# Faro Mine Complex

## Adaptive Management Plan for the Faro Mine Remediation Project

**Crown-Indigenous Relations and Northern Affairs Canada**

**Version: July 15, 2021**

# Plain Language Summary

This document is a summary of the **Faro Mine Remediation Project** (the Project) **Adaptive Management Plan.** Readers are encouraged to review the AMP if they are looking for more detailed information. The full Project Proposal is available on the Yukon Environmental and Socio-Economic Assessment Board online registry. The Project Proposal can be accessed at the following link: Project Proposal. While not specifically in the Adaptive Management Plan to help the reader a summary of the Faro Mine Site has been included as part of this summary.

## INTRODUCTION

The Faro Mine was once the largest open pit lead and zinc mine in the world. Today, it is the site of one of the most complex abandoned mine clean-up projects in Canada. The **Faro Mine Complex** spans an area of 25 square kilometres. It is located about 15 kilometres north of the Town of Faro and 200 kilometres northeast of Whitehorse, within the traditional territory of the Kaska Nations, and upstream from Selkirk First Nation.

The Faro Mine operated for almost thirty years, until it was abandoned in 1998 when the owner declared bankruptcy. Mining of the valuable minerals at the site left behind **waste rock** and finely crushed particles called **tailings**. These wastes can release metals and acid into the land and water.

The process of cleaning up the site is called **remediation**. The purpose of remediation is to improve the conditions on site, reduce effects on the environment, including air, land, and water, and make sure that the site is safe for people and wildlife. The work needed to complete the remediation will take about 15 years. Following that there will be a long period of monitoring and maintenance that will continue into the far future.

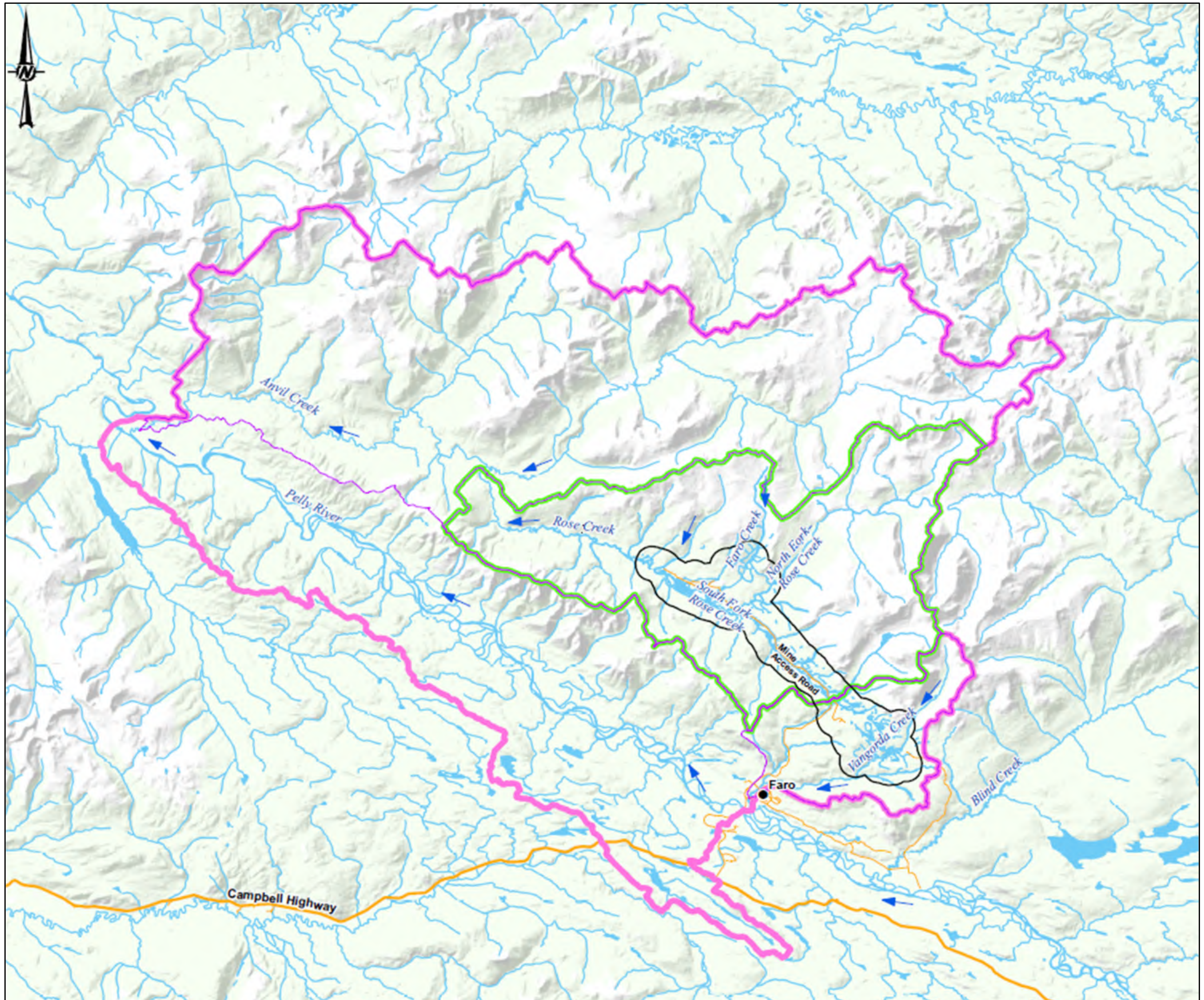
The Project **Adaptive Management Plan** was developed for the active remediation and long-term operations and maintenance phases of the **Project.** Sometimes this plan is called an AMP. **Active remediation** is the time where the Faro Mine Site is under **construction**. **Long-term operations and maintenance** is when the Faro Mine Site is being **monitored a**nd where the **water is being treated** for a very long time.

### Environmental Setting

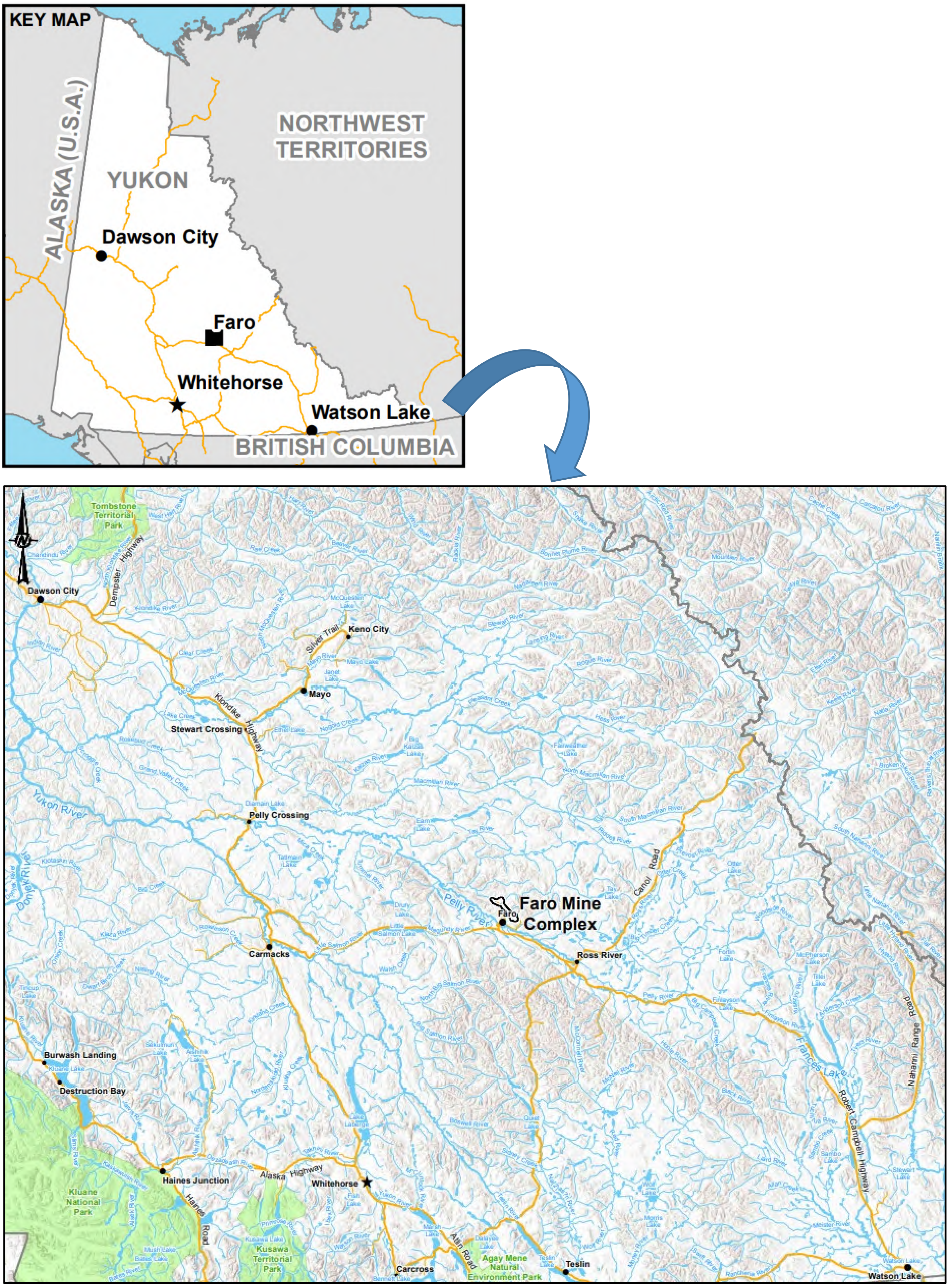
The Faro Mine Site is located in a mountainous area, on a flat upland area that borders the Anvil Mountain range to the north and east and the Rose Mountains to the south. Rolling high areas, mountain peaks, and flat areas, lakes, streams, and areas of permafrost are common throughout the area.

Groundwater is the water present beneath the ground surface in the spaces between rock, soil or sand. Two important areas of groundwater, called aquifers, lie beneath the Project area. These are the Rose Creek and North Fork Rose Creek aquifers.

The Faro Mine Complex is within the Rose Creek and Vangorda Creek watersheds. Rose Creek drains the Faro Mine Site, and flows northeast into Anvil Creek, before draining into the Pelly River downstream of the town of Faro. Vangorda Creek flows to the southwest and into the Pelly River near the Town of Faro.




**Watersheds, Creeks and Water Flow in the Area of the Faro Mine Site**




**Location of the Faro Mine Complex**

## Faro Mine Complex

There are two main areas within the Faro Mine Complex. These are the **Faro Mine Site** and the **Vangorda Plateau Mine Area**.

The Faro Mine site includes the Faro Pit, the main tailings storage area, called the Rose Creek Tailings Area, waste rock dumps, the old mill, and a back-up tailings storage area, called the Emergency Tailings Area. This Adaptive Management Plan is focused on the Faro Mine Site because only the Faro Mine Site is being remediated at this time. There is another Adaptive Management Plan that includes the Vangorda Plateau Mine Area that is used for care and maintenance but it is not described in this document because it is not included in the Faro Mine Remediation Plan.


**Faro Mine Site and Vangorda Plateau Mine Area**

Mining left behind 54 million tonnes of tailings and 260 million tonnes of waste rock at the Faro Mine Site. There is enough waste rock to cover downtown Whitehorse 90 m deep, and enough tailings to add another 30 m.

Tailings are stored in the Rose Creek Tailings Area and the Emergency Tailings Area. Several dams form a part of the Rose Creek Tailings Area, including the Original Dam, Secondary Dam, Intermediate Dam, and Cross Valley Dam.

Waste rock dumps at the Faro Mine Site include the Main Dump, Intermediate Dump, Northwest Dumps, Faro Valley Dumps, Northeast Dumps, and Intermediate Dump. Streams that flow through the site area have been diverted to allow for mining.


**Tailings Dams in the Rose Creek Tailings Area**


**The Faro Pit, Waste Rock Dumps, Faro Mill, and Emergency Tailings Area**

Mine wastes can pollute the environment by releasing metals and acid into soil and water. When it rains or when snow melts, water flowing over waste rock and through tailings storage areas can carry contaminants onto the land and into creeks.

Studies show that part of the Rose Creek Tailings Area, and some of the waste rock dumps are releasing metals and acid into nearby creeks. Groundwater under the Rose Creek Tailings Area and waste rock dumps have become contaminated with metals. If this water is not collected and pumped to the Faro Pit for storage and treatment, it could surface in Rose Creek and harm fish, wildlife, and people. Right now, only some areas of the site are causing contamination, but over time, the problem could become more widespread. While the Faro Mine Site is being remediated, the **Adaptive Management Plan** is needed to help the site respond quickly when water quality is affected by the contaminated water. Once the Faro Mine Site is remediated, the **Adaptive Management Plan** is needed to respond if the Faro Mine Site is not behaving as it should after remediation.

# ADAPTIVE MANAGEMENT PLAN APPROACH

## Overview

Adaptive management aims to improve management in the future. This is done by gathering information to learn more about what we do not know and changing management based on what has been learned. Adaptive management should start early in the planning of a project and throughout the life of a project.

An Adaptive Management Plan (AMP) is a management plan that allows for change and is flexible when responding to unexpected events and conditions. An AMP is not used to manage things we know will happen, but ~~to be in place~~ to respond to the things we are not sure about. The plan outlines the actions for gathering information to respond correctly to an unpredicted environmental situation or change in the Project. For example, while the Faro Mine Site is under construction water with metals in it could pop up somewhere unexpected and the Project would have to find a way to collect that water. Another example would be that one of the goals of the Project is to collect the water that is not safe to release, but if the systems that are built don't work as well as planned then other action would have to be taken.

## Objectives

The objectives of this AMP are as follows.

- Provide a way to guide quick action in response to unexpected events and conditions.
- Include a flexible approach to carry out actions when responding to an unforeseen event.
- Focus on water quality for all phases of the Project, including key activities during remediation.
- Identify actions to gather information and respond correctly to an unpredicted environmental situation or change in the Project, like the examples described above.

The AMP will help achieve the five over-arching objectives of the Project:

- protect human health and safety;
- protect and restore the environment including land, air, water, fish, and wildlife;

- return the mine site to an acceptable state of use that reflects pre-mining land use where possible;
- maximize the environmental, social, and economic benefits to locals and Yukoners; and
- manage long-term site risk in a cost-effective manner.

### Approach

The scope of this AMP includes the following areas and associated activities:

- groundwater quality and the influence on surface water quality when it comes to surface;
- surface water quality to determine how well remediation is working and whether other changes are happening to surface water quality due to water management;
- whether water treatment is successful at maintaining conditions in the receiving environment;
- cumulative effects of Project water quality in Rose Creek and downstream to the Pelly River, where cumulative effects are changes to water quality that are caused by a combination of past, present and future activities; and
- water quality in the Anvil Creek and Pelly River.

## ADAPTIVE MANAGEMENT INITIATIVES

An **Adaptive Management Initiative (AMI)** is used to denote a general location and general set of conditions that requires management as part of the AMP. Several AMIs have been identified for the Faro Mine Site and surrounding areas. An AMI can include several monitoring locations, both groundwater and/or surface water monitoring. Monitoring at these locations will be tracked in quarterly/annual reports. The purpose of the AMI can be varied:

- to determine if the remediation needs to happen quicker than planned in the construction schedule;
- to determine if remediation is working as expected; and
- to determine if water quality is getting worse (for example, because groundwater is getting worse or daylighting or because poor quality water is running off the Faro Mine Site before it can be treated during construction or because the water treatment plant is not working as it should).

As the Project goes through construction the focus of each AMI would change because the Project will make things better and some risks the Project team is uncertain about would be reduced as the Faro Mine Site is cleaned up. This process is shown in the table below; when the Faro Mine Site is cleaned up, concerns will change and get less.

**Change in Monitoring and Management through the Faro Mine Remediation Project Phases**

| Project Phase | Project Phase Management Approach | Monitoring Changes | Adaptive Management Focus |
|---|---|---|---|
| Early Active Remediation (i.e., early construction) | • Day to day care and maintenance activities keep going.<br>• Early construction remediation components are started.<br>• Responding to changing environment by starting parts of the Project. | • Monitoring regular day to day activities.<br>• Monitoring construction activities to confirm they are being done as they should be.<br>• Performance monitoring of existing infrastructure (for example, waste rock dumps and the tailings). | • Confirmation that the environment is not degrading more.<br>• Decision on whether areas that require remediation require faster action. |
| Mid-Point of Active Remediation (i.e., when some construction is finished for some parts of the Project, but not all) | • Day to day care and maintenance activities are on-going.<br>• Inclusion of the Adaptive and Operational parts in the Project Plans.<br>• Remediation carries on and some parts are finished.<br>• Complicated parts have been started but are not finished (e.g., Rose Creek Diversion).<br>• Responding to environment by advancing parts of the Project. | • Monitoring regular day to day activities<br>• Performance monitoring of existing infrastructure (for example, waste rock dumps and the tailings).<br>• Performance of monitoring of completed remediation parts (for example, how the permanent water treatment plant is doing, how the new creek changes are doing)<br>• Monitoring construction activities to confirm they are being done as they should be. | • Confirmation that the environment is not degrading more.<br>• Decision on whether remediated parts require faster action.<br>• Confirmation that the finished parts are performing as intended. |
| Long-term operations and maintenance | • Remediation is complete.<br>• Day to day care and maintenance activities are on-going including long-term water management and maintenance activities. | • Performance monitoring of existing infrastructure (for example, the now covered waste rock dumps and the tailings).<br>• On-going monitoring of creeks and rivers.<br>• On-going maintenance of remediated components (for example, permanent water treatment plant and ponds that capture site water before it goes to the environment). | • Confirmation that the finished remediation parts are performing as intended.<br>• Confirmation the environment has improved. |

## Links to Other Plans

To remediate the site, a great deal of planning and management is required. Many plans are used and form a management 'framework'. This framework will have plans that are for responding to situations that are expected and plans that will include adaptive management to help respond to risks or things the Project is uncertain about.

Use of these various plans is critical. This includes consideration by the various experts to fully understand:

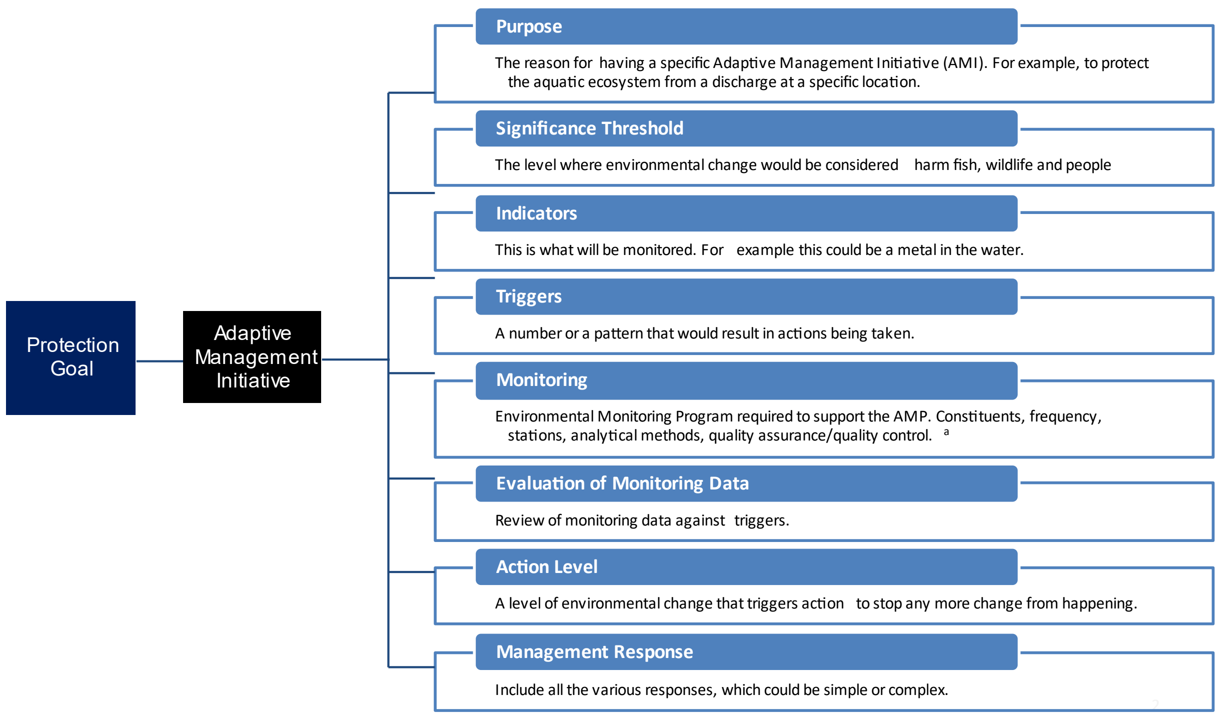
- monitoring results;
- changes seen on site;
- adaptive management actions; and

- possible need for adaptive management in the future.

Outcomes of the plans together will be summarized annually in one document known as the ‘Faro Mine Remediation Summary of Progress’.

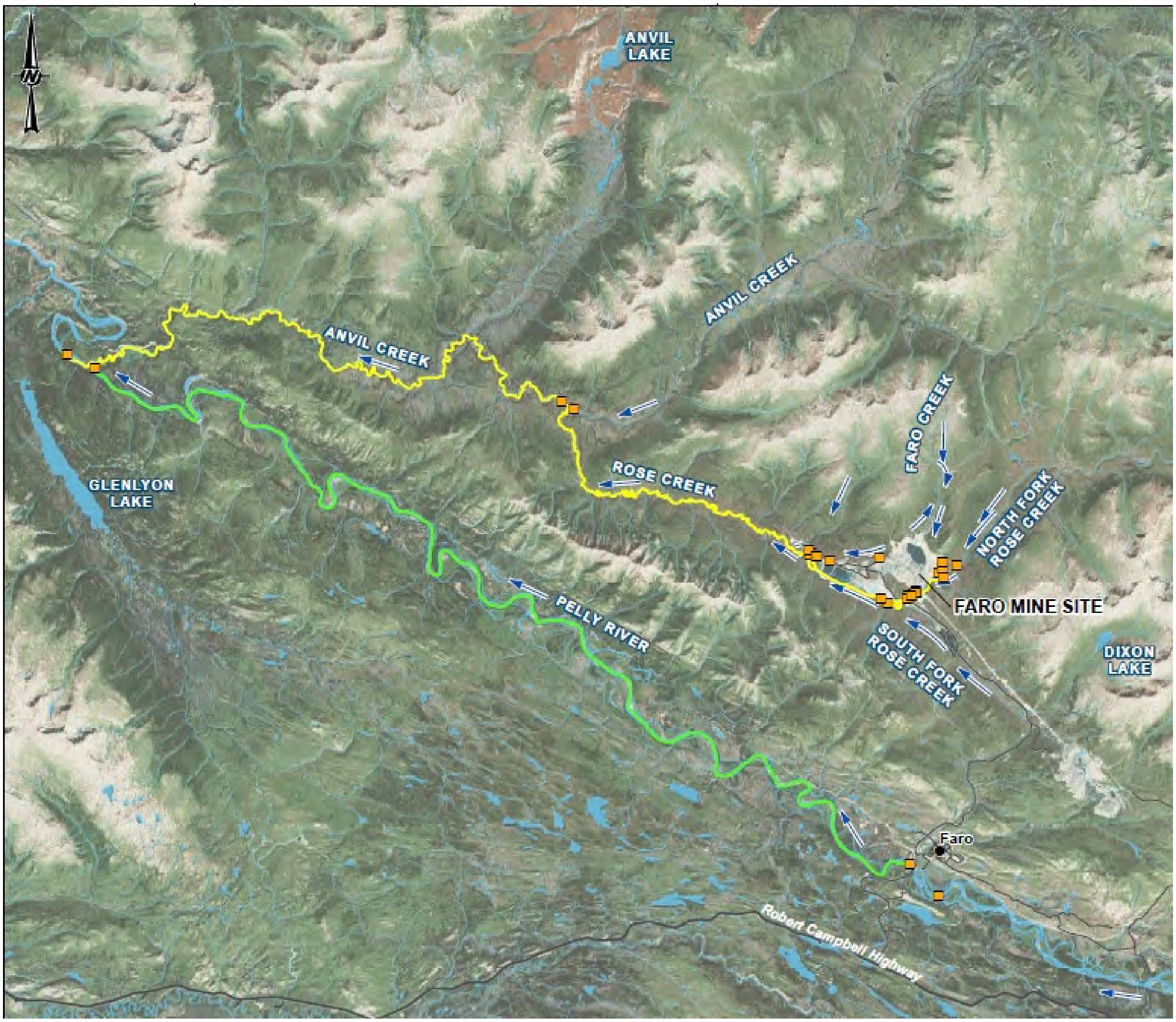
## Adaptive Management Plan Approach

The Project AMP is informed by the protection goals and key components.




[a] Source: as per Government of Yukon 2021 with simplified language

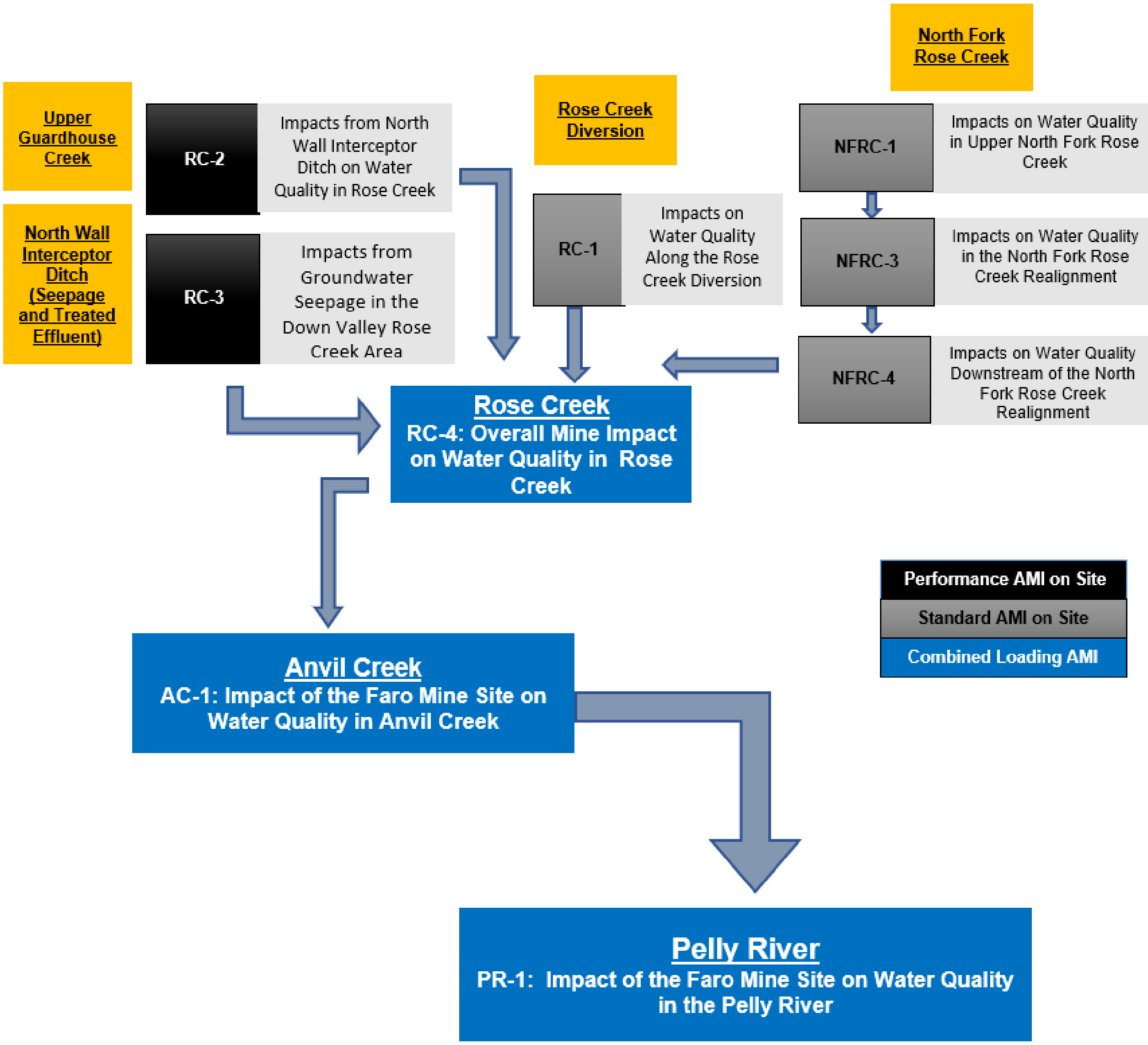
Protection goals were created for each waterbody based on Traditional Knowledge about the importance of waterbodies and fish species, as well as feedback from engagement, regulations, and general concepts of protecting fish, wildlife and people. From talking with people, it was understood how important the Anvil Creek and Pelly River are to the First Nations and that this creek and river must be protected. Going forward, if Traditional Knowledge sharing agreements can be reached, the Project will include Traditional Knowledge in more aspects of the AMP. Protection goals provide a description about the level of environmental protection that should exist for a waterbody. The protection goals are high level and are set to protect the whole ecosystem rather than water quality only. The figure below shows where protection goals apply.




**Faro Mine Site Protection Goal Application.** The yellow highlights show where protection goals apply. The green highlights areas close to the Project where there could be impacts from other sources, like the Vangorda Mine Plateau Area or the Town of Faro.

There are a number of calculations that are required to determine when there will be harm to fish, wildlife and people and when the Project would need to initiate a response. These calculations use literature and research from across Canada and the United States, but also use data collected at the Faro Mine Site, including toxicity testing which tests different types of water to see how it impacts both bugs and fish. The AMP uses words like triggers and action levels to help understand what needs to happen and when. A trigger is a number or pattern that results in the need for action. For the Faro Mine Site triggers are set around water quality and tell us about the level of risk to aquatic life in a creek or river. Water quality data is checked often to see if there are changes in the water quality over a trigger that would tell us if there is increased risk to the creek or river. When a trigger is exceeded, an action level is reached. An action level indicates the urgency of the issue and type of management response required. Every AMI has triggers so that the right action is taken at the right time.

It is important to understand that all of the AMIs at the Faro Mine Site are interrelated as we move downstream. This diagram shows the how the AMIs are connected and more information is provided below. Each AMI is given a number and a name so it is easy to track into the far-future. The name connects it to the waterbody.




Notes: Upper Guardhouse Creek flows into the North Wall Interception Ditch, which flows into Rose Creek. AMI RC-3 monitors groundwater that emerges to surface within the North Wall Interception Ditch.

## North Fork Rose Creek

The North Fork Rose Creek is located to the southeast of the Faro Waste Rock Dump (or Main Dump), Faro Pit and Zone II Pit, Zone II Outwash, Intermediate Dump and Northeast Dump. Starting around 2013 loadings of zinc and sulphate from waste rock drainage, and at the North Fork Rock Drain, have significantly influenced water quality in North Fork Rose Creek (CIRNAC 2019). There are three AMIs for the North Fork Rose Creek:

- impacts on water quality in Upper North Fork Rose Creek;
- impacts on water quality in the North Fork Rose Creek Realignment; and
- impacts on water quality downstream of the North Fork Rose Creek Realignment.

**Panoramic view of the Faro Waste Rock Dumps, the North Fork Rose Creek, and the Haul Road**

## Rose Creek

The Rose Creek watershed encompasses the Faro Mine Area and Rose Creek Tailings Area and drains west to the Pelly River via Anvil Creek. Rose Creek is fed by two tributary forks that join, the North Fork Rose Creek and the South Fork Rose Creek. There are four AMIs for Rose Creek:

- influence from seepage on Rose Creek Diversion;
- influence from North Wall Interceptor Ditch and X13 Channel on Rose Creek, including discharge from the permanent water treatment plant;
- performance of groundwater capture in the Down Valley Rose Creek area; and
- overall mine impact on aquatic life in Rose Creek.

**View of Rose Creek downstream of the Faro Mine Site, where water quality samples are taken.**

## Anvil Creek

The protection goal for the Anvil Creek is for the Anvil Creek to be safe for fish and fish food. The main stem of Rose Creek continues to the northwest where it flows into Anvil Creek, which continues for 20 km before emptying into the Pelly River. Anvil Creek has one AMI with the purpose to evaluate the influence of the Faro Mine Site on water quality in Anvil Creek and potential risk to aquatic life.

**Anvil Creek, downstream of the Faro Mine Site.**

## Pelly River

The protection goal for the Pelly River is that the Pelly River will not change because of the Project. The Pelly River has one AMI, and it evaluates the surface water quality in the Pelly River, with stations located both upstream and downstream of the Faro Mine Site. The purpose of the AMI is to evaluate the combined influence of the Faro Mine Site on water quality in the Pelly River.

**Pelly River, downstream of the Faro Mine Site and Vangorda Plateau Mine Area.**

# ANNUAL REPORTING AND REVIEW

## Annual and Quarterly reports

Monitoring will be completed monthly. Comparison of monitoring data to AMP triggers will be completed on a monthly basis.

Reporting will be completed quarterly. Quarterly reports will be issued at the end of April, July, and October and will include data from the three previous months. The fourth quarter of each year will be reported in the annual report.

Annual reporting will be completed prior to March 31 of the following year. Quarterly and annual reports will be provided to Faro Mine Complex stakeholders, including affected First Nations. Input on recommendations and possible management responses can be provided to CIRNAC.

## AMP Update

The AMP will be reviewed annually and compared to the outcomes of the annual water quality report, as well as relevant monitoring results from Aquatic Effects Monitoring Plan (see Figure 1-4).

It is expected that this AMP will evolve and be updated as required by:

- the Project's water licence;
- engagement input;
- new guidance or new water quality guidelines; and
- a concerning change in environmental conditions as indicated by monitoring results.

Updates to the AMP will occur every three years during active remediation. Updates are expected to be less frequent as the Project enters a steady state during long-term operations and maintenance.

Updates to the Project AMP may include:

- addition or exclusion of adaptive management initiatives;
- changes to triggers or station sampling frequency; and
- more general revisions to the framework.

The overall aim of these updates will be to improve the AMP and adapt to changing site conditions.

# ENGAGEMENT PLAN

CIRNAC's approach to engagement on the AMP has been guided by the feedback received on the various versions of the AMP as it has evolved since 2004.

Since 2019, the Project has been under review through the Yukon Environmental and Socio-Economic Assessment Board. Through this review process, affected First Nations representatives and other stakeholders provided comments and questions on the AMP. These considerations were incorporated into this version of the AMP. In February 2021, YESAB hosted an AMP workshop where CIRNAC presented their vision for the AMP. As part of this workshop, First Nations representatives and key stakeholders were provided opportunity to express their views on the planned approach. Collectively, these workshops and Adequacy comments were used to refine the plan to create this AMP.

## Plan for Continuing Engagement

Engagement for the AMP will be directed towards the Project stakeholders, which include:

- Affected Yukon First Nations, including Ross River Dena Council, Liard First Nation and Selkirk First Nation.
- Faro Mine Remediation Project Technical Review Committee members.
- Federal departments/regulators including Fisheries and Oceans Canada and Environment and Climate Change Canada.
- Yukon Government departments/regulators, including Water Resources, Energy Mines and Resources, and Environment.
- Town of Faro.
- Yukon Conservation Society.

This list can be expanded if other parties come forward and show an interest in receiving information or being involved in discussion about the AMP for the Project.

Specific engagement activities will include the following key elements:

- The AMP quarterly and annual reports will be distributed to stakeholders, including alerting stakeholders when exceedances occur.
- Should mitigation be triggered, the proposed strategy with will be shared with regulators, Technical Review Committee members and other key stakeholders. Their views will be sought on the proposed mitigation approach.
- During AMP updates, an opportunity will be provided to stakeholders to review the proposed changes to the AMP.

