Klohn Crippen Berger

Teck Highland Valley Copper Partnership

2019 Dam Safety Inspections

Highland Tailings Storage Facility

FINAL

CANADA BEST MANAGED COMPANIES Platinum member

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April 2020

April 3, 2020

Teck Highland Valley Copper Partnership
PO Box 1500
Logan Lake, British Columbia
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Mr. Chris Anderson P.Eng.
Manager Tailings and Water

Dear Mr. Anderson:

2019 Dam Safety Inspection Report
Highland Tailings Storage Facility
FINAL

We are pleased to submit the 2019 Dam Safety Inspection report for the Highland 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), and 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.
Program Manager

NS/MM/RF:cd

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EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2019 Dam Safety Inspection (DSI) of the Highland Tailings Storage Facility (TSF). The TSF includes retaining dams L-L Dam (west end) and H-H Dam (east end), Seepage Pond 2, Seepage Water Reclaim Pond, Slimes Pond 1, Slimes Pond 2, Slimes Pond 4, and 24 Mile Lake. The Highland TSF is the primary active storage facility for the Highland Valley Copper (HVC) mine, which is owned and operated by THVCP.

The review period of this DSI is between January 2019 to October 2019. The DSI is an annual requirement under the Health, Safety and Reclamation Code for Mines in British Columbia (MEM 2017), herein referred to as the Code.

The Highland TSF was visually in good physical condition, the observed performance and surveillance data from 2019 is within expected design conditions and consistent with past performance.

The DSI visual inspection was completed by the Engineer of Record (EoR) Designated Alternate, Mr. Rick Friedel, P.Eng., P.E., Mr. Pablo Urrutia, P.Eng., and Ms. Narges Solgi, EIT, as representatives of KCB on June 11, 2019. This report was prepared under the supervision and reviewed by EoR Mr. Bill Chin P.Eng. Mr. Chris Anderson, P. Eng., THVCP Tailings and Water Manager, is the TSF Qualified Person (as defined by the Code) for the Highland TSF.

The tailings beach slopes away from the H-H Dam towards the pond, which is approximately 7.5 km away, near the L-L Dam. Water from the tailings pond is reclaimed, via floating barges, back to the mill for use in processing. During 2019, approximately 51.2 Mt of tailings were discharged into the Highland TSF.

The L-L Dam is a cycloned sand dam with a vertical central glacial till core. As of the end of 2019, the crest elevation of L-L Dam is 1264.5 m, corresponding to a maximum downstream slope height of about 159.5 m (based on low point of toe at ~El. 1105 m).

The H-H Dam is an earthfill dam constructed of local borrow and pit waste materials. The dam comprises a glacial till core that has been raised vertically from the crest of the H-H Starter Dam, similar to the L-L Dam. The core is supported by the upstream tailings and the downstream waste rock dam shell.

The consequence classification, as per CDA (2014), for the L-L Dam (Extreme) and H-H Dam (Very High) were reviewed by THVCP and the EoR in January 2019 and no change was proposed.

The most recent Dam Safety Review (DSR) was completed by Stantec (2018) based on a site visit completed in 2017 and the report issued in 2018. Stantec (2018) did not reveal any unsafe or unacceptable conditions in relation to design, construction, maintenance and operation of the dams. Thirty recommendations were included in the DSR report, of which two are outstanding but plans to address them have been confirmed by THVCP and included in life-of-mine planning. The Code requires a DSR be undertaken every five years for tailings dams; therefore, the next DSR should be scheduled for 2022.

The 2019 crest raises at both L-L Dam (2 m) and H-H Dam (0.9 m to 2.7 m) were completed as planned. In addition to dam crest raises, the THVCP mining fleet started a campaign to convert the majority of the 24 Mile Lake area to a waste dump. The conversion of 24 Mile Lake to a waste dump, will also act as a future buttress to the H-H Dam based on the 2019 design update (KCB 2019a). THVCP will be submitting the design update to EMPR for approval in 2020.

No incidents which could have significantly compromised the integrity of either dam were observed by KCB in 2019. There were operational incidents which required routine maintenance (e.g. slope erosion, differential settlement) but did not pose a risk to the integrity of any dams. THVCP and KCB reviewed each of these instances and created appropriate work plan to resolve each.

During 2019, the Highland TSF was operated with adequate flood storage, freeboard capacity and tailings storage. The pond level rose 1.7 m relative to December 2018 which was consistent with water balance model forecasts.

The work planned for 2019 to address Seepage Pond 2 freeboard non-compliance, under design flood conditions, was delayed to 2020 due to planned dredging activities and late receipt of required archeological clearances. THVCP confirms this activity will be completed in 2020.

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

Routine visual inspections and instrument measurements were completed by THVCP at the OMS prescribed frequencies. There were no event-driven inspections in 2019 triggered by precipitation or earthquake events as defined in the OMS manual. THVCP made further improvements to the surveillance program in 2019, which included: installation of additional instrumentation; routine monthly monitoring reviews by EoR; and converted more instruments from manual to automated reading.

2019 instrumentation readings (e.g. piezometer, inclinometer, settlement) did not indicate potential issues of concern with respect to dam safety and were consistent with design assumptions. Overall performance of the facility was similar to recent past or to historic behaviour when similar construction activities were completed at the dams.

L-L Dam and H-H Dam failure modes were reviewed in 2019 and no significant changes to the failure modes or triggers were identified compared to the 2017 risk assessment (Wood 2019a, 2019b). Remaining recommendations from the 2017 risk assessment were formally closed out during 2019 and uncertainties related to key dam safety risks had been reduced and/or better defined (e.g. foundation geology, deformation modelling, 3D seepage groundwater model).

A trial exercise of the Emergency Preparedness and Response Plan (EPRP) was completed on November 26, 2019 in which THVCP and KCB representatives participated with Community representatives present.

The status of dam safety recommendations from past DSIs are summarized in Table 1. Closed recommendations are shown in *italics*. Dam safety recommendations identified during the 2019 DSI are summarized in Table 2. Outstanding recommendations with a Priority Level 2 are related to flood management of downstream surface collection ponds and action to address both has been included in the Highland TSF life-of-mine development plan.

Table 1 Status of Outstanding Recommendations for Deficiencies and Non-Conformances

ID No.	Recommended Action	Priority[(1)]	Recommended Deadline (Status)
L-L Dam			
LL-2015-06	*We recommend that key design criteria for the Highland TSF, including the probable maximum flood (PMF), freeboard requirements and seismic ground motions be reviewed during 2016.*	*4*	*Closed (Seismic hazard update completed in 2018. PMF update completed in 2019)*
LL-2016-02	*Install seepage measurement weirs at the outflow points of the North Dam (Sta. 3+600) and South Dam (Sta. 1+100) major drains to monitor seepage rates.*	*3*	*Closed* (*superseded by LL-2019-02, has be included in life-of-mine plan*)
LL-2018-01	Review, complete and/or provide written response to close out all 2017 DSR recommendations.	3	*Closed* (2 remaining recommendations captured by LL-2019-02 and LL-2019-03)
H-H Dam and 24 Mile Lake			
HH-2018-01	*Review, complete and/or provide written response to close out all 2017 DSR recommendations.*	*3*	*Closed (H-H Dam items closed)*
HH-2018-02	*Complete H-H Dam design review to confirm liquefaction susceptibility and dam stability under future loading conditions*	*2*	*Closed (Documented in 2019 design update)*
L-L Dam Seepage Collection and Slimes Ponds			
SP-2017-01	The Seepage Water Reclaim Pond has insufficient capacity to store the IDF and should be brought into compliance. Note: THVCP to include an interim plan involving pumping to manage the IDF without off-lease discharge until upgrade works are complete. Suggested interim milestones: Design in 2018, Permit and IFC in 2019 and Commissioned in 2021. *(Schedule updated in 2019)*	2	Open (EMPR Approval Pending, Construction scheduled to be completed in 2021)
SP-2017-02	Regrade Seepage Pond 2 outlet pipe to a consistent downward grade	2	Open (Delayed to 2020 due to late archeological clearance and dredging activities)
SP-2018-01	*If Slimes Pond 4 to remain as contingency slimes storage, include it in the 2019 OMS manual update.*	*3*	*Closed* (*THVCP to include in 2020 OMS Manual update*)

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

Table 2 2019 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority(1)	Recommended Deadline (Status)
L-L Dam					
LL-2019-01	Surveillance	-	Install 4 additional inclinometers at NBB (north of I17-24, I17-22, I15-25 and I19-08) to increase monitoring coverage to capture 3D behaviour and provide redundancy.	3	Q3 2021 (Multi-phase, initial installs starting in 2020)
LL-2019-02	Surveillance	DSR	Install new seepage weirs along downstream toe after SWRP has been replaced and L-L Dam constructed to ultimate toe (forecast 2021). (To resolve DSR recommendation LL-2017-06)	3	Q4 2021
LL-2019-03	Surveillance	DSR	Include potential impacts on dam surveillance for a scenario where the site is not accessible due to fire. (To resolve DSR recommendation TSF-2017-11)	3	Q4 2020
H-H Dam and 24 Mile Lake					
No new recommendations in 2019.					
L-L Dam Seepage Collection and Slimes Ponds					
No new recommendations in 2019.					

Notes:

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

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1 INTRODUCTION

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2019 Dam Safety Inspection (DSI) of the Highland Tailings Storage Facility (TSF). The TSF includes retaining dams L-L Dam (west end) and H-H Dam (east end), Seepage Pond 2, Seepage Water Reclaim Pond, Slimes Pond 1, Slimes Pond 2, Slimes Pond 4, and 24 Mile Lake. The Highland TSF is the primary active storage facility for the Highland Valley Copper (HVC) mine, which is owned and operated by THVCP. Mr. Chris Anderson, P. Eng., THVCP Tailings and Water Manager, is the TSF Qualified Person (as defined by the Code) for the Highland TSF.

The review period of this DSI is between January 2019 to October 2019. The DSI is an annual requirement under Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia (MEM 2017), herein referred to as the Code.

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.

The DSI visual inspection was completed by the Engineer of Record (EoR) Designated Alternate, Mr. Rick Friedel, P.Eng., P.E., Mr. Pablo Urrutia, P.Eng., and Ms. Narges Solgi, EIT, as representatives of KCB on June 11, 2019. This report was prepared under the supervision and reviewed by EoR Mr. Bill Chin P.Eng. The weather during the DSI was clear and sunny. Mr. Friedel made multiple trips to site during 2019 to support construction and other activities related to the Highland TSF.

The Highland TSF is operated under the following permits:

- British Columbia Ministry of Energy, Mines and Petroleum Resources (EMPR) Geotechnical Permit M11 – the permit covers the entire mine life, property and the surrounding area and communities. This permit was last amended in 2019, approving the "Bethlehem Extension Project".
- British Columbia Ministry of Environment (MOE) Water Licenses 46527 and 46528 – these licenses allow diversion and storage of water from Pukaist Creek on Crown Land.
- British Columbia MOE Effluent Permit PE-376 – this permit allows the storage of tailings and effluent in the Highland TSF.

The L-L Dam and H-H Dam have been assigned consequence classifications of “Extreme” and a “Very High”, respectively, in accordance with the Code which refers to the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2013). These classifications remained unchanged in 2019. A summary list of the consequence classifications assigned to each of the supplementary dams is provided in Section 2.1.

The Code recommends a dam safety review (DSR) be undertaken every 5 years for the L-L Dam and H-H Dam consequence classifications. The supplementary dams with lower consequence classifications have previously been included in the Highland TSF DSR. The most recent DSR for the Highland TSF dams was carried out by Stantec starting in 2017 with final report issued in June 2018 (Stantec 2018). The next DSR should be scheduled for, no later than, 2022.

Note that there are two sets of figures in this report, one set is at the end of the report numbered 1 to 5. The other set is in the body of the report with numbering by section and order, e.g. 7.1.

2 FACILITY DESCRIPTION

2.1 Highland TSF

The HVC mine is located near Logan Lake, approximately 45 km southwest of Kamloops, in the interior of British Columbia, as shown in Figure 1. The Highland TSF is located approximately 6.5 km northwest of the operating mill and is approximately 10 km long.

Tailings are retained in the Highland TSF by the L-L Dam (west end) and H-H Dam (east end), which were constructed across either end of the Highland Valley. The H-H Dam is constructed of local borrow and waste materials from the Valley Pit, while the L-L Dam is constructed of local borrow materials, processed filter materials, and cycloned tailings sand. Construction of the Highland TSF began in 1971 with the J-J Starter Dam, which was located approximately halfway between the H-H Dam and the L-L Dam. In 1972, the H-H Starter Dam was constructed, followed by the L-L Starter Dam between 1976 and 1979. By 1991, the J-J Dam was buried by tailings.

The majority of tailings have been discharged from spigots near the east and west abutments of the H-H Dam. As a result, the tailings beach slopes away from the H-H Dam towards the pond, which is approximately 7.5 km away, near the L-L Dam. No significant ponding occurs at the H-H Dam. Water from the tailings pond is reclaimed, via floating barges, back to the mill for use in processing.

In addition to L-L Dam and H-H Dam, there are several other supplementary retaining structures related to water and slimes[1] management. General information regarding each retaining structure at the Highland TSF is summarized in Table 2.1. The tailings retaining dams, L-L Dam and H-H Dam, are discussed further in Sections 2.2 and 2.3, respectively. Appendix III includes a more detailed discussion of the design, history and operations of the Highland TSF, L-L Dam, H-H Dam and supplementary structures.

[1] Slimes are tailings suspended and transported in the overflow water from the hydraulic placement cells during L-L Dam construction because the material typically comprise the finer grained fraction of the cycloned sand fill.

Table 2.1 Containment Facilities at the Highland TSF

Dam/ Facility	Consequence Classification[1]	Purpose	Dam Type	2019 Est. Crest Length (m)	2019 Est. Crest El. (m)	2018 Est. Max Downstream Slope Height (m)
L-L Dam	Extreme	Tailings and water retaining structure	A glacial till core raised centreline (i.e, vertically) from the glacial till starter dam, supported by compacted cycloned sand on the upstream and downstream sides. A drainage blanket is present beneath the downstream shell. The majority of the cycloned sand fill in the dam has been placed and densified hydraulically, rather than conventional construction equipment.	2,980	1264.5	159.5
H-H Dam	Very High	Tailings retaining structure	A glacial till core raised centreline (i.e, vertically) from the glacial till starter dam, supported on the upstream side by spigotted tailings and on the downstream side by pit waste dam fill and waste dumps.	1,800	1273 m to 1280 m	53
24 Mile Lake	Low[1,2]	Receives seepage from the H-H Dam and acts as storage for tailings spoils for the H-H Pumphouse.	The area was previously a natural lake. Tailings have been raised above the natural lake level and are encapsulated on all sides by waste rock dumps.	n/a	Min. 1220 (waste dumps)	n/a (Note 2)
Seepage Water Reclaim Pond	Significant	Primary collection pond downstream of L-L Dam, which collects and pumps water back to the TSF. Receives water from surface runoff, slimes ponds, and seepage collection ponds.	Original embankment on the west side of pond is homogeneous glacial till with downstream sand and gravel filter. Pond is unlined.	95	1103.2	5
Seepage Pond 2	Significant	Collects seepage primarily from finger drains under the northern portions of the L-L Dam.	Excavated into natural ground on three sides, with a homogenous glacial till embankment on the north side of the pond. Pond is lined with geomembrane.	80	1116.6	1.8
Slimes Pond 1	Significant	Temporary slimes cell constructed for until new slimes pond (Slimes Pond 3) is commissioned.	Excavated into natural ground. In 2018, remaining slimes and accessible lacustrine/glaciolacustrine deposits over the base of the pond were removed and the pond backfilled with sand and gravel.	NE = 500 SW = 700	1103.2	2.5 to 3.75 m
Slimes Pond 2	Significant[1]	Collects construction water and slimes[5] from hydraulic sand placement on the downstream side of L-L Dam.	Excavated into natural ground on three sides, with a homogeneous glacial till embankment on the south side. Pond is lined with geomembrane.	100	1126.9	10
Slimes Pond 4	n/a [4]	Collect construction water and slimes[5] from hydraulic sand placement on the downstream side of L-L Dam.	Contained by natural ground with small compacted till embankments to provide containment at the south and southeast ends.	n/a	1103 to 1104	<2 m

Notes:
1. As assigned during the Dam Classification Workshop held in January 2019.
2. 24 Mile Lake downstream slope – The relatively flat, more than a kilometer-wide, containment structure that separates 24 Mile Lake from the Valley Pit does not pose a static or dynamic stability concern that could result in an uncontrolled release (KCB 2018b).
3. Slimes Pond 3 was included in this table during 2017 as “under construction,” but has been removed in 2018 as construction of the pond is not yet complete and facility not in use.
4. The crest of the divider dykes are below the surrounding natural ground. Failure of any of the divider dykes would be internal to the pond only with no downstream impacts.
5. Slimes are tailings suspended and transported in the overflow water from the hydraulic placement cells during L-L Dam construction because the material typically comprises the finer grained fraction of the cycloned sand fill.

2.2 L-L Dam

Figure 2.1 is a typical design section of the L-L Dam, through the Valley Buttress Berm. General construction staging of the L-L Dam at Sta. 1+850 through 2019 is shown on Figure 2.2. Select design and construction record drawings as well as further discussion of the design and construction timeline for the L-L Dam is included in Appendix III.

The 2019 layout of the L-L Dam and associated structures is shown on Figure 2. As of the end of 2019, the crest elevation of L-L Dam is 1264.5 m, corresponding to a maximum downstream slope height of about 159.5 m (based on low point of toe at ~El. 1105 m).

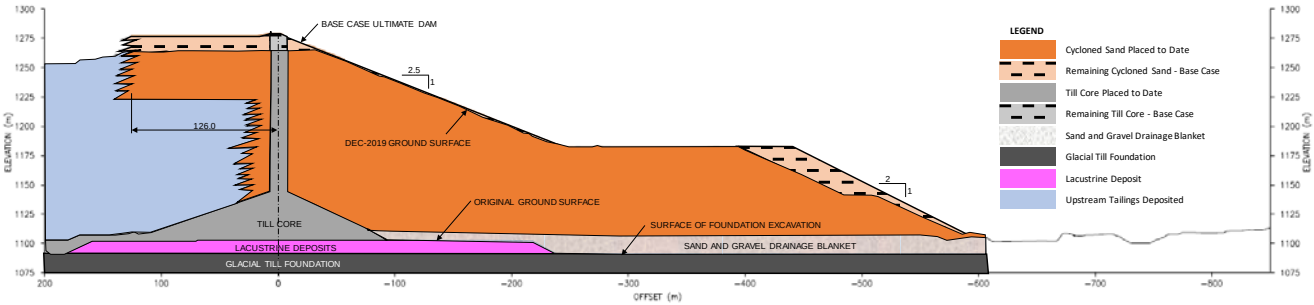
The L-L Dam is divided in five design segments based on foundation conditions (Figure 2): South Dam; Valley Buttress Berm (VBB); Valley Buttress Berm Extension (VBBE); North Buttress Berm (NBB); and North Dam. The North Dam is further subdivided into two zones: North Dam Bedrock; and North Dam Upper-Glaciolacustrine (U-GLU). Foundation conditions for each segment are discussed further in Appendix III. The overall downstream slope, measured from the downstream edge of the crest and the downstream toe, is 2.5H:1V except where foundation conditions govern the need for additional buttressing (i.e., VBB, VBBE, NBB).

The downstream cycloned sand shell is underlain by a sand and gravel blanket drain which minor and major underdrains to increase drainage capacity. The purpose of the underdrain is to maintain low piezometric pressures in the downstream shell, intercept upward seepage from the natural ground, and promote downward drainage through the cycloned sand fill during hydraulic placement. Seepage intercepted by the blanket drain flows towards the VBB, which is the low point of the natural valley, unless intercepted by an underdrain. Seepage from the dam toe is typically observed from the blanket drain at the VBB or where major drains daylight from the dam toe.

Seepage through the foundation that is not intercepted by the dam fill or drains is managed by THVCP as part of the Sulphate Adaptive Management Plan (SAMP), which includes a network of interception wells. The SAMP system is not considered a design feature of the L-L Dam but is a requirement of THVCP under the conditions of the M-11 permit (EMPR 2019). Water quality monitoring is reported by THVCP in a separate report as discussed in Section 5.6.

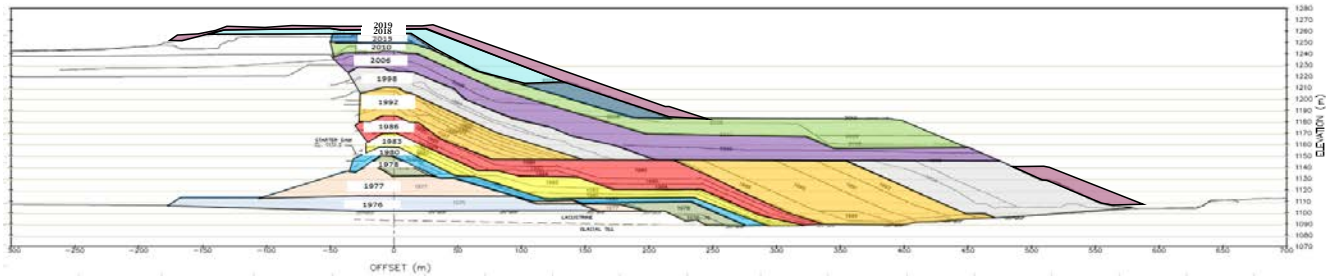
The purpose of the downstream collection ponds is to collect mine affected surface water and seepage with no off-site discharge. The Seepage Water Reclaim Pond (SWRP), located downstream of the VBB toe, is the primary collection pond where all water reports and is then pumped into the Highland TSF impoundment via a pipeline.

Figure 2.1 Schematic L-L Dam Typical Base Case Design Section at VBB (Sta. 1+850)



Note: Dam fill "placed to date" as of end of 2018.

Figure 2.2 Schematic L-L Dam Construction Sequence at VBB through 2019 (Sta. 1+850)



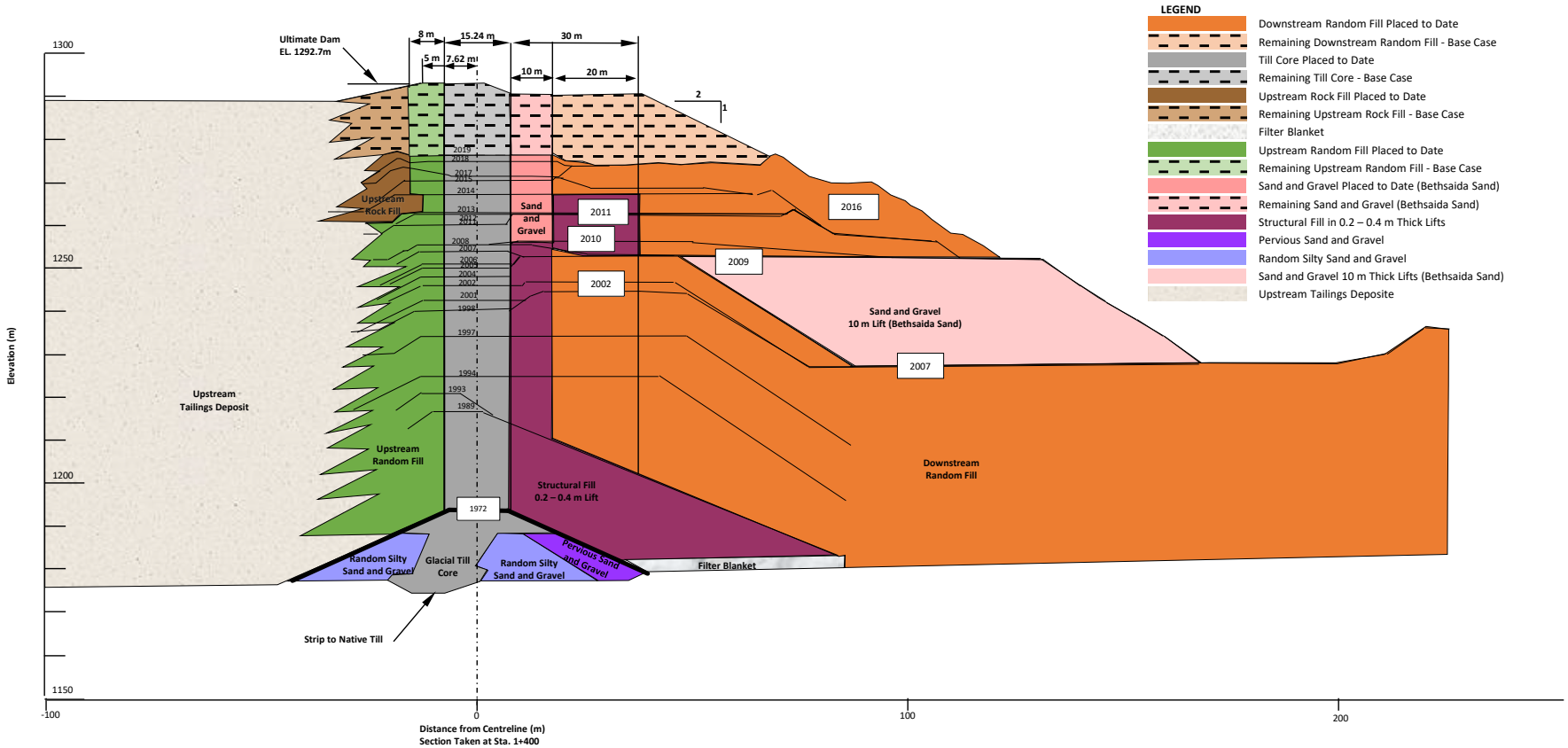
2.3 H-H Dam

Figure 2.3 is a typical design section and general construction staging of the H-H Dam. Select design and construction record drawings as well as further discussion of the design and construction timeline for the H-H Dam is included in Appendix III.

The 2019 layout of the H-H Dam and associated structures is shown on Figure 4. No overtopping concern is present at the H-H Dam because the crest is higher than the L-L Dam crest (typically ~14 m) and the tailings beach slopes away from the dam. Therefore, rather than constructing a horizontal crest to match rise of a pond surface, the H-H Dam crest is sloped to match the forecasted beach profile immediately upstream of the dam. As of the end of 2019, the crest elevation of H-H Dam ranged from El. 1273 m to El. 1280 m, corresponding to a maximum downstream fill thickness (measured near the dam core) of ~90 m. The maximum downstream slope height is only ~53 m because waste dumps have elevated the ground surface downstream of the dam by up to ~40 m.

The 24 Mile Lake tailings storage facility (Table 2.1) is located approximately 110 m downstream of the H-H Dam fill toe. The facility is physically separated from the H-H Dam by the downstream waste dump and collects seepage from the H-H Dam as well as tailings spoils from the H-H Pumphouse during periods of tailings line maintenance and/or operational upsets. The downstream extent of 24 Mile Lake (i.e. furthest side from H-H Dam) is supported by waste dumps which extend 1.5 km downstream of the tailings area. There is no credible failure mode for the 24 Mile Lake, in its current configuration, that could lead to uncontrolled release of tailings or water, nor result in offsite impacts (KCB 2019a).

Figure 2.3 Schematic H-H Dam Base Case Design and Construction Sequence through 2019 (Sta. 1+400)



Note: Structural fill below ~El. 1216.7 m is a transition zone between Glacial Till core and downstream Random Fill.

3 2019 OPERATIONS

3.1 Tailings Deposition and Available Storage

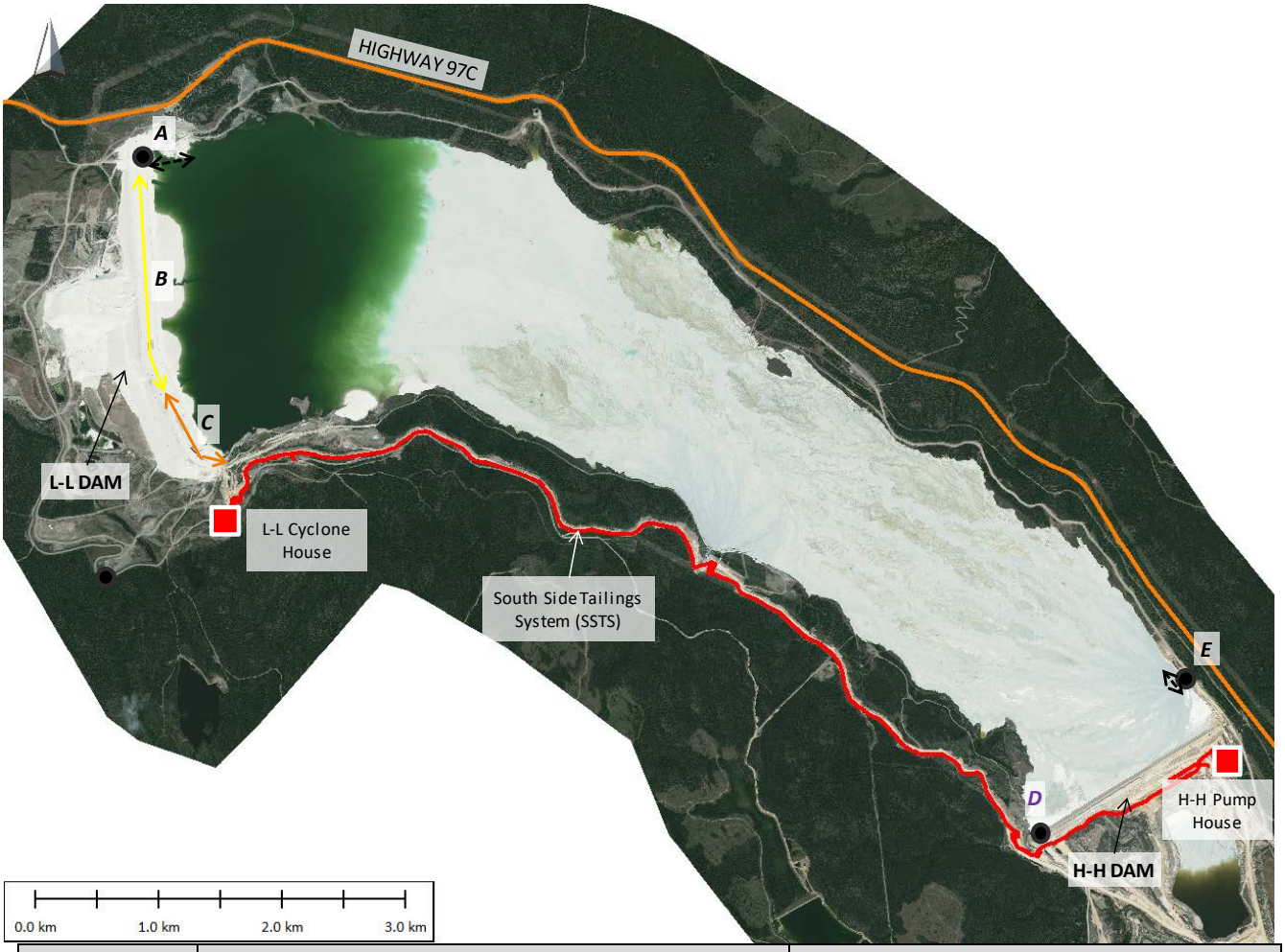
The maximum permitted ore throughput, and subsequently tailings production, allowed by the M-11 Permit (EMPR 2019) is 200,000 tonnes per day (tpd) calculated on an annual average basis. During 2019, THVCP generated approximately 51.2 million tonnes (Mt) which corresponds to an average daily production of ~140,000 tpd. All of the tailings were discharged into the Highland TSF, except for cycloned sand placed in the L-L Dam and small quantities of tailings discharged into 7-Day Pond or 24 Mile Lake during upset conditions at the Mill or H-H Pumphouse, refer to Table 3.1.

2019 tailings spigot points at the Highland TSF are shown on Figure 3.1 and the estimated volumes of tailings discharged at each location (as provided by THVCP) are summarized in Table 3.1.

THVCP sequence dam construction such that at the end of each calendar year, the Highland TSF has capacity to store the forecasted tailings production for the next year. This is in addition to flood storage and freeboard requirements. THVCP plan to produce 55 Mt of tailings in 2020. Based on forecasted pond volume and elevation, the dam crests at end of 2019 are sufficient to store forecasted 2020 tailings and maintain flood storage and freeboard.

Tailings deposition modelling completed in early 2019 (KCB 2019a) shows that the approved ultimate crests of both dams are sufficient to store the forecasted tailings production for the remaining mine life; ~430 Mt (2020 to 2027).

Figure 3.1 2019 Highland TSF Spigot Locations



Dam	Spigot Details			Tailings Type Discharged During 2019
	ID	Location/Station Range	No of Points	
L-L Dam	A	3+750	2 (1)	Primary Cyclone Overflow
	B	1+800 to 3+600	10 (2)	Primary Cyclone Underflow, Secondary Cyclone Overflow
	C	0+850 to 1+650	5 (3)	Secondary Cyclone Overflow
H-H Dam	D	West Abut	1	Whole Tailings
	E	East Abut - North	4 (4)	Whole Tailings

Notes:
1. Located at approximately Sta. 3+750.
2. Located at stations 1+800, 2+000, 2+200, 2+400, 2+600, 2+800, 3+000, 3+200, 3+400 and 3+600.
3. Located at stations 0+950, 1+200, 1+350, 1+500 and 1+650.
4. Spigot was located at 250 m, and 300 m Northwest of East abutment during first half of 2019 and second half of year, respectively.

Table 3.1 2019 Tailings Deposition

Discharge Area	Spigot Location(s)[1]	Notes	Tailings Discharged (dry weight - Mt)[4]
HIGHLAND TSF			
H-H Dam: East Abutment[1]	E	Discharge shifted from 250 m upstream of dam crest to 300 m upstream in July 2019	36.0
H-H Dam: West Abutment (SS2)	D	Typically discharged during maintenance or inactivity at the L-L Cyclone House	2.5
L-L Dam Crest	A,B, and C	Tailings are discharged as cyclone overflow or underflow via the L-L Cyclone House or secondary cyclones on dam crest	6.4
L-L Dam Cycloned Sand Fill	n/a	Cyclone underflow placed in the dam	6.3
HH PUMPHOUSE SPOILS			
24 Mile Lake	n/a		Note 2
MILL SPOILS			
7-Day Pond	n/a		Note 3
		Total 2019 Tailings:	51.2

Notes:
1. Refer to Figure 3.1 for spigot locations.
2. Volume estimate not reliable due to placement of initial capping layer over the majority of 24 Mile Lake; however, volume is not significant relative to overall production.
3. Very small volume relative to overall production (~10,000 dry tonnes).
4. Some tailings discharge quantities are measured, while others are estimated based on process-flow-diagram.

3.2 2019 Dam Construction Activities

The crest raises in 2019 at both L-L Dam and H-H Dam were completed as planned. General activities completed at each dam are summarized in Table 3.2 and Table 3.3 with the main work areas shown on Figure 18 and Figure 19. 2019 construction activities are documented in a separate construction summary report, which includes discussion of quality control/quality assurance activities and compliance with design intent. Overall, the 2019 construction activities complied with the design intent, Issued for Construction (IFC) specifications and drawings. There are no outstanding non-conformances which require further action.

Other construction activities undertaken in 2019 at the Highland TSF include:

- The majority of slimes from hydraulic cell placement at the L-L Dam that were deposited in Seepage Pond 2 during 2018 were dredged from the basin and pumped back into the Highland TSF impoundment. The slimes that remain in the facility do not significantly impact safe operation.
- A temporary slimes storage cell was established within Slimes Pond 1 and used during 2019 construction. The temporary storage is required until Slimes Pond 3, which was delayed in 2019 due to archeological constraints, is commissioned.
- THVCP started a campaign to convert the majority of the 24 Mile Lake area to a waste dump. An area at the south end of 24 Mile Lake will be left uncapped to provide ongoing storage for tailings drained from H-H Pumphouse, as required. The uncapped portion of 24 Mile Lake is referred to as the “Spoil Pond”:

- The conversion of 24 Mile Lake to a waste dump, will also act as a future buttress to the H-H Dam based on the 2019 design update (KCB 2019a). THVCP will be submitting the design update to EMPR for approval in 2020. The existing condition of the H-H Dam is in compliance with design criteria (KCB 2019a). A life-of-mine development plan has been prepared for the Highland TSF which demonstrates that milestone configurations of the H-H Dam required to maintain compliance with FOS criteria throughout operations and closure, defined in KCB (2019a) are achievable.

Table 3.2 Summary of 2019 Construction Activities at L-L Dam

Construction Activity	Dam Area				
	North Dam	NBB	VBBE	VBB	South Dam
Glacial Till Core Raise	✓	✓	✓	✓	✓
Upstream Fill (Cycloned Sand - Hydraulic)	✓	✓	✓	✓	✓
Upstream Fill (Cycloned Sand - Mechanical)	✓	-	-	-	-
Downstream Fill (Cycloned Sand - Hydraulic)	✓	✓	✓	✓	-
Downstream Fill (Cycloned Sand - Mechanical)	✓	-	-	-	✓
Abutment Preparation (incl. key-in of core zone)	✓	-	-	-	✓
Foundation Preparation	-	-	-	-	✓
Blanket Drain	-	-	-	-	✓
Finger Drains	-	-	-	-	-

Notes:
1. Refer to Figure 18.

Table 3.3 Summary of 2019 Construction Activities at H-H Dam Area

Construction Activity	Dam Area			24 Mile Lake
	West Segment	Mid Segment	East Segment	
Glacial Till Core Raise	✓	✓	✓	-
Upstream Fill (Pit Waste)	✓	✓	✓	-
Downstream Fill (Sand and Gravel Filter)	✓	✓	✓	-
Downstream Fill (Random Fill) – by Contractor	-	-	✓	-
Downstream Fill (Random Fill) – by THVCP Mining Fleet	-	✓	-	✓
Abutment Preparation (incl. key-in of core zone)	Note 2	-	Note 3	-
Foundation Preparation	-	-	-	-
Random Fill Capping Layer – by THVCP Mining Fleet	-	-	-	✓

Notes:
1. Refer to Figure 19.
2. A core raise west of Sta. 0+741 was not required in 2019; therefore, no new abutment preparation was required.
3. The 2019 core raise at the East Abutment was keyed into temporary pipegrade fill and will require rework in the future.

3.3 Incidents

There were no incidents observed by KCB during 2019 which could have significantly compromised the integrity of either dam. There were some operational incidents which did not pose a risk to the integrity of either dam but did require some remedial activities or other follow up to resolve. THVCP completed an investigation of each incident listed below with input from other involved parties to identify the cause and what additional steps or changes are required to prevent repeat occurrences:

- (L-L Dam) Localized erosion of downstream slope caused by overflows from hydraulic placement cells:
  - During hydraulic S1/S2 placement, occasional drain washouts or breaches through the hydraulic placement cells led to localized, superficial erosion of the downstream dam shell similar to those that develop as a result of snowmelt-induced runoff. Such localized erosion features do not pose a risk to the overall safety of the dam. Each case is assessed in accordance with requirements identified in CM-2018-008-01 (KCB 2018e).
- (L-L Dam) Differential settlement of cycloned sand fill upstream of core zone caused by loose zones related to frozen ground or snow burial:
  - The cycloned sand in some of the hydraulic cell containment berms placed in late 2018 and early 2019, north of ~Sta. 2+400, (i.e. during coldest period of the year) did not meet density specification. The cause was related to buried snow and fill that was frozen prior to compaction.
  - KCB reviewed the non-compliant fill (KCB 2019e) and concluded that, if left in place, the non-compliant loose berm fill will not affect overall dam safety or compliance with design intent, whether at LOM (dam crest El. 1279 m) or beyond. THVCP decided to leave the fill in place.
  - To avoid reoccurrence, THVCP and KCB agreed that the Contractor should make improved efforts to ensure snow/frozen fill are not buried in the dam and increase frequency of quality control testing within the containment berms. In addition, the situation was reviewed with the Contractor team to raise awareness of the issue.
- (L-L Dam) Erosion of upstream cycloned sand fill by secondary cyclone overflow discharge:
  - In late May, discharge from secondary cyclone overflow pipe, which had not been extended fully to the intended discharge point, eroded a portion of the upstream fill zone near Sta. 2+200. The scour was approximately 10 m to 15 m wide, up to 11 m deep, offset 100 m upstream of the dam centerline. The scour occurred above the elevation of the tailings beach at the time and was in no way a risk to dam integrity. Following the event:
    - The area was shaped and rebuilt with hydraulically placed cycloned sand fill as per design.
    - THVCP held an investigation, and additional controls regarding spigot pipe installation, commissioning and monitoring were implemented to prevent re-occurrence.

- (L-L Dam) Crack and void below frozen upstream cycloned sand fill:
  - In early March, a depression was observed in the upstream cycloned sand fill zone near Sta. 2+400, approximately 114 m upstream of the centerline.
  - Investigations revealed the large crack/sinkhole feature was likely attributed to hydraulic placement water preferentially flowing through a small crack and subsequently opening up a void in the cycloned sand fill, likely in an area of frozen ground or buried snow. The features were a reflection of the conditions within the upstream tailings beach and not associated with any downstream movements.
  - The area was excavated for approximately 85 m to a depth of 0.6 m to 1.5 m, until the crack/any voids were no longer evident. The area was backfilled mechanically with cycloned sand fill.
- (H-H Dam) Cracks through sand and gravel filter material placed in the upstream fill zone:
  - In April, various surface cracks were observed by THVCP within the fill zone upstream of the core between Sta. 0+527 and Sta. 1+705. This type of cracking is commonly observed in this area and is related to differential settlement between fill placed on the compressible tailings beach, upstream of the core zone, and fill that is not.
  - The cracks were remediated by either reworking the upper up to 0.3 m of the area or excavating to the base of the crack as defined by survey and confirmed in the field and backfilling the excavation with compacted sand and gravel fill depending on the magnitude of the crack.

4 2019 WATER MANAGEMENT

4.1 Water Balance

THVCP manages and tracks the annual water balance for the Highland TSF, refer to Appendix III-A for additional information. Refer to Appendix IV for a review of 2019 climate data and comparison to average values. Table 4.1 is a summary of annual inflows and outflows, provided by THVCP. As a check, THVCP also calculated the difference in pond volume at the end of 2018 and 2019 using weekly pond elevations combined with a stage-storage curve (Table 4.2). The water balance model based on inflows and outflows estimated an increase in pond volume over 2019 (Table 4.1); however, the measured estimates indicate a decrease over 2019 (Table 4.2).The discrepancy between modelled and measured values is attributed to the challenges associated with modelling a complicated system which is influenced by multiple variables. Overall, the difference in pond volumes are less than 3% of total inflows which is reasonably accurate for this type of model. THVCP considers the water balance model to be performing well and is adequate to allow them to proactively manage and plan; KCB agrees with this assessment.

Table 4.1 Annual Water Balance for Highland TSF – Model Estimates

Item	2019 Volume (Mm^3)
Inflows	
Runoff[1]	10.2
Consolidation water	2.4
Water in tailings through H-H	80.3
Groundwater	0.6
Seepage Pond Collection	4.1
Spatsum	0.0
Total inflow:	*97.6*
Outflows	
Evaporation[2]	5.9
Seepage to Pukaist Creek	0.8
Entrainment	13.9
Construction Losses	7.9
Reclaim to Highland Mill	67.7
Total outflow:	*96.2*
Balance	
Water gained in impoundment over the calendar year (inflows - outflows)	*1.4*

Notes:
1. Adjusted precipitation values from Shula Flats weather station used in water balance model, except for June and July when LL Weather Station data was used due to data quality issues at Shula Flats station.
2. Evaporation at the Highland TSF was assumed to be 570 mm/year.

Table 4.2 Change in Pond Volume During 2019 for Highland TSF

	Volume (Mm^3)
Pond volume on Jan 3, 2019	18.9
Pond volume on Jan 3, 2020	17.6
Change in pond volume (2020 minus 2019) - Measured	-1.3
Change in pond volume – Modelled	+1.4

Note:
1. The discrepancy between modeled and measured volume changes is associated with modelling of a complex system, including challenges of modeling over the calendar year rather than the hydrological year.

4.2 Flood Management

The summary of flood management structures and the applicable design criteria and details for the seven facilities are given in Table 4.3 below, with the following points noted:

- The containment structures, except the SWRP and Seepage Pond 2, are able to route or store, with appropriate freeboard, storm events greater than or equal to the inflow design flood (IDF) required by the Code and recommended by CDA (2013).
- The SWRP relies on pumping to maintain water levels year-round, and in its current state, has insufficient capacity to store or route the IDF (KCB 2019a). If the IDF were to occur, water from the SWRP would flood the adjacent area, mainly Slimes Pond 1, potentially impacting THVCP operations but the downstream Laura Lake public road (~El. 1108 m) would prevent an offsite discharge. Design of a replacement pond for SWRP was completed in 2018, referred to as Seepage Pond 4, with increased flood storage capacity. Seepage Pond 4 was included in the 2018 permit amendment (KCB 2018c) and, pending approval, is scheduled to be constructed and commissioned by the end of 2021.
- In its current state, Seepage Pond 2 does not meet the minimum freeboard requirement (0.5 m) during the IDF (KCB 2019a) due to the outlet pipe having a high point and not a constant downward slope. In 2016, KCB recommended THVCP commission works to lower the outlet pipe intake and re-grade the pipe:
  - This work was scheduled to be completed in 2019 but has been delayed to 2020. The delay is attributed to dredging the slimes from 2018 construction out of the pond in early 2019 and not receiving archeological clearances for the work until December 2019.
- No overtopping concern is present at the H-H Dam because the crest is higher than the L-L Dam crest (typically ~14 m) and the tailings beach slopes away from the dam.
- Flood routing for 24 Mile Lake was reviewed during 2019 as part of the dam buttress and waste dump planning. Assuming the minimum IDF required under the Code the inflow volume to be stored is ~3.2 Mm^3 (KCB 2019f). This volume can be stored within the existing configuration of 24 Mile Lake and a review is ongoing to confirm this will be met throughout mine life.

Table 4.3 Inflow Design Flood Requirements for Highland Facility

Facility	Outfall Type	Consequence Classification	Inflow Design Flood	Design Event (Precipitation Depth, Design Flow/Volume)	IDF stored or routed?	Reference
L-L Dam	None	Extreme	PMF[1]	5-day PMF (448 mm [2], 50.3 Mm^3)	Stored	(KCB 2019c)
H-H Dam	None	Very high	Refer to Note 3	-	-	-
Seepage Pond 2	Pipe	Significant	Between 100-year and 1000-year [4]	100-year 24-hour (75.5 mm, 1.9 m^3/s)	Routed [5] (to SWRP)	(KCB 2019a)
Slimes Pond 2	Pipe	Significant	Between 100-year and 1000-year [4]	100-year 24-hour (75.5 mm, 0.2 m^3/s)	Routed (to SWRP)	(KCB 2019a)
Seepage Water Reclaim Pond	Pump	Significant	Between 100-year and 1000-year [4]	100-year 24-hour (75.5 mm, 0.43 Mm^3)	Routed (Pumped to TSF)	(KCB 2019a)
24 Mile Lake	None	Low	1/3rd between 1000-year and PMF [1]	1/3rd between 1000-year and PMF (265 mm, 3.2 Mm^3)	Stored	(KCB 2019f)

Notes:
1. Per the Code (MEM 2017) for tailings dams.
2. Includes 415 mm snowmelt from the Probable Maximum Snow Accumulation (PMSA) plus 33 mm of the 100-year spring rainfall event.
3. No overtopping concern is present at the H-H Dam.
4. Per the Code (MEM 2016) for water dams.
5. Seepage Pond 2 does not have sufficient capacity to route the IDF in its current state, refer to discussion in Section 4.2.
6. Seepage Pond 2 and Slimes Pond 2 IDFs are routed to the SWRP.

4.3 Freeboard

Where available, the minimum freeboard[2] measured during 2019 based on either the DSI site visit observations and/or the latest survey, are estimated in Table 4.4. All facilities meet freeboard requirements during the respective IDFs, except for:

- SWRP is projected to be overtopped during the IDF and therefore does not meet minimum freeboard requirements around the perimeter embankment but would not result in offsite discharge, as discussed in Section 4.2, and freeboard between the peak flood level and the Laura Lake public road is greater than minimum required.
- Seepage Pond 2 – as discussed in Section 4.2.

Table 4.4 Freeboard Summary for Ponds with Regular Pond Level Monitoring

Dam	Required Minimum Flood Freeboard[1] (m)	Minimum Available Freeboard[1] in 2019 (m)	Survey Monitoring (Survey/Visual)
L-L Dam	2.0	9.9	Survey
Seepage Water Reclaim Pond	0.5	1.5	Survey
Seepage Pond 2 [2]	0.5	1.1	Visual
Slimes Pond 2	0.5	1.2	Visual
24 Mile Lake	0.5	9.7	Survey

Notes:
1. Vertical distance between peak pond level during the IDF and low point of crest to accommodate wave runup and setup per CDA (2013).
2. Seepage Pond 2 does not have sufficient capacity to route the IDF in its current state, refer to discussion in Section 4.2.

[2] The vertical distance between the pond level and the low point of the dam crest.

5 2019 DAM SURVEILLANCE SUMMARY

5.1 Surveillance Plan

During 2019, THVCP reviewed the Highland TSF Operation, Maintenance and Surveillance (OMS) Manual (THVCP 2018) and made minor updates, primarily to update organizational charts and contact details. These revisions were provided to KCB for review. The current OMS manual meets the intent of the Mining Association of Canada (MAC 2011) and CDA (2014) guidelines and provides adequate coverage for existing conditions.

The dam surveillance program defined in the OMS Manual (THVCP 2020a) is based on a "plan-do-check-act" framework to foster continual review and improvement. The main components of the program, including a summary of the related activities in 2019 are listed below:

- Performance objectives and indicators to identify deviation from normal or expected behaviour:
  - instrumentation thresholds, quantitative performance objectives (QPO) (e.g. freeboard) and qualitative indicators (e.g. observations of turbid water, cracking).
- Notification and response procedures based around Trigger-Action-Response-Plans (TARP):
  - The Highland TSF TARP contains three basic levels of thresholds and threshold responses: Notification, Unusual Condition, and Emergency.
  - Notification Level thresholds are in place to identify where the dam is actively experiencing a response to loading and/or operations. Exceedance of such threshold does not represent a dam safety concern. Reviews of these exceedances are tracked and documented but are not discussed within this DSI. Refer to Section 5.4 and 5.5 for general discussion of 2019 instrumentation response at each dam.
- Routine monitoring activities include:
  - Visual inspections (Section 5.2);
  - THVCP weekly dam performance review meetings (Section 5.3);
  - EoR instrumentation reviews (Section 5.3); and
  - Instrumentation and QPO monitoring (Sections 5.4 and 5.5).
- Event-driven monitoring activities: could be any of the routine monitoring activities which are initiated in response to a defined event (e.g. large storm, earthquake) or by the TARP, as specified in the OMS Manual.
- Review by parties who are independent of THVCP and the EoR to confirm facilities are being operating as designed:
  - Four meetings with HVC Tailings Review Board.

Over the past 3 years, the density of instruments and frequency of measurements have been increased at the L-L Dam and H-H Dam. Table 5.1 and Table 5.2 summarize the instruments installed within or near the L-L Dam and H-H Dam at the end of 2019. Of note, THVCP continued their program to convert existing manually read instruments to automated data collection integrated with the real-time monitoring system. In 2019, at the L-L Dam, 46 of the manually read standpipes were converted to vibrating wire piezometers (VWPs) and 15 inclinometers were converted to either ShapeArrays (SAAV) (14) and In-Place-Inclinometers (IPI) (x1). In total 147 of the 234 geotechnical instruments at the L-L Dam and 29 of the 51 geotechnical instruments at the H-H Dam are integrated with the real-time monitoring system.

The current suite of instruments installed at both dams are adequate to monitor dam performance of the existing structure. Going forward, KCB recommend four additional inclinometers be installed at the NBB (north of I17-24, I17-22, I15-25 and I19-08) to increase monitoring coverage to capture 3D behaviour and provide redundancy under future loading.

Table 5.1 Summary of Functional Instrumentation Installed at L-L Dam (November 2019)

Instrument	Type	Reading (1)	No.	Total
Piezometers	Standpipe	Manual	66	203
	Transducer (Converted Standpipe)	Automated	46	
	Vibrating Wire	Automated	91	
Inclinometers	Down-hole Casing	Manual	17 (3)	35
	In-Place Inclinometer (IPI) (2)	Automated	3	
	ShapeArray (SAAV)	Automated	15	
Seepage Weir	-	Manual	3	3

Notes:
1. Automated readings are transmitted through the remote monitoring system to increase data capture and summarize instrumentation.
2. IPIs are installed in down-hole casing inclinometers over a discrete elevation range which is defined by the EoR to target critical units.
3. Includes currently damaged inclinometers (I10-5, I10-6 and I15-24) which THVCP are planning to repair or potentially replace in 2020.

Table 5.2 Summary of Functional Instrumentation Installed at H-H Dam (November 2019)

Instrument	Type	Reading (1)	No.	Total
Piezometers	Standpipe	Manual	10	38
	Vibrating Wire	Automated	28	
Inclinometers	Down-hole Casing	Manual	7	8
	ShapeArray (SAAV) (2)	Automated	1	
Settlement	Sondex (3)	Manual	5	5

Notes:
1. Automated readings are transmitted through the remote monitoring system to increase data capture and summarize instrumentation.
2. A 90 m SAA array is installed in the lower portion of a 103 m drill hole (HHSAA12-1).
3. Sondex settlement monitoring systems were installed at the HH17 series inclinometers. HH17-16A was damaged and could not be recovered during 2018 construction.

5.2 Visual Inspections

The Highland TSF surveillance program includes the following visual inspections:

- Frequency of routine visual inspection by THVCP and KCB are summarized in Table 5.3. Inspections during 2019 were completed at the prescribed frequencies during periods of the year when dams are accessible. The site visit for the 2019 DSI, June 2019, constitutes one of the quarterly inspections.
- Event-driven – completed by THVCP staff in response to unusual conditions and the threshold exceedances listed below. No such inspections were triggered during 2019:
  - Triggers for event-driven inspections, as defined in the OMS Manual, are as follows:
    - rainfall event greater than the 10-year, 24-hour storm;
    - earthquake greater than magnitude 5 within 100 km of the site; and
    - non-compliance with specified QPOs, as defined in the OMS, or at the discretion of the TSF Qualified Person, EoR or approved designate, based on QPOs, qualitative indicators, or other surveillance observations.
- Annual DSI (this report) – completed by the EoR to comply with Section 10.5.3 of the Code and submitted to EMPR.

Table 5.3 Routine Visual Inspection Frequency

Dam	Inspection by THVCP	Inspection by KCB (EoR or Approved Designate)
L-L Dam	Weekly	Quarterly
H-H Dam	Weekly	Quarterly
24 Mile Lake	Quarterly	Quarterly
L-L Dam Seepage Pond 2	Monthly	Quarterly
L-L Dam Slimes Pond 1	Monthly	Quarterly
L-L Dam Slimes Pond 2	Monthly	Quarterly
L-L Dam Seepage Water Reclaim Pond	Monthly	Quarterly

5.3 Routine Monitoring Reviews

In addition to reviews initiated by a TARP or event, routine reviews of surveillance information are undertaken:

- Weekly dam performance review meetings by THVCP dam safety team. Following the meeting, presentation slides from the meeting are sent to and reviewed by the EoR or approved designate.

- Monthly reviews of instrumentation monitoring by EoR or approved designate. THVCP submits summaries of processed L-L Dam and H-H Dam instrumentation data to KCB. KCB documents the review in a Routine Monitoring Review (RMR) memo which typically includes: status of outstanding instrument exceedances; construction activity; comments on general trends or responses observed within the dam; changes to instrumentation (e.g. thresholds, repairs/replacement, operational status); identification of potential improvements; and register of actions or recommendations related to instrumentation and monitoring.

5.4 L-L Dam Performance Summary

5.4.1 Reservoir Level and Beach Width

The Highland TSF pond elevation was measured weekly (minimum) during 2019 in compliance with the OMS Manual (THVCP 2018). Figure 5.1 plots measured pond elevations over the past 5 years including 2019. Figure 5.2 plots 2019 pond elevations and volumes, estimated based on the most recent bathymetry survey. During 2019, the pond elevation rose 1.7 m which is less than the annual rise in 2018 (3.8 m) which was larger than average due to additional water being pumped into the impoundment as part of the Lornex dewatering project. The water balance forecasts a 1.4 m rise in pond level during 2020 (~El. 1254 m).

Figure 5.1 Highland TSF Tailings Pond Elevations: 2015 to 2019

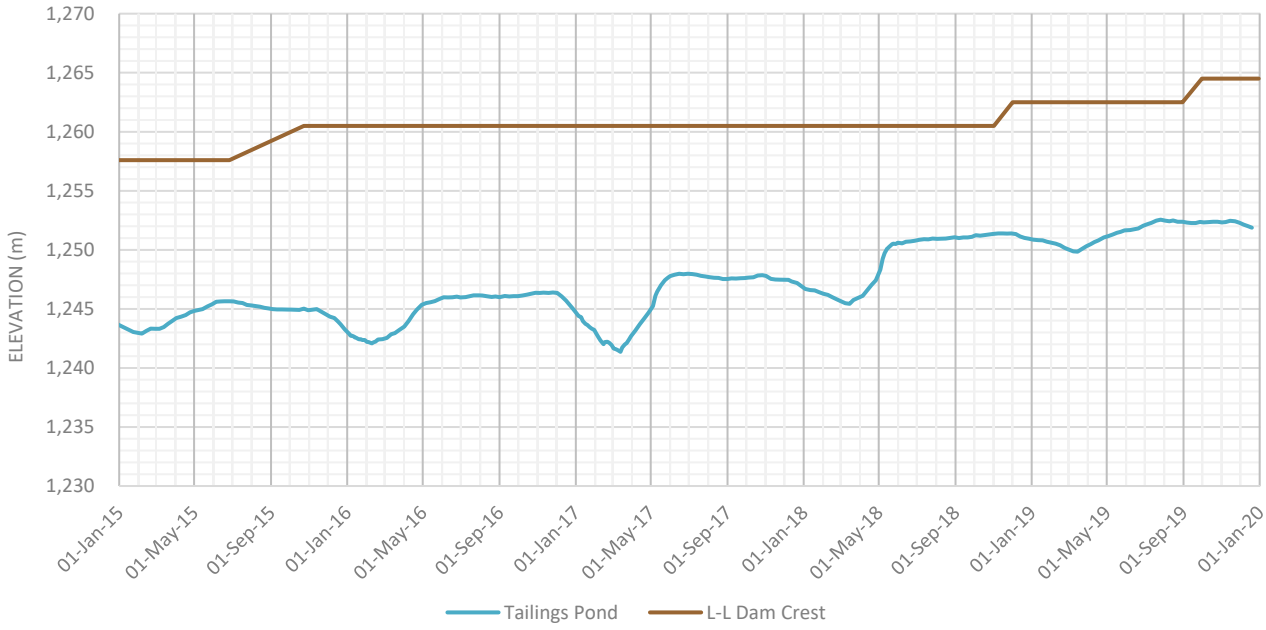
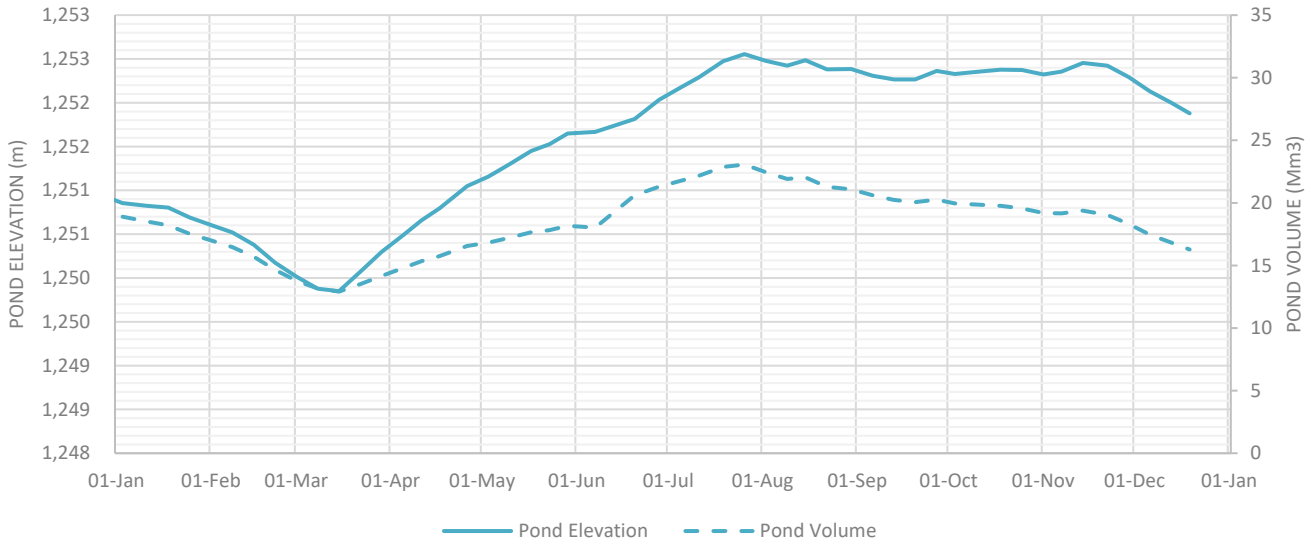


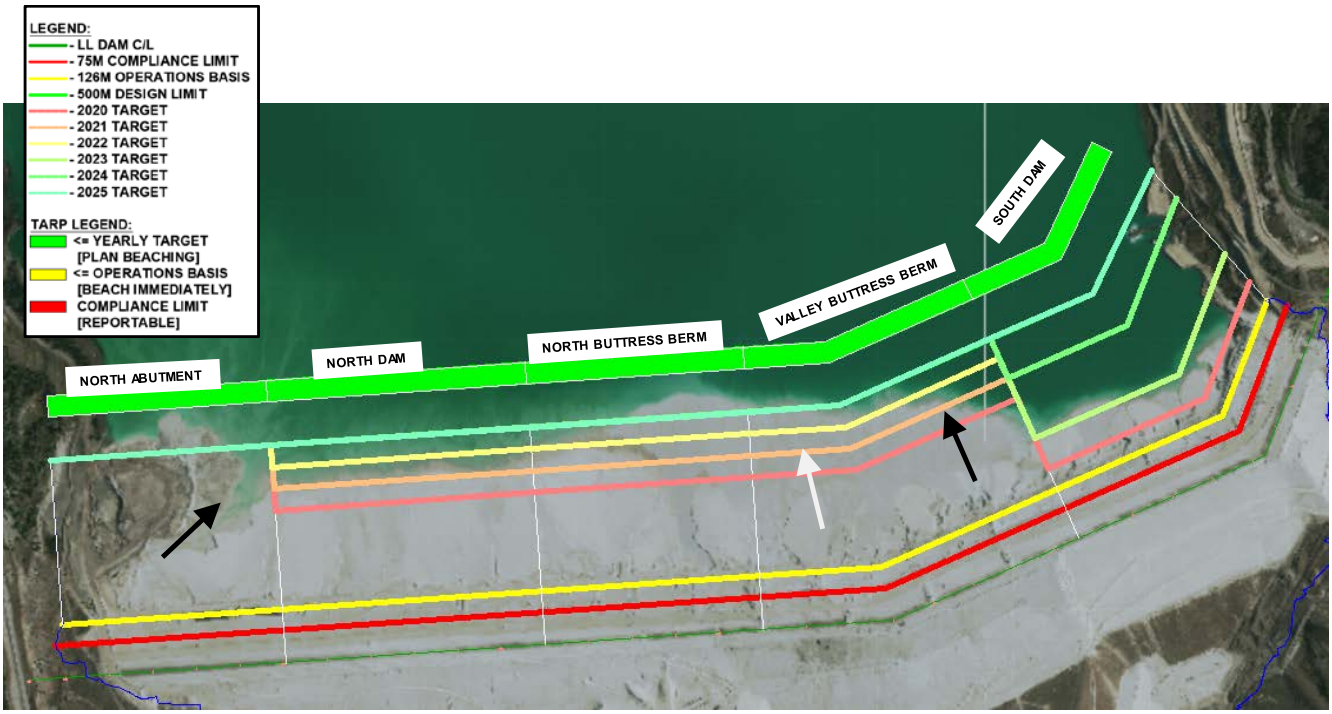
Figure 5.2 2019 Highland TSF Tailings Pond Elevations and Estimated Pond Volumes



A minimum beach width of 500 m at the North Abutment was added as a design requirement in 2019, as discussed in Section 7.4.2. During 2019, the 500 m beach width was maintained by a combination of spigotted tailings and the waste dump for foundation preparation spoils and overflow slimes from hydraulic placement, as shown on Figure 5.3.

In addition, THVCP have initiated a multi-year project to increase beach width along the length of the dam crest as a risk reduction activity. As part of this project, THVCP have set interim beach width targets. Routine monitoring of beach width at the North Abutment will be included in the 2020 OMS Manual: quarterly aerial images, and marker in the field to visually confirm 500 m beach width.

Figure 5.3 Status of L-L Dam Beach as of September 2019 and Future Beaching Plan



5.4.2 Instrumentation Trends

Piezometric and displacement behaviour based on instrumentation at segment of the L-L Dam is summarized herein. As mentioned in Section 5.1, Notification Level thresholds are not discussed herein, as they do not represent a dam safety concern and are used as a screening tool by KCB and THVCP teams. November 2019 instrumentation readings are shown on select design cross sections, through each dam segment, of the L-L Dam (Figure 6 to Figure 12). Refer to Appendix V-A for additional discussion regarding instrumentation measurements at the L-L Dam. Instrumentation summary plots are included in Appendix V-B (piezometers) and V-C (inclinometers).

5.4.2.1 South Dam

Instrumentation readings along Sta. 1+200 are shown on Figure 12. Instrumentation response during 2019 at the South Dam did not indicate any issues of concern or significant deviation from design assumptions. As shown on Figure 18, construction activity in the South Dam area during 2019 was restricted to crest raise and foundation preparation at the downstream toe. Observations based on instrumentation of note are discussed in the main text, refer to Appendix V-A for general discussion.

Piezometers

Piezometers installed within the dam footprint downstream of the core zone (e.g. VWP17-03A, VWP17-03B and VWP17-03C), near Sta. 1+050, showed a general rising trend during 2019. There was no hydraulic placement in the area during this period and the response pattern is generally consistent with pond level, albeit delayed. This is an expected response to rising pond level and not of concern.

Inclinometers

There are two inclinometers installed at the South Dam: I10-8 (~Sta. 1+200); and I10-1 (~Sta. 1+500). No observation of note related to dam safety was observed during 2019. Both instruments were converted to ShapeArray (SAAV) in late 2019.

5.4.2.2 Valley Buttress Berm

Instrumentation readings along Sta. 1+850 are shown on Figure 11. Instrumentation response during 2019 at the VBB was consistent with expectations and within design assumptions. As shown on Figure 18, construction activity in the VBB area during 2019 included a crest raise, and hydraulic fill placement at the downstream toe and upper slope. Observations based on instrumentation of note are discussed in the main text, refer to Appendix V-A for general discussion.

Piezometers

During 2019, measured piezometric levels within the Lower-Glaciolacustrine (L-GLU), which is the unit that governs stability, increased in response to construction loading, as expected, but at a rate well below assumptions in design analyses (~1/3rd of design value).

2019 piezometric levels within the Lower Sand and Gravel were relatively static with no significant response to pond level rise which was consistent with previous observations.

The piezometric response in the VBB Dam Fill primarily reflects the accumulation of seepage from all segments in the downstream shell flowing towards and collecting in the area of the VBB, which is the low point of the natural valley. During 2019, piezometric levels in the Dam Fill zone rose 2.8 m to 3.0 m. 2019 piezometric levels and response are consistent with previous behaviour during similar downstream hydraulic construction activities (e.g. 2007 to 2009 and 2018).

Starting in November 2019 (after completion of hydraulic sand placement) piezometric levels in the VBB Dam Fill began to dissipate, up to 0.2 m at some locations by the end of December 2019. With no hydraulic placement in the downstream shell planned until ~April 2020, dissipation is expected to continue. This is the first opportunity to monitor drain down in this area of the dam with near-continuous instrument readings over a relatively prolonged period.

Inclinometers

There are 12 inclinometers installed at the VBB, 10 functional at the end of 2019, refer to Table 5.4. The primary function of the instruments is to monitor deformation within the L-GLU to support implementation of the Observational Method as described in KCB (2018d). For redundancy, the instruments are roughly split along two parallel instrumentation lines perpendicular to the crest. General IDs were assigned to identify the location along the downstream slope that each inclinometer is installed (Figure 5.4).

Figure 5.4 VBB Inclinometer Location ID

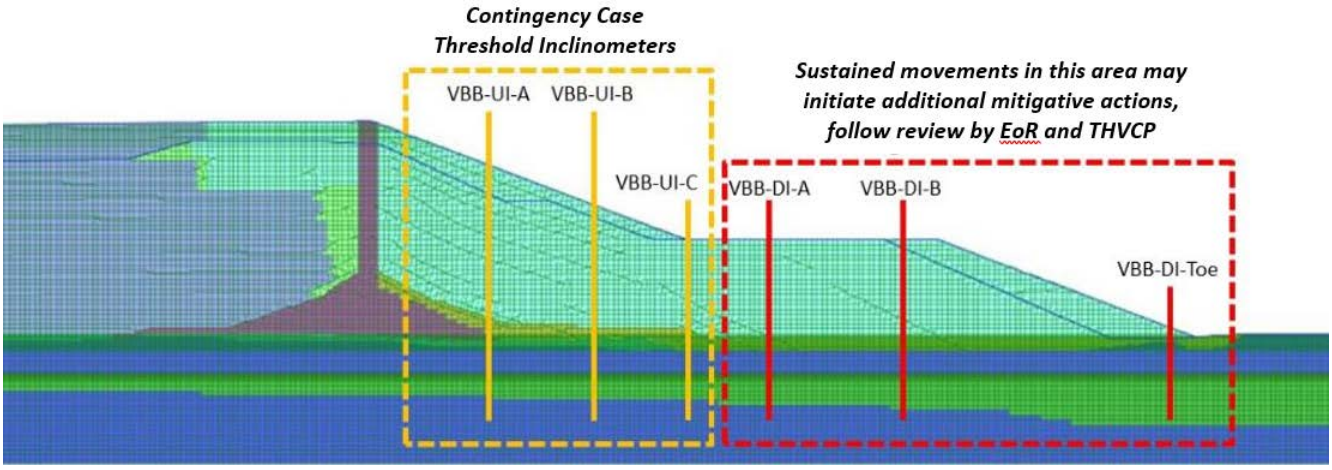


Table 5.4 VBB Inclinometers and Assigned Location ID

Location ID	Inclinometers North of ~Sta. 2+000	Inclinometers ~Sta. 1+910	Inclinometers ~Sta. 1+850
VBB-UI-A	I17-01	-	I17-06
VBB-UI-B	I10-6 (damaged)	LLSAA12-1	I10-7
VBB-UI-C	-	-	I17-02
VBB-DI-A	I17-19	-	I17-09
VBB-DI-B	I17-10	-	I15-24 (damaged)
VBB-DI-Toe	I17-11	-	I15-27

Two of the inclinometers in the lower portion of the slope were damaged and became inoperable towards the end of July 2019. THVCP is to attempt to repair or to potentially replace, if unsuccessful during 2020. As both have redundant instruments, monitoring of this area was continued throughout 2019. Readings at nearby instruments (upstream, adjacent and downstream) do not support that the instruments were damaged as a result of a mass movement of the dam. Similar to I10-5 at VBBE (see Section 5.4.2.3), the location of the damage for I10-6 was within the 2019 active hydraulic sand placement area (El. 1189 m) and is approximately at the elevation of the cycloned sand fill surface prior to 2019 construction.

Zones of movement in response to construction, primarily in the Lacustrine and L-GLU, were consistent with expectations and within design limits.

5.4.2.3 Valley Buttress Berm Extension

Instrumentation readings along Sta. 2+250 are shown on Figure 10. Instrumentation response during 2019 at the VBBE was consistent with expectations and within design assumptions. As shown on Figure 18, construction activity in the VBBE area during 2019 included a crest raise, hydraulic fill placement at the downstream upper slope, and operation of the temporary on-dam slimes cell. Observations based on instrumentation of note are discussed in the main text, refer to Appendix V-A for general discussion.

Piezometers

Between June and August 2019, the influence of hydraulic fill placement at the VBBE could be observed in piezometric levels. By October 2019, the piezometric levels had dissipated to pre-construction levels.

Inclinometers

There are four inclinometers installed at the VBBE: I10-5 (~Sta. 2+350); I10-11 (~Sta. 2+225); I17-7 (~Sta. 2+150); and I17-8 (~Sta. 2+125).

During July 2019, the inclinometer casing at I10-5 was sheared at approx. El. 1188 m (confirmed by THVCP via downhole camera inspection), which is within the cycloned sand fill, ~45 m above natural ground contact. The location of the break is approximately the elevation of the cycloned sand fill surface prior to 2019 construction. KCB reviewed and concluded that there are no observations or analyses which indicate the casing breakage at I10-5 is related in any way to the downstream progression of movement along mudstone layers (~El. 1116 m and 1156 m) at the nearby I17-24 (NBB Sta. 2+575). THVCP is in the process of attempting a repair; however, if unsuccessful a replacement is planned for early 2020.

5.4.2.4 North Buttress Berm

Instrumentation readings along Sta. 2+564 are shown on Figure 9. Instrumentation response during 2019 at the NBB was consistent with expectations and within design assumptions. As shown on Figure 18, construction activity in the NBB area during 2019 included a crest raise and operation of the temporary on-dam slimes cell. Observations based on instrumentation of note are discussed in the main text, refer to Appendix V-A for general discussion.

Piezometers

There were no piezometric responses of concern at the NBB during 2019, with readings remaining relatively constant throughout the year with no significant influence from rising pond level.

Inclinometers

There are five inclinometers installed in the NBB dam segment: I10-12 (~Sta. 2+450, dam toe); I15-25 (~Sta. 2+500, mid bench); I17-22 (~Sta. 2+550, mid bench); I17-24 (~Sta. 2+600, upper bench); and I19-08 (~Sta. 2+600, lower bench).

Movement along mudstone layers near the crest and upper bench (e.g. I17-24) have been measured since the early 1990's and are expected to continue with increased movement rates in response to loading. Movement rates are expected to attenuate after loading is completed. General observations and trends based on 2019 inclinometer readings are:

- As expected, movements were measured at I17-24 along the historic shear zones (~El. 1156 m and El. 1116 m). Rates increased in response to fill placement at the crest or in the adjacent VBBE and were consistent with previous observations. Following construction placement, movement rates started to attenuate.

- No similar shear movements were measured at inclinometers downstream of I17-24, the nearest being I17-22 which is 170 m downstream.

5.4.2.5 North Dam

Instrumentation readings along Sta. 2+800, 3+300 and 3+630 are shown on Figure 6 to Figure 8. Instrumentation response during 2019 at the North Dam was consistent with expectations and within design assumptions. As shown on Figure 18, construction activity in the North Dam area during 2019 included a crest raise and mechanical placement of cycloned sand. Observations based on instrumentation of note are discussed in the main text, refer to Appendix V-A for general discussion.

Piezometers

During 2019, piezometric response and trends were consistent with expected behaviour foundation. Piezometric levels typically rose ~1.5 m, up to 3.7 m. The rate of rise is greatest in piezometers upstream of the core zone (e.g. VWP16-03B) and progressively attenuates in the downstream direction, as would be expected. The majority of the rise during 2019 occurred starting in November 2019 which coincides with the timing when THVCP resumed beaching in the area. A similar response was observed during the previous period of extended beaching in the area (~November 2017 to February 2018).

Foundation piezometric conditions through the glacial overburden deposits at the North Dam differ from the rest of the dam as the foundation units generally indicate hydrostatic conditions (i.e similar piezometric elevation measured in each unit), rather than the presence of a strong downward gradient. This difference in behaviour at the North Dam is due to the dam core zone being keyed into the Upper Sand and Gravel Unit rather than Glacial Till or intact Bedrock, as discussed in Appendix III-A. A tailings beach is relied upon in the design to mitigate seepage and future pore pressure rise downstream of the dam core, as discussed in Section 7.4.2.

Inclinometers

There are twelve inclinometers installed at the North Dam area, refer to Appendix V-A. The North Dam segment was built to ultimate footprint along most of the dam toe in 2018. Four additional inclinometers were installed downstream of the ultimate toe to expand monitoring area beyond the dam toe. These were installed in early 2019 in response to the movements in late 2018 discussed below and so they would be in place prior to construction.

Discussion of the North Dam inclinometers is best separated into the sub-segments based on which critical foundation unit is present and governing design: North Dam Bedrock; and North Dam U-GLU:

- North Dam Bedrock (Sta. 2+800 to 3+300):
  - Movements observed in this segment of the dam during late 2018 in response to construction loading. Movement rates started to attenuate after fill placement was completed in December 2018 and levelled off in March/April of 2019. The response and attenuation related to 2018 construction is discussed in the 2018 DSI (KCB 2019b). No

significant response to 2019 construction activity, which was limited to a crest raise, was measured in this area.

- North Dam U-GLU (Sta. 3+300 to North Abutment):
  - Similar to the North Dam Bedrock segment, after attenuation of movement rates following 2018 construction, rates became relatively steady within the U-GLU throughout the remainder of 2019.

5.4.3 Seepage

Seepage measurements from weirs installed downstream of the L-L Dam, since 2013, are shown in Appendix V-D. In general, seepage rates were consistent with previous years. Spikes measured at LL-FS-04, near the VBBE toe, showed several spikes in flow which was not measured at other seepage weirs. The timing of these, and the timing of similar spikes measured in 2018 coincide with hydraulic fill placement periods which has been observed to temporarily increase seepage rates.

THVCP are developing a plan to replace and/or upgrade the seepage weirs installed downstream of the dam which was also a recommendation from the DSR (Appendix IX).

5.5 H-H Dam Performance Summary

5.5.1 Vertical Buffer Above Tailings Surface

There is no permanent pond at the H-H Dam and no risk of overtopping. Therefore, rather than freeboard, a minimum “buffer” is specified which refers to the vertical distance between the top of the upstream tailings surface and the dam crest. A minimum buffer of 1 m is to be maintained as per the 2019 revision of the M-11 Permit (EMPR 2019).

To monitor buffer in 2019, the top of beach and dam crest were surveyed weekly (minimum). The minimum buffer (1 m) was achieved along the dam crest throughout 2019. Buffer values from the December 2, 2019 survey, after the 2019 dam crest raise was completed, are shown on Figure 5.5.

Figure 5.6 shows tailings beach profile over the past 5 years at various stations along the H-H Dam crest. Note that the tailings beach has been relatively level since spigotting at the East Abutment was shifted 50 m further away from the dam in July 2019. As a result, tailings are deposited on the far side (relative to H-H Dam) of the existing tailings cone and therefore the bulk of the tailings slurry flows towards L-L Dam and not near the H-H Dam.

Figure 5.5 H-H Dam Tailings Buffer – December 2nd 2019 (after crest raise)

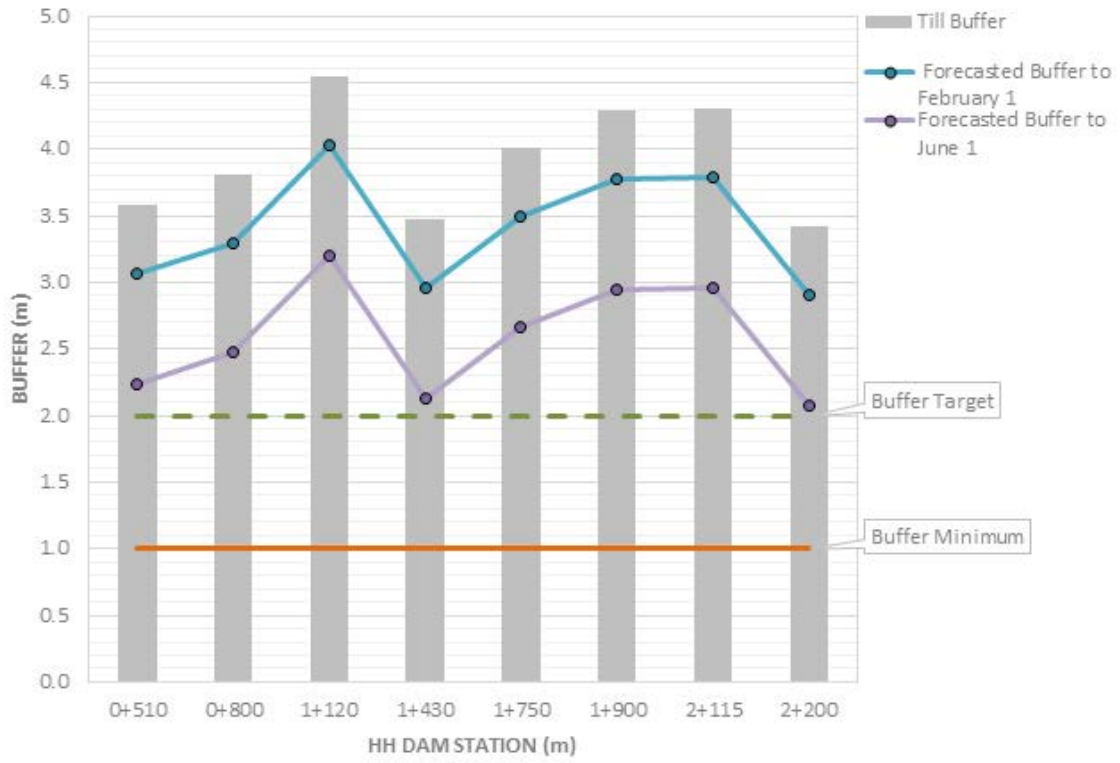
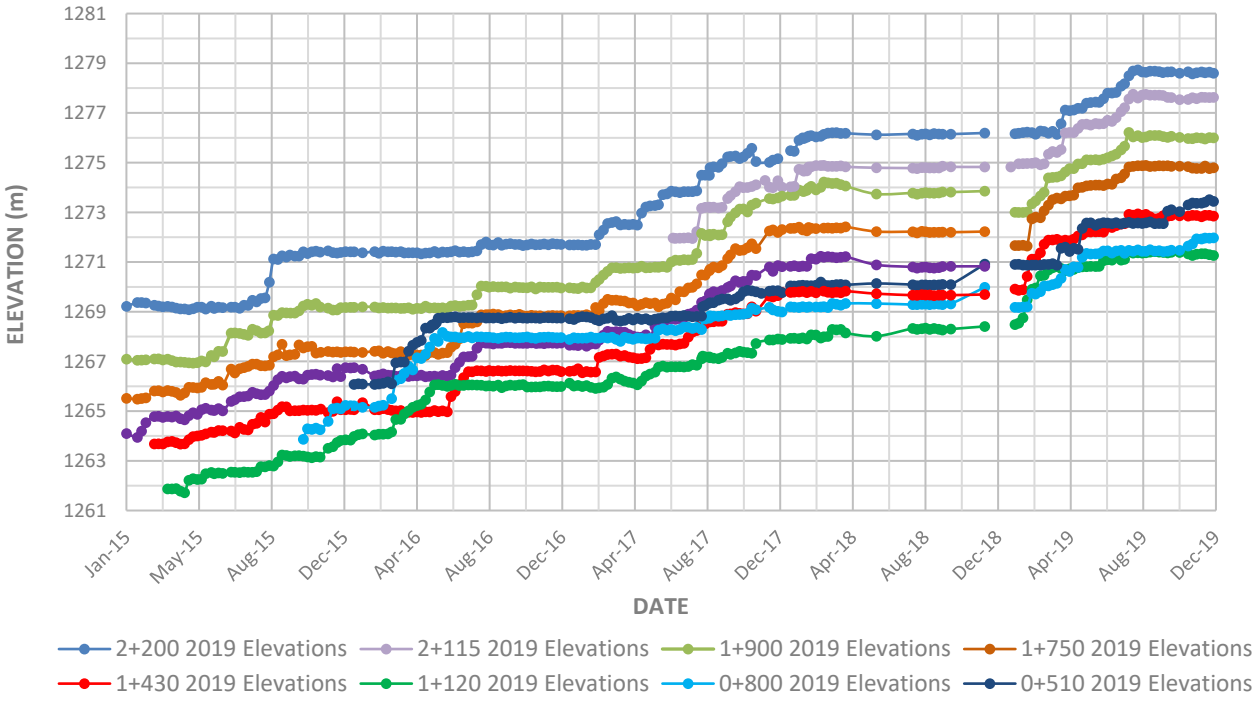


Figure 5.6 H-H Dam Tailings Beach Elevations Along Crest: 2015 to 2019



5.5.2 Instrumentation Trends

Piezometric and displacement behaviour based on instrumentation at each segment of the H-H Dam is summarized herein. As mentioned in Section 5.1, Notification Level thresholds are not discussed herein, as they do not represent a dam safety concern and are used as a screening tool by KCB and THVCP teams.

November 2019 instrumentation readings are shown on select design cross sections, through each dam segment, of the H-H Dam (Figure 13 to 17). Instrumentation summary plots are included in Appendix VI-A (piezometers) and Appendix VI-B (inclinometers).

Piezometers

Existing piezometric levels in this fill and foundation units are below design assumptions and there were no significant changes measured during 2019, other than those related to instruments continuing to equilibrate after installation.

Inclinometers and Settlement

There are 8 inclinometers and 5 Sondex settlement monitoring systems installed at the H-H Dam, refer to Table 5.5 and Figure 5. During 2019, the Sondex installed near HHSAA12-01 (~Sta. 1+280) was damaged and could not be salvaged. There remains sufficient coverage across the dam, such that the loss of this instrument does not compromise the surveillance program for the dam.

Table 5.5 Summary of Inclinometer/Sondex Installations at H-H Dam

Location	Inclinometer/Sondex					
	Sta. 1+200	Sta. 1+280	Sta. 1+460	Sta. 1+600	Sta. 1+700	Sta. 2+020
Near Core Zone	HHI17-33 / HHI17-33A	HHSAA12-01 / -	HHI15-23 / HHI17-33A	-	HHI17-16 / HHI17-16A	-
Crest of Fill Slope	-	-	-	HHI17-17 / HHI17-17A	-	-
Toe of Fill Slope	-	-	HHI17-31A / -	-	HHI17-30 / -	HHI17-14 / HHI17-14A

H-H Dam inclinometers in the dam fill have shown steady horizontal movement in the downstream Random Fill, which was placed by the mining fleet in thick lifts (up to 10 m). Since installation, settlement measured by the Sondex systems has supported the interpretation that the horizontal movements are associated with settlement of the fill. The locations of the largest settlement (HHI17-33A and HHI17-16A) correlates to the areas with the most horizontal movement. The same pattern of horizontal movement and settlement in the fill observed at the dam crest is not present at inclinometers along the toe.

Retaining Wall Survey Monuments

Ten survey monuments are installed on the lock-block wall at the toe of the H-H Dam, near the HH Pumphouse (~Sta. 2+025), and were monitored in 2019. All of the monuments show similar pattern of little to no movement, consistent with 2018 measurements.

5.6 Water Quality

Water quality downstream of the Highland TSF is monitored by THVCP. However, as per Permit PE-376, no water quality limits have been defined for this area. A summary of data to be included in the 2019 Annual Water Quality Monitoring Report was provided to KCB by THVCP for review as part of the DSI. Select observations and findings from the monitoring data are summarized as follows:

- There are six permitted surface water quality monitoring sites in the L-L Dam/Thompson Valley area, as shown on the site monitoring plan in Appendix VII. There are no surface monitoring points in the immediate area downstream of H-H Dam however there are two ground water wells sampled quarterly.
- All sampling sites were in compliance with the required sampling frequencies and parameters.
- Longer term trends in the receiving environment downstream of the L-L Dam indicate that Sulphate, Fe, Mn and Mo have been increasing over time, which may be attributed to seepage from the L-L Dam and unlined seepage collection ponds.

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

THVCP have implemented the Sulphate Adaptive Management Plan to mitigate influence of seepage from the Highland TSF on downstream water quality and increase water available to downstream users in Pukaist creek. This is a multi-year program which includes installation of interception wells downstream of the dam, lining of seepage collection ponds and diversion of non-contact water around the TSF and into Pukaist Creek.

6 2019 DSI SITE VISIT VISUAL OBSERVATIONS

The visual observations made during the DSI site visit and the selected photographs of each site are included in Appendix II. Copies of the completed field inspection forms are included in Appendix I. A summary of general observations and comments during 2019 DSI site visit is as follows:

L-L Dam

- No visual indications of a dam safety concern were observed.
- Active construction areas during the site visit included: hydraulic placement of cycloned sand in upper portion of VBBE downstream slope and VBB toe area; and mechanical sand placement along crest to support core raise.
- THVCP are in the process of a multi-year plan to maintain a wider beach between upstream cycloned sand fill and pond along the length of the dam crest. Evidence of these efforts are visible. Beach is widest at the north end of the dam and the combination of the tailings beach and spoils dump was achieving the minimum 500 m setback from the core zone where the pond is not to be in direct contact with the north slope.
- As expected, increased seepage from the toe of the VBB was observed due to the hydraulic placement in the local area. Piezometers were also showing elevated levels during this period. The seepage face from the sand and gravel drainage blanket was visible and along the base of the fill, just above the water level in Slimes Pond 1 and there was no seepage from the cycloned sand fill slope. Both observations support that there was not excessive build of seepage within the drain that was impacting hydraulic placement.
- Overflow slimes from hydraulic cycloned sand placement was being routed to the temporary on-dam cell at the VBBE or Slimes Pond 1.

H-H Dam

- No visual indications of a dam safety concern were observed.
- Active construction areas during the site visit included: THVCP mining fleet started placement of pipe grade bench downstream of dam toe.
- Tailings were being spigotted from the east abutment, approximately 300 m upstream of dam crest. Tailings slurry was flowing towards L-L Dam and not near H-H Dam.

7 2019 DAM SAFETY ASSESSMENT

7.1 Consequence Classification

The consequence classification of each of the dam included in the Highland TSF (as summarised in Table 2.1) is reviewed annually by THVCP and KCB's EoR designate representative, or approved designate, at the time. The scope of the review is to assess whether any changes identified, over the past year, with respect to the downstream environment or dam structure itself could potentially impact the existing consequence classification. The most recent review was performed on January 23, 2019, during which no changes in consequence classification were recommended.

7.2 Design Basis

An updated consolidated design basis memorandum for the L-L Dam and H-H Dam was prepared in 2019 as part of the 2019 design review (KCB 2019a). The updated design basis does not significantly change the core criteria or requirements from those of the currently approved life-of-mine designs (KCB 2010). Changes made were primarily to update applicable references to reflect current information and clarify design approach. No other changes to the design basis for L-L Dam or H-H Dam were implemented during 2019.

7.3 Status of 2017 Dam Safety Review Recommendations

The 2017 DSR was completed by representatives of Stantec Consulting Ltd. (Stantec) and issued in 2018 (Stantec 2018). No unsafe or unacceptable conditions were identified in relation to design, construction, surveillance, maintenance, and operation of the dams. Stantec concluded that the dams at the Highland TSF comply with the 19 dam safety principles from CDA (2013).

The DSR included 30 recommendations for consideration, none of them were in relation to a significant dam safety concern that required immediate follow up or action. In 2018, KCB and THVCP developed a work plan to address and close-out each of the recommendations. A summary status of the recommendations is as follows:

- Based on the work done to date, 28 of the recommendations have been closed, of which 17 were closed out in 2019, including the only recommendation that was assigned a Priority Level 2[3] which was related to sensitivity analysis of potential core cracking scenarios. The majority of the recommendations were closed out based on work reported in the 2019 design update report (KCB 2019a).
- Two recommendations are outstanding but plans to address them have been confirmed by THVCP and included in life-of-mine planning, where appropriate:
  - Include potential impacts on dam surveillance for a scenario where the site is not accessible due to fire (Priority Level 3):

[3] Based on EMPR (MEM 2016) priority levels, refer to notes for Table 8.1.

- During 2020, THVCP plan to include a “limited site access” scenario in the Tailings Management System which will cover impact to dam surveillance when the site is not accessible due to fire or some other event.

- Develop a plan to install seepage weirs by dam sector and that this should include the determination of thresholds for seepage flows (Priority Level 3):
  - Starting in 2017, the L-L Dam toe has been extended to the ultimate crest footprint, this is projected to be completed in 2021. SWRP is scheduled to be replaced in 2021 as well. At that time, new seepage monitoring points will be established along the ultimate toe. THVCP have included this sequence in the life-of-mine Highland TSF development plan. Once established, thresholds could be based to compare measured to modelled seepage rates.

A summary of the recommendation status and action take, or planned, to address each is included in Appendix IX. The Highland TSF Tailings Review Board (TRB) has been given periodic updates, twice in 2019, of progress made to address each recommendation and a summary of action(s) taken once each has been closed out.

7.4 Failure Modes

7.4.1 2019 Failure Mode Review

L-L Dam and H-H Dam failure modes were reviewed in 2019 as part of the design review (KCB 2019a) and summarized in Appendix VIII. The review focused on failure modes which could result in a large release of tailings/pond water downstream, potential triggers, existing controls and performance criteria. No significant changes to the failure modes or triggers were identified compared to the 2017 risk assessment, facilitated by a 3rd Party (Wood), which was based on the condition of the dams and controls at that time (Wood 2019a, 2019b).

At the conclusion of the 2019 design review (KCB 2019a), recommended actions from the 2017 risk assessment had been closed out and uncertainties related to key dam safety risks had been reduced and/or better defined (e.g. foundation geology, deformation modelling, 3D seepage groundwater model). In addition, some of the existing controls had been improved and/or new ones added as described in KCB (2019a).

7.4.2 L-L Dam

The status, at the end of 2019, of key L-L Dam failure modes that have the greatest influence on design or have been highlighted in previous reviews are summarized herein.

Overtopping

The Highland TSF is designed to contain the flood volume from the PMF (50.3 Mm^3) resulting from the average annual snowmelt runoff plus the 5-day PMP, which is a duration greater than required by the Code. For reference, the operating freeboard during 2019 ranged from 9.9 m to 12.6 m, which is greater than the 2019 flood routing freeboard limit of approximately 7.6 m (~5.6 m to store IDF + 2 m

of freeboard). At the end of 2019, the operating freeboard was 12.6 m based on a dam crest elevation of El. 1264.5 m and pond level of El. 1251.9 m. The current crest elevation is sufficient to store forecast 2020 tailings production in addition to flood storage and freeboard requirements.

Internal Erosion and Piping

There are no fill interfaces of concern to develop a continuous piping (i.e. internal erosion) failure of the L-L Dam and the gradients in the downstream shell are controlled by the upstream tailings beach, low permeability core and underdrainage system.

At the North Dam U-GLU, the glacial till core zone only provides a partial cutoff to seepage flow, since it terminates in the Upper Sand and Gravel Unit as key-in to the lower permeability Glacial Till, similar to the rest of the dam centreline, is not practical due to depth. To offset this and manage seepage flows and gradients through the foundation in this area, a minimum beach width (500 m) was added to the design criteria for the L-L Dam. The 500 m width is measured from the upstream edge of the core and is to separate the freewater pond from the natural slope within that 500 m offset. Throughout 2019 the beach width was achieved in part by spigotted tailings and in part by an excavation spoils dump consisting primarily of unsuitable foundation soils and hydraulic placement slimes (Section 5.4.1).

A decommissioned Low-Level Outlet (LLO) remains close to the South Abutment of the dam. The downstream outlet of the LLO was surrounded with filter compatible fills in 2015 as a design control to prevent piping (KCB 2014).

Slope Stability – Static and Seismic Loading

Based on the analysis reported in the 2019 design update (KCB 2019a), the 2019 configuration of the L-L Dam meets or exceeds relevant criteria (stability and deformation) under static and seismic loading conditions.

Compliance with slope stability criteria is checked prior to construction of each incremental crest raise, with consideration for construction related response (e.g. increased seepage through dam fill, pore pressure generation in compressible materials). All analyses are informed by a geologic/geotechnical characterization of the dam and foundation (KCB 2019a) which has been developed to meet requirements of the Engineers and Geoscientists of BC (EGBC) professional practice document (APEGBC 2016).

In the future, when the dam crest reaches El. 1269 m (forecast in 2021), modifications to the approved design of L-L Dam are required at the VBB (shallow downstream slope from 2H:1V to 2.5H:1V) and North Dam (additional buttress between Sta. 3+200 and 3+700) to meet structural stability criteria, under static loading. Under the life-of-mine development plan, the appropriate design modifications are planned for 2021 before the crest is raised to maintain compliance with FOS criteria. THVCP submitted a permit application for the modifications to EMPR in December 2018, which is pending approval. In order to continue with the planned crest raise and dam construction, THVCP requires permit approval by end of 2020.

7.4.3 H-H Dam

The status, at the end of 2019, of key H-H Dam failure modes that have the greatest influence of design or have been highlighted in previous reviews are summarized herein.

Internal Erosion and Piping

No sand and gravel filter separating the Glacial Till in the dam core from the coarse Random Fill (i.e. pit waste) is present between El. 1216.7 m and El. 1255.5 m (Figure 2.3). Above this elevation the existing sand and gravel zone was added to the design, as part of KCB (2010), and below this elevation, similar filter zones were included in the starter dam and early raises (Figure 2.3). Filter compatibility of core zone and Random Fill zone cannot be confirmed, and therefore, the potential that some internal erosion may have initiated along the fill interface cannot be ruled out.

Therefore, as part of the 2019 design review (KCB 2019a), KCB reviewed the potential for internal erosion to progress and develop into an issue of concern with respect to dam safety based on the method defined by ICOLD (2017). The review concluded that the existing controls (e.g. upstream tailings beach, setback from tailings pond, low seepage gradient) would be effective in restricting the progression of any internal erosion which may initiate along the interface in question. As a result, the risk of internal erosion leading to failure of the dam is considered very low.

Slope Stability – Static and Seismic Loading

Based on the analysis reported in the 2019 design update (KCB 2019a), the 2019 configuration of the H-H Dam meets or exceeds relevant criteria (stability and deformation) under static and seismic loading conditions.

Similar to the L-L Dam, compliance with slope stability criteria is checked prior to construction of each incremental crest raise, with consideration for construction related response in the foundation and dam fill. All analyses are informed by a geologic/geotechnical characterization of the dam and foundation (KCB 2019a) which has been developed to meet requirements of the Engineers and Geoscientists of BC (EGBC) professional practice document (APEGBC 2016).

Liquefaction assessments reported in KCB (2019a) show that both the tailings and portions of the downstream Random Fill zone are susceptible to liquefaction under seismic loading.

The condition of the H-H Dam downstream slope and waste dumps at the end of 2019 is adequate to maintain compliance with FOS criteria up to crest El. 1285 m (@Sta. 1+460) and additional downstream buttressing is required to meet post-earthquake criteria (i.e. assuming liquefaction of the liquefiable materials) before raising the dam further. The earliest crest raise forecast has El. 1285 m being reached in 2023; therefore, regulatory approval is required by 2022. THVCP are planning to submit a permit amendment to EMPR in 2020 to obtain approval for the downstream buttress.

7.5 Emergency Preparedness and Response

The OMS Manual (THVCP 2019) includes an emergency preparedness and response plan (EPRP) for the Highland TSF. This is linked to the site wide emergency response plan and includes a list of preventative measures which could be taken in response to various developing failure modes.

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

In the case of an emergency an incident command center would be established on site to coordinate with regional emergency response organizations and local authorities as part of THVCP's Site Wide Emergency Response Plan. The roles and responsibilities of key team members of the tailings team that would support this response are defined in the OMS Manual. THVCP's Emergency Reporting Procedure defines the reporting structures and who is responsible for declaring an emergency and starting the incident response.

Training and testing of the EPRP currently is done using desktop scenarios. Along with testing of the system, offsite emergency response resources are contacted regularly to ensure that contact information is still up to date. The emergency reporting contact list is also reviewed and updated as required. A tabletop exercise to review and update the Emergency Preparedness Response Plan for the HVC site was hosted by THVCP, which the current EoR participated, on November 26, 2019.

8 SUMMARY

The Highland TSF was visually in good physical condition, the observed performance and surveillance data from 2019 is within expected design conditions and consistent with past performance. The status of dam safety recommendations identified during past DSIs are summarized in Table 8.1. Closed recommendations are shown in *italics*. Dam safety recommendations identified during the 2019 DSI are summarized in Table 8.2. Outstanding recommendations with a Priority Level 2 are related to flood management of downstream surface collection ponds and action to address both has been included in the Highland TSF life-of-mine development plan.

Table 8.1 Status of Outstanding Recommendations for Deficiencies and Non-Conformances

ID No.	Recommended Action	Priority[(1)]	Recommended Deadline (Status)
L-L Dam			
LL-2015-06	*We recommend that key design criteria for the Highland TSF, including the probable maximum flood (PMF), freeboard requirements and seismic ground motions be reviewed during 2016.*	*4*	*Closed (Seismic hazard update completed in 2018. PMF update completed in 2019)*
LL-2016-02	*Install seepage measurement weirs at the outflow points of the North Dam (Sta. 3+600) and South Dam (Sta. 1+100) major drains to monitor seepage rates.*	*3*	*Closed (superseded by LL-2019-02, has be included in life-of-mine plan)*
LL-2018-01	Review, complete and/or provide written response to close out all 2017 DSR recommendations.	3	*Closed* (2 remaining recommendations captured by LL-2019-02 and LL-2019-03)
H-H Dam and 24 Mile Lake			
HH-2018-01	*Review, complete and/or provide written response to close out all 2017 DSR recommendations.*	*3*	*Closed (H-H Dam items closed)*
HH-2018-02	*Complete H-H Dam design review to confirm liquefaction susceptibility and dam stability under future loading conditions*	*2*	*Closed (Documented in 2019 design update)*
L-L Dam Seepage Collection and Slimes Ponds			
SP-2017-01	The Seepage Water Reclaim Pond has insufficient capacity to store the IDF and should be brought into compliance. Note: THVCP to include an interim plan involving pumping to manage the IDF without off-lease discharge until upgrade works are complete. Suggested interim milestones: Design in 2018, Permit and IFC in 2019 and Commissioned in 2021. *(Schedule updated in 2019)*	2	Open (EMPR Approval Pending, Construction scheduled to be completed in 2021)
SP-2017-02	Regrade Seepage Pond 2 outlet pipe to a consistent downward grade	2	Open (Delayed to 2020 due to late archeological clearance and dredging activities)
SP-2018-01	*If Slimes Pond 4 to remain as contingency slimes storage, include it in the 2019 OMS manual update.*	*3*	*Closed* (*THVCP to include in 2020 OMS Manual update*)

Notes:

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

Table 8.2 2019 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
L-L Dam					
LL-2019-01	Surveillance	-	Install 4 additional inclinometers at NBB (north of I17-24, I17-22, I15-25 and I19-08) to increase monitoring coverage to capture 3D behaviour and provide redundancy.	3	Q3 2021 (Multi-phase, initial installs starting in 2020)
LL-2019-02	Surveillance	DSR	Install new seepage weirs along downstream toe after SWRP has been replaced and L-L Dam constructed to ultimate toe (forecast 2021). (To resolve DSR recommendation LL-2017-06)	3	Q4 2021
LL-2019-03	Surveillance	DSR	Include potential impacts on dam surveillance for a scenario where the site is not accessible due to fire. (To resolve DSR recommendation TSF-2017-11)	3	Q4 2020
H-H Dam and 24 Mile Lake					
No new recommendations in 2019.					
L-L Dam Seepage Collection and Slimes Ponds					
No new recommendations in 2019.					

Notes:

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

9 CLOSING

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

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

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

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The Executive Summary is a selection of key elements of the report. It does not include details needed for the proper application of the findings and recommendations in the report.
3. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
4. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.
5. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

KLOHN CRIPPEN BERGER LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA L.B.G. CHIN

April 3, 2020

Bill Chin, P.Eng.
Engineer of Record, Approved Representative, Principal

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA R.J. FRIEDEL # 33293 2020/04/03

Rick Friedel, P.Eng., P.E.
Engineer of Record, Approved Designate, Principal

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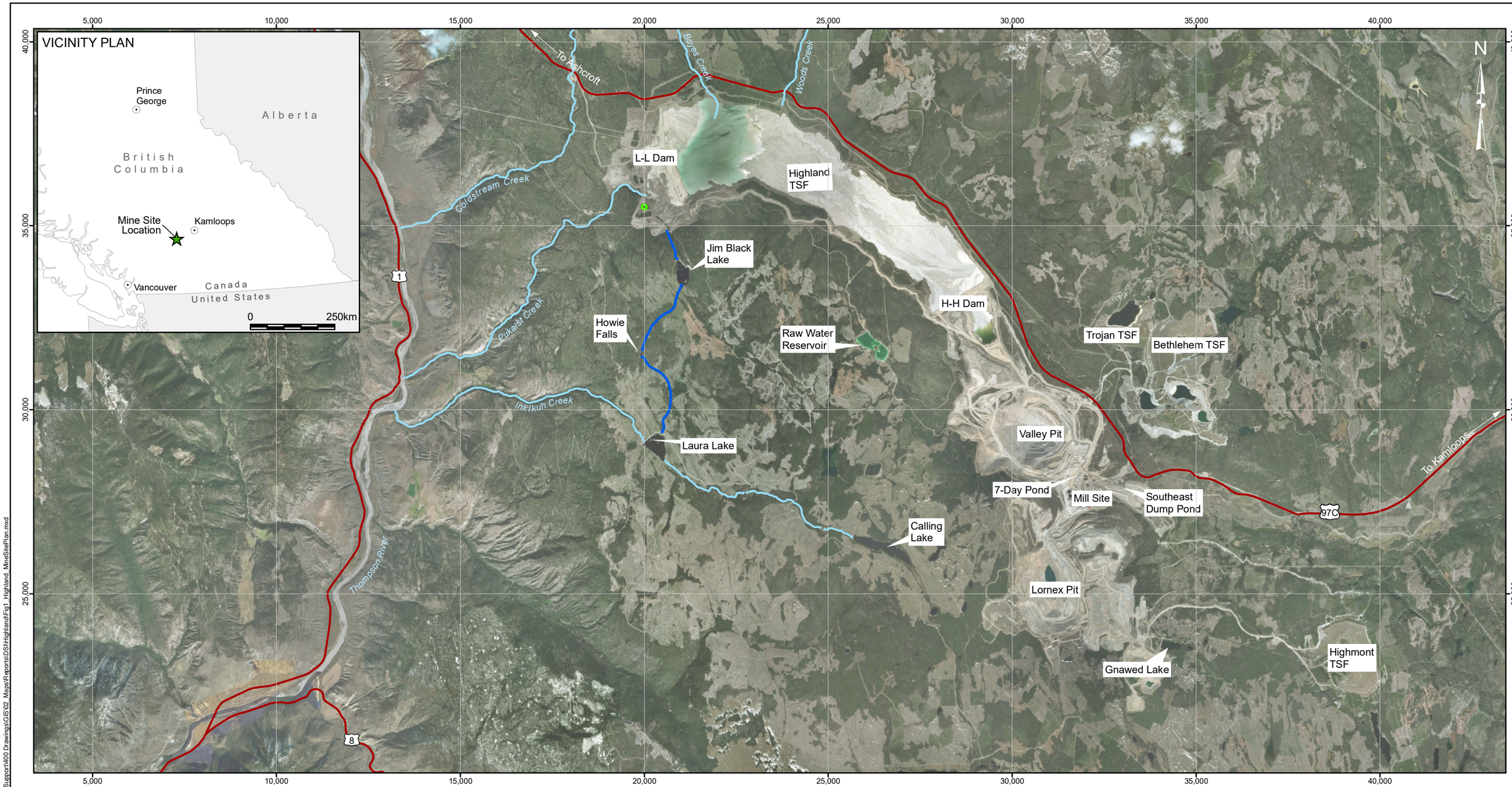
FIGURES



Legend

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

0 5km

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

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: MINE SITE PLAN

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

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Legend

- Waypoint (LL-2019-xx)
- Index Contour (25 m)
- Intermediate Contour (5 m)

0 500m

Notes:
1. Projection: HVC Mine Grid.
2. Topography from satellite photogrammetry survey conducted in September, 2019.
3. Imagery from September, 2019.

CLIENT: Highland Valley Copper / Teck	PROJECT: HIGHLAND TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION	
Klohn Crippen Berger	TITLE: L-L DAM SAFETY INSPECTION WAYPOINTS	
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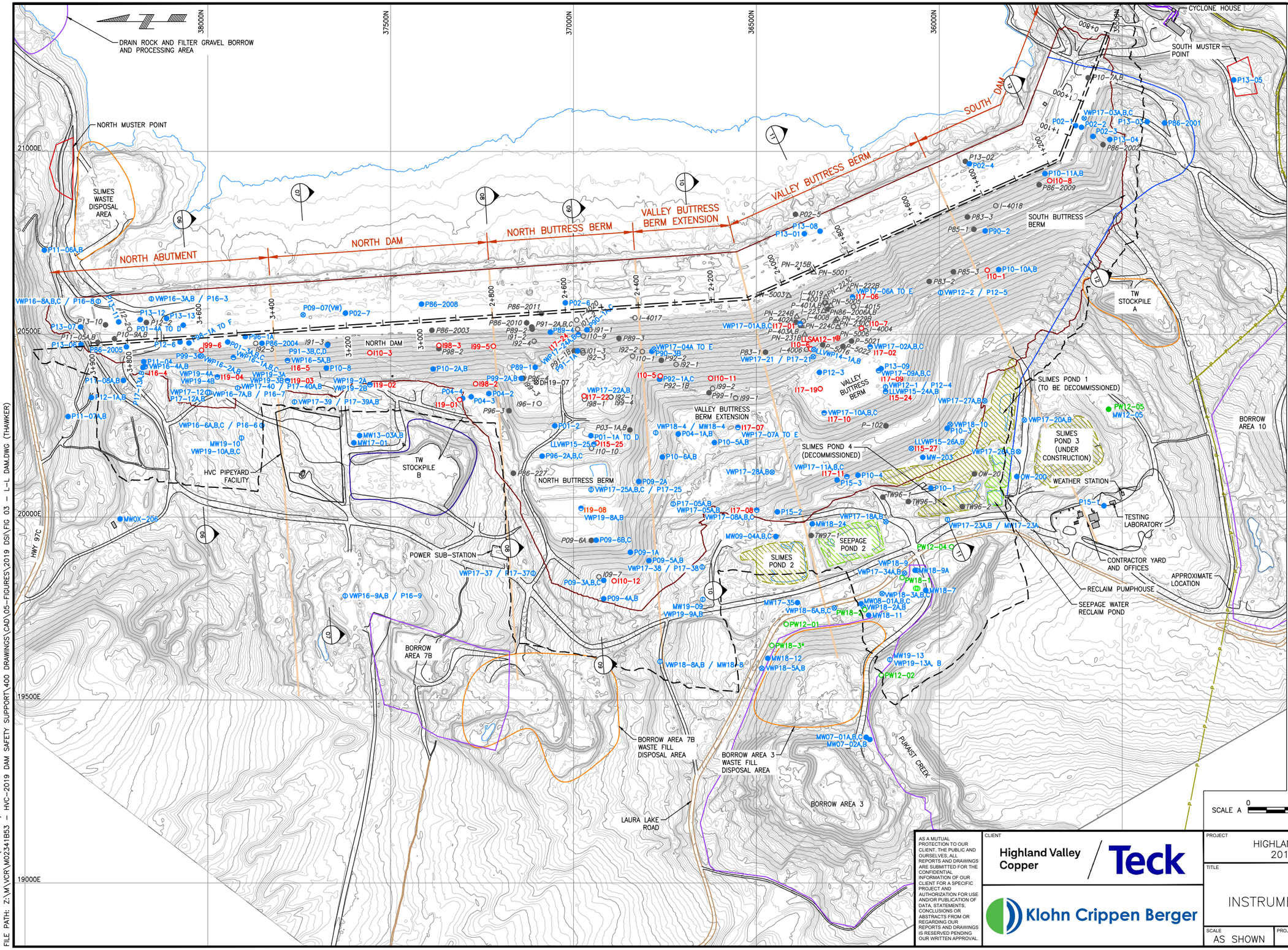

LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- 2040 PFS DAM FOOTPRINT
- L-L DAM CENTERLINE
- 0+800 — INSTRUMENTATION CROSS SECTION

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER
- STANDARD INCLINOMETER
- IN-PLACE SAA INCLINOMETER
- PUMPING WELL
- PUMPING WELL WITH STANDPIPE PIEZOMETER AND OBSERVATION WELL

DEFUNCT INSTRUMENTS AND BACKFILLED DRILLHOLES (SEE NOTE 3):

- DEFUNCT PNEUMATIC PIEZOMETER
- DEFUNCT STANDPIPE PIEZOMETER
- DEFUNCT INCLINOMETER
- BACKFILLED DRILLHOLE

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM SATELLITE IMAGERY TAKEN ON 2017-09-15 & 24 AND 2016-09-25 & 29. ALSO OCTOBER 2018
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.
4. FOR LOCATION OF SEEPAGE FLOW MONITORING WEIRS, SEE FIGURE V-D-1, APPENDIX V-D.

SCALE A 0 250 m

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM
INSTRUMENTATION LOCATION PLAN

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M02341B53	03

K2B-FIG-D-L

SAVE DATE: 2020-01-24 (10:37 AM)
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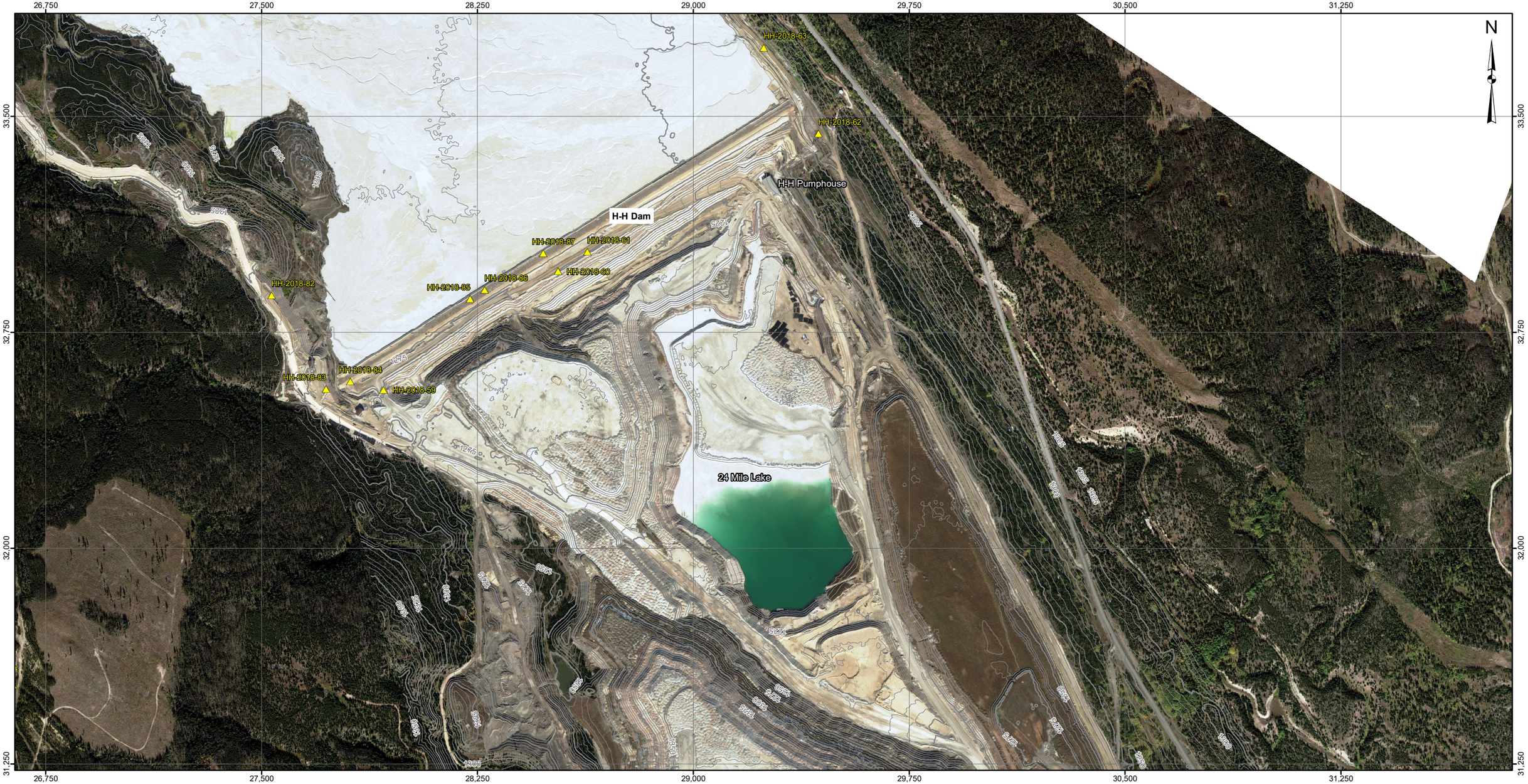

0 500m

Legend

△ Waypoint (HH-2019-xx)

Notes:
1. Projection: HVC Mine Grid.
2. Topography from satellite photogrammetry survey conducted in September, 2019.
3. Imagery from September, 2019.

CLIENT: Highland Valley Copper / Teck; Klohn Crippen Berger	PROJECT: HIGHLAND TAILINGS STORAGE FACILITY 2019 DAM SAFETY INSPECTION		
	TITLE: H-H DAM AND 24 MILE LAKE DAM SAFETY INSPECTION WAYPOINTS		
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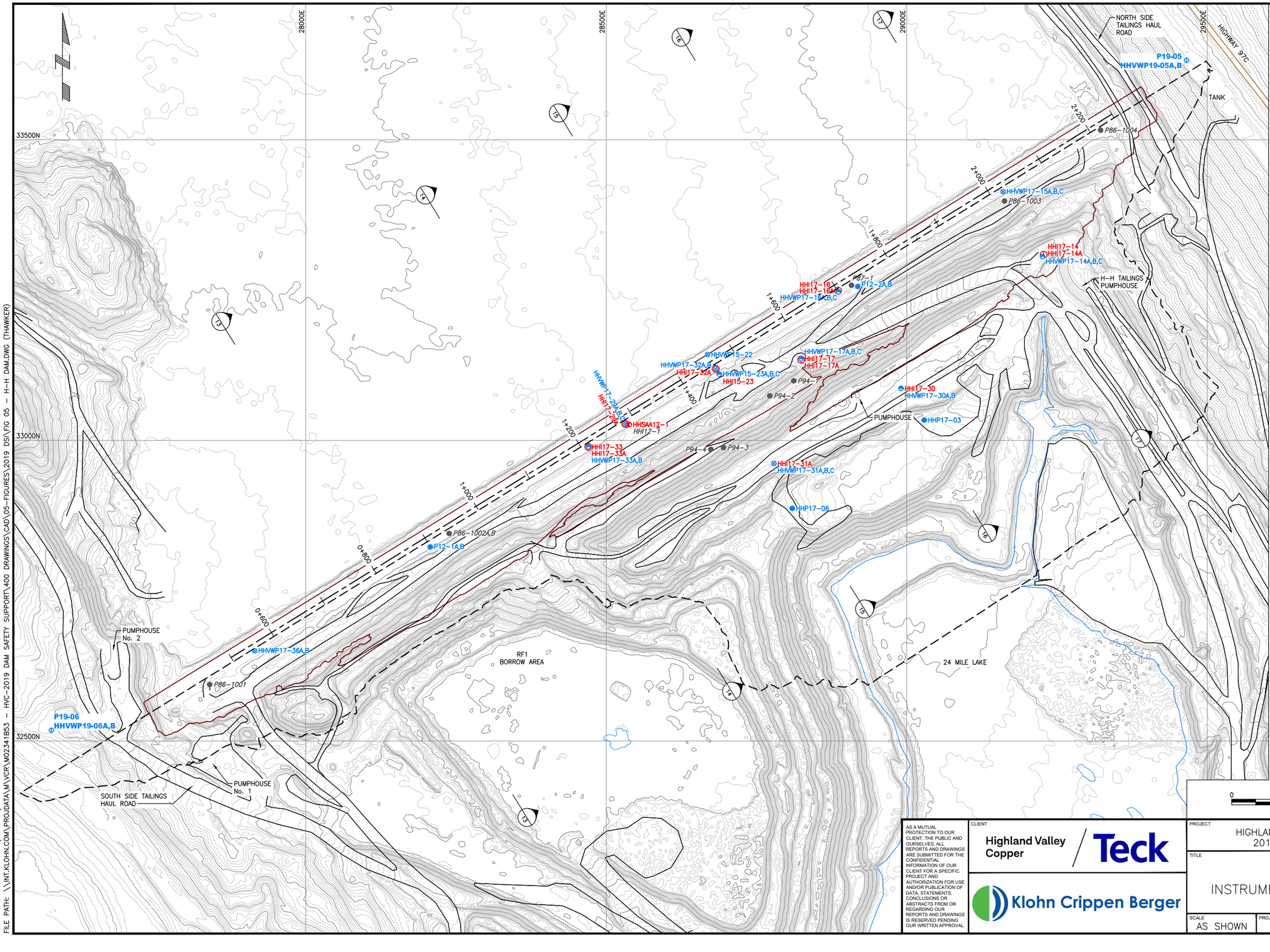

LEGEND:

- ULTIMATE DAM FOOTPRINT
- TAILINGS PIPELINE
- POWERLINE
- HAUL ROAD
- PUBLIC ROAD
- 2040 PFS DAM FOOTPRINT
- H-H DAM CENTERLINE
- 0+800
- 13 — INSTRUMENTATION CROSS SECTION

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER
- STANDARD INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND IN-PLACE SAA INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND PAIRED SONDEX SETTLEMENT SYSTEM

DEFUNCT INSTRUMENTS (SEE NOTE 3):

- DEFUNCT STANDPIPE PIEZOMETER
- DEFUNCT COMBINED STANDARD INCLINOMETER AND IN-PLACE SAA INCLINOMETER

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM SATELLITE IMAGERY TAKEN ON 2017-09-15 & 24 AND 2016-09-25 & 29. ALSO OCTOBER 2018.
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
INSTRUMENTATION LOCATION PLAN

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M02341B53	05

KCB-FIG-D-L

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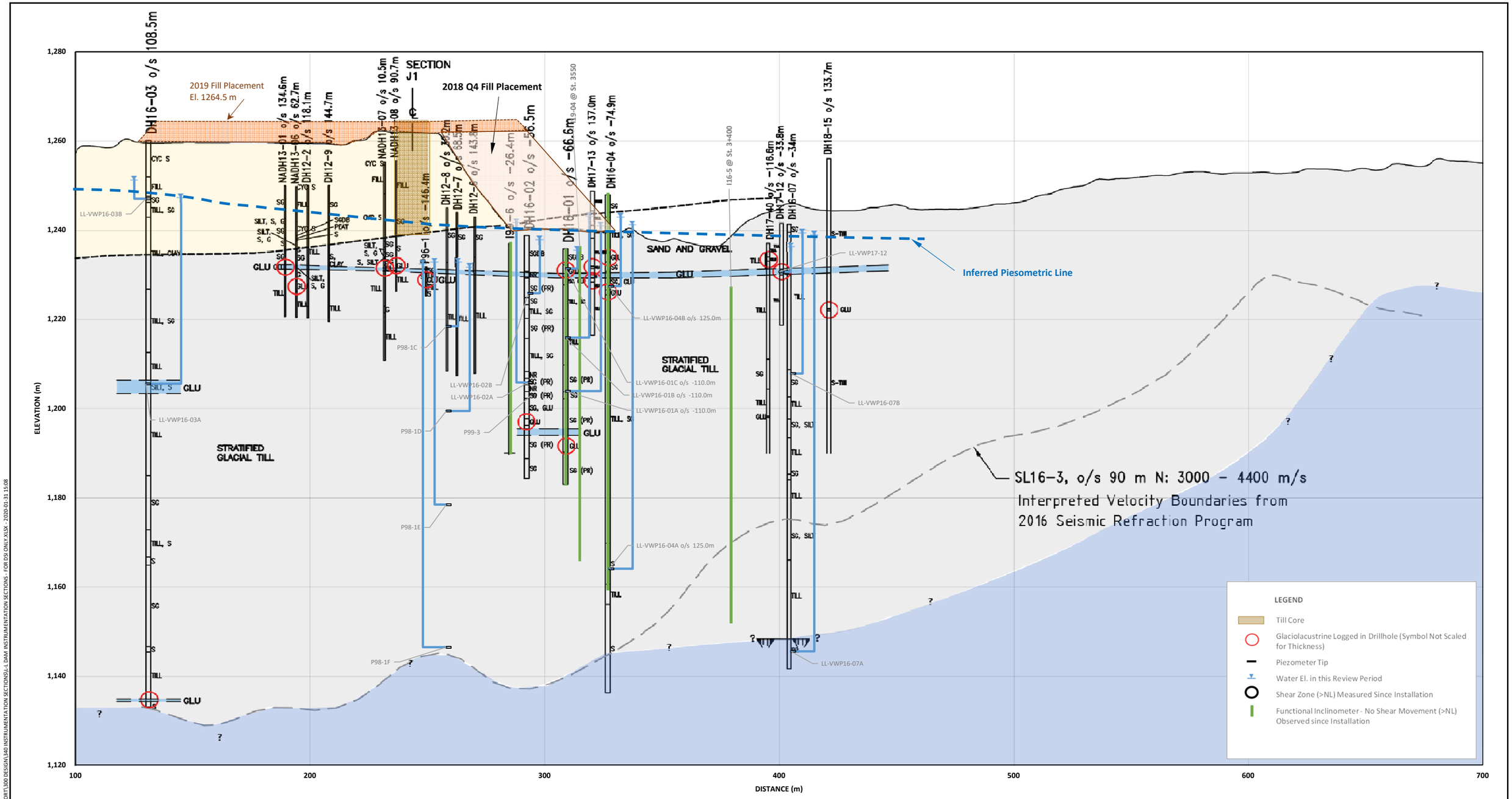

NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.

NOT FOR CONSTRUCTION

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	6

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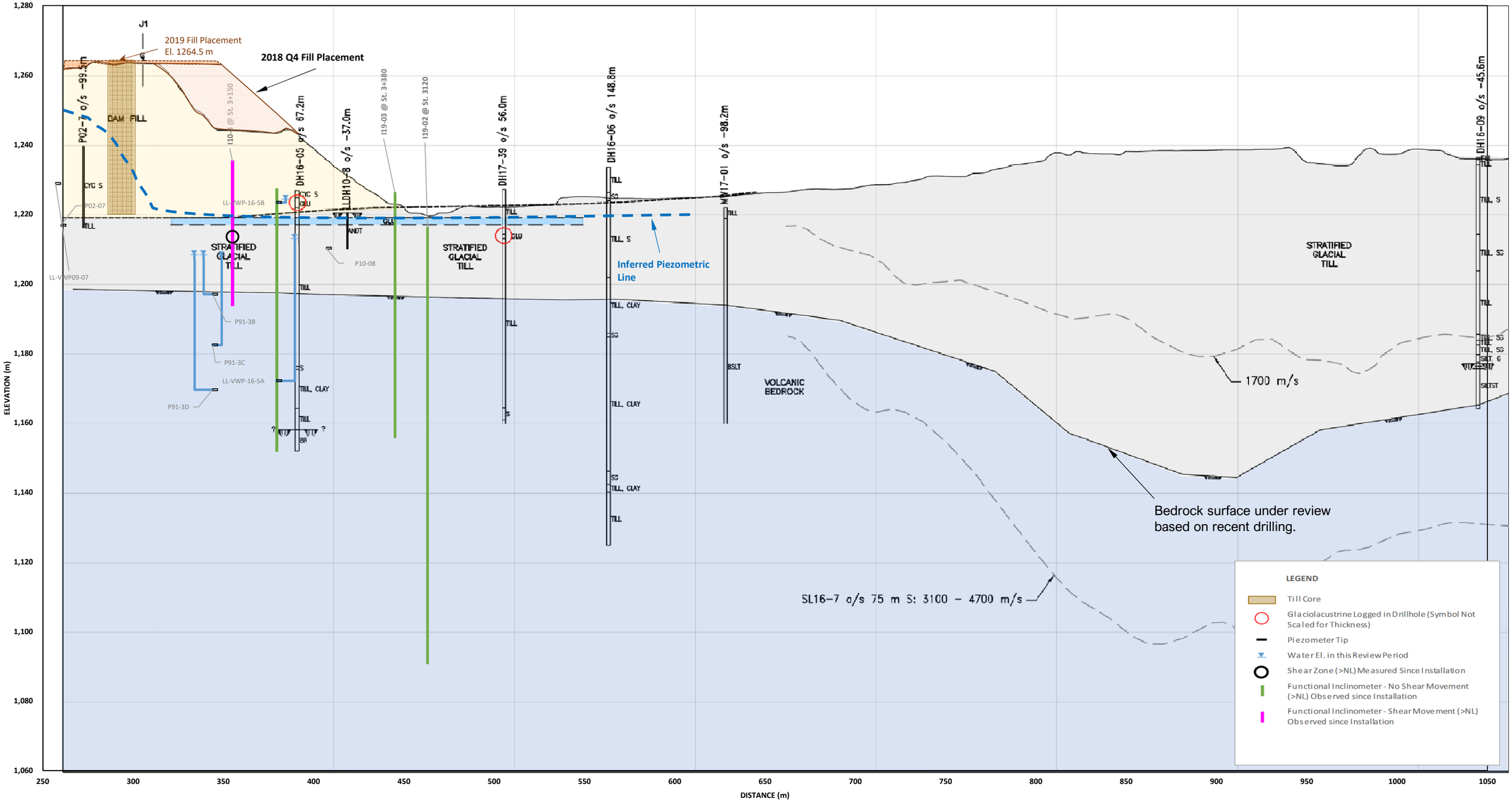

NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Water elevation at P10-08 appears to be an outlier and is not shown here.

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM SECTION
Sta. 3+300 - NORTH DAM
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	7

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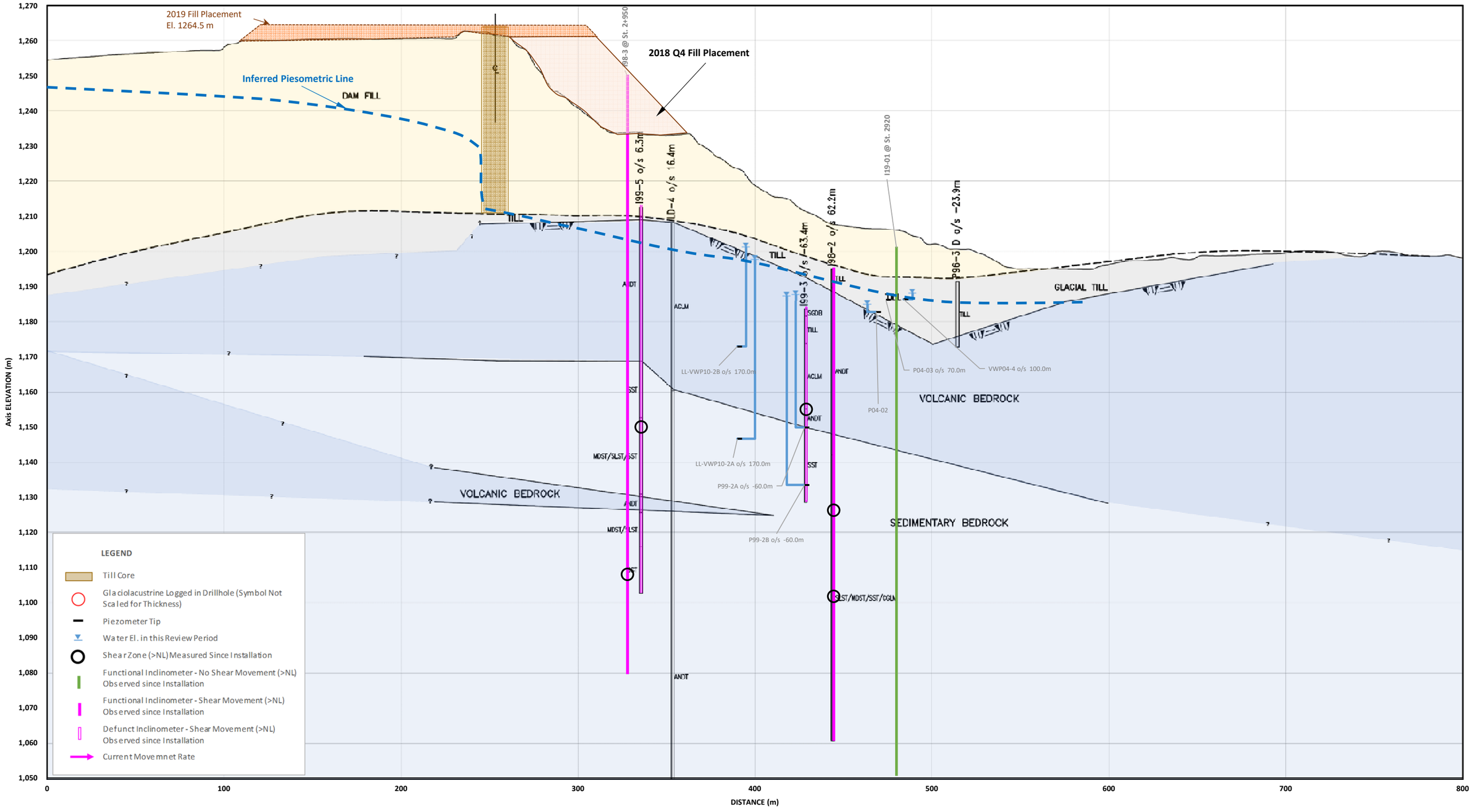

NOTES

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2. Collar elevation of inclinometers are approximate.

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM SECTION
Sta. 2+800 - NORTH DAM
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	8

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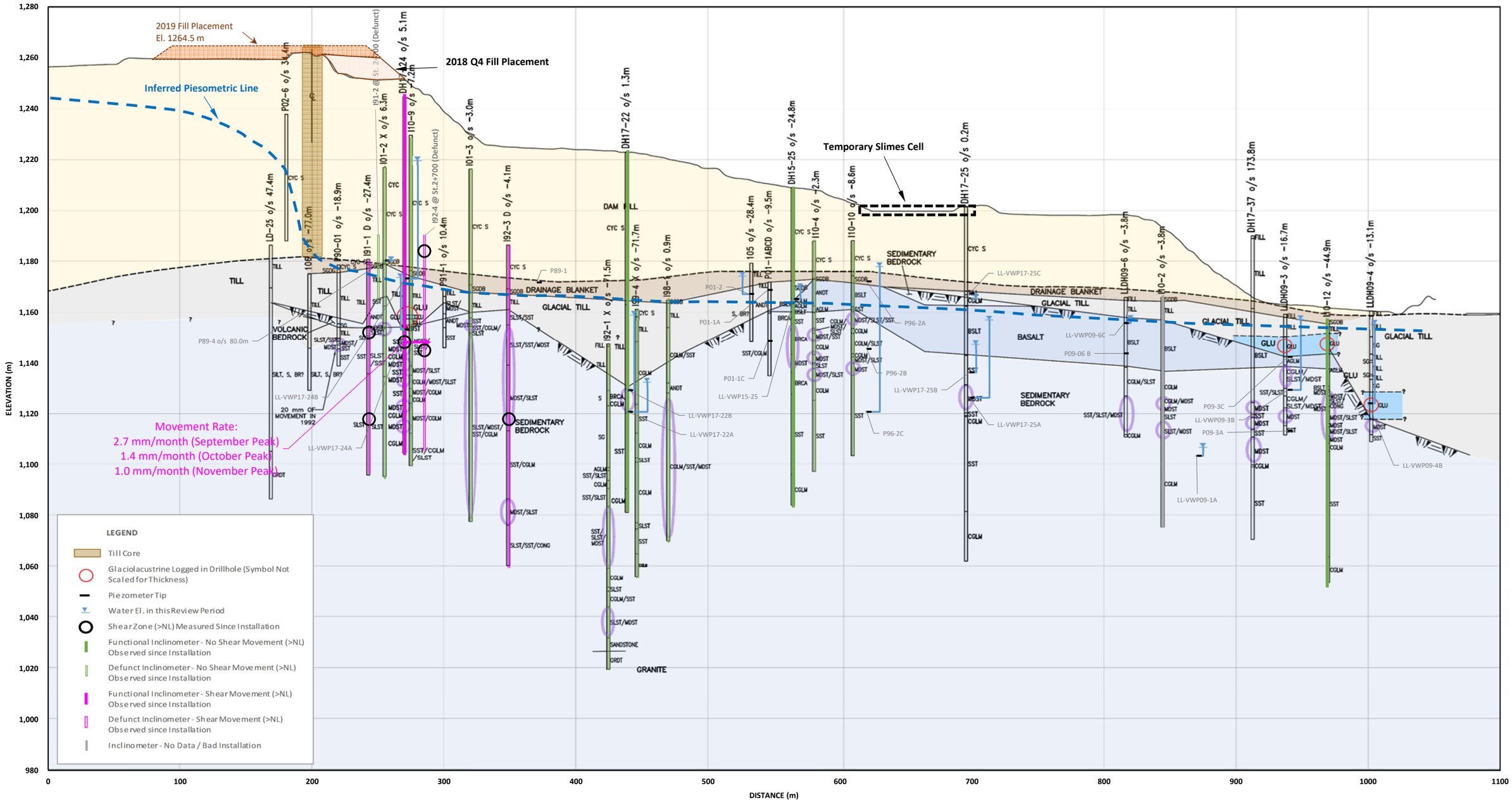

NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.

NOT FOR CONSTRUCTION

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM SECTION
Sta. 2+564 - NORTH BUTTRESS BERM
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	9

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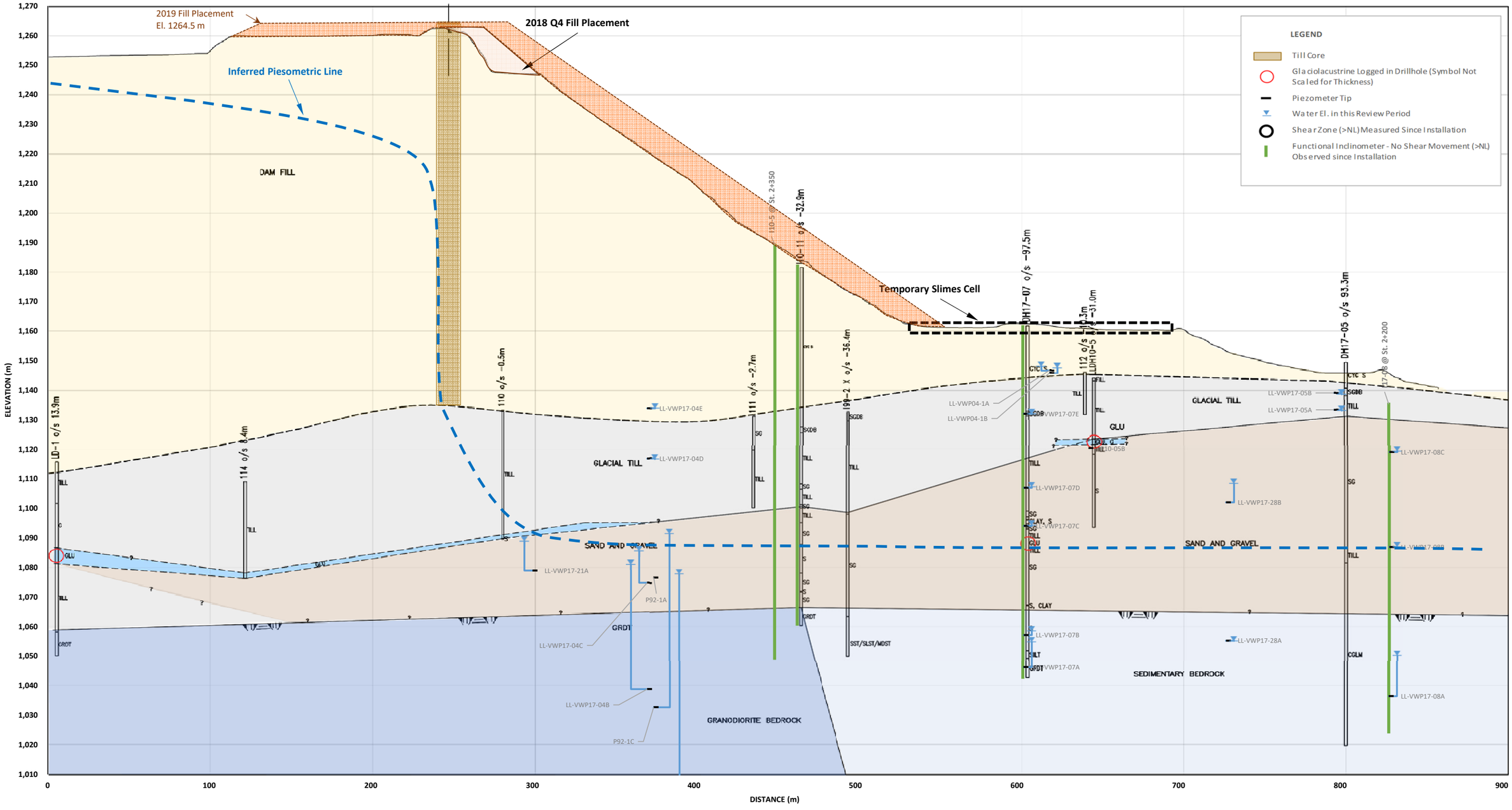

NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Water elevation at P92-1A appears to be an outlier and is not shown here.

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM SECTION
Sta. 2+250 - VALLEY BUTTRESS BERM EXTENSION
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	10

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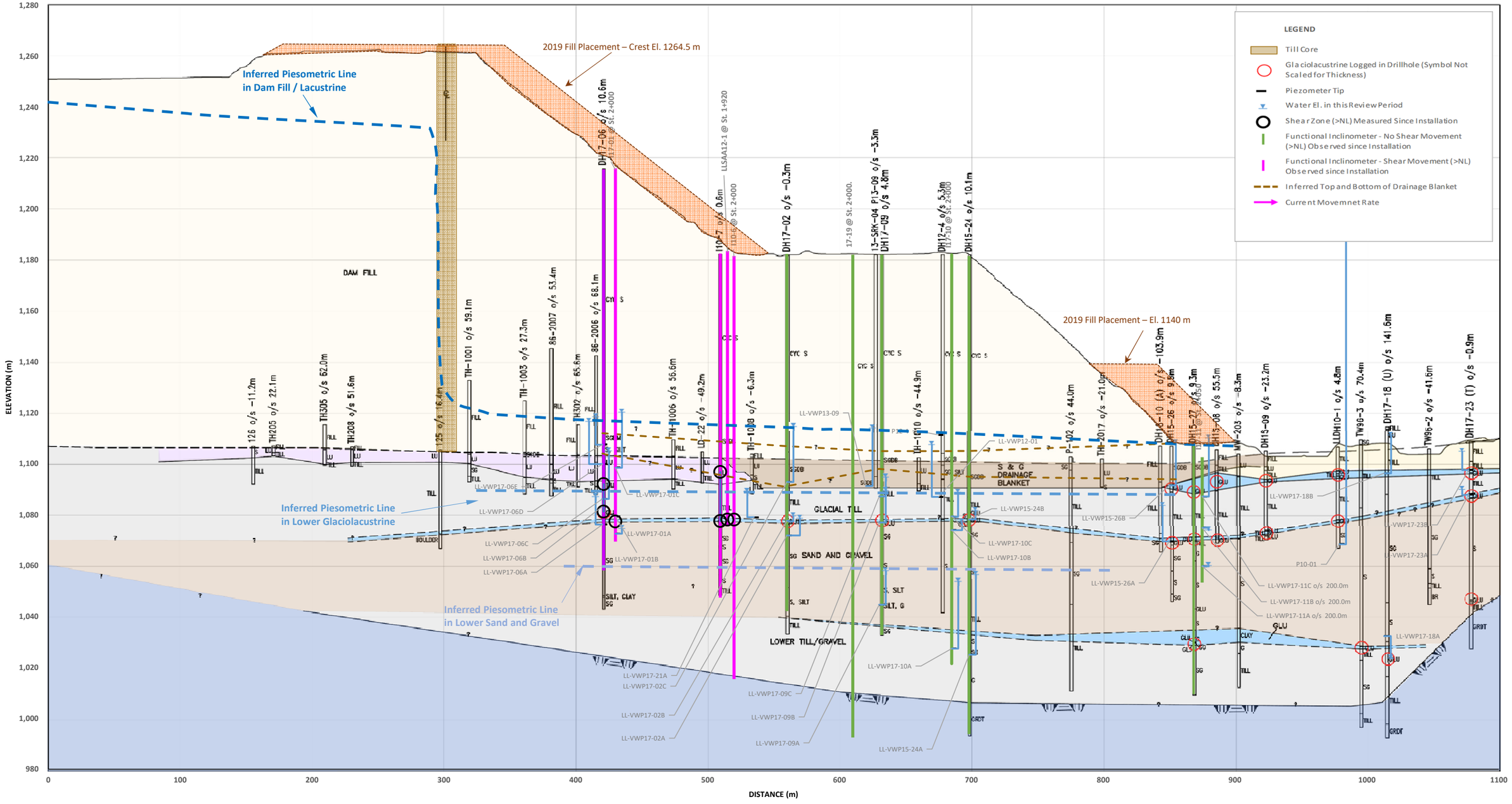

NOTES

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2. Collar elevation of inclinometers are approximate.

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM SECTION
Sta. 1+850 - VALLEY BUTTRESS BERM
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	11

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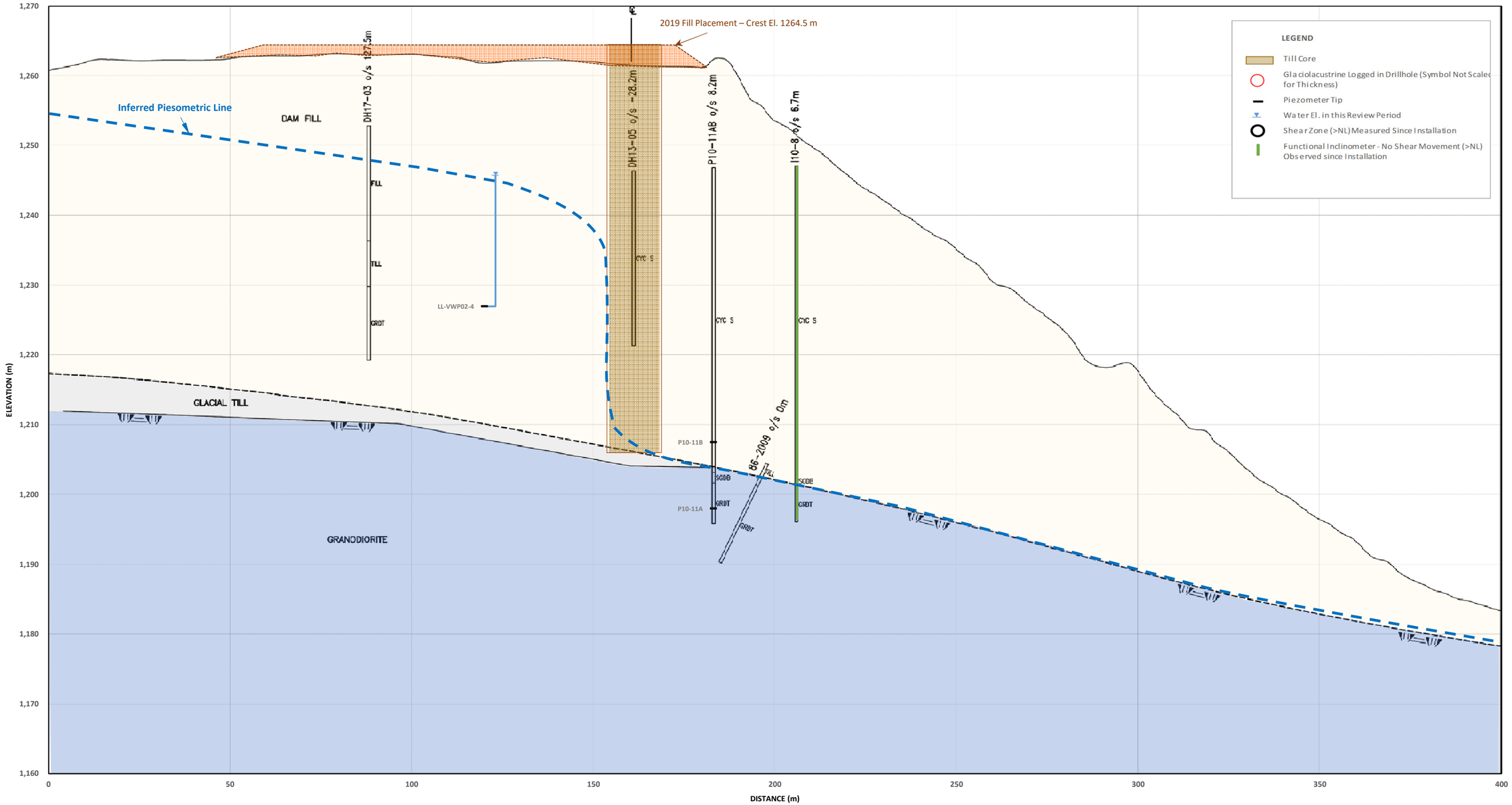

NOTES

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2. Collar elevation of inclinometers are approximate.

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CLIENT: Highland Valley Copper / Teck

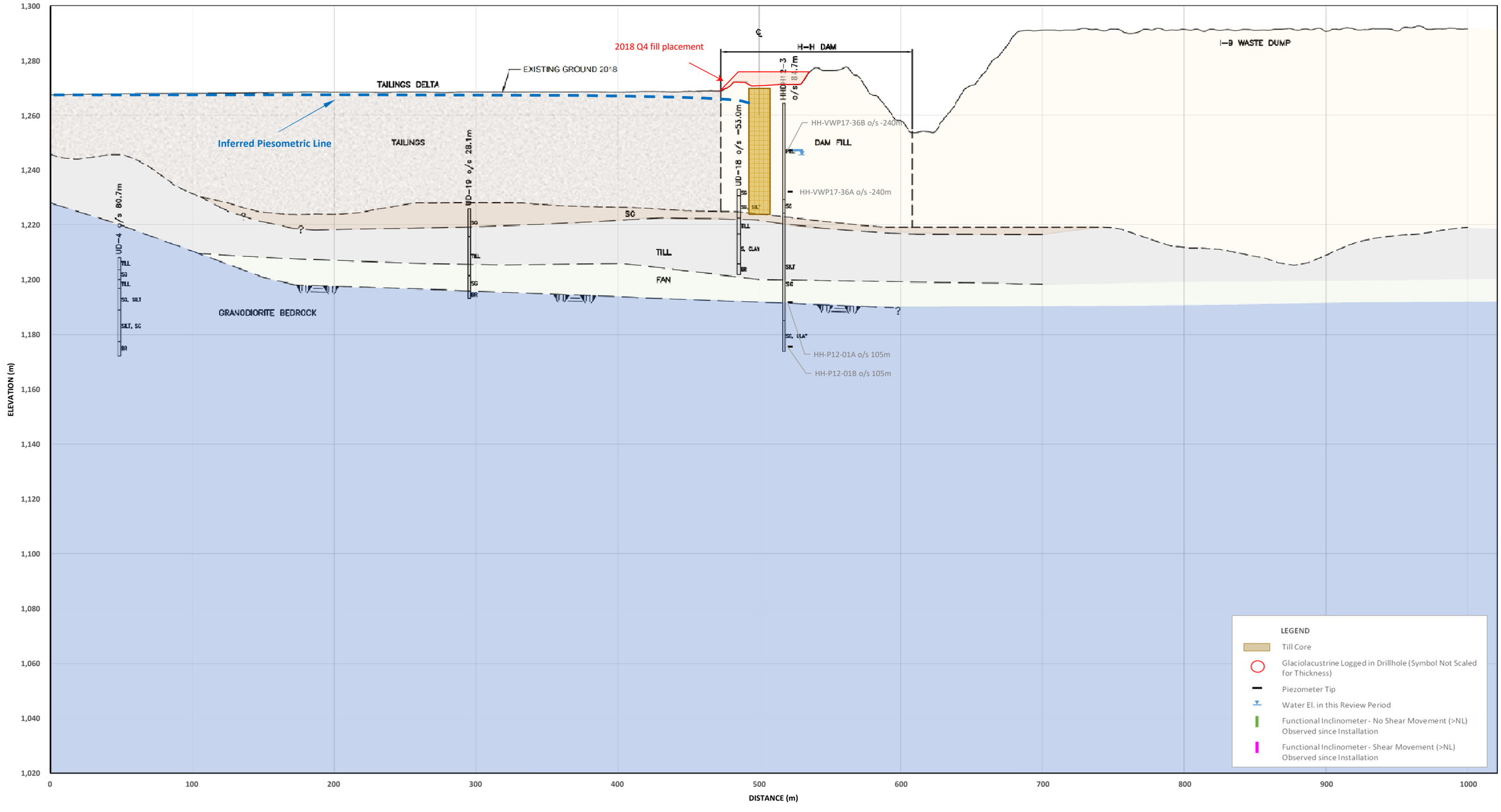
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM SECTION
Sta. 1+200 - SOUTH DAM
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	12

FILE PATH: Z:\MV\VR\M02341B53 - HVC 2019 DAM SAFETY SUPPORT\300 DESIGN\340 INSTRUMENTATION SECTIONS\L-L DAM INSTRUMENTATION SECTIONS - FOR DSI ONLY.XLSX - 2020-01-31 15:08



NOTES

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2. Collar elevation of inclinometers are approximate.

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CLIENT: Highland Valley Copper / Teck

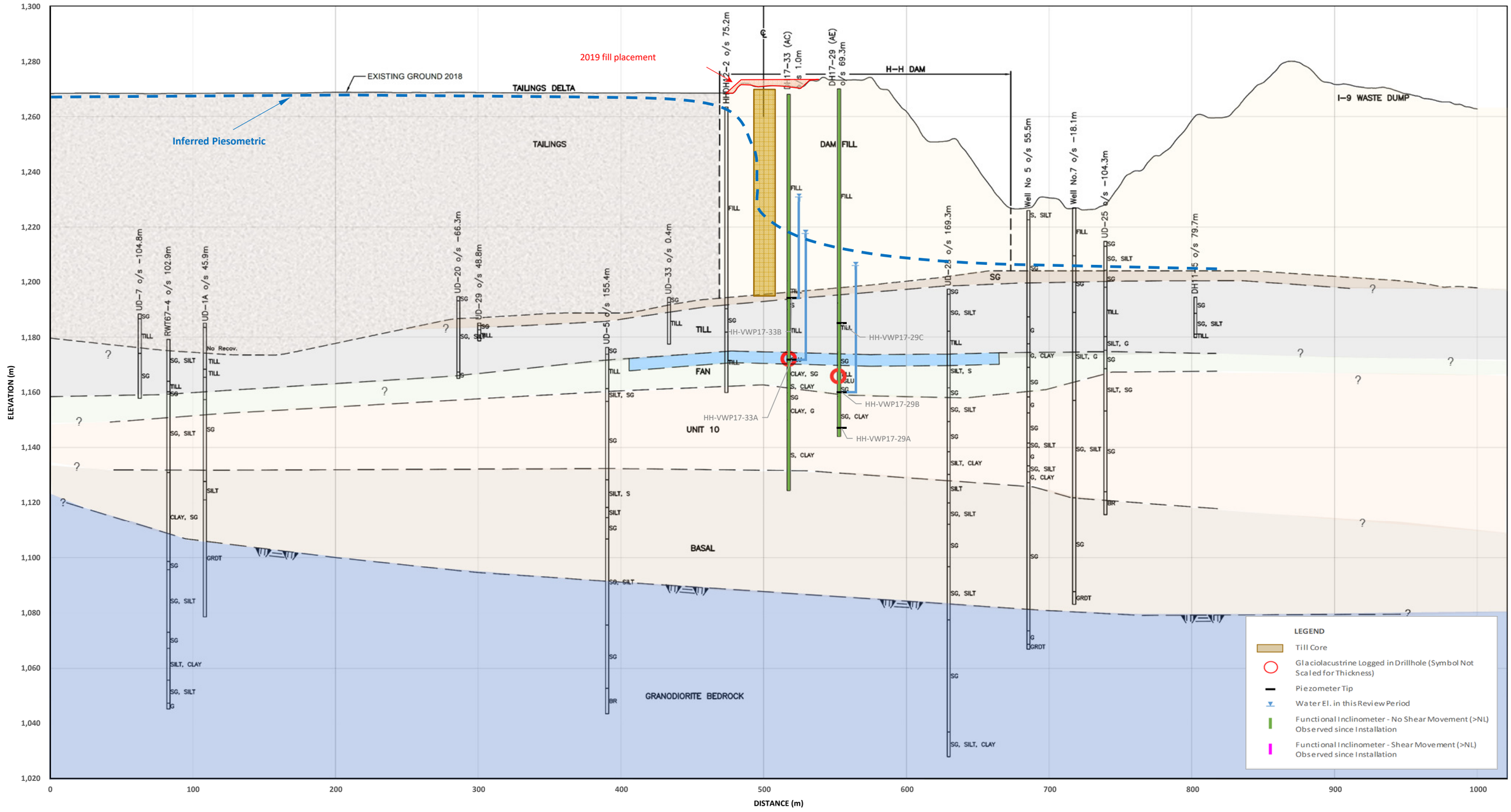
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
INSTRUMENTATION SECTION - Sta. 0+800
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	13

FILE PATH: Z:\MVCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\340 INSTRUMENTATION SECTIONS\H-H DAM INSTRUMENTATION SECTIONS - FOR DSI ONLY.XLSX - 2020-01-31 15:13



NOTES

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CLIENT: Highland Valley Copper / Teck

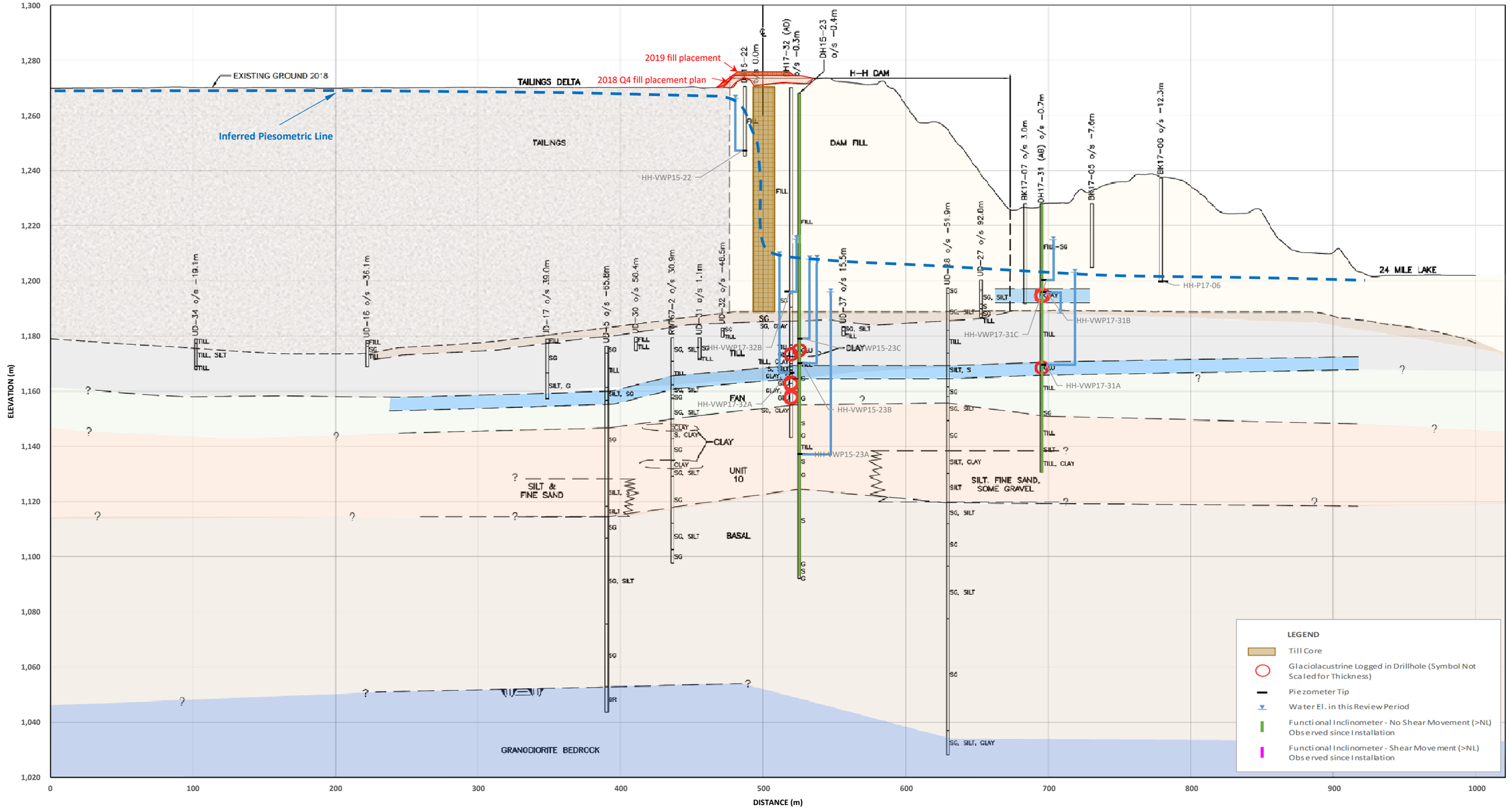
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
INSTRUMENTATION SECTION - Sta. 1+200
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	14

FILE PATH: Z:\MV\CRL\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\340 INSTRUMENTATION SECTIONS\H-H DAM INSTRUMENTATION SECTIONS - FOR DSI ONLY.XLSX - 2020-01-31 15:13



NOTES

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2. Collar elevation of inclinometers are approximate.

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CLIENT: Highland Valley Copper / Teck

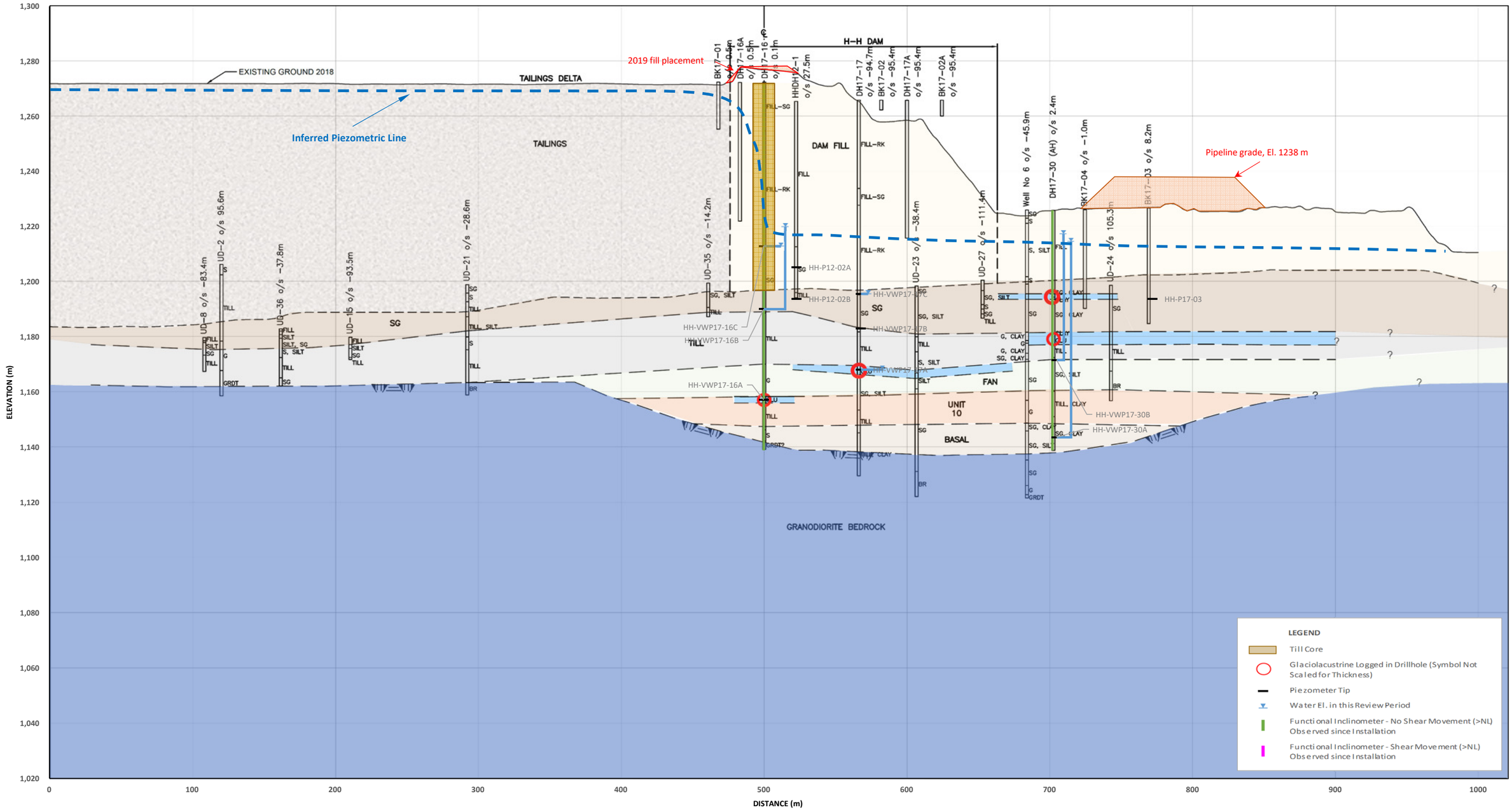
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
INSTRUMENTATION SECTION - Sta. 1+460
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	15

FILE PATH: Z:\MVCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\340 INSTRUMENTATION SECTIONS\H-H DAM INSTRUMENTATION SECTIONS - FOR DSI ONLY.XLSX - 2020-01-31 15:13



NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. HH-VWP17-17B piezometric elevation appears to be an outlier and not shown here.

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CLIENT: Highland Valley Copper / Teck

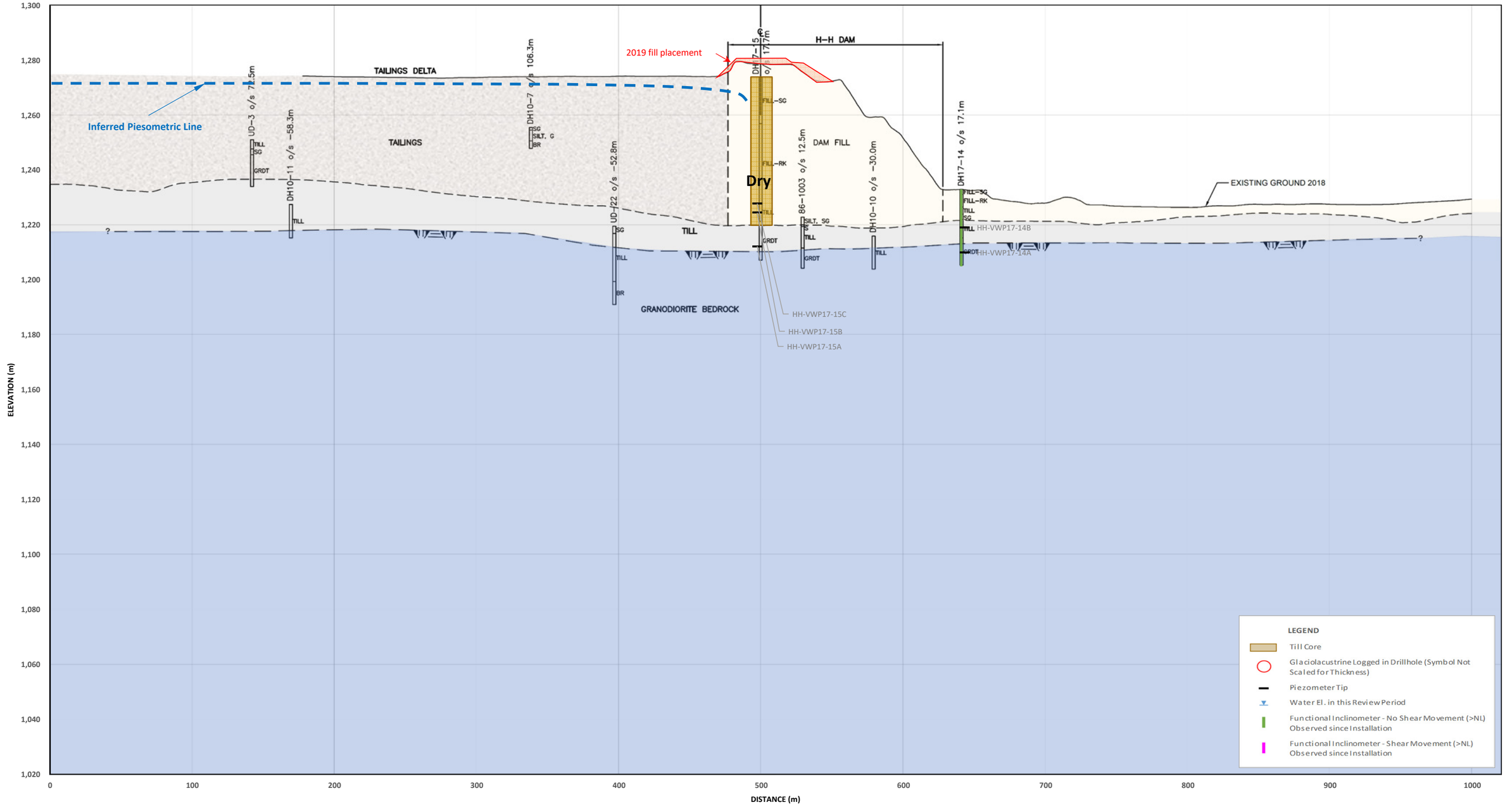
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
INSTRUMENTATION SECTION - Sta. 1+700
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	16

FILE PATH: Z:\MVC\RM\02341B53 - HVC 2019 DAM SAFETY SUPPORT\300 DESIGN\340 INSTRUMENTATION SECTIONS\H-H DAM INSTRUMENTATION SECTIONS - FOR DSI ONLY.XLSX - 2020-01-31 15:13



NOTES

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CLIENT: Highland Valley Copper / Teck

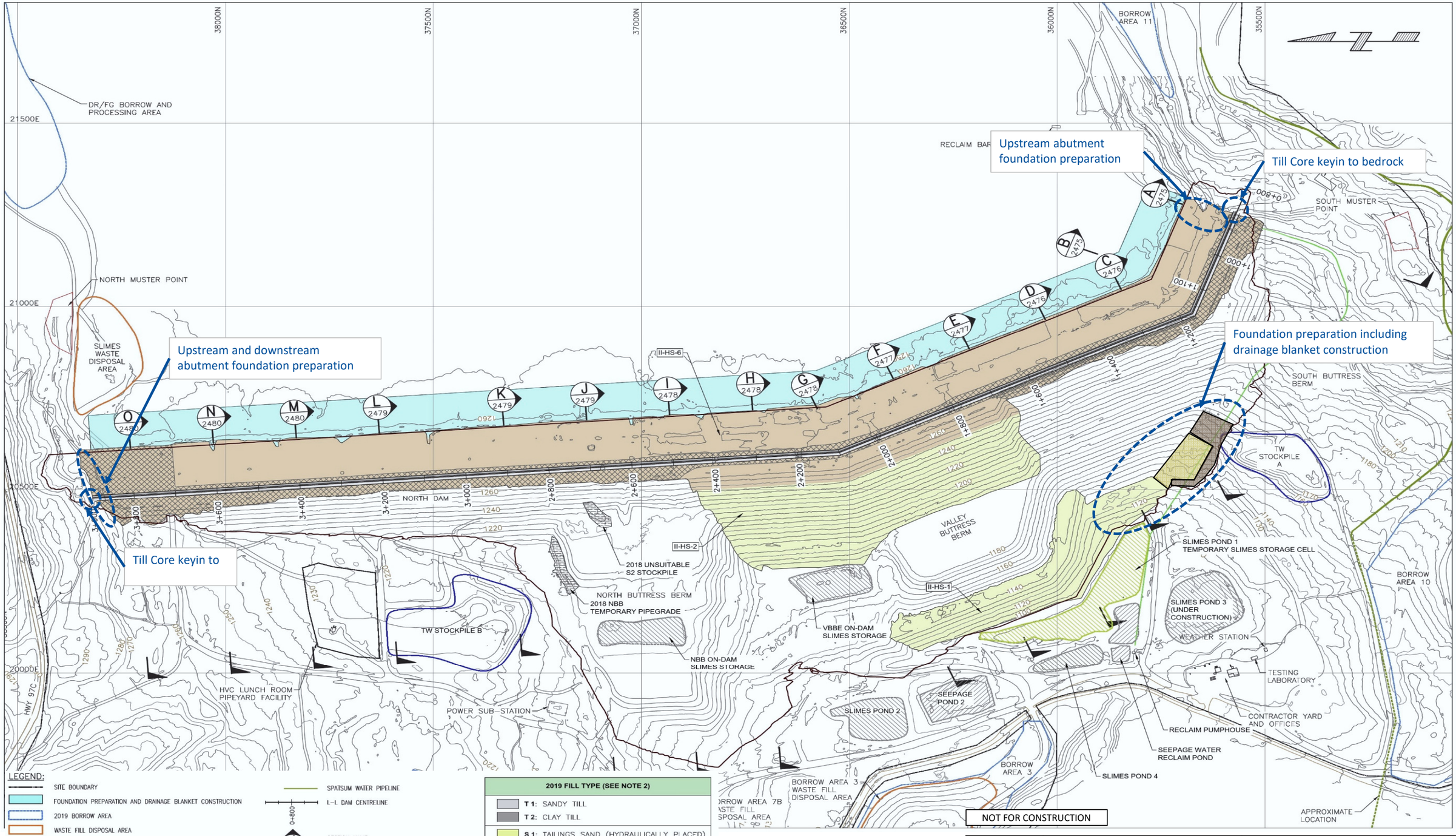
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
INSTRUMENTATION SECTION - Sta. 2+000
INSTRUMENT STATUS ON NOVEMBER 30, 2019

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	17

FILE PATH: Z:\MVC\RM\02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\340 INSTRUMENTATION SECTIONS\H-H DAM INSTRUMENTATION SECTIONS - FOR DSI ONLY.XLSX - 2020-01-31 15:13



LEGEND:

- SITE BOUNDARY
- FOUNDATION PREPARATION AND DRAINAGE BLANKET CONSTRUCTION
- 2019 BORROW AREA
- WASTE FILL DISPOSAL AREA
- EXISTING POND
- 2019 POND
- STOCKPILE AREA
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- SPATSUM WATER PIPELINE
- L-L DAM CENTRELINE
- 0+800 — SECTION NAME
- 1/03 — DRAWING NUMBER WHERE SECTION IS SHOWN
- II-HS-6 — FILL PLACEMENT AREA DESIGNATION

2019 FILL TYPE (SEE NOTE 2)
T 1: SANDY TILL
T 2: CLAY TILL
S 1: TAILINGS SAND (HYDRAULICALLY PLACED)
S 1: TAILINGS SAND (MECHANICALLY PLACED)
S 2: TAILINGS SAND (HYDRAULICALLY PLACED
S 2: TAILINGS SAND (MECHANICALLY PLACED)
SG 1: SAND AND GRAVEL
TEMPORARY FILL
BEACH

SCALE A 0 250 m

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM
2019 CONSTRUCTION WORK AREAS

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	18

FILE PATH: Z:\MV\CR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\700 DELIVERABLES\720 WORKING\2019 DS\02 HIGHLAND\FIGURES\CONSTRUCTION FIGURES.XLSX - 2019-12-19 15:50

Crest tied into exiting temporary pipegrade

Pipeline grade - by THVCP Mining Fleet

Random Fill Capping - by THVCP Mining Fleet

HIGHWAY 97C

SEE NOTE 4

8m BENCH

NORTH SIDE TAILINGS HAUL ROAD

H-H TAILINGS PUMPHOUSE

PUMPHOUSE

PUMPHOUSE No.2

PUMPHOUSE No.1

SOUTH SIDE TAILINGS HAUL ROAD

I-9 DUMP

24 MILE LAKE

33500N

33000N

32500N

28000E

29500E

SCALE A 0 200 m

LEGEND:

- BORROW AREA
- ULTIMATE DAM FOOTPRINT
- TAILINGS PIPELINE
- TAILINGS OVERFLOW PIPELINE
- PIPELINE
- ELECTRICAL LINE
- POWER LINE
- HAUL ROAD
- PUBLIC ROAD
- SITE BOUNDARY
- H-H DAM CENTRELINE
- 0+800 CHAINAGE
- A 2485 SECTION NAME / DRAWING NUMBER WHERE SECTION IS SHOWN

FILL TYPE (SEE NOTE 3)	
T1:	SANDY TILL
T2:	CLAY TILL
SG2:	SAND AND GRAVEL
RF1:	RANDOM FILL
RF2:	RANDOM FILL

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CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
2019 CONSTRUCTION WORK AREAS

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	19

FILE PATH: Z:\MV\CR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\700 DELIVERABLES\720 WORKING\2019 DS\02 HIGHLAND\FIGURES\CONSTRUCTION FIGURES.XLSX - 2019-12-19 15:50

APPENDIX I

Dam Safety Inspection Checklist

APPENDIX I-A

L-L Dam Safety Inspection Checklist

2019 ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	L-L Dam	**Inspection Date:**	June 11th, 2019
Consequence Classification:	Main Embankment (Extreme)		
Weather:	Sunny	**Inspector(s):**	Rick Friedel, P.Eng. Pablo Urrutia, P.Eng. Narges Solgi, EIT
Freeboard (pond level to dam crest):	Large freeboard 10.8m based on June 7th survey		

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

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

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

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

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

- No dam safety deficiencies observed

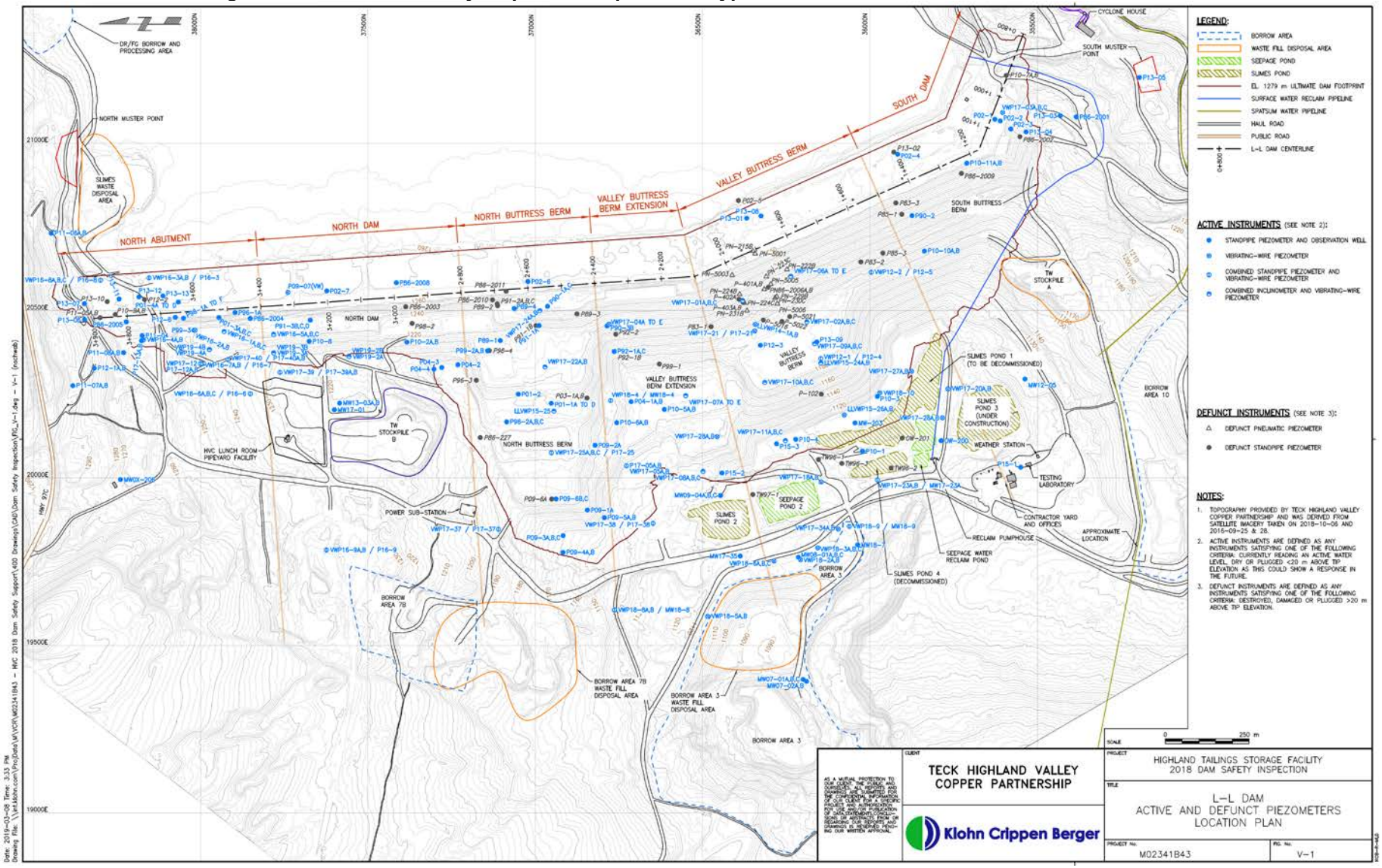
New and Outstanding deficiencies:

- No dam safety deficiencies observed

Comments / Notes:

- Ongoing mechanical sand placement upstream of the core zone.
- Hydraulics sand placement at VBB toe, upstream of Slimes Pond 1, and VBBE upstream of temporary on-dam slimes pond. Cells observed in various states (prep, active, draining).
- Temporary on-dam slimes cells: VBBE – active, ponded water but no issues of concern; NBB – no ponding, drained
- Downstream ponds: adequate freeboard and no issues of concern
- Slimes Pond 1 active. Hydraulic Sand Placement Seepage water was discharging into the pond.
- Dam crest: Some erosion along upstream edge of upstream cycloned sand area near Sta. 2+200. Area has been prepped for repair with hydraulic sand placement.

SITE PLAN – ***Refer to Figure 2 of 2019 Dam Safety Inspection Report for waypoint locations***



Relevant photos – ***Refer to Appendix II-A of 2019 Dam Safety Inspection Report***

APPENDIX I-B

H-H Dam Safety Inspection Checklist

2019 ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	H-H Dam	**Inspection Date:**	June 11th, 2019
Consequence Classification:	Main Embankment (Very High)		
Weather:	Sunny	**Inspector(s):**	Rick Friedel, P.Eng. Pablo Urrutia, P.Eng. Narges Solgi, EIT
Minimum observed buffer height (delta level to dam crest):	Variable along dam crest (>2 m) with most buffer near West Abutment		

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

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

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

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

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

- No dam safety deficiencies observed

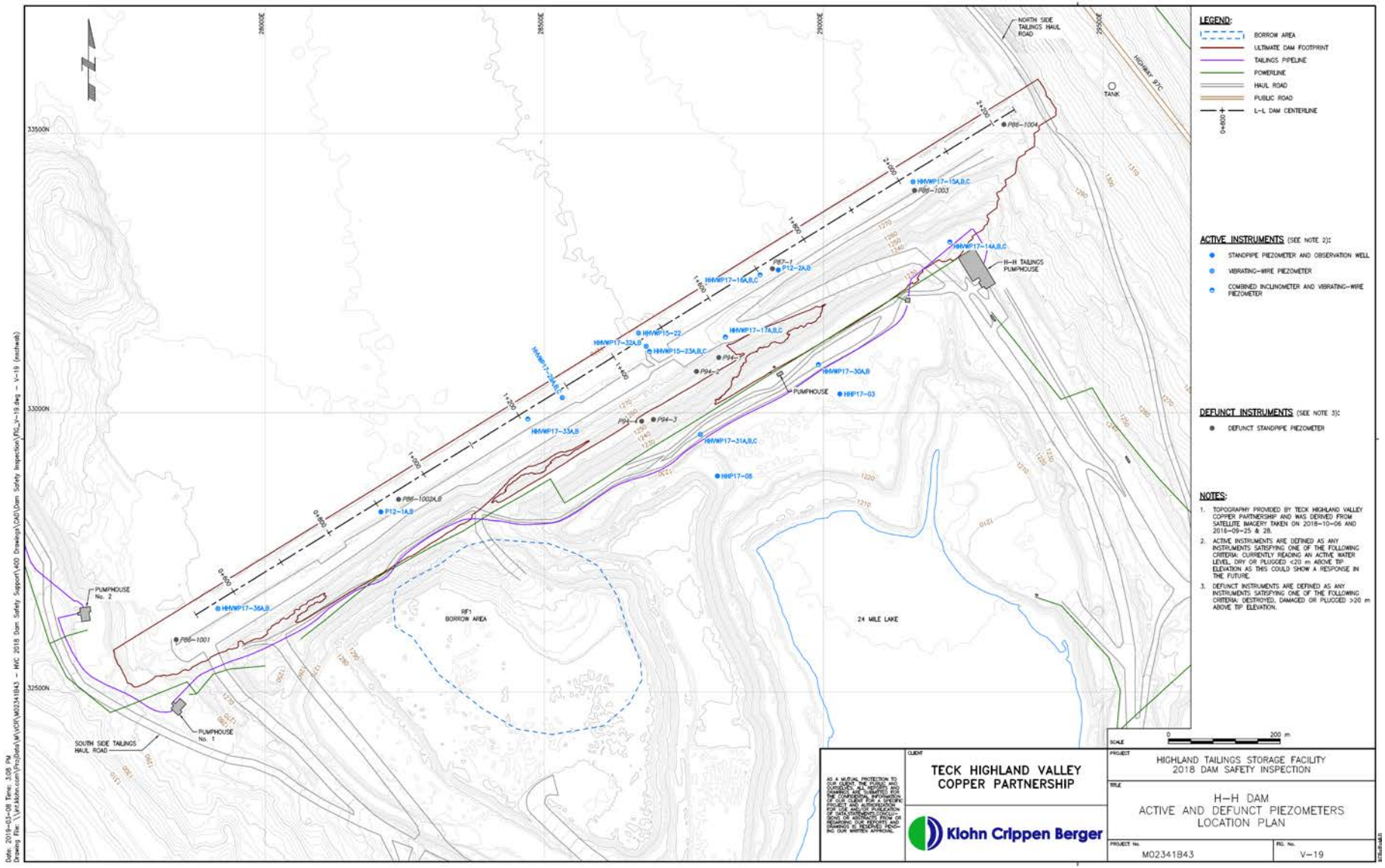
New and Outstanding deficiencies:

- No dam safety deficiencies observed

Comments / Notes:

- The only construction activity was related to the pipe bench construction near pumphouse.
- No issues of cracking or slumping observed in downstream rockfill
- Beach dry in front of dam fill except for a wet area in the low point which is likely due to the runoff. Deposition point is upstream of the main tailings cone on east abutment so no deposition near dam slope.
- Cracking upstream of and parallel to core zone. This type of cracking is typical and related to differential settlement of the dam fill placed on the tailings beach. Area has been staked by THVCP for monitoring.

SITE PLAN – ***Refer to Figure 4 of 2019 Dam Safety Inspection Report for waypoint locations***



Relevant photos – ***Refer to Appendix II-B of 2019 Dam Safety Inspection Report***

APPENDIX II

Inspection Photographs

APPENDIX II-A

L-L Dam Photographs

Appendix II-A
Visual Observations and Inspection Photograph – L-L Dam

VISUAL OBSERVATIONS

Crest and Upstream Slope

Good physical condition; no visual indicators of concern. Some erosion of upstream face of the upstream cycloned sand zone near spigot points were observed. These were localized and generally restricted to the overbuilt portion of the cycloned sand fill zone. These occurrences were noted and monitored as part of weekly inspections. A larger than typical washout occurred, prior to the site visit, near an overflow discharge pipe from one of the secondary cyclone clusters near Sta. 2+200. At the time of the site visit, the area had been prepped and was ready to be rebuilt with hydraulic sand placement (photo II-A-22). None of these erosion events represent a significant issue with respect to downstream dam safety. (Photo II A-1 and Photo II-A-2)

South Abutment

Good physical condition; significant erosion or excessive seepage not observed (Photo II A-3, Photo II A-4, Photo II-A-23 and Photo II-A-24).

North Abutment

Good physical condition; significant erosion or excessive seepage not observed (Photo II A-5).

North Dam

No observed dam safety issues of concern. At time of inspection, active construction included mechanical placement of upstream cycloned sand to support the 2019 crest raise. (Photo II-A-6, Photo II-A-7 and Photo II-A-8)

North Buttress Berm (NBB)

No observed dam safety issues of concern. At time of inspection, active construction included mechanical placement of upstream cycloned sand to support the 2019 crest raise. The temporary on-dam slimes cell storage was not in operation. (Photo II-A-8 and Photo II-A-9)

Valley Buttress Berm Extension (VBBE)

No observed dam safety issues of concern. At time of inspection, active construction included placement of upstream mechanical sand, and downstream hydraulic placement of cycloned sand on the upper portion of the slope. The temporary on-dam slimes cell storage was the active storage area overflow slimes from hydraulic placement. (Photo II-A-10 and Photo II-A-11)

Valley Buttress Berm (VBB)

No observed dam safety issues of concern. In addition to upstream mechanical sand placement, upstream of the core, downstream hydraulic placement of cycloned sand was ongoing at the toe. As expected, there was increased seepage from the area due to the hydraulic placement. Piezometers

were also showing elevated levels. The seepage face from the sand and gravel drainage blanket was visible along the base of the fill, just above the water level in Slimes Pond 1. There was no seepage from the cycloned sand fill slope. Both observations support there was not excessive build of seepage within the drain that was impacting hydraulic placement. (Photo II-A-14 to Photo II-A-18)

South Dam

No observed dam safety issues of concern. No ongoing construction activity in this dam segment during the inspection, with the exception of upstream mechanical sand placement. (Photo II-A-19)

Tailings Beach and Pond

Good physical condition. THVCP are in the process of a multi-year plan to maintain a wider beach between upstream cycloned sand fill and pond along the length of the dam crest. Evidence of these efforts are visible. Beach is widest at the north end of the dam and the combination of the tailings beach and spoils dump were achieving the minimum 500 m setback from the core zone where the pond is not to be in direct contact with the north slope. (Photo II-A-1, Photo II-A-23, and Photo II-A-24)

At the time of DSI site inspection, the pond was at El. 1251.7 m which is 10.8 m below the minimum crest of the dam at that time (El. 1262.5 m). (Photo II-A-25 and Photo II-A-26)

Seepage and Toe Collection Ditches

At the time of inspection, seepage points had emerged north of Slimes Pond 1, the formation of which coincide with commencement of hydraulic placement in the area upslope at the VBBE. Seepage was clear and flowing towards Slimes Pond 1. (Photo II-A-12)

According to site team, within the week prior to the site visit, a small pond at the toe of the dam had formed. This was seepage water from the VBBE that had collected in a low point in the ground surface and was of no concern with respect to safety of L-L Dam. KCB did recommend that the water pond be removed and area regraded to prevent future pooling in the area, and to facilitate future construction in the area. This area was dealt with by THVCP and the Contractor after the site visit. (Photo II-A-13)

Where present, primarily from the underdrains, seepage emanating from the dam fill was clear with no turbidity. All water reports to a downstream collection pond and is reclaimed back to the impoundment via the SWRP. One seepage point (FS-03) downstream of the VBB toe was decommissioned in 2018 as part of Seepage Pond 1 backfilling. Seepage flow from VBB toe now reports directly to Slimes Pond 1 before flowing into SWRP.

During the DSI site visit, slimes were discharging into Slimes Pond 1 from hydraulic cell placement. (Photo II-A-31)

INSPECTION PHOTOGRAPHS

LEGEND:

- LL = L-L Dam.
- LL-2019-## refers to 2019 Dam Safety Inspection View Points shown on Figure 2.
- All photographs taken during inspection on June 11, 2019.

Photo II-A-1 Overview of North Dam tailings beach (~600 m wide) and crest from North (LL-2019-01)

Photo II-A-2 Glacial Till core zone – Mechanically placed cycloned sand (S2) on both sides (LL-2019-02)

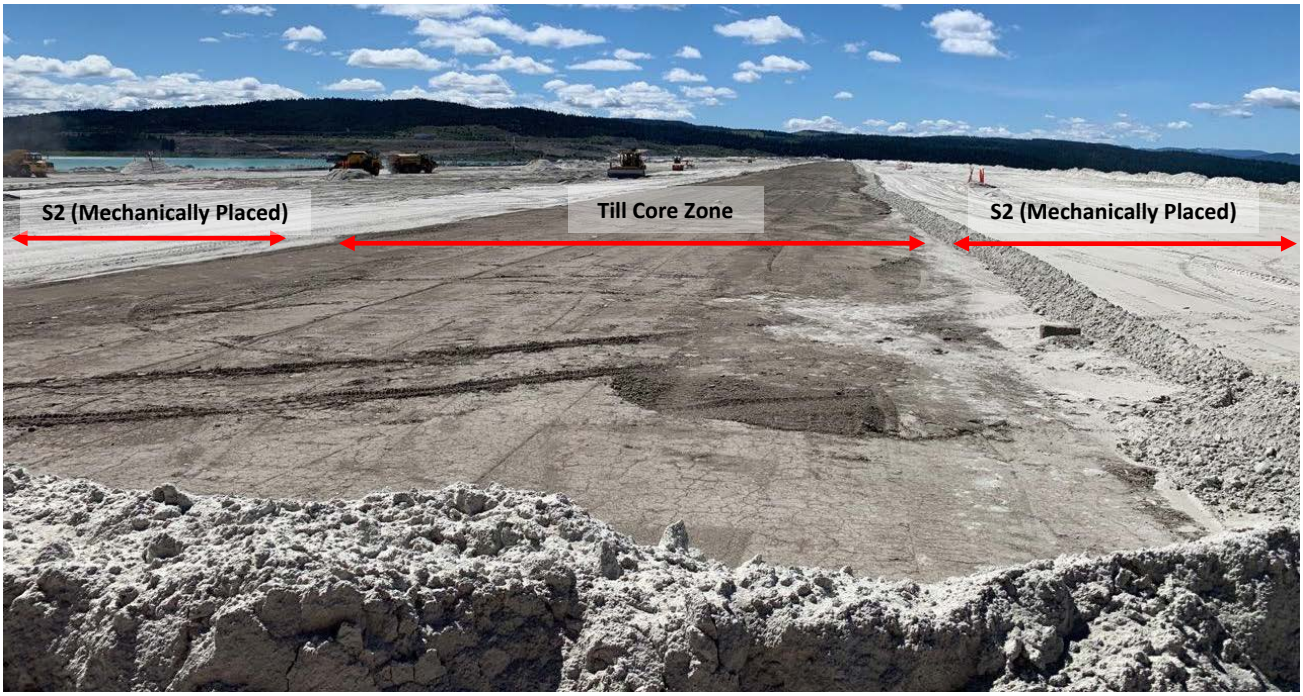


Photo II-A-3 Overview of L-L Dam crest from South Abutment (LL-2019-03)

Photo II-A-4 South abutment core zone tie-in (LL-2019-03)

Photo II-A-5 North Abutment core zone tie-in covered by cycloned sand for vehicle access over core zone. Fill is removed prior to core raise in this area. (LL-2019-02)

Photo II-A-6 Overview of North Dam Downstream Slope (LL-2019-04)

Photo II-A-7 Overview of North Dam Downstream Toe (LL-2019-05)

Photo II-A-8 Overview of downstream slope at North Dam and NBB transition – Pipe benches for cycloned sand placement are visible on slope (LL-2019-05)

Photo II-A-9 Overview of NBB Downstream Slope (LL-2019-06)

Photo II-A-10 VBBE Temporary On-dam Slimes Cell – Hydraulic sand placement is active, but water level is below outlet indicating seepage capacity through cycloned sand is greater than current inflow. (LL-2019-07)

Photo II-A-11 VBBE hydraulic cells upstream of Temporary On-dam Slimes Cell (LL-2019-07)

Photo II-A-12 Newer seepage points appear on north side of Slimes Pond 1 (figure on left). A response to hydraulic sand placement at VBBE. Seepage is only visible at the low point and does not extend to north (figure on right) (LL-2019-08)

Photo II-A-13 Water pooling in low point near toe of VBBE, appeared almost a week prior to the site visit. No evidence of seepage from cycloned sand face. KCB recommended water be drained, and area backfilled /regraded to remove low point (LL-2019-09)

Photo II-A-14 Overview of VBB hydraulic cells, and Slimes Pond 1 (LL-2019-10)

Photo II-A-15 Overview of VBB toe fill placement area (LL-2019-11)

Photo II-A-16 Typical photo of seepage from SG1 blanket during nearby hydraulic sand placement. Seepage face from blanket drain visible above Slimes Pond 1 pond level, no seepage from cycloned sand face observed. (LL-2019-11)

Photo II-A-17 Increased seepage point from SG1 blanket over top of divider dyke near Sta. 1+800 (LL-2019-12)

Photo II-A-18 No seepage from cycloned sand fill during hydraulic sand placement. SG1 blanket drain is functioning properly (LL-2019-12)

Photo II-A-19 Overview of South Dam prep area from 2019 (LL-2019-11)

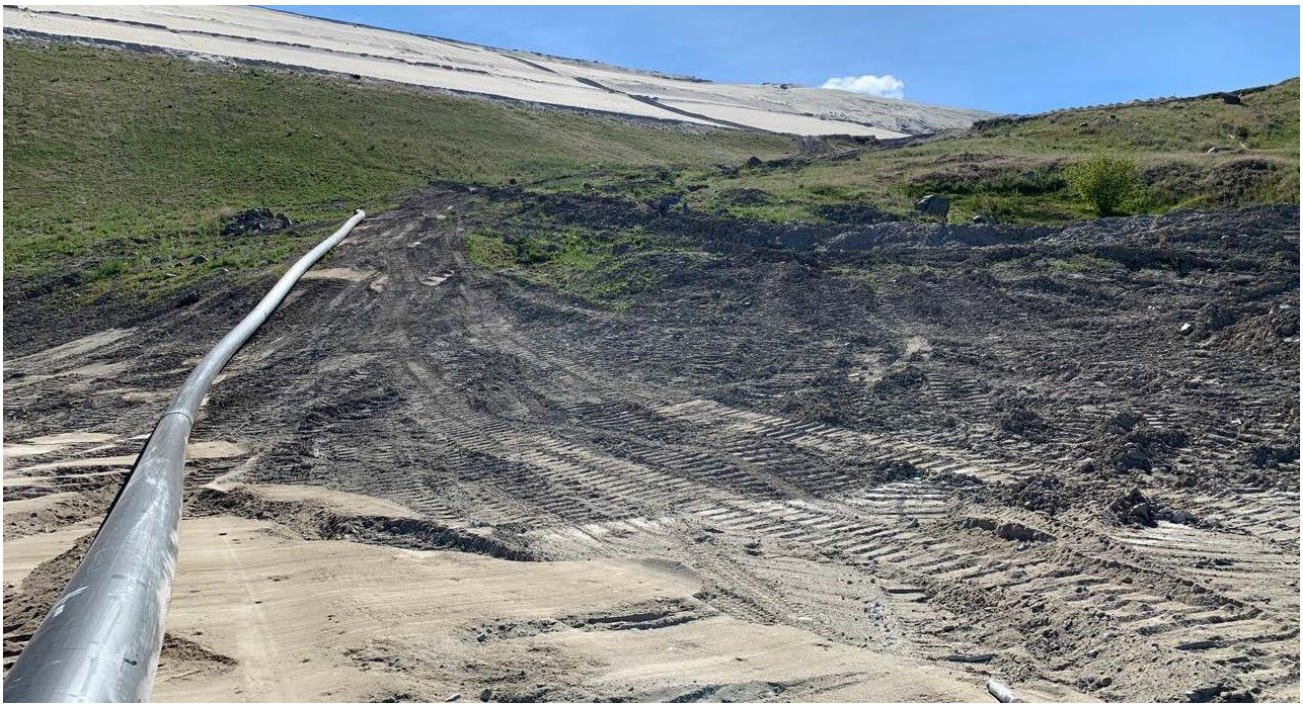


Photo II-A-20 Tailings beach overview – Looking North (LL-2019-13)

Photo II-A-21 Discharge pipes from secondary cyclone near Sta 2+200 (LL-2019-13)

Photo II-A-22 Washout prior to the site visit (around Sta. 2+200) which has been prepped to be rebuilt with hydraulic sand placement (LL-2019-13)

Photo II-A-23 Overview of South Dam beach and crest (LL-2019-14)

Photo II-A-24 Overview of L-L Dam tailings pond, beach and crest from South Abutment (LL-2019-14)

Photo II-A-25 Overview of tailings pond – Looking North from ~ 1200 m upstream of L-L Dam (LL-2019-15)

Photo II-A-26 Overview of L-L Dam tailings pond. Looking downstream from Woods Creek Diversion collection point (LL-2019-16)

Photo II-A-27 Overview of Slimes Pond 1 (LL-2019-11)

Photo II-A-28 Overview of Slimes Pond 4 and SWRP (LL-2019-17)

Photo II-A-29 Overview of Slimes Pond 3 Excavation (LL-2019-11)

Photo II-A-30 Overview of Seepage Water Reclaim Pond (SWRP) Area (LL-2019-11)

Photo II-A-31 Slimes from hydraulic cell placement discharging into Slimes Pond 1. (LL-2019-18)

Photo II-A-32 Slimes Pond 1 berm downstream slope near SWRP (looking south). Water levels elevated as pump was shut down temporarily. (LL-2019-18)

Photo II-A-33 Slimes Pond 1 berm downstream slope near SWRP (looking north). Filter gravel placed over D/S face near outlet (LL-2019-18)

Photo II-A-34 Overview of Slimes Pond 1 containment berm crest near SWRP (LL-2019-18)

Photo II-A-35 Slimes Pond 1 upstream slope (LL-2019-18)

Photo II-A-36 Slimes Pond 1 – overview of slimes cone that develops near discharge. (LL-2019-12)

Photo II-A-37 Overview of Seepage Pond 2 - dredging is ongoing (LL-2019-10)

Photo II-A-38 Overview of Seepage Pond 2 and Slimes Pond 2; Looking West (LL-2019-10)

Photo II-A-39 VBBE Major Drain daylight and weir (LL-2019-19)

Photo II-A-40 Woods Creek Diversion collection point (LL-2019-20)

APPENDIX II-B

H-H Dam Photographs

Appendix II-B
Visual Observations and Inspection Photograph – H-H Dam

VISUAL OBSERVATIONS

Crest

Good physical condition; no visual indicators of concern. There was no ongoing construction activity at H-H Dam crest during the inspection. Surficial cracking that was observed on the crest, upstream of the core, was consistent with shallow surface cracking that is typically observed along crest. This type of cracking has been reviewed by KCB and confirmed to not be an indicator of developing any dam safety concern. Development of the cracks has been attributed to differential settlement of fill placed on tailings beach and downstream rockfill which has been placed in thick (>3 m) lifts by THVCP mining fleet. Evidence of routine monitoring of the areas by THVCP was observed (e.g. areas were staked out) and are reported during weekly surveillance reviews. (Photo II-B-1 to Photo II-B-4):

West Abutment

Good physical condition; significant erosion or excessive seepage not observed. (Photo II-B-5)

East Abutment

Good physical condition; significant erosion or excessive seepage not observed. (Photo II-B-7)

Upstream Slope / Tailings Beach

Good physical condition; no erosion of the fill or indicators or concern (e.g. sinkholes) were observed on the beach surface. Tailings deposition spigot, upstream of East Abutment, was discharging on the upstream side of an existing tailings cone; as a result all no slurry flow was towards L-L Dam with no flow near the H-H Dam face. Wet area in low point of tailings beach near H-H Dam was observed during the inspection which was related to surface runoff. (Photo II-B-7, to Photo II-B-10)

Downstream Slope

No observed dam safety issues of concern (e.g. slumping, cracking or large scour). Placement of a waste platform, by THVCP mining fleet, that will extend between Sta. 1+950 to I-9 Dump was in progress during site visit. This waste was placed to support dam stability at a future crest height. No influence of placement on the dam was measured or observed. (Photo II-B-6, Photo II-B-11 and Photo II-B-14)

Lock-Block Retaining Wall

Generally good physical condition. Instrumentation installed in 2017 (survey prisms, 1x VWP, 1x inclinometer and 1x Sondex settlement system) to monitor global stability of the dam in this area remain operational. (Photo II-B-7)

Seepage

No seepage was observed at the toe of the H-H Dam.

24 Mile Lake

No observed issues of concern with potential to impact H-H Dam were observed. In 2019, THVCP began placing waste cap over the majority of 24 Mile Lake tailings surface but this was after the DSI inspection visit. A portion of the area, south end (i.e. furthest from H-H Dam), is being left open as a spoils area for tailings flushed from H-H Pumphouse. (Photo II-B-13, and Photo II-B-14)

INSPECTION PHOTOGRAPHS

LEGEND:

- HH = H-H Dam.
- HH-2019-## refers to 2019 Dam Safety Inspection View Points shown on Figure 4 of main report.
- All photographs taken during inspection on June 11, 2019.

Photo II-B-1 H-H Dam crest with core zone and tailings beach – View from West Abutment (HH-2019-01)

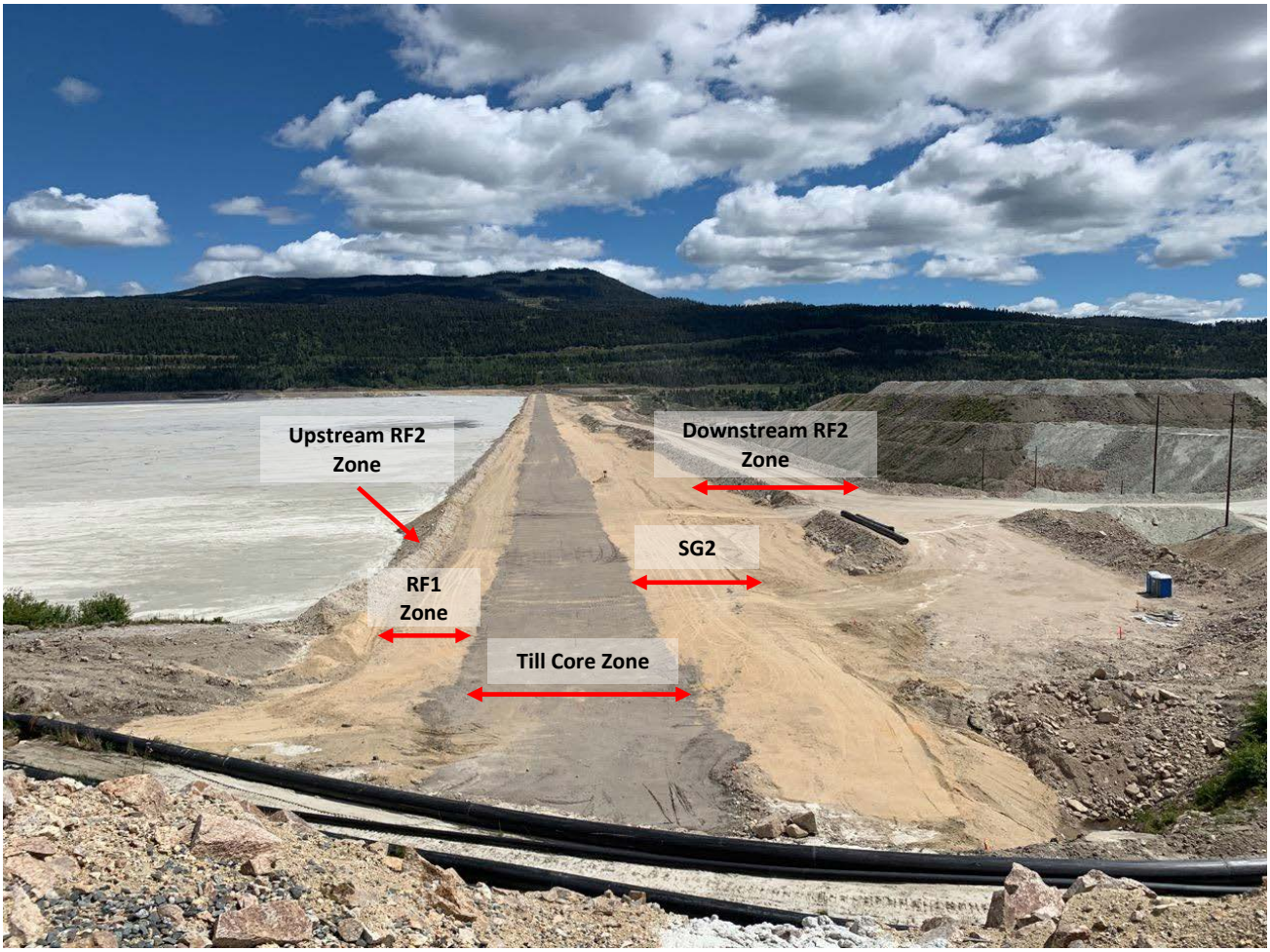


Photo II-B-2 Cracking upstream of and parallel to core zone – Type of cracking is typical and related to differential settlement of the dam fill placed on the tailings beach. Area has been staked by THVCP for monitoring. No cracking has been observed downstream of core zone along crest. (HH-2019-02)

Photo II-B-3 Additional cracking, similar to those described in Photo II-B-2 (HH-2019-03)

Photo II-B-4 Additional cracking, similar to those described in Photo II-B-2 and Photo II-B-3 marked with stakes by THVCP (HH-2019-04)

Photo II-B-5 West Abutment core zone tie-in (HH-2019-05)

Photo II-B-6 Overview of the crest and downstream slope from East Abutment– 2019 dam crest raise has not started yet. (HH-2019-06)

Photo II-B-7 Overview of East Abutment and upstream tailings beach (HH-2019-06)

Photo II-B-8 Wet area in low point of tailings beach near H-H Dam, likely related to surface runoff (HH-2019-07)

Photo II-B-9 Active spigot point (~200 m) upstream of H-H Dam away from the dam (HH-2019-08)

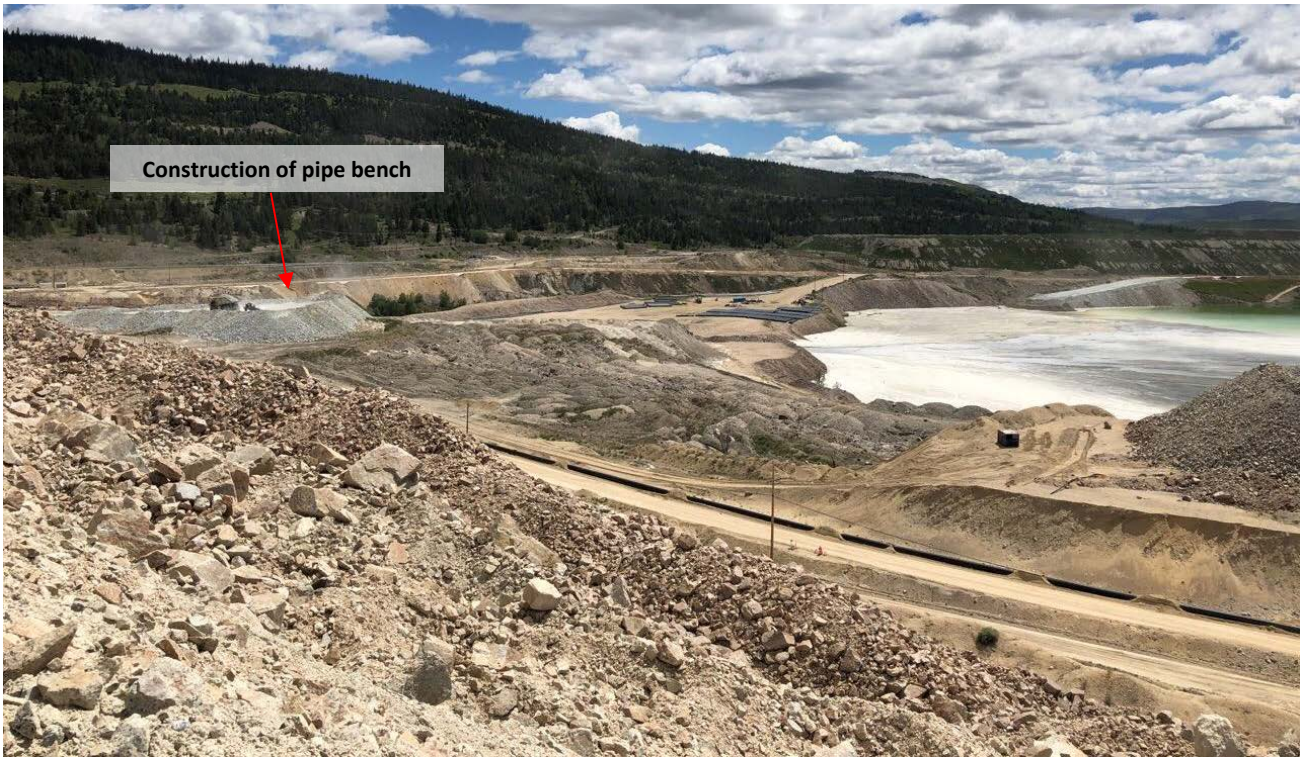
Photo II-B-10 Overview of tailings beach from ~400 m upstream of H-H Dam (HH-2019-07)

Photo II-B-11 Overview of H-H Dam Downstream Slope from West Abutment (HH-2019-09)

Photo II-B-12 Overview of I-9 Waste Dump and 24 Mile Lake from West Abutment (HH-2019-10)

Photo II-B-13 Overview of 24 Mile Lake (HH-2019-11)

Photo II-B-14 Construction of pipe bench by THVCP mining fleet near the H-H Tailings Pumphouse (HH-2019-11)



APPENDIX III

L-L Dam and H-H Dam Overview, History and Reference Dam Design Drawings

APPENDIX III-A

Overview

Appendix III-A
Highland TSF Overview

III-A-1 HIGHLAND TSF

III-A-1.1 Overview

The Highland Valley Copper (HVC) mine, which is operated by Teck Highland Valley Copper Partnership (THVCP), is located near Logan Lake, approximately 45 km southwest of Kamloops, in the interior of British Columbia, as shown in Figure 1 of main report. The Highland tailings storage facility (TSF) is approximately 10 km long and located approximately 6.5 km northwest of the operating mill.

Tailings are retained in the Highland TSF by the L-L Dam (west end) and H-H Dam (east end), which were constructed across either end of the Highland Valley. The H-H Dam is constructed of local borrow and waste materials from the Valley Pit, while the L-L Dam is constructed of local borrow materials, processed filter materials and cycloned tailings sand. Construction of the Highland TSF began in 1971 with the J-J Starter Dam, which was located approximately halfway between the H-H Dam and the L-L Dam. In 1972, the H-H Starter Dam was constructed, followed by the L-L Starter Dam between 1976 and 1979. By 1991, the J-J Dam was buried by tailings. A summary of design and construction history for the L-L Dam and H-H Dam are included in Appendix IV. Refer to Section III-A-2 and Section III-A-3 for an overview of each dam.

The majority of tailings have been discharged from spigots near the east and west abutments of the H-H Dam. As a result, the tailings beach slopes away from the H-H Dam towards the pond, which is approximately 7.5 km away, near the L-L Dam. No significant ponding occurs at the H-H Dam. Water from the tailings pond is reclaimed, via floating barge, back to the mill for use in processing.

In addition to L-L Dam and H-H Dam, there are several other supplementary retaining structures related to water and slimes[1] management. Design of these structures is outside of the scope of this report but the role of each in Highland TSF operations are described in relevant sections of this report. Further descriptions for the L-L Dam, H-H Dam and 24 Mile Lake are provided in subsequent sections of the report.

III-A-1.2 Tailings Distribution System

Figure III-A-1 shows the plan layout of the Highland TSF, tailings infrastructure, and spigot locations. Whole tailings from the Highland Mill are sent to the H-H Pumphouse where they are discharged at the H-H Dam or pumped to the L-L Dam via the South Side Tailings System (SSTS). The tailings may be gravity drained to 24 Mile Lake[2] under emergency or operational upset conditions. There are three pumphouses (SS1, SS2, SS3) along the SSTS between the H-H Pumphouse and the L-L Dam

[1] Slimes are tailings suspended and transported in the overflow water from the hydraulic placement cells during L-L Dam construction because the material typically comprise the finer grained fraction of the cycloned sand fill.
[2] THVCP plans on infilling 24 Mile Lake with waste rock beginning in 2019. Upset tailings storage will be accommodated adjacent to the H-H Pumphouse in a new tailings dump pond (location and design pending).

(Figure III-A-1). Discharge of whole tailings into the impoundment is possible at each of these pumphouses. Typically, SS2 (located at the H-H Dam west abutment) is utilized when disruptions prevent pumping to the L-L Dam, such as during shutdowns of the L-L Cyclone House. Starting in 2020, THVCP plans to utilize SS1 instead of SS2 under these conditions; however, the spigot point remains the same as both discharge near the H-H Dam west abutment (Point G).

The SSTS conveys tailings to the L-L Cyclone House where the primary cyclones separate whole tailings into overflow (fine fraction, primarily silt sizes) and underflow (coarse fraction, primarily sand sizes). The primary overflow is discharged into the impoundment while primary underflow is either used for upstream hydraulic cell construction, sent to the on-dam secondary cyclones, or discharged into the impoundment. Underflow from the secondary cyclones is used for downstream hydraulic cell construction while the overflow is discharged into the impoundment.

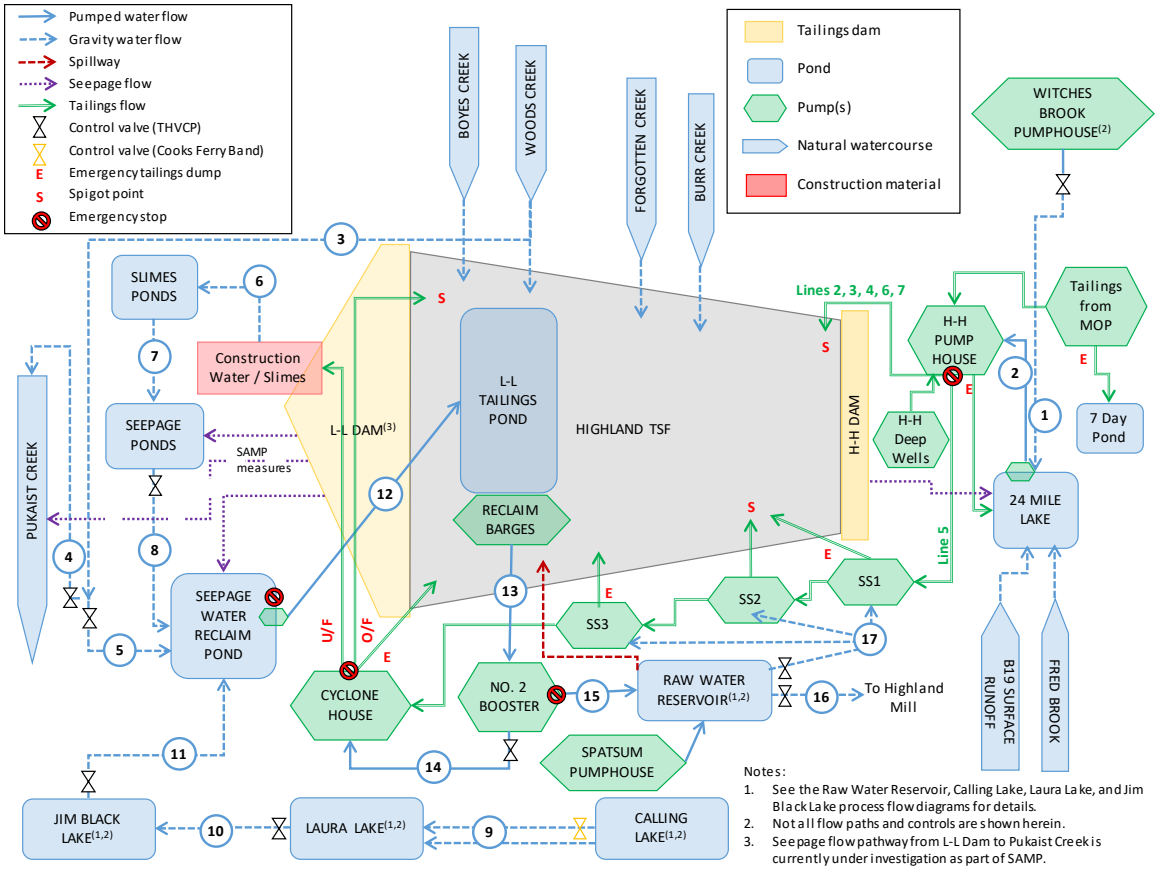
Figure III-A-1 Plan View of Highland TSF Tailings Distribution System

III-A-1.3 Water Balance

THVCP manages and tracks the annual water balance for the Highland TSF, is summarized below and shown graphically on Figure III-A-2. THVCP considers the water balance model to be performing well:

- Inflows include water from tailings slurry, precipitation on the pond, seepage return water pumped from the Seepage Water Reclaim Pond, seepage return water pumped from 24 Mile Lake, surface runoff from surrounding catchments, and inflows from Boyes Creek, Burr Creek, and Forgotten Creek all located on the northern side of the TSF:
  - A portion of flow from Woods Creek are now diverted away from the Highland TSF into Pukiast Creek downstream of the L-L Dam via the Woods Creek Diversion Scheme, which is part of the Pukiast Creek Sulphate Adaptive Management Plan (THVCP 2017).
- Outflows include seepage from both dams, reclaim water from two reclaim barges located on the south side of the impoundment near the L-L Dam which is pumped to the Raw Water Reservoir for reclaim to the Highland Mill and evaporation. The Highland TSF has no spillway and is designed to store the environmental design flood (EDF) and inflow design flood (IDF); refer to Section 4.2 of main report.

Figure III-A-2 Water Balance Flow Schematic of Highland TSF



No.	Name	Description	Status
1	Roman Road Pipeline	1x 20" HDPE pipeline	Operational
2	Dewatering to H-H Pumphouse	1x 12" HDPE pipeline	Operational
3	Woods Creek Diversion	System consists of: i) riprap-lined collection pond below Highway 97c; ii) Pumphouse and motor control center buildings; iii) 7 km HDPE pipeline (dia. varies) to Pukaist Creek; and iv) 2x 500 mm dia. HDPE pipes with knife gate valves for discharge to either SWRP or Pukaist Creek.	Operational
4	Woods Creek Diversion to Pukaist Creek	1x 500 mm dia. HDPE pipeline with knife gate valve	Operational
5	Woods Creek Diversion to SWRP	1x 500 mm dia. HDPE pipeline with knife gate valve	Operational
6	Construction Water / Slimes to Slimes Ponds	Gravity flow of water and slimes from one or more hydraulic cyclone sand cells during construction.	Operational during construction
7	Slimes Ponds to Seepage Ponds	Slimes Pond 1 drains to SWRP, and Slimes Pond 2 drains to Seepage Pond 2.	Operational
8	Seepage Pond 2 Outlet	1x 36" dia. HDPE pipe graded upward for the first 12.1 m, then downward for the next 44 m to the SWRP with control valve	Operational
9	Low-Level Outlet and Spillway (Calling Lake)	Low-level outlet: 12" dia. HDPE pipe with control valve and submerged intake trash rack. Spillway: 12' wide channel.	Operational
10	Diversion Outlet (Laura Lake)	12" dia. HDPE pipe with control valve and intake trash rack	Operational
11	Jim Black Diversion to SWRP	Open channel with U/S y-valve	Operational
12	SWRP to TSF	2x permanent pumps in the Seepage Water Reclaim Pond pumphouse feeding 2x 18" dia. HDPE pipelines to the L-L Pond	Operational
13	Reclaim Barges	#1 and #2 Reclaim Barges on the south side of the L-L Pond	Operational
14	Bypass via Reclaim Isolation Valve	Bypass line controlled by hydraulic valve	Operational
15	Reclaim to Raw Water	2x 36" dia. HDPE pipelines from No. 2 Booster to Raw Water Reservoir	Operational
16	Raw Water to Mill	Consists of Low-Level Outlet at East Dam (2x HDPE pipelines with control valves) and #3, #4 Reclaim (2x HDPE pipelines with control valves)	Operational
17	South Side Tailings Gland Water System	1x 10" HDPE pipeline	Operational

III-A-1.4 24 Mile Lake

The 24 Mile Lake facility area, which is downstream of the H-H Dam, was formally a natural lake that is now surrounded by waste dumps with no clearly defined dam structure. The facility is physically separated from the Highland TSF by a waste dump and collects seepage from the H-H Dam as well as emergency tailings disposal from the H-H Pumphouse during periods of tailings line maintenance and/or operational upsets. The layout of the H-H Dam and 24 Mile Lake are shown in Figure 4 of main report. KCB completed an assessment (KCB 2018a) at the request of THVCP to review the potential for declassifying 24 Mile Lake facility as a "dam" under HSRC (MEM 2017), which concluded:

- There is no credible failure mode for the 24 Mile Lake containment structure, in its current configuration, that could lead to uncontrolled release of tailings or water, nor result in offsite impacts. As such, 24 Mile Lake could be declassified as a dam from a regulatory reporting perspective and continue to be managed as an appurtenance of the H-H Dam. The current stewardship roles and responsibilities should be maintained.

In 2019, THVCP began capping of 24 Mile Lake with waste rock, which is a benefit and influences dam design. An area at the south end of 24 Mile Lake will be left uncapped to provide ongoing storage for tailings spoiled from H-H Pumphouse, as required.

III-A-2 L-L DAM

III-A-2.1 Overview

The L-L Dam is a cycloned sand dam with a glacial till core that extends vertically from the glacial till starter dam (Figure III-A-3). Above El. 1220 m, a wider compacted sand zone is present between the tailings and core. The 2019 layout of the L-L Dam and associated structures is shown on Figure 2 of main report. As of the end of 2019, the crest elevation of L-L Dam is 1264.5 m, corresponding to a maximum downstream slope height of about 159.5 m (based on low point of toe at ~El. 1105 m). General construction staging of the L-L Dam at Sta. 1+850 through 2017 is shown on Figure III-A-4. Select design and construction record drawings as well as a summary timeline of key construction and design milestones for the L-L Dam is included in Appendix III-B-1.

The L-L Starter Dam has a low permeability glacial till core zone supported by zoned earthfill on the upstream and downstream sides. All fill materials were sourced from nearby borrows. There is an upstream glacial till blanket and cutoff trench connected to the core. A drainage blanket is present downstream of the glacial till core zone to control seepage during start-up and maintain low piezometric pressures in the downstream dam shell.

The starter dam was raised via the centerline method with a 15.2 m wide glacial till core zone extended vertically above the starter dam. The core zone of the raises is supported on the downstream side by a zone of hydraulically placed, compacted cycloned sand and on the upstream side by a zone of compacted cycloned sand berm (above El. 1222 m) and tailings beach (deposited beneath and upstream of the compacted cyclone sand berm).

Foundation materials govern slope stability of the L-L Dam rather than the dam fill as described in Section III-A-2.2.

The overall downstream slope, measured from the downstream edge of the crest and the downstream toe, is 2.5H:1V except for segments where foundation conditions govern the need for additional buttressing to meet the minimum FOS criteria.

Prior to fill placement, the foundation is stripped of unsuitable material down to competent foundation, typically glacial till or bedrock.

Figure III-A-3 Schematic L-L Dam Typical Design Section at VBB (Sta. 1+850)

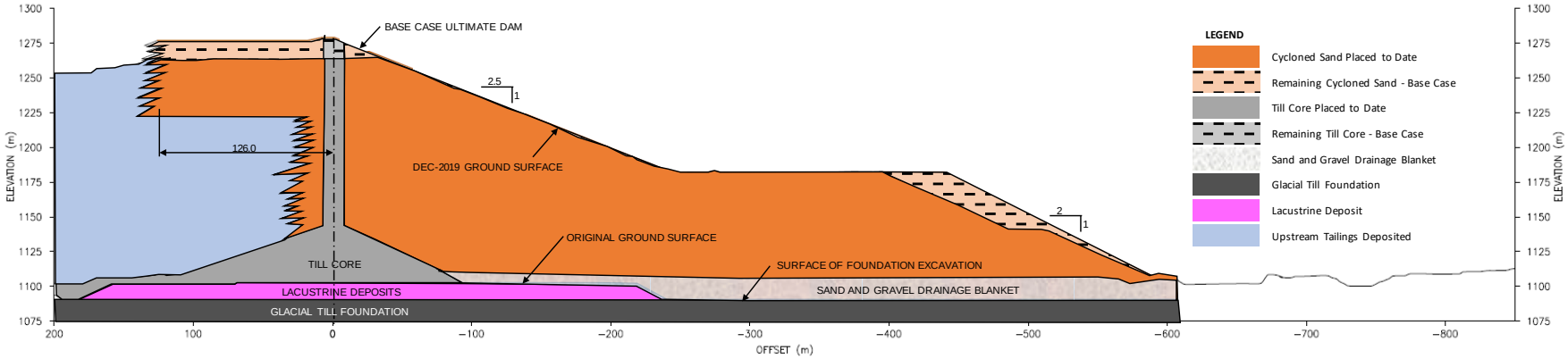
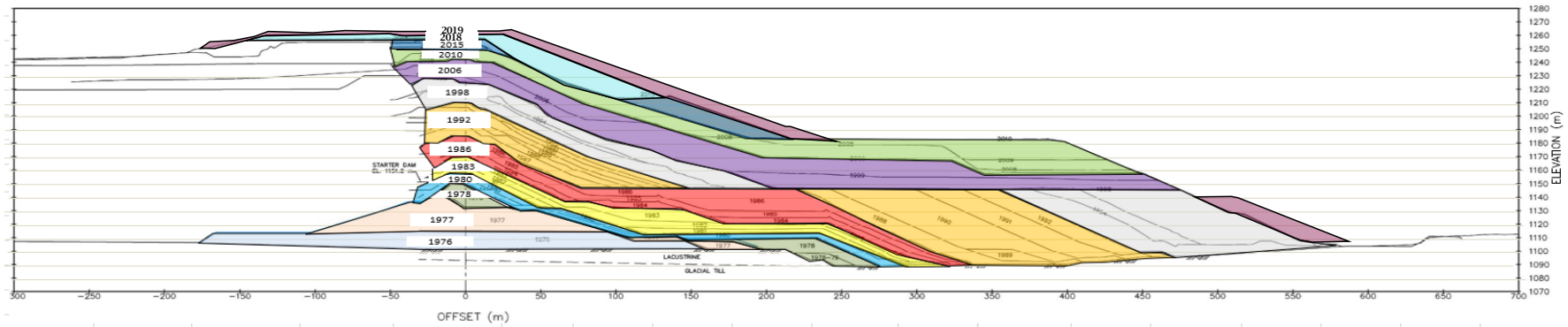


Figure III-A-4 Schematic L-L Dam Construction Sequence at VBB through 2019 (Sta. 1+850)



Note: No downstream shell fill placement in 2016 or 2017.

The prepared foundation of the downstream cycloned sand is covered with a sand and gravel blanket drain (1.5 m minimum design thickness). A network of minor and major underdrains is excavated into the blanket drain, typically north of the VBB, to increase drainage capacity. The purpose of the underdrain is to lower piezometric pressures in the downstream shell, intercept upward seepage from the natural ground, and promote downward drainage through the cycloned sand fill during hydraulic placement.

