Klohn Crippen Berger

Teck Highland Valley Copper Partnership

2017 Dam Safety Inspection Report

Trojan Tailings Storage Facility

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March 2018

Klohn Crippen Berger

March 26, 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
Trojan Tailings Storage Facility

We are pleased to submit the 2017 Dam Safety Inspection report for the Trojan 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

Trojan Tailings Storage Facility

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) were engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2016 Dam Safety Inspection (DSI) of the Trojan 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 Superintendent, is the TSF Qualified Person (as defined by the Code) for Trojan Dam.

The DSI includes the Trojan Dam and two seepage dams (R4 Seepage Pond Dam and Lower Trojan Dam). The Fish Spawning Channel Pond Dam upstream of the impoundment was intentionally 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 Trojan TSF is located 4 km north of the operating mill. The Trojan TSF is a reclaimed, inactive facility constructed in 1973 and operated until 1989. THVCP continue ongoing surveillance of the site including environmental sampling, visual inspections and maintenance activities. Under this level of site presence, the Trojan Dam 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 Trojan Dam comprises a rockfill starter dam which was raised in an upstream manner with cyclone sand. A sand and gravel filter zone separates the starter dam rockfill and the cycloned tailings sand. A pond is present in the impoundment continuously which is offset a minimum 200 m from the dam crest. The R4 Seepage Pond Dam, located downstream from Trojan Dam, collects seepage from Trojan Dam toe. The Lower Trojan Dam, located downstream from R4 Seepage Pond, collects local runoff and flows from the R3 Reclaim Pond (from Bethlehem No. 1 TSF) and from R4 Seepage Pond.

Trojan Dam has been assigned a “Very High” consequence category as defined by CDA (2013). The downstream seepage dams have been assigned a “Low” consequence category as defined by CDA (2013). There were no significant changes to the key geotechnical or hydrotechnical hazards during 2016. 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.

The free water pond, located in the center of the impoundment, varies seasonally by up to 2.0 m based on historic records (1.5 m seasonal variance in 2017). THVCP manages and tracks the annual water balance for the Trojan TSF. Since 2011, the levels at Trojan Pond had been trending downwards (with the exception of seasonal rise during freshet) at an overall rate of about 0.3 m/year. This trend was not observed in 2017, likely influenced by the May freshet event which was more pronounced than recent years.

Freeboard of each dam during the inflow design flood were reviewed in 2018 for compliance with the Code which included updated flood routing for the LTD. Based on the review, Trojan Dam and R4 Seepage Pond were in compliance but upgrades are recommended for LTD so it can safely pass the

IDF with adequate freeboard. A temporary response plan to utilize pumping to manage the IDF flow will be adopted by THVCP for the interim period while upgrades are complete.

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.

Visual inspections and instrument measurements were completed by THVCP at the prescribed frequencies during periods of the year when dams were accessible. Event-driven inspections from 2017 are described in Section 5.2. Piezometric and movement thresholds which monitor deviation from the established trend, were reviewed and some revisions made for 2018. 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.

Piezometer VW16-2A, installed in 2016, exceeded the 2017 threshold starting in the mid-point of 2017. However, the pattern of readings indicate that the instrument was still equilibrating during the first half of 2017. Therefore, the 2017 threshold which was based on a short record history from 2016 was not appropriate and was revised for 2018. No other threshold exceedances were measured.

Water quality downstream of the Trojan 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.

The Trojan 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 Deficiencies and Non-Conformances – Status Update

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
Trojan Dam					
TD-2015-01	*Stability update*	-	*Once drilling is completed, review and revise the geologic sections and update the stability.*	*3*	*Q2, 2017 (CLOSED)*
TD-2016-01	*Survey*	-	*Survey the tailings impoundment and dam crest surface near the left abutment to confirm there are no potential spill points below dam crest elevation (1440 m).*	*3*	*Q3, 2017 (CLOSED)*
TD-2016-02	*OMS*	*Annual Update*	*As part of the 2018 OMS update, incorporate the following:* *- Explicitly state the minimum reading frequency for each instrument* *- Incorporate 2017 thresholds (Sections 5.4, 5.5 and 5.6)*	*3*	*Q3, 2017 (CLOSED)*

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
TD-2016-03	*EPRP*	*Communication Plan*	*Complete assessment of warnings for downstream parties potentially impacted by a failure and update the EPRP as appropriate.*	*3*	*Q3, 2017 (CLOSED)*
R4 Seepage Pond					
R4-2016-01	*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)*
Lower Trojan Dam					
LTD-2015-02	*Vegetation*	*OMS*	*Clear vegetation from open-cut spillway inlet and channel as well as inlet area of spillway pipe.*	*4*	*April 2017 (Superseded by LTD-2017-01)*
LTD-2015-03	*Outlet valve testing*	*OMS*	*Document testing of the operation of outlet valves on an annual basis.*	*3*	*April 2017 (CLOSED)*
LTD-2015-04	*Erosion assessment*	-	*Assess the potential for toe erosion at the spillway pipe.*	*3*	*April 2017 (CLOSED)*
LTD-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)*
LTD-2016-02	*Freeboard*	*the Code*	*Conduct a detailed ground survey to confirm the existing channel depth between the spillway channel invert and the dam crest.*	*3*	*Q3, 2017 (CLOSED)*
LTD-2016-03	*Flood routing*	*the Code*	*Review the flood routing capacity of the Lower Trojan Dam spillway for a 100-year return period IDF to confirm compliance or identify if upgrades are required*	*2*	*Q4, 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.

Table2 2017 Dam Safety Recommendations

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
Trojan Dam					
TD-2017-01	Surveillance	Inclinometer Monitoring	Establish a 2018 threshold limit for inclinometer IB16-2.	4	Q4, 2018
TD-2017-02	Flood Routing	Freeboard	Raise the road in the designated area (Figure 4 4) near the left abutment to El. 1440 m, either by fill placement or grading.	3	Q4, 2018
R4 Seepage Pond					
No new recommendations from 2017					
Lower Trojan Dam					
LTD-2017-01	Flood Routing	Inflow Design Flood	Complete appropriate upgrade works to allow LTD to safely pass IDF with adequate freeboard, including decommissioning of the spillway pipe (refer to recommended options in Section 4.4)	2	Q4, 2020

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.

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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 Trojan Tailings Storage Facility (TSF) on the Highland Valley Copper (HVC) mine site. The Trojan TSF is an inactive facility constructed in 1973 and operated until 1989. The site has been reclaimed since tailings discharge ceased and THVCP continue ongoing surveillance. The DSI includes the Trojan Dam and two seepage dams downstream of the Trojan Dam (R4 Seepage Pond Dam and Lower Trojan Dam).

The Fish Spawning Channel Pond Dam upstream of the impoundment was intentionally breached in a controlled manner by THVCP in 2016 and no longer capable of retaining water. Therefore, the dam is not included in the scope of this DSI.

The reclaimed site is monitored and THVCP staff are onsite to support the ongoing operations at the site and regularly visit the Trojan TSF for environmental sampling, inspections and maintenance activities. Under this level of site presence, Trojan Dam 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 visual inspection was completed by the Engineer of Record (EoR), Mr. Rick Friedel, P.Eng., as a representative of KCB on October 24, 2017. During the inspection, the weather was cloudy with sunny periods and did not impact the inspection. Mr. Chris Anderson, P. Eng., THVCP Tailings and Water Superintendent, is the TSF Qualified Person (as defined by the Code) for the Trojan TSF.

Water discharge quantity and quality from the Trojan TSF are regulated under Permit PE 376 (09), issued by the Ministry of Environment – Waste Management Branch, dated January 1, 1971 and last amended on May 29, 2003. Other permits include water licences C114183 and C068389, issued by the Ministry of Environment – Water Rights Branch.

Trojan Dam has been assigned a “Very High” consequence category as defined by CDA (2013). The downstream seepage dams have been assigned a “Low” consequence category as defined by CDA (2013).

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 Trojan TSF is located 4 km north of the operating mill; refer to Figure 1. The Bethlehem No.1 TSF is immediately to the east of the facility; refer to Figure 2. A pond is present in the impoundment continuously which is offset a minimum 200 m from the upstream dam crest by an elevated reclaimed tailings beach.

Two seepage ponds with associated dams are located downstream of Trojan Dam (R4 and Lower Trojan Ponds). The R4 Seepage Pond Dam (Figure 4), 140 m downstream from Trojan Dam, collects seepage run-off from two collection ditches along the Trojan Dam toe. The Lower Trojan Dam (Figure 5), located approximately 1.1 km downstream from R4 Seepage Pond, collects local runoff and flows from the R3 Reclaim Pond (from Bethlehem No. 1 TSF) and from R4 Seepage Pond.

The Trojan Diversion runs around the northern perimeter of the facility (Figure 3), and intercepts runoff and diverts the flow away from the facility. The diversion ditch transitions to a pipeline near the right abutment of Trojan Dam, flows through Lower Trojan Dam, and ultimately discharges into Witches Brook.

Trojan Dam

A layout of the Trojan Dam and associated structures is shown in Figure 3 and the typical geometry and dimensions of the dam are summarized in Table 2.1. Refer to Appendix III for relevant design drawings. The Trojan Dam left abutment[1] is in contact with Bethlehem Dam No. 1. Natural high ground forms the right abutment. A spillway near the right abutment was constructed following end of tailings discharge.

General information regarding the dam is as follows:

- Dam was constructed in 1973. Construction record reports are not available, but are referenced and form the basis of section drawings in two design reports (KL 1982, KL 1987) and in a stability assessment (KC 1996). A letter detailing the as-built condition of the spillway was available (KC 2002).
- The foundation is generally noted as dense glacial deposits over bedrock. The depth to bedrock increases from about 3 m at the right abutment to about 61 m in the mid-valley. A sandy silt layer with some clay is noted at 30 m to 36 m depth in the 1973 design report of the starter dam (Gepac 1973). A drill hole was completed in 2016 (KCB 2016b) which intercepted silt and clay layers, up to 150 mm thick, that were stratified within the glacial till. No distinctive laminated glaciolacustrine clay or silt was intersected by the drill hole.
- A shallow layer of forest mat and overburden was stripped from the starter dam foundation. Muskeg deposits were removed in the area of two creeks in the foundation footprint.

[1] Left and right convention assumes point of view is in the downstream direction.

- The dam comprises a rockfill starter dam with coarse rock placed downstream of the dam axis and finer rockfill placed upstream. The starter dam was raised in an upstream manner with cyclone sand. A 25 ft to 30 ft wide sand and gravel filter zone separates the starter dam rockfill and cycloned tailings.
- Foundation drains direct seepage to the R4 Seepage Pond via two ditches that run along the toe of the dam, TB-R4-FS-01 and TB-R4-FS-02. Flow in both of these ditches is monitored using a weir.
- During operations, tailings were discharged from the dam crest to form a beach between the pond and crest. The design minimum beach length was 152 m (500 ft) under normal conditions, and 92 m (300 ft) under temporary design flood conditions. The beach was also required to extend north a minimum distance of 500 m (1,640 ft) upstream of the crest along the west side of the pond. The existing minimum beach width under normal conditions is approximately 240 m. During the IDF peak pond elevation, 1438.5 m, the beach width remains greater than 100 m except for a 50 m wide area where the beach is approximately 90 m.

R4 Seepage Pond Dam

The R4 Seepage Pond is located in the mid-valley section at the old Trojan Creek bed with the right abutment in contact with a waste dump from the Trojan Dam construction. No details are available regarding the left abutment. A layout of the R4 Seepage Pond is shown in Figure 4 and 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 is as follows:

- Dam was constructed in 1984. Construction record reports are not available. 1984 design drawings showing the dam section were appended in the *Trojan Creek Ponds – Long Term Options* design report (KCB 2005).
- The foundation was prepared with a 6 m wide cutoff trench with 1.5H:1V side slopes, excavated through the upper sand and gravel foundation layer and 0.3 m to 0.6 m into the underlying dense glacial till. The trench extends to the dam crest level at both abutments, and extends north into the waste dump tying into the till foundation soil.
- The dam is comprised of compacted glacial till fill borrowed from the Lake Zone open pit excavation, now part of the Valley Pit located approximately 4 km southwest of Trojan Dam. A 300 mm thick layer of waste rock riprap is present on the upstream slope.
- A 300 mm diameter Low Level Outlet, and a 100 mm diameter overflow pipe are embedded in the dam near the left abutment.
- An open channel spillway designed by AMEC is located near the right abutment. Record drawings of the spillway, which was constructed at a later date, are available in Appendix III (AMEC 2014d).

- Water from R4 Seepage Pond is released through a 300 mm dia. low-level outlet pipe to an open channel that leads to Lower Trojan Pond and ultimately discharges into Witches Brook. A secondary outlet (intake west of the low-level outlet) diverts water to the Highland Mill when required.

Lower Trojan Dam

A layout of the Lower Trojan Pond is shown in Figure 5 and 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 is as follows:

- Dam was constructed in 1989. Construction record reports are not available.
- A 2005 design drawing shows the existing pond and dam in plan and section (KC 2005). The section provided appears to be based on measurements taken in November 2004.
- Inflows, made up of discharge from R3 and R4 Seepage Ponds and surface runoff, are measured by THVCP upstream of the Lower Trojan Dam on the west side of the access road.
- Outflow from the pond is through a 460 mm dia. diversion pipeline with a control valve downstream of the dam. Flows join the Trojan Diversion downstream of the dam and are discharged to Witches Brook.
- A low-level outlet that discharged to Witches Brook via a 200 mm pipe with a control valve downstream of the dam has been decommissioned (the method and date of decommissioning are unknown). The outlet exited approximately 8 m downstream of the dam toe.
- A spillway near the right abutment comprises an 810 mm pipe through the dam. Spillway flows discharge to Witches Brook. An open channel spillway is also located near the right abutment.

Table 2.1 Summary of Approximate Dam Geometry

Dam	Trojan Dam	R4 Seepage Pond Dam	Lower Trojan Dam
Length (m)	1500	100	100
Crest Elevation (m)	1414 (starter rockfill dam design) 1440	1365	1297.5 to 1296
Minimum Crest Width (m)	39	5	5
Maximum Height[2] (m)	70	3	4
Upstream Slope	1.5H:1V (rockfill starter dam design)	unknown	2H:1V [3]
Downstream Slope	2.9H:1V (lower bench face) 3.5H:1V (upper bench face) [4] 3.7H:1V (overall)	2H:1V	2H:1V

1. Dimensions are estimated from 2014 LiDAR data unless otherwise noted.
2. Height measured as the vertical distance between downstream toe and crest.
3. A 2005 report indicates an upstream slope of 1.75H:1V based on a November 2004 measurement (KC 2005).
4. These slopes are shallower than those on 1987 design drawings showing cycloned sand slopes on the upper face of the dam at 3H:1V and steeper but unspecified slopes on the rockfill toe face. However, the design drawings also show raises which were never constructed.

3 HISTORY AND RECENT ACTIVITY

3.1 History

A brief history of the construction and operations of the Trojan TSF is summarized as follows:

- From 1973 to 1980, the Trojan rockfill starter dam, designed by Gepac Consultants Ltd. (Gepac), was constructed to El. 1414 m (KL 1987).
- In 1981/1982, Klohn Leonoff Ltd. reviewed the dam design and proposed an upstream raise using cycloned sand. The already placed rockfill would serve as a downstream buttress and toe drain (KL 1982).
- Between 1982 and 1984, (different reports provide different dates), the dam was raised upstream using cycloned sand. Initially cyclone overflow was pumped into Bethlehem No. 1. TSF. The dam was regularly raised until 1987 to a final El. of 1441.5 m (AMEC 2014a; KL 1987).
- In 1983, a 24-inch diameter corrugated steel culvert which provided drainage of Trojan Creek flows through the original rockfill dam in the natural channel was backfilled with concrete (AMEC 2014a).
- In 1984, the R4 Seepage Pond was constructed (KC 1996).
- During 1989 the Lower Trojan Pond was constructed and tailings deposition in the Trojan TSF was stopped (KC 1996).
- In 1995, the Fish Spawning Channel Pond Dam was constructed (KC 2005).
- In 1996, a permanent spillway was constructed at the right abutment of Trojan Dam (KC 2002).
- In 2004, a spillway was constructed at the right abutment of R4 Seepage Pond Dam (AMEC 2014d).
- In 2016, the Fish Spawning Channel Pond Dam was decommissioned as discussed.
- In 2016, two vibrating wire piezometers and an inclinometer were installed in one drill hole on the downstream face of Trojan Dam

3.2 2017 Activities

In addition to routine maintenance activities as required by the OMS manual (e.g., clearing weirs of vegetation), no repairs or construction activities were completed during 2017.

4 WATER MANAGEMENT

4.1 Overview

Water management at each structure in upstream to downstream order and how they interact with each other is summarized below. The process flow diagram for Bethlehem TSF and Trojan TSF is shown in Figure 4.1. Figure references for key operating water management structures are summarized in Table 4.1.

Trojan TSF

- The Trojan Diversion is a series of ditches, culverts and pipelines located upslope of the Trojan TSF. The direction of flow is east to west with the open channel terminating west of Trojan Dam's right abutment and spillway. The flow is then diverted into a pipeline which discharges downstream of Lower Trojan Pond into an open channel. This open channel, considered to be part of Trojan Diversion, transitions back into a pipeline approximately 1 km downstream of Lower Trojan Dam, and ultimately discharges into Witches Brook.
- Inflows include precipitation on the impoundment, surface runoff from upstream catchments, and flow from the breached Fish Spawning Channel Pond.
- The tailings free water pond is located in the center of the impoundment as shown on Figure 3. The water level varies seasonally up to 2.0 m based on historic records, typically with a peak in June and low in the winter months; refer to Figure V-1.
- Outflows include seepage and when necessary, would discharge through the spillway (no discharge through spillway to date). Seepage reports to R4 Seepage Pond via the East and West Seepage Collection Ditches. The spillway, an open channel founded partially in tailings (upstream) and partially in natural ground (downstream) and lined with vegetation and riprap where needed, discharges into an existing tributary which drains into Witches Brook.
- KCB's review of the upgrade works for the lower portion of the emergency spillway concluded that the riprap is potentially undersized during the peak IDF flow or the PMF design flood flow. If that is the case, this downstream section of the spillway channel would be damaged during extreme flood events which could include dislodging of some riprap and scouring of the channel base and sides. This is considered acceptable from a dam safety perspective because if this damage were to occur there would still be sufficient capacity in the channel to carry the flow:
  - KCB discussed with THVCP and understand that they are willing to accept risk of potentially repairing the damaged channel following an extreme event.
  - KCB recommended that this risk be documented in dam safety related documents for the Trojan Dam such as: Operations Maintenance and Surveillance manual; Emergency Preparedness and Response Plan; and the design basis for the structure.

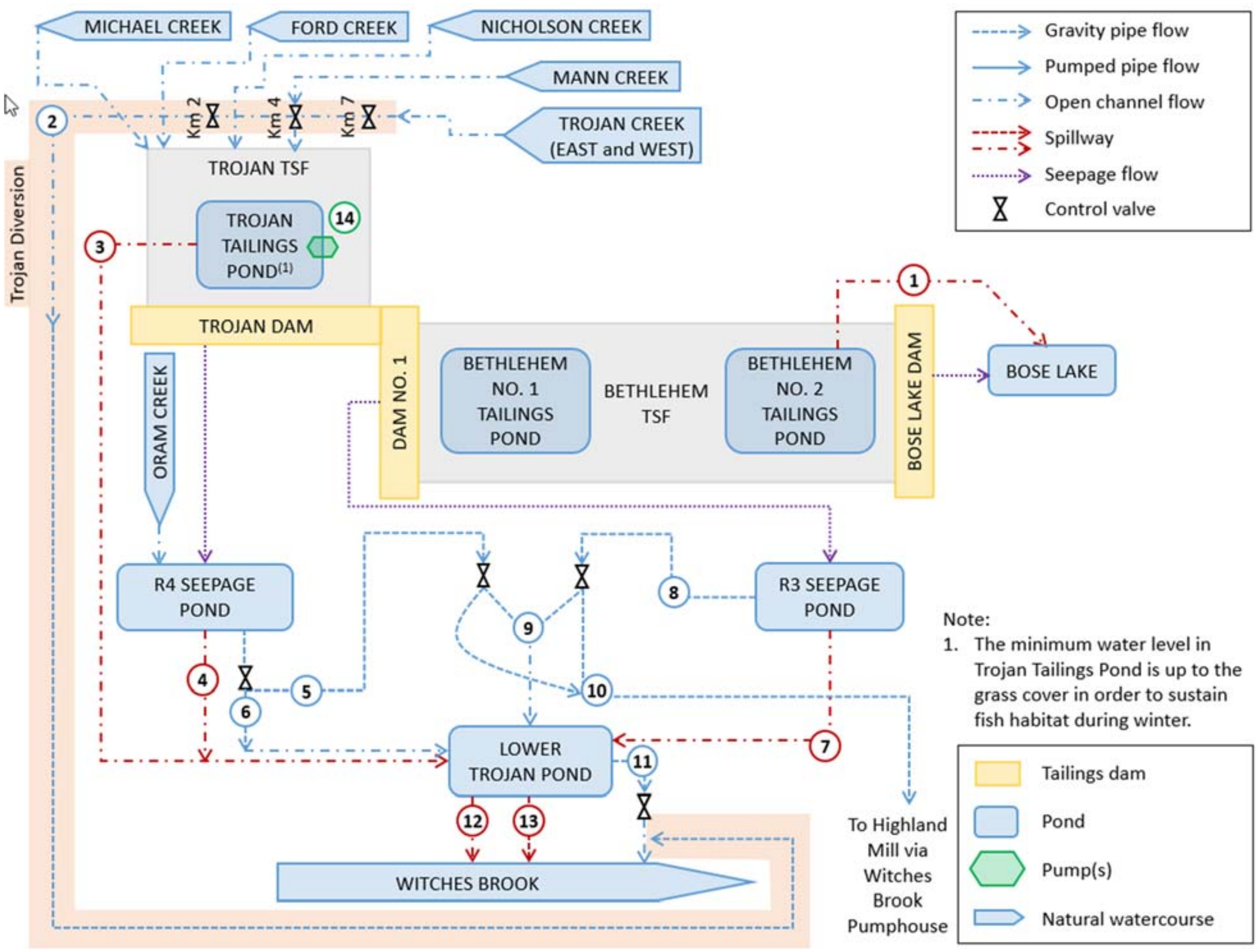
R4 Seepage Pond Dam

- Inflows include precipitation on the pond, surface runoff from upstream catchments, seepage from the Trojan Dam toe, and pumped flows from R3 Seepage Pond at the toe of Dam No. 1 (not part of regular operations). Inflows are measured monthly.
- 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 1.0 m to 1.4 m in 2017. The vertical distance between the pond and dam crest was 2 m based on a visual estimate during the 2017 DSI site visit.
- Outflows include flow through a 300 mm dia. pipeline which leads to Lower Trojan Dam, seepage and when necessary, diversion via another pipeline to the Highland Mill or discharge through the spillway. The pipeline flow to Lower Trojan Dam is controlled by a valve at the downstream toe of the dam. The spillway, a riprap-lined open channel with an energy dissipater, discharges into an existing tributary which drains into Witches Brook.

Lower Trojan Dam

- Inflows include precipitation on the pond, surface runoff from upstream catchments, outflow from R3 Seepage Pond at the toe of Dam No. 1, and outflow from R4 Seepage Pond. Flows from the Trojan Diversion bypass the Lower Trojan Dam. Inflows are measured weekly during freshet, and monthly for the remainder of the year.
- 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 1.5 m to 2.5 m in 2017. This is consistent with visual estimates during DSI site visits in 2014, 2015, and 2016 which showed the water level to be 1.7 m, 2 m, and 1.5 m below the crest of the dam, respectively. In 2017, it was estimated to be 1.5 m.
- Outflows include flow through the 460 mm dia. diversion pipeline which is the normal operating outlet. This outflow joins the Trojan Diversion and reports to Witches Brook. When necessary, water discharges through the 810 mm dia. spillway pipe and a 7 m wide open channel spillway on the right abutment. Both outflows also report 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 References for Operational Water Management Structures for Trojan Facility

Dam	Structure Name	Drawing or Figure Reference (Appendix III)
Trojan TSF	Trojan Diversion	None available, see Figure 2
	Trojan Spillway	114-808-202
	East and West Seepage Collection Ditches	D-2916-13 The East Seepage Collection Ditch has since been regraded to flow west into R4 Seepage Pond.
R4 Seepage Pond	Outlet Pipeline	B-007
	Spillway	AB-2 to AB-6
Lower Trojan Dam	Diversion Pipeline	B-004
	Spillway Pipe	B-004

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 4.2 and 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 weather station. Instead, monthly measurements at the Highland Valley snow survey station (Station No. 1C09A) near the Trojan TSF are used to track the changes in snowpack. The measurements are sorted by survey period (the first of January through May) to compare snowpack depths (in snow-water equivalent (SWE)) around the same time each year. Historical average and 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 Section 5.3).
- 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 Trojan 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

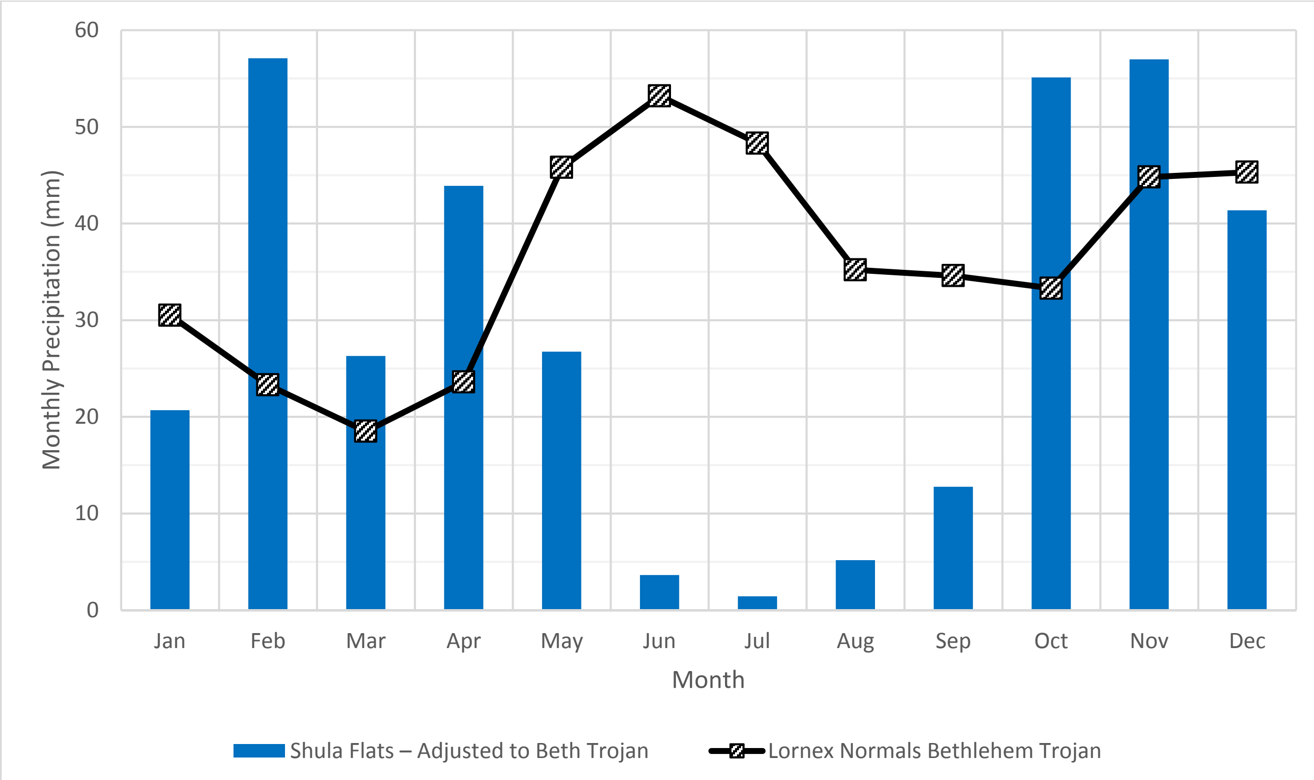
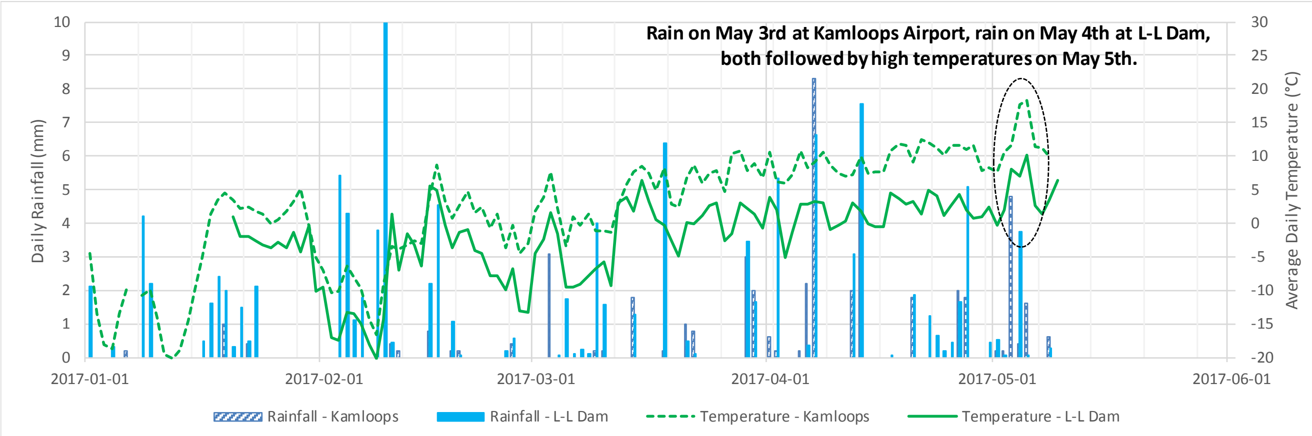


Table 4.3 Historical Average and 2017 Snowpack Depths

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 Trojan 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.

Table 4.4 Annual Water Balance for Trojan TSF

Item	Volume in 2017(1) (m^3)
Inflows	
Direct Precipitation(2)	156,300
Runoff	1,072,600
Groundwater	14,400
Outflow from Fish Spawning Channel Pond	0
Total Inflow:	*1,243,300*
Outflows	
Seepage	946,100
Evaporation(3)	231,200
Total Outflow:	*1,177,300*
Balance	
Balance (inflow minus outflow)	66,000

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 Trojan area was used in the water balance.
3. Evaporation was assumed to be 540 value mm/year.

4.4 Flood Management

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

- The Trojan TSF and R4 spillways 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 difference is small and is unlikely to materially affect the results.
- To address recommendations from previous DSIs, flood routing for the Lower Trojan Dam was updated in 2018 to assess whether the facility can safely pass the IDF (100-year return period, 24 hour duration) with adequate freeboard (KCB 2018a). Based on the results of the assessment, the following was concluded:
  - The overflow pipe that is buried through the dam crest, near the right abutment, should be decommissioned because the pipe discharges at the dam toe and there is no erosion protection at the discharge or channel to convey flow away from the dam.
  - Assuming the spillway channel at the right abutment is unobstructed (i.e. cleared of vegetation), the dam cannot safely pass the IDF with adequate freeboard. The peak flood level (El. 1296.8 m) would overtop the dam crest at the left abutment.
- Based on KCB (2018a), to bring the LTD in compliance with the Code, KCB recommends one of the following be undertaken:
  - Option 1:
    - modify the alignment of the existing spillway channel so flow is directed away from the dam toe and cover with appropriately sized riprap to protect the channel from scour; and
    - raise the dam crest and left abutment area to provide containment up to El. 1297.3 m.
  - Option 2:
    - modify the alignment of the existing spillway channel so flow is directed away from the dam toe and cover with appropriately sized riprap to protect the channel from scour; and
    - lower the inlet of the spillway to El. 1294.8 m which is 1.2 m[2] below the low point of the existing crest.

[2] 1.2 m based on 0.7 m peak flow depth during IDF and 0.5 m for freeboard (Section 4.5).

THVCP report that timeline to implement (i.e. design, permits, construction) the recommended upgrades, including approval to clear trees and vegetation form the LTD spillway channel, could extend into 2020. To manage overtopping risks during the temporary period during which upgrades are complete, THVCP and KCB agreed to define a pond level threshold if exceeded, will require THVCP to deploy a pump to the LTD to increase outflow capacity sufficient to prevent overtopping. Pumping will effectively keep the pond level below the overflow pipe and spillway intakes and discharge into the Trojan Diversion Channel. This update will be reflected in the final issue of the OMS manual in April.

Table 4.5 Inflow Design Flood for Trojan TSF and Seepage Ponds

Dam	Outfall Type	Consequence Classification	Inflow Design Flood	Spillway Design Flood (Precipitation Depth, Design Flow)		Spillway Design Reference
				Design Event	Peak Flood Level	
Trojan Dam	Open channel	Very High	2/3 between 1000-year and PMF(1)	24-hour PMF(2) (182.2 mm, 26.1 m³/s)	1438.5 m	(AMEC 2014b)
R4 Seepage Pond Dam	Open channel	Low	100-year(3)	24-hour PMF(4) (180.7 mm, 1.57 m³/s)	1364.6 m	(AMEC 2014c)
Lower Trojan Dam	Open channel and pipe	Low	100-year(3)	100-year 24-hour(5) (75.2 mm, 6.4 m³/s)	1296.8 m	(KCB 2018a)

Notes:
1. Per the Code for tailings dams.
2. Based on data from Atmospheric Environment Service (AES) climate stations at Kamloops Airport and Mamit Lake. A review of the spillway design was done in 2002 which concluded the 260 mm is comparable to the 230 mm estimated using the Highland Valley BCCL and Highland Valley Lornex climate stations and would accommodate a conservative snowmelt rate of 30 mm/day.
3. Per the Code for water dams.
4. Based on data from the Environment Canada Highland Valley Lornex climate station (Station No. 1123469).
5. Based on data from the Environment Canada Highland Valley Lornex climate station (Station No. 1123469) and adjusted for orographic effects.

4.5 Freeboard

Where available, the minimum freeboard[3] measured during 2017, is based on either the DSI site visit observations and/or by the regular surveys completed by THVCP, 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. These values were reviewed and updated in 2018 (KCB 2018a), Trojan Dam and R4 Seepage Pond meet freeboard required. As discussed in Section 4.4, upgrades are recommended for the LTD to safely pass the IDF with adequate freeboard.

[3] The vertical distance between the pond level and the low point of the dam crest during flood or normal operation.

