Klohn Crippen Berger

Teck Highland Valley Copper Partnership

2017 Dam Safety Inspection Report

Bethlehem No. 1 Tailings Storage Facility

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March 2018

March 29, 2017

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

Mr. Chris Anderson
Superintendent, Tailings and Water Management

Dear Mr. Anderson:

2017 Dam Safety Inspection Report
Bethlehem No.1 Tailings Storage Facility

We are pleased to submit the 2017 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/DB:cd

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Teck Highland Valley Copper Partnership

2017 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 2017 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., as a representative of KCB on October 24, 2017. Mr. Chris Anderson, P. Eng., THVCP Tailings and Water Engineering Superintendent, 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 2017. The most recent 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; therefore, the next DSR is scheduled for 2018.

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 trends which show 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 an inflow design flood with a return period greater than required by the Code.

The Emergency Preparedness and Response Plan (EPRP) was updated in 2017. The Operation, Maintenance and Surveillance (OMS) manual, was also reviewed and issued as draft in March 2018

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

There were no instrumentation threshold exceedences measured in 2017. The measurement frequency and threshold values were reviewed in 2018 and minor updates made based on 2017 data. No threshold has been set for the inclinometer installed in 2016 but is scheduled to be defined in 2018 based on the baseline readings collected since installation.

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 2018). All permit sampling requirements and frequency were met in 2017, except for two instances when a subset of the required water quality parameters was not measured for specific samples. These parameters were tested in subsequent samples.

Visual inspections and instrument measurements were completed by THVCP at the prescribed frequencies during periods of the year when dams are accessible. Event driven inspections were carried out in response to the May 2017 freshet, details of the inspections are described in Section 5.2.

The Bethlehem No. 1 TSF appeared to be in good physical condition and the observed performance during the 2017 site inspections is consistent with the expected design conditions and past performance. THVCP made significant progress in 2017 to close outstanding recommendations from past DSIs, refer to Table 1. Closed recommendations are shown in *italics*. Recommendations to address deficiencies and non-conformances identified during the 2017 DSI are summarized in Table 2.

Table 1 Previous Recommendations for Deficiencies and Non-Conformances – 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-2016-01	*OMS*	*Annual Update*	*As part of the 2017 OMS update, incorporate the following:* *- Explicitly state the minimum reading frequency for each instrument and measuring point* *- Update event-driven inspection criteria (Section 5.2)* *Incorporate 2017 thresholds (Sections 5.4, 5.5 and 5.6)*	*3*	*Q3, 2017 (CLOSED, pending issue of final 2018 OMS)*
BTSF-2016-02	*EPRP*	*Comm Plan*	*Complete assessment of warnings for downstream parties potentially impacted by a failure and update the EPRP as appropriate.*	*3*	*Q4, 2017 (CLOSED, pending issue of final 2018 OMS)*
Dam No. 1					
			No outstanding recommendations from previous DSIs		

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
			Bose Lake Dam		
			No outstanding recommendations from previous DSIs		
			R3 Seepage Pond		
BR3-2016-01	*Freeboard*	*the Code*	*Calculate the minimum freeboard required under the Code based on the method proposed by CDA (2013) to demonstrate compliance of existing freeboard.*	*3*	*Q3, 2017 (CLOSED)*

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 2017 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Reg. or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline
			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
			Dam No. 1		
BTSF-2017-04	Surveillance	Inclinometer Monitoring	Establish a 2018 threshold limit for inclinometer IB16-1.	4	Q4, 2018
			Bose Lake Dam		
			No new recommendations from 2017		
			R3 Seepage Pond		
			No new recommendations from 2017		

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 2017 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 in discharged into the impoundment since 1989. The site has been reclaimed since tailings discharge ceased and THVCP continue ongoing surveillance. 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 and THVCP staff 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) Mining Dam Technical Bulletin (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 inspection was completed by the Engineer of Record (EoR), Mr. Rick Friedel, P.Eng., as a representative of KCB on October 24, 2017. The weather during the DSI was cloudy with sunny periods. Mr. Chris Anderson, P.Eng., THVCP Tailings and Water Superintendent, 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 (MEM) 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 16, 2018, which the EoR (Mr. Rick Friedel, P.Eng. of KCB) participated in via teleconference.

The most recent 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; therefore, the next DSR is scheduled for 2018.

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 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 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 swamp deposits in the foundation (AMEC 2014a).
- 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 2017 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 2017.

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 1.0 m variance based on historic records (0.8 m variance in 2017), refer to Figure IV-1. Since 2014, there has been an overall downward trend in the pond level attributed to a water balance deficit. The trend is not evident in 2017, largely due to increased inflows during freshet; discussed further in Sections 4.2 and 5.3.
- 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.

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 1.0 m based on historic records (0.6 m seasonal variance in 2017); refer to Figure IV-7. Since 2015, there has been a long-term downward trend in the pond level. The trend is not evident in 2017, 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.

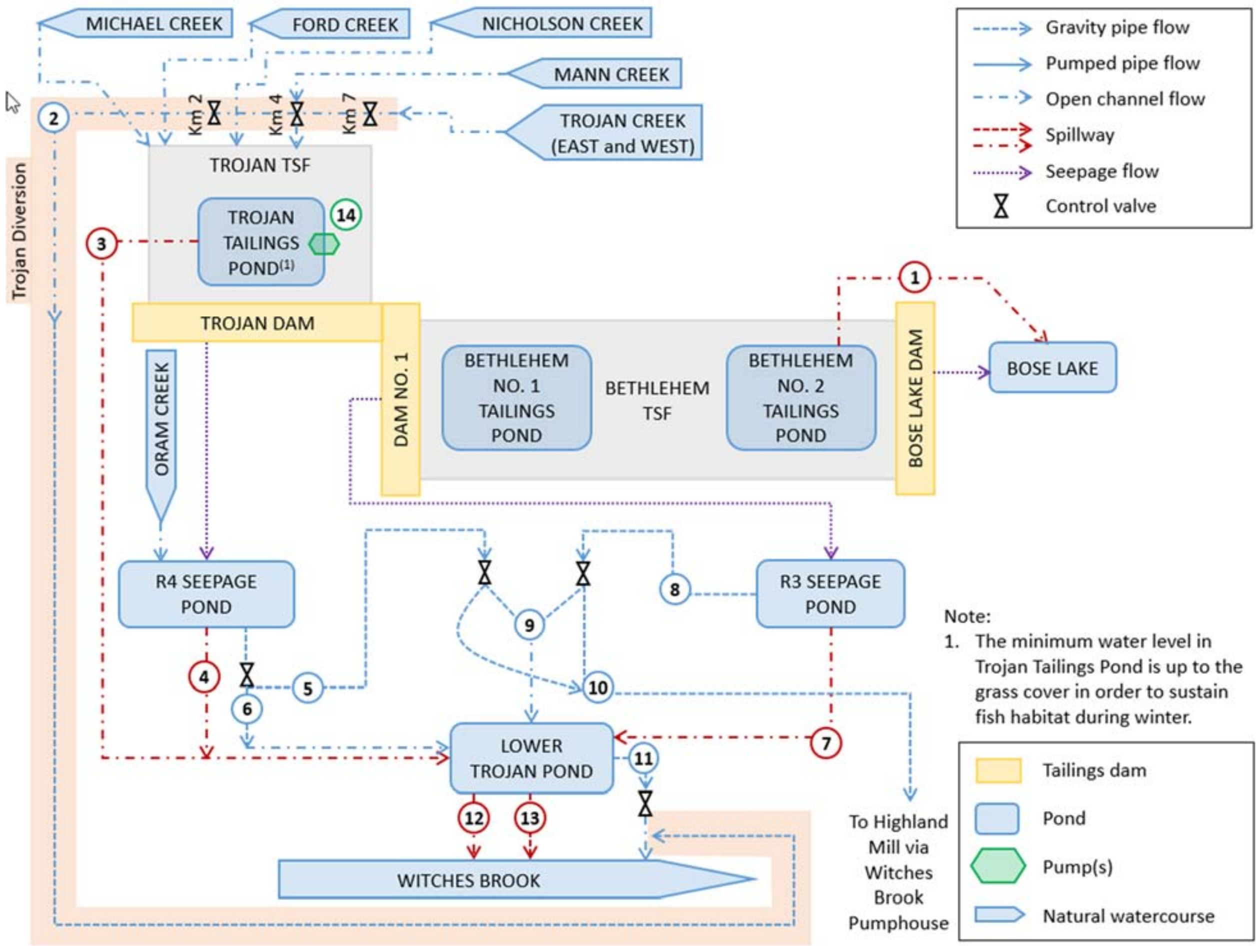
Bethlehem No. 1 TSF Spillway

- 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.

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 1.5 m in 2017. The vertical distance between the pond and dam crest was 1.3 m based on a visual estimate during the 2017 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	957 m 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 Shula Flats Weather station (El. 1208 m) maintained on site. Precipitation data from the station is summarized on Table 4.1and Figure 4.2. Climate normals (1981 to 2010) based on data from the Highland Valley Lornex Station (Environment Canada Station No. 1123469) are shown on Figure 4.2 for comparison. The Lornex climate station was located near the Highland Mill at El. 1268 m, and had the longest running record for the mine site from 1971 until being decommissioned in November 2011. Representative Bethlehem and Trojan Area Lornex data (Golder 2016) is plotted against Shula Flats data adjusted to the Bethlehem Trojan Area in Figure 4.2.

Seasonal snowpack depth is not measured at the L-L Dam or Shula Flats weather stations. 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 2017 snowpack depths based on available records are summarized in Table 4.3.

The following observations were noted for 2017:

- May through August appear noticeably drier than normal. No data was missing during this time.
- February was noticeably wetter than normal which appears to coincide with the peak pond level recorded in 2017 (see Section5.3).
- On an annual basis, precipitation at the Shula Flats weather stations was 20% lower than normal (at Lornex).
- Snowpack depths were not measured for the January 1st or February 1st survey periods. The March 1st, April 1st, and May 1st snowpack depths (in SWE) were 30%, 50%, and 271% greater than average, respectively.

During freshet, a period of rainfall followed by a sudden increase in temperature (Figure 4.3) triggered greater than normal surface runoff on site and in the region starting May 5, 2017. Available records also show the snowpack depth (in SWE) near the Trojan TSF was 3.7 times greater (relative percent difference = +271%) than average for that time of year. The combination of available snowpack and rapid melt-inducing changes led to a more severe freshet in 2017 than normal. Observations and actions in response are discussed in the relevant sections of this report.

Table 4.2 Monthly Precipitation in 2017

Month	Precipitation (mm)	
	Shula Flats – Adjusted to Bethlehem and Trojan Area(1)	Bethlehem Trojan Area Lornex Normals(2)
January	20.7	30.5
February	57.1	23.3
March	26.3	18.5
April	43.9	23.6
May	26.7	45.8
June	3.6	53.2
July	1.4	48.3
August	5.2	35.2
September	12.8	34.6
October	55.1	33.3
November	57.0	44.8
December	41.4	45.3
Annual Total	351.1	436.4

Notes:
1. The Bethlehem and Trojan Area adjustment factor of 1.1 is applied to the Shula Flats weather station in order to be more representative of the Bethlehem TSF (Golder 2016).
2. Adjusted Lornex Weather Station data presented in Table 4.1 is taken directly from the Climate Characterization Report (Golder 2016).

Figure 4.2 Monthly Precipitation in 2017 and Climate Normals

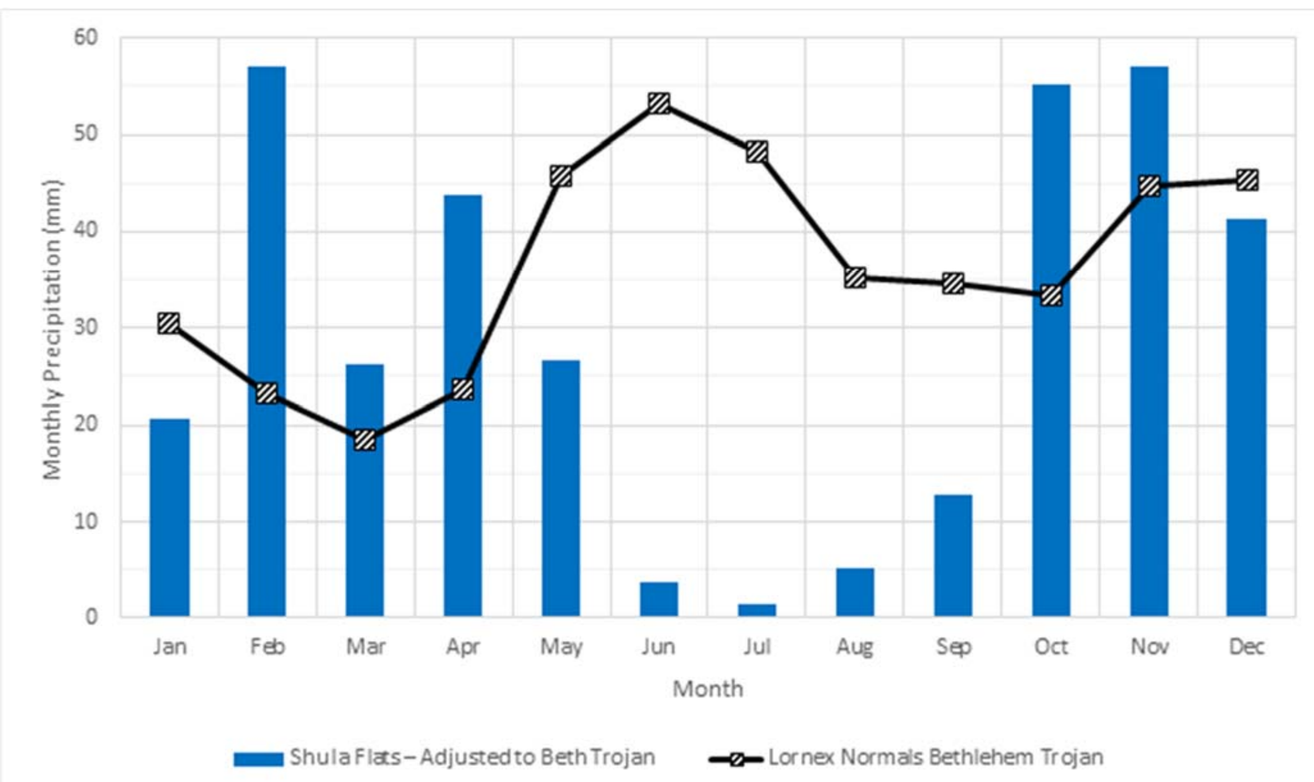
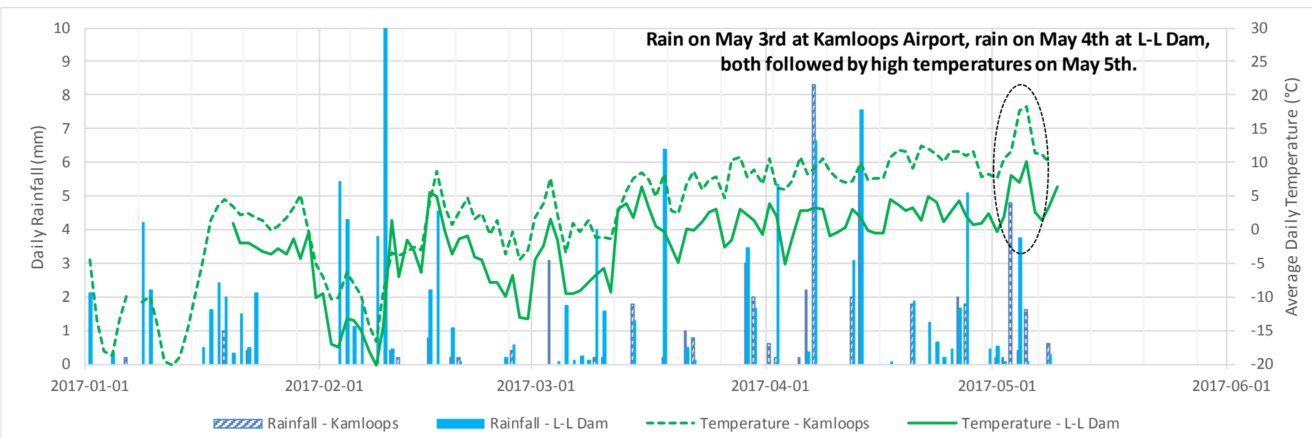


Table 4.3 Historical Average and 2017 Snowpack Depths

Survey Period	Years of Record(1)	Historic Average Snowpack Depth(2) (mm SWE(3))	2017 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	51	89.5	116(4)	+30%
April 1st	51	96.3	144(4)	+50%
May 1st	48	27.3	101(4)	+271%

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 4, 2017. The April 1st survey was conducted on April 3, 2017. The May 1st survey was conducted on May 3, 2017.

Figure 4.3 Daily Rainfall and Average Temperature at Kamloops Airport and L-L Dam Climate Stations Leading up to Freshet



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 77,857 m²;
- Assumed surface area 2,786,830 m³;
- Modelled annual precipitation 365 mm; and
- Runoff coefficient 0.45.

Table 4.4 Annual Water Balance for Bethlehem TSF

Item	Volume in 2017[1] (m^3)
Inflows	
Direct precipitation	28,400
Runoff	457,700
Total inflow:	486,100
Outflows	
Seepage	517,400
Evaporation[2]	42,000
Total outflow:	559,400
Balance	
Balance (inflow minus outflow)	-73,300

Notes:
1. Values received from THVCP have been rounded to the closest 100 m^3.
2. Precipitation from the Shula Flats weather station adjusted to the Bethlehem area was used in the water balance.
3. Evaporation was assumed to be 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.
- The 24-hour probable maximum precipitation (PMP) depth is different between two recent assessments. The reason is unknown, but the discrepancy is not great enough to impact compliance.

Table 4.5 Inflow Design Flood for Bethlehem No. 1 TSF and Seepage Pond

<table>
<tr><th rowspan="2">Dam</th><th rowspan="2">Outfall Type</th><th rowspan="2">Consequence Classification</th><th rowspan="2">Inflow Design Flood</th><th colspan="2">Spillway Design Flood (Precipitation Depth, Design Flow)</th><th rowspan="2">Spillway Design Reference</th></tr>
<tr><th>Design Event</th><th>Peak Flood Level</th></tr>
<tr><td>Dam No. 1</td><td rowspan="2">Open channel spillway (near Bose Lake Dam left abutment)</td><td>Very High</td><td>2/3 between 1000-year and PMF[1]</td><td rowspan="2">24-hour PMF[3] (182.2 mm[4], 13.7 m^3/s)</td><td rowspan="2">1471.5 m</td><td rowspan="2">(AMEC 2014b)</td></tr>
<tr><td>Bose Lake Dam</td><td>High</td><td>1/3 between 1000-year and PMF[1]</td></tr>
<tr><td>R3 Seepage Pond Dam</td><td>Open channel</td><td>Low</td><td>100-year[2]</td><td>100-year 24-hour[5] (54.3 mm, 0.16 m^3/s</td><td>1371.2 m</td><td>(AMEC 2013a)</td></tr>
</table>

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. Based on rainfall data from the Environment Canada Highland Valley Lornex climate station (Station No. 1123469). The reason for the difference between the two 24-hour PMP depths is unknown.
5. 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

Where available, the minimum freeboard[1] measured during 2017, is based on either the DSI site visit and/or monitoring records, the results are listed in Table 4.6.

The Code specifies that an evaluation of available freeboard 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 Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014). Minimum required freeboard, as per the Code, for each dam and the freeboard during the IDF based on flood routing are listed in Table 4.6. The freeboard for R3 Seepage Pond was reviewed and updated in 2018 (KCB 2018); minimum freeboard required under the Code is met for the IDF.

Both Dam No. 1 and Bose Lake Dam meet the minimum freeboard requirement, 0.3 m based on (AMEC 2014a), during the IDF. In addition, the following are of note:

- The calculated freeboard during the spillway design flood for both dams are greater than freeboard value typically required for this type of structure:
    - Bose Lake – 3.5 m based on AMEC (2014b) and a dam crest of El. 1475 m; and
    - Dam No. 1 – 5.5 m based on AMEC (2014b) and a dam crest of El. 1477 m.
- The spillway design flood assumes that the impoundment is filled to the invert of the spillway prior to the onset of the storm. This assumption is conservative given the available storage in the impoundment below the invert under normal operations.

Table 4.6 Minimum Required Freeboard

Dam	Required Freeboard During Inflow Design Flood (1)	Minimum Freeboard During Inflow Design Flood	2017 Freeboard	2017 Freeboard Surveyed/Visually Estimated
Dam No. 1	0.5 (5)	5.5 m (3)	7.7 m	Annual minimum from surveys, refer to App IV
Bose Lake Dam	0.5 (5)	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)	1.3 m	At time of DSI site inspection

Notes:
1. As per the Code.
2. Minimum required freeboard to accommodate wave run-up as per CDA (2013) is 0.2 m for R4, and 0.4 m for the Lower Trojan Dam; however, minimum freeboard specified as 0.5 m to be consistent with other similar structures around the site.
3. As per AMEC (2014b).
4. Based on peak flood level estimated by KCB using peak flow from AMEC (2014b).
5. AMEC (2014a) defines minimum required freeboard to accommodate wave run-up as per CDA (2013) as 0.3 m; however, minimum freeboard specified as 0.5 m to be consistent with minimum freeboard value defined around the site.

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

5 REVIEW OF MONITORING RECORDS AND DOCUMENTS

5.1 Monitoring Plan

The Operation, Maintenance and Surveillance (OMS) manual, was reviewed and issued as draft in March 2018 (THVCP 2018). The 2018 update supersedes the versions submitted to MEM in December 2016 and included the recommended and suggested items from the 2016 DSI (KCB 2017b):

- Updated monitoring frequency based on 2016 recommendations or as mutually agreed between THVCP and KCB;
- Updated the failure mode assessment based on AMEC (2015) failure modes and effects analysis (FMEA);
- Updated the event-driven inspection criteria (Section 5.2);
- Updated threshold levels (Sections 5.4, 5.5 and 5.6);
- Included a list of named individuals for each of the main roles of responsibility as an appendix to the OMS instead of in the main body of the text, to make it easier to update on a yearly basis;
- Included a plan(s) showing the location of all the facilities associated with the TSF (seepage ponds, slimes ponds, inflows, outflows etc.); and
- Reviewed the structure of the report and transferred data which is updated on an annual basis to an appendix which can easily be updated, rather than the body of the report (e.g., tailings production schedule, threshold levels, groundwater chemistry).

The 2018 OMS manual meets the intent of the Mining Association of Canada (MAC 2011) and CDA (2014) guidelines, is current and provides adequate coverage for existing conditions.

5.2 Inspections

The 2017 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 MEM.
- Routine – monthly inspections of Dam No. 1, Bose Lake Dam, and quarterly inspections of R3 Seepage Pond were completed by THVCP staff. Summaries of dam inspection observations have been reviewed as part of this DSI. Inspections by THVCP staff have been completed at the prescribed frequencies as described in the 2016 OMS manual which was in effect during the 2017 calendar year:
    - The frequency of routine inspections has been changed to monthly for 2017, this is reflected in the 2018 OMS. 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 OMS manual update.

- Event-driven – should be completed by THVCP staff in response to the following threshold exceedances (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.
  - Rainfall event greater than the 10-year, 24-hour duration storm.

During 2017, the following event-driven inspections were triggered:

- **May 2017:**
  - On May 4 and 5, severe freshet conditions (water levels approaching discharge / Level 1 thresholds, localized flooding) triggered increased site-wide monitoring efforts.
  - On May 6, Mr. Rick Friedel (EoR) of KCB accompanied THVCP to inspect the Bethlehem TSF, amongst other structures, via helicopter fly-over. No immediate dam safety concerns were noted for Dam No. 1, Bose Lake Dam, or R3 Seepage Pond Dam during this fly-over.
  - THVCP increased visual inspection frequency to daily during the freshet period.

5.3 Reservoir Level

The Pond No. 1 and Pond No. 2 levels are typically measured on a weekly basis, which is more frequent than prescribed in the 2018 OMS update (monthly). 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-02 collecting outflows from Seepage Pond 1, and at TB-R3-FS-01 collecting minor seepage flows that is not captured by Seepage Pond 1.

Since 2014, the levels at Pond No. 1 and Pond No. 2 have been 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. In 2017, the build up to the May freshet event was more pronounced than previous years. Since the May 2017 peak, the pond levels have steadily decreased.

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 November (when accessible) on a monthly basis with the exception of the BP-series standpipe piezometers located in the interior of the TSF, which were read once 2017. The 2016 OMS manual stipulated a minimum reading frequency of weekly. The frequency was revised for the 2018 OMS update based on recommendations from the 2016 DSI: quarterly for piezometers within the impoundment (BP-series), monthly for all other piezometers.

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

- Piezometers in the impounded tailings remained static, consistent with previous years.
- Instruments screened within the upstream dam fill located parallel to the crest were dry, consistent with previous years.
- The piezometric levels measured at VWP16-1A (screened in Glacial Till, located on downstream slope) VWP16-1B (screened in Glacial Till, located on downstream slope) have equalized since installation in April 2016.
- Instruments in the foundation, downstream of the dam, show steady seasonal fluctuations and a downward gradient within the Glacial Till. The horizontal gradient measured within the till beneath the impoundment and dam range from 0.05 to 0.1.

Bose Lake Dam

- Piezometers in the impounded tailings remained consistent with previous years and indicate a downward gradient through the tailings and into the Glacial Till foundation.
- A nested set of instruments installed in the dam fill and foundation show an upward gradient from the bedrock into the Glacial Till which extends into the dam fill.
- Measurements from piezometers downstream of the dam also remained steady with previous years. The horizontal gradient within the Glacial Till is approximately 0.05 towards Bose Lake.

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. The thresholds were reviewed for 2018 and one modification was proposed: VWP16-1B threshold was revised to be 1 m above the inferred stabilized pore pressure at the end of 2017, refer to Table 5.1.

Based on the review of the available instrumentation data, the current suite of instruments is considered sufficient for the Bethlehem No. 1 TSF. No follow up actions regarding any of the instrumentation is required.

Table 5.1 2017 Piezometric Levels and 2018 Thresholds

Instrument ID	Foundation Unit	2017 Piezometric Levels (m)		Level 1 Threshold (m)
		Maximum	Minimum	
Dam No. 1				
STANDPIPE No. 1B	Dam Fill	Dry		1440.4
STANDPIPE No. 1A	Dam Fill	Plugged		1457.9
STANDPIPE No. 3	Dam Fill	Dry		1441.6
STANDPIPE No. 4	Dam Fill			1453.6
STANDPIPE No. 7	Dam Fill			1440.5
P95-1	Downstream Foundation	1378.0	1376.1	1379.0
P95-6	Downstream Foundation	1373.0	1371.3	1373.6
13-SRK-09/P13-5	Tailings	1410.1	1409.9	1410.6
13-SRK-12B/P13-6	Glacial Till	1377.3	1377.2	1377.9
VWPB16 - 1A	Glacial Till	1351.3	1351.1	1351.7
VWPB16 - 1B	Glacial Till	1360.4	1358.3	*1359.3*
BP3A	Glacial Till	1452.6		1454.8
BP3B	Tailings	1453.9		1455.9
BP3C	Tailings	1461.9		1466.6
BP4A	Glacial Till	1464.7		1466.7
BP4B	Tailings	1450.7		1454.6
BP5A	Glacial Till	1460.6		1461.6
BP5B	Tailings	1463.6		1465.3
BP9A	Tailings	1402.5		1403.4
BP9B	Tailings	1424.2		1424.9
BP9C	Tailings	1448.5		1449.4
BP10A	Tailings	1462.8		1465.2
BP10B	Tailings	1464.2		1466.8
BP12A	Tailings	1420.6		1420.8
BP12B	Tailings	1441.2		1441.8
BP12C	Tailings	1461.4		1463.9
BP13A	Glacial Till	1440.6		1441.5
BP13B	Tailings	1445.4		1446.0
BP14A	Glacial Till	1423.9		1424.4
BP-14B	Tailings	1424.9		1425.0
BP14C	Tailings	1446.9		1447.9
BP15A	Glacial Till	Not Read		1447.7
BP15B	Tailings	Not Read		1451.0
BP15C	Tailings	Not Read		1458.6

Instrument ID	Foundation Unit	2017 Piezometric Levels (m)		Level 1 Threshold (m)
		Maximum	Minimum	
Bose Lake Dam				
No.1	Overburden / Bedrock Contact	1444.7	1444.6	1445.3
No.2	Overburden / Bedrock Contact	1444.54	1444.0	1445.2
BD-VWP14-1A	Bedrock	1451.2	1450.5	1451.6
BD-VWP14-1B	Overburden	1451.0	1450.3	1451.3
BD-VWP14-1C	Dam Fill	1448.6	1448.3	1449.9
BP6A	Glacial Till	1461.1		1462.8
BP6B	Tailings	1464.3		1466.0
BP6C	Tailings	1465.7		1467.3
BP7A	Glacial Till	1464.3		1469.1
BP7B	Tailings	1466.0		1469.1
BP7C	Tailings	1466.5		1468.3

Notes:
1. *Italics* indicates revised threshold for 2018.

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 twice in 2017: May/June and November. This exceeds the required frequency prescribed in the 2018 OMS manual (annual). Monument surveys, horizontal displacement and settlement over the past eleven years are plotted on Figure IV-4 and Figure IV-10.

Elevations are not available for the November measurements. Therefore, the settlement (vertical displacement) was only calculated for the May/June measurements. Incremental change was calculated between the June 2016 and the May/June 2017 readings, and the cumulative change was similarly calculated to the May/June 2017 readings; refer to Table 5.2.

THVCP surveys since 2014 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 2017 Survey Monument Incremental 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	18.3, parallel to dam centerline	-5.9	59.0, downstream	-193.6
DM-2	10.6, parallel to dam centerline	-5.1	43.4, downstream	-141.3
DM-3	10.1, downstream	-4.6	24.8, downstream	-87.7

Monument ID	Incremental(1)		Cumulative(2)	
	Vector Horizontal Displacement (mm)	Vertical Displacement (mm)	Vector Horizontal Displacement (mm)	Vertical Displacement (mm)
PIN-2	4.3, downstream	-4.1	40.6, downstream	-77.3
Bethlehem Sinkhole[4]	N/A	N/A	N/A	-137.0
Bose Lake Dam				
BD-1	10.9, upstream	+1.2	64.8, upstream and parallel to dam crest	-22.3
BD-2	10.1, downstream	+1.4	3.2, upstream	-10.8
BD-3	16.2, downstream	+1.0	20.3 upstream[3]	-27.8
BD-4	19.8, downstream	+2.0	3.1, upstream	-4.7
BD-5	24.8, downstream	+2.8	9.1, downstream	-0.7
BD-6	14.2, downstream	+2.6	6.0, upstream	+3.6
BD-7	8.1, downstream	+2.2	23.0, downstream	+2.4

Notes:
1. Displacements are calculated between the May/June 2017 surveys and the June 2016 survey.
2. Earliest historic reading is 2008 for BD-7, all other monuments earliest historic readings are in 1983. Cumulative displacements are calculated as difference from May/June 2017 survey and earliest historical reading.
3. Survey reference point shifted to the 2013 survey point, as there appears to have been a shift between pre and post 2013 surveys which could be the result of damage or survey datum. No observations this was an indicator of dam safety issue.
4. Bethlehem sinkhole horizonal displacement not surveyed. Incremental vertical displacement calculated between December 2017 survey and October 2016 survey. Cumulative vertical displacement calculated from December 2017 survey and October 2014 survey.

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 2018. 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 2018 Survey Monument Displacement Thresholds

Instrument ID	Total Horizontal Vector Displacement from Original Position Threshold (mm)	Incremental Vertical Displacement Between Readings Threshold (mm)	Total Vertical Displacement Threshold (mm)
DAM NO. 1			
MON 1-73	80	20	240
DM-2			170
DM-3			125
PIN-2			125
Bethlehem Sinkhole			*250*

Instrument ID	Total Horizontal Vector Displacement from Original Position Threshold (mm)	Incremental Vertical Displacement Between Readings Threshold (mm)	Total Vertical Displacement Threshold (mm)
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. Values in *italics* indicate a change from 2017 to 2018 threshold values.

Consistent with recent year, the 2017 surveys do not indicate trend of significant movements in the downstream direction, significant crest settlement or threshold exceedances. This is consistent with previous years.

5.6 Inclinometers

No inclinometers were installed in 2017. Required monitoring frequencies for the one inclinometer at Dam No. 1 (IB16-1) are defined in the 2018 OMS update (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 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. A threshold will be established in 2018 for the instrument that triggers if there is a change to the established trend. The measurement period for this instrument is not sufficient to establish a trend.

5.7 Seepage

Seepage is recorded, typically between April and November when accessible, on a monthly basis from TB-R3-FS-01 upstream of R3 Seepage Pond. This is consistent with the monitoring frequency in the 2018 OMS update. In 2017, the measured flows peaked in April/May which coincides with typical freshet periods and the downward trend of seepage over recent years continued; refer to Figure IV-6. TB-R3-FS-02 was decommissioned along with Seepage Pond 1 in 2016.

5.8 Water Quality

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. A copy of the HVC 2017 Annual Water Quality Monitoring Report (ERM 2018) 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 2017, except for two instances when a subset of the required water quality parameters was not measured for specific samples. These parameters were tested in subsequent samples.

The 2017 monitoring results were screened against applicable BC Water Quality Guidelines (WQG). Further discussion on specific WQG exceedances and water quality trends observed during 2017 can be found in the 2017 Annual Water Quality Monitoring Report (ERM 2018).