The majority of cycloned sand fill to date has been placed hydraulically in cells where compaction is achieved by a combination of downward seepage forces, vibration, and load from the tracked bulldozer that is used to distribute the sand throughout the cell during placement. Cycloned sand fill has been placed "mechanically" in near-horizontal compacted lifts in areas not amenable to hydraulic placement, such as immediately adjacent to the core zone or above underdrainage where construction water from hydraulic placement could cause damage.

An upstream compacted cycloned sand zone, 126 m (min.) wide, is present above El. 1222 m. The zone was added to the design and constructed in 2000 (KC 2000), initially to allow for steeper upstream dam slopes to facilitate the closure configuration at the time. When the design was modified to account for a mine life extension (KC 2003), the upstream cycloned sand zone was continued to meet upstream stability criteria (KC 2003). The upstream fill zone is approximately 40 m thick (vertically) at the existing dam crest.

III-A-2.2 Summary of Foundation Characterization

In general, the overburden geology beneath the L-L Dam is dominated by glacial till from the most recent glaciation, which forms a continuous sheet over the dam site. The typical stratigraphic sequence of units beneath the L-L Dam, starting from surface, are summarized in Table III-A-1.

Table III-A-1 Key Geological Units at the L-L Dam

Location	Geology Unit (from top to bottom)	Source
L-L Dam	▪ Upper Sand and Gravel Unit ▪ Lacustrine Unit ▪ Upper-Glaciolacustrine (U-GLU) Unit ▪ Upper Glacial Till Unit ▪ Lower-Glaciolacustrine Unit ▪ Lower Sand and Gravel Unit ▪ Deep Glaciolacustrine (L-GLU) Unit ▪ Lower Glacial Till / Gravel Unit ▪ Bedrock (Kamloops Group) ▪ Bedrock (Guichon Creek Granodiorite)	Appendix II-A (L-L Dam Geological and Geotechnical Site Characterization)

The foundation conditions along the length of the L-L Dam are quite variable. For design purposes, the L-L Dam has been divided into five design segments (Figure 2 of main report) based on foundation conditions: South Dam; Valley Buttress Berm (VBB); Valley Buttress Berm Extension (VBBE); North Buttress Berm (NBB); and North Dam. In 2019, the North Dam was subdivided into two zones: North

Dam Bedrock; and North Dam Upper-Glaciolacustrine (U-GLU). The geology at each dam segment and controlling foundation unit, which informed the design approach taken, are summarized below:

South Dam – South Abutment (~Sta. 0+800) to Sta. 1+600:

- Foundation mainly comprises competent glacial till overlying granodiorite bedrock.
- Stability is primarily controlled by the strength of Glacial Till.

Valley Buttress Berm (VBB) – Sta. 1+600 to Sta. 2+100:

- Foundation mainly comprises thick (90 m) sequence of glacial deposits with continuous layers of glaciolacustrine deposits.
- The L-L Starter Dam was built on top of a normally consolidated Lacustrine Unit that was present over the majority of the VBB foundation. The Lacustrine Unit governed stability of the starter dam but has been excavated from the dam foundation downstream of the L-L Starter Dam and replaced with compacted fill. At the current crest elevation, the Lacustrine Unit is sufficiently setback from the downstream toe (~300 m to 400 m) that it has a negligible influence on the overall stability of the dam in this area:
  - A glaciolacustrine layer is present, U-GLU, at the base of the Lacustrine Unit above the Glacial Till. This unit was excavated from the dam footprint and replaced with compacted fill in the same areas as the Lacustrine Unit.
- At the current and ultimate crest height, the stability is controlled by the Lower-Glaciolacustrine (L-GLU) Unit.

Valley Buttress Berm Extension (VBBE) – Sta. 2+100 to Sta. 2+400:

- Foundation transitions between the VBB and NBB as the thickness of glacial deposits reduces to the north, discontinuous layers of glaciolacustrine deposits, similar to the material in the foundation of the VBB but not continuous, are present in the foundation and govern stability.

North Buttress Berm (NBB) – Sta. 2+400 to Sta. 2+800:

- Foundation mainly comprises mixed bedrock at surface or shallow depth, between volcanic and sedimentary units of the Kamloops Group, sedimentary bedrock includes mudstone sequences.
- Stability is controlled by weak bedding planes in the high-plasticity mudstone sequences.

North Dam – Sta. 2+800 to North Abutment (~Sta. 3+900):

- North Dam Bedrock (Sta. 2+800 to 3+300) – the foundation comprises thin discontinuous glacial till overlying Volcanic and Sedimentary units of the Kamloops group. The stability in this segment is controlled by the weak shear planes in the mudstone sequence, which is similar to the NBB. However, is differentiated from the NBB because of the thick Volcanic bedrock capping above the Sedimentary unit which provides significant passive wedge resistance at the toe.

- North Dam U-GLU (Sta. 3+300 to 3+900) – the foundation comprises thicker glacial deposits compared to the North Dam Bedrock segment. The thick glacial deposits contain lenses of glaciolacustrine materials and a continuous Upper Glaciolacustrine unit (U-GLU), which generally controls stability. Where the U-GLU was present at sufficiently shallow depths for practical excavation, it has been removed from beneath the incremental dam footprint during 2018 foundation preparation.

III-A-2.3 Seepage Management

In comparison to a water retaining dam of similar height and pond level, seepage losses from the impoundment into the foundation are reduced by the presence of the low hydraulic conductivity tailings, where present. Some features of the L-L Dam are designed to limit and manage seepage as discussed below.

The compacted Glacial Till core is the primary barrier to limit seepage from the impoundment, through the dam. The glacial till core zone of the L-L Starter Dam and subsequent raises has been keyed into native ground as summarized in Table III-A-2.

Table III-A-2 Summary of L-L Dam Core Key-in to Foundation Along Crest

Stations	Summary of Core Key-in
South Abut to 1+275	Glacial Till or Bedrock (Granodiorite) - bedrock surface cleared of loose debris and weathered material - relatively thin Glacial Till overlying an uneven bedrock surface
1+275 to 1+475	Glacial Till or Bedrock (Granodiorite) - Gap in construction records (1980 to 1987) core key-in inferred based on geology
1+475 to 2+325	Glacial Till - L-L Starter Dam Foundation - cutoff trench along upstream toe keyed into Glacial Till - cutoff trench was excavated through Lacustrine
2+325 to 2+720	Glacial Till - Gap in construction records (1980 to 1987) core key-in inferred based on geology
2+720 to 3+350	Predominantly Bedrock (Volcanics) - some segments may have been keyed into surface Glacial Till deposits - much of bedrock surface was fractured and/or weathered - bedrock surface was cleaned and treated with dental concreter to fill voids, where necessary
3+350 to 3+625	Predominantly Glacial Till - some areas potentially keyed into exposed bedrock (Volcanics) or Upper-Glaciolacustrine deposits
3+625 to North Abut	Upper Sand and Gravel - excavation depth to key core into Glacial Till or Upper-Glaciolacustrine not practical due to space constraints and potential in undermine existing dam slope

The primary source of seepage through the downstream dam fill is from hydraulic placement of cycloned sand dam fill. Infiltration from precipitation, including snow melt, and flow through the core zone are also seepage sources but to lesser extent. Hydraulic placement is temporary and typically only occurs for up to eight months a year during construction.

Seepage in the downstream dam fill drains downward to the blanket or finger drains. The overall slope of natural ground promotes flow through the blanket drain towards the VBB, which is the low point of the natural valley, unless intercepted by an underdrain. This is consistent with the observed piezometric rise in the blanket drain at the VBB in response to downstream hydraulic placement at the VBB and other segments of the dam. For this reason, piezometric heads in the downstream shell, in terms of relative head above natural ground, are greatest in the VBB. Seepage from the dam toe is typically observed from the blanket drain at the VBB or from major drains.

Seepage through the foundation that is not intercepted by the dam fill or drains is managed by THVCP as part of the Sulphate Adaptive Management Plan (SAMP), which includes a network of interception wells. The design of the SAMP system assumes that the seepage management features within the L-L Dam are present but, based on hydrogeologic modelling, the performance and operation of SAMP does not significantly impact piezometric conditions that influence dam design or performance. Therefore, the SAMP system is not considered a design feature of the L-L Dam but is a requirement of THVCP under the conditions of the M-11 permit (EMPR 2019).

At the North Abutment, the core zone is keyed into the Upper Sand and Gravel Unit rather than Glacial Till or Bedrock (Table III-A-2). A tailings beach is relied upon to mitigate seepage from the tailings pond through the Upper Sand and Gravel Unit.

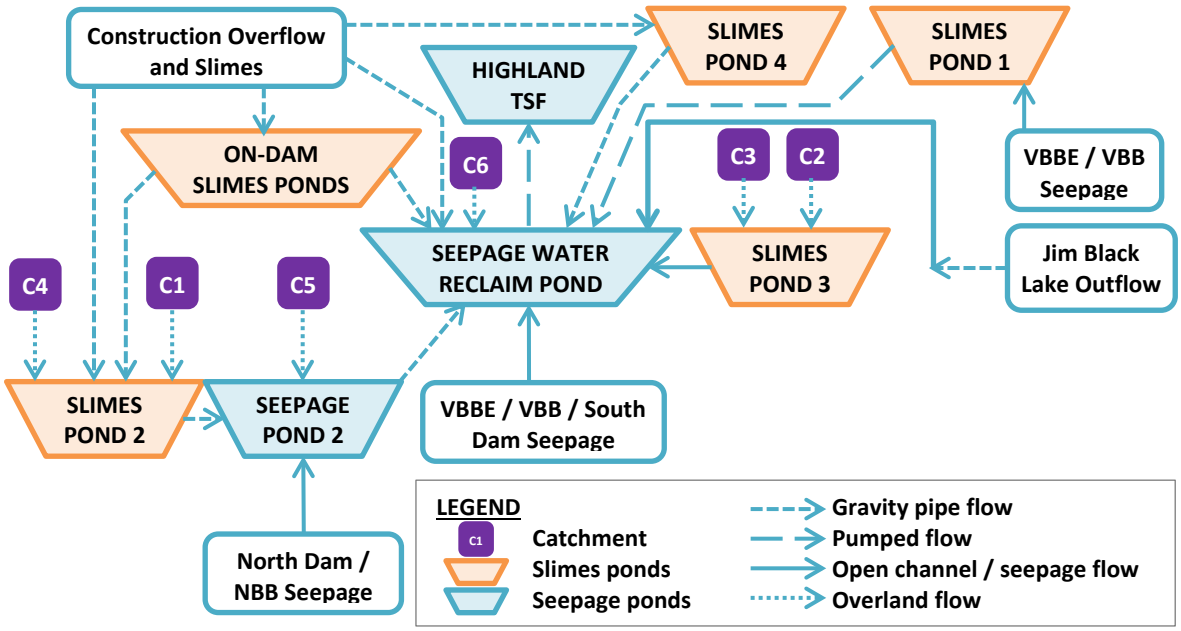
III-A-2.4 Downstream Water Management

The primary objective of downstream collection ponds (seepage and slimes) is to prevent off-site discharge of contact water, defined as any water that may be physically or chemically altered by mining activities and/or came into contact with mining areas/infrastructure. Figure III-A-5 shows the general flow schematic under existing conditions.

Seepage from the L-L Dam underdrainage system, overflow from the hydraulic placement cells, surface water runoff from the disturbed areas, and water from the SAMP interception wells report to a network of collection ponds downstream of the L-L Dam. Other relatively large catchments (Highway 97C, Jim Black Lake) report to the collection ponds in addition to the sources around the L-L Dam. The natural topography downstream of the L-L Dam directs flow to the low point downstream of VBB, which is where the primary collection pond, Seepage Water Reclaim Pond (SWRP), is located. Water collected in the SWRP is pumped into the Highland TSF impoundment via pipeline, which is outside of the dam footprint and crosses the dam centreline upslope of the core at the south abutment.

SWRP relies on pumping to maintain water levels year-round. Existing pumping capacity is not adequate to route the design flood for the pond: 72-hour duration, 200-year return period. If the attenuation and pumping system capacity of the SWRP is exceeded, water would flood the adjacent area. Under this condition, THVCP operations may be impacted but water would be contained on site by the downstream mine haul road (El. 1108 m) and would not result in discharge off-site. To date, under existing conditions, floods have been managed without water cresting out of the SWRP onto the adjacent area.

Figure III-A-5 Flow Schematic Downstream of L-L Dam – Existing Conditions



Notes:
Slimes Pond 3 is under construction at the time of this report. The pond has been partially excavated and receives runoff from upstream catchments that report to SWRP.

III-A-2.5 Downstream Slimes Management

The overflow water and slimes from hydraulic placement cells on the dam shell are conveyed via pipe to a designated slimes storage pond. The accumulated slimes in these ponds are periodically excavated and transported to the impoundment for disposal on an as needed basis.

Historic average slimes production ranges between 3% to 5.5% of cycloned sand volume, which has been assumed in design of slimes storage capacity. The volume of slimes generated varies based on factors such as cyclone performance and cell retention time.

Three active slimes ponds (Slimes Ponds 1, 2, and 4) are located at the downstream toe of the L-L Dam. Slimes stored in Slimes Pond 1 were removed and the basin backfilled with sand and gravel fill in 2018. A temporary slimes storage cell was excavated in the Slimes Pond 1 backfill to support construction until Slimes Pond 3 is commissioned.

In addition to downstream ponds, THVCP successfully trialed and implemented temporary on-dam slimes cells excavated into the dam fill during 2018. The concept of on-dam slimes storage is similar to existing hydraulic sand placement except no dozer is operated in the cell during placement. Overflow water from the on-dam cells are piped to a downstream collection pond. Once an on-dam cell is filled it is allowed to drain; slimes are then excavated and disposed in the impoundment. Temporary on-dam cells are the preferred slimes storage option and are used where feasible. THVCP are required to seek Engineer of Record approval before an on-dam cell can be used.

III-A-3 H-H DAM

III-A-3.1 Overview

The H-H Dam is an earthfill dam constructed of local borrow and mine pit waste materials. The dam comprises a glacial till core that extends vertically from the glacial till starter dam, supported on the upstream side by spigotted tailings and on the downstream side by waste materials from the Valley Pit. The beach tailings at H-H Dam are coarser than those present at L-L Dam because of proximity to the spigot points. The 2019 layout of the H-H Dam and associated structures is shown on Figure 4 of main report. As of the end of 2019, the crest elevation of H-H Dam ranged from El. 1273 m to 1280 m, corresponding to a maximum downstream fill thickness (measured near the dam core) of ~90 m. The downstream slope height of the dam is up to about 53 m because waste dumps placed around 24 Mile Lake have elevated the existing ground surface downstream of the dam by up to approximately 40 m.

General construction staging of the H-H Dam at Sta. 1+400 through 2016 is shown on Figure III-A-6. Select design and construction record drawings as well as a summary timeline of key construction and design milestones for the H-H Dam is included in Appendix III-B-2.

The H-H Starter Dam is a zoned earthfill structure with central low permeability core, which is supported by compacted more pervious upstream and downstream shells. A cut-off trench was excavated to connect the core fill with competent native Glacial Till. A drainage zone was constructed beneath the downstream shell to limit pore pressure build-up in the downstream shell during start-up. The drainage layers have subsequently been buried by 40 m or more of dam and waste dump material and does not daylight at existing ground surface. The downstream waste dumps extend 1.5 km downstream of the existing 24 Mile Lake.

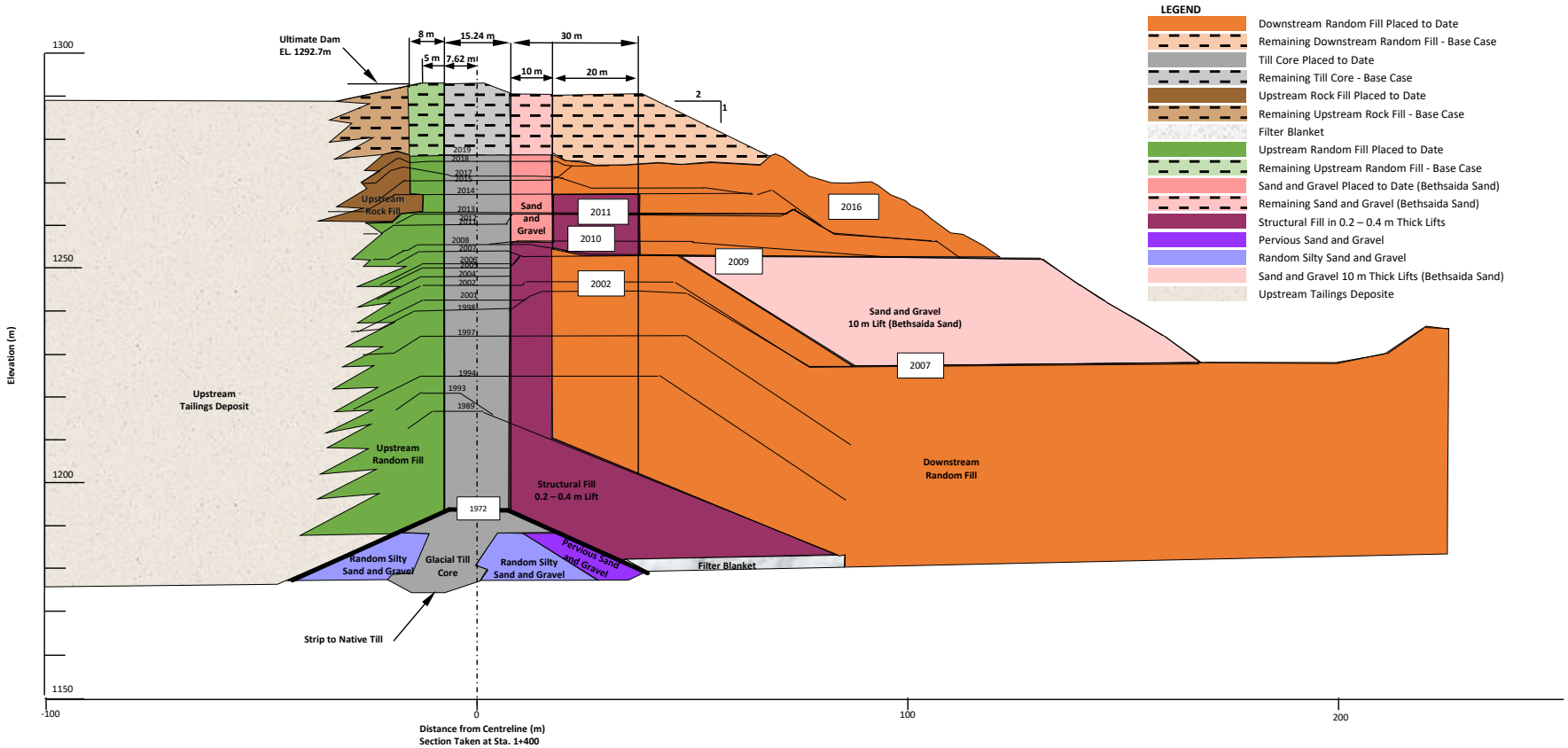
Similar to the L-L Dam, the H-H Starter Dam has been raised via the centerline method with the 15.2 m wide glacial till core zone extending vertically above the starter dam. The core zone of the raises is supported by zones of compacted fill and Random Fill that form the downstream shell, Figure III-A-6. Random fill has been placed by the THVCP mining fleet, typically in thick lifts ranging from 3 m up to 15 m. Between 2007 to 2009, the downstream Random Fill zone was constructed primarily of Bethsaida Sand, which is overburden waste from the Valley Pit (Figure III-A-6).

The H-H Dam is divided in three design segments (refer to Figure 4 of main report) based on either foundation or downstream conditions: West Segment; Mid Segment; and East Segment. Foundation conditions for each segment are discussed in Section III-A-3.2.

No overtopping concern is present at the H-H Dam because the crest is higher than the L-L Dam crest (typically ~14 m) and the tailings beach slopes away from the dam. Therefore, rather than constructing a horizontal crest, the H-H Dam crest is sloped to match the forecasted beach profile immediately upstream of the dam. The ultimate crest elevation is as follows:

- West Abutment to Sta. 1+400: El. 1292.7 m; and
- Sta. 1+400 to East Abutment: rises at 0.6% slope from El. 1297.2 to ~El. 1298 m.

Figure III-A-6 Schematic H-H Dam Design and Construction Sequence through 2019 (Sta. 1+400)



Note: Structural fill below ~El. 1216.7 m is a transition zone between Glacial Till core and downstream Random Fill.

The Base Case design added a sand and gravel filter zone between the core and Random Fill zone above El. 1255.5 m. A sand and gravel filter zone is also present below approximately El. 1217 m. The Random Fill zone is in direct contact with the core zone between these elevations. Filter compliance of this interface is discussed in Appendix VIII.

The core zone has been keyed into native glacial till or competent bedrock along the abutments. Foundation preparation beneath the downstream shell has included stripping of unsuitable surface deposits, except where the dam fill has abutted a waste dump. Foundation preparation records are not available beneath the waste dumps; however, the interface between waste dumps and native ground is sufficiently deep that it does not govern stability of the existing or ultimate structure.

III-A-3.2 Summary of Foundation Characterization

In general, the overburden geology beneath the H-H Dam is dominated by Glacial Till from the most recent glaciation, which forms a continuous sheet over the dam site. The typical stratigraphic sequence of units beneath the H-H Dam, starting from surface, are summarized in Table III-A-3.

Table III-A-3 Key Geological Units at the H-H Dam

Location	Geology Unit (from top to bottom)	Source
H-H Dam	▪ Clay Layer 1 ▪ Upper Sand and Gravel Unit ▪ Glacial Till ▪ Clay Layer 2 ▪ Lower Sand and Gravel Unit ▪ Fan Unit ▪ Unit 10 ▪ Basal Unit ▪ Bedrock (Guichon Creek Granodiorite)	Appendix II-B (H-H Dam Geological and Geotechnical Site Characterization)

The geologic conditions at the H-H Dam are not as variable as at the L-L Dam and the slope stability of the existing and ultimate dam is governed by the downstream Random Fill, not the foundation. For design, cross sections have been selected to assess the typical foundation conditions and surface profiles along the dam crest:

- West Segment (West Abutment to Sta. 1+250):
  - The I9-Dump is immediately downstream of the dam through this segment and between Sta. 0+600 to ~Sta.1+200 the top of the dump fill is equivalent to or above the existing dam crest.
  - Foundation bedrock rises towards the west abutment from approximately El. 1080 m to El. 1280 m at Sta. 0+400. The general stratigraphy is the same as through the Mid Segment but the overburden units are pinched out by bedrock as it rises to the west. At the West Abutment the bedrock surface is covered by ~10 m thick layer of Glacial Till. Clay Layer 2 is present east of ~Sta. 1+050.

- Mid Segment (Sta. 1+250 to 1+950):
  - 24 Mile Lake is immediately downstream of the dam through this segment. Existing ground between the existing dam slope and 24 Mile Lake is formed by a waste dump that is approximately 25 m to 40 m and sits atop natural ground.
  - This segment extends across the natural valley and comprises the thickest sequence of overburden. The base of the natural valley and low point of the bedrock surface is near Sta. 1+400. A clay layer is present and interpreted to extend as far east as Sta. 1+650.
- East Segment (Sta. 1+950 to East Abutment):
  - Bedrock is shallow, covered by a layer of Glacial Till up to ~10 m thick but there are some bedrock outcrops observed above El. 1280 m.

III-A-3.3 Seepage Management

Potential seepage losses at the H-H Dam are significantly reduced, relative to L-L Dam, due to the absence of a continuous pond near the dam. Seepage losses from the impoundment into the foundation at the H-H Dam, similar to the L-L Dam, are reduced by the presence of the low hydraulic conductivity tailings. Some features of the H-H Dam are designed to limit and manage seepage as discussed below.

The core zone of the H-H Starter Dam and at the abutments of subsequent raises has been keyed into native Glacial Till or competent bedrock along the length of the crest to reduce seepage losses. The function of the core is to reduce seepage losses from the impoundment through the dam. Under the existing condition, the long tailings beach (~7 km) between the dam and the pond is the primary seepage barrier and the core is preventing drain-down of the beach.

Seepage through the dam fill includes infiltration from precipitation, flow through the core zone or uplift from the foundation. Piezometric conditions in the downstream shell are governed by, and have progressively increased with, the tailings and water level in 24 Mile Lake. All seepage through the H-H Dam mixes with other seepage within the waste dump and flows south towards the Valley Pit where it is intercepted by the pit dewatering wells and pumped to the mill for reuse.

APPENDIX III-B

History

APPENDIX III-B-1

L-L Dam History

Appendix III-B-1
Summary of L-L Dam History: 1976 to 2019

III-B-1-1 DESIGN AND CONSTRUCTION HISTORY OVERVIEW

KCB completed a review of available construction and design record reports, for the period of 1976 to 2019, which are summarized in Table III-B-1-1. Select design and record drawings are attached to this appendix for reference.

The following gaps are present in the available records:

- 1980 to 1987, and
- 2005 and 2006.

The portions of the dam which were constructed during these periods have been buried under subsequent raises and are now buttressed by additional dam fill placed downstream where records are more complete. In addition, managing critical dam failure modes are not reliant solely on the portions of the dam constructed during these periods. As a result, the gaps in records do not represent a dam safety concern.

The following bullets and timeline (Figure III-B-1-1) are a consolidated summary of the design and construction history of the L-L Dam which is intended to provide an overview of key dates. The record reports (Table III-B-1-2) should be referred to for further details:

- The starter dam was constructed to El. 1151.2 m between 1976 and 1978 (KL 1978). Since then, the dam has been raised on a regular basis (typically annually).
- The first major redesign occurred with the excavation and replacement of the downstream lacustrine deposits followed by the extension of the VBB during construction of the starter dam in 1978 (KL 1988).
- Between December 1978 and March 1979, lacustrine deposits downstream of the starter dam were excavated and replaced with compacted sand and gravel fill from the ultimate dam footprint at the time.
- The Seepage Water Reclaim Pond was constructed in the 1980's.
- Slimes Pond 1 and Seepage Pond 1 were constructed in the early 1990's.
- In 1992, the initial stages of the North Buttress Berm (NBB) were constructed and design was modified based on observed performance to control foundation movements in the weaker sedimentary layers in the underlying bedrock (KL 1992, KC 1999, KCB 2018d).
- The South Buttress Berm (SBB), was added to the design in 1995 to support an upstream bend in the dam alignment (KC 1995).

- An upstream compacted cycloned sand zone was added to the design and initially constructed in 2000 (KC 2000) to allow for steeper upstream dam slopes to facilitate the closure configuration at the time. When the mine life was extended, and ultimate crest raised, the upstream cycloned sand section was continued to meet upstream stability criteria (KC 2003).
- In 2001, a Low-Level Outlet (LLO) was constructed at the south abutment of the dam (KCB 2014a). In addition, the upstream compacted cycloned sand zone was incorporated into the design.
- In 2003, dam design to increase TSF capacity was issued (KC 2003) with an ultimate L-L Dam crest up to El. 1248.7 m.
- In 2004, a Review of Component Studies of the Final Decommissioning Report was completed by Dr. Norbert Morgenstern (2004).
- In 2010, a DSR was completed by Dr. Norbert Morgenstern (Morgenstern 2010).
- Base Case design report was issued (KCB 2010) and approved under the M-11 Permit : L-L Dam crest up to El. 1279 m; and H-H Dam crest ranging from El. 1292.7 m to El. 1298 m.
- Seepage Pond 2 was constructed in 2012 (KCB 2013).
- In 2012, a DSR was completed by AMEC (AMEC 2012).
- The LLO was decommissioned by backfilling with concrete (KCB 2014a) in 2013, and in 2015 an inverted filter drain was constructed at the outlet of the decommissioned LLO to mitigate piping risks (KCB 2015).
- In 2013, the pumps in Seepage Pond 1, which controlled outflow to the Seepage Water Reclaim Pond, were removed and replaced by the installation of a gravity outlet pipe at the south end of the pond (KCB 2014b).
- The north side tailings pipeline and Cyclone House were decommissioned in 2013 as the cyclone house was becoming inundated by rising tailings level. The replacement South Side Tailings System (SSTS) and south side Cyclone House was commissioned in 2014.
- In 2014, construction of the Valley Buttress Berm Extension (VBBE) commenced, which connects the NBB to the VBB.
- Slimes Pond 2 and Slimes Pond 4 were constructed in 2014. In 2015, Slimes Pond 3 construction commenced but is not yet complete (KCB 2016b).
- There was no construction at the L-L Dam in 2015 or 2016. Construction resumed in 2017 on the next dam raise (to El. 1262.5 m).
- In 2017, a DSR was completed by Stantec (Stantec 2018).
- Permit amendment for modifications to the Base Case design at the VBB, North Dam and downstream infrastructure was submitted for approval in 2018 (KCB 2018c).

Table III-B-1-1 Review of Available Construction and Design Record Reports

Year	Crest El. (m)	Design Reports	Construction Reports	Activity Based on Available Construction Records																								Key Events and Activities
				Starter Dam			North Abutment			North Dam			NBB			VBBE			VBB			SD			South Abutment			
				Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	
1976	1100 (original ground)			x	x	x																						-Construction of starter dam at L-L axis
1977	1146	L-L Starter Dam Design (1976)	Completion Report - Tailings Starter Dam at Axis L-L	x	x	x																						-Construction of starter dam at L-L axis
1978	1151.2	Information for Review of L-L Dam	1978-1979 LU Excavation and Structural Backfill	x	x	x																						-Excavation of unsuitable material and placement of sand/gravel backfill
1979	1155.2		As-Built Construction Report - 1978-1979 Excavation and Structural Backfill	x	x																							-Excavation of unsuitable material and placement of sand/gravel backfill -No record report available for crest raise.
1988	1196	Design Report Vol I to IV (1988)	Summary of Construction Activities (1988-1995) (Additional detailed construction documents exist during this period for specific years)				x	x	x					x						x						x	x	x	-No specification of till placement - assumed entire dam -Dam crest raise of Till Core -Continue foundation prep. and expansion on N. and S. Abutments -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -u/s hydraulic Sand placement
1989	1200						x	x	x											x						x	x	-Worker strike at HVC -Till placement along entire dam referenced -Dam crest raise of Till Core -Continue foundation prep. and expansion on N. and S. Abutments -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -d/s hydraulic sand placement -u/s tailings beach construction
1990	1203						x	x	x				x	x	x	x			x						x	x	x	-Dam crest raise of Till Core -Continue foundation prep. and expansion on N. and S. Abutments -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -Sand and gravel drainage blankets placed at both abutments -u/s and d/s hydraulic sand placed
1991	1206.6						x	x	x				x	x	x	x									x	x	x	-Dam crest raise of Till Core -Continue foundation prep. and expansion on N. and S. Abutments -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -Sand and gravel drainage blankets placed at both abutments -d/s hydraulic sand placement -First movements observed in NBB
1992	1210.2	L-L Tailings Dam - North Abutment Update (1992)					x	x	x	x			x	x	x				x						x		x	-Dam crest raise of Till Core -Continue foundation prep. and expansion on N. and S. Abutments -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -Sand and gravel drainage blankets placed at both abutments -u/s and d/s hydraulic sand placement -Start of NBB construction - foundation prep., and subsequent sand placement

Year	Crest El. (m)	Design Reports	Construction Reports	Activity Based on Available Construction Records																								Key Events and Activities
				Starter Dam			North Abutment			North Dam			NBB			VBBE			VBB			SD			South Abutment			
				Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	
1993	1213.5							x	x	x	x		x	x	x				x								x	x	
1994	1217.2							x		x	x		x	x					x								x		
1995	1220.5	Proposed Modification of Dam Axis at the L-L Dam South Abutment (1995)						x		x	x	x	x	x	x				x	x		x	x				x		-Dam crest raise of Till Core -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -Sand and gravel drainage blankets placed at both abutments -u/s and d/s hydraulic sand placement of -Till Core -Work on Saddle Dam (including prep. and placement as above) -Foundation prep. for NBB -CANLEX field work
1996			1996 Construction Inspection Report				x	x		x	x		x	x		x	x		x	x		x	x		x	x			-Dam crest raise of Till Core -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -Repair slope erosion -Foundation prep. and expansion on N. and S. Abutments -Foundation prep. for NBB, Saddle Dam and Volcanic Knoll -u/s and d/s sand placement
1997	1226.8		1997 Construction Notes - L-L Dam and H-H Dam				x	x	x	x		x		x	x	x	x			x	x					x	x	x	-Dam crest raise of Till Core -Continuing excavation of LU from valley bottom and replacing w/ sand and gravel -Repair slope erosion -Foundation prep. and expansion on N. and S. Abutments, including sand and gravel placement -Foundation prep. for NBB and Volcanic Knoll -Sand and gravel placement at Saddle Dam for finger drains -Slimes Pond excavation -Construction of N. and S. Abutment drainage ditches -u/s and d/s sand placement
1998	1226.8		1998 Construction Notes - L-L Dam and H-H Dam				x	x		x			x	x	x	x			x			x			x	x			-Dam crest raise of Till Core -Foundation prep. and expansion on N. and S. Abutments -Construction of NBB finger drains -Slimes Pond construction at VBB -Sand and gravel placement at VBB toe -u/s and d/s sand placement (including VBB, NBB and beach) -Erosion repair
1999	1229		1999 Construction Notes - L-L Dam and H-H Dam							x			x	x	x	x			x			x			x	x			-Dam crest raise of Till Core -Foundation prep. on S. Abutment -Excavation of till and OB from NBB toe -NBB finger drain construction (including PFG placement) -u/s and d/s sand placement (including beach) -Erosion repair
2000	1230.4	L-L Tailings Dam - Proposed Modification of Upstream Section (2000)	2000 Final Inspection Report							x			x	x			x		x	x		x							-Dam crest raise of Till Core -Slimes Pond excavation -Foundation prep. of NBB toe -PFG and Sand and gravel placement at NBB toe -u/s and d/s sand placement (including NBB) -Low Level Outlet (LLO) construction commenced -Erosion repair

Year	Crest El. (m)	Design Reports	Construction Reports	Activity Based on Available Construction Records																								Key Events and Activities
				Starter Dam			North Abutment			North Dam			NBB			VBBE			VBB			SD			South Abutment			
				Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	
2001	1232.8	L-L Dam Spillway and Low-Level Outlet (2001)	2001 Final Inspection Report				x	x	x	x	x		x	x		x	x		x	x		x					x	-Dam crest raise of Till Core -Slimes pond excavation -Foundation prep. of NBB toe -u/s and d/s sand placement -PFG and S+G placement at NBB -Erosion repair -Saddle Dam d/s filter and drainage placement -Continued construction of LLO, including foundation prep. and intake structure
2002	1235	L-L Dam North Abutment - 2002 Review (2003)	2002 Final Inspection Report				x	x	x	x			x	x	x	x			x			x				x	x	-Dam crest raise of Till Core -Foundation prep. at N. Abutment, Saddle Dam, NBB -Continued construction of LLO pipeline through the Till Core and through to dam toe -Till placement on VBB and Saddle Dam -u/s and d/s hydraulic sand placement (including Saddle Dam) -Foundation prep. and expansion on N. and S. Abutments -Foundation prep. of dam toe
2003	1236.6	L-L Ultimate Dam - Design Update (2003)	2003 Final Inspection Report										x	x	x				x	x		x	x			x	x	-Dam crest raise of Till Core -Slimes Pond excavation -d/s sand placement (VBB, NBB, slopes) -u/s sand placement on beach only -VBB till wrap placement -Erosion repairs
2004	1236.6	Review of Component Studies of the Final Decommissioning Report (Dr. Morgenstern, 2004)	2004 Final Inspection Report				x			x			x	x	x	x			x									-Foundation prep. for NBB toe -NBB finger drain construction -d/s hydraulic sand placement (VBB and north) -u/s hydraulic sand placement (N. dam, N. Abutment and beach) -Till wrap placement from VBB and north -Slimes Pond excavation -Production of PFG -Foundation prep. at S. Abutment -Erosion repair
2007	1243.9	L-L Ultimate Dam - Design Update for Crest Elevations 1260.6 m and 1266.5 m (2007)	2007 Construction Summary Report				x			x			x			x			x	x		x	x			x		-VBB was overbuilt. Additional fill was pushed down onto the lower levels. -Seepage erosion (1+450 to 1+575)
2008	1245.9	L-L Dam Low-Level-Outlet Intake Structure 2007 Design Update (2008)	2008 Construction Summary Report				x			x			x			x			x			x				x		
2009	1248.5	L-L Dam North Buttress Berm Extension - Foundation Drainage Design (2009)	2009 Construction Summary Report				x			x			x			x		x(NBEE)	x		x(DB)	x				x		x(DB)	-Finger drain construction at the NBBE area -Seepage erosion at S. Dam (1+270 and 1+370) -Depression on LL Dam crest (3+320) which developed tension cracks
2010	1250	Design Update for L-L Dam Crest Elevation 1279 m (2010) Safety Review of L-L Dam, Highland Tailings Facility (Dr. Morgenstern, 2010)	2010 Construction Summary Report				x			x?			x?			x	x(NBBE)	x(NBBE)	x			x				x			-Core tie- in at the S. Abutment -temp. Till placement at the S. Abutment -Minor finger drain at NBBE footprint -Repair of ice lens depression u/s of dam at 3+320 -Seepage erosion at the S. Dam toe (1+270 - 1+370), sand and S+G was placed in the eroding zones -Dam between NBB and N. Abutment was underbuilt due to the lack of d/s fill for support

Year	Crest El. (m)	Design Reports	Construction Reports	Activity Based on Available Construction Records																								Key Events and Activities
				Starter Dam			North Abutment			North Dam			NBB			VBBE			VBB			SD			South Abutment			
				Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	
2011	1253		2011 Construction Summary Report				x			x	x	x(DB)	x		x(DB)	x(NBBE 2+350-2+800)	x(NBBE)	x(DB)	x			x			x			-N. Abutment tie-in was not possible to be completed along the centerline because of location of cyclone house and utilities in the area - a till berm was constructed u/s of cyclone house -Minor Finger drain at the North Dam -Seepage at NBB at the contact of S+G DB and cyclone sand
2012	1255		2012 Construction Summary Report				x	x	x	x			x		x(DB)	x(NBBE 2+350-2+800)	x(DB)	x	x(Till Wrap)	x		x			x	x		-Core key-in at both N. and S. Abutment -Seepage Pond 2 excavation, till, S&G and liner placement -Seepage at the toe of NBB cause erosion, area was repaired
2013	1257.6	L-L Dam Valley Buttress Berm Foundation Extension and Drains Layout (2013) L-L Dam - Required Minimum Beach Width (2013) Design Update for L-L Dam Crest Elevation 1279 m South Abutment (2013)	2013 Construction Summary Report				x	x		x			x	x(S+G DB)		x	x(S+G DB)	x	x	x		x			x	x		-Core tie-in at both S. and N. Abutments -VBB Finger Drain Construction -Till wrap placement in SD slope -LLO decommissioning -Gravity outlet pipe replaces pumps in Seepage Pond 1 and Seepage Water Reclaim Pond -North side tailings pipeline and Cyclone House decommissioned
2014	1257.6	Requirements for Rock Face Treatment in Low Level Outlet Area (2014) L-L Dam North & South Abutment Tie-in (2014) L-L Dam Beach Construction (2014) L-L Dam - temporary Slimes Pond Decommissioning (2014)	2014 Construction Summary Report				x	x		x?			x	x(access rd.)		x	x	x	x?	x	x	x?	x(till wrap removal)		x(drainage blanket protection)	x	x	-Core key-in at both S. and N. Abutments (drainage blanket only) -Construction of Slimes Pond 2 -Construction of temp. Slimes Ponds -Slimes Pond 1 Slimes removal -VBBE and S. Abutment Finger Drain Construction -Till wrap removal from SD d/s face -New MOP had caused major variation in the fines content -Ponded area north of NBB -South side Cyclone House commissioned -u/s settlement crack between 1+700 and 1+900
2015	1260.5	L-L Dam North Abutment Seepage Mitigation Trade-Off Study Scoping Assessment (2015) Slimes Pond 3 Design (2015)	2015 Construction Summary Report				x	x		x			x	x	x	x	x	x	x	x(slimes Pond 3 and 4)		x			x	x	x	-Core key-in at both S. and N. Abutments -Construction of Slimes Pond 3 began -Slimes excavation and rehabilitation of Slimes Pond 4 -Construction of inverted Drain Filter Construction at SBB toe -S1 fill was not raised to the crest on d/s slope of VBB. Therefore they had to construct a temp. Core arrangements -Some underflow pipes are buried in the safety berm adjacent to the Till Core zone that must be removed

Year	Crest El. (m)	Design Reports	Construction Reports	Activity Based on Available Construction Records																											Key Events and Activities
				Starter Dam			North Abutment			North Dam			NBB			VBBE			VBB			SD			South Abutment						
				Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains	Fill	Foundation preparation	Drains				
2016	1260.5	Preliminary Assessment of Potential for Erosion of L-L Dam Toe Berm Associated with Flows from Jim Black Lake Watershed (AMEC 2016) L-L Dam Valley Buttress Berm Design Review (2016)	2016-2018 Construction Summary Report							x (depression remediation)																					-Remediation of 6 surface depression u/s S2 zone along north dam
2017	1260.5										x	X (DB)																			
2018	1262.5	L-L Dam Permit Amendment Modified Base Case and Velley Buttress Berm Contingency Case 2018 Update (2018)					x	x	X (DB, major, minor)	x	x	X (DB, major, minor)	x			x			x	x (slimes pond1/slots)	x	x	x		x (DB, minor)	x	x			-Core key-in at both S. and N. Abutments -Till Core, Mechanical and hydraulic sand placement -Till Core realignment from 0+900 to 1+981 -Temp. On-Dam Slimes Pond construction on VBBE and NBB -Excavation and backfilling of Slimes Pond 1 and Seepage Pond 1 -4 Slots cut into the divider Dyke between Seepage Pond 1 and Slimes Pond 1 -11 Slots cut through the till warp at the VBB toe. -Relocation of North Haul Road started -Ditch not completed in North dam due to arc constraint
2019	1264.5	2019 Design Update: L-L Dam and H-H Dam (2019)	2019 Construction Summary Report				x	x		x			x			x			x			x	x	x(DB)	x	x				-Core key-in at both S. and N. Abutments -Till Core, Mechanical and hydraulic sand placement -Slimes Pond 1 Temp. Slimes Storage Cell Constructed

Notes:

1. NBB = North Buttress Berm, VBBE = Valley Buttress Berm Extension, VBB = Valley Buttress Berm, DS = South Dam, NBBE = North Buttress Berm Extension, DB = Drainage Blanket, Major = Major Finger Drain, Minor = Minor Finger Drain.

Figure III-B-1-1 Timeline of L-L Dam Design, Construction, and Performance

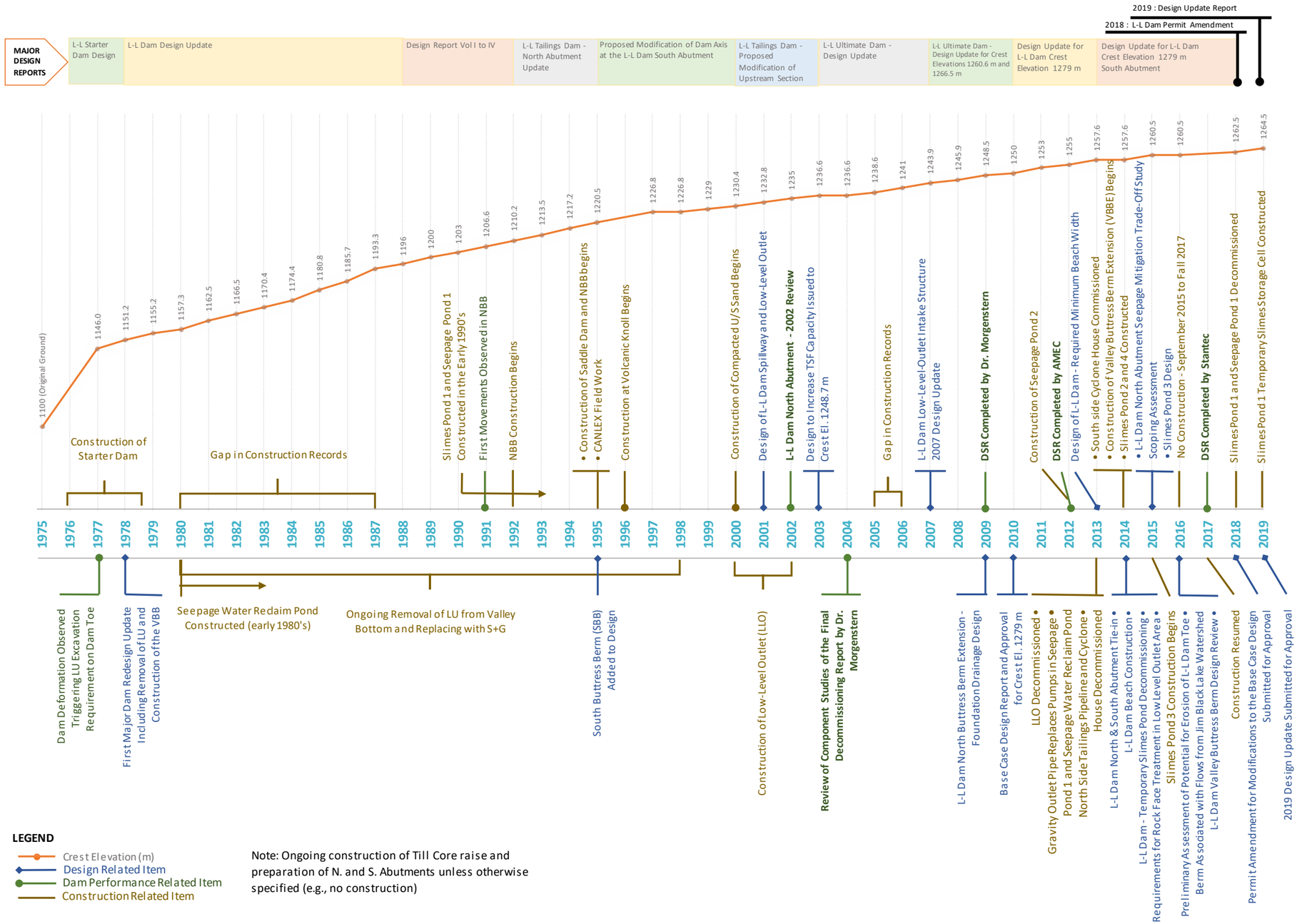


Table III-B-1-2 List of L-L Dam Construction Record and Select Design Reports

Document Title	Owner	Issue Date
L-L Starter Dam Design	Canadian Bechtel Limited	May-76
Completion Report Tailings Starter Dam at Axis L-L	Canadian Bechtel Limited	Feb-78
Information for Review of L-L Dam - Draft	Klohn Leonoff Ltd	Oct-78
1978-1979 LU Excavation and Structural Backfill- Draft	Klohn Leonoff Ltd	Oct-78
1978-1979 LU Excavation and Structural Backfill	Unknown	Sep-79
As-Built Construction Report 1978-1979 Excavation and Structural Backfill	Klohn Leonoff Ltd	May-83
1980/1981 Excavation and Backfill Drawings	Klohn Leonoff Ltd	1981
Summary of Construction Activities (1988-1995)	Highland Valley Copper?	Jan-03
Design Report Vol I to IV	Klohn Leonoff Ltd	Dec-88
1988 Construction Completion Report	Klohn Leonoff Ltd	Mar-91
1990 Construction Completion Report	Klohn Leonoff Ltd	Feb-90
1990 and 1991 Construction Notes	Klohn Leonoff Ltd	1991
1992 Construction Notes	Klohn Leonoff Ltd	1992
L-L Tailings Dam - North Abutment Update	Klohn Leonoff Ltd	Aug-92
1993 Construction Notes - HH Dam, LL Dam, Raw Water Reservoir	Klohn Leonoff Ltd	1993
1994 Construction Notes - HH Dam and LL Dam	Klohn Leonoff Ltd	Dec-94
1995 Construction Notes - HH Dam and LL Dam	Klohn Leonoff Ltd	Nov-95
Proposed Modification of Dam Axis at the L-L Dam South Abutment	Klohn-Crippen Consultants Ltd	Jun-95
Inspection Report - 1996 LL Dam and HH Dam Embankment Construction	Klohn-Crippen Consultants Ltd	1996
1997 Construction Notes - LL Dam and HH Dam - Draft	Klohn-Crippen Consultants Ltd	1997
1998 Construction Notes - LL Dam and HH Dam - Draft	Klohn-Crippen Consultants Ltd	1998
1999 Construction Notes - LL Dam and HH Dam - Draft	Klohn-Crippen Consultants Ltd	1999
2000 Final Inspection Report	Klohn-Crippen Consultants Ltd	2000
L-L Tailings Dam - Proposed Modification of Upstream Section	Klohn-Crippen Consultants Ltd	Mar-00
2001 Final Inspection Report	Klohn-Crippen Consultants Ltd	2001
L-L Dam Spillway and Low-Level Outlet	Klohn-Crippen Consultants Ltd	Jan-01
2002 Construction and Monitoring Records	Klohn-Crippen Consultants Ltd	2002
L-L Dam North Abutment - 2002 Review	Klohn-Crippen Consultants Ltd	Mar-03
2003 Final Inspection Report	Klohn-Crippen Consultants Ltd	2003
L-L Ultimate Dam - Design Update	Klohn-Crippen Consultants Ltd	Dec-03
2004 Final Inspection Report - Volume 1	Klohn-Crippen Consultants Ltd	2004
2004 Final Inspection Report - Volume 2	Klohn-Crippen Consultants Ltd	2004
Review of Component Studies of the Final Decommissioning Report	Dr. Morgenstern	Apr-04
2007 Construction Summary Report	Klohn Crippen Berger Ltd.	Oct-09
L-L Ultimate Dam - Design Update for Crest Elevations 1260.6 m and 1266.5 m	Klohn Crippen Berger Ltd.	Oct-07
L-L Dam Low-Level-Outlet Intake Structure 2007 Design Update	Klohn Crippen Berger Ltd.	Feb-08
2008 Construction Summary Report	Klohn Crippen Berger Ltd.	Oct-09

Document Title	Owner	Issue Date
2009 Construction Summary Report	Klohn Crippen Berger Ltd.	Nov-11
L-L Dam North Buttress Berm Extension - Foundation Drainage Design	Klohn Crippen Berger Ltd.	Jul-09
2010 Construction Summary Report	Klohn Crippen Berger Ltd.	Dec-11
Design Update for L-L Dam Crest Elevation 1279 m	Klohn Crippen Berger Ltd.	Sep-10
Safety Review of L-L Dam, Highland Tailings Facility	Dr. Morgenstern	
Ice Lense Removal at the L-L Dam	Klohn Crippen Berger Ltd.	Oct-11
2012 Dam Safety Review	AMEC Environment & Infrastructure (AMEC)	Dec-12
2011 Construction Summary Report	Klohn Crippen Berger Ltd.	Feb-13
2012 Construction Summary Report	Klohn Crippen Berger Ltd.	Aug-13
2013 Construction Summary Report	Klohn Crippen Berger Ltd.	Dec-14
L-L Dam Valley Buttress Berm Foundation Extension and Drains Layout	Klohn Crippen Berger Ltd.	Aug-13
L-L Dam - Required Minimum Beach Width	Klohn Crippen Berger Ltd.	Sep-13
Design Update for L-L Dam Crest Elevation 1279 m South Abutment	Klohn Crippen Berger Ltd.	Dec-13
Requirements for Rock Face Treatment in Low Level Outlet Area	Klohn Crippen Berger Ltd.	Jan-14
L-L Dam North & South Abutment Tie-in	Klohn Crippen Berger Ltd.	May-14
L-L Dam Beach Construction	Klohn Crippen Berger Ltd.	Jun-14
L-L Dam - temporary Slimes Pond Decommissioning	Klohn Crippen Berger Ltd.	Dec-14
L-L Dam Low-Level Outlet Decommissioning Construction Summary Report	Klohn Crippen Berger Ltd.	Feb-14
2014 Construction Summary Report	Klohn Crippen Berger Ltd.	Nov-15
2015 Construction Summary Report	Klohn Crippen Berger Ltd.	Jun-16
L-L Dam North Abutment Seepage Mitigation Trade-Off Study Scoping Assessment	Klohn Crippen Berger Ltd.	Jul-15
Slimes Pond 3 Design	Klohn Crippen Berger Ltd.	Jul-15
Preliminary Assessment of Potential for Erosion of L-L Dam Toe Berm Associated with Flows from Jim Black Lake Watershed	AMEC Environment & Infrastructure (AMEC)	Jul-16
L-L Dam Valley Buttress Berm Design Review	Klohn Crippen Berger Ltd.	Oct-16
2016-2018 Construction Summary Report	Klohn Crippen Berger Ltd.	Mar-19
Highland Tailings Storage Facility – 2019 Design Update: L-L Dam and H-H Dam (Final Draft)	Klohn Crippen Berger Ltd.	Nov-19
2019 Construction Summary Report	Klohn Crippen Berger Ltd.	In Progress

APPENDIX III-B-2

H-H Dam History

Appendix III-B-2
Summary of H-H Dam History: 1976 to 2019

DESIGN AND CONSTRUCTION HISTORY OVERVIEW

KCB completed a review of available construction and design record reports, for the period of 1976 to 2019, which are summarized in Table III-B-2-1. Select design and record drawings are attached to this appendix for reference.

The following gaps are present in the available records:

- 1973 to 1987; and
- 2005 to 2006.

The portions of the dam which were constructed during these periods have been buried under subsequent raises and are now buttressed by additional dam fill placed downstream where records are more complete. In addition, managing critical dam failure modes are not reliant solely on the portions of the dam constructed during these periods. As a result, the gaps in records do not represent a dam safety concern.

The following bullets and timeline (Figure III-B-2-1) are a consolidated summary of the design and construction history of the L-L Dam which is intended to provide an overview of key dates. The record reports (Table III-B-2-1) should be referred to for further details:

- H-H starter dam was constructed to El. 1193.6 m in 1972.
- Between 1972 and 2010, the upstream random fill zone was placed in lift thicknesses between 0.3 m and 0.9 m and compacted by vehicle traffic.
- Between 1987 and 1989 a foundation filter blanket was constructed and structural fill (sand and gravel) was placed directly downstream of the core in 0.2 to 0.4 lifts and compacted at a slope of 2.5H:1V .
- Starting in 1993, Random Fill downstream of the d/s Structural Fill was raised in maximum 10 m thick lifts and compacted by vehicle traffic.
- Longitudinal cracking along crest, upstream and parallel to core, has been reported since about 1995. In general, the longitudinal cracking typically occurs due to differential settlement of fill placed on or near the tailings beach. Additionally, cracking has been observed along the downstream transition structural fill which is attributed to differential settlements caused by settlement of the downstream random fill placed in thick lifts. In addition, surficial desiccation cracking has also been observed in the past.
- In 1996, localized cracks were observed in the core zone which were believed to be a response to raising the downstream fill to an elevation far exceeding the elevation of the core zone (+5 m) and not a concern for overall dam stability.

- Starting in 1997, to conserve the remaining higher plasticity Glacial Till core material in the active borrow sites, the core zone was split into two distinct zones (Zone B and Zone B1). Zone B was the upstream zone (8.24 m wide) which consisted of plastic Glacial Till. Zone B1 was directly downstream of Zone B (7 m wide) and consisted of lower plasticity Glacial Till. Although Zone B and B1 remained in the specifications, construction records indicate that after 1998, the core zone was built of Zone B only and Zone B1 was not utilized.
- From approximately 2003 to 2007, a waste dump was constructed in 10 m thick lifts downstream of the dam which was compacted by construction equipment traffic to El. 1224 m to El. 1227 m.
- Over the 2008 and 2009 construction periods, Bethsaida Sand Zone was placed in 10 m thick lifts downstream across the entire length of the dam.
- Starting in 2010 (added with the Base Case design), a 10 m wide zone of sand and gravel (referred to as SG2), was placed downstream of core to act as a filter transition between the core zone and downstream random fill.
- In 2012, a 30 m wide pit run blast rock zone was directly placed on the tailings beach immediately upstream of the dam to mitigate shallow tension cracking that were occasionally observed in the upstream random fill and core zone.
- A retaining wall was constructed upstream of the H-H Pumphouse in 2012 to maintain a minimum setback between the dam toe and pumphouse building.
- Between 2013 and 2014, the upstream random fill was split into two zones; a 5 m wide random fill zone upstream of the core zone with an upstream coarser rockfill zone sloping down to the tailings beach. The coarser outer zone (RF1) was to provide some erosion protection if tailings slurry temporarily ran along the upstream dam toe.
- In 2015, IFC specifications were modified for the upstream random fill zone, to match the downstream random fill (RF2).
- Design of the zoned till core was further adapted to a 5 m wide upstream zone (T2, >30% fines) and a 10.2 m wide downstream zone (T1, >20% fines), similar to the L-L Dam.

Table III-B-2-1 Review of Available Construction and Design Record Reports

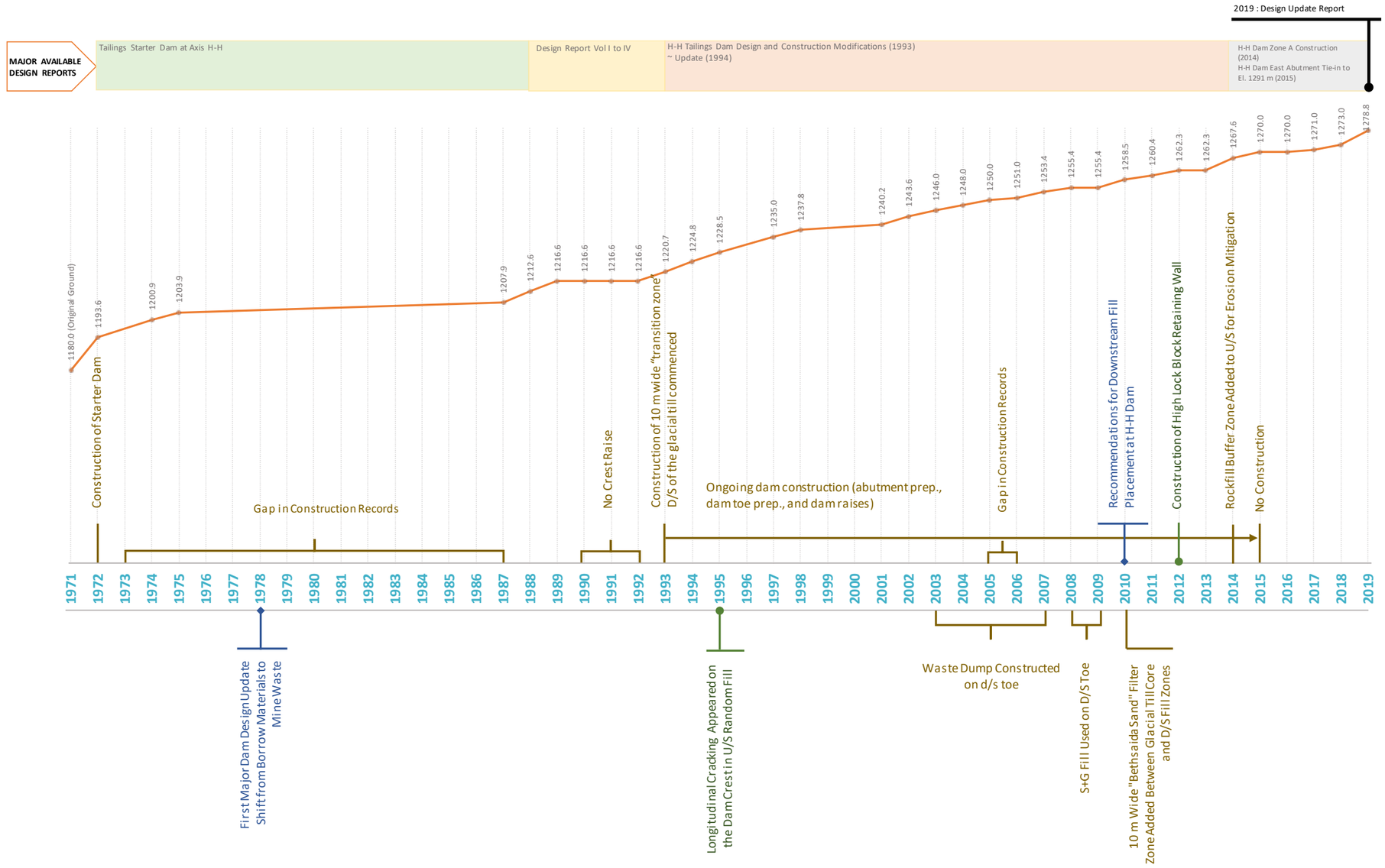
Year	Crest El. (m)[1]	Design Reports	Construction Reports	Activity Based on Available Construction Records									Key Events and Activities
				Starter Dam			West Abutment			East Abutment			
				Fill	Foundation Preparation	Drains	Fill	Foundation Preparation	Drains	Fill	Foundation Preparation	Drains	
1972	1193.6	Tailings Starter Dam at Axis H-H (1972)	Completion Report – Tailings Starter Dam at Axis H-H and 24 – Mile Lake Diversion System	X	X	X							-Construction of starter dam at H-H axis
1988	1212.6	Design Report Vol I to IV (1988)	Summary of Construction Activities (1988-1995) (Additional detailed construction documents exist during this period for specific years)				X	X		X	X		-Dam crest raise of Till Core -Foundation prep and expansion on E. and W. Abutments -Dewatering toe of dam -d/s foundation prep and fill placement -u/s RF placement
1989	1216.6						X	X	X	X	X	X	Dam crest raise of Till Core Foundation prep and expansion on E. and W. Abutments d/s foundation prep and fill placement u/s RF placement
1990	1216.6										X		-No crest raise
1991	1216.6												-No crest raise or construction
1992	1216.6												-No crest raise or construction
1993	1220.7	H-H Tailings Dam Design and Construction Modifications (1993)					X	X		X	X		-Dam crest raise of Till Core -Foundation prep on d/s toe of dam -Foundation prep and expansion on E. and W. Abutments -u/s RF placement
1994	1224.8	H-H Tailings Dam Design and Construction Modifications Update (1994)					X	X		X	X		-Dam crest raise of Till Core -Foundation prep on d/s toe of dam -Foundation prep and expansion on E. and W. Abutments -u/s RF placement
1995	1228.5						X	X		X	X		-Dam crest raise of Till Core -Foundation prep on d/s toe of dam -Foundation prep and expansion on E. and W. Abutments -d/s fill placement
1996			1996 Construction Inspection Report				X	X		X	X	X	-Dam crest raise of Till Core -Foundation prep and expansion on E. and W. Abutments -u/s RF placement -d/s Sand and Gravel placement
1997	1235		1997 Construction Notes – L-L Dam and H-H Dam				X	X		X	X		-Dam crest raise of Till Core -Foundation prep and expansion on E. and W. Abutments -u/s RF placement -d/s Sand and Gravel placement
1998	1237.8		1998 Construction Notes – L-L Dam and H-H Dam				X	X					-Dam crest raise of Till Core -Foundation prep at W. Abutment -u/s fill placement -Erosion repair
1999			1999 Construction Notes – L-L Dam and H-H Dam										-Erosion repair
2000			2000 Final Inspection Report										-Fill placement (no details)
2001	1240.2		2001 Final Inspection Report				X	X		X			-Dam crest raise of Till Core -u/s and d/s fill placement -Foundation prep of W. Abutment
2002	1243.6		2002 Final Inspection Report				X			X	X		-Dam crest raise of Till Core -Placement of u/s and d/s RF -Foundation prep for dam toe
2003	1246		2003 Final Inspection Report				X			X			-Dam crest raise of Till Core -Placement of u/s and d/s RF
2004	1248		2004 Final Inspection Report				X			X			-Dam crest raise of Till Core
2007	1253.4		2007 Construction Summary Report				x			x			-W. Abutment tie-in to the 2001 cut-off trench -E. Abutment tie-in -Waste rock was unavailable, they excavated the d/s rockfill and placed it against till for adequate support -Erosion (1+300 to 2+100) -Longitudinal cracks
2008	1255.4		2008 Construction Summary Report				x			x	x?		-Core Key-in at E. Abutment -W. Abutment cut-off trench extension was built in 2001 to the Year 2009 design crest -Shrinkage cracks on the u/s zone A RF and Zone B Till Core (1+040 to 1+975). Cracks were treated
2009	1255.4		2009 Construction Summary Report				x			x			-Waste Dump Placement
2010	1258.5		2010 Construction Summary Report				x			x			-Waste Dump Placement
2011	1260.4		2011 Construction Summary Report				x	?		x	?		-Core key-in at W. Abutment -E. Abutment tie-in was not extended because pipelines from pumphouse were not relocated
2012	1262.3		2012 Construction Summary Report				x	x		x	x		-Core tie-in at both E. and W. Abutment -Upper surface of 2011 Zone A material was ripped and recompacted.
2013	1262.3		2013 Construction Summary Report				x?			x	x		-E. Abutment Core key-in prep (temp. excavation)
2014	1267.6	H-H Dam Zone A Construction (2014)	2014 Construction Summary Report				x?	x		x?	x		-Core key-in at both W. and E. Abutments -u/s Scour protection and safety berm construction -Delta elevations raised faster than normal due to discharging all tailings at the H-H Dam -Minor cracks in the till core which was repaired before the 2014 dam raise

Year	Crest El. (m)[1]	Design Reports	Construction Reports	Activity Based on Available Construction Records									Key Events and Activities
				Starter Dam			West Abutment			East Abutment			
				Fill	Foundation Preparation	Drains	Fill	Foundation Preparation	Drains	Fill	Foundation Preparation	Drains	
2015	1270	H-H Dam East Abutment Tie-in to El. 1291 m (2015)	2015 Construction Summary Report				x			x	x		-Core tie-in at the E. Abutment -Raise between 2+000 and 2+200 was not completed due to the area obstruction by tails pipeline
2016	1270		2016-2018 Construction Summary Report				x	x					-Raised d/s crest by up to 22 m from 2016-09 -Poor compaction due to winter condition -Cracking was observed
2017	1271						x			x			-Cracking observed in SG2 zone -Crest raised between W. Abutment to E. Abutment
2018	1273						x	x		x			-Core tie-in to bedrock at the W. Abutment -Crest raised between W. Abutment to E. Abutment
2019	1278.8	2019 Design Update: L-L Dam and H-H Dam (2019)	2019 Construction Summary Report							x			-Crest raised between Sta. 0+741 to Sta. E. Abutment -Cracking observed in U/S RF2 zone

Notes:

1. Lowest crest elevation reported when crest profile is not horizontal.

Figure III-B-2-1 Timeline of H-H Dam Design, Construction, and Performance



LEGEND
- Crest Elevation (m)
- Design Related Item
- Dam Performance Related Item
- Construction Related Item

Note: Ongoing construction of Till Core raise and preparation of W. and E. Abutments unless otherwise specified (e.g., no construction)
Between 1972 and 2010, the upstream random fill zone was placed in lift thicknesses between 0.3 m and 0.9 m and compacted by vehicle traffic

Table III-B-2-2 List of Documents Reviewed

Document Title	*Owner*	*Issue Date*
Tailings Starter Dam at Axis H-H	Canadian Bechtel Limited	Jun-72
Completion Report Tailings Starter Dam at Axis H-H and 24 – Mile Lake Diversion System	Canadian Bechtel Limited	Nov-72
Summary of Construction Activities (1988-1995)	Highland Valley Copper?	Jan-03
Design Report Vol I to IV	Klohn Leonoff Ltd	Dec-88
1988 Construction Completion Report	Klohn Leonoff Ltd	Mar-91
H-H Dam 1989 As-Built Plan and Typical Section	Klohn Leonoff Ltd	Not Dated
1993 Construction Notes – HH Dam, LL Dam, Raw Water Reservoir	Klohn Leonoff Ltd	1993
H-H Tailings Dam Design and Construction Modifications	Klohn Leonoff Ltd	Feb-93
1994 Construction Notes – HH Dam and LL Dam	Klohn Leonoff Ltd	Dec-94
H-H Tailings Dam Design and Construction Modifications Update	Klohn-Crippen Consultants Ltd	May-94
1995 Construction Notes – HH Dam and LL Dam	Klohn Leonoff Ltd	Nov-95
H-H Dam Crack Repair	Klohn-Crippen Consultants Ltd	Jun-96
Inspection Report – 1996 LL Dam and HH Dam Embankment Construction	Klohn-Crippen Consultants Ltd	1996
1997 Construction Notes – LL Dam and HH Dam – Draft	Klohn-Crippen Consultants Ltd	1997
1998 Construction Notes – LL Dam and HH Dam – Draft	Klohn-Crippen Consultants Ltd	1998
1999 Construction Notes – LL Dam and HH Dam – Draft	Klohn-Crippen Consultants Ltd	1999
2000 Final Inspection Report	Klohn-Crippen Consultants Ltd	2000
2001 Final Inspection Report	Klohn-Crippen Consultants Ltd	2001
2002 Construction and Monitoring Records	Klohn-Crippen Consultants Ltd	2002
2003 Final Inspection Report	Klohn-Crippen Consultants Ltd	2003
2004 Final Inspection Report – Volume 1	Klohn-Crippen Consultants Ltd	2004
2004 Final Inspection Report – Volume 2	Klohn-Crippen Consultants Ltd	2004
2007 Construction Summary Report	Klohn Crippen Berger Ltd.	Oct-09
2008 Construction Summary Report	Klohn Crippen Berger Ltd.	Oct-09
2009 Construction Summary Report	Klohn Crippen Berger Ltd.	Nov-11
2010 Construction Summary Report	Klohn Crippen Berger Ltd.	Dec-11
Recommendations for Downstream Fill Placement at H-H Dam	Klohn Crippen Berger Ltd.	Jul-19
2011 Construction Summary Report	Klohn Crippen Berger Ltd.	Feb-13
2012 Construction Summary Report	Klohn Crippen Berger Ltd.	Aug-13
2013 Construction Summary Report	Klohn Crippen Berger Ltd.	Dec-14
2014 Construction Summary Report	Klohn Crippen Berger Ltd.	Nov-15
H-H Dam Zone A Construction	Klohn Crippen Berger Ltd.	Jun-14
2015 Construction Summary Report	Klohn Crippen Berger Ltd.	Jun-16
H-H Dam East Abutment Tie-in to El. 1291 m	Klohn Crippen Berger Ltd.	Apr-15
2016-2018 Construction Summary Report	Klohn Crippen Berger Ltd.	Mar-19
Highland Tailings Storage Facility – 2019 Design Update: L-L Dam and H-H Dam (Final Draft)	Klohn Crippen Berger Ltd.	Nov-19
2019 Construction Summary Report	Klohn Crippen Berger Ltd.	In Progress

APPENDIX III-C

Reference Drawings

Appendix III-C
Design Drawings

III-C-1 – L-L Dam

L-L Dam overview and history summary text.

Design drawings are taken from the following report:

- Klohn Crippen Berger. 2010. “Tailings Storage Facility - Ultimate Dam Crest Elevation for 2028 Mine Plan”, August 20.

List of drawings -

- Figure 4 L-L Dam General Arrangement Ultimate Dam
- Figure 9 L-L Ultimate Dam Station 1+160
- Figure 10 L-L Ultimate Dam Station 1+600
- Figure 11 L-L Ultimate Dam Station 2+000
- Figure 12 L-L Ultimate Dam Station 2+200
- Figure 13 L-L Ultimate Dam Station 2+550
- Figure 14 L-L Ultimate Dam Station 2+900
- Figure 15 L-L Ultimate Dam Station 3+200
- Figure 17 Ultimate Dam Spillway, LLO and Drainage Ditches Preliminary Arrangement – Plan
- Figure 18 Ultimate Dam Spillway and LLO Preliminary Profiles & Typ. Sections

III-C-2 – H-H Dam

H-H Dam overview and history summary text.

Design drawings are taken from the following report:

- Klohn Crippen Berger. 2010. “Tailings Storage Facility - Ultimate Dam Crest Elevation for 2028 Mine Plan”, August 20.

List of drawings -

- Figure 5 H-H Dam General Arrangement Ultimate Dam
- Figure 16 H-H Ultimate Dam Station 1+500

III-C-3 – L-L Dam Seepage and Slimes Ponds

C-3.1 – Seepage Pond 1

No design drawings available. Seepage Pond 1 was decommissioned in 2018.

C-3.2 - Seepage Pond 2

- THVCP Drawing 1011-021-SlimePond-ASB.dwg “Slimes Pond Plan and Sections”, September 2012 (as-built)
- THVCP Drawing “Seepage Pond #2 Ditch Design”, February 2014

C-3.3 – Slimes Pond 1

No design drawings available

C-3.4 – Slimes Pond 2

- Drawing No. D-74001 “Slimes Pond 2 Earthworks Plan”, Oct 2014.
- Drawing No. D-74002 “Slimes Pond 2 Cross Sections and Liner Details”, Oct 2014.
- Drawing No. D-74003 “Slimes Pond 2 Outflow Pipe and Underdrain Sump Details”, Oct 2014.
- Drawing No. D-74004 “Slimes Pond 2 Fill and Placement Specifications”, Oct 2014.

C-3.5 – Seepage Water Reclaim Pond

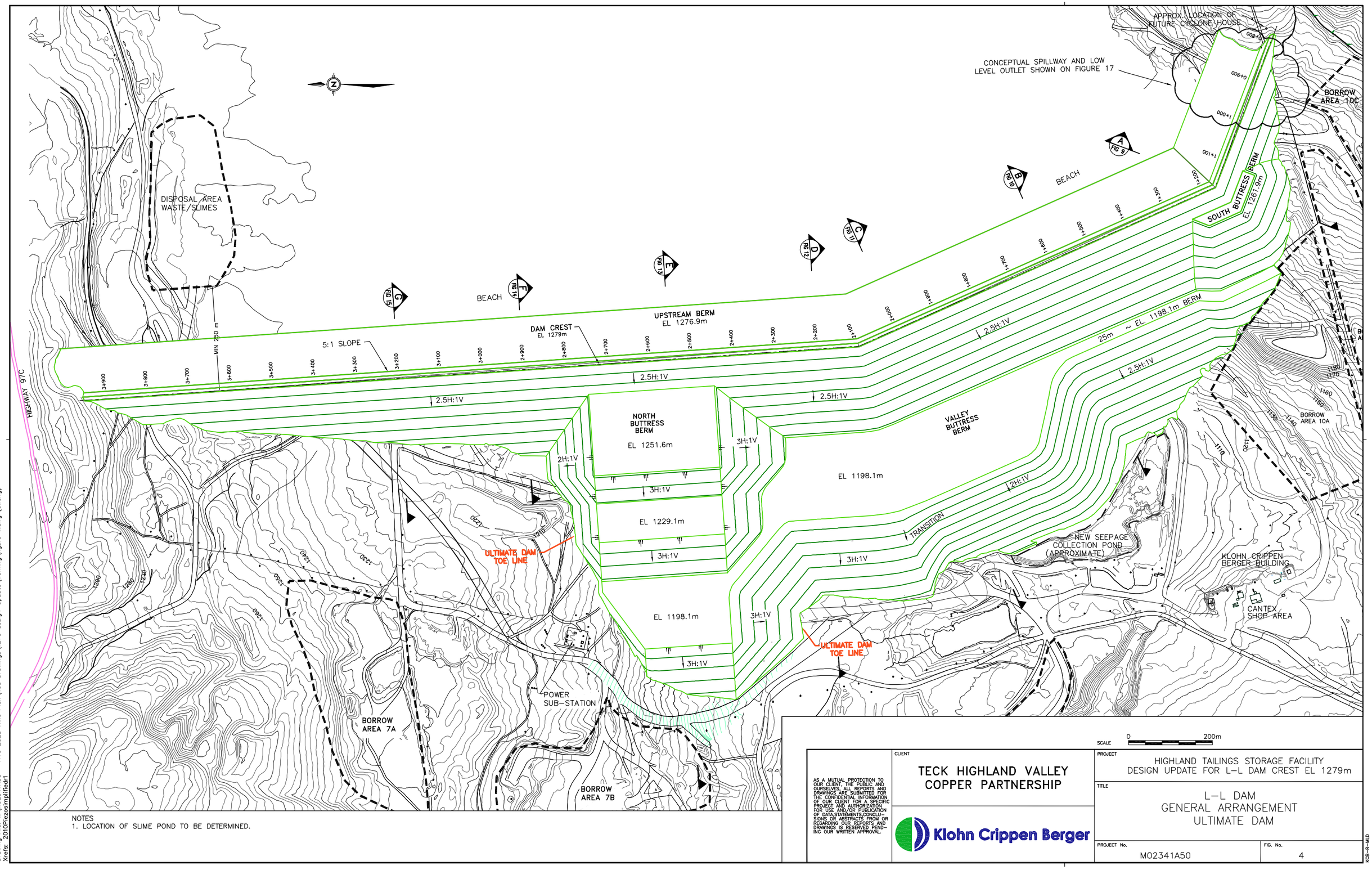
- Drawing 111-803-140 Rev 1 “Water Collection Dam L-L Axis Plan and Sections” 1977

III-C-4 – 24 Mile Lake

No design drawings available

APPENDIX III-C-1

L-L Dam



NOTES
1. LOCATION OF SLIME POND TO BE DETERMINED.

SCALE 0 200m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

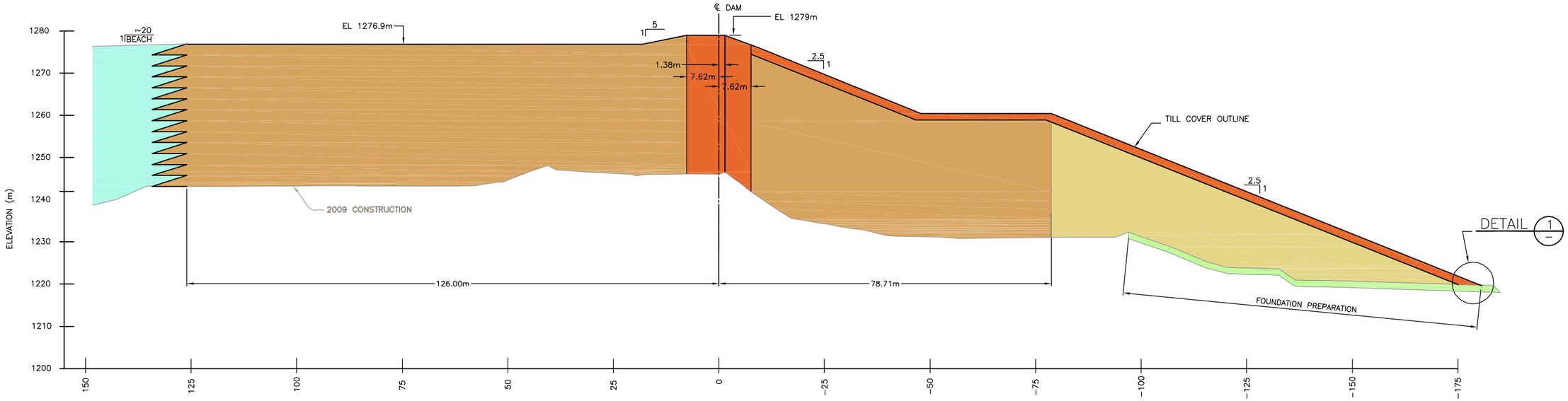
TITLE
L-L DAM
GENERAL ARRANGEMENT
ULTIMATE DAM

PROJECT No. M02341A50

FIG. No. 4

KCB-R-MLD

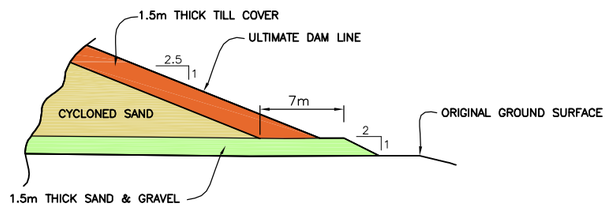
Time: 11:11:16
Date: 9/23/2010
Scale: 1=0(PS)
Drawing File: M:\M02341A50 - HVC 2028 Mine Plan\400 Drawings\1279 design-update\working\figure 4.dwg (cwong)
Xrefs: 2010Piezosimplifiedr1



SECTION TAKEN AT STN. 1+160

TYPICAL SECTION – STN. 1+110 TO STN. 1+220

SECTION A (FIG 4)



DETAIL 1
SCALE 1:500

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 50m

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CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE: L-L ULTIMATE DAM
STATION 1+160

PROJECT No. M02341A50

FIG. No. 9

Time: 15:01:11
Date: 8/31/2010
Scale: 1=5(PS)
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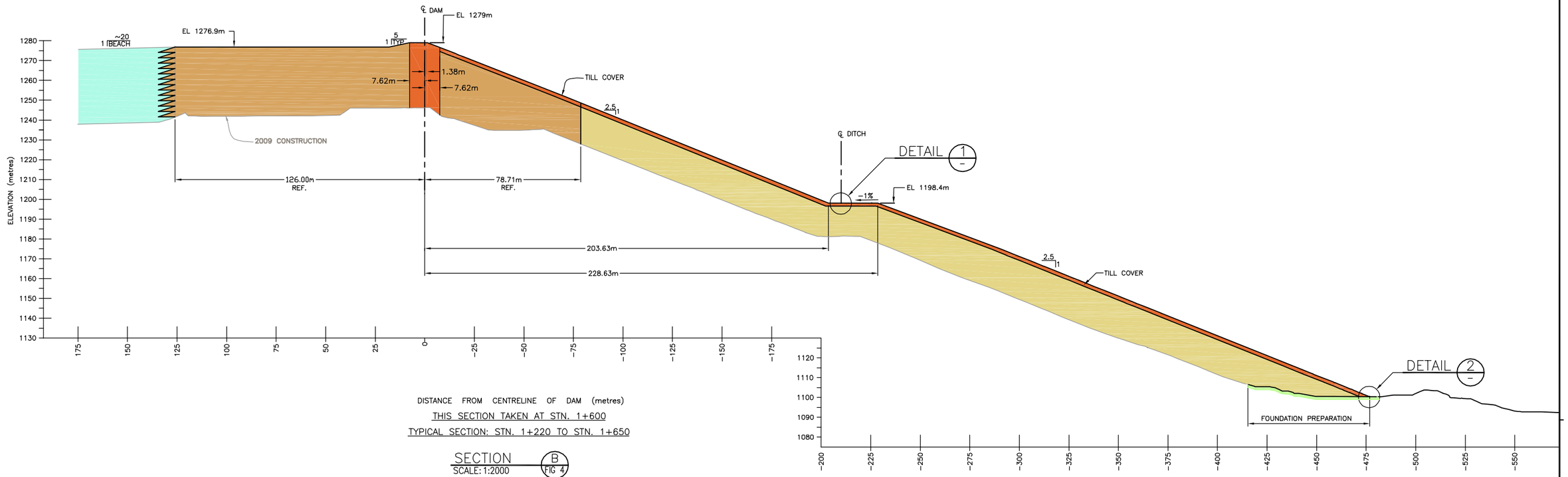
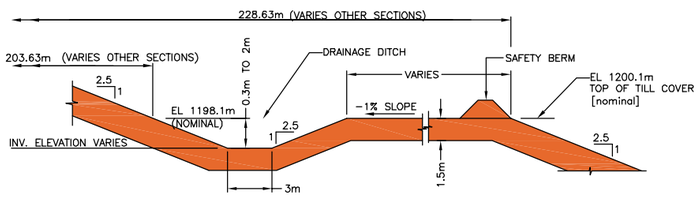


DISTANCE FROM CENTRELINE OF DAM (metres)

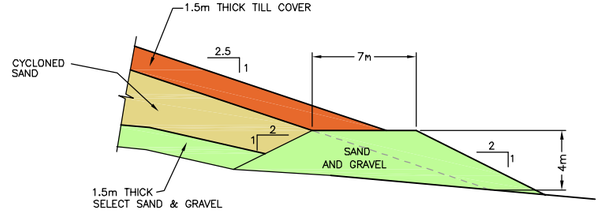
THIS SECTION TAKEN AT STN. 1+600

TYPICAL SECTION: STN. 1+220 TO STN. 1+650

SECTION B
SCALE: 1:2000 FIG 4



DETAIL 1
SCALE: 1:400



DETAIL 2
SCALE: 1:400

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 50 m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE
L-L ULTIMATE DAM
STATION 1+600

PROJECT No. M02341A50

FIG. No. 10

KCB-R-MLD

Time: 15:13:15
Date: 8/31/2010
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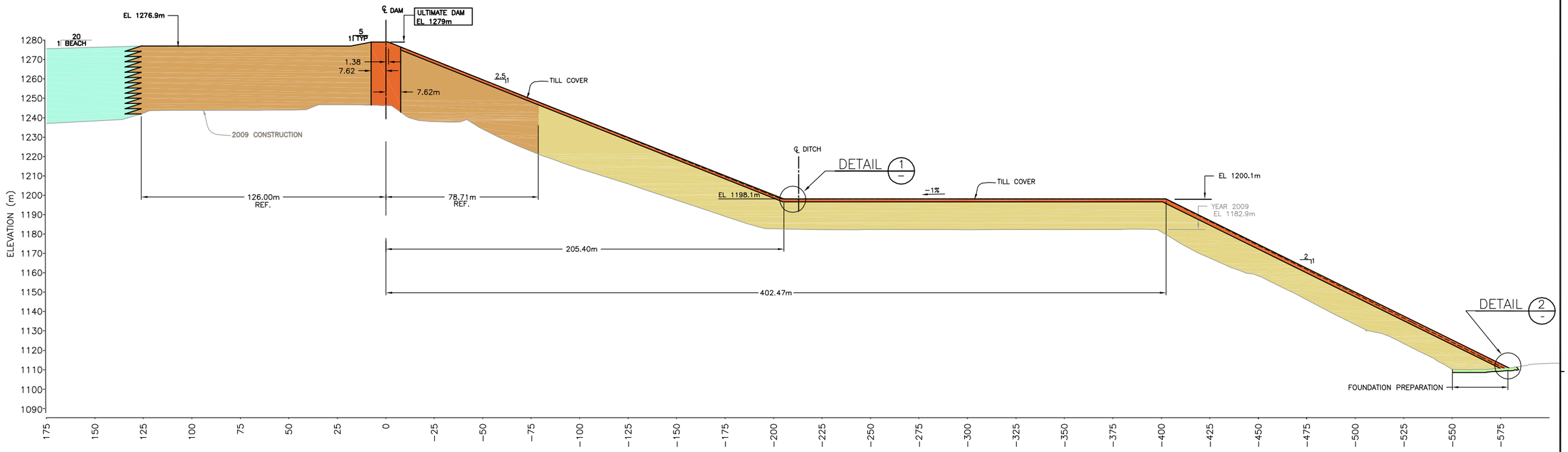
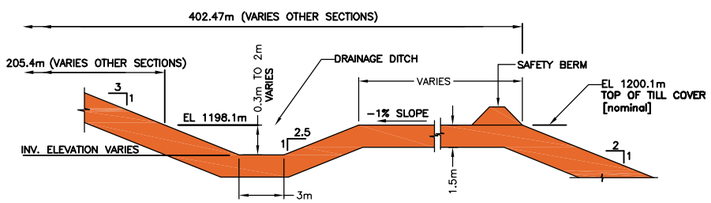
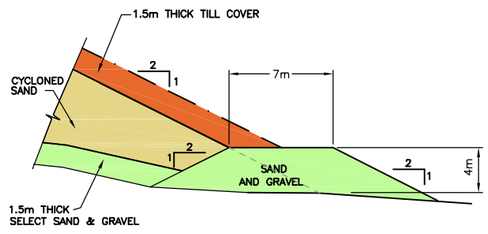


THIS SECTION TAKEN AT STN. 2+000
TYPICAL SECTION: STN. 1+650 TO 2+100

SECTION C (FIG 4)
SCALE 1:2000



DETAIL 1
SCALE 1:400



DETAIL 2
SCALE 1:400

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

0 50 m
SCALE

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE
L-L ULTIMATE DAM
STATION 2+000

PROJECT No. M02341A50

FIG. No. 11

KCB-8-MED

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Date: 8/7/2010
Scale: 1-5(PS)
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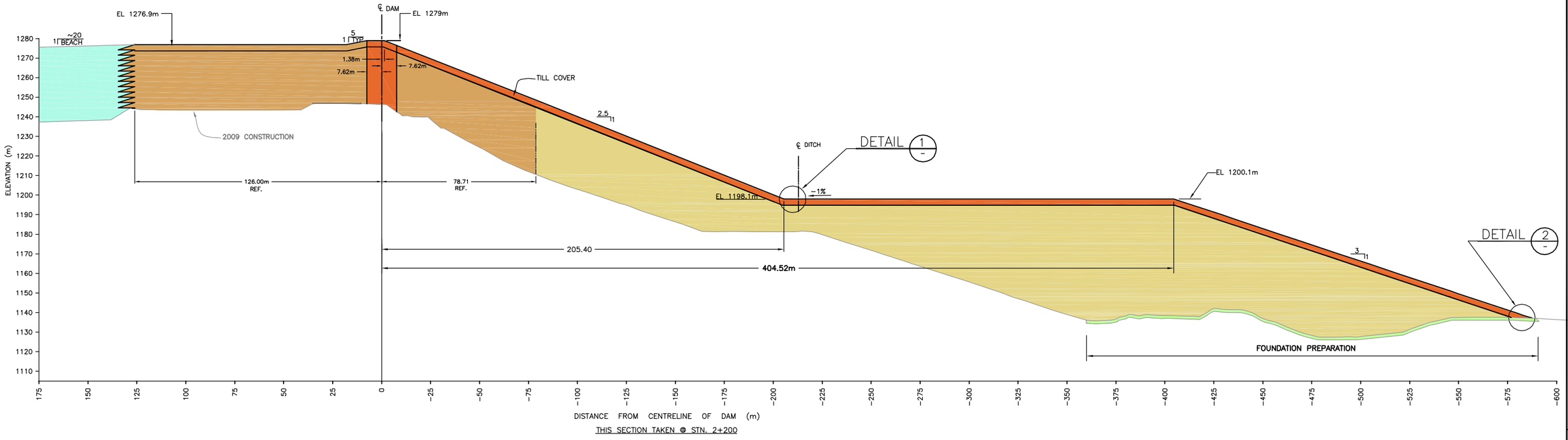
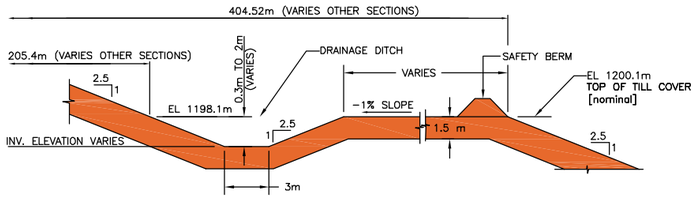


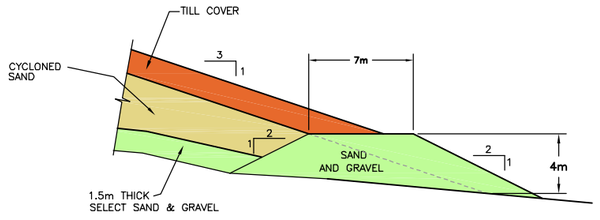
THIS SECTION TAKEN @ STN. 2+200

TYPICAL SECTION : STN. 2+100 TO STN. 2+450

SECTION D / FIG 4
SCALE: 1:2000



DETAIL 1
SCALE: 1:400



DETAIL 2
SCALE: 1:400

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 100m

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CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L–L DAM CREST EL 1279m

TITLE: L–L ULTIMATE DAM
STATION 2+200

PROJECT No. M02341A50

FIG. No. 12

KCB-4-MLD

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Date: 8/31/2010
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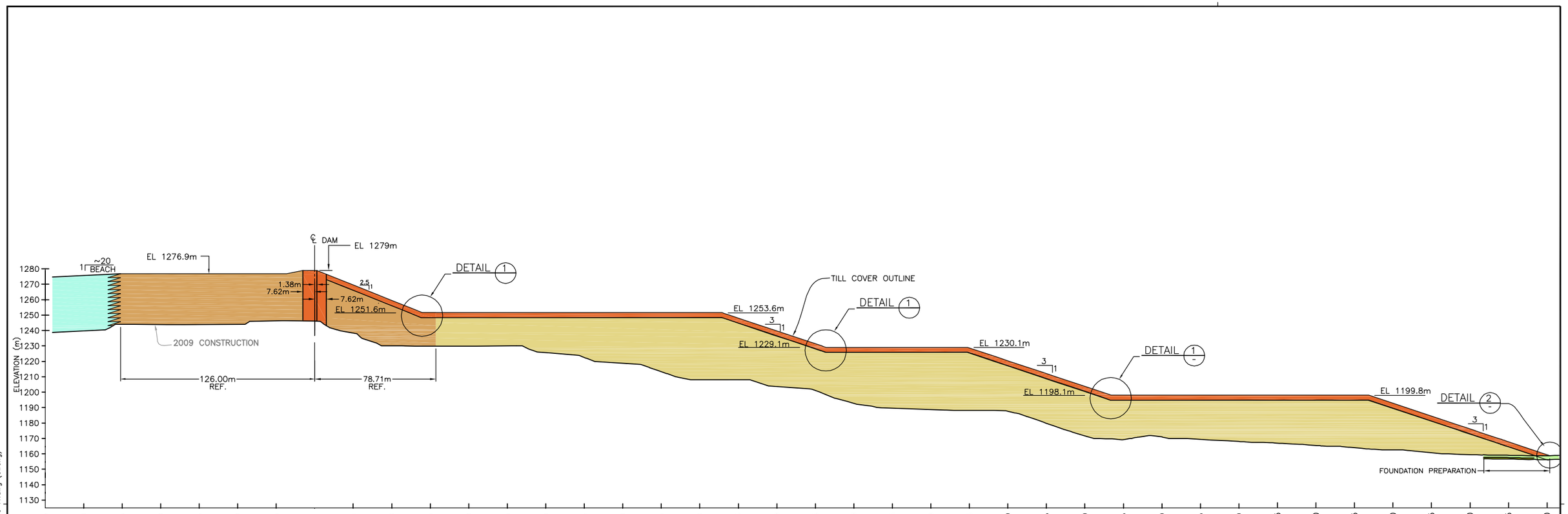
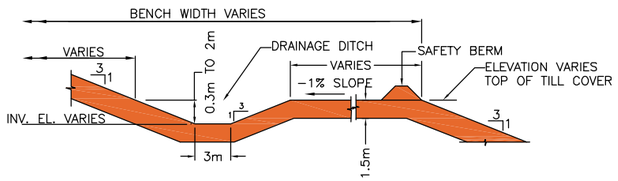


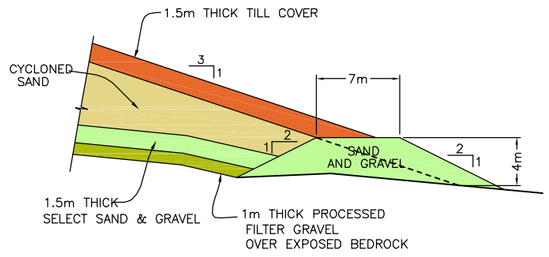
THIS SECTION TAKEN AT STN. 2+550

TYPICAL SECTION: STN. 2+450 TO STN. 2+750

SECTION E
SCALE 1:2500
FIG 4



DETAIL 1
SCALE 1:500



DETAIL 2
SCALE 1:500

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL
- PROCESSED FILTER GRAVEL

SCALE 0 100m

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

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE: L-L ULTIMATE DAM
STATION 2+550

PROJECT No. M02341A50

FIG. No. 13

KCB-R-MLD

Time: 15:28:3
Date: 8/31/2010
Scale: 1=4(PS)
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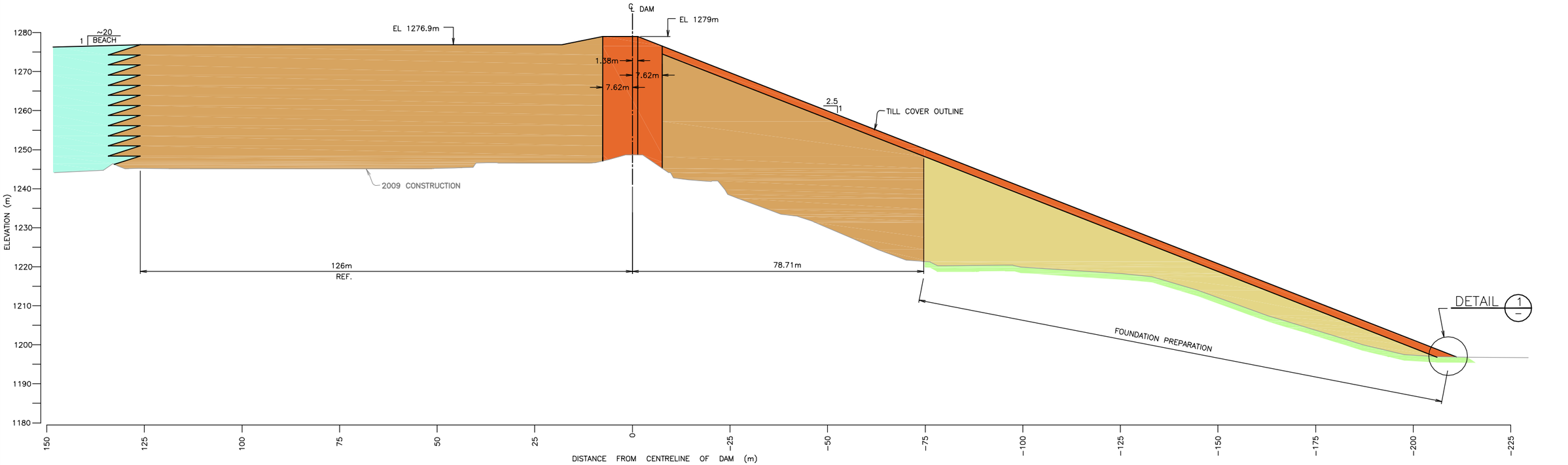
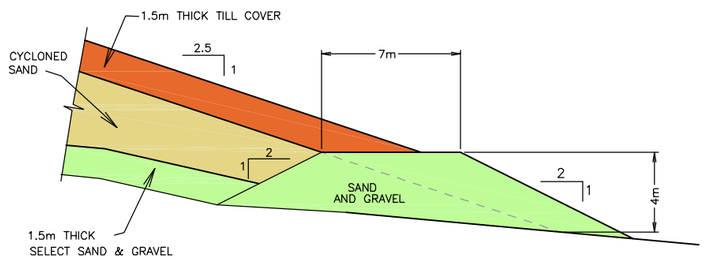


SECTION TAKEN AT STN. 2+900

TYPICAL SECTION : STN. 2+750 TO STN. 3+000

SECTION F
SCALE 1:1000 FIG 4



DETAIL 1
SCALE 1:300

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 50m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

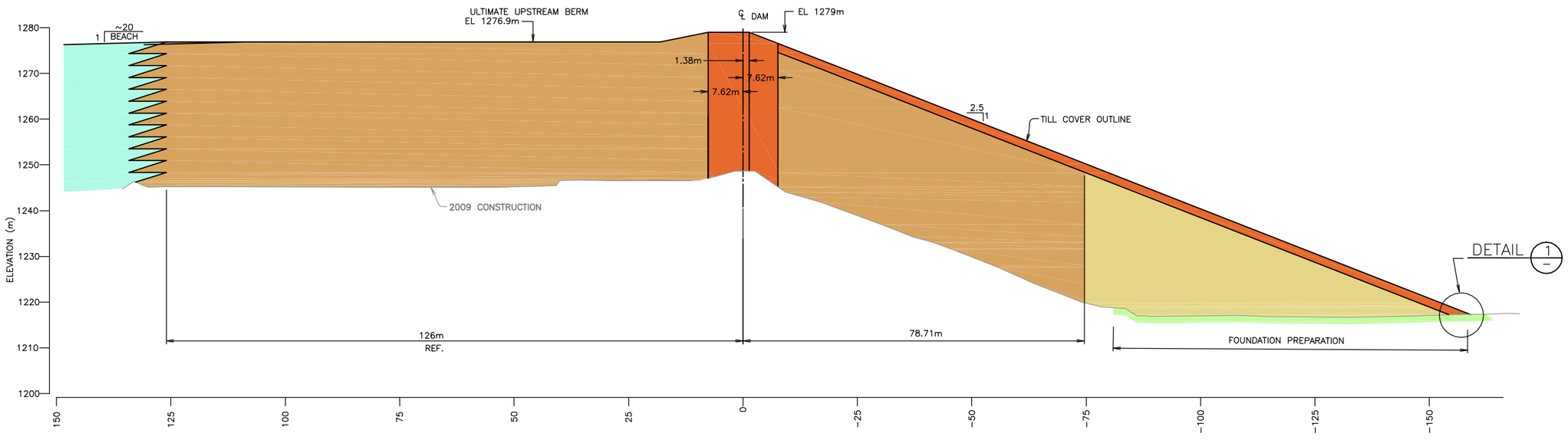
TITLE
L-L ULTIMATE DAM
STATION 2+900

PROJECT No. M02341A50

FIG. No. 14

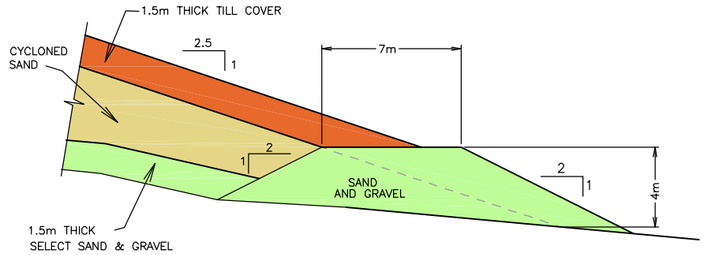
KCB-R-MD

Time: 15:30:48
Date: 8/31/2010
Scale: 1=7(PS)
Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 12-13.dwg (cwong)



DISTANCE FROM CENTRELINE OF DAM (m)
SECTION TAKEN AT STN. 3+200
TYPICAL SECTION : STN. 3+000 TO STN. 3+670

SECTION G
SCALE 1:1000 FIG 4



DETAIL 1
SCALE 1:300

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

0 50m
SCALE

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

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

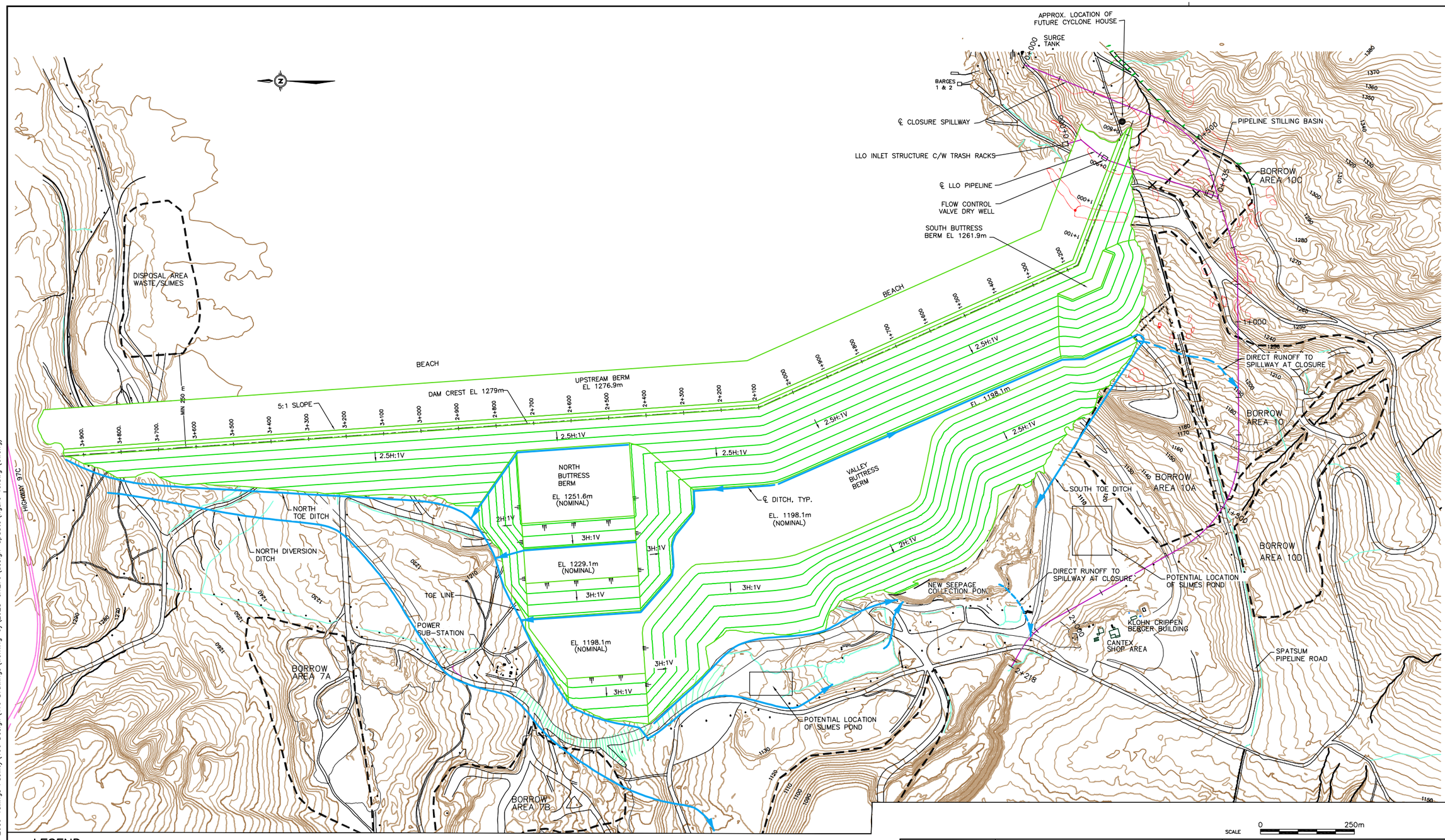
TITLE
L-L ULTIMATE DAM
STATION 3+200

PROJECT No. M02341A50

FIG. No. 15

K2B-R-MLD

Time: 15:30:48
Date: 8/31/2010
Scale: 1=7(PS)
Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 12-13.dwg (cwong)



LEGEND

- × ROCK OUTCROP LOCATION
- ROCK OUTCROP OUTLINE (NOTE 2)
- BORROW AREAS
- LLO LOW LEVEL OUTLET

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER, JAN 27, 2010.
2. ROCK OUTCROP OUTLINES WERE MAPPED IN 1990.
3. DETAILS OF UPSTREAM DAM FILL TO SUIT LOW LEVEL OUTLET ARE TO BE DETERMINED.
4. FOR PROFILE OF SPILLWAY AND LOW LEVEL OUTLET SEE FIG. 18

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

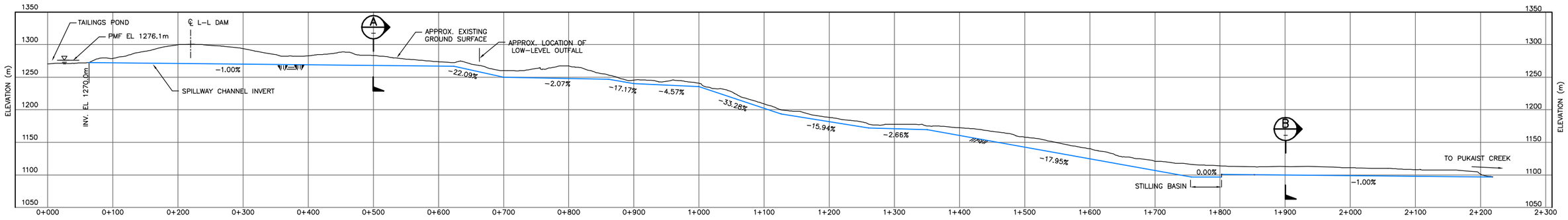
TITLE
ULTIMATE DAM
SPILLWAY, LLO AND DRAINAGE DITCHES
PRELIMINARY ARRANGEMENT-PLAN

PROJECT No. M02341A50

FIG. No. 17

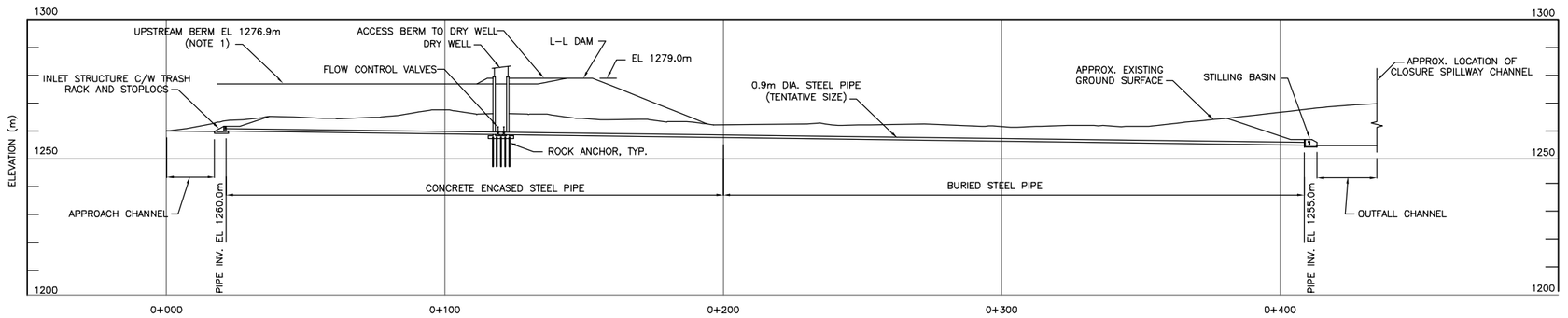
KCB-R-MLD

Time: 15:51:12
Date: 8/31/2010
Scale: 1=0
Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 16.dwg (cwong)



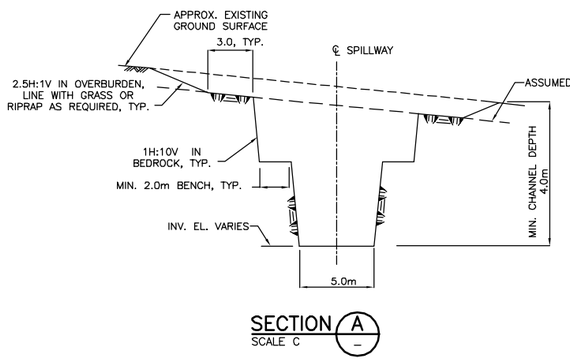
CLOSURE SPILLWAY PROFILE

(EXISTING AND PROPOSED ROADS NOT SHOWN)
SCALE A



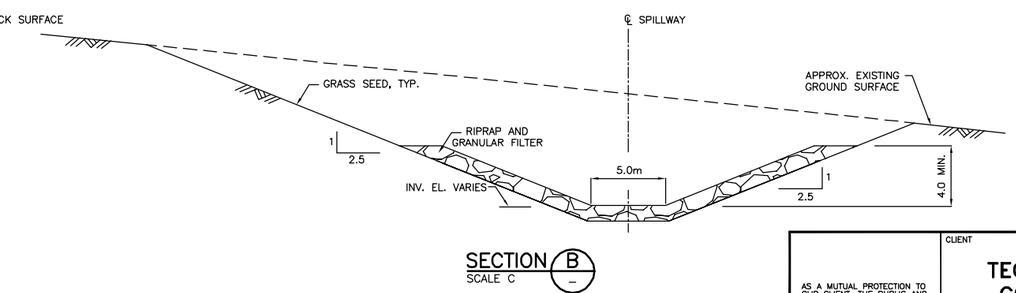
LOW LEVEL OUTLET PROFILE

SCALE B



SECTION A
SCALE C

TYP. SPILLWAY SECTION IN BEDROCK



SECTION B
SCALE C

TYP. SPILLWAY SECTION IN OVERBURDEN

NOTES:

1. DETAILS OF UPSTREAM BERM (EL 1276.9m) AND TAILING BEACH TO SUIT LOW-LEVEL OUTLET ARE TO BE DETERMINED.

SCALE

SCALE C 0 10m

SCALE B 0 50m

SCALE A 0 200m

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CLIENT

TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT

HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE

ULTIMATE DAM
SPILLWAY AND LLO
PRELIMINARY PROFILES & TYP. SECTIONS

PROJECT No. M02341A50

FIG. No. 18

KCB-R-MLD

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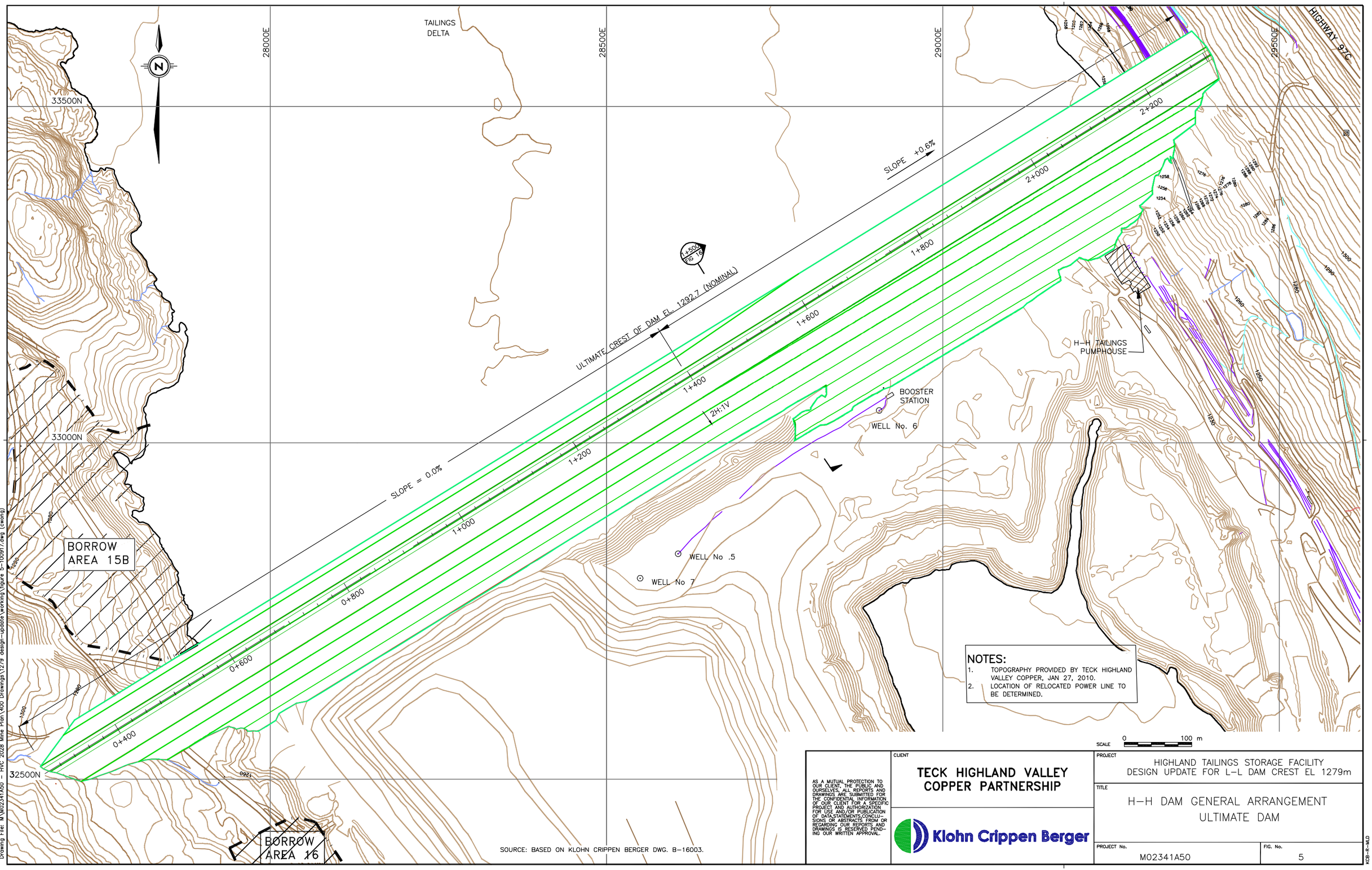
Date: 8/20/2010
Scale: 1:1
Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 16.dwg (cwong)

APPENDIX III-C-2

H-H Dam



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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE
H-H DAM GENERAL ARRANGEMENT
ULTIMATE DAM

PROJECT No. M02341A50

FIG. No. 5

KCB-R-MLD

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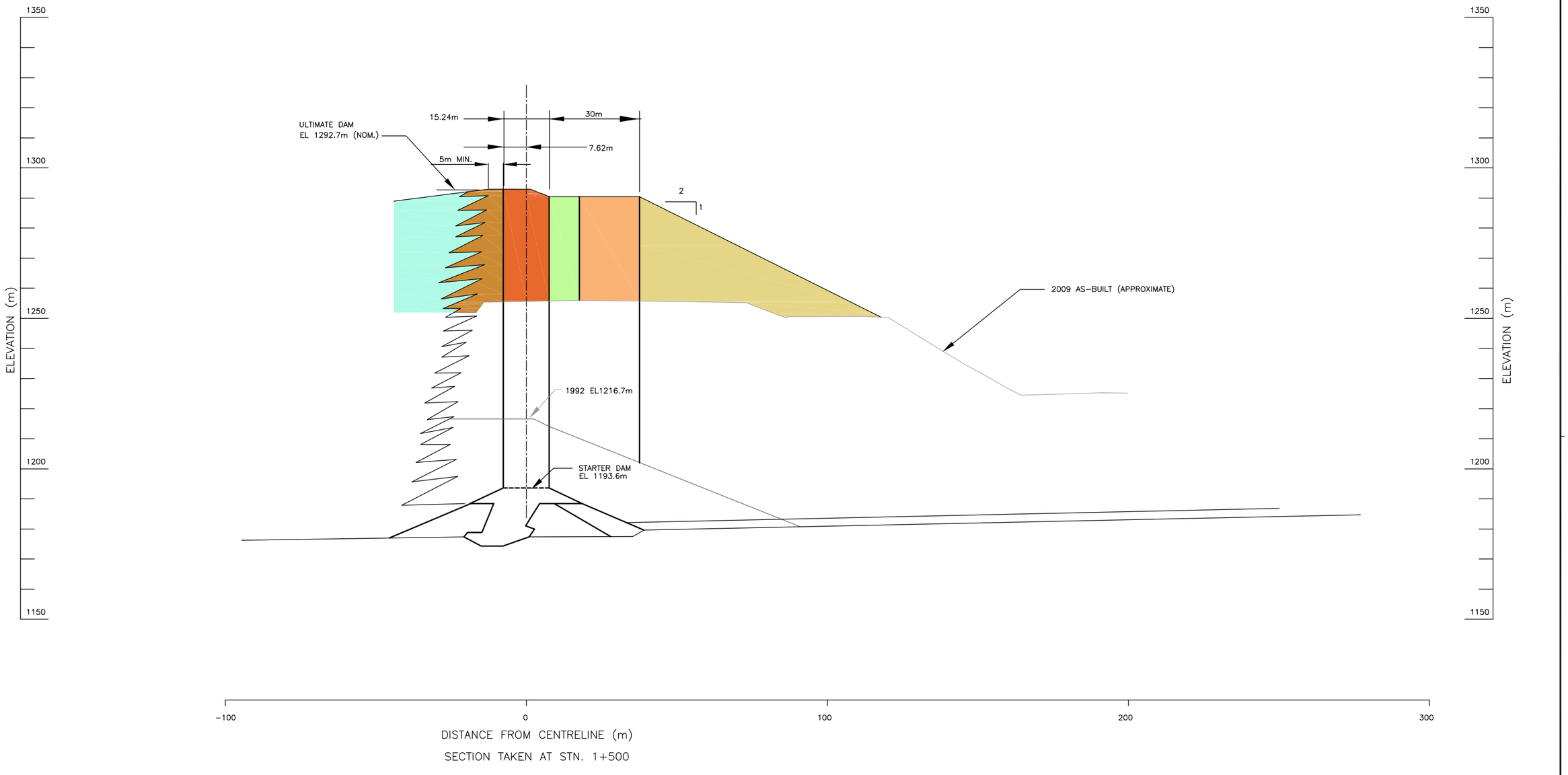

SECTION TAKEN AT STN. 1+500

LEGEND

- BEACH TAILINGS
- UPSTREAM RANDOM FILL
- DOWNSTREAM TRANSITION STRUCTURAL FILL
- DOWNSTREAM RANDOM ROCKFILL OR EARTH FILL
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

TO BE READ WITH KLOHN CRIPPEN REPORT DATED _____

SCALE 0 50m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE
H-H ULTIMATE DAM STATION 1+500

PROJECT No. M02341A50

FIG. No. 16

KCB-TM

Time: 14:40:56
Date: 9/16/2010
Scale: 1=4(PS)
Drawing File: M:\M02341A50 - HVC 2028 Mine Plan\400 Drawings\1279 design-update\working\figure 8-100916.dwg (cwong)

APPENDIX III-C-3

L-L Dam Seepage and Slimes Ponds

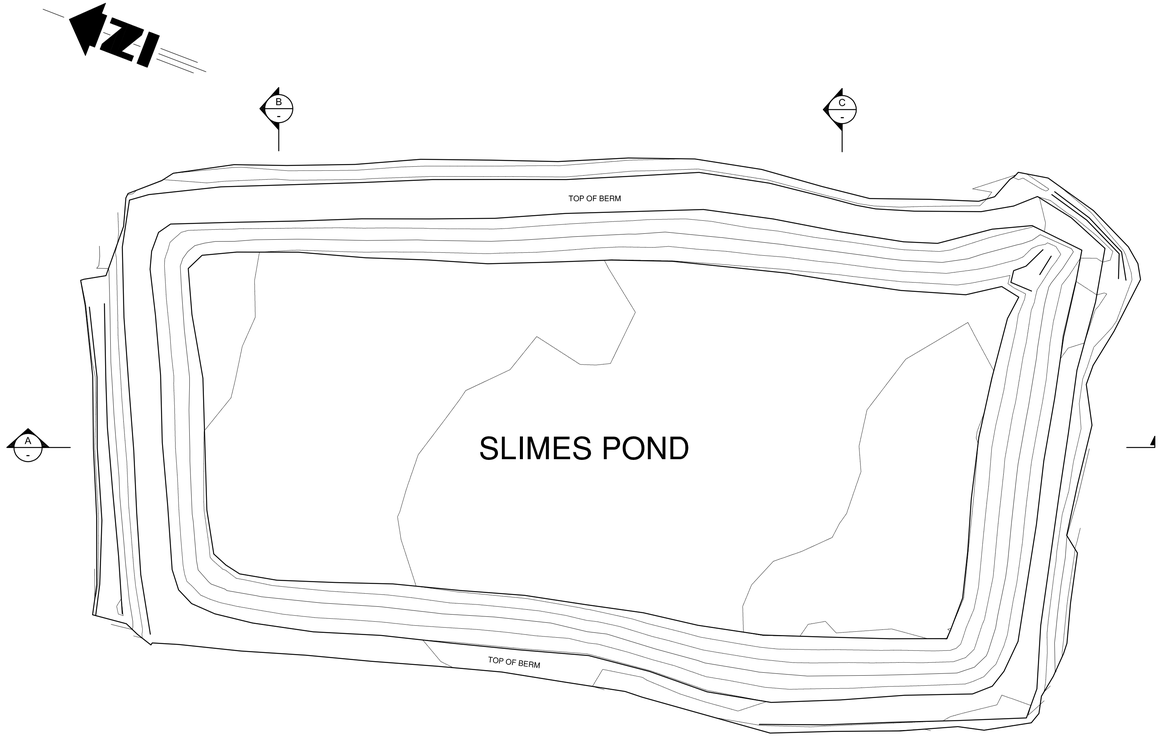
APPENDIX III-C-3.1

Seepage Pond 1

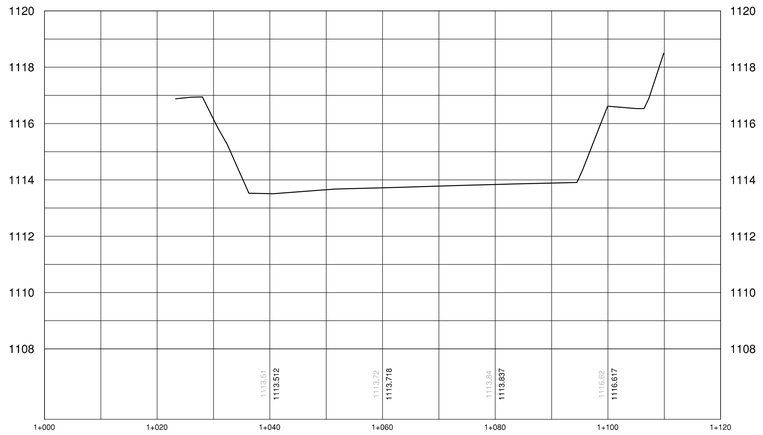
Drawings Not Available – Pond was Decommissioned in 2018

APPENDIX III-C-3.2

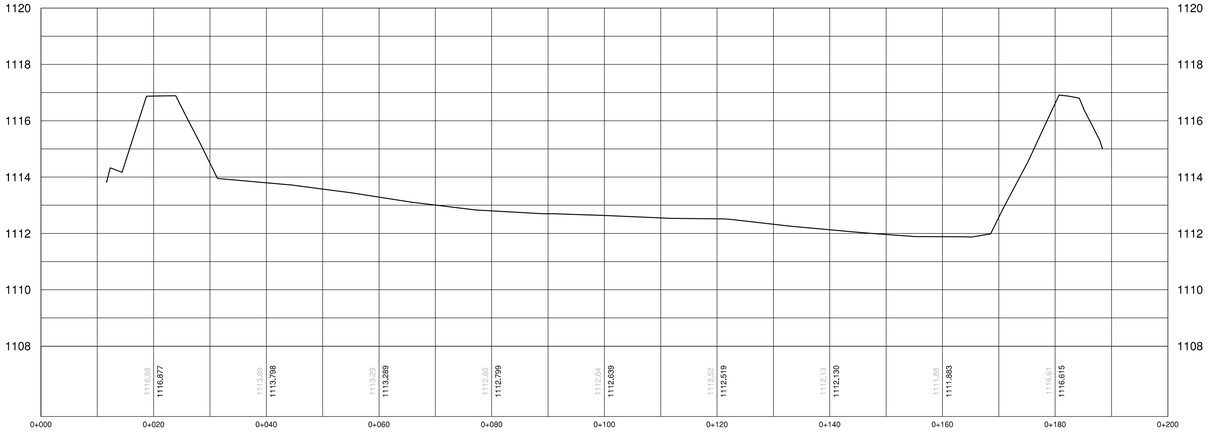
Seepage Pond 2



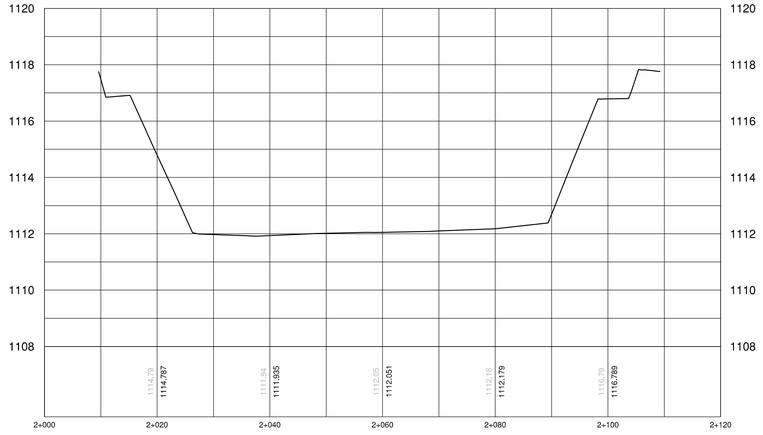
PLAN VIEW
SCALE - 1:500



B SECTION
H - 1:500
V - 1:100



A SECTION
H - 1:500
V - 1:100



C SECTION
H - 1:500
V - 1:100

NO.	ISSUE	DATE	BY	CHKD	APPD
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REF.	DWG. NO.	REFERENCE DRAWING DESCRIPTION
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ISSUED FOR: REVIEW

TRUE CONSULTING
201 - 2079 Falcon Road
Kamloops BC V2C 4J2
tel 250.828.0881
fax 250.828.0717
info@TRUE.bc.ca

DESIGNED:	CHECKED:
.	.
DRAWN:	DATE:
.	.
SCALE	CAD FILE:
.	.

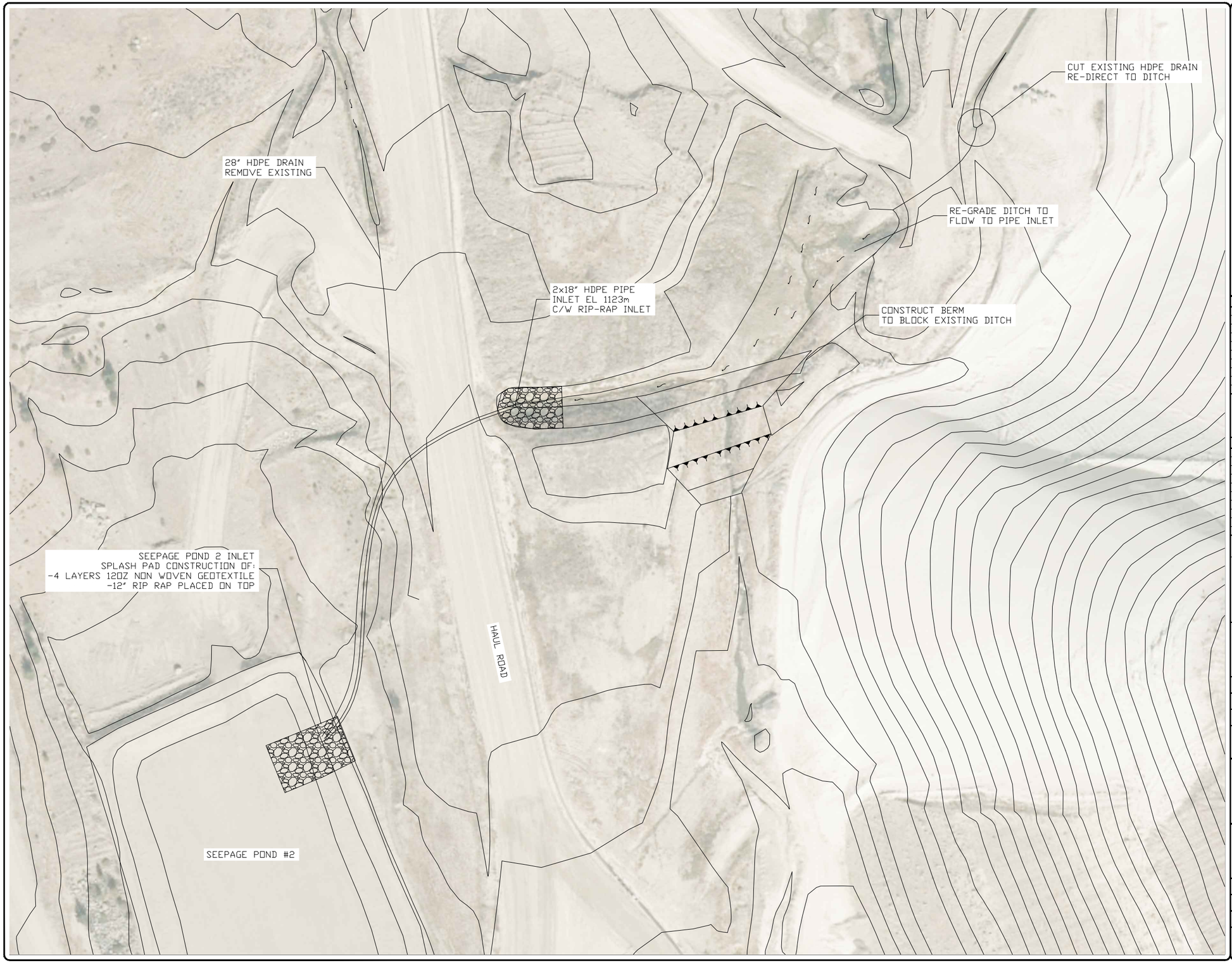
DWG NO: . REV. .

SLIMES POND PLAN AND SECTIONS

Highland Valley Copper
Teck

HVC DESIGN:	HVC CHECKED:
.	.
HVC DRAWN: SC	DATE: SEPTEMBER 2012
SCALE 1:500	HVC CAD FILE: 1011-021-SlimePond-ASB.dwg

HVC DWG NO: — REV. .



NO.	ISSUE	DATE	BY	CHKD	APPD

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REF.	DWG. NO.	REFERENCE DRAWING DESCRIPTION

ISSUED FOR:

DESIGNED:	CHECKED:
DRAWN:	DATE:
SCALE	CAD FILE:

DWG NO: REV. △

SEEPAGE POND #2
DITCH DESIGN

Highland Valley Copper
Teck

HVC DESIGN:	HVC CHECKED:
HVC DRAWN: B STEANE	DATE: FEBRUARY 2013
SCALE As Shown	HVC CAD FILE:

HVC DWG NO: REV. △

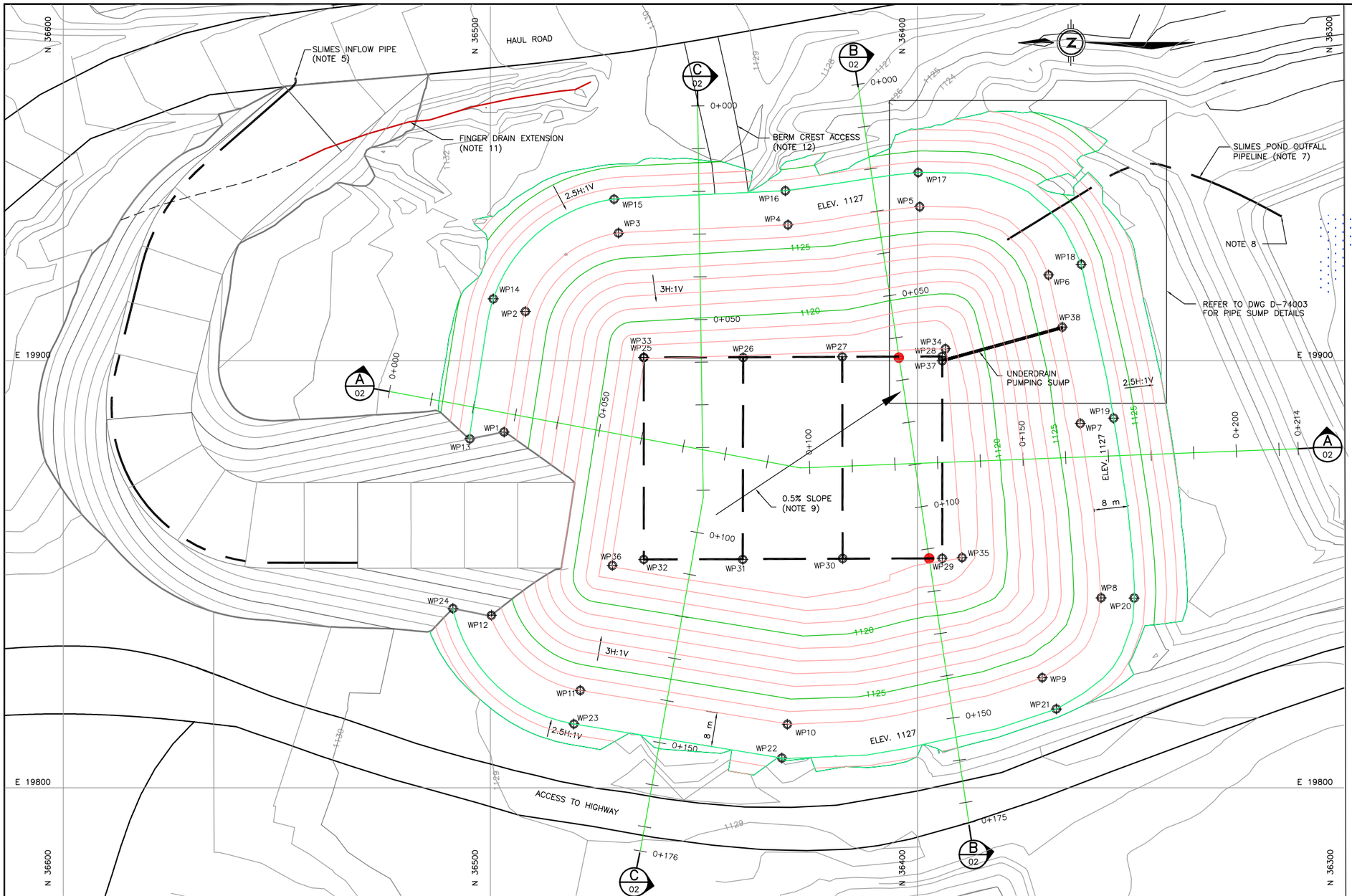
APPENDIX III-C-3.3

Slimes Pond 1

Drawings Not Available

APPENDIX III-C-3.4

Slimes Pond 2



WORK POINT	EASTING (m)	NORTHING (m)	ELEVATION (m)	LOCATION
WP1	19883.3	36496.8	1127.0	8m BERM CREST
WP2	19911.5	36491.8	1127.0	
WP3	19929.9	36470.0	1127.0	
WP4	19931.8	36430.3	1127.0	
WP5	19936.1	36399.5	1127.0	
WP6	19920.1	36369.3	1127.0	
WP7	19885.3	36361.9	1127.0	
WP8	19844.5	36357.0	1127.0	
WP9	19825.8	36370.8	1127.0	
WP10	19814.9	36430.5	1127.0	
WP11	19822.8	36479.0	1127.0	
WP12	19840.4	36499.8	1127.0	
WP13	19881.7	36504.8	1127.0	
WP14	19914.5	36499.3	1127.0	
WP15	19937.8	36471.0	1127.0	
WP16	19939.8	36431.0	1127.0	
WP17	19944.1	36399.8	1127.0	
WP18	19922.6	36361.7	1127.0	
WP19	19886.5	36354.1	1127.0	
WP20	19844.4	36349.3	1127.0	
WP21	19818.4	36367.5	1127.0	
WP22	19807.0	36431.8	1127.0	
WP23	19814.9	36480.5	1127.0	
WP24	19842.0	36508.8	1127.0	
WP25	19900.7	36464.1	—	UNDERDRAIN PIPE (NOTE 9)
WP26	19900.7	36440.8	—	
WP27	19900.7	36417.6	—	
WP28	19901.0	36394.2	—	
WP29	19853.5	36394.2	—	
WP30	19853.5	36417.5	—	
WP31	19853.5	36440.9	—	
WP32	19853.5	36464.1	—	
WP33	19900.7	36464.1	1117.0	EXCAVATION BASE
WP34	19902.8	36393.5	1117.0	
WP35	19853.9	36389.6	1117.0	
WP36	19852.1	36471.4	1117.0	
WP37	19900.0	36394.2	1117.1	UNDERDRAIN PUMPING SUMP
WP38	19907.9	36366.1	1127.0	

BILL OF QUANTITIES (NOTE 3)

EXCAVATION	46745 m^3
FILL	8356 m^3
AVAILABLE SLIMES STORAGE	53120 m^3
GEOMEMBRANE SURFACE AREA INCLUDING ANCHOR TRENCH	20080 m^2

LEGEND

UNDERDRAIN (NOTE 4)

VIBRATING WIRE PIEZOMETER (NOTE 10)

NOTES

1. BASE MAP FROM HVC 2013 CONTRACT DRAWING AND SLIMES POND EXISTING CONDITION SURVEY RECEIVED FROM HVC AUGUST 15, 2014.
2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED.
3. VOLUMES ARE NEAT-LINE COMPACTED OR IN SITU WITH NO BULKING FACTOR OR CONTINGENCY. GEOMEMBRANE AREA INCLUDES 10% CONTINGENCY FOR OVERLAP AND WASTAGE.
4. UNDERDRAIN PIPE DETAILS PROVIDED ON DWG. D-74002.
5. SLIMES INFLOW PIPE DETAILS TO BE DETERMINED BY HVC BUT NOT TO EXCEED SINGLE 24" DIA PIPE PLACED ALONG FIELD FIT ACCESS/MAINTENANCE RAMP.
6. SLIMES INFLOW PIPE DISCHARGE TO BE SET BELOW ELEV. 1125.5 m. LOCALLY PLACE RIPRAP (D_{50} = 0.3 m) IMMEDIATELY DOWNSTREAM OF THE DISCHARGE LOCATION (2 m WIDTH, 4 m LENGTH).
7. SLIMES POND OUTFALL PIPELINE, MINIMUM GRADE OF 2% REQUIRED ALONG ENTIRE ALIGNMENT. HVC SPECIFIED 36-INCH DR26 HDPE PIPE.
8. DETAILS OF DISCHARGE INTO SEEPAGE POND 2 TO BE DIRECTED BY QC ENGINEER IN THE FIELD.
9. UNDERDRAINS TO BE GRADED AT 0.5% (OVERALL) SLOPE TOWARDS SOUTHEAST CORNER, FIELD FIT DURING INSTALLATION.
10. REFER TO D-74002 FOR PIEZOMETER DETAILS. LOCATIONS TO BE SELECTED BY QC ENGINEER IN THE FIELD.
11. FIELD FIT EXTENSION TO FINGER DRAIN BELOW ACCESS RAMP AS DIRECTED BY QC ENGINEER, USING PROCESSED FILTER GRAVEL SURROUNDED BY AT LEAST 0.3 m THICKNESS OF SELECT SAND AND GRAVEL.
12. FIELD FIT BERM CREST ACCESS RAMP TO MAINTAIN MINIMUM 0.9 m COVER DEPTH OVER EXISTING BURIED PIPE.
13. ACCESS/MAINTENANCE RAMP WILL BE FIELD FIT BY HVC AND QC ENGINEER WITH MAXIMUM SLOPE 8%. LAYOUT ON THIS DRAWING SHOWN AS REFERENCE EXAMPLE.

REVISION	DESCRIPTION OF REVISION	DATE (YYYY-MM-DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	RAMP RE-ALIGNED	2014-10-14	CYW	RF	AM	NS
0	ISSUED FOR CONSTRUCTION	2014-08-28	CYW	RF	AM	NS

ISSUED FOR CONSTRUCTION

ORIGINAL SEALED BY
R.J. FRIEDEL
P. ENG.,
PROVINCE OF BRITISH COLUMBIA
OCT/16/2014

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

TITLE
SLIMES POND 2 EARTHWORKS PLAN

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	M02341A74	D-74001	1

CANCEL PRINTS BEARING PREVIOUS REVISION

KCB-DWG-D-L

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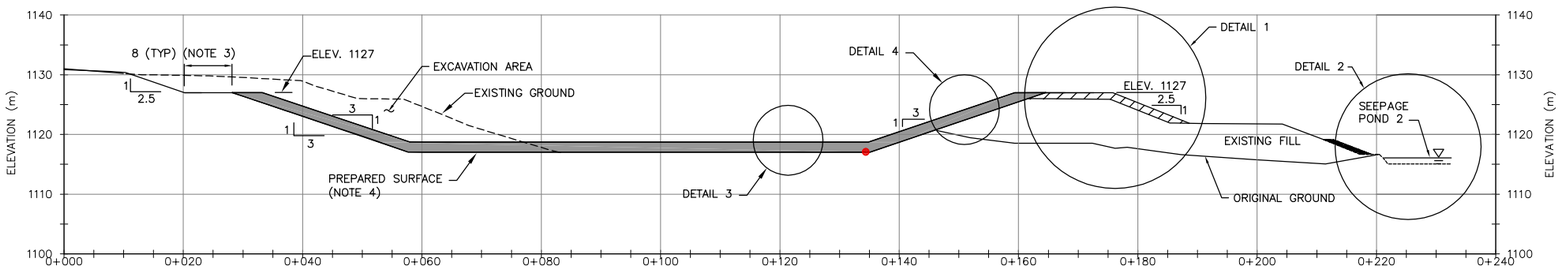

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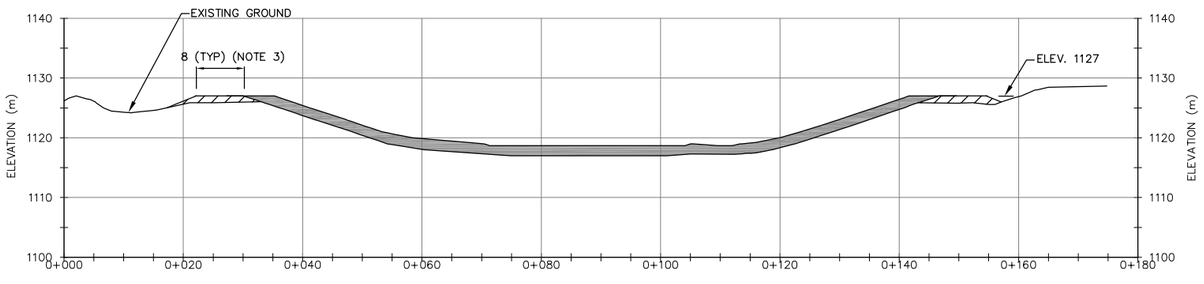
SCALE A



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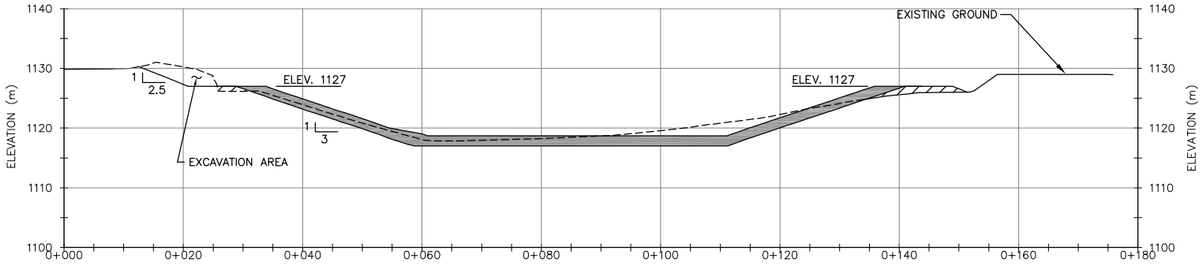

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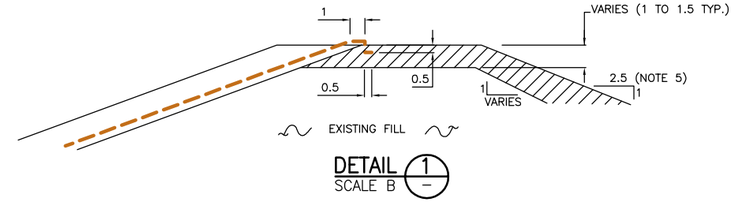

DETAIL 1
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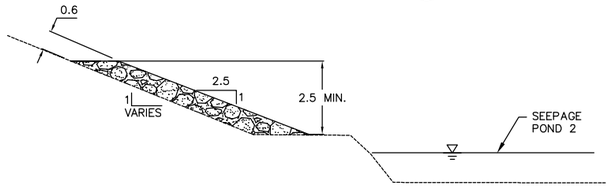
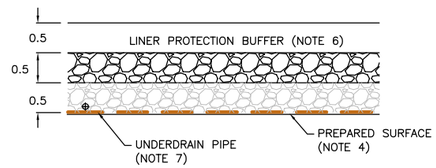
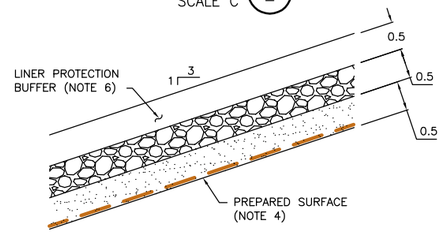


DETAIL 2
SCALE C



DETAIL 3
SCALE D



DETAIL 4
SCALE D

NOTES

1. BASE MAP FROM HVC 2013 CONTRACT DRAWING AND SLIMES POND EXISTING CONDITION SURVEY RECEIVED FROM HVC AUGUST 15, 2014.
2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED.
3. FILL CREST AND EXCAVATION BENCH WIDTHS HAVE BEEN SET FOR SINGLE LANE TRAFFIC (LIGHT VEHICLE AND 30 TONNE HAUL TRUCKS) WITH AN ALLOWANCE FOR SAFETY BERMS TO BE SIZED AND PLACED BY HVC.
4. GRADE AND COMPACT THE TILL SURFACE TO THE DESIGN LINES. RE-GRADE EXISTING SLOPES AS REQUIRED TO ACHIEVE MAXIMUM 3H:1V SLOPE FOR GEOMEMBRANE. FLATTEN SMALL RIDGELINES LEFT BY THE PACKER AND INFILL LOCAL DEPRESSIONS. REMOVE PEBBLES LARGER THAN 1 INCH NOMINAL SIZE OR, IF FEASIBLE, FORCE THEM INTO THE UNDERLYING TILL WITH THE VIBRATORY COMPACTOR. COVER ANY LOCAL GRAVEL/COBBLE ZONE (IF PRESENT) WITH FINE GRAINED TILL AND COMPACT. ALTERNATIVELY, 12.5 mm MINUS SAND AND GRAVEL MAY BE PLACED LOCALLY AS REQUIRED AND COMPACTED TO ACHIEVE A SMOOTH SURFACE.
5. FILL SLOPE TO EXTEND DOWN TO EXISTING GROUND OR FILL LEVEL.
6. FOR CALCULATION OF AVAILABLE SLIMES STORAGE, A 0.5 m BUFFER OF UNREMOVED SLIMES WAS ASSUMED ABOVE GEOMEMBRANE PROTECTION FILL.
7. UNDERDRAIN LAYOUT AS ON DWG. D-74001, 150 mmø ARMTEC BOSS-2000 DUAL WALL CORRUGATED HDPE PERFORATED DRAINAGE PIPE WITH FILTER SOCK. 4-90° ELBOWS AND 4-TEE JUNCTIONS.

PIPE DIAMETER	SLOT WIDTH	SLOT LENGTH	SLOT TYPE
150 mm	1.5 mm	17 mm	PATTERN #1

8. SOLMAX 480T-2000 HDPE TEXTURED GEOMEMBRANE (HVC SPECIFIED)
9. FILL GRADATION AND PLACEMENT SPECIFICATIONS SHOWN ON DWG. D-74004.
10. RST VW2100-HD HEAVY DUTY VIBRATING WIRE PIEZOMETER, 0.35 MPa PRESSURE RANGE, 60 m CABLE LENGTH. SATURATE TIP WITH WATER BEFORE INSTALLATION. DIG A HOLE IN THE PREPARED SURFACE, INSTALL PIEZOMETER WITH TIP POINTING UP, AND BACKFILL WITH 20-40 FILTER SAND. INSTRUMENT CABLE TO RUN INSIDE A 2-INCH Ø DR11 HDPE PIPE, RUNNING UP THE SLOPE IN A TRENCH BACKFILLED WITH TILL, AND ACROSS THE CREST BELOW THE LEVEL OF THE LINER ANCHOR TRENCH TO A READOUT LOCATION ON THE DOWNSTREAM SLOPE. INSTRUMENTS ARE TO BE READ BI-WEEKLY AS GEOMEMBRANE LEAK DETECTION.

LEGEND

- GLACIAL TILL (NOTE 9)
- UNDERFLOW SAND (NOTE 9)
- SAND AND GRAVEL FILTER (NOTE 9)
- PROCESSED BLAST ROCK (NOTE 9)
- SAND AND GRAVEL DRAINAGE LAYER (NOTE 9)
- LINER SYSTEM
- GEOMEMBRANE (NOTE 8)
- VIBRATING WIRE PIEZOMETER (NOTE 10)
- UNDERDRAIN PIPE (NOTE 7)

SCALE A 0 25 m
SCALE B 0 10 m
SCALE C 0 5 m
SCALE D 0 2.5 m

ISSUED FOR CONSTRUCTION

REVISION	DESCRIPTION OF REVISION	DATE (YYYY-MM-DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	REVISED UNDERDRAIN SPECIFICATIONS	2014-10-14	CYW	FS	AM	NS
0	ISSUED FOR CONSTRUCTION	2014-08-28	CYW	RF	AM	NS

ORIGINAL SEALED BY
R.J. FRIEDEL
P. ENG.,
PROVINCE OF BRITISH COLUMBIA
OCT/16/2014

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

TITLE
SLIMES POND 2
CROSS SECTIONS AND
LINER DETAILS

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	M02341A74	D-74002	1

CANCEL PRINTS BEARING PREVIOUS REVISION

KCB-DWG-D-L

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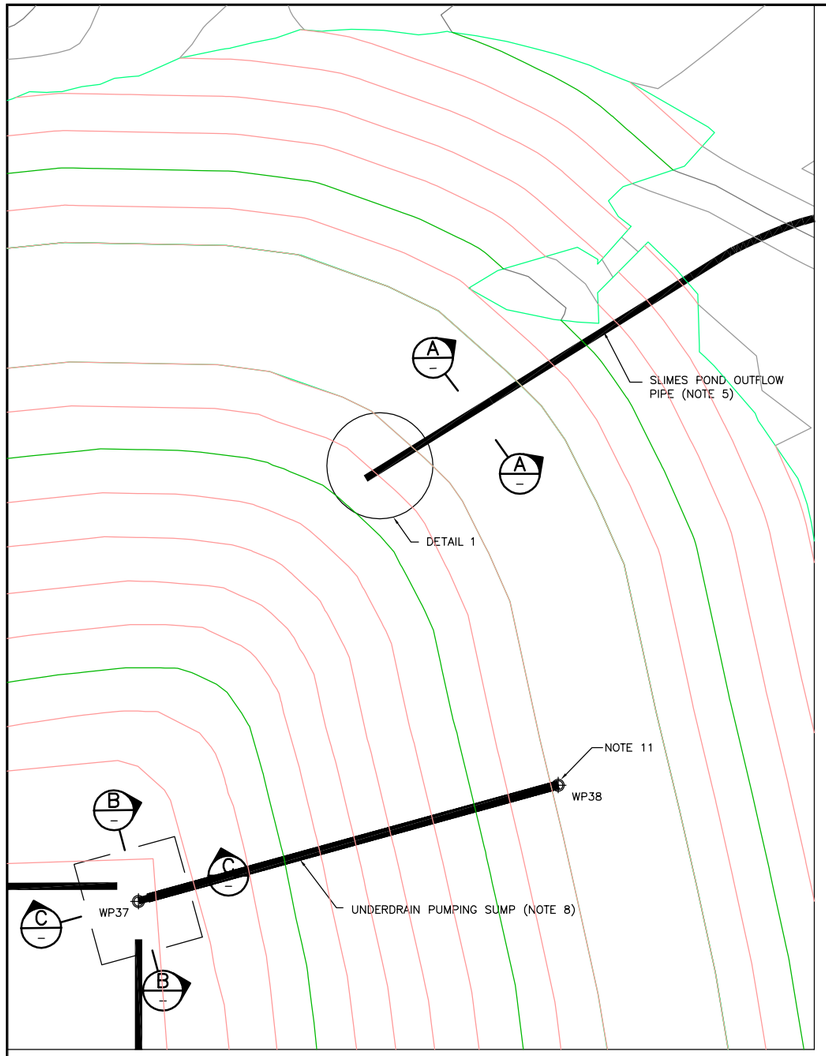
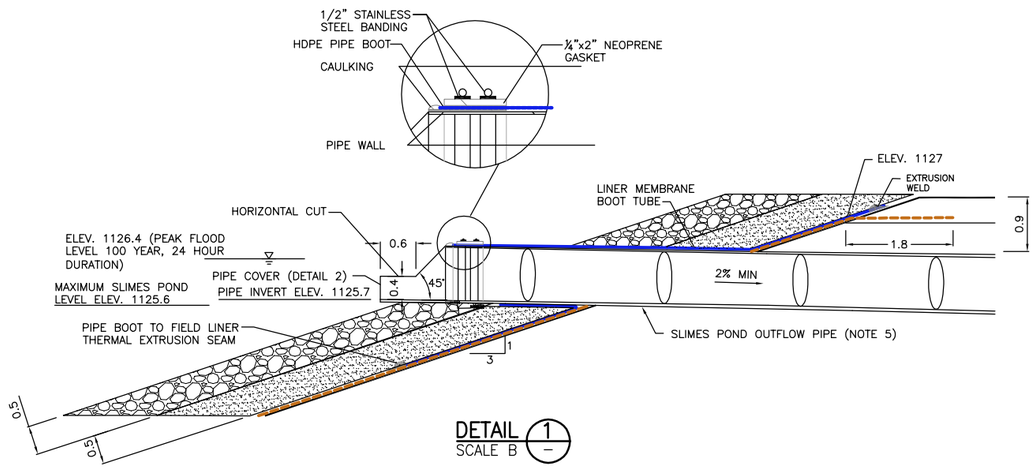
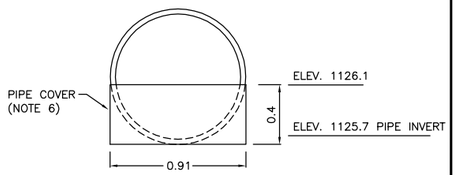


PIPE DETAIL
SCALE A



DETAIL 1
SCALE B



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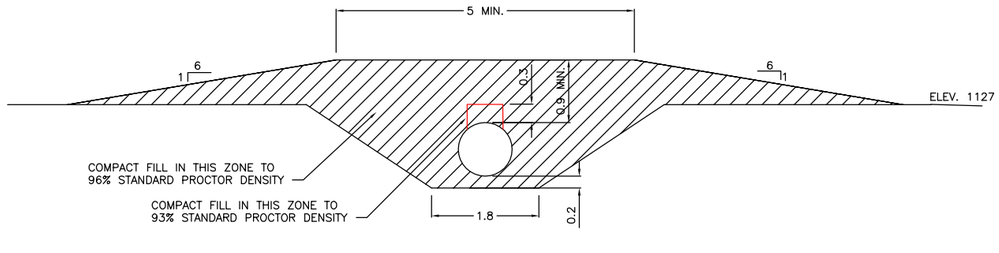
SCALE C



SECTION A
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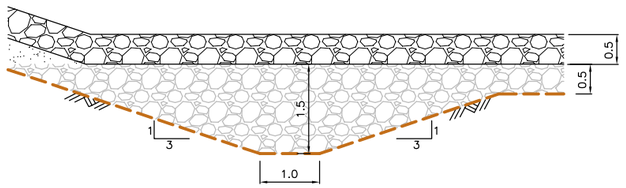
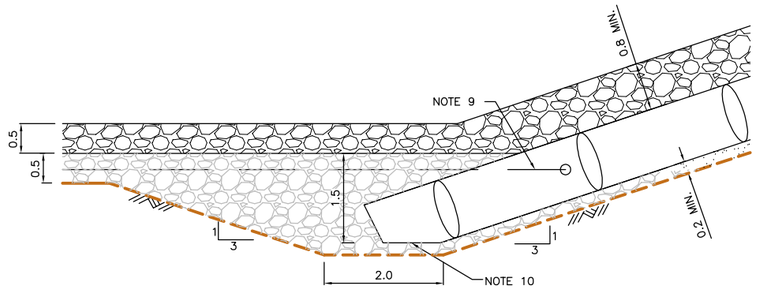
TYPICAL PIPE BURIAL DETAIL



SECTION B
SCALE B
SUMP



SECTION C
SCALE B
SUMP

LEGEND

- GLACIAL TILL (NOTE 3)
- UNDERFLOW SAND (NOTE 3)
- SAND AND GRAVEL DRAINAGE LAYER (NOTE 3)
- PROCESSED BLAST ROCK
- GEOMEMBRANE (NOTE 4)
- GEOMEMBRANE PIPE BOOT (NOTE 7)
- PIPELINE IN SECTION

NOTES

1. BASE MAP FROM HVC 2013 CONTRACT DRAWING AND SLIMES POND EXISTING CONDITION SURVEY RECEIVED FROM HVC AUGUST 15, 2014.
2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED.
3. FILL GRADATION AND PLACEMENT SPECIFICATIONS SHOWN ON DWG D-74004
4. SOLMAX 480T-2000 HDPE TEXTURED GEOMEMBRANE (HVC SPECIFIED)
5. HVC SPECIFIED 36-INCH DR26 HDPE PIPE.
6. PIPE COVER TO BE STEEL, HDPE OR EQUIVALENT MATERIAL, APPROVED BY QC ENGINEER, TO BE SECURED TO PIPE OPENING USING STAINLESS STEEL BOLTS WITH SEALANT PLACED AROUND CONTACT POINTS AND BOLTS BETWEEN PIPE COVER AND OUTFLOW PIPE. ARRANGEMENT CAN BE FIELD FIT WITH QC ENGINEER APPROVAL.
7. GEOMEMBRANE PIPE BOOT TO BE INSTALLED ACCORDING TO MANUFACTURER'S SPECIFICATIONS.
8. 36-INCH DR26 HDPE PIPE.
9. UNDERDRAIN PIPES TO DISCHARGE INTO UNDERDRAIN PUMPING SUMP. IF CONNECTIONS CANNOT BE WELDED, CUT HOLES IN SIDES OF SUMP PIPE, INSERT UNDERDRAIN PIPES AND STUFF AND SECURE GEOTEXTILE IN GAPS.
10. END OF PIPE TO BE CUT SO IT IS PLACED HORIZONTAL AND CAPPED WITH WELDED HDPE.
11. REMOVABLE TOP CAP TO PREVENT ANIMAL ACCESS AND FOR FROST PROTECTION.

REVISION	DESCRIPTION OF REVISION	DATE (YYYY-MM-DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	ADDED SUMP DETAILS	2014-10-14	CYW	RF	AM	NS
0	ISSUED FOR CONSTRUCTION	2014-10-14	CYW	RF	AM	NS

SCALE A 0 10 m
SCALE B 0 2.5 m
SCALE C 0 1 m

NOT FOR CONSTRUCTION
DRAFT

ORIGINAL SEALED BY
R.J. FRIEDEL
P. ENG.,
PROVINCE OF BRITISH COLUMBIA
OCT/16/2014

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

TITLE
SLIMES POND 2
OUTFLOW PIPE AND UNDERDRAIN
SUMP DETAILS

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	M02341A74	D-74003	1

CANCEL PRINTS BEARING PREVIOUS REVISION

KCB-DWG-D-L

Time: 17:28:09
Date: 10/16/2014
Scale: 1:0.4(F/S)
Drawing File: Z:\M\VCR\M02341A74 - HVC 2014 Eng Services\400 Drawings\slimes pond\issued to hvc\d-74003-141016.dwg (cwong)
Xref File(s):
Image File(s):

Material	Source	Gradation	Placement Method/Specification
Glacial Till	Pond Excavation	> 30% passing No. 200 Sieve	Minimum 96% Standard Proctor. Above outflow pipe: refer to DWG D–74003.
Underflow Sand	Cyclones on Dam Crest	Maximum of 10% passing the No. 200 sieve	Liner Bedding: Single lift, 2 passes with 10t vibratory smooth drum roller. Above Liner: 0.5 m lift, 4 overlapping passes with 10t smooth drum roller (no vibration).
Sand and Gravel Drainage Layer	From Stockpile	Clean 25 mm minus with less than 5% passing the No. 200 sieve	0.5 m lift, 4 overlapping passes with 10t smooth drum roller (no vibration).
Sand and Gravel Filter	Borrow Area 3	Clean 150 mm minus with less than 5% passing the No. 200 sieve	Placed with excavator bucket and tamped in place with bucket (heavy tamping as directed by QC Engineer).
Processed Blast Rock	Blast Rock	300 mm minus	0.5 m lift, 6 overlapping passes with D8 (or equivalent sized dozer) or 10t vibratory smooth drum roller.
Riprap	Blast Rock	See Table 2	Placed with excavator in an interlocking pattern as directed by QC Engineer.

	MINIMUM	MAXIMUM
D_{100}	450	510
D_{85}	360	420
D_{50}	300	345
D_{15}	120	180

ISSUED FOR CONSTRUCTION

REVISION	DESCRIPTION OF REVISION	DATE (YYYY–MM–DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	REVISED DESCRIPTION	2014–10–14	CYW	RF	AM	NS
0	ISSUED FOR CONSTRUCTION	2014–08–28	CYW	RF	AM	NS

ORIGINAL SEALED BY
R.J. FRIEDEL
P. ENG.,
PROVINCE OF BRITISH COLUMBIA
OCT/16/2014

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

TITLE
SLIMES POND 2
FILL AND PLACEMENT
SPECIFICATIONS

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	M02341A74	D–74004	1

CANCEL PRINTS BEARING PREVIOUS REVISION

KCB–DWG–D–L

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Xref File(s):
Image File(s):

APPENDIX III-C-3.5

Seepage Water Reclaim Pond

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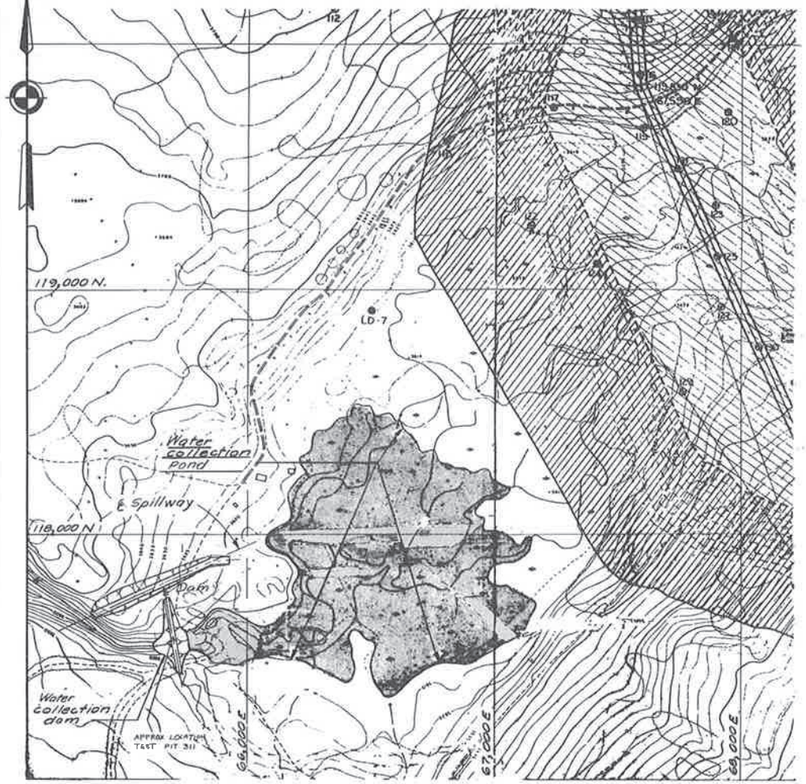
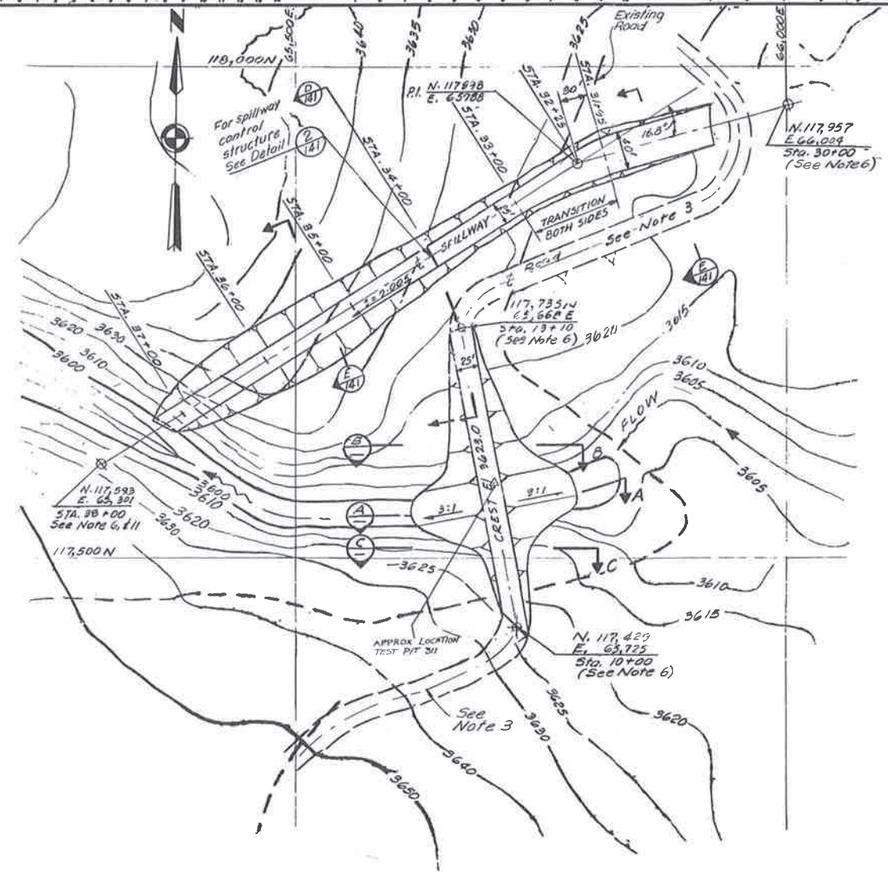


LOCATION OF WATER COLLECTION POND

Scale : 1" = 200'



PLAN

Scale : 1" = 50'

NOTES:

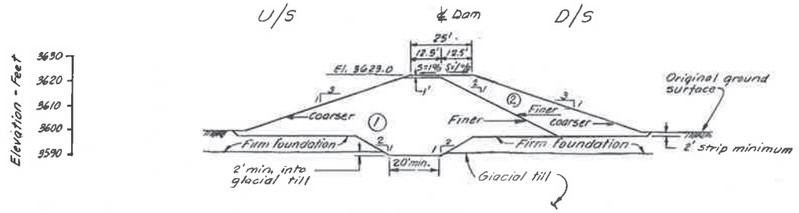
1. Original ground lines idealized for simplication.
2. Topography furnished by Lornex Mining Corporation Ltd. (Dwg. No. III-803-150 Dated May 19, 1976).
3. Connection of existing road to Dam to be determined in the field based upon actual ground contours.
4. Suitable borrow material for Zone 1 shall be obtained from spillway excavation as approved by the Manager. After using all suitable Zone 1 material from spillway excavation Zone 1 shall be obtained from borrow areas shown on Dwg. III-803-106.
5. Borrow material for Zone 2 shall be obtained from Borrow Area 3 as indicated on Dwg. III-803-106.
6. These coordinates and stations are approximate and are to be verified in field by the Manager.
7. Stations of channel entrance and outlet to be determined in field based upon actual ground contours.
8. Limits of clearing and grubbing are areas to be covered by the dam and spillway plus a strip 10 Ft. wide measured horizontally around them in all directions. Clearing shall consist of felling and removing all standing trees, brush, down trees, logs and debris. Grubbing shall include removal of all stumps, roots larger than 1-½" diameter and matted roots.
9. Waste material shall be disposed of in any borrow area shown on drawing III-803-106 or as approved by the Manager.
10. If there is a surplus of suitable Zone 1 material from the spillway excavation this material should be used as Zone 1 material in the L-L Dam as approved by the Manager.
11. Spillway excavation line and end are based upon Lornex survey January, 1977.

LEGEND

(1) Glacial till
(2) Sand and Gravel

REFERENCE DRAWINGS:

III-803-106 Investigation Borrow Plan
III-803-141 Excavation Profile, and Spillway Details.



SECTION (A)

TYPICAL SECTION ALONG CREEK BED

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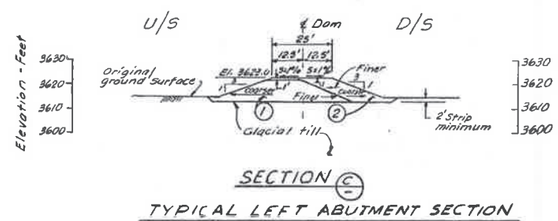

SECTION (C)

TYPICAL LEFT ABUTMENT SECTION

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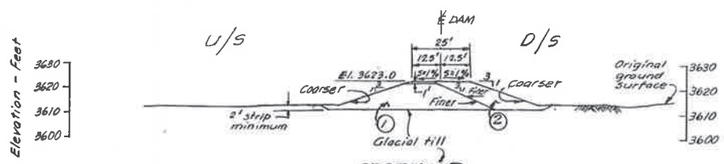

SECTION (B)

TYPICAL RIGHT ABUTMENT SECTION

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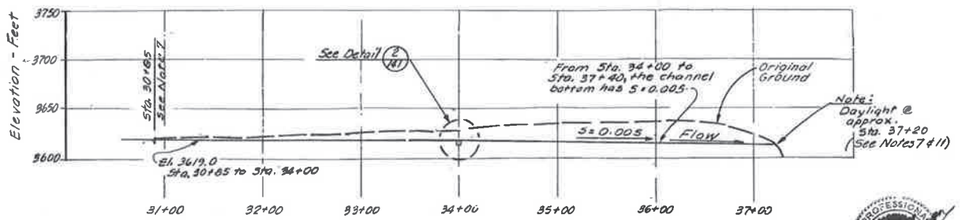


SPILLWAY CHANNEL PROFILE

Scale : 1" = 50'

Graphic Scale in Feet

0 10 20 40 60
1" = 20'

0 50 100 150
1" = 50'

0 100 200 400 600
1" = 200'

NO	DATE	REVISIONS	BY	CHK'D	ENGR SUPV	PROJ ENGR	APPD
3	3-8-77	Issued for construction	YW	GS	SB	RB	
2	1-7-77	ISSUED FOR REVIEW	YW	SB	GS	RB	

SCALE AS SHOWN | DESIGNED S. SPIGERA, R. BARONE | DRAWN P.C. | CHK'D AL ALY | LAND SURV

CANADIAN BECHTEL LTD
TORONTO, ONT.

RIO ALGOM MINES LTD.
LORNEX HIGHLAND VALLEY PROJECT

WATER COLLECTION DAM L-L AXIS

PLAN AND SECTIONS

JOB No.	DRAWING No.	REV.
9039	III-803-140	1

APPENDIX III-C-4

24 Mile Lake

Drawings Not Available

APPENDIX IV

2019 Climate Review

Appendix IV
Climate Data

THVCP provided weather data from the L-L Dam climate station (El. 1186 m) which is the nearest climate station to the site. To support key precipitation trends and impacts on observed dam performance, data from Kamloops Airport (Environment Canada Station No. 1163781, El. 345 m) was reviewed for comparison. Precipitation records from L-L Dam and Kamloops Airport between November 2018 and October 2019 are tabulated and plotted with average monthly values or climate normals in Table IV-A-1 and Figure IV-A-1 respectively. Normal precipitation data, reported in Table IV-A-1, is based on the Highland Valley Lornex climate station, adjusted for elevation to Highmont Area using Golder (2016).

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

The following observations were noted for 2019:

- January through April precipitation at Highland TSF was significantly less than historic normals (based on Highland Valley Lornex adjusted to L-L Dam) which, along with reduced snowpack, contributed to a less severe freshet than recent years.
- June and July 2019 were noticeably wetter than normal.
- Snowpack depths were not measured in January and February 2019. Snowpack was significantly shallower than average in April and May 2019.

Table IV-1 Monthly Precipitation

Month	Precipitation (mm)			
	L-L Dam Weather Station Data – unadjusted[1]	1976-2011 Highland Valley Lornex Normals Adjusted to L-L Dam Area[2]	Kamloops Airport Weather Station[3]	1981-2010 Kamloops Airport Weather Station Normals[4]
Nov-18[5]	22.3	42.5	33.5	23.3
Dec-18[5]	14.9	42.9	20.2	25.4
Jan-19	11.8	28.9	5.7	21.1
Feb-19	17.1	22.1	13.8	12.4
Mar-19	6.4	17.6	4.3	12.8
Apr-19	16.0	22.4	11.5	14.2
May-19	39.4	43.5	17.4	27.3
Jun-19	91.2	50.4	21.2	37.4
Jul-19	84.1	45.8	36	31.4
Aug-19	11.1	33.4	16.7	23.7
Sep-19	44.9	32.8	39.1	29.4
Oct-19	21.1	31.6	16.2	19.4
Annual Total	380.3	414.0	235.6	277.8

Notes:
1. Available data from L-L Dam climate station was adjusted by a L-L Dam-to-Highmont adjustment factor of 1.15 (Golder 2016).
2. Estimated by Golder (2016) using appropriate adjustment factors and average precipitation measured at Highland Valley Lornex climate station (Environment Canada ID No. 1123469 at El. 1268 m).
3. 2019 data from Kamloops Airport station with ID No. 1163781. Kamloops Airport Climate Station was relocated 500 m in 2013 from station ID No. 1163780.
4. Climate normals from data collected at previous Kamloops Airport station location (ID No. 1163780).
5. November to December 2018 were reported in 2018 DSI and outside of 2019 DSI reporting period but are included for reference.

Figure IV-1 Monthly Precipitation

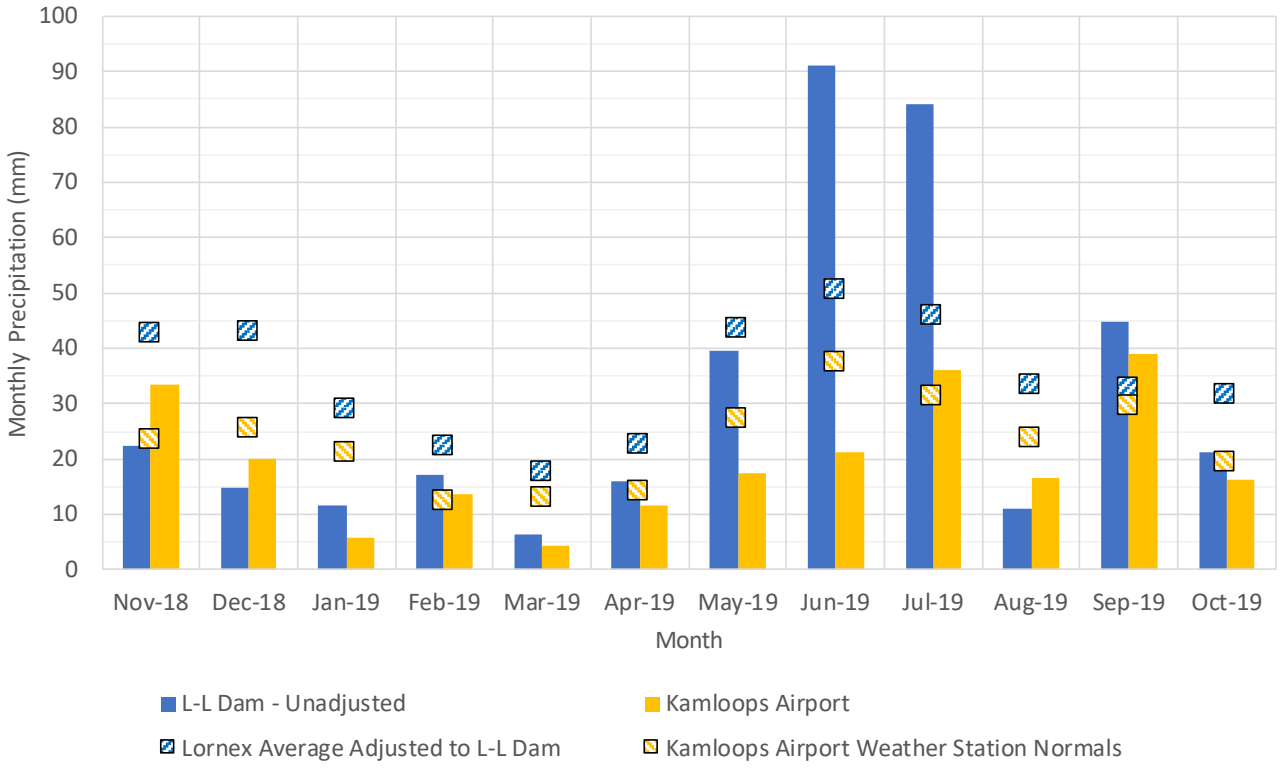


Table IV-2 Historical Average and 2019 Snowpack Depths

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

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

APPENDIX V

L-L Dam Instrumentation Summary

APPENDIX V-A

L-L Dam Response Summary

Appendix V-A
L-L Dam Instrumentation Response Summary

V-A-1 SOUTH DAM: STA. 0+800 (SOUTH ABUTMENT) TO STA. 1+500

V-A-1-1 L-L Dam Performance Summary

V-A-1-1 Reservoir Level and Beach Width

The Highland TSF pond elevation was measured weekly (minimum) during 2019 in compliance with the OMS Manual (THVCP 2018). Figure V-A-1 plots measured pond elevations over the past 5 years including 2019. Figure V-A-2 plots 2019 pond elevations and volumes, estimated based on the most recent bathymetry survey. Observations related to tailings pond during 2019:

- During 2019, the pond elevation rose 1.7 m which is less than rise the annual rise in 2018 (3.8 m) which was larger than average due to additional water being pumped into the impoundment as part of the Lornex dewatering project. 2019 pond rise was consistent with the rise that THVCP water balance forecasted (i.e. 1.9 m rise) in 2019. The water balance forecasts a 1.4 m rise in pond level during 2020 (~El. 1254 m).
- During freshet the pond level rose approximately 2.7 m, which is less than the freshet rise observed during the previous 3 years 2016 (3.8 m), 2017 (6.3 m), and 2018 (5.2 m) which is due to reduced precipitation and snowmelt compared to recent years. 2019 pond levels continued to rise throughout the year, reaching the peak level (El. 1252.6 m) in end of July, a similar trend was observed in 2015 and 2017. Consistent with previous trends, pond level and volume fell starting in December.

Figure V-A-1 Highland TSF Tailings Pond Elevations: 2015 to 2019

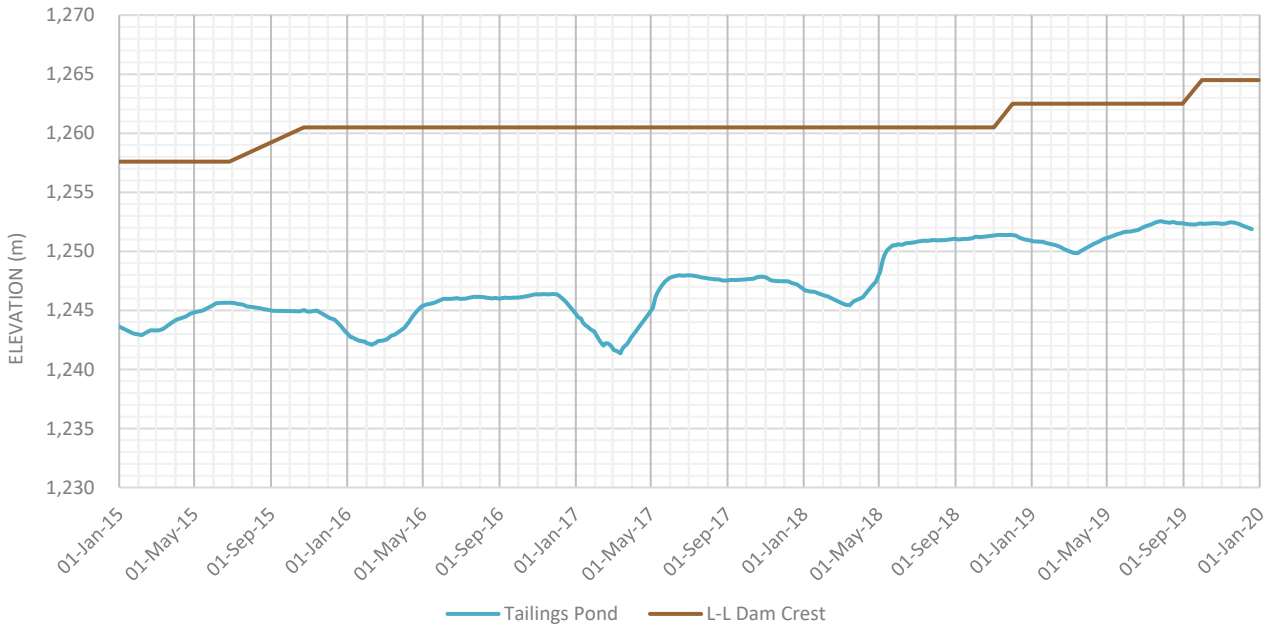
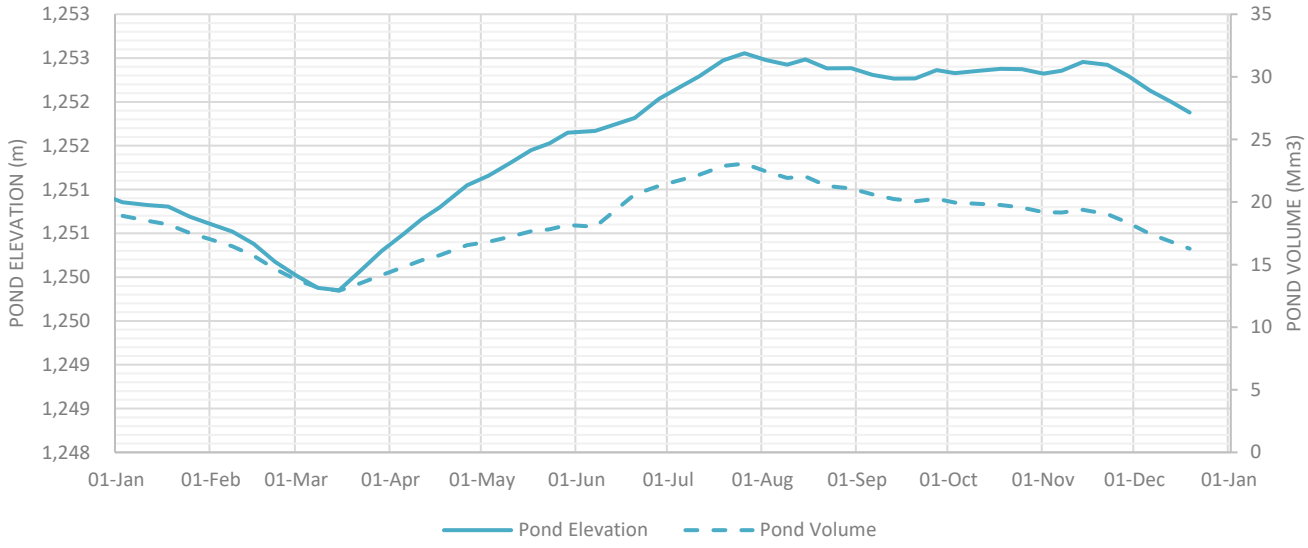


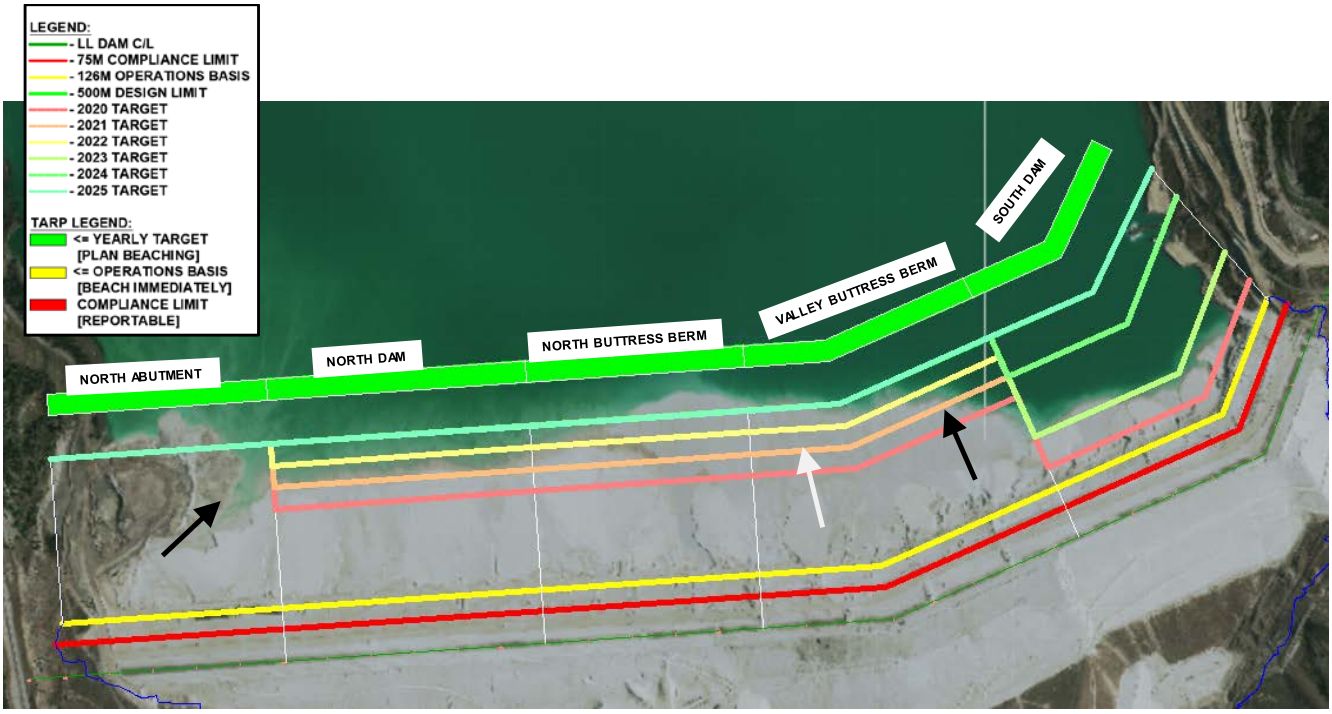
Figure V-A-2 2019 Highland TSF Tailings Pond Elevations and Estimated Pond Volumes



A minimum beach width of 500 m at the North Abutment was added as a design requirement as part of the 2019 design review (KCB 2019a). During 2019, the 500 m beach width was maintained by a combination of spigotted tailings and the waste dump for foundation preparation spoils and overflow slimes from hydraulic placement, as shown on Figure V-A-3.

In addition, THVCP have initiated a multi-year project to increase beach width along the length of the dam crest as a risk reduction activity. As part of this project, THVCP have set interim beach width targets. Routine monitoring of beach width at the North Abutment will be included in the 2020 OMS Manual: quarterly aerial images; and marker in the field to visually confirm 500 m beach width.

Figure V-A-3 Status of L-L Dam Beach as of September 2019 and Future Beaching Plan



V-A-1-2 Instrumentation Trends

General piezometric and displacement behaviour based on instrumentation at each dam segment is summarized herein. As mentioned in Section 5.1 of main text, Notification Level thresholds are not discussed herein, as they do not represent a dam safety concern and are used as a screening tool by KCB and THVCP teams.

Some trigger values were revised during the year to reflect new information and assumptions from the 2019 design update (KCB 2019a) or if the initial threshold assigned was later found not to be representative. Trigger changes are documented in RMRs and/or instrument exceedance review forms.

Over the past 3 years, the density of instruments and frequency of measurements have been increased at all segments of the L-L Dam. The greatest increase has been at the VBB which is related to the implementation of the Observational Method (Peck 1969), as described in KCB (2018c) and monitoring of the Lower-Glaciolacustrine Unit (L-GLU) which governs the design in this area. Increased instrumentation coverage and data collections has allowed for better understanding of behaviours in the dam and foundation. These behaviours have likely been occurring throughout much of the dam life but have not previously measured to this degree. The instrumentation readings provide a baseline of information that can be used to inform future design decisions and improve predictions of expected behaviour.

Table V-A-1 summarizes the instruments installed within or near the L-L Dam or foundation by the end of 2019. Of note, THVCP continued their program to convert existing manually read instruments to automated data collection integrated with the real-time monitoring system. In 2019, at the L-L Dam, 46 of the manually read standpipes were converted to vibrating wire piezometers (VWPs) and 15 inclinometers were converted to either ShapeArrays (SAAV) (x14) and In-Place-Inclinometers (IPI) (x1). In addition to increased monitoring frequency and data management, automated data collection reduces the potential sources of error in the readings. For piezometers, error related to manual data entry are significantly reduced and the SAAV remain in the casing so are not subject to the same errors from manual readings such as change in reels, calibrations and cumulative drift. In total 155 of the 241 geotechnical instruments at the L-L Dam are integrated with the real-time monitoring system.

Table V-A-1 Summary of Functional Instrumentation Installed at L-L Dam (November 2019)

Instrument	Type	Reading [1]	No.	Total
Piezometers	Standpipe	Manual	66	203
	Transducer (Converted Standpipe)	Automated	46	
	Vibrating Wire	Automated	91	
Inclinometers	Down-hole Casing	Manual	17 [3]	35
	In-Place Inclinometer (IPI) [2]	Automated	3	
	ShapeArray (SAAV)	Automated	15	
Seepage Weir	-	Manual	3	3

Notes:
1. Automated readings are transmitted through the remote monitoring system to increase data capture and summarize instrumentation.
2. IPIs are installed in down-hole casing inclinometers over a discrete elevation range which is defined by the EoR to target critical units.
3. Includes currently damaged inclinometers (I10-5, I10-6 and I15-24) which THVCP are planning to replace in early 2020.

November 2019 instrumentation readings are shown on select design cross sections, through each dam segment, of the L-L Dam (Figure 6 to Figure 12). Refer to Appendix V-A for additional discussion regarding instrumentation measurements at the L-L Dam. Instrumentation summary plots are included in Appendix V-B (piezometers) and V-C (inclinometers).

V-A-1-1-2.1 South Dam

Instrumentation readings along Sta. 1+200 are shown on Figure 12. Instrumentation response during 2019 at the South Dam did not indicate any issues of concern or significant deviation from design assumptions. As shown on Figure 18, construction activity in the South Dam area during 2019 was restricted to crest raise and foundation preparation at the downstream toe.

Piezometers

Piezometers installed within the dam footprint downstream of the core zone (e.g. VWP17-03A, VWP17-03B and VWP17-03C), near Sta. 1+050, showed a general rising trend. Pore pressures at these instruments showed a rise and dissipation during 2018 which coincided with hydraulic placement in the area. However, during 2019 there was no hydraulic placement in the area and the response pattern is generally consistent with pond level, albeit delayed. In this same general timeframe, the pond level rose above the piezometric level measured in the natural slope outside of the dam footprint (~El. 1245 m at P13-05 and P86-2001). Once this happens, it is expected that piezometric levels would respond to pond level. This is consistent with observations at the North Abutment where there was no observed influence of the pond until the pond level rose above the natural ground water level in the abutment. These observations indicate that the rise in 2019 (~2 m) is likely related to seepage through the abutment. This response is not unexpected or of concern but will continue to be monitored and 2020 thresholds will be set to identify if this trend deviates or rate of rise accelerates relative to pond level.

Seepage and pore pressure response in the downstream shell of the South Dam are managed by the upstream beach width and core zone which is keyed into Glacial Till or Bedrock (Granodiorite). THVCP have initiated a multi-year plan which will allow the beach width upstream of the South Dam and at the South Abutment to be increased. Under existing conditions, beach width in this area is limited by the location of the reclaim barge. KCB is supportive of this plan as a wider beach is an effective risk management control and would further manage influence of rising pond level on the dam in this area.

Inclinometers

There are two inclinometers installed at the South Dam: I10-8 (~Sta. 1+200); and I10-1 (~Sta. 1+500). Zones of potential movement (i.e. mudstone layers or continuous glaciolacustrine deposits) have not been identified in this segment of the dam through drilling, foundation preparation or by previous inclinometer readings. This was consistent with 2019 observations.

Both instruments were converted to ShapeArray (SAAV) in late 2019. Since conversion, the readings have been consistent (i.e. no zones of movement).

V-A-1-1-2.2 Valley Buttress Berm

Instrumentation readings along Sta. 1+850 are shown on Figure 11. Instrumentation response during 2019 at the VBB did not indicate any issues of concern. As shown on Figure 18, construction activity in the VBB area during 2019 included a crest raise, and hydraulic fill placement at the downstream toe and upper slope.

Piezometers

Based on historic monitoring, piezometric regime at the VBB can be grouped into three different zones:

- Dam Fill (includes, Sand and Gravel Drainage Blanket and Lacustrine) – influenced by seepage through the dam fill and underdrainage, primarily from hydraulic placement during construction. Flow is typically horizontal as downward flow is restricted by the underlying Glacial Till.
- L-GLU – underlies the Glacial Till and piezometric conditions are generally governed by development of excess pore pressures in response to loading from dam fill and tailings rather than rising piezometric levels upstream of the core or in the dam fill. Piezometric levels within this unit do influence the critical slip surface for the design and therefore, threshold values are tied to design assumptions and more closely linked to dam performance than the other piezometric zones.
- Lower Sand and Gravel – underlies the L-GLU and has been generally steady year on year with no significant response to rising pond level.

Inferred piezometric surfaces for each of these zones are shown on Figure 10.

During 2019, measured piezometric levels within the L-GLU increased in response to construction loading, as expected, but the rate of pore pressure increase was well below assumptions in design analyses (~1/3rd of design value).

The piezometric levels within the Lower Sand and Gravel were consistent with previous observations (i.e. relatively static with no significant response to pond level rise).

The piezometric response in the VBB Dam Fill primarily reflects the cumulative influence of seepage from all segments in the downstream shell flowing towards and collecting in the VBB, which is the low point of the natural valley. In order to drive the cumulated seepage from hydraulic fill placement out of the dam the piezometric levels build up in the VBB to increase the seepage gradient towards the toe. KCB interprets that the piezometric response observed in the Dam Fill over the past two years is a process that has occurred to varying degrees over the life of the dam but has not been previously detected until measurements became available at this many locations or at this greater frequency.

During 2019, piezometric levels in the Dam Fill zone rose 2.8 m to 3.0 m. This is consistent with 2018 when the piezometric levels rose ~3.2 m to 3.3 m. Hydraulic fill placement rate during 2018 and 2019 was greater than typical which also increased the volume of seepage flow within the dam. In addition, prior to 2018 hydraulic fill placement (~mid-April 2018), there had been no hydraulic placement within the downstream shell of the dam for ~31 months (mid-August 2015) so seepage from past hydraulic placement had likely been drained fully, or near to, from the dam.

The peak piezometric levels measured in the VBB Dam Fill zone during 2019 are consistent with, or less than, peak values measured between 2003 and 2005 from now defunct piezometers. In terms of impact on dam safety, the design of the VBB is governed by slip surfaces through the L-GLU which is a weaker unit. The piezometric levels within the Dam Fill zone would have to increase substantially from existing levels (>10 m) to change that (KCB 2019a).

Piezometer readings within the Dam Fill zone started to level off starting in late August 2019, while hydraulic sand placement was still ongoing at the VBB and VBBE. As of November 2019, rate of rise has continued to decrease and there has been minor (~0.1 m) dissipation at some instruments. No hydraulic placement in the downstream shell is planned until ~April 2020, during which the levels within these units are expected to continue decreasing. This will be the first opportunity to monitor drain down in this area of the dam with near-continuous instrument readings. This can be used to calibrate future seepage models, as appropriate.

Inclinometers

There are 12 inclinometers installed at the VBB, 10 functional at the end of 2019, refer to Table V-A-2. The primary function of the instruments is to monitor deformation within the L-GLU to support implementation of the Observational Method as described in KCB (2018d). For redundancy, the instruments are roughly split along two parallel instrumentation lines perpendicular to the crest. General IDs were assigned to identify the location along the downstream slope each inclinometer is installed (Figure V-A-4).

Monitoring of inclinometers in the upper part of the downstream slope are primarily used to compare actual to assumed behaviour, this is the portion of the slope where movements within the L-GLU are first expected to occur during future dam raising. Threshold values assigned to these instruments are intended to inform whether a Contingency Case will be required in the future as described in KCB (2018c). Sustained movements within the L-GLU in the lower portions of the slope are not anticipated by design analysis. Therefore, threshold values at these locations are intended to notify THVCP and KCB if they do.

Figure V-A-4 VBB Inclinometer Location ID

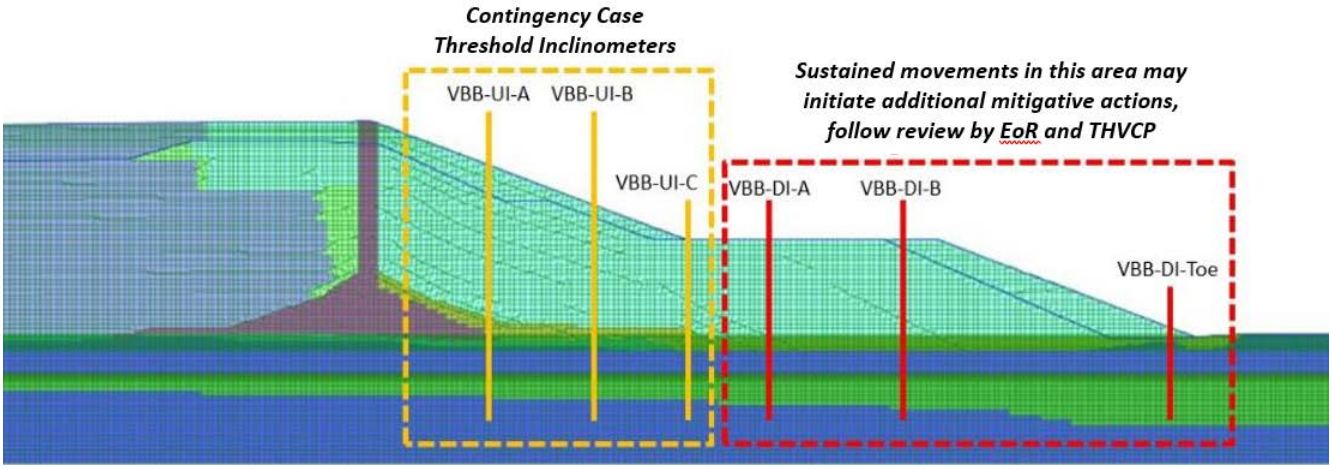


Table V-A-2 VBB Inclinometers and Assigned Location ID

Location ID	Inclinometers North of ~Sta. 2+000	Inclinometers ~Sta. 1+910	Inclinometers ~Sta. 1+850
VBB-UI-A	I17-01	-	I17-06
VBB-UI-B	I10-6 (damaged)	LLSAA12-1	I10-7
VBB-UI-C	-	-	I17-02
VBB-DI-A	I17-19	-	I17-09
VBB-DI-B	I17-10	-	I15-24 (damaged)
VBB-DI-Toe	I17-11	-	I15-27

Two of the inclinometers in the lower portion of the slope were damaged and became inoperable towards the end of July 2019. THVCP has attempted to repair both instruments, but downhole video inspections indicate that this is not feasible; the casing has either sheared in the fill (I10-6) and plugged (I15-24). However, as both have redundant instruments, monitoring of this area was continued throughout 2019. Readings at nearby instruments (upstream, adjacent and downstream) do not support that the instruments were damaged as a result of a mass movement of the dam. THVCP plans to replace both instruments in early 2020. Similar to I10-5 at VBBE, the location of the damage for I10-6 was within the 2019 active hydraulic sand placement area (El. 1189 m) is approximately the elevation of the cycloned sand fill surface prior to 2019 construction.

There were no zones of movement measured by any of the inclinometers in units other than the Lacustrine or L-GLU.

Key observations related to measured movements at inclinometers installed in the upper slope are summarized as follows:

- Lacustrine: the Lacustrine Unit is present beneath the L-L Starter Dam but was excavated from the footprint downstream of the starter dam as shown on Figure 2.1 in the main text. Refer to Appendix III-A for further discussion. As the unit is not continuous to the toe, any movement in the Lacustrine Unit is constrained to the unit itself and has a negligible influence on the

stability of the overall dam. The 2019 movement rate is consistent with rates measured during 2015 and 2018 construction (0.8 mm/month to 1.6 mm/month) where fill was placed in similar areas.

- L-GLU:
  - Measured movement rates during 2019 were consistent with those measured since installation and do not indicate a dam safety concern:
    - No Construction: typical ~0.1 mm/month, up to 0.4 mm/ month; and
    - Construction: typical ~0.2 mm/month, up to 0.9 mm/ month.
  - There is a relatively dense coverage of inclinometers in the VBB. Typical responses are similar between the inclinometers based on their relative locations; however, there is variability in movement rates and direction (Table V-A-3 and Figure V-A-5). KCB interprets this variability to be primarily a reflection of:
    - natural variability within the L-GLU deposits; and
    - inclinometer reading accuracy at such small movement increments (<1 mm/month).
  - The measured movement patterns are consistent with design expectations (i.e. movement in upper slope, where L-GLU is under greatest load and negligible movements beneath the bench or near downstream toe.
  - Inclinometer measurements during 2018 and 2019 construction are the first dataset which can be used to further calibrate the existing deformation model and predictions, this work is planned for 2020. Modelling to date has been based primarily on constitutive parameters derived from laboratory testing.

Figure V-A-5 VBB Inclinometers 2019 Movement Directions

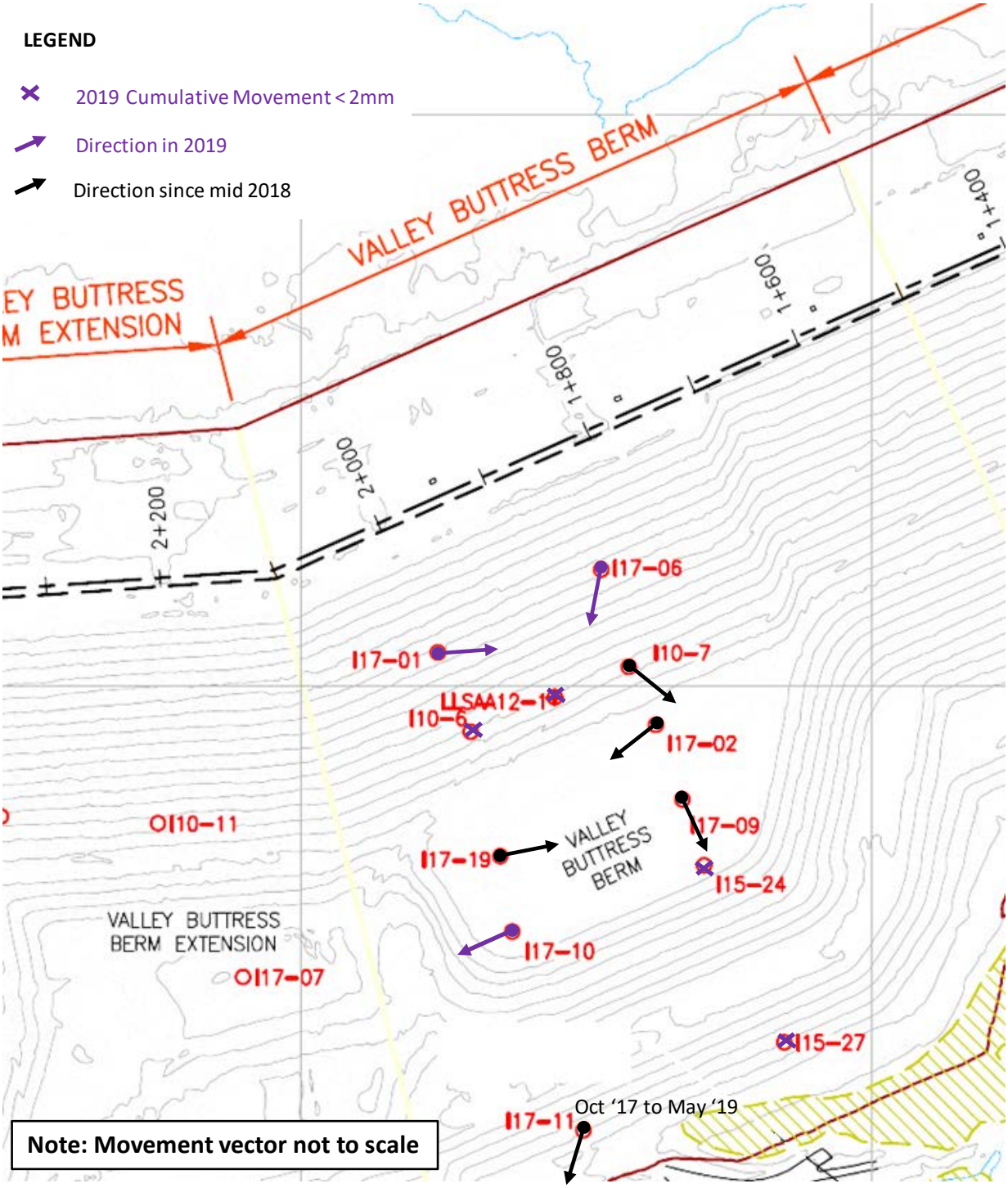


Table V-A-3 Summary Measured Movement Rates at VBB Inclinometers

Inclinometer	Location ID	L-GLU Elevation Range (est.) (m)	No Construction Movement Rates (mm/month)	Construction Movement Rates (mm/month)
I17-01	VBB-UI-A	1073.6 – 1082.6	0.1 to 0.4	1.1
I17-06	VBB-UI-A	1076.2 – 1086.2	<0.2	0.5
LLSAA12-1	VBB-UI-B	1076.0 – 1077.0	<0.1	<0.2
I10-06	VBB-UI-B	1075-1080	<0.1	<0.2
I10-7	VBB-UI-B	1070.0 – 1079.0	<0.1	1.1
I17-02	VBB-UI-C	1076.1 – 1079.1	<0.1	<0.1
I17-09	VBB-DI-A	1075.1 – 1079.1	<0.1	<0.2
I17-19	VBB-DI-A	1078.0 – 1080.4	<0.1	<0.1
I15-24	VBB-DI-B	1076.3 – 1081.3	<0.1	<0.1
I17-10	VBB-DI-B	1072.3 – 1078.3	<0.1	<0.3
I15-27	VBB-DI-Toe	1067.0 – 1071.5	<0.1	<0.1
I17-11	VBB-DI-Toe	1071.4 – 1075.4	<0.1	<0.1

V-A-1-1-2.3 Valley Buttress Berm Extension

Instrumentation readings along Sta. 2+250 are shown on Figure 10. Instrumentation response during 2019 at the VBBE did not indicate any issues of concern. As shown on Figure 18, construction activity in the VBBE area during 2019 included a crest raise, hydraulic fill placement at the downstream upper slope and operation of the temporary on-dam slimes cell.

Piezometers

The only piezometric response of note measured at the VBBE was between June and August 2019 during hydraulic fill placement. A piezometer within the drainage blanket (VWP17-07E) showed a rise (up to 2.4 m) over a 10 week period, following the start of hydraulic placement. Levels had dissipated to pre-construction levels by October 2019. Increased seepage from the underdrain was also evident during this period, as per observations from the 2019 DSI site visit (Appendix II).

With the exception of the piezometers at VWP17-04, piezometers in the foundation did not respond to rising pond level or hydraulic placement and remained relatively steady through out 2019, which is consistent with historic behaviour. Nested piezometers installed in the foundation at VWP17-04 (04A to 04E) measured a rise starting in July 2019 which began to dissipate in September 2019 and has returned to pre-July levels by November 2019 at all but 1 instrument. The timing of the response and location of the instruments (which are within footprint of 2019 hydraulic fill placement) indicate this response is related to hydraulic construction as well and not pond rise. A similar pattern was not observed at any of the near by instruments either.

Inclinometers

There are four inclinometers installed at the VBBE: I10-5 (~Sta. 2+350); I10-11 (~Sta. 2+225); I17-7 (~Sta. 2+150); and I17-8 (~Sta. 2+125). Zones of potential movement (i.e. mudstone layers or continuous glaciolacustrine deposits) have been identified in this segment of the dam through drilling. However, glaciolacustrine deposits and mudstone layers are not interpreted to be continuous. In addition, the Sedimentary Unit at the VBBE is capped by glacial overburden. Inclinometers in this dam segment support this geologic interpretation and no zones of active movement are measured.

During July 2019, the inclinometer casing at I10-5 was sheared at approx. El. 1188 m (confirmed by THVCP via downhole camera inspection) which is within the cycloned sand fill, ~45 m above natural ground contact. The location of the break is approximately the elevation of the cycloned sand fill surface prior to 2019 construction. Functioning inclinometers downstream of I10-5 are not showing movements or trends of concern. KCB reviewed and concluded that there are no observations or analyses which indicate the casing breakage at I10-5 is an indication of downstream progression of movement along mudstone layers (~El. 1116 m and 1156 m) at the nearby I17-24 (NBB Sta. 2+575). THVCP is in the process of attempting a repair; however, if unsuccessful a replacement is planned for early 2020.

V-A-1-1-2.4 North Buttress Berm

Instrumentation readings along Sta. 2+564 are shown on Figure 9. Instrumentation response during 2019 at the NBB did not indicate any issues of concern. As shown on Figure 18, construction activity in the NBB area during 2019 included a crest raise and operation of the temporary on-dam slimes cell.

Piezometers

Piezometric levels in the bedrock foundation are variable, even in the same units indicating potential for perched water tables, preferential flow paths or reflection of complex geology. The piezometric levels measured in the glacial overburden are generally more consistent. There were no significant piezometric responses at the NBB during 2019, with readings remaining relatively constant throughout the year with no significant influence from rising pond level.

The piezometric rise at some foundation piezometers that was observed during 2017 and 2018, was not measured in 2019. Water did not pond on the north side of the NBB in 2019 to the same degree that it had during 2017 or 2018 freshet. The absence of ponding and lack of piezometric response, supports KCB's interpretation that the piezometric rise was related to surface ponding and not pond rise or dam construction.

Inclinometers

There are five inclinometers installed in the NBB dam segment: I10-12 (~Sta. 2+450, dam toe); I15-25 (~Sta. 2+500, mid bench); I17-22 (~Sta. 2+550, mid bench); I17-24 (~Sta. 2+600, upper bench); and I19-08 (~Sta. 2+600, lower bench). I17-24 was installed in 2017 but is installed in a similar location to previous inclinometers, which are now defunct (e.g. I90-1 and I91-1), to measure movements along previously identified shear planes.

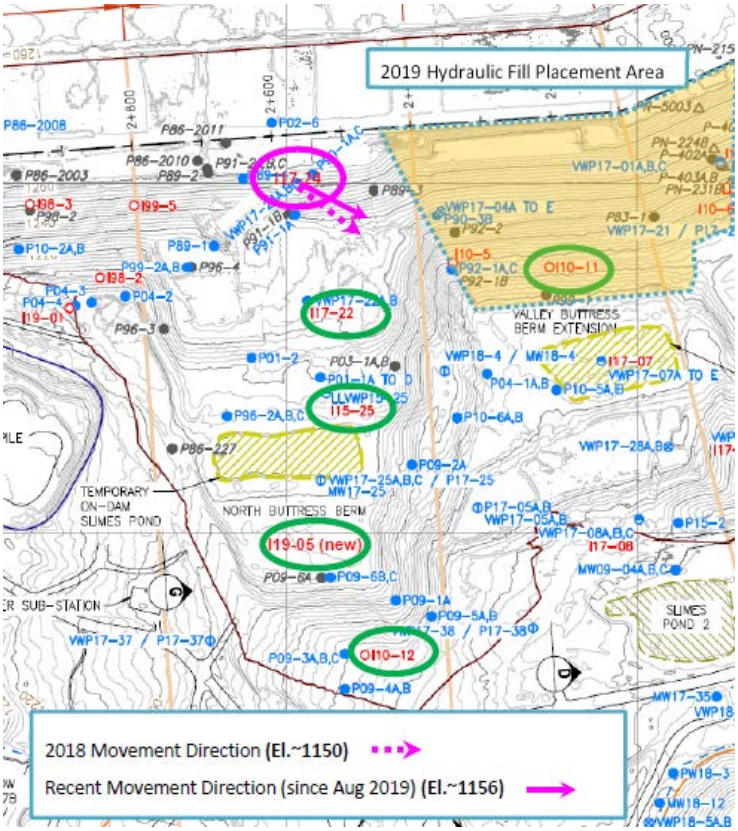
Movement along mudstone layers near the crest and upper bench (e.g. I17-24) have been measured since the early 1990's and are expected to continue with increased movement rates in response to loading. Movement rates are expected to dissipate after loading is completed. In comparison to movements in glaciolacustrine deposits, shear movements in the mudstone layers are along discrete shear planes. The objective of the NBB design is to build the buttress in such a way to reduce movements and prevent movement zones from propagating downstream to the toe (KCB 2019a).

General observations and trends based on 2019 inclinometer readings are:

- As expected, movements were measured at I17-24 along the historic shear zones (~El. 1156 m and El. 1116 m). Prior to 2019 construction, movement rates along these shear zones were ~1.3 mm/month. Rates increased in response to fill placement at the crest or in the adjacent VBBE and typically varied between ~1.6 mm/month to ~3.0 mm/month. Following construction placement, movement rates started to dissipate.
- No similar shear movements were measured at I17-22, which is the nearest downstream inclinometer (170 m) to I17-24. This indicates continuous shear zones have not progressed to I17-22 which is 300 m downstream of dam centreline and 510 m upstream of the dam toe.
- No shear movements were measured at other downstream inclinometers I15-25 or I10-12. I19-08 was initialized in August 2019 and no shear zones have been identified to date.

Of note, movement rate along the mudstone layers at I17-24 did increase during loading at the VBBE which is (~150 m south of the inclinometer). The direction of I17-24 movement was to the southwest towards the fill area (Figure V-A-6), and is consistent with recent movements. No corresponding movements were measured at any of the VBBE or other NBB inclinometers. Geologic characterization in this area indicates the bedrock stratigraphy is complex and three-dimensional (3D) effects are prevalent. KCB interprets that the response to construction and the direction of movement at I17-24 are most likely attributed to movement along a pre-sheared plane, potentially bedding.

Figure V-A-6 I17-24 Movement Direction in Response to VBBE Fill Placement



V-A-1-1-2.5 North Dam

Instrumentation readings along Sta. 2+800, 3+300 and 3+630 are shown on Figures 6 to 8. Instrumentation response during 2019 at the North Dam did not indicate any issues of concern. As shown on Figure 18, construction activity in the North Dam area during 2019 included a crest raise and mechanical placement of cycloned sand.

Piezometers

Foundation piezometric conditions through the glacial overburden deposits at the North Abutment and North Dam differ from the rest of the dam as the foundation units generally indicate hydrostatic conditions (i.e. similar piezometric elevation measured in each unit), rather than the presence of a strong downward gradient. This observation continued throughout 2019 and is evident when comparing the piezometric levels plotted on instrumentation section at Sta. 3+630 (Figure 6) to instrumentation sections from other segments of the dam.

In addition, the piezometric head drop across the dam core north of Sta. 3+500 is much less than the rest of the dam and the majority of foundation piezometers downstream of the dam core show a response to rising pond level which is also not characteristic for other dam segments. This behaviour started in 2005 when the pond level rose above the natural groundwater levels in the north abutment slope (~El. 1225 m). Prior to 2005, the natural groundwater levels were higher than the

pond level and piezometers showed no significant year-on-year rise. A similar response was observed during 2019 at the South Dam; however, piezometers in that area still show a downward gradient (Figure 12).

This difference in behaviour at the North Dam is due to the dam core zone being keyed into the Upper Sand and Gravel Unit rather than Glacial Till or intact Bedrock, as discussed in Appendix III-A. A tailings beach is relied upon in the design (KCB 2019a) to mitigate seepage and future pore pressure rise downstream of the dam core.

During 2019, foundation piezometric levels typically rose ~1.5 m, up to 3.7 m. The rate of rise is the greatest in piezometers upstream of the core zone (e.g. VWP16-03B) and progressively attenuates in the downstream direction, as would be expected. The majority of the rise during 2019 occurred starting in November 2019 which coincides with the timing when THVCP resumed beaching in the area. A similar response was observed during the previous period of extended beaching in the area (~November 2017 to February 2018). Existing piezometric levels and trends are consistent with expected behaviour. As with the piezometric levels and trends in the VBB Dam Fill zone, increased monitoring points and frequency will provide the basis to further the understanding of piezometric behaviour in this part of the dam.

Inclinometers

There are twelve inclinometers installed at the North Dam area, refer to Table V-A-4. The primary function of the instruments is to monitor deformation within the U-GLU and mudstone layers, where present. Discussion of the North Dam inclinometers is best separated into the sub-segments based on which critical foundation unit is present and governing design: North Dam Bedrock; and North Dam U-GLU.

- North Dam Bedrock (Sta. 2+800 to 3+300):
  - During 2018, the North Dam was built out to the ultimate dam toe which involved loading an area where mudstone layers were known to be present, including placement over top of an inclinometer which had previously not been loaded (I98-2). Similar to observations at the NBB, this construction activity increased movement rates along mudstone layers. At no point did these indicate an immediate dam safety concern. The instrumentation response did trigger a geology review and installation of additional instruments downstream of the ultimate toe. These movement rates started to attenuate after fill placement was completed in December 2018 and levelled off in March / April of 2019. The 2018 DSI (KCB 2019b) included a detailed discussion of the movements and follow up.
  - Following the attenuation of movement rates from 2018 construction, rates remained relatively steady throughout 2019. No significant response to 2019 construction activity, which was limited to a crest raise, was measured at any of the inclinometers in the area. The inclinometers installed at the toe during 2019 (I19-01, I19-02) have not shown any movement zones since installation.

- I10-3 (Sta. 3+150) is located within the North Dam Bedrock area but in 2018, inclinometer movements indicated that the U-GLU was present at surface and movements were measured in response to loading. Similar to mudstone layers, the movement rate at I10-3 attenuated following completion of construction and remained relatively constant for the remainder of the year.

- North Dam U-GLU (Sta. 3+300 to North Abutment):
  - Similar to the North Dam Bedrock segment, construction in 2019 was limited to crest raise, with the exception of some cycloned sand placed mechanically north of Sta. 2+800 to Sta. 3+900.
  - Also, similar to the North Dam Bedrock segment, after attenuation of the movement rates from 2018 construction, movement rates became relatively steady within the U-GLU throughout the remainder of 2019, including at the instruments installed along the toe in early 2019 (I19-03 and I19-04).

Table V-A-4 North Dam Inclinometers and 2019 Movement Summary

Inclinometer	Station	Location	Critical Unit Present Y/N (U-GLU or Mudstone)	2018 Construction Influenced Movement Rates[1] (mm/month)	Post 2018 Construction Movement Rates (mm/month)
I99-5	2+800	Upper slope	Mudstone	1.2	<0.2
I98-2	2+860	Lower slope	Mudstone	1.2	<0.2
I19-01	2+900	Toe	Mudstone	-	<0.2
I98-3	2+950	Upper slope	Mudstone	1.0	<0.2
I19-02	3+150	Toe	No	-	-
I10-3	3+150	Mid slope	U-GLU	5	<0.2
I19-03	2+900	Toe	No	-	-
I16-5	3+400	Mid slope	U-GLU	Note 2	<0.2
I16-1	3+510	Mid slope	U-GLU	Note 2	<0.2
I19-04	3+150	Toe	No	-	-
I99-6	3+600	Upper slope	No	-	-
I16-4	3+750	Toe	U-GLU	<0.2	<0.2

Notes:
1. Rates dissipated, typically between January and early April 2019.
2. In-place Inclinometers were reinitialized, and measurements were not reliable.

V-A-1-3 Seepage

Seepage measurements from weirs installed downstream of the L-L Dam, since 2013, are shown in Appendix V-D. In general, seepage rates were consistent with previous years. Spikes measured at LL-FS-04, near the VBBE toe showed several spikes in flow which was not measured at other seepage weirs. The timing of these, and the timing of similar spikes measured in 2018 coincide with hydraulic fill placement periods which has been observed to temporarily increase seepage rates.

THVCP are developing a plan to replace and/or upgrade the seepage weirs installed downstream of the dam which was also a recommendation from the DSR (Appendix IX).

V-A-1-2 H-H Dam Performance Summary

V-A-2-1 Vertical Buffer Above Tailings Surface

The top of beach and dam crest were measured weekly (minimum) during 2019 in compliance with the OMS Manual (THVCP 2018). Figure V-A-7 shows tailings beach profile over the past 5 years at various stations along the H-H Dam crest. Note that the tailings beach has been relatively level since spigotting at the East Abutment was shifted 50 m further away from the dam in July 2019. As a result, tailings are deposited on the far side (relative to H-H Dam) of the existing tailings cone and therefore flows towards L-L Dam and does not flow or pool near the H-H Dam.

There is no permanent free water pond against H-H Dam during normal operating conditions and overtopping is not a credible failure mode for the dam as discussed in Section 7.3.3 of the main text. However, the 2019 version of the M-11 Permit (EMPR 2019) included a requirement to maintain a minimum of 1 m (vertical) difference between the tailings beach and the effective dam crest[1], along the full length of the H-H Dam. This inclusion was based on the operational basis THVCP included in the 2018 OMS Manual (THVCP 2018) and had already been adopted by the site.

The H-H Dam buffer differs from the flood freeboard requirements at L-L Dam, which is in place as a control against overtopping, and is in place to manage risks related to tailings flowing over the dam crest due to unplanned changes in beach slope, deposition plans or beach development. Such an event has not occurred at the site.

The minimum buffer (1 m) was achieved along the dam crest throughout 2019. Buffer values near the end of 2019 (December 2nd), after the 2019 dam crest raise was completed, are shown on Figure V-A-8.

[1] The effective dam crest is measured between the top of the tailings beach and the top of confinement for tailings, whether that is provided by the top of the glacial till core, rockfill or any berms that are along the upstream edge of the crest.

Figure V-A-7 H-H Dam Tailings Beach Elevations Along Crest: 2015 to 2018

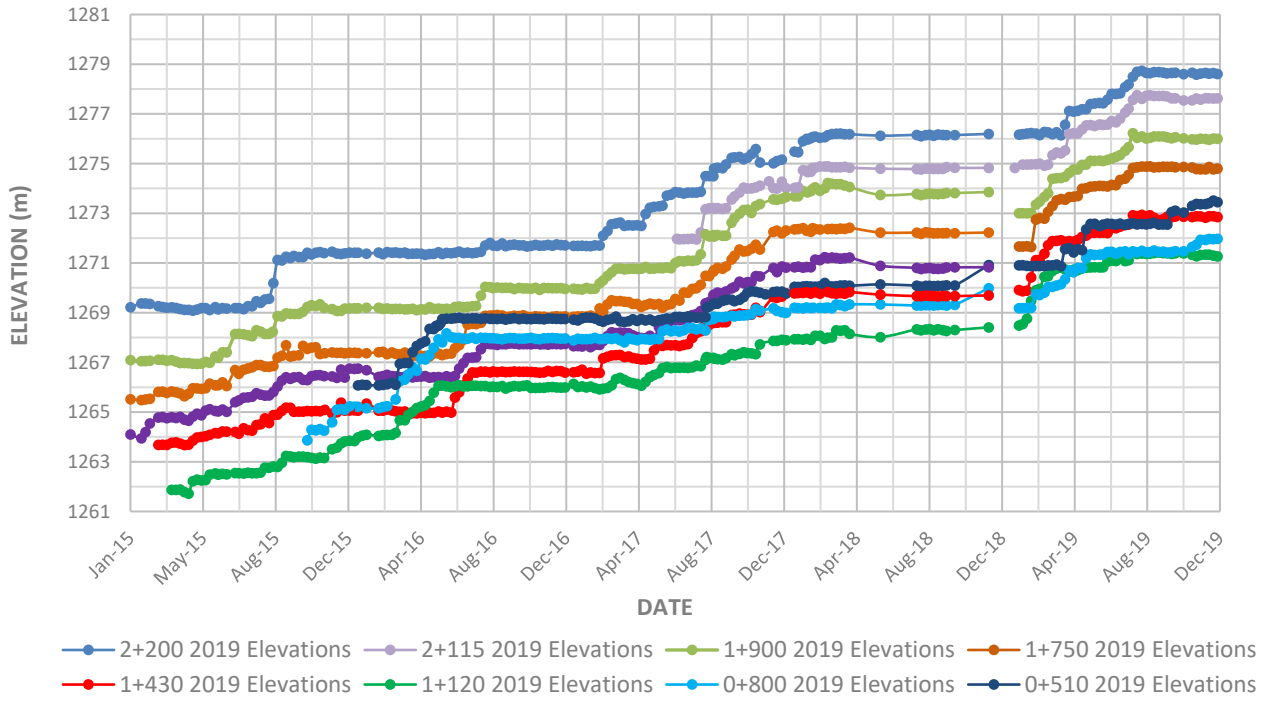
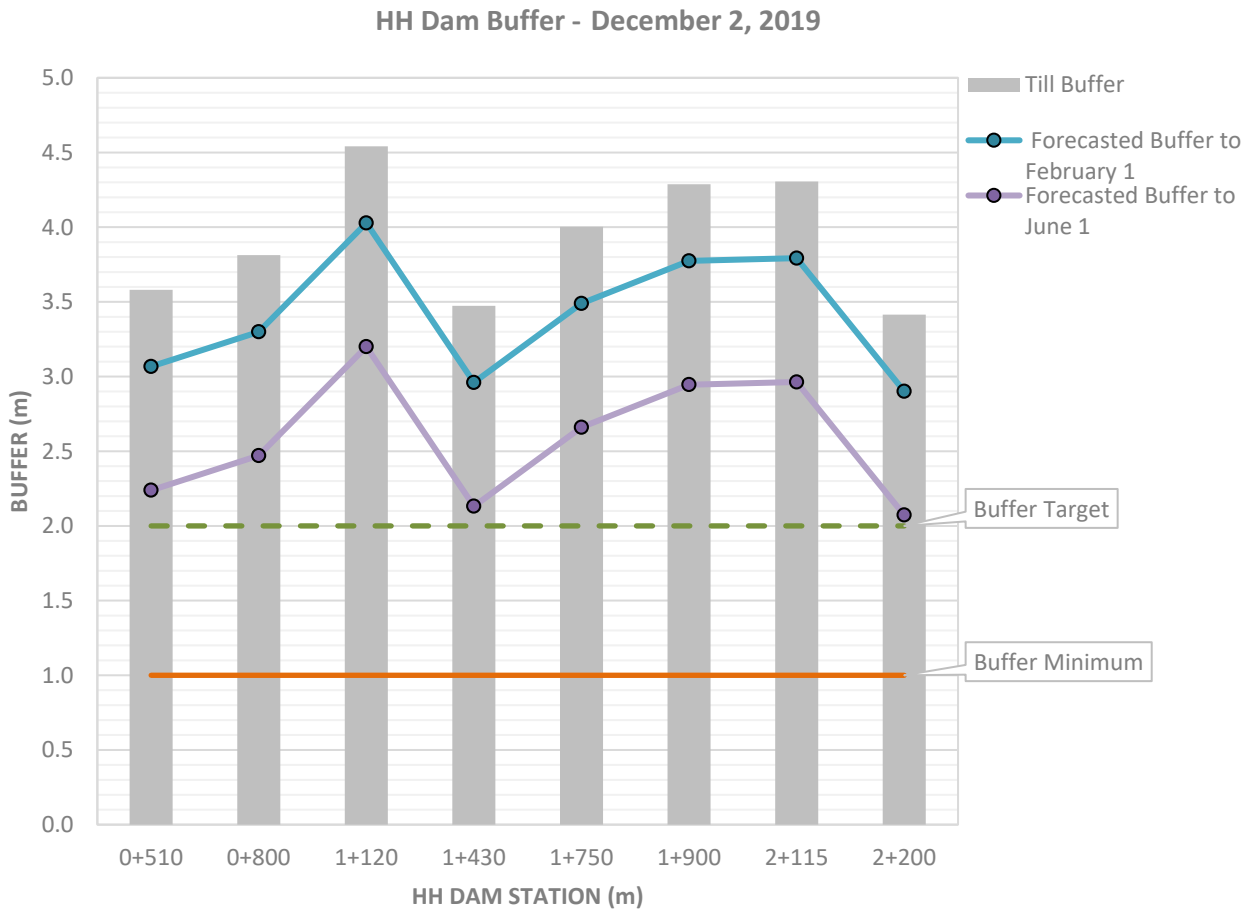


Figure V-A-8 2018 H-H Dam Tailings Buffer Along Crest After H-H Dam Crest Raise



V-A-2-2 Instrumentation Trends

General piezometric and displacement behaviour based on instrumentation at the H-H Dam is summarized herein. As mentioned in Section 5.1 of main text, Notification Level thresholds are not discussed herein, as they do not represent a dam safety concern and are used as a screening tool by KCB and THVCP teams

Some threshold values were revised during the year to reflect assumptions from the 2019 design update (KCB 2019a) or if the initial threshold assigned was later found to not be representative. Threshold changes are documented in RMRs and/or instrument exceedance review forms.