Table 4.6 Minimum Required Freeboard

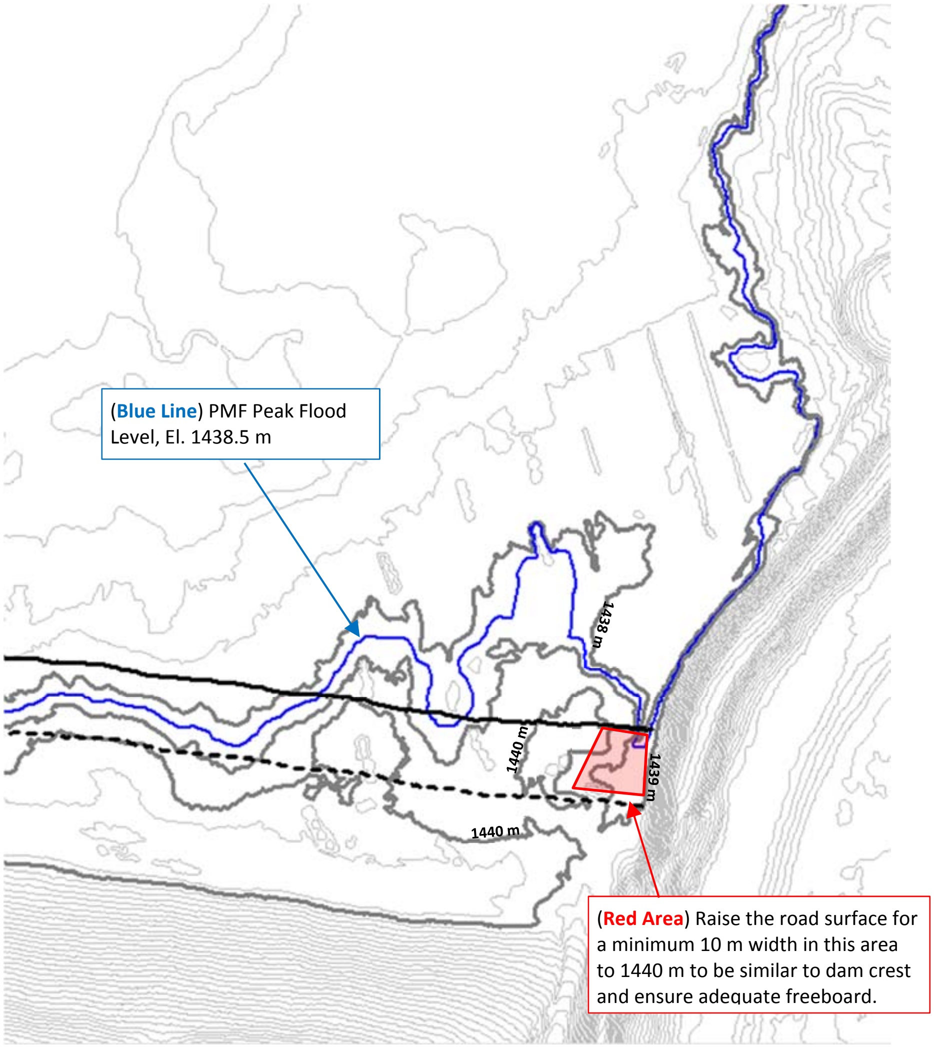
Dam	Required Freeboard During Inflow Design Flood (1)	Minimum Freeboard During Inflow Design Flood (1)	2017 Freeboard	2017 Freeboard Surveyed/Visually Estimated
Trojan Dam	0.6 m	>0.6 m (3)	6.8 m	Annual minimum from surveys, refer to App IV
R4 Seepage Pond Dam	0.5 m (2)	0.6 m	2.0 m	At time of DSI site inspection
Lower Trojan Dam	0.5 m (2)	Note 4	1.5 m	At time of DSI site inspection

Notes:

1. As per KCB (2018a).
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. Confirmation of minimum freeboard along access road at left abutment limited by survey accuracy. Action recommended to raise this to same level as dam crest.
4. As discussed in Section 4.4, upgrades are recommended to safely pass the IDF with adequate freeboard.

To address a recommendation from the 2017 DSI, THVCP completed a survey of the Trojan Dam left abutment area (Figure 4.4), including the road, tailings beach and dam crest to confirm that freeboard requirements are met in this area. Based on this survey the peak flood level during the IDF (El. 1438.5 m) is retained within the impoundment. The minimum elevation along the access road is 1439 m or greater. A minimum elevation along the road of 1439.1 m or greater is required to comply with minimum required freeboard (0.6 m). Survey accuracy limits the ability to confirm the low point to the nearest 0.1 of a meter. The low point along the road is at risk of being further trimmed during routine road maintenance. KCB recommend that the access road be raised to El. 1440 m (either by fill placement or grading) somewhere in the area identified in Figure 4.4. This would bring the road level equal to the dam crest and maintain the minimum beach width during flooding (92 m).

Figure 4.4 Survey of Trojan Dam Left Abutment Area



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 2017):

- Update monitoring frequency based on 2016 recommendations or as mutually agreed between THVCP and KCB;
- Review and update the failure mode assessment based on AMEC (2015) failure modes and effects analysis (FMEA);
- Update the event-driven inspection criteria (discussed in Section 5.2);
- Annually update threshold levels based on the recommendations in the DSI (discussed in Sections 5.4, 5.5 and 5.6);
- Include 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;
- Include a plan(s) showing the location of all the facilities associated with the TSF (seepage ponds, slimes ponds, inflows, outflows etc.); and
- Review 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 Trojan Dam 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 Trojan Dam and quarterly inspections of Lower Trojan Dam and Seepage Pond R4 are completed by THVCP. Inspections by THVCP staff have been completed at the prescribed frequencies as described in the 2018 OMS update
- Event-driven – these inspections are of more value to confirm that the changed condition (i.e. flood, earthquake) did not have a significant impact on the structures. THVCP are to complete an inspection in response to the following threshold exceedances (included in the 2018 OMS manual update):

- Piezometric and dam movement instrumentation thresholds as discussed in Sections 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 (during freshet flooding, refer to Section 4.2):
  - May 6 – Mr. Rick Friedel (EoR) of KCB accompanied THVCP to inspect the Trojan TSF, amongst other structures, via helicopter fly-over. No immediate dam safety concerns were noted for Trojan Dam, Lower Trojan Dam, or R5 Seepage Pond Dam during this fly-over.
  - May 7 – KCB performed an inspection at Lower Trojan Dam, R4, and the breached spawning channel in order to investigate the dam condition, flow conditions, pond levels, and spillway response to flow.
  - May 8 – KCB performed a follow-up inspection at Lower Trojan Dam to assess any changes from the previous inspection. Over the May freshet no issues of concern were observed at this site.

5.3 Reservoir Level

The pond level 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 level and Trojan Dam piezometric levels.
- Figure IV-6 and Figure IV-7 plots pond levels with measured weir flows at TB-R4-FS-01 and TB-R4-FS-02 collecting seepage flow from Trojan Dam, and at TB-LT-FS-01 and TB-LT-FS-02 collecting seepage flows from Seepage Ponds R3 and R4.

Since 2011, the levels at Trojan Pond had been trending downwards (with the exception of seasonal rise during freshet) at an overall rate of about 0.3 m/year. This trend was not observed in 2017, likely likely influenced by the May freshet event which was more pronounced than recent years. The peak pond level in 2017 was approximately equivalent to the peak in 2014 and less 2011 to 2013 freshet peaks. Since the May 2017 peak, the pond levels have steadily decreased.

5.4 Piezometers

There are 24 piezometers at the Trojan TSF, 11 of which are operational and being monitored, while 13 are inoperative as shown in Figure 2. Inoperative piezometers may be buried, plugged or otherwise damaged.

Piezometers were typically read between March and November (when accessible) on a monthly basis. 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 (Figure IV-1), monthly for all other piezometers.

Refer to Appendix IV for plots of all piezometer results, 2017 and historic piezometric readings are shown in Figure IV-1 to Figure IV-3. Key observations are:

- Readings for VW16-2A, installed in 2016, exceeded the 2017 threshold starting in the mid-point of 2017. However, the pattern of readings indicate that the instrument was still equilibrating during the first half of 2017. Therefore, the 2017 threshold which was based on a short record history from 2016 was not appropriate. The threshold for this instrument and VW16-2B have been revised for 2018 based on the available readings from 2016 and 2017.
- All other piezometers remained below their thresholds and no other changes to thresholds are proposed.
- Piezometers within the tailings beach (between the pond and dam crest) showed a continued downward trend which has been occurring since 2014 (~0.5 m/yr to 0.75 m/yr) which is an indication that post-closure drain-down is ongoing. The response from the 2017 is observed in the readings but readings dissipated in the later months similar to previous years.
- Piezometers in the tailings near the dam crest are dry and have been over the past several years. Instruments in the foundation in this area remained relatively constant.
- Readings from VW16-2A and VW16-2B indicate a downward gradient in the Glacial Till foundation at the dam toe.

Piezometric level thresholds for the Trojan Dam are set to monitor deviation from the established trend. Piezometer readings have been fairly consistent over the past three years or more, showing a similar pattern of seasonal variability in the impoundment and relatively constant in the dam. Therefore, the threshold for each piezometer was set at 0.5 m above the maximum elevation head; refer to Table 5.1. The threshold levels for VW16-2A and VW16-2B have been revised for 2018, as discussed above.

Table 5.1 2017 Piezometric Level and 2018 Thresholds

Instrument ID	Foundation Unit	2017 Piezometric Levels (m)		Proposed 2018 Threshold Level (m)[1]
		Maximum	Minimum	
P86-7	Sandfill			1419.8
P95-3	n/a			1415.0
P94-1	n/a			1423.6
P85-1A	Foundation	1396.8	1396.6	1399.2
TB-PS-02/P13-1	Cycloned Sand	1421.2	1419.76	1423.4
TB-PS-01/P13-2	Cycloned Sand	1416.8	1416.4	1418.6
TB-PS-04/P13-3	Sand and Gravel	1383.7	1383.5	1385.4
TB-PS-03/P13-4	Glacial Till	1388.7	1388.0	1389.7

Instrument ID	Foundation Unit	2017 Piezometric Levels (m)		Proposed 2018 Threshold Level (m)[1]
		Maximum	Minimum	
P86-1	Sandfill			1408.2
VW16-2A	Glacial Sediments / Debris	1363.9	1363.0	*1364.4*
VW16-2B	Glacial Till	1379.4	1379.2	*1379.9*

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

Based on the review of the available instrumentation data, the current suite of instruments is sufficient for the Trojan TSF. No follow up actions regarding any of the instrumentation is recommended.

5.5 Survey Monuments

Active and defunct survey monuments at the Trojan TSF are shown on Figure 2. Monuments were surveyed twice in 2017, in June and November, which is more frequent than the frequency prescribed in the 2018 OMS manual (annual). Refer to Figure IV-4 (Appendix IV) for a plot of monument surveys. The incremental change between June 2016 and 2017 surveys, and the cumulative change, are summarized in Table 5.2. THVCP surveys since 2014 use a total station with an estimated accuracy of 10 mm to 25 mm for horizontal measurements, and a digital level with an estimated accuracy of 10 mm for vertical measurements.

Table 5.2 2017 Survey Monument Incremental Displacement Summary

Monument	Incremental		Cumulative	
	Vector Horizontal Displacement[1] (mm)	Vertical Displacement[1] (mm)	Vector Horizontal Displacement[1] (mm)	Vertical Displacement[2] (mm)
TD-1	1.9, upstream	+0.7	6.9, upstream	-6.5
TD-2A	4.7, upstream	+4.8	14.9, downstream	+0.03
TD-3	1.8, upstream	-0.1	5.2, downstream	-69.0
TD-4	1.0, upstream	+0.8	15.7, downstream	-72.9
TD-5	7.7, upstream	-3.4	12.6, upstream	-48.6
TD-6	11.1, upstream	-2.1	14.8, downstream	-29.6

1. June 2016 survey compared to June 2017 survey.
2. Earliest historic reading is 2014 for TD-2A, all other monuments earliest historic readings are in 1998. Cumulative displacements are calculated as difference from June 2017 survey and earliest historical reading.

Movement thresholds (horizontal and settlement) have been established for the survey monuments; refer to Table 5.3. 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 50 mm greater than the most recent reading, based on the observed settlement trends.

Table 5.3 Proposed 2018 Survey Monument Displacement Thresholds

Instrument ID	Horizontal Vector Displacement from Original Position Threshold (mm)	Incremental Vertical Displacement Between Readings Threshold (mm)	Total Vertical Displacement Threshold (mm)
TD1	80	20	50
TD2A			50
TD3			100
TD4			100
TD5			75
TD6			75

Notes:
1. No change recommended to 2017 threshold values for 2018.

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

5.6 Inclinometers

No inclinometers were installed in 2017. The one inclinometer at Trojan Dam (IB16-2) which was installed in 2016, is to be read monthly, when accessible, as defined in the 2018 OMS manual.

Cumulative displacements measured at IB16-2 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 has been a continued trend of movement in the eastern direction, approximately 25 mm during 2017, (parallel) to the dam crest. The movement is spread evenly over the length of the casing with no discrete zones of movement. THVCP discussed with KCB and have raised an action within site tracking system to review the instrumentation records to check whether this is representative of field behaviour or an issue with data processing.

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 two weirs located at R4 Seepage Pond, and two weirs located at Lower Trojan Pond. This is consistent with the requirements in the 2018 OMS manual.

Weir TB-R4-FS-01 is 60° V-notch weir installed on the west toe drain. Weir TB-R4-FS-02 is a 90° V-notch weir installed on the east toe drain. Weir flows from 2008 to the end of 2017 are plotted on Figure IV-6. 2017 seepage flows are consistent with historical trends, with the exception of the peak in April/May which coincides with the 2017 freshet.

Weirs TB-LT-FS-01 and TB-LT-FS-02 are located downstream and upstream, respectively, of Lower Trojan Pond. Weir flows from 2016 and 2017 are plotted on Figure IV-7. Flows from previous years are not available.

5.8 Water Quality

Water quality downstream of the Trojan 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.

Trojan Dam

- **Crest**: No indication of erosion or deterioration, crest was observed to be in good physical condition. Local low points <1m and "hummocky" surface observed and believed to be from differential settlement or formed for land reclamation. Freeboard is uncompromised by these features (Photo II-A-8 and Photo II-A-9).
- **Left Abutment**: Good physical condition. Highpoint of the tailings beach is observed to be sloping towards the access road at the toe of Bethlehem Dam. Access road is located at a lower elevation than the dam crest or high point of beach between road and pond.
- **Right Abutment**: Good physical condition. Spillway channel that excavated through bedrock and Glacial Till material, which shows no signs of deterioration or erosion. Channel runs parallel to the dam abutment.
- **Downstream Slope**: Good physical condition. Downstream slope is well vegetated with grass, and has no observed locations of concern or signs of adverse displacement (Photo II-A-10 and Photo II-A-11).
- **Tailings Beach:** Good physical condition. No issues of concerns observed during inspection. Elevation of the vegetated portion of the beach is approximately 1.5 m to 2 m above the reservoir level. Reservoir level observed to have minor increase compared to level during 2016 inspection (Photo II-A-12), refer to Section 5.3 for discussion of overall downward trend.
- **Pond**: No indication of recent high-water event, at the time of inspection spillway invert was approximately 3 m above the pond elevation (Photo II-A-5).
- **Spillway Inlet**: Log booms secured in place, with no obstructions present besides minor vegetation. Spillway in good condition with no signs of deterioration (Photo II-A-13).
- **Spillway Channel**: Good physical condition. Initial section of channel is heavily vegetated with grass and slopes at minimal grade towards the first curve of the dam spillway. Following the first curve the vegetated Glacial Till channel transitions to a bedrock excavated channel at the right abutment of the dam. Along this segment water has accumulated along the bottom of the channel where it extends until the channel transitions from bedrock to riprap lined. Spillway channel riprap increases in size as the channel grade steepens towards the outfall. No major obstructions, signs of erosion, or deterioration was observed along the channel (Photo II-A-14 to Photo II-A-24).
- **Toe Collection Ditches:** Good physical condition. Extensive vegetation observed, which provides a measure of erosion protection. Seepage flow observed through ditches and weirs. Weirs in good condition, and no sign of obstructions in either toe collection ditch (Photo II-A-25 and Photo II-A-26).

- **Seepage:** No seepage observed, except for seepage flow within the toe collection ditches (Photo II-A-27 and Photo II-A-28).
- **Diversion Channel:** Good physical condition. Some sections have minor vegetation within the lined channel, and at two locations there is damage to the channel liner. The till section of the channel has good consistent shape, no signs of erosion or deterioration, with only minor vegetation present (Photo II-A-29 and Photo II-A-33).

R4 Seepage Pond Dam

- **Crest**: Good physical condition. No observed signs of deterioration, lateral movement, or cracking.
- **Left and Right Abutments**: Good physical condition. Little vegetation at abutments, and no signs of deterioration observed.
- **Downstream Slope**: Good physical condition. Tall grass and vegetation present, no signs of deterioration or erosion (Photo II-B-9).
- **Pond**: During inspection, the pond water level was observed to be approximately 1.3 m below the spillway invert. Water level appears to be same level as 2016 inspection level (Photo II-B-1).
- **Spillway**: Good physical condition through the whole spillway. No observed signs of recent flow, channel erosion, or deterioration. No obstructions present in spillway (Photo II-B-4 to Photo II-B-7).
- **Low-level Outlet**: Minor vegetation growth on log-boom, along with minor leaf obstruction on trash rack. Obstructions are monitored and cleared as part of THVCP ongoing monitoring and routine maintenance plan (Photo II-B-3).
- **Seepage**: No observed signs of seepage during inspection.

Lower Trojan Dam

- **Crest**: Good physical condition. Moderately vegetated with no signs of erosion, deterioration, or cracking observed (Photo II-C-2).
- **Left and Right Abutment**: Good physical condition. Right abutment covered in tree debris (Photo II-C-6).
- **Downstream Slope**: Good physical condition. Minor vegetation present, no signs of erosion or deterioration (Photo II-C-7).
- **Pond**: Level at time of inspection consistent with level at 2016 inspection. Invert of spillway and pond approximately 0.5m apart.
- **Spillway**: Heavy vegetation present in front of pond overflow pipe resulting in potential for an obstruction. Spillway channel filled with tree debris, channel flow path is no longer visible. Spillway should be cleared of vegetation and debris, and flood routing at this site should be reviewed or upgraded (Photo II-C-4 to Photo II-C-6).

- **Low-level Outlet**: Debris boom in good condition. Build up of leaves present on intake cage (Photo II-C-10).
- **Seepage**: None observed.

7 ASSESSMENT OF DAM SAFETY

7.1 Dam Classification Review

The latest DSR (AMEC 2014a) a "Very High" consequence classification, as defined by CDA (2013), was recommended for the Trojan Dam. The R4 Seepage Pond and Lower Trojan Dam were both 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 Trojan Dam

Based on the DSI and review of available documents regarding Trojan Dam, the potential failure modes included in the Canadian Dam Safety Guidelines (CDA 2013) were reviewed:

Overtopping

The Trojan TSF has an open channel spillway designed (AMEC 2014a) to safely pass a flood (PMF, 24-hour duration) greater than the minimum IDF recommended under the Code. Given the presence of the spillway and wide tailings beach that would be present between the pond and crest while discharging the IDF through the spillway, the likelihood of overtopping during the IDF is considered very low.

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.

A 24-inch diameter corrugated steel culvert provided drainage of Trojan Creek flows through the original rockfill dam in the natural channel until 1983 when tailings storage began. No indicators of piping related failure (e.g., turbid water) have been observed in seepage from this area. The likelihood of a piping related failure developing around the culvert at this stage is considered very low.

Stability

The dam is a founded on dense glacial till overlying bedrock with a downstream slope of 3.5H:1V for the upper cycloned sand raises and 2.9H:1V for the rockfill toe. Slope stability analyses (KL 1987, KCB 2018b) indicate the Factor of Safety (FOS) of a failure through the foundation is greater than required by the Code (1.5). The piezometric levels in the dam and impoundment have reduced relative to those assumed in the 1996 analysis which would enhance stability since that time. Therefore, the likelihood of a slope instability failure through the foundation developing is considered very low.

Surface Erosion

The downstream slope is well vegetated with grass with no significant erosion features. Progressive erosion that develops over time or multiple events are managed through routine monitoring and maintenance. The likelihood of surface erosion over the downstream slope resulting in a failure from a single event is considered negligible.

Earthquakes

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.

7.2.2 R4 Seepage Dam

Based on the DSI and review of available documents regarding Trojan Dam, the potential failure modes included in the Canadian Dam Safety Guidelines (CDA 2013) were reviewed:

Overtopping

The R4 Seepage Pond has an open channel spillway designed to safely pass a flood (PMF, 24-hour duration) significantly greater than the minimum IDF recommended under the Code (100-year flood). Given the presence of the spillway, the likelihood of overtopping during the IDF are 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 the likelihood failure by internal erosion under existing conditions is low.

Stability

Based on a stability analysis completed by KCB to support this DSI, the FOS of a deep-seated failure through the dam fill or foundation was greater than the minimum FOS (1.5) required by the Code.

Surface Erosion

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

Earthquakes

The design seismic load of the dam used in previous stability analysis, which indicated satisfactory FOS, 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.

7.2.3 Lower Trojan Dam

Based on the DSI and review of available documents regarding Trojan Dam, the potential failure modes included in the Canadian Dam Safety Guidelines (CDA 2013) were reviewed:

Overtopping

Flood routing conducted for the Lower Trojan Dam in 2017 indicates that upgrades are required so the facility can safely pass the IDF event, as per the Code. KCB recommended upgrades are discussed in Section 4.4 and included in the recommendation summary (Table 8.2).

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

Slope stability analyses conducted in 2005 showed the FOS for downslope stability is greater than the minimum FOS (1.5) required by the Code. A shallow surficial (~2 m deep) failure surface within the upstream dam fill had a FOS of 1.3 (KC 2005); but there have been no incidents of instability or adverse displacement (e.g., sloughing) along the upstream slope observed in the available monitoring records nor observed during the 2017 DSI site inspection.

Surface Erosion

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

Earthquakes

The design seismic load 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 Trojan 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. 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 Trojan 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 Deficiencies and Non-Conformances – Status Update

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
Trojan Dam					
TD-2015-01	*Stability update*	-	*Once drilling is completed, review and revise the geologic sections and update the stability.*	*3*	*Q2, 2017 (CLOSED)*
TD-2016-01	*Survey*	-	*Survey the tailings impoundment and dam crest surface near the left abutment to confirm there are no potential spill points below dam crest elevation (1440 m).*	*3*	*Q3, 2017 (CLOSED)*
TD-2016-02	*OMS*	*Annual Update*	*As part of the 2018 OMS update, incorporate the following:* *- Explicitly state the minimum reading frequency for each instrument* *- Incorporate 2017 thresholds (Sections 5.4, 5.5 and 5.6)*	*3*	*Q3, 2017 (CLOSED)*
TD-2016-03	*EPRP*	*Communication Plan*	*Complete assessment of warnings for downstream parties potentially impacted by a failure and update the EPRP as appropriate.*	*3*	*Q3, 2017 (CLOSED)*
R4 Seepage Pond					
R4-2016-01	*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)*
Lower Trojan Dam					
LTD-2015-02	*Vegetation*	*OMS*	*Clear vegetation from open-cut spillway inlet and channel as well as inlet area of spillway pipe.*	*4*	*April 2017 (Superseded by LTD-2017-01)*
LTD-2015-03	*Outlet valve testing*	*OMS*	*Document testing of the operation of outlet valves on an annual basis.*	*3*	*April 2017 (CLOSED)*
LTD-2015-04	*Erosion assessment*	-	*Assess the potential for toe erosion at the spillway pipe.*	*3*	*April 2017 (CLOSED)*
LTD-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)*
LTD-2016-02	*Freeboard*	*the Code*	*Conduct a detailed ground survey to confirm the existing channel depth between the spillway channel invert and the dam crest.*	*3*	*Q3, 2017 (CLOSED)*

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
LTD-2016-03	*Flood routing*	*the Code*	*Review the flood routing capacity of the Lower Trojan Dam spillway for a 100-year return period IDF to confirm compliance or identify if upgrades are required*	*2*	*Q4, 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 8.2 2017 Dam Safety Recommendations

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
Trojan Dam					
TD-2017-01	Surveillance	Inclinometer Monitoring	Establish a 2018 threshold limit for inclinometer IB16-2.	4	Q4, 2018
TD-2017-02	Flood Routing	Freeboard	Raise the road in the designated area (Figure 4 4) near the left abutment to El. 1440 m, either by fill placement or grading.	3	Q4, 2018
R4 Seepage Pond					
No new recommendations from 2017					
Lower Trojan Dam					
LTD-2017-01	Flood Routing	Inflow Design Flood	Complete appropriate upgrade works to allow LTD to safely pass IDF with adequate freeboard, including decommissioning of the spillway pipe (refer to recommended options in Section 4.4)	2	Q4, 2020

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

9 CLOSING

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KLOHN CRIPPEN BERGER LTD.

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

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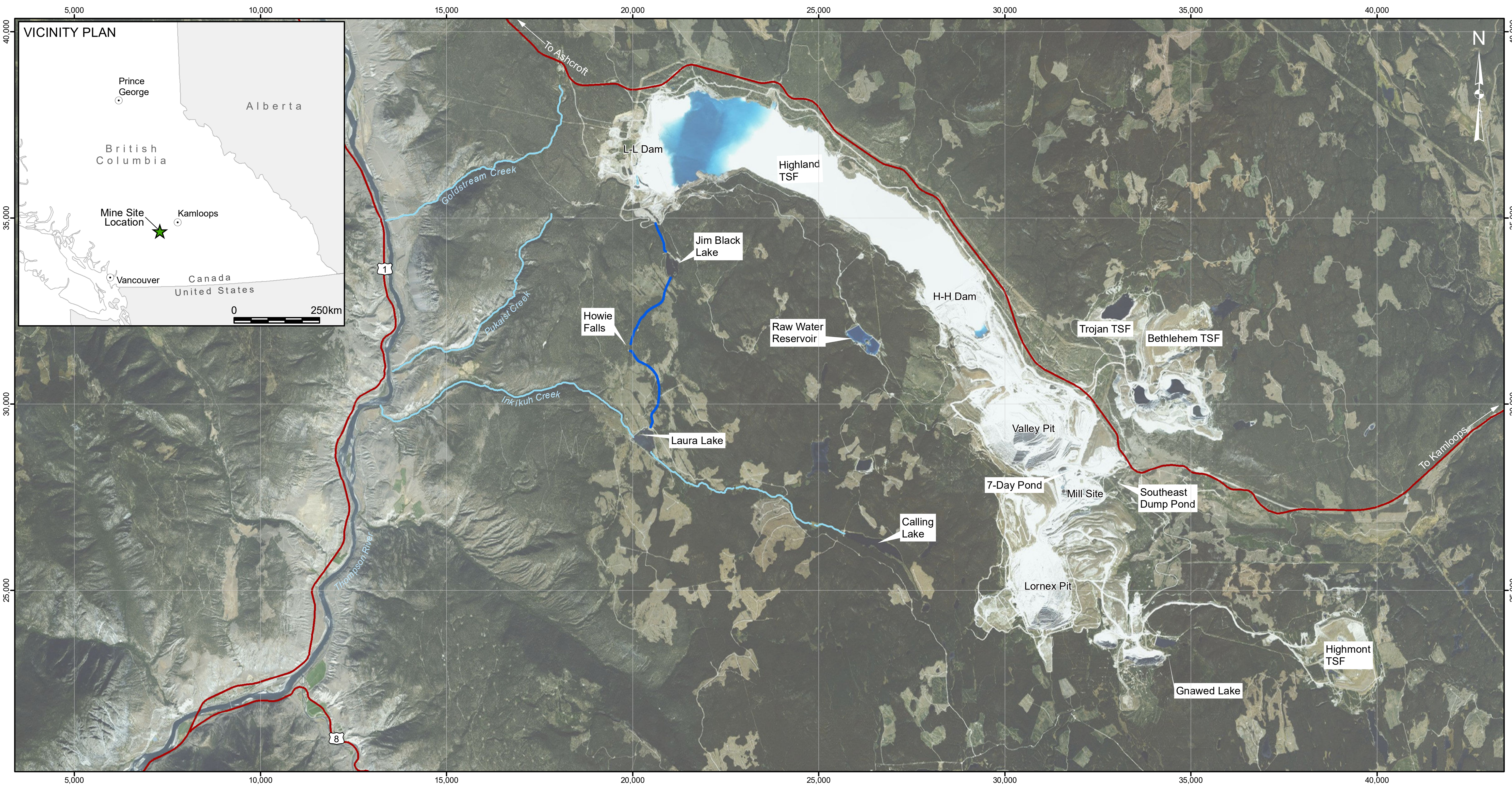
FIGURES



Legend
- Creek / River
- Highway
- Ditch

0 5km

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

Date: 2017-12-01
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CLIENT TECK HIGHLAND VALLEY COPPER PARTNERSHIP	PROJECT TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE MINE SITE PLAN
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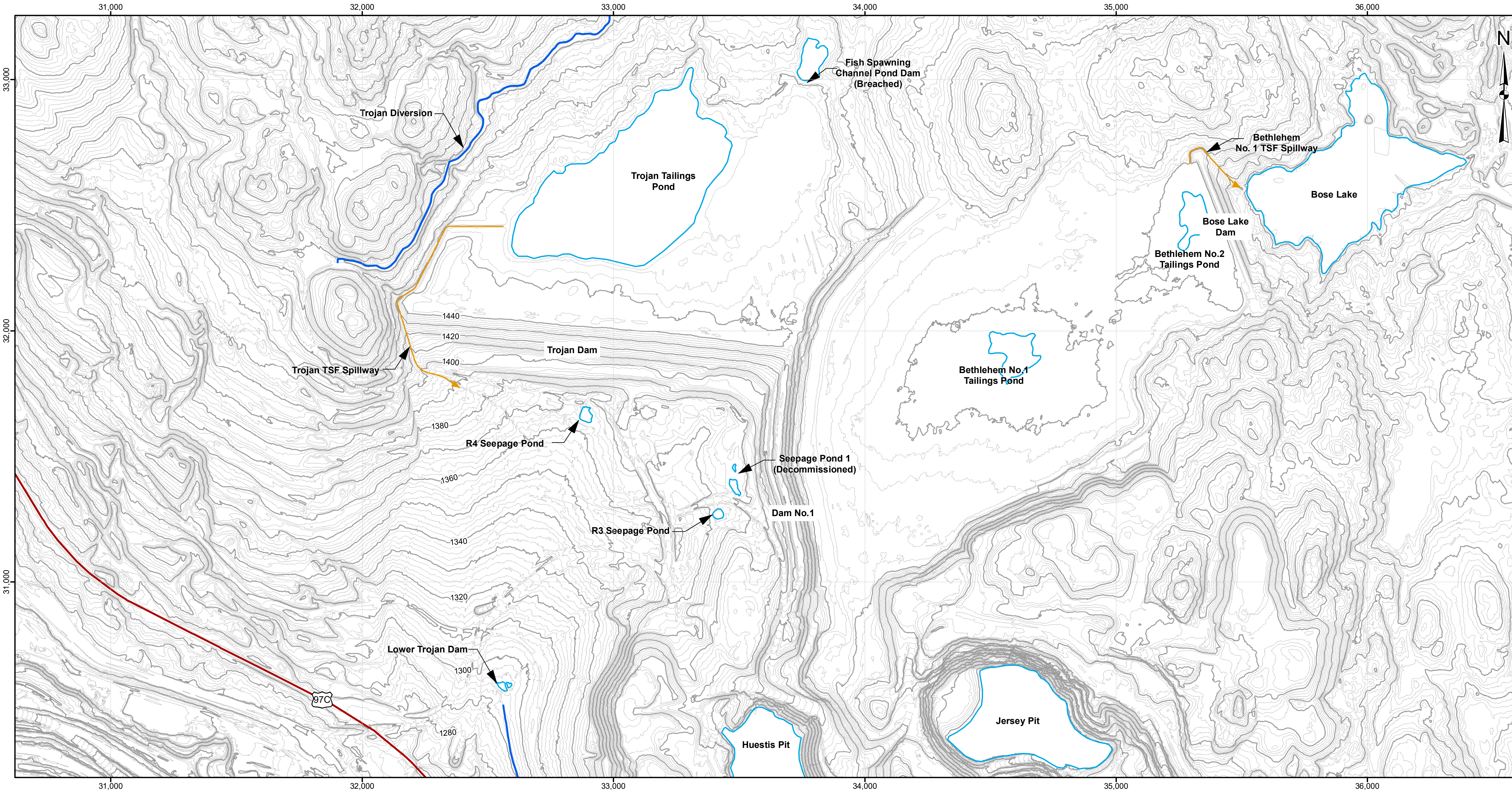


Legend

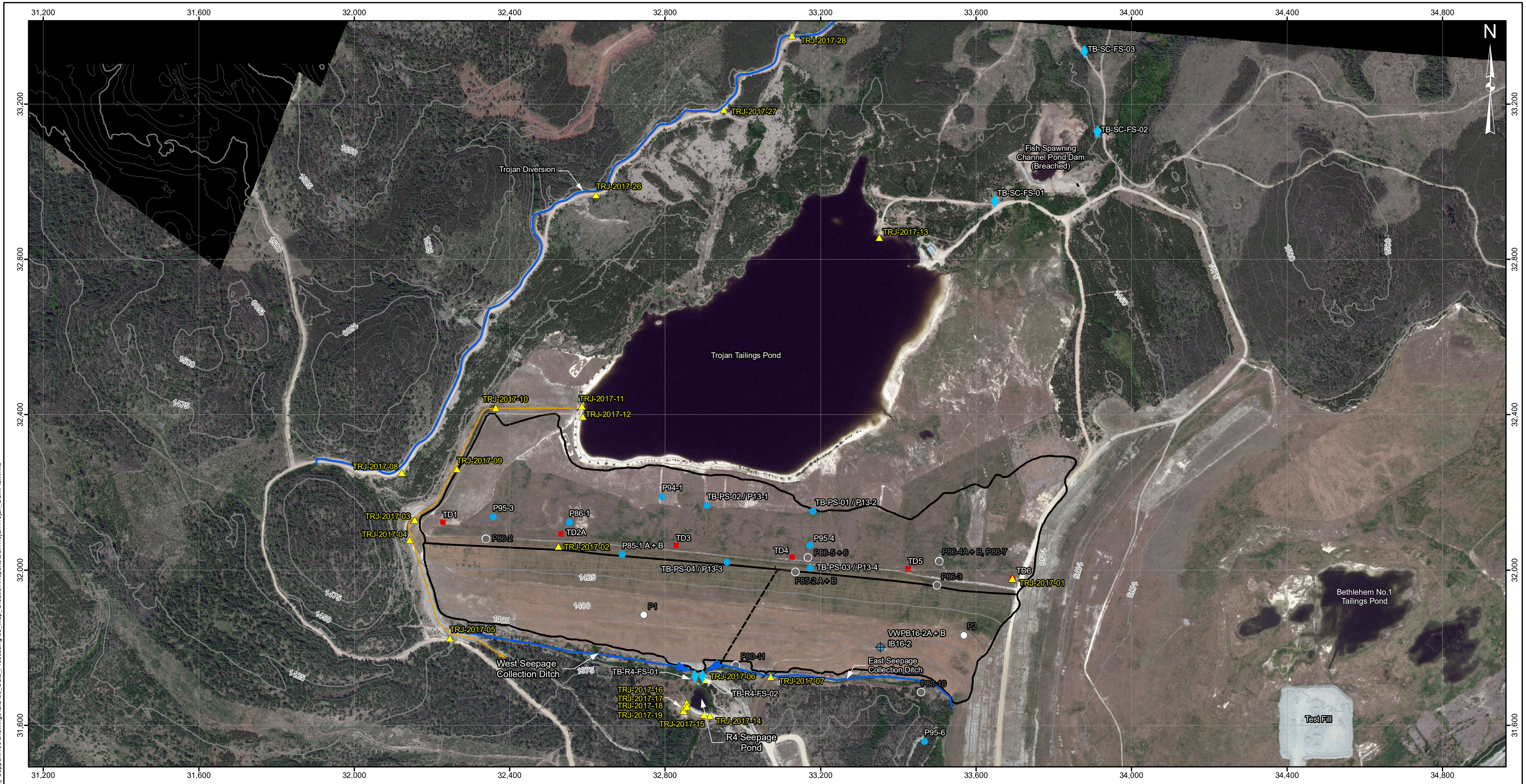
- Ditch
- Spillway
- Highway
- Index Contour (10 m)
- Intermediate Contour (2 m)
- Waterbody

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: 2018-02-22
Document Path: Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Trojan\Trojan_Overview.mxd

CLIENT	PROJECT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP	TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: TROJAN TAILINGS STORAGE FACILITY OVERVIEW

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



Legend

Instrument Type (Active)	Instrument Type (Defunct)		
Standpipe Piezometer	Standpipe Piezometer	Waypoint (TRJ-2017-xx)	Spillway
Vibrating Wire Piezometer	Pneumatic Piezometer	Plugged Diversion Culvert	Ditch
Inclinometer			Index Contour (25 m)
Survey Monument			Intermediate Contour (5 m)
Weir			

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: 2018-02-22
Document Path: Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Trojan\Trojan_DamPlan.mxd

CLIENT	PROJECT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP	TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: TROJAN DAM PLAN
	SCALE 1:9,500 · PROJECT No. M02341B26 · FIG No. 3

Legend

Instrument Type (Active)	Instrument Type (Defunct)		
Weir	Standpipe Piezometer	Waypoint (TRJ-2017-xx)	Index Contour (5 m)
		Culvert	Intermediate Contour (1 m)
		Spillway	
		Buried Pipeline	

0 50m

Notes:
1. Projection: HVC Mine Grid.
2. Imagery obtained July 1st, 2017
3. Topography from HVC, LiDAR flown on August 23rd, 2014.
4. The status of the original outlet pipe is unknown.
5. Locations of buried pipes are approximate.