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.
- **Left Abutment**: Good Physical condition. The precise location of the abutment is not visible due to the blending of dam fill and waste rock from a previously used waste dump. Due to the presence of a ridge of high ground, the pond would be setback from the abutment by approximately 400 m even in the case of an extreme flood.
- **Right Abutment**: Good physical condition. No signs of significant erosion, deterioration, or cracking.
- **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. A 35-mm wide crack was observed on top of rockfill placed in September 2015 to repair one of the erosion features. The progression of the crack is being monitored by THVCP. (Photo II-A-3 through 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. Seepage flows were observed to be clear.

Bose Lake Dam

- **Crest**: Good physical condition. No indications of major lateral movement, depressions, or cracking. Vehicle access along the crest has been blocked off.
- **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.
- **Downstream Slope**: Good physical condition. No signs of adverse displacement or cracking. Minor surficial rilling (not a dam safety concern) was observed on the exposed till slope from the dam crest down to the coarse rockfill (Photo II-B-20). 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-22 and Photo II-B-23)

- **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.
- **Pond**: During inspection, the pond did not appear to change size since the 2016 DSI. The pond remains approximately 40 m upstream of the crest in a localized depression. (Photo II-B-19)
- **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-12)
- **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-13 to Photo II-B-17)
- **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 2 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-9 through Photo II-B-11)

R3 Seepage Pond Dam

- **Crest**: Good physical condition. No indication of adverse lateral movement, depressions or cracking. (Photo II-C-4)
- **Left and Right Abutment**: Good physical condition. No signs of significant erosion, deterioration, or cracking.
- **Downstream Slope**: Good physical condition. No indication of adverse displacement. No signs of erosion, deterioration, or seepage.
- **Pond**: At the time of inspection pond was observed to be approximately 0.8 m below the invert of the spillway. (Photo II-C-1)
- **Spillway**: Good physical condition. No indicators of recent flow through the channel. No visual signs of riprap degradation. Wood debris was observed in the energy dissipater which should be cleared as part of THVCP routine monitoring and maintenance.
- **Low-level Outlet**: The outlet pipe trash rack was clear of debris. Upstream debris fence partially obstructed; this is cleared as part of THVCP routine monitoring and maintenance.
- **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).

Based on the latest dam consequence review hosted by THVCP on January 16, 2018, 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. THVCP are in progress of completing an updated risk assessment of TSFs with KCB involvement. Outcomes of the study will be incorporated into 2018 DSI.

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

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 (2018) completed a stability analyses assuming a continuous layer of Stratified Glacial Till is beneath the dam which conservatively assuming that the thin (~150 mm) silt and clay layers were also continuous and normally consolidated; the FOS criteria was still met for this scenario. Therefore, the likelihood of a slope instability failure developing is considered very low.

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.

Earthquake

Based on the stability analysis (KC 1996 and KCB 2018) using a seismic coefficient corresponding to a higher load than the minimum earthquake design ground motion (EDGM) required under the Code; therefore, the likelihood of a seismic-related failure during the EDGM is considered low.

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 forms a part of the OMS manual. KCB understands the 2018 update is in progress and as such, the following discussion will be in reference to the 2016 EPRP.

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 a representative of the EOR on November 20, 2017.

8 SUMMARY

The Bethlehem No. 1 TSF appears in good physical condition and the observed performance during the 2017 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 2017 DSI are summarized in Table 8.2

Table 8.1 Previous Recommendations for Deficiencies and Non-Conformances – Status Update

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline (Status)
Bethlehem Tailings Storage Facility					
BTSF-2016-01	*OMS*	*Annual Update*	*As part of the 2017 OMS update, incorporate the following:* *- Explicitly state the minimum reading frequency for each instrument and measuring point* *- Update event-driven inspection criteria (Section 5.2)* *Incorporate 2017 thresholds (Sections 5.4, 5.5 and 5.6)*	*3*	*Q3, 2017 (CLOSED, pending issue of final 2018 OMS)*
BTSF-2016-02	*EPRP*	*Comm Plan*	*Complete assessment of warnings for downstream parties potentially impacted by a failure and update the EPRP as appropriate.*	*3*	*Q4, 2017 (CLOSED, pending issue of final 2018 OMS)*
Dam No. 1					
			No outstanding recommendations from previous DSIs		
Bose Lake Dam					
			No outstanding recommendations from previous DSIs		
R3 Seepage Pond					
BR3-2016-01	*Freeboard*	*the Code*	*Calculate the minimum freeboard required under the Code based on the method proposed by CDA (2013) to demonstrate compliance of existing freeboard.*	*3*	*Q3, 2017 (CLOSED)*

Notes:
2. 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 2017 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Reg. or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline
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
Dam No. 1					
BTSF-2017-04	Surveillance	Inclinometer Monitoring	Establish a 2018 threshold limit for inclinometer IB16-1.	4	Q4, 2018
Bose Lake Dam					
			No new recommendations from 2017		
R3 Seepage Pond					
			No new recommendations from 2017		

Notes:

2. 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

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KLOHN CRIPPEN BERGER LTD.

PROFESSIONAL PROVINCE OF R. J. FRIEDEL # 33293 BRITISH COLUMBIA ENGINEER

2018/03/29

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

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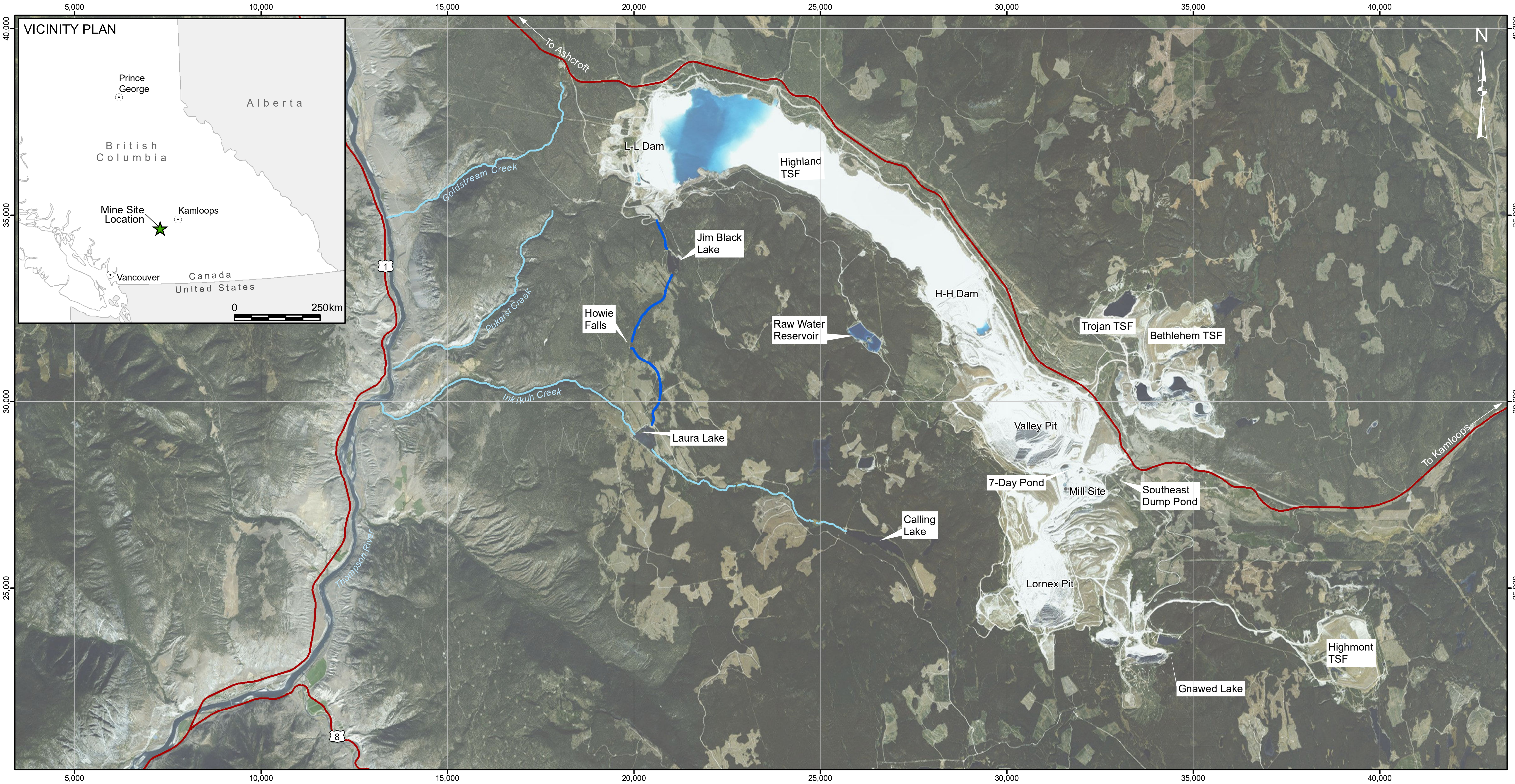
FIGURES



Legend

- Creek / River
- Highway
- Ditch

0 5km

CLIENT TECK HIGHLAND VALLEY COPPER PARTNERSHIP	PROJECT BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION		
Klohn Crippen Berger	TITLE MINE SITE PLAN		
	SCALE 1:100,000	PROJECT No. M02341B26	FIG No. 1

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

Date: 2017-12-01
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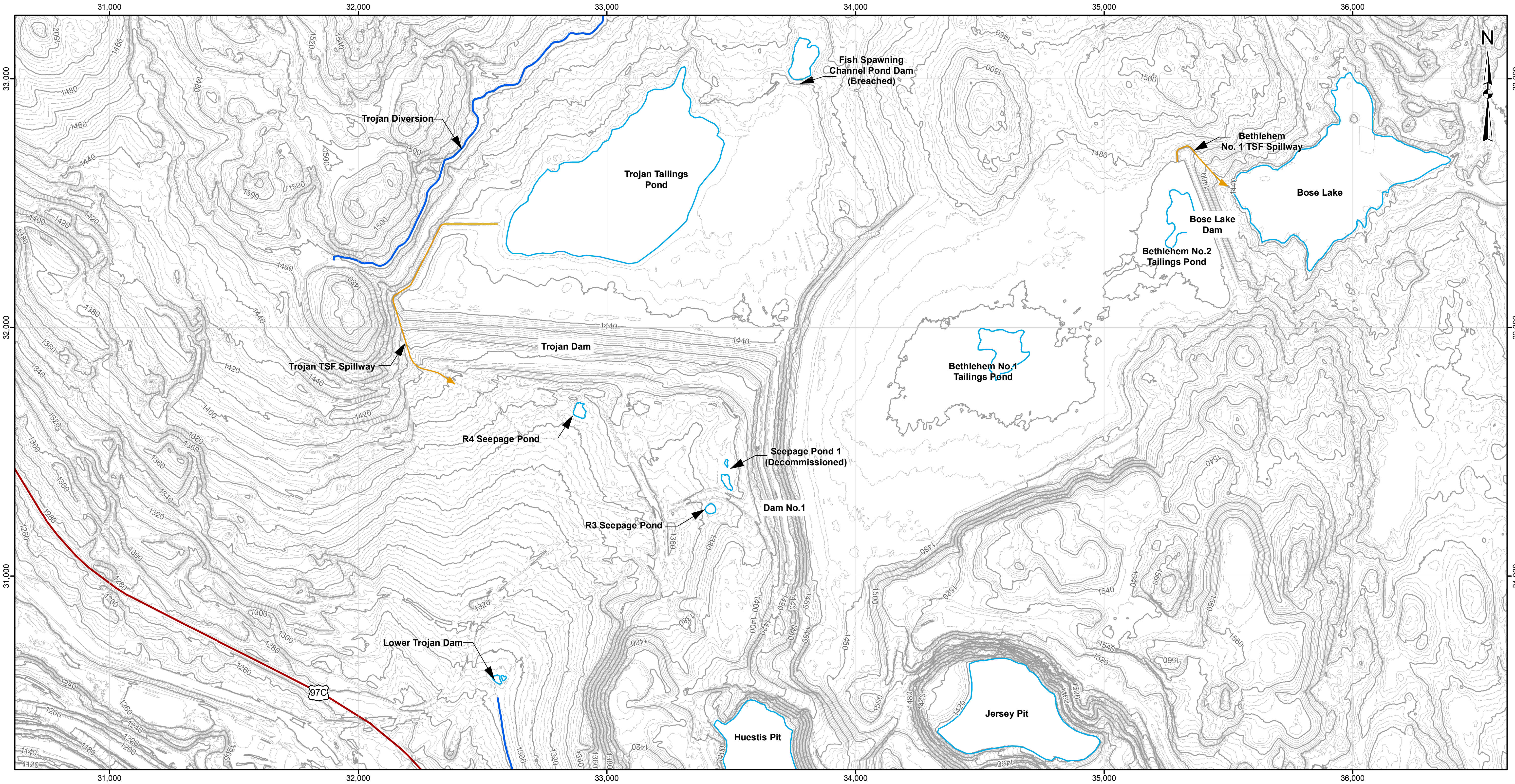


Legend

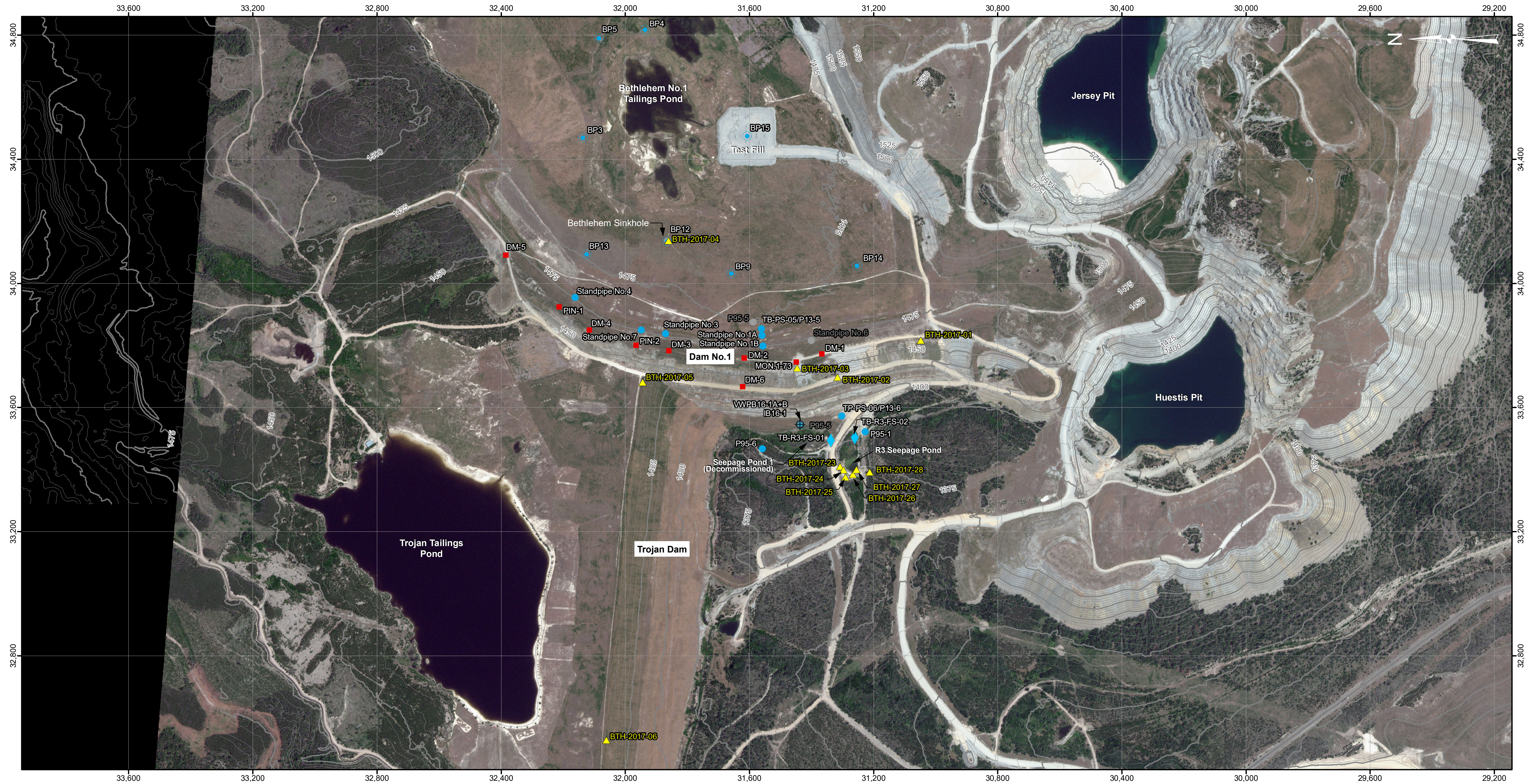
- Spillway
- Ditch
- 97C Highway
- Index Contour (10 m)
- Intermediate Contour (2 m)
- Waterbody

CLIENT	PROJECT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP	BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: BETHLEHEM OVERVIEW

SCALE	PROJECT No.	FIG No.
1:15,000	M02341B26	2

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

Date: 2018-02-20
Document Path: Z:\MI\VCR\M02341B26 - HVC-2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Bethlehem\Bethlehem_Overview.mxd



Legend

Instrument Type (Active)
- Standpipe Piezometer
- Vibrating Wire Piezometer
- Inclinometer
- Weir
- Survey Monument

Instrument Type (Defunct)
- Standpipe Piezometer

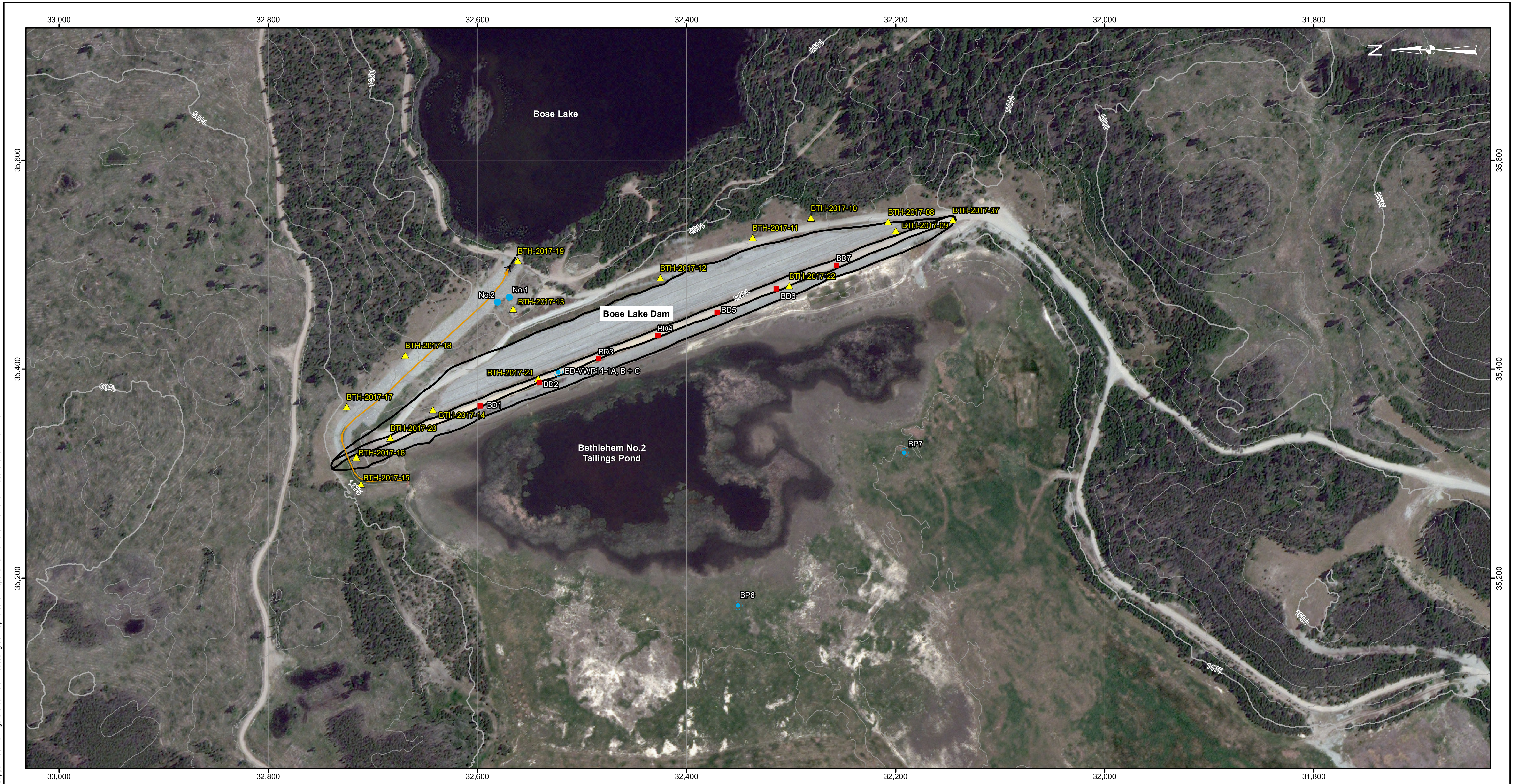
- Waypoint (BTH-2017-xx)
- Index Contour (25 m)
- Intermediate Contour (5 m)

0 250m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained July 1st, 2017
3. Topography from HVC, LiDAR flown on August 23rd, 2014.

Date: 2018-03-05
Document Path: Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Bethlehem\Bethlehem_DamNo1_Plan.mxd

CLIENT TECK HIGHLAND VALLEY COPPER PARTNERSHIP	PROJECT BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE DAM No.1 & SEEPAGE POND 1 PLAN
	SCALE 1:12,000 | PROJECT No. M02341B26 | FIG No. 3



Legend

Instrument Type (Active)

- Standpipe Piezometer
- Vibrating Wire Piezometer
- Survey Monument

- Culvert
- Spillway

- Waypoint (BTH-2017-xx)
- Index Contour (25 m)
- Intermediate Contour (5 m)

0 125m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained July 1st, 2017
3. Topography from HVC, LiDAR flown on August 23rd, 2014.

Date: 2018-02-20
Document Path: Z:\MVCR\M02341B26 - HVC-2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Bethlehem\Bethlehem_BoseLakeDam_Plan.mxd

CLIENT TECK HIGHLAND VALLEY COPPER PARTNERSHIP	PROJECT BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE BOSE LAKE DAM PLAN
	SCALE 1:3,500 / PROJECT No. M02341B26 / FIG No. 4

Legend

Instrument Type (Active)
- Standpipe Piezometer
- Weir

Instrument Type (Defunct)
- Standpipe Piezometer

- Spillway
- Buried Pipeline
- Waypoint (BTH-2017-xx)
- Index Contour (5 m)
- Intermediate Contour (1 m)

0 25m

CLIENT	PROJECT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP	BETHLEHEM No. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: R3 SEEPAGE POND DAM PLAN

SCALE	PROJECT No.	FIG No.
1:750	M02341B26	5

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained July 1st, 2017
3. Topography from HVC, LiDAR flown on August 23rd, 2014.
4. Location of buried pipes are approximate.

Date: 2018-02-20
Document Path: Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Bethlehem\Bethlehem_R3Seepage_Plan.mxd

APPENDIX I

Dam Safety Inspection Checklist

APPENDIX I-A

Dam Safety Inspection Checklist – Dam No. 1

2017 ANNUAL DAM INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Bethlehem Dam No.1	**Inspection Date:**	24-Oct-17 (RF/DB/TT)
Consequence Classification:	Very High		
Weather:	Partial sun and cloud	**Inspector(s):**	Rick Friedel, Delton Breckenridge, Thayaparan Theenathayarl
Freeboard (pond level to dam crest):	8.59m (based on HVC pond survey on 12-Oct-17)		

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

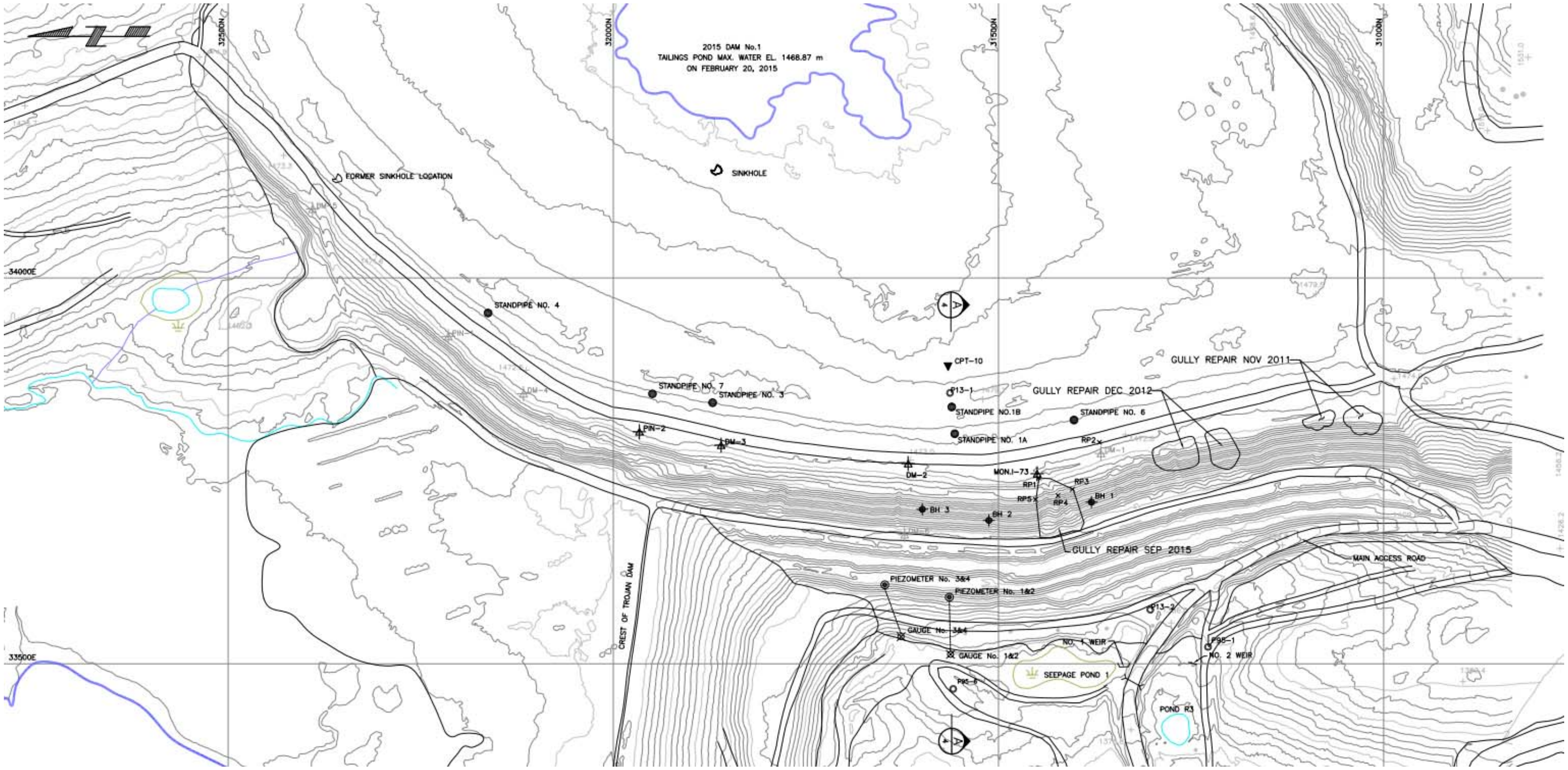
List and describe any deficiencies (all deficiencies require assessment and/or repair):

None.

Comments / Notes:

1) Crack on rockfill bench formed during the September 2015 repair of an erosion gully was observed. Location of crack continues to be marked with stakes, and was observed to be approximately 35mm wide. The crack progression, if any, should be continuously monitored.
2) Sinkhole on tailings beach diameter observed and appears to be unchanged from 2016 inspection. No signs of widening or deepening of sinkhole.
3) Four erosion gullies previously repaired by THVCP using sand and gravel (November 2011 and December 2011) show minor rill erosion and should be monitored.

SITE PLAN


32500N
32000N
31500N
31000N
34000E
33500E
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
PIN-2
DM-3
CPT-10
P13-1
STANDPIPE NO.1B
STANDPIPE NO. 1A
STANDPIPE NO. 6
GULLY REPAIR DEC 2012
GULLY REPAIR NOV 2011
RP2
DM-2
MON.I-73
RP1
RP3
RP5
RP4
BH 1
BH 3
BH 2
GULLY REPAIR SEP 2015
MAIN ACCESS ROAD
CREST OF TROJAN DAM
PIEZOMETER No. 3&4
PIEZOMETER No. 1&2
P13-2
GAUGE No. 3&4
GAUGE No. 1&2
NO. 1 WEIR
P95-1
NO. 2 WEIR
SEEPAGE POND 1
P95-6
POND R3

APPENDIX I-B

Dam Safety Inspection Checklist – Bose Lake Dam

2017 ANNUAL DAM INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Bose Lake Dam	**Inspection Date:**	24-Oct-17 (RF/DB/TT)
Consequence Classification:	Very High		
Weather:	Partial sun and cloud	**Inspector(s):**	Rick Friedel, Delton Breckenridge, Thayaparan Theenathayarl
Freeboard (pond level to spillway invert):	6.98 m (Based on HVC pond survey 12-Oct-17)		

Outlet Condition

Description	Was it flowing?	Flow rate
	☐ Yes ☒ No	N/A

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

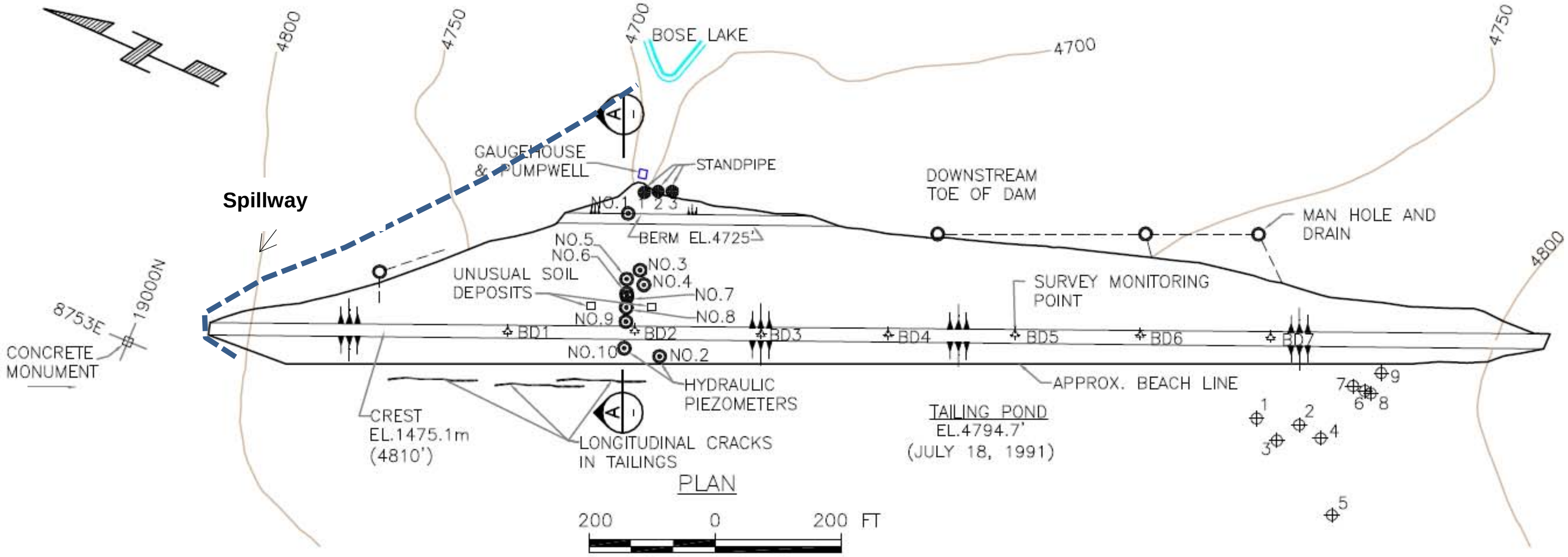
List and describe any deficiencies (all deficiencies require assessment and/or repair):

None.

Comments/ Notes:

1) Sporadic growth of vegetation amongst the upstream portion of riprap lined channel near the concrete sill. Increase in vegetation could cause a decrease in spillway capacity. Growth should be monitored, in the short term the vegetation should not loosen the interlocked riprap.
2) Seepage collection system outlet flowing at approximately 2 L/s.
3) In multiple locations, minor surface erosion observed stretching from the crest down the downstream slope roughly 1m.
4) Crest still closed off to traffic.
5) Potential animal burrowing (minor) near left and right abutments observed.

