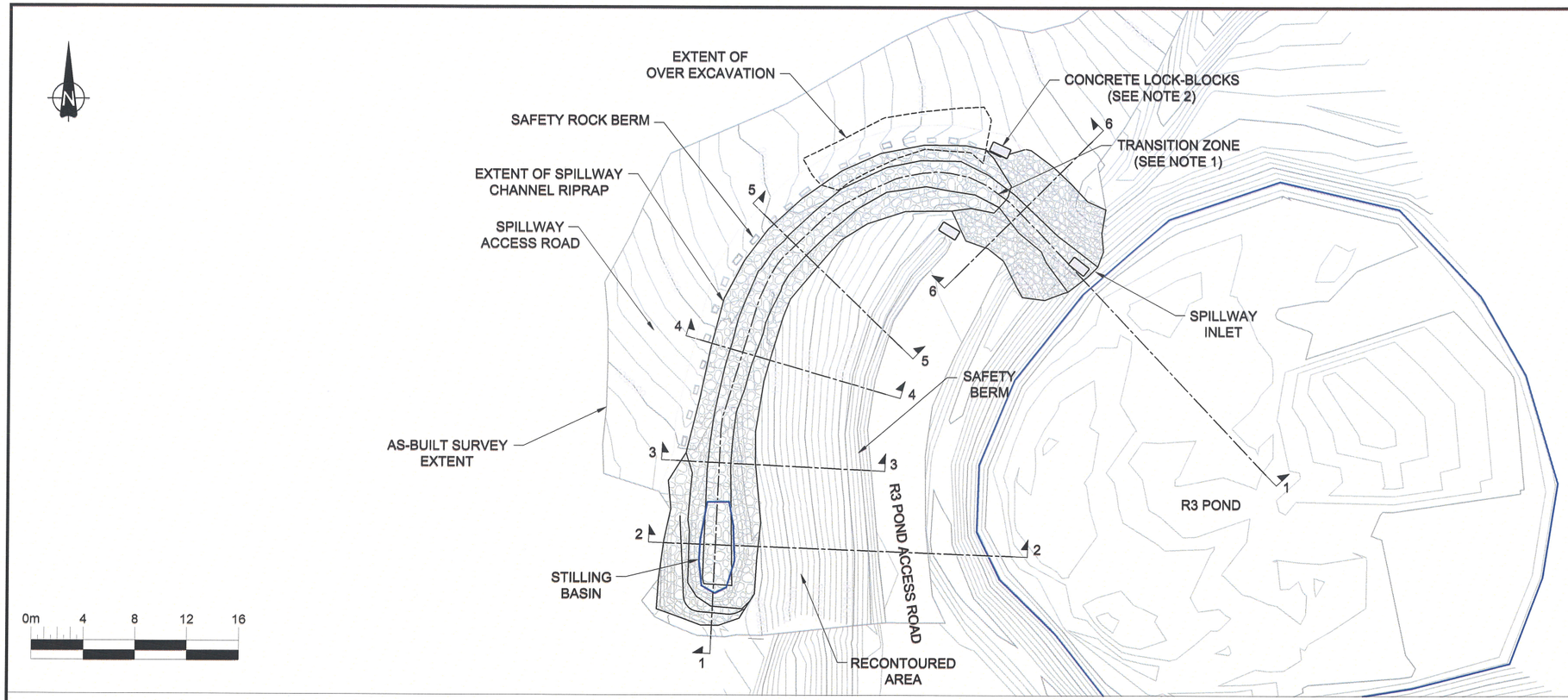
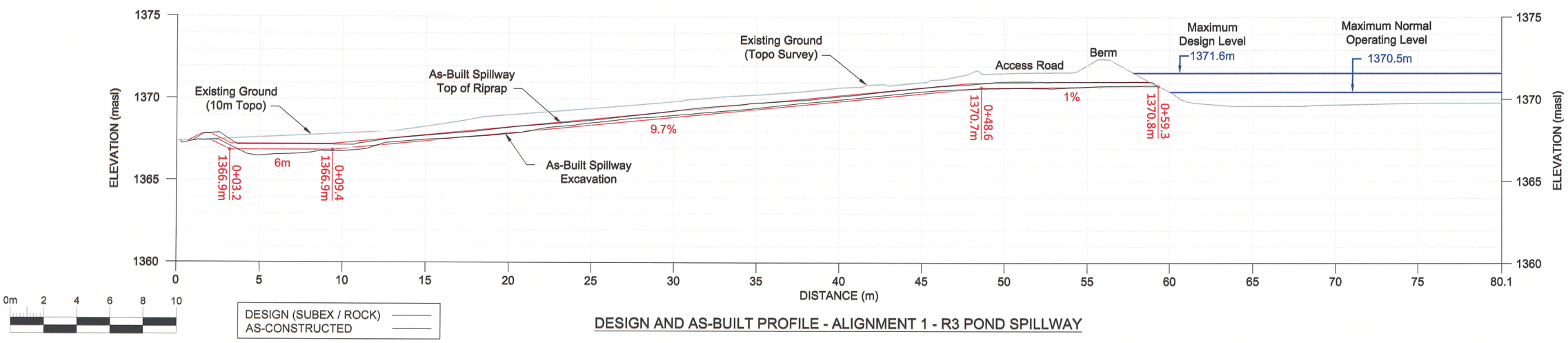


NOTES:

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

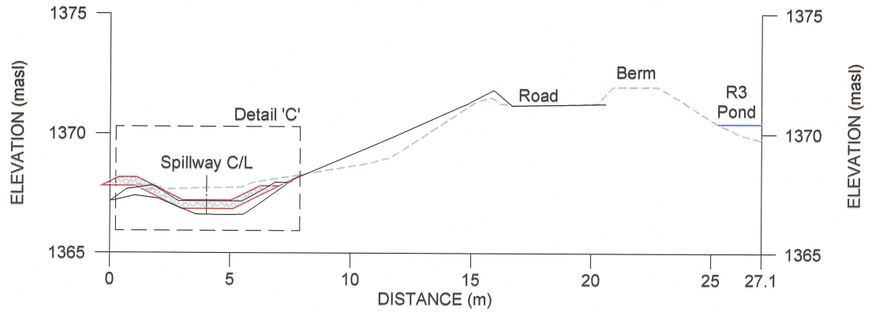
DWN BY:	TH
CHK'D BY:	HY/AF
DATUM:	MINE
PROJECTION:	MINE
SCALE:	AS SHOWN

PROJECT: CONSTRUCTED SPILLWAY - TROJAN - BETHLEHEM RECLAIM 3

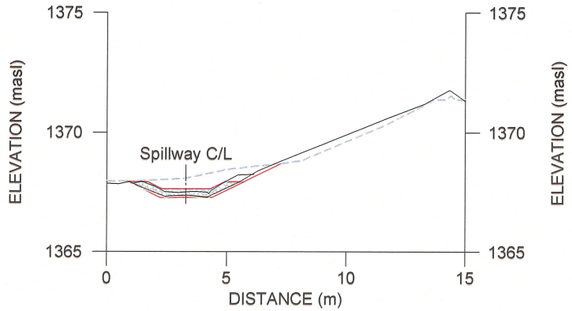
TITLE: AS CONSTRUCTED PLAN AND PROFILE

DATE:	DECEMBER 2013
PROJECT NO:	VW1031
REV. NO:	A
FIGURE NO:	AB-002

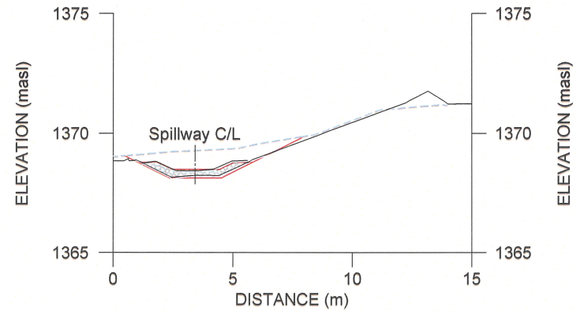
W:\Projects\VW1031 – Tech Highland Valley Copper\Drawings\As-Built Drawings\VW1026-R3-Pond-Berm-Spillway-AsBuilt.Dec.6.dwg – Plan and Profile – Dec. 17, 2013 11:43am – hamid.yousefbeigi



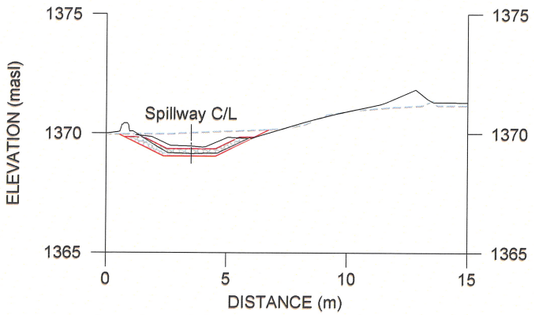
SECTION - ALIGNMENT 2
STILLING BASIN
(See Detail 'C')