Date: 2018-02-22
Document Path: Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Trojan\Trojan_R4SeepagePond.mxd

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP	PROJECT: TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: R4 SEEPAGE POND DAM PLAN
SCALE: 1:1,000	PROJECT No. M02341B26 — FIG No. 4

Legend

Instrument Type (Active)
- Weir
- Waypoint (TRJ-2017-xx)
- Spillway
- Buried Pipeline
- Ditch
- Index Contour (5 m)
- Intermediate Contour (1 m)

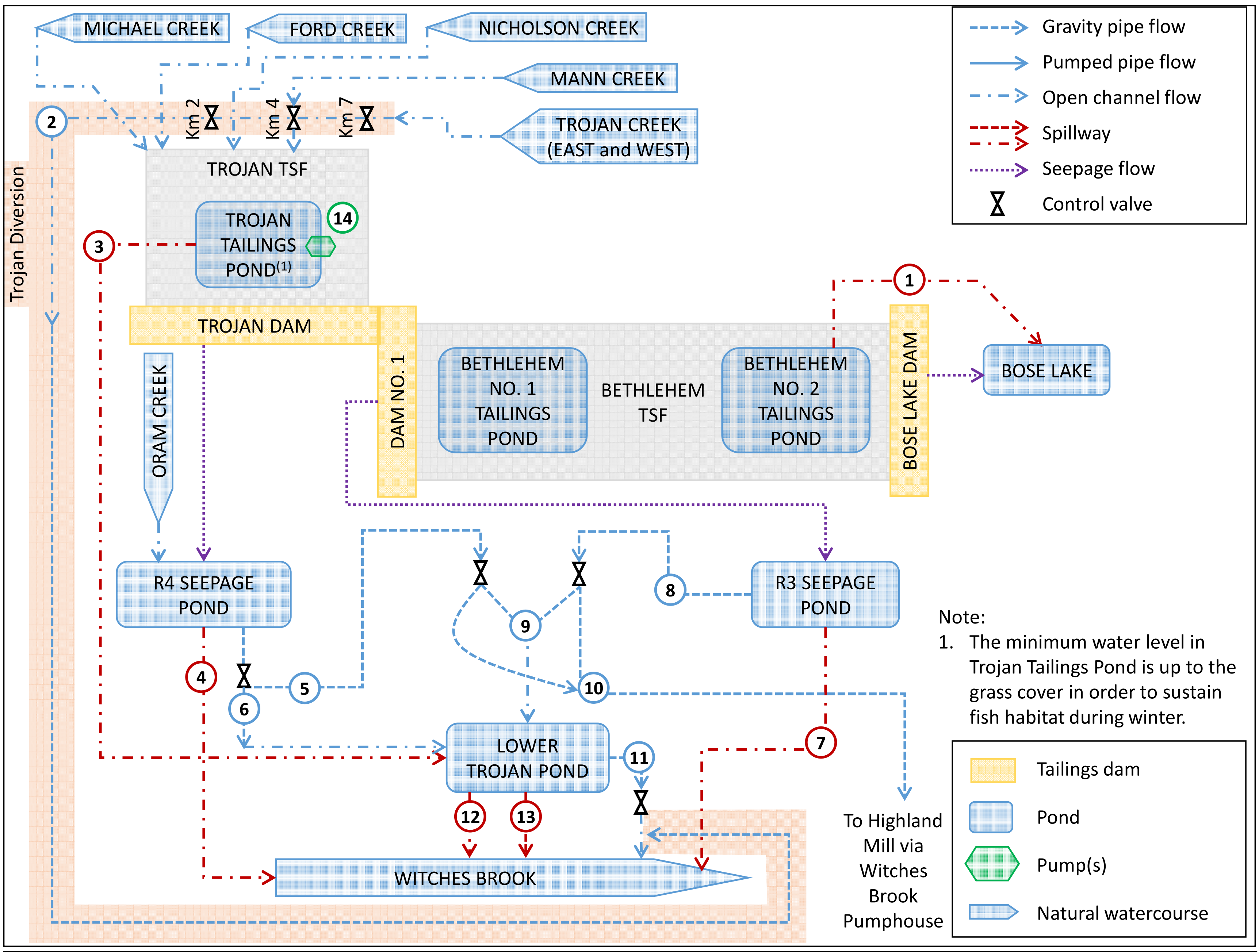
0 — 50m

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

CLIENT	PROJECT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP	TROJAN TAILNGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION
Klohn Crippen Berger	TITLE: LOWER TROJAN DAM PLAN
	SCALE 1:1,000 — PROJECT No. M02341B26 — FIG No. 5

Date: 2018-02-22
Document Path: Z:\M\VCR\M02341B26 - HVC\2017 Dam Safety Support\400 Drawings\GIS\03_Data_Processing\03_Map_Creation\Reports\DSI\Trojan\Trojan_LowerTrojanDam.mxd

Figure 6 Bethlehem and Trojan Process Flow Diagram



No.	Name	Description	Status	Permit[1] Constraints / Notes	Operational Constraints / Notes
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	Wording on limitations for discharge through spillways to come from Environment.	The two CSP culverts (1380 mm dia., 600 mm dia.) downstream of the spillway are kept clear.
2	Trojan Diversion	6.5 km long series of channels, culverts, and pipelines	Operational	April 27, 1999 amendment to PE-376: In accordance with Permit PE-376, Subsection 9.2, the following levels of concern shall be met in Trojan Creek at the End of Diversion: *Copper - 30 µg/l* *Molybdenum - 350 µg/l* *Manganese - 500 µg/l* *Nitrate & Nitrite - 5 mg/l* *Ammonia - 0.5 mg/l.*	Control valves at km 2, 4, 7 (U/S to D/S direction) divert water into Trojan Pond. Km 2 valve is typically opened during freshet to alleviate load on Witches Brook, and attenuate using Trojan Tailings Pond instead.
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	Wording on limitations for discharge through spillways to come from Environment.	None
4	R4 Spillway	2 m wide riprap-lined channel	Operational	Wording on limitations for discharge through spillways to come from Environment.	None
5	R4 Low-Level Outlet	300 mm dia. HDPE pipe with U/S and D/S control valves and intake trash rack	Operational	None, flow eventually reports to end of Trojan Diversion which is subject to PE-376 constraints (see #2 Trojan Diversion).	U/S valve is open year-round to allow water to discharge from R4 Pond. D/S valve is operated based on freeboard at LTD, demands at the Mill, and flowrate in Witches Brook (compliance point).
6	R4 Overflow	100 mm dia. HDPE pipe with U/S control valve	Operational		Not typically operated unless the water level in R4 Pond cannot be drawn down by the LLO and spillway.
7	R3 Spillway	2 m wide riprap-lined channel	Operational	Wording on limitations for discharge through spillways to come from Environment.	None
8	R3 Low-Level Outlet	460 mm dia. HDPE pipeline with D/S control valve	Operational	None, flow eventually reports to end of Trojan Diversion which is subject to PE-376 constraints (see #2 Trojan Diversion).	Valve is operated based on freeboard at LTD, demands at the Mill, and flowrate in Witches Brook (compliance point).
9	Seepage to LTD	## mm dia. buried pipeline	Operational		U/S valves for R3, R4 discharge are operated based on freeboard at LTD, demands at the Mill, and flowrate in Witches Brook (compliance point). Typically, discharge to the Mill is maximized.
10	Northern Collection Line	## mm dia. buried pipeline	Operational	None	
11	LTD Low-Level Outlet	460 mm dia. HDPE pipe with control valve and intake trash rack	Operational	None, flow eventually reports to end of Trojan Diversion which is subject to PE-376 constraints (see #2 Trojan Diversion).	This outlet is open year-round.
12	LTD Spillway	7 m wide channel	Operational	Wording on limitations for discharge through spillways to come from Environment.	Spillway channel is blocked with heavy vegetation and debris.
13	LTD Overflow	810 mm dia. HDPE pipe	Operational		None
14	Trojan Pump	Pump for Trojan Tailings Pond	Non-operational	Water in the Trojan TSF cannot be moved to other locations. If needed, the pump and pipes could be configured to water the Trojan tailings beach.	The pump is at the Trojan TSF, but there are no pipes connected to take water out of Trojan Pond.

Notes:

1. Bethlehem/Trojan is operated under the following: permits M-11, PE-376; water licenses 68389, C114183. Constraints shown herein are summaries for identified flow paths only – Environment must be consulted for complete permit/license constraints.
2. Day-to-day operations, changes to or maintenance done on the Bethlehem/Trojan system are carried out by Mill Operations and Mill Maintenance. TWM are responsible for surveillance activities.

APPENDIX I

Dam Safety Inspection Checklist

APPENDIX I-A

Dam Safety Inspection Checklist – Trojan Dam

2017 ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Trojan Dam	**Inspection Date:**	24-Oct-17 (RF/DB/TT)
Weather:	Partial sun and cloud	**Inspector(s):**	Rick Friedel, Delton Breckenridge, Thayaparan Theenathayarl
Pond Elevation:	1432.763 m (based on HVC pond survey done 19-Oct-17)		
Freeboard:	8.24 m (based on HVC pond survey done 19-Oct-17)		

Condition	Spillway
Was it flowing?	☐ Yes ☒ No
Flow rate:	N/A

Are the following components of your dam in _SATISFACTORY CONDITION_?
(check one if applicable)

EMBANKMENT	Yes/No	SPILLWAY	Yes/No
U/S Beach	☒ Yes ☐ No	Debris Boom	☒ Yes ☐ No
Crest	☒ Yes ☐ No	Entrance	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No	Channel	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No	Channel Slopes	☒ Yes ☐ No
Drains	☒ 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):

1) None.

Comments / Notes:

1) Crest is hummocky due to either differential settlement or formation as part of land reclamation efforts. Does not compromise freeboard and appears to be in the same condition as 2016 inspection.
2) High point of tailings beach appears to slope towards access road along left abutment and toe of Bethlehem Dam. Access road lower elevation then crest and under IDF conditions could affect freeboard. Ground survey of this area could resolve these concerns.

SITE PLAN

Legend

Instrument Type (Active)	Instrument Type (Defunct)		
Standpipe Piezometer	Standpipe Piezometer	Waypoint (TRJ-2016-xx)	Spillway
Vibrating Wire Piezometer	Pneumatic Piezometer	Plugged Diversion Culvert	Ditch
Inclinometer			Index Contour (25 m)
Survey Monument			Intermediate Contour (5 m)
Weir			

APPENDIX I-B

Dam Safety Inspection Checklist – R4 Seepage Pond Dam

2017 ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	R4 Seepage 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):	2m estimated		

Outlet Condition Survey

Description	Outlet Controls?	Was it flowing?	Flow rate	Visual Review?	Testing / Detailed Inspection?
Low Level Outlet	☒ Yes ☐ No	☒ Yes ☐ No	N/A	☒ Yes ☐ No	☐ Yes ☒ No
Spillway Channel	N/A	☐ Yes ☒ No	N/A	☒ Yes ☐ No	N/A
Original Outlet Pipe	☐ Yes ☒ No	☐ Yes ☒ No	N/A	☒ Yes ☐ No	☐ Yes ☒ No

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

EMBANKMENT	Yes/No	LOW LEVEL OUTLET	Yes/No	SPILLWAY CHANNEL	Yes/No
U/S Slope	☒ Yes ☐ No	Outlet Pipe	☒ Yes ☐ No	Entrance	☒ Yes ☐ No
Crest	☒ Yes ☐ No	Outlet Channel	☒ Yes ☐ No	Channel	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No	Outlet Controls	☒ Yes ☐ No	Channel Slopes	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No				

ORIGINAL OUTLET PIPE	Yes/No
Entrance	☒ Yes ☐ No
Pipe	☒ Yes ☐ No

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

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

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

1) None.

Comments / Notes:

1) Minor vegetation present on low-level outlet log boom. Monitoring and clearing is part of THVCP routine dam inspections.

SITE PLAN

APPENDIX I-C

Dam Safety Inspection Checklist – Lower Trojan

2017 ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	Lower Trojan 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):	1.5m estimate from inspection		

Outlet Condition Survey

Description	Outlet Controls?	Was it flowing?	Flow rate	Visual Review?	Testing / Detailed Inspection?
460 mm HDPE Outlet to Weir	☒ Yes ☐ No	☒ Yes ☐ No	1/3 full	☒ Yes ☐ No	☐ Yes ☒ No
200 mm HDPE Low Level Outlet	☐ Yes ☒ No	☐ Yes ☒ No	Decommissioned	☒ Yes ☐ No	☐ Yes ☒ No
810 mm HDPE Spillway Pipe	☐ Yes ☒ No	☐ Yes ☒ No	N/A	☒ Yes ☐ No	N/A
Spillway Channel	N/A	☐ Yes ☒ No	N/A	☒ Yes ☐ No	N/A

Are the following components in *__SATISFACTORY CONDITION__*?
(check one if applicable)

EMBANKMENT	Yes/No	OUTLET	Yes/No	LOW LEVEL OUTLET	Yes/No
U/S Slope	☒ Yes ☐ No	Outlet Pipe	☒ Yes ☐ No	Outlet Pipe	☒ Yes ☐ No
Crest	☒ Yes ☐ No	Outlet Channel	☒ Yes ☐ No	Outlet Channel	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No	Outlet Controls	☒ Yes ☐ No	Outlet Controls	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No				

SPILLWAY PIPE	Yes/No	SPILLWAY CHANNEL	Yes/No
Entrance	☒ Yes ☐ No	Entrance	☐ Yes ☒ No
Pipe	☒ Yes ☐ No	Channel	☐ Yes ☒ No
		Channel Slopes	☐ Yes ☒ No

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

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

INDICATOR	SPILLWAY PIPE	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

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

1) Inlet and outlet of spillway pipe surrounded by tall vegetation. To mitigate the risk of blockage during storm flows this should be cleared.
2) Spillway intake excessively vegetated. Spillway channel full of tree debris and heavily vegetated. Flow path of water is no longer visible, and cross-sectional shape of channel is unclear. Erosion protection requirements unknown and inspection difficult due to lack of access. Spillway should be cleared of debris and vegetation.

Comments / Notes:

1) Vegetation growing around catwalk to low-level outlet, continued growth could lead to loss of access to trash rack.
2) Upstream slope of dam heavily vegetated and full of debris. This should be monitored and cleared as part of normal operating procedure.

SITE PLAN


TRJ-2016-42
Spillway Channel (Decommissioned)
Lower Trojan Dam
TRJ-2016-41
TRJ-2016-43
Lower Trojan Pond
810 mm Dia. Spillway Pipe
200 mm Dia. Low-Level Outlet Pipe (Decommissioned)
TRJ-2016-45
TRJ-2016-44
TRJ-2016-40
TB-LT-FS-01
Control Valve
460 mm Dia. Diversion Pipeline
TRJ-2016-46
TRJ-2016-47
TRJ-2016-48
Diversion Ditch
1300
1285
1280
Legend
Instrument Type (Active)
Weir
Waypoint (TRJ-2016-xx)
Spillway
Buried Pipeline
Ditch
Index Contour (5 m)
Intermediate Contour (1 m)

APPENDIX II

Inspection Photographs

APPENDIX II-A

Inspection Photographs – Trojan Dam

Appendix II-A
Inspection Photographs - Trojan Dam

LEGEND:

- TRJ = Trojan Tailings Facility
- TRJ-2017-## refers to 2017 DSI waypoint shown on Figure 3
- All photographs taken during inspection on October 24, 2017

Photo II-A- 1 Overview of downstream slope view towards left abutment (TRJ-2017-08)

Photo II-A- 2 Overview of impoundment view from right abutment towards Bethlehem (TRJ-2017-08)

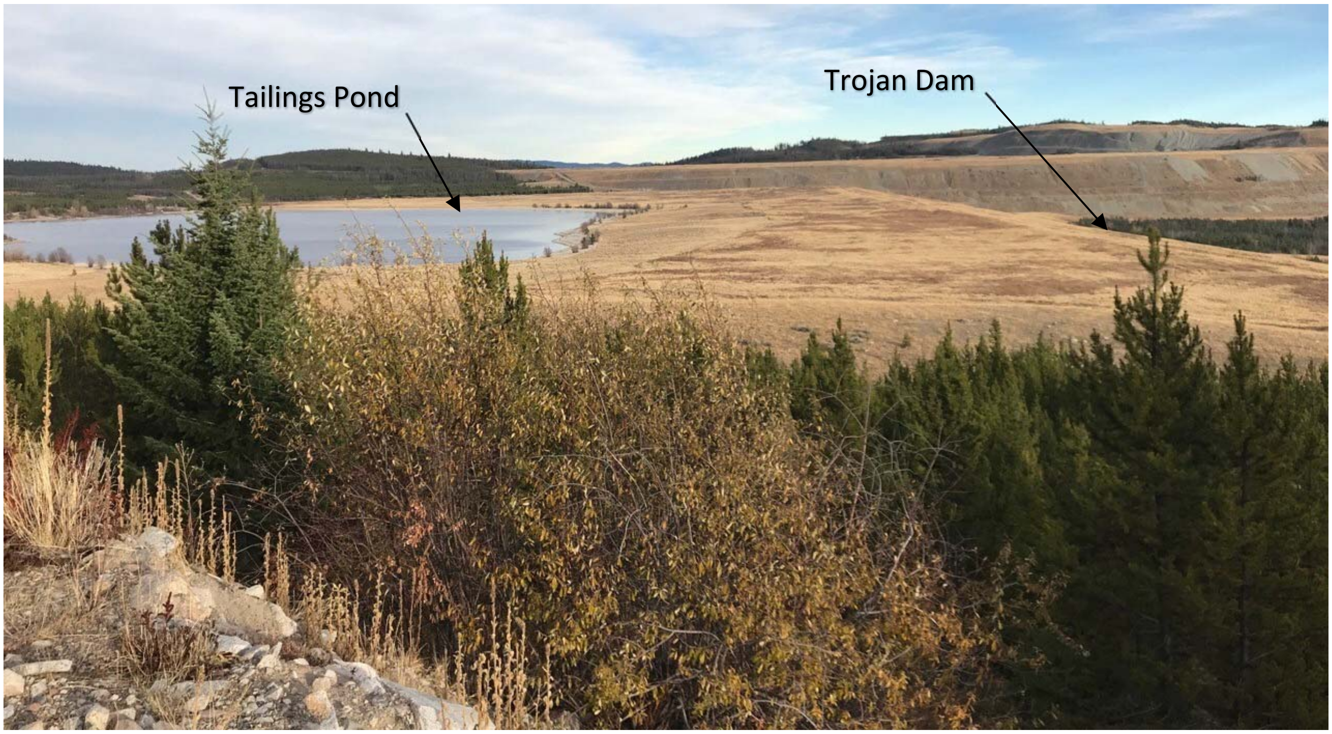


Photo II-A- 3 Upstream side of pond view of boat launch and climate station (TRJ-2017-13)

Photo II-A- 4 Upstream side of pond view of natural catchment inflow location (TRJ-2017-13)

Photo II-A- 5 Impoundment view towards Trojan Dam (TRJ-2017-13)

Photo II-A- 6 High point of beach view towards right abutment (TRJ-2017-01)

Photo II-A- 7 High point of beach view towards left abutment, ground slopes towards access road which is lower than the crest (TRJ-2017-01)

Photo II-A- 8 Vegetated crest view towards left abutment (TRJ-2017-02)

Photo II-A- 9 Vegetated crest view towards right abutment and spillway (TRJ-2017-02)

Photo II-A- 10 Vegetated downstream slope view towards right abutment (TRJ-2017-02)

Photo II-A- 11 Vegetated downstream slope view towards left abutment (TRJ-2017-02)

Photo II-A- 12 Tailings pond and tailings beach view towards natural inlet (TRJ-2017-12)

Photo II-A- 13 Spillway entrance and debris boom view downstream (TRJ-2017-11)

Photo II-A- 14 Spillway inflection point view towards inlet (TRJ-2017-10)

Photo II-A- 15 Spillway inflection point view downstream (TRJ-2017-10)

Photo II-A- 16 Spillway channel with exposed bedrock on righthand side view downstream (TRJ-2017-09)

Photo II-A- 17 Spillway channel with exposed bedrock and pooled water view upstream (TRJ-2017-09)

Photo II-A- 18 Spillway curve at transition point from till to bedrock view upstream (TRJ-2017-03)

Photo II-A- 19 Spillway channel transition to bedrock with pooled water at low point, minor water level decrease from 2016 DSI inspection (TRJ-2017-03)

Photo II-A- 20 Spillway channel transition from bedrock to riprap along the toe of the dam, view downstream (TRJ-2017-03)

Photo II-A- 21 Transition from small rip rap to large riprap at this point where the channel grade steepens, view downstream (TRJ-2017-04)

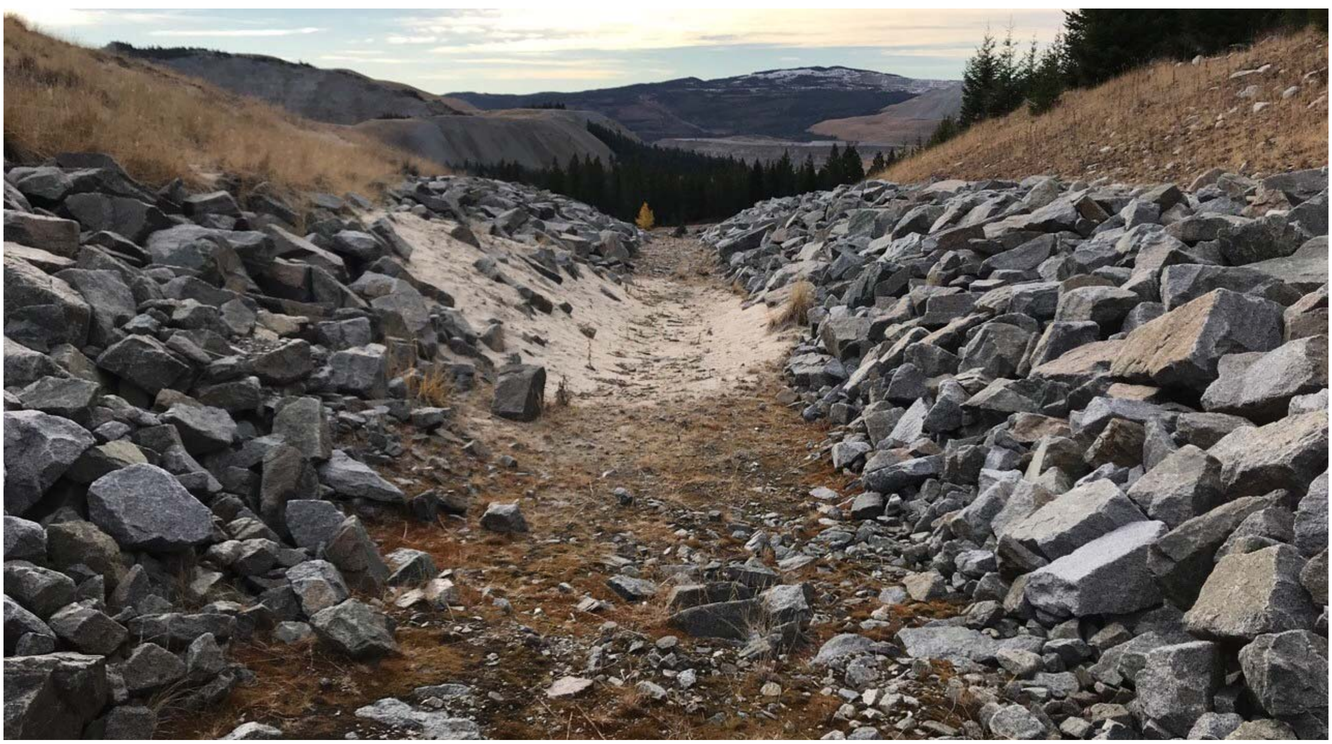


Photo II-A- 22 Overview of large riprap at transition point from large to small. Small riprap ~100mm, Coarser riprap ~150-1200mm (TRJ-2017-04)

Photo II-A- 23 Spillway channel lower left bank view upstream. Riprap in good condition boulders >1m in size (TRJ-2017-05)

Photo II-A- 24 Spillway lower left bank view downstream towards outfall (TRJ-2017-05)

Photo II-A- 25 Seepage collection ditch view towards Bethlehem Dam. Flow observed, along with local ponding at channel low points (TRJ-2017-07)

Photo II-A- 26 Seepage collection ditch view towards right abutment, flow observed (TRJ-2017-07)

Photo II-A- 27 Weir for left abutment seepage toe drain, flow observed (TRJ-2017-06)

Photo II-A- 28 Weir for right abutment seepage toe drain, flow observed (TRJ-2017-06)

Photo II-A- 29 Lined diversion channel looking upstream, minor vegetation present (TRJ-2017-08)

Photo II-A- 30 Damage to liner observed on diversion channel (TRJ-2017-26)

Photo II-A- 31 Diversion channel transition point from till to lined channel (TRJ-2017-27)

Photo II-A- 32 Diversion channel intersection point, road culvert free of obstructions (TRJ-2017-28)

Photo II-A- 33 Continuation of till lined section of diversion channel (TRJ-2017-28)

APPENDIX II-B

Inspection Photographs – R4 Seepage Pond Dam

Appendix II-B
Inspection Photographs - R4 Seepage Pond Dam

LEGEND:

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

Photo II-B- 1 Overview of R4 seepage pond. (TRJ-2017-14)

Photo II-B- 2 Dam Crest and upstream slope of pond, view towards right abutment (TRJ-2017-15)

Photo II-B- 3 Low-level outlet to Witches Brook (via Lower Trojan Dam) and wooden debris boom. Debris boom has minimal vegetation, and minor obstructions present in trash rack, therefore material was cleared since 2016 inspection (TRJ-2017-15)

Photo II-B- 4 Dam spillway entrance, and crest, view towards Bethlehem Dam (TRJ-2017-16)

Photo II-B- 5 Transition from smaller riprap to coarser riprap as grade steepens, view upstream (TRJ-2017-16)

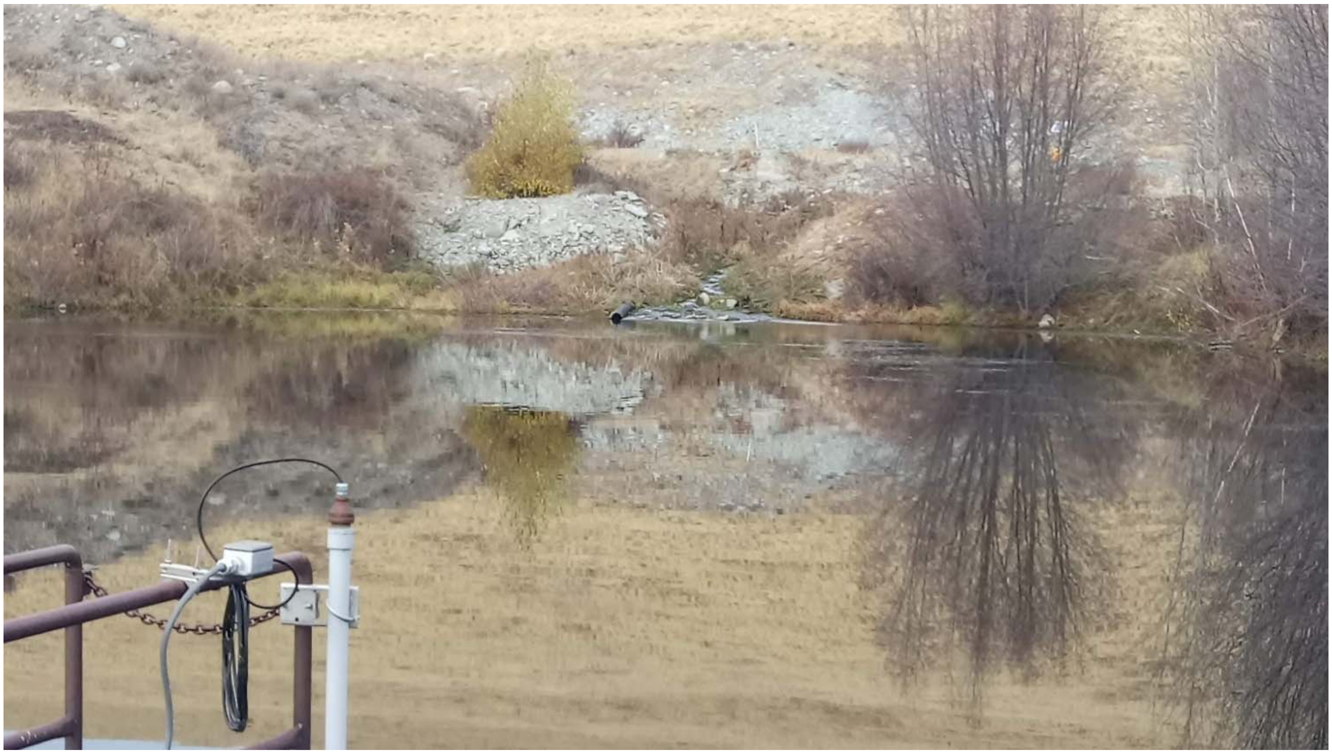
Photo II-B- 6 Dam spillway, no signs of erosion or vegetation present, view downstream (TRJ-2017-18)

Photo II-B- 7 Final portion of spillway riprap, view downstream towards outfall (TRJ-2017-19)

Photo II-B- 8 Riprap coarse material size 35-125mm (TRJ-2017-16)

Photo II-B- 9 Downstream slope, no signs of erosion, view from spillway (TRJ-2017-17)

Photo II-B- 10 East and West toe drain channel outlets and inflow pipe view towards Trojan Dam (TRJ-2017-15)



APPENDIX II-C

Inspection Photographs – Lower Trojan Dam

Appendix II-C
Inspection Photographs - Lower Trojan Dam

LEGEND:

- **TRJ = Trojan Tailings Facility.**
- **TRJ-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 R4 seepage pond (TRJ-2017-20)

Photo II-C- 2 Dam Crest, view towards left abutment (TRJ-2017-23)

Photo II-C- 3 Overflow near right abutment. Heavy vegetation in front of pipe which could lead to an obstruction. Flow discharges to the dam's right toe (TRJ-2017-23)

Photo II-C- 4 Dam spillway inlet, extensive vegetation present, and no visible channel (TRJ-2017-24)

Photo II-C- 5 Spillway route filled with debris, no visible channel or flow path (TRJ-2017-24)

Photo II-C- 6 Spillway curve around right abutment along the toe of the dam, view downstream. No visible channel, flow path filled with debris (TRJ-2017-24)

Photo II-C- 7 Dam downstream slope, view towards left abutment (TRJ-2017-22)

Photo II-C- 8 Dam downstream slope, view towards right abutment and spillway (TRJ-2017-22)

Photo II-C- 9 Catwalk and low-level outlet intake (TRJ-2017-21)

Photo II-C- 10 Debris boom and outfall intake. Obstruction from plant debris present (TRJ-2017-21)

Photo II-C- 11 Low-level outlet discharge pipe, no obstructions present (TRJ-2017-25)

Photo II-C- 12 Inflow culvert from Trojan Diversion Ditch (TRJ-2017-25)

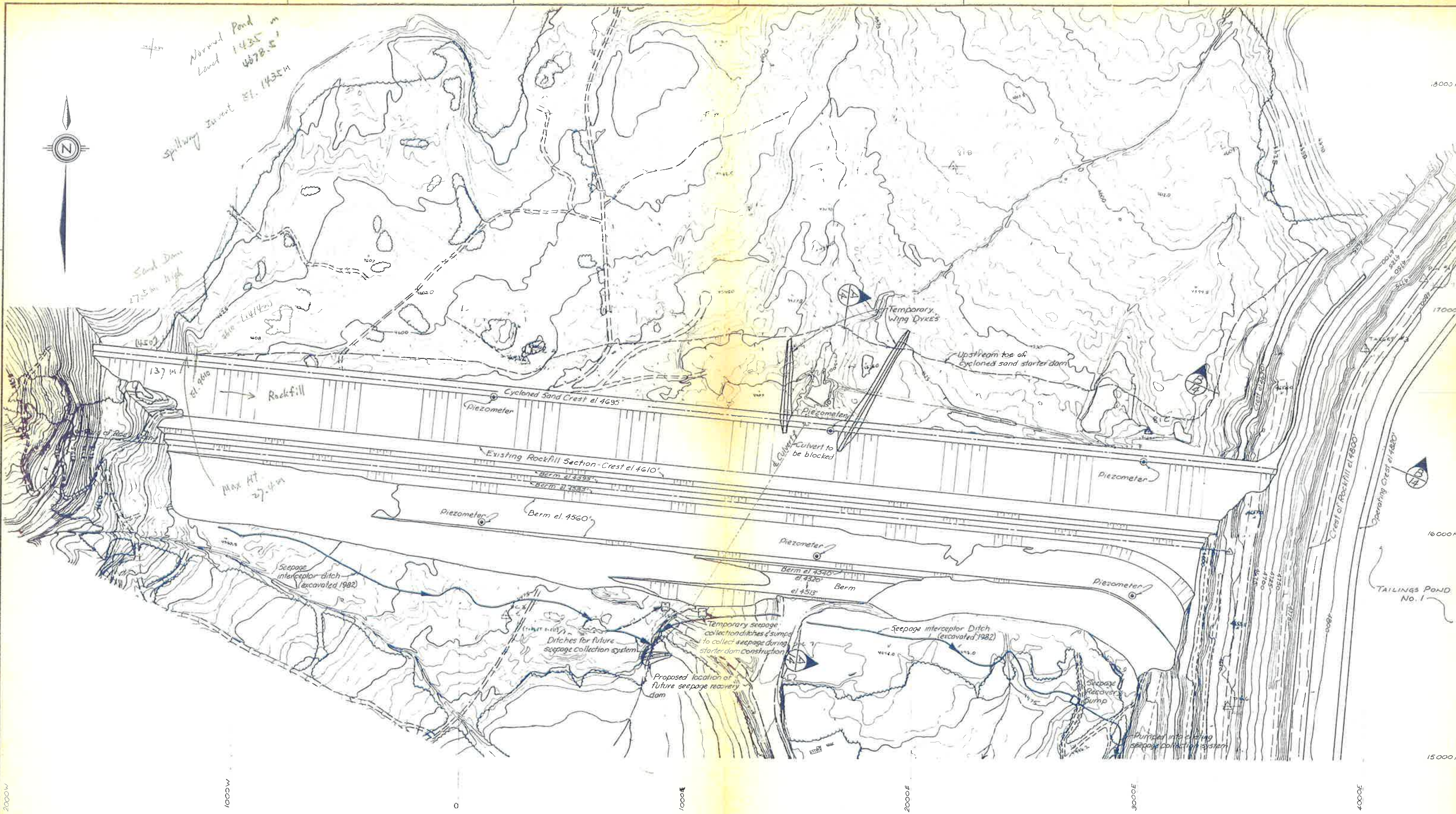
Photo II-C- 13 Discharge channel to weir, obstruction from large rocks present in channel (TRJ-2017-25)