SITE PLAN



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

APPENDIX I-C

Dam Safety Inspection Checklist – R3 Seepage Pond Dam

2017 ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	R3 Seepage Reclaim Pond Dam	**Inspection Date:**	24-Oct-17 (RF/DB/TT)
Weather:	Partial sun and cloud	**Inspector(s):**	Rick Friedel, Delton Breckenridge, Thayaparan Theenathayarl
Freeboard (pond level to dam crest):	Approximately 1.3m		

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

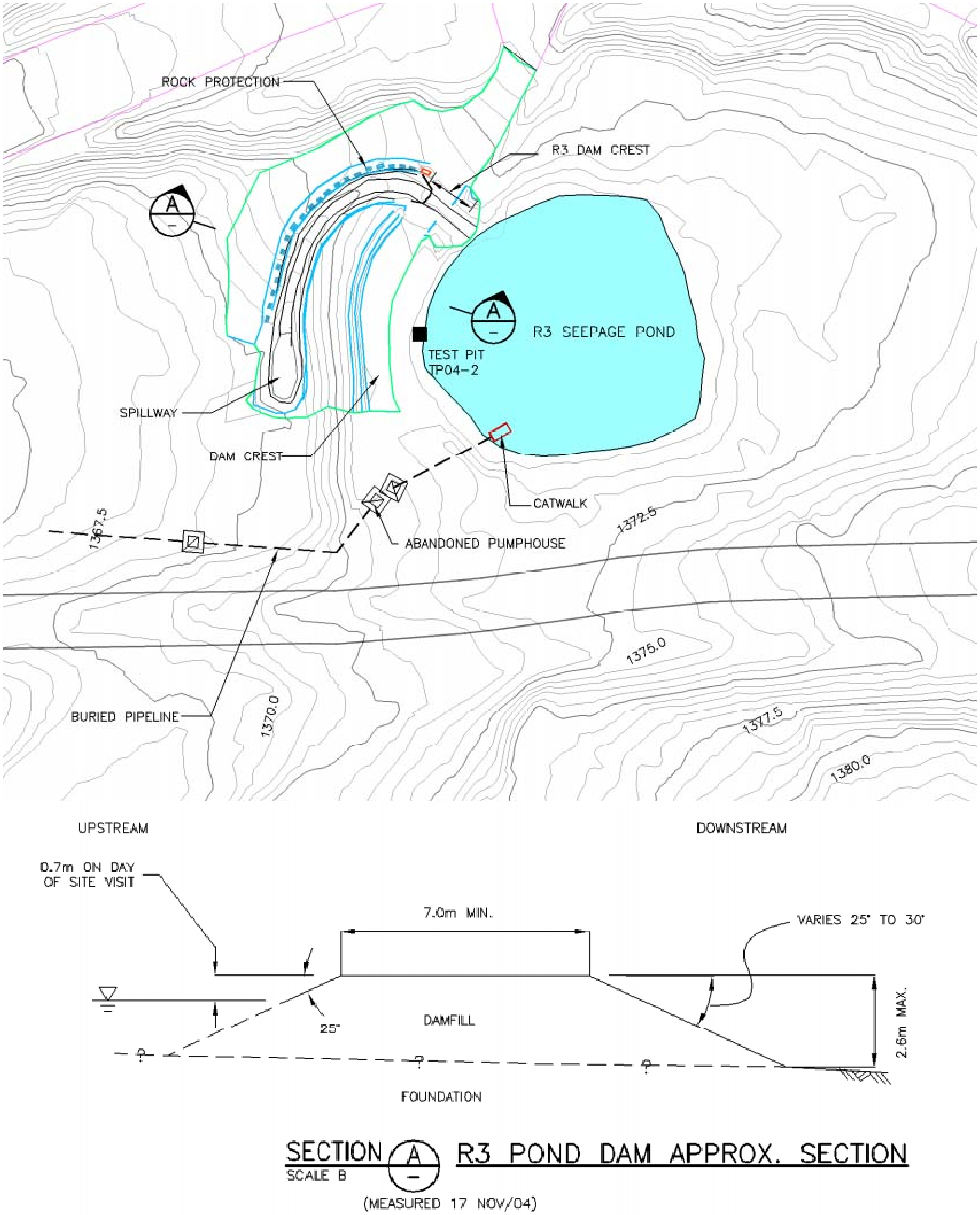
Deficiencies:

1) Wood debris located at end of spillway riprap in the outlet basin should be removed as part of THVCP regular maintenance.

Comments:

1) Minor sloughing of road fill material into right side slope of spillway channel was observed.

SITE PLAN


ROCK PROTECTION
R3 DAM CREST
A
R3 SEEPAGE POND
TEST PIT
TP04-2
SPILLWAY
DAM CREST
CATWALK
ABANDONED PUMPHOUSE
1367.5
1372.5
1375.0
1370.0
1377.5
1380.0
BURIED PIPELINE
UPSTREAM
DOWNSTREAM
0.7m ON DAY
OF SITE VISIT
7.0m MIN.
VARIES 25° TO 30°
25°
DAMFILL
2.6m MAX.
FOUNDATION
SECTION 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-2017-## refers to 2017 DSI waypoint shown on Figure 3.
- All photographs taken during inspection on October 24, 2017.

Photo II-A-1 Downstream Slope of Dam No. 1, rockfill bench and overview of Seepage Pond 1 (BTH-2017-01)

Photo II-A-2 Crack from September 2015 rockfill placement (repair of erosion gully). Area marked and monitored by THVCP, no visible change from 2016 report, crack width ~35mm (BTH-2017-03)

Photo II-A-3 Downstream slope of dam, historic repair of slope scar, no new signs of erosion or scouring. View towards left abutment (BTH-2017-02)

Photo II-A-4 Downstream slope of dam, historic repair of slope scar, no new signs of erosion or scouring. View towards left abutment lower down (BTH-2017-02)

Photo II-A-5 Downstream slope of dam, historic repair of slope scar, no signs of erosion or scouring. View towards right abutment (BTH-2017-02)

Photo II-A-6 Downstream slope of dam, view looking south (BTH-2017-05)

Photo II-A-7 Downstream slope of dam, view looking east from Trojan Dam crest (BTH-2017-06)

Photo II-A-8 Sinkhole on tailings beach, no additional cracks or depressions since 2016 inspection (BTH-2017-04)

Photo II-A-9 Sinkhole on tailings beach and it's instrumentation (BTH-2017-04)

APPENDIX II-B

Inspection Photographs – Bose Lake Dam

Appendix II-B
Inspection Photographs - Bose Lake Dam

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2017-## refers to 2017 DSI waypoint shown on Figure 4.
- All photographs taken during inspection on October 24, 2017.

Photo II-B-1 Dam crest looking towards left abutment while standing at right abutment. The crest has no visible depressions and shows no signs of differential movement (BTH-2017-07)

Photo II-B-2 Upstream slope of dam looking towards left abutment. The rockfill riprap on the upstream slope is intact and shows no signs of degradation or erosion (BTH-2017-07)

Photo II-B-3 Downstream slope of dam including toe drain near right abutment, no signs of erosion or scouring in outer rock layer (BTH-2017-08)

Photo II-B-4 Downstream slope of dam including toe drain near right abutment, view towards right abutment (BTH-2017-08)

Photo II-B-5 Toe drain located along fence line, no visible damage, view downstream (BTH-2017-10)

Photo II-B-6 Toe drain, no visible damage, view towards left abutment (BTH-2017-11)

Photo II-B-7 Toe drain, no visible damage, view towards left abutment. Lower portion of dam from toe drain to the service road, transitions from rockfill armour to till, no signs of erosion or deterioration observed (BTH-2017-12)

Photo II-B-8 Toe drain, no visible damage, view towards right abutment at the till/rockfill armour transition point (BTH-2017-12)

Photo II-B-9 Old gauge-house and decommissioned pump-well. Piezometer 1 standpipe visible on the left, directly behind gauge-house (BTH-2017-13)

Photo II-B-10 Seepage outfall valve control at gauge-house (BTH-2017-13)

Photo II-B-11 Seepage outflow to riprap lined infiltration basin. Flow is clear and steady flowing at approximately 2 L/s (BTH-2017-13)

Photo II-B-12 Spillway inlet at the fence, view downstream towards the log boom. Extensive vegetation including some isolated wet sections in the low-lying areas of the channel (BTH-2017-15)

Photo II-B-13 Spillway channel transition point from till to riprap lining. Concrete sill shows no signs of damage or cracking, and the slope shows no signs of erosion (BTH-2017-16)

Photo II-B-14 Spillway transition point, view upstream. Trapezoidal channel in good condition with no signs of erosion. Minor vegetation at the invert, should continue to be monitored to ensure it does not reduce spillway capacity (BTH-2017-16)

Photo II-B-15 Spillway transition form fine riprap to coarse riprap as the channel steepens, view towards dam crest. Fine riprap size approximately 50-125mm, Coarse riprap approximately 150-300mm (BTH-2017-17)

Photo II-B-16 **Spillway channel looking downstream towards Bose Lake. Flow discharges past the road via two culverts (~1.2m and 0.5m in size) no signs of deterioration to spillway channel observed (BTH-2017-18)**

Photo II-B-17 **Water accumulation on upstream side of spillway culverts, no flow observed at time of inspection. Both culverts clean, and free of obstructions (BTH-2017-19)**

Photo II-B-18 Crest of dam view towards right abutment, vehicle access blocked off at time of inspection (BTH-2017-20)

Photo II-B-19 View of upstream slope and tailings pond, no signs of erosion observed (BTH-2017-20)

Photo II-B-20 Signs of erosion along crest and upper till section of the downstream slope of the dam (BTH-2017-21)

Photo II-B-21 View of fenced off reclamation area from crest of dam (BTH-2017-22)

Photo II-B-22 Possible animal burrow site near dam left abutment (BTH-2017-14)

Photo II-B-23 Possible animal burrow site near right dam abutment. (BTH-2017-09)

APPENDIX II-C

Inspection Photographs – R3 Seepage Pond Dam

Appendix II-C
Inspection Photographs - R3 Seepage Pond Dam

LEGEND:

- BTH = Bethlehem Tailings Facility.
- BTH-2017-## refers to 2017 DSI waypoint shown on Figure 5.
- All photographs taken during inspection on October 24, 2017.

Photo II-C-1 Overview of pond and dam looking south (BTH-2017-23)

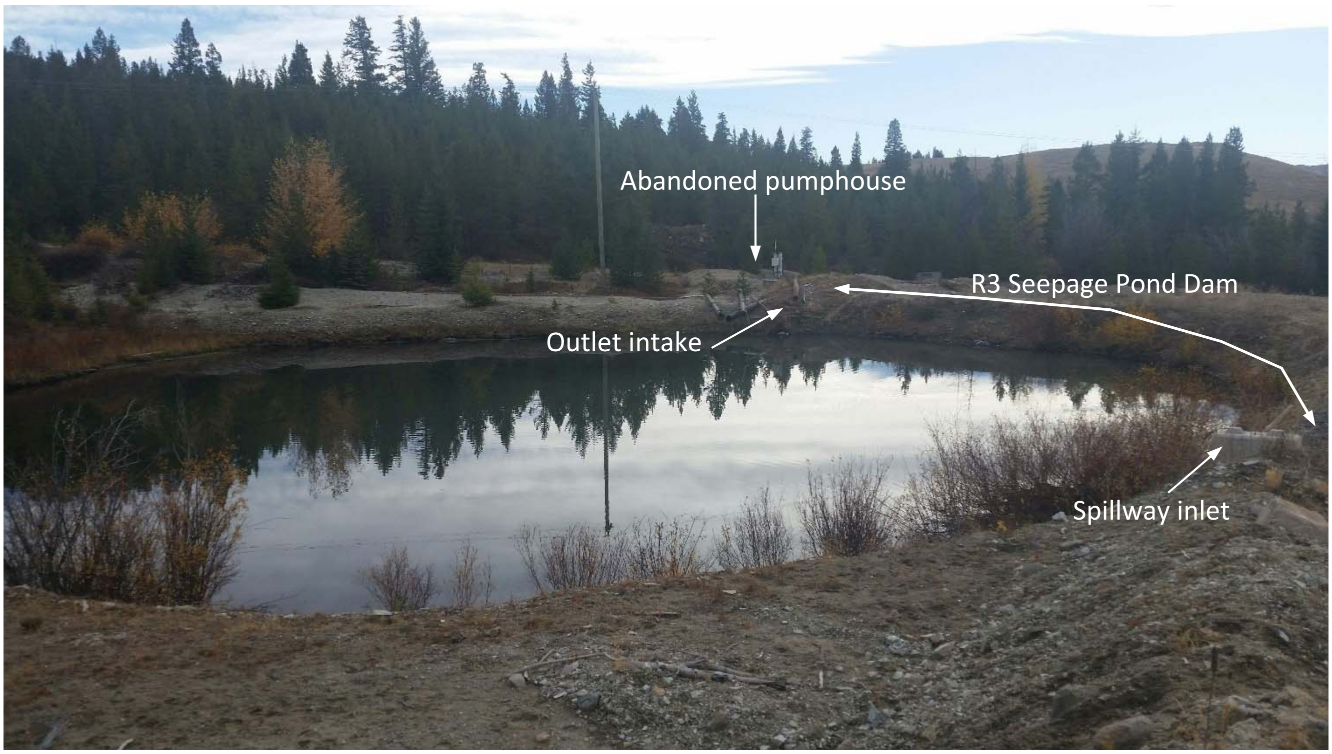


Photo II-C-2 Decommissioned outflow pipes, and surrounding debris (BTH-2017-27)

Photo II-C-3 Outlet intake with clear trash rack and debris fence with minor obstructions (BTH-2017-27)

Photo II-C-4 Dam crest view towards left abutment and spillway swale, Uneven ground where spillway cuts through dam crest (BTH-2017-23)

Photo II-C-5 Spillway inlet, trapezoidal channel in good condition, no signs of erosion in fine riprap (BTH-2017-24)

Photo II-C-6 Spillway view downstream from crest of dam, transition to large riprap as channel steepens (BTH-2017-24)

Photo II-C-7 Spillway channel in good condition, no signs of deterioration. Downstream riprap material size 50-300mm with outliers as large as 600mm (BTH-2017-25)

Photo II-C-8 Spillway view downstream from channel bend, no signs of erosion of deterioration, log obstruction present in lower section (BTH-2017-25)

Photo II-C-9 Accumulation of water at the end of spillway riprap (BTH-2017-26)

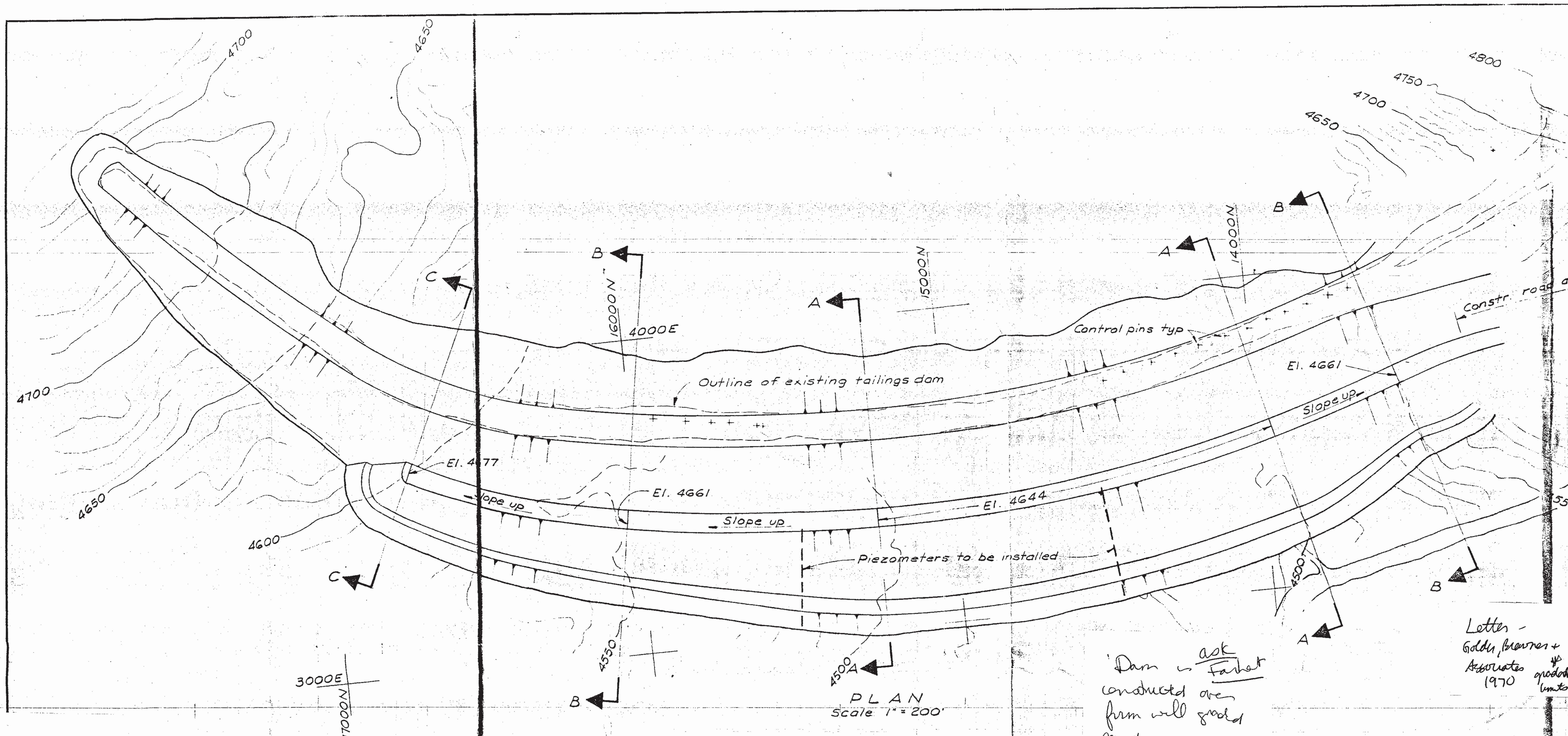
Photo II-C-10 Downstream slope of dam, view towards right abutment and spillway, no signs of erosion or deterioration (BTH-2017-28)

APPENDIX III

Reference Dam Design Drawings

APPENDIX III-A

Reference Dam Design Drawings – Dam No. 1

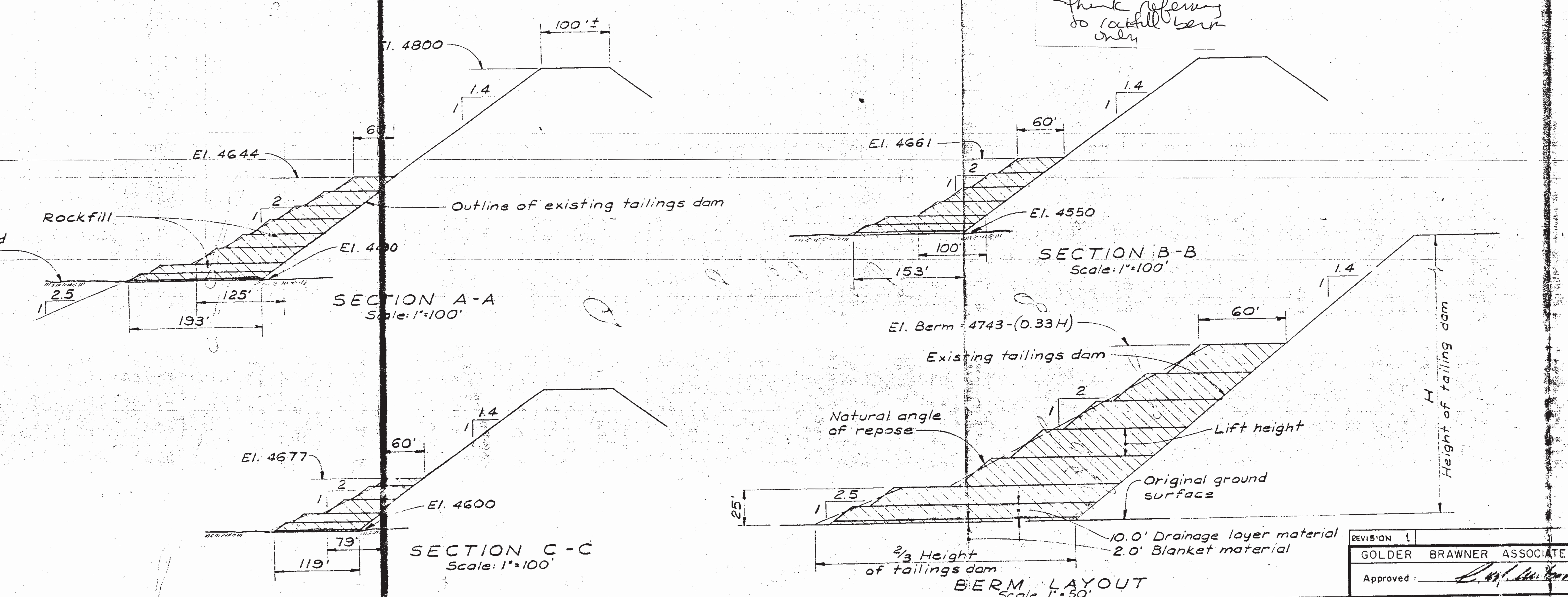


Letter -
Golder Brawner + Associates 1970
gradation limits

'Dam is Farhat
constructed over
from well graded
sand mar OG.

Think referring
to rockfill berm
only

Foundation drain
under the dam
direct seepage
via two
collection ditches



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: [signature]

REV. NO.	DATE	MADE	CHKD.	INSP.	SUBD.	RECD.	APPD.
1	Nov 3/70	H.C.					H.R.
2							
3							
4							
5							

BETHLEHEM COPPER CORPORATION LTD.

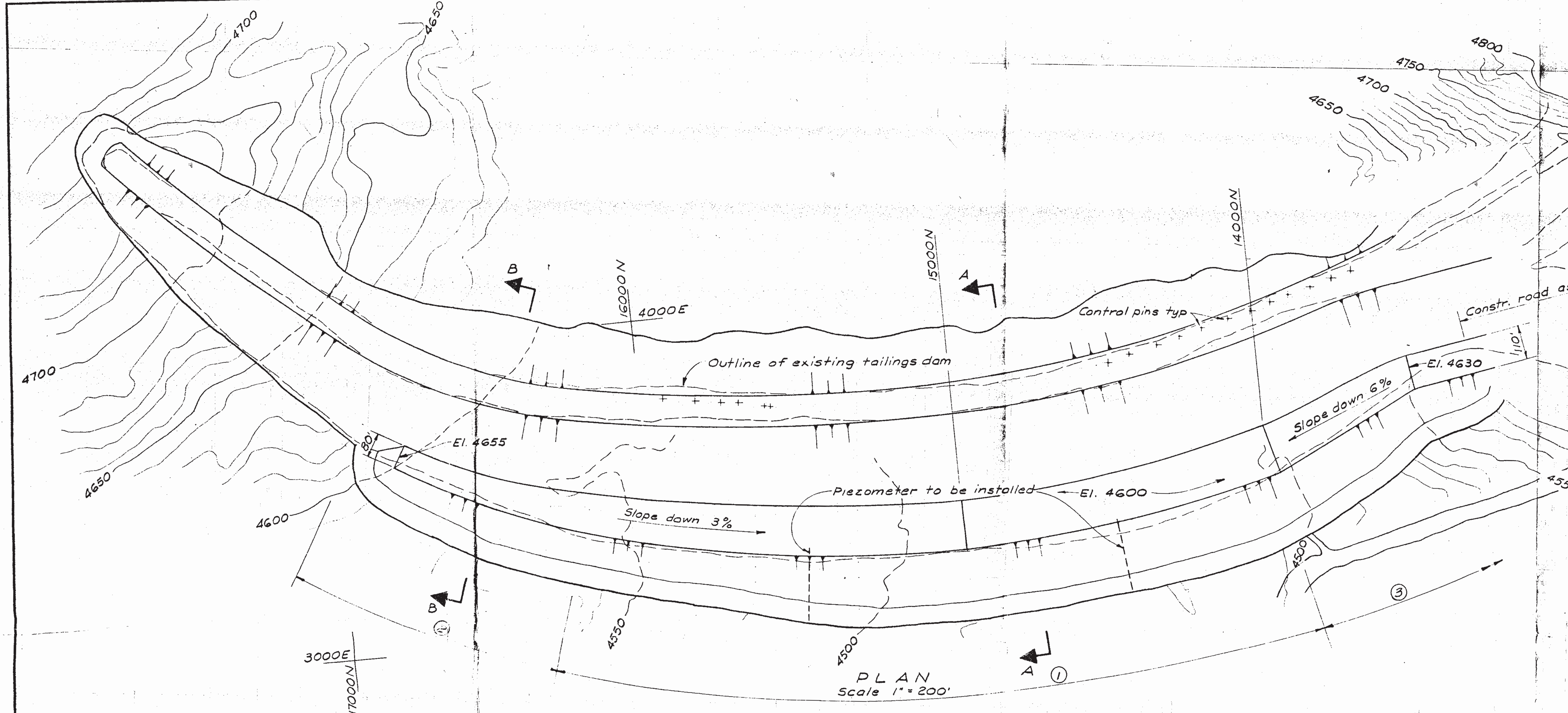
HIGHLAND VALLEY TAILINGS DAM

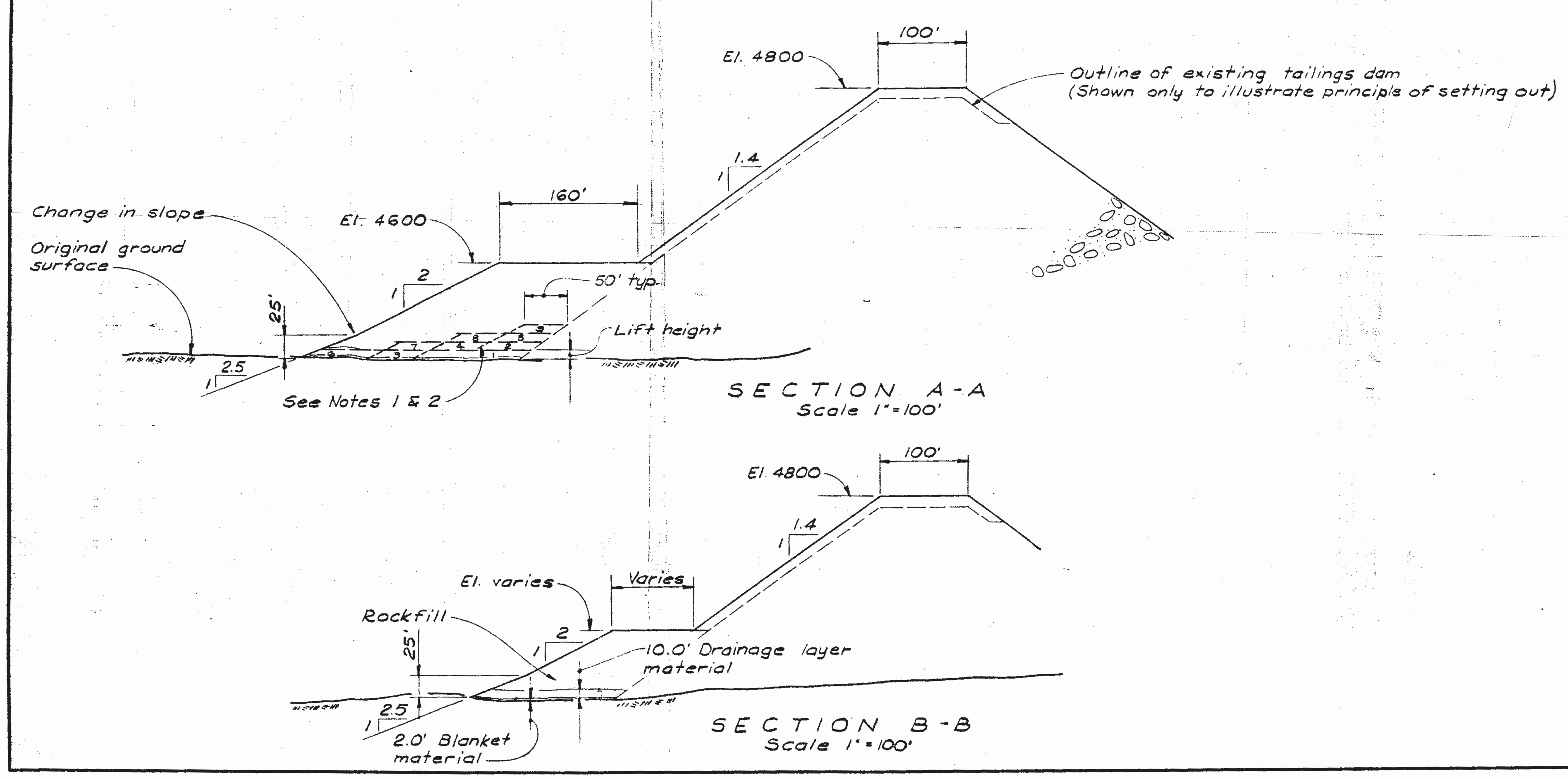
DETAILS OF DOWNSTREAM BERM

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

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

SCALE: As Shown
DATE: Sept. 9, 1970
221-02-102 R1





Materials

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

Construction

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

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

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

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

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

Scheduling

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

NOTES:

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

CONSTRUCTION ISSUE

GOLDER BRAWNER ASSOCIATES
Approved :

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

BETHLEHEM COPPER CORPORATION LTD.

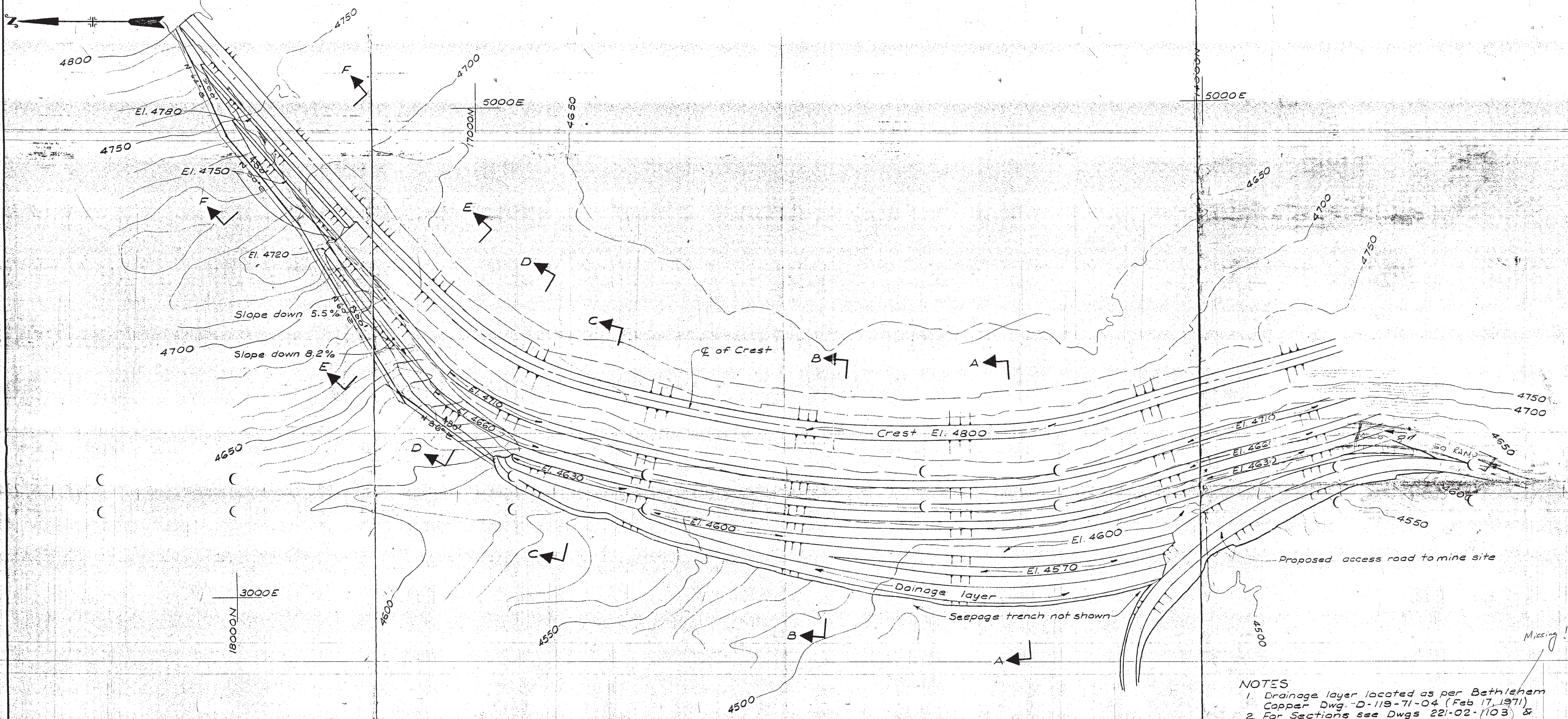
HIGHLAND VALLEY TAILINGS DAM

DETAILS OF DOWNSTREAM BERM

T. INGLEDOW & ASSOCIATES LIMITED
CONSULTING ENGINEERS VANCOUVER, CANADA

DESIGNED
DRAWN H.C.
CHECKED
INSPECTED
SUBMITTED
RECOMMENDED 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

Missing!