The majority of the existing instruments at the H-H Dam were installed during 2017. THVCP is currently building baseline data for future comparison with design assumptions. The stability of the H-H Dam is governed by the post-earthquake condition of the saturated, loose random fill (Section 7.3.3 of main text). Piezometric conditions assumed in design of the H-H Dam take into consideration the reduced record of piezometric information available, in comparison to L-L Dam.

Table V-A-1 summarizes the instruments installed within or near the H-H Dam or foundation at the end of 2019. Similar to the L-L Dam, THVCP continued their program to convert existing manually read instruments to automated data collection integrated with the electronic monitoring system In total 29 of the 51 geotechnical instruments at the H-H Dam are integrated with the real-time monitoring system.

Table V-A-5 Summary of Functional Instrumentation Installed at H-H Dam (November 2019)

Instrument	Type	Reading [1]	No.	Total
Piezometers	Standpipe	Manual	10	38
	Transducer (Converted Standpipe)	Automated	-	
	Vibrating Wire	Automated	28	
Inclinometers	Down-hole Casing	Manual	7	8
	ShapeArray (SAAV) [2]	Automated	1	
Settlement	Sondex [3]	Manual	5	5

Notes:
1. Automated readings are transmitted through the remote monitoring system to increase data capture and summarize instrumentation.
2. A 90 m SAA array is installed in the lower portion of a 103 m drill hole (HHSAA12-1).
3. Sondex settlement monitoring systems were installed at the HH17 series inclinometers. HH17-16A was damaged and could not be recovered during 2018 construction.

November 2019 instrumentation readings are shown on select design cross sections, through each dam segment, of the H-H Dam (Figure 13 to 17). Refer to Appendix VI-A for additional discussion regarding instrumentation measurements at the L-L Dam. Instrumentation summary plots are included in Appendix VI-B (piezometers) and Appendix VI-C (inclinometers).

Piezometers

Existing piezometric levels in this fill and foundation units are below design assumptions and there were no significant changes measured during 2019, other than those related to instruments continuing to equilibrate after installation. General observations from the piezometer data are:

- There is one instrument installed in the dam fill upstream of the core zone (HH-VWP15-22) which measured a head ~El. 1262.5 m at the end of 2018 which is ~3 m less than the peak value from 2017. During 2018, most of the deposition was upstream of the tailings cone near the east abutment resulting in very little tailings flowing over or water ponding on the tailings immediately upstream of the dam relative to 2017.
- Piezometric levels in the dam fill generally grade towards 24 Mile Lake, ranging from El. 1210 m to El. 1215 m near the core and ~El. 1202 m at the slope toe. In 2018, the water level in 24 Mile Lake was on the far side of the facility relative to the dam but the tailings are still likely saturated and the lower permeability of the tailings act as a restriction on flow.
- The general stratigraphy in the dam foundation along the middle of the valley (~Sta. 1+200 to Sta 1+850), listed in descending order, comprises of: Glacial Till; Clay Layer 2; and Sand and Gravel:

- With the exception of the outlier at HH17-33A, piezometric levels in the Sand and Gravel suggest the piezometric level grades from the abutments (to the base of the natural valley). Where multiple piezometers are installed at a single location, the water level in the Sand and Gravel is less than measured in the overlying unit, suggesting a downward gradient.
- Piezometric levels measured in the unit referred to as Clay Layer 2 show the opposite pattern as the values in the dam fill where the piezometers levels are higher near the dam toe (~El. 1218 m) than near the dam core (El. 1207 m). This trend is under further review.
- With the exception of the outlier at HH17-32B, piezometric levels in the glacial till in the middle of the valley and East Abutment range between El. 1215 m and El. 1220 m.

Inclinometers and Settlement

There are 8 inclinometers and 5 Sondex settlement monitoring systems installed at the H-H Dam, refer to Table V-A-6. During 2019, the Sondex installed near HHSAA12-01 (~Sta. 1+280) was damaged and could not be salvaged. There remains sufficient coverage across the dam, such that the loss of this instrument does not compromise the surveillance program for the dam.

Table V-A-6 Summary of Inclinometer / Sondex Installations at H-H Dam

Location	Inclinometer / Sondex					
	Sta. 1+200	Sta. 1+280	Sta. 1+460	Sta. 1+600	Sta. 1+700	Sta. 2+020
Near Core Zone	HHI17-33 / HHI17-33A	HHSAA12-01 / -	HHI15-23 / HHI17-33A	-	HHI17-16 / HHI17-16A	-
Crest of Fill Slope	-	-	-	HHI17-17 / HHI17-17A	-	-
Toe of Fill Slope	-	-	HHI17-31A / -	-	HHI17-30 / -	HHI17-14 / HHI17-14A

H-H Dam inclinometers in the dam fill have shown consistent horizontal movements distributed fairly uniformly in the downstream fill. The Sondex systems were installed to measure settlement to validate the interpretation that horizontal movements are related to settlement of the downstream fill. As described below, settlement and horizontal movements do occur at the same locations.

Horizontal movements in the fill do not extend below El. 1210 m or El. 1215 m depending on the location. Below this elevation range the downstream shell is comprised of Structural Fill which was placed in lifts up to 2 m and compacted. This fill would be much less prone to settlement than the overlying Random Fill, where horizontal movements are measured, which was placed by the mining fleet in thick lifts (up to 10 m).

Summary plots of inclinometer and Sondex monitoring are included in Appendix VI-C. Measurements from the instruments indicate the following:

- Near Core Zone (HHI17-33 / HHSAA12-01 / HHI15-23 / HHI17-16):
  - No zones of sustained downstream movement were measured in the dam foundation at any of the inclinometers.
  - All of the inclinometers show some degree of horizontal movement in the waste fill above ~El. 1210 m. Ranging between 7 mm and 65 mm during 2019.
  - A comparison of inclinometer and Sondex measurements does support the interpretation that the horizontal movements in the upper fill is primarily related to fill settlement. The locations of the largest settlement (HHI17-33A and HHI17-16A) correlates to the areas with the most horizontal movement.
  - The Sondex systems were installed from the top of fill at the time of drilling down to ~El. 1225 m. Additional settlement may be occurring below this level that would not be measured by the Sondex rings.
- Crest of Fill Slope (HHI17-17):
  - The same pattern of horizontal movement and settlement observed at the near crest inclinometers is also observed at HHI17-17.
- Toe of Fill Slope (HHI17-31A / HHI17-30 / HHI17-14):
  - Both of the inclinometers along the toe upstream of 24 Mile Lake (HHI17-30 and HHI17-31A) show compression zones along their depth but there are no zones of sustained downstream movements in the foundation. The same pattern of horizontal movement in the fill observed at the dam crest is not present at these locations.
  - The incremental movement plots for the inclinometer installed near the dam toe upstream of the lock-block wall (HHI17-14) shows negligible horizontal movements in the fill or foundation. The Sondex at the same location (HHI17-14A) is measuring relatively small amounts of settlement.

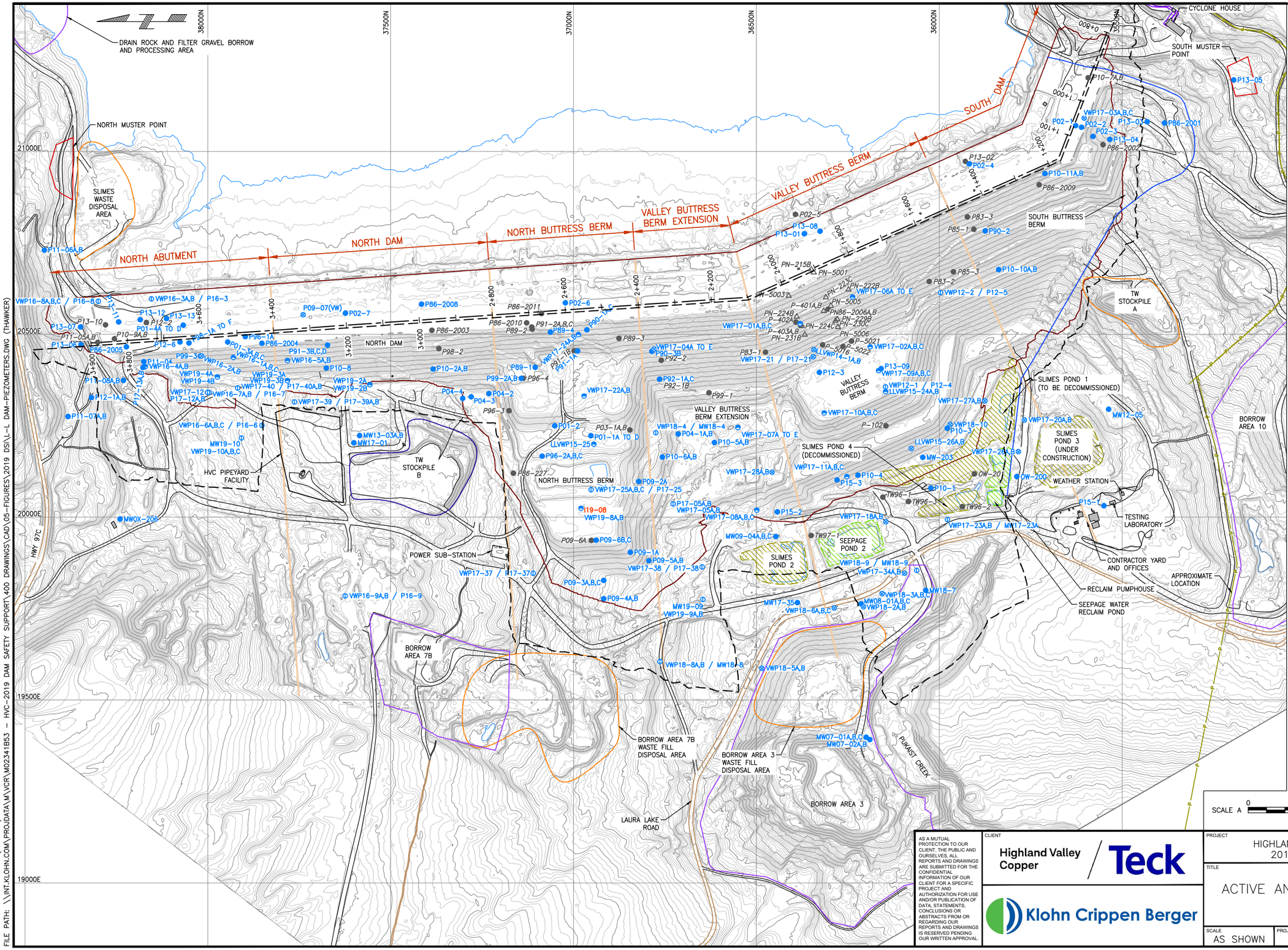
Retaining Wall Survey Monuments

Ten survey monuments were installed on the lock-block wall at the toe of the H-H Dam, near the HH Pumphouse (~Sta. 2+025), have been monitored in 2018. All of the monuments show similar pattern of little to no movement, consistent with 2018 measurements.

APPENDIX V-B

L-L Dam Piezometer Plots

L-L DAM PIEZOMETER LOCATION MAP



LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- 2040 PFS DAM FOOTPRINT
- L-L DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER

DEFUNCT INSTRUMENTS AND BACKFILLED DRILLHOLES (SEE NOTE 3):

- DEFUNCT PNEUMATIC PIEZOMETER
- DEFUNCT STANDPIPE PIEZOMETER

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM PHOTOSAT SURVEY DATED 2019-09-30 (L-L DAM) AND 2017-09-15 & 24 AND 2016-09-25 & 29 (OUTSIDE OF 2019 SURVEY EXTENT).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.

SCALE A 0 250 m

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

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM
ACTIVE AND DEFUNCT PIEZOMETERS
LOCATION PLAN

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M02341B53	

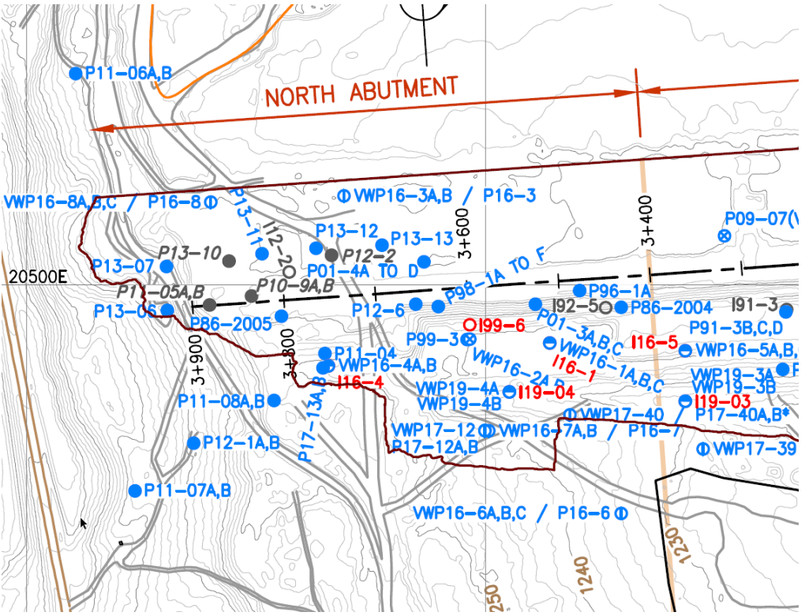
K:\3-FIG\D-L

SAVE DATE: 2019-12-16 (3:01 PM)
FILE PATH: \\INT.KLOHN.COM\PROJDATA\MV\VCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\400 DRAWINGS\CAD\05-FIGURES\2019 DS\L-L DAM-PIEZOMETERS.DWG (THAWKER)

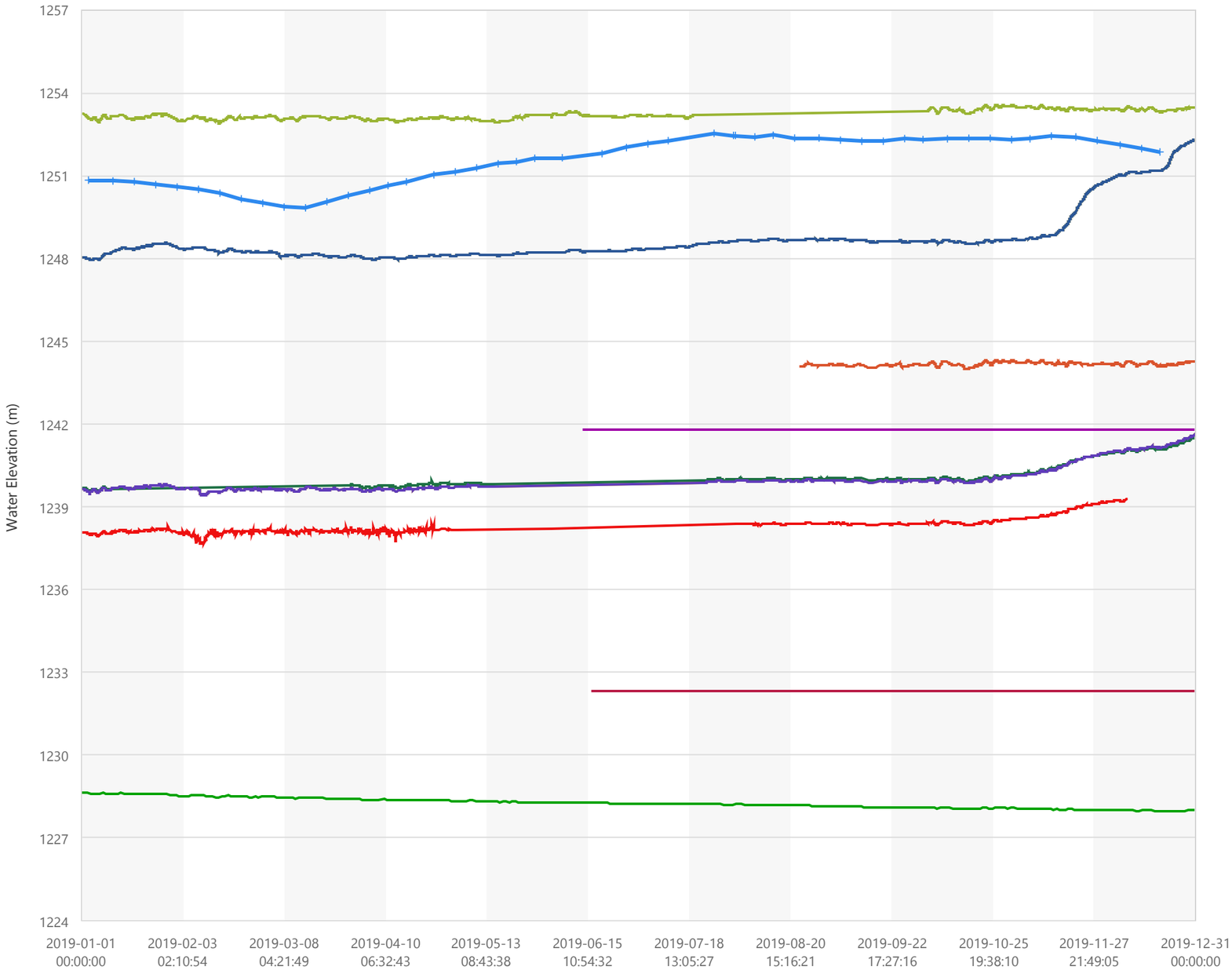
APPENDIX V-B-1

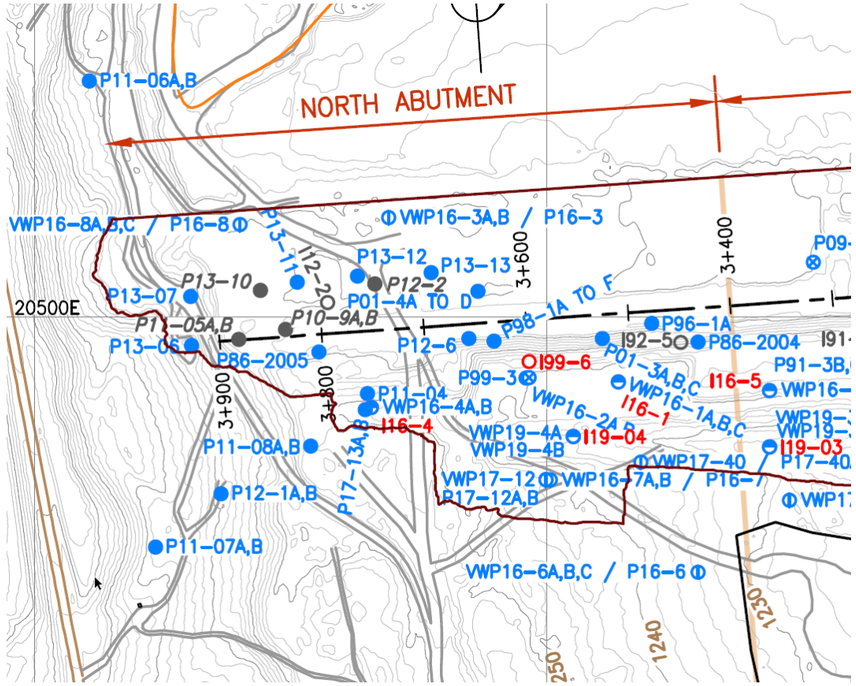
L-L DAM PIEZOMETERS: 2019 WATER ELEVATIONS

NORTH ABUTMENT – 2019 WATER ELEVATIONS

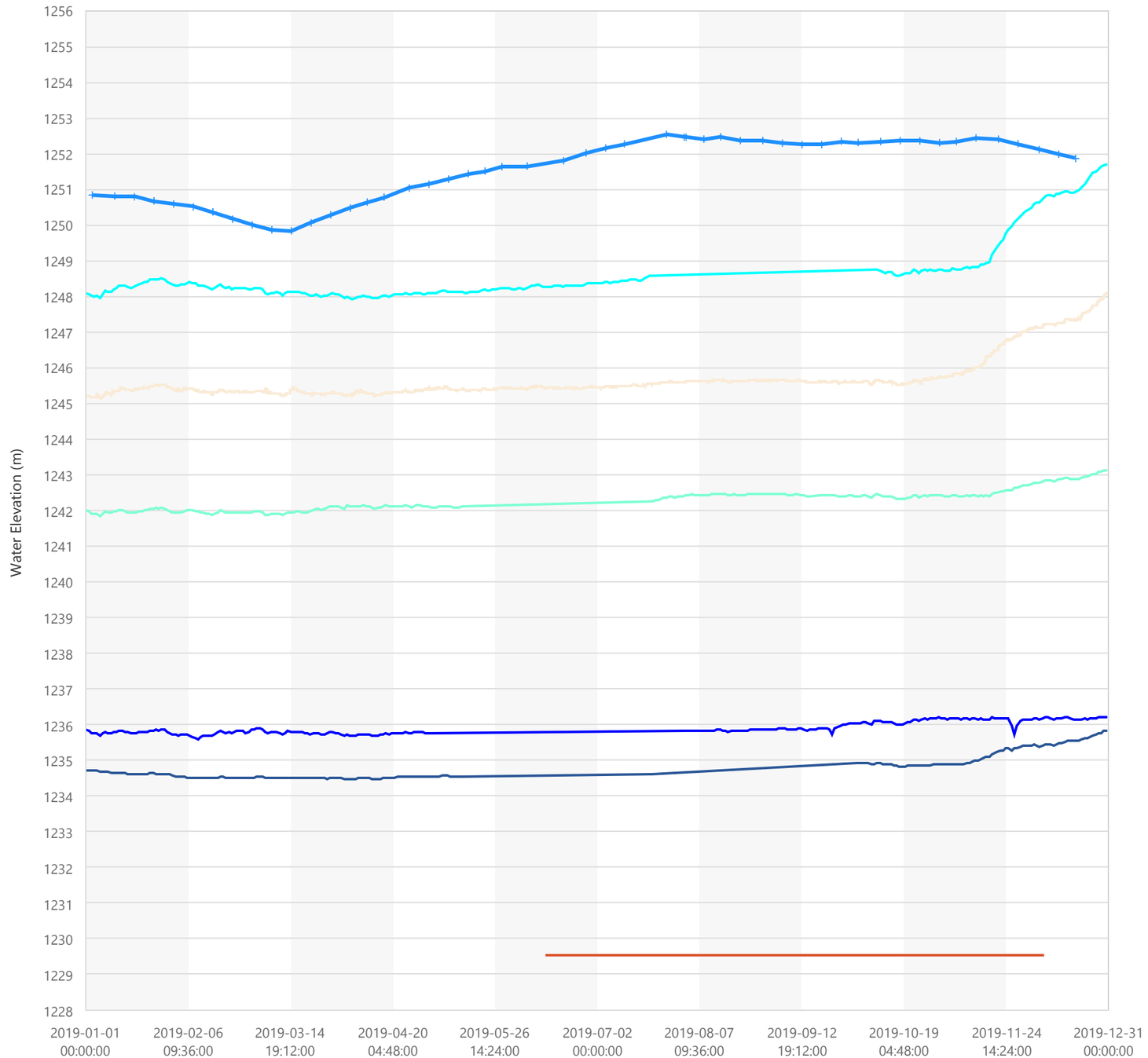


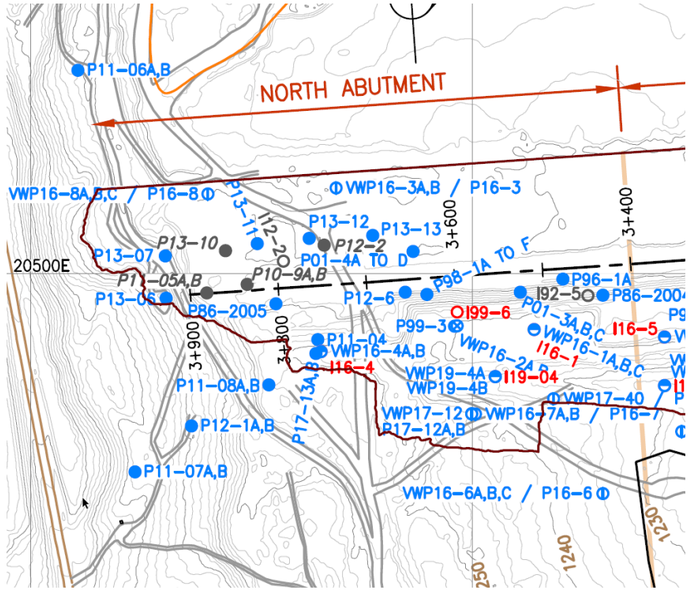
North Abutment - Sand and Gravel



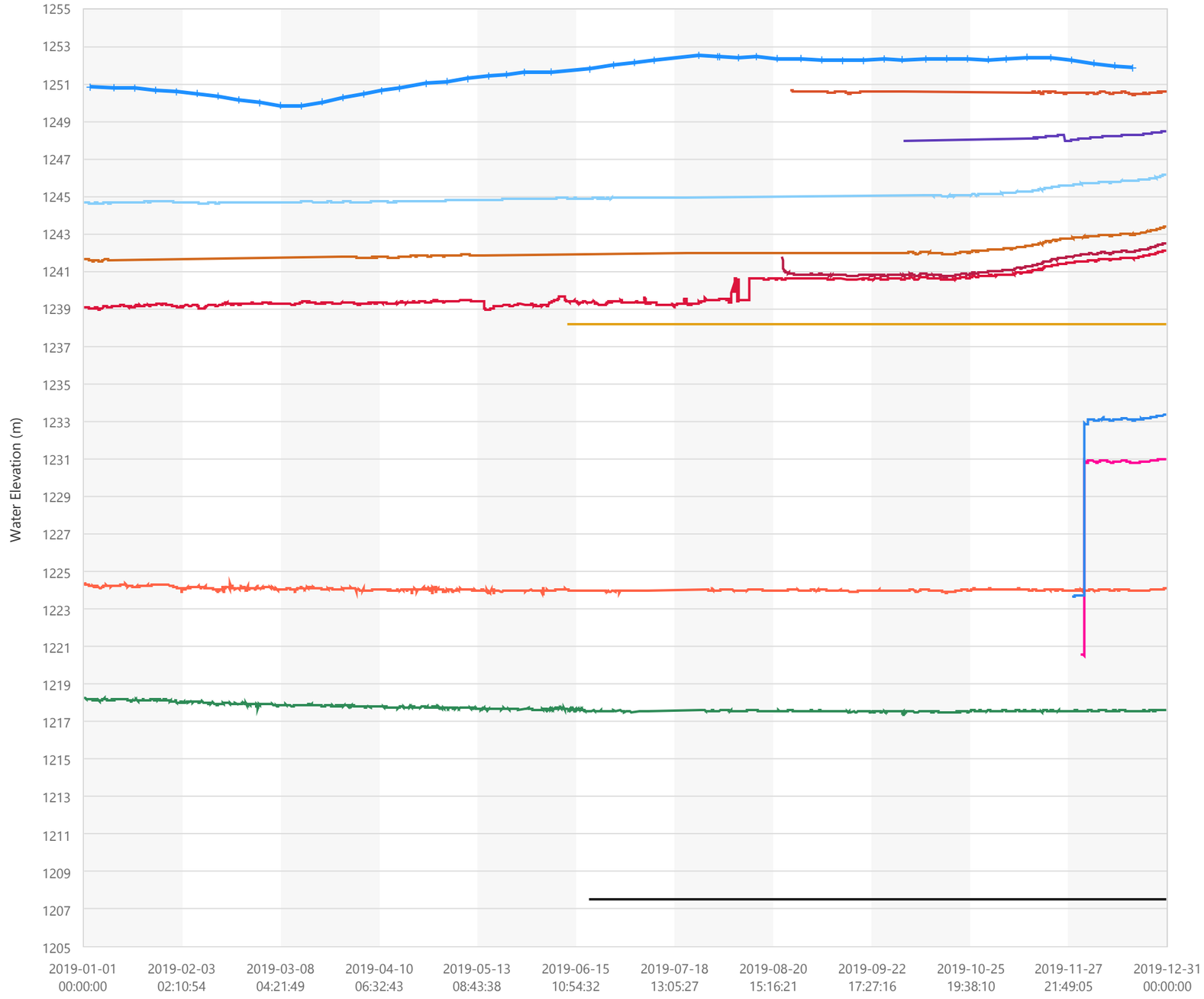


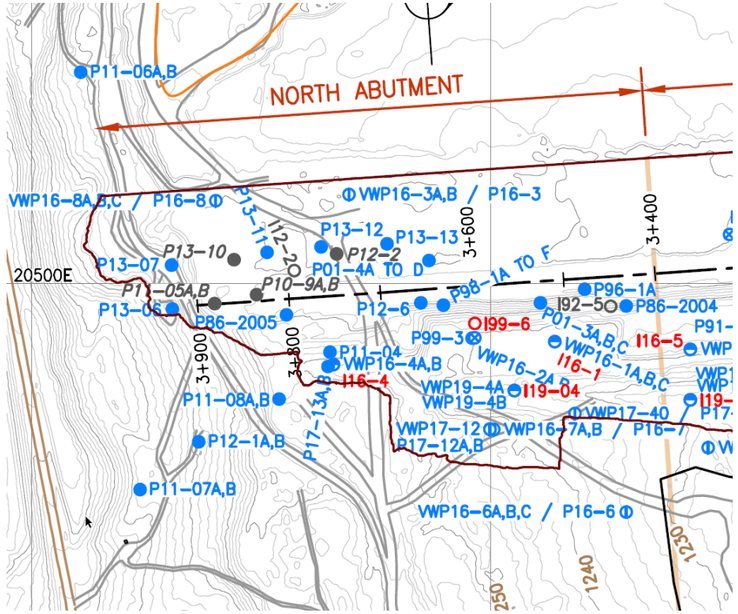
North Abutment - Glaciolacustrine



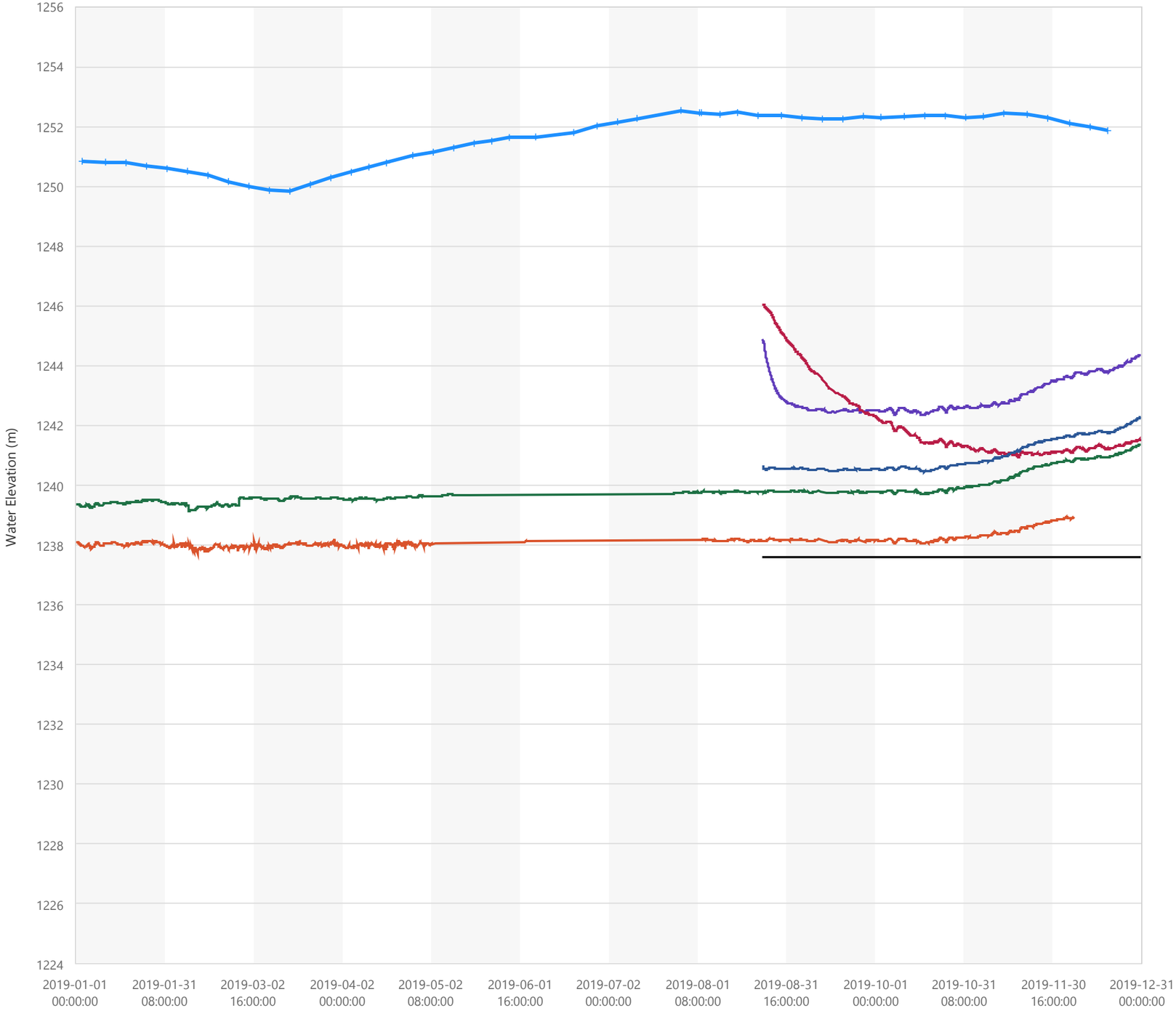


North Abutment - Glacial Till

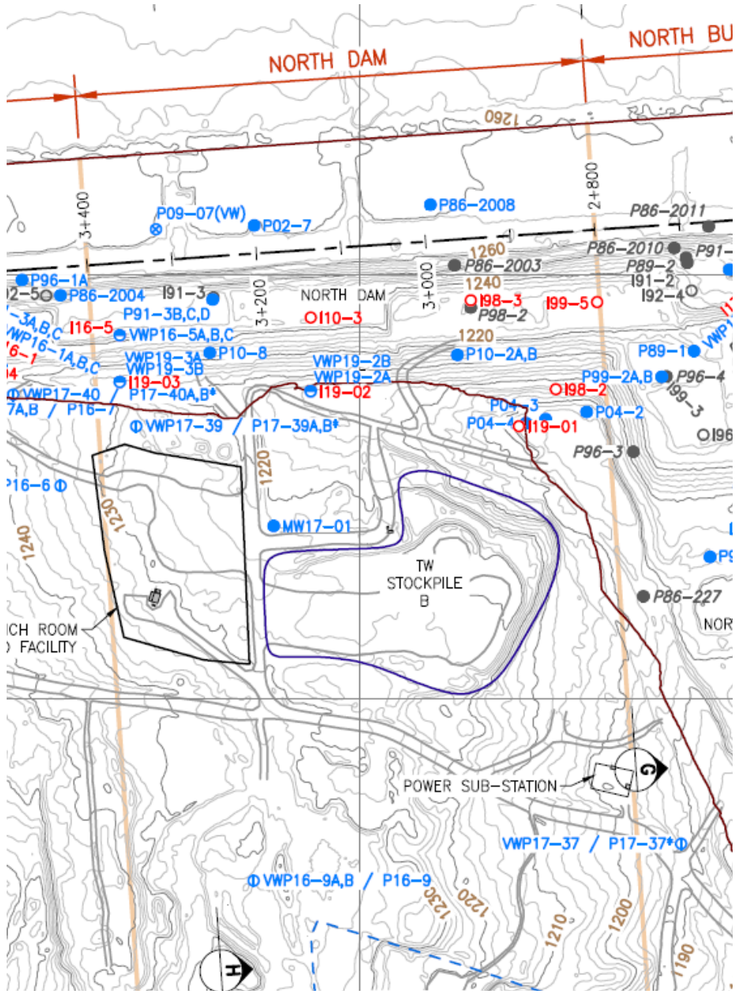




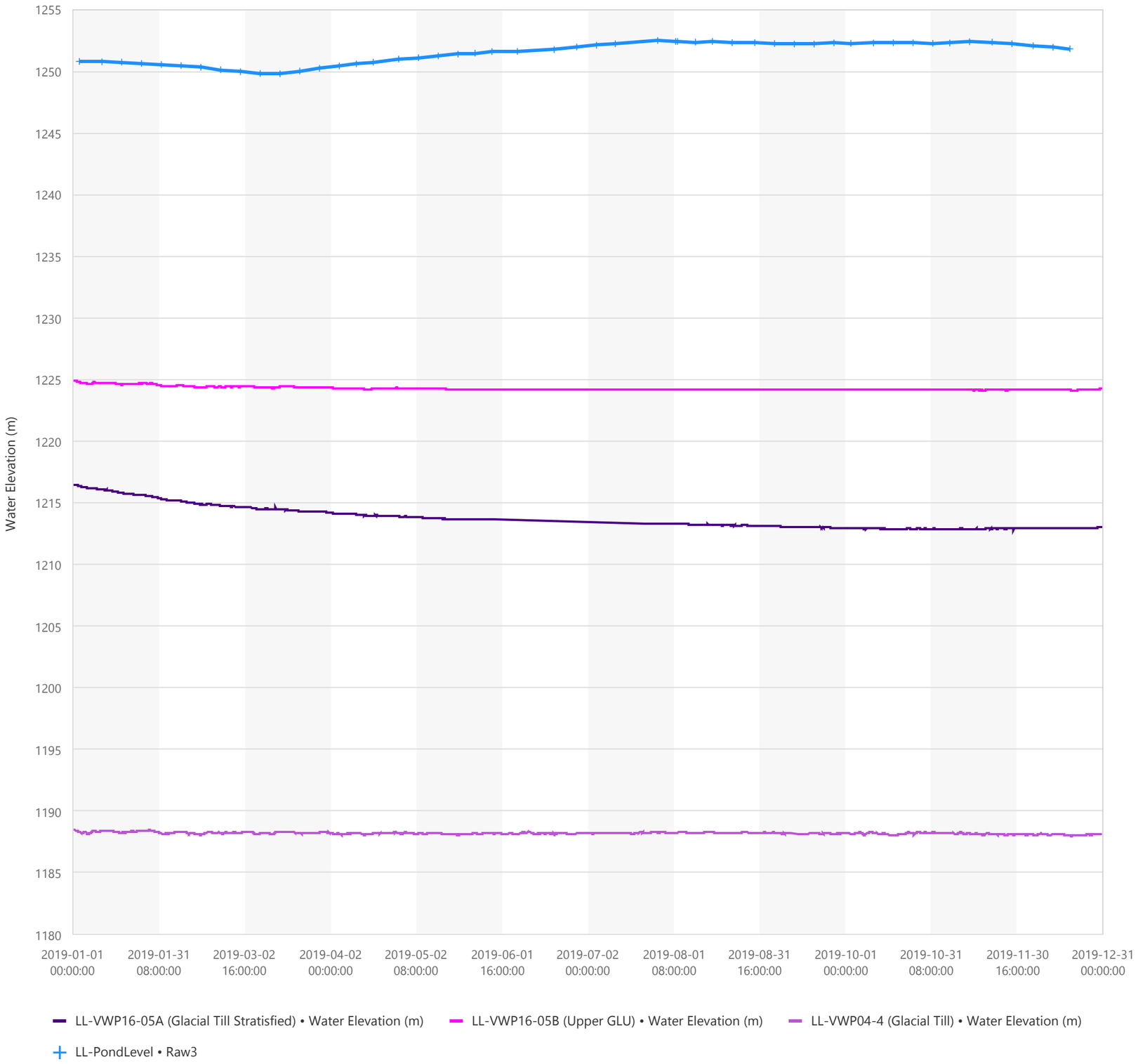
North Abutment - Foundation Rock

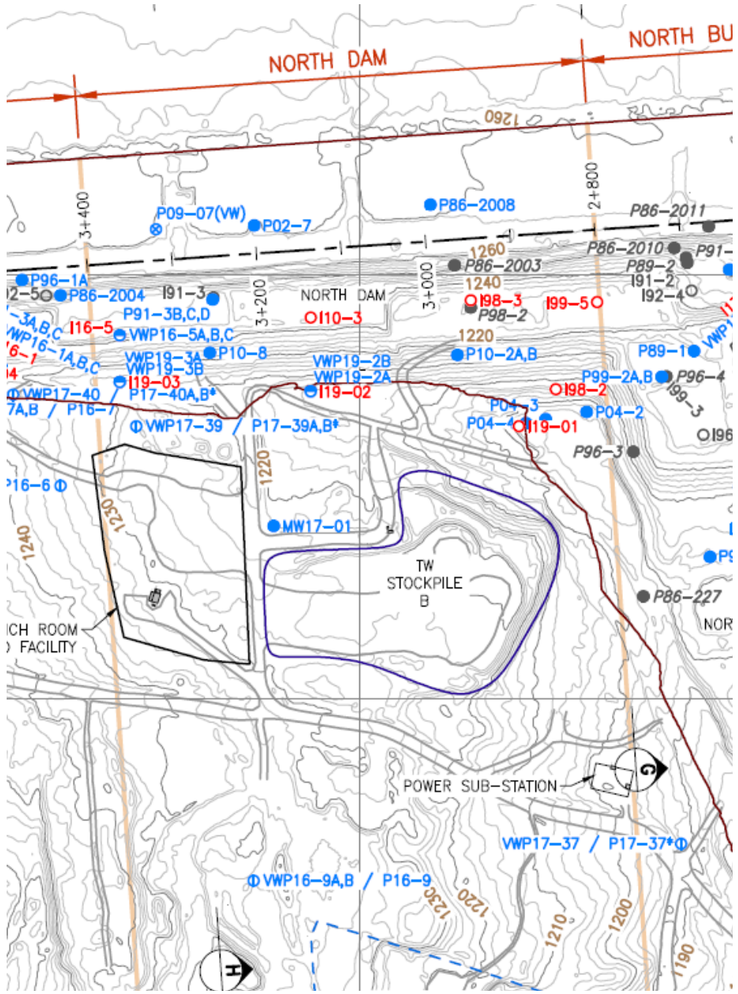


NORTH DAM – 2019 WATER ELEVATIONS

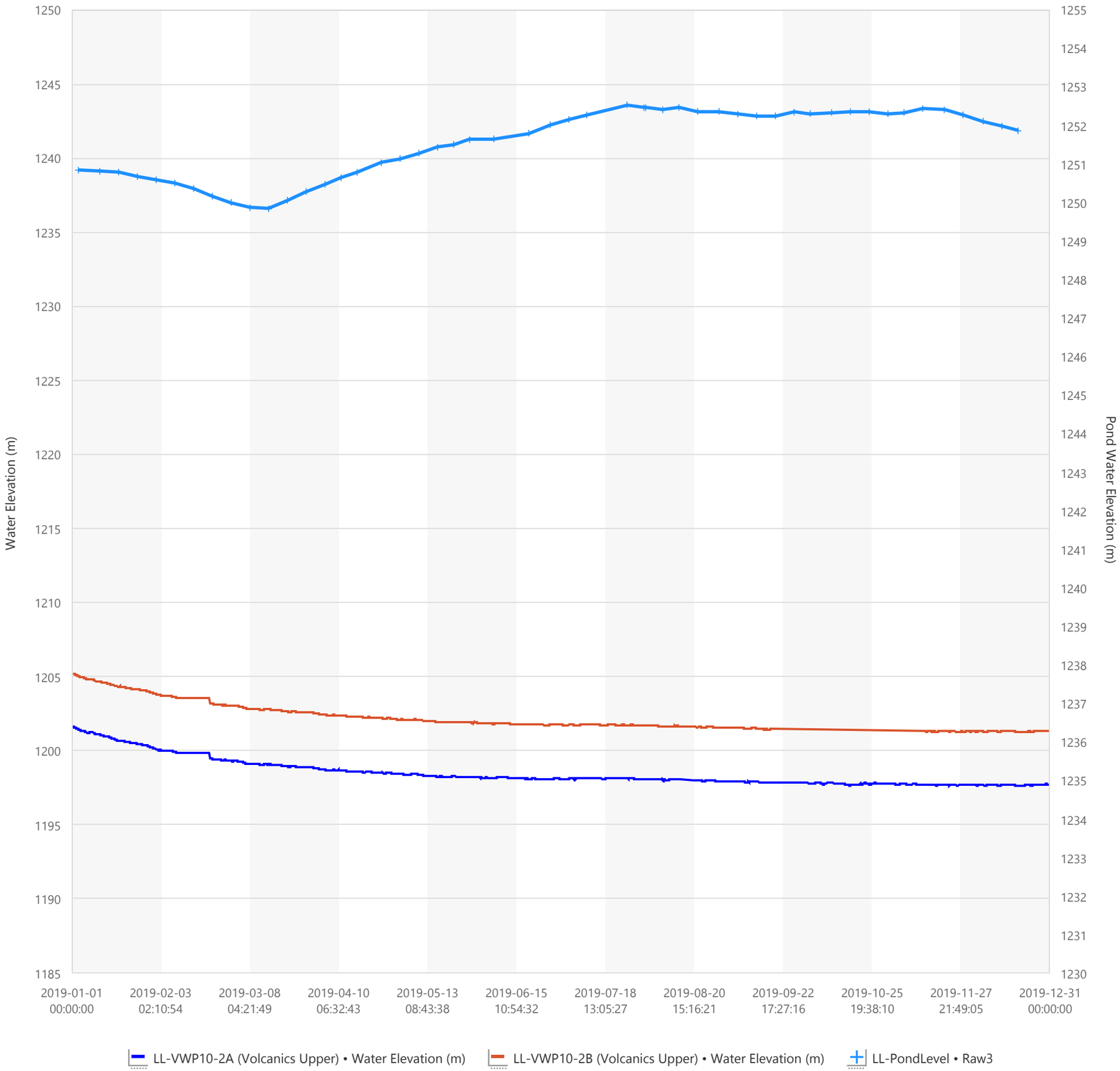


North Dam - Glacial Till, Sand, Upper GLU

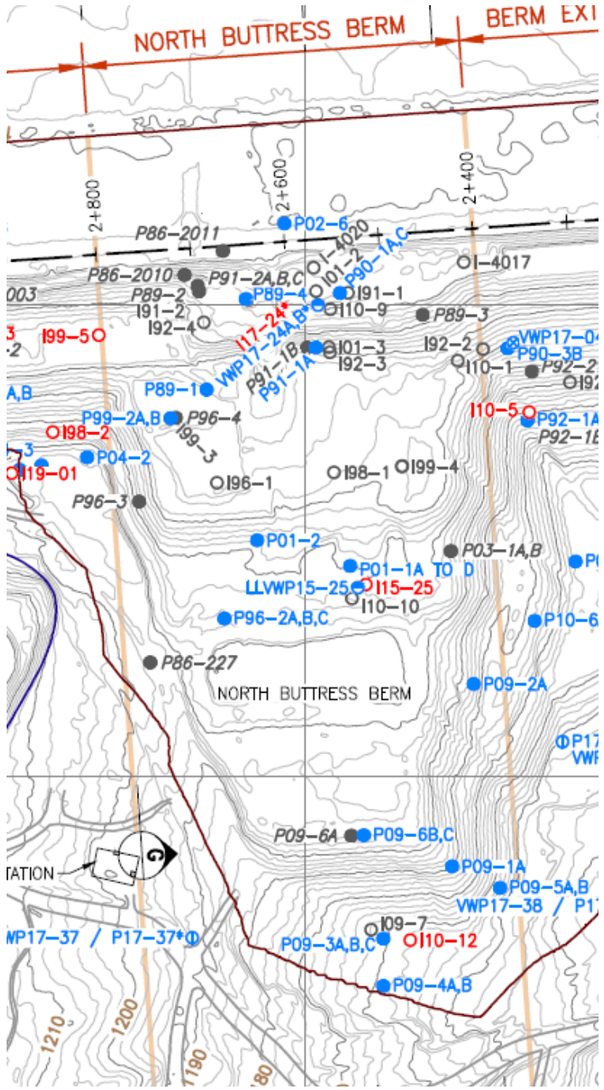




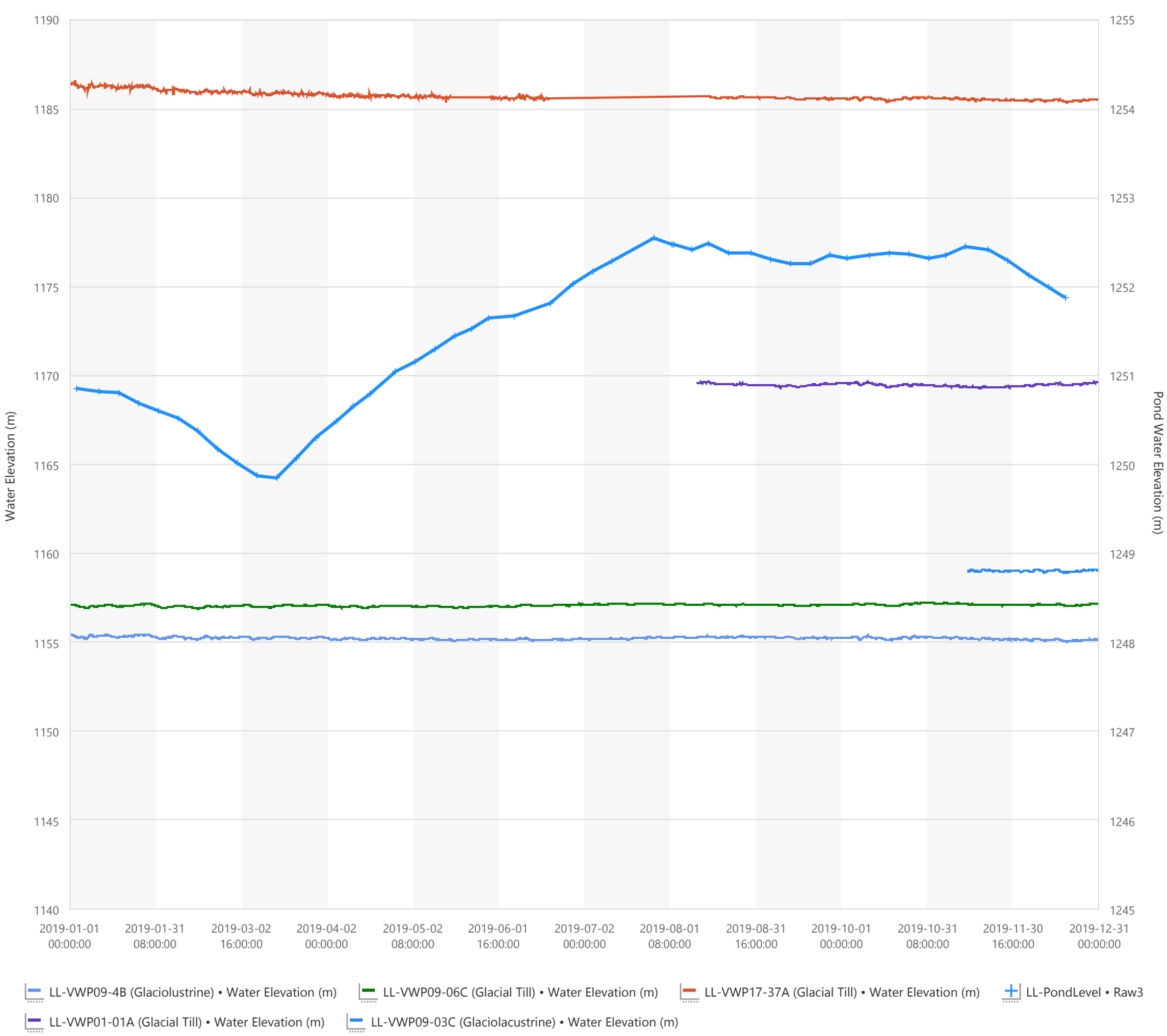
North Dam - Volcanics

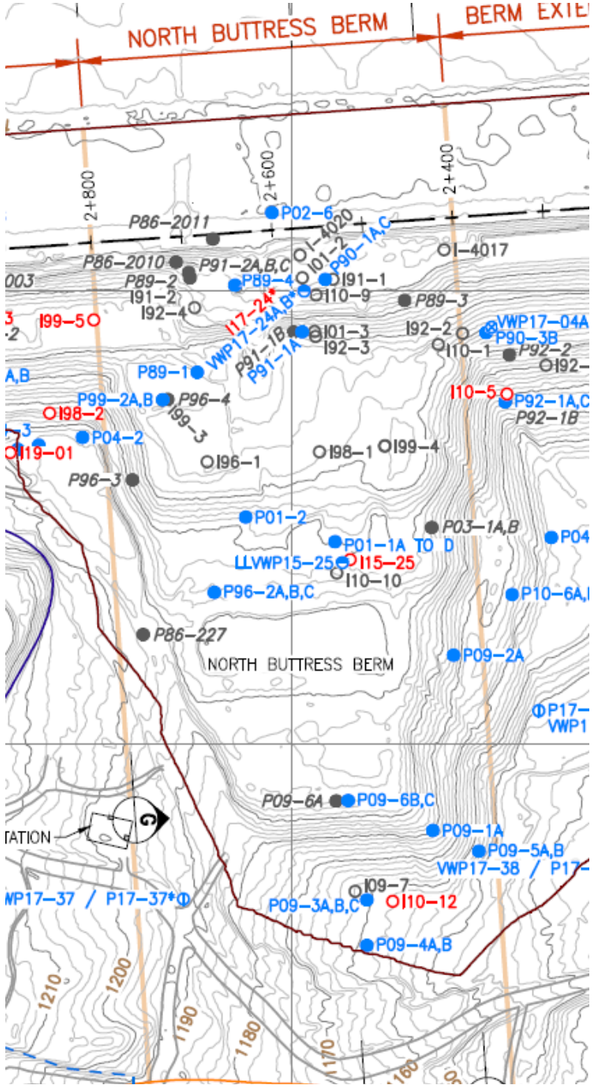


NORTH BUTTRESS BERM – 2019 WATER ELEVATIONS

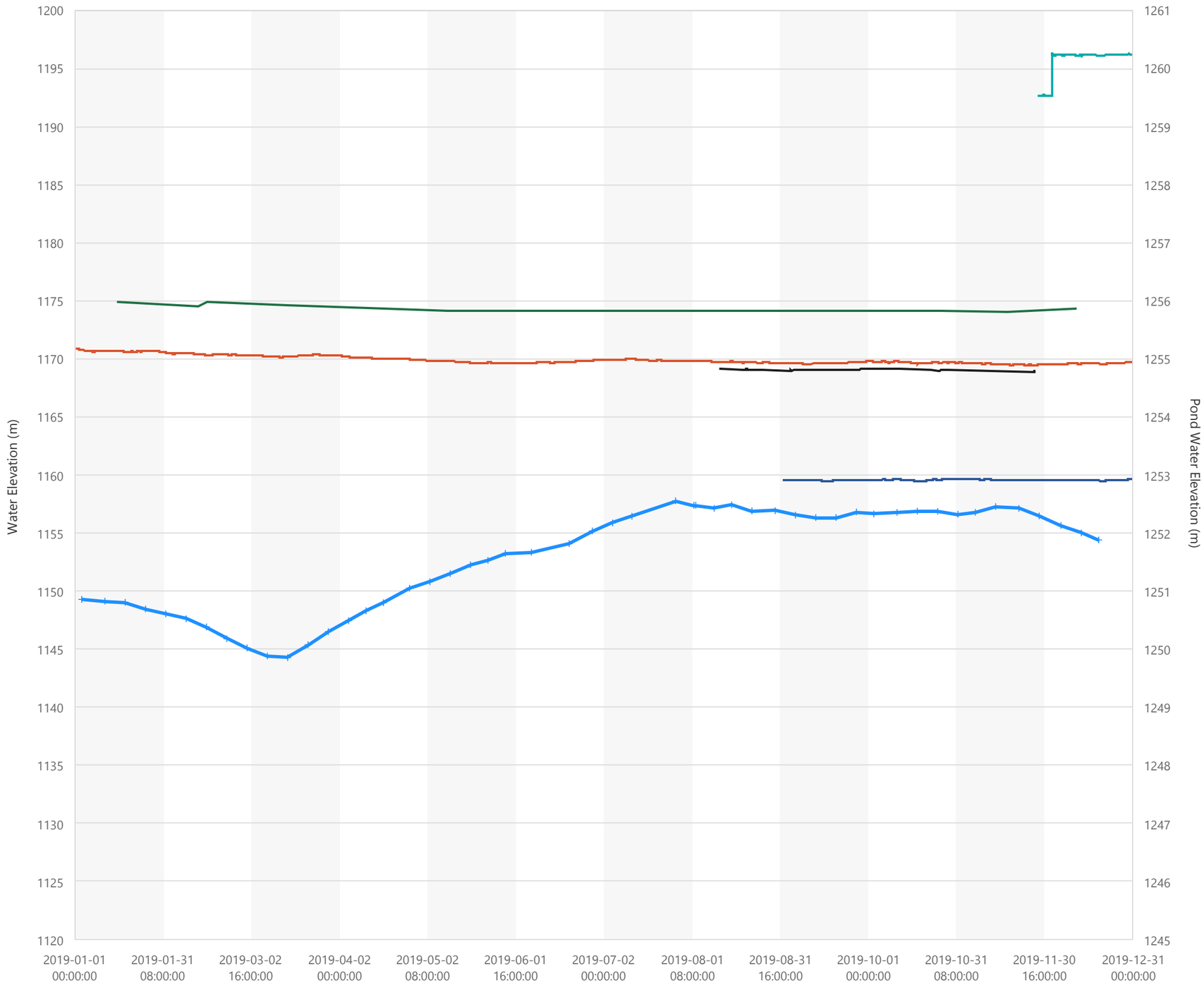


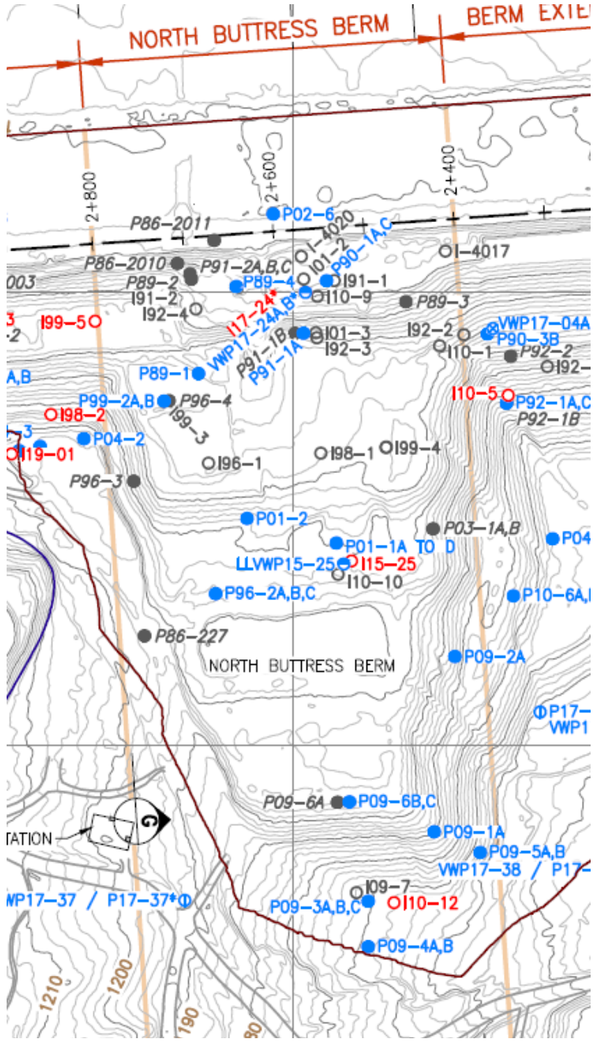
NBB - Overburden



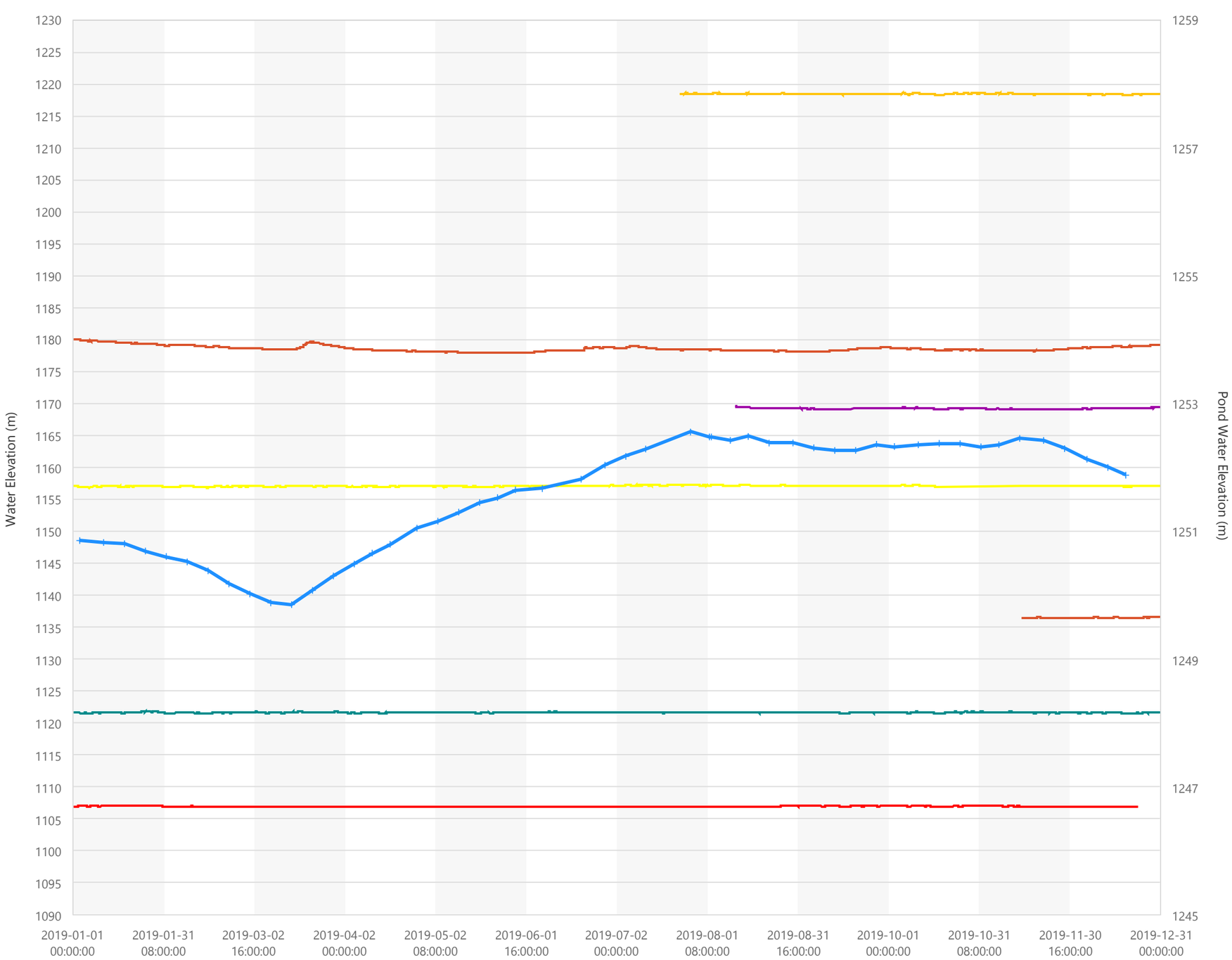


NBB - Volcanics

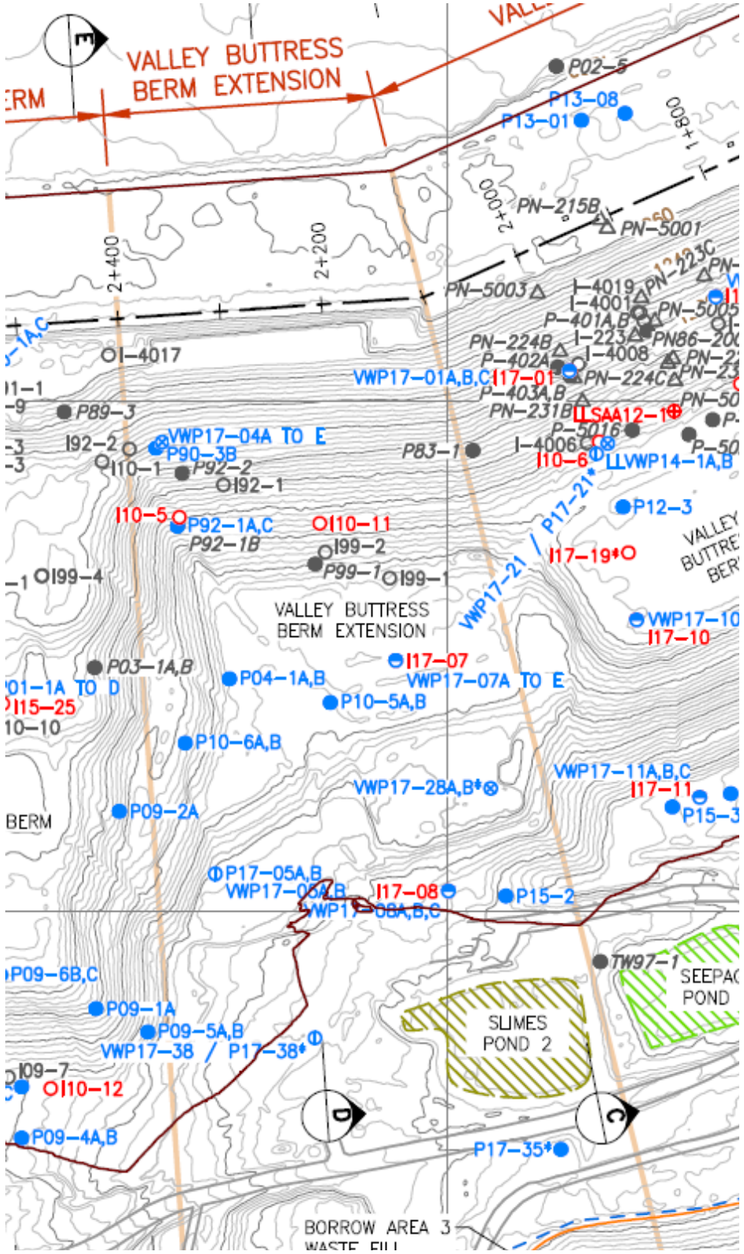




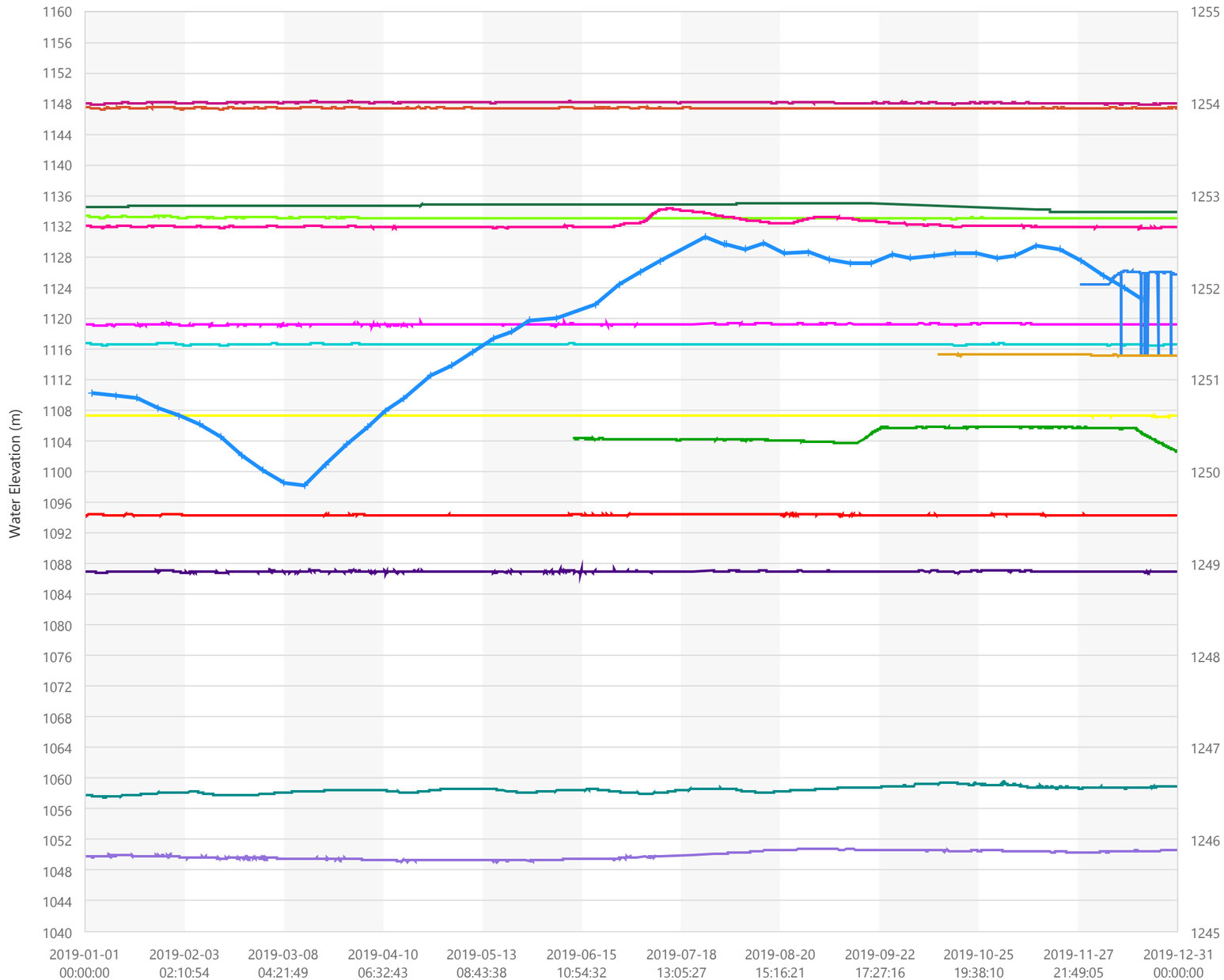
NBB - Sedimentary

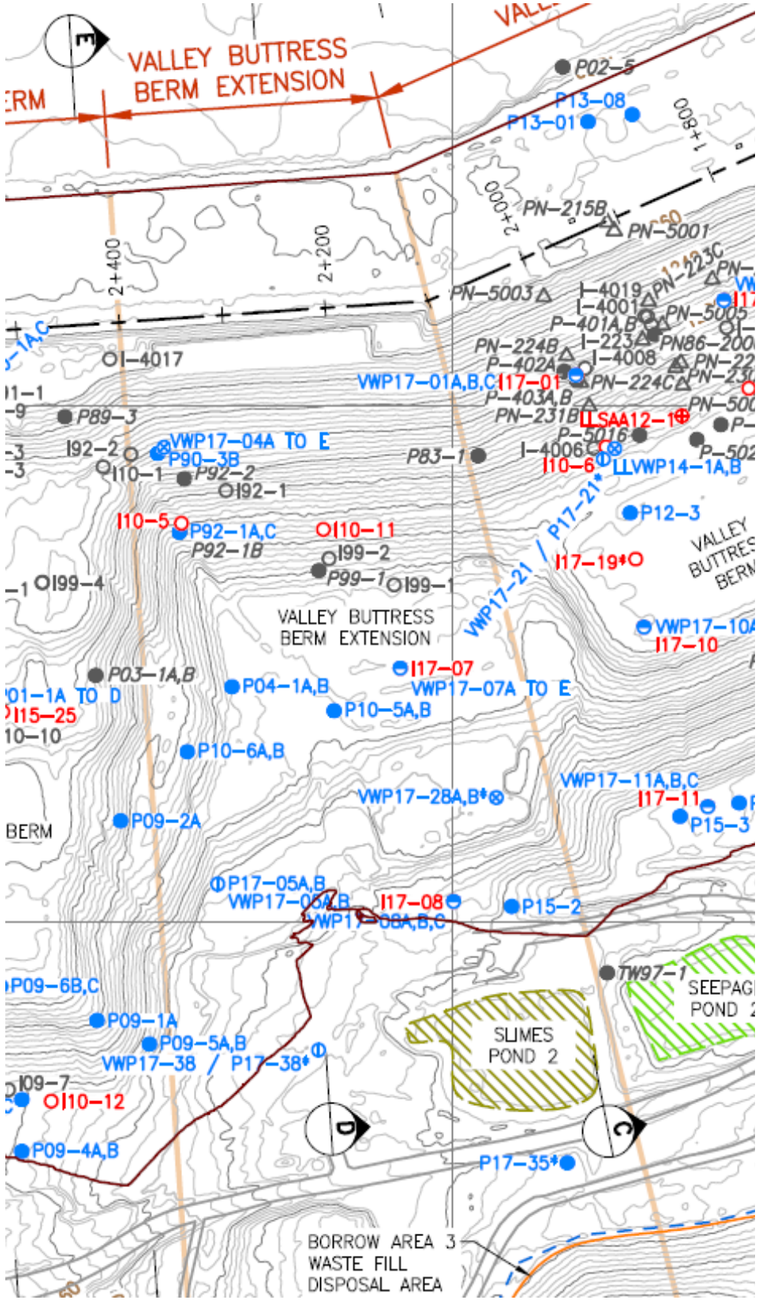


VALLEY BUTTRESS BERM EXTENSION – 2019 WATER ELEVATIONS

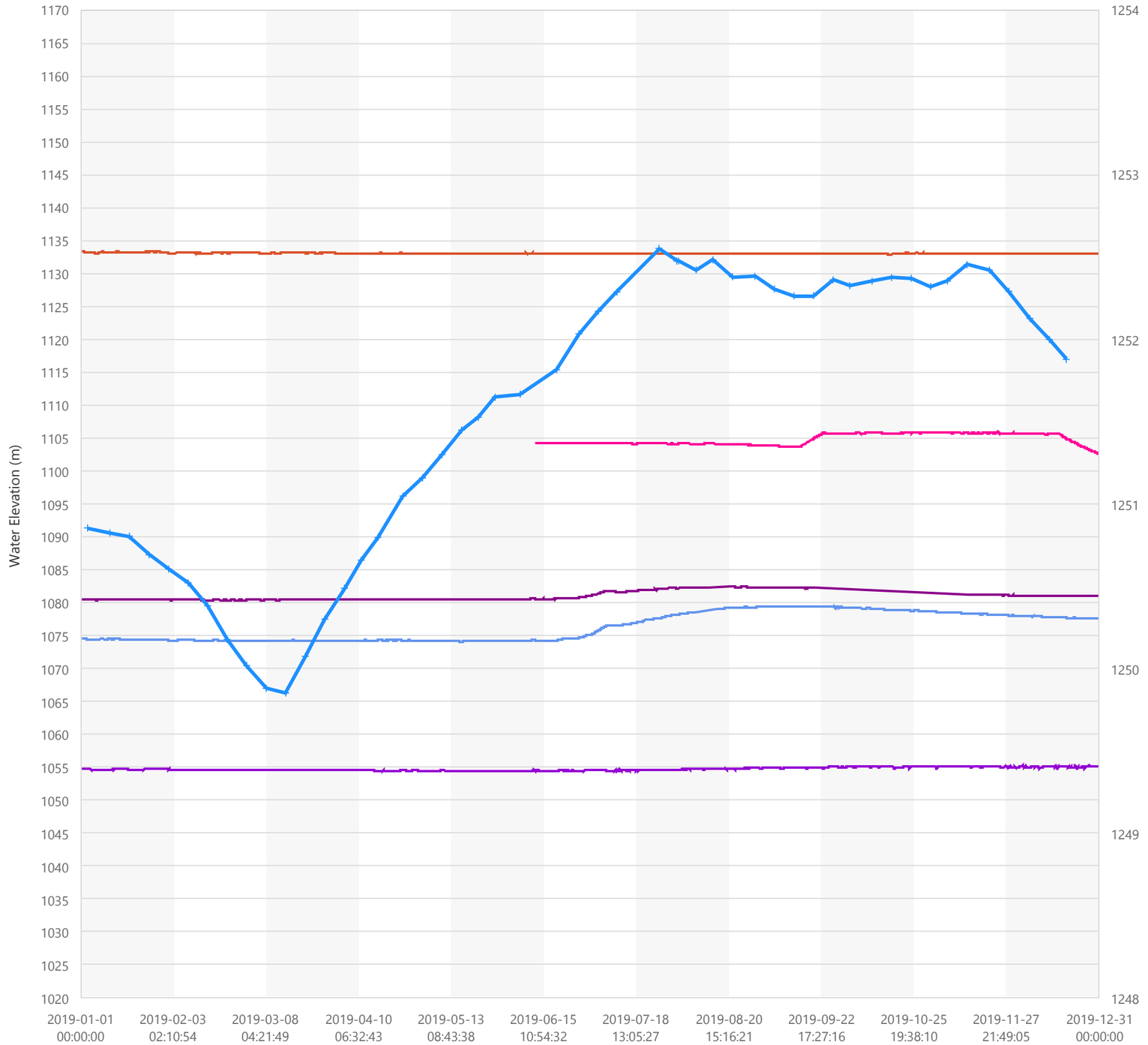


VBBE - Overburden and Dam Fill

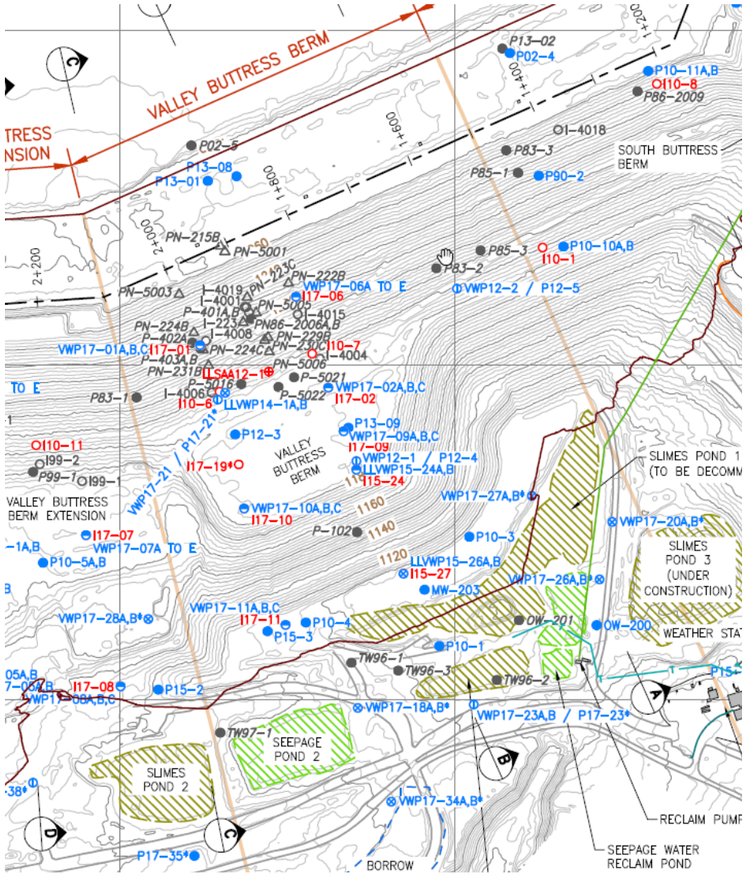




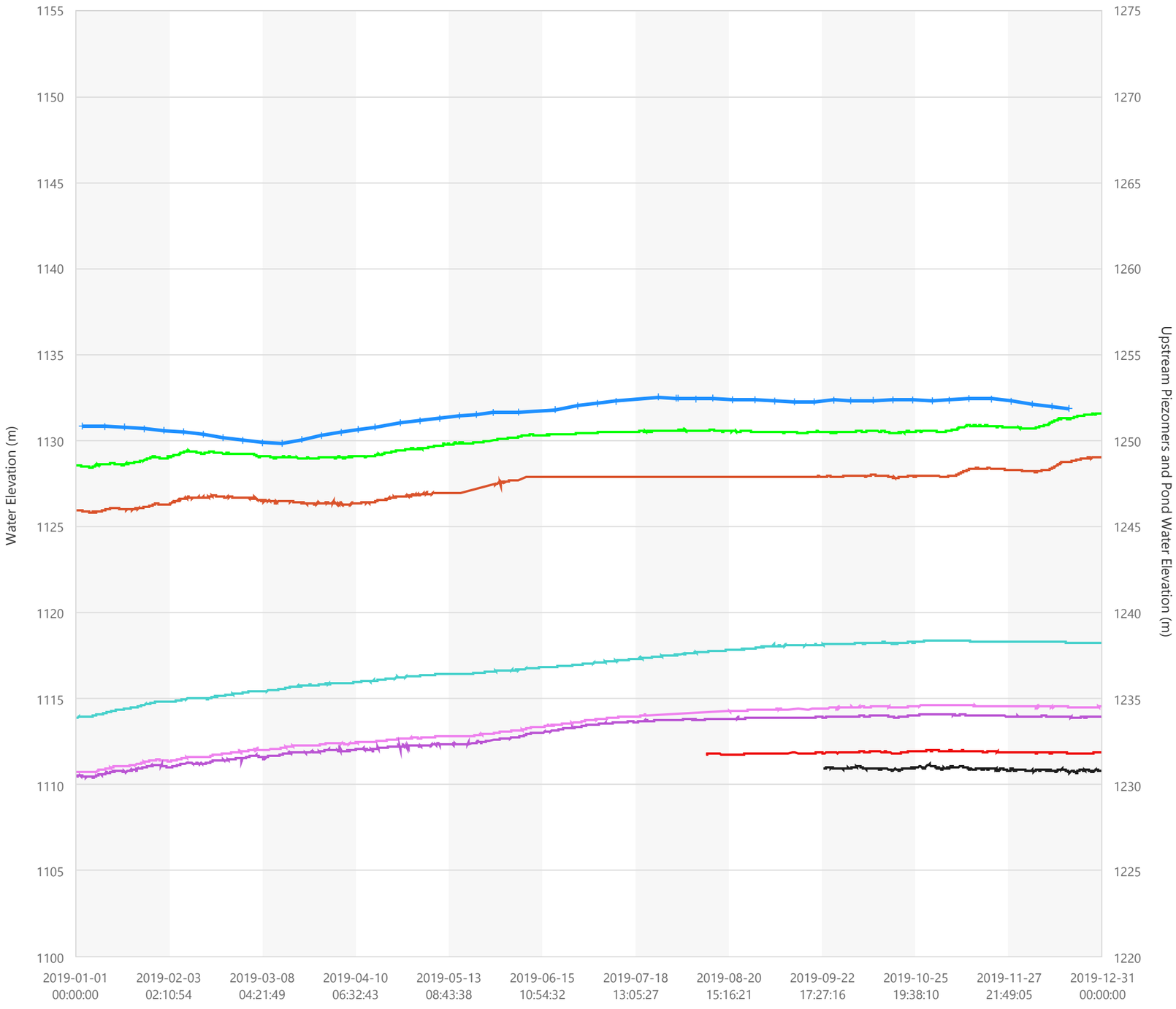
VBBE - Foundation Rock



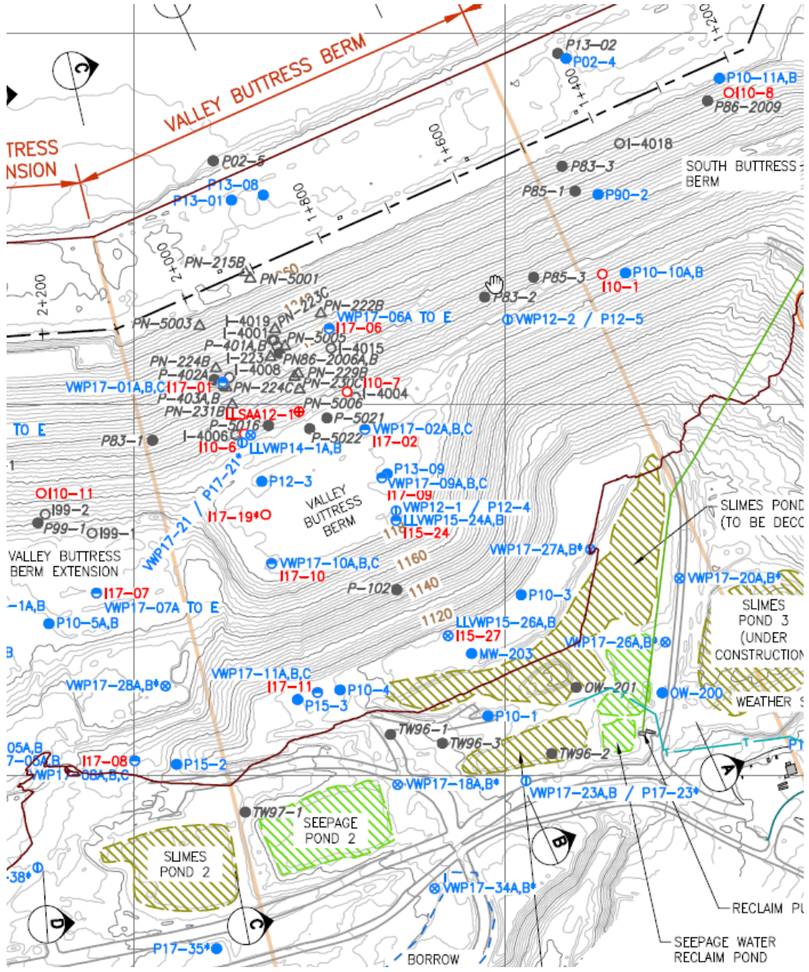
VALLEY BUTTRESS BERM – 2019 WATER ELEVATIONS



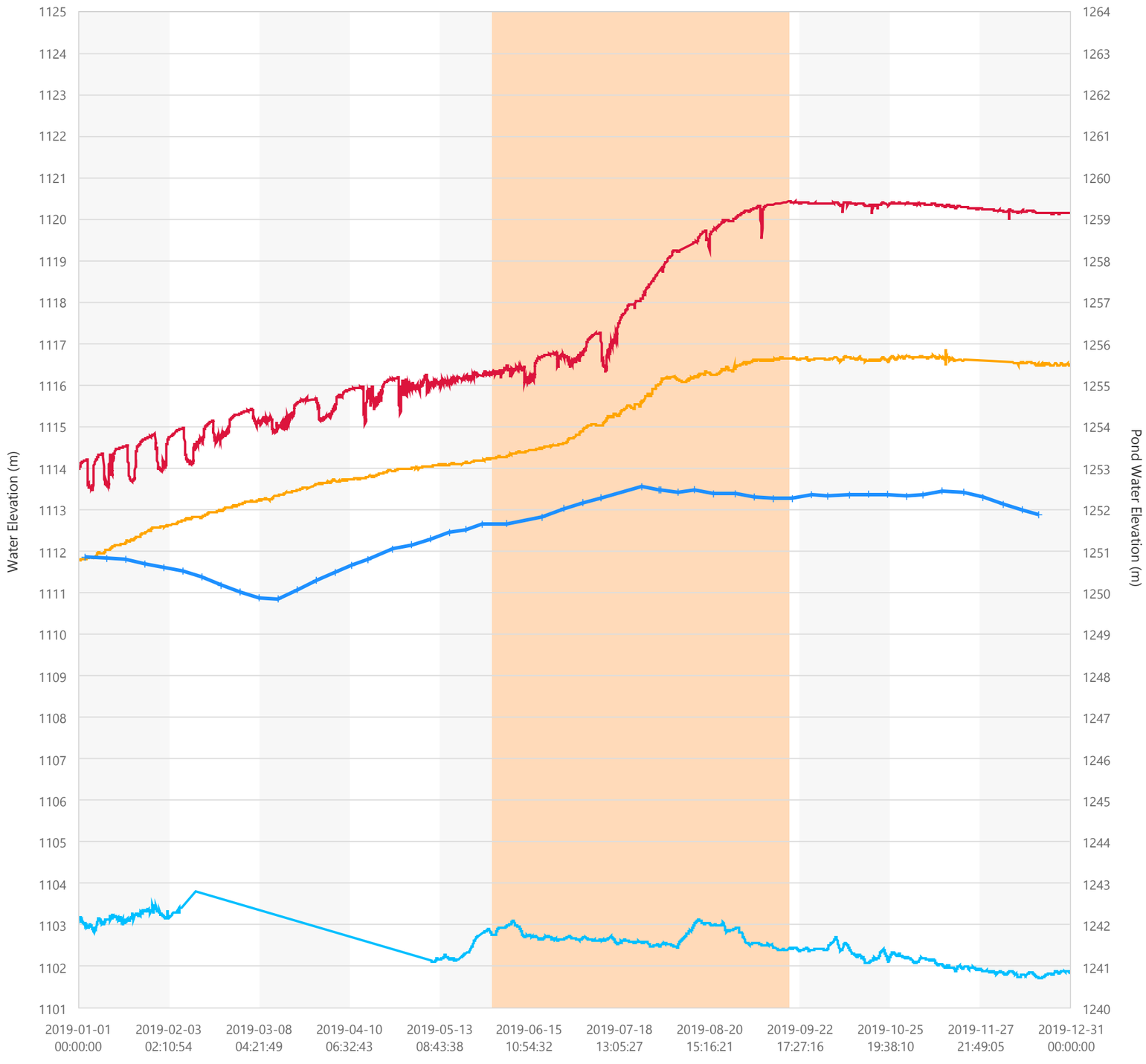
VBB - Dam Fill

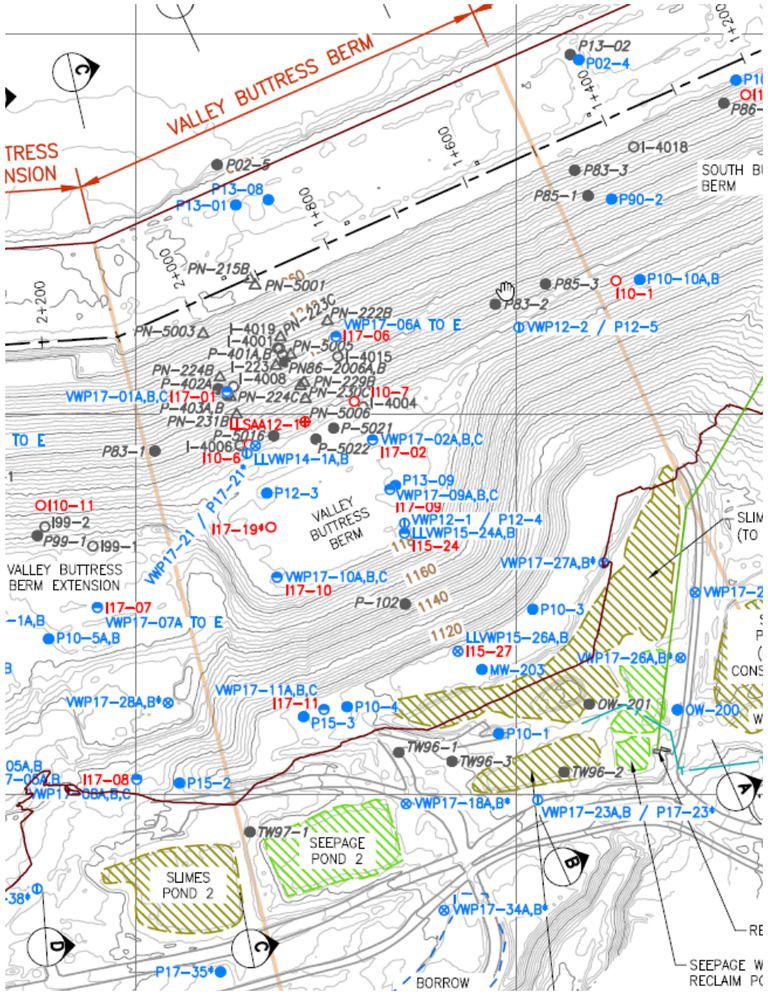


LL-VWP17-02C (S&G Drainage Blanket) • Water Elevation (m)
LL-VWP17-06E (S&G Drainage Blanket) • Water Elevation (m)
LL-VWP13-09 (S&G Drainage Blanket) • Water Elevation (m)
LL-VWP13-01 (Upstream Sand) • Water Elevation (m)
LL-VWP13-08m (Upstream Sand) • Water Elevation (m)
LL-PondLevel • Raw3
LL-VWP102 (Glacial Till) • Water Elevation (m)
LL-VWP12-04 • Water Elevation (m)

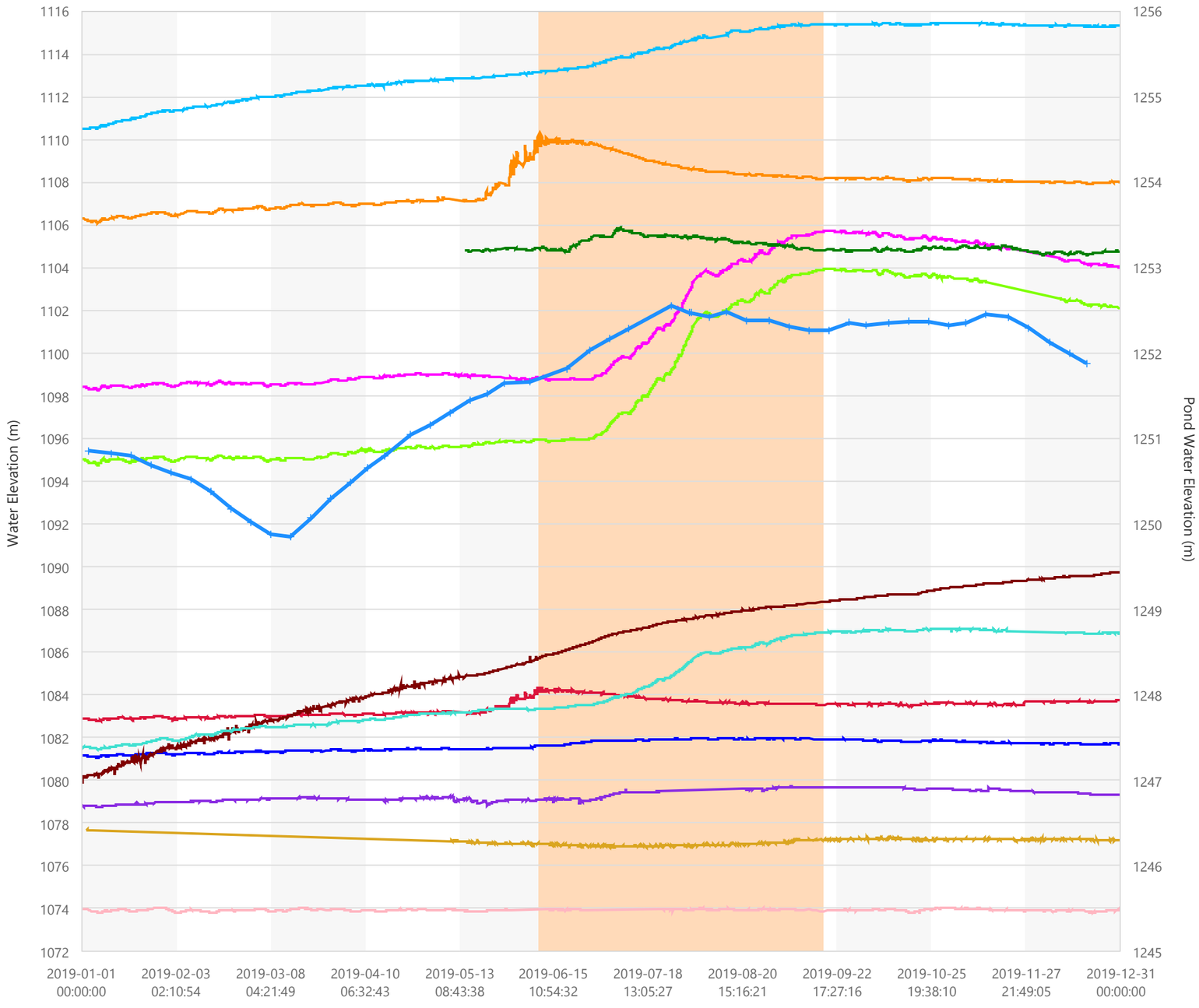


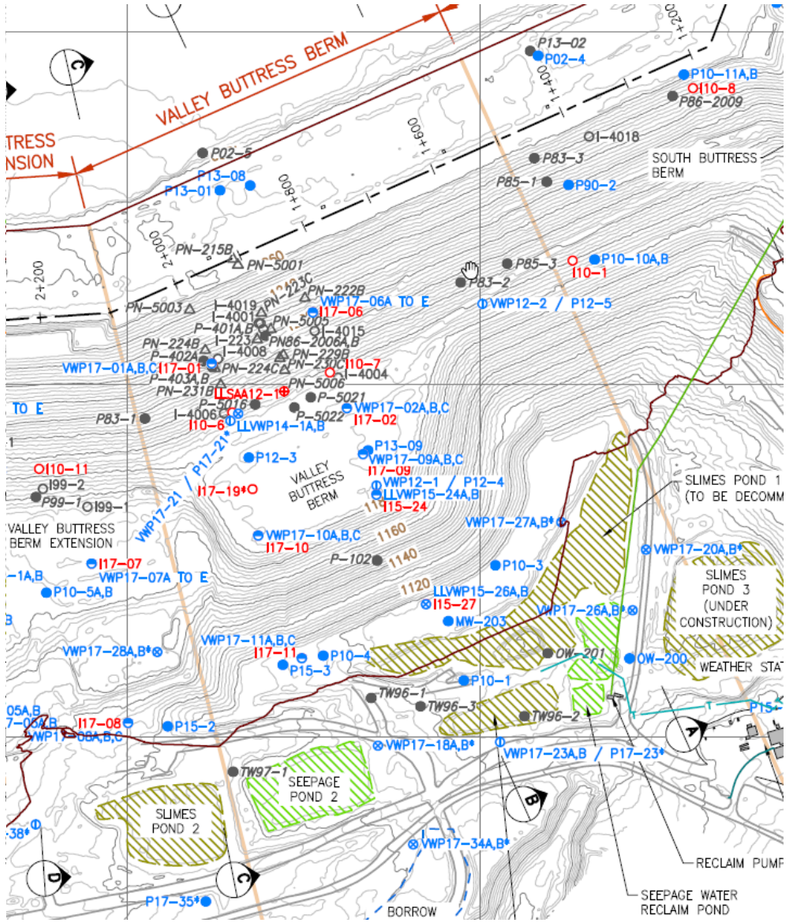
VBB - Lacustrine



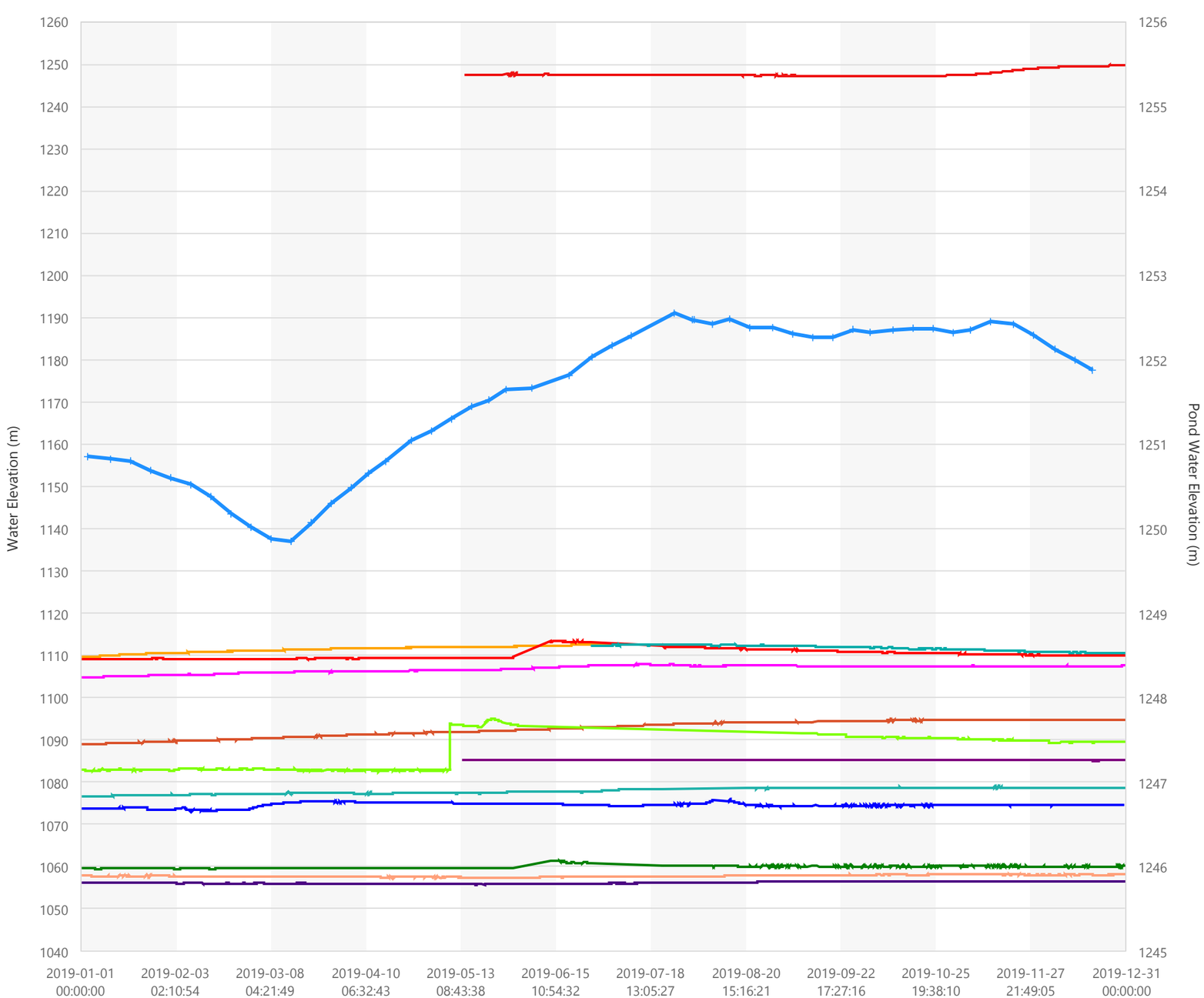


VBB - Glaciolacustrine

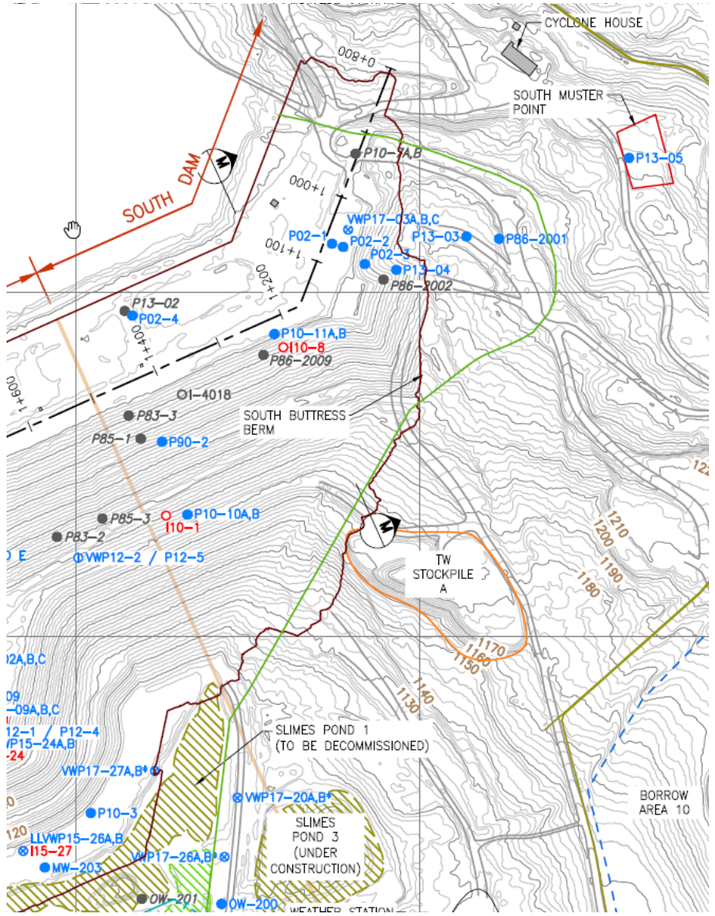




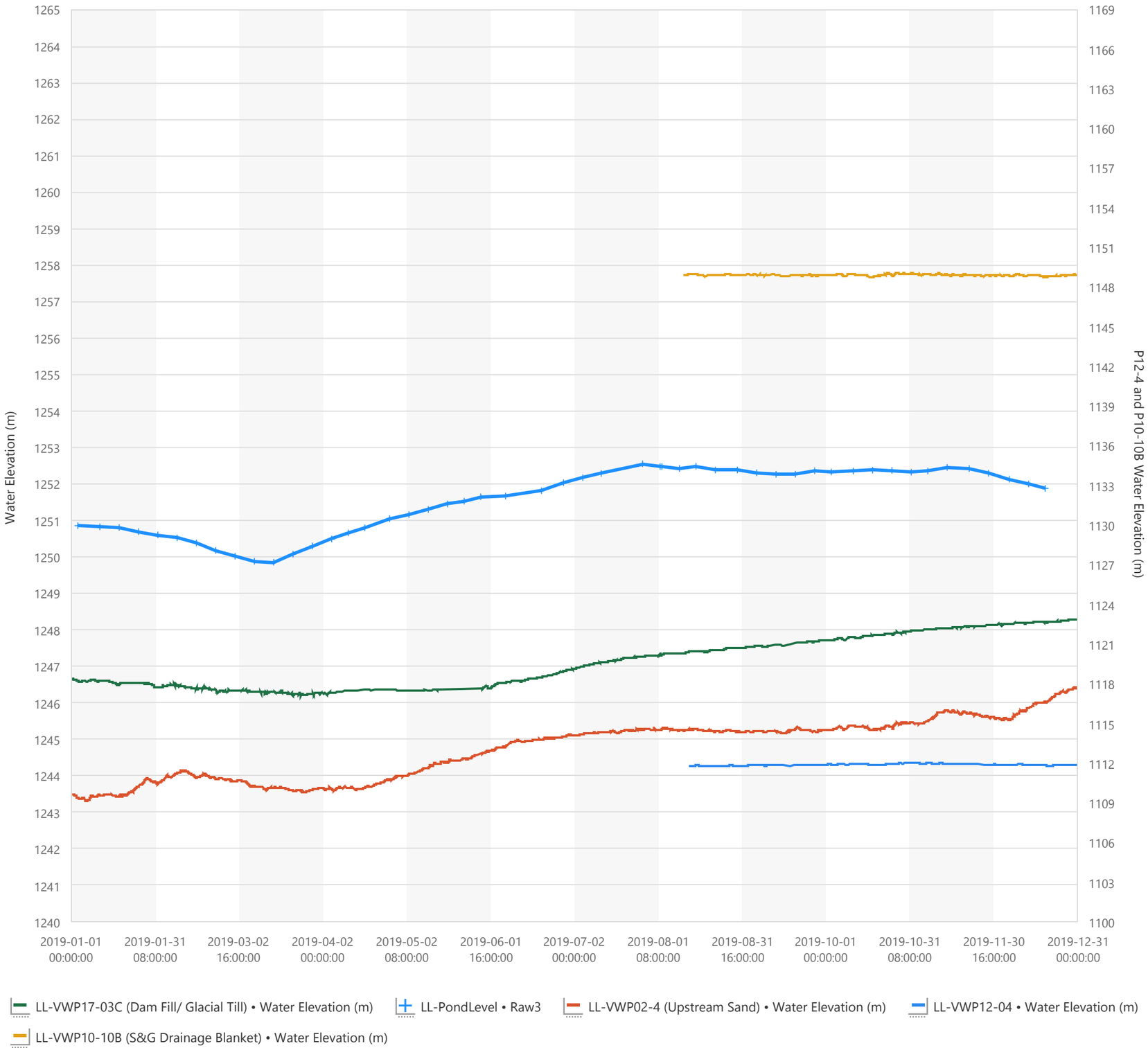
VBB - Glacial Till, Sand and Gravel

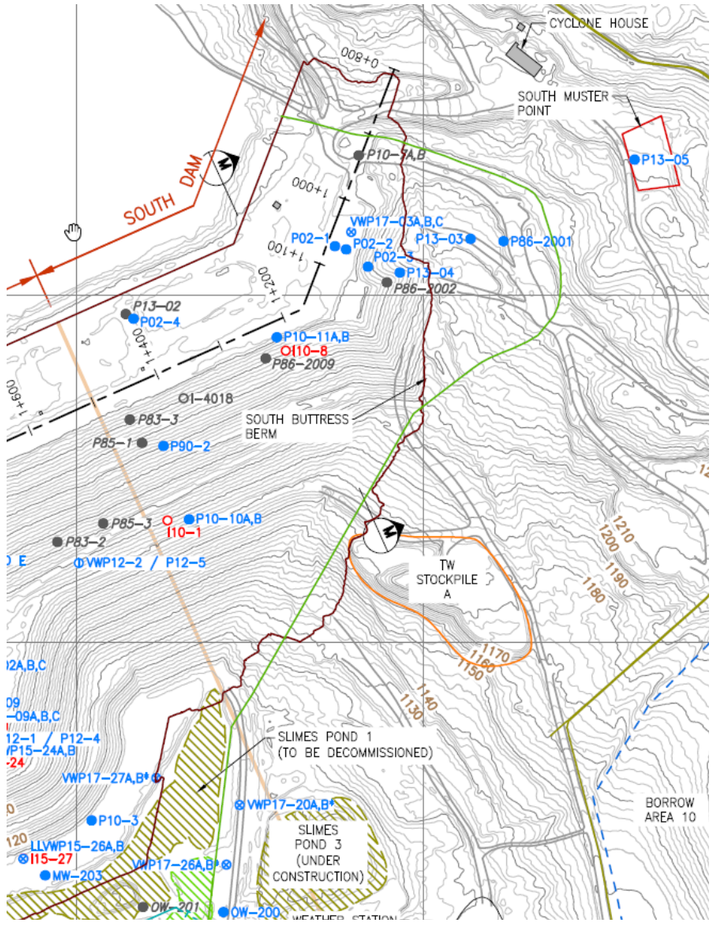


SOUTH DAM – 2019 WATER ELEVATIONS

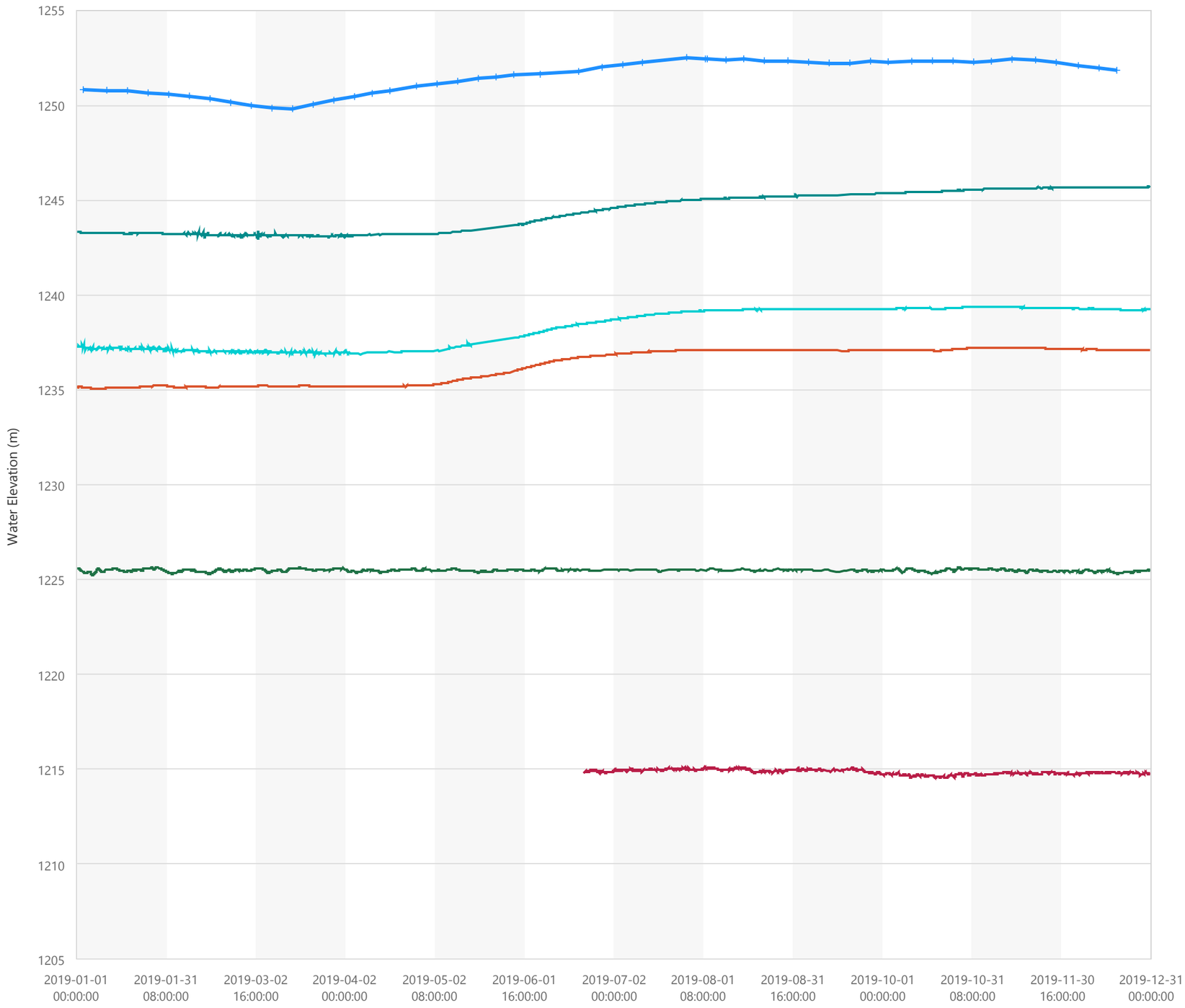


South Dam - Dam Fill





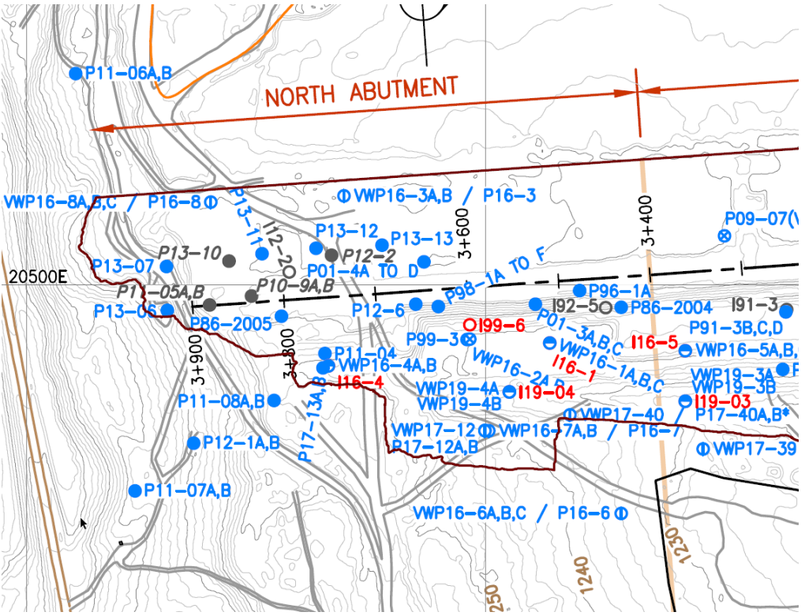
South Dam - Granodiorite
Foundation Rock and Glacial Till



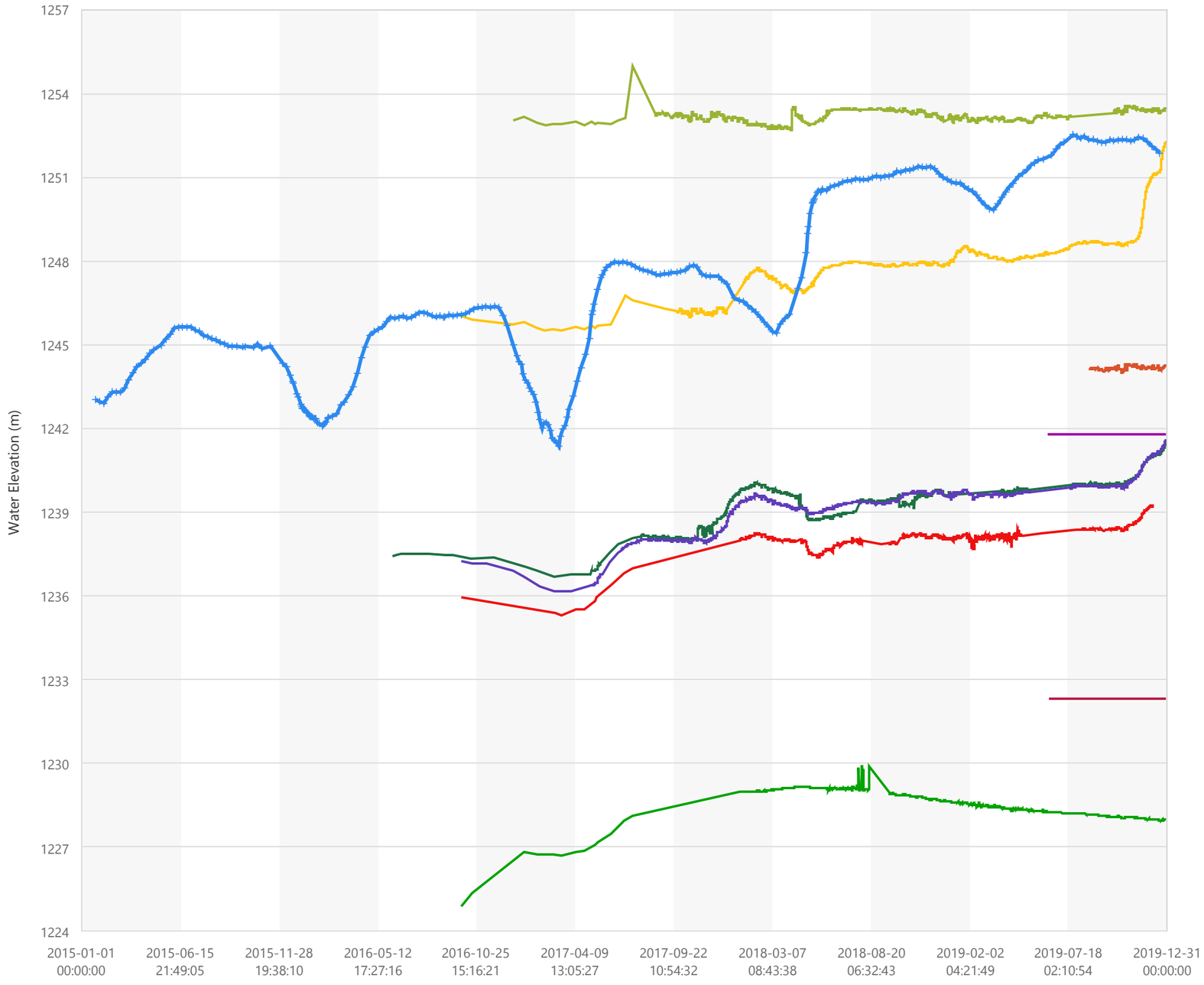
APPENDIX V-B-2

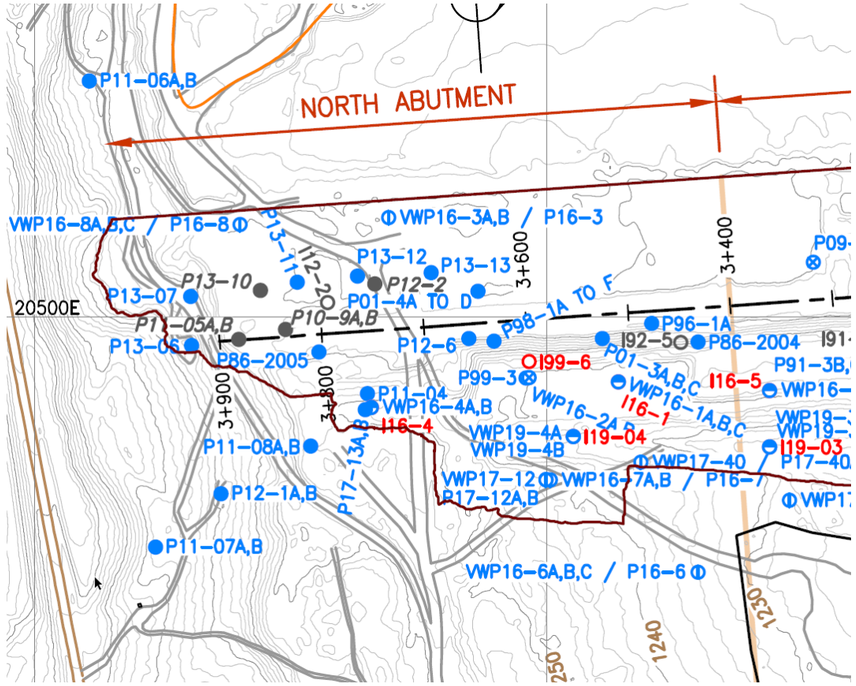
L-L DAM PIEZOMETERS: WATER ELEVATIONS SINCE 2015

NORTH ABUTMENT – WATER ELEVATIONS SINCE 2015

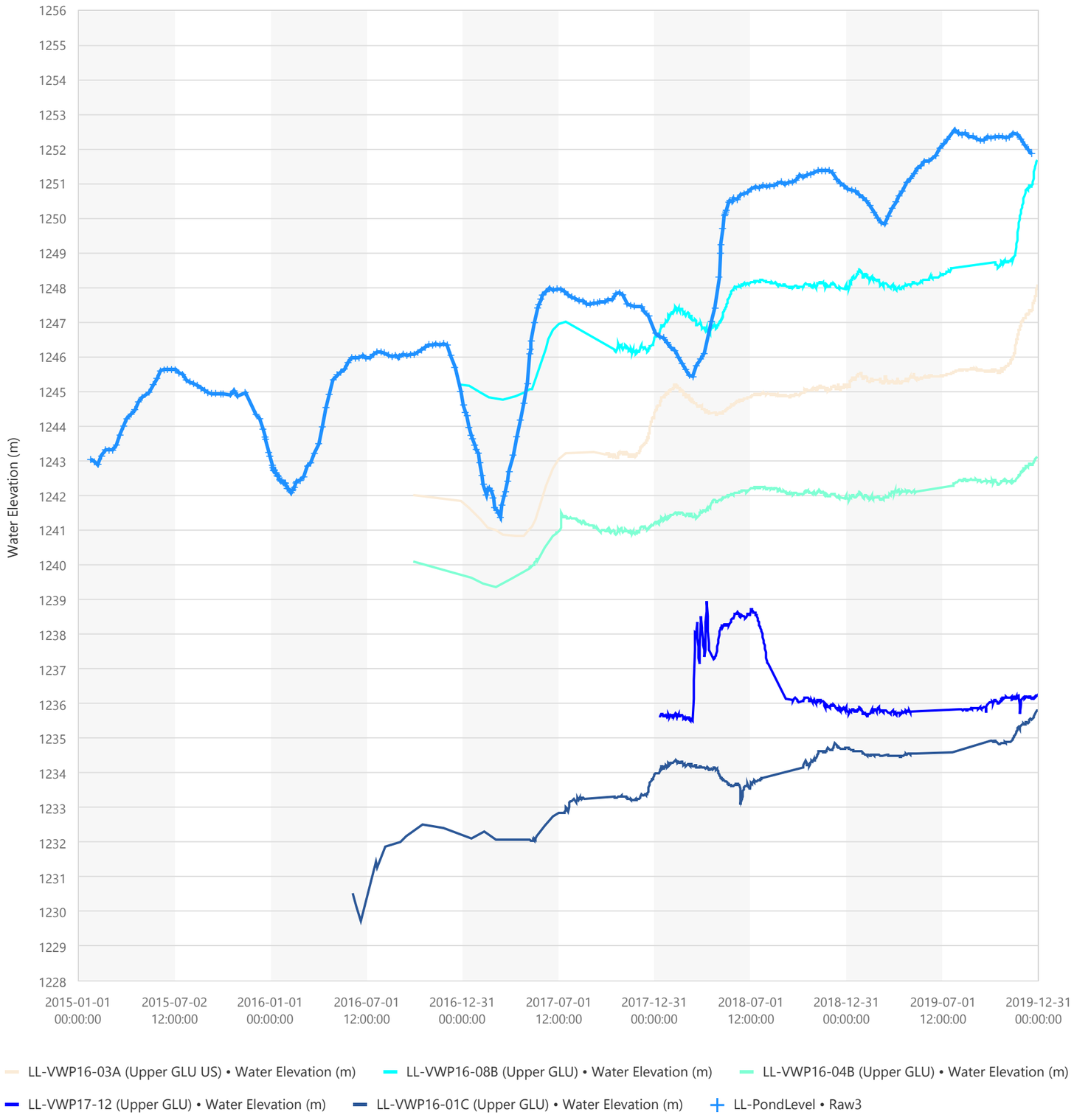


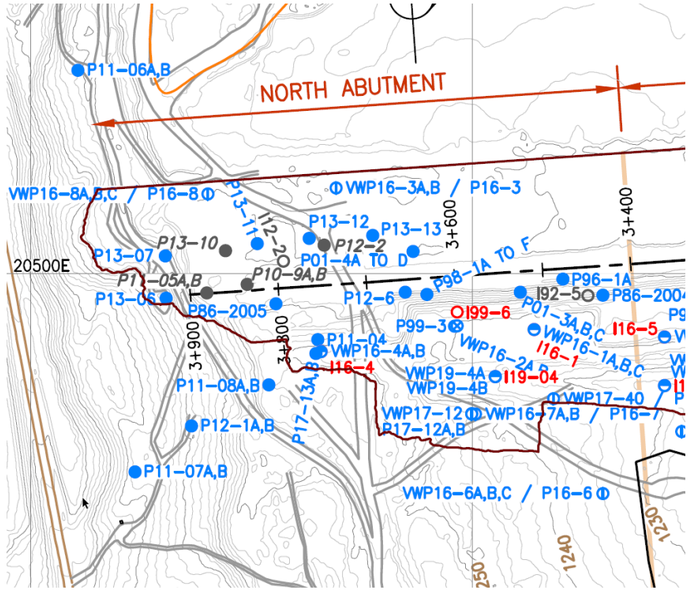
North Abutment - Sand and Gravel



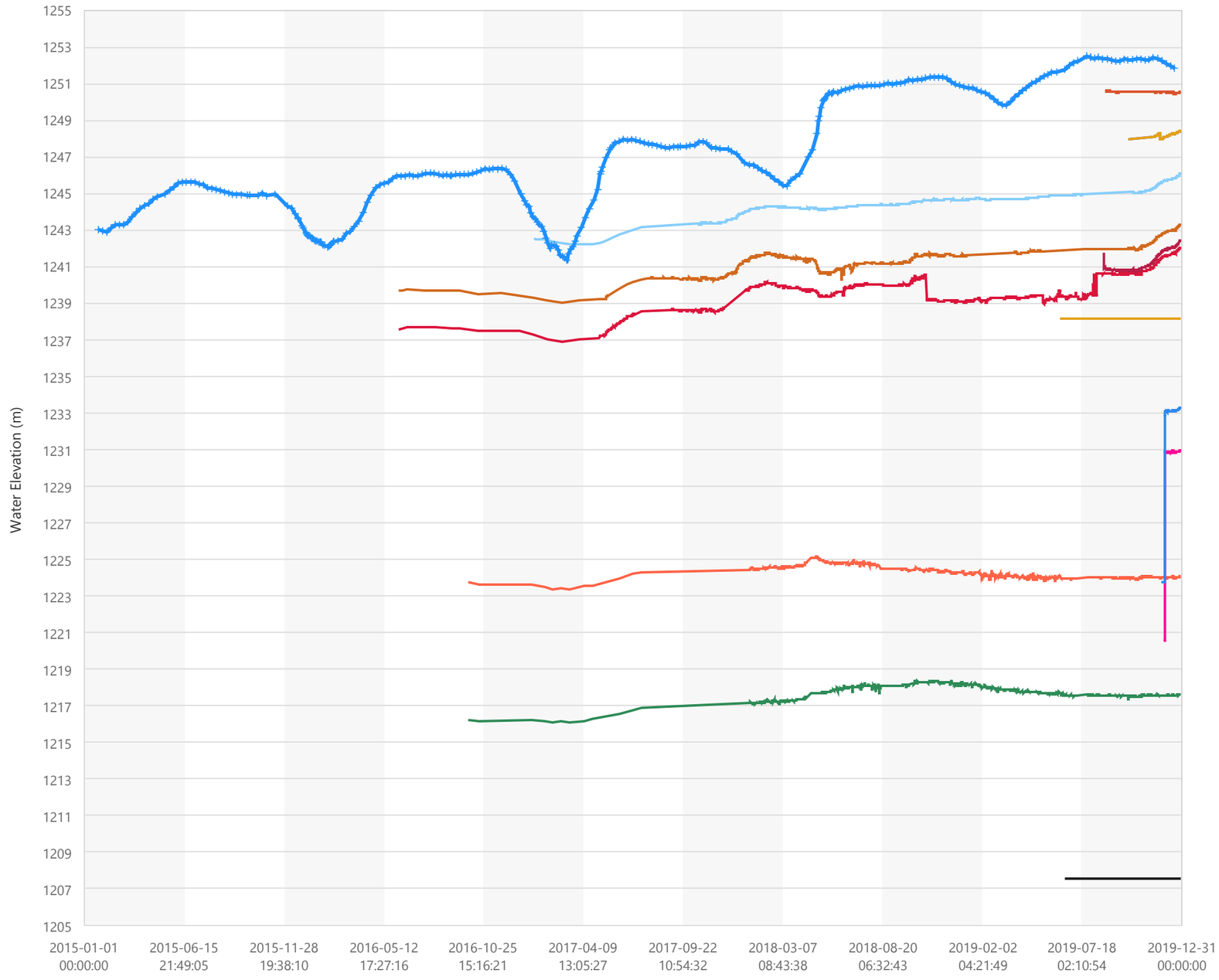


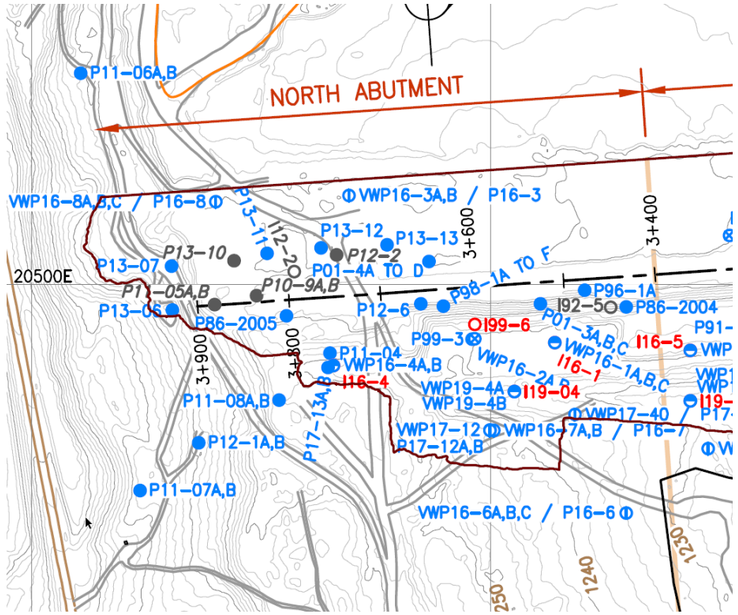
North Abutment - Glaciolacustrine



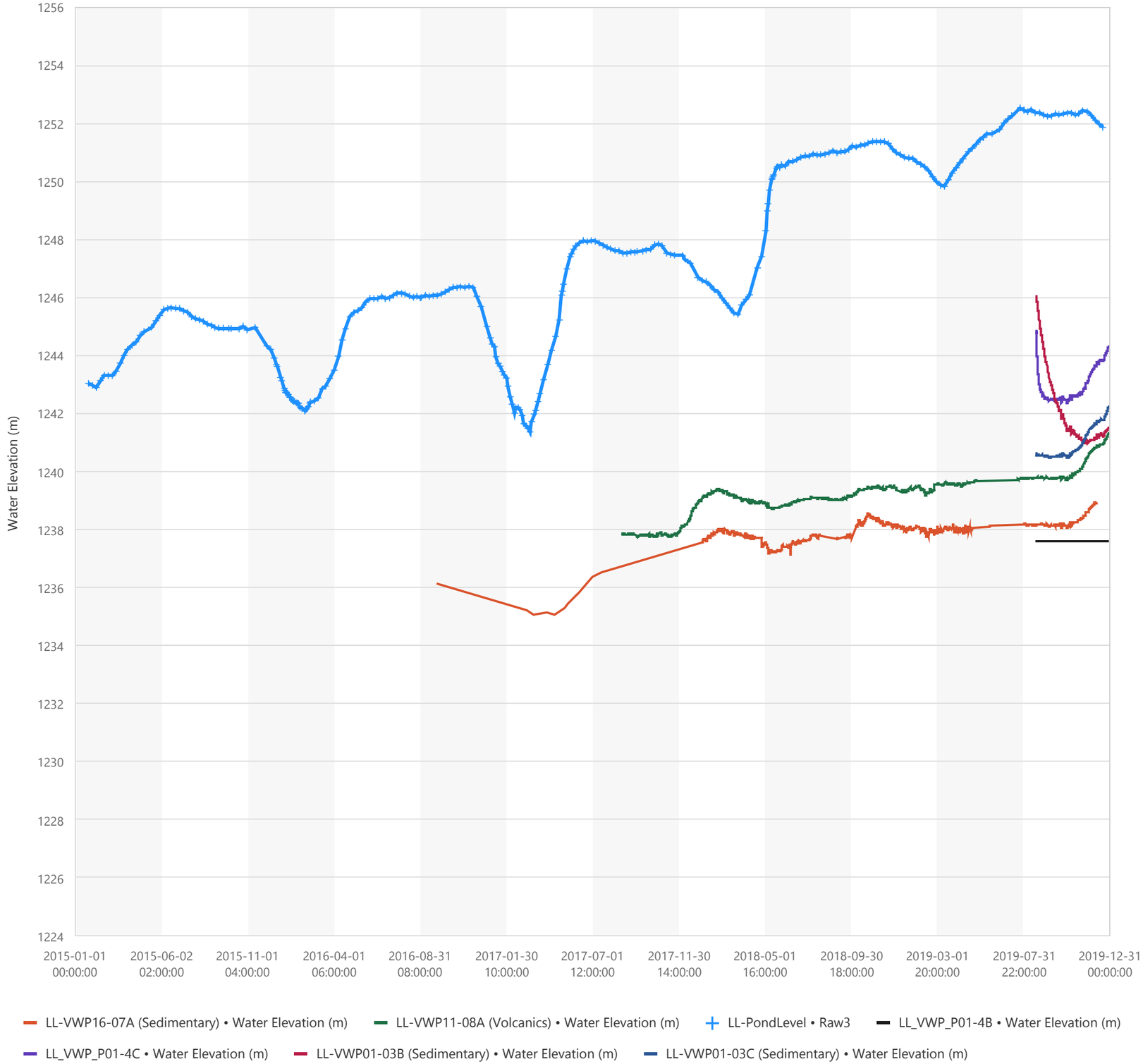


North Abutment - Glacial Till

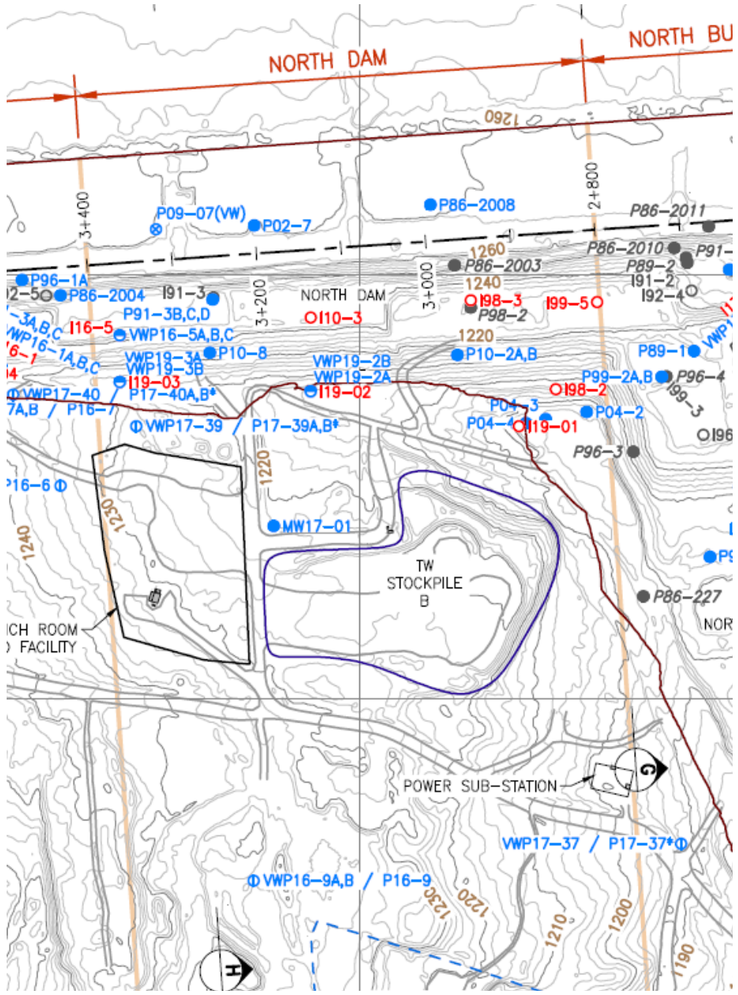




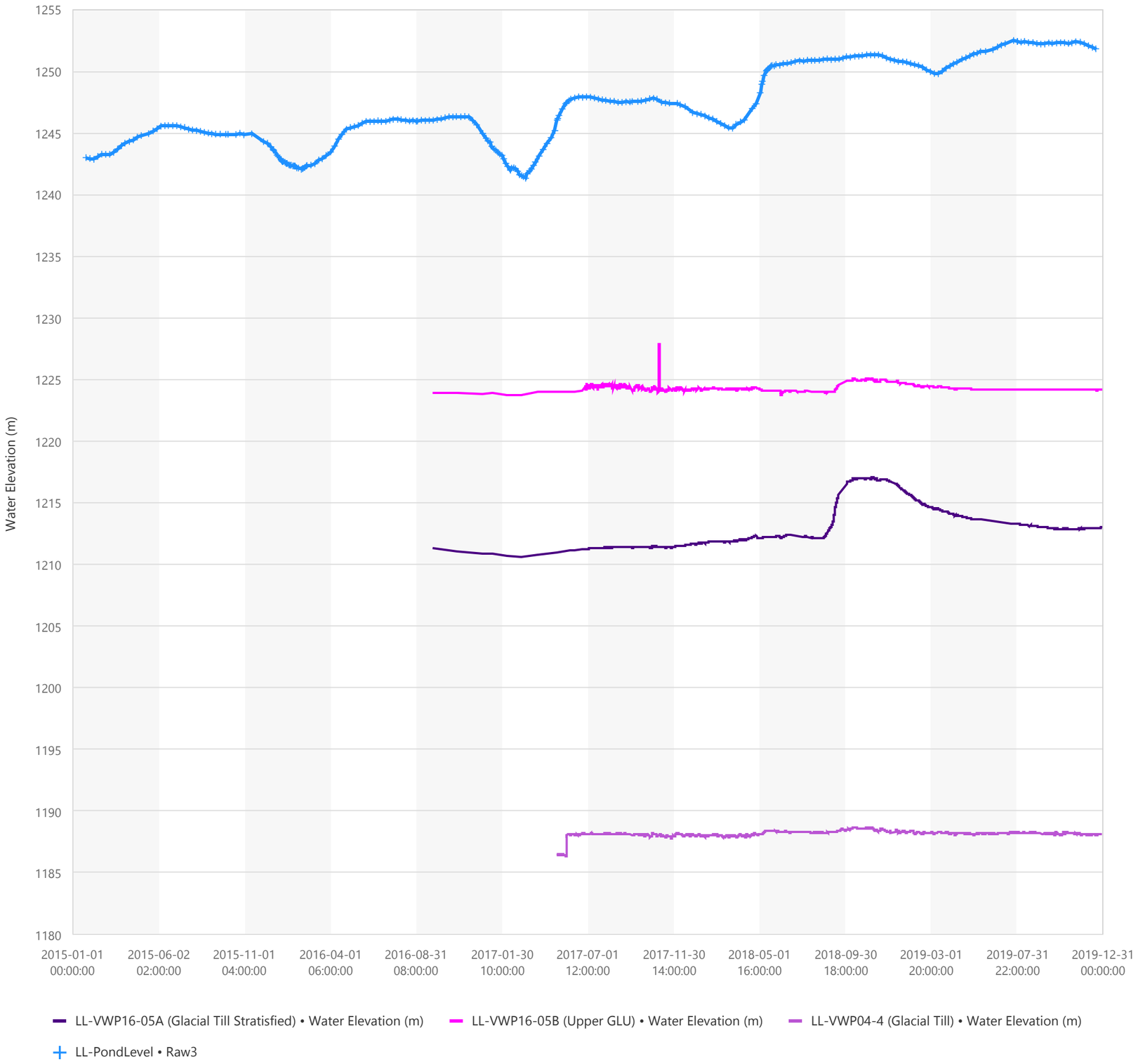
North Abutment - Foundation Rock

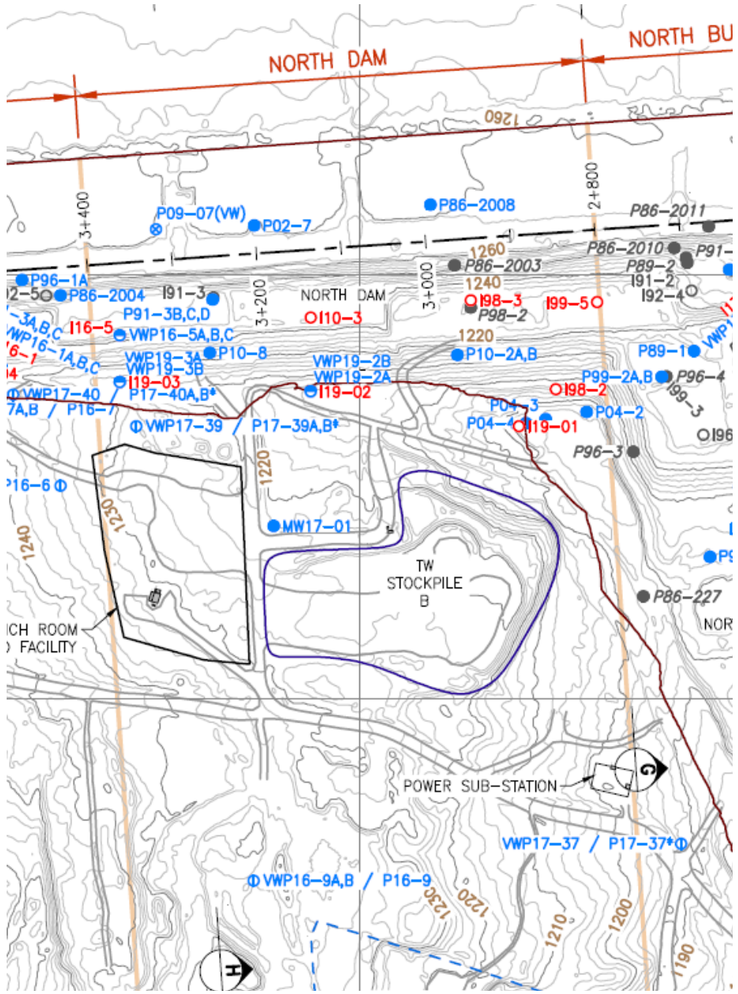


NORTH DAM – WATER ELEVATIONS SINCE 2015

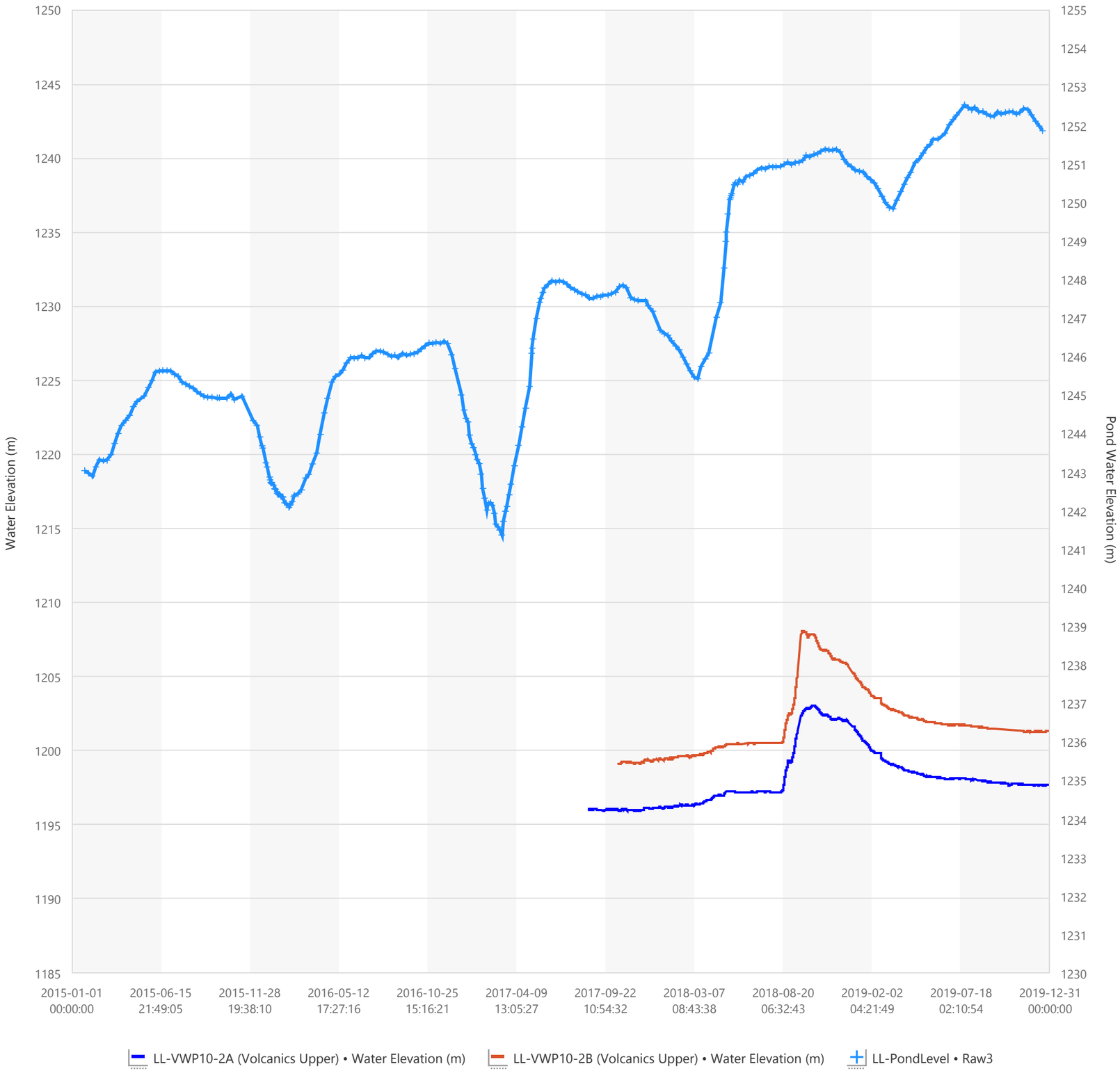


North Dam - Glacial Till, Sand, Upper GLU

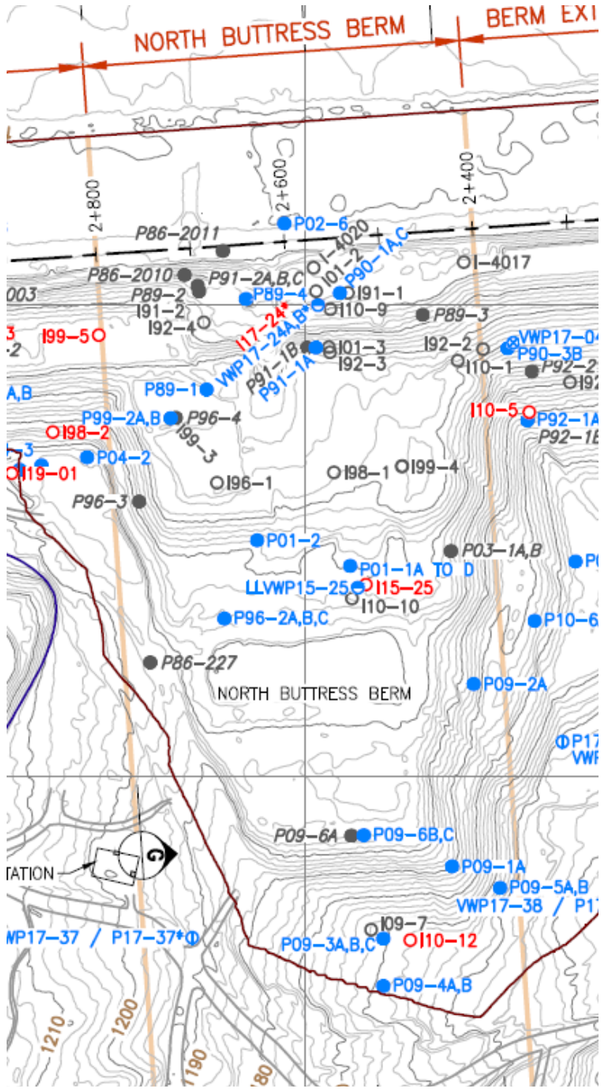




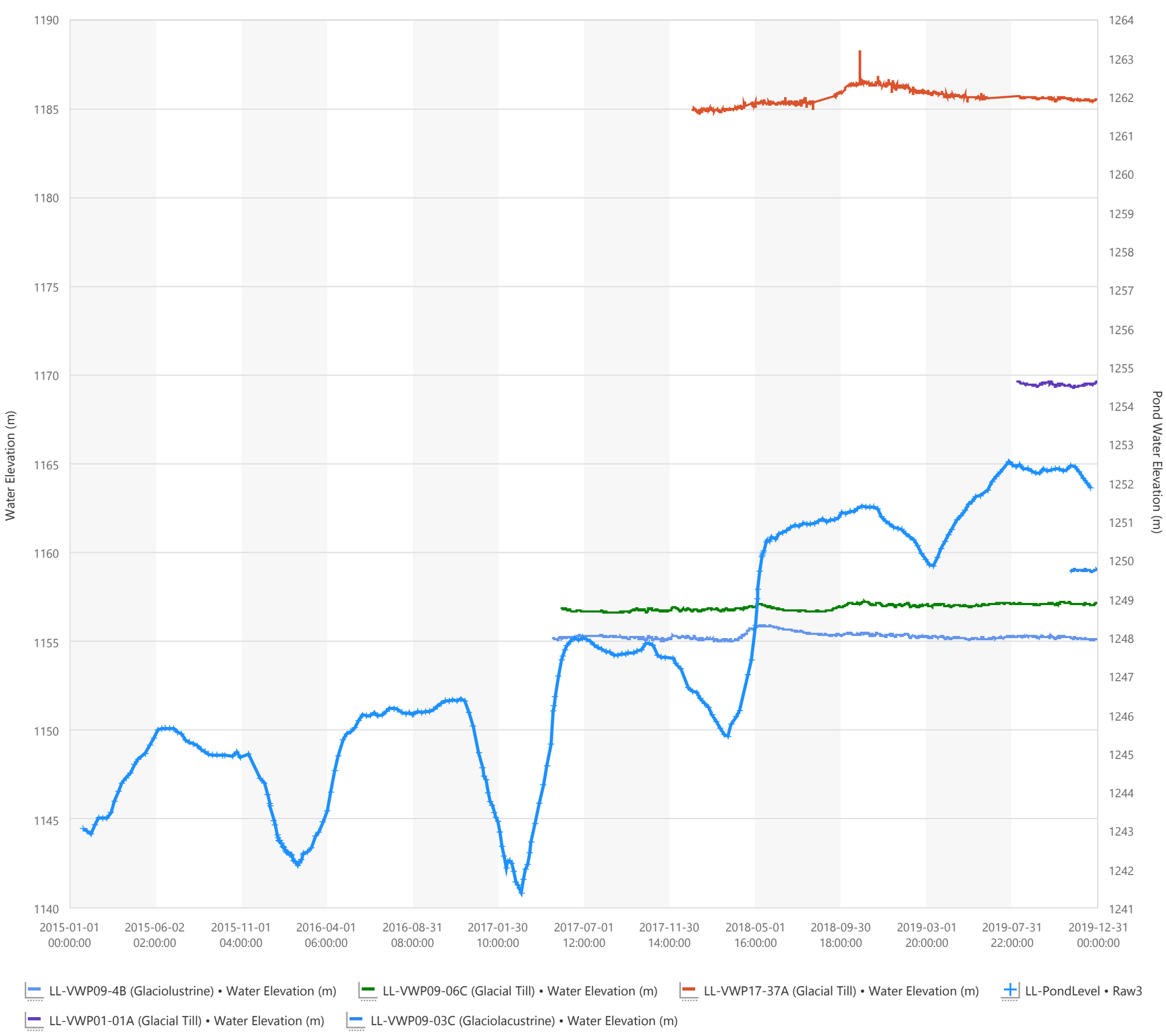
North Dam - Volcanics

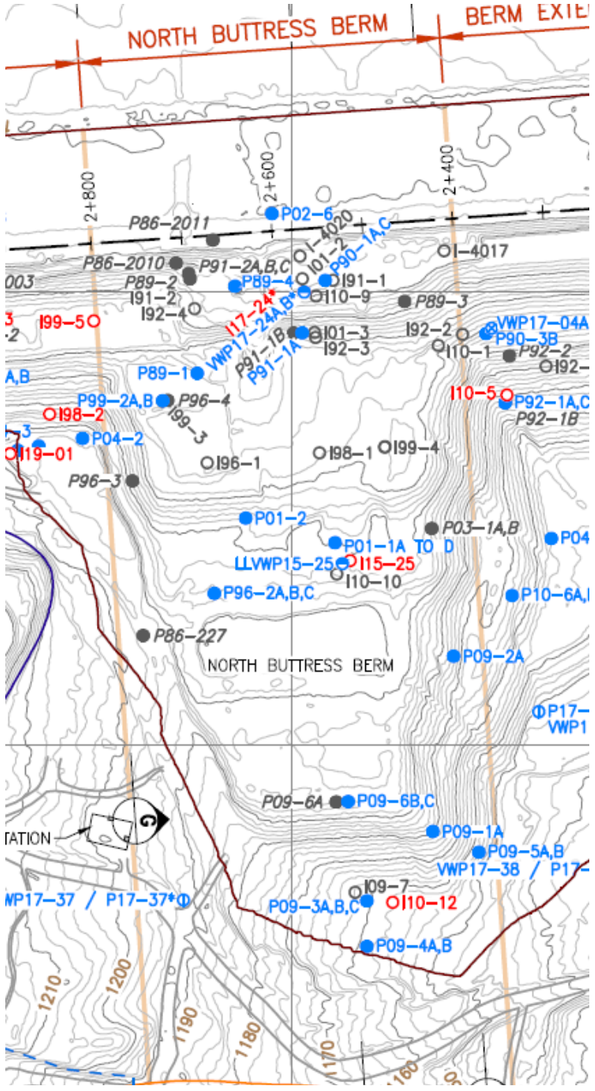


NORTH BUTTRESS BERM – WATER ELEVATIONS SINCE 2015



NBB - Overburden





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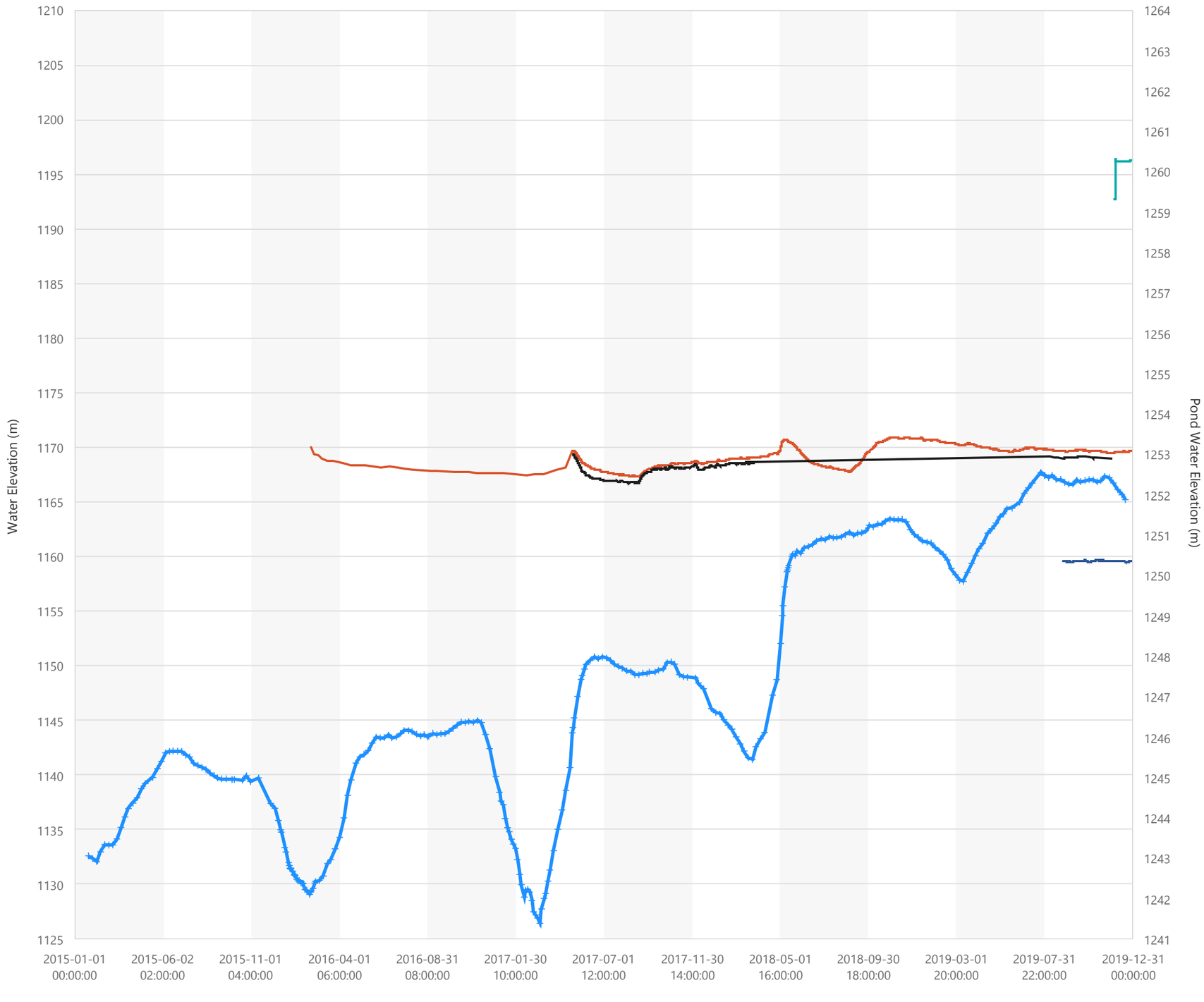
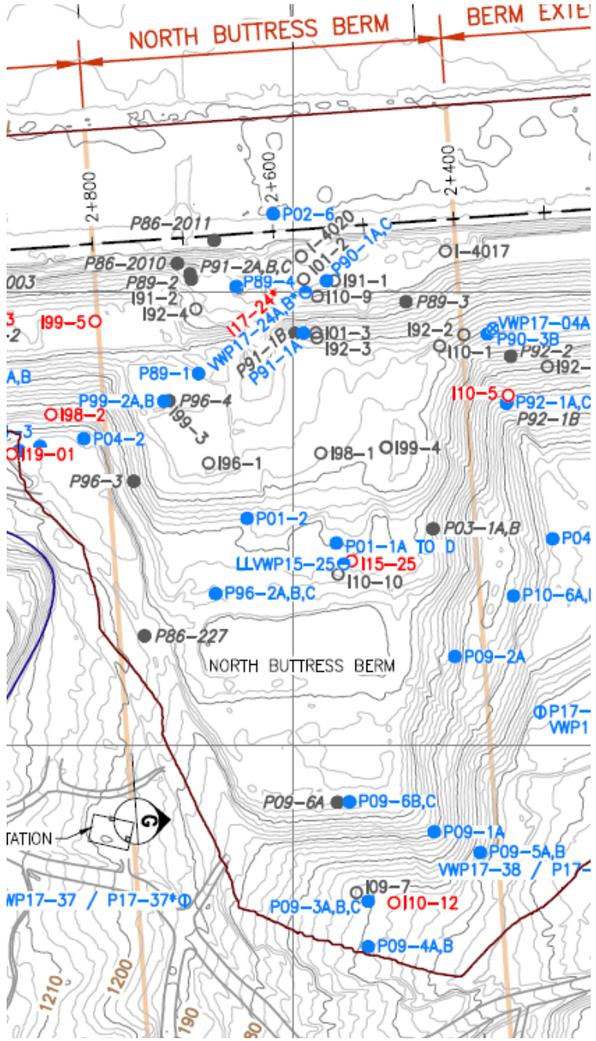
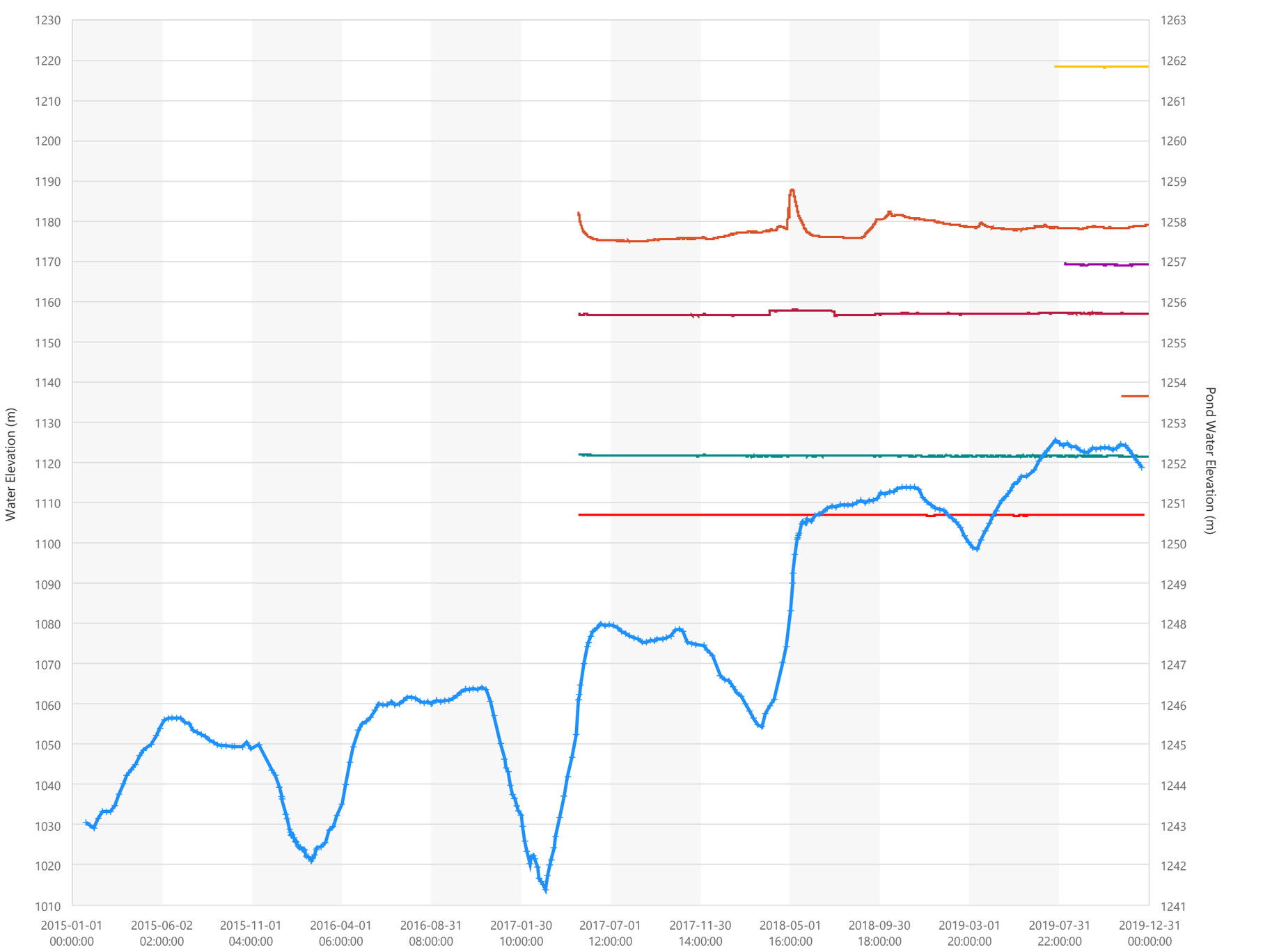
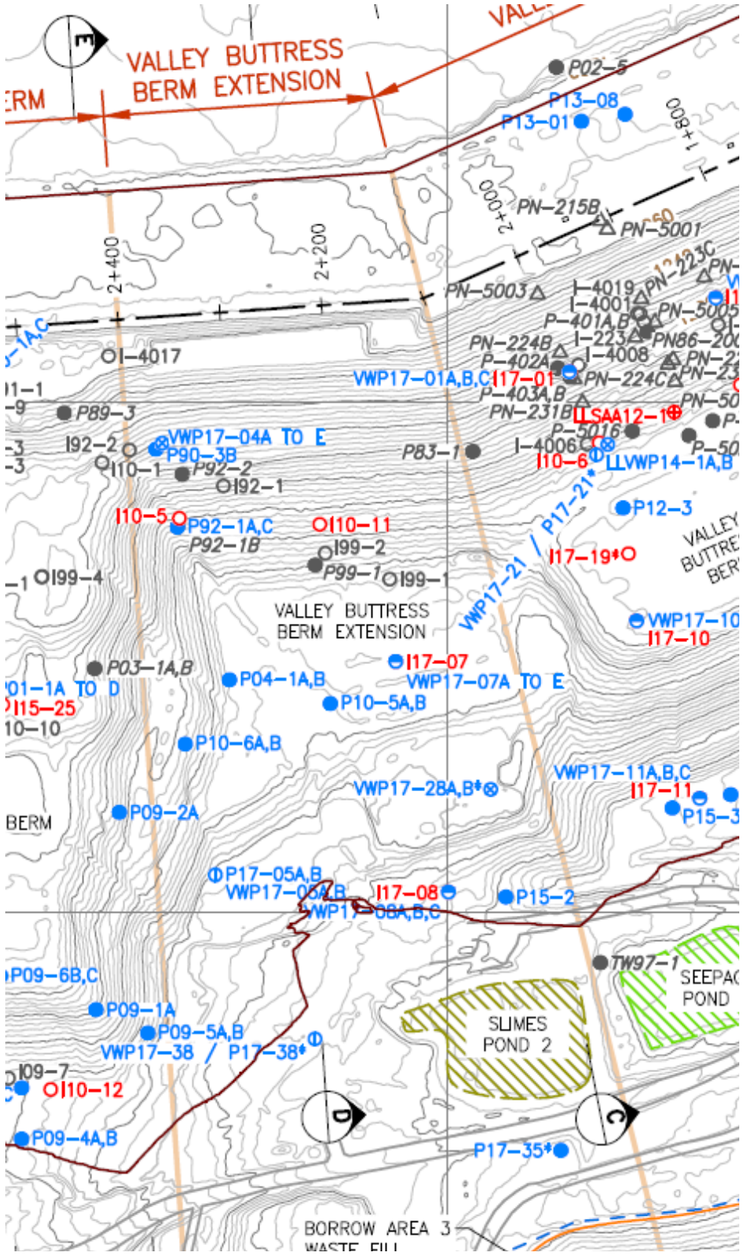




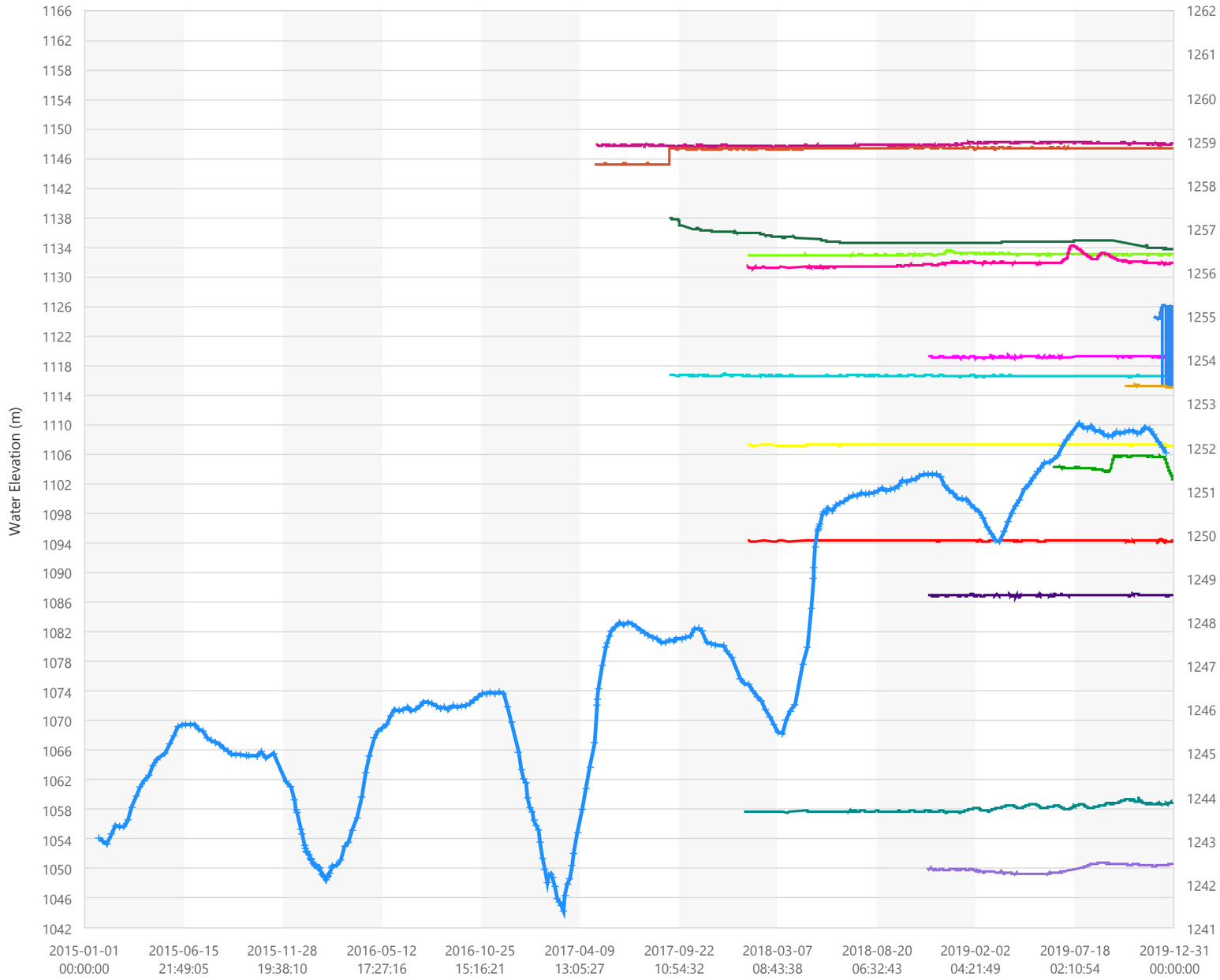
NBB - Sedimentary

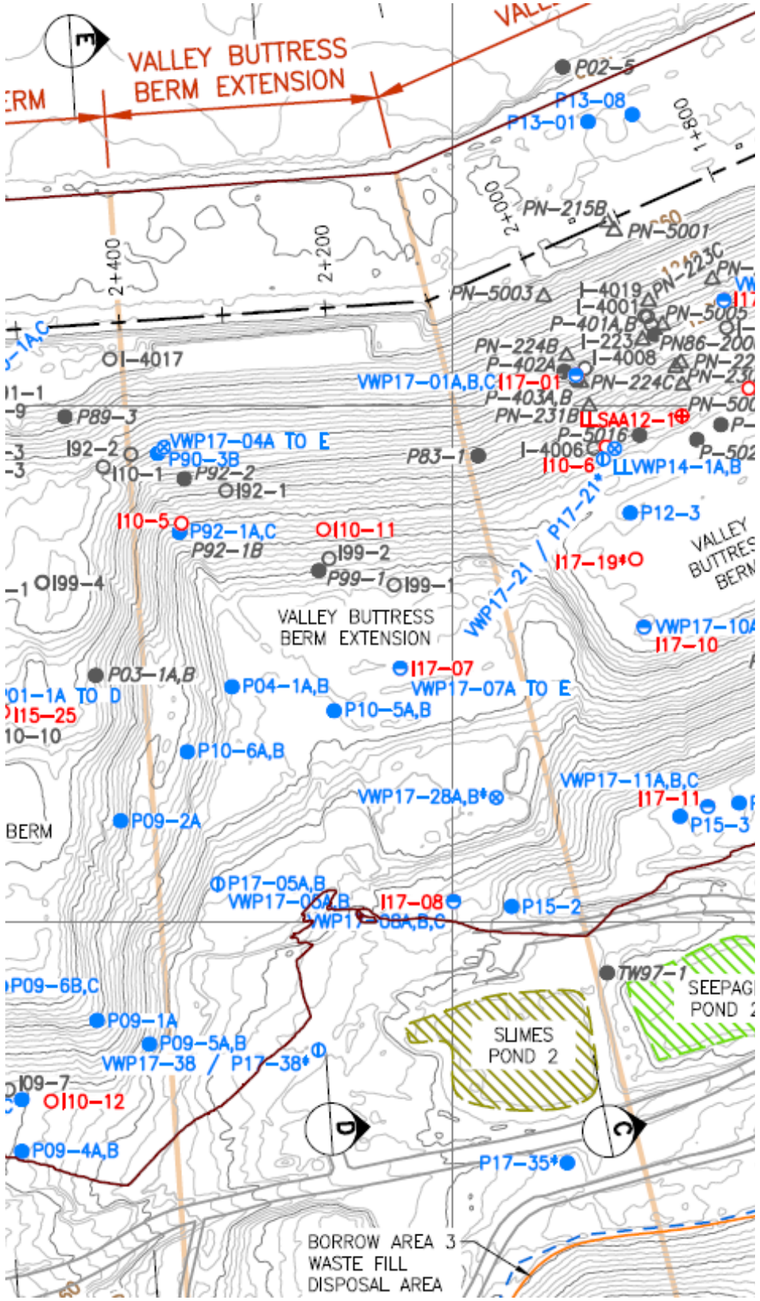


VALLEY BUTTRESS BERM EXTENSION – WATER ELEVATIONS SINCE 2015

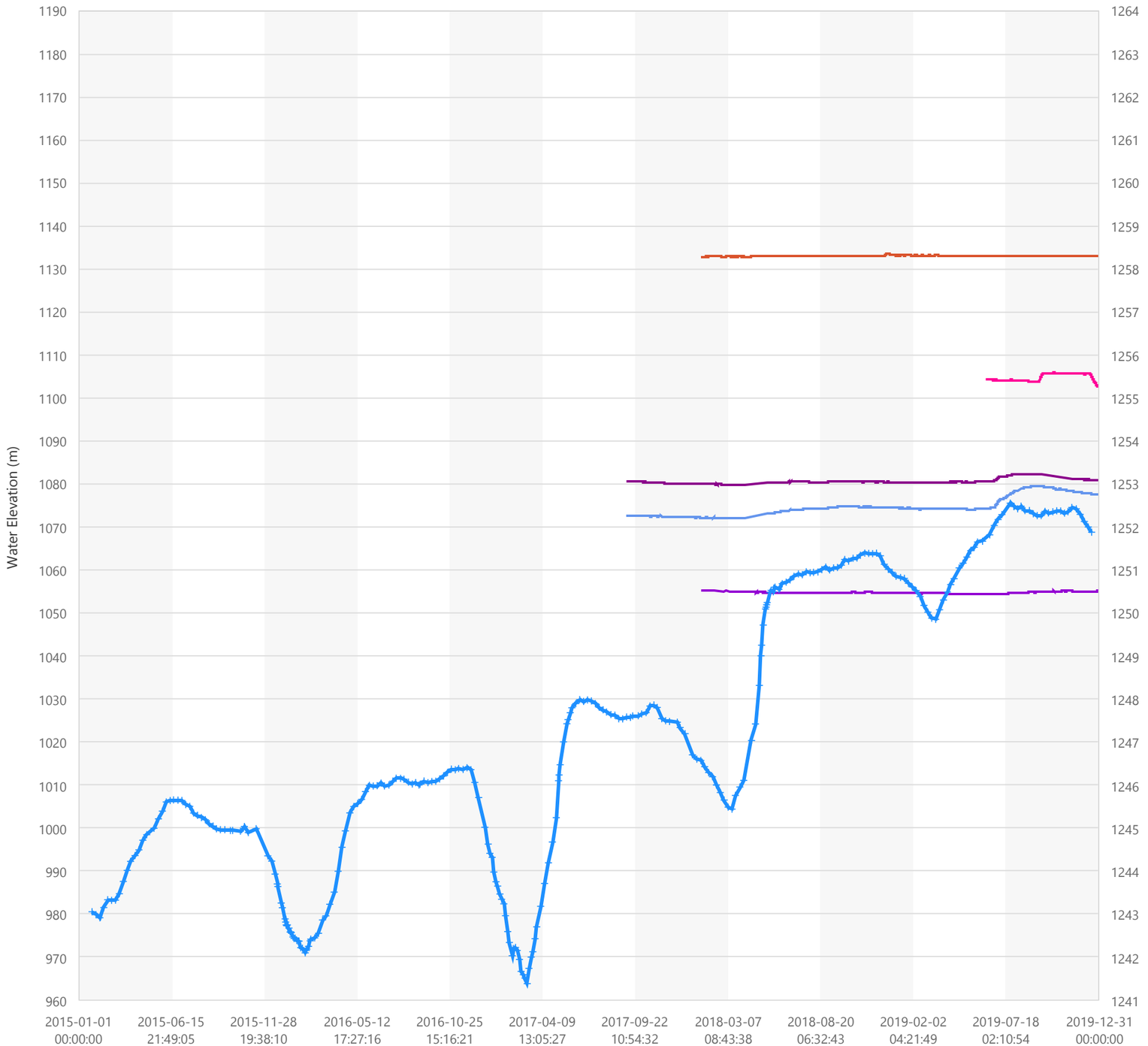


VBBE - Overburden and Dam Fill

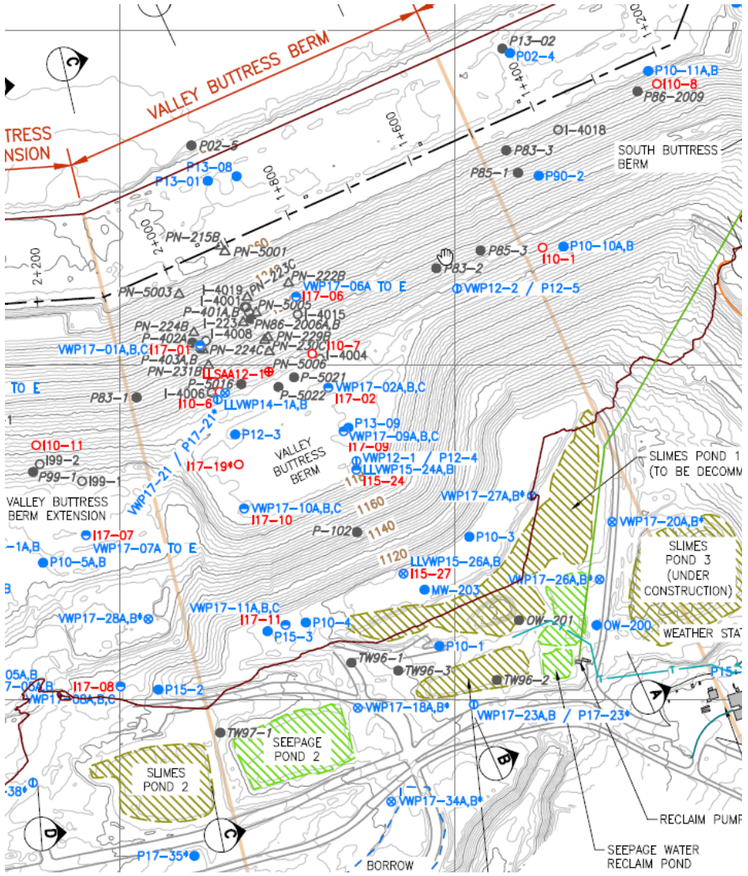




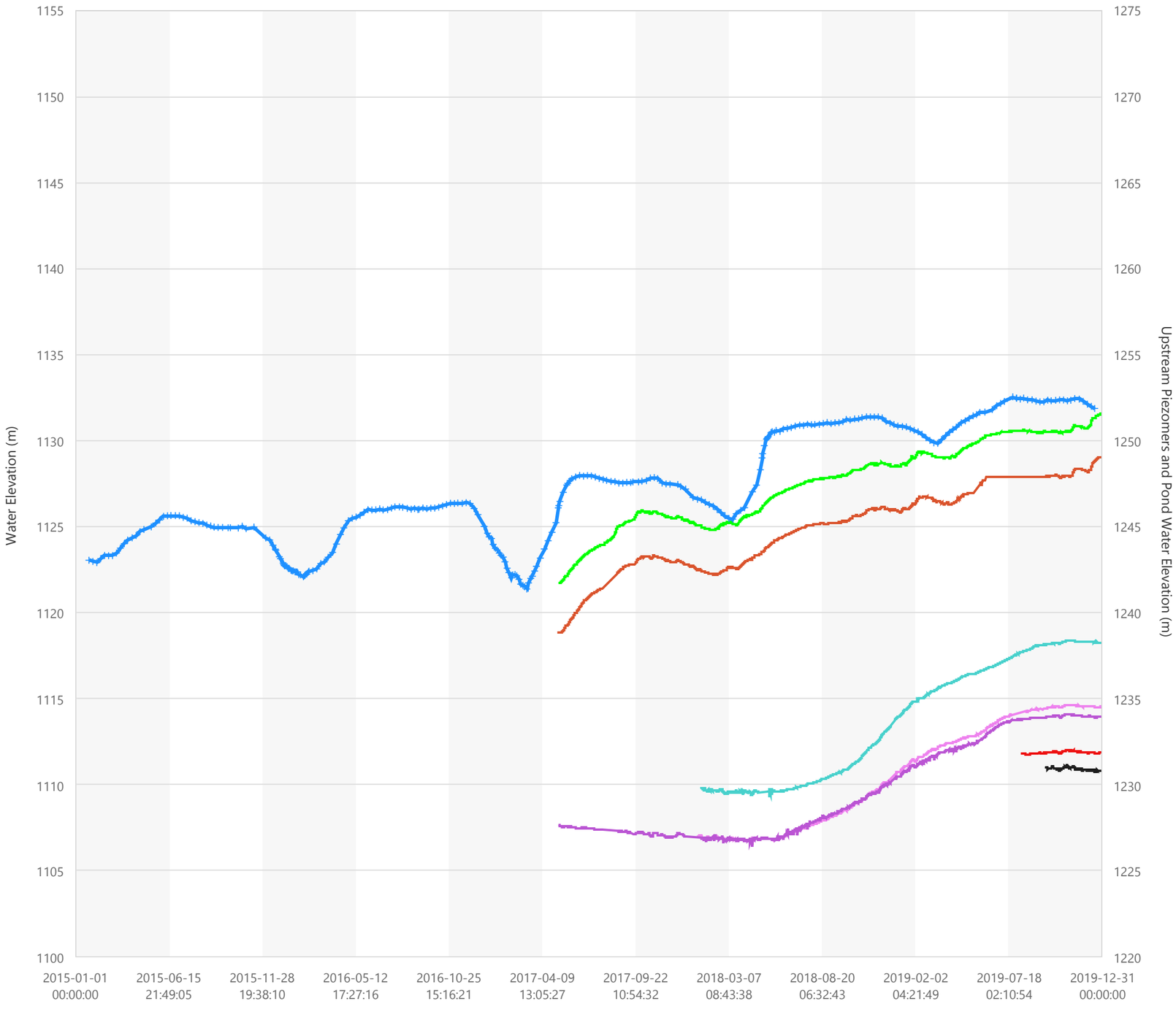
VBBE - Foundation Rock



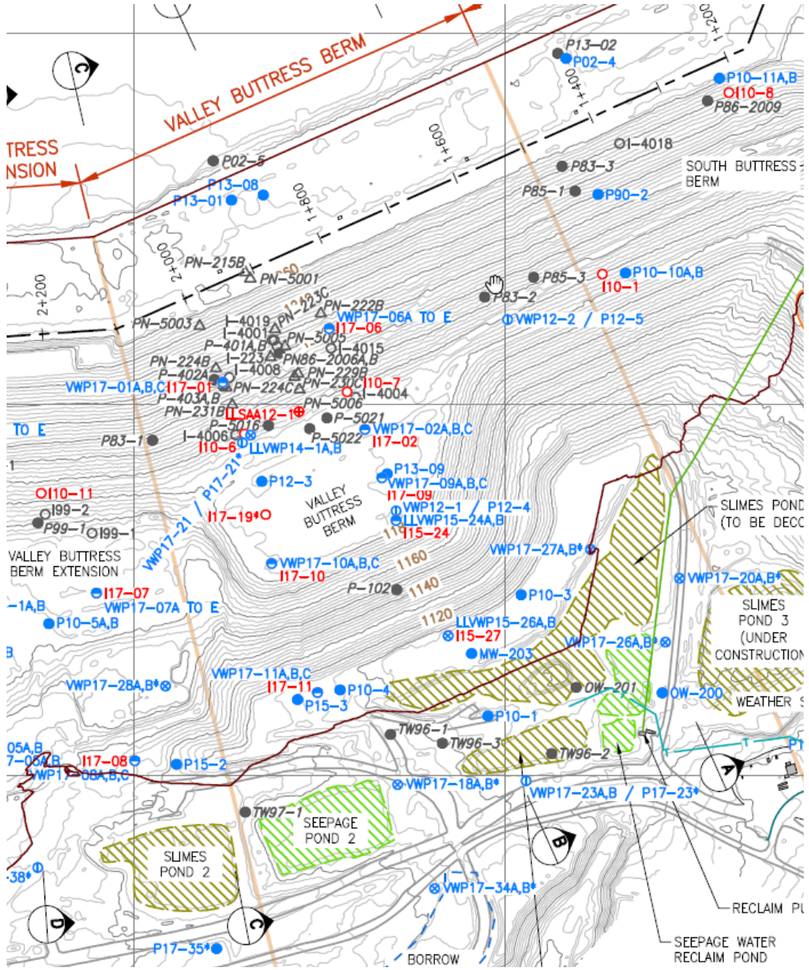
VALLEY BUTTRESS BERM – WATER ELEVATIONS SINCE 2015



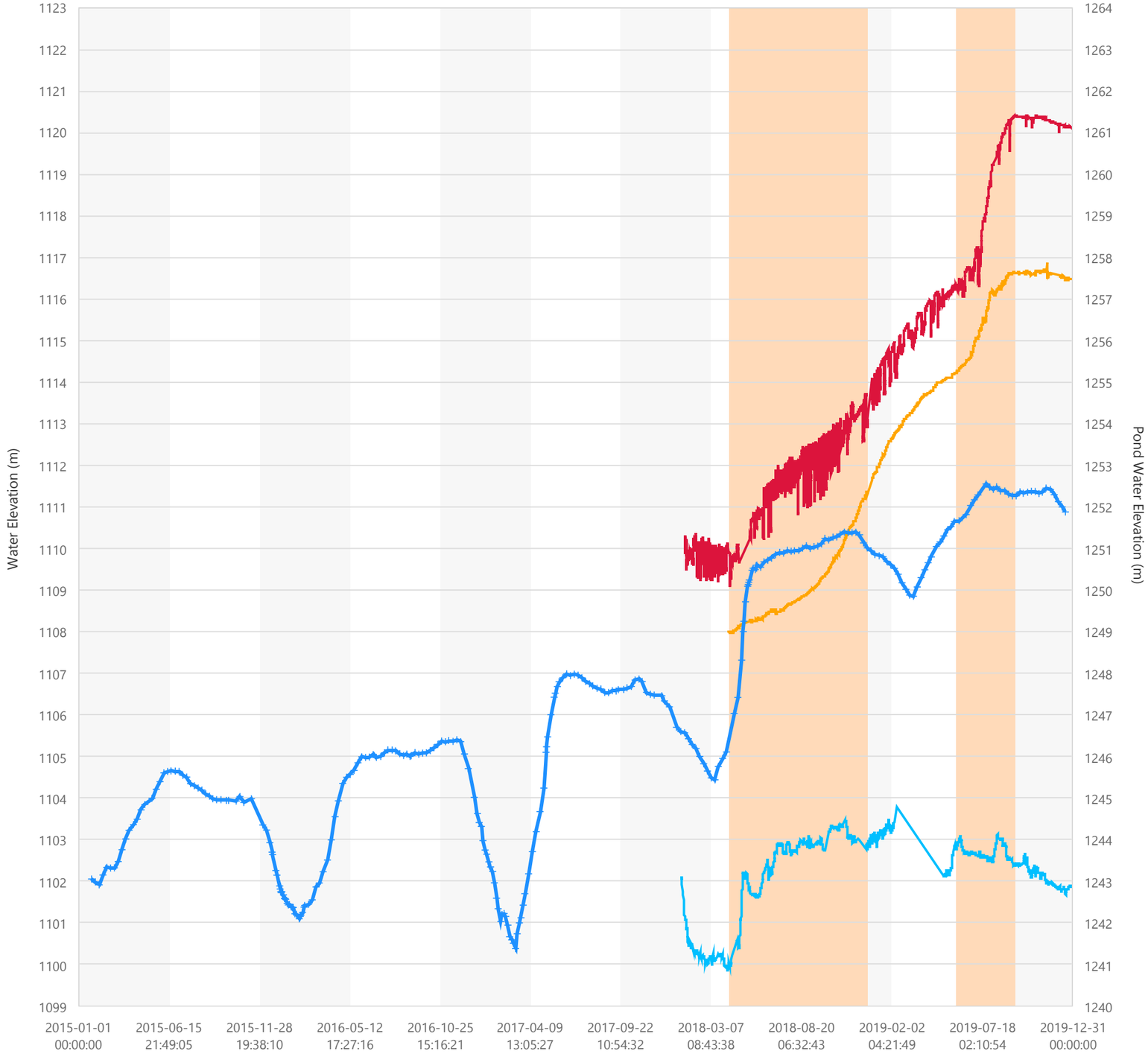
VBB - Dam Fill

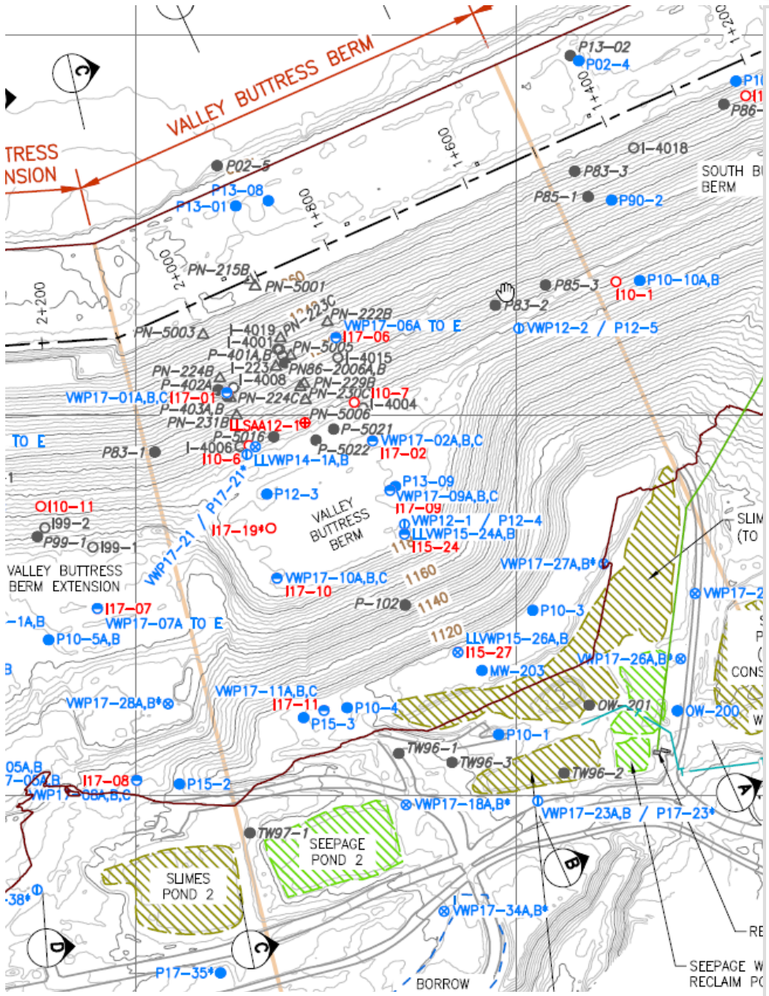


LL-VWP17-02C (S&G Drainage Blanket) • Water Elevation (m)
LL-VWP17-06E (S&G Drainage Blanket) • Water Elevation (m)
LL-VWP13-09 (S&G Drainage Blanket) • Water Elevation (m)
LL-VWP13-01 (Upstream Sand) • Water Elevation (m)
LL-VWP13-08m (Upstream Sand) • Water Elevation (m)
LL-PondLevel • Raw3
LL-VWP102 (Glacial Till) • Water Elevation (m)
LL-VWP12-04 • Water Elevation (m)

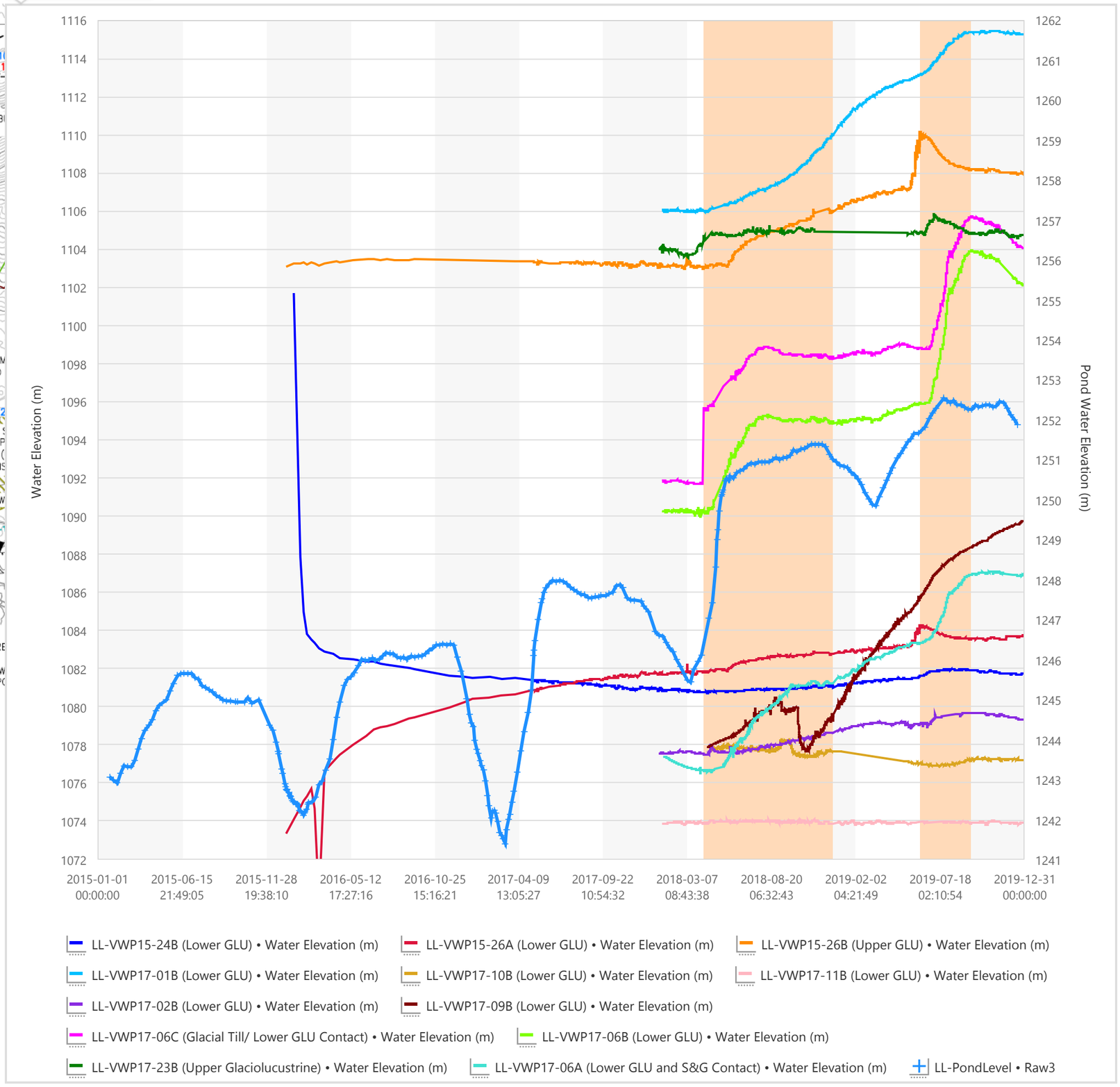


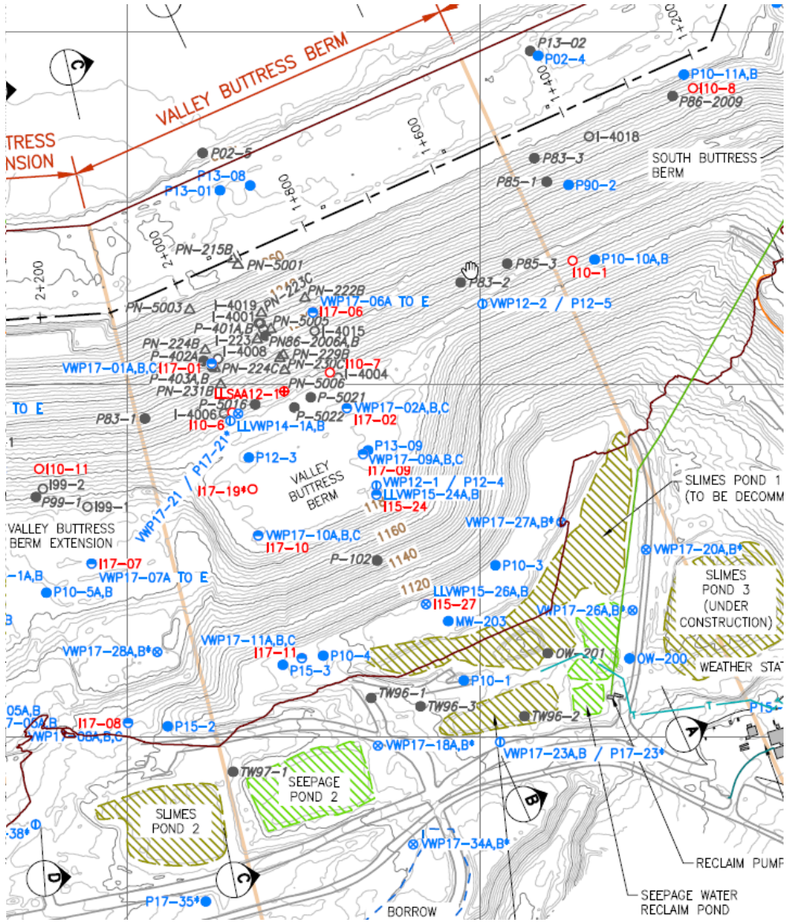
VBB - Lacustrine



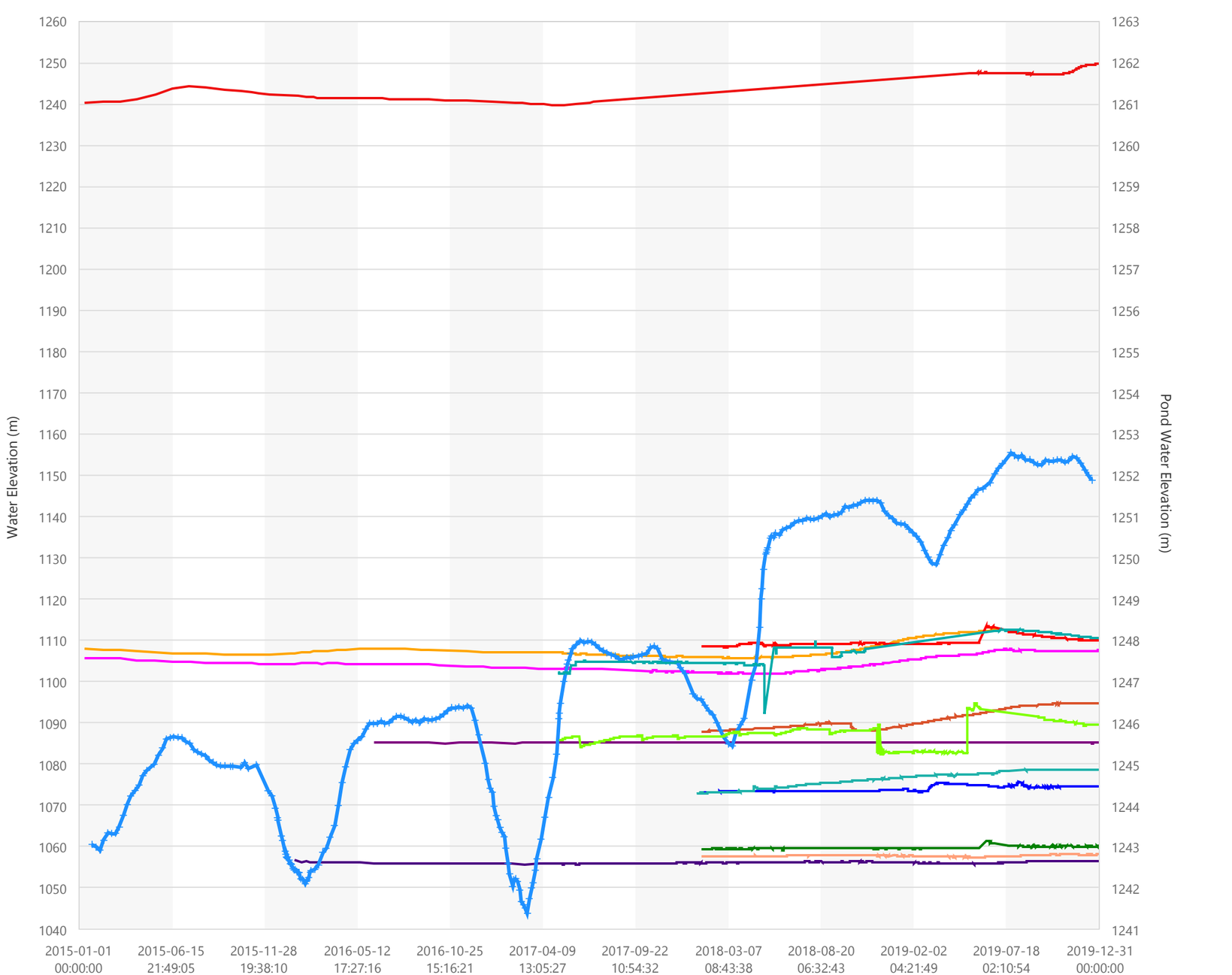


VBB - Glaciolacustrine

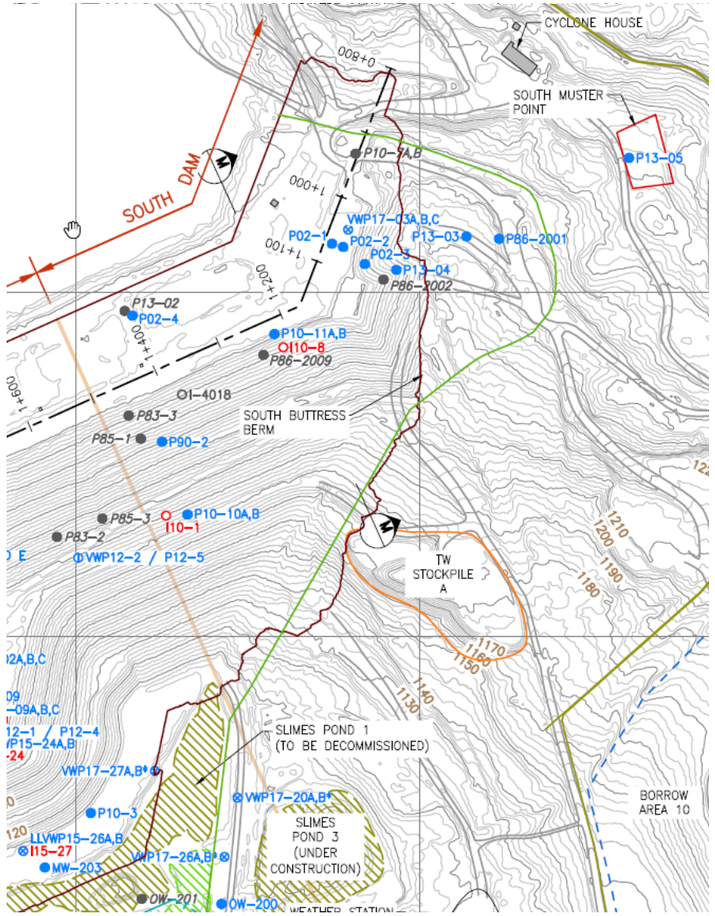




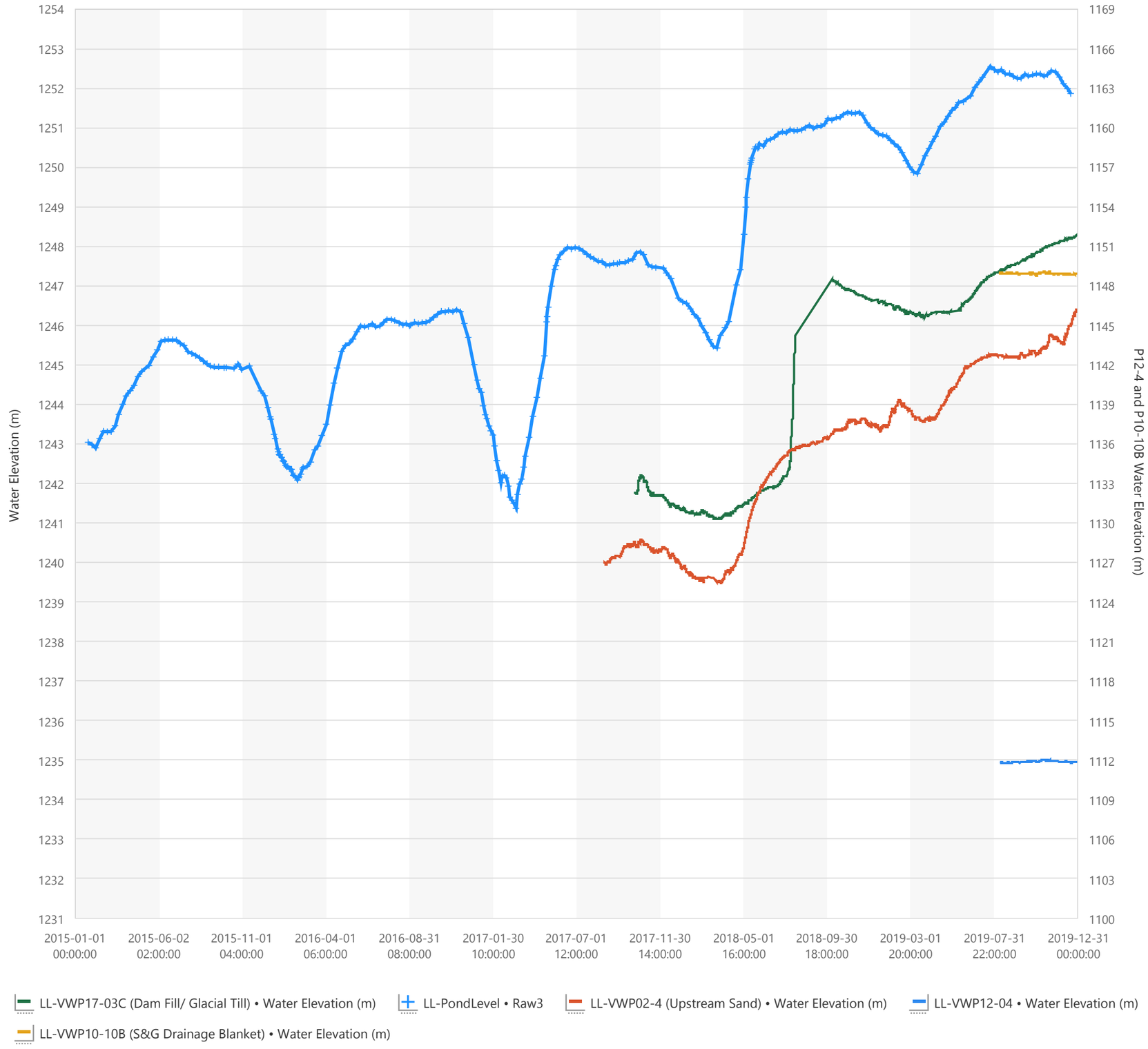
VBB - Glacial Till, Sand and Gravel

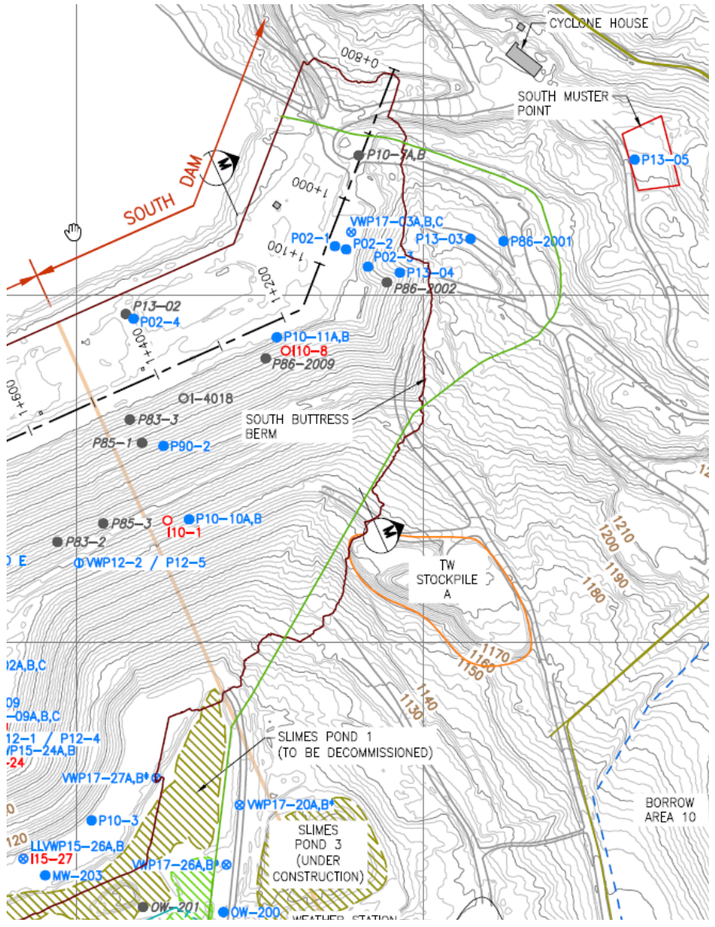


SOUTH DAM – WATER ELEVATIONS SINCE 2015

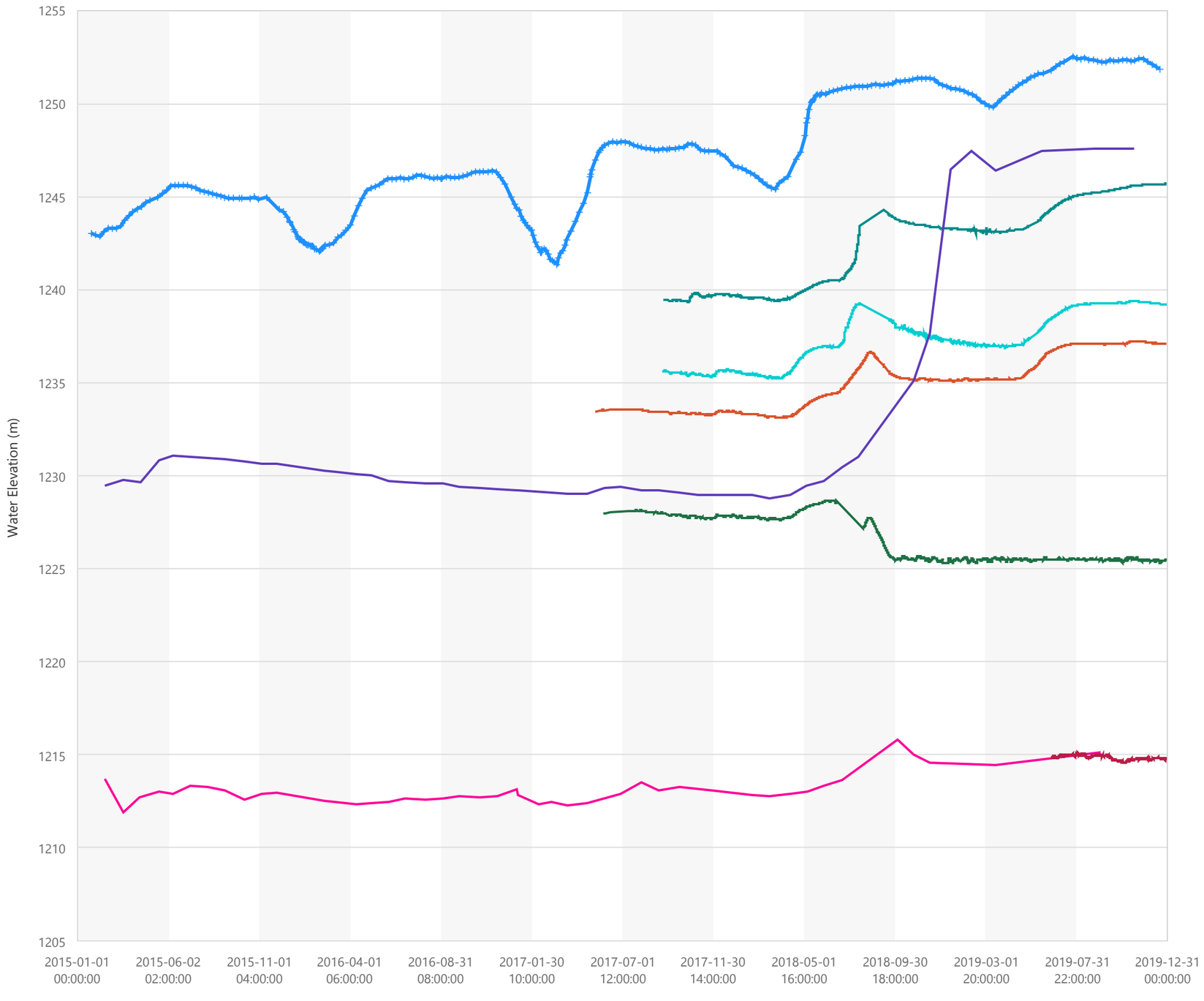


South Dam - Dam Fill





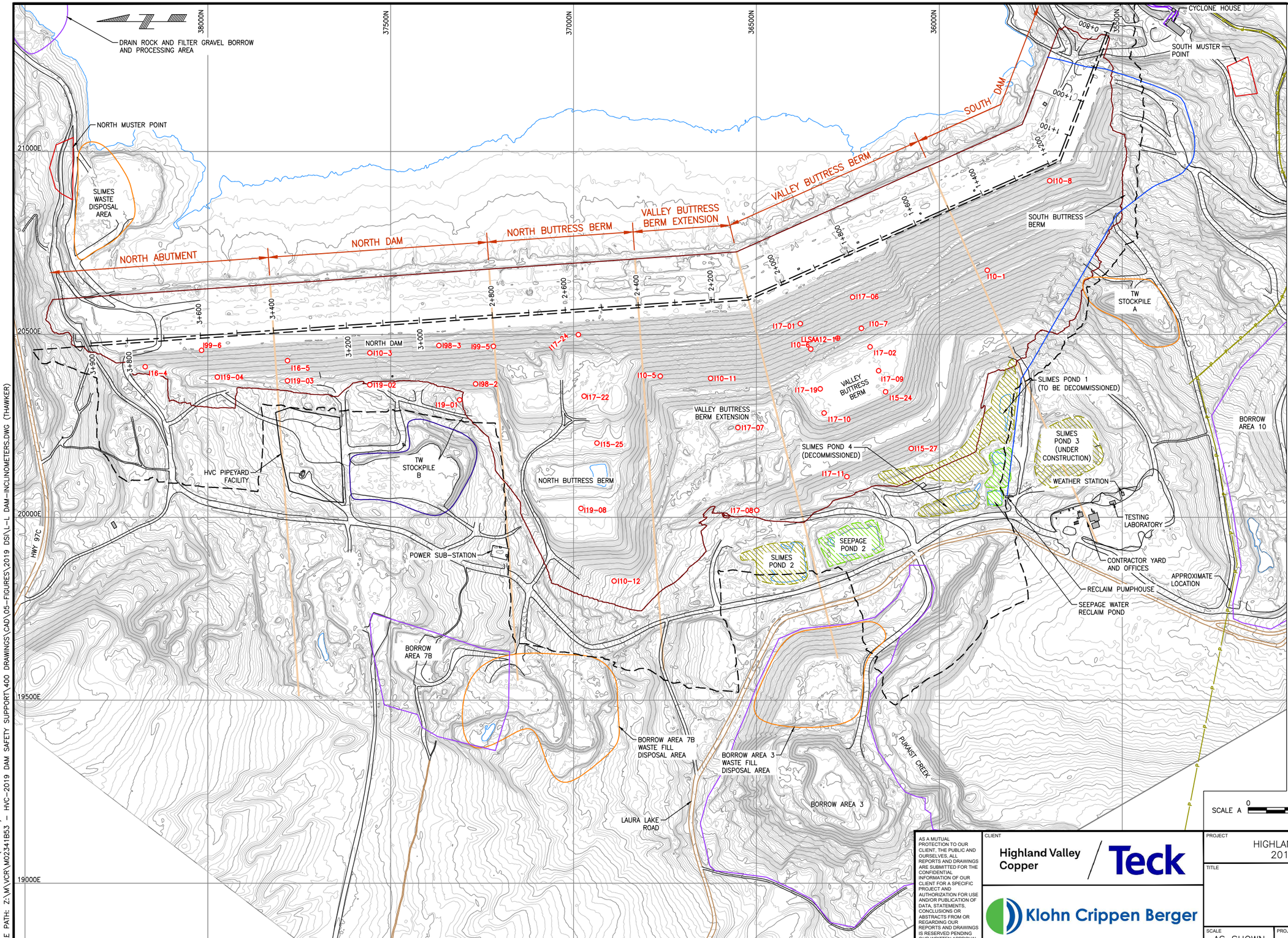
South Dam - Granodiorite Foundation Rock and Glacial Till



APPENDIX V-C

L-L Dam Inclinometer Plots

L-L DAM INCLINOMETER LOCATION PLAN



LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- 2040 PFS DAM FOOTPRINT
- L-L DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDARD INCLINOMETER
- IN-PLACE SAA INCLINOMETER

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM PHOTOSAT SURVEY DATED 2019-09-30 (L-L DAM) AND 2017-09-15 & 24 AND 2016-09-25 & 29, (OUTSIDE OF 2019 SURVEY EXTENT).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.

SCALE A 0 250 m

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

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM INCLINOMETERS LOCATION PLAN

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M02341B53	

KCB-FIG-D-L

SAVE DATE: 2019-12-16 (3:04 PM)
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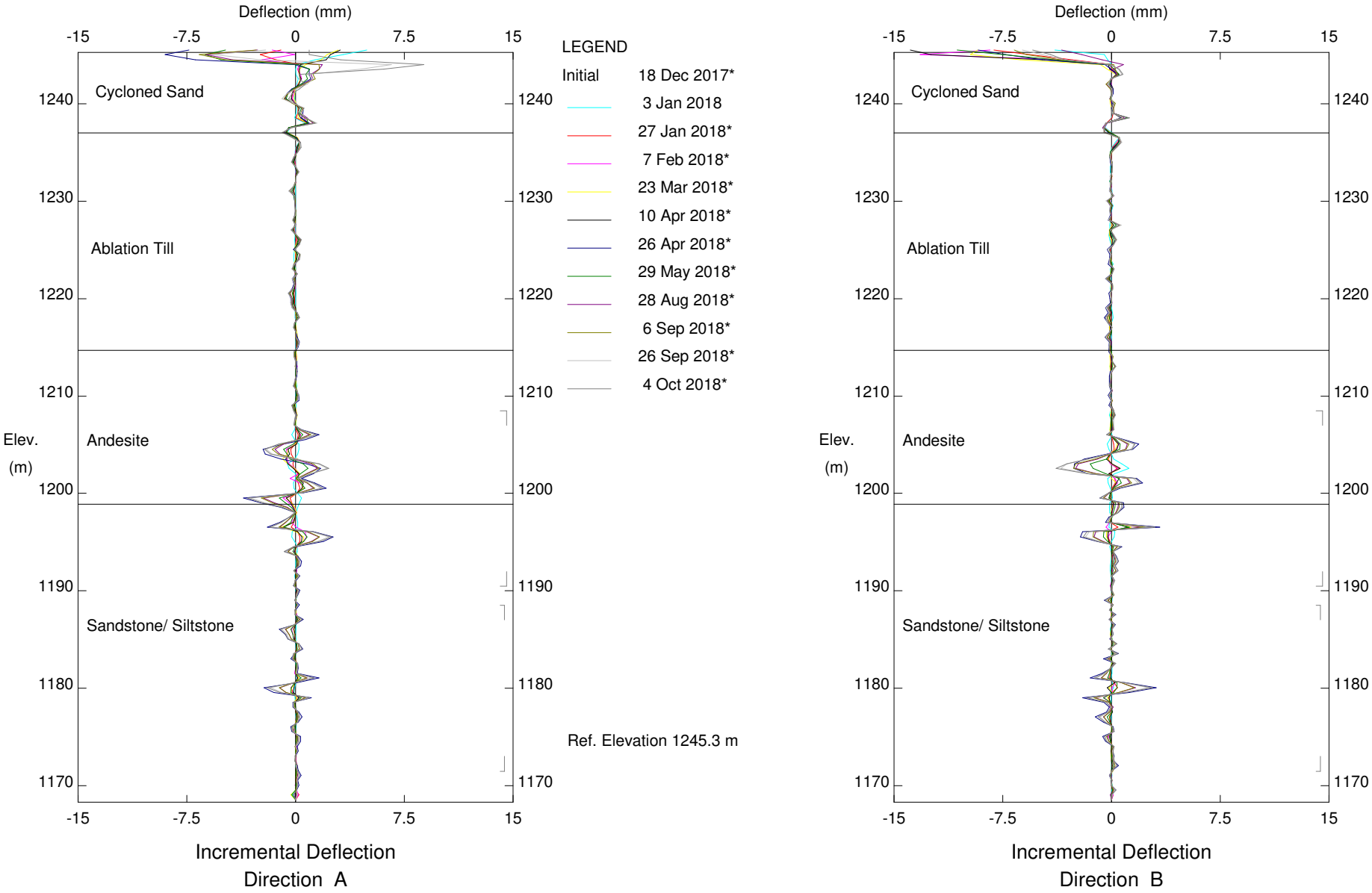
NORTH ABUTMENT

I99-06

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I99-06

Sets marked * include zero shift and/or rotation corrections.

