

**Mount Nansen Water Quality and Quantity Adaptive Management Plan**

**Prepared for: Assessment and Abandoned Mines  
Department of Energy, Mines and Resources  
Government of Yukon**

**15 March 2018**

**MOUNT NANSEN WATER QUALITY AND QUANTITY ADAPTIVE MANAGEMENT PLAN**

Adapted from:

SLR 2015

Prepared by

Lorax Environmental

for

**GOVERNMENT OF YUKON, DEPARTMENT OF ENERGY, MINES AND RESOURCES,  
ASSESSMENT AND ABANDONED MINES**

15 March 2018

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## 1.0 INTRODUCTION

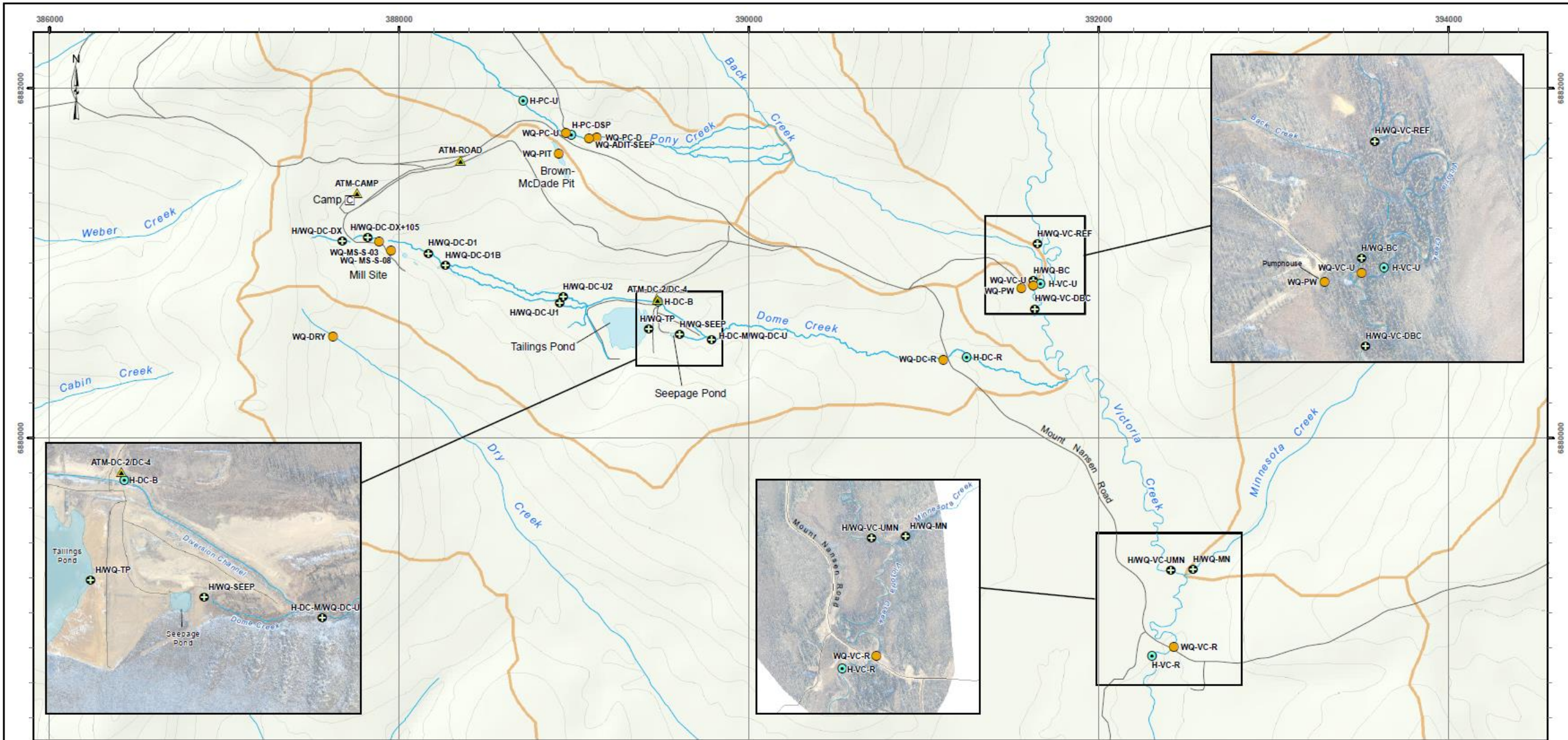
The Mount Nansen Site (the Site) is an abandoned mine located approximately 45 km west of the Town of Carmacks Yukon (70 km by road), within the Traditional Territory of the Little Salmon Carmacks First Nation (LSCFN). Water from the Site makes its way to Victoria Creek, the receiving environment downstream of the site, which also flows through LSCFN settlement land and supports fish and fish habitat values.

The Mount Nansen Site consists of the following main components (Figure 1-1):

- underground workings (e.g. Huestis and Brown McDade);
- Brown McDade open pit from which 269,000 m<sup>3</sup> of ore and several hundred thousand cubic meters of waste rock were extracted;
- a tailings pond in the Dome Creek valley containing approximately 258,000 m<sup>3</sup> of tailings;
- a seepage collection dam and pump facilities immediately downstream of the main tailings dam;
- the former mill/generators/workshop complex;
- cookhouse and bunkhouse buildings;
- Victoria Creek wellhouse building and pump; and,
- various pipelines and power lines.

The former owners of the Site (BYG Natural Resources Inc. entered receivership and PricewaterhouseCoopers (PwC) was appointed Interim Receiver of the Site in April 2004 and Trustee in Bankruptcy in November 2006. Day-to-day operations on the Site have been managed by Assessment and Abandoned Mines (AAM), Department of Energy, Mines and Resources of the Government of Yukon since 2003.

AAM is preparing for an assessment of proposed care and maintenance activities at the Site, with care and maintenance activities anticipated to continue until a Site remediation plan can be prepared, permitted, and implemented. This Adaptive Management Plan (AMP) provides the structure through which to monitor for degradation of environmental conditions, particularly surface water, and to ensure that mitigative measures can be put in place where needed during the care and maintenance activities.

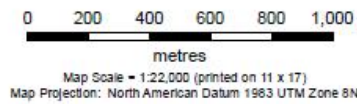


### Mount Nansen Site: Hydrometric Stations and Water Quality Sites

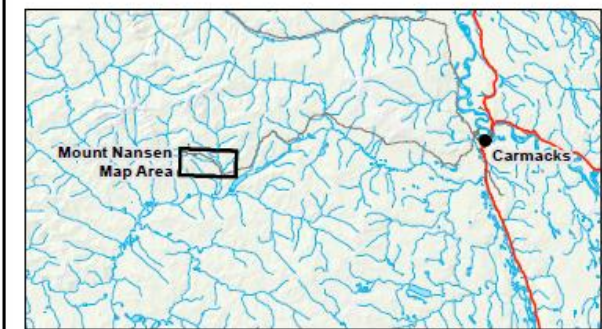
#### Legend

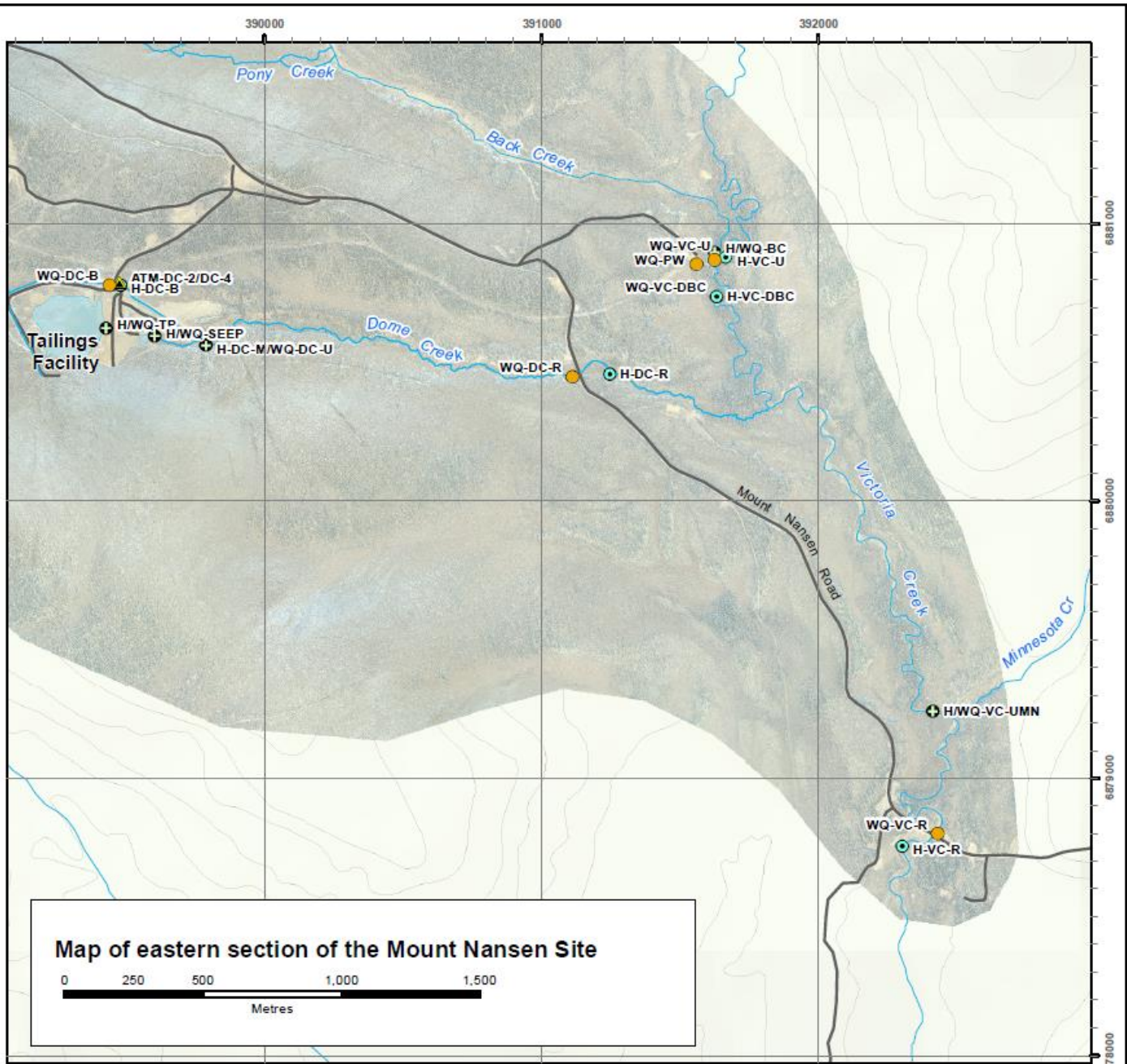
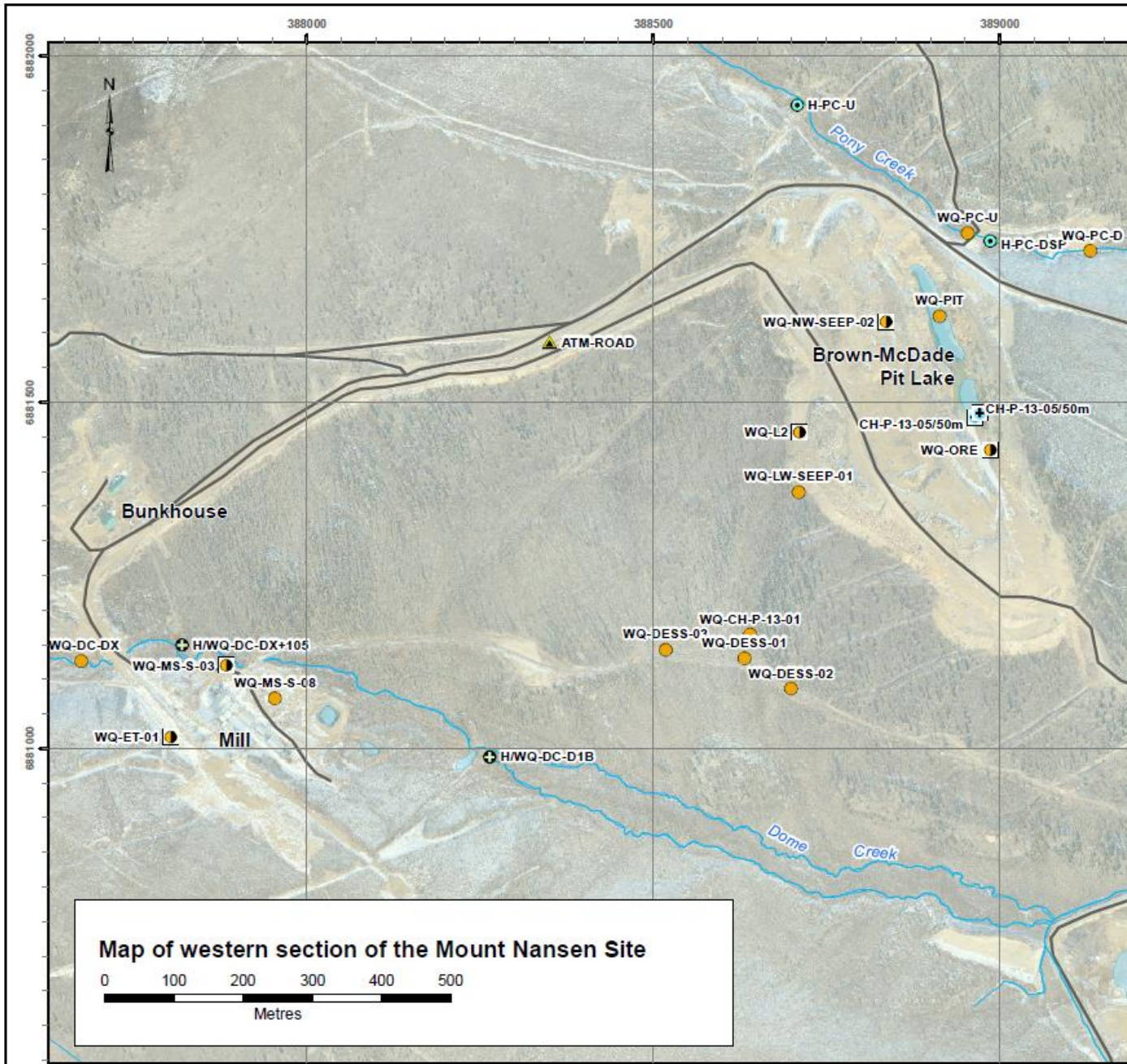
- Atmospheric Station (label ex: ATM-DC-2)
- Hydrometric Station and Water Quality Site (label ex: HWQ-VC-UMN)
- Hydrometric Station (label ex: H-VC-R)
- Water Quality Site (label ex: WQ-PC-U)
- Unpaved Road/Access
- Drainage Areas (Local)

1:50,000 and 1:250,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (Corporate Spatial Warehouse) www.geomatics.yukon.ca.  
 Digital Elevation Model provided by Geomatics - Yukon Government via online source (Corporate Spatial Warehouse) www.geomatics.yukon.ca.  
 Watercourse, drainage areas and Mount Nansen Road layers digitized / modified by EDI (2011) using orthophotos provided by Yukon Government, Energy, Mines and Resources (2011).  
 Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2011) was obtained using Garmin GPS technology.  
 This document is not an official land survey and the spatial data presented is subject to change.



Drawn: LG      Checked: MM      **FIGURE 1**      Date: 28/10/2013





### Mount Nansen Site: Hydrometric Stations and Water Quality Sites

**Legend**

- Atmospheric Station (label ex: ATM-DC-2)
- Hydrometric Station and Water Quality Site (label ex: H/WQ-VC-UMN)
- Hydrometric Station (label ex: H-VC-R)
- Water Quality Site (label ex: WQ-PC-U)
- Temporary Hydrometric Station
- Temporary Water Quality Site
- Unpaved Road/Access

**Notes:**  
 1:50,000 and 1:250,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (Corporate Spatial Warehouse) www.geomatics.yukon.ca.  
 Digital Elevation Model provided by Geomatics - Yukon Government via online source (Corporate Spatial Warehouse) www.geomatics.yukon.ca.  
 Watercourse, drainage areas and Mount Nansen Road layers digitized / modified by EDI (2011) using orthophotos provided by Yukon Government, Energy, Mines and Resources (2011).  
 Imagery provided by Yukon Government - Energy, Mines and Resources - Abandoned Mines Branch.  
 Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2014) was obtained using Garmin GPS technology.  
 This document is not an official land survey and the spatial data presented is subject to change.

Map Projection: North American Datum 1983 UTM Zone 8N

Drawn: LG	Checked: MM	<b>FIGURE 2</b>	Date: 28/05/2014
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## 2.0 AMP CONTEXT

The AMP for the Site was originally developed by AAM, Indigenous and Northern Affairs Canada (INAC) and Little Salmon Carmacks First Nation (LSCFN) in 2015 as a management strategy. The AMP was required to bridge an interim period while remediation planning for the site was underway. The AMP is intended to guide monitoring at the Site for the potential degradation of conditions; to help with identification of circumstances where active intervention may be necessary; and to ensure appropriate management actions are implemented. A draft of the AMP was used to manage the Site in 2014 until finalization could be completed in 2015. This 2017 version is the first revision to the original AMP.