REFERENCES
Bethlehem Copper Corporation Ltd. Drawings

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

CONSTRUCTION ISSUE

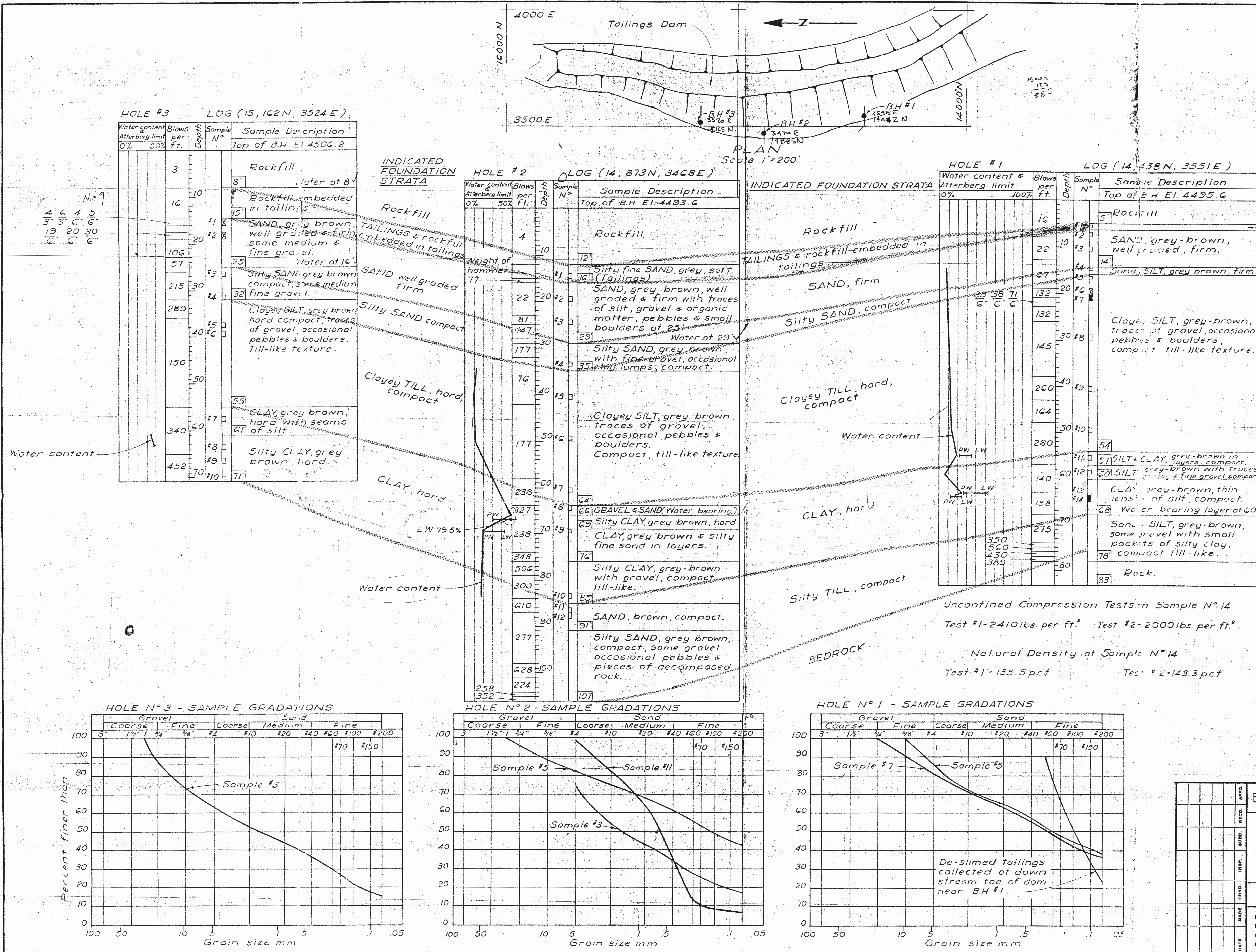
BETHLEHEM COPPER CORPORATION LIMITED

TAILINGS DAM NUMBER ONE
REDESIGN JULY 1971
PLAN

GEPAC CONSULTANTS LTD.
CONSULTING ENGINEERS VANCOUVER, CANADA

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

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



Water table of El. 4492.6

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

LEGEND

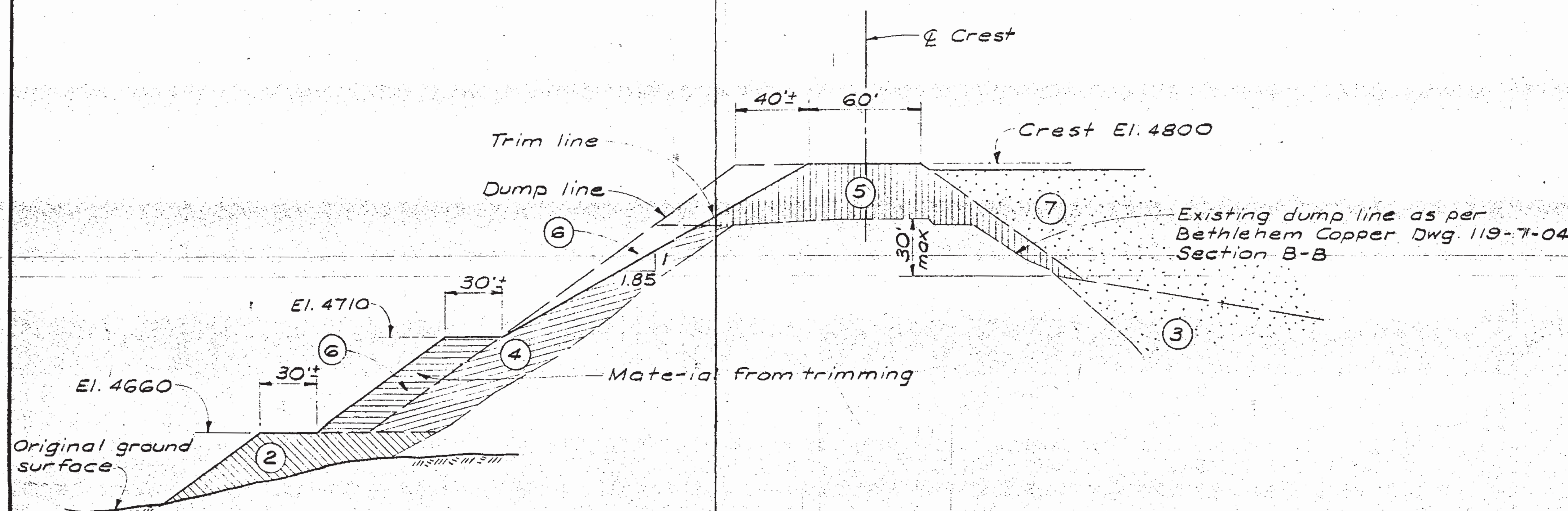
- □ Sample from recovered cuttings
- ⊠ Split spoon sample
- ▮ Shelby tube sample, 3" O.D.
- LW Liquid limit water content.
- PW Plastic limit water content.

BETHLEHEM COPPER CORPORATION

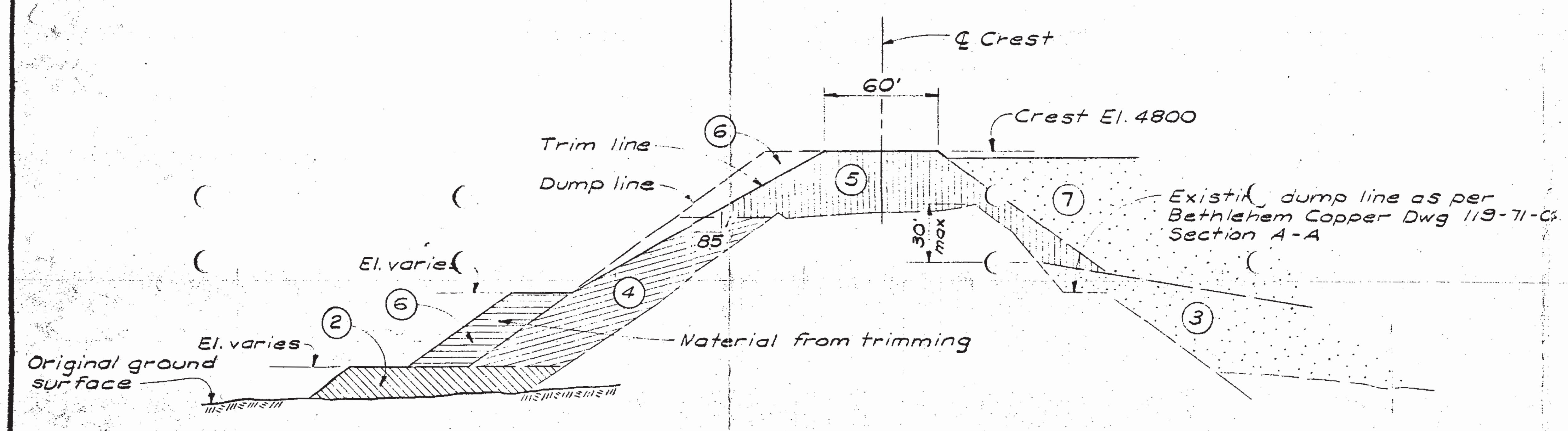
HIGHLAND VALLEY MINE
TAILINGS DAM FOUNDATION
SOIL CHARACTERISTICS

T. INGLEDOW & ASSOCIATES LIMITED
CONSULTING ENGINEERS VANCOUVER, CANADA

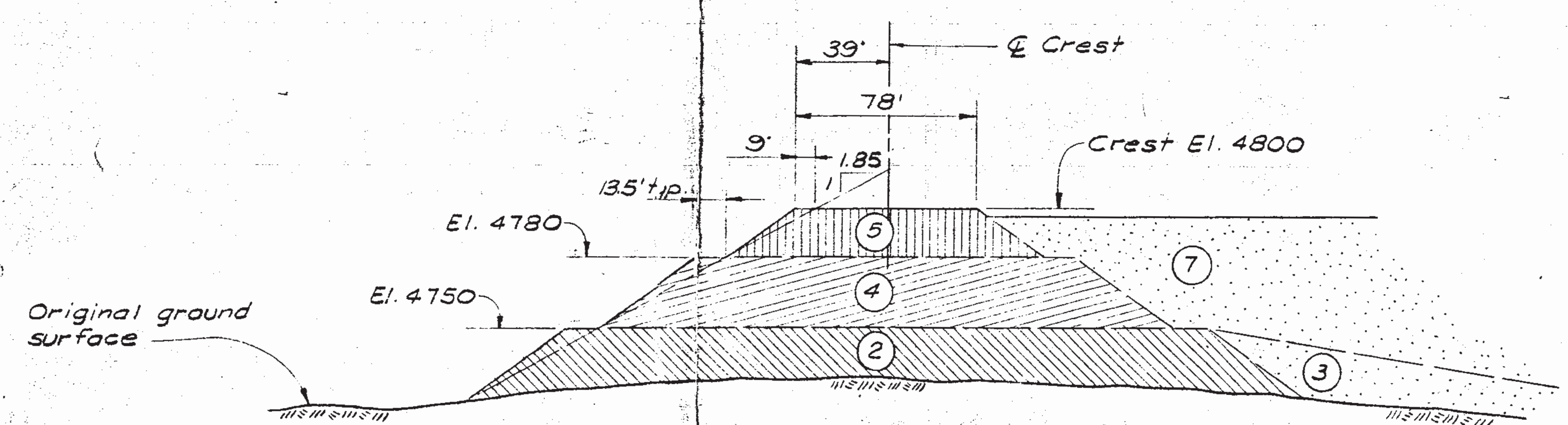
DESIGNED D.C.	SCALE As Shown
DRAWN W.J.	DATE OCT 10, 1966
CHECKED	221
INSPECTED	02-1004
SUBMITTED	
RECOMMENDED	
APPROVED	



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



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



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

LEGEND

(1) Sequence of construction

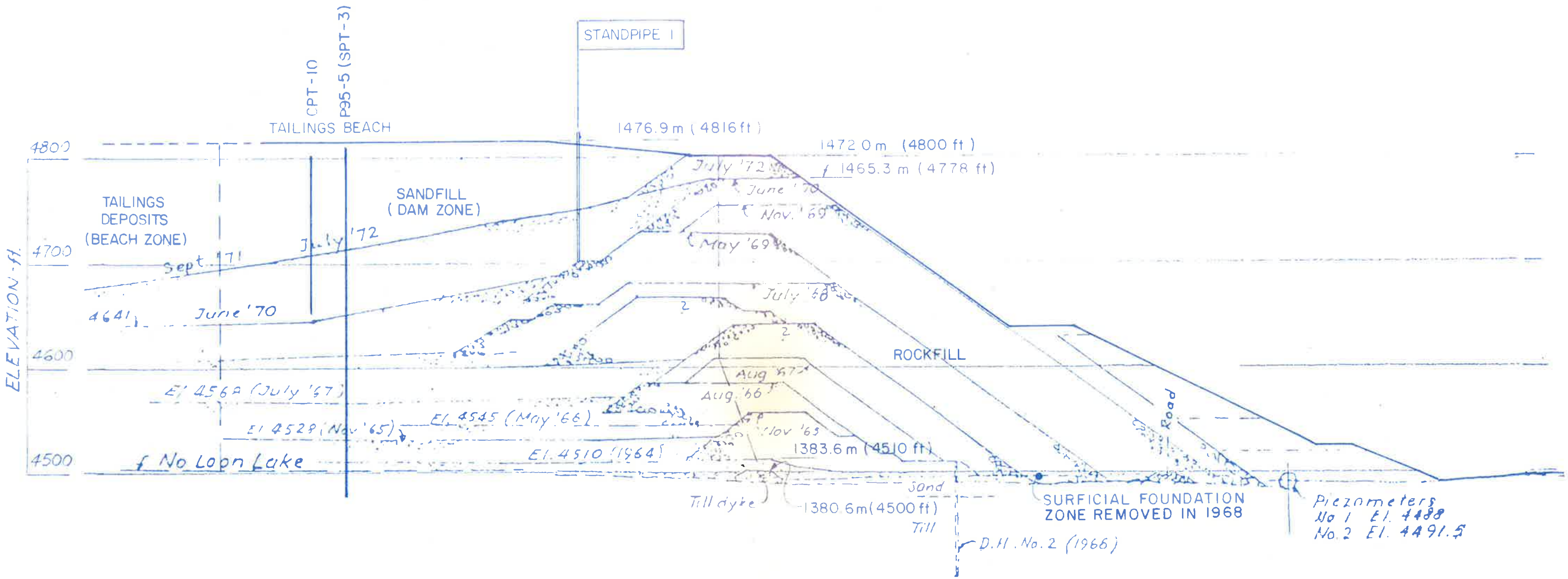
NOTES

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

CONSTRUCTION ISSUE

BETHLEHEM COPPER CORPORATION LIMITED	
TAILINGS DAM NUMBER ONE REDESIGN JULY 1971 SECTIONS - SHEET 2 OF 2	
GEPAC CONSULTANTS LTD. CONSULTING ENGINEERS VANCOUVER, CANADA	
DESIGNED DRAWN H. COULTER CHECKED J. A. Knowles INSPECTED SUBMITTED [signature] RECOMMENDED APPROVED [signature]	SCALE 1" = 50' DATE 221 02-1104

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



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

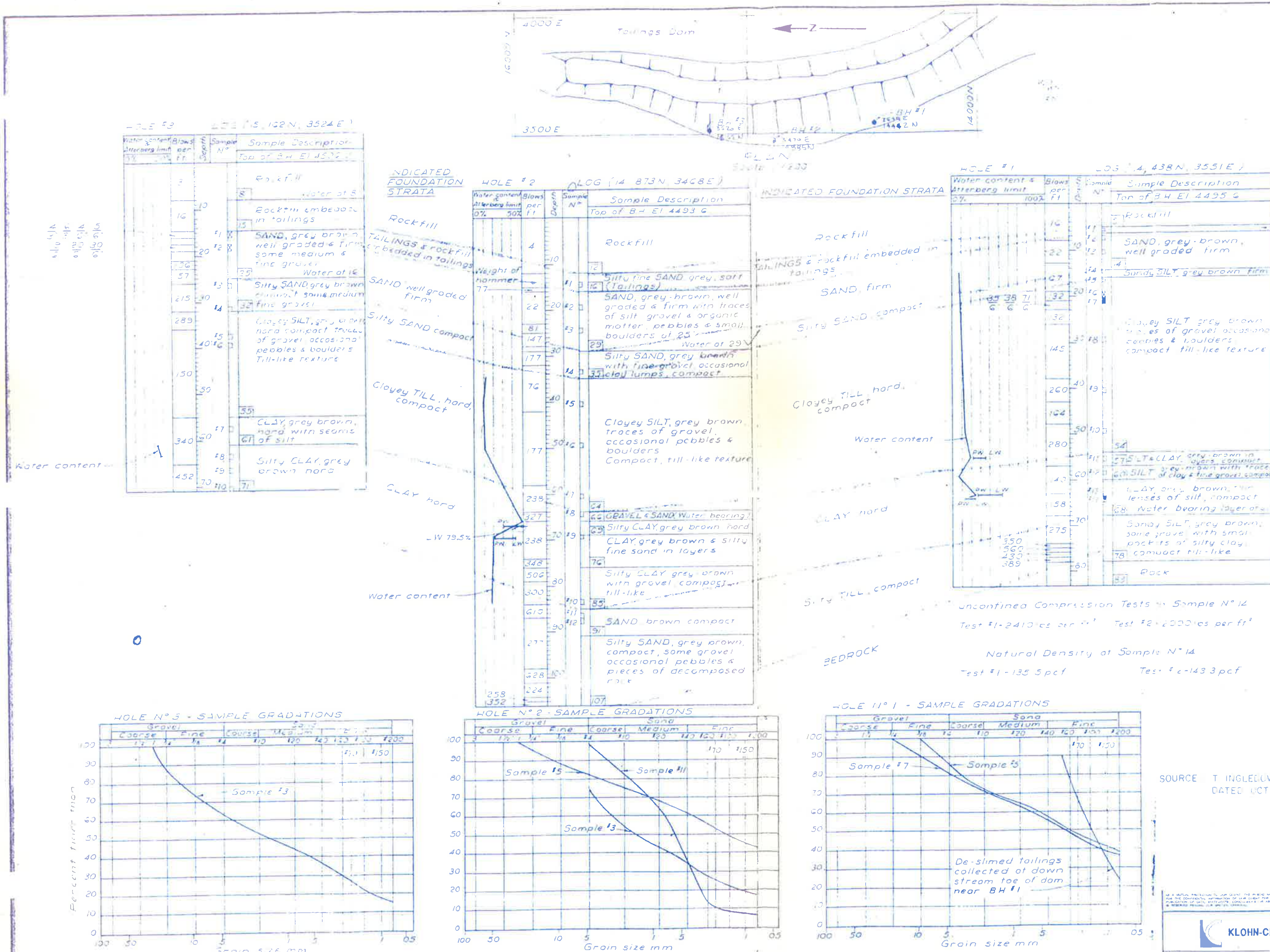
CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: TYPICAL SECTION DAM No. 1

SCALE

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



NOTES

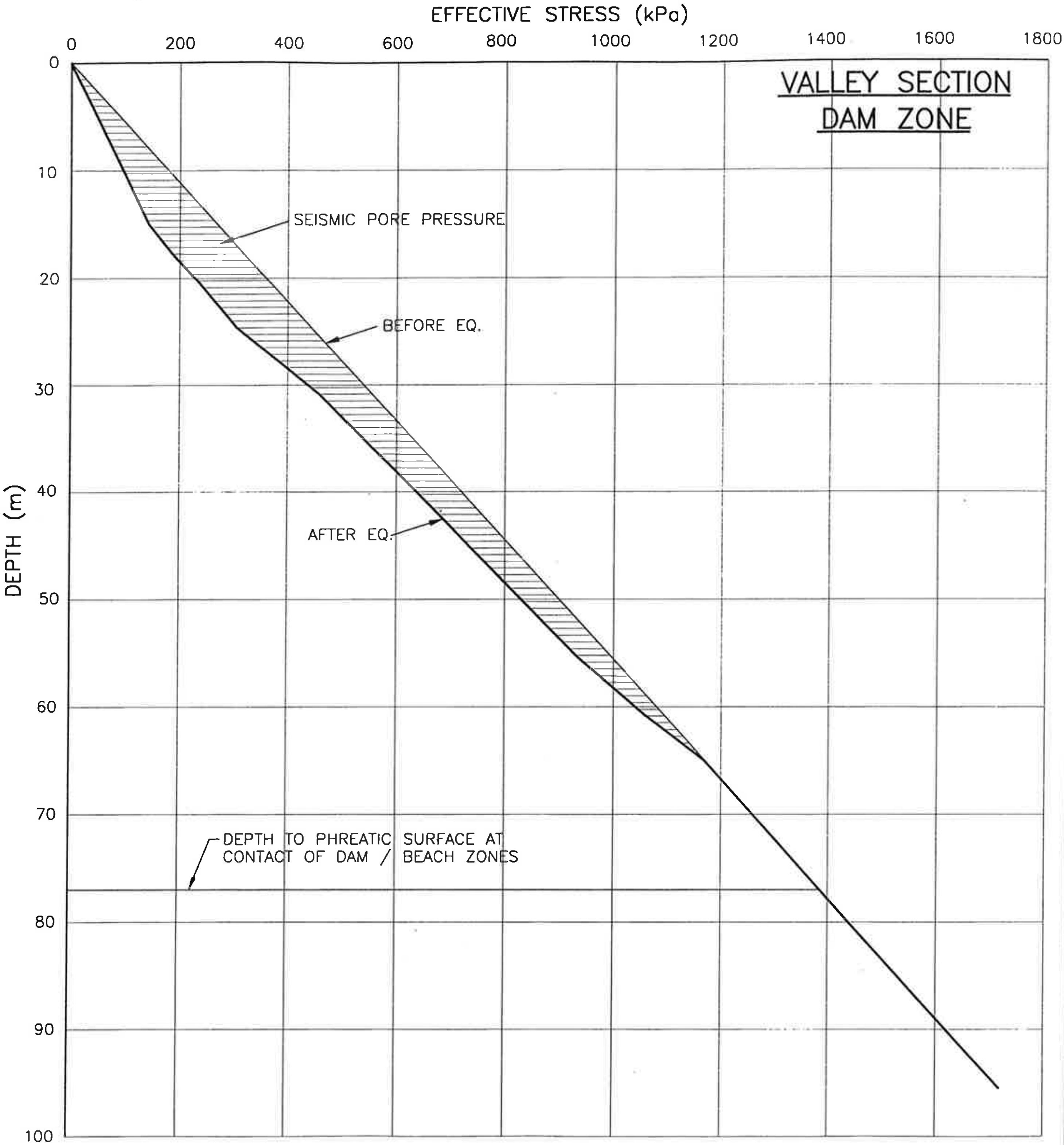
1. Blow counts shown are averages for the indicated hole section required to drive a 5½" OD casing with a diesel hammer developing 8000 ft lb
2. Standard penetration resistance referred to sections in inches shown thus 20/6 and indicating the number of blows of a 140 lb weight falling 30" required to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

LEGEND

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

SOURCE: T. INGLEDOW & ASSOCIATES LIMITED DWG. No. 231-02-1004, DATED OCT 10, 1966

KLOHN-CRIPPEN	PROJECT: LONG-TERM STABILITY ASSESSMENT
	TITLE: SUBSOIL DATA - DAM No 1
CLIENT: HIGHLAND VALLEY COPPER	DATE OF ISSUE: DEC 9, 1996 · PROJECT No: PM2916 23 · DWG No: B-23008



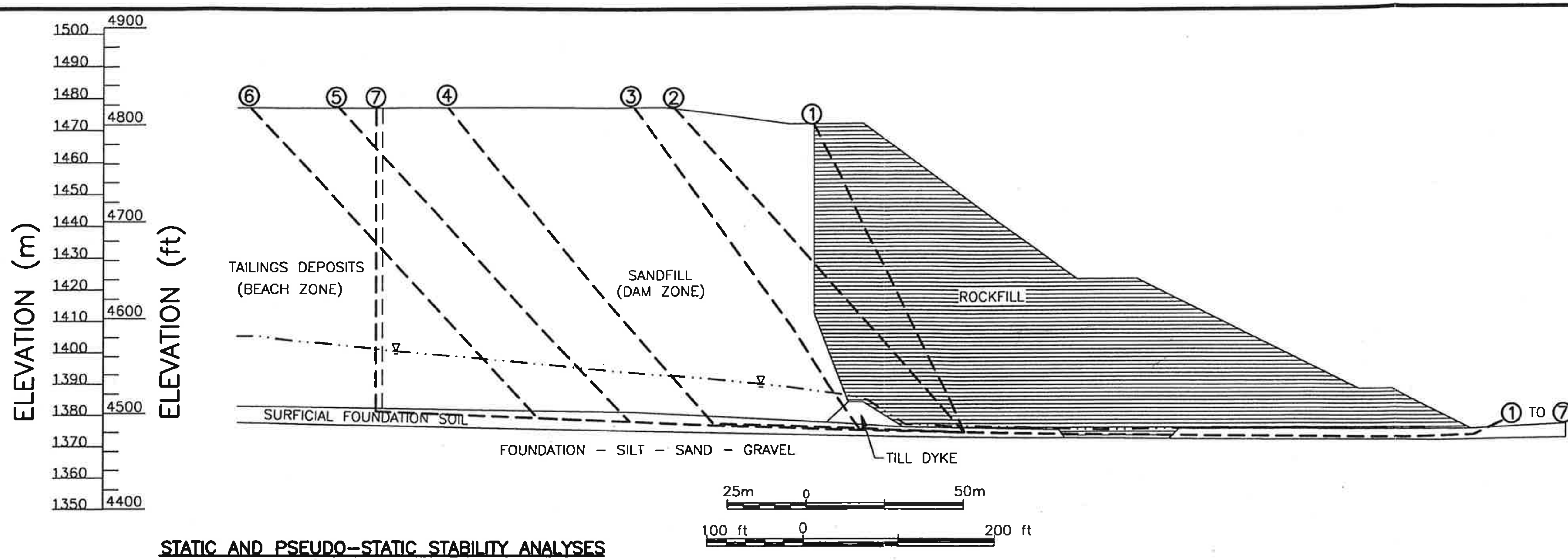
SCALE

KLOHN-CRIPPEN

PROJECT: LONG–TERM STABILITY ASSESSMENT

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

CLIENT:	DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
HIGHLAND VALLEY COPPER	DEC. 9, 1996 APPROVED	PM2916 23	A–23009	



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/m^3)	γ_{sat} (kN/m^3)	
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/m^2

(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

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

KLOHN-CRIPPEN

CLIENT: HIGHLAND VALLEY COPPER

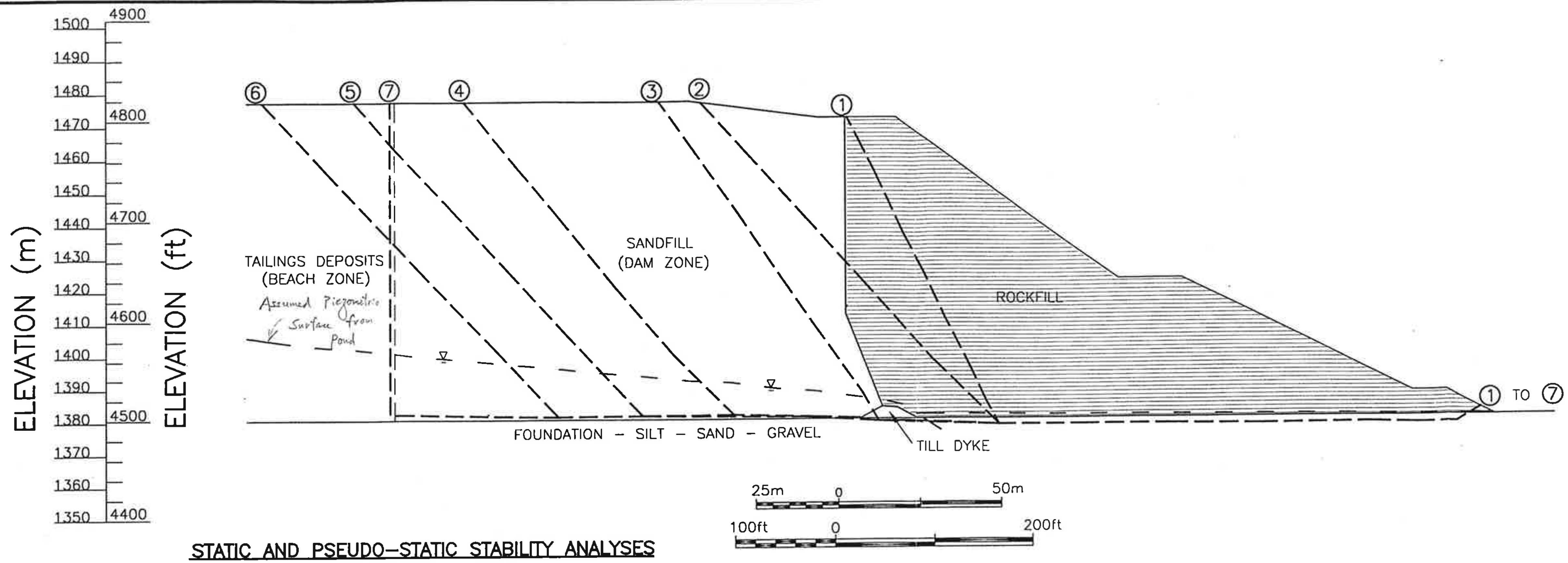
PROJECT: LONG–TERM STABILITY ASSESSMENT

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

SCALE

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 ϕ' (degree)
	γ_{moist} (kN/m^3)	γ_{sat} (kN/m^3)	
ROCKFILL	18.9	–	37
SANDFILL (DAM ZONE)	18	–	30
TAILINGS DEPOSITS (BEACH ZONE)	–	19	25
TILL DYKE	–	22.8	35
SILT/SAND/GRAVEL FOUNDATION	–	18.9	30

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

POST-EARTHQUAKE STABILITY ANALYSIS SUMMARY OF SAFETY FACTOR

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

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

LEGEND

④– – – –④ FAILURE SURFACE No.4

– ▽ – PIEZOMETRIC SURFACE

NOTES

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

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

KLOHN-CRIPPEN		DATE
DESIGNED	PH	JUNE 96
DRAWN	CYW	
CHECKED		
RECOMMENDED		
APPROVED	RHO	DEC 96

KLOHN-CRIPPEN

CLIENT: HIGHLAND COPPER VALLEY

PROJECT: LONG-TERM STABILITY ASSESSMENT

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

SCALE

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

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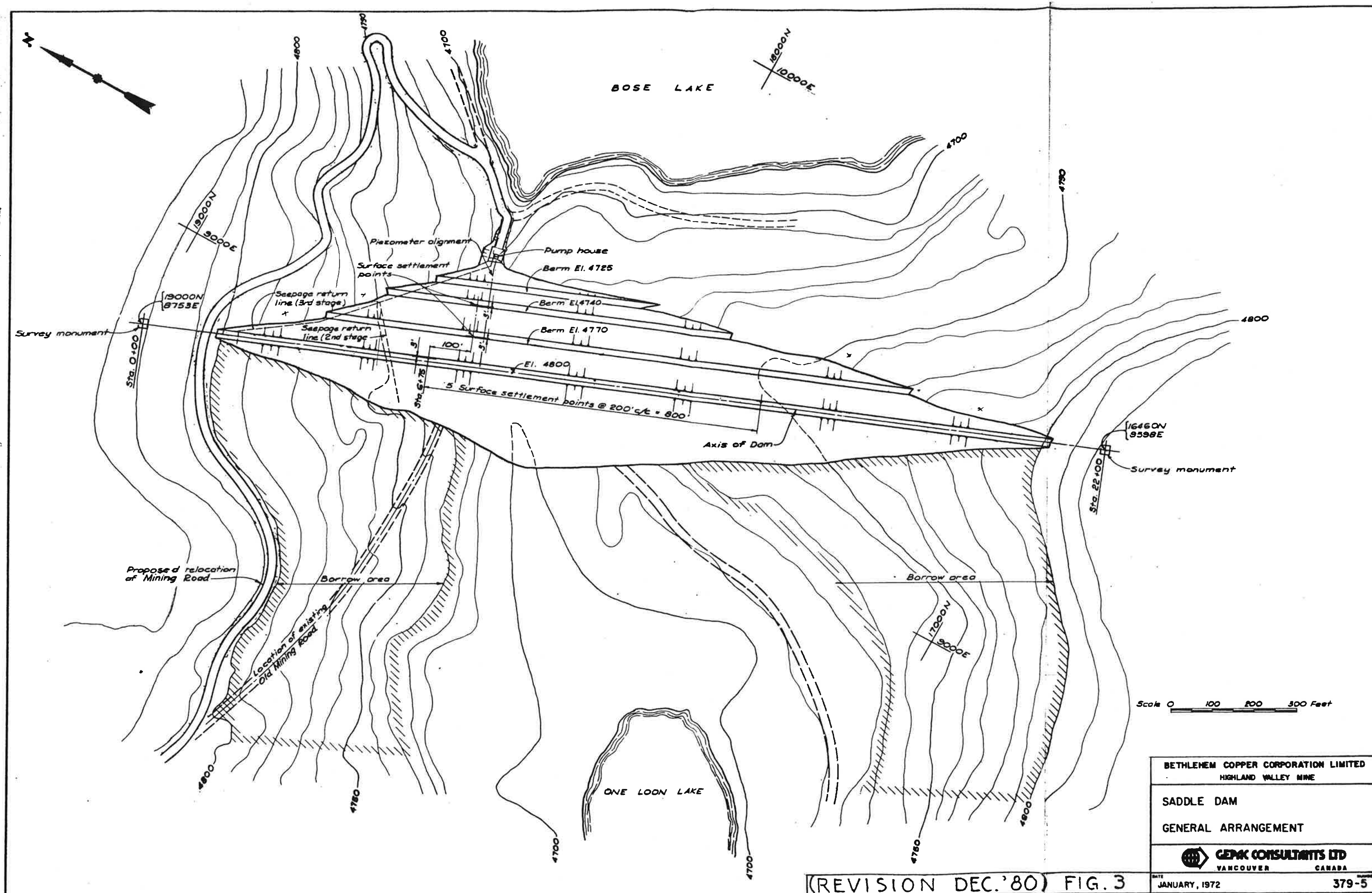
10/08/96 TIME: 2.30