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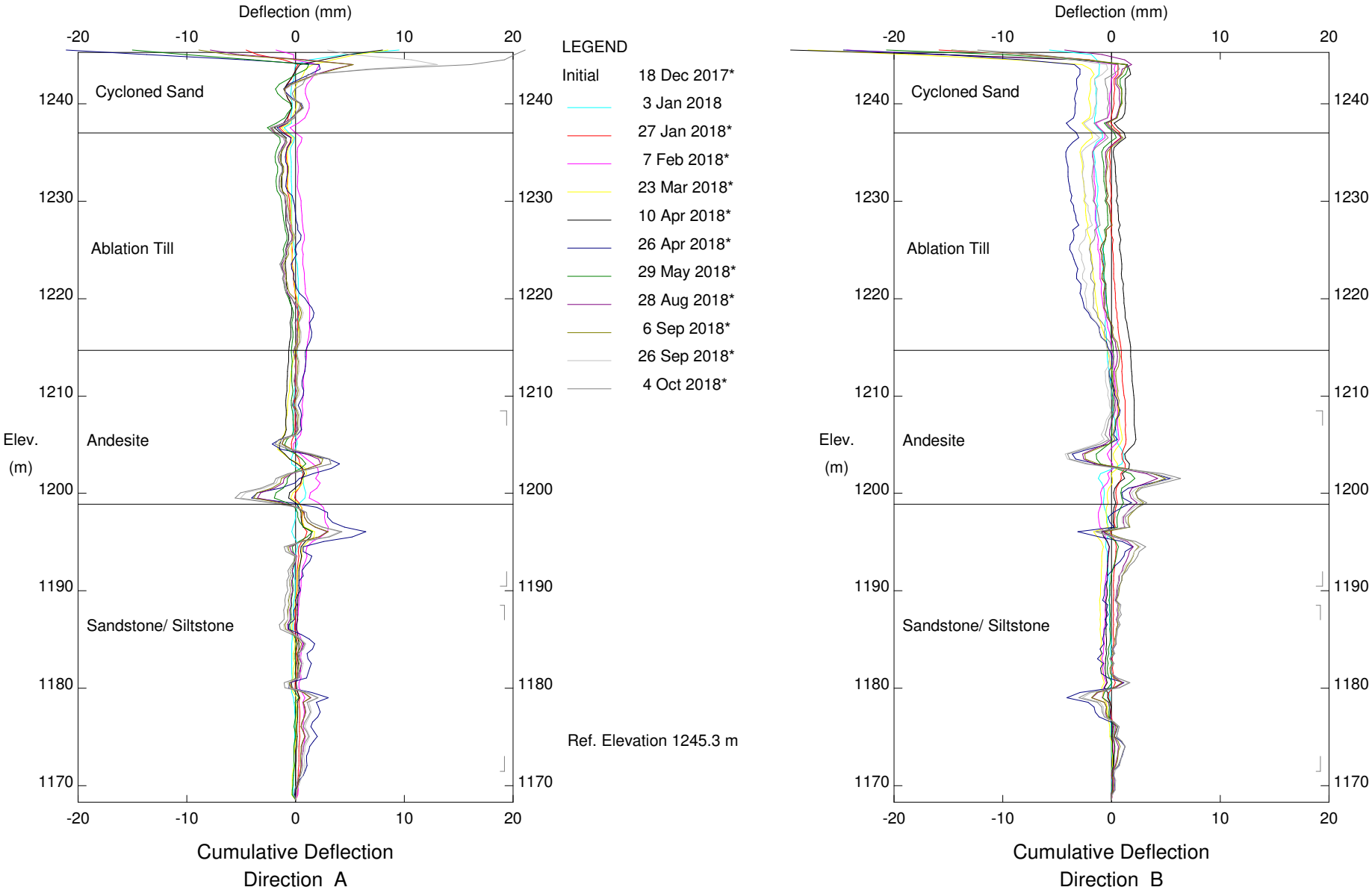
Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I99-06

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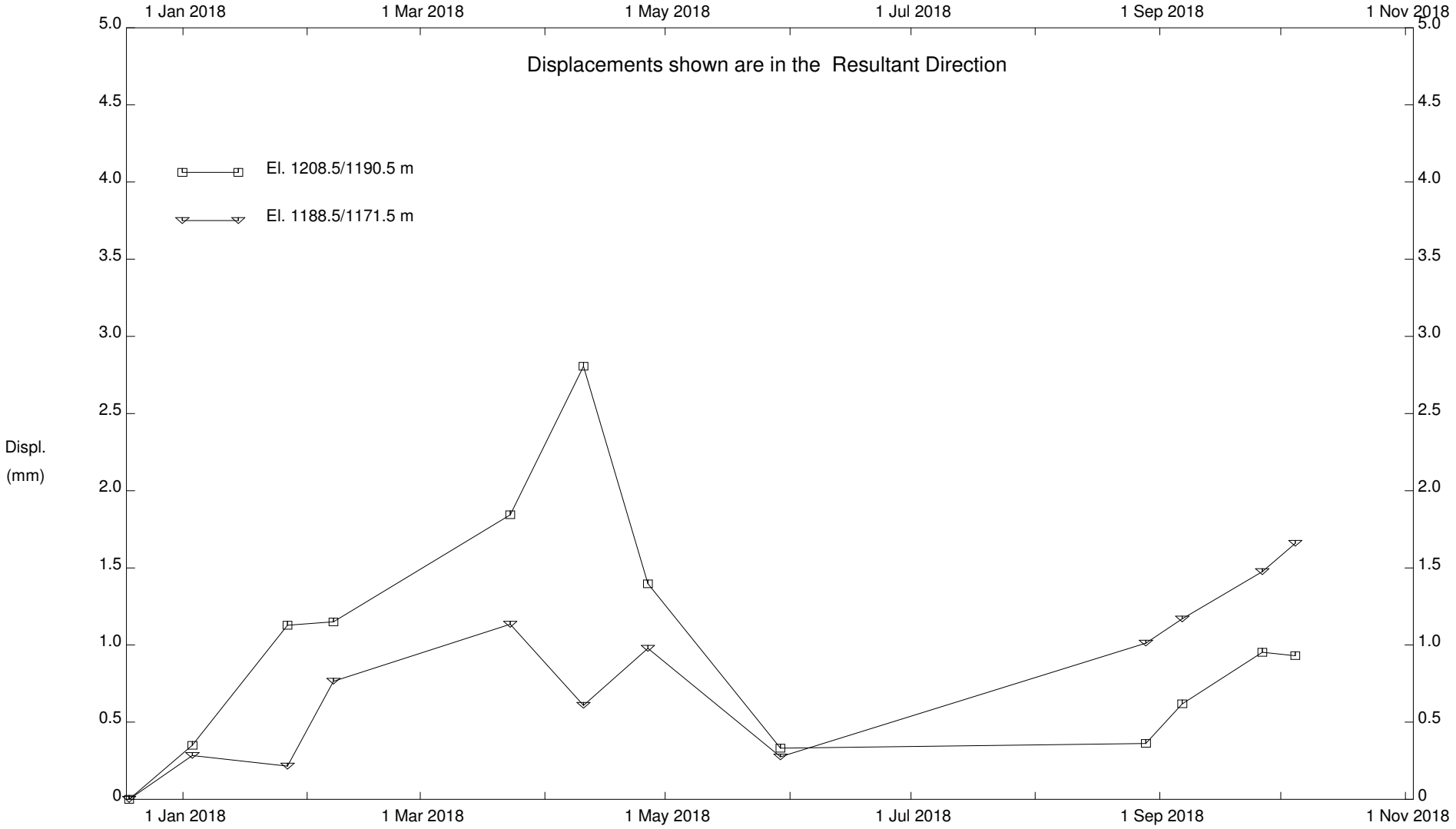
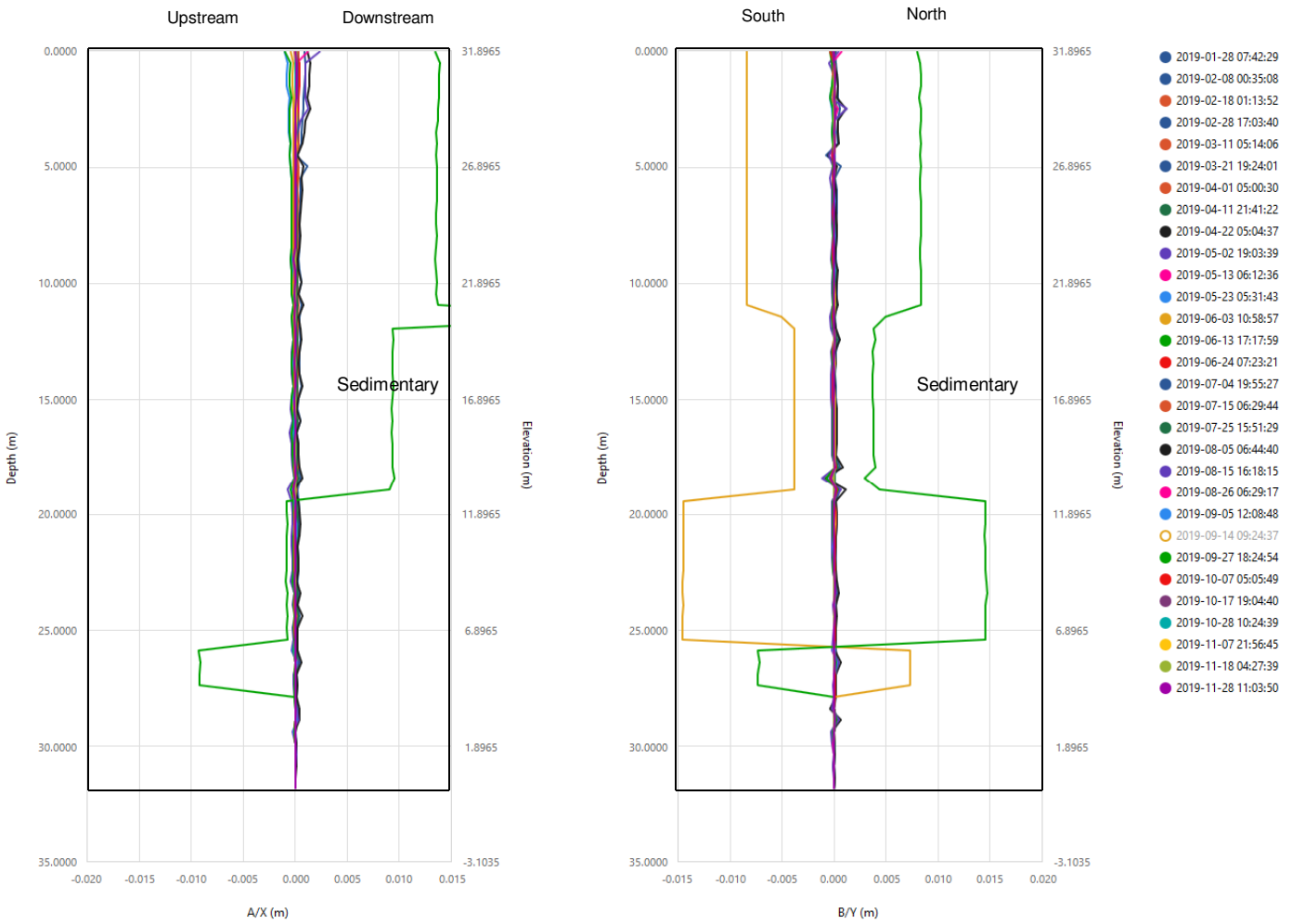
Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I99-06

SAAV I99-06

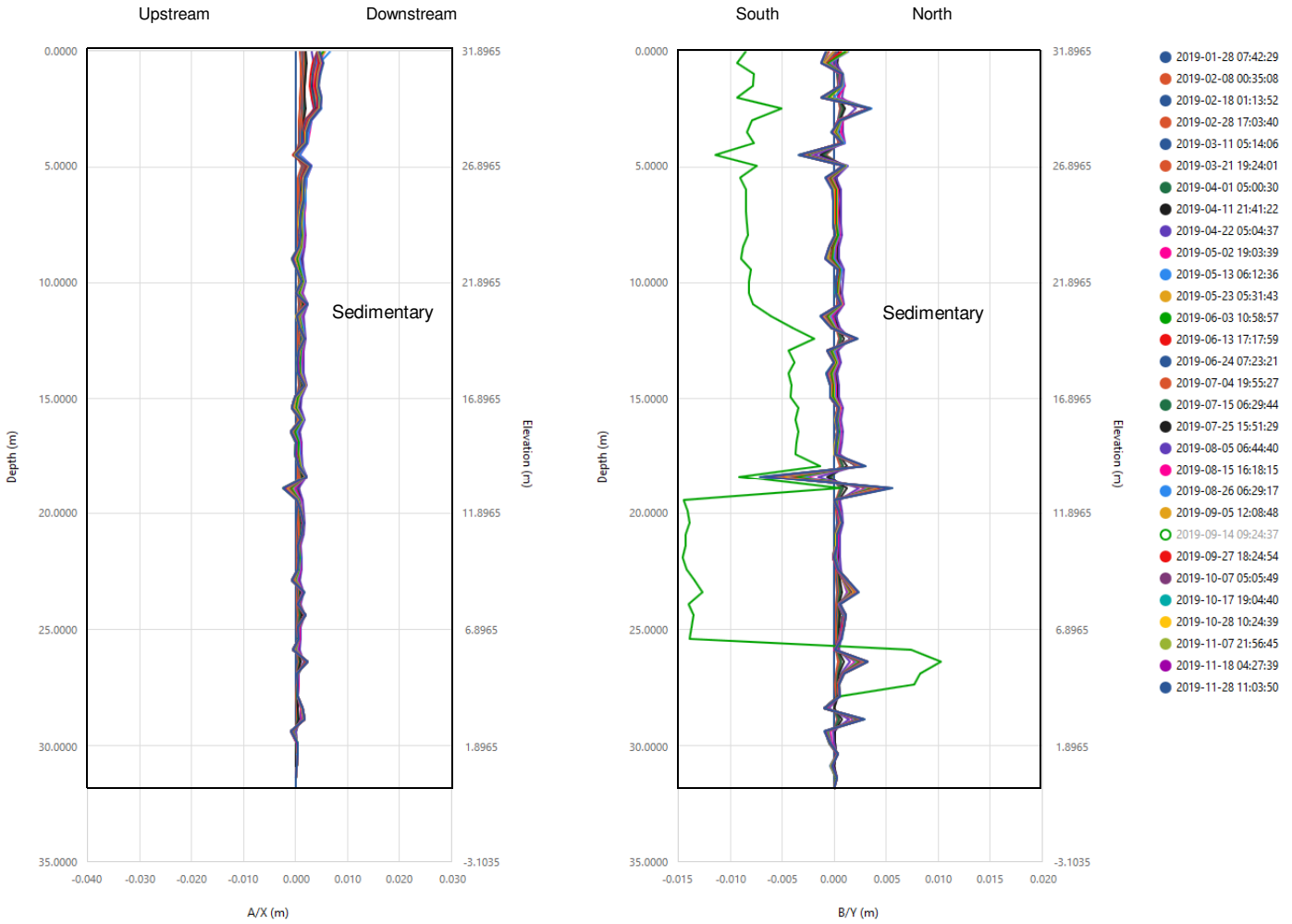
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
99-06	Volcanic	1194.3	1191.3	0.5	3
	Sedimentary	1191.3	1164.3	3	30

SAAV I99-06

Cumulative Plot



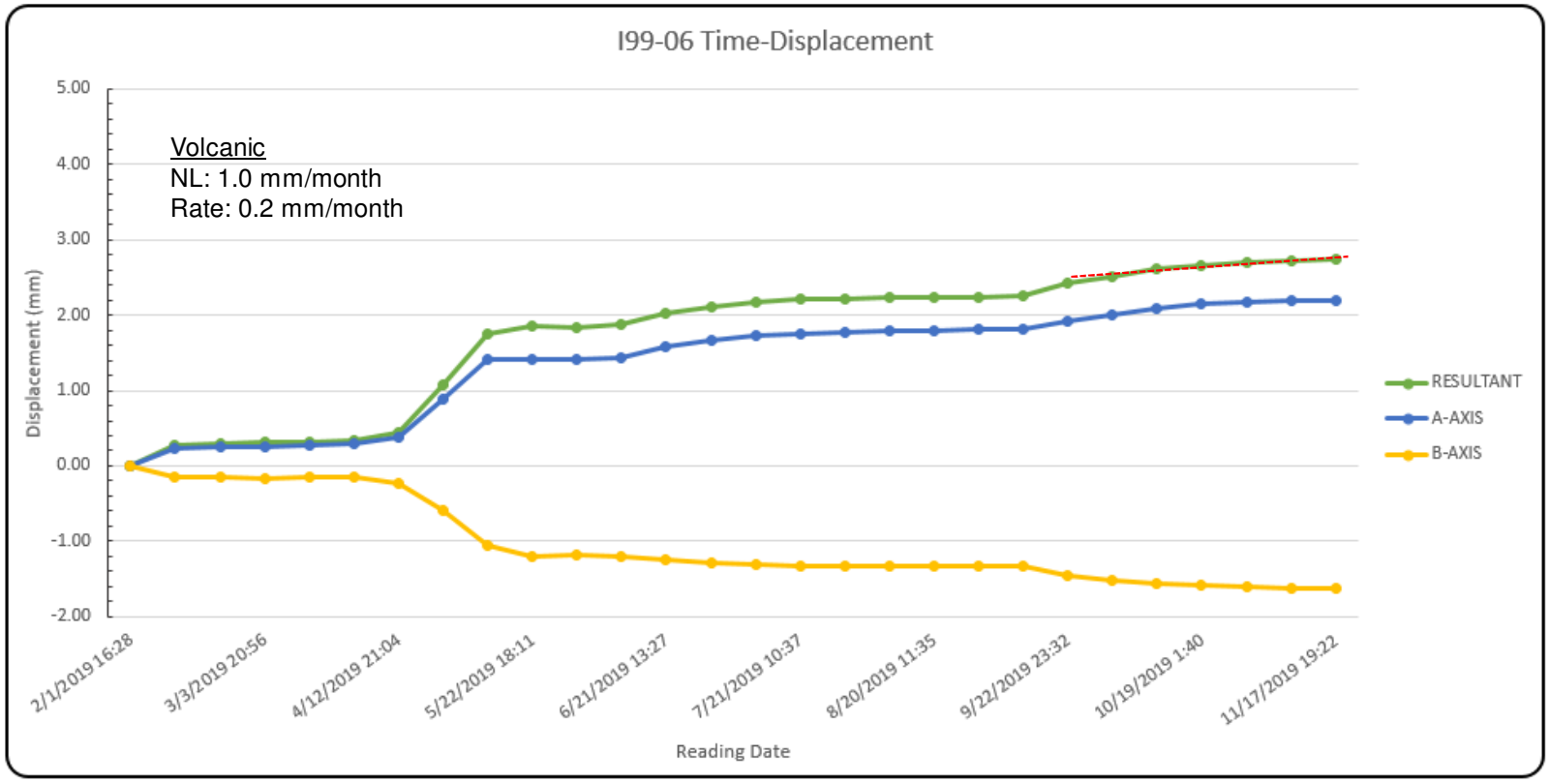
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
99-06	Volcanic	1194.3	1191.3	0.5	3
	Sedimentary	1191.3	1164.3	3	30

SAAV I99-06

Displacement Plot

Unit	Upper Depth	Lower Depth
Volcanic	0.5	3
Sedimentary	3	30

Upper Depth	0.5 m
Lower Depth	3.0 m

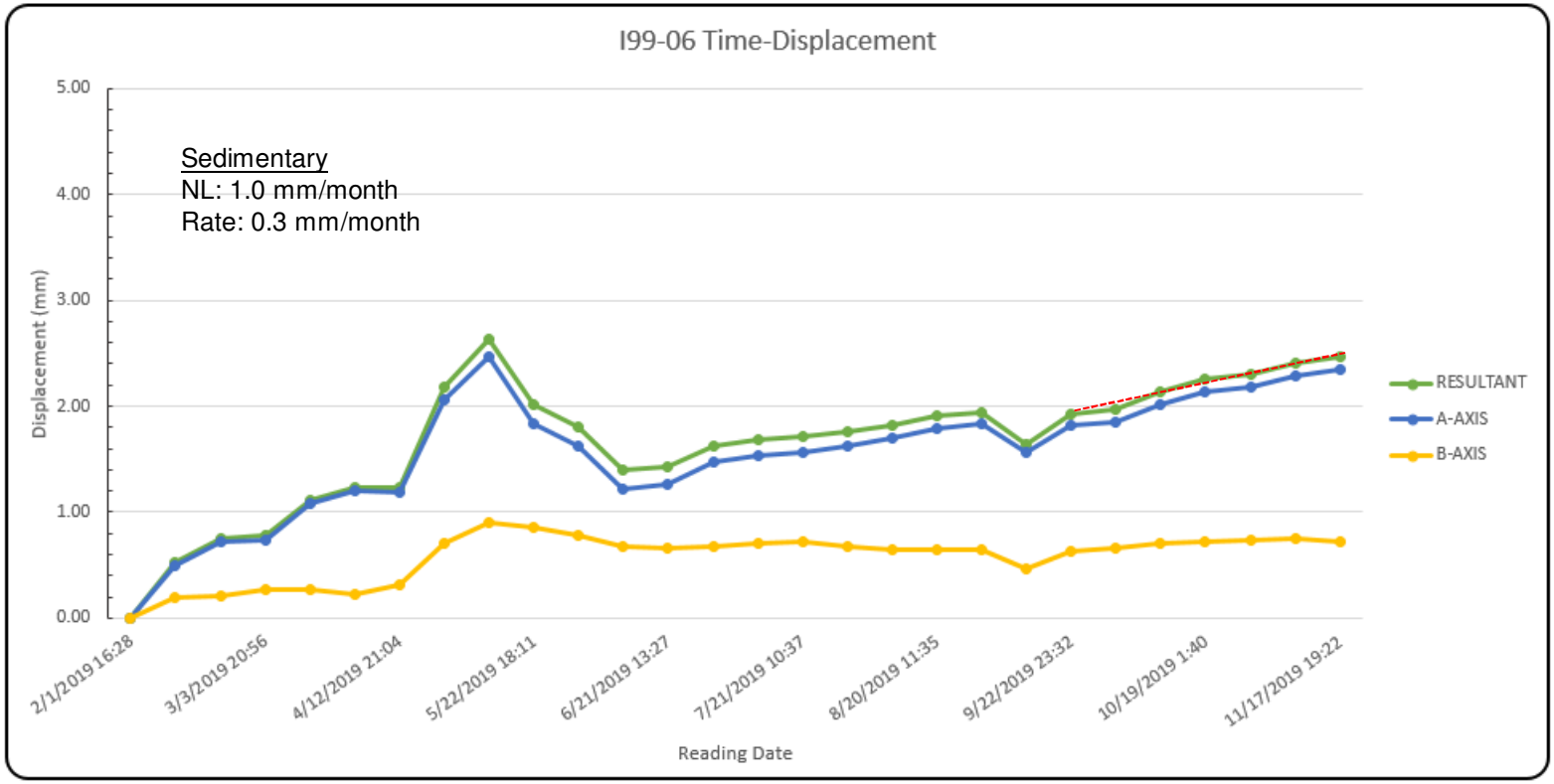


SAAV I99-06

Displacement Plot

Unit	Upper Depth	Lower Depth
Volcanic	0.5	3
Sedimentary	3	30

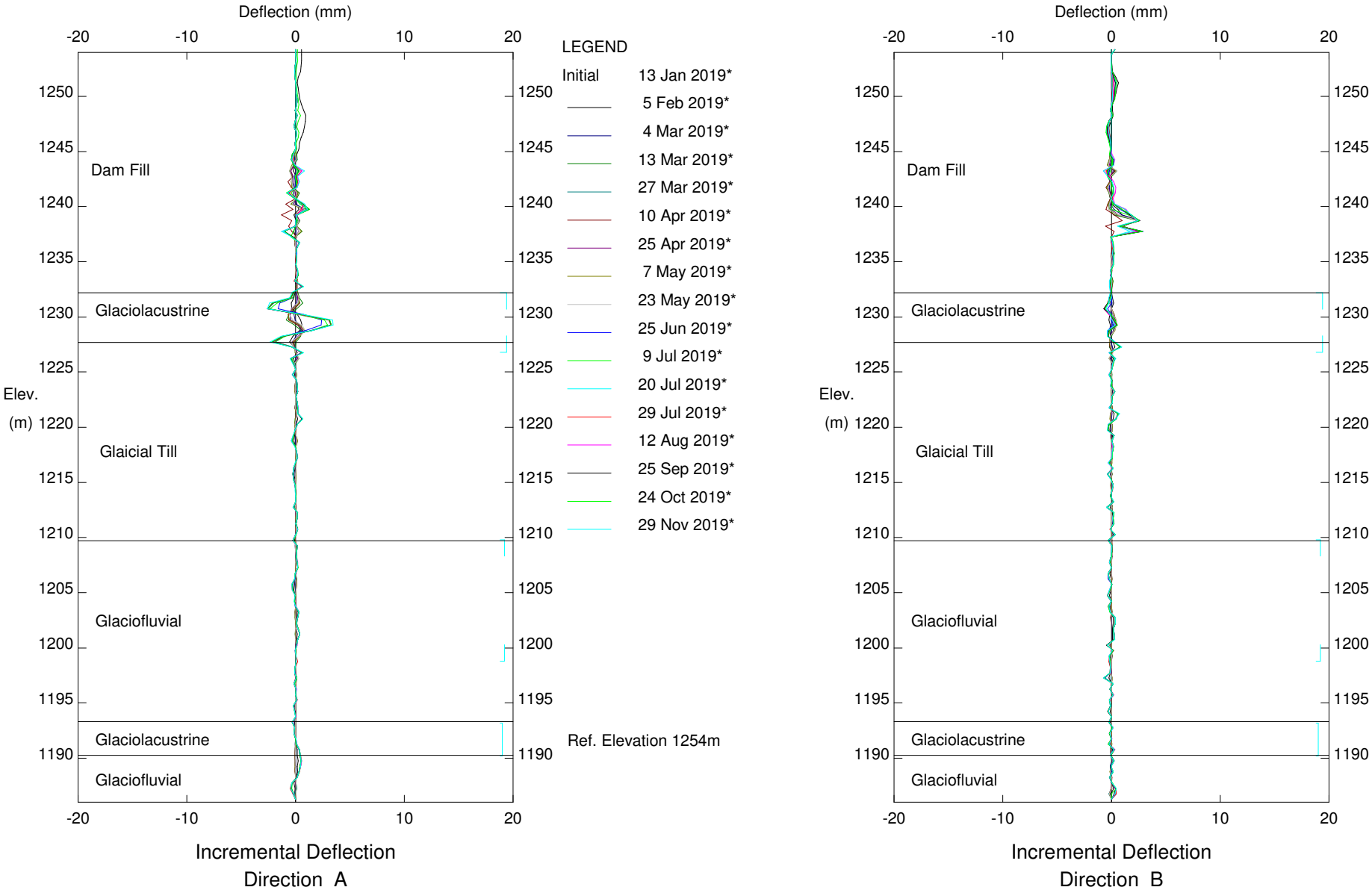
Upper Depth	3.0 m
Lower Depth	30.0 m



NORTH ABUTMENT

I16-01

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer 16-01

Sets marked * include zero shift and/or rotation corrections.

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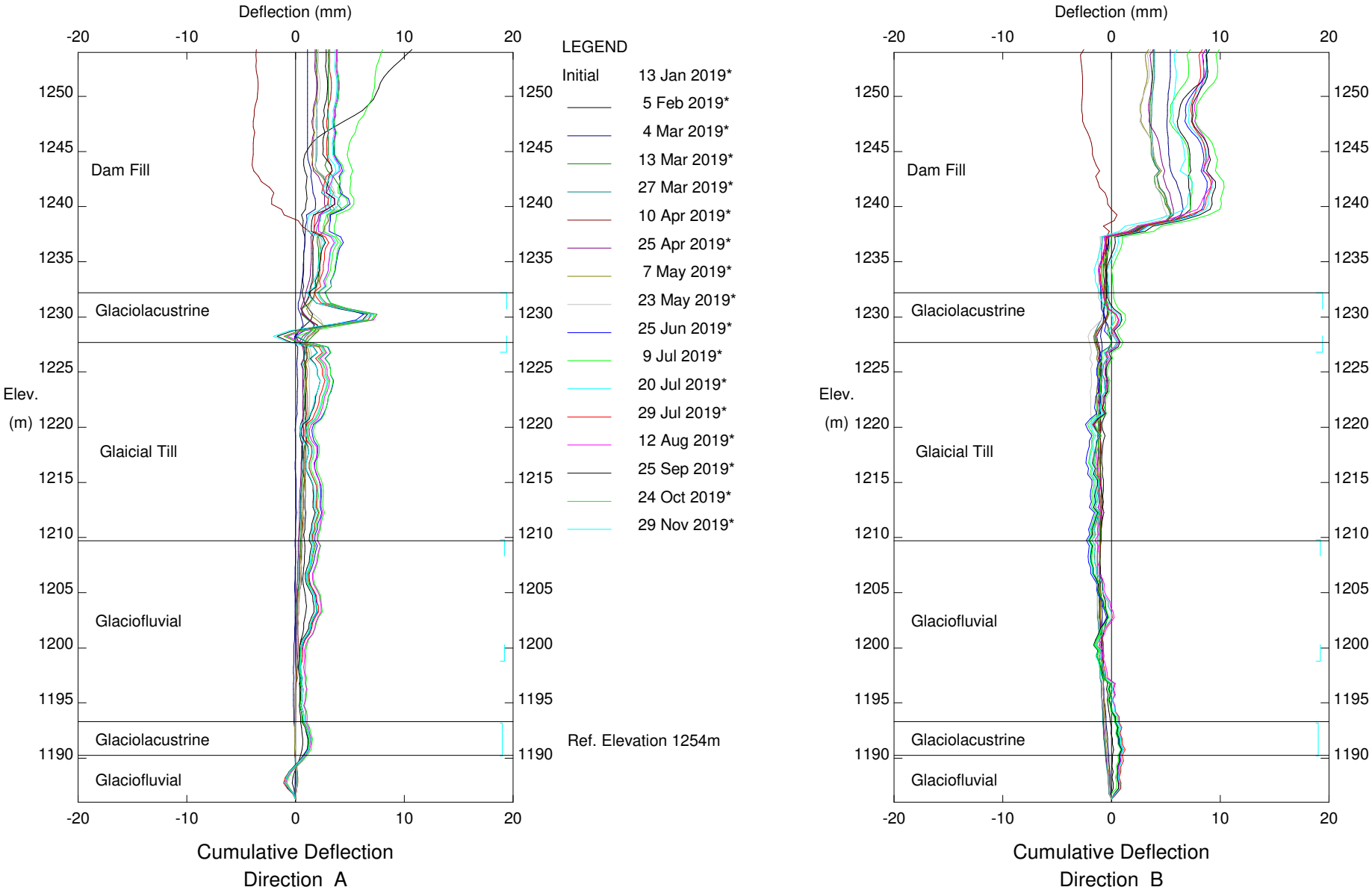
Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer 16-01

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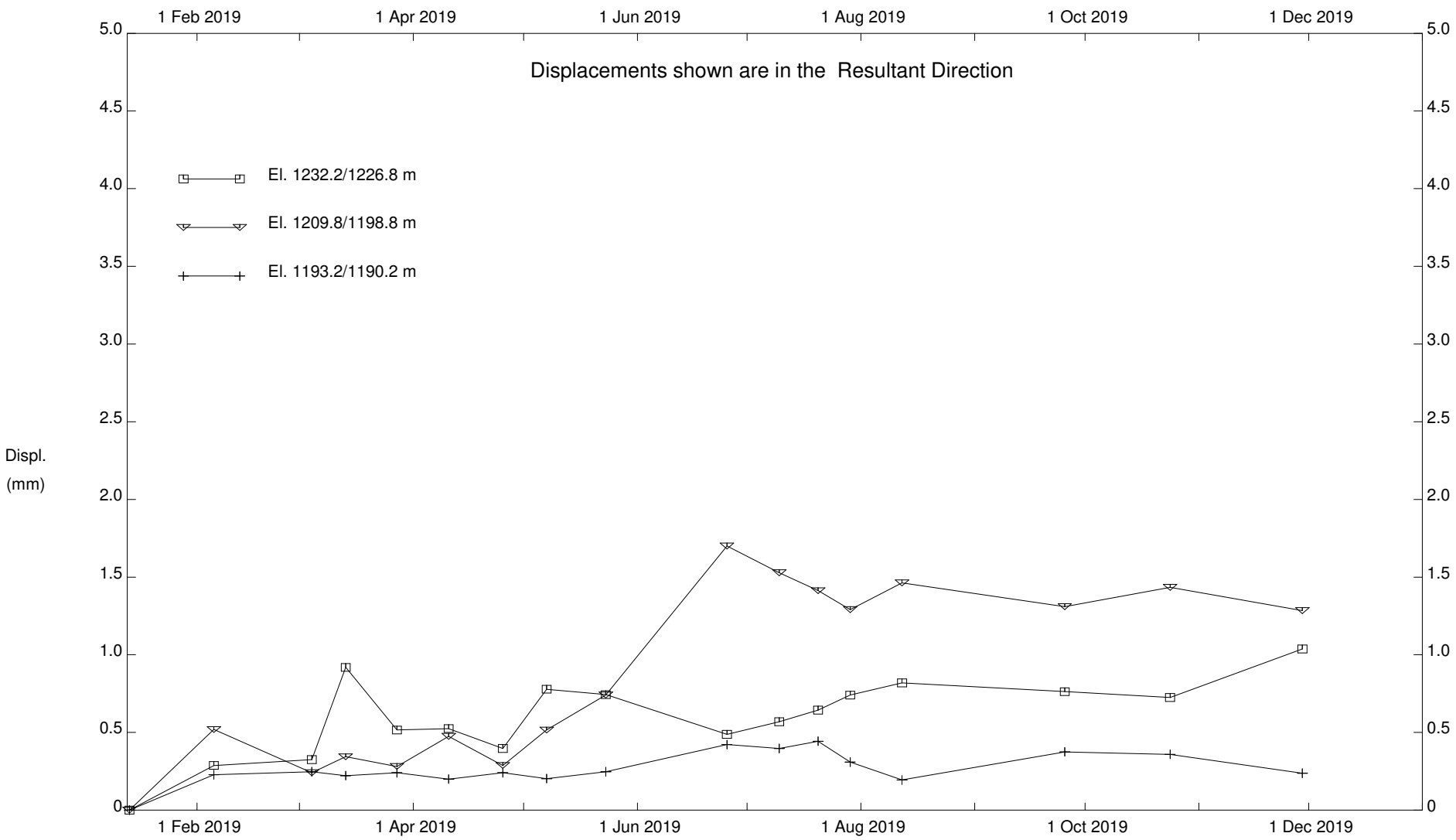
Highland Valley Copper - Logan Lake, BC

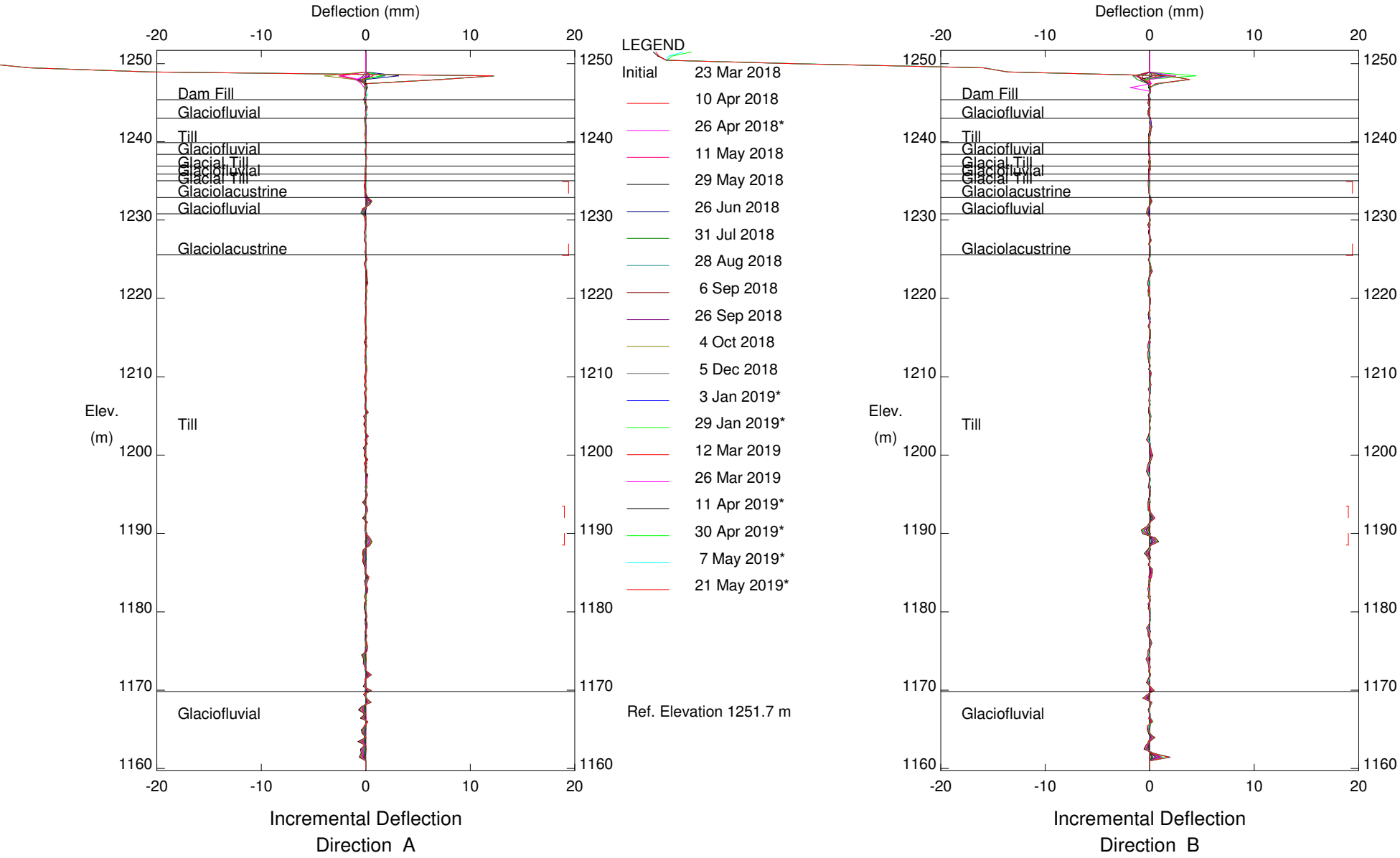


LL Dam, Inclinometer 16-01

NORTH ABUTMENT

I16-04

Highland Valley Copper - Logan Lake, BC

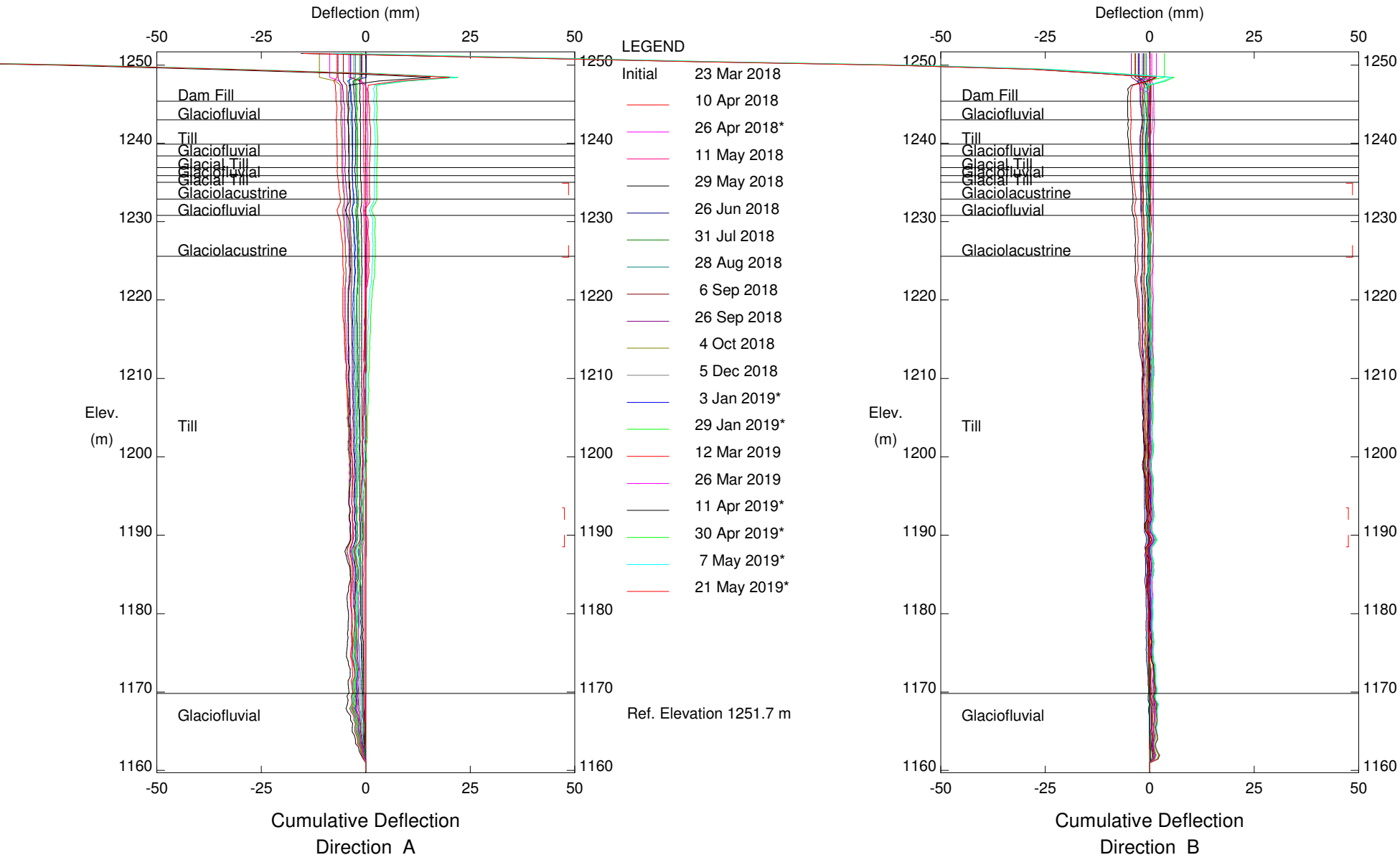


LL Dam - Dam fill excluded, Inclinometer I16-4

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC



LL Dam - Dam fill excluded, Inclinometer I16-4

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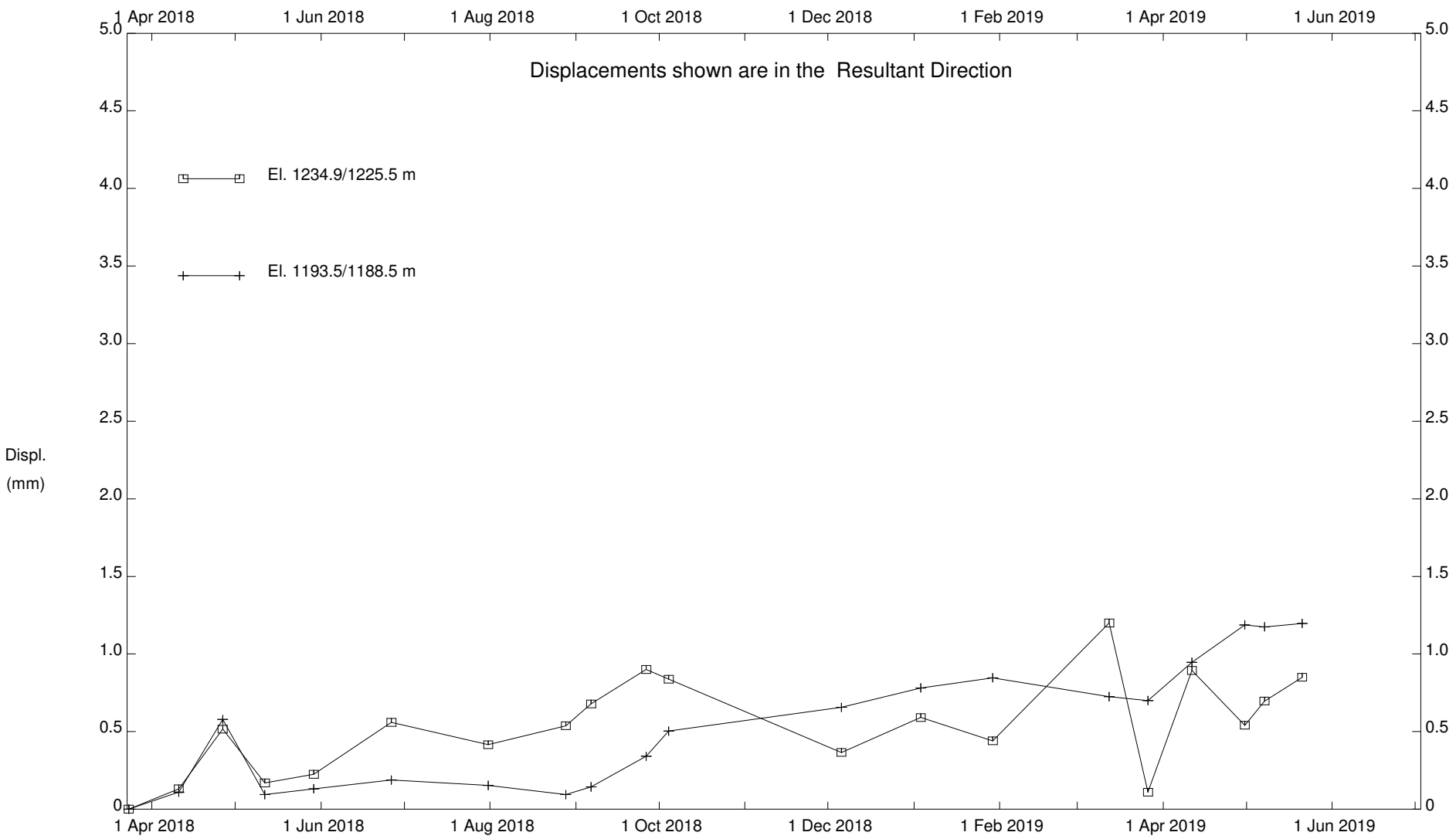
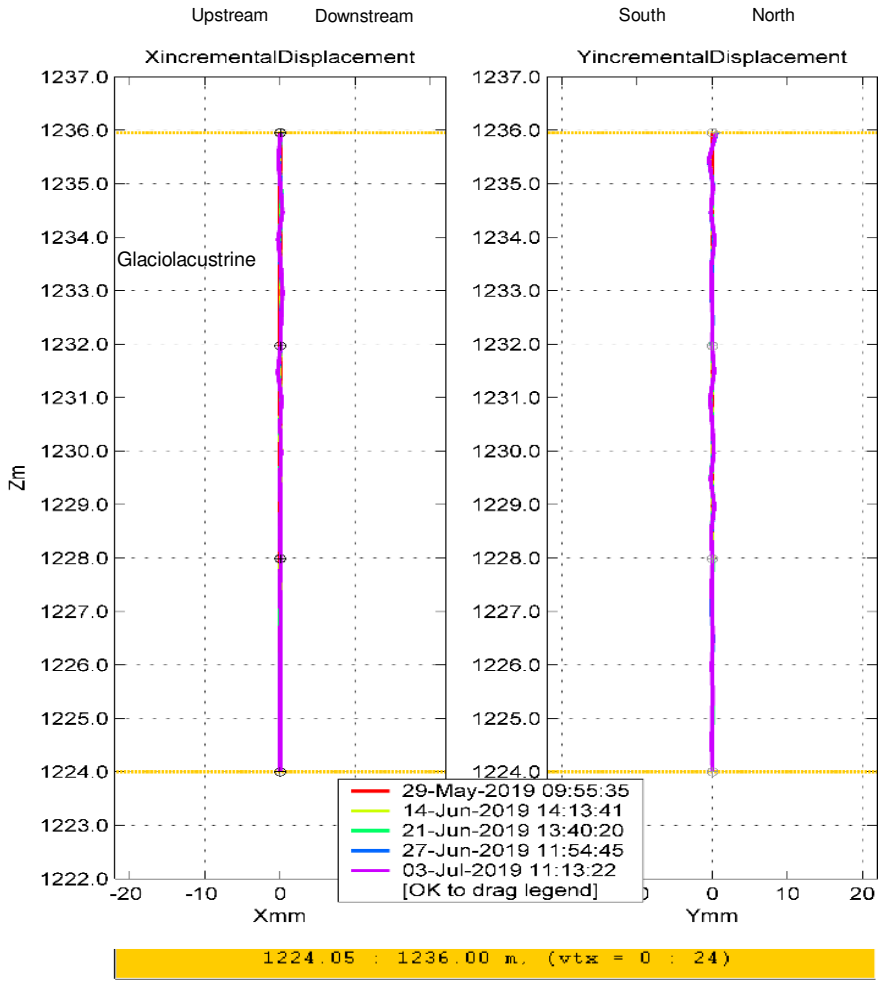
Highland Valley Copper - Logan Lake, BC



LL Dam - Dam fill excluded, Inclinometer I16-4

Inclinometer I16-04

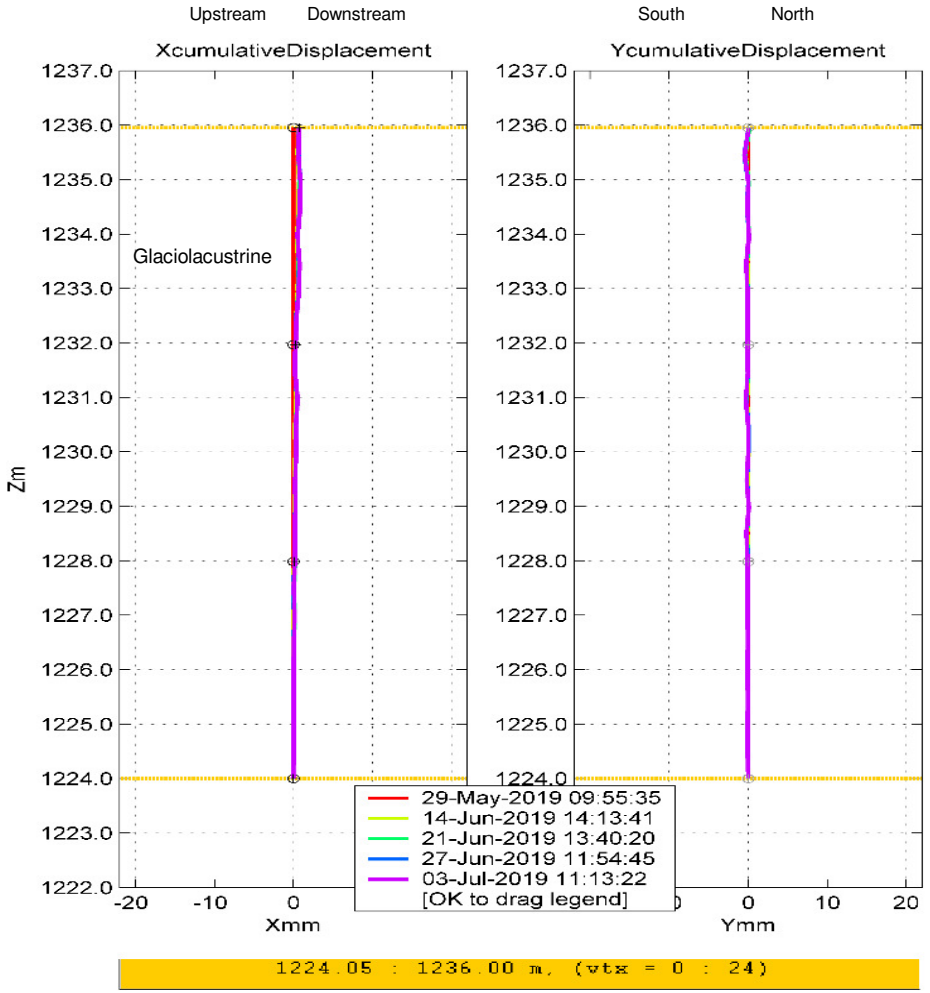
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
16-04	Glaciolacustrine	1235	1223.6	1	12

Inclinometer I16-04

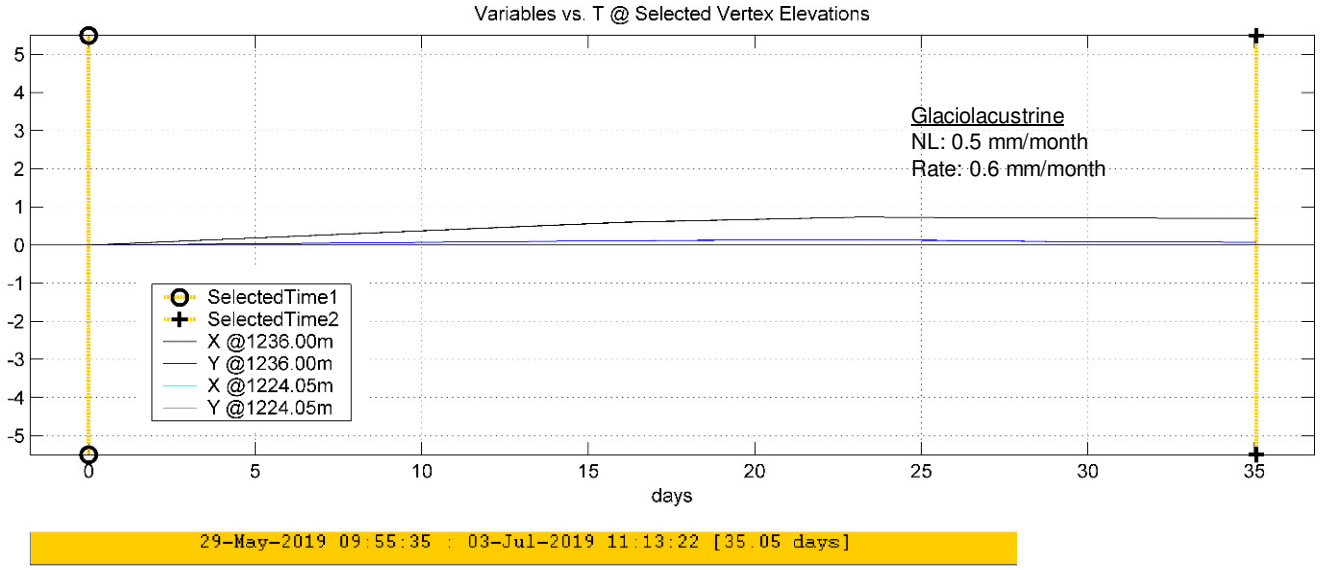
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
16-04	Glaciolacustrine	1235	1223.6	1	12

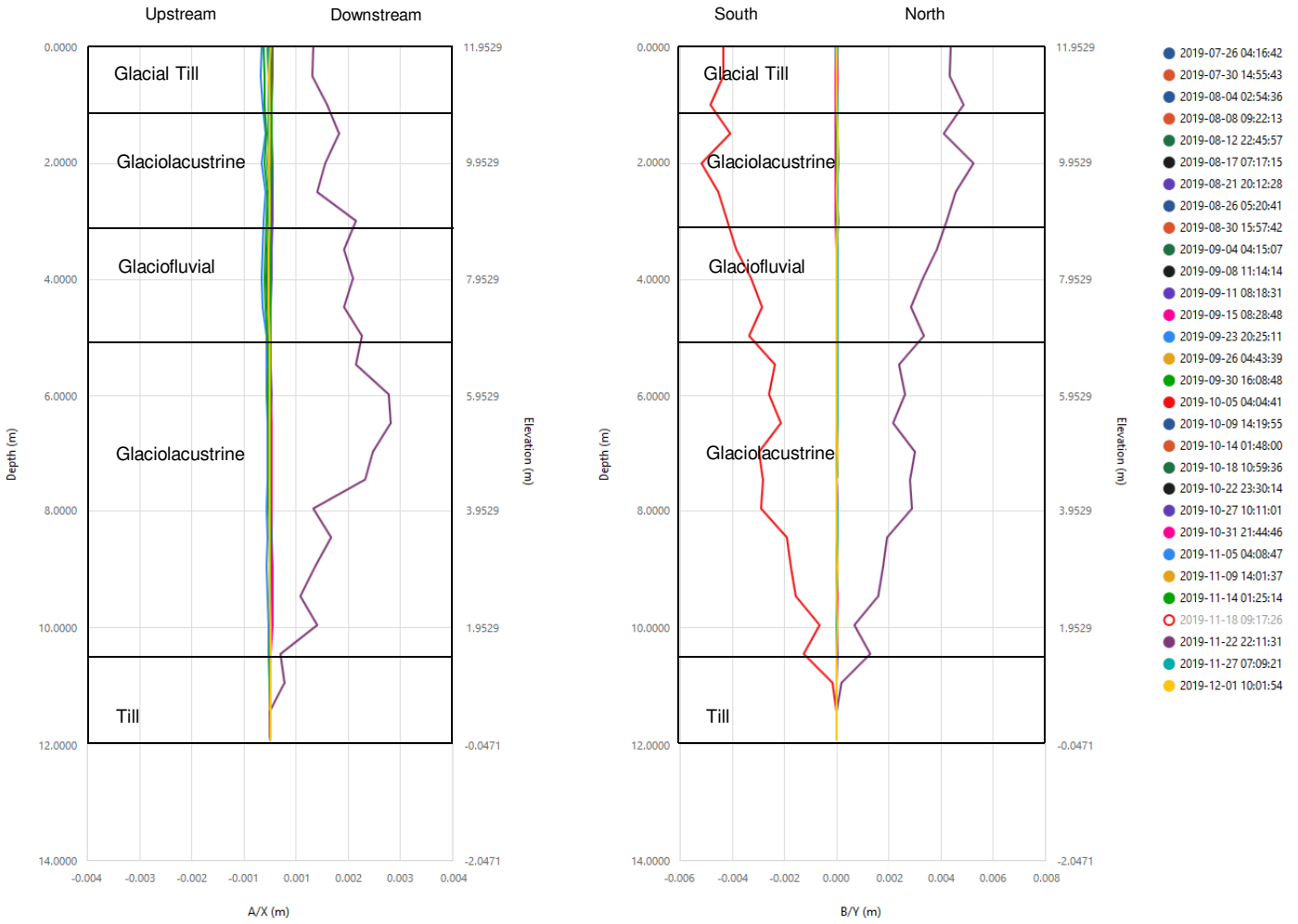
Inclinometer I16-04

Displacement Plot



SAAV I16-04

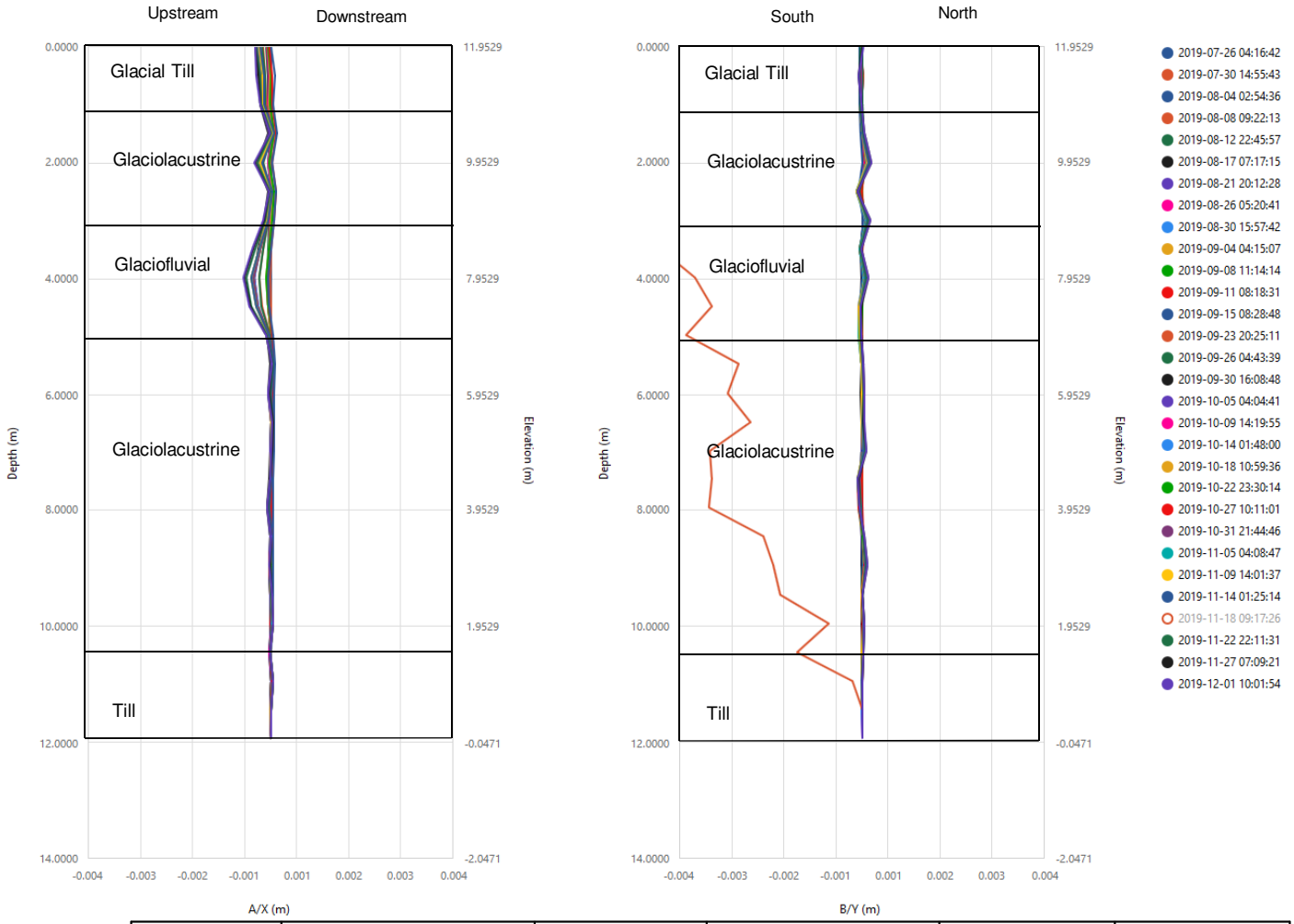
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
16-04	Glaciolacustrine	1235	1223.6	1	12

SAAV I16-04

Cumulative Plot



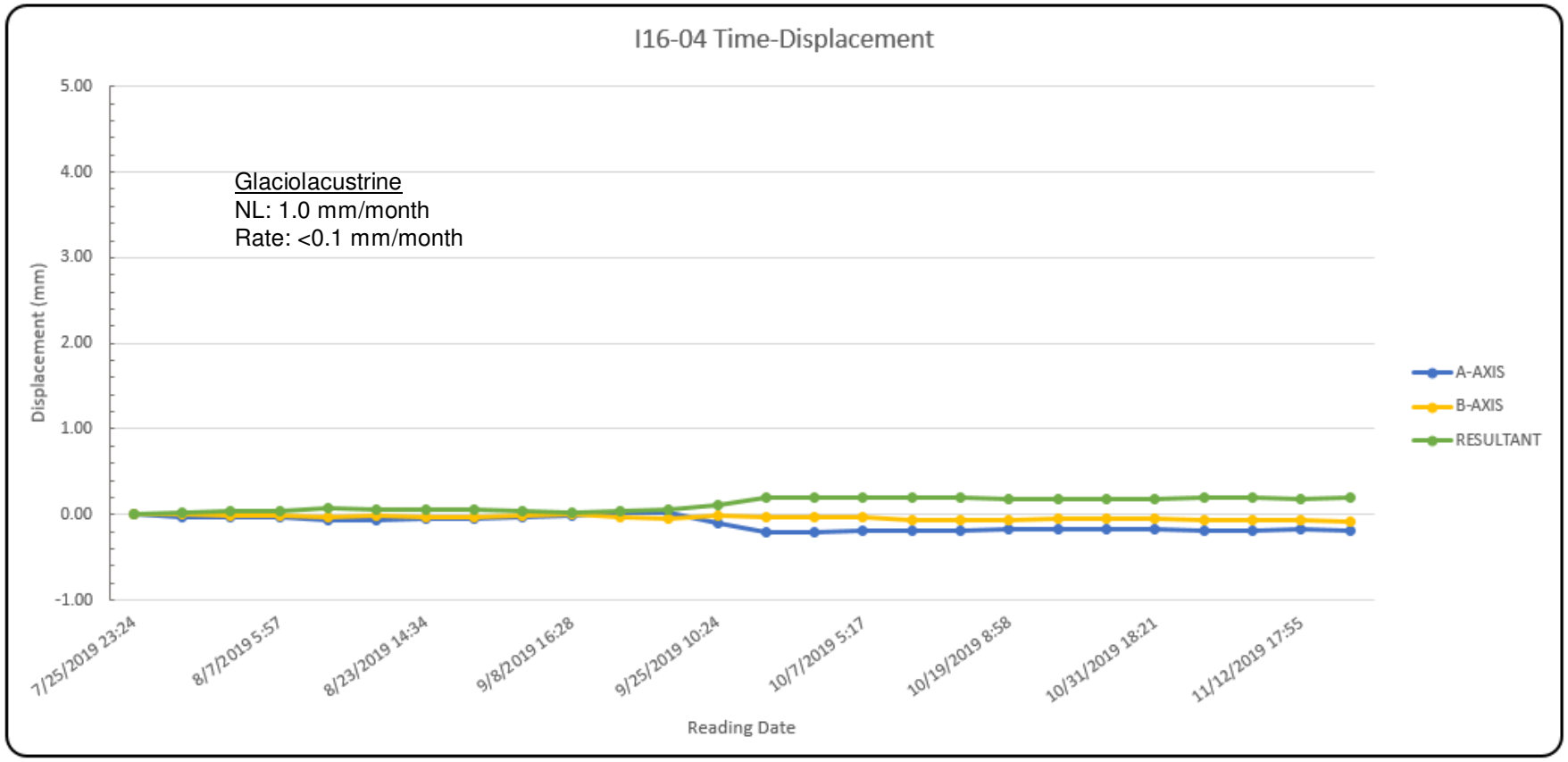
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
16-04	Glaciolacustrine	1235	1223.6	1	12

SAAV I16-04

Displacement Plot - Glaciolacustrine

Unit	Upper Depth	Lower Depth
Glaciolacustrine	1	10

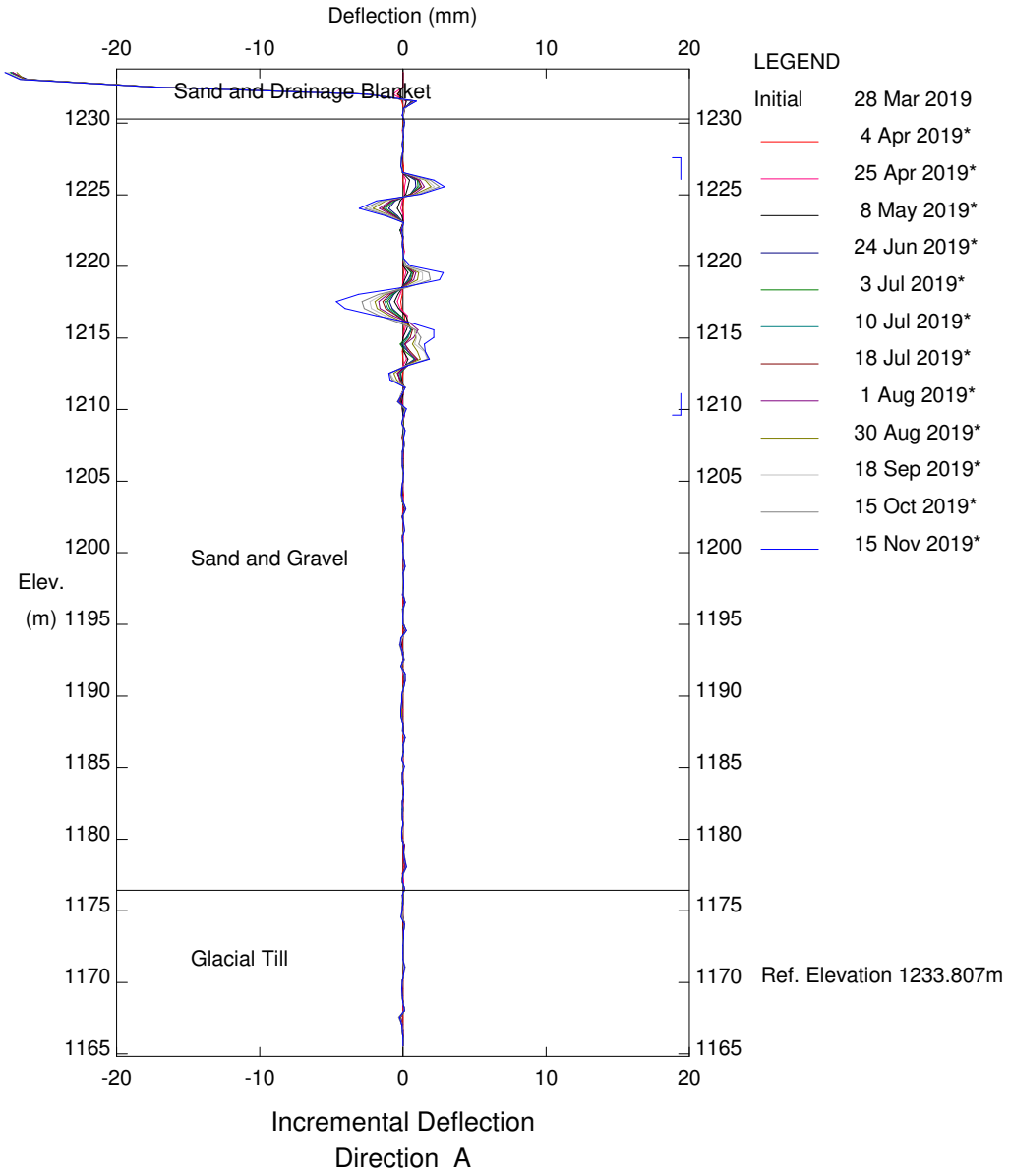
Upper Depth	1.0 m
Lower Depth	10.0 m

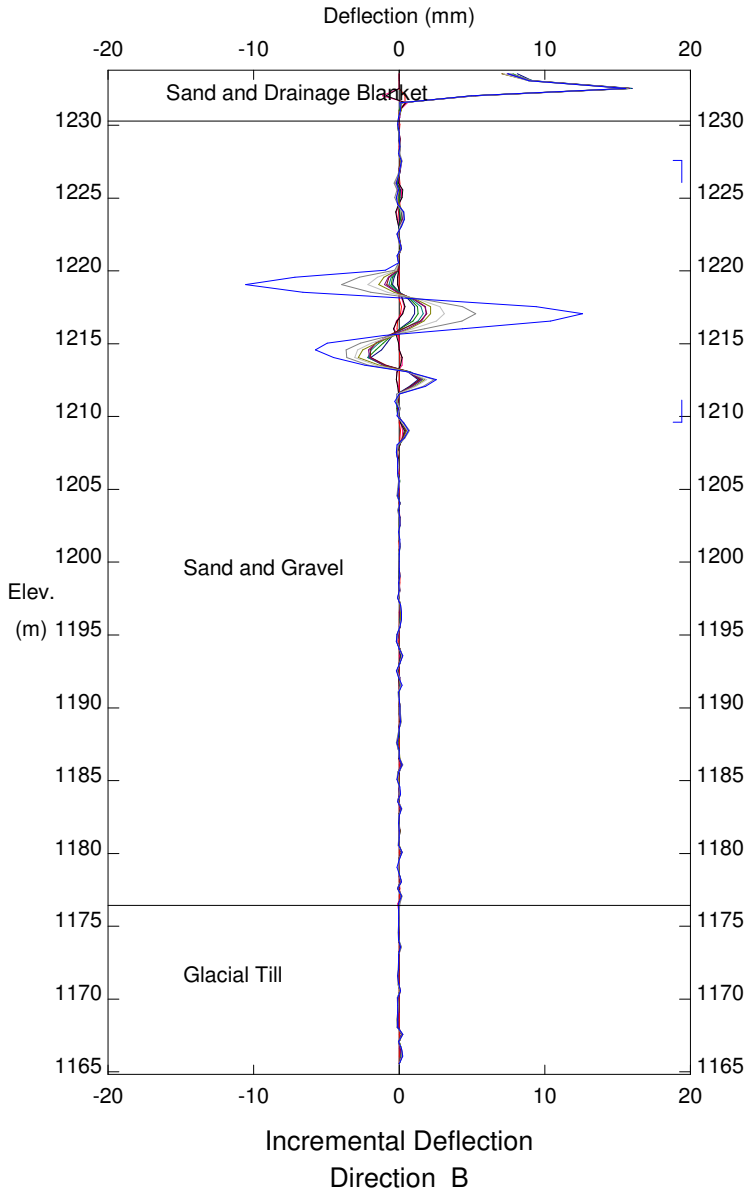


NORTH ABUTMENT

I19-04

Highland Valley Copper - Logan Lake, BC



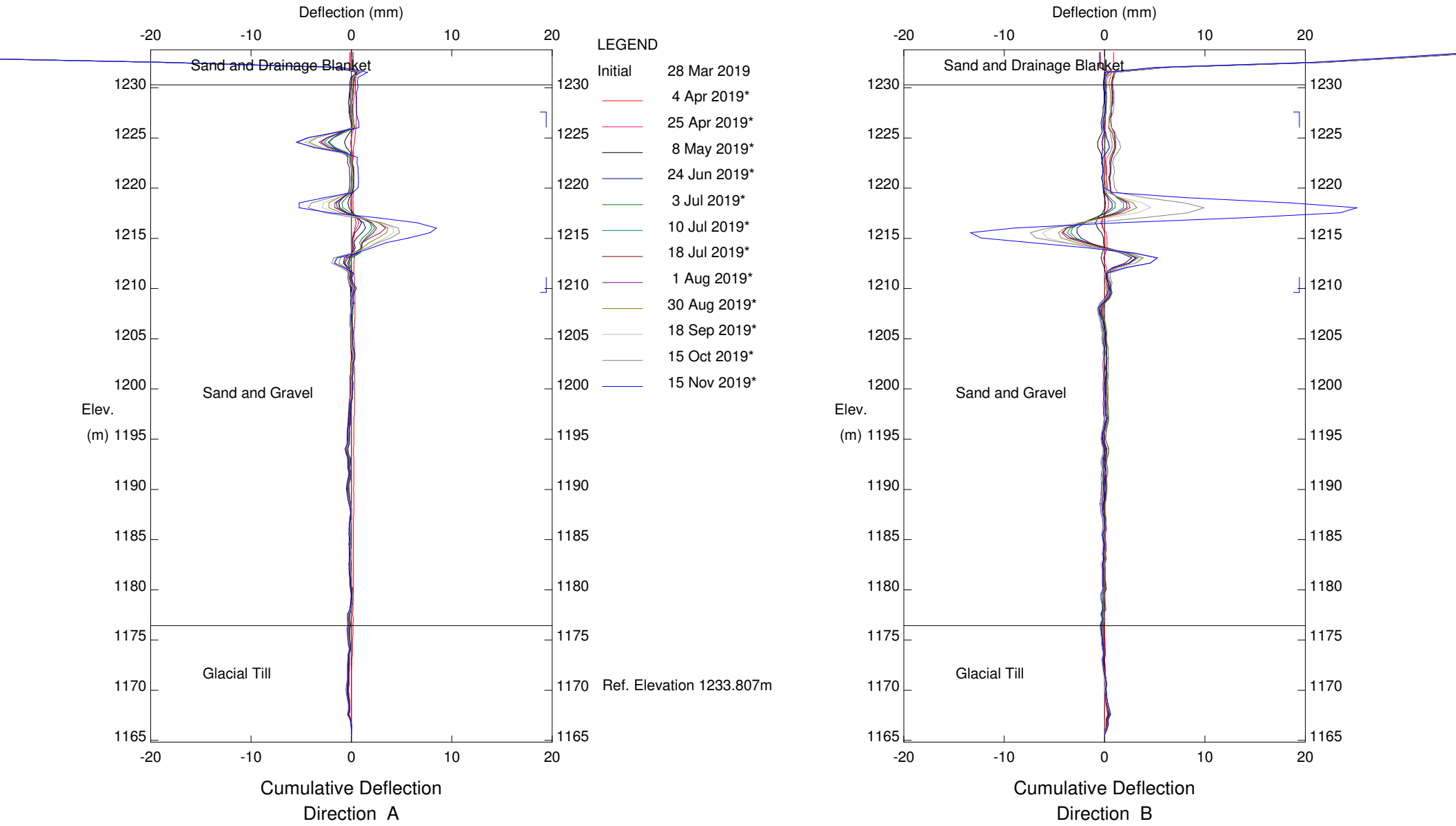


Dam Fill Excluded, Inclinometer 19-4

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC

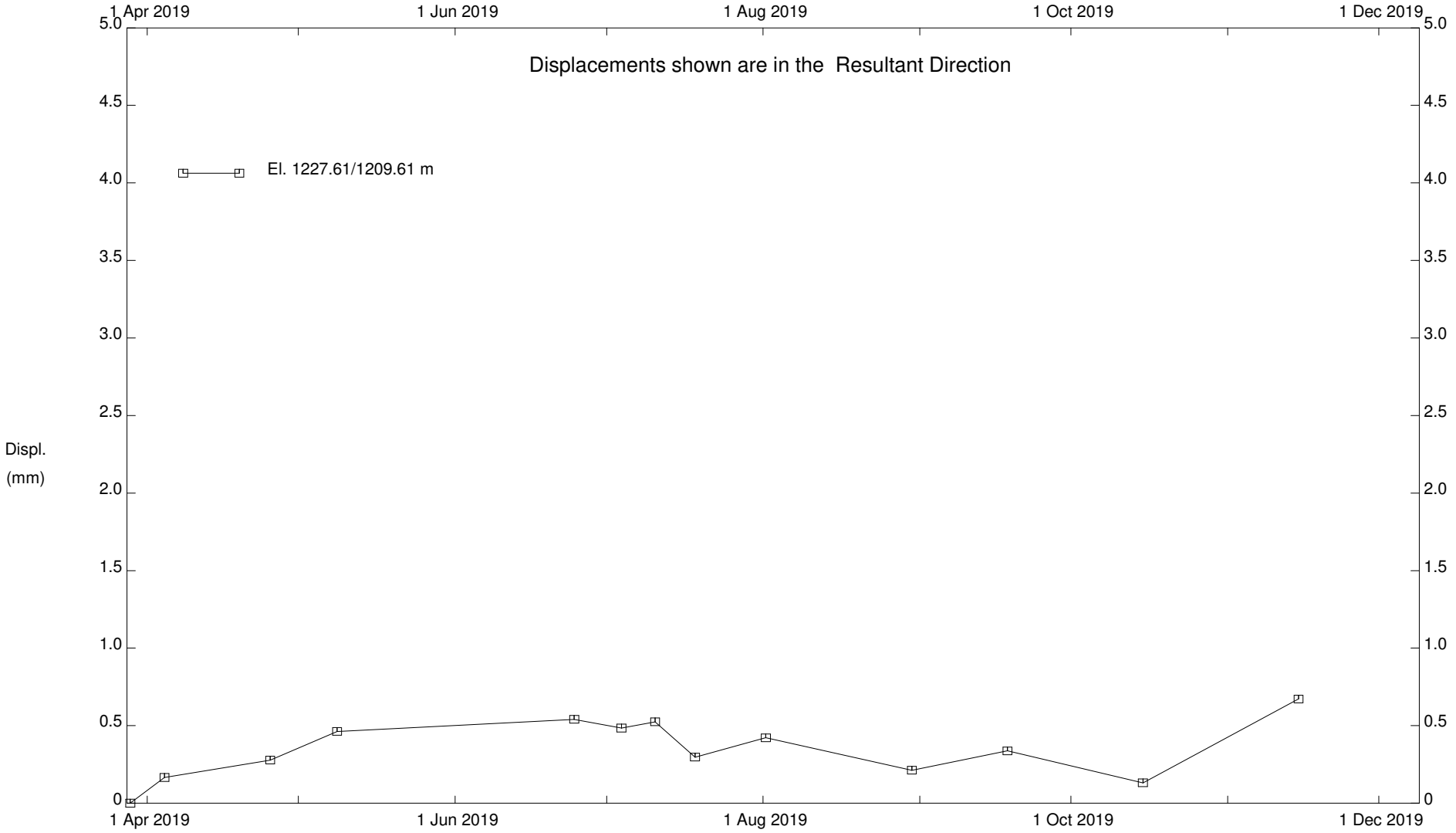


Dam Fill Excluded, Inclinometer 19-4

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC

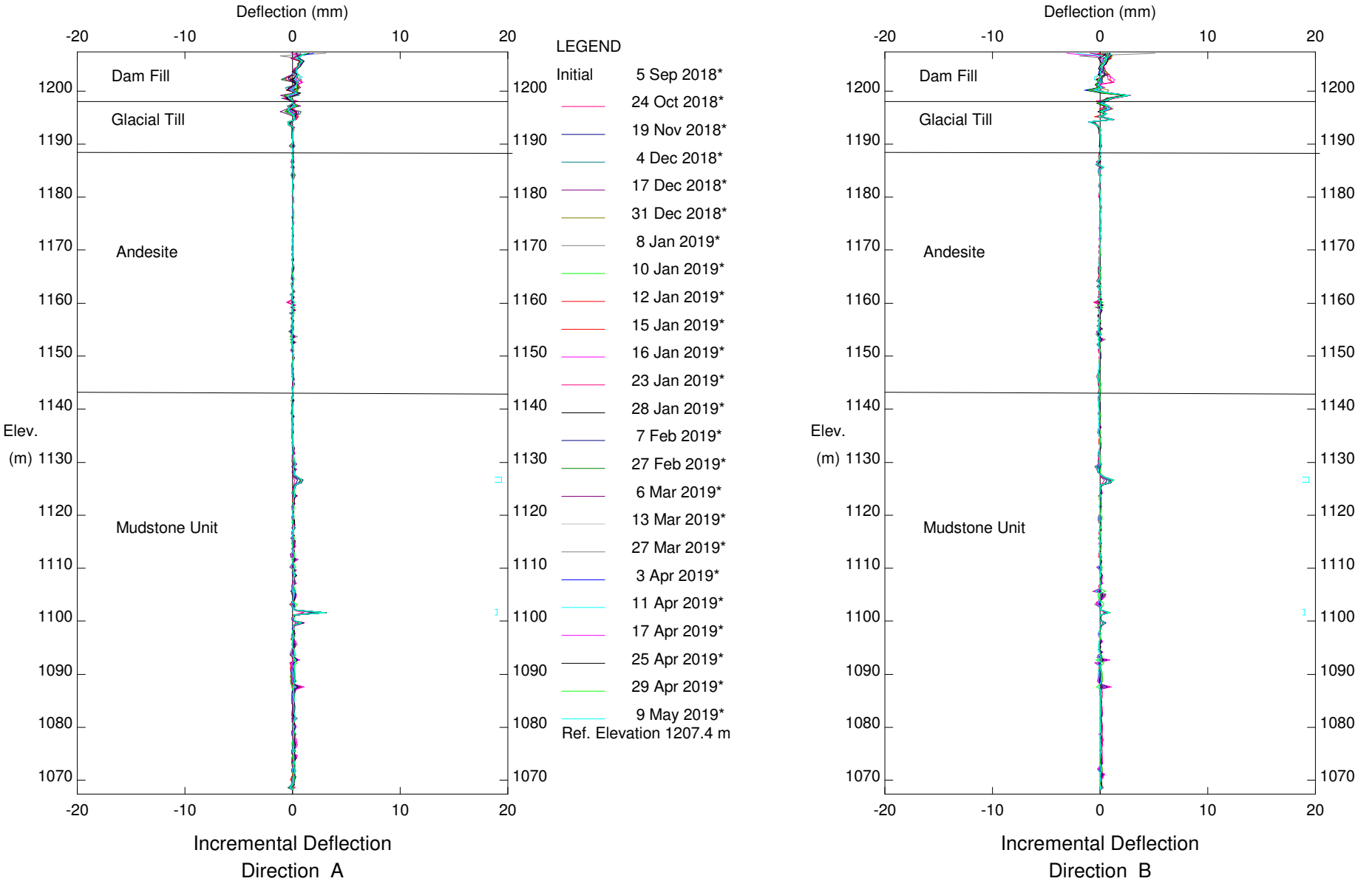


Dam Fill Excluded, Inclinometer 19-4

NORTH DAM

I98-02

Highland Valley Copper - Logan Lake, BC

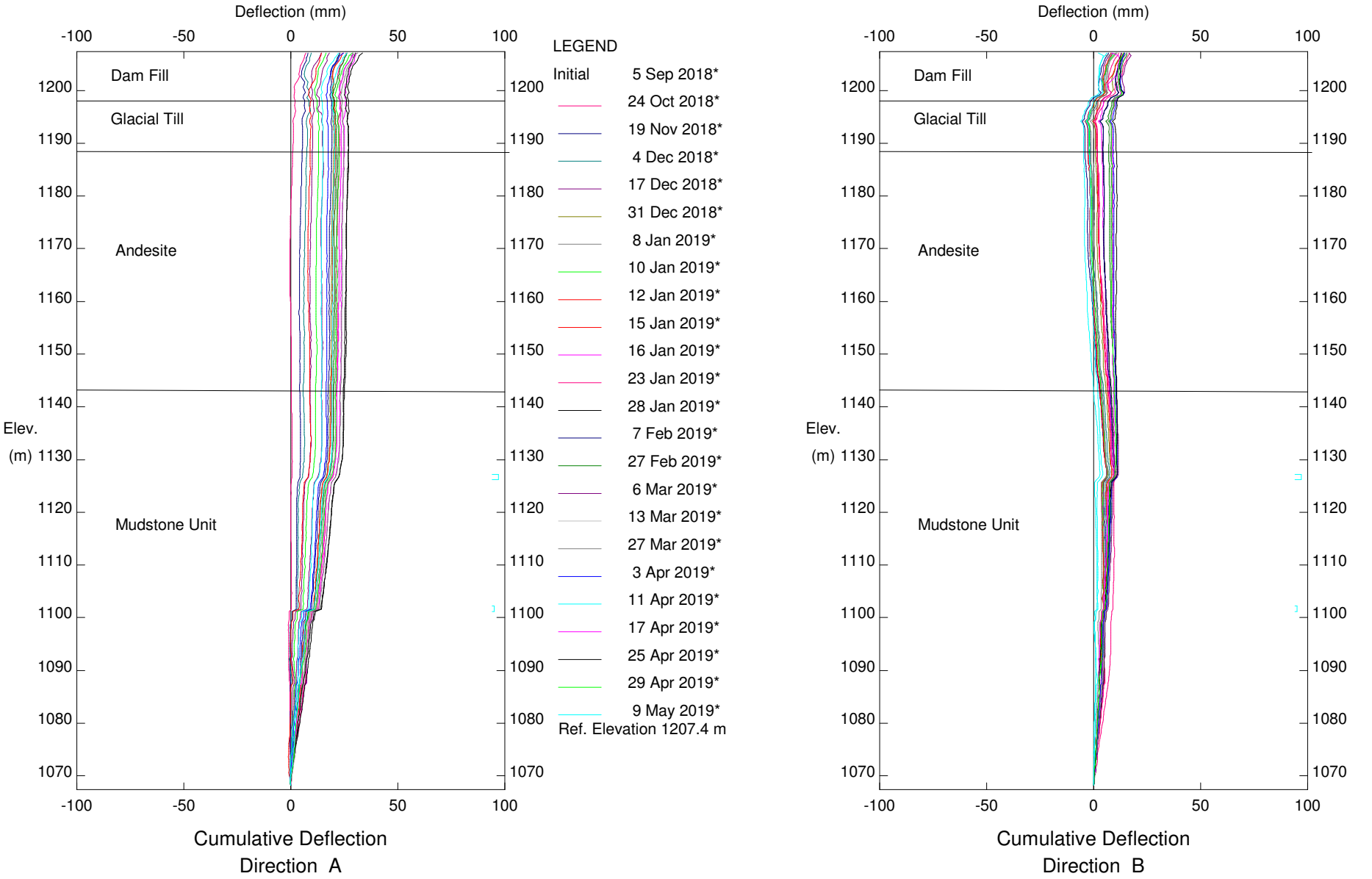


LL Dam - Dam fill excluded, Inclinometer I98-2

Sets marked * include zero shift and/or rotation corrections.

Z:\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\I98-02.g

Highland Valley Copper - Logan Lake, BC



LL Dam - Dam fill excluded, Inclinometer I98-2

Sets marked * include zero shift and/or rotation corrections.

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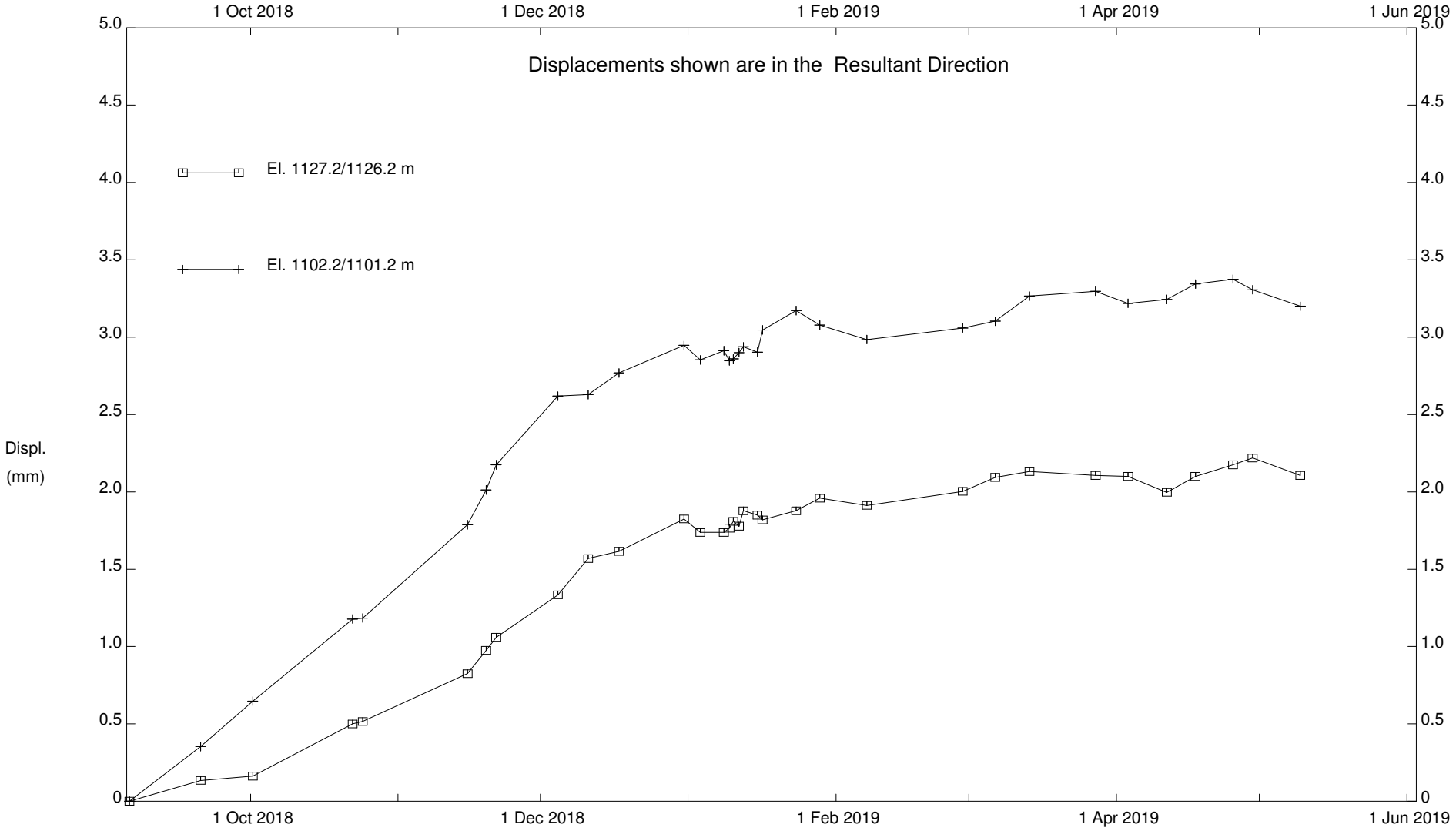
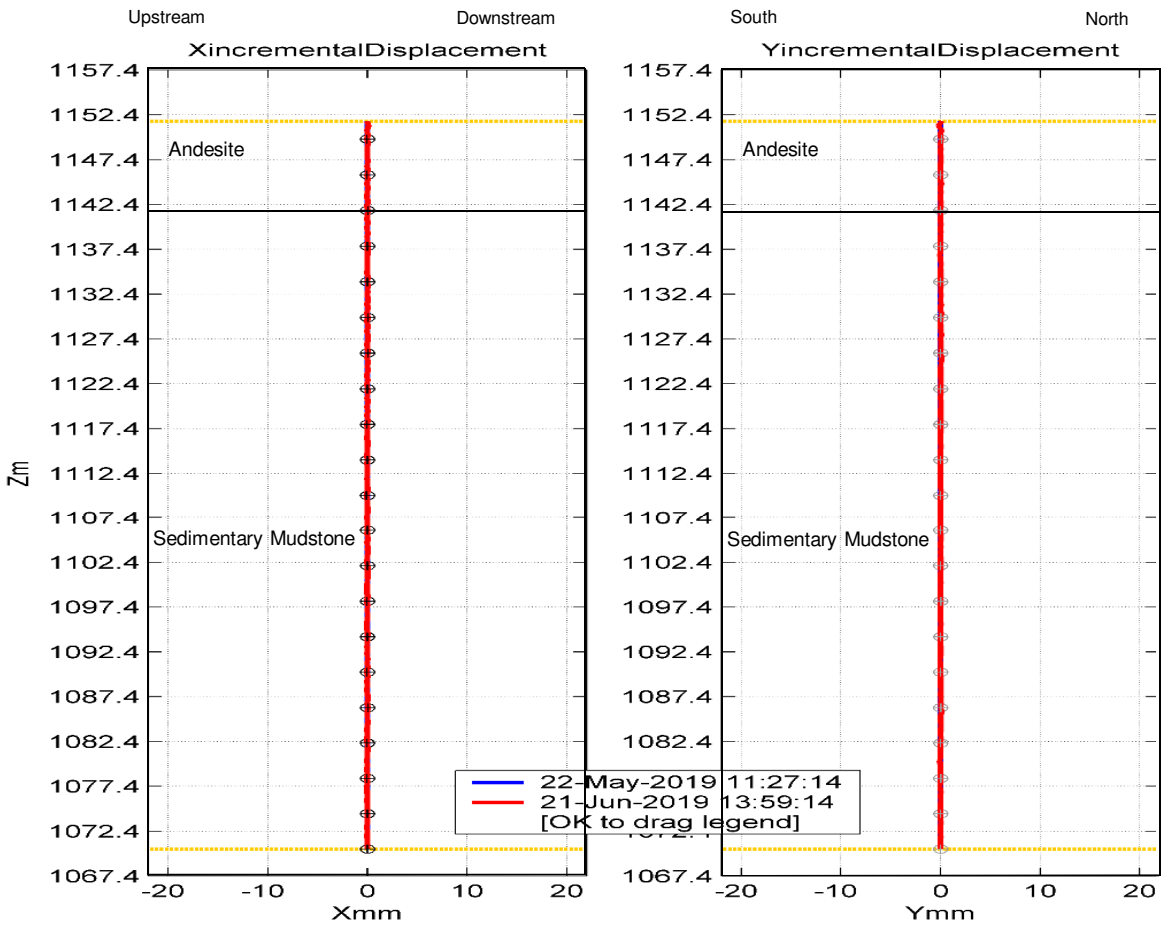
Highland Valley Copper - Logan Lake, BC



LL Dam - Dam fill excluded, Inclinometer I98-2

Inclinometer I98-02

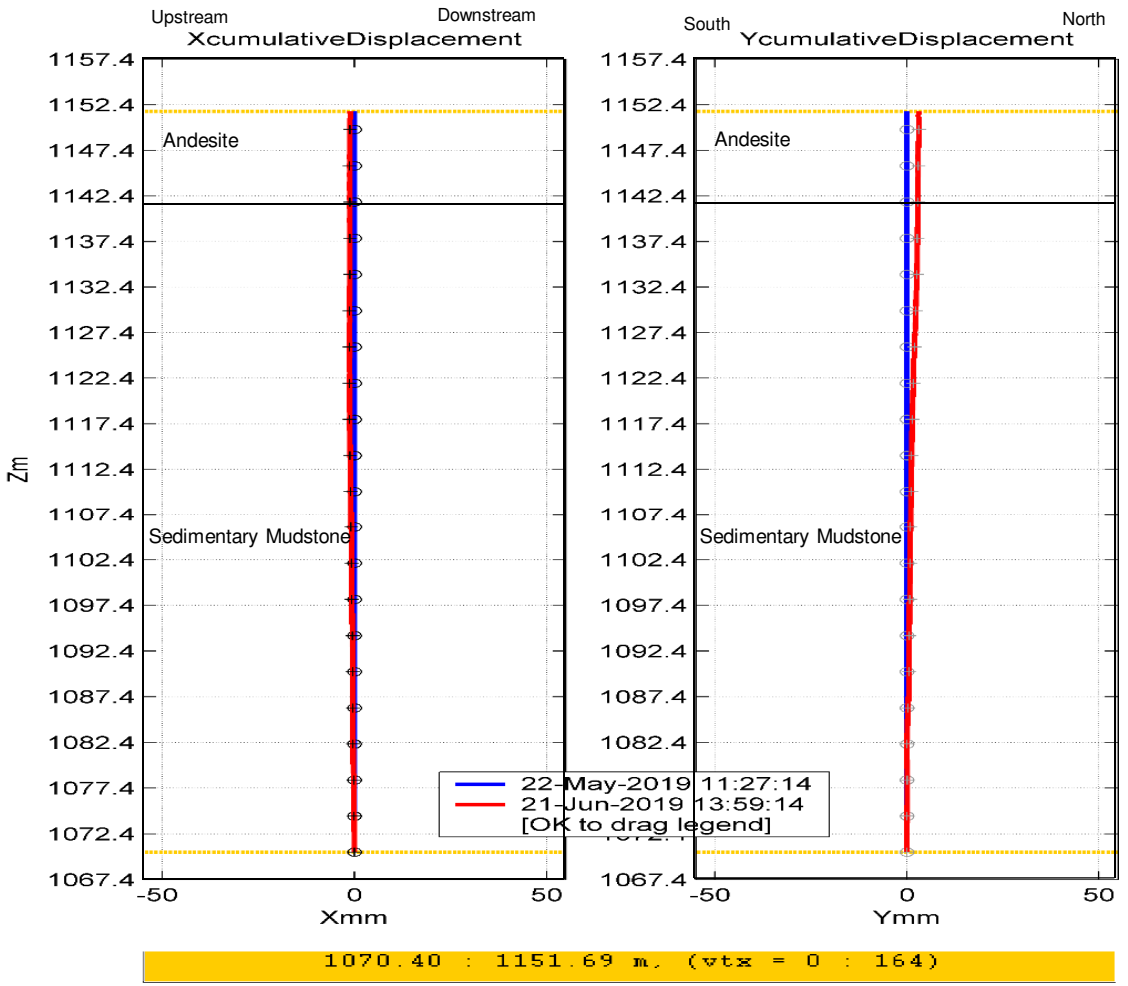
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
98-02	Sedimentary	1127.2	1125.2	25	27
	Sedimentary	1102.5	1100.5	50	52

Inclinometer I98-02

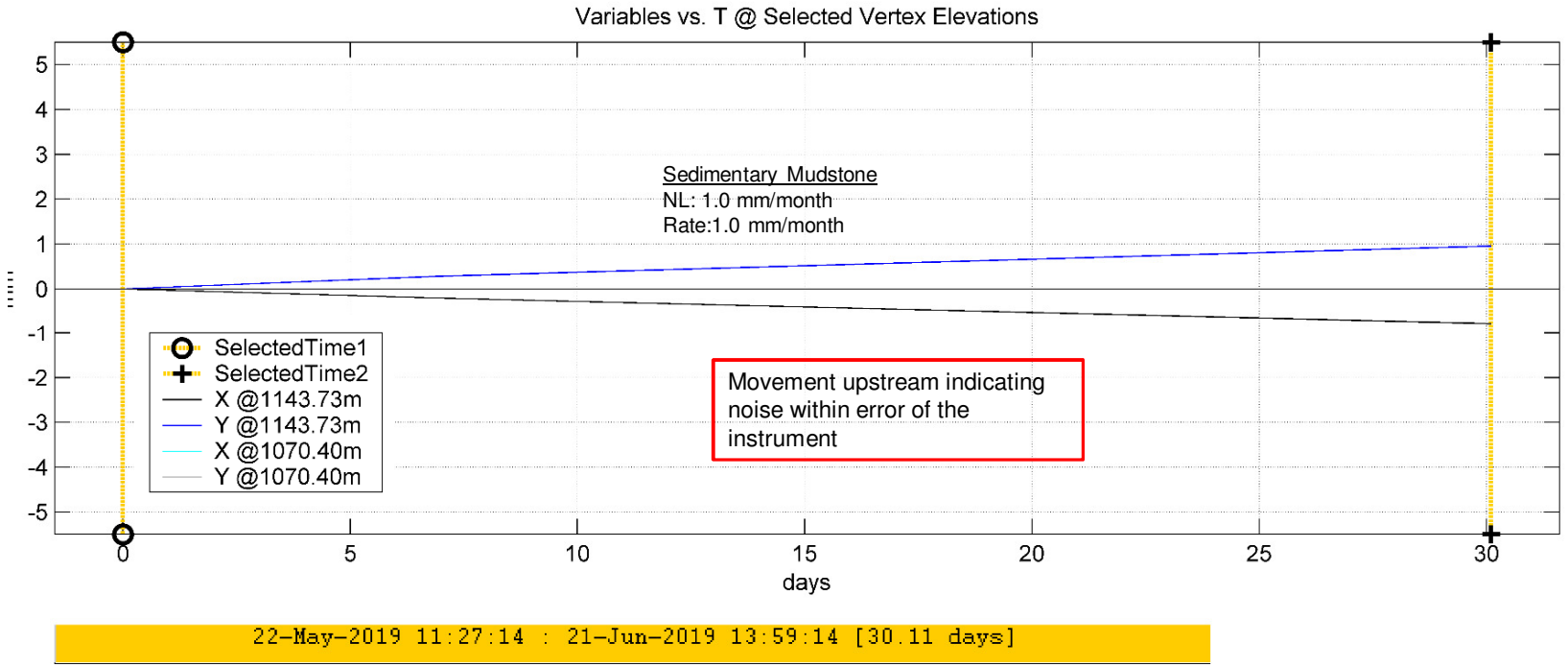
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
98-02	Sedimentary	1127.2	1125.2	25	27
	Sedimentary	1102.5	1100.5	50	52

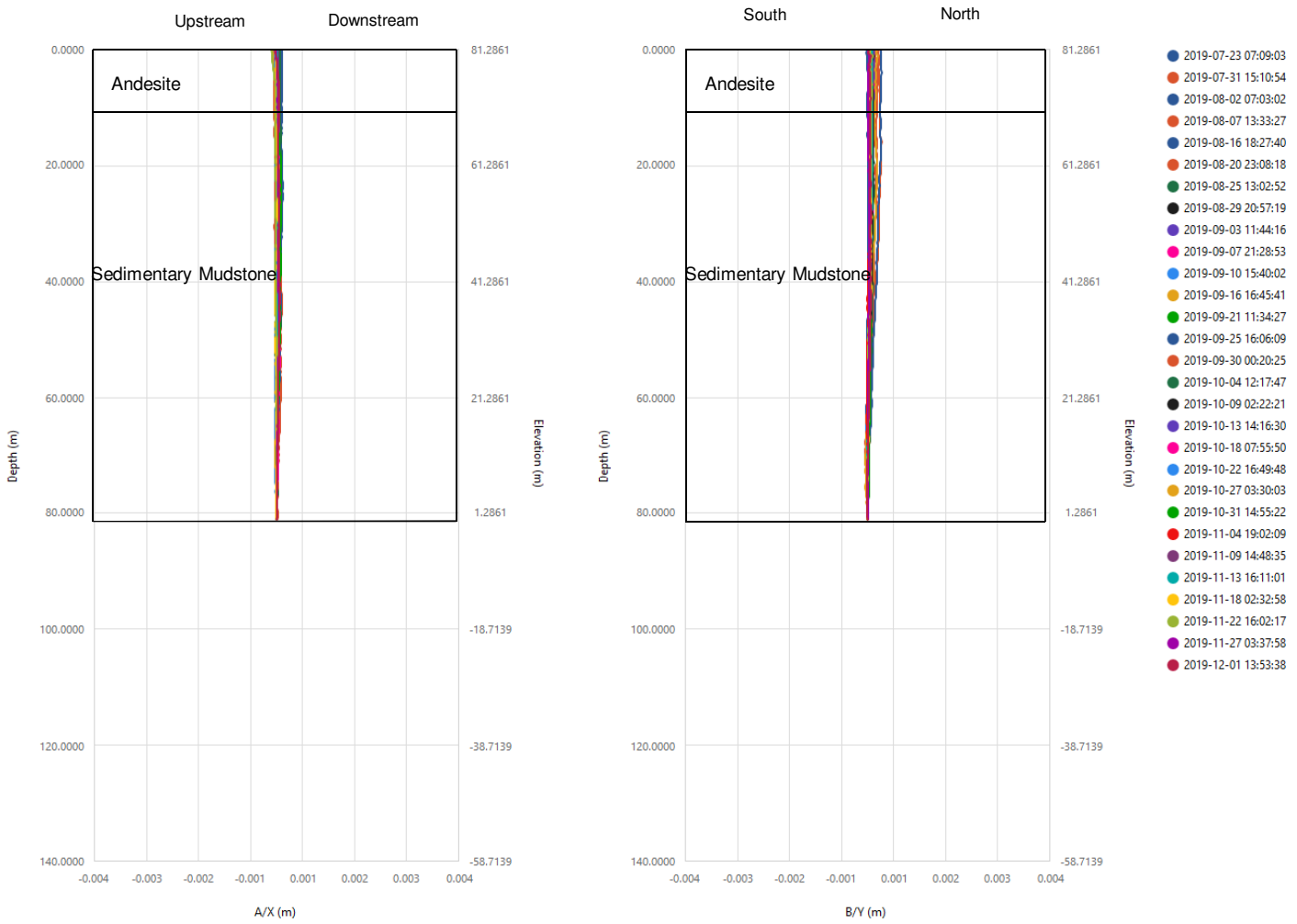
Inclinometer I98-02

Displacement Plot – Sedimentary



SAAV I98-02

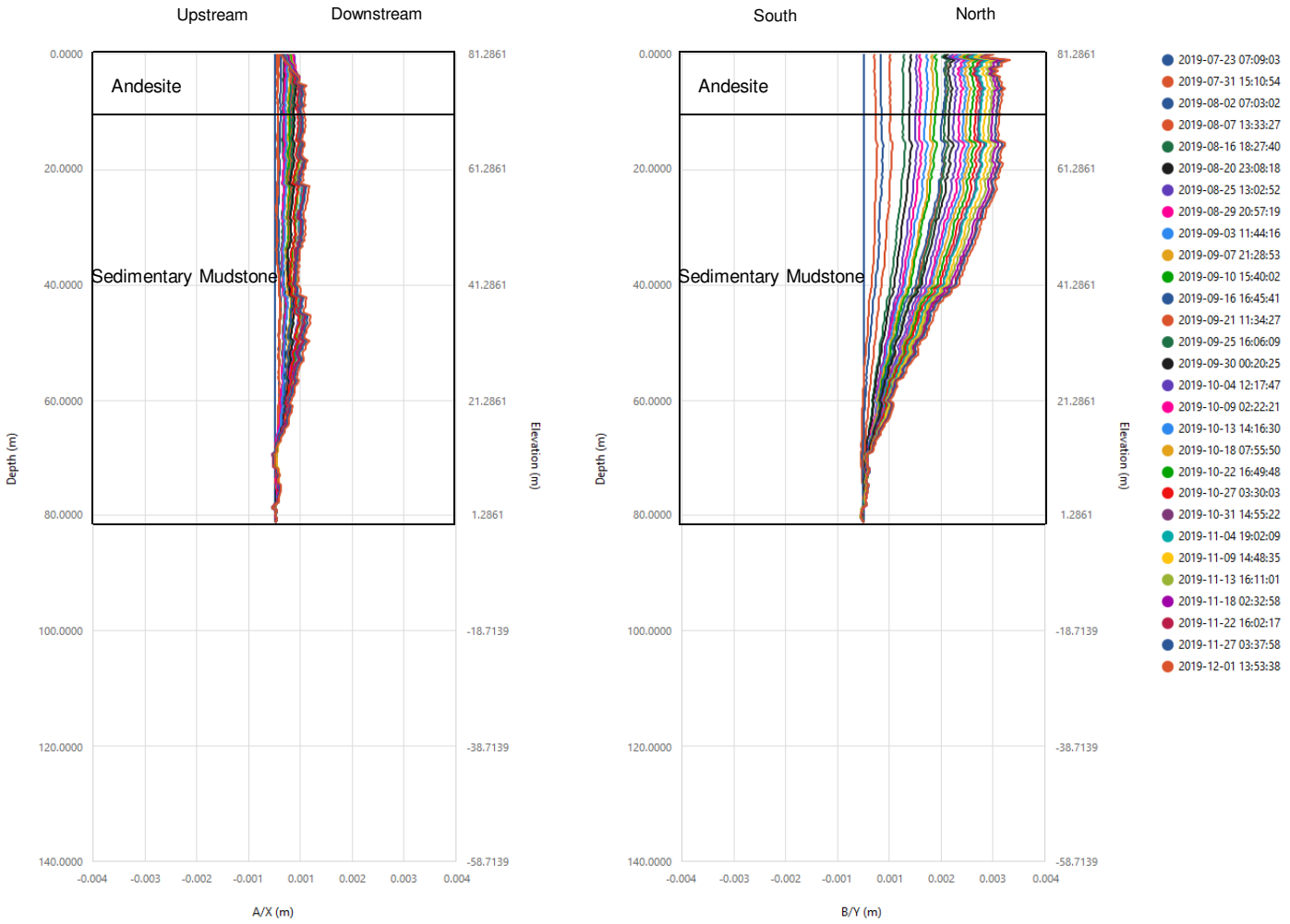
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
98-02	Sedimentary	1127.2	1125.2	25	27
	Sedimentary	1102.5	1100.5	50	52

SAAV I98-02

Cumulative Plot



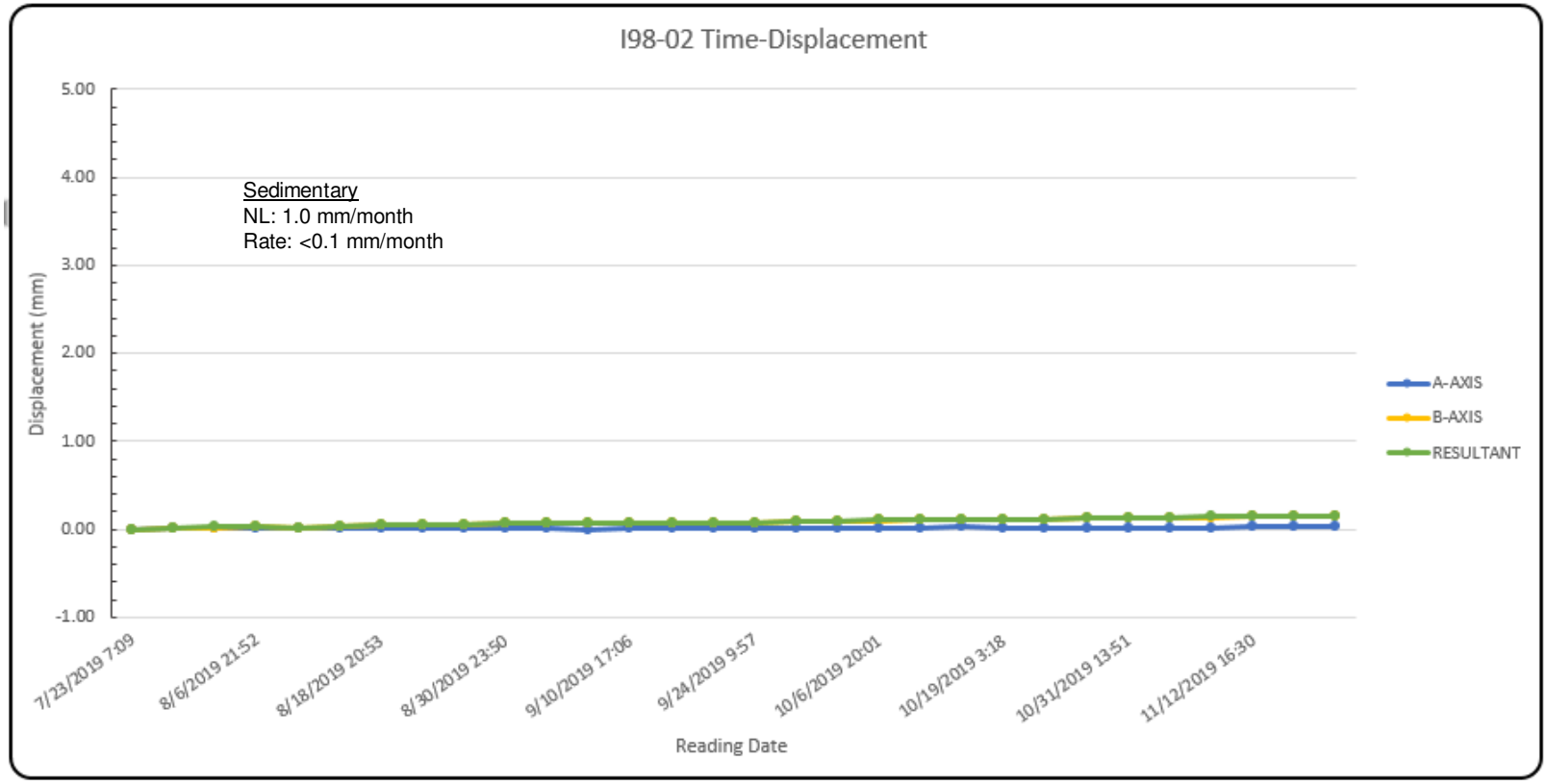
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
98-02	Sedimentary	1127.2	1125.2	25	27
	Sedimentary	1102.5	1100.5	50	52

SAAV I98-02

Displacement Plot - Sedimentary

Unit	Upper Depth	Lower Depth
Sedimentary	25	27
Sedimentary	50	52

Upper Depth	25.0 m
Lower Depth	27.0 m

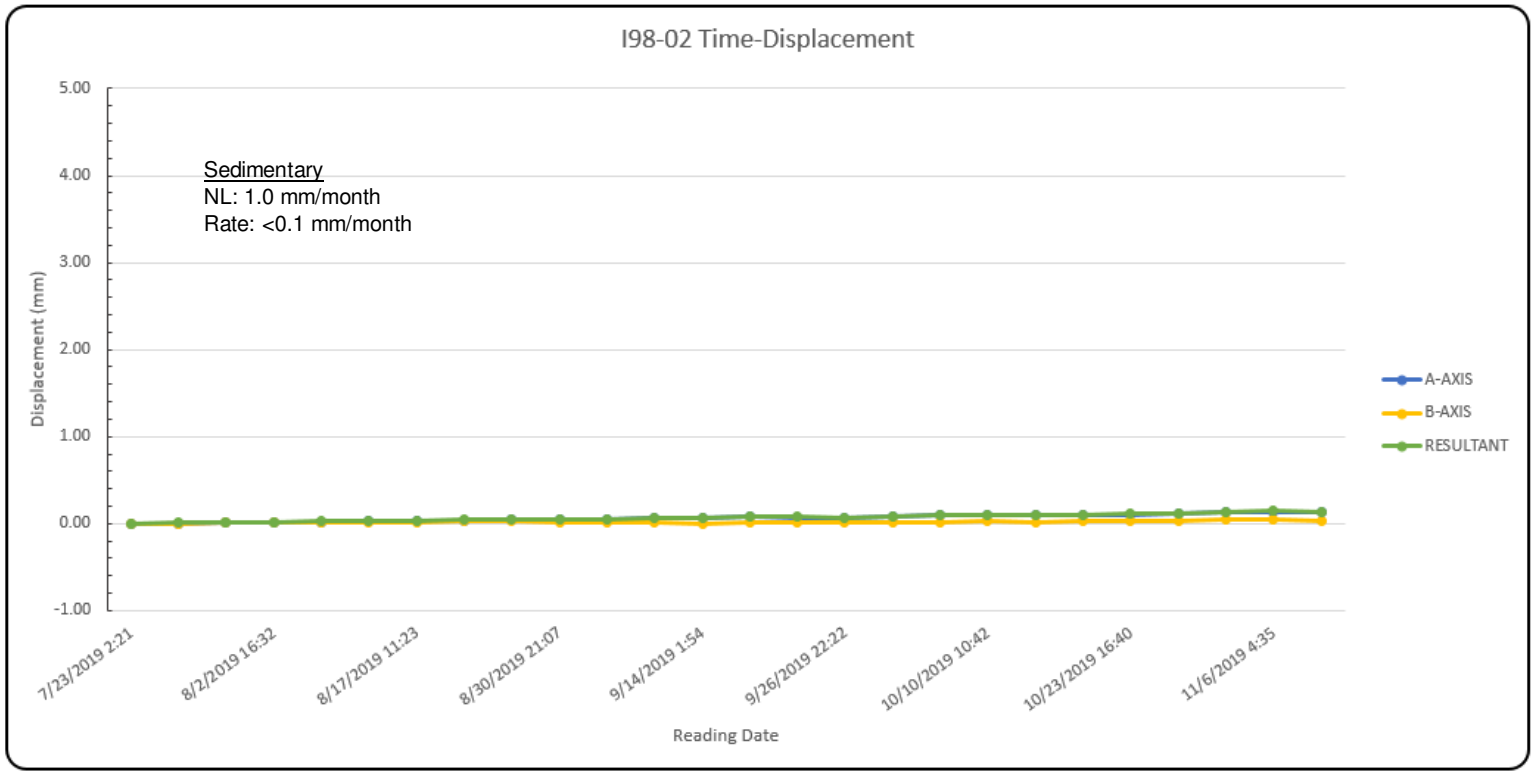


SAAV I98-02

Displacement Plot - Sedimentary

Unit	Upper Depth	Lower Depth
Sedimentary	25	27
Sedimentary	50	52

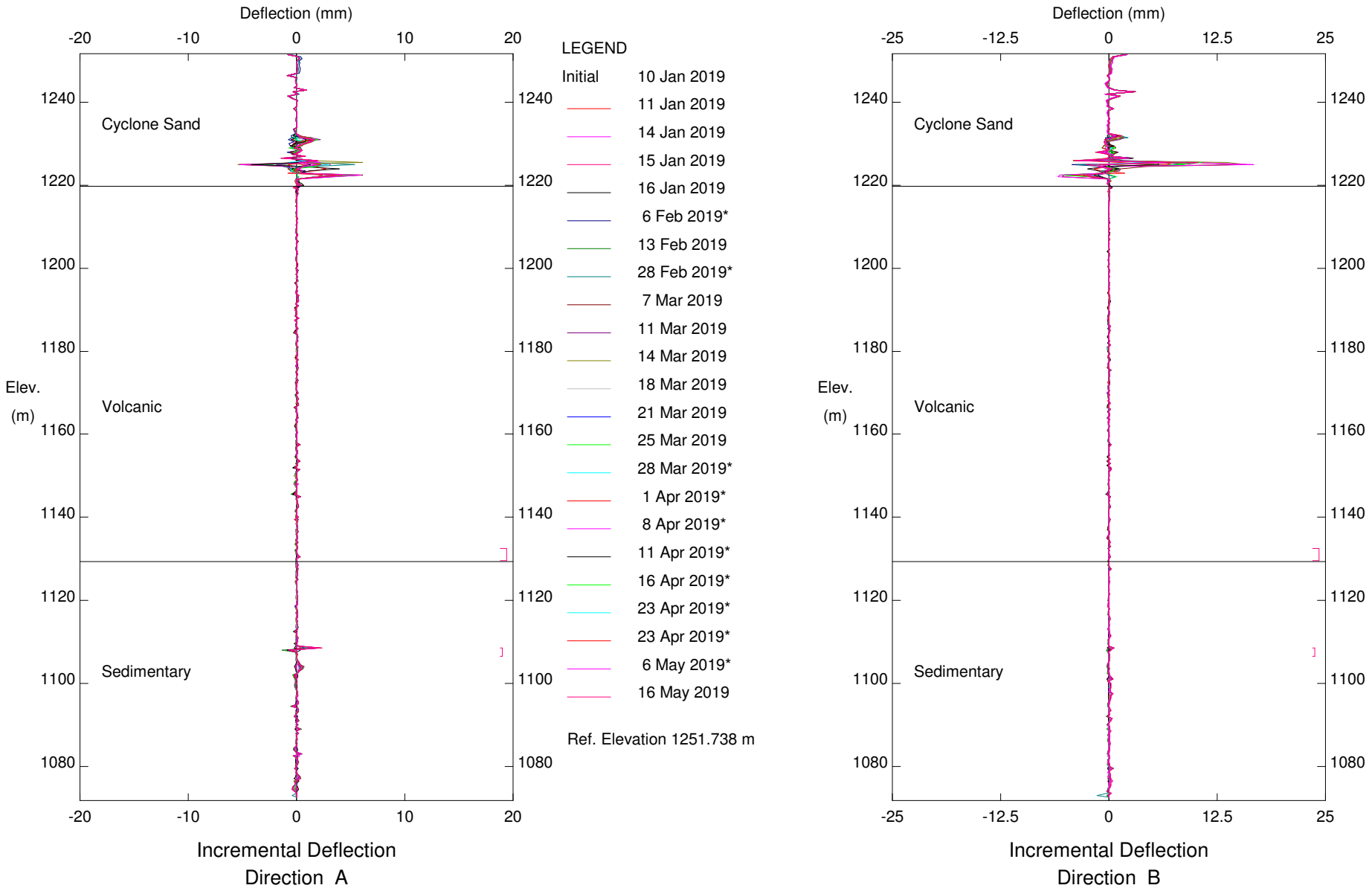
Upper Depth	50.0 m
Lower Depth	52.0 m



NORTH DAM

I98-03

Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I98-3,,,

Sets marked * include zero shift and/or rotation corrections.

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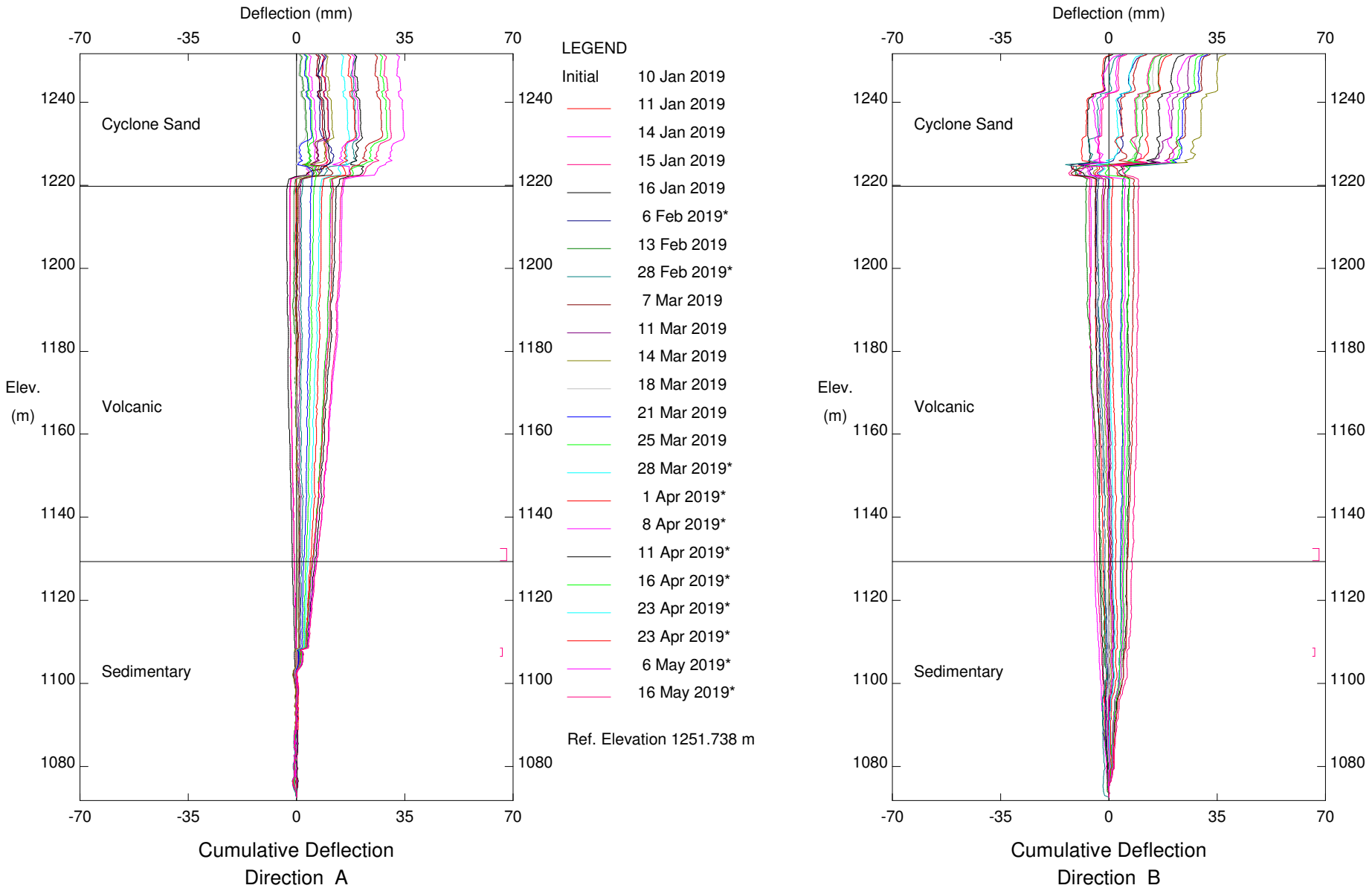
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I98-3,,,

Sets marked * include zero shift and/or rotation corrections.

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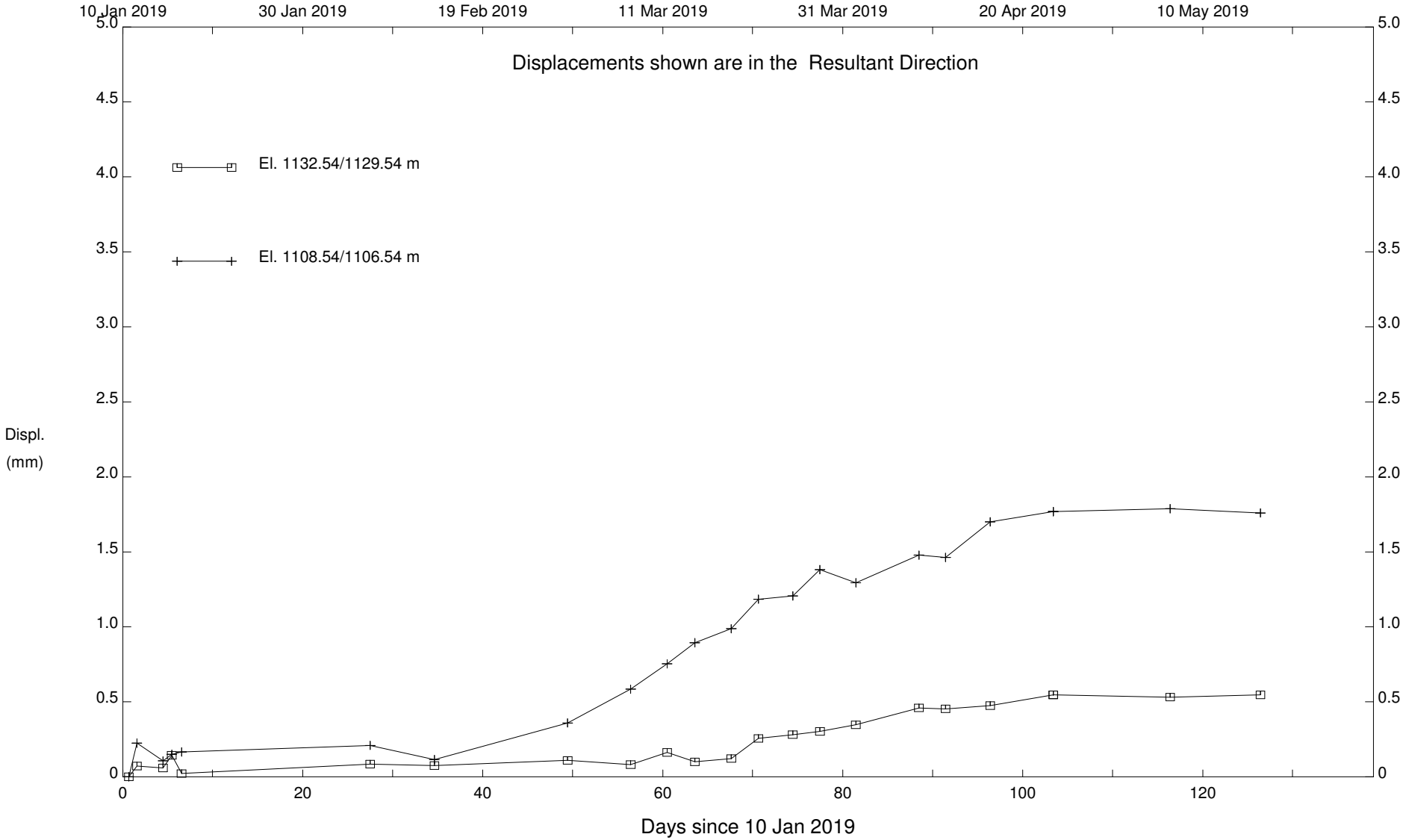
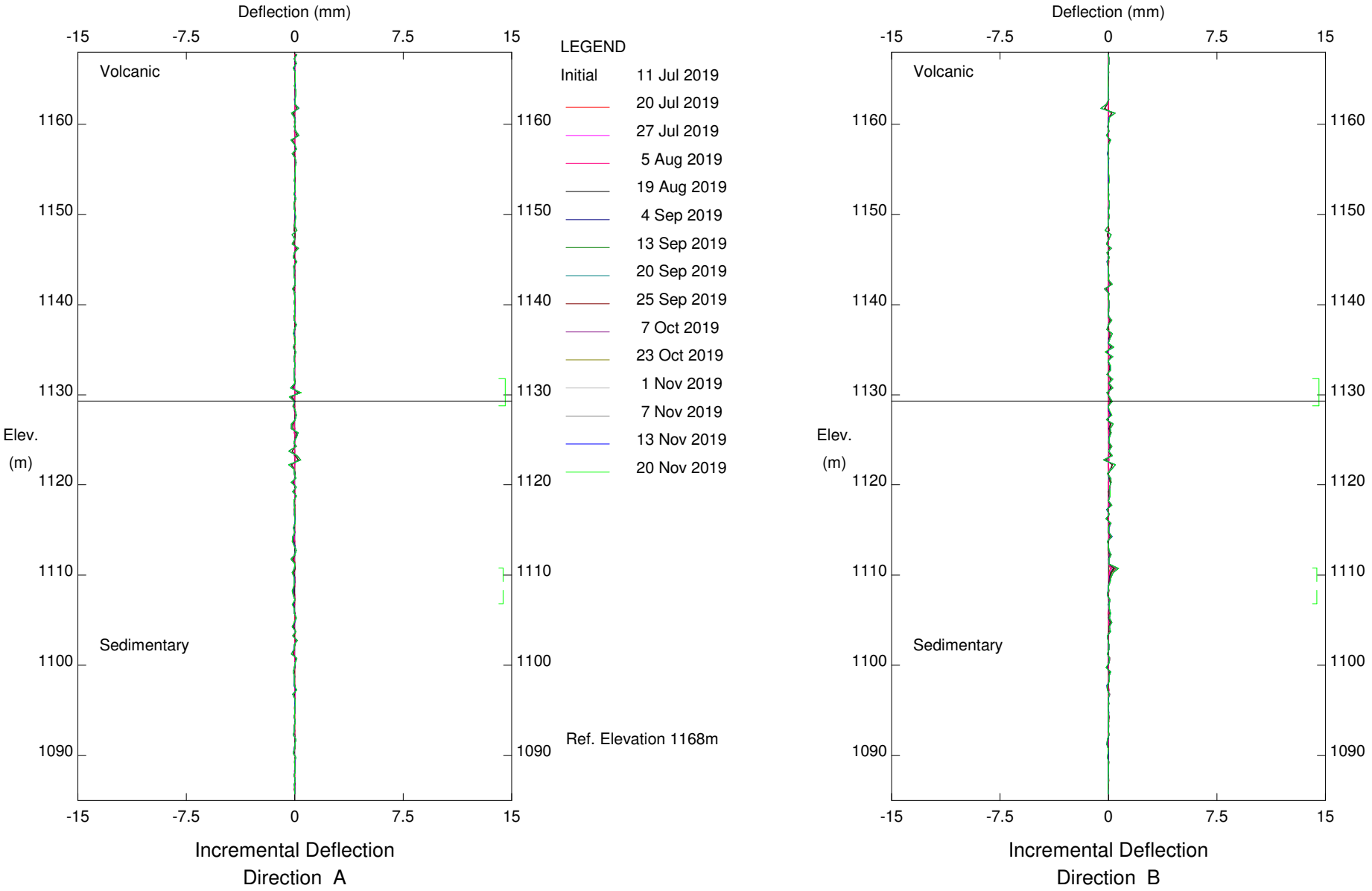
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I98-3,,,

Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I98-3,,,

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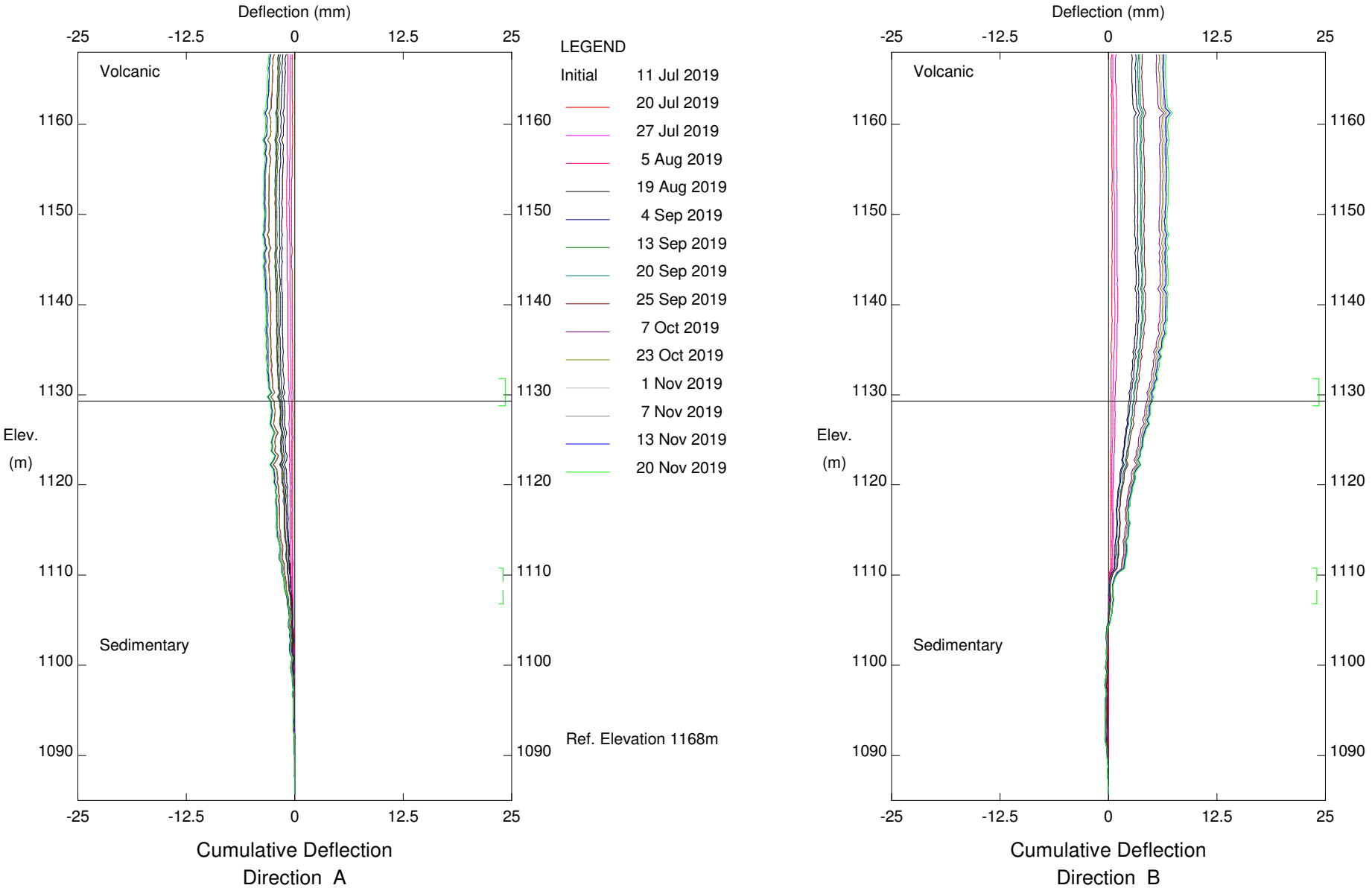
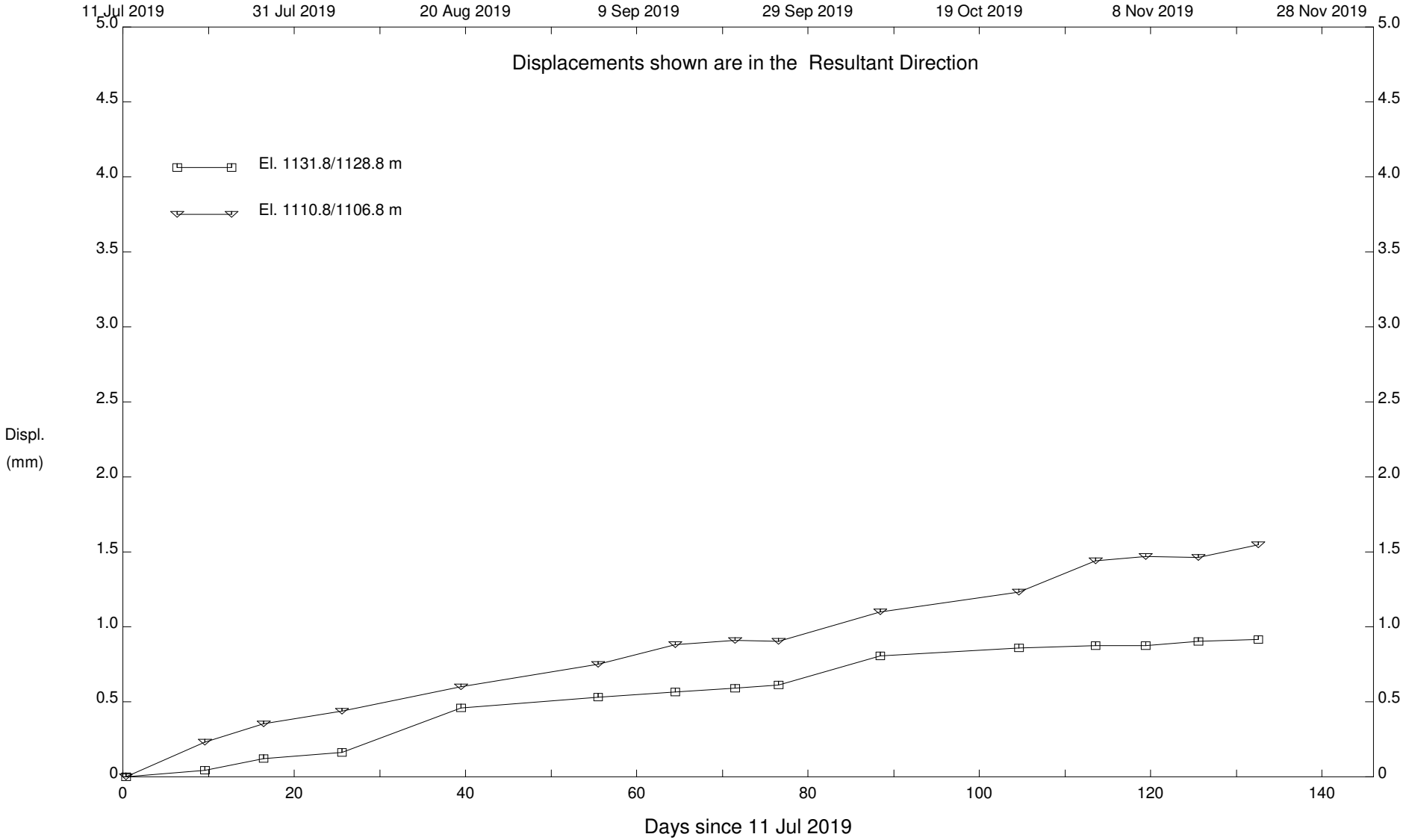
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I98-3,,,

T:\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\SAAV\I98-03.gtl

Highland Valley Copper - Logan Lake, BC

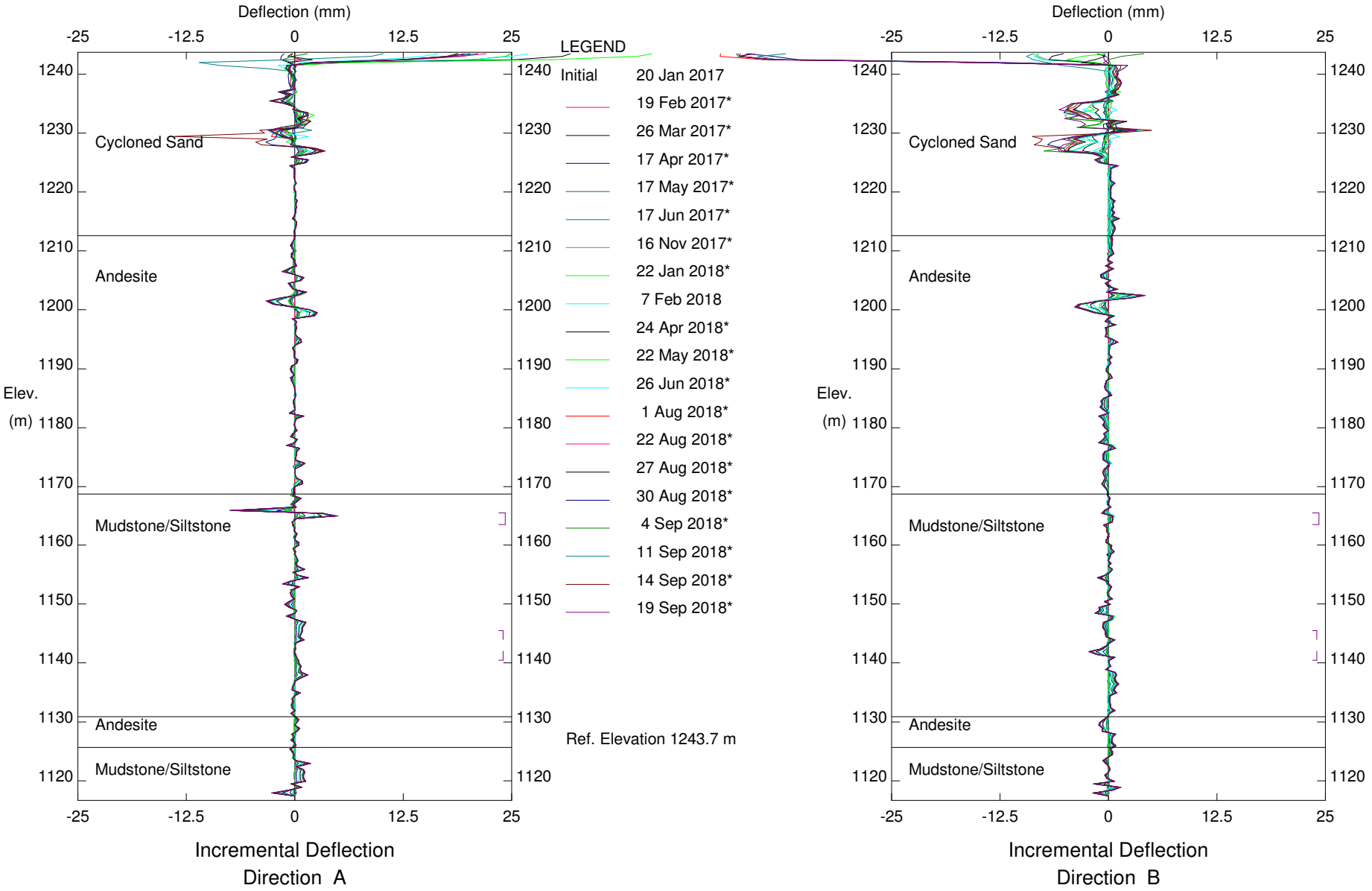


Dam Fill Excluded,,,, Inclinometer I98-3,,,

NORTH DAM

I99-05

Highland Valley Copper - Logan Lake, BC

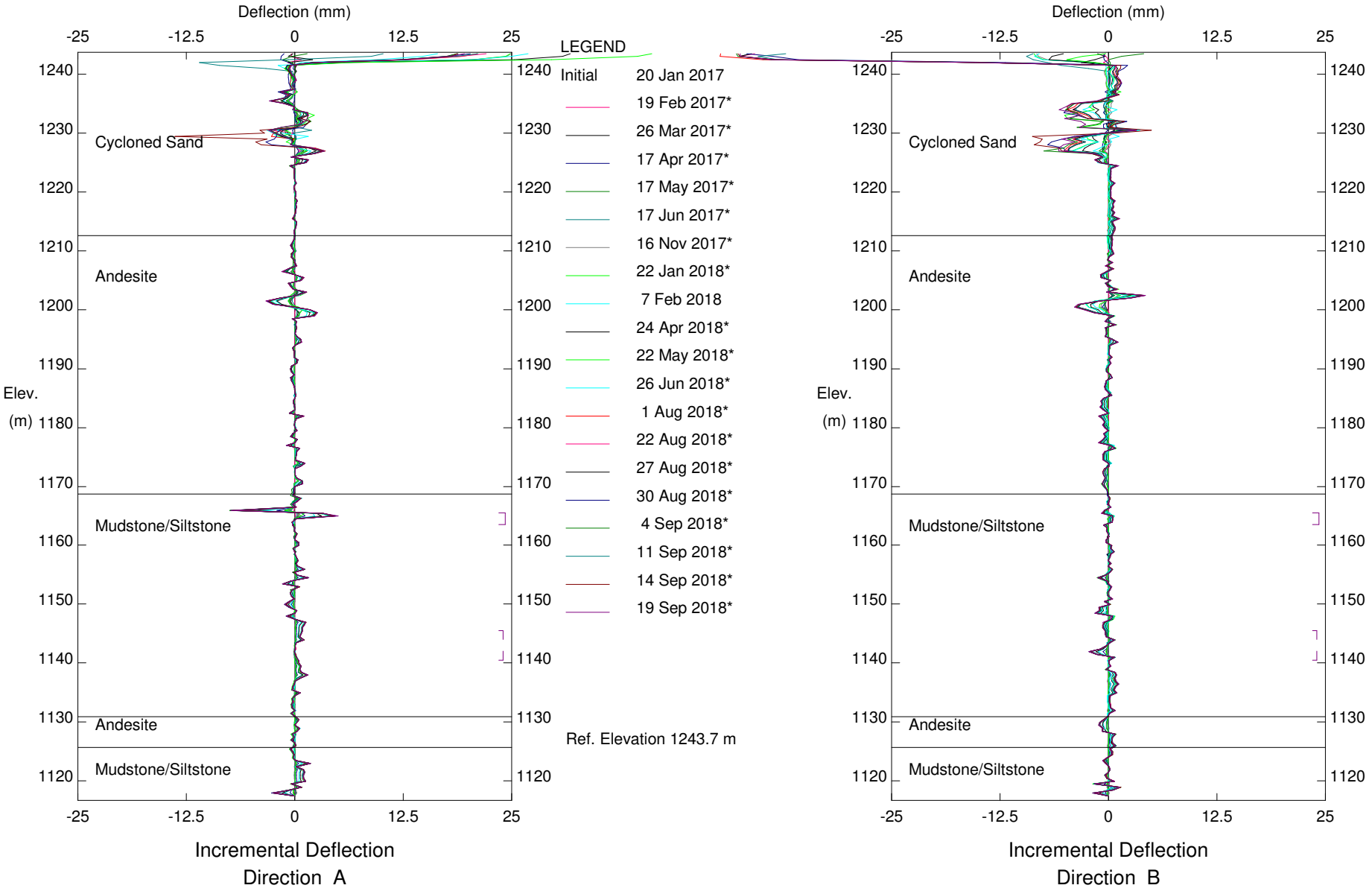


Saddle Dam, Inclinometer I99-5

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC



Saddle Dam, Inclinometer I99-5

Sets marked * include zero shift and/or rotation corrections.

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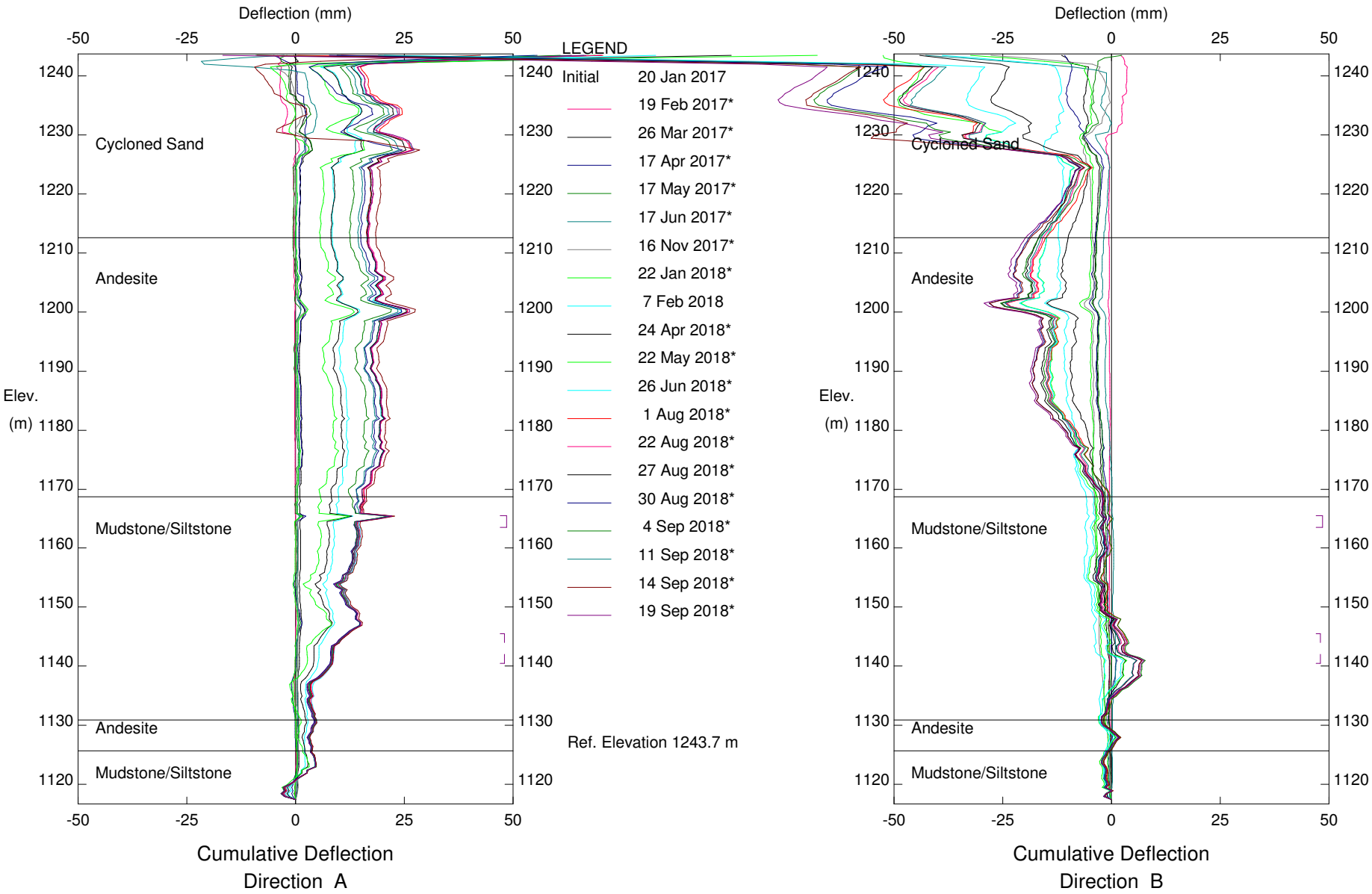
Highland Valley Copper - Logan Lake, BC



Saddle Dam, Inclinometer I99-5

Sets marked * include zero shift and/or rotation corrections.

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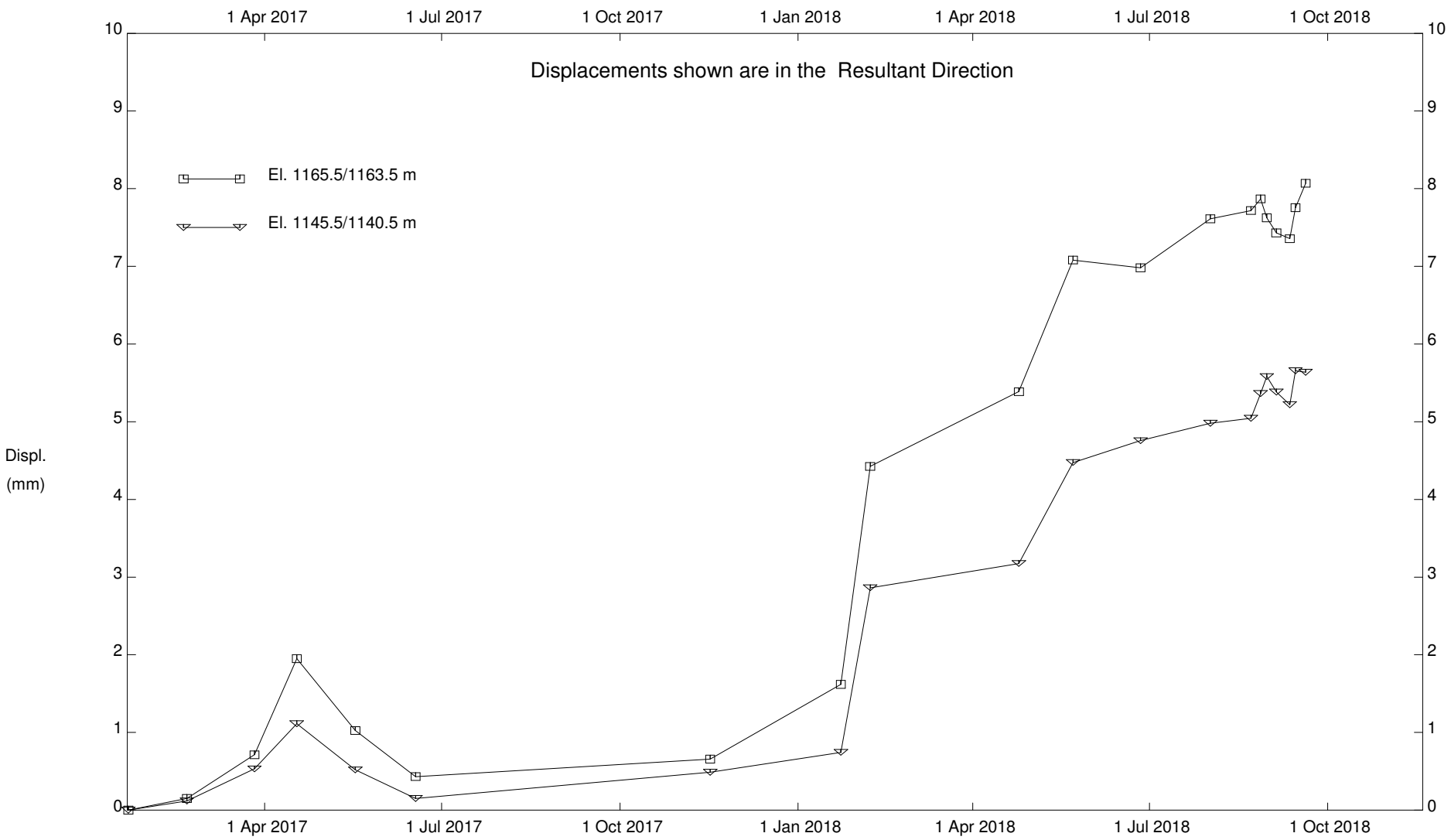
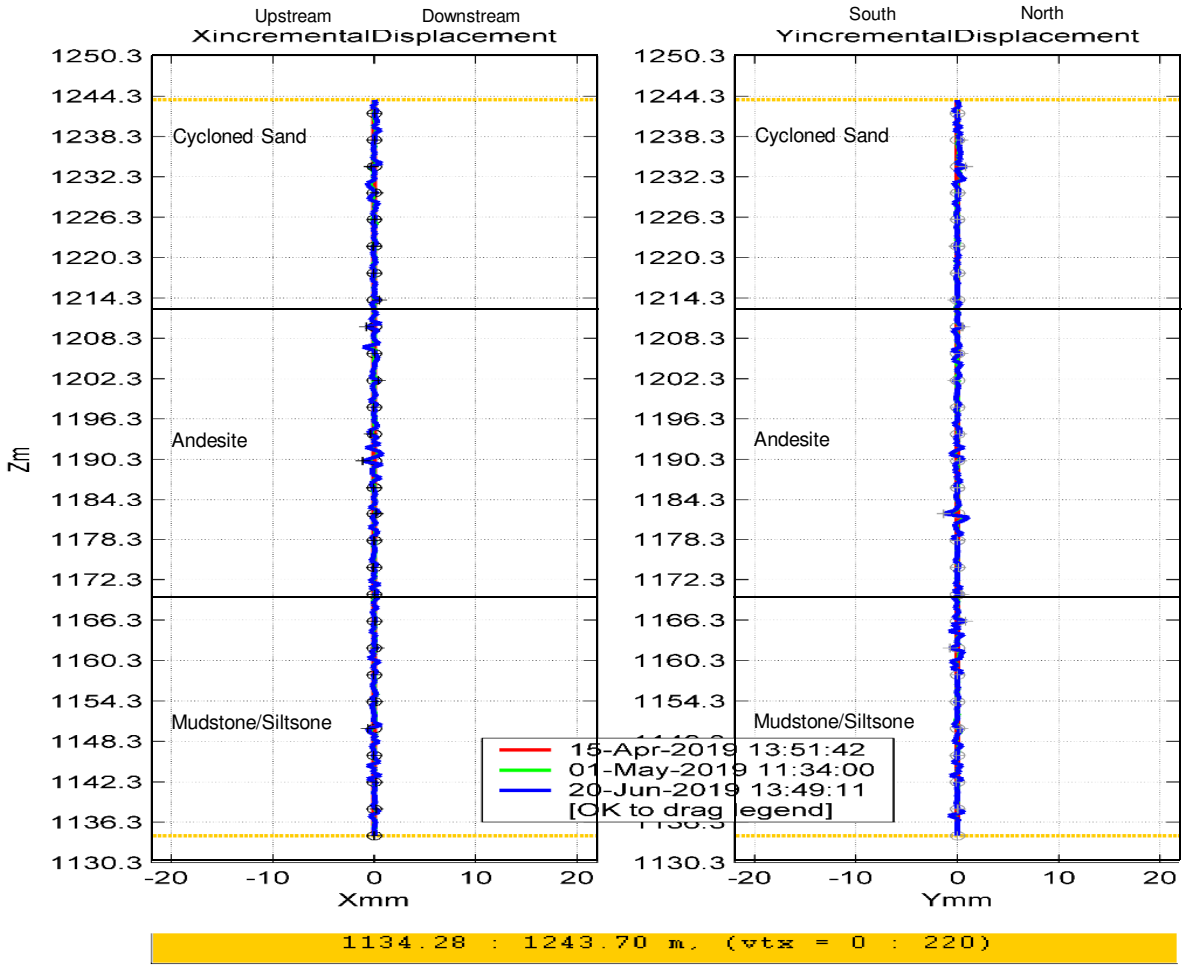
Highland Valley Copper - Logan Lake, BC



Saddle Dam, Inclinometer I99-5

Inclinometer I99-05

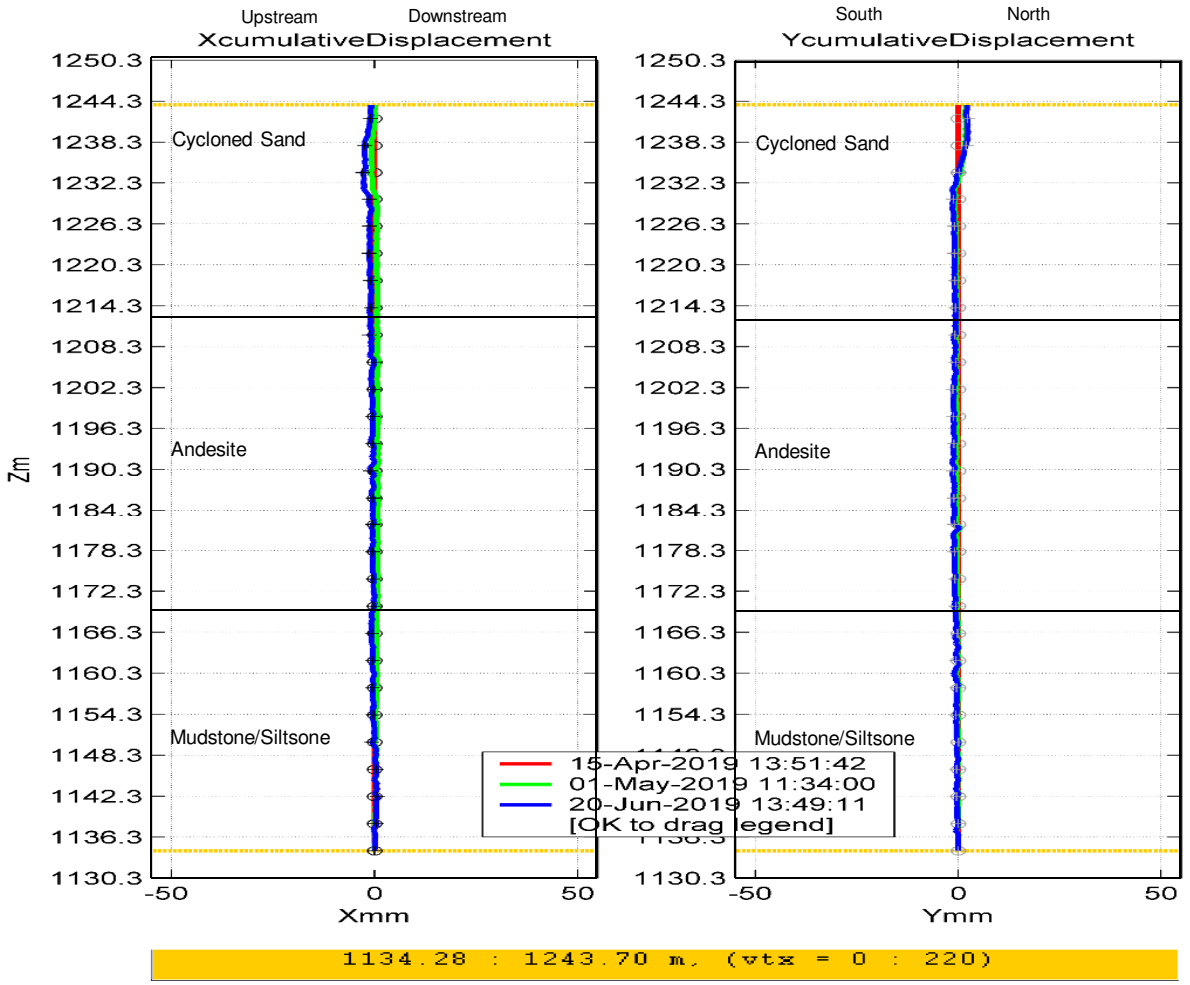
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
99-05	Sedimentary(1)	1166	1163	61	64
	Sedimentary(2)	1157.5	1141.5	70	86

Inclinometer I99-05

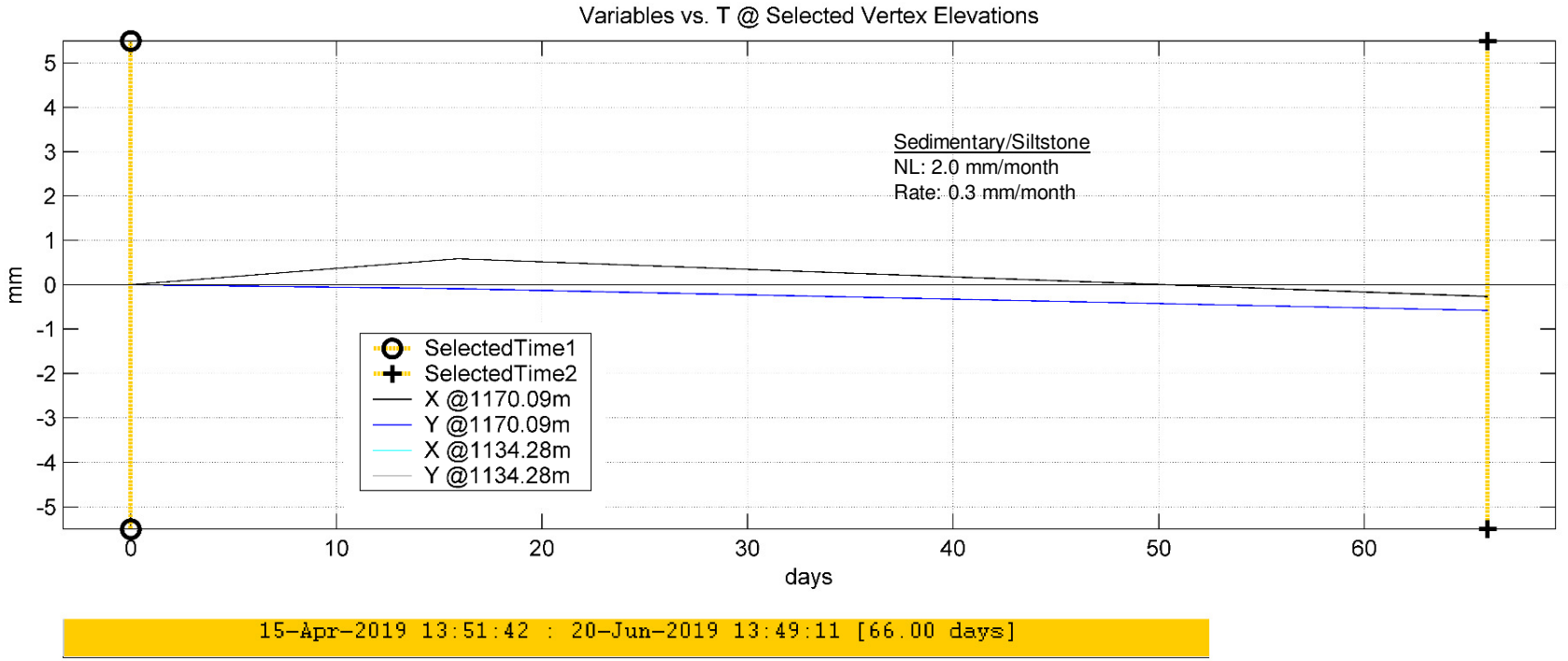
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
99-05	Sedimentary(1)	1166	1163	61	64
	Sedimentary(2)	1157.5	1141.5	70	86

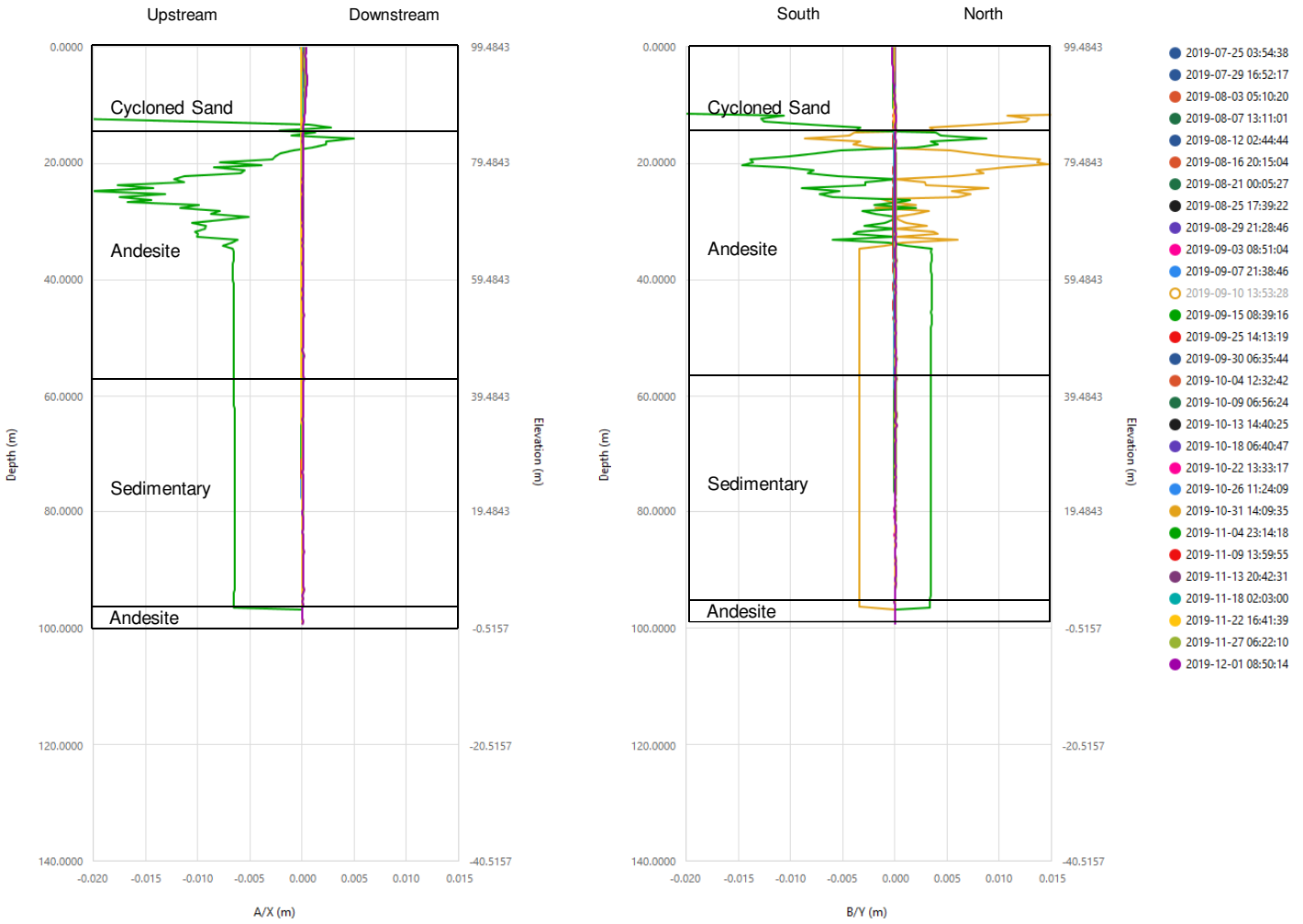
Inclinometer I99-05

Displacement Plot – Sedimentary/Siltstone



SAAV I99-05

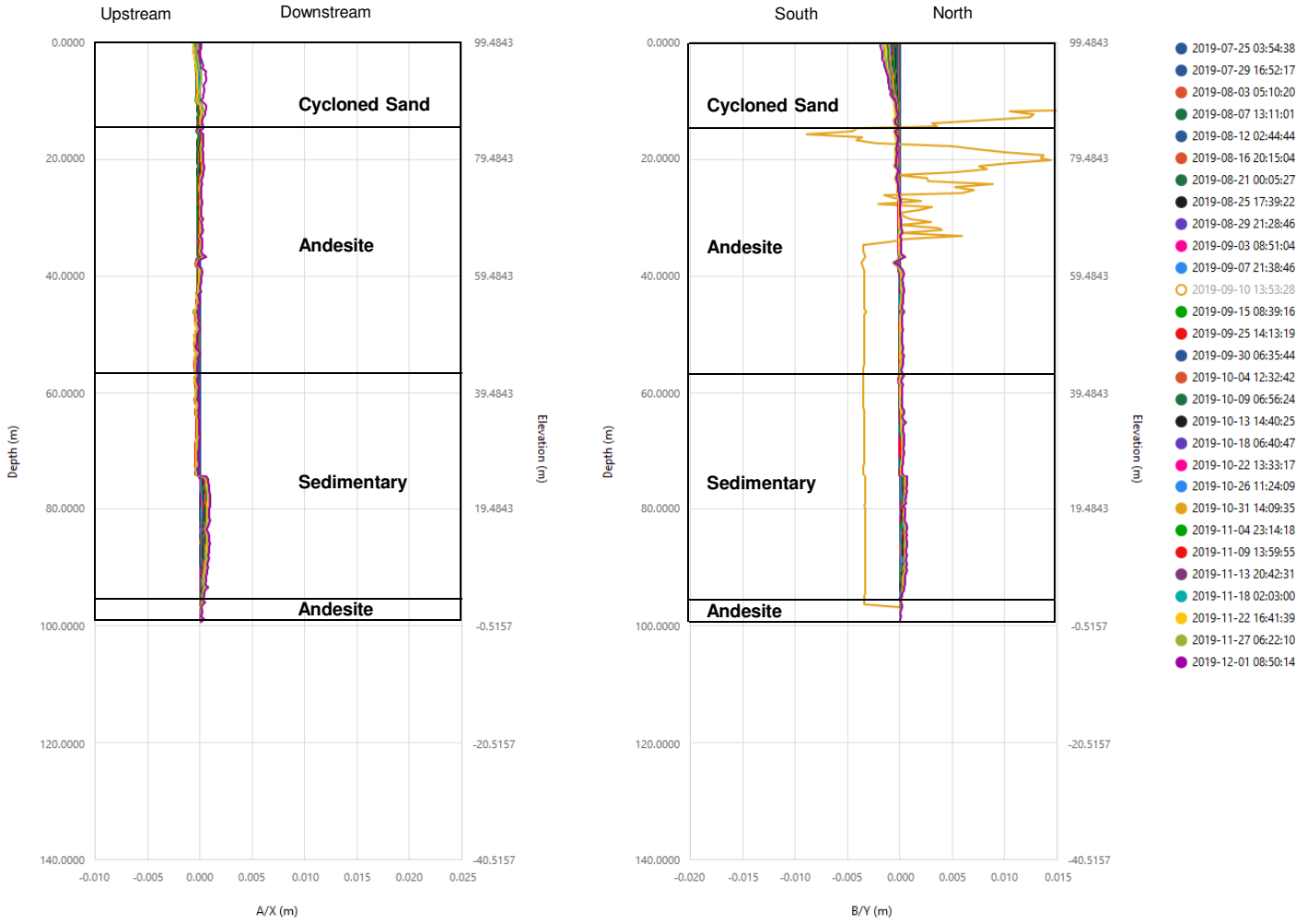
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
99-05	Sedimentary(1)	1166	1163	61	64
	Sedimentary(2)	1157.5	1141.5	70	86

SAAV I99-05

Cumulative Plot



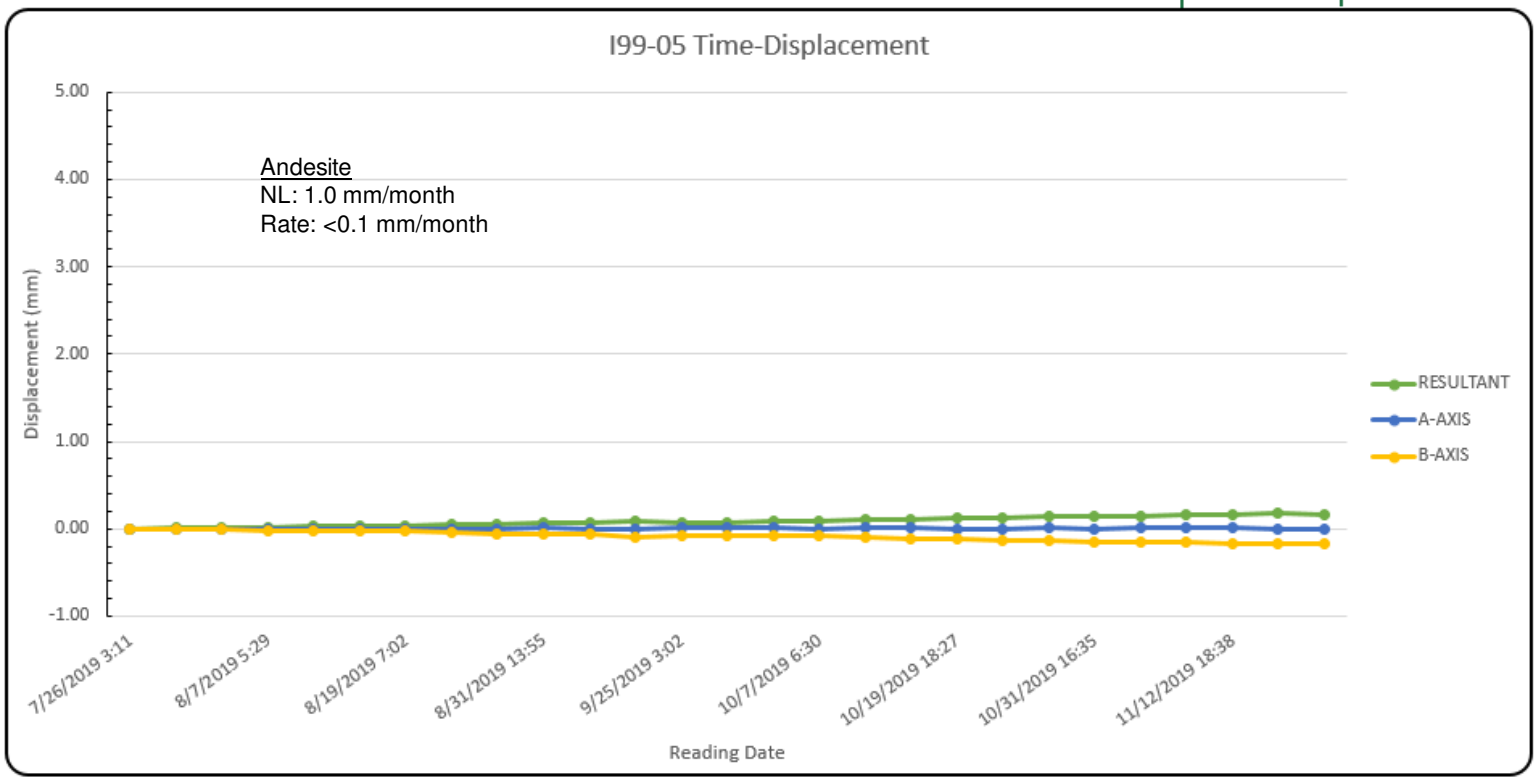
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
99-05	Sedimentary(1)	1166	1163	61	64
	Sedimentary(2)	1157.5	1141.5	70	86

SAAV I99-05

Displacement Plot - Andesite

Unit	Upper Depth	Lower Depth
Andesite	24	26
Sedimentary	61	64
Sedimentary	72	76

Upper Depth	24.0 m
Lower Depth	26.0 m

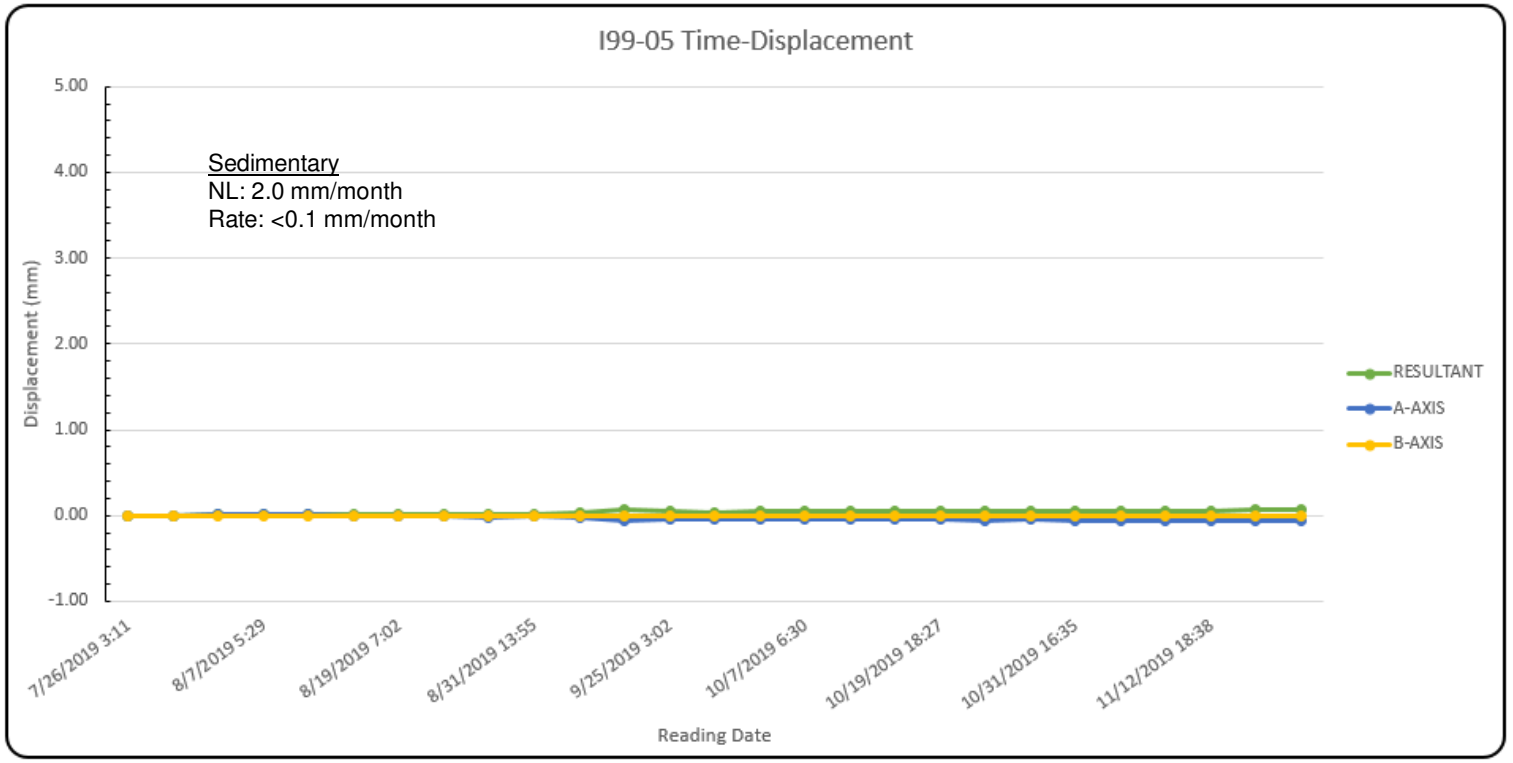


SAAV I99-05

Displacement Plot - Sedimentary

Unit	Upper Depth	Lower Depth
Andesite	24	26
Sedimentary	61	64
Sedimentary	72	76

Upper Depth	61.0 m
Lower Depth	64.0 m

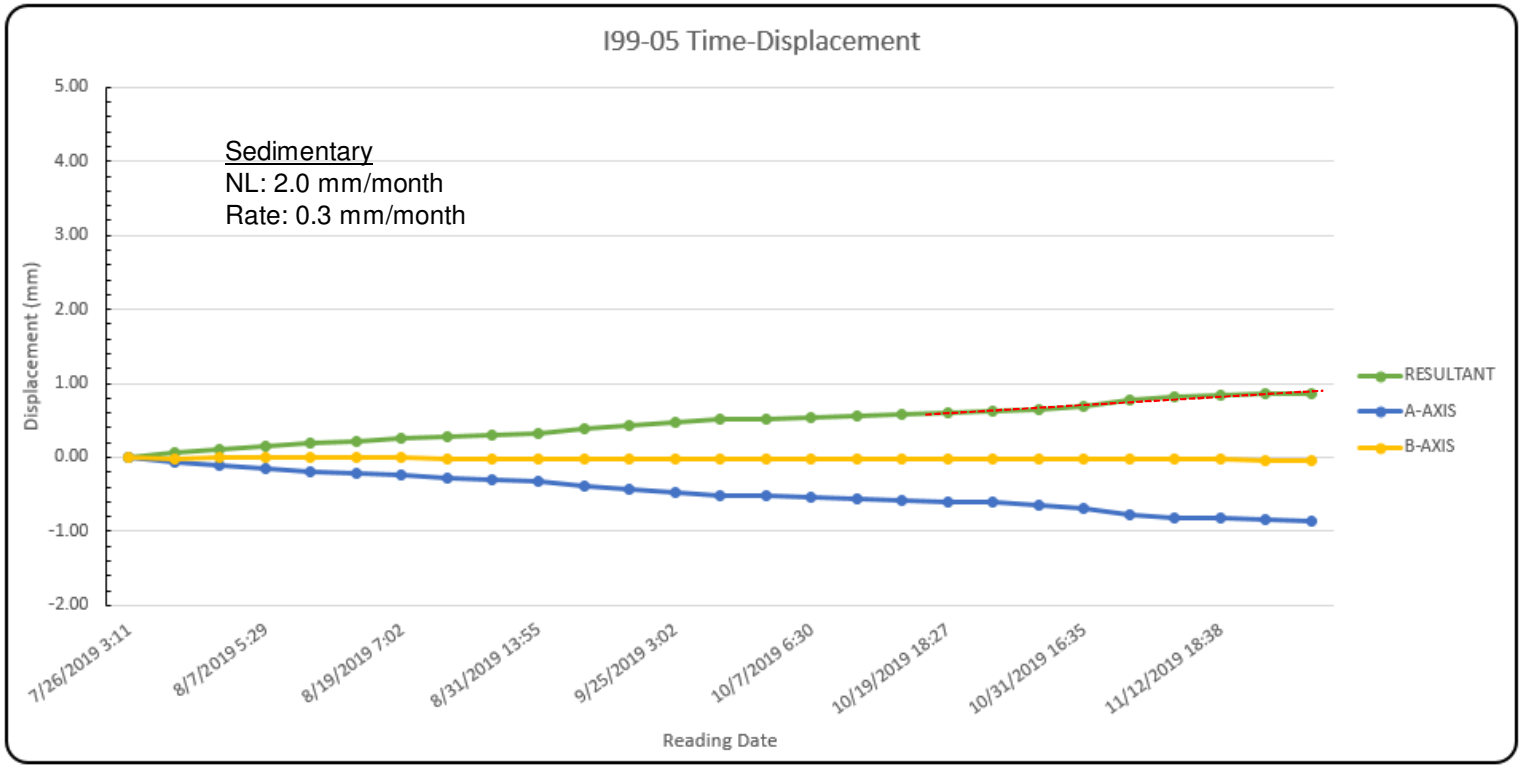


SAAV I99-05

Displacement Plot - Sedimentary

Unit	Upper Depth	Lower Depth
Andesite	24	26
Sedimentary	61	64
Sedimentary	72	76

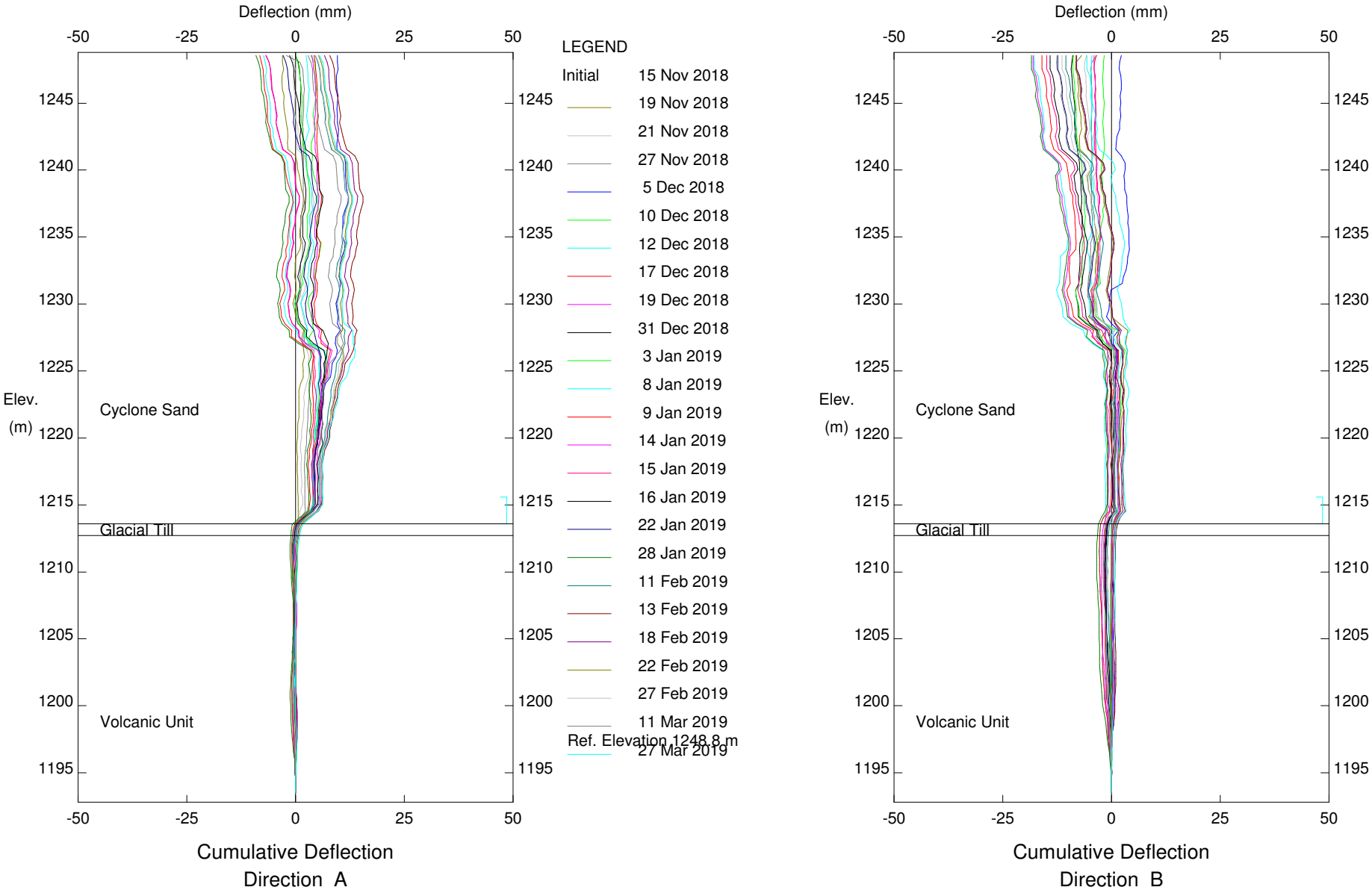
Upper Depth	72.0 m
Lower Depth	76.0 m



NORTH DAM

I10-03

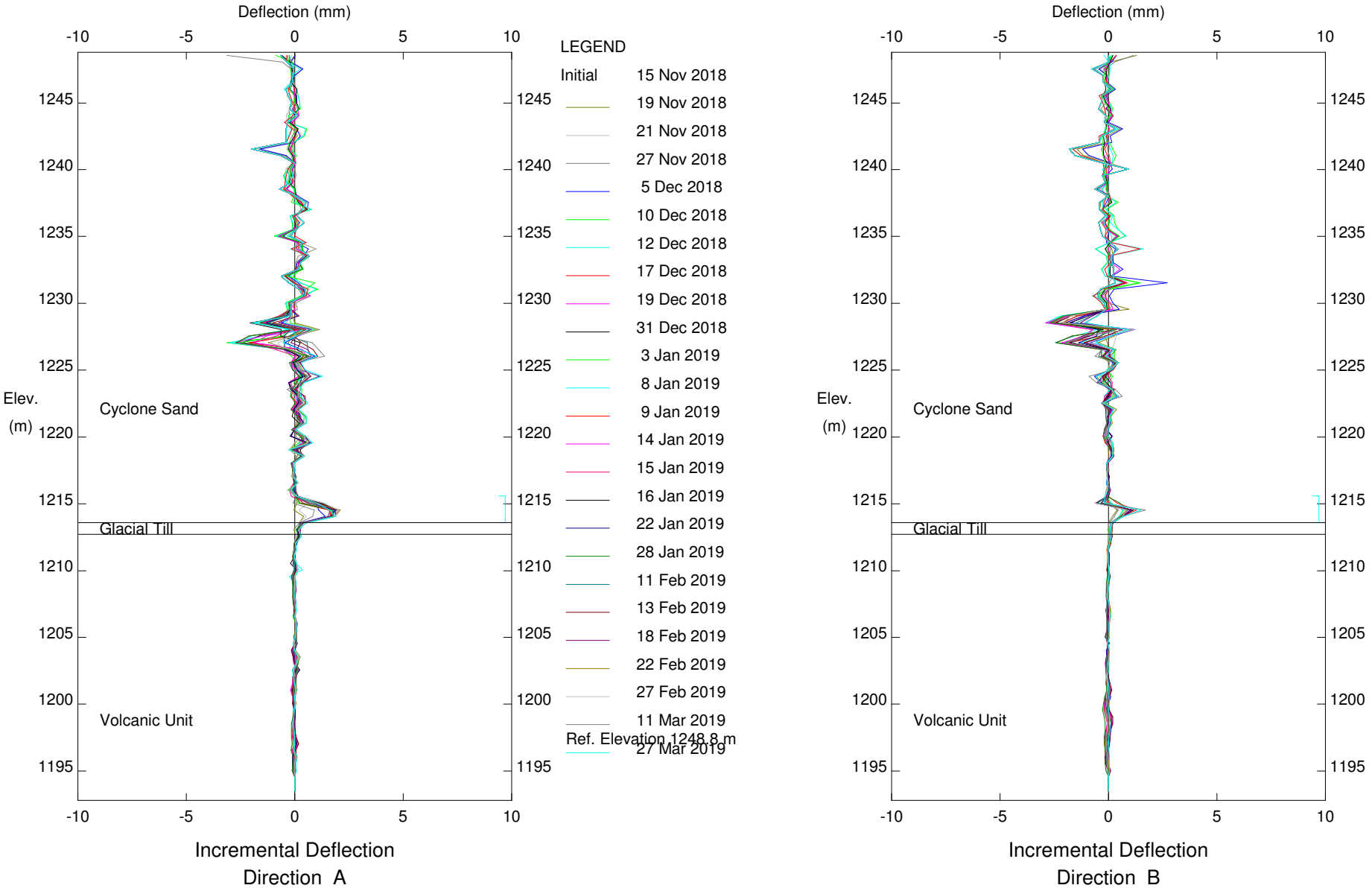
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I10-3,,,

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\I10-03.gtl

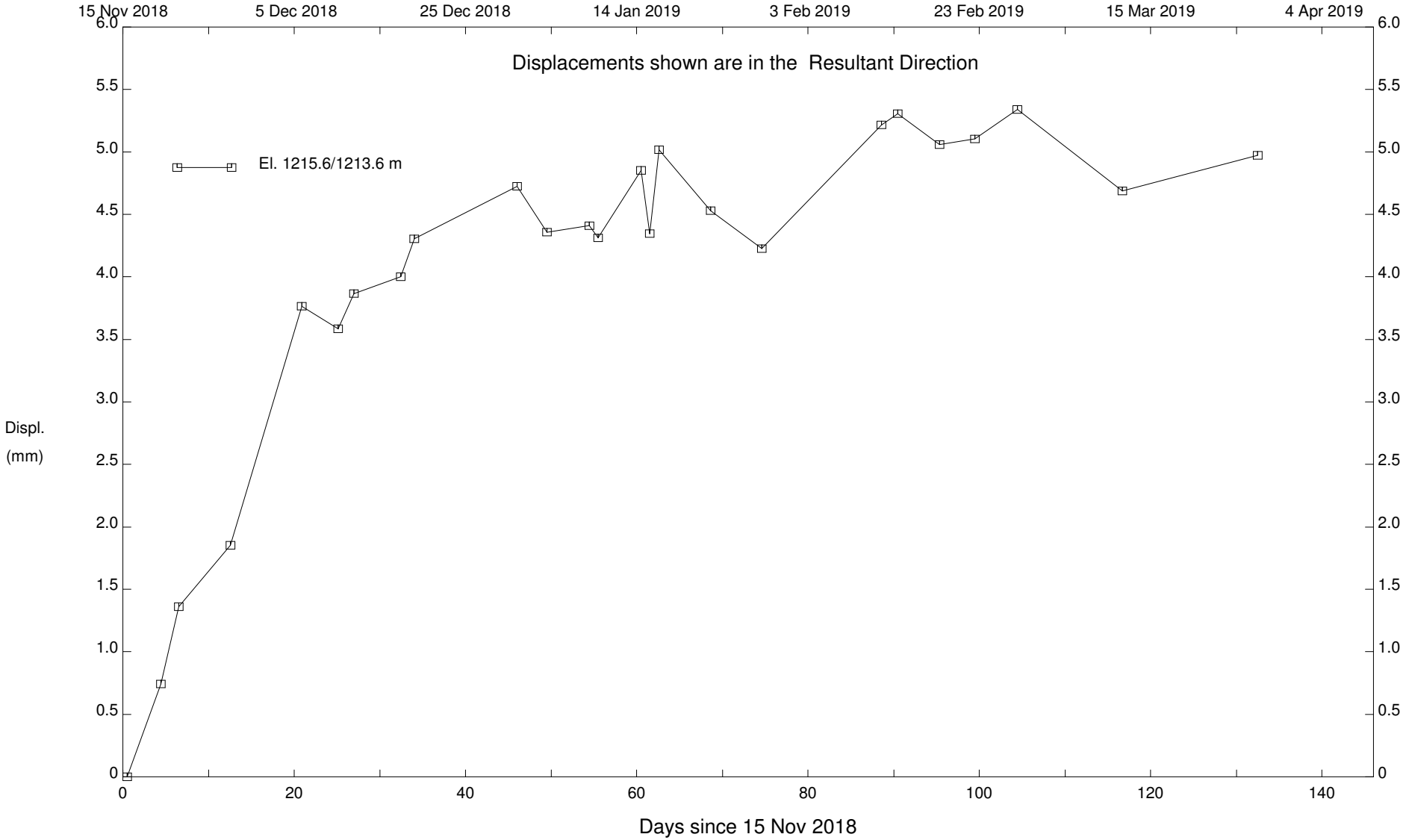
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I10-3,,,

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\I10-03.gtl

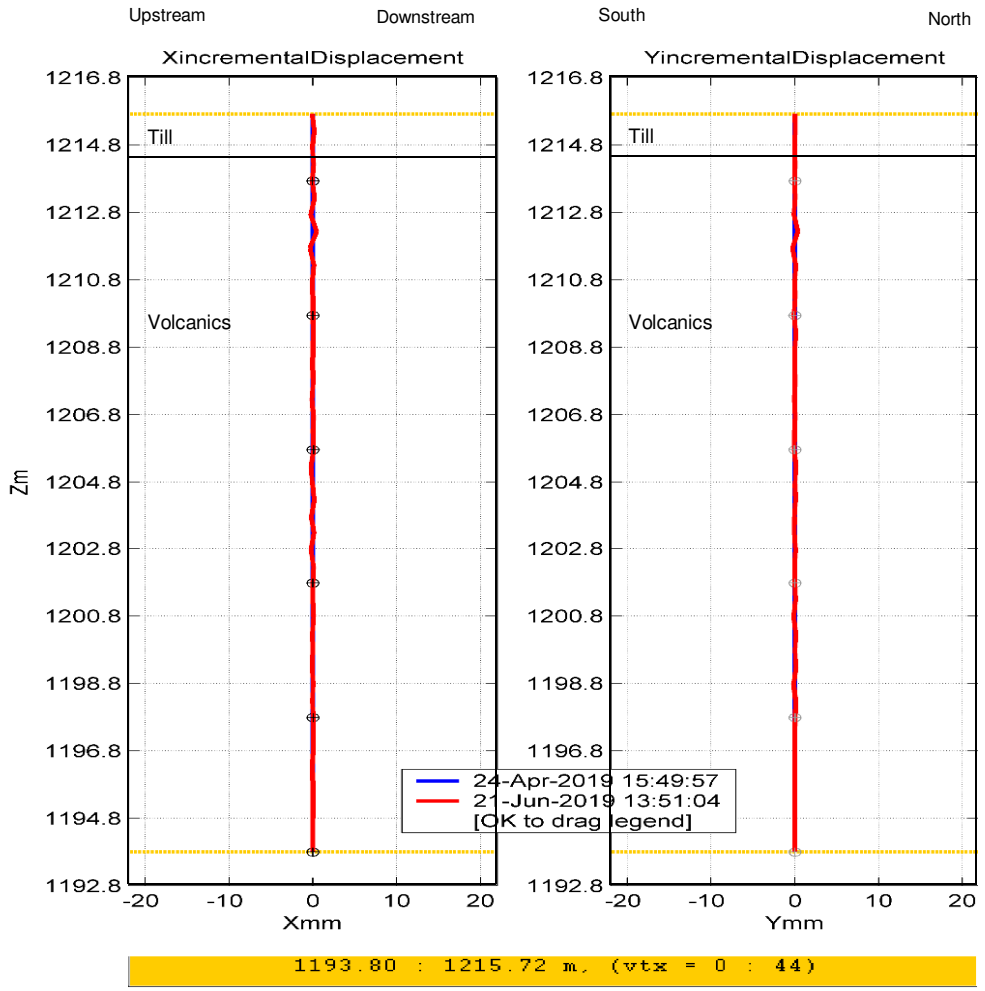
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I10-3,,

Inclinometer I10-03

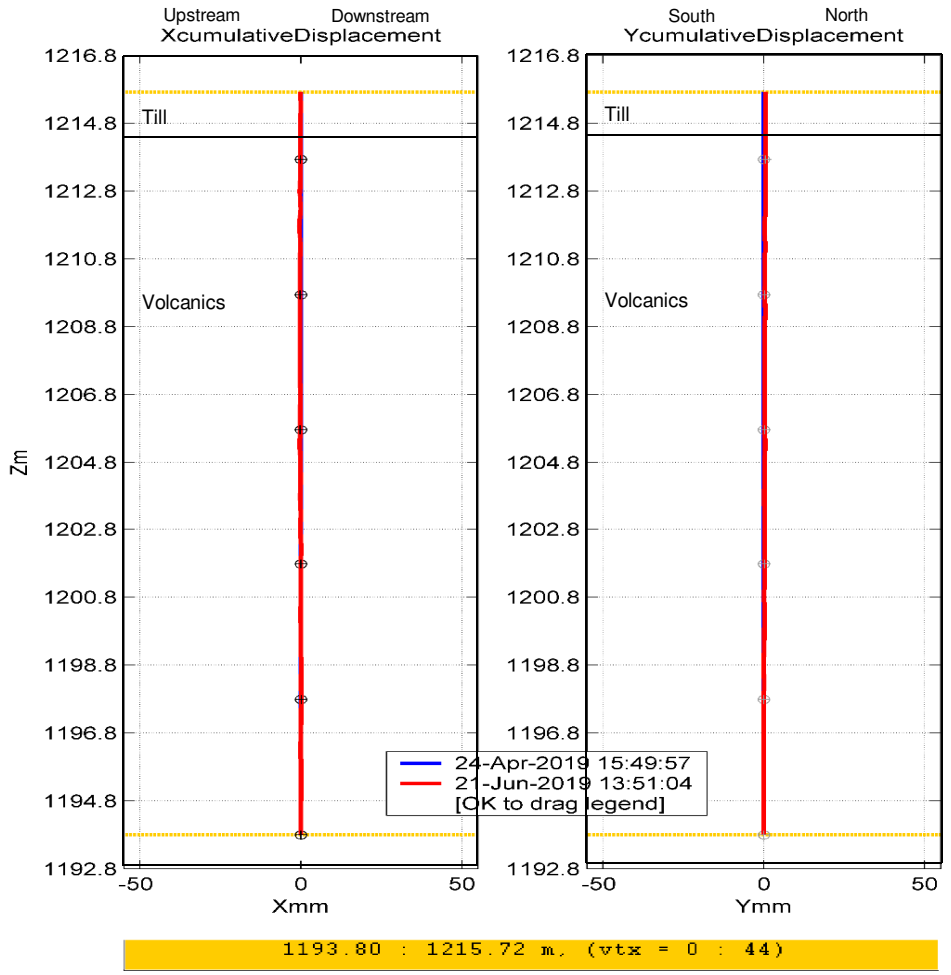
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-03	Volcanic	1215.6	1194	0	22

Inclinometer I10-03

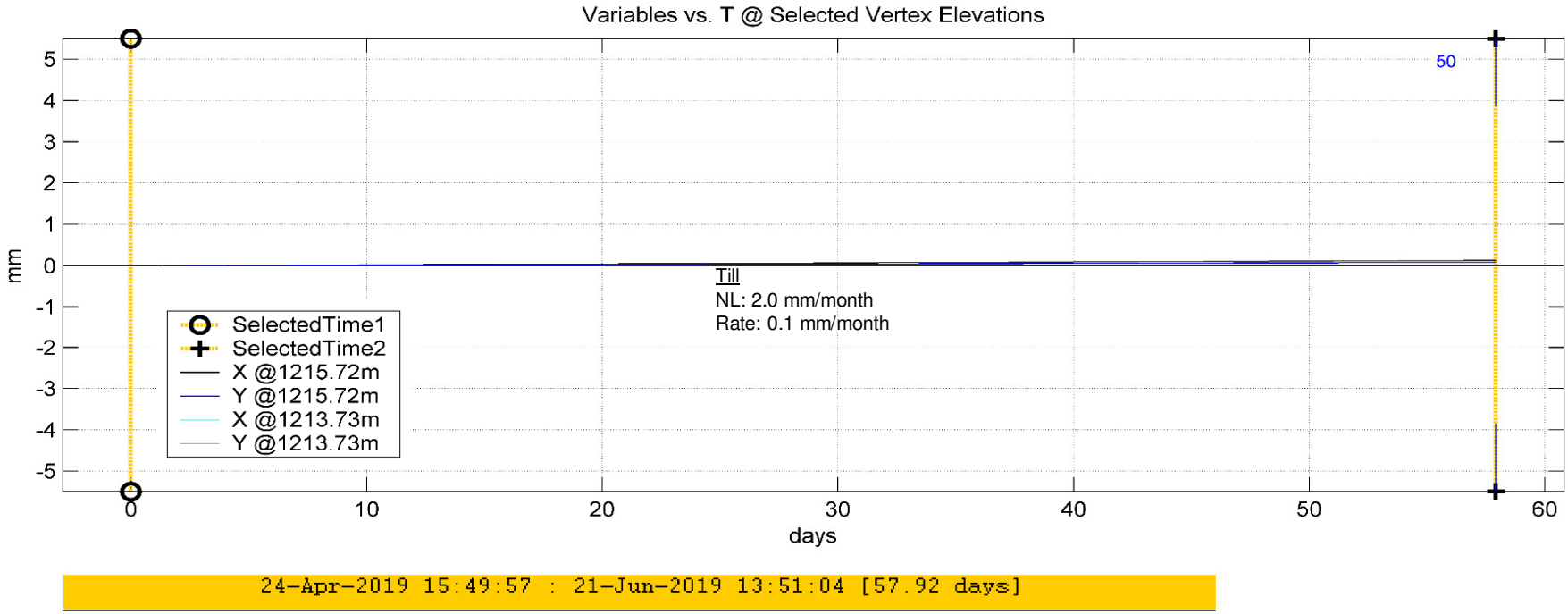
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-03	Volcanic	1215.6	1194	0	22

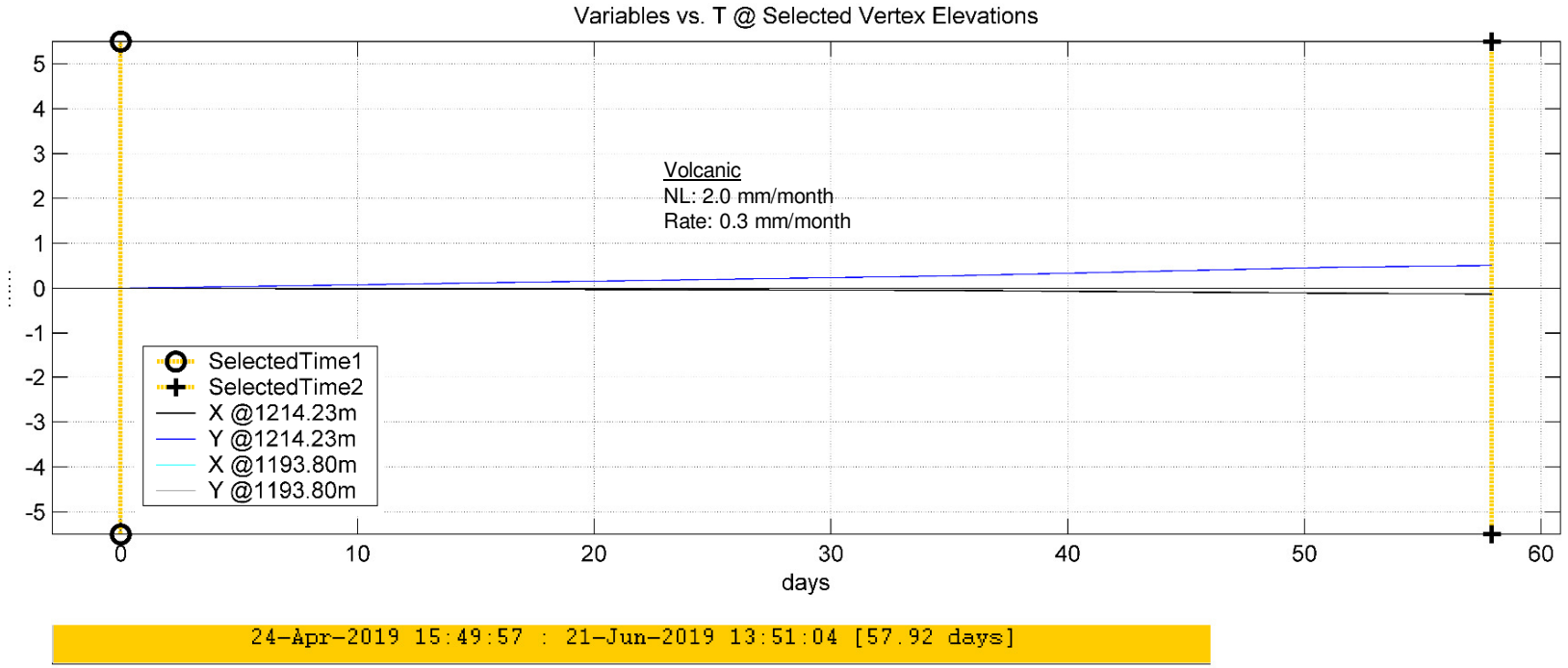
Inclinometer I10-03

Time Displacement Plot - Till



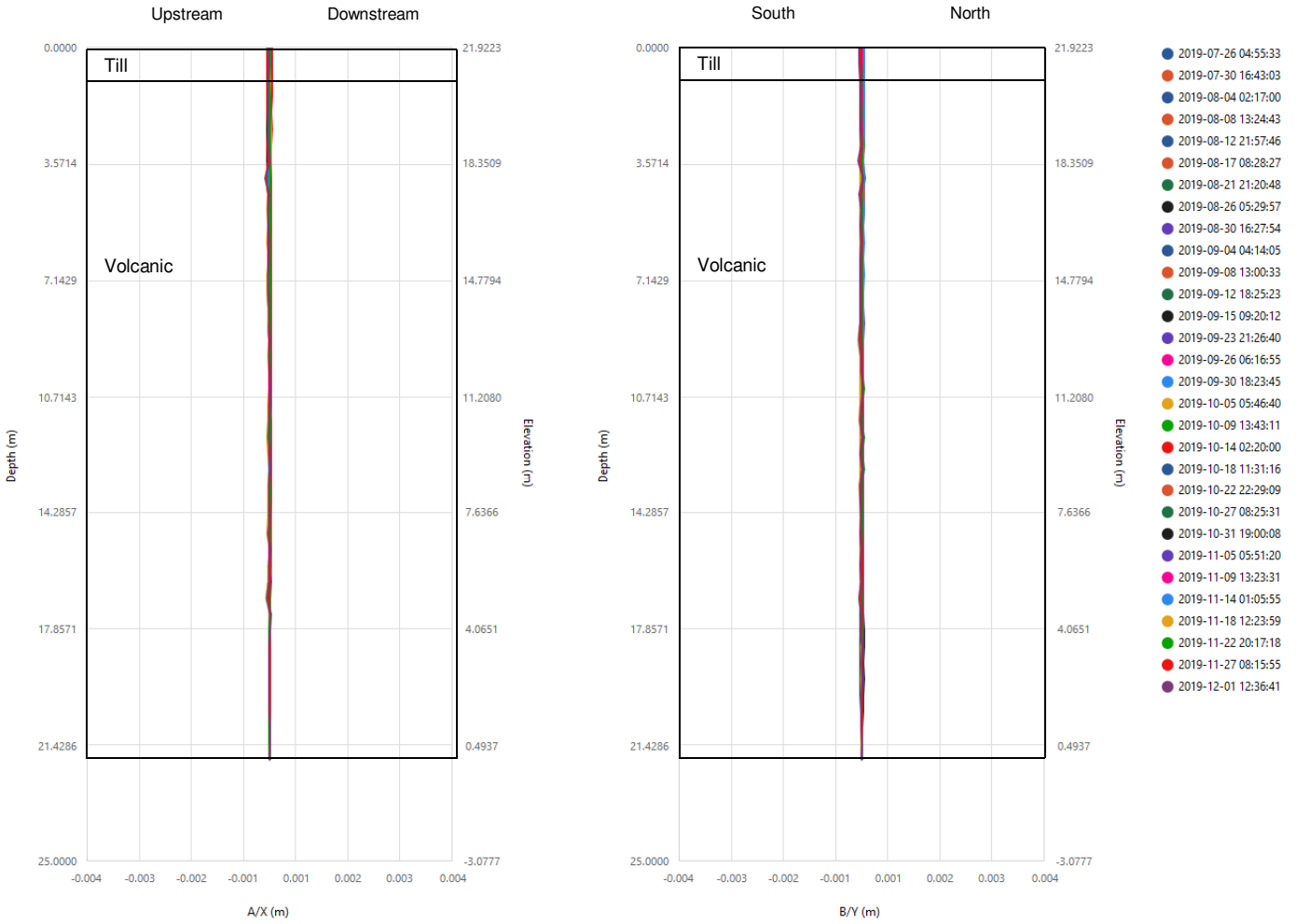
Inclinometer I10-03

Time Displacement Plot - Volcanic



SAAV I10-03

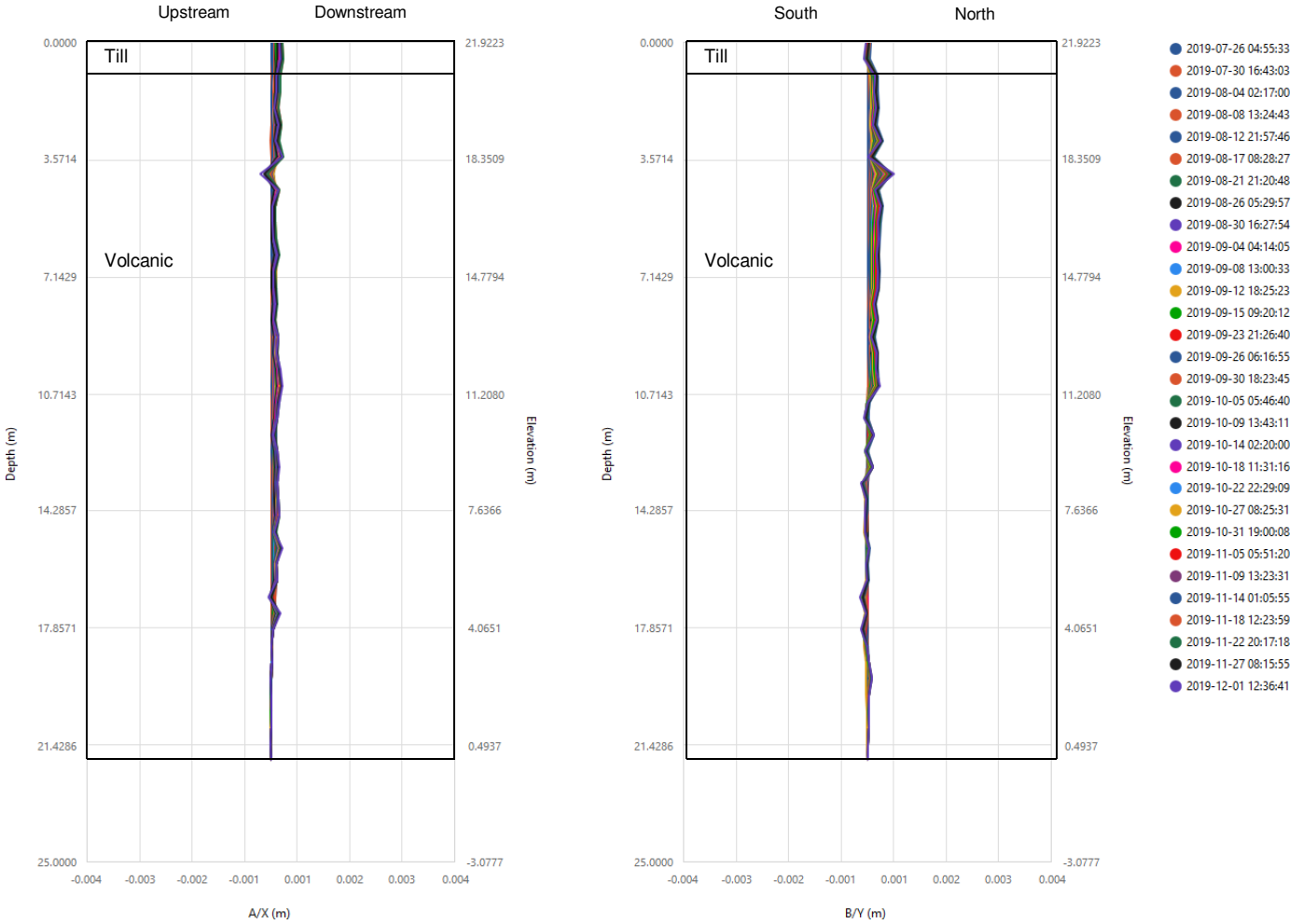
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-03	Volcanic	1215.6	1194	0	22

SAAV I10-03

Cumulative Plot



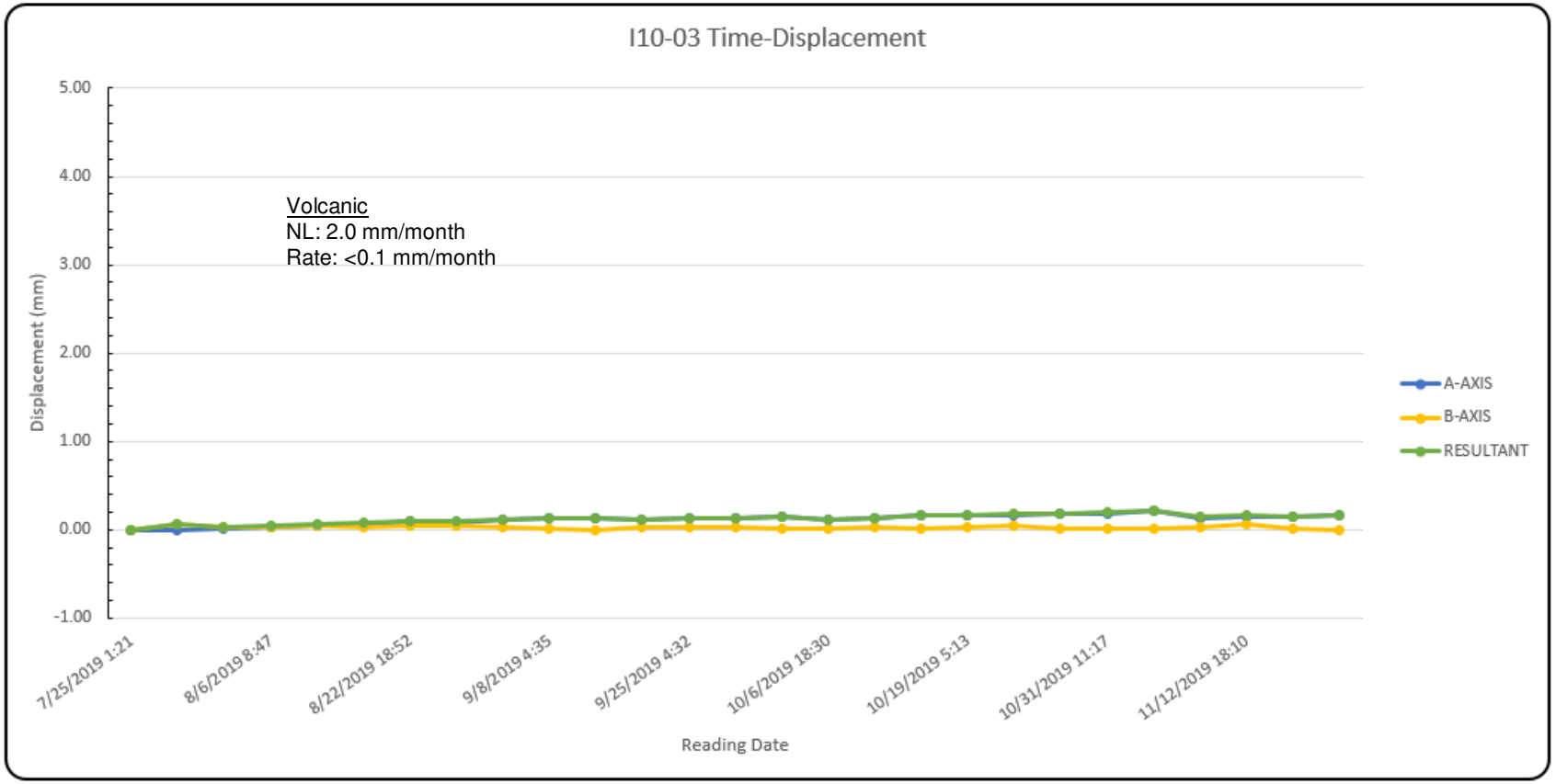
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-03	Volcanic	1215.6	1194	0	22

SAAV I10-03

Displacement Plot – Volcanic

Unit	Upper Depth	Lower Depth
Volcanic	0	22

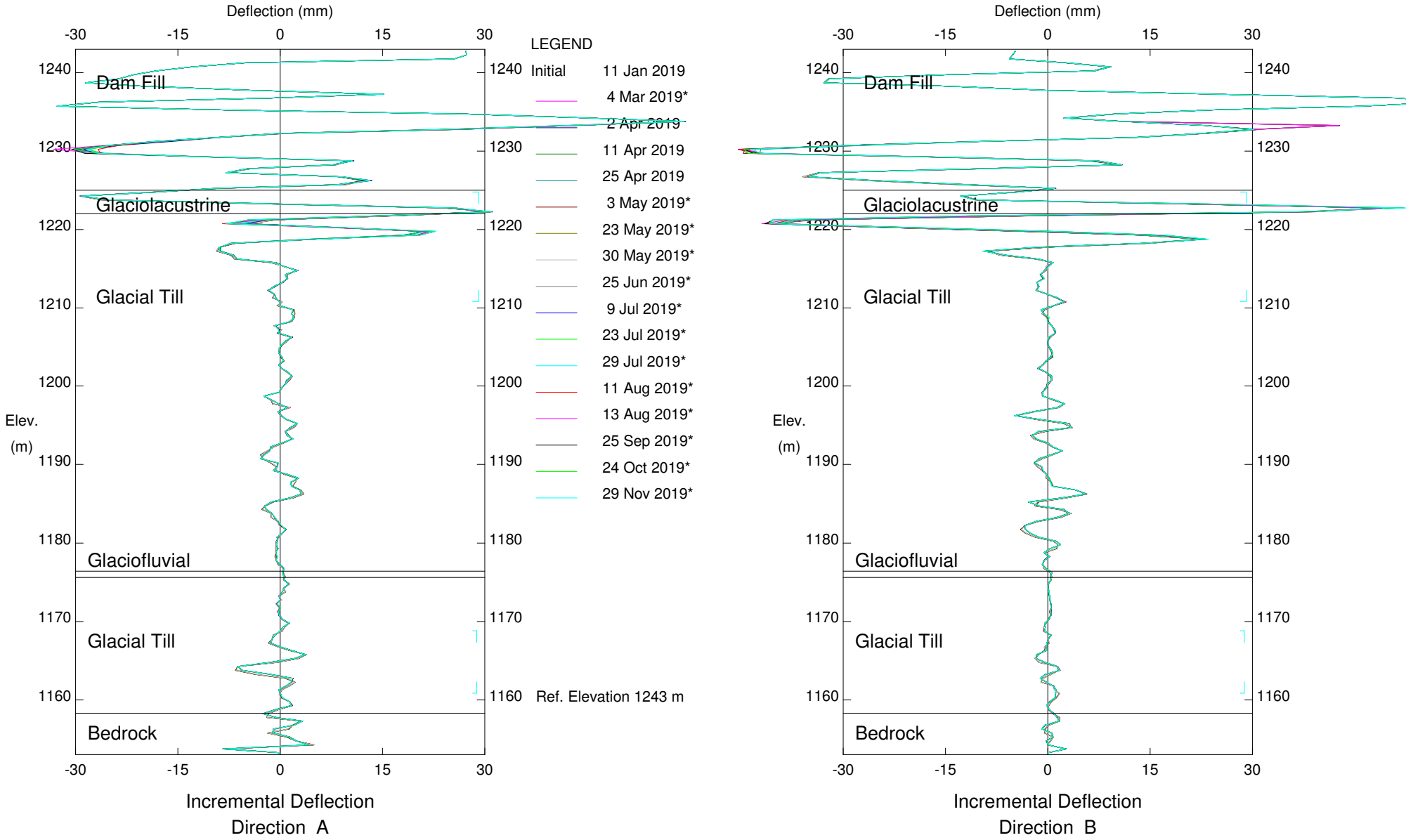
Upper Depth	0.0 m
Lower Depth	22.0 m



NORTH DAM

I16-05

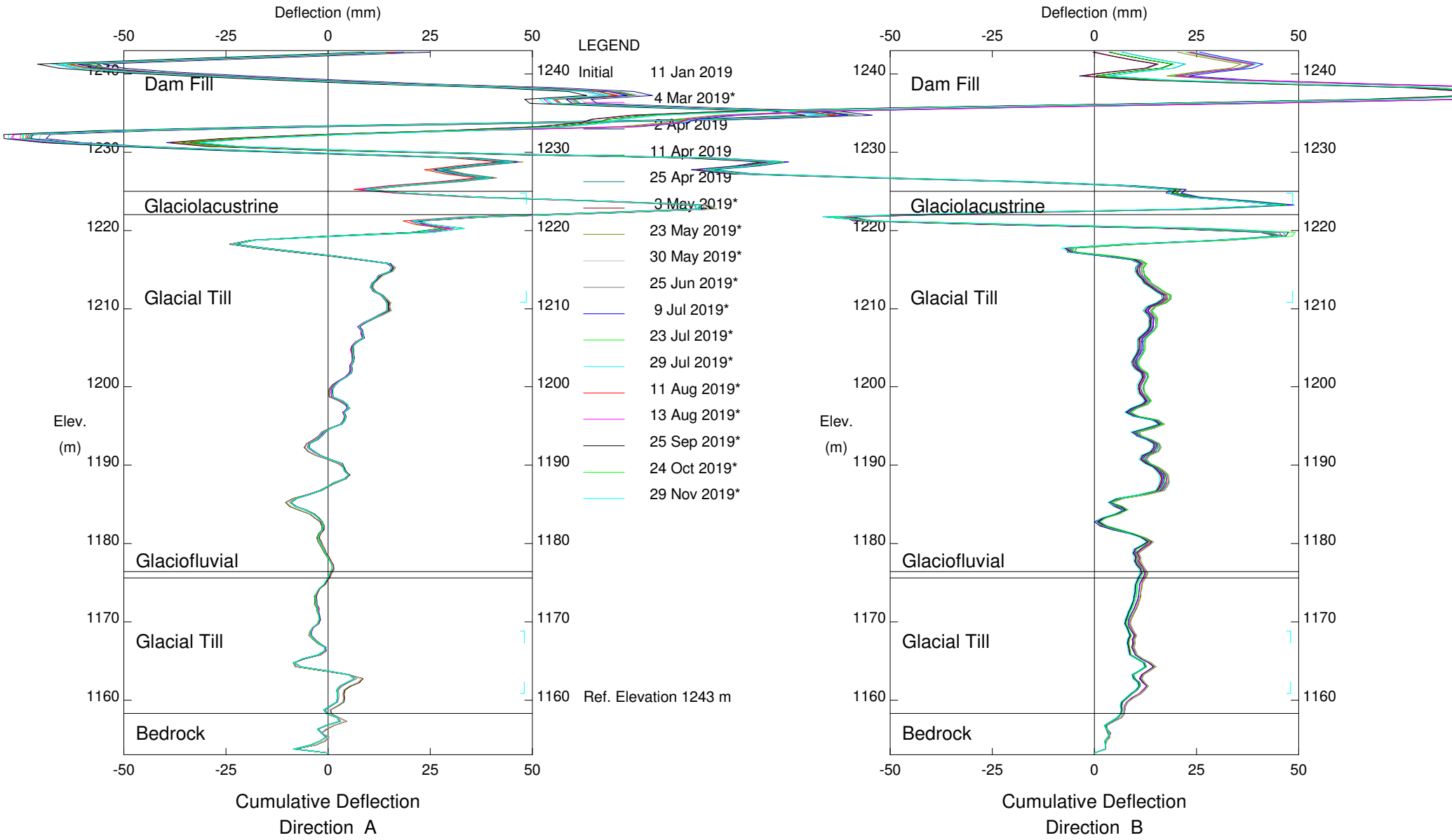
Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I16-5

Sets marked * include zero shift and/or rotation corrections.

Highland Valley Copper - Logan Lake, BC

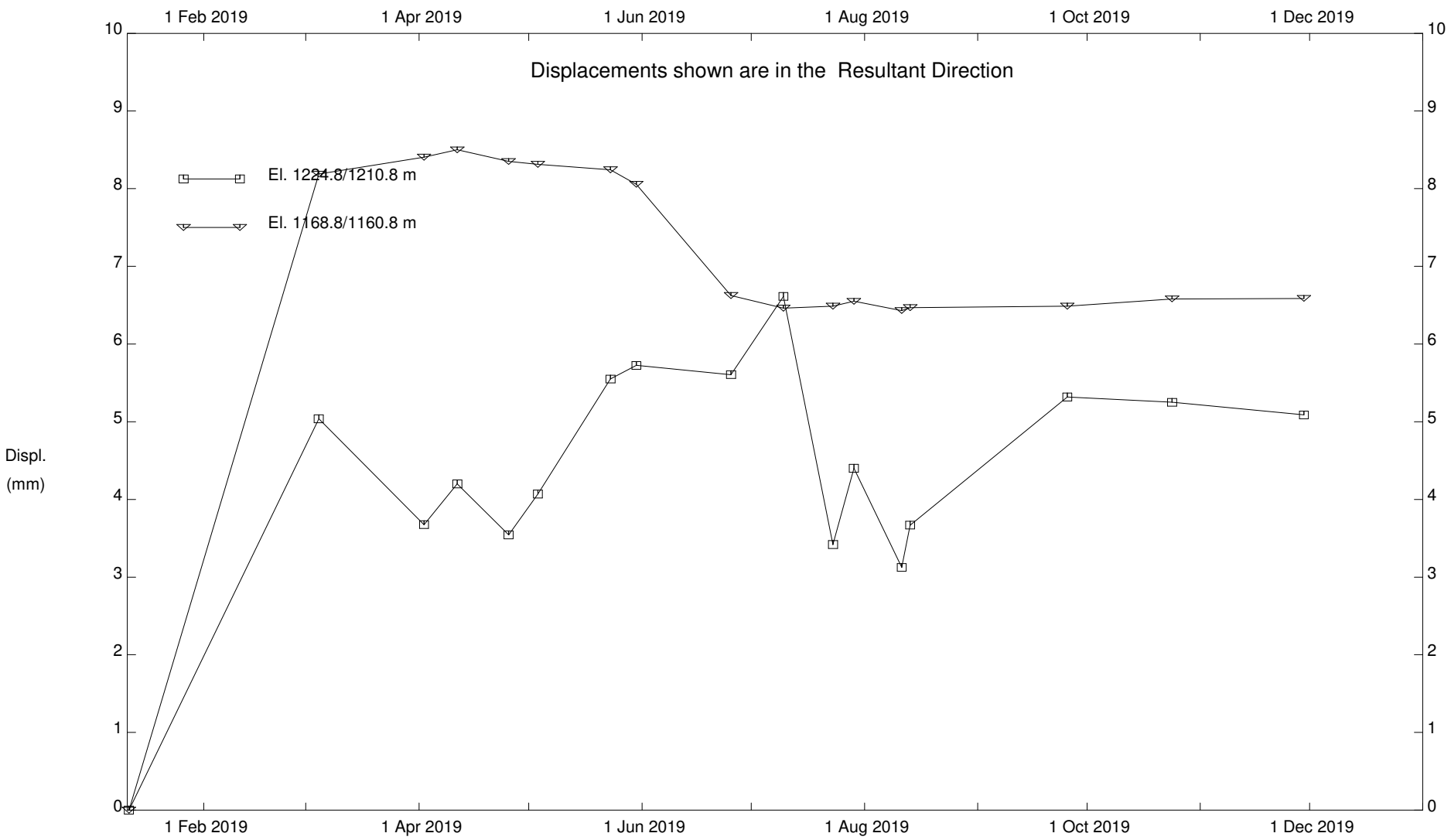


LL Dam, Inclinometer I16-5

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC

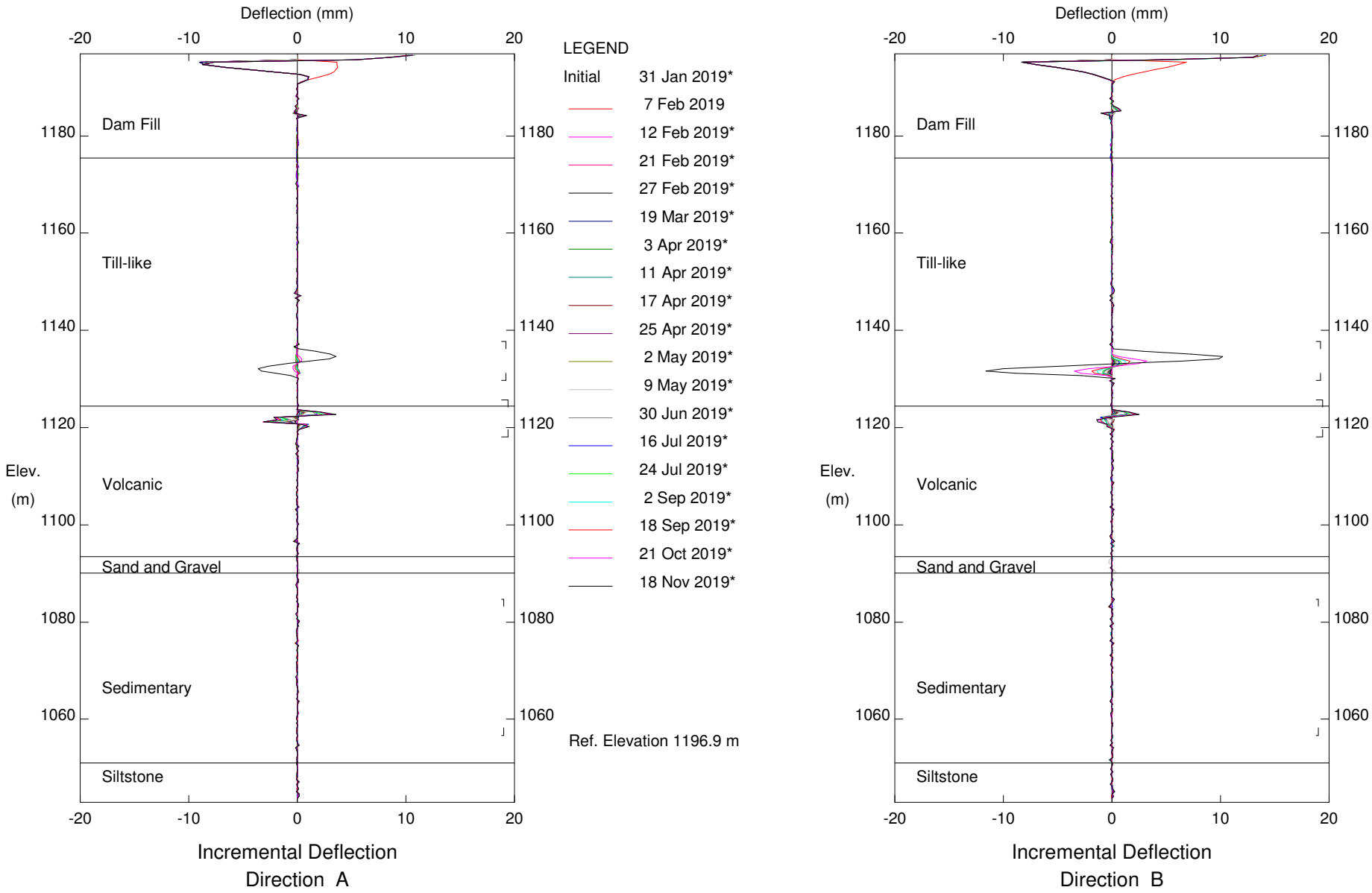


LL Dam, Inclinometer I16-5

NORTH DAM

I19-01

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I19-1

Sets marked * include zero shift and/or rotation corrections.

