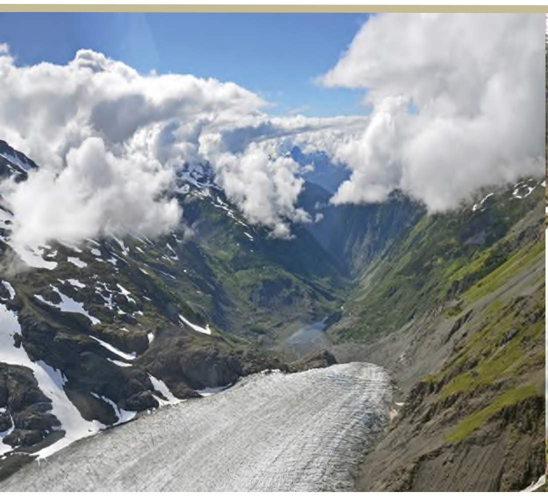
TETRA TECH

2021 Annual Report
Long-Term Performance Monitoring Program
Clinton Creek Mine, Yukon



PRESENTED TO

Government of Yukon
Department of Energy, Mines and Resources
Assessment and Abandoned Mines Branch

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LIMITATIONS OF REPORT

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1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch (YG-AAM) to carry out the 2021 Long-Term Performance Monitoring Program (LTPMP) at the abandoned Clinton Creek asbestos mine, located near Dawson City, YT.

1.1 Site Overview

The former Clinton Creek Mine operated as an asbestos mine from 1968 to 1978, owned by the Cassiar Asbestos Corporation. The mine was abandoned in 1978 and currently holds Type II mine site status, under which care and maintenance is managed jointly by the Government of Canada and Government of Yukon, with consultation and involvement of Tr'ondëk Hwëch'in (TH).

The site is located approximately 100 km northwest of Dawson City, and is accessible in the summer (mid-May to mid-October) by the Top of the World Highway and the Clinton Creek access road. Road access is not possible in the winter months when the Top of the World Highway is closed. The site can be accessed in the winter by snowmobile or helicopter.

The site includes the following components, which are illustrated on Figures 1 through 18:

- Clinton Creek Access Road;
- Clinton Creek Ford Crossings No. 1 and No. 2;
- Porcupine Pit;
- Snowshoe Pit;
- Creek Pit;
- Clinton Creek Waste Rock Dump;
- Porcupine Creek Waste Rock Dump;
- Hudgeon Lake Outlet;
- Gabion Drop Structures Nos. 1 through 4;
- Clinton Creek Channel;
- Clinton Creek Natural Slopes;
- Former Mill Site;
- Wolverine Creek Tailings Piles;
- Wolverine Creek Ponds;
- Wolverine Creek Channel; and
- Wolverine Creek Natural Slopes.

During mining operations, asbestos ore was extracted from the open pits and transported to a mill located near the top of the tailings piles for processing. Waste rock was deposited near the open pits in loose, uncontrolled piles. Waste rock was dumped in several locations throughout the period of operation, including several overlapping dump areas along the Clinton Creek channel (the Clinton Creek waste rock dump) and the Porcupine Creek channel (the Porcupine Creek waste rock dump). Similarly, tailings were deposited by dumping near the mill in three overlapping zones near the crest of the natural slope on the west side of the Wolverine Creek channel.

Downslope movement of the waste rock and tailings piles has caused partial blockages of Clinton Creek, Porcupine Creek, and Wolverine Creek. Hudgeon Lake was formed in the Clinton Creek channel upstream from the Clinton Creek waste rock piles, and two ponds were formed along Wolverine Creek upstream from two lobes of the tailings that have entered the creek channel.

1.1.1 Site Access Road

The Clinton Creek mine site is accessed in the summer months via the George Black Ferry from Dawson City, the Top of the World Highway, and the Clinton Creek Access Road. The Clinton Creek road turnoff is at km 60 on the Top of the World Highway. The Clinton Creek Road is maintained by Government of Yukon Department of Highways and Public Works up to the Fortymile River Bridge. The remaining length of the road, including the access road within the site, is maintained by YG-AAM.

Access to the site is controlled by a locked gate just before the confluence of Wolverine Creek and Clinton Creek. Large boulders have been placed to block access to the Wolverine Creek access road. Immediately within the site, the access road crosses over the Wolverine Creek culvert. Shortly after, the road crosses Clinton Creek via Ford Crossing No. 1 and traverses the toe of the Clinton Creek waste rock dump. The access road previously paralleled the south bank of Clinton Creek; however, ongoing erosion and collapse of the waste rock into the creek encroached on the access road alignment, leading to the closure of a section of the access road along the toe of the waste rock pile. The access road currently follows a detour that traverses the mid-slope area of the waste rock pile. Ford Crossing No. 2 is located near the Hudgeon Lake outlet.

After Ford Crossing No. 2, the access road climbs to the former mill site and the top of the tailings pile. The top of the tailings pile is the end of the access road. A steep, narrow trail descends from near the mill site and provides vehicle access to the bottom of the tailings. The trail was established in 2018 to provide access for geotechnical drilling on the tailings and is not maintained. The trail is presently accessible to a 4x4 pickup truck when conditions are dry.

Other minor roads and trails exist on the site to provide access to other site components (e.g., the Porcupine Creek waste rock dump). These trails are not regularly maintained, and in some cases are blocked by locking chains and/or boulders or overgrown with vegetation.

1.1.2 Open Pits and Waste Rock Dumps

There are three open pits at the Clinton Creek mine site: the Porcupine Pit, the Snowshoe Pit, and the Creek Pit. The Porcupine Pit is the largest of the three, and is bordered by the Clinton Creek waste rock dump to the north and by the Porcupine Creek waste rock dump to the south. The Snowshoe and Creek Pits are relatively small, and are roughly located along the Porcupine Creek channel, downstream from the Porcupine Creek waste rock dump.

About 60 million tonnes of waste rock were placed in the Clinton Creek waste rock dump. The waste rock forms the south bank of Clinton Creek through most of the mine site, and the toe of the waste rock is being continually eroded by the creek as material moves downslope and into the creek channel. The gradient of the Clinton Creek channel is relatively steep near the outlet of Hudgeon Lake, which flows over the toe of the waste rock dump.

About 3 million tonnes of waste rock were placed in the Porcupine Creek waste rock dump. Downslope movement of the waste rock has impounded a small pond fed by Porcupine Creek. There is much less surface water flow along the toe of the Porcupine Creek waste rock dump, compared to the Clinton Creek waste rock dump. Instead, it is believed that much of the water from Porcupine Creek flows through the waste rock as groundwater.

The waste rock material was placed by end dumping without compaction. Catastrophic failure of the waste rock has occurred in the past (e.g., sliding of the Clinton Creek waste rock dump to impound Hudgeon Lake).

1.1.3 Hudgeon Lake, Gabion Drop Structures, and Clinton Creek Channel

Hudgeon Lake was formed when the Clinton Creek waste rock dump partially blocked Clinton Creek, and has a volume of about 10 Mm^3. The steep creek gradient immediately downstream of the lake outlet has historically resulted in significant, ongoing erosion of the waste rock in the creek channel. Erosion has been somewhat mitigated by channel armouring and the construction of four drop structures (DS1 through DS4), which were built between 2002 and 2004. The drop structures are considered to be a temporary measure until final closure design is completed. Drop structures consist of wire mesh gabion baskets filled with crushed rock. Flood events in 2009 and 2010 caused damage to the drop structures, especially to DS4.

In 2015, DS4 was repaired and upgraded with a 40 m-long “drop chute” made of articulated concrete block (ACB) mats placed downstream of the gabion baskets. High flows during the 2018 freshet caused erosion, undermining, and severe damage to the ACB mats. Temporary repairs in fall 2018 were completed and reinforced in fall 2019. These temporary repairs have remained in place for the 2020 and 2021 freshets.

Downstream from the drop structures, the channel can be divided into three sections:

- **Upper Channel:** the upper channel begins immediately downstream of DS4 and extends to about Sta. 0+685. The upper channel is narrow and relatively linear and is constrained between the toe of the Clinton Creek waste rock pile to the south and the bedrock-controlled natural slope to the north. The gradient in the upper channel is about 4%, based on survey results from the 2020 LTPMP. Erosion of the waste rock and natural bedrock is ongoing, with occasional collapse of the waste rock and/or toppling of the bedrock into the creek channel.
- **Middle Channel:** The middle channel extends from about Sta. 0+685 to Ford Crossing No. 1 at about Sta. 0+890. The middle channel is slightly less narrow, but still flows near the toe of the Clinton Creek waste rock pile to the south. The middle channel section appears to flow over waste rock, rather than bedrock. The gradient in the middle channel is about 3.2%, based on survey results from the 2020 LTPMP. Significant erosion occurred during the 2020 freshet in the channel just upstream from Ford Crossing No. 1, which required repairs to maintain vehicle access at the ford crossing.
- **Lower Channel:** The lower channel begins immediately downstream of Ford Crossing No. 1, at about Sta. 0+890, and extends to the confluence of Wolverine Creek and Clinton Creek near the site access gate, at about Sta. 1+150. The creek flows near the toe of the waste rock pile through this section, however there is relatively little ongoing erosion. The gradient in the lower channel is about 1.6%, based on survey results from the 2020 LTPMP.

1.1.4 Former Mill Site, Tailings Piles, and Wolverine Creek

The former mill site is located on a hilltop to the north of Clinton Creek and west of Wolverine Creek. Tailings generally consist of silty sand produced by mill operations when asbestos ore was crushed. Tailings were dumped adjacent to the mill at the top of the natural slope on the west side of Wolverine Creek. Tailings were initially placed immediately to the east of the mill site, until the pile failed 1974 and tailings slid down the hill and blocked Wolverine

Creek. The blockage was later breached, transporting tailings for several hundred metres down the channel. This portion of the tailings is referred to as the “South Lobe”.

After the 1974 failure, tailings were placed in a new pile to the north of the South Lobe. Catastrophic failure of this lobe has not occurred, however by 1985 the new tailings pile had crept downslope and partially blocked Wolverine Creek. This portion of the tailings is referred to as the “North Lobe”.

A third, smaller tailings pile is located adjacent to the north lobe, referred to as the Northwest Lobe. The Northwest Lobe does not impact the Wolverine Creek channel, and experiences less downslope movement than the North and South Lobes.

The North and South Lobes continue to move downslope into Wolverine Creek, which progressively erodes the tailings material and transports it downstream. Small ponds have been impounded immediately upstream from each lobe. Downstream from the tailings, Wolverine Creek flows through an approximately 250 m-long, rock-lined channel with boulder weirs installed at a regular spacing. The rock-lined channel is intended to limit erosion where the creek flows over the loose tailings and the channel gradient is relatively steep. Downstream of the rock-lined channel, the creek follows its natural channel for approximately 800 m, after which it flows through a culvert under the site access road and into Clinton Creek.

1.2 LTPMP Overview

The scope of the LTPMP continues to evolve based on site understanding and monitoring requirements. Tetra Tech has carried out the LTPMP since 2017, and provide annual recommendations to YG-AAM to adjust the scope of the program to meet the following monitoring objectives:

- Capture year-to-year movement of site components, including the access road, gabion drop structures, creek channels, waste rock dumps, tailings pile, and open pits;
- Assess the risk of failure of stabilization works (e.g., the gabion drop structures); and
- Evaluate the movement of the waste rock and tailings pile slopes for indications of increased mobility that could create a hazard to the environment, human safety, traditional land use, or site access, and develop recommendations for intervention if required.

The LTPMP generally consists of alternating “small” and “large” programs. The “large” program occurs in even-numbered years and has normally included a geotechnical site visit and a ground-based, topographic survey of all the various site components and movement monitoring points that have been installed at the site. The “small” program occurs in odd-numbered years, and has normally included a geotechnical site visit, plus a limited topographic survey that focuses on critical site components and selected movement monitoring pins.

Since 2018, the Tetra Tech has retained TRE Altamira Inc. (TRE) to provide movement analysis using satellite-based interferometric synthetic aperture radar (InSAR), to supplement and potentially replace the ground-based survey. Low-resolution satellite imagery from the Sentinel satellite was used for the 2018 and 2019 LTPMPs, and high-resolution imagery from the TerraSAR-X (TSX) and PAZ satellites was used in 2020.

Following the pattern of alternating “large” and “small” LTPMPs, the 2021 LTPMP consists of a modified “small” program, including the typical geotechnical site visit, InSAR monitoring by TRE using high-resolution imagery from the TSX and PAZ satellites, and no ground-based topographic survey.

1.3 2021 Field Program

Field work for the 2021 LTPMP consisted of the geotechnical site visit, plus three site visits to collect instrumentation readings. As noted in Section 1.2, no ground-based survey was included in the scope of the 2021 LTPMP.

The geotechnical site visit was completed on June 15 and 16, 2021, by Adam Wallace and Shawn Matthies from Tetra Tech's Whitehorse office. Observations and recommendations from the site visit were presented in a technical memorandum, which was issued for use on August 2, 2021, and is attached in Appendix B. Recommendations from the visual geotechnical inspection have been incorporated into this report.

The first two site visits to collect instrumentation readings were conducted on June 17-18 and September 28-29, 2021. The third site visit for instrumentation data collection is planned for February 2022. Instrumentation data collection is conducted jointly by Tetra Tech and TH. During each visit, data is collected from slope indicators (SI), vibrating wire piezometers (VWP) and ground temperature cables (GTC) that were installed in boreholes drilled in various locations at the site in 2016 and 2018. A technical memorandum was prepared to transmit the instrumentation data to YG-AAM following each site visit.

2.0 METHOD OF ANALYSIS FOR PERFORMANCE MONITORING

Observations from the geotechnical site visit and the results of the InSAR monitoring were reviewed to evaluate the performance of the site components.

Previous LTPMPs have included a ground-based survey of various monitoring points installed on slopes and other selected site components (e.g., drop structures); however, the ground-based survey has been omitted for the 2021 LTPMP.

2.1 InSAR Monitoring

InSAR monitoring uses a series of satellite radar images that are processed to estimate ground movement by detecting changes in the successive images over time. Imagery is collected by synthetic aperture radar satellites travelling on a polar orbit, from both "ascending" (i.e., satellite travelling from south to north) and "descending" (i.e., satellite travelling from north to south) orbits. Processed InSAR data consists of individual data points, with each point consisting of a time history of displacement along the line-of-sight (LoS) of the satellite. LoS displacement for the ascending and descending orbits can be combined and further processed to estimate the two-dimensional ground movement, in the east-west and vertical directions. Due to the orientation of the satellite lines-of-sight, InSAR does not effectively detect north-south movement.

InSAR monitoring has been included in the scope of the LTPMP since 2018, with satellite data collection and processing provided by TRE. In 2018 and 2019, InSAR monitoring used imagery collected by the Sentinel satellite, with a resolution of 5 by 20 m. In 2020, InSAR monitoring used high-resolution imagery collected by the TSX and PAZ satellites, with a resolution of 1 by 1 m.

For 2021, InSAR monitoring is continued from the 2020 program. High-resolution satellite imagery collected by the TSX and PAZ satellites has been processed by TRE and added to the 2020 InSAR monitoring data.

The InSAR monitoring report produced by TRE is included in Appendix C. The processed data, including LoS and 2-D displacement models, are accessible through TRE's online mapping application, TREmaps. Login credentials to TREmaps have been provided to Tetra Tech and YG-AAM. The LoS and 2-D data is also presented on Figures 21 through 28, attached.

Additional figures showing InSAR data for specific areas of interest are presented in Figures 29 through 38.

2.2 Triggers, Monitoring Recommendations, and Annual Program Review

Various "triggers" for each of the site components have been established and updated since the inception of the LTPMP. Triggers consist of qualitative conditions or quantitative values of a given attribute (e.g., displacement, slope angle, amount of channel migration) that are assigned to a specific site component. Triggers are evaluated during the annual LTPMP using the available observations and monitoring data. Exceedance of a trigger represents an undesirable and/or potentially unstable condition that prompts a predefined response to correct and/or mitigate any potential consequences.

Triggers are evaluated annually as follows:

- Evaluate monitoring data (i.e., visual observations, survey data, and/or InSAR data) to determine if a trigger has been exceeded.
- Determine if the appropriate trigger response has been undertaken and/or identify factors that would prevent the appropriate response from being undertaken.
- Review trigger criteria and associated response actions to determine if they are appropriate, or if they should be revised or removed from future LTPMPs.

Many triggers are normally evaluated using ground-based survey data. Since a ground-based survey was not completed for the 2021 LTPMP, triggers have been evaluated based on InSAR monitoring and/or visual observations, where appropriate. Some triggers could not be reliably evaluated in the 2021 LTPMP due to the absence of a ground-based survey program.

In addition to reviewing and modifying triggers, recommendations for modification to the LTPMP are also made on an annual basis. Monitoring recommendations are used to adjust the scope of the LTPMP to respond to evolving site conditions and/or understanding, for example by increasing the density of monitoring points in areas of sparse coverage, establishing monitoring points at new or repaired site components, or replacing monitoring points that have been damaged or destroyed.

3.0 PERFORMANCE MONITORING

Performance monitoring assessments for the various site components are provided in the following sections. Discussion and recommendations related to these assessments are provided in Section 4.

A summary of the trigger evaluations and recommendations for all of the site components is provided in Appendix F.

3.1 Clinton Creek Access Road

The Clinton Creek access road was assessed mainly based on the observations from the geotechnical site visit in June. The site access road is generally inspected from a moving vehicle while traveling to, from and within the site, with stops to observe areas of interest more closely on foot.

The locations of observations on the access road are identified by the approximate mileage along the road, measured using a vehicle odometer with km 0 at the Top of the World Highway.

3.1.1 Top of the World Highway to Forty Mile Bridge

The access road from the Top of the World Highway to the Forty Mile Bridge is maintained by Highways and Public Works and is generally very good condition.

There were no areas in need of repairs at the time of the site visits conducted in June or September.

3.1.2 Forty Mile Bridge to Site Access Gate

The access road beyond the Forty Mile Bridge is maintained by Highways and Public Works up to about km 35. The road beyond km 35 and within the site boundaries is maintained by YG-AAM.

Repairs were made in 2020 to repair potholes, ruts and eroded areas where the road condition was relatively poor, which has improved trafficability in this section of the road. Some potholes and rutted/eroded areas remain but do not significantly impact accessibility on the road. Similarly, some areas were observed with small amounts of ponded water and/or water flowing over the road, but none that impact accessibility.

Trees overhang or lean toward the road in some places, which limit the trafficable width of the road and could obstruct traffic if they fall.

The landslide at about km 36 continues to show signs of slow, ongoing movement, but does not encroach on the road other than some overhanging vegetation. InSAR detects westward horizontal movement of the landslide at a rate of a few centimetres per year, which is expected given the west-facing slope aspect, but also detects upward vertical movement. This may be an indication that the reference points used to process the InSAR data are not perfectly stable.

3.1.3 Site Access Gate to Former Mill Site

The site access gate remains in good condition. Boulders placed on either side of the site access gate to block unauthorized traffic from bypassing the gate were moved some time before the June site visit, replaced, and moved again before the September site visit.

No new damage was observed to the access road or the Wolverine Creek culverts under the road since the road was washed out and repaired in 2020.

Moderate erosion and rutting is present along the access road shortly after Ford Crossing No. 1, where the road traverses the toe of the Clinton Creek waste rock dump. Small erosion gullies leading to the Clinton Creek channel do not appear to be growing significantly and do not encroach on the access road.

The section of the road beyond the second ford crossing, which climbs a long hill up to the former mill site, is relatively more rutted, gullied and overgrown. Some trees were found to have fallen and blocked the road during the site visit, and were removed by hand. The road remains passable to a light pickup truck.

3.1.4 Ford Crossings

Both ford crossings were repaired/improved in 2020, and new staff gauges were installed to allow for the water depth to be observed before crossing.

Both ford crossings were observed to be in very good condition in 2021.

3.1.5 Minor Roads and Trails

Minor roads and trails that access other areas and component within the site are in varying condition.

It was possible to access all of the required site components for the geotechnical inspection in a light pickup truck during the site visit in 2021. However, the road that accesses the Porcupine Creek waste rock dump is becoming overgrown with vegetation, and the road along the Wolverine Creek channel that accesses the toe of the tailings piles from near the site access gate is blocked with large boulders and not accessible. During the site visit it was possible to access the toe of the tailings by descending the trails established for the drilling program in 2018.

3.1.6 Closed Section of Site Access Road

The closed section of the access road, which experienced major erosion and bank loss in 2020, appeared largely unchanged beyond ongoing development of tension cracks near the crest of the slope.

No new significant embankment loss was observed in 2021, based on visual observations and comparison of photographs from 2020 and 2021.

Movement detected by InSAR in the closed access road is generally consistent with movement in the surrounding areas of the waste rock pile, discussed in Section 3.6. No abnormally rapid movement or acceleration was detected, compared to historical movement rates. However, the principal direction of movement in this area is to the north, which is not detected by InSAR.

3.1.7 Trigger Summary

Three triggers are used to evaluate the performance of the closed section of the access road in the LTPMP, which are summarized on Table 1.

As shown on the table, Trigger AR-1 relates to movement of monitoring points that is tracked through the ground-based survey and could not assessed for the 2021 LTPMP.

Triggers are not used to evaluate the performance of the active access road.

Table 1: Trigger Summary – Clinton Creek Access Road

Trigger ID	Description	Trigger Criteria	Exceeded in 2021?
AR-1	Horizontal movement of baseline	Average horizontal movement greater than 10 cm (less the average reported survey precision) for the baseline spikes, compared to the previous year's survey.	Not assessed
AR-2	Embankment loss	Average horizontal embankment loss greater than 1 m along the length of the baseline, compared to the previous year's survey.	No (based on visual observations)
AR-5	Increased risk of slope failure	Significant apparent increase in the risk of slope failure, based on visual inspection and review of survey data by a Professional Engineer.	No (based on visual observations)

3.2 Hudgeon Lake Outlet

3.2.1 General / Visual Observations

The Hudgeon Lake outlet was inspected during the geotechnical site visit. The log booms were not installed at the time of the inspection. The outlet was clear of debris and the water level appeared to be similar to previous site visits.

Cracking was observed around the log boom abutments and along the crest of the short slope above the lakeshore, but there was no sign of significant new cracking or erosion compared to previous years.

For the 2021 LTPMP, Tetra Tech also completed an assessment of the stability of the log boom abutments. The results of the assessment were presented in a technical memorandum, which is attached in Appendix D. As described in the memorandum, frost jacking appears to be causing ongoing uplift of the post foundations at both abutments. The average uplift of the abutment posts was estimated to be 52 cm on the north abutment and 26 cm on the south abutment since they were installed in 2013, based on survey data from September 2020.

3.2.2 InSAR Monitoring

InSAR monitoring of the ground surface surrounding the Hudgeon Lake outlet showed very little movement, approximately 1 cm, which effectively indicates static conditions. Data coverage is relatively good in the vicinity of the log boom abutment system, however InSAR monitoring is not well suited to monitoring small, localized structures such as the individual log boom abutment posts, and cannot detect movement of the lake bottom beneath the water level.

3.2.3 Trigger Summary

Two triggers are used to assess the performance of the Hudgeon Lake outlet, which are summarized on Table 2.

As shown on the table, Trigger HL-2 relates to movement of the log boom abutments that is tracked through the ground-based survey and could not assessed for the 2021 LTPMP.

Table 2: Trigger Summary – Hudgeon Lake Outlet

Trigger ID	Description	Trigger Criteria	Exceeded in 2021?
HL-2	Movement of log boom abutments	Horizontal movement greater than 30 cm or vertical movement greater than 10 cm (less the reported horizontal or vertical movement precision), compared to previous year's survey.	Not assessed
HL-3	Erosion at log boom abutments	Significant erosion around the base of the abutment structures, based on visual assessment and/or review of survey data by a Professional Engineer.	No (based on visual observations)

3.3 Gabion Drop Structures

3.3.1 General / Visual Observations

The gabion drop structures were inspected during the geotechnical site visit. The inspection included the collection of detailed photo and video documentation using a drone. The photo/video record was used to conduct a hydrotechnical review of the temporary repairs at DS4, the general condition of the other three drop structures, and the Clinton Creek channel downstream from the drop structures. The hydrotechnical review was documented in a technical memorandum, which is attached in Appendix E.

The drop structures were relatively free of debris during the geotechnical site visit. DS1 typically experiences greater accumulation of sticks and logs, however only a few small logs were noted this year. These were removed by hand during the site visit. All of the drop structures appeared to be functioning as intended, with little to no visible changes compared to their condition in 2020.

Erosion of material from the gabion baskets appears to be ongoing, especially at DS3. Minor cracking is present at the crest of the slopes around some of the drop structures but does not appear to be worsening compared to previous years.

DS4 was severely damaged during the 2018 freshet, and temporary emergency repairs were completed 2018 and 2019. As described in the hydrotechnical review, the temporary repairs have performed well but are not considered to be adequate to maintain long term channel stability around DS4. The "plunge pool" just downstream from DS4 has been partially re-filled with gravel, presumably fill material that has been eroded from the former ACB mat area.

3.3.2 InSAR Monitoring

InSAR monitoring detects relatively little ground movement in the vicinity of the gabion drop structures, typically a few centimetres of settlement and practically no east-west horizontal displacement over the monitoring period. Movement of the individual gabions in the drop structures is not reliably captured by InSAR, and areas under moving water do not return coherent reflectors required for InSAR monitoring.

3.3.3 Trigger Summary

Four triggers are used to assess the gabion drop structures in the LTPMP, which are summarized on Table 3.

GDS-1 is normally evaluated based on topographic survey results but is considered to not be triggered in 2021, on the basis of no visible changes since the last topographic survey in 2020.

GDS-2, GDS-4 and GDS-5 remain triggered at DS4, similar to the past several years, but are not triggered at the other three drop structures.

Table 3: Trigger Summary – Gabion Drop Structures

Trigger ID	Description	Trigger Criteria	Exceeded in 2021?
GDS-1	Drop structure side slopes	Side slopes of drop structure increases to steeper than 2H:1V.	No (based on visual observations)
GDS-2	Freeboard at design flow	Freeboard of less than 0.6 m (to top of gabion baskets) under design flow.	Yes, former ACB mat area only
GDS-4	Erosion/Piping	Visual evidence of erosion, piping, undermining, or water flowing beneath the drop structures warranting further assessment or mitigation measures in the opinion of a Professional Engineer.	Yes, DS4 only
GDS-5	Gabion damage	Visual evidence of damage to wire mesh gabion baskets or concrete blocks of the ACB mats.	Yes, DS4 only

3.4 Clinton Creek Channel

3.4.1 General / Visual Observations

The Clinton Creek channel was assessed primarily based on visual observations made during the geotechnical site visit.

Erosion, deposition, channel migration, and periodic sloughing of material into the channel from the natural slope to the north and the waste rock dump to the south are ongoing, particularly in the upper part of the channel, but there were no major changes observed compared to the previous geotechnical site visit in any of the upper, middle or lower sections of the creek channel.

3.4.2 InSAR Monitoring

InSAR coverage in the creek channel was generally poor, particularly with respect to trigger criteria, which focus on erosion, deposition and migration of the creek channel.

InSAR does not detect coherent reflectors on moving water, and therefore could not be used to evaluate triggers in the Clinton Creek channel.

3.4.3 Trigger Summary

Four triggers are used to assess the Clinton Creek channel in the LTPMP, all of which are normally evaluated using ground-based survey results.

For 2021, triggers for the Clinton Creek channel have been evaluated based on visual observations from the geotechnical site visit. The Clinton Creek channel triggers are summarized on Table 4.

Table 4: Trigger Summary – Clinton Creek Channel

Trigger ID	Description	Trigger Criteria	Trigger Exceeded in 2021?
CC-1	Channel downcutting	More than 0.5 m of downcutting in the Upper Channel, between DS4 and Sta. 0+300, compared to the baseline (2010) survey.	No (based on visual observations)
CC-2	Channel downcutting	More than 1.5 m of downcutting over a significant portion (i.e., more than 50 m) of the creek channel downstream from Sta. 0+300, compared to the baseline (2010) survey.	No (based on visual observations)
CC-3	Channel deposition	More than 0.3 m of material deposition in any portion of the creek channel, compared to the previous year's survey.	No (based on visual observations)
CC-4	Lateral channel migration	Middle Channel (Sta. 0+685 to 0+890) migrates laterally by more than 5 m to the south, towards the toe of the waste rock dump, compared to the previous year's survey.	No (based on visual observations)

3.5 Clinton Creek Natural Slope

3.5.1 General / Visual Observations

The Clinton Creek natural slope was inspected during the geotechnical site visit.

Tension cracking and shallow slope failures continue to occur on the slope, and material continues to slough into the creek channel from time to time. The bedrock at the base of the slope continues to be eroded by the creek. However, there was no sign of significant, new slope movement observed during the site visit.

Erosion from water flowing down the drill access trail to BH18-08 has continued as in previous years, and a gully has developed on the downhill side of the trail near Drop Structures 2 and 3.

3.5.2 InSAR Monitoring

InSAR coverage on the natural slope is generally poor, due the dense cover of vegetation. Temporary coherent scatters (TCS) in the InSAR data provide somewhat better coverage, however these do not indicate any consistent movement pattern. TCS is discussed in more detail in TRE's InSAR monitoring report.

3.5.3 Trigger Summary

No triggers are used to evaluate the performance of the Clinton Creek natural slope.

3.6 Clinton Creek Waste Rock Dump

3.6.1 Waste Rock Units

The Clinton Creek waste rock dump can be considered as four units, each corresponding to different periods of deposition during mine operations and displaying a distinct pattern of deformation. Units 1, 2 and 3 have been discussed in previous LTPMP reports. The waste rock dumped around the north rim of the Snowshoe Pit has been discussed in previous reports, and is formalized as "Unit 4" in this report.

- Unit 1 is located on the west site of the waste rock dump, between the Porcupine Pit, Hudgeon Lake, and the gabion drop structures. This is the oldest and largest pile of the waste rock dump, where the original dump failure occurred in 1974. Unit 1 displays radial outward movement from the upper, central portion of the pile that moves downslope toward Hudgeon Lake and the drop structures.
- Unit 2 is located adjacent to the east side of Unit 1 and the north end of the Porcupine Pit. Waste rock was placed in Unit 2 after the failure of the first waste rock pile (Unit 1); Unit 2 is not as high or steep and is considered to be relatively stable, with a few exceptions in localized steep areas (e.g., the steep slope just northeast of the Porcupine Pit).
- Unit 3 is adjacent to the east side of Unit 2 and northwest of the Snowshoe Pit. Unit 3 is relatively small but has not been closely monitored and has only had a few monitoring points installed for tracking movement with the ground-based survey.
- Unit 4 consists of waste rock dumped around the north rim of the Snowshoe Pit. No monitoring points for ground-based survey have been installed in this area, but InSAR monitoring shows that Unit 4 spreads radially down and out from the top of the pile.

The waste rock can also be divided into slope segments, delineated by elevation as follows:

- Upper Slope, above El. 450 m.
- Mid-Slope, between El. 420 and 450 m.
- Lower Slope, below El. 420 m.

The waste rock units and slope segments in the Clinton Creek waste rock dump are illustrated on Figure 19.

3.6.2 Visual Observations

No evidence of significant new movement was observed on the Clinton Creek waste rock dump. Erosion and gullying are ongoing where surface water flows over the waste rock.

3.6.3 InSAR Monitoring

The Clinton Creek waste rock pile is well suited to monitoring using InSAR, due to its large area, relative lack of vegetation cover and its characteristic gradual, progressive movement behaviour. Excellent coverage with InSAR is achieved practically throughout Units 1 and 2, and some gaps in coverage are visible in the InSAR data for parts of Units 3 and 4 where relatively thick vegetation is present.

Despite the good coverage practically throughout, utility of InSAR monitoring for the Clinton Creek waste rock dump is somewhat limited since InSAR does not detect north-south movement. Historical ground-based survey results show that the principal direction of movement in some areas of the waste rock dump is to the north (e.g., along the Clinton Creek channel, mid-slope portion of Unit 1). While the north-south component of movement is not detected directly using InSAR, displacement in general can still be detected in the LoS displacements and 2-D vertical displacement (Figures 21, 22 and 24), and northward movement can be inferred where vertical settlement is detected by InSAR in areas that are known to principally move to the north (e.g., downslope movement along north-facing slopes).

Average movement in most of Unit 1 is practically zero in the east-west direction, and typically 1 to 2 cm of vertical settlement during the InSAR monitoring period. However, considering the average east-west movement throughout Unit 1 will be somewhat misleading since the horizontal movement of the unit is by radial spreading. A localized area of relatively high movement where the western toe of the waste rock enters Hudgeon Lake is shown on Figure 29. As shown on the figure, the westward displacement rate is approximately 6 cm/yr and the vertical settlement rate is approximately 7 cm/yr in this area. Horizontal and vertical movement rates have been nominally constant throughout the InSAR monitoring period.

Average movement throughout Unit 2 is practically zero in the east-west movement. Vertical settlement up to about 10 cm was observed in the Upper Slope area, and relatively little settlement was observed in the lower and mid-slope areas. A localized area of relatively high movement near the access trail leading to the northeast side of Porcupine Pit shows is shown on Figure 30. As shown on the figure, the westward movement rate is approximately 8 cm/yr and was nominally constant throughout the InSAR monitoring period. The vertical settlement rate was approximately 7 cm/yr for the first year of InSAR monitoring, decelerating to about 4 cm/yr after September 2020.

Average movement detected by InSAR in Unit 3 is relatively small. However, InSAR coverage in Unit 3 is localized in relatively level areas where high movement rates would not be expected. The steeply sloping portion of Unit 3 that falls to the Clinton Creek channel is vegetated and has almost no coverage with InSAR. It is assumed that Unit 3 spreads radially outward from the top of the lobe, however movement is not well understood due to the poor InSAR coverage and lack of historical ground-based survey data.

Unit 4 includes several distinct, relatively small piles of waste rock, which are expected to move by radial spreading outward from the top of each individual pile. Movement of the westernmost pile of Unit 4, near the northwest corner of the Snowshoe Pit, is illustrated on Figure 31. The western toe of the pile is spreading westward at a rate of approximately 6 cm/yr, and the eastern toe of the lobe is spreading eastward at a rate of approximately 4 cm/yr. There is slight variability in the movement rate of these areas, however no distinct trends of acceleration or deceleration are visible in the data. The upper part of the pile shows approximately 7 cm/yr of vertical settlement. The lower part showed about 2 cm of settlement over the first monitoring year (September 2019 to September 2020), and about 2 cm of uplift over the second monitoring year (September 2020 to September 2021). The uplift is likely reflective of downslope movement from the top of the pile causing bulging at the toe; the preceding apparent settlement may be due to instability in the reference point. Overall, the lower part of Unit 4 is experiencing little movement.

3.6.4 Trigger Summary

One trigger is used to evaluate the performance of the Clinton Creek waste rock dump, shown on Table 5.

The trigger is normally evaluated using ground-based survey data but can also be evaluated based on visual observations and InSAR monitoring data.

Table 5: Trigger Summary – Clinton Creek Waste Rock Dump

Trigger ID	Description	Trigger Criteria	Trigger Exceeded in 2021?
CCWR-1	Movement of waste rock dump	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	No

3.7 Porcupine Creek Waste Rock Dump

3.7.1 General / Visual Observations

The Porcupine Creek waste rock dump is located south of Porcupine Pit. The waste rock encroaches on the creek channel, which is constrained between the toe of the waste rock pile and the natural slope on the east side of the valley.

The surface and slopes of the waste rock dump appear to be relatively stable. Movement appears to be limited to occasional sloughing on the slopes of the waste rock dump.

A small pond is located on the Porcupine Creek channel just upstream from the waste rock. Water from the creek is believed to flow partially within the constrained channel, and partially as underground seepage through the base of the waste rock. Seepage water daylights near BH18-19 and flows north on the surface for approximately 100 m before collecting in a shallow depression and infiltrating again as groundwater. Downcutting and erosion downslope from this depression suggest that the pond may overflow during wet periods (e.g., high rainfall and/or spring freshet).

3.7.2 InSAR Monitoring

InSAR monitoring of the Porcupine Creek waste rock dump indicates vertical settlement at an average rate of 5 cm/yr and downslope movement toward Porcupine Creek. Relatively high displacement rates are detected in localized areas near the eastern southern edges of the waste rock.

Figure 32 shows displacement detected by InSAR near the eastern toe of the Porcupine Creek waste rock dump. Horizontal displacement to the east is steady at about 5 cm/yr over the two-year monitoring period. Vertical settlement was approximately 6 cm/yr in 2020, decelerating to about 4 cm/yr in 2021.

3.7.3 Trigger Summary

One trigger is used to evaluate the performance of the Porcupine Creek waste rock dump, shown on Table 6.

Table 6: Trigger Summary – Wolverine Creek Waste Rock Dump

Trigger ID	Description	Trigger Criteria	Trigger Exceeded in 2021?
PCWR-1	Movement of waste rock dump	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	No

3.8 Porcupine and Snowshoe Pits

3.8.1 General / Visual Observations

The Porcupine Pit was visually assessed from the lookout on the Clinton Creek waste rock dump near the north end of the pit, and from the southeast rim of the pit near the Porcupine Creek waste rock dump. The condition of the pit was similar to previous years. Minor rockfalls and sloughing continue to occur as the pit walls and benches weather to residual slopes. Evidence of large, historic landslides is visible on the southwest and southeast walls, near the rim of the pit, but there is no visible evidence of significant, new movement. The water level in the pit was similar to previous years.

The Snowshoe Pit was visually assessed from a viewpoints on the Clinton Creek and Porcupine Creek waste rock dumps. Like the Porcupine Pit, the Snowshoe Pit is in similar condition to previous years. Small rockfalls and sloughing from the pit walls are ongoing, but there is no evidence of any significant, new movement.

3.8.2 InSAR Monitoring

InSAR monitoring provides relatively good coverage throughout both open pits, with some gaps in coverage on the western extent of the Porcupine Pit. Movement detected by InSAR in the open pits is generally in accordance with expected movement patterns.

Movement on the northwest wall of the Porcupine Pit is shown on Figure 33. As shown on the figure, downslope movement is relatively uniform throughout the area, with little variation in displacement rates across the pit wall. Eastward movement was approximately 22 cm from September 2019 to September 2020, decelerating to about 16 cm over the remainder of the monitoring period. Downward movement was approximately 9 cm from September 2019 to September 2020, decelerating to about 6 cm over the remainder of the monitoring period.

The southeast wall of the Porcupine Pit has a localized zone of movement in the central portion of the wall, which is shown in Figure 34. The area shown in the figure may correspond to an old, relatively large landslide that originated from near the pit rim, where a possible headscarp has been observed during site inspections. InSAR detected about 12 cm of westward movement and 4 cm of downward movement of the landslide over the monitoring period. Movement of the surrounding areas of the pit wall was less than approximately 2 cm over the same period. This is illustrated by the movement profiles shown on Figure 34, where localized movement is observed at about 200 m distance along the surface profile. InSAR coverage in the top of the landslide area near the pit rim is poor, possibly due to a lack of coherent reflectors detected from the descending orbit; however, LoS results from the ascending orbit indicates low to moderate movement away from the satellite, which would be consistent with downslope movement on the steep headscarp near the pit rim.

InSAR coverage is poor in the western extent of the Porcupine Pit. This area includes a possible large, historic landslide block that may have detached from the pit rim. The lack of coherent reflectors is understood to be partly due to an unfavourable slope angle with respect to the satellite's line of sight, and may also be affected by the movement behaviour in the area, which appears to consist of more sporadic, rapid movements (e.g., periodic rockfalls) which cannot be reliably tracked using InSAR compared to more consistent, gradual movement (e.g., slope creep) that is observed elsewhere on the pit walls.

InSAR detects relatively little movement in the Snowshoe Pit, with movement rates generally less than a few centimetres per year.

3.8.3 Trigger Summary

One shared trigger has been used in the LTPMP to evaluate the performance of both the Porcupine and Snowshoe Pits. For 2021, a second trigger is proposed to evaluate the Snowshoe Pit separately from the Porcupine Pit and eliminate potential for confusion in case the shared trigger was exceeded in one (but not both) of the open pits. The two triggers are shown on Table 7.

Table 7: Trigger Summary – Porcupine and Snowshoe Pits

Trigger ID	Description	Trigger Criteria	Trigger Exceeded in 2021?
PP-1	Movement of open pit slopes (Porcupine Pit)	Significant increase in movement rates (horizontal or vertical settlement) observed in the Porcupine Pit, warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	No
SP-1	Movement of open pit slopes (Snowshoe Pit)	Significant increase in movement rates (horizontal or vertical settlement) observed in the Snowshoe Pit, warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	No

3.9 Wolverine Ponds

3.9.1 General / Visual Observations

The Wolverine Ponds were assessed during the visual geotechnical site inspection.

The south pond appears to be largely unchanged compared to the previous year. The small beaver dam at the outlet of the south pond is still present, but is partially breached and does not appear to be significantly restricting the flow of water or increasing the water level in the pond.

A new beaver dam is present at the outlet of the north pond. This beaver dam is approximately 1 m high (above the water level on the downstream side) and has caused the water level in the north pond to increase.

A third, small beaver dam exists approximately midway between the north and south ponds, first observed during the 2021 geotechnical site visit. This beaver dam does not appear to be significantly restricting stream flow.

3.9.2 InSAR Monitoring

InSAR was not used to evaluate the ponds, since InSAR cannot detect coherent reflectors over water.

3.9.3 Trigger Summary

Three triggers are used to evaluate the performance of the Wolverine Creek ponds, shown on Table 8.

WP-1 and WP-3 were evaluated based on visual observations during the site visit. WP-2 was not assessed in 2021, since it is based on survey results.

Table 8: Trigger Summary – Wolverine Ponds

Trigger ID	Description	Trigger Criteria	Trigger Exceeded in 2021?
WP-1	Pond surface area	Surface area of one or both Wolverine Ponds increases by more than 25%, compared to previous year's survey.	Yes, North Pond (based on visual observations)
WP-2	Pond outlet width	Outlet width of one or both Wolverine Ponds decreases by more than 15%, compared to the previous year's survey.	Not assessed
WP-3	Pond outlet invert elevation	Pond outlet elevation at one or both Wolverine Ponds changes (increase or decrease) by more than 0.5 m, compared to previous year's condition.	Yes, in north pond (based on visual observations)

3.10 Wolverine Creek Channel

3.10.1 General / Visual Observations

The Wolverine Creek channel was assessed during the geotechnical site visit. The condition of the creek channel appears to be similar to previous years.

Some minor accumulation of debris (logs, sticks, and brush) has occurred in the channel, especially near the pond outlets. Gradual erosion of the channel bottom, toes of the tailings lobes, and toe of the natural slope is ongoing in areas where the tailings encroach on the creek channel. The western bank of the channel in this area is steep and composed of loose tailings which are more susceptible to erosion than the natural slope on the east side. No major erosional or depositional events appear to have occurred since the 2020 geotechnical site visit.

No significant changes were observed in the rock-lined section of the Wolverine Creek channel. This section of the creek is in good condition, with only minor erosion observed and no obstructions to creek flow.

The creek channel between the rock-lined channel and the access road culvert crossing is similar to previous years. The area immediately upstream of the culverts beneath the site access road, which was cleared and widened following the road washout in 2020, remains clear and the creek has begun to establish a meandering, braided path through this section. The culverts were clear of vegetation which has been noted in past site visits.

3.10.2 InSAR Monitoring

Similar to the Clinton Creek channel, InSAR coverage in the Wolverine Creek channel was generally poor, particularly with respect to trigger criteria, which focus on erosion, deposition and migration of the creek channel.

InSAR does not detect coherent reflectors on moving water, and therefore could not be used to evaluate triggers in the Clinton Creek channel.

3.10.3 Trigger Summary

Five triggers are used to evaluate the performance of the Wolverine Creek channel, shown on Table 9.

Similar to triggers for the Clinton Creek channel, the Wolverine Creek triggers are normally evaluated using ground-based survey data, but were evaluated based on visual observations from the geotechnical site visit for 2021.

Table 9: Trigger Summary – Wolverine Creek Channel

Trigger ID	Description	Trigger Criteria	Trigger Exceeded in 2021?
WC-1	Channel downcutting	More than 1 m of downcutting over a significant portion (i.e., more than 50 m length) of the creek channel between Sta. 0+975 and 1+500, compared to the baseline (2003) survey.	No (based on visual observations)
WC-2	Channel downcutting	More than 0.5 m of downcutting over a significant portion (i.e., more than 50 m) of the creek channel between Sta. 0+685 and 0+975, compared to the baseline (2003) survey.	No (based on visual observations)
WC-3	Channel instability	Visual evidence of erosion, instability, or loss of rock in rock-lined channel (Sta. 0+435 to 0+685).	No (based on visual observations)
WC-4	Channel deposition	More than 0.3 m of material deposited in any portion of the creek channel, compared to the previous year's survey.	No (based on visual observations)
WC-5	Lateral channel migration	Channel migrates laterally by more than 5 m, compared to the previous year's survey.	No (based on visual observations)

3.11 Wolverine Creek Natural Slope

3.11.1 General / Visual Observations

No significant changes were observed in the Wolverine Creek natural slope compared to the previous LTPMP.

Near the base of the tailings lobes, material from the natural slope sloughs into the creek channel from time to time where the base of the slope is eroded by the creek.

No signs of significant slope movement were visible on the natural slopes along the length of the creek downstream from the tailings.

3.11.2 InSAR Monitoring

Similar to the Clinton Creek natural slope, InSAR coverage is sparse on the natural slopes surrounding Wolverine Creek, due to the relatively thick vegetation that obscures the ground surface.

3.11.3 Trigger Summary

No triggers are used to evaluate the performance of the Wolverine Creek natural slopes.

3.12 Wolverine Creek Tailings Pile

3.12.1 Tailings Lobes

Similar to the Clinton Creek waste rock dump, the Wolverine Creek tailings can be considered as three separate lobes, where each lobe represents a different era of tailings disposal and displays a distinct pattern of displacement:

- **South Lobe**: tailings were initially deposited in the South Lobe, until the pile failed and slid into Wolverine Creek in 1974. The south lobe generally creeps downslope to the east, into the Wolverine Creek channel. The Wolverine Creek south pond is impounded on the upstream (north) side of the South Lobe;
- **North Lobe**: tailings were placed in the North Lobe following the failure of the South Lobe in 1974. The North Lobe has not experienced catastrophic failure, but over time it has crept downslope and impacted Wolverine Creek. The Wolverine Creek north pond is impounded on the upstream (north) side of the North Lobe; and
- **Northwest Lobe**: tailings were placed in the Northwest Lobe after displacement was observed in the North Lobe. The Northwest Lobe does not impact the creek and is relatively stable. However, downslope movement of the tailings does occur on the north and east sides of the Northwest Lobe.

The tailings pile can also be divided into slope segments, delineated by elevation as follows:

- Upper Slope, above El. 530 m.
- Mid-Slope, between El. 420 and 530 m.
- Lower Slope, below El. 420 m.

The tailings lobes and slope segments are illustrated in Figure 20.

3.12.2 Visual Observations

The tailings continue to show signs on ongoing downslope movement, erosion, and gullying, but there was no sign of significant, new movement since 2020.

3.12.3 InSAR Monitoring

Similar to the waste rock dumps, the Wolverine Creek tailings pile is well suited to monitoring by InSAR due to its large area, lack of vegetation, and slow, steady movement. Most of the tailings move downslope in a nominally eastward direction, which is captured very well by InSAR.

Annual displacement is typically less than 5 cm/yr across the upper and mid-slope areas of the North and South lobes. Higher displacement rates up to about 15 cm/yr were observed in localized zones on the mid-slope of the

South Lobe, North Lobe, and the toe of the Northwest Lobe. Time-series displacement charts are presented in Figures 35 through 38 for these localized areas on the tailings piles where relatively high movement rates are detected:

- The lower slope of the South Lobe, shown on Figure 35, shows approximately 15 cm/yr of eastward movement and 5 cm/yr of vertical settlement. The movement rate is nominally constant throughout the InSAR monitoring period.
- The toe of the North Lobe, shown on Figure 36, shows less than 4 cm/yr of eastward movement and negligible vertical movement. The eastward movement rate is nominally uniform and the vertical movement rate shows a possible slight acceleration during 2021, although net movement over the two-year monitoring period is practically zero.
- The area of the tailings between the North and South Lobes, shown on Figure 37, shows approximately 15 cm/yr of eastward movement and 6 cm/yr of vertical settlement. The movement rate is nominally constant throughout the InSAR monitoring period.
- The toe of the Northwest Lobe, shown on Figure 38, shows approximately 7.5 cm/yr of eastward movement and 6 cm/yr of vertical settlement. The movement rate is nominally constant throughout the InSAR monitoring period.

3.12.4 Trigger Summary

One trigger is used to evaluate the performance of the Wolverine Creek tailings pile, shown on Table 10.

Table 10: Trigger Summary – Wolverine Creek Tailings Pile

Trigger ID	Description	Trigger Criteria	Trigger Exceeded in 2021?
TP-1	Movement of tailings pile	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	No

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Site Access Road

4.1.1 General

The site access road is generally in good condition, and the site is easily accessible to light pickup trucks. In general, there is no immediate or critical action required other than to monitor the road condition and make repairs when required to maintain access to the site.

Boulders placed around the site access gate appear to be ineffective in deterring unauthorized site access. Boulders beside the gate had been moved prior to the June site visit, and were moved again prior to the September site visit.

The Wolverine Creek culverts, immediately past the site access gate, remain undersized and this section of road remains at risk of washout during periods of high flow, as occurred during the 2020 freshet. We understand that

YG-AAM may prefer to leave the culverts as-is and make repairs when necessary, due to the high cost of upgrading the culverts to provide enough capacity for estimated flood volumes. It is likely that the re-shaping and removal of vegetation from the creek channel just upstream from the culverts has significantly improved the flow-handling capacity of the existing culverts, which would reduce the likelihood of future washouts.

Within the site, erosion and encroachment of vegetation into the roadway is ongoing in various locations, most notably where the road parallels the Clinton Creek channel just beyond Ford Crossing No. 1, and where the road climbs to the former mill site beyond Ford Crossing No. 2. The erosion gully at about km 41.8 (along the climb to the former mill site) is still visible but appears to be inactive. No imminent risk to site access was noted.

Both ford crossings are in good condition, having sustained the 2021 freshet with no visible damage.

Accessibility to the Porcupine Creek waste rock is becoming more difficult as vegetation continues to grow on the minor road that accesses the area. Vehicle access to the base of the tailings piles is currently possible using the drilling trails, but the trails are very steep and may not be practical to maintain, and it is expected that they may not remain accessible in the long term.

Based on the conditions of the access road observed during the geotechnical site visit, no critical or immediate repairs to the access road are required. Tetra Tech's recommendations are generally focused on repairing relatively minor damage and/or removing obstructions as needed to maintain ready site access.

Tetra Tech recommends the following actions be implemented for the site access road:

- The road between the Top of the World Highway and the Forty Mile Bridge should be maintained as required to allow vehicle and equipment access. We understand this section of the road is maintained by YG-HPW.
- The road between the Forty Mile Bridge and the former mill site should be maintained as needed to allow vehicle and equipment access.
- Mileage markers should be installed to reduce uncertainty in estimating location/distance along the access road.
- Larger boulders or a permanent fence should be installed around the site access gate to prevent future tampering and more effectively limit unauthorized site access.
- Hydrotechnical studies done in 2020 suggest that the Wolverine Creek culverts near the site access gate are undersized. The culverts should be upgraded to handle design flows, or the area should be regularly monitored (especially at freshet), culverts kept clear of debris/blockages, and damage repaired as needed to maintain site access.
- Measures for erosion protection should be considered along the road and/or in the Clinton Creek channel in the section between Ford Crossing No. 1 and the closed access road, to prevent ongoing/future erosion that could impact access to the site.
- A swale or berm should be installed around the top of the erosion gully on the road between Ford Crossing No. 2 and the former mill site (about km 41.8) to reduce the potential for future erosion.
- The site access road between Ford Crossing No. 2 and the former mill site should be re-graded to repair erosion and gullying, and vegetation should be trimmed to maintain vehicle access.
- Boulders and berms blocking the access road to the Wolverine Creek channel and base of the tailings piles should be removed and replaced with a locking gate, to allow authorized vehicle access to these areas in case the existing trail that descends the tailings pile becomes inaccessible.

- Minor roads and trails on the site should be cleared of vegetation and maintained as required to provide access to all site components. Specifically, clearing of vegetation is required on the minor roads accessing the Porcupine Creek waste rock dump.

4.1.2 Closed Portion of Access Road

The closed section of the access road showed no significant deterioration since the relatively major episode of embankment loss in 2020. No significant new embankment loss and little to no new tension cracking was observed. The waste rock material that collapsed into the creek channel in 2020 appears to be temporarily supporting the slope, and it is possible that no more major embankment loss will occur until it is washed away and the creek continues to undermine the embankment.

The ditch-like swale near the toe of the slope on the uphill (south) side of the closed access road continues to collect and divert surface water away from the collapsing crest of the embankment. This swale could be improved to formalize a ditch that will continue to divert surface water away from the slope.

- The closed section of the access road should remain closed.
- The existing swale along the uphill (south) side of the closed access road should be improved to establish a formalized ditch that will carry surface water away from the slope crest and slow the rate of erosion and embankment loss into the Clinton Creek channel.

4.2 Hudgeon Lake Outlet

The Hudgeon Lake outlet was assessed visually during the geotechnical site visit.

Frost jacking of the log boom abutments is likely ongoing, as discussed in the log boom stability assessment memorandum. The trigger for movement of the log boom abutment (HL-2) could not be evaluated in 2021 since there was no ground-based survey, but it was exceeded in 2020 for vertical displacement (upward), and it is expected that frost jacking is ongoing with each seasonal freeze-thaw cycle. Ongoing frost jacking will eventually de-stabilize the abutments.

No significant erosion, horizontal movement or settlement of the ground surface was observed around the abutments and the lake outlet. Minor cracking around the abutments near the crest of the short slope above the lakeshore continues to be observed. InSAR monitoring did not detect any significant movement in the area of the Hudgeon Lake outlet.

The log booms were not installed at the time of the geotechnical site visit or fall instrumentation visit. Both booms were resting on the lakeshore near the south abutment.

Tetra Tech recommends the following for the Hudgeon Lake outlet:

- The log boom abutments should be surveyed in 2022 to track ongoing frost jacking.
- Repairs to the log boom abutments should be considered to mitigate the effect of frost jacking. Repairs would generally consist of re-installing both abutments at their original embedded depths and backfilling with non-frost susceptible fill to reduce the potential for continued frost jacking issues.
- The Hudgeon Lake outlet should be monitored for beaver activity (dam building) or other debris/blockages, which should be cleared promptly when observed.

- The log booms should be installed when Hudgeon Lake is unfrozen, to reduce the amount of debris that enters the creek channel and the resulting potential for damage to the drop structures.

4.3 Gabion Drop Structures

No significant changes were observed at the gabion drop structures during the 2021 site visit.

DS1, DS2, and DS3 remain in relatively good condition, however the erosion of undersized rock from within the gabion baskets is ongoing, which may eventually result in damage to the wire gabions and/or failure of the drop structure.

The condition of DS4 is also similar to previous years. The temporary repairs continue to function as intended; however, the repairs are still considered to be temporary. The triggers for freeboard (GDS-2), erosion/piping at the drop structures (GDS-4) and damage to the gabion baskets (GDS-5) remain active. We understand that Parsons has been retained by YG-AAM to design long-term improvements to the drop structures, and that construction is scheduled for 2022.

Tetra Tech recommends the following:

- Logs and other debris that become lodged in the drop structures should be removed to reduce the potential for damage to the gabion baskets.
- Long-term improvements to the drop structures should be implemented in 2022. If the improvements cannot be built in 2022 as planned, then at a minimum the interim repairs outlined in Tetra Tech's hydrotechnical review (Appendix E) should be implemented to reinforce the temporary repairs at DS4.

4.4 Clinton Creek Channel

The Clinton Creek channel is in similar condition to previous years. No significant new erosion, deposition or channel migration was observed during the site visit, including in the area of the closed access road where a significant volume of waste rock fell into the creek channel in 2020.

Deposition of gravel from the DS4 is ongoing in the former ACB mat area immediately downstream from the drop structures.

Erosion of the natural slope and the waste rock dump on the north and south sides of the creek, respectively, is ongoing in the upper portion of the creek channel. There does not appear to be any imminent risk of the channel being completely blocked by material entering from the natural slope or the waste rock dump, but sloughing material enters the channel from time to time, which partially obstructs the flow of water in some locations. A larger-than-average landslide or collapse of waste rock into the channel could cause a temporary blockage of the creek, which would likely be overtopped and eroded relatively quickly. Due to the remote nature of the site (i.e., no full-time staff on site, relatively infrequent site visits), it is likely that the entire sequence of blockage, overtopping and erosion to restore a semi-stable creek channel would occur before the initial blockage is detected. The consequence of such an event would likely be limited to a period of increased erosion and sedimentation as the blockage is washed away and deposited downstream. If a significant depth of water were to pool behind a large blockage, there would be a temporary increase in the potential for additional movement/failures on the surrounding slopes until the blockage is breached.

The repairs completed at Ford Crossing No. 1 in 2020 continue to perform well.

The long-term solution for the Clinton Creek channel will be to implement permanent stabilization measures to control erosion along both sides of the upper creek channel, between the gabion drop structures and Ford Crossing No. 1.

Tetra Tech recommends the following:

- The creek channel should be monitored for blockages by debris, logs, beaver dams, or similar. Any blockage should be removed promptly when observed.
- Permanent repairs or improvements should be made to stabilize the creek channel to reduce erosion and sloughing from the channel and the surrounding slopes.

4.5 Clinton Creek Natural Slope

The Clinton Creek natural slope continues to experience tension cracking and small, shallow landslides. Slope movements generally appear to consist of vegetation and a thin layer of overburden soil sliding over bedrock. Toppling of bedrock occurs in the creek channel, where the rock is eroded and undermined by the creek.

As described in Section 4.4, small landslides and toppling of bedrock impact and partially block the creek channel from time to time, but there is no sign that any large landslides are likely to occur that would completely block the channel. However, if a large landslide occurred it is possible that the debris would cause a blockage of the creek channel, especially in the upper creek where the channel is narrow and constrained between the natural slopes and the waste rock dump.

Diversion of surface water and erosion is ongoing on the access trail to BH18-08. Increased gullying near the base of the trail was observed in 2021. There was no sign of water crossing the trail and spilling onto the natural slope, but there is risk that this could occur during spring freshet and/or during heavy rainfall, which could lead to landslides on the natural slope that could impact the drop structures.

Extensometers could be installed to monitor development of existing tension cracks, especially on the slopes above the upper channel and drop structures where there is relatively greater potential that a slope failure could block the creek. Simple extensometers can be constructed using wooden stakes and fishing line and could be installed during the 2022 geotechnical site inspection.

Tetra Tech recommends the following:

- Extensometers should be installed to monitor movement/widening of existing tension cracks on the slope.
- The access trail to BH18-08 that climbs the natural slope to the north of the drop structures should be decommissioned to restore natural drainage on the slope, and/or a berm or ditch should be established to ensure that water is carried all the way to the base of the trail and is not allowed to spill onto the natural slope.

4.6 Clinton Creek Waste Rock Dump

The Clinton Creek waste rock dump continues to move according to established movement rates and patterns.

Mass movement is understood (from historical survey data) to be principally northward, which is not captured by the InSAR monitoring. Northward movement in previous years has been gradual, and no indication of any acceleration was noted during the site visit.

Units 1 and 2 move to the north and west, towards Hudgeon Lake and the Clinton Creek channel. In theory, a large mass movement event could have serious consequences, including damage to the gabion drop structures and/or blockage of the flow in Clinton Creek. However, since the original failure of the waste rock dump in 1974, movement of the waste rock has been characteristically slow and steady (creep), and large landslides from the waste rock are considered to be unlikely. The largest events that have impacted the creek channel in recent years have been episodes of embankment collapse along the closed access road. However, the assessment of movement in Units 1 and 2 is limited since InSAR does not detect movement in the principal direction (northward) in the most critical locations (along the creek channel). Northward movement can be inferred based on vertical settlement detected by InSAR, but ground-based survey would be required to confirm movement rates and directions in this area.

The base of Unit 3 encroaches on the lower channel of Clinton Creek, which retains a nominally natural stream gradient and is laterally unconfined, compared to the middle or upper channel sections which are relatively steep and confined between the waste rock and the natural slope. Ongoing downslope movement is considered to be of low consequence, since it would be practically impossible for the creek channel to be blocked even by a very large slope failure occurring in Unit 3.

Based on satellite imagery, the western waste rock pile in Unit 4 appears to be encroaching on a series of beaver ponds and the lower Clinton Creek channel to the north, and the Porcupine Creek channel to the west. Other piles of waste rock within Unit 4 encroach on the lower Clinton Creek channel. Similar to Unit 3, the width of the lower Clinton Creek channel is such that even a very large failure would not block the channel. It is possible that a sudden, large slope failure could block the Porcupine Creek channel, just upstream from the confluence with the beaver pond area and the Clinton Creek channel. However, there is no sign of accelerating movement that would suggest that such a slope failure is imminent.

Generally, InSAR monitoring does not indicate any slope instability that requires further investigation or remedial action. Movement throughout the waste rock dump is generally characterized as steady, gradual creep with no significant changes compared to historical movement rates and patterns.

Tetra Tech recommends the following:

- The seepage from the toe of the waste rock near DS4 should be observed and photographed whenever engineering staff visit the site. Any apparent increase in erosion on the slope face or sediment in the seepage water should be reported to YG-AAM and Tetra Tech immediately.

4.7 Porcupine Creek Waste Rock Dump

The Porcupine Creek waste rock dump is encroaching on Porcupine Creek, which is constrained between the moving waste rock dump to the west and the natural valley slope to the east. The slopes on the south and east sides of the waste rock dump show downslope movement, while the flatter central and northwest areas show little movement.

The mobile zone on the east slope of the waste rock dump encroaches on Porcupine Creek and is constrained by the natural valley slope to the east. Water from Porcupine Creek is understood to infiltrate the waste rock pile and travel as groundwater slightly north of this movement zone, so encroachment of the waste rock into the creek channel is not a major concern.

Erosion is visible on the down-valley portion of the waste rock dump. No flow of surface water was observed in this area during the site visit, but surface water likely overflows from the observed pond from time to time and flows down the eroded gully towards the ponds at the base of the Creek and Snowshoe Pits.

Tetra Tech recommends the following:

- Vegetation should be cleared from roads and trails to maintain access to all areas of the Porcupine Creek waste rock dump.

4.8 Porcupine and Snowshoe Pits

The Porcupine and Snowshoe Pits showed no signs of significant, new movement. There was no evidence of active, deep-seated slope movement, but superficial slope movement (e.g., rockfall, sloughing, raveling) associated with weathering of the pit walls and benches is ongoing.

Movement on the northwest pit wall in the Porcupine Pit is relatively uniform. This slope movement is attributed to superficial instability, rather than an indication of deep slope failure.

Movement on the southeast wall of the Porcupine Pit appears to indicate similar, relatively uniform, downslope movement across most of the wall, with a higher movement rates detected in the area of a possible large, historic landslide. Visually, the landslide area forms a depression relative to the rest of the southeast pit wall, and a headscarp is visible at the pit rim. The relatively mobile landslide area appears to be decelerating with time, suggesting that the mass of debris is gradually stabilizing. Movement on the pit wall surrounding the possible landslide area is relatively uniform and slow, similar to movement detected on the northwest pit wall.

We understand that YG-AAM may wish to install a water level logger in the Porcupine Pit pond. Depending on the planned location of the instrument, installation may require access to the rockfall hazard areas in the pit. A safe access plan should be developed for access in the pit, and the level logger should be set up to allow for data collection from outside the pit (e.g., wireless data collection or a long lead cable to connect to the instrument from outside of the hazard zone).

Movement rates in the Snowshoe Pit are relatively slow. The excellent InSAR coverage and slow movement rates indicate that movement on the Snowshoe Pit walls is generally superficial, similar to the northwest wall of the Porcupine Pit, and there is no sign of developing deep seated slope movement.

Tetra Tech recommends the following:

- Access on or below the walls of the open pits should remain restricted due to ongoing pit wall instability. If access is required to install a water level logger or other equipment in the Porcupine Pit, a safe access plan should be developed.

4.9 Wolverine Creek Ponds

As shown on Table 8, Trigger WP-1 and WP-3 were exceeded in 2021, due to a new beaver dam built just downstream from the outlet of the north pond. The new dam has increased the area and depth of the north pond compared to 2020 and could cause a short-term increase in erosion in the creek channel if it were suddenly breached. Based on visual observations, there does not appear to be a very large volume of water stored behind the dam, and it is likely that the effects of a sudden breach would be limited to within a short distance downstream, possibly to within the stream channel between the north and south ponds.

Smaller dams that partially block the flow of water were also observed in the creek channel between the north and south ponds, and near the outlet of the south pond.

None of the beaver dams observed in 2021 are considered to pose a major hazard to the stability of the creek channel or the tailings pile. However, dam building activity should be curtailed to prevent further increases to the size of either pond or obstruction to flow in the creek channel. This could be accomplished by removing the dams and/or installing a protected underflow culvert system (e.g., "Beaver Deceiver") through the dams to allow impounded water to drain. It is likely practical to remove the smaller dams, which are relatively easily accessible from the toes of the tailings lobes, but installation of a culvert may be preferable for the larger dam, which would be more difficult to access with heavy equipment and is likely to be rebuilt practically immediately after removal.

Tetra Tech recommends the following:

- The pond inlets/outlets should continue to be monitored for obstructions (e.g., beaver dams, logs) that may impede flow. Any obstructions should be removed promptly when observed.
- Beaver dams along Wolverine Creek in the vicinity of the ponds should be removed and/or fitted with underflow culverts ("Beaver Deceiver") to drain impounded water.

4.10 Wolverine Creek Channel

No evidence of significant erosion, downcutting, deposition, or channel migration was seen at the Wolverine Creek channel during the geotechnical site visit. The condition of the creek was largely the same as observed in 2020.

Erosion at the toes of the tailings lobes and the natural slopes immediately opposite the tailings is ongoing, similar to previous years. New beaver dam building activity was observed in 2021 and should be addressed (discussed in Section 4.9).

The rock-lined channel and the natural creek channel downstream continue to perform well, with no significant changes noted compared to previous years.

The culverts where the creek flows beneath the site access road near the front gate have not been altered or upgraded since the initial work was done to repair the road washout in 2020. A high-level hydrotechnical assessment completed by Tetra Tech in 2020 found these culverts to be undersized and may be vulnerable to damage during future high flow events. However, there was no sign of damage or water overtopping the road observed during the geotechnical site visit, and it is likely that the re-shaping of the channel and clearing of vegetation from around the culvert inlets in 2020 has significantly improved the capacity of the existing culverts. We understand that YG-AAM may prefer to monitor and repair damage to the culverts as required, in lieu of upgrading the culverts.

Tetra Tech recommends the following:

- Hydraulic upgrades should be designed and installed where Wolverine Creek passes beneath the site access road, to increase the capacity compared to the existing culverts and prevent repeated washouts. Alternatively, the culverts and access road should be monitored, kept clear of debris/blockages, and damage repaired as required to maintain site access.
- Debris and brush in the channel just downstream from the Wolverine Creek south pond outlet should be removed to maintain unobstructed flow in the channel.

4.11 Wolverine Creek Natural Slope

The natural slopes surrounding Wolverine Creek are considered to be generally stable.

Slope movement occurs most noticeably where the base of the slope is eroded by the creek, mainly near the base of the tailings lobes. Evidence of downslope creep and other natural slope processes are visible in other locations on the slope, but none are expected to be large enough to impact the creek channel.

Ground-based survey results from previous years of the LTPMP support this assessment.

No action is required on the Wolverine Creek natural slopes, other than to continue monitoring in the LTPMP to identify and correct any issues that may develop in the future.

4.12 Wolverine Creek Tailings Pile

Downslope movement on all lobes of the Wolverine Creek tailings pile continues at rates similar to those observed in previous years. Similar to the waste rock dumps, recent movement of the tailings is characterized as gradual, ongoing creep.

Based on the movement rates detected by InSAR for the North and South Lobes, any impact to Wolverine Creek in the near future would likely be caused by localized sloughing of the eroded, oversteepened slopes at the toes of the tailings lobes, as opposed to any rapid, deep-seated movement. Sloughing can cause some blockage of the creek, which would be eroded away relatively quickly by water flowing in the channel.

The Northwest Lobe is not creeping toward Wolverine Creek, or any other site component considered vulnerable to tailings encroachment. Downslope creep of the Northwest Lobe is not expected to have any significant impacts.

No action is required on the Wolverine Creek tailings piles, other than to continue monitoring in the LTPMP to identify and correct any issues that may develop in the future.

5.0 PROGRAM REVIEW

5.1 General

The 2021 LTPMP consisted of a modified "small" program, with the usual geotechnical site inspection, high-resolution InSAR monitoring, and no ground-based survey. Compared to the "traditional" LTPMP before InSAR was introduced, the "small" program included a limited ground-based survey. In recent years, annual modifications to the scope of the program have been made to adjust the level of effort and balance between the ground-based topographic survey and satellite-based monitoring using InSAR, in order to achieve the program goals.

InSAR using the high-resolution TSX and PAZ satellites provides very good coverage throughout most of the site and is considered to be a very effective tool to monitor ground movements, with some limitations as follows:

- Physically small, discrete site components cannot be reliably monitored using InSAR. This affects the ability to monitor the log boom abutments and gabion drop structures.
- North-south movement is not detected. In some cases, north-south movement can be inferred based on vertical settlement where the movement direction is known (e.g., on a north facing slope). This affects the ability to monitor large portions of the Clinton Creek waste rock dump.

- Movement detected by InSAR is sensitive to the reference points selected in the data processing. If the reference points are mobile, it will bias the movement observed throughout the InSAR dataset by the same amount. There is evidence that the reference points used at Clinton Creek are not perfectly stable (e.g., upward vertical movement indicated in areas that are known to be stable).
- Heavily vegetated areas cannot be effectively monitored using InSAR, since vegetation obscures the ground from view of the satellites. This affects the ability to monitor the natural slopes throughout the site, and some areas on the waste rock dumps.
- Water-covered areas cannot be monitored using InSAR, since the water surface is constantly changing and no coherent reflectors are present in the images. This affects the ability to monitor the lakes, ponds and creeks throughout the site.
- InSAR is best suited to monitoring relatively slow, progressive ground movement (e.g., slope creep), as opposed to sporadic slope movement where large displacements occur in a short period of time (e.g., rockfall). This affects the ability to monitor some areas of the Porcupine Pit.

The recommended approach for the LTPMP in the future is generally to rely on InSAR to monitor movement throughout most of the site, with ground-based survey used in a targeted way to fill gaps and overcome limitations in the InSAR monitoring.

5.2 Recommended Scope for 2022 LTPMP

The 2022 LTPMP is expected to consist of a “large” program.

For 2022, we recommend that the LTPMP include the annual geotechnical site inspection, InSAR monitoring using the TSX/PAZ satellites, and a ground-based survey with the scope targeted to fill gaps and overcome the limitations that have been observed in the InSAR monitoring. Options to establish stable reference points and/or improve confidence in the stability of the existing reference points used to process the InSAR data should be reviewed with TRE during the proposal/planning stage of the 2022 LTPMP.

The scope of the ground-based survey would be confirmed following the geotechnical site visit in 2022; however, it is expected that the survey will generally include some or all of the movement monitoring points on the Clinton Creek waste rock dump (where northward movement is observed), the Clinton Creek channel (including the Hudgeon Lake outlet and gabion drop structures), the closed access road, and the Clinton Creek natural slope.

The open pits, Porcupine Creek waste rock dump, and Wolverine Creek area can be omitted from the scope of the ground-based survey since these areas do not appear to pose any immediate risks to health, safety or the environment, and they can be effectively monitored by visual inspection and InSAR. For 2022, this will significantly reduce the cost of the “large” LTPMP, which traditionally includes survey of all site components.

Detailed recommendations for the scope of the 2022 LTPMP are provided in Appendix F.

5.3 Recommended Scope for 2023 LTPMP

The 2023 LTPMP is expected to consist of a “small” program.

In general, this will likely include a geotechnical site visit and InSAR monitoring. It will likely be practical to forego any ground-based survey unless specific survey requirements are identified.

Detailed recommendations for the scope of the 2023 LTPMP should be provided in the 2022 LTPMP report.