APPENDIX III-B

Reference Dam Design Drawings – Bose Lake Dam



BETHLEHEM COPPER CORPORATION LIMITED

HIGHLAND VALLEY MINE

SADDLE DAM

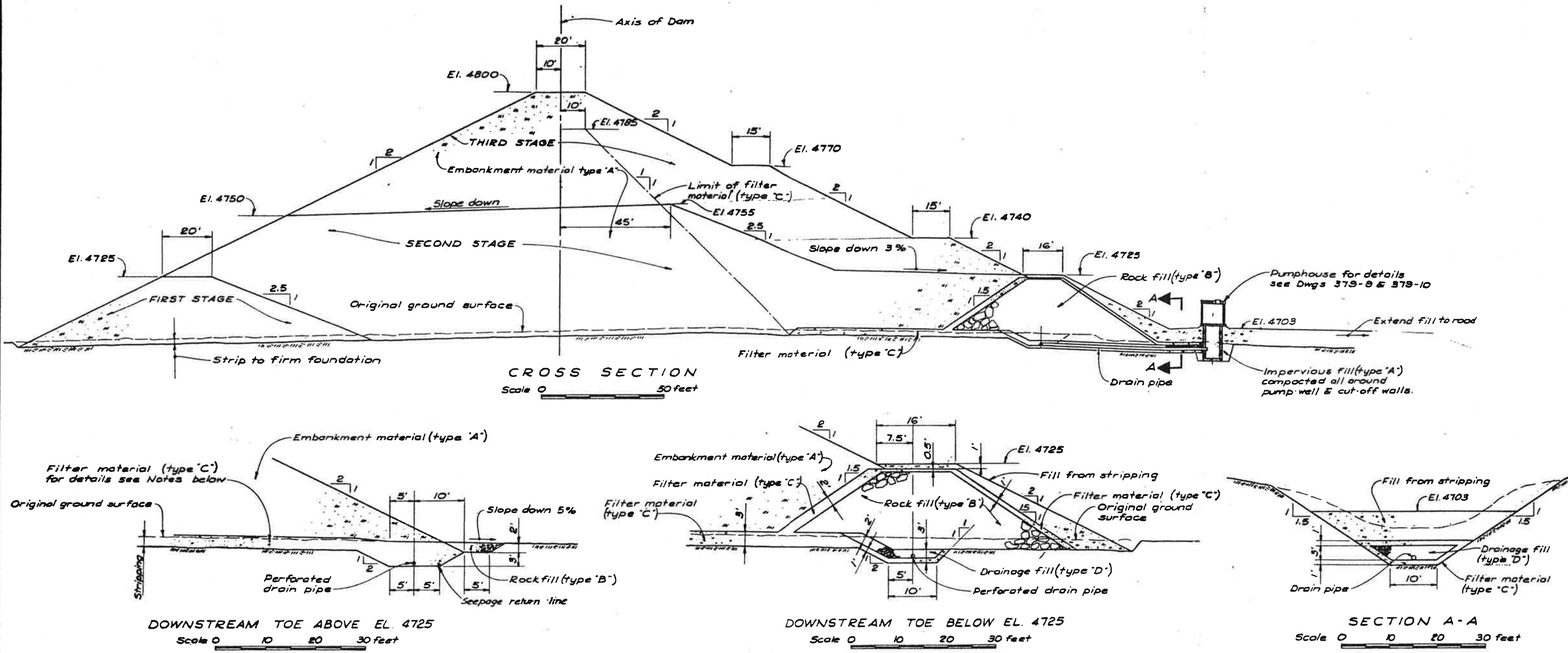
GENERAL ARRANGEMENT

GEPAC CONSULTANTS LTD
VANCOUVER CANADA

(REVISION DEC.'80) FIG. 3

DATE JANUARY, 1972

379-5



NOTES

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

CONSTRUCTION MATERIAL

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

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

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

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

BETHLEHEM COPPER CORPORATION LIMITED
HIGHLAND VALLEY MINE

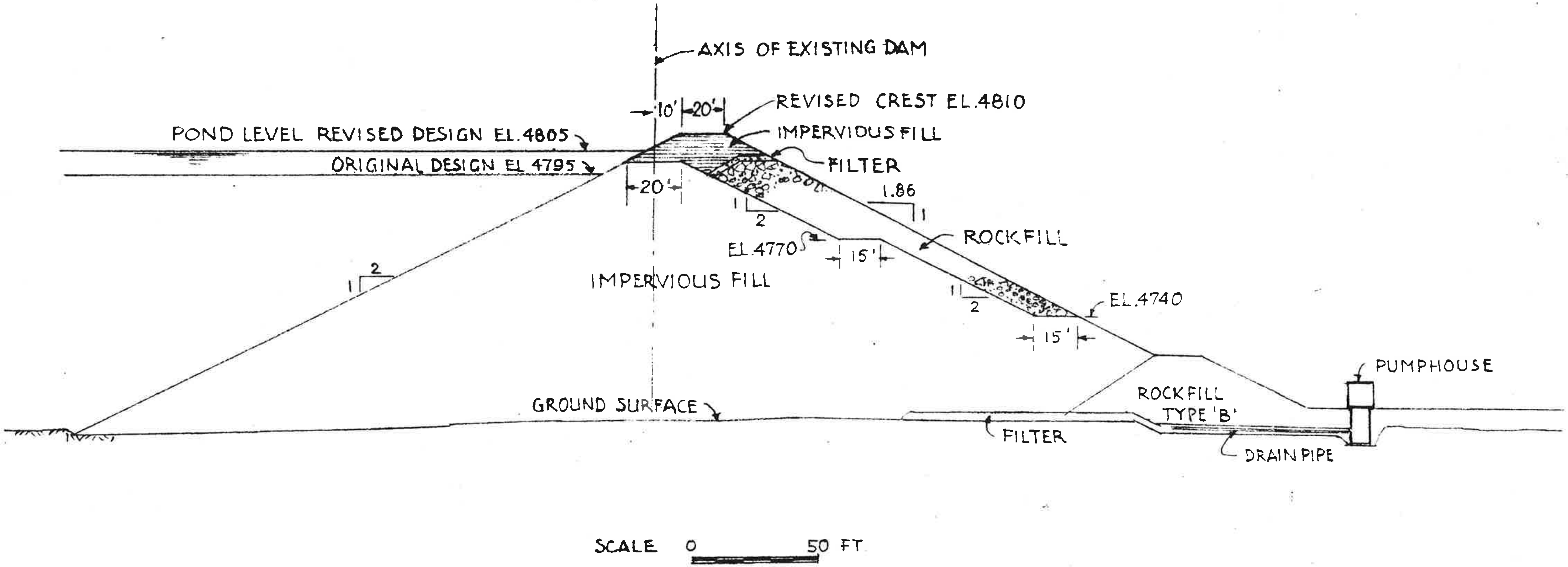
SADDLE DAM
SECTIONS AND DETAILS

GEPAC CONSULTANTS LTD
VANCOUVER CANADA

(REVISION DEC. '80) FIG. 4

DATE JANUARY, 1972

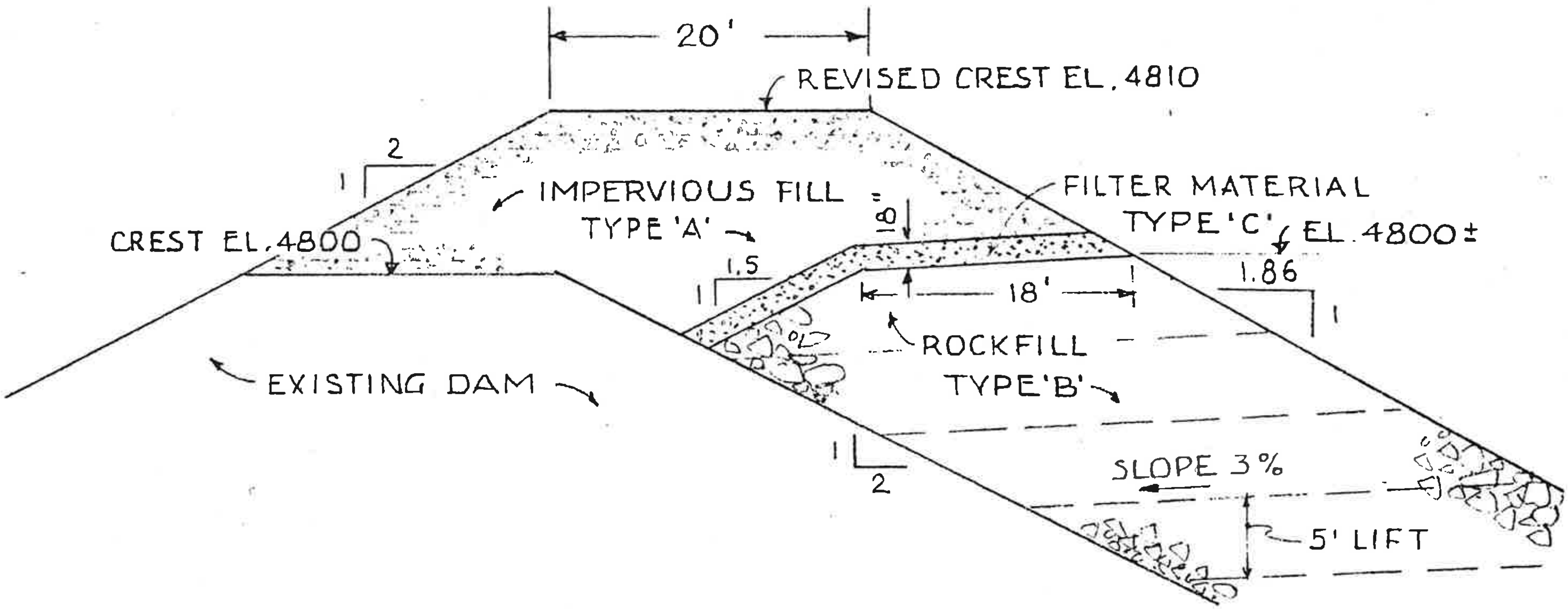
NUMBER 379-6



BOSE LAKE DAM
REVISED CROSS-SECTION

DEC.1980

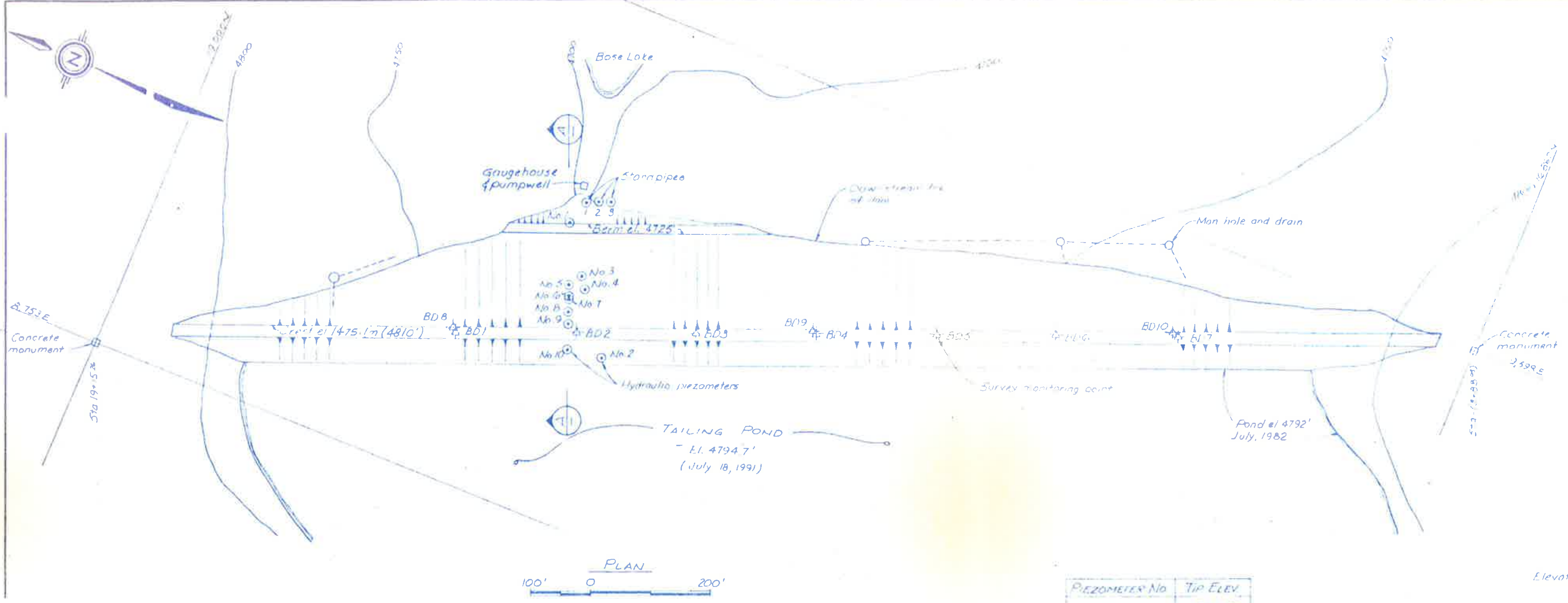
FIGURE 5



SCALE 1" = 10'

FIG. 6

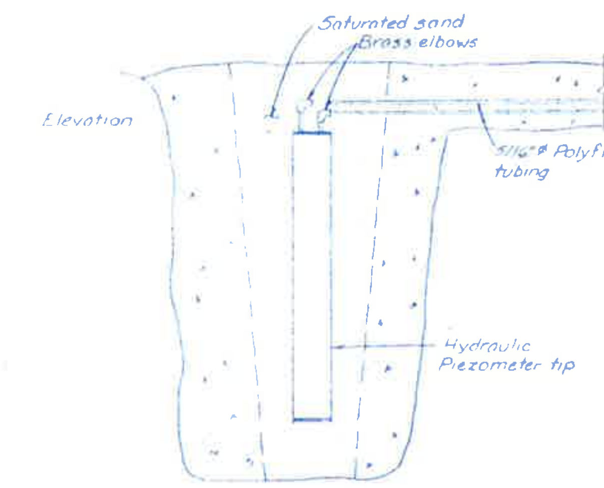
BOSE LAKE DAM
REVISED CREST DETAIL
DEC. 1980 FIGURE 6



Construction Material Specifications (Note 3)

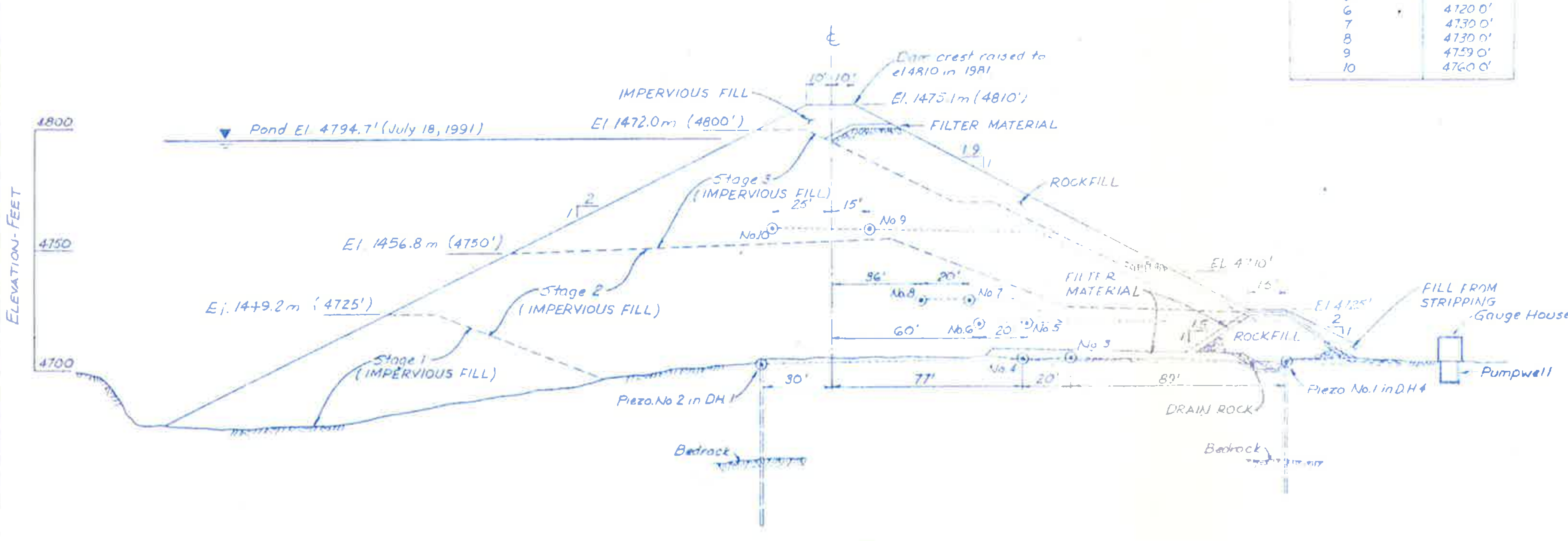
- **Impervious Fill** - Well-graded silty sand and gravel, max. size 6", with >10% finer than No 200 sieve.
- **Rockfill** - Rock and sandy gravel, reasonably sound, max size 24", less than 30% finer than No 4 seive.
- **Filter Material** - Medium to coarse sandy gravel, sound and durable, max size 3",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

Piezometer No	Tip Elev
1	4704.63'
2	4703.36'
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



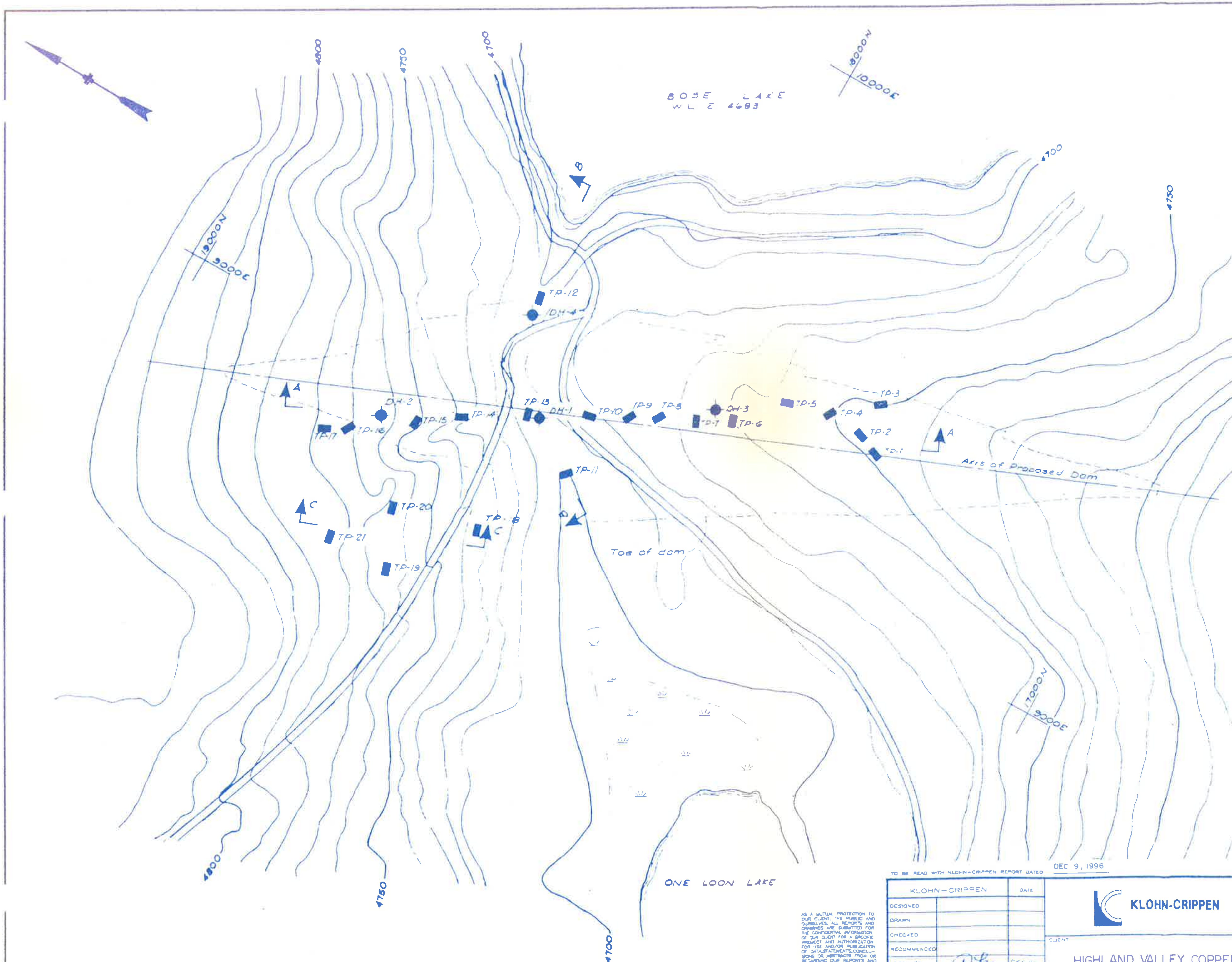
Notes

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

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

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

SCALE:	
REV	DATE
REVISION DETAILS	
DESIGN	
DRAWN	E D P
DATE	MARCH, 1983
SCALES	AS SHOWN
	KLOHN-CRIPPEN
PROJECT	LONG-TERM STABILITY ASSESSMENT
TITLE	PLAN AND TYPICAL SECTION BOSE LAKE DAM
CLIENT:	HIGHLAND VALLEY COPPER
DATE OF ISSUE	DEC 9, 1996
PROJECT No	PM2916 23
DWG No	B-23012



NOTES

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

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

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

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

4 Sections are shown on Dwg 379-4

LEGEND

Drill Holes

Test Pits

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

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

KLOHN-CRIPPEN

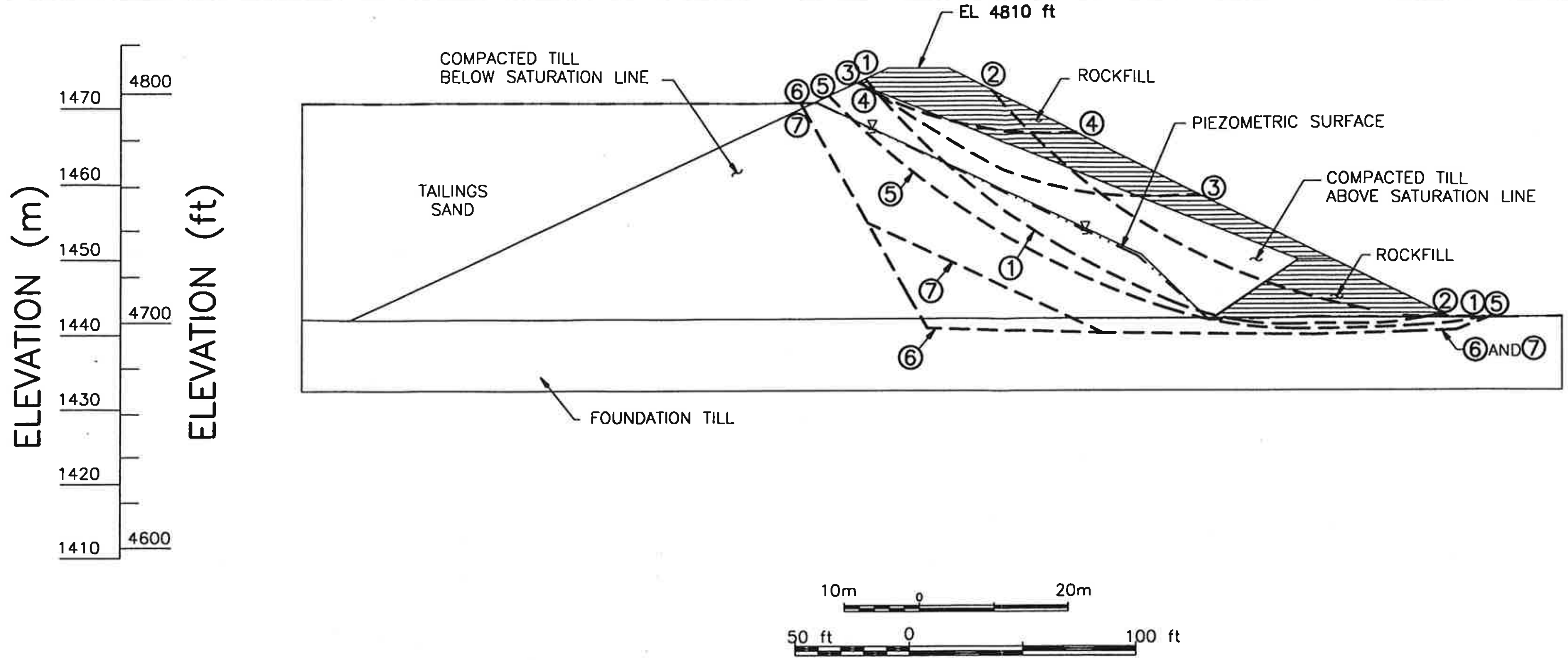
CLIENT: HIGHLAND VALLEY COPPER

SCALE

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 ϕ' (degree)
	γ_{moist} (kN/m^3)	γ_{sat} (kN/m^3)	
ROCKFILL	18.9	–	37
COMPACTED TILL (ABOVE SATURATION LINE)	21.5	–	35
COMPACTED TILL (BELOW SATURATION LINE)	–	22.0	35
FOUNDATION TILL	–	22.8	35

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

LEGEND

4 – – – 4 FAILURE SURFACE No.4

– · · ▽ · · – PIEZOMETRIC SURFACE

NOTES

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

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

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

KLOHN-CRIPPEN

CLIENT
HIGHLAND COPPER VALLEY

SCALE

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	

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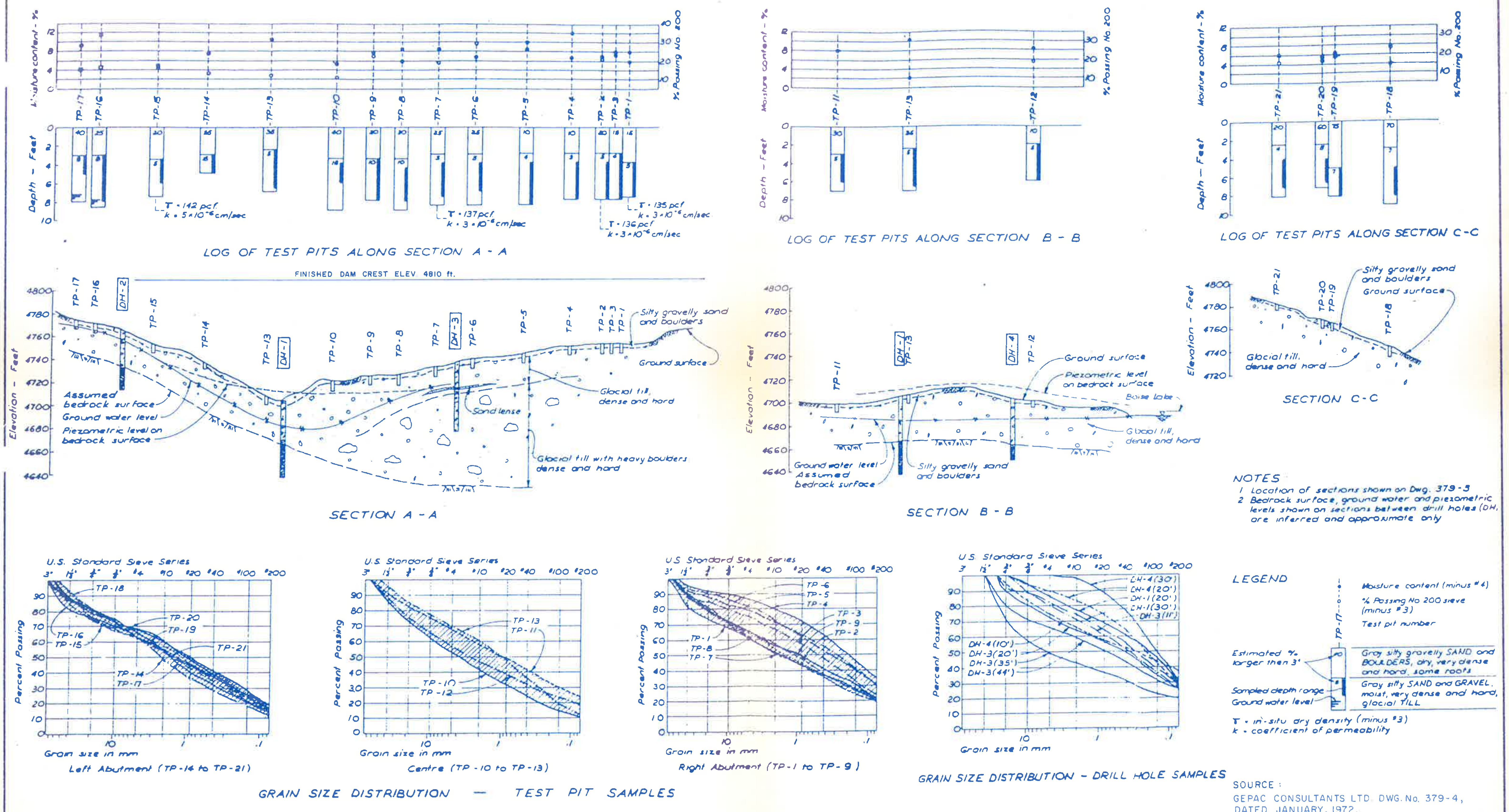
08/23/96 time 4:30



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

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

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

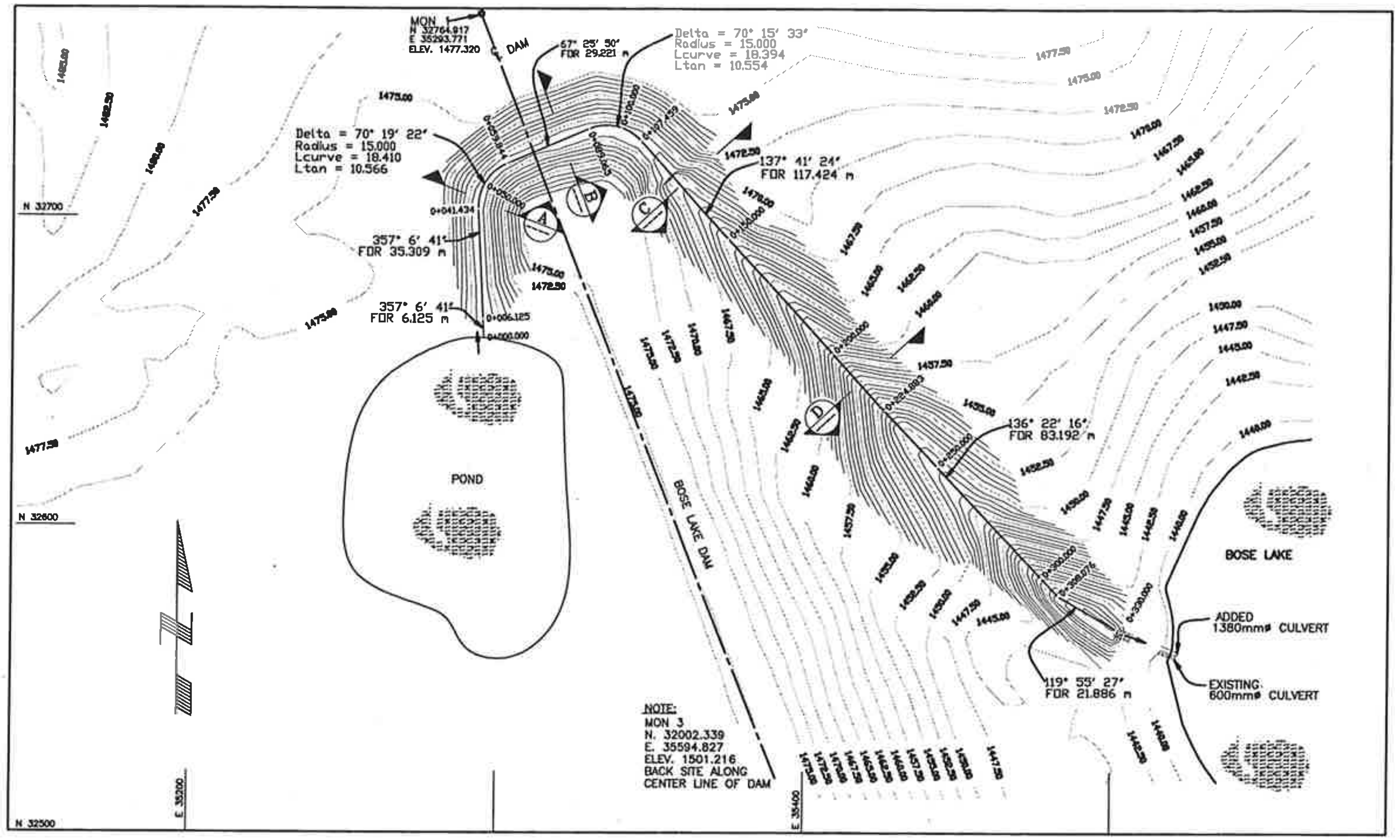
KLOHN-CRIPPEN

CLIENT: HIGHLAND VALLEY COPPER

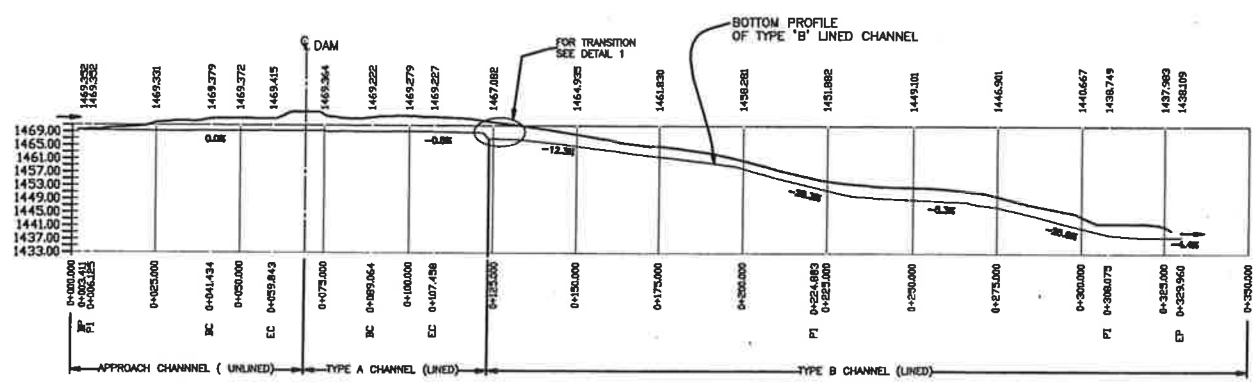
PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: SUBSOIL DATA - BOSE LAKE DAM