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**FIGURES**

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# VERSION HISTORY

| Version | Title | Date of Issuance | Description |
|---|---|---|---|
| 1.0 | Appendix 11G Adaptive Management Plan 2019 Project Proposal | | Conceptual AMP provided as part of the Project Proposal. |
| 1.1 | Adaptive Management Plan for the Faro Mine Remediation Project | | Submitted in response to Information Request 2-8 for review by YESAB. The document was significantly updated to reflect:<br>- concerns and questions raised during adequacy<br>- comments from consultation held by CIRNAC on the Operational AMP<br>- new Yukon Government Guidance on AMPs |

# CONCORDANCE WITH R2-8:

| Direction from YESAB (R2-8) | Where addressed in document? |
|---|---|
| Clearly articulates the framework, objectives, goals and approach for developing the Project AMP. | Section 1.2 (Objectives), Section 3 (Approach) |
| Identifies clear protection and management goals and explains how they were defined in consultation with First Nations and stakeholders. | Section 3.2 provides the considerations that were included and rationale; Appendix B outlines engagement comments, including those related to protection goals and how comments from representatives were addressed. |
| Lists (at a minimum) all of the proposed Adaptive Management Initiatives (AMIs) with a narrative description of the response for each of the AMIs. | Section 4.0 lists the AMIs, Section 3.9 outlines generic responses for AMIs, Section 5 through 8 outlines each AMI and some more specific responses if an action level is exceeded |
| Includes the same level of detail for any AMI carried forward from the initial AMP submitted with the proposal. A lesser level of detail (as outlined in the YG guidance) could be reasonable for any new AMI, however, CIRNAC should provide as much information as possible regarding the description of each AMI, indicators, triggers, action levels, monitoring requirements and plans. | Section 5 to 8 include detailed information for each AMI, acknowledging these are draft and expected to change through water licensing. Sections 5 to 8 also provide an indication how AMIs will evolve over time to capture remediation. The Pelly River AMI is new and was not presented in the 2019 AMP submitted with the proposal. Its triggers are presented as concepts until more data is collected to finalize these. |
| Identifies how CIRNAC has engaged or will engage with First Nations and stakeholders at the AMI identification stage. | Section 1, Section 2.1, Section 2.3, Appendix B list past engagement and Section 10 outlines future engagement for results or revaluation of the AMP. Appendix A provides |

| Direction from YESAB (R2-8) | Where addressed in document? |
|---|---|
| Non-water-quality-based AMIs could be developed through this process. | additional information on approach to socio-economic adaptive management components. |
| Clearly outlines how the development of the Project AMP has incorporated First Nations and stakeholder engagement as well as Traditional Knowledge. Provides sufficient explanation of mechanisms for their continued integration into the AMP going forward. | Section 1, Section 3.2, Section 10, Appendix B |
| Includes clear definitions for the following terms: trigger, action level, maximum allowable condition, significance threshold, and protection goal – and a narrative that distinguishes between them. | Glossary provides definitions and Section 3 provides a narrative description. |
| Includes a table that provides: Interim protection goals; Final protection goals; Maximum allowable condition for each interim and final protection goal; Final protection goal for each interim protection goal; Confirmation if each interim protection goal is expected to be met during the Project (25 years). | Section 3.2, Table 3-1, Table 3-6 |
| Identifies all the monitoring plans for the Project, and how these plans will interact with each other presented in schematic plus narrative form | Section 2.1, Appendix A |
| Demonstrates how the various monitoring and response plans interact with the AMP so that it is clear which monitoring plan(s) address each individual AMI, each protection goal, and each significance threshold (or equivalent). This should include any non-water-quality-based AMIs. | Section 2.1, Section 2.2, Figure 2-5, Section 3.2, Appendix A. Non-water quality based AMIs such as those in the Aquatic Effects Monitoring Plan and the Terrestrial Management and Effects Monitoring Plan were developed prior to the change in guidance. The level of detail in these plans is believed to be sufficient for adequacy and will be further developed as described in this plan (See Volume IV, Section 11 CIRNAC 2019) |

## ACRONYMS AND GLOSSARY OF KEY TERMS

| Term | Definition |
|---|---|
| active remediation | Major construction activities required to remediate and decommission the Faro Mine Area and Rose Creek Tailings Area and on-going care and maintenance, including water treatment, monitoring and adaptive management. |
| action level | A level of environmental change that triggers action under the Adaptative Management Plan (YG 2021). |
| Adaptive Management Initiative (AMI) | A specific condition that is anticipated to required monitoring, assessment and management as part of the adaptive management plan (YG 2021). |
| AMP | Adaptive Management Plan |
| Benchmark | Concentrations above which effects to a receptor may occur (see definition under "low-effect benchmark"). |
| CIRNAC | Crown-Indigenous Relations and Northern Affairs Canada |

| Term | Definition |
|---|---|
| Constituent of potential concern (COPC) | A metal or chemical compound in the air, water, sediment, and/or soil and then transferred or taken up by plants and animals and people and has potential to be toxic to living organisms and adversely affect growth, reproduction and/or survival (health). |
| ECx | Effective concentration causing x% reduction in an endpoint that has only two possible outcomes for individual organisms, such as survival (dead or alive) or normal development (normal or abnormal) (e.g., $EC_{20}$). |
| Low-Effect Benchmark | The low-effect benchmarks represent concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. When available, the low-effect benchmark is selected as an appropriate $EC_{20}$ generated with site-specific toxicity testing. Otherwise, the benchmark is selected from a toxicity dataset of $EC_{20}$ values (or threshold representing a low-effect level) found in the toxicological literature. This use of the $EC_{20}$ is consistent with the Canadian Council Of Ministers of the Environment (2007) definition for low effect level (i.e., $EC_{15-25}$). |
| ICx | Inhibitory concentration causing x% reduction in an endpoint that is a continuous measurement, such as growth (length or weight) for individual organisms (e.g., $IC_{20}$). See Appendix C for application. |
| long-term operations and maintenance | Defined as the period of time in which the efficacy of the active remediation success is confirmed through performance monitoring, and adaptive management is implemented to achieve a predictable steady-state that meets the overarching objectives of the Project. Once a predictable steady-state is achieved, ongoing water treatment, monitoring, and maintenance will continue to occur into the very far future. |
| LOEC | Lowest Observed Effect Concentration is determined as the lowest test concentration with a significant difference in test organism response compared to the control group. See Appendix B for application. |
| NFRC | North Fork Rose Creek |
| NWID | North Wall Interceptor Ditch |
| Reference Condition | Upstream water quality monitoring station(s) that are not influenced by the Faro Mine Site |
| Significance Threshold | Threshold where environmental change would be considered significantly adverse (Government of Yukon 2021). |
| Site-specific water quality objective (SSWQO) | SSWQOs represent concentrations below which no negative effects on aquatic life are expected during indefinite exposures. They were derived from desktop analysis of literature-based toxicity, including customization to exposure and toxicity modifying factors, and preferentially using the Canadian Council Ministers of the Environment Type A derivation procedure (Canadian Council Ministers of the Environment 2007) including use of Species Sensitivity Distributions. Derived using the same protocol as for federal water quality guidelines, SSWQOs have a similar level of protection (i.e., protect all forms of aquatic life including sensitive species and life stages in long-term exposures); however, they are only protective of the aquatic life that can be found at this specific site. Site-specific water quality objectives may be validated with site-specific toxicity testing, and if warranted, revised based on more recent toxicological literature. |
| Trigger | A threshold (numerical value) and/or a trend (tendency in numerical values) that if reached will result in the initiation of specific action or management response. (Government of Yukon 2021) |
| Water Quality Guideline | Generic water quality guideline that is developed to be protective of aquatic life for all water bodies without customization to a site. A water quality guideline may be a fixed value, or an equation that incorporates one of more toxicity modifying factors. |

# ADAPTIVE MANAGEMENT PLAN

## 1.0 Background and Objectives

This Adaptive Management Plan (AMP) was developed for the active remediation and long-term operations and maintenance phases of the Faro Mine Remediation Project (the Project). The Faro Mine Complex is located in south-central Yukon and includes the Faro Mine Site and the Vangorda Plateau Mine Area (Figure 1-1). The Faro Mine Complex is presently in a care and maintenance process to protect human health and safety and the environment. This AMP is applicable to the Faro Mine Site as influenced by the Project (Volume I, Appendix 5A). As noted in Volume I, Section 1.0 (Introduction), the Vangorda Plateau Mine Area is not within the scope of the Project; however, an operational AMP (CIRNAC 2021) for ongoing care and maintenance is currently in place that includes the Vangorda Plateau Mine Area.

Version 1.0 of this AMP was provided in 2019 as an appendix to the Project Proposal for the Faro Mine Site. At YESAB's (Yukon Environmental and Socio-Economic Assessment Board) request, a revised version of the AMP has been prepared for the screening phase of the assessment of the Project Proposal. This is Version 1.1, referred to as the Project AMP. Revisions are based on feedback obtained through the YESAB regulatory process, engagement with affected First Nations representatives, governments, and regulators and consideration of the Guidelines for Developing Adaptive Management Plans in Yukon for Quartz Mining, Water-related components of quartz mining projects (Government of Yukon 2021). The guidelines were released in early 2021 (hereafter referred to as 'the guidelines').

### 1.1 What is an Adaptive Management Plan?

An AMP is a "management tool that provides a consistent and pre-planned approach for understanding and responding to deviations in project performance or unforeseen environmental conditions" (Government of Yukon 2021). An AMP is intended to provide a framework for responding to events and conditions beyond those predicted or expected. An AMP also allows for a phased, adaptive approach to implement mitigation measures when the timing of an event is uncertain. The plan identifies, in advance, the actions that must be taken to gather information and respond appropriately if an unanticipated, or unpredictable environmental circumstance occurred, or the project did not perform as predicted.

In the Yukon, for mining projects, AMPs 'address uncertainties, improve and ensure culturally informed environmental management and minimize unintended impacts' (Government of Yukon 2021) for water-related issues. The guidelines clarify that an AMP is not suitable if:

- the risk of harm is too high;
- outcomes are difficult to control;
- there is already high certainty in the design of the project; and
- it is not possible to respond in timeframe to prevent harm.



**LEGEND**

- FARO MINE SITE
- CITY
- TOWN
- VILLAGE
- SETTLEMENT
- TERRITORIAL BORDER
- HIGHWAY
- ROAD
- WATERCOURSE
- WATERBODY
- PARK

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**REFERENCE(S)**
DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
**FARO MINE SITE LOCATION**

CONSULTANT
GOLDER
MEMBER OF WSP

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| YYYY-MM-DD | 2021-07-15 |
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| PREPARED | LH |
| REVIEWED | HM |
| APPROVED | HM |

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The remediation of the Faro Mine Site is complex, and some aspects of the Project are uncertain (see Volume I, Section 5.8). Adaptive management is required for the Project through remediation design as well as through management and monitoring on Site. With regards to the remediation design, numerous engineering designs have incorporated redundancies to help reduce future uncertainties: for example, building a permanent water treatment plant with extra capacity in the event water volumes are higher than predicted, including a redundant seepage capture system in the design of the Down Valley seepage interception system (SIS), and realigning and widening a creek to the probable maximal flood to prevent flood risk near tailings dams. Adaptive management monitoring will be conducted to protect against multiple types of uncertainties as outlined in specific monitoring/management plans. The focus of the Project AMP is water quality-related uncertainties.

## 1.2 Objectives

The objectives of this AMP are as follows:

- Provide a framework for responding to events and conditions beyond those predicted or expected in a timely manner.
- Outline a phased adaptive approach to implement mitigation measures when timing or occurrence of an event is uncertain.
- Focus on water quality, for active remediation and long-term operations and maintenance phases of the Project, including consideration of key activities expected to take place during active remediation.
- Identify types of actions that must be taken to gather information and respond appropriately if an unanticipated, or unpredictable environmental circumstance occurred, or the project did not perform as predicted.

Implementation of an effective AMP will help the Project achieve the Project's five overarching objectives:

- protect human health and safety;
- protect and, to the extent practicable, restore the environment including land, air, water, fish, and wildlife;
- return the mine site to an acceptable state of use that reflects pre-mining land use where practicable;
- maximize local and Yukon socio-economic benefits; and,
- manage long-term site risk in a cost-effective manner.

For details on the framework of the AMP, refer to Section 3.

## 1.3 Lifecycle of the AMP

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) has been implementing an AMP for the current care and maintenance period (prior to Active Remediation); this is referred to as the Operational AMP. The Operational AMP, with a new update pending approval and with a fulsome review/update planned every three years, will be used to manage and respond to unanticipated conditions until the start of the Project and to manage the Vangorda Mine Plateau Area. The Project AMP will apply from the beginning of active remediation activities through long-term operations and maintenance and will apply to the Faro Mine Site. It is anticipated that this version of the Project AMP will be updated after the YESAB process and prior to water licensing. A final version of the AMP will be submitted to the Yukon Water Board for approval. As outlined in the guideline, it is expected that this AMP will then evolve and be updated as required by the Project's water licence or if conditions change on Site.

During the application of this AMP, it is expected that this AMP would require addendums or updates through the Water Board approximately every two to three years during active remediation, based on the frequency for other mines and expected milestones for remediation activities. The frequency of review and updates is expected to evolve as the Project enters a steady state during long-term operations and maintenance. Updates to the Project AMP would be based primarily on results of annual reporting and may include addition or exclusion of adaptive management initiatives (see Section 3.3), changes to triggers or station sampling frequency, or more general revisions to the framework. Following these updates, any changes affecting on-site monitoring will be incorporated into the relevant plans. For example, this could include updates to aspects of performance monitoring (Volume IV, Appendix 11A, Section 11A.10) and Aquatic Effects Monitoring Plan (Volume IV, Appendix 11D) such that site monitoring remains consistent with AMP requirements (Section 1.1.4). The overall intent of these updates will be to allow for continuous improvement to the AMP and adaptation to changing site conditions.

## 1.4 Adaptive Management Plan Scope

As noted above, the AMP is one mechanism to manage uncertainty, but the Project also manages uncertainty through design and routine management. Routine monitoring and operational items (e.g., performance of the water treatment plant, physical stability inspections/maintenance) are excluded from the scope of this AMP and are handled through operational monitoring; non-water related adaptive management components will be included in separate Project plans (see section 1.5 below and Appendix A).

Therefore, the scope of this AMP includes the following areas and associated activities:

- groundwater quality on Site and the potential influence on surface water quality through seepage;
- surface water quality to evaluate effectiveness of capture, and potential groundwater quality changes in the North Fork Rose Creek and Down Valley SIS areas and in the receiving environment along North Fork Rose Creek, the Rose Creek Diversion, and Rose Creek downstream of the Faro Mine Site due to water management infrastructure;
- effectiveness of water treatment for maintaining conditions in the receiving environment;
- cumulative effects of Project water quality in Rose Creek;
- cumulative effects of care and maintenance of the Vangorda Mine Plateau on the Pelly River; and
- water quality in the far-downstream receiving environment (Anvil Creek, Pelly River).

# 2.0 Project Context

## 2.1 Linkages with other Site Management Plans

*General linkages in monitoring/management*

As noted above, an AMP is intended to provide a framework for responding to events and conditions beyond those predicted or expected. CIRNAC proposed a broad environmental management and monitoring framework in the Project Proposal (see Section 11 of the Project Proposal). This section is intended to provide clarity about monitoring and adaptive management measures are proposed in other management plans and how data collected as part of other programs are considered holistically within the Project. The Project AMP and these other management plans provide the framework for how CIRNAC will monitor and adaptively manage the Project during the active remediation and long-term operations and monitoring phases. The Faro Mine Site proposes to develop an 'ISO certification' type approach to the monitoring framework that would involve policies, monitoring plans, audits, inspections, and continuous improvement. The monitoring measures described in these plans provide information that is used to determine if the Project is proceeding as predicted.

Figure 2-1 provides a schematic showing the overarching environmental management framework proposed for the Faro Mine Site outlining the requirement for monitoring and adaptive management to be continually linked. In general, the blue boxes are indicative of operational management where responses are in "real time" and green boxes are indicative of the environmental management framework and the continuous management and monitoring that would feed both changes in operational management system and the environmental management plans. Appendix A summarizes other management and monitoring plans for the site which include operational and adaptive management components. Table 2-1 provides a summary of the evolution of monitoring and adaptive management through the Project phases. This provides a general overview based on discrete points in time; the specifics may vary depending on the remediation implementation schedule.

**Figure 2-1 Environment Management and Monitoring Framework**

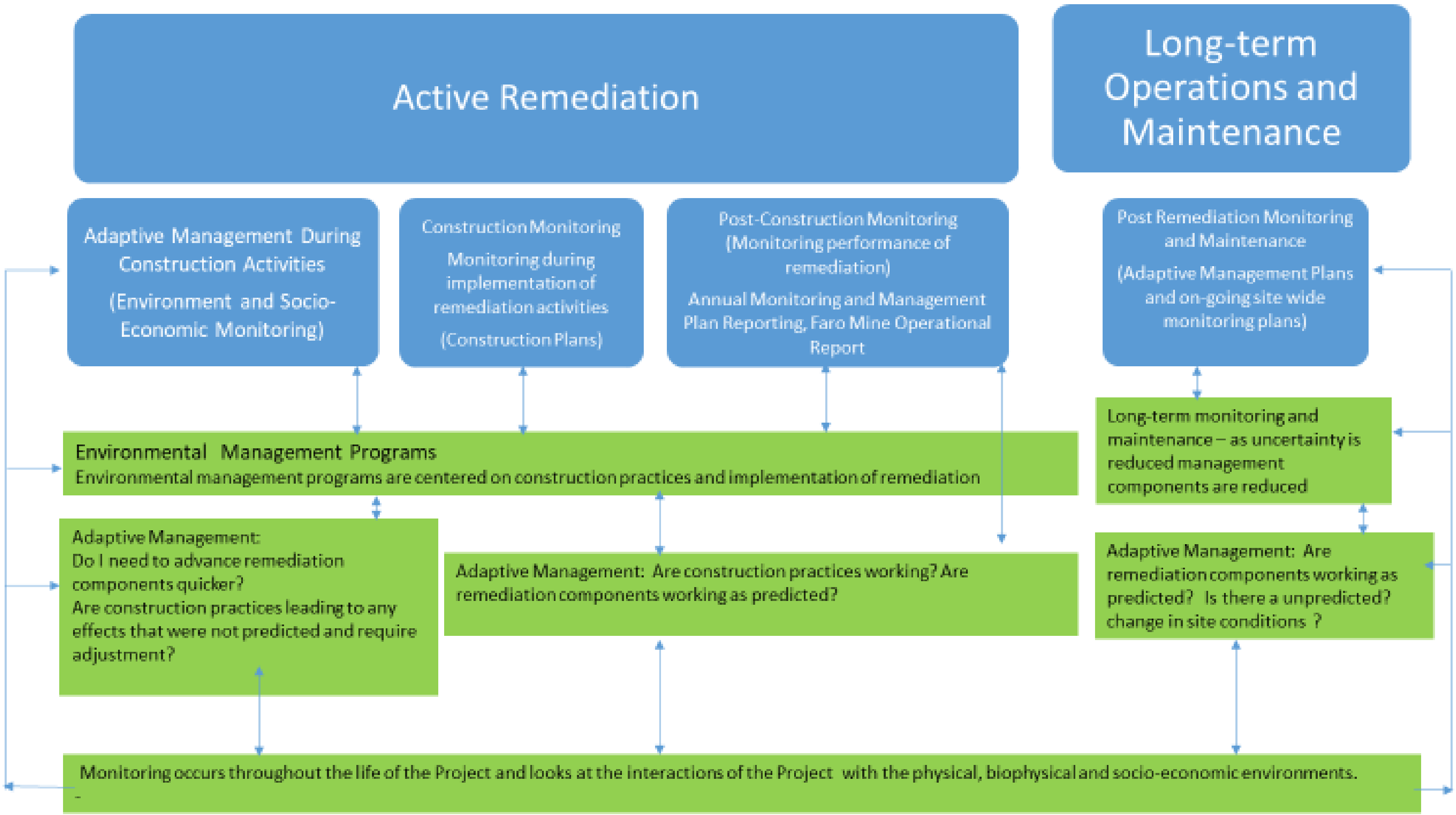


**Table 2-1 Evolution of Monitoring and Management through the Faro Mine Remediation Project Phases**

| Project Phase | Project Phase Management Approach | Monitoring Evolution | Adaptive Management Focus |
|---|---|---|---|
| Early Active Remediation (i.e., Day 1 of Water Licence) | • Day to day care and maintenance activities are on-going.<br>• Ongoing implementation of the Adaptive and Operational Components in the Project Plans.<br>• Early construction remediation components are initiated.<br>• Responding to changing physical, biophysical and socio-economic environment by advancing components of the Project. | • Care and maintenance monitoring.<br>• Construction Monitoring.<br>• Performance monitoring of existing infrastructure. | • Confirmation that the receiving environment is not degrading further.<br>• Determination as to whether remediation components required accelerated implementation. |
| Mid-Point of Active Remediation | • Day to day care and maintenance activities are on-going.<br>• Ongoing implementation of the Adaptive and Operational Components in the Project Plans.<br>• Remediation is advancing and some aspects of remediation are complete.<br>• Larger complex aspects have been initiated but are not complete (e.g., Rose Creek Diversion).<br>• Responding to changing physical, biophysical and socio-economic environment by advancing components of the Project. | • Care and maintenance monitoring.<br>• Performance monitoring of existing infrastructure.<br>• Performance of monitoring of completed remediation components.<br>• Construction monitoring. | • Confirmation that the receiving environment is not degrading further.<br>• Determination as to whether remediation components required accelerated implementation.<br>• Confirmation that the completed remediation components are performing as intended. |
| Long-term Operations and Maintenance | • Remediation is complete.<br>• Day to day care and maintenance activities are on-going including long-term water management and maintenance activities. | • Performance monitoring of existing infrastructure<br>• On-going monitoring of receiving of environment.<br>• On-going maintenance of remediated components. | • Confirmation that the completed remediation components are performing as intended (with the focus narrowing over time as confidence increases in long-term performance).<br>• Confirmation the receiving environment has improved and remains improved from pre-remediation conditions. |

*Site Management 'Framework'*

To manage the Site to meet the Project's overarching remediation objectives, a great deal of planning and management is required. Numerous management and monitoring plans are used and form a management 'framework' (see Appendix A for additional description). This framework is outlined in two groups:

1) Overview of Management/Monitoring: These components provide a framework for responding to events and conditions within those predicted or expected (Figure 2-2).

2) Management/Monitoring including Adaptive Management: Many management/monitoring plans will include adaptive management components. As per the guidance (Government of Yukon 2021), these plans/documents provide a framework for responding to events and conditions beyond those predicted or expected (Figure 2-3). CIRNAC intends to consult in a similar fashion on AMP components on interest to First Nations as was completed to date, specifically in relation to terrestrial AMP components and aquatic effects components. Appendix A provides the approach to socio-economic related AMP components.

Communication and integration of these various documents is critical. This includes consideration between/among the various disciplines to fully understand monitoring results, changes observed on site, adaptive management actions and potential future needs for adaptive management. For this reason, the site changes and findings from various plans/documents will be summarized annually in one document known as the 'Faro Mine Remediation Summary of Progress'. It will be reviewed with the technical experts responsible for the various management plans/documents.

**Figure 2-2 Faro Mine Remediation Project's Overview of Management and Monitoring Plans**

### Health and Safety Management Plan
- Health and Safety Management Plan, and Reports including the Health and Safety Risk Register
- Occupation Air Monitoring Plan and Reports
- Medical Monitoring Program and Reports

### Water Quality Monitoring Plan
- Water Quality Monitoring Plan and Reports
- Toxicity Monitoring Plan and Reports

### Operational Water Balance
- Pit and pond level spreadsheet
- Water pumped spreadsheets
- Volumes of treated and discharged water reporting

### Socio-Economic Management and Monitoring Plan
- Socio-Economic Management and Monitoring Plans and Reports including information on: Family Structure and Values Plans, Community Infrastructure and Services, Human Health and Local and Traditional Land Use

### Discharge Protocols
- Interim Water Treatment Plant Discharge Protocol and Reporting
- Vangorda Water Treatment Plant Discharge Protocol and Reporting
- Cross Valley Pond Water Treatment Plant Discharge Protocol and Reporting

### Geotechnical Monitoring
- Operations, Maintenance and Surveillance Manual
- Ground Control Management Plan

### Standard Operating Procedures for Seepage Interception Systems
- System specific Operation Plan Reports
- System specific Maintenance Plan

### Materials Management Plan
- Materials Management Plan and Reports

### Work Package Construction Management Plans
- Execution Plans and Progress Reports for work-packages

### Environmental Management Plan
- Site-wide Environmental Management Plan and Work Package Environmental Protection Plans and Reports, i.e.:
  - Sediment and Erosion
  - Borrow Management Plan
  - Waste Management Plan
  - Traffic Control Plan
  - Emergency Response Plan
  - Air Quality and Meteorological Monitoring Plan
  - Heritage Resource Protection Plan
  - Geochemical Monitoring Plan

| Legend |
|---|
| These documents contain Operational Management Components |
| These documents feed data, methods and requirements into their associated operational management documents |

**Figure 2-3 Faro Mine Remediation Project: Management and Monitoring Plans with Adaptive Management Components**

### Water Quality Adaptive Management Plan

- Water Quality Monitoring Plan and Reports (including seeps, groundwater and surface water)
- Hydrological Monitoring Plan and Reports
- Sediment and Erosion Management Plan and Reports

### Terrestrial Effects Monitoring Plan

- Air Quality & Meteorological Monitoring Plan and Reports
- Sediment and Erosion Management Plan and Reports
- Reports on Contaminant Loading in plants
- Ecological Land Classification Monitoring Plan and Reports

### Aquatic Effects Monitoring Plan

- Aquatic Effect Monitoring Plan and Reports
- Water Quality Monitoring Plan and Reports (including the Hydrological Monitoring Plan and Reporting)
- Work Package Water Quality Management Plans and Reports
- Sediment and Erosion Management Plan and Reports

### Revegetation Plan

- Revegetation Monitoring Plans and Reports

### Geotechnical Emergency Response Plan

- Dam Safety Review Plan and Reports
- Geotechnical Monitoring Program and Reports
- Water Balance Reporting
- Hydrological Monitoring Plan and Reporting

### Performance Monitoring Plans

- Geochemical Monitoring Plans and Reports
- Project-specific Water Quality Monitoring Plans and Reports for post project (including seeps, groundwater and surface water)
- Project-specific Hydrological Monitoring Plans and Reports for post project
- Project-specific Geotechnical Plans and Reports for post project
- Work Package Water Quality Management Plans and Reports
- Sediment and Erosion Management Plan and Reports

### Socio-Economic Management and Monitoring Plan

- Socio-Economic Management and Monitoring Plans and Reports including information on: Procurement and Contracting, Training and Employment

**These documents contain Adaptive Management Components**

These documents feed data, methods and requirements into their associated documents with adaptive management components

## 2.2 Data Sources for the AMP

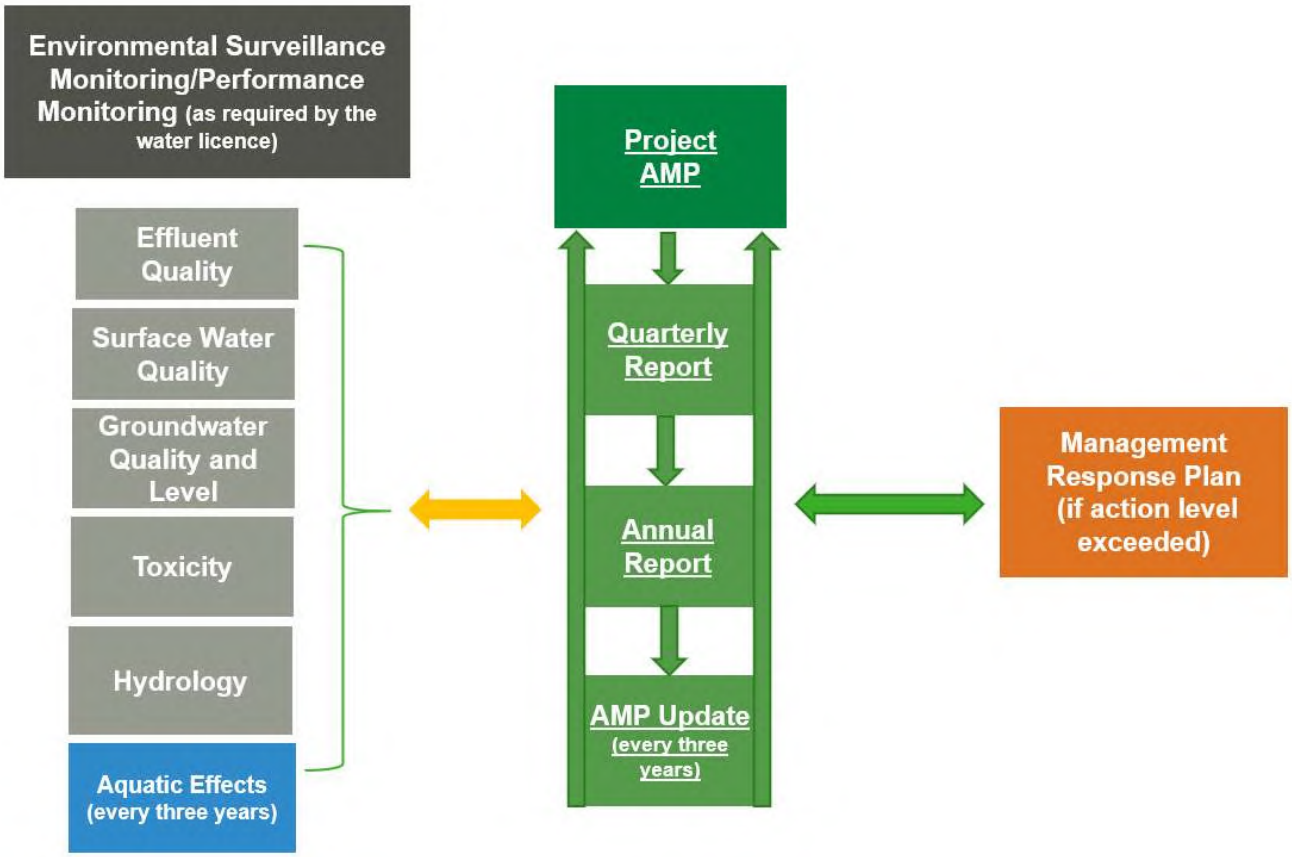
Surface water, groundwater, and seepage monitoring data are routinely collected at various locations within the Faro Mine Site, and the surrounding area, and are reported on an annual basis (e.g., Golder 2019a, Golder 2020a) and will continue to be reported annually through both an anticipated water licence report as well as the above-mentioned Faro Mine Remediation Summary of Progress (see Section 2 for more information). The data collected serves several purposes, including to inform program design, document conditions, confirm compliance, evaluate remediation activity performance, satisfy specific requests from stakeholders, and inform adaptive management (See Figure 2-4).

Routine water monitoring will be completed as part of the Performance Monitoring for the Project, which will be used to: inform the data analysis in the Aquatic Effects Monitoring Plan for the downstream receiving environment, to characterize events as part of the AMP, and support in determining if/when additional indicators or changes to the AMP may be required. It is anticipated that current programs at the Faro Mine Site will be incorporated into the Environmental Surveillance Monitoring and Performance Monitoring Plans and the associated Aquatic Effects Monitoring Plan as follows:

- **Effluent** Monitor the chemistry and toxicity of treated effluent discharged to the environment to assess if the effluent release meets the standards of the Water Licence for the Project:
    - **Groundwater**– expected to be sampled for groundwater quality and level (includes wells that will be monitored biennially [every other year], semi-annually [spring and fall], or annually).
    - **Seepage**– monitoring of seepage quality (includes seeps that are expected to be monitored semi-annually [spring and fall]).
    - **Surface Water** – will include surface water quality and quantity (includes stations that are monitored monthly or less frequently). Samples are collected between January and December of each year, seven times in a year. This includes stations near Site (near-field) as well as farther away from Site (far-field).
    - **Aquatic Effects** - benthic invertebrate, fish and fish habitat data are collected every 3 years.

In addition to the monitoring programs, various non-routine, investigations or special studies will be completed at the Faro Mine Site to support the advancement of the design or as part of management response in relation to AMP. Where appropriate, this data will be considered and applied to this AMP. Examples of additional studies include toxicity studies for zinc, sulphate, iron, and manganese (Golder 2019b, 2020b, 2020c).

**Figure 2-4 Monitoring directly linked to Project Adaptive Management Plan**




## 2.3 Incorporation of Traditional Knowledge and affected First Nation's views

Traditional Knowledge was incorporated into the AMP using the available sources of information at the time. The proponent respects that Traditional Knowledge rests with affected First Nations and has committed to continuing to work with First Nations leadership and representatives on this topic. The Faro Mine Remediation Project team has incorporated Traditional Knowledge into the Project Proposal and accommodated feedback, wherever possible with the information available. Where agreement can be reached on confidentiality and sharing, future Traditional Knowledge informatioFign will continue to be integrated into the AMP and other environmental and socio-economic management and monitoring plans.

## 2.4 Environmental Setting

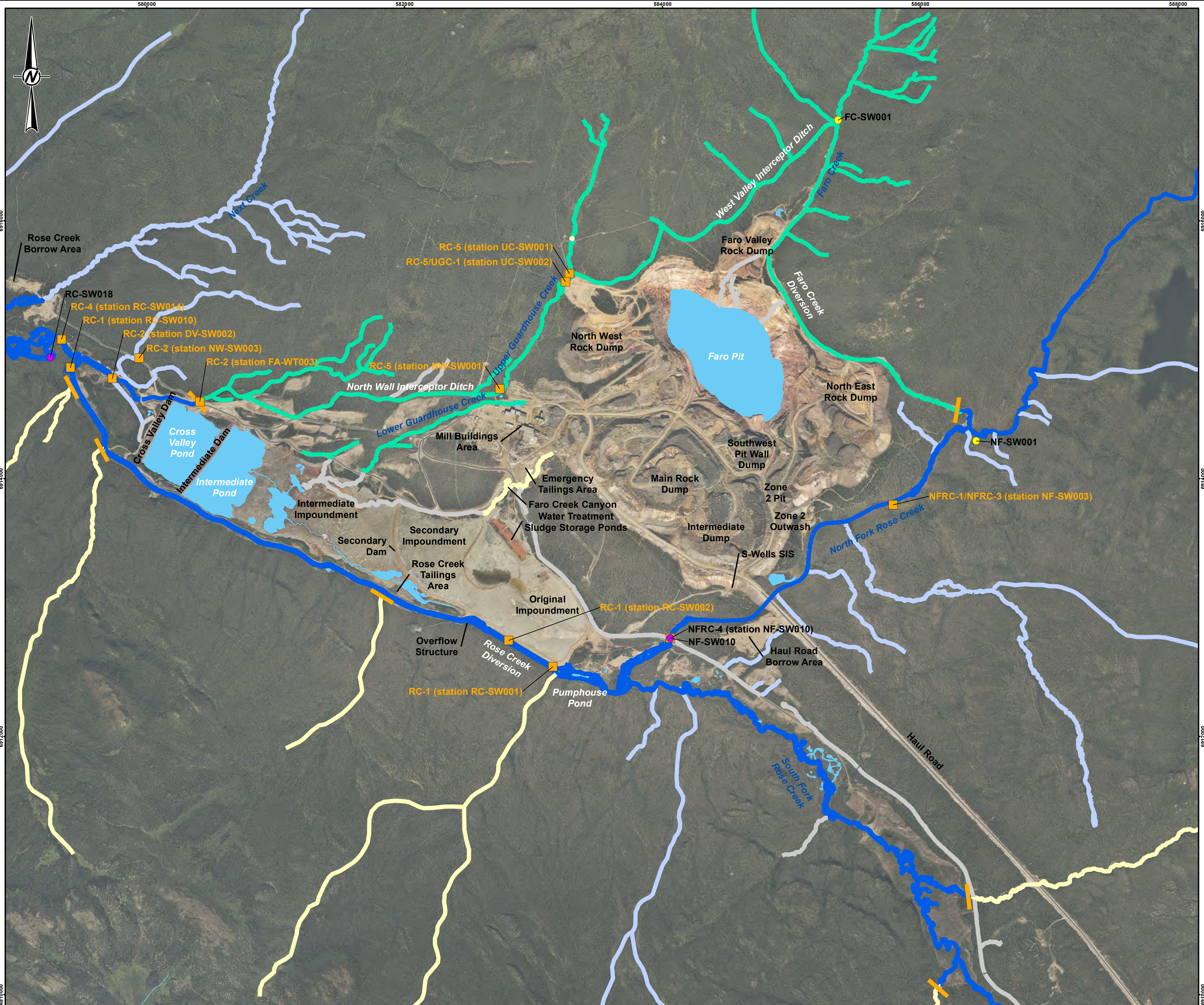
**Location—**The Faro Mine Complex is located on the Vangorda Plateau, a northwest to southeast oriented rolling upland located at an elevation of between 1000 and 1400 metres above sea level (masl) and is surrounded by the Anvil Range to the north and east, and Rose Mountains to the south. The Faro Mine Complex is located within the regional Vangorda Creek and Rose Creek watersheds. The climate in this region is characterized by long cold winters and short summers: temperature inversions are common during winter months and winter temperatures may be as much as 10°C cooler in the valley bottoms than in the uplands.

**Watershed—**The Rose Creek watershed has a total drainage area of approximately 337 $km^2$ and encompasses the Faro Mine Site and drains northwest to the Pelly River via Anvil Creek. Rose Creek is fed by two tributary forks: the North Fork Rose Creek and the South Fork Rose Creek. The North Fork Rose Creek drains south from the Anvil Range and is partially fed by Faro Creek and other small tributaries. South Fork Rose Creek drains Mt Mye by flowing southwest from Dixon Lake into the Rose Creek Valley, then flows northwest to the confluence with North Fork Rose Creek; it also receives input from small tributaries. Flow through the Faro Mine Site is influenced by surface water management infrastructure that has been constructed including retention ponds as well as a series of interceptor/collection ditches and diversion channels. Downstream of the Faro Mine Site, the main stem of Rose Creek continues to the northwest where it flows into Anvil Creek, which continues for several kilometres before emptying into the Pelly River.

The Vangorda Creek watershed encompasses the Vangorda Plateau Mine Area of the Faro Mine Complex, with a total drainage area of approximately 90 $km^2$. Vangorda Creek originates north of the Faro Mine Complex and drains to the Pelly River to the southwest, near the Town of Faro. Grum Creek and several smaller tributaries join the creek near the Faro Mine Complex. West Vangorda Creek originates north of the Faro Mine Complex and joins Vangorda. While Vangorda Creek is not the subject of the AMP, it drains to the Pelly River and its contribution is relevant to monitoring in the Pelly (also see Section 4).

**Fish presence: Faro Mine Site -** Slimy Sculpin (*Cottus cognatus*), Arctic Grayling (*Thymallus arcticus*), Chinook Salmon (*Oncorhynchus tshawytscha*), Burbot (*Lota lota*), Round Whitefish (*Prosopium cylindraceum*), and Longnose Sucker (*Catostomus catostomus*) have been reported in surface waters around and downstream from the Faro Mine Complex (Department of Indian Affairs and Northern Development 2019) (Figure 1-2). Based on sampling within the Rose-Anvil Creek system to date, Slimy Sculpin tend to be most abundant, followed by Arctic Grayling. Both species appear to use surface waters in the Rose-Anvil Creek year-round, although a proportion of Arctic Grayling do migrate to the Pelly River for overwintering. Based on sampling since the early 2000's juvenile Chinook Salmon have occasionally been observed in the Rose Creek system near the Faro Mine Site as far upstream as the confluence with the South Fork of Rose Creek; spawning adult Chinook have only been observed occasionally in the lower section of the Rose Creek Diversion. Juvenile Chinook Salmon were captured in 2009 in the Rose Creek Diversion, in 2017 in Rose Creek downstream of the Rose Creek Tailings Area, and in 2018 a few hundred metres downstream of station RC-SW014, Rose Creek below the confluence with the North wall Interceptor Ditch (WMEC 2010; AECOM 2018).

**Fish presence: Anvil Creek -** Arctic Grayling (*Thymallus arcticus*), Chinook Salmon (*Oncorhynchus tshawytscha*), Slimy Sculpin (*Cottus cognatus*), Round Whitefish (*Prosopium cylindraceum*), Burbot (*Lota lota*), Longnose Sucker (*Catostomus catostomus*), and Lake Chub (*Couesius plumbeus*) have all been historically captured in Anvil Creek downstream of the confluence with Rose Creek (Appendix 7G, CIRNAC 2019). Juvenile Chinook Salmon have been observed or captured in the lower reaches of Anvil Creek downstream from Rose Creek, as well as Lake Chub, which were captured near the mouth (Access et al. 2006). A study of Chinook spawning in Anvil Creek and the Pelly River suggested Anvil Creek typically has low numbers of spawners (WMEC 2010). A map of the areas where fish presence is known or suspected is provided (Figure 2-5). Attempts have been made to obtain Traditional Knowledge as outlined in the Project Proposal as noted in Section 1.6 if an agreement can be made, Traditional Knowledge information will be added to future re-iterations of this plan.




**LEGEND**

- BENTHIC INVERTEBRATE COMMUNITY EXPOSURE STATION
- BENTHIC INVERTEBRATE COMMUNITY REFERENCE STATION
- ADAPTIVE MANAGEMENT PLAN STATION
- FISH MIGRATION BARRIER
- ROAD
- WATERCOURSE
- WATERBODY

**FISH BEARING STATUS**

- CONFIRMED FISH-BEARING
- ASSUMED FISH-BEARING
- CONFIRMED NON-FISH-BEARING
- ASSUMED NON-FISH-BEARING
- NO DATA AVAILABLE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**NOTE(S)**

1. THE STATIONS INCLUDED IN BENTHIC INVERTEBRATE COMMUNITY MONITORING PROGRAMS DIFFERED THROUGHOUT THE HISTORICAL RECORD.

**REFERENCE(S)**

1. AERIAL PHOTOGRAPHY ACQUIRED BY PEREGRINE AERIAL SURVEYORS INC. AND EAGLE MAPPING IN AUGUST 2012.
2. ORTHOPHOTOGRAPHY PREPARED BY CRITIGEN CANADA CORP.

DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
**FARO MINE FISH DISTRIBUTION: FARO MINE SITE**

CONSULTANT
GOLDER

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**Site Conditions—** Acid rock drainage is evident in on-site materials at very high concentrations (hundreds of mg/L; Volume I, Appendix 5A, Supporting Document 13), and these waters are migrating toward the site boundaries, primarily at North Fork Rose Creek, and towards the Down Valley Area. Acid rock drainage and metal leaching is a pervasive issue that will continue to degrade on-site conditions over several decades. As a result, significant management efforts as outlined in the Remediation Plan (Volume I, Appendix 5A) will be required to contain and manage on-site water and to maintain existing downstream water quality. Physical stability of the Faro Mine Site is influenced by slope angles and ground stability of the various stockpiles, dams, and open pits on-site. Physical stability is addressed in the Remediation Plan, through various efforts including covers and revegetation. Areas of concern with respect to physical stability are identified below in the description of site activities.

## 2.5 Current Site Activities

The care and maintenance operations at the Faro Mine Site are primarily focused on water management activities, including the operation of water treatment facilities and SISs. These activities address short term risks at the abandoned mine site that may pose a risk to human health and safety and the environment. For the purposes of this document, "contact water," or "contaminated," water is that water influenced by acid rock drainage or metal leaching, whereas "non-contact water," or "clean," water is that water uninfluenced by acid rock drainage or metal leaching (i.e., water from upstream reference locations and surface runoff or seepage that shows no indicators of acid rock drainage).