APPENDIX III

Reference Dam Design Drawings

APPENDIX III-A

Reference Dam Design Drawings – Trojan Dam



Reference

Base plan taken from Pencil manuscript supplied by Bethlehem Copper Corporation dwg 81-184, dated July 17, 1981

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

SCALE: 200 0 400FT

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT: BETHLEHEM COPPER CORPORATION

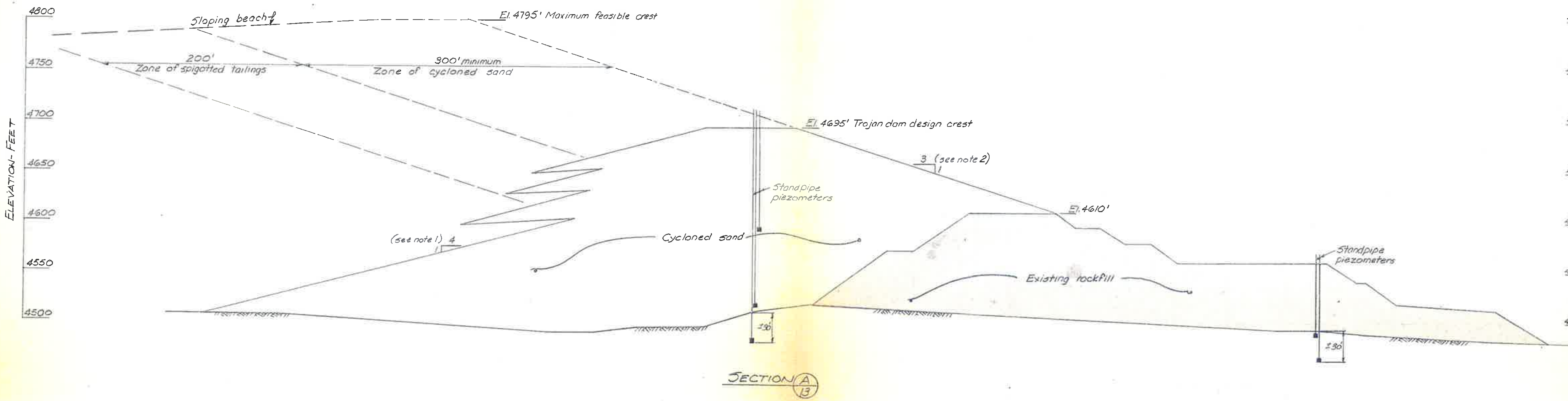
REV.	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
S.R.	EDP	NOV. 1982	AS SHOWN

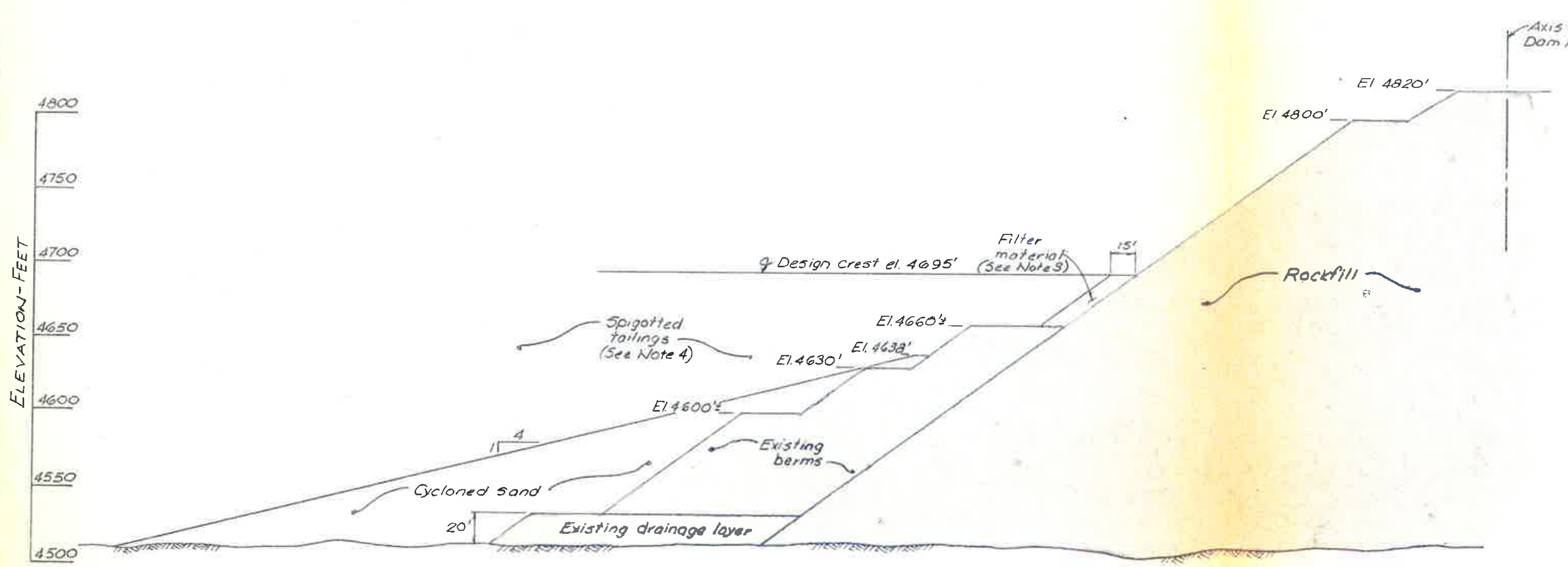
PROJECT: TROJAN TAILINGS DAM

TITLE: PLAN OF TROJAN DAM

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APPROVED Steve Rice	VA2916	D-2916-13	



SECTION A/13



SECTION B/13

NOTES:

1. Upstream slopes of the cycloned sand dam should be no flatter than 4 horizontal to 1 vertical and can be steepened if placement procedures allow.

2. An average downstream slope of 3 horizontal to 1 vertical should be achieved by constructing a series of toe berms on the downstream edge of the dam to retain the cycloned sand.

3. Filter material to conform to the design gradation shown on figure 2, appendix 1. Material should be placed in maximum 18 inch lifts, heavily watered and compacted.

4. Tailings will be hydraulically placed from spigot points along the dam crest to develop uniform beaches.

5. For construction schedule and sequencing see drawing D-2916-16

6. For location of standpipe piezometers see drawing D-2916-13.

7. The design presented in this report is for the dam constructed to elev. 4695 ft. The section above 4695 ft is presented to illustrate the feasibility of future dam raising.

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

SCALE: 50 0 50 100FT.

REV.	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
S R	E D P	NOV., 1982	AS SHOWN

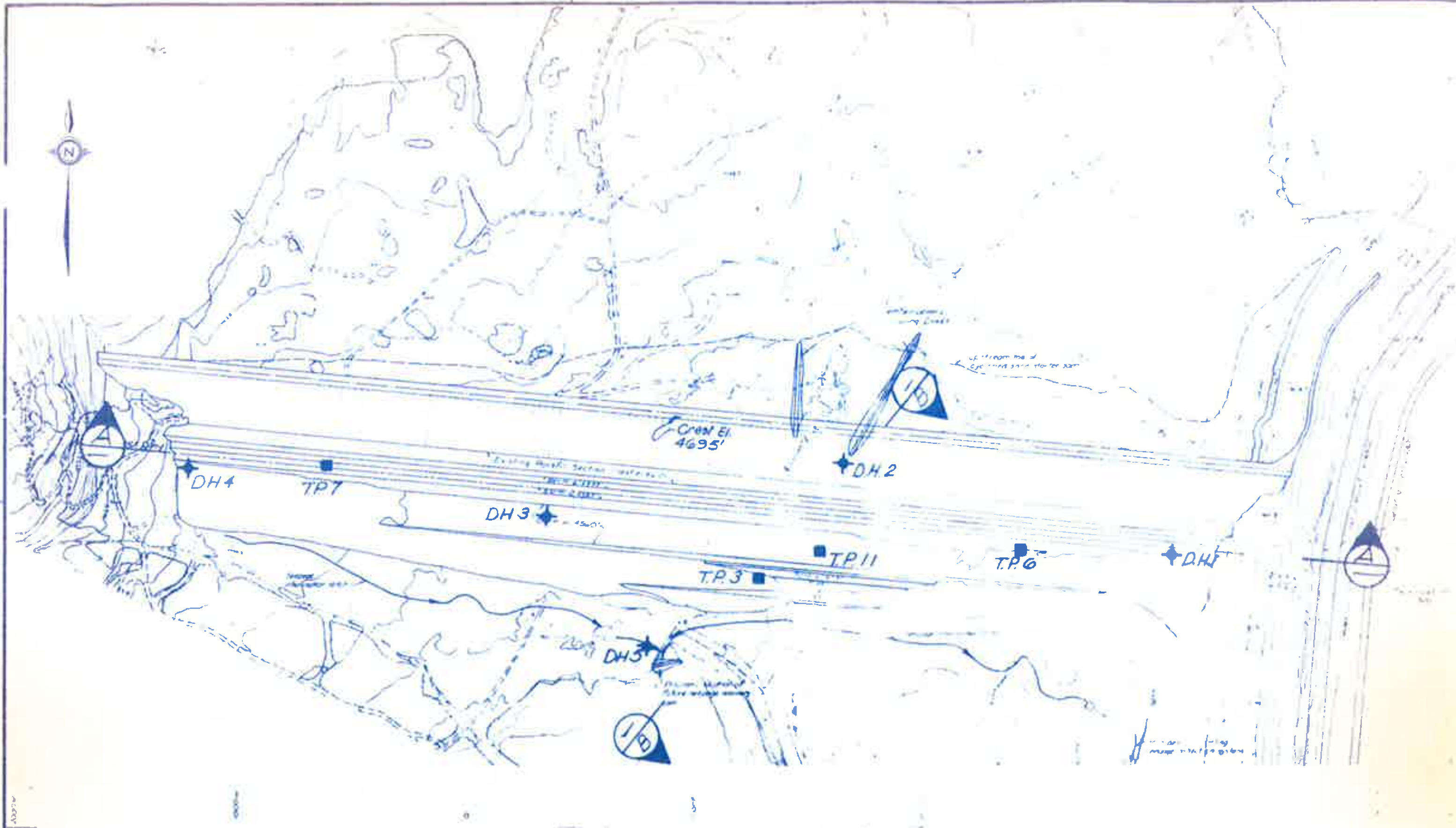
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: TROJAN TAILINGS DAM

TITLE: TYPICAL DESIGN SECTIONS

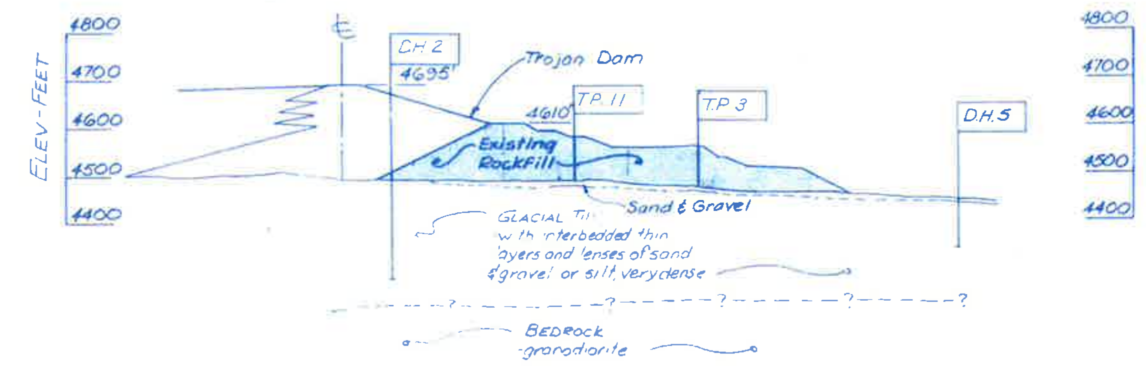
CLIENT: BETHLEHEM COPPER CORPORATION

DATE OF ISSUE	PROJECT No	DWG. No	REV.
APPROVED Steve Rice	VA2916	D-2916-14	

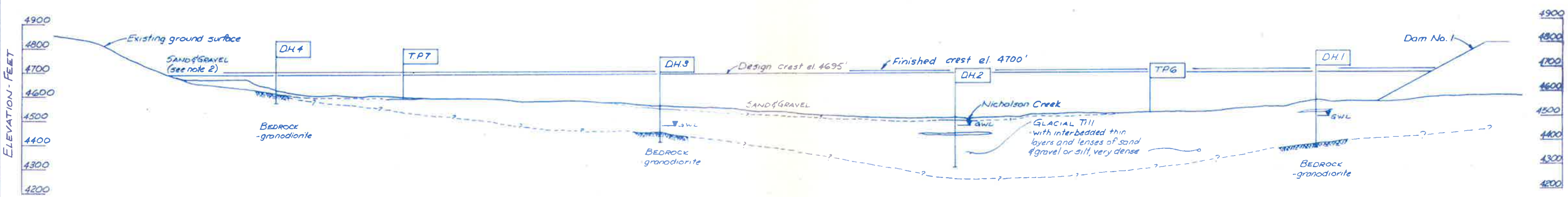


LOCATION PLAN

400' 0 800'



SECTION B



SECTION A

NOTES

1. Subsoil information based on site investigation carried out by Geopac Consultants Ltd in April & May, 1972.

2. Sand & gravel at west end of Trojan Dam used for Filter on Trojan Dam.

3. Foundation conditions have been simplified and inferred between test holes.

SOURCE : KLOHN LEONOFF PROJECT VA 2916
DWG. No. D-2916-18, DATED NOV. 22, 1982.

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

SCALE: 200' 0 400'

KLOHN-CRIPPEN

CLIENT: HIGHLAND VALLEY COPPER

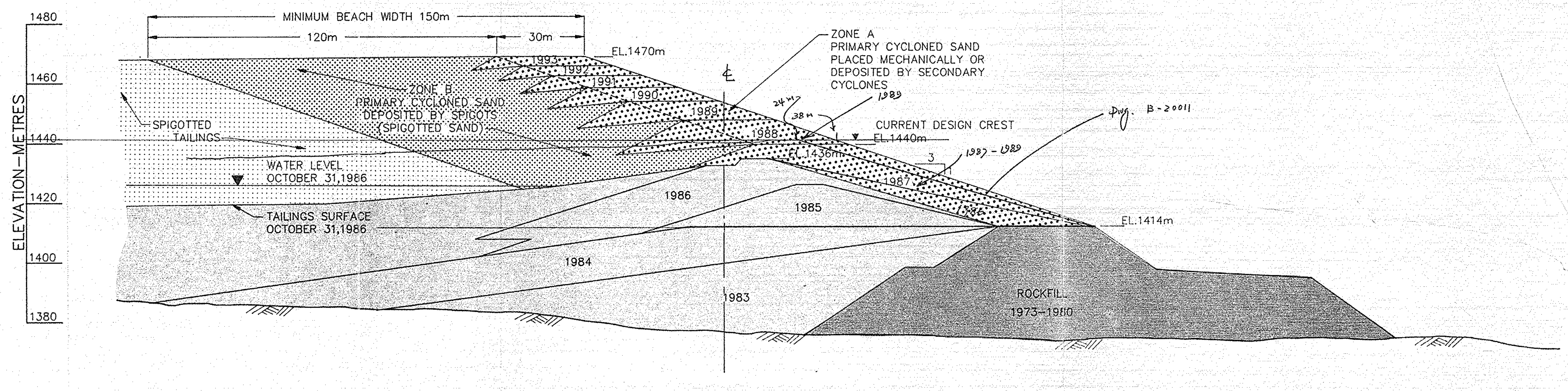
REV.	DATE	REVISION DETAILS		
DESIGN S.R.		DRAWN EDP	DATE NOV. 1982	SCALES AS SHOWN

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: SUBSOIL DATA - TROJAN DAM

DATE OF ISSUE	PROJECT No.	DWG. No.
DEC 9, 1996	FM2916 23	B-23018

APPROVED

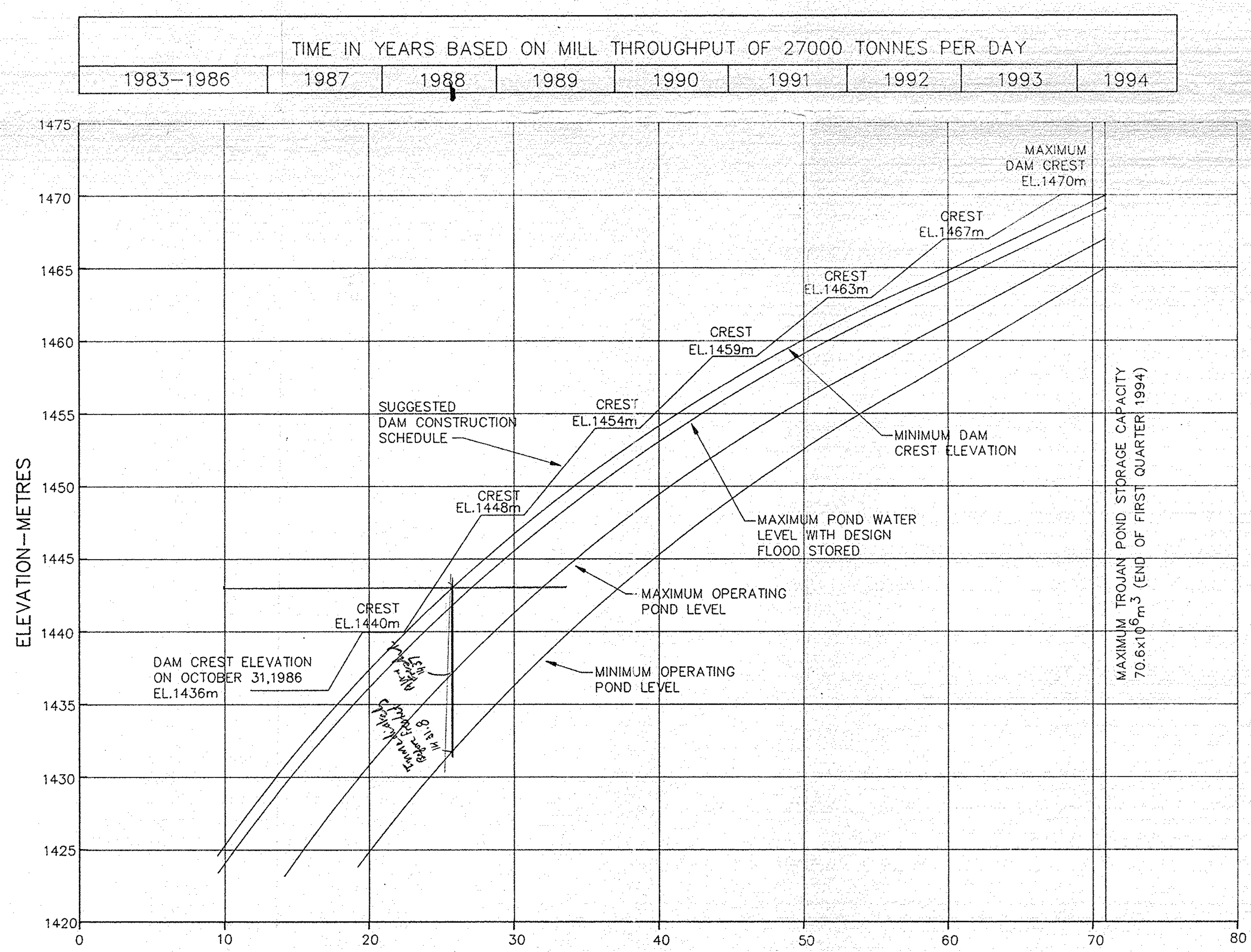


SECTION (A / 10008)

TYPICAL DESIGN SECTION AND CONSTRUCTION SCHEDULE

LEGEND

- ZONE A–PRIMARY CYCLONED SAND PLACED MECHANICALLY OR DEPOSITED BY SECONDARY CYCLONES
- ZONE B–PRIMARY CYCLONED SAND DEPOSITED BY SPIGOT
- SPIGOTTED TAILINGS
- EXISTING TAILINGS SAND EMBANKMENT
- ROCKFILL



TAILINGS POND STORAGE CURVES

YEAR	DESIGN CREST ELEVATION (m)	APPROXIMATE SAND VOLUME ZONE A (m³)
1987	1440	0.98×10^6
1988	1448	0.78×10^6
1989	1454	0.54×10^6
1990	1459	0.39×10^6
1991	1463	0.31×10^6
1992	1467	0.27×10^6
1993	1470	0.22×10^6

APPROXIMATE ZONE A CONSTRUCTION SCHEDULE AND CYCLONED SAND VOLUMES

min – 4668
max – 4685 — Nov. 2, 1987 4673 ft

NOTES:

1. THE PRIMARY CYCLONED SAND DEPOSITED IN ZONES A AND B SHALL CONTAIN LESS THAN 10 PERCENT BY WEIGHT PASSING THE No. 200 SIEVE AND SHALL BE DEPOSITED WITH THE FOLLOWING MINIMUM AVERAGE IN–SITU DRY DENSITY:

ZONE	DRY DENSITY (kN/m³)
A	14.4
B	14.9

2. THE MINIMUM DAM CREST ELEVATION REQUIRED AT ANY TIME DURING THE OPERATION OF TROJAN POND WILL PROVIDE THE FOLLOWING DESIGN STORAGE REQUIREMENTS, PLUS 1m OF FREEBOARD:
   a) THE TAILINGS PRODUCED BY THE MILL;
   b) A MINIMUM OPERATING POND CONTAINING $1.2 \times 10^6 m^3$ OF WATER;
   c) A MAXIMUM OPERATING POND CONTAINING $2.2 \times 10^6 m^3$ OF WATER FOLLOWING THE SPRING FRESHET; AND
   d) FLOOD STORAGE OF $3.4 \times 10^6 m^3$, ABOVE THE MAXIMUM OPERATING POND LEVEL, TO STORE THE PROBABLE MAXIMUM FLOOD.
3. THE SUGGESTED DAM CONSTRUCTION SCHEDULE IS BASED ON AN AVERAGE MILL THROUGHPUT RATE OF 27000 TONNES PER DAY(tpd) AND IS PRESENTED AS A GUIDE. THE ACTUAL DAM CONSTRUCTION SCHEDULE SHALL BE REVIEWED ANNUALLY AND ADJUSTED IN ACCORDANCE WITH OPERATING CONDITIONS.
4. TAILINGS STORAGE VOLUMES ARE BASED ON THE FOLLOWING ASSUMED IN–SITU DRY DENSITIES:

SLIMES	=	$9.4kN/m^3$ ($0.96t/m^3$)
SPIGOTTED TAILINGS	=	$13.0kN/m^3$ ($1.33t/m^3$)
ZONE A SAND	=	$14.4kN/m^3$ ($1.47t/m^3$)
ZONE B SAND	=	$14.9kN/m^3$ ($1.52t/m^3$)

DRAFT

TO BE READ WITH KLOHN LEONOFF REPORT DATED

SCALE: 20m 0 50m

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT: HIGHLAND VALLEY COPPER

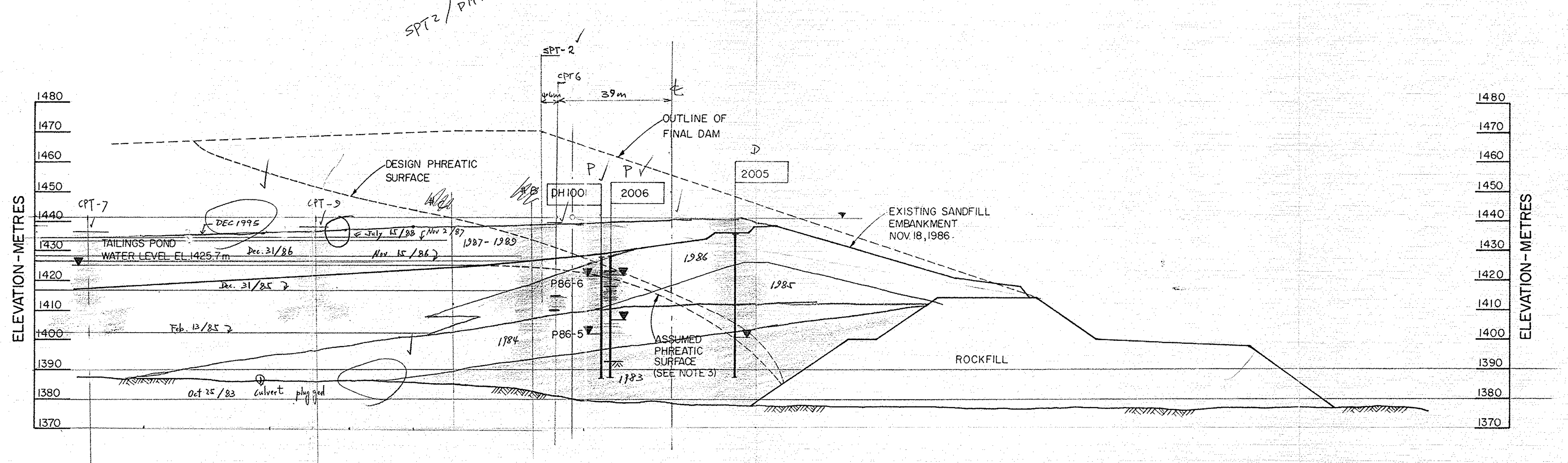
REV.	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
S.R.	E.D.P.	MAY,1987	AS SHOWN

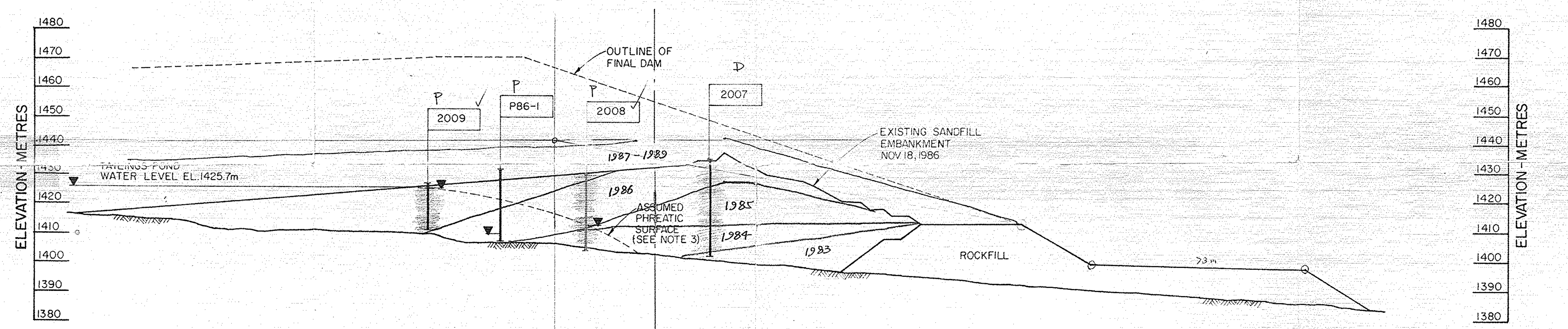
PROJECT: TROJAN TAILINGS DAM

TITLE: TROJAN DAM DESIGN SECTION, CONSTRUCTION SCHEDULE AND POND STORAGE CURVES

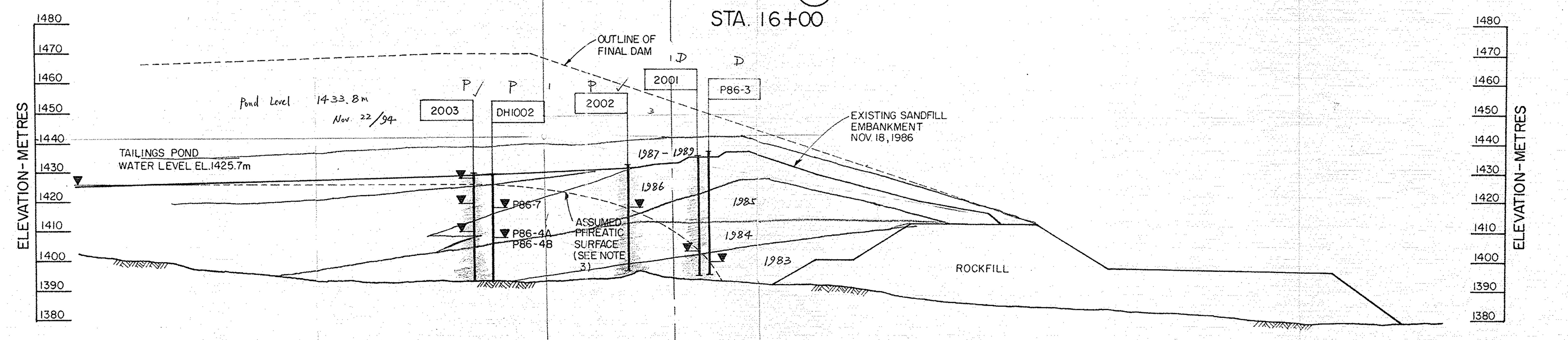
DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APPROVED	PB291610	D-10009	



SECTION A (10004)
STA. 36+00



SECTION B (10004)
STA. 16+00



SECTION C (10004)
STA. 47+00

LEGEND

2003	CONE PENETRATION TEST
DH1001	SAMPLED DRILLHOLE
P86-1	STANDPIPE PIEZOMETER
▼	MEASURED WATER LEVEL OR WATER LEVEL INTERPRETED FROM CONE LOG
▼P86-6	MEASURED WATER LEVEL IN STANDPIPE PIEZOMETER INSTALLED IN, OR ADJACENT TO, SAMPLED DRILLHOLE

NOTES

1. FOR TEST HOLE LOCATIONS SEE DRAWING D-10004.
2. WATER LEVELS IN THE CONE PENETRATION TEST HOLES WERE INTERPRETED FROM THE CONE LOGS (SEE APPENDIX II). WATER LEVELS IN STANDPIPE PIEZOMETERS WERE MEASURED APPROX. ONE MONTH AFTER THE FIELD INVESTIGATION.
3. THE ASSUMED PHREATIC SURFACE PLOTTED ON THE SECTIONS CORRESPONDS TO THE HIGHEST MEASURED WATER LEVEL.
4. SECTIONS BASED ON AS-BUILT SECTIONS PROVIDED BY HIGHLAND VALLEY COPPER.