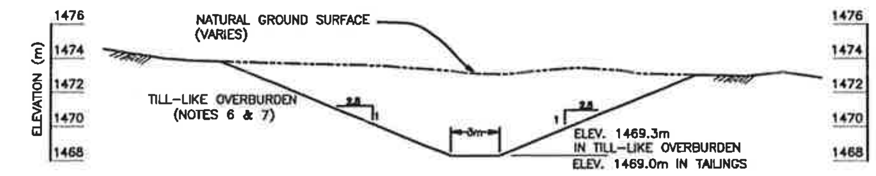
DATE OF ISSUE	PROJECT No.	DWG No.	REV.
DEC. 9, 1996	PM2916 23	B-23014	



GENERAL ARRANGEMENT – PLAN

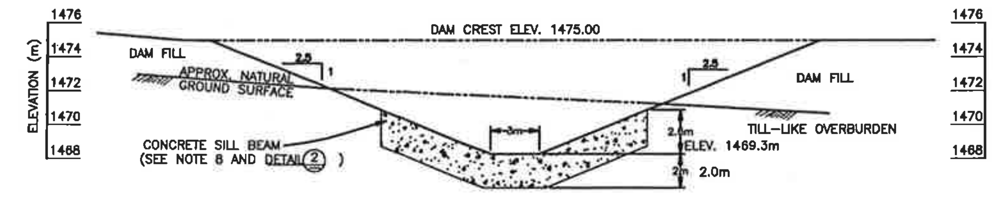


PROFILE ALONG SPILLWAY CHANNEL



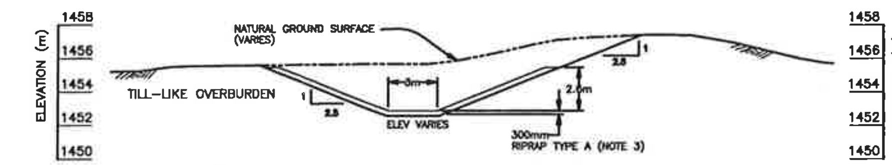
TYPICAL UNLINED CHANNEL

SECTION A
1:200



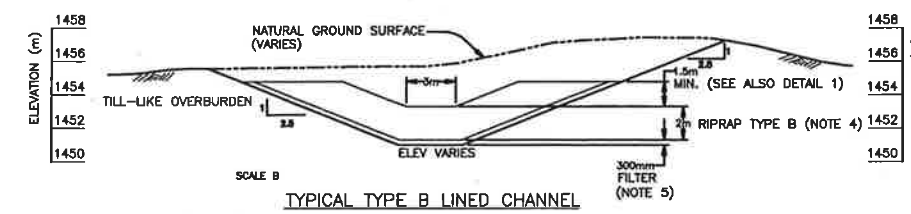
CONCRETE SILL BEAM

SECTION B
1:200



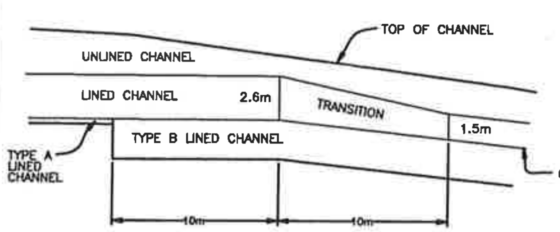
TYPICAL TYPE A LINED CHANNEL

SECTION C
1:200



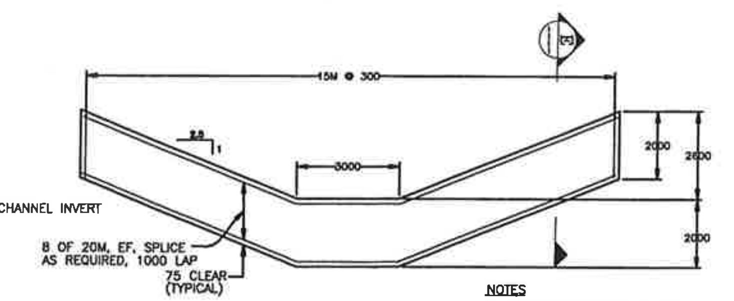
TYPICAL TYPE B LINED CHANNEL

SECTION D
1:200



TRANSITION DETAIL

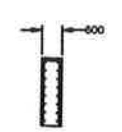
DETAIL 1
1:200



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/m³. 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/m³. 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

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

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

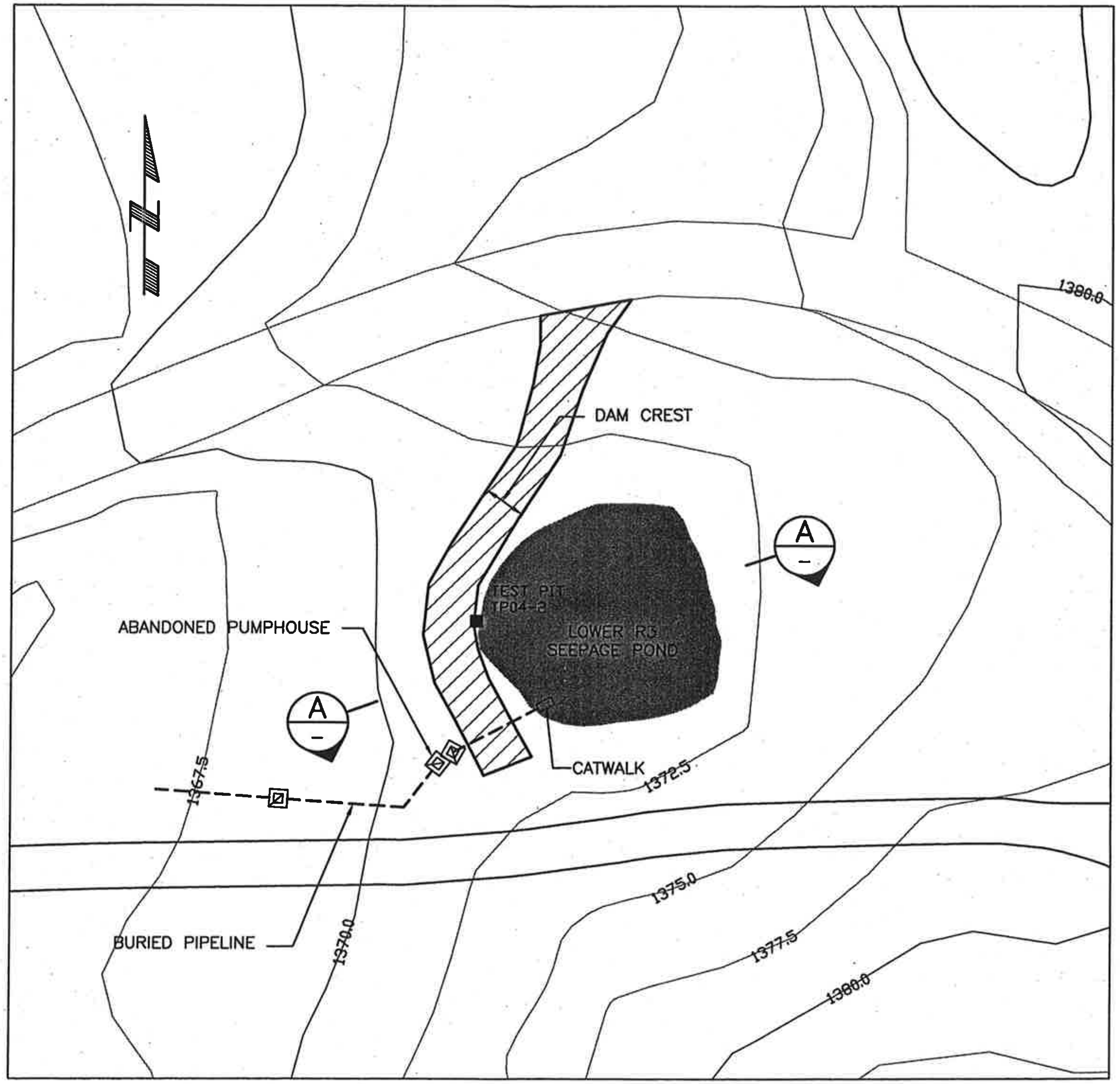
Highland Valley Copper

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

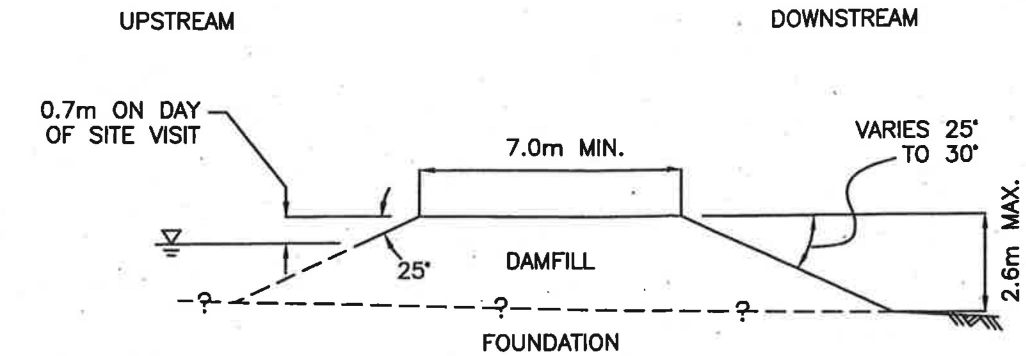
DRAWN H. P. — CHECKED
DATE 98 11 27 — SCALE 1:1000
114-808-201-1 (DWG No.) — REV. 1

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

NOT FOR CONSTRUCTION

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

SCALE

CLIENT
HIGHLAND VALLEY COPPER

KLOHN CRIPPEN

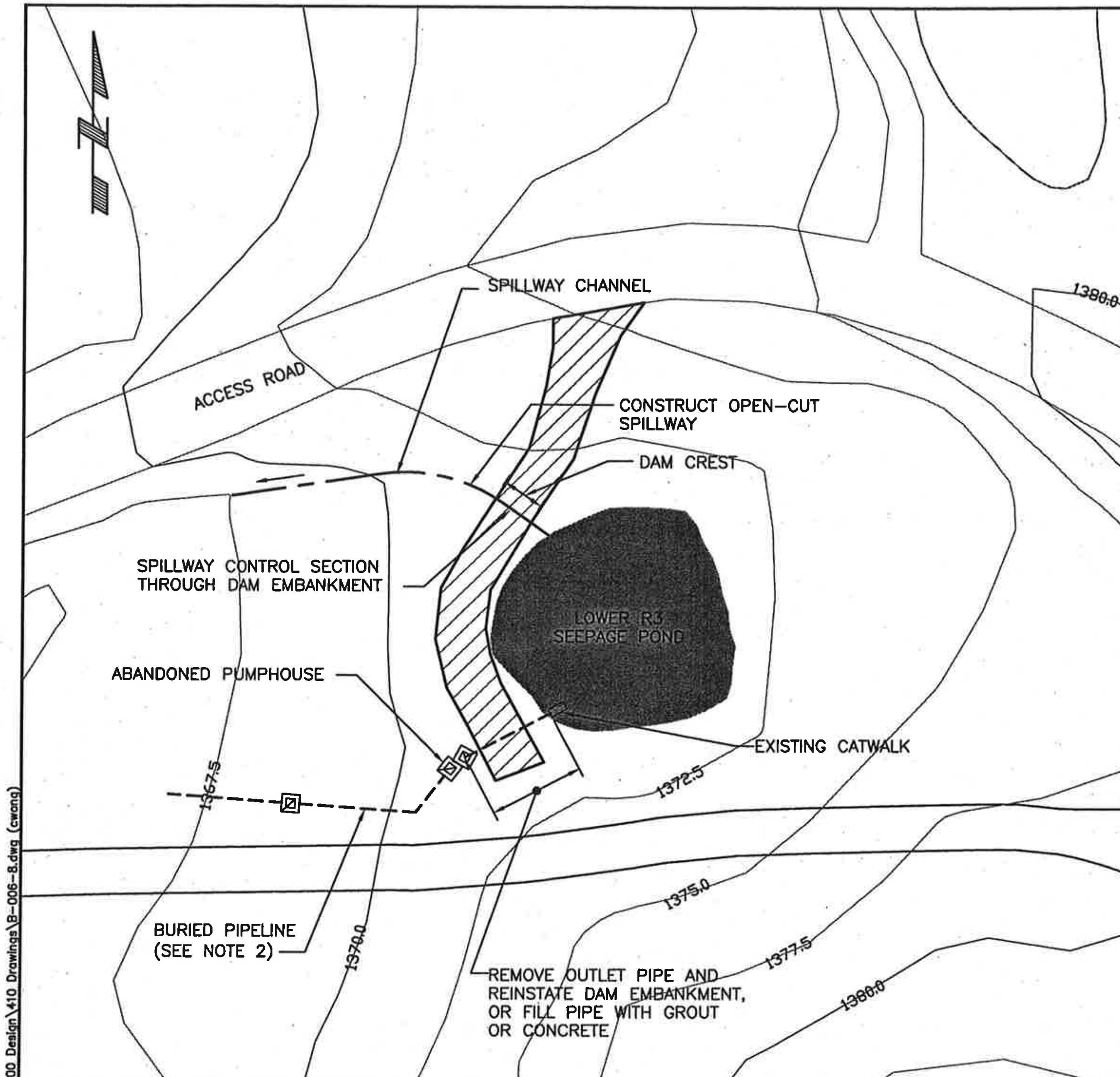
PROJECT
TROJAN CREEK PONDS

TITLE
LOWER R3 SEEPAGE POND PLAN AND DAM SECTION

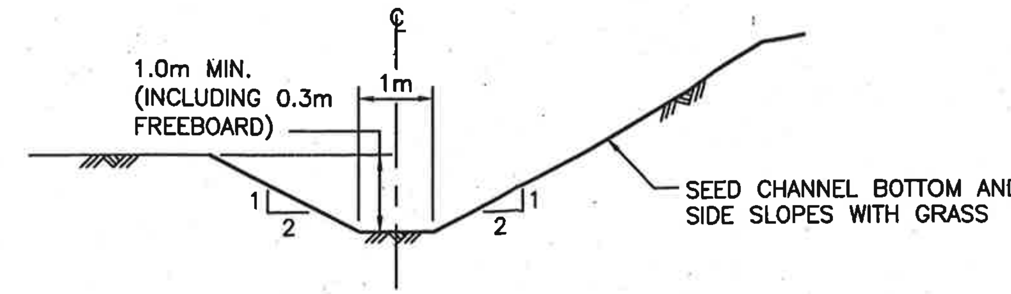
PROJECT No.
M 02341 A3105

FIG. No.
B-002

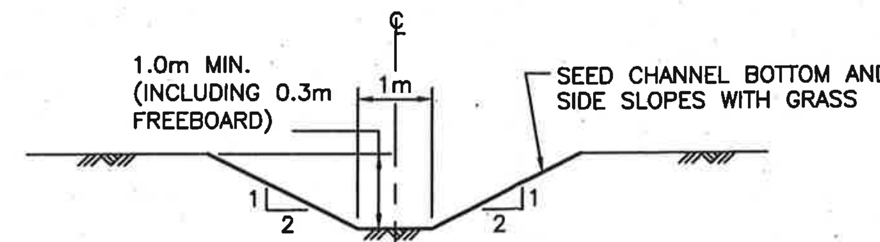
Time: 13:27:53
Date: 3/9/2005
Scale: 1=5(PS)
Drawing File: M:\M02341A3105 - Trojan Creek Ponds\400 Design\410 Drawings\B-001-5.dwg (cwong)
Xrefs: FIG-BASE



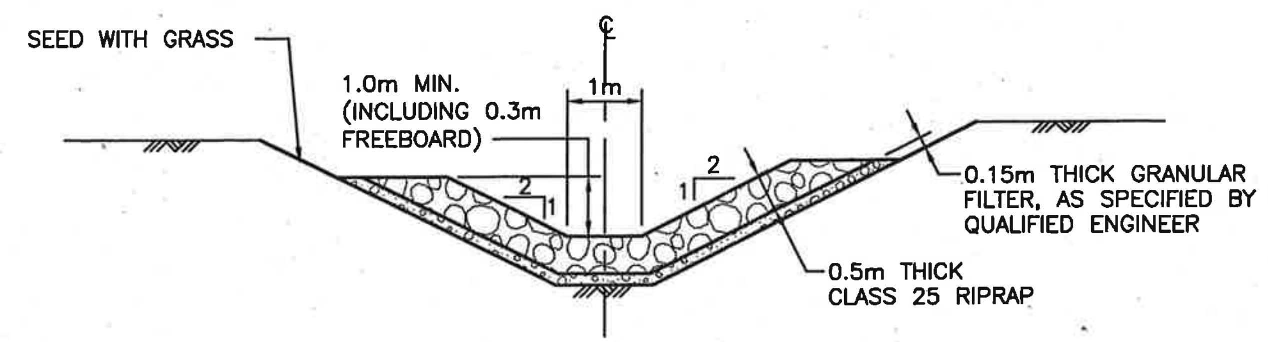
PLAN
SCALE A



SPILLWAY CONTROL SECTION THROUGH DAM
SCALE B



SPILLWAY CHANNEL SECTION FOR 0.5% OR FLATTER BED SLOPE
SCALE B



SPILLWAY CHANNEL SECTION FOR 0.6% TO 10% BED SLOPE
SCALE B

CLASS 25 RIPRAP GRADATION

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

NOTES:

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

SCALE B 0 5m

SCALE A 0 50m

NOT FOR CONSTRUCTION

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

CLIENT: HIGHLAND VALLEY COPPER

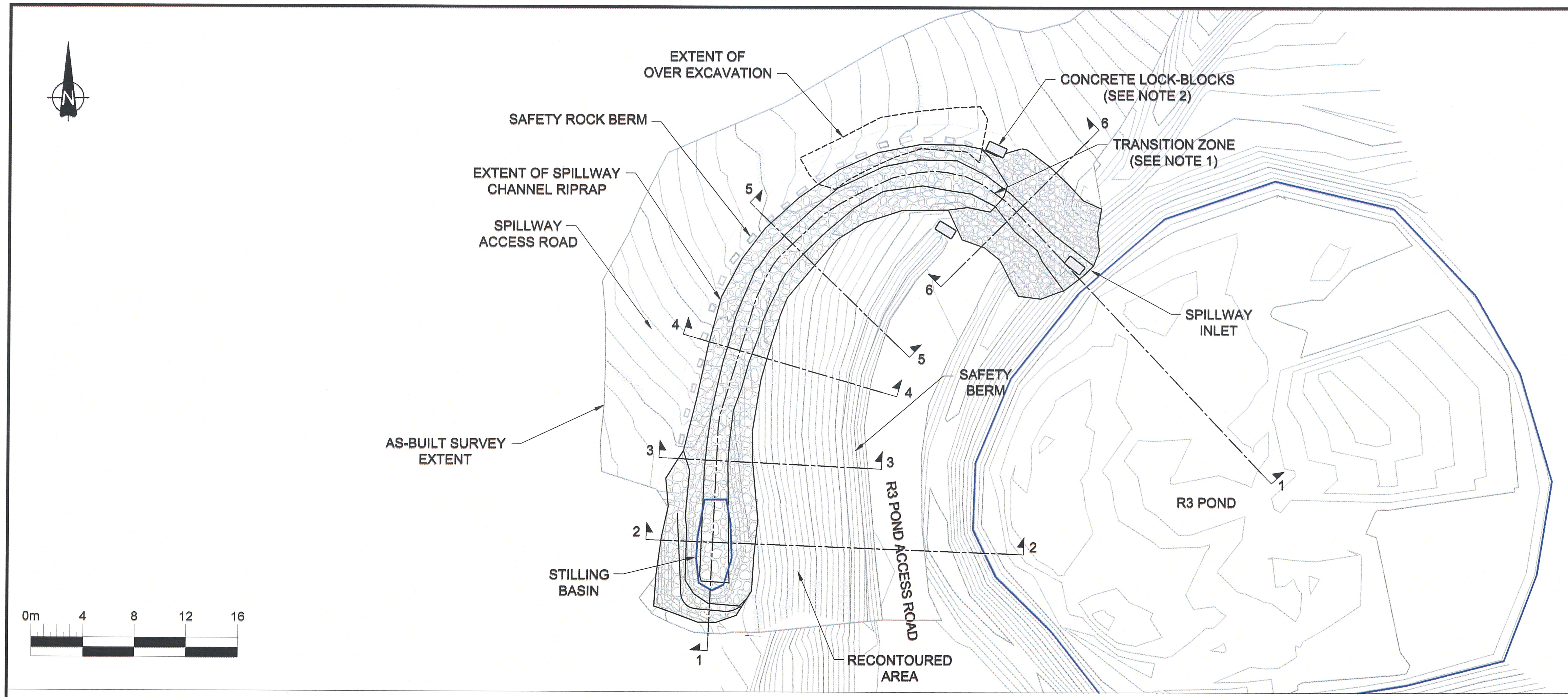
KLOHN CRIPPEN

PROJECT: TROJAN CREEK PONDS

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

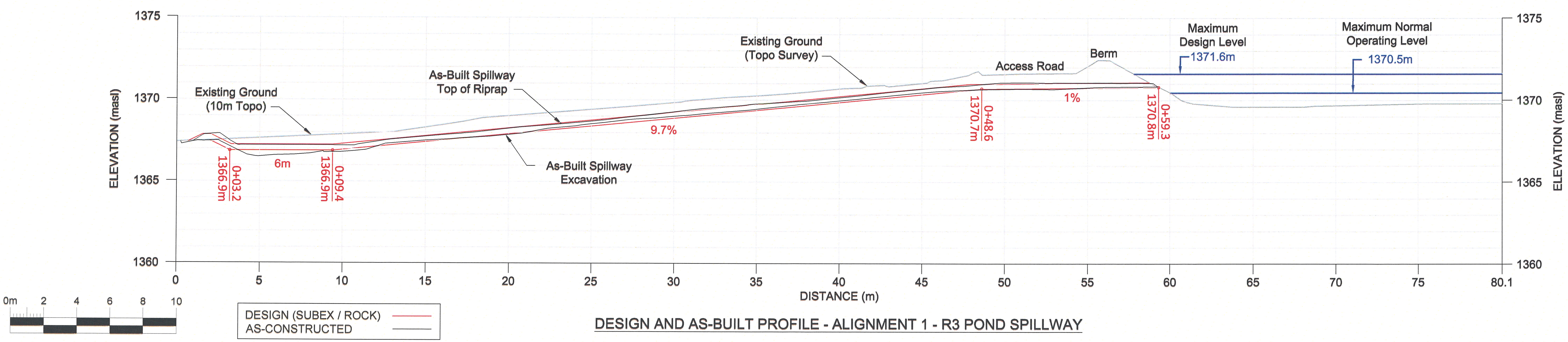
PROJECT No. M 02341 A3105

FIG. No. B-006



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.

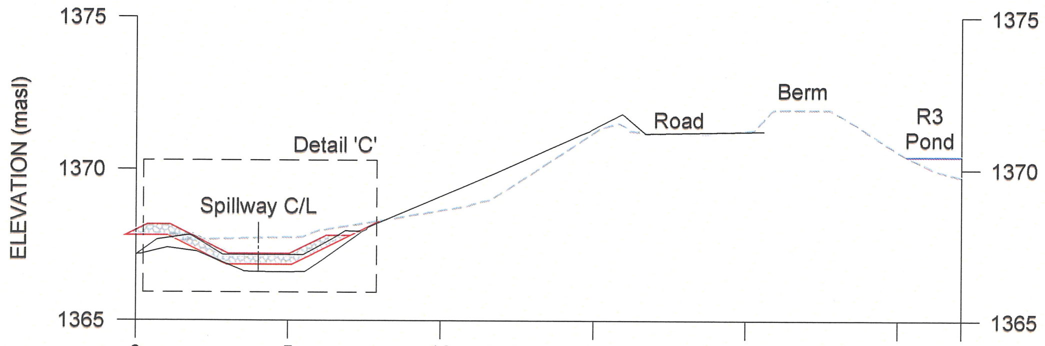


DESIGN AND AS-BUILT PROFILE - ALIGNMENT 1 - R3 POND SPILLWAY

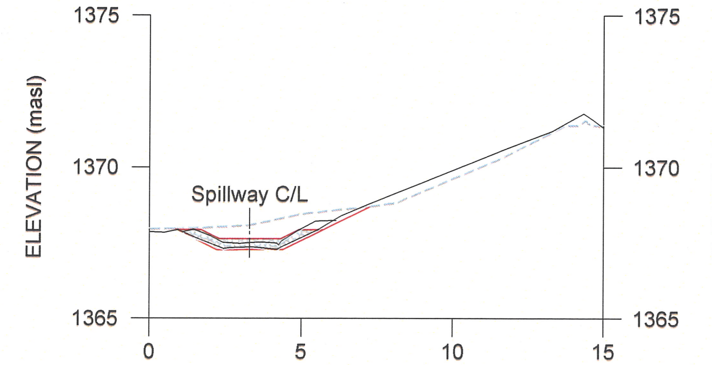
CLIENT: Highland Valley Copper Teck	DWN BY: TH	PROJECT: CONSTRUCTED SPILLWAY - TROJAN - BETHLEHEM RECLAIM 3	DATE: DECEMBER 2013
	CHK'D BY: HY/AF		PROJECT NO: VW1031
AMEC Environment & Infrastructure Suite 600 - 4445 Lougheed Highway Burnaby, BC V5C 0E4 Tel. 604-294-3811 Fax 604-294-4664	DATUM: MINE	TITLE: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

AS-BUILT DRAWINGS

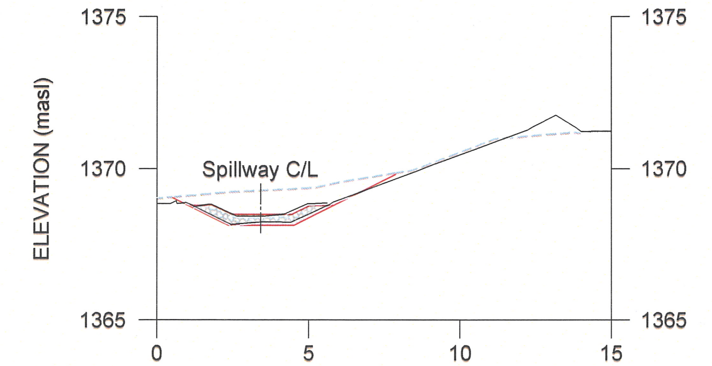
W:\Projects\VW1031 - Tech Highland Valley Copper\Drawings\As-Built Drawings\VW1026-R3-Pond-Berm-Spillway-AsBuilt.Dec.6.dwg - Plan and Profile - Dec. 17, 2013 11:43am - hamid.yousefbeigi



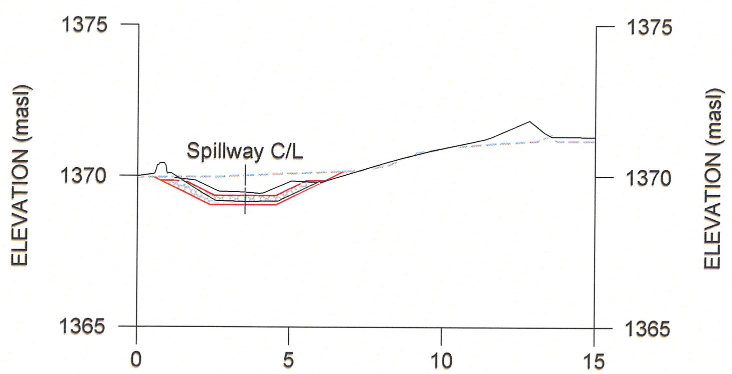
SECTION - ALIGNMENT 2
STILLING BASIN
(See Detail 'C')



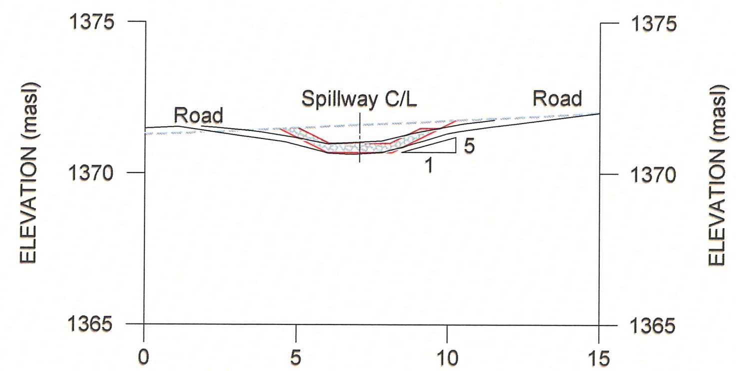
SECTION - ALIGNMENT 3
SPILLWAY
(See Detail 'B')



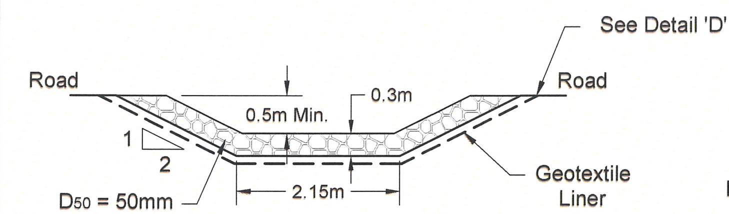
SECTION - ALIGNMENT 4
SPILLWAY
(See Detail 'B')



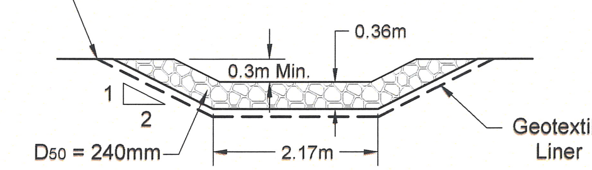
SECTION - ALIGNMENT 5
SPILLWAY
(See Detail 'B')



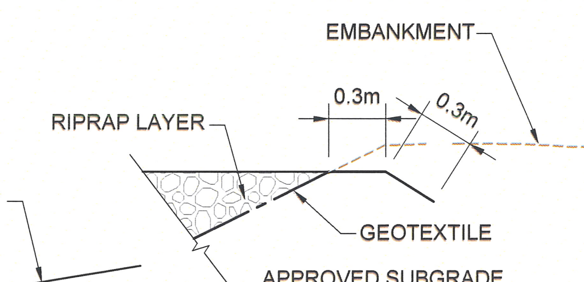
SECTION - ALIGNMENT 6
R3 POND BERM / ACCESS ROAD
(See Detail 'A')



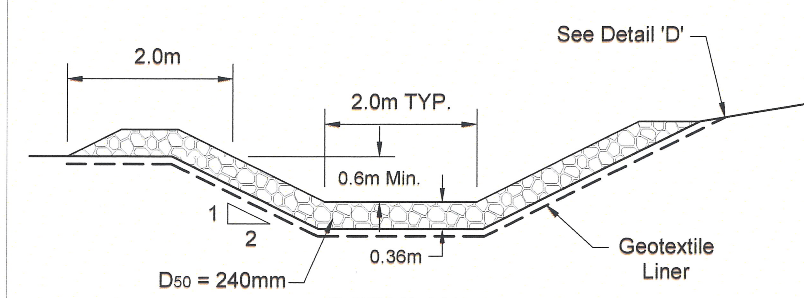
DETAIL 'A'
TYPICAL SECTION - SPILLWAY
CHANNEL 1% GRADE



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



DETAIL 'D'
TYPICAL SECTION - ANCHORE
DETAIL



DETAIL 'C'
TYPICAL SECTION - STILLING
BASIN

0m 1 2 3 4

DESIGN (SUBEX / ROCK)	——
AS-CONSTRUCTED	——

0m 4 8 12 16

NOTES:

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

AS-BUILT DRAWINGS

CLIENT: Highland Valley Copper
Teck

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

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

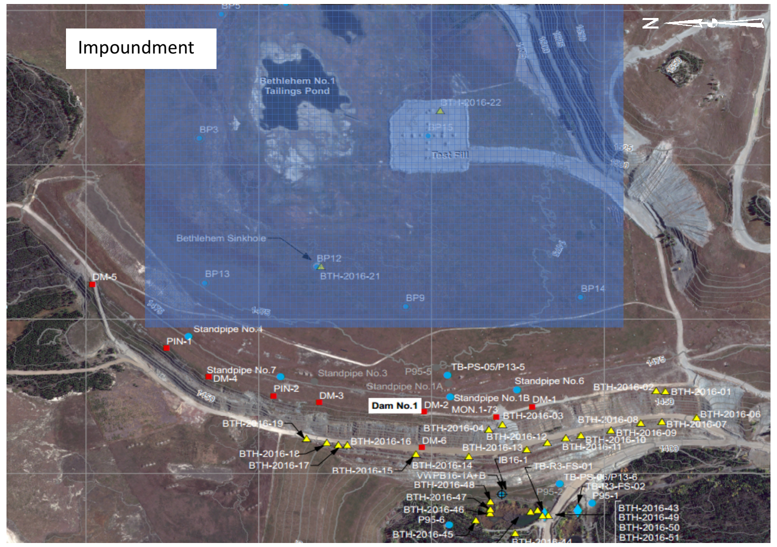
PROJECT: CONSTRUCTED SPILLWAY - TROJAN - BETHLEHEM RECLAIM 3