The main surface water diversions that convey clean water around the site are the Faro Creek Diversion and the Rose Creek Diversion. Contact water is collected using pits, ponds, and seepage interception systems. Collected water from these interception systems is pumped to the pits and conveyed from the pits by pumping and piping to for treatment. While water collection occurs throughout the year, water treatment occurs from April to November, with water being stored in the Faro Pit during the winter months.

Key site activities to be completed prior to the start of active remediation (as described in Volume I, Appendix 5A) include the North Fork Rose Creek Realignment the construction of a seepage capture system near station X13, downstream of the Cross Valley Pond, commissioning and seasonal operation of the Cross Valley Pond Treatment Plant, and installation of a capture system in the Down Valley Area.

## 2.6 Remediation Activities

The Remediation Plan (Volume I, Appendix 5A) provides an outline of the overall expected activities that will take place during implementation of active remediation and long-term operations and maintenance. Remediation activities related to maintaining or preserving receiving water quality are described in detail in Volume I, Section 5.0 and Volume I, Appendix 5A.

Active remediation activities include:

- Continued development, as well as upgrading and maintenance, of the Faro Creek Diversion, North Fork Rose Creek Diversion, Northwest Diversion, North Wall Interception Ditch, and Rose Creek Diversions to convey clean water around the mine site.
- Ongoing operation of existing groundwater interception systems (Zone 2 Pit collection) and/or installation of additional SISs on an as needed basis at North Fork Rose Creek, intermediate tailings sump, and Down Valley SIS (downstream of the Rose Creek Tailings Area) for collection of impacted groundwater.

- Collection and storage of contact water from the waste rock, tailings, and mine site in the Faro Pit for seasonal treatment and discharge.
- Installation of the permanent water treatment plant.
- Design and placement of covers for the waste rock dumps and tailings areas with variable infiltration appropriate for the waste rock dump.
- Design and placement of covers of appropriate quality and slope to enhance surface water runoff thereby reducing potential interaction with acid generating materials.
- Revegetation following placement of covers to reduce erosion.

The key activities during active remediation related to improvements in physical stability are described in the Remediation Plan (Volume I, Appendix 5A) and include:

- Pit access will be restricted through construction of a safety berm.
- Tailings dams will be stabilized as necessary.
- Mine area, waste rock, and tailings area stabilization will include re-shaping, covering, revegetating, and establishing surface drainage.
- Water management (diversions) will be upgraded to increase flood capacity and the Faro Creek Diversion will be re-located away from the Faro Pit wall.
- Dust will be controlled through dust suppression activities or vegetation for long-term dust control.
- Borrow areas will be graded and revegetated.

Long-term operations and maintenance activities include:

- monitoring, treatment and management of contact water, including the operation, maintenance, repair and upgrading as required of major water collection, storage, conveyance, and treatment systems as required over the long-term;
- management of water levels in permanent water management infrastructure;
- inspection, monitoring, operation, field maintenance, repair of all engineered permanent non-contact water structures and systems including diversions and control ponds;
- use, maintenance and repair of permanent access roads and associated watercourse crossings, if required
- use of electrical distribution system;
- operation, maintaining, and performing repairs on the electrical distribution system as required to carry out activities;
- planning, scheduling and performing preventative maintenance and repair activities at the site on real property, permanent site infrastructure, equipment and supplies, including covers on the waste rock dumps and tailings facility;
- maintaining health and safety in compliance with the Yukon's *Occupational Health and Safety Act*; and
- implementation of engineered adaptive management measures (See Volume I, Appendix 5A, Section 7.4).

# 3.0 Adaptive Management Plan Approach

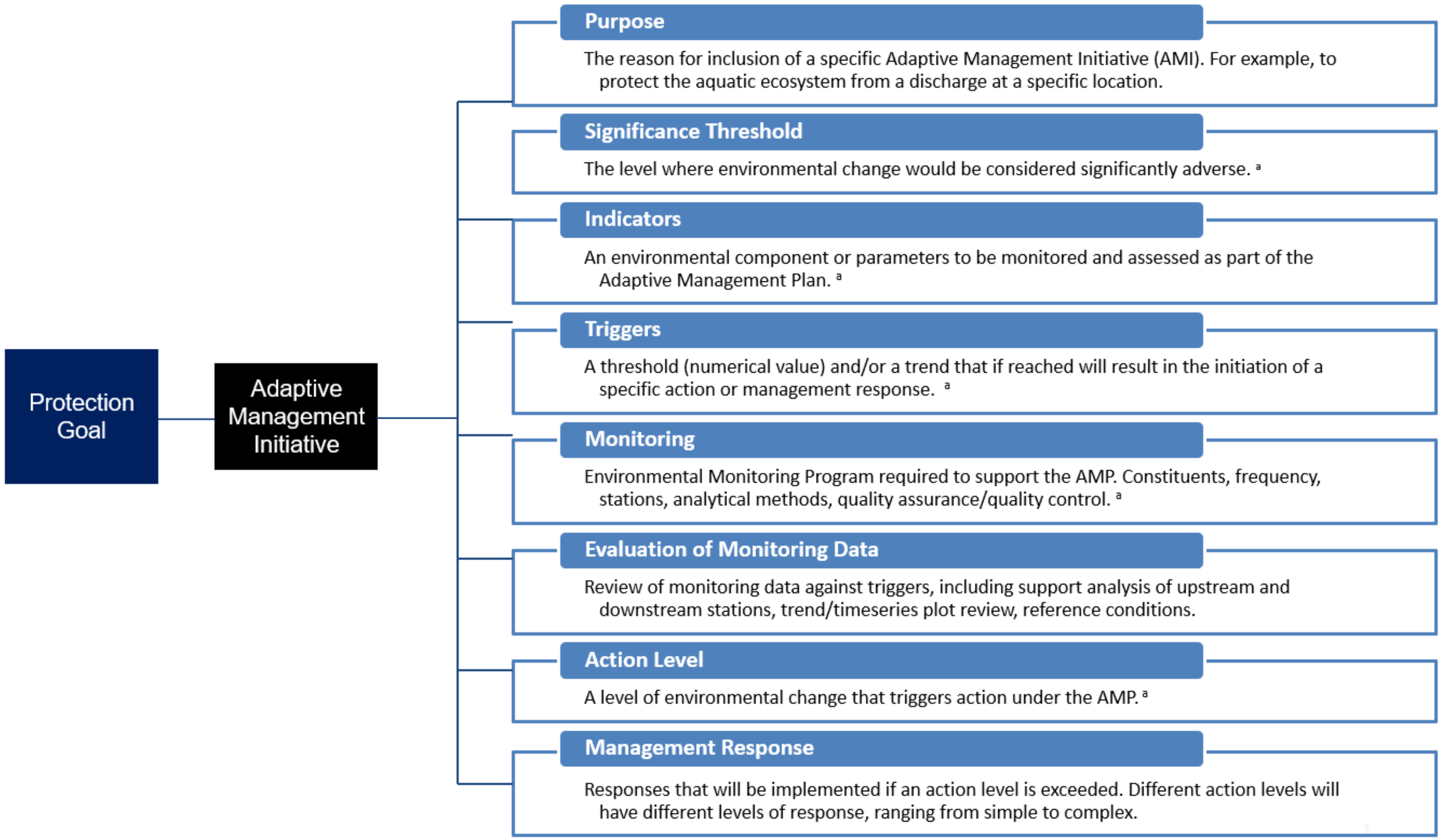
The Project AMP is informed by the protection goals and key components (see Figure 3-1). The key components of the AMP are based on the guidelines (Government of Yukon. 2021), with some aspects specific to the Project.

## 3.1 Principles of the Adaptive Management Plan

The following guiding principles were applied to the development of the Project AMP and will apply to its implementation:

- ***Organizational Commitment:*** Effectively implementing an AMP requires organizational commitment. This includes commitments to ongoing monitoring and evaluation of conditions with respect to triggers, and commitment to implement responses once triggers are reached.
- ***Engagement:*** Respectful ongoing collaboration as outlined in Section 10 and consideration of affected First Nations.
- ***Site Management and Project Decision-Making:*** For the Project AMP to be effective, it must be explicitly integrated into the overall site management and project decision-making processes.
- ***Proactive:*** The Project AMP is intended to be proactive and act as an early warning system so that water quality does not reach limits of unacceptable conditions in the receiving environment; the point of reaching this condition is called the "significance thresholds" in the guidelines. Indicators and triggers should be designed to avoid unacceptable conditions, taking into consideration the time required to plan, design, and implement responses. Multiple tiers of early warning measures are applied, including specific water quality benchmarks linked to escalating levels of concern, with indicators and triggers designed to link the scale and urgency of response to the monitoring results.
- ***Appropriate Technical Expertise:*** Effectively implementing the Project AMP requires dedication of resources with appropriate expertise. Exceedance of triggers should lead to engagement of appropriate technical experts to define responses.
- ***Define Limits of Acceptable Receiving Water Quality Conditions:*** The Project AMP should specifically define the limits of acceptable water quality conditions for receiving water and these limits are customized to different water bodies and project stages.
- ***Appropriate Responses:*** The Project AMP may define multiple levels of response, where the type of response may vary depending on the rate of change of the observed conditions.
- ***Deteriorated Water Quality does not Justify Inaction:*** The deterioration of receiving water quality due to loading from one mine component does not provide justification for inaction in addressing loading from another mine component.
- ***AMP is Dynamic:*** The logic and effectiveness of the Project AMP must be regularly re-evaluated as water quality conditions at the site change. Two linked activities are required to maintain the Project AMP: (1) annual comprehensive review of site water quality data to identify any new or changing conditions that were not previously considered; and (2) evaluating components of the AMP framework (including the benchmarks and triggers) every 2 to 3 years and adjust as required.

**Figure 3-1 Components of the Project AMP**




[a] Source: as per Government of Yukon 2021

## 3.2 Protection Goals and Significance Thresholds

Protection goals are narrative statements about the level of environmental protection desired for a waterbody. First Nations had a high level of interest in identifying this for the Project AMP. The guidelines include “significance thresholds” as part of an AMP. These are defined in the guidance as “the threshold where environmental change would be considered significantly adverse.” Given the high interest in setting protection goals from First Nations, and the already deteriorated conditions at the Faro Mine Site requiring remediation, the Project AMP has set both protection goals and significance thresholds. Both are discussed below.

**Protection goals:** Protection goals are listed in Table 3-1. They were requested by First Nations representatives. Protection goals were defined based on feedback from First Nations representatives through, numerical data, and/or achievability. First Nations and their representatives provided comment on the concerns through early consultation for the Project Proposal (Volume I, Section 2 CIRNAC 2019), adequacy review, and workshops held by both CIRNAC and YESAB (i.e., YESAB AMP workshop and scoping workshops held in early 2021 and CIRNAC workshop held in October 2020). Draft protection goals were shared in both the CIRNAC and YESAB workshops for feedback. This feedback indicated that there the Anvil Creek and Pelly River should be fully protected due to the importance of Chinook Salmon and while effects in the Rose Creek were acceptable, these should be limited to the extent practicable. There was also a desire to see protection goals become stricter following remediation, which was accommodated. This feedback has resulted in numerous iterations of the protection goals to attempt to meet these desires of the First Nations, while balancing the practicalities of the Project.

Identification of protection goals supports in the establishment of action levels and triggers; specifying protection goals for each waterbody and project performance period also supports in evaluation of whether the actions and mitigations implemented are effective and sufficient to protect aquatic environments downstream of the Faro Mine Site. The protection goals are meant to be narrative and high level. They will apply to results from the Project AMP and the aquatic effects monitoring programs. The goal for the Pelly River is an exception; it is, by necessity, more specific since it is about defining non-degradation (see below).

Where and when protection goals would apply was determined based on the following considerations:

- Current use: Is the area a constructed channel for treated effluent discharge, a creek, or a river?
- Practicalities: What is reasonably achievable prior to implementation of the Faro Mine Remediation and in the early years of remediation? What is feasible for long term operations and maintenance when water quality reflects the implementation of the Project?
- Ecological: What are the aquatic species, including fish, in the creeks and rivers potentially influenced by the Faro Mine Complex? Are critical habitats or threatened or endangered species present in these habitats? What organism types and life stages are representative of the aquatic habitats?
- Traditional Knowledge: What are key species of interest to the First Nations within and downstream of the Faro Mine Complex?
- Regulatory: What are the applicable federal and territorial regulations?
- First Nations Agreements: What agreements exist between the federal government and the First Nations potentially impacted by the Faro Mine Site?

- Spatial application: Where is it appropriate to apply goals (e.g., spacing and position of monitoring and compliance locations) based on available monitoring data and influence of the Faro Mine Site?
- Remediation Plan: What are the future habitat conditions predicted to be, based on implementation of engineering measures, achievement of predicted water quality, and other land use planning?
- Feedback from engagement: What features of the environment are most important to protect?

Protection goals were established for Rose Creek, Anvil Creek, and the Pelly River. The protection goals for Rose Creek and Anvil Creek are proposed as “interim” as it is recognized that the level of protection in these areas will evolve as the Remediation Plan is implemented. Final protection goals were also proposed for these waterbodies post remediation. No interim protection goal was developed for the Pelly River because change to this waterbody related to or as a result from the Faro Mine Site should not be allowed before or after remediation. Further, for the Pelly River, the federal government recognizes the importance of Chinook Salmon as a culturally important and harvested species (Selkirk First Nation 2018). Protection goals will not apply in operational channels (e.g., North Wall Interceptor Ditch and inflows upstream of NW-SW003) as these will be managed through operational management system and standard operating procedures for the Faro Mine Site. Figure 3-2 provides an overview of where the protection goals apply.

**Table 3-1 Protection Goals for the Adaptive Management Plan**

| Location | When does it apply? | Protection Goal | Where does it Apply? | Rationale for Protection Goal |
|---|---|---|---|---|
| Rose Creek | Interim (pre-remediation and during active remediation) | Water quality in Rose Creek supports survival and reproduction of fish and benthic invertebrate communities. | North Fork Rose Creek,<br>South Fork Rose Creek,<br>Rose Creek | Rose Creek is a stream containing contact water and freshwater and portions of the stream have been realigned (Rose Creek Diversion and North Fork). Treated effluent is discharged to the creek. Precipitate from the Faro Mine Site discharge is present. Numerous fish species are present in the creek. Beaver dams are present. An interim goal was set to acknowledge that prior to completion of remediation components, there may be some change or lack of improvement in surface water concentrations such that water quality objectives may not be met. However, water quality will still support a functioning aquatic ecosystem such that fish and benthic invertebrate communities are present (evidenced by fish able to survive and reproduce and are sustained by the continued presence of benthic invertebrates). |
| | Final (post-remediation) | Water quality in Rose Creek supports the maintenance of self-sustaining populations of fish and self-sustaining and functional communities of invertebrates and aquatic plants. The communities will continue to perform necessary ecological services including provision of diversity and abundance of food for fish. | North Fork Rose Creek,<br>South Fork Rose Creek,<br>Rose Creek | After remediation, water quality leaving the Faro Mine Site is to be improved such that site-specific water quality objectives (SSWQOs) are generally met in the receiving environment of Rose Creek. The Aquatic Health Risk Assessment (AHRA) in the Project Proposal evaluated whether implementation of the Project would result in the maintenance of self-sustaining and ecologically effective populations of fish and amphibians, and self-sustaining and ecologically effective communities of invertebrates and aquatic plants. Self-sustaining populations of fish and amphibians are those populations that will be maintained into the future with a low risk of extirpation. Self-sustaining populations are healthy and viable populations, which are robust and capable of withstanding environmental change and accommodating stochastic population processes (Reed et al. 2003). Self-sustaining and ecologically effective communities of invertebrates and aquatic plants will likewise be maintained into the future, and will continue to perform necessary ecological services, including provision of food for fish. Although the AHRA predicted some exceedances of the SSWQOs for some parameters (i.e., sulphate, total iron, and zinc) during long-term operations and maintenance, which may potentially lead to low-level effects on sensitive species, no population or community level changes were expected as a result of the predicted water quality[a] and will meet the outcome of First Nation consultation to keep fish and wildlife safe. |

**Table 3-1 Protection Goals for the Adaptive Management Plan**

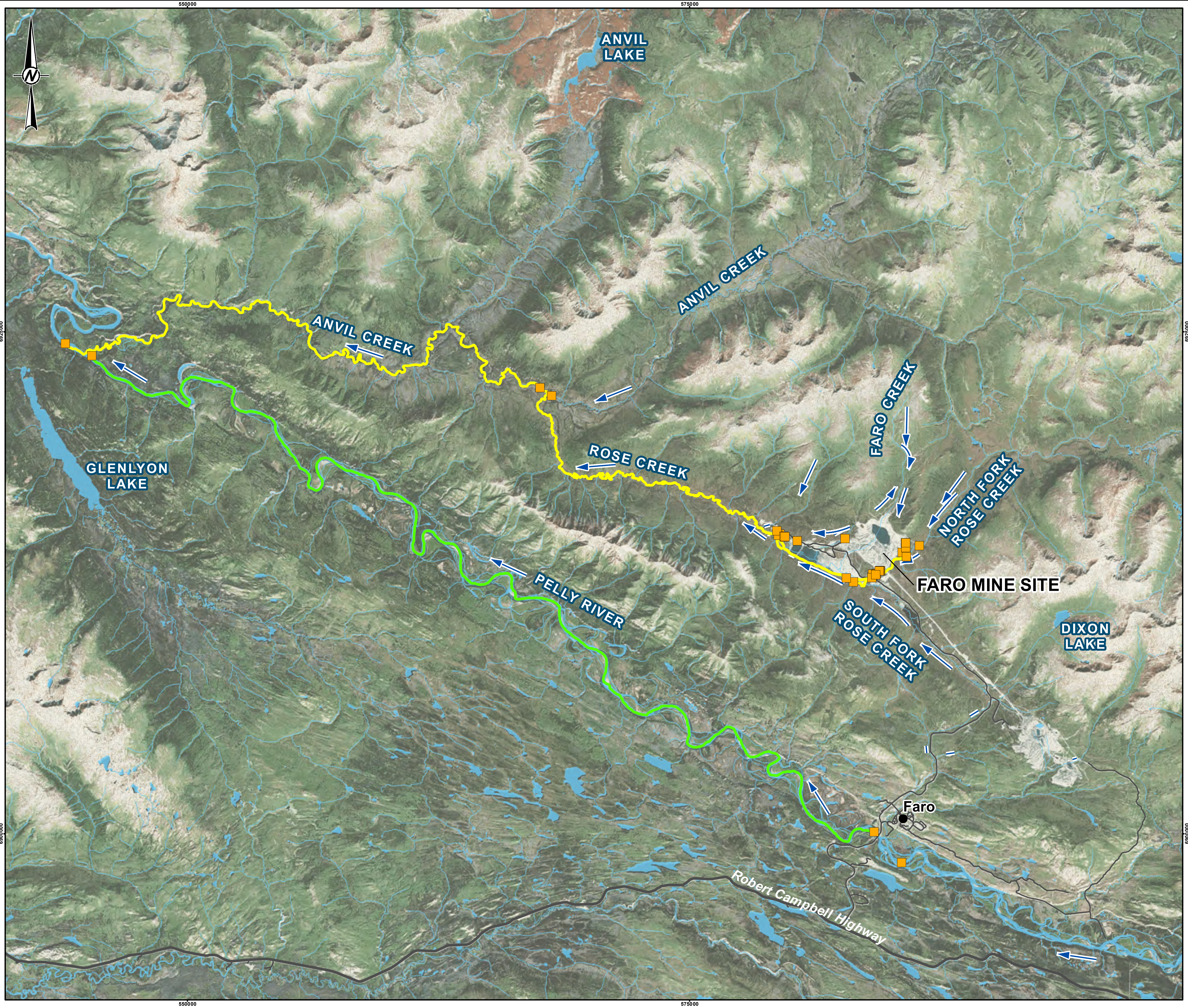
| Location | When does it apply? | Protection Goal | Where does it Apply? | Rationale for Protection Goal |
|---|---|---|---|---|
| Anvil Creek | Interim (pre-remediation, during active remediation) | Water quality in Anvil Creek supports the maintenance of self-sustaining populations of fish, and self-sustaining and functional communities of invertebrates and aquatic plants that will continue to perform necessary ecological services including provision of food for fish. | Anvil Creek downstream of the Faro Mine Site | Anvil Creek water quality should protect the ecosystem (populations of fish, and communities that provide fish food) and specifically protect important species such as Chinook salmon with high confidence. Pre-remediation and during active remediation, a healthy ecosystem must be maintained but some water quality changes will exist; the interim goal acknowledges that prior to completion of remediation, there may be some change or lack of improvement in surface water concentrations. However, despite small changes to water quality, the risk of adverse responses to ecological communities will be negligible or low. Water quality will still support a diverse and productive aquatic ecosystem such that fish and benthic invertebrate communities are present, and fish are growing normally. Based on feedback from consultation that Chinook Salmon are a crucial species for the First Nations and must not be negatively impacted from the Project in Anvil Creek. |
| | Final (Post-remediation) | Same narrative goals as Interim, but with greater frequency of meeting more stringent water quality benchmarks such as SSWQOs. | | Anvil Creek water quality should protect the ecosystem and important species such as Chinook Salmon. After remediation, water quality leaving Faro Mine Site is to be improved such that SSWQOs are generally met in Anvil Creek with only occasional exceedances predicted. SSWQOs represent substance concentrations below which changes to aquatic health would not be expected. They were generally derived using the protocol outlined by the Canadian Council of Ministers of the Environment (2007) for the derivation of water quality guidelines in Canada. The preferential use of no-effect thresholds in the derivation of the SSWQOs imparts a high level of protection, similar to that of a Canadian water quality guideline (i.e., protect all species, all life stages, all of the time). Thus, the protection goal would allow a high level of protection of aquatic life in Anvil Creek. Based on feedback from consultation that Chinook Salmon are a crucial species for the First Nations and must not be negatively impacted from the Project in Anvil Creek. |

**Table 3-1 Protection Goals for the Adaptive Management Plan**

| Location | When does it apply? | Protection Goal | Where does it Apply? | Rationale for Protection Goal |
|---|---|---|---|---|
| Pelly River | Final (pre, during and after remediation) | No measurable change in Pelly River water quality concentrations due to the Project. | Pelly River downstream of the Faro Mine Site | The Pelly River is a natural freshwater river, with currently no measurable influence from the Faro Mine. It has multiple users for traditional and recreational purposes. There are numerous fish species. First Nations identified the Pelly River as critical for Chinook salmon in the area, which are of high social and cultural importance to the Selkirk First Nation. First Nations use this watercourse as an important source of food and water and as a transportation system. The Pelly River at the Faro Mine Site is upstream of the Selkirk First Nation. Given this background, a conservative, final protection goal was set. It prevents degradation of the water quality of the river due to the Faro Mine Site as measured by a comparison of background/upstream water quality to water quality concentrations downstream of the Site. Based on feedback during engagement, the Pelly River is a crucial river for the First Nations and must be fully protected from the Project. |

(a) Amphibians are implicitly protected because they are expected to be equally or less sensitive to sulphate, total iron, and zinc relative to fish. Amphibians as a receptor group was removed from the protection goal for the AMP because amphibians (specifically larval wood frogs) are not expected to utilize the watercourses due to limited habitat.

SSWQO = site-specific water quality objectives; AHRA = Aquatic Health Risk Assessment.




**LEGEND**

- MONITORING STATION
- TOWN
- PROTECTION GOALS APPLICABLE TO THE PROJECT AMP
- PROTECTION GOAL APPLICABLE TO THE OPERATIONAL AMP
- HIGHWAY
- ROAD
- DIRECTION OF FLOW
- WATERCOURSE
- WATERBODY


0 4 8

1:190,000 KILOMETRES

**REFERENCE(S)**

1. IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT

CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT

ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE

**FARO MINE SITE PROTECTION GOAL APPLICATION**

CONSULTANT

GOLDER
MEMBER OF WSP

| | |
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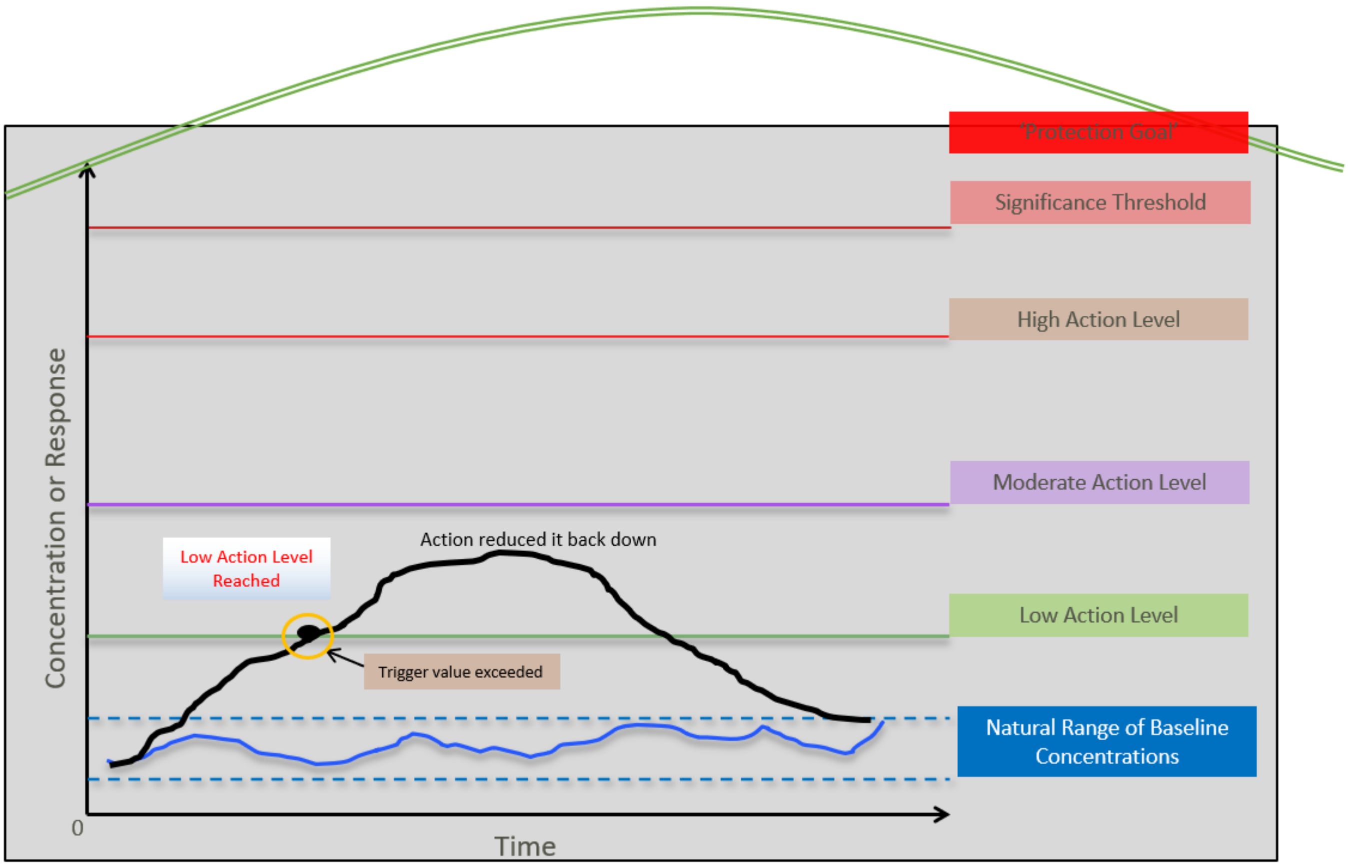
**Significance threshold:** A significance threshold is defined as a threshold above which environmental changes are significantly adverse. It can be interpreted as an indication of when there is a threat to maintenance of the protection goal. The protection goal informs the significance threshold. The action levels (with associated triggers) are set well below the significance thresholds (Figure 3-3; also see below for more information on action levels and triggers). As noted in Table 3-1, protection goals are specific to the waterbody and project phase and so too are the significance thresholds.

The guidance outlines that the significance threshold should be made operational using predetermined triggers based on specific parameters and the project conditions. For the Project AMP the significance threshold was set using water quality benchmarks (e.g., the low effect or the moderate effect benchmark depending on the location) relative to the Project and the phase of the Project. Section 3.6 provides descriptions of benchmarks. Section 3.8 illustrates how the protection goals and significance thresholds, and triggers are linked, and how they vary by waterbody and Project phase.

**Figure 3-3 Graphical Representation of Protection Goal, Significance Threshold and Action Levels**




Modified from WLWB (2010)

### 3.2.1 Adaptive Management Initiatives

An Adaptive Management Initiative (AMI) is a specific condition that is anticipated to require monitoring, assessment, and management (Government of Yukon 2020). An AMI can include several monitoring locations, both groundwater and/or surface water monitoring. The naming conventions for AMIs in the Project AMP provide the general location and possible sources to the location. Should a new AMI be required, it would be assigned the next sequential number for the given site location. In general, the AMIs are numbered from upstream to downstream in a waterbody.

Each AMI will be tracked in quarterly/annual reports and AMP re-evaluation/update reports to preserve a record of previous AMIs that make up the past AMPs or future AMIs in future AMPs. A summary table of each AMI will be presented annually. Should an AMI no longer be required, it will be designated as ‘discontinued or superseded’. To avoid confusion, the numbering of the AMI’s that are discontinued will be ‘retired’ and not used again. Should an AMI be modified over time, it will be designated as ‘updated or revised’. The main purpose of each AMI at the start of active remediation is noted in Table 3-3 and discussed in Section 4.0. Details for each AMI are provided in tables and figures in Section 5.0 to 9.0. As active remediation is advanced these AMIs will evolve to account for completed components of remediation (Section 3.11).

In the case of the Faro Mine Site where several urgent works are installed or underway prior to active remediation, the purpose of the AMI can be varied: to determine if an urgent work implemented prior to initiation of the Project is effective, to determine if the timing of the remediation activity needs to be advanced, to determine if water quality is degrading from a potential source(s) and/or to determine if a remediation component is performing as expected. As noted above, details regarding specific AMIs are provided in Sections 4.0 through 8.0. Also as noted in Section 1.0, there are other adaptive management components monitored at the Faro Mine Site through separate plans (e.g., fish health or effluent quality); annual reports will be used to bring risks/uncertainties together between plans to provide a comprehensive review of exceedances each year.

**Table 3-2 List of Adaptive Management Initiatives at the Start of Active Remediation**

| Waterbody | No. | AMI | Purpose |
|---|---|---|---|
| North Fork Rose Creek | 1 | NFRC-1 | To evaluate whether water entering the North Fork Rose Creek Realignment has been influenced by the North East Rock Dump and/or construction activities associated with the Faro Mine Remediation Project, and whether these sources pose a potential risk to aquatic life. |
| | 2 | NFRC-3 | To evaluate whether water leaving the North Fork Rose Creek Realignment (i.e., non-contact diversion channel) has been influenced by mine-impacted seepage or groundwater, and/or other construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. |
| | 3 | NFRC-4 | To evaluate whether surface water downstream of the North Fork Rose Creek Realignment has been influenced by several contact water sources (e.g., bypass of the S-Wells SIS, bypass from the NFRC Contact Water Interim Measure, or unmanaged groundwater impacted by the Main Dump or Intermediate Dump areas), and/or construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. |

**Table 3-2 List of Adaptive Management Initiatives at the Start of Active Remediation**

| Waterbody | No. | AMI | Purpose |
|---|---|---|---|
| Rose Creek | 4 | RC-1 | To evaluate whether surface water in the Rose Creek Diversion has been influenced by seepage or groundwater, and/or construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. |
| | 5 | RC-2 | To evaluate water quality leaving the North Wall Interceptor Ditch channel and whether the combined sources contributing flow to this channel pose a potential risk to aquatic life within Rose Creek. |
| | 6 | RC-3 | To evaluate groundwater quality in the Down Valley Area and determine whether groundwater seepage poses a potential risk to aquatic life in Rose Creek. |
| | 7 | RC-4 | To evaluate the combined loadings from the Faro Mine Site and whether changes in water quality due to the Faro Mine Site pose a potential risk to aquatic life in Rose Creek. |
| Anvil Creek | 8 | AC-1 | To evaluate the impact of the Faro Mine Site on water quality in Anvil Creek and whether this poses a potential risk to aquatic life. |
| Pelly River | 9 | PR-1 | To evaluate the impact of the Faro Mine Site on water quality in the Pelly River and whether this constitutes a change from natural variation (i.e., violation of the non-degradation goal). |

## 3.3 Indicators

Indicators are constituents used to evaluate water quality conditions for an AMI. The parameters of potential concern for the Project phases were reviewed (Section 7.3.4 of Project Proposal, Volume II) and included as indicators for the Project phases with two exceptions. Silver and fluoride were not carried forward as indicators because concentrations in 2008 to 2019 were less than reference and water quality guidelines as confirmed through review of recent monitoring data for AMP exposure and reference stations. A final list of indicators for the start of active remediation and rationale is provided in Appendix C.

In summary, the final list of indicators was selected based on the following:

- Inclusion of key acid rock drainage indicators for all areas, regardless of the magnitude of concentrations of these parameters (e.g., sulphate, iron, manganese, and zinc).
- Screening for constituents of potential concern (COPCs) based on procedures described by Government of Yukon (2019; Appendix B) and in previous screenings completed as part of the Project Proposal (Volume II, Section 7.3.4).
- Consideration of whether concentration of COPCs were greater than reference conditions and either generic water quality guidelines (for Anvil Creek) or SSWQOs (for Rose Creek and North Fork Rose Creek areas).
- Inclusion of indicators identified for upstream AMIs, regardless of the magnitude of concentrations (i.e., indicators identified upstream were automatically adopted for downstream AMIs despite dilution from the receiving environment).
- Pelly River only:
    - Inclusion of indicators identified at the Vangorda Plateau Mine Area were carried forward for the Pelly River AMI (PR-1) to address possible cumulative effects from the Vangorda Plateau Mine Area on the

Pelly. It is recognized that CIRNAC currently manages care and maintenance for both Faro Mine Site and the Vangorda Plateau Mine Area. It is assumed that through the water licence process and requirements that the indicators can be refined over time if there is a new owner.

- Only dissolved metals are included for the Pelly River as indicators. Total metals will be monitored but the indicator will be dissolved. This is done to account for the variability in total suspended solids in the river (<1 to 150 mg/L based on current conditions data).

For simplicity and to be conservative, one list of indicators is proposed for all Project phases for this version of the Project AMP (Table 3-3). It is assumed that, under a water licence, the list of indicators can be refined over time as conditions change. The indicators identified for each AMI are summarized in Sections 5.0 to 8.0. The intent is to have a set of indicators that adequately characterizes and/or measures the environmental conditions, which will detect potential changes in environmental conditions, are representative of the issue being assessed, and are easily measurable. Even if a constituent is not included as an indicator in this AMP, it will continue to be monitored and reported in the Annual Water Quality Report; if there is a change in that constituent (e.g., trending upward), it may be brought forward to the Project AMP.

**Table 3-3 Indicators for the Project Adaptive Management Plan**

| Area | Indicators |
|---|---|
| Rose Creek | sulphate, total ammonia, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, and dissolved zinc |
| North Fork Rose Creek | sulphate, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, and dissolved zinc |
| Anvil Creek | sulphate, total ammonia, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, and dissolved zinc |
| Pelly River[a] | sulphate, total ammonia, nitrate, dissolved aluminium, dissolved cadmium, dissolved cobalt, dissolved iron, dissolved manganese, dissolved selenium, dissolved uranium, and dissolved zinc |

(a) The Pelly River includes indicators for both the Faro Mine Site and the Vangorda Plateau Mine Area

## 3.4 Action Levels

An action level is a level of environmental change that triggers action to be taken in response to a monitoring result. It can be thought of as a general category that reflect the level of concern; the guidelines recommend tiered action levels such as “low”, “moderate”, and “high” (see Figure 3-2). The triggers for each action level differ depending on the AMI (see Sections 5 through 8 for detailed on each AMI) and are outlined in Section 3.5 and 3.6. The high action level is considered a water quality condition above which mitigative actions must be taken. The low and moderate action levels represent levels where response is necessary but may not yet include mitigative actions. The final decision to advance or ‘de-escalate’ an AMI to a different action level based on an evaluation of monitoring data and triggers will be made by the project’s internal AMP Committee headed by the Faro Project Director. Any mitigation actions with cost implications will be ultimately vetted by the Faro Project Director, based on priority works and availability of budget. Exceedances of action levels will be reported quarterly and annually (see Section 9.0) and management response plans will be prepared for AMIs with exceedances.

An example to illustrate the difference between action levels and triggers (Section 3.6) is shown below:

| 'Category of concern' | 'Numeric value/trend' that defines each level |
|---|---|
| **Action Level** | **Triggers** |
| **LOW** | >SSWQO at station X for any sample collected within a year |
| **MODERATE** | >75% of water quality benchmark at station X for 2 consecutive winter months |
| **HIGH** | > water quality benchmark at station X for any sample collected within a year |

## 3.5 Triggers

A trigger is a numeric value or a trend in a numeric value (Government of Yukon 2021) set for each action level. If a trigger for a corresponding action level is exceeded, it will result in initiation of management response. Triggers for each action level were developed to act as an early warning system based on a risk-management approach as follows:

- reduce risk of exceeding the significance thresholds, in that they allow sufficient space and time to respond before the significance threshold is approached or a protection goal threatened;
- based on risk to aquatic life, including predictions from water quality and measurement of observed effects through monitoring programs;
- based on site-specific conditions using data collected and managed through the annual water quality monitoring programs;
- designed to be practical to use such that they can be assessed quarterly;
- use a "parallel approach" across the AMIs such that managers can prioritize issues and more quickly see where action is needed; and
- focus each AMI on specific sources and increase confidence that trigger exceedances indicate changing conditions at the Faro Mine Site.

The standard approach of "meet or outperform SSWQOs" could not always be set as the trigger for each AMI at Project initiation or active remediation. This is because conditions are deteriorating at the Faro Mine Site and, in some instances, constituents of potential concern are currently above SSWQOs (and will continue to be at the start of active remediation). The Project is needed to address these conditions. In these cases, different triggers were developed based on a combination of inputs: direct feedback from engagement (see Section 1.2, Table 1-1), achievability with existing treatment and capture systems, and water quality objectives or benchmarks supported by site-specific toxicity testing (Golder 2019b, 2020b, 2020c). Refer to Appendix C for more information on development of triggers based on water quality benchmarks. For long term operation and maintenance, triggers were provided as conceptual only and it is assumed they will be refined, under a water licence, to reflect the updated conditions at the time (including input from biological monitoring, as appropriate) and these may be concentrations, trend, or prediction based. Appendix E provides a comparison of the Project Proposal predictions for a conservative dry year for the project phases against the proposed triggers.

An AMI may use one or more of four general types of measurements/numerics in the trigger: 1) water quality concentration, 2) laboratory toxicity testing, 3) performance based (mass loading), or 4) reference/baseline condition. These are then combined with the frequency of exceedance and a condition that the change must be due to activities at the Faro Mine Site or a specified source. Thus, a full trigger for an AMI is: *Measurement + frequency + due to the Faro Mine Site*. This is described below and details on the types of measurements are found in Appendix C.

**Water Quality Concentration**

- SSWQOs and low-effect benchmarks were used in triggers; they are defined for each AMP indicator. Definitions of these two terms are provided below, further details concerning the technical rationale for each can be found in Section 3.7 below and Appendix C.
- SSWQOs represent concentrations below which no meaningful adverse effects on aquatic life are expected during indefinite exposures (i.e., no-effect concentrations per Canadian Council of Ministers of the Environment definitions).
- Low-effect benchmarks represent concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. Low-effect benchmark exceedances do not typically translate into population or community level responses until higher concentrations are attained.