1 : 100

DRAFT

TO BE READ WITH KLOHN LEONOFF REPORT DATED ______

SCALE: 20m 0 50m

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT: HIGHLAND VALLEY COPPER

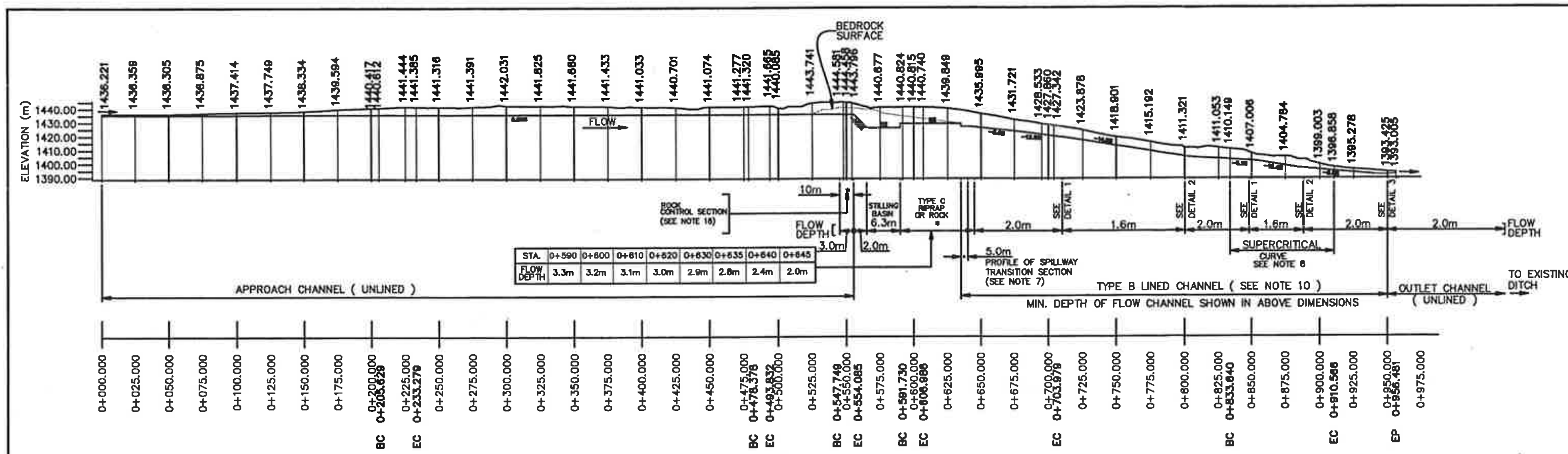
REV.	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
S.R	E.D.P	AUG, 1987	AS SHOWN

PROJECT: TROJAN TAILINGS DAM

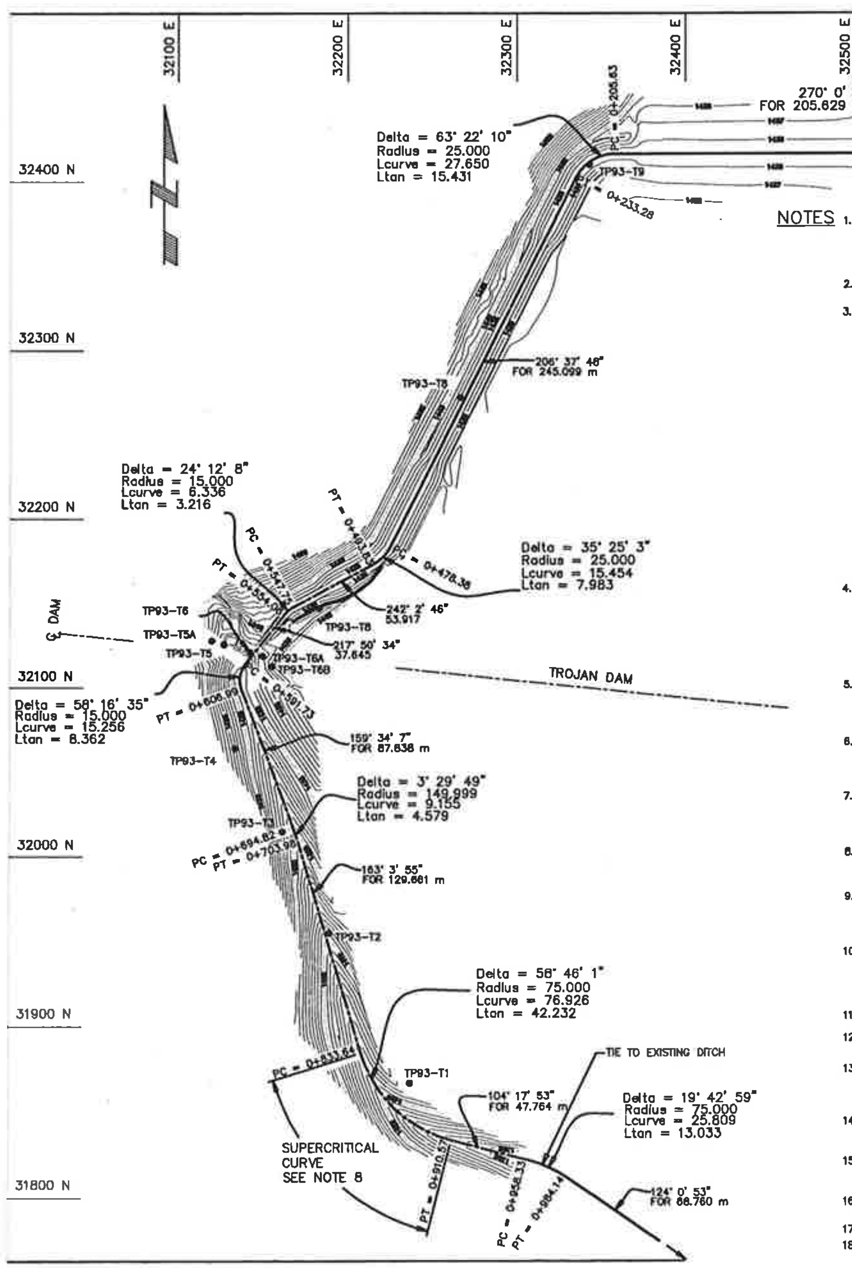
TITLE: SECTIONS

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APPROVED	PB2916-10	D-10005	



PROFILE ALONG SPILLWAY CHANNEL

(SEE NOTE 14)



GENERAL ARANGEMENT – PLAN

NOTES

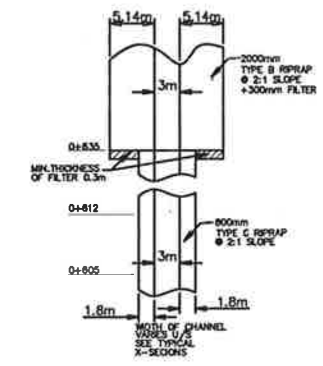
1. BASE TOPOGRAPHY AND AS-BUILT SURVEY WERE SUPPLIED BY HIGHLAND VALLEY COPPER. THE TOPOGRAPHIC MAP AND 1993 TEST PITTING DATA FORMED THE BASIS OF THE ORIGINAL SPILLWAY DESIGN. DESIGN MODIFICATIONS AND CONSTRUCTION ADJUSTMENTS ARE BASED ON ADDITIONAL TEST PITTING DATA OBTAINED IN 1995 AND THE ACTUAL GROUND CONDITIONS ENCOUNTERED.
2. APPROACH CHANNEL HORIZONTAL AT ELEV. 1435.5m FROM START OF TAILINGS CHANNEL AT STA. 0+000 TO STA. 0+555.3 IN ROCK CHANNEL.
3. TYPE B LINED CHANNEL RIPRAP TO CONSIST OF A 2000mm THICK LAYER OF HARD DURABLE ROCK WITH UNIT WEIGHT NOT LESS THAN 2400 kg/m^3. NO DIMENSION OF AN INDIVIDUAL ROCK SHOULD BE LESS THAN 1/3 OF LARGEST DIMENSION. NO ROCK SHALL HAVE OBVIOUS FRACTURE PLANES OR FISSURES. 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

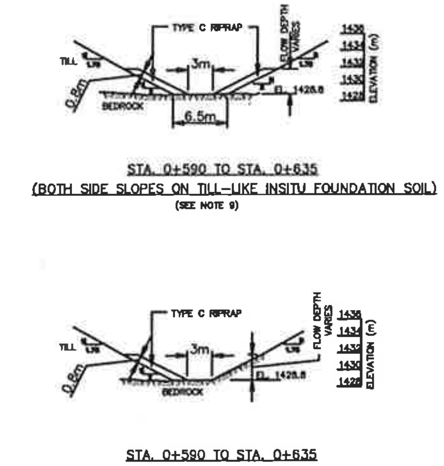
TYPE C RIPRAP TO CONSIST OF A 800mm THICK LAYER OF HARD DURABLE ROCK WITH UNIT WEIGHT NOT LESS THAN 2400 kg/m . NO DIMENSION OF AN INDIVIDUAL ROCK SHOULD BE LESS THAN 1/3 OF LARGEST DIMENSION. NO ROCK SHALL HAVE OBVIOUS FRACTURE PLANES OR FISSURES. THE RIPRAP SHOULD BE WELL GRADED AND CONFORM TO THE FOLLOWING:

% LESS THAN BY WEIGHT	WEIGHT (kg)	DIA. (mm)
100	70 TO 140	350 TO 450
50	35 TO 60	300 TO 360
15	10 TO 30	190 TO 290
5	9	180

4. FILTER MATERIAL FOR TYPE B RIPRAP ON TILL-LIKE FOUNDATION SOIL SHOULD BE WELL GRADED AND CONFORM TO THE FOLLOWING:
   MAXIMUM PARTICAL SIZE = 400mm
   D_{85}= 150mm TO 300mm
   D_{50}= 40mm TO 100mm
   D_{15}= 10mm TO 30mm
5. WHERE EXCAVATION WAS IN TAILINGS BELOW HIGH FLOW LEVEL, SIDE SLOPES WERE 10H:1V. SIDE SLOPES ABOVE HIGH FLOW LEVEL WERE NO STEEPER THAN 2.5H:1V. BETWEEN APPROX. STA. 0+200 AND 0+525, THE UPPER PORTION OF THE FLOW SECTION MAY BE IN TILL-COVERED TAILINGS-SAND SLOPE LOCALLY.
6. WHERE EXCAVATION WAS THROUGH TILL-LIKE FOUNDATION SOIL BELOW HIGH FLOW LEVEL, SIDE SLOPES WERE NO STEEPER THAN 2H:1V. SIDE SLOPES ABOVE HIGH FLOW LEVEL WERE NO STEEPER THAN 1.75H:1V IN TILL-LIKE FOUNDATION SOIL AND NO STEEPER THAN 2H:1V IN SAND DAMFILL.
7. WHERE EXCAVATION WAS THROUGH BEDROCK, SIDE SLOPES WERE NO STEEPER THAN 0.25H:1V. DOWNSTREAM OF STA. 0+635, TYPE B RIPRAP AND FILTER ZONE WERE IMPLEMENTED IN A TRANSITION SECTION FOR A LENGTH OF AT LEAST 5m AT HORIZONTAL GRADE.
8. TYPE B RIPRAP AND FILTER ZONES AT OUTER CHANNEL SLOPE BETWEEN STA. 0+834 AND STA. 0+911 WERE 0.5m ABOVE THE HIGH FLOW LEVEL TO ACCOUNT FOR FLOW SUPERELEVATION.
9. THE CHANNEL ALIGNMENT AND DESIGN WERE MODIFIED AFTER OVERLYING SAND DAMFILL WAS REMOVED. A STILLING BASIN WAS IMPLEMENTED BETWEEN STA. 0+565 AND 0+590, AND LIGHTER TYPE C RIPRAP WITH NO FILTER WAS PLACED BETWEEN STA. 0+590 AND 0+635.
10. TYPE B LINED CHANNEL SECTION WAS IN TILL-LIKE FOUNDATION SOIL FOR THE FULL DEPTH OF THE RIPRAP LINED SECTION. MINIMUM DEPTH OF FLOW SECTION ABOVE INVERT VARIES WITH CHANNEL SLOPE AS SHOWN ON SPILLWAY CHANNEL PROFILE. TRANSITION DETAIL BETWEEN FLOW DEPTHS IS SHOWN IN DETAIL 1 AND 2.
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. MODIFICATIONS TO THE SPILLWAY AND CONSTRUCTION MATERIALS FOR RIPRAP AND FILTERS REQUIRED FOR LINING THE SPILLWAY CHANNEL WERE CHECKED BY FIELD ENGINEER AND DESIGNERS FOR COMPLIANCE WITH THE DESIGN INTENT.
14. CHANNEL PROFILE SHOWS EXCAVATION ELEVATION ALONG CENTRELINE. FINISHED ELEVATION WILL DEPEND ON LINING AND FILTER THICKNESS, IF ANY.
15. EXISTING DIVERSION DITCH WAS ENLARGED WITHIN THE SEGMENT OF OUTLET CHANNEL. BEYOND STA. 1+053, SMOOTH TRANSITION TO EXISTING DITCH WAS MADE.
16. DETAIL 3 SHOWS END SECTION OF TYPE B RIPRAP AND FILTER AT STA. 0+950.
17. CHANNEL SLOPE TRANSITIONS HAD A VERTICAL RADIUS OF 5m.
18. IN ROCK CONTROL SECTION, APPROX. 0+545.3 TO 0+555.3, ENTIRE FLOW SECTION WAS IN COMPETENT BEDROCK.
19. UNLINED OUTLET CHANNEL MAY REQUIRE RIPRAP PROTECTION IF EXCESSIVE EROSION DEVELOPS IN THE FUTURE.

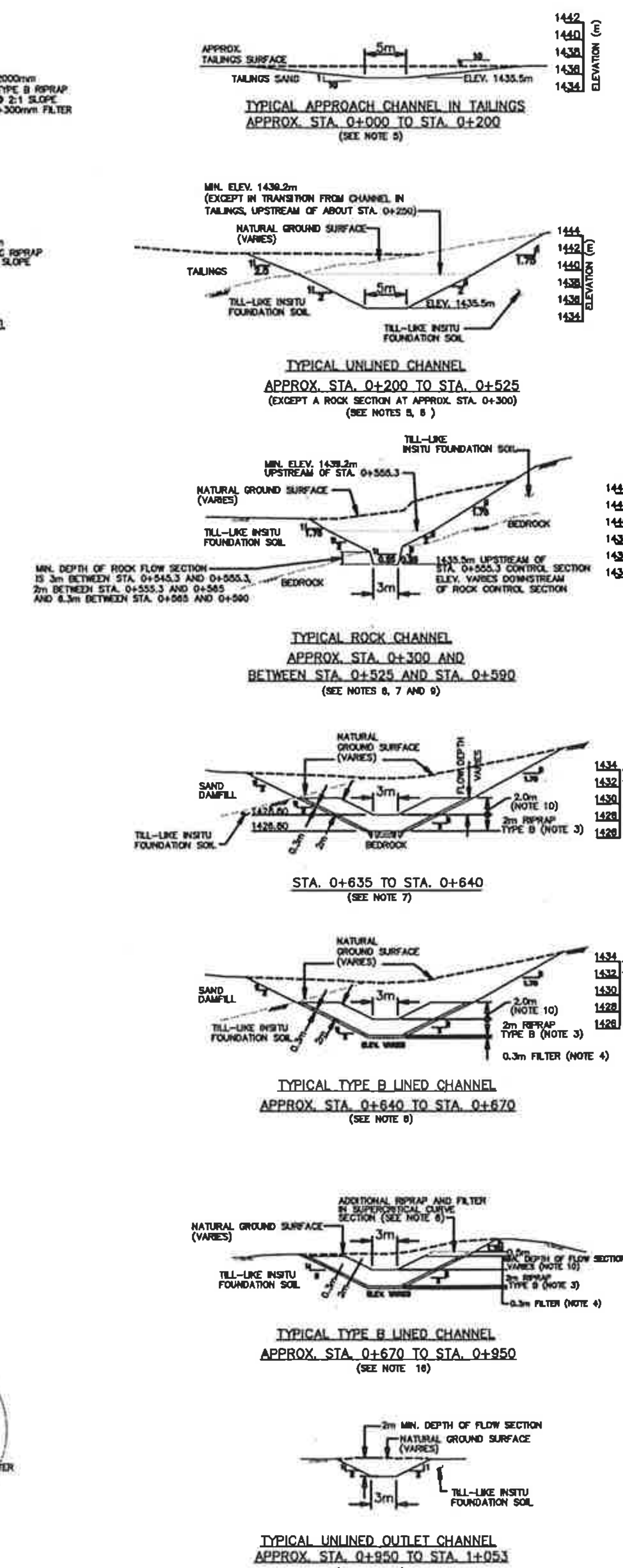


PLAN @ 0+635



STA. 0+590 TO STA. 0+635 (BOTH SIDE SLOPES ON TILL-LIKE INSITU FOUNDATION SOIL) (SEE NOTE 9)

STA. 0+590 TO STA. 0+635 (ONE SIDE SLOPE ON TILL-LIKE INSITU FOUNDATION SOIL) (SEE NOTE 9)



TYPICAL APPROACH CHANNEL IN TAILINGS APPROX. STA. 0+000 TO STA. 0+200 (SEE NOTE 5)

TYPICAL UNLINED CHANNEL APPROX. STA. 0+200 TO STA. 0+525 (EXCEPT A ROCK SECTION AT APPROX. STA. 0+300) (SEE NOTES 5, 6)

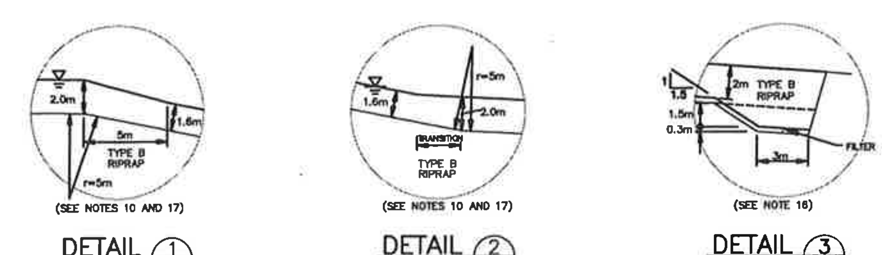
TYPICAL ROCK CHANNEL APPROX. STA. 0+300 AND BETWEEN STA. 0+525 AND STA. 0+590 (SEE NOTES 6, 7 AND 9)

STA. 0+635 TO STA. 0+640 (SEE NOTE 7)

TYPICAL TYPE B LINED CHANNEL APPROX. STA. 0+640 TO STA. 0+670 (SEE NOTE 6)

TYPICAL TYPE B LINED CHANNEL APPROX. STA. 0+670 TO STA. 0+950 (SEE NOTE 10)

TYPICAL UNLINED OUTLET CHANNEL APPROX. STA. 0+950 TO STA. 1+053 (SEE NOTE 15)



(SEE NOTES 10 AND 17) DETAIL 1 1:200

(SEE NOTES 10 AND 17) DETAIL 2 1:200

(SEE NOTE 16) DETAIL 3 1:200

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

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

CAD File: 114-808-202-1

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

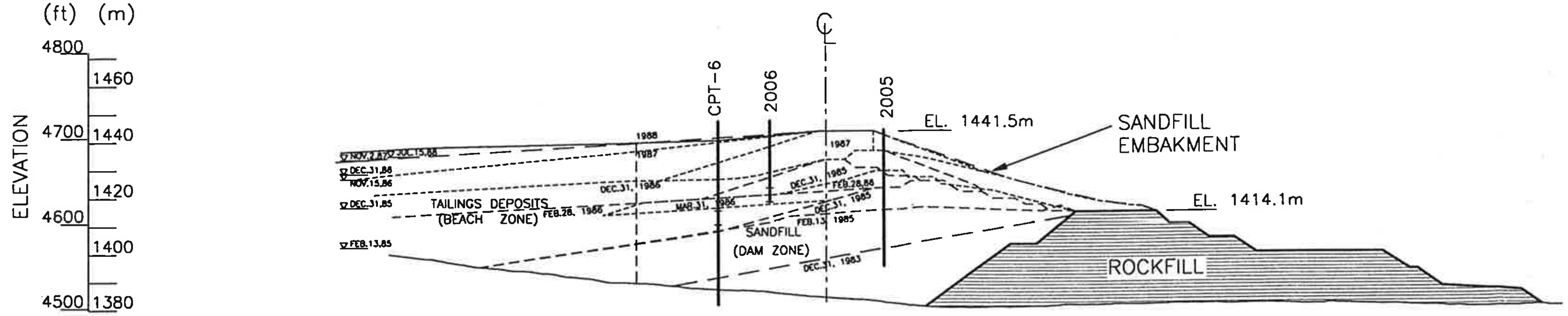
KLOHN CRIPPEN

PROJECT No. PM 2916 29 | DWG. No. D-29002

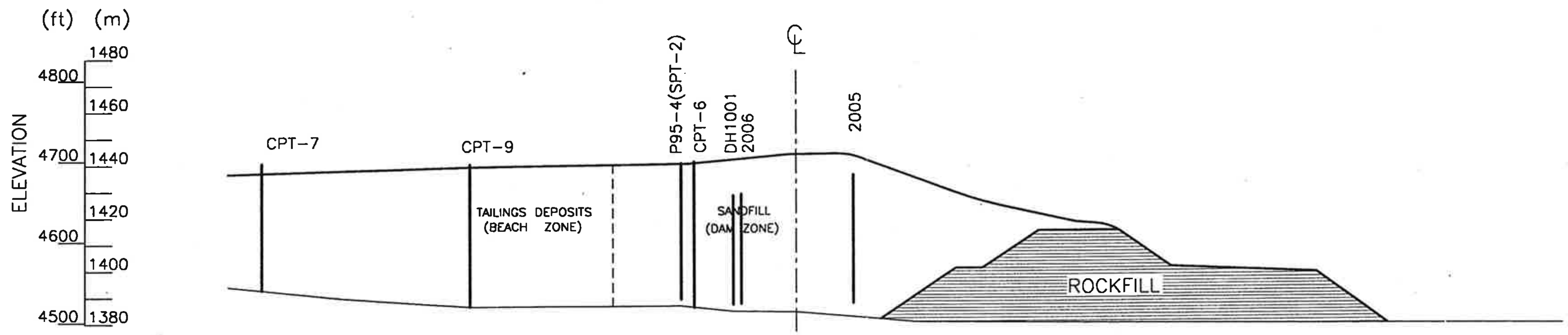
Highland Valley Copper

AS-BUILT TROJAN DAM SPILLWAY PLAN, PROFILE & SECTIONS

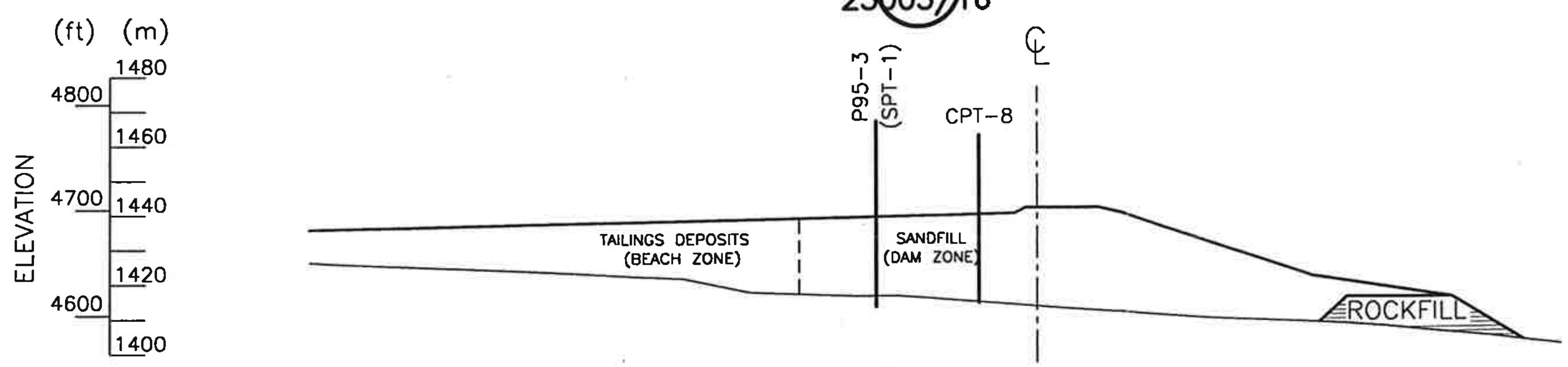
DRAWN	CHECKED	DWG No.	REV.
H.P.		114-808-202	1
DATE 99 03 08	SCALE 1:2000		



TYPICAL CONSTRUCTION SEQUENCE



SECTION (A) 23005/16 VALLEY SECTION



SECTION (B) 23005/16 ABUTMENT SECTION

100 0 200ft

40 0 100m

SCALE

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

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

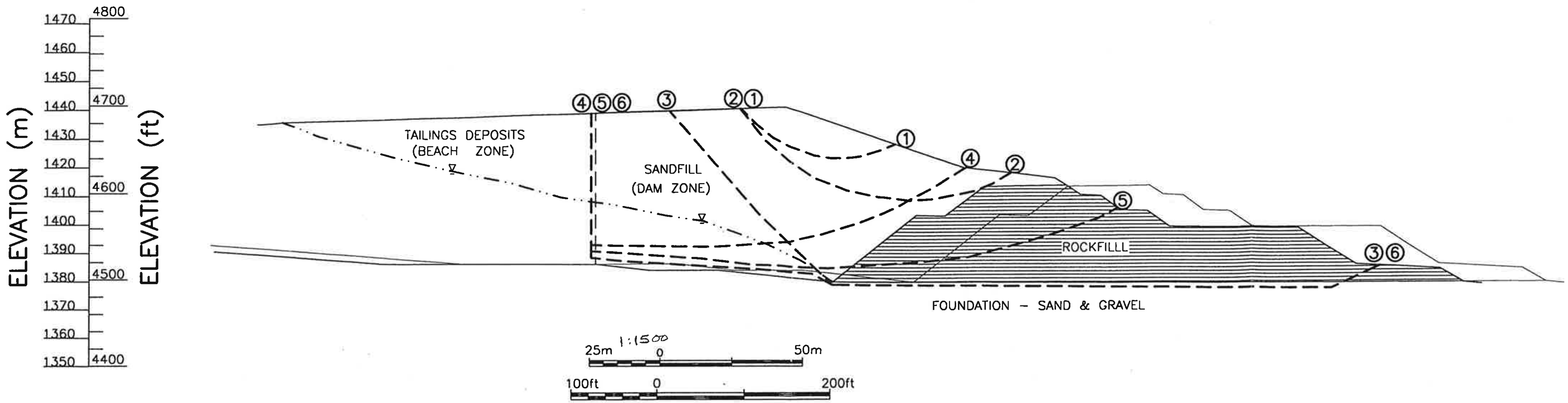
KLOHN-CRIPPEN

CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: TYPICAL SECTIONS TROJAN DAM

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
DEC. 9, 1996	PM2916 23	B-23017	



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	3.22	2.24	0.45
②	2.85	2.05	0.42

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

MATERIAL PROPERTIES

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

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

POST-EARTHQUAKE STABILITY ANALYSIS
SUMMARY OF SAFETY FACTOR

FAILURE SURFACE NUMBER	FACTOR OF SAFETY (1)
①	1.26
②	1.21
③	2.72
④	2.72
⑤	1.68
⑥	2.86

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

LEGEND

④– – – –④ FAILURE SURFACE No.4

– · · ∇ · · – PIEZOMETRIC SURFACE

NOTES

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

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

SCALE

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

KLOHN-CRIPPEN

CLIENT: HIGHLAND VALLEY COPPER

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: STABILITY ANALYSES TROJAN DAM SECTION A-A – VALLEY SECTION

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
DEC. 9, 1996	PM2916 23	B-23020	

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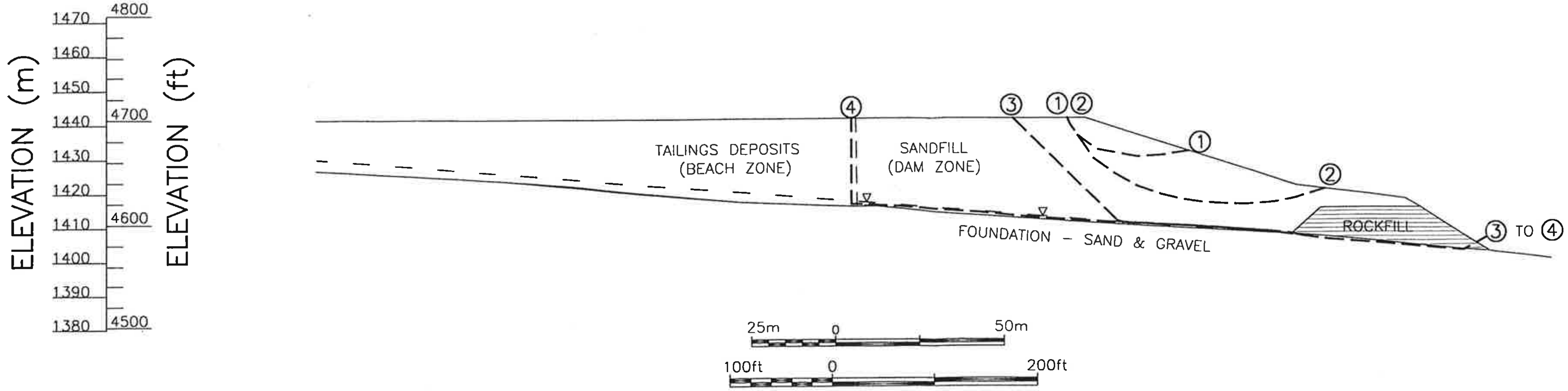

STATIC AND PSEUDO-STATIC STABILITY ANALYSES SUMMARY OF SAFETY FACTOR AND YIELD ACCELERATION

FAILURE SURFACE NUMBER	FACTOR OF SAFETY (1)		YIELD ACCELERATION (g)
	STATIC	PSEUDO-STATIC (a=0.1g)	
①	2.72	1.97	0.42
③	3.05	2.02	0.43

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

(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	1.17
②	1.18
③	1.75
④	2.52

(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	RJO	DEC.96

KLOHN-CRIPPEN

CLIENT: HIGHLAND VALLEY COPPER

SCALE

PROJECT: LONG-TERM STABILITY ASSESSMENT

TITLE: STABILITY ANALYSES TROJAN DAM SECTION B-B – WEST ABUTMENT SECTION

DATE OF ISSUE: DEC. 9, 1996 | PROJECT No. PM2916 23 | DWG. No. B-23021 | REV

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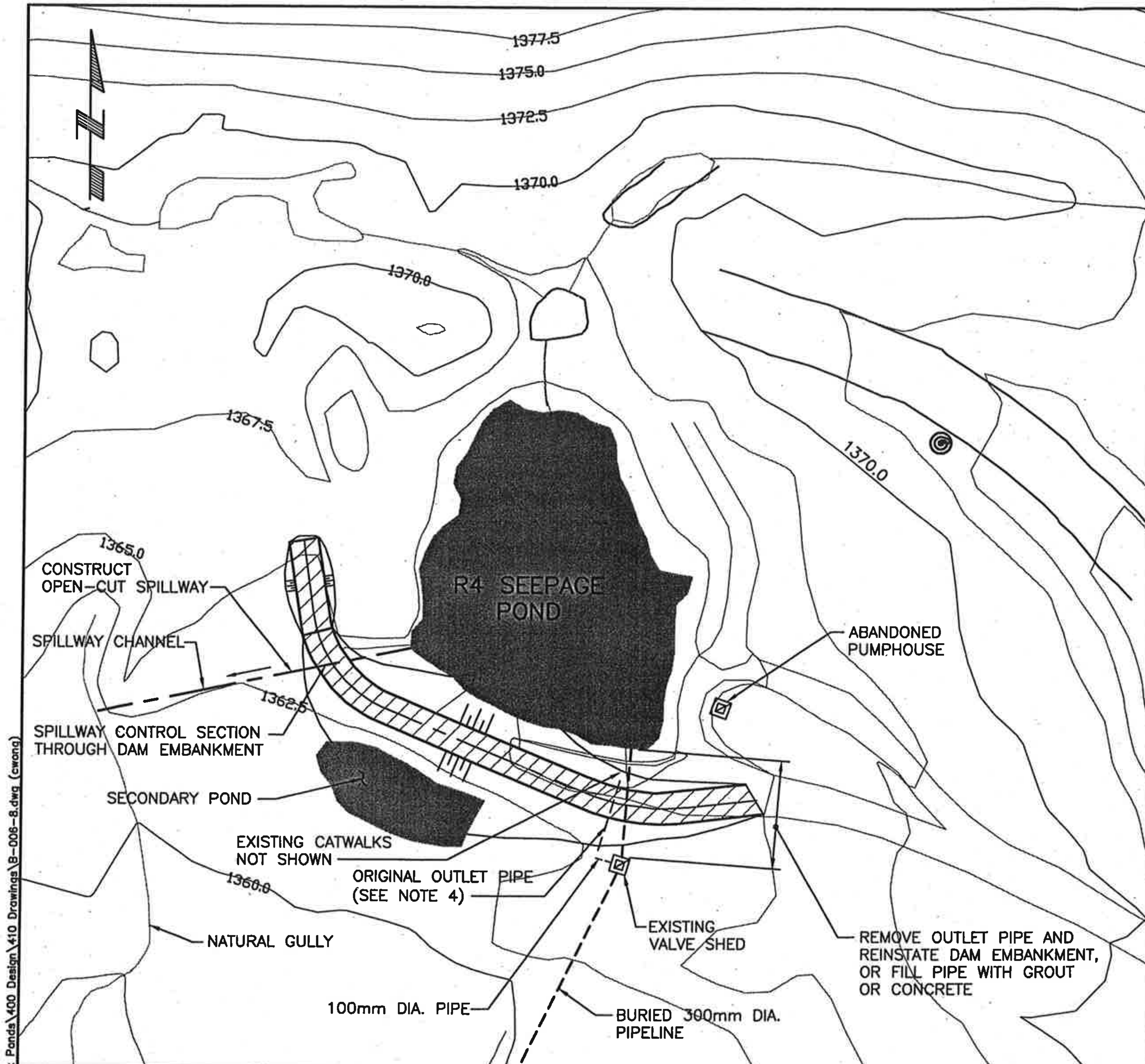
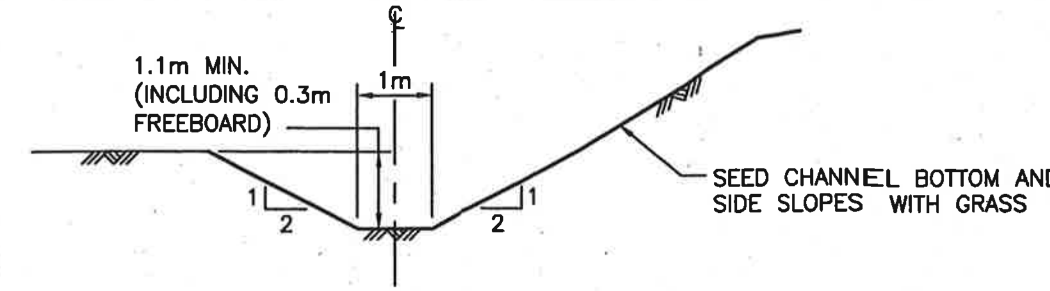
10/09/96 TIME: 3:10

APPENDIX III-B

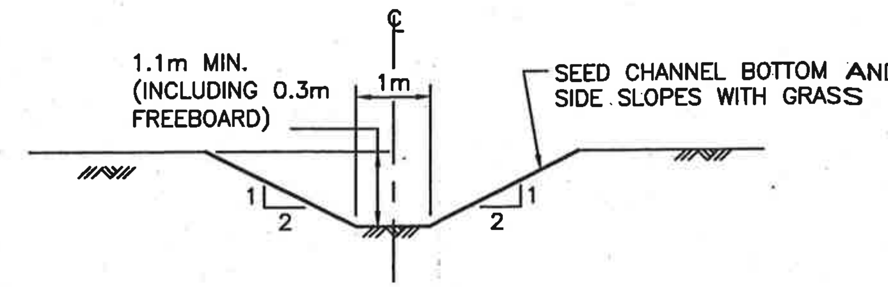
Reference Dam Design Drawings - R4 Seepage Pond Dam



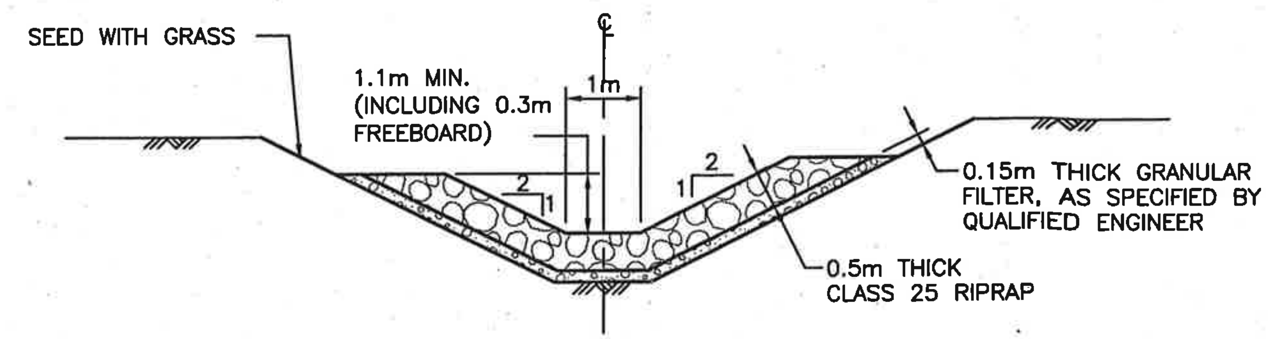
PLAN
SCALE A



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

NOTES:

1. FOR LOCATION OF POND SEE FIG. B-001.
2. FOR RIPRAP GRADATION SEE FIG. B-006.
3. LOCATIONS OF BURIED PIPELINES ARE APPROXIMATE.
4. STATUS OF THE ORIGINAL OUTLET PIPE AND DECOMMISSIONING REQUIREMENTS, IF ANY, ARE TO BE DETERMINED.