6.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

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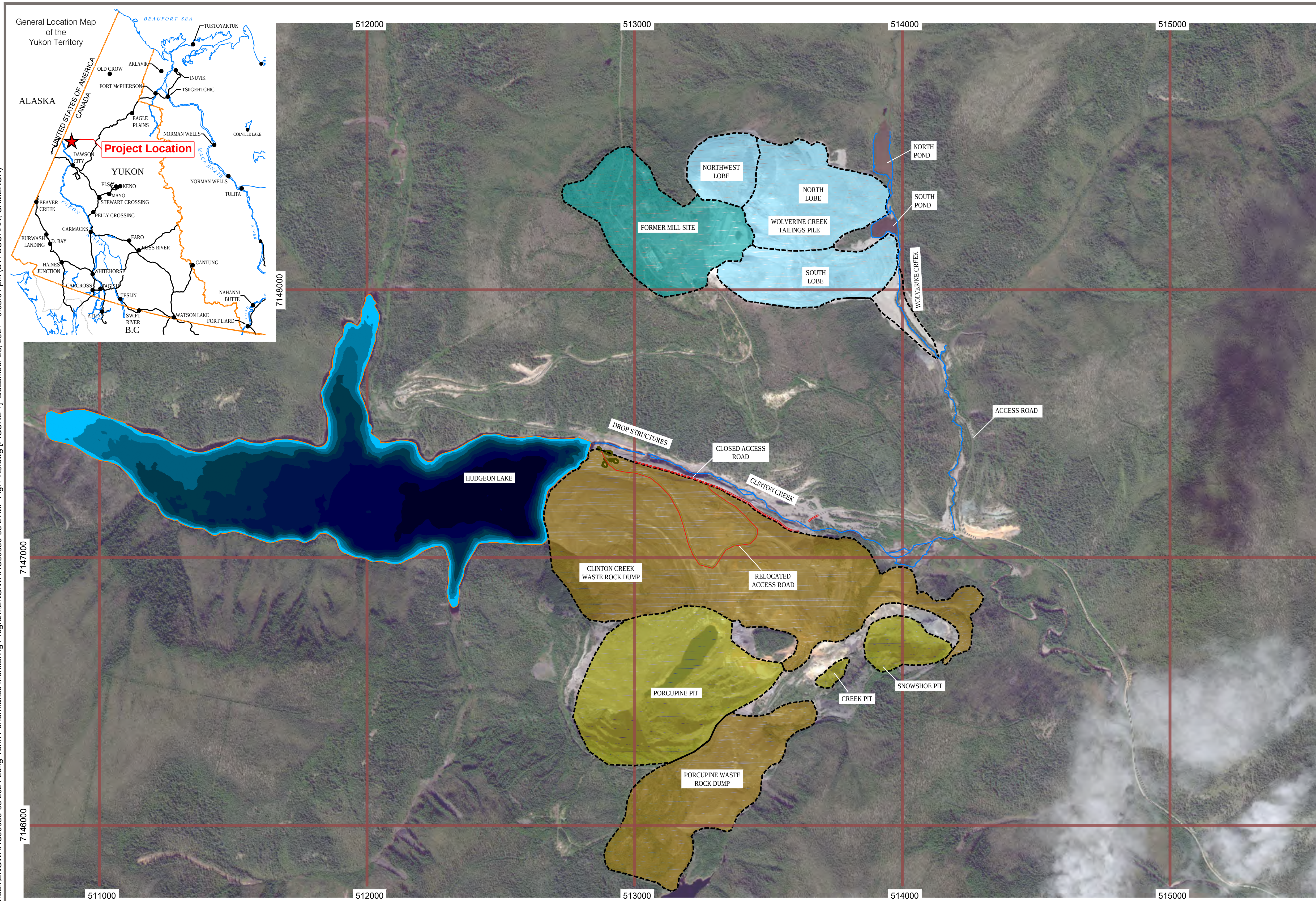
FIGURES



DRAWING NO.	TITLE
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FIGURE 2	SITE PLAN SHOWING 2020 SURVEY AREA AND MONITORING PINS
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FIGURE 38	WOLVERINE CREEK TAILINGS PILE NORTHWEST LOBE TOE DISPLACEMENT 1-D AND 2-D SqueeSAR ANALYSIS

LEGEND

- FORMER MILL SITE
- WOLVERINE CREEK TAILINGS PILE
- CLINTON CREEK WASTE ROCK DUMPS
- PORCUPINE AND SNOWSHOE PIT
- HUDGEON LAKE
- SURVEY BOUNDARY
- CLINTON CREEK

NOTE : DIMENSIONS AND ELEVATIONS ARE IN METRES

0 500m

Scale: 1:15,000 @ 11"x17"

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

TETRA TECH

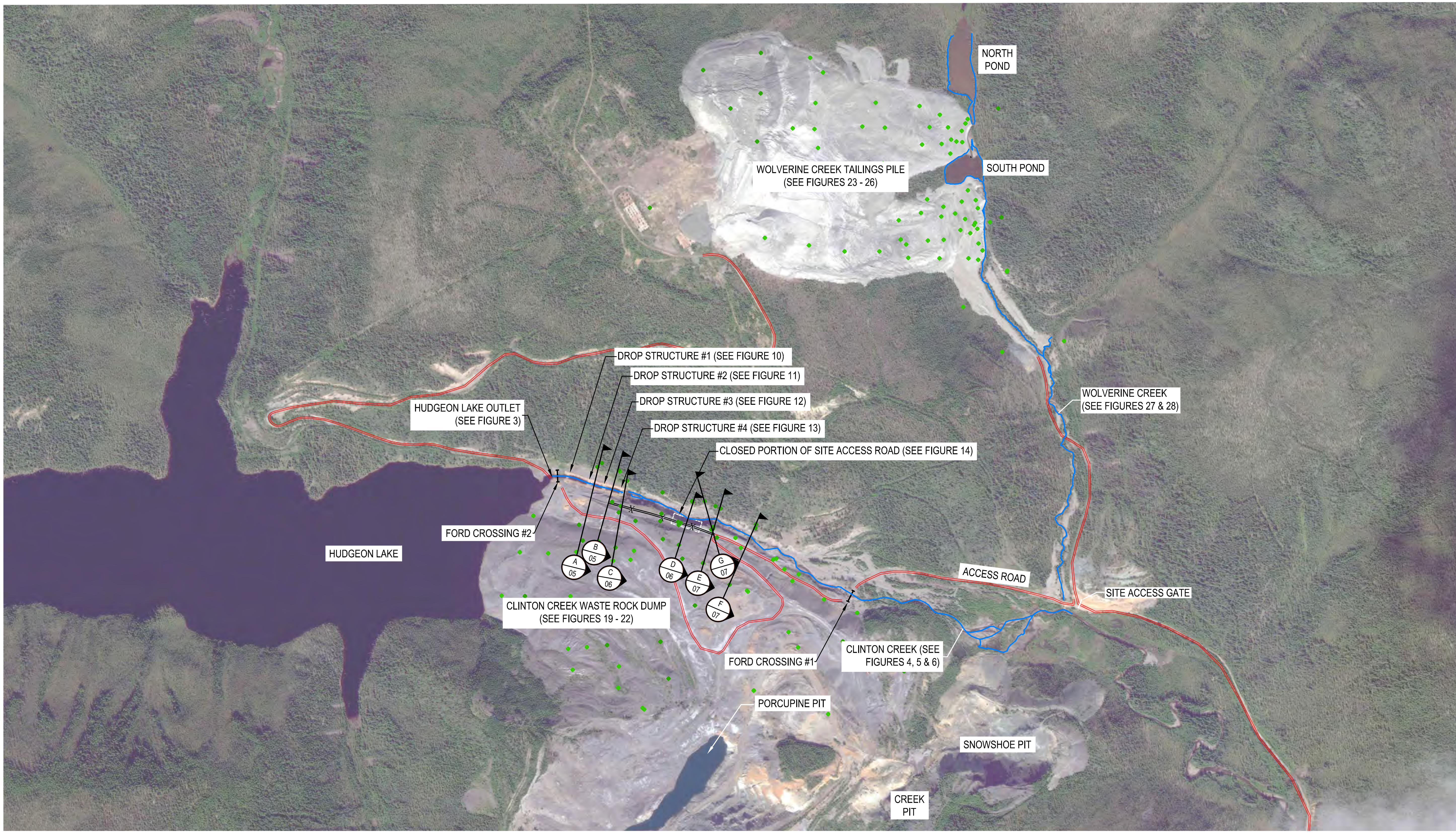
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

OVERALL SITE PLAN SHOWING
LOCATIONS OF SITE COMPONENTS

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0
OFFICE	DATE		
EBA-WHSE	December 22, 2021		

Figure 1

Q:\Whitehorse\Data\0201drawings\Clinton Creek\ENGWARC03956-03 2021 Long Term Performance Monitoring Program\ENG.WARC03956-03 LTMP Fig.1-R0.dwg [FIGURE 1] December 23, 2021 - 3:55:01 pm (BY: BUCHAN, CAMERON)



LEGEND

- CREEK CENTRELINE (2020)
- SURVEY DATA (2020)
- ACCESS ROAD
- CLOSED ACCESS ROAD
- MONITORING PIN

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. STATIONING IS BASED ON 2018 CREEK CENTRELINE

0 200m

Scale: 1:4,000 @ 11"x17"

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

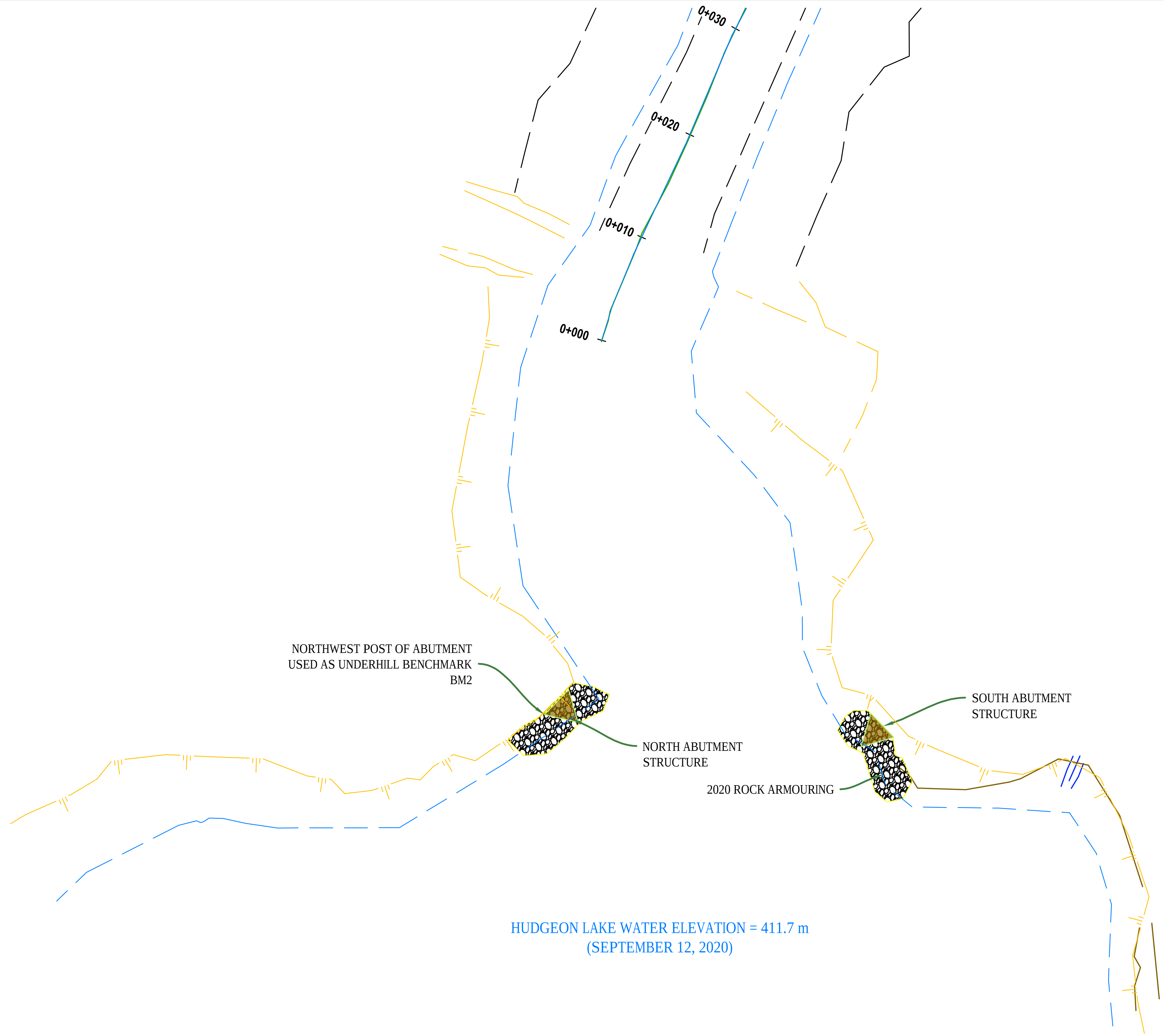
TETRA TECH

CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

SITE PLAN SHOWING 2020 SURVEY AREA AND MONITORING PINS

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0
OFFICE	DATE		
EBA-WHSE	December 22, 2021		

Figure 2



LEGEND

- 2020 CREEK CENTRELINE
- 2020 SURVEYED TOP OF BANK
- 2020 SURVEYED WATERLINE

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES

0 20m

Scale: 1:400 @ 11"x17"

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

TETRA TECH

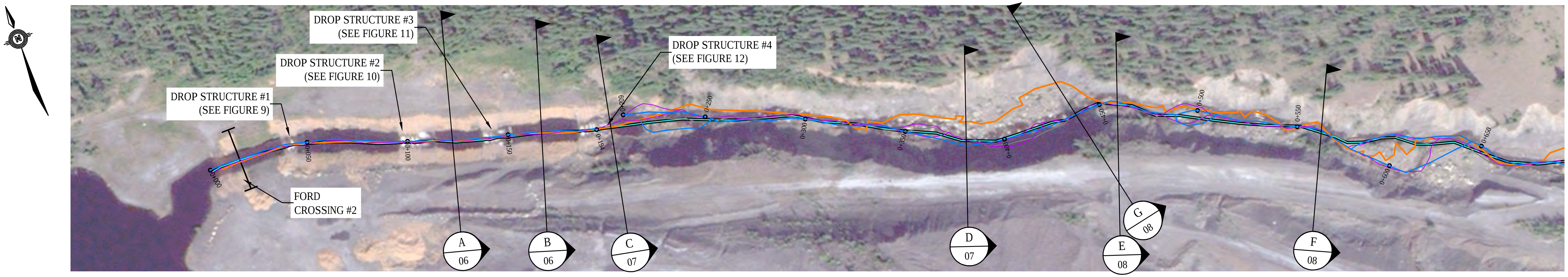
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

HUDGEON LAKE OUTLET

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

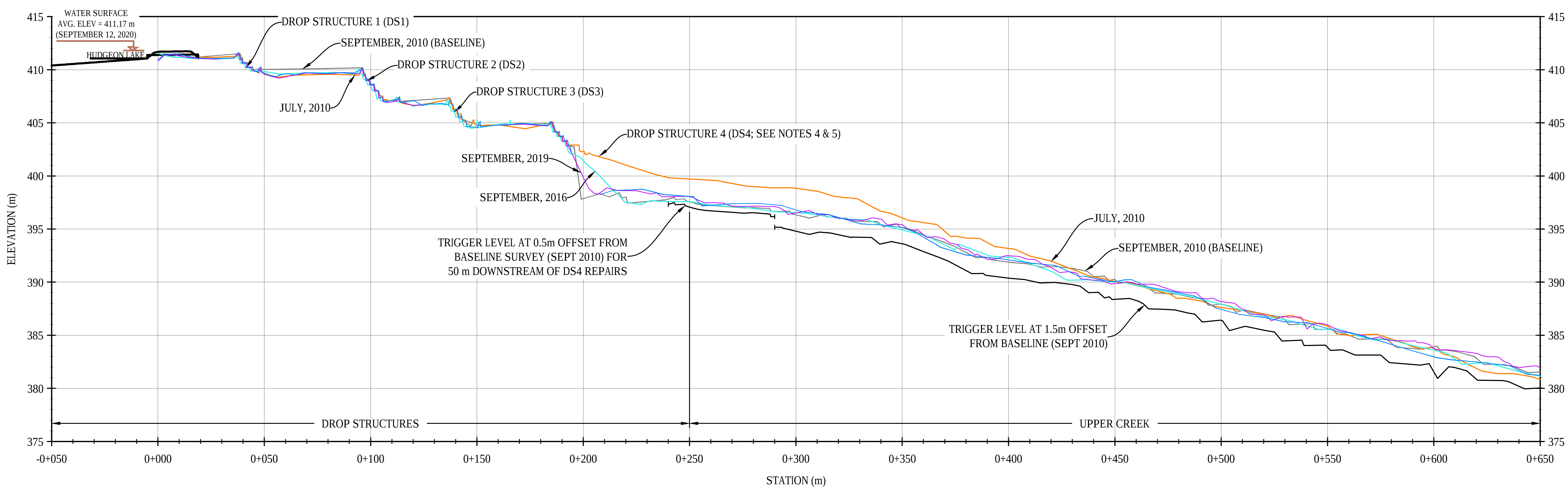
OFFICE	DATE
EBA-WHSE	December 22, 2021

Figure 3



PLAN VIEW

0 100m
Scale: 1:2,000 @ 11"x17"



PROFILE VIEW

0 100m
Scale: 1:2,000 @ 11"x17"
HORIZONTAL SCALE

0 20m
Scale: 1:400 @ 11"x17"
VERTICAL SCALE

LEGEND

- PROFILE JULY 2010
- PROFILE SEPTEMBER 2010 (BASELINE)
- PROFILE SEPTEMBER 2016
- PROFILE SEPTEMBER 2019
- PROFILE SEPTEMBER 2020

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. STATIONING IS BASED ON 2020 CREEK CENTRELINE WITH THE START OF THE CENTRELINE AT STATION 0+000.
3. PROFILES OF THE CHANNEL FROM MONITORING SURVEYS COMPLETED IN 1983, 1984, 2001, 2004, 2006, 2007, 2008, 2011, 2012, 2014, 2015, 2017 AND 2018 ARE NOT SHOWN FOR THE SAKE OF CLARITY.
4. REPAIRS TO DROP STRUCTURE 4, INCLUDING THE INSTALLATION OF AN ARTICULATED CONCRETE BLOCK DROP CHUTE, ALTERED THE CHANNEL PROFILE IN 2015.
5. DAMAGE AND TEMPORARY REPAIRS TO THE ARTICULATED CONCRETE BLOCK CHUTE ALTERED THE CHANNEL PROFILE IN 2018.

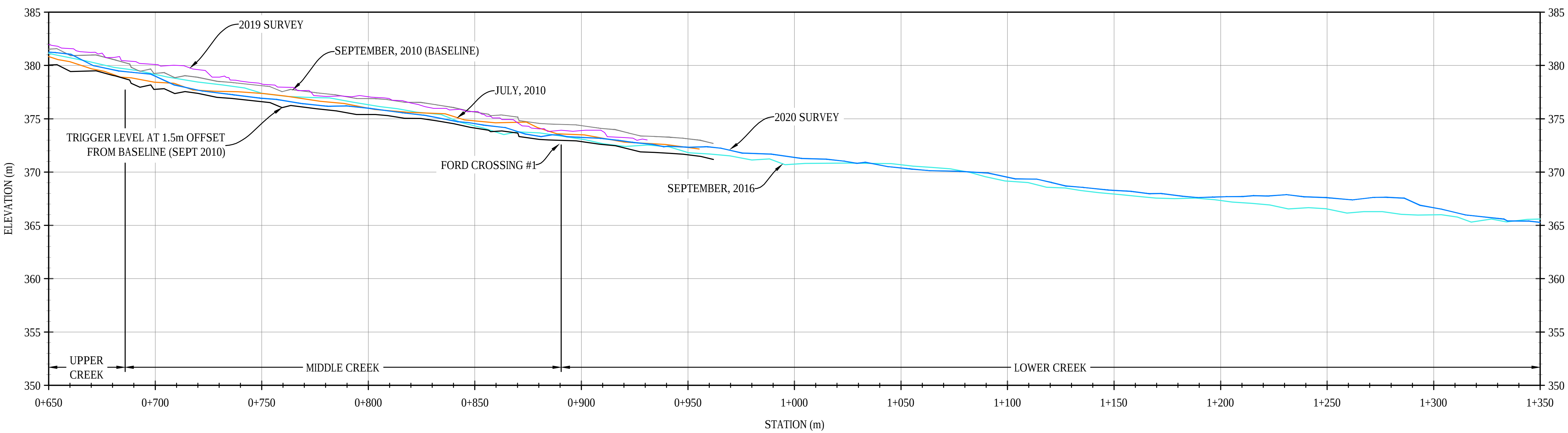
CLIENT	CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM			
Yukon Government Department of Energy, Mines and Resources Assessment and Abandoned Mines	CLINTON CREEK ALIGNMENT AND PROFILE GABION DROP STRUCTURES AND UPPER CREEK CHANNEL			
TETRA TECH	PROJECT NO. ENG.WARC03956-03	DWN CB	CKD AW	REV 0
	OFFICE EBA-WHSE	DATE December 22, 2021		

Figure 4

PLAN VIEW

0 100m

Scale: 1:2,000 @ 11"x17"



PROFILE VIEW

0 100m — Scale: 1:2,000 @ 11"x17" — HORIZONTAL SCALE

0 20m — Scale: 1:400 @ 11"x17" — VERTICAL SCALE

LEGEND

- PROFILE JULY 2010
- PROFILE SEPTEMBER 2010 (BASELINE)
- PROFILE SEPTEMBER 2016
- PROFILE SEPTEMBER 2019
- PROFILE SEPTEMBER 2020

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. STATIONING IS BASED ON 2020 CREEK CENTRELINE WITH THE START OF THE CENTRELINE AT STATION 0+000.
3. PROFILES OF THE CHANNEL FROM MONITORING SURVEYS COMPLETED IN 1983, 1984, 2001, 2004, 2006, 2007, 2008, 2011, 2012, 2014, 2015, 2017 AND 2018 ARE NOT SHOWN FOR THE SAKE OF CLARITY.

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

TETRA TECH

CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

CLINTON CREEK ALIGNMENT AND PROFILE
MIDDLE AND LOWER CREEK CHANNEL

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

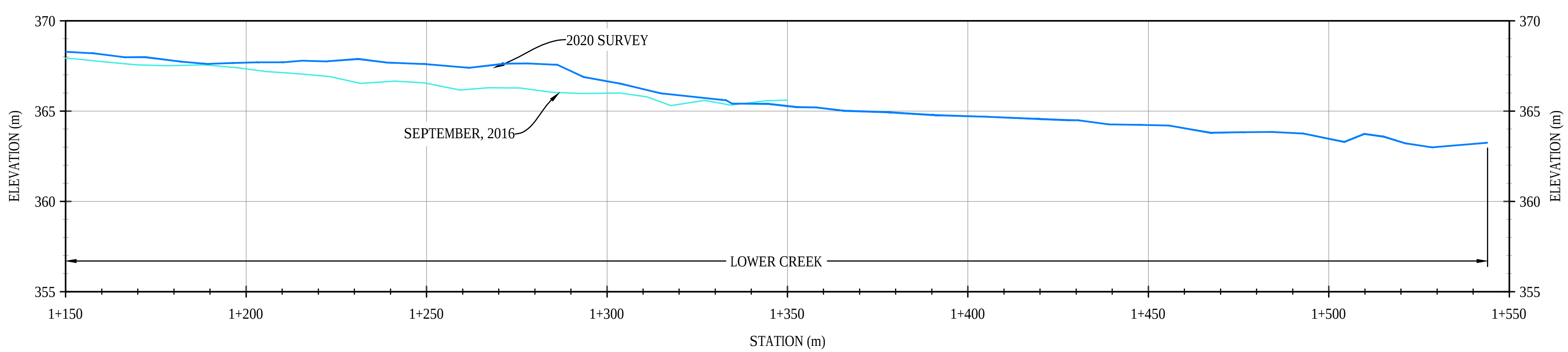
Figure 5

Q:\Whitehorse\Data\0201drawings\Clinton Creek\ENGWARC03956-03 2021 Long Term Performance Monitoring Program\ENG.WARC03956-03 LTMP Fig.5-R0.dwg [FIGURE 5] December 22, 2021 - 4:57:11 pm (BY: BUCHAN, CAMERON)

PLAN VIEW

0 50m

Scale: 1:1,500 @ 11"x17"



PROFILE VIEW - CLINTON CREEK

0 50m

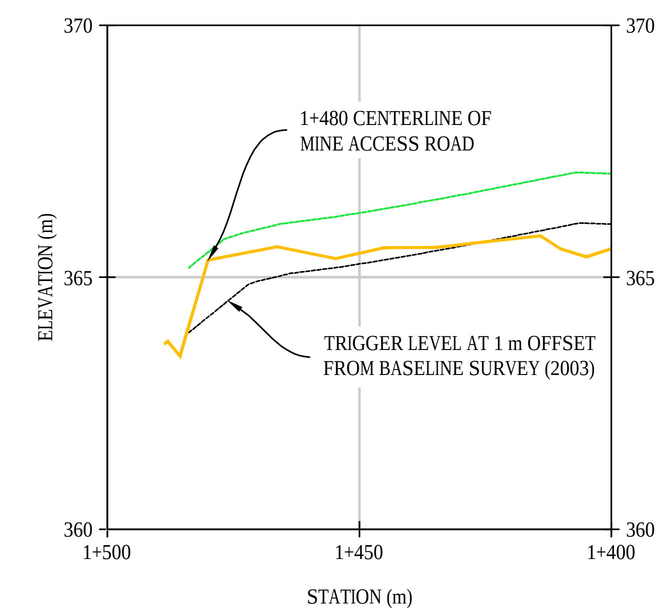
Scale: 1:1,500 @ 11"x17"

HORIZONTAL SCALE

0 15m

Scale: 1:300 @ 11"x17"

VERTICAL SCALE



PROFILE VIEW - WOLVERINE CREEK

0 50m

Scale: 1:1,500 @ 11"x17"

HORIZONTAL SCALE

0 5m

Scale: 1:150 @ 11"x17"

VERTICAL SCALE

LEGEND

- CLINTON CREEK PROFILE SEPTEMBER 2016
- CLINTON CREEK PROFILE SEPTEMBER 2020
- WOLVERINE CREEK PROFILE (2003)
- WOLVERINE CREEK PROFILE (2020)

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. STATIONING IS BASED ON 2020 CREEK CENTRELINE WITH THE START OF THE CENTRELINE AT STATION 0+000.
3. PROFILES OF THE CLINTON CREEK CHANNEL FROM MONITORING SURVEYS COMPLETED IN 1983, 1984, 2001, 2004, 2006, 2007, 2008, 2011, 2012, 2014, 2015, 2017 AND 2018 ARE NOT SHOWN FOR THE SAKE OF CLARITY.
4. PROFILES AND CENTERLINES FOR WOLVERINE CREEK RECORDED AS PART OF PREVIOUS MONITORING SURVEYS IN 2006, 2007, 2008, 2010, 2011, 2012, 2014 AND 2016 ARE NOT SHOWN FOR THE SAKE OF CLARITY.

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Yukon Government
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Assessment and Abandoned Mines

TETRA TECH

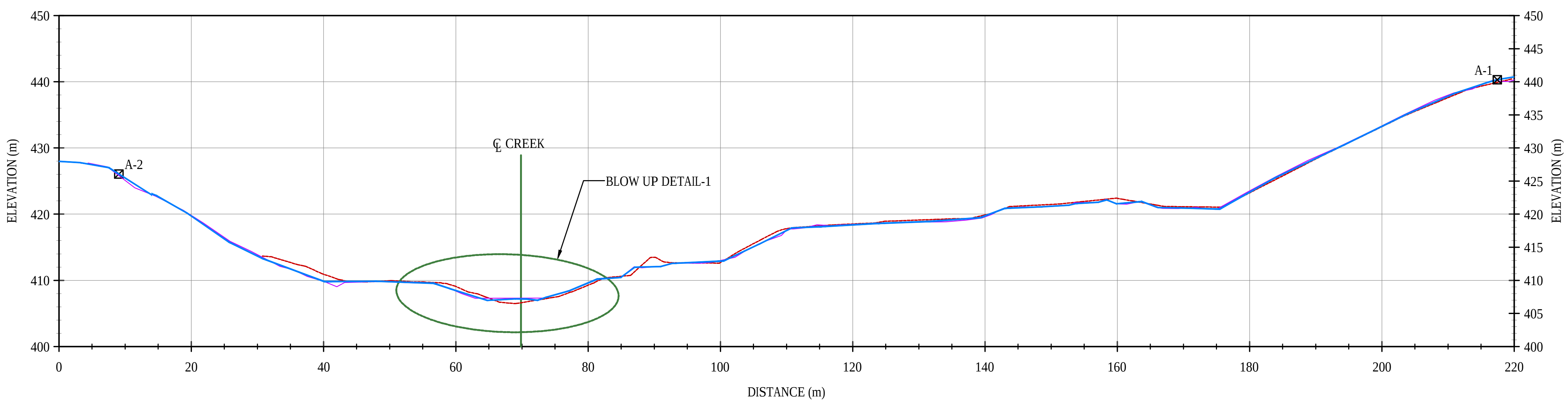
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

CLINTON CREEK ALIGNMENT AND PROFILE
LOWER CREEK CHANNEL AND TOPOGRAPHIC SURVEY
NEAR CONFLUENCE WITH WOLVERINE CREEK

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0
OFFICE	DATE		
EBA-WHSE	December 22, 2021		

Figure 6

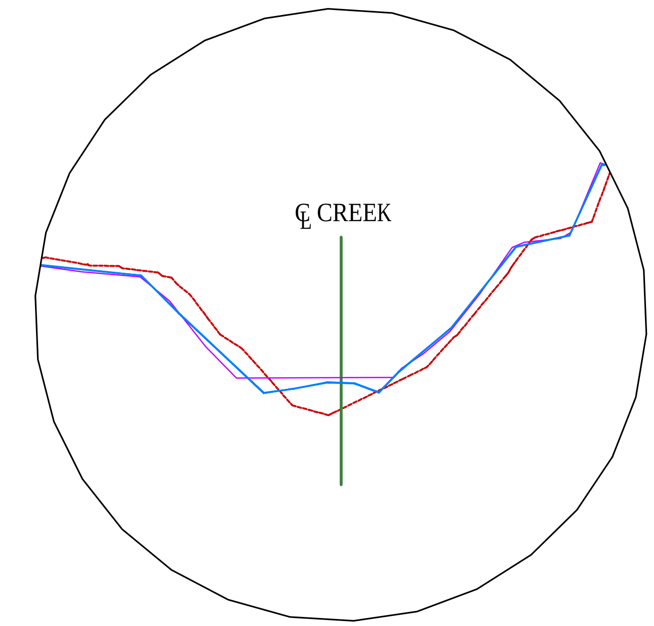
Q:\Whitehorse\Data\0201drawings\Clinton Creek\ENGWARC03956-03 2021 Long Term Performance Monitoring Program\ENG.WARC03956-03 LTMP Fig.6-R0.dwg [FIGURE 6] December 22, 2021 - 4:58:24 pm (BY: BUCHAN, CAMERON)



SECTION A - A

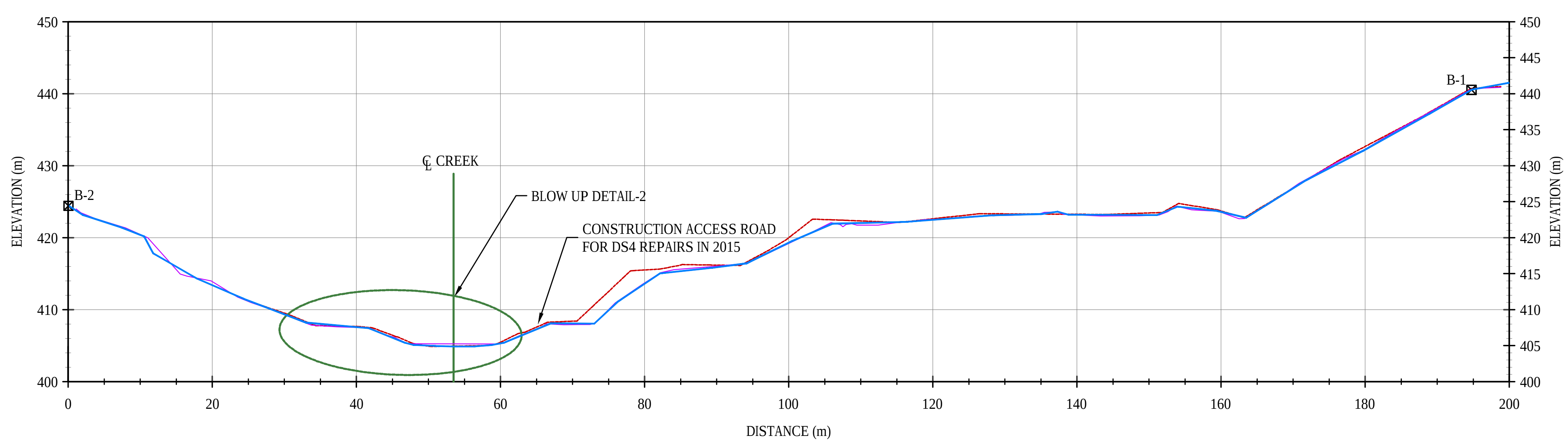
0 25m

Scale: 1:750 @ 11"x17"



DETAIL-1

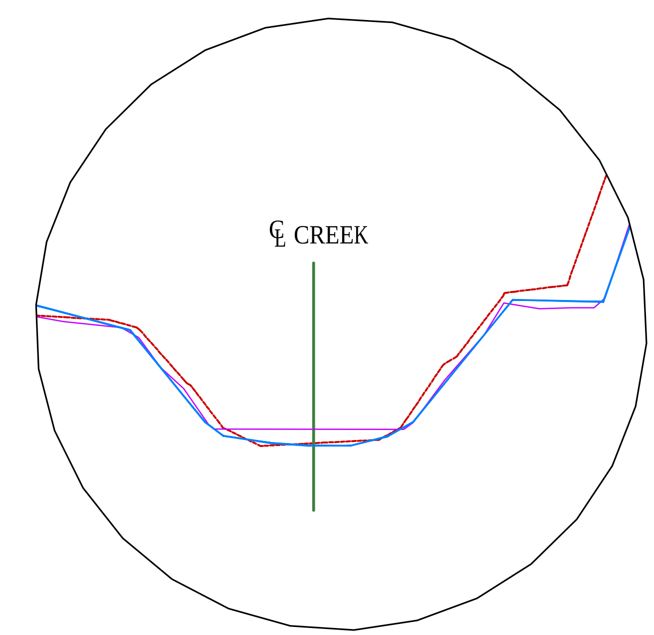
NOT TO SCALE



SECTION B - B

0 25m

Scale: 1:750 @ 11"x17"



DETAIL-2

NOT TO SCALE

LEGEND

- 2012 SURVEYED GROUND
- 2019 SURVEYED GROUND
- 2020 SURVEYED GROUND
- ☒ - MOVEMENT MONITORS INSTALLED TO BOUND CROSS-SECTIONS IN JUNE 2018

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. THE CROSS-SECTIONS SHOWN WERE RECORDED AT SLIGHTLY DIFFERENT STATIONS (OFFSET BY Ñ0.3m) IN EACH MONITORING PERIOD AND ARE NOT NECESSARILY REPRESENTATIVE OF THE EXACT SAME SECTION OF THE CHANNEL.

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Assessment and Abandoned Mines

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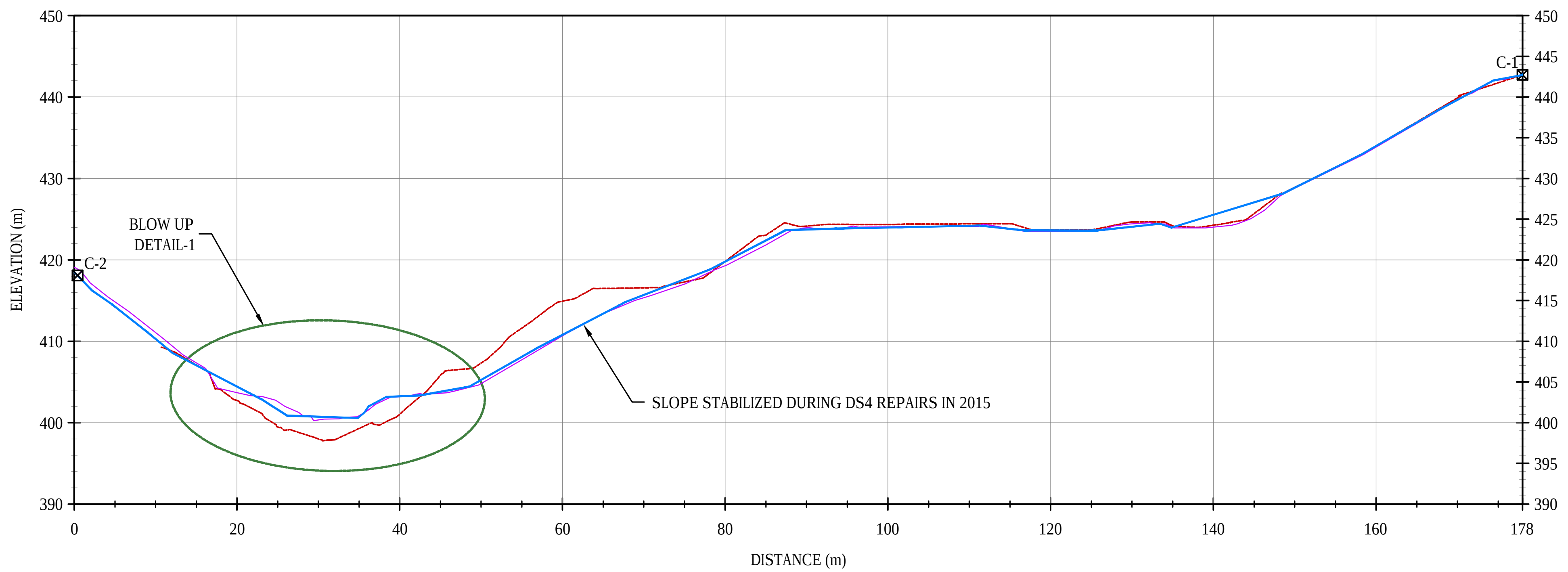
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

CLINTON CREEK CHANNEL
CROSS-SECTIONS A AND B

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

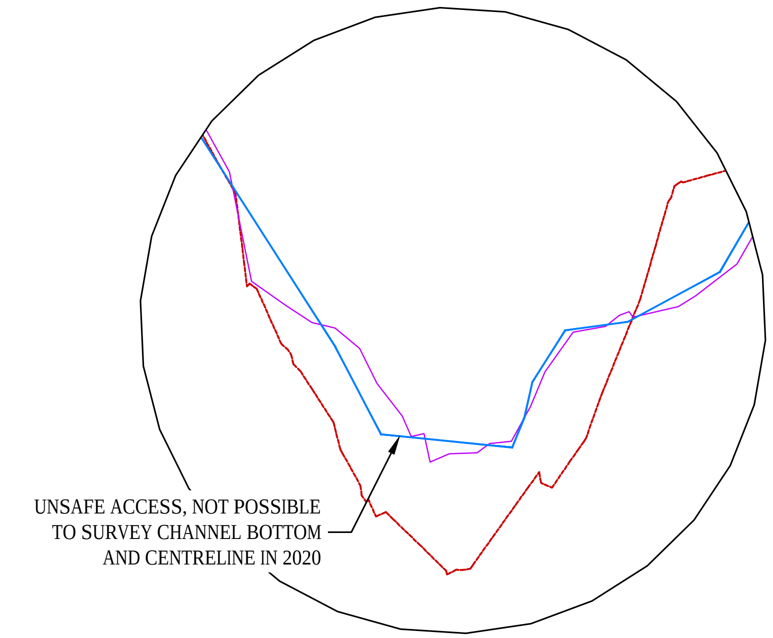
Figure 7



SECTION C - C

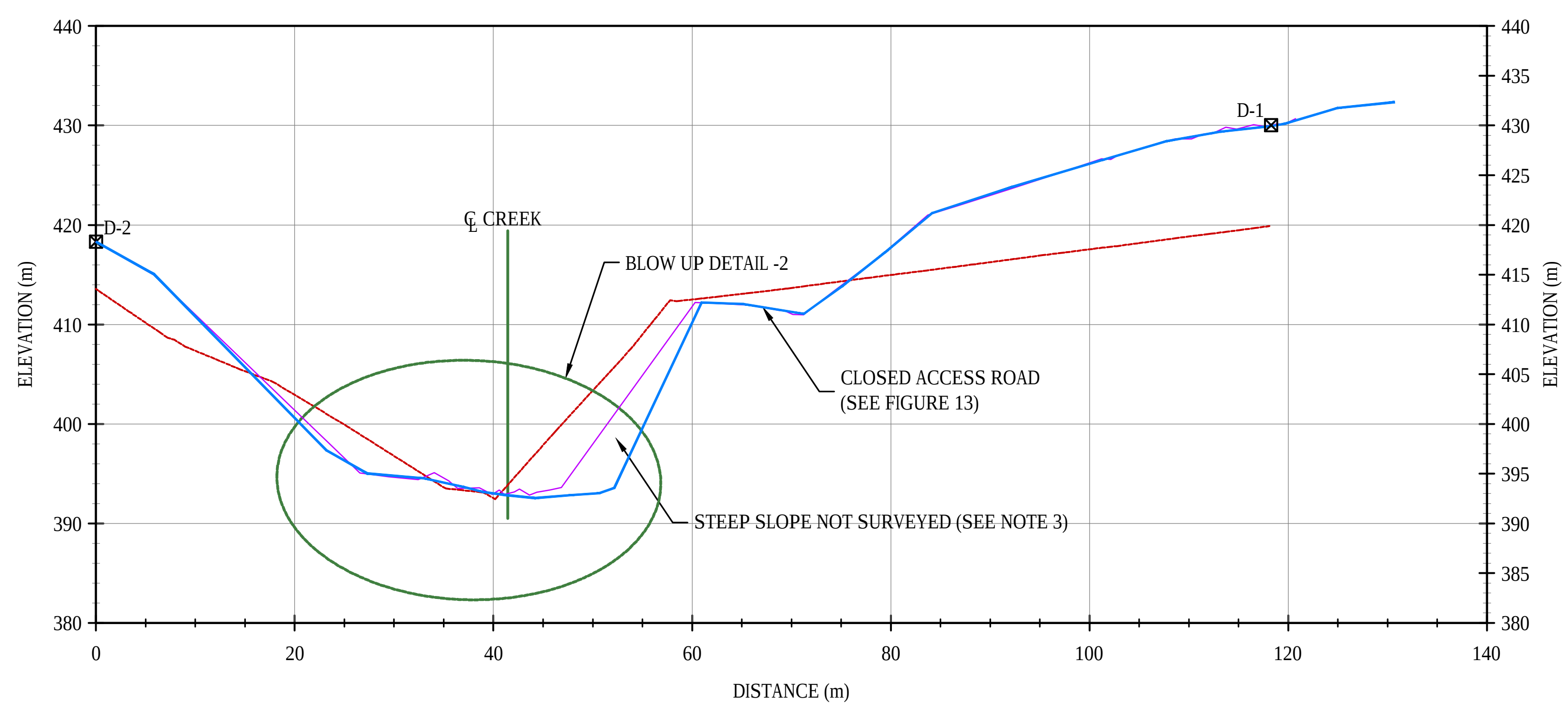
0 25m

Scale: 1:750 @ 11"x17"



DETAIL-1

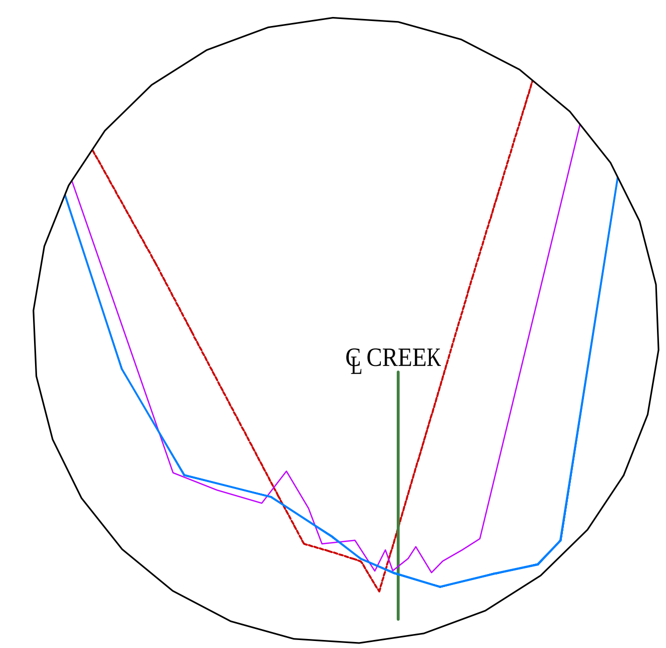
NOT TO SCALE



SECTION D - D

0 25m

Scale: 1:750 @ 11"x17"



DETAIL-2

NOT TO SCALE

LEGEND

- 2012 SURVEYED GROUND
- 2019 SURVEYED GROUND
- 2020 SURVEYED GROUND
- ⊠ - MOVEMENT MONITORS INSTALLED TO BOUND CROSS-SECTIONS IN JUNE 2018

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. THE CROSS-SECTIONS SHOWN WERE RECORDED AT SLIGHTLY DIFFERENT STATIONS (OFFSET BY Ñ0.3m) IN EACH MONITORING PERIOD AND ARE NOT NECESSARILY REPRESENTATIVE OF THE EXACT SAME SECTION OF THE CHANNEL.

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Department of Energy, Mines and Resources
Assessment and Abandoned Mines

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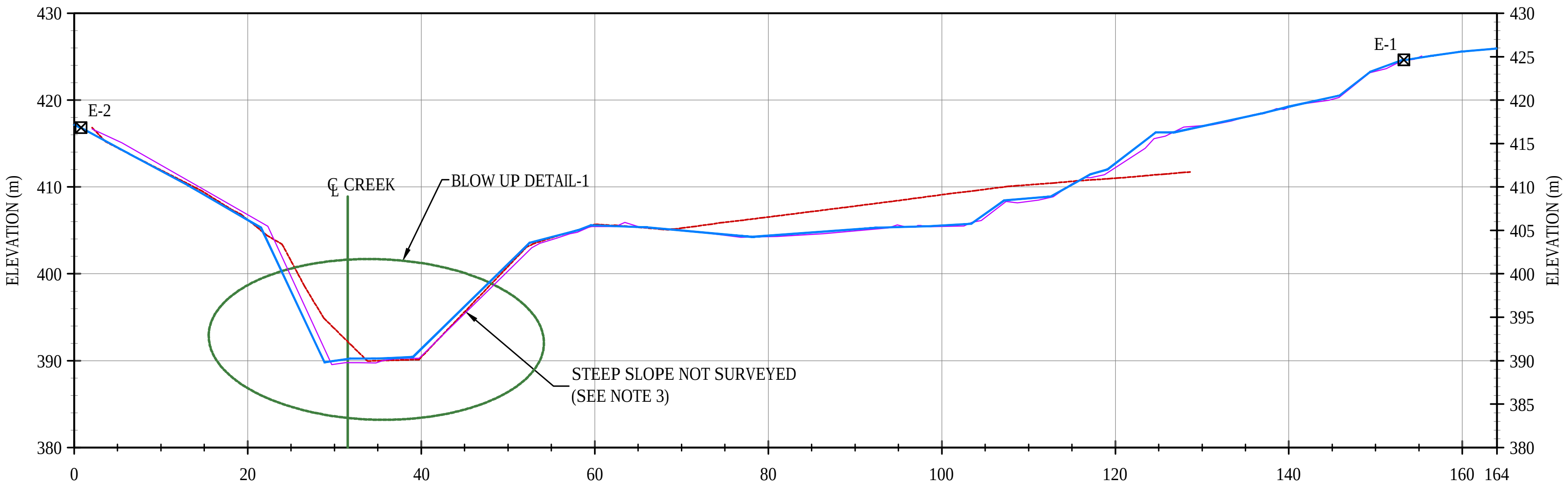
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

CLINTON CREEK CHANNEL
CROSS-SECTIONS C AND D

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0
OFFICE	DATE		
EBA-WHSE	December 22, 2021		

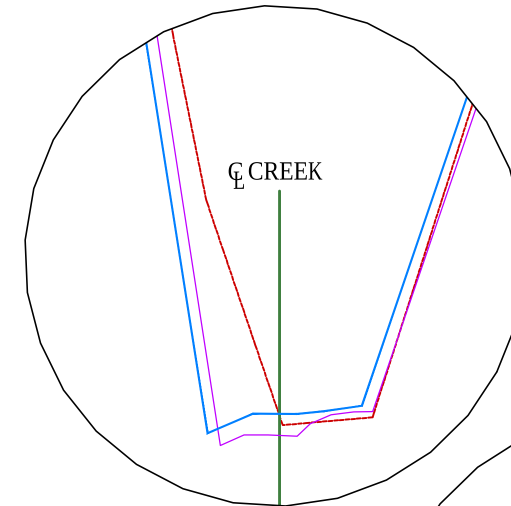
Figure 8



SECTION E - E

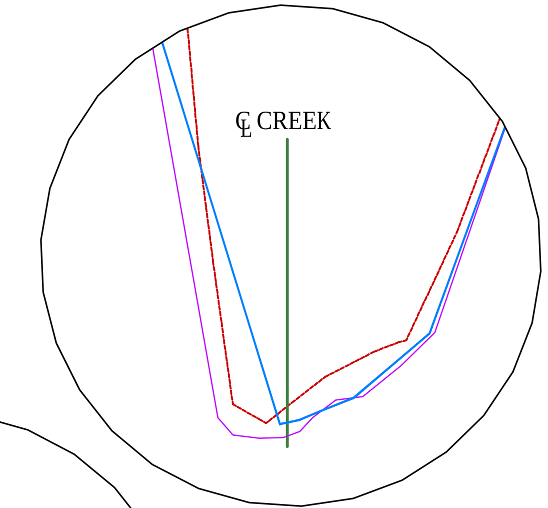
0 25m

Scale: 1:750 @ 11"x17"



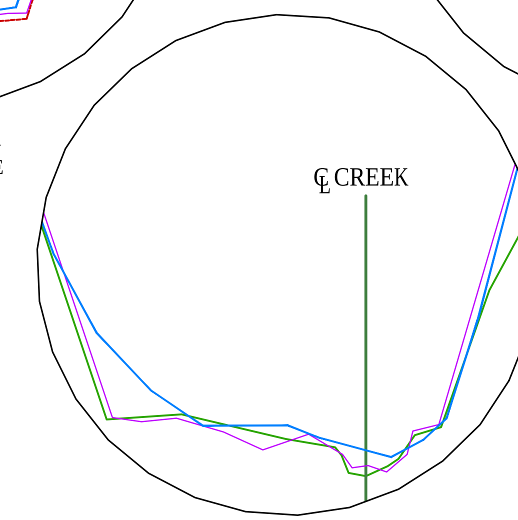
DETAIL-1

NOT TO SCALE



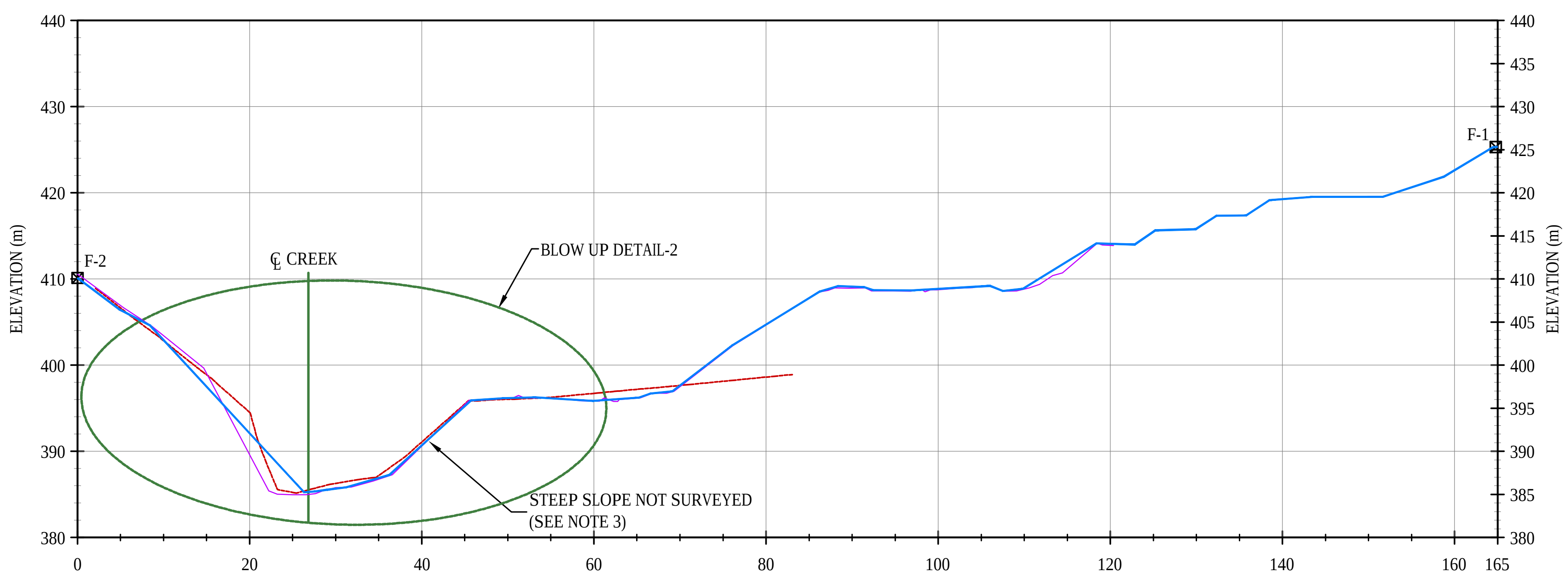
DETAIL-2

NOT TO SCALE



DETAIL-3

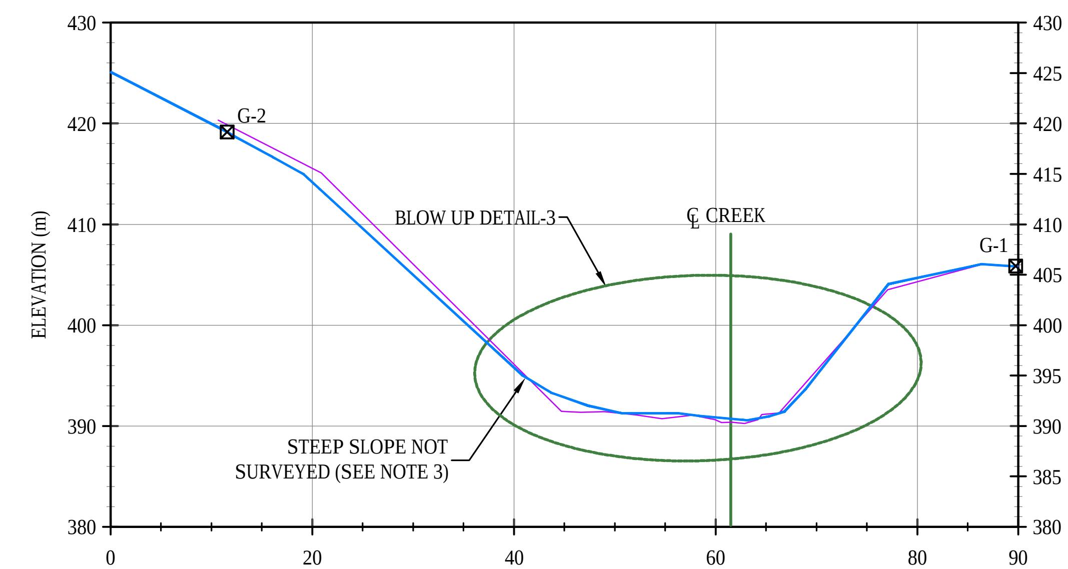
NOT TO SCALE



SECTION F - F

0 25m

Scale: 1:750 @ 11"x17"



SECTION G - G

0 25m

Scale: 1:750 @ 11"x17"

LEGEND

- 2012 SURVEYED GROUND
- 2019 SURVEYED GROUND
- 2020 SURVEYED GROUND
⊠ - MOVEMENT MONITORS INSTALLED TO BOUND CROSS-SECTIONS IN JUNE 2018

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. THE CROSS-SECTIONS SHOWN WERE RECORDED AT SLIGHTLY DIFFERENT STATIONS (OFFSET BY Ñ0.3m) IN EACH MONITORING PERIOD AND ARE NOT NECESSARILY REPRESENTATIVE OF THE EXACT SAME SECTION OF THE CHANNEL.
3. THE PORTIONS OF CROSS SECTIONS E, F AND G LOCATED BETWEEN THE TOP AND TOE OF THE EMBANKMENT WERE NOT SURVEYED DUE TO THE STEEPNESS OF THE EMBANKMENT.

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Assessment and Abandoned Mines

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CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

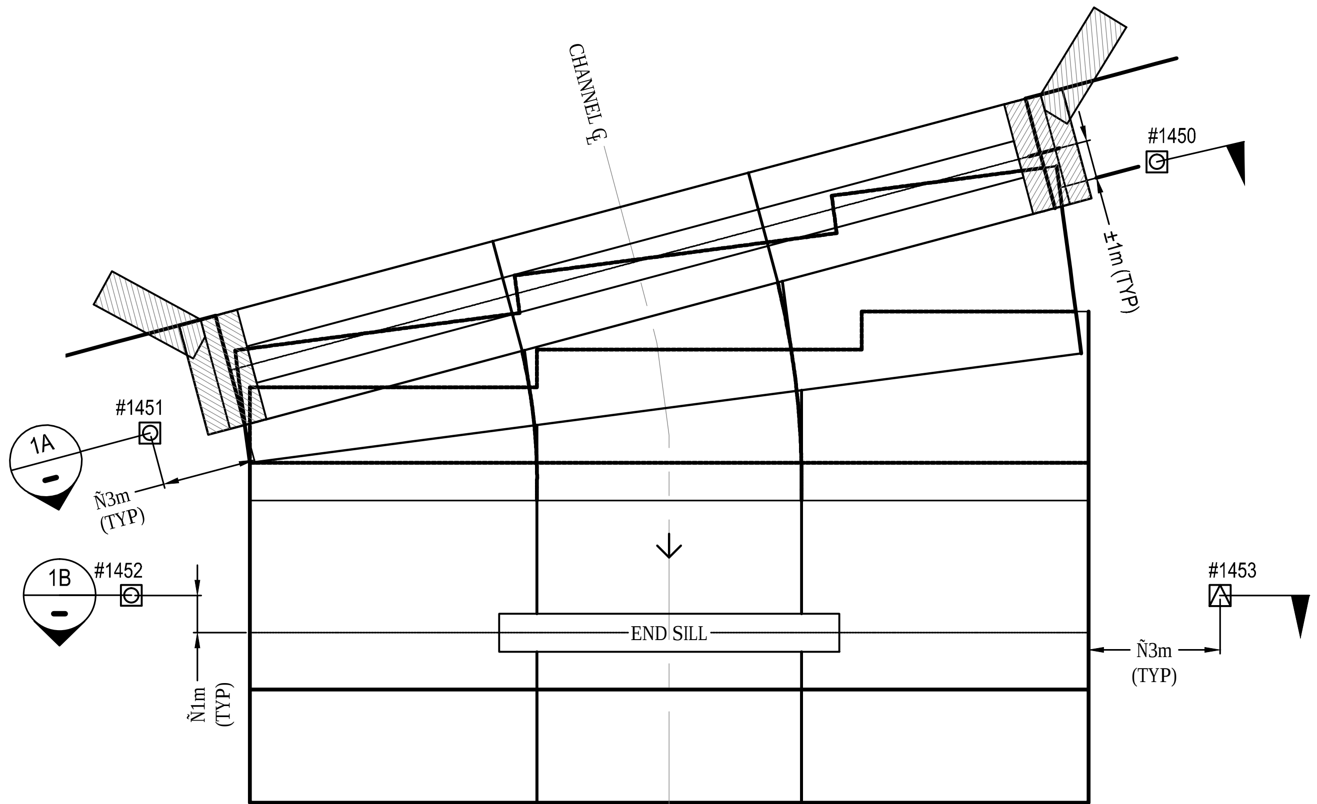
CLINTON CREEK CHANNEL
CROSS-SECTIONS E, F AND G

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

Figure 9

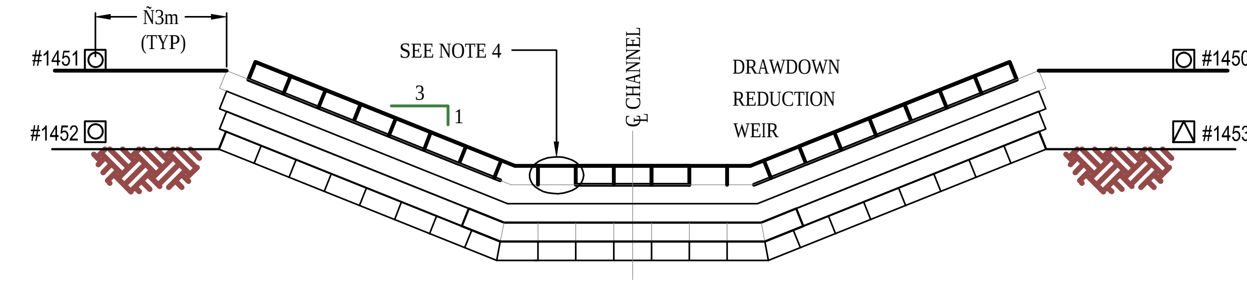
Q:\Whitehorse\Data\0201drawings\Clinton Creek\ENGWARC03956-03 2021 Long Term Performance Monitoring Program\ENG.WARC03956-03 LTMP Figs.7-9-R0.dwg [FIGURE 9] December 22, 2021 - 5:01:09 pm (BY: BUCHAN, CAMERON)



DROP STRUCTURE #1 PLAN VIEW

0 10m

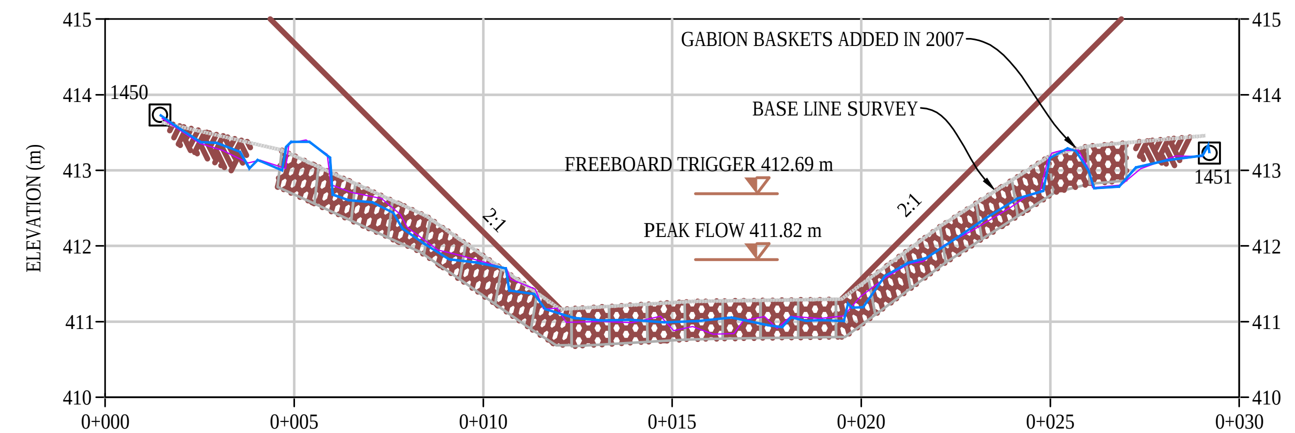
Scale: 1:200 @ 11"x17"



DROP STRUCTURE #1 END VIEW

0 10m

Scale: 1:200 @ 11"x17"

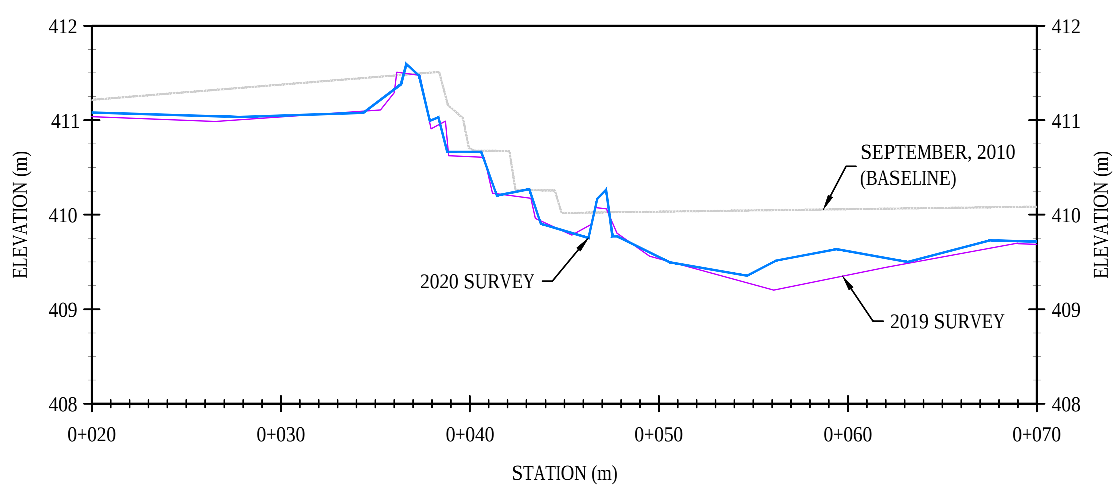


SECTION 1A

0 10m | 0 5m

Scale: 1:200 @ 11"x17" HORIZONTAL SCALE

Scale: 1:100 @ 11"x17" VERTICAL SCALE

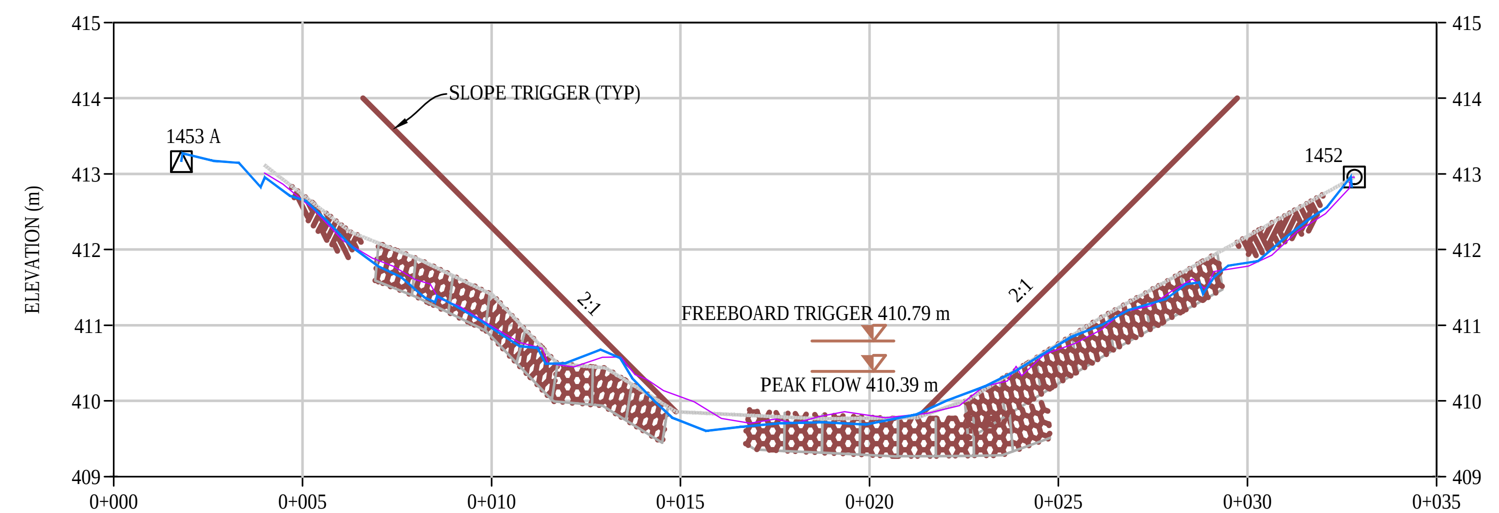


DROP STRUCTURE #1 PROFILE

0 20m | 0 3m

Scale: 1:400 @ 11"x17" HORIZONTAL SCALE

Scale: 1:80 @ 11"x17" VERTICAL SCALE



SECTION 1B

0 10m | 0 5m

Scale: 1:200 @ 11"x17" HORIZONTAL SCALE

Scale: 1:100 @ 11"x17" VERTICAL SCALE

LEGEND

- BASELINE SURVEY (2010)
- 2019 SURVEYED GROUND
- 2020 SURVEYED GROUND
- ◯ - CHANNEL CLOSURE MOVEMENT MONITOR (19mm Ï STEEL PIN) INSTALLED DURING 2006 SURVEY
- △ - CHANNEL CLOSURE MOVEMENT MONITOR RE-ESTABLISHED IN 2012 (TYP.)

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES.
2. FREE BOARD TRIGGER SHOWN AT 600 mm BELOW TOP OF GABION BASKETS.
3. PEAK FLOW ELEVATION BASED ON PEAK FLOW RATE OF 29 m^3/S.
4. GABION FILL REMOVED FROM THIS CELL OF THE DRAWDOWN WEIR IN 2007 TO FACILITATE DRAWING DOWN HUDGEON LAKE WATER LEVEL DURING LOW FLOW PERIODS.
5. REFER TO AECOM's "FORMER CLINTON CREEK ASBESTOS MINE - EMERGENCY DROP STRUCTURE REPAIRS, CONSTRUCTION ACTIVITY REPORT, 2011" R94 FOR 2011 REPAIR DETAILS.

CLIENT

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TETRA TECH

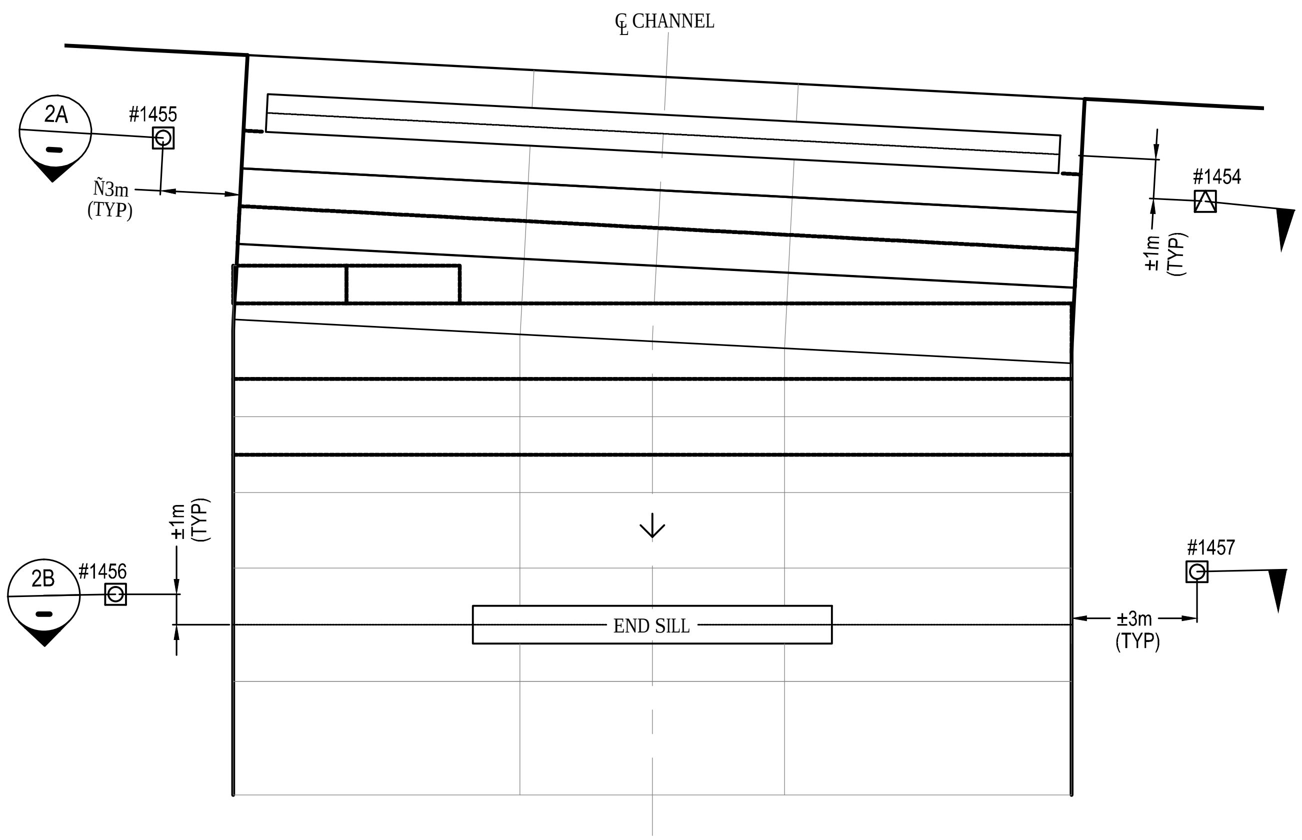
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

GABION DROP STRUCTURE #1 (DS1)

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

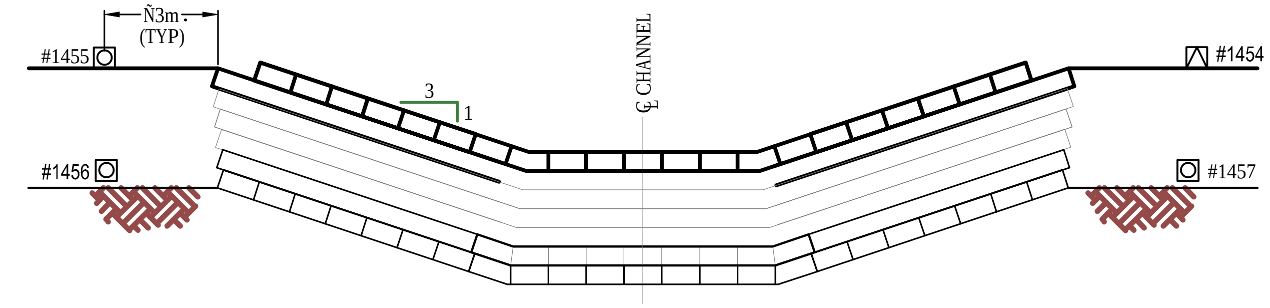
Figure 10



DROP STRUCTURE #2 PLAN VIEW

0 10m

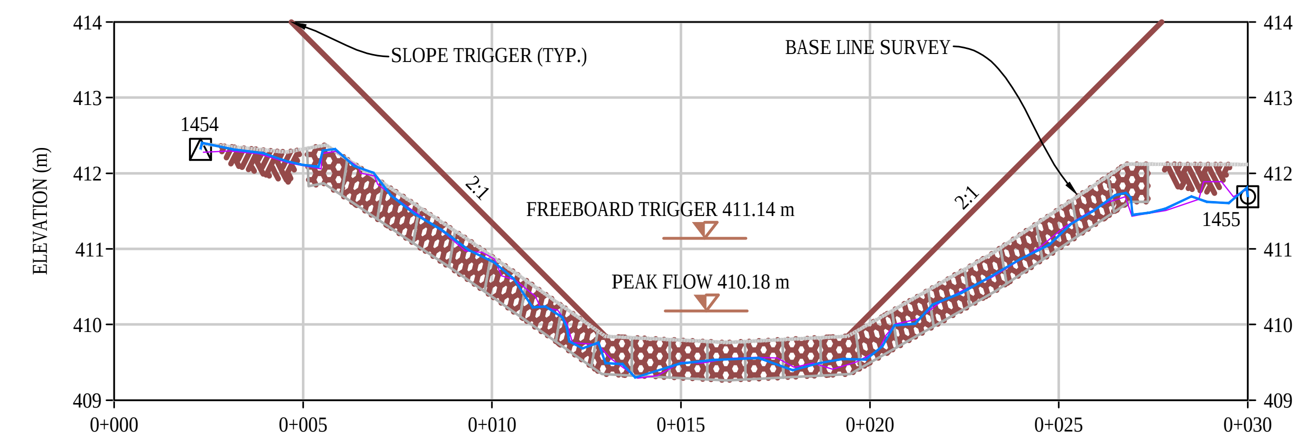
Scale: 1:200 @ 11"x17"



DROP STRUCTURE #2 END VIEW

0 10m

Scale: 1:200 @ 11"x17"



SECTION 2A

0 10m

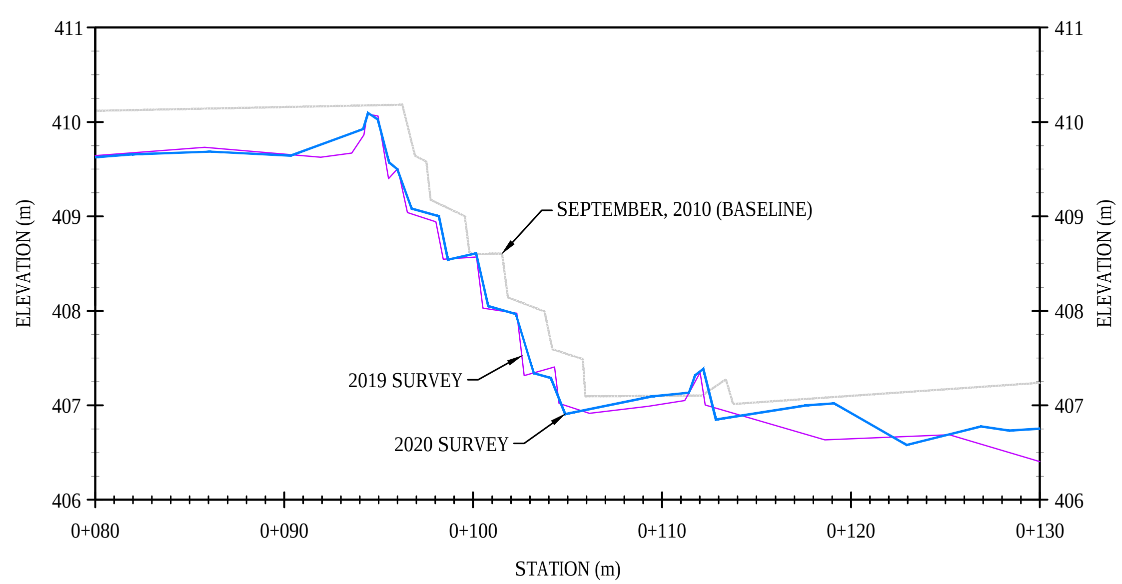
Scale: 1:200 @ 11"x17"

HORIZONTAL SCALE

0 5m

Scale: 1:100 @ 11"x17"

VERTICAL SCALE



DROP STRUCTURE #2 PROFILE

0 20m

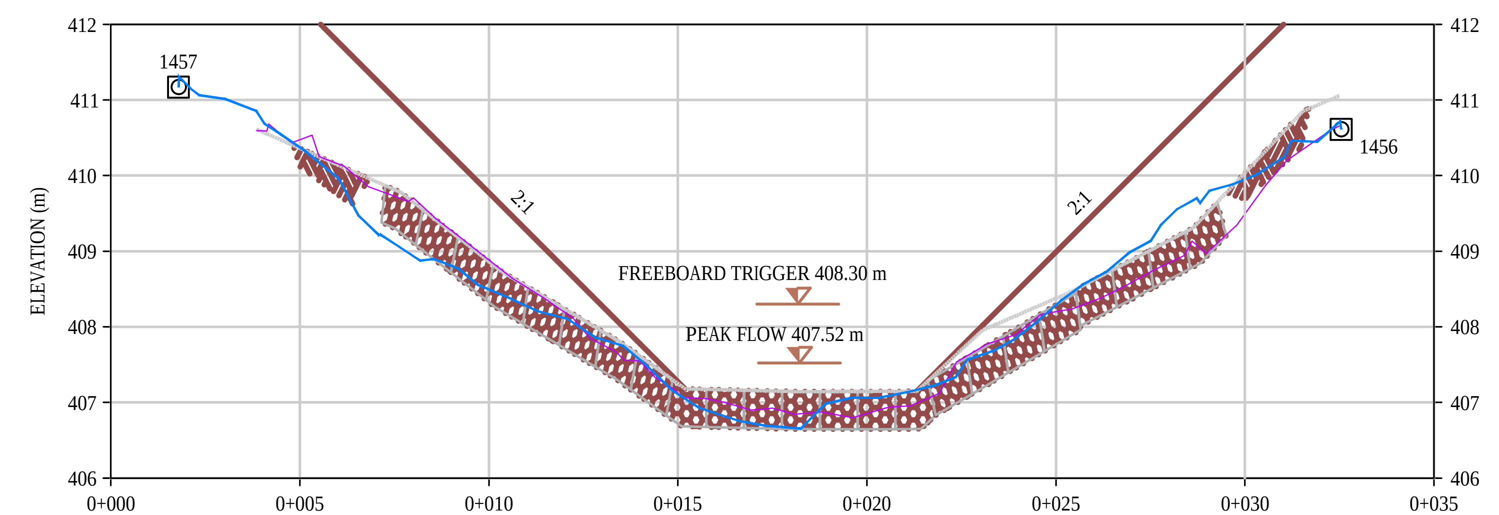
Scale: 1:400 @ 11"x17"

HORIZONTAL SCALE

0 3m

Scale: 1:80 @ 11"x17"

VERTICAL SCALE



SECTION 2B

0 10m

Scale: 1:200 @ 11"x17"

HORIZONTAL SCALE

0 5m

Scale: 1:100 @ 11"x17"

VERTICAL SCALE

LEGEND

- BASELINE SURVEY (2010)
- 2019 SURVEYED GROUND
- 2020 SURVEYED GROUND
- CHANNEL CLOSURE MOVEMENT MONITOR (19mm Ï STEEL PIN) INSTALLED DURING 2006 SURVEY
- CHANNEL CLOSURE MOVEMENT MONITOR RE-ESTABLISHED IN 2012 (TYP.)