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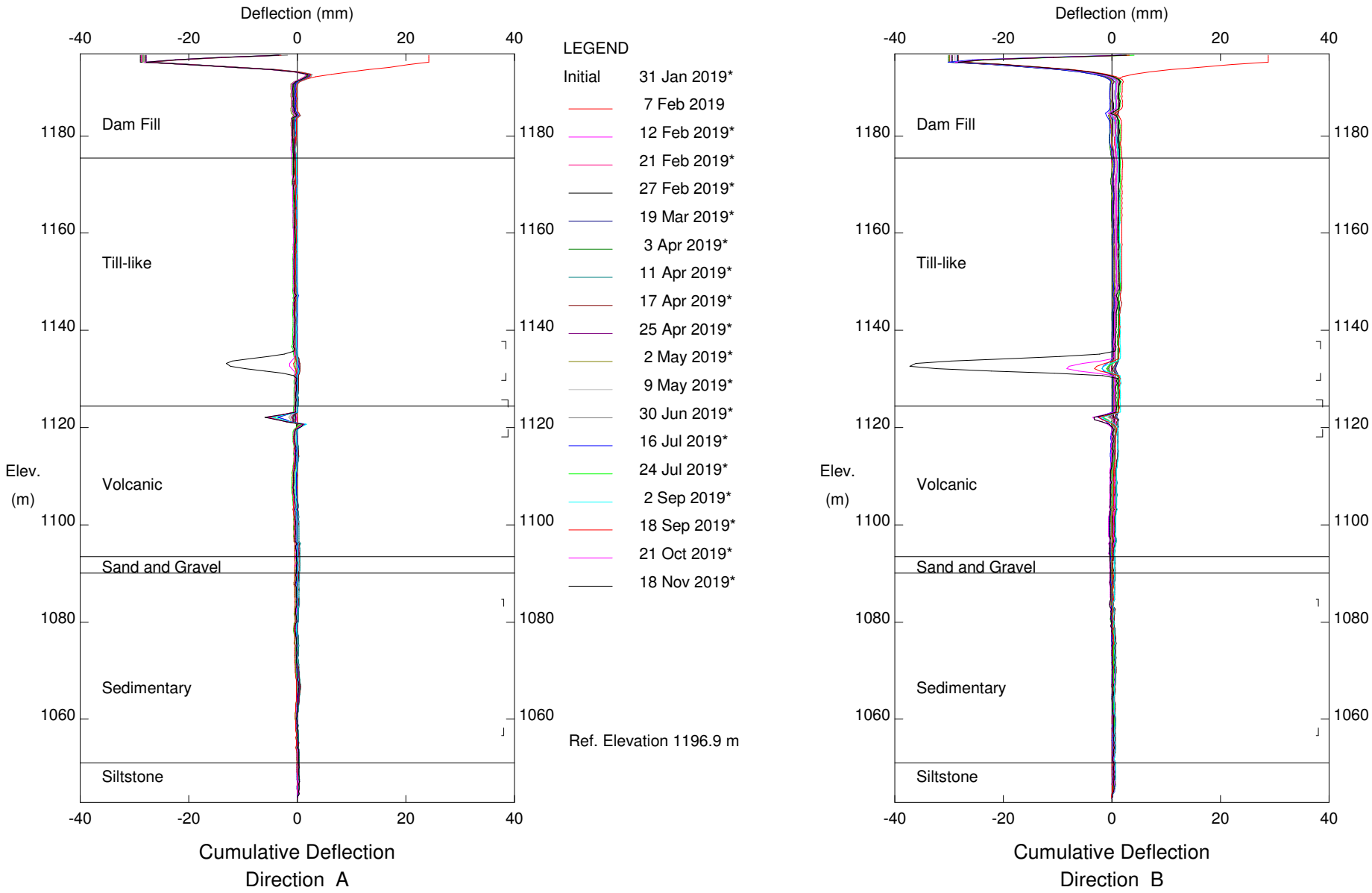
Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I19-1

Sets marked * include zero shift and/or rotation corrections.

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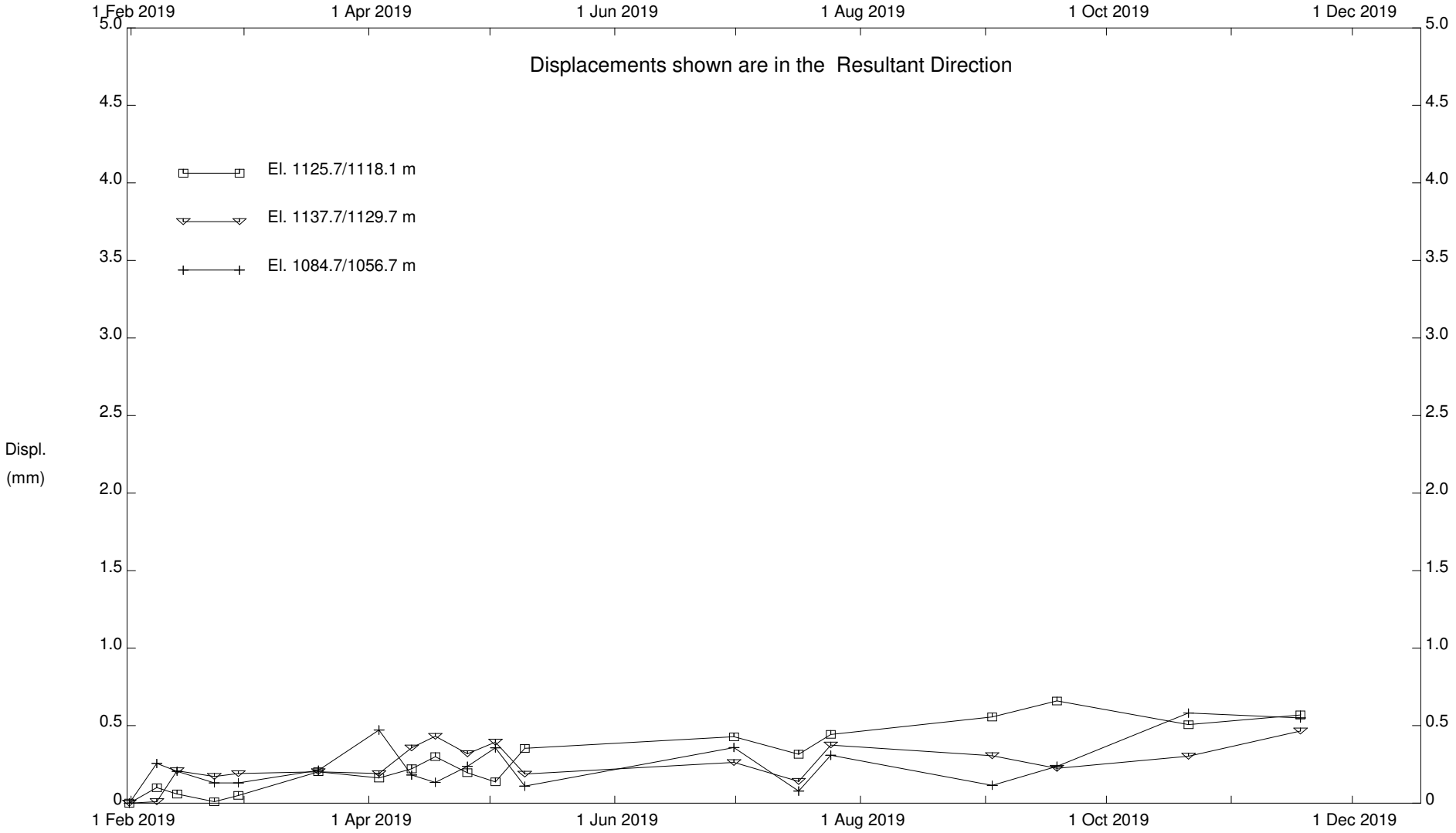
Highland Valley Copper - Logan Lake, BC

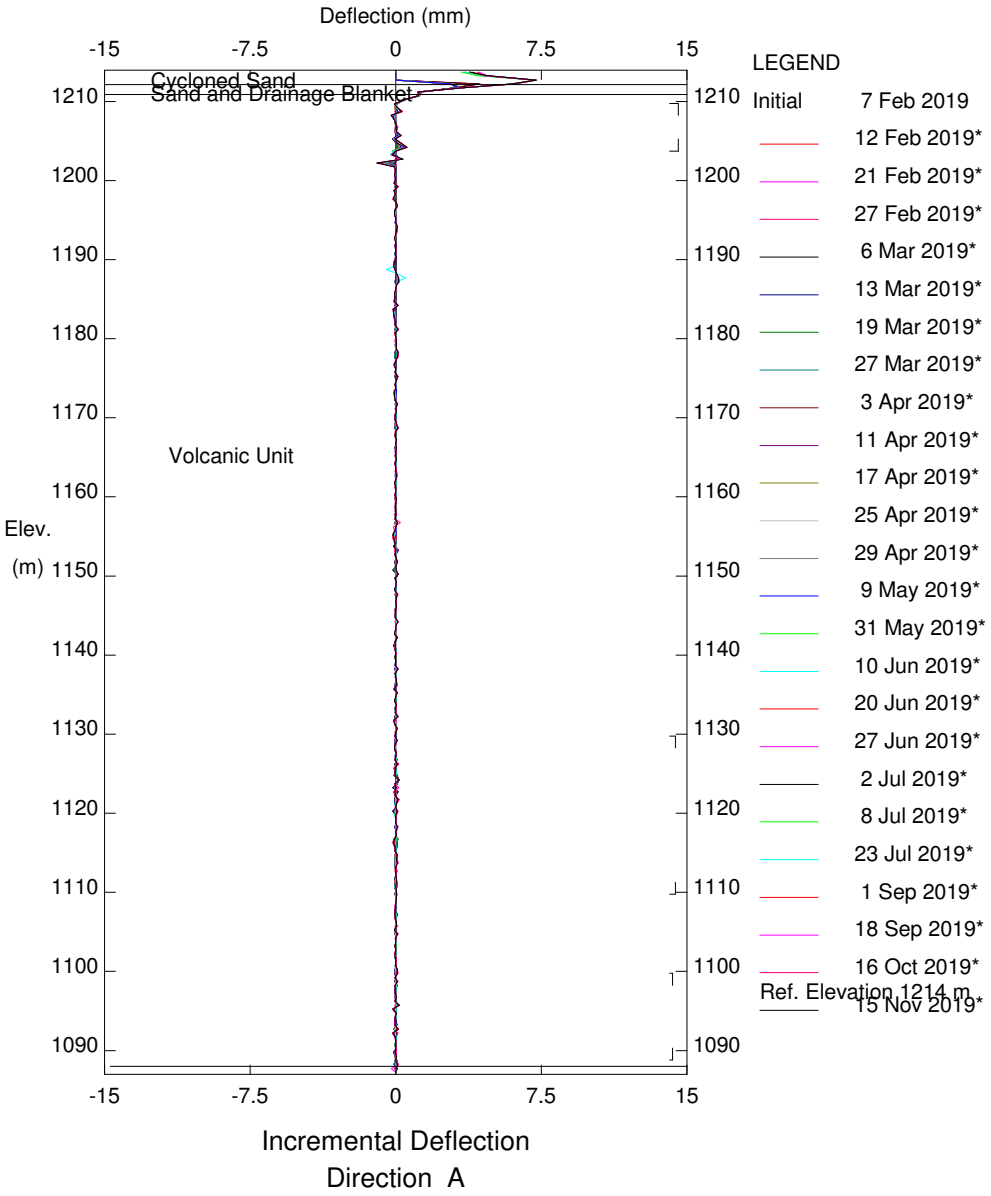


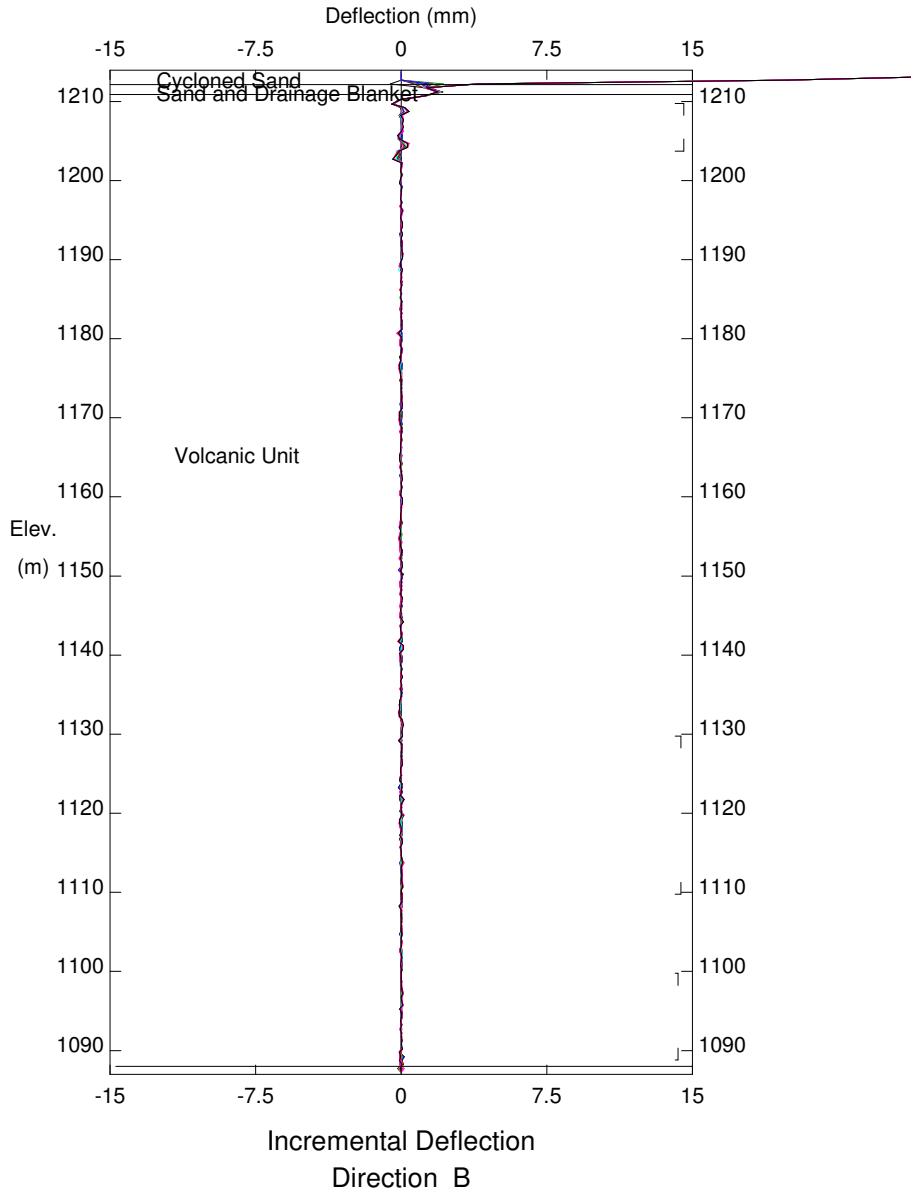
LL Dam, Inclinometer I19-1

NORTH DAM

I19-02

Highland Valley Copper - Logan Lake, BC





Dam Fill Excluded, Inclinometer 19-02

Sets marked * include zero shift and/or rotation corrections.

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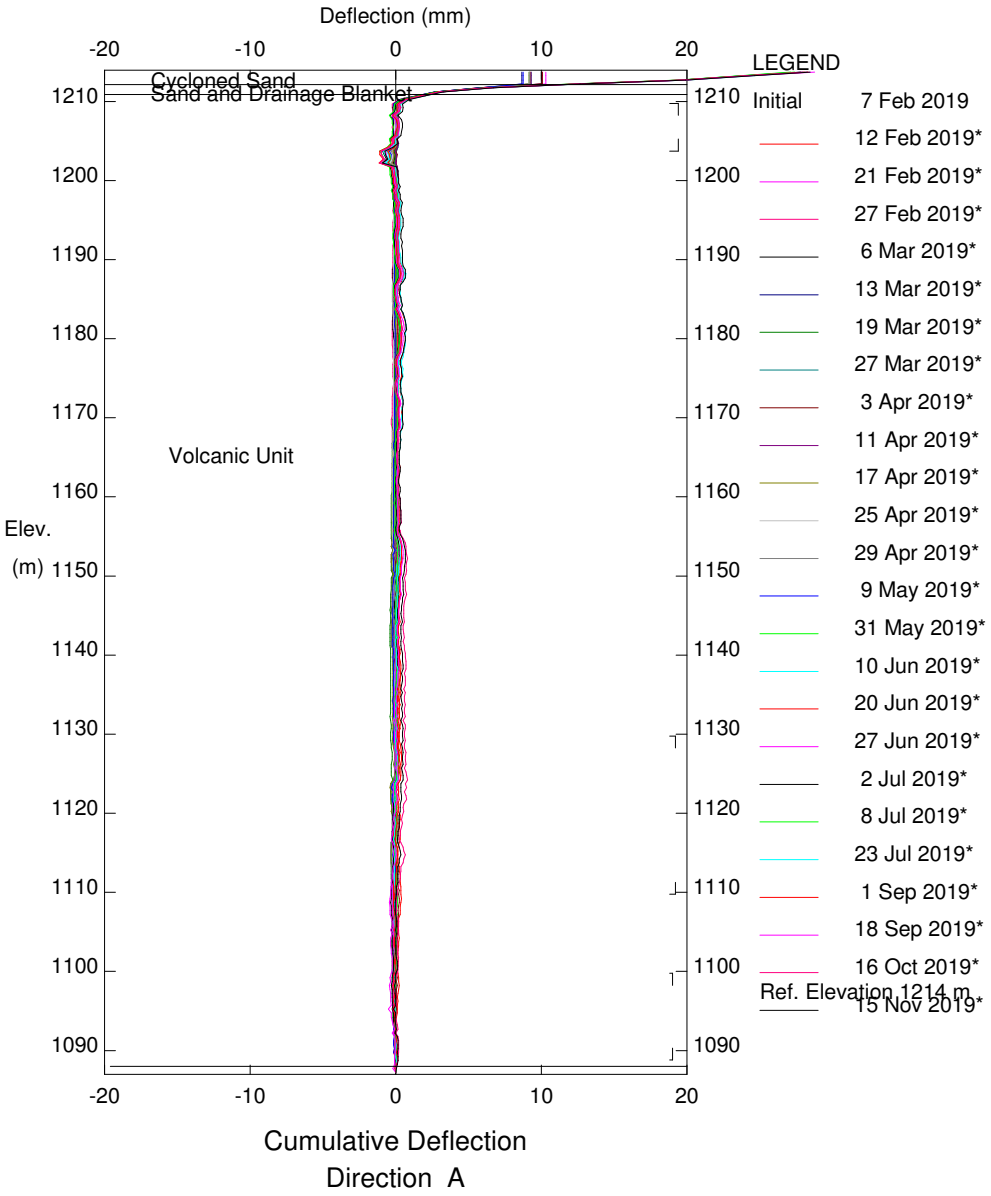
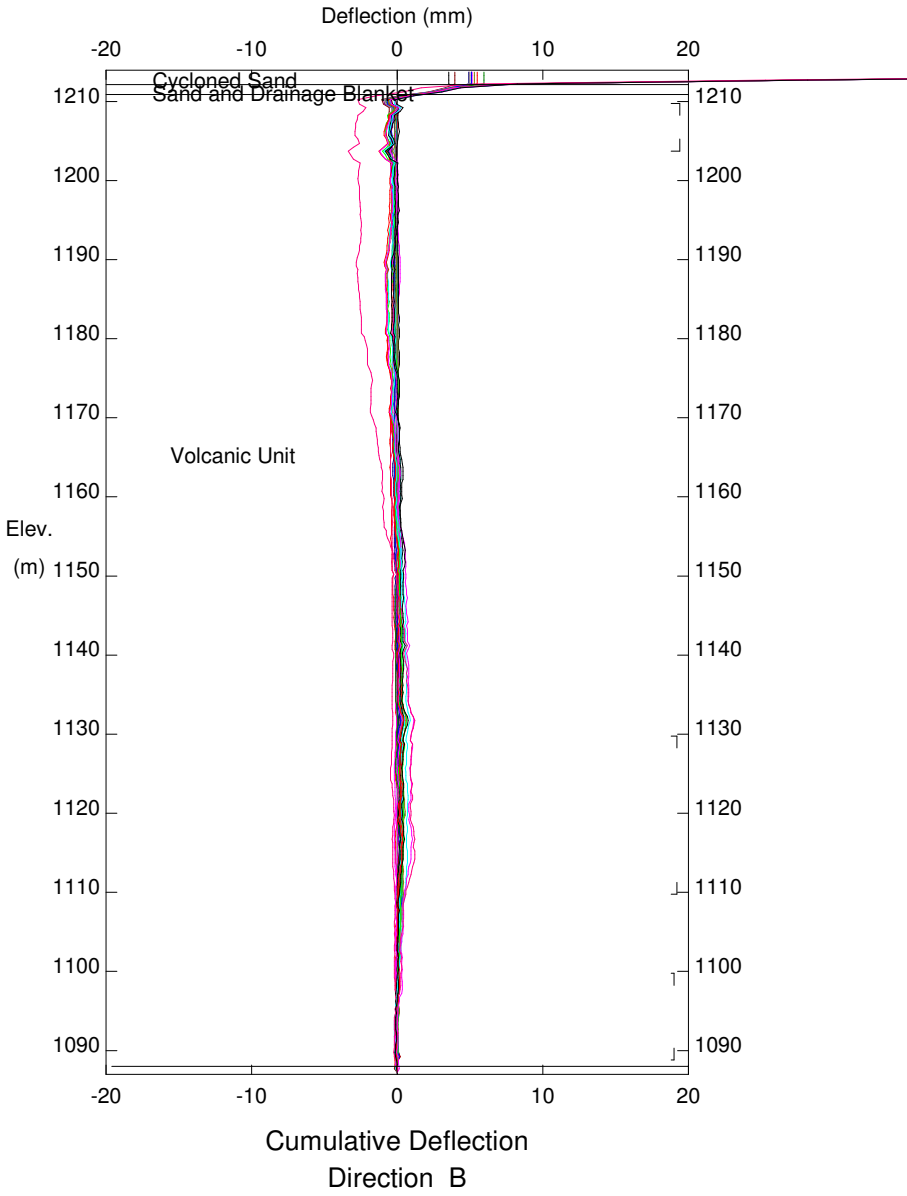
Highland Valley Copper - Logan Lake, BC



Cumulative Deflection
Direction A



Cumulative Deflection
Direction B

Dam Fill Excluded, Inclinometer 19-02

Sets marked * include zero shift and/or rotation corrections.

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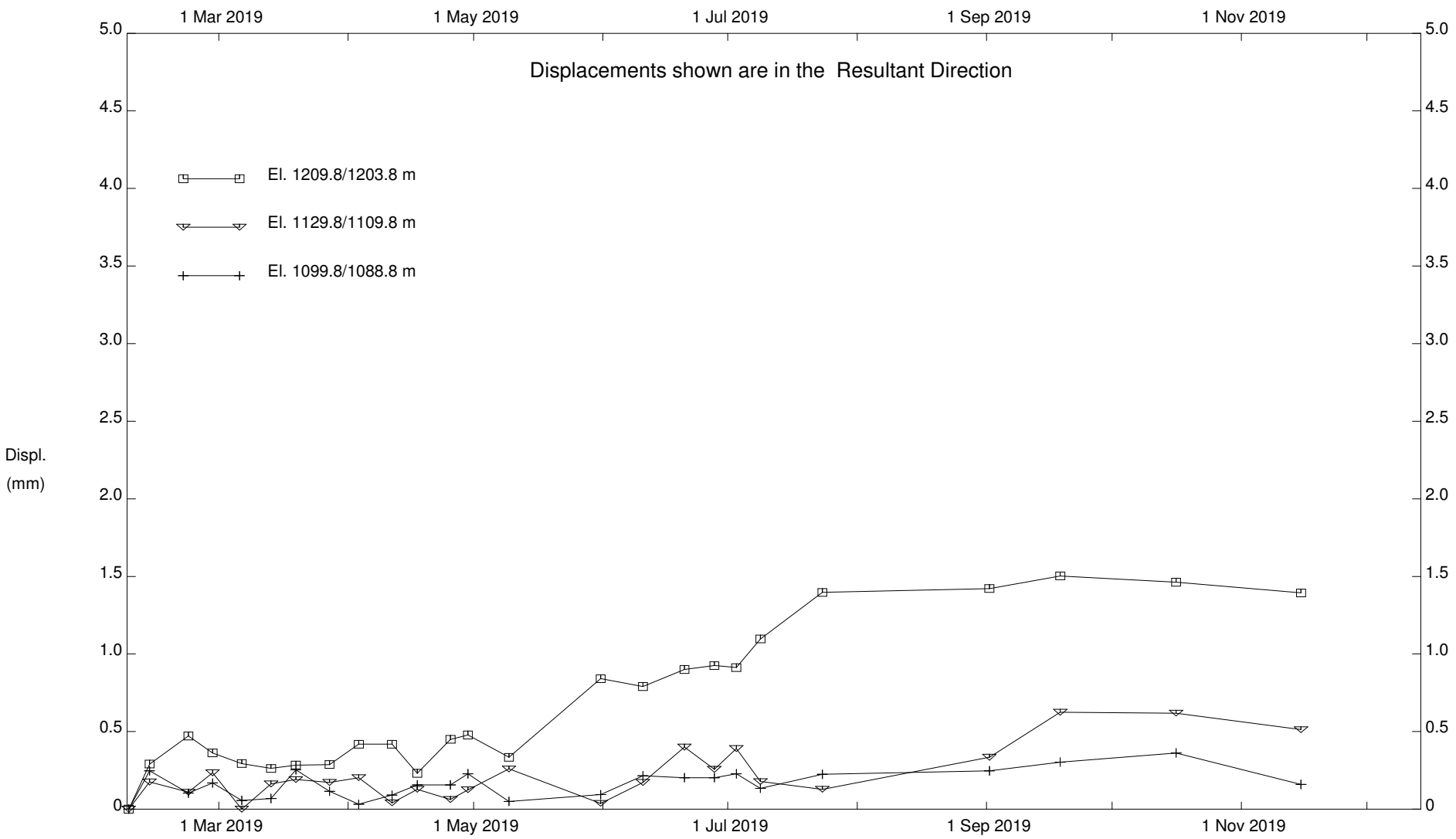
Highland Valley Copper - Logan Lake, BC

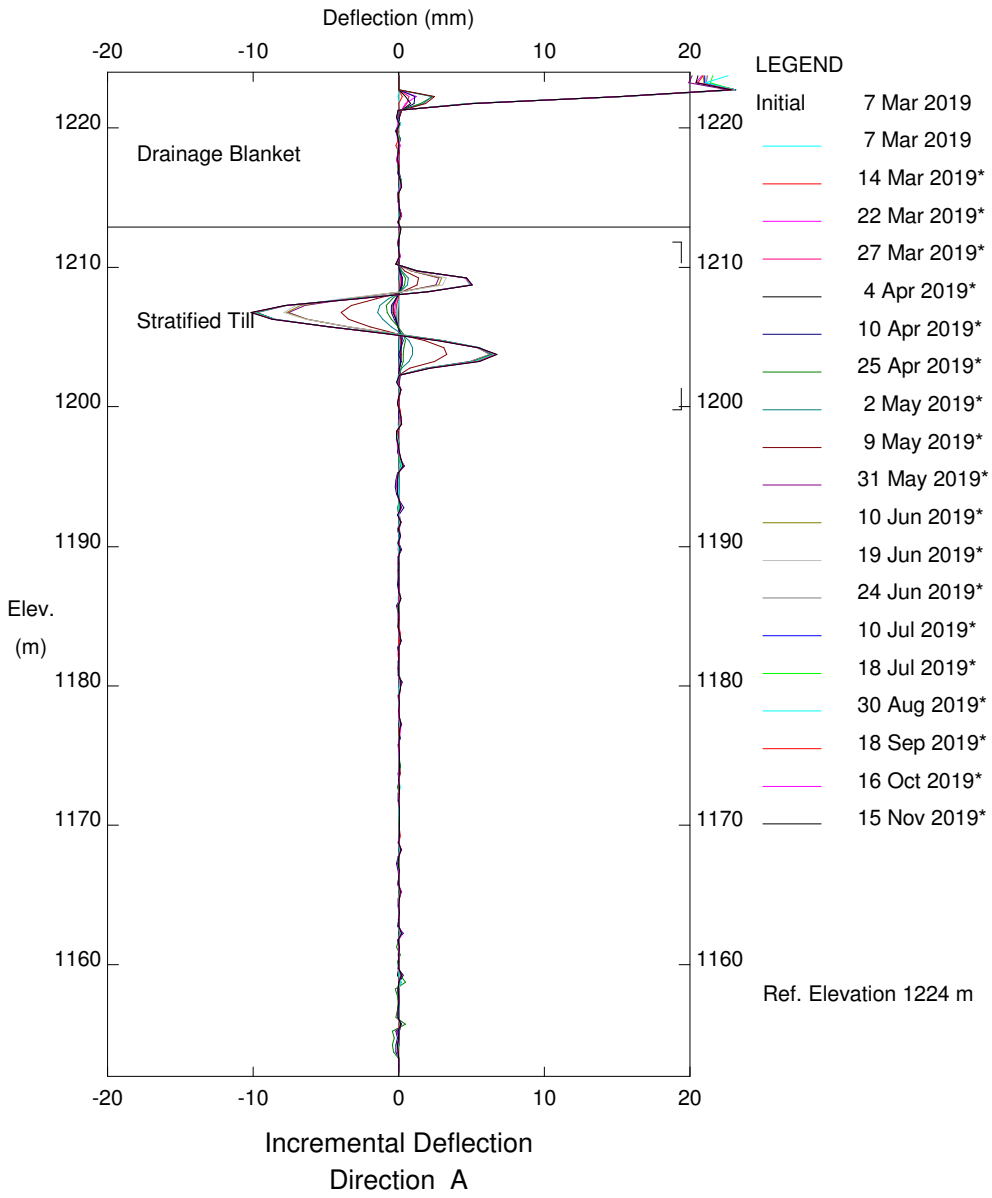


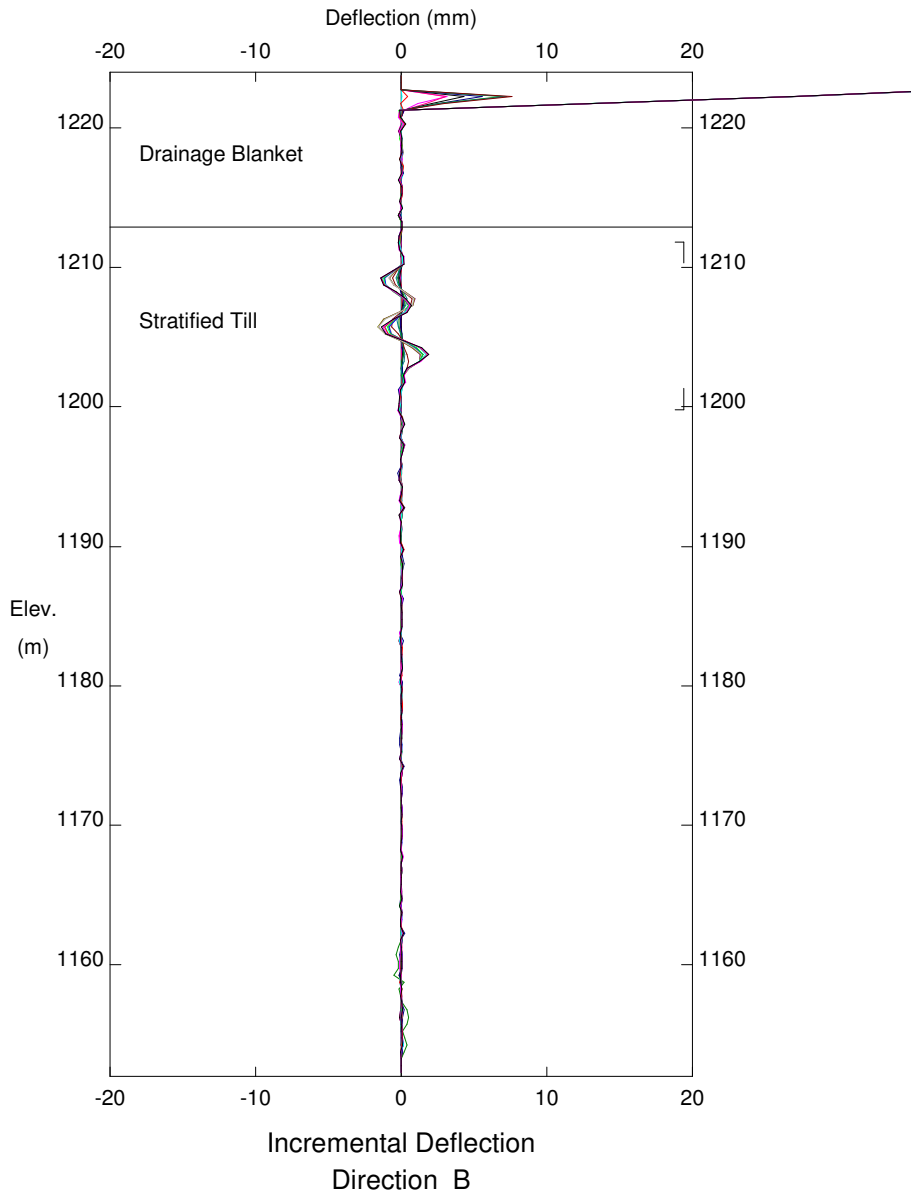
Dam Fill Excluded, Inclinometer 19-02

NORTH DAM

I19-03

Highland Valley Copper - Logan Lake, BC





Dam Fill Excluded, Inclinometer 19-3

Sets marked * include zero shift and/or rotation corrections.

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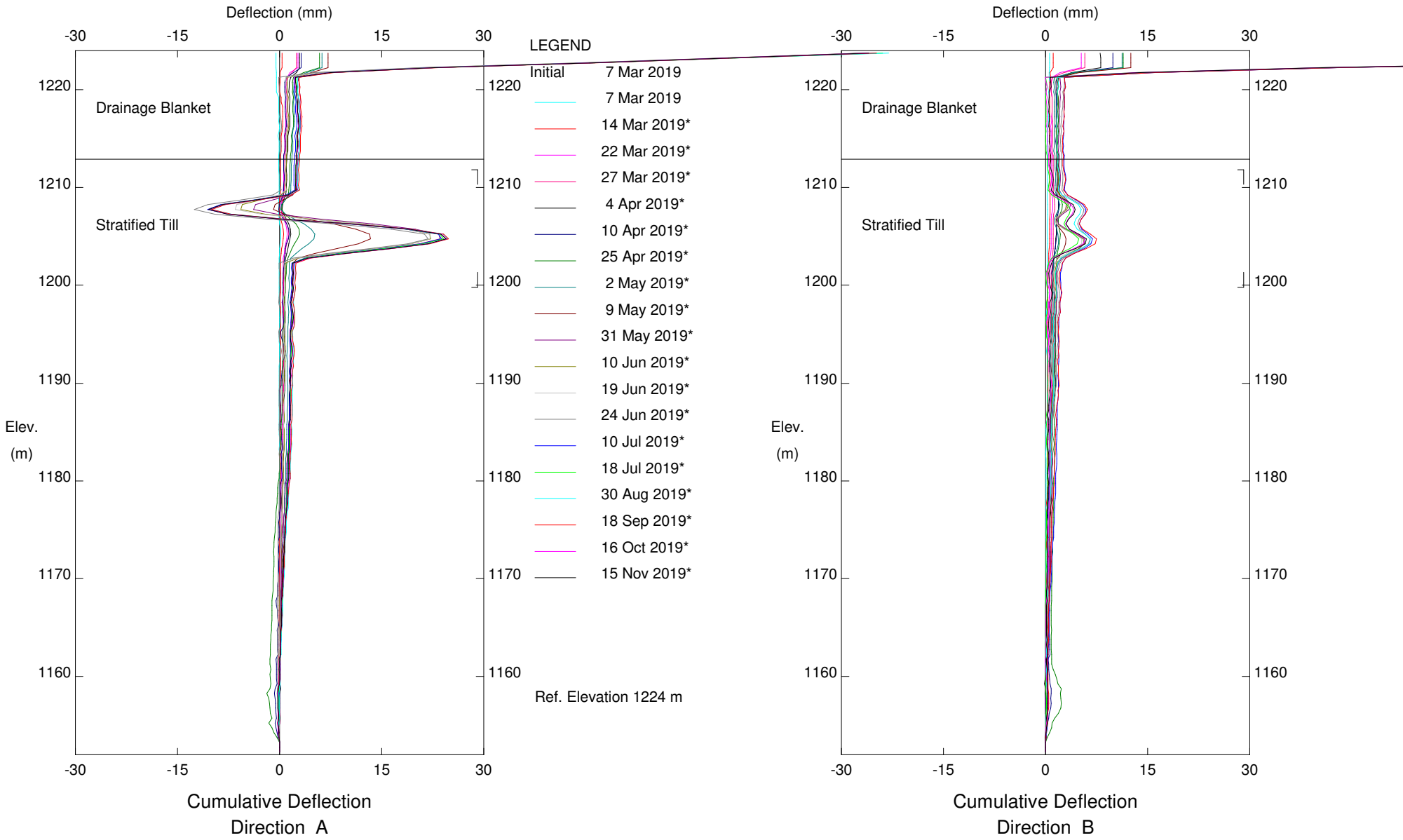
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer 19-3

Sets marked * include zero shift and/or rotation corrections.

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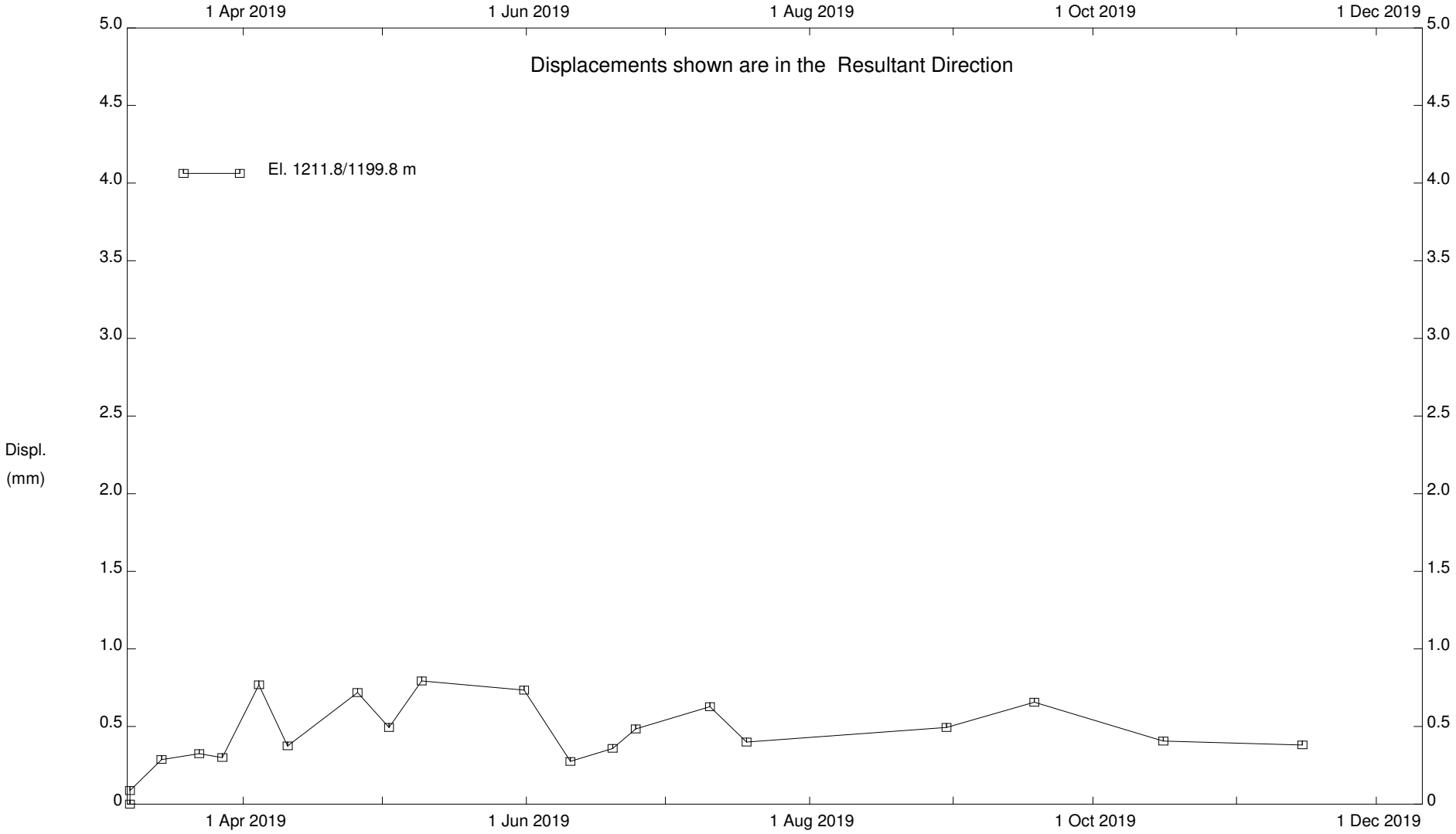
Highland Valley Copper - Logan Lake, BC

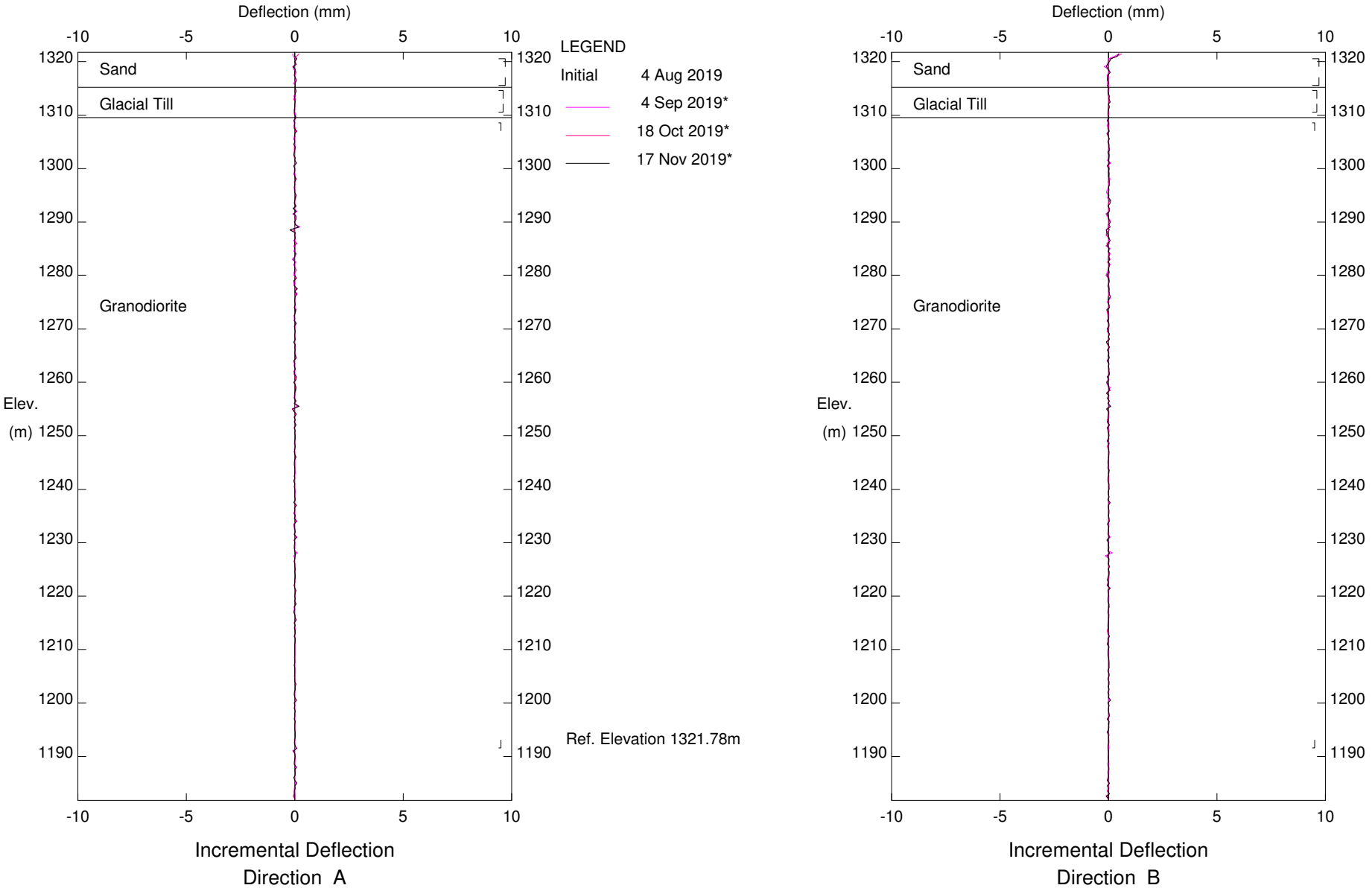


Dam Fill Excluded, Inclinometer 19-3

NORTH DAM

I19-08

Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I19-08

Sets marked * include zero shift and/or rotation corrections.

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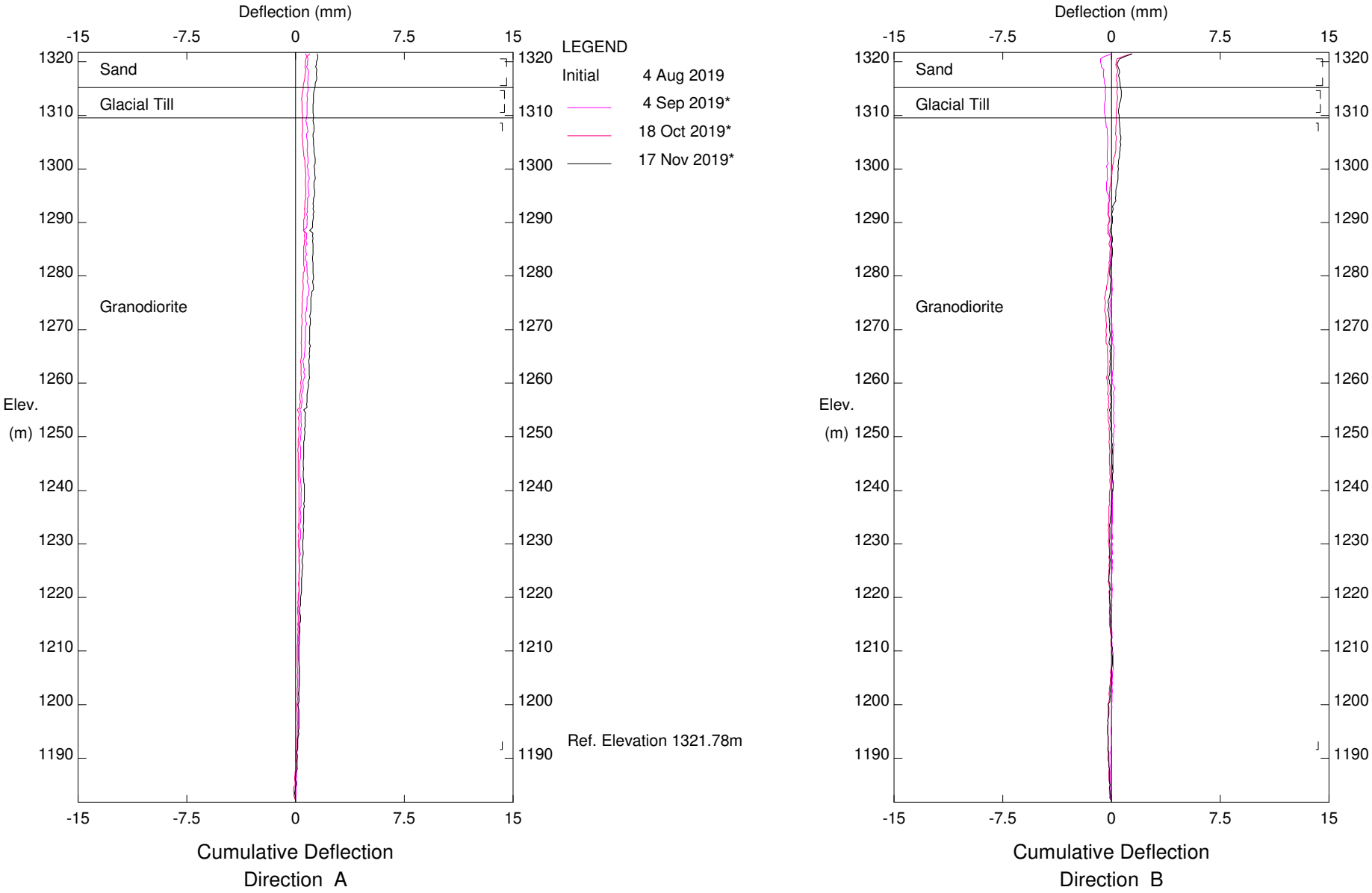
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I19-08

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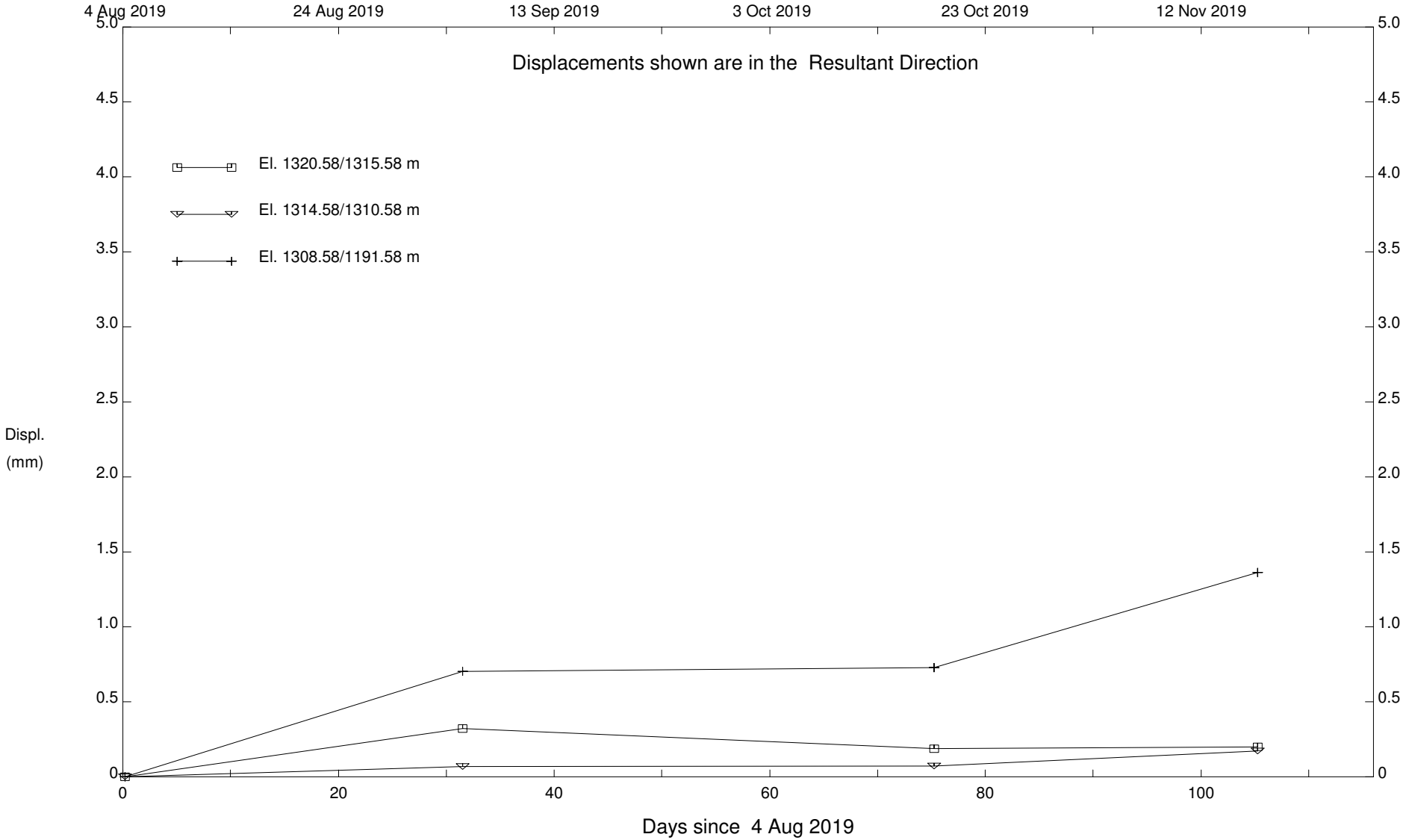
Highland Valley Copper - Logan Lake, BC

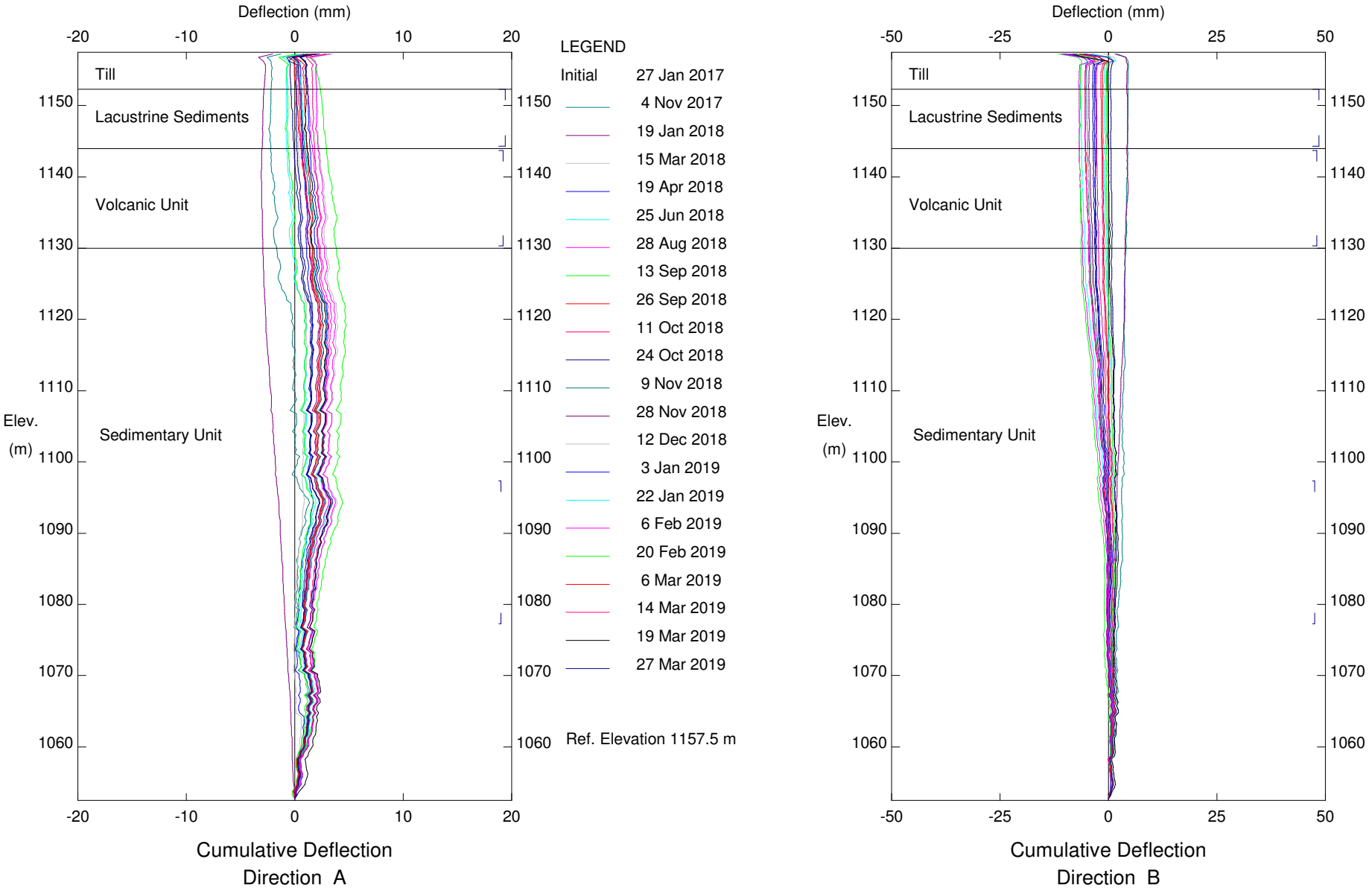


Dam Fill Excluded, Inclinometer I19-08

NORTH BUTTRESS BERM

I10-12

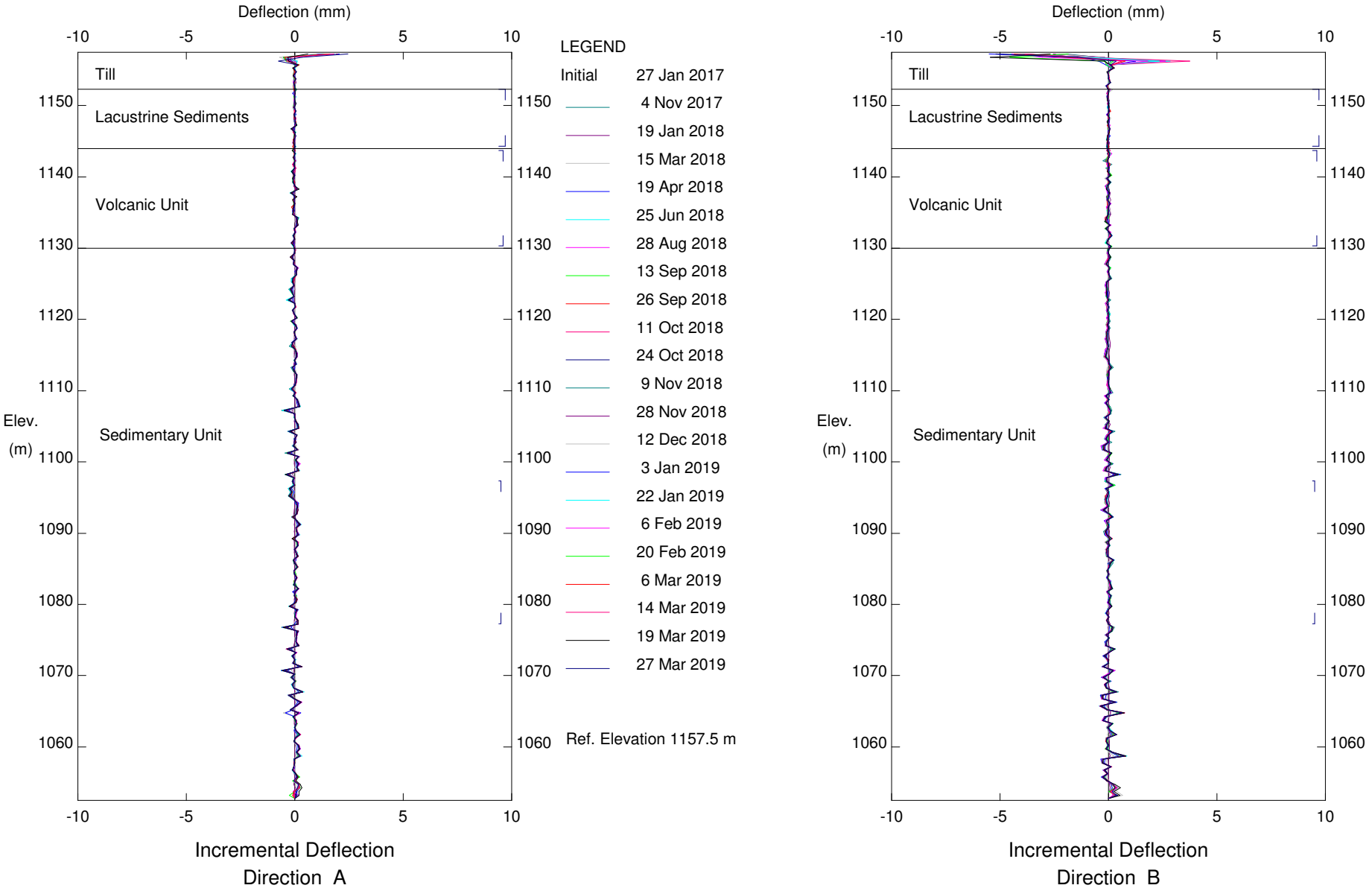
Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I10-12

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\I10-12.gtl

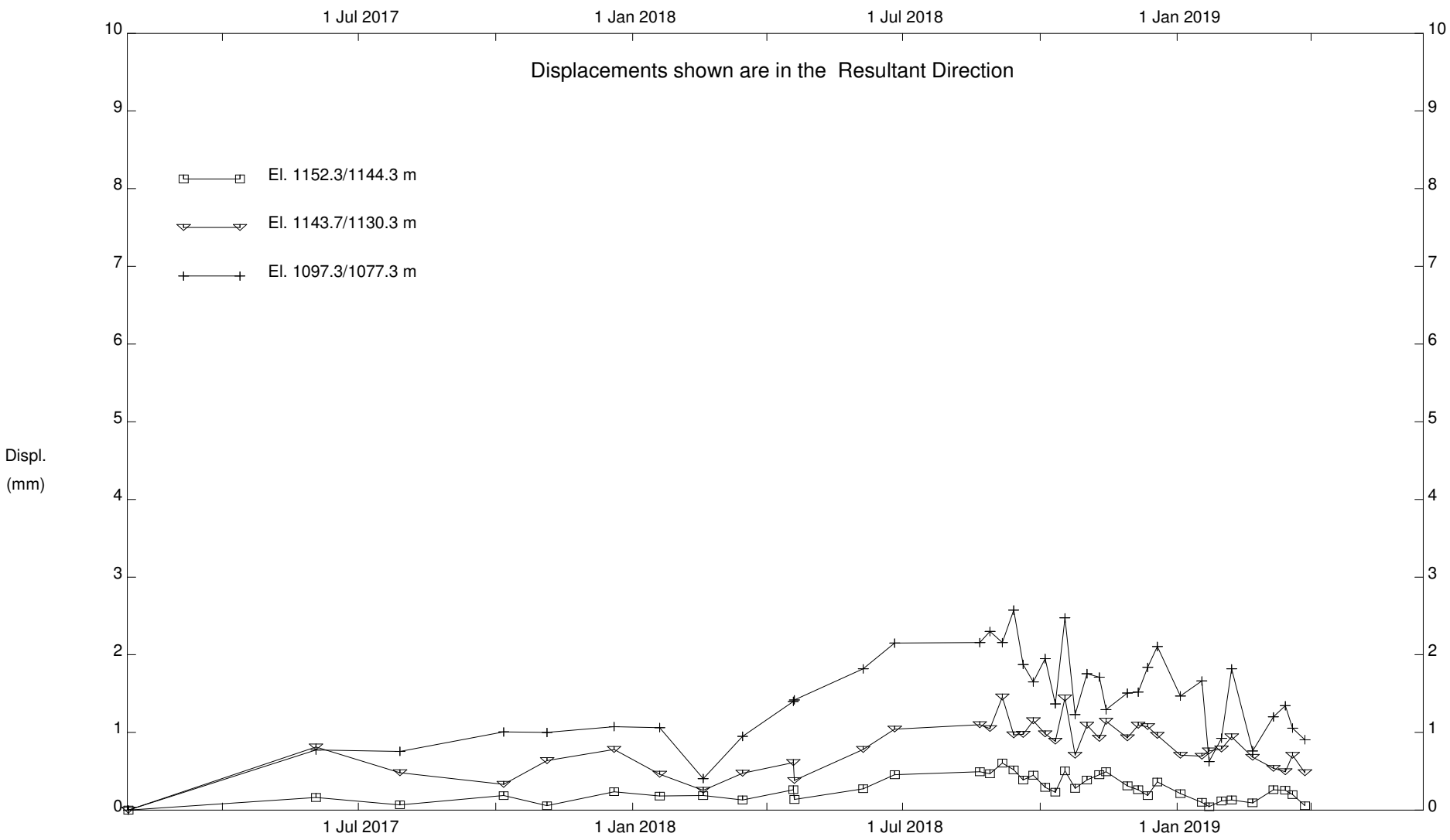
Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I10-12

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\I10-12.gtl

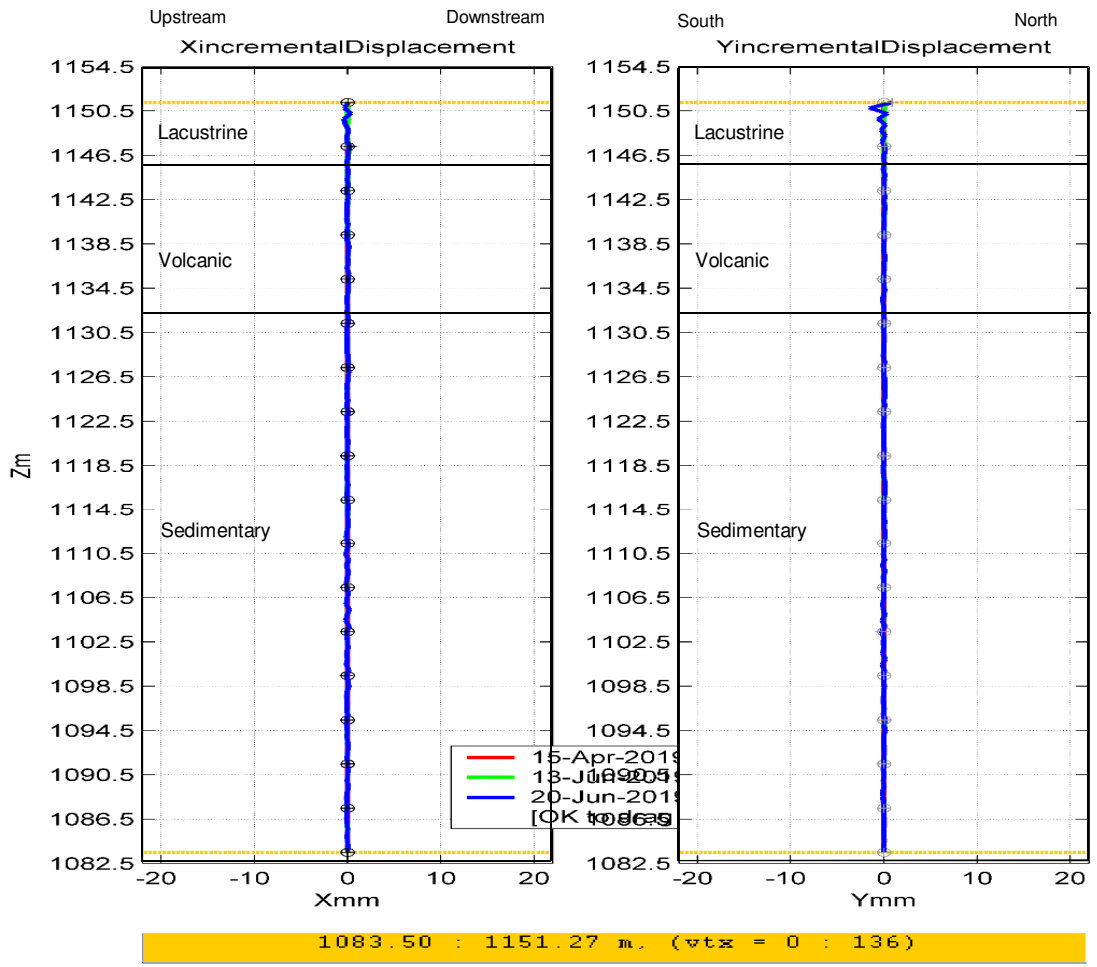
Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I10-12

Inclinometer I10-12

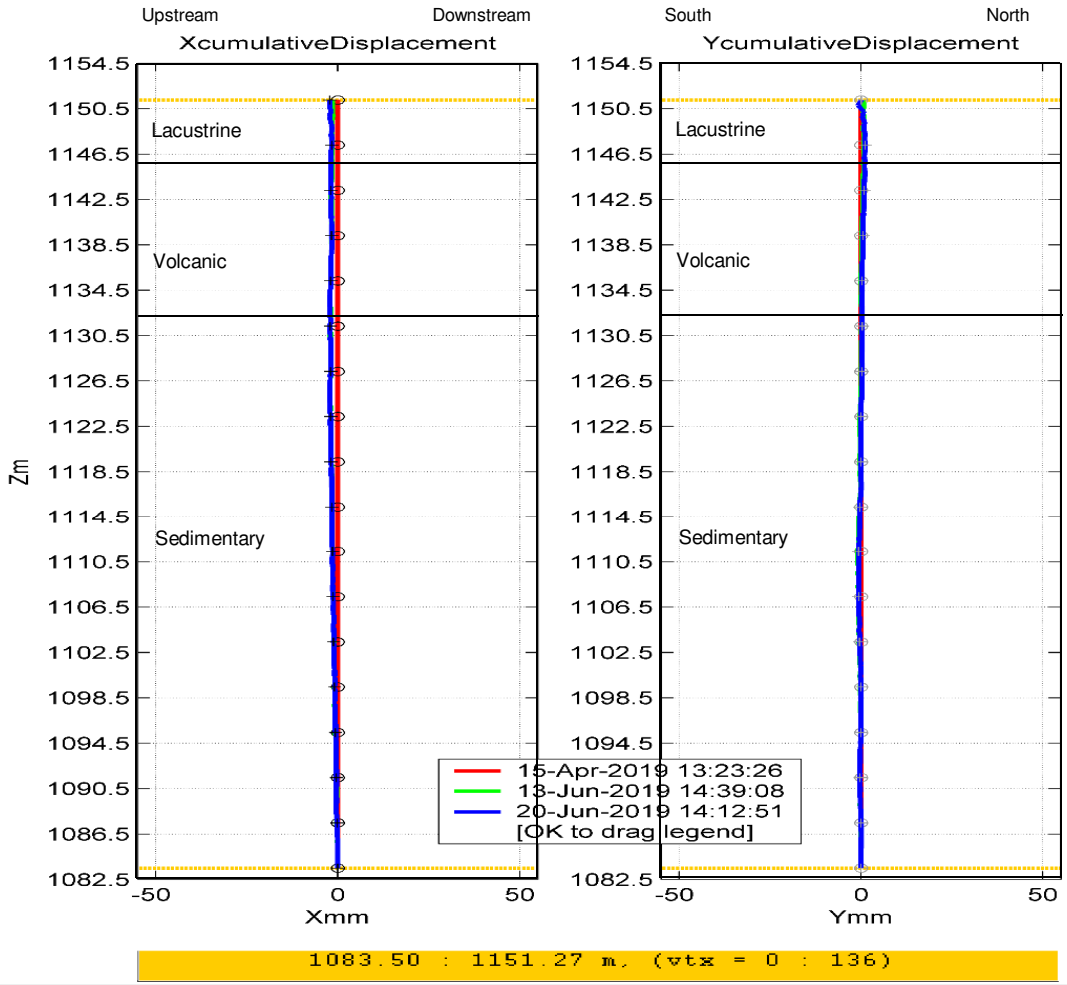
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-12	Lacustrine	1151.3	1144	0	8
	Volcanic	1143.8	1130.3	8	21
	Sedimentary	1097	1083.5	55	68

Inclinometer I10-12

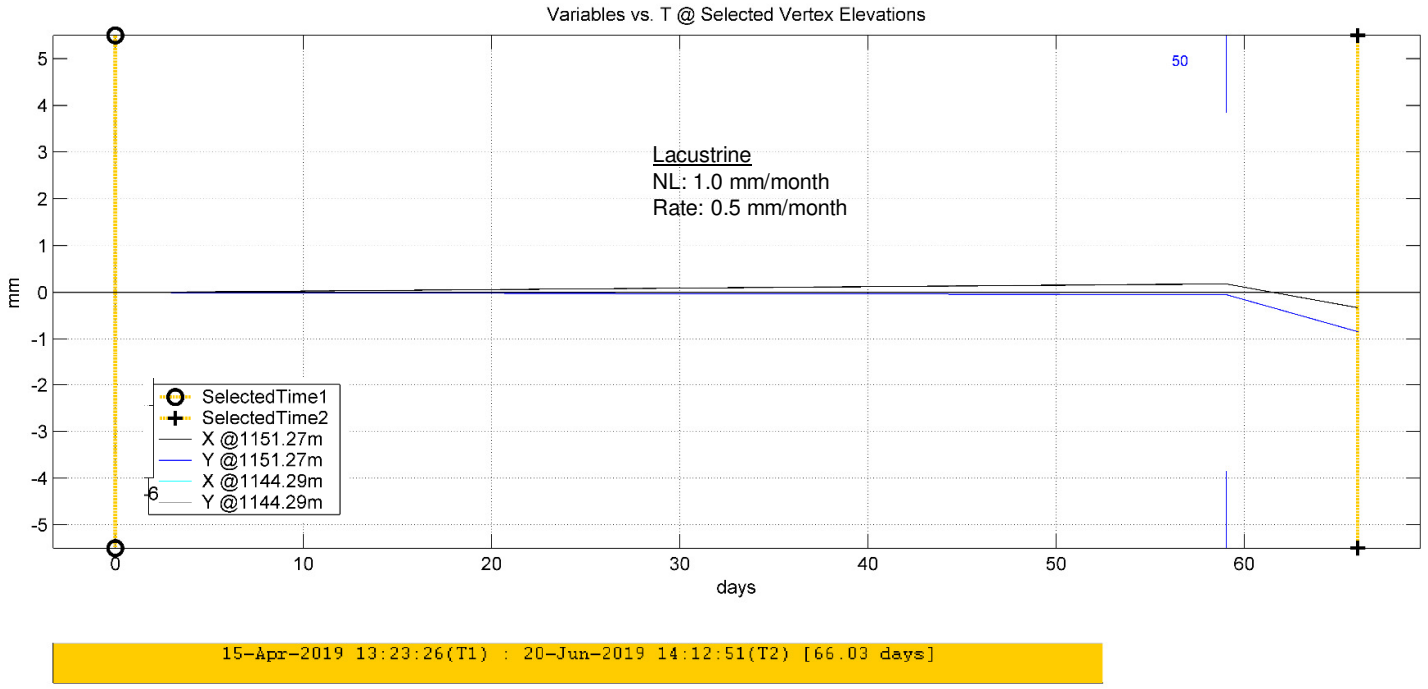
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-12	Lacustrine	1151.3	1144	0	8
	Volcanic	1143.8	1130.3	8	21
	Sedimentary	1097	1083.5	55	68

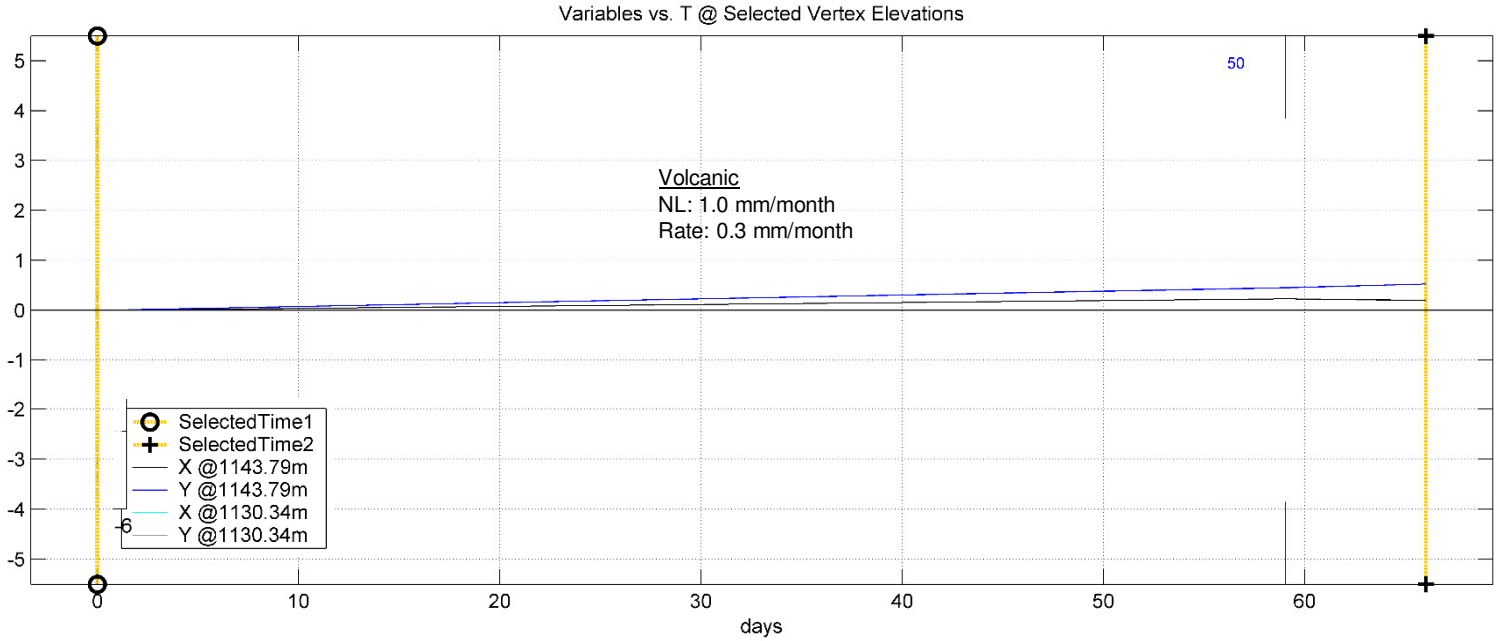
Inclinometer I10-12

Time Displacement Plot – Lacustrine



Inclinometer I10-12

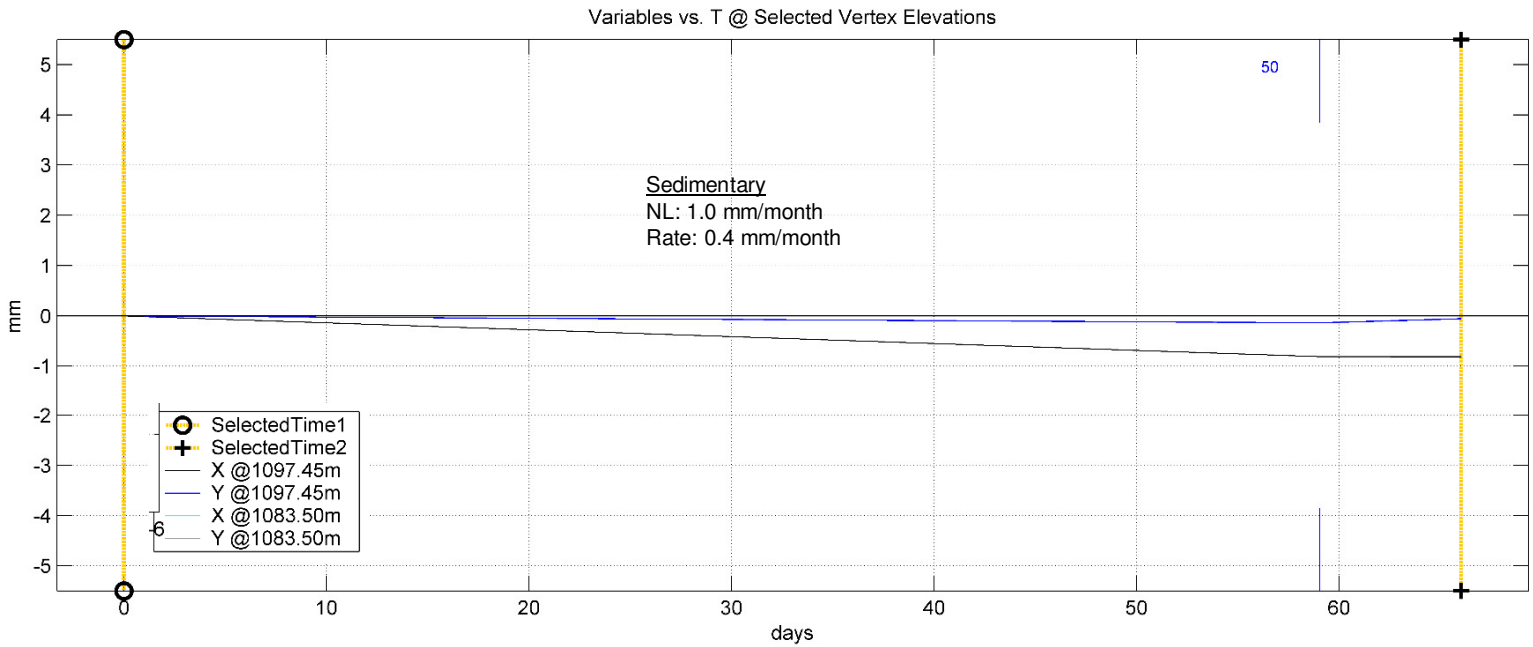
Time Displacement Plot – Volcanic



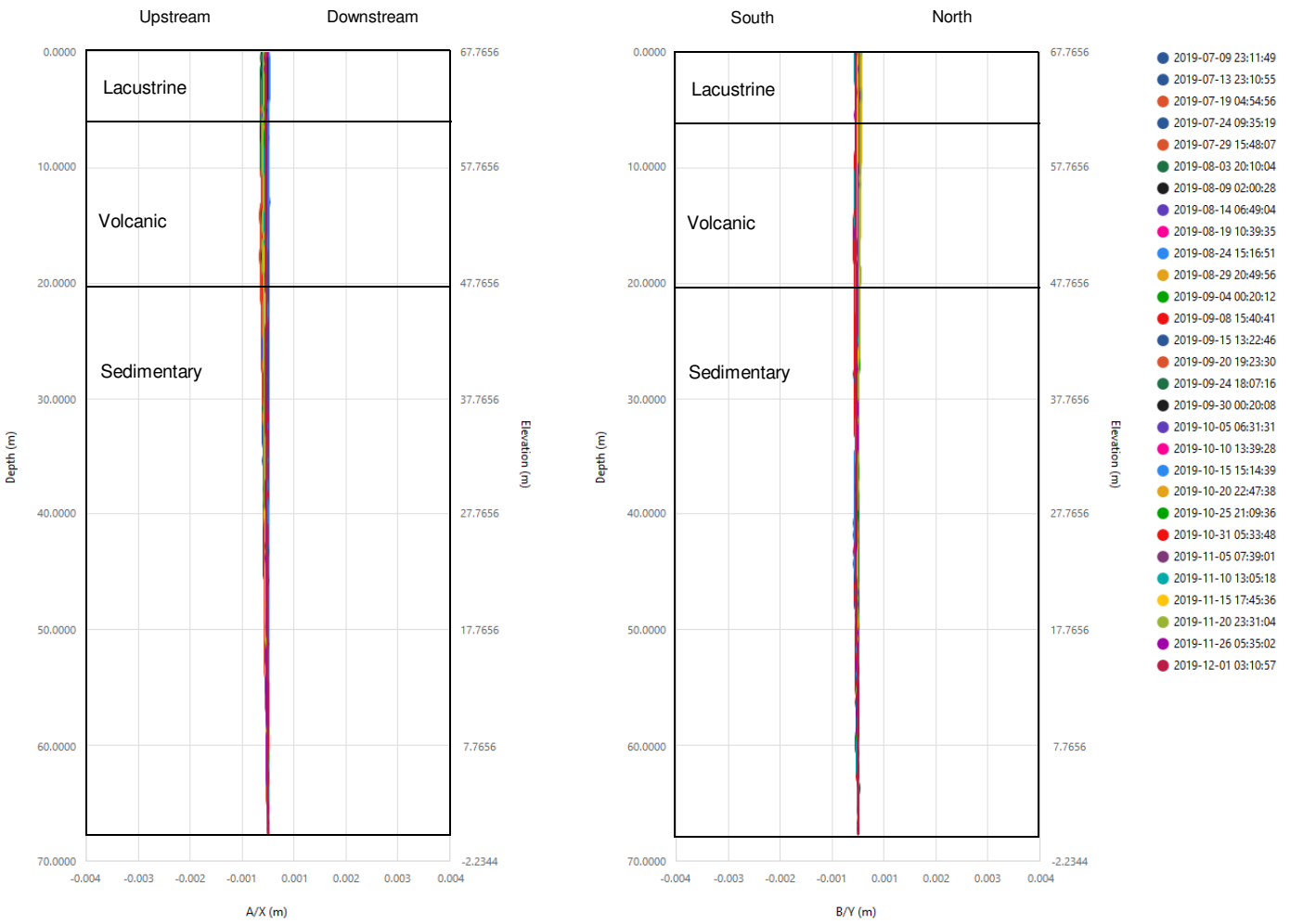
15-Apr-2019 13:23:26(T1) : 20-Jun-2019 14:12:51(T2) [66.03 days]

Inclinometer I10-12

Time Displacement Plot – Sedimentary

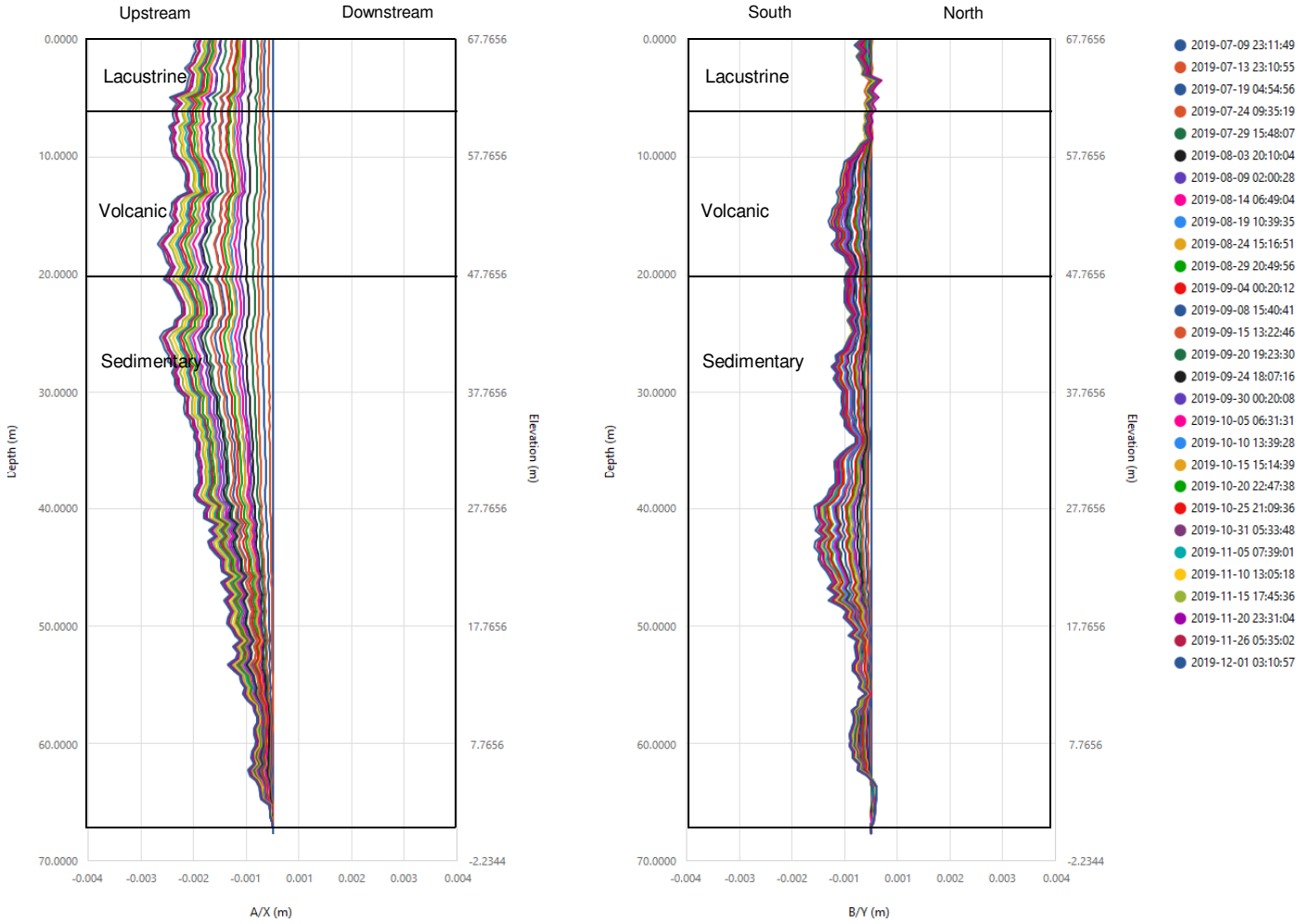


SAAV I10-12
Incremental plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-12	Lacustrine	1151.3	1144	0	8
	Volcanic	1143.8	1130.3	8	21
	Sedimentary	1097	1083.5	55	68

SAAV I10-12
Cumulative Plot



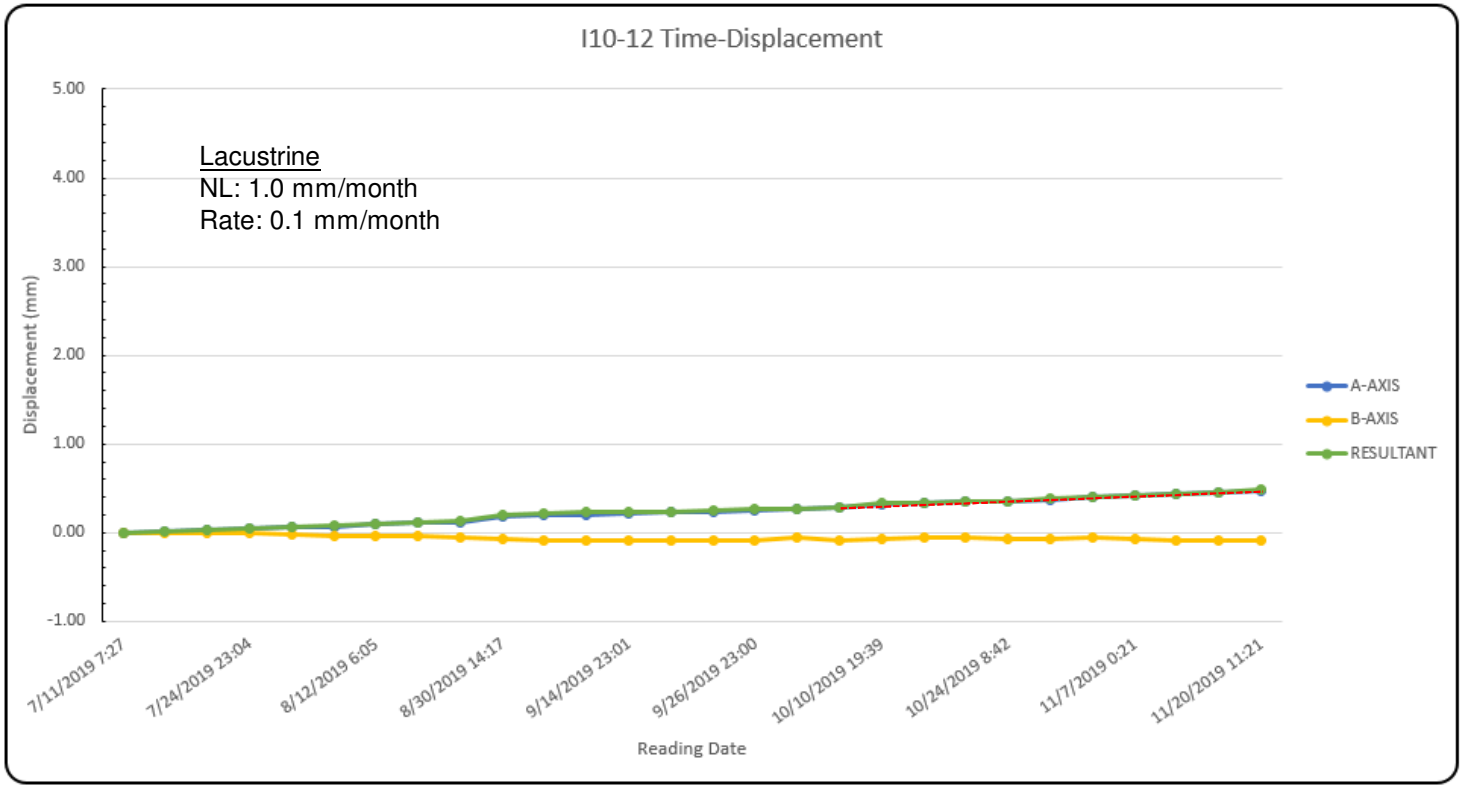
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-12	Lacustrine	1151.3	1144	0	8
	Volcanic	1143.8	1130.3	8	21
	Sedimentary	1097	1083.5	55	68

SAAV I10-12

Displacement Plot – Lacustrine

Unit	Upper Depth	Lower Depth
Lacustrine	0	8
Volcanic	8	21
Sedimentary	55	68

Upper Depth	0.0 m
Lower Depth	8.0 m

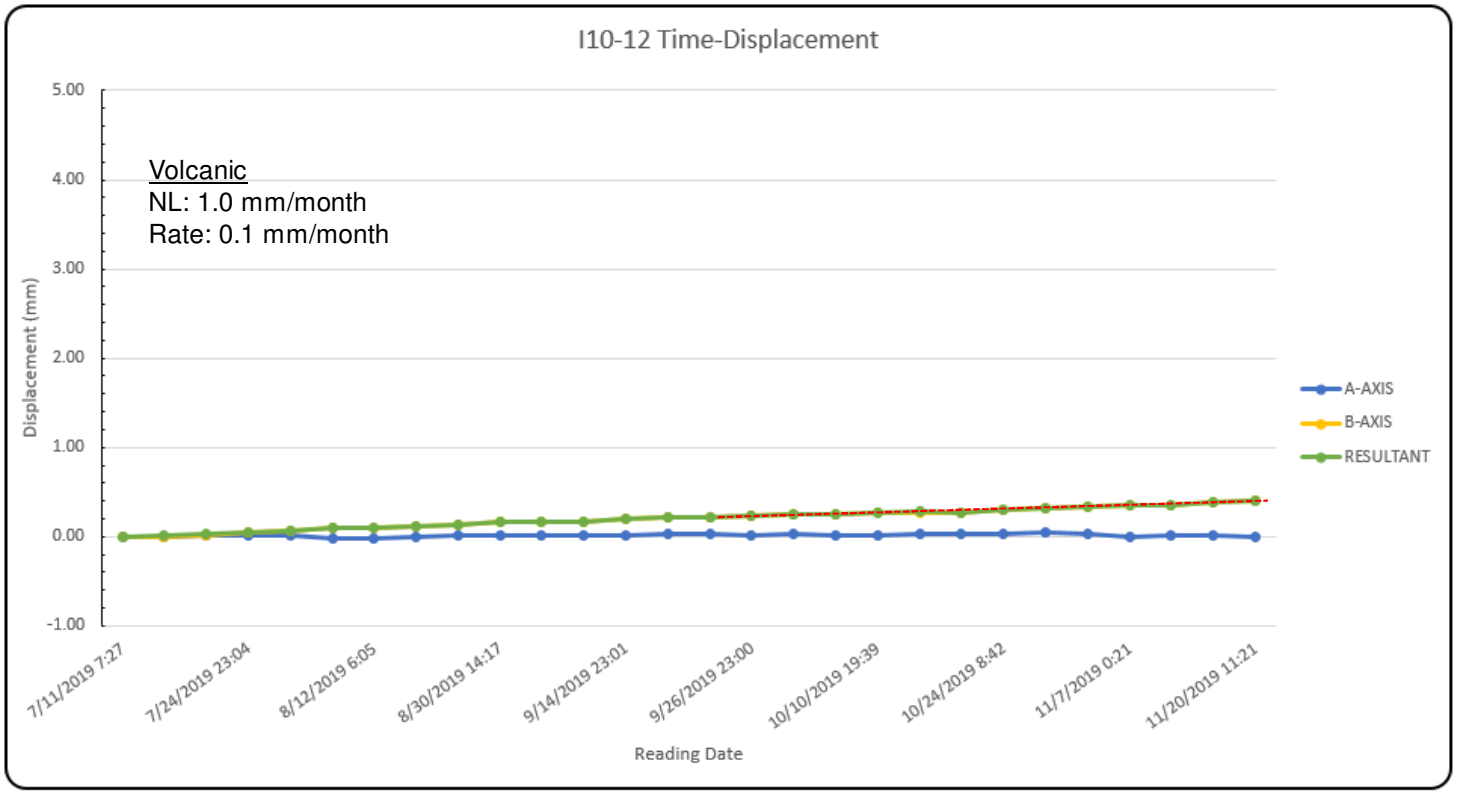


SAAV I10-12

Displacement Plot – Volcanic

Unit	Upper Depth	Lower Depth
Lacustrine	0	8
Volcanic	8	21
Sedimentary	55	68

Upper Depth	8.0 m
Lower Depth	21.0 m

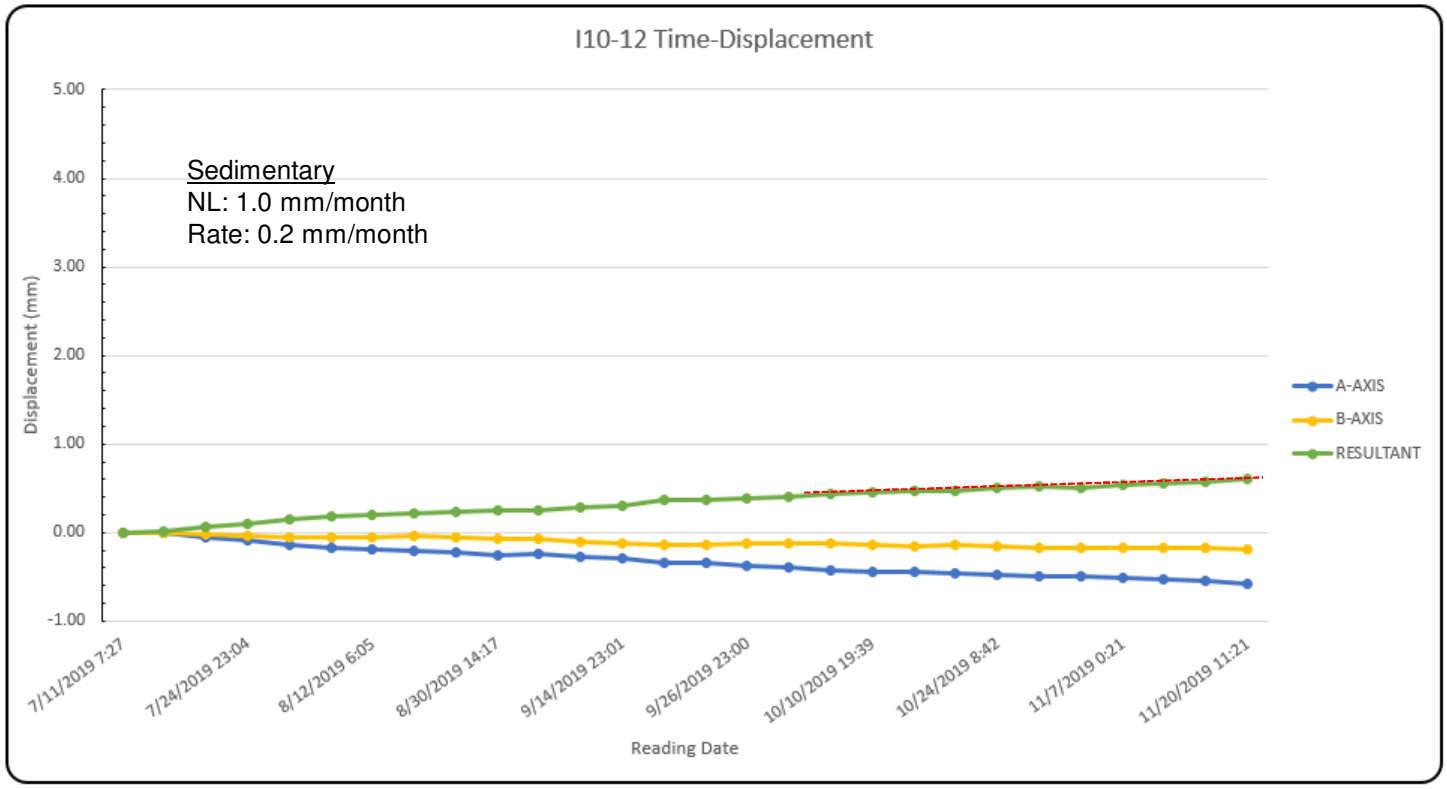


SAAV I10-12

Displacement Plot – Sedimentary

Unit	Upper Depth	Lower Depth
Lacustrine	0	8
Volcanic	8	21
Sedimentary	55	68

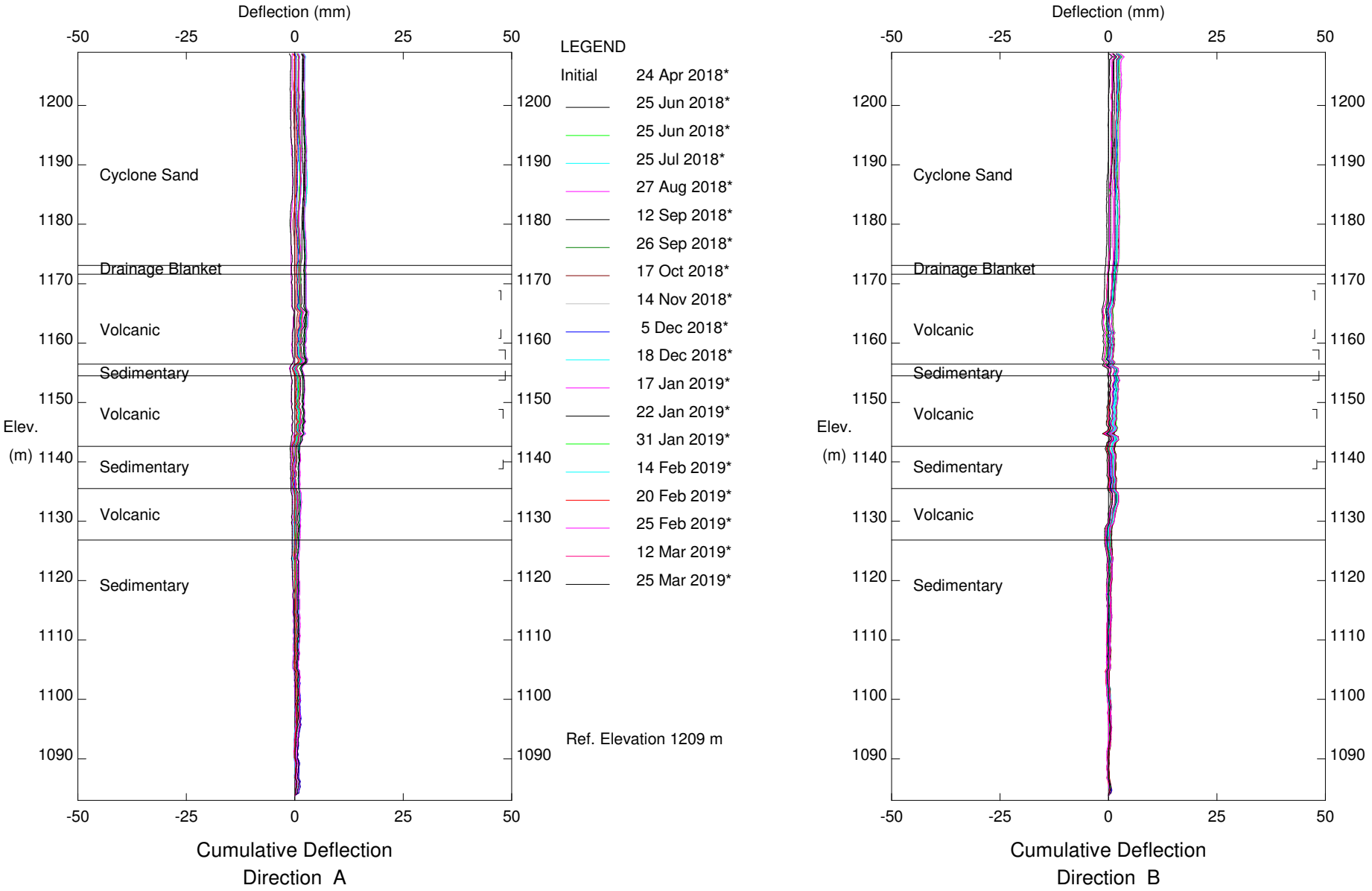
Upper Depth	55.0 m
Lower Depth	68.0 m



North Buttress Berm

I15-25

Highland Valley Copper - Logan Lake, BC

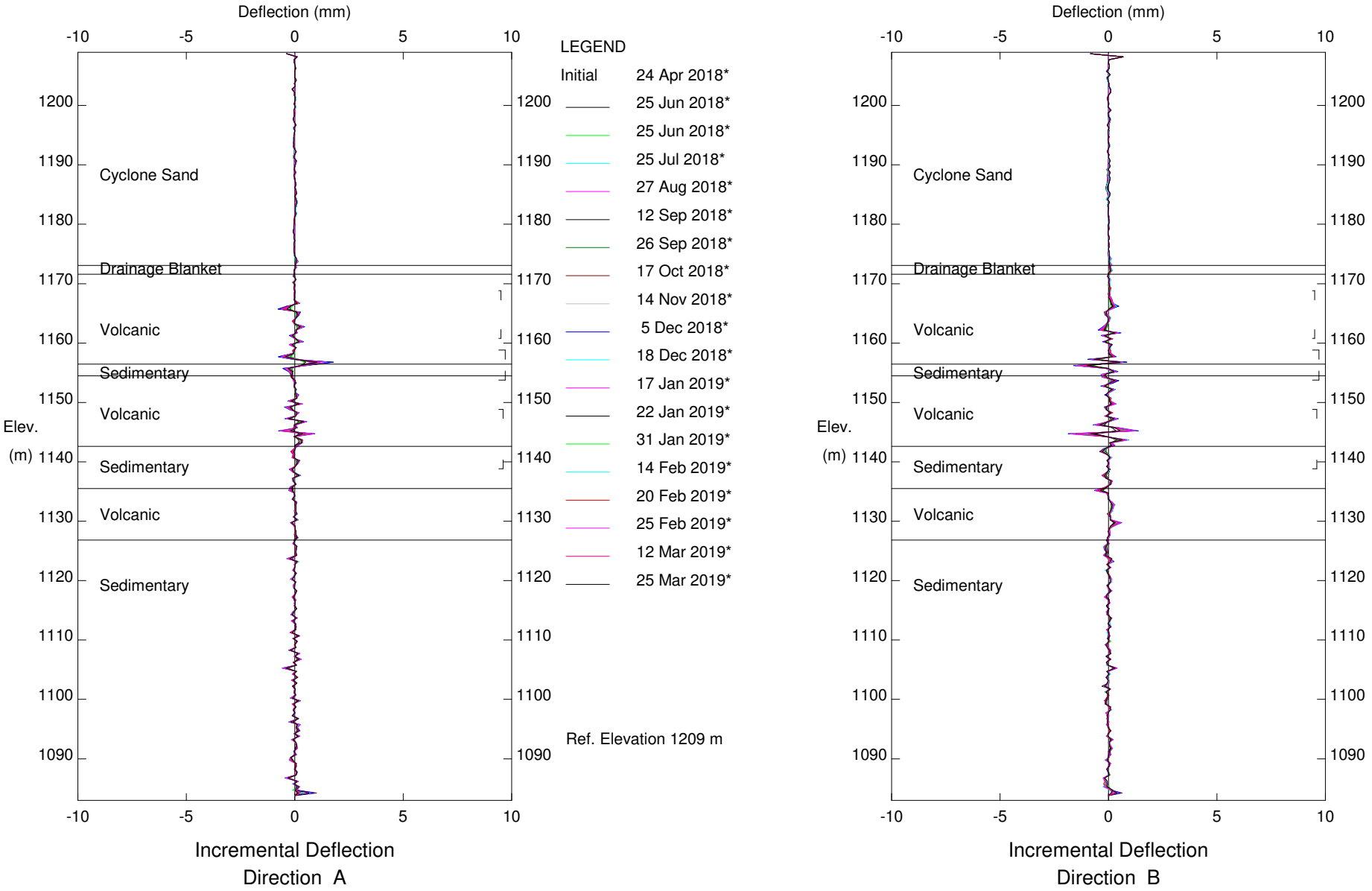


North Buttress Berm, Inclinometer I15-25

Sets marked * include zero shift and/or rotation corrections.

V:\03 CIVIL GROUP\01 DAM MANAGEMENT\09 GEOTECHNICAL\INSTRUMENTATION\DAM MOVEMENT MONITORING\L-L DAM\SI MONITORING\GTPLUS32 FILES\I15-25.GTL

Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I15-25

Sets marked * include zero shift and/or rotation corrections.

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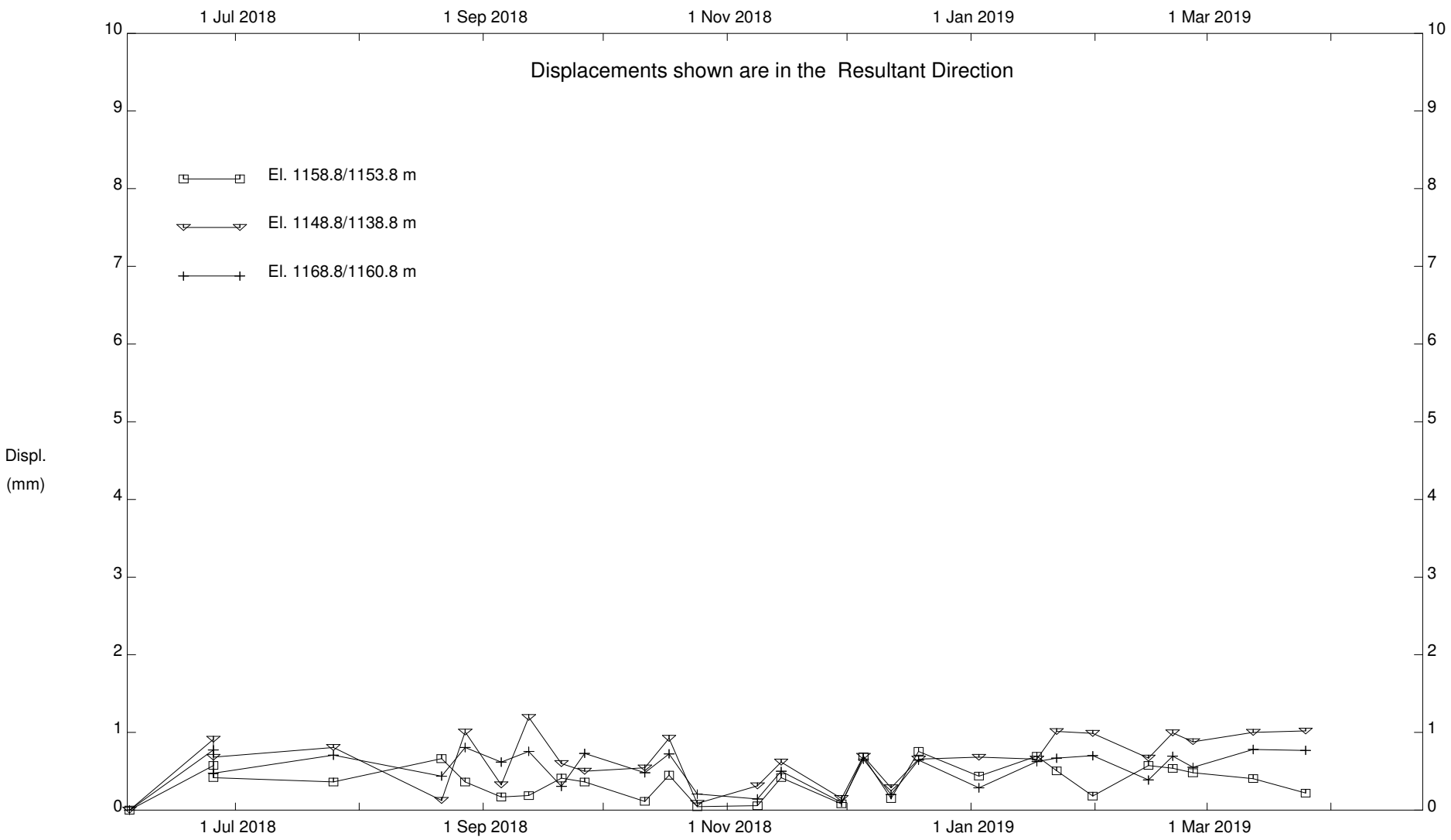
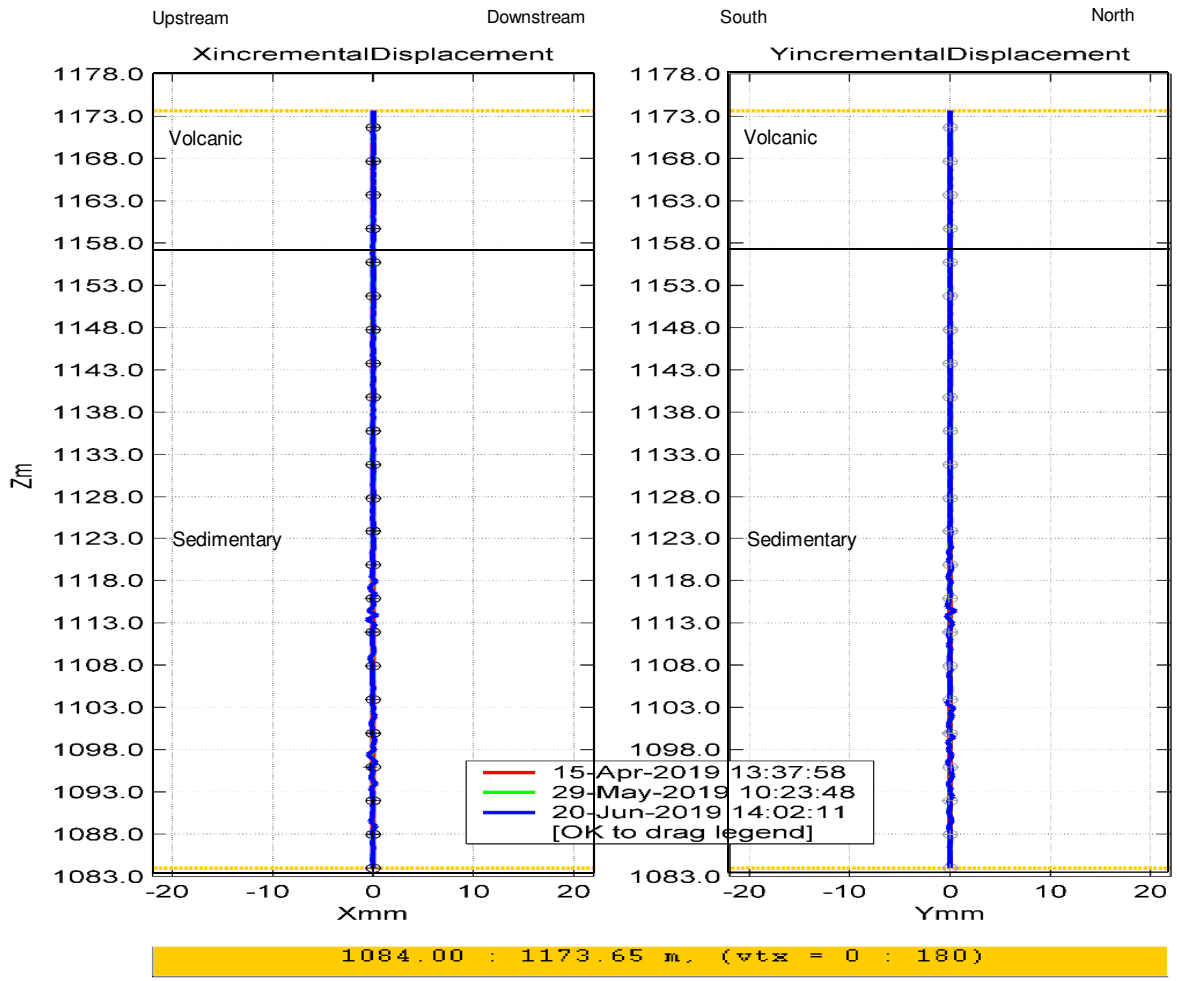
Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I15-25

Inclinometer I15-25

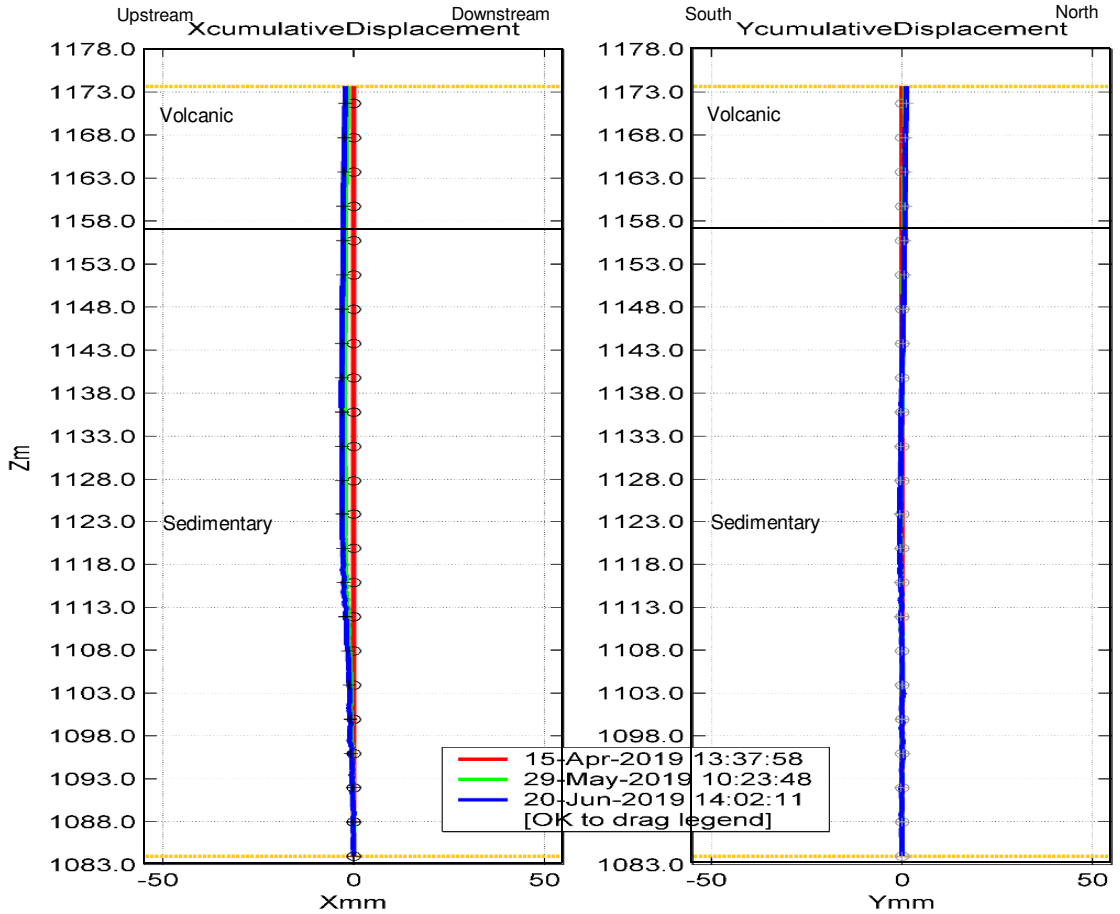
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
15-25	Volcanic	1168.8	1160.8	5	13
	Sedimentary(1)	1158.8	1153.8	15	20
	Sedimentary(2)	1148.8	1138.8	25	35

Inclinometer I15-25

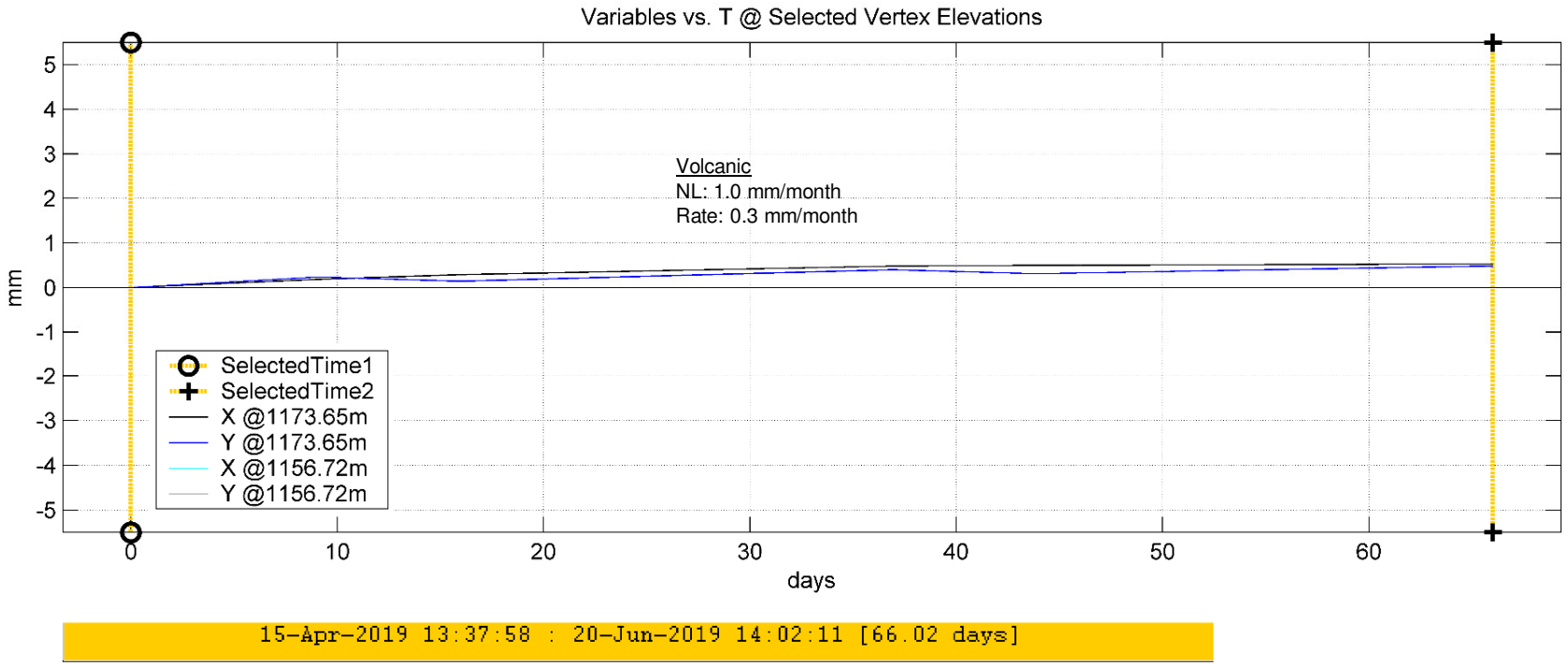
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
15-25	Volcanic	1168.8	1160.8	5	13
	Sedimentary(1)	1158.8	1153.8	15	20
	Sedimentary(2)	1148.8	1138.8	25	35

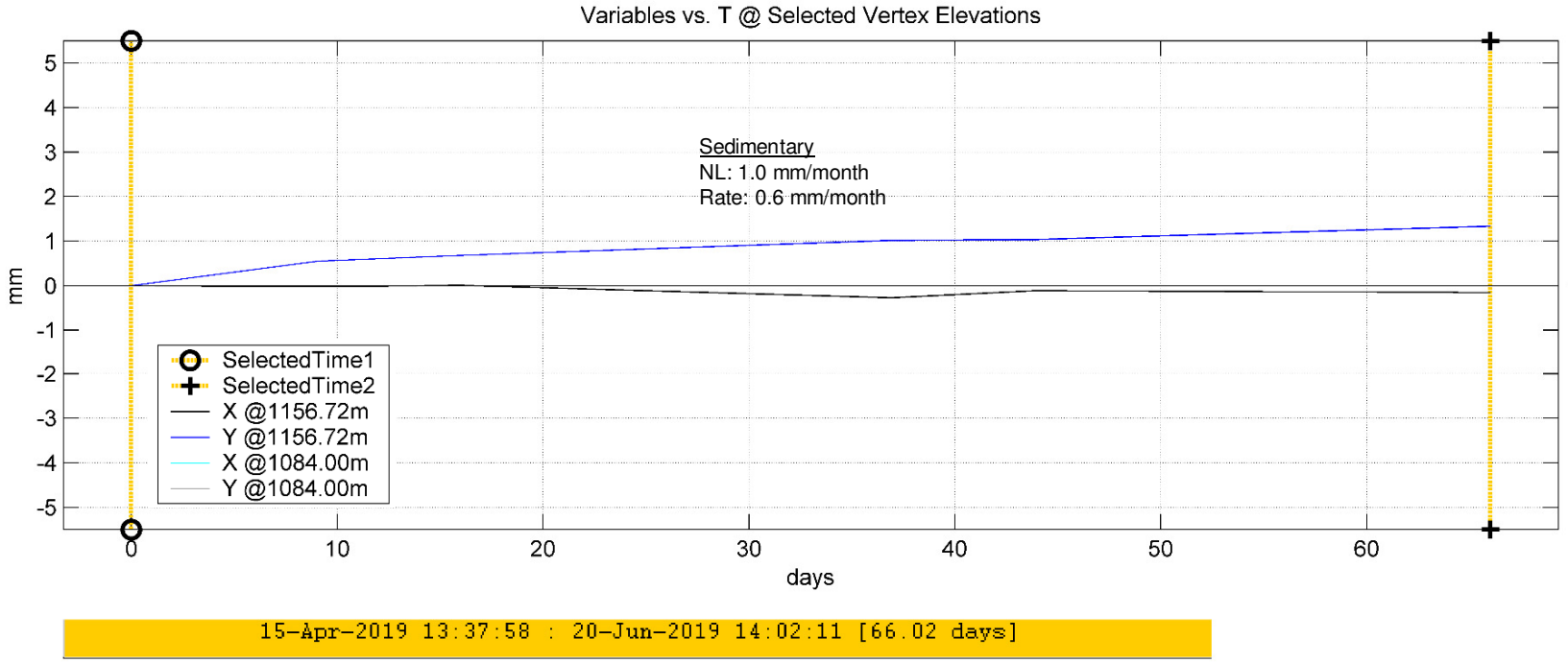
Inclinometer I15-25

Time Displacement Plot – Volcanic



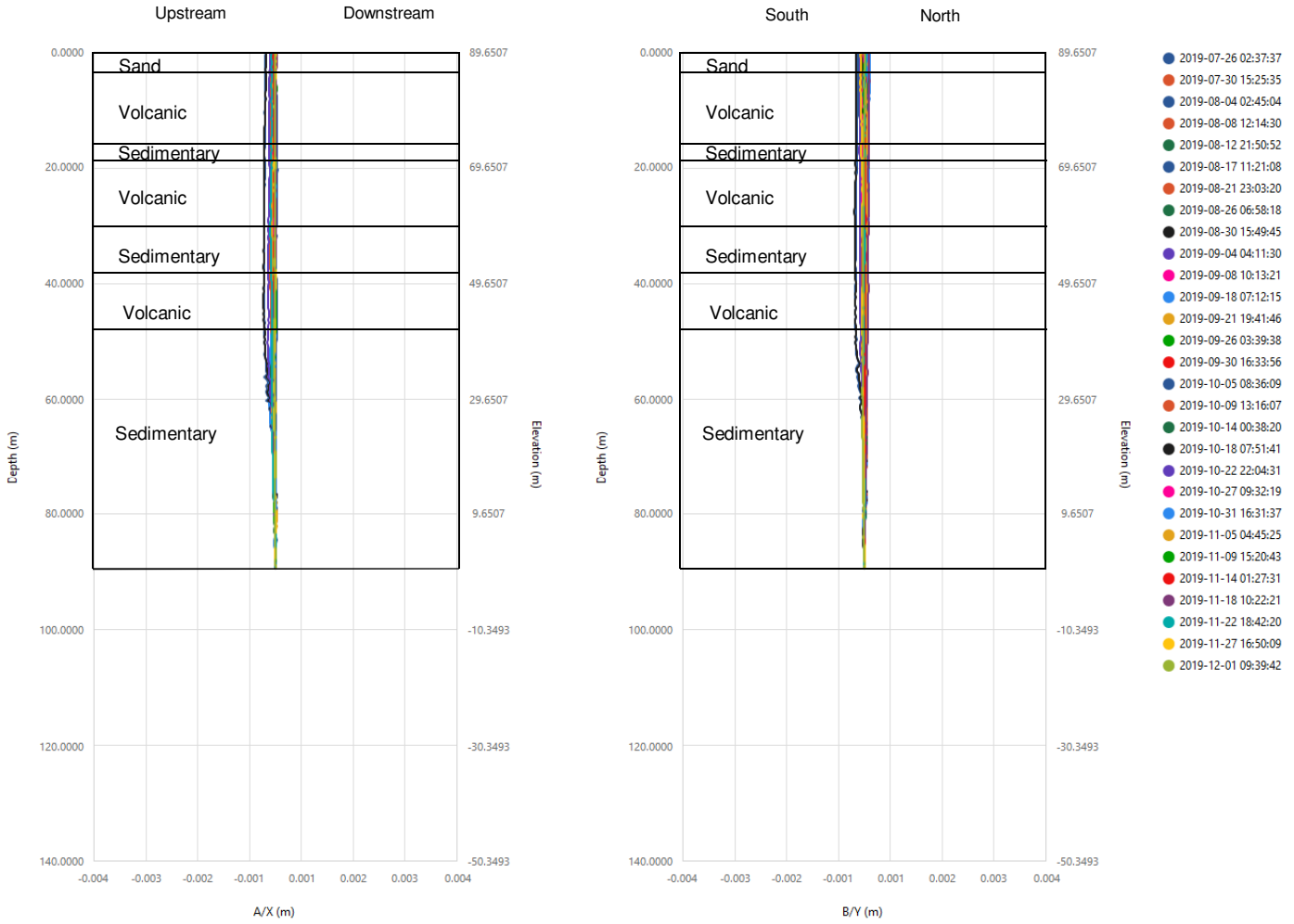
Inclinometer I15-25

Time Displacement Plot – Sedimentary



SAAV I15-25

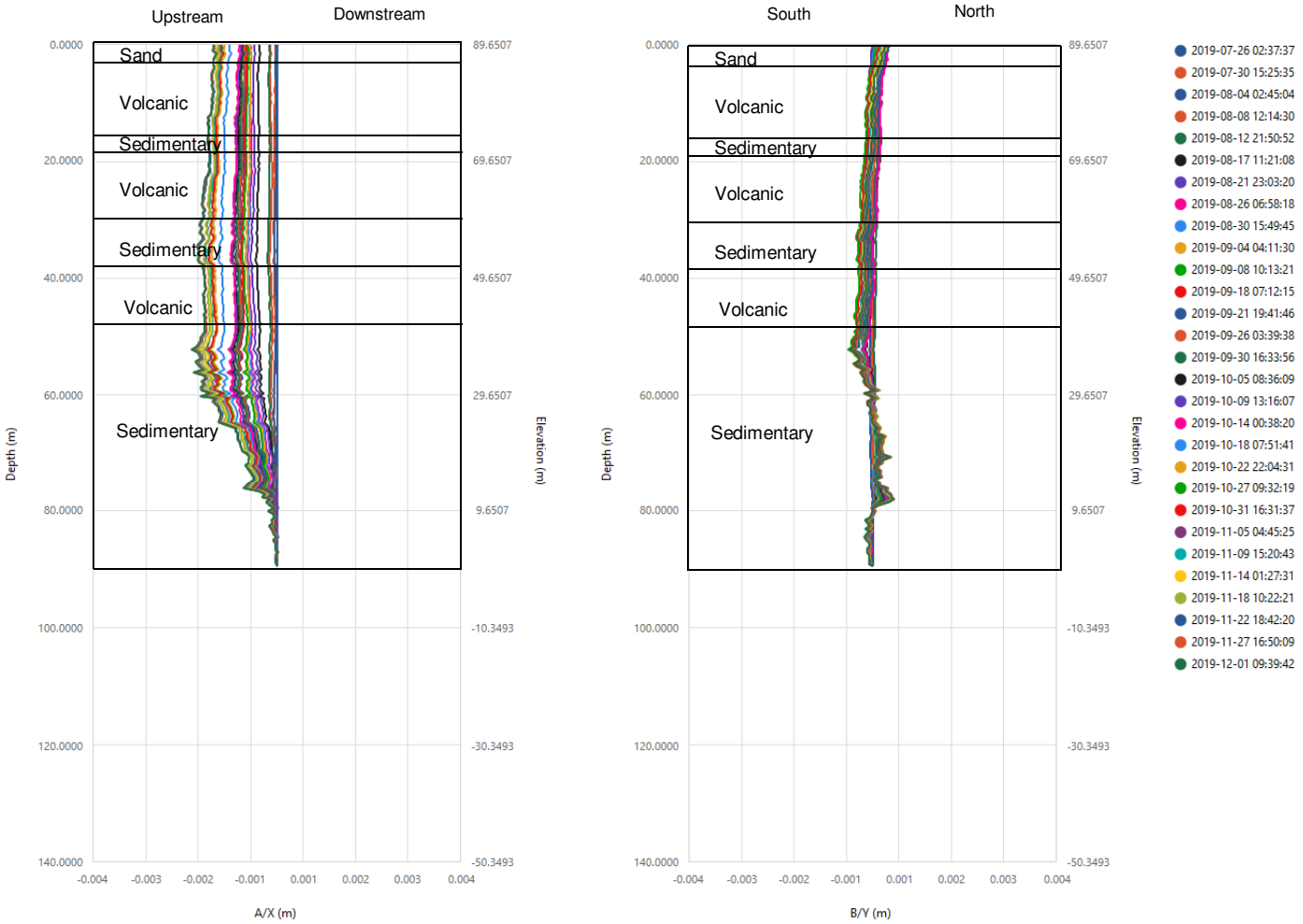
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
15-25	Volcanic	1168.8	1160.8	5	13
	Sedimentary(1)	1158.8	1153.8	15	20
	Sedimentary(2)	1148.8	1138.8	25	35

SAAV I15-25

Cumulative Plot



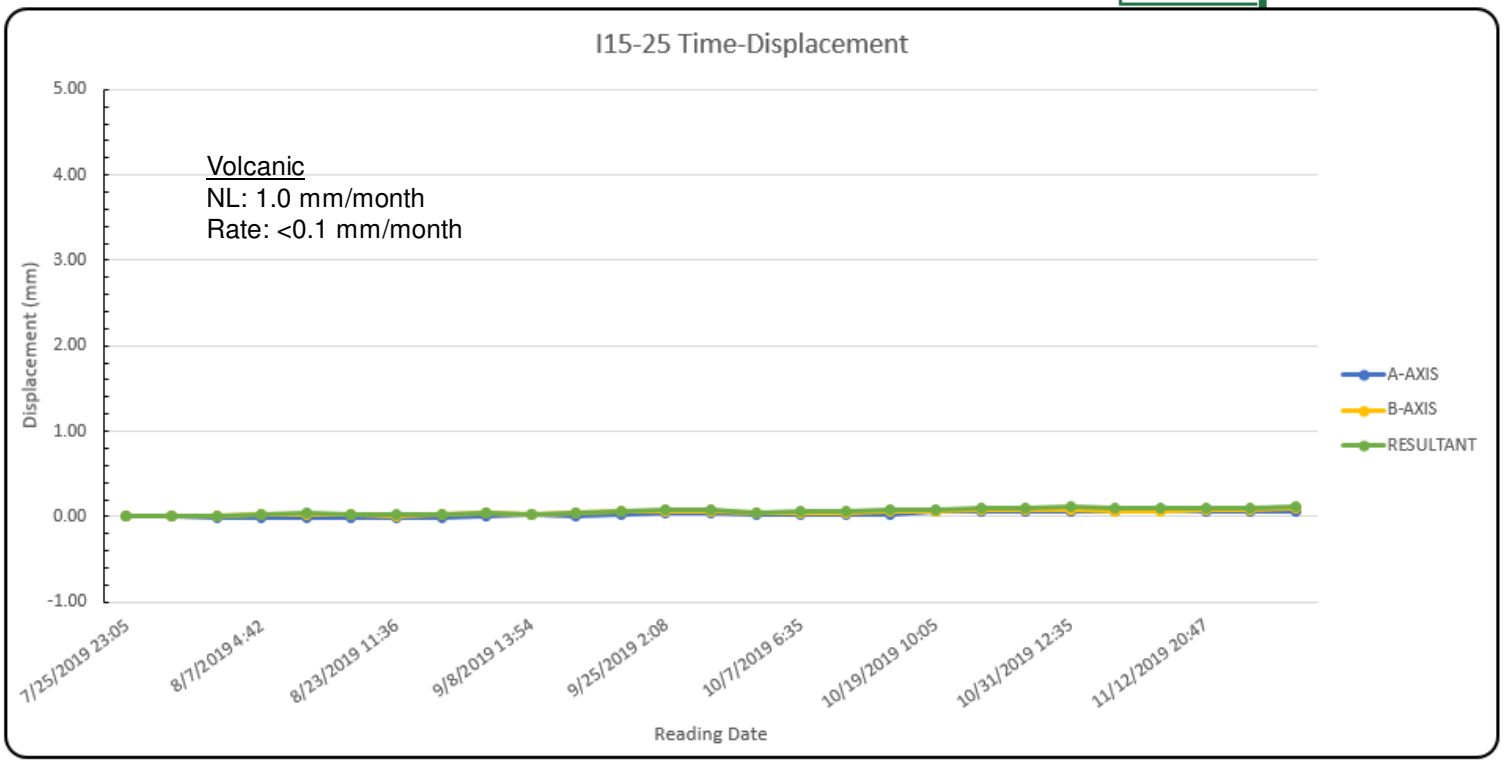
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
15-25	Volcanic	1168.8	1160.8	5	13
	Sedimentary(1)	1158.8	1153.8	15	20
	Sedimentary(2)	1148.8	1138.8	25	35

SAAV I15-25

Displacement Plot – Volcanic

Unit	Upper Depth	Lower Depth
Volcanic	5	13
Sedimentary	15	20
Sedimentary	25	35

Upper Depth	5.0 m
Lower Depth	13.0 m

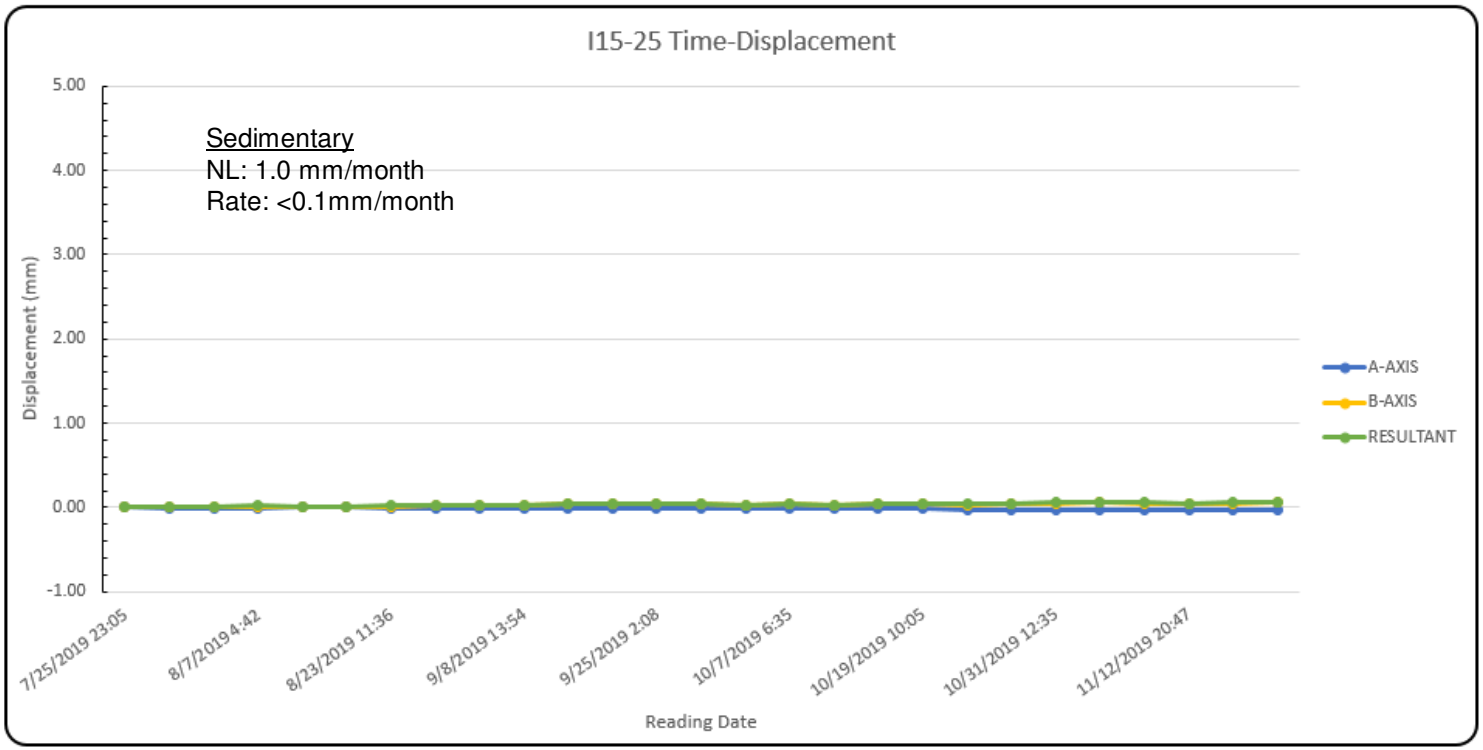


SAAV I15-25

Displacement Plot – Sedimentary

Unit	Upper Depth	Lower Depth
Volcanic	5	13
Sedimentary	15	20
Sedimentary	25	35

Upper Depth	15.0 m
Lower Depth	20.0 m

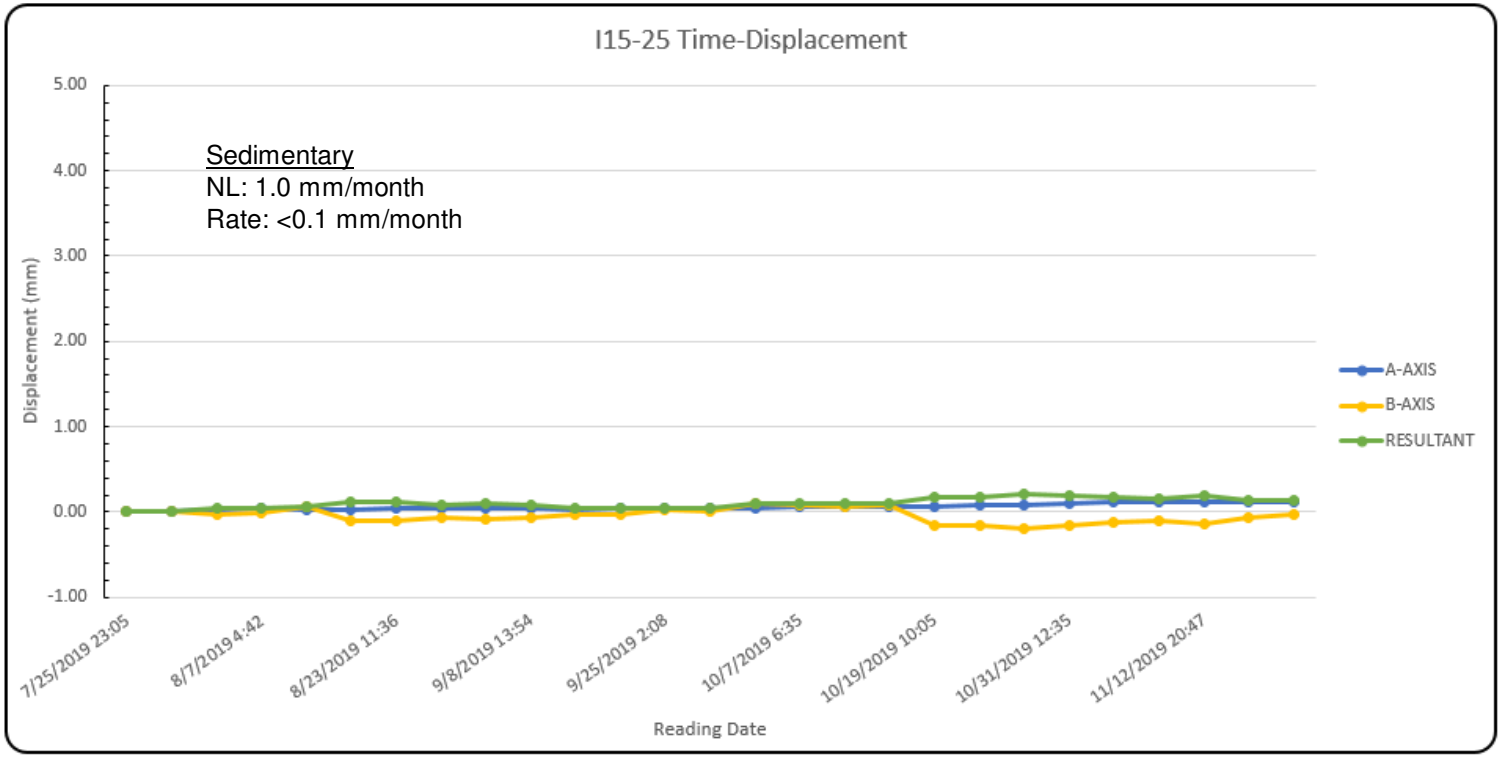


SAAV I15-25

Displacement Plot – Sedimentary

Unit	Upper Depth	Lower Depth
Volcanic	5	13
Sedimentary	15	20
Sedimentary	25	35

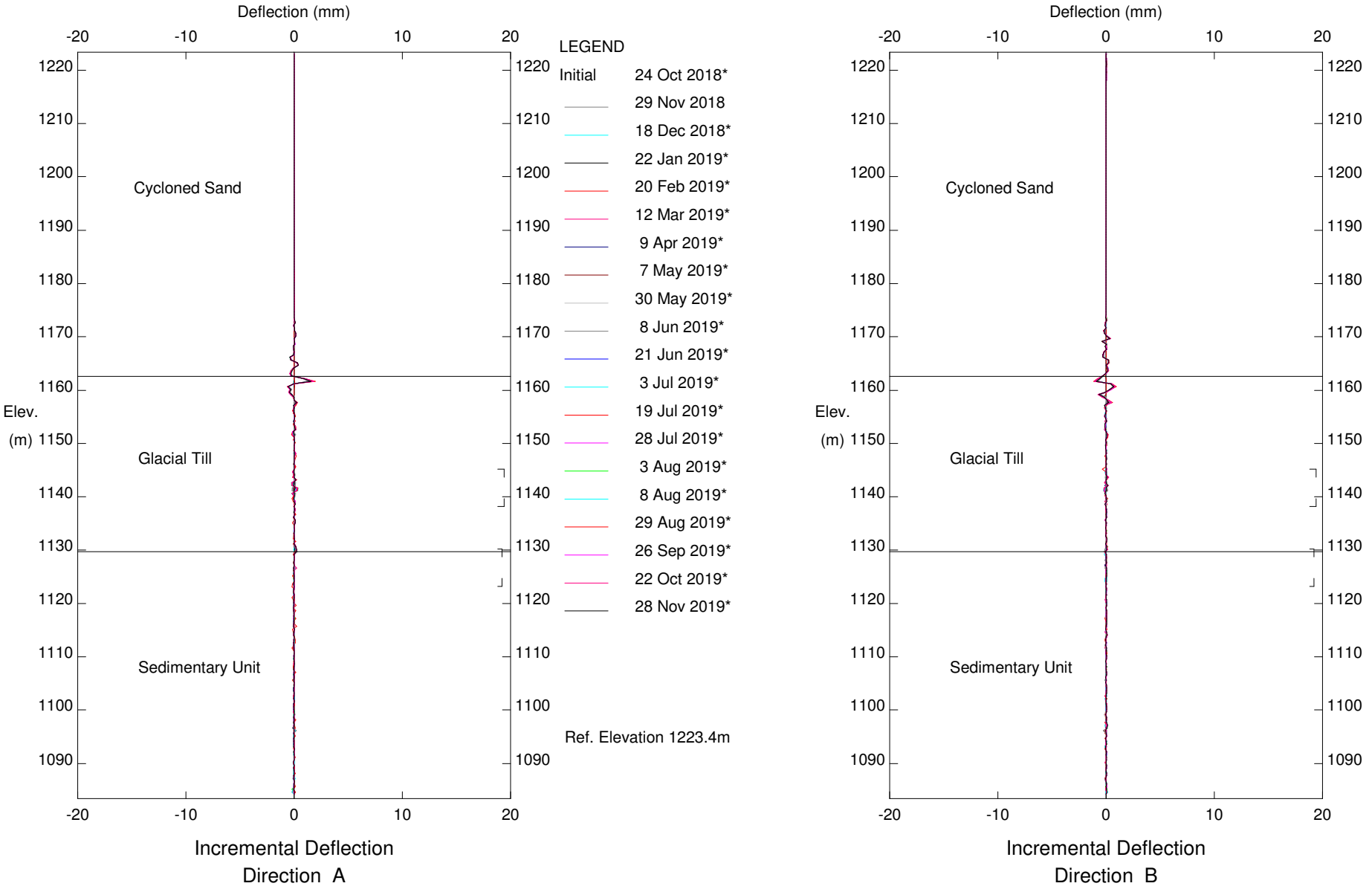
Upper Depth	25.0 m
Lower Depth	35.0 m



NORTH BUTTRESS BERM

I17-22

Highland Valley Copper - Logan Lake, BC



LL Dam - Dam fill excluded,,,, Inclinometer I17-22,,,

Sets marked * include zero shift and/or rotation corrections.

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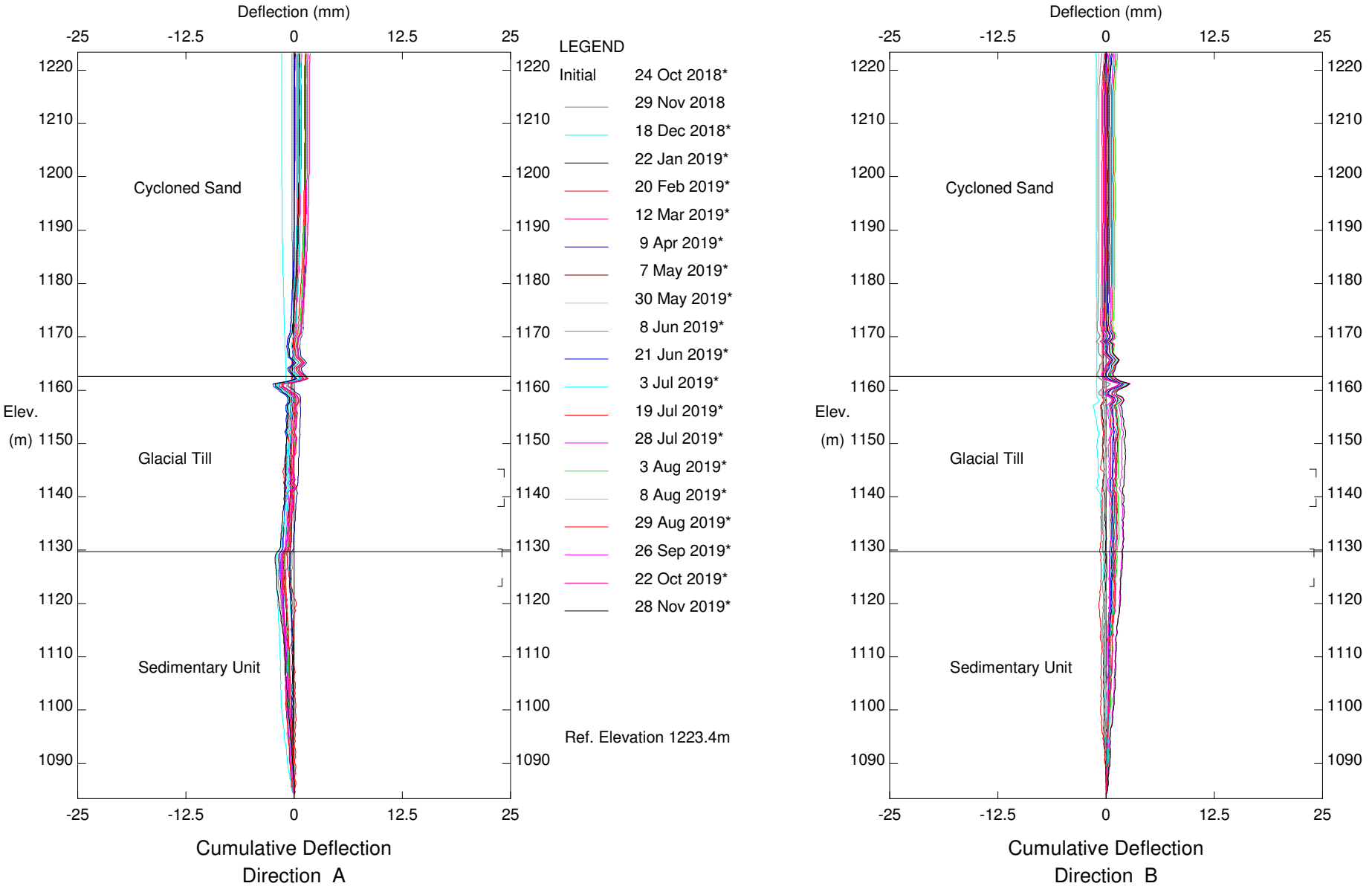
Highland Valley Copper - Logan Lake, BC



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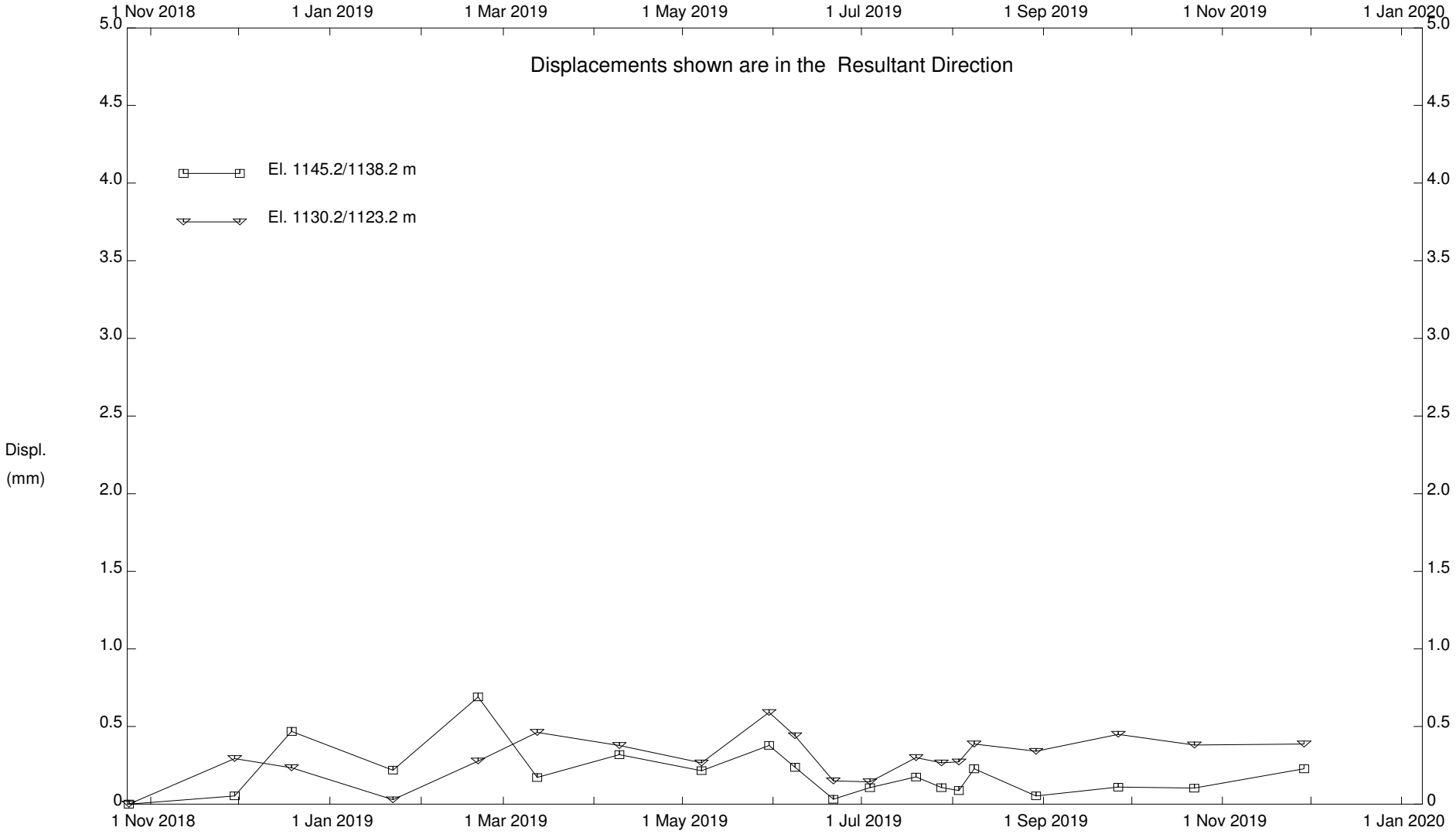
Highland Valley Copper - Logan Lake, BC



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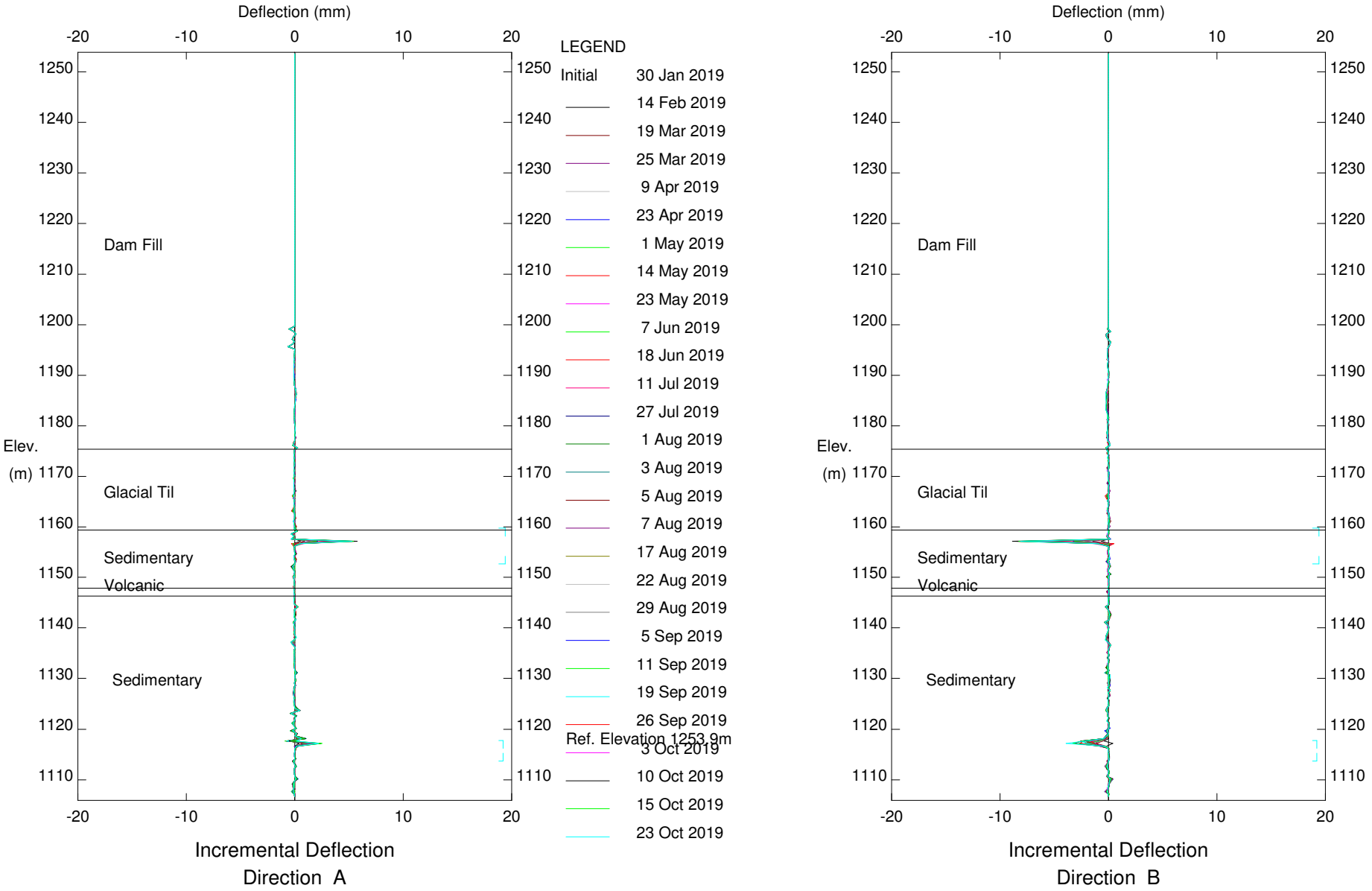
NORTH BUTTRESS BERM

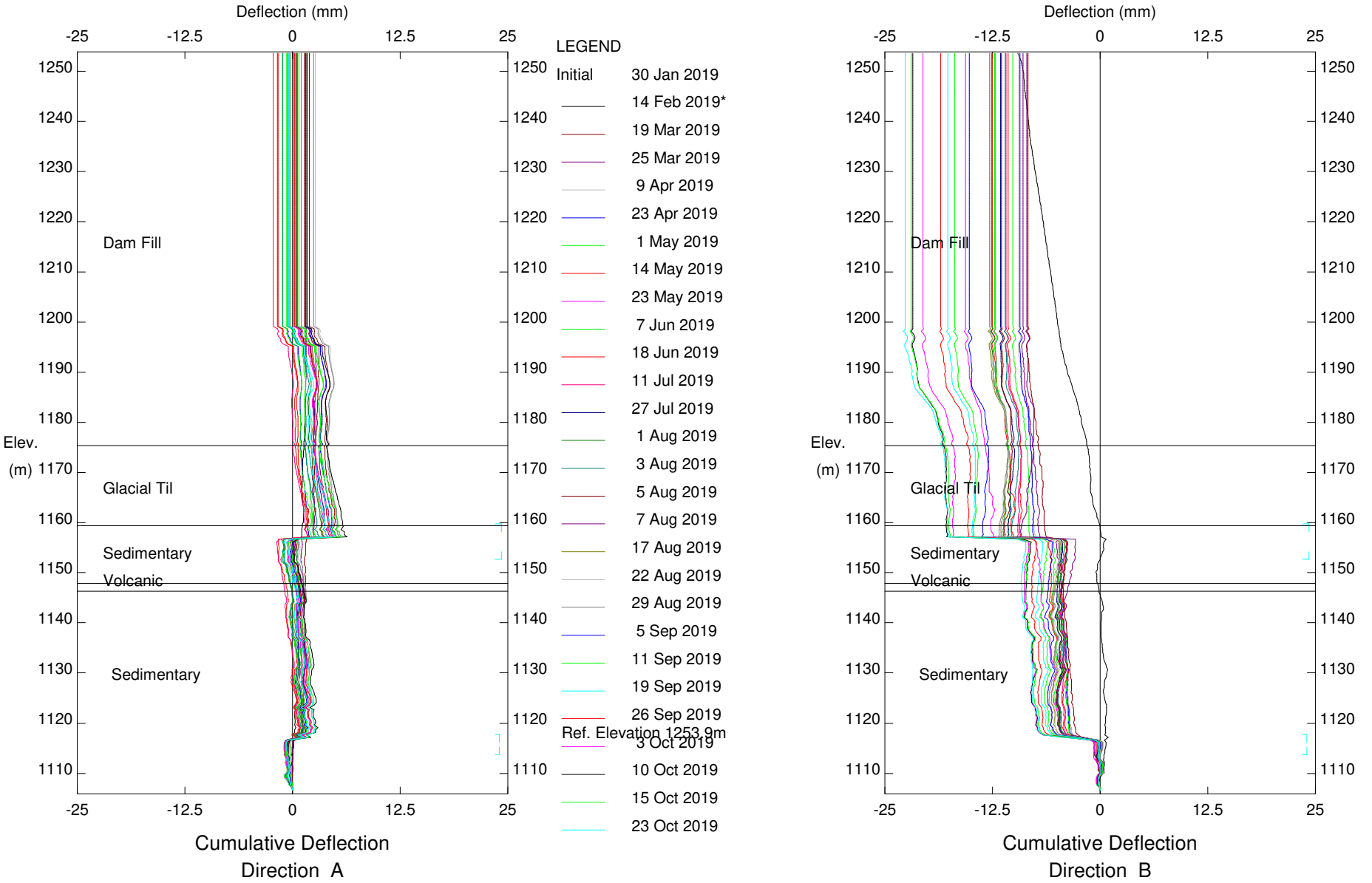
I17-24

Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I17-24

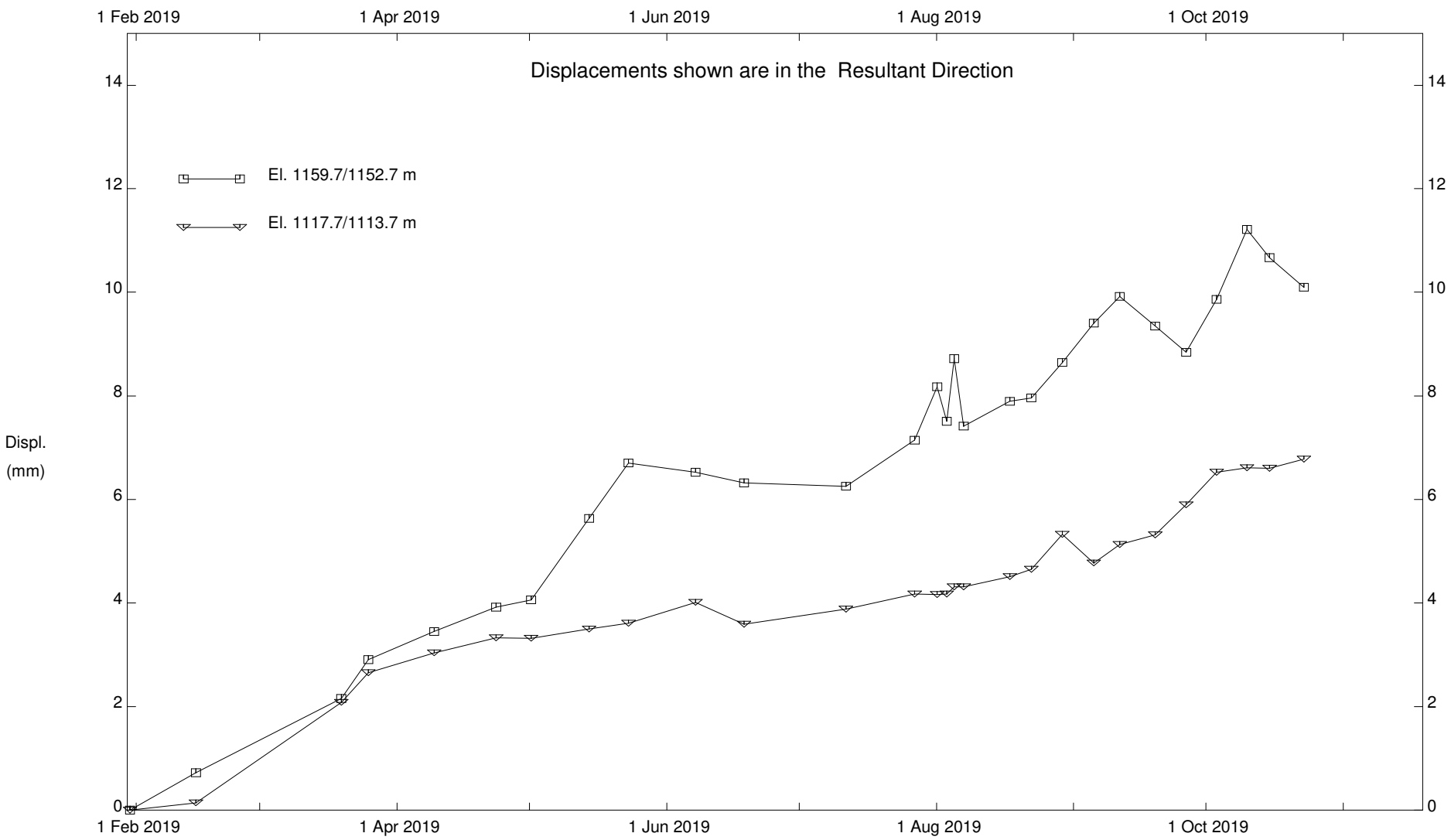
Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I17-24

Sets marked * include zero shift and/or rotation corrections.

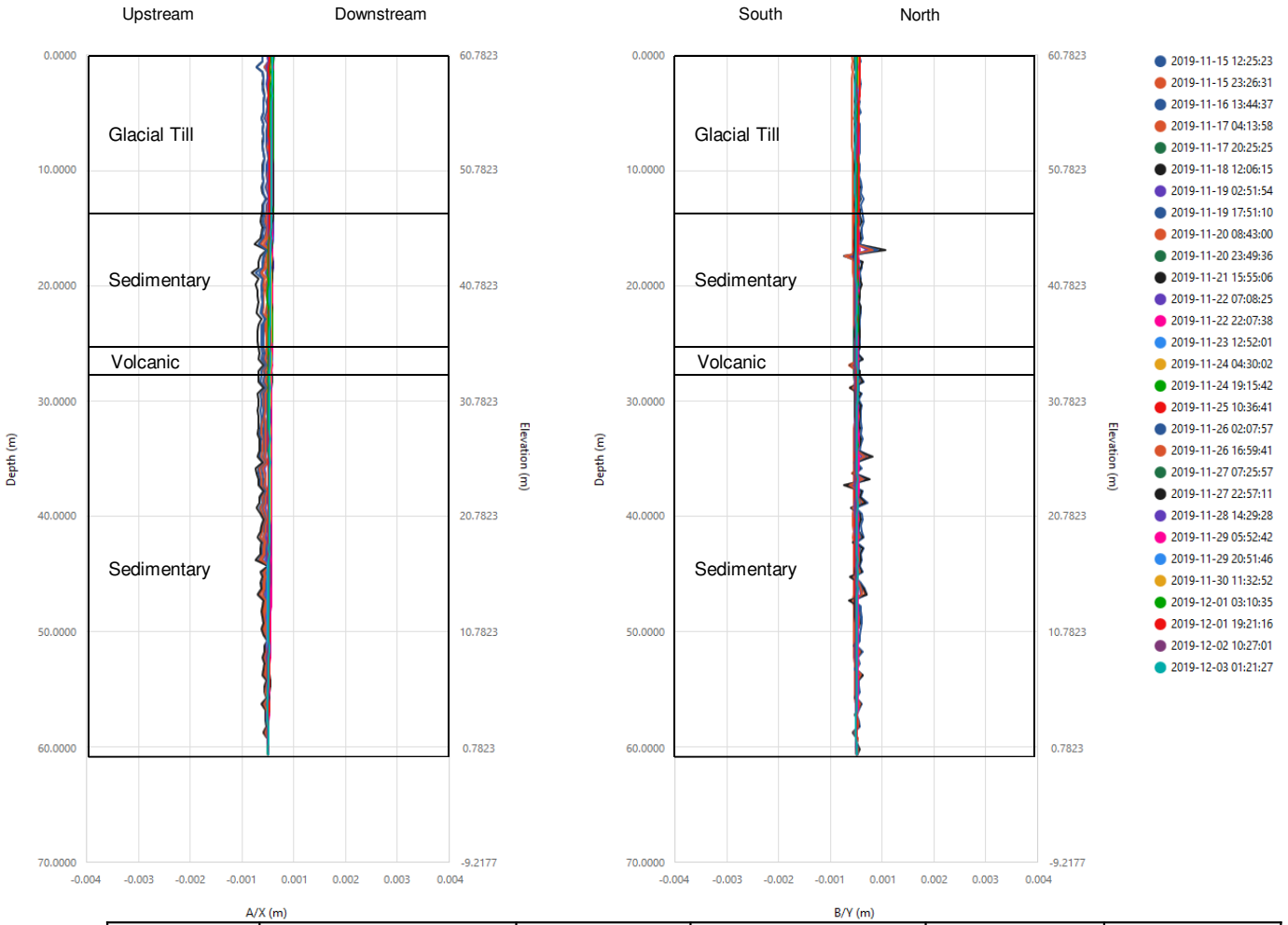
Highland Valley Copper - Logan Lake, BC



North Buttress Berm, Inclinometer I17-24

SAAV I17-24

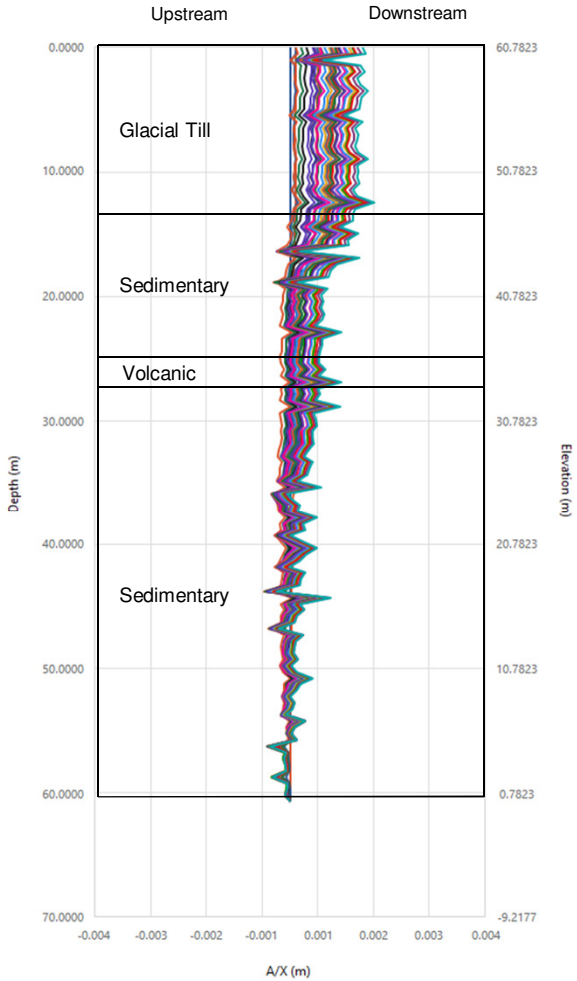
Incremental Plot

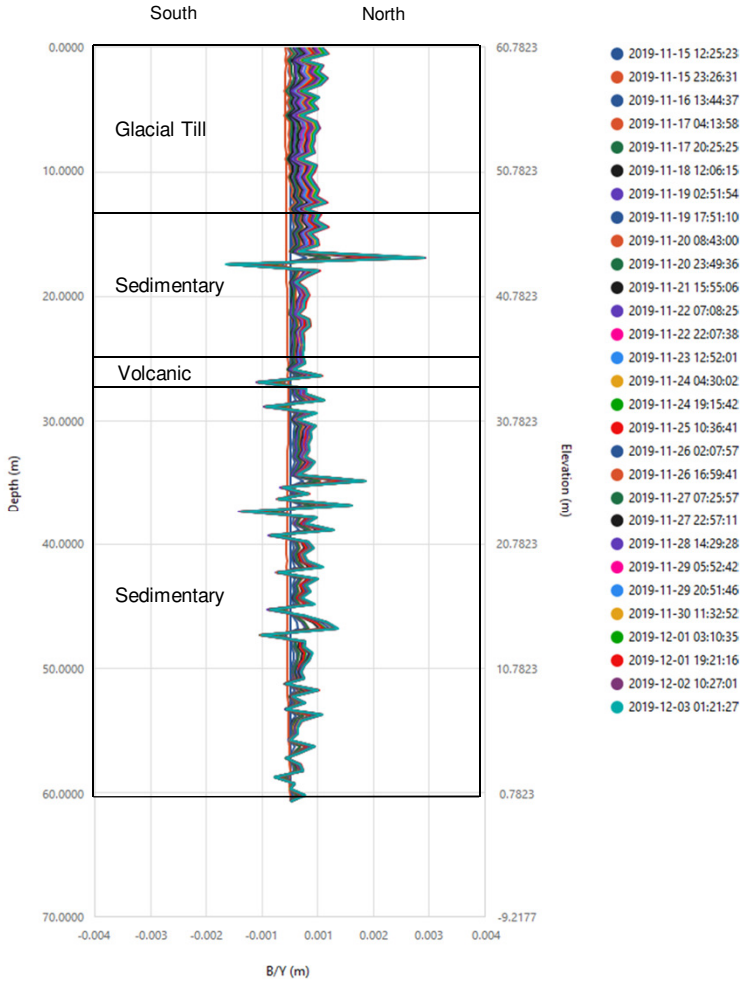


Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
17-24	Sedimentary	1159.7	1152.7	14	21
	Sedimentary	1117.7	1113.7	56	60

SAAV I17-24

Cumulative Plot





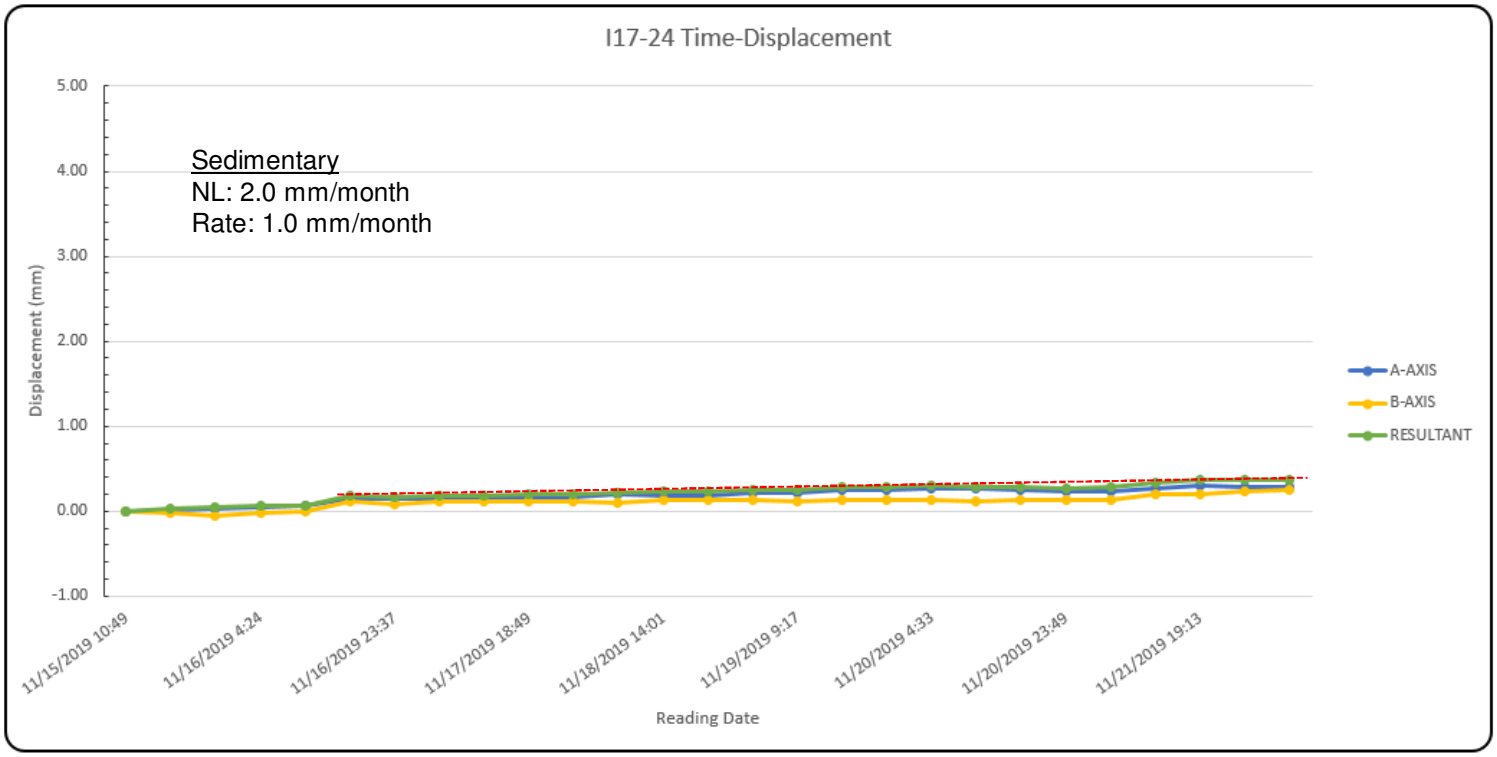
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
17-24	Sedimentary	1159.7	1152.7	14	21
	Sedimentary	1117.7	1113.7	56	60

SAAV I17-24

Displacement Plot – Upper Sedimentary

Unit	Upper Depth	Lower Depth
Sedimentary	14	26
Sedimentary	29	61

Upper Depth	14.0 m
Lower Depth	26.0 m

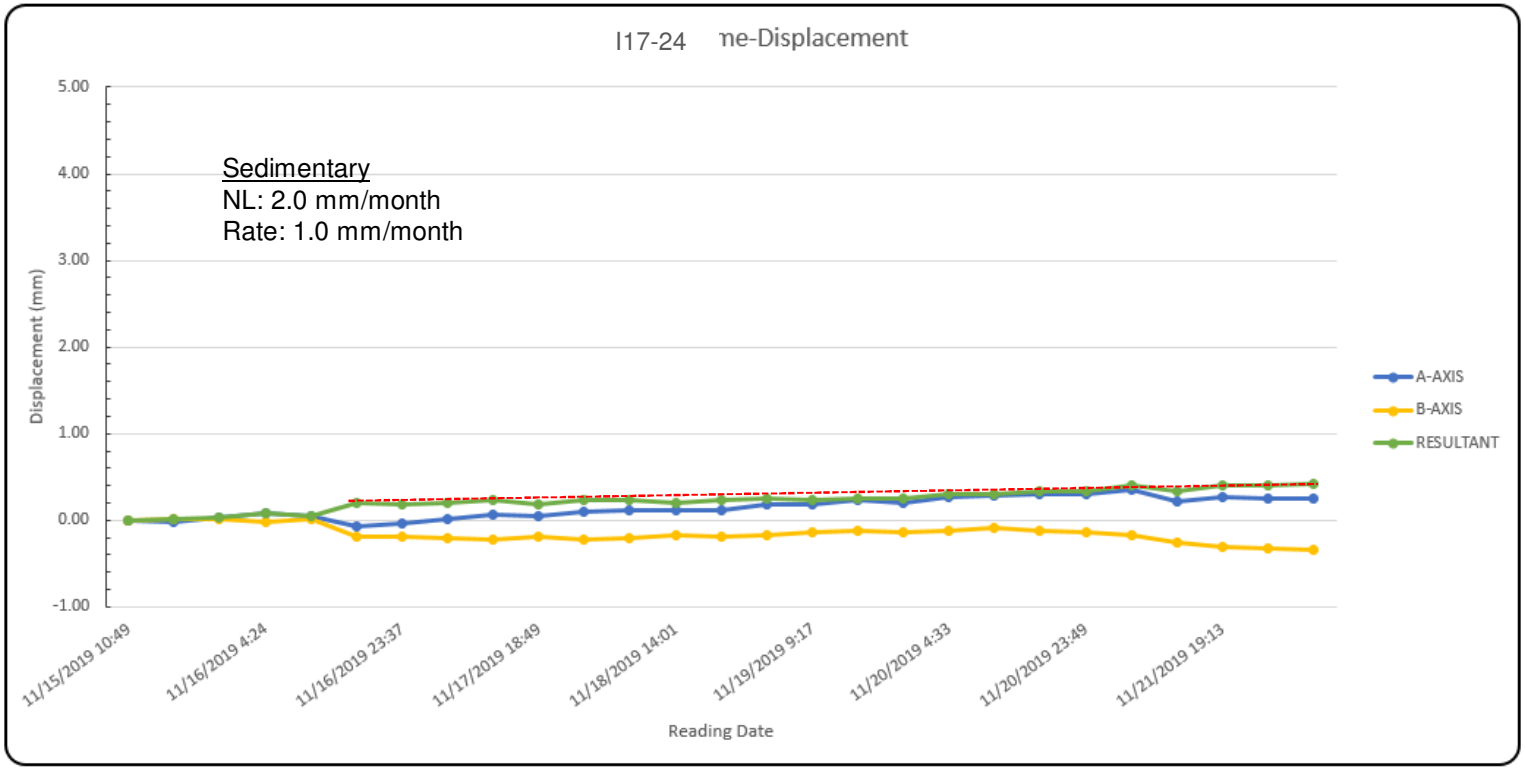


SAAV I17-24

Displacement Plot – Lower Sedimentary

Unit	Upper Depth	Lower Depth
Sedimentary	14	26
Sedimentary	29	61

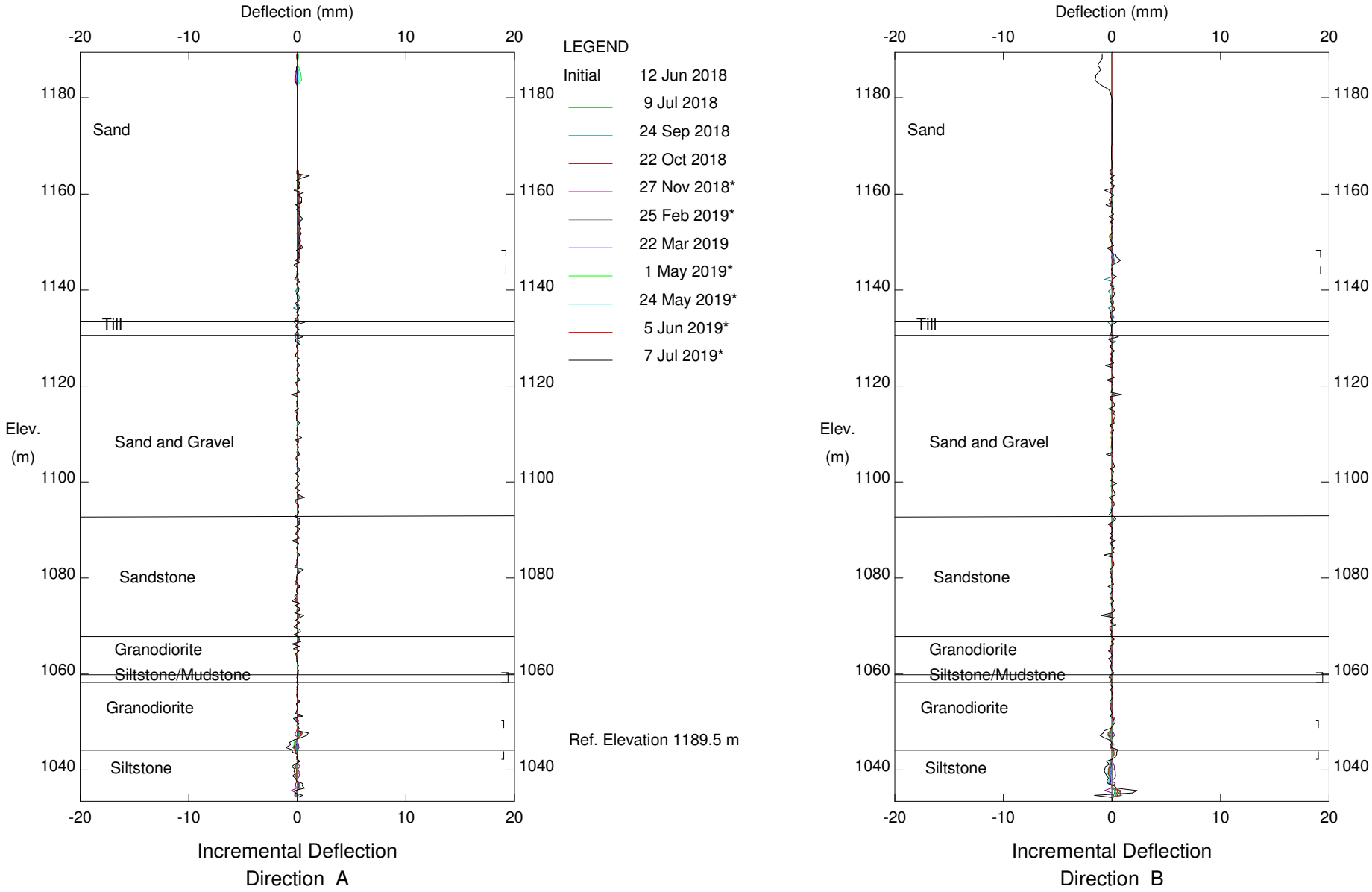
Upper Depth	29.0 m
Lower Depth	61.0 m



VALLEY BUTTRESS BERM EXTENSION

I10-05

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I10-5

Sets marked * include zero shift and/or rotation corrections.

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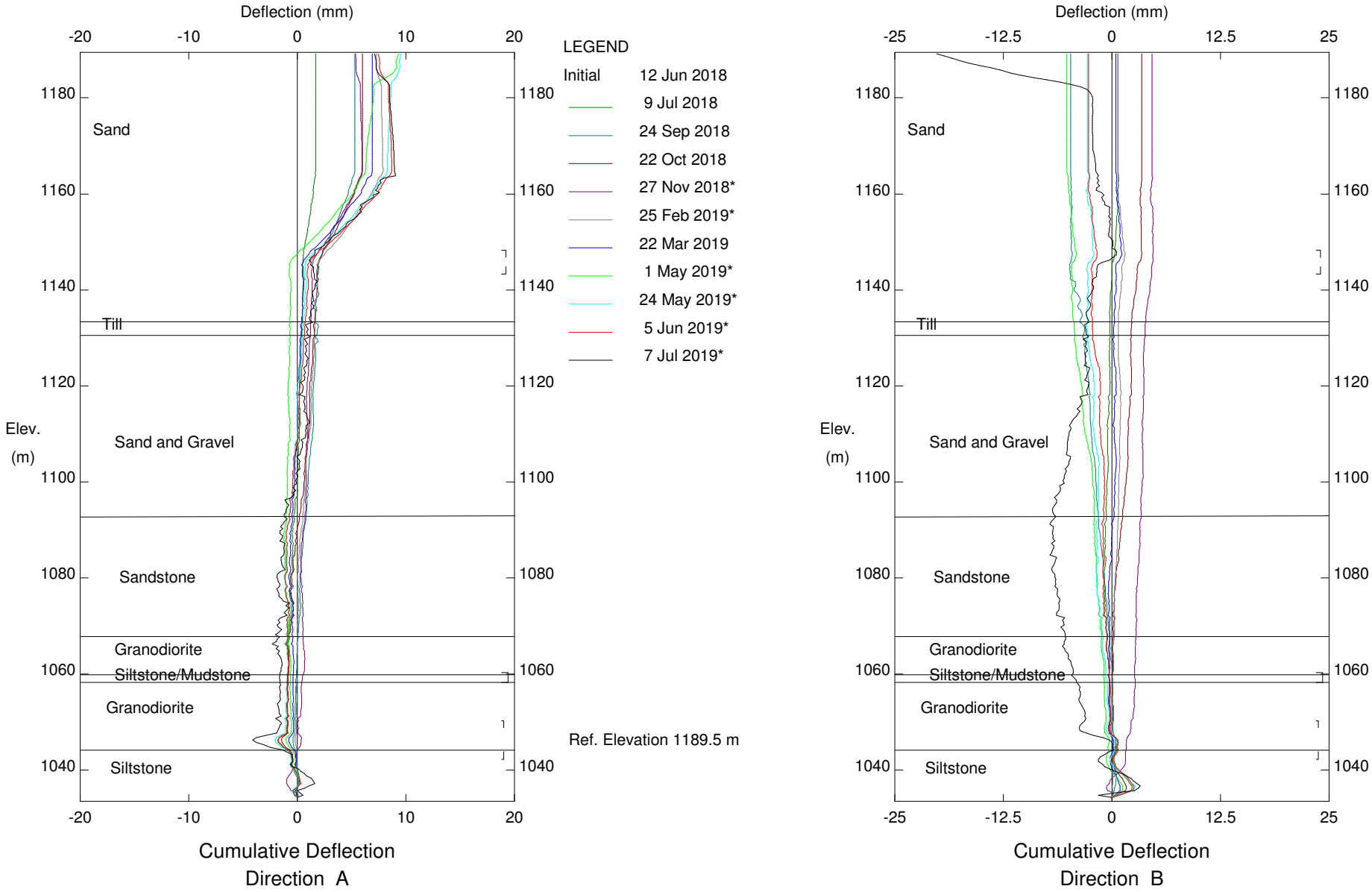
Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I10-5

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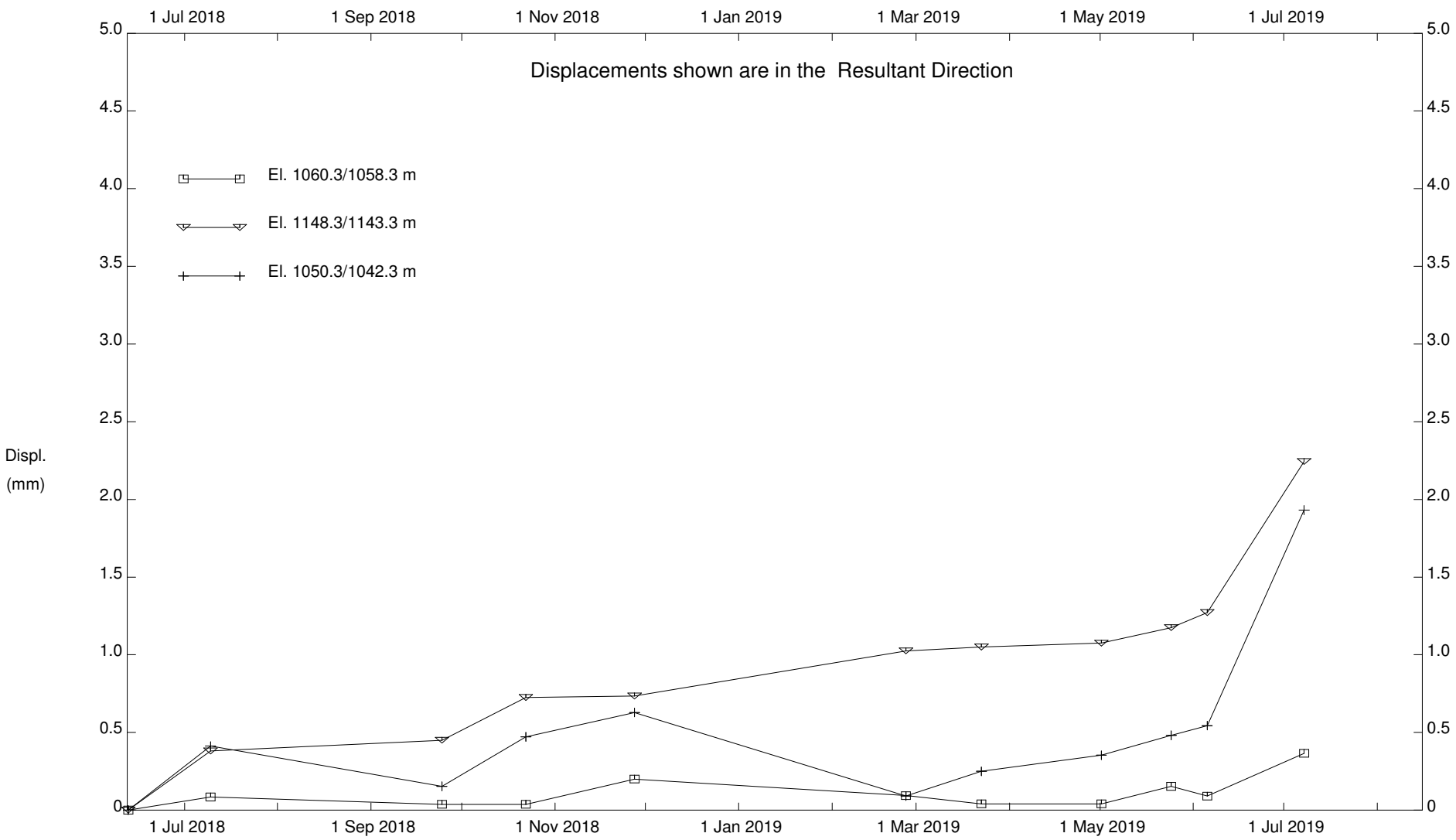
Highland Valley Copper - Logan Lake, BC

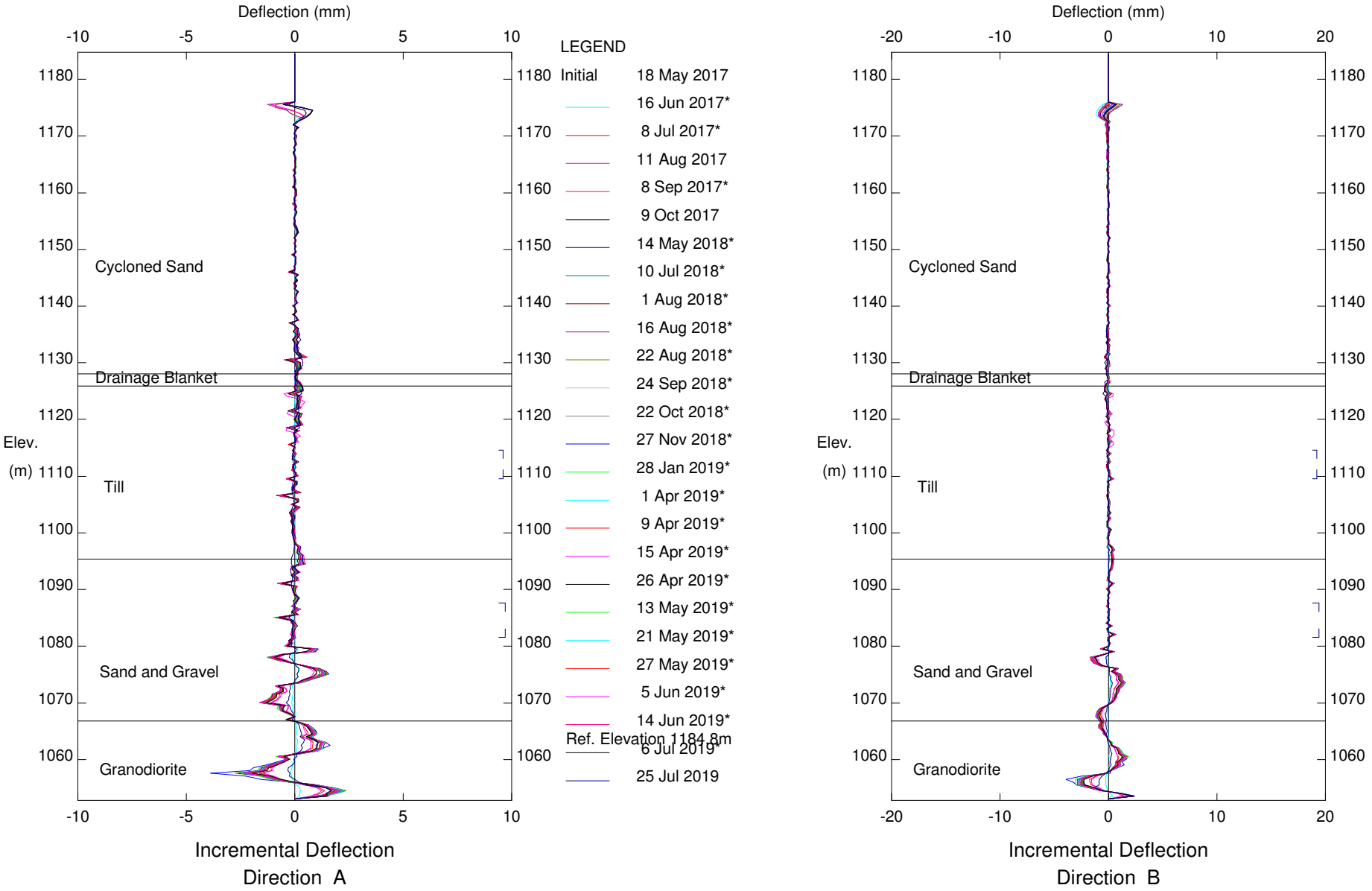


LL Dam, Inclinometer I10-5

VALLEY BUTTRESS BERM EXTENSION

I10-11

Highland Valley Copper - Logan Lake, BC



LL Dam,,,, Inclinometer I10-11

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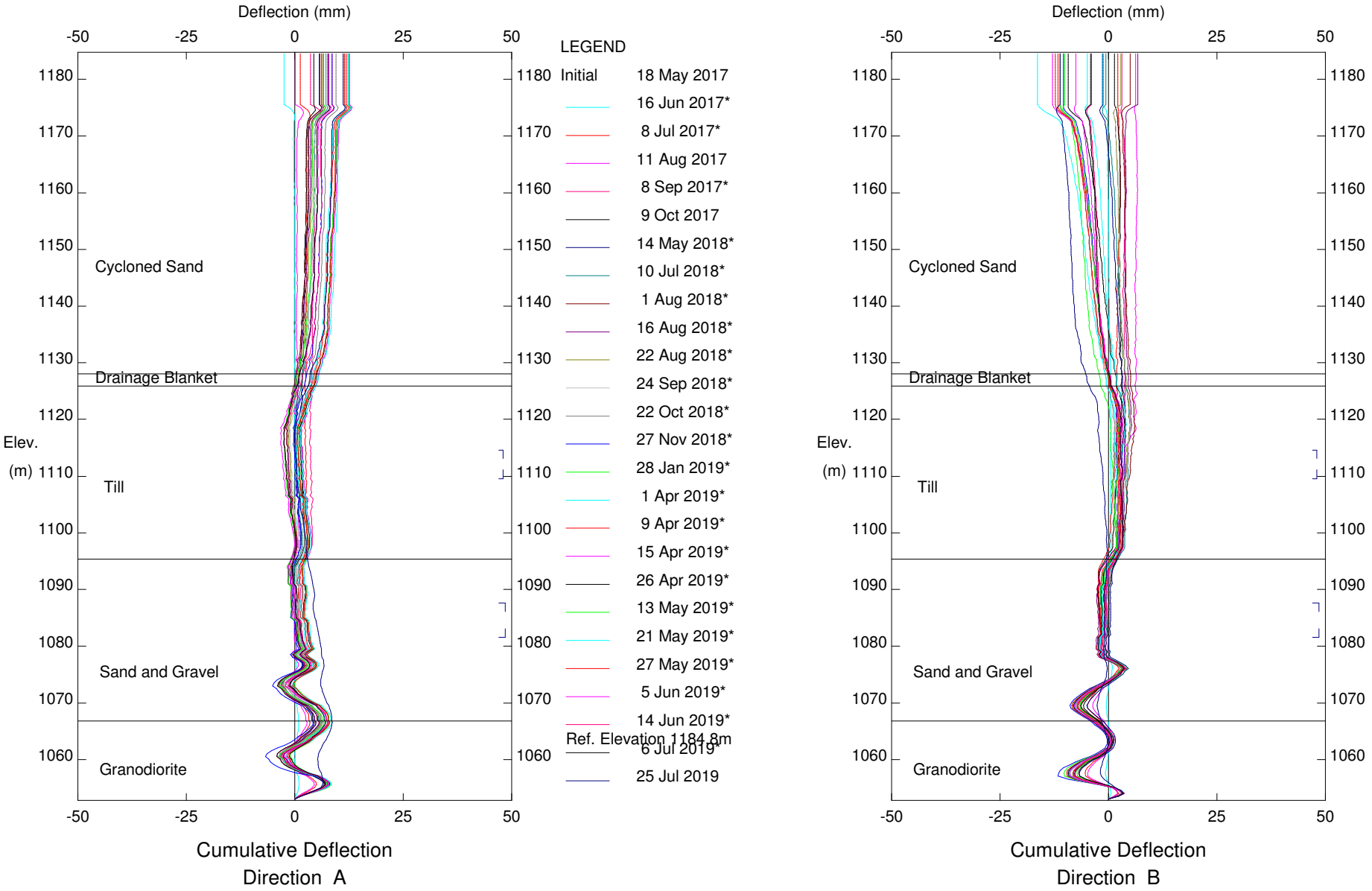
Highland Valley Copper - Logan Lake, BC



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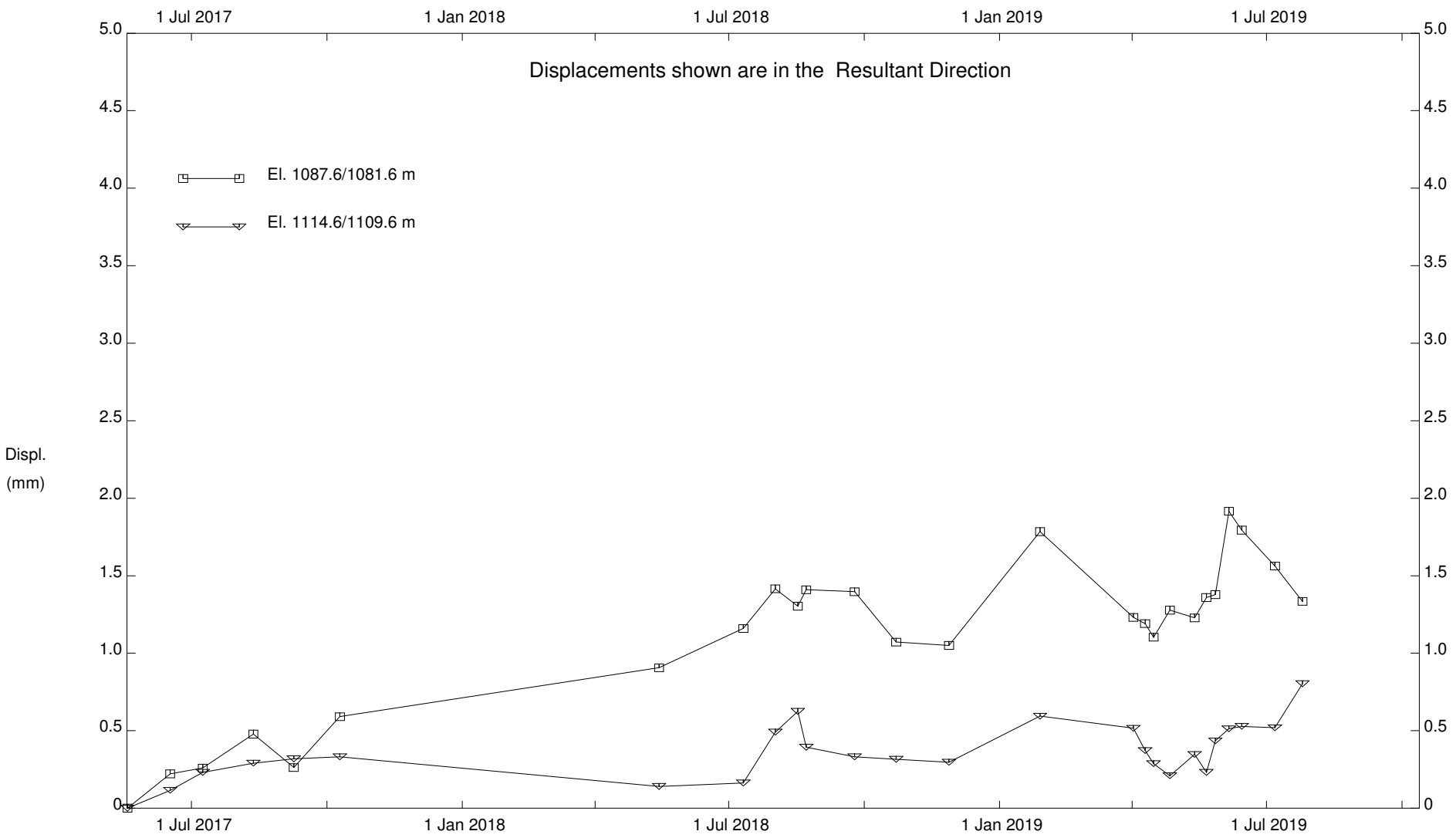
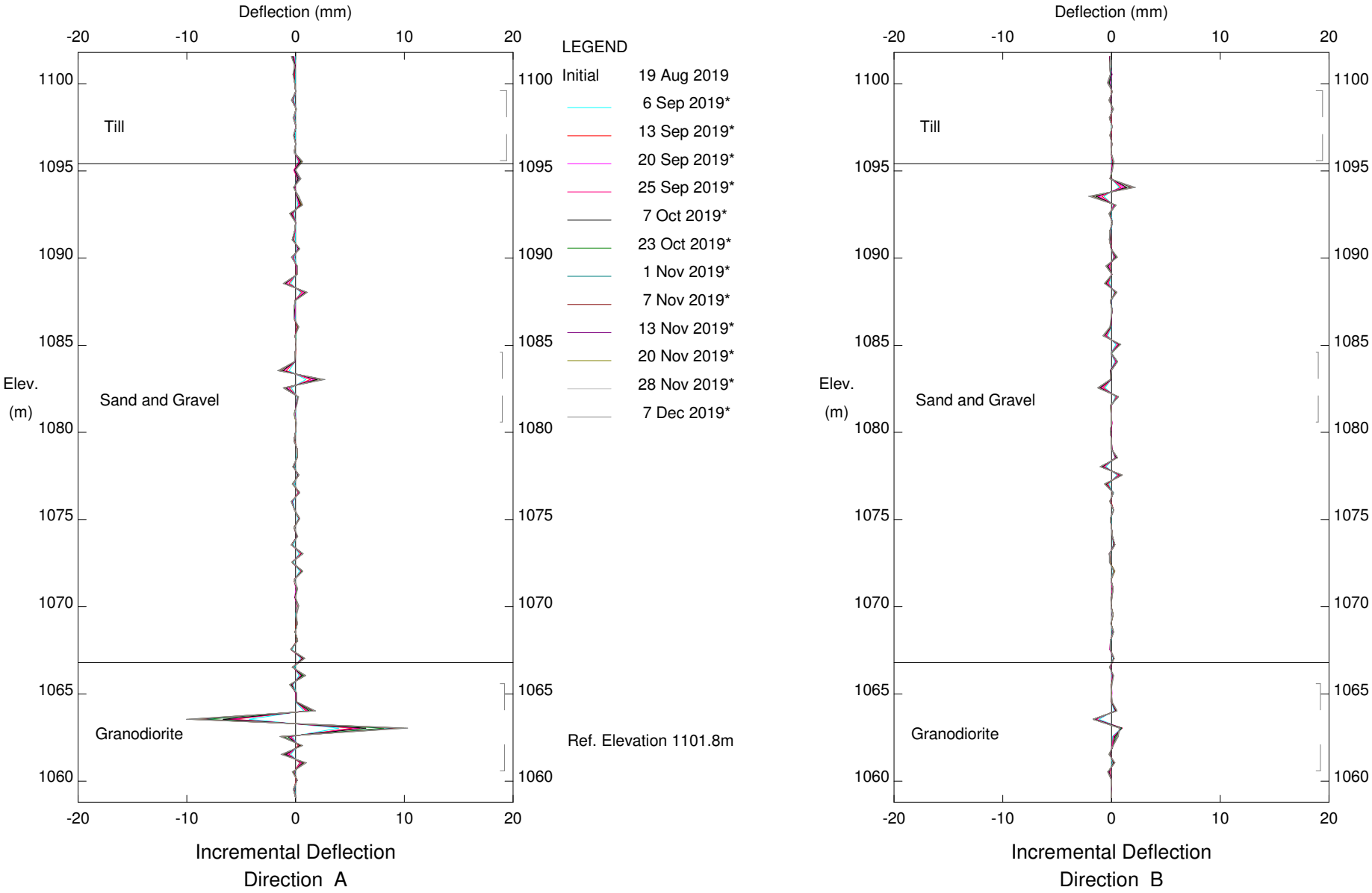
Highland Valley Copper - Logan Lake, BC



LL Dam,,,, Inclinometer I10-11

Highland Valley Copper - Logan Lake, BC



LL Dam,,,, Inclinometer I10-11

Sets marked * include zero shift and/or rotation corrections.

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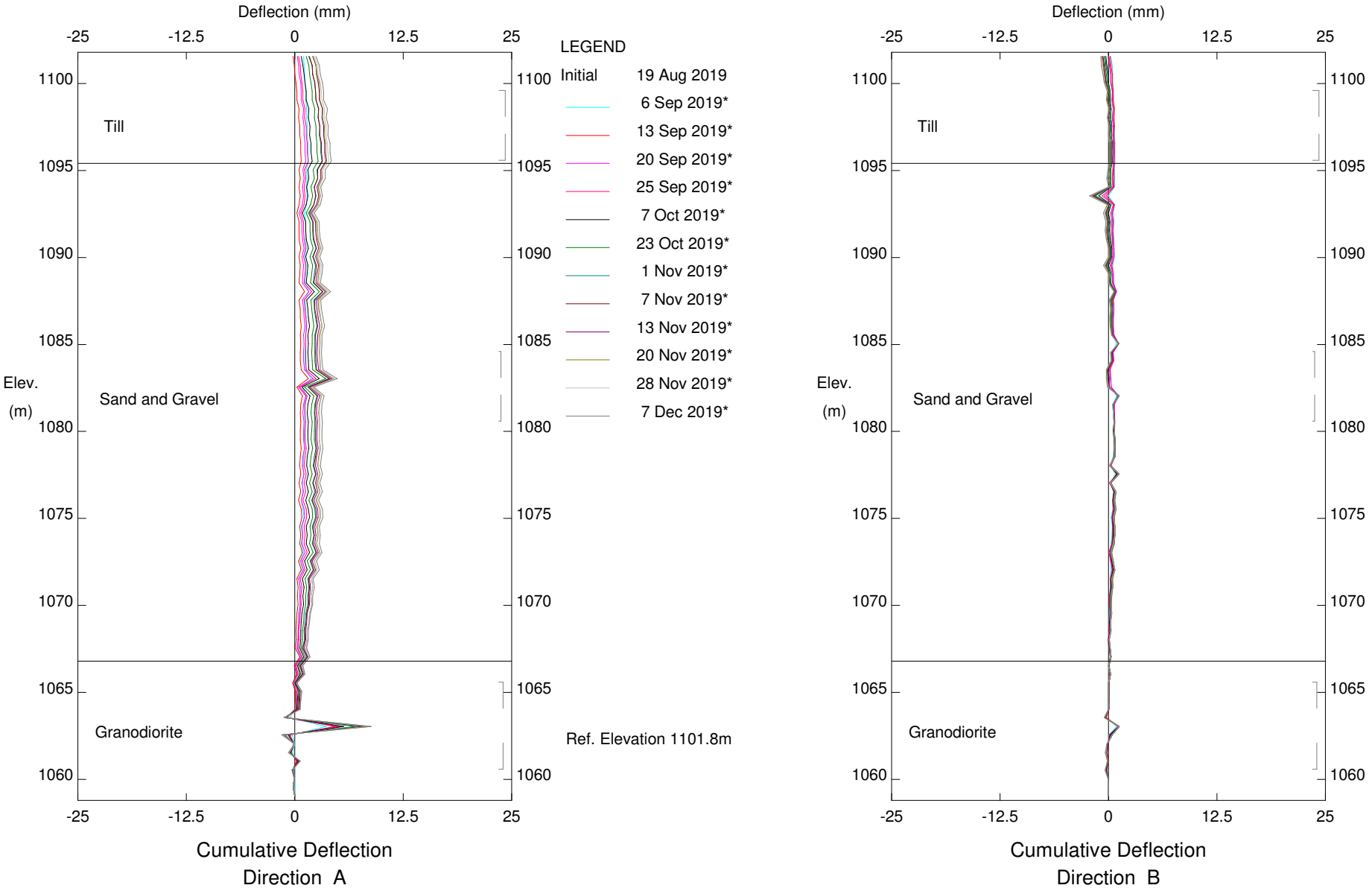
Highland Valley Copper - Logan Lake, BC



LL Dam,,,, Inclinometer I10-11

Sets marked * include zero shift and/or rotation corrections.

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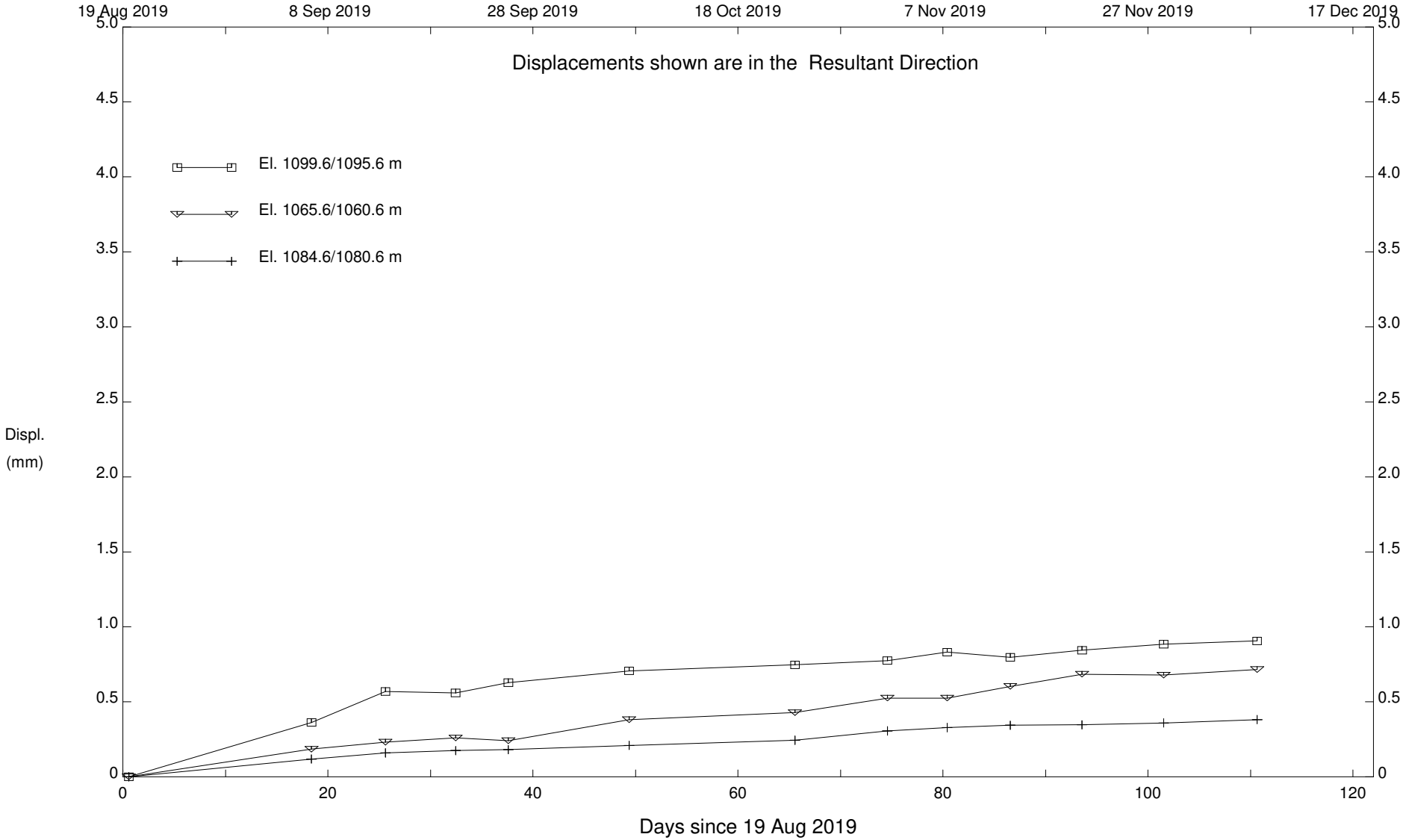
Highland Valley Copper - Logan Lake, BC

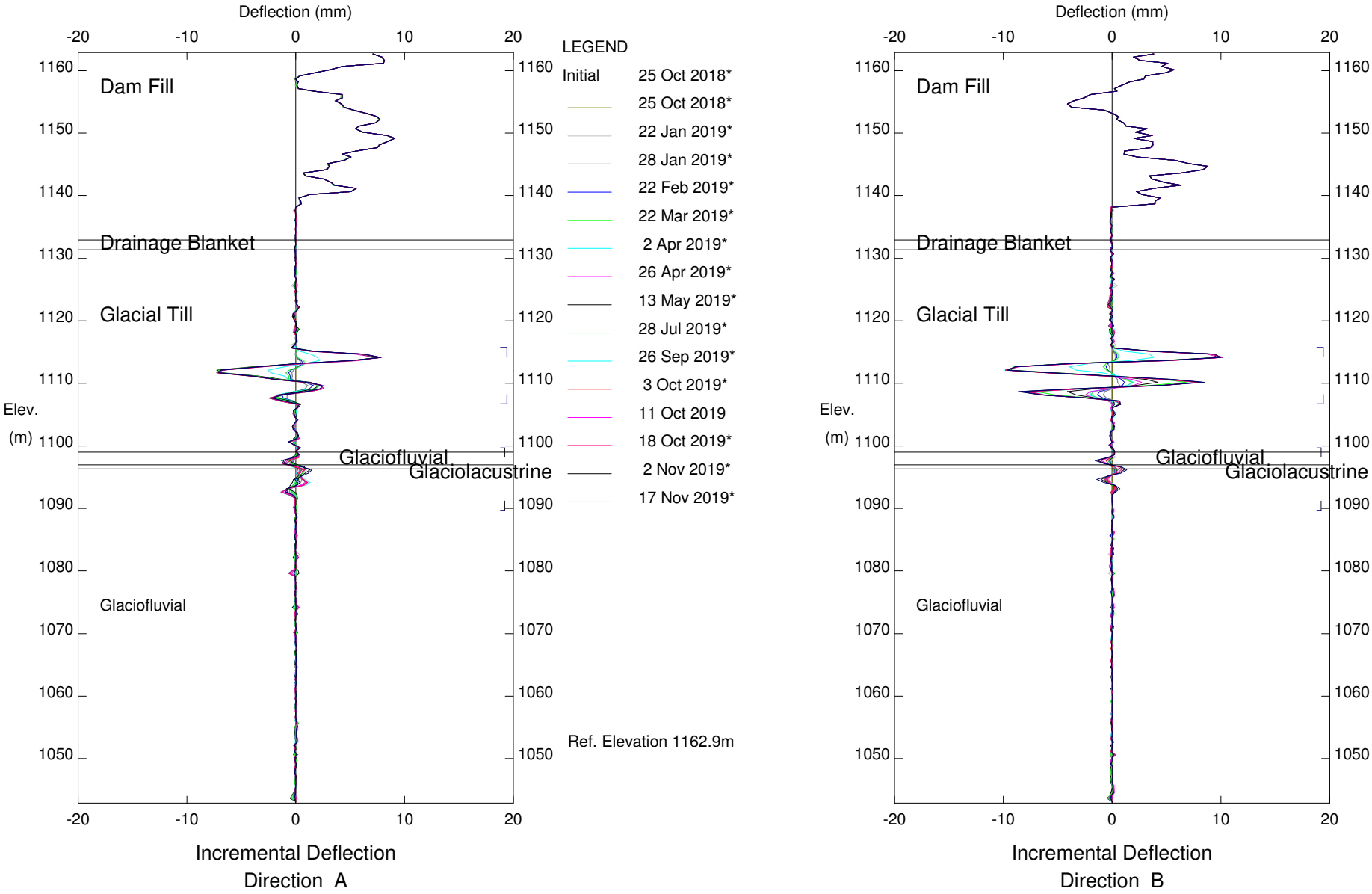


LL Dam,,,, Inclinometer I10-11

VALLEY BUTTRESS BERM EXTENSION

I17-07

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I17-07

Sets marked * include zero shift and/or rotation corrections.

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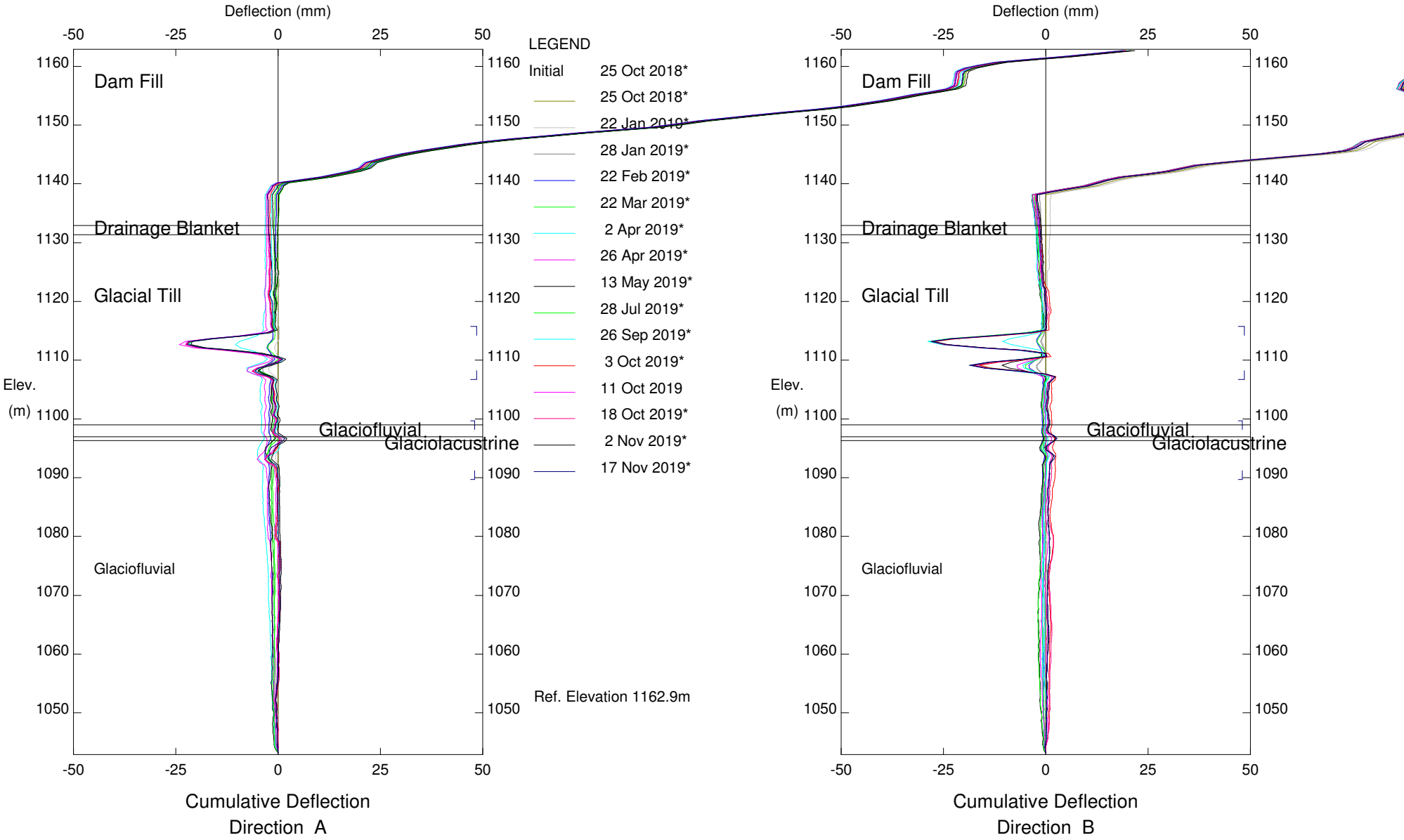
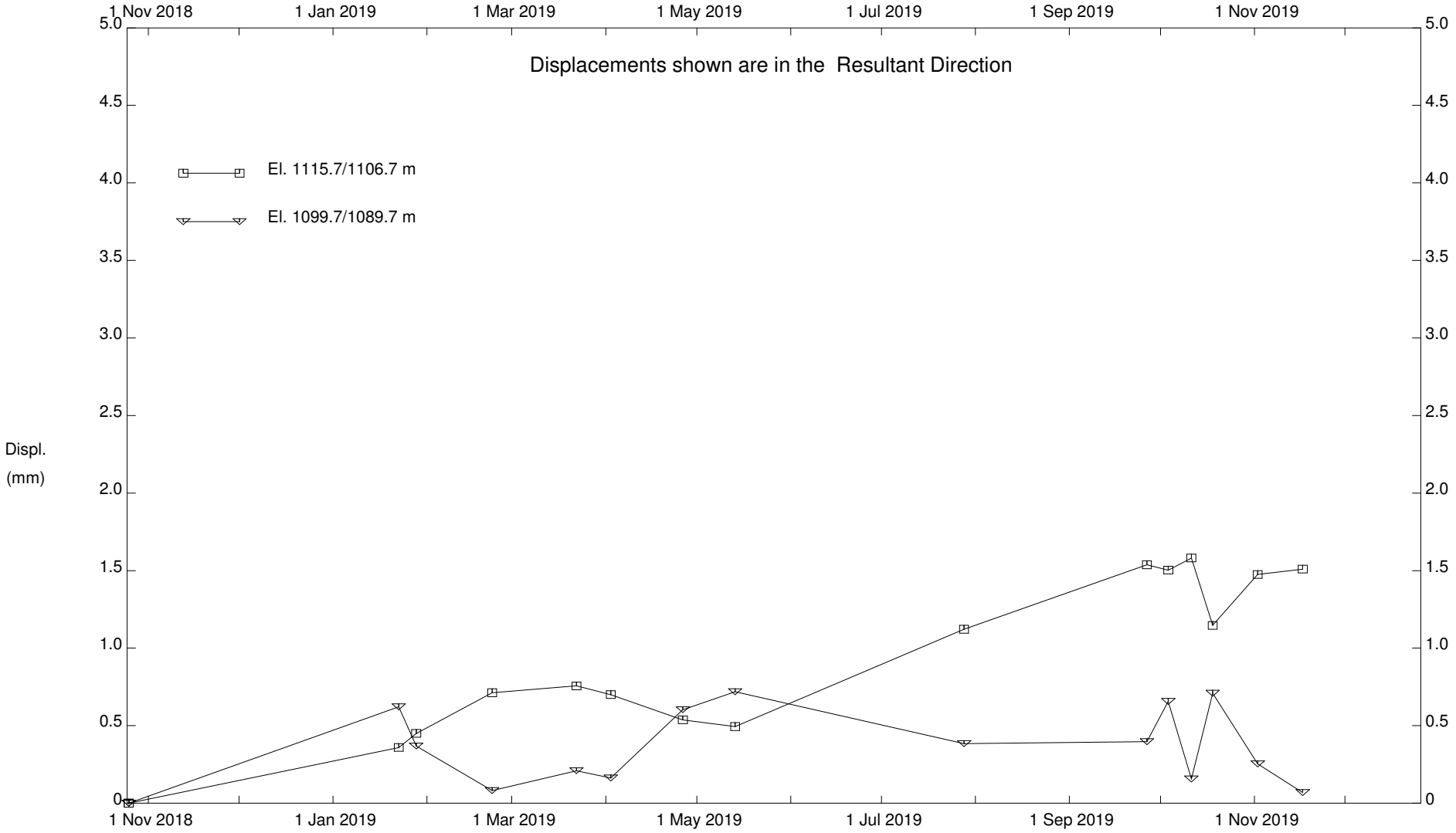
Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I17-07

Sets marked * include zero shift and/or rotation corrections.