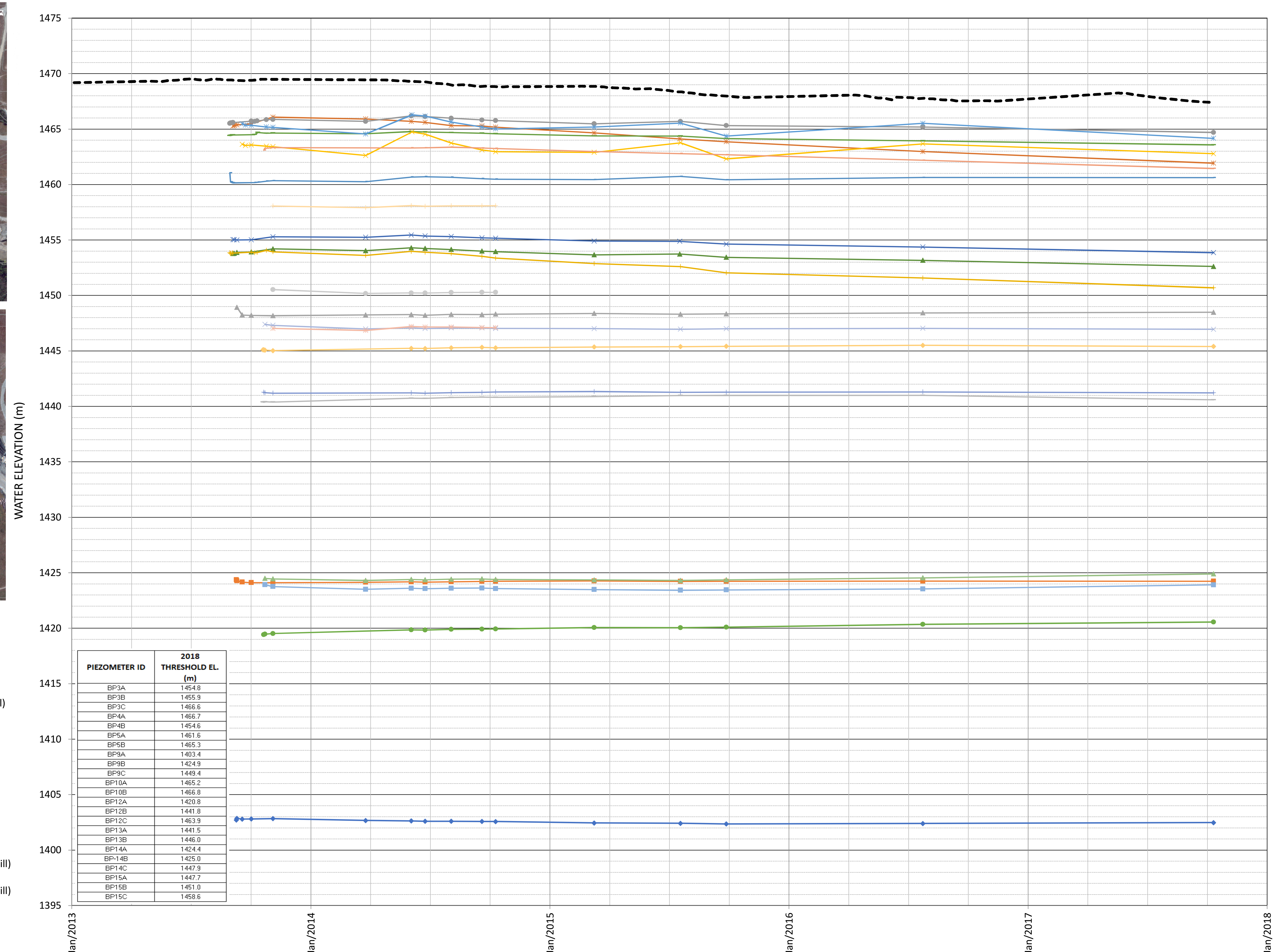
TITLE: AS CONSTRUCTED CHANNEL SECTIONS AND TYPICAL DETAILS

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

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:

- 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:

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY
2017 DAM SAFETY INSPECTION

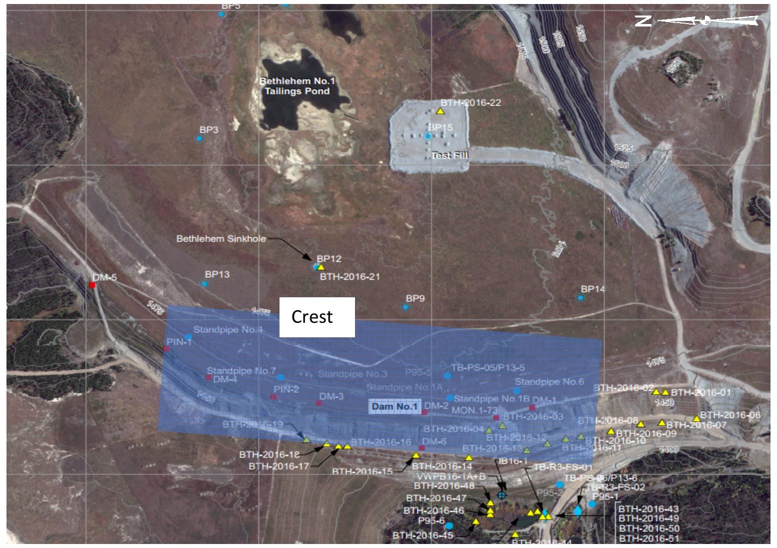
TITLE
DAM No. 1 PIEZOMETRIC DATA
2013-2017

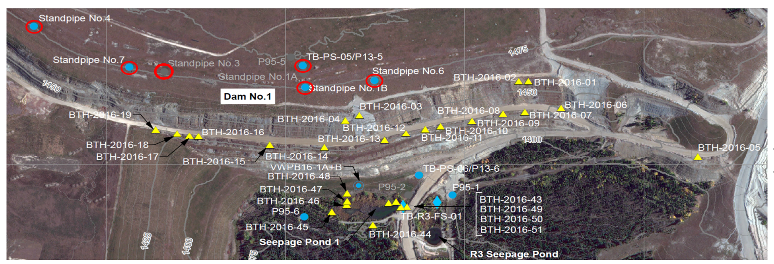
IMPOUNDMENT

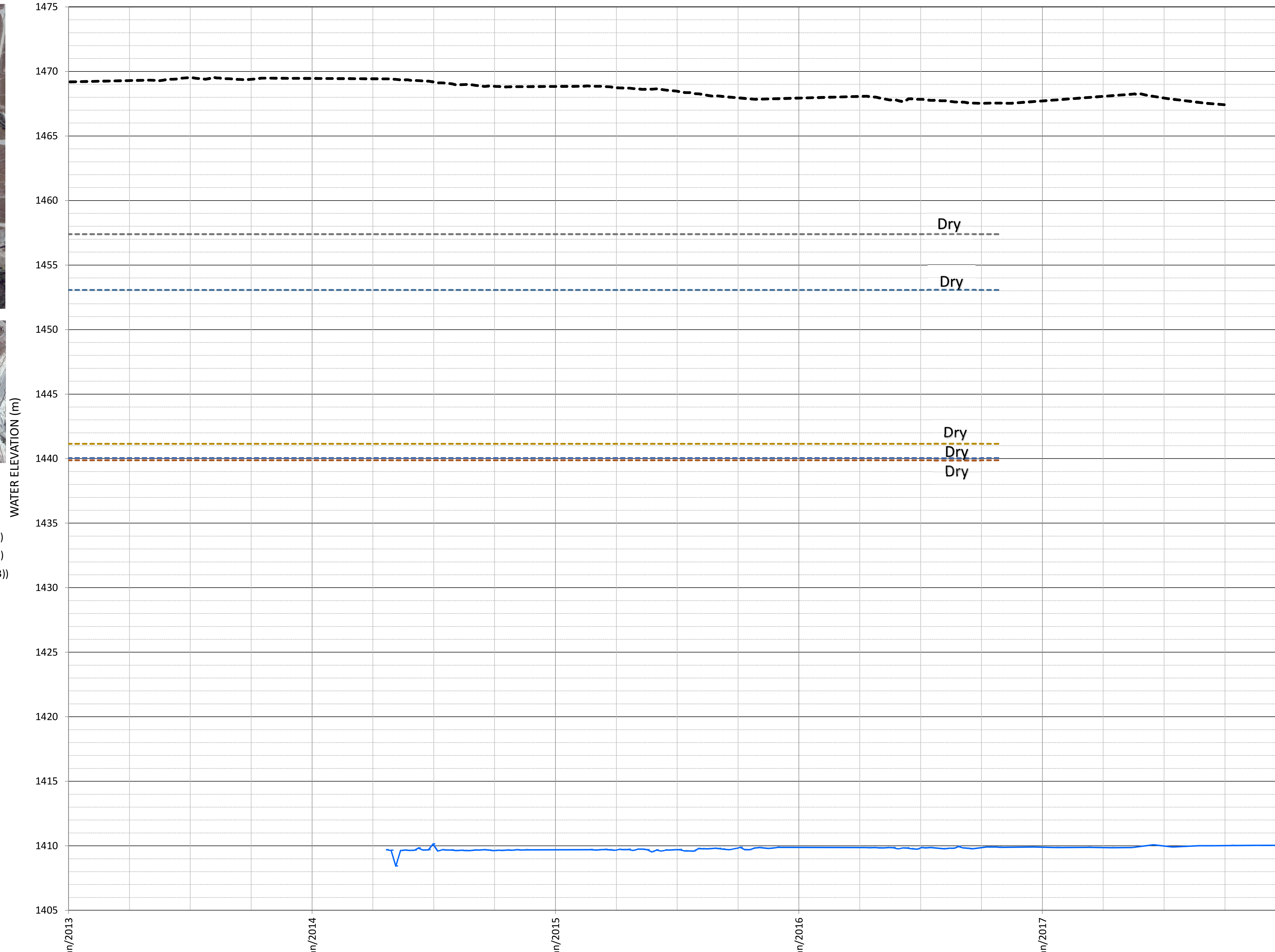
PROJECT No. M02341B26

FIG No. IV-1

March 26, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Bethlehem\[180326 Bethlehem Piezo.xlsx]Piezo Data Entry No.1







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 2017 DAM SAFETY INSPECTION

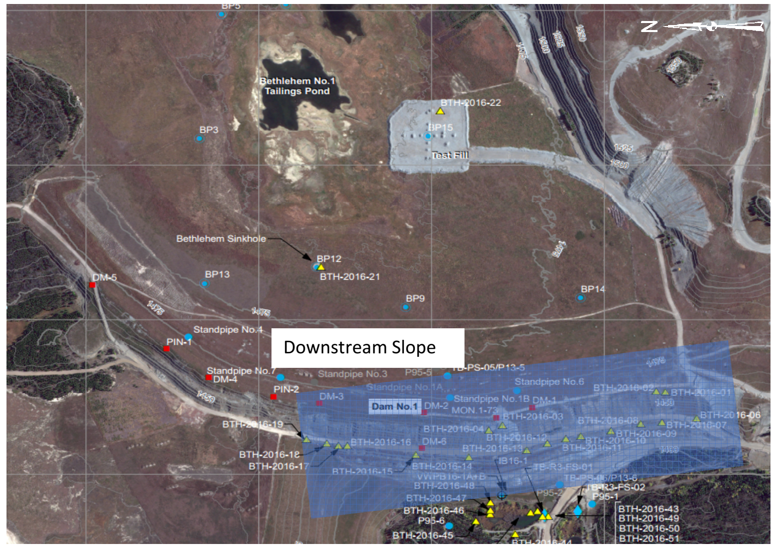
TITLE: DAM No. 1 PIEZOMETRIC DATA 2013-2017

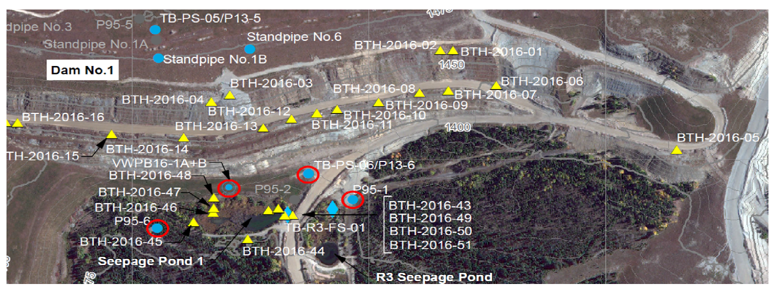
CREST

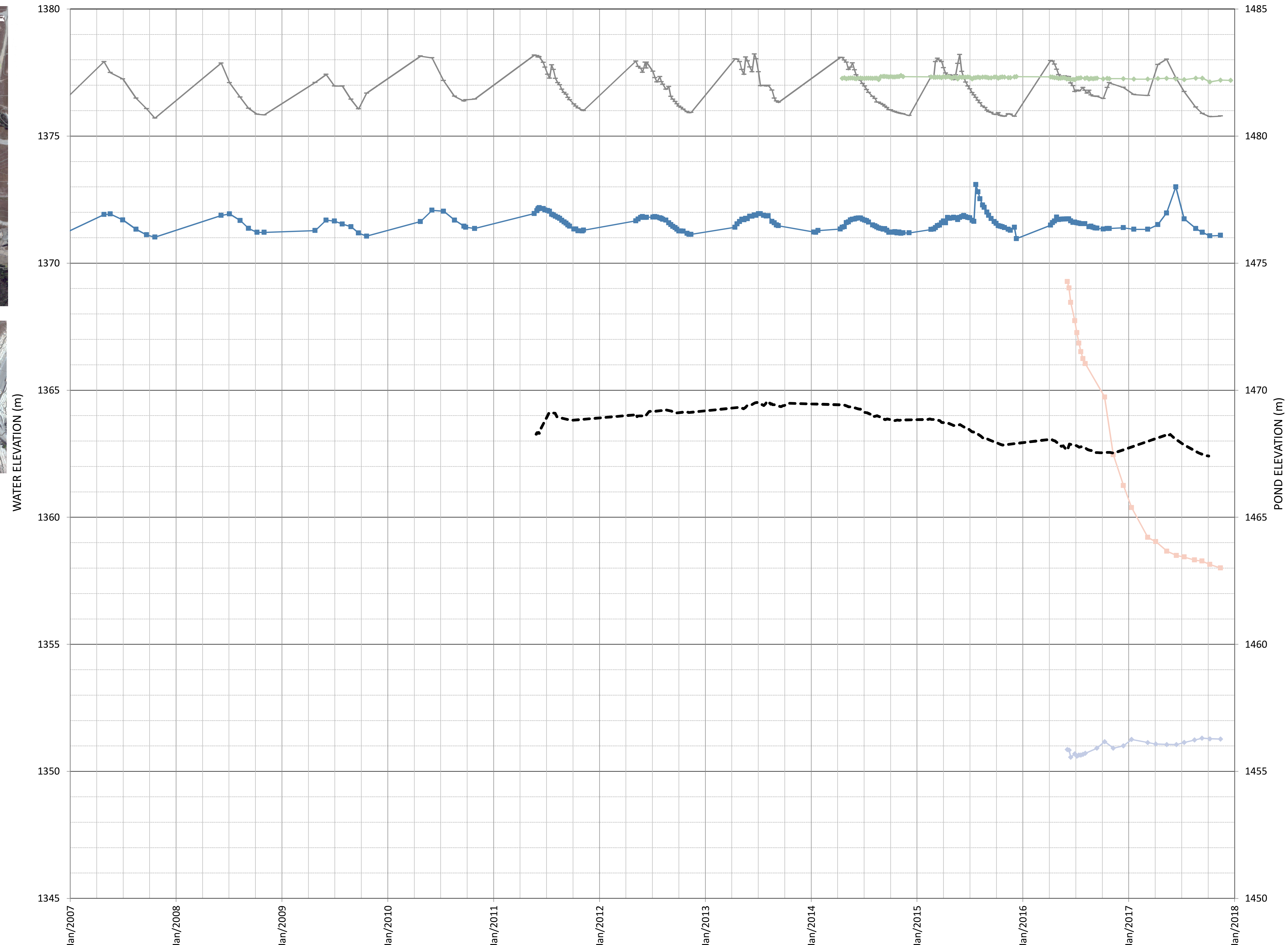
PROJECT No. M02341B26

FIG No. IV-2

February 16, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Bethlehem\[180216 Bethlehem Piezo.xlsx]BLD DOWNSTREAM TOE







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

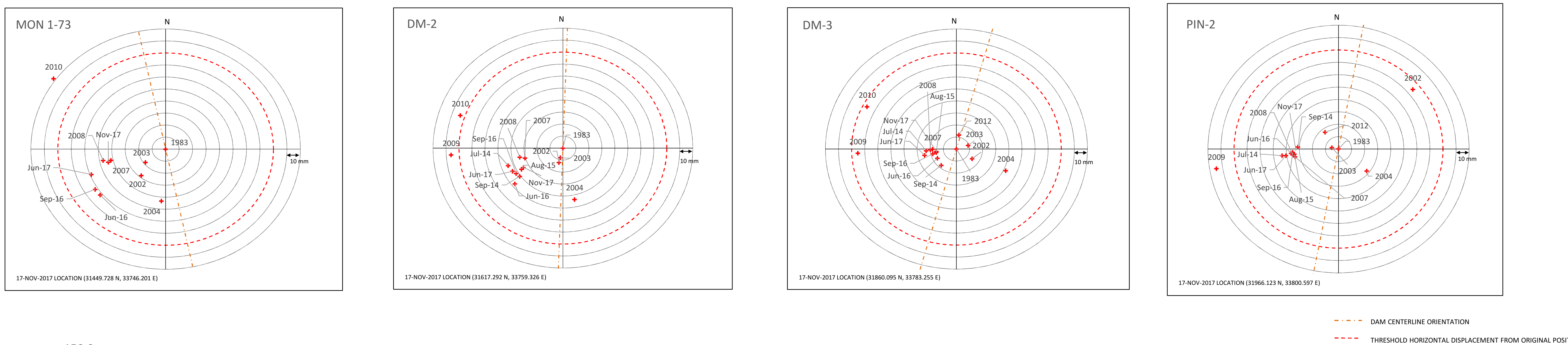
Klohn Crippen Berger

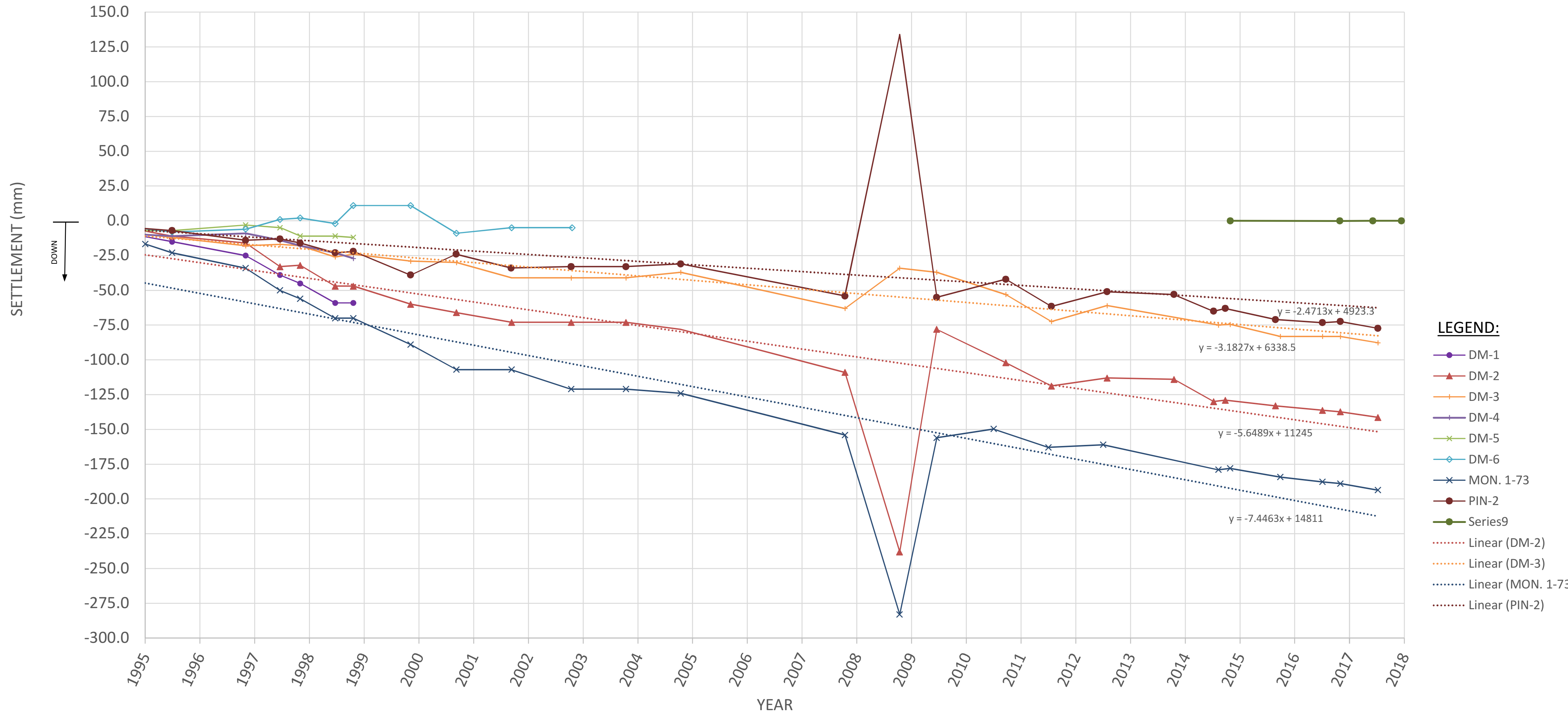
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

TITLE: DAM No. 1 PIEZOMETRIC DATA 2007-2017

DOWNSTREAM SLOPE

PROJECT No. M02341B26 | FIG No. IV-3





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

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.

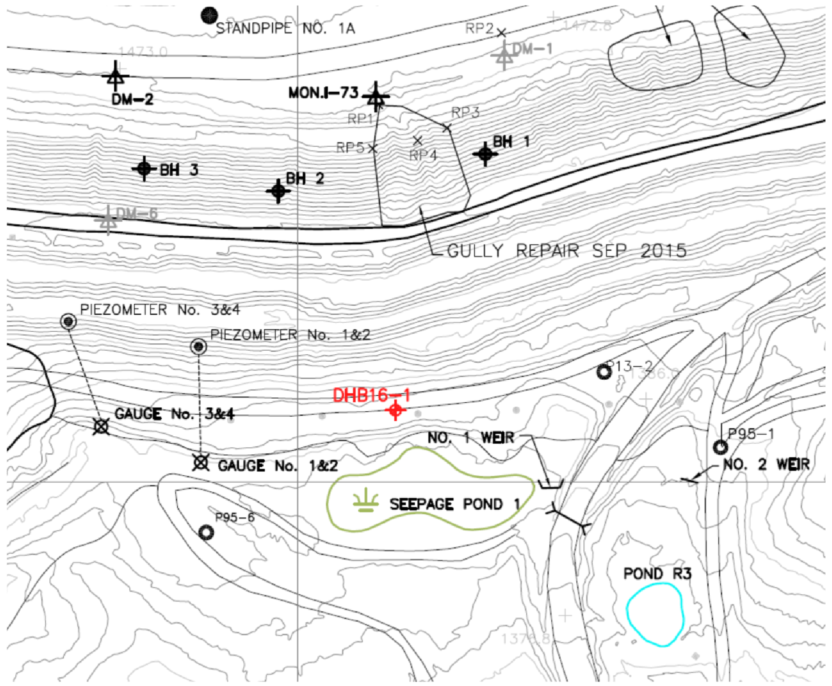
CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

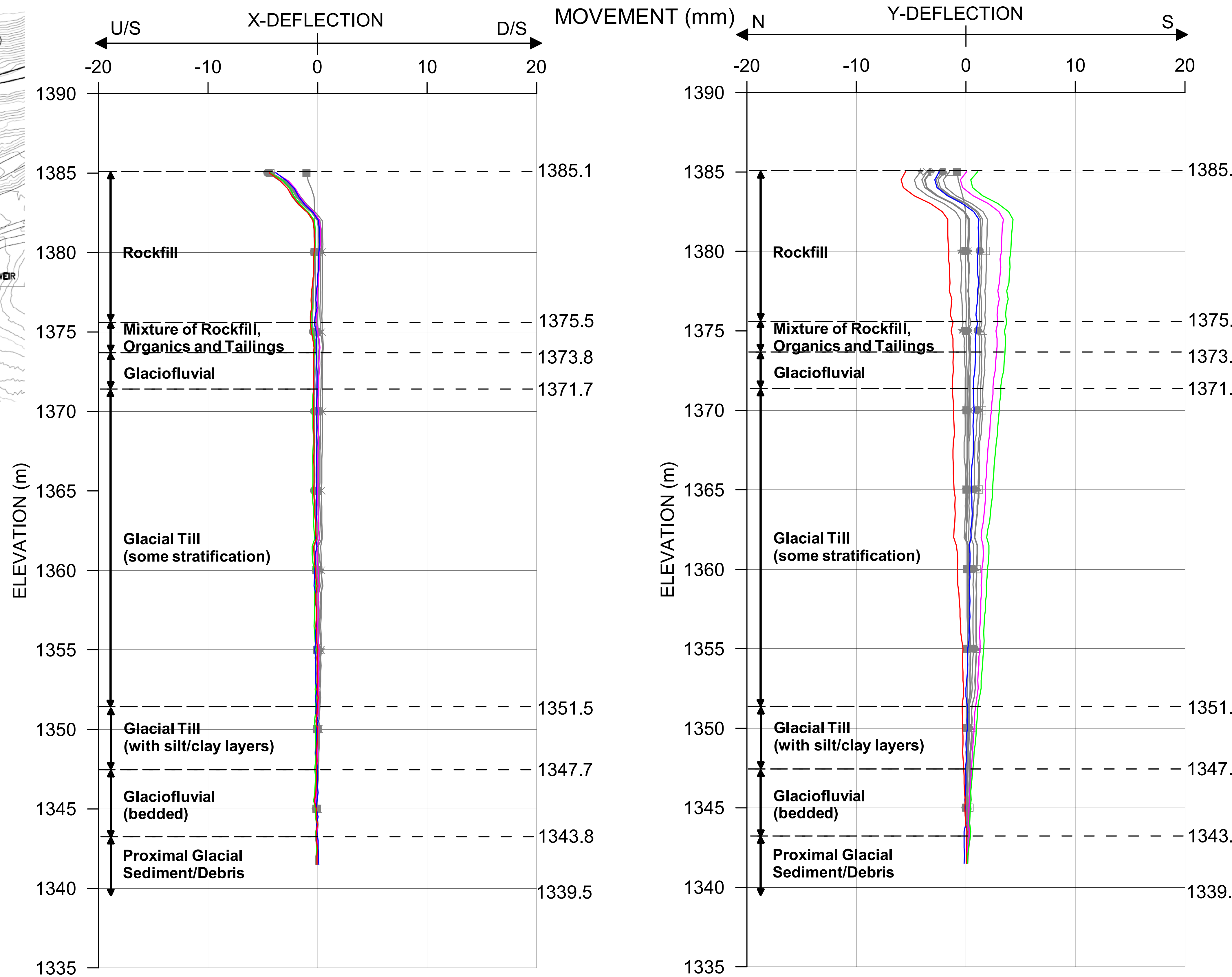
Klohn Crippen Berger

PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

TITLE: DAM NO. 1 SURVEY MONUMENT READINGS

PROJECT No. M02341B26 | FIG No. IV-4





LEGEND

- June 7, 2016
- July 6, 2016
- August 17, 2016
- September 19, 2016
- October 19, 2016
- November 9, 2016
- December 20, 2016
- January 17, 2017
- April 12, 2017
- June 23, 2017
- September 20, 2017
- October 16, 2017

NOTES:

1) Initial reading = June 7, 2016
2) Not all readings are plotted

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

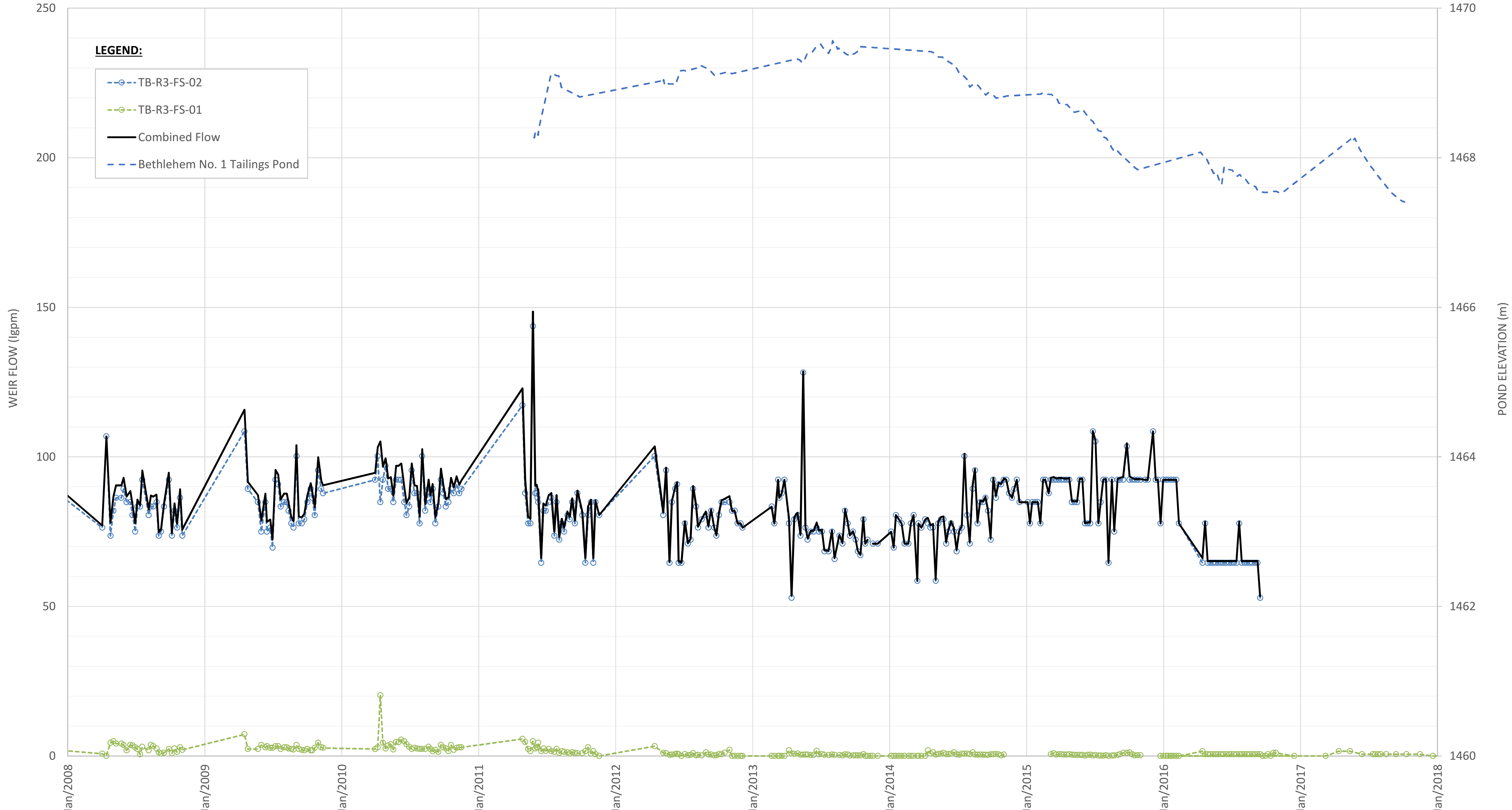
PROJECT
DAM NO. 1 TAILINGS STORAGE FACILITY
2017 INCLINOMETER DATA

TITLE
INCLINOMETER CUMULATIVE DISPLACEMENT PROFILE
IB16-1

PROJECT No. M02341B26

FIG No. IV-5

Date: November 23, 2017
\\int.klohn.com\ProjData\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Inclinometer Data\Inclinometer processing\Bethlehem Complex\Dam No. 1\IB16-1\Grapher Files\IB16-1.grf