**Toxicity Testing**

- Toxicity based triggers relative to chronic toxicity results were set for one AMI (RC-4 at station RC-SW014).
- Toxicity based triggers relative to acute toxicity results were set for one AMI (RC-2 at station NW-SW003).
- Toxicity triggers were based on the magnitude of adverse effects on individual test organisms, the number and type of species affected (i.e., fish, invertebrates, plants), and frequency of adverse effects (e.g., whether observed in one or more sampling events).

**Performance-Based**

- For AMIs that monitor performance targets (e.g., load reduction targets or loading limits for the receiving environment), triggers were developed to indicate early warning prior to exceeding these conditions.
- Surface water modelling was used to determine a loading limit under which action levels are not exceeded. Loading could be monitored directly at surface water stations using a synoptic sampling program, with triggers indicating an escalation to the maximum load.
- Surface water loading limits (described above) were also be used to inform groundwater quality triggers. This was only possible where groundwater loading predictions have been generated based on groundwater quality monitoring data (e.g., RGC 2020). Groundwater quality triggers would provide early warning for whether increased groundwater loading has the potential to cause exceedance of action levels within the receiving environment.

**Reference/background condition**

- A non-degradation goal was established for the Pelly River, such that water quality within the Pelly River remains within a range of variability defined by background conditions measured upstream of the input from the Project through Anvil Creek.
- Upstream conditions will be determined from the Pelly River monitoring station upstream of the Faro Mine Site input (PR-SW003). Currently there are only three years of data for this station, but additional sampling will be conducted prior to the licensing phase to increase the sample size.
- Triggers were set to indicate possible risk of exceeding upstream 'background conditions' as defined by water quality stations upstream of the confluence of Anvil Creek with the Pelly River.
- Appendix C provides further information on the methods/data for this approach.

## 3.6 Water Quality Benchmarks as Triggers and Significance Thresholds

Three types of water quality related benchmarks were developed for the Project. Equations for calculating these are provided in Table 3-4, where a range is provided benchmarks are dependent on toxicity modifying factors and are calculated individually for each sample. Technical rationales for each benchmark are provided in Appendix C. A description of each and how the benchmarks are used in the Project AMP is provided below. Table 3-5 provides an outline of the benchmarks for each Project phase and waterbody.

### 3.6.1 Site-specific Water Quality Objectives

- In general, where water quality concentrations have been identified above generic water quality guidelines, toxicological literature was reviewed to develop SSWQOs for the Project Proposal (Volume II, Appendix 7H; Information Request R3-14).
- SSWQOs represent concentrations below which no negative effects on aquatic life are expected during indefinite exposures (i.e., the no-effect benchmark). As they are derived using the same protocol as for federal water quality guidelines, they have a similar level of protection (i.e., protect all forms of aquatic life including sensitive species and life stages in long-term exposures); however, they are only protective of the aquatic life that can be found at this specific site, which means SSWQOs are in some cases less conservative than generic water quality guidelines. SSWQOs are derived using toxicity estimates compiled from the toxicological literature.
- For sulphate, total iron, dissolved manganese, and dissolved zinc, SSWQOs were validated and refined using site-specific toxicity testing (Golder 2019b, 2020b, 2020c), further improving the confidence that they are protective.
- For AMIs where conditions are less than SSWQO at Project initiation and during active remediation, triggers for action levels were set as follows: Low: 60% of SSWQO, Moderate: 75% of SSWQO and High: >SSWQO (see Table 3-6). In long term operations and maintenance, the Project may be able to lower the triggers below this because remediation activities will improve water quality. It is assumed the specific triggers can be developed through the regulatory process at the time.

### 3.6.2 Low Effect Benchmarks

- Low effect benchmarks are concentrations at which low magnitude adverse effects could occur on at least one representative species in long-term exposures. These response sizes are based on effects observed in individuals of sensitive species, not populations, and emphasize chronic sublethal test endpoints. When available, the low effect benchmark is selected as representative of a 20% effect ($EC_{20}$) level generated with site specific toxicity testing of one or more species. If the results from more than one species are considered appropriate, that is, more than one species have similar $EC_{20}$s and thus similar sensitivity to low-level effects, then the geometric mean of the $EC_{20}$s is selected as the low effect benchmark. Otherwise, an appropriate benchmark that is representative of the site and a suitably sensitive species is selected from a toxicity dataset of $EC_{20}$ values (or threshold representing a low effect level) found in the toxicological literature. This use of the $EC_{20}$ is consistent with the Canadian Council Ministers of the Environment (2007) definition for low effect level (i.e., $EC_{15-25}$).
- For AMIs where conditions are greater than SSWQO at Project initiation and during active remediation (mostly conditions right near Site), triggers for action levels were set as follows around the low effect benchmark: Low:> SSWQO, Moderate: 75% of low effect benchmark and High: > low effect benchmark (Table 3-6). In long term operations and maintenance, the project expects to lower the triggers because remediation activities will improve water quality. It is assumed the specific triggers can be developed through the regulatory process at the time.
- The low effect benchmark is also used as the significance threshold for some AMIs (Table 3-5).

### 3.6.3 Moderate Effect Benchmarks

- Moderate effect benchmarks are selected to reflect a potential for chronic, sublethal effects of approximately 50% effect size on individuals of sensitive species and life stages of invertebrates and fish, and potential effects on multiple species within a receptor group in long-term exposures. These higher response sizes are only for the most sensitive species within the community; many species would remain unaffected or affected to a much lower degree relative to the sensitive indicator species.
- Concentrations greater than the moderate effect benchmark are interpreted to represent a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes.
- For areas near the Faro Mine Site where water quality conditions have deteriorated and cannot be fully improved until later in active remediation (i.e., Rose Creek and North Fork Rose Creek areas), the moderate effect benchmark will be applied as the significance threshold (Table 3-5).

**Table 3-4 Proposed Water Quality Benchmarks For the Project**

| INDICATOR | Unit | SSWQO (No Effect benchmark) | Low Effect Benchmark | Moderate Effect Benchmark |
|---|---|---|---|---|
| | | **No Effect Level** | **Low Effect Level** | **Moderate Effect Level** |
| Sulphate | mg/L | Hardness dependent:<br>128 mg/L at hardness 0 to 30 mg/L as $CaCO_3$<br>218 mg/L at hardness 31 to 75 mg/L as $CaCO_3$<br>309 mg/L at hardness 76 to 180 mg/L as $CaCO_3$<br>429 mg/L at hardness 181 to 250 mg/L as $CaCO_3$<br>430 to 799 mg/L at hardness between 251 and 432 mg/L as $CaCO_3$ based on the equation ((2.0385 x [hardness]) - 80.615)<br>800 at hardness ≥432 mg/L as $CaCO_3$ | 1.5 x SSWQO<br>= 192 to 1200 | 1.75 x SSWQO<br>= 224 to 1400 |
| Total Ammonia | mg/L as N | pH and temperature dependent:<br>Look up Table<br>= 0.102 at pH 9.0 and temperature 20.0°C to 2.08 at pH 6.5 and temperature 0°C | pH and temperature dependent:<br>Look up Table<br>= 0.08 at pH 9.0 and temperature 30°C to 4.9 at pH 6.5 and temperature 0-7°C | pH and temperature dependent:<br>(0.041/(1/(POWER(10,((0.0901821+2729.92/(Temperature+273.15))-pH))+1)))*0.8224<br>= 0.173 at pH 6.0 and temperature 0°C to 192 at pH 10.0 and temperature 30°C |
| Cadmium, Dissolved | µg/L | Hardness dependent:<br>$exp^{((0.736 \times ln(hardness)) - 4.943)}$<br>= 0.0176 to 0.457 based on calibration range for hardness of 3.4 to 285 mg/L | 2.5 x SSWQO<br>= 0.0440 to 1.14 | 4 x SSWQO<br>= 0.0704 to 1.83 |
| Cobalt, Total | µg/L | Hardness dependent:<br>$exp^{((0.414 \times ln(hardness)) - 1.29)}$<br>= 1.41 to 3.27 based on the calibration range for hardness of 52 to 396 mg/L | 11 x SSWQO<br>= 15.5 to 36.0 | 35 x SSWQO<br>= 49.4 to 114 |
| Iron, Total | µg/L | pH and DOC dependent:<br>$exp^{((0.671 \times ln(DOC)) + (0.171 \times pH) + 5.586)}$<br>= 337 to 4961 based on calibration range for DOC and pH of 0.3 to 9.9 mg/L and pH 6.1 to 8.1 | 2.7 x SSWQO<br>= 910 to 13 395 | 3.6 x SSWQO<br>= 1213 to 17 860 |
| Iron, Dissolved | µg/L | 350 | 1000 | Not derived[(a)] |
| Manganese, Dissolved | µg/L | pH and hardness dependent:<br>CCME Calculator<br>= 200 to 1500 based on the calibration range for hardness and pH of 25 to 670 mg/L and pH 5.8 to 8.4 | Hardness-dependent Level 1 Fish Benchmark[(b)]<br>$exp^{(ln(1096) - 0.411 \times (ln(50)-ln(hardness)))}$<br>= 823 to 3201 based on the calibration range for hardness of 25 to 670 mg/L | Hardness-dependent Level 2 Fish Benchmark[(b)]<br>$exp^{(ln(2052) - 0.411 \times (ln(50)-ln(hardness)))}$<br>= 1541 to 5993 based on the calibration range for hardness of 25 to 670 mg/L |
| Zinc, Dissolved | µg/L | Hardness, pH, and DOC dependent:<br>$exp^{((0.947 \times ln(hardness])) - (0.815 \times pH) + (0.398 \times ln(DOC) + 4.625)}$<br>= 1.7 to 516 based on the calibration range for hardness, pH, and DOC of 23.4 to 399 mg/L, pH 6.5 to 8.13, and 0.3 to 22.9 mg/L | 4 x SSWQO<br>= 6.8 to 2062 | 6 x SSWQO<br>= 10.2 to 3096 |

(a) There is insufficient information to derive a moderate effect benchmark for dissolved iron.
(b) Level 1, 2, and 3 receptor-specific benchmarks were derived in Attachment 7I-2 of Appendix 7I Aquatic Health Risk Assessment of the 2019 Project Proposal (CIRNAC 2019).
Notes: Where a range is provided, benchmarks are dependent on exposure and toxicity modifying factors and are calculated individually for each sample. Technical rationales for each benchmark are provided in Appendix C. The benchmarks are provided for project initiation and active remediation and are used for long term operations and maintenance; however, it is expected these could be updated for water licensing and as new information arises.
SSWQO = site-specific water quality objective; DOC = dissolved organic carbon; CCME = Canadian Council of Ministers of the Environment.

**Table 3-5 Project Adaptive Management Plan Components and Incorporation of Water Quality Benchmarks**

| **Waterbody** | **North Wall Interceptor Ditch Channel** | **Rose Creek, North Fork Rose Creek, South Fork Rose Creek** | | | **Anvil Creek** | | | **Pelly River** |
|---|---|---|---|---|---|---|---|---|
| **Timeframe** | **Project Initiation/Active Remediation[a]** | **Project Initiation** | **Active Remediation[b]** | **Long-term Operations and Maintenance** | **Project Initiation** | **Active Remediation[b]** | **Long-term Operations and Maintenance** | **All Project Phases** |
| **Protection Goal** | None developed for the Project AMP. | Water quality in Rose Creek supports survival and reproduction of fish and benthic invertebrate communities. | | Water quality in Rose Creek supports the maintenance of self-sustaining populations of fish and self-sustaining and functional communities of invertebrates and aquatic plants that will continue to perform necessary ecological services including provision of food for fish. | Water quality in Anvil Creek supports the maintenance of self-sustaining populations of fish, including Chinook salmon, and self-sustaining and functional communities of invertebrates and aquatic plants that will continue to perform necessary ecological services including provision of food for fish. | | Water quality in Anvil Creek supports the survival, growth, and reproduction of aquatic life. | No measurable change in Pelly River water quality concentrations due to the Project. |
| **Level of protection** | Low level of protection to aquatic life - limited to protecting against acute lethality. | Low level of protection to populations of sensitive species of any receptor group; focus of protection is on the level of community. | | High level of protection to fish populations and invertebrate and aquatic plant communities, but not to individuals. | High level of protection to fish populations and invertebrate and aquatic plant communities, but not to individuals. | | Very high level of protection to all resident receptors including Chinook salmon, such that all species, all life stages, are protected all of the time. | Very high level of protection such that water quality changes should be limited and therefore all species, all life stages, are protected all of the time from the Project. |
| **Water Management Approach** | n/a | Use restoration[c] | | Use restoration[c] | Use restoration[c] | | Use restoration[c] | Non-degradation |
| **Significance Threshold** - what numerical benchmark describes "a threshold above which environmental change is significantly adverse"; it is an indication of threat to the protection goal | n/a | Moderate effect benchmark. | | Tentative[d]: Low effect benchmark. | Low effect benchmark. | | SSWQO (no-effect benchmark). | Water quality concentrations in Pelly River at designated downstream station exceed upstream background conditions and it is due to the Project |
| **High Action Level** | See Section 6: AMI RC2 and RC3. | Low effect benchmark. | | Tentative[d]: 75% of low effect benchmark. | SSWQO | | TBD[d] | *Concept:* seasonal rolling mean/median > X upper confidence limit of the mean/median of upstream station OR samples in a given season > X percentile of upstream station (see Section 8) |
| **Moderate Action Level** | See Section 6: AMI RC2 and RC3. | 75% of low effect benchmark. | | Tentative[d]: SSWQO (no effect benchmark). | 75% of SSWQO | | TBD[d] | |
| **Low Action Level** | See Section 6: AMI RC2 and RC3. | SSWQO (no effect benchmark). | | Tentative: 75% of SSWQO[d] | 60% of SSWQO | | TBD[d] | |

(a) North Wall Interceptor Ditch channel will be removed during first few years of remediation activities and will not exist later in Active Remediation nor in Long-term Operations and Maintenance.
(b) During Active Remediation, it is expected that there will be some transition on an uncertain time frame towards the Long-term Operations and Maintenance protection goals.
(c) The draft Yukon guideline for derivation of water quality objectives (Government of Yukon 2019) state that the Use Restoration approach aims at protection of less sensitive species at first, then progressing to more sensitive species. As the approach to the SSWQO derivation was consistent with the Use Restoration approach (see Appendix 7H of the Project Proposal), this approach is noted as applicable to Rose Creek and Anvil Creek.
(d) Significance thresholds, and action levels associated with the Long-term Operations and Maintenance project phase are conceptual or not yet developed and will be finalized through further Water Licence regulatory processes with input from stakeholders.
AMP = Adaptive Management Plan; AMI = Adaptive Management Initiative; n/a = not applicable; SSWQO = site-specific water quality objective.

## 3.7 Monitoring

Monitoring includes water quality monitoring required to support the Project AMP. For each water quality station, a full suite of parameters is monitored and reported in the water quality quarterly and annual reports; a subset of these undergo a full review and analysis through the Project AMP. For each AMI, the relevant stations, monitoring frequency and indicators are outlined in Section 5 through Section 9. The specific constituents, frequency, and stations are outlined in Appendix D. The monitoring program is evaluated annually by CIRNAC with input from technical consultants, with the opportunity for input from the Technical Review Committee.

## 3.8 Evaluation of Monitoring Data

**Initial evaluation:** Once data are received from the laboratory (typically 2-3 weeks after collection), the monitoring results are evaluated. Data are reviewed and quality assurance/quality control checks are completed monthly, with quarterly reporting. Prior to confirming the exceedance of a trigger for a given action level, the data are examined to confirm its validity (i.e., a verification step) (see Figure 3-4). An exceedance may be due to lab error or field error and not due to Site activities. An additional sampling program in the subsequent month or week (depending on the AMI and the severity of the potential exceedance) may be required to confirm the validity of an exceedance. Possible outcomes of the data evaluation are:

- If an exceedance is determined to be non-valid, no further management actions will be taken, and the action level will not be exceeded.
- If an exceedance is validated, then the trigger will be considered confirmed and the action level exceeded.

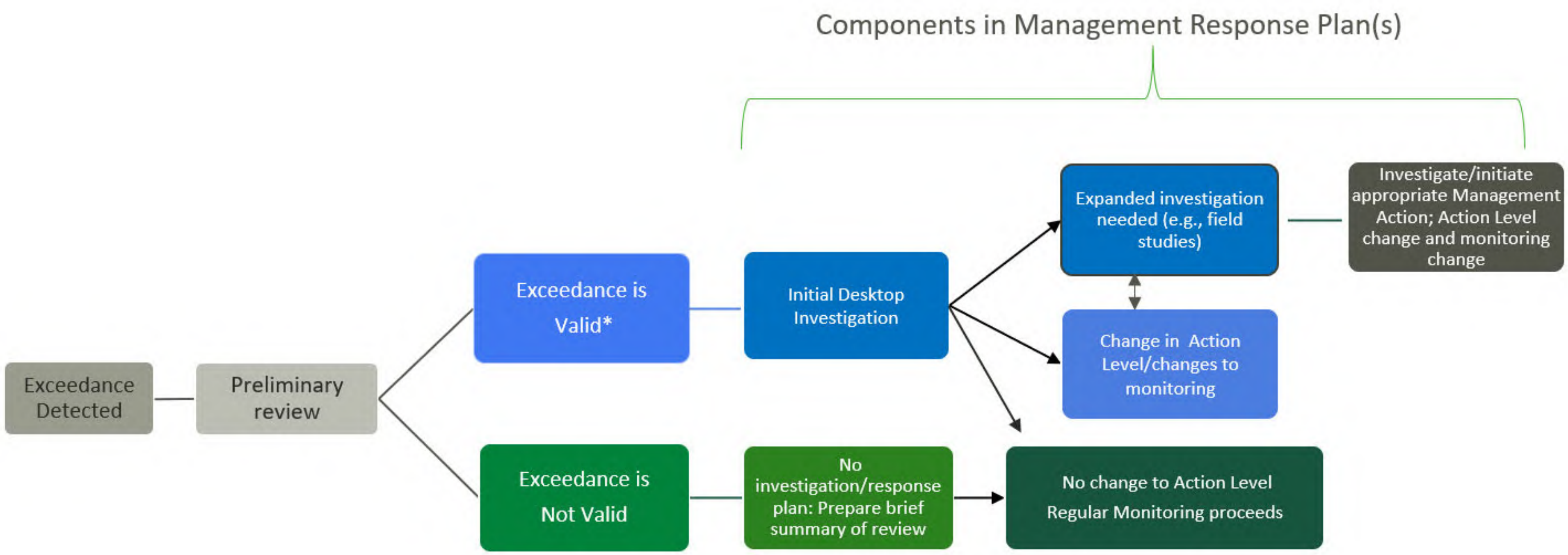
**Confirmed exceedance:** Once an action level is exceeded, a management response plan will be prepared (see Section 3.10).

**Confirmed improvement:** If monitoring results show an AMI is improved and expected to be stable, the action level will be lowered or 'de-escalated'. In some cases, a process for de-escalation from one action level to a lower action level is required. This process includes the following decision criteria that will be used to evaluate and confirm a de-escalation:

- the station is at a steady state (i.e., no increasing trend);
- the constituents of concern are no longer being triggered at an assigned action level for that AMI; and,
- if triggers are exceeded only seasonally, de-escalation would not occur until the next year's season where it could be confirmed that there is no longer a seasonal issue.

**Annual full evaluation of the AMI:** Methods for comparison of monitoring data for each trigger is provided for each AMI in Sections 5 through 8. Additional data analyses will be required annually in the evaluation of the AMI or to better understand the condition under which an exceedance occurred; this is outlined in more detail in Section 3.9.1.

**Figure 3-4 Process for Addressing Exceedances of Action Level**




*Valid exceedance = no lab or field error, confirmed in immediate follow-up sample or subsequent sample program, and is due to Site

### 3.8.1 Supporting Analyses/Information Review

To support understanding of conditions for each AMI, several analyses will be completed quarterly and annually. This includes a qualitative review of historical data, statistical trend analysis, evaluation of mass loading for each indicator constituent, and comparison of exposure conditions to a reference or baseline station. The information generated through these supporting analyses are not directly used to determine action level exceedances but are instead used to further an understanding of emerging or existing issues and advise the selection of an appropriate management response, if required. The exception would be comparison of exposure conditions to a reference or baseline station, which are directly applicable to determining a trigger exceedance and whether a concentration exceedance is "due to the Faro Mine Site" or an "AMI specific source". Further details concerning each of these supporting analyses are provided below.

### 3.8.2 Trend Evaluation

Historical data are reviewed annually to evaluate changes in water quality conditions overtime. The objective of this evaluation is to; 1. Monitor changing water quality conditions associated with the Project, 2. Identify stations where water quality may deteriorate under future conditions, and 3. Where data are sufficient, estimate a timeline for conditions to exceed water quality concentration triggers.

To meet the first objective, summary statistics will be calculated for each dataset and timeseries plots will be reviewed to visually evaluate whether any gradual or abrupt changes in concentrations occurred within the period of record. Each timeseries will be noted as either stable, increasing, decreasing, or insufficient data, along with a description of the inferred pattern (e.g., increasing gradually since 2014).

To identify stations where water quality may deteriorate under future conditions, each timeseries will be screened to determine whether data are sufficient to a conduct a statistical trend analysis. Statistical tests will be completed if the dataset is found to meet the following criteria:

- Timeseries have sufficient data to conduct the selected analysis. A minimum of 5-years of monthly or seasonal data are required for monotonic trend analysis (e.g., Meals et. Al. 2011; Hirsch 1988, Berryman 1988).
- Indicator has sufficient detectable data (minimum 80% of data are above the laboratory's detection limit).
- Station is not influenced by major mitigations within the analyzed timeseries (i.e., no known disruption of long-term monotonic trends, e.g., North Fork Rose Creek Realignment or X13 SIS). Note that trend analysis for Project AMP exposure stations located on Anvil Creek and Pelly River will be exempt from this criterion but would not proceed to forward forecasting.

Statistical trend analysis was completed previously as part of the Operational AMP 2020 Annual Report (Golder 2021) using the seasonal Kendall test for trend (e.g., Hirsch et al. 1982). Alternative methods may also be used that account for seasonality (e.g., USGS 2020), if deemed appropriate through further data review. Results from these tests will be used as a screening analysis to identify timeseries that would proceed to forward forecasting (i.e., estimating a timeline for conditions to exceed water quality triggers). Trends that would proceed to forward forecasting would show significantly increasing trends (i.e., p-value $<0.05$) based on this initial analysis. Additional data review may be required to identify an appropriate approach to forecast future concentrations. For example, forward forecasting may be more appropriate for a specific season or monthly trend opposed to an entire seasonal dataset. The purpose of this analysis is to make a conservative estimate of potential water quality trigger exceedances, and therefore the most significant seasonal trend with the greatest predicted magnitude of change should be used. To identify seasonally specific trends, additional within-season analysis may be required (e.g., Mann-Kendall trend tests on monthly or seasonal data). The guidance also references parametric procedures for forward forecasting if data are found to meet the required statistical assumptions (Government of Yukon 2021).

### 3.8.3 Mass Loading Evaluation

Mass loading will be calculated for each indicator constituent at selected Project AMP surface water stations. Mass loading is calculated as flow multiplied by the indicator concentration at a given point, for a given duration. This information is used to track the change in mass loading between two points in the system, the load added to the system at various stations, and the mass load contribution from potential sources. Mass loading will be evaluated annually for each receiving watercourse (i.e., North Fork Rose Creek, Rose Creek, Anvil Creek, and Pelly River). For each watercourse, timeseries plots of mass loading will be reviewed. This analysis supports in determining if there are changes in inputs that have the potential to influence the downstream concentrations to an extent that could result in an action level exceedance.

### 3.8.4 Reference & Baseline Conditions

Several AMIs use a comparison to reference or baseline conditions as part of the triggers for a given Action Level. When indicator concentrations are found to be above water quality triggers/AMP benchmarks, a comparison to reference or baseline conditions is used to determine whether this is "due to the Faro Mine Site" or "due to AMI specific sources". When the term "reference condition" or "reference station" is used, this indicates that the station is located upstream from potential influence of the Site. When the term "baseline condition" or "baseline station" is used, this indicates the station is located upstream from potential influence of AMI specific sources but has potential to be impacted by another upstream source or AMI. When the term "exposure station" is used, this indicates the station is located downstream from a potential source. To complete a comparison of exposure and reference conditions, water quality is reviewed against water quality triggers/AMP benchmarks at both stations. This provides a comparison of whether upstream to downstream changes in water quality have caused concentrations to report above an AMP benchmark. If concentrations are above triggers at both stations for the same sampling event, the issue is assumed to be caused by an upstream source and is not attributed to AMI specific sources; however, if concentrations are only above water quality triggers at the exposure station, or above a higher-level benchmark at the exposure station, the issue is attributed to AMI specific sources and verified to be used to determine whether an Action Level has been exceeded. Triggers are applicable to exposure stations, whereas reference and baseline stations are used only to verify the source.

### 3.8.5 Source or Supporting Stations

In addition to exposure, reference, and baseline stations, several AMIs also include monitoring of source or supporting stations. These stations typically represent a known or potential source of mine-related loading and are in closer proximity to that source compared to the exposure station. Action levels are not applicable to source or supporting stations. Data from these stations are reviewed as part of the Project AMP to provide further supporting information that can be used to characterize or identify a source of constituent loading or provide further earlier warning of a progressing or emerging issue. Data analysis of source or supporting stations includes annual trend evaluation and review of mass loading to surface water.

### 3.9 Responses

**Process for Response**: Once an exceedance of an action level is confirmed, a management response plan will be prepared (see Figure 3-3). The response plan may be short and focused on simple responses like reanalysis or additional sampling. It may also be more complex outlining additional studies or mitigations (e.g., pumping of contaminated water or alteration of a water treatment process). A range of possible responses could be implemented dependent on the trigger and the associated action level.

Because of the degradation at the Faro Mine Site, it is possible triggers could be exceeded in a non-sequential manner, particularly early in active remediation, (i.e., a moderate action level could be triggered before a low action level). Given this possibility, a management response plan may be prepared for each action level exceedance or group of interrelated exceedances in a waterbody. This will allow an evaluation of the conditions surrounding the exceedance in full. For ease of reporting/tracking, low action level management response plans may be reported in the annual Project AMP report as part of the recommendation section or an associated appendix. It is anticipated that moderate or high management response plans would be more comprehensive and require additional time to prepare and could not be provided at the time of the annual Project AMP report.

**Types of Management Responses:** The specific response will depend upon the AMI, other activities occurring in the vicinity, and the monitoring data; however, the general response steps that would be followed if a trigger is reached will include:

- Consider if sampling protocol needs updating or collect additional quality control samples during the next sampling, and/or increase sample frequency at the current station or new stations in the area [for infrequently sampled stations].
- Investigate to determine if there are other activities (e.g., construction) or conditions (e.g., large rain event, slumping of a creek bank) that could have caused a change in the monitoring data.
- Examine the ecological relevance of the data (e.g., will exceedance result in possible ecological effects in the short term or long term that require immediate response).
- Re-evaluate the triggers and determine if it is reasonable to adjust the trigger, continue monitoring, or to implement mitigation steps.

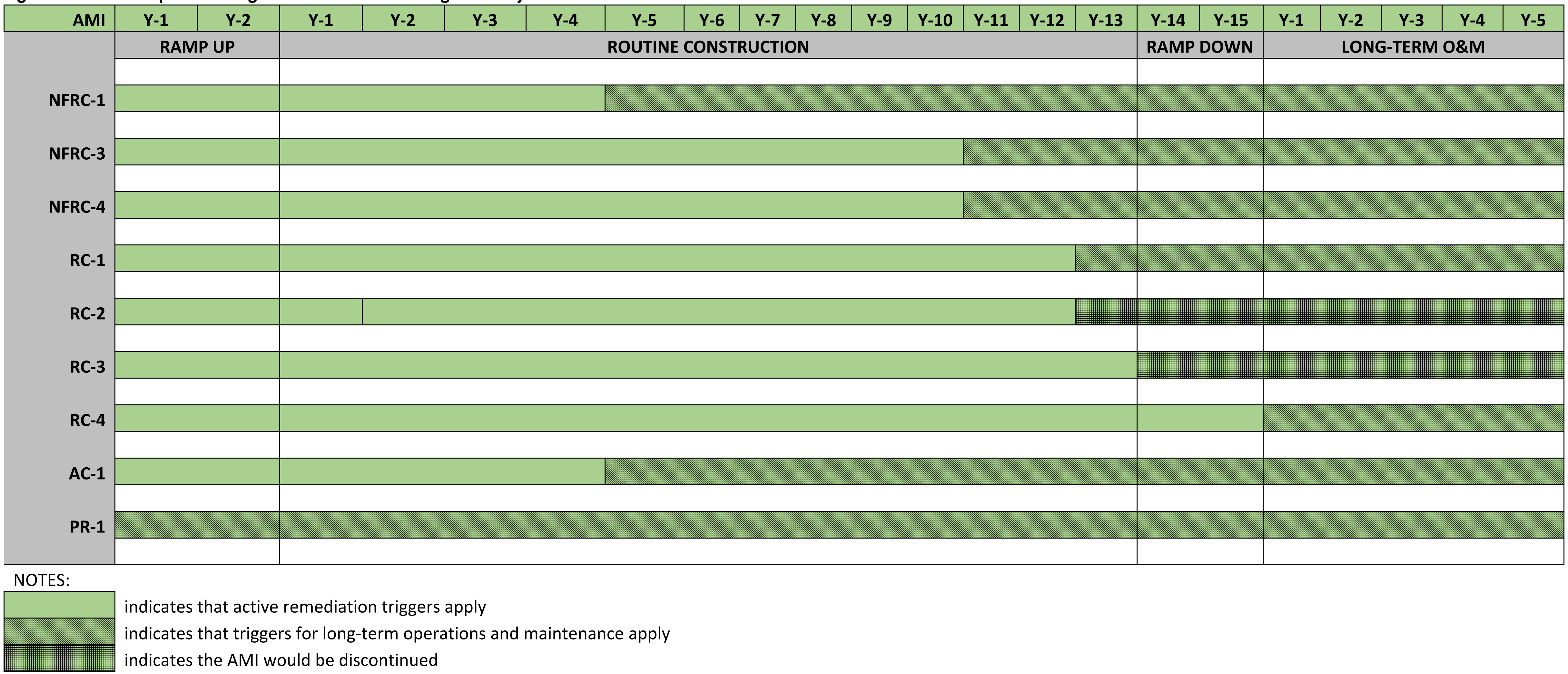
Once an action level is confirmed to be exceeded and mitigation is required, the mitigation response will be dependent on the AMI and the associated action level. Table 3-6 provides a summary of generic responses for each action level. The guidelines note that 'in most situations the specific management responses will not be known in advance but a 'toolbox' of potential mitigations and management response for each AMI' should be provided. Where the AMI is in receiving water, additional review of monitoring data, review of mass loading data, or additional sampling may be required to trace back the source of loading to the system, and the source may require additional investigation to determine how to control the source term. For performance monitoring or groundwater AMIs, the response may result in reviewing and upgrading an existing interception system or implementing additional measures. In addition to the generic response outline in Table 3-6, Section 5 through 8 outline the 'toolbox' of possible mitigation measures related to each AMI.

## 3.10 AMIs Evolve through the Project Phases

As described in Table 3-1, project protection goals are applicable to each watercourse and vary overtime depending on the Project phase. The evolution of AMIs themselves is described in Sections 5 to 8. The AMIs are deliberately focused in the receiving environment to account for any changes that may occur at the Faro Mine Site and to verify all sources of contact water are accounted for at all times. However, dependent on the remediation component additional shot-term AMIs may be added to account for a specific-aspects of remediation related to the performance to avoid contact water interacting with receiving environment. For example as the remediation is completed, AMIs may be applied to sedimentation ponds to identify if/when changes may be required to so that these ponds can eventually be directly discharged to the environment. It is anticipated that for the foreseeable future all current AMIs would be required for active remediation and for the first few years into long-term operations and maintenance. As the Project advances through long-term operations and maintenance, and remediation is proven out AMIs may be discontinued (See Section 6 Rose Creek area for additional detail). As noted in Section 1, the Project AMP will be re-visited every 3 years so multiple opportunities will exist to add or remove AMIs as warranted.

In accordance with a change in protection goal, the significance threshold and action levels associated with each AMI will also evolve based on Project phase. At Project initiation, each AMI will use the action levels established for active remediation (refer to Sections 5.0 through 8.0). These action levels will remain applicable throughout remediation. This includes all stabilization, landforming, cover construction, and construction water management activities that have potential to impact Project AMP surface water monitoring stations. Following the completion of remediation activities in each area, triggers will be revised through Project AMP updates and regulatory approvals and remain applicable through long-term operations and maintenance. Performance-based AMIs will also be reviewed through this process to determine a suitable timeline to discontinue these initiatives and transition management to operational procedures. The decision of whether to discontinue a performance-based AMI will require a detailed review of performance monitoring results covering an acceptable period of post remediation conditions. Where required, long-term operations and maintenance triggers (i.e., triggers applicable post remediation) for each AMI will become applicable through a staged process, with some AMIs transitioning once a particular Project component is complete, and others once the remediation project has been fully implemented. At the start of long-term operations and maintenance, all remaining AMIs will be transitioned to long-term operations and maintenance triggers. In some cases, AMIs may also be temporarily deactivated to accommodate instream construction activities. Figure 3-5 shows an example of how each AMI may progress from active remediation to long-term operations and maintenance triggers. Sections 5.0 to 8.0 provide details on the action level triggers anticipated for each project phase.

**Figure 3-5 Adaptive Management Initiatives Throughout Project Phases**



### Table 3-6 General Management Plan Responses for Action Levels

<table>
<tr><th>Action Level</th><th>Possible Response for AMIs near Site</th><th>Possible Response for AMIs downstream of the Faro Mine Site</th></tr>
<tr><td>LOW</td><td colspan="2">• Continue monitoring.<br>• Investigate source(s) of exceedance via desktop analysis, field sampling and/or reconnaissance.<br>• Consider additional sampling frequency/locations.<br>• Consider additional investigations, trend analyses, advancement of groundwater and/or surface water modelling to evaluate risk of exceeding next action level.</td></tr>
<tr><td>MODERATE</td><td>• Confirm monitoring is appropriate or expand.<br>• Complete additional investigations as required. This may include confirmation of source, site-specific toxicity sampling, biological monitoring, or continued advancement of groundwater and/or surface water modelling to support mitigation option selection and implementation planning.<br>• Consider increasing sample frequency.<br>• Continue advancement of groundwater and/or surface water modelling to support option selection and estimate timeline for exceeding the high action level.<br>• Evaluate if exceedance of acute water quality guidelines is possible.<br>• Evaluate timeline of implementing mitigation against the predicted timeline and magnitude of exceeding the high action level.<br>• Evaluate potential risk of protection goal failure.<br>• Determine mitigation options and estimate timeline for design, construction, and operation. Select mitigation option and determine when it might be required so it can be implemented when required.<br>• Develop emergency response plan (e.g., deployment of temporary pumps, or procedures for temporary groundwater conveyance).<br>• If appropriate based on the outcome of investigation, implement mitigations/emergency response plan if investigations show exceedances of high action level or acute water quality guidelines is imminent (within 1-2 years) and/or if trends show short-term potential to trigger the high action level.<br>• If emergency response plan not appropriate, consider implementing remediation plan activity.</td><td>• Complete investigations, confirm that upstream sources are being controlled.<br>• Review if nearby Vangorda Plateau Mine Area is contributing to Pelly River trigger<br>• Confirm geographic range of monitoring stations is appropriate or expand monitoring.<br>• Expand frequency of sampling.<br>• Consider installation of automated sampling devices or loggers.<br>• Review possible climate change considerations in wider geographic area not considered in the low action level (e.g., permafrost melt or landslide).<br>• Consider toxicity sampling. or biological monitoring<br>• Consider community involvement and use of traditional knowledge to support understanding of regional data/patterns, where available and appropriate</td></tr>
<tr><td>HIGH</td><td>• Implement responses from moderate action level, if not already completed<br>• Conduct expanded investigations.<br>• If not previously developed, develop emergency response plan (e.g., deployment of temporary pumps, or procedures for temporary groundwater conveyance) and implement.<br>• If emergency response plan not appropriate, consider implementing remediation plan activity.<br>• If predictions for exceedance show it will continue, implement emergency response plan and/or implement planned mitigation to avoid or resolve exceedance.</td><td>• Implement response from moderate action level if not already completed.<br>• Advance groundwater and/or surface water modelling to support mitigation option selection and implementation planning at upstream locations.</td></tr>
</table>

AMIs = Adaptive Management Initiatives.

# 4.0 Overview of Adaptive Management Initiatives

AMIs were developed for four key waterbodies at/near the Faro Mine Site:

- North Fork Rose Creek
- Rose Creek
- Anvil Creek
- Pelly River

The location of each waterbody, a brief description of the background and the possible risks from the surrounding site are outlined below. The general layout of the Faro Mine Site relative to the waterbodies is provided in Figures 4-1 through Figure 4-3.

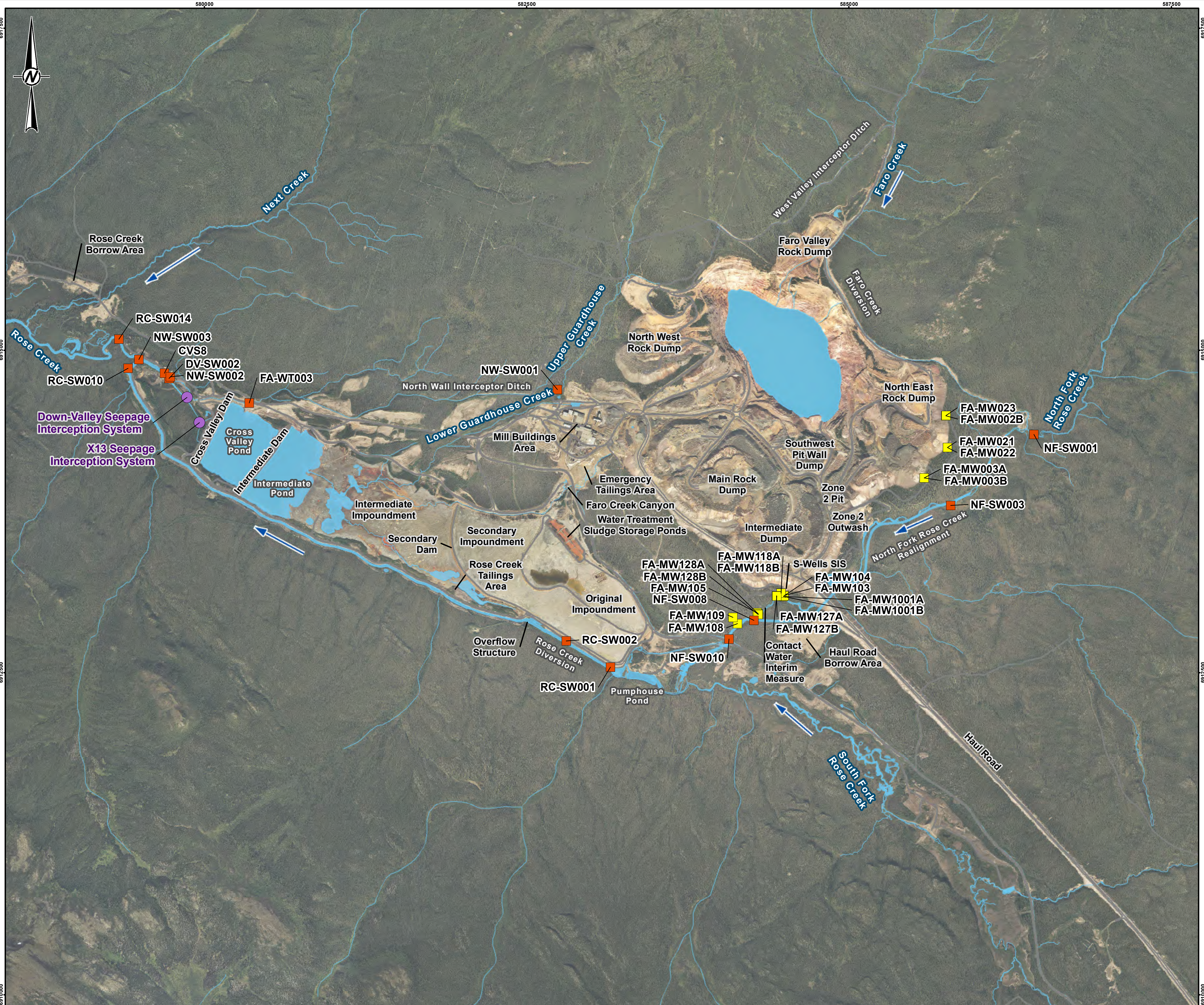
## 4.1 Overview of Waterbodies and Project Risks

### 4.1.1 North Fork Rose Creek

**Location:** The North Fork Rose Creek is located to the southeast of the Faro Waste Rock Dump (or Main Dump), Faro Pit and Zone 2 Pit, Zone 2 Outwash, Intermediate Dump and Northeast Dump (Figure 4-1). Starting around 2006, loadings of zinc and sulphate from waste rock drainage, and at the North Fork Rock Drain, have significantly influenced water quality in North Fork Rose Creek (CIRNAC 2019). Previous studies have suggested that this loading occurs year-round with concentrations in the receiving water most pronounced during the winter months, due to a higher relative proportion of groundwater contribution to the flow system (SLR 2017; SRK 2010).