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES.
2. FREE BOARD TRIGGER SHOWN AT 600 mm BELOW TOP OF GABION BASKETS.
3. PEAK FLOW ELEVATION BASED ON PEAK FLOW RATE OF 29 m^3/S.
4. REFER TO AECOM's "FORMER CLINTON CREEK ASBESTOS MINE - EMERGENCY DROP STRUCTURE REPAIRS, CONSTRUCTION ACTIVITY REPORT, 2011" FOR 2011 REPAIR DETAILS.

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Assessment and Abandoned Mines

TETRA TECH

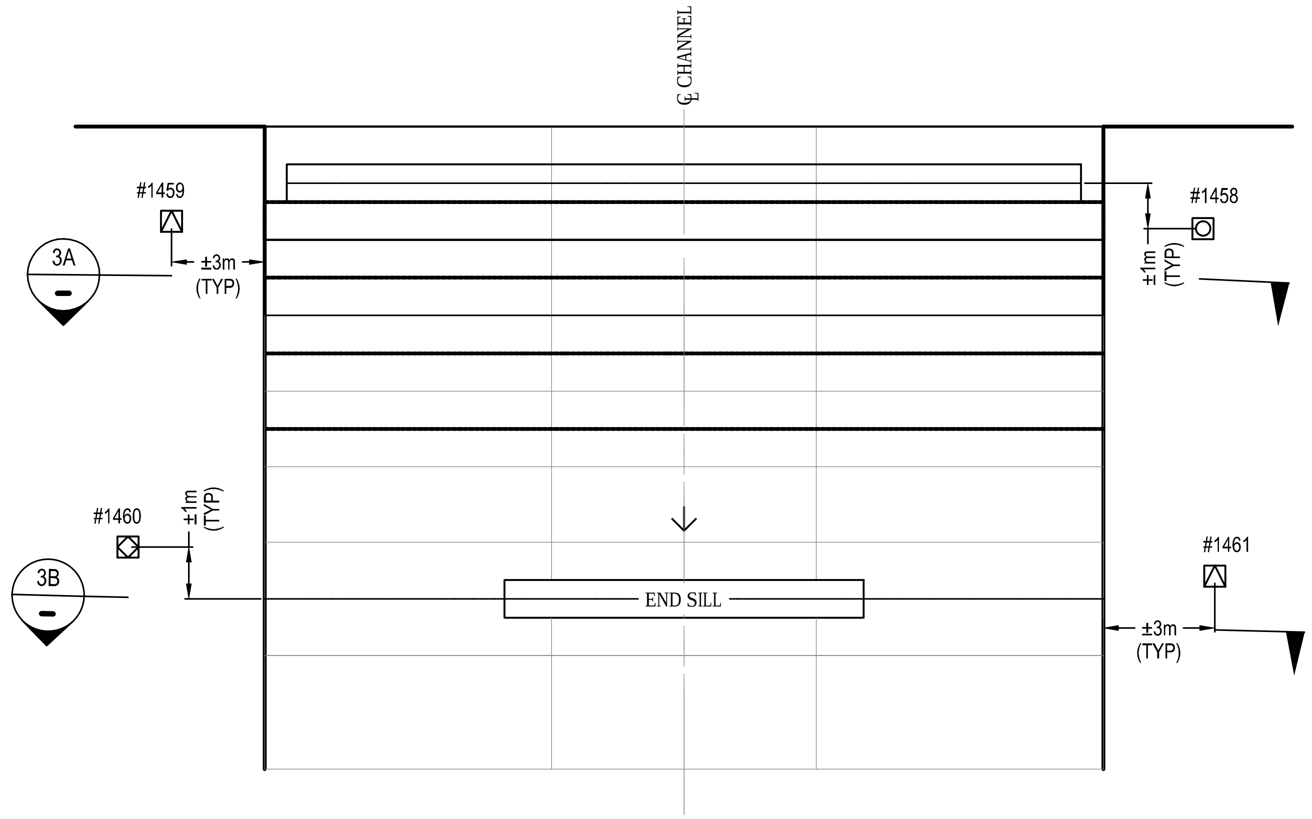
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

GABION DROP STRUCTURE #2 (DS2)

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

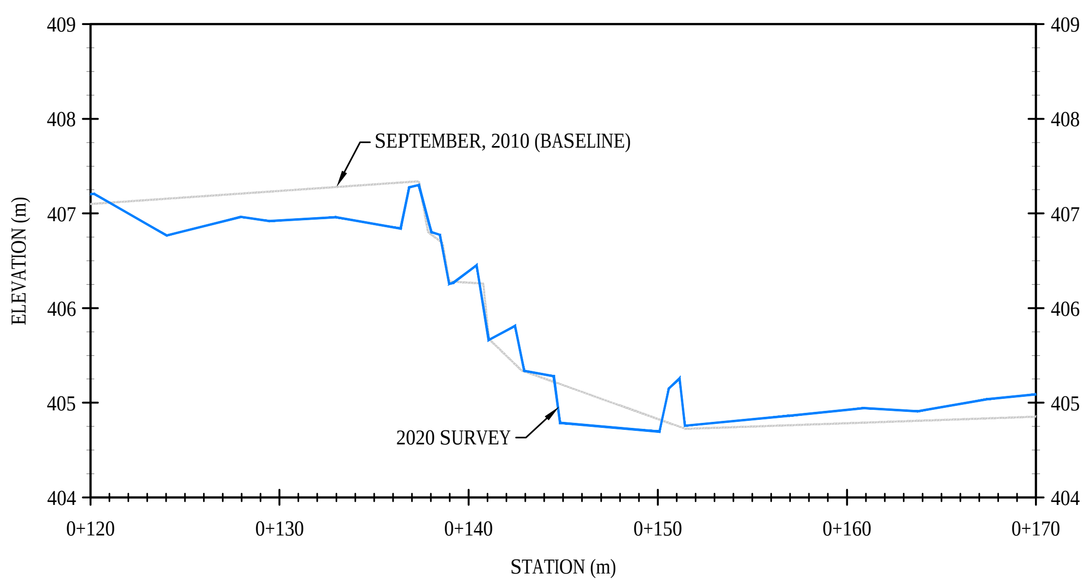
OFFICE	DATE
EBA-WHSE	December 22, 2021

Figure 11



DROP STRUCTURE #3 PLAN VIEW

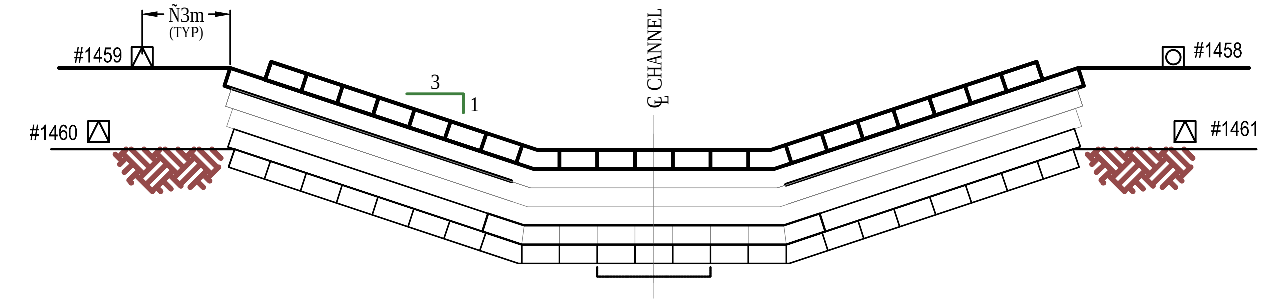
0 10m
Scale: 1:200 @ 11"x17"



DROP STRUCTURE #3 PROFILE

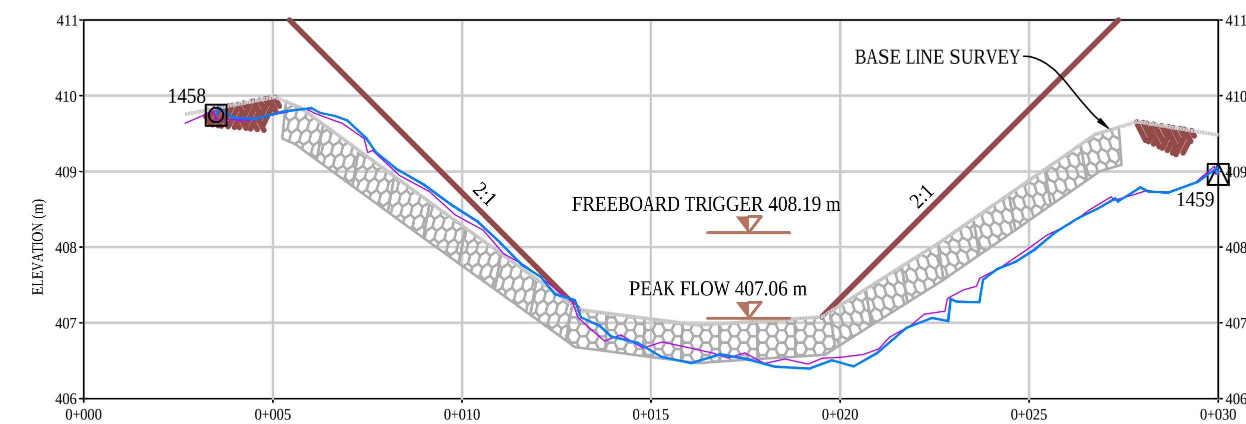
0 20m
Scale: 1:400 @ 11"x17"
HORIZONTAL SCALE

0 3m
Scale: 1:80 @ 11"x17"
VERTICAL SCALE



DROP STRUCTURE #3 END VIEW

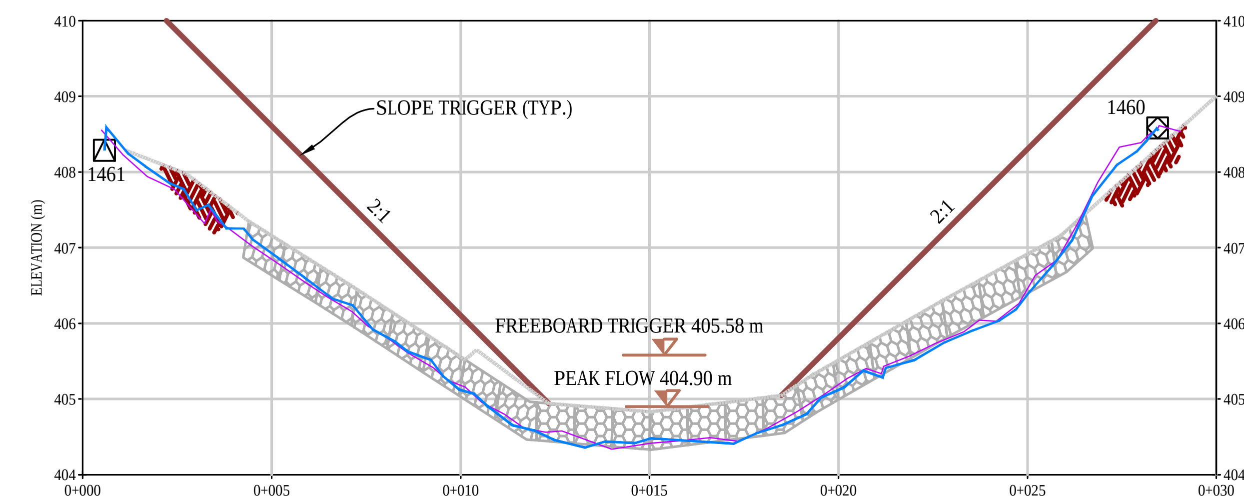
0 10m
Scale: 1:200 @ 11"x17"



SECTION 3A

0 10m
Scale: 1:200 @ 11"x17"
HORIZONTAL SCALE

0 5m
Scale: 1:100 @ 11"x17"
VERTICAL SCALE



SECTION 3B

0 10m
Scale: 1:200 @ 11"x17"
HORIZONTAL SCALE

0 5m
Scale: 1:100 @ 11"x17"
VERTICAL SCALE

LEGEND

- BASELINE SURVEY (2010)
- 2019 SURVEYED GROUND
- 2020 SURVEYED GROUND
- CHANNEL CLOSURE MOVEMENT MONITOR (19mm Ï STEEL PIN) INSTALLED DURING 2006 SURVEY
- CHANNEL CLOSURE MOVEMENT MONITOR RE-ESTABLISHED IN 2012 (TYP.)
- CHANNEL CLOSURE MOVEMENT MONITOR RE-ESTABLISHED IN 2015 (TYP.)

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES.
2. FREE BOARD TRIGGER SHOWN AT 600 mm BELOW TOP OF GABION BASKETS.
3. PEAK FLOW ELEVATION BASED ON PEAK FLOW RATE OF 29 m^3/S.
4. REFER TO AECOM's "FORMER CLINTON CREEK ASBESTOS MINE - EMERGENCY DROP STRUCTURE REPAIRS, CONSTRUCTION ACTIVITY REPORT, 2011" FOR 2011 REPAIR DETAILS.
5. DROP STRUCTURE #3 CENTRELINE NOT SURVEYED IN 2019 DUE TO UNSAFE ACCESS.

CLIENT
Yukon Government
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Assessment and Abandoned Mines

TETRA TECH

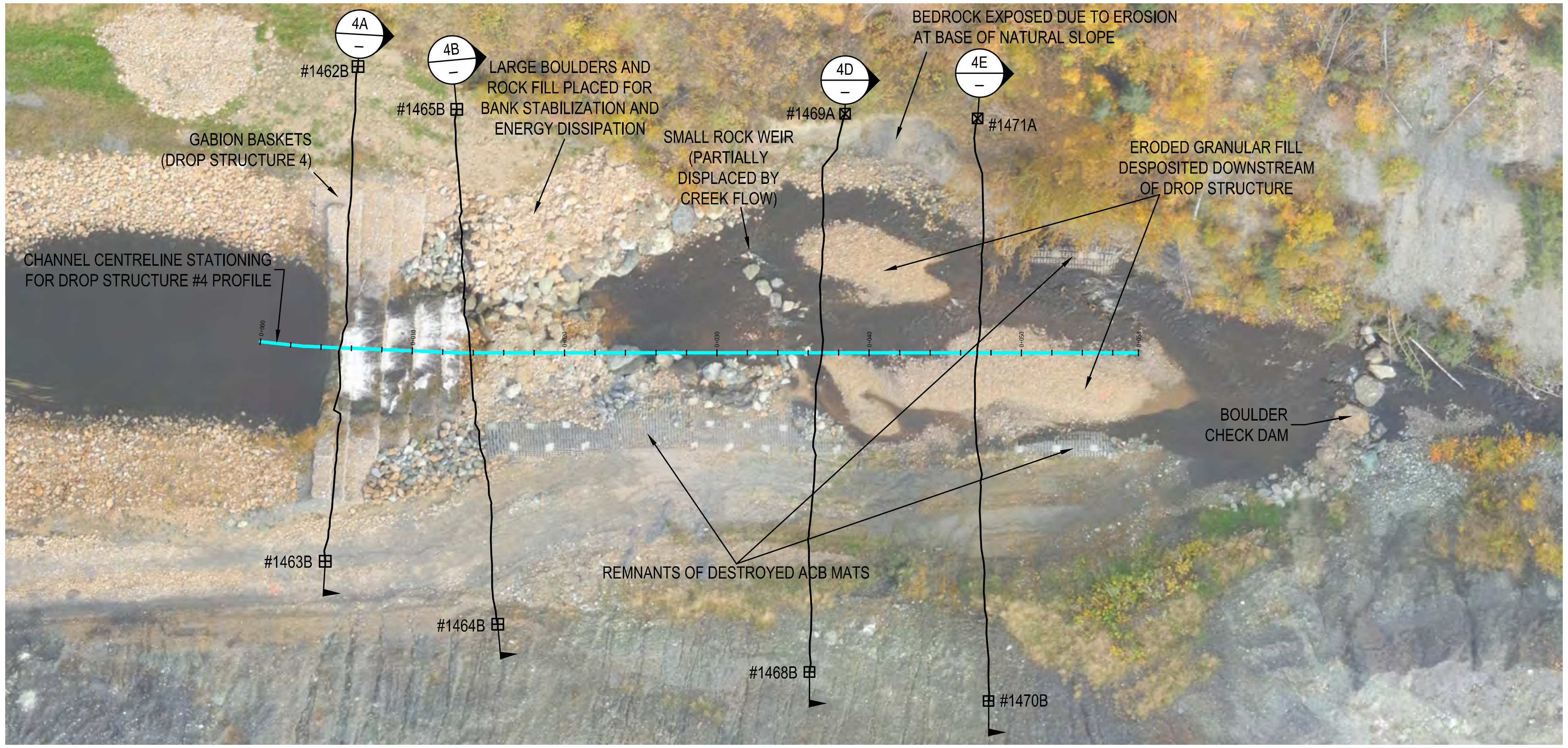
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

GABION DROP STRUCTURE #3 (DS3)

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

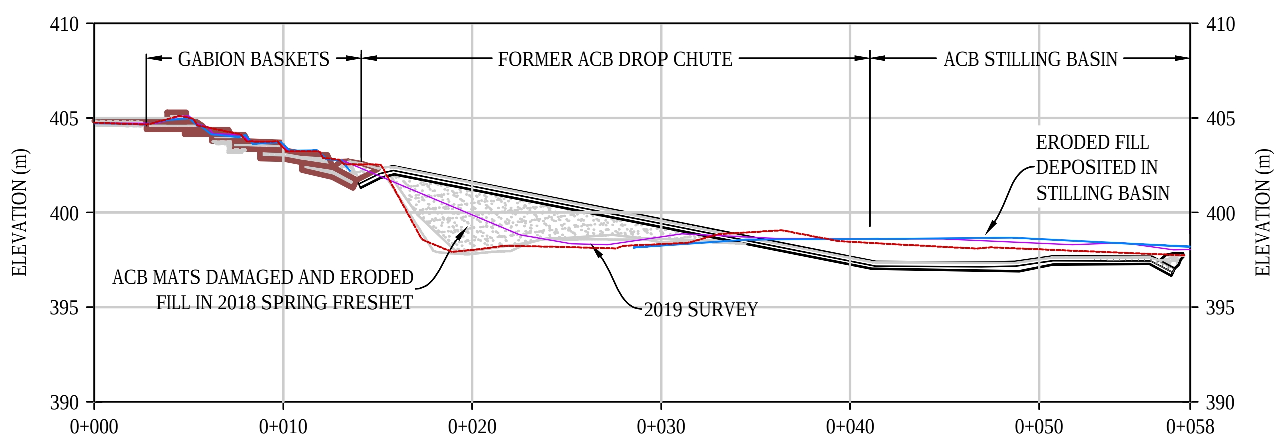
Figure 12



DROP STRUCTURE #4 PLAN

0 15m

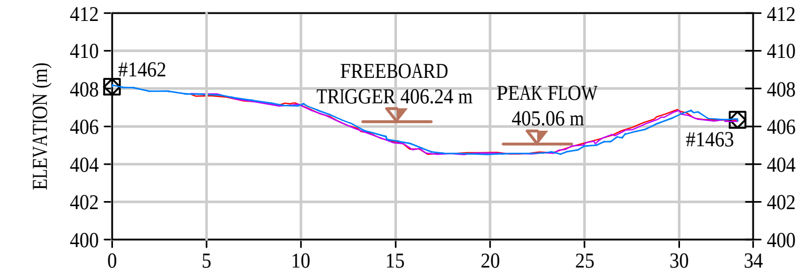
Scale: 1:300 @ 11"x17"



DROP STRUCTURE #4 PLAN

0 20m

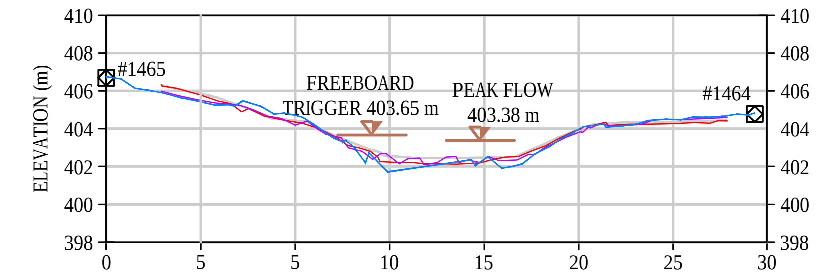
Scale: 1:400 @ 11"x17"



SECTION 4A

0 20m

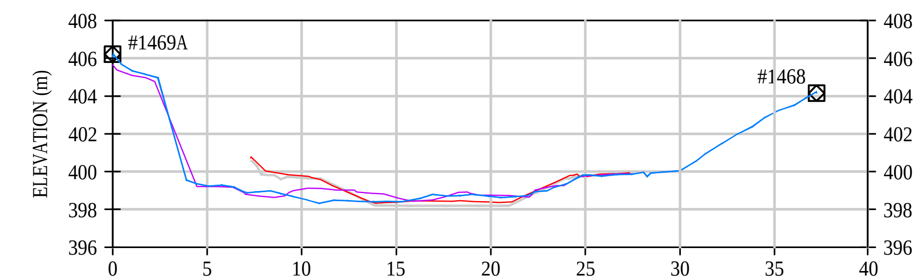
Scale: 1:400 @ 11"x17"



SECTION 4B

0 20m

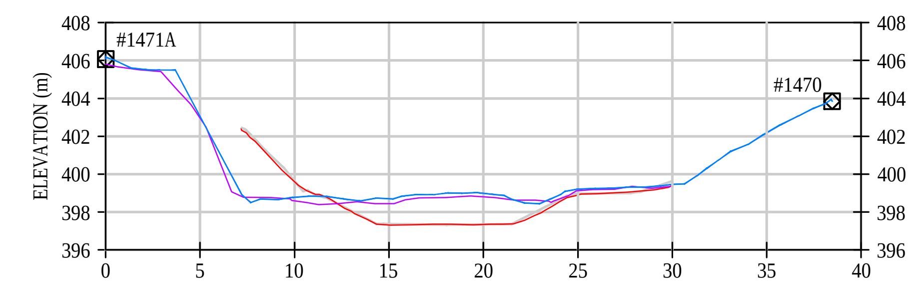
Scale: 1:400 @ 11"x17"



SECTION 4D

0 20m

Scale: 1:400 @ 11"x17"



SECTION 4E

0 20m

Scale: 1:400 @ 11"x17"

LEGEND

- BASELINE SURVEY (2010)
- 2012 SURVEYED GROUND
- 2017 SURVEYED GROUND
- 2019 SURVEYED GROUND
- 2020 SURVEYED GROUND
- CHANNEL CLOSURE MOVEMENT MONITOR RE-ESTABLISHED IN 2015 (TYP.)
- CHANNEL CLOSURE MOVEMENT MONITOR RE-ESTABLISHED IN 2018 (TYP.)
- CHANNEL CLOSURE MOVEMENT MONITOR RE-ESTABLISHED IN 2019 (TYP.)

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES.
2. FREE BOARD TRIGGER SHOWN AT 600 mm BELOW TOP OF GABION BASKETS.
3. PEAK FLOW ELEVATION BASED ON PEAK FLOW RATE OF 29 m^3/S.
4. REFER TO AECOM's "FORMER CLINTON CREEK ASBESTOS MINE - EMERGENCY DROP STRUCTURE REPAIRS, CONSTRUCTION ACTIVITY REPORT, 2011" FOR 2011 REPAIR DETAILS.
5. REFER TO TETRA TECH'S CONSTRUCTION MEMO "CLINTON CREEK DS4 EMERGENCY REPAIRS" FOR 2018 REPAIR DETAILS

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

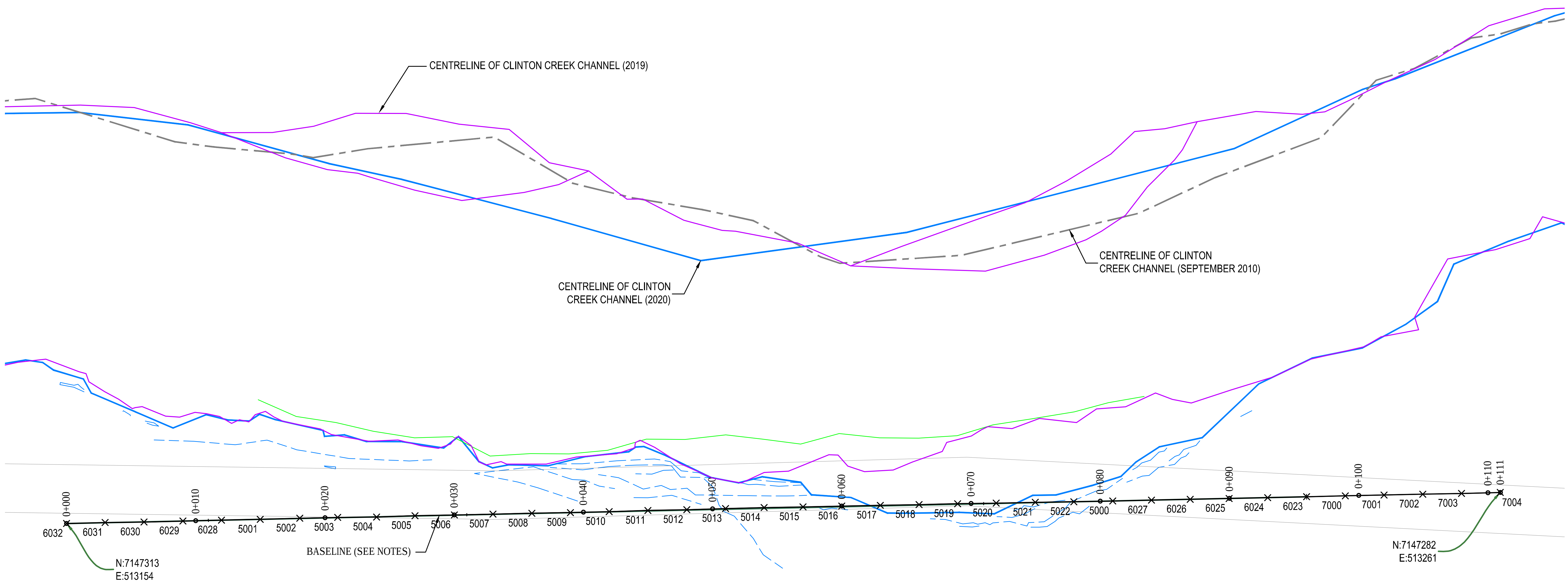
TETRA TECH

CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

GABION DROP STRUCTURE #4 (DS4) AND ACB MATS

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0
OFFICE	DATE		
EBA-WHSE	December 22, 2021		

Figure 13



LEGEND

- 2012 TOP OF BANK
- 2019 TOP OF BANK
- 2020 TOP OF BANK
- 2020 TENSION CRACKS
- MONITORING SPIKE LOCATION

NOTES :

- ALL DIMENSIONS AND ELEVATIONS ARE IN METRES
- SPIKES 5000 TO 5022 INSTALLED TO ESTABLISH 66 m LONG BASELINE IN 2012
- SPIKES 6023 TO 6032 ADDED TO EXTEND BASELINE TO 96 m LONG IN 2015
- SPIKES 7000 TO 7004 ADDED TO EXTEND BASELINE TO 111 m LONG IN 2017
- SPIKES 5017 TO 5020 DESTROYED DUE TO ENBANKMENT LOSS IN SPRING 2020

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

TETRA TECH

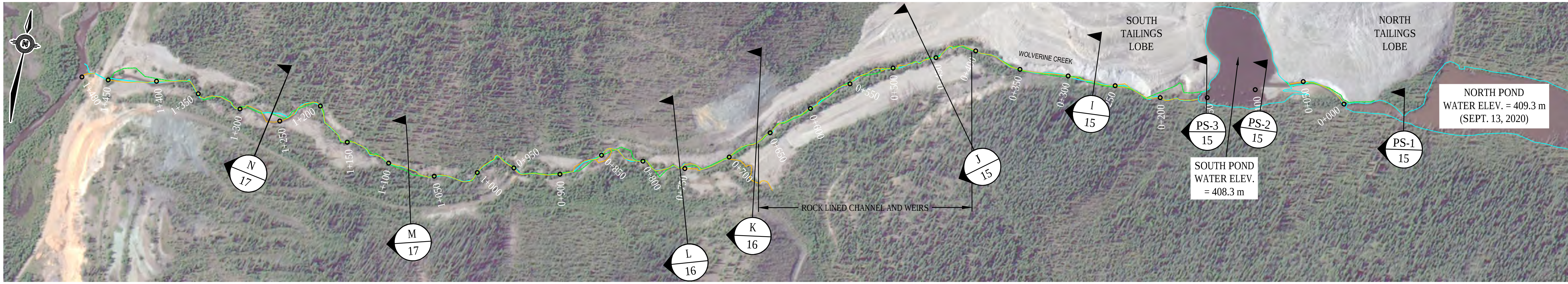
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

CLOSED ACCESS ROAD

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0
OFFICE	DATE		
EBA-WHSE	December 22, 2021		

Figure 14

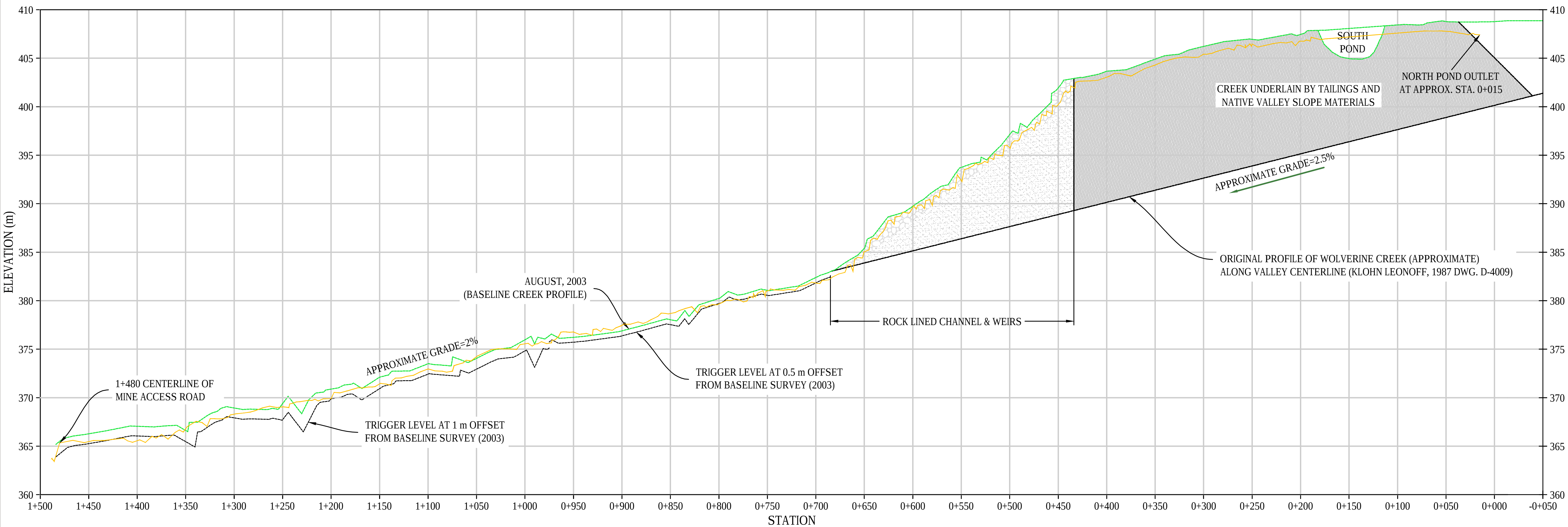
Q:\Whitehorse\Data\0201drawings\Clinton Creek\ENG.WARC03956-03 2021 Long Term Performance Monitoring Program\ENG.WARC03956-03 LTMP Fig.14-R0.dwg [FIGURE 14] December 22, 2021 - 5:13:51 pm (BY: BUCHAN, CAMERON)



PLAN VIEW

0 200m

Scale: 1:4,000 @ 11"x17"



PROFILE

0 200m

Scale: 1:4,000 @ 11"x17"
HORIZONTAL SCALE

0 20m

Scale: 1:400 @ 11"x17"
VERTICAL SCALE

LEGEND

- 2003 PROFILE (BASELINE)
- 2018 SURVEYED PROFILE
- 2020 SURVEYED PROFILE

NOTES :

1. DIMENSIONS AND ELEVATIONS ARE IN METRES
2. 2003 CREEK CENTER LINE IS USED AS REFERENCE LINE.
3. SURVEYED SECTIONS PS-1 TO N SEE FIGURES 16, 17 AND 18.
4. PROFILES AND CENTERLINES RECORDED AS PART OF PREVIOUS MONITORING SURVEYS IN 2006, 2007, 2008, 2010, 2011, 2012, 2014 AND 2016 ARE NOT SHOWN FOR THE SAKE OF CLARITY.

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

TETRA TECH

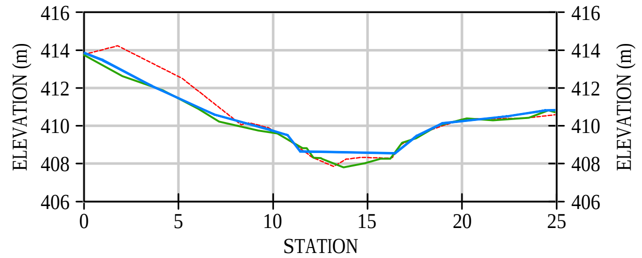
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

WOLVERINE CREEK ALIGNMENT AND PROFILE

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

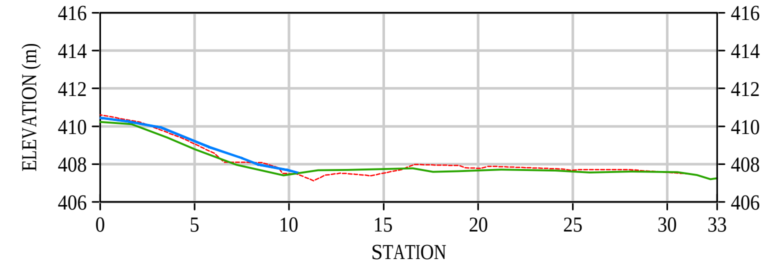
Figure 15



PS-1

0 20m

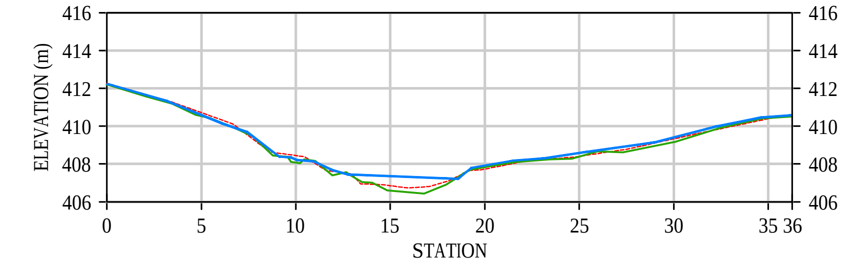
Scale: 1:400 @ 11"x17"



PS-2

0 20m

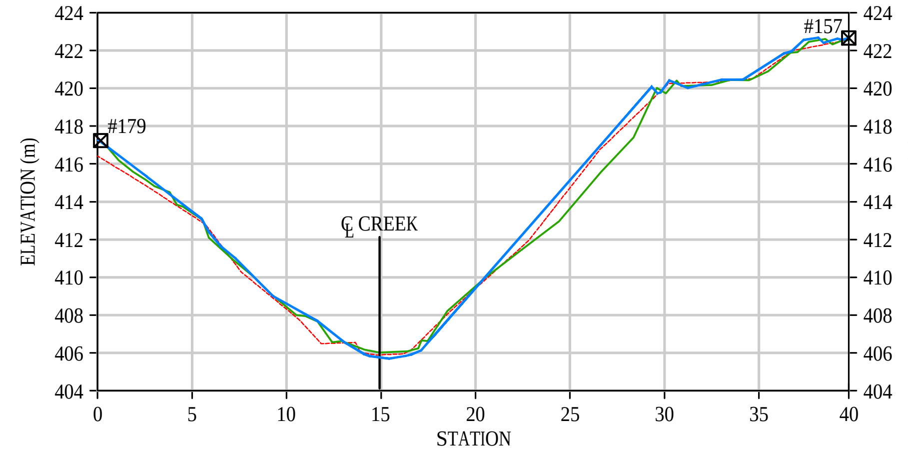
Scale: 1:400 @ 11"x17"



PS-3

0 20m

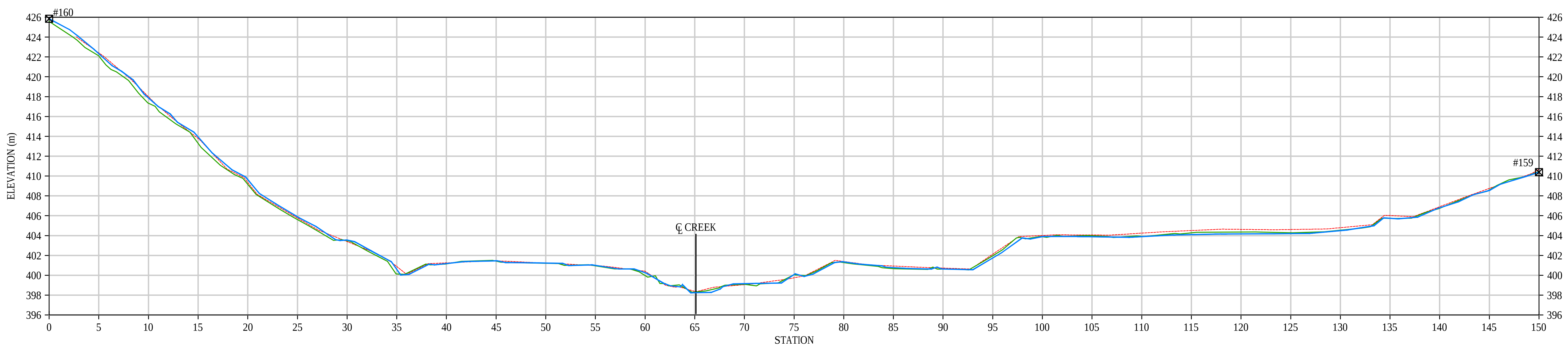
Scale: 1:400 @ 11"x17"



SECTION I

0 20m

Scale: 1:400 @ 11"x17"



SECTION J

0 20m

Scale: 1:400 @ 11"x17"

LEGEND

- 2014 SURVEYED PROFILE
- SEPTEMBER 2018 SURVEYED PROFILE
- 2020 SURVEYED PROFILE
- MOVEMENT MONITORS INSTALLED TO BOUND CROSS-SECTIONS

NOTE : DIMENSIONS AND ELEVATIONS ARE IN METRES

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

TETRA TECH

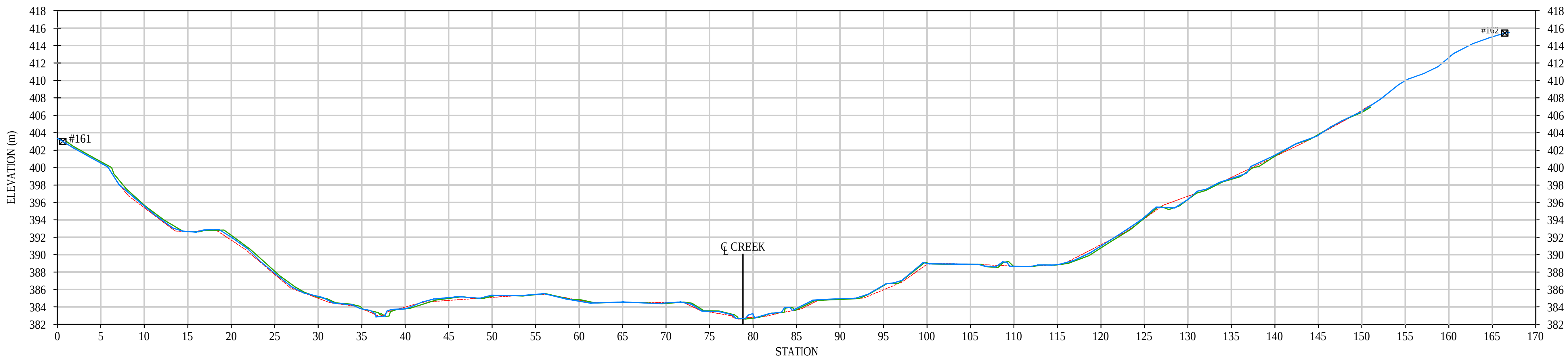
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

WOLVERINE CREEK PONDS AND CHANNEL
CROSS-SECTIONS PS-1, PS-2, PS-3, I AND J

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

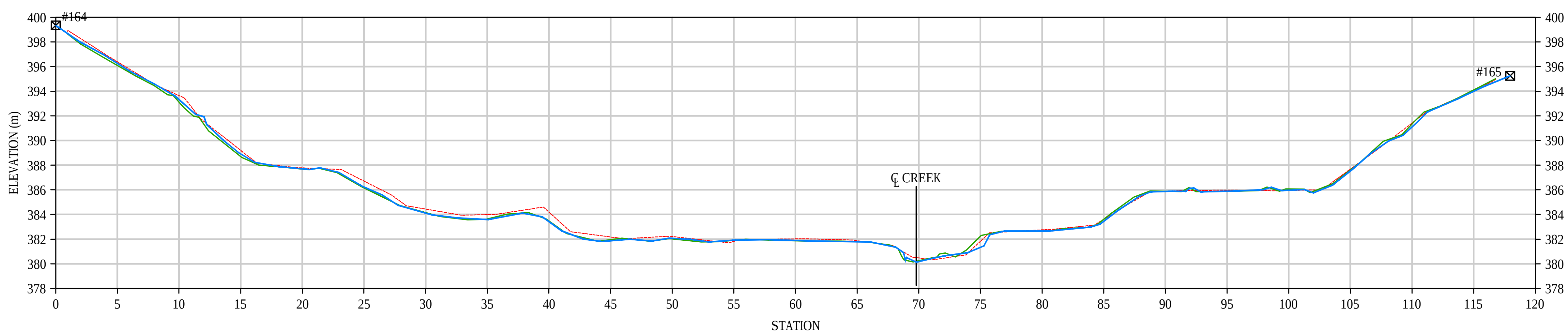
Figure 16



SECTION K

0 25m

Scale: 1:500 @ 11"x17"



SECTION L

0 20m

Scale: 1:400 @ 11"x17"

LEGEND

- 2014 SURVEYED PROFILE
- SEPTEMBER 2018 SURVEYED PROFILE
- 2020 SURVEYED PROFILE
- MOVEMENT MONITORS INSTALLED TO BOUND CROSS-SECTIONS

NOTE : DIMENSIONS AND ELEVATIONS ARE IN METRES

CLIENT

Yukon Government
Department of Energy, Mines and Resources
Assessment and Abandoned Mines

TETRA TECH

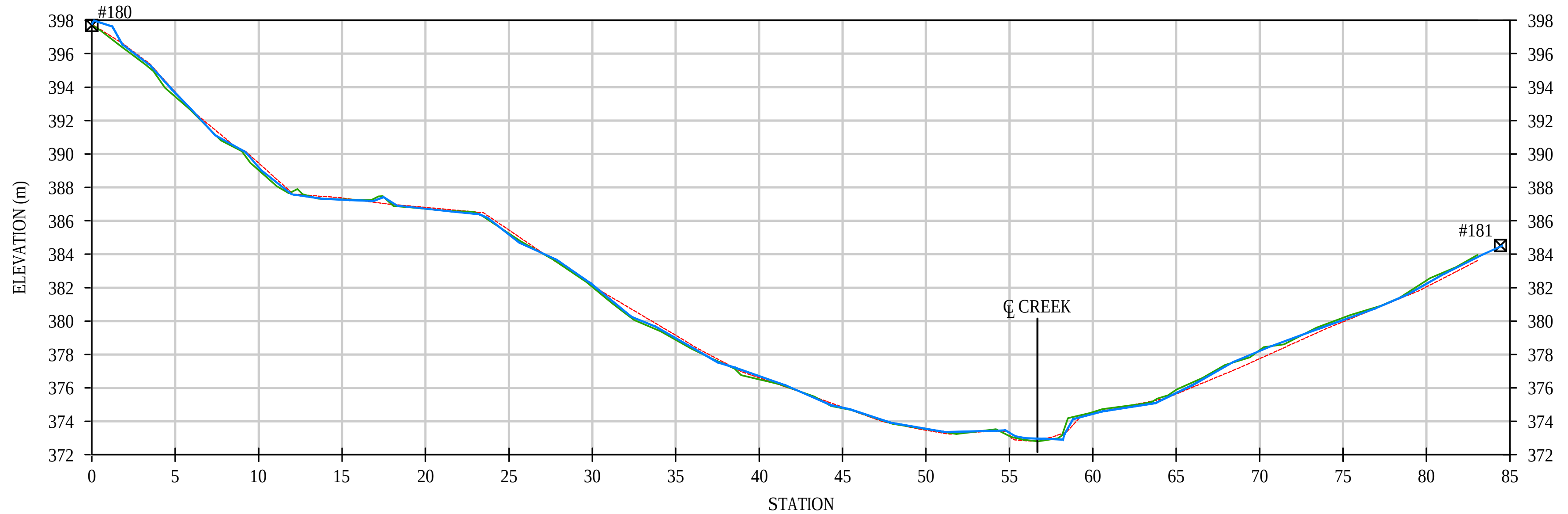
CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

WOLVERINE CREEK PONDS AND CHANNEL
CROSS-SECTIONS K AND L

PROJECT NO.	DWN	CKD	REV
ENG.WARC03956-03	CB	AW	0

OFFICE	DATE
EBA-WHSE	December 22, 2021

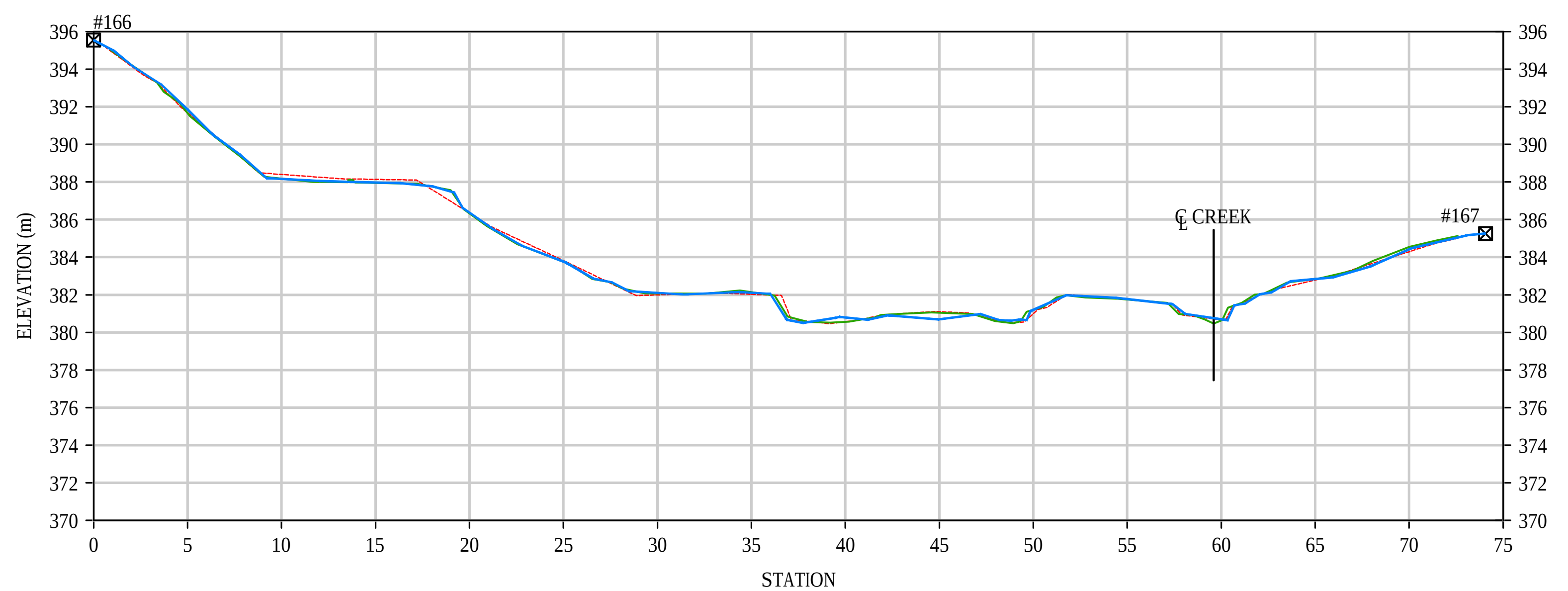
Figure 17



SECTION M

0 20m

Scale: 1:400 @ 11"x17"



SECTION N

0 20m

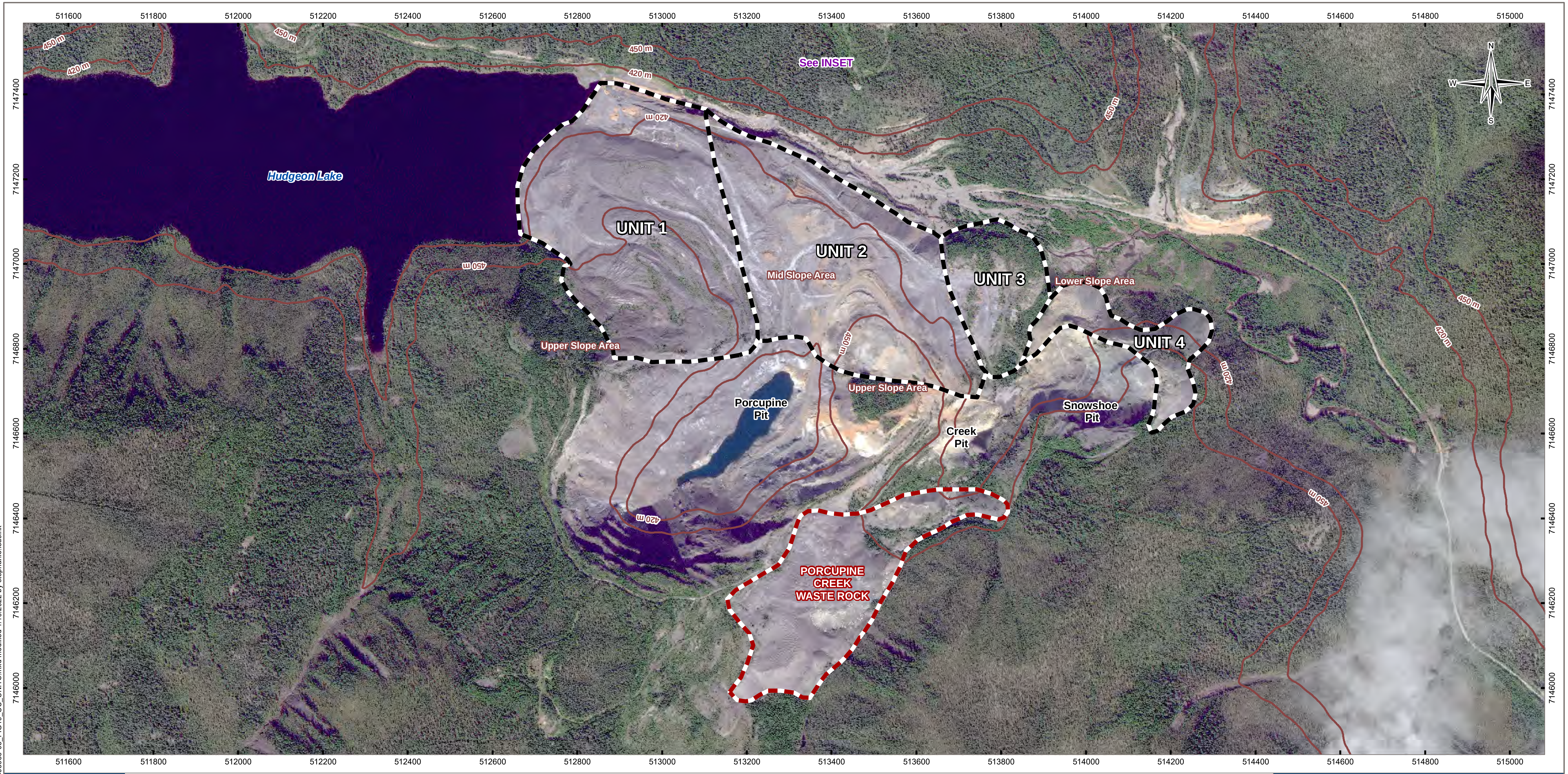
Scale: 1:400 @ 11"x17"

LEGEND

- 2014 SURVEYED PROFILE
- SEPTEMBER 2018 SURVEYED PROFILE
- 2020 SURVEYED PROFILE
☒ - MOVEMENT MONITORS INSTALLED TO BOUND CROSS-SECTIONS

NOTE : DIMENSIONS AND ELEVATIONS ARE IN METRES

CLIENT	CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM				
Yukon Government Department of Energy, Mines and Resources Assessment and Abandoned Mines	WOLVERINE CREEK PONDS AND CHANNEL CROSS-SECTIONS M AND N				
TETRA TECH	PROJECT NO. ENG.WARC03956-03	DWN CB	CKD AW	REV 0	Figure 18
	OFFICE EBA-WHSE	DATE December 22, 2021			



LEGEND

- Clinton Creek Waste Rock Unit Boundary
- Porcupine Creek Waste Rock
- Slope Zone Boundary

Upper Slope: Elevation > 450 m
Mid Slope: 420 m < Elevation < 450 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).

CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Clinton Creek Waste Rock Pile Showing Extents of Waste Rock Units

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:9,000
100 50 0 100
Metres

TETRA TECH

FILE NO.
WARC03956-03_FIG19_CC_UNITS.mxd

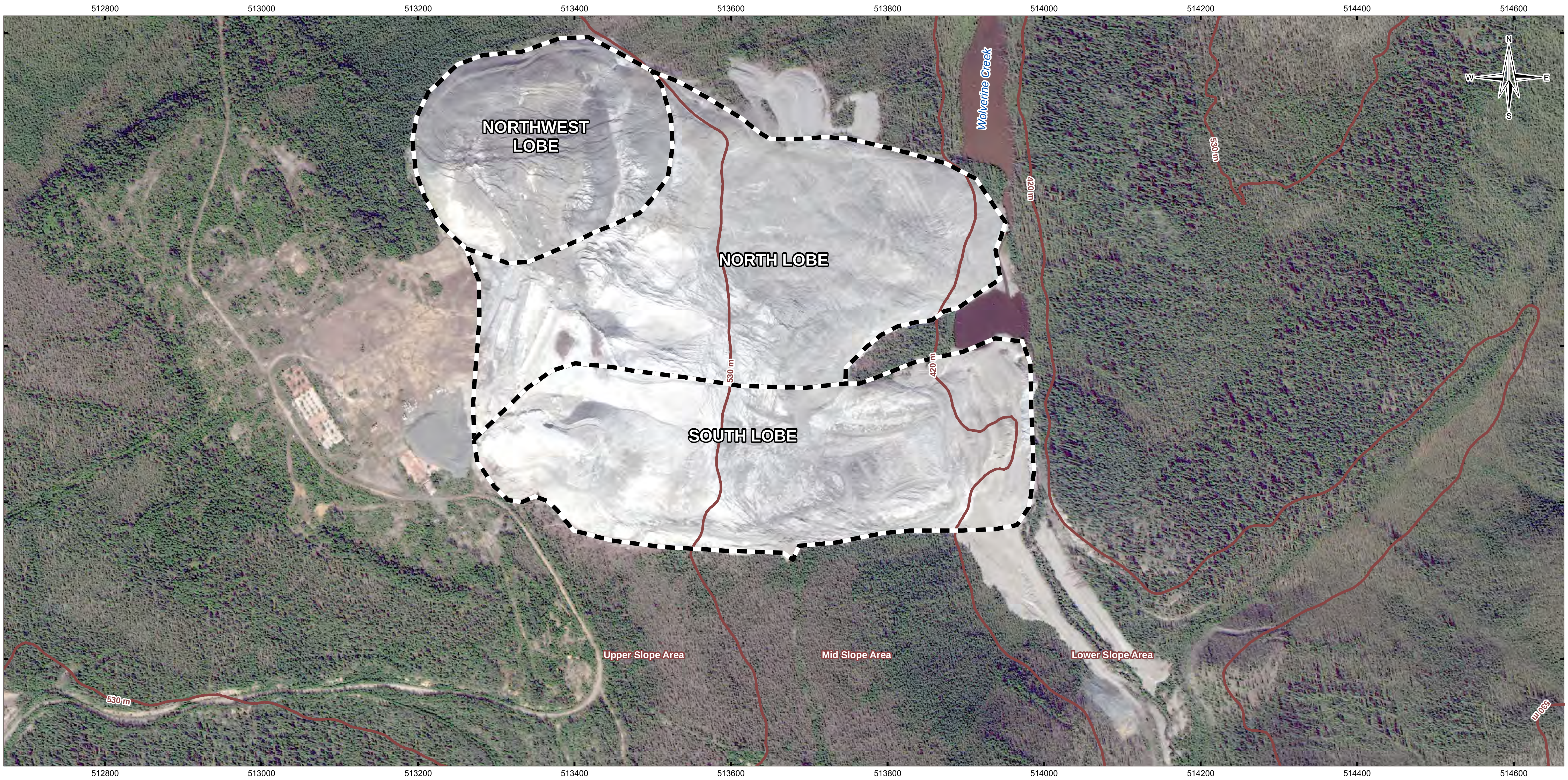
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE: January 10, 2022
PROJECT NO.: ENG.WARC03956-03

STATUS
ISSUED FOR REVIEW

Figure 19

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG19_CC_UNITS.mxd modified 1/10/2022 by stephanie.leusink



LEGEND

Tailings Pile Lobe Boundary

Slope Zone Boundary

Upper Slope: Elevation > 530 m
Mid Slope: 420 m < Elevation < 530 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Wolverine Creek Tailings Pile Showing Extents of Tailings Lobes

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:5,000
100 50 0 100
Metres

TETRA TECH

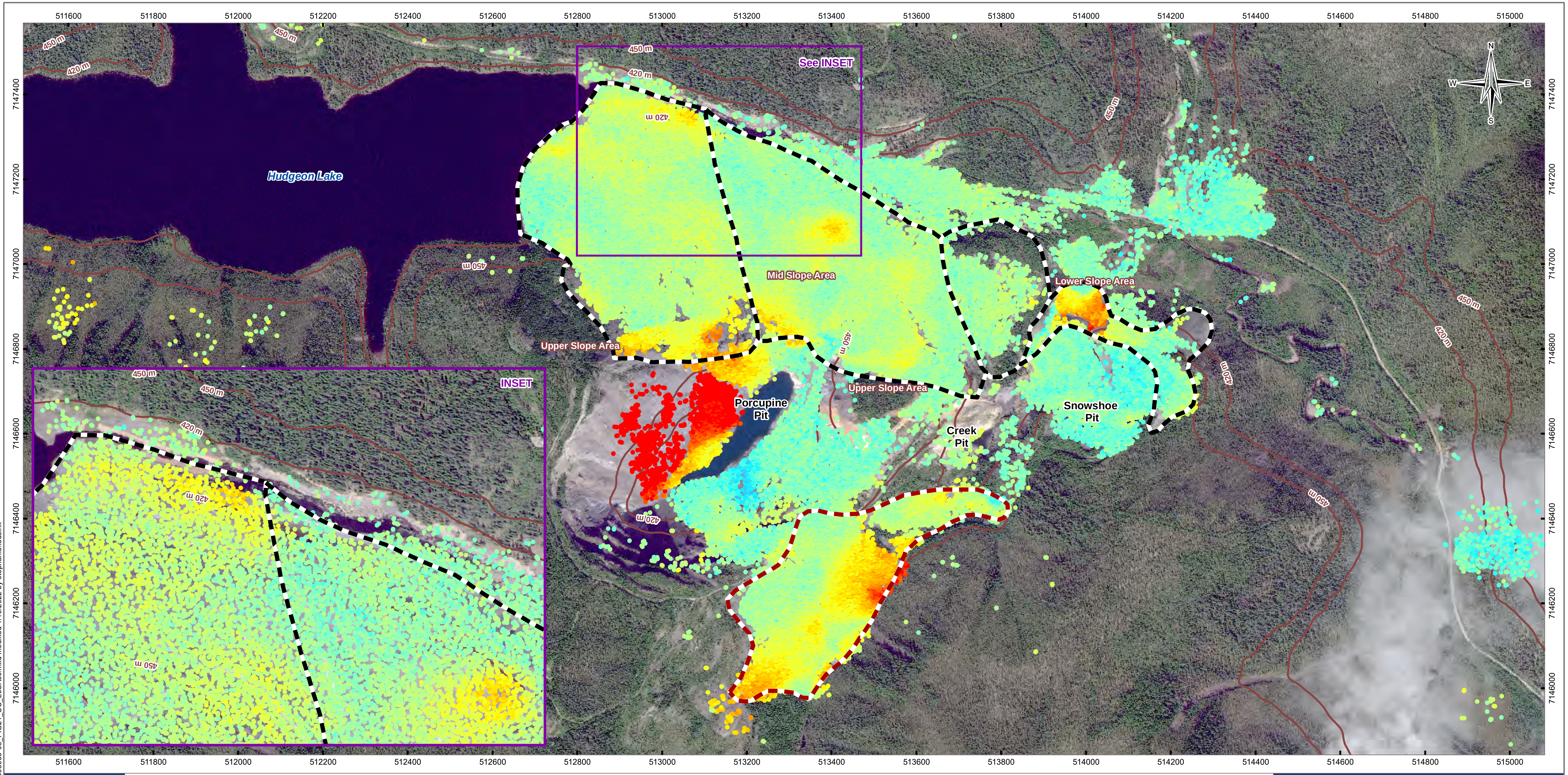
FILE NO.
WARC03956-03_FIG20_WC_LOBES.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE	PROJECT NO.
December 23, 2021	ENG.WARC03956-03

Figure 20

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG20_WC_LOBES.mxd modified 12/23/2021 by stephanie.leusink



LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Clinton Creek Waste Rock Unit Boundary

Porcupine Creek Waste Rock

Slope Zone Boundary

Upper Slope: Elevation > 450 m
Mid Slope: 420 m < Elevation < 450 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Clinton Creek Waste Rock Pile LoS InSAR Ascending Orbit

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:9,000
100 50 0 100
Metres

FILE NO.
WARC03956-03_FIG21_CC_LoSAsc.mxd

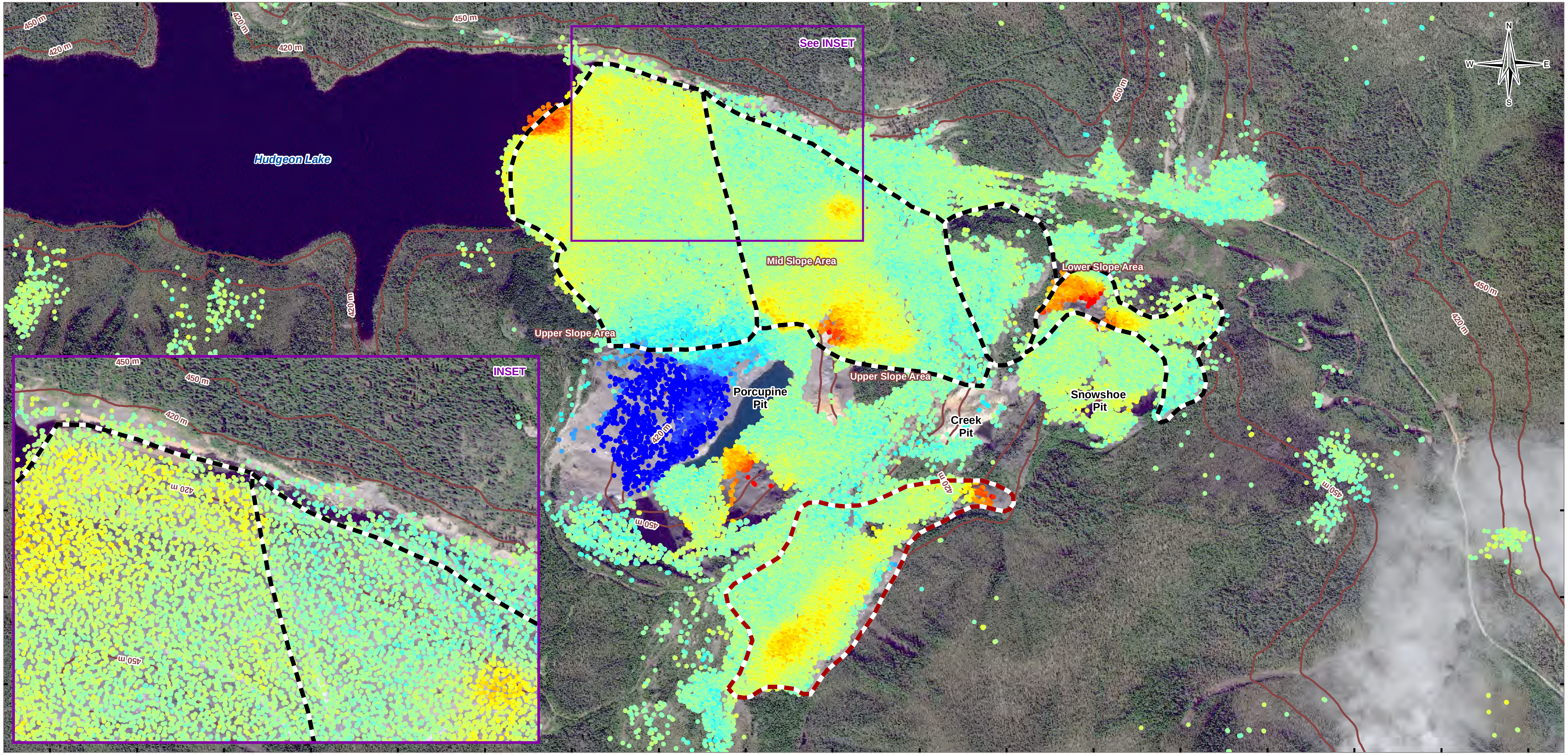
TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE	PROJECT NO.
January 10, 2022	ENG.WARC03956-03

Figure 21

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG21_CC_LoSAsc.mxd modified 1/10/2022 by stephanie.leusink



LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Clinton Creek Waste Rock Unit Boundary

Porcupine Creek Waste Rock

Slope Zone Boundary

Upper Slope: Elevation > 450 m
Mid Slope: 420 m < Elevation < 450 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Clinton Creek Waste Rock Pile LoS InSAR Descending Orbit

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:9,000 (Metres)

FILE NO. WARC03956-03_FIG22_CC_LoSDesc.mxd

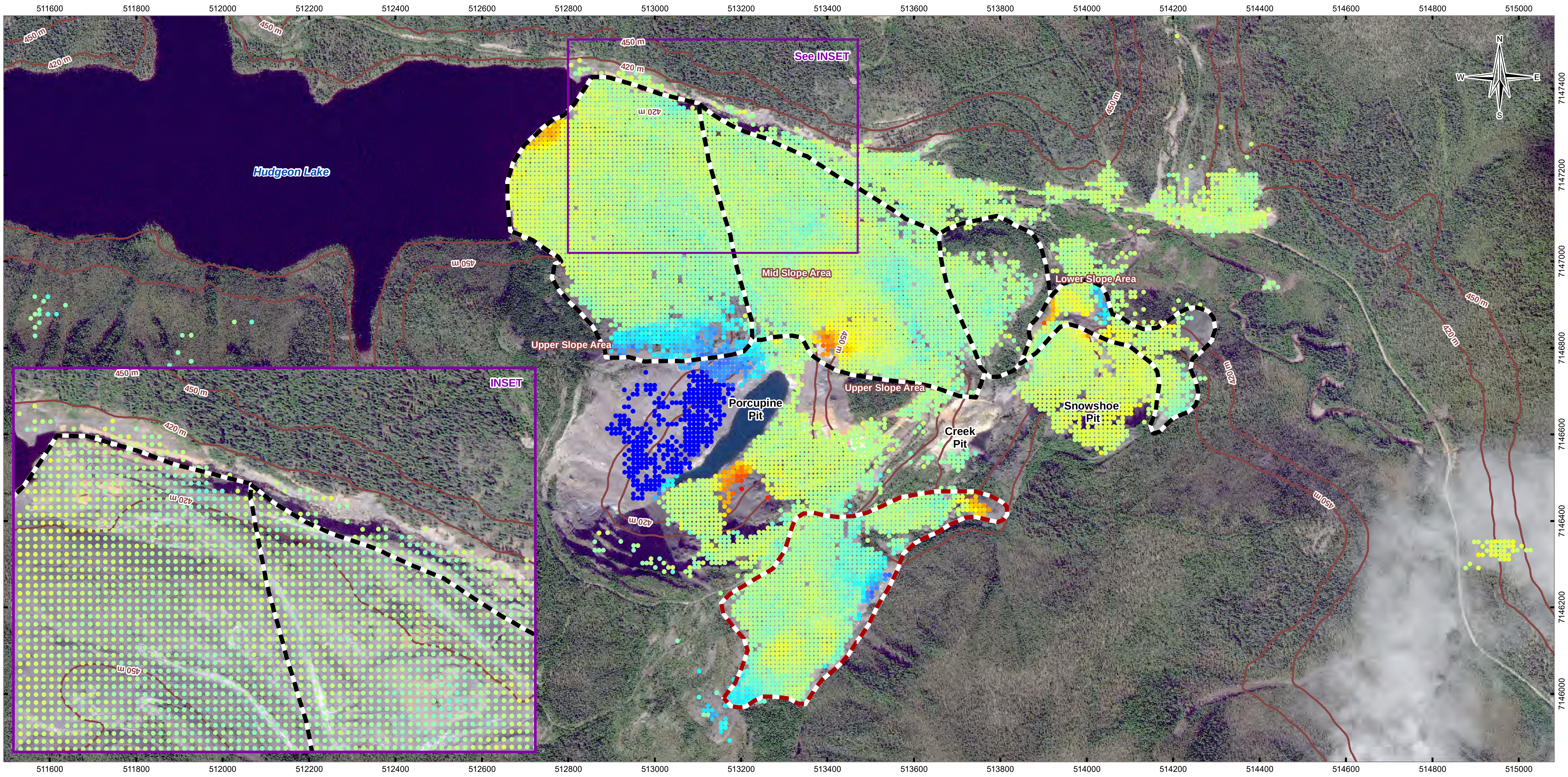
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE	PROJECT NO.
January 10, 2022	ENG.WARC02956-03