SCALE B 0 — 5m

SCALE A 0 — 50m

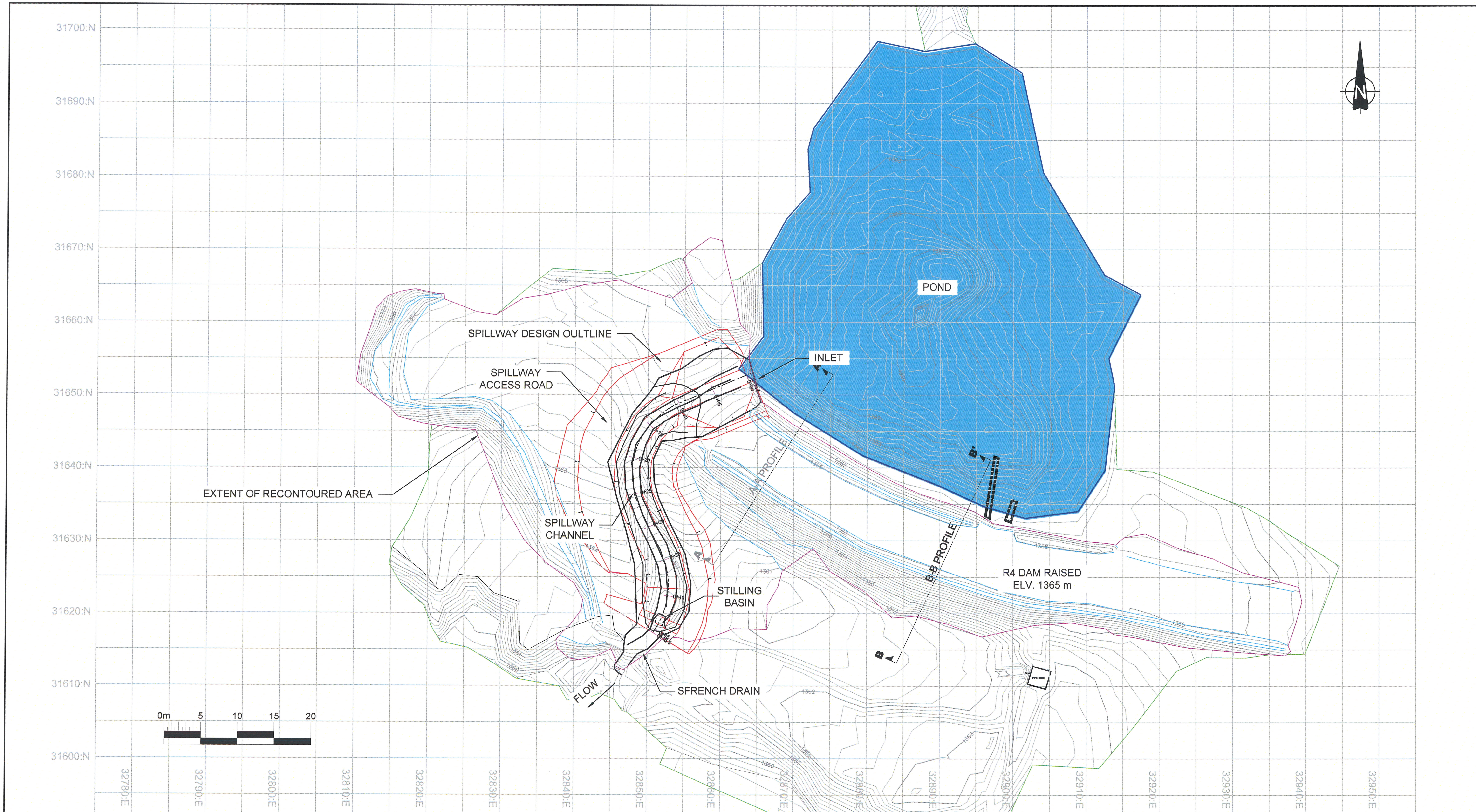
NOT FOR CONSTRUCTION

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

CLIENT	HIGHLAND VALLEY COPPER
PROJECT	TROJAN CREEK PONDS
TITLE	R4 SEEPAGE POND PROPOSED DECOMMISSIONING WORK PLAN AND SECTIONS
PROJECT No.	M 02341 A3105
FIG. No.	B-007

KLOHN CRIPPEN

Time: 9:e:18
Date: 6/10/2005
Scale: 1=10(PS)
Drawing File: M:\M02341A3105 - Trojan Creek Ponds\400 Design\410 Drawings\B-006-8.dwg (cwong)



NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC ENVIRONMENT & INFRASTRUCTURE LETTER (FILE No. VW1035) DATED NOVEMBER 2014.

RECORD DRAWINGS

CLIENT: Highland Valley Copper
Teck

AMEC Environment & Infrastructure
Suite 600 - 4445 Lougheed Highway
Burnaby, BC V5C 0E4
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amec

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

PROJECT: SPILLWAY DESIGN - TROJAN RECLAIM DAM 4

TITLE: GENERAL LAYOUT

DATE:	NOVEMBER 2014
PROJECT NO:	VW1035
REV. NO:	A
FIGURE NO:	AB - 2

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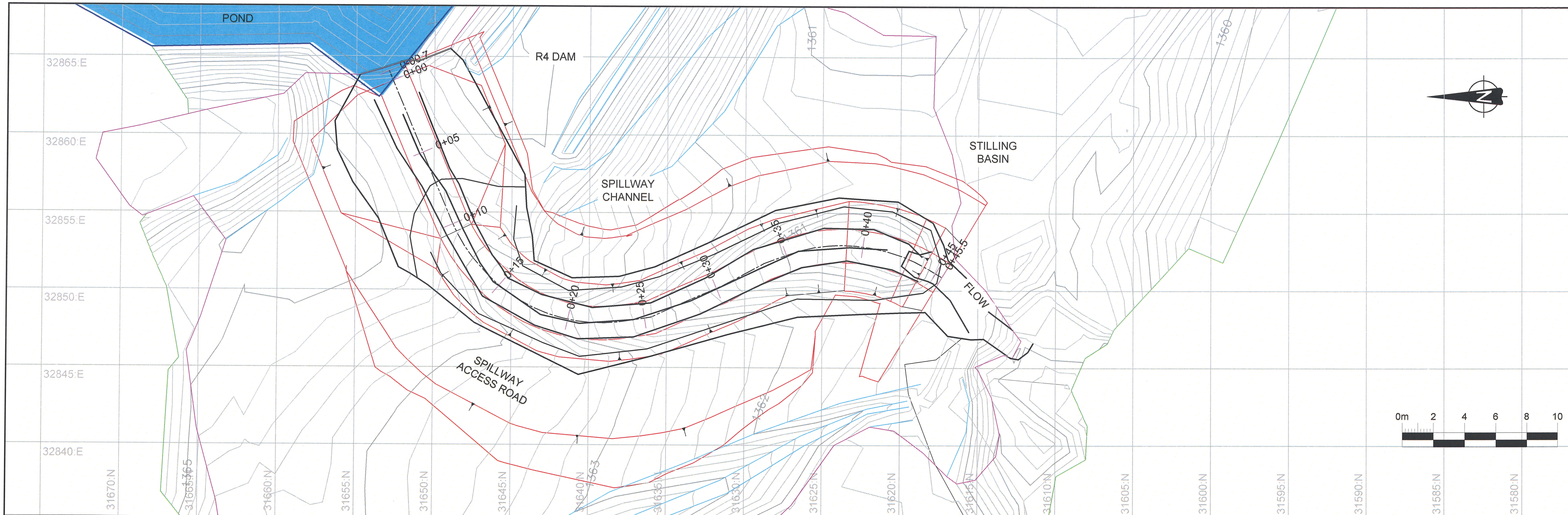

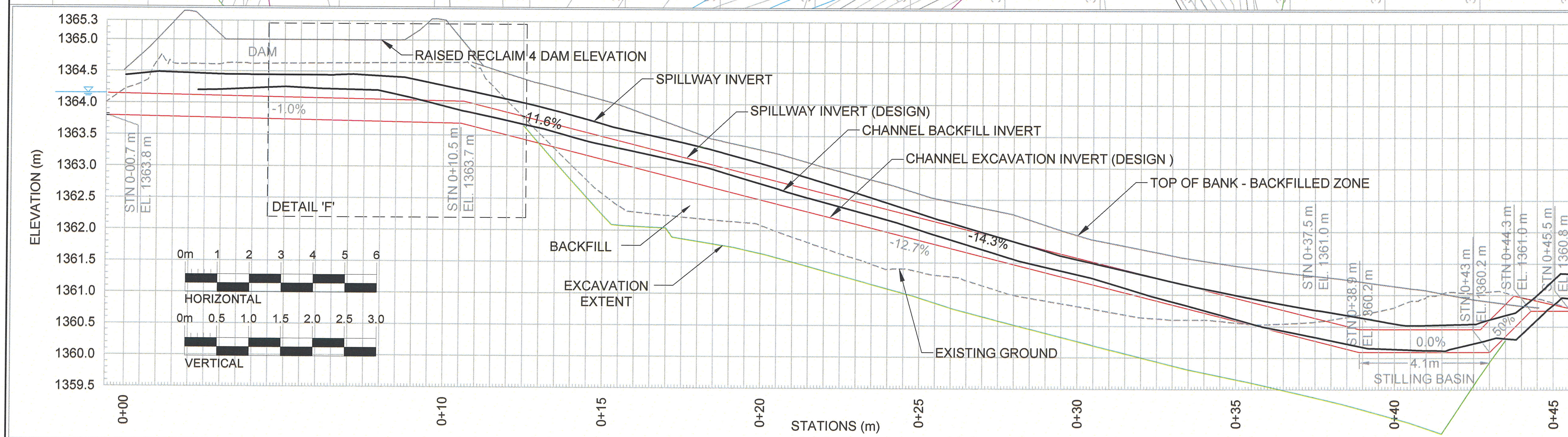

Station (m)	Excavation Elevation (m)	X	Y
0+00.4	1364.3	32863.1	31652.5
0+05.0	1364.2	32858.9	31650.7
0+09.0	1364.2	32855.2	31649.2
0+10.0	1364.1	32854.2	31648.8
0+15.0	1363.4	32850.3	31645.8
0+20.0	1362.7	32848.1	31641.4
0+25.0	1362.0	32848.2	31636.4
0+30.0	1361.3	32850.1	31631.8
0+35.0	1360.6	32852.3	31627.3
0+38.9	1360.1	32852.9	31624.3
0+40.0	1360.1	32852.8	31622.4
0+43.0	1360.1	32852.3	31620.3
0+45.0	1360.9	32851.1	31617.7
0+45.5	1360.8	32850.9	31617.3

NOTE: FIELD MODIFIED DESIGN COORDINATES AND ELEVATION

NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC ENVIRONMENT & INFRASTRUCTURE LETTER (FILE No. VW1035) DATED NOVEMBER 2014.

RECORD DRAWINGS

CLIENT: Highland Valley Copper
Teck

AMEC Environment & Infrastructure
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amec

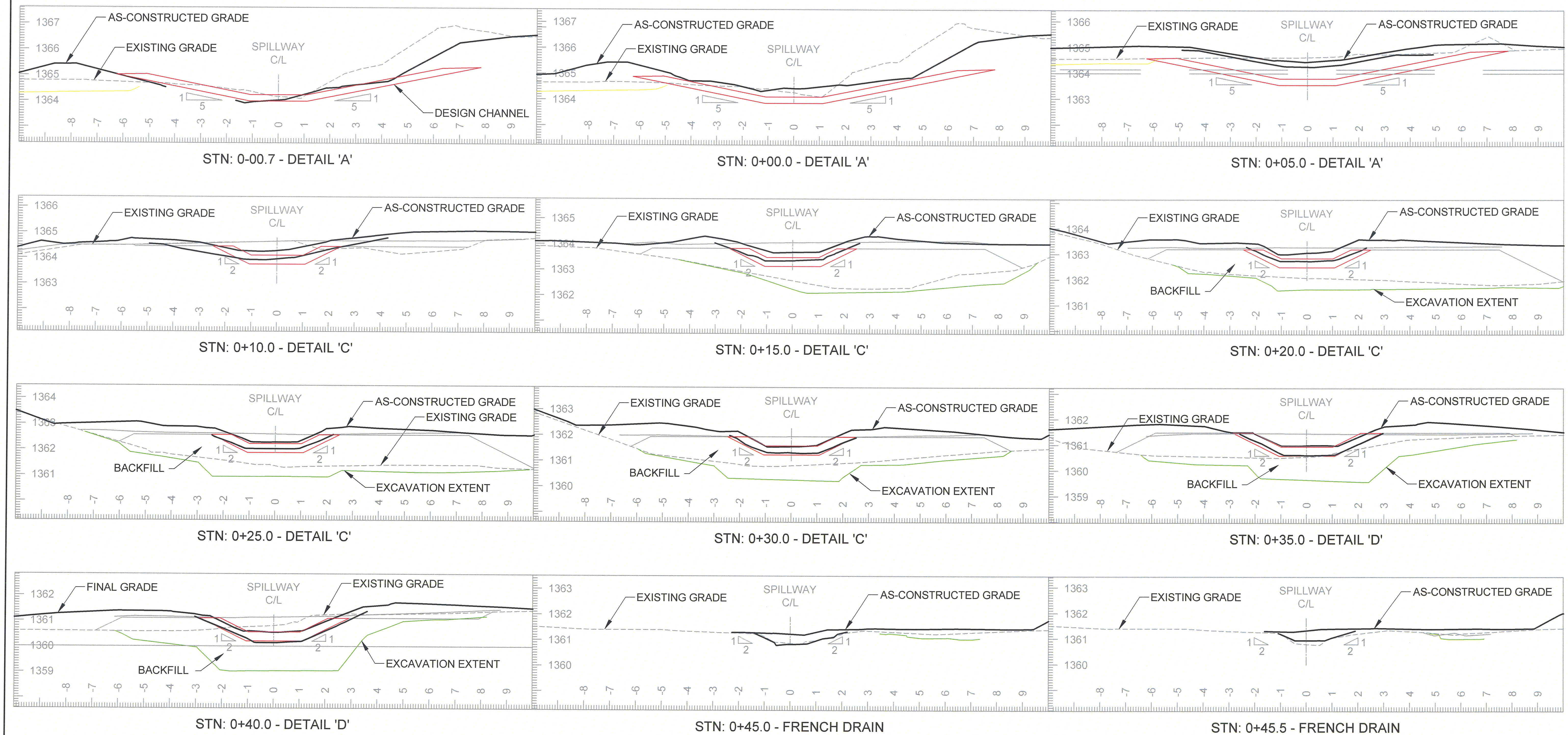
DWN BY: HY
CHK'D BY: AF
DATUM: MINE
PROJECTION: MINE
SCALE: AS SHOWN

PROJECT: SPILLWAY DESIGN - TROJAN RECLAIM DAM 4

TITLE: PLAN AND PROFILE

DATE: NOVEMBER 2014
PROJECT NO: VW1035
REV. NO: A
FIGURE NO: AB - 3

W:\Projects\VW1035 – HVC R4 Spillway\Drawings\As-Built Drawings\FINAL\R4-Spillway-Figures-002-007 Oct. 2014.FINAL.dwg – AB-3-Plan&Profile – Nov. 26, 2014 4:32pm – hamid.yousefbeigi



SPILLWAY CROSS SECTIONS AT 5.0 m STATION INTERVALS

0m 1 2 3 4 5 6

NOTE: CROSS SECTIONS CUT LOOKING DOWNSTREAM

NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC ENVIRONMENT & INFRASTRUCTURE LETTER (FILE No. VW1035) DATED NOVEMBER 2014.

RECORD DRAWINGS

CLIENT: Highland Valley Copper
Teck

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Burnaby, BC V5C 0E4
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amec

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

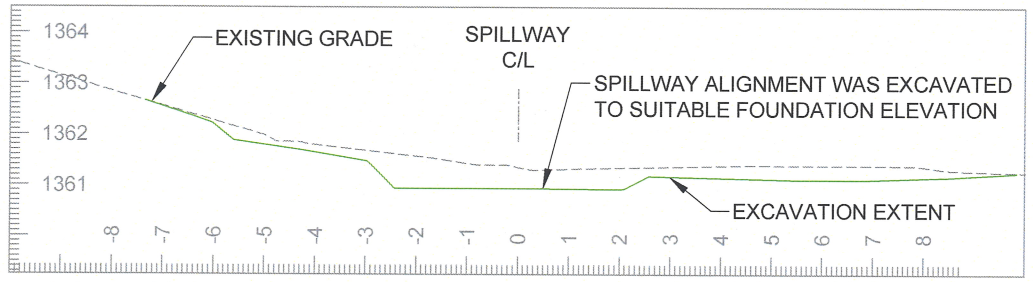
PROJECT: SPILLWAY DESIGN - TROJAN RECLAIM DAM 4

TITLE: CROSS SECTIONS

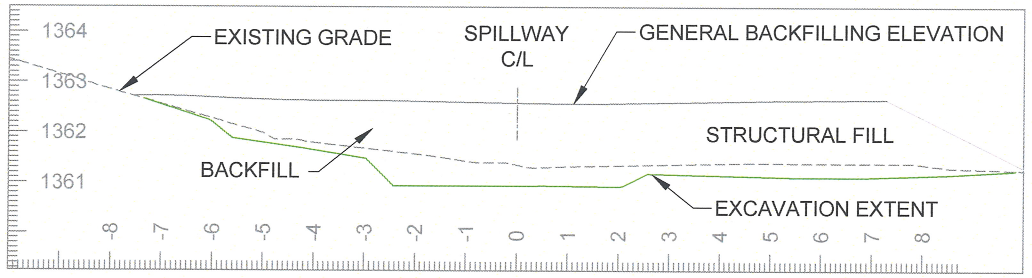
DATE:	NOVEMBER 2014
PROJECT NO:	VW1035
REV. NO:	A
FIGURE NO:	AB - 4

W:\Projects\VW1035 - HVC R4 Spillway\Drawings\As-Built Drawings\FINAL\R4-Spillway-Figures-002-007 Oct. 2014.FINAL.dwg - AB-4-Cross-Sections - Nov. 26, 2014 4:32pm - hamid.yousefbeigi

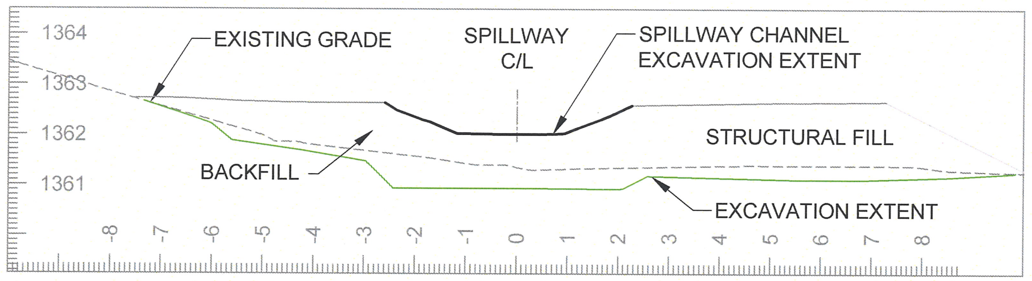
CONSTRUCTION SEQUENCING AND STAGING SHOWN AT STATION 0+25



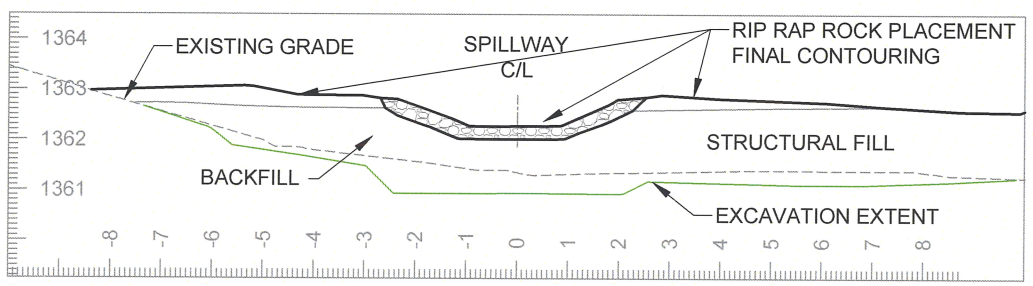
STAGE 1 - FOUNDATION EXCAVATION



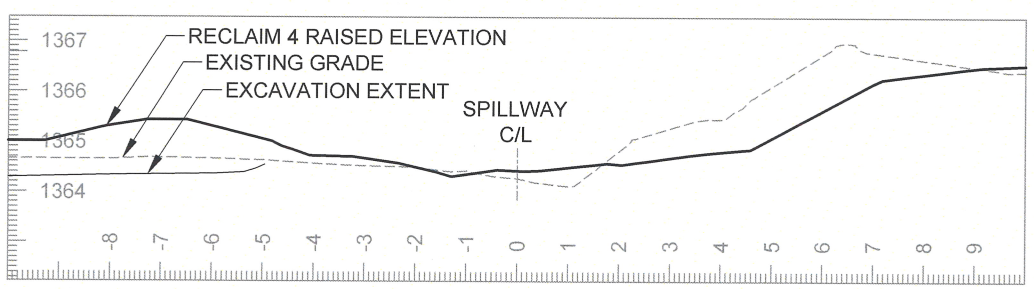
STAGE 2 - GENERAL BACKFILLING OF THE SPILLWYA AND ACCESS ROAD



STAGE 3 - SPILLWYA CHANNEL WAS EXCAVATED TO THE DESIGN ALIGNMENT

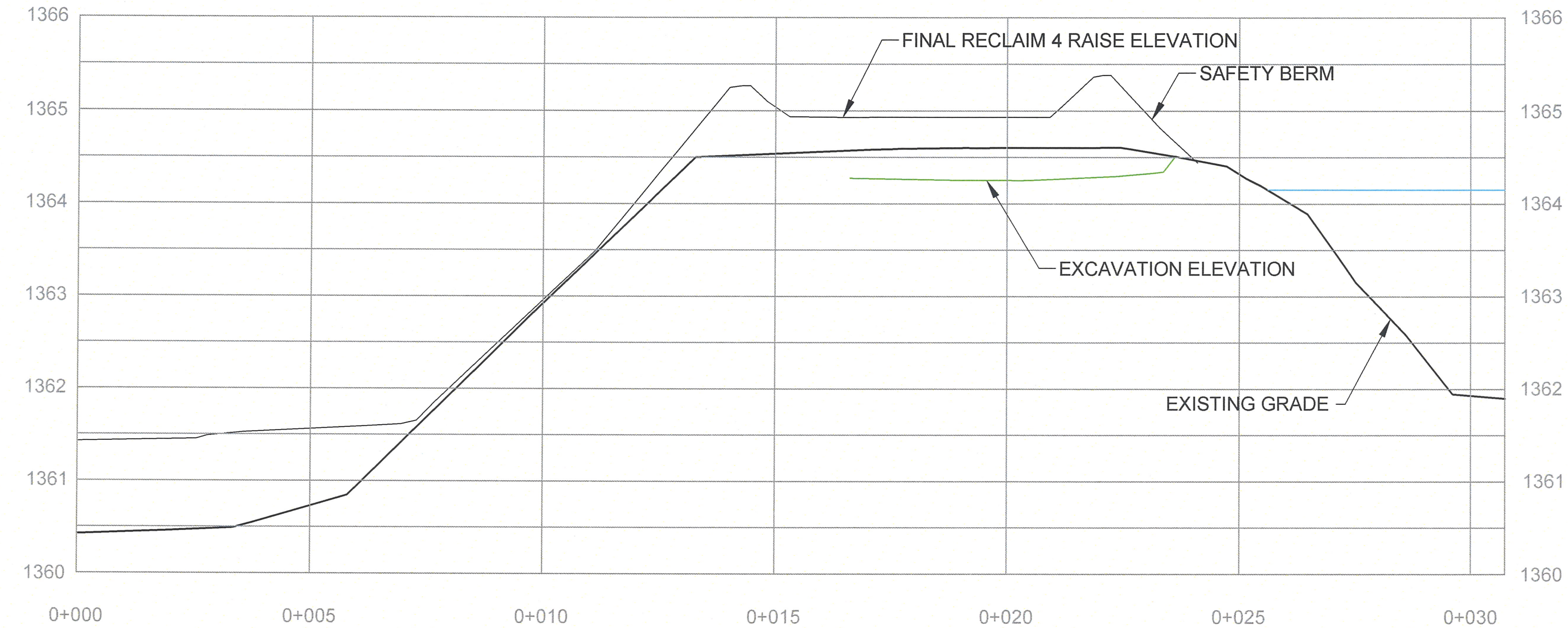


STAGE 4 - RIP RAP ROCK PLACEMENT IN THE CHANNEL AND CONTOURING

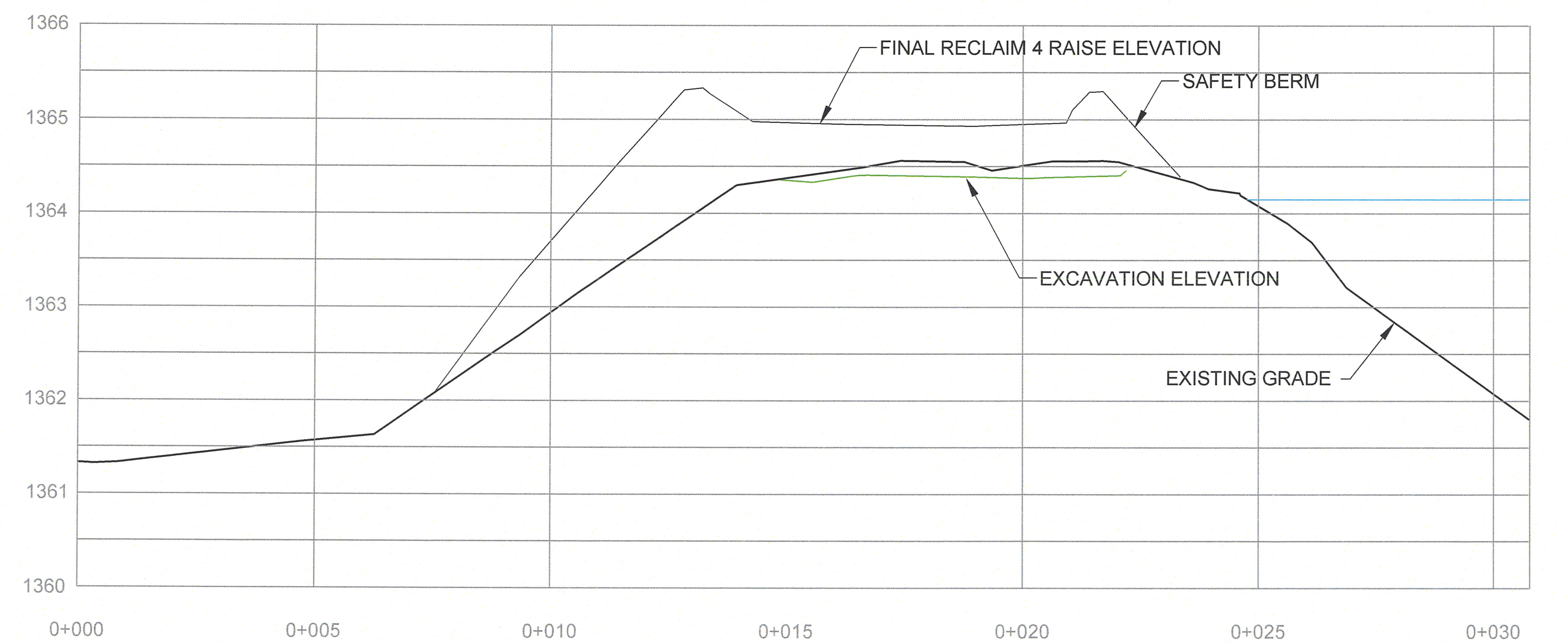


STN: 0+00.0 - DAM RAISE SECTION

A-A PROFILE



B-B SECTION

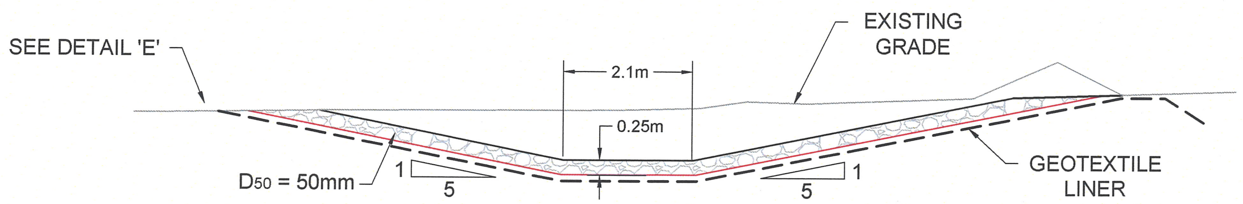


NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC ENVIRONMENT & INFRASTRUCTURE LETTER (FILE No. VW1035) DATED NOVEMBER 2014.

RECORD DRAWINGS

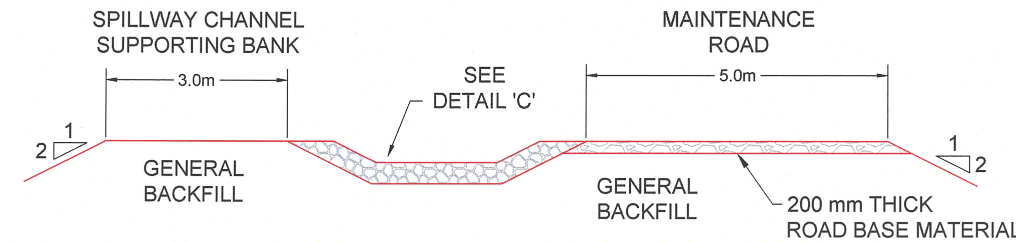
CLIENT:	Highland Valley Copper / Teck
	AMEC Environment & Infrastructure Suite 600 - 4445 Lougheed Highway Burnaby, BC V5C 0E4 Tel. 604-294-3811 Fax 604-294-4664
DWN BY:	HY
CHK'D BY:	AF
DATUM:	MINE
PROJECTION:	MINE
SCALE:	AS SHOWN
PROJECT:	SPILLWAY DESIGN - TROJAN RECLAIM DAM 4
TITLE:	DETAILS AND DETAIL SECTIONS
DATE:	NOVEMBER 2014
PROJECT NO:	VW1035
REV. NO:	A
FIGURE NO:	AB - 5

W:\Projects\VW1035 – HVC R4 Spillway\Drawings\As-Built Drawings\FINAL\R4-Spillway-Figures-002-007 Oct. 2014.FINAL.dwg – AB-5-Cross-Sections Dam – Nov. 26, 2014 4:32pm – hamid.yousefbeigi



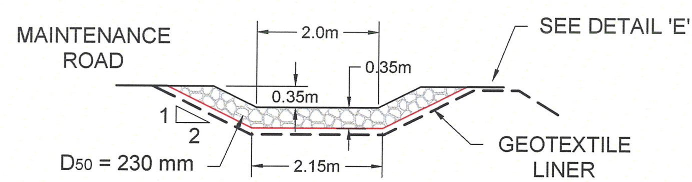
DETAIL 'A'
SECTION - SPILLWAY CHANNEL - 1% GRADE
STATION 0+05.0m

0m 1 2 3 4 5



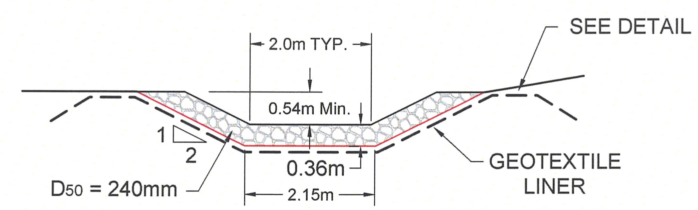
DETAIL 'B'
TYPICAL BACKFILL ZONE AND SPILLWAY CHANNEL
(LOOKING DOWNSTREAM)

0m 1 2 3 4 5



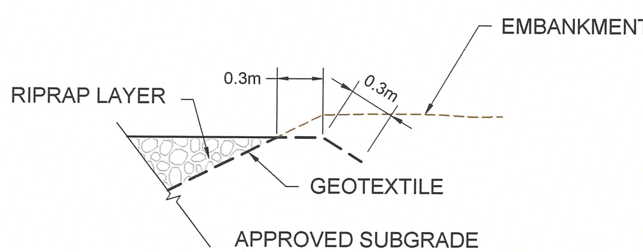
DETAIL 'C'
TYPICAL SECTION - SPILLWAY CHANNEL -12.7% GRADE

0m 1 2 3 4 5

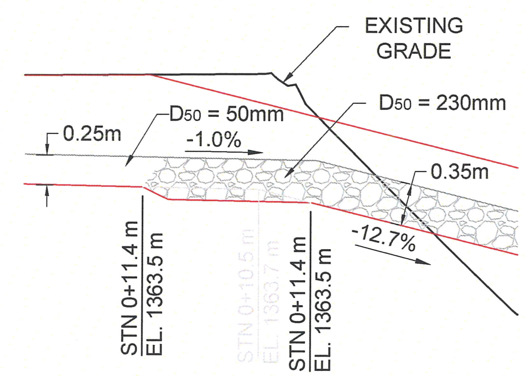


DETAIL 'D'
SECTION - STILLING BASIN
STATION 0+40.0m

0m 1 2 3 4 5



DETAIL 'E'
TYPICAL SECTION - ANCHOR DETAIL
(NTS)



DETAIL 'F'
SLOPE TRANSITION
NTS

NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC ENVIRONMENT & INFRASTRUCTURE LETTER (FILE No. VW1035) DATED NOVEMBER 2014.