During the implementation of the draft AMP, Dome Creek water quality (WQ) (DC-D1b) and seepage collection pond (SEEP) WQ events were triggered due to elevated levels of zinc at DC-D1b and elevated levels of arsenic, iron and manganese at SEEP. In response, AAM conducted further sampling and investigations to understand the source of the contamination and appropriate action. Further information related to monitoring and effects analysis may be found in the 2017 Lorax report, *Mount Nansen Dome Creek and Victoria Creek Surface Water Quality Evaluation and Preliminary Aquatic Effects Assessment* (Lorax 2017). The AMP has since been updated to reflect the results of the referenced effects analysis.

As an outcome to implementing the AMP and in support of the Care and Maintenance Project Proposal (CMPP), water treatment has been proposed to treat discharge from the seepage collection pond. An existing conditions surface water quality assessment was conducted in support of the CMPP. Changes to analytical methods in 2012 and field sampling methods in 2011 to 2012 (namely field filtration for dissolved metals sampling) has resulted in an overall improvement in the quality and representativeness of water quality results.

Based on the above, an interim change to baseline water quality for this AMP is proposed as necessary to inform decision-making until a new baseline can be achieved following implementation of water treatment. Specifically, a change to baseline data to the 2014-2016 period is proposed. The 2014-2016 period was selected as it represents current water quality conditions in the seepage collection pond and affected locations downstream, including lower Dome Creek and Victoria Creek stations downstream of Dome Creek. The 2014-2016 period represents a period of time in which water quality monitoring was conducted consistently in Dome and Victoria Creeks. Triggers in the previous version of the AMP considered data from different periods of time for different stations, partly due to a shift in monitoring locations in upper Dome Creek. In summary, new water quality triggers based on the 2014-2016 period are assessed for the site for consistency and to inform interim decision-making until a new baseline is established following the implementation of water treatment.

A comparison of water quality statistics has been conducted to provide context for the revised water quality triggers (Appendix A). Proposed changes to water quality triggers are exclusive to Dome Creek and Victoria Creek and include the events listed below:

- Event 1: Degraded water quality in Dome Creek downstream of mill area;
- Event 2: Changes in water quality in the seepage pond;
- Event 6: Degraded water quality in Dome Creek downstream of tailings facility;
- Event 7: Degraded water quality in Victoria Creek downstream of mine area; and,
- Event 8: Degraded water quality in Pony Creek downstream of mine area.

Further refinement of this AMP includes the addition of water management and water treatment related events (Event 3, 4, 5 and 9). These events will be refined following commissioning and operation of the water treatment plant. In this regard, this draft AMP may be considered an interim AMP until these processes have been finalized.

## **3.0 APPROACH TO THE AMP**

### **3.1 Objectives for the Adaptive Management Plan (AMP)**

The AMP is a management tool that provides a consistent and predictable framework for identifying and responding to unforeseen deteriorating environmental conditions on site. The AMP provides the site operator, and AAM, with a pre-planned framework within which problems can be identified in a timely manner and decisions can be quickly and efficiently made. The AMP also provides regulators with the security of a consistent and predictable approach to unforeseen events.

The AMP takes the Precautionary Principle Approach: it provides a mechanism to identify potential environmental risks as they emerge and provides for a management response before an environmental impact occurs.

The AMP must be linked to the site operational plan and a comprehensive monitoring program that provides an indication of when management intervention is necessary. This assures that the necessary data and information for the assessment of environmental conditions are being collected, analysed and evaluated against predetermined “triggers” or “thresholds.”

Although some of the specific environmental conditions that may be encountered are, by definition, unknown, with the current understanding of the site conditions, many of the potential issues are generally understood. As such, the AMP should not provide detailed description of specific management responses but rather present a toolbox of possible management responses that range in level of intervention or mitigation. The level of intervention required is based on the assessment of the timing and impact on the receiving environment. The AMP therefore provides general descriptions of a range of possible responses that may be adapted or otherwise used to guide the design of an appropriate response that best suits the needs of the specific environmental conditions that are encountered. This approach is inherent to the fundamental purpose of the AMP.

Areas where there is uncertainty about site conditions, or where possible future conditions could lead to unacceptable environmental effects, have been identified, and the AMP provides an approach that will be used to monitor, detect, and respond to changing conditions. Such an approach includes the following key components:

- Proactive monitoring to detect changing conditions in areas of expected uncertainty within a timeframe that allows for effective response;
- Clear and defensible triggers that will assure timely implementation of effective responses; and,
- Appropriate measures that can be undertaken to address unacceptable conditions and performance.

### **3.2 AMP Events**

There are ten events for the Mount Nansen AMP for Mount Nansen. These events represent anticipated environmental conditions that may significantly decline and therefore require a management response. These events specifically focus on locations on site where deteriorating conditions, including water quality, may affect receiving environments. The ten events include the following:

1. Degraded water quality in Dome Creek downstream of the mill area.
2. Changes in water quality in the seepage pond.

3. Changes in water quality in water treatment plant effluent.
4. Changes in seepage pond inflows/volume outside of historic norms.
5. Water level in seepage pond reaches maximum operating level.
6. Degraded water quality in Dome Creek downstream of the tailings facility.
7. Degraded water quality in Victoria Creek downstream of mine area.
8. Degraded water quality in Pony Creek downstream of mine area.
9. Changes in groundwater quality downgradient of the Brown-McDade Pit.
10. Water level in the tailings pond reaches maximum desired water level.

The AMPs for each of these events are described individually in subsequent sections below.

### **3.3 Common Elements**

To maintain consistency within the AMP, each of the AMP Events is described according to common elements. These common elements provide a structure that will ensure that a consistent approach is followed for each event and that the AMP will be proactive in detecting changes and implementing appropriate responses before any unacceptable environment effects occur. The following common elements form part of each specific AMP Event.

Event – This element describes the specific event that is addressed by the AMP.

Possible Environmental Consequence – This element describes the environmental consequences that could arise if the event was allowed to proceed without appropriate response.

Narrative Trigger – This is a description of the AMP trigger event and leads to the development of the specific indicators and thresholds. In general, the narrative trigger states that monitoring results indicate a specific type of environmental condition is deteriorating.

Specific Indicators – This element describes the environmental parameters to be monitored and assessed as part of the AMP. These indicators will be selected to provide early detection of relevant changes in environmental conditions or system performance. They should be representative of the issue being monitored and assessed, easily measured, and reproducible.

Specific Thresholds – This element defines thresholds, in terms of specific indicators, that would lead to actions being taken. They may be a series of staged thresholds or multiple thresholds for an individual AMP event, and where warranted, may include seasonally-based thresholds.

Monitoring Requirements – This element describes the monitoring that will be carried out to support implementation of the AMP. Parameters and general locations for sampling are discussed as part of the AMP framework. Physical inspections and visual monitoring can also form part of the monitoring requirements. Monitoring requirements may change at various stages of the AMP.

Evaluation of Monitoring Results – This element describes the methods and frequencies that will be used to evaluate the monitoring data and determine whether specific thresholds have been reached or exceeded.

Response Approach – This element describes the overall approach to responses to be implemented if thresholds have been reached or exceeded. In most cases, the responses will include a range of actions that

may be taken to address the events. The selection of the appropriate responses would depend on changed site conditions or system performance and the associated impact on the receiving environment.

Within the context of implementing the AMP, there will be an ongoing need to understand the validity of monitoring results and confirm the circumstances of threshold or trigger activation. This validation and confirmation process will be conducted in a timely manner and is necessary to verify that response actions are applied in the appropriate circumstances. For each AMP element, if monitoring identifies conditions that are approaching or meeting triggers or thresholds, a stepped response will be implemented for validation and confirmation. Although presented in a sequential order, some steps may occur concurrently or be omitted, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

1. Notification & Validation

The initial response to the trigger will be to notify AAM, followed by the verification of the monitoring information. The verification will involve a comprehensive analysis of the laboratory results or field data (e.g. in the case of water levels).

2. Preliminary Identification

The second step will be a comprehensive analysis of the other related monitoring results from the locations including the monitoring data collected to directly support the AMP and other relevant site monitoring data, possibly including results collected for other associated AMP Events. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation.

3. Analysis and Investigation

The third step will be an analysis of the timing and potential consequences of trigger activation on the receiving environment including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to prevent or mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Modelling may also be used to assess the effectiveness and impact of various mitigative options. Increased monitoring intensity may also be required (parameters, locations, and frequency) to verify and understand the cause/source of the trigger activation. This may entail detail site investigation work, such as seepage or groundwater investigations, to delineate the source of the trigger activation.

4. Response Plan

A response plan will subsequently be developed based on the comprehensive analysis and investigation described above. Generally, this plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of intervention required will, in part, be based on the assessment of the timing and impact of the trigger activation on the receiving environment.

### **3.4 Approach to Trend Analysis**

Trend analysis plays a key part of the AMP protocol, with several of the AMP Events having a statistically significant trend as one of the thresholds or triggers. To facilitate trend assessment a standardized approach is adopted using Microsoft Excel, as previously defined as per the Mount Nansen AMP protocol. Except for Pony Creek, an updated baseline is presented within this AMP and is composed of data from 2014 to 2016. The baseline was updated to reflect changes in water quality and associated event trigger levels and

to provide a consistent basis of comparison across the Site for the various AMP events (Appendix A). Proposed water treatment will have a beneficial effect on water quality in lower Dome Creek and Victoria Creek. As an interim measure, revised water quality triggers apply to the period leading up to and following water treatment implementation until a new baseline can be established once water quality parameters stabilize post-treatment. As per AMP protocol, a water quality trend analysis will be conducted annually.

For the trend analysis and determination of a significant trend, the least squares method of linear regression is used to fit a trend line to the data. This can be done using the LINEST function in Excel. The F-statistic for this regression is calculated from the ratio of the variances. The F-statistic is used to test the null hypothesis that the data is a random scatter of points with a zero slope with non-positive or negative trend. The calculated F-statistic is compared to critical values of F-statistic found in standard statistic tables. If the F-statistic is greater than the critical value, the null hypothesis fails and the linear model, and associated trend, is significant. Using a significance level of 0.05, if the calculated statistic is greater than the critical value, then we are 95% confident that the data is not a random scatter and the linear regression is justified.

### 3.5 Management Reviews, Annual Review and Reporting

An annual AMP review will be completed that assesses the adequacy and appropriateness of the elements of each Event such as trigger locations, specific indicators and thresholds, and monitoring requirements. Updates, amendments or other changes to the AMP will be recommended as part of this annual review.

Each AMP Event includes a management review by the AAM Environmental Monitoring Officer or contractor, of the relevant data to assess if a trigger has occurred. These reviews will occur monthly or annually, depending on the specific requirements of the AMP Event. The results of the monthly review, where a trigger occurs will be reported monthly. The results of these reviews will also be summarized as part of the annual review.

### 3.6 AMP Event Communication

Should an AMP Event occur the following communications will take place:

Party	Action	Timeline
AAM	Receives and reviews water quality data.	Monthly
AAM	If unusual, contractor returns to site for confirmatory sampling.	ASAP
AAM	If result is similar, AAM notified LSCFN and AANDC.	Immediately following results of confirmatory sampling.
AAM	Develops and circulates proposed mitigation plan.	ASAP – dependent on Event.

The type and frequency of communication following circulating the proposed mitigation plan will depend on the type and scale of the Event.

## **4.0 AMP EVENT 1 - DEGRADED WATER QUALITY IN DOME CREEK DOWNSTREAM OF MILL AREA**

### **4.1 Description**

The water quality in Dome Creek downstream of the mill area is currently affected by surface water runoff and seepage inflows from the mill area. Water quality in Dome Creek is monitored monthly, when flowing, at WQ-DC-D1b except for spring freshet. Samples are collected at a higher frequency (bi-weekly) in the period leading up to freshet, during freshet and following freshet to capture variability during this period. Historically, water quality in Dome Creek downstream of the mill area was measured further upstream at WQ-DC-D1. In 2012 it was identified that this location no longer contained most of the flow in Dome Creek due to migration of the Dome Creek channel. A new monitoring location was moved further downstream to station WQ-DC-D1b in 2013 and Station D1 was discontinued. Monthly water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, total and dissolved metals. The flow in Dome Creek in this area is measured at HC-DC-D1b.

The environmental consequence of degraded water quality in Dome Creek downstream of the mill is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants. The mill area is a known source of contaminants to Dome Creek including sulphate, arsenic, cadmium, and zinc.

### **4.2 Specific Information or Issues**

Water quality data in Dome Creek at WQ-DC-D1b has been collected since 2012. A comparison of data collected from both WQ-DC-D1 and WQ-DC-D1b in 2012 and in May 2013 indicates that although similar parameters are elevated at each station, there were slight variations between the water quality data from these two stations. Specifically, sulphate, ammonia, aluminum, antimony, arsenic, iron and manganese were present at higher concentrations at WQ-DC-D1b than WQ-DC-D1. It is postulated that point source inputs from historic water management ponds and/or discharge from historic underground workings may be contributing to the increase in concentrations at WQ-DC-D1, however this has not been confirmed. While concentrations have been shown to increase spatially, more recent temporal trends indicate concentrations are stable or are decreasing over time. As station WQ-DC-D1b is located further downstream, it is better suited to capture effects from the mill. A summary of the 2014 to 2016 water quality data for Dome Creek at WQ-DC-D1b is presented in Table 4-1. Water quality results below detection limit are assumed to be at detection limit for the purposes of statistical and graphical analysis.

### **4.3 Narrative Trigger**

The trigger for the implementation of the AMP is “contaminant concentrations in Dome Creek downstream of the mill area as measured at WQ-DC-D1b display a statistically significant increase”.

### **4.4 Specific Indicators**

The specific indicators that should be monitored at Station WQ-DC-D1b to provide the information necessary to assess whether the trigger has been achieved are:

- Sulphate (mg/L);
- Total and dissolved arsenic (mg/L);
- Total cadmium (mg/L); and
- Total zinc (mg/L).

**Table 4-1 Summary of 2014 to 2016 Water Quality (mg/L) Data for Dome Creek at WQ-DC-D1b.**

<b>Statistic</b>	<b>Sulphate</b>	<b>TSS</b>	<b>Total Arsenic</b>	<b>Dissolved Arsenic</b>	<b>Total Cadmium</b>	<b>Diss. Cadmium</b>
Minimum	145	2	0.011	0.010	0.00029	0.00008
5 <sup>th</sup> Percentile	151	2	0.018	0.010	0.00031	0.00009
Median	605	14	0.034	0.016	0.00061	0.00023
95 <sup>th</sup> Percentile	719	25	0.077	0.022	0.00182	0.00090
Maximum	740	269	0.113	0.038	0.00196	0.00102
Number of Samples	22	22	22	22	22	22

<b>Statistic</b>	<b>Total Iron</b>	<b>Diss. Iron</b>	<b>Total Manganese</b>	<b>Diss. Manganese</b>	<b>Total Zinc</b>	<b>Diss. Zinc</b>
Minimum	0.20	0.10	0.452	0.41	0.086	0.072
5 <sup>th</sup> Percentile	0.24	0.11	0.471	0.45	0.099	0.080
Median	1.64	0.22	0.829	0.78	0.172	0.134
95 <sup>th</sup> Percentile	7.02	0.49	1.30	1.37	0.363	0.307
Maximum	9.54	0.54	1.43	1.37	0.439	0.355
Number of Samples	22	22	22	22	22	22

## 4.5 Specific Thresholds

The specific thresholds or triggers that will initiate an action plan, for any one of the specific indicators, will be as follows:

- A statistically significant (0.05) increasing trend in the monitoring results from WQ-DC-D1b using the trend analysis technique outlined in Section 2.4.

## 4.6 Monitoring Requirements

The monitoring information required monthly (when available) is: sulphate, total and dissolved arsenic, total cadmium and total zinc concentrations measured at WQ-DC-D1-b. This data will be used to update the trend analysis for each parameter.

Additional monitoring information that is required for analysis should the AMP triggers be activated include surface and subsurface water quality and flow data from locations upstream of D1b. Both water quality and flow data are essential as they enable not only the analysis of contaminant concentrations but loadings as well. The locations required are surface water quality stations upstream in the Dome Creek Drainage and from any surface, seepage and groundwater monitoring locations located in and downgradient of the mill area. The monitoring locations are outlined in Table 4-2.

**Table 4-2 Summary of Water Quality Sites for Dome Creek at D1b AMP**

Site Name	Description
WQ-DC-B	Dome Creek at bridge over tailings diversion channel
WQ-DC-D1b	Dome Creek at D1-b, downstream of mill area
WQ-DC-DX	Dome Creek at DX, upstream of mine site area
WQ-DX+105	Dome Creek at DX+105, 105 m downstream from DX
MS-S-03	Mill Site Seep 03
MS-S-08	Mill Site Seep 08
Groundwater Wells	Monitoring wells in and downgradient of mill area

## 4.7 Evaluation of Monitoring Results

The management review of the relevant water quality data (D1b) will be carried out monthly. This review will be completed when the QA/QC'd water quality data has been received from the contractor responsible for the routine site water quality monitoring program. For the assessment of triggers during periods with bi-weekly sample events, the bi-weekly concentrations will be averaged for the month. This average monthly value will then be carried forward and assessed as per the AMP Protocol.