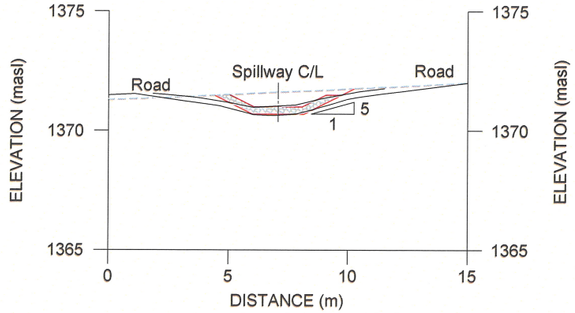
SECTION - ALIGNMENT 3
SPILLWAY
(See Detail 'B')



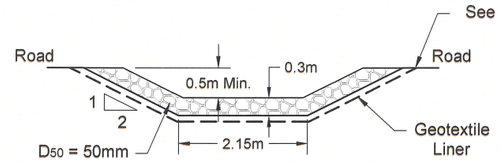
SECTION - ALIGNMENT 4
SPILLWAY
(See Detail 'B')



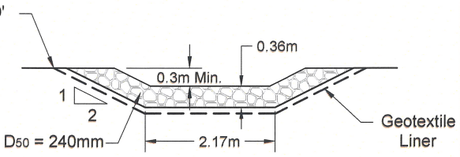
SECTION - ALIGNMENT 5
SPILLWAY
(See Detail 'B')



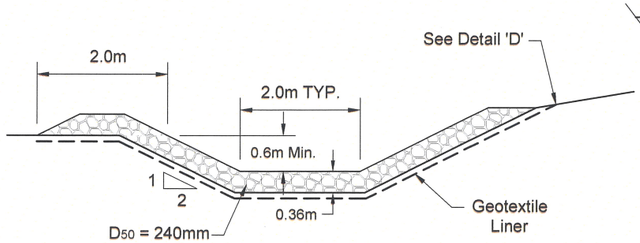
SECTION - ALIGNMENT 6
R3 POND BERM / ACCESS ROAD
(See Detail 'A')



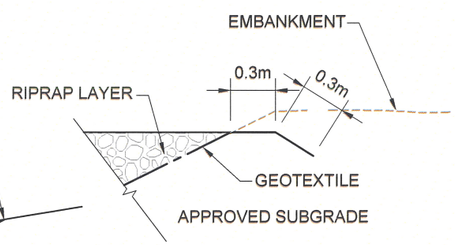
DETAIL 'A'
TYPICAL SECTION - SPILLWAY
CHANNEL 1% GRADE



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



DETAIL 'C'
TYPICAL SECTION - STILLING
BASIN



DETAIL 'D'
TYPICAL SECTION - ANCHORE
DETAIL

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

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

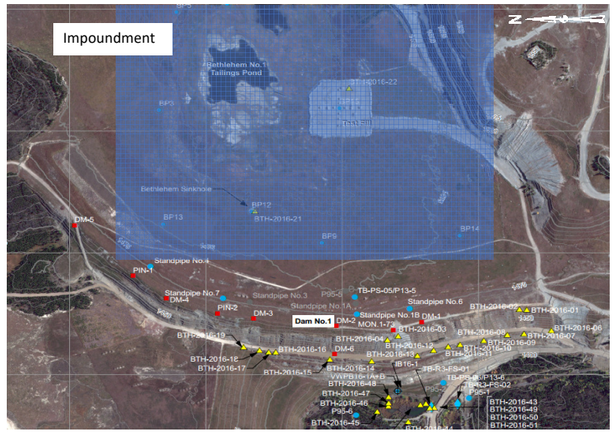
PROJECT: CONSTRUCTED SPILLWAY - TROJAN - BETHLEHEM RECLAIM 3

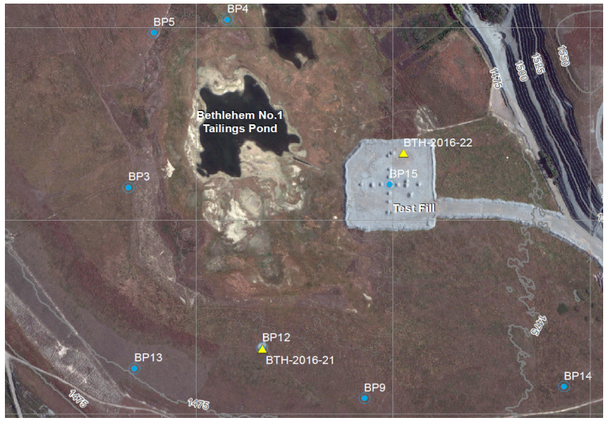
TITLE: AS CONSTRUCTED CHANNEL SECTIONS AND TYPICAL DETAILS

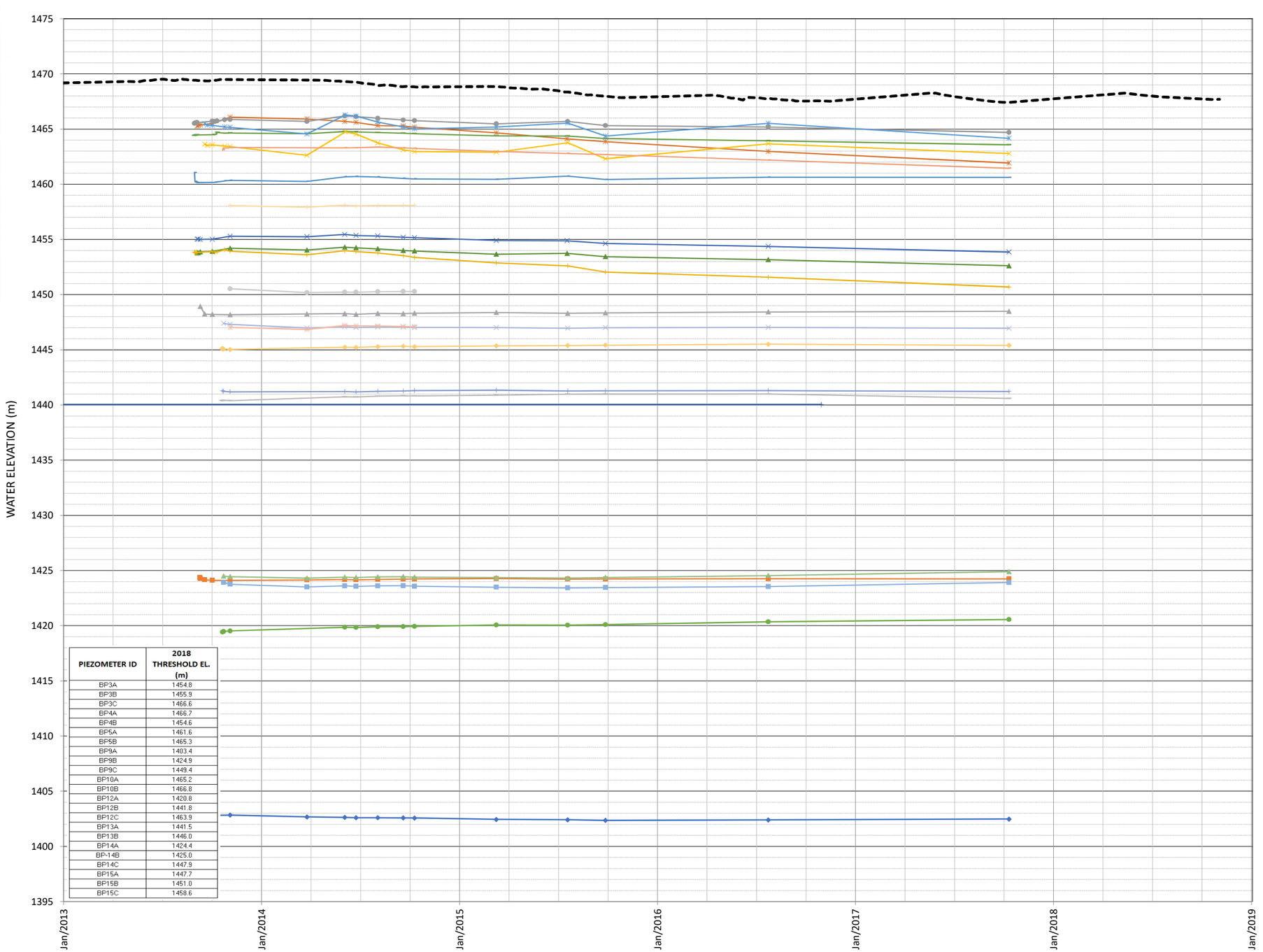
DATE: DECEMBER 2013
PROJECT NO: VW1031
REV. NO: A
FIGURE NO: AB-003

APPENDIX IV

Instrumentation Plots







PIEZOMETER ID	2018 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

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

NOTES:

1. NO READINGS WERE TAKEN IN 2018.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

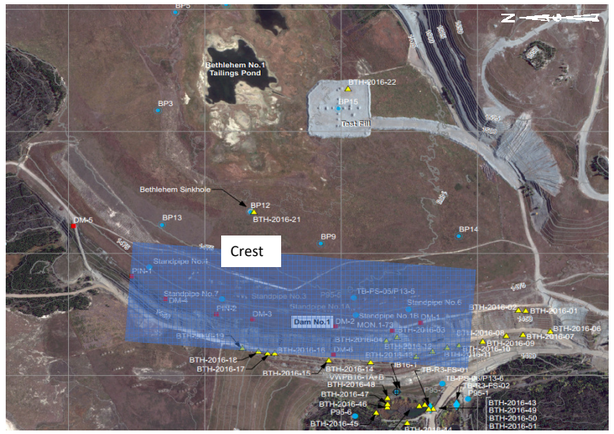
TITLE: DAM No. 1 PIEZOMETRIC DATA
2013-2018