Highland Valley Copper - Logan Lake, BC

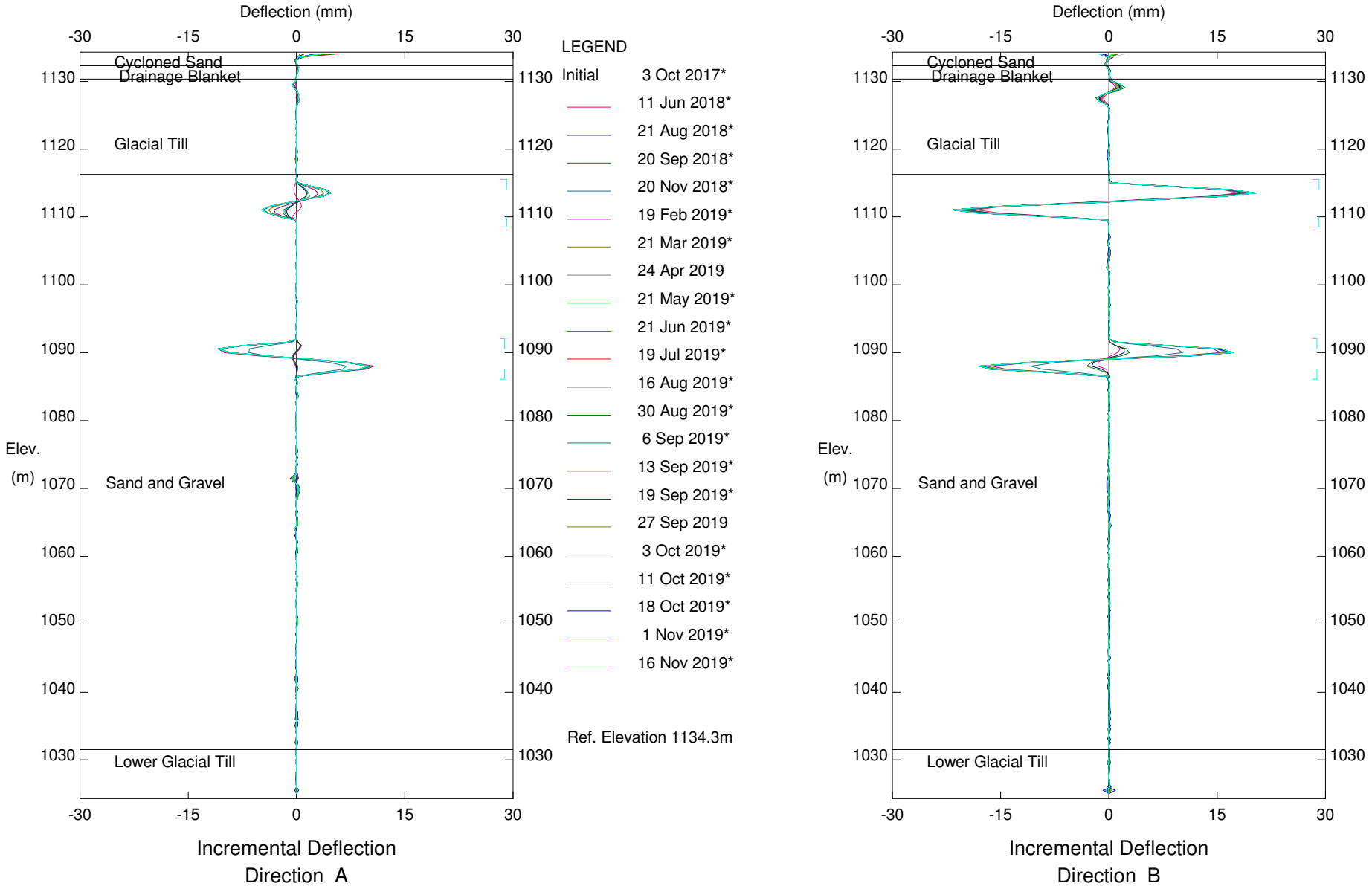


LL Dam, Inclinometer I17-07

VALLEY BUTTRESS BERM EXTENSION

I17-08

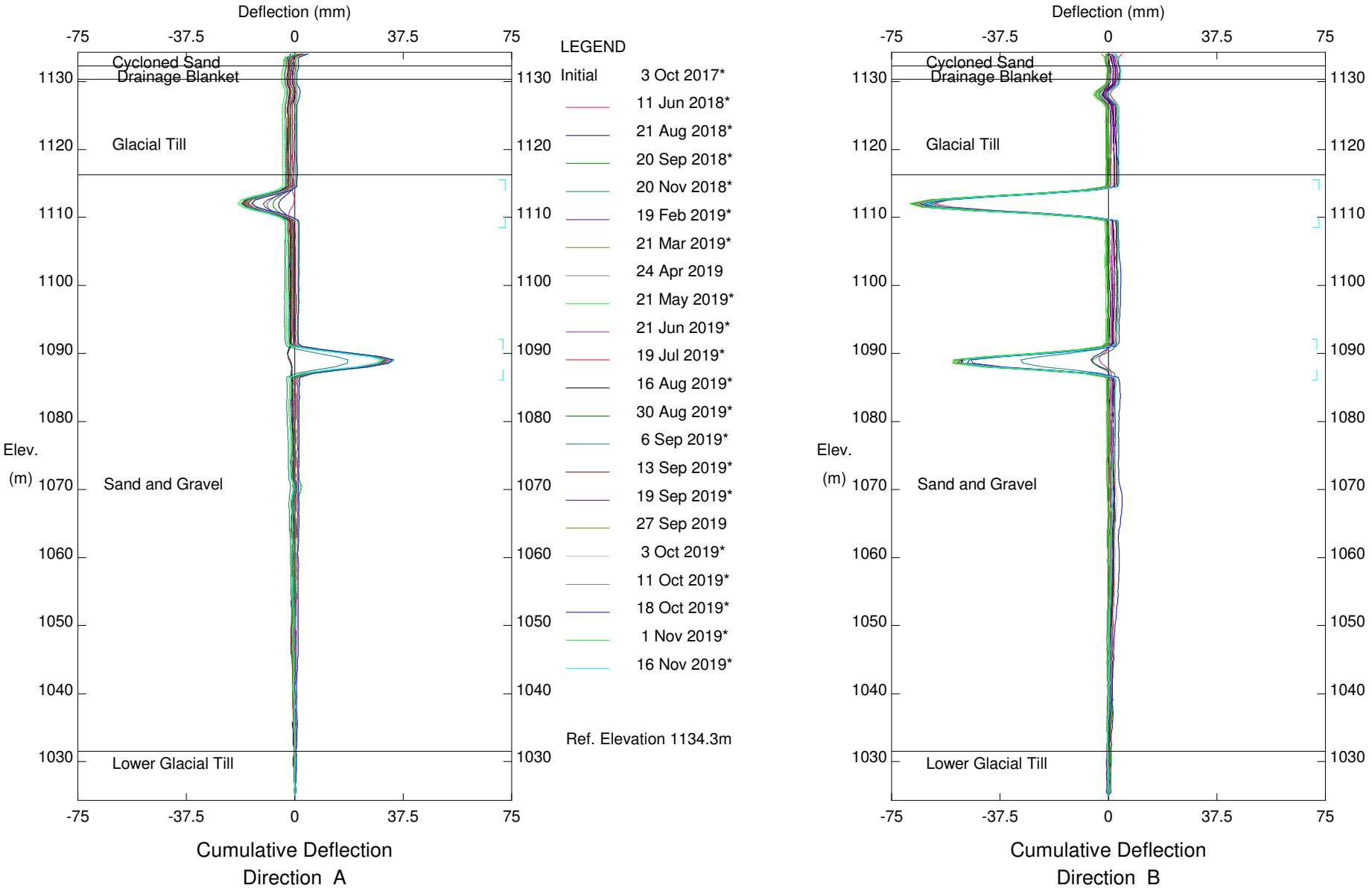
Highland Valley Copper - Logan Lake, BC



Valley Buttress Berm Extension, Inclinometer I17-08

Sets marked * include zero shift and/or rotation corrections.

Highland Valley Copper - Logan Lake, BC



Valley Buttress Berm Extension, Inclinometer I17-08

Sets marked * include zero shift and/or rotation corrections.

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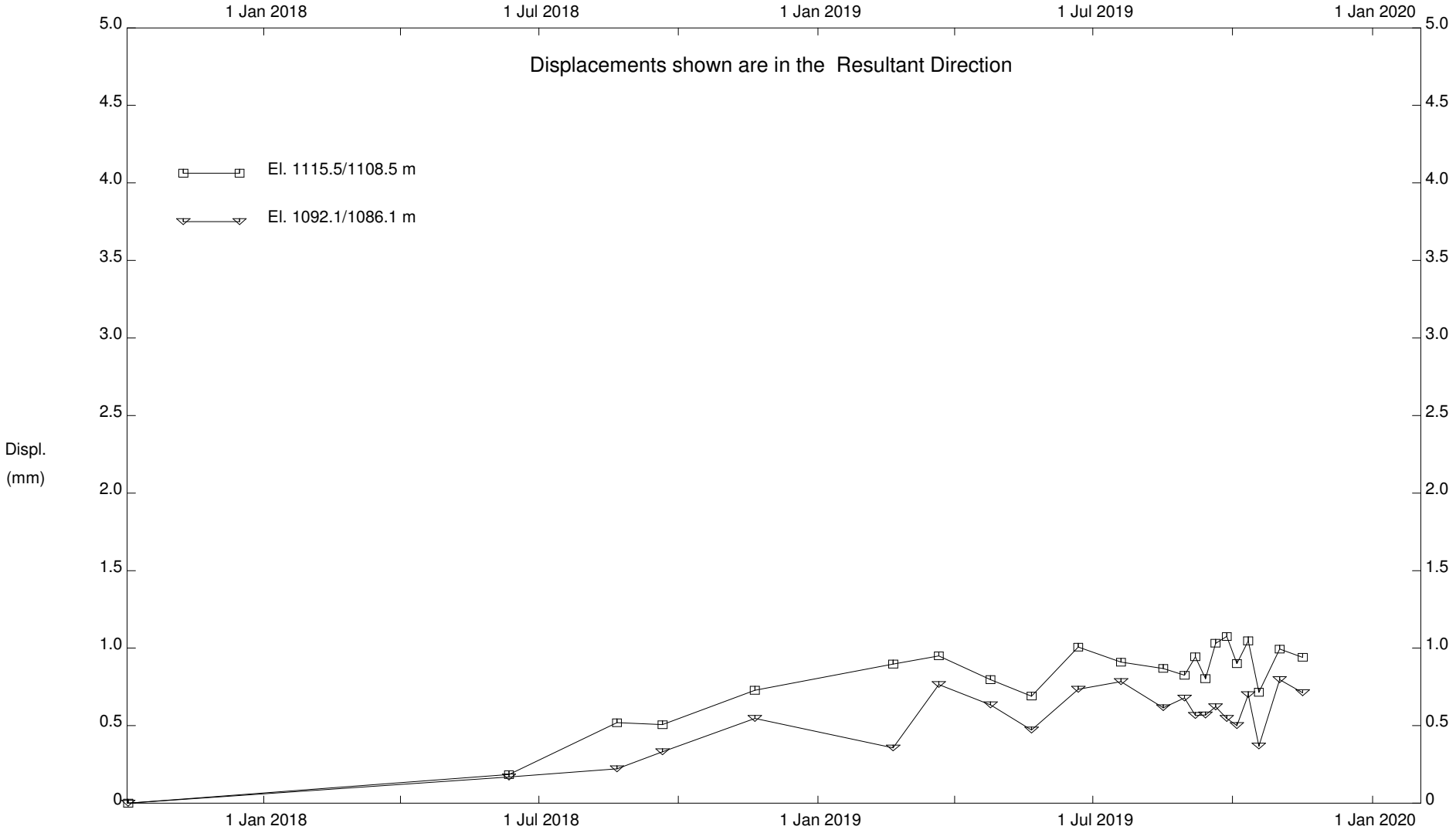
Highland Valley Copper - Logan Lake, BC

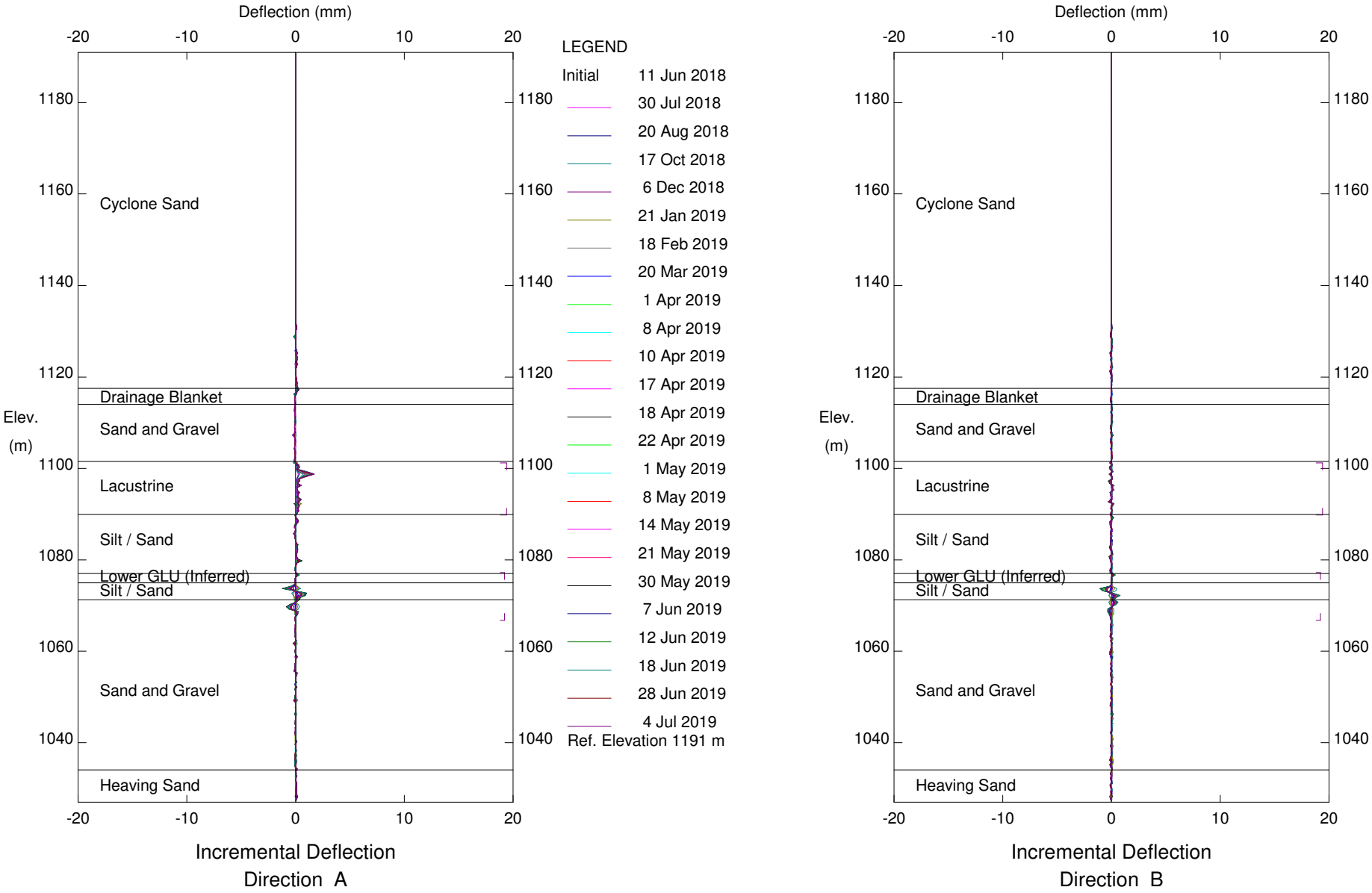


Valley Buttress Berm Extension, Inclinometer I17-08

VALLEY BUTTRESS BERM

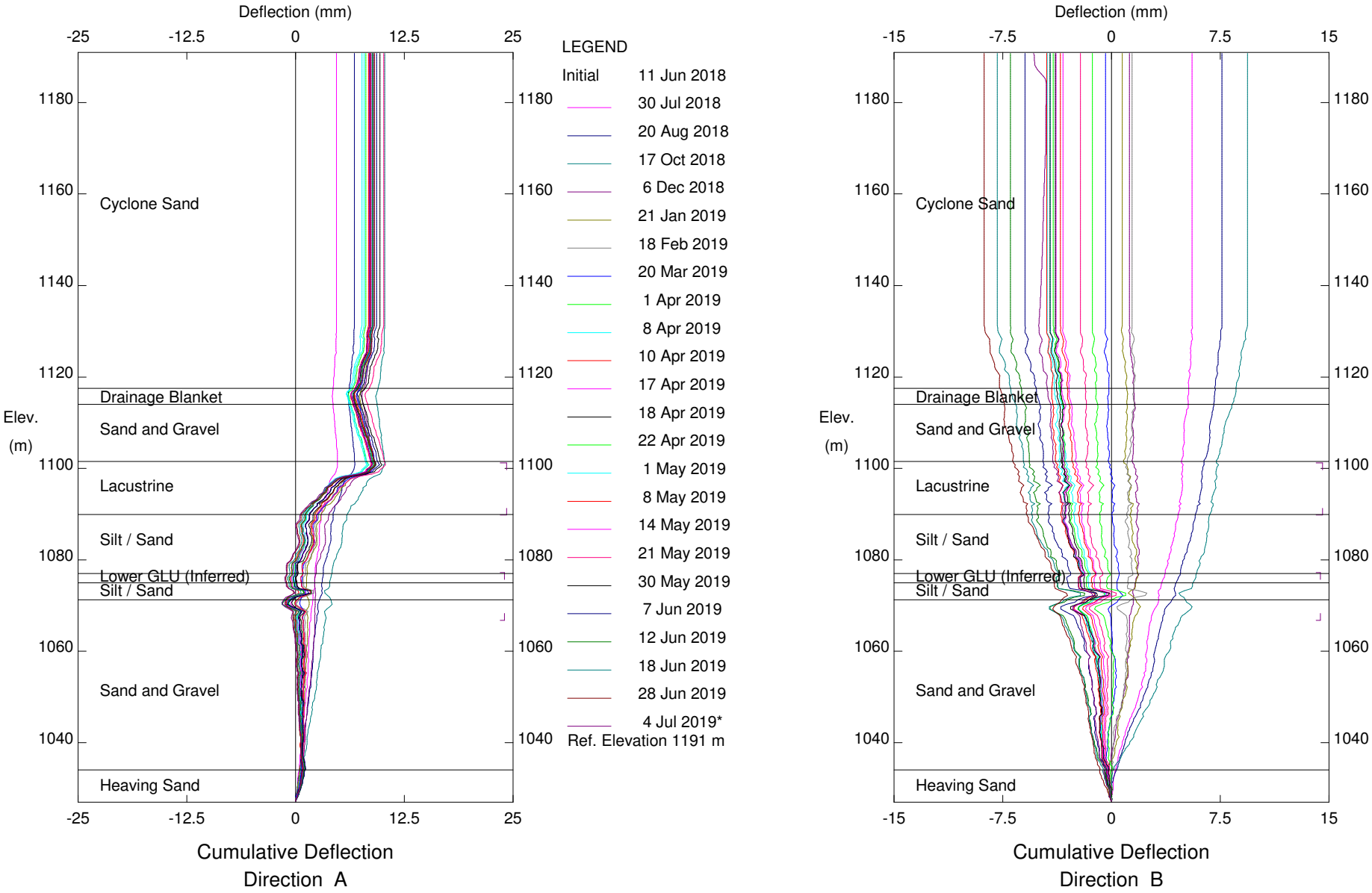
I10-06

Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I10-6,,,

Highland Valley Copper - Logan Lake, BC

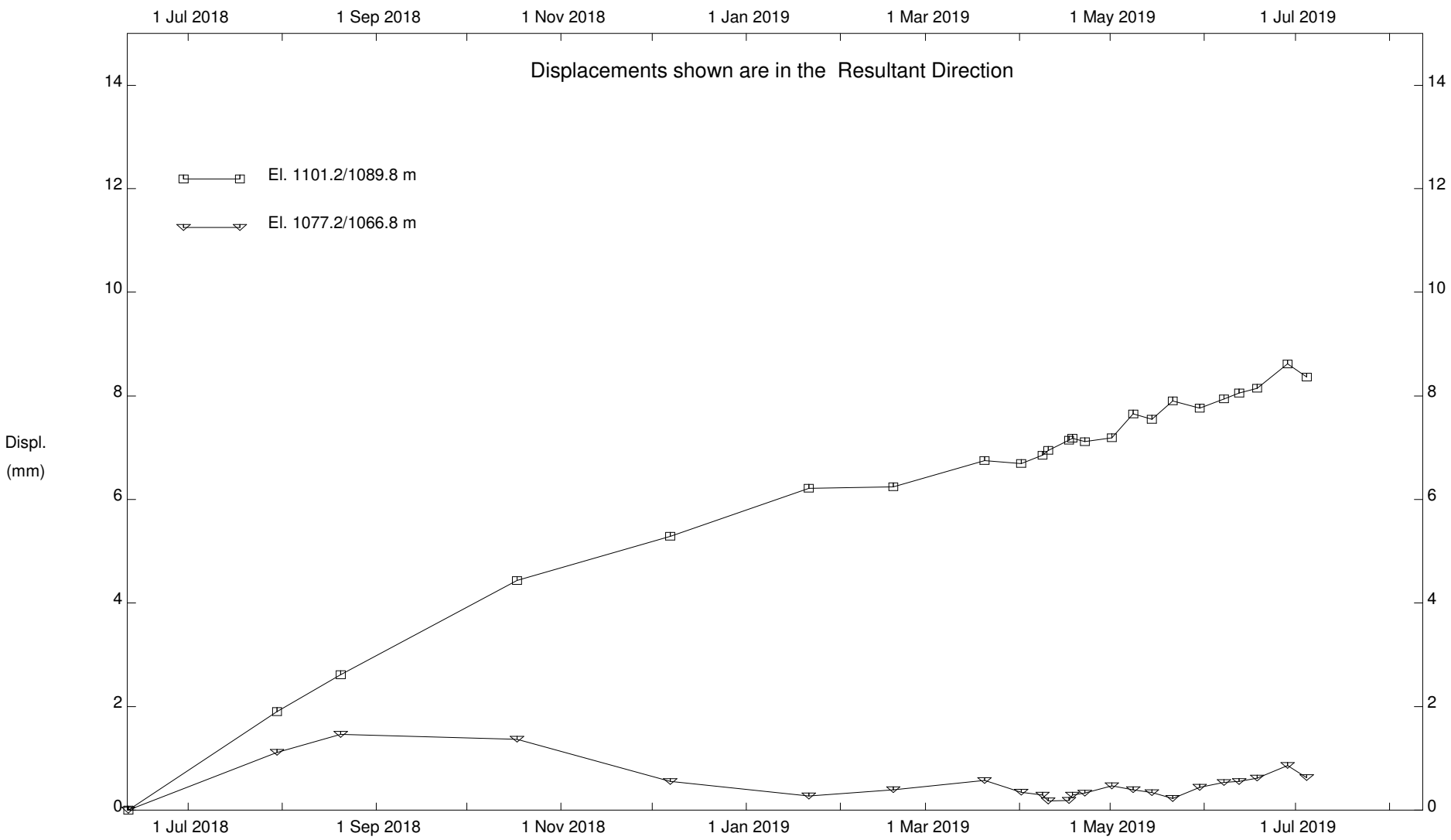


Dam Fill Excluded,,,, Inclinometer I10-6,,,

Sets marked * include zero shift and/or rotation corrections.

Z:\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\I

Highland Valley Copper - Logan Lake, BC



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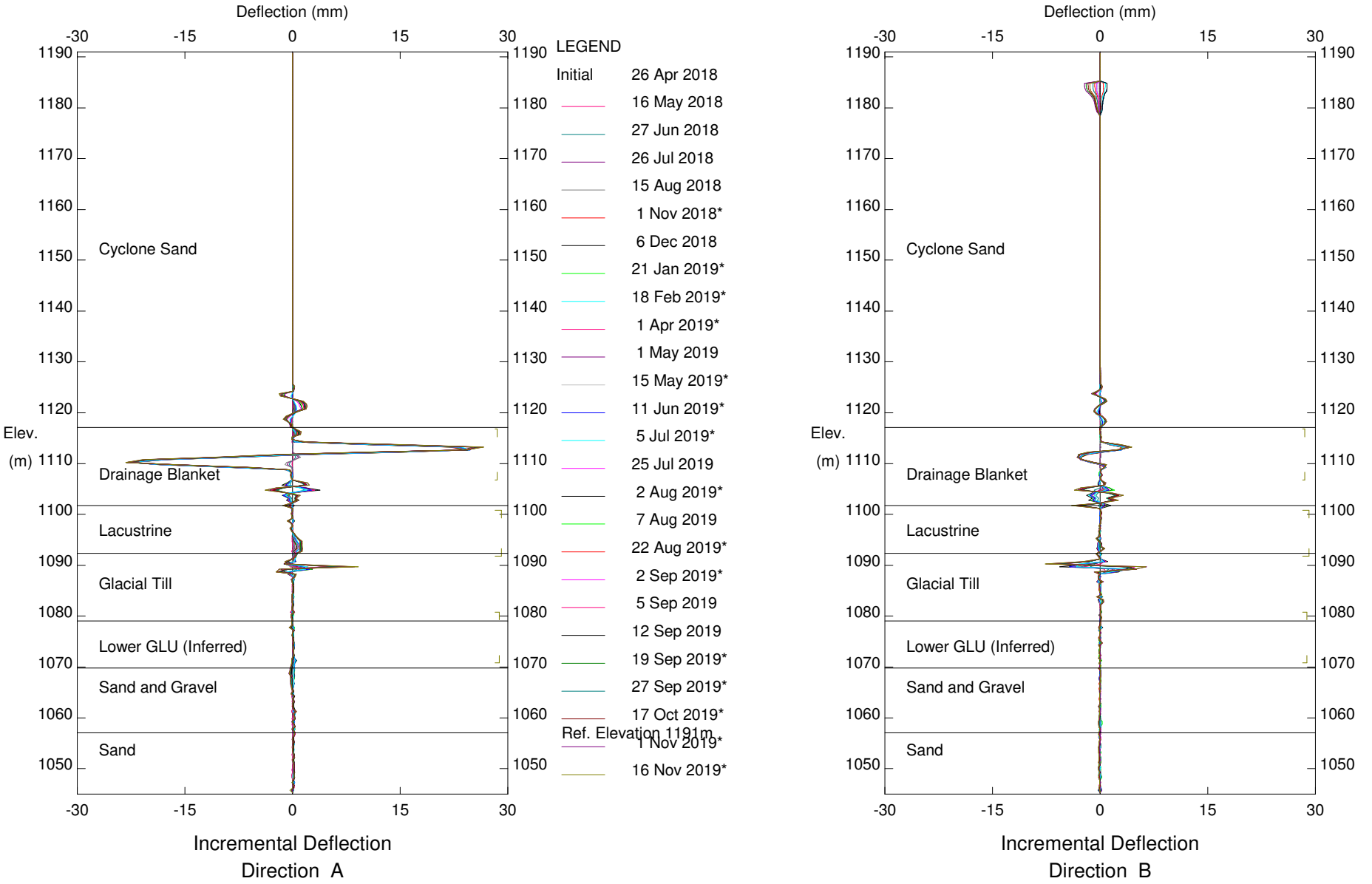
VALLEY BUTTRESS BERM

I10-07

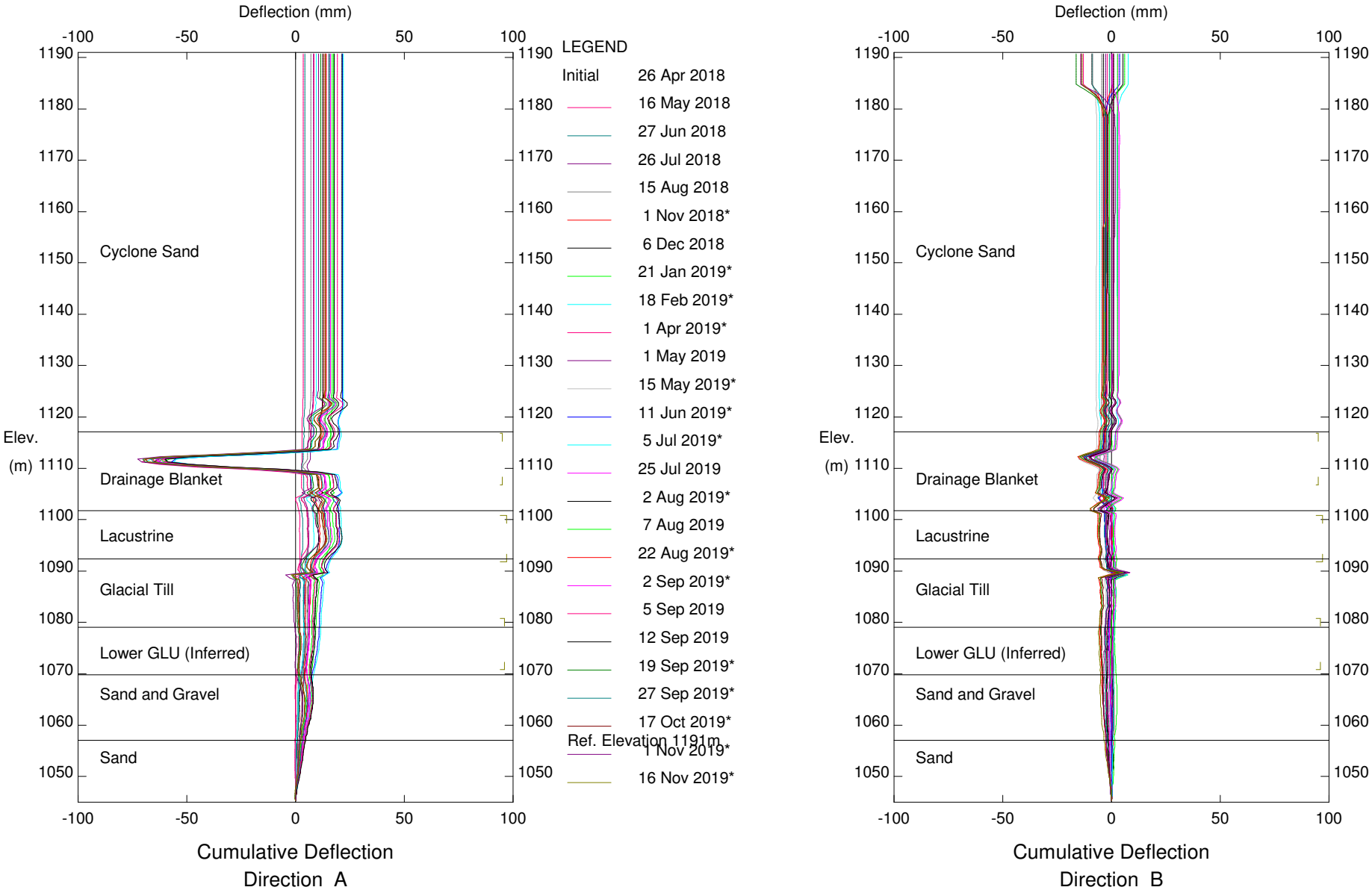
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I10-7,,,

Sets marked * include zero shift and/or rotation corrections.

Highland Valley Copper - Logan Lake, BC

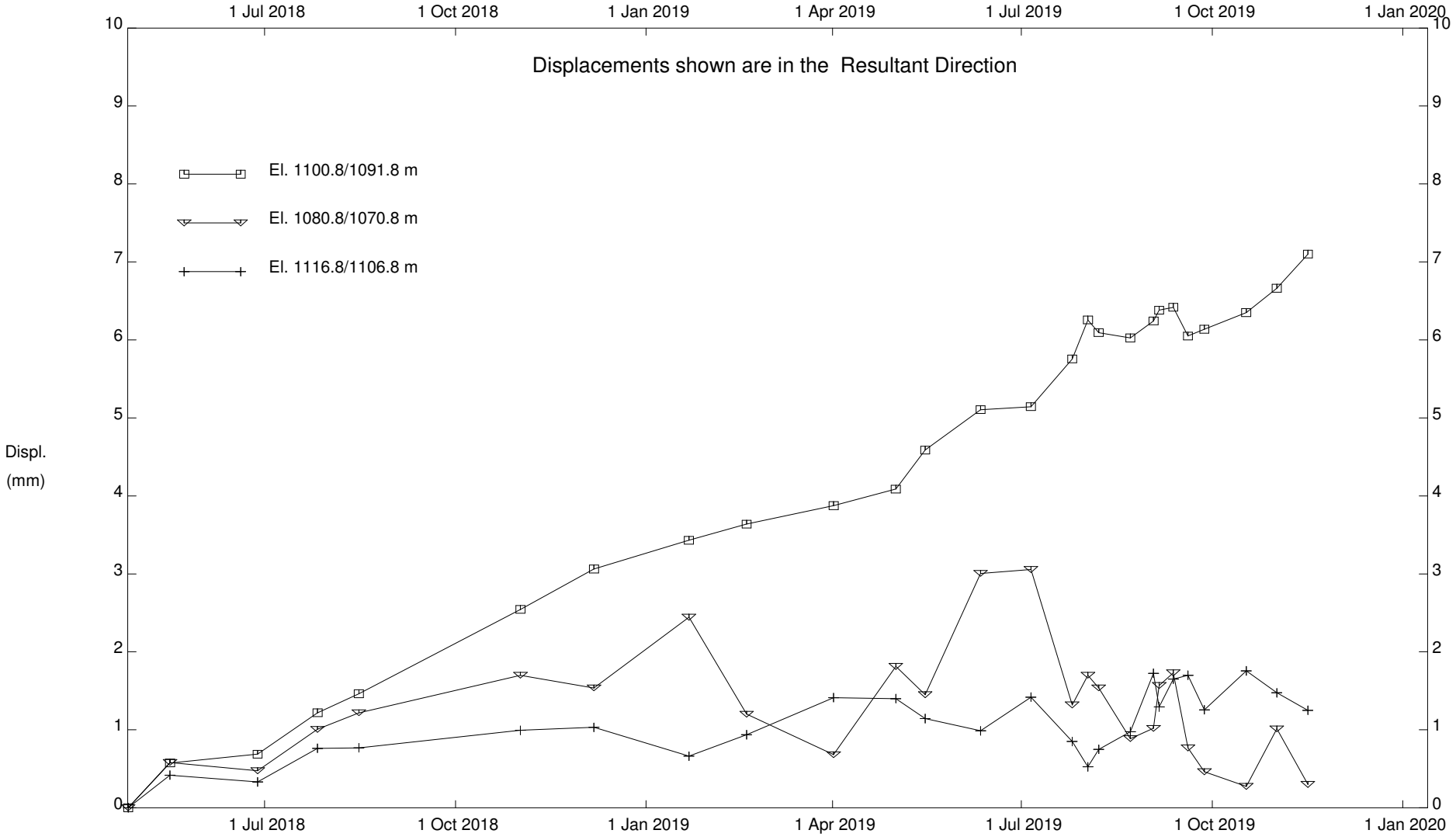


Dam Fill Excluded,,,, Inclinometer I10-7,,,

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC



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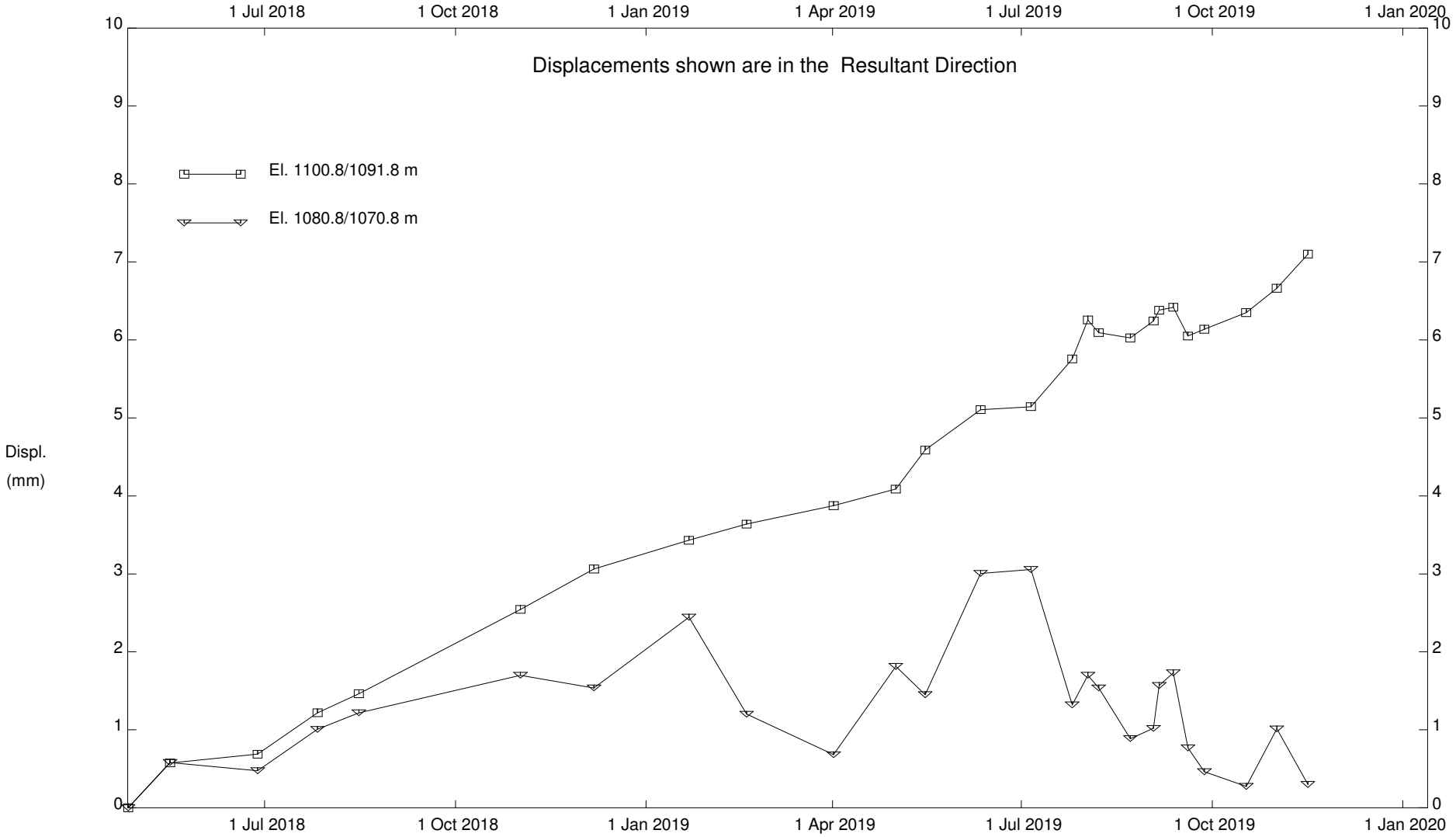
Highland Valley Copper - Logan Lake, BC



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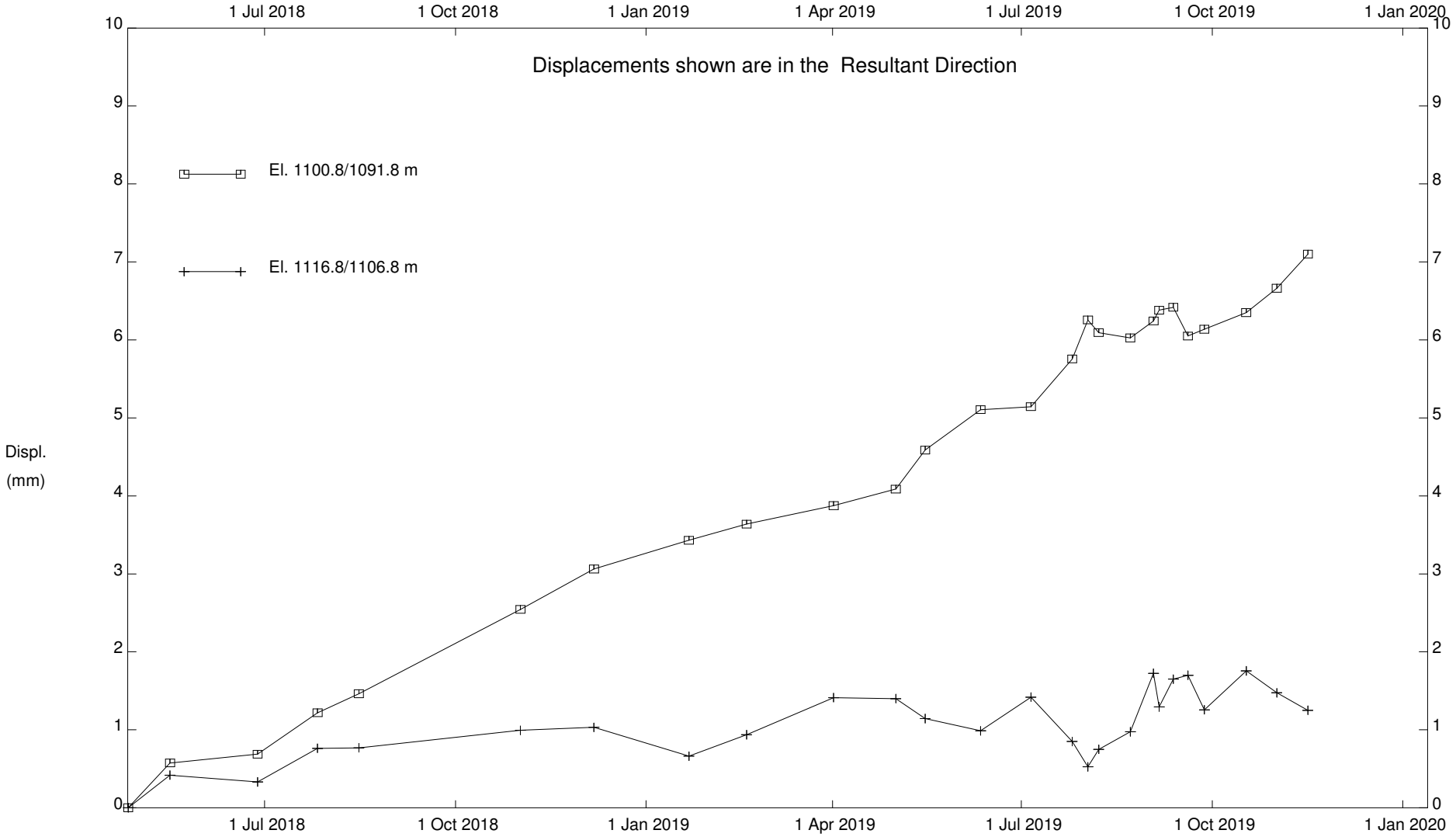
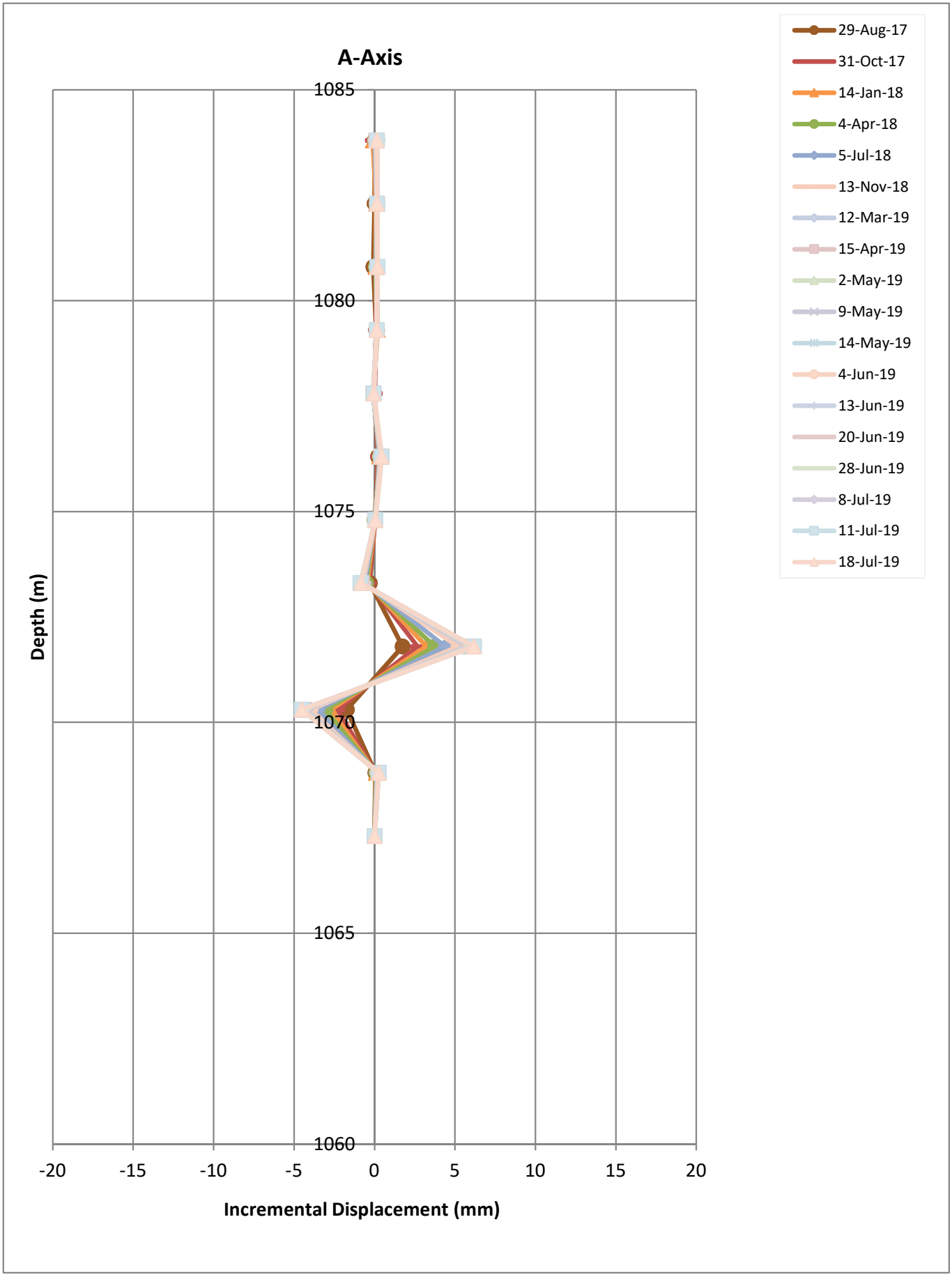
Highland Valley Copper - Logan Lake, BC

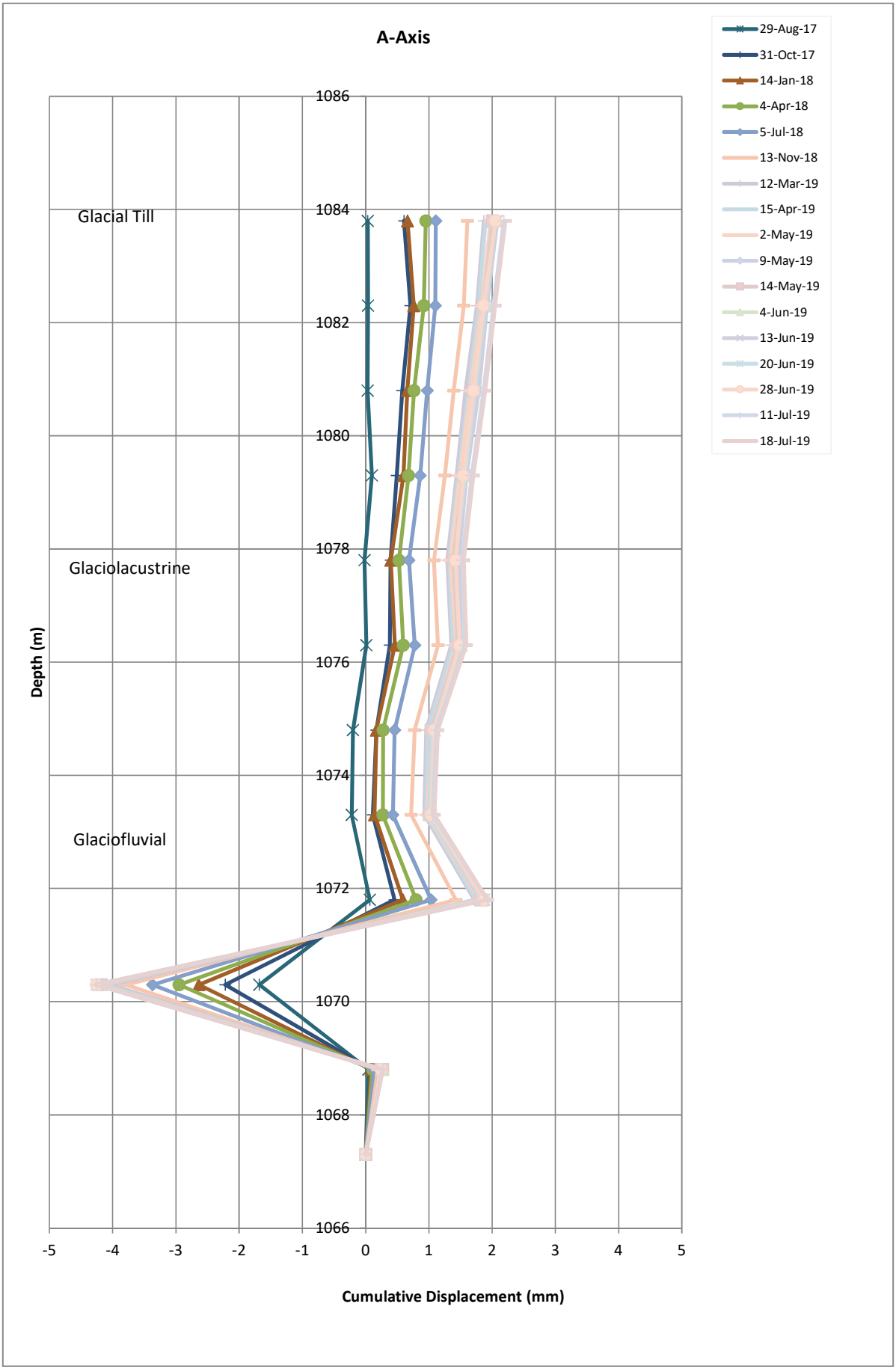


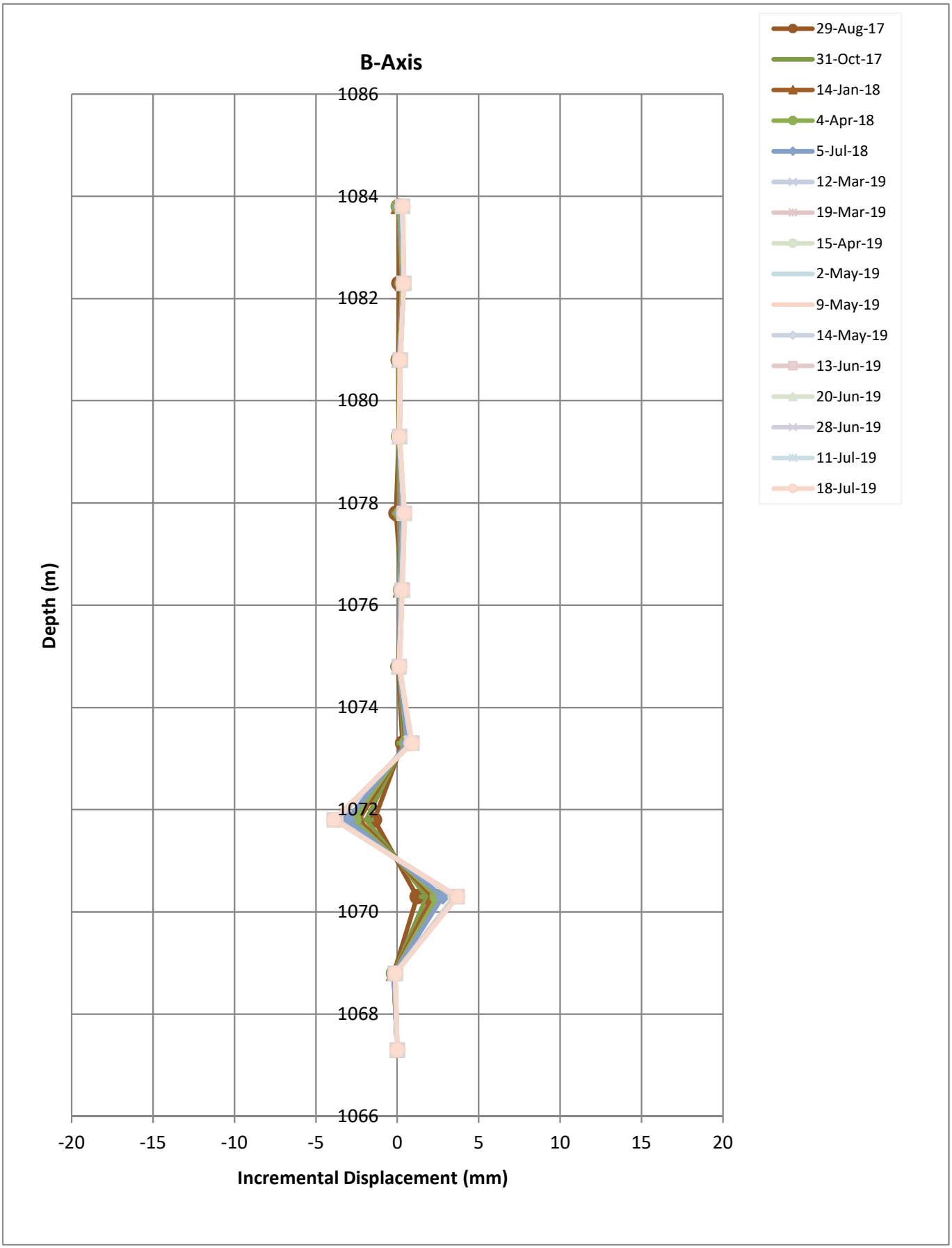
Dam Fill Excluded,,,, Inclinometer I10-7,,,

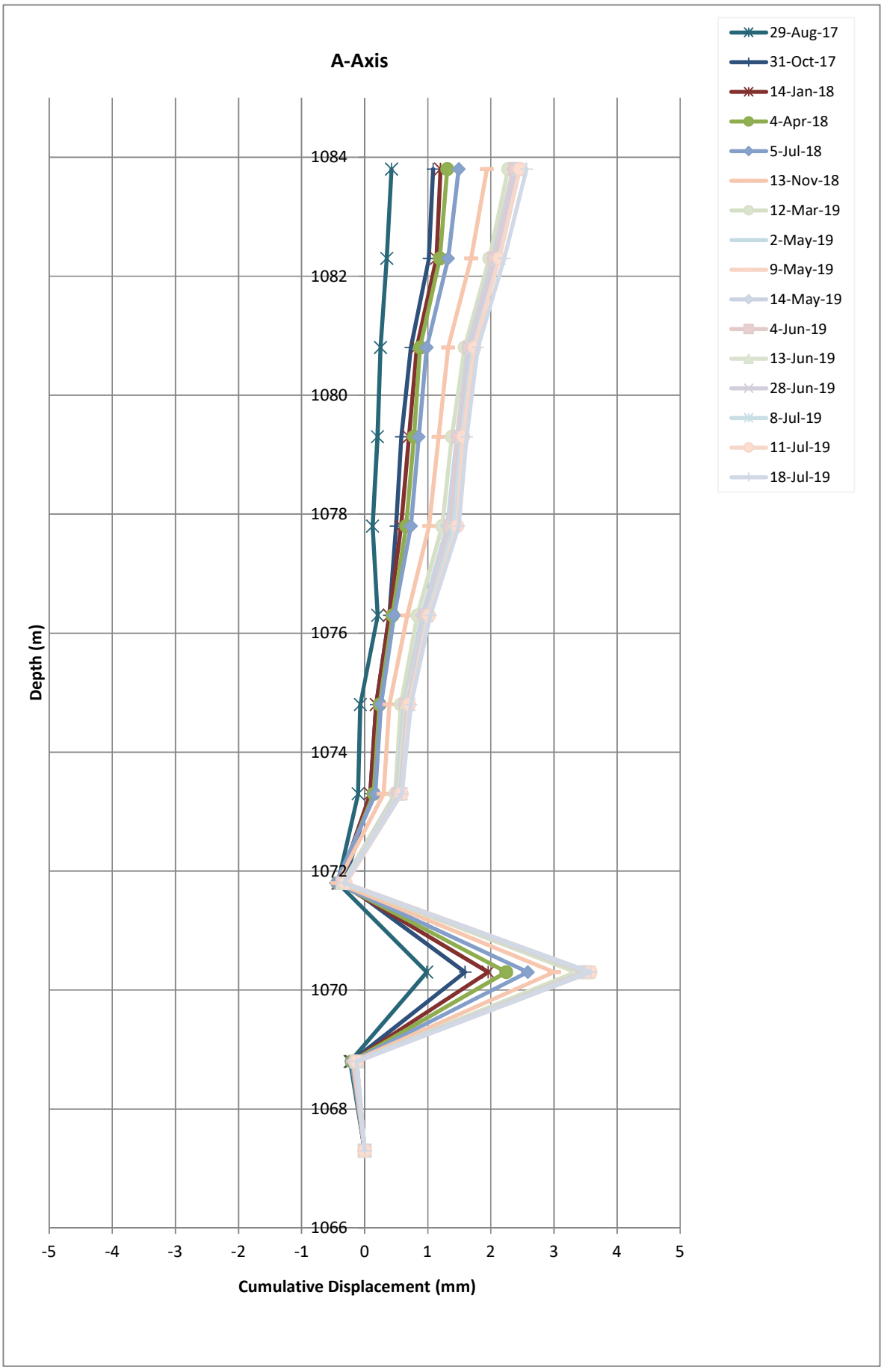
VALLEY BUTTRESS BERM

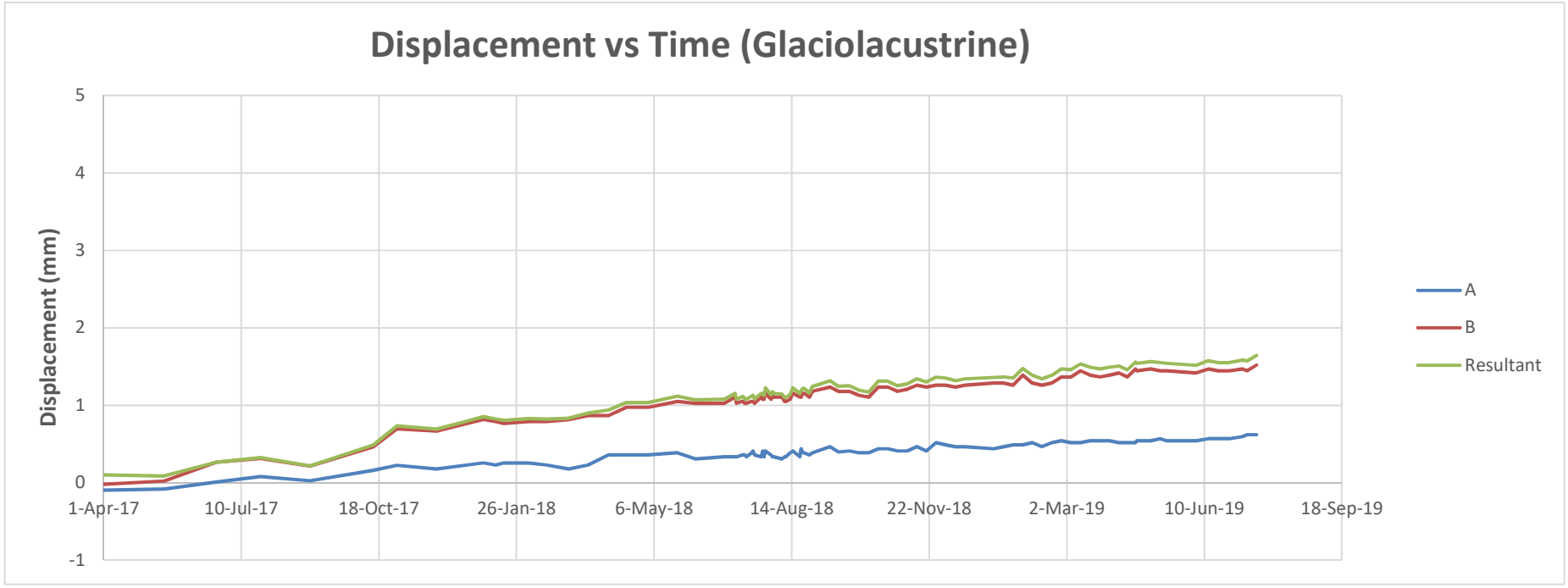
I15-24


A-Axis
Depth (m)
1085
1080
1075
1070
1065
1060
-20
-15
-10
-5
0
5
10
15
20
Incremental Displacement (mm)
29-Aug-17
31-Oct-17
14-Jan-18
4-Apr-18
5-Jul-18
13-Nov-18
12-Mar-19
15-Apr-19
2-May-19
9-May-19
14-May-19
4-Jun-19
13-Jun-19
20-Jun-19
28-Jun-19
8-Jul-19
11-Jul-19
18-Jul-19


A-Axis
29-Aug-17
31-Oct-17
14-Jan-18
4-Apr-18
5-Jul-18
13-Nov-18
12-Mar-19
15-Apr-19
2-May-19
9-May-19
14-May-19
4-Jun-19
13-Jun-19
20-Jun-19
28-Jun-19
11-Jul-19
18-Jul-19
Glacial Till
Glaciolacustrine
Glaciofluvial
Depth (m)
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)

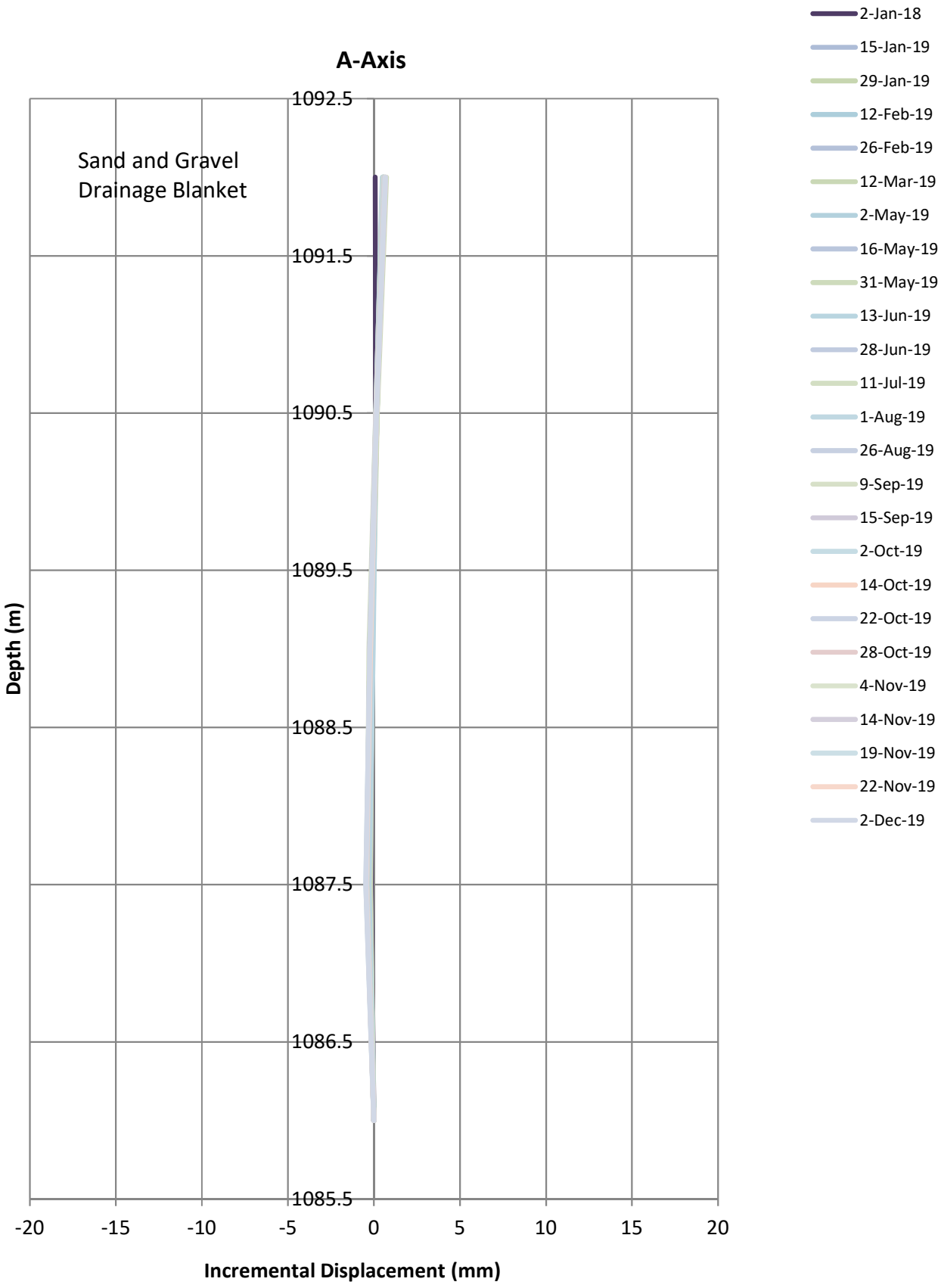

B-Axis
Depth (m)
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
-20
-15
-10
-5
0
5
10
15
20
Incremental Displacement (mm)
29-Aug-17
31-Oct-17
14-Jan-18
4-Apr-18
5-Jul-18
12-Mar-19
19-Mar-19
15-Apr-19
2-May-19
9-May-19
14-May-19
13-Jun-19
20-Jun-19
28-Jun-19
11-Jul-19
18-Jul-19

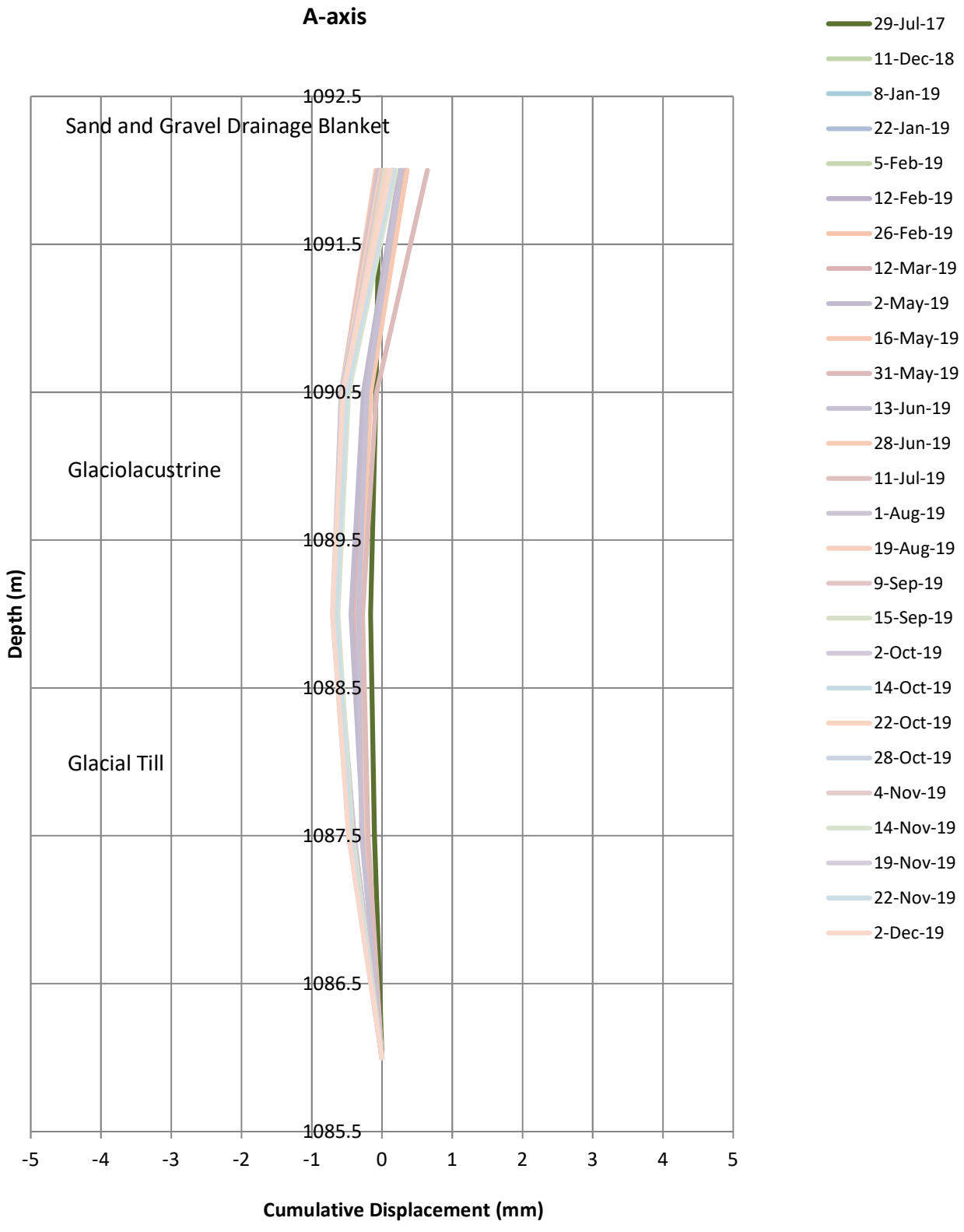

A-Axis
29-Aug-17
31-Oct-17
14-Jan-18
4-Apr-18
5-Jul-18
13-Nov-18
12-Mar-19
2-May-19
9-May-19
14-May-19
4-Jun-19
13-Jun-19
28-Jun-19
8-Jul-19
11-Jul-19
18-Jul-19
Depth (m)
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)


Displacement vs Time (Glaciolacustrine)
Displacement (mm)
5
4
3
2
1
0
-1
1-Apr-17
10-Jul-17
18-Oct-17
26-Jan-18
6-May-18
14-Aug-18
22-Nov-18
2-Mar-19
10-Jun-19
18-Sep-19
A
B
Resultant

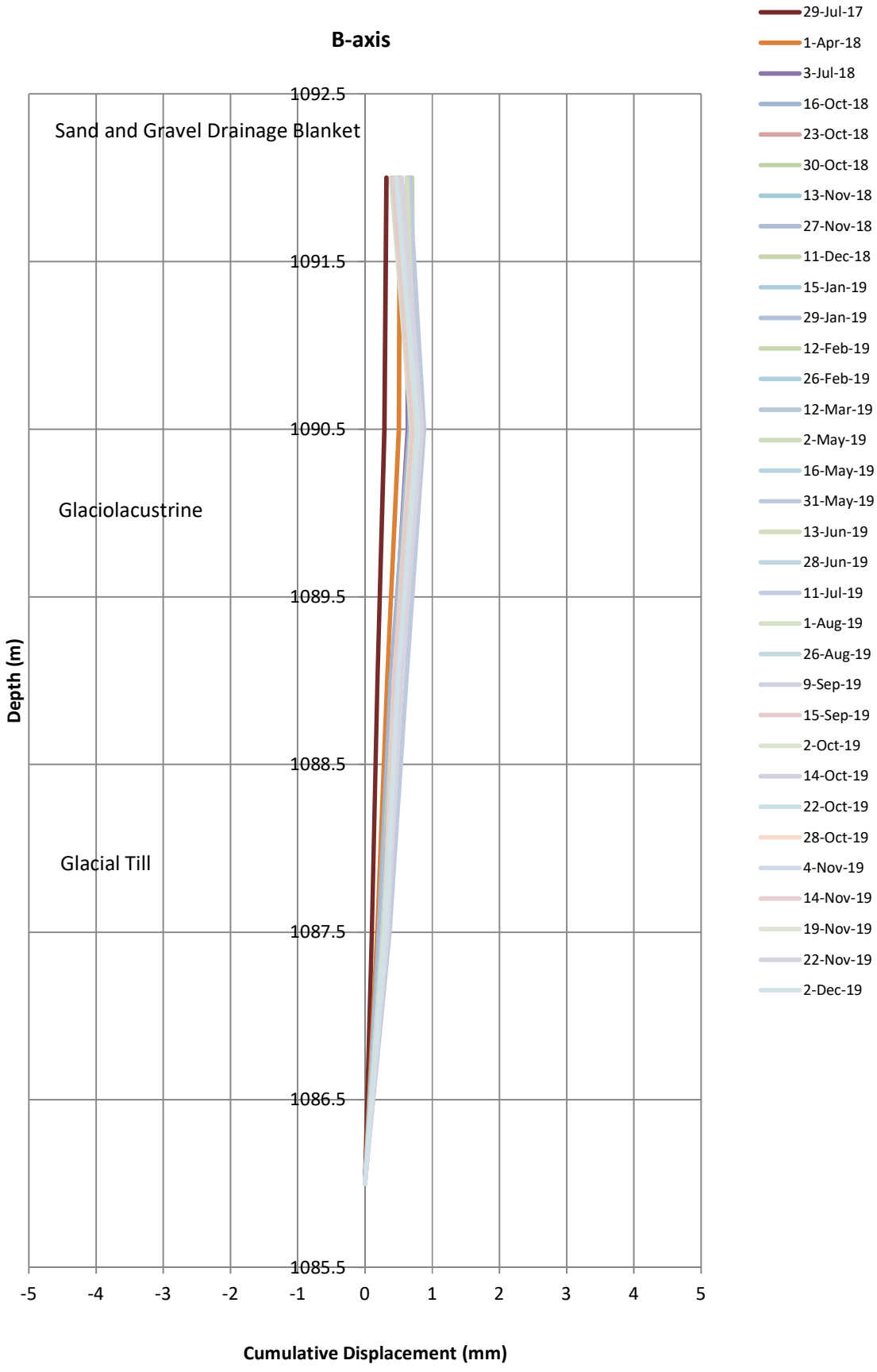
VALLEY BUTTRESS BERM

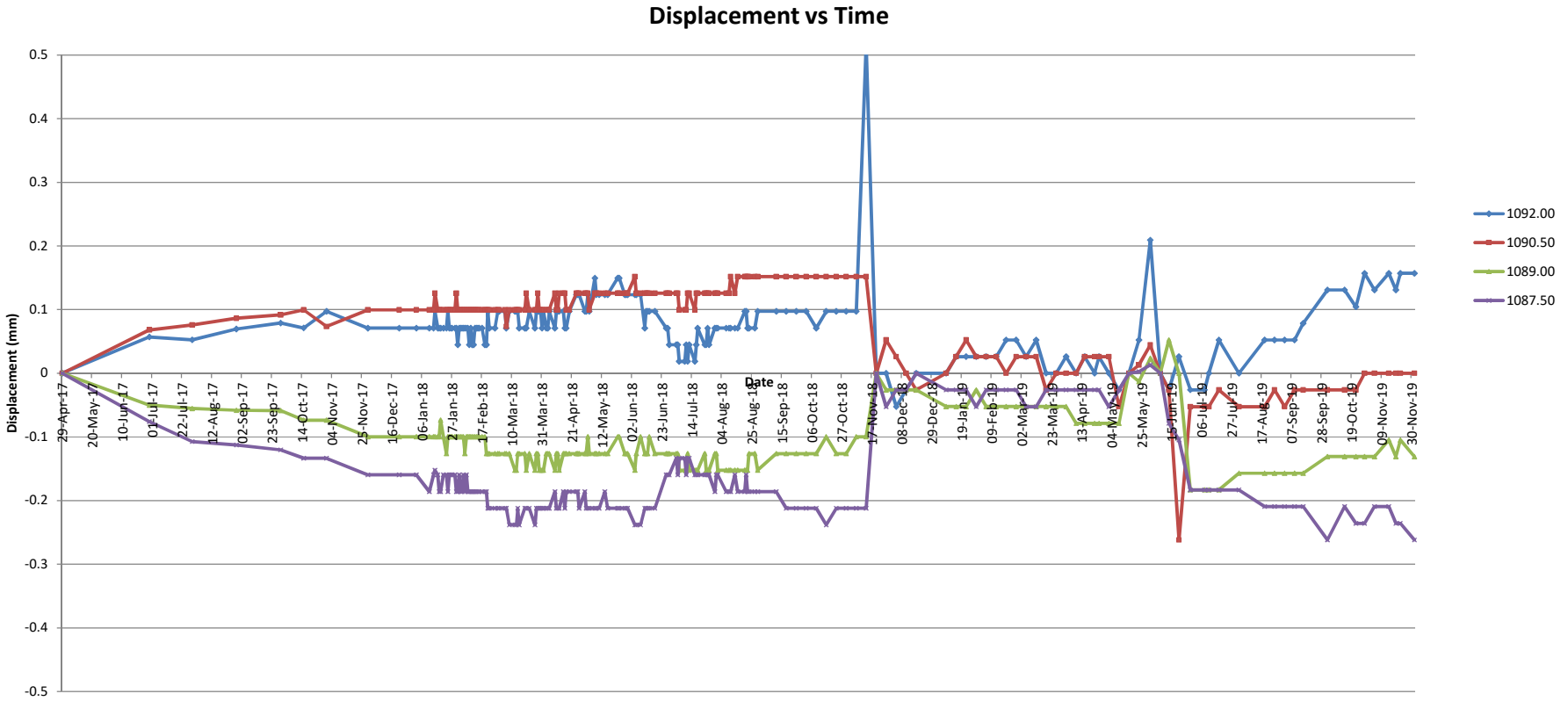
I15-27a

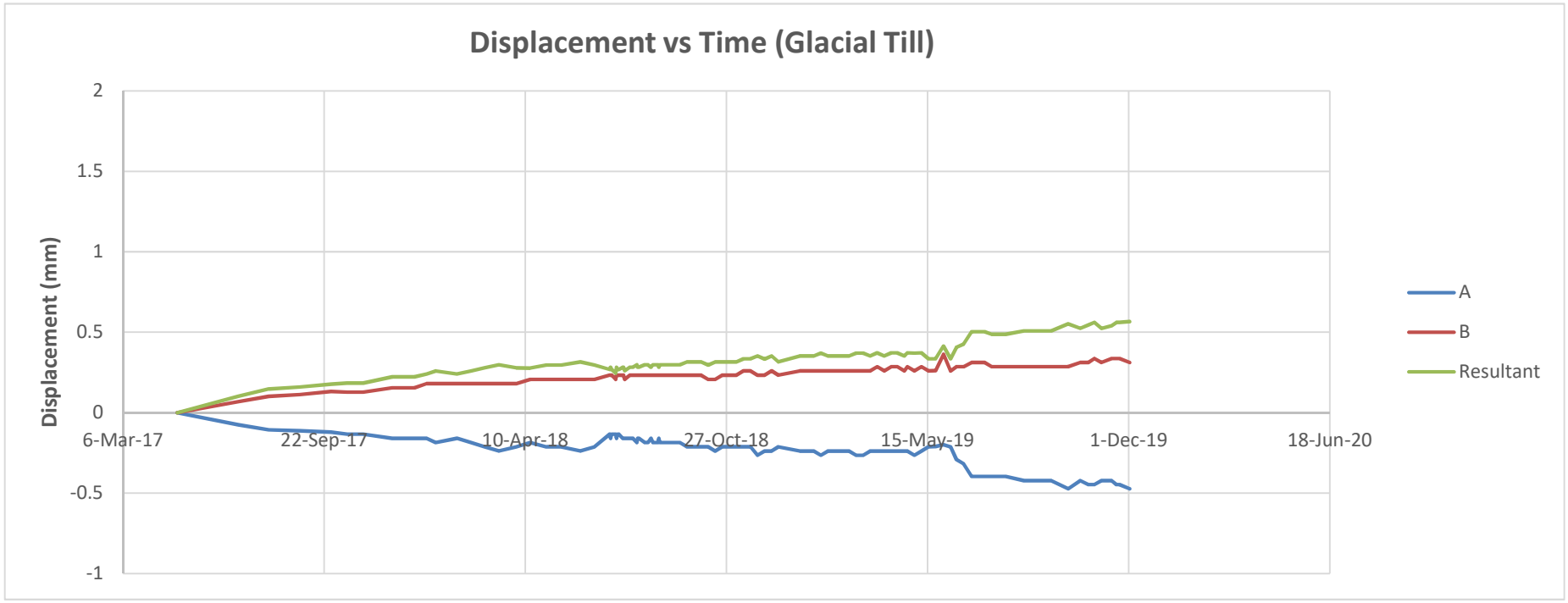

A-Axis
Sand and Gravel
Drainage Blanket
1092.5
1091.5
1090.5
1089.5
1088.5
1087.5
1086.5
1085.5
Depth (m)
-20
-15
-10
-5
0
5
10
15
20
Incremental Displacement (mm)
2-Jan-18
15-Jan-19
29-Jan-19
12-Feb-19
26-Feb-19
12-Mar-19
2-May-19
16-May-19
31-May-19
13-Jun-19
28-Jun-19
11-Jul-19
1-Aug-19
26-Aug-19
9-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
28-Oct-19
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19

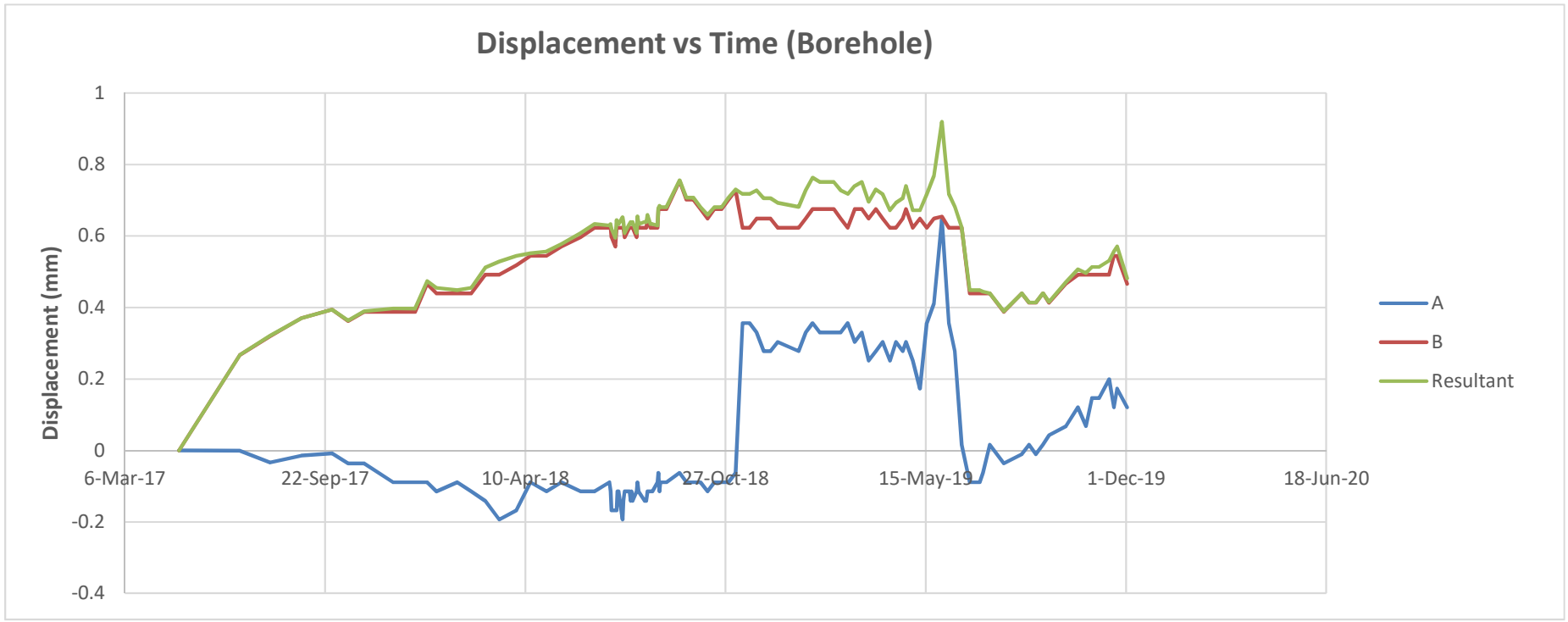

A-axis
Sand and Gravel Drainage Blanket
Glaciolacustrine
Glacial Till
Depth (m)
1092.5
1091.5
1090.5
1089.5
1088.5
1087.5
1086.5
1085.5
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)
29-Jul-17
11-Dec-18
8-Jan-19
22-Jan-19
5-Feb-19
12-Feb-19
26-Feb-19
12-Mar-19
2-May-19
16-May-19
31-May-19
13-Jun-19
28-Jun-19
11-Jul-19
1-Aug-19
19-Aug-19
9-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
28-Oct-19
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19

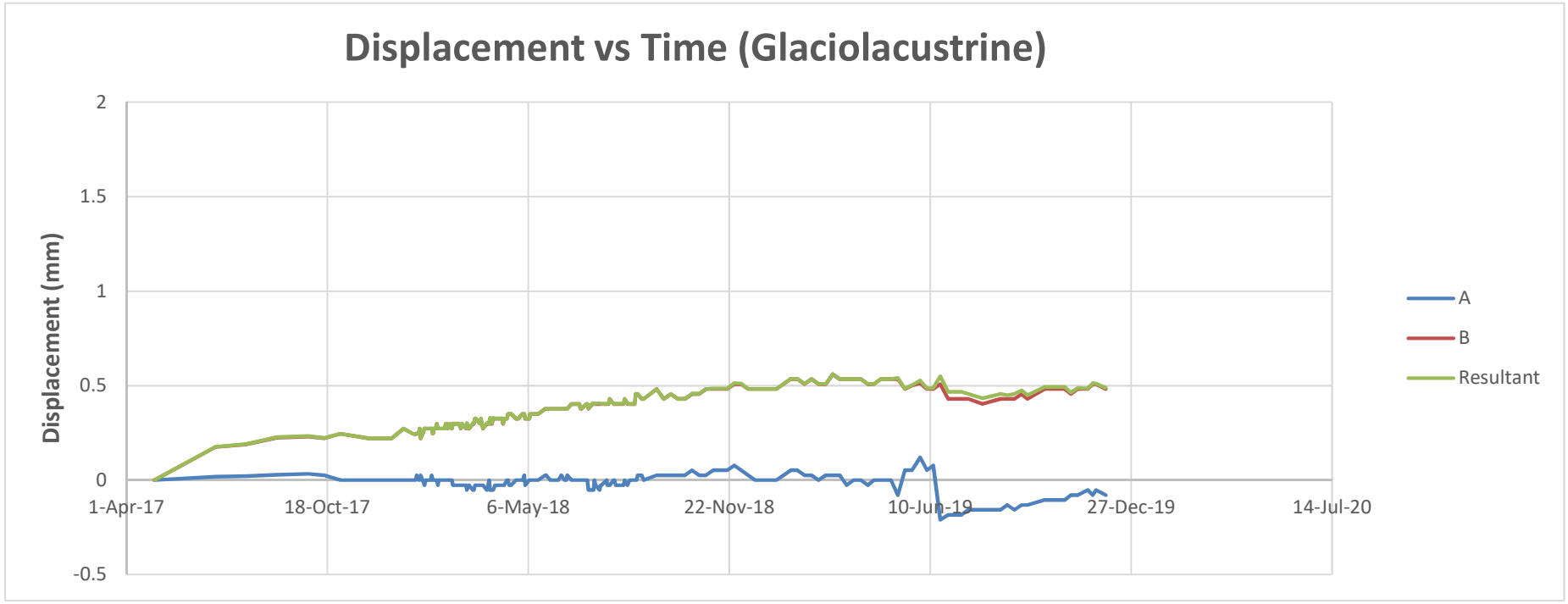
B-Axis
Sand and Gravel
Drainage Blanket
Glaciolacustrine
Glacial Till
Depth (m)
1092.5
1091.5
1090.5
1089.5
1088.5
1087.5
1086.5
1085.5
-20
-15
-10
-5
0
5
10
15
20
Incremental Displacement (mm)
2-Jan-18
1-Apr-18
3-Jul-18
16-Oct-18
30-Oct-18
13-Nov-18
27-Nov-18
4-Dec-18
18-Dec-18
8-Jan-19
22-Jan-19
5-Feb-19
19-Feb-19
26-Feb-19
12-Mar-19
2-May-19
16-May-19
31-May-19
13-Jun-19
28-Jun-19
11-Jul-19
1-Aug-19
26-Aug-19
9-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
28-Oct-19
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19


B-axis
Sand and Gravel Drainage Blanket
Glaciolacustrine
Glacial Till
Depth (m)
1092.5
1091.5
1090.5
1089.5
1088.5
1087.5
1086.5
1085.5
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)
29-Jul-17
1-Apr-18
3-Jul-18
16-Oct-18
23-Oct-18
30-Oct-18
13-Nov-18
27-Nov-18
11-Dec-18
15-Jan-19
29-Jan-19
12-Feb-19
26-Feb-19
12-Mar-19
2-May-19
16-May-19
31-May-19
13-Jun-19
28-Jun-19
11-Jul-19
1-Aug-19
26-Aug-19
9-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
28-Oct-19
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19


Displacement vs Time
Displacement (mm)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
Date
29-Apr-17
20-May-17
10-Jun-17
01-Jul-17
22-Jul-17
12-Aug-17
02-Sep-17
23-Sep-17
14-Oct-17
04-Nov-17
25-Nov-17
16-Dec-17
06-Jan-18
27-Jan-18
17-Feb-18
10-Mar-18
31-Mar-18
21-Apr-18
12-May-18
02-Jun-18
23-Jun-18
14-Jul-18
04-Aug-18
25-Aug-18
15-Sep-18
06-Oct-18
27-Oct-18
17-Nov-18
08-Dec-18
29-Dec-18
19-Jan-19
09-Feb-19
02-Mar-19
23-Mar-19
13-Apr-19
04-May-19
25-May-19
15-Jun-19
06-Jul-19
27-Jul-19
17-Aug-19
07-Sep-19
28-Sep-19
19-Oct-19
09-Nov-19
30-Nov-19
1092.00
1090.50
1089.00
1087.50

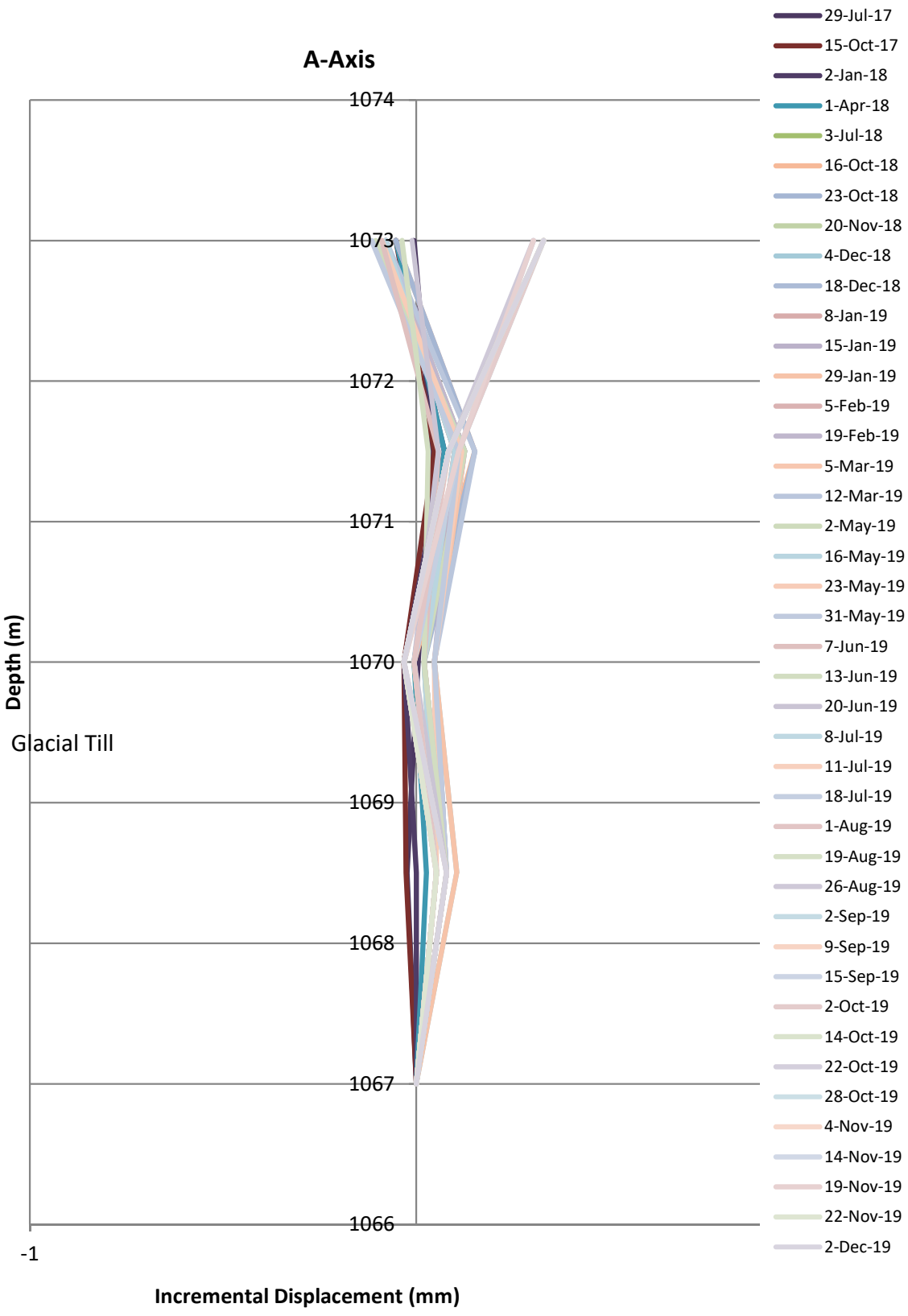

Displacement vs Time (Glacial Till)
Displacement (mm)
2
1.5
1
0.5
0
-0.5
-1
6-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
15-May-19
1-Dec-19
18-Jun-20
A
B
Resultant

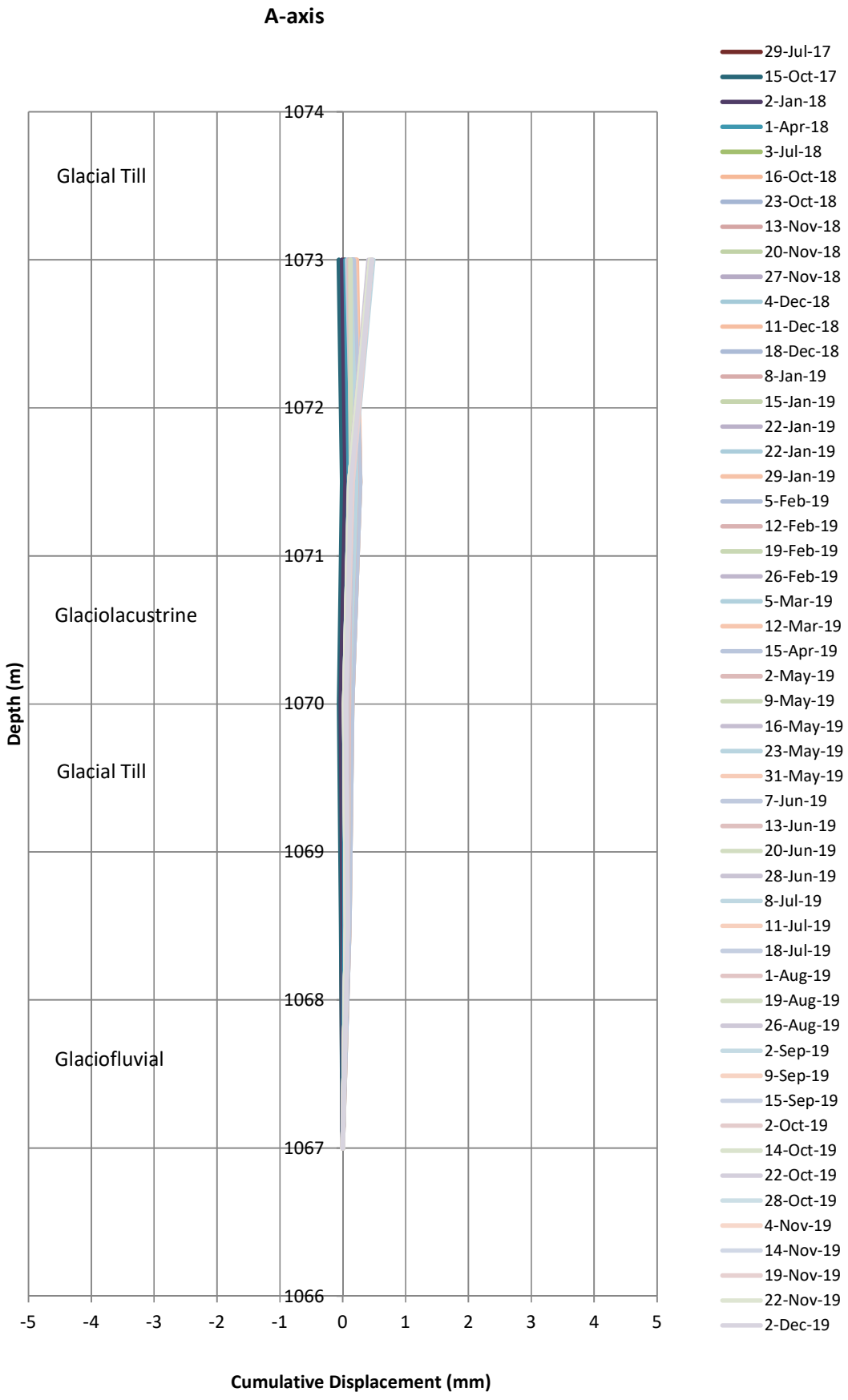

Displacement vs Time (Borehole)
Displacement (mm)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
6-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
15-May-19
1-Dec-19
18-Jun-20
A
B
Resultant

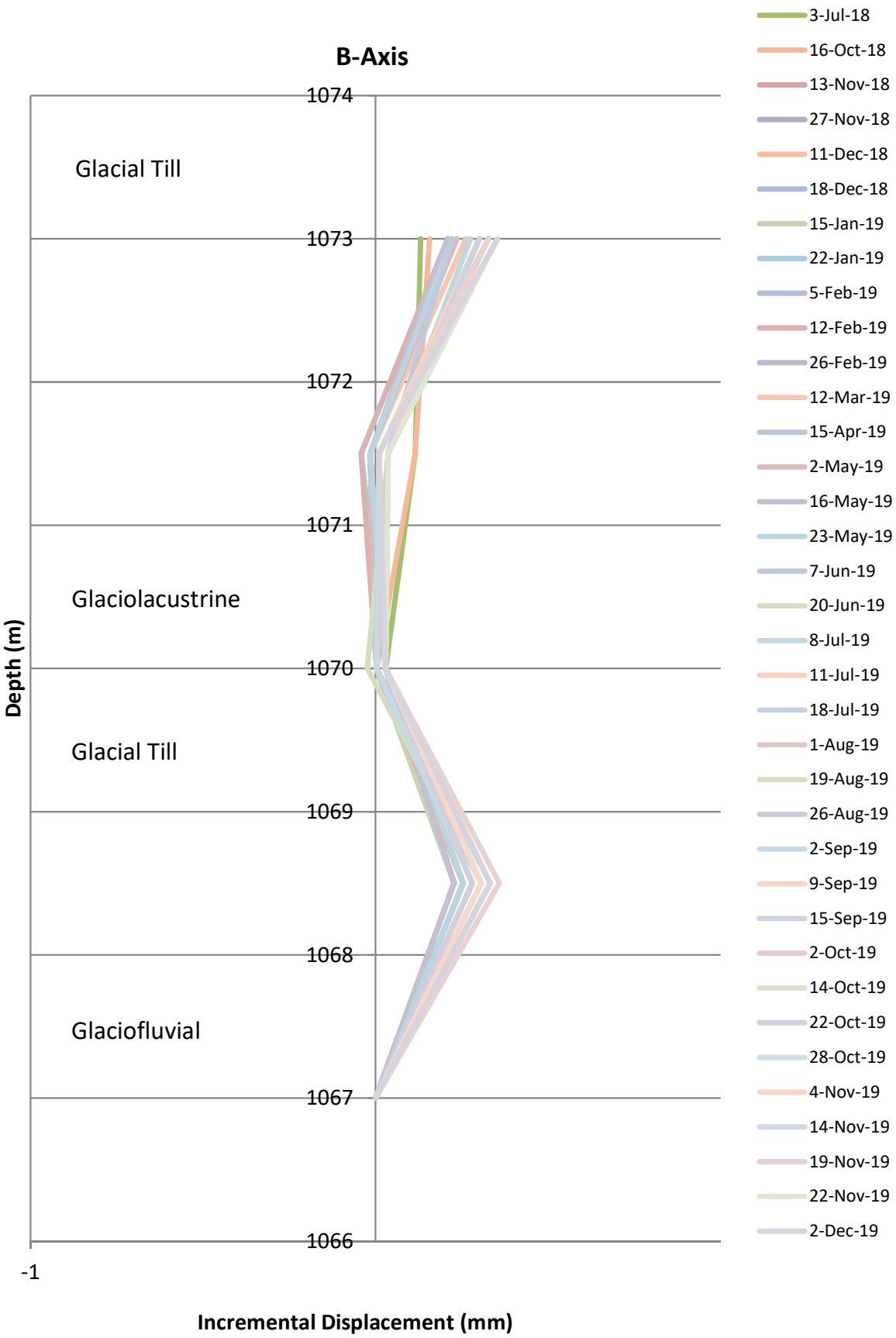

Displacement vs Time (Glaciolacustrine)
Displacement (mm)
2
1.5
1
0.5
0
-0.5
1-Apr-17
18-Oct-17
6-May-18
22-Nov-18
10-Jun-19
27-Dec-19
14-Jul-20
A
B
Resultant

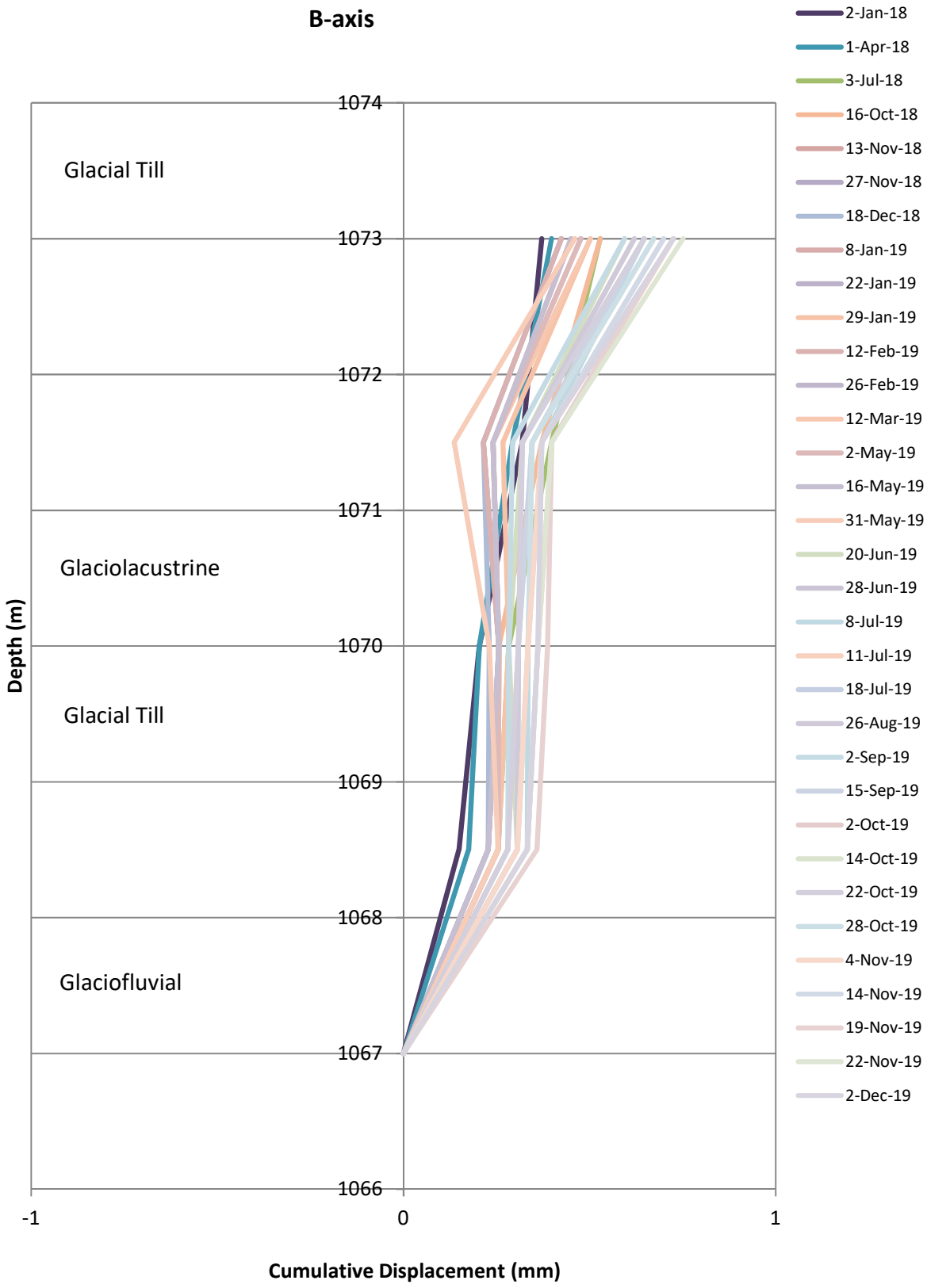
VALLEY BUTTRESS BERM

I15-27b


A-Axis
1074
1073
1072
1071
1070
1069
1068
1067
1066
Depth (m)
Glacial Till
-1
Incremental Displacement (mm)
29-Jul-17
15-Oct-17
2-Jan-18
1-Apr-18
3-Jul-18
16-Oct-18
23-Oct-18
20-Nov-18
4-Dec-18
18-Dec-18
8-Jan-19
15-Jan-19
29-Jan-19
5-Feb-19
19-Feb-19
5-Mar-19
12-Mar-19
2-May-19
16-May-19
23-May-19
31-May-19
7-Jun-19
13-Jun-19
20-Jun-19
8-Jul-19
11-Jul-19
18-Jul-19
1-Aug-19
19-Aug-19
26-Aug-19
2-Sep-19
9-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
28-Oct-19
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19


A-axis
Glacial Till
Glaciolacustrine
Glacial Till
Glaciofluvial
1074
1073
1072
1071
1070
1069
1068
1067
1066
Depth (m)
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)
29-Jul-17
15-Oct-17
2-Jan-18
1-Apr-18
3-Jul-18
16-Oct-18
23-Oct-18
13-Nov-18
20-Nov-18
27-Nov-18
4-Dec-18
11-Dec-18
18-Dec-18
8-Jan-19
15-Jan-19
22-Jan-19
22-Jan-19
29-Jan-19
5-Feb-19
12-Feb-19
19-Feb-19
26-Feb-19
5-Mar-19
12-Mar-19
15-Apr-19
2-May-19
9-May-19
16-May-19
23-May-19
31-May-19
7-Jun-19
13-Jun-19
20-Jun-19
28-Jun-19
8-Jul-19
11-Jul-19
18-Jul-19
1-Aug-19
19-Aug-19
26-Aug-19
2-Sep-19
9-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
28-Oct-19
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19


B-Axis
1074
1073
1072
1071
1070
1069
1068
1067
1066
Glacial Till
Glaciolacustrine
Glacial Till
Glaciofluvial
Depth (m)
-1
Incremental Displacement (mm)
3-Jul-18
16-Oct-18
13-Nov-18
27-Nov-18
11-Dec-18
18-Dec-18
15-Jan-19
22-Jan-19
5-Feb-19
12-Feb-19
26-Feb-19
12-Mar-19
15-Apr-19
2-May-19
16-May-19
23-May-19
7-Jun-19
20-Jun-19
8-Jul-19
11-Jul-19
18-Jul-19
1-Aug-19
19-Aug-19
26-Aug-19
2-Sep-19
9-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
28-Oct-19
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19


B-axis
Glacial Till
Glaciolacustrine
Glacial Till
Glaciofluvial
1074
1073
1072
1071
1070
1069
1068
1067
1066
Depth (m)
-1
0
1
Cumulative Displacement (mm)
2-Jan-18
1-Apr-18
3-Jul-18
16-Oct-18
13-Nov-18
27-Nov-18
18-Dec-18
8-Jan-19
22-Jan-19
29-Jan-19
12-Feb-19
26-Feb-19
12-Mar-19
2-May-19
16-May-19
31-May-19
20-Jun-19
28-Jun-19
8-Jul-19
11-Jul-19
18-Jul-19
26-Aug-19
2-Sep-19
15-Sep-19
2-Oct-19
14-Oct-19
22-Oct-19
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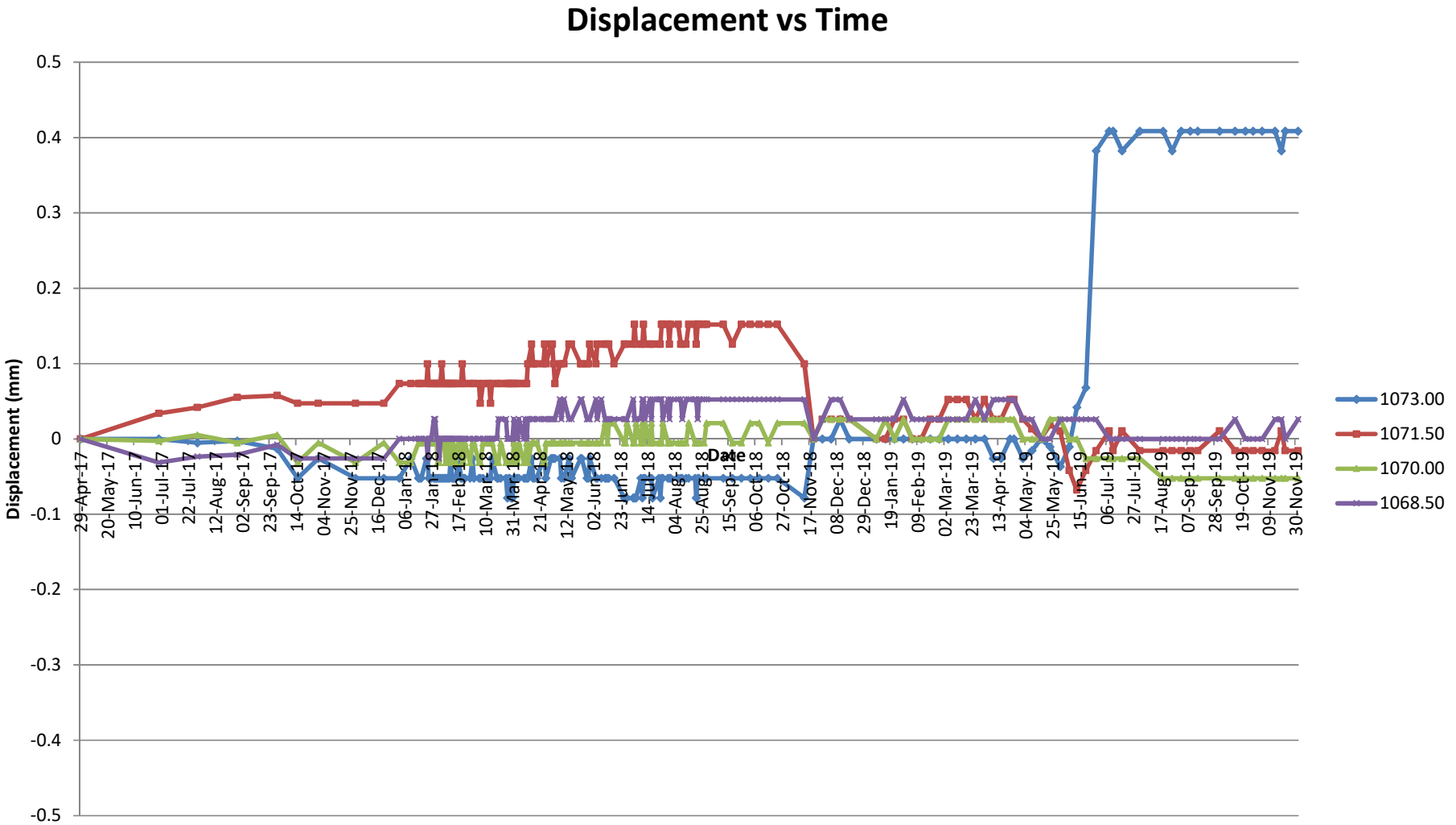
4-Nov-19
14-Nov-19
19-Nov-19
22-Nov-19
2-Dec-19


Displacement vs Time
Displacement (mm)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
29-Apr-17
20-May-17
10-Jun-17
01-Jul-17
22-Jul-17
12-Aug-17
02-Sep-17
23-Sep-17
14-Oct-17
04-Nov-17
25-Nov-17
16-Dec-17
06-Jan-18
27-Jan-18
17-Feb-18
10-Mar-18
31-Mar-18
21-Apr-18
12-May-18
02-Jun-18
23-Jun-18
14-Jul-18
04-Aug-18
25-Aug-18
15-Sep-18
06-Oct-18
27-Oct-18
17-Nov-18
08-Dec-18
29-Dec-18
19-Jan-19
09-Feb-19
02-Mar-19
23-Mar-19
13-Apr-19
04-May-19
25-May-19
15-Jun-19
06-Jul-19
27-Jul-19
17-Aug-19
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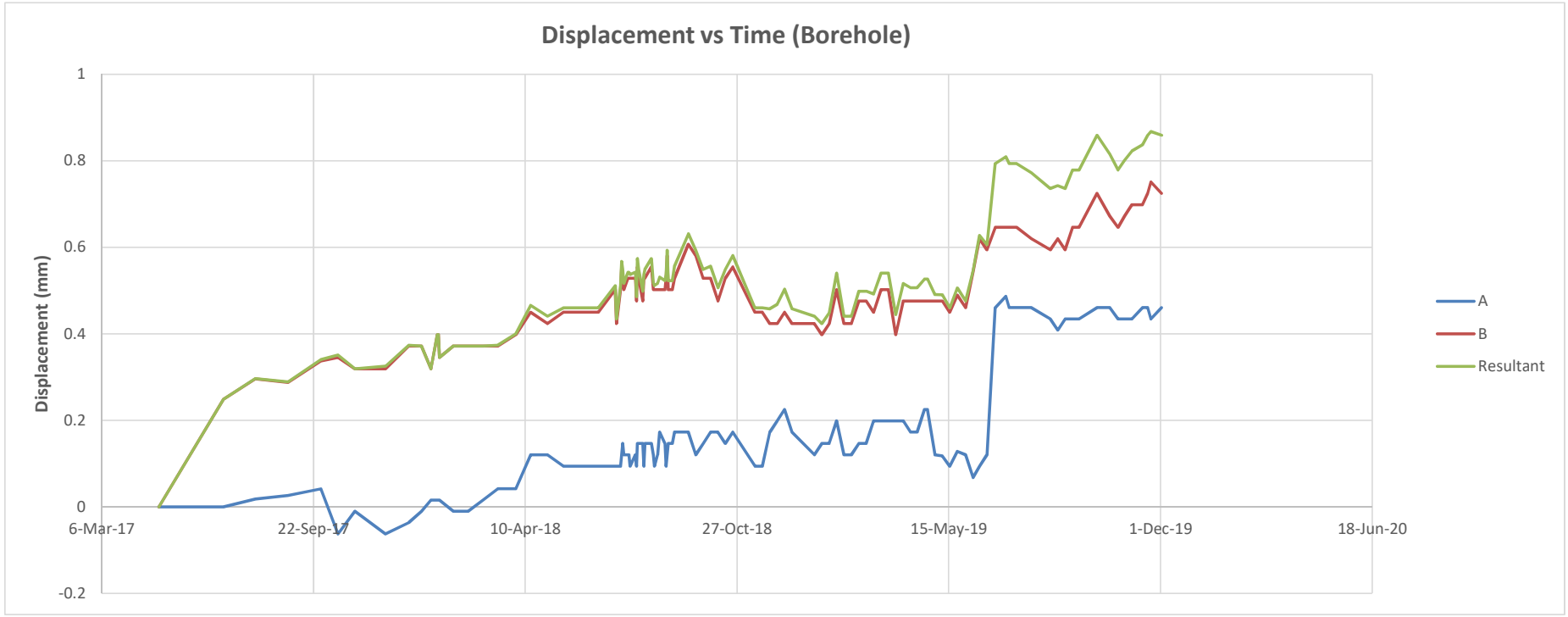
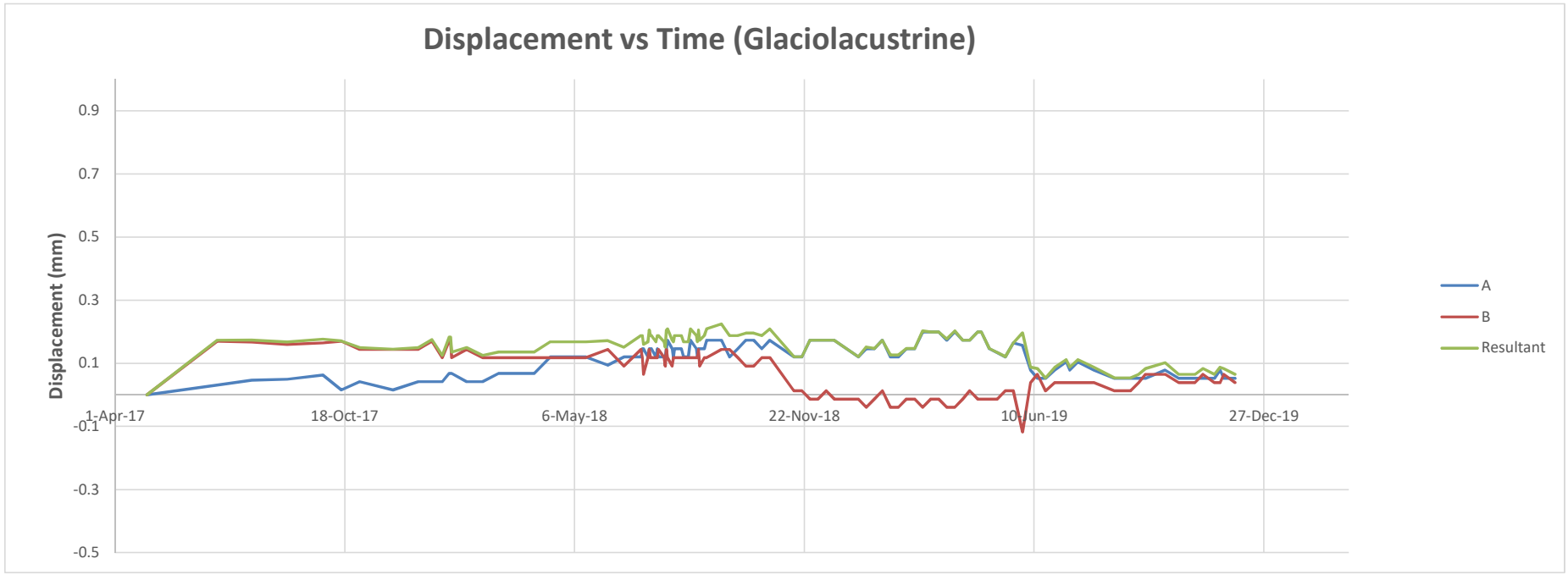
1070.00
1068.50

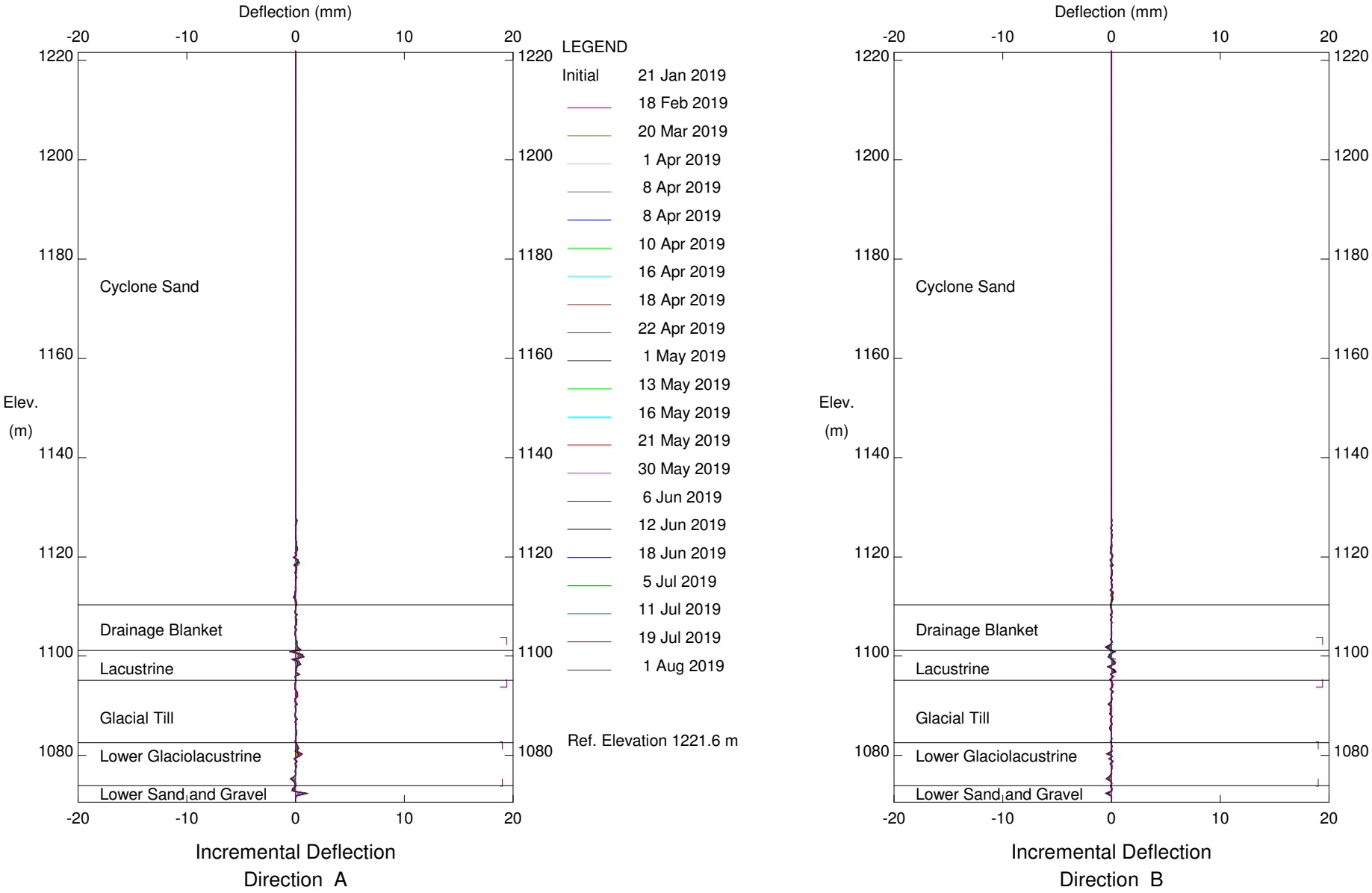

Displacement vs Time (Borehole)
Displacement (mm)
1
0.8
0.6
0.4
0.2
0
-0.2
6-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
15-May-19
1-Dec-19
18-Jun-20
A
B
Resultant


Displacement vs Time (Glaciolacustrine)
Displacement (mm)
0.9
0.7
0.5
0.3
0.1
-0.1
-0.3
-0.5
1-Apr-17
18-Oct-17
6-May-18
22-Nov-18
10-Jun-19
27-Dec-19
A
B
Resultant

VALLEY BUTTRESS BERM

I17-01

Highland Valley Copper - Logan Lake, BC



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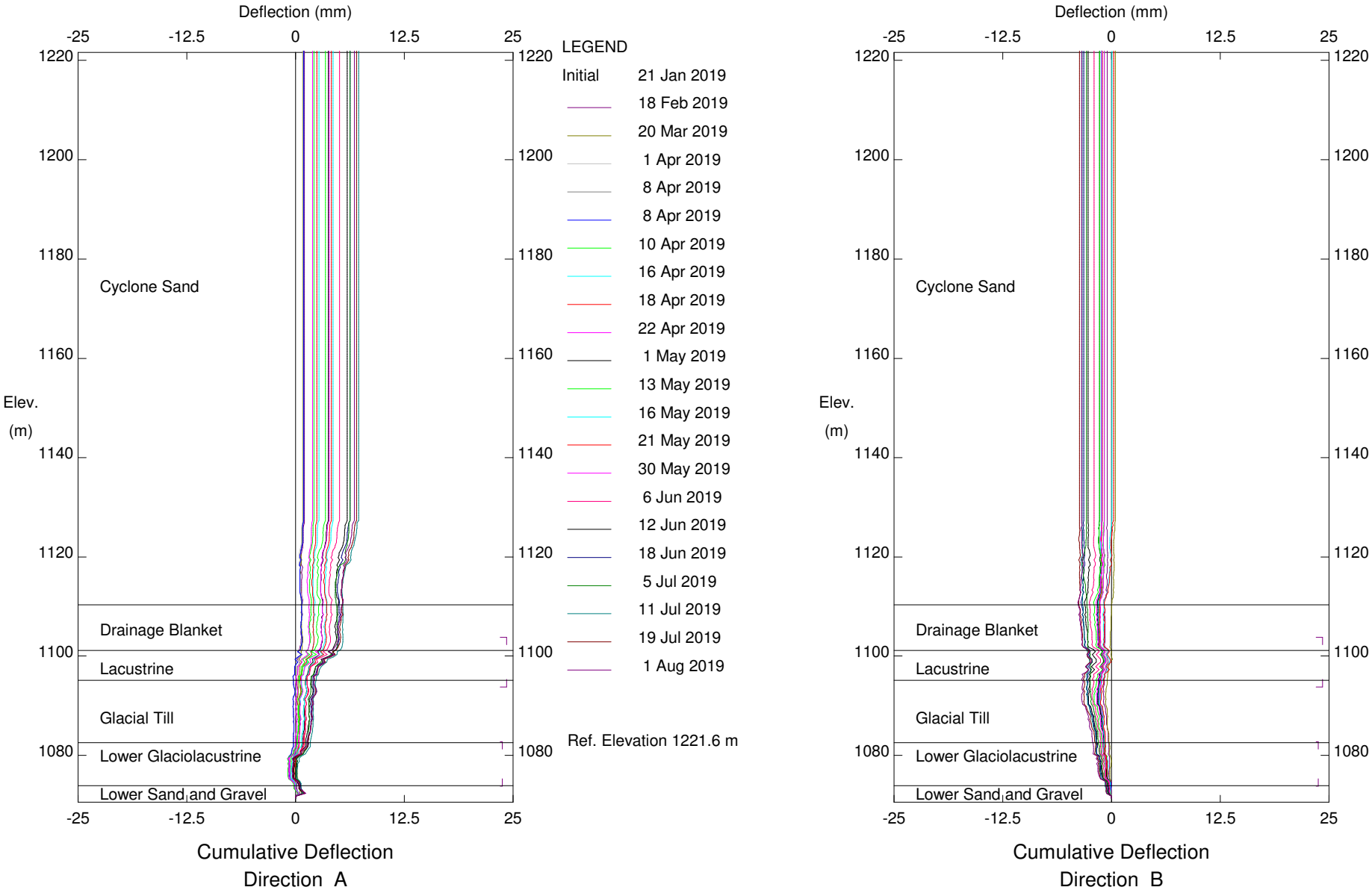
Highland Valley Copper - Logan Lake, BC



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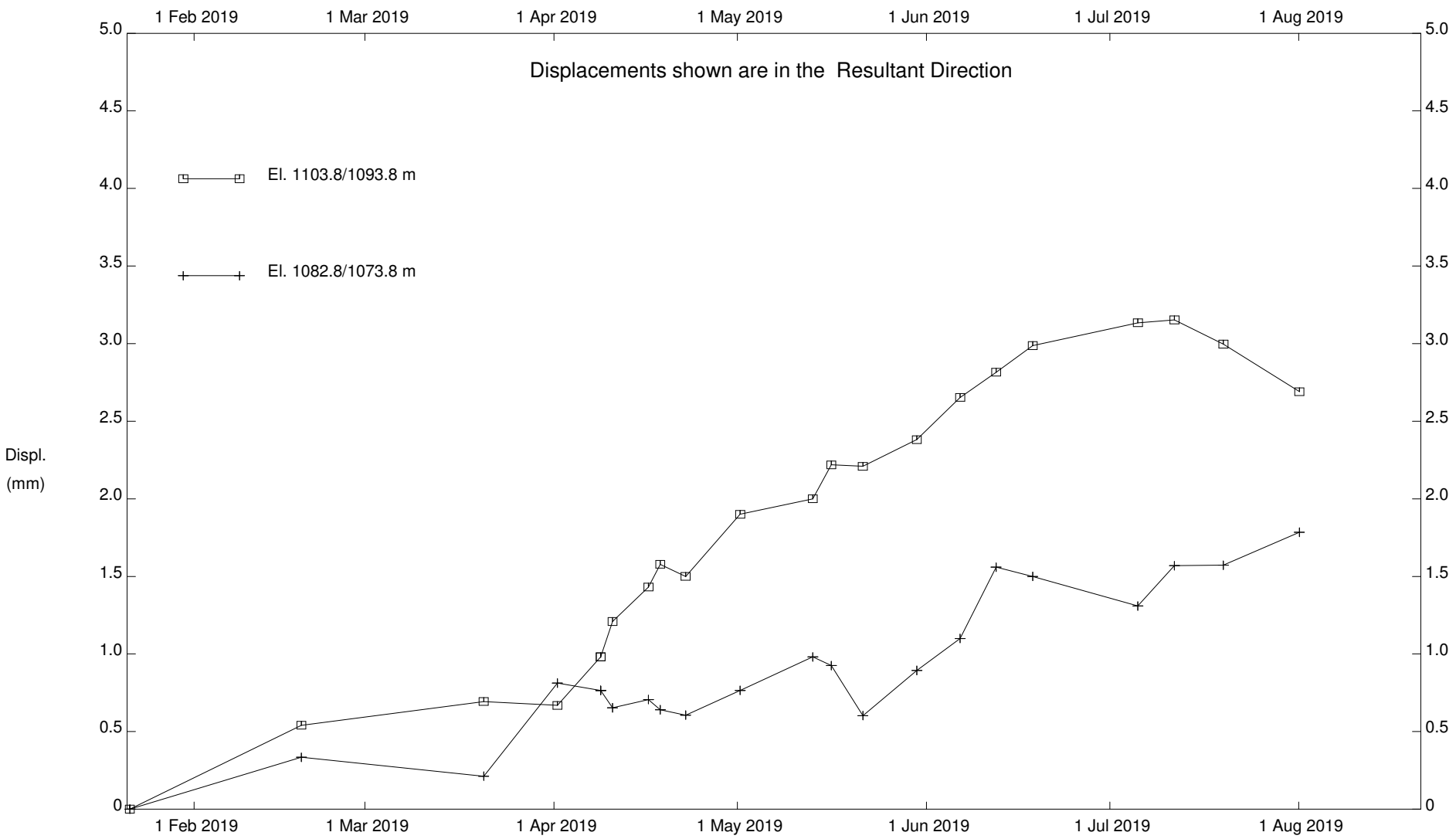
Highland Valley Copper - Logan Lake, BC



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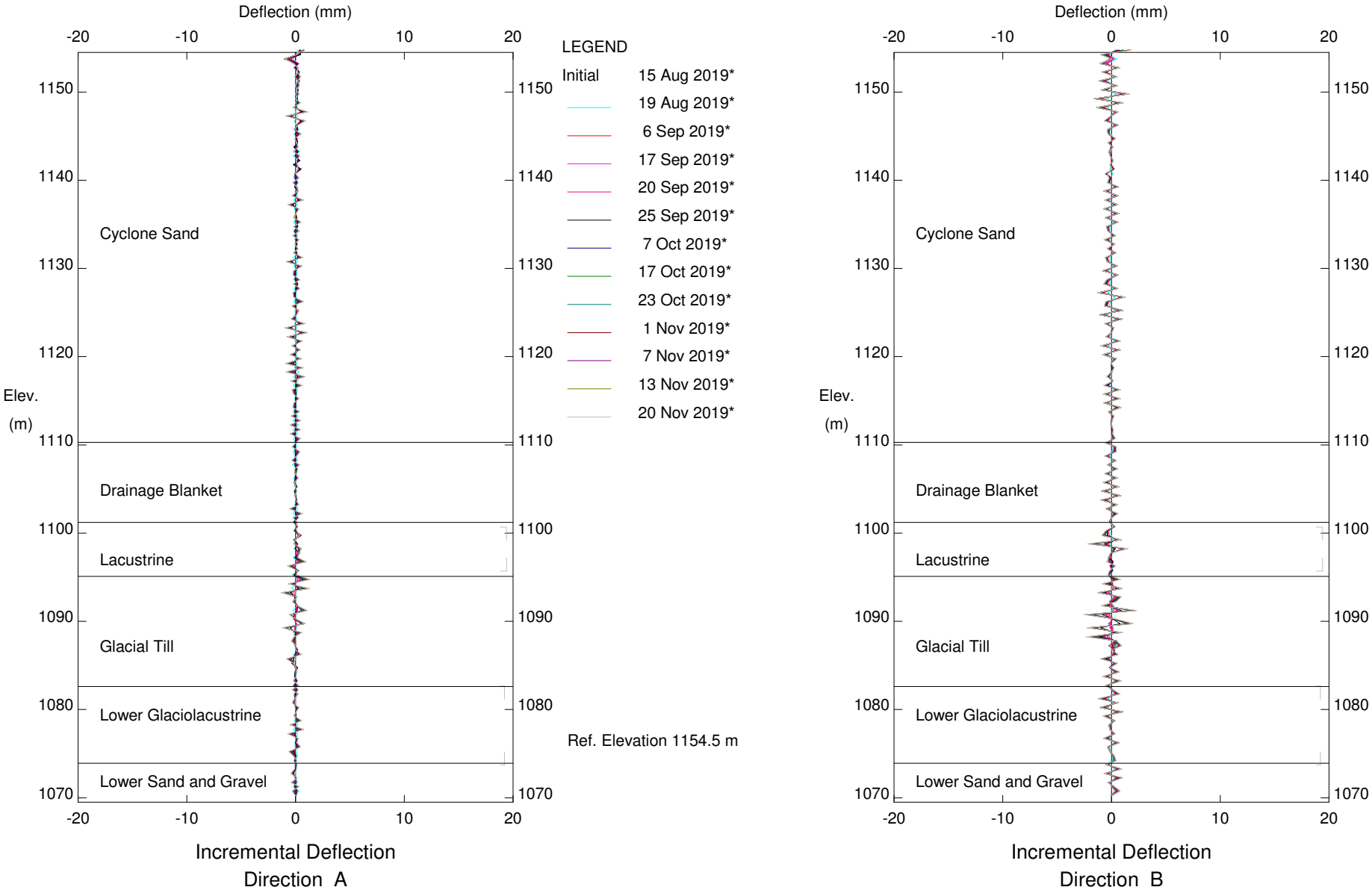
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I17-01,,,

Sets marked * include zero shift and/or rotation corrections.

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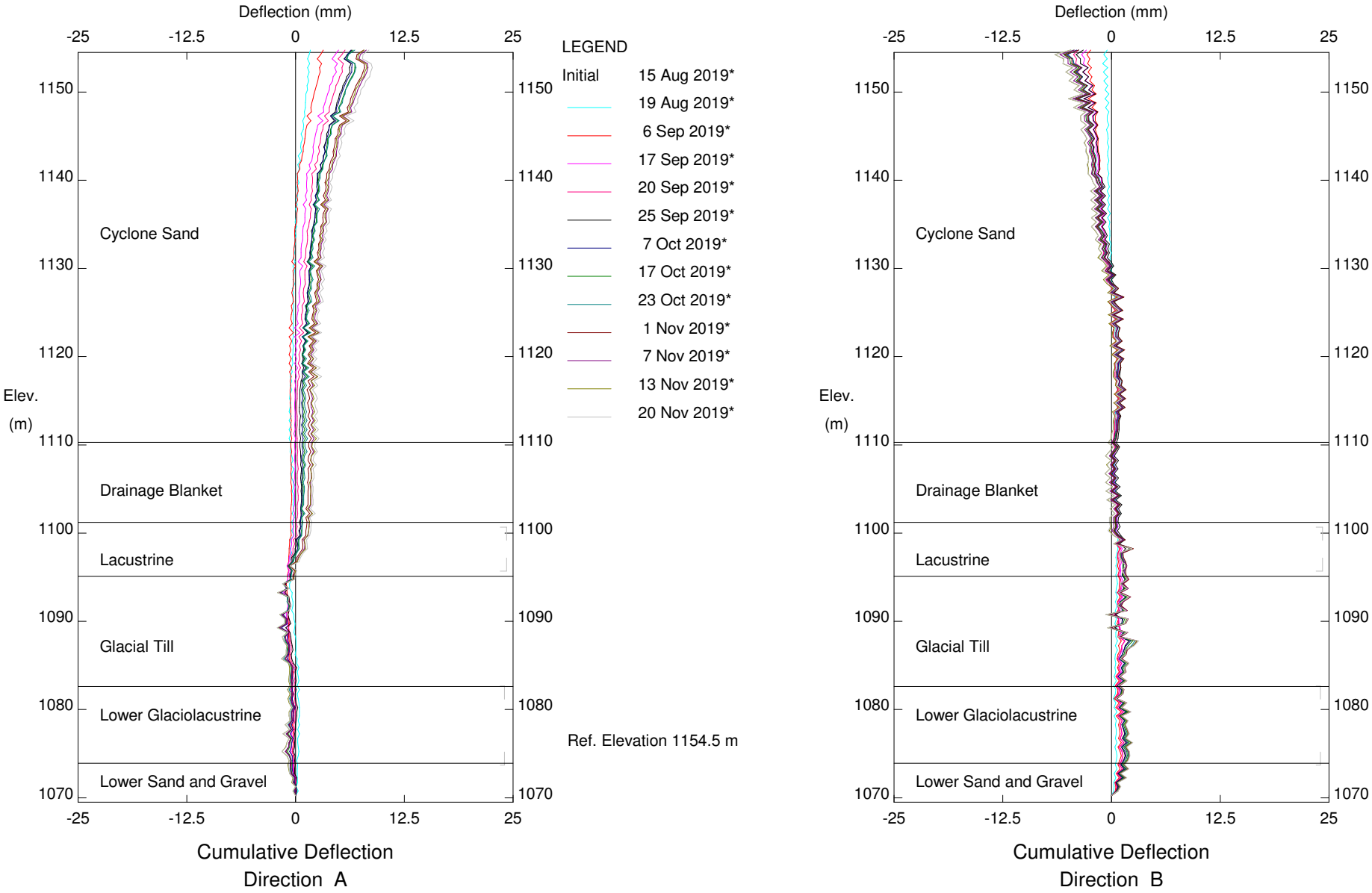
Highland Valley Copper - Logan Lake, BC



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Sets marked * include zero shift and/or rotation corrections.

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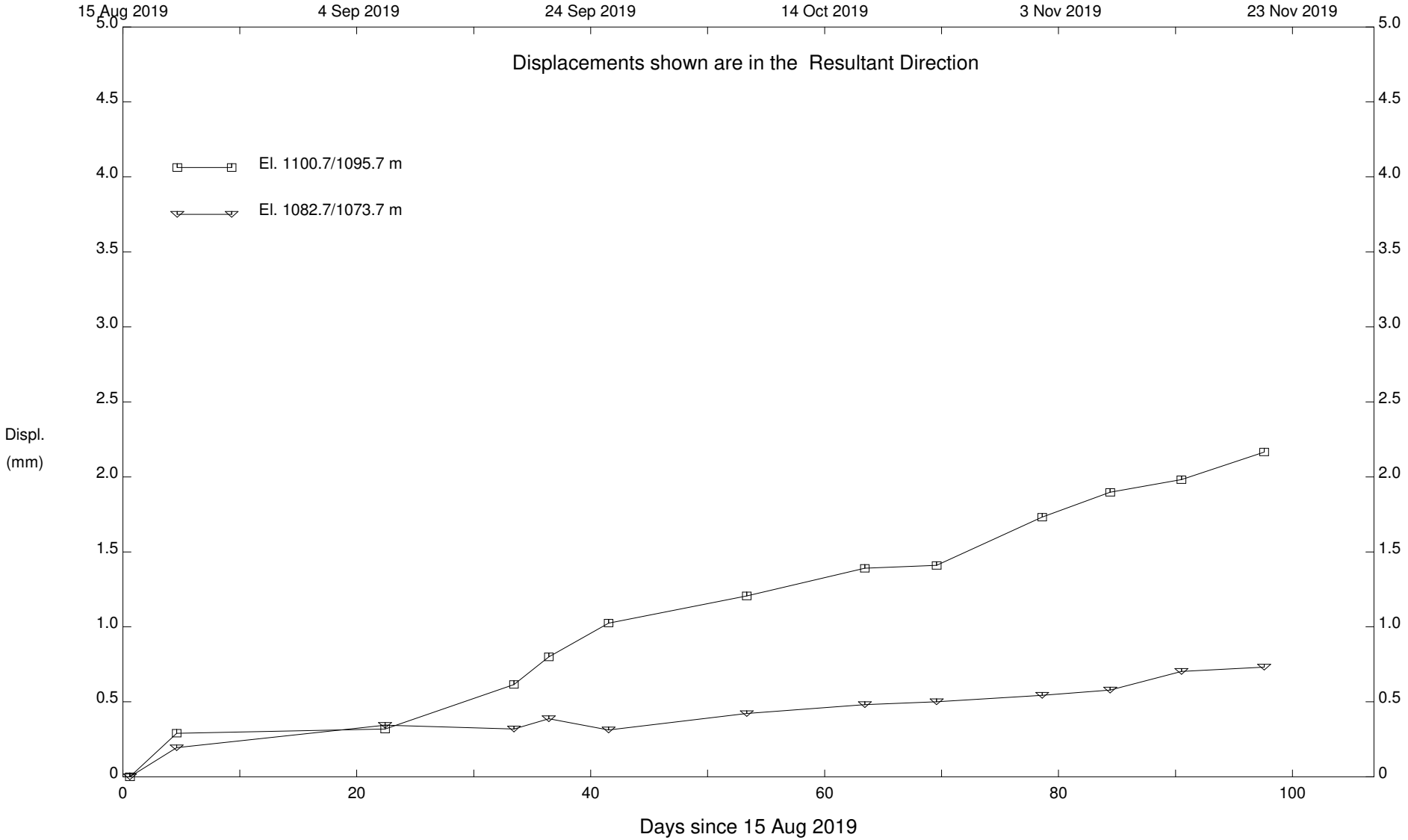
Highland Valley Copper - Logan Lake, BC



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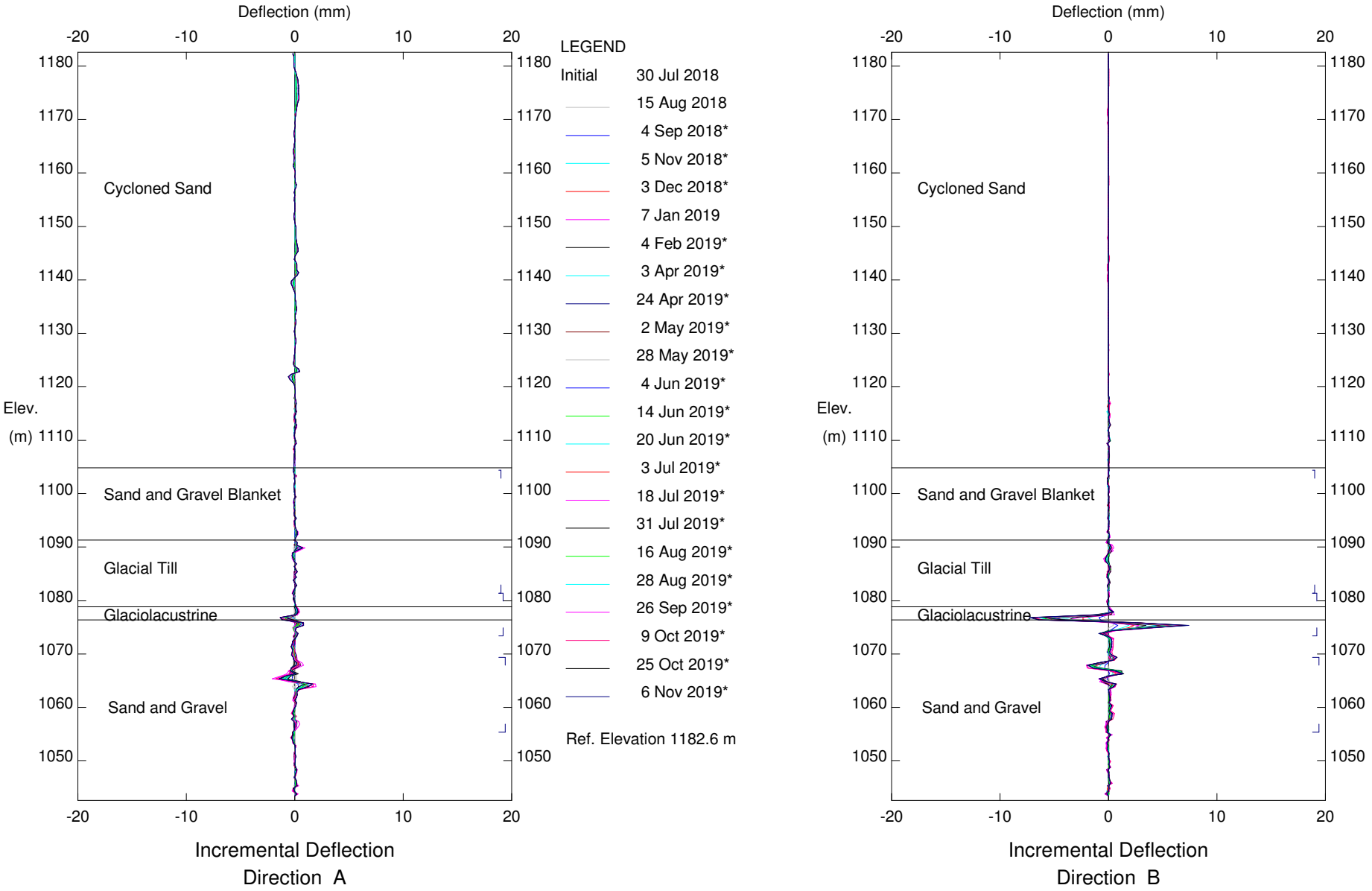
VALLEY BUTTRESS BERM

I17-02

Highland Valley Copper - Logan Lake, BC



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Sets marked * include zero shift and/or rotation corrections.

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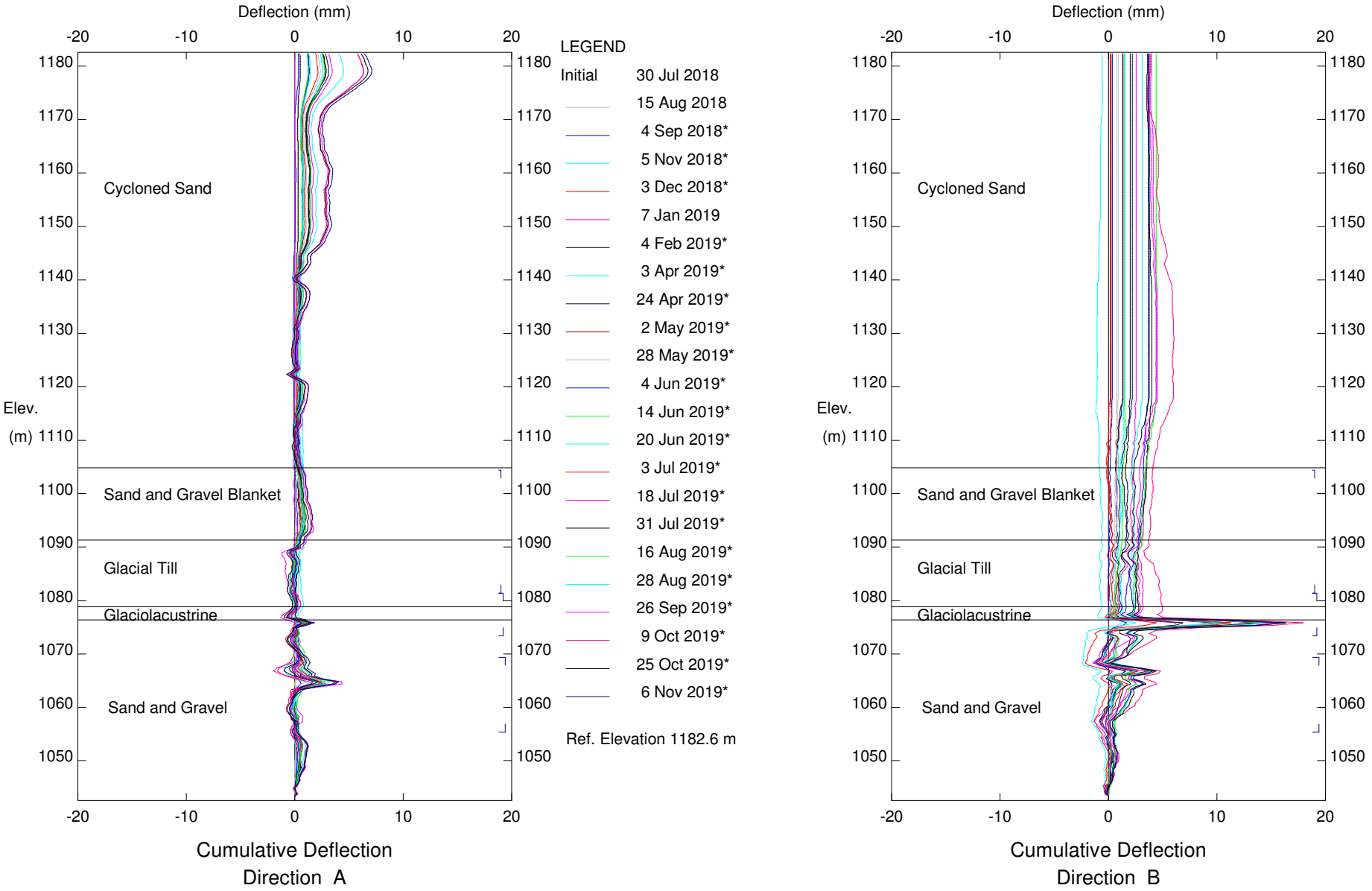
Highland Valley Copper - Logan Lake, BC



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Sets marked * include zero shift and/or rotation corrections.

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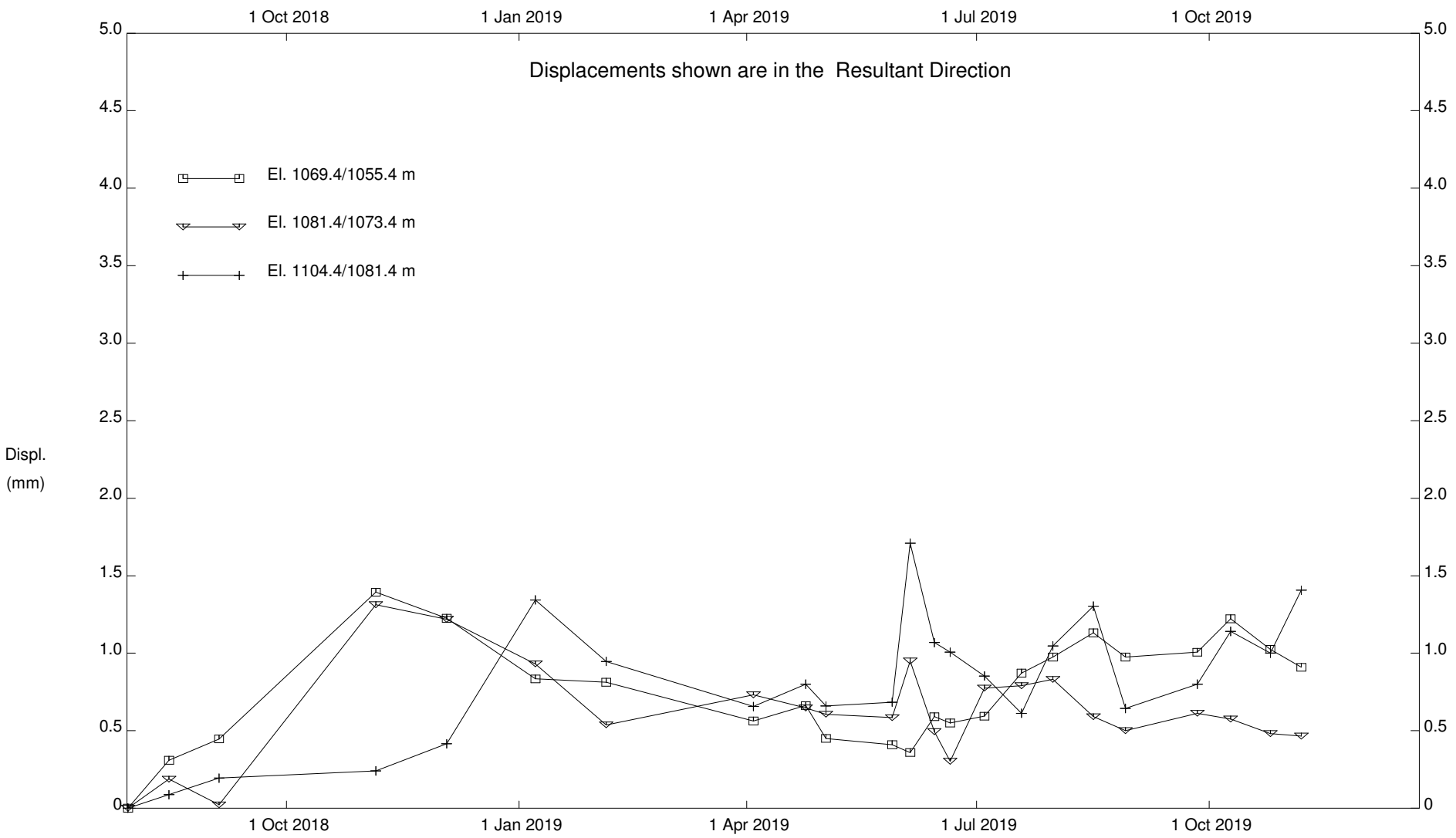
Highland Valley Copper - Logan Lake, BC

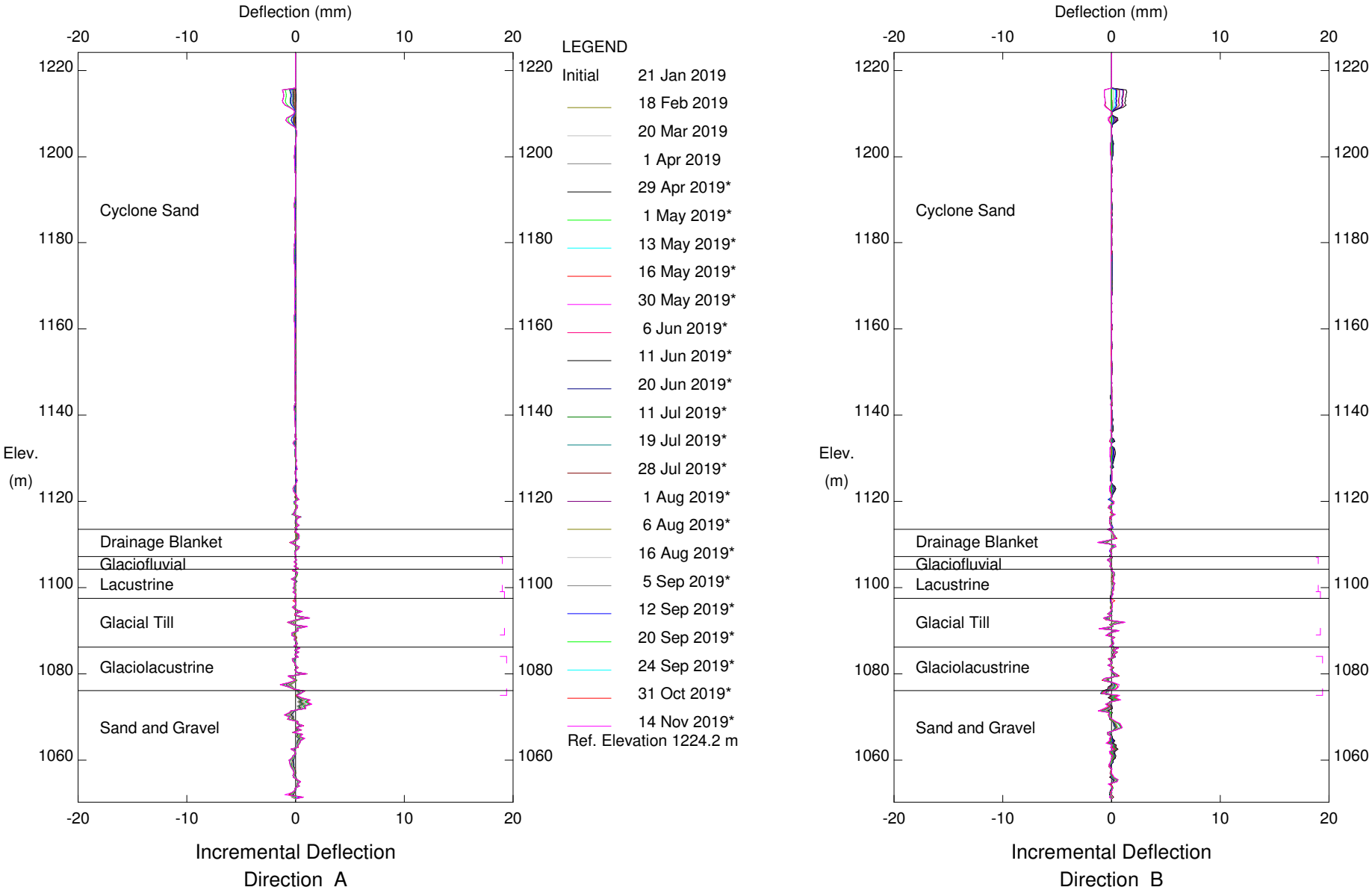


Dam Fill Excluded,,,, Inclinometer I17-02,,,

VALLEY BUTTRESS BERM

I17-06

Highland Valley Copper - Logan Lake, BC



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Sets marked * include zero shift and/or rotation corrections.

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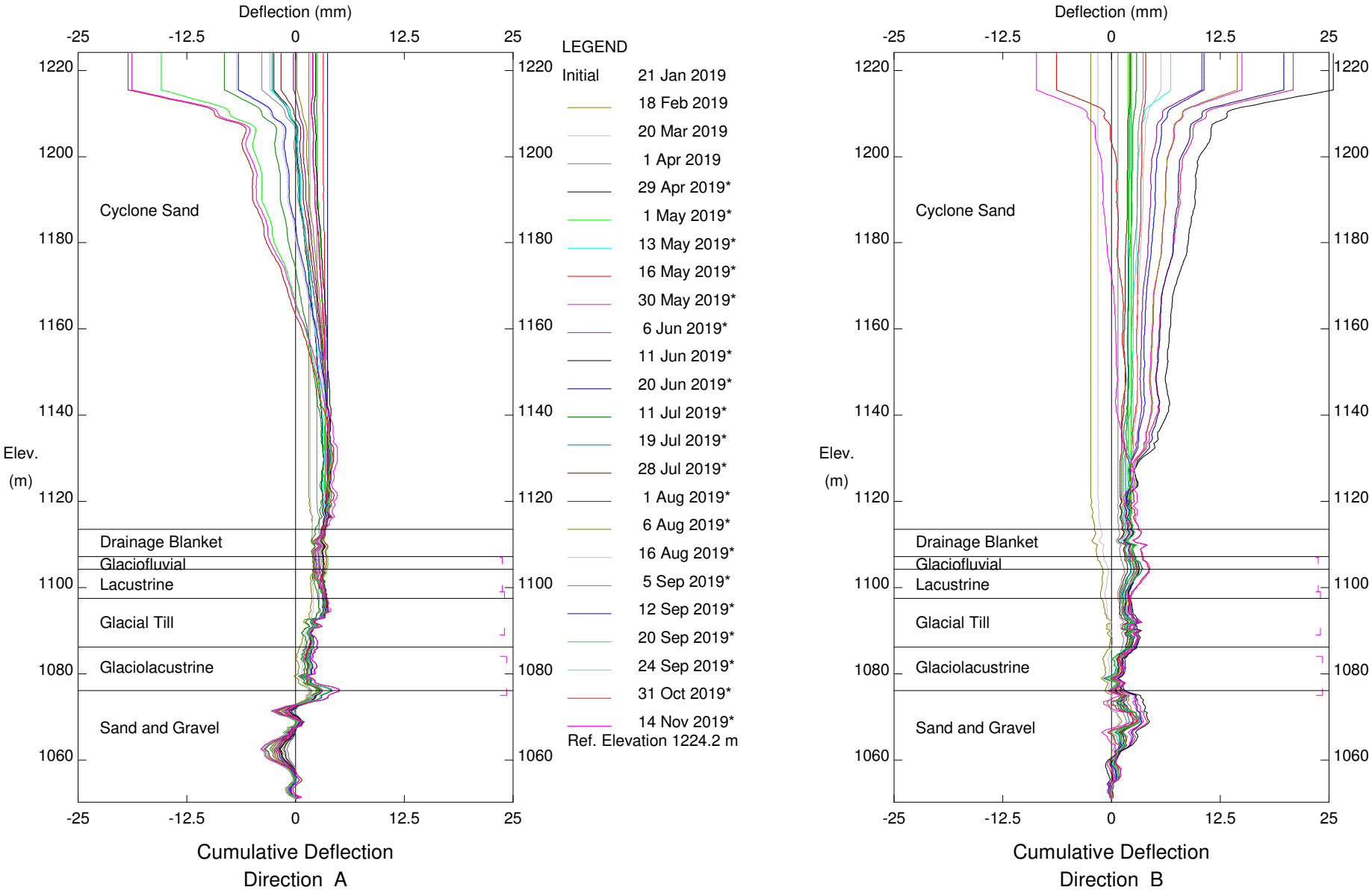
Highland Valley Copper - Logan Lake, BC



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Sets marked * include zero shift and/or rotation corrections.

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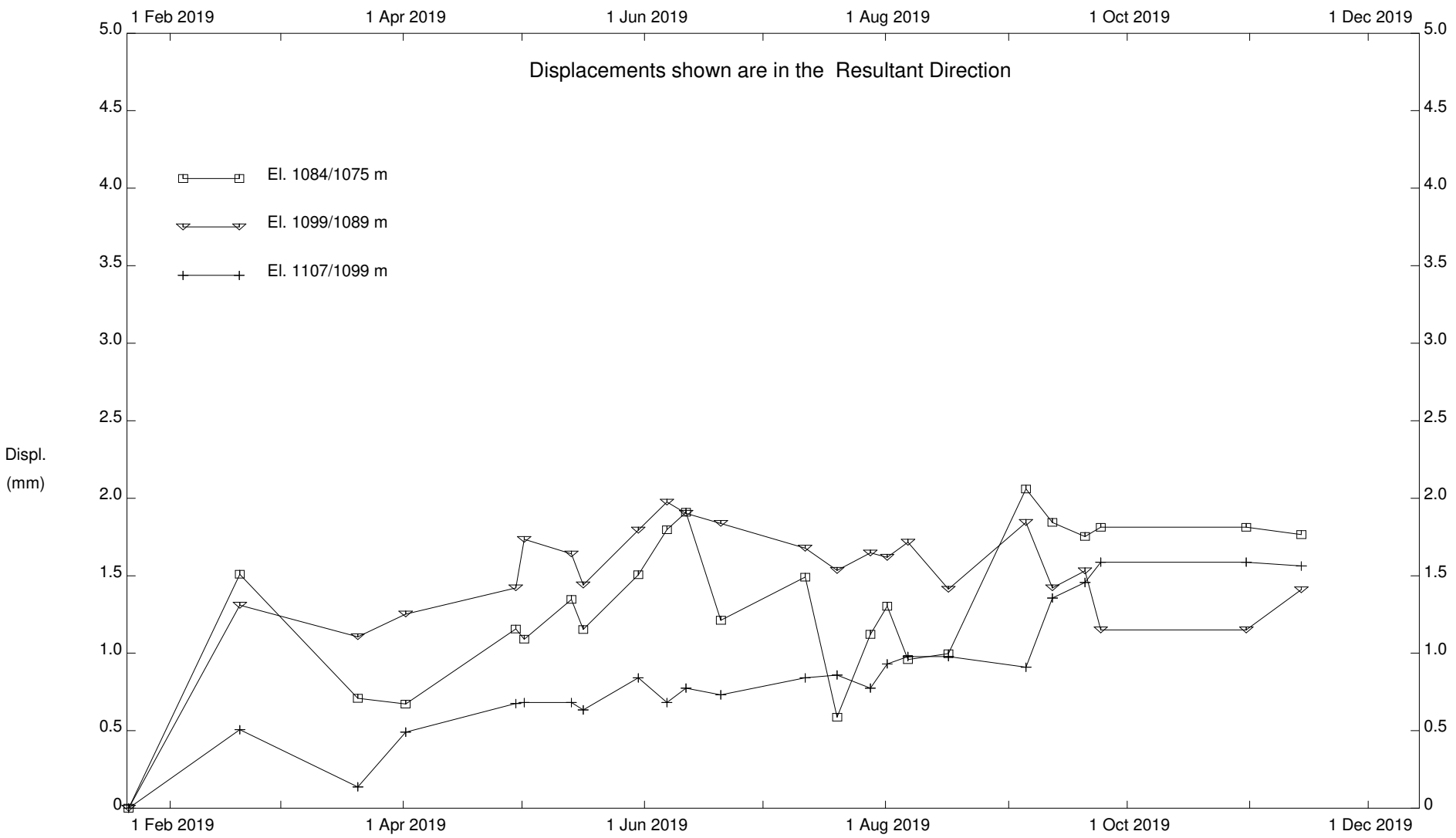
Highland Valley Copper - Logan Lake, BC



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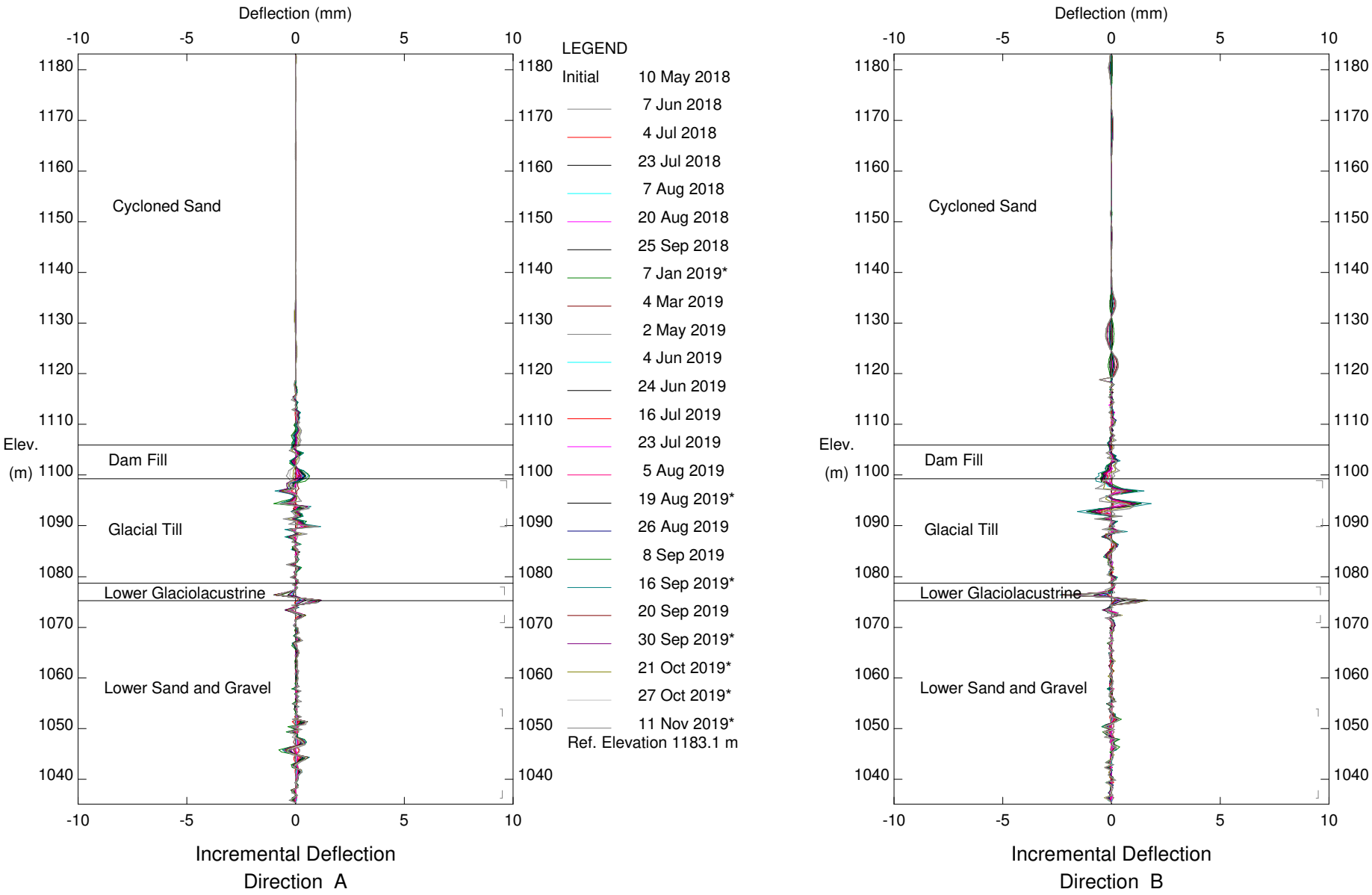
VALLEY BUTTRESS BERM

I17-09

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I17-9

Sets marked * include zero shift and/or rotation corrections.

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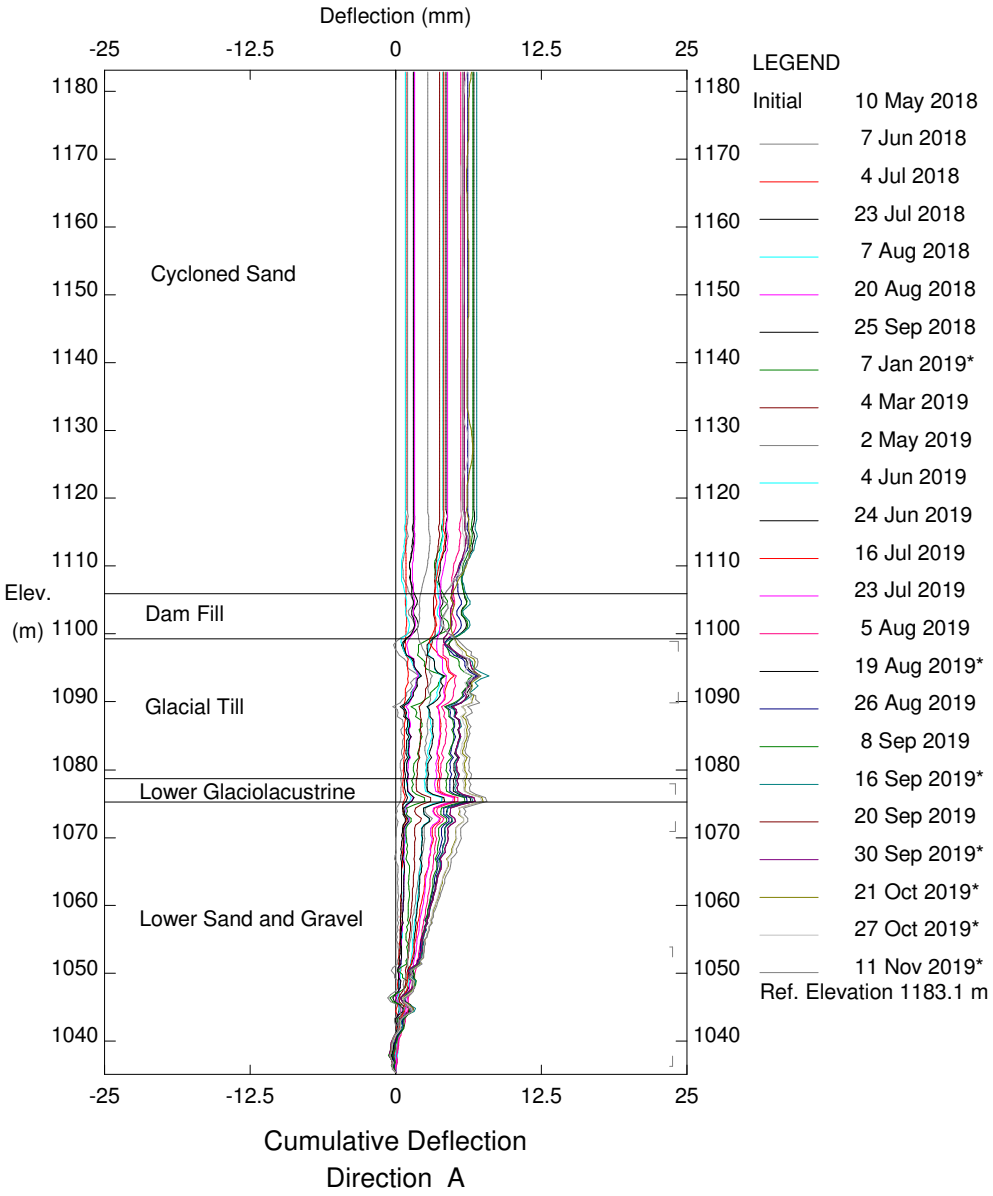
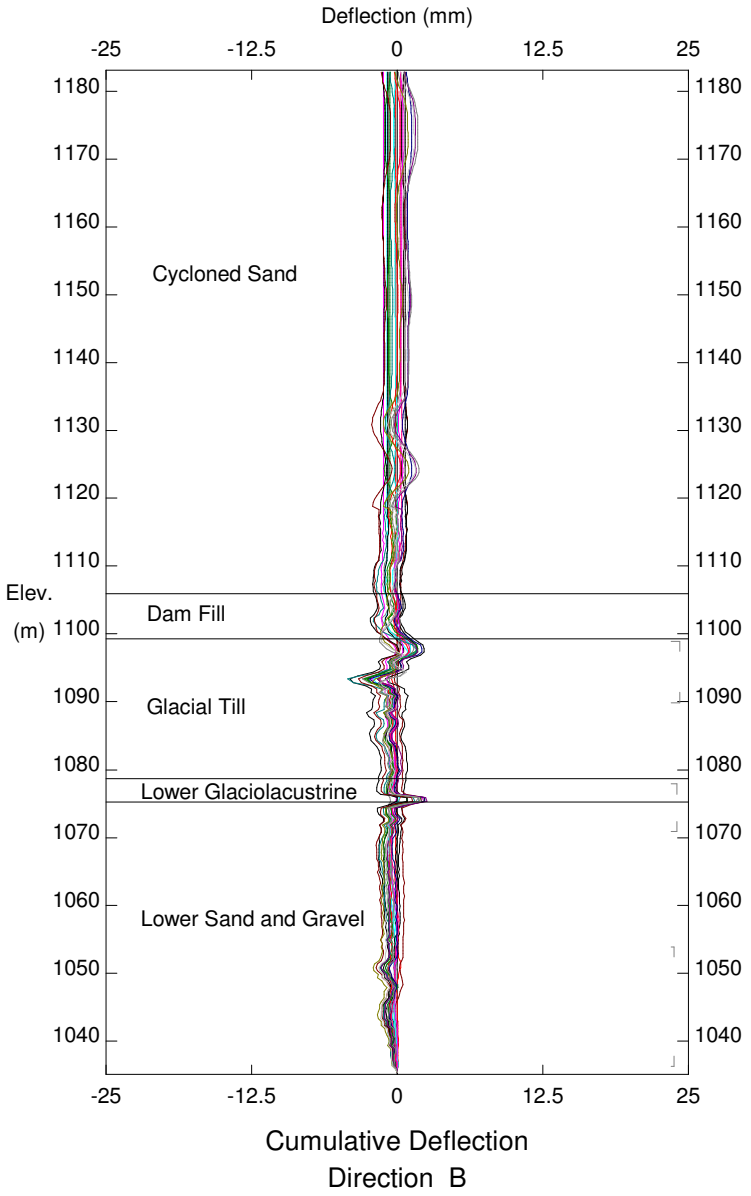
Highland Valley Copper - Logan Lake, BC

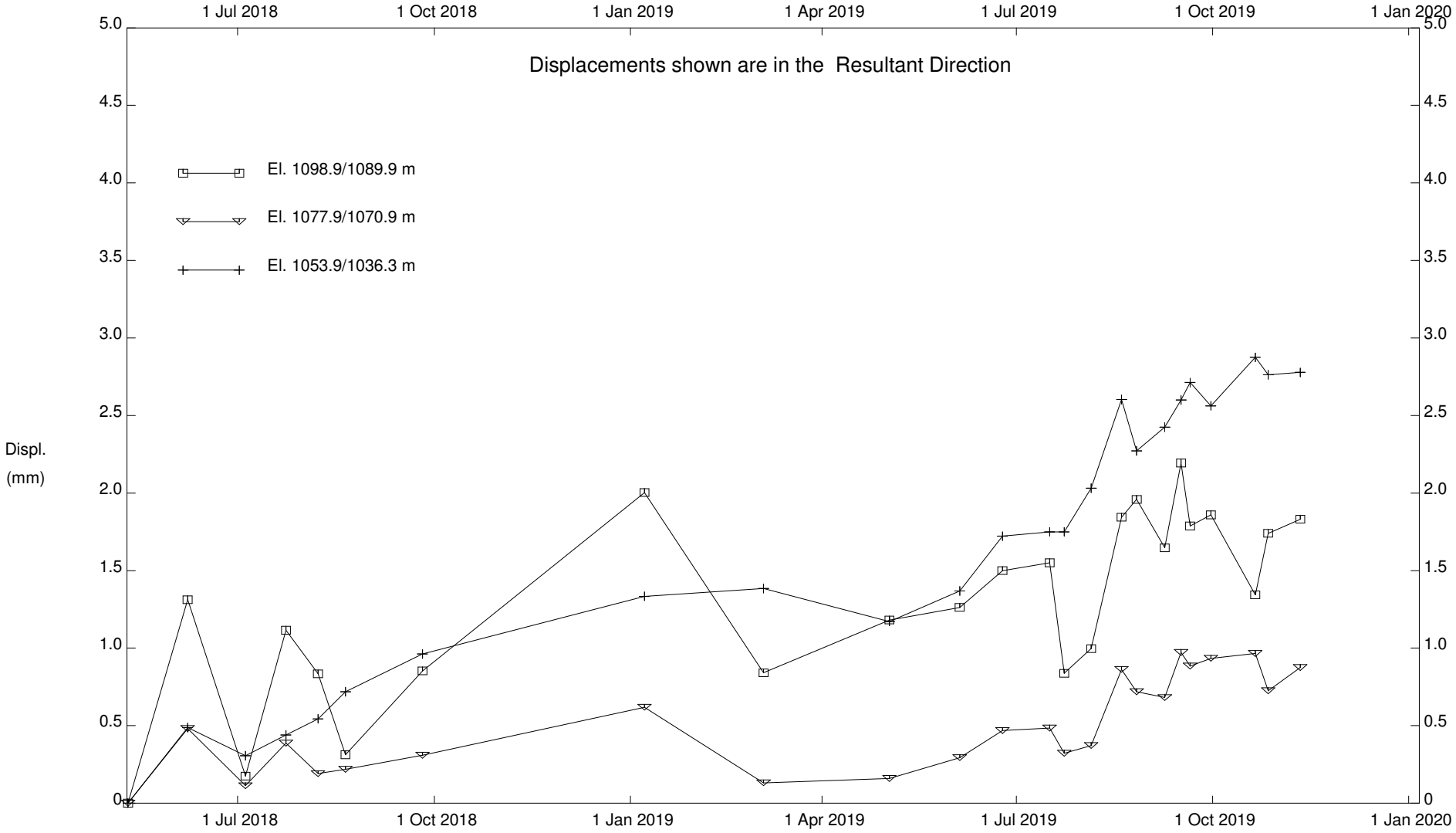




LL Dam, Inclinometer I17-9

Sets marked * include zero shift and/or rotation corrections.

Highland Valley Copper - Logan Lake, BC

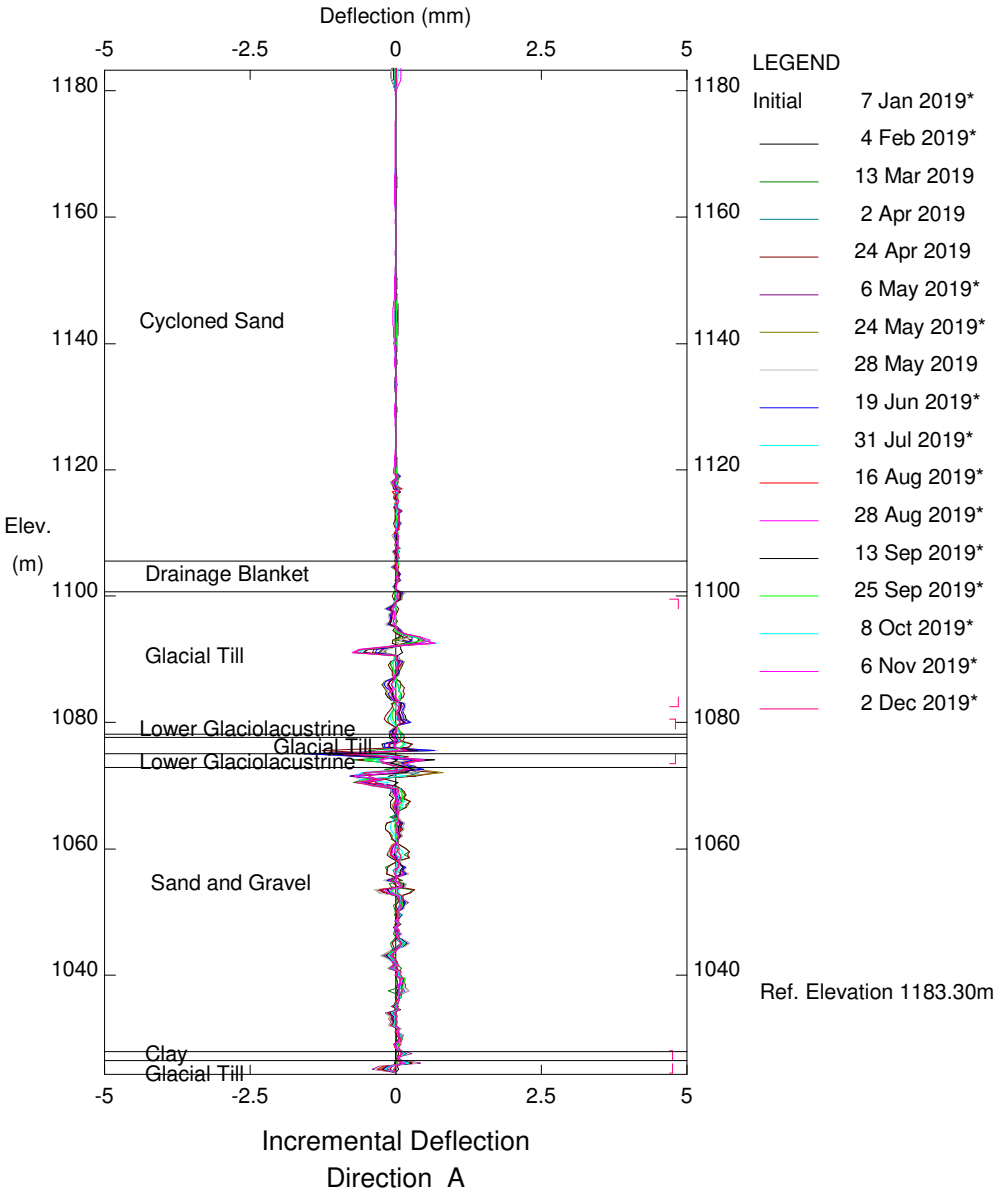


LL Dam, Inclinometer I17-9

VALLEY BUTTRESS BERM

I17-10

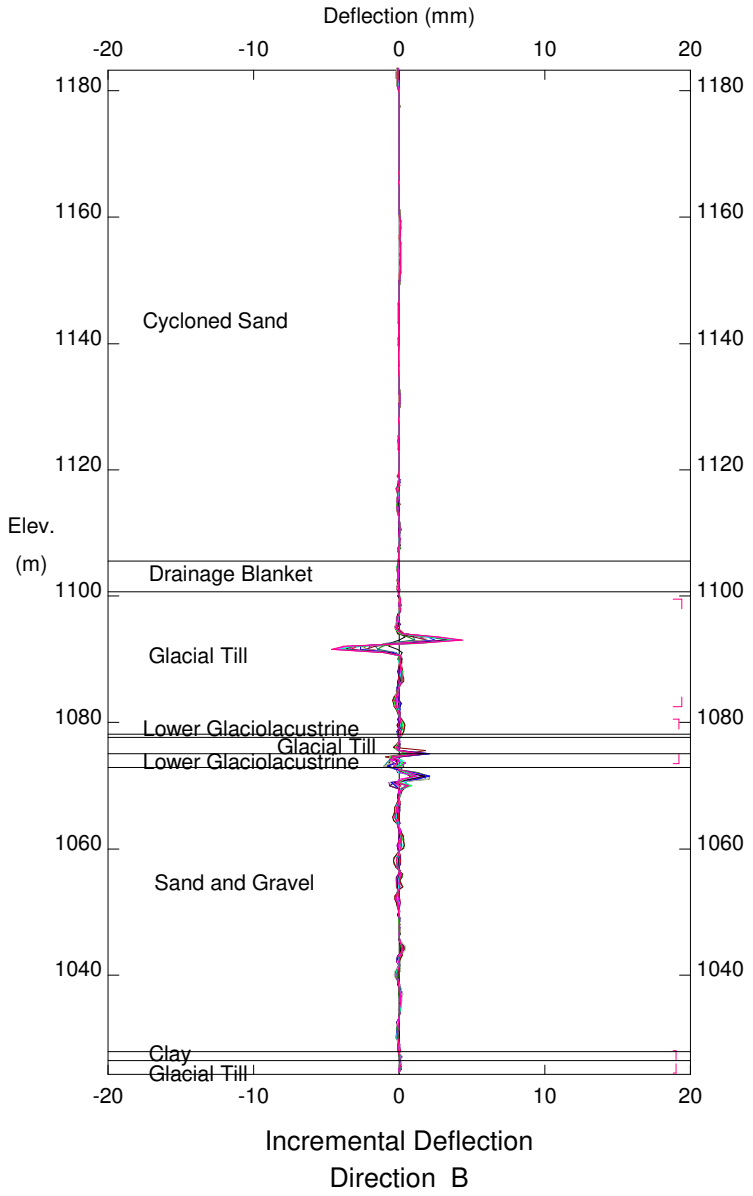
Highland Valley Copper - Logan Lake, BC



LEGEND

Initial	7 Jan 2019*
	4 Feb 2019*
	13 Mar 2019
	2 Apr 2019
	24 Apr 2019
	6 May 2019*
	24 May 2019*
	28 May 2019
	19 Jun 2019*
	31 Jul 2019*
	16 Aug 2019*
	28 Aug 2019*
	13 Sep 2019*
	25 Sep 2019*
	8 Oct 2019*
	6 Nov 2019*
	2 Dec 2019*

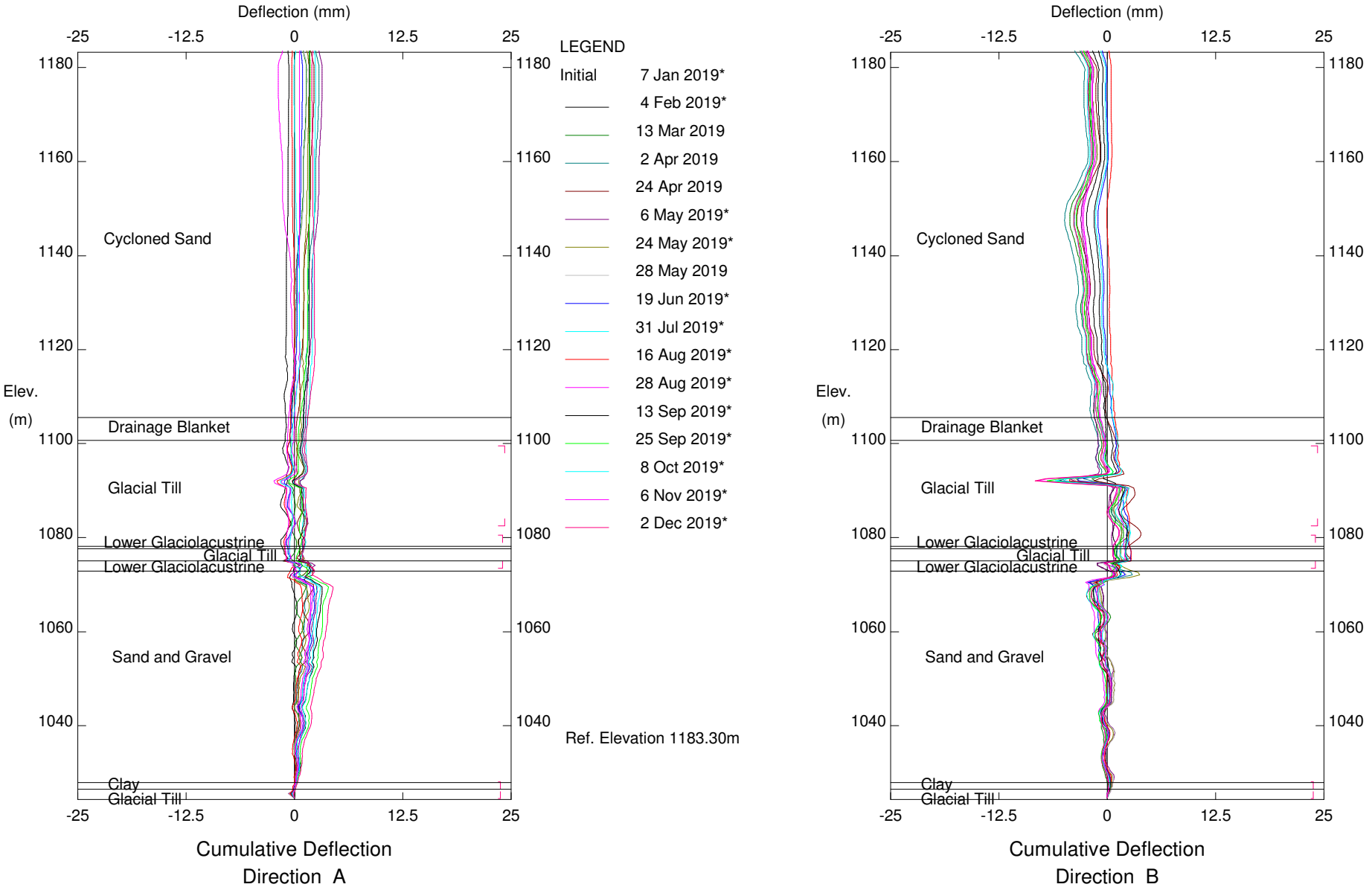
Ref. Elevation 1183.30m



Valley Buttress Berm, Inclinometer I17-10

Sets marked * include zero shift and/or rotation corrections.

Highland Valley Copper - Logan Lake, BC



Valley Buttress Berm, Inclinometer I17-10

Sets marked * include zero shift and/or rotation corrections.

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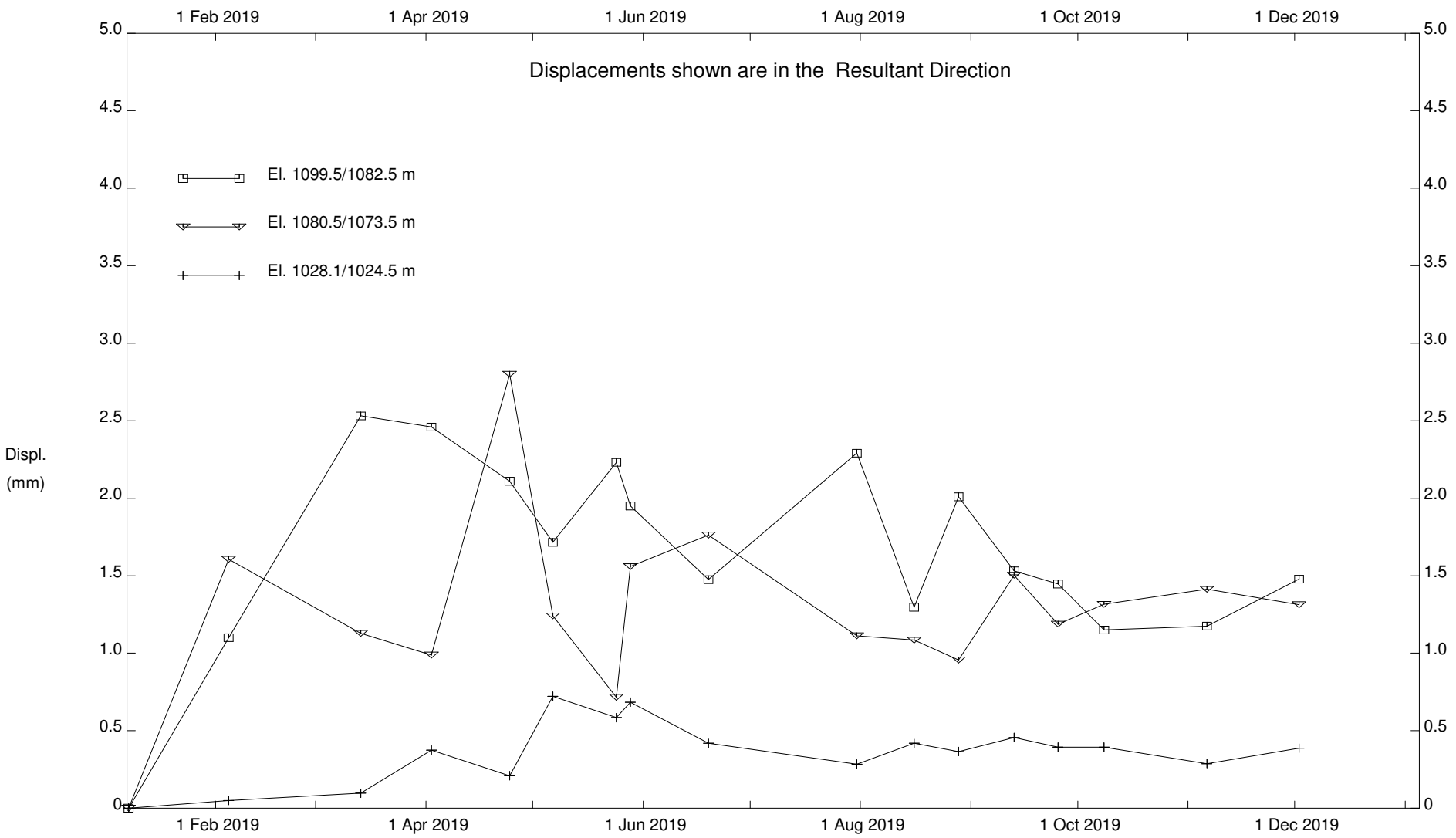
Highland Valley Copper - Logan Lake, BC

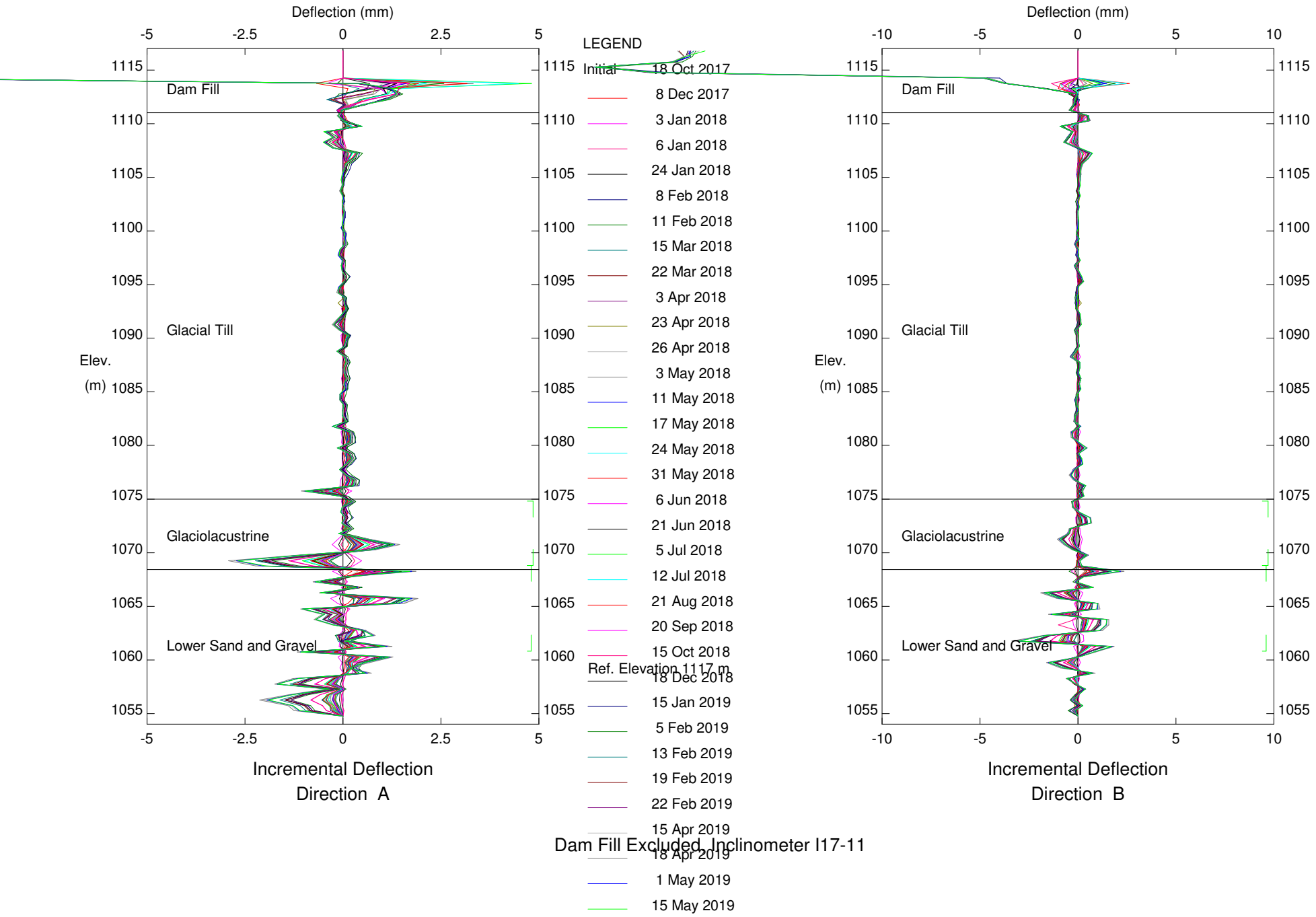


Valley Buttress Berm, Inclinometer I17-10

VALLEY BUTTRESS BERM

I17-11

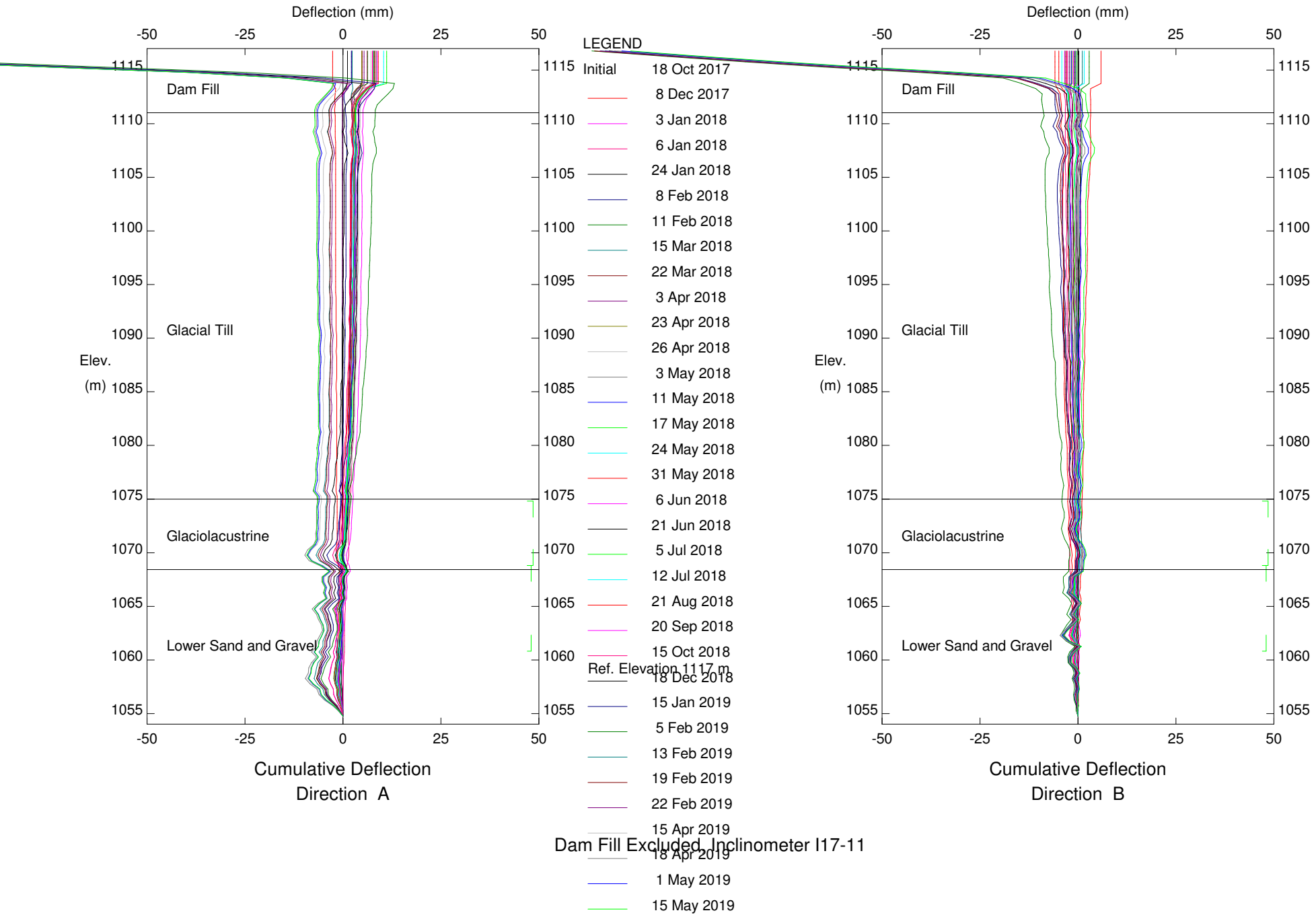
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I17-11

Z:\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\I17-11.g

Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I17-11

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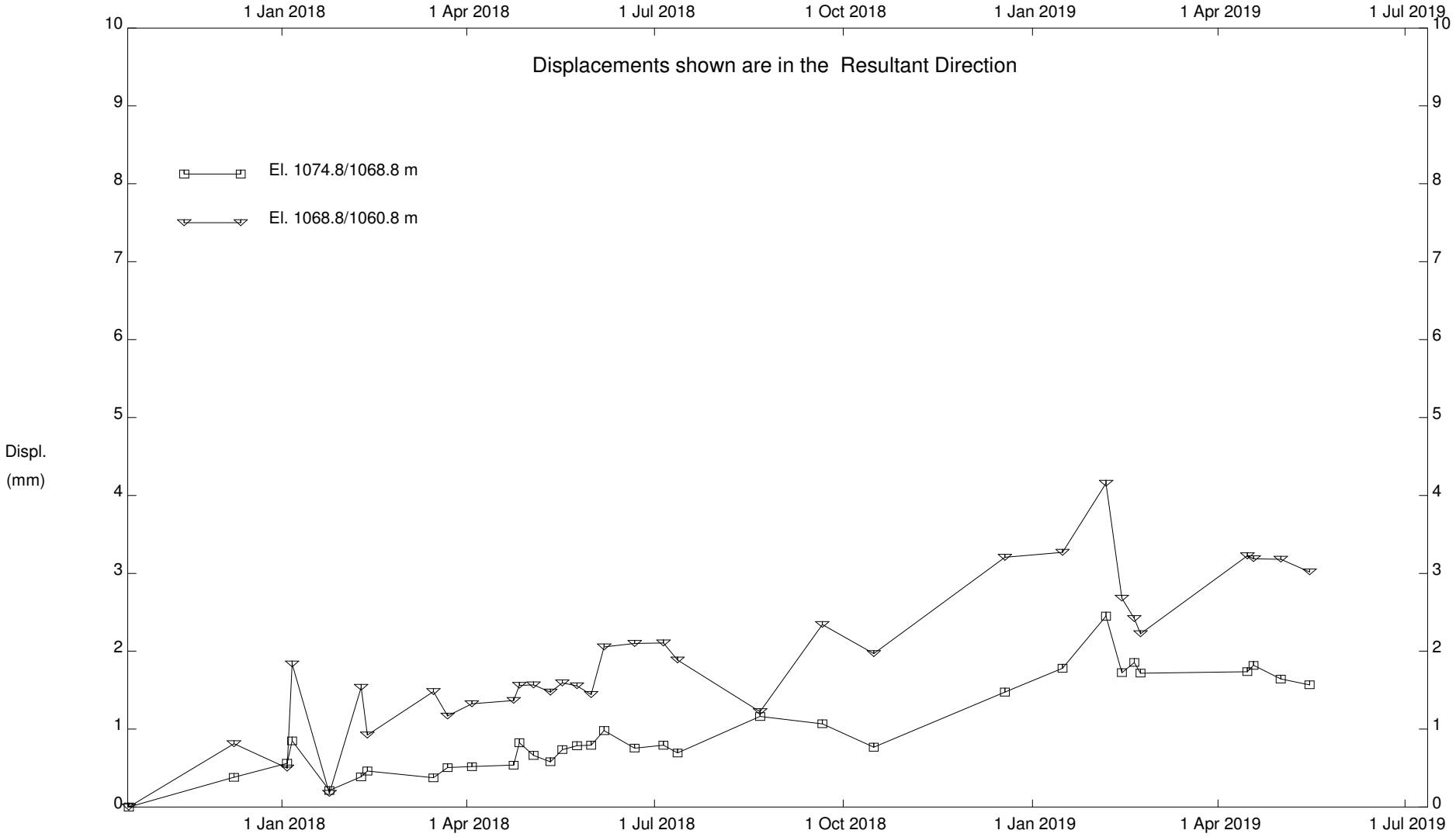
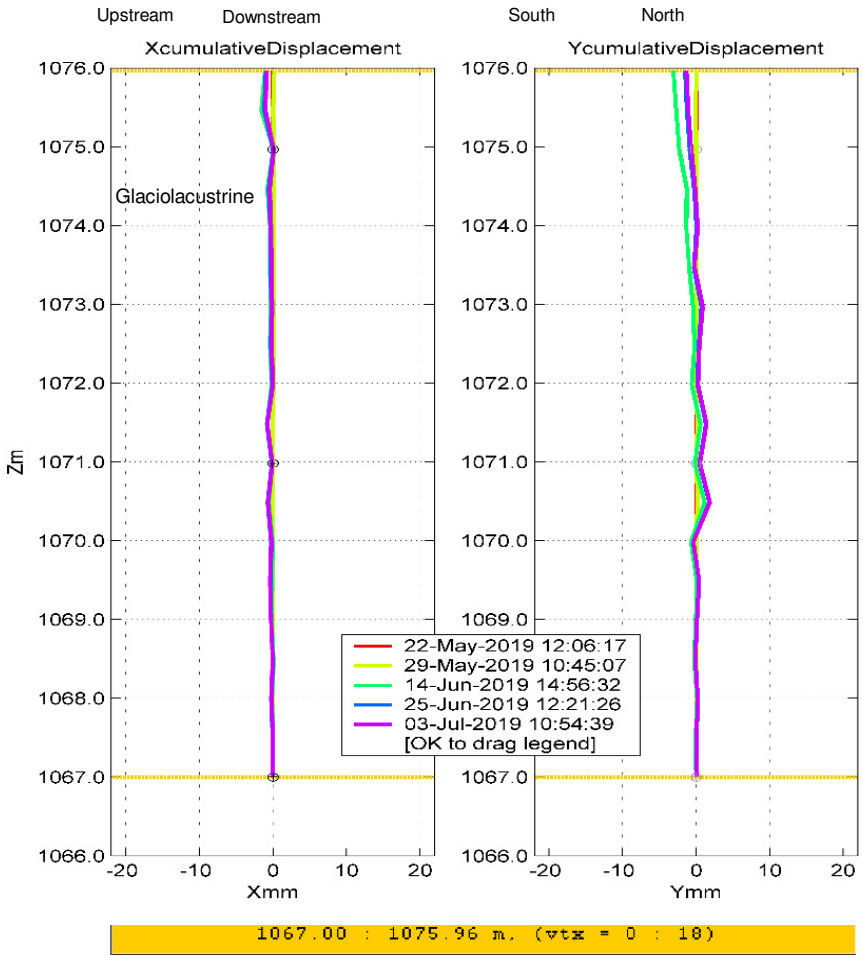
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I17-11

Inclinometer I17-11

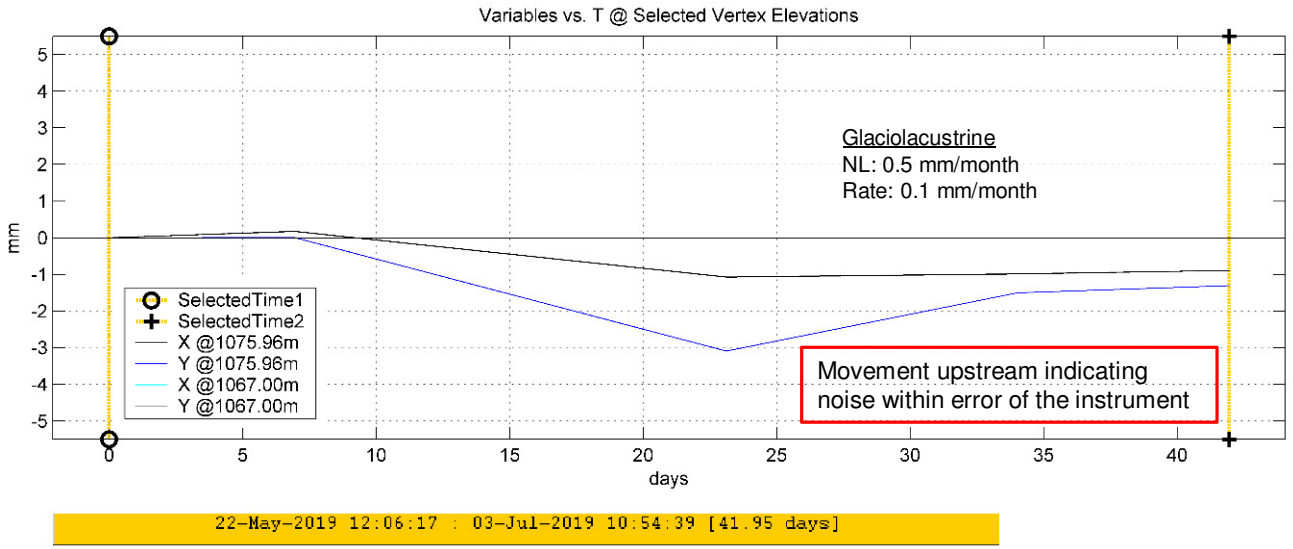
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
17-11	Glaciolacustrine	1074.8	1068.8	1	7

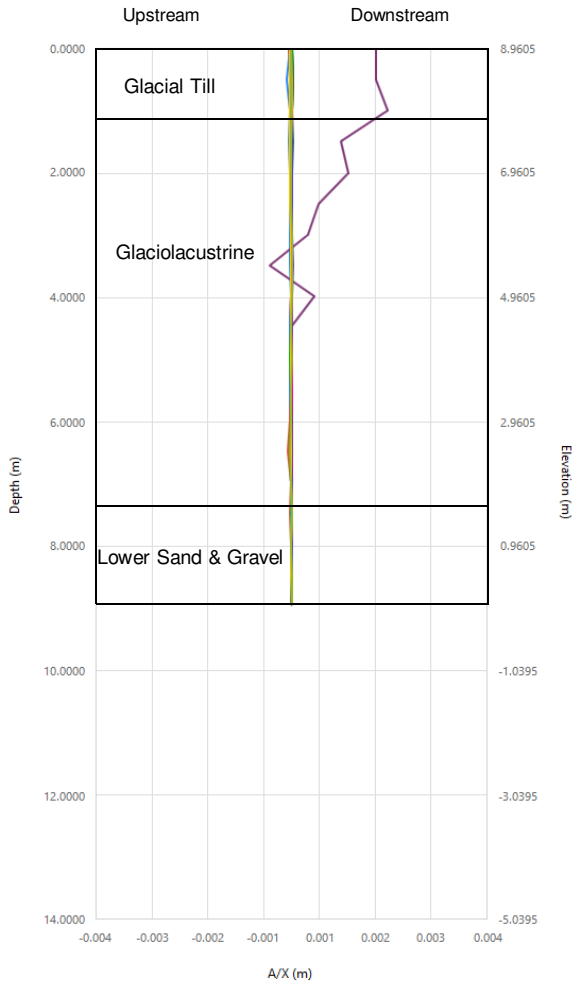
Inclinometer I17-11

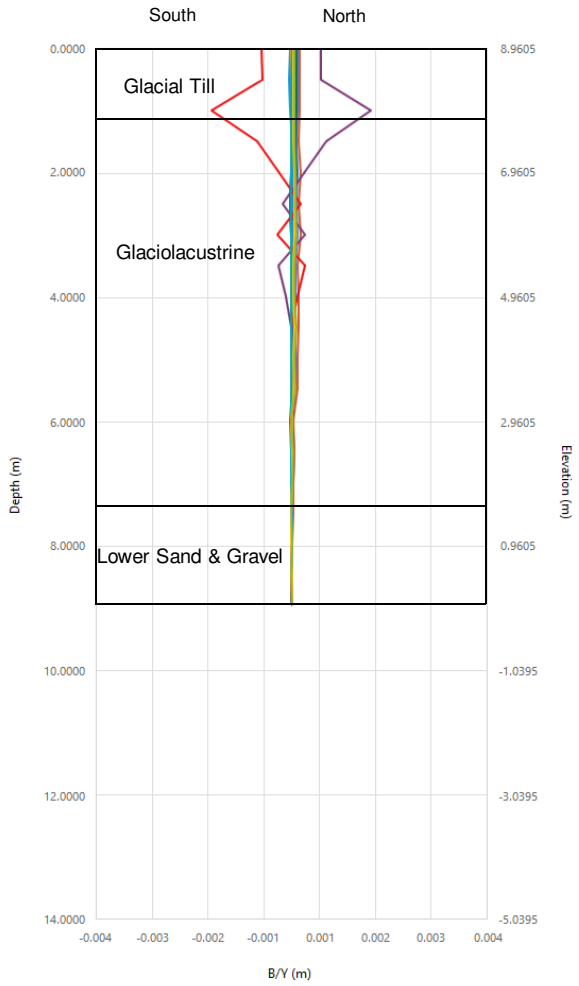
Displacement Plot - Glaciolacustrine



SAAV I17-11

Incremental Plot

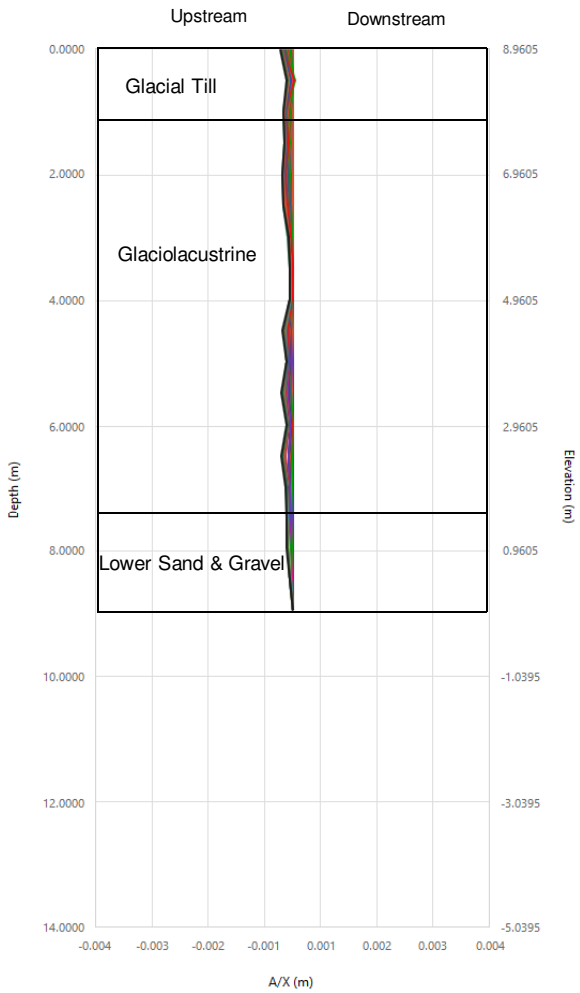


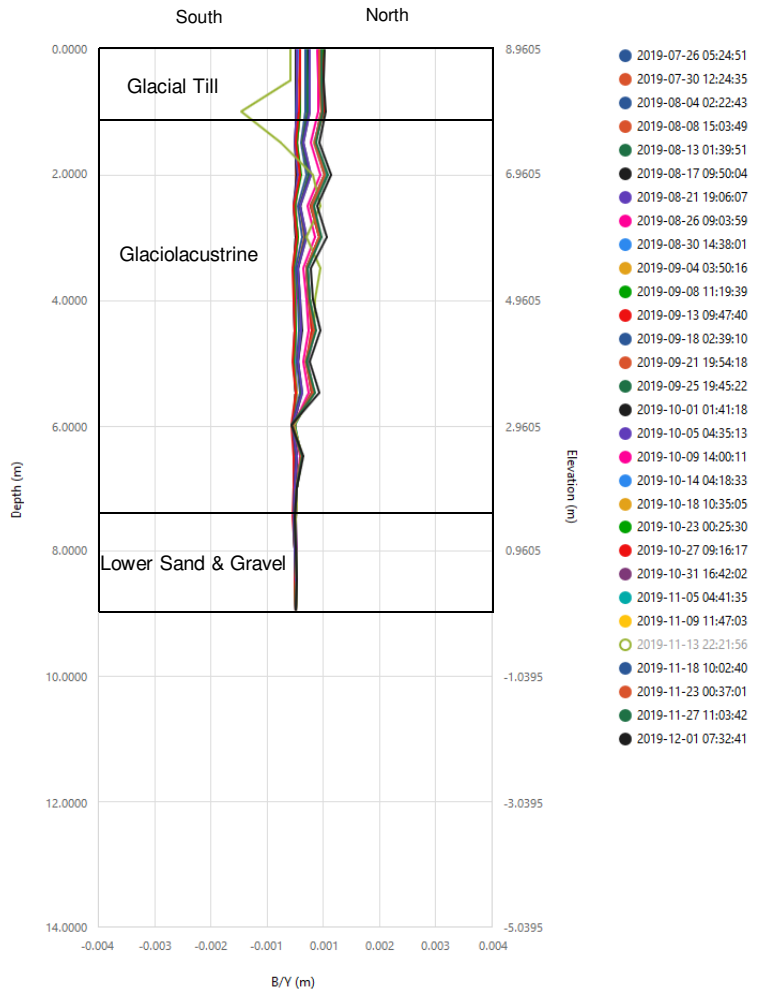


Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
17-11	Glaciolacustrine	1074.8	1068.8	1	7

SAAV I17-11

Cumulative Plot





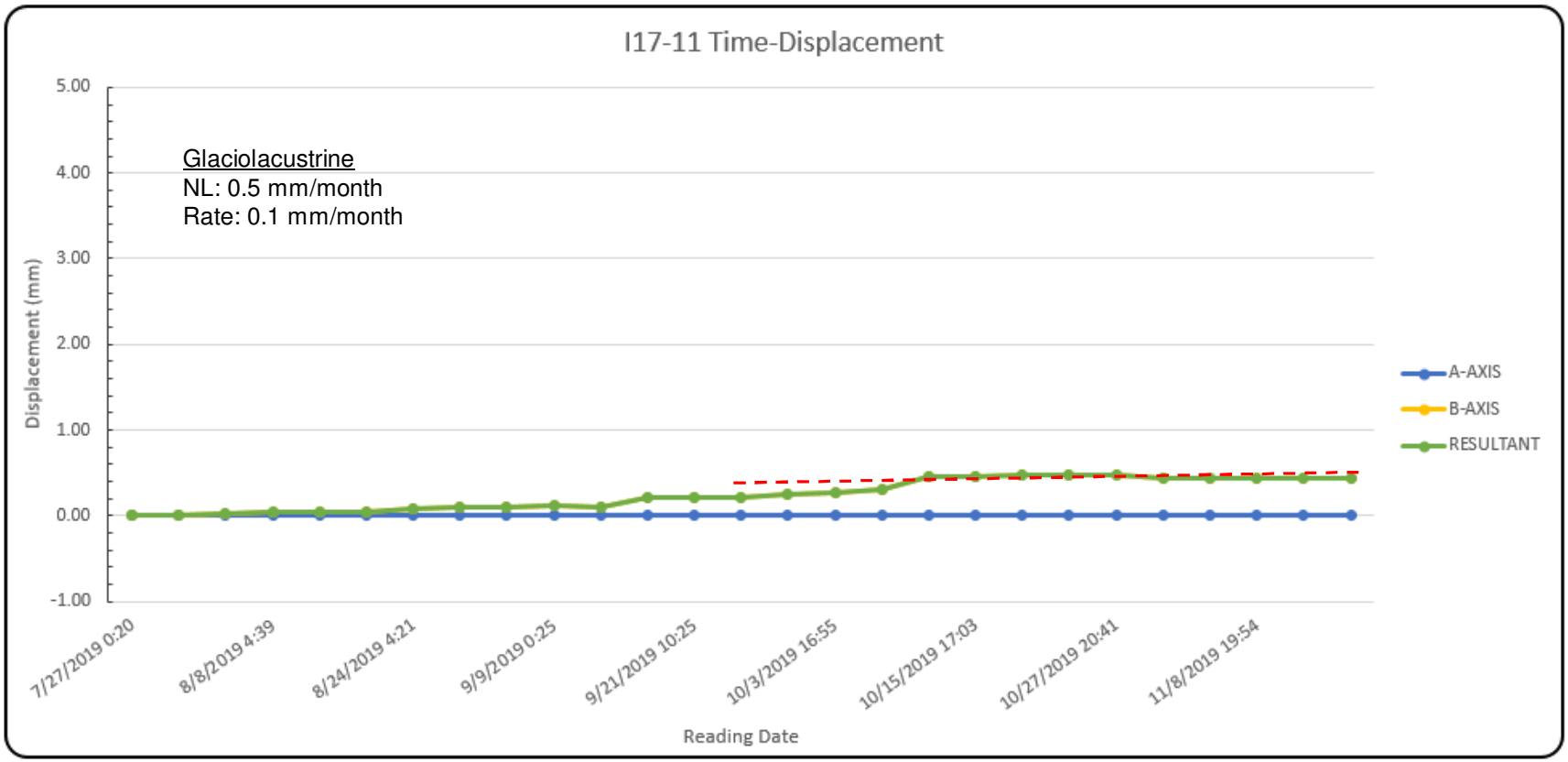
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
17-11	Glaciolacustrine	1074.8	1068.8	1	7

SAAV 17-11

Displacement Plot - Glaciolacustrine

Unit	Upper Depth	Lower Depth
Glaciolacustrine	1	7

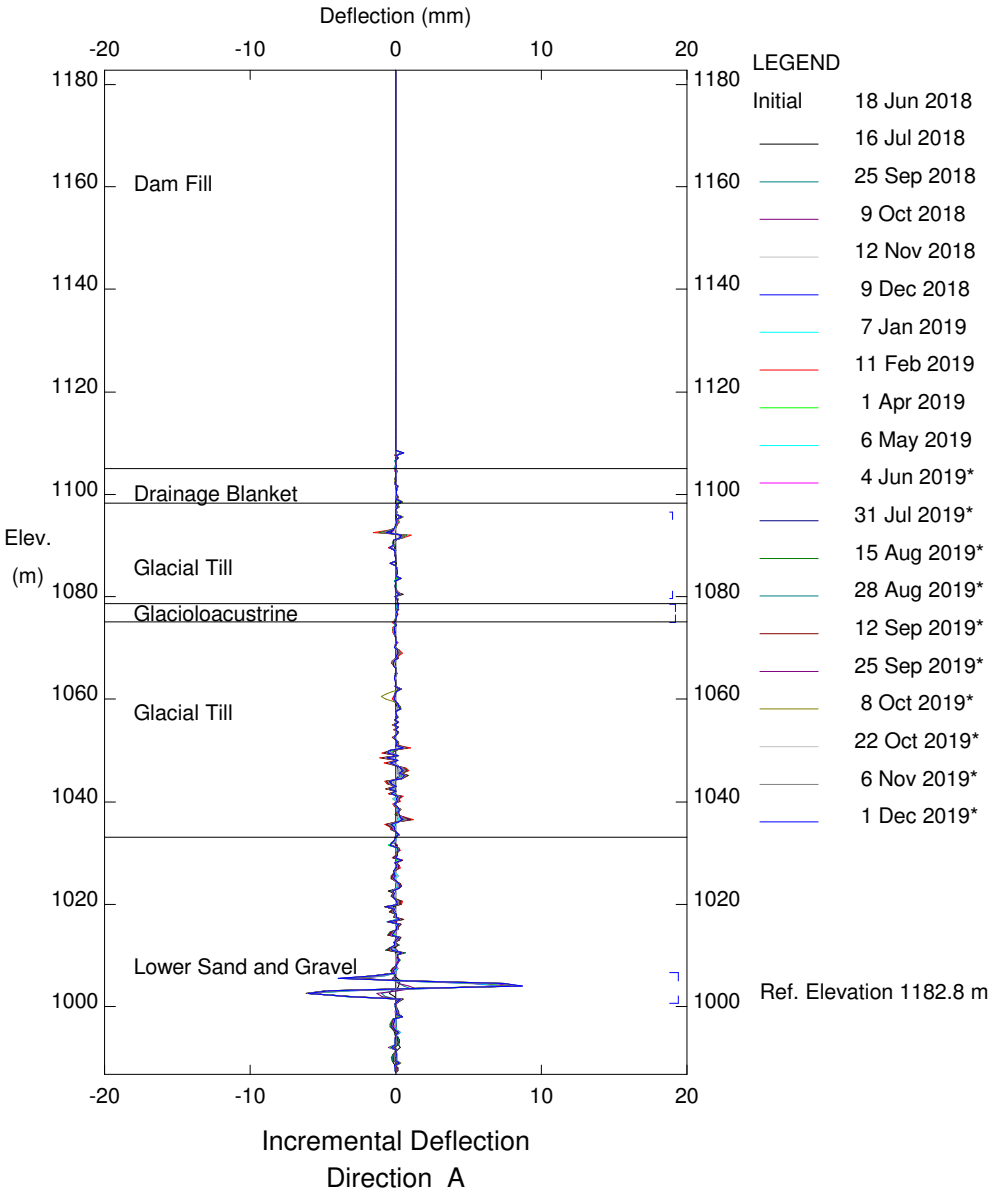
Upper Depth	1.0 m
Lower Depth	7.0 m

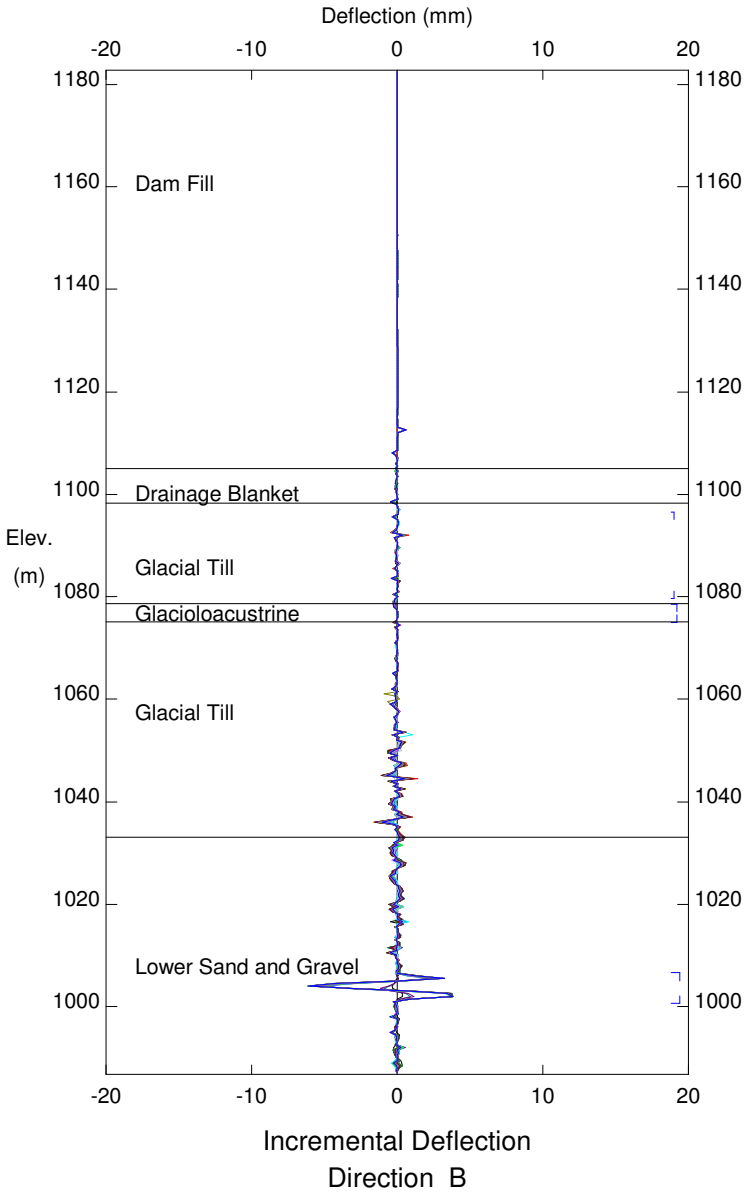


VALLEY BUTTRESS BERM

I17-19

Highland Valley Copper - Logan Lake, BC





Valley Buttress Berm, Inclinometer I17-19

Sets marked * include zero shift and/or rotation corrections.