## 4.8 Response Approach

As per the general approach to the AMP, a staged response to degraded water quality in Dome Creek downstream of the mill area will be implemented if one of the triggers is activated. Four major steps are identified below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

### 1. Notification & Validation

The initial response to the trigger will be the verification of the monitoring information. This will involve a comprehensive analysis of the laboratory results. The water quality at WQ-DC-D1-b may then require re-

sampling if warranted (i.e. if QA/QC data or field notes indicates sampling issues/errors). This re-sampling should be done within approximately 1 to 4 weeks of the previous sampling time. Upon verification of the monitoring data that a threshold has been crossed and that the mill area is the likely cause, notification to AAM will be provided.

## 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined in Table 3-2 will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation.

## 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis, increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require detailed site investigation work such as seepage, groundwater or surface water quality investigations. For example, a conductivity survey along Dome Creek may be required to identify potential point sources that may be contributing the Dome Creek water quality (e.g., discharge from historic water management ponds and/or historic underground workings).

## 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of contamination in conjunction with the assessment of the timing and environmental consequence of the trigger activation. The following provides a list of the range of potential responses:

- Diversion of “clean” runoff water away from mill area to minimize the pathway to Dome Creek;
- Interception, collection, and/or management of the identified source; and
- Early implementation of components of the MNRP in targeted areas to minimize ongoing source loading to the receiving environment.

## **5.0 AMP EVENT 2 – CHANGES IN WATER QUALITY IN THE SEEPAGE POND**

### **5.1 Description**

The seepage pond at the toe of the tailings impoundment collects shallow groundwater seepage from the tailings area. The seepage collected in the pond is continuously pumped to Dome Creek. Following installation of a water treatment plant (WTP), water will be pumped from the seepage collection pond to the water treatment plant. Water treatment effluent will discharge to Dome Creek at the present location or to the Dome Creek Diversion Channel.

Water quality in the seepage pond is measured monthly, at the seepage pond outlet pipe, WQ-SEEP, except for spring. In spring, samples are collected at a higher frequency (bi-weekly) in the period leading up to freshet, during freshet and following freshet. Water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, hardness, total and dissolved metals. The pond water levels are measured daily, during open water, via a staff gauge. The discharge pumping rate is measured daily via an inline flowmeter (H-SEEP) and routinely checked using timed volumetric measurements.

Water quality will continue to be monitored at the SEEP so as to inform performance and suitability of existing water treatment infrastructure. Water quality in the seepage collection pond is elevated in TSS, sulphate, metals, cyanide, and cyanide degradation products (e.g., ammonia and nitrate). Concentrations have generally been declining over time or have remained stable. Exceptions this include TSS, iron and arsenic, which have more recently increased following denitrification and a change in redox within the impoundment. These processes are attributed to the continued decline in cyanide and associated cyanide degradation products, including nitrate and ammonia. Implementation of water treatment is expected to reduce concentrations of TSS, arsenic and iron to acceptable levels, as outlined in Event 3. Concentrations of cadmium and zinc have also shown evidence of increasing, particularly during winter low-flow. Clear trends in water quality have not been demonstrated for these parameters. While not conclusive, there is some evidence that metal leaching associated with the oxidation of exposed (unsaturated) tailings may be occurring. Early onset of metal leaching (ML) and associated acid mine drainage (AMD) is a potential, long-term concern, as tailings within the impoundment are potentially acid generating (PAG). Monitoring of water quality from groundwater monitoring wells within the tailings impoundment may be used to provide an indication of evolving ML/AMD processes. Water quality parameters including pH, sulphate, cadmium and zinc are early indicators of ML/AMD and should be monitored closely.

The environmental consequence of degraded water quality in Dome Creek downstream of the seepage pond discharge is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants. The discharge from the seepage pond is a primary source of contaminants to Dome Creek including sulphate, arsenic, iron, TSS, manganese, cadmium, and zinc. Water quality in Dome Creek is expected to improve following implementation of water treatment. Degradation of SEEP water quality may have implications on the performance of the water treatment plant as designed, either due to an increase in contaminant loading or due to additional contaminants that require separate treatment processes not included in the existing water treatment plant design.

### **5.2 Specific Information or Issues**

An analysis of the 2014 to 2016 water quality data for the seepage pond discharge (WQ-SEEP) was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 5-1. For reference, where applicable the reference EQS is also provided. Water quality results below detection limit are assumed to be at detection limit for the purposes of statistical and graphical analysis.

**Table 5-1 Summary of 2014 to 2016 Water Quality Data (mg/L) for Seepage Pond Discharge (WQ-SEEP)**

<b>Statistic</b>	<b>TSS</b>	<b>Sulphate</b>	<b>Total Arsenic</b>	<b>Dissolved Arsenic</b>	<b>Total Iron</b>	<b>Dissolved Iron</b>	<b>Total Zinc</b>
Minimum	19	419	0.039	0.027	6.6	4.7	0.006
5 <sup>th</sup> Percentile	21	569	0.046	0.029	9.1	5.8	0.007
Median	31	721	0.059	0.042	12.3	10.9	0.021
95 <sup>th</sup> Percentile	47	865	0.101	0.069	18.9	17.4	0.114
Maximum	96	882	0.126	0.081	20.4	19.8	0.122
Number of Samples	39	39	40	40	40	40	40

<b>Statistic</b>	<b>Total Cadmium</b>	<b>Dis. Cadmium</b>	<b>Total Manganese</b>	<b>Dis. Manganese</b>	<b>Total Cyanide</b>	<b>WAD Cyanide</b>	<b>Dissolved Zinc</b>
Minimum	0.00025	0.00010	3.6	3.4	0.015	0.003	0.006
5 <sup>th</sup> Percentile	0.00027	0.00019	5.1	4.9	0.021	0.003	0.007
Median	0.00053	0.00038	6.6	6.4	0.057	0.012	0.019
95 <sup>th</sup> Percentile	0.00117	0.00067	8.6	8.6	0.142	0.019	0.109
Maximum	0.00142	0.00080	9.2	9.5	0.349	0.026	0.123
Number of Samples	40	40	40	40	39	33	40

### 5.3 Narrative Trigger

The trigger for the implementation of the AMP is “contaminant concentrations in the seepage pond discharge as measured at Station WQ-SEEP display a sustained and statistically significant increase over the 2014 to 2016 reference period”.

### 5.4 Specific Indicators

The specific indicators that should be monitored at WQ-SEEP to provide the information necessary to assess whether the trigger has been achieved are:

- TSS (mg/L);
- Sulphate (mg/L);
- Total and dissolved arsenic (mg/L);
- Total and dissolved cadmium (mg/L);
- Total and dissolved iron (mg/L);
- Total and dissolved manganese (mg/L);
- Total and dissolved zinc (mg/L); and
- Total and WAD Cyanide (mg/L).

### 5.5 Specific Thresholds

The specific thresholds or triggers that will initiate an action plan, for any one of the specific indicators, will be as follows:

- Monitoring results at Seep above the reference EQS; or
- Three consecutive monitoring results at Seep greater than the upper 95<sup>th</sup> percentile of the reference period (2014 to 2016); or
- A statistically significant trend in the monitoring results from Seep as defined as statistically significant (0.05) increasing trend which, when extrapolated forward one year, would result in values greater than the 95<sup>th</sup> percentile. This trend assessment will be carried out using the trend analysis technique outlined in Section 2.4.

### 5.6 Monitoring Requirements

Required monthly monitoring includes the following: field and lab pH, conductivity, TSS, anions, total and dissolved metals, and total and WAD cyanide measured at the seepage discharge (WQ-SEEP). This data will be used for direct comparison to the specific thresholds and to enable an updated projected trend.

Additional monitoring information that is required for analysis should the AMP triggers be activated include surface and subsurface water quality and water level data from locations upstream of the seepage pond in the tailings impoundment area along with seepage pond pumping records. The monitoring locations are outlined in Table 5-2.

**Table 5-2 Summary of Water Quality Stations for Seepage Pond Discharge AMP**

Site Name	Description
WQ-SEEP	Seepage Pond Discharge – To be updated following construction of WTP
WQ-TP	Tailings Pond Water Quality
Seepage site	Seepage monitoring locations upgradient of the seepage pond
Groundwater Wells	Monitoring wells upgradient of the seepage pond and within the Tailings Impoundment Area

## 5.7 Evaluation of Monitoring Results

The management review of the relevant water quality data from WQ-SEEP will be carried out monthly. This review will be completed when the QA/QC'd water quality data, has been received from the contractor responsible for the routine site water quality monitoring program. For the assessment of triggers during periods with bi-weekly sample events, the bi-weekly concentrations will be averaged for the month. This average monthly value will then be carried forward and assessed as per the AMP Protocol.

## 5.8 Response Approach

As per the general approach to the AMP, a staged response to changing water quality in the seepage pond discharge will be implemented if one of the triggers is activated. Four major steps are identified below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should be conducted to expedite the response to trigger activation.

### 1. Notification & Validation

The initial response to the trigger will be the verification of the monitoring information. This will involve a comprehensive analysis of the laboratory results. The water quality at WQ-SEEP may then require re-sampling if warranted (i.e. QA/QC data or field notes indicates sampling issues/errors). This re-sampling should be done within approximately 1 to 4 weeks of the previous sampling time. Upon verification of the monitoring data that a threshold has been crossed and that mine related facilities are the likely cause, notification to AAM will be provided.

### 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined in Table 5-2 will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation.

### 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis, increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require

detailed site investigation work such as seepage, groundwater or surface water quality investigations. Groundwater/seepage modelling may be used to provide an indication of the contaminant transport pathways and the rate and development of changes in contaminant loading to the seepage pond.

#### 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of contamination in conjunction with the assessment of the timing and environmental consequence of the trigger activation. The following provides a list of the range of potential responses following the implementation of the seepage pond WTP:

- Assess potential evolution of metal leaching (ML) and/or acid mine drainage (AMD) associated with the oxidation of tailings that are not flooded and are exposed to the atmosphere;
- If ML and/or AMD is occurring and/or evolving, specific source control mitigation measures may be required;
- Assessment of WTP capabilities in relation to water quality and implementation of improvements as required;
- In cases where treated water fails to meet target limits, WTP effluent will be sent back to seepage pond or to the tailings impoundment, as per Event 3; and
- Pump back of seepage pond water to tailings pond when seepage pond storage capacity is full, as per Event 5.

## **6.0 AMP EVENT 3 – CHANGES IN WATER QUALITY IN WATER TREATMENT EFFLUENT**

### **6.1 Description**

The following event is linked to Event 2 and associated seepage collection pond water quality which is the source of influent to the proposed WTP. The WTP is specifically designed to remove TSS, iron and arsenic to acceptable levels prior to discharge to Dome Creek. The WTP is also expected to reduce concentrations of cadmium, manganese, and zinc, however the quantitative removal of these parameters is not required and has not been specified in the WTP design. Discharge of WTP effluent to Dome Creek may either occur at its present location, or at the Dome Creek Diversion Channel. Water quality of discharge from the WTP will be continuously monitored, with temporal resolution of water quality grab samples to be determined. Water quality samples are to be analyzed for a full suite of parameters including pH, TSS, cyanide species, nitrogen species, sulphate, hardness, and total and dissolved metals.

Following installation of the WTP, measurement practices may change, and water quality will be continuously monitored via instrumentation installed within the WTP for parameters such as turbidity (as a proxy for TSS) and pH. In scenarios where treated seepage pond water fails to meet specification, effluent will be recycled back to the seepage pond until target limits are met. Changes in water quality in the seepage pond will be treated by tailoring the water treatment process to influent water quality (Event 2). The seepage collection pond has limited storage capacity. In the event maximum operating levels are approached, water will be pumped back to the tailings impoundment, as described in Event 5.

Conditions and actions associated with Events 3, 4 and/or 5 are linked and may affect the respective response approaches for one another. For example, an increase in Seepage Pond inflows above WTP capacity in combination with high Seepage Pond water levels may result in the pump back of water to the tailings impoundment, as described in Event 5. Water levels within the tailings impoundment have shown a steady decline over time and seepage flows reporting to the seepage collection pond have declined over time accordingly and have stabilized since approximately 2014. An increase in tailings pond elevation may result in an increase in flows reporting to the seepage collection pond.

The environmental consequence of degraded water quality in Dome Creek downstream of the seepage pond discharge is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants. The discharge from the seepage pond is a primary source of contaminants to Dome Creek including TSS, sulphate, arsenic, iron, manganese, cadmium, and zinc. Water quality in Dome Creek is expected to improve following implementation of water treatment.

### **6.2 Specific Information or Issues**

Effluent from the WTP will be continuously monitored to avoid discharge of off-specification water to the downstream environment. Draft target limits are provided below in Table 6-1, under model assumption effluent, and driven by TSS and iron concentrations. These targets are consistent with the design specifications established through bench testing and are reasonably achievable for the design treatment process. Final effluent water quality targets will be established following WTP commissioning and implementation. Should total suspended solids concentrations increase over target limits, automatic processes within the WTP will immediately divert water back to the seepage pond, preventing the discharge of off-specification water to the downstream environment. Pumping of off-specification water back into the

seepage pond will cause the water level to increase with time, and demands that seepage pond water level be managed, as specified in Event 5.

**Table 6-1 Draft target water quality concentrations with triggers for TSS, T-As, T-Fe, and D-Fe based on bench study performance.**

<b>Parameter</b>	<b>Target Effluent Concentration</b>
<b>Units</b>	<b>mg/L</b>
TSS	<15
CN-WAD	0.03
Ammonia	6
Nitrate	1.3
Nitrite	0.06
Sulphate	900
<b>Dissolved Metals</b>	
Al	0.07
As	0.05
Ca	313
Cd	0.0004
Cr	0.001
Co	0.01
Cu	0.003
Fe	0.1
Mg	68
Mn	9.5
Zn	0.06
<b>Total Metals</b>	
As	0.05
Ca	313
Cd	0.0004
Cr	0.001
Co	0.01
Cu	0.003
Fe	0.5
Mg	68
Mn	9.5
Zn	0.06

### 6.3 Narrative Trigger

The trigger for the implementation of the AMP is “contaminant concentrations in WTP discharge are higher than target values” (Table 6-1). Draft target values are based on pilot study results and will be finalized following commissioning of the WTP.

For parameters such as TSS, Fe and As, the response approach is to be tailored via adjustments relevant to existing WTP processes. For other parameters of concern, further refinement of WTP processes may be required.

## 6.4 Specific Indicators

The specific indicators that should be monitored at WQ-SEEP to provide the information necessary to assess whether the trigger has been achieved are:

- TSS (mg/L);
- Total and dissolved iron (mg/L);
- Total and dissolved arsenic (mg/L);
- Total and dissolved manganese (mg/L);
- Total and dissolved cadmium (mg/L); and
- Total and dissolved zinc (mg/L).

## 6.5 Specific Thresholds

Water quality results at WTP discharge above the target limits for TSS, T-As, T-Fe, and D-Fe (Table 6-1) will initiate an action plan. Draft target values are based on what the plant is expected to achieve and are informed by pilot study results. Draft target values should meet or be lower than effluent standards to be established for the site and will be finalized following commissioning of the WTP.

## 6.6 Monitoring Requirements

Monitoring requirements include field and lab pH, conductivity, TSS, anions, and total and dissolved metals.

Additional monitoring information that is required for analysis should the AMP triggers be activated include WTP discharge data reporting to the Dome Creek Diversion Channel, Dome Creek, or the seepage collection pond. The monitoring locations are outlined in Table 6-2.

**Table 6-2 Summary of Water Quality Stations for Seepage Pond Discharge AMP**

Site Name	Description
Dome Creek Diversion Channel (DC-B)	Upstream of WTP Seepage Collection Pond
WTP Influent	As measured at WTP
WTP Effluent	As measured at WTP
DC-U	Dome Creek downstream of WTP
DC-R	Dome Creek at road downstream of DC-U

## 6.7 Evaluation of Monitoring Results

The management review of the relevant water quality data from the WTP will be carried out monthly with further refinement following the commissioning process. This review will be completed when the QA/QC'd water quality data has been received from the contractor responsible for the routine site water quality monitoring program.

## 6.8 Response Approach

As per the general approach to the AMP, a staged response to changing water quality in the seepage pond discharge will be implemented if one of the triggers is activated. Four major steps are identified below which follow those established for Event 2. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

### 1. Notification & Validation

The initial response to the trigger will be the verification of the monitoring information. This will involve a comprehensive analysis of the WTP chemistry and flow data, in addition to operations records recording the use of reagent concentrations used in the water treatment process. The water quality at the WTP discharge may then further monitoring if warranted (i.e. QA/QC data or field notes indicates sampling issues/errors). Temporal resolution of re-sampling is to be determined concurrent with commissioning. Upon verification of the monitoring data that a threshold has been crossed and that mine related facilities are the likely cause, notification to AAM will be provided.

### 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined in Table 6-2 will be carried out. While the downstream receiving environment is relevant to this event, effluent from the WTP is the primary point of compliance and is the focus of this analysis. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation as it pertains to WTP performance and operation.