**Background:** As part of past AMP response measures, an initial seepage interception system was installed in 2009 (the system was later expanded): the “S-Wells” and the North Fork Rock Drain. Currently, the S-Wells is effectively capturing seepage, whereas the North Fork Rock Drain system is no longer operated due to poor seepage capture and has been decommissioned. Construction of a clean water diversion channel (i.e., North Fork Rose Creek Realignment) was initiated in 2018 and commissioned in October 2020. This non-contact water diversion system segregates and diverts clean water away from potential contamination sources. The new non-contact water channel is re-aligned to the east and rejoins North Fork Rose Creek downstream of the haul road. Much of the existing North Fork Rose Creek channel, which formerly received seepage discharge is now part of an interim contact water collection system that collects mine impacted seepage and groundwater which is conveyed to Faro Pit for storage and treatment. Water quality in the realigned channel will be monitored at project initiation as part of an AMI to determine whether additional seepage capture may be required prior to the full remediation of the Faro Mine Site.

**Future condition:** As part of the Faro Mine Remediation Plan, the North Fork Rose Creek SIS will be put in place to limit discharge of contaminated waste rock seepage and continue localized capture of known high strength sources to reduce loadings to the Rose Creek Aquifer. While much of the North Fork Creek has been realigned, the area between the North Fork Rose Creek Diversion and the toe of the re-sloped waste rock (upstream of the haul road) will be graded to create a positive gradient that conveys surface runoff toward the North Fork Rose Creek Diversion. In addition, the North Fork Rose Creek Realignment will require integration with the post-remediation surface water management. The North Fork Rose Creek Diversion is planned to convey only non-contact water following remediation. As described in Section 7.3.8 of the Project Proposal and based on the downstream model, while there is overall improvement in water quality there may be some exceedances of SSWQOs due to seepage bypass as modelled (Volume II, Appendix 7F) for zinc and iron in active remediation and long-term operations and maintenance. Appendix E of this document compares the predictions for dry years from the Project Proposal for each phase against action levels. Note that as predicted, on occasion some exceedances of the SSWQO are predicted and may trigger the AMP. It's possible future versions of the AMP including a comparison to predictions once modelling predictions are updated for water licensing or after an AMP investigation.




**LEGEND**

**MONITORING STATION**

- GROUNDWATER MONITORING WELLS
- SURFACE WATER MONITORING STATION
- SEEPAGE INTERCEPTION SYSTEM
- ROAD
- DIRECTION OF FLOW
- WATERCOURSE
- WATERBODY

**REFERENCE(S)**

1. MINE ROADS, WATERCOURSES OBTAINED FROM CH2MHILL.
2. AERIAL PHOTOGRAPHY ACQUIRED BY PEREGRINE AERIAL SURVEYORS INC. AND EAGLE MAPPING IN AUGUST 2012.
3. ORTHOPHOTOGRAPHY PREPARED BY CRITIGEN CANADA CORP.
4. INSET DATA OBTAINED FROM YUKON GEOMATICS.

DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT

CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT

ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE

**FARO MINE SITE GENERAL LAYOUT AND MONITORING STATIONS**

CONSULTANT

GOLDER MEMBER OF WSP

| | |
|---|---|
| YYYY-MM-DD | 2021-07-15 |
| DESIGNED | AN |
| PREPARED | LH |
| REVIEWED | HM |
| APPROVED | HM |

| PROJECT NO. | PHASE | REV. | FIGURE |
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**LEGEND**

- MONITORING STATION
- TOWN
- HIGHWAY
- ROAD
- DIRECTION OF FLOW
- WATERCOURSE
- WATERBODY


0 3,000 6,000

1:150,000 METRES

**REFERENCE(S)**
1. WATERCOURSES OBTAINED FROM CH2MHILL.
2. IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.
3. INSET DATA OBTAINED FROM YUKON GEOMATICS.

DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
**LOCATION OF ANVIL CREEK AND PELLY RIVER MONITORING STATIONS**

CONSULTANT
GOLDER
MEMBER OF WSP

| | |
|---|---|
| YYYY-MM-DD | 2021-07-15 |
| DESIGNED | AN |
| PREPARED | LH |
| REVIEWED | HM |
| APPROVED | HM |

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### 4.1.2 Rose Creek

**Location:** The Rose Creek watershed encompasses the Faro Mine Site and drains west to the Pelly River via Anvil Creek. Rose Creek is fed by two tributary forks that join the North Fork Rose Creek and the South Fork Rose Creek. The North Fork Rose Creek drains south from the southern slopes of the Anvil Range and is partially fed by Faro Creek and other small tributaries.

Upper Guardhouse Creek is located to the west of the Faro Pit and the North West Rock Dump (Figure 4-1). Water from Upper Guardhouse Creek flows into the North Wall Interceptor Ditch, which combines with water from the X13 channel downstream of NW-SW002 and flows into Rose Creek upstream of station RC-SW0014 (Figure 4-1). Water quality within Upper Guardhouse Creek has the potential to be influenced by seepage from the North West Rock Dump, which in turn could influence downstream water quality within Rose Creek.

Currently the interim water treatment system discharges into the North Wall Interceptor Ditch through the effluent outflow pipe at station FA-WT003, which is located approximately 2 km downstream of NW-SW001 and flows into North Wall Interceptor Ditch to NW-SW002, located approximately 750 meters downstream of the discharge location. During remediation and long term operations and maintenance a permanent water treatment plant will discharge to a similar location.

Downstream of the confluence of North Fork Rose Creek and South Fork Rose Creek, surface waters flow through the Rose Creek Diversion (Figure 4-1). The Rose Creek Diversion is a constructed channel that runs southwest of the Original Impoundment, Secondary Impoundment, Intermediate Impoundment, Intermediate Pond and Cross Valley Pond. The Rose Creek Alluvial Aquifer underlies this area, located along a reach of the original Rose Creek channel. Water quality within the Rose Creek Diversion and the Rose Creek Alluvial Aquifer is currently influenced by upstream sources and seepage from the surrounding tailings; resulting in elevated concentrations of certain metals (e.g., iron and manganese). This was particularly evident at stations in the X13 Channel (i.e., DV-SW001 and DV-SW002), located downstream of the Cross Valley Dam.

The Rose Creek Alluvial Aquifer is located along the reach of the original Rose Creek channel. This ranges from upgradient of the Rose Creek Tailings Area, below the Original Tailings Impoundment, Secondary Impoundment, Intermediate Tailings Impoundment, Intermediate Dam, and Cross Valley Pond, downgradient past the X13 capture system.

The South Fork Rose Creek originates further east and drains northwest along the Vangorda Plateau Mine Area, joining the North Fork Rose Creek just east of the Rose Creek Tailings Area. Downstream from the confluence of the North and South Forks of Rose Creek, the mainstem of Rose Creek is diverted around the tailings, which terminates downstream of the Rose Creek Tailings Area, where the creek rejoins its original channel just northwest of the Cross Valley Dam.

**Background**: A series of response measures were undertaken to prevent mine impacted water from reaching Rose Creek, including several groundwater components that may be required to intercept both shallow and deep groundwater seepage migrating through the Rose Creek Alluvial Aquifer. In 2018, construction of the X13 capture system was completed, and the system became fully operational in late January 2019. This project was implemented specifically to address elevated concentrations of metals (e.g., iron and manganese) observed in shallow groundwater seepage and surface water downstream of the Cross Valley Dam. Captured water is pumped to the Intermediate Pond and eventually to the Faro Pit.

In 2020, an investigation into ongoing exceedances for AMP Events (now referred to as AMIs) RC-2 (Effectiveness of the X13 capture system), RC-3 (Prevent downstream migration of Rose Creek Alluvial Aquifer contaminated plume) and RC-4 (Overall mine impact on Rose Creek at station RC-SW014) was completed. The investigation included examination of water quality to determine if discharge could adversely impact aquatic life and to determine whether additional mitigation measures would be required (Golder 2020d). The investigation concluded that despite significant improvements made with the X13 capture system and expected improvements from the completion of the North Fork Rose Creek realignment and associated capture systems, future concentrations of COPCs are predicted to continue to rise and exceed generic acute and chronic water quality guidelines for some constituents, with persistent chronic toxicity (Golder 2020d). In response to this prediction, CIRNAC initiated the design of a short-term capture system in the Down Valley Area that is expected to be implemented in 2021. It should also be noted that the Cross Valley Pond Treatment Plant is expected to commence operations in the spring of 2021 and that the outflow pipe will discharge adjacent to the existing Interim Water Treatment System outfall (i.e., station FA-WT003).

**Future condition:** Substantial remediation of the Rose Creek Diversion is required to increase the capacity to convey the probable maximum flood. The channel will be aligned such that it roughly follows the alignment of the existing Rose Creek Diversion Channel, with a combined overflow and routine flow channel. Near the Intermediate and Cross Valley Dam the channel will be deepened to situate it entirely in bedrock. The Down Valley SIS will be installed to maintain the Rose Creek Diversion Channel. The Rose Creek Diversion Channel is planned to convey only non-contact water following remediation. As described in Section 7.3.8 of the Project Proposal (CIRNAC 2019) and based on the downstream model, while there is overall improvement in water quality there may be some exceedances of SSWQOs as modelled (Appendix 7F, Project Proposal) for sulphate, zinc, and iron during active remediation and into long-term operations and maintenance. Appendix E of this document compares the predictions for dry years from the Project Proposal for each phase against action levels. Note that as predicted, on occasion some exceedances of the SSWQO are predicted and may trigger the AMP. Its possible future versions of the AMP including a comparison to predictions once modelling predictions are updated for water licensing or after an AMP investigation.

### 4.1.3 Anvil Creek and Pelly River

Water quality in Rose Creek downstream of RC-SW014 is monitored at stations RC-SW020 and RC-SW025, located approximately 5.5 and 13 km northwest of the Faro Mine Site, respectively. Rose Creek then flows into Anvil Creek downstream of RC-SW025 where water quality is monitored at reference station RC-SW040 (see Figure 4-2), located approximately 250 m upstream of the confluence of Rose and Anvil Creeks, and at RC-SW030, located approximately 600 m downstream of the confluence. Water quality of Anvil Creek is also monitored at AC-SW001, approximately 20 km downstream, prior to flowing into the Pelly River. Water quality in the Pelly River is monitored upstream and downstream of the confluence with Anvil Creek at stations PR-SW003 and PR-SW004, respectively, though sampling at PR-SW003 was only recently resumed in 2018 (Golder 2020a). Water quality in the Pelly River is also monitored at stations PR-SW001 and recently PR-SW002, located upstream and downstream of the confluence of Vangorda Creek with the Pelly River.

**Future condition**: As described in Section 7.3.8 of the Project Proposal (CIRNAC 2019) and based on the downstream model, while there is overall improvement in water quality that influences the Anvil Creek there may be some exceedances of SSWQOs as modelled (Appendix 7F, Project Proposal) for iron during long-term operations and maintenance, which is partially due to natural occurrence of total suspended solids. During active remediation the conditions in the Pelly River are expected to be consistent with the conditions at Project initiation and no exceedances of SSWQOs are expected in the Pelly River during long-term operations and maintenance. Appendix E of this document compares the predictions for dry years from the Project Proposal for each phase against action levels. Note that as predicted, on occasion some exceedances of the SSWQO are predicted and may trigger the AMP. It is possible future versions of the AMP include a comparison to predictions once modelling predictions are updated for water licensing or after an AMP investigation.

## 4.2 Adaptive Management Initiative Structure

A total of 9 AMIs are included in this version of the Project AMP (Table 4-1). These are focused on surface waters near or immediately downstream of the mine area(s), and groundwater downgradient of potential sources of contamination (e.g., waste rock and tailings). Figure 4-3 provides an overview of the structure of the AMIs. Figure 4-4 shows an overview of monitoring stations for each AMI; figures for each area are provided in Sections 5. 0 through 8.0.

Each AMI can be categorized as either a 'near-field' or 'far-field' initiative. Near-field initiatives are intended to evaluate specific contact-water sources to assess whether these sources pose a potential risk to aquatic life and/or its relative contribution to the combined loadings from the site. These AMIs monitor conditions near the source and have a system to validate whether the issue identified is due to AMI specific sources, so that trigger exceedances, and the associated response, are focused on specific sources and not falsely triggered due to upstream influence. Far-field initiatives evaluate the combined influence of multiple contact-water sources. These AMIs are intended to trigger in account of all upstream influences. Because these AMIs are not directed at a specific source, when an issue is flagged (through trigger exceedances) source identification is still required. For this reason, monitoring of mass loading is used to track the relative contribution of known upstream sources. For AMIs that monitor the combined loadings from the site, the response required may vary considerably as management intervention will more typically focus on individual sources.

## 4.3 Summary of AMIs

As noted above, the interconnection between the various AMIs in each waterbody is provided in Figure 4-3. Table 4-1 provides a summary of the AMIs and rationale for each as well as key changes from AMP filed in 2019 with YESAB, with an overview in Figure 4-4. Sections 5 through 8 provide the details of each AMI.

**Figure 4-3 Interrelationships of the Faro Mine Site Adaptive Management Initiatives during Active Remediation**

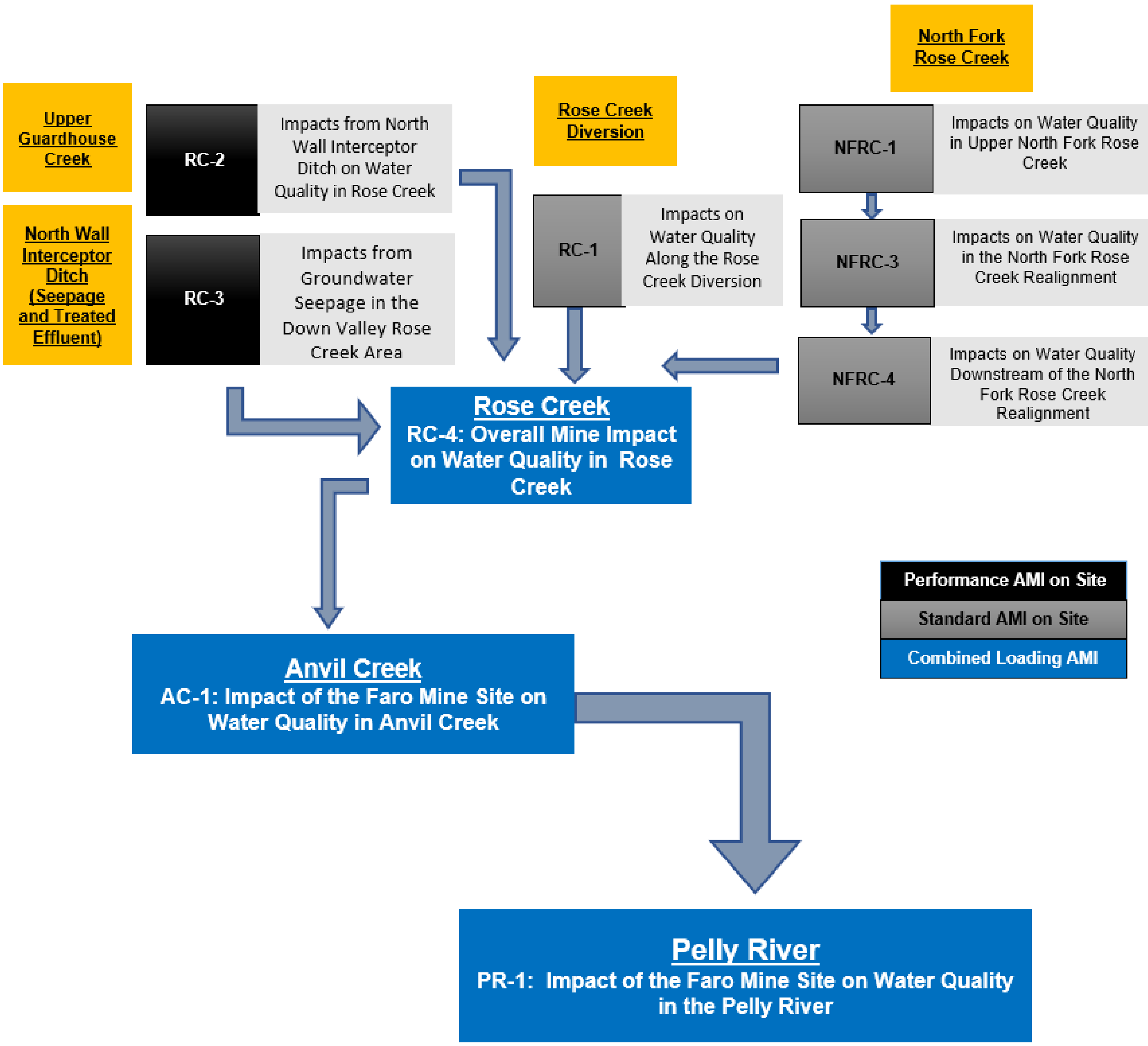


**Table 4-1 Adaptive Management Initiative Descriptions for Project Initiation and Active Remediation**

| Group | AMI# | Purpose | Monitoring | Refinements for Version 2 of the Project AMP |
|---|---|---|---|---|
| North Fork Rose Creek | NFRC-1 | To evaluate whether water entering the North Fork Rose Creek Realignment has been influenced by the North East Rock Dump and/or construction activities associated with the Faro Mine Remediation Project, and whether these sources pose a potential risk to aquatic life. | Surface water quality, hydrology, groundwater | NFRC-1 and NFRC-2, as described in the Project AMP filed in 2019 with YESAB, have now been combined into a single AMI (i.e., NFRC-1). Action levels have been revised to focus on aquatic life protection and strengthen functionality for providing early warning of potential aquatic life impacts associated with seepage from the North East Rock Dump and/or other construction actives related to project (e.g., Faro Creek Diversion). NFRC-1 now includes both surface water and groundwater stations, as well as exposure, reference, and source monitoring stations. Action levels are applicable to surface water conditions at the exposure station, whereas source and groundwater stations are used to provide early warning of an emerging issue or changing condition. The addition of a reference station allows for mass loading to be calculated to determine whether trigger exceedances are due to the Site. |
| | NFRC-3 | To evaluate whether water leaving the North Fork Rose Creek Realignment (i.e., non-contact diversion channel) has been influenced by mine-impacted seepage or groundwater, and/or other construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. | Surface water quality, hydrology | NFRC-3, as described in the Project AMP filed in 2019 with YESAB, has been modified to focus on the non-contact water channel component of the NFRC Realignment project, and/or other construction actives related to project (e.g., construction in the Zone 2 Dump and Intermediate Dump areas). Action levels have been revised to focus on aquatic life protection and strengthen functionality for providing early warning of potential aquatic life impacts. NFRC-3 now includes a new exposure station (from NF-SW010 to the realignment outlet), and addition of an upstream baseline station (NF-SW003). The addition of station NF-SW003 provides a baseline for calculating mass loading and determining whether trigger exceedances are due specifically to impacts occurring within the North Fork Rose Creek Realignment. |
| | NFRC-4 | To evaluate whether surface water downstream of the North Fork Rose Creek Realignment has been influenced by several contact water sources (e.g., bypass of the S-Wells SIS, bypass from the North Fork Rose Creek CWIM, or unmanaged groundwater impacted by the Main Dump or Intermediate Dump areas), and/or construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. | Surface water quality, hydrology, groundwater | NFRC-4, as described in the Project AMP filed in 2019 with YESAB, has been modified to focus on the contact water collection and conveyance component of the North Fork Rose Creek Realignment project, and/or other construction activities associated with the Project (e.g., construction in the Intermediate Dump and Main Dump areas). Action levels have been revised to focus on aquatic life protection and strengthen functionality for providing early warning of potential aquatic life impacts related to multiple contact water contributions, including bypass of the S-Wells SIS, bypass of the North Fork Rose Creek CWIM, and inputs from unmanaged groundwater impacted by the Main Dump area. NFRC-4 now includes both surface water and groundwater stations as well as both an exposure and baseline station. Action levels are applicable to surface water conditions at the exposure station, whereas groundwater stations are used to provide early warning of an emerging issue or changing condition. The addition of the North Fork Rose Creek Realignment outlet station also provides a baseline for calculating mass loading and determining whether trigger exceedances are due to AMI specific sources. |

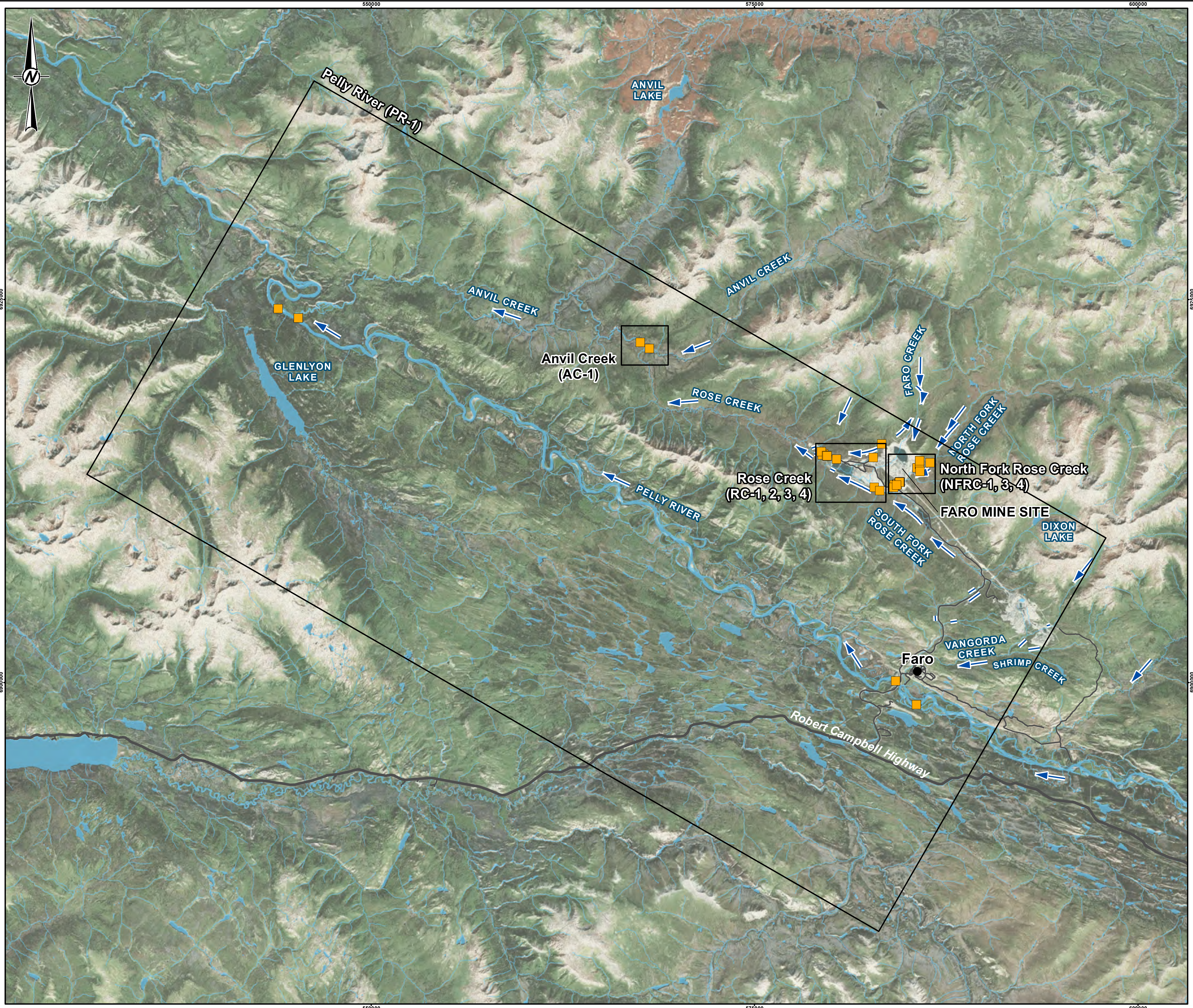
**Table 4-1** **Adaptive Management Initiative Descriptions for Project Initiation and Active Remediation**

| Group | AMI# | Purpose | Monitoring | Refinements for Version 2 of the Project AMP |
|---|---|---|---|---|
| Rose Creek (RC) | RC-1 | To evaluate whether surface water in the Rose Creek Diversion has been influenced by seepage or groundwater, and/or construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. | Surface water quality, hydrology | RC-1, as described in the Project AMP filed in 2019 with YESAB, has been modified to evaluate the Rose Creek Diversion Channel as a whole, as opposed to loading only from the Secondary Impoundment. A second exposure station has been added (RC-SW010) to accommodate this change. The addition of station RC-SW001 provides a baseline to calculate mass loading and determine whether trigger exceedances are due to AMI specific sources. Action levels have been revised to focus on aquatic life protection and strengthen functionality for providing early warning of potential aquatic life impacts associated with seepage along the Rose Creek Diversion and/or other construction actives related to project (e.g., upgrades to the Rose Creek Diversion). |
| | RC-2 | To evaluate water quality leaving the NWID channel and whether the combined sources contributing flow to this channel pose a potential risk to aquatic life within Rose Creek. | Surface water quality, hydrology | RC-2, as described in the Project AMP filed in 2019 with YESAB, has been modified to evaluate the cumulative effects from multiple sources of loading to the North Wall Interceptor Ditch, and the potential for this to impact water quality and aquatic life within Rose Creek. Previously, monitoring for this AMI was completed at station DV-SW002, which represents bypass of the X13 SIS and additional groundwater seepage that occurs downstream of the X13 sump. The exposure station has now been changed to NW-SW003, which represents the combined loadings to the North Wall Interceptor Ditch channel prior to its discharge to Rose Creek. Additional source stations have been added to facilitate mass load calculations and allow tracking of the relative contribution from each source. Action levels have now been revised to use concentration limits derived through surface water model predictions. These predictions represent the minimum concentrations expected to result in action level exceedances in Rose Creek. Toxicity sampling and screening relative to acute water quality guidelines have also been incorporated as an action level trigger. |
| | RC-3 | To evaluate groundwater quality in the Down Valley Area and whether groundwater seepage poses a potential risk to aquatic life in Rose Creek. | Groundwater | RC-3, as described in the Project AMP filed in 2019 with YESAB, has been modified to evaluate the potential for groundwater seepage in the down valley Rose Creek area to impact water quality and aquatic life within Rose Creek. Previously, RC-3 used deviation from baseline groundwater concentrations to developing action levels. Action levels have been revised to use concentration limits derived through surface water and groundwater model predictions. These predictions represent the minimum groundwater concentrations expected to result in action level trigger exceedances in Rose Creek. |
| | RC-4 | To evaluate the combined loadings from the Faro Mine Site and whether changes in water quality due to the Site pose a potential risk to aquatic life in Rose Creek. | Surface water quality, hydrology, toxicity | RC-4, as described in the Project AMP filed in 2019 with YESAB, has been refined to evaluate the combined loading from the Faro Mine Site. Action levels have been revised to focus on aquatic life protection and strengthen functionality for providing early warning of potential aquatic life impacts associated with all project activities. RC-4 now includes evaluation of relative mass loading to surface water from each upstream AMI (i.e., NFRC-1, NFRC-3, NFRC-4, RC-1, and RC-2). Toxicity sampling has also been incorporated as an action level trigger. |

**Table 4-1** **Adaptive Management Initiative Descriptions for Project Initiation and Active Remediation**

| Group | AMI# | Purpose | Monitoring | Refinements for Version 2 of the Project AMP |
|---|---|---|---|---|
| Anvil Creek | AC-1 | To evaluate the impact of the Faro Mine Site on water quality in Anvil Creek and whether this poses a potential risk to aquatic life. | Surface water quality, hydrology | AC-1 is a newly proposed surface water AMI in response to engagement feedback. This AMI has been added to evaluate impacts from the Faro Mine Site on water quality in Anvil Creek. Action levels have been developed to focus on aquatic life protection and strengthen functionality for providing early warning of potential aquatic life impacts associated with all project activities. AC-1 includes both an exposure and reference station, which are used to calculate mass loading and determine whether trigger exceedances are due to the Site. |
| Pelly River | PR-1 | To evaluate the impact of the Faro Mine Site on water quality in the Pelly River and whether this constitutes a change from natural variation (i.e., violation of the non-degradation goal). | Surface water quality | PR-1 is a newly proposed surface water AMI in response to engagement feedback. This AMI has been added to evaluate impacts from the Faro Mine Site on water quality in the Pelly River. Action levels have been developed to focus on whether this influence from the site constitutes a change from natural variation and a violation of the non-degradation goal. PR-1 includes both an exposure and baseline station, as well as two additional stations used to help determine whether trigger exceedances are due to the Faro Mine Site. |

PR = Pelly River; AN= Anvil Creek; NFRC = North Fork Rose Creek; RC = Rose Creek; NWID = North Wall Interceptor Ditch; seepage Interception System.




**LEGEND**

- MONITORING STATION
- TOWN
- DIRECTION OF FLOW
- HIGHWAY
- ROAD
- WATERCOURSE
- WATERBODY


0 5 10
1:250,000 KILOMETRES

**REFERENCE(S)**

1. IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.
DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
**OVERVIEW OF LOCATIONS OF ADAPTIVE MANAGEMENT INITIATIVES FOR THE FARO MINE SITE**

CONSULTANT
GOLDER MEMBER OF WSP

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| YYYY-MM-DD | 2021-07-15 |
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| PREPARED | LH |
| REVIEWED | HM |
| APPROVED | HM |

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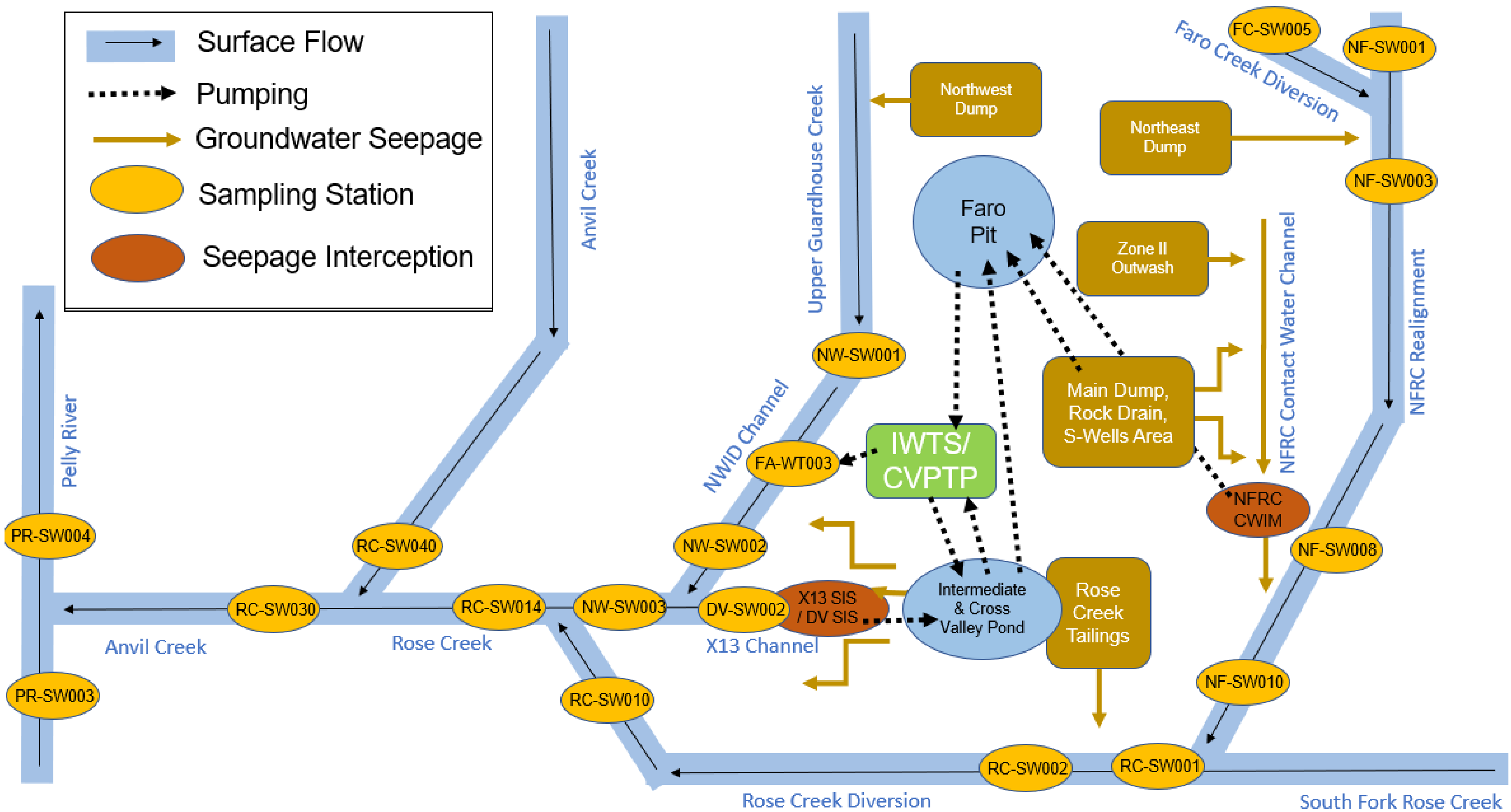
## 4.4 Conceptual Overview of Monitoring Stations and Flow Paths

To support an understanding of how site flows connect to monitoring stations, a conceptual figure is provided (Figure 4-5). This is applicable to conditions at project initiation and the first few years of active remediation. An updated figure(s) can be developed for the later years of active remediation and for long term operations and maintenance.

**Figure 4-5 Conceptual overview of the Site flow paths for the Faro Mine Site during Project Initiation and first years of Active Remediation**

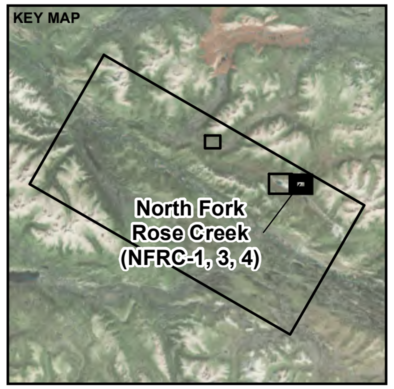


# 5.0 AMIs: North Fork Rose Creek Area

There are three AMIs for the North Fork Rose Creek. Figure 5-1 provides and overview of the monitoring locations in this area. Each AMI is outlined below in detail.


LEGEND

- NFRC-1 GROUNDWATER MONITORING STATION
- NFRC-1 SURFACE WATER MONITORING STATION
- NFRC-1/NFRC-3 SURFACE WATER MONITORING STATION
- NFRC-3/NFRC-4 SURFACE WATER MONITORING STATION
- NFRC-4 GROUNDWATER MONITORING STATION
- NFRC-4 SURFACE WATER MONITORING STATION
- ROAD
- DIRECTION OF FLOW
- WATERCOURSE
- WATERBODY




0 200 400
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REFERENCE(S)
1. MINE ROADS, WATERCOURSES OBTAINED FROM CH2MHILL.
2. AERIAL PHOTOGRAPHY ACQUIRED BY PEREGRINE AERIAL SURVEYORS INC. AND EAGLE MAPPING IN AUGUST 2012.
3. ORTHOPHOTOGRAPHY PREPARED BY CRITIGEN CANADA CORP.
4. INSET DATA OBTAINED FROM YUKON GEOMATICS.
DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
NFRC-1, 3 AND 4: LOCATION RELATIVE TO SITE FEATURES

CONSULTANT
GOLDER
MEMBER OF WSP

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| YYYY-MM-DD | 2021-07-15 |
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| APPROVED | HM |

| PROJECT NO. | PHASE | REV. | FIGURE |
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## 5.1 NFRC-1: Impacts on Water Quality in Upper North Fork Rose Creek

The Faro Creek Diversion and upper North Fork Rose Creek are part of a non-contact water conveyance system within the Northeast perimeter water management area (Section 5.0 Project Description: Non-contact Water Management Infrastructure). Throughout the life cycle of the Project, these channels will divert clean surface water through and around the Faro Mine Site. Currently, no groundwater and or seepage interception measures are planned for this area. Groundwater quality has degraded at some locations in the North East Rock Dump area and there is uncertainty around the potential for mine-impacted seepage to influence surface water quality in North Fork Rose Creek. The Faro Mine Remediation Plan also consists of several project components that have potential to temporarily influence surface water quality in this area, these include borrow development activities, extension, relocation and upgrade to the Faro Creek Diversion, as well as stabilization, landforming, and cover construction in the North East Rock Dump area.

At Project initiation, NFRC-1 will evaluate whether surface water entering the North Fork Rose Creek Realignment has been impacted by the Faro Mine Site and provides action levels to respond if this poses a potential risk to aquatic life. As the Project evolves through active remediation, NFRC-1 may be deactivated during instream construction works (e.g., upgrade to the Faro Creek Diversion). Following instream works, NFRC-1 will continue to evaluate surface water entering the North Fork Rose Creek Realignment, including whether other active remediation activities may be causing impacts to water quality in North Fork Rose Creek. Once remediation in this area is complete, NFRC-1 will use reduced action levels to verify that Project is performing as expected and that water entering the North Fork Rose Creek Realignment continues to reflect non-contact water conditions and does not pose a potential risk to aquatic life. Table 5-1 summarizes the indicators, triggers and monitoring for this AMI.