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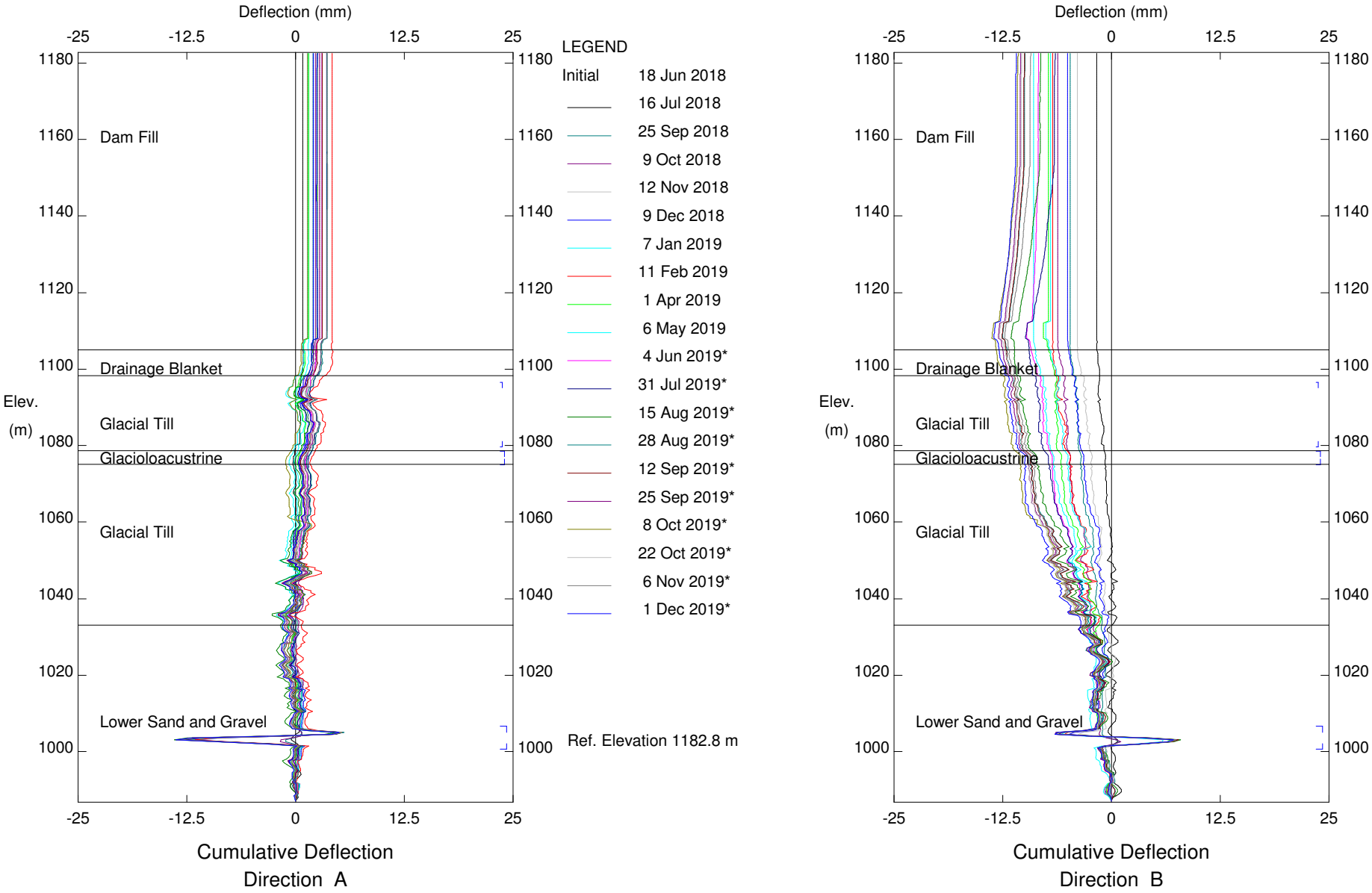
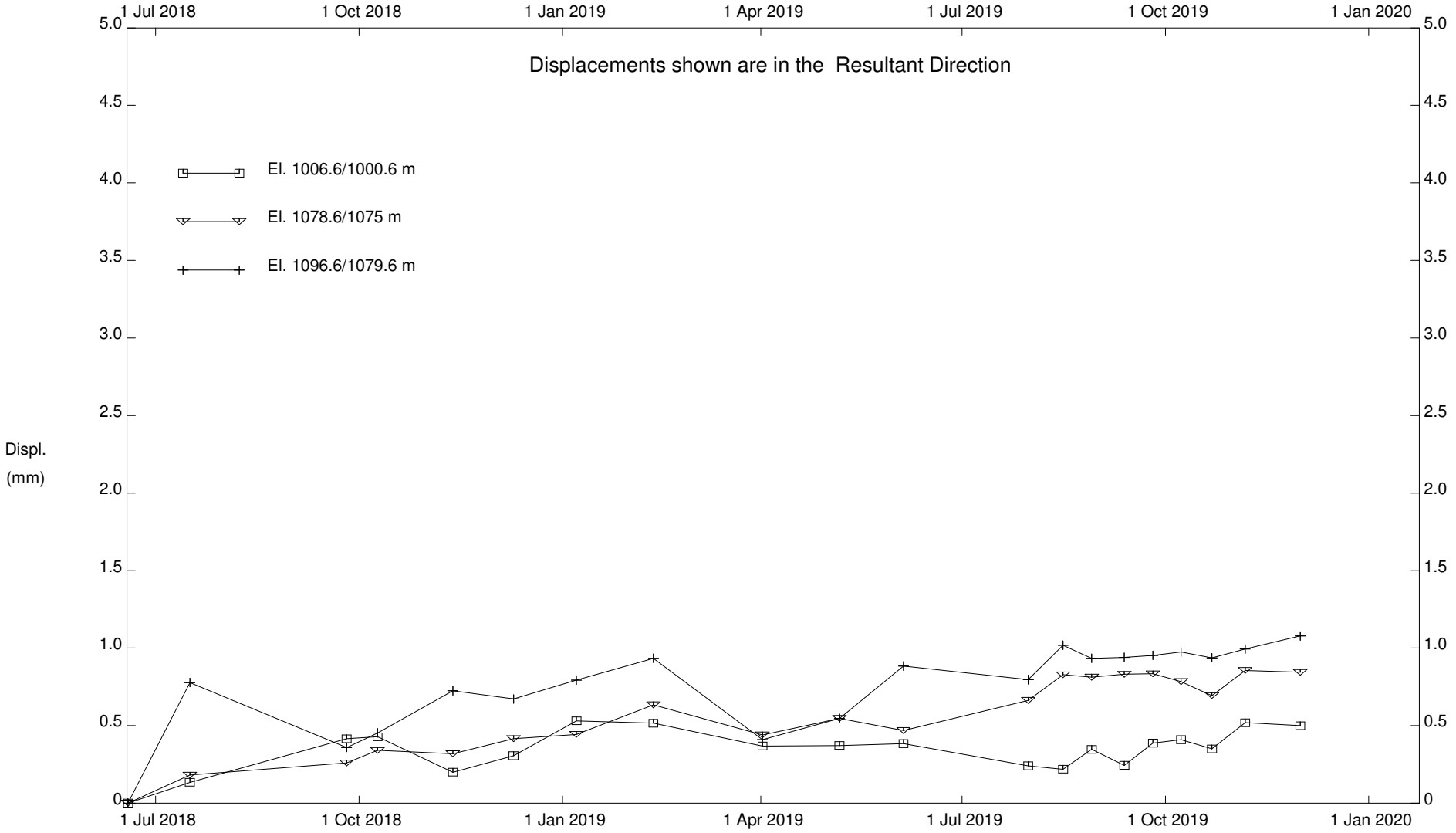
Highland Valley Copper - Logan Lake, BC



Valley Buttress Berm, Inclinometer I17-19

Sets marked * include zero shift and/or rotation corrections.

Highland Valley Copper - Logan Lake, BC



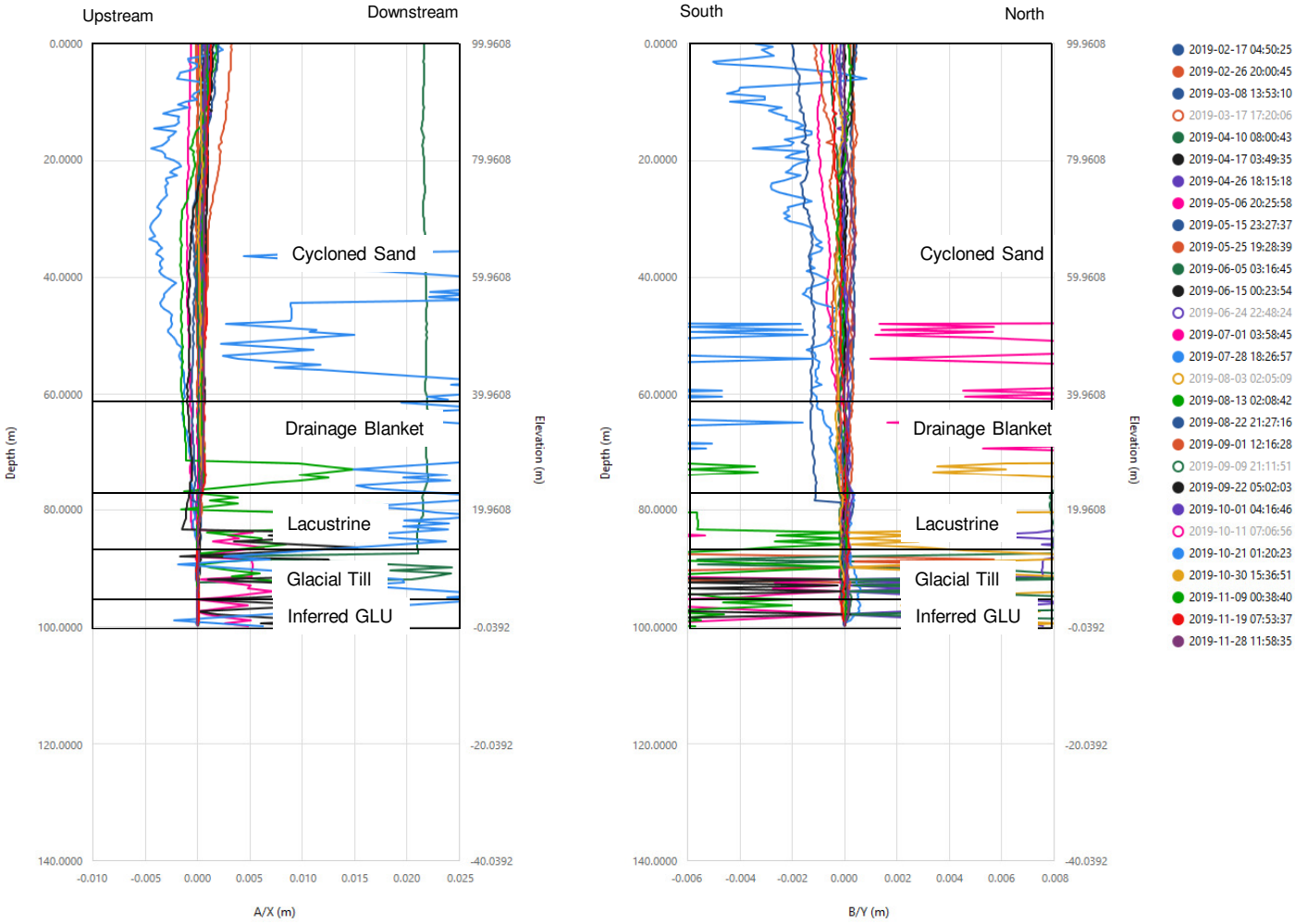
Valley Buttress Berm, Inclinometer I17-19

VALLEY BUTTRESS BERM

SAA I12-01

SAA I12-01

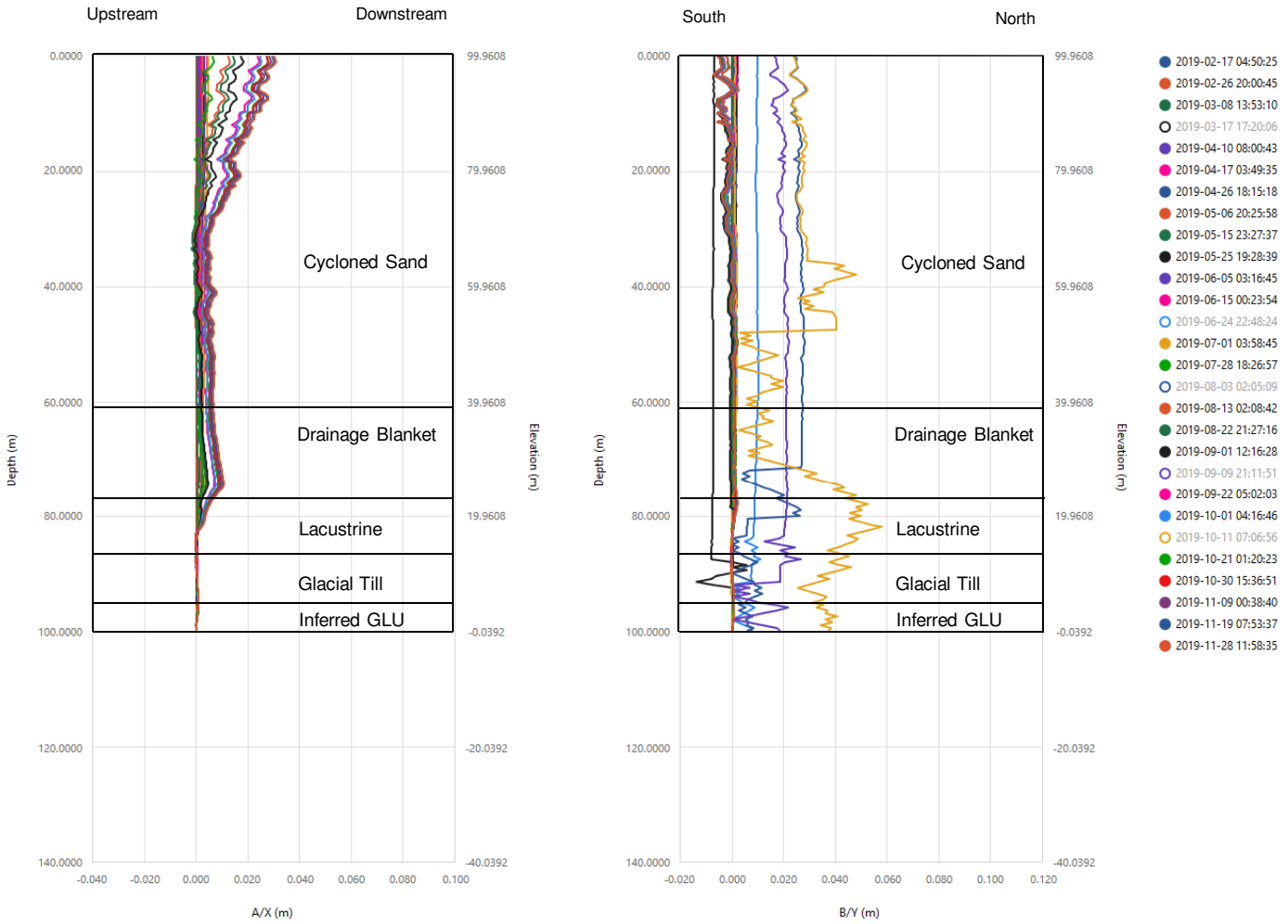
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
12-01	Lacustrine	1098	1087.1	75	86
	Glacial Till	1087.1	1078.1	86	95
	Glaciolacustrine	1078.1	1073	95	100

SAA I12-01

Cumulative Plot



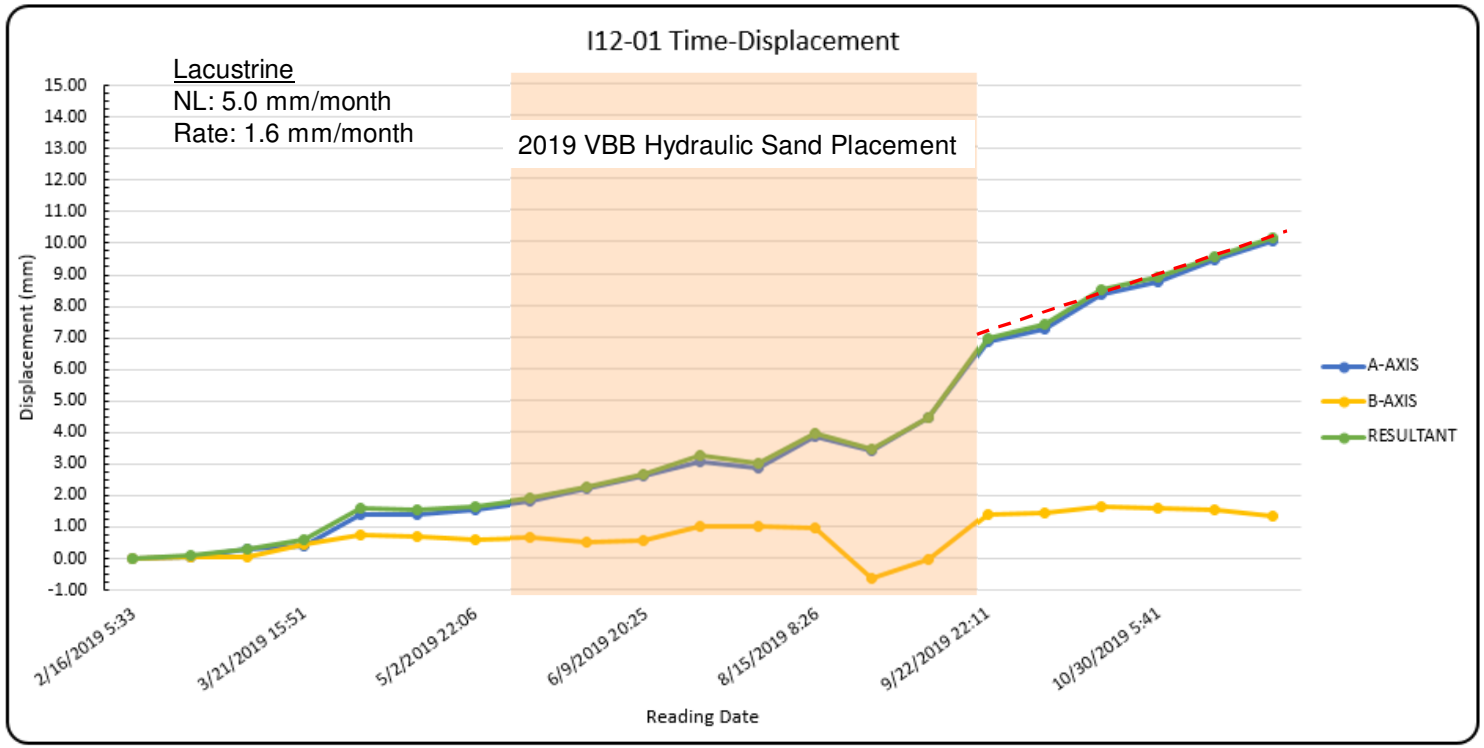
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
12-01	Lacustrine	1098	1087.1	75	86
	Glacial Till	1087.1	1078.1	86	95
	Glaciolacustrine	1078.1	1073	95	100

SAA I12-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Lacustrine	75	86
Glacial Till	86	95
Glaciolacustrine	95	100

Upper Depth	75.0 m
Lower Depth	86.0 m

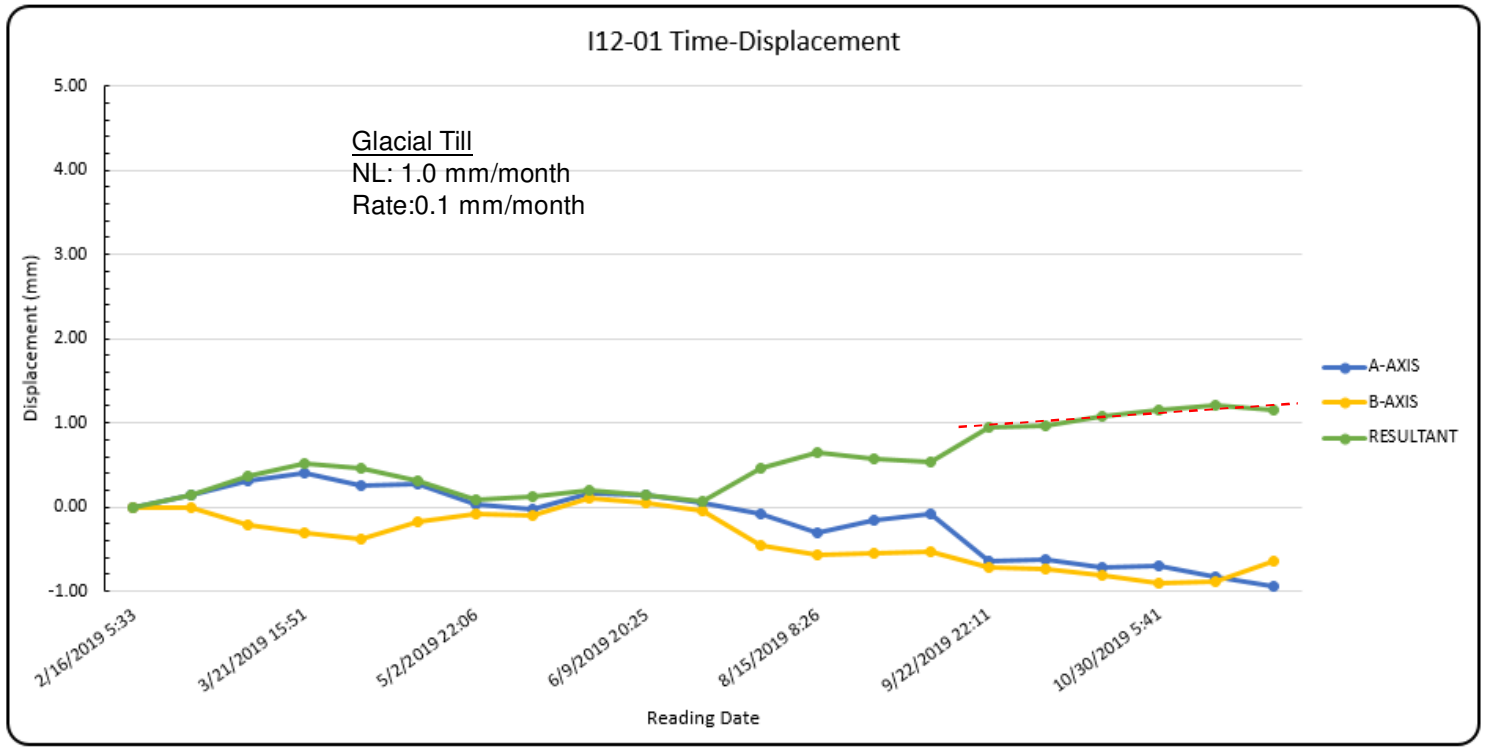


SAA I12-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Lacustrine	75	86
Glacial Till	86	95
Glaciolacustrine	95	100

Upper Depth	86.0 m
Lower Depth	95.0 m

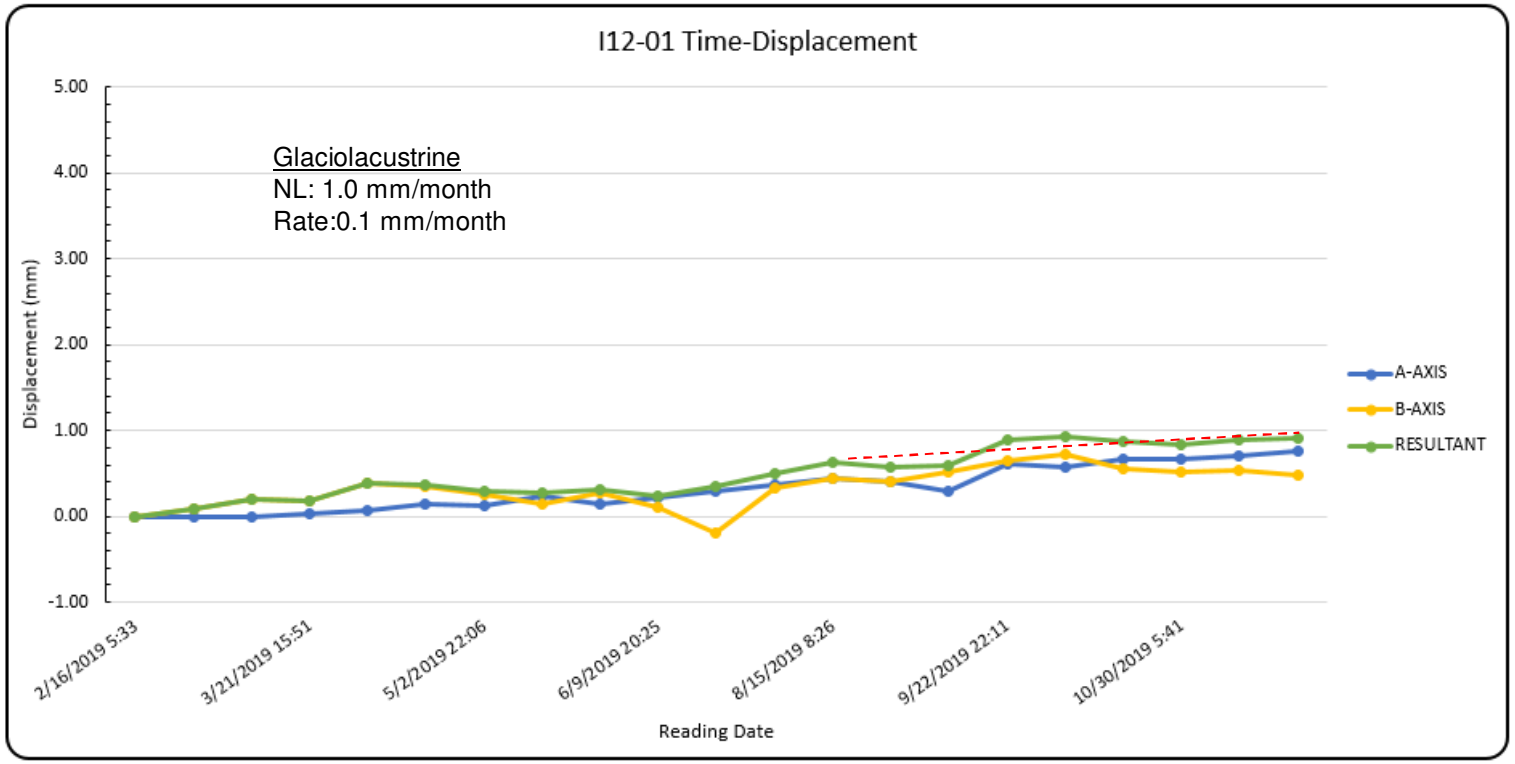


SAA I12-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Lacustrine	75	86
Glacial Till	86	95
Glaciolacustrine	95	100

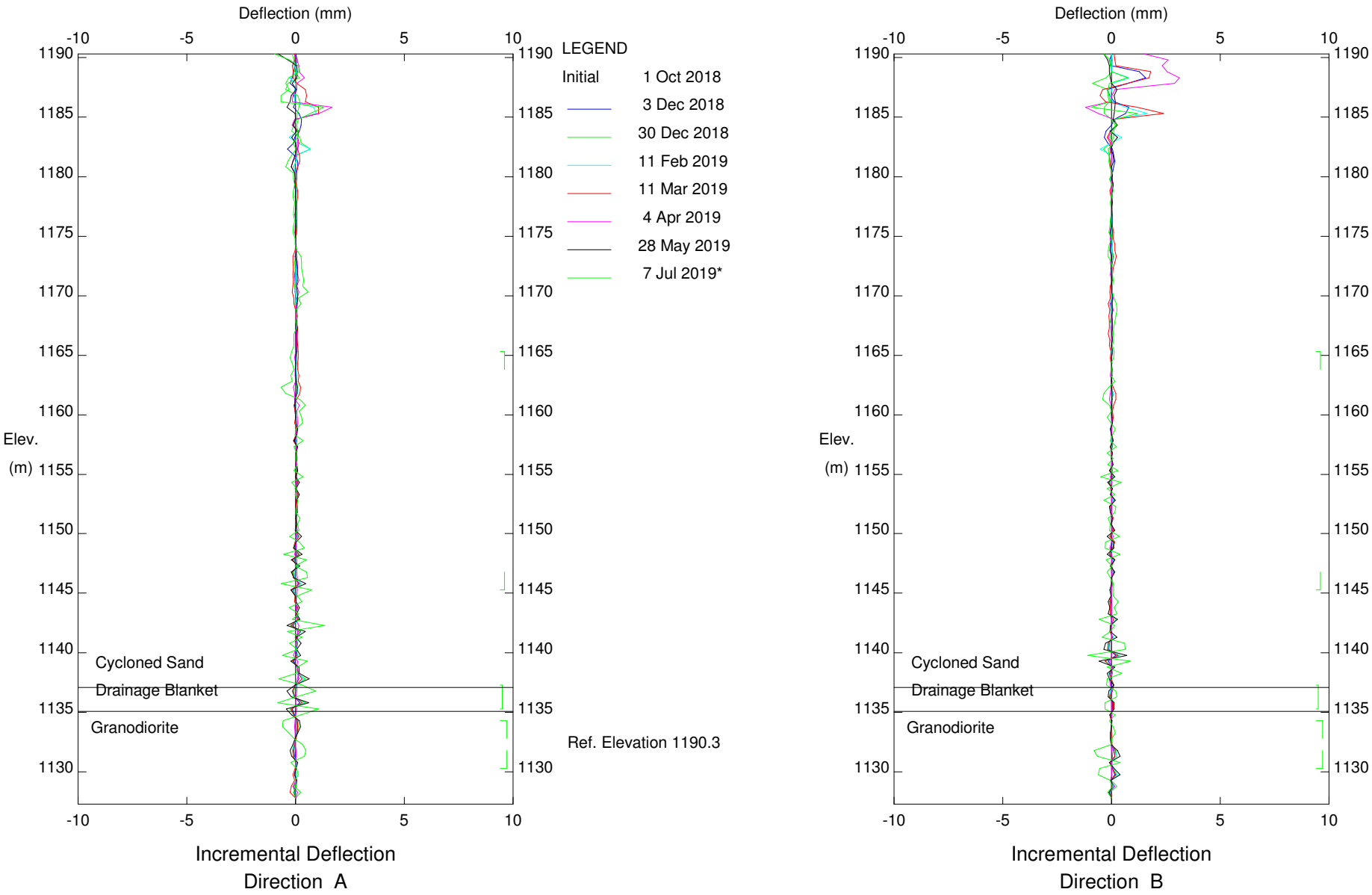
Upper Depth	95.0 m
Lower Depth	100.0 m



SOUTH DAM

I10-01

Highland Valley Copper - Logan Lake, BC

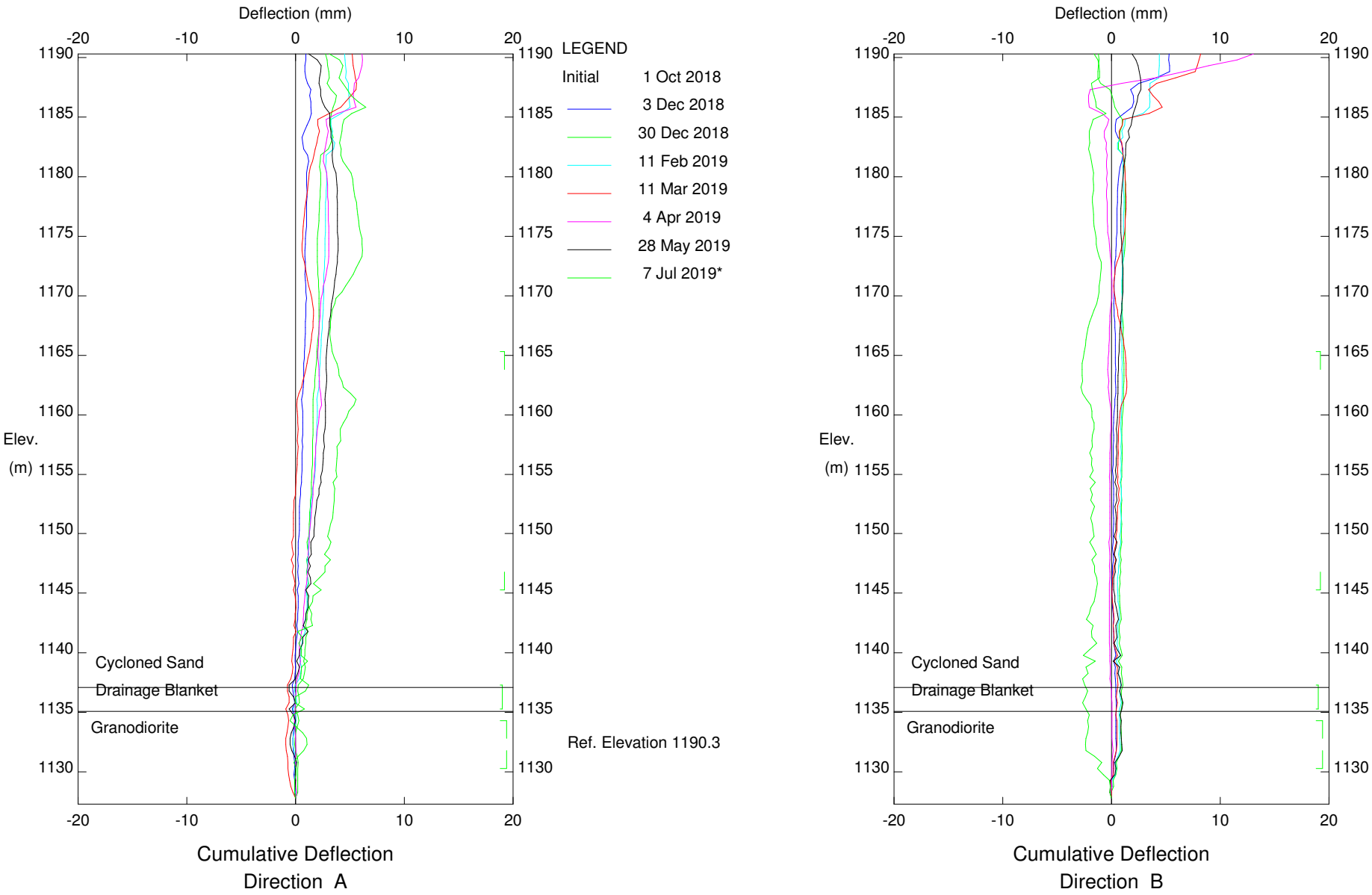


South Dam,,,, Inclinometer SAAV 10-01

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

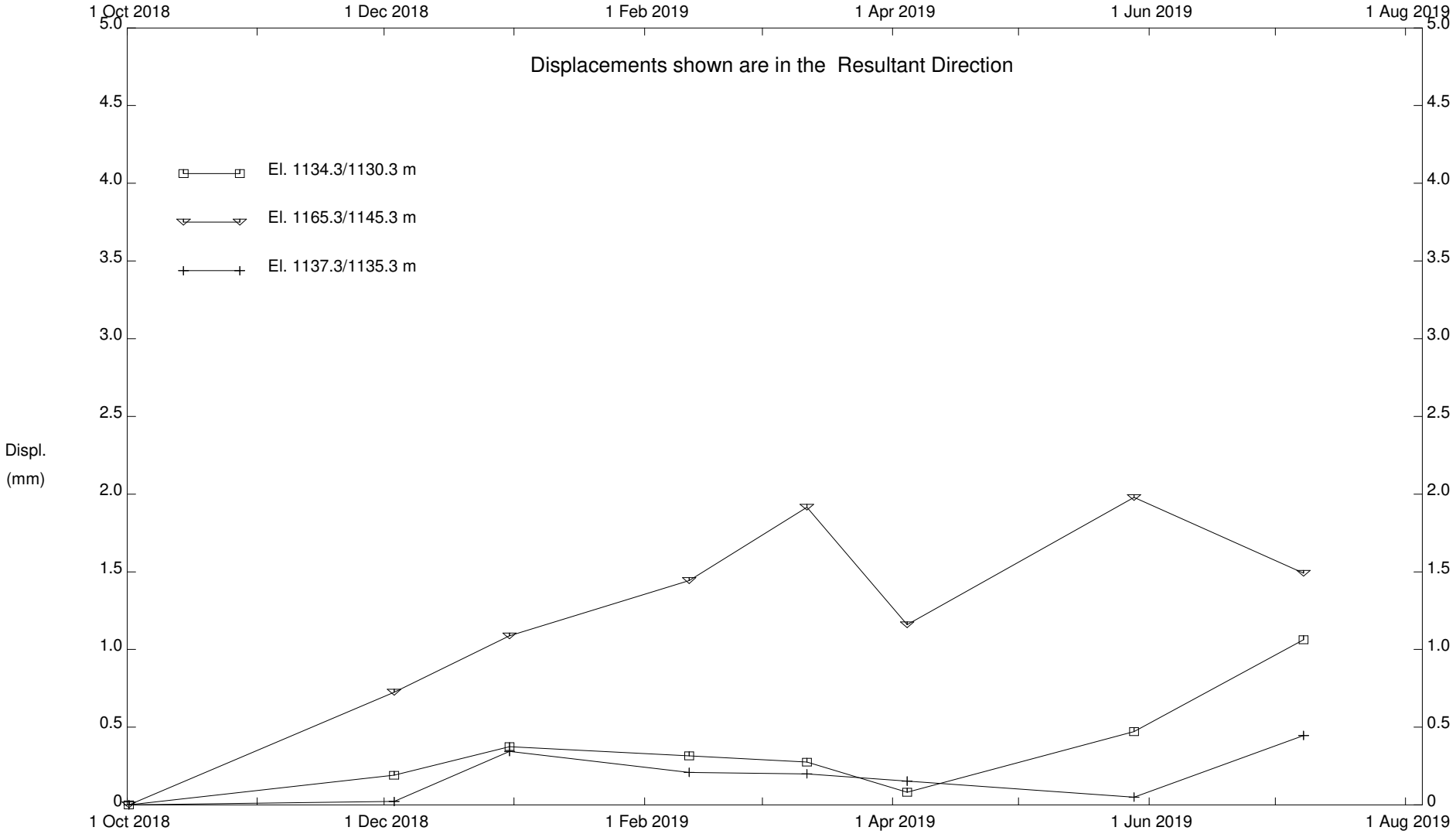
Highland Valley Copper - Logan Lake, BC



South Dam,,,, Inclinometer SAAV 10-01

Sets marked * include zero shift and/or rotation corrections.

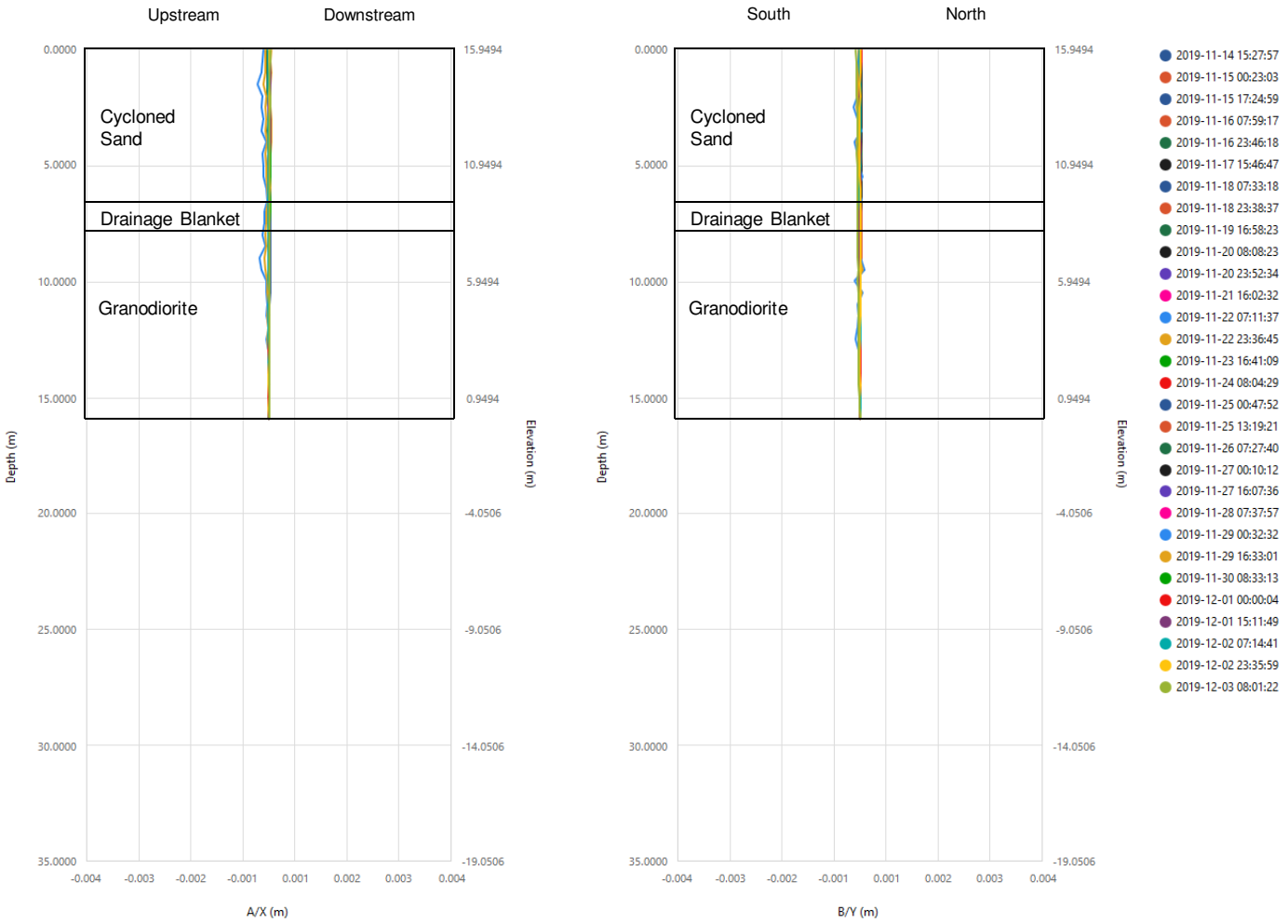
Highland Valley Copper - Logan Lake, BC



South Dam,,,, Inclinometer SAAV 10-01

SAAV I10-01

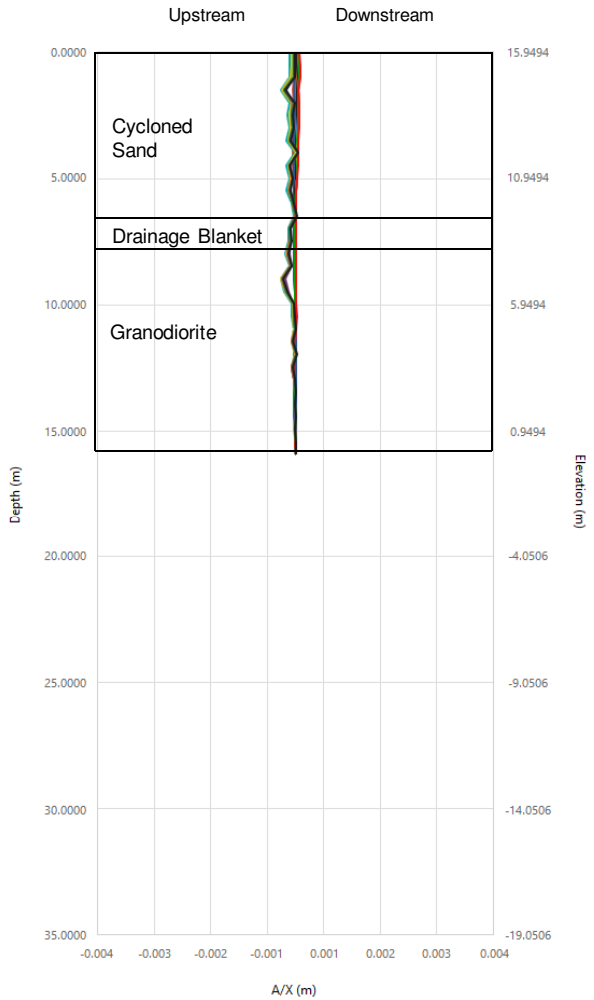
Incremental Plot

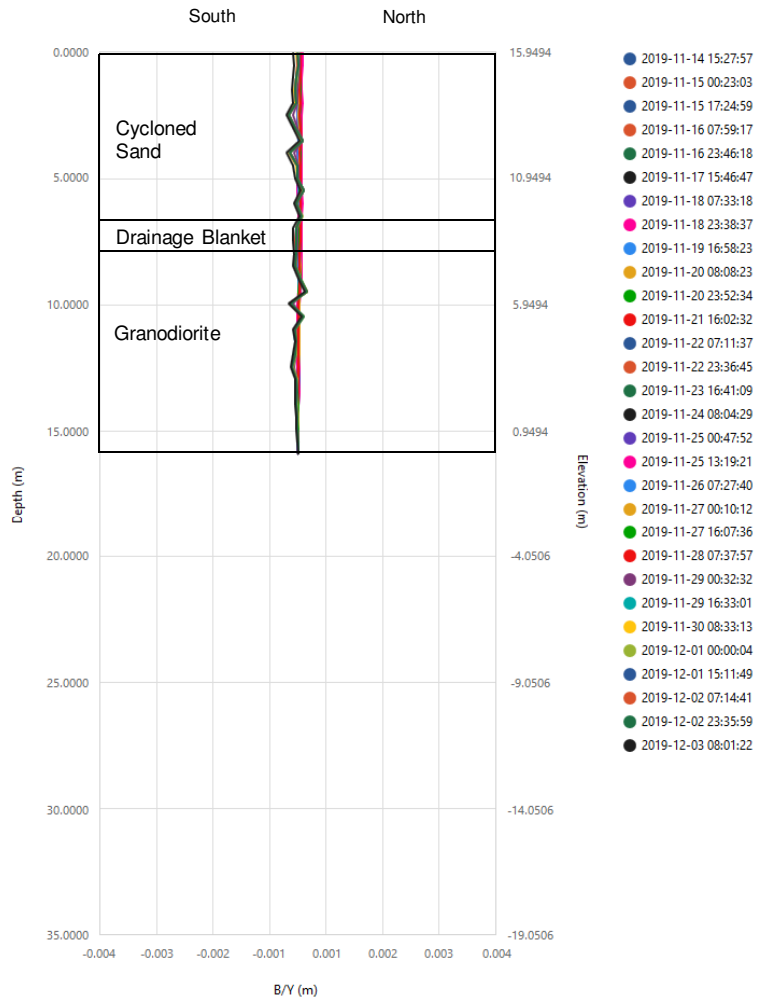


Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-01	S&G Drainage Blanket	1137	1135.2	7	9
	Granodiorite	1135.2	1127.8	9	16

SAAV I10-01

Cumulative Plot





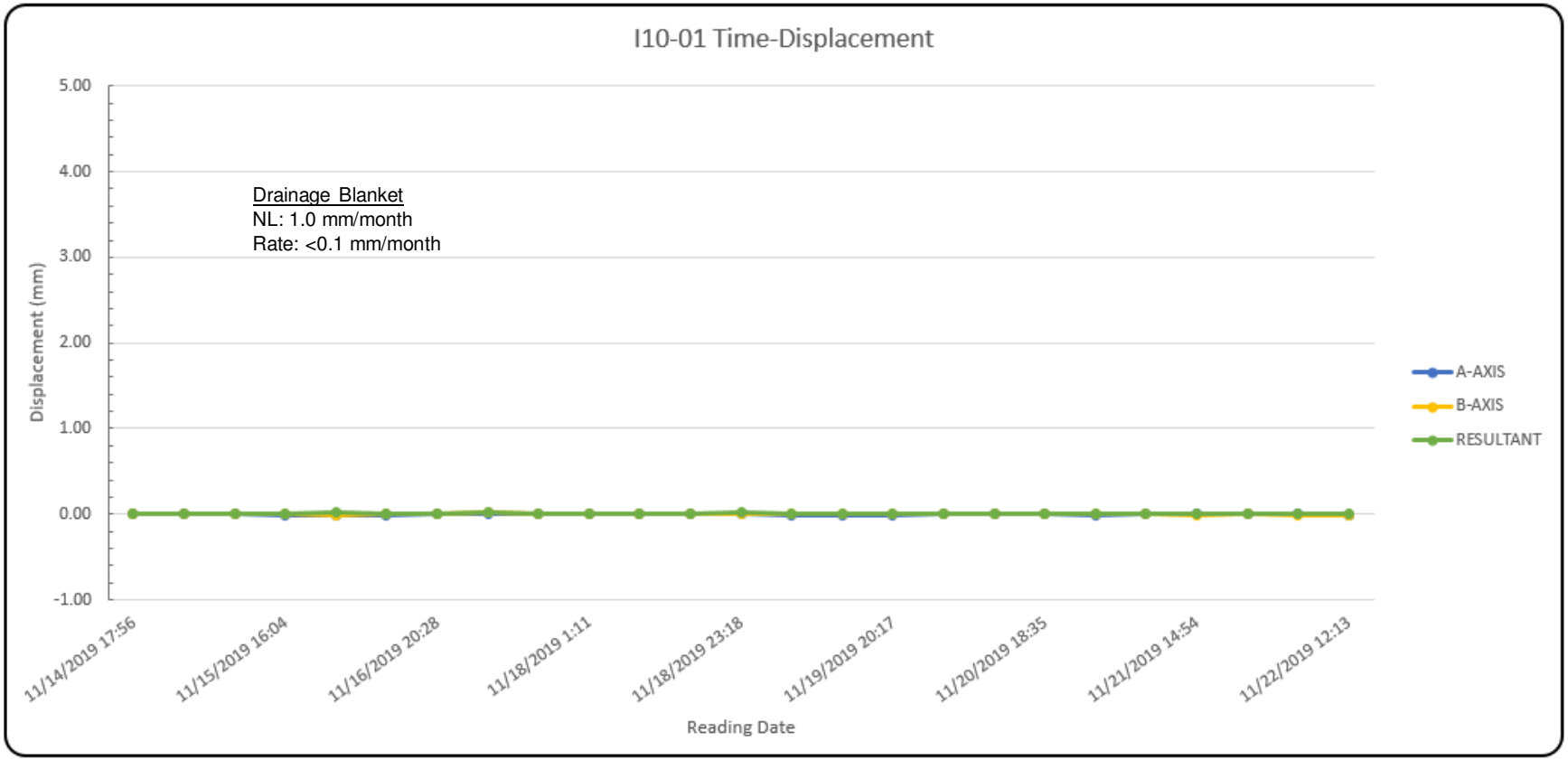
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-01	S&G Drainage Blanket	1137	1135.2	7	9
	Granodiorite	1135.2	1127.8	9	16

SAAV 10-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Drainage Blanket	6	8
Volcanic	8	16

Upper Depth	6.0 m
Lower Depth	8.0 m

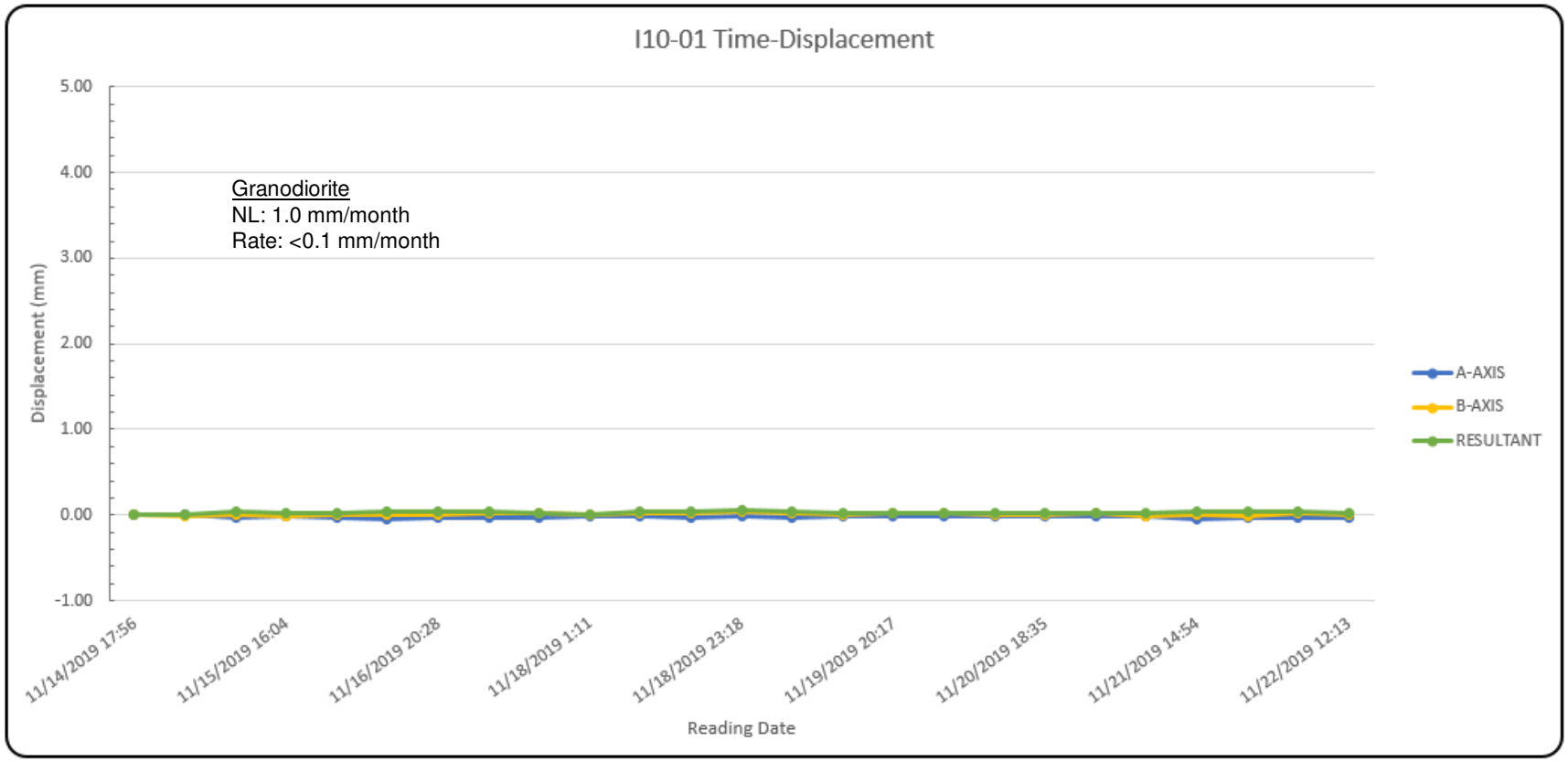


SAAV 10-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Drainage Blanket	6	8
Volcanic	8	16

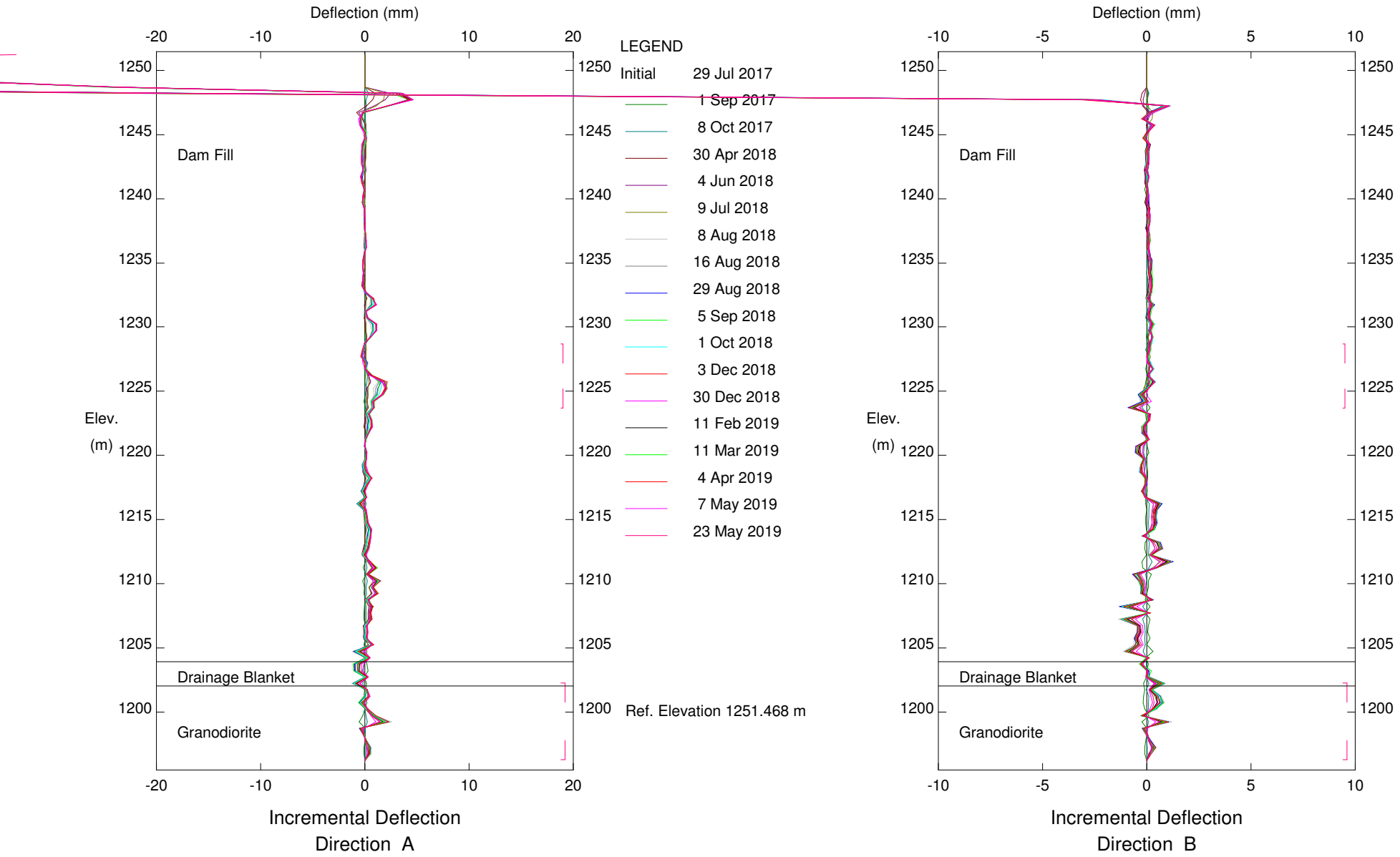
Upper Depth	8.0 m
Lower Depth	16.0 m



SOUTH DAM

I10-08

Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I10-8

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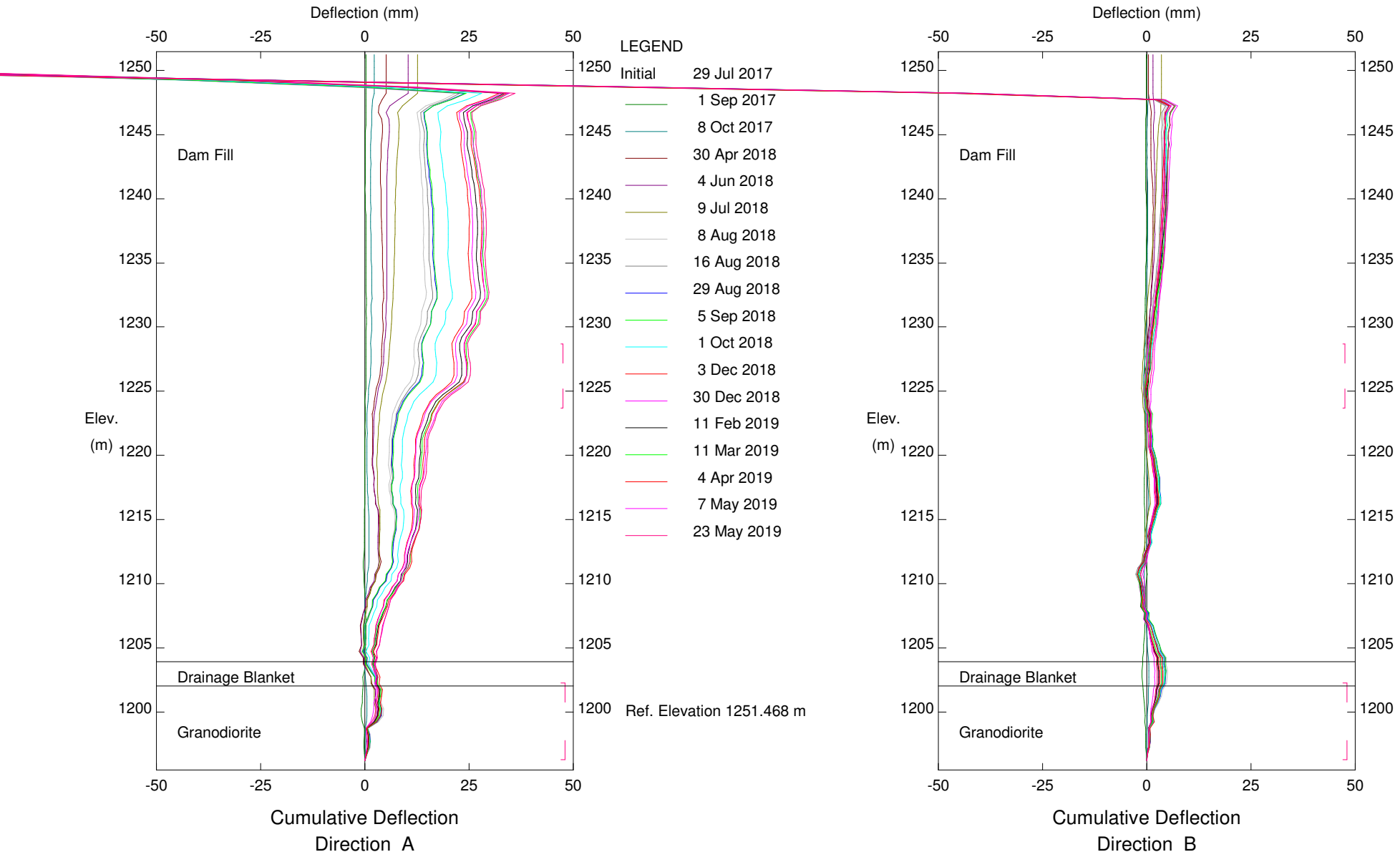
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I10-8

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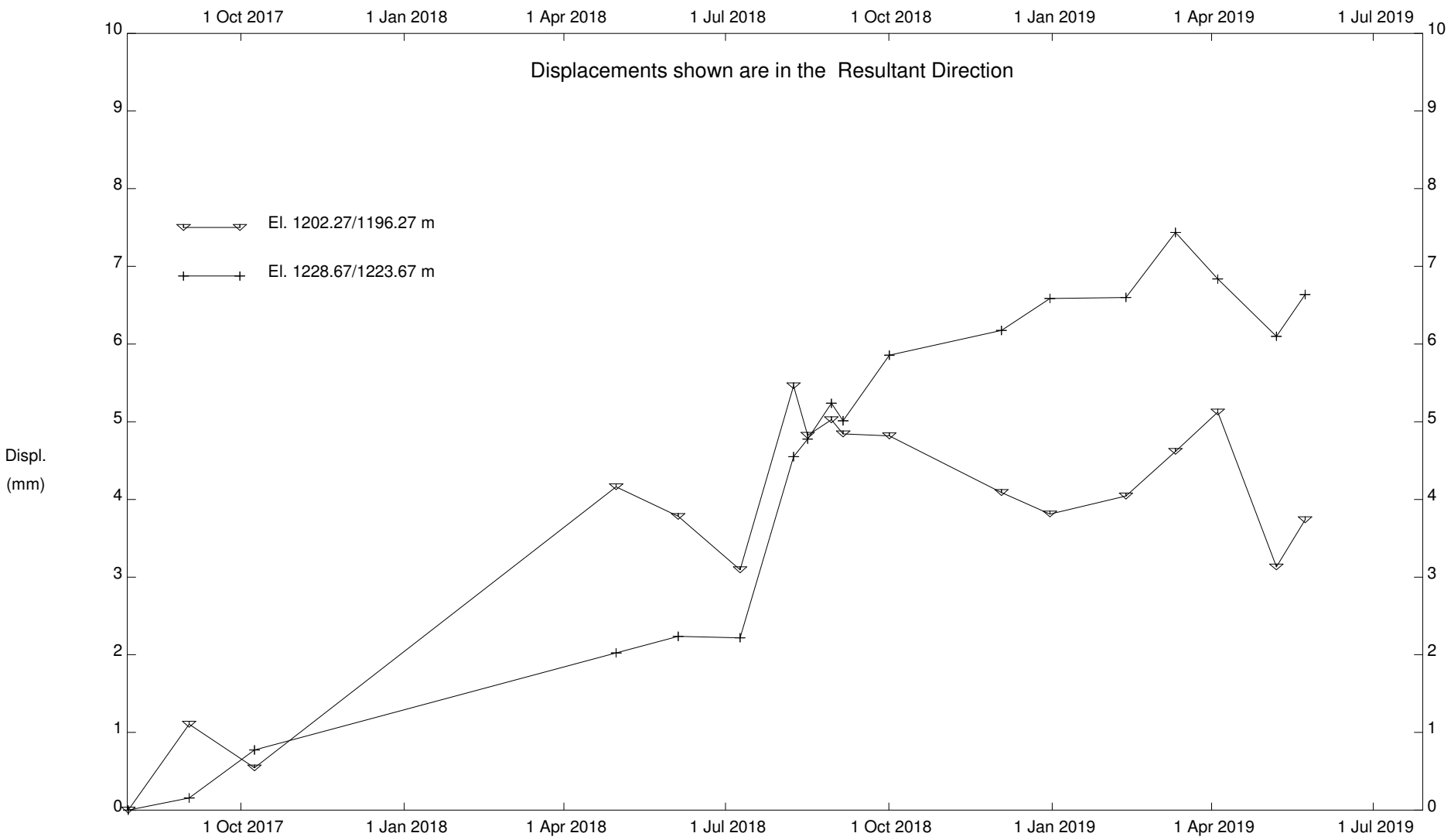
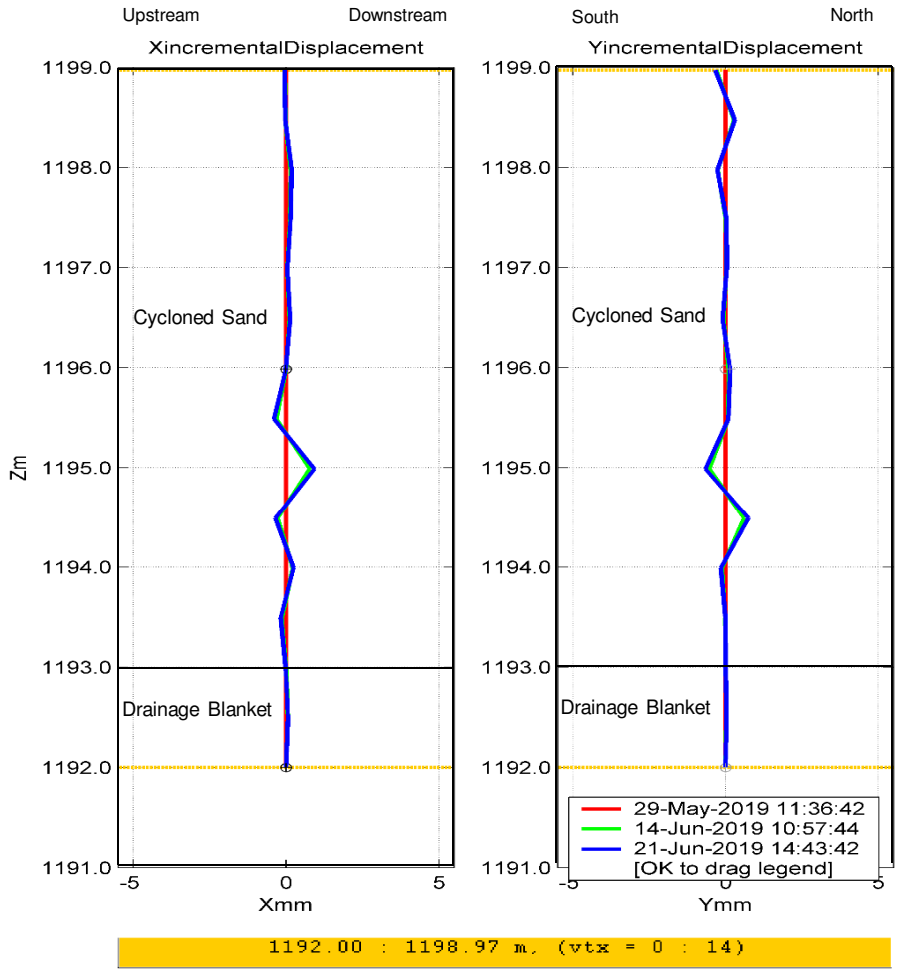
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I10-8

Inclinometer I10-08

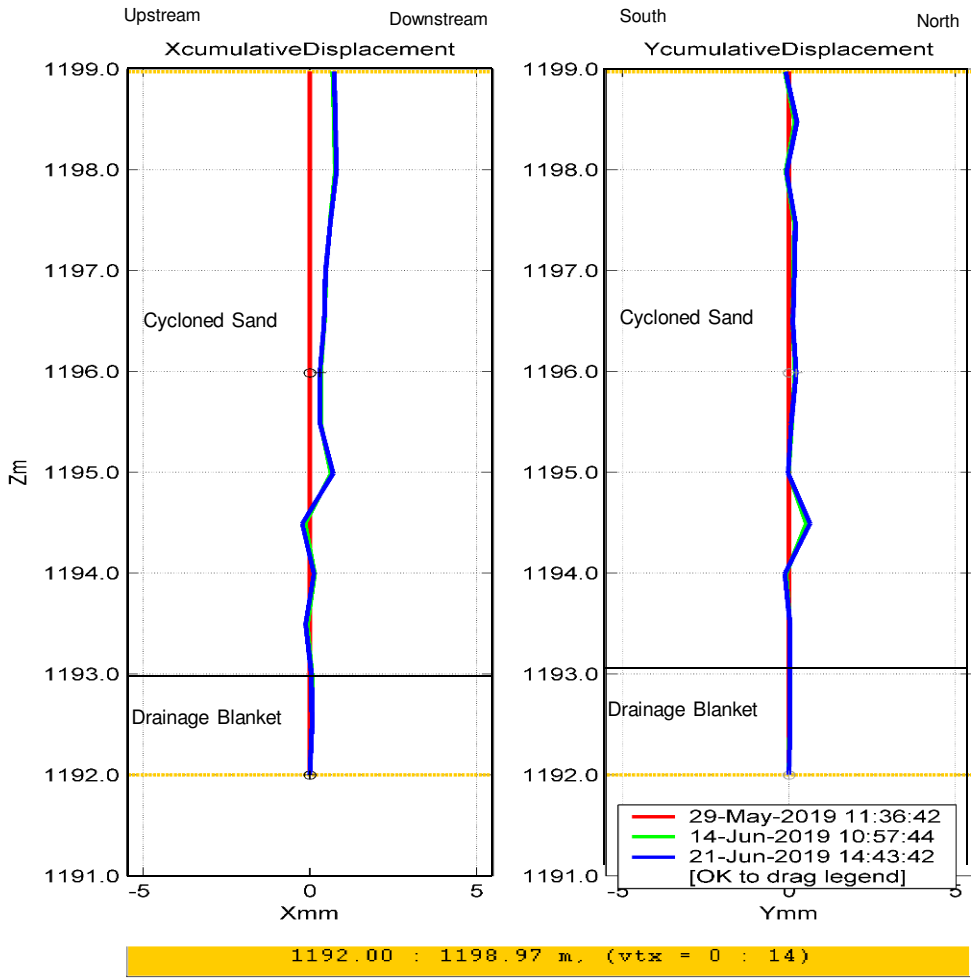
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-08	Granodiorite	1202.5	1196.5	1	7

Inclinometer I10-08

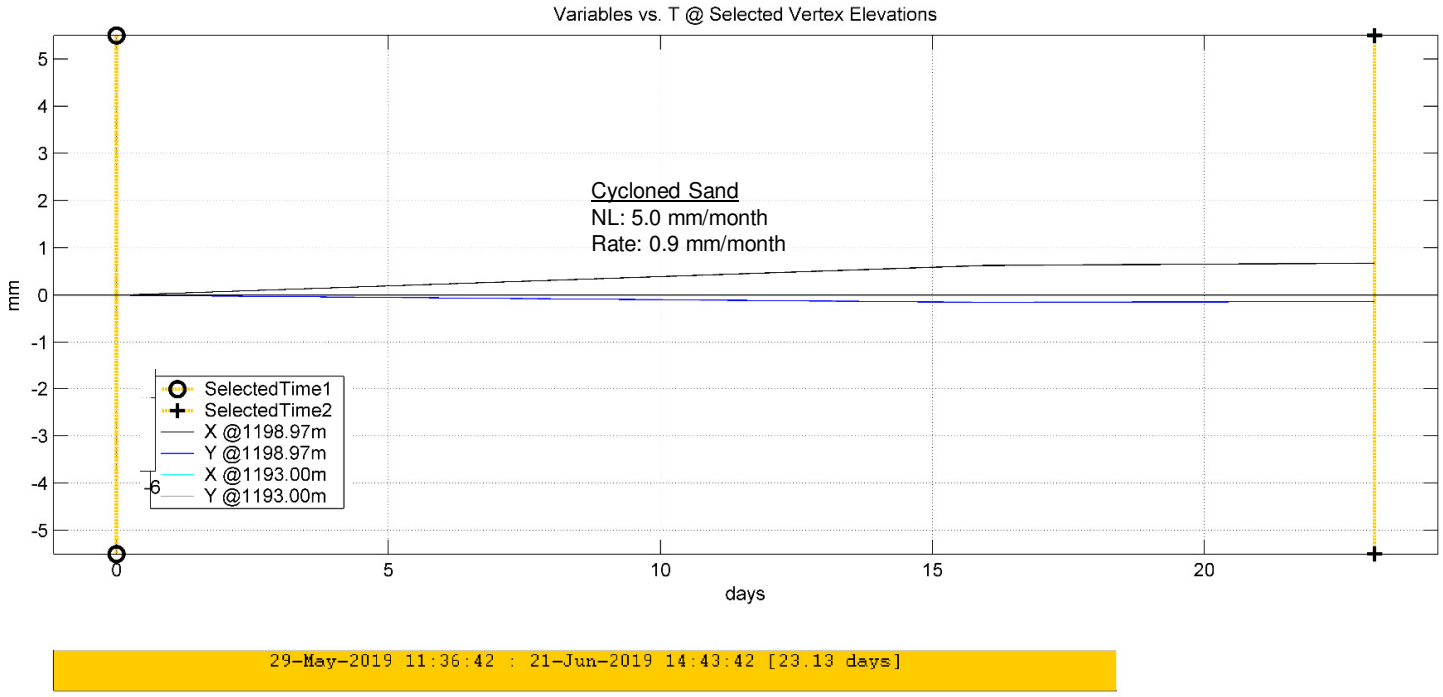
Cumulative Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-08	Granodiorite	1202.5	1196.5	1	7

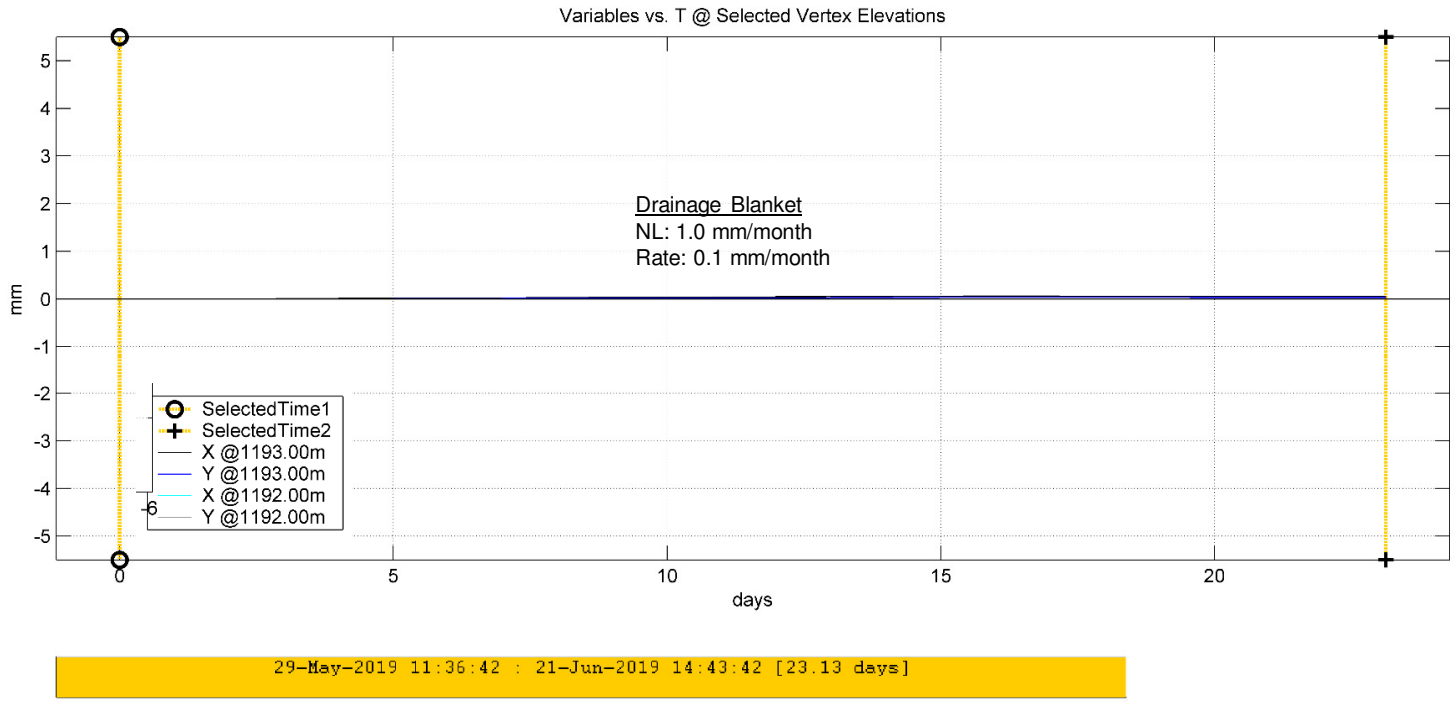
Inclinometer I10-08

Time Displacement Plot – Cycloned Sand



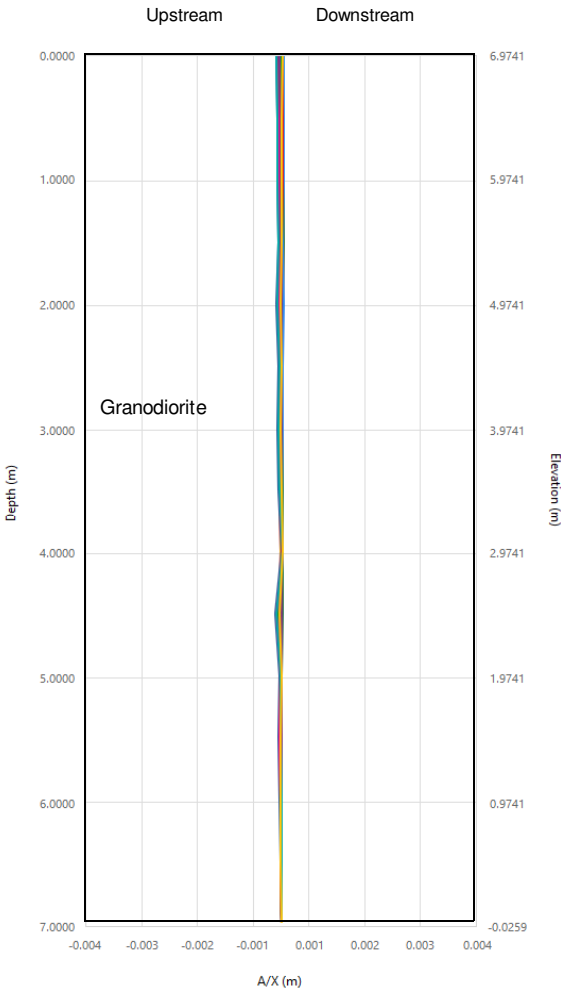
Inclinometer I10-08

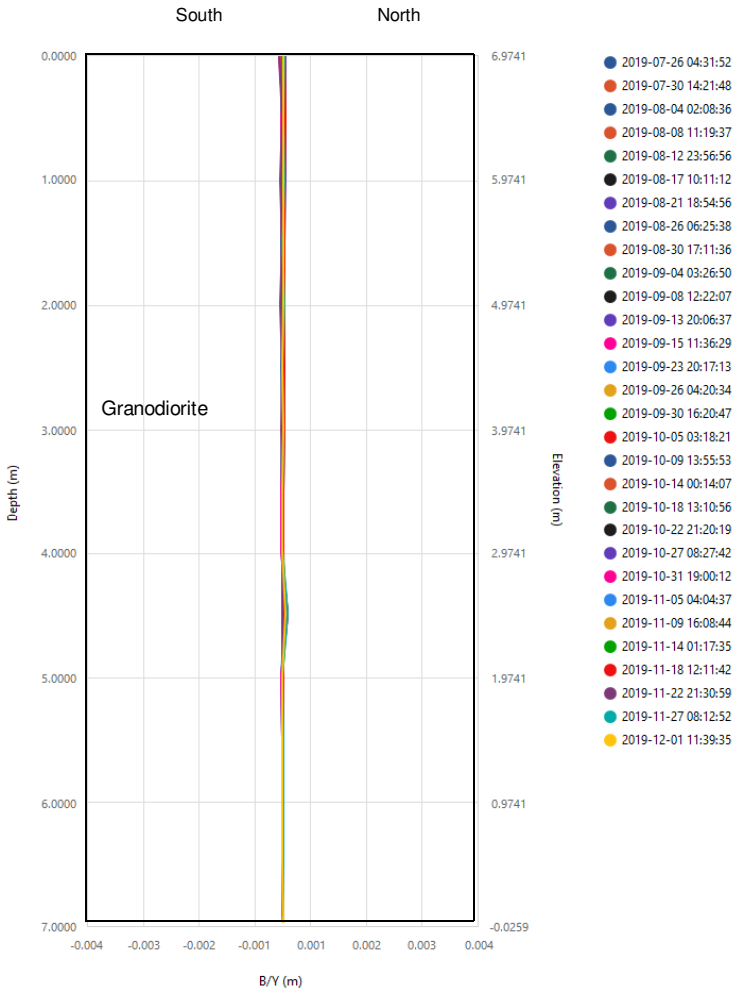
Time Displacement Plot – Drainage Blanket



SAAV I10-08

Incremental Plot

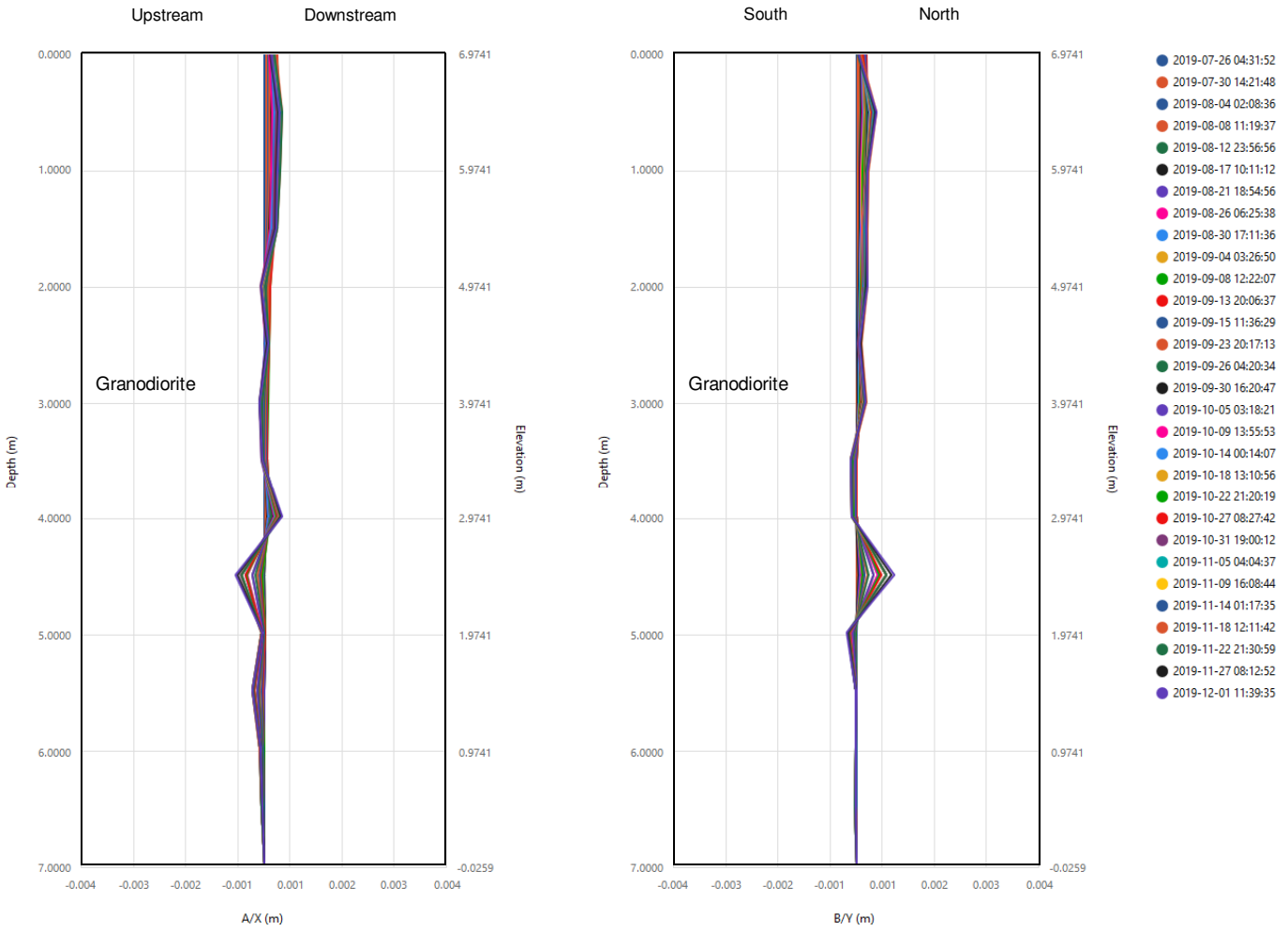




Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-08	Granodiorite	1202.5	1196.5	1	7

SAAV I10-08

Cumulative Plot



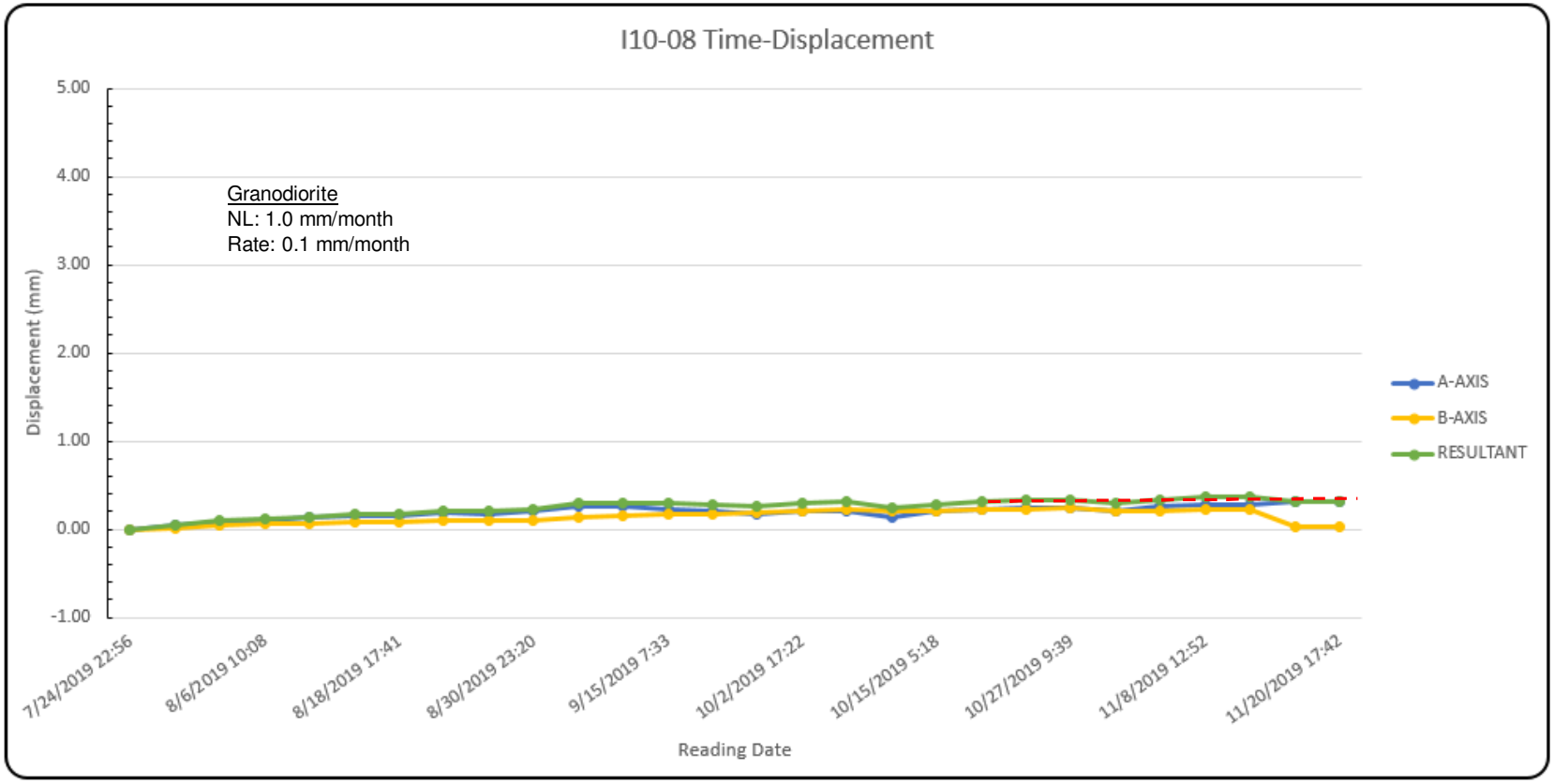
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
10-08	Granodiorite	1202.5	1196.5	1	7

SAAV 10-08

Displacement Plot

Unit	Upper Depth	Lower Depth
Granodiorite	1	7

Upper Depth	1.0 m
Lower Depth	7.0 m



APPENDIX V-D

L-L Dam Seepage Flow Data Plots

38000N
37500N
37000N
36500N
36000N
35500N
35000N
21500E
21000E
20500E
20000E
19500E
BORROW AREA 11
RECLAIM BARGE 1 & 2
CYCLONE HOUSE
SOUTH MUSTER POINT
0+800
1+000
1+200
1+400
1+600
1+800
2+000
2+200
2+400
2+600
2+800
3+000
3+200
3+400
3+600
NORTH DAM
SOUTH BUTTRESS BERM
LL-JB-FS-01
TW STOCKPILE A
VALLEY BUTTRESS BERM
VALLEY BUTTRESS BERM EXTENSION
SLIMES POND 1 (TO BE DECOMMISSIONED)
LL--FS-03
SLIMES POND 3 (UNDER CONSTRUCTION)
BORROW AREA 10
BORROW AREA 10 WASTE FILL DISPOSAL AREA
TW STOCKPILE B
HVC LUNCH ROOM PIPEYARD FACILITY
NORTH BUTTRESS BERM
KCB3
LL--FS-02
LL--FS-04
WEATHER STATION
TESTING LABORATORY
LL--FS-01
SEEPAGE POND 2
SLIMES POND 2
POWER SUB-STATION
CONTRACTOR YARD AND OFFICES
APPROXIMATE LOCATION
RECLAIM PUMPHOUSE
SEEPAGE WATER RECLAIM POND
BORROW AREA 3
SLIMES POND 4 (DECOMMISSIONED)
BORROW AREA 3 WASTE FILL DISPOSAL AREA
BORROW AREA 7B
BORROW AREA 7B WASTE FILL DISPOSAL AREA

SCALE A 0 250 m

LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- L-L DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- SEEPAGE FLOW MONITORING WEIR

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM PHOTOSAT SURVEY IMAGERY DATED 2019-09-30 (L-L DAM) AND 2016-09-25 & 28 (OUTSIDE OF 2019 SURVEY EXTENT).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. PUKAIST CREEK WEIR IS NOT SHOWN AND IS LOCATED AT E 17448 N 34452.

THVCP WEIR NAME	KCB WEIR NAME
LL--FS-01	FINGER DRAIN #1
LL--FS-02	UVD/LVD
LL--FS-03	POINT B
LL--FS-04	SEEPAGE POND 2
KCB3	POINT A
LL-JB-FS-01	POINT D

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

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

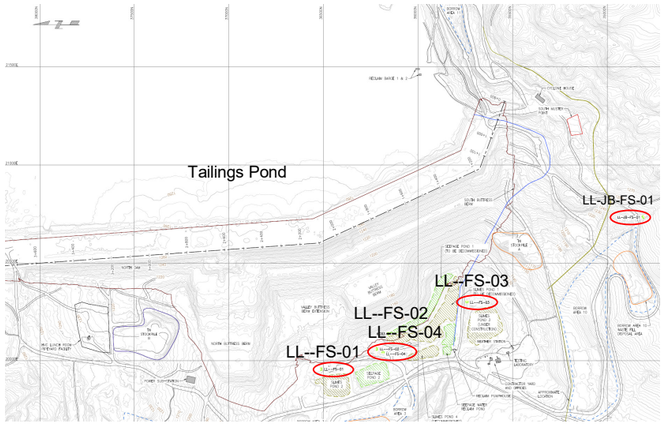
PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: L-L DAM
SEEPAGE FLOW MONITORING STATIONS

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M02341B53	V-D-I

KCB-FIG-D-L

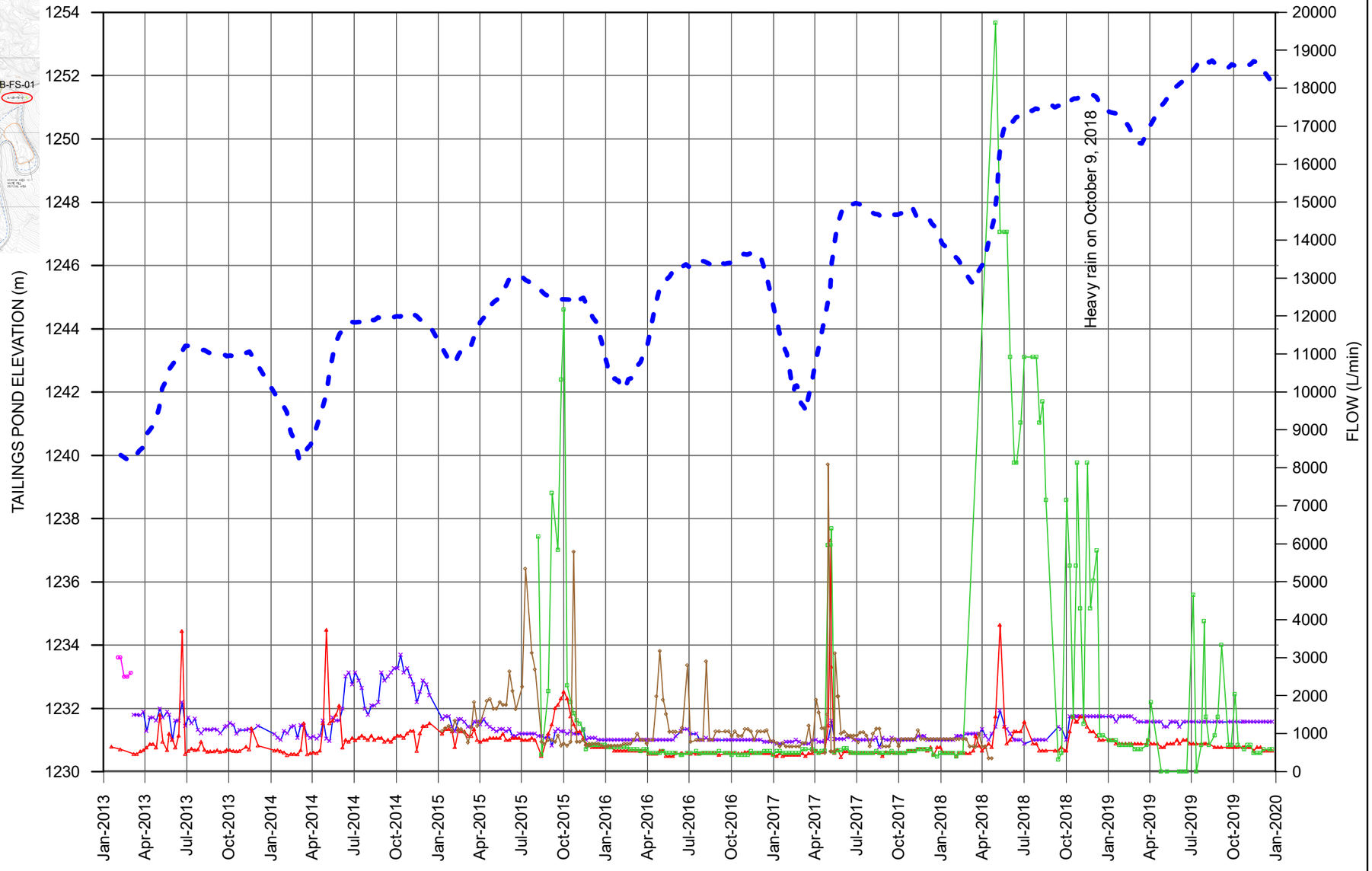
SAVE DATE: 2019-12-16 (2:46 PM)
FILE PATH: \\INT.KLOHN.COM\PROJDATA\MV\VCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\400 DRAWINGS\CAD\05-FIGURES\2019 DSI\SEEPAGE-FLOW-MONITORING.DWG (THAWKER)



LEGEND

- LL--FS-01
- LL--FS-02
- LL--FS-04
- LL--FS-02 plus LL--FS-01 Combined Flows (2012 to Mar-2013)
- Seepage from VBB Toe (LL--FS-03 minus LL-JB-FS-01)
- Tailings Pond

KCB Weir Name	THVCP Weir Name
Finger Drain #1	LL--FS-01
UVD/LVD	LL--FS-02
Point B	LL--FS-03
Seepage Pond 2 Weir	LL--FS-04
Point D	LL-JB-FS-01
Pukaist Weir	OS-PC-FS-02



Notes:

- In 2016, OS-PC-FS-02 was measured using a datalogger. One manual reading of the weir by THVCP suggested that the datalogger was reading lower than actual flow rates.
- As of June 2018, the seepage pond was backfilled and the seepage weir at LL--FS-03 was decommissioned.
- Higher flows measured at LL-FS-04, between April 2018 and December 2018, were due to heavy dewatering and hydraulic sand inflow.
- Valve of LL-FS-04 was reported closed from April 26, 2019 to May 31, 2019 to aid in dredging.
- Runoff was observed on March 29, 2019 at LL-FS-01.

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

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY 2019 DAM SAFETY SUPPORT

TITLE: L-L DAM POND LEVEL AND SEEPAGE FLOW 2013-2019

PROJECT No.: M02341B53

FIG No.: V-D-2

Date: January 31, 2020
Z:\MVCR\M02341B53 - HVC-2019 Dam Safety Support\300 Design\360 Seepage Data\Highland\Seepage (2019 DSI Only).grf

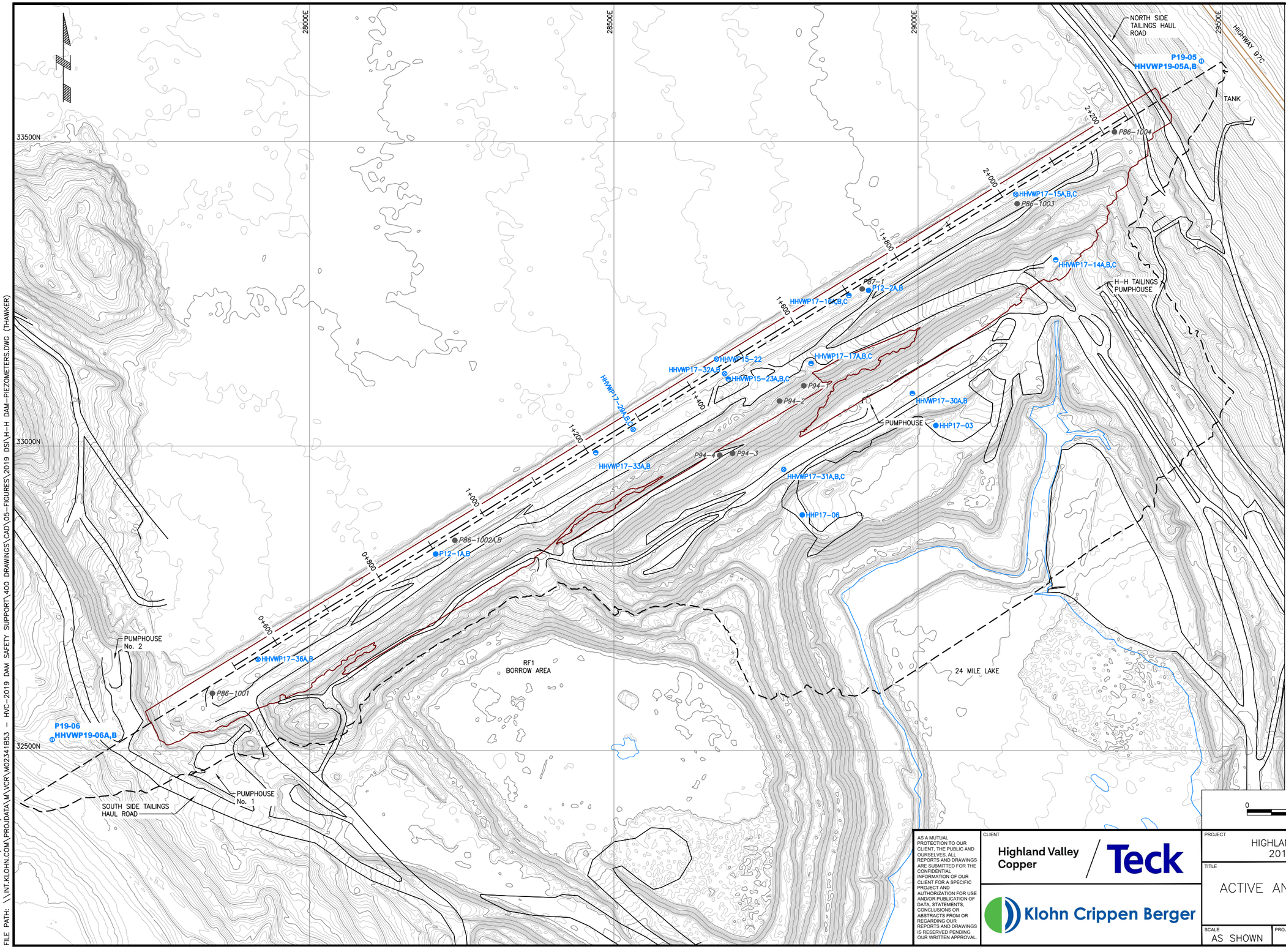
APPENDIX VI

H-H Dam Instrumentation Summary

APPENDIX VI-A

H-H Dam Piezometer Plots

H-H DAM PIEZOMETER LOCATION MAP



LEGEND:

- ULTIMATE DAM FOOTPRINT
- TAILINGS PIPELINE
- POWERLINE
- HAUL ROAD
- PUBLIC ROAD
- 2040 PFS DAM FOOTPRINT
- H-H DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER

DEFUNCT INSTRUMENTS (SEE NOTE 3):

- DEFUNCT STANDPIPE PIEZOMETER

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM PHOTOSAT SURVEY DATED 2019-09-30 (H-H DAM) AND 2017-09-15 & 24, AND 2016-09-25 & 29 (OUTSIDE OF 2019 SURVEY EXTENT).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.

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

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
ACTIVE AND DEFUNCT PIEZOMETERS
LOCATION PLAN

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M02341B53	

KCB-FIG-D-L

SAVE DATE: 2019-12-16 (3:01 PM)
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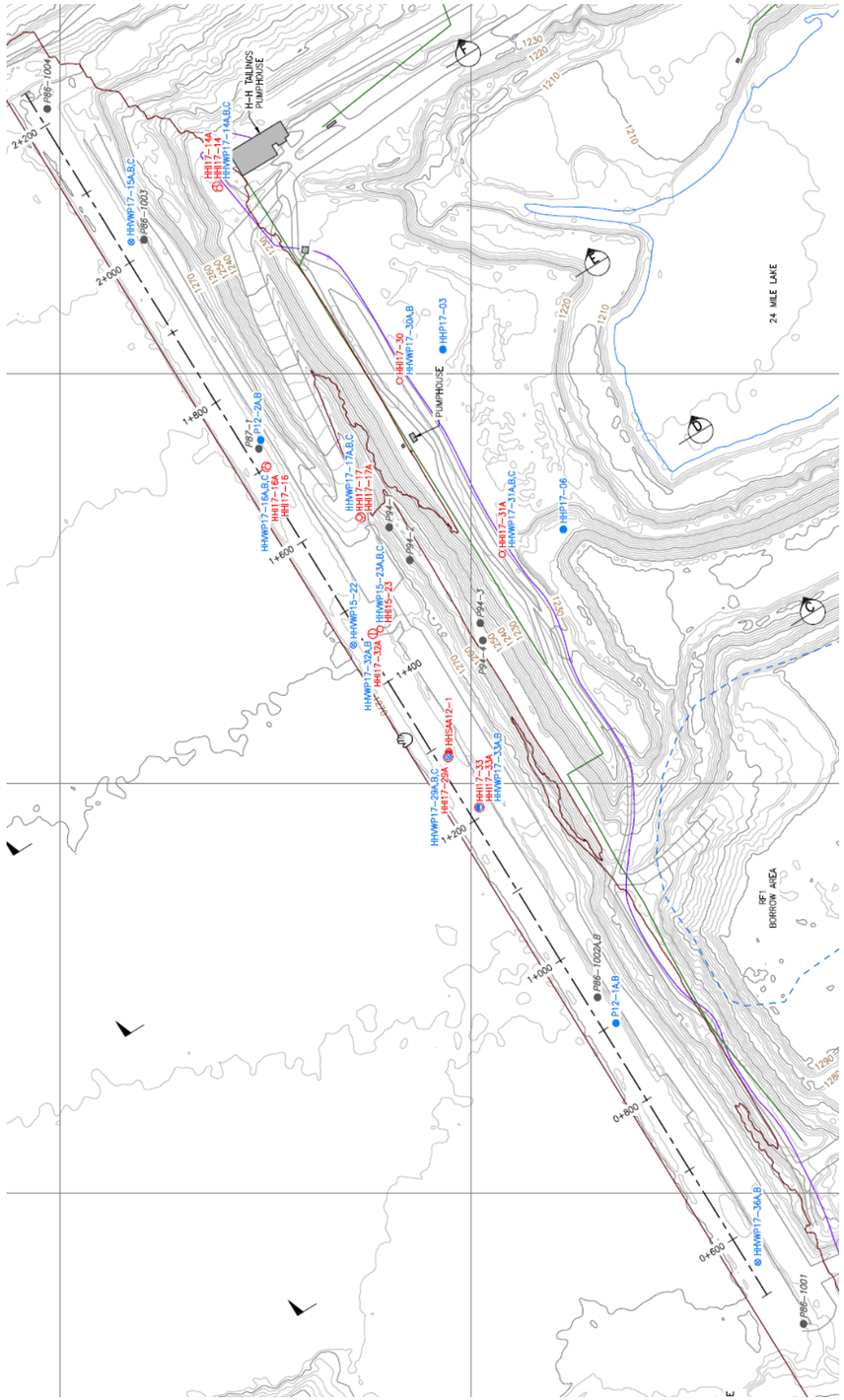
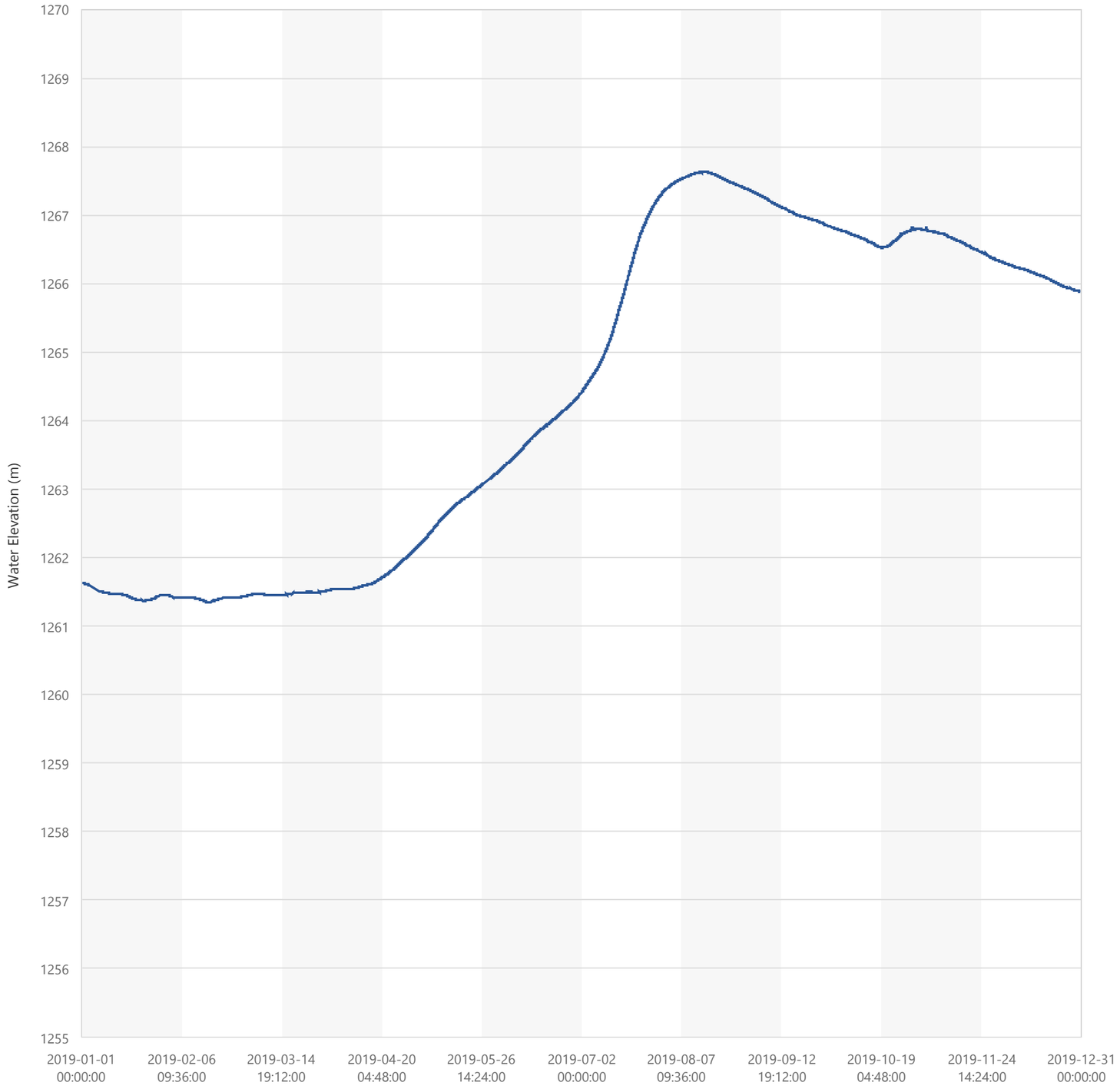
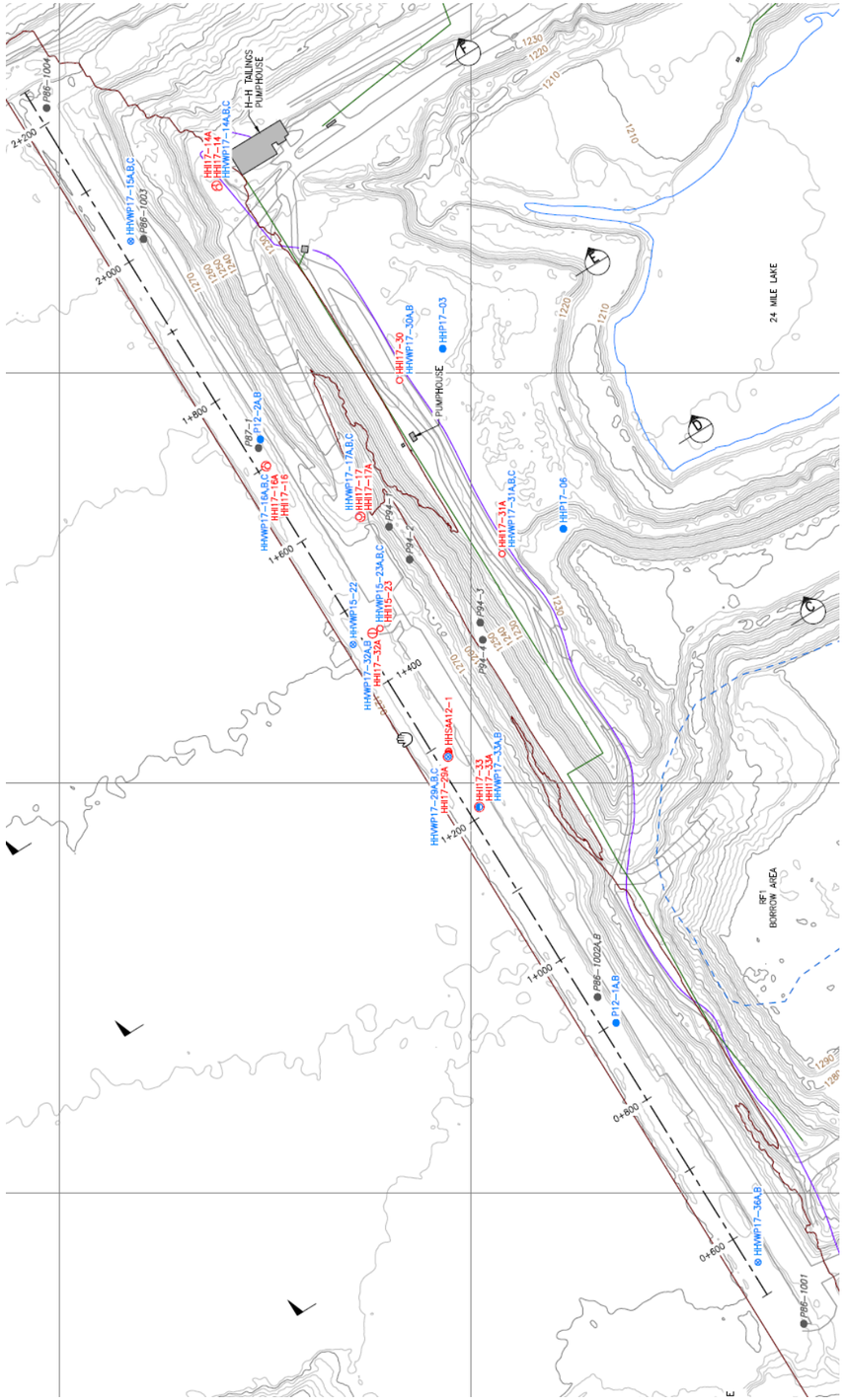
APPENDIX VI-A-1

H-H DAM PIEZOMETERS: 2019 WATER ELEVATIONS

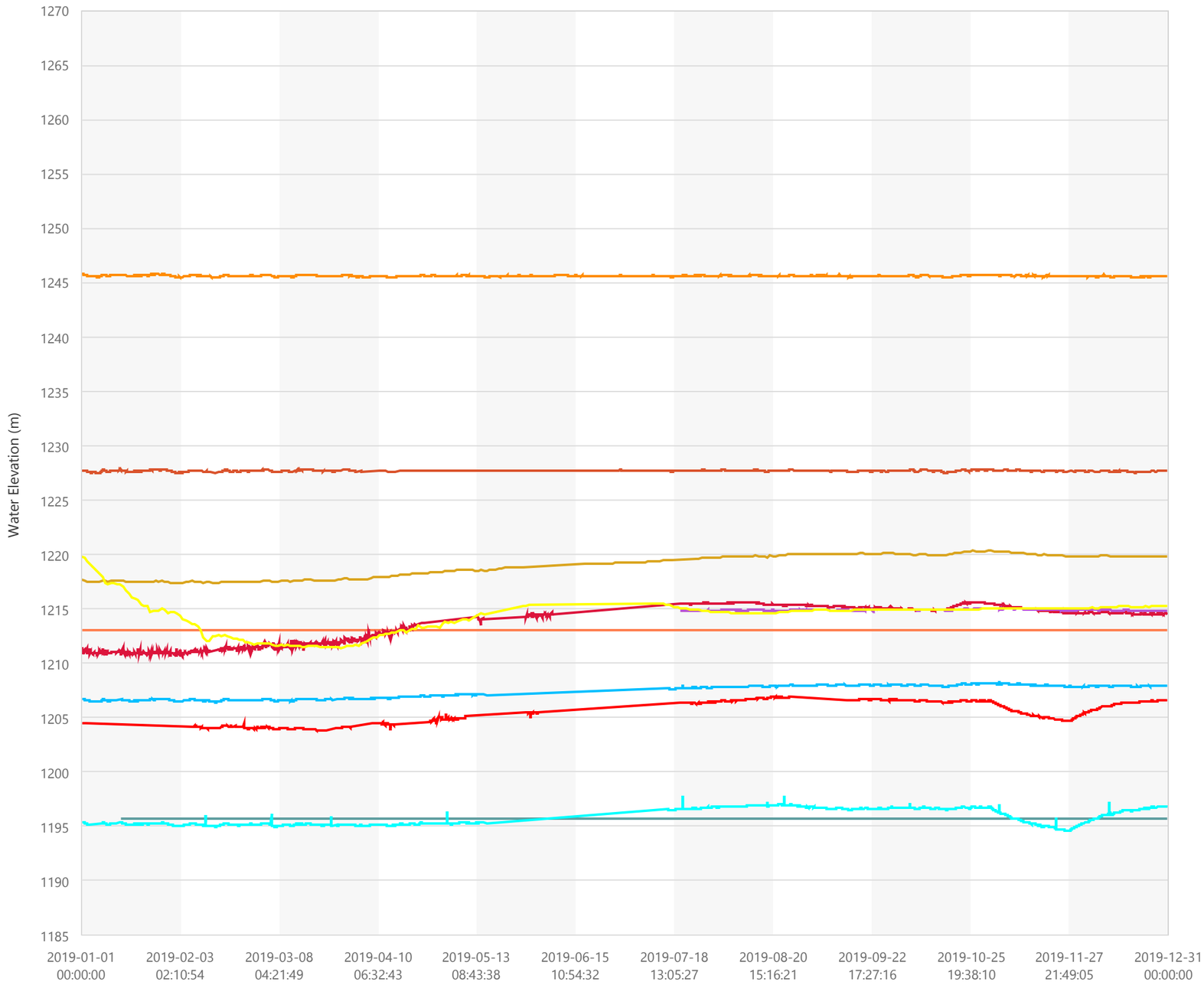


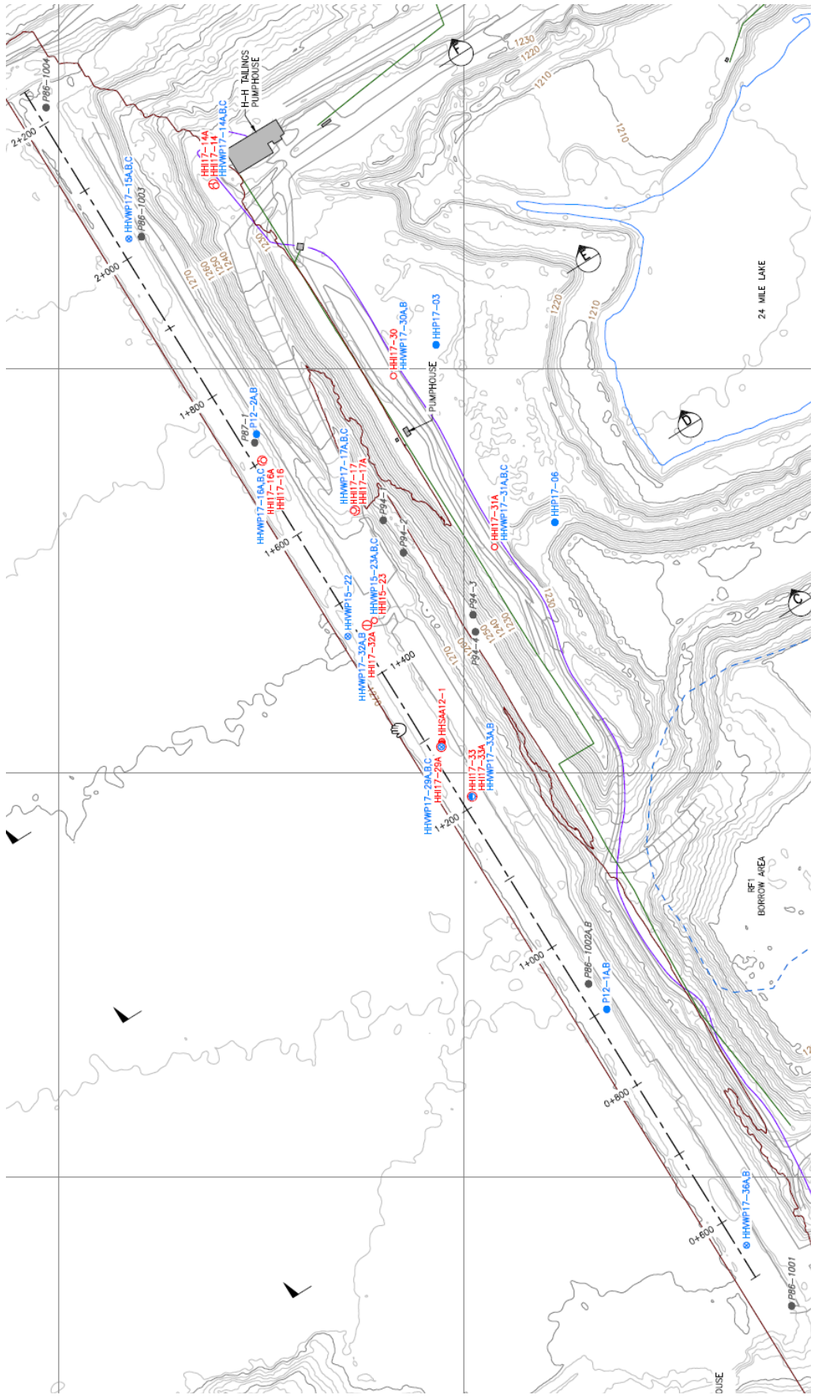
HH - Upstream of Core



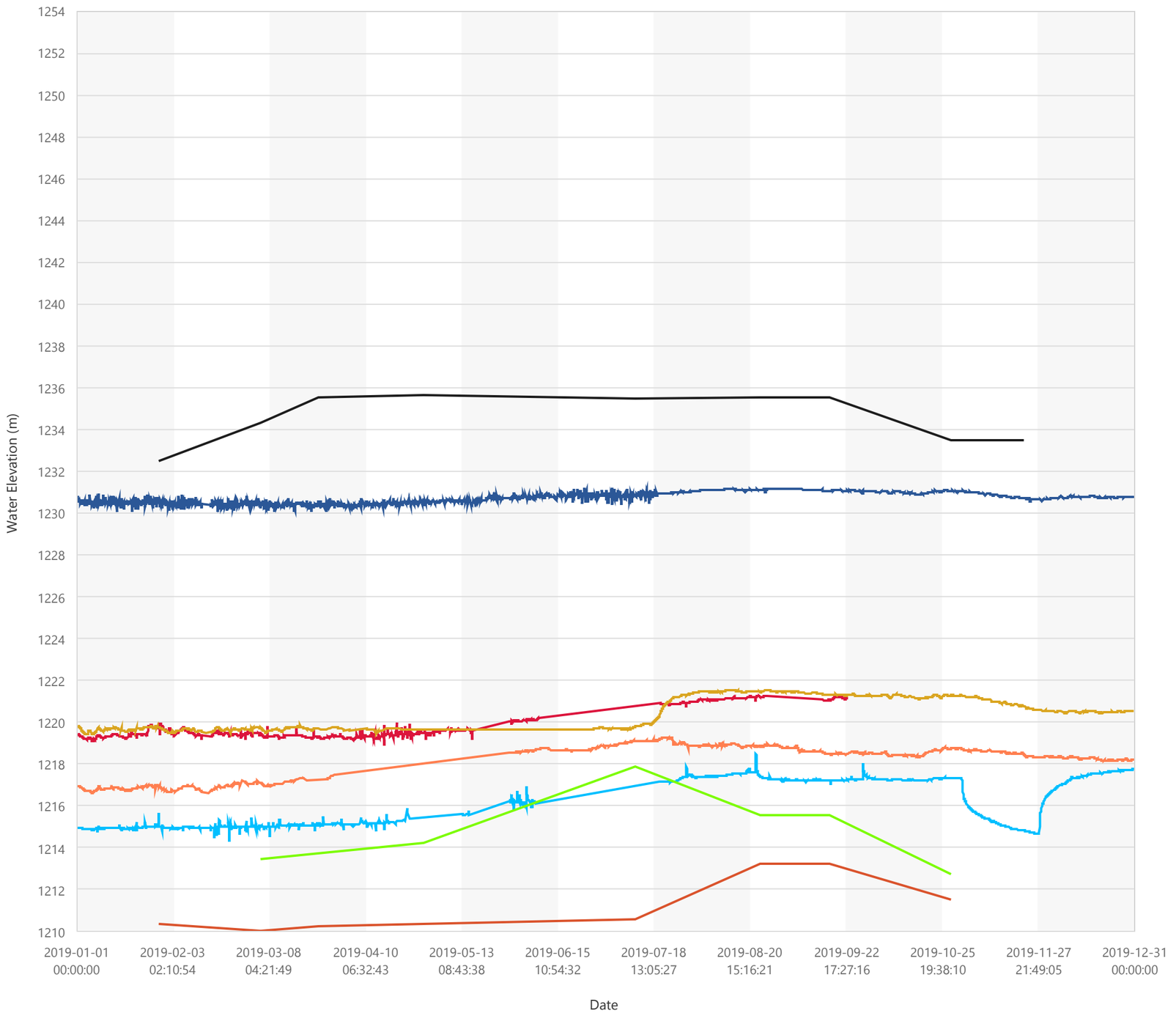


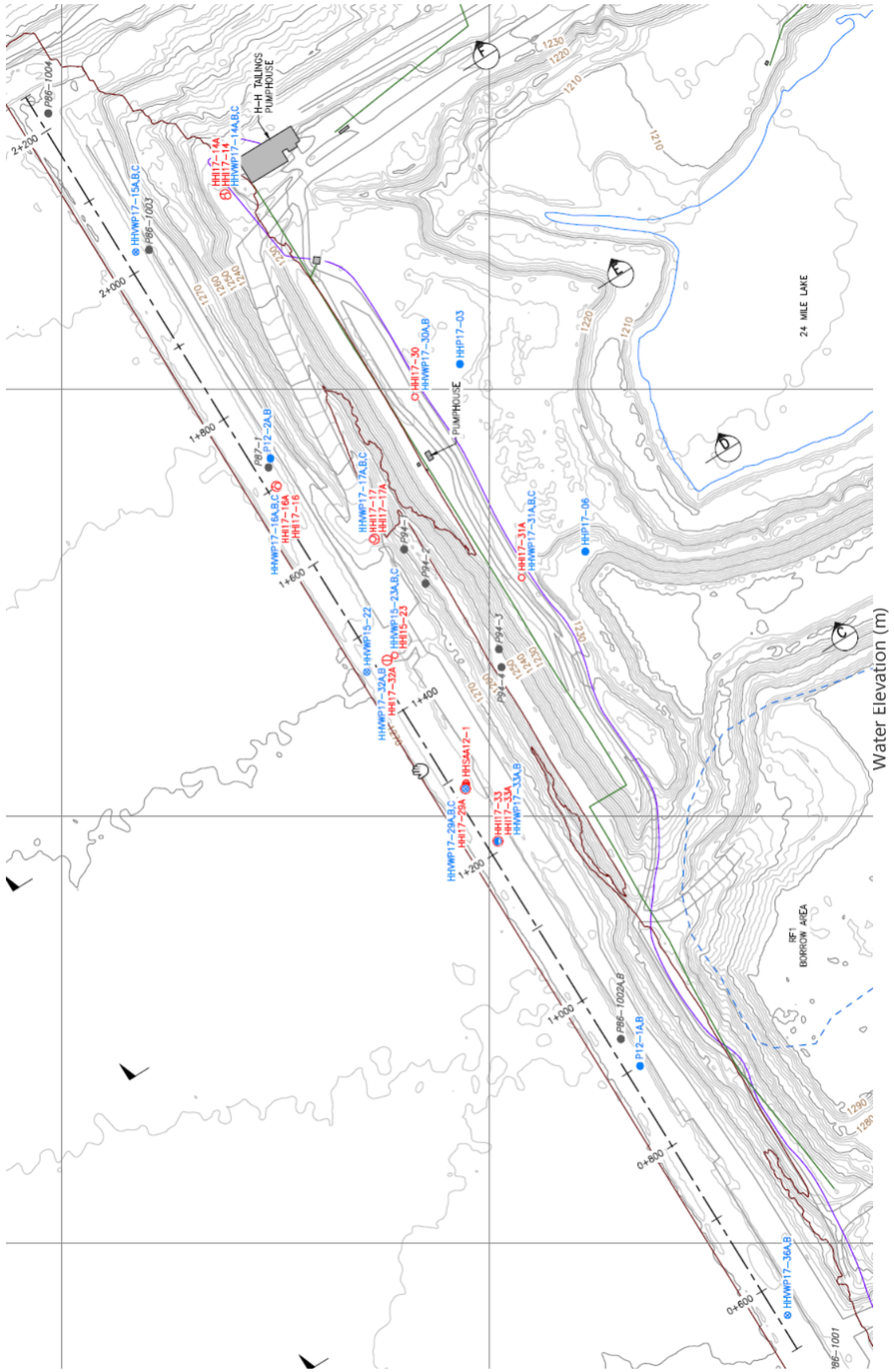
HH - Dam Fill, Sand and Gravel



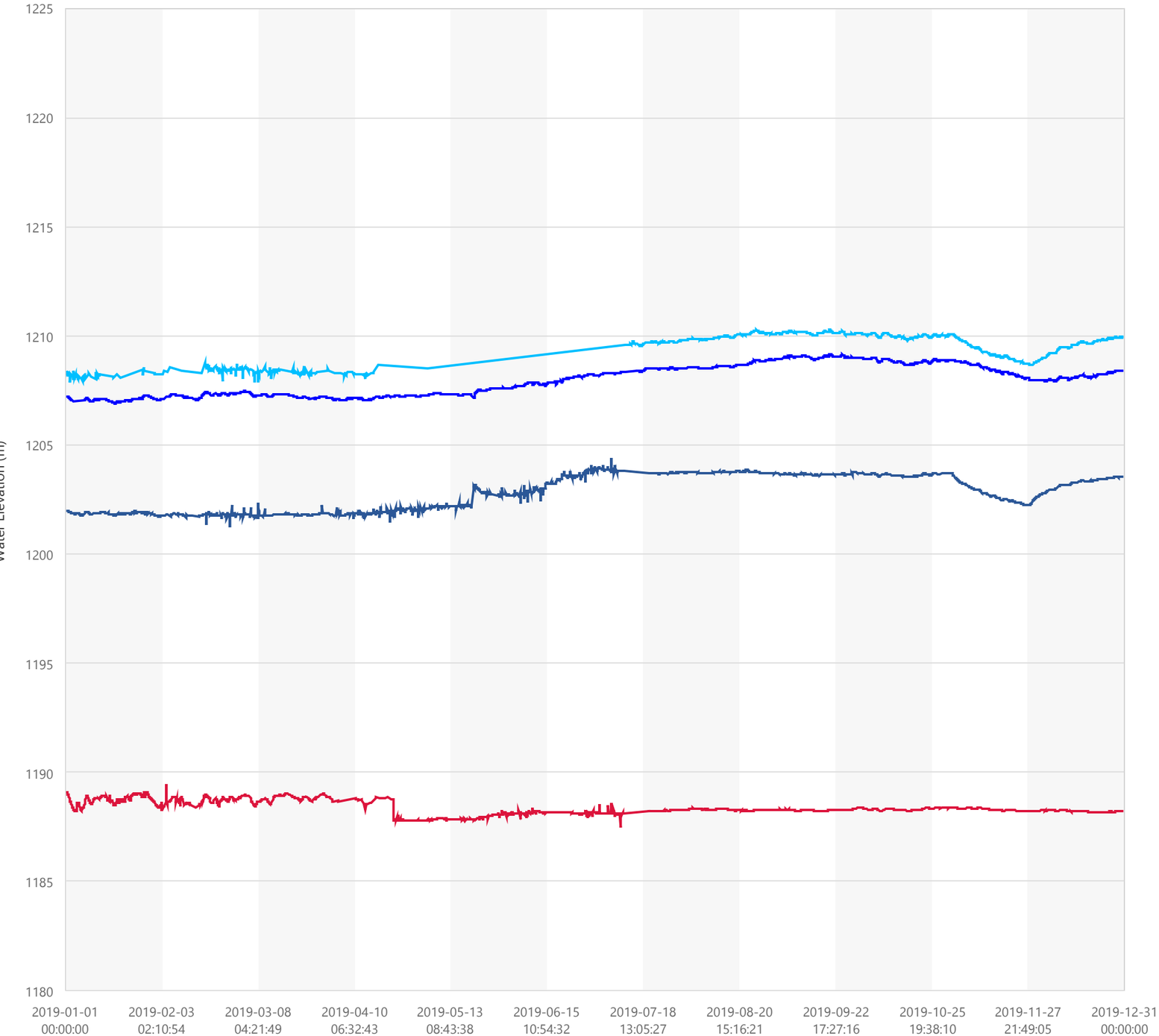


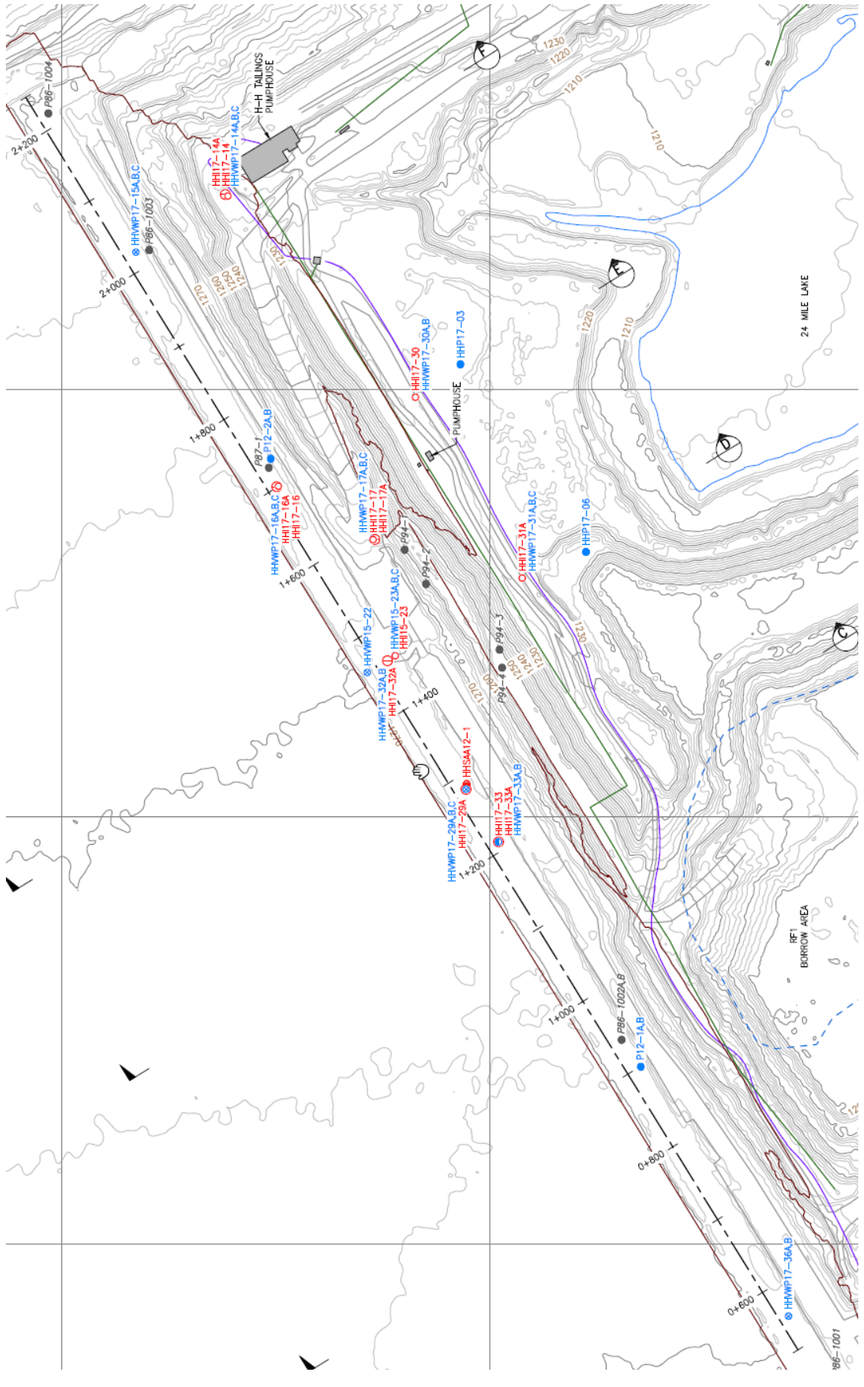
HH - Glacial Till and Clay, Silt



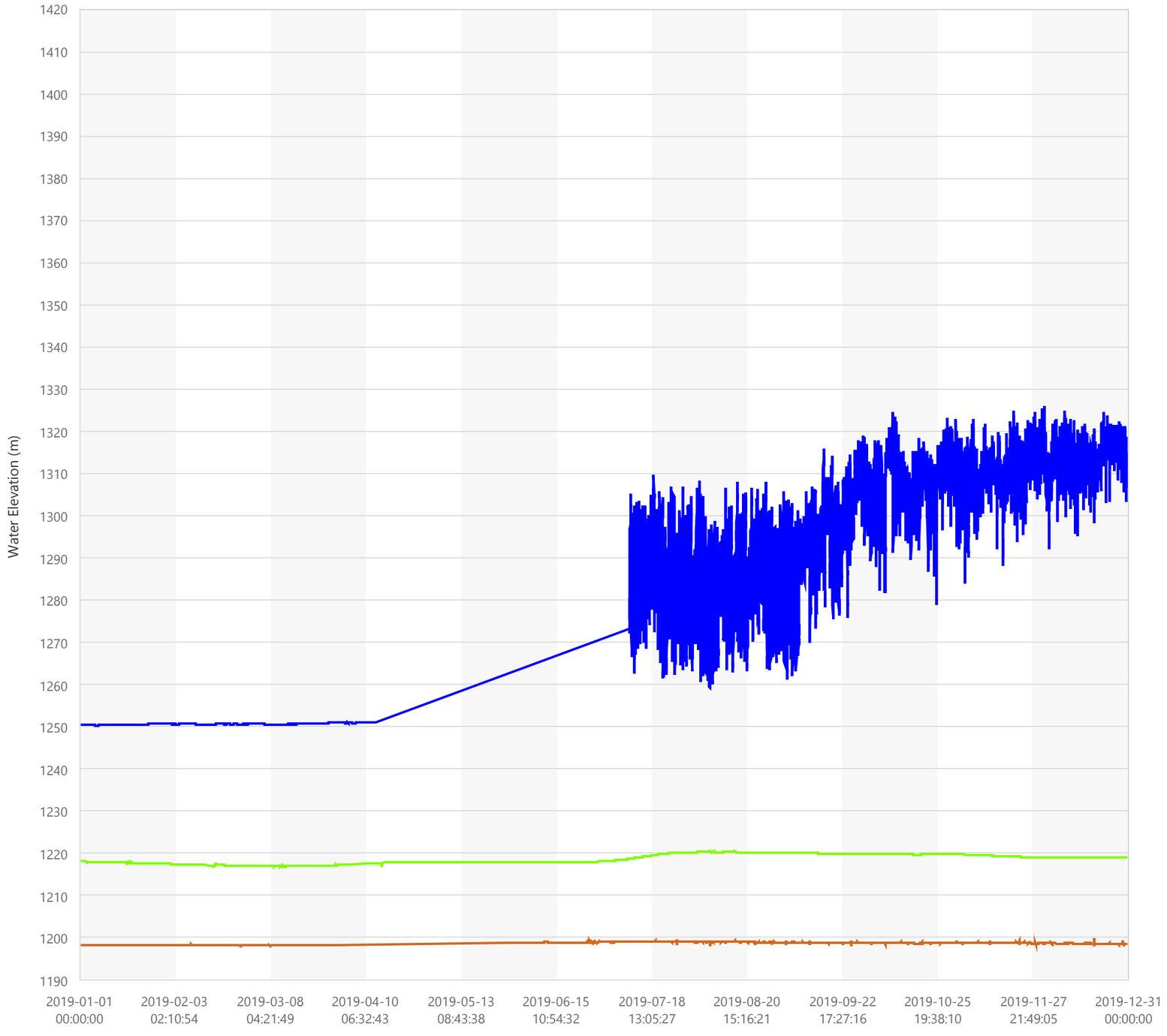


HH - Glaciolacustrine



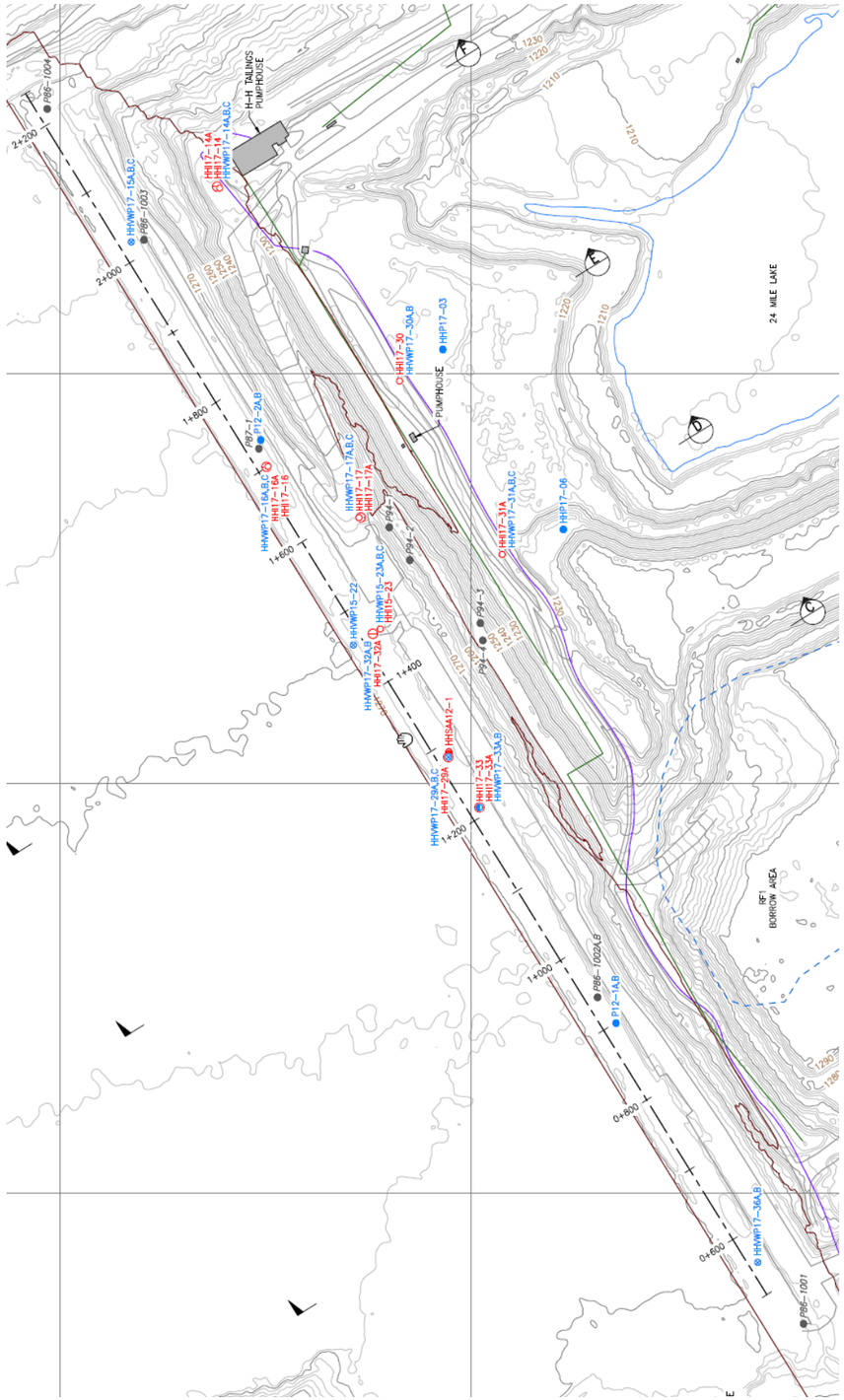


HH - Foundation Rock

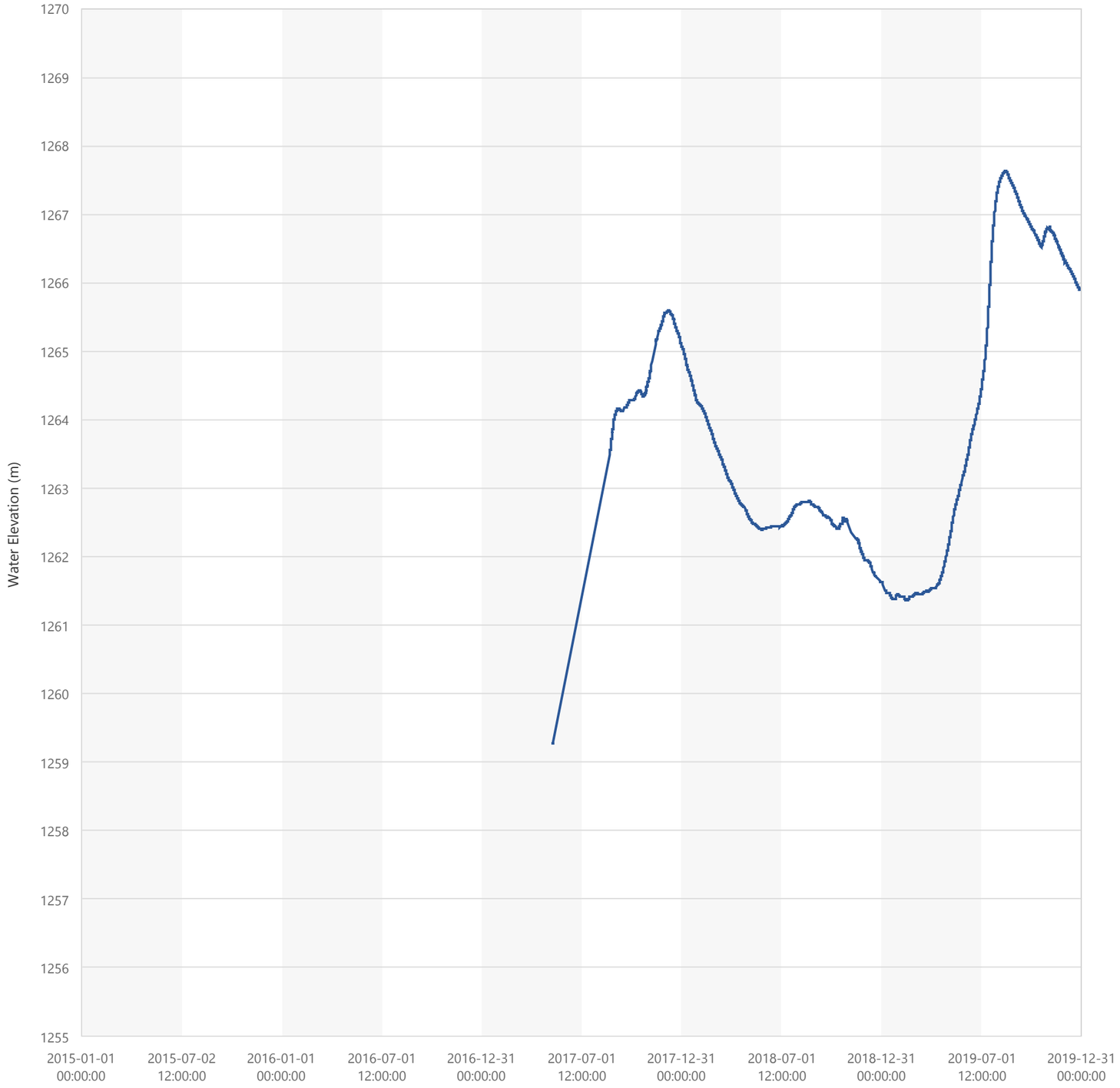


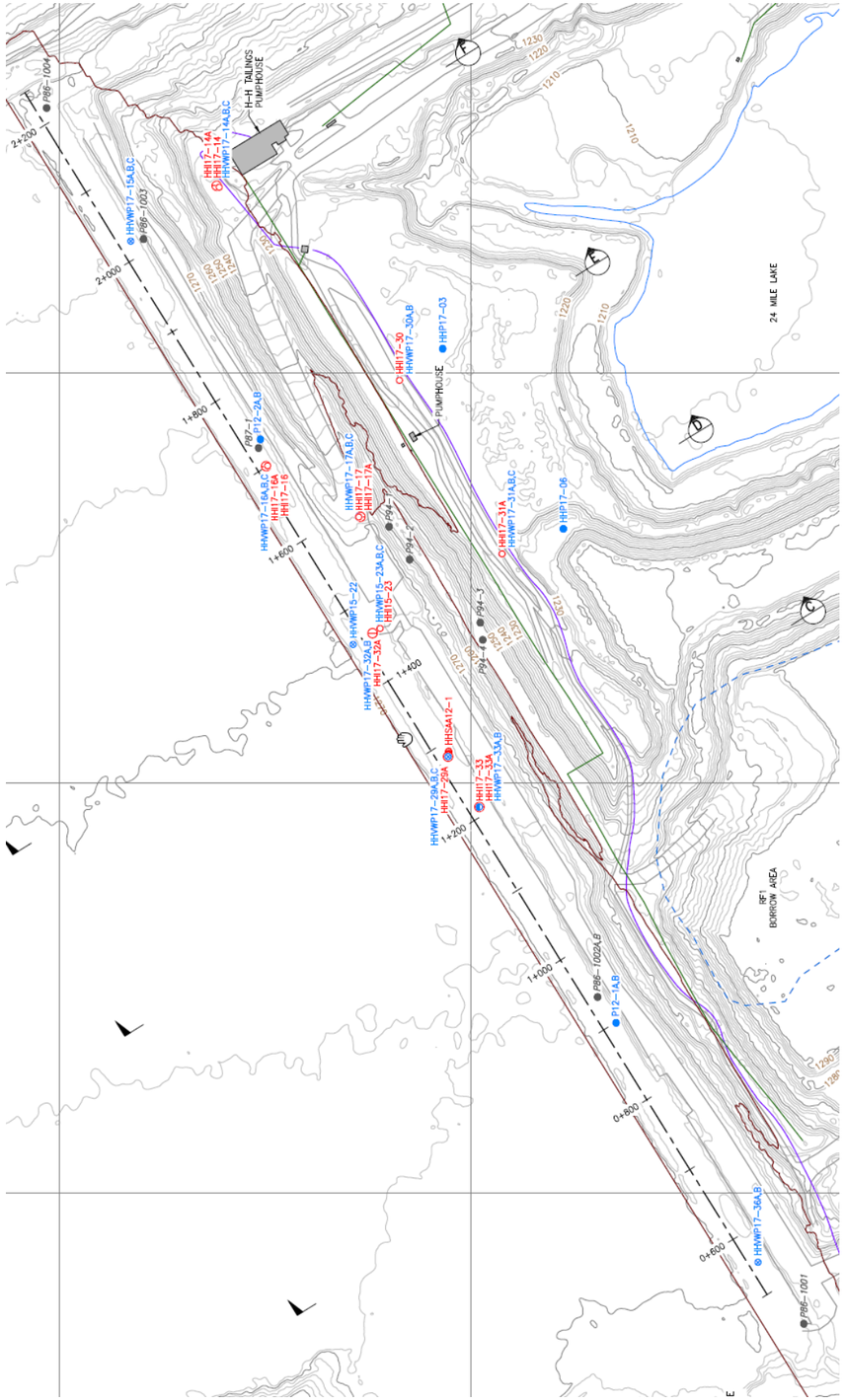
APPENDIX VI-A-2

H-H DAM PIEZOMETERS: WATER ELEVATIONS SINCE 2015

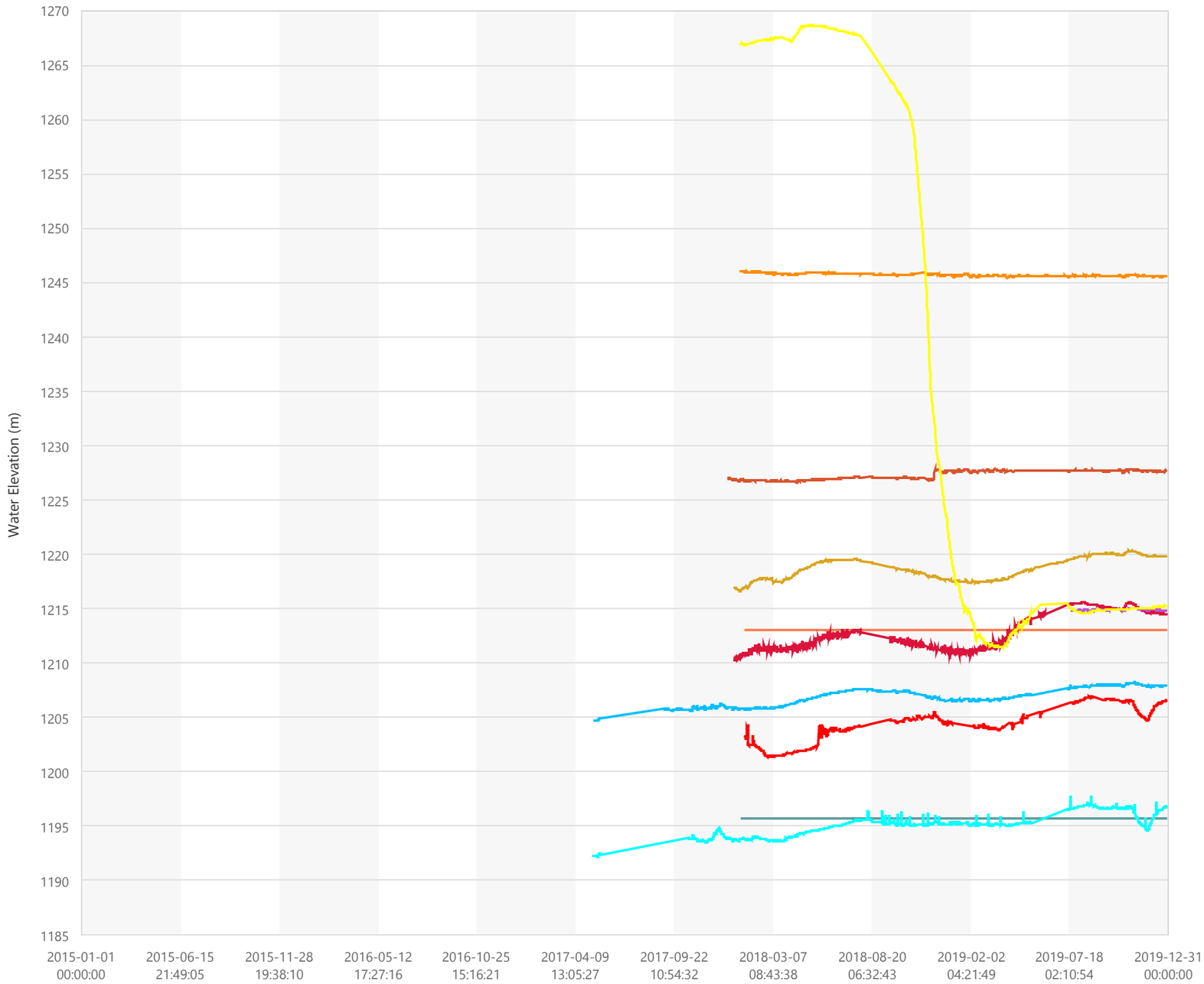


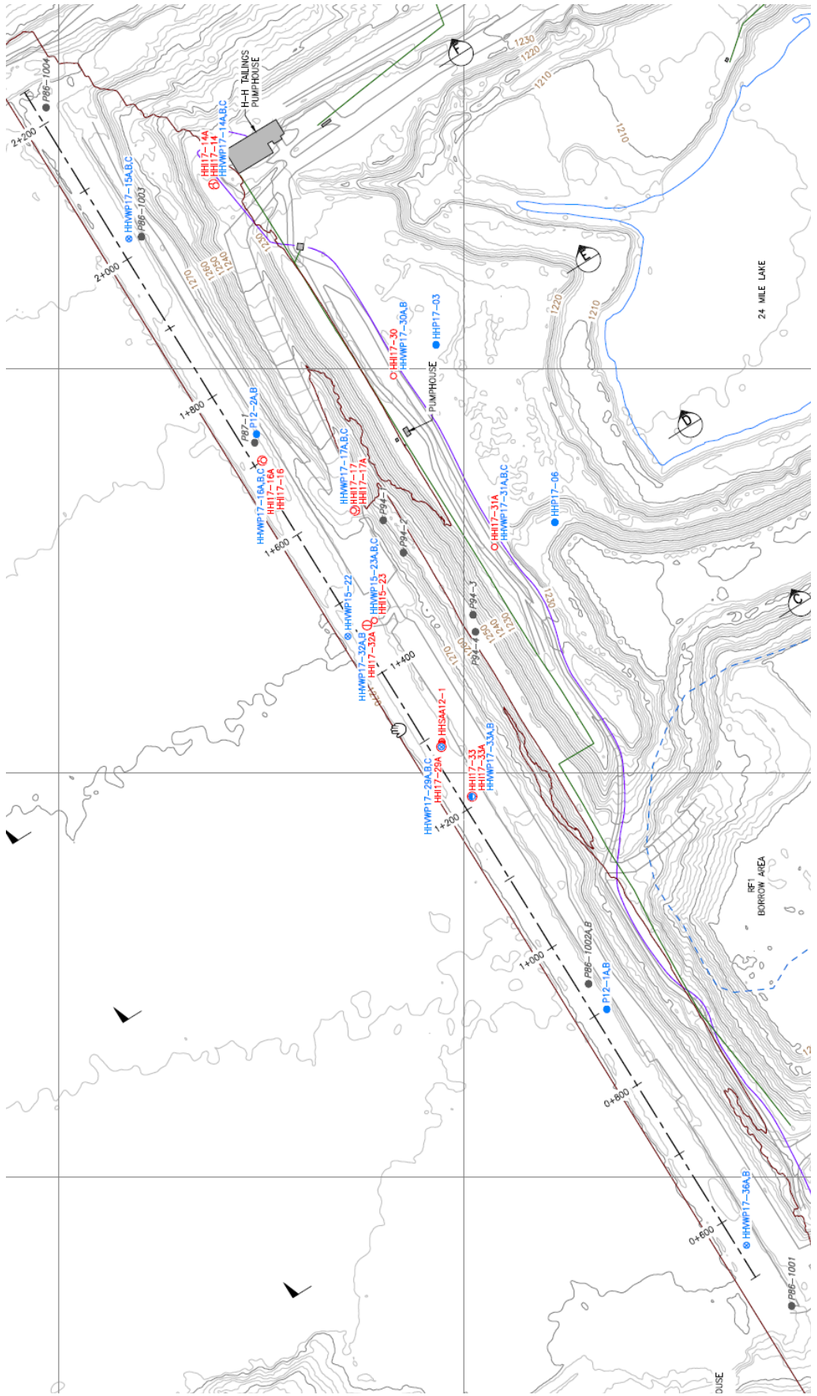
HH - Upstream of Core



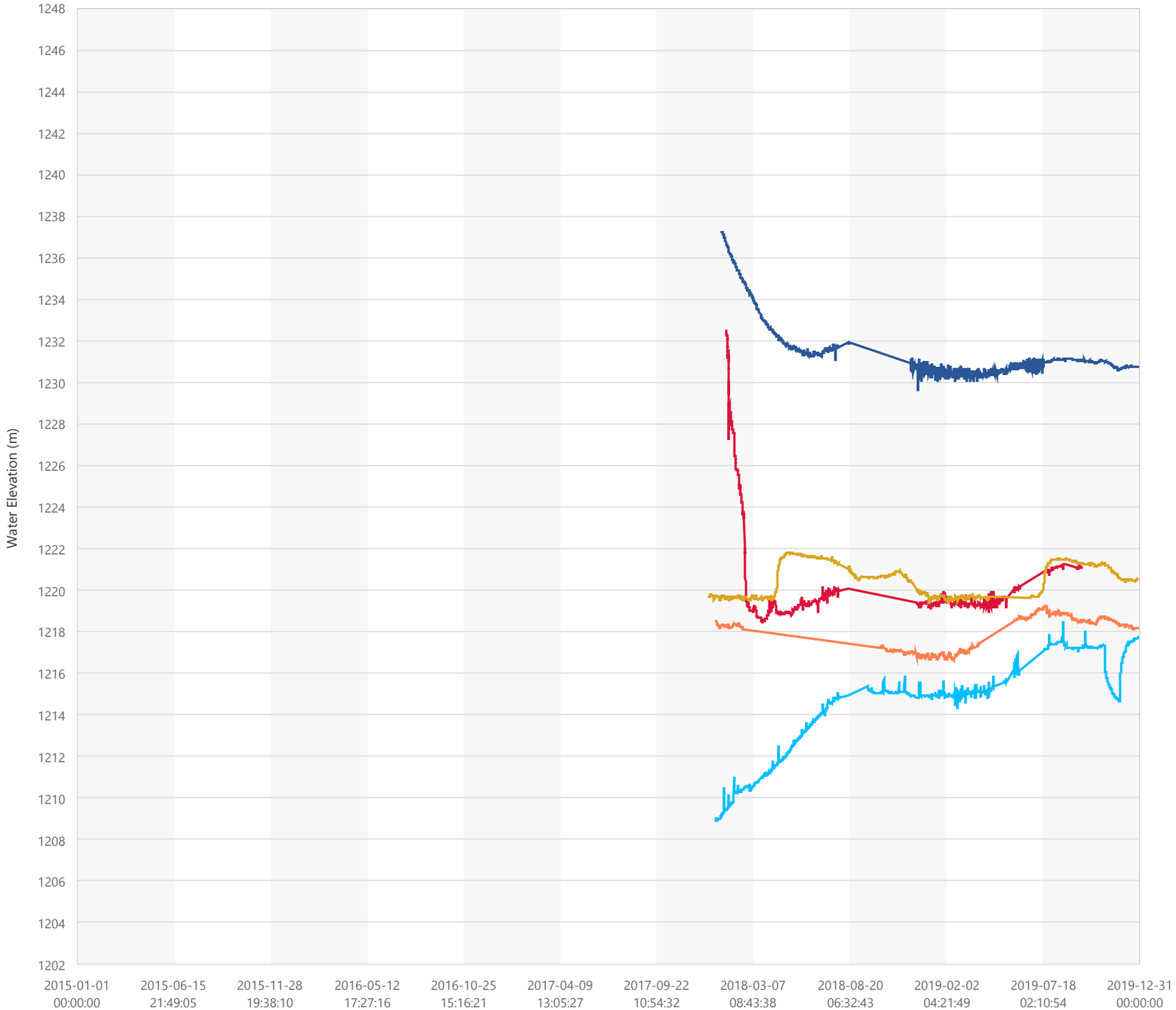


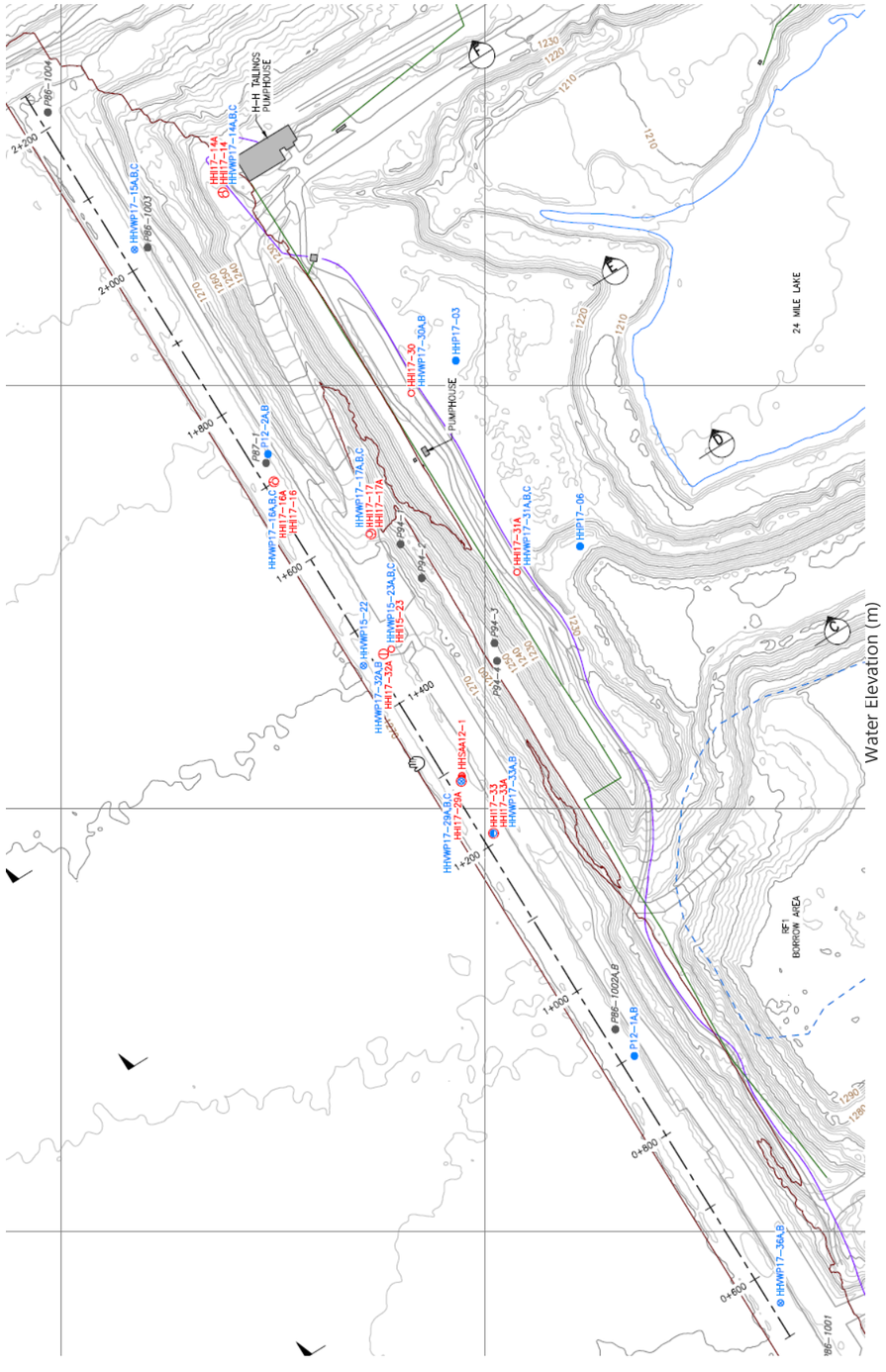
HH - Dam Fill, Sand and Gravel





HH - Glacial Till and Clay, Silt





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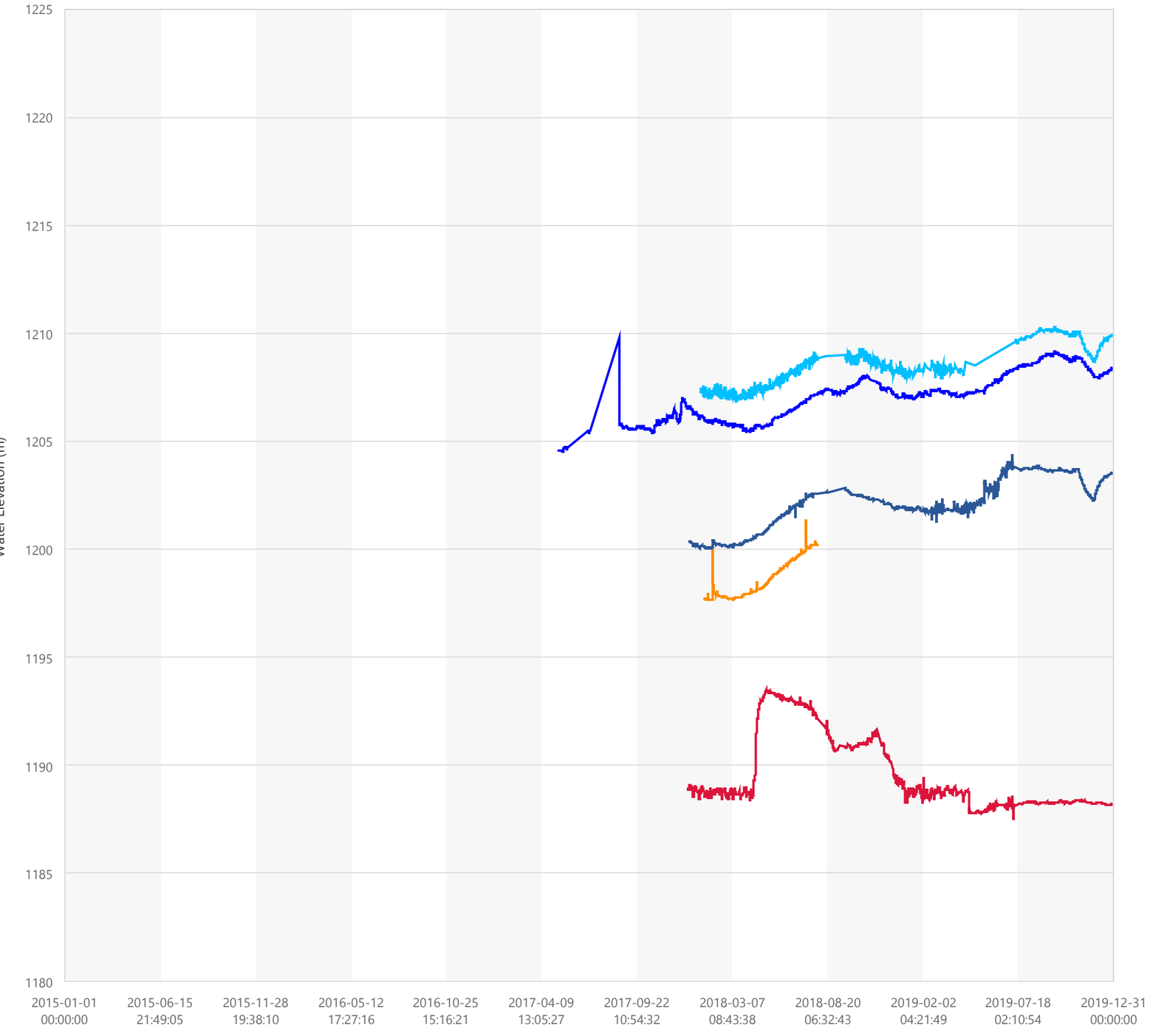
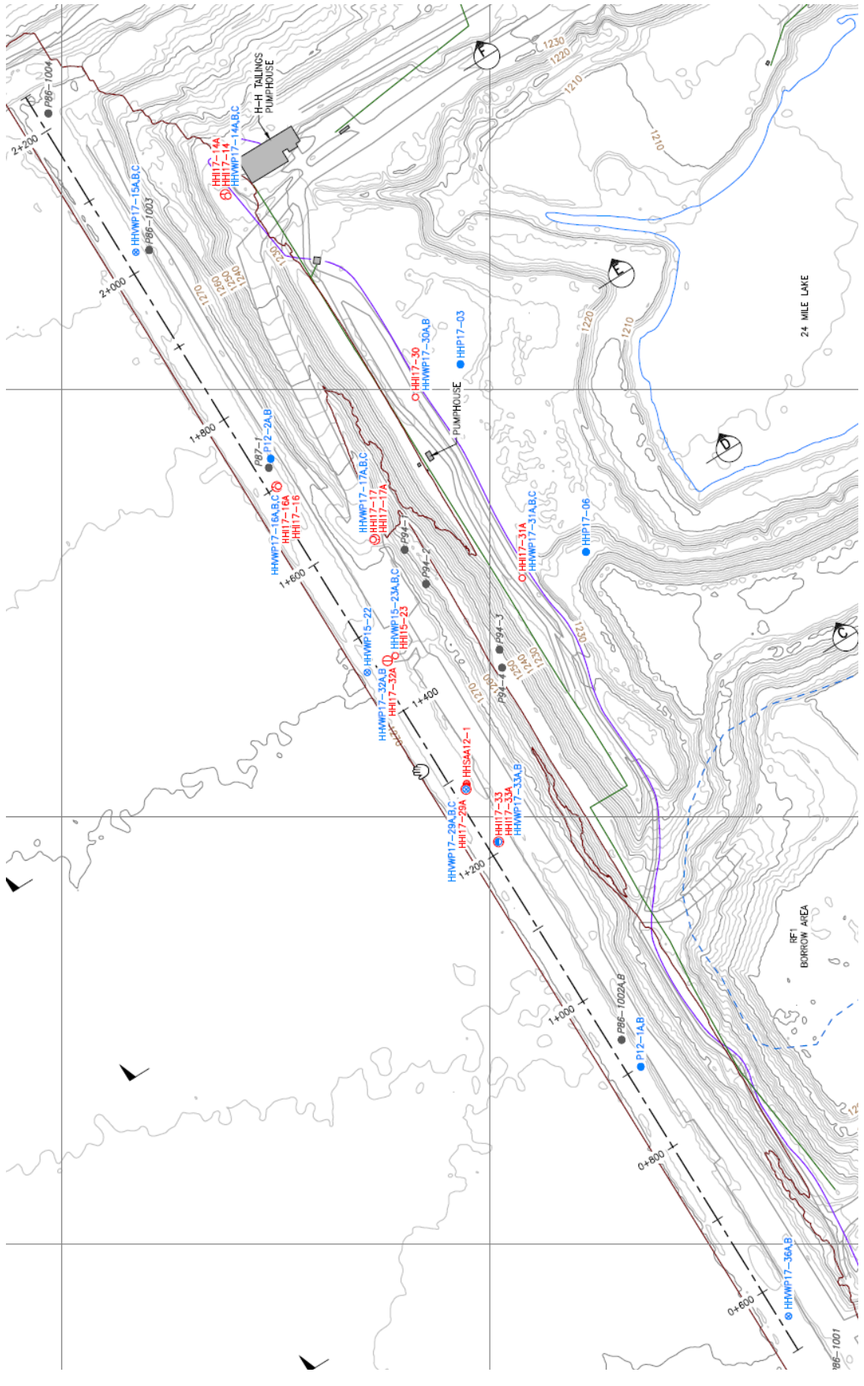
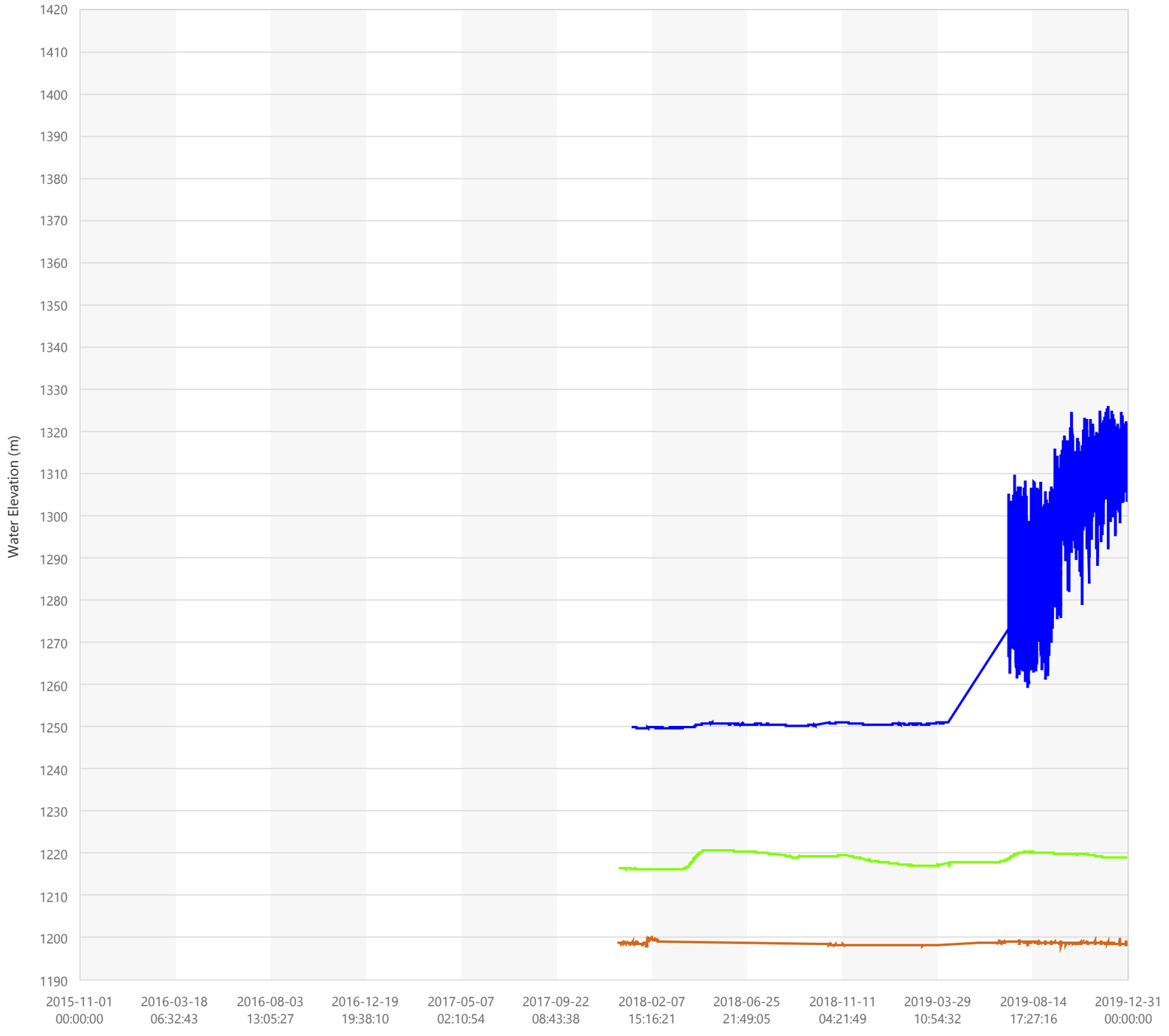




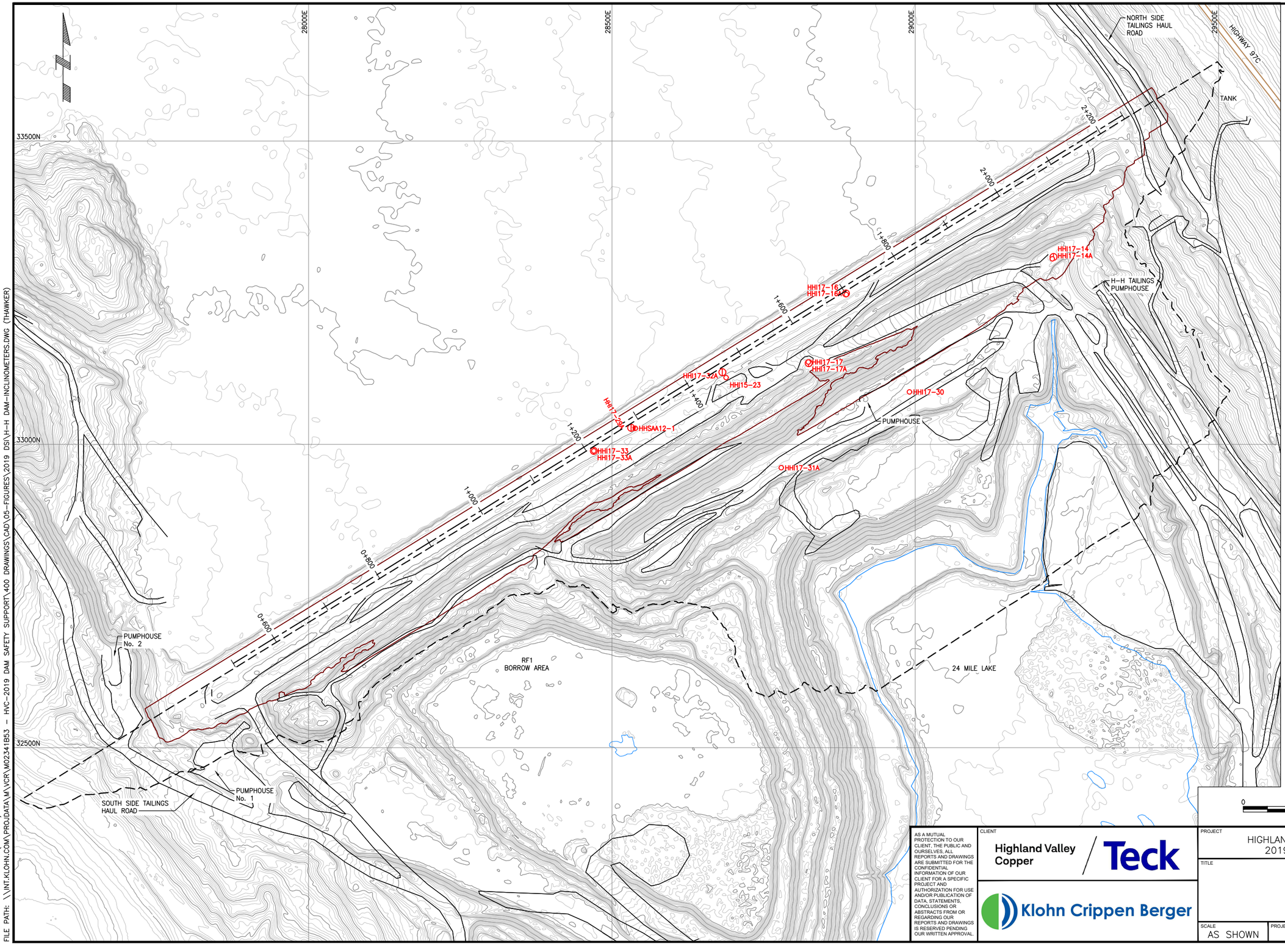
HH - Foundation Rock



APPENDIX VI-B

H-H Dam Inclinometer Plots

H-H DAM INCLINOMETER LOCATION PLAN



LEGEND:

- ULTIMATE DAM FOOTPRINT
- TAILINGS PIPELINE
- POWERLINE
- HAUL ROAD
- PUBLIC ROAD
- 2040 PFS DAM FOOTPRINT
- H-H DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDARD INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND IN-PLACE SAA INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND PAIRED SONDEX SETTLEMENT SYSTEM

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM PHOTOSAT SURVEY DATED 2019-09-30 (H-H DAM) AND 2017-09-15 & 24 AND 2016-09-25 & 29 (OUTSIDE OF 2019 SURVEY EXTENT).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.

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

CLIENT: Highland Valley Copper / Teck

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM
INCLINOMETERS
LOCATION PLAN

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M02341B53	

KCB-FIG-D-L

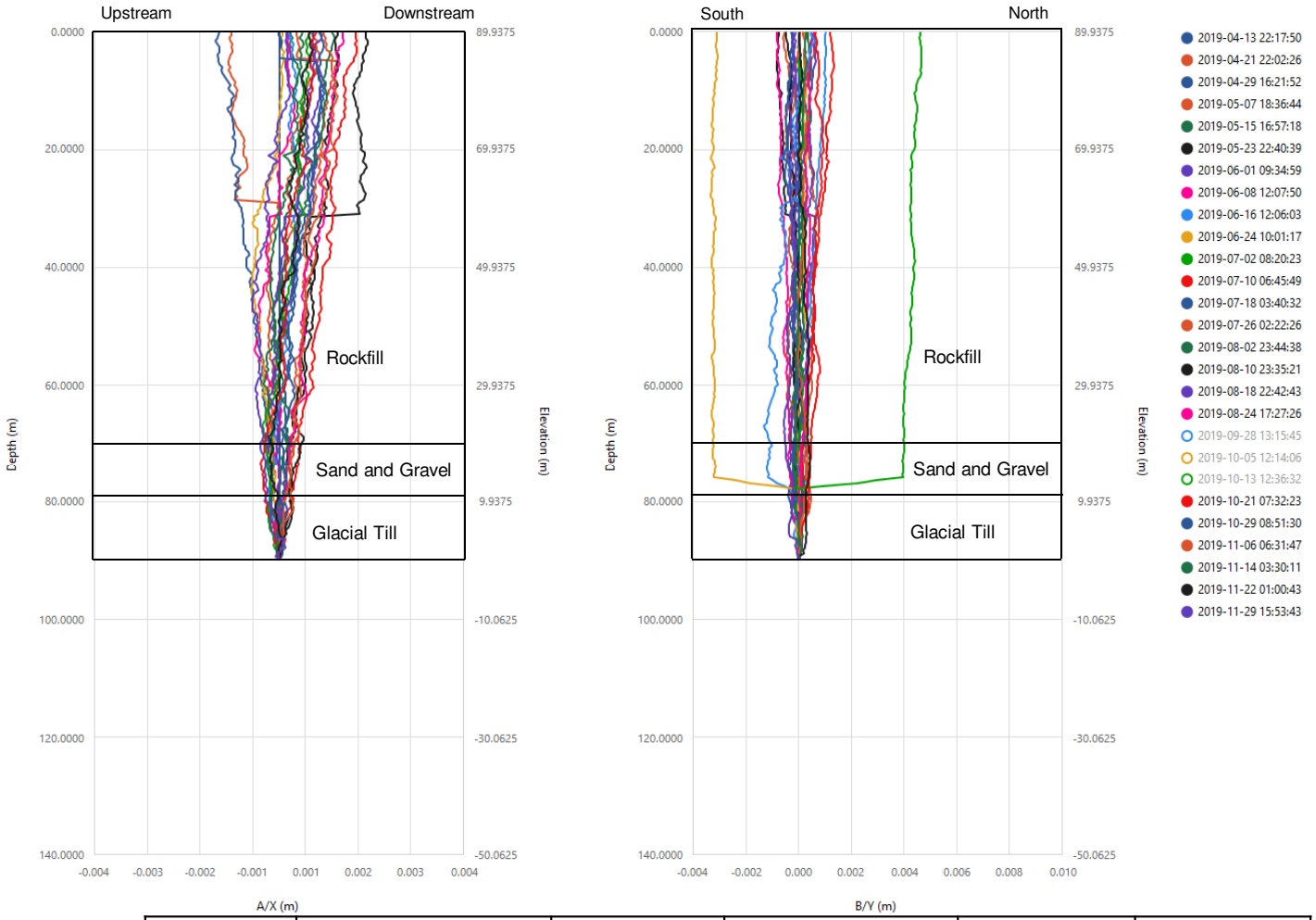
SAVE DATE: 2019-12-16 (3:02 PM)
FILE PATH: \\INT.KLOHN.COM\PROJDATA\MV\CR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\400 DRAWINGS\CAD\05-FIGURES\2019 DSI\H-H DAM-INCLINOMETERS.DWG (THAWKER)

H-H DAM

I12-01

HHSAA12-01

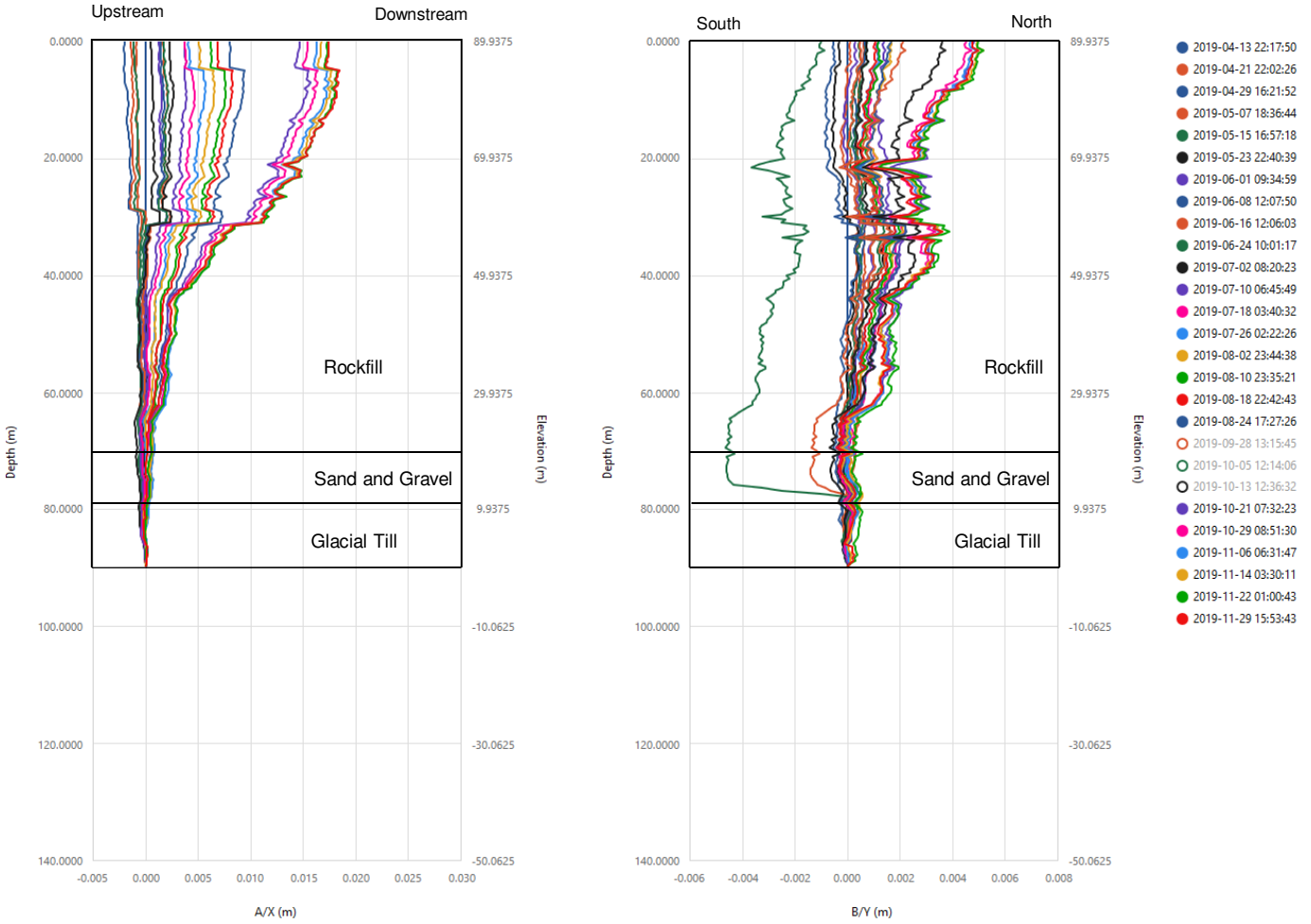
Incremental Plot



Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
12-01HH	Rockfill	1274.1	1275	7	6
	Rockfill	1252.1	1249.1	29	32
	Sand and Gravel	1208.8	1192	72	89
	Glacial Till	1192	1190.1	89	91

HHSAA12-01

Cumulative Plot



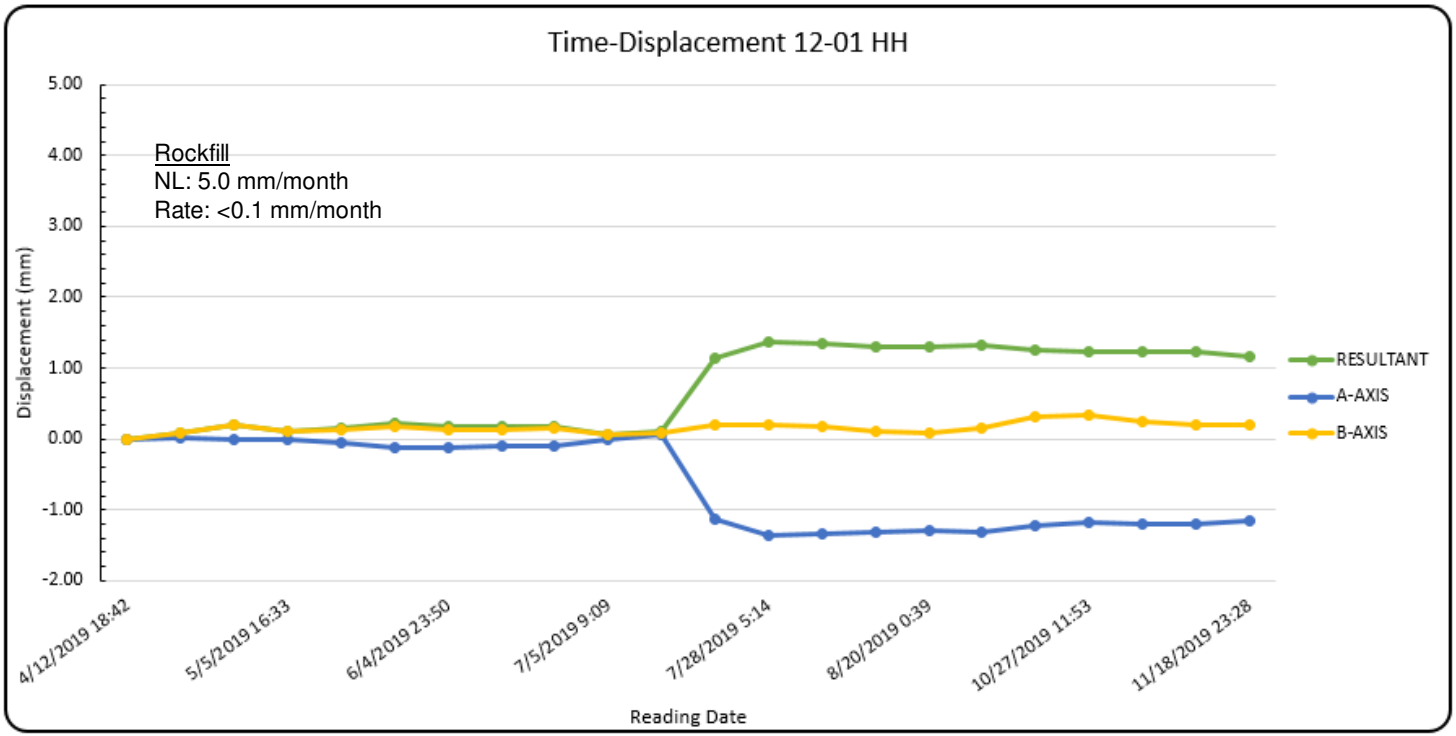
Borehole ID	Unit	Top Elevation	Bottom Elevation	Top Depth	Bottom Elevation
12-01HH	Rockfill	1274.1	1275	7	6
	Rockfill	1252.1	1249.1	29	32
	Sand and Gravel	1208.8	1192	72	89
	Glacial Till	1192	1190.1	89	91

HHSAA12-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Rockfill	4	6
Rockfill	29	32
Sand and Gravel	70	79
Glacial Till	79	90

Upper Depth	4.0 m
Lower Depth	6.0 m

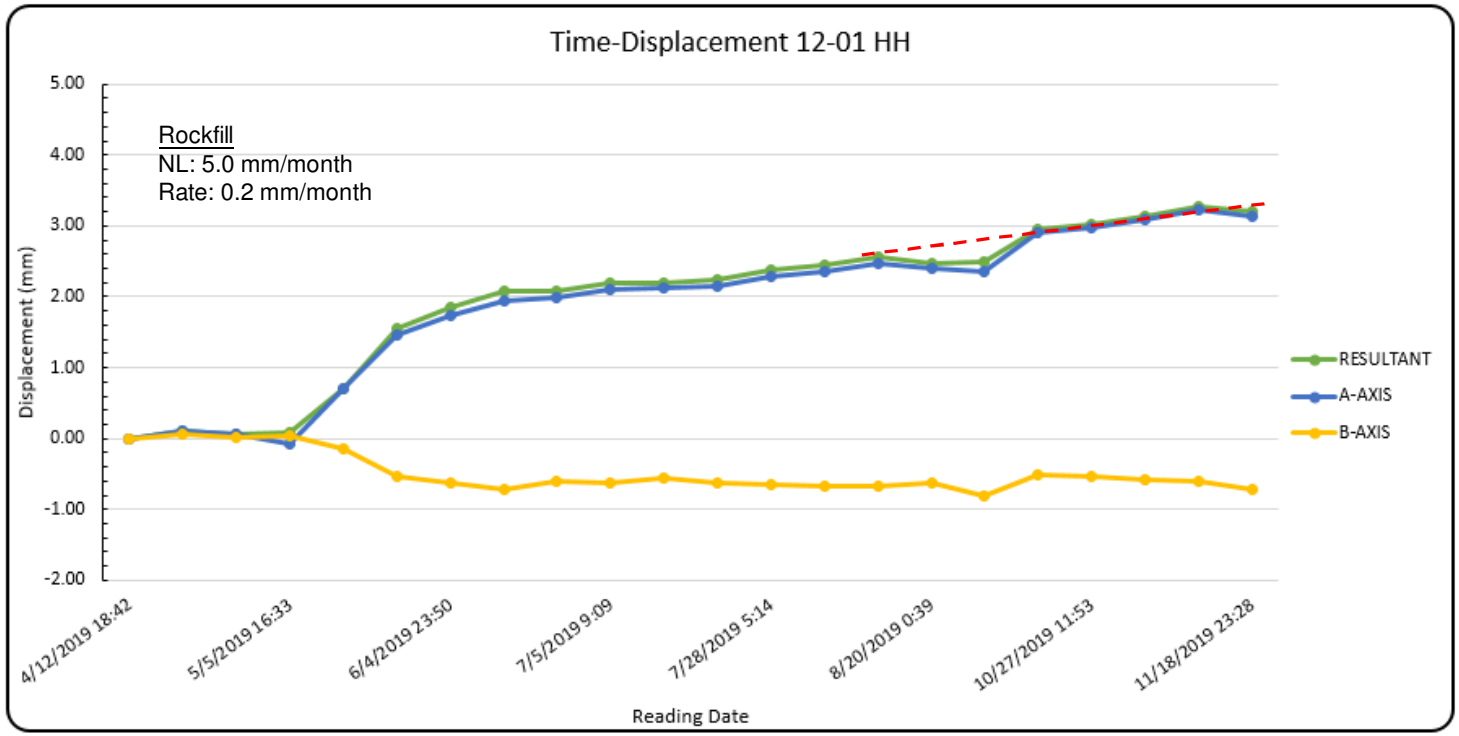


HHSAA12-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Rockfill	4	6
Rockfill	29	32
Sand and Gravel	70	79
Glacial Till	79	90

Upper Depth	29.0 m
Lower Depth	32.0 m

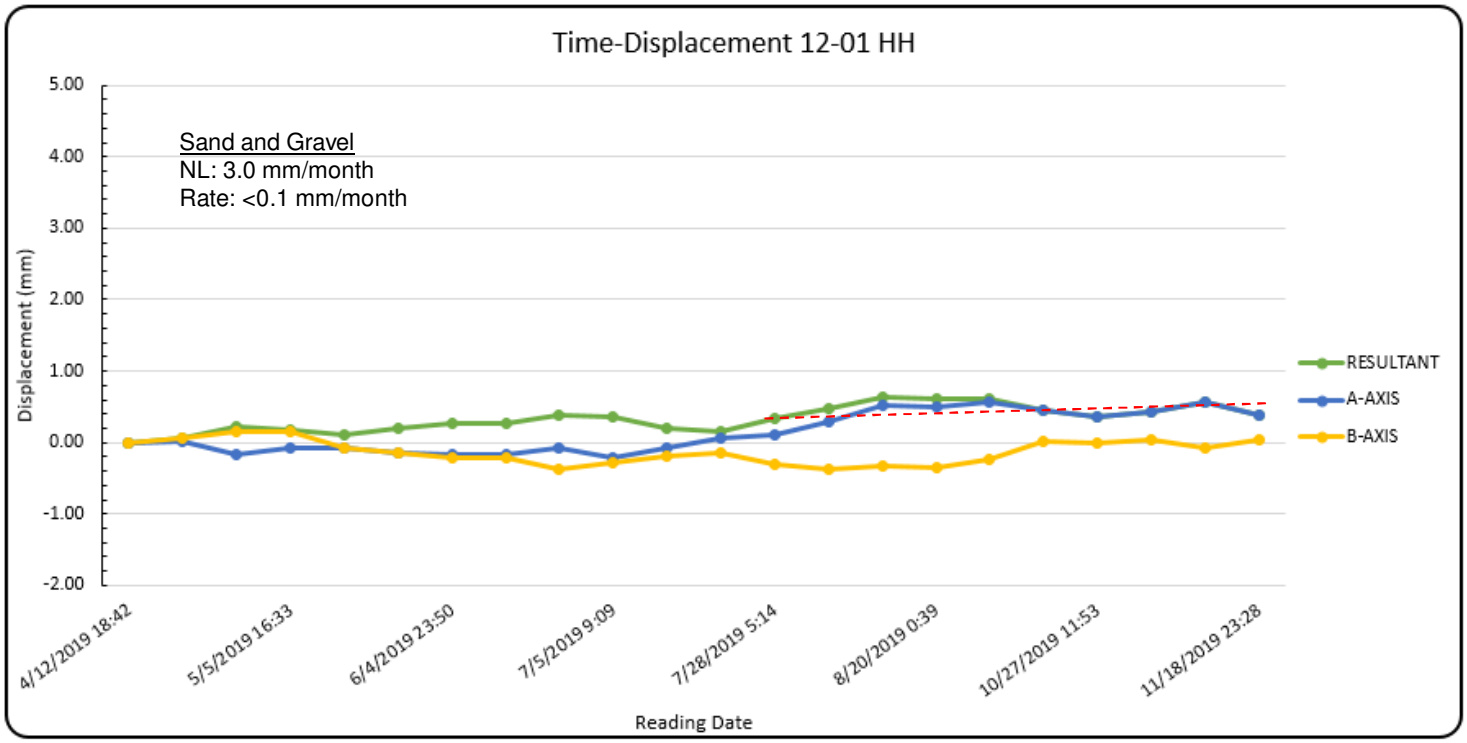


HHSAA12-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Rockfill	4	6
Rockfill	29	32
Sand and Gravel	70	79
Glacial Till	79	90

Upper Depth	70.0 m
Lower Depth	79.0 m

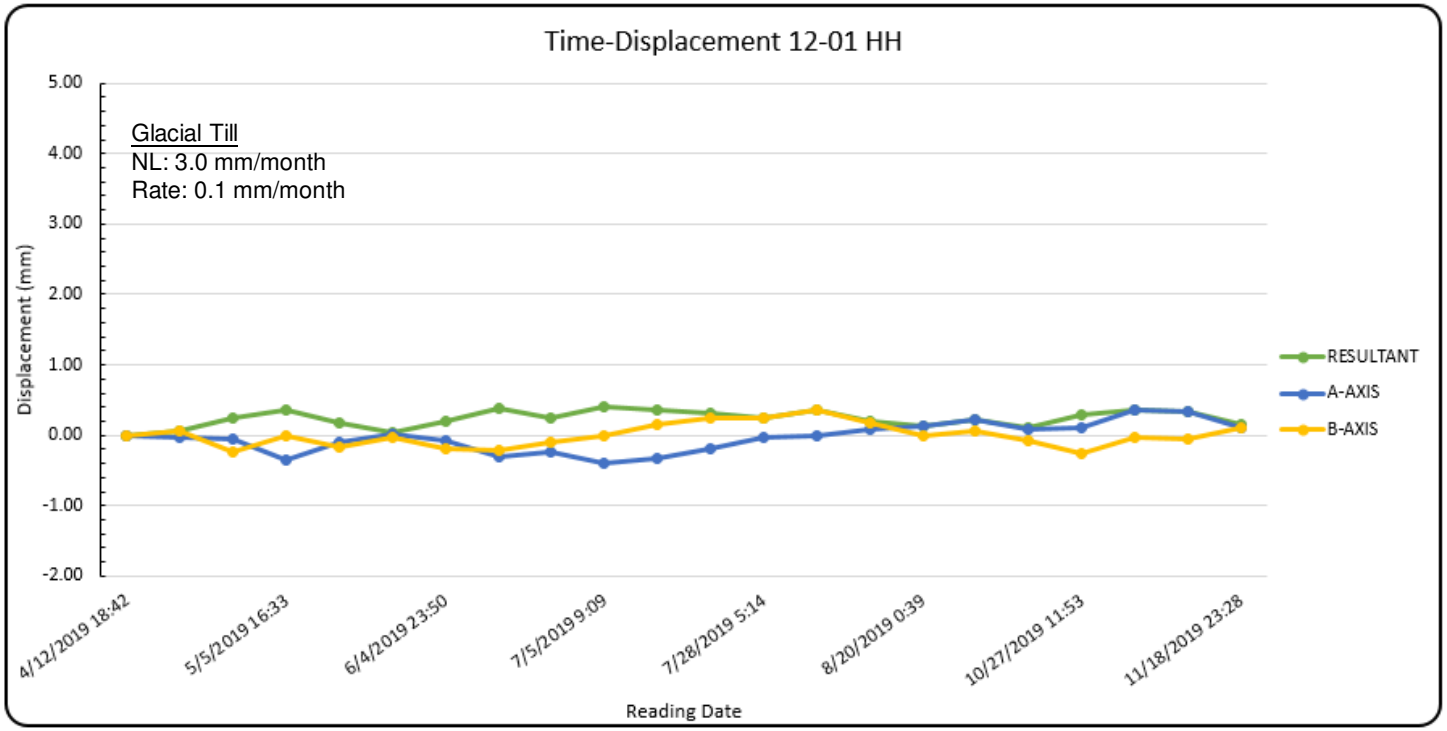


HHSAA12-01

Displacement Plot

Unit	Upper Depth	Lower Depth
Rockfill	4	6
Rockfill	29	32
Sand and Gravel	70	79
Glacial Till	79	90

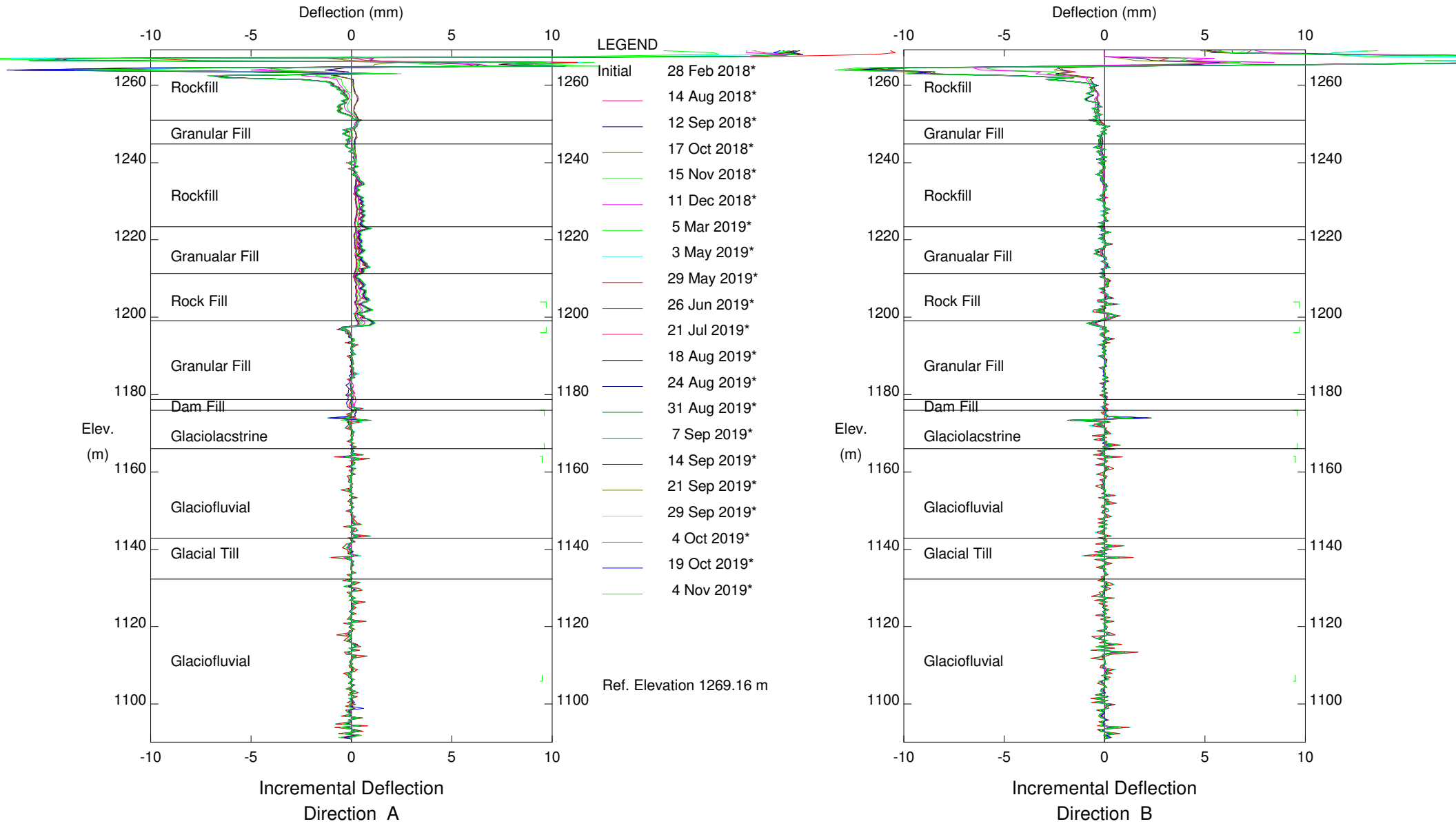
Upper Depth	79.0 m
Lower Depth	90.0 m



H-H DAM

I15-23

Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I15-23

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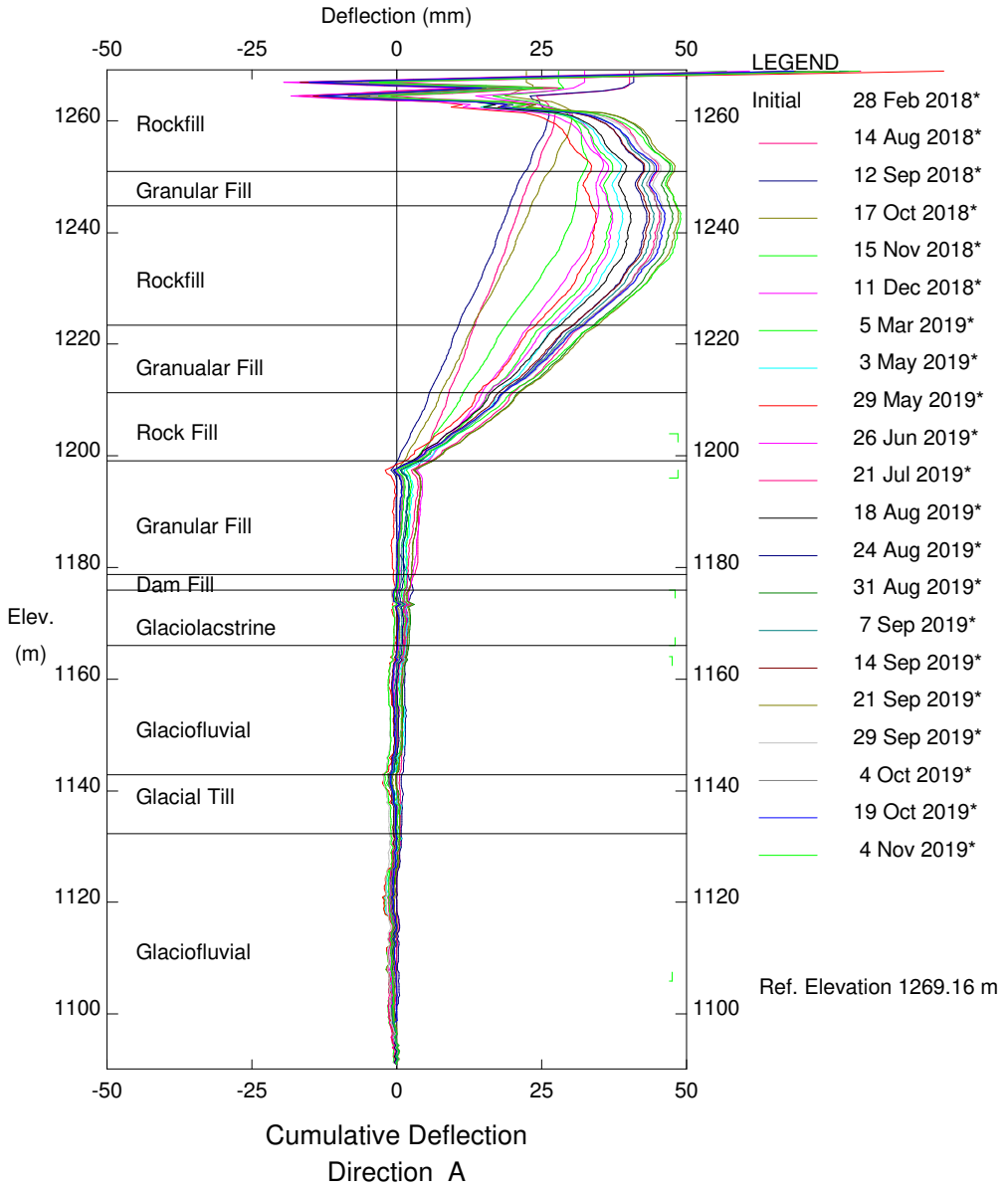
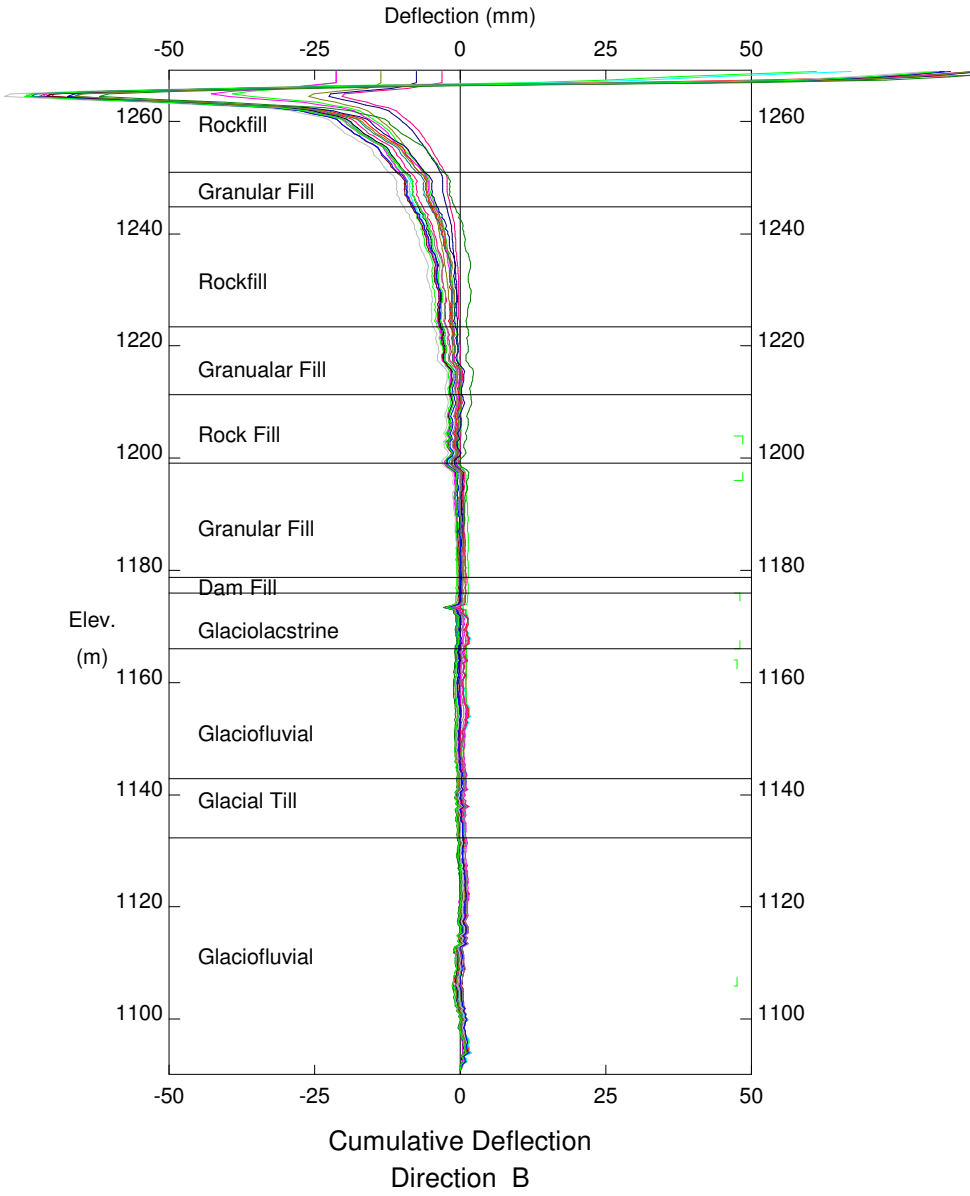
Highland Valley Copper - Logan Lake, BC





H-H Dam, Inclinometer I15-23

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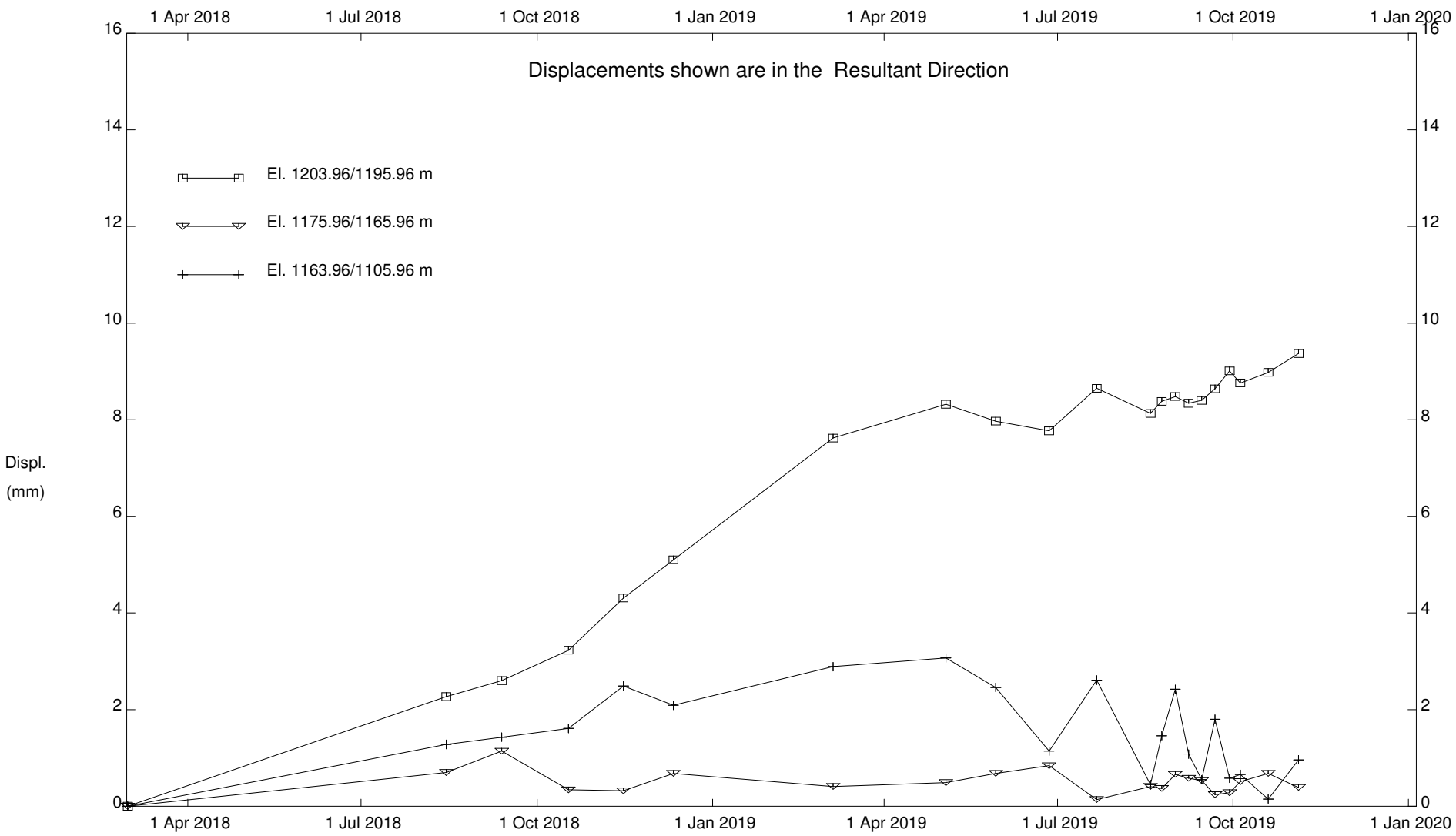
Highland Valley Copper - Logan Lake, BC

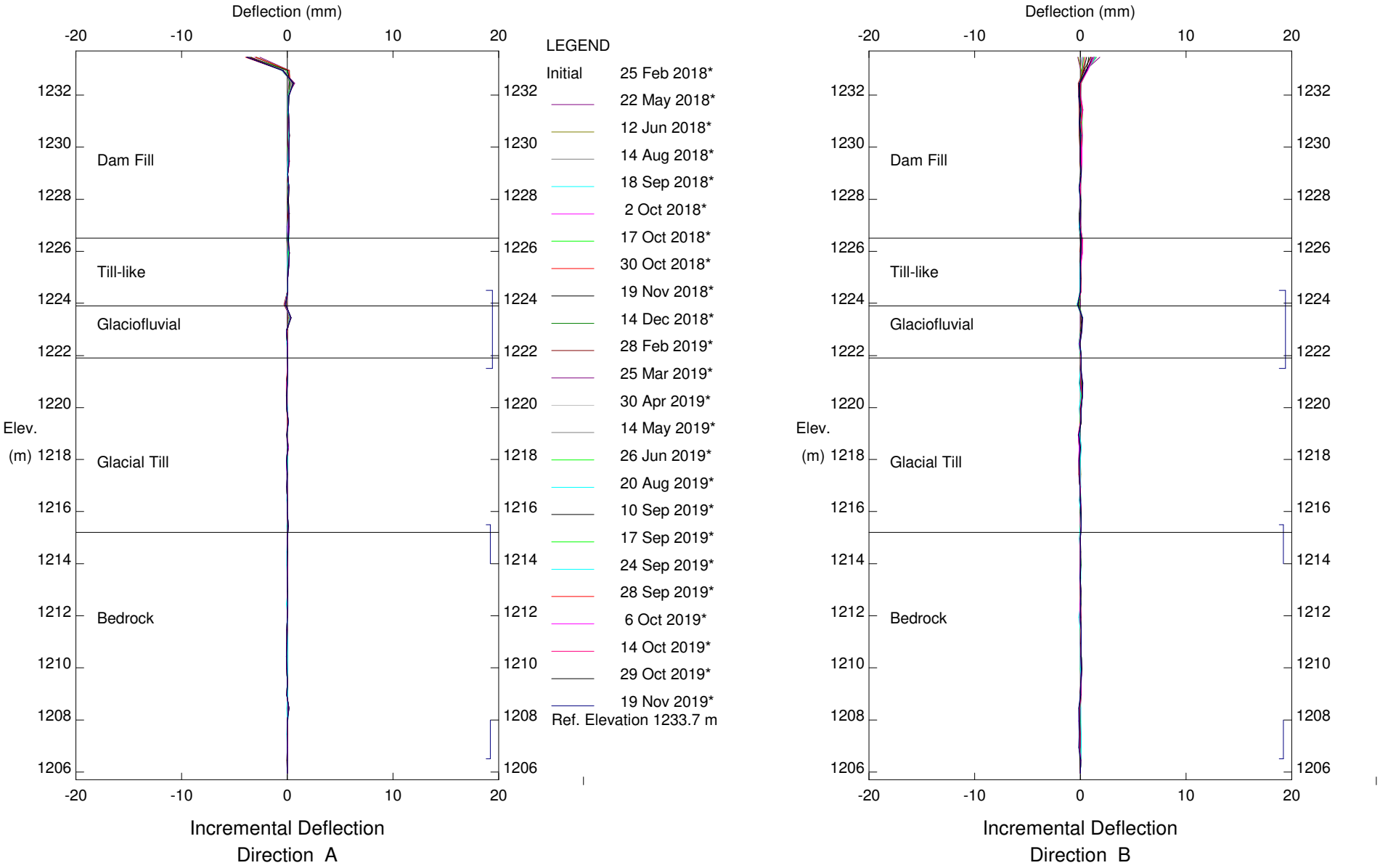


H-H Dam, Inclinometer I15-23

H-H DAM

I17-14

Highland Valley Copper - Logan Lake, BC



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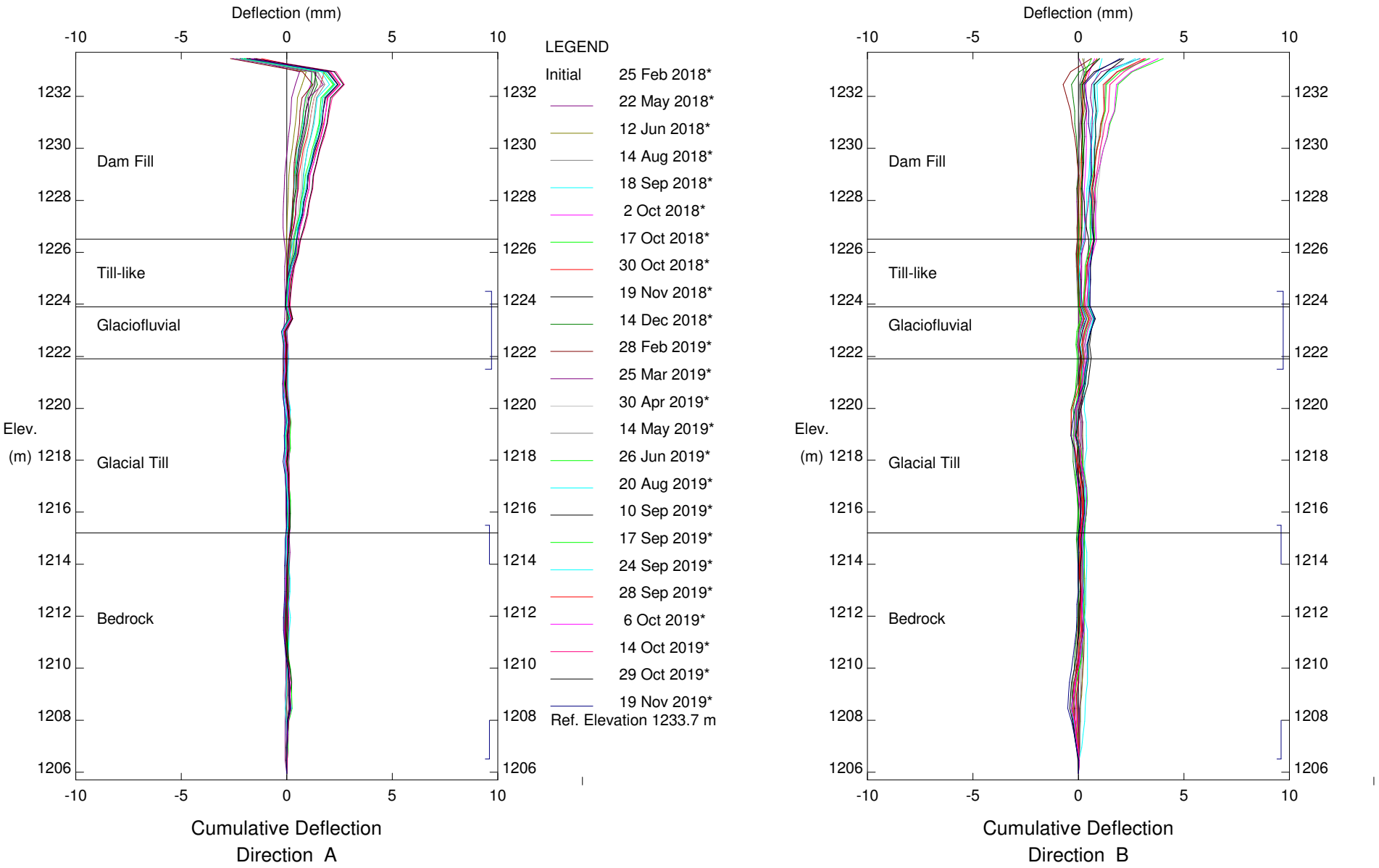
Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-14

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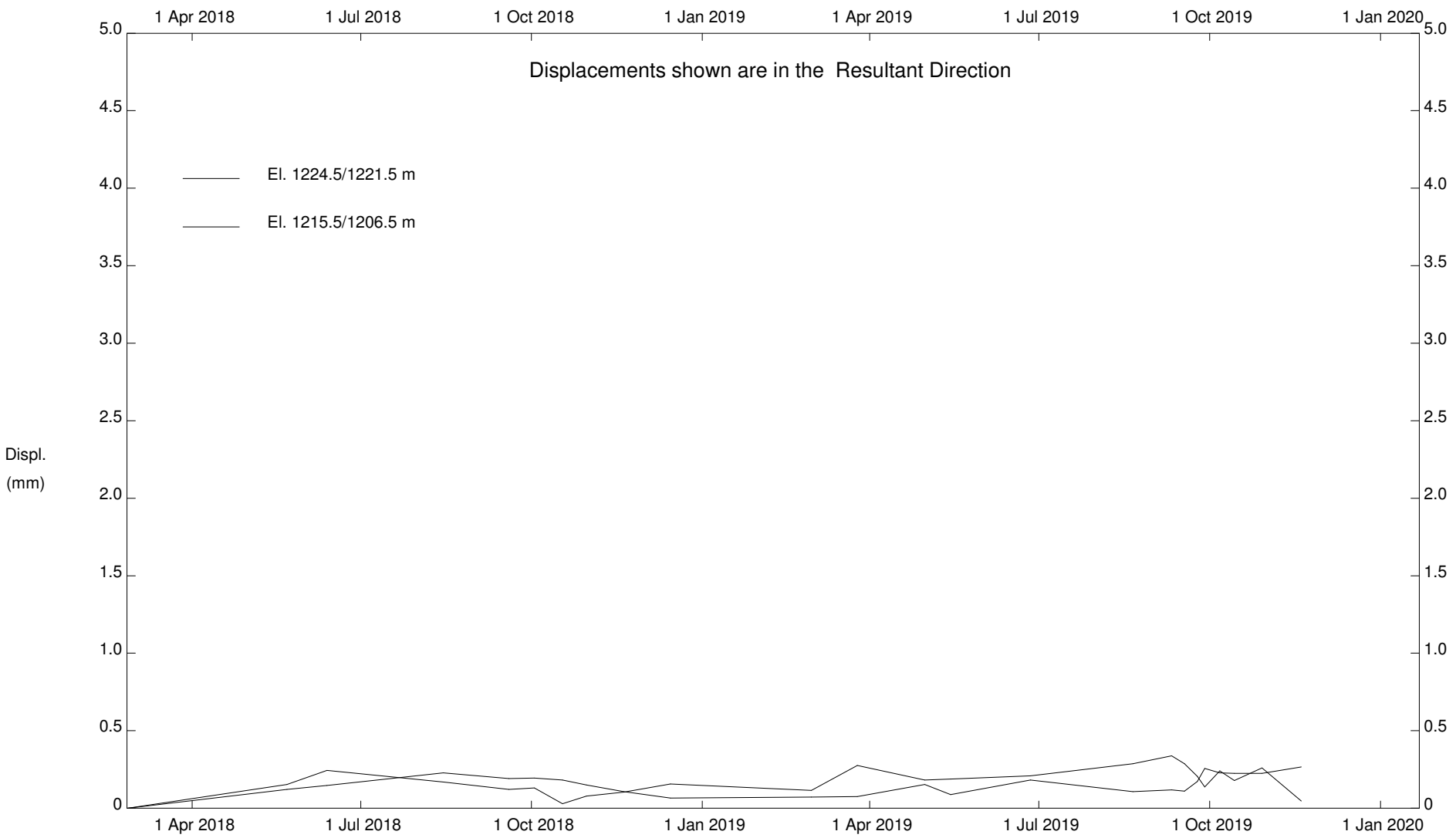
Highland Valley Copper - Logan Lake, BC