### 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on WTP performance and operation will be conducted. As well, context within effects to the receiving environment will be considered, including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to WTP operation and monitoring. Following this analysis, modification to the WTP operating and monitoring procedures may be required to ensure that effluent WQ targets and primary compliance are being met.

### 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of contamination in conjunction with the assessment of the timing and environmental consequence of the trigger activation. The following provides a list of the range of potential responses following the implementation of the seepage pond WTP:

- Assessment of WTP functionality with respect to both targeted and untargeted parameters, and troubleshooting of treatment chain;
- Assess changes in seepage pond water quality as influent to WTP (Event 2); and
- In cases where treated water fails to meet target limits, WTP effluent will be sent back to seepage pond.

## 7.0 AMP EVENT 4 – CHANGES IN SEEPAGE POND INFLOWS/VOLUME OUTSIDE OF HISTORIC NORMS

### 7.1 Description

As discussed in Section 5.1, the seepage pond collection pond collects shallow groundwater seepage from the tailings dam and tailings area. Under current conditions, seepage collected in the pond is continuously pumped to Dome Creek. Upon implementation of water treatment, seepage will be pumped to the water treatment facility. In the event inflows increase beyond the capacity of the water treatment plant, water levels will increase in the seepage collection pond. The maximum design operating level of the seepage pond is 1078.1 masl. The pond water levels are measured daily, during open water, via a staff gauge. The pumping rate is measured daily via a new inline flowmeter (H-SEEP) installed in 2012 and routinely checked using timed volumetric measurements. Monitoring of pumping flow rate will continue in support of water treatment plant operation.

Changes in the seepage pond inflows/volumes above historic norms and beyond water treatment plant capacity may result in an increase water level within the seepage collection pond. In the event this occurs such that the maximum design operating level is approach, action will be taken to pump water back to the tailings impoundment so as to avoid discharge of water to the downstream receiving environment. In addition, higher than normal seepage inflows may cause instability of the dam structure, as discussed in Event 5.

Conditions and actions associated with Events 3, 4 and/or 5 are linked and may affect the respective response approaches for one another. For example, an increase in Seepage Pond inflows above WTP capacity in combination with high Seepage Pond water levels may result in the pump back of water to the tailings impoundment, as described in Event 5. Water levels within the tailings impoundment have shown a steady decline over time and seepage flows reporting to the seepage collection pond have declined over time accordingly and have stabilized since approximately 2014. An increase in tailings pond elevation may result in an increase in flows reporting to the seepage collection pond.

### 7.2 Specific Information or Issues

An analysis of the seepage pond daily pumping records (H-SEEP) from January 2014 to November 2016 and the open water season seepage pond water level data for 2014 and 2015 was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 7-1.

**Table 7-1 Summary of Seepage Pond Discharge Rates and Water Level (2014 – 2016)**

Statistic	Pumping Rate (L/min)	Water Level (masl)	Water Level Rate of Change (m/day)
Minimum	112	1076.94	-0.16
5 <sup>th</sup> Percentile	123	1077.09	-0.100
Median	162.5	1077.21	0.000

<b>Statistic</b>	<b>Pumping Rate (L/min)</b>	<b>Water Level (masl)</b>	<b>Water Level Rate of Change (m/day)</b>
95 <sup>th</sup> Percentile	194.52	1077.33	0.05
Maximum	326	1077.47	0.13
Number of Samples	1077	307	305

### 7.3 Narrative Trigger

The trigger for the implementation of the AMP is “seepage pond water levels and pumping rates display a sustained change from the 2014 to 2016 pumping rate, water level and/or rate of water level change.”

### 7.4 Specific Indicators

The specific indicators that should be monitored at the seepage pond to provide the information necessary to assess whether the trigger has been achieved are:

- Seepage pond pumping rate (L/s);
- Seepage pond water level (masl); and
- Seepage pond water level rate of change.

### 7.5 Specific Thresholds

The specific thresholds or triggers that will initiate an action plan, for any of the specific indicators will be as follows:

- Four consecutive average weekly results greater than the upper 95<sup>th</sup> percentile or lower than the lower 5<sup>th</sup> percentile of the 2014 to 2016 data record for pumping rate and/or seepage pond water level; or
- A statistically significant (0.05) increasing or decreasing trend in the monitoring results as defined as statistically significant using the trend analysis technique outlined in Section 2.4.

### 7.6 Monitoring Requirements

The monitoring information that is required is:

- Seepage Pond water elevation data; and
- Pumping rate.

The daily water level and discharge data will be compiled monthly for assessment against the specified thresholds. Additional monitoring information that is required for analysis should the AMP triggers be activated include:

- Results of routine dam inspections (weekly) carried out by site personnel including identification of any new seeps;
- Local precipitation data from the site meteorological station;

- Water level data from groundwater monitoring wells upgradient of the seepage pond in the tailings impoundment area;
- Water level data from the tailings pond;
- Annual pond drawdown and refilling test to assess for any changes in the rate of inflow to the pond;
- Annual review of thermistor and piezometer data; and
- Spring and fall geotechnical inspections.

This additional data will be compiled to facilitate an annual review of the Seepage Pond AMP Event.

## **7.7 Evaluation of Monitoring Results**

A management review of the Seepage Pond water elevations and pumping rates will be made monthly when updated data from the site is available. This will provide for an immediate assessment against the specific thresholds. Although the pond is actively managed to ensure the water level remains below the maximum target elevation, routine inspection of this data will enable the assessment of any changes in pumping rates required to keep the pond at its target elevation. A comprehensive annual review of this data will also be carried out as part of the annual AMP review.

## **7.8 Response Approach**

As per the general approach to the AMP, a staged response to changing Seepage Pond water elevation and discharge rate will be implemented if one of the triggers is activated. Four major steps are identified and summarized below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

### **1. Notification & Validation**

The initial response to the trigger will be the verification of the monitoring information. This will include assessment of the pond elevation and discharge data including comparison to manual measurements such as volume bucket test data and cross-checking with site operational records. This should be done within 2 weeks of the initial indication of trigger activation. Upon verification of the monitoring data that a threshold has been crossed and that there are no operational changes which resulted in the change, notification to AAM will be provided. Where substantial changes (increasing or decreasing) in seepage rates are noted immediate investigation of the cause should be carried out as it could relate to stability issues.

### **2. Preliminary Identification**

A comprehensive analysis of the other related monitoring results from the locations outlined in Section 7.6 will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation and will incorporate an assessment of pond water balance as well as recent results of routine site inspections and bi-annual geotechnical inspections.

### **3. Analysis and Investigation**

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects as well as implications for water treatment capacity and overall system storage as per Event 5 and Event 12. The results of this analysis will

be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis, increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require additional groundwater elevation and seepage inflow measurements. Groundwater/seepage modelling may be used to provide an indication of the inflow pathways to the pond and the rate and development of changes in inflows. This may also be required increasing the frequency and number of samples collected.

#### 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of the trigger activation in conjunction with the assessment of the timing and environmental consequence of the trigger activation. Given the linkages between this AMP Event and dam stability, where substantial increases or decreases in seepage rates are noted, immediate investigation of the cause should be carried. The following provides a list of the range of potential responses:

- Diversion/routing of non-impacted water away from the seepage pond;
- Increase pumping capacity to the WTP and/or increased pumping capacity for pump back to the tailings storage facility, as per Event 5 and Event 12;
- Pump back to tailings to reduce water level in the seepage pond; and
- Engagement of engineer to address any physical stability issues of the tailings and seepage dams associated with changes in seepage rates and/or volumes.

Direct discharge to Dome Creek via pumping may be considered as a last resort and only as necessary to maintain the integrity of the seepage collection pond dam and/or the tailings dam. An emergency discharge authorization should be obtained prior to implementing any direct discharge to Dome Creek.

## **8.0 AMP EVENT 5 – WATER LEVEL IN SEEPAGE POND REACHES MAXIMUM OPERATING LEVEL**

### **8.1 Description**

Event 4 and 5 are closely related. As discussed in Event 4 (Section 7), the seepage pond collection pond collects shallow groundwater seepage from the tailings dam and tailings area. Under current conditions, seepage collected in the pond is continuously pumped to Dome Creek. Upon implementation of water treatment, seepage will be pumped to the water treatment facility. In the event inflows increase beyond the capacity of the water treatment plant, water levels will increase in the seepage collection pond. The maximum design operating level of the seepage pond is 1078.1 masl. The pond water levels are measured daily, during open water, via a staff gauge. The pumping rate is measured daily via a new inline flowmeter (H-SEEP) installed in 2012 and routinely checked using timed volumetric measurements. Monitoring of pumping flow rate will continue in support of water treatment plant operation.

Changes in the seepage pond inflows/volumes above historic norms and beyond water treatment plant capacity may result in an increase water level within the seepage collection pond. In the event this occurs such that the maximum design operating level is approach, action will be taken to pump water back to the tailings impoundment so as to avoid discharge of water to the downstream receiving environment. These systems will be in place and operational as part of water treatment plant commissioning. In addition, higher than normal seepage inflows may cause instability of the dam structure, as discussed in Event 5.

Conditions and actions associated with Events 3, 4 and 5 are linked and may affect the respective response approaches for one another. For example, an increase in Seepage Pond inflows above WTP capacity in combination with high Seepage Pond water levels may result in the pump back of water to the tailings impoundment. Water levels within the tailings impoundment have shown a steady decline over time and seepage flows reporting to the seepage collection pond have declined over time accordingly and have stabilized since approximately 2014. An increase in tailings pond elevation may result in an increase in flows reporting to the seepage collection pond.

The environmental consequence of changes in the seepage pond inflows/volumes above historic norms is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants in the downstream receiving environment in Victoria Creek due to increased seepage from the tailings impoundment area. Dam structure stability may also be affected by higher than normal water levels within the seepage collection pond.

### **8.2 Specific Information or Issues**

This event is specific to seepage pond water elevation following installation of the seepage pond WTP. An analysis of the seepage pond daily pumping records (H-SEEP) from January 2014 to November 2016 and the open water season seepage pond water level data for 2014 and 2015 was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 8-1. This section relates to the potential necessity for the pumping of excess seepage pond volume to the TSF during extended periods of halted or off-specification WTP operations. Two key factors are to be considered in the management of seepage pond water: 1) maintenance of seepage pond water level to as low as level as feasible during normal WTP operations; and 2) evaluating a short-term maximum seepage pond water level above 1078.1 masl for short durations (scale of hours to days) only. These two factors will allow for maximization of periods of

emergency cessation of WTP operations prior to pumping of excess seepage volume to the TSF is necessitated.

**Table 8-1 Summary of Seepage Pond Discharge Rates and Water Level (2014 – 2016)**

<b>Statistic</b>	<b>Pumping Rate (L/min)</b>	<b>Water Level (masl)</b>	<b>Water Level Rate of Change (m/day)</b>
Minimum	112	1076.94	-0.16
5 <sup>th</sup> Percentile	123	1077.09	-0.100
Median	162.5	1077.21	0.000
95 <sup>th</sup> Percentile	194.52	1077.33	0.05
Maximum	326	1077.47	0.13
Number of Samples	1077	307	305

### 8.3 Narrative Trigger

The trigger for the implementation of the AMP is “water level in seepage pond reaches maximum operating level.”

### 8.4 Specific Indicators

The specific indicators that should be monitored at the seepage pond to provide the information necessary to assess whether the trigger has been achieved are:

- Pumping rate from seepage collection pond (L/s);
- Seepage pond water level (masl); and
- Seepage pond water level rate of change (masl/day).

### 8.5 Specific Thresholds

The specific thresholds or triggers that will initiate an action plan, for any of the specific indicators will be as follows:

- Cessation of WTP operations; or
- WTP discharge directed back into seepage collection pond, rather than Dome Creek or Dome Creek Diversion Channel; or
- Water level in seepage collection pond reaches trigger threshold of 1077.33 masl (95<sup>th</sup> percentile water level for 2014-2016 period).

### 8.6 Monitoring Requirements

The monitoring information that is required is:

- Seepage Pond water elevation data;
- Seepage pond pumping rate data;
- WTP influent and effluent pumping rate data reporting from and to seepage collection pond; and
- Pumping rate data from the seepage pond to the TSF.

The daily water level and discharge data will be compiled monthly for assessment against the specified thresholds. Additional monitoring information that is required for analysis should the AMP triggers be activated include:

- Results of routine dam inspections (weekly) carried out by site personnel including identification of any new seeps;
- Local precipitation data from the site meteorological station;
- Water level data from groundwater monitoring wells upgradient of the seepage pond in the tailings impoundment area;
- Annual pond drawdown and refilling test to assess for any changes in the rate of inflow to the pond;
- Annual review of thermistor and piezometer data; and
- Spring and fall geotechnical inspections.

This additional data will be compiled to facilitate an annual review of the Seepage Pond AMP Event.

## **8.7 Evaluation of Monitoring Results**

A management review of the Seepage Pond water elevations and pumping rates will be made monthly when updated data from the site is available. This will provide for an immediate assessment against the specific thresholds. Although the pond is actively managed to ensure the water level remains below the maximum target elevation, routine inspection of this data will enable the assessment of any changes in pumping rates required to keep the pond at its target elevation. This assessment should be undertaken in combination with those specified for Events 3 and 4 to identify potential root causes. A comprehensive annual review of this data will also be carried out as part of the annual AMP review.

## **8.8 Response Approach**

As per the general approach to the AMP, a staged response to changing Seepage Pond water elevation and discharge rate will be implemented if one of the triggers is activated. Four major steps are identified and summarized below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

### **1. Notification & Validation**

The initial response to the trigger will be the verification of the monitoring information. This will include the combined and constant assessment of pond elevation, pond influent rates, and WTP pumping rates from and reporting to seepage pond. Automated alarms will notify the operator so that action can be taken in a timely manner (e.g., pump back to the TSF). Upon verification of the monitoring data that a threshold has been crossed and that there are no operational changes which resulted in the change, notification to AAM will be provided. Where substantial changes (increasing or decreasing) in seepage rates are noted immediate investigation of the cause should be carried out as it could relate to stability issues.

## 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined previously will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation and will incorporate an assessment of pond water balance as well as recent results of routine site inspections and bi-annual geotechnical inspections.

## 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis, increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require further inquiry into issues which may have influenced an increase in water level at the seepage collection pond, cessation of WTP operations, or WTP discharge to seepage collection pond.

## 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of the trigger activation in conjunction with the assessment of the timing and environmental consequence of the trigger activation. Given the linkages between this AMP Event and dam stability, where cessation of WTP operations will allow for the increase of water volume in the seepage collection pond, immediate investigation of the cause should be carried. The following provides a list of the range of potential responses:

- Immediate troubleshooting and reparation of WTP, if necessary;
- If possible, increase WTP treatment rate, provided seepage collection pond water level has reached or exceeded 95<sup>th</sup> percentile level of 1077.3 masl;
- Prepare pumps for pump-back of water in seepage collection pond to TSF, provided seepage pond water level has exceeded 1078.0 masl threshold;
- Pump back of water in seepage collection pond to TSF to reduce water level in the seepage pond, provided seepage pond water level has increased to maximum threshold of 1078.1 masl; and
- Engagement of engineer to address any physical stability issues of the tailings and seepage dams associated with changes in seepage rates and/or volumes. This may involve an assessment characterizing possible effects of seepage collection pond water level above the maximum water level of 1078.1 masl for short-term durations on the scale of hours to days.

## **9.0 AMP EVENT 6 – DEGRADED WATER QUALITY IN DOME CREEK DOWNSTREAM OF TAILINGS FACILITY**

### **9.1 Description**

Dome Creek, downstream of the tailing impoundment area, receives inputs from the mine site via direct discharge from the Seepage Pond, inflows from the mill area, and seepage and groundwater inflows from mine site facilities. The water quality in Dome Creek below the mine site facilities is measured at Stations WQ-DC-U and WQ-DC-R. Station WQ-DC-U is located downstream of the confluence of Dome Creek and the Seepage Pond discharge. Station WQ-DC-R is further downstream on Dome Creek at the mine access road crossing. Station WQ-DC-B is located upstream of the tailings facility and Seepage Pond and is a proxy for background water quality upstream of discharge from the water treatment plant. Water quality samples are collected monthly, except for spring, where samples are collected at a higher frequency (bi-weekly) in the period leading up to freshet. Water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, hardness, total and dissolved metals. Two corresponding hydrological monitoring stations are also established in Dome Creek: H-DC-U and H-DC-R.

The environmental consequence of degraded water quality in Dome Creek downstream of the mine facilities is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants. Water quality in Dome Creek below the mine site facilities shows a clear mine-related influence with elevated concentrations of key contaminants of concern including sulphate, arsenic, iron, manganese, cadmium, and zinc. Total and WAD cyanide is also present in Dome Creek below the mine facilities, although at concentrations typically well below the CCME guidelines, at or near detection limits.

### **9.2 Specific Information or Issues**

An analysis of the 2014 to 2016 water quality data for the Dome Creek (WQ-DC-U and WQ-DC-R) was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 9-1 and Table 9-2 with further details provided in Appendix A. Water quality results below detection limit are assumed to be at detection limit for the purposes of statistical and graphical analysis. Following implementation of water treatment, water quality is expected to improve in Dome Creek. As a result, a new baseline will likely need to be developed from which to compare on-going water quality monitoring in support of AMP decision-making.