**Table 5-1 NFRC-1 Indicators, Action Levels, Monitoring and Responses**

| | |
|---|---|
| **Watercourse** | North Fork Rose Creek |
| **AMI** | NFRC-1: Impacts on Water Quality in Upper North Fork Rose Creek |
| **Purpose** | To evaluate whether water entering the North Fork Rose Creek Realignment has been influenced by the North East Rock Dump and/or construction activities associated with the Faro Mine Remediation Project, and whether these sources pose a potential risk to aquatic life. |
| **Risk or Project Uncertainty** | Mine-impacted seepage or groundwater, or other construction related sources, have the potential to impact surface water quality and aquatic life in upper North Fork Rose Creek. NFRC-1 has been established to manage risk and uncertainty around the magnitude and timing of these potential impacts. |
| **Significance Threshold** | **Active Remediation:** Moderate Effect Benchmarks – concentrations at which a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes. **Long-term Operations & Maintenance (Draft):** Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. |
| **Stations** | **Surface Water:** NF-SW001 (reference), NF-SW004 (exposure), FC-SW005 (supporting); **Groundwater**: FA-MW0021, FA-MW0022, FA-MW0023, FA-MW0002B, FA-MW0003A, FA-MW0003B, FA-MW0020, and FA-MW0019 (supporting). |
| **Indicators** | sulphate, total iron, dissolved iron, dissolved manganese, dissolved zinc |
| **Modifying Factors** | pH, hardness (as $CaCO_3$), dissolved organic carbon |

**Table 5-1 NFRC-1 Indicators, Action Levels, Monitoring and Responses**

<table>
<tr><td>Monitoring</td><td colspan="3">Surface Water: water quality samples are collected monthly from stations NF-SW001, NF-SW004 and FC-SW005. Hydrology: Discharge measurements are completed monthly at stations NF-SW001, NF-SW004 and FC-SW005 in unison with water quality sample collection. Field Instructions: surface water quality sampling and discharge measurements are completed as a synoptic sampling program (i.e., monthly monitoring is completed within a 24-hour period of consistent weather conditions). Groundwater: groundwater quality samples are collected biannually from six wells; FA-MW021, FA-MW022, FA-MW023, FA-MW002B, FA-MW003A, and FA-MW003B. Groundwater samples are collected during the following months, June and September. Details on the full suite of analytical parameters are provided in Appendix D.</td></tr>
<tr><td>Evaluation of Monitoring Results</td><td colspan="3">Monthly analysis will be completed in two steps. Step 1 - Compare monthly surface water quality for station NF-SW004 to AMP triggers (see below), Step 2 - Verify that trigger exceedances observed at station NF-SW004 are due to the Site, using station NF-SW001 as the reference. Three additional steps will be completed as part of an annual analysis; Step 3 - Evaluate mass loading at stations NF-SW001, NF-SW004 and FC-SW005. Mass loading will be calculated using monthly surface water quality samples and discharge measurements and used to evaluate relative source contributions, Step 4 - Evaluate trends in groundwater quality in the North East Rock Dump Area, including a winter trend review as data permits, and Step 5 - Evaluate trends in surface water quality at stations NF-SW001, NF-SW004, and FC-SW005. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required.</td></tr>
<tr><td>Project Phases</td><td colspan="3">Active Remediation: Active remediation triggers will remain applicable throughout construction activities in this area. This includes extension, relocation, and upgrade to the Faro Creek Diversion, as well as stabilization, landforming, and cover construction in the North East Rock Dump area. Following completion of this work, long-term operations and maintenance triggers will be revised through AMP updates and regulatory approvals.<br>Long-term Operations & Maintenance: Long-term operations and maintenance triggers are applicable.</td></tr>
<tr><td>Action Level</td><td>Active Remediation Triggers</td><td>Long-term Operations and Maintenance Triggers (Draft)[b]</td><td>Possible Management Response</td></tr>
<tr><td>LOW</td><td>>SSWQO[a] at station NF-SW004 due to the Site, confirmed for 4 monthly samples collected within a year</td><td>>75% SSWQO[a] at station NF-SW004 due to the Site, confirmed for 4 monthly samples collected within a year</td><td rowspan="3">Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, potential 'tools' appropriate for this area include:<br>• North Fork Rose Creek contingency measures to line upper reach<br>• construction of cut-off wall<br>• consider advancing the waste rock cover design (as per the Faro Mine Remediation Plan) to facilitate early implementation<br>• construction of additional groundwater capture, and/or mobile treatment<br>• evaluation of construction water management controls</td></tr>
<tr><td>MODERATE</td><td>>75% of low-effect benchmark[a] at station NF-SW004 due to the Site, confirmed for 3 monthly samples collected within a year</td><td>>SSWQO[a] at station NF-SW004 due to the Site, confirmed for 3 monthly samples collected within a year</td></tr>
<tr><td>HIGH</td><td>>Low-effect benchmark[a] at station NF-SW004 due to the Site, confirmed for 2 monthly samples collected within a year</td><td>>75% of Low-effect benchmark[a] at station NF-SW004 due to the Site, confirmed for 2 monthly samples collected within a year</td></tr>
</table>

(a) Further details on the development of indicators, benchmarks, and triggers are provided in Appendix C.

(b) Long-term operations and maintenance triggers will be revised through Project AMP updates and regulatory approvals; triggers are expected to be based on post-remediation conditions, with action levels to prevent exceeding SSWQOs or deviation from background conditions observed post remediation.

## 5.2 NFRC-3: Impacts on Water Quality in the North Fork Rose Creek Realignment

The North Fork Rose Creek Realignment Project was designed to separate non-contact surface water in North Fork Rose Creek from contact water impacted by the adjacent waste rock dumps. This work consisted of two components, the non-contact diversion channel (i.e., the North Fork Rose Creek Realignment) and the contact water collection and conveyance system. Construction of the North Fork Rose Creek Realignment was completed as an "urgent works" prior to active remediation. Construction of the project was initiated in 2018 and commissioned in October 2020, this included completion of the non-contact water channel and the first phase of the contact water collection system (i.e., the Contact Water Interim Measure; refer to NFRC-4 for further details). In addition to monitoring the effectiveness of the realignment work, the Faro Mine Remediation Plan includes several other project components that have potential to temporarily influence surface water quality within this channel, these include borrow development activities, stabilization, landforming, and cover construction in the Zone 2 Dump and Intermediate Dump areas, as well as construction of the East Waste Cover Channel, and other construction water management infrastructure planned for the area (e.g., collection channels and sediment control ponds).

At Project initiation, NFRC-3 will evaluate whether water leaving the NFRC non-contact water conveyance system has been impacted by the Faro Mine Site and provides action levels to respond if this poses a potential risk to aquatic life. As the Project evolves through active remediation, NFRC-3 may be deactivated during instream remedial works. Following instream works, NFRC-3 will return to evaluating surface water leaving the non-contact diversion channel, including whether other active remediation activities may be causing impacts to water quality within the new channel. Once remediation in this area is complete, NFRC-3 will use reduced action levels to verify that the Project is performing as expected and that water leaving the North Fork Rose Creek Realignment continues to reflect non-contact water conditions and does not pose a potential risk to aquatic life. Table 5-2 summarizes the indicators, triggers and monitoring for this AMI.

**Table 5-2 NFRC-3 Indicators, Action Levels, Monitoring and Responses**

| | |
|---|---|
| **Watercourse** | North Fork Rose Creek |
| **AMI** | NFRC-3: Impacts on the North Fork Rose Creek Realignment |
| **Purpose** | To evaluate whether water leaving the North Fork Rose Creek Realignment (i.e., non-contact diversion channel) has been influenced by mine-impacted seepage or groundwater, and/or other construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. |
| **Risk or Project Uncertainty** | Mine-impacted seepage or groundwater, and other construction activities associated with the Project, have the potential to impact surface water quality and aquatic life in the North Fork Rose Creek Realignment. NFRC-3 has been established to manage risk and uncertainty around the magnitude and timing of these potential impacts. |
| **Significance Threshold** | **Active Remediation:** Moderate Effect Benchmarks – concentrations at which a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes.<br>**Long-term Operations & Maintenance (Draft):** Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. |
| **Stations** | **Surface Water:** NF-SW004 (baseline) and NF-SW008 (exposure) |
| **Indicators** | sulphate, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, dissolved zinc |
| **Modifying Factors** | pH, hardness (as $CaCO_3$), dissolved organic carbon |
| **Monitoring** | **Surface Water:** water quality samples are collected monthly from stations NF-SW004 and NF-SW008. **Hydrology:** Discharge measurements are completed monthly at stations NF-SW004 and NF-SW008 in unison with water quality sample collection.<br>**Field Instructions:** surface water quality sampling and discharge measurements are completed as a synoptic sampling program (i.e., monthly monitoring for both stations is completed within a 24-hour period of consistent weather conditions). Details on the full suite of analytical parameters are provided in Appendix D. |

### Table 5-2 NFRC-3 Indicators, Action Levels, Monitoring and Responses

<table>
<tr><td>Evaluation of Monitoring Results</td><td colspan="3">Monthly analysis will be completed in two steps; Step 1 - Compare monthly surface water quality for station NF-SW008 to AMP triggers (see below), Step 2 - Verify that trigger exceedances observed at station NF-SW008 are due to AMI specific sources, using station NF-SW004 as the baseline. Two additional steps will be completed as part of an annual analysis; Step 3 - Evaluate mass loading at stations NF-SW004 and NF-SW008. Mass loading will be calculated using monthly surface water quality samples and discharge measurements and used to evaluate relative source contributions, Step 4 - Evaluate trends in surface water quality at stations NF-SW004 and NF-SW008; including a winter trend review as data permits. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required.</td></tr>
<tr><td>Project Phases</td><td colspan="3">Active Remediation: Active remediation triggers will remain applicable throughout construction activities in this area. This includes borrow development activities, stabilization, landforming, and cover construction in the Zone 2 Dump and Intermediate Dump areas, as well as construction of the East Waste Cover Channel, and other construction water management infrastructure planned for the area (e.g., collection channels and sediment control ponds). Following completion of this work, long-term operations and maintenance triggers will be revised through AMP updates and regulatory approvals. Long-term Operations & Maintenance: Long-term operations and maintenance triggers are applicable.</td></tr>
<tr><td>Action Level</td><td>Active Remediation Triggers</td><td>Long-term Operations and Maintenance Triggers (Draft)[b]</td><td>Possible Management Response</td></tr>
<tr><td>LOW</td><td>>SSWQO[a] at station NF-SW008 due to AMI specific sources, confirmed for 4 monthly samples collected within a year</td><td>>75% SSWQO[a] at station NF-SW008 due to AMI specific sources, confirmed for 4 monthly samples collected within a year</td><td rowspan="3">Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<br>• investigate the source internal to the realigned channel and take measures to isolate source<br>• liner placement or repairs<br>• groundwater or seepage interception<br>• material replacement<br>• evaluation of construction water management controls</td></tr>
<tr><td>MODERATE</td><td>>75% of low-effect benchmark[a] at station NF-SW008 due to AMI specific sources, confirmed for 3 monthly samples collected within a year</td><td>>SSWQO[a] at station NF-SW008 due to AMI specific sources, confirmed for 3 monthly samples collected within a year</td></tr>
<tr><td>HIGH</td><td>>Low-effect benchmark[a] at station NF-SW008 due to AMI specific sources, confirmed for 2 monthly samples collected within a year</td><td>>75% of Low-effect benchmark[a] at station NF-SW008 due to AMI specific sources, confirmed for 2 monthly samples collected within a year</td></tr>
</table>

(a) Further details on the development of indicators, benchmarks, and triggers are provided in Appendix C.

(b) Long-term operations and maintenance triggers will be revised through Project AMP updates and regulatory approvals; triggers are expected to be based on post-remediation conditions, with action levels to prevent exceeding SSWQOs or deviation from background conditions observed post remediation.

## 5.3 NFRC-4: Impacts on Water Quality Downstream of the North Fork Rose Creek Realignment

Downstream of the North Fork Rose Creek Realignment (i.e., the non-contact diversion channel), North Fork Rose Creek has the potential to be impacted by several contact water sources, these include bypass of the S-Wells SIS, bypass from the North Fork Rose Creek contact water conveyance system, or unmanaged groundwater impacted by adjacent waste rock dumps. Currently (2021) contact water continues to be captured by the S-Wells pumped to the Faro Pit. Construction of the North Fork Rose Creek Realignment was completed in mid-November 2020, and construction of the Contact Water Interim Measure (CWIM) was completed through November and December 2020. Completion of CWIM represents the first phase of a multi-phased design. The CWIM includes an excavated trench, sump, pumphouse, and conveyance pipeline, designed to intercept seepage along the old North Fork Rose Creek creek bed and convey a portion of this seepage to the Faro Pit for storage and treatment. The Faro Mine Remediation Plan also consists of several Project components that have potential to temporarily influence surface water quality downstream of the North Fork Rose Creek Realignment, these include borrow development activities, stabilization, landforming, and cover construction in the Intermediate Dump and Main Dump areas, as well as other construction water management infrastructure planned for the area (e.g., collection channels and sediment control ponds).

At Project initiation, NFRC-4 evaluates whether water quality downstream of the North Fork Rose Creek Realignment has been impacted by the Site and provides action levels to respond if this poses a potential risk to aquatic life. Action levels for NFRC-4 will be used to trigger upgrade of the CWIM, and/or implementation of the full North Fork Rose Creek Contact Water Conveyance System. If action levels are not triggered, the full North Fork Rose Creek Contact Water Conveyance System will be implemented as currently scheduled as part of the overall remediation plan. As the Project evolves through active remediation, NFRC-4 will also evaluate whether construction during active remediation may be causing impacts to water quality in this area. NFRC-4 may also be temporarily deactivated during instream construction activities. Once remediation in this area is complete, NFRC-4 will use reduced action levels to verify that the Project is performing as expected and that contact water in this area is effectively managed to mitigate potential effects to aquatic life. Table 5-3 summarizes the indicators, triggers and monitoring for this AMI.

**Table 5-3 NFRC-4 Indicators, Action Levels, Monitoring and Responses**

| | |
|---|---|
| **Watercourse** | North Fork Rose Creek |
| **AMI** | NFRC-4: Impacts on Water Quality Downstream of the North Fork Rose Creek Realignment |
| **Purpose** | To evaluate whether surface water downstream of the North Fork Rose Creek Realignment has been influenced by contact water sources (e.g., bypass of the S-Wells SIS, bypass from the North Fork Rose Creek CWIM, or unmanaged groundwater impacted by the Main Dump or Intermediate Dump areas), and/or construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. |
| **Risk or Project Uncertainty** | Mine-impacted seepage or groundwater, or other construction activities associated with the Project, have the potential to impact surface water quality and aquatic life downstream of the North Fork Rose Creek Realignment. NFRC-4 has been established to manage risk and uncertainty around the magnitude and timing of these potential impacts. |
| **Significance Threshold** | **Active Remediation:** Moderate Effect Benchmarks – concentrations at which a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes. **Long-term Operations & Maintenance (Draft):** Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. |

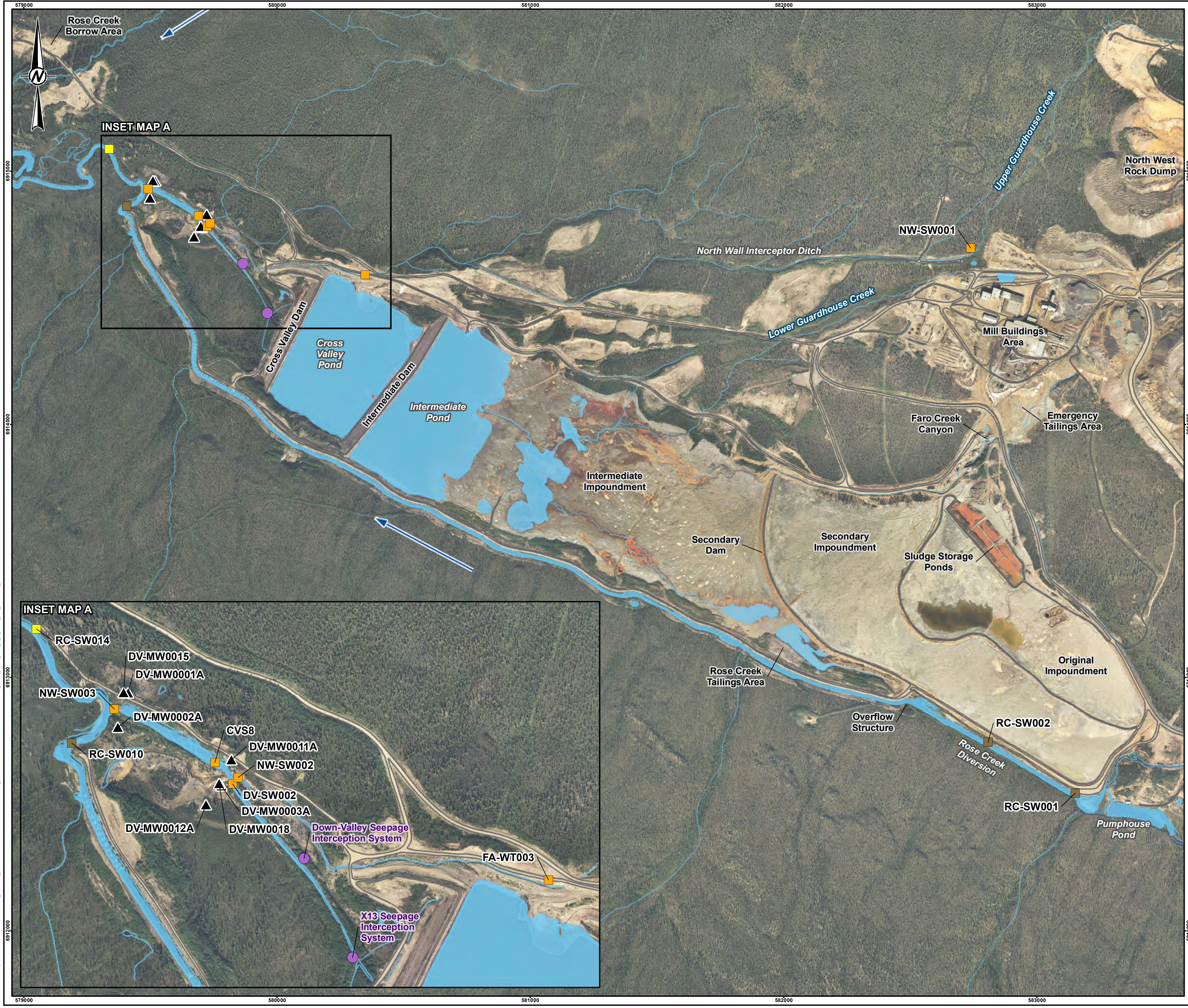
**Table 5-3 NFRC-4 Indicators, Action Levels, Monitoring and Responses**

| | | | |
|---|---|---|---|
| **Stations** | **Surface Water:** NF-SW008 (baseline) and NF-SW010 (exposure); Groundwater: FA-MW1005, FA-MW1008, FA-MW1009, FA-MW1001A, FA-MW1001B, FA-MW1003, FA-MW1018A, FA-MW1027A, FA-MW1027B, FA-MW1004, FA-MW1115, FA-MW1116, FA-MW1117, FA-MW1118, FA-MW1119, and FA-MW1120 (supporting). | | |
| **Indicators** | sulphate, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, dissolved zinc | | |
| **Modifying Factors** | pH, hardness (as $CaCO_3$), dissolved organic carbon | | |
| **Monitoring** | **Surface Water:** water quality samples are collected monthly from stations NF-SW008 and NF-SW010. **Hydrology:** Discharge measurements are completed monthly at stations NF-SW008 and NF-SW010 in unison with water quality sample collection. **Field Instructions:** surface water quality sampling and discharge measurements are completed as a synoptic sampling program (i.e., monthly monitoring for both stations is completed within a 24-hour period of consistent weather conditions). Details on the full suite of analytical parameters are provided in Appendix D. | | |
| **Evaluation of Monitoring Results** | Monthly analysis will be completed in two steps. **Step 1** - Compare monthly surface water quality for station NF-SW010 to AMP triggers (see below), **Step 2** - Verify that trigger exceedances observed at station NF-SW010 are due to AMI specific sources, using station NF-SW008 as the baseline. Three additional steps will be completed as part of an annual surface water analysis; **Step 3** - Evaluate mass loading at stations NF-SW008 and NF-SW010. Mass loading will be calculated using monthly surface water quality samples and discharge measurements and used to evaluate relative source contributions, **Step 4 -** Evaluate trends in groundwater quality at the specified monitoring wells, and **Step 5** - Evaluate trends in surface water quality at stations NF-SW008 and NF-SW010 including a winter trend review as data permits. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required. | | |
| **Project Phases** | **Active Remediation:** Active remediation triggers will remain applicable throughout construction activities in this area. This includes borrow development activities, stabilization, landforming, and cover construction in the Intermediate Dump and Main Dump areas, as well as other construction water management infrastructure planned for the area (e.g., collection channels and sediment control ponds). Following completion of this work, long-term operations and maintenance triggers will be revised through AMP updates and regulatory approvals. **Long-term Operations & Maintenance:** Long-term operations and maintenance triggers are applicable. | | |
| **Action Level** | **Active Remediation Triggers** | **Long-term Operations and Maintenance Triggers (Draft)[b]** | **Possible Management Response** |
| **LOW** | >SSWQO[a] at station NF-SW010 due to AMI specific sources, confirmed for 4 monthly samples collected within a year | >75% SSWQO[a] at station NF-SW010 due to AMI specific sources, confirmed for 4 monthly samples collected within a year | Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<br>• Upgrade Contact Water Interim Measure,<br>• Implement full North Fork Rose Creek Contact Water Conveyance System,<br>• Evaluation of construction water management controls. |
| **MODERATE** | >75% of low-effect benchmark[a] at station NF-SW010 due to AMI specific sources, confirmed for 3 monthly samples collected within a year | >SSWQO[a] at station NF-SW010 due to AMI specific sources, confirmed for 3 monthly samples collected within a year | |
| **HIGH** | >Low-effect benchmark[a] at station NF-SW010 due to AMI specific sources, confirmed for 2 monthly samples collected within a year | >75% of Low-effect benchmark[a] at station NF-SW010 due to AMI specific sources, confirmed for 2 monthly samples collected within a year | |

(a) Further details on the development of indicators, benchmarks, and triggers are provided in Appendix C.
(b) Long-term operations and maintenance triggers will be revised through Project AMP updates and regulatory approvals; triggers are expected to be based on post-remediation conditions, with action levels to prevent exceeding SSWQOs or deviation from background conditions observed post remediation.
SSWQO = site-specific water quality objective; NFRC = North Fork Rose Creek; AMI = Adaptive Management Initiatives.

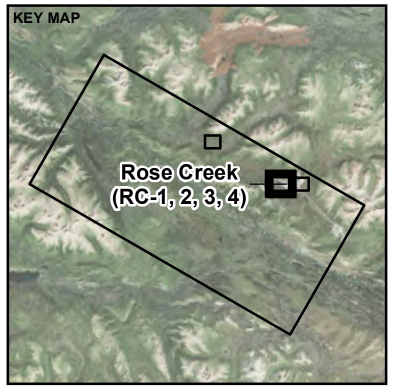
## 6.0 AMIs: Rose Creek Area

There are four AMIs for Rose Creek. Figure 6-1 provides and overview of the monitoring locations in this area. Each AMI is outlined below in detail.




LEGEND

- RC-1 SURFACE WATER MONITORING STATION
- RC-2 SURFACE WATER MONITORING STATION
- RC-4 SURFACE WATER MONITORING STATION
- GROUNDWATER STATION
- SEEPAGE INTERCEPTION SYSTEM
- ROAD
- DIRECTION OF FLOW
- WATERCOURSE
- WATERBODY




0 300 600

1:15,000 METRES

REFERENCE(S)
1. MINE ROADS, WATERCOURSES OBTAINED FROM CH2MHILL.
2. AERIAL PHOTOGRAPHY ACQUIRED BY PEREGRINE AERIAL SURVEYORS INC. AND EAGLE MAPPING IN AUGUST 2012.
3. ORTHOPHOTOGRAPHY PREPARED BY CRITIGEN CANADA CORP.
4. INSET DATA OBTAINED FROM YUKON GEOMATICS.
DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
RC-1, 2, 3 AND 4 - LOCATION RELATIVE TO SITE FEATURES

CONSULTANT

GOLDER MEMBER OF WSP

| | |
|---|---|
| YYYY-MM-DD | 2021-07-15 |
| DESIGNED | AN |
| PREPARED | LH |
| REVIEWED | HM |
| APPROVED | HM |

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 21454941 | 9000/9500 | 0 | 6-1 |

## 6.1 RC-1: Impacts on Water Quality Along the Rose Creek Diversion

The Rose Creek Diversion conveys non-contact water around the Rose Creek Tailings Area. This diversion will be redesigned as part of the Faro Mine Remediation Plan to increase flood conveyance capacity and prevent failure of the Intermediate Dam and release of tailings to the receiving environment. Construction activities associated with the Rose Creek Diversion have the potential to temporarily influence water quality in Rose Creek. These included construction activities directly associated with the channel redesign, as well as other project components required in the area (e.g., tailings landforming, borrow development, tie-in of North Fork Rose Creek and SFRC confluence, and east Secondary Dam stabilization). In addition to these planned remediation activities, water quality in the Rose Creek Diversion also has the potential to be influenced by mine-impacted seepage or groundwater occurring along the Secondary Dam. During active and post remediation, the stations currently used to evaluate this AMI will need to be adjusted to accommodate remediation activities within the diversion.

At Project initiation, RC-1 will evaluate whether water quality in the Rose Creek Diversion has been impacted by the Faro Mine Site and provides action levels to respond if this poses a potential risk to aquatic life. During this phase, action levels for RC-1 will be used to trigger planned remediation activities associated with the Rose Creek Diversion. If action levels are not triggered, these activities will be implemented as currently scheduled as part of the overall remediation plan. As the Project evolves through active remediation, RC-1 will evaluate whether remediation activities may be causing impacts to water quality. RC-1 may also be temporarily deactivated during instream construction activities. Once remediation in this area is complete, RC-1 will use reduced action levels to verify that the Project is performing as expected and that the new diversion channel has effectively mitigated the potential for tailings seepage to impact water quality within the diversion. Table 6-1 summarizes the indicators, triggers and monitoring for this AMI.

**Table 6-1 RC-1 Indicators, Action Levels, Monitoring and Responses**

| | |
|---|---|
| **Watercourse** | Rose Creek |
| **AMI** | RC-1: Impacts on Water Quality Along the Rose Creek Diversion |
| **Purpose** | To evaluate whether surface water in the Rose Creek Diversion has been influenced by seepage or groundwater, and/or construction activities associated with the Faro Mine Remediation Project, and whether these potential sources pose a risk to aquatic life. |
| **Risk or Project Uncertainty** | Seepage from the Secondary Impoundment, or other construction activities associated with the Project, may cause contaminant concentrations in the Rose Creek Diversion to increase to levels that pose a potential risk to aquatic life. RC-1 has been established to manage uncertainty around the timing and magnitude of these potential impacts. |
| **Significance Threshold** | **Active Remediation:** Moderate Effect Benchmarks – concentrations at which a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes. **Long-term Operations & Maintenance (Draft):** Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. |
| **Stations** | **Surface Water:** RC-SW001 (baseline), RC-SW002 (exposure) and RC-SW010 (exposure) |
| **Indicators** | sulphate, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, dissolved zinc |
| **Modifying Factors** | pH, hardness (as $CaCO_3$), dissolved organic carbon |
| **Monitoring** | **Surface Water:** water quality samples are collected monthly from stations RC-SW001, RC-SW002, and RC-SW010. **Hydrology:** Discharge measurements are completed monthly at stations RC-SW001, RC-SW002, and RC-SW010 in unison with water quality sample collection. **Field Instructions:** surface water quality sampling and discharge measurements are completed as a synoptic sampling program (i.e., monthly monitoring for both stations is completed within a 24-hour period of consistent weather conditions) with stations associated with AMI RC-1, RC-2, and RC-4. Details on the full suite of analytical parameters are provided in Appendix D. |

**Table 6-1 RC-1 Indicators, Action Levels, Monitoring and Responses**

<table>
<tr><td>Evaluation of Monitoring Results</td><td colspan="3">Monthly analysis will be completed in two steps; Step 1 - Comparison of monthly surface water quality for stations RC-SW002 and RC-SW010 to AMP triggers (see below), Step 2 - Verify that trigger exceedances observed at stations RC-SW002 and RC-SW010 are due to AMI specific sources, using station RC-SW001 as the baseline. Two additional steps will be completed as part of an annual analysis; Step 3 - Evaluate mass loading at stations RC-SW001, RC-SW002 and RC-SW010. Mass loading will be calculated using monthly surface water quality samples and discharge measurements and used to evaluate relative source contributions, and Step 4 - Evaluate trends in surface water quality at stations RC-SW001, RC-SW002, and RC-SW010; including a winter trend review as data permits. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required.</td></tr>
<tr><td>Project Phases</td><td colspan="3">Active Remediation: Active remediation triggers will remain applicable throughout construction activities in this area. This includes construction activities directly associated with the channel design, as well as other project components required in the area (e.g., tailings landforming, borrow development, tie-in of North Fork Rose Creek and SFRC confluence, and east Secondary Dam stabilization). Following completion of this work, long-term operations and maintenance triggers will be revised through AMP updates and regulatory approvals. Long-term Operations & Maintenance: Long-term operations and maintenance triggers are applicable.</td></tr>
<tr><td>Action Level</td><td>Active Remediation Triggers</td><td>Long Term Operations and Maintenance Triggers (Draft)(b)</td><td>Possible Management Response</td></tr>
<tr><td>LOW</td><td>>SSWQO(a) at station RC-SW010 or RC-SW002 due to AMI specific sources, confirmed for 4 monthly samples collected within a year</td><td>>75% SSWQO(a) at RC-SW010 or RC-SW002 due to AMI specific sources, confirmed for 4 monthly samples collected within a year</td><td rowspan="3">Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<br>• Expand monitoring to confirm contaminate source and location.<br>• Isolate source using liners, barriers or interception/pumping where practical.<br>• If pre-remediation, implement the final remediation plan sooner than scheduled, where feasible.<br>• If post remediation - investigate the source to the diversion channel and take measures to isolate source.<br>• Liner placement or repairs, material replacement.<br>• Evaluation of construction water management controls.</td></tr>
<tr><td>MODERATE</td><td>>75% of low-effect benchmark(a) at station RC-SW010 or RC-SW002 due to AMI specific sources, confirmed for 3 monthly samples collected within a year</td><td>>SSWQO(a) at station RC-SW010 or RC-SW002 due to AMI specific sources, confirmed for 3 monthly samples collected within a year</td></tr>
<tr><td>HIGH</td><td>>Low-effect benchmark(a) at station RC-SW010 or RC-SW002 due to AMI specific sources, confirmed for 2 monthly samples collected within a year</td><td>>75% of Low-effect benchmark(a) at station RC-SW010 or RC-SW002 due to AMI specific sources, confirmed for 2 monthly samples collected within a year</td></tr>
</table>

(a) Further details on the development of indicators, benchmarks, and triggers are provided in Appendix C.

(b) Long-term operations and maintenance triggers will be revised through Project AMP updates and regulatory approvals; triggers are expected to be based on post-remediation conditions, with action levels to prevent exceeding SSWQOs or deviation from background conditions observed post remediation.

SSWQO = site-specific water quality objective; AMI = Adaptive Management Initiative; AMP = Adaptive Management Plan.

## 6.2 RC-2: Impacts from North Wall Interceptor Ditch on Water Quality in Rose Creek

The North Wall Interception Ditch is an operational channel that currently receives contributing flow from several contact-water sources, including bypass from the X13 SIS and other surface water flows from the X13 channel, additional groundwater seepage to the X13 or North Wall Interceptor Ditch (NWID) channel, seasonal discharge from the Interim Water Treatment System, and surface water flows from Upper Guardhouse Creek, which has potential to be impacted by Northwest Rock Dump seepage. Several project components planned in this area will permanently influence future water quality conditions in the NWID, these include implementation of additional phases of the Down Valley SIS (i.e., Short-term and full Down Valley SIS), and the addition of effluent discharge from the Cross Valley Pond Treatment Plant. Other planned remediation activities have potential to temporary influence water quality in NWID, such as construction activities associated with the removal of Upper Northwest Dump toe from Upper Guardhouse Creek, removal of Lower Parking Lot waste rock dump in upper NWID, as well as stabilization, landforming, and cover construction in the Northwest Dump and Mill areas. During the active remediation period, the existing NWID will be maintained to convey water for the West Tailings Channel, Intermediate Dam Spillway, and Down Valley Diversion. Near the end of active remediation, the NWID will be breached to re-establish the connection between Upper and Lower Guardhouse Creek.

At Project Initiation and during active remediation, this AMI evaluates water leaving the NWID channel and whether NWID poses a potential risk to aquatic life within Rose Creek. To evaluate this potential, RC-2 uses concentrations limits derived through surface water model predictions (Appendix C). These predictions represent the minimum concentrations expected to result in Action Level trigger exceedances in Rose Creek (see RC-4). Action levels for RC-2 are currently considered interim. This is because concentration limits are based on model predictions that include assumptions about existing constituent loading, surface water flow, and seepage capture. Concentration limits therefore require annual update to maintain applicability to existing conditions; they will be reviewed and updated at project initiation and annually thereafter throughout active remediation. Quarterly toxicity sampling, and monthly comparisons to acute water quality guidelines, are also completed to confirm discharge from NWID is not acutely toxic to aquatic life. Although the contribution of multiple sources to NWID creates a challenge for developing an AMI at this location, uncertainty concerning the cumulative effects of these sources on water quality in Rose Creek requires an adaptive management approach. Several source monitoring stations have currently been selected to assist with source identification. Source stations will need to be adjusted during active remediation as various project components become operational. During post-remediation, NWID will no longer discharge to the environment and RC-2 will be reviewed to determine an appropriate time to discontinue this AMI.

**Table 6-2 RC-2 Indicators, Action Levels, Monitoring and Responses (Interim)**

| | |
|---|---|
| **Watercourse** | Rose Creek |
| **AMI** | **RC-2:** Impacts from North Wall Interceptor Ditch (NWID) on Water Quality in Rose Creek |
| **Purpose** | To evaluate water quality leaving the NWID channel and whether the combined sources contributing flow to this channel pose a potential risk to aquatic life within Rose Creek. |
| **Risk or Project Uncertainty** | Outflow from the NWID represents the combined loading from multiple contact water sources that may pose a potential risk to aquatic life. RC-2 has been established to manage uncertainty around the cumulative effects of these sources, and the potential for this to impact water quality and aquatic life within Rose Creek. |
| **Significance Threshold** | **Active Remediation:** Moderate Effect Concentration Limits- Concentrations indicate potential of exceeding the moderate effect benchmark in Rose Creek (station RC-SW014). Moderate Effect Benchmarks are interpreted to represent a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes. **Long-term Operations & Maintenance (Draft):** RC-2 will be discontinued during post-remediation. |
| **Stations** | **Surface Water:** NW-SW003 (exposure), NW-SW002 (supporting), DV-SW002 (supporting), FA-WT003 (supporting), NW-SW001 (supporting), CVS8 (supporting) |
| **Indicators[(a)]** | sulphate, total ammonia[(a)], dissolved cadmium[(a)], total cobalt[(a)], total iron, dissolved iron, dissolved manganese[(a)], dissolved zinc[(a)] |
| **Modifying Factors[(c)]** | pH, temperature, hardness (as $CaCO_3$), dissolved organic carbon. |
| **Monitoring** | **Surface Water:** water quality samples are collected monthly from stations NW-SW003, NW-SW002, DV-SW002, FA-WT003, and NW-SW001. **Hydrology:** Discharge measurements are completed monthly at station NW-SW003, NW-SW002, FA-WT003, NW-SW001, and CVS8, in unison with water quality sample collection. Note that CVS8 is used to estimate discharge at DV-SW002. **Toxicity:** acute toxicity sampling is completed quarterly at station NW-SW003 (March, June, September, and December) in unison with water quality sampling and discharge measurements. **Field Instructions:** monitoring is completed as a synoptic program (i.e., all monitoring is completed within a short timeframe of consistent weather conditions, ideally within a 24-hour period) with stations associated with AMI RC-1 and RC-4. Details on the full suite of analytical parameters are provided in Appendix D. |
| **Evaluation of Monitoring Results** | Monthly analysis will be completed in two steps; **Step 1** – Comparison of monthly surface water quality for station NW-SW003 to AMP triggers (see below), and **Step 2** – Screen monthly surface water quality for station NW-SW003 against acute water quality guidelines (Appendix C). One additional step will be completed as part of a quarterly analysis; **Step 3** - Compare quarterly toxicity results for station NW-SW003 to AMP triggers (see below). Three final steps will be completed as part of an annual analysis; **Step 4** - Evaluate mass loading at stations NW-SW003, NW-SW002, DV-SW002, FA-WT003, and NW-SW001. Mass loading will be calculated using monthly surface water quality samples and discharge measurements and used to evaluate relative source contributions, **Step 5** - Evaluate trends in surface water quality at stations NW-SW003, NW-SW002, DV-SW002, FA-WT003, and NW-SW001, including a winter trend review as data permits, and **Step 6** – Update concentration limits for the following year. Note that concentration limits are subject to several assumptions about the loading sources and flows in the lower North Wall Interception Ditch (NWID) and Rose Creek and need to be updated annually to remain applicable to current conditions. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required. |
| **Project Phases** | **Active Remediation:** Active remediation triggers will remain applicable throughout construction activities in this area. This includes activities such as removal of Upper Northwest Dump toe from Upper Guardhouse Creek, removal of Lower Parking Lot waste rock dump in upper NWID, stabilization, landforming, and cover construction in the Northwest Dump and Mill areas. The concentration limits used for action level triggers will require annual review and update throughout the active remediation period. These updates will include review and revision of model assumptions and source terms to ensure concentration limits remain applicable to current conditions. Following breach of the North Wall Interceptor Ditch and construction activities associated with the West Tailings Channel, Intermediate Dam Spillway, and Down Valley Diversion, RC-2 will be evaluated to determine an appropriate period to discontinue this AMI. **Long-term Operations & Maintenance:** RC-2 will be discontinued. |

### Table 6-2 RC-2 Indicators, Action Levels, Monitoring and Responses (Interim)

<table>
<tr><th>Action Level</th><th>Active Remediation Triggers</th><th>Long-term Operations and Maintenance Triggers (Draft)</th><th>Active Remediation Triggers</th></tr>
<tr><td>LOW</td><td>>low concentration limits at station NW-SW003, confirmed for 4 monthly samples collected within a year</td><td rowspan="3">RC-2 will be discontinued during the post-remediation period.</td><td rowspan="3">Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<ul><li>Adjustments to Interim Water Treatment System.</li><li>Adjustments to Cross Valley Pond – Treatment Plant.</li><li>Temporary suspension or flow pacing of effluent discharge.</li><li>Implement the final remediation plan sooner than scheduled, where feasible (e.g., removal of Upper Northwest Dump toe from Upper Guardhouse Creek).</li><li>Capturing of groundwater or seepage to Upper Guardhouse Creek.</li><li>Possible management responses associate with RC-3.</li></ul></td></tr>
<tr><td>MODERATE</td><td>>moderate concentration limits at station NW-SW003, confirmed for 3 monthly samples collected within a year</td></tr>
<tr><td>HIGH</td><td>>high concentration limits at station NW-SW003, confirmed for 2 monthly samples collected within a year, OR >acute water quality guidelines, OR, acute toxicity in laboratory samples[b]</td></tr>
</table>

(a) Indicates parameters that have acute water quality guidelines. These include a selection of the most recently revised aquatic life guidelines from CCME (1999) and BC MoE (2019).

(b) Acute toxicity is defined as more than 50% mortality in 100% sample in an acute lethality test (e.g., 96-hr rainbow trout test or 48-hr Daphnia magna test)

(C) Modifying factors for RC-2 are not applied directly when comparing monthly surface water quality data to concentration limits. Modifying factors are applied as parameters within the model when developing the concentration limits. Modifying factors are however directly applicable when screening against acute water quality guidelines, as required for the high action level trigger.

AMI = Adaptive Management Initiative; AMP = Adaptive Management Plan; SSWQO = site-specific water quality objective; NWID = North Wall Intercept Ditch.