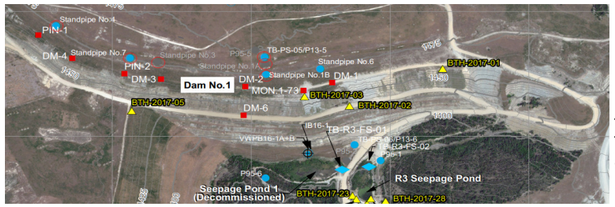
IMPOUNDMENT

PROJECT No. M02341B43

FIG No. IV-1

March 22, 2019
Z:\M\VC\RM\02341B43 - HVC 2018 Dam Safety Support\300 Design\Piezometer Data\Piezo Data\Bethlehem\[190321 Bethlehem Piezo.xlsx]Piezo Data Entry BLD

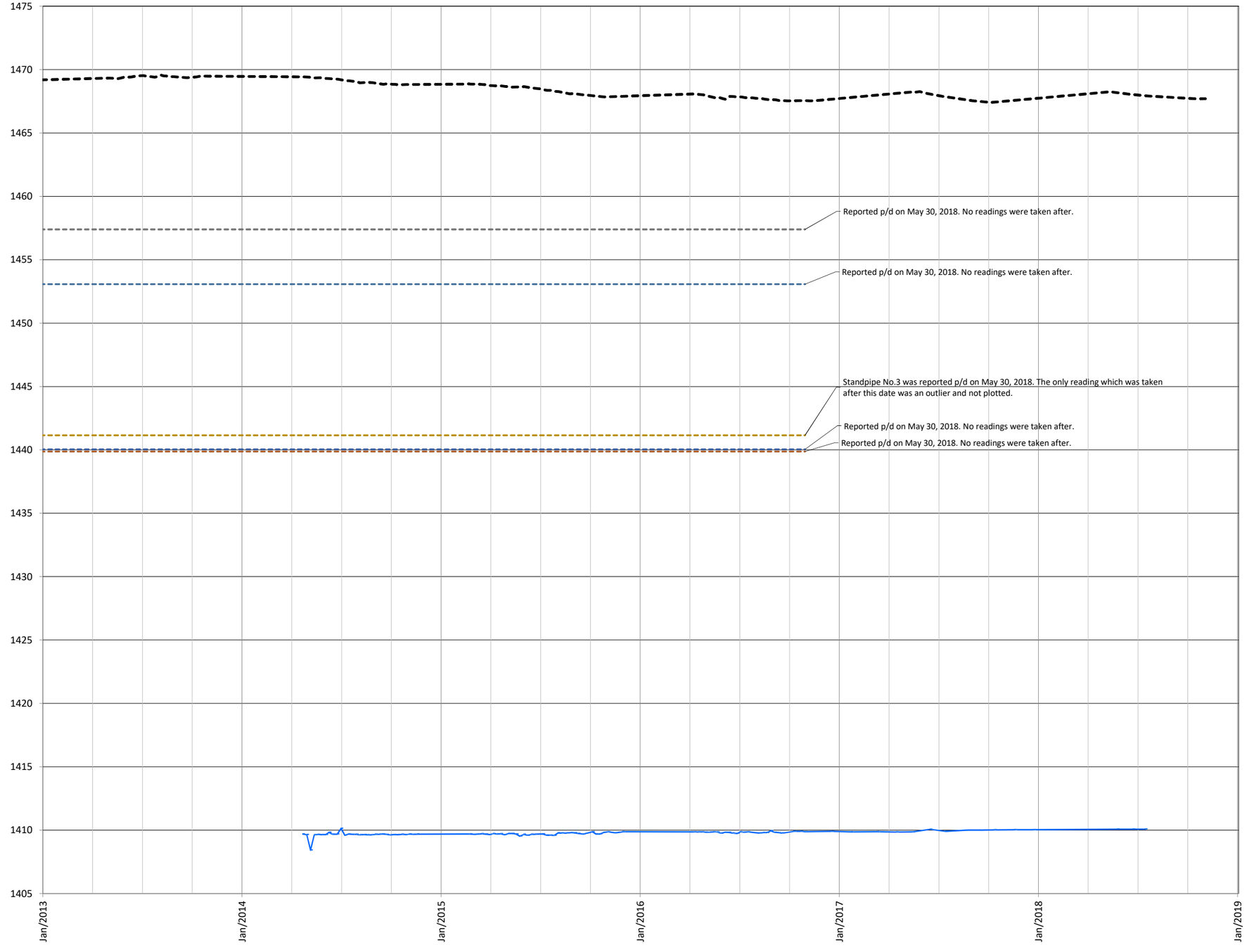




LEGEND:

- 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	2018 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: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

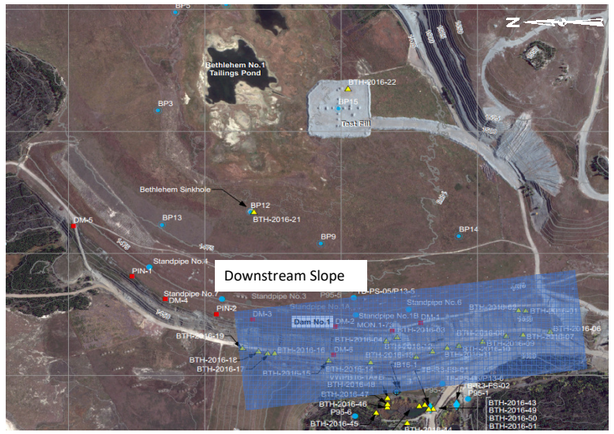
TITLE: DAM No. 1 PIEZOMETRIC DATA
2013-2018

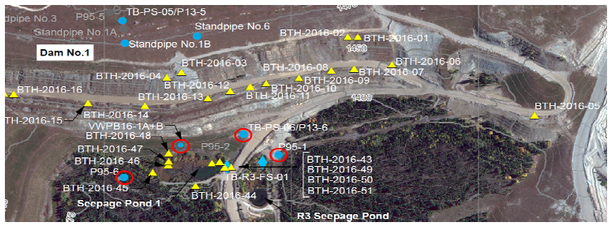
CREST

PROJECT No. M02341B43

FIG No. IV-2

March 22, 2019
Z:\MVCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Piezometer Data\Piezo Data\Bethlehem\191022 Bethlehem Piezo.xlsx\Piezo Data Entry BLD