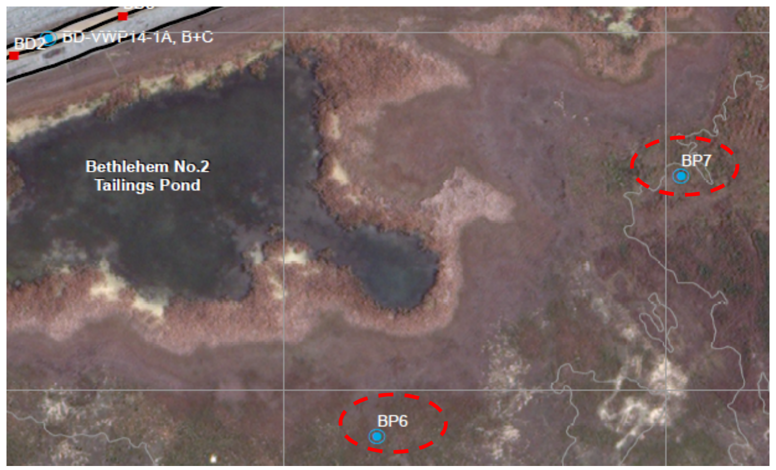


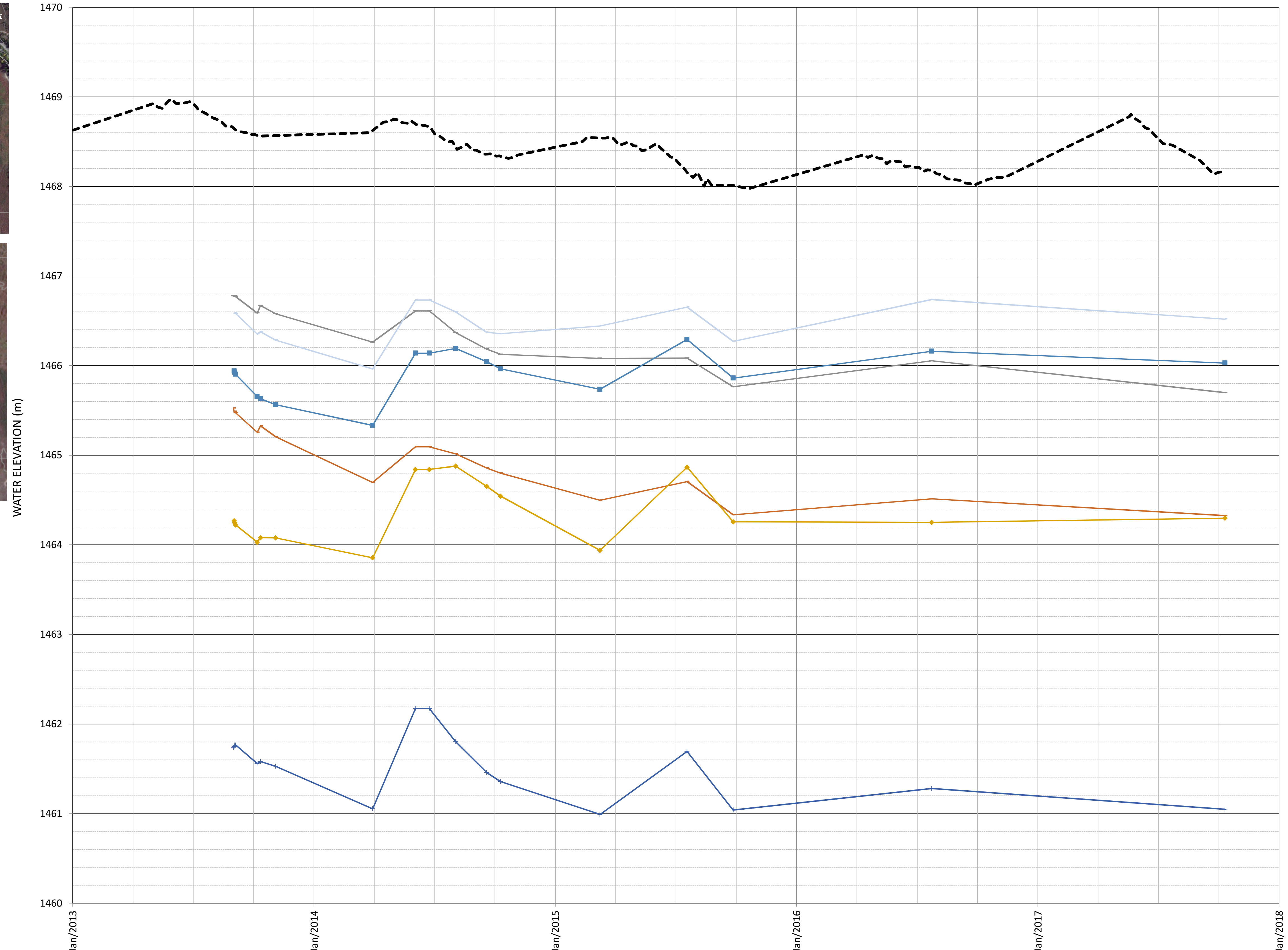
NOTES:

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	PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: DAM NO. 1 WEIR FLOWS
PROJECT No. M02341B26	FIG No. IV-6

March 28, 2018
Z:\MV\CR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Seepage Data\Bethlehem\[180328 Beth Weir.xlsx]Weirs





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:

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

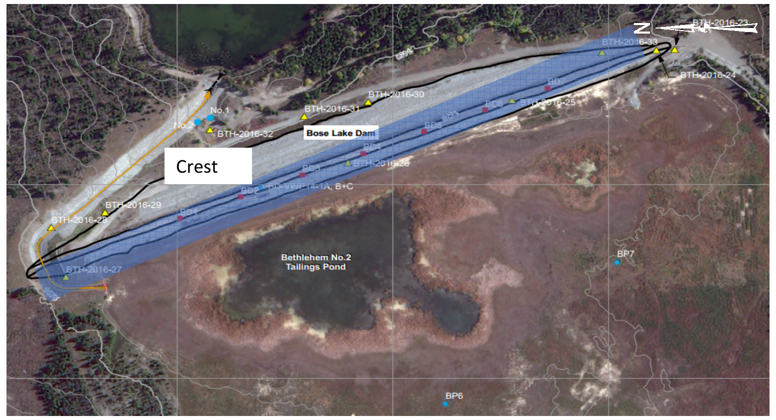
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

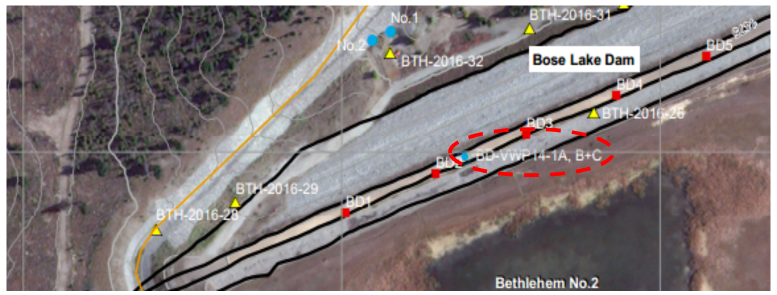
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA 2013-2017

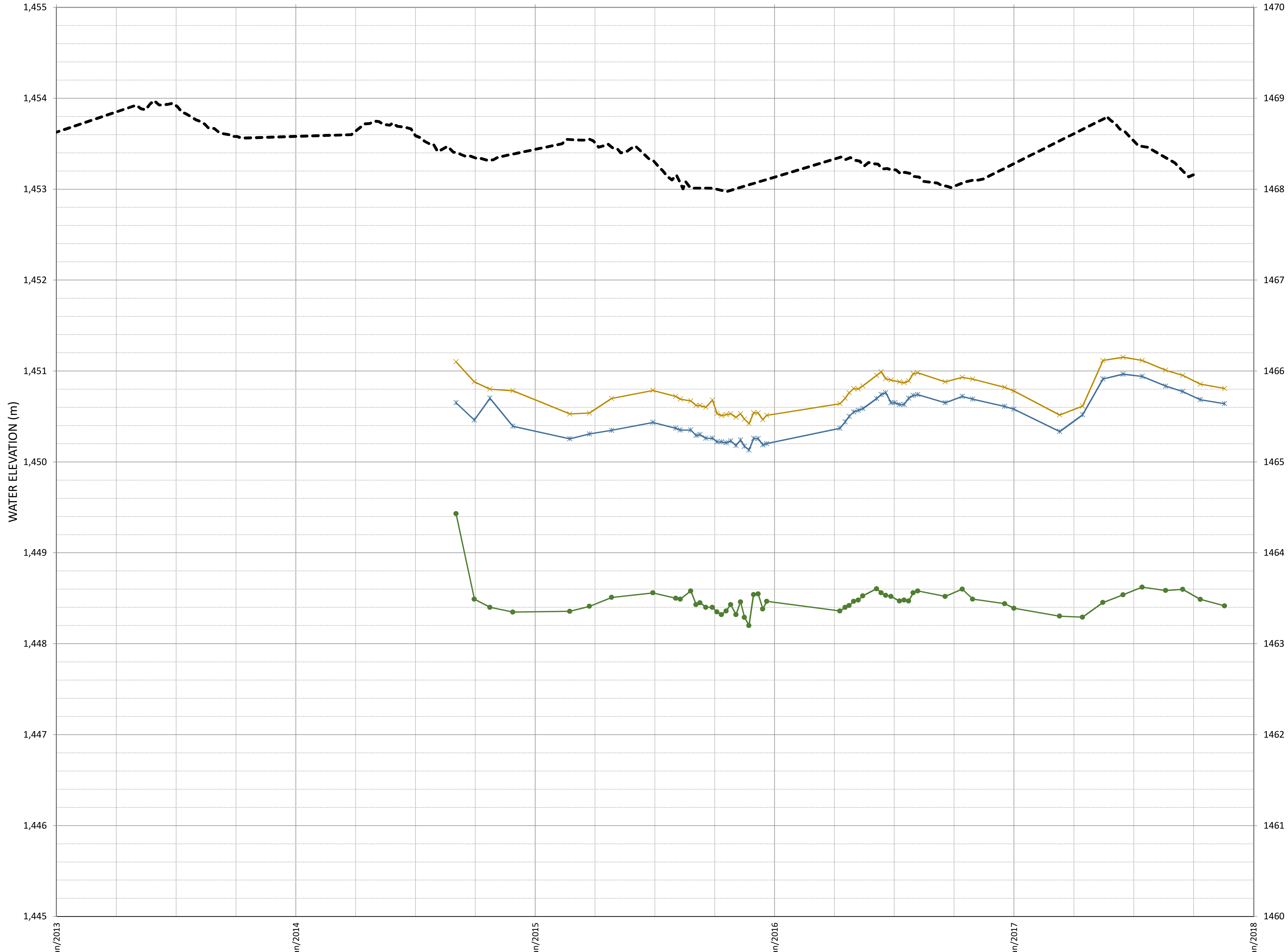
IMPOUNDMENT

PROJECT No. M02341B26 | FIG No. IV-7

March 26, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Bethlehem\[180326 Bethlehem Piezo.xlsx]Piezo Data Entry No.1







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.

March 1, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Bethlehem\(180219 Bethlehem Piezo.xlsx)Piezo Data Entry BLD

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

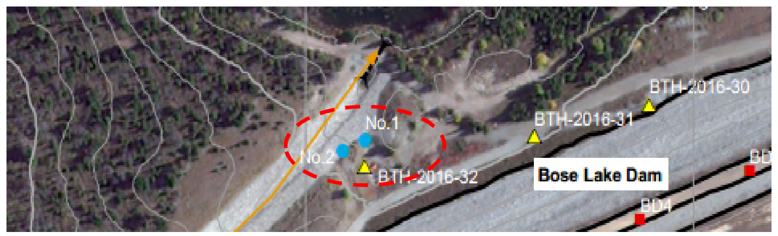
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

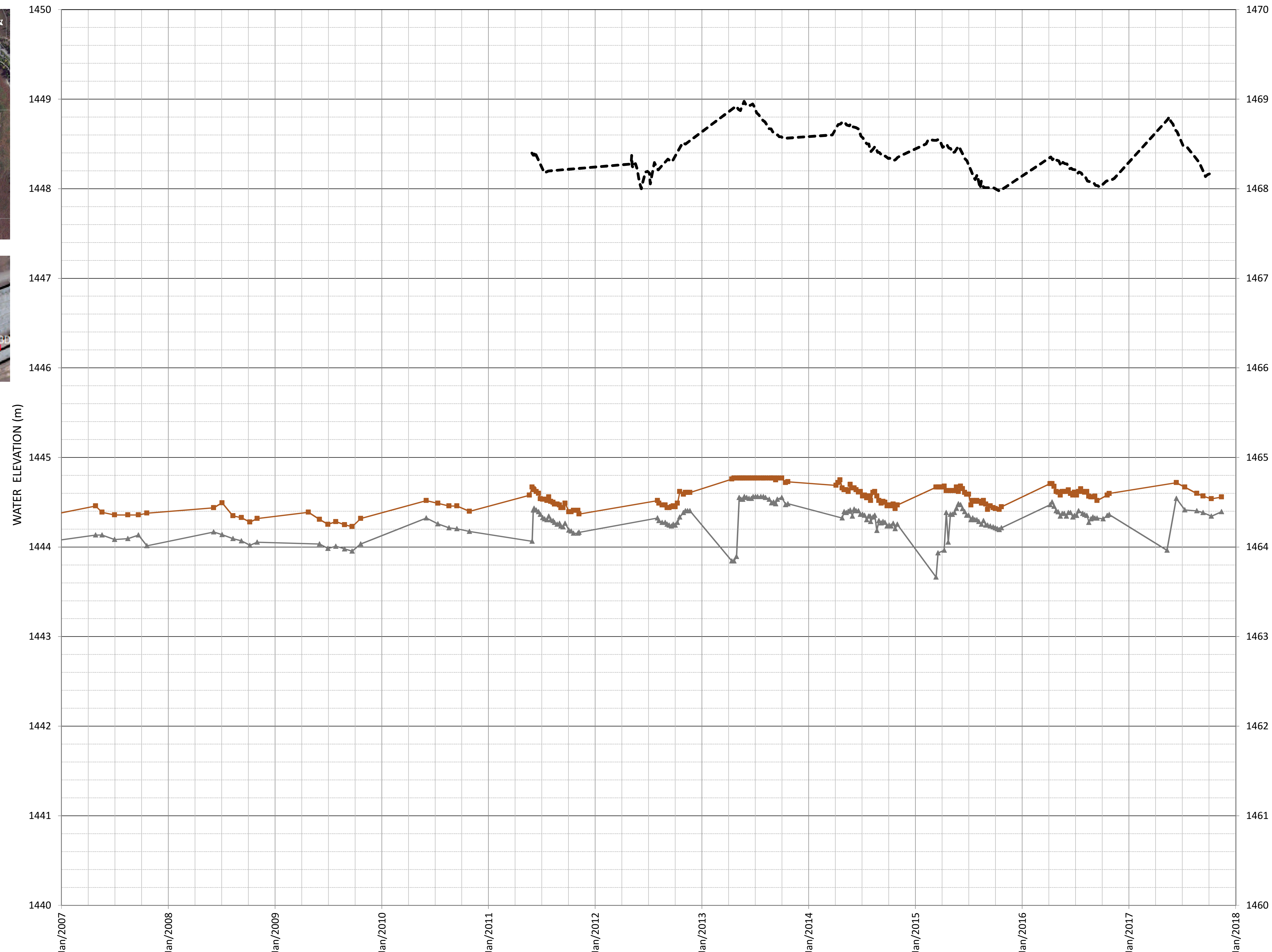
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA 2013-2017

CREST

PROJECT No. M02341B26

FIG No. IV-8





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

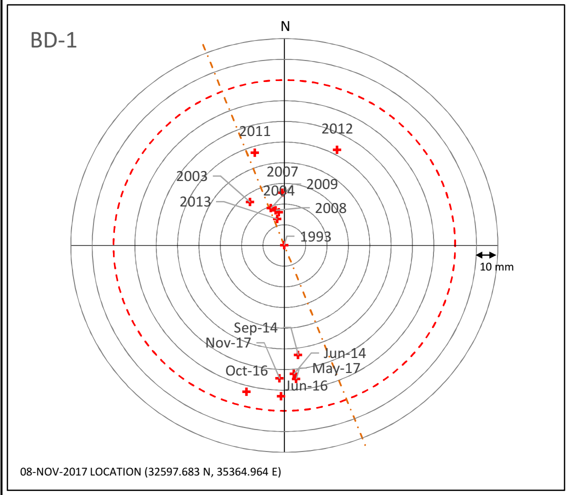
PROJECT: BETHLEHEM NO. 1 TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

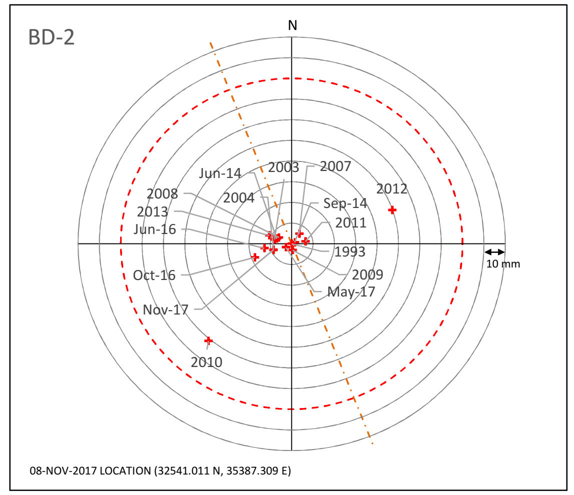
TITLE: BOSE LAKE DAM PIEZOMETRIC DATA 2007-2017

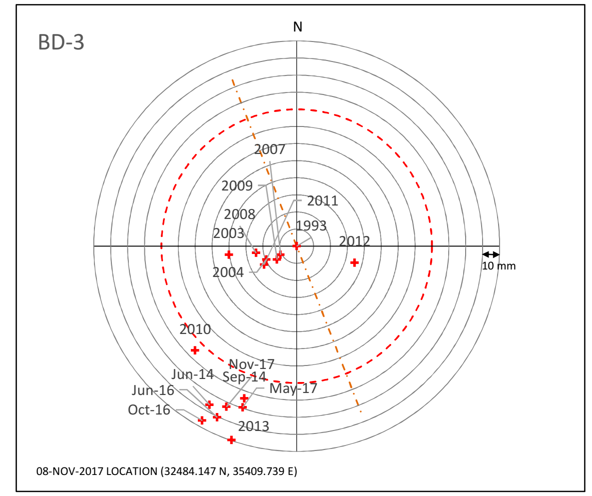
DOWNSTREAM TOE

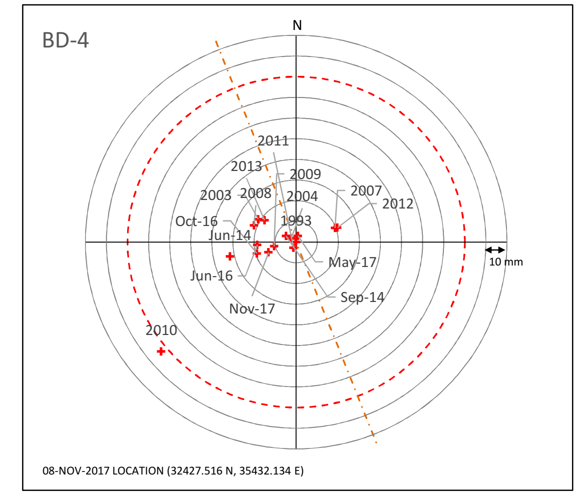
PROJECT No. M02341B26 | FIG No. IV-9

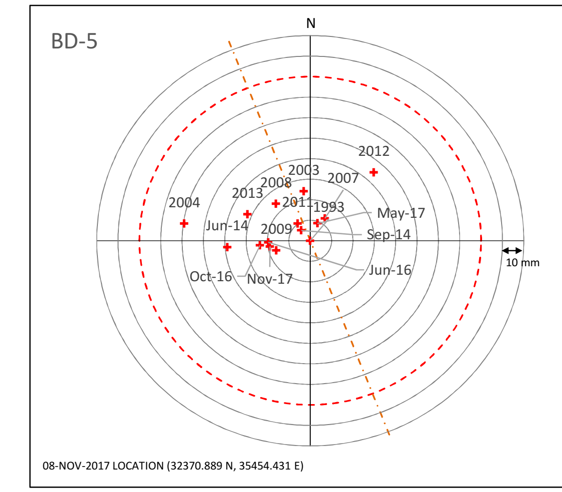
February 16, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Bethlehem\[180216 Bethlehem Piezo.xlsx]BLD DOWNSTREAM TOE

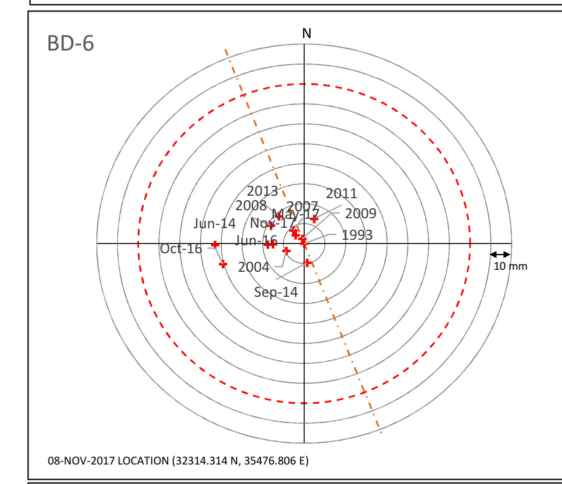


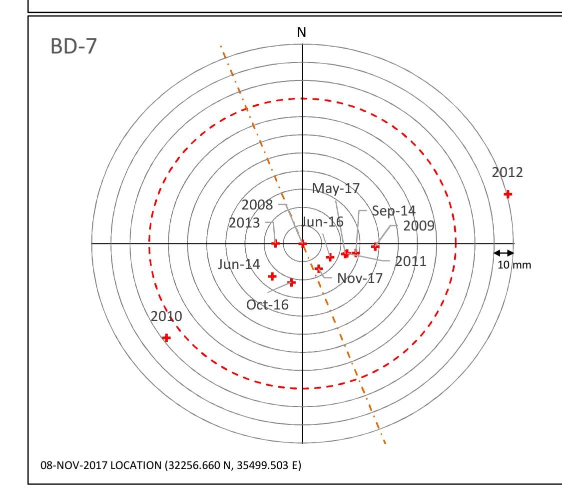


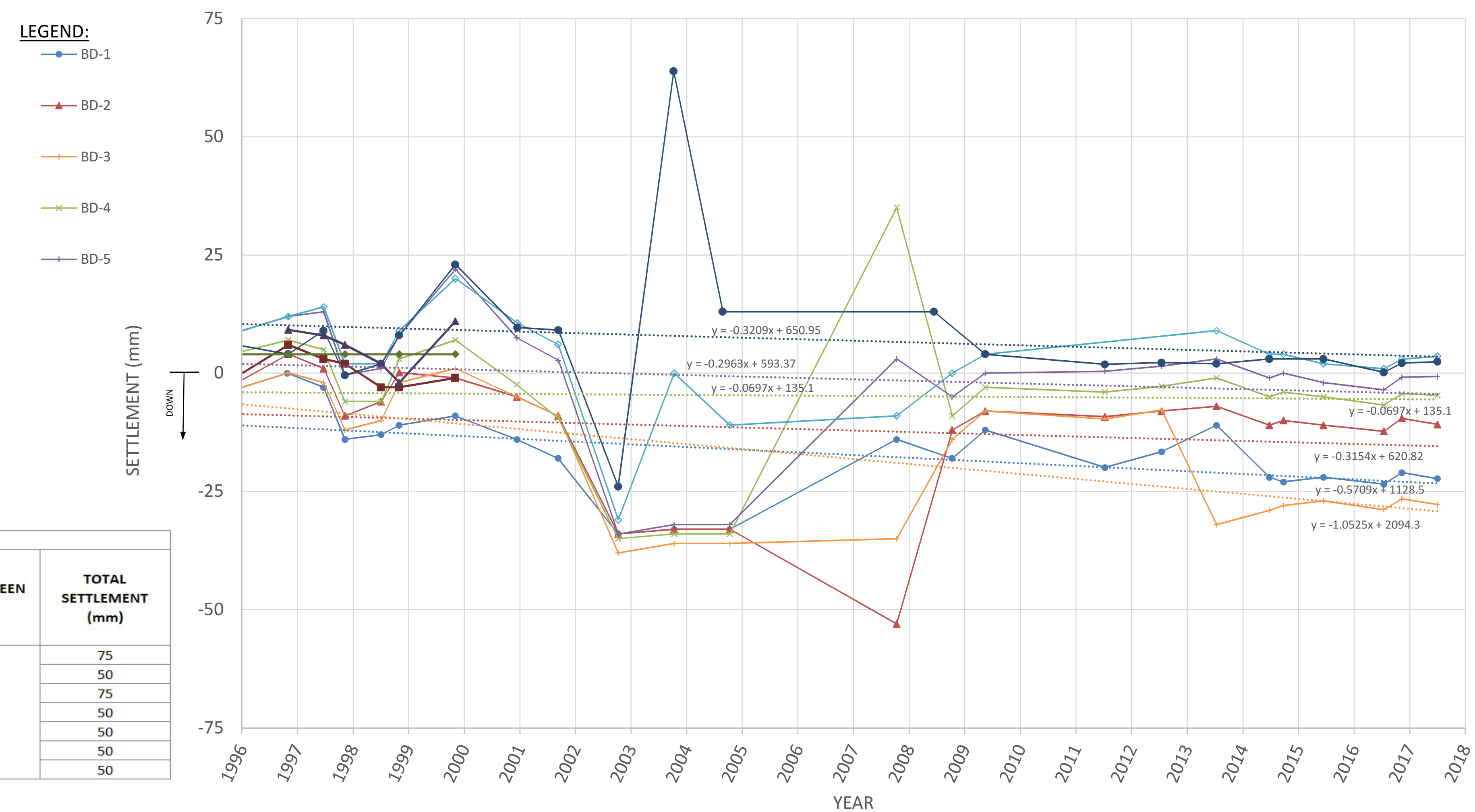












DAM CENTERLINE ORIENTATION

THRESHOLD HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION

	2018 THRESHOLDS		
MONUMENT ID	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.

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
BETHLEHEM BOSE LAKE DAM TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

TITLE
BOSE LAKE DAM SURVEY MONUMENT READINGS

PROJECT No. M02341B26

FIG No. IV-10

February 19, 2018
Z:\MV\CR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Monument Data\Bethlehem\[180219 BoseLakeDamMonitoring.xlsm]Fig V-10

APPENDIX V

Map of Water Quality Monitoring Points

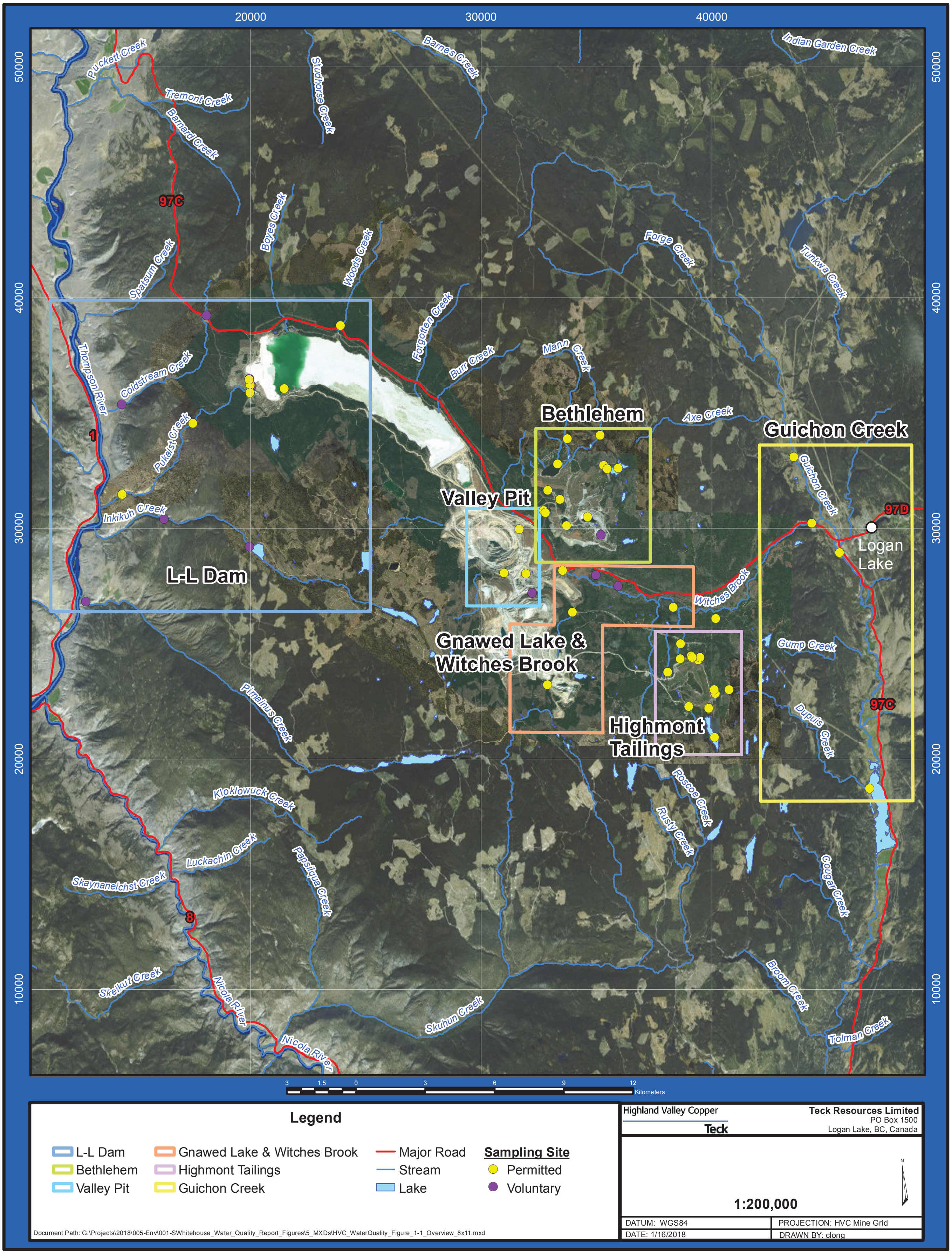


Figure 1-1 Water Quality Monitoring Sites Highland Valley Copper, 2017

Figure 3.2-17 Water Quality Monitoring Sites in the Bethlehem Area, Highland Valley Copper, 2017

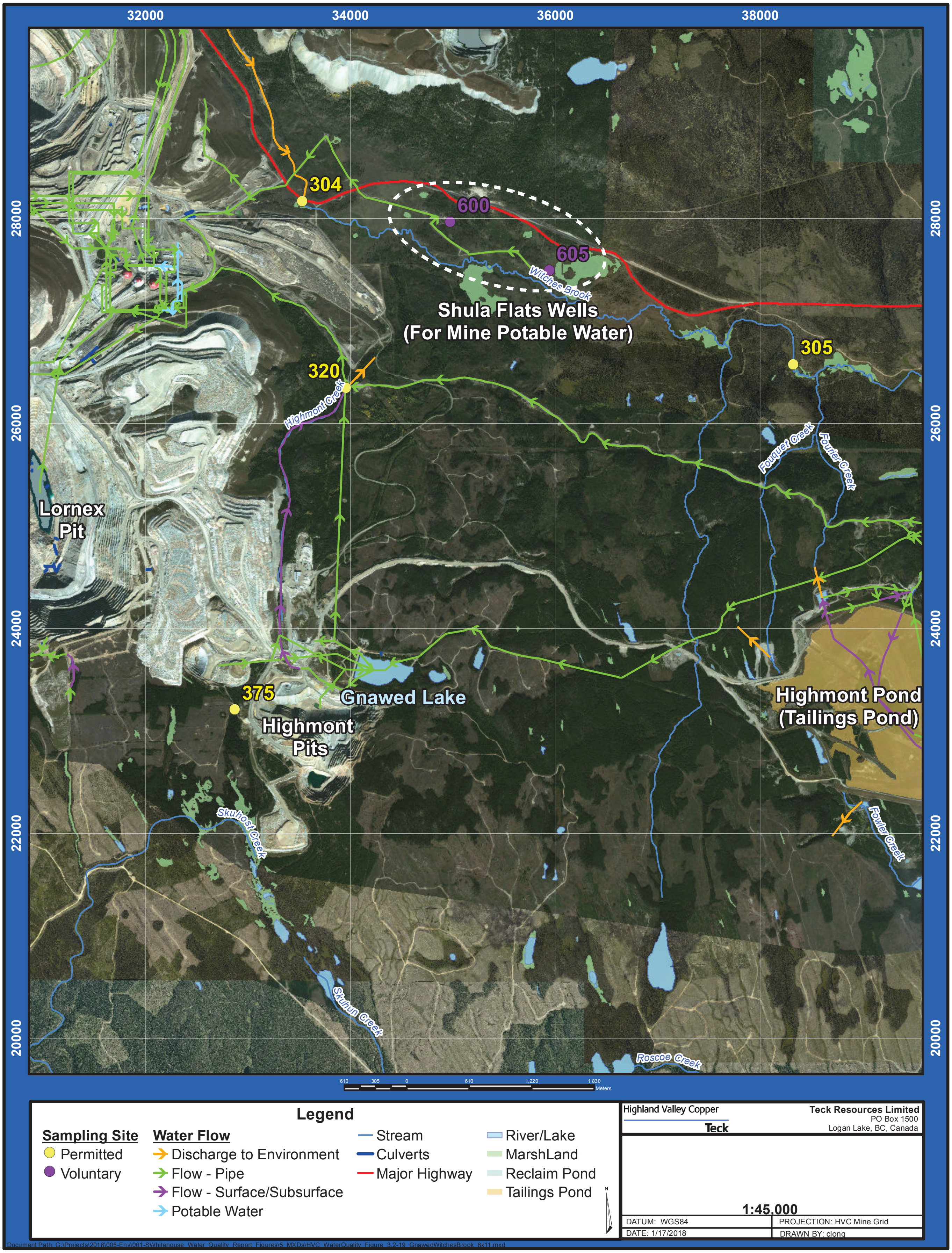


Figure 3.2-26 Water Quality Monitoring Sites in the Witches Brook and Gnawed Lake Area, Highland Valley Copper, 2017