## 6.3 RC-3: Impacts from Groundwater Seepage in the Down Valley Rose Creek Area

Groundwater seepage containing high concentrations of certain metals (e.g., iron and manganese) is currently reporting from groundwater to surface in the vicinity of the X13 channel, downstream of the Cross Valley Dam. To prevent this contact water from reaching Rose Creek, a surface water capture system was installed in the X13 channel in 2018 and began operation in 2019. An additional short-term capture system (i.e., the short-term Down Valley SIS) will be installed in 2021, with plans to implement the full Down Valley SIS during active remediation.

At Project initiation and during active remediation, the purpose of RC-3 is to evaluate the effectiveness of these capture systems, and the current potential for groundwater seepage in this area to impact aquatic life within Rose Creek. To evaluate this potential, RC-3 uses concentrations limits derived through surface water and groundwater model predictions (Appendix C). These predictions represent the minimum concentrations expected to result in Action Level trigger exceedances in Rose Creek (see RC-4). Action levels for RC-3 are currently considered interim. This is because concentration limits are based on model predictions that include assumptions about existing constituent loading, surface water flow, and seepage capture. Concentration limits therefore require annual update to maintain applicability to existing conditions; they will be reviewed and updated at project initiation and annually thereafter throughout active remediation. During long-term operations and maintenance, RC-3 will be reviewed to evaluate the necessity for maintaining an AMI for this purpose. If the full Down Valley SIS has been shown to effectively manage the potential for seepage impacts to Rose Creek, RC-3 will be discontinued, and management response will be allocated to operational procedures related to the seepage interception systems.

**Table 6-3 RC-3 Indicators, Action Levels, Monitoring and Responses (Interim)**

| | |
|---|---|
| **Watercourse** | Rose Creek |
| **AMI** | RC-3: Impacts from Groundwater Seepage in the Down Valley Rose Creek Area |
| **Purpose** | To evaluate groundwater quality in the Down Valley Area and whether groundwater seepage poses a potential risk to aquatic life in Rose Creek. |
| **Risk or Project Uncertainty** | Without seepage interception, groundwater seepage in the Down Valley area has the potential to cause contaminant concentrations in Rose Creek to increase to levels that pose a potential risk to aquatic life. RC-3 has been established to manage uncertainty around the magnitude and timing of these impacts, and to advise the timing for implementation of further management response. |
| **Significance Threshold** | **Active Remediation:** Moderate Effect Concentration Limits - Concentrations indicate potential of exceeding the moderate effect benchmark in Rose Creek (station RC-SW014). Moderate Effect Benchmarks are interpreted to represent a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes.<br>**Long-term Operations & Maintenance (Draft):** RC-3 will be discontinued during post-remediation. |
| **Stations** | **Groundwater:** X13 SIS Group; DV-MW008C, DV-MW008B, DV-MW008A, DV-MW023B, DV-MW023A, DV-MW032A, and DV-MW032B; Short-Term Down Valley SIS Group; DV-MW003A, DV-MW003B, DV-MW003C, DV-MW011B, DV-MW011A, MW17-12D, DV-MW012B, DV-MW012A, DV-MW018. Note that well selection may also be adjusted when concentration limits are updated. |
| **Indicators** | sulphate, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, dissolved zinc |
| **Modifying Factors** | None. |
| **Monitoring** | **Groundwater:** groundwater quality samples are collected quarterly (February, June, September, and December) from 16 monitoring wells; DV-MW008C, DV-MW008B, DV-MW008A, DV-MW023B, DV-MW023A, DV-MW032A, DV-MW032B; DV-MW003A, DV-MW003B, DV-MW003C, DV-MW011B, DV-MW011A, MW17-12D, DV-MW012B, DV-MW012A, DV-MW018. Details on the full suite of analytical parameters are provided in Appendix D. |

**Table 6-3 RC-3 Indicators, Action Levels, Monitoring and Responses (Interim)**

<table>
<tr><td>Evaluation of Monitoring Results</td><td colspan="3">Quarterly analysis will be completed in two steps: Step 1 – Comparison of quarterly groundwater quality for the X13 SIS group of monitoring wells to AMP triggers (see below), Step 2 – Comparison of quarterly groundwater quality for the Short-term Down Valley SIS group of monitoring wells to AMP triggers (see below). Note that different triggers apply to each monitoring well group. Two additional steps will be completed as part of an annual analysis; Step 3 - Evaluate trends in groundwater quality at the selected monitoring wells, and Step 4 – Update concentration limits for the following year. Note that concentration limits are subject to several assumptions about the loading sources and flows in the lower North Wall Interception Ditch (NWID) and Rose Creek and need to be updated annually to remain applicable to current conditions. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required.</td></tr>
<tr><td>Project Phases</td><td colspan="3">Active Remediation: Active remediation triggers will remain applicable throughout remediation activities in this area. This includes during and following construction of the short-term and full down valley SIS phases of the project. The concentration limits used for action level triggers will require annual review and update throughout the active remediation period. These updates will include review and revision of model assumptions and source terms to ensure that the derived concentration limits remain applicable to current conditions. Following construction of the full down valley SIS, RC-3 will be evaluated to determine an appropriate period to discontinue this AMI. Long-term Operations & Maintenance: RC-3 will be discontinued.</td></tr>
<tr><td>Action Level</td><td>Active Remediation Triggers</td><td>Long-term Operations and Maintenance Triggers (Draft)</td><td>Possible Management Response</td></tr>
<tr><td>LOW</td><td>>low concentration limits, in one or more select monitoring wells, confirmed for 2 quarterly samples collected within a year</td><td rowspan="3">RC-3 will be discontinued during long-term operations and maintenance.</td><td rowspan="3">Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<br>• adjustments to X13 SIS,<br>• additional interim seepage capture in the down valley area (e.g., Short-term Down Valley SIS),<br>• adjustments to Short-term Down Valley SIS, and<br>• advancing the schedule for full Down Valley groundwater capture system including line 3 of the remediation plan Down Valley SIS.</td></tr>
<tr><td>MODERATE</td><td>>moderate concentration limits, in one or more select monitoring wells, confirmed for 2 quarterly samples collected within a year</td></tr>
<tr><td>HIGH</td><td>>high concentration limits, in two or more select monitoring wells, confirmed for 2 quarterly samples collected within a year</td></tr>
</table>

AMP = Adaptive Management Plan; DV = Down Valley; SIS = seepage interception system; AMI = Adaptive Management Initiative; NWID = North Wall Interception Ditch.

## 6.4 RC-4 Overall Site Impact on Water Quality in Rose Creek

The overall impact to water quality from the Project will be monitored in Rose Creek, directly downstream of the Site (station RC-SW014). Station RC-SW014 receives the combined loading from the Faro Mine Site and has the potential to be impacted by all sources monitored through each upstream AMI; NFRC-1, NFRC-2, NFRC-3, NFRC-4, RC-1, RC-2, and RC-3. Permanent changes in water quality in Rose Creek are expected to result from the following activities: implementation of the Down Valley SIS, addition of effluent discharge from the Cross-Valley Pond Treatment Plant, and addition of effluent discharge from the Permanent Water Treatment Plant. Many other construction activities associated with the Project have potential to temporarily influence water quality in downstream Rose Creek; these include all stabilization, landforming, and cover construction work, and other construction water management activities.

Throughout the Project, RC-4 will evaluate the combined impacts from the Project on water quality in Rose Creek and provides action levels to respond if this poses a potential risk to aquatic life. Quarterly toxicity sampling has also been added to confirm benchmarks are appropriately protective. This AMI is expected to be required through all Project phases. Once the Project has been fully implemented at the start of long-term operations and maintenance; RC-4 will use reduced action levels. Table 6-4 provides the information on the stations, indicators, triggers/action levels.

**Table 6-4 RC-4 Indicators, Action Levels, Monitoring and Response**

| | |
|---|---|
| **Watercourse** | Rose Creek |
| **AMI** | **RC-4:** Overall Site Impact on Water Quality in Rose Creek |
| **Purpose** | To evaluate the combined loadings from the Faro Mine Site and whether changes in water quality due to the Site pose a potential risk to aquatic life in Rose Creek. |
| **Risk or Project Uncertainty** | Contaminant concentrations in Rose Creek, downgradient from the Faro Mine, increase to levels that pose a potential risk to aquatic life. RC-4 has been established to manage uncertainty around the cumulative effects of the combined sources from the Faro Mine on water quality in Rose Creek. |
| **Significance Threshold** | **Active Remediation:** Moderate Effect Benchmarks – concentrations at which a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes. **Long-term Operations & Maintenance (Draft):** Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. |
| **Stations** | **Surface Water**: RC-SW014 (exposure) |
| **Indicators** | sulphate, total ammonia, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, dissolved zinc |
| **Modifying Factors** | pH, temperature, hardness (as $CaCO_3$), dissolved organic carbon |
| **Monitoring** | **Surface Water:** water quality samples are collected monthly from station RC-SW014 throughout the year, and weekly during effluent discharge. **Hydrology:** Discharge measurements are completed monthly at station RC-SW014 in unison with water quality sample collection. Station RC-SW014 currently has a data logger that allows estimates for continuous discharge. **Toxicity:** chronic toxicity sampling is completed quarterly at station RC-SW014 (March, June, September, and December) in unison with water quality sampling and discharge measurements. **Field Instructions:** surface water quality sampling and discharge measurements are completed as a synoptic sampling program (i.e., monthly monitoring for both stations is completed within a 24-hour period of consistent weather conditions) with stations associated with AMI RC-1, RC-2, and RC-4. Details on the full suite of analytical parameters are provided in Appendix D. |

**Table 6-4 RC-4 Indicators, Action Levels, Monitoring and Response**

<table>
<tr><td>Evaluation of Monitoring Results</td><td colspan="3">Monthly analysis will be completed in one step; Step 1 - Compare monthly surface water quality for station RC-SW014 to AMP triggers (see below), One additional step will be completed as part of a quarterly analysis; Step 2 - Compare quarterly toxicity results for station RC-SW014 to AMP triggers (see below). Two final steps will be completed as part of an annual analysis; Step 3 - Evaluate the relative mass load contribution from each supporting AMI. Station RC-SW014 is used to evaluate the combined loadings from the Faro Mine Site, including sources monitored as part of upstream AMIs; NFRC-1, NFRC-3, NFRC-4, RC-1, and RC-2. Mass loading will be calculated using monthly surface water quality samples and discharge measurements collected at station RC-SW014 (combined loadings), as well as the loading contributed from each upstream AMI (NFRC-1, NFRC-3, NFRC-4, RC-1, and RC-2). Results of this evaluation will be used to prioritize urgent works and investigative studies based on AMI source contributions. Step 4 - Evaluate trends in surface water quality at station RC-SW014, including a winter trend review as data permits. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required.</td></tr>
<tr><td>Project Phases</td><td colspan="3">Active Remediation: Active remediation triggers will remain applicable throughout the Project. Following completion of all remediation activities, long-term operations and maintenance triggers will be revised through AMP updates and regulatory approvals. Long-term Operations & Maintenance: Long-term operations and maintenance triggers are applicable.</td></tr>
<tr><td>Action Level</td><td>Active Remediation Triggers</td><td>Long-term Operations and Maintenance Triggers (Draft)[d]</td><td>Possible Management Response</td></tr>
<tr><td>LOW</td><td>>SSWQO[a] at station RC-SW014, confirmed for 4 monthly samples collected within a year</td><td>>75% of SSWQO[a] at station RC-SW014, confirmed for 4 samples collected within a year</td><td rowspan="3">Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<br>• adjustments to Water Treatment System(s),<br>• all engineering mitigations outlined for upstream locations.</td></tr>
<tr><td>MODERATE</td><td>>75% of low-effects benchmark[a] at station RC-SW014, confirmed for 3 monthly samples collected within a year, OR, pronounced chronic toxicity in laboratory samples[b] OR, 25% or greater mortality to standard test species</td><td>>SSWQO[a] at station RC-SW014, confirmed for 3 monthly samples collected within a year</td></tr>
<tr><td>HIGH</td><td>>Low-effect benchmark[a] at station RC-SW014, confirmed for 2 monthly samples collected within a year, or substantial and pervasive chronic toxicity[c] in laboratory samples, OR, 50% or greater mortality to standard test species</td><td>>75% of low-effects benchmark[a] at station RC-SW014, confirmed for 2 monthly samples collected within a year, OR, pronounced chronic toxicity in laboratory samples[b] OR, 25% or greater mortality to standard test species</td></tr>
</table>

(a) Further details on the development of indicators, benchmarks, and triggers are provided in Appendix C.

(b) Pronounced chronic toxicity is defined as more than 25% adverse response to two or more test species in a single sampling event, or a high magnitude (>50%) response to fish or invertebrates in a single sampling event.

(c) Substantial and pervasive chronic toxicity is defined as more than 50% adverse response to two or more test species, including either a fish or invertebrate endpoint, and in consecutive sampling events.

(d) Long-term operations and maintenance triggers will be revised through Project AMP updates and regulatory approvals; triggers are expected to be based on post-remediation conditions, with action levels to prevent exceeding SSWQOs or deviation from background conditions observed post remediation.

AMP = Adaptive Management Plan; AMI = Adaptive Management Initiative; SSWQO = site-specific water quality objective.

# 7.0 AMI: Anvil Creek

## 7.1 AC-1- Impact to Water Quality in Anvil Creek from the Faro Mine Site

The overall impact of the Project to water quality in Anvil Creek will be monitored at the confluence between Rose Creek and Anvil Creek. Monitoring for AC-1 is completed at two surface water stations: RC-SW040 and RC-SW030. Station RC-SW040 is a reference station located on Anvil Creek prior to its confluence with Rose Creek, upstream from potential influence from the Faro Mine Site. Station RC-SW030 is an exposure station located on Anvil Creek, downstream from the Rose Creek confluence. Monitoring station RC-SW030 receives the combined loading from the Faro Mine Site and has the potential to be impacted by all sources monitored through each upstream AMI; NFRC-1, NFRC-2, NFRC-3, NFRC-4, RC-1, RC-2, RC-3, and RC-4. Confirmed action level trigger exceedances at AC-1 indicate a mitigation or management response is required for an upstream source or AMI. Major changes in water quality in Rose Creek (refer to RC-4) are expected to influence constituent loading to Anvil Creek.

Throughout the Project, AC-1 will evaluate the impact of the Faro Mine Site on water quality in Anvil Creek, and whether this poses a potential risk to aquatic life. This AMI is expected to be required for all Project phases; AC-1 will use the same action levels during long-term operations and maintenance. Table 7-1 provides the information on the stations, indicators, triggers/action levels. Figure 7-1 provides and overview of the monitoring locations in this area.

**Table 7-1 AC -1 Indicators, Action Levels, Monitoring and Response**

| | |
|---|---|
| **Watercourse** | Anvil Creek |
| **AMI** | AC-1: Impact to Water Quality in Anvil Creek from the Faro Mine Site |
| **Purpose** | To evaluate the impact of the Faro Mine Site on water quality in Anvil Creek and whether this poses a potential risk to aquatic life |
| **Risk or Project Uncertainty** | Contaminant concentrations in Anvil Creek, downgradient from the Faro Mine, increase to levels that pose a potential risk to aquatic life. AC-1 has been established to manage uncertainty around the cumulative effects of the combined sources from the Faro Mine on water quality in Anvil Creek. |
| **Significance Threshold** | **Active Remediation:** Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. **Long-term Operations & Maintenance (Draft):** No change. |
| **Stations** | **Surface Water:** RC-SW040 (reference) and RC-SW030 (exposure) |
| **Indicators** | sulphate, total ammonia, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, dissolved zinc |
| **Modifying Factors** | pH, temperature, hardness (as $CaCO_3$), dissolved organic carbon |
| **Monitoring** | **Surface Water:** water quality samples are collected six times per year from station RC-SW040 and RC-SW030 during April, May, June, September, October, and February. **Hydrology:** Discharge measurements are completed monthly at stations RC-SW040 and RC-SW030 in unison with water quality sample collection. A data logger has also been installed at station RC-SW040 to allow for continuous discharge measurements. Continuous discharge at RC-SW030 is estimated as RC-SW025 + RC-SW040. **Field Instructions:** surface water quality sampling is completed as a synoptic sampling program (i.e., monthly monitoring for both stations is completed within a 24-hour period of consistent weather conditions) with stations RC-SW040 and RC-SW030. Details on the full suite of analytical parameters are provided in Appendix D. |

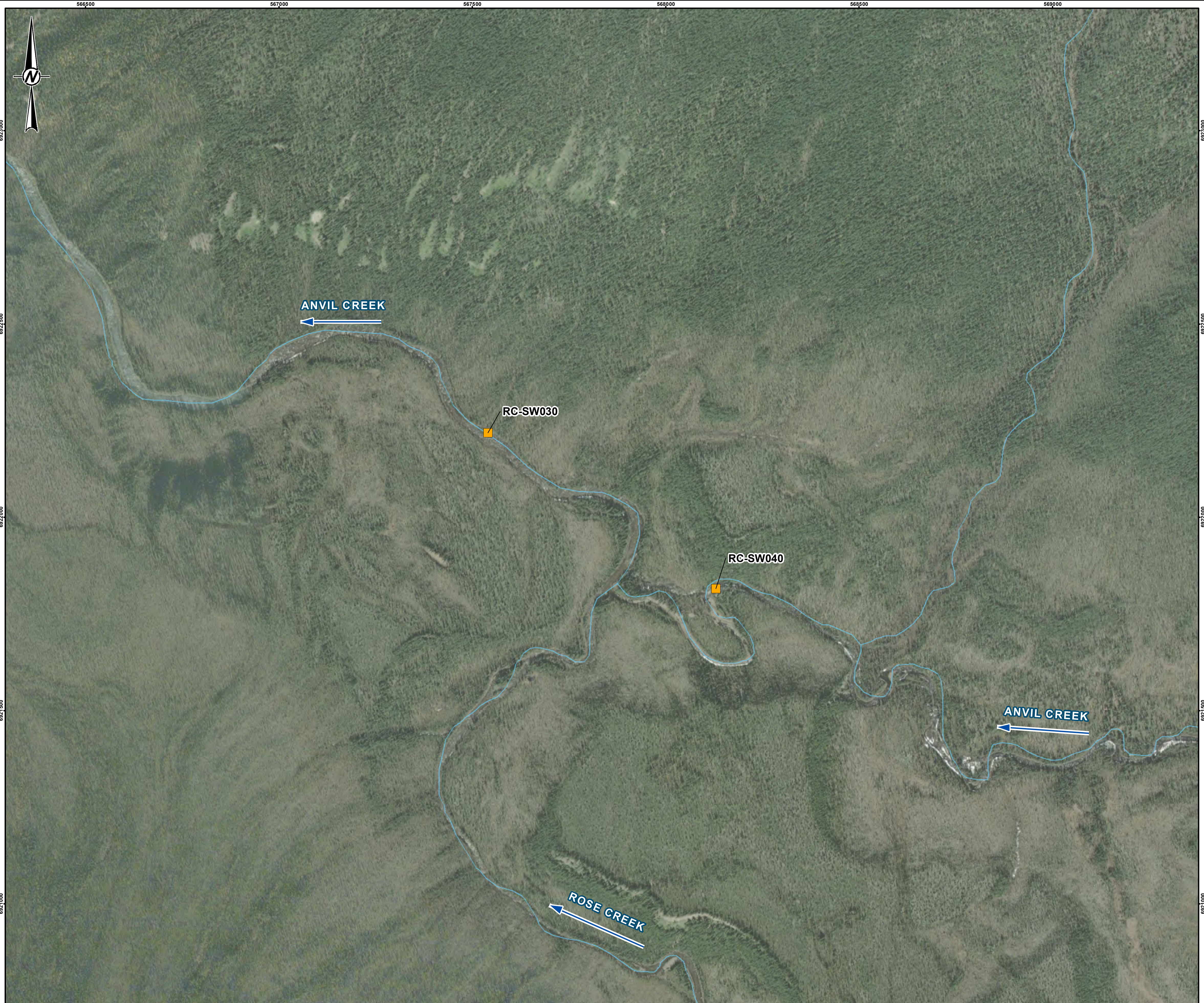
### Table 7-1 AC -1 Indicators, Action Levels, Monitoring and Response

| | | | |
|---|---|---|---|
| **Evaluation of Monitoring Results** | Monthly analysis will be completed in two steps; **Step 1** - Comparison of monthly surface water quality for stations RC-SW040 and RC-SW030 to AMP triggers, **Step 2** - Verify that trigger exceedances observed at station RC-SW030 are due to the Site, using station RC-SW040 as a reference. Two additional steps will be completed as part of an annual analysis; **Step 3** - Evaluate mass loading at stations RC-SW040 and RC-SW030. Mass loading will be calculated using monthly surface water quality samples and discharge measurements and used to evaluate relative source contributions, and **Step 4** - Evaluate trends in surface water quality for stations RC-SW040 and RC-SW030, including a winter trend review as data permits. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required. | | |
| **Project Phases** | **Active Remediation:** Active remediation triggers will remain applicable throughout the Project. Following completion of all remediation activities, long-term operations and maintenance triggers will be revised through AMP updates and regulatory approvals. **Long-term Operations & Maintenance:** Long-term operations and maintenance triggers are applicable. | | |
| **Action Level** | **Active Remediation Triggers** | **Long Term Operations and Maintenance Triggers (Draft)(b)** | **Possible Management Response** |
| **LOW** | >60% of SSWQO(a) at station RC-SW030 due to the Site, confirmed for 3 samples collected within a year | Triggers to be determined through AMP updates and regulatory approvals; triggers are expected to remain similar to those established for the active remediation period, with action levels to prevent exceedance of SSWQOs or predicted concentrations. | Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<br>• all engineering mitigations outlined for upstream locations |
| **MODERATE** | >75% of SSWQO(a) at station RC-SW030 due to the Site, confirmed for 3 samples collected within a year | | |
| **HIGH** | >SSWQO(a) at station RC-SW030 due to the Site, confirmed for 2 samples collected within a year | | |

(a) Further details on the development of indicators, benchmarks, and triggers are provided in Appendix C.

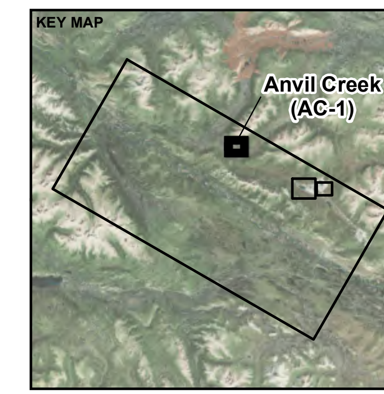
(b) Triggers to be determined through Project AMP updates and regulatory approvals; triggers are expected to be based on post-remediation conditions and/or long-term modelling predictions, with action levels to prevent exceeding SSWQOs or predicted concentrations.

SSWQO = site-specific water quality objective; AMP = Adaptive Management Plan; AMI = Adaptive Management Initiative.




**LEGEND**

- SURFACE WATER MONITORING STATION
- DIRECTION OF FLOW
- WATERCOURSE




0 200 400

1:10,000 METRES

**REFERENCE(S)**
1. MINE ROADS, WATERCOURSES OBTAINED FROM CH2MHILL.
2. AERIAL PHOTOGRAPHY ACQUIRED BY PEREGRINE AERIAL SURVEYORS INC. AND EAGLE MAPPING IN AUGUST 2012.
3. ORTHOPHOTOGRAPHY PREPARED BY CRITIGEN CANADA CORP.
4. INSET DATA OBTAINED FROM YUKON GEOMATICS.

DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
**AC-1 - LOCATION RELATIVE TO SITE FEATURES**

CONSULTANT
GOLDER
MEMBER OF WSP

| | |
|---|---|
| YYYY-MM-DD | 2021-07-15 |
| DESIGNED | AN |
| PREPARED | LH |
| REVIEWED | HM |
| APPROVED | HM |

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 21454941 | 9000/9500 | 0 | 7-1 |

# 8.0 AMI: Pelly River

## 8.1 PR-1: Impact to Water Quality in the Pelly River from the Faro Mine Site

PR-1 evaluates the influence of the Faro Mine Site on water quality in the Pelly River to determine whether the non-degradation goal is met; this AMI also considers the possible influence of the Vangorda Mine Plateau Area and has included indicators relevant to that site. This AMI is expected to be required through active remediation and long-term operations and maintenance. Table 8-1 provides the information on the stations, indicators, triggers/action levels.

The overall influence of the Project on water quality in the Pelly River will be monitored at several Pelly River monitoring stations. Monitoring for PR-1 is completed at four surface water stations: PR-SW001, PR-SW002, PR-SW003, and PR-SW004 (Figure 8-1). Station PR-SW001 is a reference station located upstream of Vangorda Creek and prior to any potential influence associated with the Faro Mine Site or the Vangorda Plateau Mine Area (i.e., reference station). Station PR-SW002 is located downstream of Vangorda Creek and is intended to represent influence from the Vangorda Plateau Mine Area. Stations PR-SW001 and PR-SW002 are monitored as part of PR-1 as support stations, meaning that AMP triggers are not applicable at these stations as data are reviewed only to assess upstream influences. Station PR-SW003 is used as a baseline station for PR-1 and is located downstream of Vangorda Creek and upstream of Anvil Creek; this station represents water quality prior to influence from the Faro Mine Site. Station PR-SW003 is used instead of the further upstream reference station (PR-SW001) to reduce data variability and improve likelihood for PR-1 to detect changes in water quality associated specifically with Anvil Creek and the Faro Mine Site. Station PR-SW004 is an exposure station for PR-1 and is located downstream of Anvil Creek. Station PR-SW004 is intended to represent water quality downstream of potential sources associated with the Project.

As noted in Appendix C, the Pelly River indicators and sampling stations are inclusive of both the Faro Mine Site and the Vangorda Mine Plateau Area. This was done to allow detection of possible cumulative effects of both sites and/or other upstream sources including climate change and to potentially differentiate between the effects of each. The Project AMP would not formally trigger an action level due to the effects of climate change or Vangorda Mine Plateau Area but potential chemistry changes would be flagged in the reporting and analysis. Differentiating the effects of climate-related changes on water quality from the Project or other sources may require additional investigations, possibly through a management response plan or through partnership with other parties (e.g., a future owner of the Vangorda area or other government department/university/First Nation working on climate change). This is because many of the indicators of climate change in surface water from melting permafrost/changes in groundwater flow regimes in winter are the same as ground water from the Project (i.e., metals, salts) (see Streiker 2016).


LEGEND
- MONITORING STATION
- TOWN
- HIGHWAY
- ROAD
- DIRECTION OF FLOW
- WATERCOURSE
- WATERBODY


0 3,000 6,000
1:150,000 METRES

REFERENCE(S)
1. WATERCOURSES OBTAINED FROM CH2MHILL.
2. IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.
3. INSET DATA OBTAINED FROM YUKON GEOMATICS.
DATUM: NAD83 CSRS PROJECTION: UTM ZONE 8

CLIENT
CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

PROJECT
ADAPTIVE MANAGEMENT PLAN FOR THE FARO MINE REMEDIATION PROJECT

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

TITLE
**LOCATION OF PELLY RIVER MONITORING STATIONS**

CONSULTANT
GOLDER
MEMBER OF WSP

| | |
|---|---|
| YYYY-MM-DD | 2021-07-15 |
| DESIGNED | AN |
| PREPARED | LH |
| REVIEWED | HM |
| APPROVED | HM |

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 21454941 | 9000/9500 | 0 | 8-1 |



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**Table 8-1 PR-1 - Indicators, Action Levels, Monitoring and Responses**

| | |
|---|---|
| **Watercourse** | Pelly River |
| **AMI** | **PR-1:** Impact to Water Quality in the Pelly River from the Faro Mine Site |
| **Purpose** | To evaluate the influence of the Faro Mine Site on water quality in the Pelly River and whether this constitutes a change from natural variation (i.e., violation of the non-degradation goal). |
| **Risk or Project Uncertainty** | The combined influences from the Project have the potential to change the water quality in the Pelly River downstream of the Project (i.e., PR-SW004). PR-1 is used to identify deviation from baseline conditions (i.e., water quality conditions prior to influence from the Project). |
| **Significance Threshold** | **Active Remediation:** Water quality concentrations in the Pelly River at designated downstream station exceed upstream background conditions and it is due to the Project. **Long-term Operations & Maintenance:** No change. |
| **Stations** | **Surface Water:** PR-SW001 (supporting), PR-SW002 (supporting), PR-SW003 (baseline), and PR-SW004 (exposure). |
| **Indicators** | sulphate, total ammonia, nitrate, dissolved aluminium, dissolved cadmium, dissolved cobalt, dissolved iron, dissolved iron, dissolved manganese, dissolved selenium, dissolved uranium, dissolved zinc |
| **Modifying Factors** | None[a] |
| **Monitoring** | **Surface Water:** water quality samples are currently collected six times per year from stations PR-SW001, PR-SW002, PR-SW003, and PR-SW004 during April, May, June, September, October, and February. **Hydrology**: No discharge measurements are completed at these stations, discharge for Pelly River stations is estimated based on daily discharge measured at an ECCC hydrometric station located on the Pelly River downstream of Vangorda Creek at (WSC ID 09BC004). **Field Instructions:** surface water quality sampling is completed as a synoptic sampling program (i.e., monitoring for both stations is completed within a 24-hour period of consistent weather conditions) with stations PR-SW001, PR-SW002, PR-SW003, and PR-SW004. Details on the full suite of analytical parameters are provided in Appendix D. |
| **Evaluation of Monitoring Results** | Analysis will be completed in three steps; **Step 1** - Compare individual samples from station PR-SW004 to the 85$^{th}$, 90$^{th}$, and 95$^{th}$ percentile for upstream baseline conditions (station PR-SW003), **Step 2** – Compare the seasonal[b] rolling[c] mean (or median[d]) for station PR-SW004 to the one-tailed 85%, 90%, and 95%, seasonal[b] rolling[c] upper confidence limit of the mean (or median[c]) for station PR-SW003. Two additional steps will be completed as part of an annual analysis; **Step 3** - Evaluate mass loading at stations PR-SW001, PR-SW002, PR-SW003, and PR-SW004. Mass loading will be calculated using monthly surface water quality samples and estimated discharge measurements and used to evaluate changes in loadings to the river, and **Step 4** – Evaluate trends in indicator concentrations at PR-SW001, PR-SW002, PR-SW003, and PR-SW004, including a winter trend review as data permits. Results of this evaluation will be used to further advise the selection of an appropriate management response, if required. |
| **Project Phases** | Although the same triggers are anticipated to be appropriate for Active Remediation and Long-term Operations & Maintenance phases of the Project, the data used to generate specific statistics may vary, based on the adequacy (e.g., detectable concentrations) of the datasets at PR-SW003 (baseline) and PR-SW004 (exposure). Trends, water quality predictions or other forward forecasting tools may be used as triggers in future versions of the AMP as data collection increases. |

**Table 8-1 PR-1 - Indicators, Action Levels, Monitoring and Responses**

| Action Level | Active Remediation Triggers (draft) | Long-term Operations and Maintenance Triggers (Draft)[b] | Possible Management Response |
|---|---|---|---|
| **Low** | Individual samples at station PR-SW004 >85th percentile for upstream baseline conditions (station PR-SW003),<br>OR,<br>seasonal[b] rolling[c] mean (or median[d]) for station PR-SW004 >one-tailed 85% seasonal[b] rolling[c] upper confidence limit of the mean (or median[c]) for station PR-SW003.<br>AND,<br>Due to the Project. | Triggers to be determined through AMP updates and regulatory approvals; triggers are expected to remain similar to those established for the active remediation period, with action levels to prevent degradation in the Pelly River. | Potential response for each action level is provided in Table 3-6. Should a mitigation measure/urgent work need to be proposed for this AMI, some 'tools' appropriate for this area include:<br>• engineering mitigations outlined for upstream locations on site |
| **Moderate** | Individual samples at station PR-SW004 >90th percentile for upstream baseline conditions (station PR-SW003),<br>OR,<br>seasonal[b] rolling[c] mean (or median[d]) for station PR-SW004 >one-tailed 90% seasonal[b] rolling[c] upper confidence limit of the mean (or median[c]) for station PR-SW003.<br>AND,<br>Due to the Project. | | |
| **High** | Individual samples at station PR-SW004 >95th percentile for upstream baseline conditions (station PR-SW003),<br>OR,<br>seasonal[b] rolling[c] mean (or median[d]) for station PR-SW004 >one-tailed 95% seasonal[b] rolling[c] upper confidence limit of the mean (or median[c]) for station PR-SW003.<br>AND,<br>Due to the Project. | | |

(a) Modifying factors are not monitored as part of PR-1. Triggers for PR-1 are based on changing water quality in the Pelly River from a baseline condition which does not require modifying factors or calculation of water quality benchmarks.
(b) "Seasonal" indicates that values will be calculated individually for a specific season (e.g., open-water or under-ice).
(c) "Rolling" indicates that the past 20 samples, or another appropriate number of samples, will be used.
(d) Whether to use mean or median values should be based on whether the data is normally distributed.
ECCC = Environment and Climate Change Canada; AMP = Adaptive Management Plan; AMI = Adaptive Management Initiative.

# 9.0 Reporting and Review

### Annual and Quarterly reports

Comparison of monitoring data to Project AMP triggers will be completed monthly, within 30-days of laboratory receipt for each monthly field program by CIRNAC. Reporting of monthly data will be completed quarterly, following field programs conducted in March, June, and September. Quarterly reports will be issued at the end of April, July, and October approximately; the fourth quarter of each year will be reported in the annual report (Table 9-1).

**Table 9-1 Reporting schedule for the Project Adaptive Management Plan**

| Report | Data Collected | Data Types Included | Report Issued |
|---|---|---|---|
| Q1 | Jan, Feb, Mar. | SW (Jan-Mar.), GW. (Feb.), TOX. (Jan.) | End of April |
| Q2 | Apr., May, Jun. | SW (Apr.-Jun), GW. (Jun.), TOX. (Apr.) | End of July |
| Q3 | Jul., Aug., Sept. | SW (Jul.-Sept.), GW. (Sept.), TOX. (Jul.) | End of October |
| Annual | Jan.-Dec. | SW (Jan.-Dec.), GW. (Feb., Jun., Sept., Dec.), TOX. (Jan., Apr., Jul., Oct.) | End of March |

NOTES: SW = surface water; GW = groundwater; TOX – chronic toxicity samples

Annual reporting will be completed prior to March 31 of the following year. Quarterly and annual reports are provided to Faro Mine Site stakeholders as described in Section 1.3, including affected First Nations. Input on recommendations and possible management responses can be provided to CIRNAC.

### Management Response Plans

As noted in Section 3, should an action level be exceeded and confirmed, a management response plan will be prepared. These will be provided to the project's internal AMP Committee and the Technical Review Committee. Input on recommendations and possible management responses can be provided to CIRNAC for consideration, should a detailed investigation or urgent work be required. Once a water licence is obtained, it is expected some management response plans will be required for submittal to the Yukon Water Board.

### Project AMP Update

The AMP will be reviewed every 3 years and a workshop will be held with stakeholder and interested parties to share results and solicit feedback. Comparisons to the outcomes of the annual water quality report will be made as well as any relevant monitoring results from the Aquatic Effects Monitoring Plan. If required, the Project AMP will be updated to address new or emerging concerns. On a regular cycle, currently proposed as every three years, the AMP will be re-evaluated, and an updated Project AMP will be generated. This will include the results of the last three years of monitoring, engagement input, new guidance, or new water quality guidelines/data. Once a water licence is obtained, it is expected a revised AMP will be required by the Yukon Water Board at frequencies outlined by the water licence.

# 10.0 Engagement

## 10.1 Engagement on Plan

To date, CIRNAC's approach to engagement on the AMP has been tied directly to the feedback received on the Operational AMP as it has evolved over time. The first AMP for the Faro Mine Complex was prepared in response to a water licence (QZ06 075 1) requirement (Gartner Lee Limited 2004). An implementation protocol for the AMP was developed in 2004 (Gartner Lee Limited 2004) with monthly and annual summary reports completed through 2016 (e.g., SLR Consulting Ltd. 2017). The first AMP reviews and workshops were conducted in 2016 and early 2017 (Slater 2016; Slater 2017), and in December 2017, which led to the development of the 2018 Operational AMP (Golder 2018).

In late September 2020, the 2018 Operational AMP was re-evaluated. This included a workshop with affected First Nations representatives and key stakeholders, which includes representatives from the Yukon Government, Environment and Climate Change Canada, Fisheries and Oceans Canada, and the Yukon Conservation Society. A draft of the AMP was provided to the attendees of the workshops in January 2021 for further feedback (CIRNAC 2021). The information provided in this workshop is directly applicable to the AMP for remediation and CIRNAC has committed to apply the information solicited during the workshop and the formal written feedback to this AMP, as applicable (see Appendix B).

Over the course of Adequacy, affected First Nations representative and other stakeholders provided comments and questions on the AMP. These considerations were incorporated into this version of the AMP. In February 2021, YESAB hosted an AMP workshop where CIRNAC presented their vision for the AMP, where First Nations representatives and key stakeholders expressed their views on the planned approach. Collectively, these workshops and Adequacy comments were used to refine the plan to create this AMP. Appendix B provides a summary of comments provided through Adequacy and the 2021 YESAB workshop and how they were addressed in this plan. Comments related to the Operational AMP relevant to this Project AMP incorporated herein are also summarized in Appendix B.

## 10.2 Plan for Continuing Engagement

Engagement for the AMP will be directed towards the Project stakeholders, which include:

- Affected Yukon First Nations, including Ross River Dena Council, Liard First Nation and Selkirk First Nation.
- Faro Mine Remediation Project Technical Review Committee members.
- Federal departments/regulators including Fisheries and Oceans Canada and Environment and Climate Change Canada.
- Yukon Government departments/regulators, including Water Resources, Energy Mines and Resources, and Environment.
- Town of Faro.
- Yukon Conservation Society.

This list can be expanded if other parties come forward and show an interest in receiving information or being involved in discussion about the AMP for the Project.

Specific engagement activities will include the following key elements:

- Annual plain language summary of the AMP report. There can also be meetings on request to talk about the AMP and/or the results of other activities associated with the Project.
- Sharing AMP quarterly and annual reports with stakeholders (Table 10-1), including alerting stakeholders when exceedances occur.
- Should investigations/management response plans be triggered, sharing of proposed strategy with regulators, Technical Review Committee members and other key stakeholders and seeking their views on the proposed approach. For more critical situations (e.g., exceedance of a Level 3 benchmark), hosting of specific workshops with all listed stakeholders to inform them of the situation, of the proposed approach to resolve the issue and to seek their views on the path forward.
- Every 3rd year or more frequently if required, providing an opportunity to stakeholders to review the proposed changes to the AMP. The engagement will include sharing a draft of the changes to the AMP, as well as, for any major changes, the hosting of a workshop where participants will be able to provide their views on the proposed changes and on the need to establish any other AMIs.

**Table 10-1 Engagement on the Adaptive Management Plan**

| Item | Frequency | Format |
|---|---|---|
| Quarterly Report | April, July, October | Electronic report. |
| Annual Report | Annual (by February) | Electronic report, and/or virtual meeting to review key results if requested. |
| Scope/results of AMP exceedance Investigation | As required for Management Response Plan | Electronic report, meeting/workshop if required. |
| AMP updates | Every three years or more frequently as required | Draft of report for comment, meeting/workshop if required. |
| Community meetings on Annual Reports | Upon request | In person plain language presentations on the outcomes of monitoring at the Faro Mine Site upon request. |

AMP = Adaptive Management Plan.

## 11.0 References


Access Consulting Group, Laberge Environmental Services, and White Mountain Environmental Consulting. 2006. Pelly River Aquatic Effects Assessment – 2005. Prepared for the Selkirk First Nation.

AECOM. 2018. 2017 Aquatic Effects Monitoring Program Report for the Faro Mine Site. Prepared for Indigenous and Northern Affairs Canada.