TETRA TECH

Figure 22

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG22_CC_LoSDesc.mxd modified 1/10/2022 by stephanie.leusink



LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Clinton Creek Waste Rock Unit Boundary

Porcupine Creek Waste Rock

Slope Zone Boundary

Upper Slope: Elevation > 450 m
Mid Slope: 420 m < Elevation < 450 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Clinton Creek Waste Rock Pile 2D InSAR East-West

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:9,000
100 50 0 100
Metres

FILE NO.
WARC03956-03_FIG23_CC_2D_EW.mxd

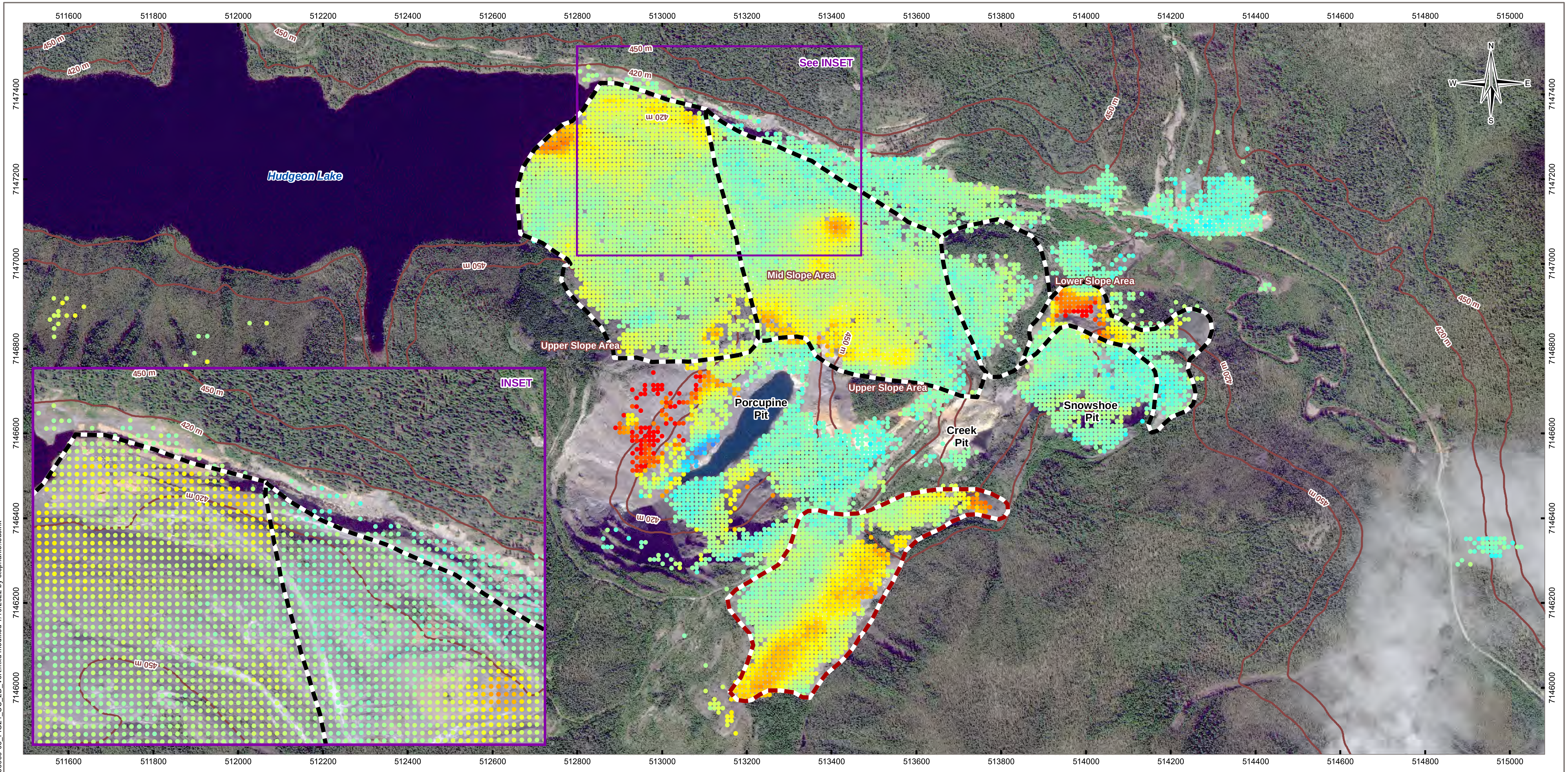
TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE	PROJECT NO.
January 10, 2022	ENG.WARC03956-03

Figure 23

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG23_CC_2D_EW.mxd modified 1/10/2022 by stephanie.leusink



LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Clinton Creek Waste Rock Unit Boundary

Porcupine Creek Waste Rock

Slope Zone Boundary

Upper Slope: Elevation > 450 m
Mid Slope: 420 m < Elevation < 450 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Clinton Creek Waste Rock Pile 2D InSAR Vertical

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:9,000
100 50 0 100
Metres

FILE NO.
WARC03956-03_FIG24_CC_2D_Vert.mxd

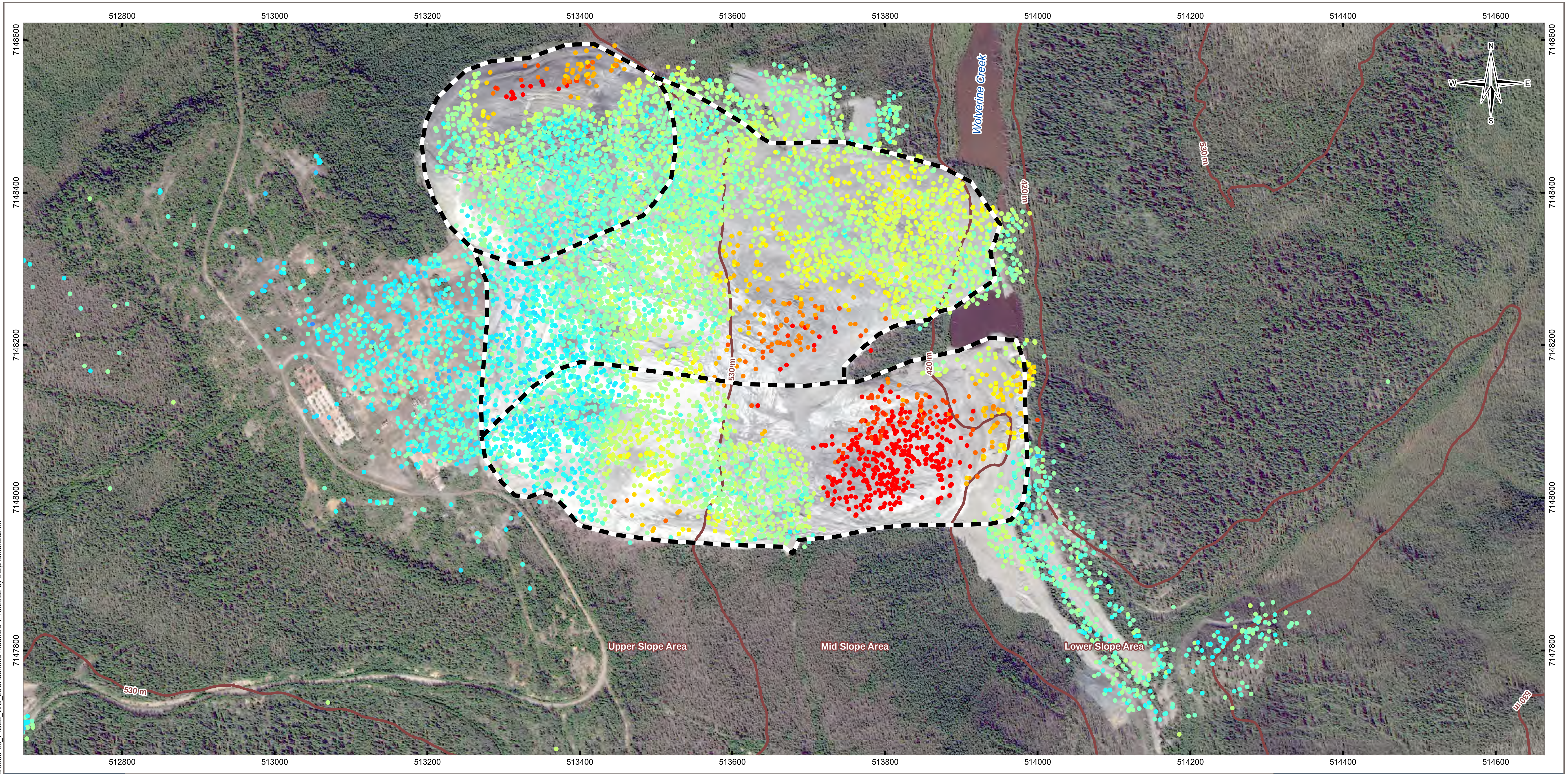
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE	PROJECT NO.
January 10, 2022	ENG.WARC03956-03

TETRA TECH

Figure 24

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG24_CC_2D_Vert.mxd modified 1/10/2022 by stephanie.leusink



LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Tailings Pile Lobe Boundary

Slope Zone Boundary

Upper Slope: Elevation > 530 m
Mid Slope: 420 m < Elevation < 530 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Wolverine Creek Tailings Pile
LoS InSAR Ascending Orbit

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

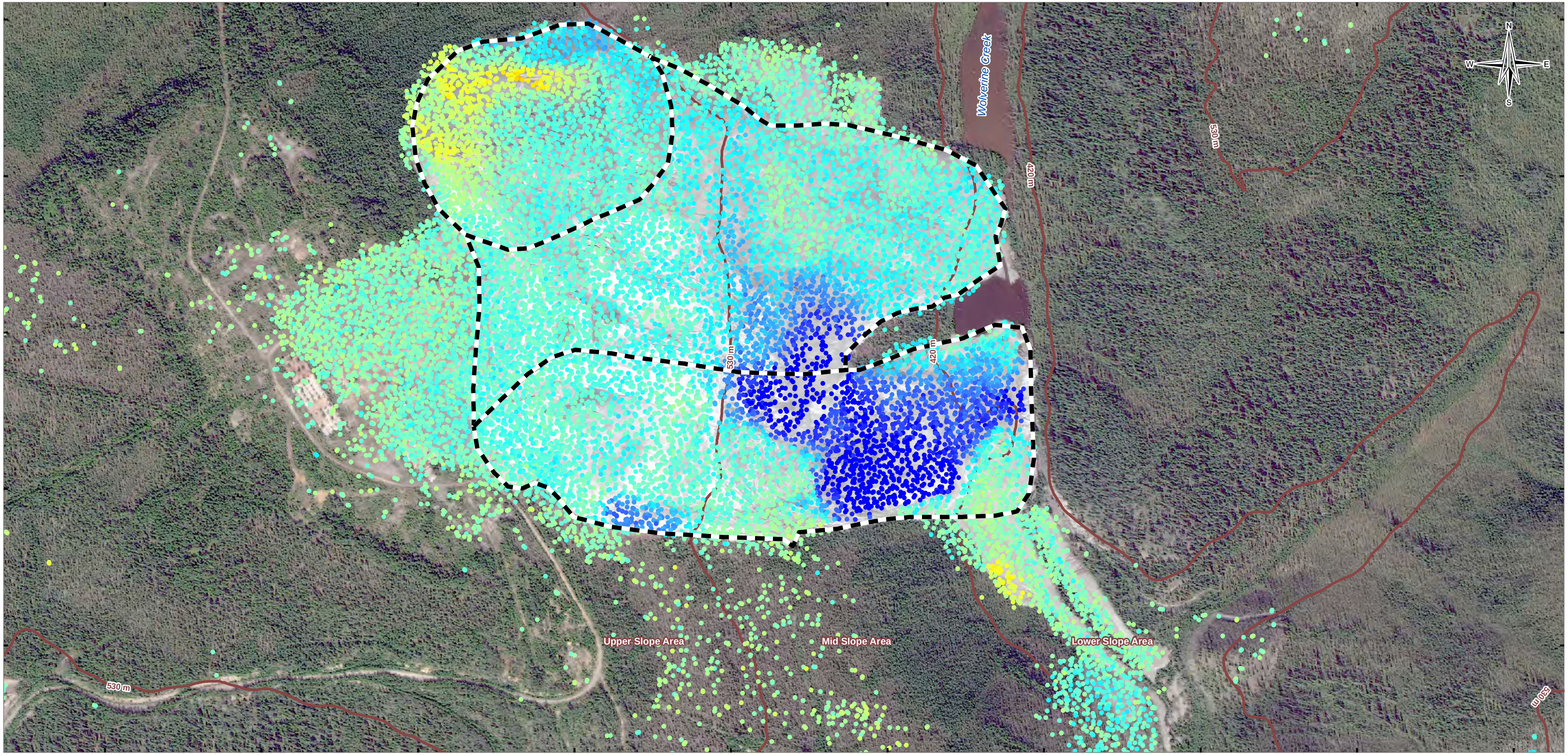
Scale: 1:5,000
100 50 0 100
Metres

TETRA TECH

FILE NO.				
WARC03956-03_FIG25_WC_LoSAsc.mxd				
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0
DATE	PROJECT NO.			
January 10, 2022	ENG.WARC03956-03			

Figure 25

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG25_WC_LoSAsc.mxd modified 1/10/2022 by stephanie.leusink



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LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Tailings Pile Lobe Boundary

Slope Zone Boundary

Upper Slope: Elevation > 530 m
Mid Slope: 420 m < Elevation < 530 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE
2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Wolverine Creek Tailings Pile
LoS InSAR Descending Orbit

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:5,000
100 50 0 100
Metres

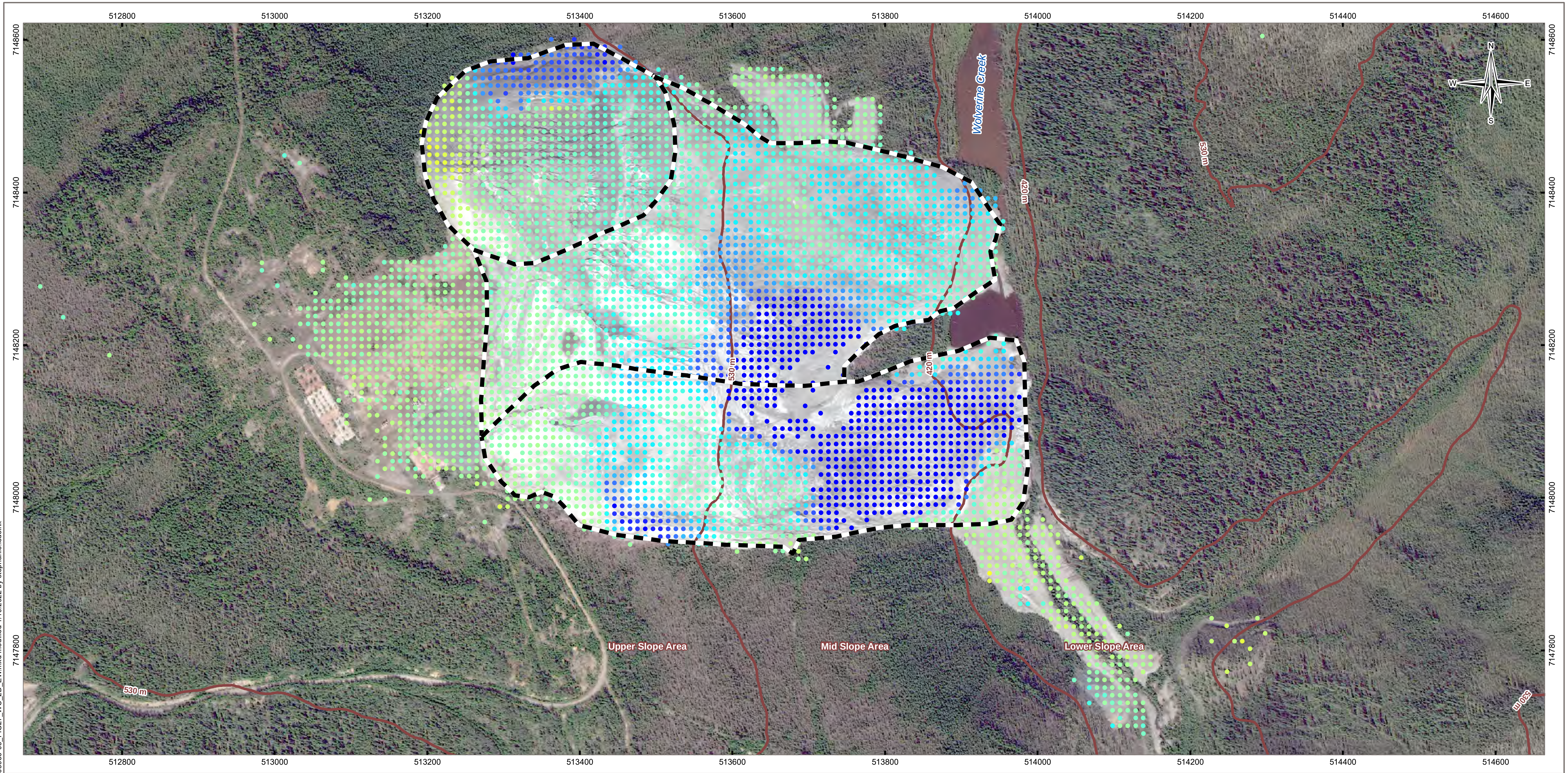
FILE NO.
WARC03956-03_FIG26_WC_LoSDesc.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE	PROJECT NO.
January 10, 2022	ENG.WARC03956-03

Figure 26



LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Tailings Pile Lobe Boundary

Slope Zone Boundary

Upper Slope: Elevation > 530 m
Mid Slope: 420 m < Elevation < 530 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Wolverine Creek Tailings Pile 2D InSAR East-West

PROJECTION: UTM Zone 7
DATUM: NAD83
CLIENT: Yukon

Scale: 1:5,000
100 50 0 100
Metres

TETRA TECH

FILE NO.: WARC03956-03_FIG27_WC_2D_EW.mxd

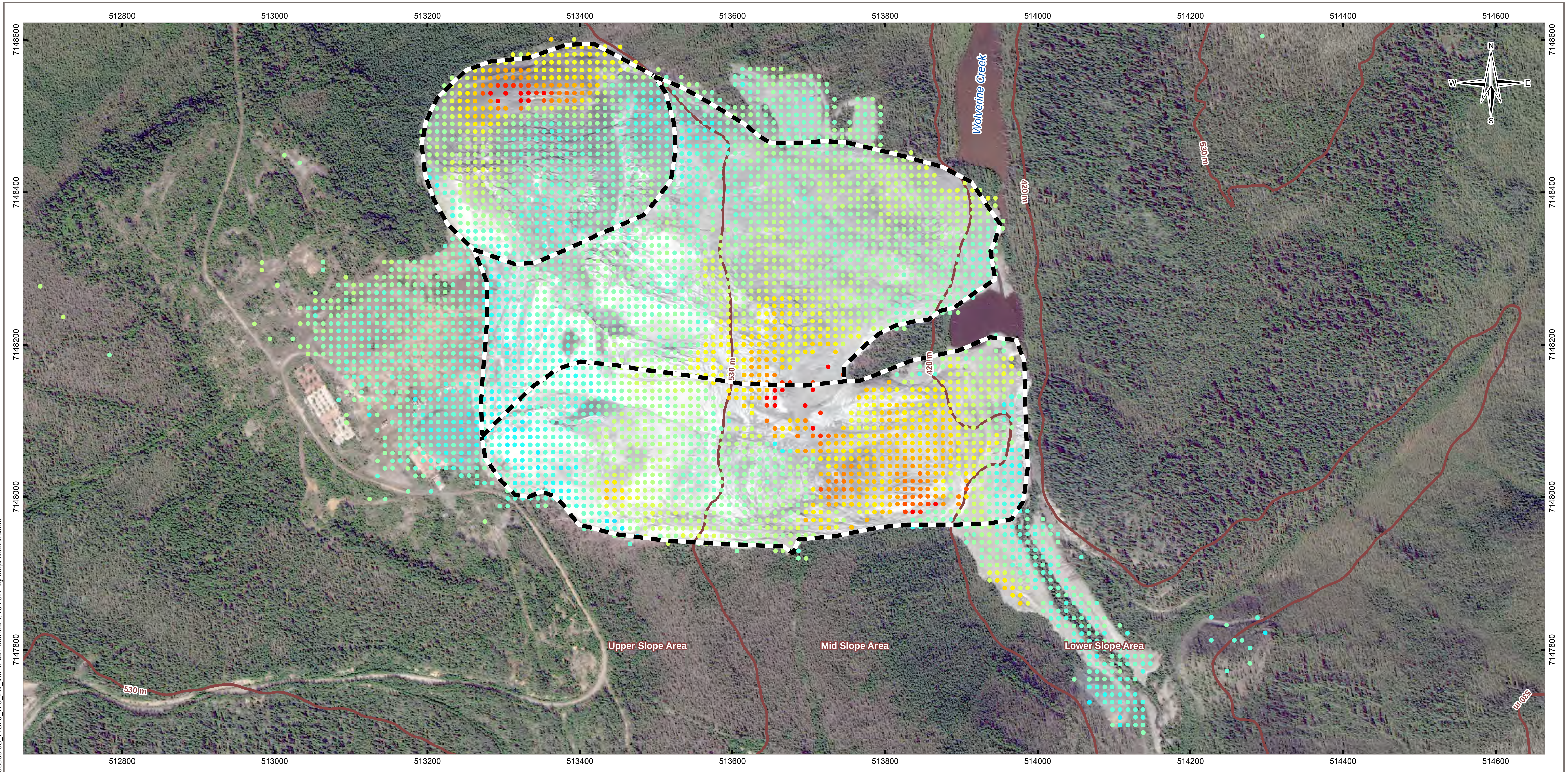
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE: January 10, 2022
PROJECT NO.: ENG.WARC03956-03

STATUS: ISSUED FOR REVIEW

Figure 27

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG27_WC_2D_EW.mxd modified 1/10/2022 by stephanie.leusink



Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03956-03\Maps\WARC03956-03_FIG28_WC_2D_Vert.mxd modified 1/10/2022 by stephanie.leusink

LEGEND

Line Of Sight Deformation Rate (mm/yr)

> 100

< -100

Tailings Pile Lobe Boundary

Slope Zone Boundary

Upper Slope: Elevation > 530 m
Mid Slope: 420 m < Elevation < 530 m
Lower Slope: Elevation < 420 m

NOTES
Imagery Source: WorldView (provided by client).
InSAR Data: TRE Altamira (November 2021).

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE SITE 2021 LONG TERM PERFORMANCE MONITORING PROGRAM

Wolverine Creek Tailings Pile 2D InSAR Vertical

PROJECTION	DATUM	CLIENT
UTM Zone 7	NAD83	Yukon

Scale: 1:5,000
100 50 0 100
Metres

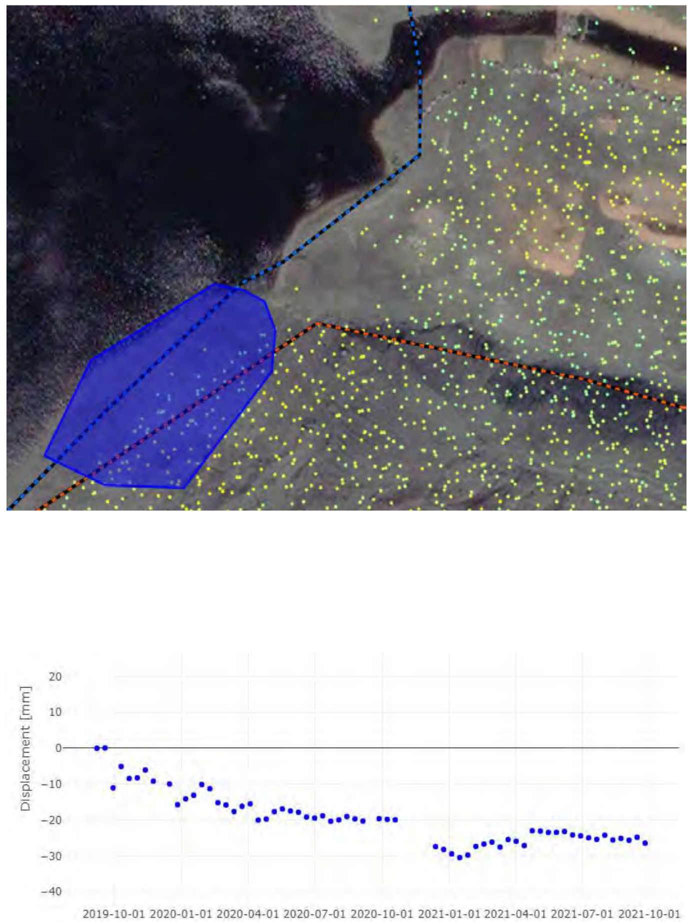
TETRA TECH

FILE NO.
WARC03956-03_FIG28_WC_2D_Vert.mxd

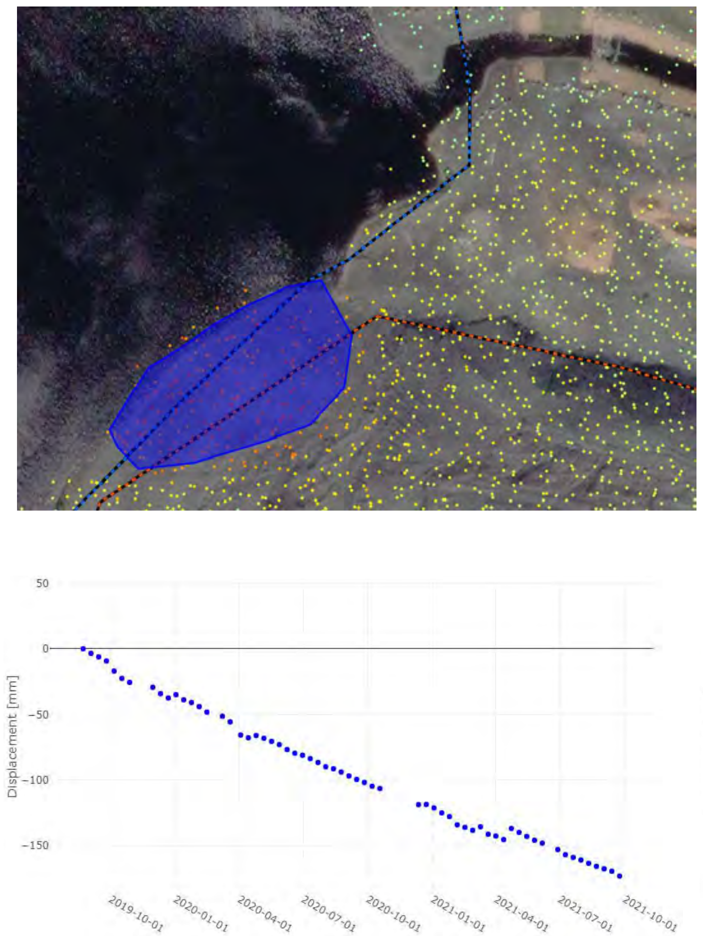
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	SM	0

DATE	PROJECT NO.
January 10, 2022	ENG.WARC03956-03

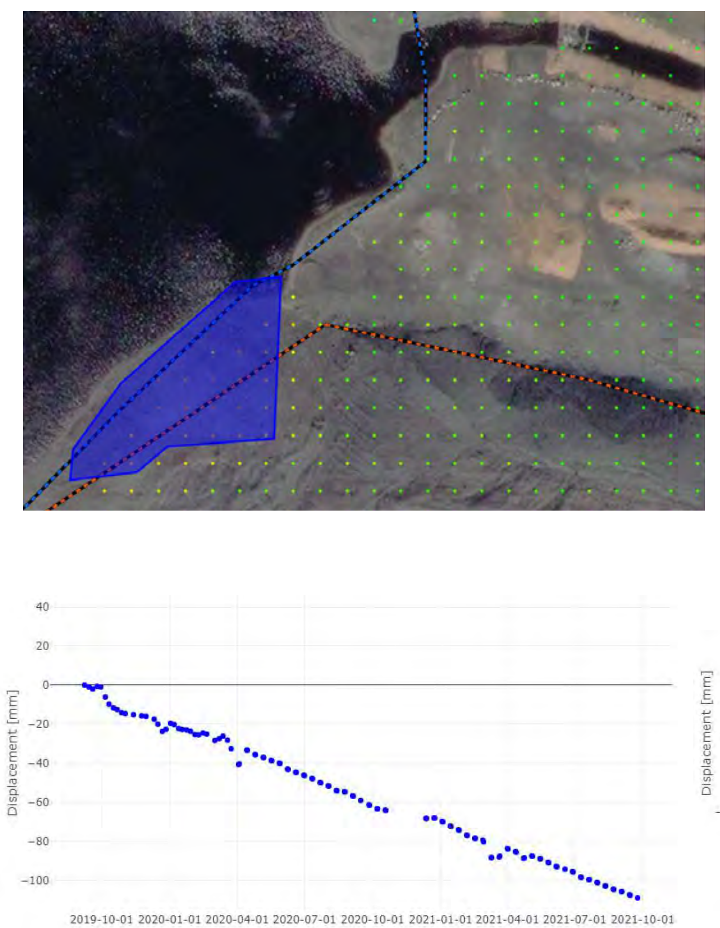
Figure 28



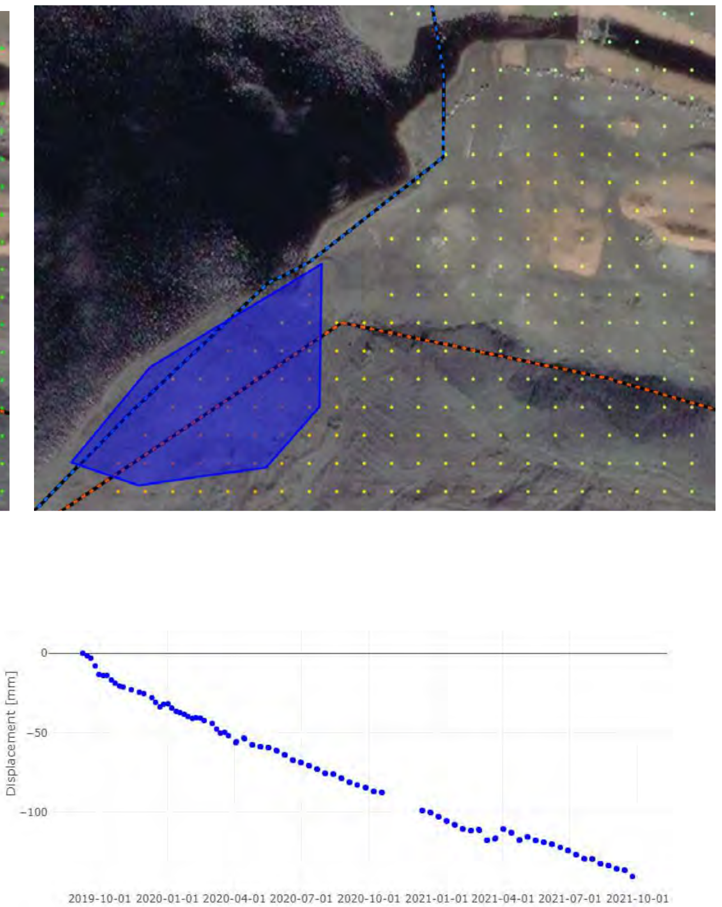
1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT



2-D EAST-WEST DISPLACEMENT



2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

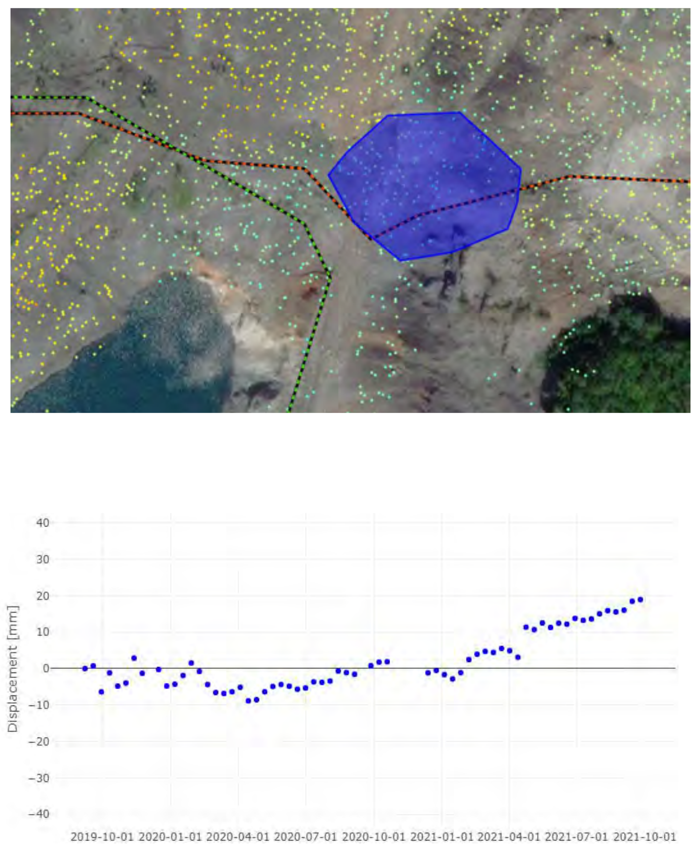
2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

CLINTON CREEK WASTE ROCK DUMP
UNIT 1 NORTHWEST LOCALIZED MOVEMENT
1-D AND 2-D SqueeSAR ANALYSIS

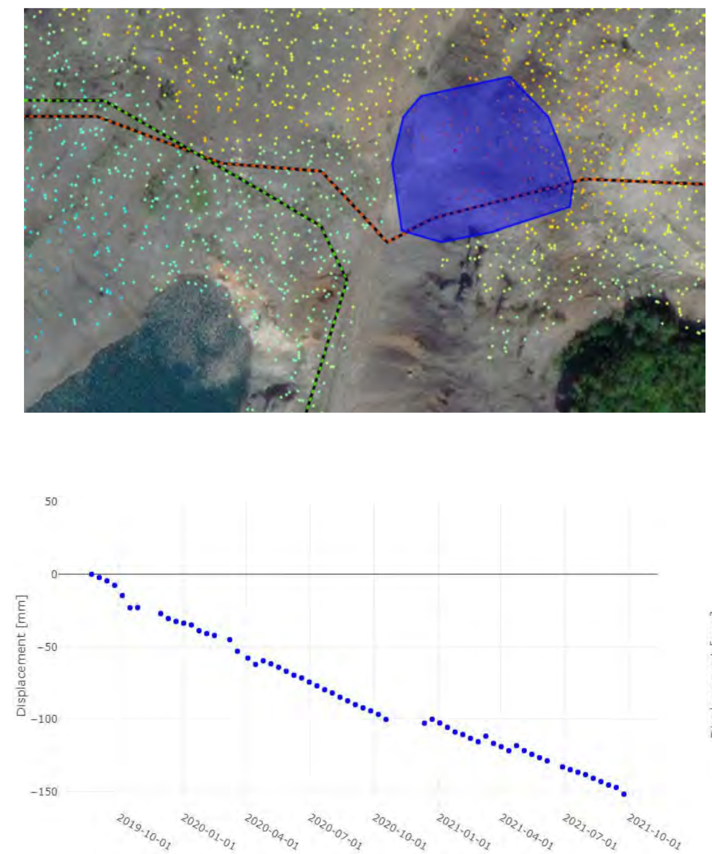
CLIENT
Yukon

TETRA TECH

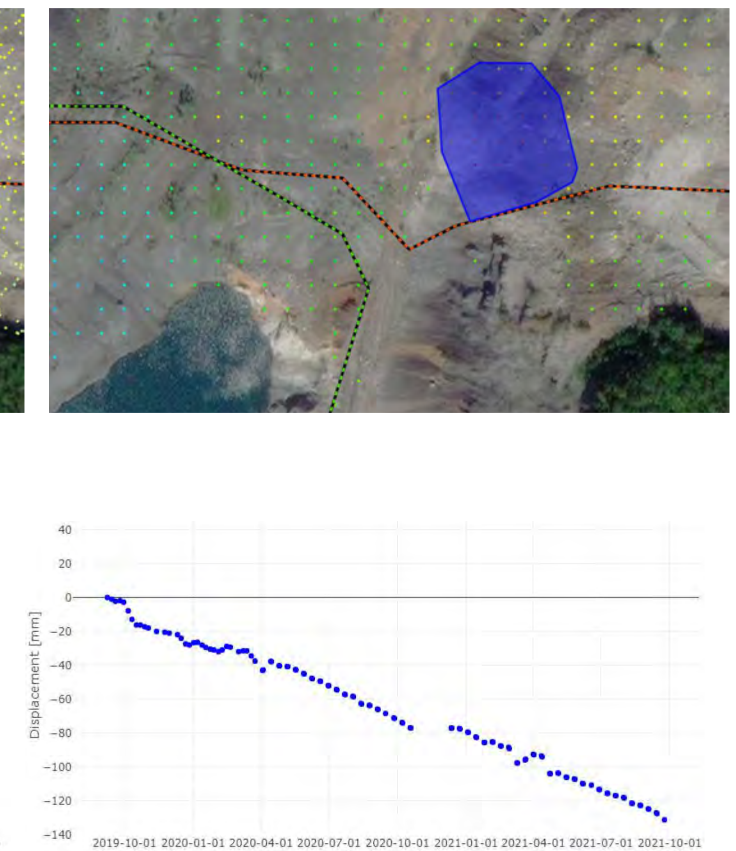
OFFICE	DWN	CKD	REV	
EBA-WHSE	SAM	AWW	0	**FIGURE 29**
DATE: JANUARY 10, 2022	PROJECT NO.: ENG.WARC03956-03			



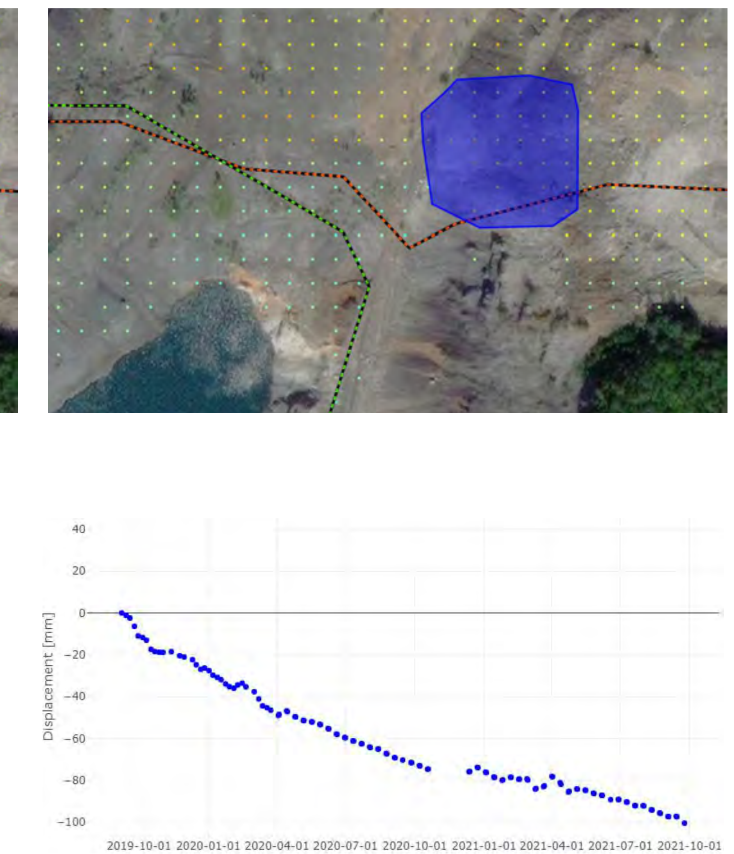
1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT



2-D EAST-WEST DISPLACEMENT



2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

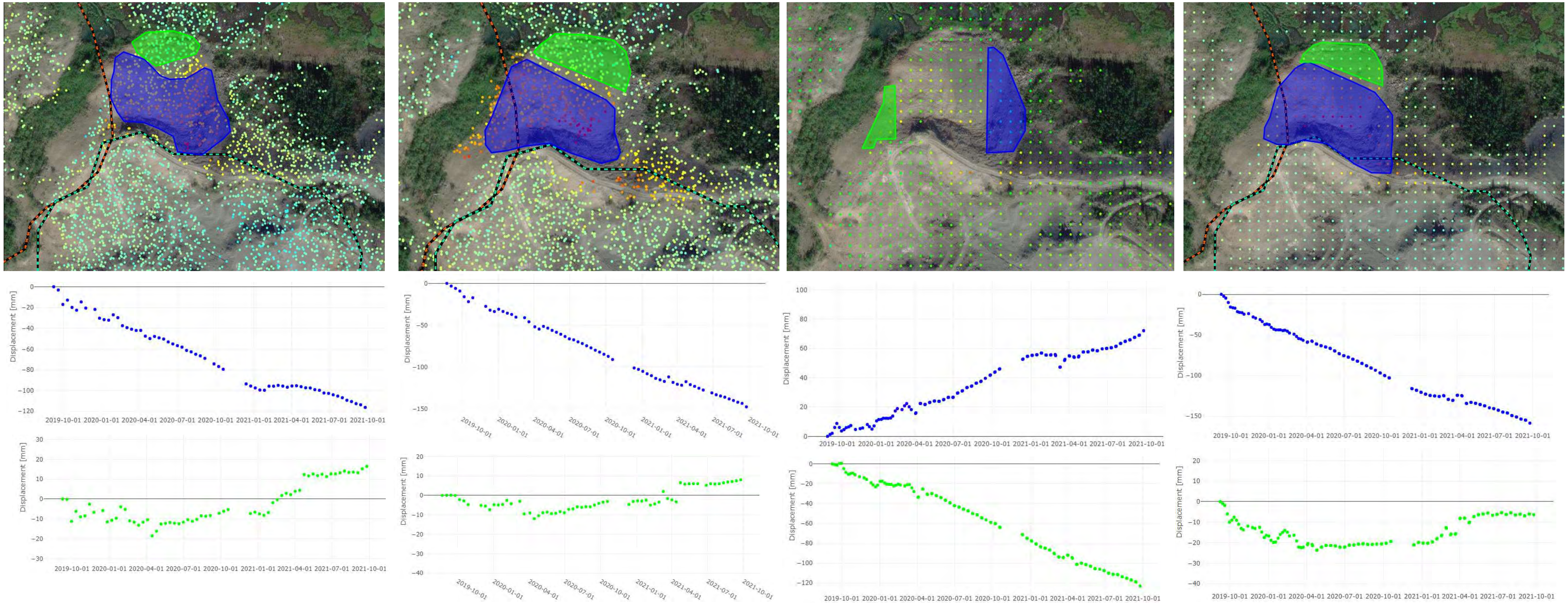
CLINTON CREEK WASTE ROCK DUMP
UNIT 2 LOCALIZED MOVEMENT NEAR PORCUPINE PIT
1-D AND 2-D SqueeSAR ANALYSIS

CLIENT
Yukon

TETRA TECH

OFFICE		DWN	CKD	REV
EBA-WHSE		SAM	AWW	0
DATE	PROJECT NO.			
JANUARY 10, 2022	ENG.WARC03956-03			

FIGURE 30



1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT

1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT

2-D EAST-WEST DISPLACEMENT

2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK
- TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

CLINTON CREEK WASTE ROCK DUMP
UNIT 4 LOCALIZED MOVEMENT
1-D AND 2-D SqueeSAR ANALYSIS

CLIENT: Yukon

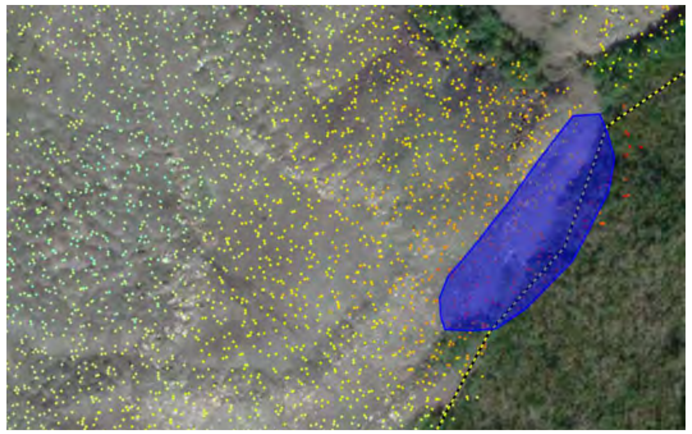
TETRA TECH

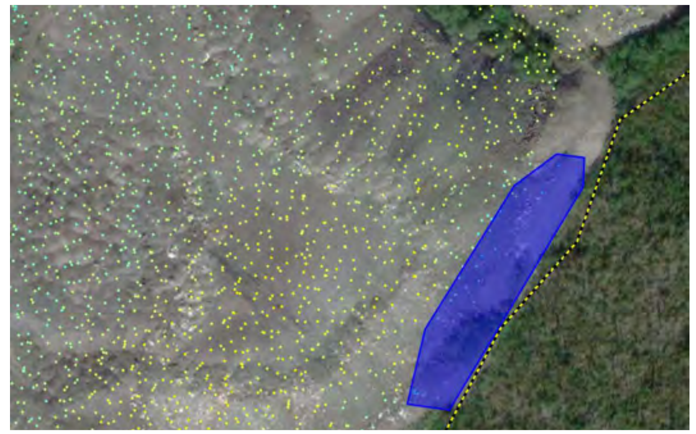
OFFICE	DWN	CKD	REV
EBA-WHSE	SAM	AWW	0

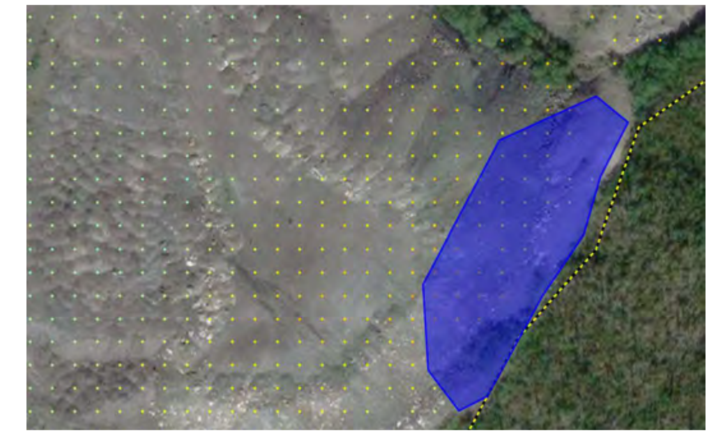
DATE	PROJECT NO.
JANUARY 10, 2022	ENG.WARC03956-03

STATUS: ISSUED FOR REVIEW

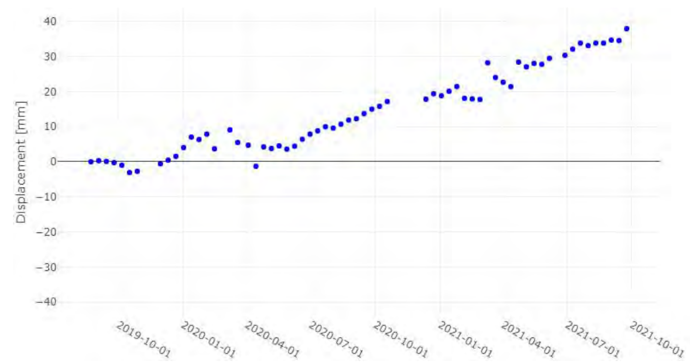
FIGURE 31





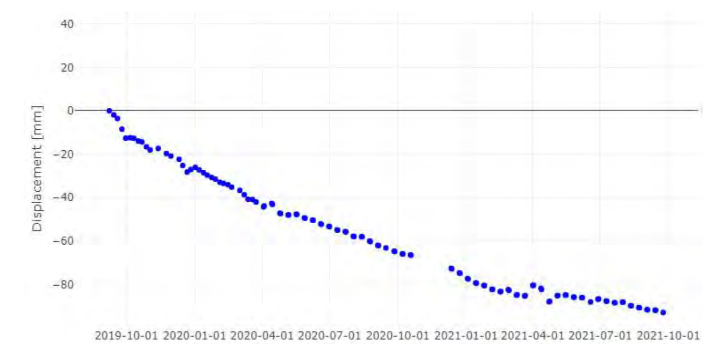


1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT

2-D EAST-WEST DISPLACEMENT



2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

PORCUPINE CREEK WASTE ROCK DUMP
EAST TOE LOCALIZED MOVEMENT
1-D AND 2-D SqueeSAR ANALYSIS

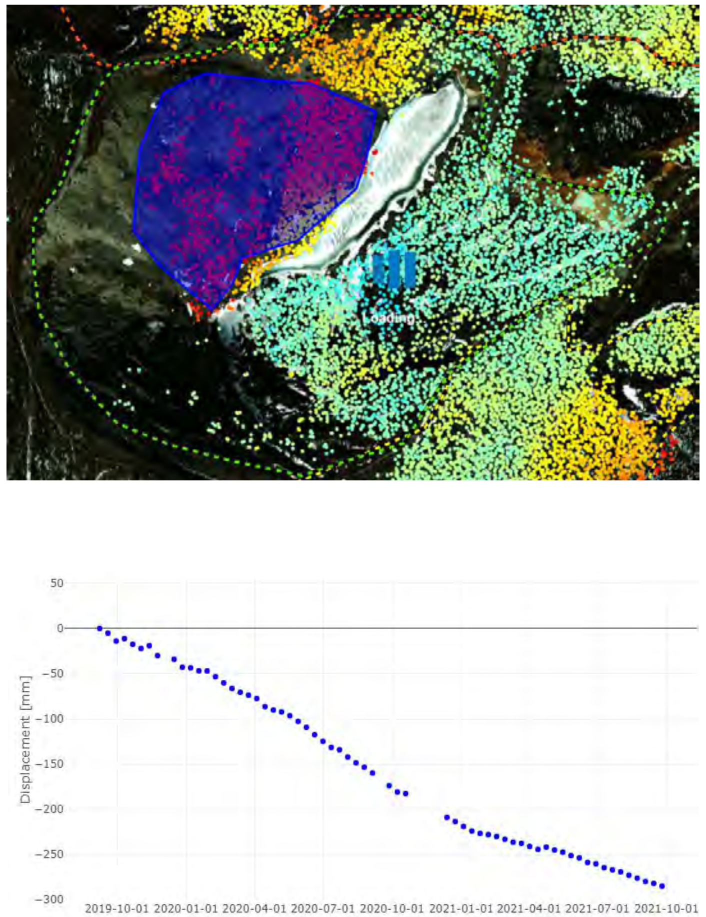
CLIENT
Yukon

TETRA TECH

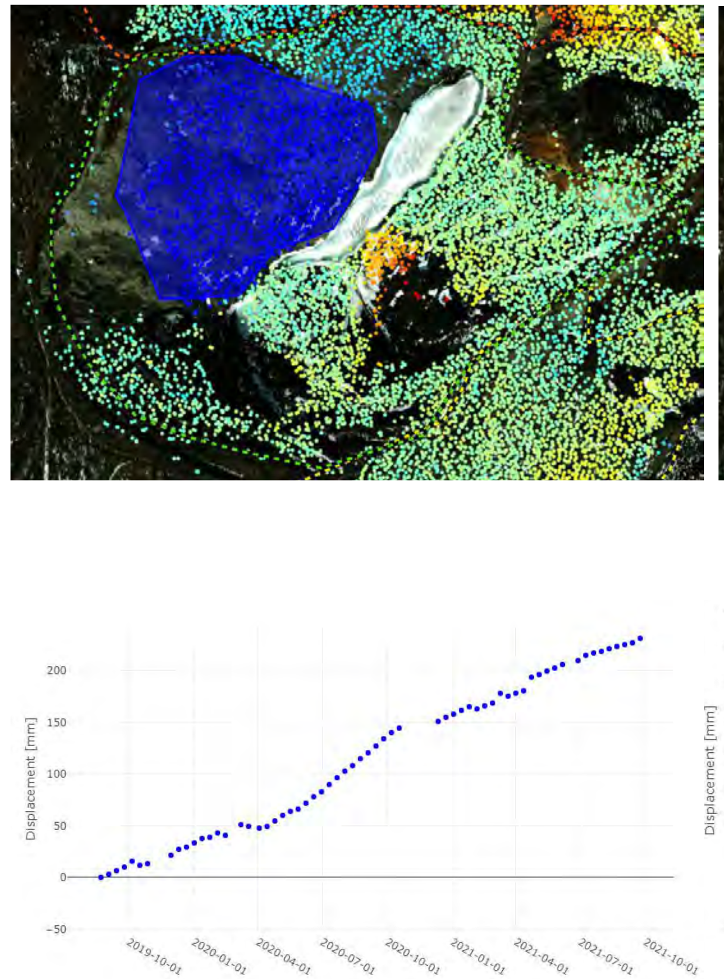
OFFICE	DWN	CKD	REV
EBA-WHSE	SAM	AWW	0

DATE	PROJECT NO.
JANUARY 10, 2022	ENG.WARC03956-03

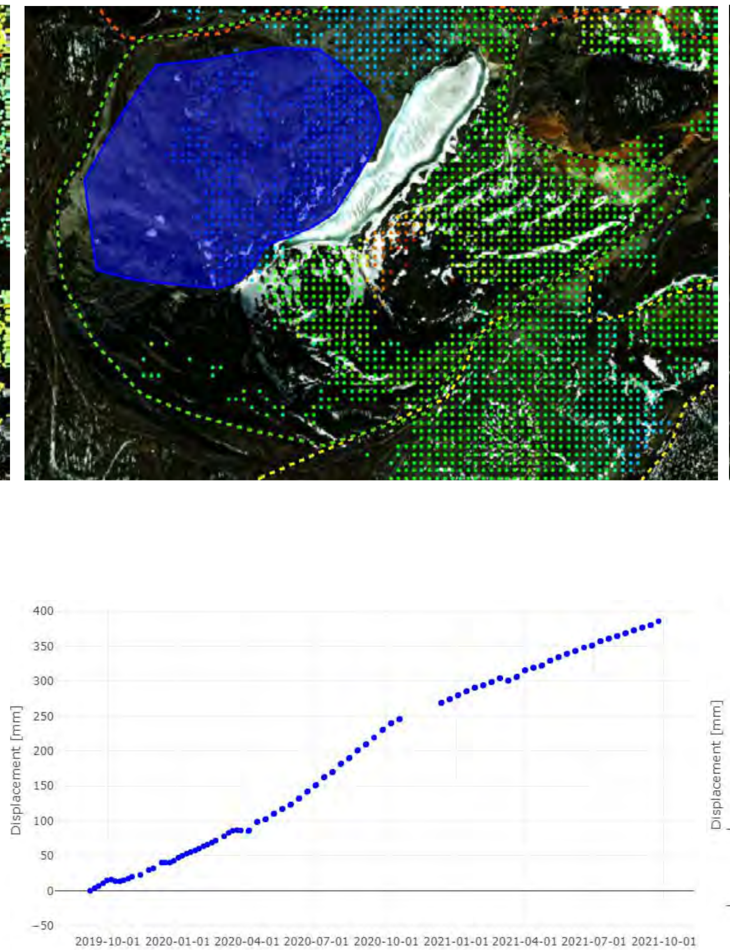
FIGURE 32



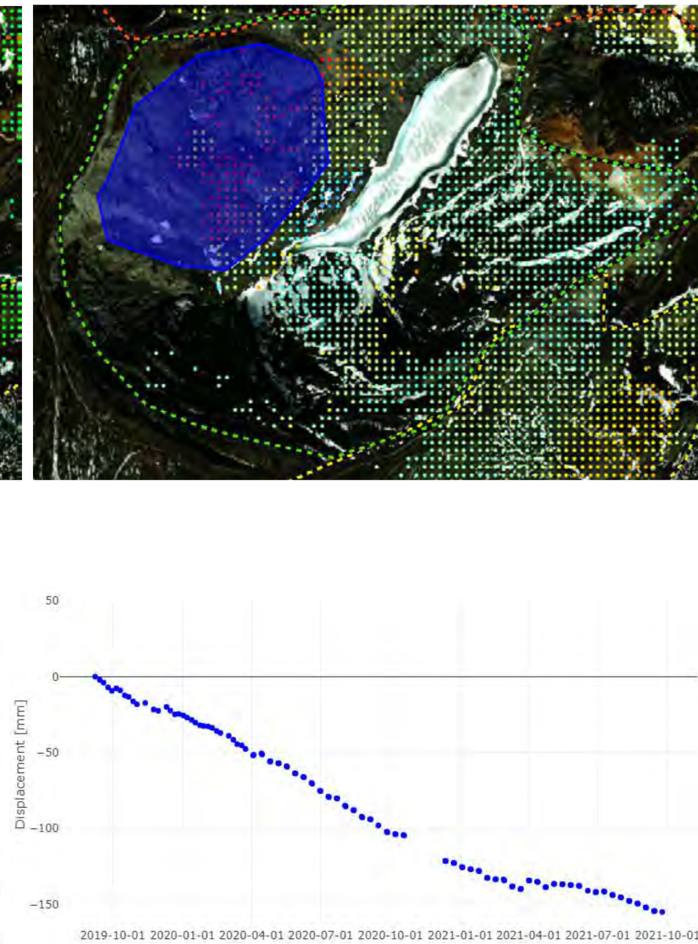
1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT



2-D EAST-WEST DISPLACEMENT



2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

PORCUPINE PIT
NORTHWEST SLOPE DISPLACEMENT
1-D AND 2-D SqueeSAR ANALYSIS

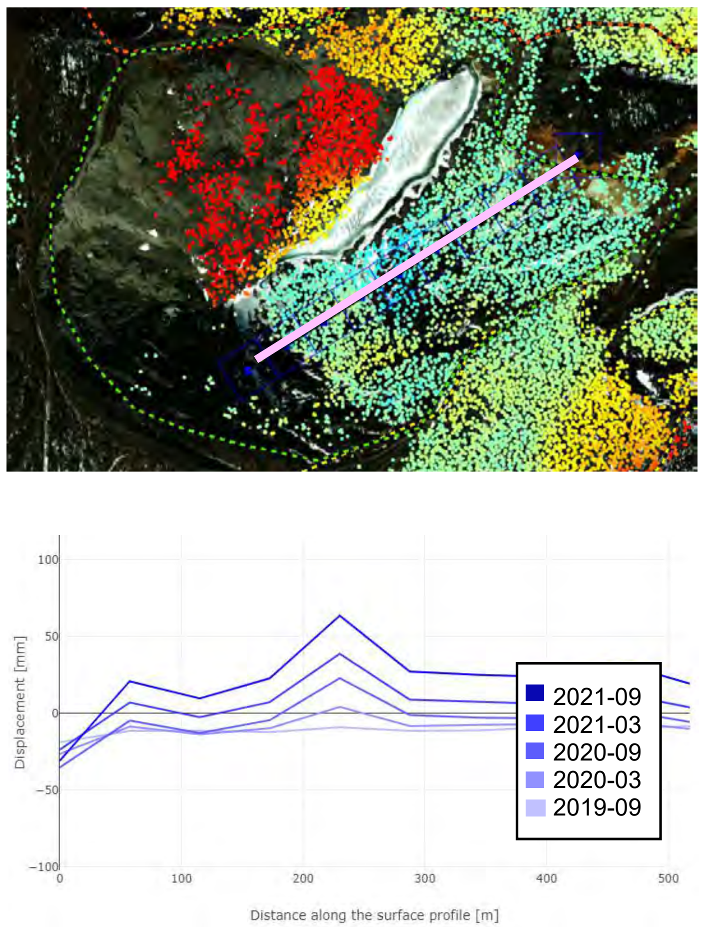
CLIENT
Yukon

TETRA TECH

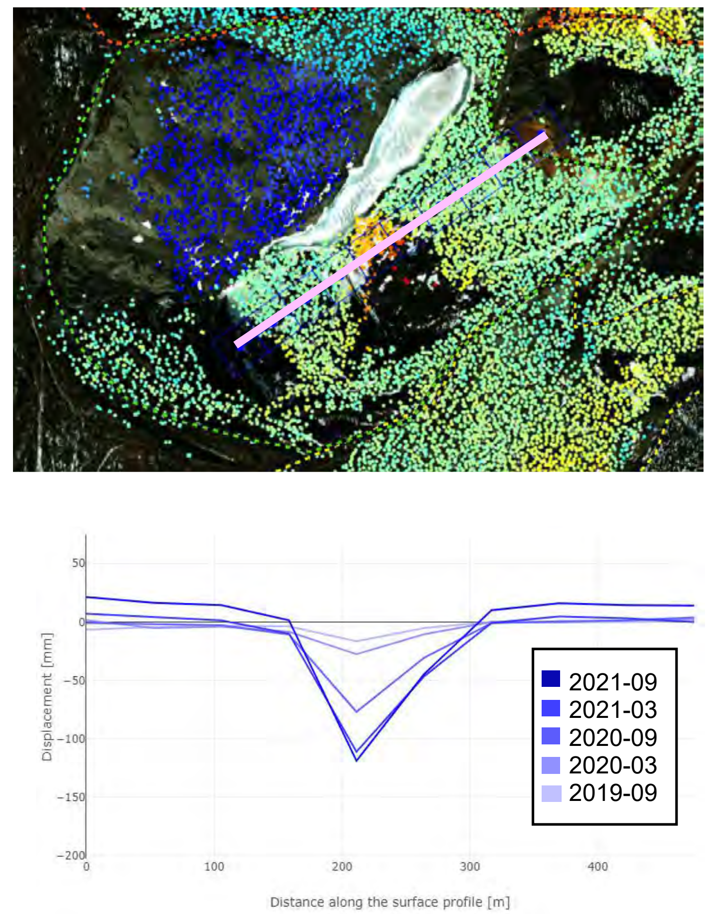
OFFICE	DWN	CKD	REV
EBA-WHSE	SAM	AWW	0

DATE	PROJECT NO.
JANUARY 10, 2022	ENG.WARC03956-03

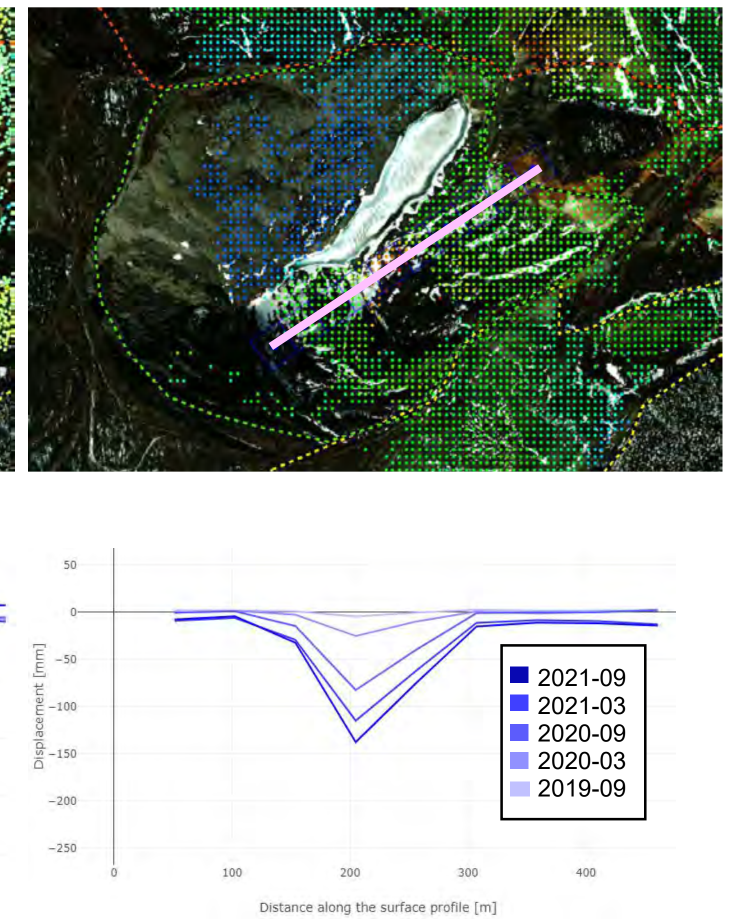
FIGURE 33



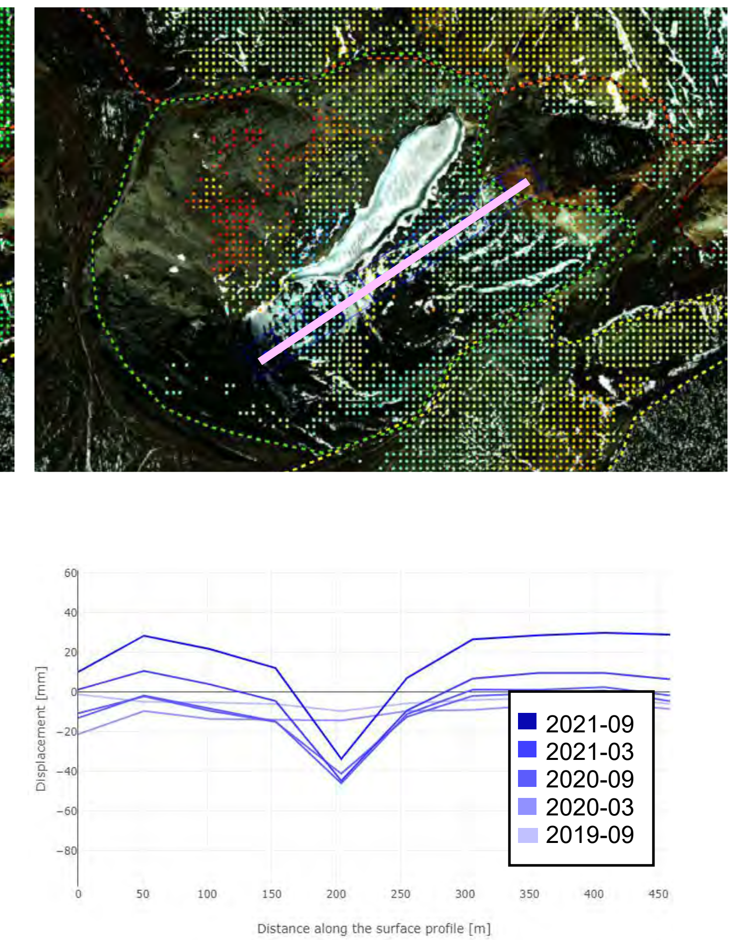
1-D LINE OF SIGHT DISPLACEMENT ALONG PROFILE, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT ALONG PROFILE, DESCENDING ORBIT



2-D EAST-WEST DISPLACEMENT ALONG PROFILE



2-D VERTICAL DISPLACEMENT ALONG PROFILE

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

PORCUPINE PIT
SOUTHEAST SLOPE DISPLACEMENT PROFILE
1-D AND 2-D SqueeSAR ANALYSIS

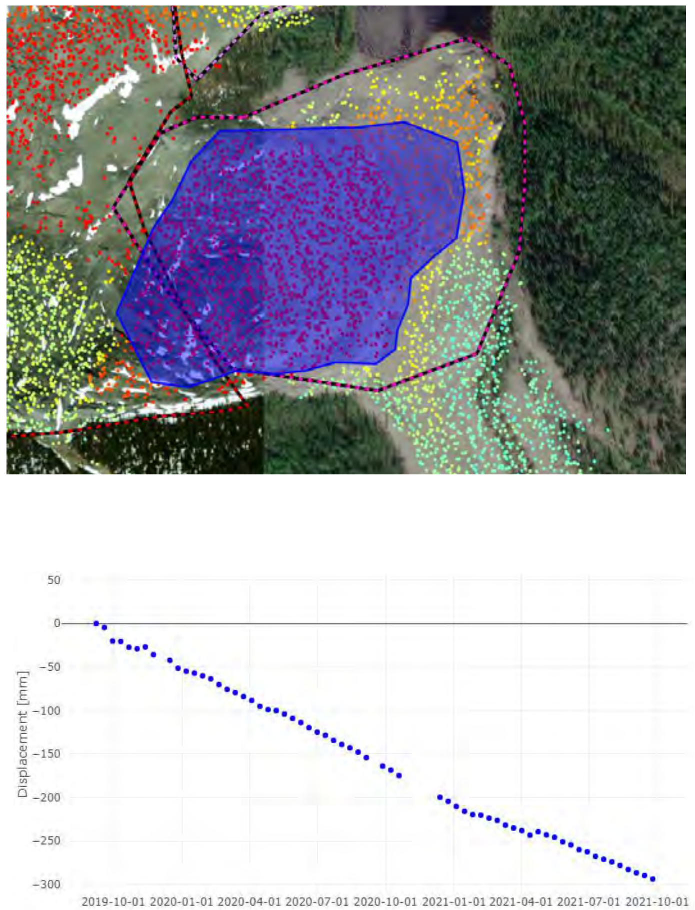
CLIENT
Yukon

TETRA TECH

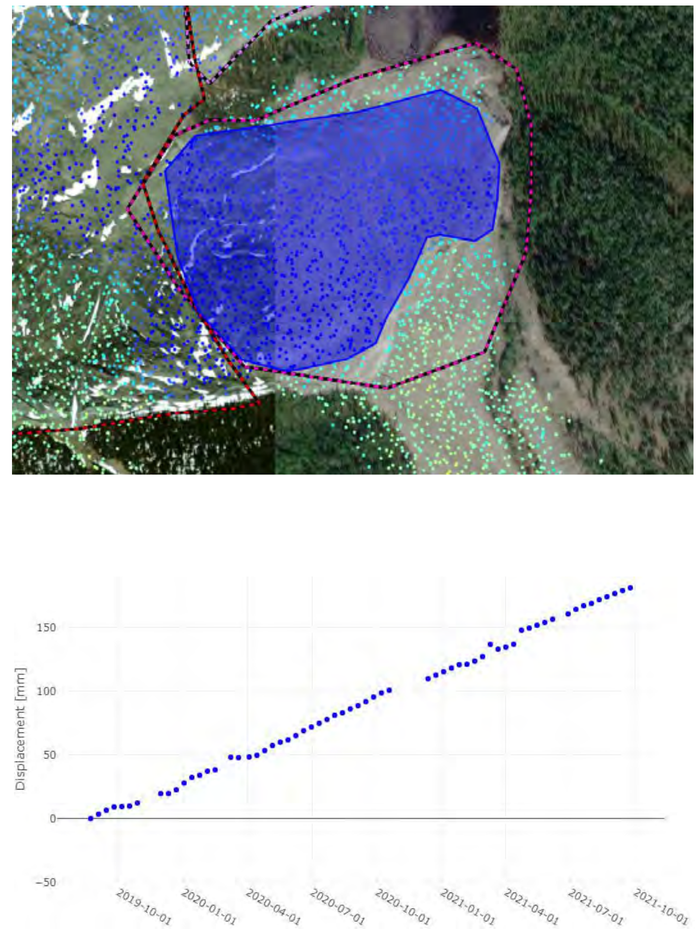
OFFICE	DWN	CKD	REV
EBA-WHSE	SAM	AWW	0

DATE	PROJECT NO.
JANUARY 10, 2022	ENG.WARC03956-03

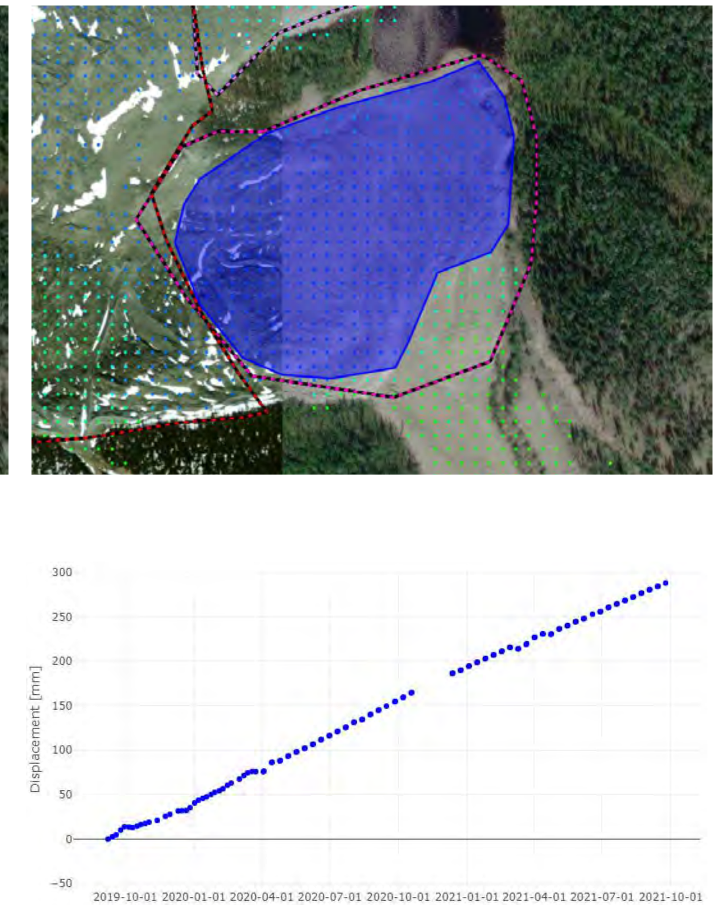
FIGURE 34



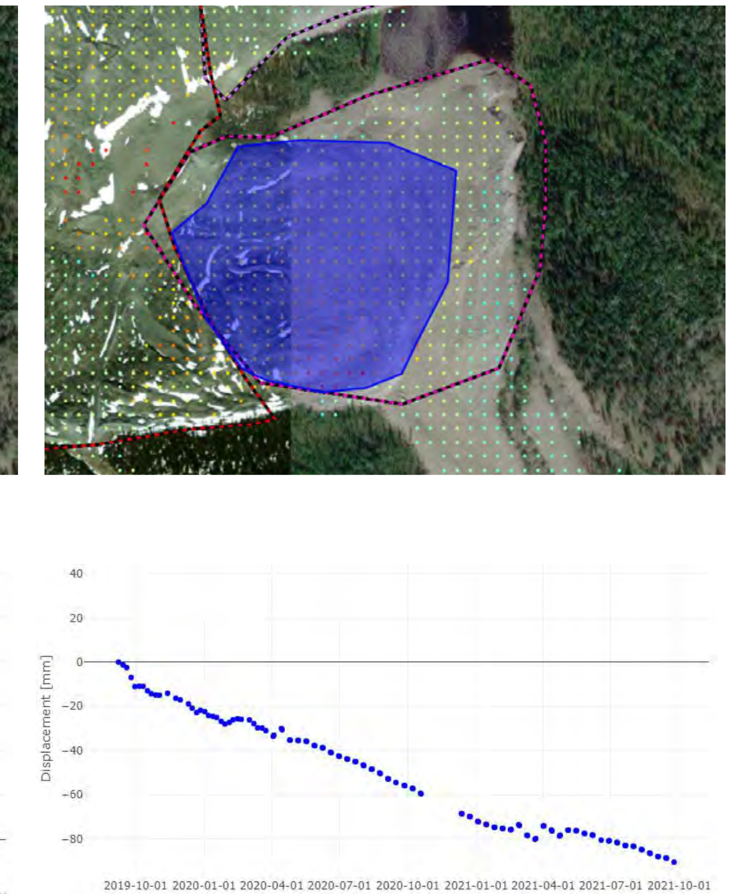
1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT