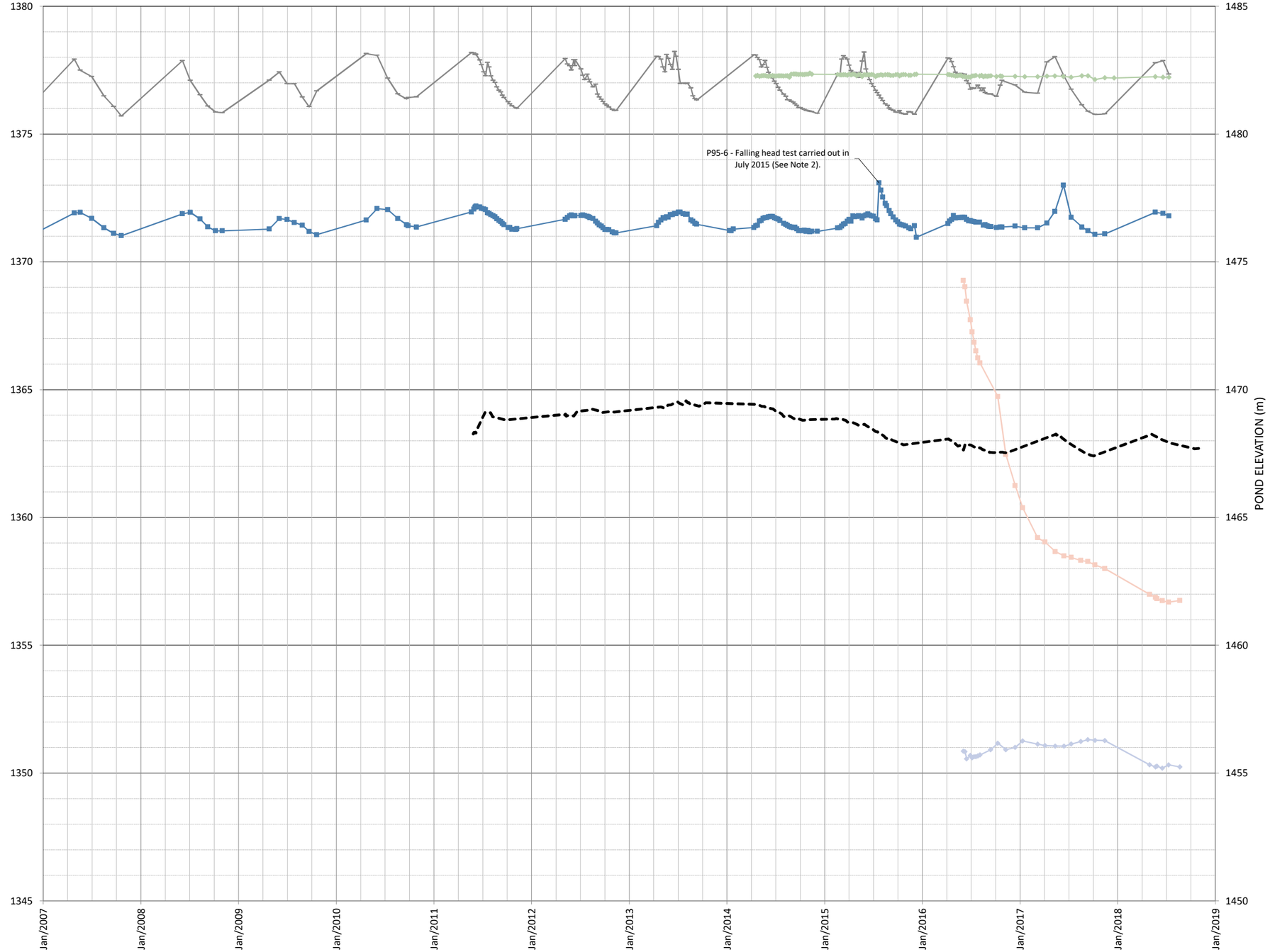




LEGEND:

- 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	2018 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: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

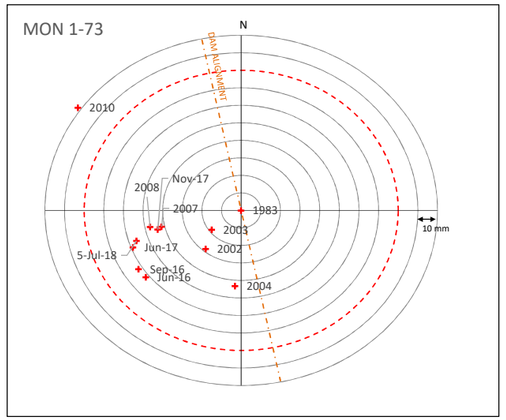
TITLE: DAM No. 1 PIEZOMETRIC DATA
2007-2018

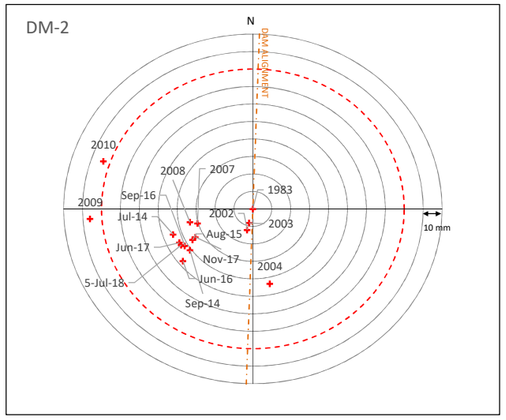
DOWNSTREAM SLOPE

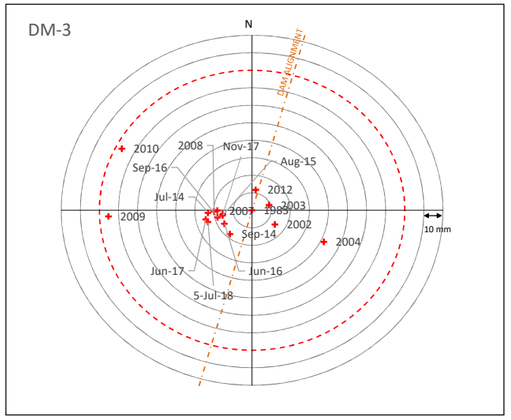
PROJECT No. M02341B43

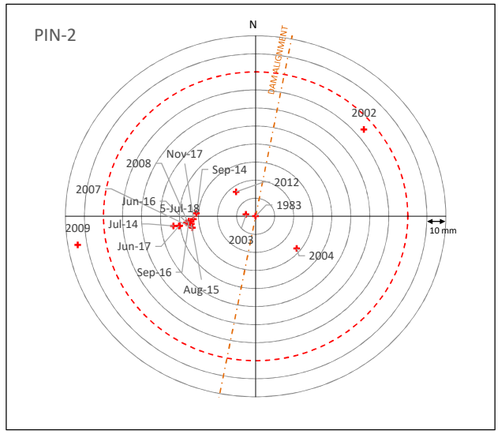
FIG No. IV-3

March 22, 2019
Z:\MV\CFR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Piezometer Data\Piezo Data\Bethlehem\190321 Bethlehem Piezo.xlsx|Piezo Data Entry BLD









DAM CENTERLINE ORIENTATION

THRESHOLD HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION

MONUMENT ID	2018 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

LEGEND:

- DM-1
- DM-2
- DM-3
- DM-4
- DM-5
- DM-6
- MON. 1-73
- PIN-2
- Bethlehem Sinkhole
- Linear (DM-2)
- Linear (DM-3)
- Linear (MON. 1-73)
- Linear (PIN-2)

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.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

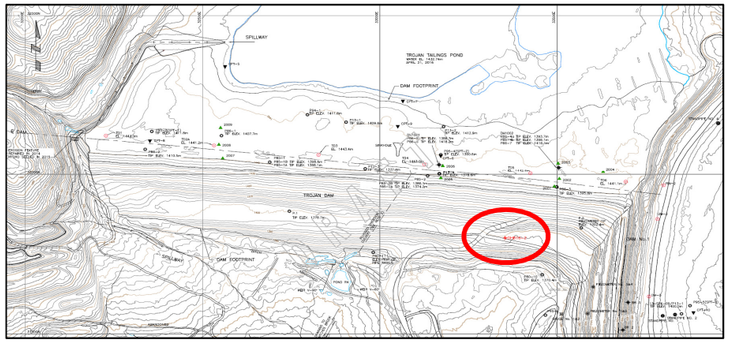
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

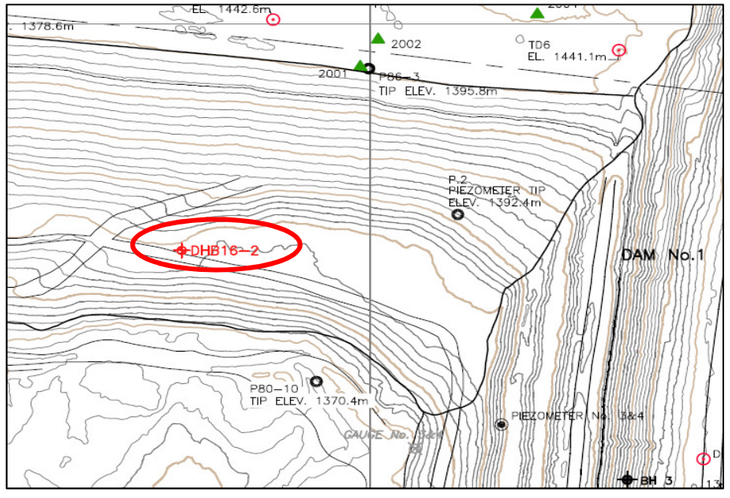
TITLE: DAM NO. 1
SURVEY MONUMENT READINGS

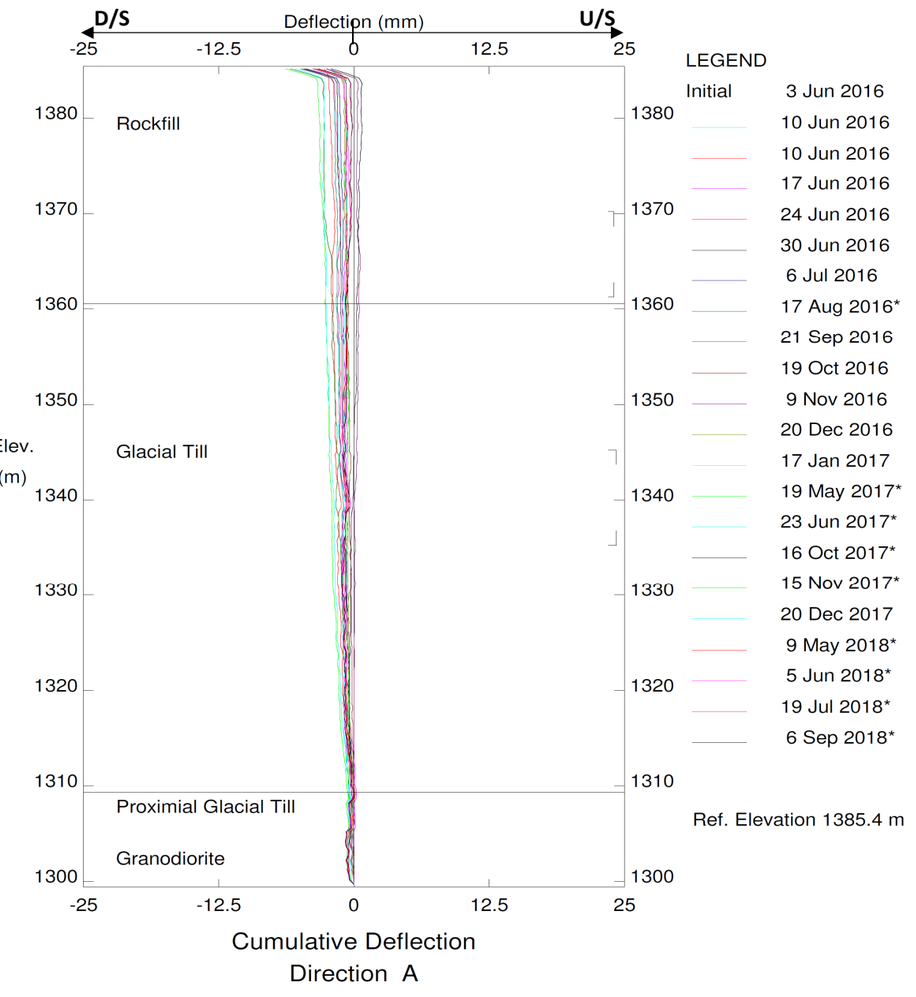
PROJECT No. M02341B43

FIG No. IV-4

March 26, 2019
Z:\M\VCP\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Monument Data\Bethlehem\190326 BethMainDamMonitoring.xlsm\Summary