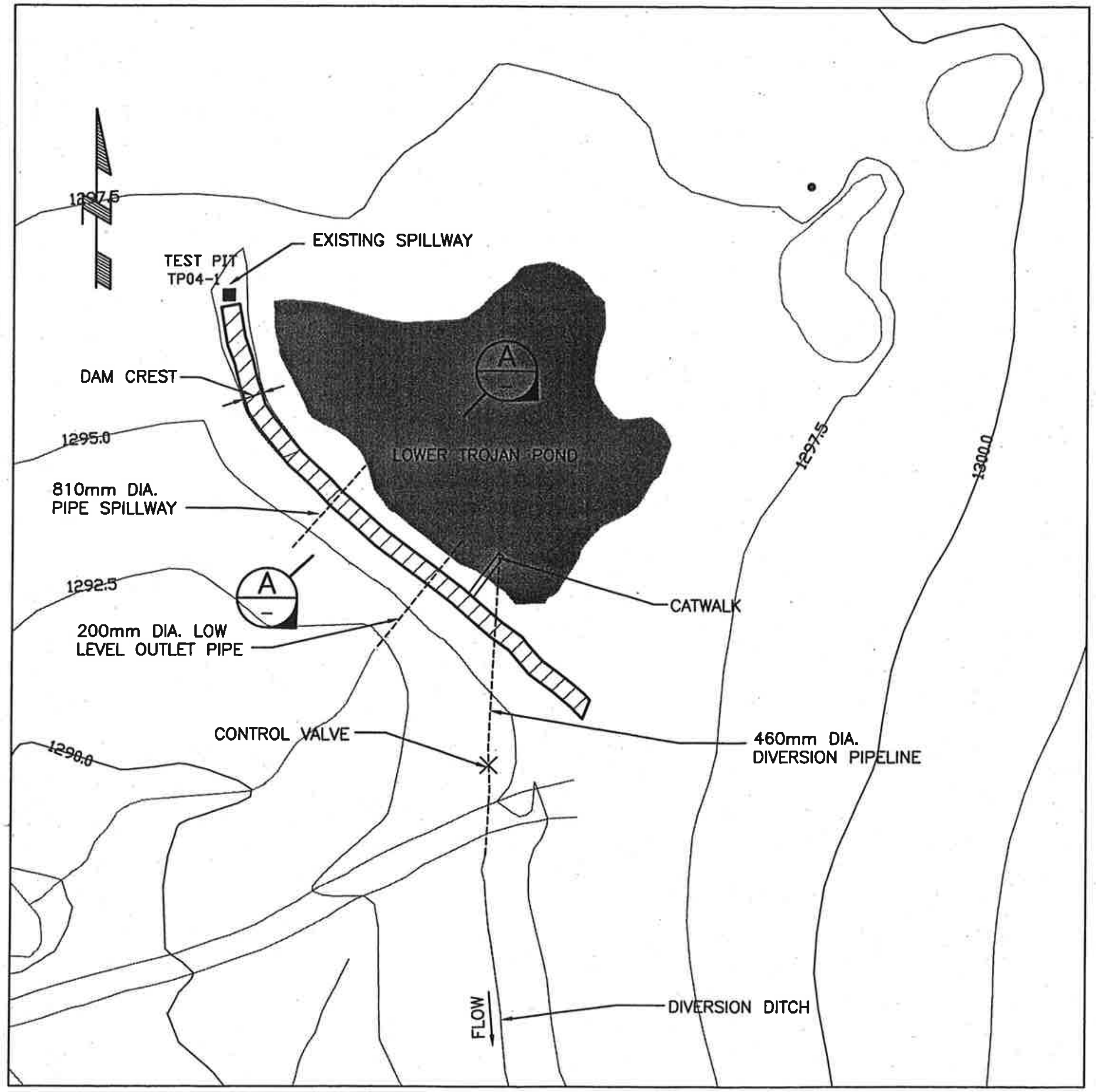
RECORD DRAWINGS

CLIENT: Highland Valley Copper / Teck	DWN BY: HY	PROJECT: SPILLWAY DESIGN - TROJAN RECLAIM DAM 4	DATE: NOVEMBER 2014
	CHK'D BY: AF		PROJECT NO: VW1035
AMEC Environment & Infrastructure, Suite 600 - 4445 Lougheed Highway, Burnaby, BC V5C 0E4, Tel. 604-294-3811 Fax 604-294-4664	DATUM: MINE	TITLE: DESIGN DETAILS AND SECTIONS	REV. NO: A
	PROJECTION: MINE		FIGURE NO: AB - 6
	SCALE: AS SHOWN		

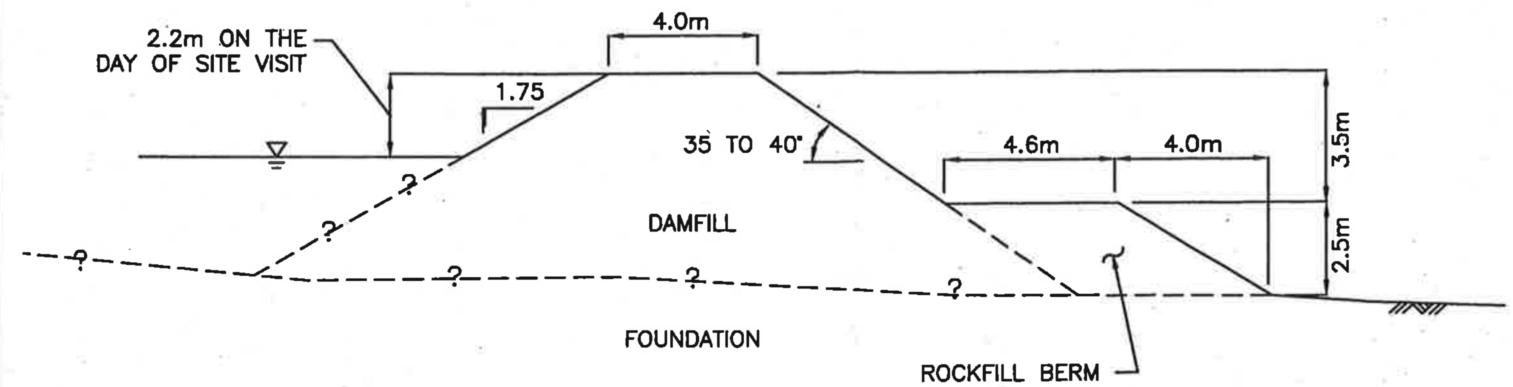
W:\Projects\VW1035 - HVC R4 Spillway\Drawings\As-Built Drawings\FINAL\R4-Spillway-Figures-002-007 Oct. 2014.FINAL.dwg - AB-6-Details - Nov. 26, 2014 4:32pm - hamid.yousefbeigi

APPENDIX III-C

Reference Dam Design Drawings – Lower Trojan



PLAN
SCALE A



LOWER TRAJAN POND DAM
APPROX. SECTION AT HIGHEST POINT IN DAM
(MEASURED 17 NOV/04)
SCALE B

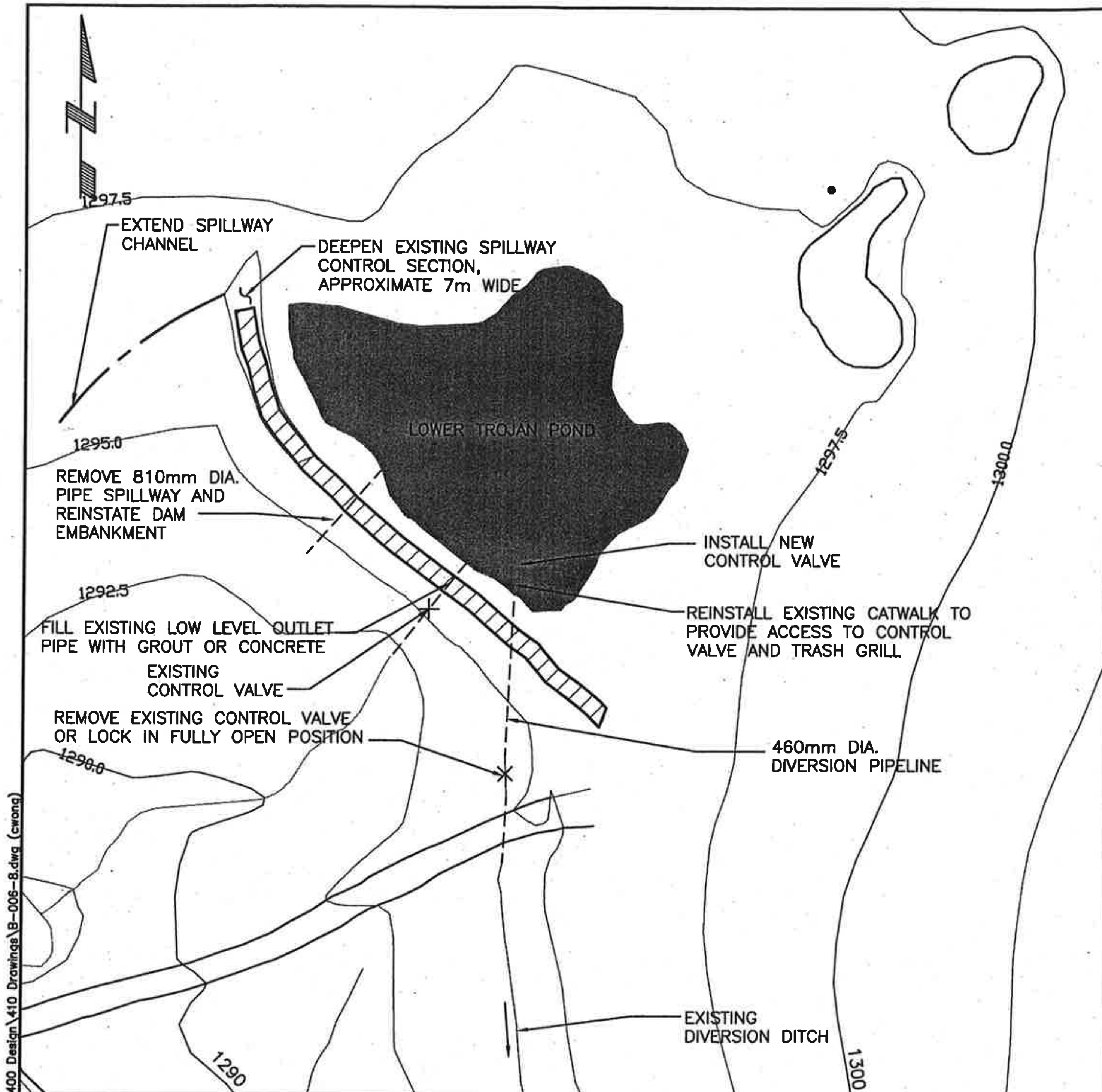
NOTES:
1. FOR LOCATION OF POND SEE FIGURE B-001.
2. LOCATION OF BURIED PIPES ARE APPROXIMATE.

SCALE B 0 10m
SCALE A 0 50m
SCALE

NOT FOR CONSTRUCTION
TO BE READ WITH KLOHN CRIPPEN REPORT DATED JUNE 10, 2005

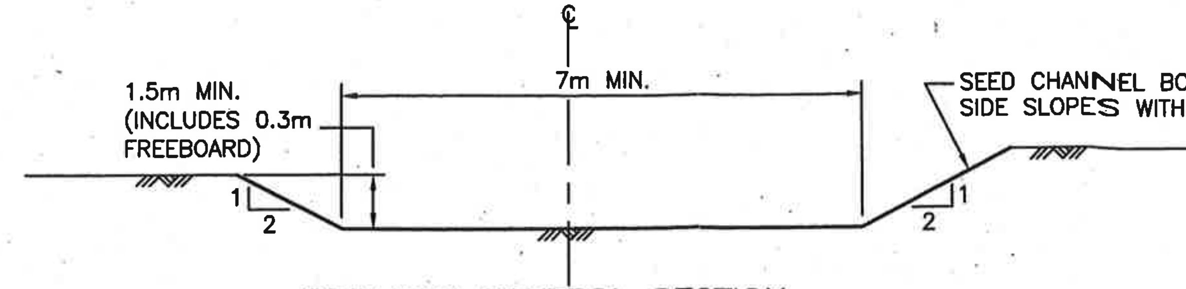
CLIENT	HIGHLAND VALLEY COPPER
	KLOHN CRIPPEN
PROJECT	TROJAN CREEK PONDS
TITLE	LOWER TROJAN POND PLAN AND DAM SECTION
PROJECT No.	M 02341 A3105
FIG. No.	B-004

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



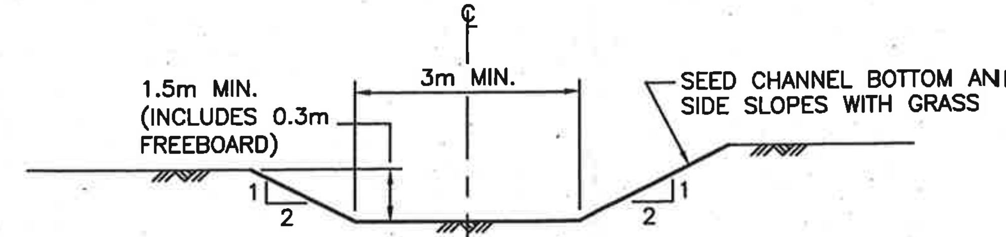
PLAN

SCALE A



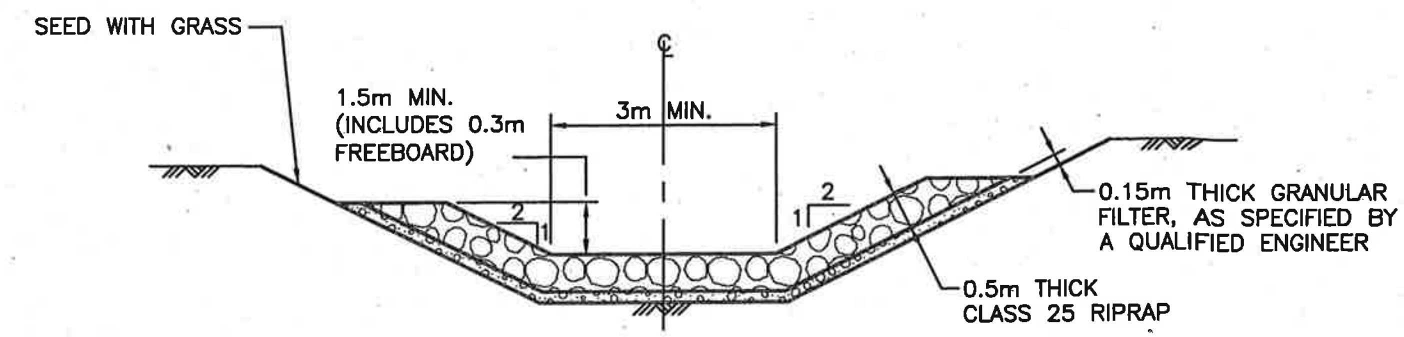
SPILLWAY CONTROL SECTION

SCALE B



SPILLWAY CHANNEL SECTION DOWNSTREAM OF DAM FOR 0.5% OR FLATTER BED SLOPE

SCALE B



SPILLWAY CHANNEL SECTION DOWNSTREAM OF DAM FOR 0.6% TO 10% BED SLOPE

SCALE B

NOTES:

1. FOR LOCATION OF POND SEE FIG. B-001.
2. FOR RIPRAP GRADATION SEE FIG. B-006.
3. LOCATIONS OF BURIED PIPELINES ARE APPROXIMATE.

SCALE B 0 — 5m

SCALE A 0 — 50m

SCALE

NOT FOR CONSTRUCTION

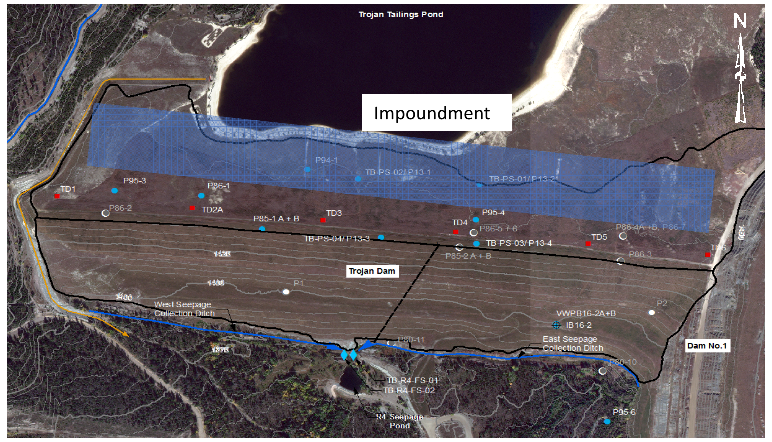
TO BE READ WITH KLOHN CRIPPEN REPORT DATED JUNE 10, 2005

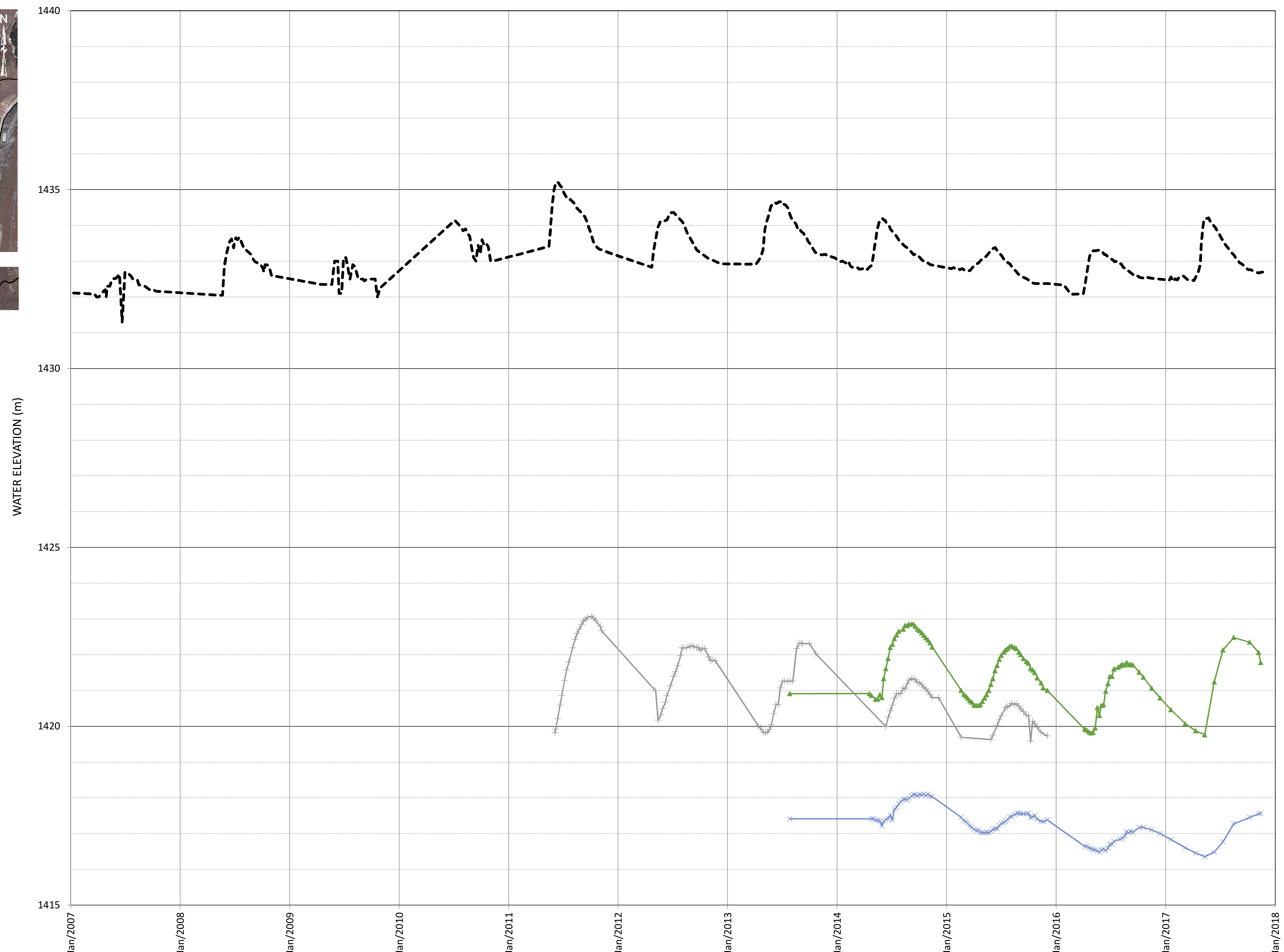
CLIENT	HIGHLAND VALLEY COPPER
	KLOHN CRIPPEN
PROJECT	TROJAN CREEK PONDS
TITLE	LOWER TROJAN POND PROPOSED DECOMMISSIONING WORK PLAN AND SECTIONS
PROJECT No.	M 02341 A3105
FIG. No.	B-008

Time: [illegible]
Date: 6/10/2005
Scale: 1=10(PS)
Drawing File: M:\M02341A3105 - Trojan Creek Ponds\400 Design\410 Drawings\B-006-8.dwg (cwong)

APPENDIX IV

Instrumentation Plots





LEGEND:

- P94-1 (Tip El. unknkown m, Sandfill)
- TB-PS-02/P13-1 (Tip El. 1409.5 m, Cycloned Sand)
- TB-PS-01/P13-2 (Tip El. 1413 m, Cycloned Sand)
- Trojan Pond Level

PIEZOMETER ID	2018 THRESHOLD EL. (m)
P94-1	1423.6
TB-PS-02/P13-1	1423.4
TB-PS-01/P13-2	1418.6

NOTES:

1. POND WATER LEVEL REPORDED ON NOVEMBER 8, 2009 HAD A 10 m JUMP AND IS NOT PLOTTED AS IT IS ALMOST CERTAINLY A MEASURMENT OR DATA ENTRY ERROR.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

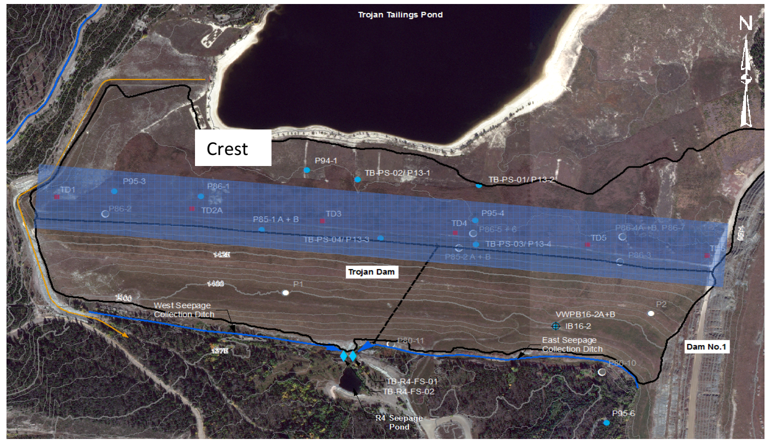
PROJECT: TROJAN TAILINGS STORAGE FACILITY
2017 DAM SAFETY INSPECTION

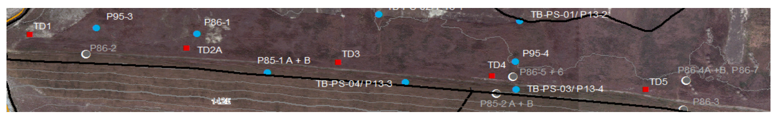
TITLE: TROJAN DAM PIEZOMETRIC DATA
2007-2017

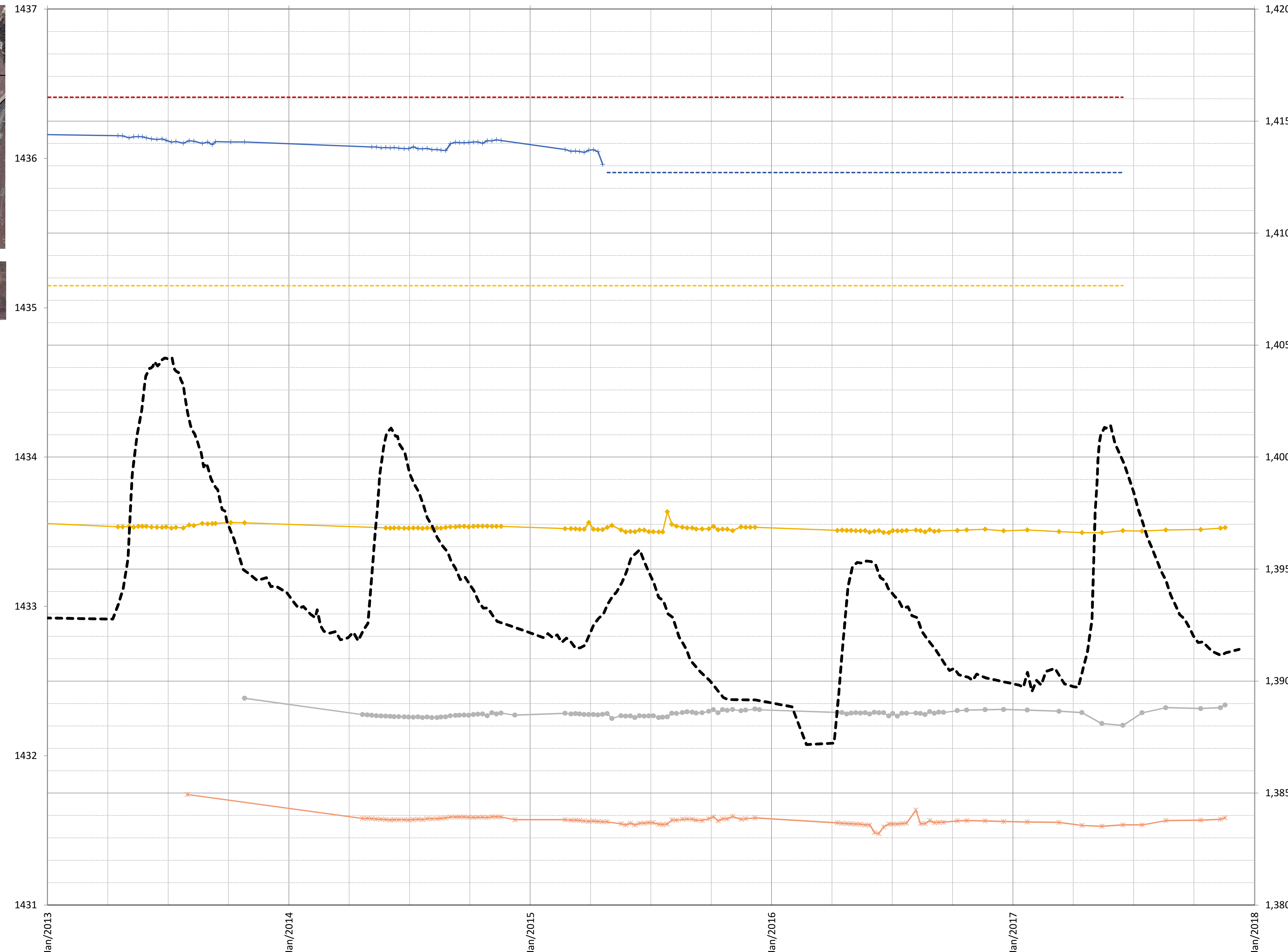
IMPOUNDMENT

PROJECT No. M02341B26 | FIG No. IV-1

February 21, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Trojan\[180222 Trojan Piezo.xlsx]DOWNSTREAM SLOPE







LEGEND:

- P86-7 dry elevation
- P95-3 (Tip El. 1412.7 m, Foundation)
- P95-3 dry elevation
- P85-1A (Tip El. 1388.12 m, Foundation)
- TB-PS-04/P13-3 (Tip El. 1376.2 m, Sand and Gravel)
- TB-PS-03/P13-4 (Tip El. 1376.6 m, Till)
- P86-1 dry elevation
- Trojan Pond Level

PIEZOMETER ID	2018 THRESHOLD EL. (m)
P85-1A	1399.2
P86-1	1408.2
P86-7	1419.8
P95-3	1415.0
TB-PS-04/P13-3	1385.4
TB-PS-03/P13-4	1389.7

NOTES:

1. PIEZOMETER WATER ELEVATIONS PLOTTED ON PRIMARY (LEFT) AXIS, POND ELEVATION PLOTTED ON SECONDARY (RIGHT) AXIS.
2. POND WATER LEVEL RECORDED ON NOVEMBER 8, 2009 HAD A 10 m JUMP AND IS NOT PLOTTED AS IT IS ALMOST CERTAINLY A MEASUREMENT OR DATA ENTRY ERROR.
3. FALLING HEAD TESTS WERE CONDUCTED IN P85-1A (JULY 23, 2015), P95-4 (JULY 24, 2015, DEFUNCT) AND P85-1B (JULY 23, 2015, DEFUNCT). THE ELEVATED READINGS FOR P85-1A DURING THIS TIME WERE NOT USED TO DETERMINE THE REVISED PIEZOMETRIC LEVEL THRESHOLD.
4. THE FOLLOWING PIEZOMETERS WERE FUNCTIONING BUT DRY IN 2017: P86-1, P86-7, P95-3.
5. THE FOLLOW PIEZOMETERS ARE PLUGGED AND NOT SHOWN ON THIS FIGURE: P86-3 IS PLUGGED AT ~6 m DEPTH; P86-4A, P86-4B AND P85-2A ARE PLUGGED AT BETWEEN 15 m AND 30 m DEPTH; P85-1B IS PLUGGED AT 43 m DEPTH AND WAS HISTORICALLY DRY.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

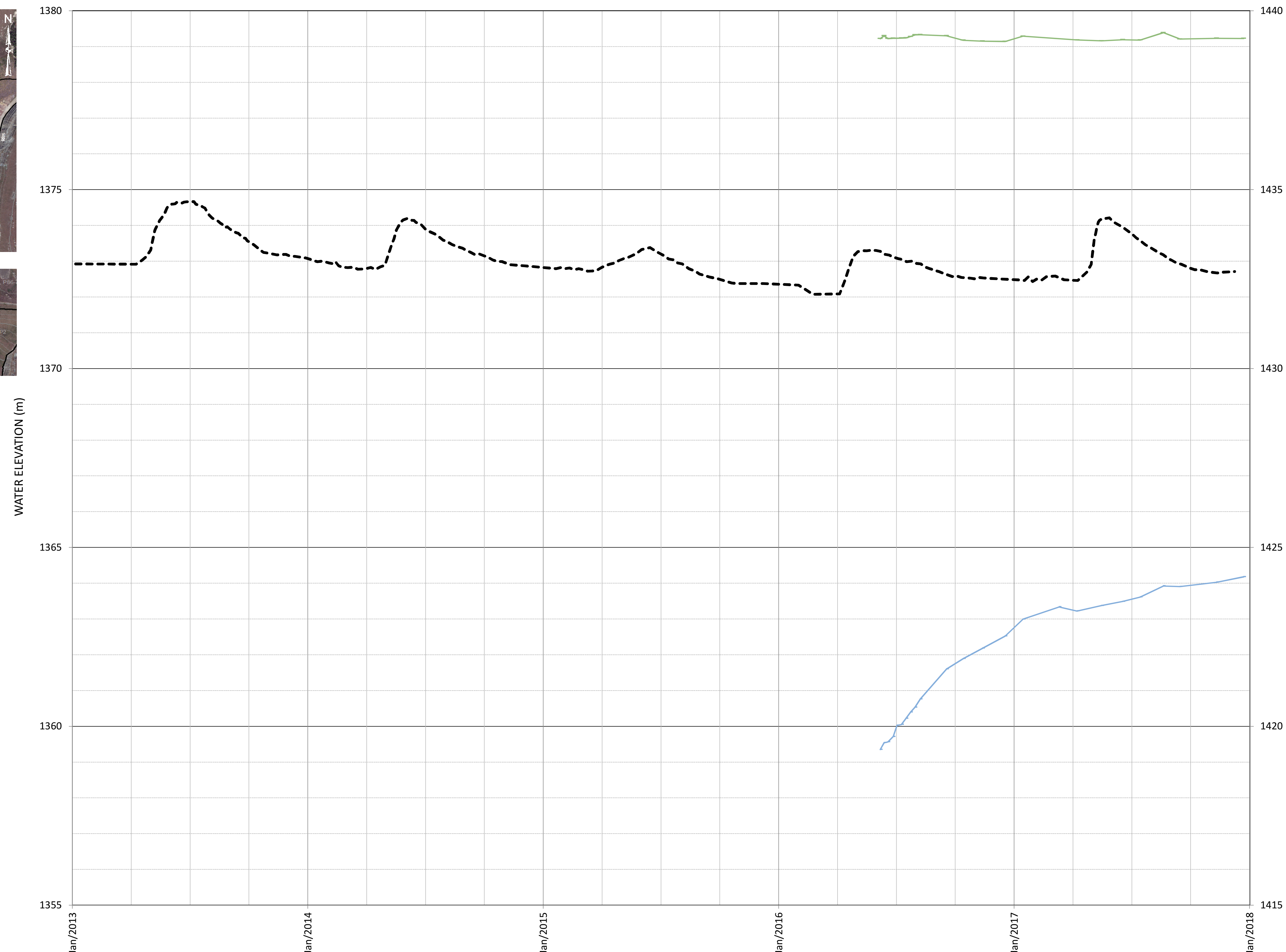
PROJECT: TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

TITLE: TROJAN DAM PIEZOMETRIC DATA 2007-2017

CREST

PROJECT No. M02341B26 | FIG No. IV-2

March 6, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Trojan\[180222 Trojan Piezo.xlsx]IMPOUNDMENT



LEGEND:

VW16-2A (Tip El. 1321.85 m, Glacial Sediments / Debris)
VW16-2B (Tip El. 1373.35 m, Glacial Till)
Trojan Pond Level

PIEZOMETER ID	2018 THRESHOLD EL. (m)
VW16-2A	1363.0
VW16-2B	1379.8

NOTES:
1. PIEZOMETER WATER ELEVATIONS PLOTTED ON PRIMARY (LEFT) AXIS, POND ELEVATION PLOTTED ON SECONDARY (RIGHT) AXIS.
2. POND WATER LEVEL REPORDED ON NOVEMBER 8, 2009 HAD A 10 m JUMP AND IS NOT PLOTTED AS IT IS ALMOST CERTAINLY A MEASURMENT OR DATA ENTRY ERROR.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

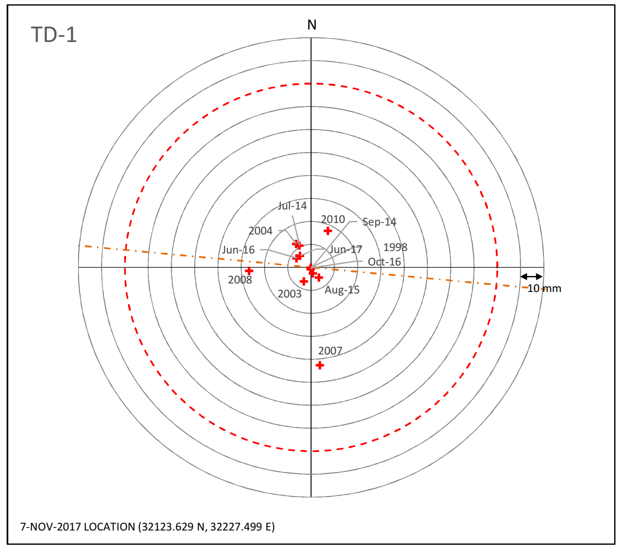
TITLE: TROJAN DAM PIEZOMETRIC DATA 20013-2017

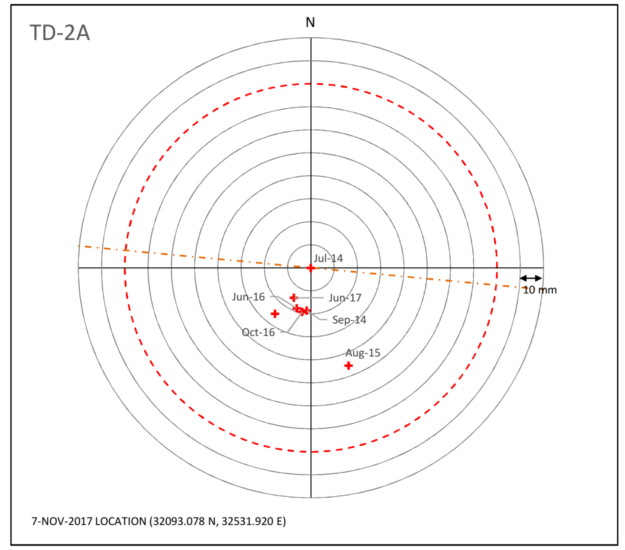
DOWNSTREAM SLOPE

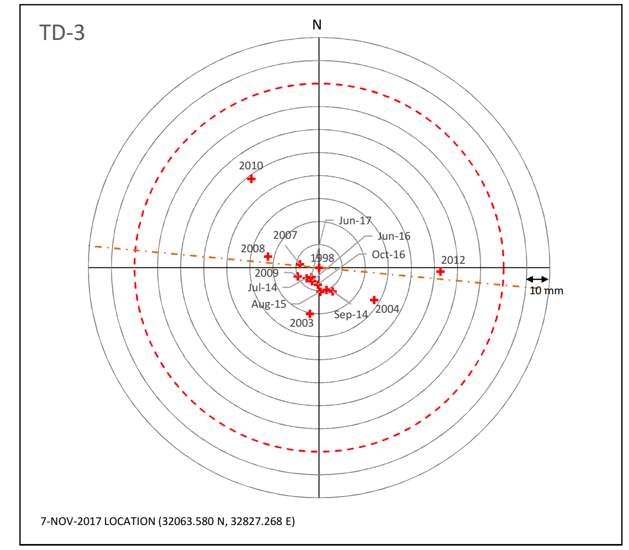
PROJECT No. M02341B26

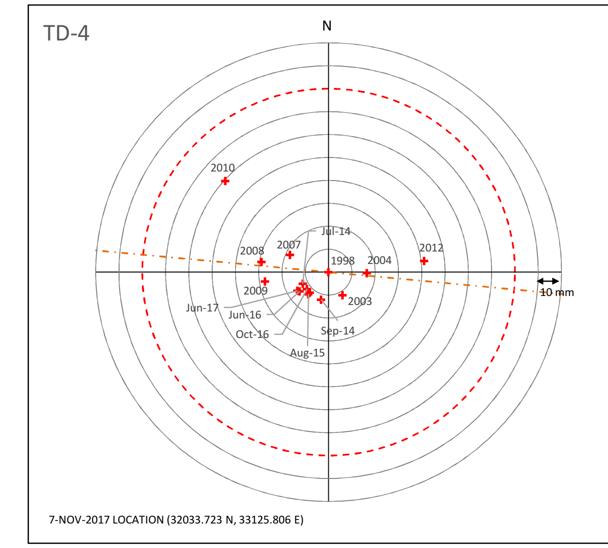
FIG No. IV-3

February 21, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Piezo Data\Trojan\[180222 Trojan Piezo.xlsx]DOWNSTREAM SLOPE