2-D EAST-WEST DISPLACEMENT



2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

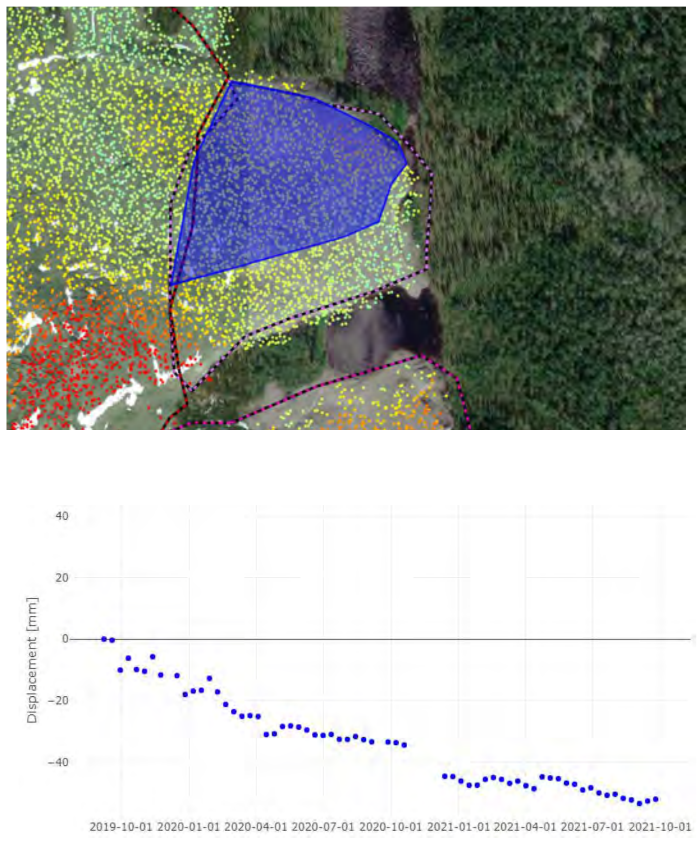
2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

WOLVERINE CREEK TAILINGS PILE
SOUTH LOBE TOE DISPLACEMENT
1-D AND 2-D SqueeSAR ANALYSIS

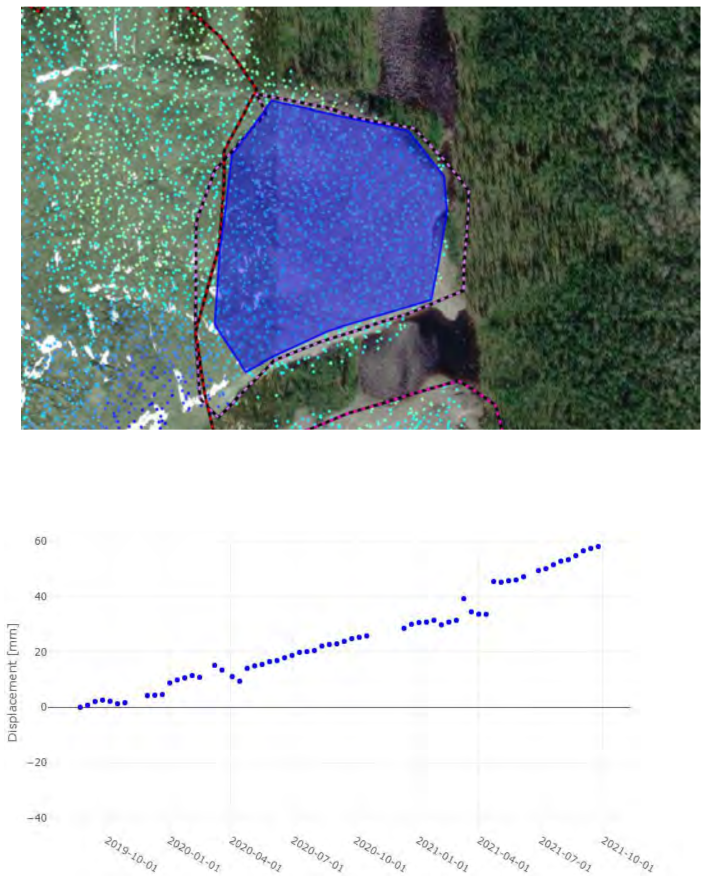
CLIENT
Yukon

TETRA TECH

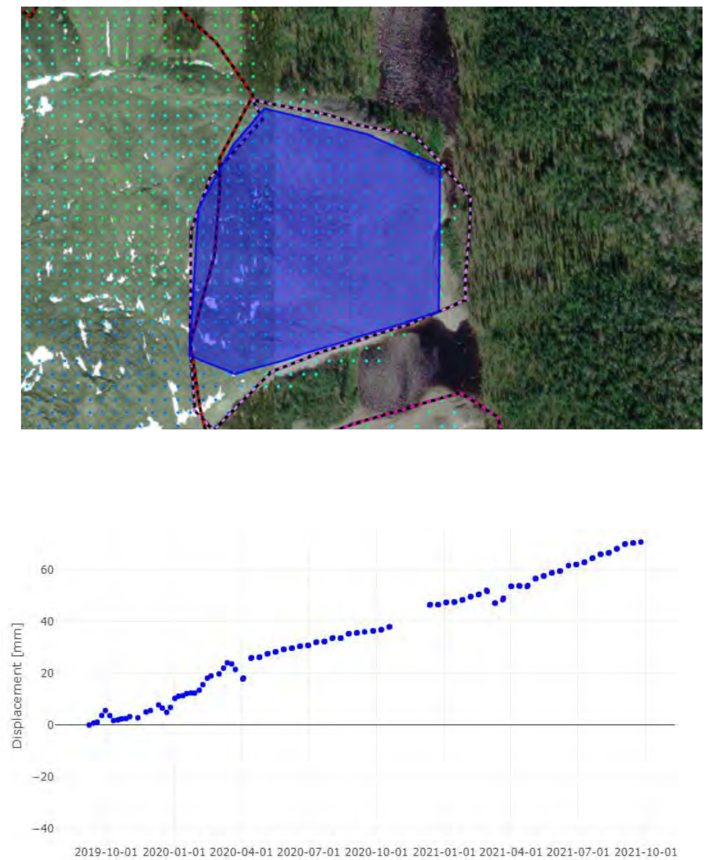
OFFICE	DWN	CKD	REV	
EBA-WHSE	SAM	AWW	0	**FIGURE 35**
DATE: JANUARY 10, 2022	PROJECT NO.: ENG.WARC03956-03			



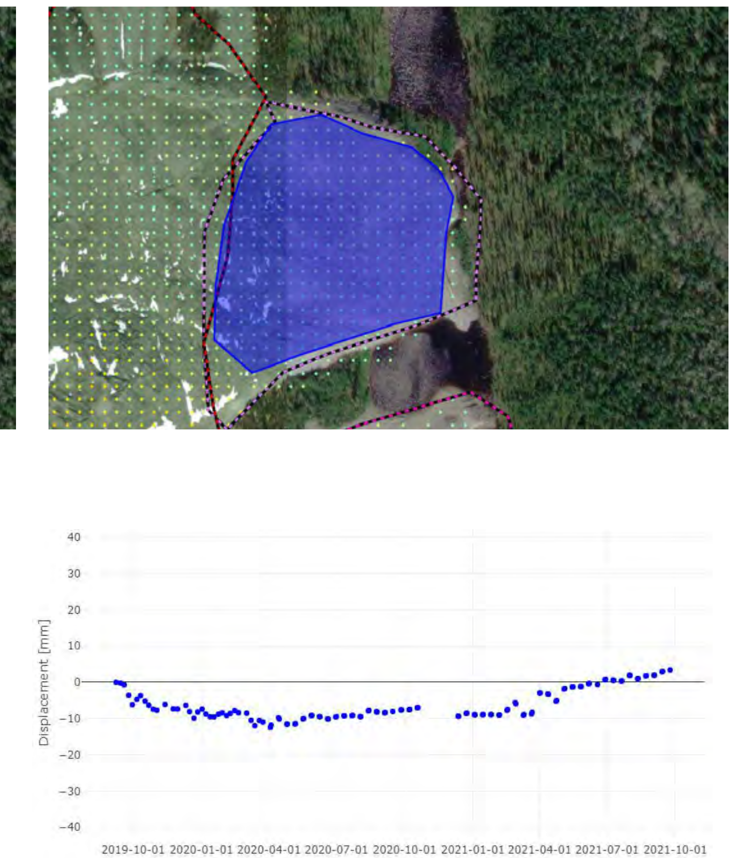
1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT



2-D EAST-WEST DISPLACEMENT



2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

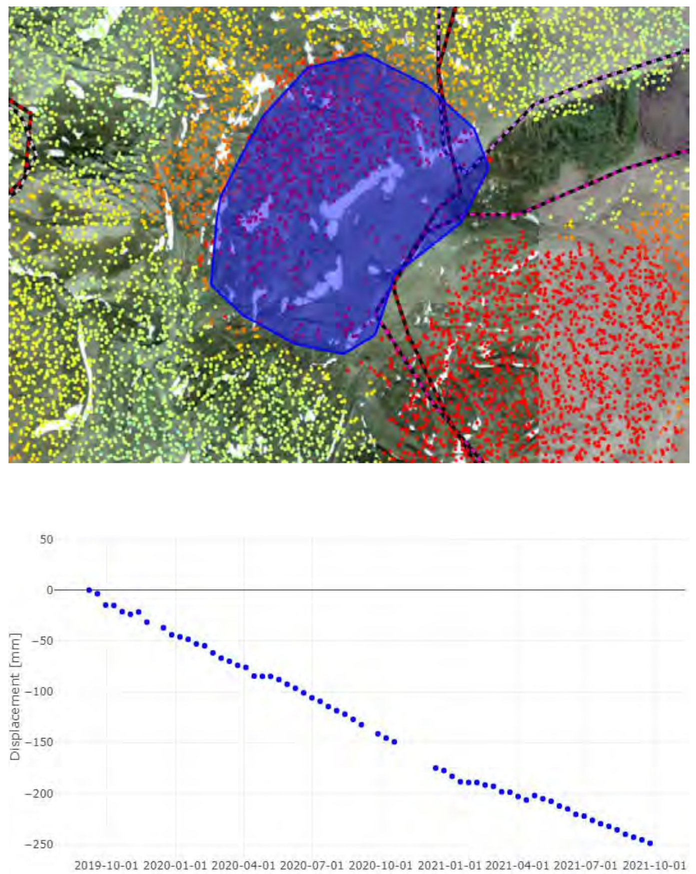
2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

WOLVERINE CREEK TAILINGS PILE
NORTH LOBE TOE DISPLACEMENT
1-D AND 2-D SqueeSAR ANALYSIS

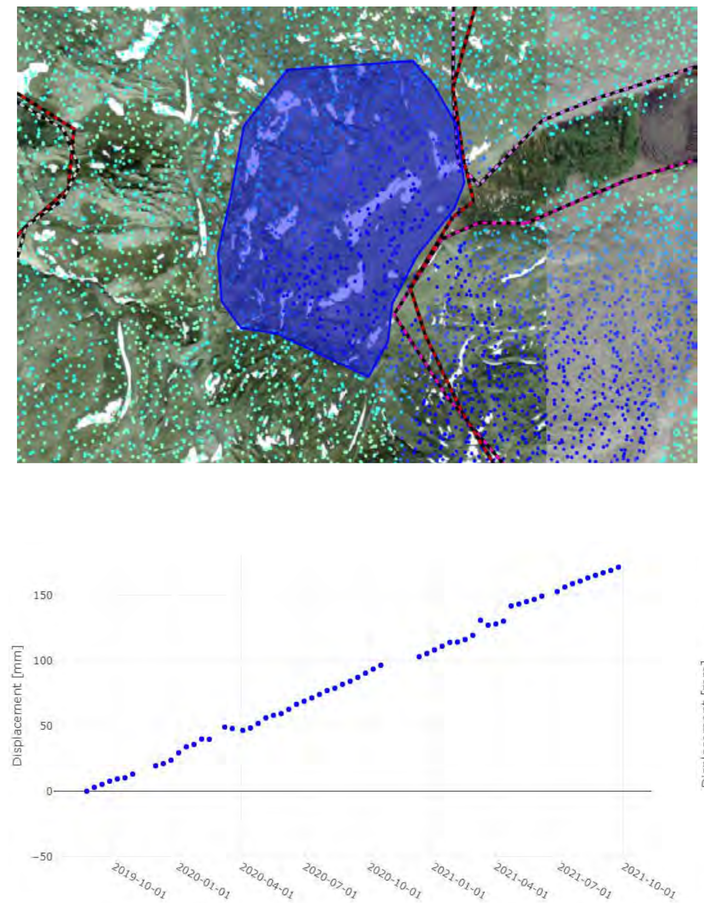
CLIENT
Yukon

TETRA TECH

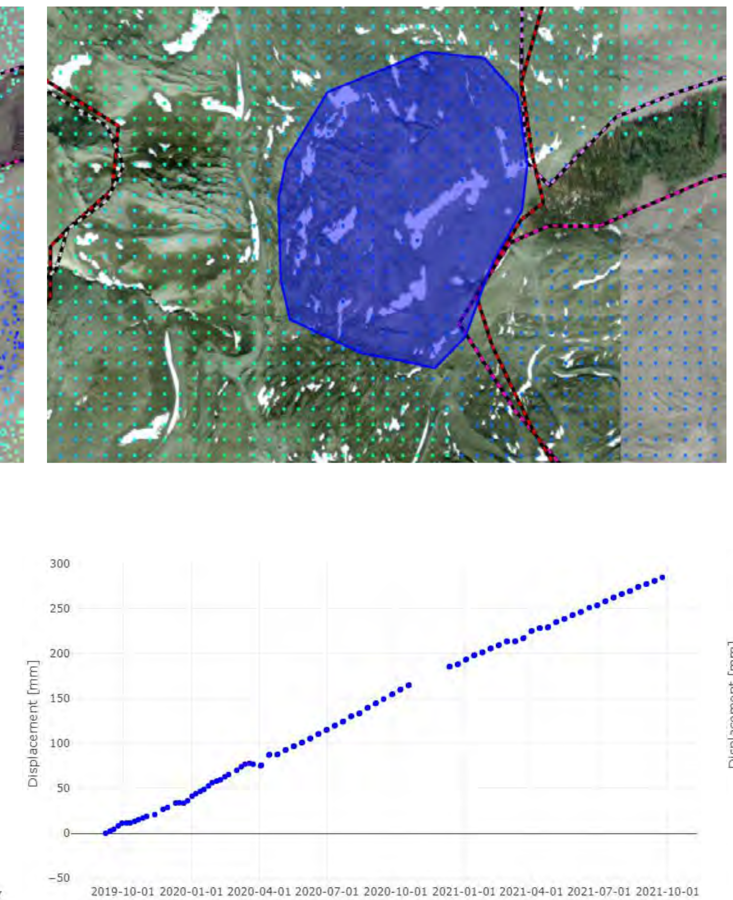
OFFICE	DWN	CKD	REV	
EBA-WHSE	SAM	AWW	0	FIGURE 36
DATE: JANUARY 10, 2022	PROJECT NO.: ENG.WARC03956-03			



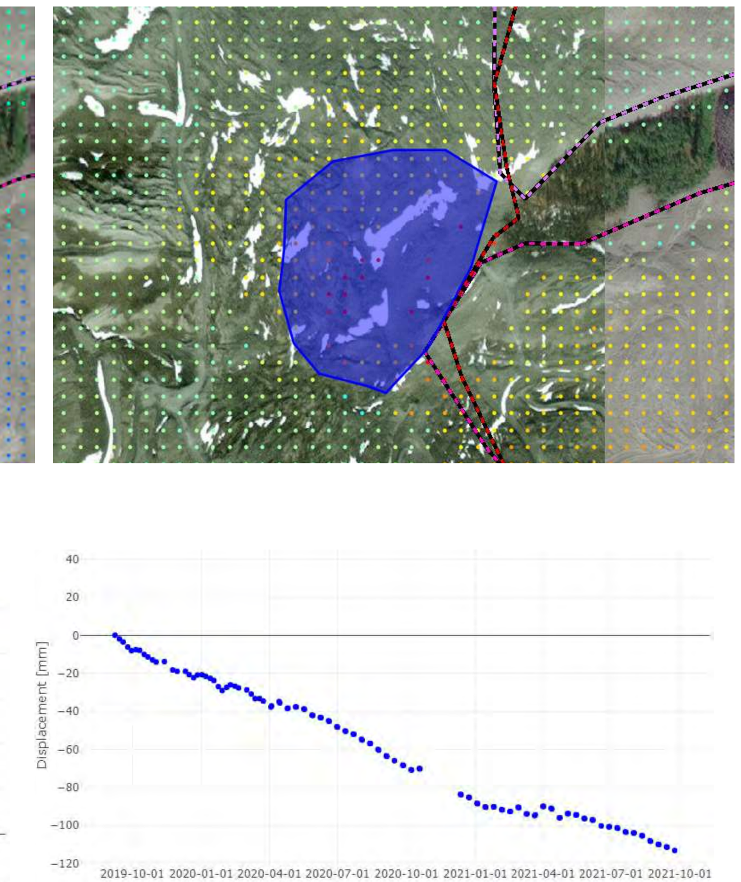
1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT



2-D EAST-WEST DISPLACEMENT



2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

WOLVERINE CREEK TAILINGS PILE
CENTRAL MID-SLOPE DISPLACEMENT
1-D AND 2-D SqueeSAR ANALYSIS

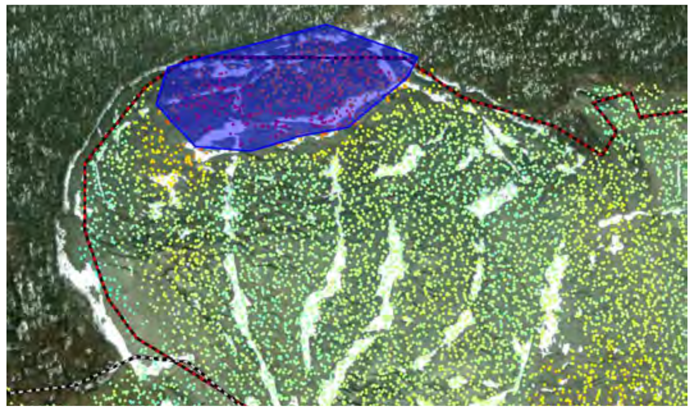
CLIENT
Yukon

TETRA TECH

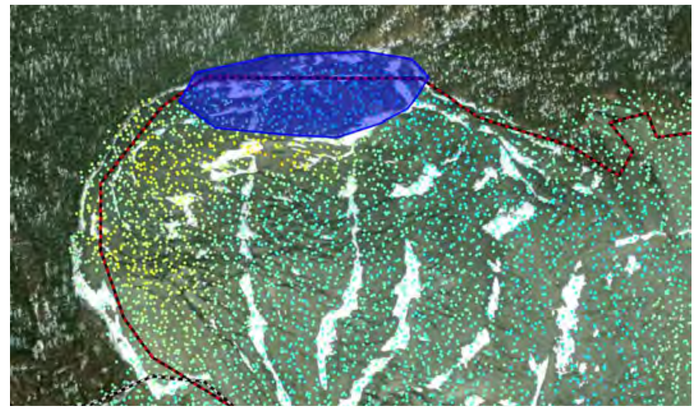
OFFICE	DWN	CKD	REV
EBA-WHSE	SAM	AWW	0

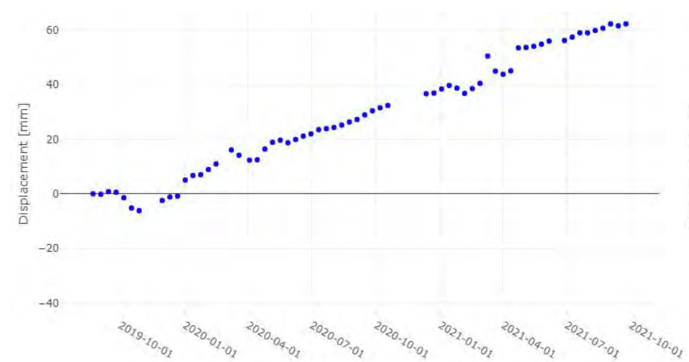
DATE	PROJECT NO.
JANUARY 10, 2022	ENG.WARC03956-03

FIGURE 37

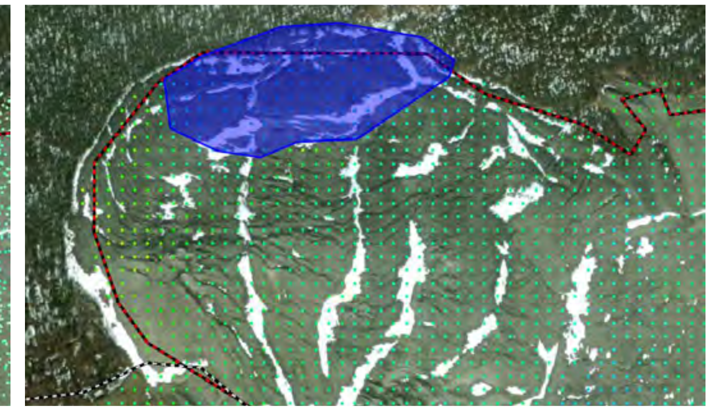


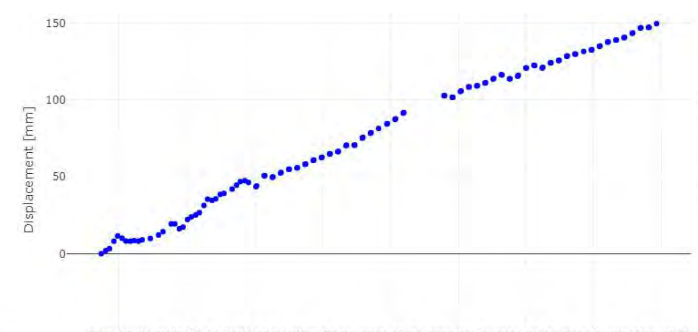
1-D LINE OF SIGHT DISPLACEMENT, ASCENDING ORBIT



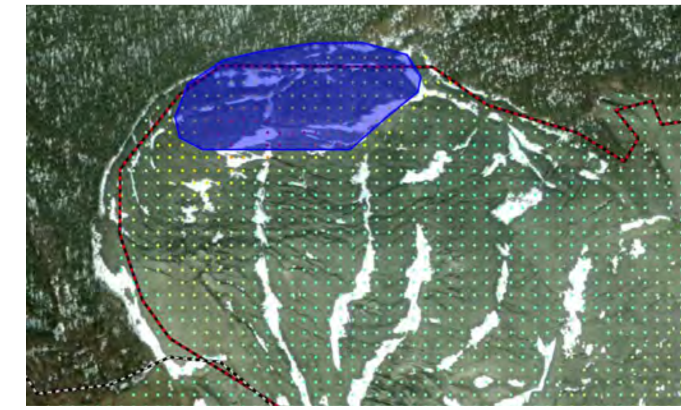


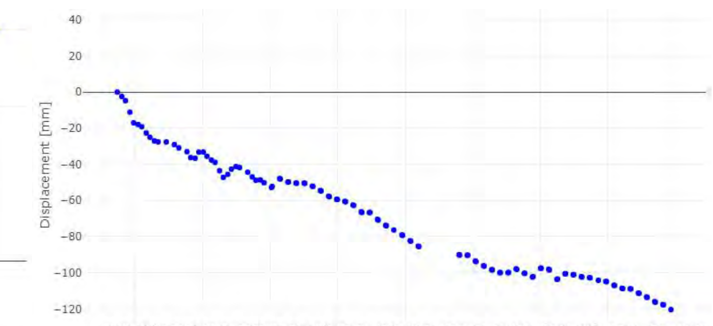
1-D LINE OF SIGHT DISPLACEMENT, DESCENDING ORBIT





2-D EAST-WEST DISPLACEMENT





2-D VERTICAL DISPLACEMENT

LEGEND

- CLINTON CREEK WASTE ROCK PILE
- CREEK PIT
- FORMER MILL SITE
- HUDGEON LAKE
- NORTH LOBE
- PORCUPINE PIT
- PORCUPINE WASTE ROCK PILE
- SNOWSHOE PIT
- SOUTH LOBE
- WOLVERINE CREEK TAILINGS PILE

NOTES:

1. Positive values on 1-D Line of Sight Displacement plots indicate movement toward the satellite.
2. Positive values on 2-D East-West Displacement plots indicate movement to the east.
3. Positive values on 2-D Vertical Displacement plots indicate movement upward.

STATUS
ISSUED FOR REVIEW

2021 LONG TERM MONITORING PROGRAM
CLINTON CREEK MINE SITE, YUKON

WOLVERINE CREEK TAILINGS PILE
NORTHWEST LOBE TOE DISPLACEMENT
1-D AND 2-D SqueeSAR ANALYSIS

CLIENT
Yukon

TETRA TECH

OFFICE	DWN	CKD	REV	
EBA-WHSE	SAM	AWW	0	**FIGURE 38**
DATE: JANUARY 10, 2022	PROJECT NO.: ENG.WARC03956-03			

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – YUKON GOVERNMENT

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the use of TETRA TECH's Client, its officers, employees, agents, representatives, successors and assigns (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH. Any changes to the conclusions, opinions, and recommendations presented in TETRA TECH's Professional Document must be authorized by TETRA TECH.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems, as per agreed project deliverable formats. TETRA TECH makes no representation about the compatibility of these files with the Client's future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be brought to the attention of TETRA TECH within a reasonable time.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, and subject to the standard of care herein, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage, except where TETRA TECH has subcontracted for such information.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to make, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the Client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.8 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.9 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.10 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.11 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.12 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.13 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.14 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.15 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.16 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.17 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.18 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.19 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

GEOTECHNICAL SITE INSPECTION MEMORANDUM

TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Alex Machica, Project Manager	**Date:**	August 2, 2021
c:	Carrie Gillis, Senior Project Manager	**Memo No.:**	001
From:	Shawn Matthies, EIT	**File:**	704-ENG.WARC03956-03
Subject:	Geotechnical Site Inspection Memorandum 2021 Long-Term Performance Monitoring Program – Clinton Creek Mine, Yukon		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Government of Yukon Department of Energy, Mines, and Resources, Assessment and Abandoned Mines Branch (YG-AAM) to carry out the 2021 Long-Term Performance Monitoring Program (LTPMP) at the abandoned Clinton Creek Mine, located near Dawson City, Yukon.

This report describes the observations from Tetra Tech's 2021 geotechnical site inspection completed as a part of the LTPMP as well as associated recommendations for remedial action. These observations will be evaluated alongside the results of other site monitoring activities as a part of the annual LTPMP report for 2021.

2.0 PROJECT DESCRIPTION

The Clinton Creek Mine is a former asbestos mine that was in operation between 1968 and 1978. The mine is located about 100 km northwest of Dawson City, Yukon, and is accessed (in the summer) via the Top of the World Highway and the Clinton Creek Road. The mine was abandoned following the closure of mining operations, and several ongoing issues exist with respect to site safety, maintenance, geotechnical stability, and environmental care.

As a part of YG-AAM's program to monitor and address these issues, Tetra Tech has completed the Clinton Creek Mine LTPMP for the past four years. One element of this LTPMP is a site visit to carry out a visual geotechnical assessment of various site components.

The geotechnical site inspection was completed on June 15 and 16, 2021 by Adam Wallace and Shawn Matthies from Tetra Tech's Whitehorse office. Alex Machica and Carrie Gillis of YG-AAM were present for the first day of the inspection on June 15.

The following site components were assessed during the inspection:

- The site access road, divided into the following sections:
  - The Top of the World Highway to Forty Mile River;
  - Forty Mile River to the Clinton Creek site access gate;
  - Clinton Creek site access gate to the former mill site;
  - The closed portion of the access road; and
  - Ford Crossings No. 1 and No. 2, near the site access gate and the Hudgeon Lake outlet, respectively.

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61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

- The Hudgeon Lake outlet and log boom abutments;
- The gabion drop structures;
- The Clinton Creek channel and natural slopes;
- The Clinton Creek waste rock dump and surrounding natural slopes;
- The Porcupine Creek waste rock dump;
- The Porcupine Pit;
- The Snowshoe and Creek Pits;
- The Wolverine Creek channel and natural slopes;
- The Wolverine Creek tailings piles and surrounding natural slopes; and
- The Wolverine Creek ponds.

3.0 SITE OBSERVATIONS

Tetra Tech's observations from the site inspection are summarized in the following sections. Photos from the site inspection are attached to this report in the Photographs section.

3.1 Site Access Road

The site access road is in generally good condition and repairs completed in recent years continue to perform well. Some areas show minor deterioration, erosion, or overgrown vegetation, but there are no significant barriers to site access, and the site is easily accessible in a pickup truck.

The site access road is generally inspected from the moving vehicle while traveling to and from the site, with stops to observe areas of interest more closely on foot. Distance along the access road is estimated using the vehicle odometer, beginning at km 0 at the junction from the Top of the World Highway to the Clinton Creek Access Road. It is acknowledged that features along the highway are often referenced at slightly different locations from year to year, likely due to the limited accuracy of odometers on most vehicles (typ. +/-10%). Therefore, mileage references along the access road should be considered to be approximate.

3.1.1 Top of the World Highway to Forty Mile Bridge

This section of the road is maintained by the Government of Yukon Department of Highways and Public Works and is in very good condition. The road surface appears to be regularly graded, with few potholes or other issues. The sections of surfacing gravel placed prior to Tetra Tech's 2020 geotechnical site visit are still visible, and no other sections appear to need resurfacing.

3.1.2 Forty Mile Bridge to Site Access Gate

This section of the road is in good condition. We understand that this section of the road is maintained by Highways and Public Works up to about km 35. Repairs completed in 2020 (e.g., gravel placed in eroded or wet sections) are holding up well, and the road is accessible to light vehicles. Some minor potholes and ruts are present but do not limit site accessibility. Some low-lying areas had standing water or saturated conditions at the surface, however the most significant wet areas noted in previous years are well covered by the gravel placed in 2020.

Trees overhang or lean toward the road in several places. Many of these trees are large enough to block the road when they eventually fall. A number of smaller trees have already fallen on the road; these trees are either small enough to drive over in a pickup or do not block the entire roadway, however they do limit safe two-way traffic on the road.

A landslide previously observed at about km 36.0 on the access road continues to show signs of slow, ongoing movement, however the slide is not impacting the road and no indications of imminent major movement were observed.

Typical road conditions in this section are shown in Photos 1 to 4. An aerial view of the landslide at about km 36.0 is shown in Photo 5.

3.1.3 Site Access Gate to Former Mill Site

The site access gate is intact and in good condition. Several boulders on the north side of the access gate have been moved to allow vehicles to bypass the gate and obtain unauthorized site access (see Photo 6). Tire tracks were visible on the ground around the gate. One boulder was moved directly in front of the Wolverine Creek overflow culvert inlet. A spare gate key that is normally hidden near the gate was missing, however we understand that the lock on the gate was replaced in Fall 2020. The Wolverine Creek road crossing, which was washed out during the spring 2020 freshet, is in good condition and there is no sign that water overtopped the road during the 2021 freshet (shown in Photo 7). Rutting increases somewhat upon entrance to the mine site however the road is still easily passable to light vehicles.

Some moderate surface erosion and rutting is present along the portion of the access road that traverses the waste rock dump, where surface water flows down the waste rock slopes and onto the road surface (see Photos 8 and 9). This erosion has created a number of small gullies on the waste rock slopes and the road surface (see Photos 10 and 11). There are also small erosion gullies along the Clinton Creek channel where water flows off of the road and spills into the creek channel (see Photo 12); this erosion is ongoing and will eventually impact the road alignment.

Between Ford Crossing No. 2 and the former mill site, the road becomes more rutted, gullied, and overgrown (see Photos 13 and 14). Many trees are overhanging or leaning toward the road. Several small fallen trees blocking the road were encountered and removed by hand by Tetra Tech personnel. The small gully on the downslope side of the road at about km 41.8 is still present (see Photo 15), however minimal new erosion was observed compared to the 2020 inspection and the eroded gully appears to be re-vegetating, which suggests that erosion is not ongoing. This section of the road is in fair condition, and is passable in a pickup truck, however very wet conditions or large trees falling (see Photo 16) may limit access in this section of the access road.

3.1.4 Closed Section of Site Access Road

The closed section of the site access road experienced major erosion and embankment loss during the spring freshet in 2020. Comparatively little new movement was observed during this year’s site inspection (see Photo 17), and no additional survey pins were lost from the monitoring baseline (four pins fell into the Clinton Creek channel due to erosion in 2020). Some minor new tension cracking was observed (see Photos 18 and 19). A shallow erosion gully on the upslope side of the road continues to function as a ditch to collect and divert surface water to the east, onto the active access road (visible in Photos 18 and 20); tension cracks are spreading and may eventually intersect this gully, which would result in increased surface water flow and erosion over the edge of the embankment.

3.1.5 Ford Crossings

The ford crossings are in very good condition compared to previous years (see Photos 21 and 22). Both crossings were easily passable in a vehicle with moderate clearance, such as a light pickup truck. Ford crossing approaches were previously very steep, however repairs completed in 2020 have established a gentler grade and are holding up well. Staff gauges indicated a water depth of approximately 1 ft (0.3 m) at both crossings.

3.2 Hudgeon Lake Outlet

The Hudgeon Lake outlet was in similar condition to previous inspections. The outlet area was free of debris and water flow into the Clinton Creek channel was gentle and unobstructed. The log booms were not installed. Minor tension cracking was visible along the banks of the outlet area and near the log boom abutments, however no significant changes were noted from previous years.

As in previous years, the log boom abutments show signs of ongoing upward movement, presumably due to frost jacking. The north log boom abutment shows an approximately 3° tilt toward the water, which may be a result of more severe jacking of two rear abutment posts that are set back from the lake. The wooden backing on the abutments are not fixed to the steel frames and the embedment depth is shallow enough that some boards can be pulled out of the ground by hand. Tetra Tech has completed a detailed assessment of the log boom abutments for the 2021 LTPMP, which will be presented in a separate technical memorandum.

The log boom abutments are shown in Photos 23 to 28.

3.3 Gabion Drop Structures

The gabion drop structures (DS1 to DS4) are in generally fair condition and appear to have performed adequately during the 2021 spring freshet without sustaining any substantial erosion or damage. Some small sticks and debris were observed and removed from the gabion baskets by hand. No large logs or other debris were observed lodged in the gabion baskets.

Minor tension cracking exists on the north bank near DS1, and significant cracking and erosion are ongoing on the south bank near DS2. This condition has been noted in previous inspections and is not believed to signify any new or significant movement. Minor tension cracking was also observed on the south bank near DS3. Several gabion baskets have experienced significant erosion of undersized material from within the basket mesh, especially at DS3, which reduces the stability of the baskets and makes them more vulnerable to damage. Erosion of material from within the baskets is presumably ongoing, however the condition of the baskets appeared to be similar to that observed in the 2020 inspection.

Seepage from the waste rock pile persists on the south bank near DS4 above the abandoned articulated concrete block (ACB) mats. Some erosion from surface runoff is also ongoing in this area. The temporary repairs made to DS4 in 2018 and 2019 appear to be performing well. More gravel fill material has been eroded from the DS4 area and deposited in the stilling basin in the former ACB area, just downstream of DS4.

The drop structures are shown in Photos 29 to 40.

3.4 Clinton Creek Channel

No major changes to the Clinton Creek channel or surrounding natural slopes were noted compared to recent inspections. The creek continues to cut into the foliated bedrock and small blocks of rock topple into the creek channel. No significant channel migration or erosion was observed at the channel bottom on the south side of the channel where Clinton Creek erodes the toe of the waste rock pile.

Tetra Tech obtained aerial footage of the creek channel and natural slopes using a drone. This provided higher quality imagery and better access than can be obtained on foot; drones should be used in future inspections to monitor the condition of the creek channel.

The Clinton Creek channel is shown in Photos 41 and 42.

3.5 Clinton Creek Natural Slopes

Sloughing of surficial material on the north slopes is ongoing, and shallow slope movement is ongoing, which generally consists of rafts of roots, soil, and vegetation moving down the slope and ultimately toppling into the creek channel (see Photos 41, 42 and 43). Some of these rafts may partially block the creek channel, however none were observed that would be large enough to completely obstruct the channel, and none were in a position likely to impact the drop structures. A small (less than about 5 m^3) landslide near DS4 occurred, however the debris does not obstruct the stream channel (see Photo 44).

Cracking is visible on the natural slope above and just downstream from DS4, which has been noted in previous inspections (see Photo 45). No significant changes were noted in the visual inspection, although it is likely that slope movement is ongoing.

The trail that climbs the natural slope above the drop structure to access Wood's BH18-08 is in fair condition. Erosion gullies continue to develop on the trail, and a gully on the downslope side near the bottom of the road has increased in size since 2020 (visible in Photo 46). The erosion gully is not likely to impact the drop structures or the natural slope in the near future, however sediment could be washed into Clinton Creek and ongoing erosion may eventually destabilize the natural slope. Minor seepage was observed emerging from the upslope side of the trail (see Photo 47). There was no visible evidence of water spilling over the road and onto the underlying natural slope.

The area south of the trail and north of DS1 was observed to be dry, with desiccation cracking visible on the ground surface (visible in Photo 46). This area was wet during the 2020 inspection.

3.6 Clinton Creek Waste Rock Dump

No significant, recent movement was observed at the Clinton Creek waste rock dump. Surficial slumping, erosion, and gully formation has continued as in previous years; no new signs of deep movement or large tension cracks were seen during the visual inspection. The typical condition of the waste rock dump is illustrated in Photo 48.

Several gullies on the slope to the south of Ford Crossing No. 1 have continued to develop (examples visible in Photos 9 and 49). In one of these gullies, a section of culvert has become dislodged (see Photo 49). An additional length of culvert is protruding slightly from the back of the eroded gully. The location of the culvert inlet and the area that the culvert is intended to drain is unknown. The outlet of the culvert was dry at the time of the inspection.

No signs of instability were observed on the natural slopes adjacent to the waste rock dump.

3.7 Porcupine Creek Waste Rock Dump

The Porcupine Creek waste rock dump appeared to be largely unchanged compared to the 2020 inspection. The surrounding natural slopes appear to be generally stable, with no visible signs of distress or failure.

The water in the creek channel continues to flow toward the waste rock pile and seep through the base of the pile. Downstream seepage collects in a small pond just beyond the downstream toe of the waste rock pile, where it infiltrates and flows as groundwater before spilling into the pond near the base of the Creek and Snowshoe Pits.

The access trails leading to the various areas of the Porcupine Creek waste rock dump are becoming overgrown with vegetation. The trails remain accessible to passenger vehicles, but growth of woody vegetation will eventually limit access and/or damage vehicles.

The Porcupine Creek waste rock dump is shown in Photos 50 and 51.

3.8 Porcupine Pit

The Porcupine Pit was viewed from the lookout on the Clinton Creek waste rock dump near the north end of the pit and from the southeast rim of the pit near the Porcupine Creek waste rock dump.

Sloughing and raveling of surficial material is ongoing but no significant changes in condition were observed. The water level in the bottom of the pit appears to be similar to previous inspections.

The Porcupine Pit is shown in Photos 52 and 53.

3.9 Snowshoe and Creek Pits

The Snowshoe and Creek Pits were observed from the toe of the Porcupine waste rock dump and from the edge of the pond near the base of the pits. Road access to base of the Snowshoe Pit is blocked by a gravel berm. Weathering, erosion, and small rockfall events continue to occur in the Snowshoe and Creek Pits, however no significant changes in condition were observed. The pond near the base of the pits appears to be in similar condition to previous years.

The Snowshoe Pit is shown in Photo 54 and the Creek Pit and pond are shown in Photo 55.

3.10 Wolverine Creek Channel and Natural Slopes

The Wolverine Creek channel is in similar condition to previous years. The natural slopes to the east of the creek, opposite the tailings, show no signs of significant slope movement. Creep on the natural slope and erosion in the creek channel is ongoing, and material that enters the creek channel is being washed away by the creek before forming any significant obstructions in the channel (see Photo 56). There is some debris (logs, sticks, and brush) in the channel slightly downstream of the south pond (see Photo 57).

The rock-lined section of the Wolverine Creek Channel is in good condition, with no visible issues (see Photo 58).

The natural slopes in the downstream portion of Wolverine Creek show no signs of significant or new slope movement (see Photo 59).

Near the site access gate (see Photo 60), the meandering morphology of the creek channel is beginning to be re-established following the re-shaping of the creek channel during the 2020 access road repairs. As discussed in Section 3.1.3, the main culvert is unobstructed, but a boulder has fallen directly in front of the overflow culvert. The overflow culvert was dry at the time of the inspection but ripples on the ground suggest that water has flowed through the culvert since the 2020 repair work, presumably during the spring freshet in 2021. There was no visible evidence that water had overtopped the road since the repairs were done; it is likely that removal of vegetation near the inlet of the main culvert (during the 2020 road repairs) has improved the flow capacity of the culvert system passing under the road.

The access road to the west of the creek is in good condition and provides easy access on foot to the bottom of the tailings slopes. Boulders remain in place to block vehicle access to the Wolverine Creek channel and the bottom of the tailings pile.

3.11 Wolverine Creek Tailings Piles

The Wolverine Creek tailings piles show signs of ongoing creep, erosion, and gullying. Changes since the 2020 inspection are minor, and no significant new slope movement was observed. The typical condition of the tailings piles is illustrated is Photos 61 to 64.

The access trail that descends the tailings pile (established during the 2018 drilling program) was accessed using heavy duty, 4x4 pickup trucks to collect measurements from instrumentation installed on the tailings piles. The section of the trail that traverses mid-slope from the south to the north lobe (access to BH18-13) is beginning to show signs of slumping, probably at the cut/fill interface from trail construction; vehicle access along this trail may be impacted if slumping continues.

3.12 Wolverine Creek Ponds

The water level in the south pond appeared to be similar to previous years (see Photo 65), and the water level in the north pond was slightly higher than typical (see Photo 66).

Several new beaver dams were observed around the Wolverine Creek ponds. There is a significant dam (approx. 1 m high above downstream water level) at the outlet of the north pond (see Photo 67), which has resulted in the elevated water level in the pond, and a second, smaller dam approximately midway between the north and south ponds (see Photo 68). A third, partially breached dam is present at the outlet of the south pond (see Photo 69), which is partially obstructing flow at the outlet but does not appear to be affecting the water level in the pond.

4.0 RECOMMENDATIONS

Recommendations for remedial work based on the observations from the 2021 geotechnical site inspection, as well as relevant recommendations from previous inspections, are presented below in Table 1.

Table 1: Summary of Recommendations

Location	Date	Priority	Recommended Action	Status
Site Access Road	Ongoing	Medium	GENERAL: The road between the Top of the World Highway and Forty Mile Bridge should be maintained as required to allow vehicle and equipment access. We understand this section of the road is maintained by YG-HPW.	Ongoing
Site Access Road	Ongoing	Medium	GENERAL: The road between the Forty Mile Bridge and the former mill site should be maintained/repaired as needed to allow vehicle and equipment access.	Ongoing
Site Access Road	July 2021	Low	GENERAL: Mileage markers could be installed to estimate mileage/location more accurately along the access road.	New

Location	Date	Priority	Recommended Action	Status
Site Access Road	July 2019	High	Hydrotechnical studies done in 2020 suggest that the Wolverine Creek culverts near the site access gate are undersized. The culverts should be upgraded to handle design flows, or the area should be regularly monitored (especially at freshet) and damage repaired as needed to maintain site access.	Ongoing
Site Access Road	July 2021	Medium	The boulders near the site access gate intended to block unauthorized access should be replaced. Larger boulders or a fence should be installed to discourage future tampering.	New
Site Access Road	Ongoing	High	The closed section of the access road should remain closed.	Ongoing
Site Access Road	July 2021	Medium	The erosion gully along the closed portion of the access road should be improved to establish a ditch that will improve surface water runoff away from the slope crest and limit future erosion of the waste rock into the creek channel.	New
Site Access Road	July 2018	Low	A swale or berm should be installed around the top of the erosion gully on the road between Ford Crossing No. 2 and the former mill site (near km 41.8) to reduce the potential for future erosion.	Not Complete
Site Access Road	July 2020	Medium	The site access road between Ford Crossing No. 2 and the former mill site should be re-graded to repair erosion and gullying, and vegetation should be trimmed to maintain vehicle access.	Not Complete
~~Ford Crossing No. 1~~	~~July 2020~~	~~High~~	~~The erosion that occurred at Ford Crossing No. 1 during the spring freshet must be repaired to improve accessibility for light vehicles. Only heavy-duty pickup trucks or larger vehicles with high ground clearance should attempt to cross the ford until repairs are complete.~~	~~Complete~~
~~Ford Crossing No. 2~~	~~July 2019~~	~~Low~~	~~A new staff gauge could be installed at Ford Crossing No. 2 to allow the water depth to be checked before crossing.~~	~~Complete~~
Hudgeon Lake Outlet	Ongoing	Medium	The log booms should be installed when Hudgeon Lake is unfrozen, to reduce the amount of debris that enters the creek channel and the potential for debris causing damage to the drop structures.	Ongoing
Drop Structures 1, 2, and 3	Ongoing	Medium	Logs and other debris that become lodged in the drop structures should be removed to reduce the potential for damage to the gabion baskets.	Ongoing
Clinton Creek Natural Slope	July 2020	Medium	The access trail to BH18-08 that climbs the natural slope to the north of the drop structures should be decommissioned to restore natural drainage on the slope. Alternatively, a berm or ditch could be established to ensure that water collected along the trail is carried down the trail all the way to the base of the slope and is not allowed to spill onto the natural slope, which could cause slope failures.	Not Complete
~~Drop Structure 4~~	~~July 2019~~	~~High~~	~~Additional repairs should be undertaken to reinforce the temporary repairs made to DS4 in 2018, to reduce the potential for additional damage or erosion to the drop structure and/or surrounding slopes.~~	~~Partially Complete~~
Drop Structure 4	July 2021	High	Permanent repairs for DS4 should be designed and implemented. YG-AAM has advised that design work is underway (by others) and construction is planned for Summer 2022.	In Progress

Location	Date	Priority	Recommended Action	Status
Drop Structure 4	July 2021	High	Temporary repairs should be implemented in Summer 2021 in advance of permanent repair work in 2022. Refer to recommendations in Tetra Tech's hydrotechnical review of DS4 (separate memorandum).	New
Clinton Creek Waste Rock Dump	Ongoing	High	The seepage from the toe of the waste rock near DS4 should be observed and photographed whenever engineering staff visit the site. Any apparent increase in erosion on the slope face or sediment in the seepage water should be reported to YG-AAM and Tetra Tech immediately.	Ongoing
Porcupine Creek Waste Rock Dump	July 2020	Medium	Vegetation should be cleared from roads and trails to maintain access to all areas of the Porcupine Creek waste rock dump.	Not Complete
Wolverine Creek Channel	Ongoing	Medium	GENERAL: The creek channel, pond outlets, and culverts should be monitored for blockages by debris, beaver dams, or similar. Any blockages should be removed.	Ongoing
Wolverine Creek Channel	July 2021	High	The boulder near the intake of the overflow culvert under the site access road should be removed.	New
Wolverine Creek Channel	July 2021	Medium	Debris and brush in the channel just downstream from the Wolverine Creek south pond outlet should be removed to maintain unobstructed flow in the channel.	New
Wolverine Creek Channel	Oct. 2017	Low	Boulders that block the access road to the base of the tailings piles should be removed and replaced with a locking gate to allow for authorized vehicle access along the Wolverine Creek channel and to the base of the tailings.	Not Complete
Wolverine Creek Ponds	July 2021	Medium	The three beaver dams observed near the north and south ponds should be removed. The larger dam at the north pond outlet should be removed in stages to draw down the elevated water level in the pond at a controlled rate.	New
Porcupine and Snowshoe Pits	Ongoing	High	Access on or below the walls of the open pits should remain restricted due to ongoing pit wall instability.	Ongoing
Porcupine Pit	July 2021	High	We understand that YG-AAM is considering the installation of a water level logger in the pit pond. If this work proceeds, an access plan should be developed for safe installation and ongoing data collection from the instrument, to limit exposure to rockfall hazards.	New

5.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

PROFESSIONAL ENGINEER
YUKON
ADAM W. WALLACE
TERRITORY
2 August 2021

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PERMIT TO PRACTICE
TETRA TECH CANADA INC.
SIGNATURE
Date 2 August 2021
PERMIT NUMBER PP003
Association of Professional
Engineers of Yukon

PHOTOGRAPHS

Photo 1: Typical Access Road condition from Forty Mile Bridge to Site Access Gate.
Clinton Creek Road km 33.2, facing southeast.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 2: Water on road surface in area of 2020 repairs.
Clinton Creek Road km 34.6, facing northwest.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 3: Overhanging tree above road.
Clinton Creek Road km 35.1, facing northwest.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 4: Small tree fallen on road.
Clinton Creek Road km 39.0, facing west.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 5: Active landslide along Access Road.
Clinton Creek Road km 36.0.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 6: Boulders on north side of site access gate moved, facing west.
Photo taken by Adam Wallace, June 15, 2021.

Photo 7: Washout repair just inside of the site access gate, facing south.
Photo taken by Adam Wallace, June 15, 2021.

Photo 8: Minor rutting on road surface.
Access Road km 39.5, facing southeast.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 9: Rutting on road surface.
Access Road km 40.6, facing west.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 10: Erosion gully above road.
Access Road km 39.5, facing southwest.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 11: Erosion gullies on road surface.
Access Road km 39.6, facing west.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 12: Erosion gully leading to Clinton Creek channel.
Access Road km 39.5, facing east.
Photo taken by Adam Wallace, June 16, 2021.

Photo 13: Typical condition of road between Ford Crossing No. 2 and the former mill site.
Access Road km 41.0, facing west.
Photo taken by Shawn Matthies, June 16, 2021.

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Access Road km 41.9 facing east.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 15: Gully on downslope side of road.
Access Road km 41.8 facing south.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 16: Tree leaning toward road.
Access Road km 41.8, facing northwest.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 17: Closed section of access road, facing west.
Photo taken by Adam Wallace, June 16, 2021.

Photo 18: Tension cracks on closed section of access road, facing west.
Photo taken by Adam Wallace, June 16, 2021.

Photo 19: Tension cracks on closed section of access road, facing east.
Photo taken by Adam Wallace, June 16, 2021.

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Photo taken by Adam Wallace, June 16, 2021.

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Photo taken by Adam Wallace, June 15, 2021.

Photo 22: Ford Crossing No. 2, facing north toward Clinton Creek natural slope.
Photo taken by Adam Wallace, June 15, 2021.

Photo 23: North log boom abutment, facing west.
The frame tilts approximately 3° toward Hudgeon Lake.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 24: Open space around steel post on the north log boom abutment.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 25: Tension cracks on the north bank of the Hudgeon Lake outlet, facing west.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 26: South log boom abutment, facing southwest.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 27: Tension cracks on the south bank of the Hudgeon Lake outlet facing north.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 28: Hudgeon Lake outlet, facing east.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 29: Drop Structure 1, facing west.
Photo taken by Adam Wallace, June 16, 2021.

Photo 30: Drop Structure 2, facing west.
Photo taken by Adam Wallace, June 16, 2021.

Photo 31: Erosion on south bank of DS2, facing north.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 32: Drop Structure 3, facing west.
Photo taken by Adam Wallace, June 16, 2021.

Photo 33: Tension cracks on south bank of DS3, facing east.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 34: Void inside gabion basket at DS3, caused by loss of undersized gabion basket fill.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 35: Drop Structure 4, facing west.
Photo taken by Adam Wallace, June 16, 2021.

Photo 36: Drop Structure 4, facing southwest.
Photo taken by Adam Wallace, June 16, 2021.

Photo 37: Eroded fill material deposited in stilling basin at DS4, facing east.
Photo taken by Adam Wallace, June 16, 2021.

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Photo taken by Adam Wallace, June 16, 2021.

Photo 39: Seepage area from toe of waste rock at DS4, facing south.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 40: Aerial view of drop structures and Hudgeon Lake outlet.
Photo taken by Adam Wallace, June 16, 2021.

Photo 41: Clinton Creek north bank, facing northeast.
Sloughing and shallow slope movement on the natural slope and erosion in the creek channel is ongoing.
Photo taken by Adam Wallace, June 16, 2021.

Photo 42: Clinton Creek north bank, facing northeast.
The creek is cutting into bedrock, toppling of small blocks of rock is ongoing.
Photo taken by Adam Wallace, June 16, 2021.

Photo 43: Vegetation rafts on Clinton Creek north slope, facing north.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 44: Small landslide downstream of DS4, facing northwest.
Photo taken by Shawn Matthies, June 16, 2021.

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Photo taken by Shawn Matthies, June 16, 2021.

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Erosion gully on trail to BH18-08 (top).
Photo taken by Shawn Matthies, June 16, 2021.

Photo 47: Seepage on upslope side of trail to BH18-08, facing northwest.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 48: Western portion of the Clinton Creek waste rock dump, looking towards the Porcupine Pit.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 49: Gullying and dislodged culvert on bank south of Ford Crossing No. 1, facing north.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 50: Toe of the Porcupine Creek waste rock dump, facing southwest.
Photo taken by Adam Wallace, June 15, 2021.

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Photo taken by Adam Wallace, June 15, 2021.

Photo 52: Porcupine Pit, facing northwest.
Photo taken by Adam Wallace, June 15, 2021.

Photo 53: Porcupine Pit, facing west.
Photo taken by Adam Wallace, June 15, 2021.

Photo 54: Snowshoe Pit, facing east.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 55: Creek Pit and Creek/Snowshoe Pit Pond, facing northeast.
Photo taken by Adam Wallace, June 15, 2021.

Photo 56: Wolverine Creek, downstream of south pond, facing southeast.
Photo taken by Shawn Matthies, June 15, 2021.

Photo 57: Debris in Wolverine Creek channel, downstream of south pond, facing southwest.
Photo taken by Shawn Matthies, June 15, 2021.

Photo 58: Rock-lined section of Wolverine Creek channel, facing northeast.
Photo taken by Adam Wallace, June 15, 2021.

Photo 59: Ongoing minor slope movement on Wolverine Creek east slope, facing east.
Photo taken by Adam Wallace, June 15, 2021.

Photo 60: Wolverine Creek at culvert leading to Clinton Creek confluence, facing south.
The main culvert is free of debris and the creek has re-established a meandering path.
Photo taken by Adam Wallace, June 15, 2021.

Photo 61: Wolverine Creek Tailings Pile north lobe, facing northeast.
Photo taken by Shawn Matthies, June 16, 2021.

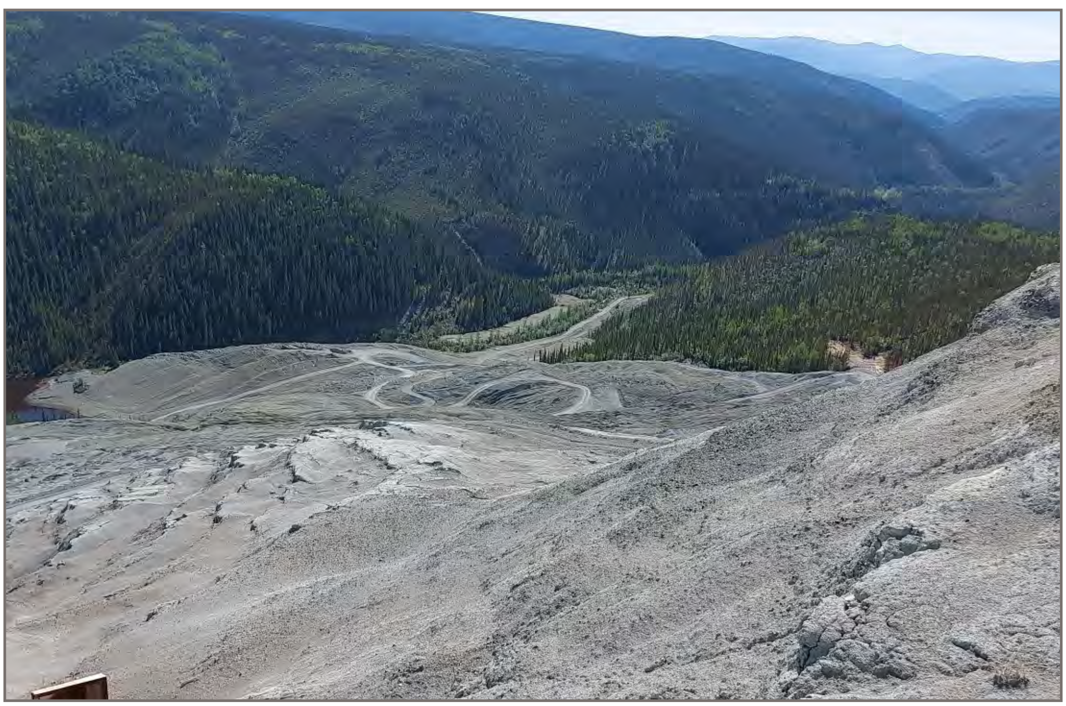

Photo 62: Wolverine Creek Tailings Pile south lobe, facing southeast.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 63: Wolverine Creek Tailings Pile north lobe, facing north.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 64: Development of gullying and sediment fan on the north lobe of the Wolverine Creek tailings, facing north.
Photo taken by Shawn Matthies, June 16, 2021.

Photo 65: Wolverine Creek south pond, facing south.
Photo taken by Adam Wallace, June 15, 2021.

Photo 66: Wolverine Creek north pond, facing north.
Photo taken by Adam Wallace, June 15, 2021.

Photo 67: Beaver dam at outlet of north pond, facing north.
Photo taken by Adam Wallace, June 15, 2021.

Photo 68: Small beaver dam between Wolverine Creek north and south ponds, facing east.
Photo taken by Adam Wallace, June 15, 2021.

Photo 69: Partially breached beaver dam at outlet of Wolverine Creek south pond, facing south, Photo taken by Shawn Matthies, June 15, 2021.

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – YUKON GOVERNMENT

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the use of TETRA TECH's Client, its officers, employees, agents, representatives, successors and assigns (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH. Any changes to the conclusions, opinions, and recommendations presented in TETRA TECH's Professional Document must be authorized by TETRA TECH.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems, as per agreed project deliverable formats. TETRA TECH makes no representation about the compatibility of these files with the Client's future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be brought to the attention of TETRA TECH within a reasonable time.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, and subject to the standard of care herein, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage, except where TETRA TECH has subcontracted for such information.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to make, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the Client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.8 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.9 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.10 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.11 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.12 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.13 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.14 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.15 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.16 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.17 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.18 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client’s expense upon written request, otherwise samples will be discarded.

1.19 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX C

INSAR MONITORING REPORT (TRE ALTAMIRA)

InSAR Analysis of Ground Displacement at Clinton Creek Mine

SqueeSAR Report **26 November 2021**

TRE ALTAMIRA
A CLS Group Company

Report specifications

Client:

Adam Wallace

Geotechnical Engineer, Arctic Region

TetraTech Canada

Whitehorse, YK

Canada

Reference:

Title:	InSAR Ground Deformation Analysis for the Clinton Creek Mine
TRE ALTAMIRA Delivery Reference:	JO21-1445-CA

Prepared by:

TRE ALTAMIRA

Authors:	Riccardo Tortini
Approved by:	Giacomo Falorni
Date:	26 November 2020
Version:	1.0

Executive Summary

TRE ALTAMIRA Inc. (TREA) has been contracted by TetraTech to continue monitoring ground displacement over Clinton Creek Mine, in the Yukon. The data processed for the present report was acquired by the high-resolution TerraSAR-X (TSX) and PAZ satellites, and comprises 63 radar images acquired from an ascending orbit (08 September 2019 - 25 September 2021) and 62 images from a descending orbit (23 August 2019 - 24 September 2021).

TREA applied a suite of algorithms and techniques (SqueeSAR®, 2-D movement decomposition, change detection, and Temporary Coherent Scatterers (TCS)) to identify and highlight ground displacement over the entire mine site.

The main observations are summarized below.

- The measurement point (MP) density has further increased compared to previous years over all major assets, with improved spatial coverage over the west wall of the Porcupine Pit and the Wolverine Creek South Lobe.
- The Reference Point (REF) was maintained on the Clinton Creek Tailings Rock Pile, south of the Drop Structures, due to widespread decorrelation previously identified within the ascending results over the Former Mill Site.
- The resulting 2-D displacement measurements are of high quality and used in the observations, except for a few localized areas where the LOS results highlight additional information (i.e. Drop Structures, Snowshoe Pit).
- The Line of Sight (LOS) results are year-round and include the snow periods of 2019, 2020, and 2021. However, time-series should be viewed with caution during the winter months as they are noisier in that period.
- With the use of high-resolution imagery, it was possible to apply the Rapid Motion Tracking (RMT) algorithm over Clinton Creek Mine; however, no displacements were rapid enough to be detected.
- Deceleration was identified within the Drop Structures and the Porcupine Pit, preceded by an acceleration during summer/fall 2020.
- The average measurement precision for the ascending and descending SqueeSAR data is ±1.3 mm/yr and ±1.1 mm/yr, respectively.

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Acronyms and abbreviations

AOI	Area of Interest
ATS	Average Time Series
CS	Cross-Section
DEM	Digital Elevation Model
InSAR	Interferometric Synthetic Aperture Radar
LOS	Line of Sight
RMT	Rapid Motion Tracking
SAR	Synthetic Aperture Rad
SNT	Sentinel
SqueeSAR®	Advanced InSAR algorithm patented by TREA
TCS	Temporary Coherent Scatterers
TSX	TerraSAR-X

1. Area of Interest

The Clinton Creek mine is located in the Dawson mining sector in Yukon, Canada. For the 2021 monitoring, the area of interest (AOI) was reduced from 14.8 km² to 11.9 km² to include the area occupied by the abandoned mine and any remaining assets but reduce coverage of areas outside of the mine sight. This approach has the advantage of reducing the size of the data sets and of marginally improving the quality of the remaining data (Figure 1).

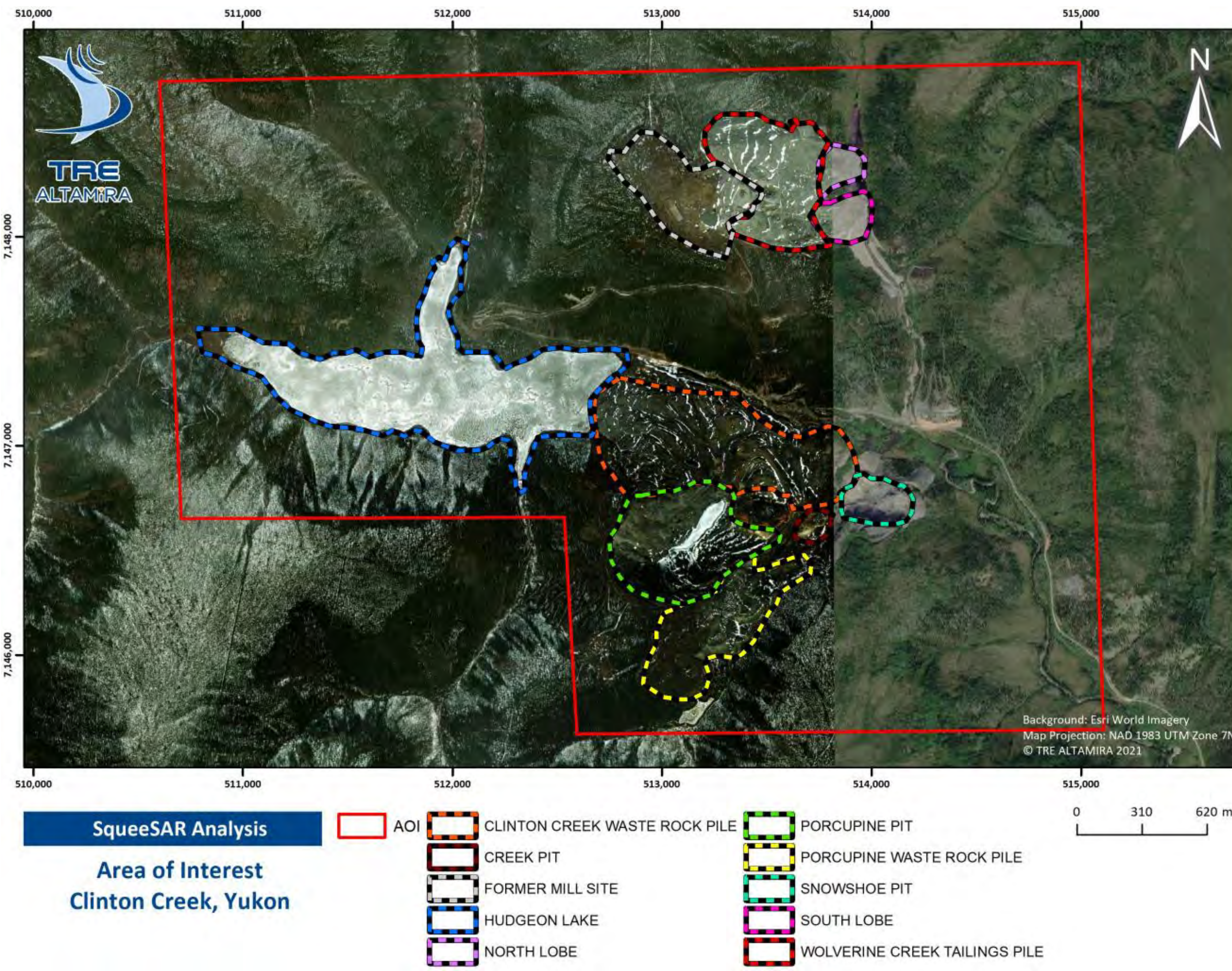

Figure 1: AOI (red boundary) and asset location map.

2. Imagery

The satellite imagery for the 2021 monitoring continues using high-resolution TerraSAR-X (TSX) and Paz Spotlight data (1 m x 1 m) after being upgraded from low-resolution Sentinel (5 m x 20 m) for the 2020 monitoring. Radar images were acquired by TSX from an ascending orbit (satellite travelling from south to north and imaging to the east) and by the twin satellites, TSX and PAZ from a descending orbit (satellite travelling from north to south and imaging to the west). The number of images and the period of coverage are indicated in Table 1, while the temporal distribution of the radar imagery is shown in Figure 2.

Table 1: Satellite acquisition parameters and image acquisition information for the AOI.

Satellite	Mode	Geometry	Track	LOS Angle (°)	# of Images	Date Range
TSX	Spotlight	Ascending	31	44.85	63	08 Sept 2019 – 25 Sept 2021
TSX/PAZ	Spotlight	Descending	130/16	47.80	62	23 Aug 2019 – 24 Sept 2021

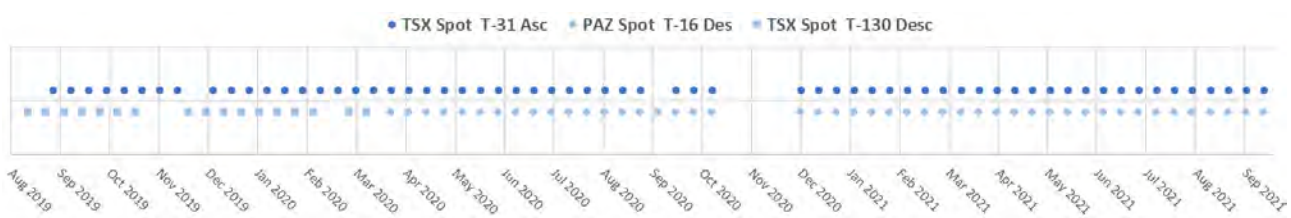

Figure 2: Temporal distribution of the radar imagery over the Clinton Creek mine.

3. Results

3.1 SqueeSAR® Analysis

To maximize measurement point density the LOS results are separated into two snow-free periods. In a LOS analysis, negative values (red) indicate 1-D displacement away from the satellite along the LOS, while positive values (blue) indicate displacement towards the satellite (Figure 3).

The number and average density of measurement points (MP) identified is reported in Table 2.

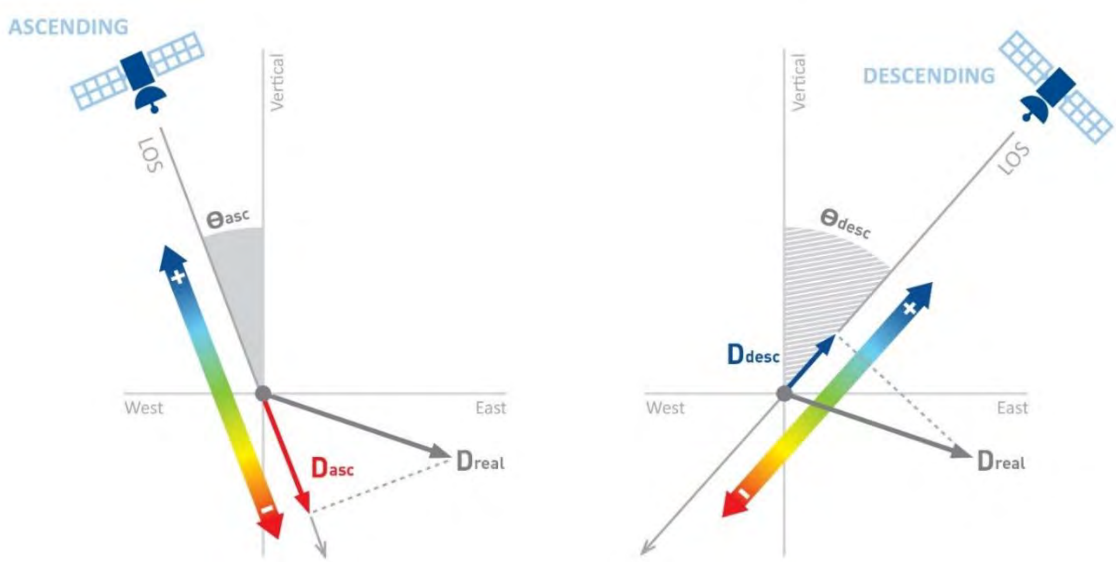

Figure 3: SqueeSAR measures the projection of real movement (D_{real}) onto the LOS. The same real movement (D_{real}) will produce a different value from a different LOS (different inclination or different acquisition geometry). The standard convention for the displacement value sign and MP color on maps: positive values and colours from green to blue indicate movement toward the satellite; negative values and colours from green to red indicate movement away from the satellite

Table 2: Number and density of MP identified within the AOI

Geometry	Total Measurement Points	MP Density
Ascending	73,772	6,221 MP/km^2
Descending	60,123	5,070 MP/km^2

The line-of-sight (LOS) displacement rates derived from the SqueeSAR processing are presented in this section. Due to the short temporal baseline of the processing (approximately 2 years) and the nature of the snow cover, the output is a continuous dataset that did not have to be divided into snow-free periods. The 2-D (East-West and Vertical) results, which cover the August 2019 to September 2021 period, are followed by the LOS ascending and descending data.

Displacement rates are calculated from a linear regression of the time series for the period covered by the satellite images. Each point corresponds to a Permanent Scatterer (PS) or Distributed Scatterer (DS) and is colour-coded according to its annual rate of movement. Displacement rates are relative to a reference point chosen based on its location and radiometric characteristics. After being reassigned from the Former Mill Site during the 2020 monitoring, the reference points were maintained in the previous Clinton Creek Waste Rock Pile location.

3.1.1. 2-D Results

The 2-D results use the overlapping (08 September 2019 to 24 September 2021) portions of the ascending and descending LOS datasets to produce true vertical and east-west displacements with millimetric precision (Figure 4). Full 2-D coverage of the site was achieved, with the exception the western end of the Former Mill Site and the west wall of the Porcupine Pit, where partial data coverage is provided. In any case, coverage at both of these sites has improved significantly compared to the previous analysis.