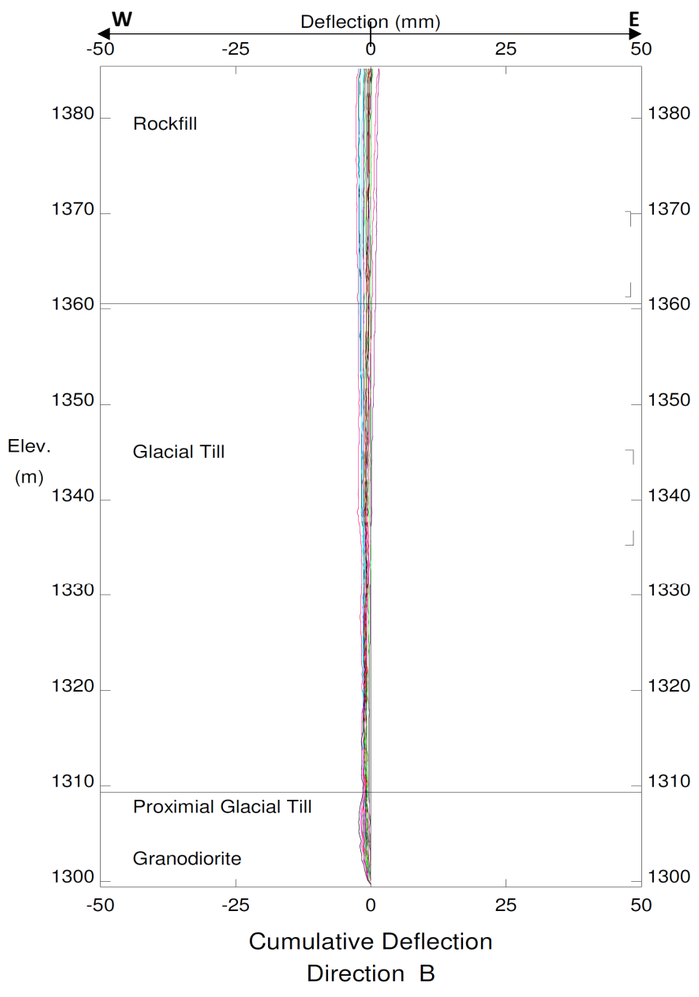




LEGEND

Initial	3 Jun 2016
	10 Jun 2016
	10 Jun 2016
	17 Jun 2016
	24 Jun 2016
	30 Jun 2016
	6 Jul 2016
	17 Aug 2016*
	21 Sep 2016
	19 Oct 2016
	9 Nov 2016
	20 Dec 2016
	17 Jan 2017
	19 May 2017*
	23 Jun 2017*
	16 Oct 2017*
	15 Nov 2017*
	20 Dec 2017
	9 May 2018*
	5 Jun 2018*
	19 Jul 2018*
	6 Sep 2018*

Ref. Elevation 1385.4 m



NOTES:

1) IB16-2 was installed on April 29, 2016.
2) IB16-2 was initialized on June 10, 2016.
3) Reel/Probe Serial Number for the initial reading: DR15020000/DP06580000.
4) Not all readings are plotted.

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

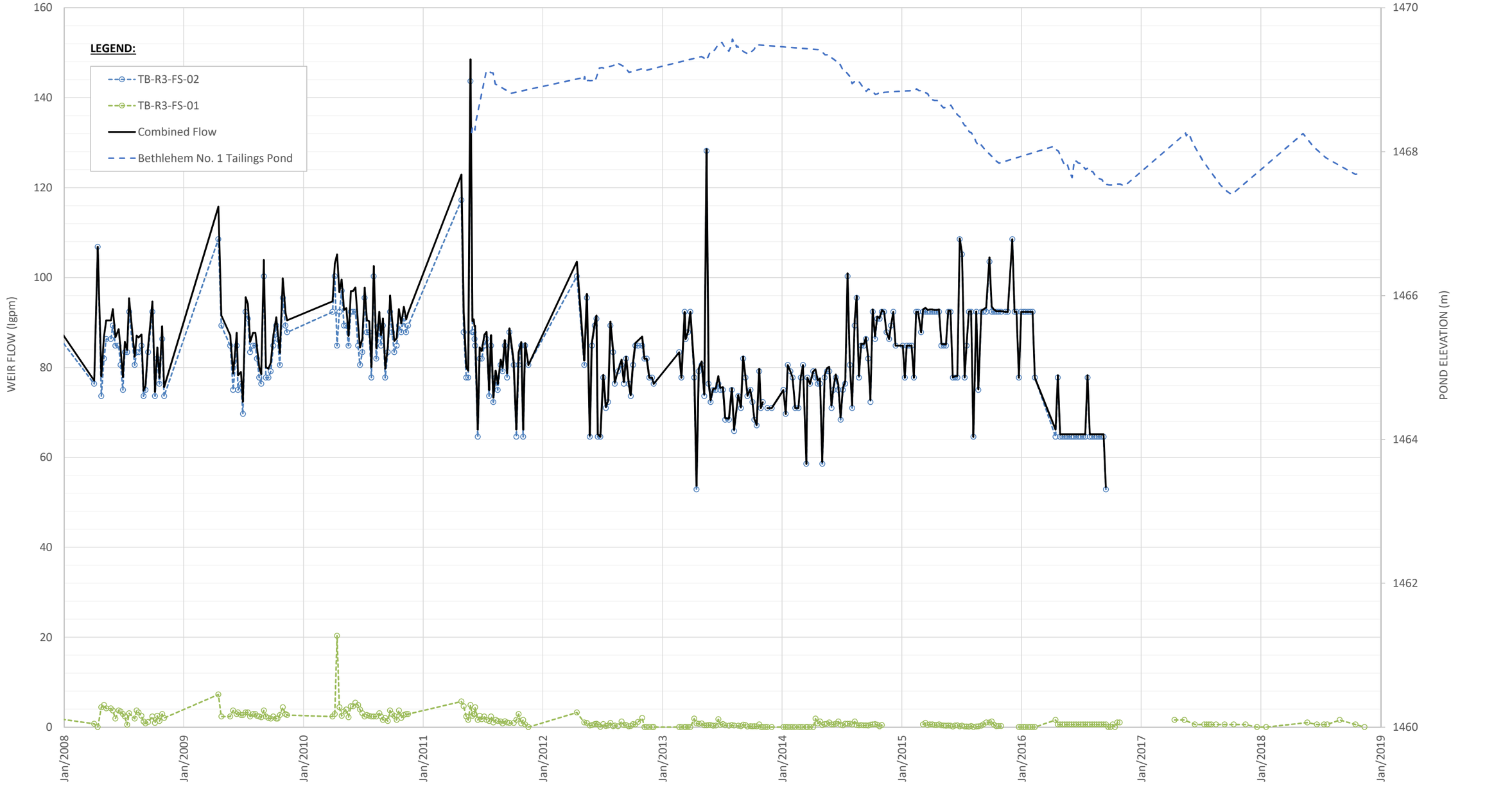
PROJECT
TROJAN DAM TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
INCLINOMETER CUMULATIVE DISPLACEMENT PROFILE
IB16-2

PROJECT No. M02341B43

FIG. No. IV-5

Date & Time: 2019-03-25 16:52
Figure File: Z:\MVCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Inclinometer Data\Inclinometer processing\Bethlehem Complex\[190325 Inclinometer plots (Beth and Troj).xlsx]Fig. IV-5 (IB16-2) (2)



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: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

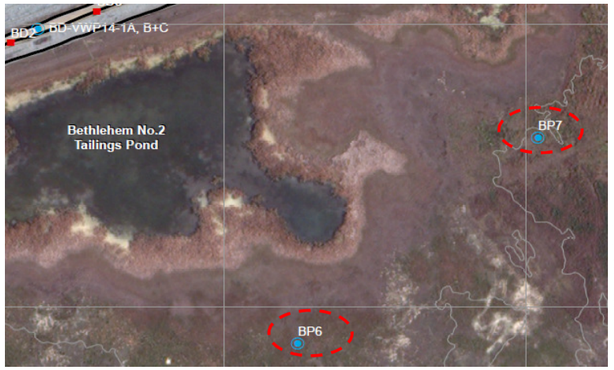
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