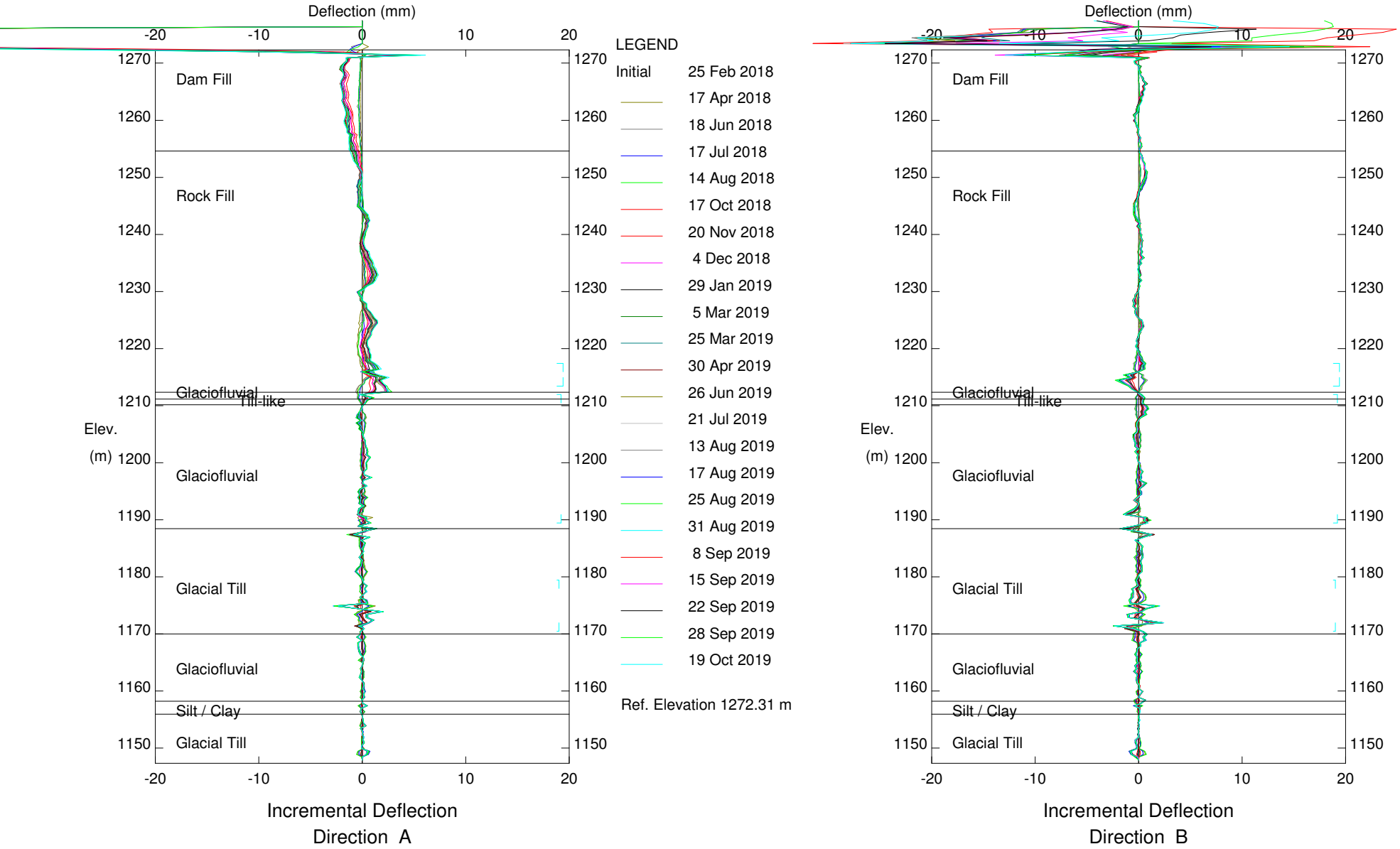


H-H Dam, Inclinometer I17-14

H-H DAM

I17-16

Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-16

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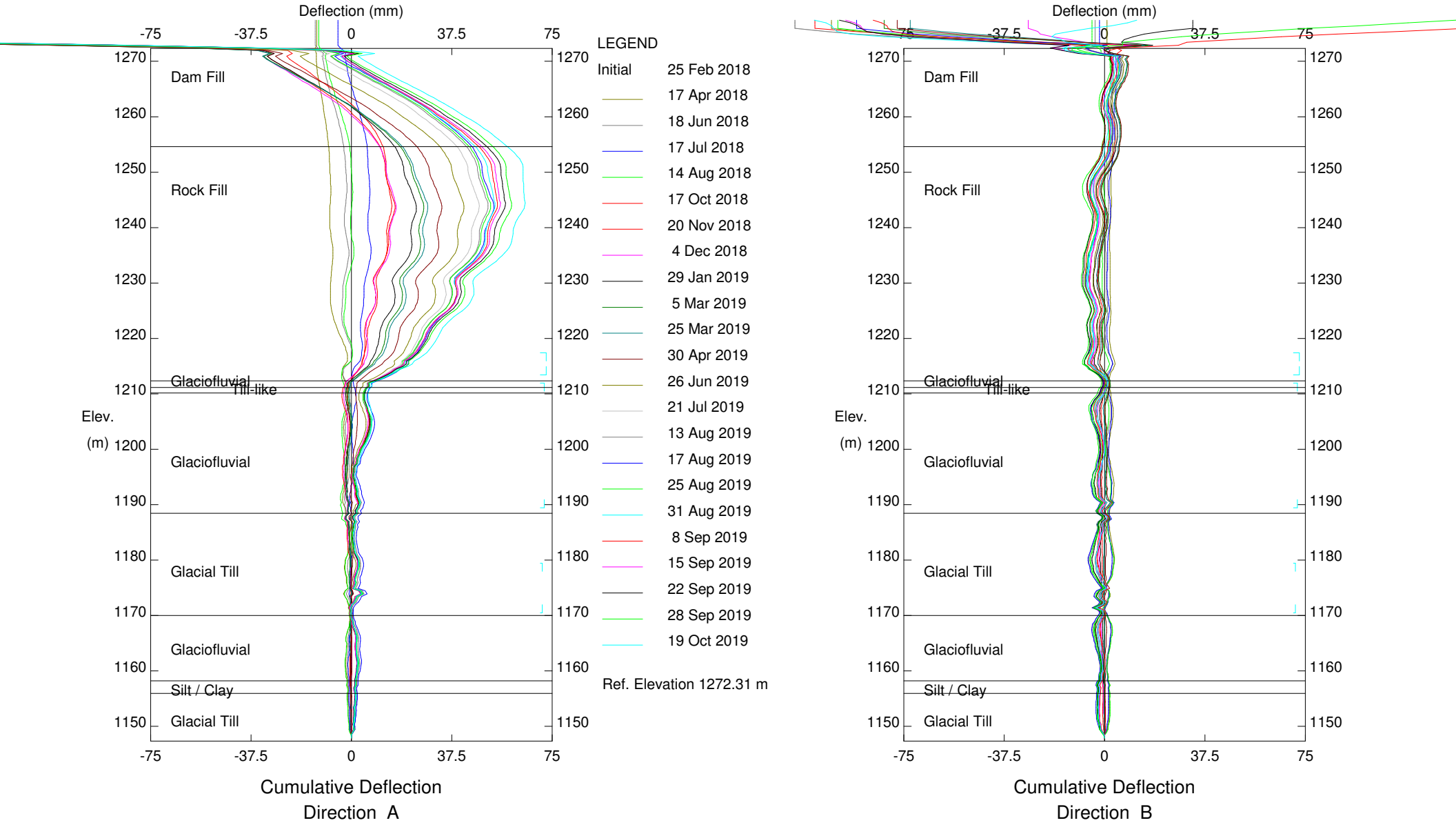
Highland Valley Copper - Logan Lake, BC



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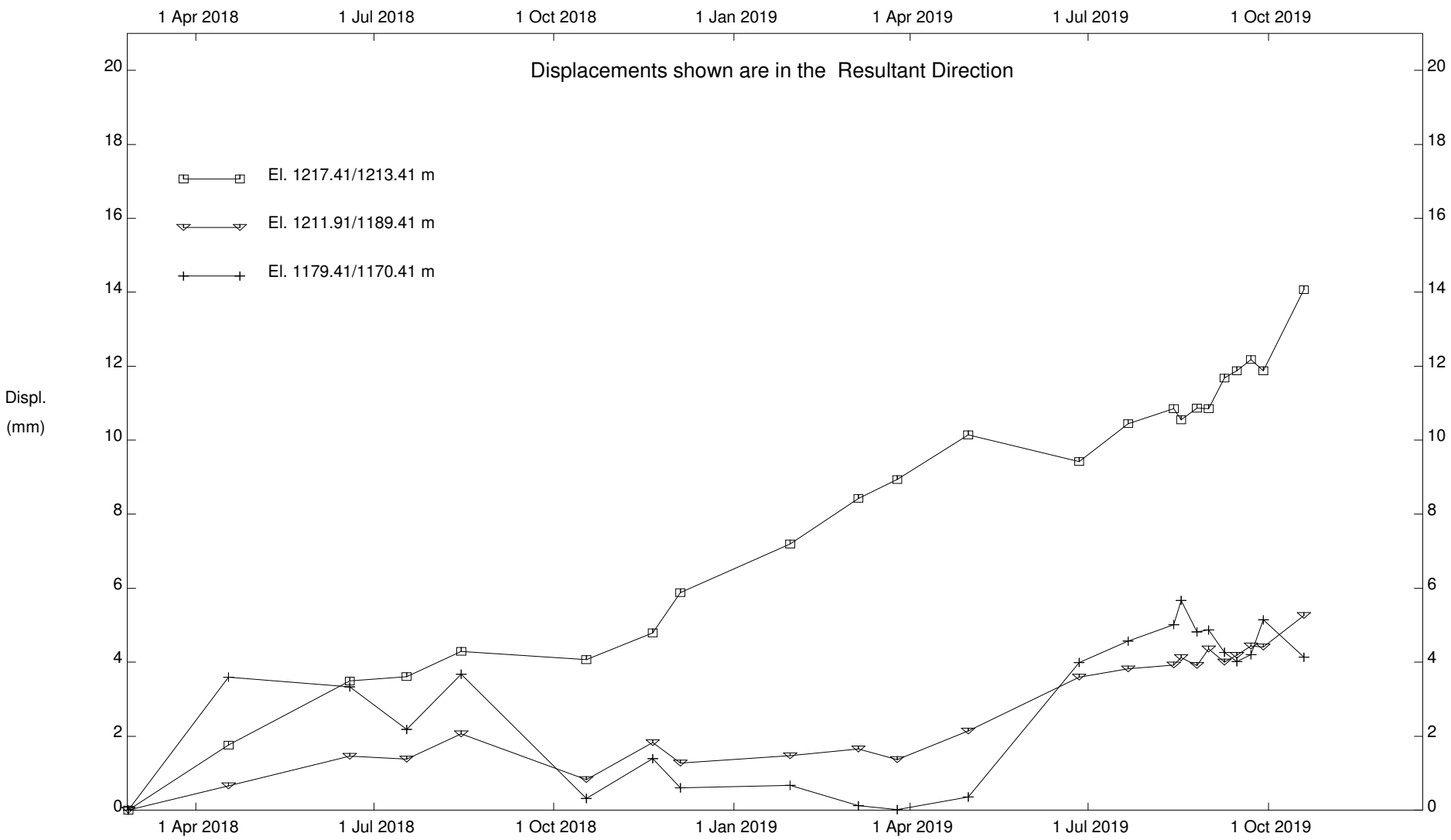
Highland Valley Copper - Logan Lake, BC

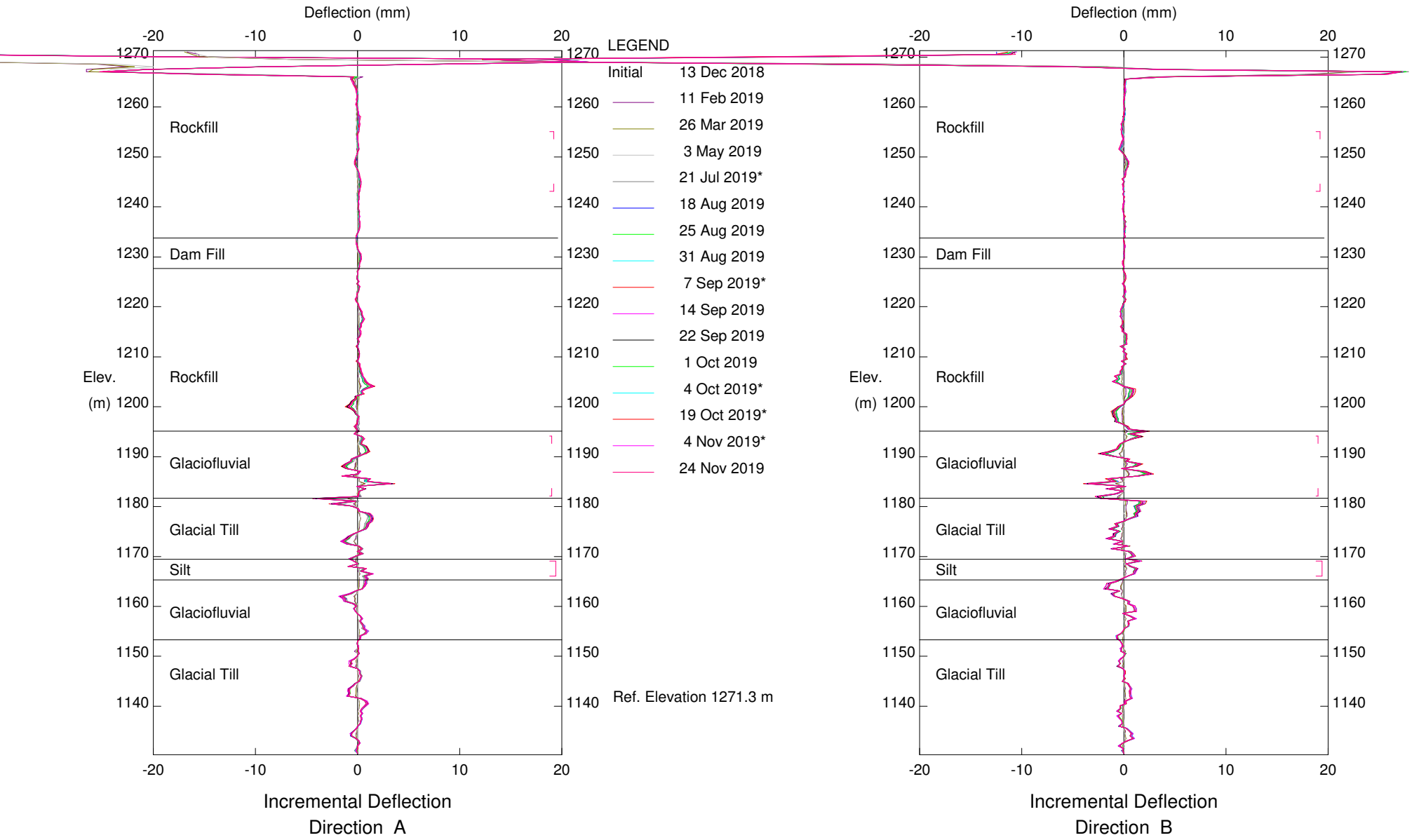


H-H Dam, Inclinometer I17-16

H-H DAM

I17-17

Highland Valley Copper - Logan Lake, BC



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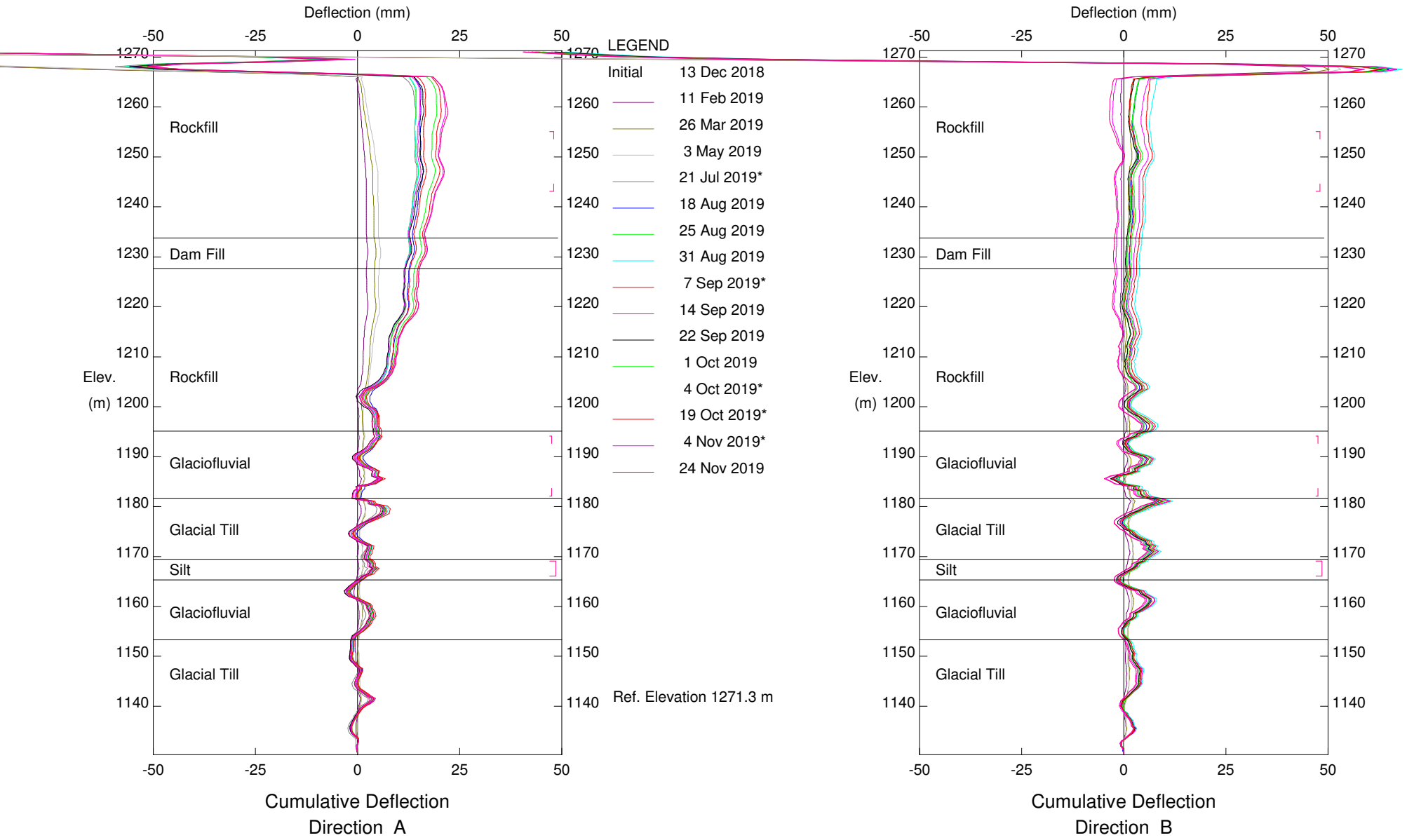
Highland Valley Copper - Logan Lake, BC



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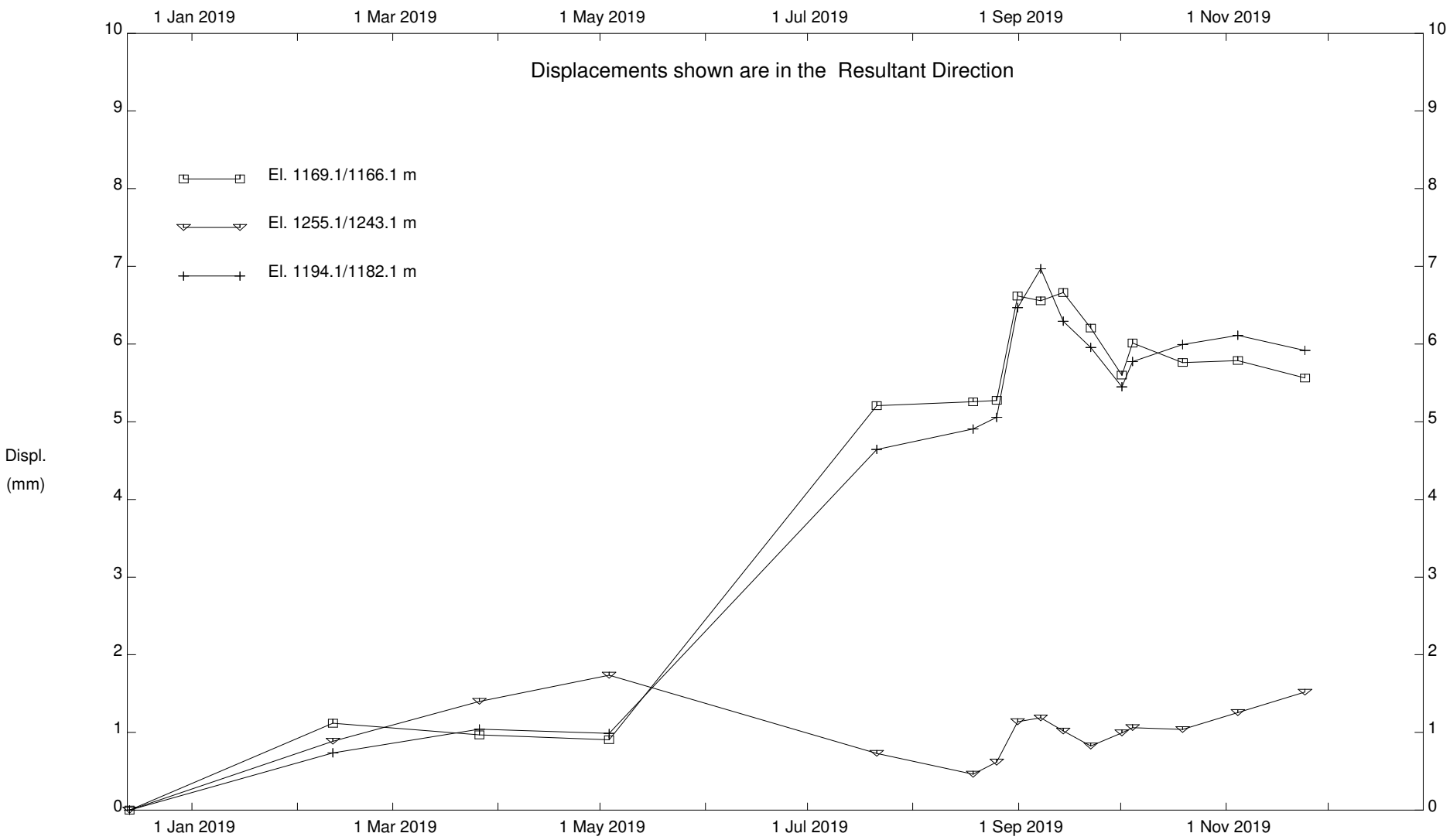
Highland Valley Copper - Logan Lake, BC



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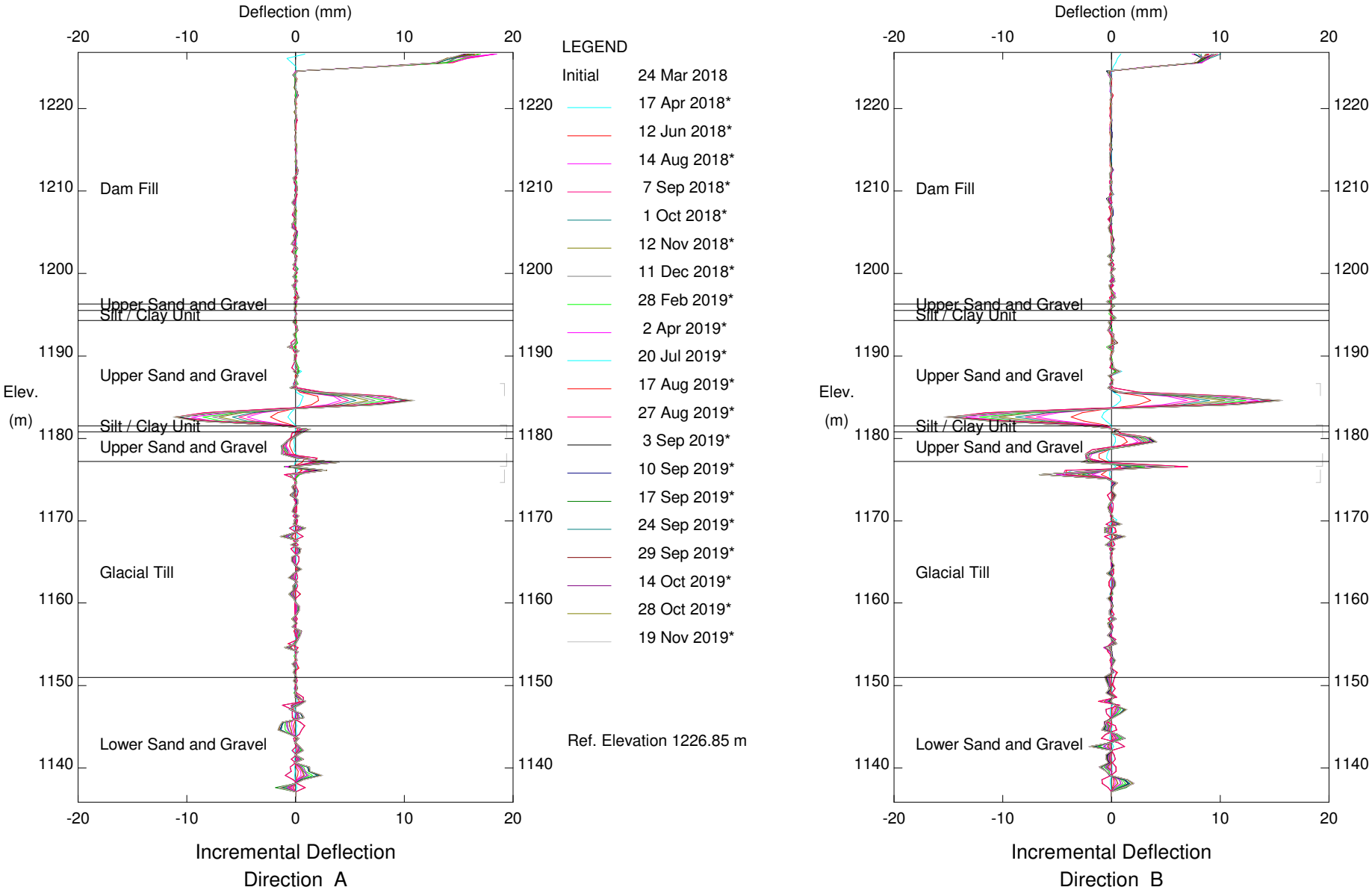
H-H DAM

I17-30

Highland Valley Copper - Logan Lake, BC

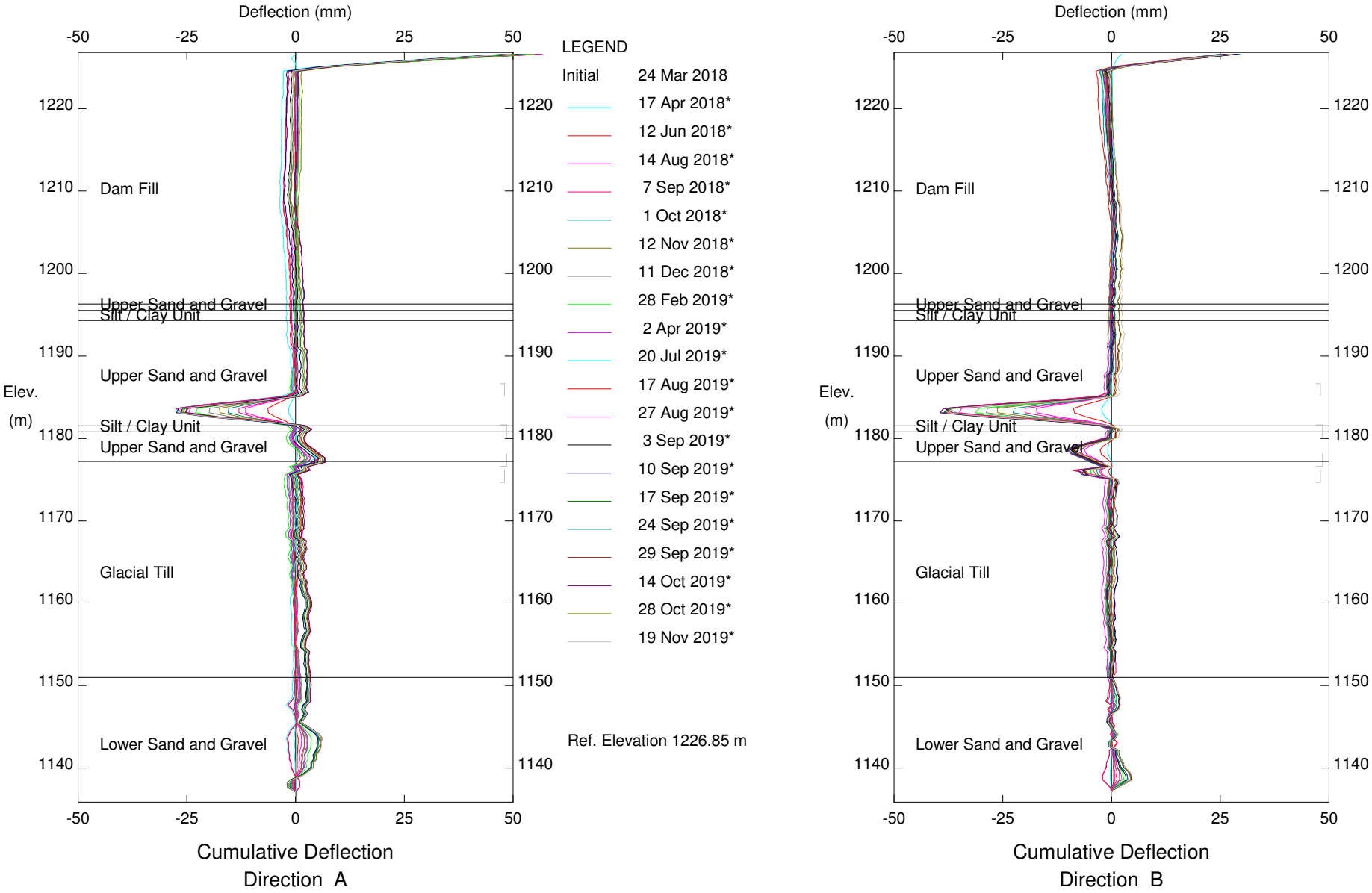


HH Dam,,,,,,,,,,,,,,,,, Inclinometer I17-30,,,,,,

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC

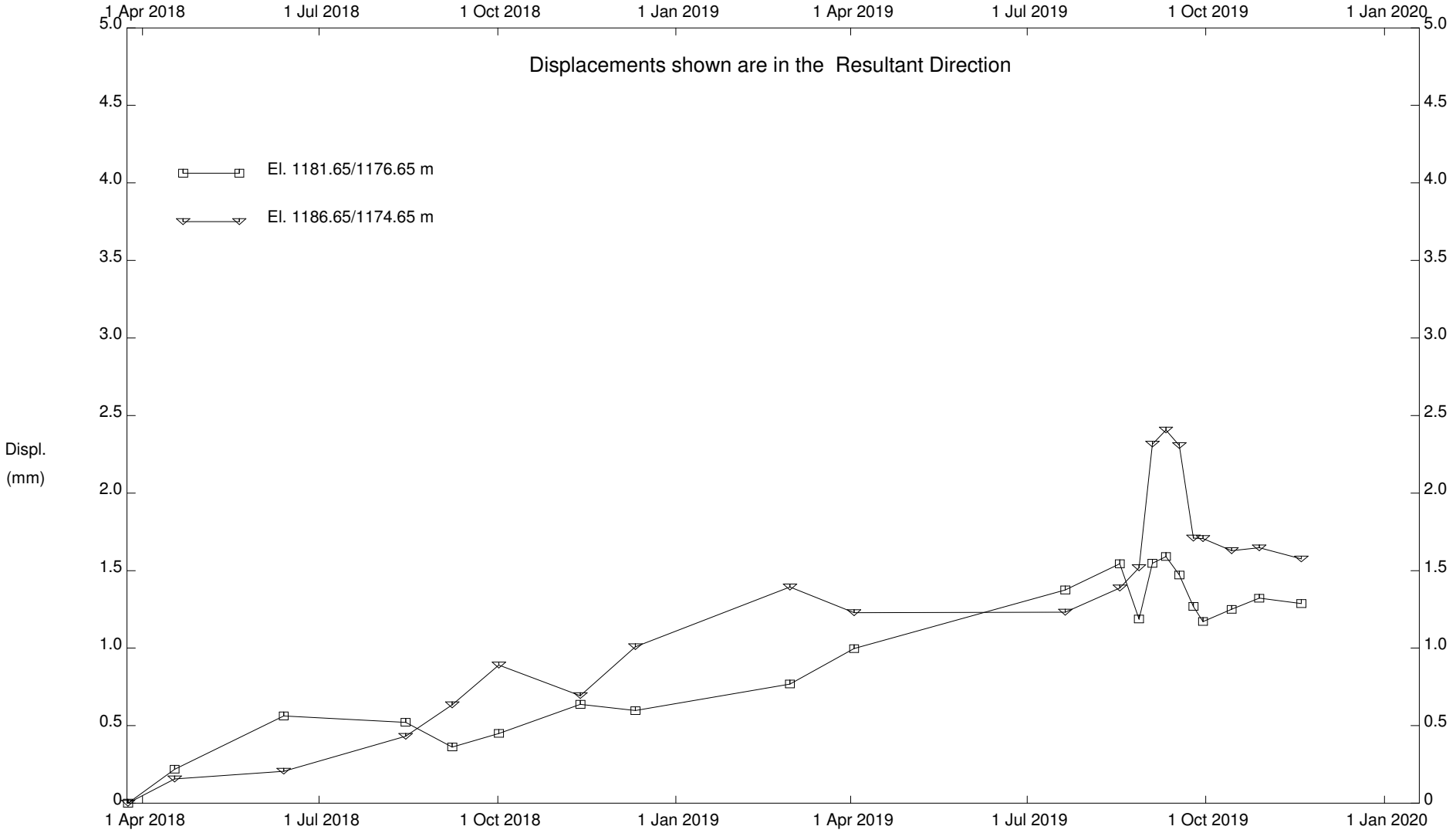


HH Dam,,,,,,,,,,,,,,,,, Inclinometer I17-30,,,,,,

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC

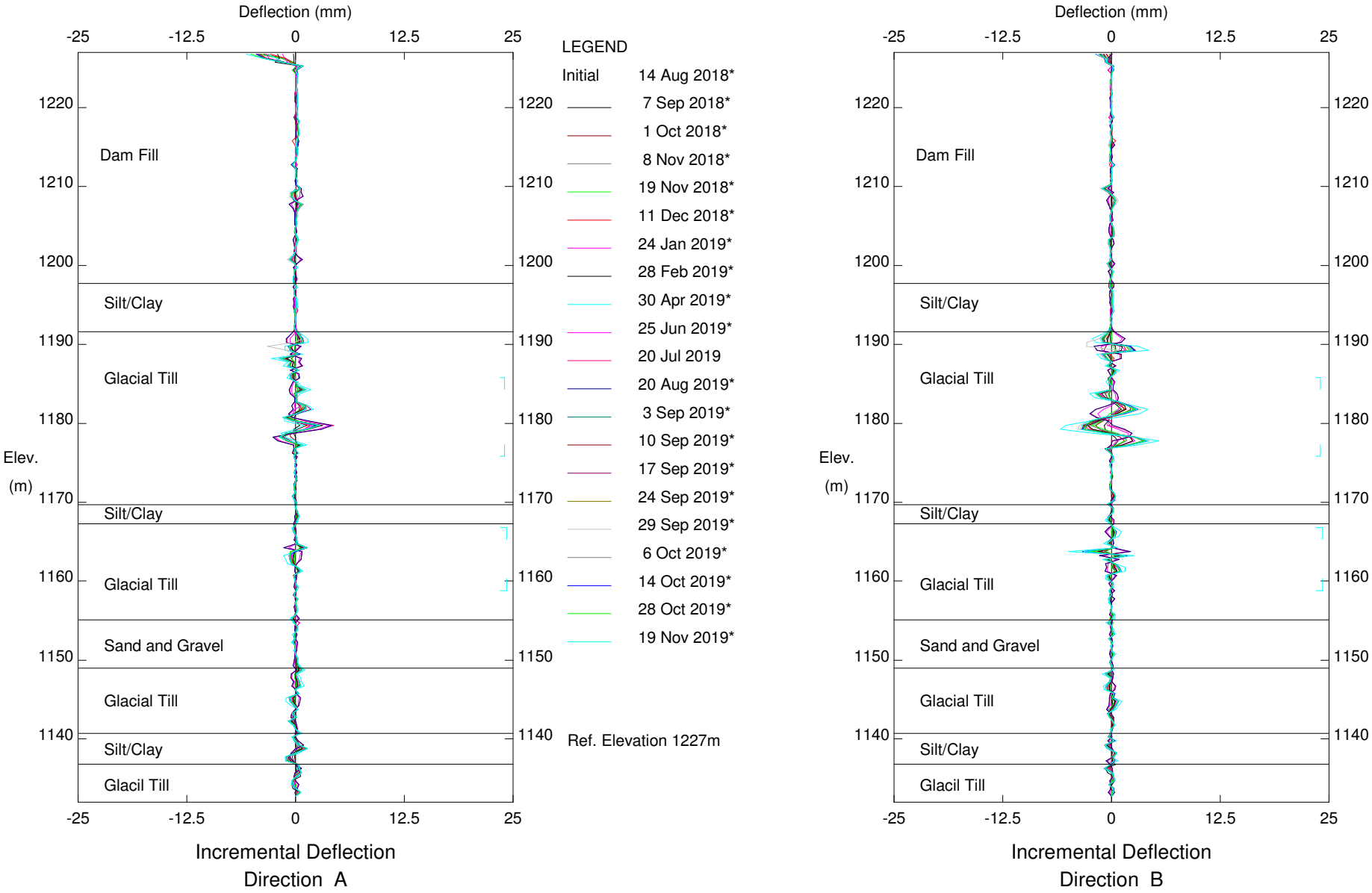


HH Dam,,,,,,,,,,,,,,,,, Inclinometer I17-30,,,,,,

H-H DAM

I17-31

Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-31

Sets marked * include zero shift and/or rotation corrections.

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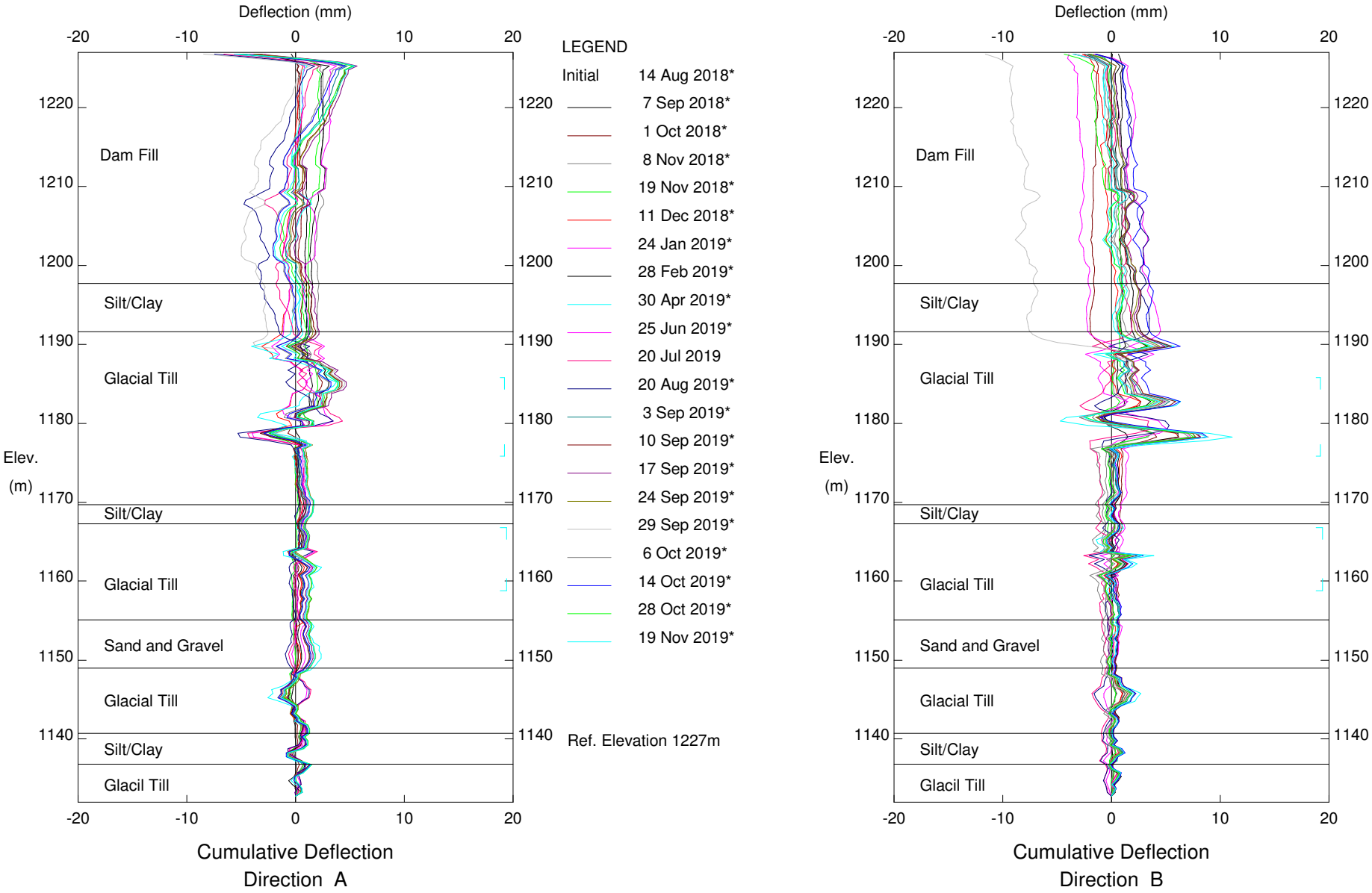
Highland Valley Copper - Logan Lake, BC

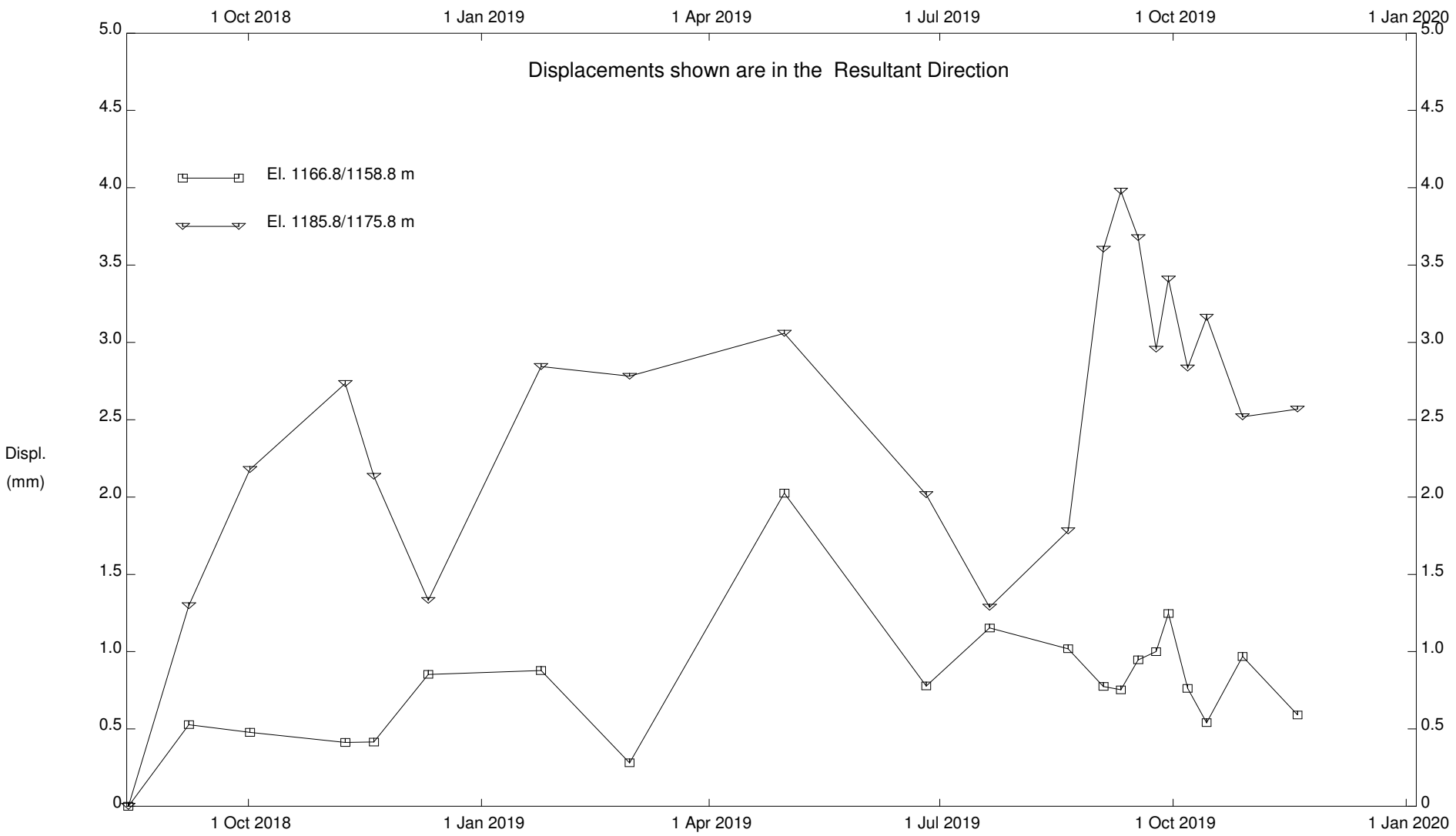


H-H Dam, Inclinometer I17-31

Sets marked * include zero shift and/or rotation corrections.

\\teckcominco.loc\hvc\groups\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring

Highland Valley Copper - Logan Lake, BC

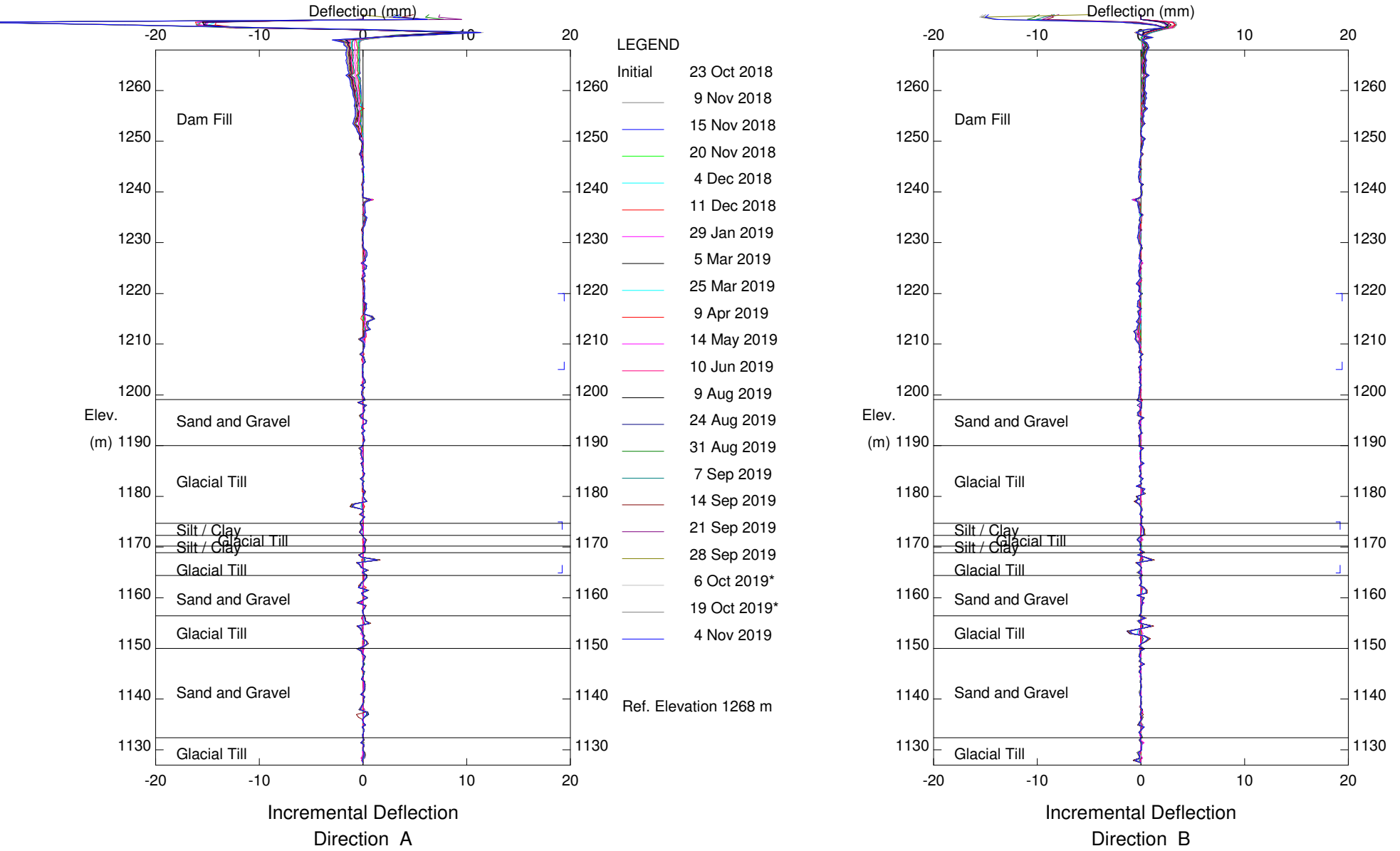


H-H Dam, Inclinometer I17-31

H-H DAM

I17-33

Highland Valley Copper - Logan Lake, BC

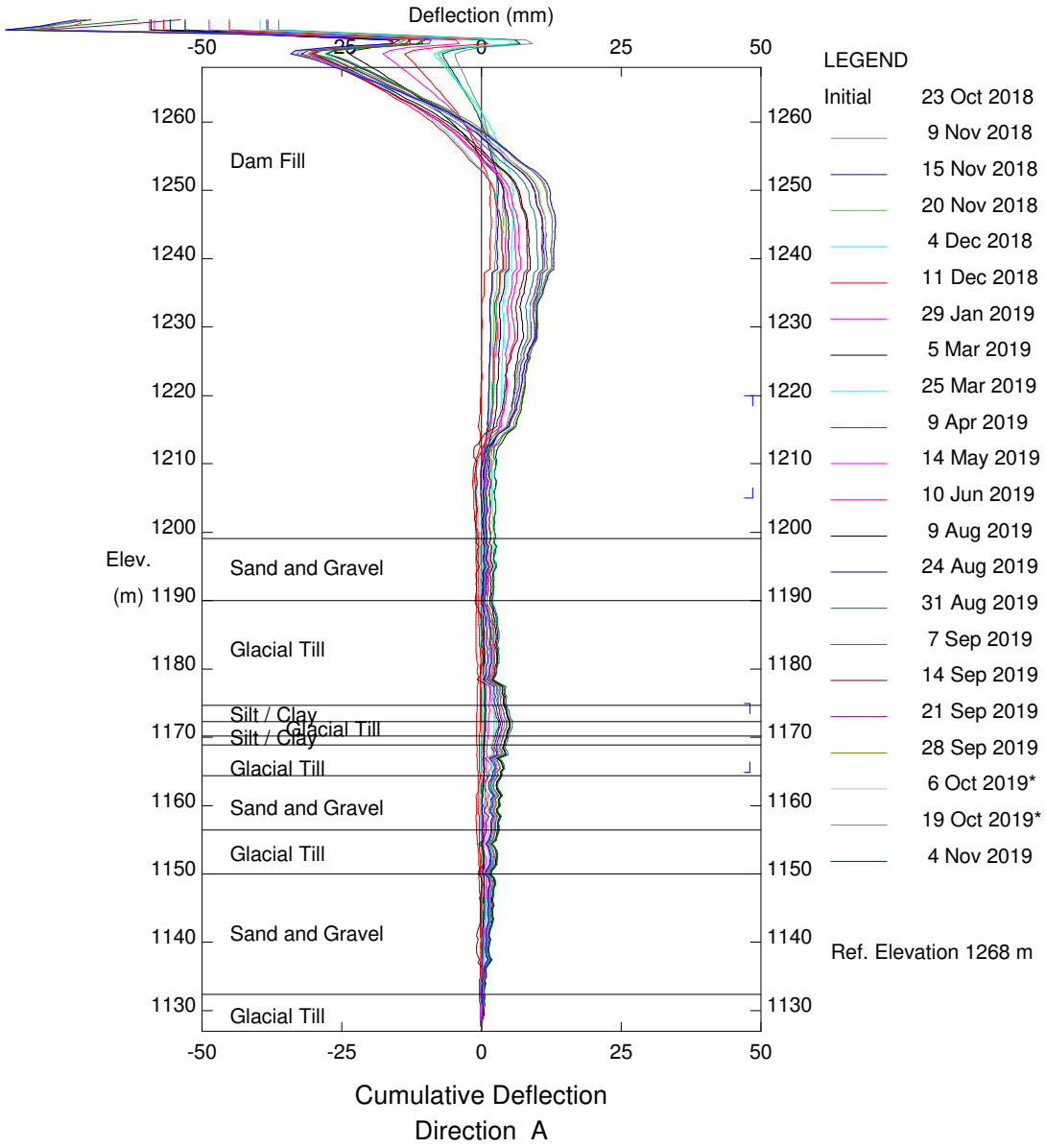


H-H Dam, Inclinometer I17-33

Sets marked * include zero shift and/or rotation corrections.

T:\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\HH\I17-33.gtl

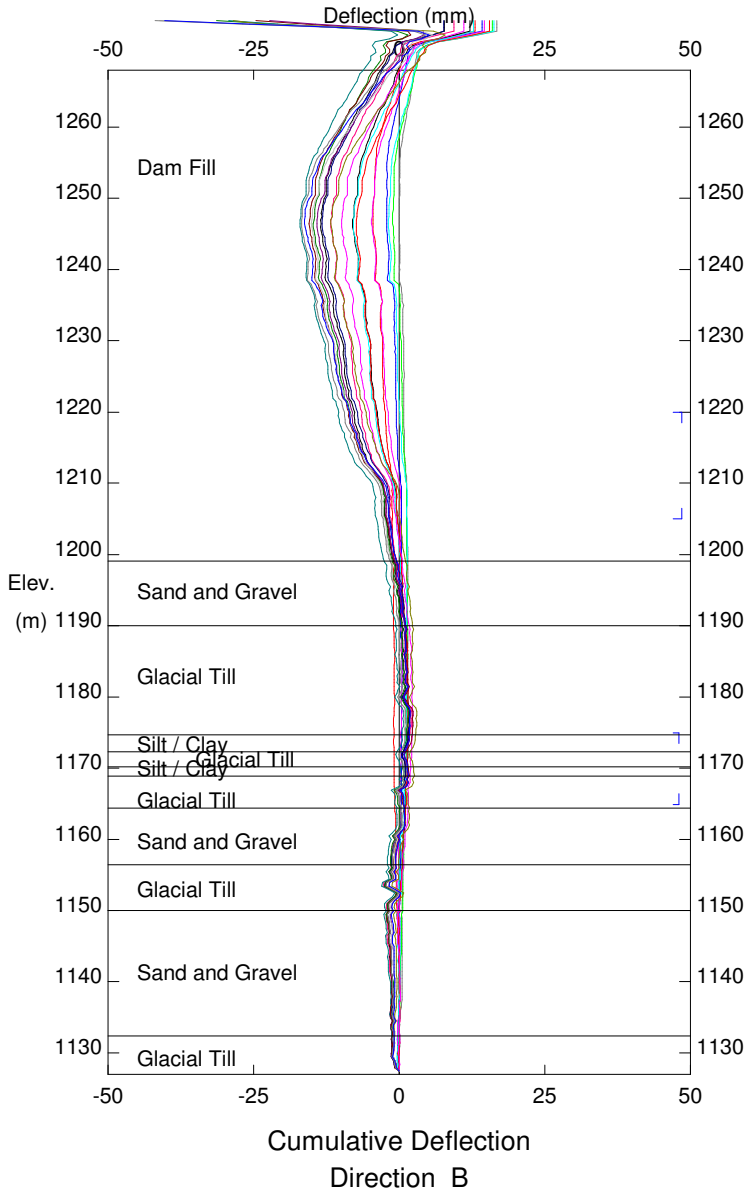
Highland Valley Copper - Logan Lake, BC



LEGEND

Initial	23 Oct 2018
	9 Nov 2018
	15 Nov 2018
	20 Nov 2018
	4 Dec 2018
	11 Dec 2018
	29 Jan 2019
	5 Mar 2019
	25 Mar 2019
	9 Apr 2019
	14 May 2019
	10 Jun 2019
	9 Aug 2019
	24 Aug 2019
	31 Aug 2019
	7 Sep 2019
	14 Sep 2019
	21 Sep 2019
	28 Sep 2019
	6 Oct 2019*
	19 Oct 2019*
	4 Nov 2019

Ref. Elevation 1268 m

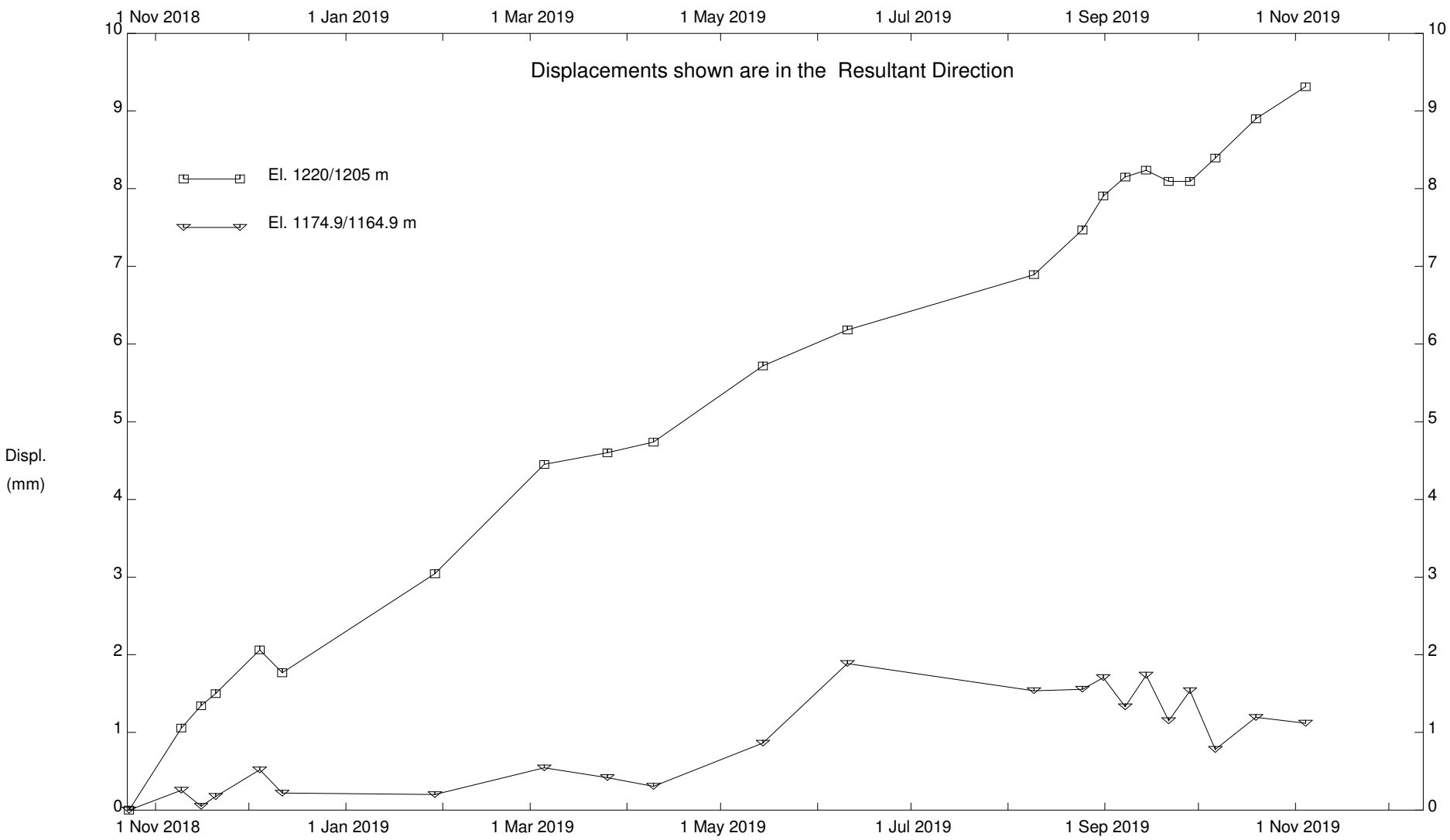


H-H Dam, Inclinometer I17-33

Sets marked * include zero shift and/or rotation corrections.

T:\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\03 - Dam Movement Monitoring\L-L Dam\SI Monitoring\GTPLUS32 Files\HH\I17-33.gtl

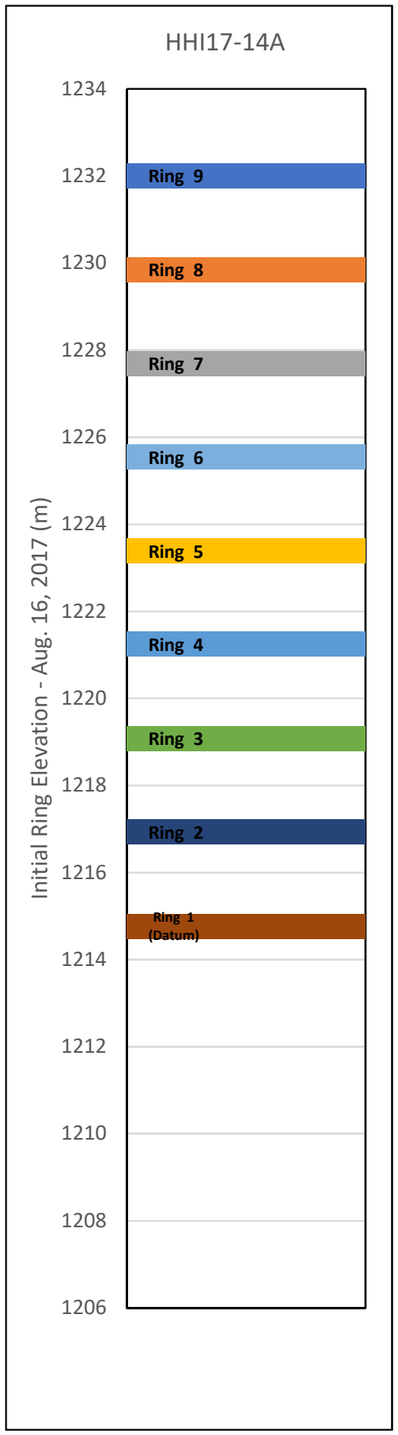
Highland Valley Copper - Logan Lake, BC

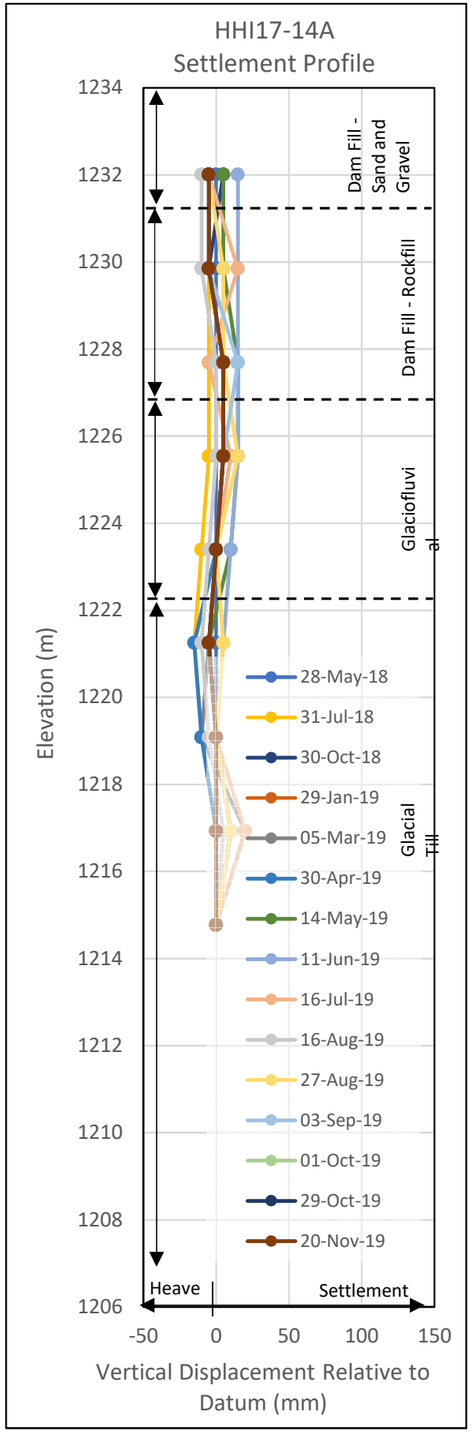


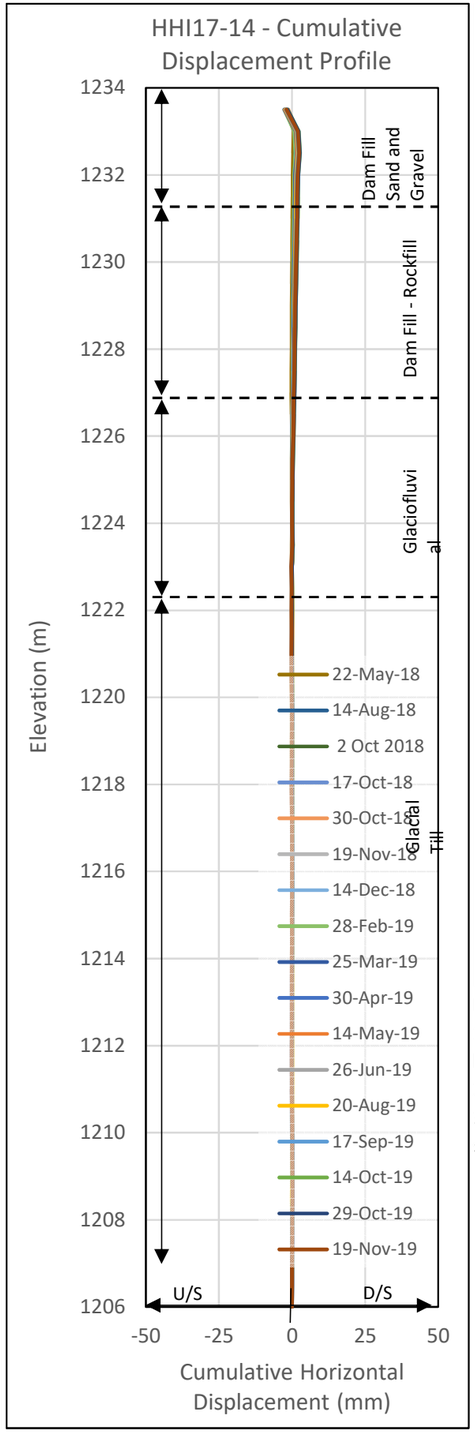
H-H Dam, Inclinometer I17-33

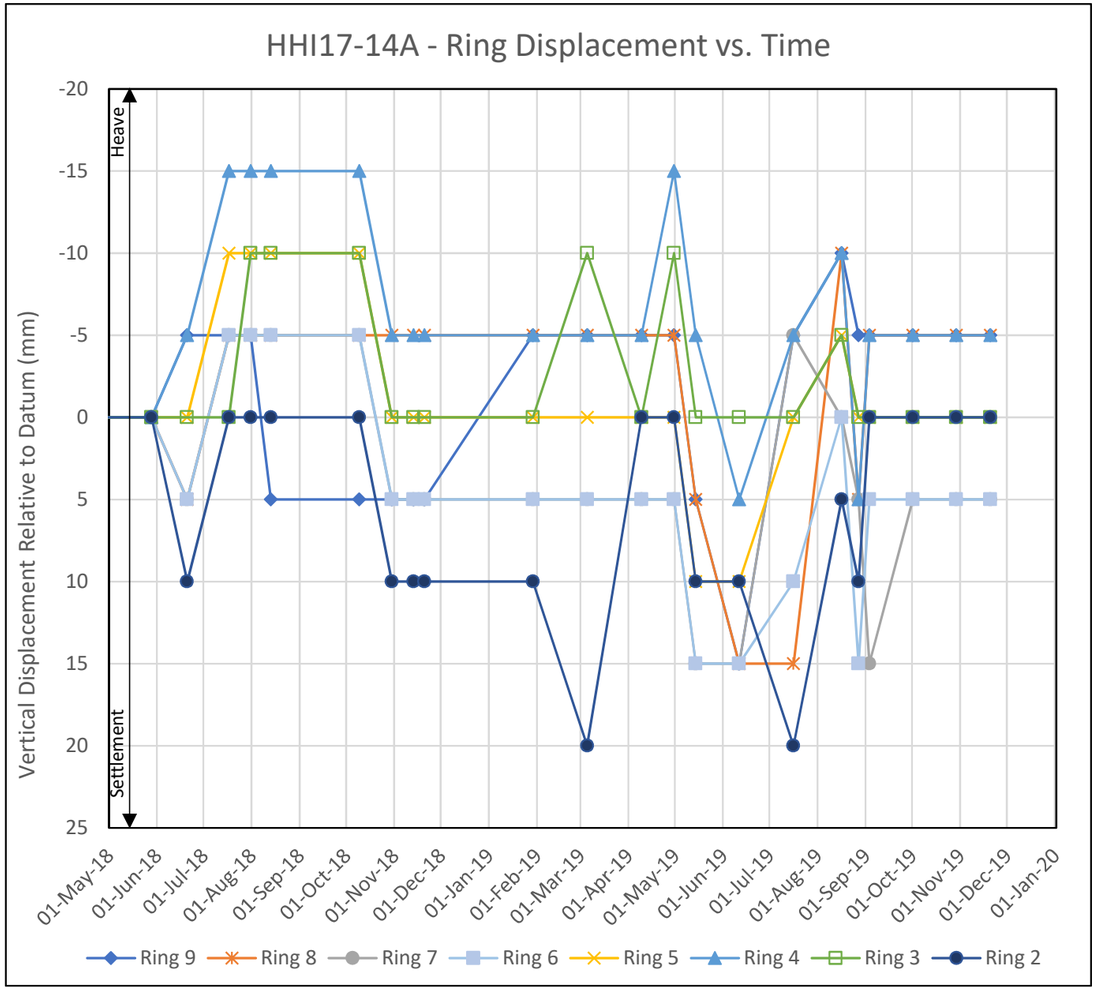
H-H DAM

SONDEX









Notes:

1. Ring displacements are calculated relative to the elevations for each ring measured on May 28, 2018. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The Ring 4 reading from February 10, 2018 was not consistent with readings in the rings above and below, due to a suspected data entry error. The reading was adjusted to match the trends of Ring 3 and Ring 5.

Initial readings were taken on August 16, 2017. However, to compare the settlement profiles with horizontal displacement profiles, May 28, 2018 reading was used to calculate cumulative settlement.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

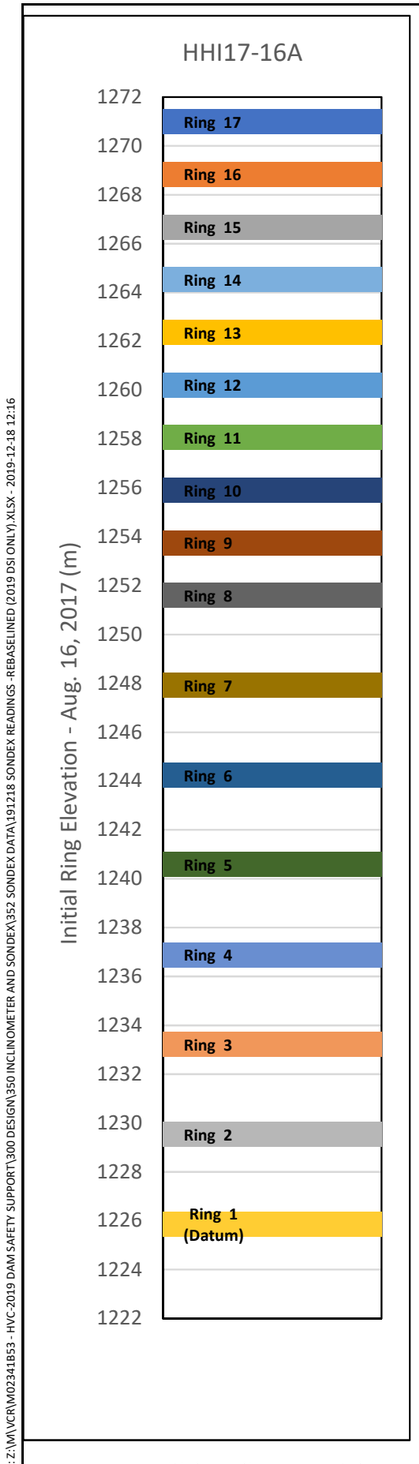
Klohn Crippen Berger

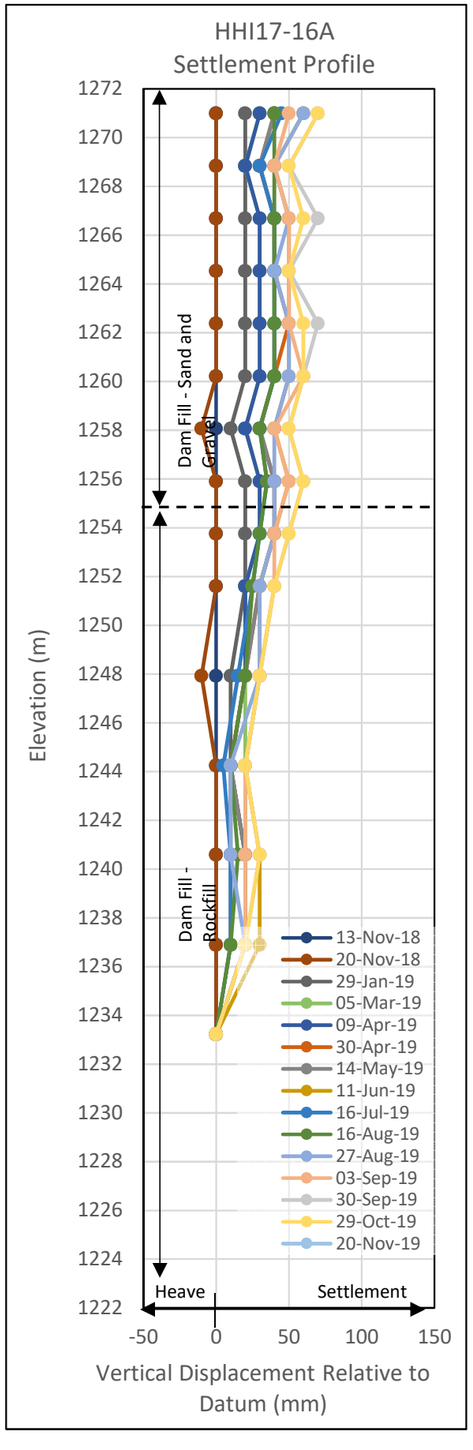
HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

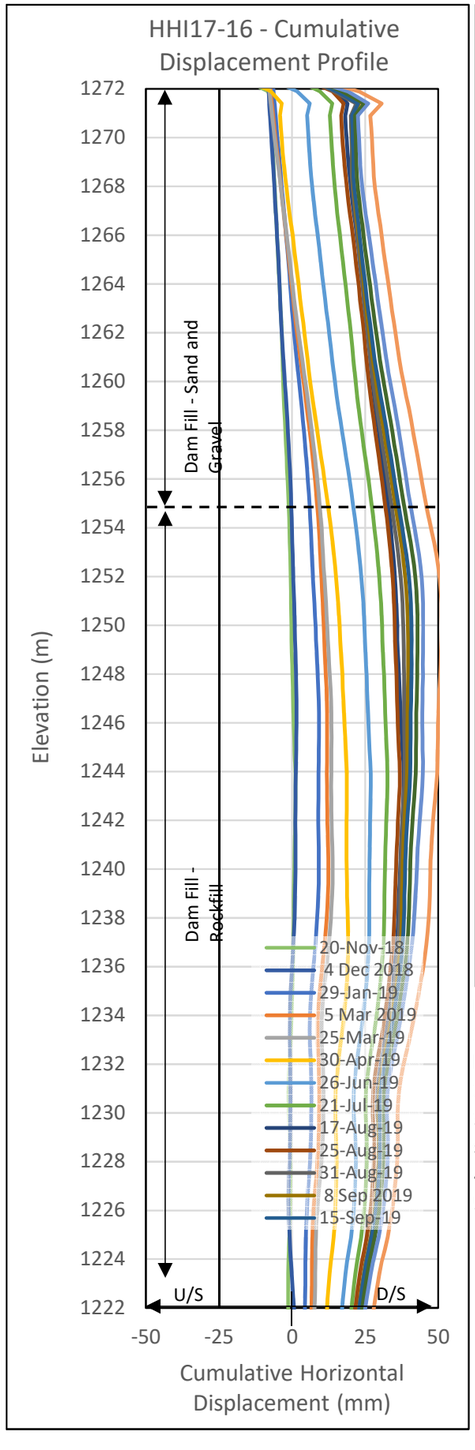
H-H Dam Vertical Displacements - HHI17-14A (Soundex)

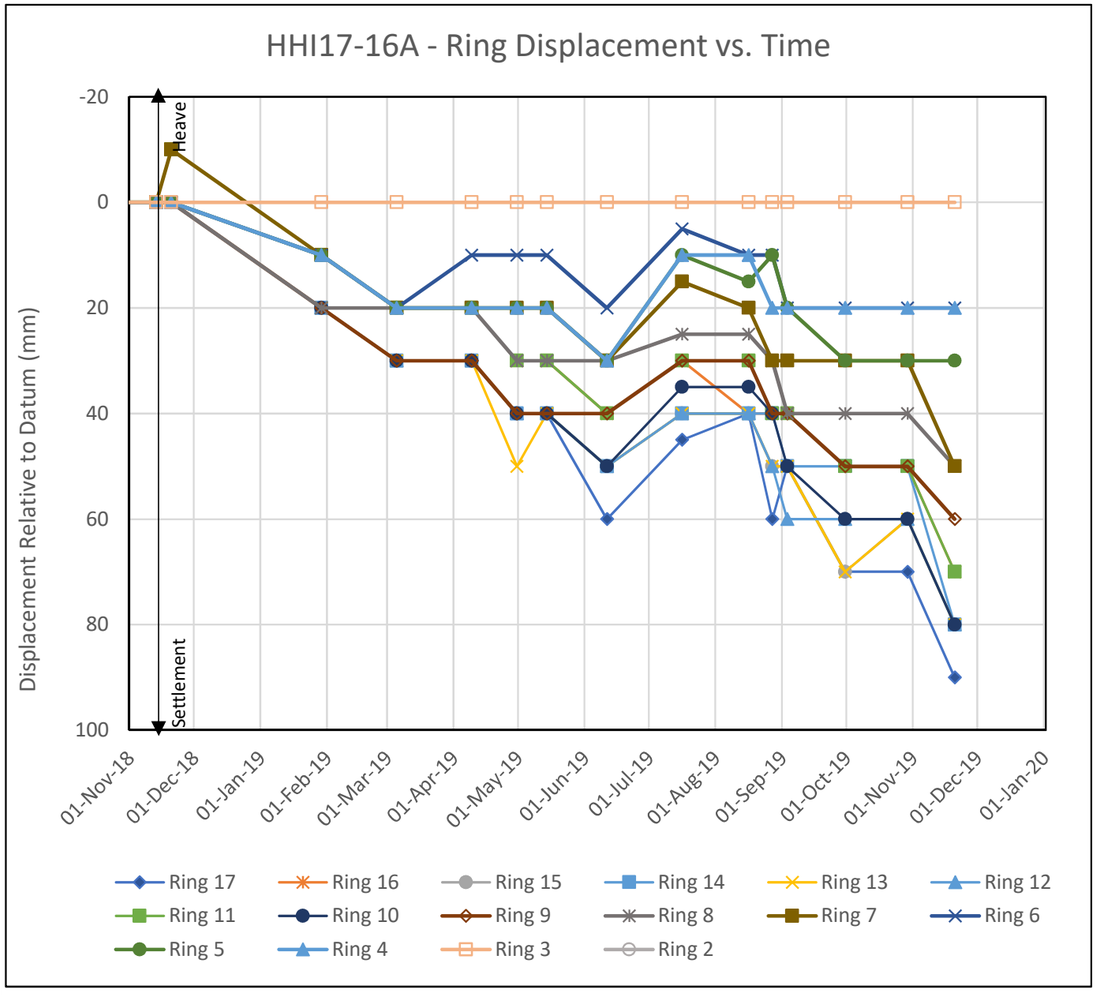
M02341B53

FILE PATH: Z:\MV\VCR\M02341B53 - HVC 2019 DAM SAFETY SUPPORT\300 DESIGN\350 INCLINOMETER AND SONDEX\352 SONDEX DATA\191218 SONDEX READINGS -REBASELINED (2019 DSI ONLY).XLSX - 2019-12-18 12:16









Notes:

1. Ring displacements are calculated relative to the elevations for each ring measured on November 13, 2018. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The Ring 12 reading from December 11, 2017 was not consistent with readings in the rings above and below, due to a suspected data entry error. The reading was adjusted to match the trends of Ring 11 and Ring 13.
4. Data from October 09, and 30, 2018 were not consistent with other readings and not showed here.
5. No readings recorded for Ring 1 and 2 after October 09, 2018

Initial readings were taken on August 16, 2017. However, to compare the settlement profiles with horizontal displacement profiles, November 13, 2018 reading (taken after collar raise) was used to calculate cumulative settlement.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

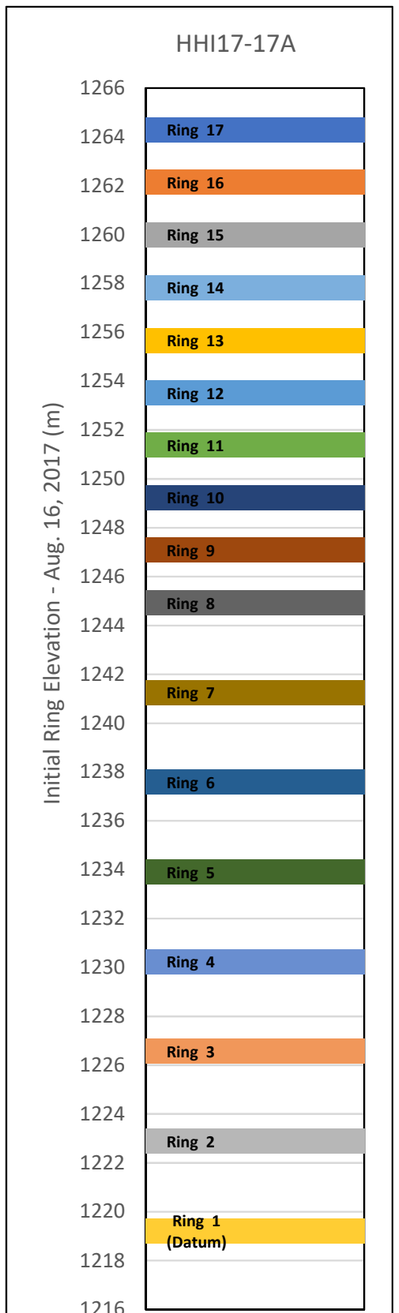
Klohn Crippen Berger

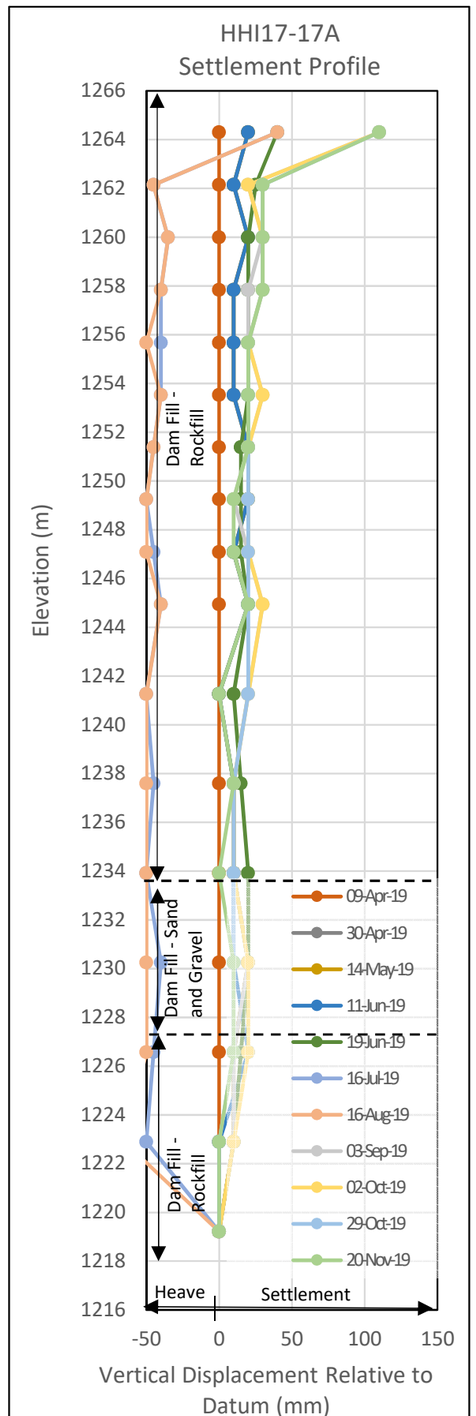
HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

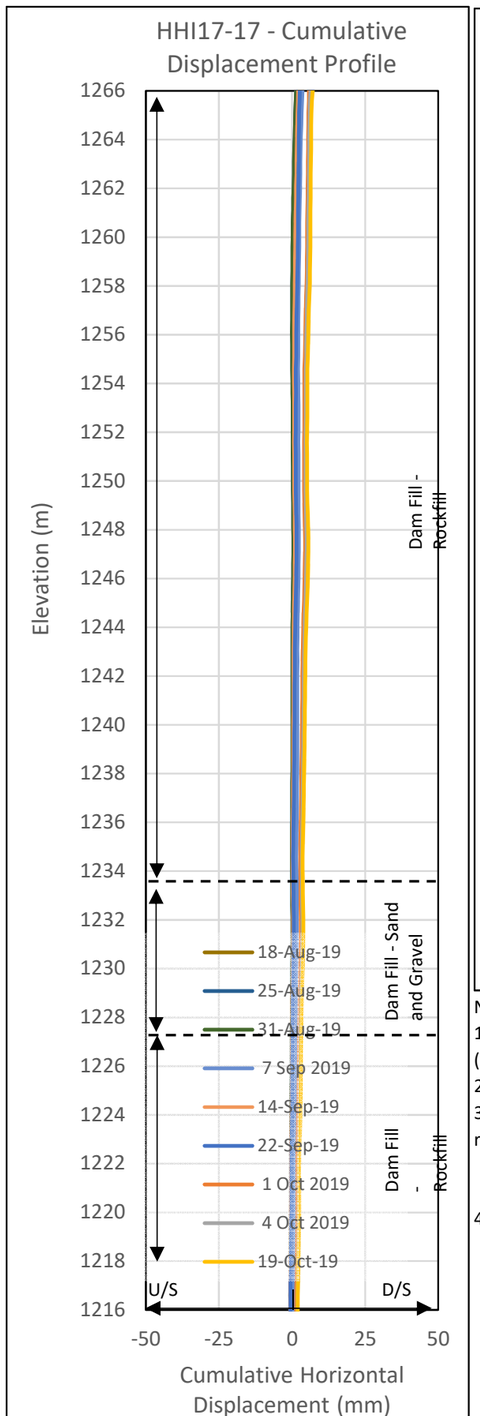
H-H Dam Vertical Displacements - HHI17-16A (Sondex)

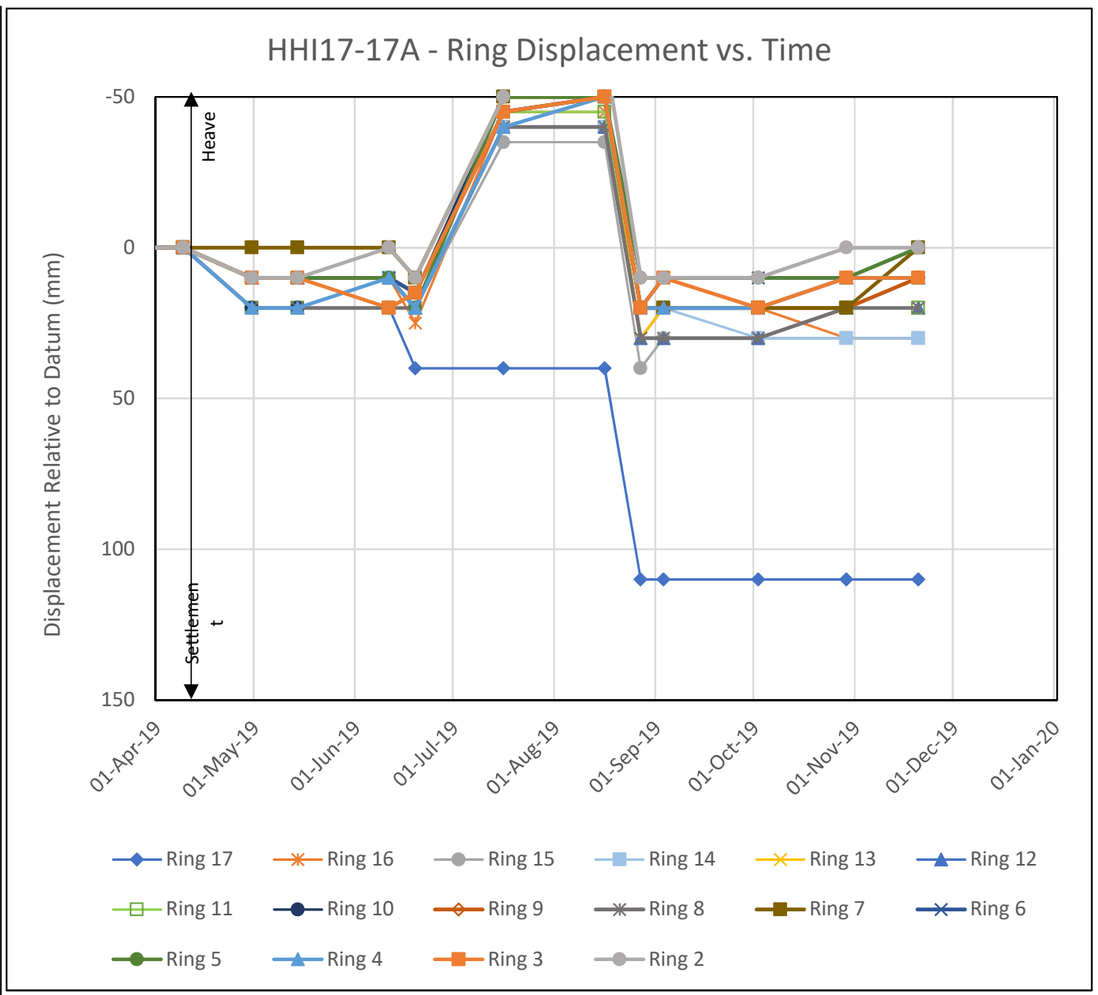
M02341B53

FILE PATH: Z:\MV\CR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\350 INCLINOMETER AND SONDEX\352 SONDEX DATA\191218 SONDEX READINGS -REBASELINED (2019 DSI ONLY).XLSX - 2019-12-18 12:16









Notes:

1. Ring displacements are calculated relative to the elevations for each ring measured on April 9, 2019. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The following readings were not consistent with readings in the rings above and below, due to suspected data entry errors. The readings were adjusted to match the trends of adjacent rings:
   -Ring 5 (December 11, 2017, January 3, 2018, February 10, 2018)
   -Ring 6 (January 3, 2018)
4. April readings were suspect to error and not shown here.

Collar was raised in January 2019. The first reading was taken in April 2019 after the raise and was used as a baseline to calculate cumulative settlement.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

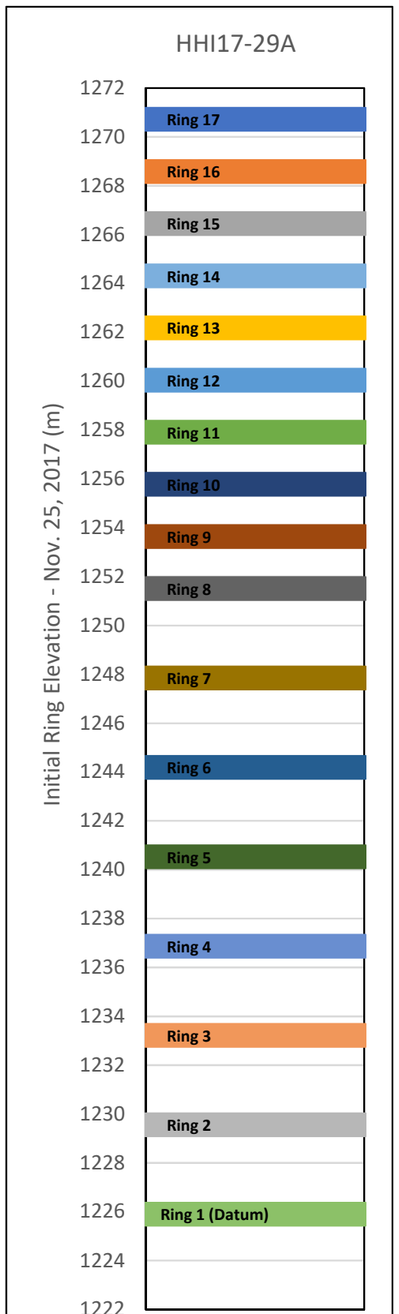
Klohn Crippen Berger

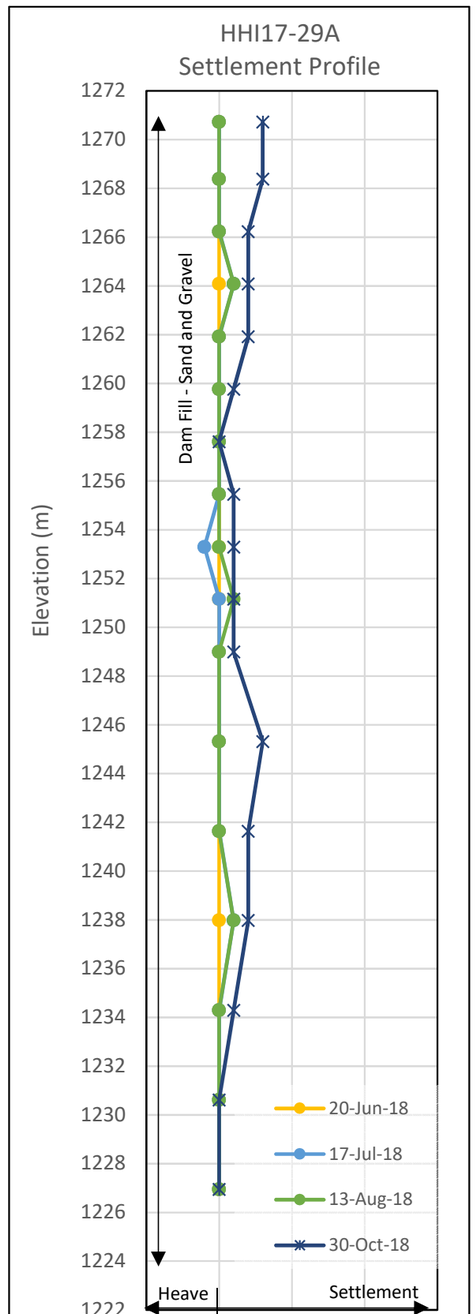
HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

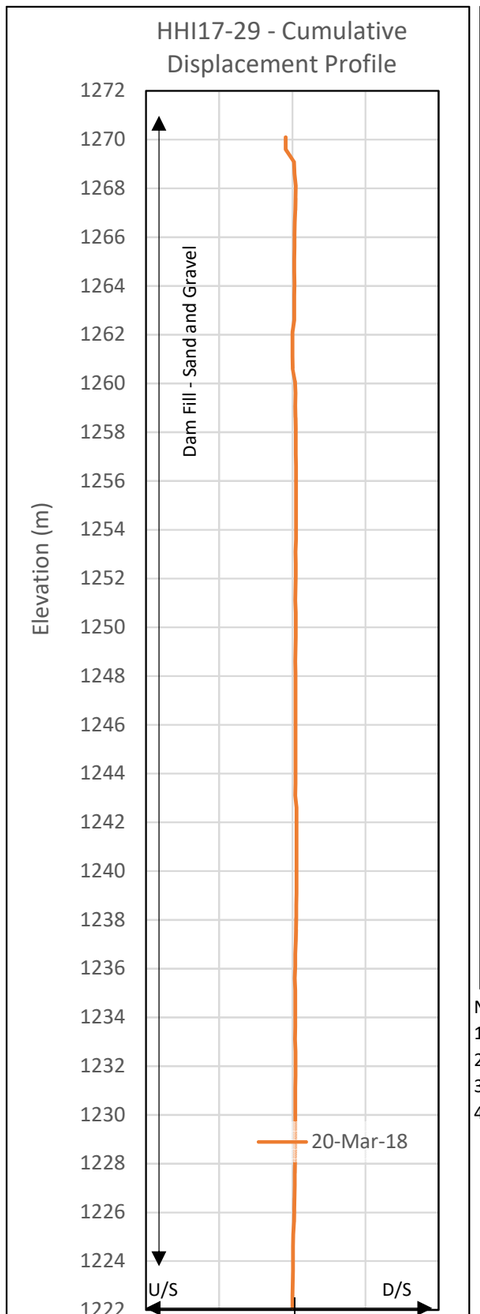
H-H Dam Vertical Displacements - HHI17-17A (Sondex)

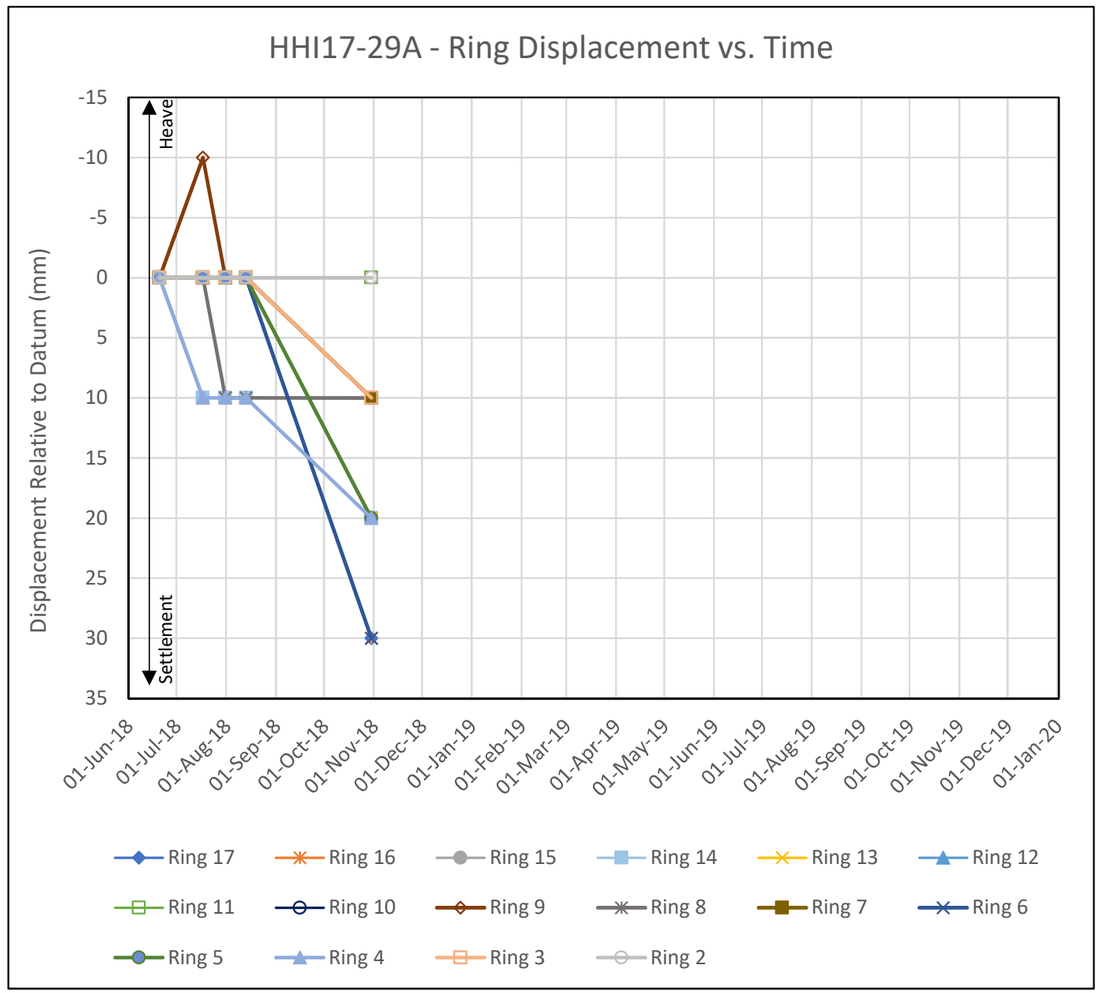
M02341B53

FILE PATH: Z:\MV\CRM\02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\350 INCLINOMETER AND SONDEX\352 SONDEX DATA\191218 SONDEX READINGS -REBASELINED (2019 DSI ONLY).XLSX - 2019-12-18 12:16









Notes:
1. Ring displacements are calculated relative to the initial elevations for each ring. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The baseline reading of vertical displacemnet plot is Jun 20, 2018.
4. No readings after October 30, 2018. Instrument is blocked at less than 5 m downhole.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

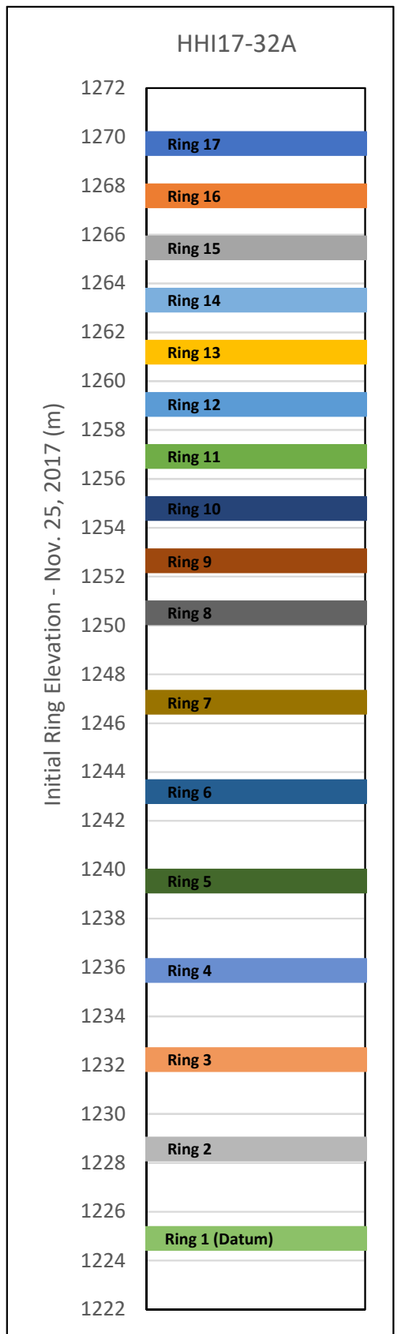
Klohn Crippen Berger

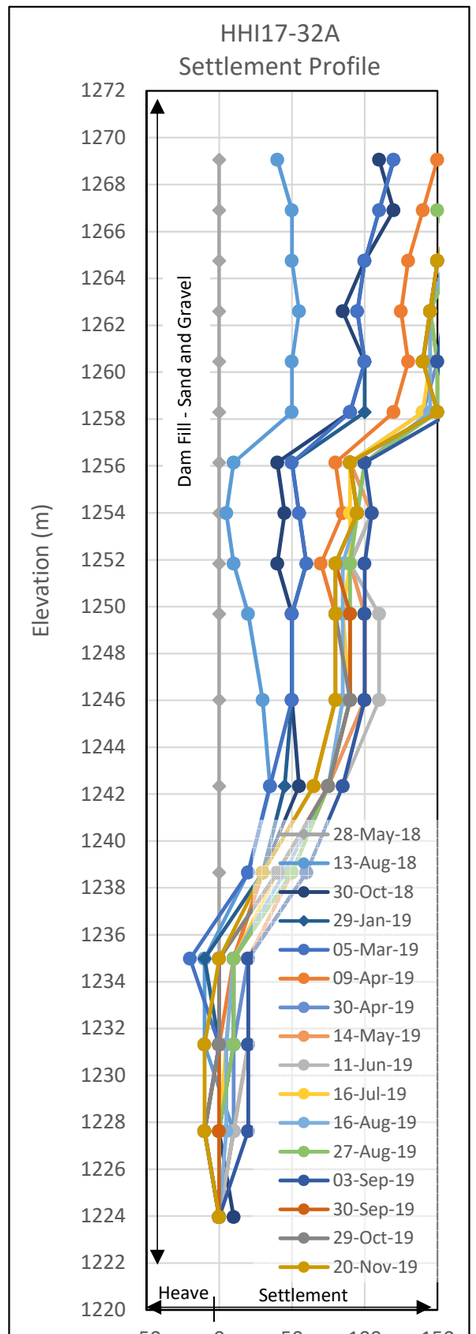
HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

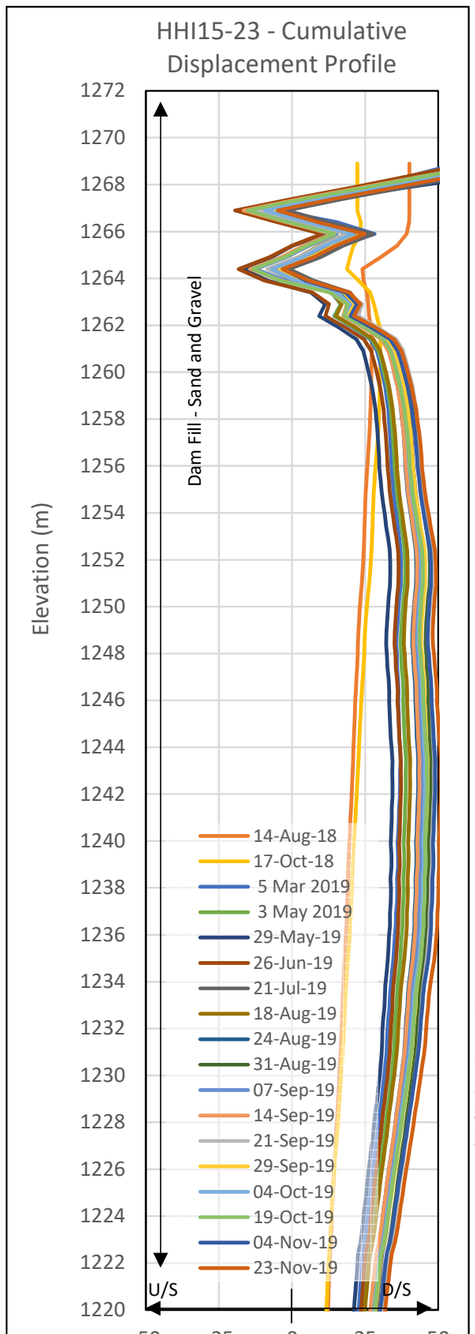
H-H Dam Vertical Displacements - HHI17-29A (Sondex)

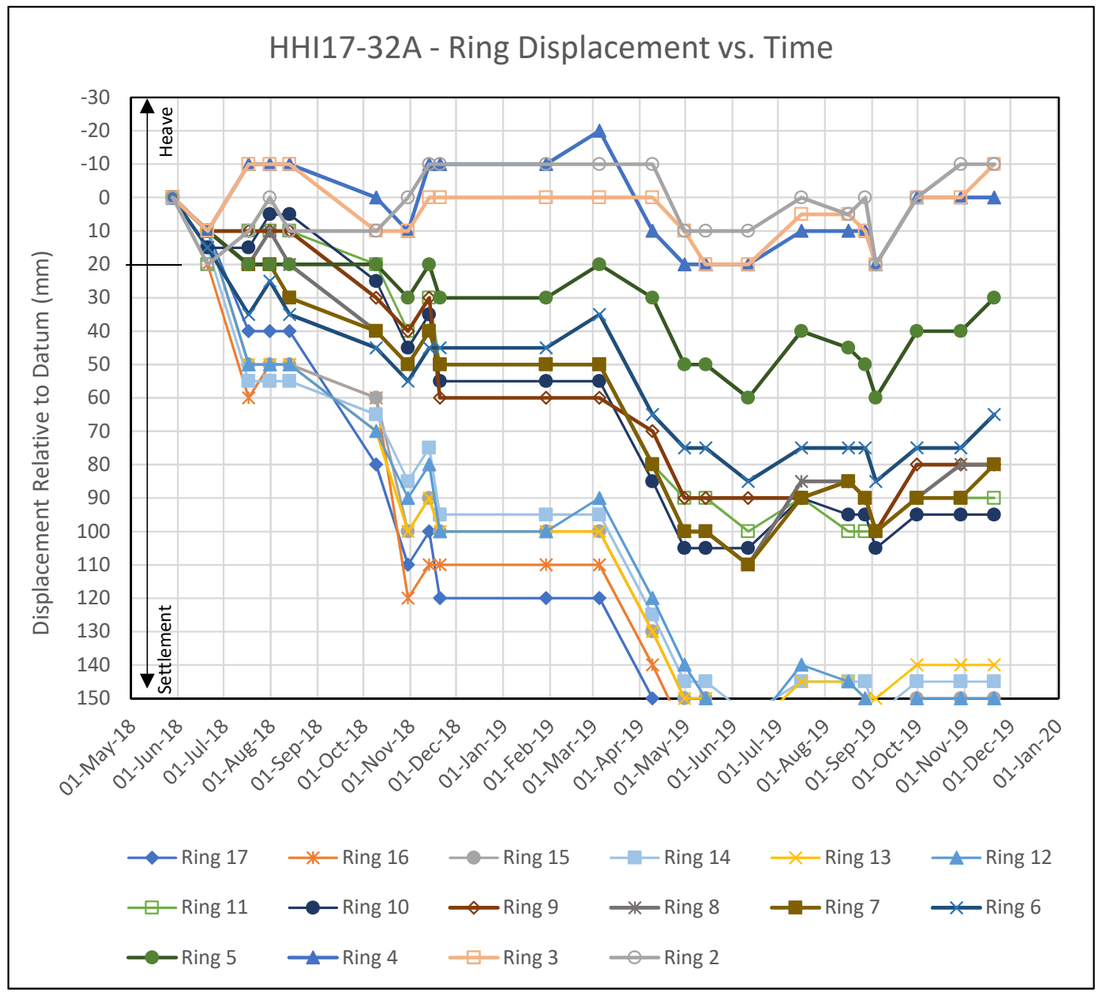
M02341B53

FILE PATH: Z:\MI\VCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\350 INCLINOMETER AND SONDEX\352 SONDEX DATA\191218 SONDEX READINGS -REBASELINED (2019 DSI ONLY).XLSX - 2019-12-18 12:16









Notes:

1. Ring displacements are calculated relative to the elevations for each ring measured on May 28, 2018. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. Readings of October 30, and November 13, 2018 were not consistent and are adjusted.
3. The baseline reading of vertical displacemnet plot is May 28, 2018.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

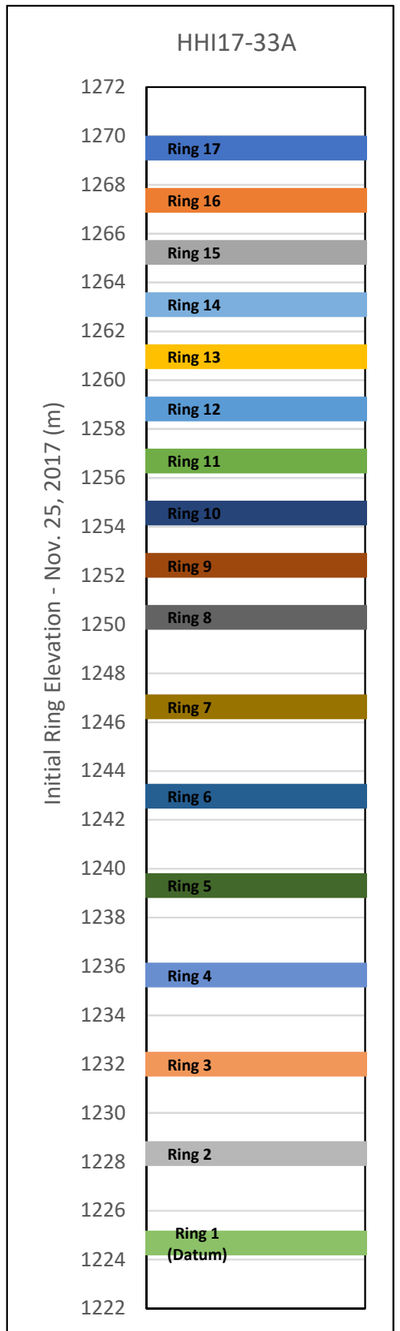
Klohn Crippen Berger

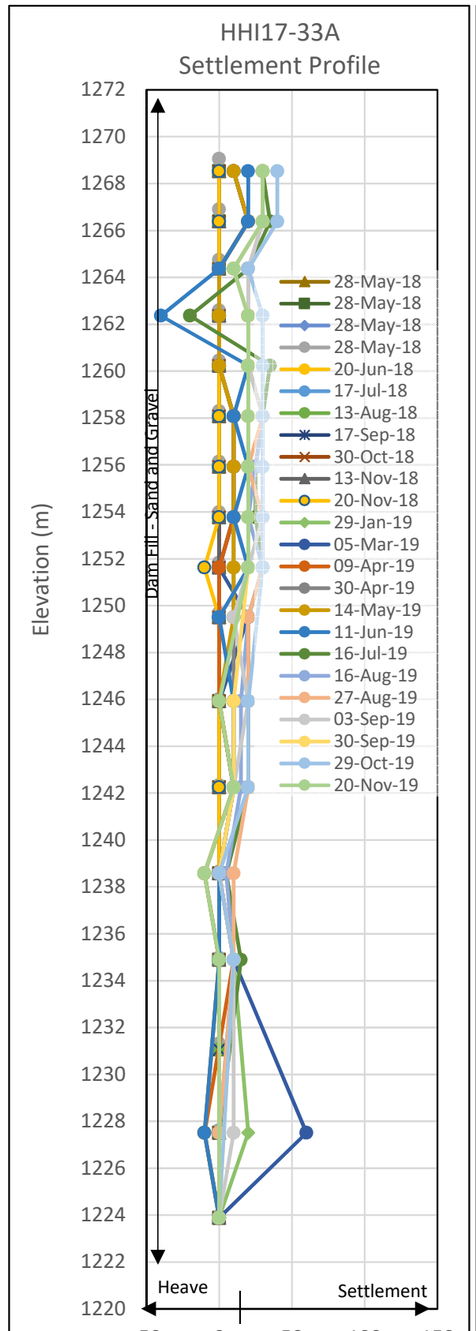
HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

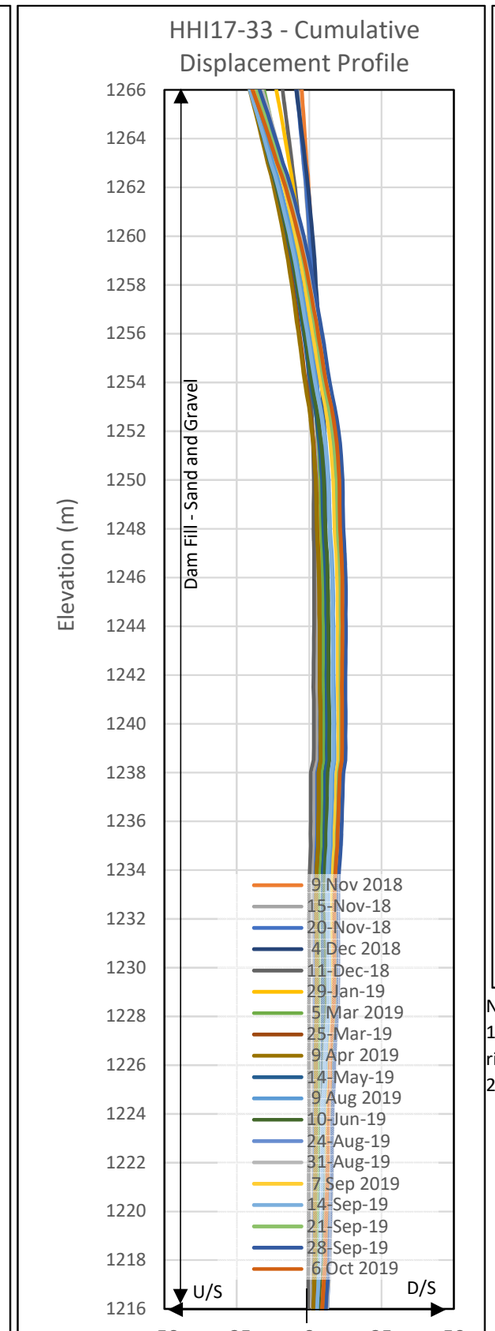
H-H Dam Vertical Displacements - HHI17-32A (Sondex)

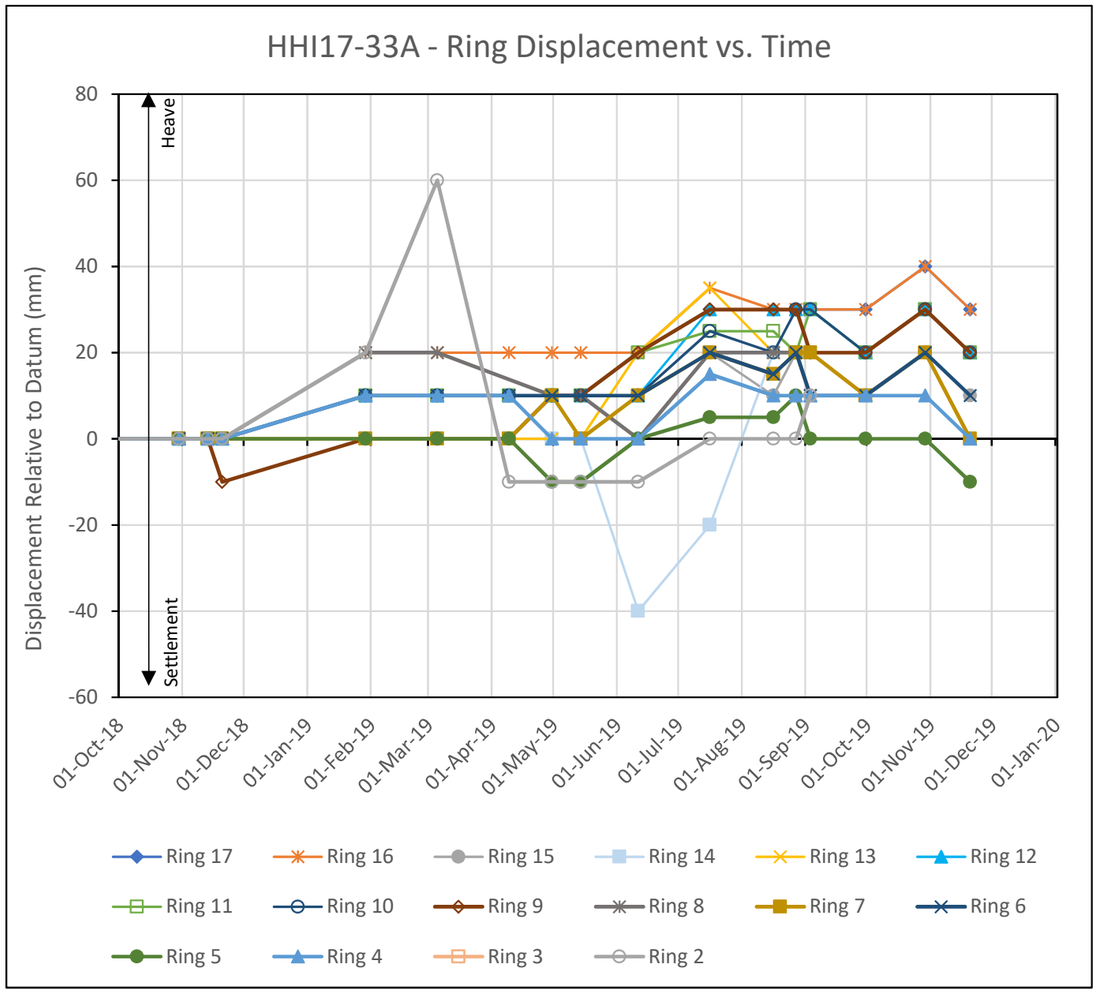
M02341B53

FILE PATH: Z:\M\VCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\350 INCLINOMETER AND SONDEX\352 SONDEX DATA\191218 SONDEX READINGS -REBASELINED (2019 DSI ONLY).XLSX - 2019-12-18 12:16









Notes:
1. Ring displacements are calculated relative to the elevations for each ring measured on October 30, 2018. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.

- Initial readings were taken on December 01, 2017. However, to compare the settlement profiles with horizontal displacement profiles, October 30, 2018 reading (taken after collar raise) was used to calculate cumulative settlement.
- Reading of Ring 3 in September 2018 is suspected to error. This ring became off-line after this date.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

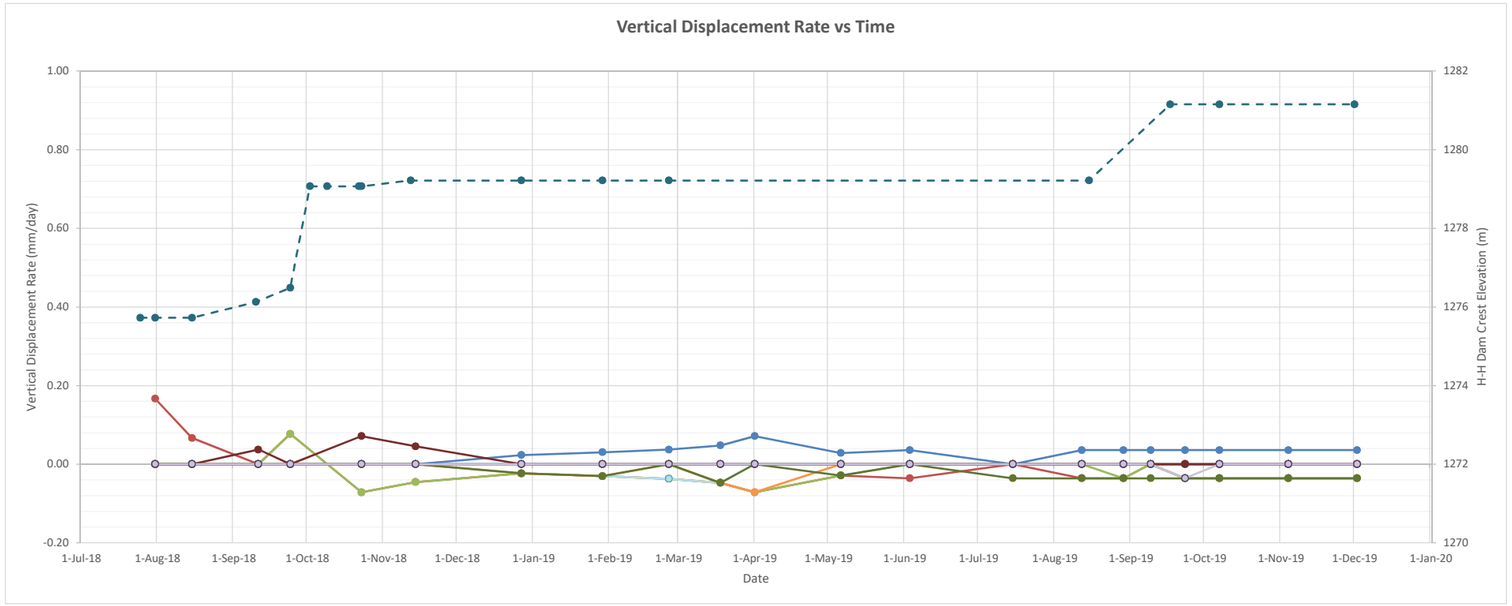
H-H Dam Vertical Displacements - HHI17-33A (Sondex)

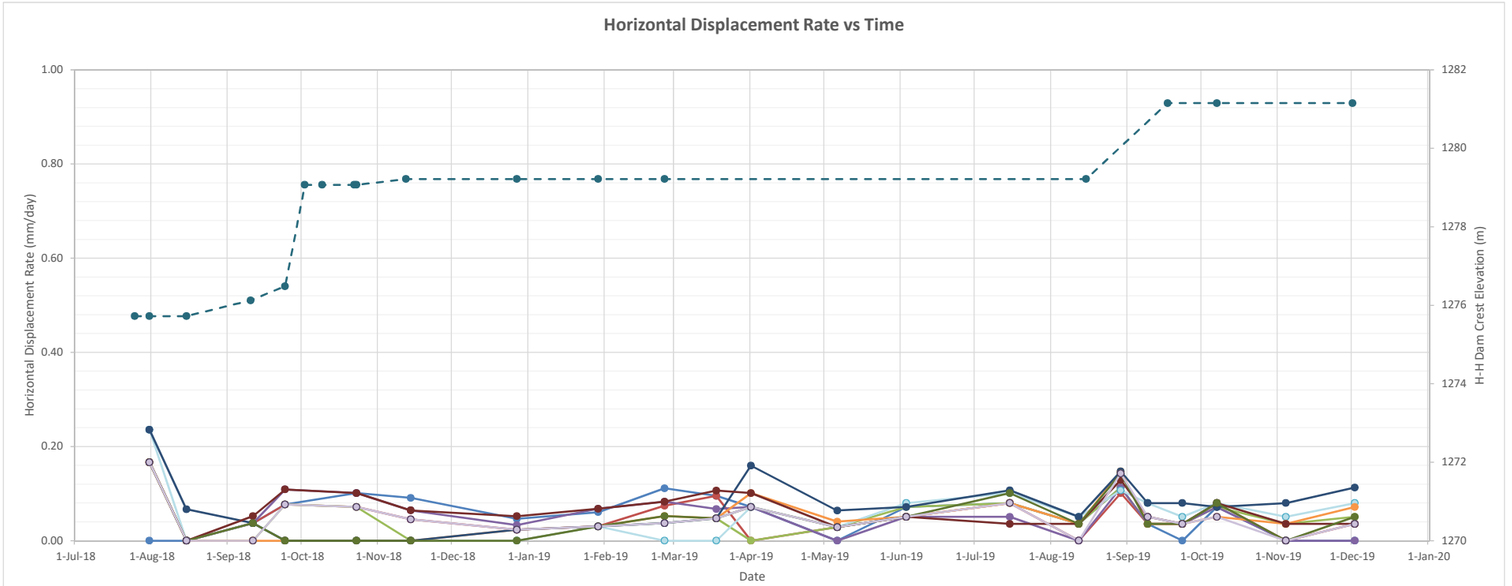
M02341B53

FILE PATH: Z:\MV\CR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\350 INCLINOMETER AND SONDEX\352 SONDEX DATA\191218 SONDEX DATA\191218 SONDEX READINGS -REBASELINED (2019 DSI ONLY).XLSX - 2019-12-18 12:16

APPENDIX VI-C

H-H Dam Monument Data





NOTES:

1. All data provided by THVCP.
2. Till Core raise timeline is approximate.

January 23, 2020
Z:\MVCN\M02341B53 - HVC 2019 Dam Safety Support\300 Design\370 Survey Monument\H-H Dam\[200123 HH Pumphouse Retaining Wall Monitoring DSI Figs.xlsm]Data

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

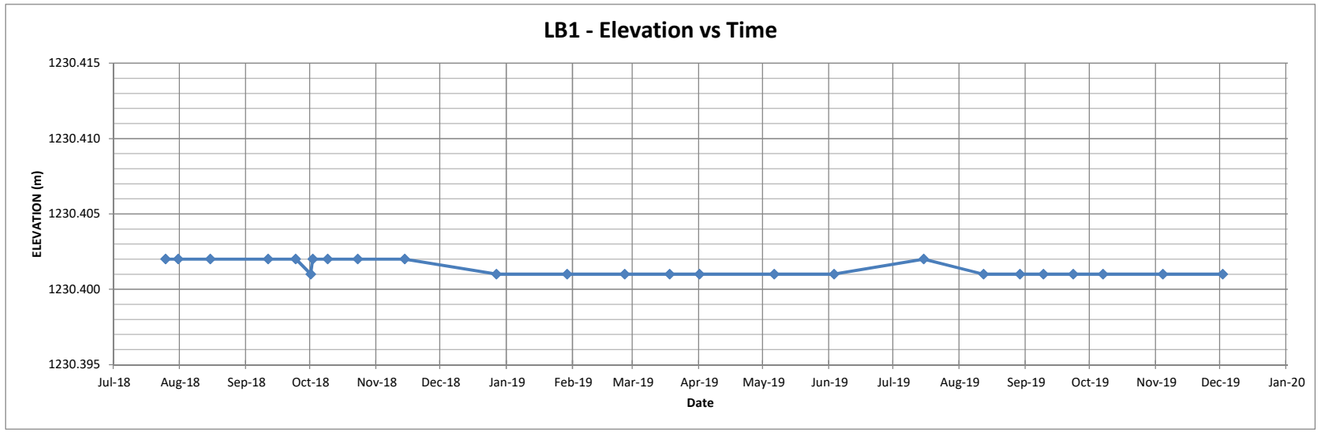
Klohn Crippen Berger

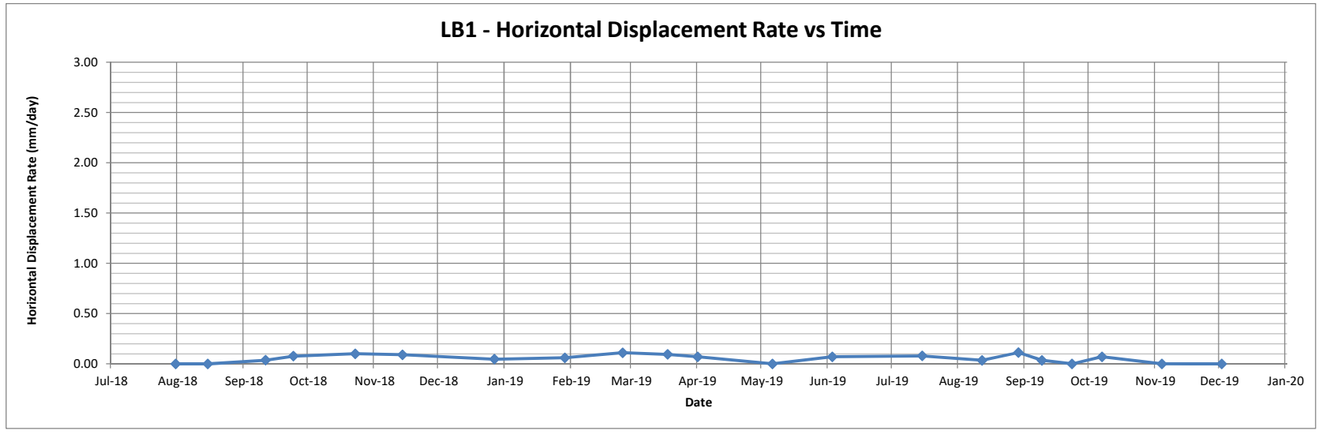
PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

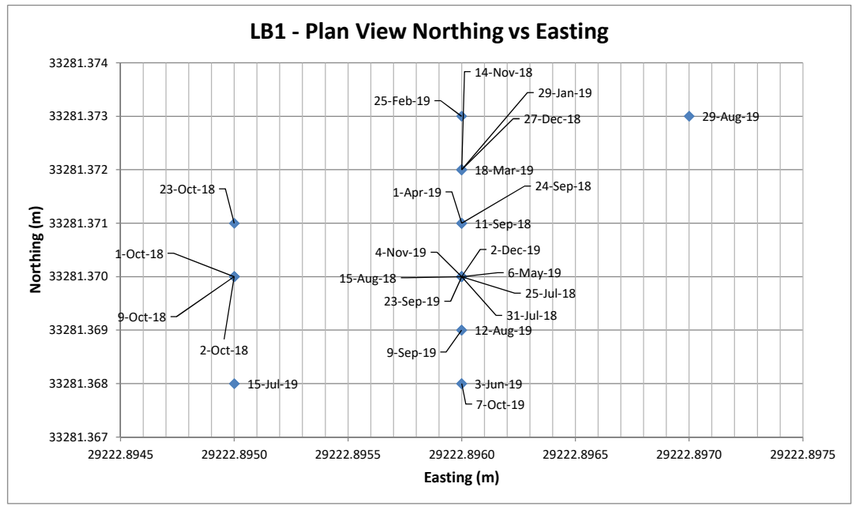
TITLE
H-H DAM LOCK-BLOCK RETAINING WALL SURVEY MONUMENT READINGS SUMMARY

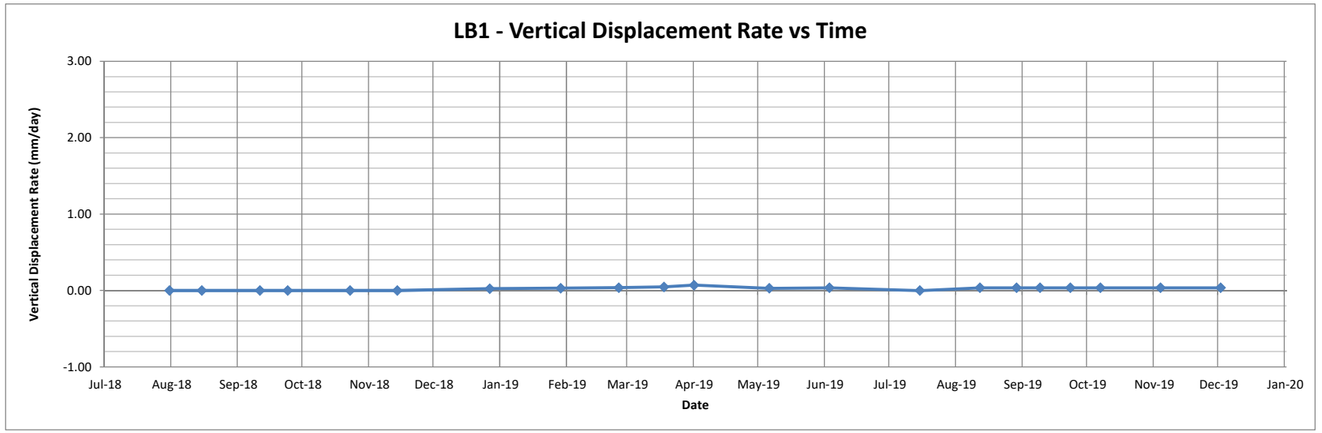
PROJECT No. M02341B53

FIG No. VI-C-1









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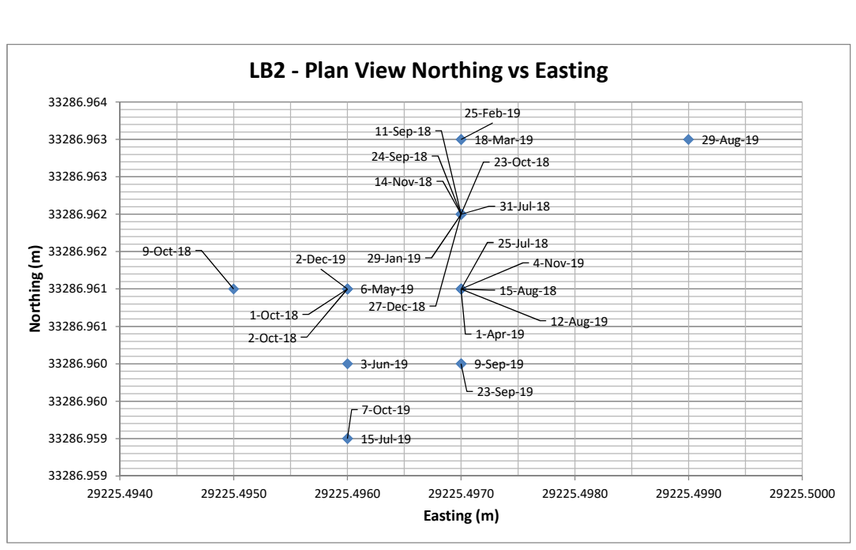
PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

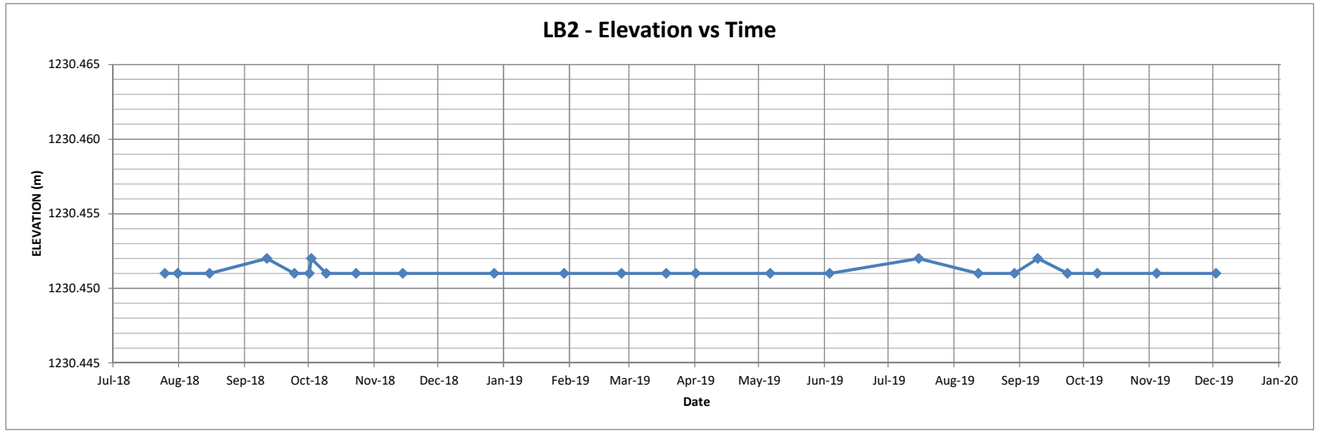
TITLE
H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB1

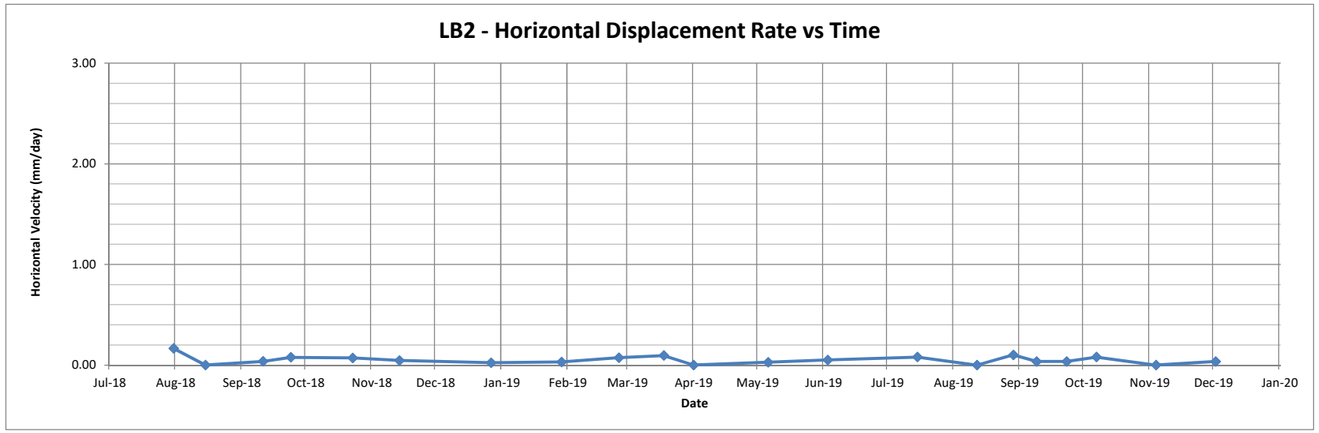
PROJECT No. M02341B53

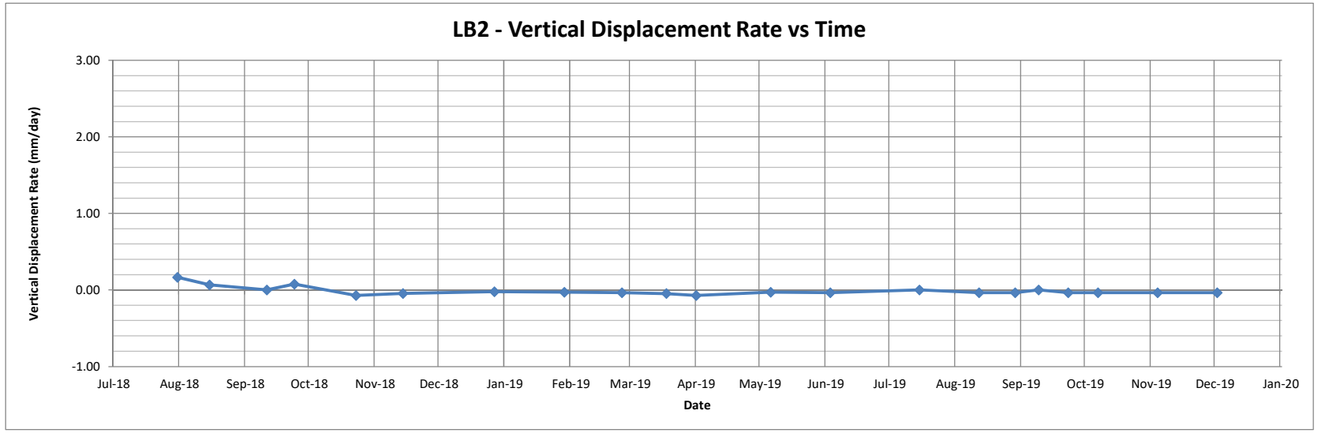
FIG No. VI-C-2

January 29, 2020
Z:\MVCR\M02341B53 - HVC 2019 Dam Safety Support\300 Design\370 Survey Monument\H-H Dam\[200123 HH Pumphouse Retaining Wall Monitoring DSI Figs.xlsm]Data









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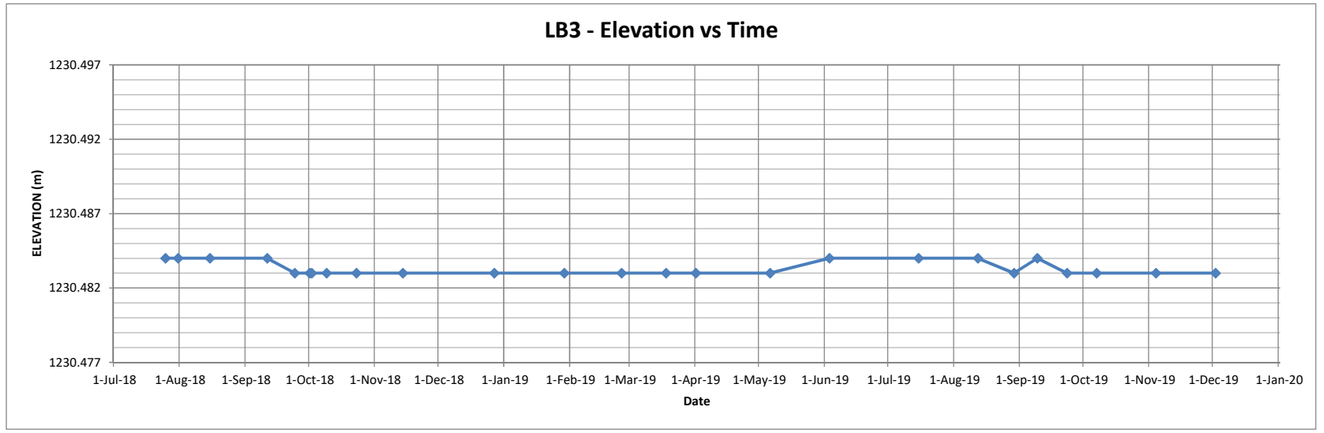
2019 DAM SAFETY INSPECTION

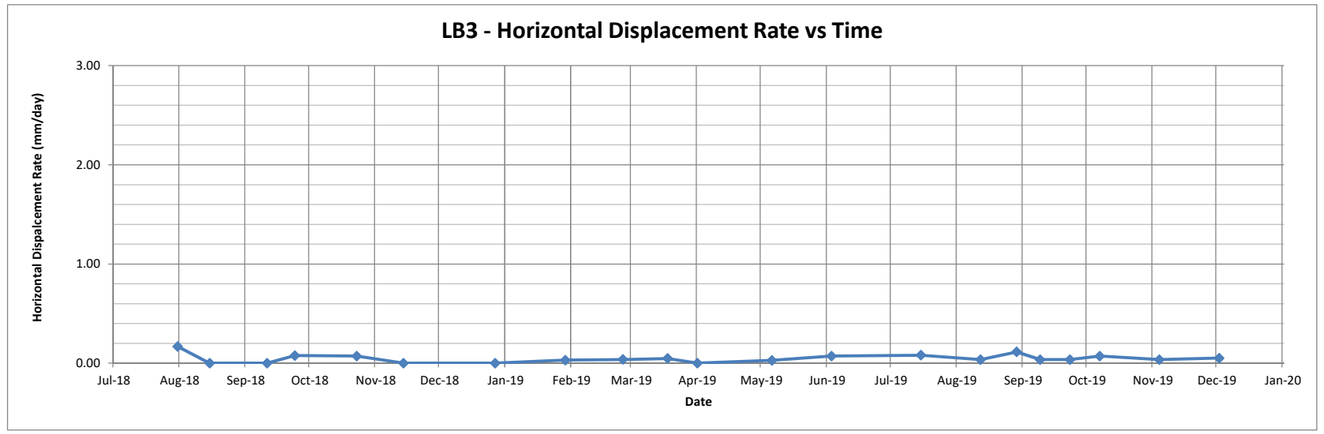
TITLE
H-H DAM LOCK-BLOCK RETAINING WALL SURVEY MONUMENT READINGS
LB2

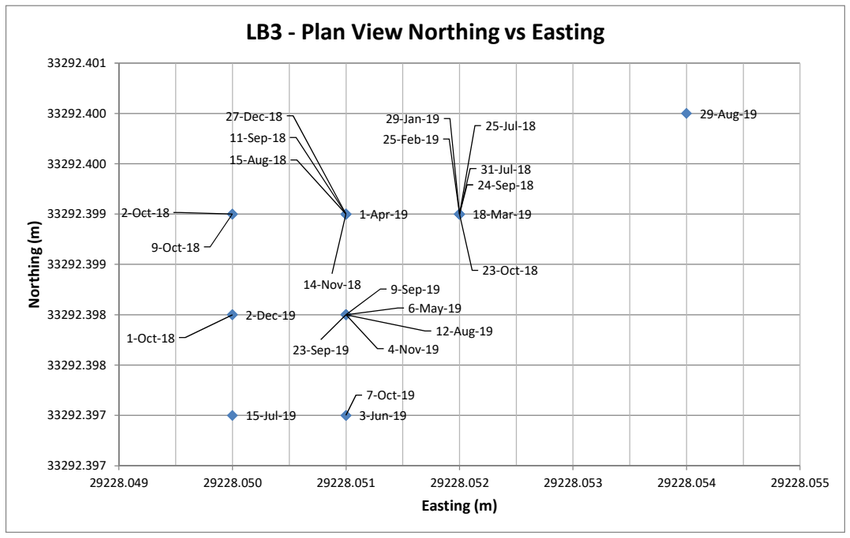
PROJECT No. M02341B53

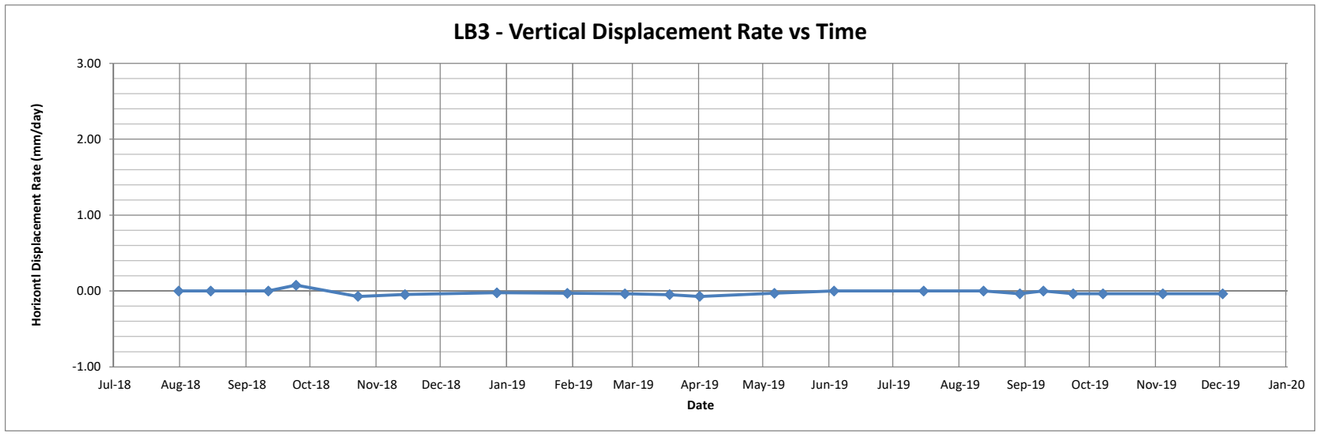
FIG No. VI-C-3

January 29, 2020
Z:\MVCR\M02341B53 - HVC 2019 Dam Safety Support\300 Design\370 Survey Monument\H-H Dam\[200123 HH Pumphouse Retaining Wall Monitoring DSI Figs.xlsm]Data









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2019 DAM SAFETY INSPECTION

TITLE
H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB3

PROJECT No. M02341B53

FIG No. VI-C-4

January 29, 2020
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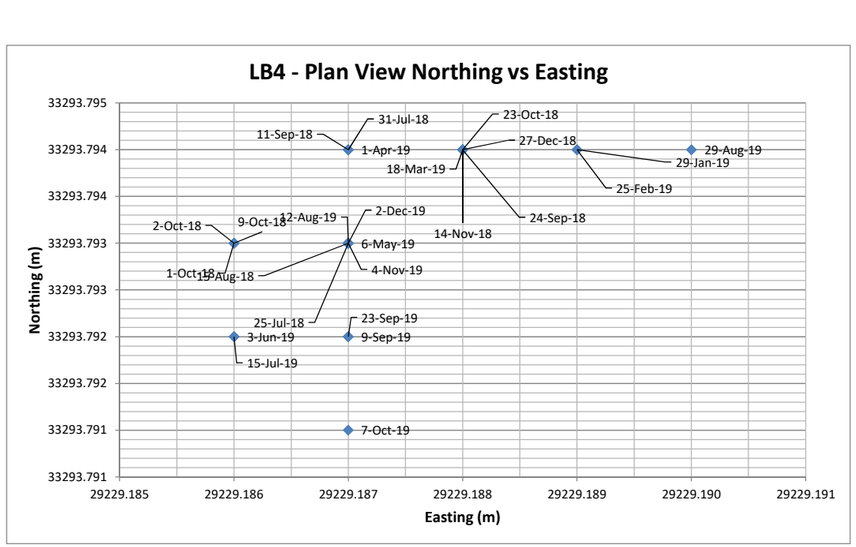

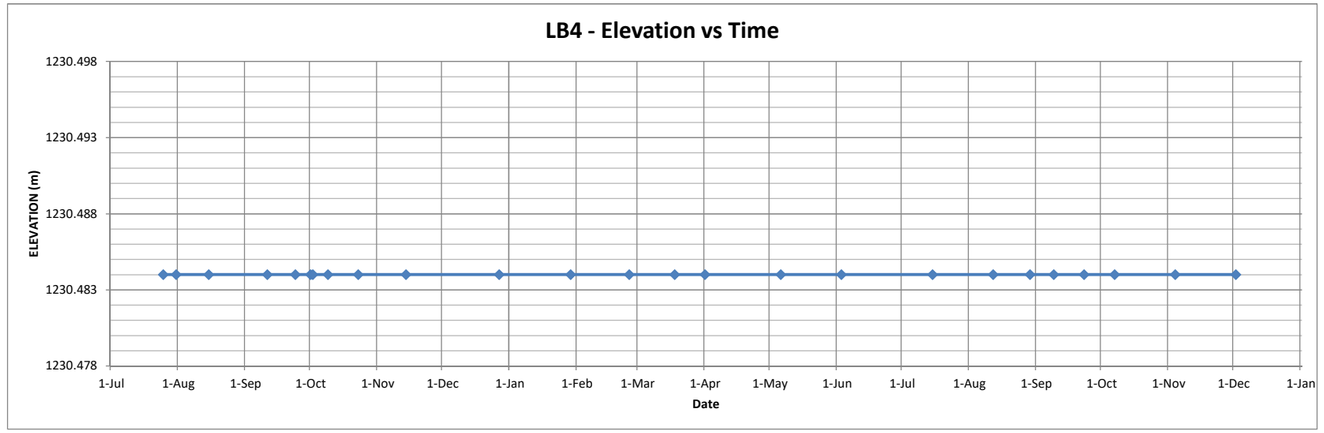

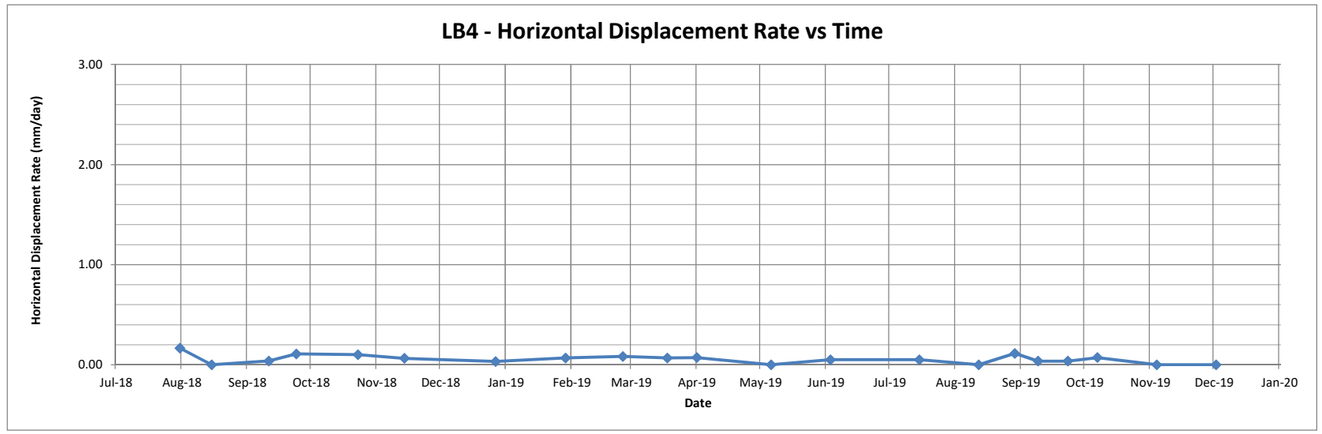

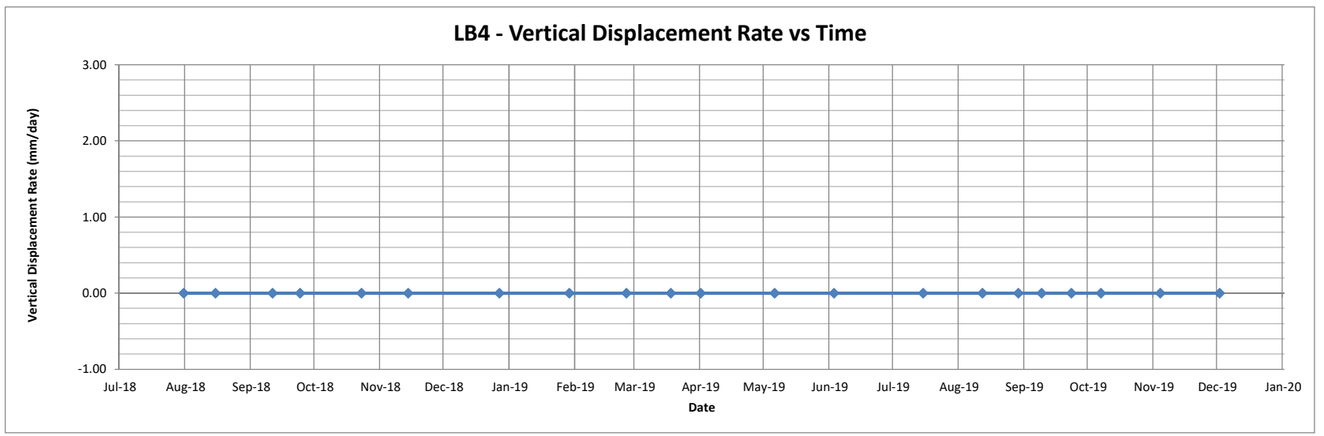

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2019 DAM SAFETY INSPECTION

TITLE: H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB4

PROJECT No. M02341B53

FIG No. VI-C-5

January 23, 2020
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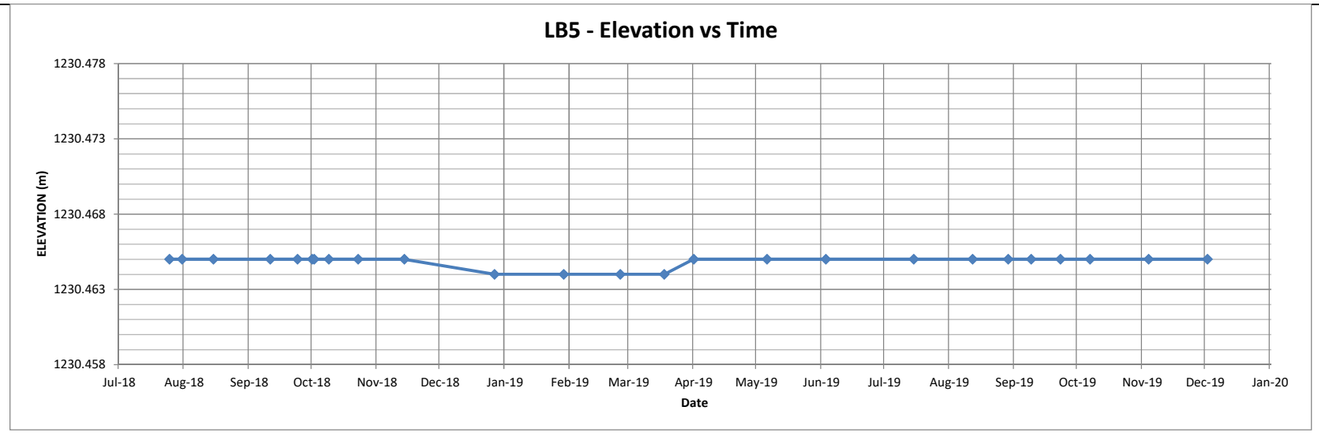

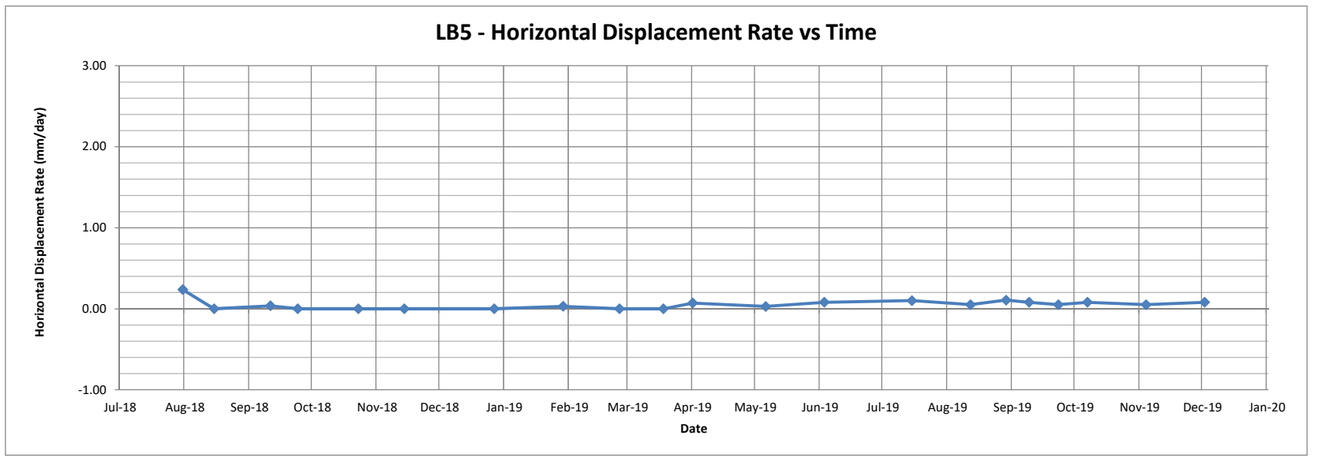

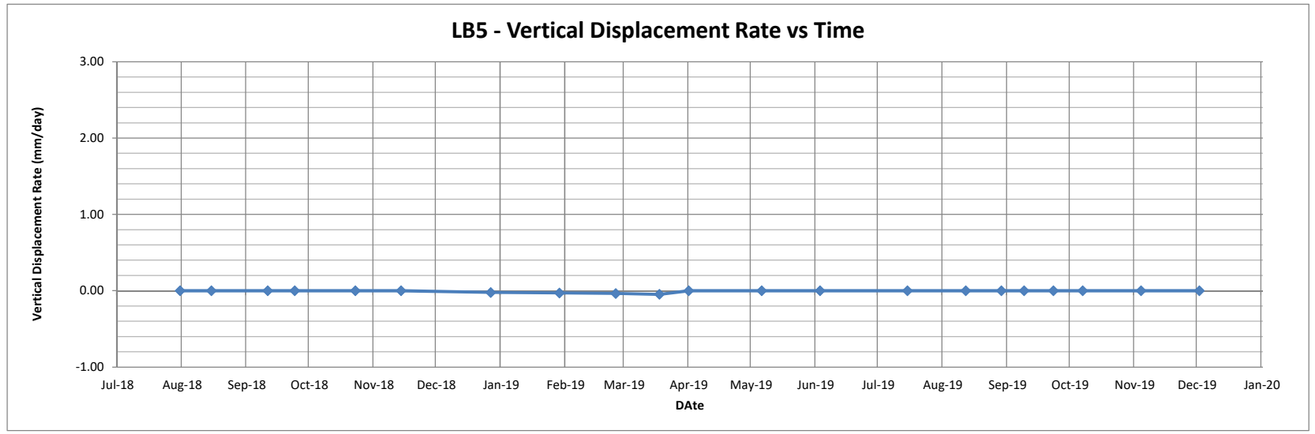

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PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB5

PROJECT No. M02341B53

FIG No. VI-C-6

January 23, 2020
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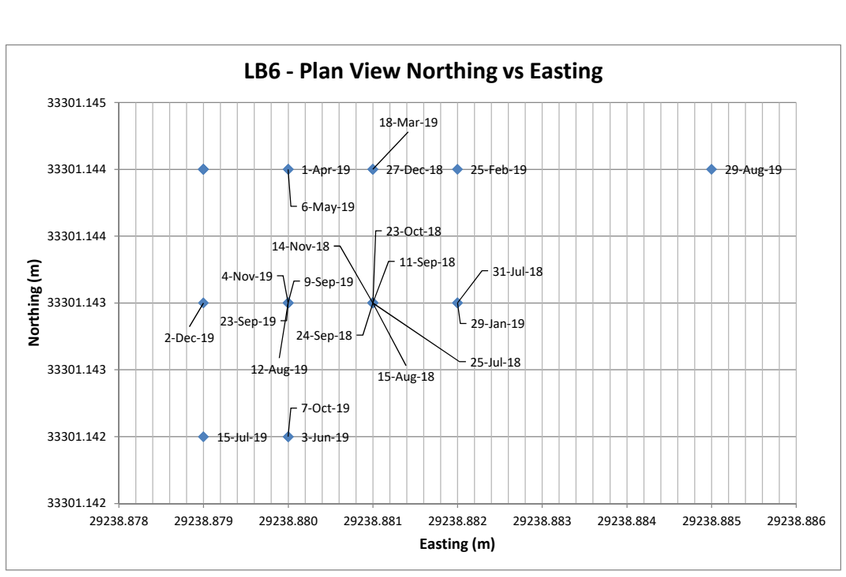

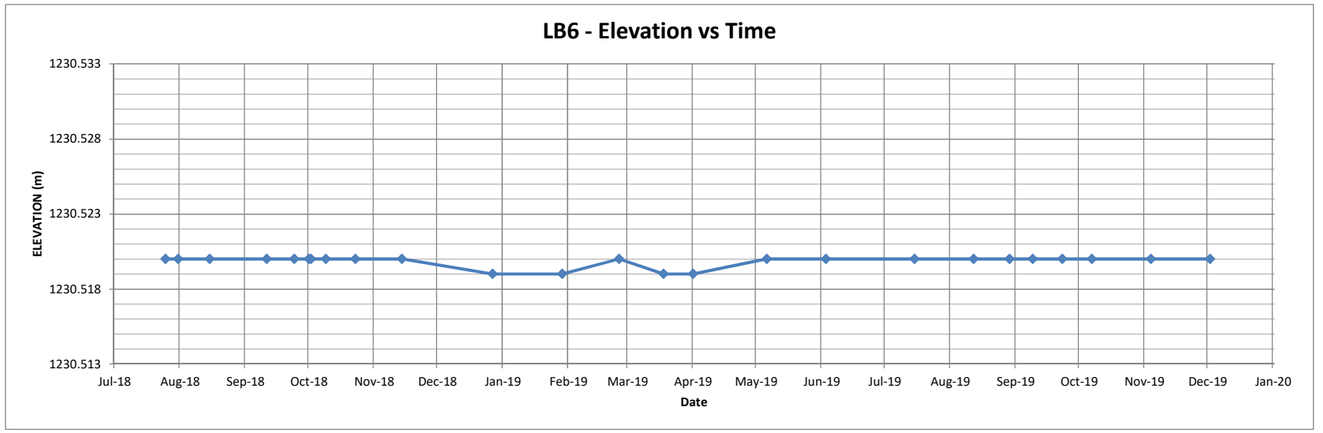

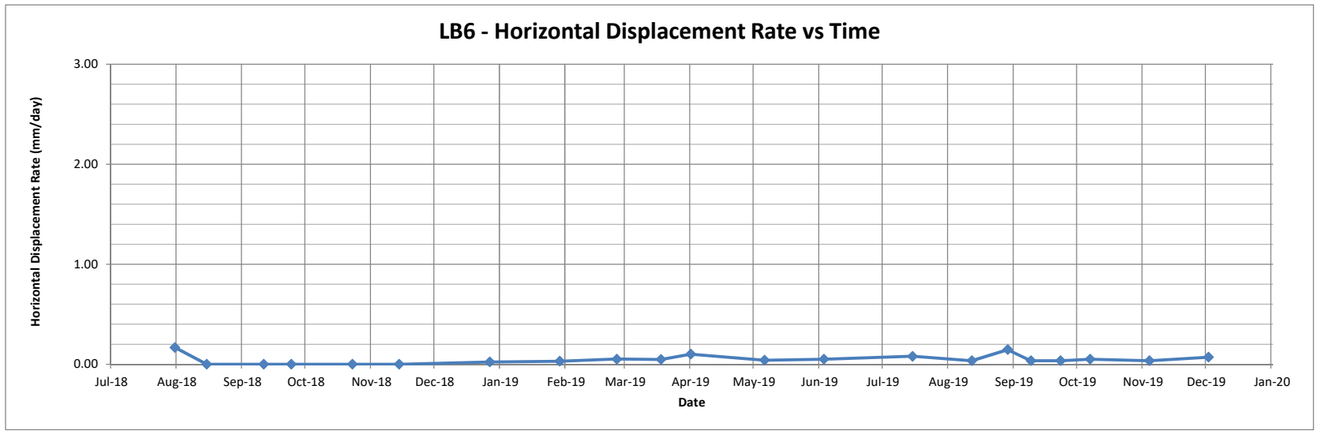

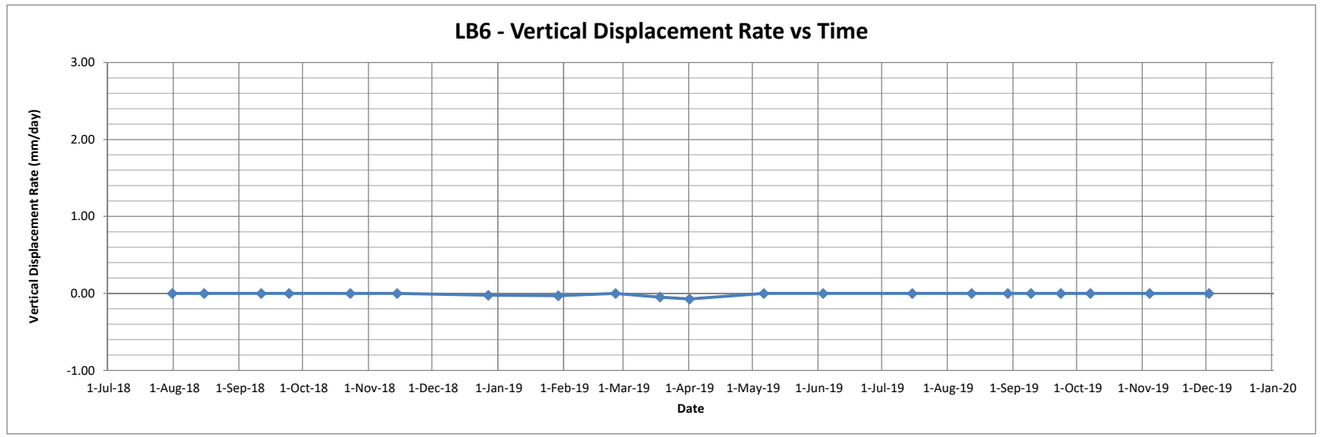

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TITLE: H-H DAM LOCK-BLOCK RETAINING WALL SURVEY MONUMENT READINGS
LB6

PROJECT No. M02341B53

FIG No. VI-C-7

January 29, 2020
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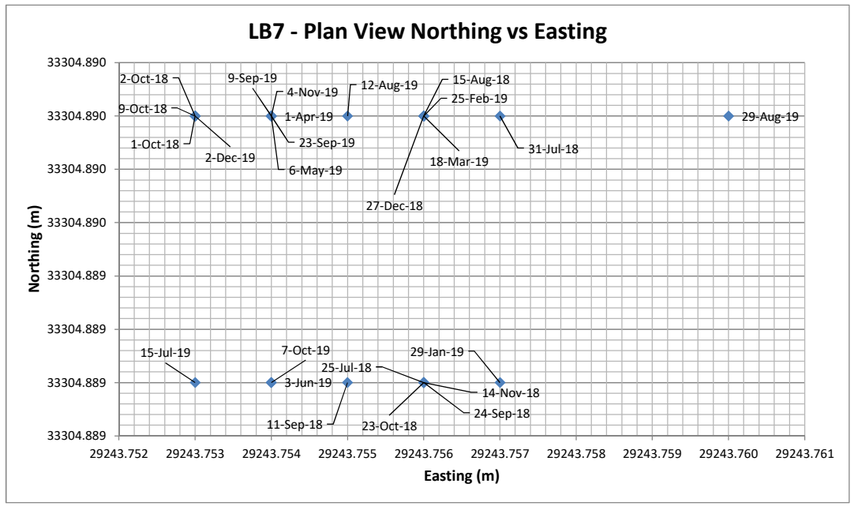

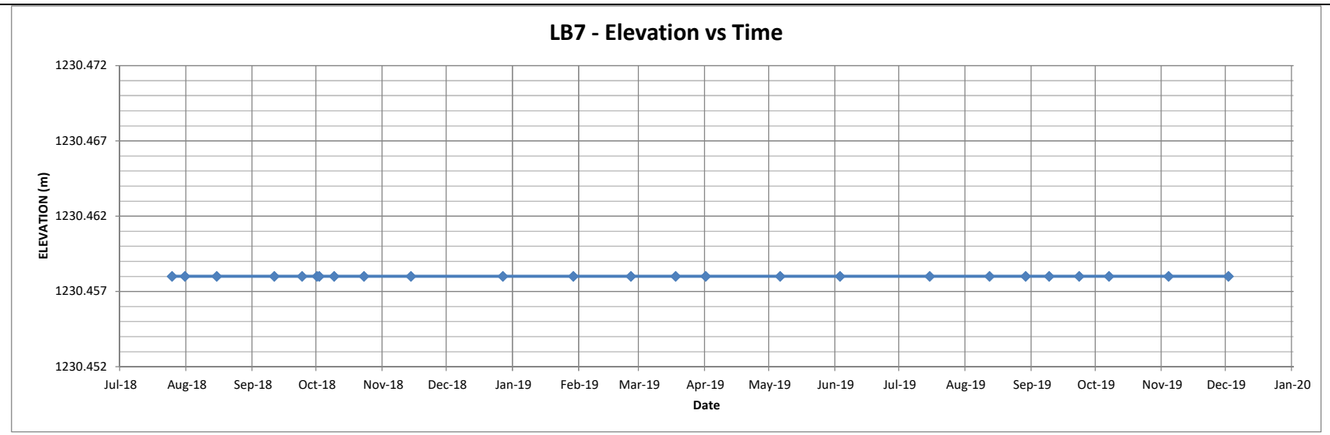

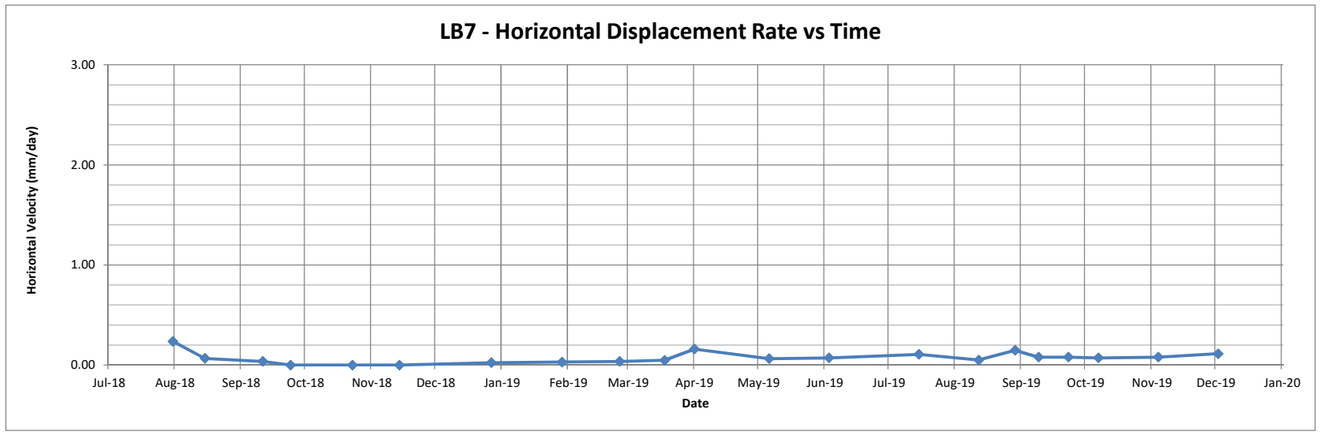

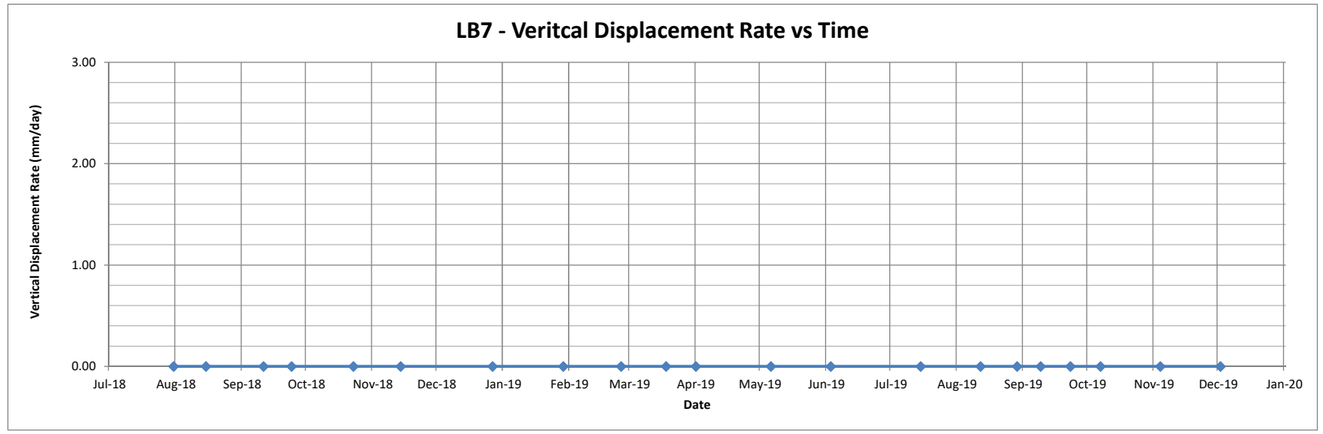

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2019 DAM SAFETY INSPECTION

TITLE: H-H DAM LOCK-BLOCK RETAINING WALL SURVEY MONUMENT READINGS LB7

PROJECT No. M02341B53

FIG No. VI-C-8

January 23, 2020
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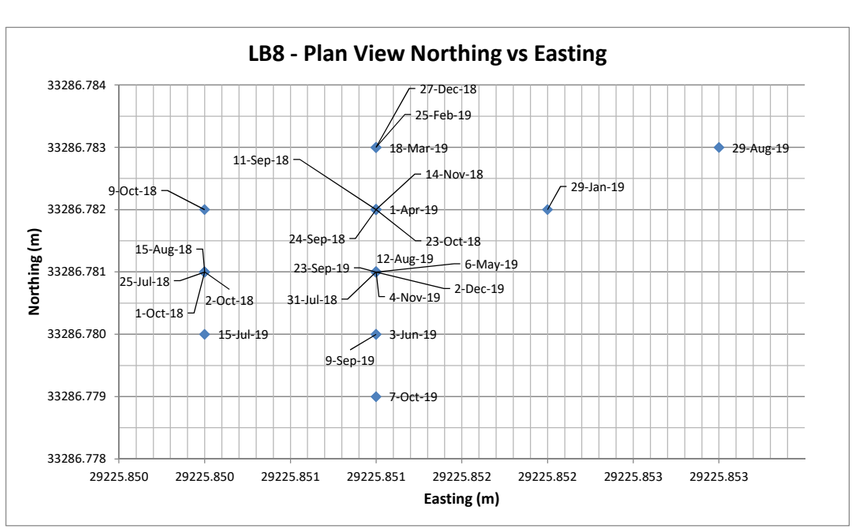

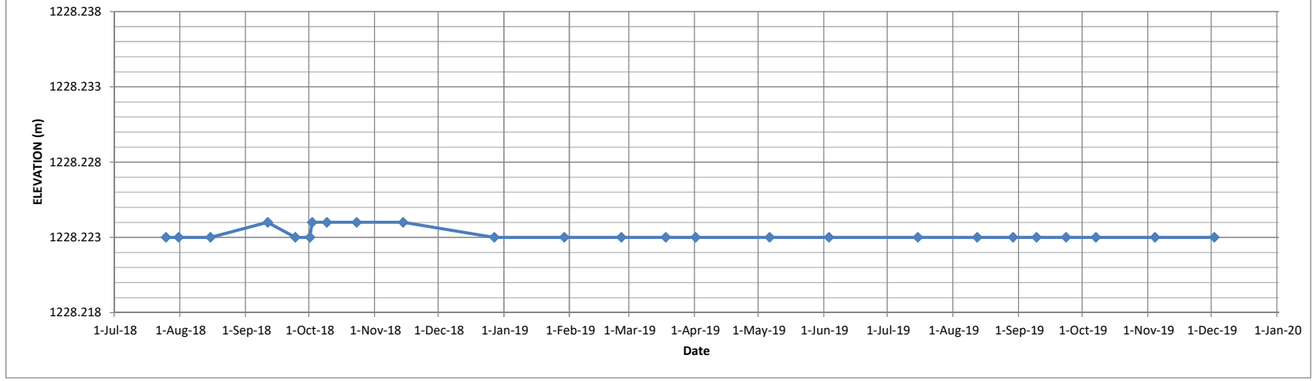

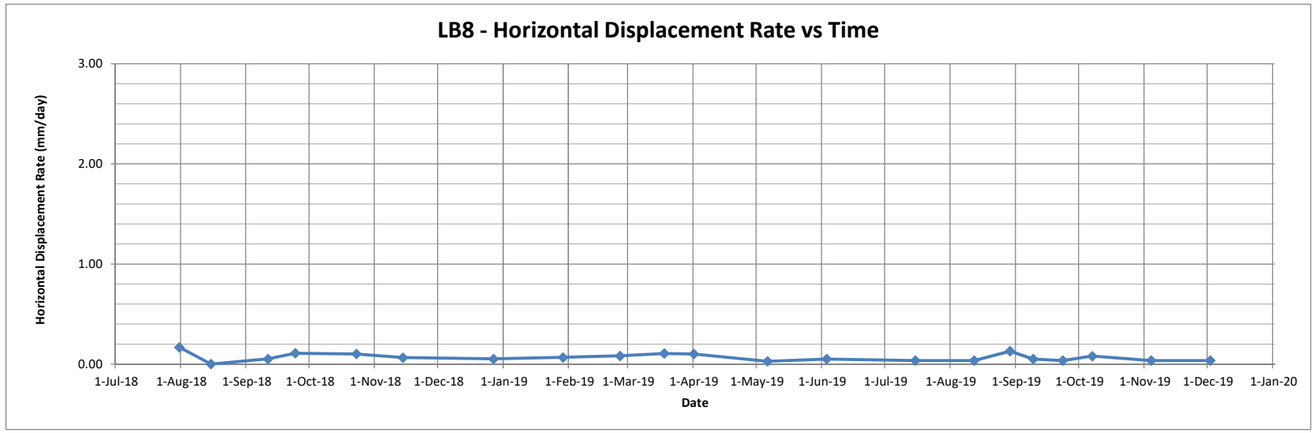

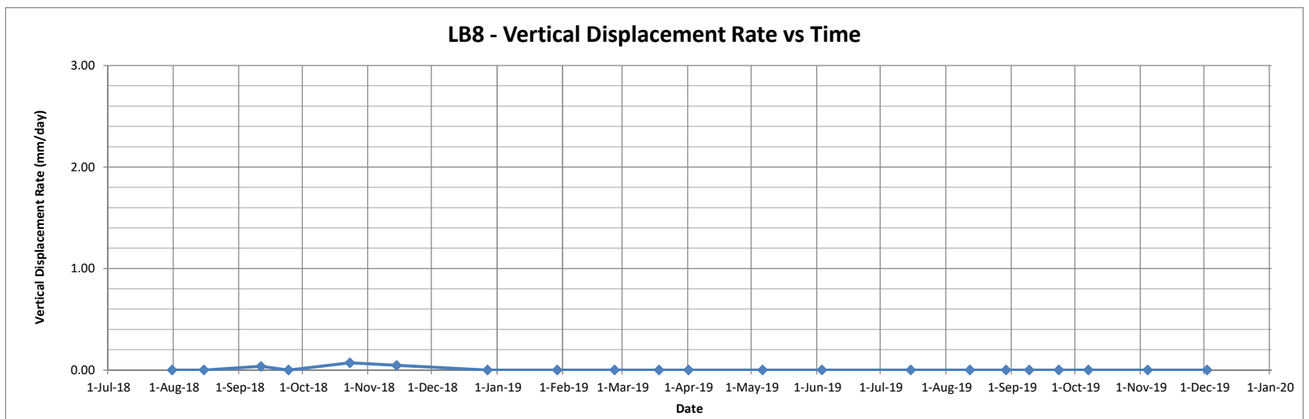

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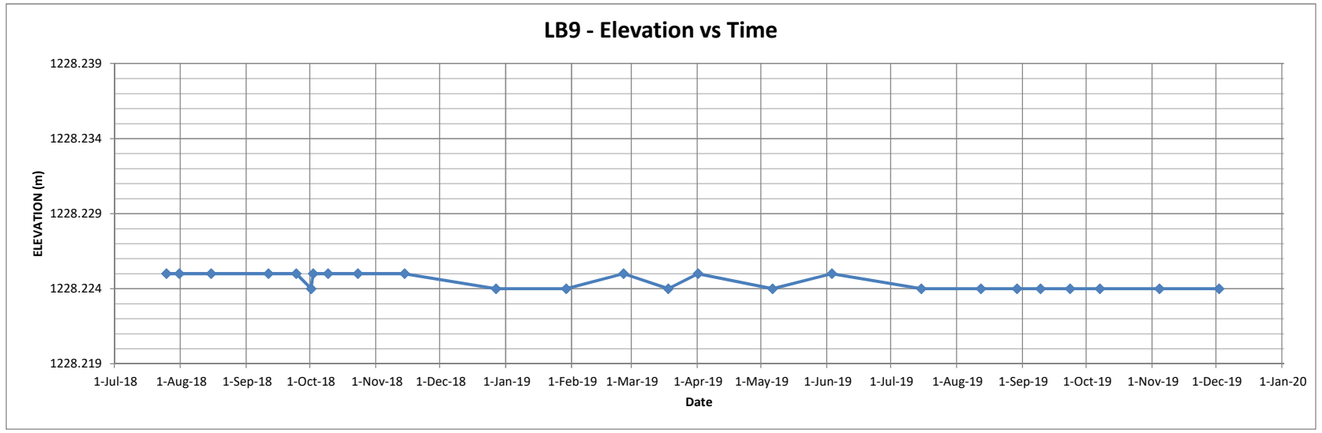
PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

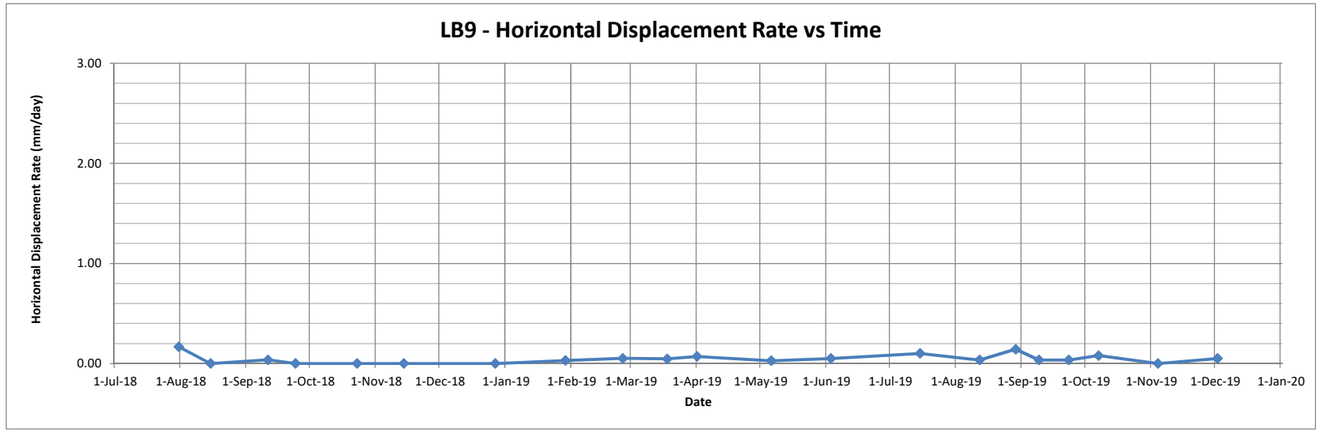
TITLE: H-H DAM LOCK-BLOCK RETAINING WALL SURVEY MONUMENT READINGS LB8

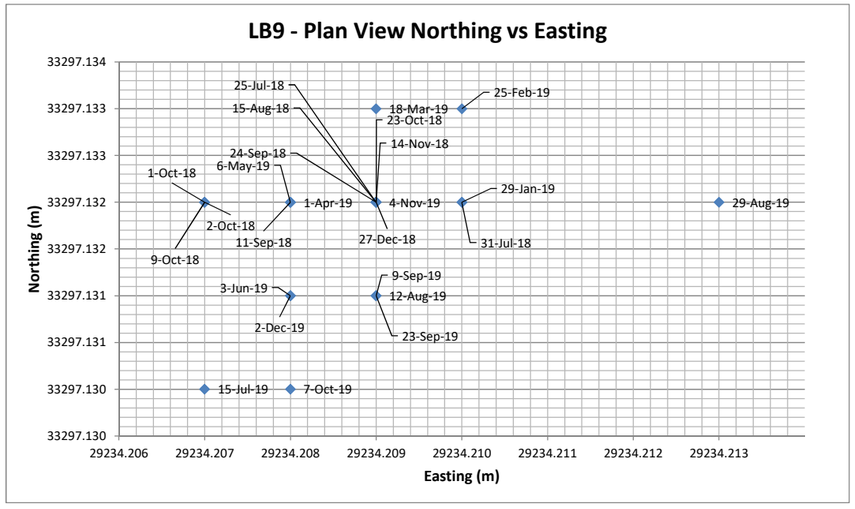
PROJECT No. M02341B53

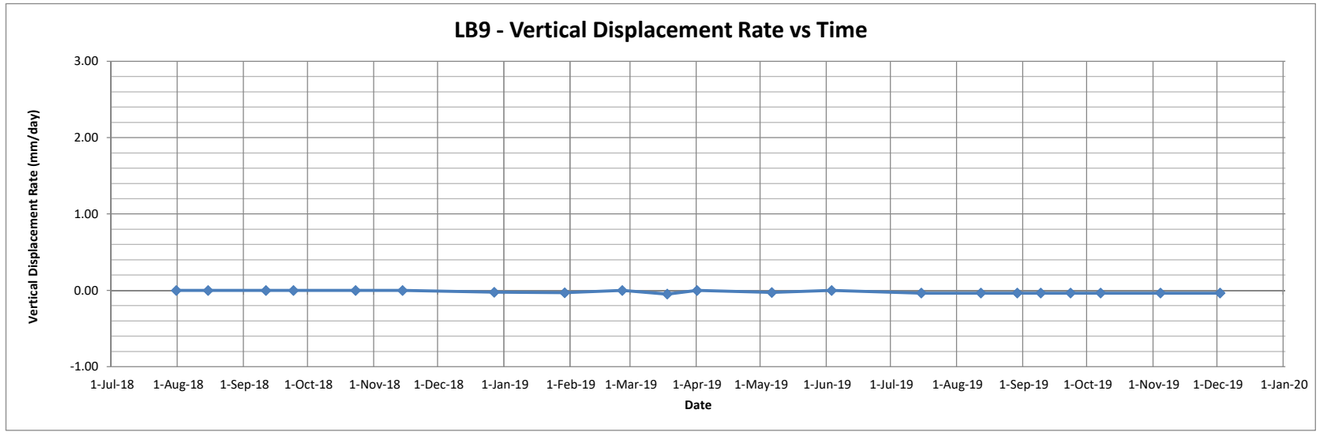
FIG No. VI-C-9

January 23, 2020
Z:\MVCH\M02341B53 - HVC 2019 Dam Safety Support\300 Design\370 Survey Monument\H-H Dam\200123 HH Pumphouse Retaining Wall Monitoring DSI Figs.xlsm]Data









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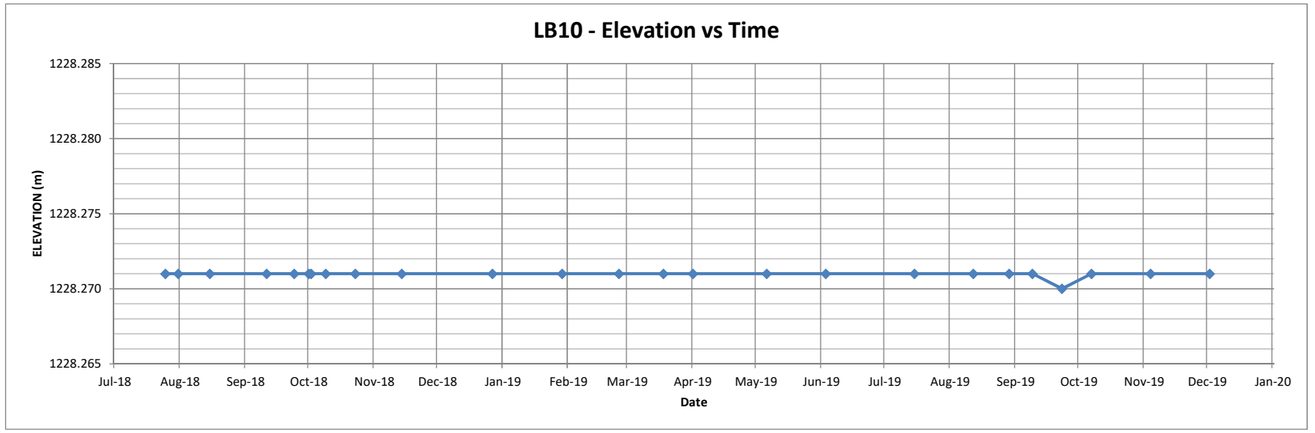
PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

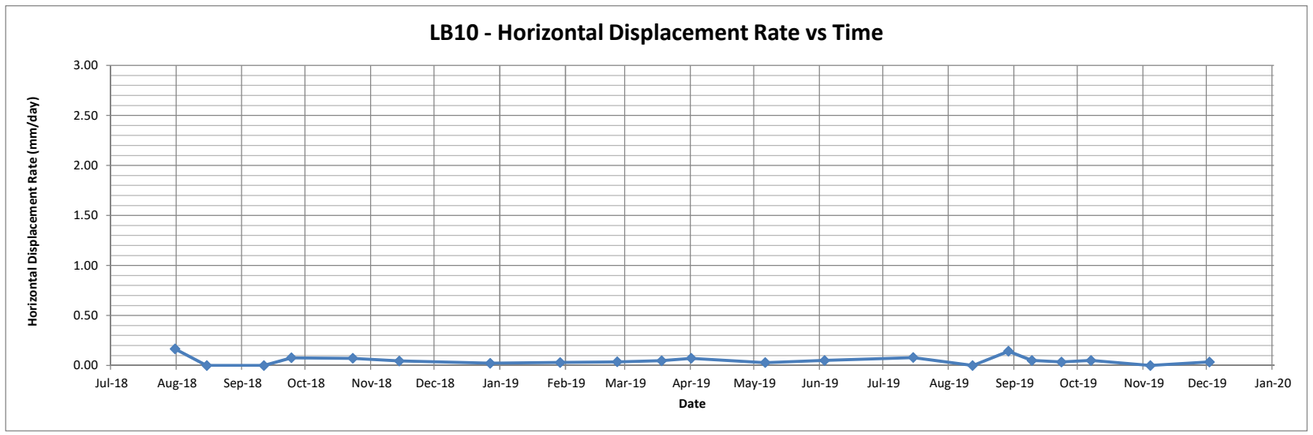
TITLE: H-H DAM LOCK-BLOCK RETAINING WALL SURVEY MONUMENT READINGS
LB9

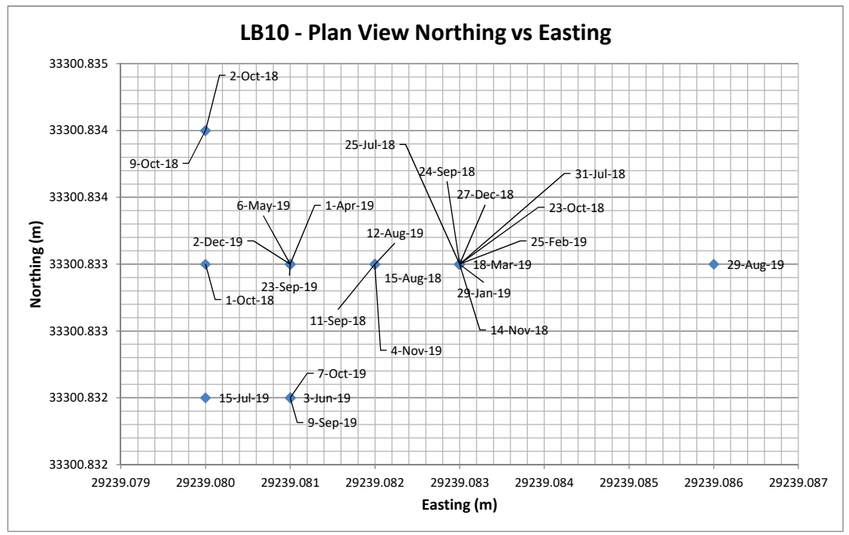
PROJECT No. M02341B53

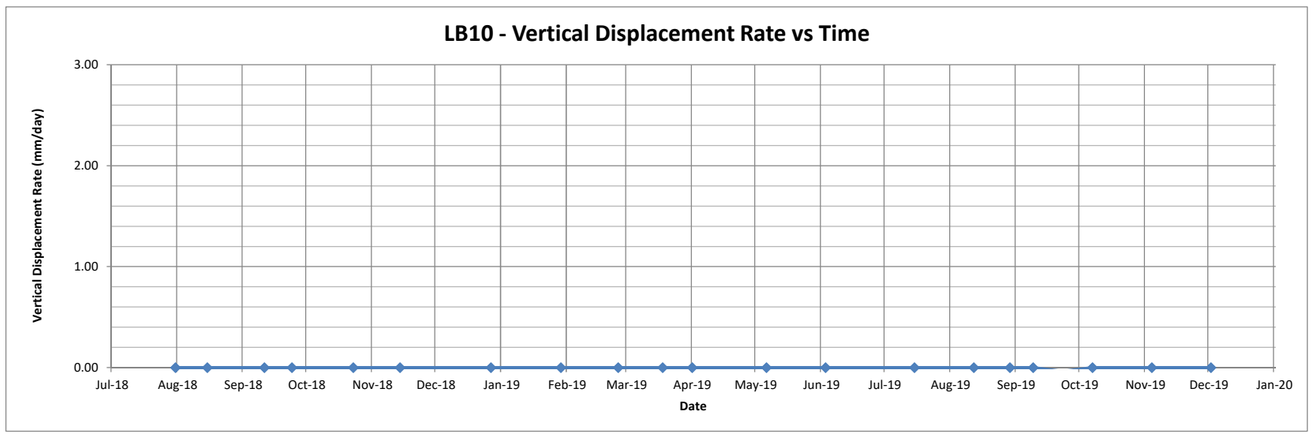
FIG No. VI-C-10

January 29, 2020
Z:\MV\CRM\02341B53 - HVC-2019 Dam Safety Support\300 Design\370 Survey Monument\H-H Dam\[200129 HH Pumphouse Retaining Wall Monitoring DSI Figs.xlsm]Data









NOTES:

1. All data provided by THVCP.

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CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2019 DAM SAFETY INSPECTION

TITLE: H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB10

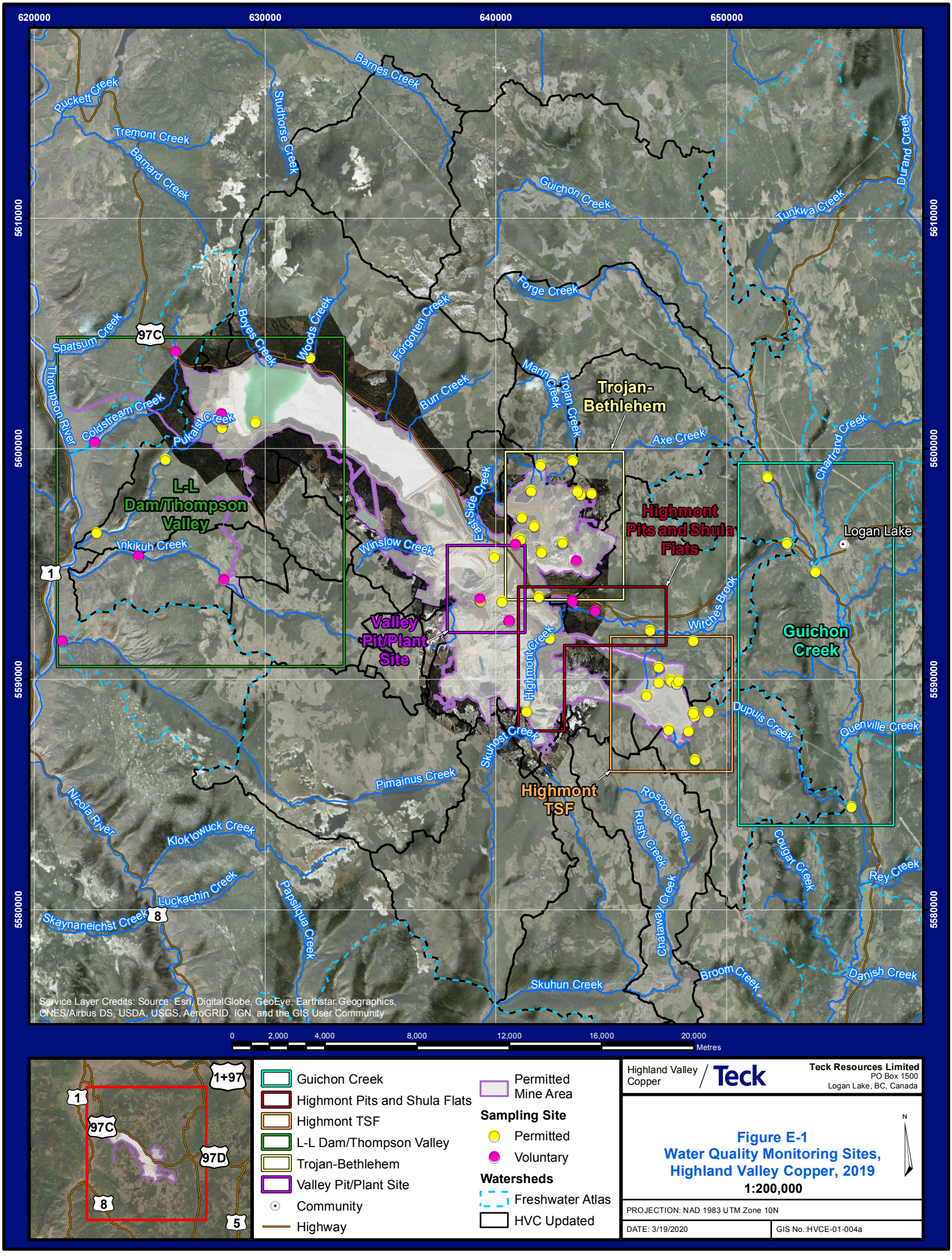
PROJECT No. M02341B53

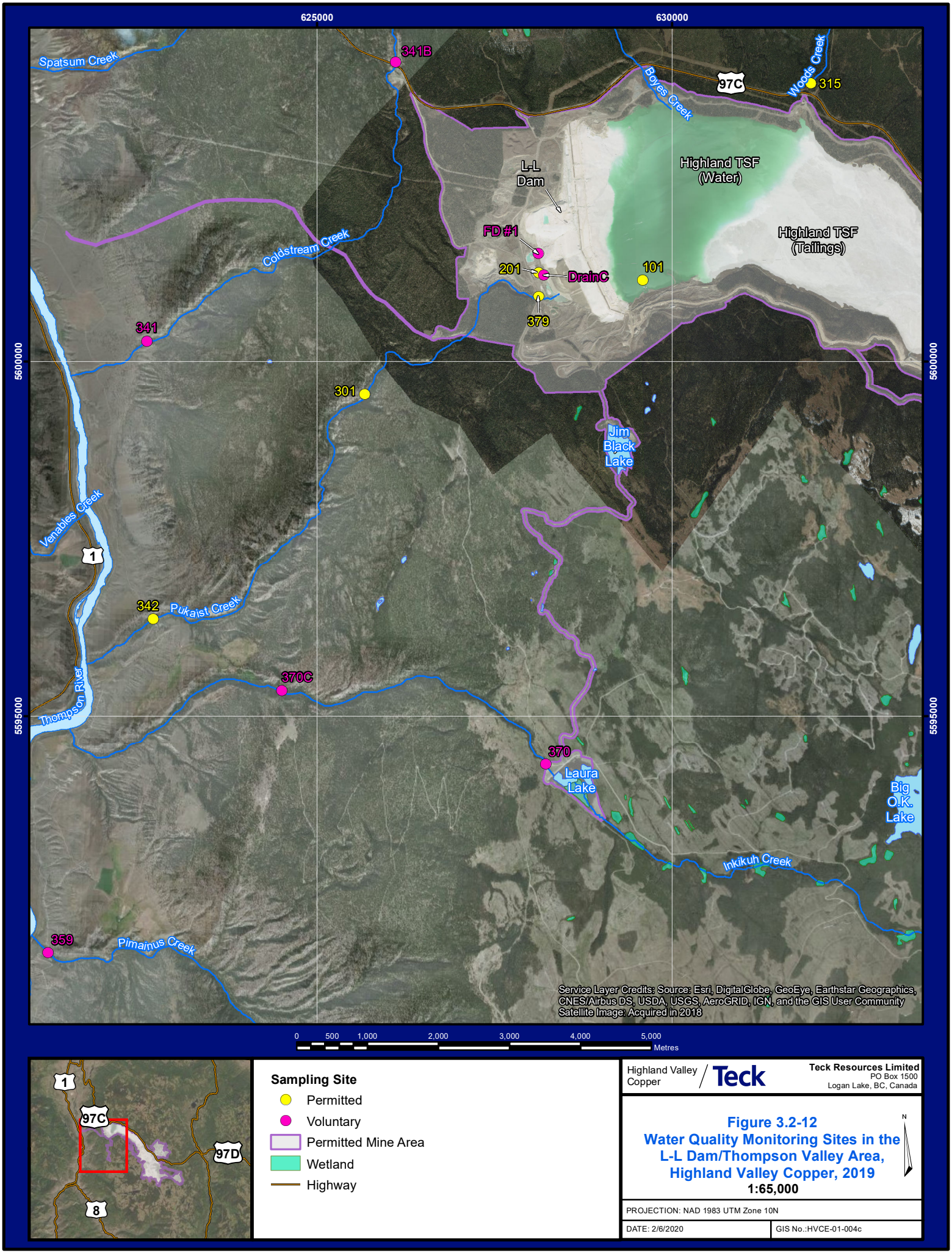
FIG No. VI-C-11

January 23, 2020
Z:\MVCN\M02341\B53 - HVC-2019 Dam Safety Support\300 Design\370 Survey Monument\H-H Dam\[200123 HH Pumphouse Retaining Wall Monitoring DSI Figs.xlsm]Data

APPENDIX VII

Map of Water Quality Monitoring Points


620000
630000
640000
650000
5610000
5600000
5590000
5580000
Puckett Creek
Tremont Creek
Barnard Creek
Studhorse Creek
Barnes Creek
Durand Creek
Guichon Creek
Tunkwa Creek
Forge Creek
Spatsum Creek
97C
Boyes Creek
Woods Creek
Forgotten Creek
Thompson River
Coldstream Creek
Pukaist Creek
Burr Creek
Mann Creek
Trojan Creek
Trojan-Bethlehem
Axe Creek
Chartrand Creek
L-L Dam/Thompson Valley
Inkikuh Creek
1
East Side Creek
Winslow Creek
Highmont Pits and Shula Flats
Logan Lake
Witches Brook
Valley Pit/Plant Site
Highmont Creek
Guichon Creek
Dupuis Creek
Quenville Creek
Skuhost Creek
Pimainus Creek
Highmont TSF
Roscoe Creek
Rusty Creek
Nicola River
Klokowuck Creek
Cougar Creek
Rey Creek
Luckachin Creek
Papsilqua Creek
Skaynaneichst Creek
8
Chatawa Creek
Broom Creek
Danish Creek
Skuhun Creek
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0
2,000
4,000
8,000
12,000
16,000
20,000
Metres
1+97
1
97C
97D
8
5
Guichon Creek
Highmont Pits and Shula Flats
Highmont TSF
L-L Dam/Thompson Valley
Trojan-Bethlehem
Valley Pit/Plant Site
Community
Highway
Permitted Mine Area
Sampling Site
Permitted
Voluntary
Watersheds
Freshwater Atlas
HVC Updated
Highland Valley Copper
Teck
Teck Resources Limited
PO Box 1500
Logan Lake, BC, Canada
N
Figure E-1
Water Quality Monitoring Sites, Highland Valley Copper, 2019
1:200,000
PROJECTION: NAD 1983 UTM Zone 10N
DATE: 3/19/2020
GIS No.:HVCE-01-004a


625000
630000
5600000
5595000
Spatsum Creek
341B
Boyes Creek
97C
Woods Creek
315
L-L
Dam
Highland TSF
(Water)
Highland TSF
(Tailings)
FD #1
Coldstream Creek
201
DrainC
101
379
341
301
Jim
Black
Lake
Venables Creek
1
342
Pukaist Creek
370C
Thompson River
370
Laura
Lake
Big
O.K.
Lake
Inkikuh Creek
359
Pimainus Creek
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Satellite Image: Acquired in 2018
0
500
1,000
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4,000
5,000
Metres
1
97C
97D
8
Sampling Site
Permitted
Voluntary
Permitted Mine Area
Wetland
Highland Valley Copper
Teck
Teck Resources Limited
PO Box 1500
Logan Lake, BC, Canada
Figure 3.2-12
Water Quality Monitoring Sites in the L-L Dam/Thompson Valley Area, Highland Valley Copper, 2019
1:65,000
N
PROJECTION: NAD 1983 UTM Zone 10N
DATE: 2/6/2020
GIS No.:HVCE-01-004c

APPENDIX VIII

Failure Mode Summary: L-L Dam and H-H Dam

Appendix VIII
Failure Mode Summary: L-L Dam and H-H Dam

VIII-1 INTRODUCTION

This appendix summarizes the review of plausible failure modes for the L-L Dam and H-H Dam based on the 2019 design review (KCB 2019a).

The design of both dams incorporates measures to prevent failure modes from occurring as well as reduce uncertainty and associated risks based on understanding of the site and operating conditions. This is, in part, achieved by adopting the principles of the Observational Method (Peck 1969), such as: developing appropriate geological and geotechnical characterization for the dam and foundation; design and sensitivity analyses to inform key assumptions and controls; and incorporating observed performance into design to manage residual risk and uncertainty. All steps of the Observational Method (Peck 1969), including development of a Contingency Case, have been adopted for the design of the Valley Buttress Berm (VBB) as described in the 2018 permit amendment report (KCB 2018c) which THVCP submitted for regulatory approval in December 2018.

VIII-2 FAILURE MODE ASSESSMENT

CDA (2013) identifies three general dam failure modes:

- Overtopping: water flows over the crest of the dam, contrary to design intent;
- Structural Collapse: internal resistance to the applied forces is inadequate; and
- Contaminated Seepage: contaminated fluid escapes to the natural environment.

Each of these failure modes can be triggered by the occurrence of an extreme event (e.g., a flood or earthquake) or by the presence of a latent geotechnical/geological hazard (e.g., weak foundation conditions, incompatible gradations between adjacent materials leading to internal erosion, etc.). These failure modes can also change or evolve over the life of the dam in terms of the trigger / hazard, likelihood and consequence. Therefore, assessment of failure modes should not only be location-specific, it should also be time- or stage-specific and be kept up-to-date as new information becomes available. Failure modes for the life-of-mine dam designs were last reviewed during the 2019 design review (KCB 2019a).

Refer to Appendix III-A, for an overview of the L-L Dam design and foundation characterization which is the basis for the failure mode review described herein. Table IV-1 and Table VIII-4 summarize the plausible failure modes for L-L Dam and H-H Dam, based on KCB (2019a), along with:

- potential triggers / associated hazards;
- design rationale for risk mitigation; and
- suitable quantitative performance objectives (QPOs) for monitoring.

Table VIII-1 Summary of L-L Dam Plausible Failure Modes and Rationale for Risk Mitigation

Failure Mode	Trigger / Hazard	Design Rationale for Risk Mitigation	Quantifiable Performance Objectives (QPOs)
Overtopping	Crest deformation leading to loss of freeboard and release of pond water	N/A during active crest raising.	Crest elevation, visible deformations, available freeboard.
	Meteorological events resulting in flood volumes beyond design capacity.	Provide sufficient flood storage in the TSF to contain the Inflow Design Flood, which is the Probable Maximum Flood (PMF), plus allowance for wave run-up and settlement.	Operating freeboard, minimum beach length, maximum operating pond volume.
Structural Collapse	Internal Erosion due to material incompatibility or hydraulic fracturing	Cycloned sand is inherently filter compatible with till core and tailings. Sand and gravel filter layer protects interface between the cycloned sand shell and the foundation.	Seepage water quality, observance of sinkholes or seepage faces.
	Piping along buried structures in the dam	The Low-Level Outlet (LLO) on the left abutment is the only buried structure in the dam. It was decommissioned by filling with concrete in 2013 and installing an inverted filter drain at the outlet in 2015.	Seepage water quality, observance of sinkholes.
	Surface Erosion	Slopes at to ultimate configuration to be covered with a closure cover to prevent wind and rain erosion of the cyclone sand. Interim slopes which are not yet protected are prone to surface erosion due to wind, rain, freshet runoff and/or breaks in tailings/water pipelines.	Visible erosion; maintain regular and event driven inspections, and carry out maintenance of surface erosional features as required; incorporate containment measures in areas prone to pipeline breakage
	Slope Instability due to Static Loadings	Each dam segment is designed based on geologic and hydrogeology conditions of the local area. Deformation modelling informed by field measurements, laboratory testing and sensitivity analyses are used to assess behaviour and response of critical foundation units. Design assumptions take uncertainty and sensitivity into consideration.	Movement thresholds, visual observations, performance expectations for critical units (i.e. mudstone and glaciolacustrine)
	Slope Instability due to Static or Dynamic Liquefaction of liquefiable units	Compacted downstream shell (not prone to liquefaction) with low piezometric levels. Foundation materials beneath the L-L Dam are not susceptible to liquefaction. Design for fully liquefied tailings in post-earthquake conditions.	Construction QA/QC; piezometric levels, site investigations
	Seepage face development and soft toe conditions	Include underdrainage system of blanket and finger drains.	Piezometric levels, seepage flow rates.
Contaminated Seepage	Failure of seepage management system resulting in impacts to downstream receiving environment	Downstream seepage collection and slimes ponds to be designed for maximum seepage from L-L Dam. Groundwater impacts managed under Sulfate Adaptive Management Plan (SAMP).	Piezometric levels, seepage flow rates, equipment failure, visual observations, seepage water quality.

Table VIII-2 Summary of H-H Dam Plausible Failure Modes and Rationale for Risk Mitigation

Failure Mode	Trigger / Hazard	Design Rationale for Risk Mitigation	Quantifiable Performance Objectives (QPOs)
Overtopping	Crest deformation leading to loss of freeboard and release of pond water	N/A because the crest of the H-H Dam is generally about 14 m higher than the crest of the L-L Dam.	N/A
	Meteorological events beyond design capacity		N/A
Structural Collapse	Internal Erosion due to material incompatibility or hydraulic fracturing	Between El. 1216.7 m and El. 1255.5 m, no filter zone is present between the core and downstream random fill, which given the variability may not function as a filter against migration of fines from the core. Location of the pond (~7 km away from H-H Dam) and upstream tailings beach limit the potential for progression of internal erosion if it does develop, refer to Section VIII-5.3.2.1.	Observance of sinkholes (downstream and upstream of core), monitor piezometric levels
	Piping along buried structures in the dam	N/A as there are no buried structures within the dam.	N/A
	Surface Erosion	Majority of downstream face comprises rockfill, at low risk of erosion. Areas of exposed sand and gravel fill will be covered at ultimate configuration to prevent wind and rain erosion. Interim slopes which are not yet protected are prone to surface erosion due to wind, rain, freshet runoff and/or breaks in tailings/water pipelines.	Visible erosions; maintain regular and event driven inspections and carry out maintenance of surface erosional features as required; incorporate containment measures in areas prone to pipeline breakage.
	Slope Instability due to Static Loadings	Each dam segment is designed based on geologic and hydrogeology conditions of the local area. Design assumptions take uncertainty and sensitivity into consideration.	Movement thresholds, visual observations, performance expectations
	Slope Instability due to Static or Dynamic Liquefaction of liquefiable units	Design using liquefied strengths in susceptible zones of downstream shell. Control compaction of Modified Base Case downstream buttress fill in areas potentially below future water table to prevent liquefaction in that material.	Construction QA/QC; piezometric levels, site investigations.
	Seepage face development and soft toe conditions	N/A because downstream shell of H-H Dam consists of relatively high permeability random waste fill and there is no nearby pond so seepage potential is low. Majority of seepage that is present flows to 24 Mile Lake in the random fill that is present between existing and natural ground. Seepage does not daylight along the dam slope.	Piezometric levels
Contaminated Seepage	Failure of seepage management system resulting in impacts to downstream receiving environment	Downstream seepage from H-H Dam is captured by either 24 Mile Lake or Valley Pit dewatering, so there is no uncontrolled release to the environment.	Piezometric levels, visual observations.

APPENDIX IX

DSR Recommendations and Status Update

Appendix IX
Dam Safety Review Recommendations

Table IX-1 December 2019 STATUS of 2017 Highland TSF Dam Safety Review Recommendations

ID	Priority	Comment	Topic	Response - Jan 2020	Mar 2020 Status
TSF-2017-01	*4*	*'The DSR is a snapshot at a particular point in time of the assessment of whether the dam is being reasonably safely operated using the current state of practice for dam safety analysis….if it is clear during the review process, that imminent changes are to be made, or are in the process of being made, to the dam or the dam's environment, the QPE should assess the impact of these changing conditions on the safe operation of the dam in the immediate future and document these impacts in the DSR report' (EGBC, 2016).* *We understand that there will be a site characterization update in 2018 which may trigger design changes. If these changes are significant, there should be an update of this DSR or independent review of the updated 2018 design to reflect the changes in dam design.*	*Update*	*Closed (2018)* *Next DSR scheduled for 2022 (5-years frequency)*	*Closed*
TSF-2017-02	*4*	*We noted that several reports were not finalized (AMEC, 2012) (AMEC, 2014) (AMEC, 2015) (KCB, 2016) (KCB, 2017) (KCB, 2017). We recommend reports* *are finalized in line with best management practice.*	*Documentation*	*Closed (Q3 2019)* *Key documents in draft have been finalized or are superseded by 2019 Design Update Report.*	*Closed*
TSF-2017-03	*4*	*LiDAR surveys are collected every six months, but we understand that successive surveys are not compared. We recommend production of incremental change maps and cumulative change maps after every survey. This is an economical way to:* *· Supplement the existing observation and surveillance program* *· Highlight areas of significant surface movement (within limits of resolution), such as toe bulges etc.* *· Confirm wind sand loss and migration of the toe berms at L-L dam is not significant.* *· Highlight areas of significant settlement at H-H dam* *· Aid interpretation of settlement vs. movement at H-H Dam.* *· Confirm the waste dumps adjacent to 24 Mile Lake are not demonstrating movement.*	*Surveillance*	*Closed (2018)* *Incremental surveys are reviewed, as available, to identify significant change not identified by other surveillance. Not adopted as part of routine maintenance.*	*Closed*
TSF-2017-04	*4*	*The data review has found that there is a significant quantity of design reports, construction reports and memorandums since 2010. This does not include data from the early 1970s'. For example, we have found several iterations and design updates, on discrete dam sections, presented in a range of reports and appendices with somewhat unrelated titles, whilst the current design is from 2010.* *Given the nature of large TSF's, where design is updated in sections according to priority and design issues, we recommend that THVCP complete a summary that lists the latest reports, design basis, stability, seepage, geological characterization and failure modes for each section. This could be included within the OMS manual and updated annually.*	*Documentation*	*Closed (Q3, 2019)* *2019 Design Update Report includes consolidated design summary, history and register of key documents.*	*Closed*
TSF-2017-05	*4*	*We understand that significant geotechnical investigation and testing has been undertaken in 2017. Any subsequent update to parameters based on this new investigation should be clearly documented and checked against the current 2010 design to determine if design updates are required.*	*Design*	*Closed (Q3, 2019)* *Refer to App. II-B of 2019 Design Update Report.*	*Closed*
TSF-2017-06	*3*	*Our screening review of the geology model has identified localized discrepancies between cross-sections and longitudinal-sections. It is recommended that the geological boundaries defined in each design section be confirmed by considering the 3D geology.*	*Characterization*	*Closed (Q3, 2019)* *Sections have been reviewed for 2019 Design Update Report. Additional work planned for 2020 to aid visualization.*	*Closed*
TSF-2017-07	*3*	*Further testing of controlling foundation units such as weak rock units and different tailings streams (including slimes) and dam fill materials using appropriate techniques (such as ring shears, relationship between sample size and strain softening etc.). is recommended to better characterize the behavior of these materials.*	*Characterization*	*Closed (Q3, 20196)* *Recent laboratory testing program included in foundation characterization documents for each dam (App II-A and App II-B of 2019 Design Update Report)*	*Closed*
TSF-2017-08	*3*	*The identification of piezometers that are found to be newly 'plugged' should trigger a review of surrounding piezometers and inclinometers (level 1 threshold) to eliminate the possibility that the plugging is due to movement. Consideration should be given to cleaning out or replacing instruments found to be plugged.*	*Surveillance*	*Closed (2018)* *Instruments that become plugged are reviewed and instruments nearby checked to identify if pattern response observed. THVCP working to convert standpipes to vibrating wire piezometers.*	*Closed*
TSF-2017-09	*3*	*The OMS manual should be updated to incorporate new instrumentation and associated thresholds related to the design when available.*	*Documentation*	*Closed (2018)* *Incorporated into 2018 OMS Manual*	*Closed*
TSF-2017-10	*3*	*Based on the longitudinal upstream cracking observed historically in the H-H dam and the potential for cracking of the core to increase the phreatic surface in the downstream shell, we recommend that a minimum PI in the till core is considered in the specification.*	*Construction*	*Closed (2018)* *Suitability of Glacial Till borrow, including plasticity, is confirmed prior to construction as part of borrow characterization and not added to specification.*	*Closed*
TSF-2017-11	3	We recommend the emergency procedures following fire or fire evacuation and their impact on the observation and surveillance program are considered within the OMS manual,	Documentation	THVCP is located in a region that can experience wildfire hazards throughout the year. Contingency planning around wildfires will be incorporated into the surveillance portion of future OMS update.	Captured by DSI recommendation LL-2019-03. To be completed in 2020.

ID	Priority	Comment	Topic	Response - Jan 2020	Mar 2020 Status
TSF-2017-12	*4*	*Stantec routine check of stability at each dam indicated that the stability was not likely sensitive to the undrained strength ratio adopted for the upstream tailings. Due to uncertainties in the value of the undrained strength ratio, we recommend that sensitivity is undertaken for other design sections when the design is updated. This will highlight whether in-situ investigations are valuable. be used to better characterize the engineering properties of the tailings*	*Characterization*	*Closed (Q3, 2019)* *Captured in 2019 Design Update Report.*	*Closed*
LL-2017-01	*3*	*We recommend further investigation and stability modeling of the zone at around St. 3+500 m which may contain weak rock horizons layers is located between design sections and is understood to contain a basal flow unit overlain by weathered basalt. The basal flow unit was described as very closely sheared, highly to extremely weathered and weak. The overlying basalt rock mass was described as closely to extremely closely-spaced jointed. The consideration of a failure along the basal flow unit should be considered. The geology of the 'rock knoll' is not delineated and further investigation and modelling is recommended to understand this zone better.*	*Design*	*Closed (Q3, 2019)* *Documented in 2019 Design Update Report and reviewed with TRB (Meeting No. 21)*	*Closed*
LL-2017-02	*4*	*The GLU at the north abutment, described as 'rising in steps' (KCB, 2016) and the geological interpretation (KCB, 2016) should be reviewed.*	*Characterization*	*Closed (Q3, 2019)* *No change made as interpretation (multiple layers found at risign elevations) is supported by site investigations.*	*Closed*
LL-2017-03	*3*	*We recommend additional investigation and laboratory testing to confirm the strength parameters and the extent of bedrock under the NBB and VBBE as the stability is sensitive to the extent and strength of this layer; however, there has been limited investigation or advanced strength testing on the weak mudstone. The investigations should confirm the lateral constraints of the weak mudstone, any overlying constraining stronger volcanic units and the its geotechnical behavior.*	*Characterization*	*Closed (Q3, 2019)* *Laboratory testing and model calibration reported in 2019 Design Update Report.*	*Closed*
LL-2017-04	*3*	*Foundation conditions in the northern portion of the VBBE are understood to be similar to that of the NBB; however, the berm is notably smaller at this location. The VBBE slope stability analyses (KCB, 2017c) indicate that the proposed ultimate dam design configuration at this location does not comply with the minimum FOS criteria for all assumed elevations of the mudstone residual zone. Following the completion of LL-2017-03, we recommend the VBBE design is reassessed to evaluate if any modifications are required to achieve the design criteria FOS. We recommend future construction considers the potential for residual strengths within this material.*	*Design*	*Closed (2018)* *The Sedimentary Unit, is present beneath the VBBE. However, mudstone layers within the Sudimentary Unit are not continuous, and is present at greater depths with a thicker overburden cap when compared to the mudstone layers beneath the NBB. As a result, mudstone layers do not controll stability at VBBE.*	*Closed*
LL-2017-05	*3*	*The impact and likelihood of failure of the Jim Black Dam on the L-L dam should be reviewed. This issue was raised in the Risk Assessment Report (AMEC, 2015) but we understand that this not been closed out yet.*	*Risk*	*Closed (2018)* *AMEC completed an assessment of L-L Dam toe erosion potential (AMEC 2016) which estimated a peak flood level of El. 1106 m resulting from a Jim Black Lake breach during a probable maximum flood (PMF). The top surface of downstream sand and gravel toe bench (min. 10 m wide) is El. 1108 m along the toe of the L-L Dam in the potential flood zone. Natural ground in this area is approximately El. 1104 m to 1105 m, resulting in potentially 1 m to 2 m of flow against the fill. This would result in some erosion of toe bench or dam fill which would require maintenance but not sufficient to trigger a concern regarding failure of the L-L Dam.*	*Closed*
LL-2017-06	3	We recommend the development of an action plan to install seepage weirs by dam sector and that this should include the determination of thresholds for seepage flows	Surveillance	THVCP is planning to install new seepage weirs alond downstream toe in 2021 after SWRP has been replaced and L-L Dam is constructed to ultimate toe.	Captured by DSI recommendation LL-2019-02. To be completed in 2021.
LL-2017-07	*2*	*Given the core geometry and known deformations at the dam we recommend an evaluation of some sensitivity studies on the impact of core cracking and dam stability*	*Design*	*Closed (Q3, 2019)Sensitivity cases run to simulate cracked core condition with 3D groundwater model, documented in 2019 Design Update Report.*	*Closed*
LL-2017-08	*3*	*We recommend future construction to the design grades to prevent a repeat of the over-steepening of L-L Dam.*	*Construction*	*Closed (2018)* *Practice had been adopted, starting in 2017 construction and steepened areas addressed in 2018.*	*Closed*
LL-2017-09	*3*	*A 20 % reduction in the L-GLU strengths was applied for post-earthquake loading conditions in the VBBE stability analyses, presumably to account for cyclic softening. There is no discussion regarding the rationale for not applying this to other potentially susceptible units such as the till core. This should be further evaluated and information to justify this assumption should be presented. If this assumption is not justified, the analyses should be updated to consider cyclic softening in other susceptible units.*	*Design*	*Closed (Q3, 2019)* *Discussed and analysis (including sensitivity) reported in 2019 Design Update Report.*	*Closed*

ID	Priority	Comment	Topic	Response - Jan 2020	Mar 2020 Status
HH-2017-1	*3*	*We recommend a review of as-built records and assessment of the range of as-built filter widths and how these relate to ongoing design.*	*Construction*	*Closed (Q3, 2019) Construction Review and assessment of material erosion failure mode included in 2019 Design Update Report.*	*Closed*
HH-2017-2	*4*	*We recommend that the design parameters of the rockfill are calibrated against the performance of the waste dumps at the mine as these are composed of similar fill rockfill and heights, and that a shear-normal curve adopted for the rockfill*	*Design*	*Closed (2018) Majority of downstream fill in H-H Dam has a significant sand and gravel component rather than coarse rockfill. As the internal static shear strength of the downstream rockfill influences local bench and sloughing failures only (i.e. doesn't govern overall dam stability) this approach is not planned to be adopted.*	*Closed*
HH-2017-3	*3*	*We recommend that consideration is given to either to the relocation, continued monitoring or additional support of the lock-block; and that the thresholds are included in the OMS manual. Movement of the wall could trigger failure of the tailings pipes or instability.*	*Design*	*Closed (Q3, 2019) 2019 Design Update Report includes modified H-H Dam section with setback from lock-block wall.*	*Closed*
HH-2017-4	*3*	*We recommend the installation of instruments to understand the sensitivity of the phreatic surface upstream of the core and to understand deformation and settlement within the dam.*	*Surveillance*	*Closed (2018) Instruments to achieve these functions were installed in 2017/2018. No further action planned.*	*Closed*
HH-2017-5	*4*	*There is a disconnect between documentation of the 2017 monitoring systems and the observational approach which we recommend should be rectified.*	*Documentation*	*Closed (2018) Incorporated into 2018 OMS Manual*	*Closed*
HH-2017-6	*3*	*The suitability of the interface between the core and the adjacent structural fill in the lower portion of the H-H Dam should be demonstrated from a core particle retention standpoint.*	*Design*	*Closed (Q3, 2019) Described in 2019 Design Update Report failure mode review and presented to TRB at Meeting No. 21.*	*Closed*
HH-2017-7	*3*	*We recommend the construction specifications include a requirement that the filter materials be non-plastic, as the use of plastic filter materials represents a dam safety risk as such materials may allow for a crack to be maintained and piping to initiate. This risk is further compounded by the settlements observed at the H-H Dam to date. A review of construction testing data should be performed to evaluate if plastic filter material has been placed at the dam. If this material has been placed, the potential for this material to maintain a crack should be assessed.*	*Construction*	*Closed (Q3, 2019) No change proposed. Material/ screening characterization made in borrow or from stockpile prior to contractor approval to use.*	*Closed*
HH-2017-9	*3*	*The SGM and geotechnical characterization of the H-H Dam is not as understood compared to the L-L Dam. We understand there is already a plan for further investigation and we recommend this plan is executed.*	*Characterization*	*Closed (Q3, 2019) Refer to App II-B of 2019 Design Update Report.*	*Closed*
H-H-2017-10	*3*	*Based on relatively large deformations within the rockfill at H-H dam and the historical longitudinal upstream cracking observed in the H-H dam, we recommend an evaluation of the settlement potential of the rockfill and its associated impact on the core.*	*Design*	*Closed (Q3, 2019) Horizontal movement in waste fill related to settlement but not measured adjacent to core.*	*Closed*

Notes:
1- Priority guidelines are defined as follows (MEM 2016):
- Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
- Priority 2: If not corrected, could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
- Priority 3: Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
- Priority 4: Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

2- Deficiency: an inadequacy, or uncertainty in the adequacy, of the dam system to meet its performance goals in accordance with good dam safety practices.
3- Non-Conformance: an inadequacy in the nonphysical controls (procedures, processes and management systems) necessary to maintain the safety of the dam.