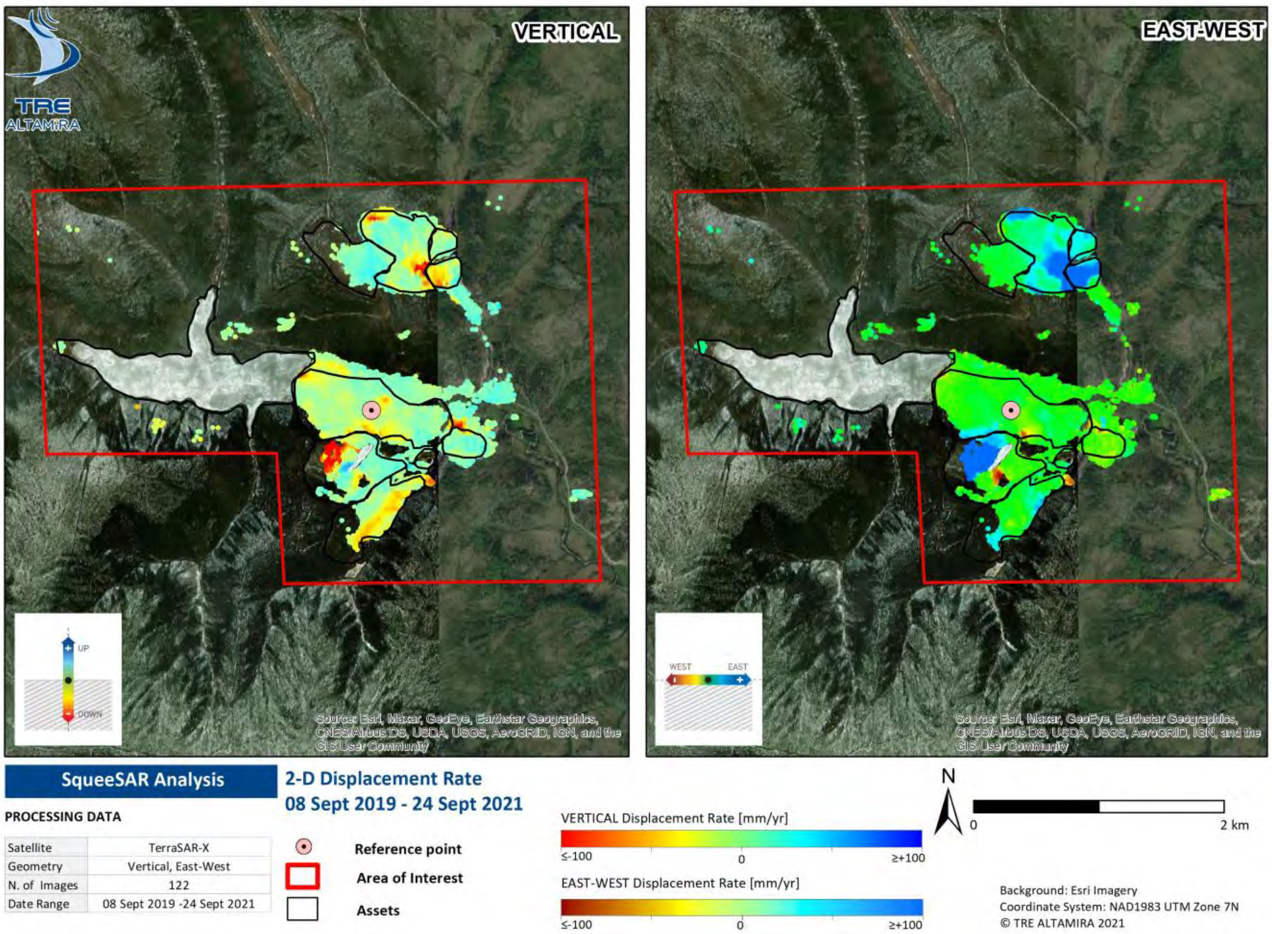

Figure 4: 2021 2-D results over Clinton Creek Mine.

The vertical component of displacement is shown in Figure 5. The colour-coding is similar to the LOS data sets, with negative (red) values indicating subsidence and positive (blue) values indicating uplift. The highest subsidence rates during the 2019 - 2021 monitoring period are identified on the west wall of the Porcupine Pit, reaching a velocity of -175.0 mm/yr, the southern portion of the South Lobe (max -142.2 mm/yr), within the corner of Wolverine Creek Tailings Pile (max -137.2 mm/yr), and directly north of the Snowshoe Pit (max

-130.7 mm/yr). Other areas identified to have subsidence were the Waste Rock Piles and the Drop Structures. Uplift reaching +67.9 mm/yr is identified within the Porcupine Pit. The average standard deviation for the vertical 2-D results was ±1.1 mm/yr.

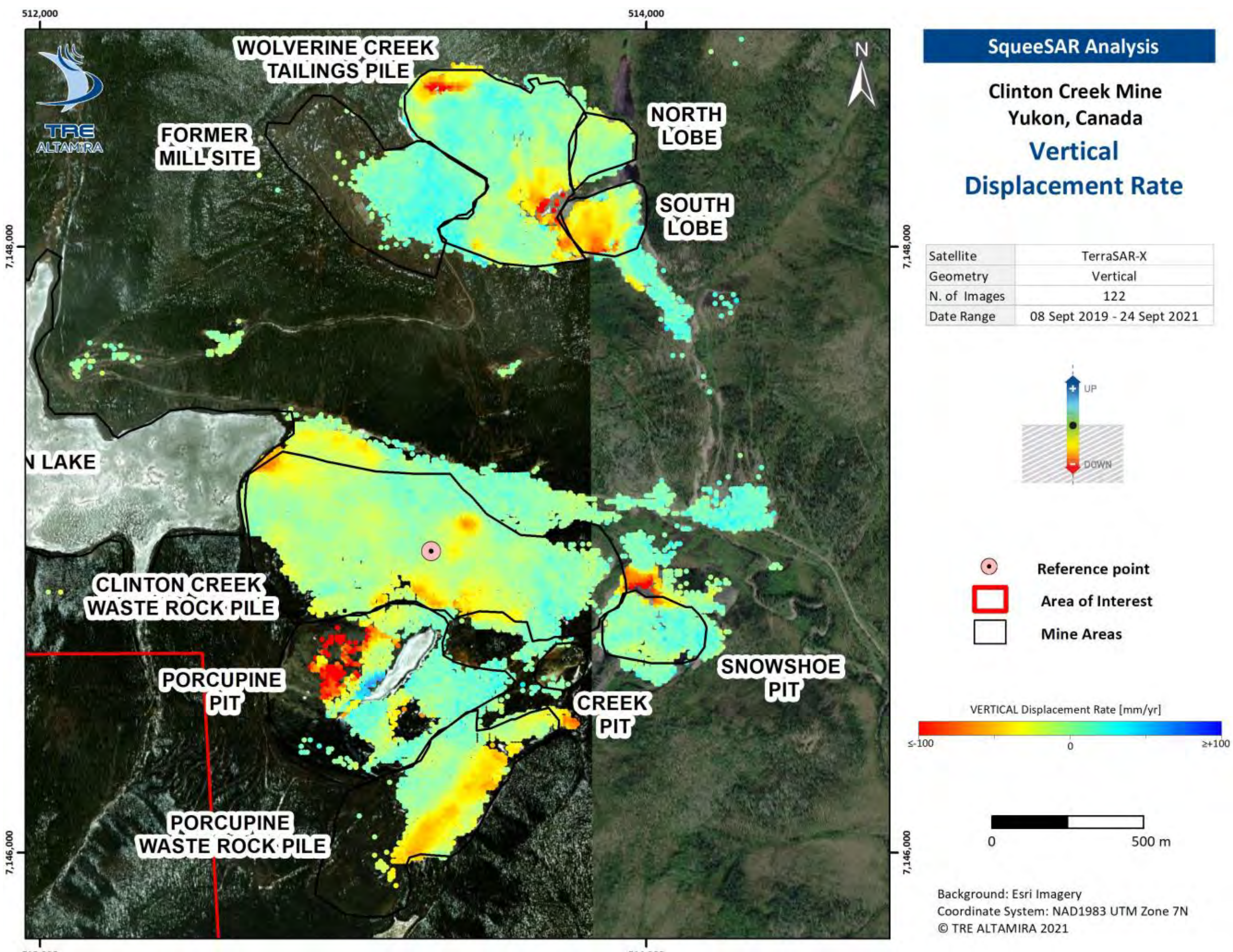

Figure 5: Vertical displacement rate for the period 08 September 2019 to 24 September 2021.

Figure 6 shows the E-W horizontal movement with negative (brown) values indicating westward movement and positive values (blue) indicating eastward movement. Maximum westward movement is observed on the east wall of the Porcupine Pit, reaching a velocity of up 120.1 mm/yr, and in the eastern and south-central regions of the Clinton Creek Waste Rock Pile (up to 87.9 mm/yr and 83.9 mm/yr, respectively). Westward trends are also identified within the northern region of the Snowshoe Pit and the boundary of the Waste Pile. The highest eastward rates are observed within the Wolverine Creek Tailings Pile (up to 367.6 mm/yr) at the edge with the South Lobe, within the Porcupine Pit (up to 355.9 mm/yr) and in the South Lobe (up to 245.3 mm/yr) with eastward trends also identified within the North Lobe and the eastern boundary of the Waste Rock Piles. The average standard deviation for the E-W 2-D results was ±1.0 mm/yr.

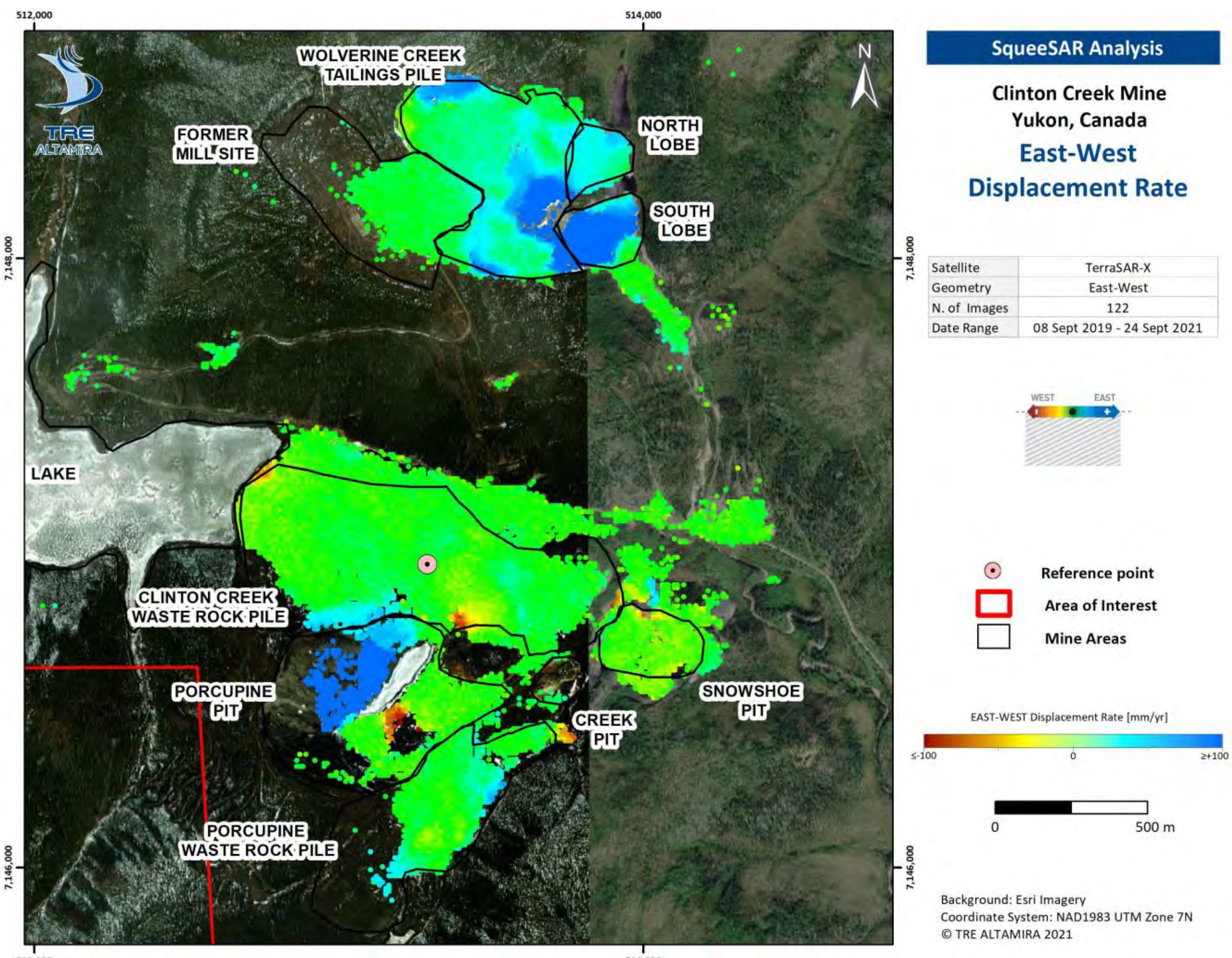

Figure 6: East-West displacement rate for the period 08 September 2019 to 24 September 2021.

3.1.2. Line of Sight (LOS) Results

The LOS results are shown in Figure 7. Negative values (red) indicate displacement away from the satellite while positive values (blue) indicate displacement towards the satellite.

The displacement rates in the LOS data set range from -339.8 mm/yr to +54.8 mm/yr (ascending) and from -154.9 mm/yr to +230.1 mm/yr (descending). The highest displacement totals away from the satellite are located primarily within the Porcupine Pit and the South Lobe, as well as at the Wolverine Creek Tailings Pile, Waste Rock Pile, Clinton Creek Waste Pile, and north of the Snowshoe Pit. Similarly, the highest displacement totals towards the satellite are located within the Porcupine Pit and South Lobe, as well as the Wolverine Creek Tailings Pile.

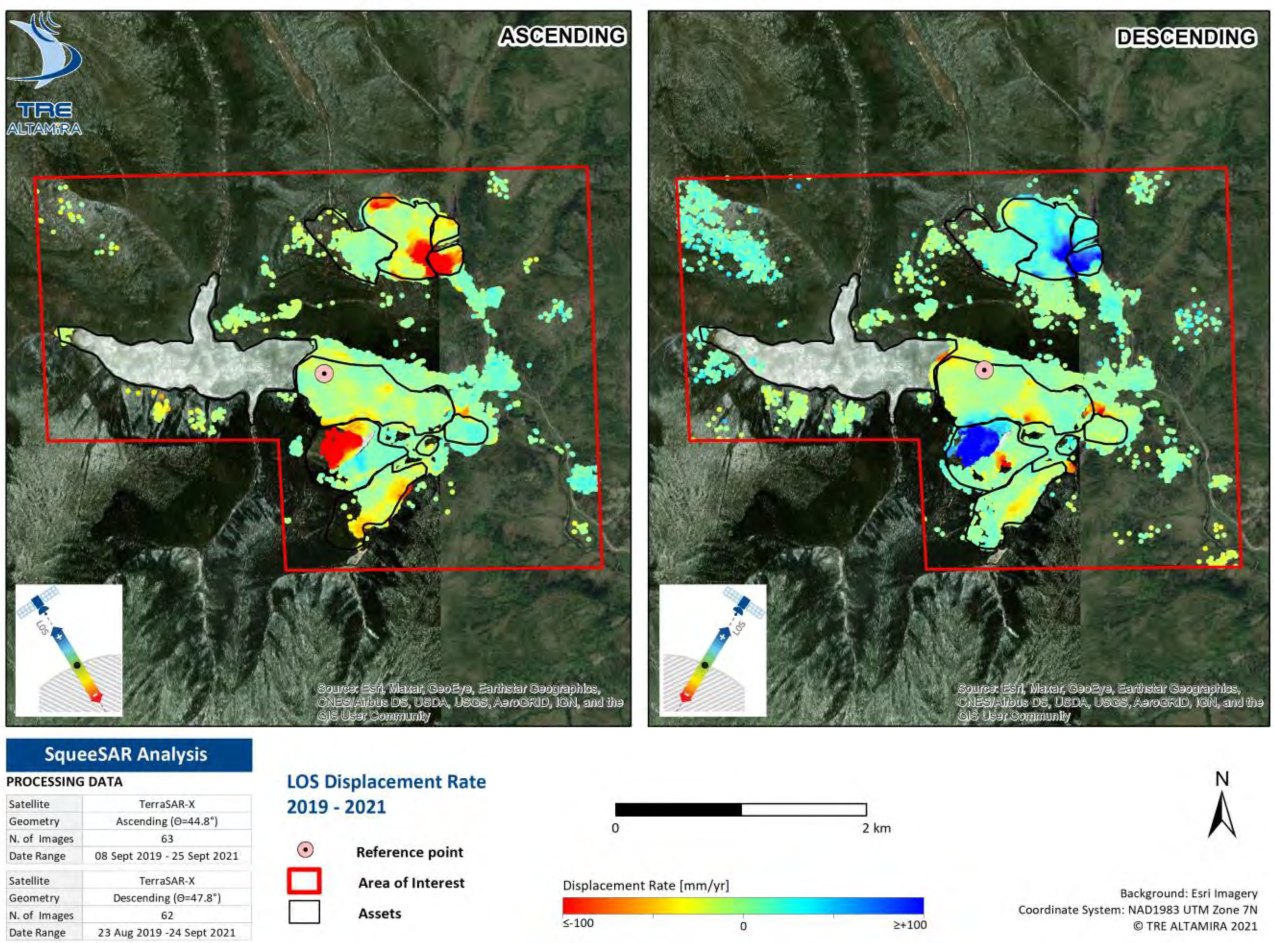

Figure 7: LOS displacement rate for ascending (left) and descending (right).

3.2 Additional Tools: Temporary Coherent Scatterers and Change Detection

Temporary Coherent Scatterers (TCS) are an advanced approach used by TREA to extend the coverage of the ground displacement measurements. The TCS approach extracts displacement information from pixels exhibiting a stable radar response even only for limited periods of time (e.g. weeks or months) and thus provides additional displacement information in areas affected by strong variations in surface reflectivity (e.g. active operations, vegetation, snow accumulation). As each TCS point is derived from a different subset of images they do not have an associated time series but instead provide an average annual deformation rate. The combination of SqueeSAR (high quality, robust measurement points with a displacement history) with TCS provides an optimal combination of both maximum spatial density and reliable ground deformation histories for specific points.

As observed in the 2020 TSX monitoring, given the high spatial density already provided by the snow-free LOS SqueeSAR results, the TCS for the 2021 TSX monitoring provide less additional coverage compared to the 2019 SNT study. The TCS are combined with the LOS SqueeSAR results in Figure 8**Error! Reference source not found.**.

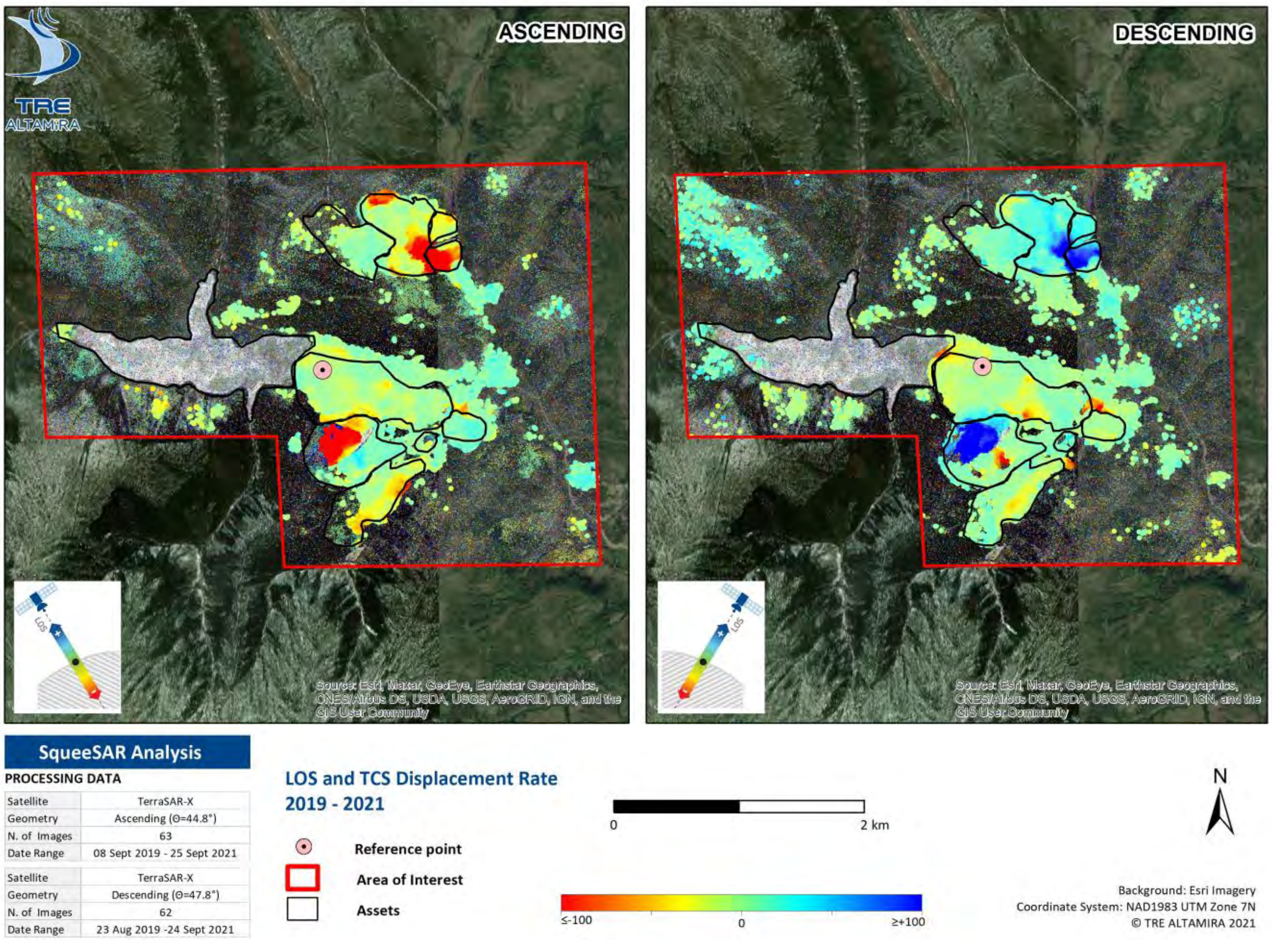

Figure 8: LOS displacement rate for ascending (left) and descending (right) with TCS.

4. Observations

4.1. Clinton Creek Area

4.1.1 Drop Structures

Both the LOS 1-D (Figure 17) and the 2-D (Figure 9) results are used to display localized displacement at the Drop Structures. ATS1 through ATS4 (Figure 10 - Figure 13) display the average displacement over Drop Structure 1 through 4, respectively, where subsidence and westward displacement are identified. ATS5 through ATS7 (Figure 14 - Figure 16) highlight movement directly south of the Drop Structures on the Clinton Creek Waste Pile.

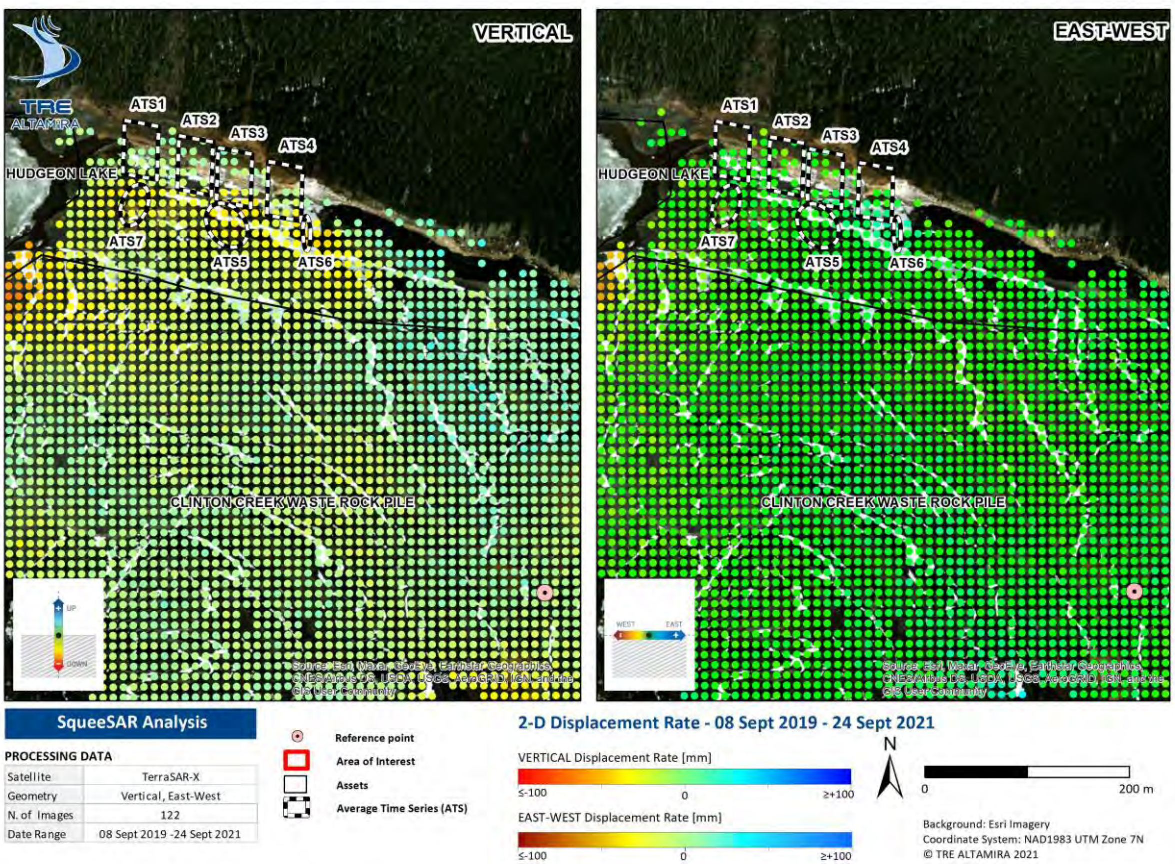

Figure 9: 2-D displacement rates over the Drop Structures from 08 September 2019 to 24 September 2021.

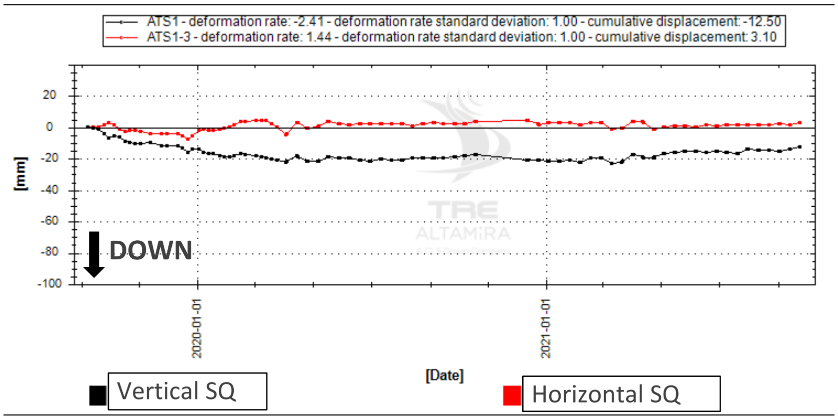

Figure 10: SqueeSAR Time Series for ATS1.

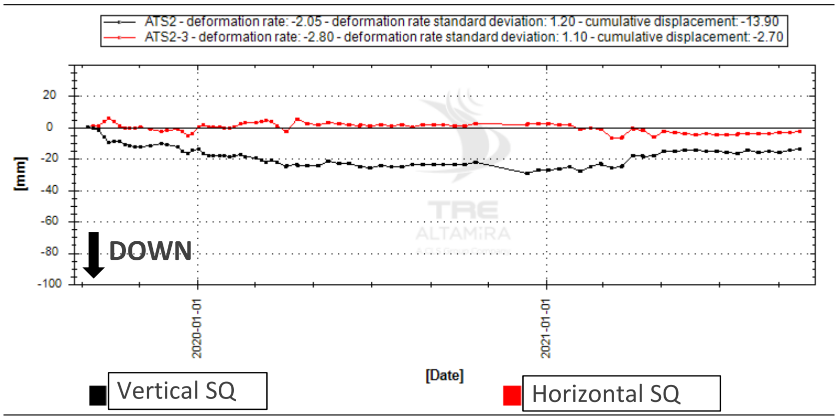

Figure 11: SqueeSAR Time Series for ATS2.

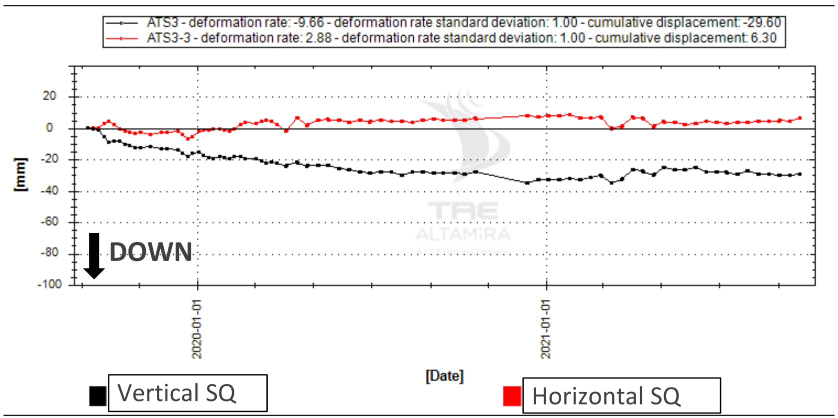

Figure 12: SqueeSAR Time Series for ATS3.

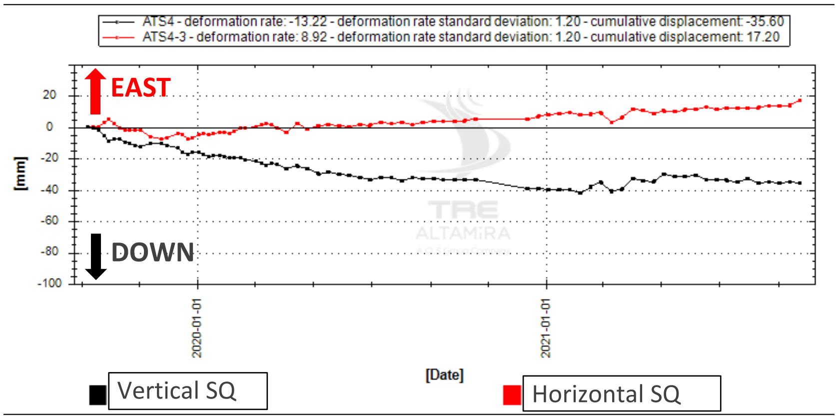

Figure 13: SqueeSAR Time Series for ATS4.

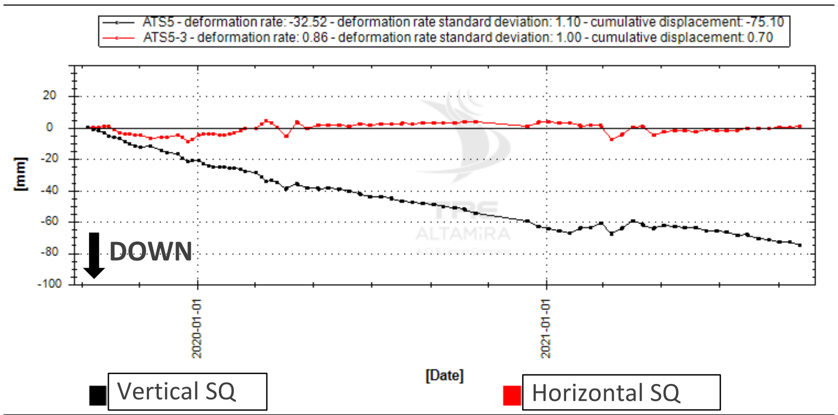

Figure 14: SqueeSAR Time Series for ATS5.

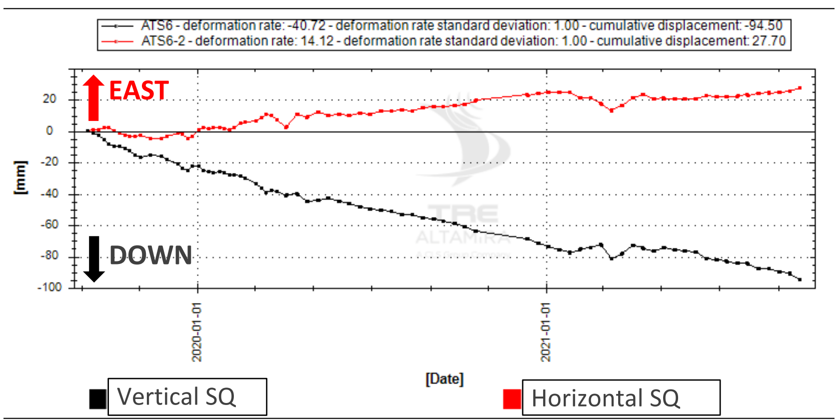

Figure 15: SqueeSAR Time Series for ATS6.

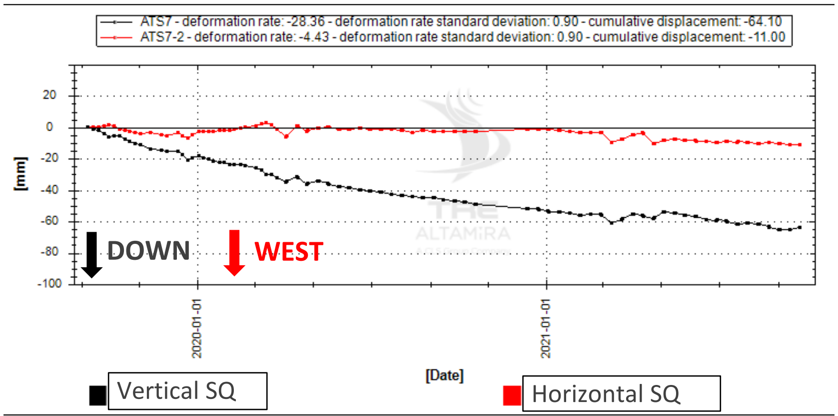

Figure 16: SqueeSAR Time Series for ATS7.

Further analysis is highlighted below (Figure 17) and includes the TCS results. ATS8 (Figure 18) uses the descending LOS to highlight subsidence on the upper bank of the boundary between Hudgeon Lake and Drop Structure 1. ATS10 (Figure 20) highlights localized displacement away from the satellite below Drop Structure 3 within the descending results. ATS9 (Figure 19) provides the displacement average for a localized feature southeast of the Drop Structures. Cross-section A-A' (Figure 17, Figure 21) uses a buffer of 50 meters with nodes every 10 meters.

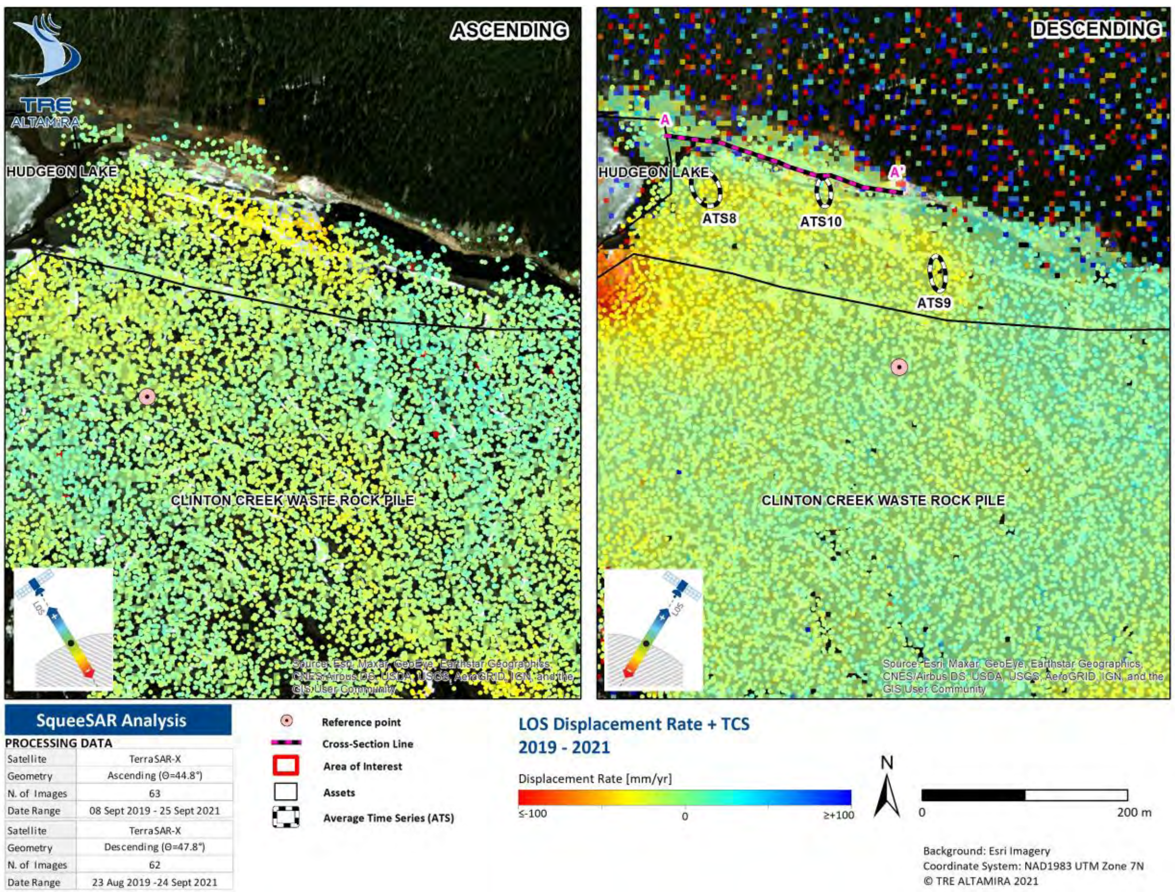

Figure 17: LOS Displacement Rate and TCS on the Drop Structures from September 2019 to September 2021.

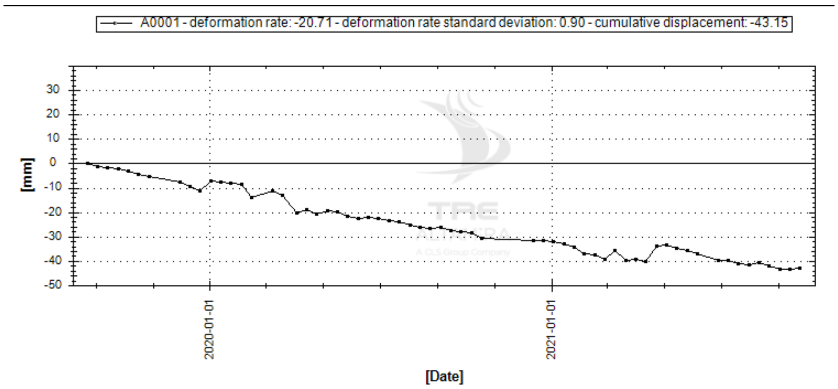

Figure 18: SqueeSAR LOS descending Time Series for ATS8.

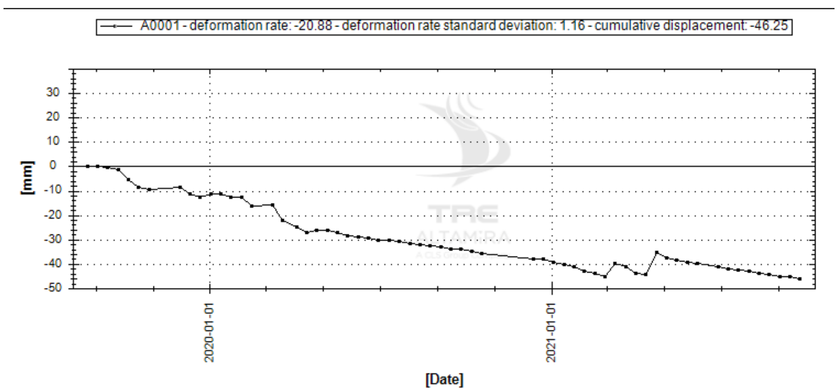

Figure 19: SqueeSAR LOS descending Time Series for ATS9.

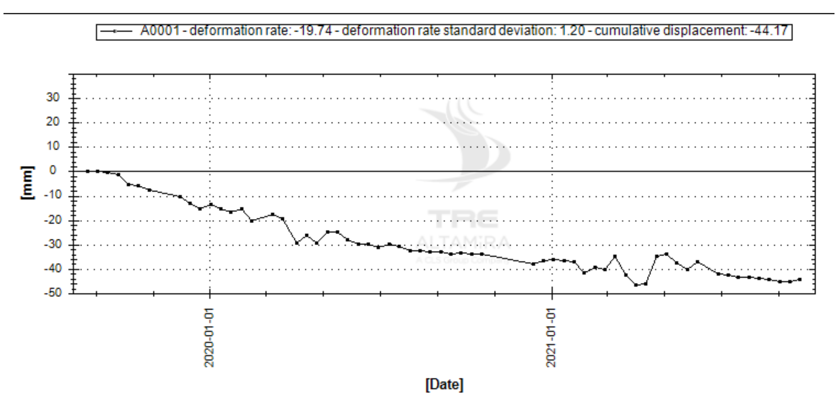

Figure 20: SqueeSAR LOS descending Time Series for ATS10.

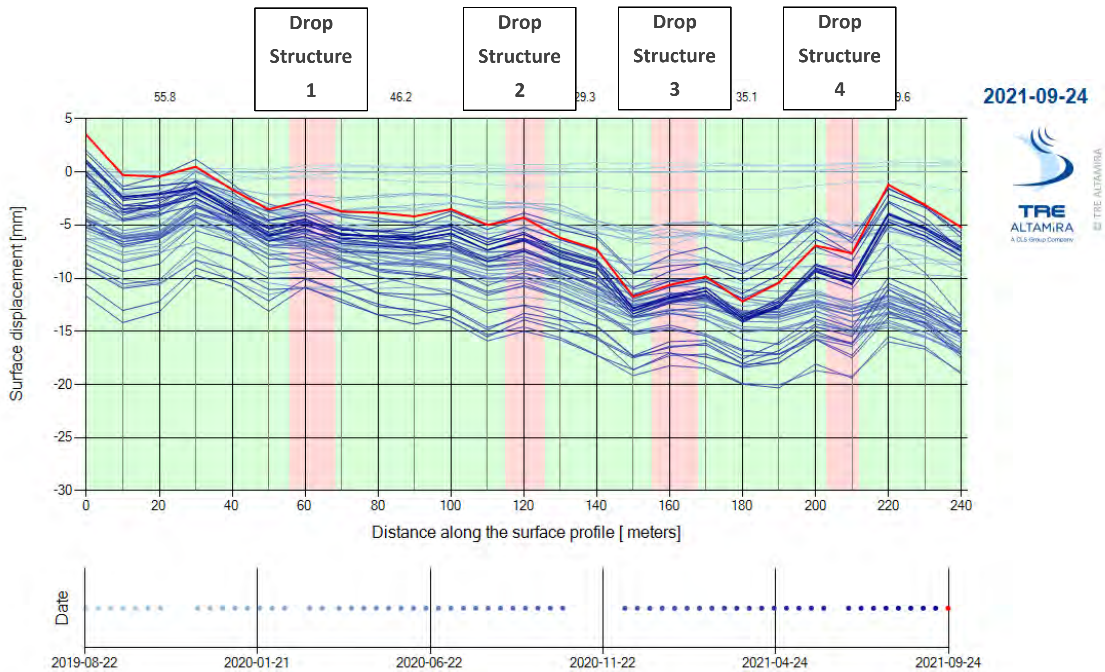

Figure 21: Cross-Section CS1 using the descending LOS results, the red line corresponds to the last image date (24 September 2021).

4.1.2 Clinton Creek Waste Rock Pile

The Clinton Creek Waste Rock Pile area is characterized by localized areas of subsidence and horizontal displacement (Figure 22). ATS1 (Figure 23) and ATS2 (Figure 24) focus on the boundary of Hudgeon Lake, ATS3 (Figure 25), ATS4 (Figure 26), and ATS7 (Figure 29) highlight localized features along the southern extent of the Waste Rock Pile. ATS5 (Figure 27) highlights westward displacement at the eastern extent of the Clinton Creek Waste Rock Pile while ATS6 (Figure 28) highlights localized subsidence at the northeastern boundary of the asset. A cross-section runs along the base of the Waste Pile (Figure 22, Figure 30) and uses a buffer of 100 meters with nodes every 25 meters.

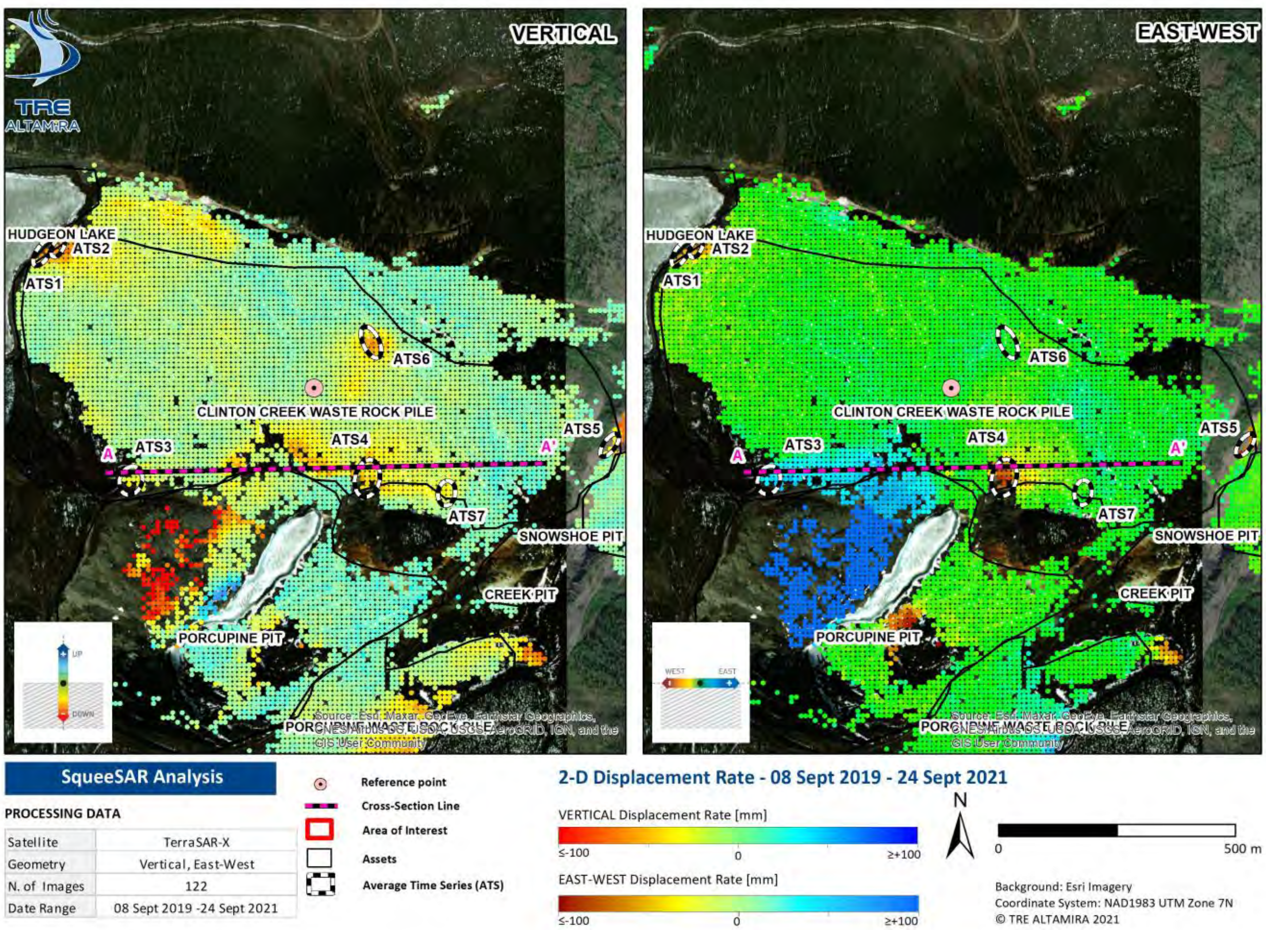

Figure 22: 2-D displacement rates over the Clinton Creek Waste Rock Pile from September 2019 to September 2021.

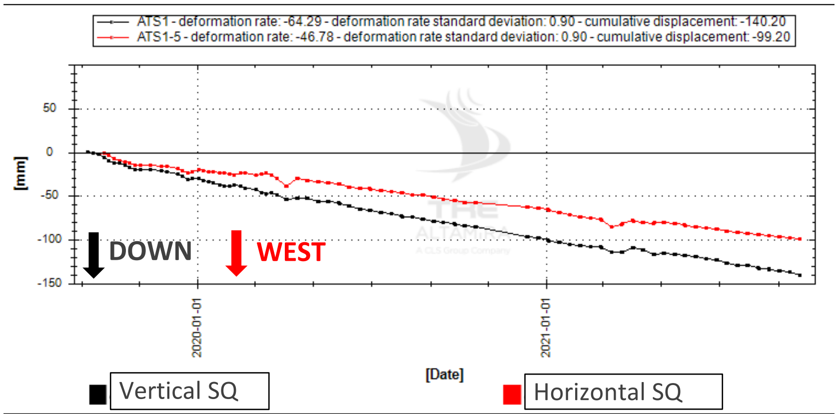

Figure 23: SqueeSAR Time Series for ATS1.

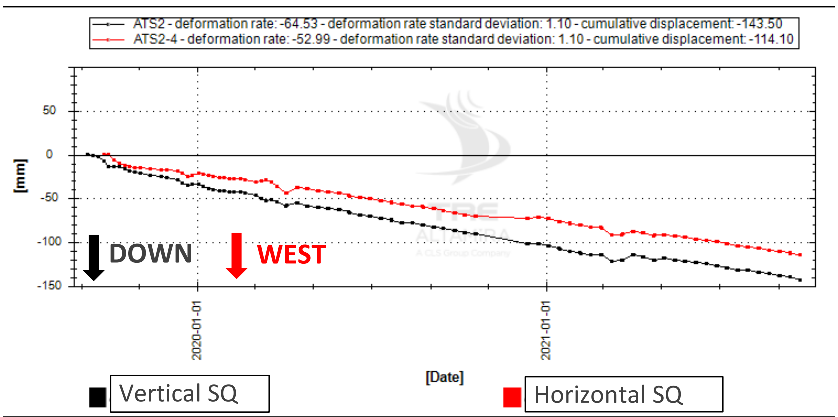

Figure 24: SqueeSAR Time Series for ATS2.

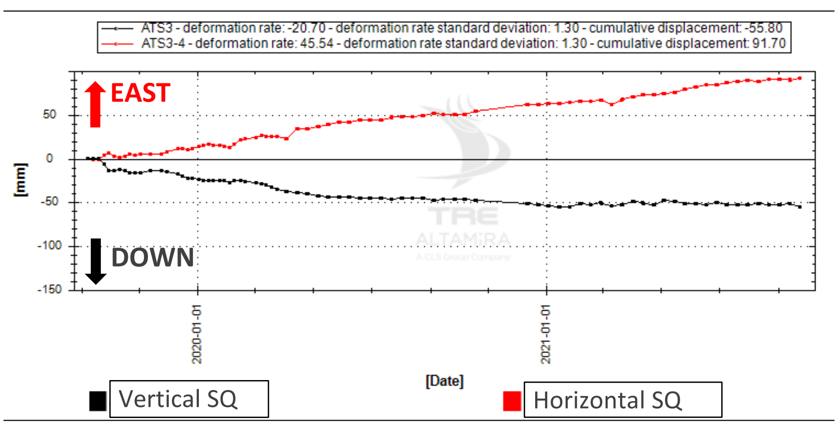

Figure 25: SqueeSAR Time Series for ATS3.

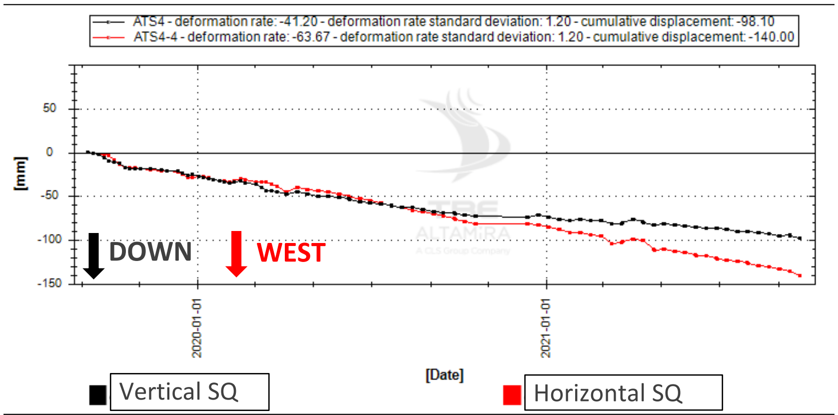

Figure 26: SqueeSAR Time Series for ATS4.

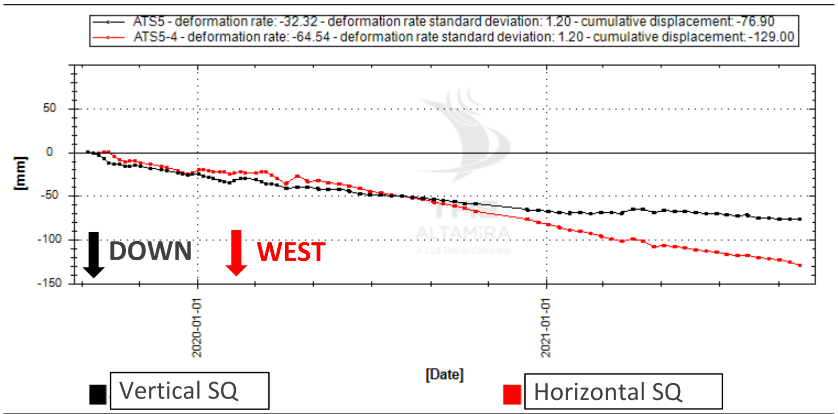

Figure 27: SqueeSAR Time Series for ATS5.

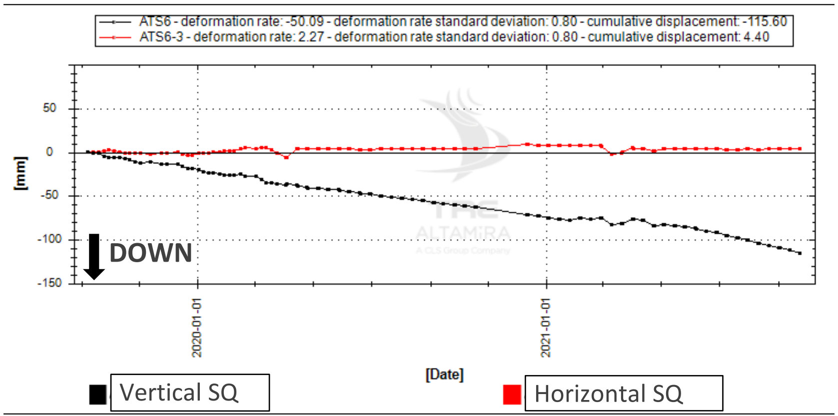

Figure 28: SqueeSAR Time Series for ATS6.

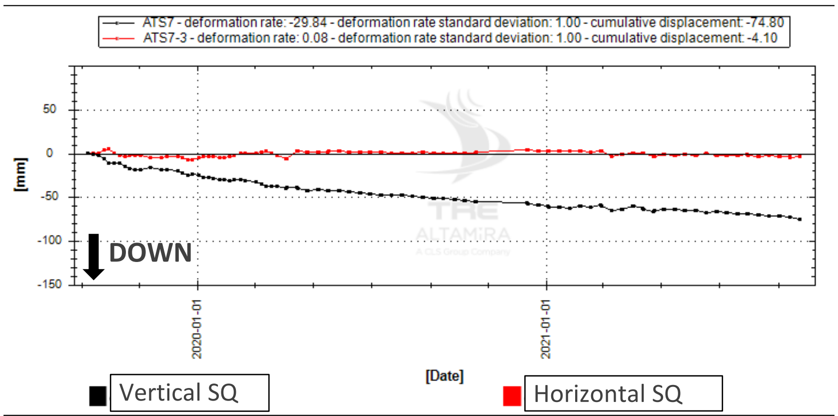

Figure 29: SqueeSAR Time Series for ATS7.

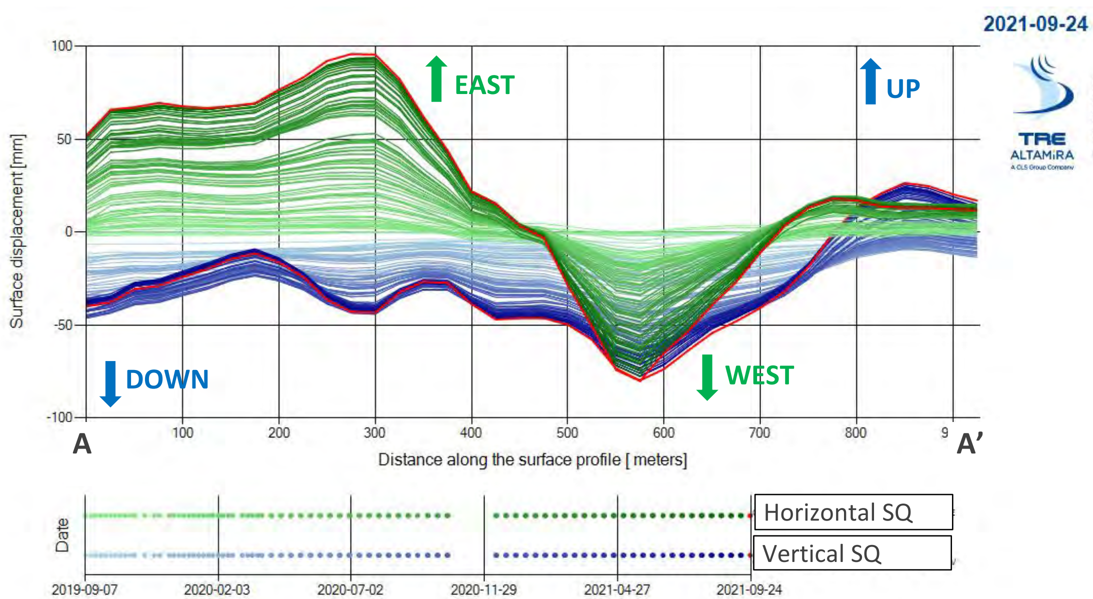

Figure 30: Cross-section along the Clinton Creek Waste Rock Pile. Green lines = horizontal displacement; blue lines = vertical displacement.

4.1.3 Porcupine Pit

The 2-D results are used to highlight displacement over the Porcupine Pit (Figure 31). Despite the steep angle of the west wall, the 2021 SqueeSAR update provides improved MP coverage, highlighting movement downward and eastward. ATS1 through ATS4 (Figure 32 - Figure 35) illustrate local maximums within this area, indicating a general acceleration in summer/fall 2020 followed by a deceleration in 2021. A cross-section runs across the west wall (Figure 31, Figure 36: Cross-section along the west wall of the Porcupine Pit. Green lines = horizontal displacement; blue lines = vertical displacement.Figure 36) and uses a buffer of 100 meters with nodes every 25 meters.

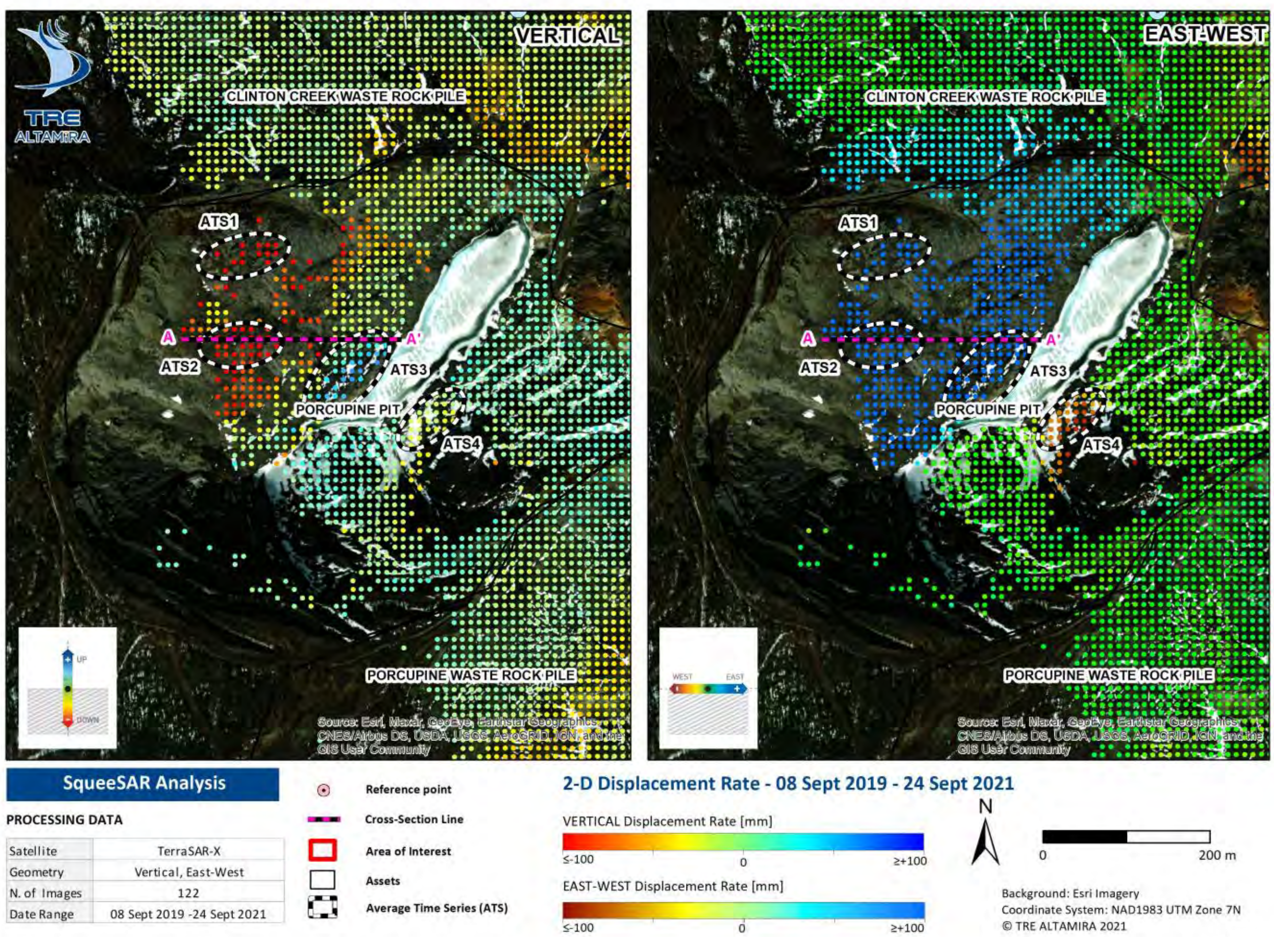

Figure 31: 2-D SqueeSAR displacement rates over the Porcupine Pit from September 2019 to September 2021.

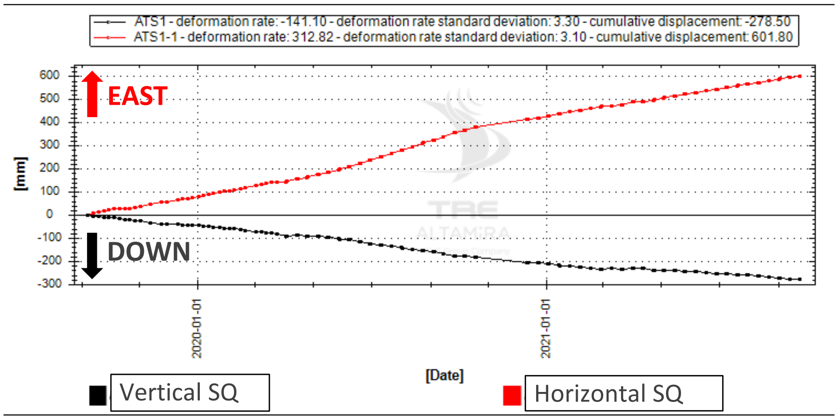

Figure 32: SqueeSAR Time Series for ATS1.

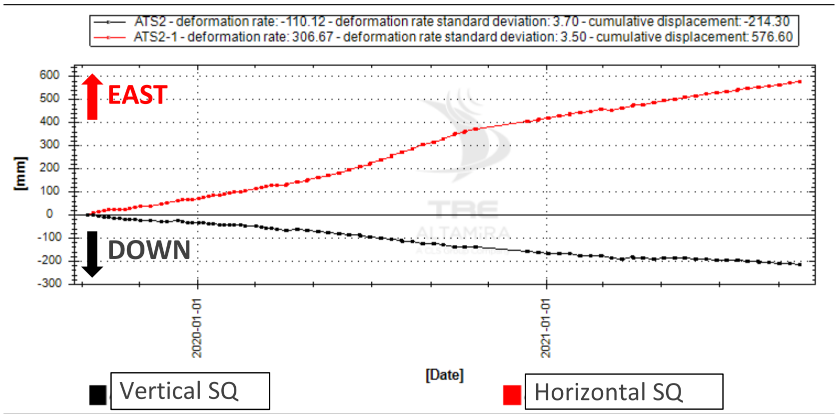

Figure 33: SqueeSAR Time Series for ATS2.

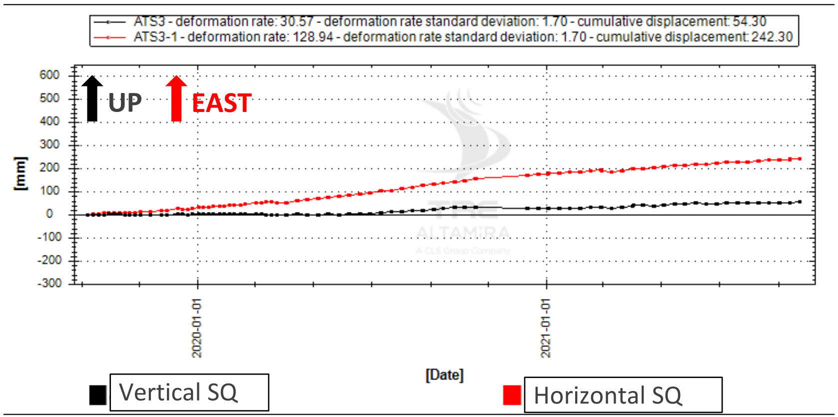

Figure 34: SqueeSAR Time Series for ATS3.

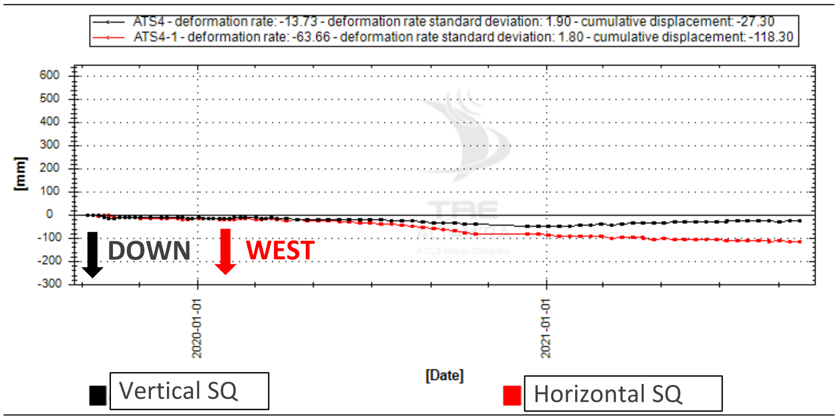

Figure 35: SqueeSAR Time Series for ATS4.

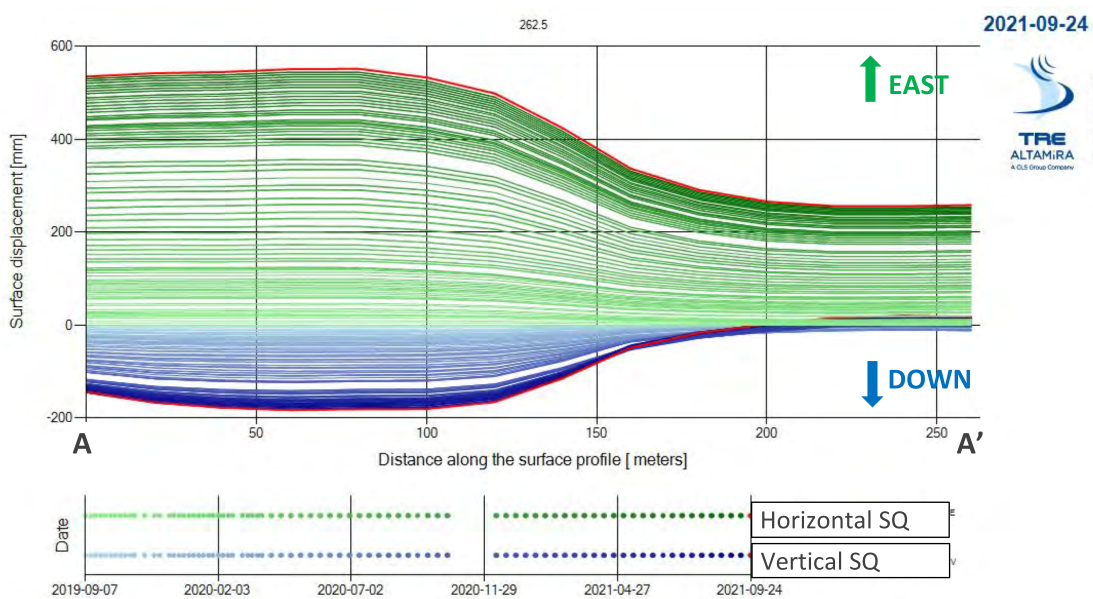

Figure 36: Cross-section along the west wall of the Porcupine Pit. Green lines = horizontal displacement; blue lines = vertical displacement.

4.1.4 Snowshoe & Creek Pit

The LOS results are used to highlight displacement over the Snowshoe and Creek Pit (Figure 37). Localized displacement above the Snowshoe Pit is highlighted by ATS1 in Figure 38 and ATS2 in Figure 39. The Creek Pit has minimal coverage within the LOS results. ATS3 highlights minimal localized displacement away from the satellite in the southern portion of the Snowshoe Pit (Figure 40).

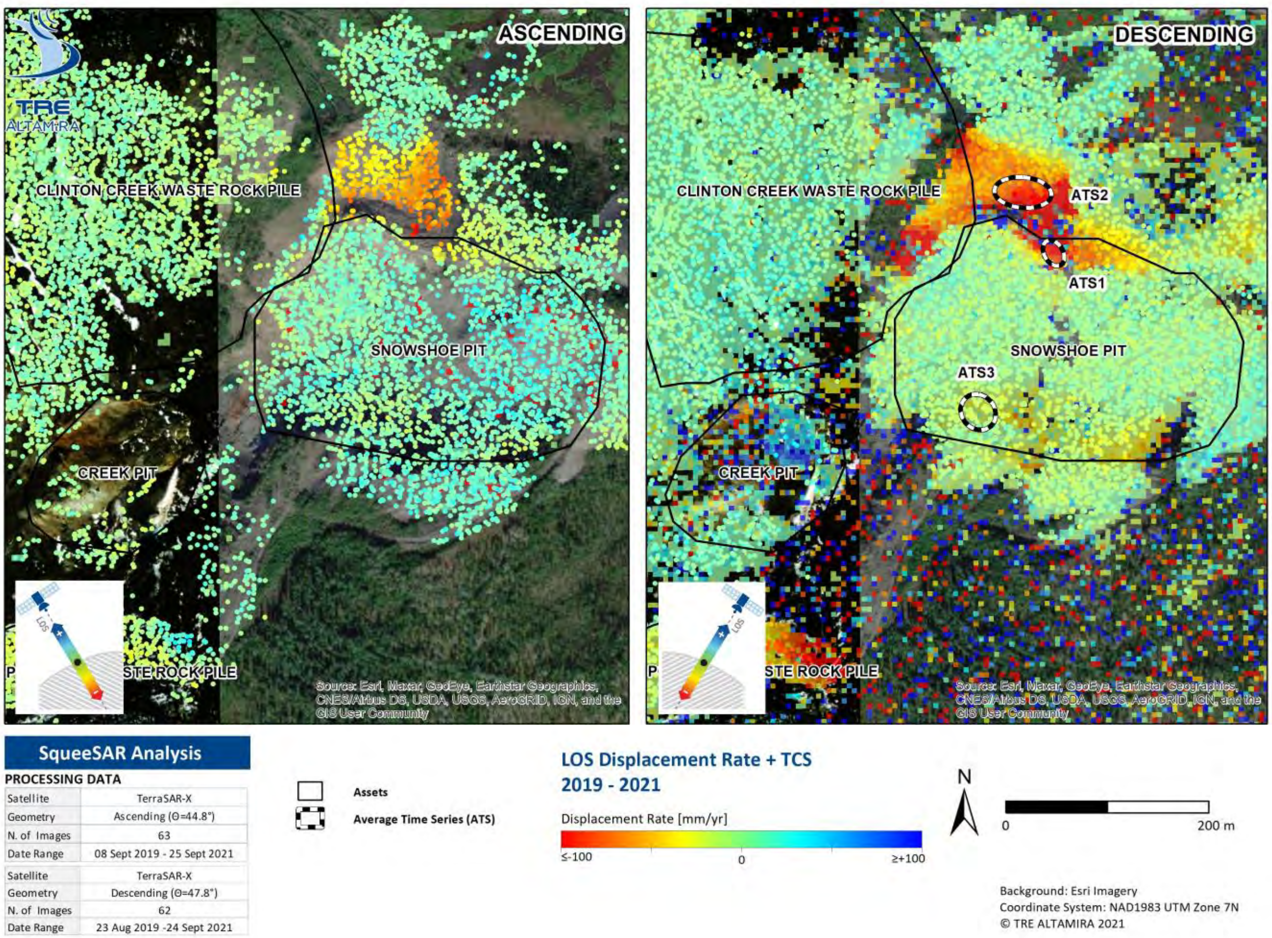

Figure 37: LOS displacement rates and TCS over the Pits from September 2019 to September 2021.

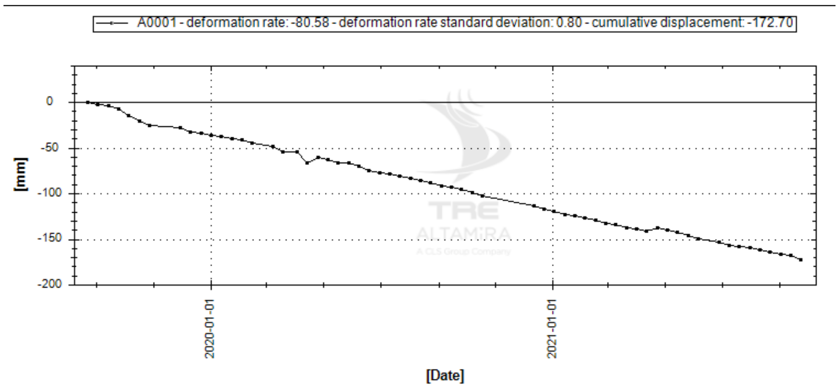

Figure 38: SqueeSAR LOS descending Time Series for ATS1.

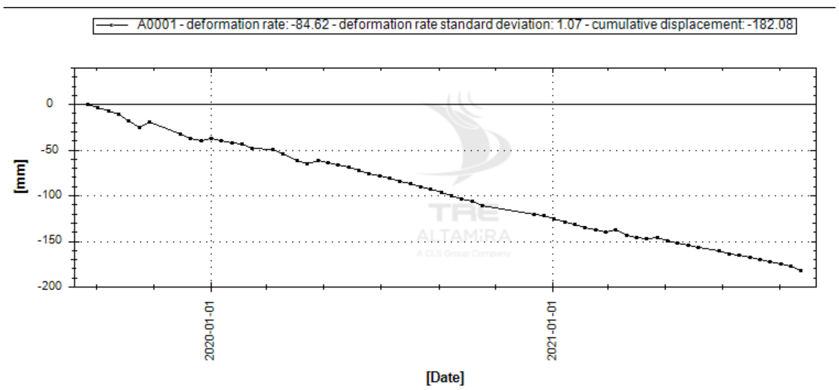

Figure 39: SqueeSAR LOS descending Time Series for ATS2.