### **9.3 Narrative Trigger**

The trigger for the implementation of the AMP is “contaminant concentrations Dome Creek as measured at Stations WQ-DC-U and WQ-DC-R display a sustained and statistically significant increase over the 2014 to 2016 reference period”.

**Table 9-1 Summary of 2014 to 2016 Water Quality Data (mg/L) for Dome Creek (WQ-DC-U)**

<b>Statistic</b>	<b>Sulphate</b>	<b>TSS</b>	<b>Total Arsenic</b>	<b>Dissolved Arsenic</b>	<b>Total Iron</b>	<b>Dissolved Iron</b>
Minimum	171	5	0.010	0.005	1.6	0.2
5 <sup>th</sup> Percentile	214	6	0.014	0.006	1.8	0.3
Median	573	22	0.032	0.013	4.6	1.0
95 <sup>th</sup> Percentile	788	188	0.054	0.043	9.8	5.2
Maximum	850	739	0.095	0.050	13.5	5.7
Number of Samples	31	31	31	31	31	31
<b>Statistic</b>	<b>Total Cadmium</b>	<b>Diss. Cadmium</b>	<b>Total Manganese</b>	<b>Dis. Manganese</b>	<b>Total Zinc</b>	<b>Diss. Zinc</b>
Minimum	0.00005	0.00001	0.5	0.5	0.003	0.002
5 <sup>th</sup> Percentile	0.00005	0.00002	0.8	0.6	0.004	0.002
Median	0.00019	0.00008	2.2	2.1	0.016	0.008
95 <sup>th</sup> Percentile	0.00054	0.00024	7.0	6.9	0.057	0.039
Maximum	0.00058	0.00033	7.7	7.7	0.099	0.055
Number of Samples	31	31	31	31	31	31

**Table 9-2 Summary of 2014 to 2016 Water Quality Data (mg/L) for Dome Creek (WQ-DC-R)**

<b>Statistic</b>	<b>Sulphate</b>	<b>TSS</b>	<b>Total Arsenic</b>	<b>Dissolved Arsenic</b>	<b>Total Iron</b>	<b>Dissolved Iron</b>
Minimum	170	3	0.001	0.006	0.7	0.4
5 <sup>th</sup> Percentile	199	3	0.011	0.006	1.1	0.4
Median	373	6	0.015	0.008	1.9	0.8
95 <sup>th</sup> Percentile	570	17	0.030	0.012	4.2	1.5
Maximum	587	147	0.046	0.045	5.0	3.7
Number of Samples	24	24	24	24	24	24

<b>Statistic</b>	<b>Total Cadmium</b>	<b>Diss. Cadmium</b>	<b>Total Manganese</b>	<b>Dis. Manganese</b>	<b>Total Zinc</b>	<b>Dissolved Zinc</b>
Minimum	0.00004	0.00003	0.2	0.2	0.004	0.002
5 <sup>th</sup> Percentile	0.00004	0.00003	0.4	0.4	0.005	0.003
Median	0.00007	0.00004	1.2	1.1	0.009	0.006
95 <sup>th</sup> Percentile	0.00017	0.00011	2.5	2.5	0.027	0.024
Maximum	0.00018	0.00012	4.5	4.2	0.054	0.026
Number of Samples	24	24	24	24	24	24

## 9.4 Specific Indicators

The specific indicators that should be monitored at WQ-DC-U and WQ-DC-R to provide the information necessary to assess whether the trigger has been achieved are:

- Sulphate (mg/L);
- Total and dissolved arsenic (mg/L);
- Total cadmium and total zinc (mg/L);
- Total and dissolved iron (mg/L);
- Total and dissolved manganese (mg/L).

## 9.5 Specific Thresholds

The specific thresholds or triggers that will initiate an action plan, for any one of the specific indicators, will be as follows:

- Three consecutive monitoring results at WQ-DC-U or WQ-DC-R greater than the upper 95<sup>th</sup> percentile of the reference period (2014 to 2016); or
- A statistically significant trend (0.05) in the monitoring results from WQ-DC-U or WQ-DC-R which, when extrapolated forward one year, would result in values greater than the 95<sup>th</sup> percentile. This trend assessment will be carried out using the trend analysis technique outlined in Section 2.4.

## 9.6 Monitoring Requirements

The monitoring information required monthly includes TSS, sulphate, total and dissolved arsenic, dissolved cadmium, total and dissolved iron, total and dissolved manganese, and total zinc concentrations. This data will be used for direct comparison to the specific thresholds and to enable an updated projected trend.

Additional monitoring information that is required for analysis should the AMP triggers be activated include surface and subsurface water quality and flow data from locations upstream (WQ-DC-B) and downstream of WTP effluent discharge (WQ-DC-U and WQ-DC-R). Water quality and flow data are required to assess the contributions from upstream sources (WQ-DC-B) relative to WTP discharges to Dome Creek. The locations required are surface water quality stations locations upstream in the Dome Creek drainage and from any surface, seepage and groundwater monitoring locations located downgradient of mine related facilities in the Dome Creek catchment. Monitoring data assessed as part of AMP Event 1 (Mill Area) and AMP Event 3 (WTP Effluent) will also provide important information should the Dome Creek AMP be activated. The monitoring locations are outlined in Table 9-3.

Further, environmental effects monitoring, as outlined within the Aquatic Effects Monitoring Program (AEMP) will inform future decision making as it pertains to water quality improvement following WTP implementation and overall health of the Dome Creek and Victoria Creek aquatic receiving environment.

**Table 9-3 Summary of Water Quality Stations for Dome Creek AMP**

Site Name	Description
WQ-DC-U	Dome Creek, downstream of confluence with Seepage Discharge
WQ-DC-R	Dome Creek, at Mine Access Road
WQ-SEEP	Seepage Pond Discharge
WQ-DC-B	Monitoring location in Dome Creek Diversion (upstream of WTP discharge)
WQ-DC-D1b	Dome Creek at D1-b, downstream of mill area
WQ-DC-DX	Dome Creek at DX, upstream of mine site area
WQ-DX+105	Dome Creek at DX+105, 105 m downstream from DX
Seepage site	Seepage monitoring locations downgradient of mine facilities
Groundwater Wells	Monitoring wells downgradient of mine facilities

## 9.7 Evaluation of Monitoring Results

The management review of the relevant water quality data from WQ-DC-U and WQ-DC-R will be carried out monthly. This review will be completed when the QA/QC'd water quality data, has been received from the contractor responsible for the routine site water quality monitoring program. For the assessment of triggers during periods with bi-weekly sample events, the bi-weekly concentrations will be averaged for the month. This average monthly value will then be carried forward and assessed as per the AMP Protocol.

## 9.8 Response Approach

As per the general approach to the AMP, a staged response to changing water quality in the seepage pond discharge will be implemented if one of the triggers is activated. Four major steps are identified and summarized below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should be taken to expedite the response to trigger activation.

### 1. Notification & Validation

The initial response to the trigger will be the verification of the monitoring information. This will involve a comprehensive analysis of the laboratory results. The water quality at WQ-DC-B, WQ-DC-U and WQ-DC-R may then require re-sampling if warranted (i.e. QA/QC data or field notes indicates sampling issues/errors). This re-sampling should be done within approximately 1 to 4 weeks of the previous sampling time. Upon verification of the monitoring data that a threshold has been crossed and that mine related facilities are the likely cause, notification will be provided.

### 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined in Table 8-3 will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation.

### 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects and within context of the AEMP. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis, increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require detailed site investigation work such as seepage, groundwater or surface water quality investigations. Groundwater/seepage modelling may be used to provide an indication of the contaminant transport pathways and the rate and development of changes in contaminant loading to Dome Creek.

### 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of contamination in conjunction with the assessment of the timing and environmental consequence of the trigger activation. The following provides a list of the range of potential responses:

- Refinement of WTP processes and associated effluent targets;
- Potential seepage bypassing the seepage collection pond;
- Interception/collection and routing to tailings pond of seepage flows from other mine related facilities including mill area, pit or waste rock areas;
- Seepage from sources listed above that may be reporting further downstream in Dome Creek; and
- Aquatic risk assessment of impact in Victoria Creek of parameters with activated triggers in Dome Creek.

## **10.0 AMP EVENT 7 - DEGRADED WATER QUALITY IN VICTORIA CREEK DOWNSTREAM OF MINE AREA**

### **10.1 Description**

Victoria Creek, downstream of the mine site area, receives inputs from the mine site from surface water inflows and from groundwater inflows from mine site facilities. The receiving environment for the site is represented by sampling location WQ-VC-UMN. This location is downstream of inputs from both Dome and Back Creek and includes all potential mine related inputs to the receiving environment. In contrast to Dome Creek, Victoria Creek is known to support fish and fish habitat. The water quality in Victoria Creek at WQ-VC-UMN is collected monthly, except for spring, where samples are collected at a higher frequency in the period leading up to freshet, during freshet and following freshet. Water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, hardness, total and dissolved metals. A corresponding hydrological monitoring station is also established in Victoria Creek at VC-R station: H-VC-R.

The environmental consequence of degraded water quality in Victoria Creek is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants. The water quality in Victoria Creek, below the mine site facilities, shows a clear mine-related influence with elevated concentrations of key contaminants of concern, compared to background, including sulphate, dissolved arsenic, dissolved iron, dissolved manganese, dissolved cadmium, and dissolved zinc.

### **10.2 Specific Information or Issues**

The water quality in Victoria Creek at WQ-VC-R is influenced by elevated levels of suspended solids from both natural and anthropogenic sources (including placer mining in Back Creek watershed) with total suspended solids concentrations historically measured. Due to this influence of upstream sediment inputs, the development of the AMP Event for Victoria Creek is based on dissolved metals. Taking this approach enables the isolation of site-related influences and eliminates the interfering effects of elevated suspended solids contributed from upstream, in the Victoria Creek catchment.

An analysis of the 2014 to 2016 water quality data for the Victoria Creek (WQ-VC-UMN) was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 10-1. Water quality results below detection limit are assumed to be at detection limit for the purposes of statistical and graphical analysis.

Following implementation of water treatment, water quality is expected to improve in Victoria Creek. As a result, a new baseline will likely need to be developed from which to compare on-going water quality monitoring in support of AMP decision-making.

**Table 10-1 Summary of 2014 to 2016 Water Quality Data (mg/L) for Victoria Creek (WQ-VC-UMN)**

<b>Statistic</b>	<b>Sulphate</b>	<b>TSS</b>	<b>Total Arsenic</b>	<b>Dissolved Arsenic</b>	<b>Total Iron</b>	<b>Dissolved Iron</b>
Minimum	11	3	0.001	0.001	<0.1	<0.1
5 <sup>th</sup> Percentile	20	3	0.001	0.001	<0.1	<0.1
Median	37	3	0.002	0.001	<0.1	<0.1
95 <sup>th</sup> Percentile	53	75	0.009	0.003	2.5	0.2
Maximum	132	268	0.015	0.004	7.7	0.3
Number of Samples	39	39	39	39	39	39
<b>Statistic</b>	<b>Total Cadmium</b>	<b>Diss. Cadmium</b>	<b>Total Manganese</b>	<b>Dis. Manganese</b>	<b>Total Zinc</b>	<b>Dissolved Zinc</b>
Minimum	0.00001	0.00001	<0.1	<0.1	0.003	0.001
5 <sup>th</sup> Percentile	0.00001	0.00001	<0.1	<0.1	0.003	0.001
Median	0.00004	0.00002	0.1	<0.1	0.004	0.002
95 <sup>th</sup> Percentile	0.00020	0.00007	0.2	0.1	0.019	0.007
Maximum	0.00028	0.00010	0.3	0.2	0.036	0.008
Number of Samples	39	39	39	39	39	39

### 10.3 Narrative Trigger

The trigger for the implementation of the AMP is “contaminant concentrations Victoria Creek as measured at WQ-VC-UMN display a sustained and statistically significant increase over the 2014 to 2016 reference period”.

### 10.4 Specific Indicators

The specific indicators that should be monitored at WQ-VC-UMN to provide the information necessary to assess whether the trigger has been achieved are:

- Sulphate (mg/L);
- TSS (mg/L);
- Total and dissolved arsenic (mg/L);
- Total and dissolved cadmium (mg/L);
- Total and dissolved iron (mg/L);
- Total and dissolved manganese (mg/L); and
- Total and dissolved zinc (mg/L).

### 10.5 Specific Thresholds

The specific thresholds or triggers that will initiate an action plan, for any one of the specific indicators, will be as follows:

- Three consecutive monitoring results at WQ-VC-UMN greater than the upper 95<sup>th</sup> percentile of the reference period (2014 to 2016); or
- A statistically significant trend (0.05) in the monitoring results from WQ-UMN which, when extrapolated forward one year, would result in values greater than the 95<sup>th</sup> percentile. This trend assessment will be carried out using the trend analysis technique outlined in Section 2.4.

### 10.6 Monitoring Requirements

The monitoring information required monthly is: sulphate and dissolved arsenic, cadmium, iron, manganese, and zinc concentrations. This data will be used for direct comparison to the specific thresholds and to enable an updated projected trend.

Additional monitoring information that is required for analysis, should the AMP triggers be activated include surface and subsurface water quality and flow data from locations upstream of WQ-VC-UMN. Both water quality and flow data are essential as they enable not only the analysis of contaminant concentrations but loadings as well. The locations required are surface water quality sites upstream in the Dome Creek drainage and Victoria Creek drainage and from any surface, seepage and groundwater monitoring locations located downgradient of mine related facilities in the Dome Creek catchment. Monitoring data assessed as part of AMP Event 1 (Mill Area), AMP Event 2 (Seepage Pond Discharge) and AMP Event 4 (Dome Creek) will also provide important information should the Victoria Creek AMP be activated. The monitoring locations are outlined in Table 10-2.

Further, environmental effects monitoring, as outlined within the Aquatic Effects Monitoring Program (AEMP) will inform future decision making as it pertains to water quality improvement following WTP implementation and overall health of the Dome Creek and Victoria Creek aquatic receiving environment.

**Table 10-2 Summary of Water Quality Stations for Victoria Creek AMP**

Site Name	Description
WQ-VC-R/+100	Victoria Creek, at Mine Access Road
WQ-VC-UMN	Victoria Creek, upstream of Minnesota Creek (downstream of Dome Creek)
WQ-VC-U	Victoria Creek, upstream of Back Creek Confluence
WQ-VC-DBC	Victoria Creek, downstream of Back Creek
WQ-DC-U	Dome Creek, downstream of confluence with Seepage Discharge
WQ-DC-R	Dome Creek, at Mine Access Road
WQ-SEEP	Seepage Pond Discharge
WQ-DC-D1-b	Dome Creek at D1-b, downstream of mill area
WQ-DC-DX	Dome Creek at DX, upstream of mine site area
WQ-DX+105	Dome Creek at DX+105, 105 m downstream from DX
Seepage site	Seepage monitoring locations downgradient of mine facilities
Groundwater Wells	Monitoring wells downgradient of mine facilities

## 10.7 Evaluation of Monitoring Results

The management review of the relevant water quality data from WQ-VC-UMN will be carried out monthly. This review will be completed when the QA/QC'd water quality data, has been received from the contractor responsible for the routine site water quality monitoring program. For the assessment of triggers during periods with bi-weekly sample events, the bi-weekly concentrations will be averaged for the month. This average monthly value will then be carried forward and assessed as per the AMP Protocol.

## 10.8 Response Approach

As per the general approach to the AMP, a staged response to changing water quality in the seepage pond discharge will be implemented if one of the triggers is activated. Four major steps are identified and summarized below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

### 1. Notification & Validation

The initial response to the trigger will be the verification of the monitoring information. This will involve a comprehensive analysis of the laboratory results. The water quality at WQ-VC-UMN may then require

re-sampling if warranted (i.e. QA/QC data or field notes indicates sampling issues/errors). This re-sampling could be done within approximately 1 to 4 weeks of the previous sampling time. Upon verification of the monitoring data that a threshold has been crossed and that mine related facilities are the likely cause, notification to AAM will be provided.

## 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined in Table 9-2 will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation.

## 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis, increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require detailed site investigation work such as seepage, groundwater or surface water quality investigations. Groundwater/seepage modelling and/or surface water quality load modelling may be used to provide an indication of the contaminant transport pathways and the rate and development of changes in contaminant loading to Victoria Creek.

## 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of contamination in conjunction with the assessment of the timing and environmental consequence of the trigger activation. The following provides a list of the range of potential responses:

- Aquatic risk assessment of impact in Victoria Creek of parameters with activated triggers.
- Refinement of WTP processes and associated effluent targets;
- Potential seepage bypassing the seepage collection pond;
- Interception/collection and routing to tailings pond of seepage flows from other mine related facilities including mill area, pit or waste rock areas including loadings from Pony Creek;
- Seepage from sources listed above that may be reporting further downstream; and
- Contaminant loadings and contributions associated with placer activity in the Victoria Creek watershed including Pony and Back Creeks.