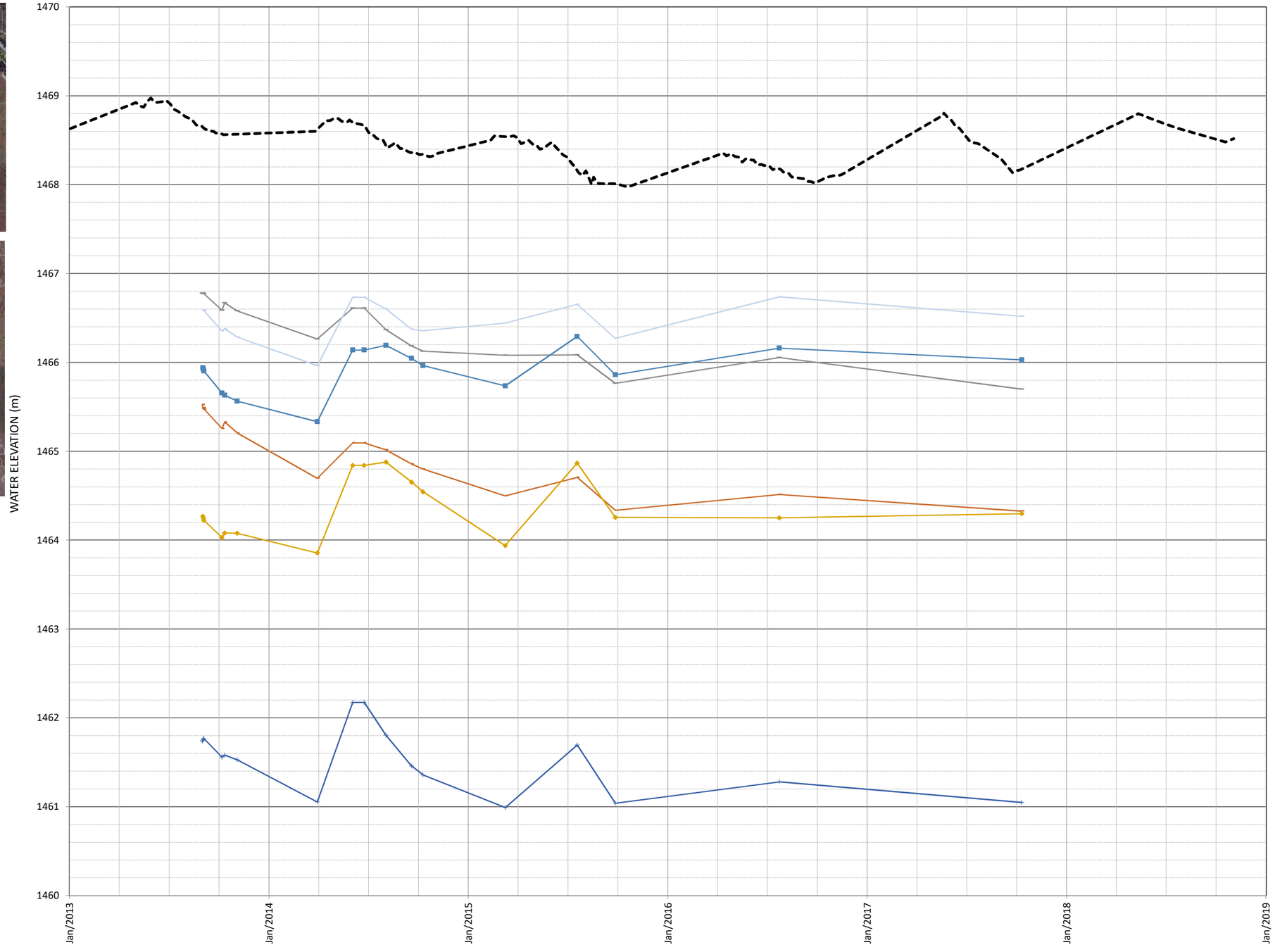
TITLE: DAM NO. 1
WEIR FLOWS

PROJECT No. M02341B43

FIG No. IV-6

December 5, 2018
Z:\M\VCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Seepage Data\Bethlehem\[181205 Beth Weir.xlsx]Fig V-6





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	2018 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 2018.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

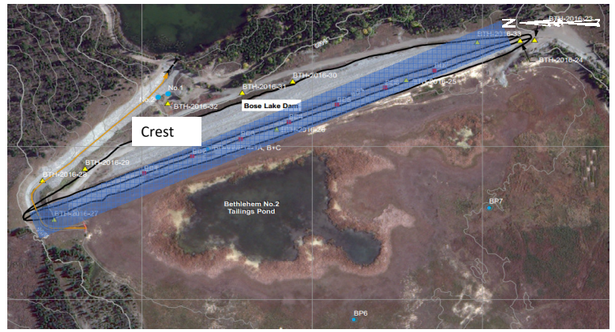
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA
2013-2018

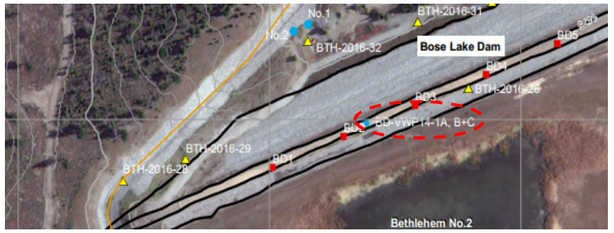
IMPOUNDMENT

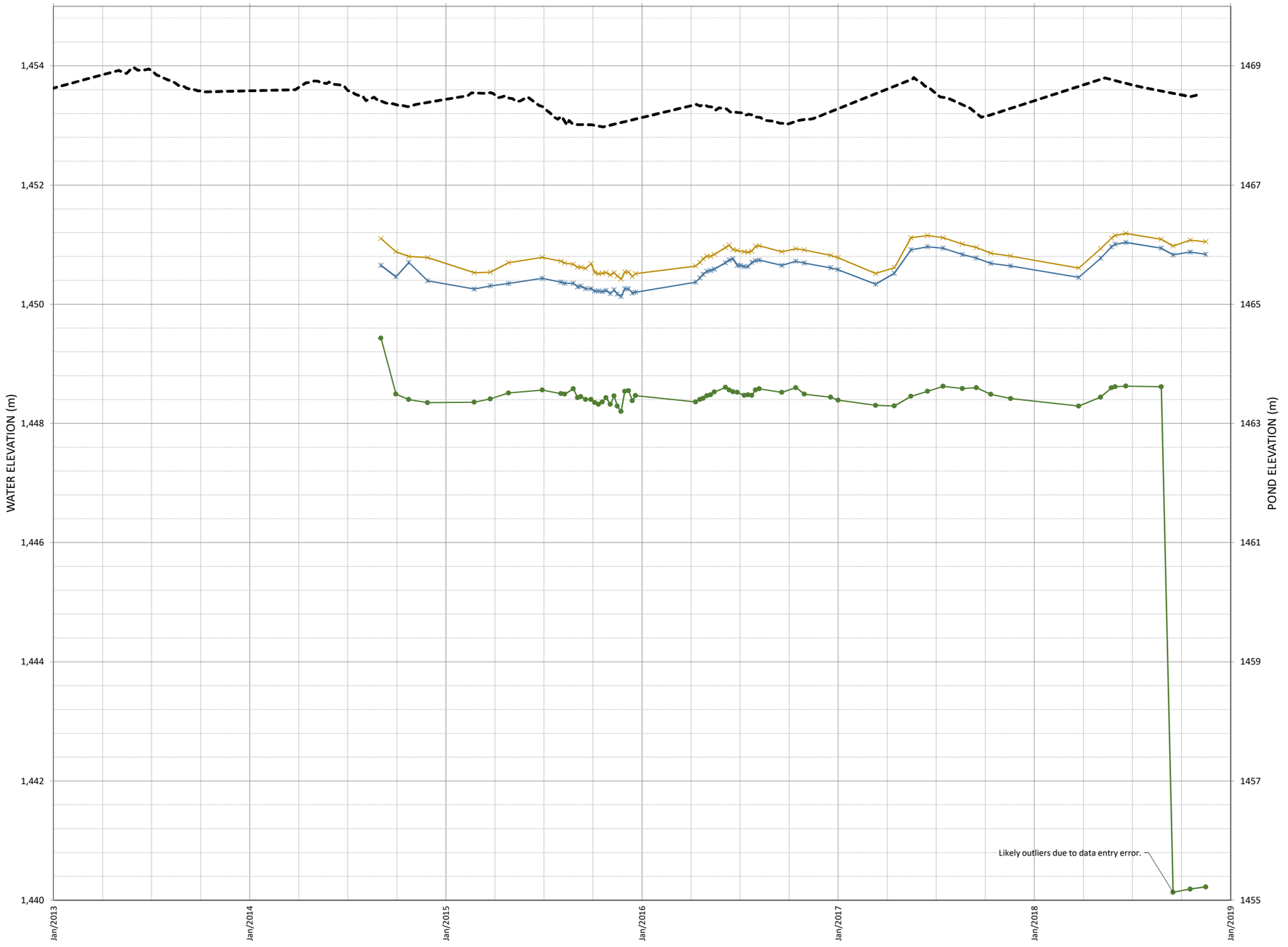
PROJECT No. M02341B43

FIG No. IV-7

March 22, 2019
Z:\MVCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Piezometer Data\Piezo Data\Bethlehem\190321 Bethlehem Piezo.xlsx]Piezo Data Entry BLD