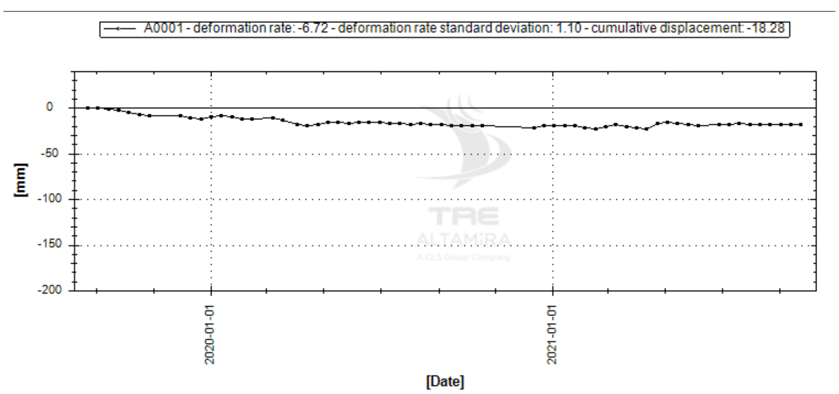

Figure 40: SqueeSAR LOS descending Time Series for ATS3.

4.2. Wolverine Creek Area

4.2.1. North & South Lobe & Wolverine Creek

The 2-D results provide improved MP coverage over the Wolverine Creek and Lobe areas (Figure 41). Eastward movement identified within the South Lobe extends into the southwestern tip of the North Lobe and eastern edge of the Wolverine Creek Waste Pile, increasing gradually from north to south. ATS1 (Figure 42), ATS3 (Figure 44), ATS4 (Figure 45), and ATS5 (Figure 46) highlight this eastward feature and also display the vertical results. ATS2 (Figure 43) highlights displacement at the northeastern corner of the North Lobe while ATS6 (Figure 47) highlights displacement at the boundary of Wolverine Creek and South Lobe.

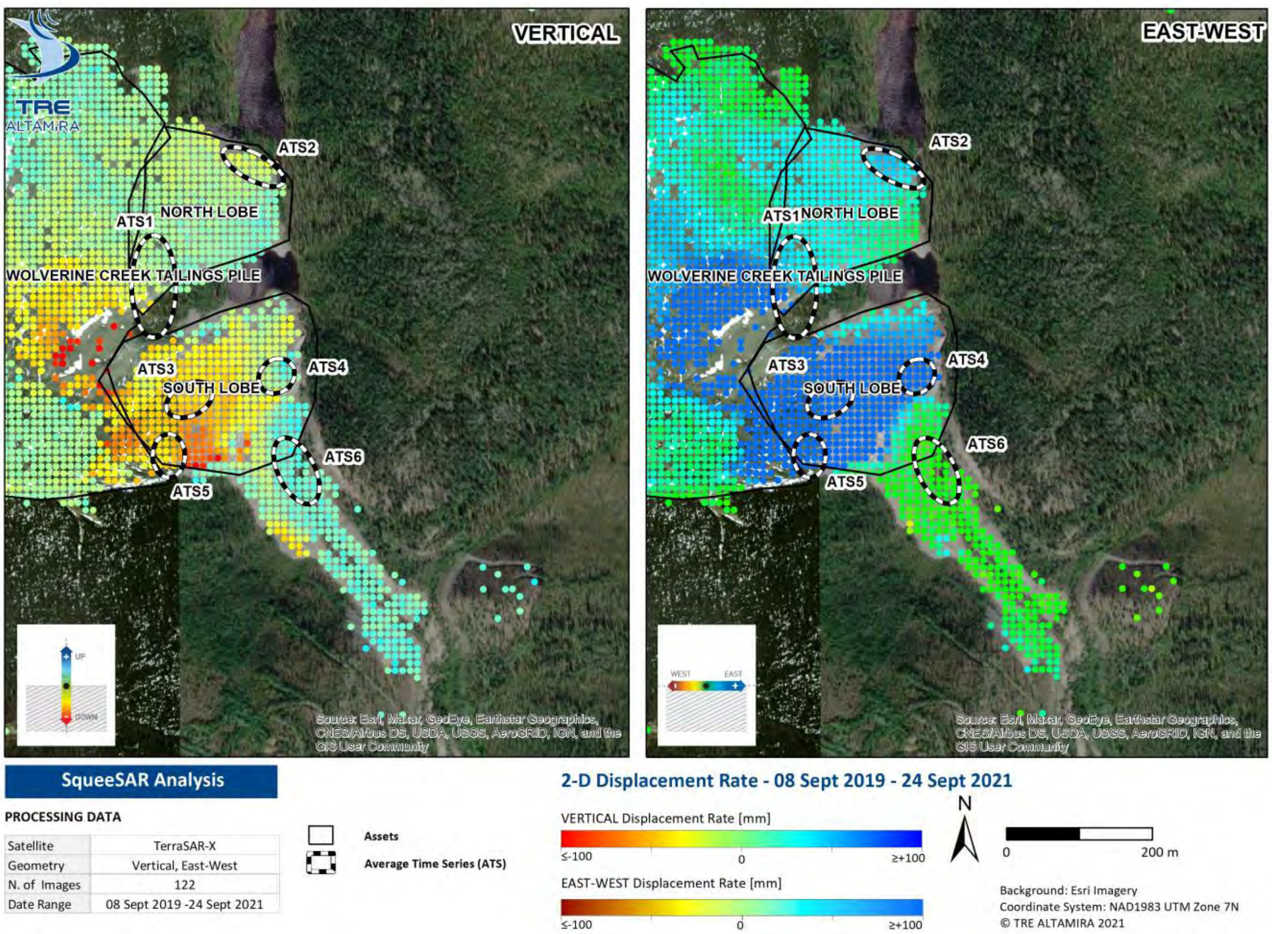

Figure 41: 2-D displacement rates over the Wolverine Creek and Lobe area from 08 September 2019 to 26 September 2020.

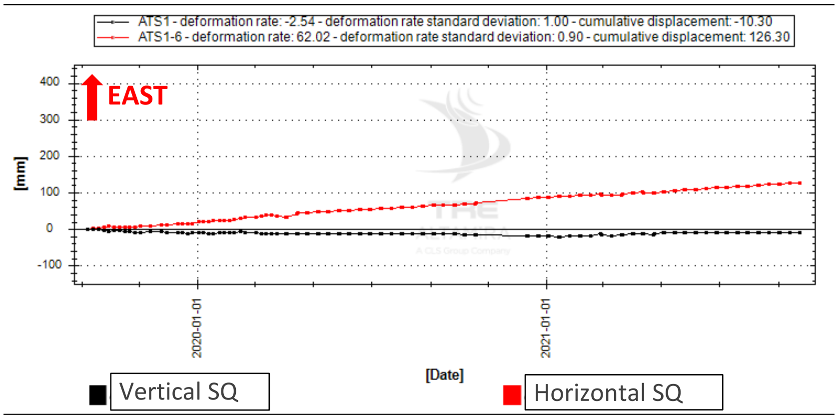

Figure 42: SqueeSAR Time Series for ATS1.

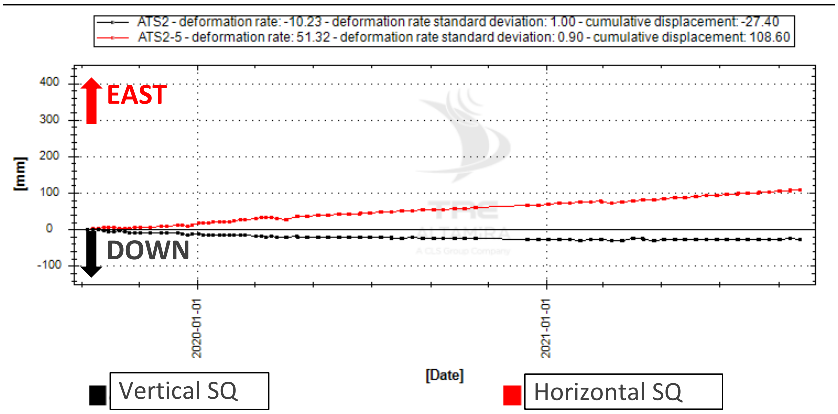

Figure 43: SqueeSAR Time Series for ATS2.

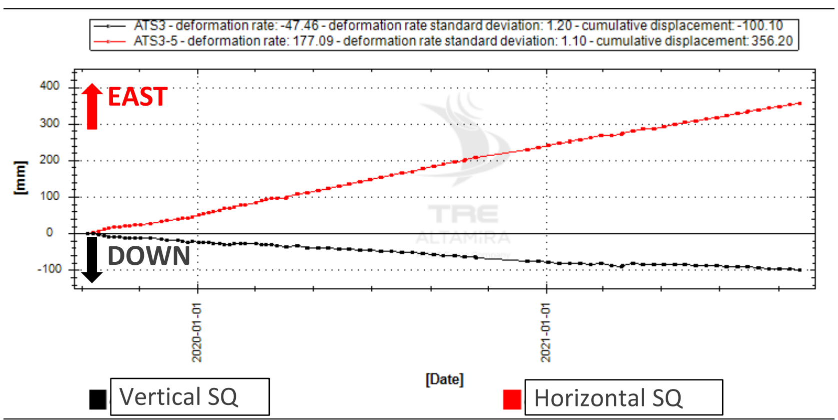

Figure 44: SqueeSAR Time Series for ATS3.

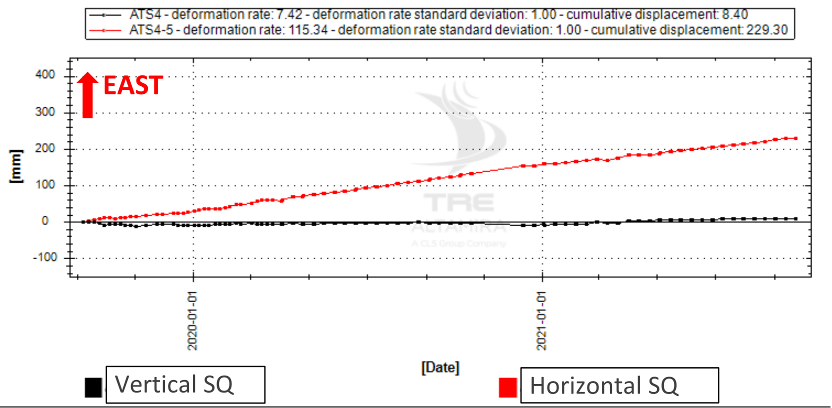

Figure 45: SqueeSAR Time Series for ATS4.

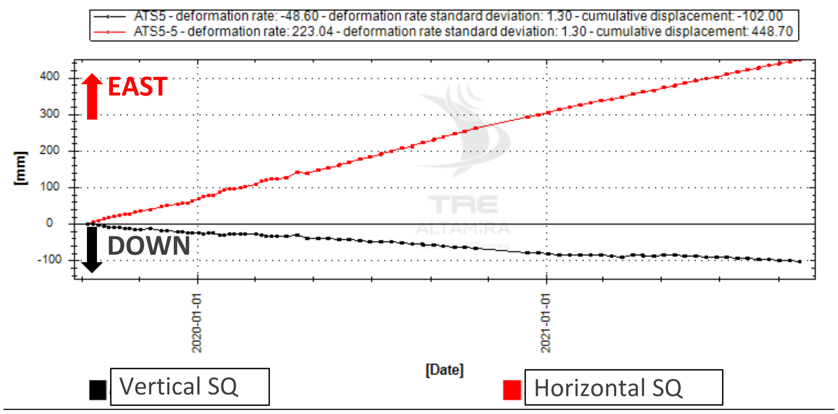

Figure 46: SqueeSAR Time Series for ATS5.

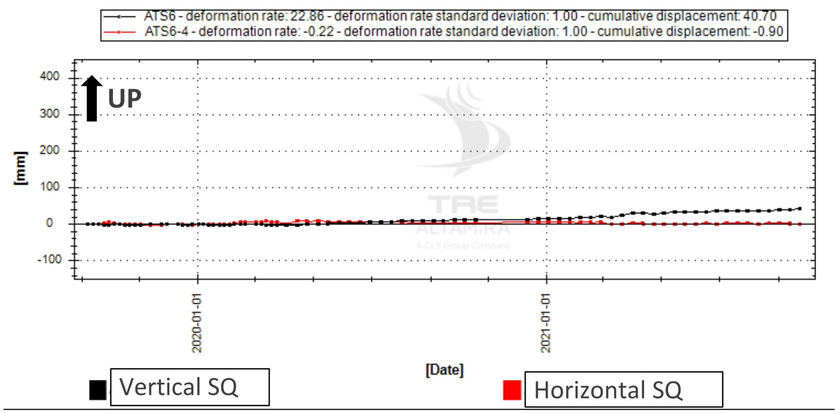

Figure 47: SqueeSAR Time Series for ATS6.

4.2.2. Wolverine Creek Tailings Pile

The 2-D results (Figure 48) are used to highlight displacement information within the Wolverine Creek Tailings Pile. The Wolverine Creek Tailings Pile area is characterized by localized areas of subsidence and eastward displacement. ATS1 (Figure 49) and ATS2 (Figure 50) display averages of the subsidence and eastward displacement observed within the northwestern corner of the tailings pile. ATS3 (Figure 51) highlights a localized feature of eastward displacement not identified in the 2019 monitoring study. ATS4 (Figure 52) and ATS5 (Figure 53) highlight the eastward displacement that reaches into the South Lobe. A cross-section runs along the base of the Tailings Pile and across the southern region of the South Lobe (Figure 48, Figure 54) and uses a buffer of 100 meters with nodes every 25 meters.

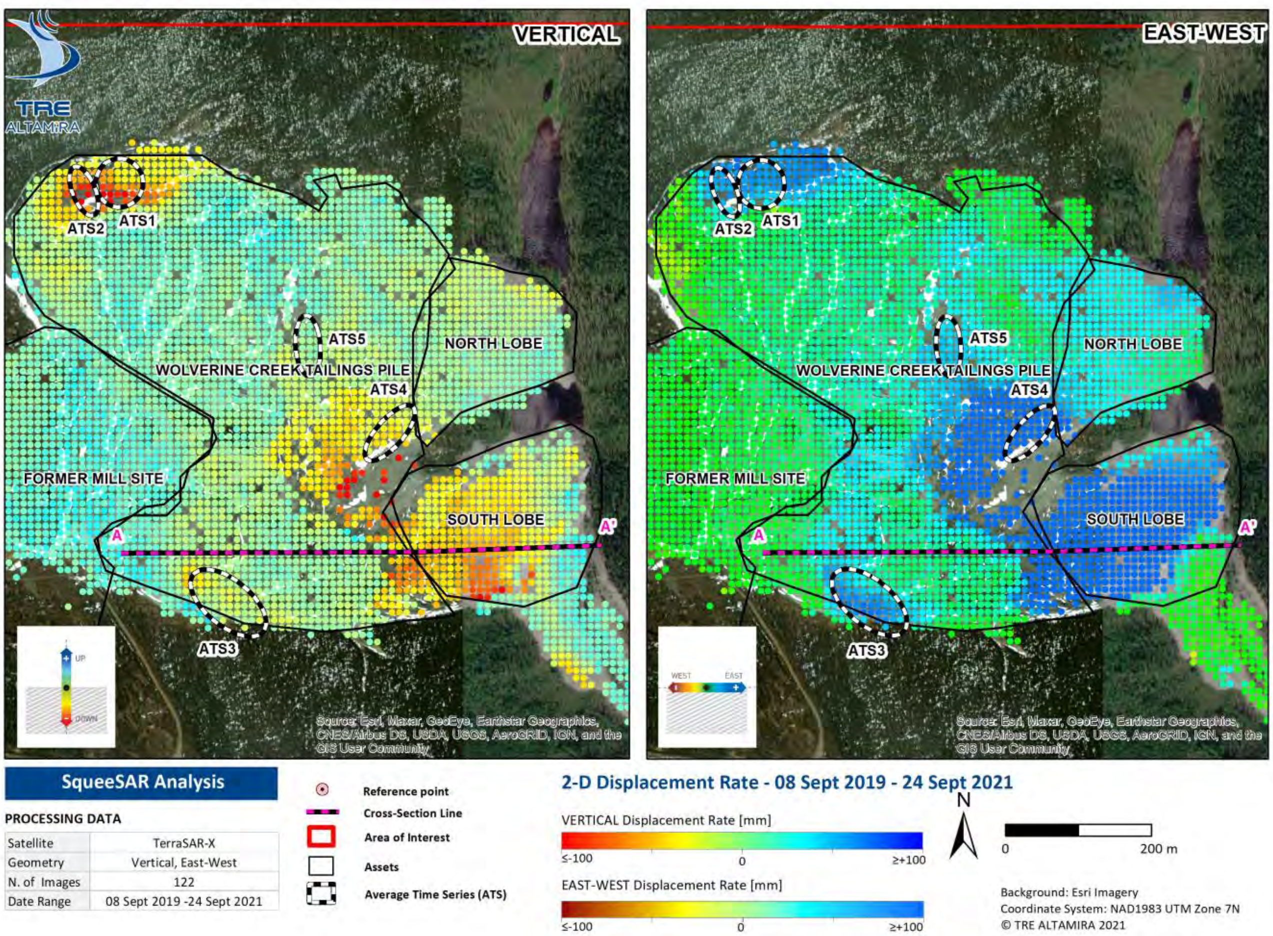

Figure 48: 2-D SqueeSAR displacement rates over the Wolverine Creek Tailings Pile from 08 September 2019 to 26 September 2020.

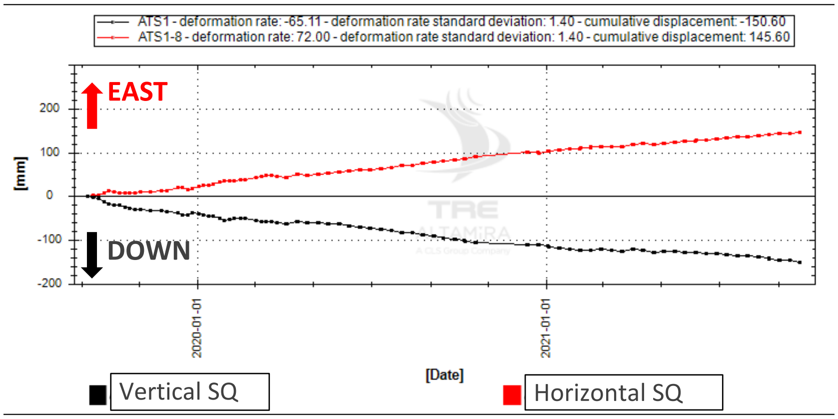

Figure 49: SqueeSAR Time Series for ATS1.

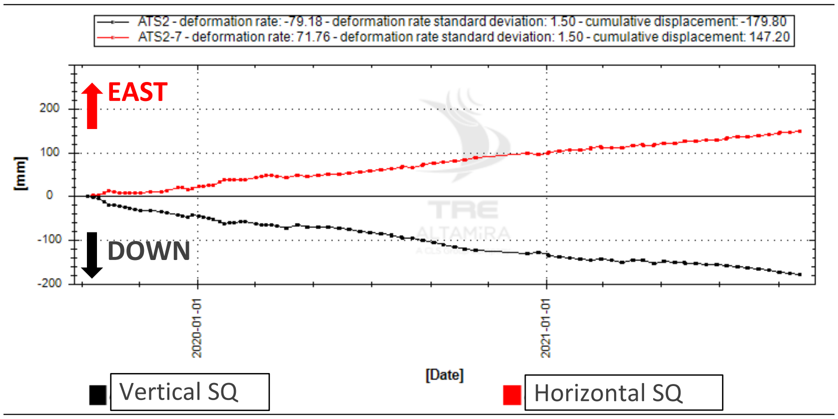

Figure 50: SqueeSAR Time Series for ATS2.

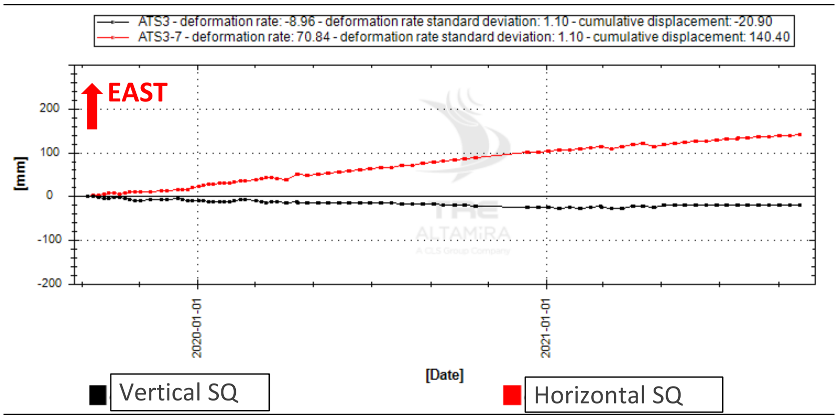

Figure 51: SqueeSAR Time Series for ATS3.

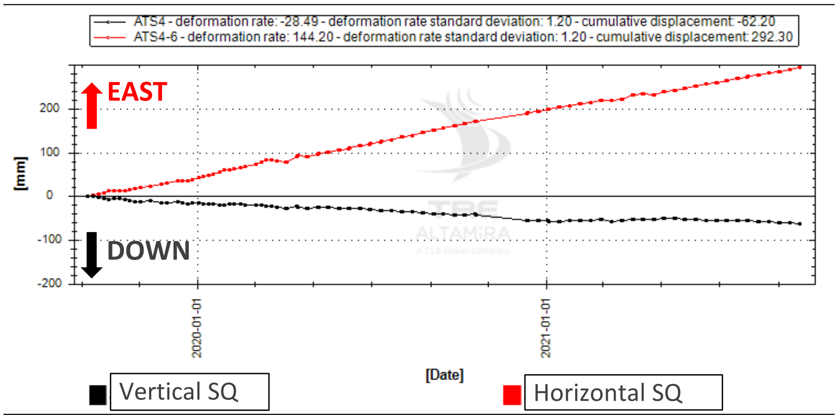

Figure 52: SqueeSAR Time Series for ATS4.

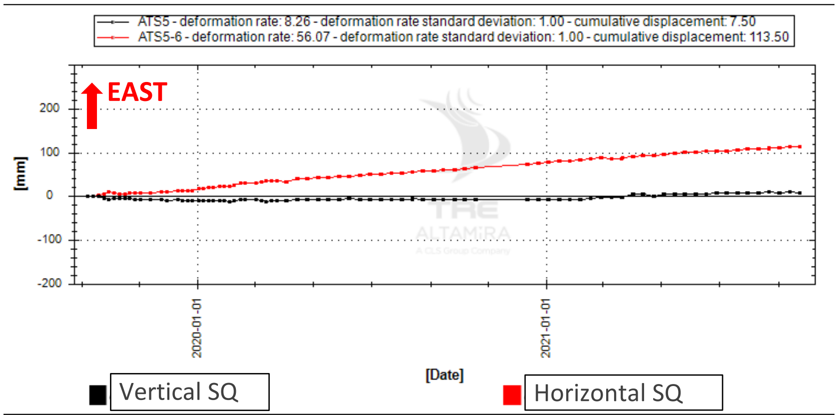

Figure 53: SqueeSAR Time Series for ATS5.

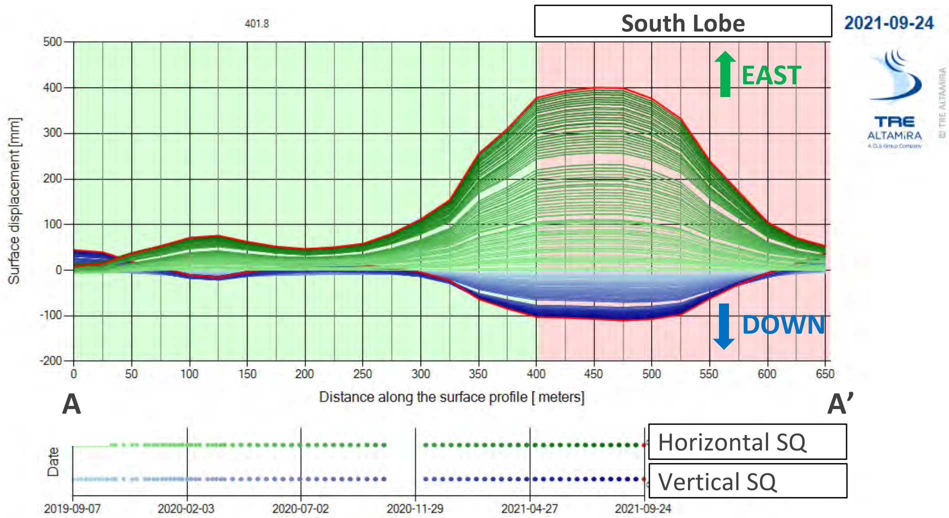

Figure 54: Cross-section along the Wolverine Creek Tailings Pile and South Lobe. Green lines = horizontal displacement; blue lines = vertical displacement.

5. Measurement Precision and Target Density

The SqueeSAR processing of the high frequency TSX/PAZ satellite imagery over a reduced AOI covering the Clinton Creek mine assets has substantially improved the spatial coverage of the ground displacement information (Table 3). **Error! Reference source not found.** compares the current 2021 TSX/PAZ 2-D results to the 2020 TSX/PAZ 2-D and 2019 SNT 2-D monitoring results.

Table 3: Statistics of the LOS SqueeSAR analysis. Current results are highlighted in grey. Fields marked with * were affected by the updated extent of the AOI for the 2021 processing.

	Ascending			Descending		
Processing	SNT 2019	TSX 2020	TSX 2021	SNT 2019	TSX 2020	TSX 2021
Time period (months)	30	12	24	30	13	24
N. of images processed	53	33	63	65	34	62
% of PS	87	15	31	100	21	34
% of DS	13	85	69	0	79	66
Total Number of Measurement Points*	6,375	36,315	73,772	7,815	56,723	60,123
Density (pts/km^2)*	321	1,831	6,199	394	2,860	5,052
Average Displacement Rate Standard Deviation (mm/yr)	±1.2	±2.2	±1.3	±0.9	±2.1	±1.1

Table 4: Statistics of the 2-D SqueeSAR analysis. Current results are highlighted in grey. Fields marked with * were affected by the updated extent of the AOI for the 2021 processing.

	Vertical			East-West		
Processing	SNT 2019	TSX 2020	TSX 2021	SNT 2019	TSX 2020	TSX 2021
Time period (months)	30	12	24	30	12	24
N. of images processed	113	64	122	113	64	122
Total Number of Measurement Points*	206	11,702	14,211	206	11,702	14,211
Average Displacement Rate Standard Deviation (mm/yr)	±0.6	±1.7	±1.1	±0.7	±1.6	±1.0

6. List of deliverables

The SqueeSAR vector data are delivered in a shapefile format with a NAD 1983 UTM Zone 7N Projection and geographic WGS84 coordinates. The shapefile of each elaboration contains details about the measurement points identified, including displacement rate, elevation, displacement, and quality index. The information associated within the database files (dbf) are described in Table 5 and the complete list of delivered data is reported in Table 6.

TRE-ALTAMIRA provides its clients with a toolbar for ESRI® ArcGIS 10.x which allows the final users to easily load, visualize and analyze the SqueeSAR results. For set-up procedure and functionalities, see the attached manual *TREClientToolbarSetup_5.0.pdf*.

Please note that results can be also visualized and downloaded from the TREmaps web-based portal (https://tremaps.tre-altamira.com/). SqueeSAR results are superimposed onto an ESRI background and time-series can be loaded on mouse click. The access to the data is through a secure Client login (only authorised users will have access to the SqueeSAR results). For TREmaps functionalities see: http://tre-altamira.com/tremaps/getting-started/.

Table 5: Description of the fields contained in the database of the vector data. *Field is only present in the LOS datasets.

Field	Description
CODE	Measurement Point (MP) identification code.
HEIGHT [m]	Topographic Elevation referred to WGS84 ellipsoid of the measurement point.
H_STDEV [m]	Height standard deviation of the measurement point.
VEL [mm/yr]	MP displacement rate. ➢ **Ascending LOS:** Positive values correspond to motion toward the satellite (i.e. uplift and/or westward movement); negative values correspond to motion away from the satellite (i.e. subsidence and/or eastward movement). ➢ **Descending LOS:** Positive values correspond to motion toward the satellite (i.e. uplift and/or eastward movement); negative values correspond to motion away from the satellite (i.e. subsidence and/or westward movement). ➢ **Vertical (VEL_V):** Positive values indicate uplift; negative values indicate subsidence. ➢ **E-W Horizontal (VEL_E):** Positive values indicate eastward movement; negative values westward movement.
V_STDEV [mm/yr]	Displacement rate standard deviation [mm/yr].
COHERENCE*	Quality measure between 0 and 1.
EFF_AREA [m^2]	This parameter represents the effective extension of the area covered by Distributed Scatterers (DS). For permanent scatterers (PS), its value is set to 0.
Dyyyymmdd [mm]	Series of columns that contain the displacement values of successive acquisitions relative to the first acquisition available. Displacement values are expressed in mm.

Table 6: List of delivered files.

Deliverable	Description	File name
SqueeSAR Data [WGS84] & [NAD83]	Height, velocity, velocity standard deviation, coherence and timeseries of all the PS and DS identified in the analysis (metric and imperial measurement units)	***Ascending LOS Dataset:*** CLINTON_CREEK_TSX_T31_A_SEP2021_CA3784A1S.shp CLINTON_CREEK_TSX_T31_A_SEP2021_NAD83_CA3784A1S.shp ***Descending LOS Dataset:*** CLINTON_CREEK_TSX_T16_D_SEP2021_CA237842S.shp CLINTON_CREEK_TSX_T16_D_SEP2021_NAD83_CA3784A2S.shp ***2D Decomposed Vertical Component:*** CLINTON_CREEK_TSX_VERT_SEP2021_CA3784A3V.shp CLINTON_CREEK_TSX_VERT_SEP2021_NAD83_CA3784A3V.shp ***2D Decomposed Horizontal (east – west) Component:*** CLINTON_CREEK_TSX_EAST_SEP2021_CA3784A4E.shp CLINTON_CREEK_TSX_EAST_SEP2021_NAD83_CA3784A4E.shp
TCS		***Descending TCS*** Clinton_Creek_TSX_D_VEL_TCS_data.tif Clinton_Creek_TSX_D_VEL_TCS_NAD83_data.tif ***Descending TCS*** Clinton_Creek_TSX_D_VEL_TCS_data.tif Clinton_Creek_TSX_D_VEL_TCS_NAD83_data.tif ***Ascending TCS*** Clinton_Creek_TSX_A_VEL_TCS_data.tif Clinton_Creek_TSX_A_VEL_TCS_NAD83_data.tif
Change Detection		***Cumulative Change Detection Ascending*** ClintonCreek_change_detection_TSX_A_SEP2021_data.tif ClintonCreek_change_detection_TSX_A_SEP2021_NAD83_data.tif ***Cumulative Change Detection Descending*** ClintonCreek_change_map_TSX_D_SEP2021_data.tif ClintonCreek_change_map_TSX_D_SEP2021_NAD83_data.tif
Report	Technical Report	ClintonCreek_TSX_InSAR_Monitoring_Report_2021
MXD	ESRI ArcGIS map document containing all SqueeSAR data and AOI shapefile (in version 10.8 and version 10.0)	ClintonCreek_TSX_October2021.mxd
TRE ALTAMIRA Toolbar	ESRI® ArcGIS 10.x, 9.x Toolbar	TREToolbar_5.0esriAddIn TREClientToolbarSetup_5.0.pdf

7. Summary and Recommendations

The SqueeSAR processing of high-resolution PAZ and TSX spotlight satellite imagery produced LOS and 2-D measurements of ground deformation over Clinton Creek mine that build on the previous low-resolution analysis performed using Sentinel imagery and 2020 high resolution update. The following main points are highlighted:

- Linear displacement prevails within the Clinton Creek Waste Rock Pile, Snowshoe Pit, Wolverine Creek North and South Lobe, and Wolverine Creek Tailings Pile.
- Non-linear deformation is observed at the Drop Structures (deceleration) and Porcupine Pit (summer/fall 2020 acceleration, 2021 deceleration).
- The RMT analysis did not highlight any areas of rapid movement.

The continued use of both ascending TSX and descending TSX+PAZ data allows 2-D monitoring of ground displacement providing nearly full coverage over all mine assets.

The data currently being collected over Clinton Creek could also be used to provide more frequent updates for more operational monitoring and early detection of new areas of movement or for the timely identification of accelerating movement.

TREA recommends the continued use of high resolution TerraSAR-X/PAZ data, as it drastically improves density and delineation of displacement boundaries. The image acquisitions are scheduled to continue until the end of March 2022 - an extension is required (before the end of March 2022) to continue uninterrupted spring and summer acquisitions for 2022.

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APPENDIX D

STABILITY REVIEW OF LOG BOOM ABUTMENTS (IFR)

TETRA TECH

TECHNICAL MEMO

ISSUED FOR REVIEW

To:	Alexander Machica, PMP Project Manager	**Date:**	August 11, 2021
c:		**Memo No.:**	003
From:	Shawn Matthies	**File:**	704-ENG.WARC03956-03
Subject:	Log Boom Abutment Stability Review Clinton Creek Mine, Yukon		

This 'Issued for Review' document is provided solely for the purpose of client review and presents our interim findings and recommendations to date. Our usable findings and recommendations are provided only through an 'Issued for Use' document, which will be issued subsequent to this review. Final design should not be undertaken based on the interim recommendations made herein. Once our report is issued for use, the 'Issued for Review' document should be either returned to Tetra Tech Canada Inc. (Tetra Tech) or destroyed.

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch (YG-AAM) to carry out the 2021 Long-Term Performance Monitoring Program (LTPMP) at the abandoned Clinton Creek asbestos mine, located near Dawson City, Yukon.

As a part of the LTPMP, Tetra Tech has completed a review of the stability of the log boom abutments at the Hudgeon Lake outlet to evaluate the amount and potential impact of frost jacking, which is believed to be affecting the abutment foundations.

2.0 LOG BOOM ABUTMENT STABILITY REVIEW

2.1 General

Tetra Tech has reviewed the installation report for the log boom abutments, prepared by Boreal Engineering Ltd. (BEL), dated January 14, 2014. The report is included in Appendix B and includes as-built drawings and survey data. As described in the installation report, the log boom abutments consist of triangular steel frames, each with three, 3 m-long, 200 mm diameter post foundations. Pressure-treated wood boards were placed along the rear face of each abutment. The abutments were installed with the 3 m-long foundation nearly completely embedded in the ground on the rear side of the abutment, with reduced embedment (approx. 1.5 m) for the third post, which was installed nominally at the water's edge in Hudgeon Lake.

Photos showing the as-built condition of the log boom abutments and the condition during the 2021 geotechnical site visit are included in the attached Photographs section.

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2.2 Horizontal Displacement

Horizontal displacement of the log boom abutments can be determined by comparison of the coordinates (UTM northing and easting) of the abutment post foundations that are surveyed as part of the annual LTPMP program. Horizontal displacement for post foundations S-2 and N-2, respectively located at the south and north abutments, is presented in Figure 1.

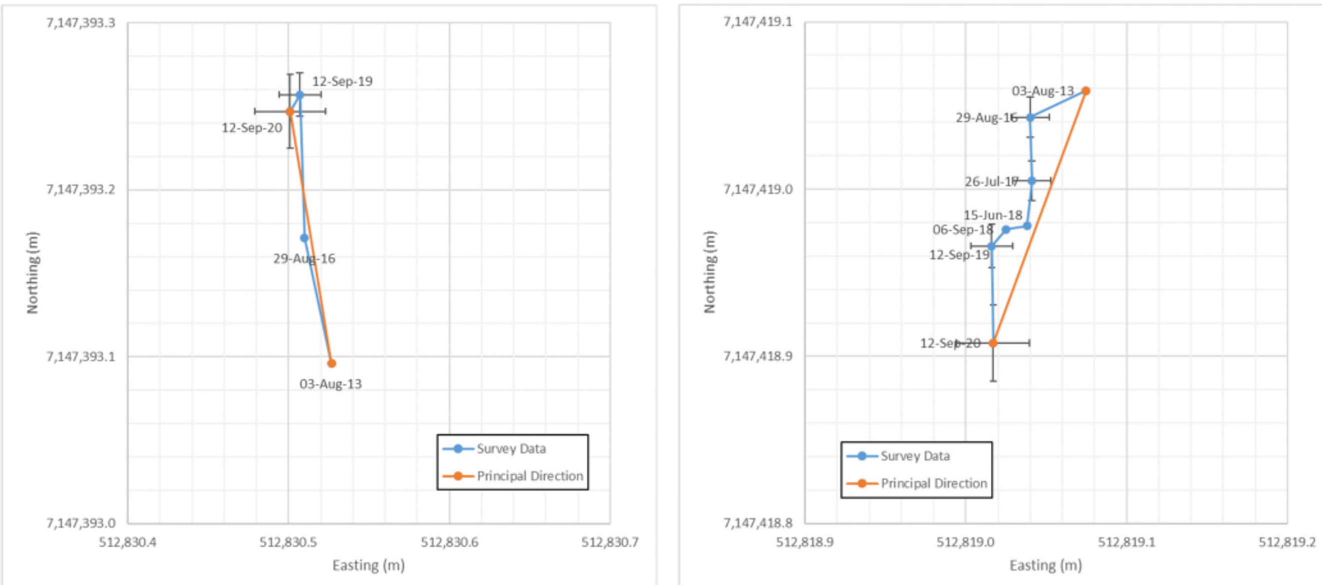

Figure 1: Horizontal displacement of south abutment post S-2 (left) and north abutment post N-2 (right)

The south abutment post S-2 moves at an average rate of about 2 cm per year to the north, which is the general direction of the lake shore. The other posts at the south abutment (S-1 and S-3) move at a similar rate and direction. The north abutment post N-2 moves at an average rate of about 2 cm per year to the south-southwest, which is also generally towards the lake shore. The other posts at the north abutment (N-1 and N-2) move at a similar rate and direction. All of the abutment posts have moved between about 10 to 20 cm in total since they were installed in 2013, generally towards Hudgeon Lake.

The observed movement of the abutments towards Hudgeon Lake is believed to be mainly related to settlement and lateral spreading of the waste rock in the direction of the free face (i.e., the slope of the lakeshore). Visual inspection of the log boom abutments during the annual LTPMP has detected cracking on the ground surface around the abutments and along the lake shore, which is consistent with lateral spreading of the waste rock towards the lake.

There is no evidence that loading from the log booms, which would be directed away from the water, has caused any significant foundation movement or distress.

2.3 Vertical Displacement

As-built elevations for the tops of the post foundations were compared to survey results from the annual LTPMP to estimate the amount of movement that has occurred at the two abutments since installation. A summary of the as-built and most recent survey data and the estimated vertical displacement is shown in Table 1 and illustrated in Figure 2. From inspection of the table and figure, it is apparent that significant vertical displacement has occurred at both abutments; about 0.25 m on average at the south abutment, and more than about 0.5 m at the north abutment.

Before 2019, the LTPMP survey included surveying the ground surface adjacent to each post, but not the top of the post itself. Therefore, only a limited number of survey points is available for five of the six posts. However, post N-2 at the north abutment is used as a benchmark in the annual LTPMP survey and more data is available for this post, including from 2018 when both a spring and fall survey were completed. The data collected in 2018 shows a seasonal pattern of vertical displacement that suggests frost jacking, with uplift (jacking) in the winter as the ground freezes (between September 2017 and June 2018) followed by partial relaxation and settlement in the summer as the ground thaws (between June and September 2018).

Table 1: Log Boom Abutment Survey Data and Vertical Displacement

Post Foundation	August 3, 2013 (As-Built)			September 12, 2020			Vertical Displacement (m)
	Northing (m)	Easting (m)	Elevation (m)	Northing (m)	Easting (m)	Elevation (m)	
S-1	7,147,392.74	512,827.83	413.165	7,147,392.92	512,827.76	413.473	+ 0.308
S-2	7,147,393.10	512,830.53	413.180	7,147,393.25	512,830.50	413.398	+ 0.218
S-3	7,147,390.53	512,829.50	413.251	7,147,390.71	512,829.43	413.508	+ 0.257
N-1	7,147,416.37	512,819.51	413.054	7,147,416.19	512,819.47	413.534	+ 0.480
N-2	7,147,419.06	512,819.07	413.073	7,147,418.91	512,819.02	413.591	+ 0.518
N-3	7,147,418.04	512,821.65	413.054	7,147,417.94	512,821.60	413.618	+ 0.564

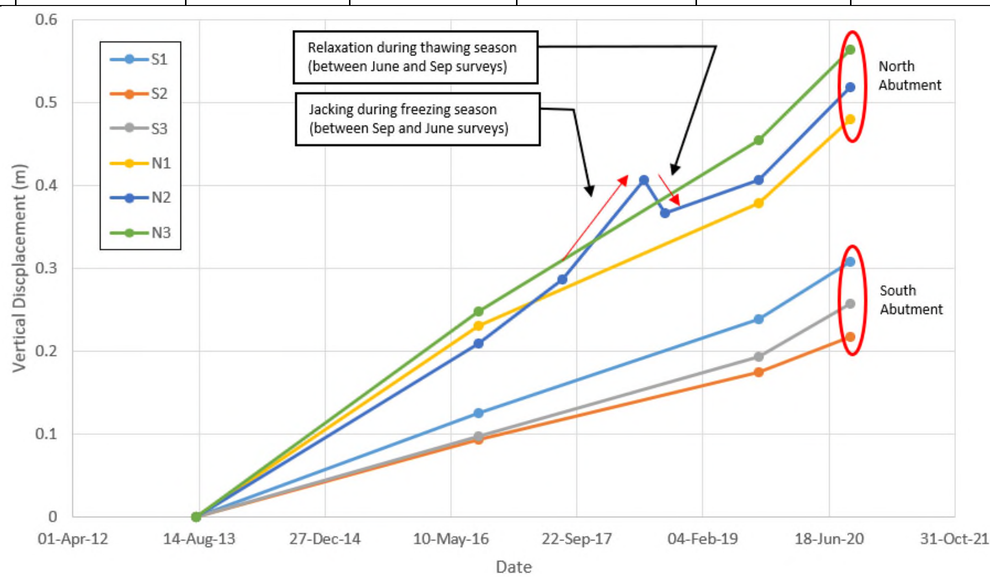

Figure 2: Vertical displacement of post foundations at log boom abutments

2.4 Estimated Embedment Depth

The embedment depth of each post foundation was calculated by comparing the top of post elevation with the surrounding ground elevation and is presented on Table 2. The as-built embedment was estimated using the ground elevations surveyed in 2020, since the as-built ground elevation was not surveyed in 2013. From inspection of as-built photographs in BEL's report, it appears that the actual as-built embedment was greater than shown on the table, which suggests that some post-construction ground settlement has occurred around both abutments. Abutment embedment depths are shown in Table 2.

Table 2: Log Boom Abutment Embedment Depths

Post Foundation	Post Length	Embedment Depth		
		August 3, 2013 (As-Built)	September 12, 2020	% of As-Built
S-1	3 m	1.15 m	0.84 m	73%
S-2	3 m	2.22 m	2.00 m	90%
S-3	3 m	2.31 m	2.05 m	89%
N-1	3 m	1.46 m	0.98 m	67%
N-2	3 m	2.11 m	1.59 m	75%
N-3	3 m	2.15 m	1.58 m	74%

2.5 Estimated Lateral Resistance

Lateral resistances were estimated using Coulomb's theory of lateral earth pressure, assuming passive conditions with a passive earth pressure coefficient (K_p) of 3.0 and a soil unit weight of 22 kN/m^3. Estimates of lateral resistance are presented below in Table 3. The lateral resistances presented on the table assume passive earth pressure developing on the area of the wooden boards on the inland/upslope side of the abutment. The embedment depth of the abutment posts/boards and the groundwater elevation were assumed based on the 2020 LTPMP survey. The lower estimated resistance at the north abutment is due mainly to the greater amount of frost jacking and reduced embedment depth compared to the south abutment.

Table 3: Estimated Lateral Resistances for Log Boom Abutments

Location	Estimated Lateral Resistance
South Abutment	259 kN
North Abutment	152 kN

3.0 DISCUSSION AND RECOMMENDATIONS

From review of the available survey data, the south and north abutments have been jacked upward by an average of about 260 and 520 mm, respectively, since construction in 2013. Upward movement due to seasonal frost jacking is expected to continue if remedial work is not completed.

The seasonal freeze-thaw cycle may eventually jack the log boom abutments completely out of the ground. The abutments would likely fail under loading from the log boom abutments before this happens. Failure of the abutments with the log booms installed would likely result in the log boom and any retained debris entering the Clinton Creek channel, which could obstruct flow in the creek and/or damage the gabion drop structures. Horizontal movement of the log boom abutments has typically been limited to a few centimeters per year (toward the lake), which suggests that the abutments are able to withstand loading from the log booms. However, lateral resistance of the abutments will progressively decrease as the embedded length of the post foundations continues to be jacked out of the ground. Loading from the log boom abutments could be estimated and compared to the estimated lateral resistance at the abutments in order to estimate the minimum embedment depth where abutment failure might occur.

Frost jacking can be prevented, and long-term stability of the abutments can be improved by re-installing the abutment foundations using compacted, non-frost susceptible backfill, which generally consists of coarse sand and/or gravel fill with less than 10% fines content by weight (percent passing the No. 200 sieve). The abutments could also be modified to include a bottom plate or mesh to mobilize the weight of the soil mass enclosed within the abutment posts to provide additional resistance to potential frost jacking forces.

Tetra Tech recommends continuing to use the log booms during the summer months, while Hudgeon Lake is unfrozen, and continuing to monitor the abutments for signs of continued frost jacking and/or accelerating horizontal movement. Monitoring should consist of visual inspection and surveying as scheduled in the annual LTPMP, and additional survey whenever survey crews are available at the site on other business.

4.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

5.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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/cr

Enclosure: Photographs
Appendix A - Limitations on the Use of this Document
Appendix B – Boreal Engineering Ltd. Report on 2013 Site Works

PHOTOGRAPHS

Photo 1: South Log Boom Abutment showing the as-built condition in 2013, facing east.
Photo taken by Boreal Engineering Ltd.

Photo 2: South Log Boom Abutment showing the condition during the 2021 geotechnical site visit, facing northeast.
Photo taken by Shawn Matthies, June 16, 2021.

TETRA TECH

Photo 3: North Log Boom Abutment showing the as-built condition in 2013, facing south. Photo taken by Boreal Engineering Ltd.

Photo 4: North Log Boom Abutment showing the condition during the 2021 geotechnical site visit, facing west.
Photo taken by Shawn Matthies, June 16, 2021.

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – YUKON GOVERNMENT

1.1 USE OF DOCUMENT AND OWNERSHIP

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The Professional Document is intended for the use of TETRA TECH's Client, its officers, employees, agents, representatives, successors and assigns (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH. Any changes to the conclusions, opinions, and recommendations presented in TETRA TECH's Professional Document must be authorized by TETRA TECH.

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Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems, as per agreed project deliverable formats. TETRA TECH makes no representation about the compatibility of these files with the Client's future software and hardware systems.

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Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be brought to the attention of TETRA TECH within a reasonable time.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, and subject to the standard of care herein, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage, except where TETRA TECH has subcontracted for such information.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to make, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the Client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.8 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.9 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.10 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.11 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.12 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.13 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.14 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.15 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.16 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.17 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.18 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.19 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

BOREAL ENGINEERING LTD. REPORT ON 2013 SITE WORKS

Appendix A:

Implementation of Immediate Actions at the Former Clinton Creek Asbestos Mine Site (Boreal, 2014)

Contains: Log boom specifications, as-built drawings, tools and equipment list, and installation/removal procedures

Government of Yukon
Energy Mines and Resources
Assessment and Abandoned Mines

Implementation of Immediate Actions at the Former Clinton Creek Asbestos Mine Site

January 18, 2014

Erik Nyland, P.Eng.

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Introduction

Boreal Engineering Ltd. (BEL) was contracted by Assessment and Abandoned Mines (AAM) to implement immediate actions at the former Clinton Creek asbestos mine site. These works were completed during the 2013 summer season.

Project Purpose and Objective

During the Performance Monitoring Program completed in August 2012, several items/areas of concern were identified and direction was provided that access to the site should be closed until these were addressed. The consultant, Associated Engineering, provided a list of immediate actions that should be undertaken prior to allowing government personnel and contractors access to the site. This project was required in order to ensure that human health and safety is protected and so that various works can continue at the site (i.e. provide workers with safe access to the site for monitoring, care and maintenance and remedial works). The purpose of the work was to address those immediate actions provided by the consultant in order to mitigate several specific safety hazards at the site (i.e. as identified in the 2012 technical memo titled *Inspections at the Clinton Creek Site during August 6 to 8, 2012)*.

Scope of Work

The scope of work included:

1. Repair of sections of site roads;
2. Closure of various sections of site roads through the installation of barricades;
3. Scaling of rocks above sections of site roads;
4. Installation of warning signage;
5. Construction and installation of a log-boom at the outlet of Hudgeon Lake; and
6. Removal of beaver dams and brushing within the high-water mark on Wolverine Creek.

Work Summary

Health and Safety

BEL was responsible for on-site health and safety, although the Health and Safety Plan was developed by the owner with input from BEL.

Personnel

Personnel used for this project, and their roles in the project were as follows;

- Erik Nyland, P.Eng, Project Manager and Project Engineer
- Craig Bibby, Safety and First Aid, Labourer
- Ian Nyland, Labourer and Equipment Operator/Truck Driver
- Heiko Nyland, Labourer

Equipment

Equipment utilised over the course of the project included:

- Kenworth truck and low-bed trailer
- Emergency transport vehicle
- Dodge pickup with slip tank
- Travel trailer camp

- Kawasaki Mule RTV
- 226B Cat skid steer loader
- KX080-4 Kubota excavator

Tools

Tools required for the tasks included:

- Gas powered cement mixer
- Gas powered generator
- Plate packer
- Electric hammer drill with concrete bits
- Chain saws (2)
- Hand tools including axes, shovels, wrenches etc.
- Chains, slings and tie downs
- Water Pump and hose
- Slide hammer for signs

Principal Work

The following is a summary of how the scope of work was achieved:

1. **Repair of sections of site roads**

   Road repairs throughout the site were completed under the supervision of BEL as well as the AAM representatives, Brett Hartshorne and Erik Pit. Gammie Trucking of Dawson provided a Hitachi ZX200 LC5 excavator and operator to carry out the work. The preliminary reconnaissance trip revealed that the site access road from the Forty Mile River Bridge to site had previously been repaired so it was not necessary to spend time and budget addressing that portion of the road. The excavator was used to address sections of the access road which were susceptible to or affected by landslides, to modify the crossing at Clinton Creek to allow access with the truck and low-bed, and it was further used to repair eroded sections of the road.

2. **Closure of various sections of site roads through the installation of barricades**

   Those roads identified to be closed were blocked with the use of "lock-block" gates secured by a 12.5 mm chain and locked with padlocks. The lock-blocks were placed with the excavator. Upon placement, the blocks were drilled for installation of Hilti mechanical expanding anchors to hold the gate/sign posts. Berms and boulders were also installed at secondary access points to certain locations.

   A swinging gate was installed at the location approved by the engineer and the AAM representative near the confluence of Wolverine Creek and Clinton Creek (i.e. the site entrance). This gate was secured by a lock that is keyed alike all of the other locks. Both the gate post and the tie post were installed per the design using concrete in the post holes. After construction, this gate was tampered with and taken off the hinge post; repairs will be completed by BEL later in the fall, 2013. See Appendix A for locations of gate and barricades.

3. **Scaling of rocks above sections of site roads**

   On the waste rock pile, an erosion gully had exposed a large rock above the road which poses a threat to the travelling public. This rock was removed with the use of the excavator and was rolled to a location below the road. After the removal operation was completed the road was cleaned and the rock placed to one side away from the travelled portion of the road. The work was completed by the excavator.

4. Installation of warning signage

Total of 24 signs were installed at site including:

a. 1 of `*No Access Beyond this Point*'
b. 2 of `*No Vehicle Access Beyond This Point*'
c. 2 of `*Slide Hazard Do Not Stop For 300 m'*
d. 2 of `*Slide Hazard Next 3 km'*
e. 10 of `*Road Closed*'
f. 4 of `*Soft Shoulder'*
g. 1 information sign provided by AAM
h. 2 Staff Gauges

Further to this, two more signs supplied by AAM were removed from the junction of the Clinton Creek Road and the Yukon River Fish Camp Road and re-installed at the junction of the Clinton Creek Road and the Top of the World Highway. The signs had inadvertently been installed in the wrong location. See Appendix A for locations of warning signage.

5. Construction and installation of a log-boom at the outlet of Hudgeon Lake:

The log boom was constructed as per the drawings developed previously by BEL. The two HDPE pipes required for the log-boom were delivered to site using the BEL truck and low-bed trailer. The end caps and abutment anchors for the log-booms were manufactured by Mobile Maintenance Services of Whitehorse. BEL had originally intended to pressure test the log-booms (i.e. with the end caps installed) in Whitehorse prior to mobilizing to site, however, due to a delay in the manufacturing of the end caps and the timing of the equipment availability on the site, the pipes were delivered to the site prior to the installation of the end caps. The end caps were installed on site and sealed as planned using silicone sealant. Due to an incompatibility between the HDPE and the sealant the connection between the caps and the pipes were not found to be water proof resulting in a necessity to remove the pipes from the water and transport back to Whitehorse for resolution. A final solution was found with the assistance of the HDPE pipe manufacturer, Wolseley Engineered Pipe Group, to install preformed polystyrene foam into the pipes and use the manufacturer's recommended method of using a roofing tar to seal the end caps to the pipe (see Appendix D). The polystyrene foam has now been installed and the end capes sealed with the roofing tar; although at this time the log-booms are stored in the BEL yard in Whitehorse and it is the intent that they be transported to site after freshet (i.e. Spring 2014) and installed as per the original intention.

Log Boom Properties:

Length	15.24 m
Inside Diameter	0.582 m
Wall Thickness	0.085 m
Outside Diameter	0.752 m
Inside Volume	4.054 m³
Total Volume	6.769 m³
Volume of HDPE	2.715 m³
Density of HDPE	0.93 g/cm³
Mass of HDPE	2,525.0kg
Mass of 2 end caps	440 kg
Mass of 1 Log Boom	2,965.0 kg
Total Water Displacement	6,764 kg
Outside Diameter of Foam Insert	0.552 m
Volume of Foam Insert	3.647 m³
Vol of Voids in Pipe	0.407 m³
Mass of Water in Voids	407 kg
Water Absorption of Foam Insert	145.9 kg
Mass of Log Boom Saturated	3,517.9 kg

Details of the calculations can be found in Appendix F.

The Log Boom with the foam, and assuming that the sealant does not remain watertight and allows water to enter the pipe, has a total mass of 3,513.3 kg per section, including 4% water absorption of the foam and all cavities in the pipe are filled with water. Total displacement of the log boom per section is 6,764 kg. This results in approximately 52% submergence, of each section. The diameter of each section is 762 mm so approximately 400 mm of the log boom will be submerged and 362 mm will be above water. The weight of the log boom is equal to the weight of water it displaces when the log boom is 52% submerged, so the remainder of the log boom (48%) will remain above the level of the water.

Installation of the abutment anchors was completed as per the drawings and the approval of the engineer. They were installed as intended and a plate packer was used to compact the backfill. Rip rap was placed around the base of the abutment to mitigate some erosion concern however due to the nature of the soils the entire area may be subject to deterioration during a high flow event.

6. Removal of beaver dams and brushing within the high-water mark on Wolverine Creek

Removal of the beaver dams was done by hand, utilising labourers provided by BEL. Dam materials were removed by hand using pike poles, mattocks and shovels. Materials removed were placed above the high water mark at the side of the stream. The recommendations of the design report were followed.

A portion of this work also included the removal of foliage within the stream, back to approximately one meter above the high water mark in the rock weir channel. Brush removed was placed away from the stream bed and out of reach of any future high water events. Tools included chain saws and axes.

Secondary Work

Over the course of the project it became apparent that there were tasks which should be completed that were outside the original scope of work.

These tasks included:

- GPS survey of all installed items;
- Removal and re-install of the two signs;
- Remove a ladder from the abandoned drill to restrict public access;
- Place "*Warning – Keep Off*" signs on the abandoned drill and shovel ;
- Erosion prevention tasks by placing boulders at the toe of the slope near Clinton Creek;
- Grading a sloped area to allow for installation and removal of the log-booms from Hudgeon Lake;
- Excavation of rocks from the log-boom locations to allow sufficient water depth for floatation;
- Erosion protection near the confluence of Wolverine Creek and access road by placing large rocks on the downstream side where water had previously flowed over the road; and
- Clearing of a blocked culvert at the confluence of Wolverine Creek and access road.

Schedule

The following is an account of when the work was completed:

- **July 18:** BEL first mobilized to the site on July 18 and met the Gammie Trucking excavator operator on site which had also arrived that morning. The excavator made some modifications to the Clinton Creek crossing (i.e. regarding) to allow access for the BEL truck and low-bed. The truck and low-bed had some difficulty climbing the hill on the south side of the creek and 6 of the 12 lock blocks had to be removed from the trailer to get the truck up the hill. Once through the creek and up the hill the first 6 blocks were off loaded at each required location and the truck and low-bed returned to reload the other blocks for distribution. On that day the labourers began the clearing of the beaver dams and brushing along Wolverine Creek.
- **July 19:** Beaver dam removal and brushing in the creek was continued and the remainder of the blocks were distributed. Some of the sign posts were installed as well on this day.
- **July 20:** The remainder of the sign posts were installed and the removal of the beaver dams and brushing of Wolverine Creek were completed. BEL demobilised back to Whitehorse to get more materials.
- **July 22:** 5 more lock-blocks were loaded with the pipes and the abutments for the debris boom, and transported to Dawson.
- **July 23:** The materials were transported from Dawson to the site and one of the abutments was installed. On this day the posts were attached to the lock blocks with the Hilti drill and the Hilti bolts.
- **July 24:** The second abutment was installed. The remainder of the blocks were distributed as required and the excavator removed the large rock from the steep slope above the road. The road was then widened and some erosion prevention work was completed at the toe of the slope near Clinton Creek. The culvert

was cleaned at the site entrance gate and holes were excavated for installation of the swinging gate. BEL and Gammie Trucking demobilized from site.

- **July 30:** BEL mobilized to site again to install the caps on the pipes and place the log-booms in the water. Two of the caps were installed on that day and were sealed to the pipe with silicone.
- **July 31:** Two more caps were installed and the pipes were placed in the water.
- **August 1:** It was discovered that the sealant had not sealed the end caps and that the pipes were partially filled with water. The pipes were pumped out, removed, and placed on the shore.
- **August 2:** The abutments were surveyed using a level, the sign installation was completed and the staff gauge posts were placed. BEL then demobilized to Whitehorse to determine a solution to the sealant issue.
- **September 7:** BEL returned to site with a Kubota KX 080-4 excavator to load the log-booms and transport them to Whitehorse. The intention was to install flotation foam into the pipes in Whitehorse. At that time the skid steer loader was also loaded with the pipes and returned to Whitehorse. The excavator remained at site.
- **September 28**: BEL returned to site to use the excavator to grade the ramp to be used to remove the pipes from the water, grade the bottom of the lake at the location for the pipes and demobilize the excavator. At this time all items included in the project were surveyed using the BEL RTK GPS survey instrument. The data is attached.

At this time the pipes remain in Whitehorse and will be transported to site again in 2014, post freshet, and re-installed.

Recommendations

Some erosion protection has been placed around the foundation of the abutments however some consideration should be given to improving this. During a high flow event there is a possibility that the materials around the abutment may erode and potentially destabilize the structure. Some materials are located nearby and a further quantity is located near the entrance to the site. Some analysis and design work should be undertaken to assess stream flow velocities, soils properties, rip rap sizing, and extents of the protection. There is a possibility that the materials at the connection between the pipe and the abutment could erode faster due to the flow being directed to this area by the floating pipe.

The log booms have been designed to withstand summer conditions only and will need to be removed seasonally. A procedure has been developed for this process and is included within this report (see Appendix B). A skid way should be constructed at the current location of the ramp. The issue is that the pipes will not roll back into the water easily without some assistance due to the rough nature of the ground.

Performance of the log boom should be monitored monthly during the first season of operation and twice yearly after that, with a focus on the following:

- Monitor floating depth of the pipe to record freeboard from the water to the top of the pipe. This will allow an assessment of the degree of saturation of the flotation foam or whether the end cap seals are water tight.

- Assess erosion around the abutments by looking for settlement of the rip rap around the base of the abutments. Particular attention should be paid to the area at the connection of the abutment and the log boom.
- View erosion along both shores up and down stream of the abutments. Pictures must be taken to analyse yearly changes of the shorelines.
- Volume of materials directed to shore by the log booms should be monitored for scheduling purposes and to ensure timely cleaning. Materials directed to shore should be removed by hand using ropes and saws or axes if necessary.

This report has been prepared for the exclusive use of Government of Yukon. It has been prepared with generally accepted engineering practice. We trust that the report meets your requirements at this time. If further information is required please contact the undersigned.

Erik Nyland, P.Eng.
Boreal Engineering Ltd.
enyland@borealengineering.ca

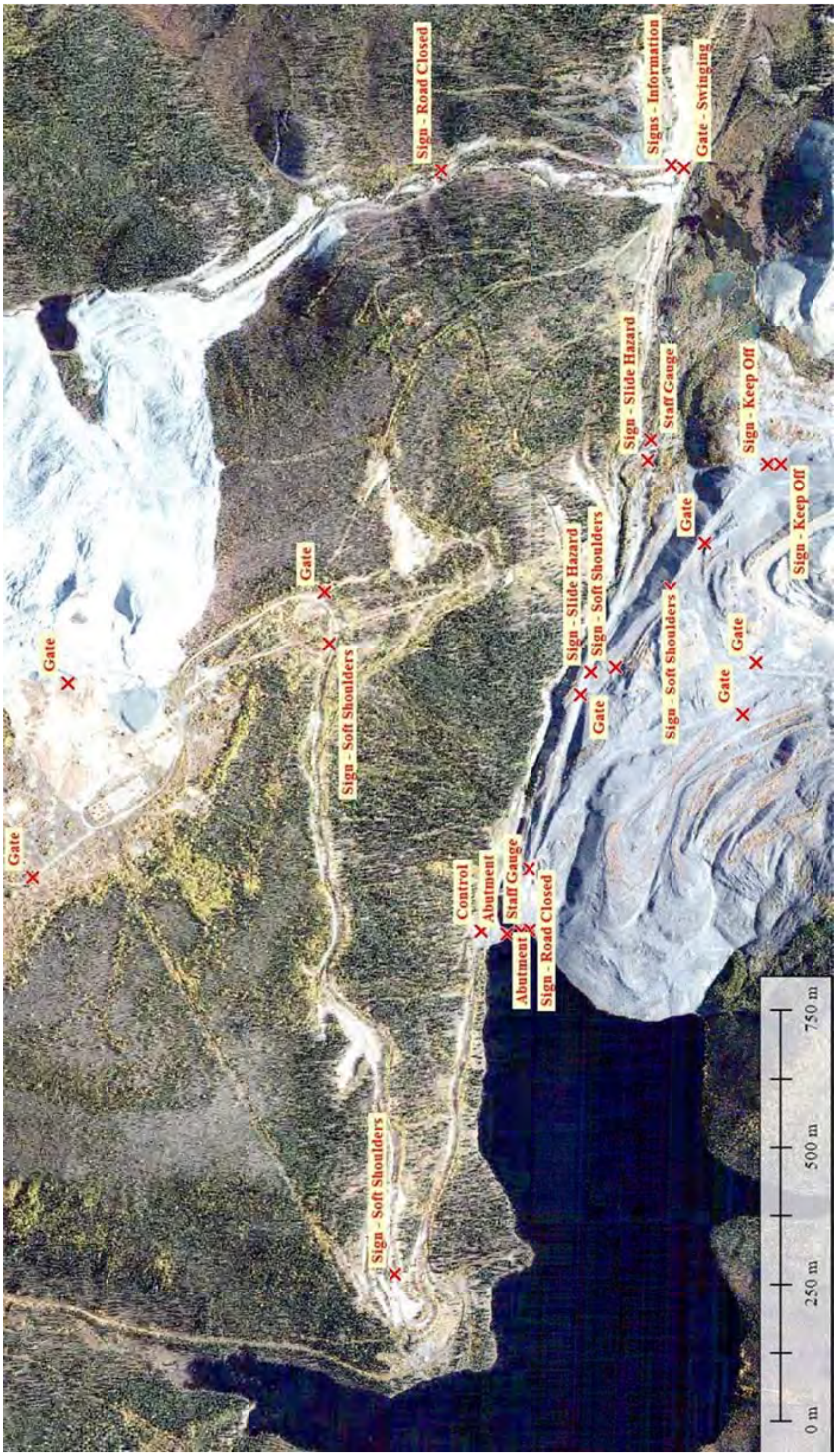
Jan 20 2014
Date

PROFESSIONAL ENGINEER
YUKON TERRITORY
ERIK NYLAND
Jan 20, 2014

PERMIT TO PRACTICE
BOREAL ENGINEERING LTD.
SIGNATURE
Date Jan 20, 2014
PERMIT NUMBER PP272
Association of Professional Engineers of Yukon

Appendices

Appendix A: Site Plan and Survey Data



Pt #	Northing	Easting	Elevation	Description
1	7148207.686	513273.7195	596.2288	GT PST
2	7148215.044	513270.9385	596.0573	GT PST
3	7148272.04	512927.237	598.5236	GT PST
4	7148269.103	512923.6722	598.4587	GT PST
5	7147751.642	513434.0107	566.4563	GT PST
6	7147754.506	513439.097	566.4253	GT PST
7	7147738.875	513328.0249	557.3348	SGN SOFT SH
8	7147601.921	512159.9784	455.1423	SGN SOFT SH
9	7147419.059	512819.0748	413.0726	ABUT
10	7147418.036	512821.6506	413.0539	ABUT
11	7147416.366	512819.5105	413.054	ABUT
12	7147458.762	512825.1765	415.0202	CTL
13	7147392.742	512827.8262	413.1647	ABUT
14	7147393.096	512830.5268	413.1804	ABUT
15	7147390.532	512829.5039	413.251	ABUT
16	7147387.766	512824.1686	411.6524	WATER
17	7147372.713	512827.4003	412.3879	STAFF
18	7147370.665	512906.8792	415.2576	SIGN RD CL
19	7146986.56	513232.1716	431.9418	GATE PST
20	7146992.456	513228.4087	432.4535	GATE PST
21	7146959.139	513312.5306	426.2147	GATE PST
22	7146962.772	513317.199	426.0706	GATE PST
23	7147069.869	513508.4569	420.1207	GATE PST
24	7147075.415	513510.6429	420.1296	GATE PST
25	7147118.573	513449.8325	417.0239	SIGN SOFT SH
26	7147216.74	513322.1422	406.9514	SIGN SOFT SH
27	7147259.795	513301.7737	401.9399	SIGN SLIDE HAZ
28	7147288.619	513273.5911	405.606	0219 UGL
29	7147286.863	513264.1235	406.8126	GATE PST
30	7147281.278	513261.8227	406.4155	GATE PST
31	7147275.807	513259.5278	406.2495	GATE PST
32	7147531.003	514210.4161	379.0462	SIGN NO VEH ACC
33	7147098.309	514216.5495	368.0292	SIGN FRENCH
34	7147097.586	514216.147	367.9388	SIGN ENGLISH
35	7147094.689	514212.1895	367.5849	GATE SWING
36	7147089.592	514211.1174	367.3123	GATE SWING
37	7147111.055	514220.1803	369.039	SIGN RD CL
38	7146928.327	514617.7881	376.2599	SIGN SLIDE 3K
39	7144737.543	516245.7913	337.0079	SIGN SLIDE 3K
40	7147108.896	513640.1581	374.6439	STAFF
41	7147105.624	513603.8501	380.1228	SIGN SLIDE HAZ

Appendix B: Installation and Removal Procedure for Log-boom

Equipment and Tools Required

The following equipment and tools are required to install and remove the log-booms:

- Two large pry bars
- Mid-size to large 4x4 pick-up truck
- Two 40m lengths of ropes
- Two 15m lengths of ropes
- Two 15m lengths of chain
- Adjustable wrench

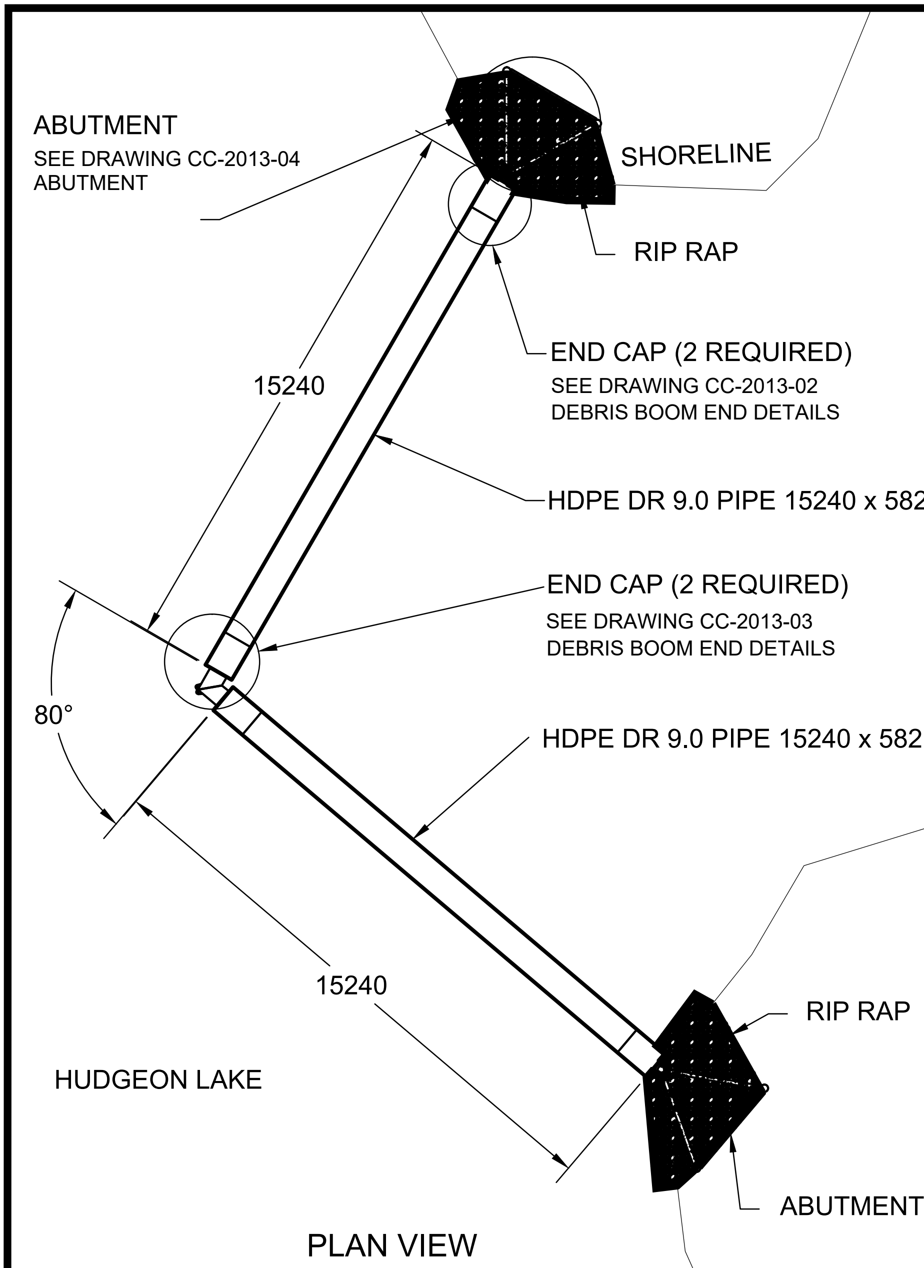
Installation

Steps	Actions
Step 1	Install inspection covers and remove rocks securing log-booms in place on ramp.
Step 2	Attach long ropes to the abutment side end-caps of each log-boom.
Step 3	Attach short ropes to end-caps on the other end of each log-boom.
Step 4	Push log-booms into the water using pry bars with ropes secured to shore.
Step 5	Use the short and long ropes to bring the log-booms into place near shore and ensure they are oriented in the right way (i.e. if they are not oriented the right way, then they need to be turned around using the ropes).
Step 6	In the shallow water by the log-boom ramp, join the end-caps of each log-boom using the clevis fasteners; use adjustable wrench to tighten.
Step 7	Detach the short ropes from the end-caps.
Step 8	Run the rope to the other side (i.e. north side) of the lake outlet and pull the log-boom end cap towards the abutment on that side (i.e. by hand with assistance of truck if necessary).
Step 9	Secure the chain around the abutment post on that side with the lock and remove the long rope.
Step 10	Pull the log-boom end-cap towards the abutment on the other side (i.e. south side).
Step 11	Secure the chain around the abutment post on that side with the lock and remove the long rope.