# 11.0 AMP EVENT 8 - DEGRADED WATER QUALITY IN PONY CREEK DOWNSTREAM OF MINE AREA

## 11.1 Description

The water quality in Pony Creek downgradient of the mine area (below the Brown-McDade Pit) is currently affected by potential seepage flowpaths from the Brown-McDade pit and/or waste rock including the historic practice of depositing waste rock within the stream channel. The water quality in Pony Creek in this area is measured monthly, when flowing, at WQ-PC-D except for spring. Samples are collected at a higher frequency (bi-weekly) in the period leading up to freshet, during freshet and following freshet. The collected water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, total and dissolved metals. The flow in Pony Creek in this area is measured at H-PC-DSP, located in Pony Creek upstream of WQ-PC-D.

The environmental consequence of degraded water quality in Pony Creek is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants. Water quality in Pony Creek in this area shows a clear site-related influence with elevated levels of total cadmium, copper and zinc in comparison to background water quality.

## 11.2 Specific Information or Issues

An analysis of the 2008 to 2013 water quality data for Pony Creek downstream of the mine area (WQ-PC-D) was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 11-1. Water quality results below detection limit are assumed to be at detection limit for the purposes of statistical and graphical analysis.

**Table 11-1 Summary of 2008 to 2013 Water Quality Data (mg/L) for Pony Creek at WQ-PC-D.**

Statistic	Sulphate	Total Cadmium	Dissolved Cadmium	Total Copper	Dissolved Copper	Total Zinc	Dissolved Zinc
Minimum	16	0.00017	0.00006	0.003	<0.001	0.001	<0.001
5 <sup>th</sup> Percentile	21	0.00021	0.00018	0.005	0.004	0.019	0.015
Median	97	0.00106	0.00102	0.010	0.008	0.096	0.086
95 <sup>th</sup> Percentile	164	0.00551	0.00441	0.044	0.019	0.465	0.442
Maximum	187	0.00789	0.00624	0.135	0.025	0.731	0.617
Number of Samples	66	69	68	69	68	69	68

### **11.3 Narrative Trigger**

The trigger for the implementation of the AMP is “contaminant concentrations in Pony Creek as measured at Station WQ-PC-D display a sustained and statistically significant increase over the 2008 to 2013 reference period”.

### **11.4 Specific Indicators**

The specific indicators that should be monitored at WQ-PC-D to provide the information necessary to assess whether the trigger has been achieved are:

- Sulphate (mg/L);
- Total and dissolved cadmium (mg/L);
- Total and dissolved copper (mg/L); and
- Total and dissolved zinc (mg/L).

### **11.5 Specific Thresholds**

The specific thresholds or triggers that will initiate an action plan, for any one of the specific indicators, will be as follows:

- Three consecutive monitoring results at WQ-PC-D greater than the upper 95<sup>th</sup> percentile of the reference period (2008 to 2013); or
- A statistically significant trend in the monitoring results from WQ-PC-D as defined as statistically significant (0.05) increasing trend which, when extrapolated forward one year, would result in values greater than the 95<sup>th</sup> percentile. This trend assessment will be carried out using the trend analysis technique outlined in Section 2.4.

### **11.6 Monitoring Requirements**

The monitoring information required monthly (when available) is sulphate and total and dissolved cadmium, copper and zinc concentrations measured at WQ-PC-D. This data will be used for direct comparison to the specific thresholds and to enable an updated projected trend.

Additional monitoring information that is required for analysis should the AMP triggers be activated include surface and subsurface water quality and flow data from locations upstream of WQ-PC-D. Both water quality and flow data are essential as they enable not only the analysis of contaminant concentrations but loadings as well. The locations required are surface water quality stations locations upstream in the Dome Creek Drainage and from any surface, seepage and groundwater monitoring locations located downgradient of mine related facilities in the Pony Creek catchment. The monitoring locations are outlined in Table 11-2.

**Table 11-2 Summary of Water Quality Stations for Pony Creek AMP**

Site Name	Description
WQ-PC-D	Pony Creek, downstream of Pit
WQ-PC-U	Pony Creek, upstream of Pit and waste rock
WQ-ADIT-SEEP	Pony Creek Adit Seepage Monitoring Site
Groundwater Wells	Monitoring wells downgradient of mine facilities in Pony Creek catchment

## 11.7 Evaluation of Monitoring Results

The management review of the relevant water quality data from WQ-PC-D will be carried out monthly. This review will be completed when the QA/QC'd water quality data, has been received from the contractor responsible for the routine site water quality monitoring program. For the assessment of triggers during periods with bi-weekly sample events, the bi-weekly concentrations will be averaged for the month. This average monthly value will then be carried forward and assessed as per the AMP Protocol.

## 11.8 Response Approach

As per the general approach to the AMP, a staged response to degraded water quality in Pony Creek downstream of the mine area will be implemented if one of the triggers is activated. Four major steps are identified and summarized below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

### 1. Notification & Validation

The initial response to the trigger will be the verification of the monitoring information. This will involve a comprehensive analysis of the laboratory results. The water quality at WQ-PC-D may then require re-sampling if warranted (i.e. QA/QC data or field notes indicates sampling issues/errors). This re-sampling could be done within approximately 1 to 4 weeks of the previous sampling time. Upon verification of the monitoring data that a threshold has been crossed and that the mill area is the likely cause, notification to AAM will be provided.

### 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined in Table 10-2 will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation.

### 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis, increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require

detailed site investigation work such as seepage, groundwater or surface water quality investigations. Groundwater/seepage modelling and/or surface water quality load modelling may be used to provide an indication of the contaminant transport pathways and the rate and development of changes in contaminant loading to Pony Creek.

#### 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of contamination in conjunction with the assessment of the timing and environmental consequence of the trigger activation. The following provides a list of the range of potential responses:

- Identification of source material (i.e. waste rock) and removal into pit catchment;
- Interception/collection and routing to pit of identified seepage flows; and
- Targeted remediation of components in Pony Creek catchment.

## **12.0 AMP EVENT 9 – CHANGES IN GROUNDWATER QUALITY DOWNGRAIENT OF THE BROWN- MCDADE PIT**

The water quality in the Brown-McDade Pit is currently above the reference EQS for several parameters including iron, manganese and zinc. Water is not actively discharged from the pit and the water level in the Pit currently fluctuates between approximately 1181 masl and 1184 masl. As discussed in Section 9.0, the water balance of the pit is dominated by precipitation and runoff from its immediate catchment, although there is a continual discharge from the Pit via groundwater, estimated at approximately 0.5 L/s (AMEC 2014a). The discharge via groundwater from the Pit follows regional groundwater flow towards Dome and ultimately Victoria Creek. In 2013, as part of the site investigation program carried out by AMEC (AMEC 2014b), several new monitoring wells were installed downgradient of the Pit. Of the monitoring wells installed, two are located along or adjacent to the inferred regional groundwater flow pathway between the Pit and Dome Creek: CH-13-03 and CH-13-04. Water quality samples collected from these locations can be used to track potential changes in groundwater quality due to the ongoing seepage from the Pit.

The environmental consequence of changes in groundwater quality is the potential exposure of aquatic and terrestrial resources and human users to increased contaminant loading to the downstream receiving environment of Dome and Victoria Creeks.

### **12.1 Specific Information or Issues**

Two new monitoring wells, CH-13-03 (10 m/50 m) and CH-13-04 (10 m/35 m), were installed in 2013 downgradient of the pit, each completed with monitoring locations at two depths. These wells are monitored three times per year as part of the routine groundwater monitoring program. Water quality data is currently only available for CH-13-03/50. Since 2015, both CH-13-04/10 and CH-13-04/35 have consistently been reported as frozen during site sampling events. In addition, CH-13-03/10 is currently packed with sand and bentonite and requires rehabilitation.

An analysis of the 2016 and 2017 groundwater quality data for CH-13-03/50 was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 12-1. Monitoring data prior to 2016 was not included in this assessment due to insufficient volume for proper sample collection and elevated turbidity levels. Water quality results below detection limit are assumed to be at detection limit for the purposes of statistical and graphical analysis.

**Table 12-1 Summary of 2016/17 Groundwater Quality Data (mg/L) CH-13-03/50.**

<b>Statistic</b>	<b>Sulphate</b>	<b>Dissolved Arsenic</b>	<b>Dissolved Cadmium</b>	<b>Dissolved Iron</b>	<b>Dissolved Manganese</b>	<b>Dissolved Zinc</b>
Minimum	1140	0.0004	0.00018	0.011	0.207	0.0075
5 <sup>th</sup> Percentile	1176	0.00041	0.00019	0.011	0.210	0.0084
Median	1500	0.00045	0.00031	0.016	0.274	0.0149
95 <sup>th</sup> Percentile	1545	0.00074	0.00045	0.023	0.416	0.0225
Maximum	1550	0.00079	0.00046	0.023	0.433	0.0237
Number of Samples	3	4	4	4	4	4

For the AMP remaining wells, there is insufficient data to provide any statistical assessment of the available data. When, and if, sufficient data is available, these wells will be included as part of the AMP assessment and reporting. Given the linkage between this AMP Event and closure it is recommended that staged triggers be developed for this AMP once sufficient data has been collected to characterize the groundwater quality downgradient of the pit.

## 12.2 Narrative Trigger

The trigger for the implementation of the AMP is “changes in groundwater quality in groundwater downgradient of the Pit as measured at CH-13-03 and CH-13-04 display a statistically significant increasing trend”.

## 12.3 Specific Indicators

The specific indicators that should be monitored at CH-13-03 (10 m/50 m) and CH-13-04 (10 m/35 m) to provide the information necessary to assess whether the trigger has been achieved are:

- Sulphate;
- Dissolved arsenic (mg/L);
- Dissolved cadmium (mg/L);
- Dissolved iron (mg/L);
- Dissolved manganese (mg/L); and
- Dissolved zinc (mg/L).

## 12.4 Specific Thresholds

The specific thresholds or triggers that will initiate an action plan, for any one of the specific indicators, will be as follows:

- A statistically significant trend in the monitoring results defined as statistically significant (0.05) increasing trend. This trend assessment will be carried out using the trend analysis technique outlined in Section 2.4.

## 12.5 Monitoring Requirements

The monitoring information required is sulphate, dissolved arsenic, dissolved cadmium, dissolved iron, dissolved manganese and dissolved zinc concentrations measured at CH-13-03 and CH-13-04. This data will be collected as part of the routine groundwater monitoring program three times per year: early spring, summer, and late fall. This data will be used to enable an updated trend assessment.

Additional monitoring information that is required for analysis should the AMP triggers be activated include pit water quality data and well water level data. Obtaining pit water quality data will be dependent on current and future pit wall stability assessments. Both water quality and water level data are essential as they enable not only the analysis of contaminant concentrations but changes in groundwater flow patterns.

## 12.6 Evaluation of Monitoring Results

The management review of the relevant groundwater quality data from CH-13-03 and CH-13-04 will be carried out three times per year following each sampling event. This review will be completed when the QA/QC'd groundwater quality data, following routine QA/QC, has been received from the contractor responsible for the routine site water quality monitoring program.

## 12.7 Response Approach

As per the general approach to the AMP, a staged response to changing groundwater quality downgradient of the Pit will be implemented if one of the triggers is activated. Four major steps are identified and summarized below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation decision-making.

### 1. Notification & Validation

The initial response to the trigger will be the verification of the monitoring information. This will involve a comprehensive analysis of the laboratory results. This may include re-sampling if warranted (i.e. QA/QC data or field notes indicates sampling issues/errors). This re-sampling could be done within approximately 1 to 4 weeks of the previous sampling time. Upon verification of the monitoring data that a threshold has been crossed, notification to AAM will be provided.

### 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined in Section 12.5. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation.

### 3. Analysis and Investigation

An analysis of the impacts of the trigger activation on the receiving environment will be conducted, including magnitude, spatial extent and reversibility of potential effects. The results of this analysis will be used as a basis for the development of an appropriate response plan to mitigate any identified or predicted impacts and to highlight any required modifications to the monitoring program. Following this analysis,

increased monitoring intensity may be required (parameters, locations and frequency) to verify the source that resulted in the trigger activation. Depending on the preliminary source identification, this may require detailed site investigation work such as seepage, groundwater or surface water quality investigations. Groundwater/seepage modelling and/or surface water quality load modelling may be used to provide an indication of the contaminant transport pathways and the rate and development of changes in contaminant loading in groundwater downgradient of the Pit.

#### 4. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of contamination in conjunction with the assessment of the timing and environmental consequence of the trigger activation. The following provides a list of the range of potential responses:

- Detailed assessment of the impact of increasing concentrations in groundwater on the receiving environment in Dome and Victoria Creeks including timing, magnitude and reversibility;
- Installation of additional monitoring wells to delineate the migration of contaminants via groundwater downgradient of the pit;
- Investigation of the cause of the increases in groundwater concentrations including increased outflow from the pit or depletion of attenuation capacity along the flow path;
- Establishment of stage triggers for the design and implementation of an appropriate remediation plan; and
- Design of an appropriate remediation plan which could include:
  - In-situ treatment; or
  - Groundwater interception, collection and/or treatment system.

## **13.0 AMP EVENT 10 – WATER LEVEL IN TAILINGS POND REACHES MAXIMUM DESIRED WATER LEVEL**

### **13.1 Description**

The tailings impoundment area holds an estimated 240,000 m<sup>3</sup> of tailings along with residual mill process chemicals including copper sulphate, lime, cyanide and associated degradation compounds including cyanate, thiocyanate, ammonia, nitrite, and nitrate. Currently, there are minor exceedances in concentrations of dissolved arsenic, iron, manganese, and zinc above the EQS. Concentrations of total and WAD cyanide are present in tailings pond water near detection limit, well below the EQS. Water is not actively discharged from the tailings pond and it is understood that there will be no discharge from the pond prior to closure implementation. At that point, any discharge from the tailings pond will be actively treated and managed as per the MNRP. Tailings pond water levels are measured daily, during open water, via a staff gauge. The emergency spillway invert elevation is 1097.8 masl and the maximum operating water level elevation for the tailings pond is 1097.8 masl (Tetra Tech, 2015).

The water quality in the tailings pond is significantly different than that in the seepage pond, particularly with respect to nitrogen species, cyanide species (including cyanate and thiocyanate) and some key metals species including arsenic, cadmium, copper, iron, lead, manganese and zinc. The tailings pond water quality has lower concentrations of nitrogen species, cyanide species (including cyanate and thiocyanate), manganese and iron while it has higher concentrations of total arsenic, dissolved arsenic, total cadmium, total copper, total lead and total zinc.

Conditions and actions associated with Events 5 and 10 are linked and may affect the respective response approaches for one another. For example, an increase in Seepage Pond inflows above WTP capacity in combination with high Seepage Pond water levels may result in the pump back of water to the tailings impoundment. Water levels within the tailings impoundment have shown a steady decline over time and seepage flows reporting to the seepage collection pond have declined over time accordingly and have stabilized since approximately 2014. An increase in tailings pond elevation may result in an increase in flows reporting to the seepage collection pond.

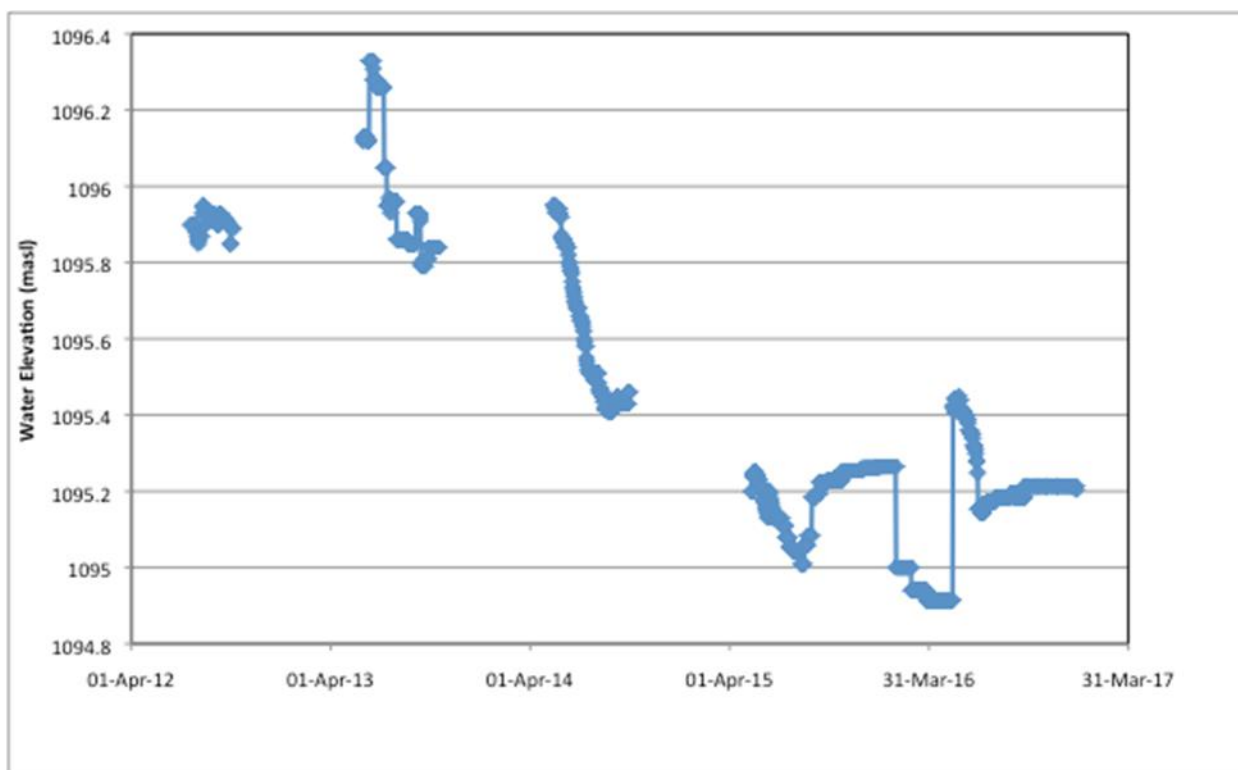
The environmental consequence of increasing water levels in the tailings ponds is the potential for release of pond water to Dome Creek via the emergency spillway under a high return period storm/runoff event as well as the potential for increased seepage through the tailings dam. In addition, increased water levels increase the potential for stability issues related to dam stability. This could result in the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants.