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	2018 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: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

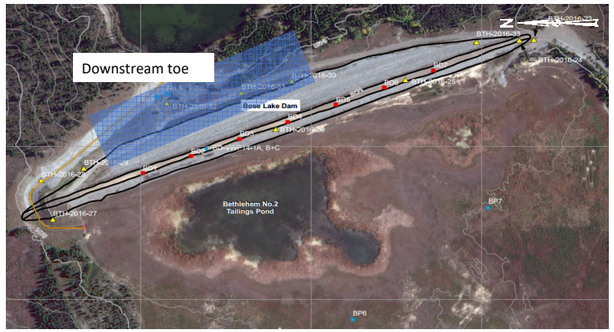
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA
2013-2018

CREST

PROJECT No. M02341B43

FIG No. IV-8

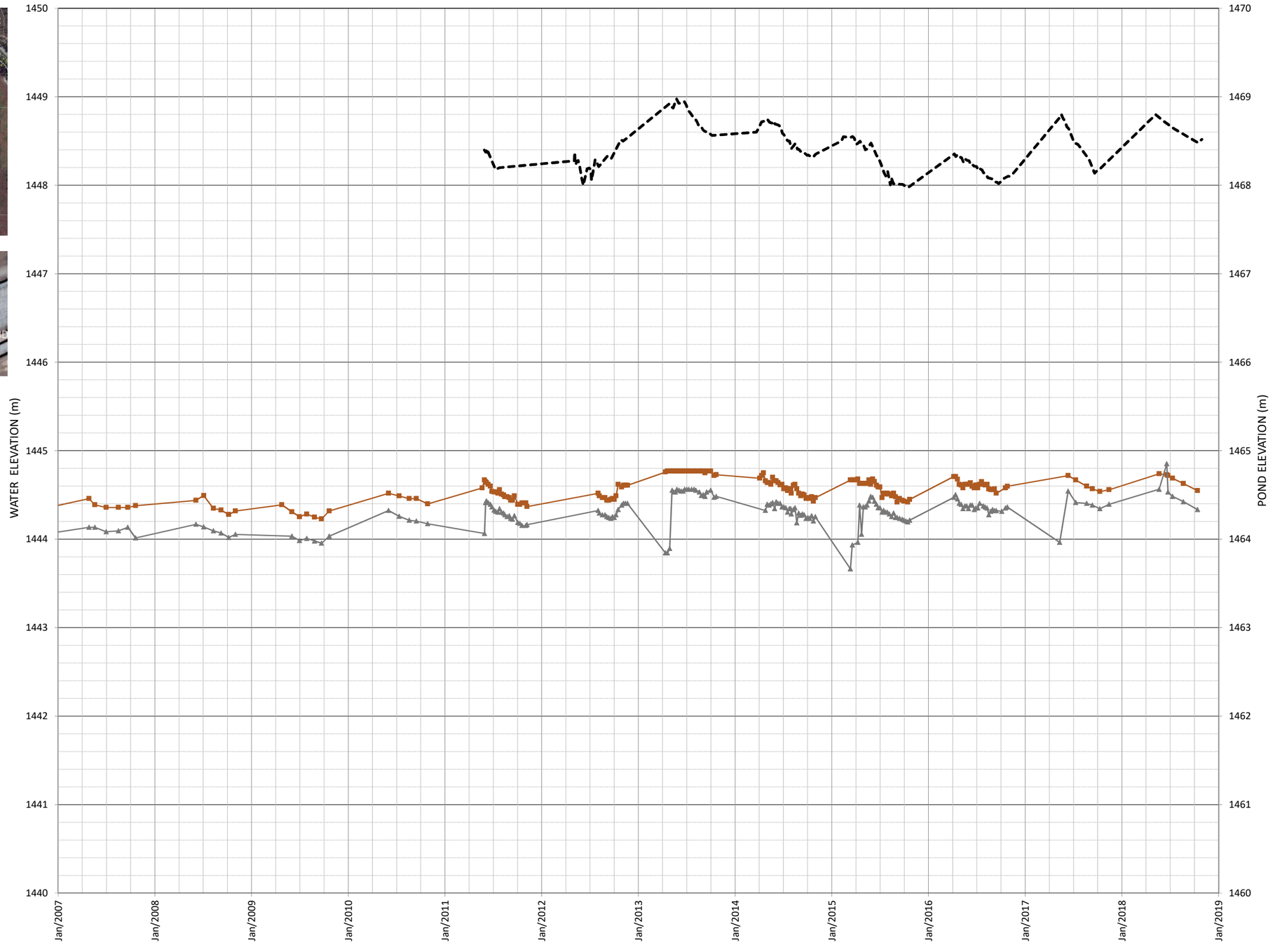
March 22, 2019
Z:\MVCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Piezometer Data\Piezo Data\Bethlehem\[190321 Bethlehem Piezo.xlsx]Piezo Data Entry BLD



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	2018 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: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2018 DAM SAFETY INSPECTION

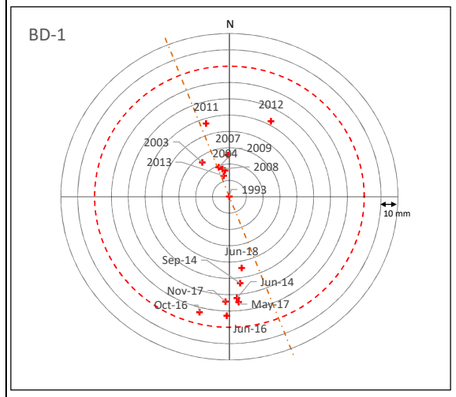
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA 2007-2018

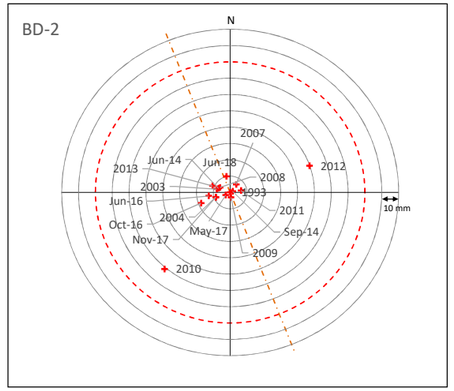
DOWNSTREAM TOE

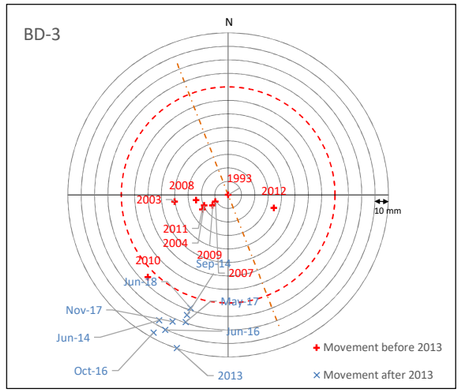
PROJECT No. M02341B43

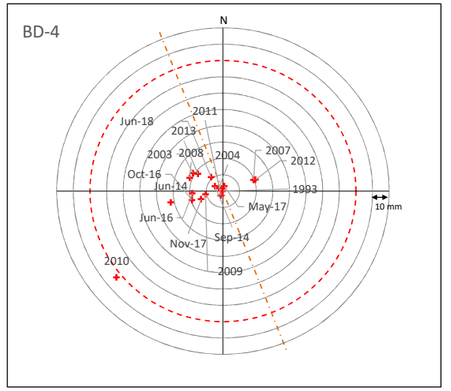
FIG No. IV-9

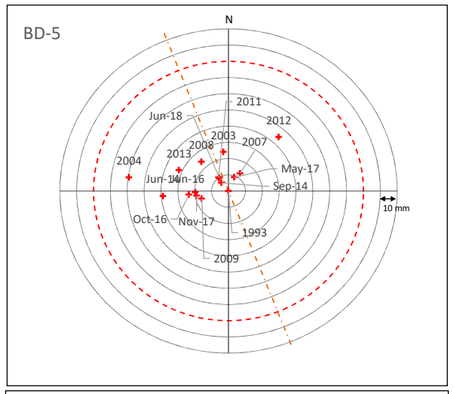
March 22, 2019
Z:\MVCP\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Piezometer Data\Piezo Data\Bethlehem\[190321 Bethlehem Piezo.xlsx]Piezo Data Entry BLD