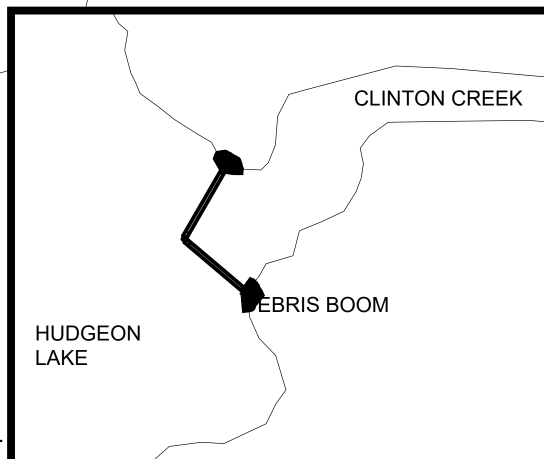
Removal

Steps	Actions
Step 1	Attach long ropes to the abutment side end-caps of each log-boom.
Step 2	Remove locks from chains around abutments.
Step 3	Pull the rope on the south side log-boom end-cap towards the log-boom ramp (i.e. pulling both log-booms since they are still connected).
Step 4	Pull the log-booms near the shore (i.e. ensure that you can reach the clevis fasteners in the middle in shallow water)
Step 5	Attach short ropes to each of the end-caps that are joined.
Step 6	Remove the clevis fastener that is joining the two log-booms.
Step 7	Move one of the log-booms aside and secure to shore with ropes.
Step 8	Wrap chain around centre of log-boom once; apply chain tensioner/tightener clamp.
Step 9	Continue wrapping chain around log-boom (i.e. +/- 8 wraps) and remove ropes.
Step 10	Connect other chain to the chain on the log-boom and pull with truck and this will cause log-boom to roll upslope.
Step 11	Repeat Steps 8 – 10 until at least 30m upslope on ramp.
Step 12	Remove chains and secure the log-boom with rocks on downslope side.
Step 13	Move the other log-boom into place (i.e. in front of ramp)
Step 14	Repeat Steps 8 – 12 for the second log-boom.
Step 15	Remove inspection covers from both ends of each log boom to allow water to drain

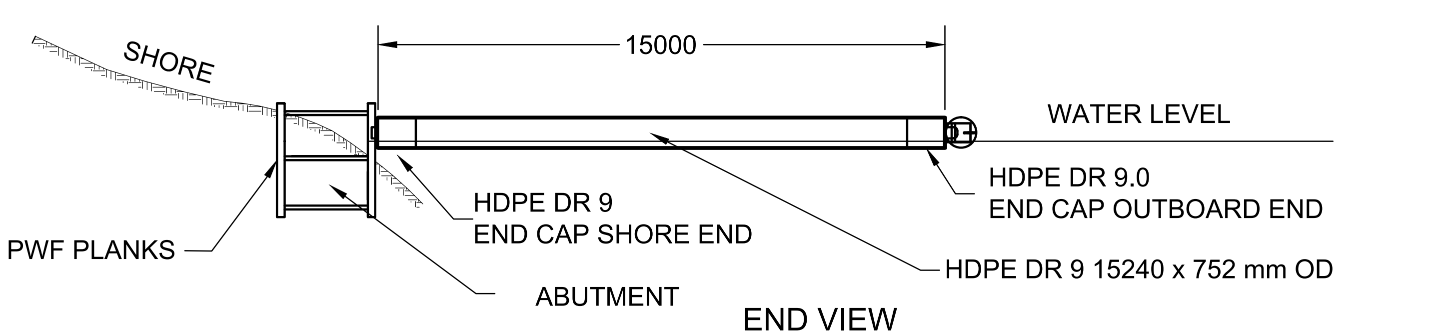
Appendix C: As-built Drawings



PLAN VIEW



SITE PLAN



END VIEW

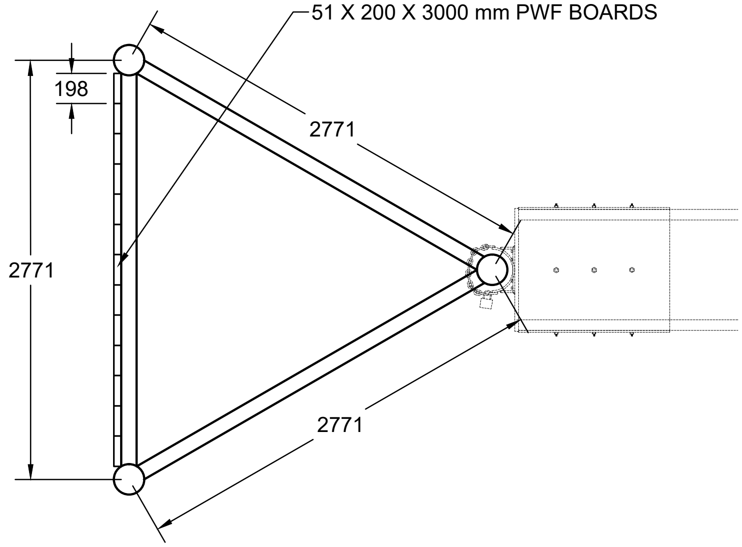
BOREAL ENGINEERING LTD.

Yukon Government

CLINTON CREEK SITE PLAN

ENERGY MINES AND RESOURCES,
ASSESSMENT AND ABANDONED MINES

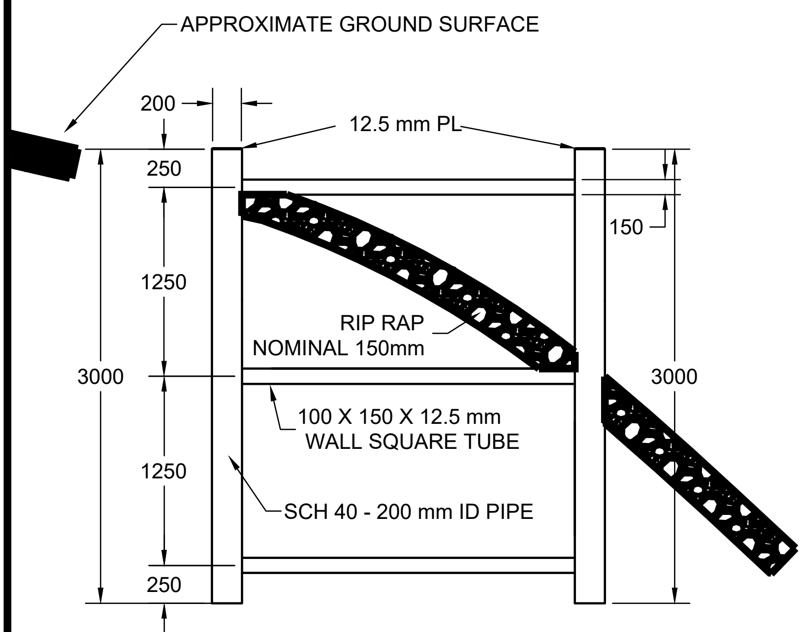
DESIGNED:	E NYLAND
DRAWN:	E Nyland
DATE:	January 18, 2014
DWG#:	CC-2013-01



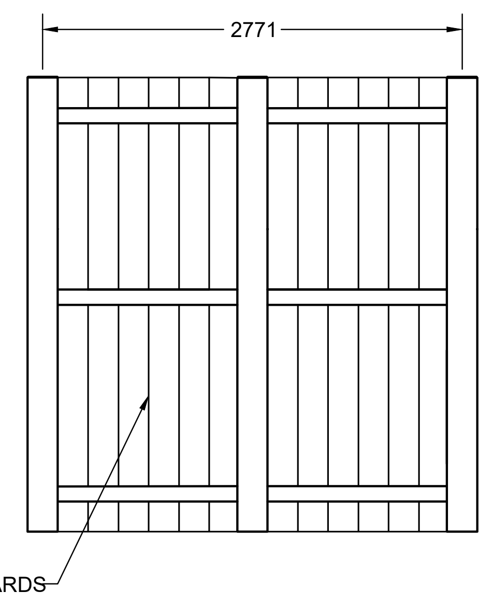
TOP VIEW

NOTES:

1) ALL STEEL TO BE MILD
2) PAINT ENTIRE STRUCTURE WITH RUST PAINT
3) STRUCTURE TO BE PAINTED ORANGE
4) ALL DIMENSIONS IN mm
5) ABUTMENT TO BE ALIGNED PER DRAWINGS
7) BACKFILL TO BE COMPACTED TO THE SATISFACTION OF THE ENGINEER.
8) STRUCTURE TO BE BACKFILLED IN LAYER NO THICKER THAN 200 mm
9) BOARDS TO BE PLACED PRIOR TO BACKFILL AND ATTACHED TO SQUARE TUBE WITH 2 x 6 mm SELF TAPPING SCREWS AT INTERSECTIONS
10) PIPE TO BE SCHEDULE 40 200 mm ID
11) SQUARE TUBE TO BE 100 X 150 X 12.5 mm WALL
12) FABRICATION OF STRUCTURES TO BE COMPLETED IN A CWB CERTIFIED SHOP BY A QUALIFIED WELDER
13) STRUCTURE TO BE PLACED IN EXCAVATION AND APPROVED BY ENGINEER PRIOR TO BACKFILL
14) BOARDS TO BE PWF TREATED
15) ABUTMENT TO BE BURIED SIMILAR TO THE PLAN AND TO THE ENGINEER'S APPROVAL



END VIEW



FRONT VIEW

CLINTON CREEK SITE	DESIGNED: E NYLAND
ABUTMENT	DRAWN: E Nyland
ENERGY MINES AND RESOURCES,	DATE: JAN 18, 2014
ASSESSMENT AND ABANDONED MINES	DWG#: CC-2013-04

BOREAL ENGINEERING LTD.

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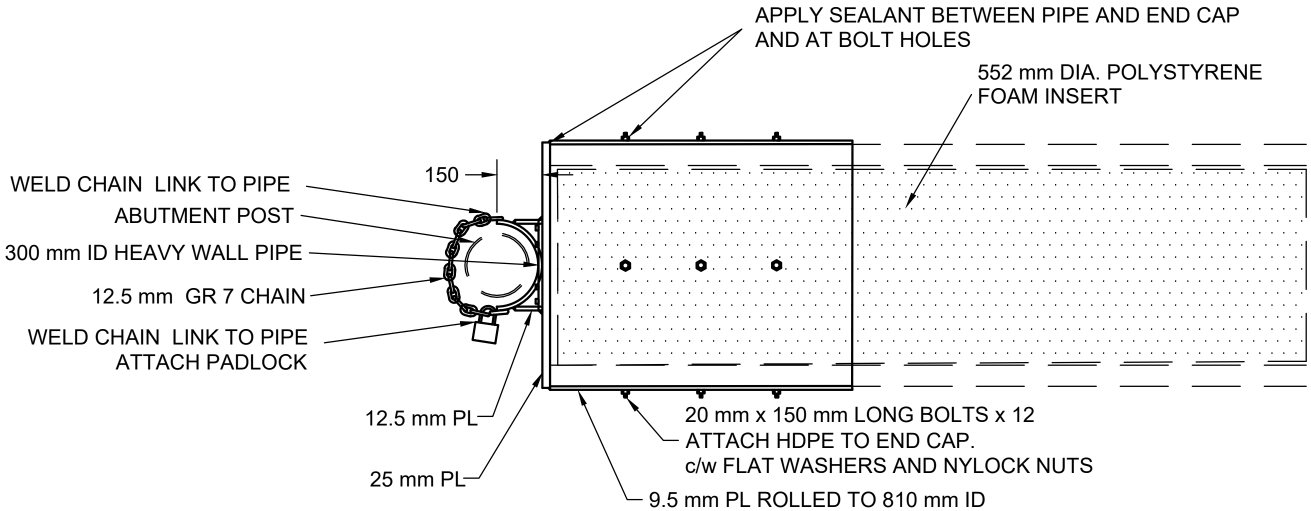
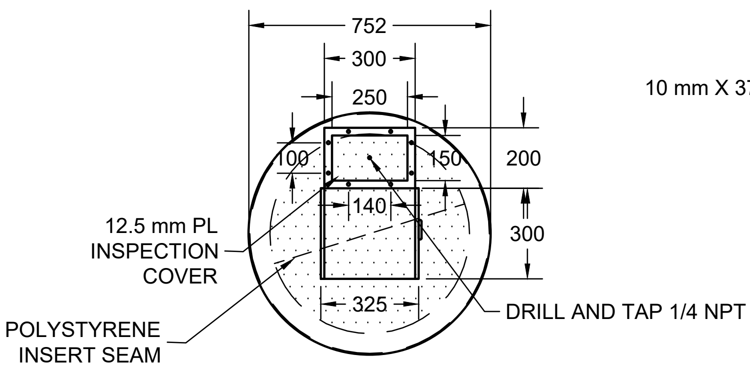


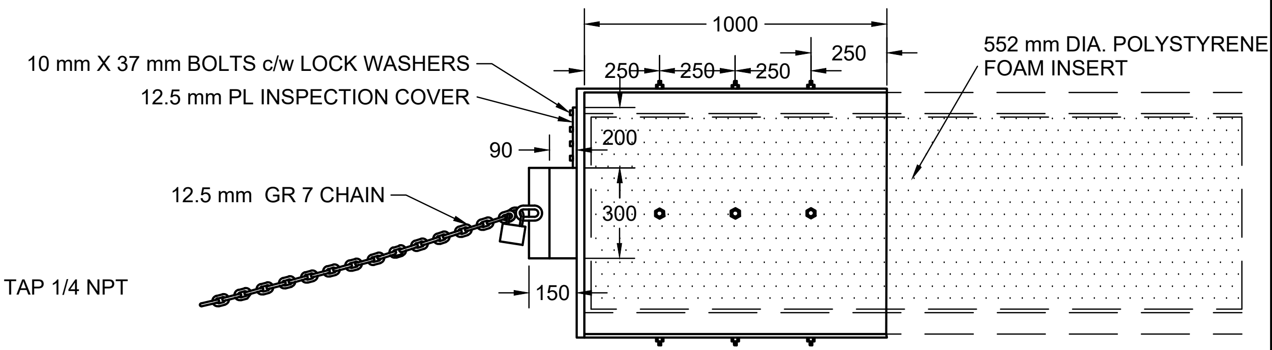
PLAN VIEW

NOTES:

1) ALL STEEL TO BE MILD
2) PAINT ENTIRE STRUCTURE WITH RUST PAINT
3) STRUCTURE TO BE PAINTED BLACK
4) ALL DIMENSIONS IN mm
5) ALL INSPECTION COVERS TO BE FITTED WITH GASKETS AND SEALANT
6) JOINT BETWEEN HDPE AND END CAP TO BE TREATED WITH SEALANT PRIOR TO ASSEMBLY
7) END CAP TO BE FABRICATED IN SHOP PRIOR TO TRANSPORT TO SITE
8) ALL BOLTS TO BE GRADE 8 OR BETTER
9) CHAIN TO BE GRADE 7 OR BETTER
10) FABRICATION OF STRUCTURES TO BE COMPLETED IN A CWB CERTIFIED SHOP BY A QUALIFIED WELDER
11) END CAPS TO BE FITTED TO HDPE PRIOR TO MOBILIZATION TO SITE
12) DRILL AND TAP INSPECTION COVER BOLT HOLES
13) ALL WELDS TO BE MINIMUM 5 mm FILLET OR BACK
14) WELDS TO BE TESTED WATER TIGHT
15) HDPE PIPES TO BE FILLED WITH POLYSTYRENE FOAM INSERTS



END VIEW



SIDE VIEW

ABUTMENT END

DESIGNED:	E Nyland
DRAWN:	E Nyland
DATE:	January 18, 2014
DWG#:	CC-2013-02-AB

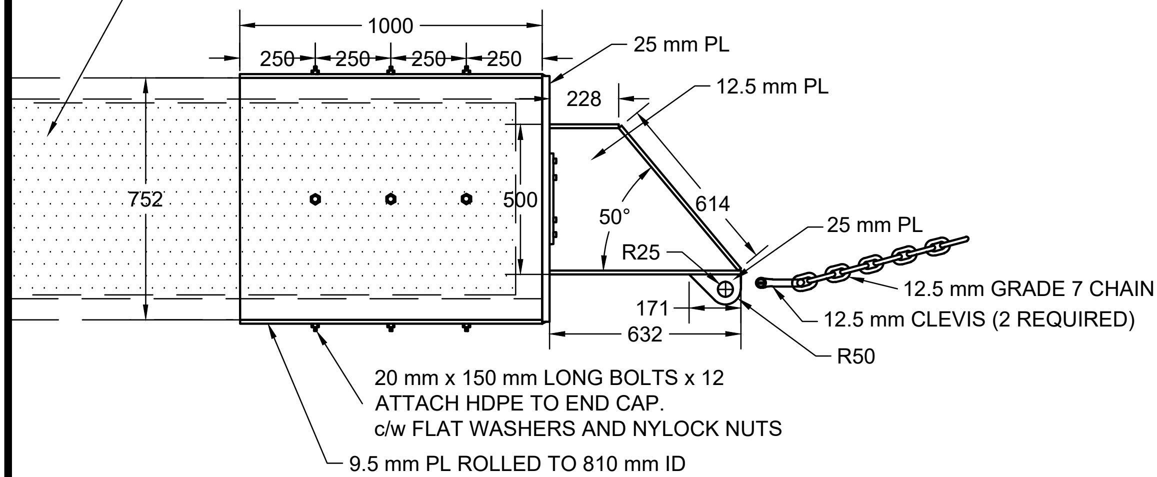
BOREAL ENGINEERING LTD.

Yukon Government

CLINTON CREEK SITE

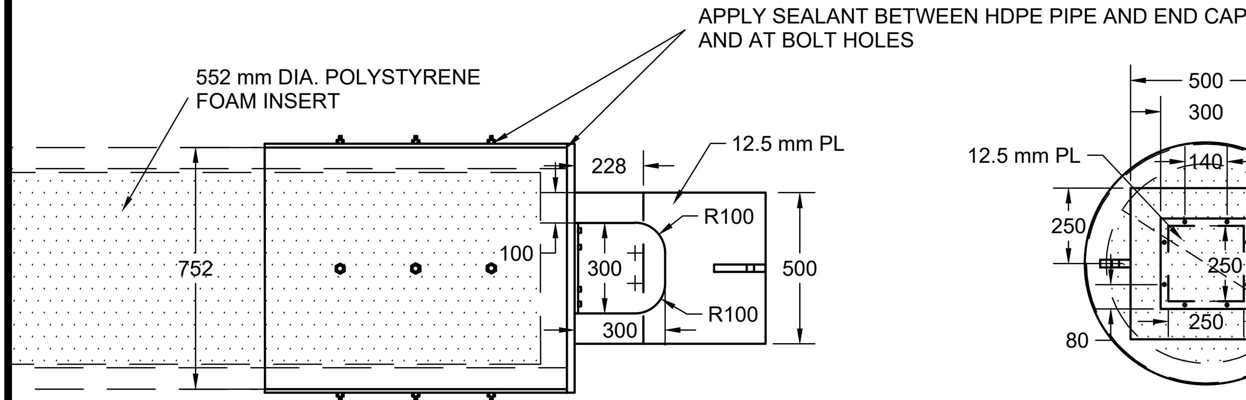
DEBRIS BOOM END DETAILS

ENERGY MINES AND RESOURCES, ASSESSMENT AND ABANDONED MINES

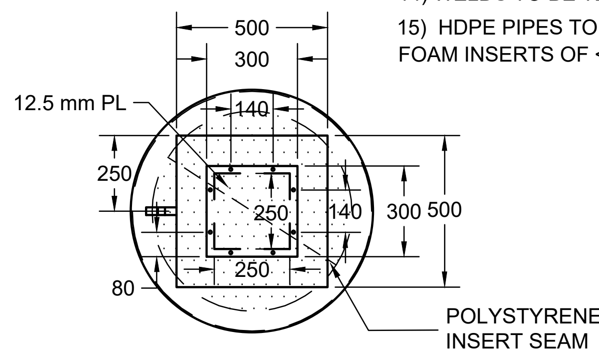


TOP VIEW

NOTES:
1) ALL STEEL TO BE MILD
2) PAINT ENTIRE STRUCTURE WITH RUST PAINT
3) STRUCTURE TO BE PAINTED ORANGE
4) ALL DIMENSIONS IN mm
5) ALL INSPECTION COVERS TO BE FITTED WITH GASKETS AND SEALANT
6) JOINT BETWEEN HDPE AND END CAP TO BE TREATED WITH SEALANT PRIOR TO ASSEMBLY
7) END CAP TO BE FABRICATED IN SHOP PRIOR TO TRANSPORT TO SITE
8) ALL BOLTS TO BE GRADE 8 OR BETTER
9) CHAIN TO BE GRADE 7 OR BETTER
10) FABRICATION OF STRUCTURES TO BE COMPLETED IN A CWB CERTIFIED SHOP BY A QUALIFIED WELDER
11) END CAPS TO BE FITTED TO HDPE PRIOR TO MOBILIZATION TO SITE
12) DRILL AND TAP INSPECTION COVER BOLT HOLES
13) ALL WELDS TO BE MINIMUM 5 mm FILLET OR BACK
14) WELDS TO BE TESTED WATER TIGHT
15) HDPE PIPES TO BE FILLED WITH POLYSTYRENE FOAM INSERTS OF <4% WATER ABSORPTION RATE



SIDE VIEW



END VIEW

OUTBOARD END

CLINTON CREEK SITE

DEBRIS BOOM END DETAILS

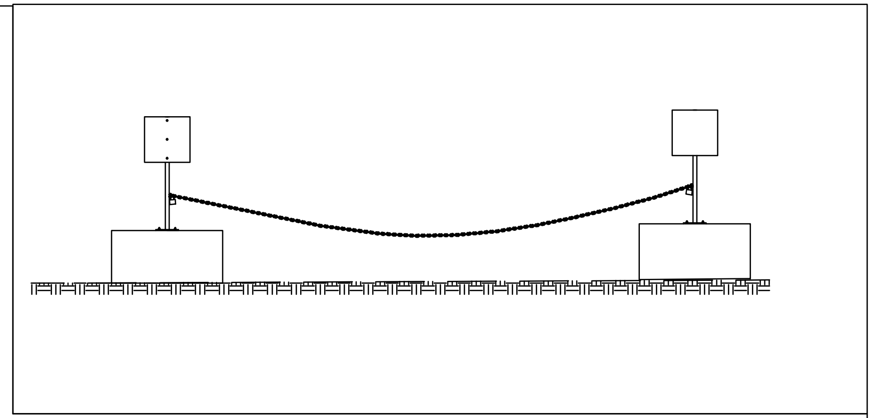
ENERGY MINES AND RESOURCES, ASSESSMENT AND ABANDONED MINES

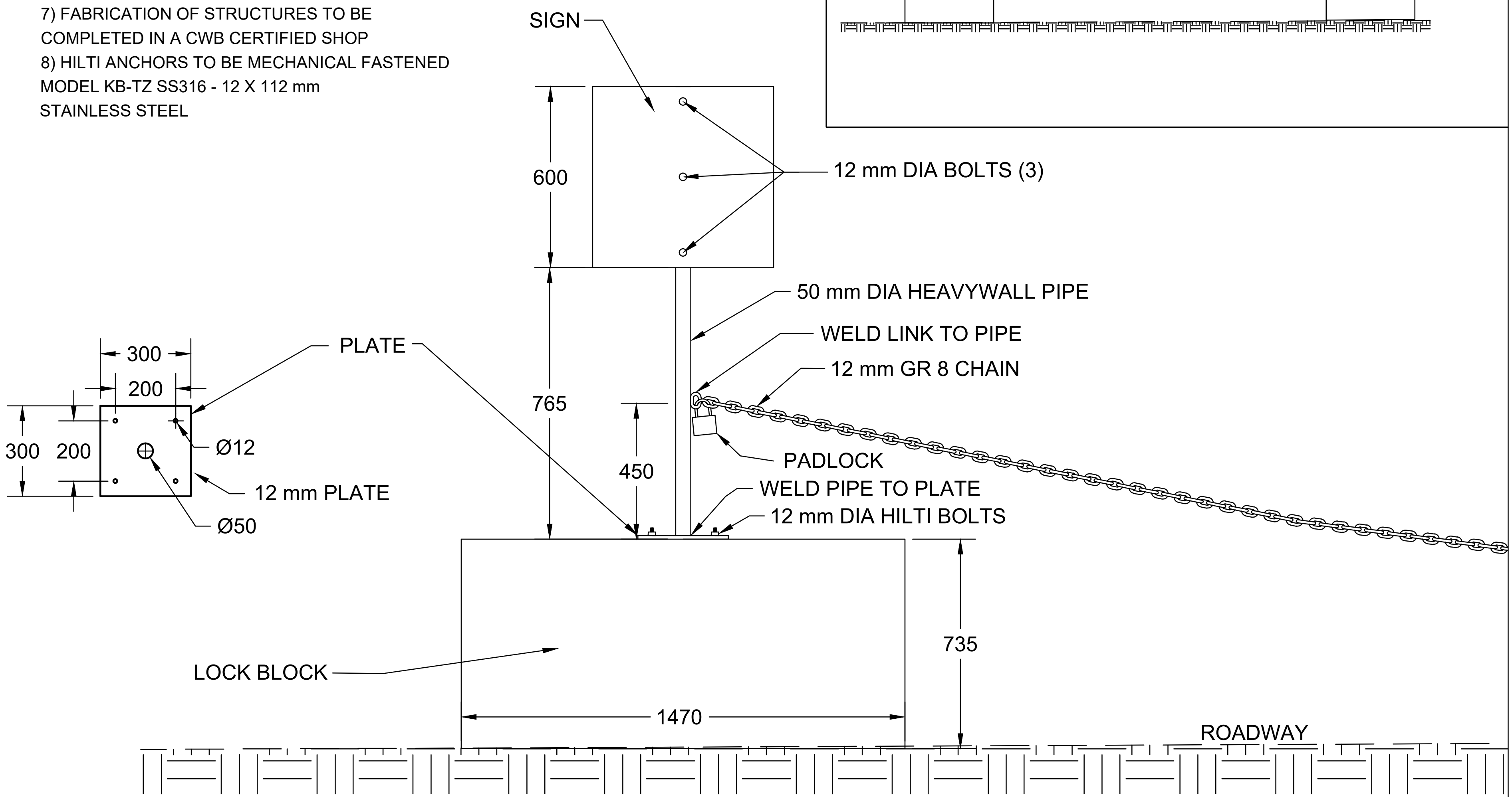
BOREAL ENGINEERING LTD.

Yukon Government

DESIGNED:	E Nyland
DRAWN:	E Nyland
DATE:	JANUARY 18, 2014
DWG#:	CC-2013-03-AB

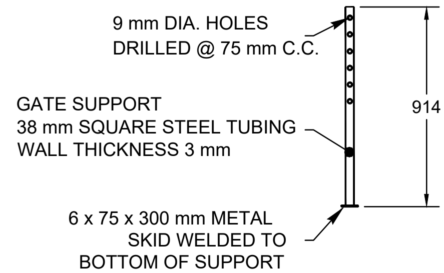
NOTES:
1) ALL STEEL TO BE MILD
2) PAINT ENTIRE STRUCTURE WITH RUST PAINT
3) STRUCTURE TO BE PAINTED ORANGE
4) ALL DIMENSIONS IN mm
5) ALL BOLTS TO BE GRADE 8 OR BETTER
6) CHAIN TO BE GRADE 7 OR BETTER
7) FABRICATION OF STRUCTURES TO BE COMPLETED IN A CWB CERTIFIED SHOP
8) HILTI ANCHORS TO BE MECHANICAL FASTENED MODEL KB-TZ SS316 - 12 X 112 mm STAINLESS STEEL



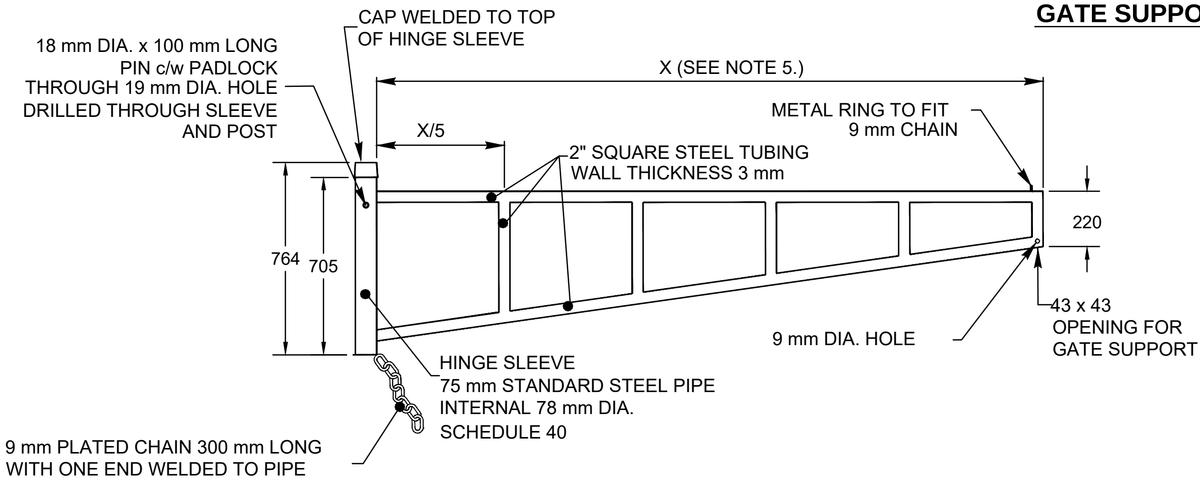


BOREAL ENGINEERING LTD. / Yukon Government	CLINTON CREEK SITE **LOCK BLOCK GATE** ENERGY MINES AND RESOURCES, ASSESSMENT AND ABANDONED MINES	DESIGNED: E Nyland DRAWN: E Nyland DATE: March 26, 2013 DWG#: CC-2013-07

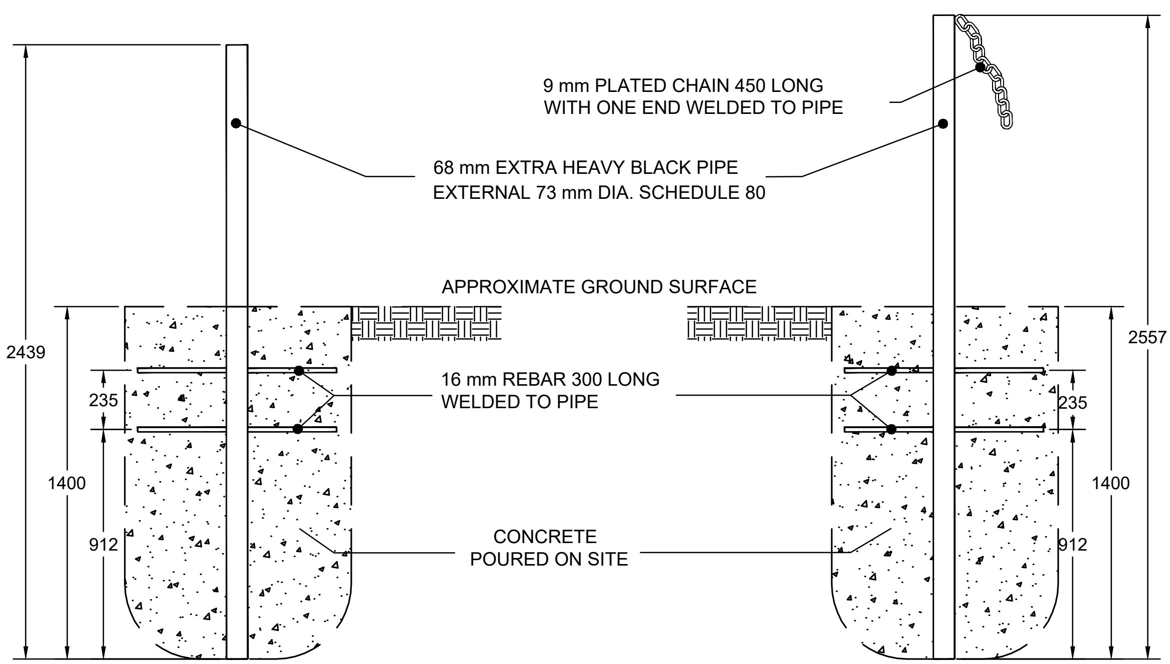
NOTES:
1. ALL STEEL TO BE BLACK
2. GRIND OFF ALL SHARP EDGES , BURRS AND SLAG
3. PAINT ALL PARTS WITH PRIMER AND 2 COATS SAFETY YELLOW RUST INHIBITING INDUSTRIAL ENAMEL
4. ONE SINGLE SWING GATE SET INCLUDES:
   - 1 GATE PANEL - 1 SUPPORT - 1 HINGE POST - 2 HITCH POSTS
5. THE VALUE OF "X" WILL BE PROVIDED ON A PER JOB BASIS
6. ALL DIMENSIONS IN mm



GATE SUPPORT



GATE PANEL



HINGE POST

HITCH POST

CLINTON CREEK SITE
GATE

ENERGY MINES AND RESOURCES,
ASSESSMENT AND ABANDONED MINES

DESIGNED:	Yukon Government
DRAWN:	E Nyland
DATE:	March 24, 2013
DWG#:	CC-2013-06

Appendix D: Log-boom Foam Specifications Sheet and Communications

Erik Nyland < enyland@gmail.com>

Foam...

8 messages

Jay.Khan@wolseleyinc.ca < Jay.Khan@wolseleyinc.ca> Thu, Sep 12, 2013 at 1:49 PM
To: enyland@gmail.com
Cc: James.Pont@wolseleyinc.ca

Subject: Spec Sheet Polystyrene

Hi Erik,

Please see attached spec sheet.

I will say that the sooner we can get a PO# from you. The sooner the Fab shop can start!

It will take approximately 8 business days to complete this order. I would add a couple of more days to get this to your site. (8-10 business days should be good)

Please advise asap.

Thanks

Jay

TYPE1 Foam Data Sheet.pdf
87K

Erik Nyland < enyland@gmail.com> Thu, Sep 12, 2013 at 1:55 PM
To: Josée Perron <josee.perron@gov.yk.ca>

Here is the foam specced by Jay Khan
Not sure I like it the water absorption is at 4.0%
I will forward it to Ralph Ford for confirmation.

Erik

[Quoted text hidden]

--
Erik Nyland, P.Eng.
Boreal Engineering Ltd.
Cell (867) 335-0211
www.borealengineering.ca

TYPE1 Foam Data Sheet.pdf
87K

Erik Nyland < enyland@gmail.com> Thu, Sep 12, 2013 at 1:57 PM
To: ralph.ford@wolseleyind.com

Hi Ralph,
Jay Khan has organized a local Vancouver area firm to provide us with preformed foam to fit inside the pipes. The spec is attached.
I am not sure this is completely appropriate because the water absorption is 4.0%, which is higher than the Poly Urethane.
Can you advise whether this is appropriate?
Erik

---------- Forwarded message ----------
From: <Jay.Khan@wolseleyinc.ca>
Date: Thu, Sep 12, 2013 at 1:49 PM
Subject: Foam...
To: enyland@gmail.com
Cc: James.Pont@wolseleyinc.ca

[Quoted text hidden]

--
Erik Nyland, P.Eng.
Boreal Engineering Ltd.
Cell (867) 335-0211
www.borealengineering.ca

TYPE1 Foam Data Sheet.pdf
87K

---

ralph.ford@wolseleyind.com < ralph.ford@wolseleyind.com> Thu, Sep 12, 2013 at 2:11 PM
To: enyland@gmail.com
Cc: cesar.gallardo@wolseleyind.com

Erik; the spec sheet Jay sent you came from my associate Cesar who sets 8' from me in our office. This is the foam we use in all our projects. The absorption is rated at less than 4% but in actuality it is 2%, and it is a closed cell so it does not increase absorption long term while most polyurethane is rated for a lesser term at 3%. I was out yesterday so Cesar gave Jay the info I would have been sending you. Best of luck.

Ralph Ford | HDPE Technical Advisor

WOLSELEY Industrial Group

Industrial Plastics Division

740 South 28th Street

Washougal, Washington 98671

360.835.4004 Direct

360.835.2129 Main Office

360.835.3521 Fax

ralph.ford@wolseleyind.com

www.hdpe.com

www.wolseleyindustrialgroup.com

ISO 9001 CERTIFIED FM APPROVED

From: Erik Nyland [mailto:enyland@gmail.com]
Sent: Thursday, September 12, 2013 1:58 PM
To: Ford, Ralph [Ferguson] - 3067 Washougal
Subject: Fwd: Foam...

[Quoted text hidden]

Erik Nyland < enyland@gmail.com> Thu, Sep 12, 2013 at 3:09 PM
To: Josée Perron <josee.perron@gov.yk.ca>

Erik Nyland, P.Eng.
Boreal Engineering Ltd
Sent from my iPhone

Begin forwarded message:

> **From:** <ralph.ford@wolseleyind.com>
> **Date:** 12 September, 2013 2:11:19 PM PDT
> **To:** <enyland@gmail.com>
> **Cc:** <cesar.gallardo@wolseleyind.com>
> **Subject: RE: Foam...**

[Quoted text hidden]

Erik Nyland < enyland@gmail.com> Thu, Sep 12, 2013 at 4:28 PM
To: "<Jay.Khan@wolseleyinc.ca>" <Jay.Khan@wolseleyinc.ca>

Hi jay
Please proceed with the order. We do not use POs however I can issue a cheque right away if that helps.
Please encourage the supplier to expedite this as fast as possible because we expect snow in that area almost any time now. Snow would prevent us from accessing the site.
Erik

Erik Nyland, P.Eng.
Boreal Engineering Ltd
Sent from my iPhone
[Quoted text hidden]

<TYPE1 Foam Data Sheet.pdf>

Erik Nyland < enyland@gmail.com> Thu, Sep 12, 2013 at 5:14 PM
To: Josée Perron <josee.perron@gov.yk.ca>

Erik Nyland, P.Eng.
Boreal Engineering Ltd
Sent from my iPhone

Begin forwarded message:

From: <ralph.ford@wolseleyind.com>
Date: 12 September, 2013 2:11:19 PM PDT
To: <enyland@gmail.com>
Cc: <cesar.gallardo@wolseleyind.com>
Subject: RE: Foam...

[Quoted text hidden]

Jay.Khan@wolseleyinc.ca < Jay.Khan@wolseleyinc.ca> Thu, Sep 12, 2013 at 10:18 PM
To: enyland@gmail.com

Erik,

I will advise Friday with delivery status.

Thanks

Jay

From: Erik Nyland [mailto:enyland@gmail.com]
Sent: Thursday, September 12, 2013 4:29 PM
To: Khan, Jay [Canada] EPG
Subject: Re: Foam...

[Quoted text hidden]

Description

InsulFoam I is a versatile insulation consisting of a superior closed-cell, lightweight and resilient expanded polystyrene (EPS). InsulFoam I meets or exceeds the requirements of ASTM C578, Type I, *Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.* InsulFoam I has a nominal density of 1.0 lb/ft^3. In addition, InsulFoam I offers a long-term stable R-Value and has excellent dimensional stability, compressive strength and water resistance properties.

Uses

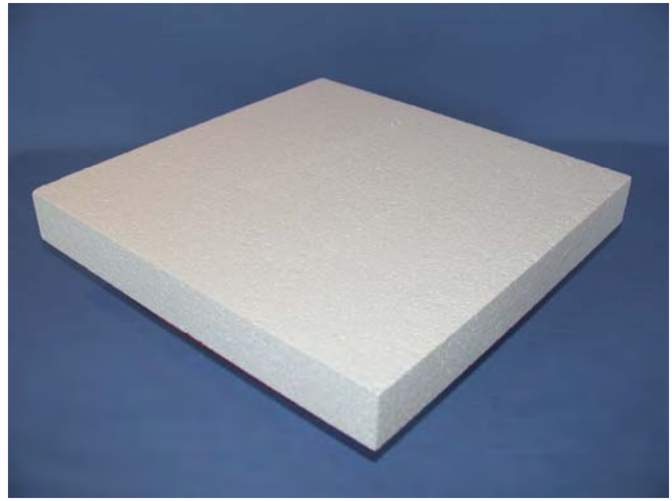
InsulFoam I is a quality EPS product and is used in numerous building construction applications.

Roofing: InsulFoam I is well suited for single ply roof applications employing mechanically fastened or ballasted TPO, PVC, EPDM and CSPE as well as low-sloped built-up, modified bitumen and fully adhered single ply roofs incorporating a coverboard or slip sheet. Please consult local building codes and membrane manufacturers for system requirements.

Other Construction Applications: InsulFoam I is used in assorted building applications including pre-stressed and pre-cast structural concrete panels, lightweight concrete deck fill, metal roof flute fill, siding backer board, building sheathing, roads and bridge fill, below slab and perimeter insulation and numerous other geofoam applications.

Advantages

- *Environmentally friendly.* It contains no formaldehyde or ozone-depleting CFC's or HCFC's, contains recycled material and is 100% recyclable if ever removed or replaced.
- *Stable R-Value.* Designers are well served knowing the product's thermal properties will remain stable over the entire service-life. There is no thermal "drift" so the product is eligible for an Insulfoam 20-year thermal performance warranty.
- *Proven Performance.* The same fundamental EPS chemistry has been in use since the mid-1950s so the actual performance of the product is well known.
- *Water Resistant.* EPS is not hygroscopic (does not readily absorb moisture from the atmosphere) and does not promote migration of moisture into the insulation.
- *Code Approvals:* Insulfoam EPS is recognized by the International Code Council Evaluation Service (ICC-ES) and has numerous Underwriter Laboratory and Factory Mutual Approvals. Please contact your local Insulfoam representative for details.



Sizes

InsulFoam I is typically available in 4' x 4' and 4' x 8' sizes with thickness from ¼" to 40" and readily available in custom lengths and widths with little or no impact on lead time. It can also be provided in tapered panels.

Typical Tested Physical Properties*

Property	Test Method	Value
Density (nom. pcf)	ASTM C303	1.0
C-Value (Conductance) – per inch BTU/(hr•ft^2•ºF) @ 25º F @ 40º F @ 75º F R-Value (Resistance) - per inch (hr•ft^2•ºF)/BTU @ 25º F @ 40º F @ 75º F	 ASTM C518 or ASTM C177 ASTM C518 or ASTM C177	 0.23 0.24 0.26 4.35 4.17 3.85
Compressive Strength (psi, 10% consolidation)	ASTM D161	10-14
Flexural Strength (psi)	ASTM C203	25-30
Dimensional Stability (maximum %)	ASTM D2126	< 2.0
Water Vapor Transmission (perm. In)	ASTM E96	2.0-5.0
Absorption (% vol.)	ASTM C272	< 4.0
Capillarity	--	none
Flame Spread	--	<20
Smoke Developed		150-300

* Properties based on data provided by resin manufacturers, independent test agencies and Insulfoam

Appendix E: Photo Diary

Photo 1 – Lock Blocks on truck in Whitehorse

Photo 2 – Truck stuck at Clinton Creek Crossing

Photo 3 – Hitachi ZX 200 unloading lock blocks at gate locations

Photo 4 – Placing lock blocks at the airport road

Photo 5 – Road blocked at the gabion baskets to prevent access along creek

Photo 6 – Road blockage along creek near gabion baskets

Photo 7 – Rock removed from slope above road

Photo 8 – Rock removed from slope and area it came from

Photo 9 – Information signs

Photo 10 - Brushing in Wolverine Creek

Photo 11 - Tailings at Wolverine Creek

Photo 12 – Lower Beaver Dam Removed

Photo 13 - Upper Beaver Dam Removed

Photo 14 - Brush removed from Wolverine Creek

Photo 15 - Brush removed from Wolverine Creek

Photo 16 - Delivery of pipes and abutment structures to site

Photo 17 - Unload abutment structure from truck

Photo 18 - Installing abutment structure and compacting backfill

Photo 19 – Installed south abutment

Photo 20 - Installing north abutment

Photo 21 Placing rip rap around north abutment

Photo 22 - Signage at Wolverine Creek crossing

Photo 23 - Signage and gate at top of tailings pile

Photo 24 - Signage and gate at airport access road

Photo 25 - Signage and gate at trail off mill site access road

Photo 26 - Soft shoulder sign on mill site access road

Photo 27 - Signage on mill site access road

Photo 28 - Installed north abutment

Photo 29 - Installed south abutment

Photo 30 - Post for staff gauge

Photo 31 - Gate and sign at trail on waste rock pile

Photo 32 - Gate and sign at trail on waste rock pile

Photo 33 - Gate and sign at access road to abandoned shovel and drill

Photo 34 - Sign and evidence of ladder removed from abandoned drill

Photo 35 - Sign on abandoned shovel

Photo 36 - Soft Shoulder sign on road along waste rock pile

Photo 37 -- Sign along road on waste rock pile

Photo 38 Gate and sign at abandoned section of road on waste rock pile

Photo 39 - Sign along road on waste rock pile

Photo 40 - Sign on waste rock pile near Clinton Creek

Photo 41 - Signage at site access

Photo 42 - Sign and rock blockage at Wolverine Creek access

Photo 43 - Log-booms on shore after removal from water

Photo 44 - Log-booms in place showing settlement in the water

Photo 45 - Log-booms loaded for transport to Whitehorse

Photo 46 – Flotation foam installed in pipes

Photo 47 - Foam inserted into pipe.

Photo 48 - Foam being placed in pipe

Photo 49 - Foam installed in pipe and end cap installed

Photo 50 - Foam installation complete with inspection covers installed

Appendix F: Details of Log Boom Calculations

Log Boom Specifications and Calculations

Element / Component	Value	Formula	Calculations
Length	15.240 m		
Inside Diameter	0.582 m		
Wall Thickness	0.085 m		
Outside Diameter	0.752 m		
Inside Volume	4.054 m^3		
Total Volume	6.769 m^3		
Volume of HDPE	2.715 m^3		
Density of HDPE	930 kg/m^3		
Mass of HDPE	2525.0 kg		
Mass of 2 End Caps	440.0 kg		
Mass of 1 Log Boom	2965.0 kg	[Mass of 1 Log Boom] = [Mass of HDPE] + [Mass of 2 End Caps]	2965.0 kg = 2525.0 kg + 440.0 kg
Density of Freshwater	1000 kg/m^3		
Total Water Displacement (Mass) – Floating	3517.9 kg	[Total Water Displacement (weight)] = [Mass of Log Boom Saturated] *	3517.9 kg = 3517.9 kg
Total Water Displacement (Volume) – Floating	3.518 m^3	[Total Water Displacement (volume)] = [Mass of Log Boom Saturated] / [Density of Water]	3.518 m^3 = 3517.9 kg / 1000 kg/m^3
Outside Diameter of Foam Insert	0.552 m		
Volume of Foam Insert	3.647 m^3	[Volume of Foam Insert] = π([Outside Diameter of Foam Insert] / 2)^2 X [Length]	3.647 m^3 = π (0.552 m/ 2)^2 X 15.24 m
Volume of Voids in Pipe	0.407 m^3	[Volume of Voids in Pipe] = [Inside Volume] – [Volume of Foam Insert]	0.407 m^3 = 4.054 m^3 – 3.647 m^3
Mass of Water in Voids	407 kg	[Mass of Water in Voids] = [Volume of Voids in Pipe] X [Density of Water]	407 kg = 0.407 m^3 X 1000 kg/m^3
Percentage of Absorption of Foam	4%		
Water Absorption of Foam Insert (Mass)	145.9 kg	[Water Absorption of Foam Insert (Mass)] = [Volume of Foam Insert] X [Percentage of Absorption of Foam] X Density of Water	145.9 kg = 3.647 m^3 X 4% X 1000 kg/m^3
Mass of Log Boom Saturated	3517.9 kg	[Mass of Log Boom Saturated] = [Mass of 1 Log Boom] + [Mass of Water in Voids] + [Water Absorption of Foam Insert (Mass)]	3517.9 kg = 2965.0 kg + 407 kg + 145.9 kg
Total Water Displacement (Mass) – Submerged	6769 kg	[Total Water Displacement (Mass) – Submerged] = [Total Volume] X [Density of Water]	6769 kg = 6.769 m^3 X 1000 kg/m^3
Buoyancy (Submergence Percentage)	52%	[Buoyancy (Submergence Percentage)] = [Mass of Log Boom Saturated] / [Total Water Displacement (Mass) – Submerged] **	52% = 3517.9 kg / 6769 kg
Buoyancy (Submergence Height)	0.391 m	[Buoyancy (Submergence Height)] = [Buoyancy (Submergence Percentage)] X [Outside Diameter]	0.391 m = 52% X 0.752 m

*This is calculated as the actual weight of water displaced by the floating object.

**Given that the buoyancy of an object is a function of its density; submergence percentage can be calculated by dividing the total mass of the object by total mass of water displaced by the object if it were fully submerged (i.e. the total mass of the object if it had the density of fresh water).

APPENDIX E

HYDROTECHNICAL REVIEW OF TEMPORARY REPAIRS AT DS4

TECHNICAL MEMO

TETRA TECH

ISSUED FOR USE

To:	Alex Machica, Project Manager	**Date:**	October 14, 2021
c:	Adam Wallace, P.Eng.	**Memo No.:**	004
From:	David Moschini, P.Eng.	**File:**	704-ENG.WARC03956-03
Subject:	Hydrotechnical Review of Gabion Drop Structures 2021 Long-Term Performance Monitoring Program – Clinton Creek, Yukon		

1.0 INTRODUCTION

In 2018, Tetra Tech Canada Inc. (Tetra Tech) was retained by the Government of Yukon Department of Energy, Mines and Resources, Assessment and Abandoned Mines (YG-AAM) to provide: Engineering and Construction Monitoring Services to assist in the Emergency Repair Works for Clinton Creek Drop Structure 4 (DS4) Repair Work.

A channel chute armoured with articulating concrete block (ACB) mats was built downstream of DS4 in 2015. High flows during the 2018 freshet caused the ACB mat to fail. Jacobs (2018) conducted a review of plausible failure causes and presented recommendations for long-term solutions. On September 2018, YG-AAM hired Tetra Tech and Chute Creek Construction to complete a series of emergency repair works in preparation for the spring freshet of 2019.

As the intent of the emergency works was to prepare for the 2019 spring freshet, in June of 2019, the Government of Yukon hired Tetra Tech to review the condition of the repair works completed in the fall and asses if additional works were required to stabilise DS4 in preparation for the 2020 spring freshet.

On July 3, 2019, David Moschini, P.Eng., was accompanied by Adam Wallace, P.Eng., and by Nafis Jalil, EIT, to complete a visual inspection of the DS4 structure during the geotechnical site visit that is normally included in the annual Long-Term Performance Monitoring Program (LTPMP). The findings and recommendations of the site visit were presented in a field inspection memo (DS4 Emergency Repairs Follow-Up Inspection, 2021 LTPMP – Clinton Creek, Yukon).

On June 15 and 16, 2021, Adam Wallace, P.Eng., and Shawn Matthies, EIT, from Tetra Tech's Whitehorse office completed the annual geotechnical site inspection, which included collection of a comprehensive photographic record detailing current site conditions at the drop structures and the former ACB mat area. This technical memorandum is intended to summarise the observed site conditions, document noticeable changes, and present recommendations designed to stabilise the subject area until closure plans are advanced.

YG-AAM has advised that interim stabilization measures are currently being designed by Parsons and are scheduled for construction in 2022. Interim stabilization measures are intended to allow the channel to handle flow volumes up to the 25-year design flood, pending long-term channel stabilization during the overall site remediation and closure.

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2.0 DROP STRUCTURES

Between 2002 and 2004, a series of four temporary gabion drop structures were constructed to allow for a gradual transition between Hudgeon Lake and the lower reaches of Clinton Creek. Each drop structure is composed of metal gabion baskets, filled with rock, installed in steps across the creek channel (Jacobs 2018).

The following is a summary of some of the changes we have noticed along each of the drop structures.

2.1 DS1

As detailed in Figure 1, in 2019 woody debris were noticed at DS1. At the time Tetra Tech had recommended to remove these as these were likely to promote a greater accumulation of debris and potentially limit the capacity of the channel. Accumulation of debris at the drop structures, especially DS1, is typically an annual occurrence at the site. Monitoring debris accumulation at DS1 is important to preserve the hydraulic capacity of the channel. We understand that debris is normally cleared annually through regular site maintenance.

June 2021	July 2019

Figure 1: DS 1 Comparison

2.2 DS2

As detailed in Figure 2, we have not noticed any significant changes between 2019 and 2020. Except for a decrease in vegetation growth along the wetted section of the drop structure, it appears that the structure has retained its overall structural integrity.

	
June 2021	July 2019

Figure 2: DS 2 Comparison

2.3 DS3

As detailed in Figure 3, it appears that the third and fourth step of the drop structure is displaying greater deformations as compared to 2019. As previously noticed, the gravel/rocks used to construct the gabion baskets are smaller, in many instances, than the mesh size used to form the gabions. Over time, without the presence of an internal matrix supporting the mesh, the gabion baskets will continue to deform and eventually fail (Tetra Tech 2019). DS3 should be reconstructed, and each gabion filled with properly sized rocks (typically crushed rocks greater than 4” in diameter). Figure 4 details the extent of the voids within the DS3 gabions. The same issue was noticed, to a lesser degree, at the other drop structures.

	
June 2021	July 2019

Figure 3: DS 3 Comparison

Figure 4: DS 3 Voids in Gabions

2.4 DS4

As detailed in Figure 5, it appears that DS4 has retained its structural integrity and has survived the intense flow rates of 2020 (See Figure 6) and the (relatively lighter) freshet in 2021. Similar to DS3, some of the gabions at DS4 have lost some of the rocks needed to maintain the structural integrity of the gabion baskets (See Figure 7). It appears that the temporary works completed in 2019 remain intact including the bank stabilization works and the large energy dissipation boulders placed just downstream from the gabions.

	
June 2021	July 2019

Figure 5: DS 4 Comparison

Figure 6: 2020 Freshet – May 11 Flow Over DS4

Figure 7: Voids in DS4 Gabions – June 2021

3.0 PLUNGE POOL AREA

As detailed in Figure 8, the plunge pool downstream of DS4 witnessed significant flows during the 2020 freshet. In 2019, a rock weir was constructed to backup water and promote the formation of a deeper pool at the base of DS4. A check dam at the downstream end of the pool was also constructed for the same purpose. Based on the photographic record (See Figure 9), it appears that both structures have partly survived the recent freshets. Some of the smaller rocks were likely washed away. Portions of the south bank remain unprotected, and sections of the filter fabric remain exposed. As previously recommended, the south bank should be reconstructed and the existing Articulated Concrete Blocks (ACB) system should be removed and replaced with larger rocks, similar to the work completed along the north bank (See Figure 10).

Figure 8: Plunge Pool – May 2020

	
Rock Weir	Check Dam
Figure 9: Plunge Pool Weir and Check Dam (2021)	

Figure 10: Exposed Filter Fabric along the South Bank

4.0 CLINTON CREEK CHANNEL

As detailed by some of the record pictures collected in 2020 and 2021, significant sections of the waste rock materials exposed on the south slope of the Clinton Creek channel has failed into the creek. The intense flows and the absence of a proper revetment system has exposed the toe of the slope to the intense erosive forces of the annual spring freshet. Left unchecked, the erodible embankments will continue to fail into the creek. A proper revetment system should be designed and constructed along the entire creek section to protect the base of the slope. Figure 11 details the extent of the erosion just downstream of the check dam. Figure 12 details the extent of the erosion witnessed along Clinton Creek.

Figure 11: Eroded Embankment D/S of the Plunge Pool – June 2021

Figure 12: Eroded Embankment Along Clinton Creek – May 2020

5.0 RECOMMENDATIONS

In 2019 Tetra Tech had made a series of recommendations included below. As the recommendations included in this section are intended to assist in developing a second iteration of emergency works, we also recommend that in addition to the proposed works that YG-AAM commissions a study and detailed design to identify practical, long-term solution to the erosion issues. We understand that this design work is currently in progress by Parsons.

We recognize that YG-AAM may be considering implementing another set of emergency works in the immediate term, before the freshet of 2022. As detailed in the following sections, we have developed a set of recommendations designed to temporarily improve the stability of the site. If only temporary works are to be conducted, we recommend that another inspection be conducted following the freshet of 2022. The following sections provide recommendations for each of the components integral to the DS4.

5.1 Check Dam

As detailed in Section 3.1, the check dam constructed in 2018 remains intact. It continues to maintain a higher water level within the upstream plunge pool and promote the deposition of gravels. On the other hand, the slope on the south side of the check dam was oversteepened, with visible cracks on that slope and signs of material sloughing into the creek channel, which suggested that erosion at the base of the slope was active. The more recent slope failures confirmed our concerns. As part of the emergency works, we recommend that the toe of the slope be stabilized and protected with large boulders. Ideally, the slope could also be pulled back so to develop a more stable slope. The rock placement proposed in 2019 should be extended up the slope. (Figure 13 provides a sketch of the original upgrades proposed in 2019).

Figure 13: Check Dam South Slope Recommendations

5.2 Plunge Pool

The plunge pool is again full of gravel material. In 2019 we had recommended to remove the gravels/sediments (Figure 14). As Parsons is currently working on the final upgrade plans, we don't feel this should be included in the list of critical upgrades for this summer.

Figure 14: Original Recommendations Provided in 2019 (Plunge Pool Gravel Removal)

5.3 Bank Stabilization Works

As mentioned in 2019, the stabilization works completed in 2018 along the north bank continue to protect the bank against erosion. The north bank is stable. That said, we have noticed small voids along the toe of the large rocks forming the embankment. To further protect the slope, we had recommended that the line of boulders placed in 2018 be buttressed by another row of larger boulders partly embedded into the substrate of the plunge pool. The goal was to protect the toe of the larger boulders and protect these from being undermined. Figure 15 provides an illustration of the proposed upgrades. As the works completed in 2018 are only intended to survive another freshet, we don't think this to be critical for this summer.

As for the south bank, we had proposed that the remaining ACB mats be removed completely and that the exposed south bank be stabilized with the same treatment as the north bank, using large rocks (See Figure 16). Flows appear to find a way to undermine the existing ACB system and destabilize the embankment. We do believe this to remain a critical item and if possible, it should be advanced this summer.

Figure 15: Proposed Upgrades along North Toe of Slope

Figure 16: Proposed Upgrades along South Toe of Slope

5.4 Large Rocks for Energy Dissipation

The large rocks placed at the toe of DS4 have not moved and continue to serve their purpose. To further protect the transition zone and the constructed slope, we had recommended infilling some of the voids with smaller rocks. This is no longer a critical item to be advanced this summer. As long as we don't witness an extreme event during the 2022 freshet, the rocks should survive the event. (See Figure 17).

Figure 17: Partly Infill Voids within the Larger Rocks

5.5 Reinstatement of Small Weir Downstream of DS4

In 2018 a series of boulders were used to formalize a weir downstream of DS4. Based on the field observations, some of the boulders have moved. We believe the intensity of the freshet has pushed some of these boulders allowing water to move unimpeded into the downstream pool. To reinstate the weir, we had proposed that a set of larger rocks be used to build a larger weir concentrating the flows towards the centre of the channel. Figure 18 provides an overview of the configuration of the proposed weir. Based on the ability of the system to survive the 2020 freshet, we believe this not to be a critical upgrade.

Figure 18: Proposed Rock Weir

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Government of Yukon and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Government of Yukon, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

7.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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PROFESSIONAL ENGINEER YUKON TERRITORY ADAM W. WALLACE 14 October 2021

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Enclosure: Limitations on the Use of this Document

PERMIT TO PRACTICE
TETRA TECH CANADA INC.
SIGNATURE
Date 14 Oct 2021
PERMIT NUMBER PP003
Association of Professional Engineers of Yukon

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – YUKON GOVERNMENT

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the use of TETRA TECH's Client, its officers, employees, agents, representatives, successors and assigns (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH. Any changes to the conclusions, opinions, and recommendations presented in TETRA TECH's Professional Document must be authorized by TETRA TECH.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems, as per agreed project deliverable formats. TETRA TECH makes no representation about the compatibility of these files with the Client's future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be brought to the attention of TETRA TECH within a reasonable time.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, and subject to the standard of care herein, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage, except where TETRA TECH has subcontracted for such information.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to make, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the Client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.8 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.9 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.10 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.11 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.12 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.13 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.14 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.15 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.16 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.17 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.18 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.19 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX F

SUMMARY OF TRIGGERS, MAINTENANCE AND MONITORING RECOMMENDATIONS

2021 LTPMP TRIGGER SUMMARY

Trigger ID	Description	Trigger Criteria	Action if Triggered	2021 Status	Discussion / Recommended Action
AR-1 (2014)	Horizontal movement of baseline	Average horizontal movement greater than 10 cm (less the average reported survey precision) for the baseline spikes, compared to the previous year's survey.	Develop mitigation plan	Not evaluated	▪ Survey baseline monitoring points and evaluate trigger in 2022.
AR-2 (2014)	Loss of road embankment at slope crest	Average horizontal embankment loss greater than 1 m along the length of the baseline, compared to the previous year's survey.	Develop mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Closed section of access road to remain closed. ▪ Continue to monitor.
~~AR-3 (2014)~~	Trigger removed and replaced with AR-5 in 2016				
~~AR-4 (2014)~~	Trigger removed and replaced with AR-5 in 2016				
AR-5 (2016)	Increase in risk of slope failure	Significant apparent increase in the risk of slope failure, based on visual inspection and review of survey data by a Professional Engineer.	Develop mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor.
~~HL-1 (2014)~~	Trigger removed in 2016				
HL-2 (2014)	Movement of log boom abutments	orizontal movement greater than 30 cm or vertical movement greater than 10 cm (less the reported horizontal or vertical survey precision), compared to previous year's survey.	Investigate base structure and develop mitigation plan	Not evaluated	▪ Survey log boom abutment posts and evaluate trigger in 2022.
HL-3 (2014)	Erosion at log boom abutments	Significant erosion around base of abutment structures, based on visual assessment and review of survey data by a Professional Engineer.	Install additional erosion protection and stabilize abutments if required	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor.
GDS-1 (2005, revised 2017, revised 2021)	Drop structure side slopes	Side slopes of drop structure increases to steeper than 2H:1V.	Develop mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Revised to remove reference to sideslopes of destroyed ACB mats. ▪ Continue to monitor.

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2021 LTPMP TRIGGER SUMMARY

Trigger ID	Description	Trigger Criteria	Action if Triggered	2021 Status	Discussion / Recommended Action
GDS-2 (2005, revised 2016)	Freeboard at design flow	Freeboard of less than 0.6 m (to top of gabion baskets) under design flow.	Develop mitigation plan	Triggered (former ACB mat area only, due to 2018 damage)	▪ Evaluated based on visual observations. ▪ Design and implement permanent channel reinforcement at DS4, and other drop structures if required based on hydraulic analysis.
~~DS-3 (2005, revised 2017)~~	Trigger removed in 2018				
GDS-4 (2005)	Erosion/undermining of drop structures	Visual evidence of erosion, piping, undermining, or water flowing beneath the drop structures warranting further assessment or mitigation measures in the opinion of a Professional Engineer.	Immediate repair prior to end of construction season	Triggered (active seepage and erosion beneath DS4 / in former ACB mat area, due to 2018 damage)	▪ Evaluated based on visual observations. ▪ Design and implement permanent channel reinforcement at DS4, and other drop structures if required based on hydraulic analysis.
GDS-5 (2005, revised 2017)	Damage to gabion baskets or ACB mats	Visible evidence of damage to the wire mesh of the gabion baskets or concrete blocks of the ACB mats.	Immediate repair prior to end of construction season	Triggered (DS4 ACB mats and downstream edge of DS4 gabions, due to 2018 damage)	▪ Evaluated based on visual observations. ▪ Design and implement permanent channel reinforcement at DS4, and other drop structures if required based on hydraulic analysis.
~~DS-6 (2014)~~	Trigger removed in 2016				
CC-1	Channel downcutting	More than 0.5 m of downcutting in Upper Channel, between DS4 and Sta. 0+300, compared to baseline (2010) survey.	Develop mitigation plan including stabilization of	Not triggered	▪ Evaluated based on visual observations.

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Trigger ID	Description	Trigger Criteria	Action if Triggered	2021 Status	Discussion / Recommended Action
(2005, revised 2016)			channel and toe of waste rock pile		▪ Survey creek channel and evaluate using survey data in 2022.
CC-2 (2005, revised 2016)	Channel downcutting	More than 1.5 m of downcutting over a significant portion (i.e., more than 50 m) of the creek channel downstream from Sta. 0+300, compared to the baseline (2010) survey.	Develop mitigation plan including stabilization of channel and toe of waste rock pile	Not triggered	▪ Evaluated based on visual observations. ▪ Survey creek channel and evaluate using survey data in 2022.
CC-3 (2014)	Channel deposition	More than 0.3 m of material deposited in any portion of the creek channel, compared to previous year's survey.	Develop localized mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Survey creek channel and evaluate using survey data in 2022.
CC-4 (2014)	Lateral channel migration	Middle Channel (Sta. 0+685 to 0+890) migrates laterally by more than 5 m to the south, towards the toe of the waste rock dump, compared to the previous year's survey.	Develop localized mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Survey creek channel and evaluate using survey data in 2022.
CCWR-1 (2014, revised 2016, revised 2021)	Movement of waste rock dump	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	Stability assessment and, if warranted, mitigation measures	Not triggered	▪ Evaluated based on visual observations and InSAR. ▪ Continue to monitor ▪ Trigger description and criteria revised to allow evaluation by InSAR in lieu of ground-based survey.
PCWR-1 (2020)	Movement of waste rock dump	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	Stability assessment and, if warranted, mitigation measures	Not triggered	▪ Continue to monitor
PP-1 (2014, revised 2016,	Movement of open pit slopes (Porcupine Pit)	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	Stability assessment and, if warranted, mitigation measures	Not triggered	▪ Evaluated based on visual observations and InSAR. ▪ Continue to monitor

Trigger ID	Description	Trigger Criteria	Action if Triggered	2021 Status	Discussion / Recommended Action
revised 2021)					▪ Trigger description and criteria revised to allow evaluation by InSAR in lieu of ground-based survey.
SP-1 (New)	Movement of open pit slopes (Snowshoe Pit)	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	Stability assessment and, if warranted, mitigation measures	Not triggered	▪ Trigger added to evaluate Snowshoe Pit separately from Porcupine Pit. ▪ Evaluated based on visual observations and InSAR. ▪ Continue to monitor
WP-1 (2014)	Pond surface area	Surface area of one or both Wolverine Ponds increases by more than 25%, compared to previous year's survey.	Develop localized mitigation plan	Triggered (North Pond, due to beaver dam)	▪ Evaluated based on visual observations. ▪ Remove beaver dam and/or install underflow culvert to lower pond elevation and reduce surface area/volume of water. ▪ Continue to monitor.
WP-2 (2014)	Pond outlet width	Outlet width of one or both Wolverine Ponds decreases by more than 15%, compared to previous year's survey.	Develop localized mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor
WP-3 (2014)	Pond outlet invert elevation	Pond outlet invert elevation at one or both Wolverine Ponds changes (increase or decrease) by more than 0.5 m, compared to previous year's survey.	Develop localized mitigation plan	Triggered (North Pond, due to beaver dam)	▪ Evaluated based on visual observations. ▪ Remove beaver dam and/or install underflow culvert to lower pond elevation and reduce surface area/volume of water. ▪ Continue to monitor.

2021 LTPMP TRIGGER SUMMARY

Trigger ID	Description	Trigger Criteria	Action if Triggered	2021 Status	Discussion / Recommended Action
WC-1 (2005)	Channel downcutting	More than 1 m of downcutting over a significant portion (i.e., more than 50 m) of the creek channel between Sta. 0+975 and 1+500, compared to the baseline (2003) survey.	Develop mitigation plan including channel stabilization works	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor.
WC-2 (2005)	Channel downcutting	More than 0.5 m of downcutting over a significant portion (i.e., more than 50 m length) of the creek channel between Sta. 0+685 and 0+975, compared to the baseline (2003) survey.	Develop mitigation plan including channel stabilization works	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor.
WC-3 (2005, revised 2016)	Channel instability	Visual evidence of erosion, instability, or loss of rock in rock-lined channel (Sta. 0+435 to 0+685).	Develop mitigation plan including channel stabilization works	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor.
WC-4 (2014)	Channel deposition	More than 0.3 m of material deposited in any portion of the creek channel, compared to previous year's survey	Develop localized mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor.
WC-5 (2014)	Lateral channel migration	Channel migrates laterally by more than 5 m, compared to the previous year's survey.	Develop localized mitigation plan	Not triggered	▪ Evaluated based on visual observations. ▪ Continue to monitor.
TP-1 (2014, revised 2016, revised 2021)	Movement of tailings pile	Significant increase in movement rates (horizontal or vertical settlement), warranting further assessment of stability or mitigation measures in the opinion of a Professional Engineer.	Stability assessment and, if warranted, mitigation measures	Not triggered	▪ Evaluated based on visual observations and InSAR. ▪ Continue to monitor ▪ Trigger description and criteria revised to allow evaluation by InSAR in lieu of ground-based survey.

2021 LTPMP MAINTENANCE RECOMMENDATIONS

ID	Site Component	Priority	Description
1	Site Access Road	Low (Ongoing / As Required)	The road between the Top of the World Highway and the Forty Mile Bridge should be maintained as required to allow vehicle and equipment access.
2	Site Access Road	Low (Ongoing / As Required)	The road between Forty Mile Bridge and the former mill site should be maintained as needed to allow vehicle and equipment and equipment access.
3	Site Access Road	Low	Mileage markers should be installed to reduce uncertainty in estimating location/distance along the access road.
4	Site Access Road	Medium	Larger boulders or a permanent fence should be installed around the site access gate to prevent future tampering and more effectively limit unauthorized site access.
5	Site Access Road / Wolverine Creek Channel	High	Hydrotechnical studies done in 2020 suggest that the Wolverine Creek culverts near the site access gate are undersized. The culverts should be upgraded to handle design flows, or the area should be regularly monitored (especially at freshet), culverts kept clear of debris/blockages, and damage repaired as needed to maintain site access.
6	Site Access Road	Low	Measures for erosion protection should be considered along the road and/or in the Clinton Creek channel between Ford Crossing No. 1 and the closed access road, to prevent ongoing/future erosion that could impact access to the site.
7	Site Access Road	Low	A swale or berm should be installed around the top of the erosion gully on the road between Ford Crossing No. 2 and the former mill site (about km 41.8) to reduce the potential for future erosion.
8	Site Access Road	Medium	The site access road between Ford Crossing No. 2 and the former mill site should be re-graded to repair erosion and gullying, and vegetation should be trimmed to maintain vehicle access.
9	Site Access Road	Medium	Boulders and berms blocking the access road to the Wolverine Creek channel and base of the tailings piles should be removed and replaced with a locking gate, to allow authorized vehicle access to these areas in case the existing trail that descends the tailings pile becomes unaccessible.
10	Site Access Trails	Medium (Ongoing / As Required)	Minor roads and trails on the site should be cleared of vegetation and maintained as required to provide access to all site components.
11	Closed Access Road	Low	The existing swale along the uphill (south) side of the closed access road should be improved to establish a formalized ditch that will carry surface water away from the slope crest and slow the rate of erosion and embankment loss into the Clinton Creek channel.
12	Hudgeon Lake Outlet	Medium	Repairs to the log boom abutments should be considered to mitigate the effect of frost jacking. Repairs would generally consist of re-installing both abutments at their original embedded depths and backfilling with non-frost susceptible fill to reduce the potential for continued frost jacking issues.
13	Hudgeon Lake Outlet	Low (Ongoing / As Required)	The Hudgeon Lake outlet should be monitored for beaver dam building activity, or accumulation of any other debris that would impede flow into the Clinton Creek channel. Any dams or other debris should be removed when observed.

2021 LTPMP MAINTENANCE RECOMMENDATIONS

ID	Site Component	Priority	Description
14	Hudgeon Lake Outlet	Medium	The log booms should be installed when Hudgeon Lake is unfrozen, to reduce the amount of debris that enters the creek channel and the resulting potential for damage to the drop structures.
15	Gabion Drop Structures	Medium (Ongoing / As Required)	Logs, wood, and/or other debris lodged in the drop structures should be removed to reduce the risk of damage to the gabion baskets.
16	Gabion Drop Structures	High	Long-term improvements to the drop structures should be implemented in 2022. If the improvements cannot be built in 2022 as planned, then at a minimum the interim repairs outlined in Tetra Tech's hydrotechnical review (Appendix E) should be implemented to reinforce the temporary repairs at DS4.
17	Clinton Creek Channel	Medium (Ongoing / As Required)	The creek channel should be monitored for blockages by debris, logs, beaver dams, or similar. Any blockage should be removed promptly when observed.
18	Clinton Creek Channel	Medium	Permanent repairs or improvements should be made to stabilize the creek channel to reduce erosion and sloughing from the channel and the surrounding slopes.
19	Clinton Creek Natural Slope	Low	Extensometers should be installed to monitor movement/widening of existing tension cracks on the slope.
20	Clinton Creek Natural Slope	Medium	The access trail to BH18-08 that climbs the natural slope to the north of the drop structures should be decommissioned to restore natural drainage on the slope, and/or a berm or ditch should be established to ensure that water is carried all the way to the base of the trail and is not allowed to spill onto the natural slope.
21	Porcupine Creek Waste Rock Dump	Medium	Vegetation should be cleared from roads and trails to maintain access to all areas of the Porcupine Creek waste rock dump.
22	Wolverine Creek Ponds and Channel	Medium (Ongoing / As Required)	The creek channel, pond inlets and outlets, and culverts should be monitored for blockages and construction of beaver dams, and any obstructions should be removed.
23	Wolverine Ponds	Medium	Beaver dams along Wolverine Creek in the vicinity of the ponds should be removed and/or fitted with underflow culverts ("Beaver Deceiver") to drain impounded water.
24	Wolverine Creek Channel	Medium	Debris and brush in the channel just downstream from the Wolverine Creek south pond outlet should be removed to maintain unobstructed flow in the channel.

2021 LTPMP MONITORING RECOMMENDATIONS

ID	Site Component	Description	Implementation
1	2022 LTPMP (General)	The 2022 LTPMP should consist of a "large" program, including: ▪ Geotechnical site inspection; ▪ InSAR monitoring using high resolution imagery from the TSX/PAZ satellite; and ▪ Ground-based topographic survey of selected monitoring points and site components.	▪ Geotechnical site inspection should be completed shortly after spring freshet, so that maintenance recommendations can be addressed during the summer season. ▪ InSAR should be processed in the fall, so that the processed dataset includes as many images as practical before the ground becomes covered with snow for the winter. ▪ Options to identify new, stable reference points and/or improve confidence in the stability of the existing reference points that are used to process the InSAR data should be reviewed with TRE while planning for the 2022 LTPMP. ▪ The ground-based topographic survey will be limited to selected monitoring points and site components where InSAR is not able to provide comprehensive, detailed monitoring.
2	2022 LTPMP (Ground-Based Survey)	The ground-based survey should include the following site components: ▪ Clinton Creek waste rock dump. ▪ Log boom abutments at the Hudgeon Lake outlet. ▪ Gabion drop structures. ▪ Clinton Creek channel. ▪ Closed access road. A detailed scope and survey field plan should be developed following the 2022 geotechnical site visit.	2022 LTPMP
3	2023 LTPMP	The 2023 LTPMP would normally consist of a "small" program. The scope of the 2023 LTPMP should be developed with reference to the results of the 2022 program, and in conjunction between YG-AAM, CIRNAC, the LTPMP consultant, and the mine site remediation design consultant, so that the monitoring program can contribute to the long-term maintenance, remediation and closure of the site. At this time it is expected that the 2023 program will include the typical geotechnical site visit and displacement monitoring using InSAR. It is expected that ground-based survey can be excluded from the scope of the 2023 LTPMP.	2023 LTPMP