### **13.2 Specific Information or Issues**

An analysis of the tailings pond open water elevation data for 2014 and 2016 was carried out in preparation of the AMP protocol. A summary of this analysis is presented in Table 13-1. Following a steady decline since 2012, the tailings pond water elevation has remained relatively stable since 2015 (Figure 13-1).

**Table 13-1 Summary of Tailings Pond Water Level (2014 – 2016)**

Statistic	Water Level (masl)
Minimum	1094.914
5 <sup>th</sup> Percentile	1094.914
Median	1095.214
95 <sup>th</sup> Percentile	1095.712
Maximum	1095.950
Number of Samples	738



**Figure 13-1 Tailings Pond Open Water Elevation Data (2012 – 2016)**

During a design inflow event (1:200 two-hour rainfall), the tailings pond is expected to rise approximately 1.0 m (Tetra Tech, 2015) from a starting elevation of 1096.0 masl. Based on this, the recommended “trigger” elevation is 1097.0 m (about 0.8 m below spillway invert) and when the tailings pond water reaches this elevation, pumping should commence. The pond should be pumped down at a rate not to exceed 28,000 L/min to an elevation of 1096.0 m (Tetra Tech, 2015). Should a design event occur before the pond is drawn down, the water would rise from 0.65 m to an elevation of 1097.65 masl, 0.15 m below the spillway invert.

### **13.3 Narrative Trigger**

The trigger for the implementation of the AMP is “the water elevation in the tailings pond reaches the AMP trigger elevation of 1097.0 masl”.

### **13.4 Specific Indicators**

The specific indicators that should be monitored to provide the information necessary to assess whether the trigger has been activated are:

- Tailings pond water elevation; and
- Projected timeframe to maximum desired water elevation.

Supplementary monitoring information regarding tailings pond water chemistry would be beneficial if an action plan that includes the treatment of tailings pond water is required. However, this information is not essential to the AMP.

### **13.5 Specific Thresholds**

The specific thresholds or triggers that will initiate an action plan will be as follows:

- Tailings pond water level elevation reaches the AMP trigger elevation; and
- The projected timeline for reaching the maximum desired water level elevation (1097.8 masl) is projected to be one year or less (timing to be confirmed based on discussions with the parties).

### **13.6 Monitoring Requirements**

The monitoring information that is required is:

- The tailings pond water elevation data; and
- Local precipitation data to enable an updated projection of the filling timeframe.

Information from site operational reports and the bi-annual geotechnical inspection reports will also be used.

### **13.7 Evaluation of Monitoring Results**

The management review of the tailings pond water level data will be carried out monthly when updated data from the site is available. This will provide for an immediate assessment against the specific AMP trigger elevation. A comprehensive annual review will be carried out, including updating of the pond filling projection trend, will be carried out as part of the annual AMP review.

### **13.8 Response Approach**

As per the general approach to the AMP, a staged response increasing water level in the tailings pond will be implemented if the trigger is activated. Four major steps are identified and summarized below. Although presented in a sequential order, some steps may occur concurrently or may be eliminated, depending on the individual circumstances of the trigger activation. In all cases, the approach to responses should expedite trigger activation responses.

### 1. Notification & Validation

The initial response to the trigger will be upon pumping water from the seepage collection pond to the tailings pond as per Event 5. Further verification may include either a re-survey of the pond elevation or recalculation and cross-checking of the pond filling projection. This should be done immediately following initial trigger activation. Upon verification of the monitoring data that a threshold has been crossed and that there are no operational changes which resulted in the change, notification to AAM will be provided. Where substantial changes in pond water level are immediate investigation of the cause should be carried out as it could relate to stability issues.

### 2. Preliminary Identification

A comprehensive analysis of the other related monitoring results from the locations outlined previously will be carried out. The goal of this analysis is to provide for a preliminary identification of the cause of the trigger activation and will incorporate an assessment of pond water balance as well as recent results of routine site inspections and bi-annual geotechnical inspections.

### 3. Response

A response plan will subsequently be developed based on the comprehensive trigger analysis described above. This plan will include short-term mitigation to be implemented as an interim measure prior to implementation of the MNRP. The level of response will depend on the identified source of the trigger activation in conjunction with the assessment of the timing and environmental consequence of the trigger activation. Given the linkages between this AMP Event and dam stability, where substantial increases in water level are noted, immediate investigation of the cause should be carried. The following is a list of potential responses:

- Design, where required, and implementation of pumping systems for transfer of excess water to pit for storage to reduce water level if not suitable for discharge; or
- Design and implementation of pond treatment system for discharge of pond water to receiving environment; or
- Design and implementation of pumping systems for transfer of excess water to the water treatment plant for treatment. Additional treatment capacity may be required.

## 14.0 REFERENCES

- AMEC (2014a). *Mount Nansen Remediation Project 30% Design Report*. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon. March 2014.
- AMEC (2014b). *Mount Nansen Remediation Project 2013 Site Investigation Report*. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon. March 2014.
- Lorax Environmental Services Ltd. 2017. *Mount Nansen Dome Creek and Victoria Creek Surface Water Quality Evaluation and Preliminary Aquatic Effects Assessment*. Prepared for Little Salmon Carmacks First Nation. 2017.
- Tetra Tech EBA (2015). *Final Updated Drawdown and Pumping Analysis – Tailings and Seepage Collections Ponds Mount Nansen Site, YT*. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon. October 2015
- SLR (2015). *Mount Nansen Water Quality and Quantity Adaptive Management Plan*. Prepared for Assessment and Abandoned Mines Branch, Dept. of Energy, Mines, and Resources, Yukon Government dated March 31, 2015.

# **Appendix A:**

## **Comparison of Baseline Statistics**

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### **1.1 Introduction**

A comparison of baseline statistics is provided below in support of establishing water quality decision-making triggers for the Mount Nansen Adaptive Management Plan (AMP). Changes to water quality in the seepage collection pond near the end of 2014 triggered an investigation as per AMP protocol. As an outcome to implementing the AMP and in support of the Care and Maintenance Project Proposal (CMPP), water treatment has been proposed to treat discharge from the seepage collection pond. An existing conditions surface water quality assessment was conducted in support of the CMPP. Changes to analytical methods in 2012 and field sampling methods in 2011 to 2012 (namely field filtration for dissolved metals sampling) has resulted in an overall improvement in water quality results.

Based on the above, an interim change to baseline water quality for this AMP is proposed as necessary to inform decision-making until a new baseline can be achieved following implementation of water treatment. Specifically, a change to baseline data to the 2014-2016 period is proposed. The 2014-2016 period was selected as it represents current water quality conditions in the seepage collection pond and affected locations downstream, including lower Dome Creek and Victoria Creek stations downstream of Dome Creek. 2014-2016 represents a period of time in which water quality monitoring was conducted consistently in Dome and Victoria Creeks. Triggers in the previous version of the AMP considered data from different periods of time for different stations, partly due to a shift in monitoring locations in upper Dome Creek. In summary, new water quality triggers based on the 2014-2016 period are assessed for the site for consistency and to inform interim decision-making until a new baseline is established following the implementation of water treatment.

A comparison of water quality statistics is provided below to inform the selection of appropriate AMP water quality triggers. For consistency, this assessment includes water quality monitoring stations relevant to established AMP events including upper Dome Creek, upper Victoria Creek, and Pony Creek. The proposed water quality trigger for each event is assessed on several factors: (1) degree and direction of change to frame increases or decreases in concentrations between the two data sets; (2) continuity of the data and sample count; and (3) spatial setting that each monitoring station sits in relation to the seepage collection pond.

The assessment of water quality triggers is described by AMP event and is described below as:

- Event 1: Degraded water quality in Dome Creek downstream of mill area;

- Event 2: Changes in water quality in the seepage pond;
- Event 6: Degraded water quality in Dome Creek downstream of tailings facility;
- Event 7: Degraded water quality in Victoria Creek downstream of mine area; and,
- Event 8: Degraded water quality in Pony Creek downstream of mine area.

### **1.2 Dome Creek downstream of the Mill Area (Event 1)**

Dome Creek station DC-D1-b is located downstream of the mill area and upstream of the tailings storage facility (TSF). Two baseline periods are assessed from which to inform AMP Event 1 triggers. These two base periods consist of surface water quality data from 2012-2013 and 2014-2016. Parameters of concern for this period as carried forward from the 2015 AMP report consist of sulphate, total and dissolved arsenic, total cadmium, and total zinc (Table 1). There are 16 water quality measurements for the 2012-2013 period, and 22 for the 2014-2016 period.

Median sulphate values are not enriched between the two periods (577 and 605 mg/L SO<sub>4</sub>, respectively). However, variability of data on a monthly basis appears to increase through the 2014-2016 base period, with early seasonal sulphate data displaying lower concentrations than those observed through the 2012-2013 period, and an enrichment value of 0.3 for minimum values between the two respective periods (Table 1).

Total and dissolved arsenic values across the two periods are consistent between 2013-2016, with similar season variability. However, due to low values measured in 2012, median arsenic values show an enrichment factor of 1.4 through 2014-2016 as compared to the 2012-2013 period.

With respect to total cadmium and total zinc, seasonal concentrations decrease with time. Median total cadmium concentrations show an enrichment factor of 0.3 between the 2012-2013 and 2014-2016 periods. Median total zinc concentrations show an enrichment factor of 0.4 between the two respective periods. Data from 2014-2016 provide a more representative basis from which to compare future water quality.

Given the low values associated with the 2012 period for total and dissolved arsenic concentrations, the steady decrease in total and dissolved zinc and cadmium concentrations with time, and continuous data collection over the period, proposed WQ triggers for DC-D1b are based on the 2014 to 2016 data set.

**Table 1:**  
**Summary of statistics water quality data (mg/L) for Dome Creek downstream of mill area at DC-D1-b for the periods of 2012 to 2013 and 2014 to 2016. Enrichment factors quantify changes in these data sets.**

**2012 to 2013**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-As</b>	<b>D-As</b>	<b>T-Cd</b>	<b>T-Zn</b>
Minimum	437	0.015	0.008	0.00078	0.24
5 <sup>th</sup> Percentile	469	0.015	0.010	0.00085	0.25
Median	577	0.027	0.012	0.00203	0.44
95 <sup>th</sup> Percentile	665	0.072	0.021	0.00412	0.76
Maximum	720	0.116	0.025	0.00801	1.39
Number of Samples	16	16	16	16	16

**2014 to 2016**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-As</b>	<b>D-As</b>	<b>T-Cd</b>	<b>T-Zn</b>
Minimum	145	0.011	0.010	0.00029	0.086
5 <sup>th</sup> Percentile	151	0.018	0.010	0.00031	0.099
Median	605	0.034	0.016	0.00061	0.172
95 <sup>th</sup> Percentile	719	0.077	0.022	0.00182	0.363
Maximum	740	0.113	0.038	0.00196	0.439
Number of Samples	22	22	22	22	22

**Enrichment Factor**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-As</b>	<b>D-As</b>	<b>T-Cd</b>	<b>T-Zn</b>
Minimum	0.3	0.7	1.2	0.4	0.4
5 <sup>th</sup> Percentile	0.3	1.2	1.0	0.4	0.4
Median	1.0	1.3	1.4	0.3	0.4
95 <sup>th</sup> Percentile	1.1	1.1	1.0	0.4	0.5
Maximum	1.0	1.0	1.5	0.2	0.3

### 1.3 Seepage Collection Pond (Event 2)

The two data sets are compared for establishing water quality triggers for the seepage collection pond (WQ-SEEP): 2008-2013 and 2014-2016. The 2008-2013 period consists of ~100 sampling events per parameter (13 for total cyanide), and the 2014-2016 period consisting of ~70 sampling events per parameter (49 for total cyanide) (Table 2).

Median concentrations for several parameters of concern increased in the 2014-2016 base-period relative to 2008-2013. Concentrations for dissolved arsenic and dissolved iron are enriched in the 2014-2016 period relative to the historic 2008-2013 baseline. Median dissolved arsenic concentration is 10 times median 2008-2013 concentration (0.004 mg/L to 0.042 mg/L d-As). Median dissolved iron concentration is 4.4 times that of the median 2008-2013 concentration (2.2 mg/L to 10.9 mg/L d-Fe). Increases dissolved arsenic and iron are influenced by the implementation of field-filtration methods and a change in geochemical conditions within the TSF. The later changes are evident in the comparison of total arsenic and total iron between these data sets. Total arsenic and total iron saw an increase by 70% and 20%, respectively over the two data sets (Table 2). Sulphate and total cadmium also saw a modest increase of approximately 20% and may be an indication of tailings oxidation processes.

Changes to water quality in the seepage collection pond near the end of 2014 triggered an investigation as per AMP protocol. As an outcome to implementing the AMP and in support of the Care and Maintenance Project Proposal (CMPP), water treatment has been proposed to treat discharge from the seepage collection pond. Proposed water quality triggers for WQ-SEEP will be based on the 2014-2016 period to avoid further triggers until water treatment is implemented. After water treatment is implemented and following stabilization of downgradient parameters, a new baseline will be assessed for establishing post-treatment AMP triggers.

**Table 2:**  
**Summary of statistics water quality data (mg/L) for Seepage Pond Discharge at WQ-SEEP for the periods of 2008 to 2013 and 2014 to 2016. Enrichment factors quantify changes in these data sets.**

**2008 to 2013**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-As</b>	<b>D-As</b>	<b>T-Fe</b>	<b>D-Fe</b>	<b>T-Cd</b>	<b>T-Mn</b>	<b>D-Mn</b>	<b>T-CN</b>	<b>WAD CN</b>
Minimum	289	0.008	0.002	3.2	<0.1	0.00037	3.7	1.0	0.019	0.003
5 <sup>th</sup> Percentile	450	0.021	0.002	5.7	<0.1	0.00050	5.1	4.9	0.021	0.004
Median	621	0.035	0.004	10.5	2.2	0.00069	6.4	6.3	0.044	0.01
95 <sup>th</sup> Percentile	812	0.057	0.033	19.4	9.9	0.00114	9.0	8.8	0.075	0.015
Maximum	1210	0.071	0.048	31.6	11.4	0.00155	15.5	13	0.077	0.020
Number of Samples	105	107	107	107	105	107	104	99	13	35

**2014 to 2016**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-As</b>	<b>D-As</b>	<b>T-Fe</b>	<b>D-Fe</b>	<b>T-Cd</b>	<b>T-Mn</b>	<b>D- Mn</b>	<b>T-CN</b>	<b>WAD CN</b>
Minimum	419	0.039	0.027	6.6	4.7	0.00025	3.6	3.4	0.015	0.003
5 <sup>th</sup> Percentile	569	0.046	0.029	9.1	5.8	0.00027	5.1	4.9	0.021	0.003
Median	721	0.059	0.042	12.3	10.9	0.00053	6.6	6.4	0.057	0.012
95 <sup>th</sup> Percentile	865	0.101	0.069	18.9	17.4	0.00117	8.6	8.6	0.142	0.019
Maximum	882	0.126	0.081	20.4	19.8	0.00142	9.2	9.5	0.349	0.026
Number of Samples	39	40	40	40	40	40	40	40	39	33

**Enrichment Factor**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-As</b>	<b>D-As</b>	<b>T-Fe</b>	<b>D-Fe</b>	<b>T-Cd</b>	<b>T-Mn</b>	<b>D- Mn</b>	<b>T-CN</b>	<b>WAD CN</b>
Minimum	1.4	4.9	16.9	2.1	466	1.1	0.9	3.4	0.8	1.0
5 <sup>th</sup> Percentile	1.2	2.2	16.2	1.5	151	0.9	1.0	1.0	1.0	0.6
Median	1.2	1.7	10.1	1.2	4.4	1.2	1.0	1.0	1.3	1.2
95 <sup>th</sup> Percentile	1.1	1.8	2.1	1.0	1.8	1.6	1.0	1.0	1.9	1.3
Maximum	0.7	1.8	1.7	0.6	1.7	1.5	0.6	0.7	3.9	1.3

#### **1.4 Dome Creek downstream of tailings facility (Event 6)**

Two monitoring locations exist in support of AMP Event 6 for monitoring water quality in Dome Creek downstream of the tailings facility. These locations are WQ-DC-U, and WQ-DC-R. Data sets for both stations are consistent and include 2008-2013 and 2014-2016 (Table 3, Table 4). Dome Creek sits immediately downstream of the seepage collection pond. Proposed water treatment will have a beneficial effect on these locations in lower Dome Creeks. As an interim measure, and as described previously, proposed triggers for the AMP are based on the 2014-2016 period until water treatment is implemented and a new baseline can be established once water quality parameters stabilize post-treatment. A comparison of water quality for the two data sets is described below for consistency and context.