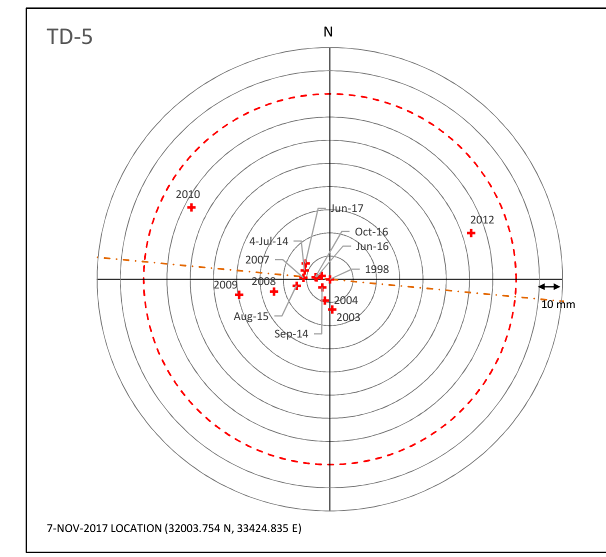


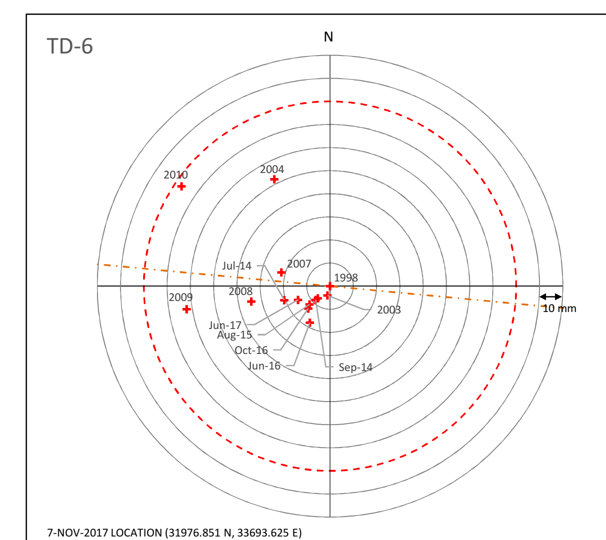


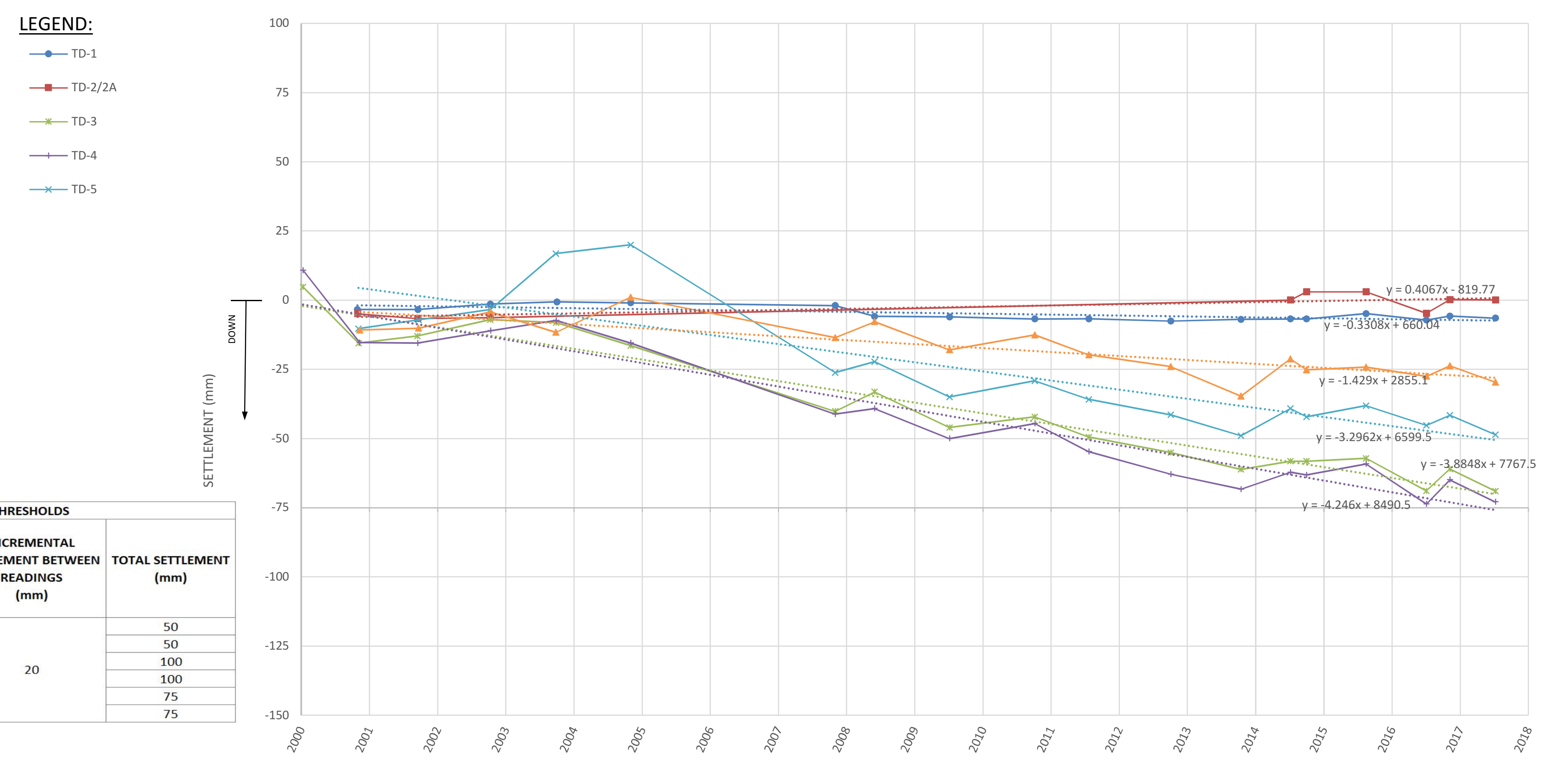


DAM CENTERLINE ORIENTATION

THRESHOLD HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION







MONUMENT ID	2018 THRESHOLDS HORIZONTAL DISPLACEMENT FROM ORIGINAL POSITION (mm)	INCREMENTAL SETTLEMENT BETWEEN READINGS (mm)	TOTAL SETTLEMENT (mm)
TD-1	80	20	50
TD-2/2A			50
TD-3			100
TD-4			100
TD-5			75
TD-6			75

NOTES:

1. TROJAN DAM MOVEMENT MONITORING DATA PRIOR TO 2000 NOT SHOWN.
2. REFER TO FIGURE 3 FOR MONUMENT LOCATIONS IN PLAN VIEW.
3. TD-1 RELOCATED AFTER OCT 2001.
4. TD-1 2009 READING (NOT SHOWN IN PLAN PLOT) LOCATED 297 mm FROM INITIAL 1998 READING . READING WAS REVIEWED AND FOUND MORE LIKELY RELATED TO SURVEY ERROR THAN DISPLACEMENT.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

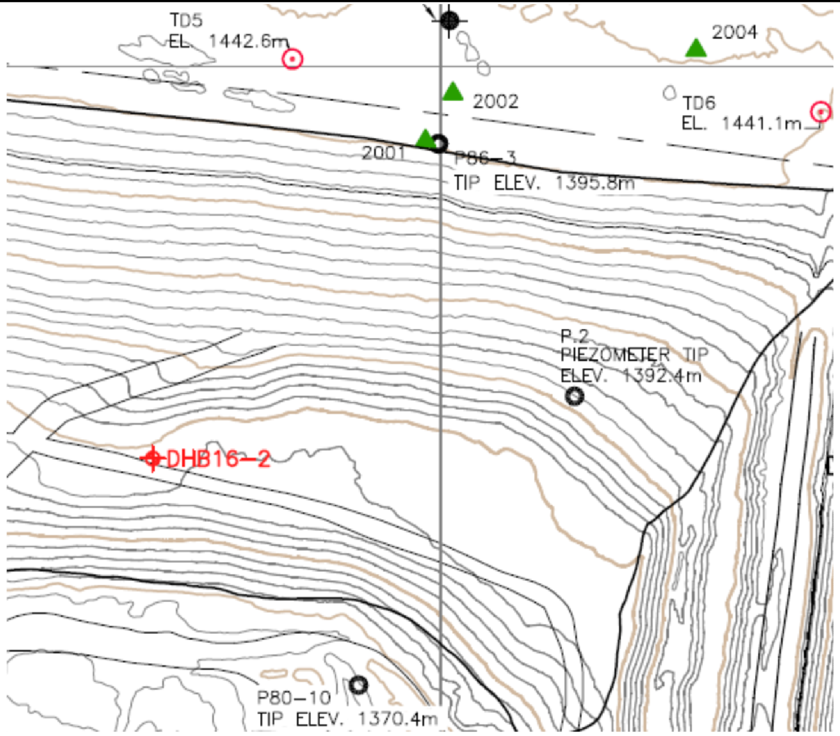
Klohn Crippen Berger

PROJECT: TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

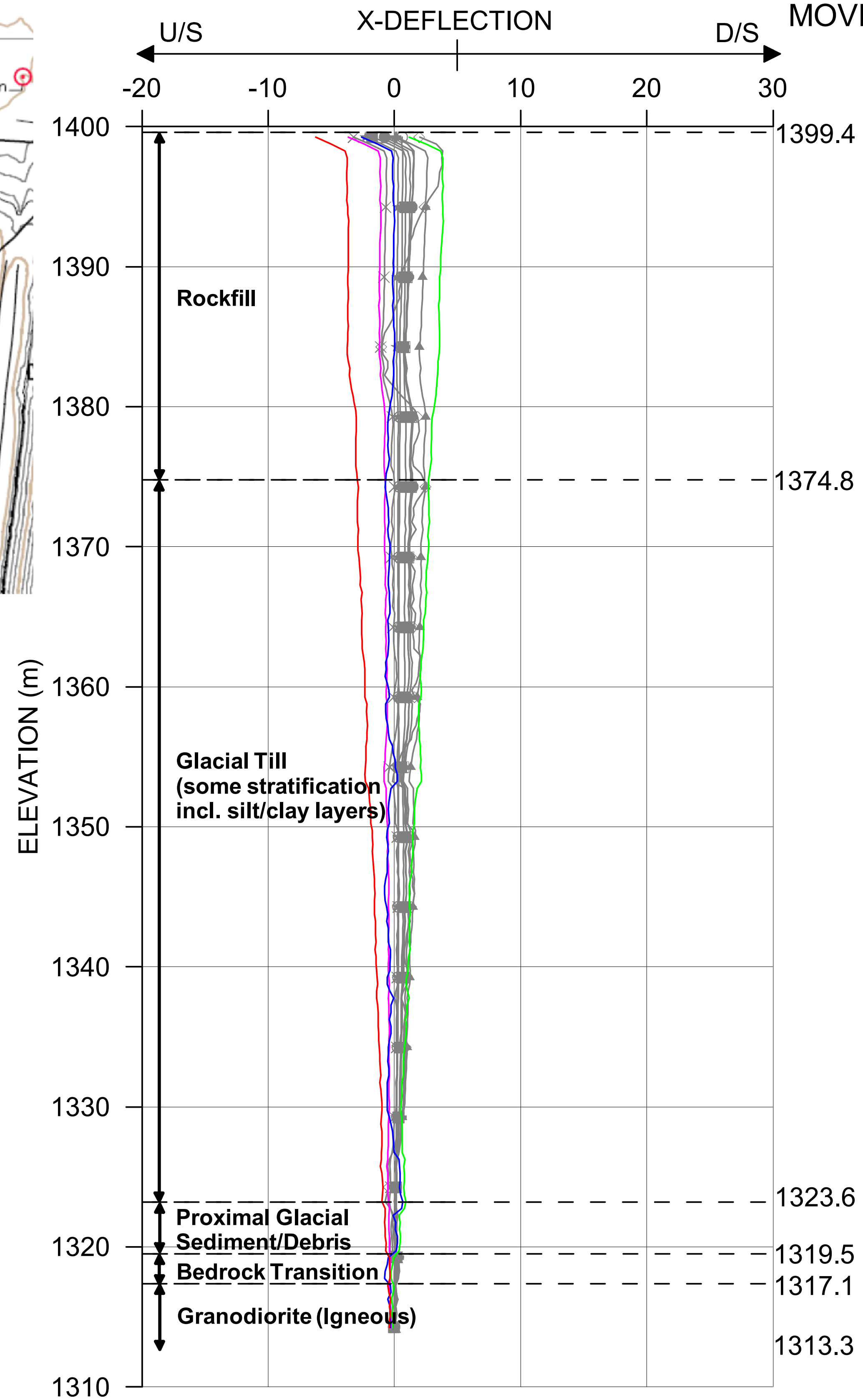
TITLE: TROJAN DAM SURVEY MONUMENT READINGS

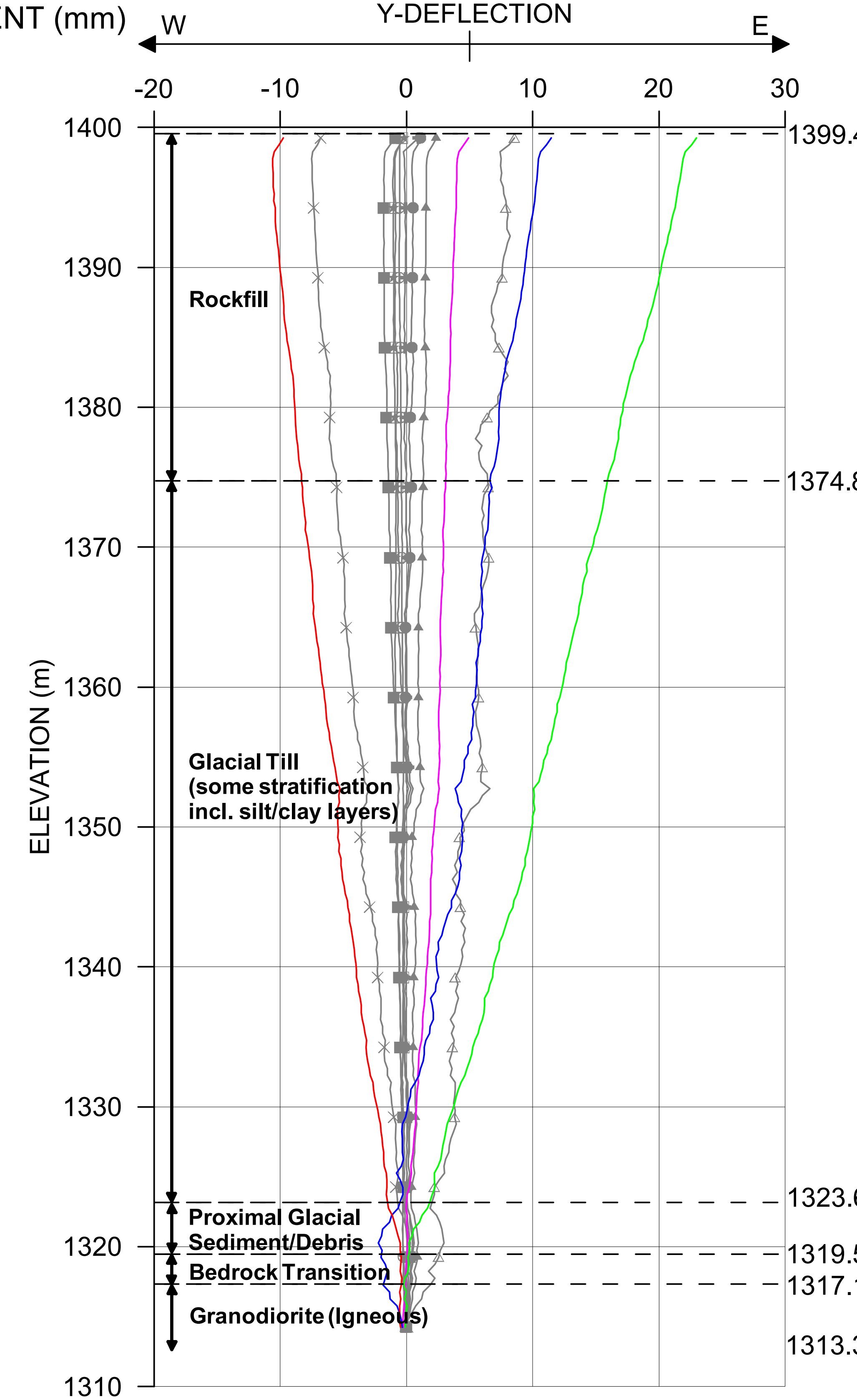
PROJECT No. M02341B26 | FIG No. IV-4

February 21, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Monument Data\Trojan\[180221 TrojanDamMonitoring.xlsm]Fig V-4



MOVEMENT (mm)





LEGEND

- June 10, 2016
- July 6, 2016
- August 17, 2016
- September 21, 2016
- October 19, 2016
- November 9, 2016
- December 20, 2016
- January 17, 2017
- March 13, 2017
- May 19, 2017
- July 12, 2017
- August 23, 2017
- October 16, 2017

NOTES:

1) Initial reading = June 10, 2016
2) Not all readings are plotted

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

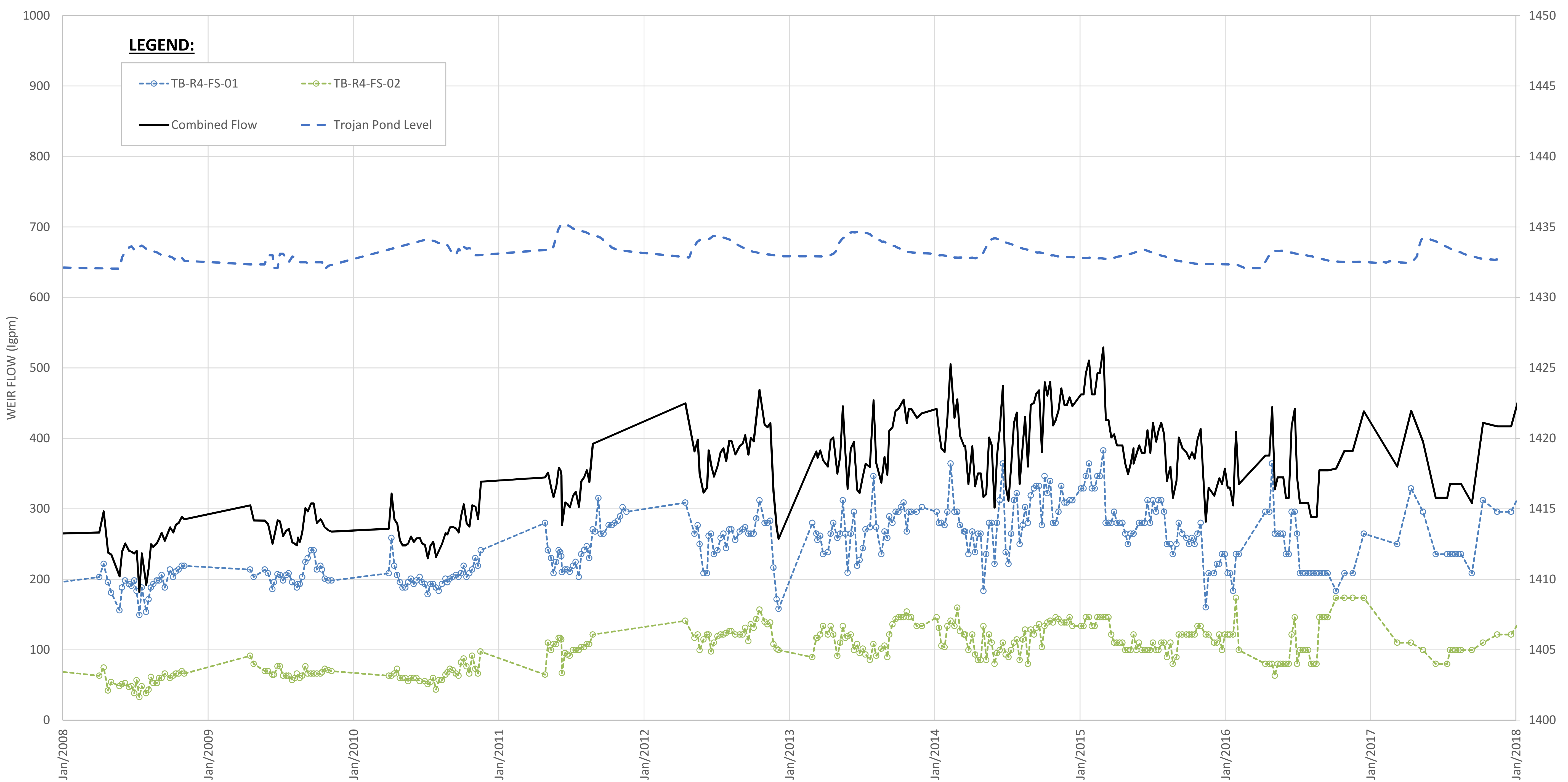
PROJECT
TROJAN DAM TAILINGS STORAGE FACILITY
2017 INCLINOMETER DATA

TITLE
INCLINOMETER CUMULATIVE DISPLACEMENT PROFILE
IB16-2

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\Trojan Dam\IB16-2\Grapher Files\IB16-2.grf



NOTES:

1. WEIR FLOW PLOTTED ON PRIMARY (LEFT) AXIS, TROJAN POND ELEVATION PLOTTED ON SECONDARY (RIGHT) AXIS.
2. POND WATER LEVEL RECORDED ON NOVEMBER 8, 2009 HAD A 10 m JUMP AND IS NOT PLOTTED AS IT IS ALMOST CERTAINLY A MEASUREMENT OR DATA ENTRY ERROR.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

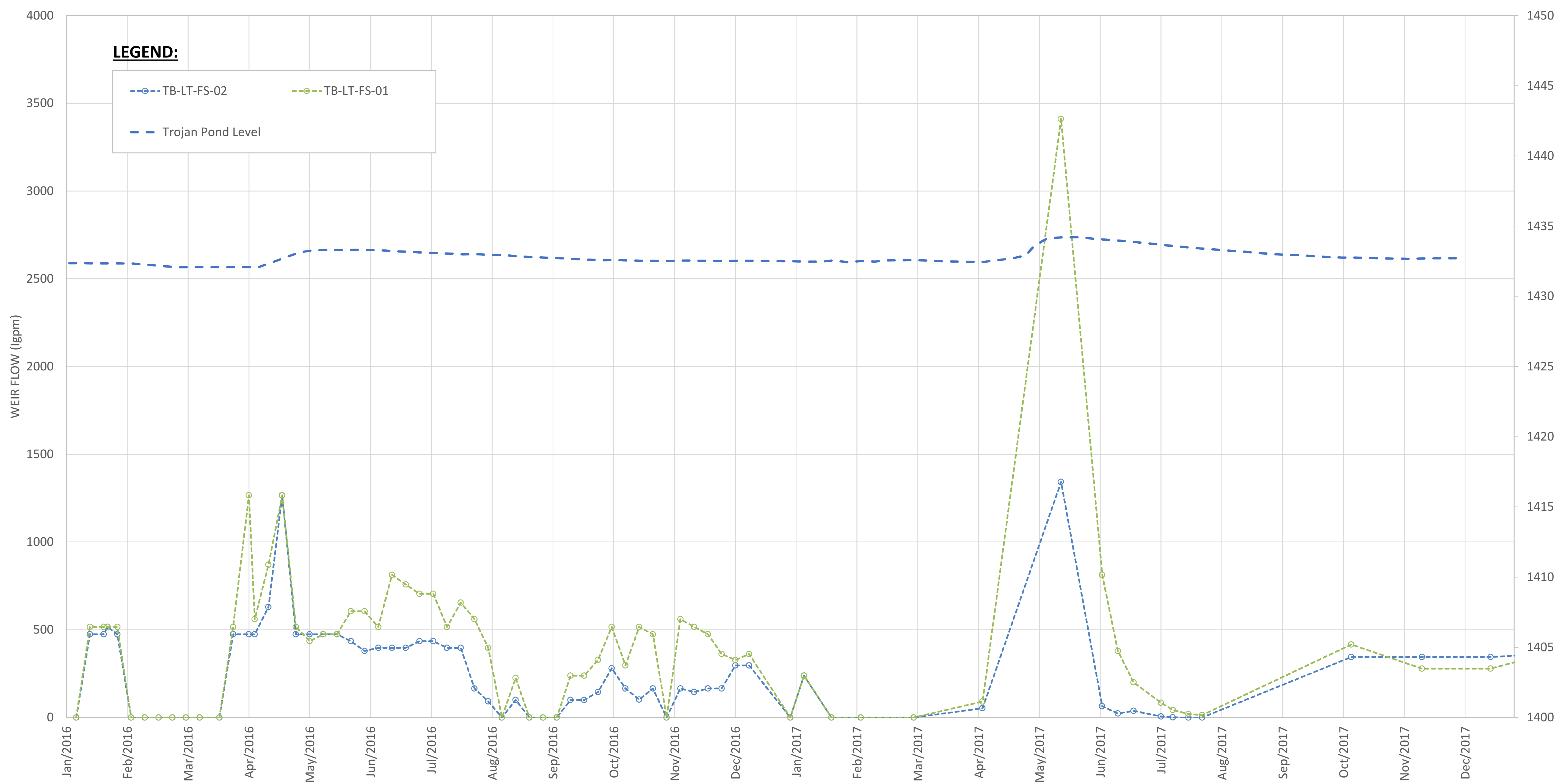
Klohn Crippen Berger

PROJECT: TROJAN TAILINGS STORAGE FACILITY 2017 DAM SAFETY INSPECTION

TITLE: TROJAN DAM WEIR FLOWS

PROJECT No. M02341B26 | FIG No. IV-6

March 28, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Seepage Data\Trojan\[180221 Troj Weir.xlsx]Weirs



CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
TROJAN TAILINGS STORAGE FACILITY
2017 DAM SAFETY INSPECTION

TITLE
LOWER TROJAN POND
WEIR FLOWS

PROJECT No. M02341B26 | FIG No. IV-7

March 28, 2018
Z:\M\VCR\M02341B26 - HVC-2017 Dam Safety Support\300 Design\Seepage Data\Trojan\[180221 Troj Weir.xlsx]Weirs

APPENDIX V

Map of Water Quality Monitoring Points

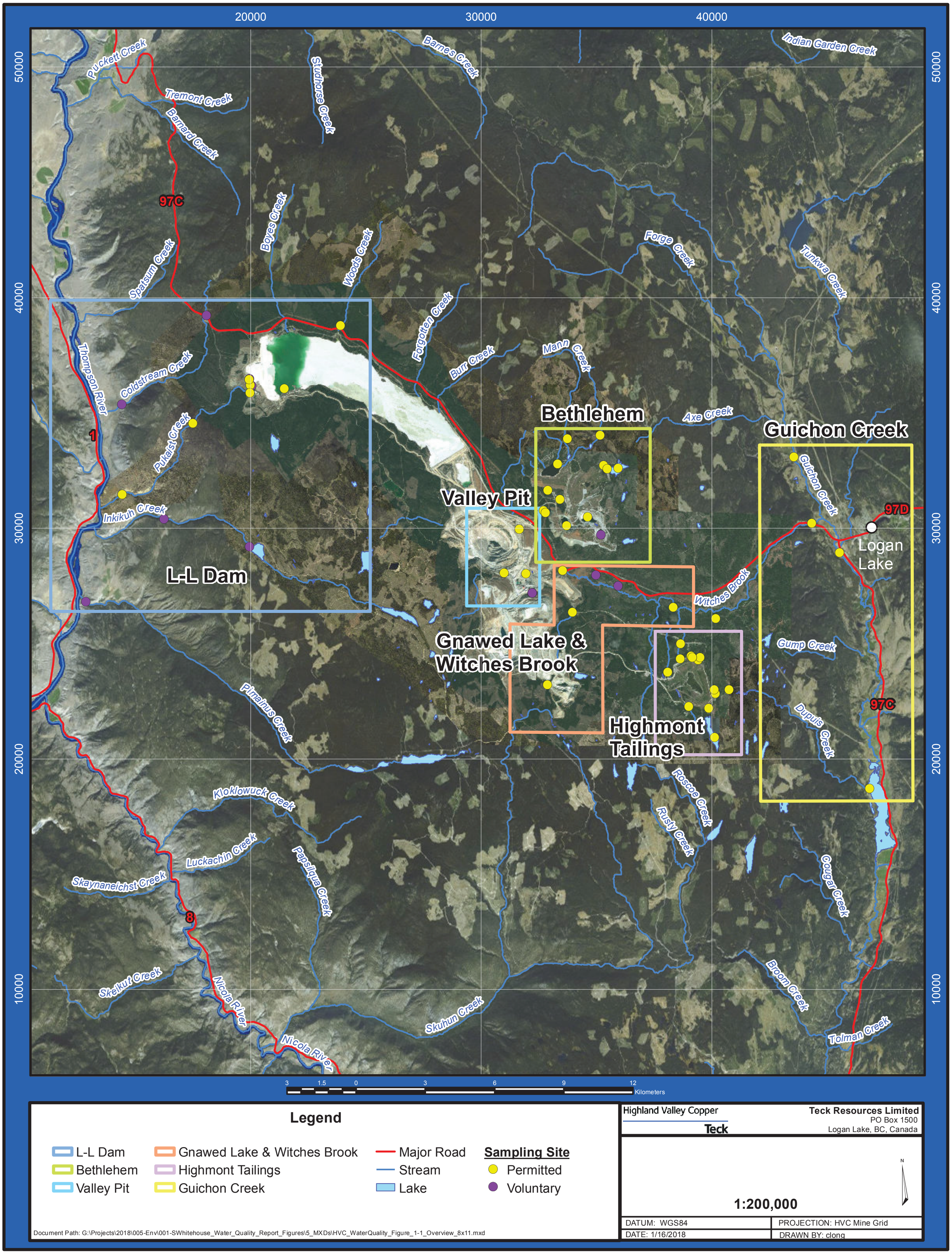


Figure 1-1 Water Quality Monitoring Sites Highland Valley Copper, 2017

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

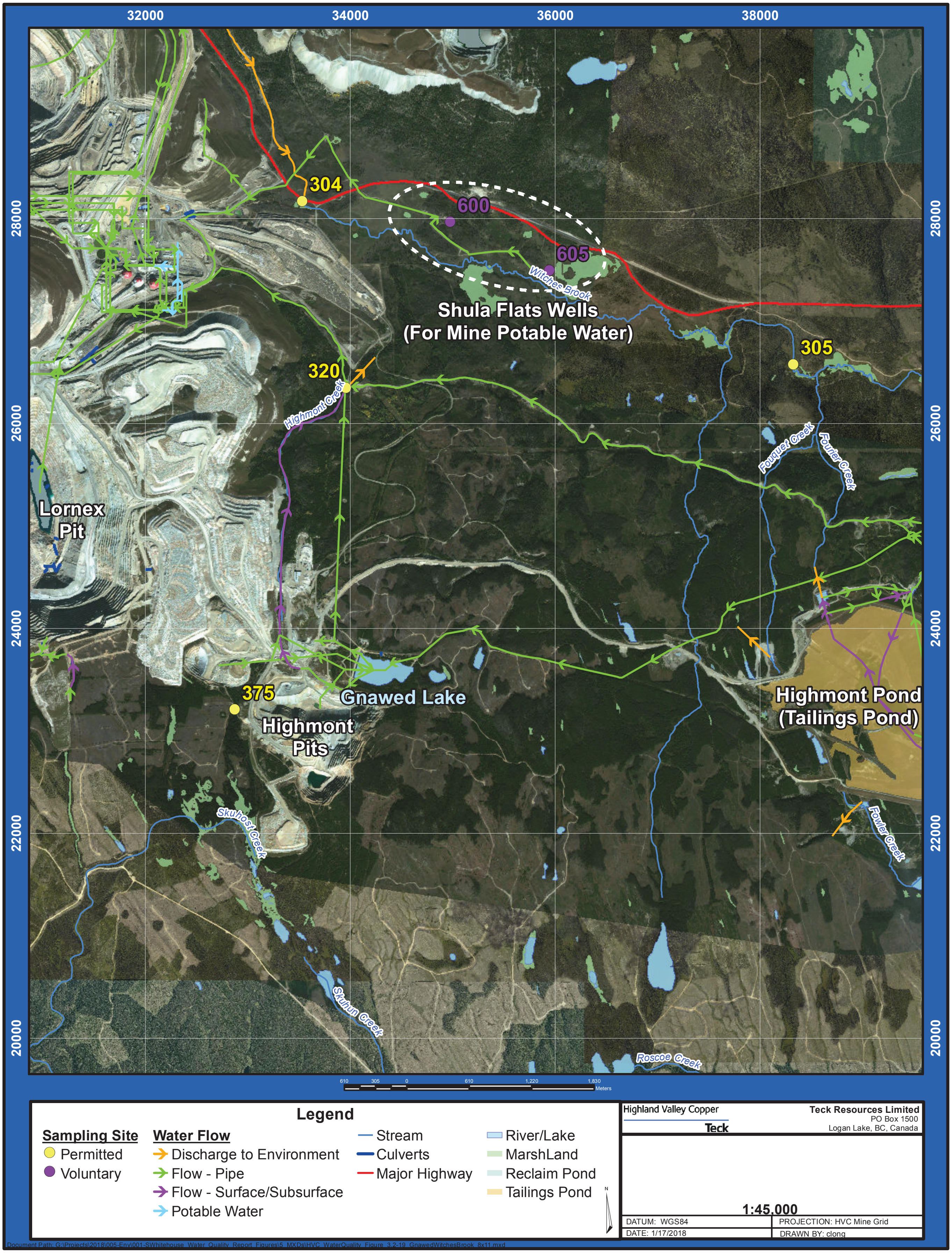


Figure 3.2-26 Water Quality Monitoring Sites in the Witches Brook and Gnawed Lake Area, Highland Valley Copper, 2017