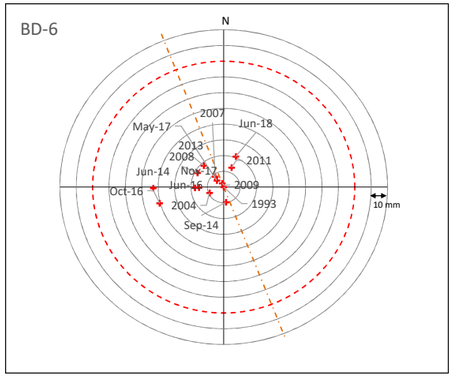


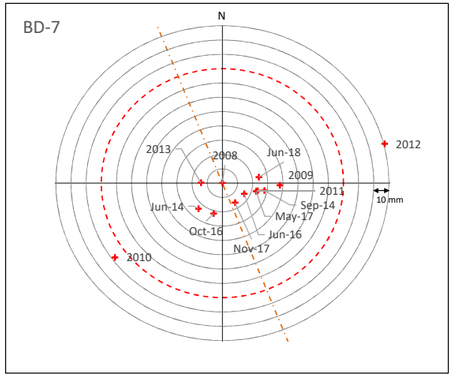






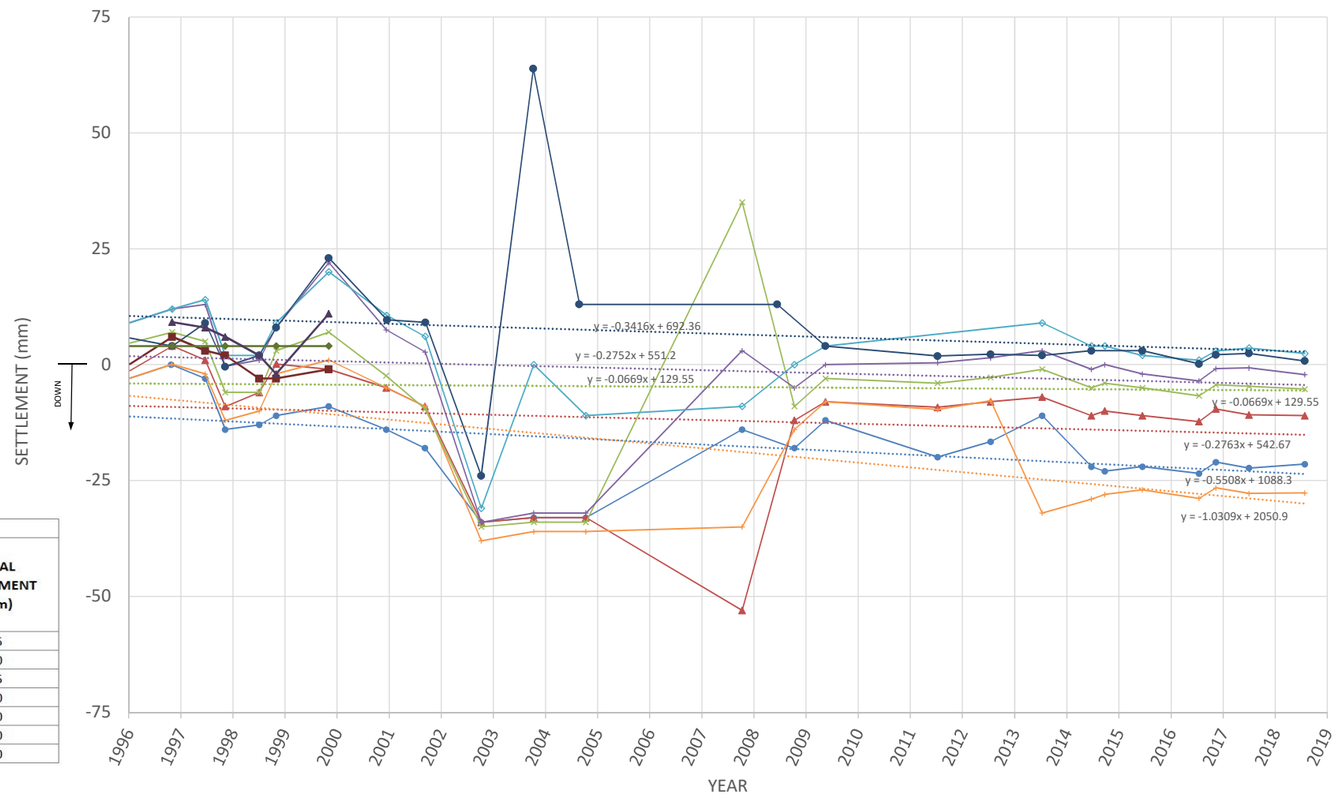






DAM CENTERLINE ORIENTATION

THRESHOLD HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION



MONUMENT ID	2018 THRESHOLDS		
	HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION (mm)	INCREMENTAL SETTLEMENT BETWEEN READINGS (mm)	TOTAL SETTLEMENT (mm)
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. 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.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: BETHLEHEM BOSE LAKE DAM TAILINGS STORAGE FACILITY 2018 DAM SAFETY INSPECTION

TITLE: BOSE LAKE DAM SURVEY MONUMENT READINGS

PROJECT No. M02341B43

FIG No. IV-10

February 13, 2019
Z:\MV\CP\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Monument Data\Bethlehem\181219 BoseLakeDamMonitoring.xlsm]Fig V-10

APPENDIX V

Map of Water Quality Monitoring Points

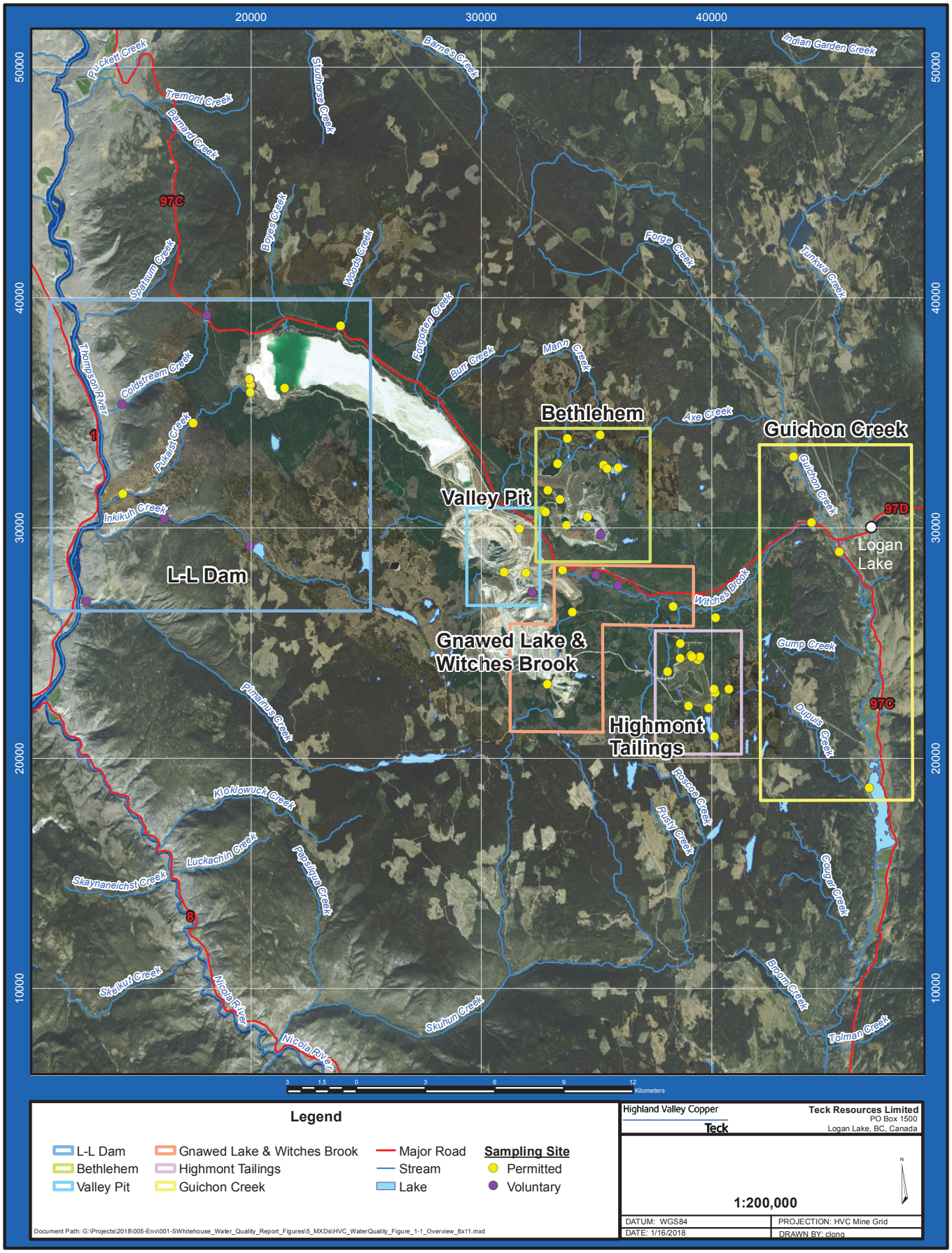


Figure E-1 Water Quality Monitoring Sites, Highland Valley Copper, 2018

Figure 3.2-17 Water Quality Monitoring Sites in the Bethlehem Area, Highland Valley Copper, 2018

Figure 3.2-26 Water Quality Monitoring Sites in the Witches Brook and Gnawed Lake Area, Highland Valley Copper, 2018