At WQ-DC-U, approximately 90 samples compose the 2008-2013 base-period and 31 compose the 2014-2016 period (Table 3). Between these two periods, all parameters of concern are enriched in the 2014-2016 period apart from total cadmium and total zinc (enrichment factors of median concentration by 0.8) (Table 3). The largest enrichments observed are associated with dissolved arsenic and dissolved iron (enrichments of 1.8 and 4.8 for median concentrations, respectively) and are in part influenced by changes in sampling protocol in 2011 (field filtration) as well as an increase in measured concentrations in the discharge from the seepage collection pond (Section 1.3).

**Table 3:**  
**Summary of statistics water quality data (mg/L) for Dome Creek downstream of tailings facility at WQ-DC-U for the periods of 2008 to 2013 and 2014 to 2016. Enrichment factors quantify changes in these data sets.**

**2008 to 2013**

Statistic	Sulphate	T-As	D-As	T-Fe	D-Fe	T-Cd	T-Mn	D-Mn	T-Zn
Minimum	104	0.007	0.003	0.7	<0.1	0.00007	0.3	0.1	0.001
5 <sup>th</sup> Percentile	168	0.010	0.003	1.3	<0.1	0.00008	0.6	0.5	0.006
Median	409	0.021	0.007	3.6	0.2	0.00025	1.3	1.2	0.020
95 <sup>th</sup> Percentile	681	0.060	0.029	12.2	4.9	0.00084	5.6	5.4	0.102
Maximum	904	0.084	0.035	18.7	7.4	0.00197	7.6	7.0	0.236
Number of Samples	88	90	90	90	90	90	90	83	90

**2014 to 2016**

Statistic	Sulphate	T-As	D-As	T-Fe	D-Fe	T-Cd	T-Mn	D-Mn	T-Zn
Minimum	171	0.010	0.005	1.6	0.2	0.00005	0.5	0.5	0.003
5 <sup>th</sup> Percentile	214	0.014	0.006	1.8	0.3	0.00005	0.8	0.6	0.004
Median	573	0.032	0.013	4.6	1.0	0.00019	2.2	2.1	0.016
95 <sup>th</sup> Percentile	788	0.054	0.043	9.8	5.2	0.00054	7.0	6.9	0.057
Maximum	850	0.095	0.050	13.5	5.7	0.00058	7.7	7.7	0.099
Number of Samples	31	31	31	31	31	31	31	31	31

**Enrichment Factor**

Statistic	Sulphate	T-As	D-As	T-Fe	D-Fe	T-Cd	T-Mn	D-Mn	T-Zn
Minimum	1.6	1.5	1.6	2.3	20.0	0.7	1.6	4.2	1.5
5 <sup>th</sup> Percentile	1.3	1.4	1.9	1.4	30.0	0.6	1.3	1.2	0.3
Median	1.4	1.5	1.8	1.3	4.8	0.8	1.7	1.7	0.8
95 <sup>th</sup> Percentile	1.2	0.9	1.8	0.8	1.1	0.6	1.3	1.3	0.4
Maximum	0.9	1.1	1.4	0.7	0.8	0.3	1.0	1.1	0.2

At WQ-DC-R, approximately 70 samples compose the 2008-2013 baseline and 24 samples compose the 2014-2016 period (Table 4). Concentrations across these two periods show decreases or minor increases in concentrations for median values (Table 3). Dissolved iron concentrations are an exception, and are enriched in this 2014-2016 period in median, 5<sup>th</sup> percentile, and minimum value statistics and are mainly attributed to the implementation of field filtration in 2011 as previously discussed. Data continuity across months and years for

total and dissolved arsenic, iron, and cadmium, and total zinc, appear to stabilize through the 2014-2016 period. Manganese concentrations are generally consistent across both periods and sulphate exhibits an upward trend with greater variability across data points in the 2014-2016 period.

**Table 4:**  
**Summary of statistics water quality data (mg/L) for Dome Creek downstream of tailings facility at WQ-DC-R for the periods of 2008 to 2013 and 2014 to 2016. Enrichment factors quantify changes in these data sets.**

**2008 to 2013**

Statistic	Sulphate	T-As	D-As	T-Fe	D-Fe	T-Cd	T-Mn	D-Mn	T-Zn
Minimum	21	0.008	0.003	0.5	<0.1	0.00006	0.2	0.1	0.001
5 <sup>th</sup> Percentile	130	0.015	0.005	1.2	<0.1	0.00008	0.6	0.5	0.008
Median	323	0.031	0.009	3.7	0.3	0.00016	1.0	1.0	0.019
95 <sup>th</sup> Percentile	479	0.066	0.018	7.5	1.5	0.00053	2.9	2.8	0.076
Maximum	519	0.088	0.021	22	4.0	0.00116	3.8	3.6	0.160
Number of Samples	68	69	70	69	70	69	69	64	69

**2014 to 2016**

Statistic	Sulphate	T-As	D-As	T-Fe	D-Fe	T-Cd	T-Mn	D-Mn	T-Zn
Minimum	170	0.001	0.006	0.7	0.4	0.00004	0.2	0.2	0.004
5 <sup>th</sup> Percentile	199	0.011	0.006	1.1	0.4	0.00004	0.4	0.4	0.005
Median	373	0.015	0.008	1.9	0.8	0.00007	1.2	1.1	0.009
95 <sup>th</sup> Percentile	570	0.030	0.012	4.2	1.5	0.00017	2.5	2.5	0.027
Maximum	587	0.046	0.045	5.0	3.7	0.00018	4.5	4.2	0.054
Number of Samples	24	24	24	24	24	24	24	24	24

**Enrichment Factor**

Statistic	Sulphate	T-As	D-As	T-Fe	D-Fe	T-Cd	T-Mn	D-Mn	T-Zn
Minimum	8.1	1.3	1.9	1.3	140	0.7	1.2	2.1	4.0
5 <sup>th</sup> Percentile	1.5	0.7	1.3	0.9	22	0.5	0.6	0.7	0.6
Median	1.2	0.5	0.9	0.5	2.3	0.4	1.2	1.1	0.5
95 <sup>th</sup> Percentile	0.4	0.2	0.4	0.2	0.3	0.1	0.2	0.2	0.1
Maximum	1.1	0.5	2.2	0.2	0.9	0.2	1.2	1.2	0.3

### **1.5 Victoria Creek downstream of mine area (Event 7)**

The purpose of event 7 is to inform AMP decision-making based on water quality observations in Victoria Creek. For the purposes of monitoring water quality in Victoria Creek downstream of the mine area, two sampling locations have been used historically. These locations are WQ-VC-R/+100 (with sampling data from 2008 to 2016) (Table 5) and WQ-VC-UMN (with data from 2012-2016) (Table 6). For the purposes of defining baseline in the interim period in which water treatment plant data at the seepage collection pond is gathered, WQ-VC-UMN data from 2014 – 2016 is proposed as baseline.

Reasons in support of the selection of this site are as follows:

1. WQ-VC-UMN often has flowing conditions during periods when WQ-VC-R is iced over and can not be sampled.
2. WQ-VC-UMN sits above the confluence of Victoria Creek and Minnesota Creek which is a significant source of dilution. The mine signature on water quality in Victoria Creek is therefore most evident at location WQ-VC-UMN.

Proposed water treatment will have a beneficial effect on lower Dome Creek and Victoria Creek. As an interim measure, and as described previously, proposed triggers for the AMP are based on the 2014-2016 period until water treatment is implemented and a new baseline can be established once water quality parameters stabilize post-treatment. A comparison of water quality for the two data sets is described below for consistency and context.

Key parameters include sulphate and metals including arsenic, cadmium, iron, manganese, and zinc. Neither station shows large enrichments to median values for any of the outlined parameters between the two periods.

At WQ-VC-R/+100, data periods are 2008-2013 and 2014-2016. Parameter trends are consistent across both periods, with median dissolved manganese concentrations decreasing slightly in the 2014-2016 period relative to initial baseline (0.052 mg/L Mn in 2008-2013 to 0.036 mg/L Mn in 2014-2016) (Table 5). Data periods at WQ-VC-UMN are 2012-2013 and 2014-2016, as 2012 is when sampling at this location was initiated. A similar trend is observed across the parameter suite, except for dissolved iron. Median dissolved iron concentrations at WQ-VC-R decrease by a factor of three between the 2012-2013 period and the 2014-2016 period. Median manganese concentrations decrease a similar amount to those at the WQ-VC-R location (0.067 mg/L Mn in 2012-2013 to 0.043 mg/L Mn in 2014-2016), and other parameters stable values across both periods (Table 6).

Between the two stations during the 2014-2016 periods, values for all outlined parameters are comparable, except for dissolved iron, which is moderately higher at WQ-VC-R than at WQ-VC-UMN (median values of 0.1 mg/L D-Fe at WQ-VC-R and <0.1 mg/L D-Fe at WQ-VC-UMN) (Table 5 and Table 6).

**Table 5:**  
**Summary of statistics water quality data (mg/L) for Victoria Creek at WQ-VC-R**  
**downstream of mine area for the periods of 2008 to 2013 and 2014 to 2016. Enrichment**  
**factors quantify changes in these data sets.**

**2008 to 2013 (WQ-VC-R/+100)**

<b>Statistic</b>	<b>Sulphate</b>	<b>D-As</b>	<b>D-Cd</b>	<b>D-Fe</b>	<b>D-Mn</b>	<b>D-Zn</b>
Minimum	6	<0.001	0.00001	<0.1	<0.1	<0.001
5 <sup>th</sup> Percentile	11	0.001	0.00001	<0.1	<0.1	0.001
Median	26	0.001	0.00002	0.1	0.1	0.002
95 <sup>th</sup> Percentile	43	0.002	0.00009	0.3	0.1	0.011
Maximum	119	0.005	0.00015	0.5	0.3	0.021
Number of Samples	90	91	91	91	85	91

**2014 to 2016 (WQ-VC-R/+100)**

<b>Statistic</b>	<b>Sulphate</b>	<b>D-As</b>	<b>D-Cd</b>	<b>D-Fe</b>	<b>D- Mn</b>	<b>D-Zn</b>
Minimum	10	0.001	0.00001	<0.1	<0.1	0.001
5 <sup>th</sup> Percentile	18	0.001	0.00001	<0.1	<0.1	0.001
Median	33	0.001	0.00002	0.1	<0.1	0.002
95 <sup>th</sup> Percentile	52	0.002	0.00005	0.3	0.1	0.006
Maximum	130	0.003	0.00010	0.3	0.2	0.009
Number of Samples	38	38	37	38	38	37

**Enrichment Factor**

<b>Statistic</b>	<b>Sulphate</b>	<b>D-As</b>	<b>D-Cd</b>	<b>D-Fe</b>	<b>D- Mn</b>	<b>D-Zn</b>
Minimum	1.5	2.5	0.9	5.0	1.3	2.5
5 <sup>th</sup> Percentile	1.7	0.8	1.1	1.0	0.2	1.0
Median	1.2	1.1	1.1	0.9	0.7	0.9
95 <sup>th</sup> Percentile	1.2	0.9	0.5	1.0	0.7	0.6
Maximum	1.1	0.6	0.7	0.7	0.8	0.4

**Table 6:**  
**Summary of statistics water quality data (mg/L) for Victoria Creek at WQ-VC-UMN downstream of mine area for the periods of 2012 to 2013 and 2014 to 2016. Enrichment factors quantify changes in these data sets.**

**2012 to 2013 (WQ-VC-UMN)**

Statistic	Sulphate	D-As	D-Cd	D-Fe	D-Mn	D-Zn
Minimum	11	0.001	0.00001	<0.1	<0.1	0.001
5 <sup>th</sup> Percentile	14	0.001	0.00001	<0.1	<0.1	0.001
Median	28	0.001	0.00002	0.1	0.1	0.002
95 <sup>th</sup> Percentile	64	0.004	0.00009	0.2	0.2	0.009
Maximum	145	0.005	0.00018	0.3	0.4	0.016
Number of Samples	38	38	38	38	38	38

**2014 to 2016 (WQ-VC-UMN)**

Statistic	Sulphate	D-As	D-Cd	D-Fe	D- Mn	D-Zn
Minimum	11	0.001	0.00001	<0.1	<0.1	0.001
5 <sup>th</sup> Percentile	20	0.001	0.00001	<0.1	<0.1	0.001
Median	37	0.001	0.00002	<0.1	<0.1	0.002
95 <sup>th</sup> Percentile	53	0.003	0.00007	0.2	0.1	0.007
Maximum	132	0.004	0.00010	0.3	0.2	0.008
Number of Samples	39	39	39	39	39	39

**Enrichment Factor**

Statistic	Sulphate	D-As	D-Cd	D-Fe	D- Mn	D-Zn
Minimum	1.0	0.9	0.5	0.5	0.6	0.5
5 <sup>th</sup> Percentile	1.4	1.2	1.3	0.5	4.3	0.5
Median	1.3	1.0	1.1	0.3	0.6	0.8
95 <sup>th</sup> Percentile	0.8	0.8	0.8	0.9	0.5	0.8
Maximum	0.9	0.7	0.6	0.9	0.6	0.5

### **1.6 Pony Creek downstream of mine area (Event 8)**

To inform baseline water quality data for Event 8 (Changes to water quality in Pony Creek downstream of mine area), two base-periods are outlined. These periods consist of water quality data from 2008-2013 (69 samples) and 2014-2016 (12 samples with no data from 2015) (Table 7). Pony Creek is upstream and lateral to Dome Creek and therefore will not be influenced by proposed water treatment.

**Table 7:**  
**Summary of statistics water quality data (mg/L) for Pony Creek downstream of mine area for the periods of 2008 to 2013 and 2014 to 2016. Enrichment factors quantify changes in these data sets.**

**2008 to 2013**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-Cd</b>	<b>D-Cd</b>	<b>T-Cu</b>	<b>D-Cu</b>	<b>T-Zn</b>	<b>D-Zn</b>
Minimum	16	0.00017	0.00006	0.003	<0.001	0.001	<0.001
5 <sup>th</sup> Percentile	21	0.00021	0.00018	0.005	0.004	0.019	0.015
Median	97	0.00106	0.00102	0.010	0.008	0.096	0.086
95 <sup>th</sup> Percentile	164	0.00551	0.00441	0.044	0.019	0.465	0.442
Maximum	187	0.00789	0.00624	0.135	0.025	0.731	0.617
Number of Samples	66	69	68	69	68	69	68

**2014 to 2016**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-Cd</b>	<b>D-Cd</b>	<b>T-Cu</b>	<b>D-Cu</b>	<b>T-Zn</b>	<b>D-Zn</b>
Minimum	19	0.00022	0.00002	0.006	0.001	0.019	0.006
5 <sup>th</sup> Percentile	25	0.00036	0.00009	0.008	0.002	0.037	0.007
Median	108	0.00125	0.00025	0.013	0.006	0.117	0.029
95 <sup>th</sup> Percentile	388	0.04200	0.00330	0.056	0.012	0.480	0.330
Maximum	602	0.00425	0.00401	0.093	0.012	0.629	0.363
Number of Samples	13	13	13	13	13	13	13

**Enrichment Factor**

<b>Statistic</b>	<b>Sulphate</b>	<b>T-Cd</b>	<b>D-Cd</b>	<b>T-Cu</b>	<b>D-Cu</b>	<b>T-Zn</b>	<b>D-Zn</b>
Minimum	1.2	1.3	0.4	2.1	14.4	31.8	14.8
5 <sup>th</sup> Percentile	1.2	1.7	0.5	1.6	0.4	2.0	0.5
Median	1.1	1.2	0.2	1.3	0.8	1.2	0.3
95 <sup>th</sup> Percentile	2.4	7.6	0.7	1.3	0.6	1.0	0.7
Maximum	3.2	0.5	0.6	0.7	0.5	0.9	0.6

Project effects on Pony Creek are attributable to seepage that reports to Pony Creek along sub-surface pathways from adjacent waste rock and possibly the Brown-McDade pit. Pony Creek is also heavily influenced by placer mining activity which commenced in approximately 2014. Most notable influences from placer mining include sedimentation and erosion as well as the effect from water diversions which has exacerbated the ephemeral nature of Pony Creek. Parameters of interest for Pony Creek include sulphate and total and dissolved metals

(cadmium, copper, and zinc). Median values for sulphate and total metals are slightly enriched in the 2014-2016 base period (Table 7). However, median dissolved values for cadmium, copper, and zinc, are lower in the 2014-2016 period than in the 2008-2013 period (enrichments of 0.2, 0.8, and 0.3, respectively).

In general, changes to data trends and statistics are not consistent within any of the parameters across these time periods. However, the comparison and interpretation of these data are obfuscated by placer mining activity and the lack of data over the 2015 period when there was no flow in Pony Creek (attributable to placer activity). Due to the limitations in the data, no changes are proposed for Pony Creek water quality triggers.