BGC (BGC Engineering Inc.). 2018. Faro North Fork Rose Creek Realignment Project, Contact Water Monitoring Plan. Final. Submitted to Geoff Karcher, Crown-Indigenous Relations and Northern Affairs Canada. Vancouver BC: BGC Engineering Inc. Project Ref: 131098. 21 November 2018. 49 p.

CCME (Canadian Council for Ministers of the Environment). 2007. A protocol for the derivation of water quality guidelines for the protection of aquatic life 2007. In: Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment. Winnipeg MB. ceqg-rcqe.ccme.ca/download/en/220/.

Crown Indigenous Relations and Northern Affairs Canada. 2019. Faro Mine Remediation Project. Project Proposal submitted May 2019 to the Yukon Environmental and Socio-Economic Assessment Board.

DIAND (Department of Indian Affairs and Northern Development). 2019. Faro Mine Remediation Project, Project Proposal Submitted May 2019. Submitted to the Yukon Environmental and Socio-economic Assessment Board. May 2019. Gatineau QC: Department of Indian Affairs and Northern Development. 4 vol.

Gartner Lee Limited. 2004. Anvil Range Mine adaptive management plan implementation protocol. Prepared for Deloitte & Touche. June 2004.

Golder (Golder Associates Ltd.) 2018. 2017 Faro Mine Complex annual water monitoring report. Prepared for Department of Indigenous Affairs and Northern Development. Edmonton AB: Golder Associates Ltd. March 2017.

Golder. 2019a. Faro Mine Remediation Project – 2018 Annual Water Monitoring Report. Prepared for the Department of Indigenous Affairs and Northern Development. April 2019. 893 p.

Golder. 2019b. Faro Mine Complex and Faro Mine Remediation Project – 2019 Chronic Toxicity Testing Program for Zinc. Technical Memorandum, submitted to Marie-France Therrien, Crown-Indigenous Relations and Northern Affairs Canada. October 2019.

Golder. 2020a. Faro Mine Remediation Project – 2019 Annual Water Monitoring Report. Prepared for the Department of Indigenous Affairs and Northern Development. June 2020. 980 p.

Golder. 2020b. Faro Mine Complex and Faro Mine Remediation Project – 2019 Acute and Chronic Toxicity Testing Program with Sulphate. Technical Memorandum. Submitted to Marie-France Therrien, Crown-Indigenous Relations and Northern Affairs Canada. January 2020.

Golder. 2020c. Faro Mine Complex and Faro Mine Remediation Project- 2020 Acute and Chronic Toxicity Testing Program with Total Iron and Dissolved Manganese. Submitted to Crown Indigenous and Northern Affairs Canada. November 2020

Golder. 2020d. Faro Mine Complex Operational Adaptive Management Plan Investigation: Event RC2, RC3 and RC4. Submitted to Crown-Indigenous and Northern Affairs Canada. June 2020.

Golder. 2020e. Faro Mine Complex Operational Adaptive Management Plan Investigation: Exceedances at Event VG-1. Submitted to Crown-Indigenous and Northern Affairs Canada. April 2020.

Golder. 2020f. Faro Mine Complex Operational Adaptive Management Plan Investigation: Exceedances at Events VG-2 and VG-4. Submitted to Crown-Indigenous and Northern Affairs Canada. April 2020.

Golder. 2021. Adaptive Management Plan 2020 Annual Report – Faro Mine Complex. Submitted to Crown-Indigenous and Northern Affairs Canada. April 2021.

Government of Yukon. 2019. Draft Yukon Guide for Developing Water Quality Objectives and Effluent Quality Standards for Quartz Mining Projects. Whitehorse, Yukon. December 2019.

Government of Yukon. 2021. Guidelines for developing adaptive management plans in Yukon. Water-related components of quartz mining projects. January 2021. Available at: https://yukon.ca/en/guidelines-developing-adaptive-management-plans-yukon-water-related-components-quartz-mining.

Hirsch, R.M. 1988. Statistical methods and sampling design for estimating step trends in surface water quality. Water Resour. Res. 24:493-503.

Meals, D.W, Spooner, J., Dressing, S.A, and Harcum J.B. 2011. Statistical analysis for monotonic trends, Tech Notes 6, November 2011. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 23 p. Available online at https://www.epa. gov/polluted-runoff-nonpoint-source-pollution/nonpoint-source-monitoringtechnical-notes.

Robertson Geoconsultants Inc. (RGC). 2019. REV0-Initial X13 SIS Performance Review, Faro Mine, Yukon. Prepared for SRK Consulting (Canada) Inc. Submitted on August 15, 2019.

RGC. 2020. Future Contaminant Loads in Groundwater, Cross Valley Dam Area. Vancouver BC: Robertson Geoconsultants Inc. Project No. 1CA030.020. 22 April 2020. REV1.

Selkirk First Nation. 2018. Selkirk First Nation Traditional Use Study 2017. Selkirk First Nation, Pelly Crossing, Yukon.

Slater (Slater Environmental). 2016. Memorandum on Faro Mine water monitoring workshop: January 20-21, 2016. Slater Environmental to Assessment and Abandoned Mines Branch, EMR, Government of Yukon dated March 24, 2016.

Slater. 2017. Memorandum on Faro Mine Remediation Project: adaptive management plan workshop, March 7-8 2017. Slater Environmental to Assessment and Abandoned Mines Branch, EMR, Government of Yukon.5 May 2017.

SLR Consulting Ltd. 2017. 2016 Faro Mine complex adaptive management plan annual review. Prepared for Assessment and Abandoned Mines Branch, EMR, Government of Yukon. March 2017.

SRK (SRK Consulting Engineers and Scientists). 2010. Faro Mine Complex closure and remediation plan: project description – Draft 4A. Prepared for Yukon Government. March 2010.

Streicker, J., 2016. Yukon Climate Change Indicators and Key Findings 2015. Northern Climate ExChange, Yukon Research Centre, Yukon College, 84 p

USGS. 2020. Statistical Methods in Water Resources. Chapter 3 of Section A, Statistical Analysis Book 4, Hydrologic Analysis and Interpretation

WMEC. 2010. Report on the Findings of Investigations into Chinook Salmon Spawning Habitat Assessments Conducted on the Pelly River near Anvil Creek during August of 2009. Prepared for Assessment Abandoned Mines, Government of Yukon. January 2010.

Yukon Water Board. 2004. Water Licence Number QZ03-059. Granted to Deloitte & Touche Inc. by the Yukon Water Board on 30 March 2004.

# APPENDIX A - ADAPTIVE MANAGEMENT COMPONENTS IN VARIOUS PLANS

**Table A1. Plans with Adaptive Management Components[1], to be implemented during the Faro Mine Remediation Project**

| Document Title | Adaptive Management Component | Development of Adaptive Management Action and Response | Associated Report | Frequency of Reporting | Review Frequency of the Plan |
|---|---|---|---|---|---|
| Water Quality Adaptive Management Plan | Water quality and quantity at key locations. Supported by an extensive monthly water quality and flow program, as well as, chronic and acute bioassay test results. The following conditions are evaluated in this plan:<br>- Water entering the NFRC Realignment degraded by the North East Rock Dump and/or the Faro Creek Diversion.<br>- Water leaving the NFRC Realignment degraded by seepage or groundwater inputs occurring along the realignment channel.<br>- Water downstream of the NFRC Realignment degraded by contact water from bypass of the S-wells SIS, bypass of the NFRC Temporary Contact Water Conveyance System or inputs from unmanaged groundwater impacted by the Main Dump area.<br>- Water leaving the Rose Creek Diversion degraded by seepage or groundwater inputs along the diversion channel.<br>- Increases in combined loadings from the North Wall Interceptor Ditch channel that could eventually affect surface water.<br>- Increase in combined loadings from site degrade surface water quality in Rose Creek.<br>- Increase in combined loadings from site degrade surface water quality in Anvil Creek.<br>- Pelly River Increase in combined loadings from Faro and Vangorda site alter surface water quality in the Pelly River. | The plan has been updated during the YESAB adequacy process to include significance thresholds, triggers, action levels for both active remediation and long-term operations as part of adequacy request R2-8. This includes values for significance thresholds and triggers. It is anticipated that feedback during the screening process will result in additional edits for the Yukon Water Board submission. | Project Adaptive Management Plan Report | Quarterly and Annually | As required or every 3 years |
| Air Quality and Metrological Monitoring Plan | Air quality monitoring outcomes that indicate concentrations are above what was predicted or expected and will inform subsequent mitigation measures in the dust management plan. | This plan will be updated prior to Project implementation (i.e. prior to construction) with triggers that will then inform mitigation measures that would be required as part of the Dust Management Plan. | Air Quality and Meteorological Monitoring Report | Annually | Annually |
| Terrestrial Effects Monitoring Plan | Observed waterfowl interactions with the Project through the avifauna and general wildlife monitoring programs. | Triggers will be set in the first year of pre-construction monitoring and following completion of the revegetation trials | Terrestrial Effects Monitoring Report | Annually | Annually |
| | Large mammal interactions with the Project through the avifauna and general wildlife monitoring programs. | | | | |
| | Contaminant Loading in plants (for covers and ambient environment) | | | Every 2 Years | Every 2 Years |
| | | | | Annually (in the Water Monitoring Report) | Annually (in the Water Monitoring Report) |

**Table A1. Plans with Adaptive Management Components[1], to be implemented during the Faro Mine Remediation Project**

| Document Title | Adaptive Management Component | Development of Adaptive Management Action and Response | Associated Report | Frequency of Reporting | Review Frequency of the Plan |
|---|---|---|---|---|---|
| Aquatic Effects Monitoring Plan | Aquatic Toxicity- Current Low level action level states that chronic toxicity results (from laboratory toxicity tests performed with Rainbow Trout (O. mykiss), the water flea *Ceriodaphnia dubia*, and *Pseudokirchneriella subcapitata)* on samples collected in receiving waters statistically different from upstream reference and exceed a minimum effect size of 20% (Volume IV, Appendix 11D, Section 11.D.9). | Low level action levels have been proposed for surface water quality, aquatic toxicity, surface water quantity, benthic invertebrates and fish health. In most cases once low action levels are triggered than the next levels would be developed. It is anticipated that low level action levels will be adjusted and re-submitted as the second draft of the AEMP is submitted as part of the Water Licence Application. | Aquatic Effects Monitoring Report | Annually (in the Water Monitoring Report) | Every 3 to 5 Years |
| | Water quality - will be aligned with the Adaptive Management Plan | | | | |
| | Water Quantity -Departure in annual water yield or daily annual low flows normalized by area between the exposure and reference stations by more than 30%. | | | | |
| | Benthic Invertebrates- Species richness, EPT relative abundance, Chironomid relative abundance, or Bray-Curtis Index are above or below 2 standard deviation from reference. | | | Every 3 Years | |
| | Fish health effects- will be identified if the statistical difference between reference and exposure values for a condition that was 90% of the defined Critical Effect Size | | | Every 3 Years | |
| Revegetation Plan | Assessment of the ability of surficial materials to support ecosystem redevelopment (based on key physical characteristics) to confirm projected post-closure ecosite groups | Formalized adaptive management components and appropriate triggers will be developed following completion of revegetation trials and with input from local stakeholders. | Revegetation Monitoring Report | Annually at the completion of a revegetation effort; however, the frequency of monitoring will be reduced as vegetation communities age and are observed to be on stable developmental trajectories. | To be determined |
| | Cover and composition of plant re-establishment | | | | |
| | Assessment of functional aspects of vegetation-community re-establishment and development | | | | |
| | Assessment of re-establishment of vegetation-related land-use (primarily by Indigenous land users) and wildlife-habitat requisites of reclaimed ecosystems | | | | |
| Geotechnical Emergency Response Plan | Assessment of stability of the tailings dams, pit highwalls, waste rock dumps through data collection and interpretation from piezometers, slope inclinometers, photogrammetry analysis, seepage flows, staff gauges and visual observations shows trend of increasing pressure, water levels or movement. This will result in the immediate requirement to complete a visual inspection. action will be determined by the observations from the visual inspection and include the need to reduce the water levels, through pumping and or syphoning water into alternate location, buttress unstable waste rock dumps, clear areas of personnel and fast moving equipment. | Currently, this plan has been developed for operational use at the Faro Mine Site for current conditions. This document will be provided to the Yukon Water Board for the Faro Mine Remediation Project for the start of active remediation. As active remediation is completed this plan would evolve as stability increases on site. | Annual Geotechnical Report and Annual Pit Stability Report | Annually | Annually |
| | Notification of Seismic event greater than 3, and within 100 km's of the FMC. This will result in an immediate requirement to conduct a visual inspection of the tailings, water retaining & water diversion structures & read all piezometers | | | | |
| Performance Monitoring for Remediated Components | There will be a number of plans related to remediated components that will monitor the design and performance criteria for the engineered structures/remediated components. | The Remediation Plan for the Yukon Water Board will provide the conceptual performance targets. The final construction and monitoring plan for each would have final performance targets/ criteria as well as adaptive management action levels if the engineered structured/remediation component is deviating from the target. | | Annually | Each plan is completed once for each engineering design/remediated component |

**Table A1. Plans with Adaptive Management Components[1], to be implemented during the Faro Mine Remediation Project**

| Document Title | Adaptive Management Component | Development of Adaptive Management Action and Response | Associated Report | Frequency of Reporting | Review Frequency of the Plan |
|---|---|---|---|---|---|
| Socio-economic Management and Monitoring Plan | CIRNAC is currently forming a socio-economic monitoring and management committee with local community representatives, including the affect First Nations. Components requiring an adaptive management component would be discussed and selected through this mechanism in the following areas: | CIRNAC will form a socio-economic monitoring in management committee, in which one of the key roles will be to confirm the components that require adaptive management and the triggers. It is anticipated that this committee would be formed in 2021 and the plan would be updated prior to Project implementation. | Socio-economic Management and Monitoring Report | Annually | To be determined |
| | Procurement and Contracting | | | | |
| | Training and Employment | | | | |
| | Family Structure and Values | | | | |
| | Community Infrastructure and Services | | | | |
| | Human Health | | | | |
| | Local and Traditional Land Use | | | | |

**Table A2. Overview of Management and Monitoring's with Operational Management Components, to be implemented during the Faro Mine Remediation Project**

| Current Operational Management Document | Project Proposal Context | Operational Management Components | Associated Report | Frequency of Reporting | Review Frequency of the Plan |
|---|---|---|---|---|---|
| Health and Safety Management Plan | A health and safety plan will be required, a conceptual Occupational Health and Safety Plan is provided in part of the Project Proposal | Health and Safety including the Health and Safety Risks | Health and Safety Management Report | Annually | Annually |
| | | Occupational Air Monitoring Plan | | | |
| | | Medical Monitoring Program | | | |
| Water Monitoring Plan | Once the Project is permitted, it is expected that multiple plans will be used to manage water as currently described in the Performance Monitoring Plan and Water Management Plan | Water quality and flow at seeps, surface water, and groundwater across site and downstream of site | Water Monitoring Report | Annually | Annually |
| | | Toxicity Monitoring (chronic and acute tests) | | | |
| Operational Water Balance | Once the Project is permitted, it is expected that managing volumes of water on-site will be part of the Water Management Plan, but also be managed as through an operational procedure. | Pit and pond water levels | Operational Water Balance Report | Annually | 3 years |
| | | Water pumped into or out of contaminated water storage facilities | | | |
| | | Volumes of water treated and discharged effluent | | | |
| Water Treatment System's Discharge Protocol | Water treatment is part of the Water Management Plan; however the specifics of the discharge protocol will be part of the Operational Management System for the Site. | Compliance with Interim Water Treatment Plant's Discharge Protocol | Water Monitoring Report | Annually | 3 years |
| | | Compliance with the Vangorda Water Treatment Plant's Discharge Protocol | | | |
| | | Compliance with Cross Valley Pond Water Treatment Plant's Discharge Protocol | | | |
| Standard Operating Procedures for Seepage Interception Systems | While seepage interceptions systems are part of the Water Management Plan, standard operating procedures are part of the of the Operational Management System for the Site | Seepage collection system volume collected | Water Moved spreadsheet | Monthly | Annually |
| | | Compliance with the System Specific Maintenance Plan | Annual maintenance records from C&M | | |
| Work Package Construction Management Plans | N/A | Environmental Protection Plan (including: Water Quality Monitoring Plan, Sediment and Erosion Management Plan, Spill Response Plan, Metals Leaching and Acid Drainage Plan etc.) | To be determined | To be determined | To be determined |
| Environmental Management Plan | Sediment and Erosion Control Plan | Implementation, monitoring and maintenance of sediment and erosion control measures | Annual Environmental Management Plan Report | Annually | Annually |
| | Dust Management Plan | Implementation, monitoring and maintenance related to dust | | | |
| | Borrow Management Plan | Implementation, monitoring and maintenance of borrow sources | | | |
| | Waste Management Plan | Storage, monitoring and maintenance of waste | | | |
| | Roads and Traffic Management Plan | Implementation, monitoring and maintenance of traffic control measures | | | |
| | Emergency Response Plan | Implementation, monitoring and maintenance of Emergency Response Plan | | | |
| | Air Quality and Meteorological Monitoring Plan | Implementation, monitoring per the Air Quality and Meteorological Monitoring Plan | | | |
| | Heritage Resources Protection Plan | Implementation, monitoring and maintenance of Heritage Resource Protection Measures | | | |
| | Performance Monitoring Plan | Implementation, monitoring and maintenance of the Geochemical Monitoring | | | |
| Materials Management Plan | Materials Management Plan | Implementation, monitoring and maintenance of Materials Management Plan | To be determined | To be determined | To be determined |
| Geotechnical Monitoring | Geotechnical monitoring is described in the Remediation Plan and is a requirement for the Project. | Operations, Maintenance and Surveillance reports including routine monitoring and inspection requirements. | Annual Geotechnical Report | Annually | Annually |
| | | Ground Control Management Plan and Reports including the Open Pit Physical Stability Operations document including routine monitoring and inspection requirements. | Annual Geotechnical Report | Annually | Annually |

[1] Note: Operational management components are the plans, procedures, protocols and tools used to manage change on site that are expected to fall within an accepted/understood range of variation. Adaptive management components are used to manage change on site that may be unexpected.

# APPENDIX B - ENGAGEMENT KEY COMMENTS AND RESPONSES

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| Use of Event to describe a specific condition was found to be confusing to some participants | • Operational AMP Workshop | Revised to follow the language used in the Yukon AMP draft guidelines such that Event is replaced with Adaptive Management Initiative | Glossary |
| Request for protection goals and clarification around wording on natural variability | • Operational AMP Workshop<br>• Adequacy Round 2<br>• YESAB Remediation AMP Workshop | Protection goals were added, as well as the methods for how to define upstream reference condition for the Pelly River. | 3.2 and 3.6 |
| Concerns that the AMP was not acting as an early warning system and triggers need to be set such that there is time to react without reaching the next action level | • Operational AMP Workshop<br>• Adequacy Round 2<br>• YESAB Remediation AMP Workshop | Revised triggers and action levels were provided to allow for an early warning approach. In addition, triggers are proposed to be reduced once the Faro Mine Site is remediated. | 3.6 and 5 through 8 |
| Proactive targets/triggers to allow time for a management action | • Operational AMP Workshop<br>• Adequacy Round 2<br>• YESAB Remediation AMP Workshop | | |
| Protection goals should strive to meet 14.8.1 and fulfil obligations within the Selkirk First Nation Final Agreement. Non-degradation goal in the Pelly River | • Operational AMP Workshop<br>• Adequacy Round 2<br>• YESAB Remediation AMP Workshop | A non-degradation protection goal has been proposed for the Pelly River including an associated significance threshold and triggers. This protection goal is intended to help prevent measurable change in Pelly River water quality due to the Project. | 3.2, Table 8-1 |
| Mitigation needs to be consistent with meeting protection goals | • Operational AMP Workshop | Possible responses for AMIs downstream of the Faro Mine Site have been provided | Table 3-7; 5 through 8 |
| Anvil Creek requires a protection goal, given its important fisheries resources, particularly Chinook Salmon | • Operational AMP Workshop<br>• YESAB Remediation AMP Workshop | A protection goal was added for Anvil Creek including an associated significance threshold and triggers. | 3.2, Table 7-1 |
| No degradation beyond an $EC_{20}$ level in Rose Creek | • Operational AMP Workshop | The action levels for Rose Creek were set with at a high action level at the $EC_{20}$ level | 3.3.; 5 and 6, Appendix C |
| Cumulative effects from the Faro Mine Complex impact | • Operational AMP Workshop<br>• Round 1 Adequacy | PR-1 evaluates the impact from the Faro Mine Site to water quality in the Pelly River. This AMI includes stations and indicators to assess upstream influences, including the Vangorda Plateau Mine Area | 8 |
| AMP should inform discharge protocol for the Faro Mine Site | • Operational AMP Workshop<br>• Adequacy Round 1 | Treated effluent loading is included for AMI RC-2, in addition to several other sources to the NWID channel. Appendix A outlines other plans with adaptive management components, including those linked to WTP management. A mechanism is proposed to link plans together. | 2.1, Appendix A |
| Include a new event that is related to discharges from the Faro water treatment plants | | | |
| Evaluation of specific AMP events should focus on the attainment of the protection goals | • Operational AMP Workshop | Protection goals have been set such that they evolve as the Faro Mine Site is remediated (i.e., become more protective overtime). Significance thresholds have been added that reflect changes in water quality that could risk protection goal failure. Triggers have been added to ensure action is taken prior to exceedance of the significance threshold. | 3.2 through 3.6 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| Consider a 3-stage approach | • Operational AMP Workshop | A 3-Stage approach to action level has been adopted | 3.5 |
| Biological monitoring may not be appropriate for an AMP but is required to confirm water quality is sufficiently protective | • Operational AMP Workshop<br>• YESAB Remediation AMP Workshop | Biological monitoring will continue to be conducted as part of the Aquatic Effects Monitoring Plan and the AMP annual report can include results from aquatics every three years. A mechanism has been proposed that link these plans together. | 2.1, Appendix A |
| Need an understanding of how fish health is factored and considered | | | |
| Improve AMP figures | • Operational AMP Workshop | AMP figures have been updated. | Full document |
| Would like to see a Continuous Improvement Framework | • Operational AMP Workshop | The AMP was updated as per the Yukon AMP draft guidelines | n/a |
| Would like to see one AMP for both care and maintenance and remediation | • Operational AMP Workshop | It is not possible to have one AMP for both operation and remediation because the operational AMP includes the Vangorda Plateau Mine Area, which is out of the scope of the remediation project before YESAB. Once a water licence is obtained for the Project, a single AMP will be prepared for the Faro Mine Site. The Faro AMP will evolve over time as remediation advances. A separate AMP will then be prepared for the Vangorda Plateau Mine Area. However, the Vangorda Plateau Mine Area is factored into the AMI related to Pelly River. | 1.0 and 1.4 |
| CIRNAC should not release effluent that is chronically toxic | • Operational AMP Workshop | CIRNAC is committed to meeting protection goals and working with the appropriate government representatives. | Section 3.2, 5 through 8 |
| Cumulative effects from Vangorda | • YESAB Remediation AMP Workshop | Vangorda indicators are included in the Pelly River AMI | 8 |
| Details of responses to threshold exceedances | • Adequacy Round 1 | The AMP was updated to follow the Yukon guidance and give an overview of types of responses. The new requirements for a management response plan following an exceedance of an action level allows specific responses to be developed. | 3.9 |
| Incorporation of Traditional Knowledge in the AMP | • Adequacy Round 1<br>• Adequacy Round 2 | A mechanism has been proposed for incorporating Traditional Knowledge. | 2.3 |
| Process schematic showing the interactions between monitoring programs | • Adequacy Round 2 | A process schematic has been provided in the main document, with additional text. | Figure 2.1 and 2.1 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| Triggers should allow for sufficient time to identify trends and react to potential issues | • Adequacy Round 2<br>• YESAB Remediation AMP Workshop | Action levels were adjusted to indicate when conditions are progressing toward a significance threshold, with triggers allowing for action to be taken prior to exceedance. Trend analysis will be completed annually, including forward forecasting for all timeseries with sufficient data that show increasing concentrations. Additional supporting information, such as monitoring of mass loading, will help track the relative contribution from various sources and improve early warning of emerging issues. | 3.6; 5 through 8 |
| Responses/actions or mitigations focused on prevention and reducing long-term risk and timing of mitigations related to action levels | • Adequacy Round 1<br>• Adequacy Round 2<br>• YESAB Remediation AMP Workshop | The AMP was updated to follow the Yukon guidance and give an overview of types of responses. The new requirements for a management response plan following an exceedance of an action level allow specific responses to be developed. A description of management responses is in Table 3-7. Timelines for responses are not provided in the main document, as this would depend on the complexity of mitigation and urgency of the situation. Timelines will be described within a Management Response Plan once the issue and response can be further understood. | 3.9 |
| Timelines for responses to a trigger | • Adequacy Round 2 | | |
| Explain what has been used as thresholds in the AMP and difference between thresholds and maximum allow condition | • Adequacy Round 2<br>• Adequacy Round 3<br>• YESAB Remediation AMP Workshop | A maximum allowable condition was proposed to meet the Selkirk First Nation request to not exceed an $EC_{20}$ level in water quality in Rose Creek. Reviewers found the concept confusing, and it is removed from the Project AMP and the high action level was set at the $EC_{20}$ level in water quality in Rose Creek. | 3.3 through 3.6 |
| Thresholds in monitoring and management plans unrelated to water | • Adequacy Round 2<br>• YESAB Remediation AMP Workshop | The Project AMP includes an updated section on various types of plans where there are adaptive management components unrelated to water (e.g., wildlife). | 2.1, Appendix A |
| Engagement opportunities outside of every three years when the plan is updated | • YESAB Remediation AMP Workshop | CIRNAC will meet with stakeholders upon request. | 10 |
| Timing of management response plans and how much can be done in anticipation and how much is done after triggering | • YESAB Remediation AMP Workshop | Management response plans have been incorporated into the Project AMP and the timing has been tied to the exceedance of action level | 3.9 and Table 3.7 |
| AMP requires sufficient detail to demonstrate that the actions taken will prevent significant adverse effects | • YESAB Remediation AMP Workshop | The AMP has been updated to provide full details for early active remediation with a fulsome description of how AMIs would evolve through long-term operations and maintenance | 3.10 and 5 through 8 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| An AMI in South Fork Rose Creek | • YESAB Remediation AMP Workshop | At this time an AMI has not been developed for the South Fork Rose Creek (SFRC) because this area has not been identified as a major risk to downstream water quality. Water quality sampling within SFRC will continue throughout the Project as part of routine monitoring. If water quality in SFRC changes under a future condition an AMI could be added during the AMP updating process. Any substantial changes in water quality to SFRC would currently be detected as a contributing source to RC-4. | n/a |
| AMIs around water quantity | • YESAB Remediation AMP Workshop | Water quantity on the Faro Mine Site will be managed through the operational water balance. In addition, there is an adaptive management component in the Aquatic Effects Monitoring Plan related to water quantity in the receiving environment. | Appendix A, Table A-1 and A-2 |
| Consider the duration of an interim goal and the expected exposure to some effects in the revised AMP. | • YESAB Remediation AMP Workshop | A description of the duration of Interim Protection goals has been clarified and triggers and benchmarks have been revised to factor in the length of time for active remediation. | 3.5, 3.6 and Table 3-7, Appendix C |
| Clarification on the use of protection goals, versus maximum allowable condition and significance thresholds. Concerns around how these terms are used and applied. | • YESAB Remediation AMP Workshop | Protection goals and significance thresholds have been provided in the Project AMP, with definitions and how these apply. Maximum allowable condition has been excluded given the requests to incorporate significance thresholds. | 3.2 |
| At Action Level 2 the Project should be past planning and have made a decision on action | • YESAB Remediation AMP Workshop | The moderate action level includes developing an emergency response plan, and if appropriate, implementing outcomes of this plan. | Table 3-7 |
| How and when do all the plans communicate with each other | • YESAB Remediation AMP Workshop | The Project AMP provides a mechanism for how the plans will communicate with each other | 2.1, Appendix A |
| Will the AMP have AMIs related to the evaluation of effectiveness of measures? | • YESAB Remediation AMP Workshop | Yes, AMIs will evolve as remediation is completed to evaluate both construction and whether remediation components are performing as expected. For AMIs where urgent works has been completed or will be completed prior to licensing, evaluation of those activities is also included. | 5 to 8 |
| Concerns around trust that CIRNAC will follow through on commitments | • YESAB Remediation AMP Workshop | CIRNAC has proposed an engagement approach that is intended to build trust and allow for transparency around meeting commitments. | 10 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| Inclusion of Traditional Knowledge in the AMP and working with communities to obtain and integrate Traditional Knowledge | • YESAB Remediation AMP Workshop | CIRNAC has provided an approach to incorporation of Traditional Knowledge that indicates that intent to include Traditional Knowledge if data sharing agreements can be established. | 2.3 |
| Request for yearly meetings with the communities or community representatives that share the results of the monitoring from a give year. | • YESAB Remediation AMP Workshop | At this time CIRNAC is not proposing yearly meetings but will meet upon request. | 10 |
| Use the Maximum Allowable Concentration as a "NO GO" threshold and develop action levels accordingly. | • Written Operational AMP Feedback | Maximum allowable condition is not included in the Project AMP. Based on feedback during continuing engagement, reviewers found the concept confusing as written. Rather significance thresholds have been added. | n/a |
| Revise the "Type of Management Response" section | • Written Operational AMP Feedback | CIRNAC revised the text to clarify that some responses could include implementation. | Table 3-7 and 5 to 8 |
| Revise indicators for AMIs meant to evaluate potential risk to aquatic life. | • Written Operational AMP Feedback | Risk to aquatic life is evaluated through the Aquatic Effects Monitoring Plan and includes adaptive management components. The outcomes of this information would be incorporated into the AMP evaluation every 3 years and into annual AMP reports. | Appendix A |
| Discuss how adaptive management processes related to elements other than receiving water quality are incorporated into operational plans | • Written Operational AMP Feedback | CIRNAC added additional graphics and tables to clarify where other adaptive management related monitoring is done under other monitoring plans. | 2.1, Appendix A |
| Indicate timeline when RC-2 and RC-3 indicators, action levels, monitoring and management responses will be defined | • Written Operational AMP Feedback | RC-2 and RC-3 AMIs have been provided in the Project AMP. | 6.2 and 6.3 |
| Define trend analysis and include trends as action level triggers. | • Written Operational AMP Feedback | Trend analysis has been defined and trends will be determined for each indicator. | 3.8.1 |
| Suggest pick a specific cycle which given present dynamics is best to be 2 years for the time being. | • Written Operational AMP Feedback | CIRNAC will maintain a 3-year cycle because of the time it takes for review, engagement and adjustments. | 9 |
| If the plants are discharging, how could they not be causing at least in part the exceedance? It seems that it should be a SOP to cease or dial back plant discharges if an exceedance is triggered and then conduct the investigation. | • Written Operational AMP Feedback | CIRNAC has provided a list of operational management plans including those related to water treatment. | Appendix A |
| Provide context in the environment setting and confirm accuracy with Traditional Knowledge. Statements should be checked with First Nations specifically. | • Written Operational AMP Feedback | CIRNAC altered text to acknowledge statements are based on current sampling effort not on historical Traditional Knowledge. | 2.3 |
| Recommend confirming statements related to Chinook Salmon with Traditional Knowledge or at least acknowledge there is uncertainty on the historical intensity of use by chinook which may have been different than presently observed. | • Written Operational AMP Feedback | CIRNAC is working with the First Nations to come to agreement on sharing Traditional Knowledge. | 2.3 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| Missing is that protection goals are necessary to establish significance thresholds. | • Written Operational AMP Feedback | A section that aligns protection goals and significance thresholds has been included. | 3.2 |
| How is the North Fork Rose Creek below Faro Creek Diversion included in the AMP. | • Written Operational AMP Feedback | AMI NFRC-1 has been established in this area. This evaluates Project related impacts occurring upstream of the NFRC Realignment, including those within the Faro Creek Diversion. Refer to main document for further details. | 5.1 |
| Protection Goals The caption "Where does it apply?" i in the table is mis-leading. I suspect you mean what monitoring stations will be used to determine attainment which is not the same as what reaches of the Creek or River are intended to be protected to the stated goal. | • Written Operational AMP Feedback | CIRNAC thanks the reviewer for this observation. Table, text and figure have been updated for clarity. | 3.2 and Table 3.1 |
| The description should also identify that effluent loading in particular Mn from the treatment plants is a concern and that operational discharge volume management is going to be required to limit this loading. | • Written Operational AMP Feedback | Treated effluent loading is included for Rose Creek (RC2). Appendix A outlines other plans with adaptive management components. A mechanism is proposed to link plans together. | 2.1, Appendix A |
| seepage into the channel from tailings is only possible along the secondary dam and there are diluting tributaries between this reach and RC-SW010. So evaluating at RC-SW010 could miss unacceptable impacts occurring upstream. The correct question is whether water within the RCD is influenced not whether the water leaving the RCD is influenced. RC-SW002 should come into play in this AMI. | • Written Operational AMP Feedback | The AMI was kept the same as the philosophy of the AMP is to focus on key exposure areas, where there is enough data to evaluate the monitoring results. If a low action level is hit than an investigation would look into contributing factors. | 6.1 |
| One of AMIs should address two questions:<br>1. Are the SIS components achieving their design objectives (100% of surface and 95% of groundwater interception)<br>2. Is the plume chemistry what was expected or is it worse? | • Written Operational AMP Feedback | AMIs have been adjusted to recognize as remediation is completed, they will be used to evaluate performance, including the performance of the permanent water treatment plant. | Section 6 |
| Account for the binary nature of discharges: Treatment season and non-treatment season. During treatment season you are sampling weekly and so evaluation of triggers should be done based on that frequency. | • Written Operational AMP Feedback | Evaluation of triggers is proposed on a quarterly basis as past experience has determined that a more frequent review does not result in an increased response time. However, there is a Water Treatment Discharge Protocol in place and data from the plant is evaluated on a daily and weekly basis. | Appendix A |
| Other Indicators: Effluent quality, total volume treated, sludge, unplanned downtime, flow pacing. | Written Operational AMP Feedback | These parameters are handled operationally in the WTP Discharge Protocol. | Appendix A |
| New AMI #2: Focus on water balance of the Faro Pit and maintaining sufficient storage. | • Written Operational AMP Feedback | CIRNAC agrees this is critical. Pit water level and action levels related to this will be put the appropriate operational plan as defined in Appendix A. | Appendix A |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| New AMI #3: Focus on potential loadings to Upper Guardhouse Creek from the Northwest Rock Dump. | • Written Operational AMP Feedback | A new AMI specific to Upper Guardhouse Creek was not added to the AMP at this point. However, to improve the functionality of RC-2 at identifying sources, several supporting stations were added. These stations will be used to monitor mass loading and evaluate trends to help track the relative contribution of each contributing source. This includes station NW-SW001, which will be used to monitor the influence of Upper Guardhouse Creek on NWID, and ultimately on Rose Creek. | 6.2 |
| RC-3: Focus on the performance and adequacy of seepage interception systems in the down valley/X13 channel area and amount of uncaptured seepage (whether a deep groundwater plume or otherwise). | • Written Operational AMP Feedback | RC-3 has been adjusted to reflect how this AMI would evolve through active remediation and long-term operation and maintenance including the performance of remediation components. | 6.3 |
| RC-2: Revised to focus on cumulative effects on water entering Rose Creek from the NWID channel. Content relating to NWID loading from treated effluent, upstream NWID loading, and seepage would be moved to the new AMI #1, new AMI #3 and RC-3 respectively. | • Written Operational AMP Feedback | RC-2 uses concentration limits estimated using the downstream water quality model to evaluate the cumulative effects of NWID on Rose Creek. Additional supporting stations have been added to facilitate source identification, including those related to effluent discharge, X13-SIS bypass, and flow from Upper Guardhouse Creek. RC-3 continues to use a similar modelling approach but is focused exclusively on groundwater seepage and SIS bypass. No additional AMIs have been added to this area. | 6.2 |
| Determine whether the channel between NW-SW003 and CVS8 is considered fish habitat.<br>If it is, develop an AMI for this area and implement reasonable protection measures (i.e. develop low-effect benchmarks/SSWQOs for this area using local water quality and apply mitigation measures to achieve this). If not, prevent fish from accessing the area using a fish fence. | • Written Operational AMP Feedback | The loading from the NWID channel (including NW-SW003 to CVS8 area) is covered under the RC-2 AMI. | 6.2 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| Incorporate seasonal year-over-year exceedances of benchmarks into action level triggers (i.e., multiple consecutive years where exceedances occur at the same monitoring point for 1-3 months should trigger AMI actions). | • Written Operational AMP Feedback | Seasonality and year-over-year exceedances have not been incorporated into the triggers based on water quality benchmarks. The required frequency of exceedance for these triggers decreases as the potential risk to aquatic life increases. This approach balances the need for confirmation of an issue with its associated risk to the environment. In many cases the triggers indicate a progression toward a water quality benchmark, with some representing a proportion of that benchmark (e.g., 75%). The SSWQO for example is a benchmark below which no adverse effects on aquatic life for indefinite exposures are expected. Seasonality is factored into annual trend evaluation for each AMI in the annual report. It is also included in the triggers for the Pelly River, as these triggers relate to changes in water quality opposed to potential for aquatic life effects. | 3.8 and 8 |
| Include observation of iron and manganese precipitate in riverbed sediment as an indicator for AMIs. | • Written Operational AMP Feedback | Fe and Mn precipitate are monitored annually and reported in the annual WQ report. This looks at spatial extent and quality of precipitate. The precipitate is intermittent depending on water quality discharges from site and flow rates of the stream making it ill-suited as an indicator in the AMP. However, CIRNAC agrees its critical to monitor and to pair this with possible effects to aquatics through the Aquatic Effects Monitoring Program rather than the Project AMP. | n/a |
| Review SSWQOs and benchmarks when site specific toxicity testing is complete and revise AMP if necessary. | • Written Operational AMP Feedback | This is complete - the early life stage testing and final Mn/Fe memo results were used to inform the draft benchmarks proposed in the Project AMP. The toxicity information was submitted as part of Round 3 of adequacy. | |
| Implementation of urgent remediation measures should be expected to improve aquatic ecosystem conditions in areas near the mine, for example in NFRC and Rose Creek. The AMP should recognize the purpose of the urgent works and set protection goals that aim at improvement of aquatic conditions in areas where urgent works are expected to result in benefits. | • Written Operational AMP Feedback | AMIs have been adjusted to account for evaluation of remediated components to confirm that the remediation components are performing as expected. In addition, the protection goals and triggers are expected to be lowered after remediation where improvement is expected. | 3.1, Table 3-5, and 5 through 8 |
| A strong rationale should be provided for choosing to rely on an alternative method for evaluating attainment of non-degradation conditions. | • Written Operational AMP Feedback | CIRNAC added rationale on the approach to evaluating the Pelly River and outlined attempts to get closer to the guidance, recognizing data limitations. | 3.5 and 8 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| The Action Levels should be defined for each AMI and indicator based on the specific conditions. For AMP purposes, is neither logical nor proactive to establish Action Level 1 as the SSWQO or 60% of the SSWQO if exceeding these would entail a major shift if water quality. Instead, Action Level 1 should be aimed at identifying statistically significant shifts in water quality or comparison with water quality guidelines, depending on location/parameter specific conditions. | • Written Operational AMP Feedback | An action level is a level of environmental change that triggers action to be taken in response to a monitoring result. It can be thought of as a general category that reflect the level of concern; the guidelines recommend tiered action levels such as “low”, “moderate”, and high” (see Figure 3-2). The triggers for each action levels differ depending on the AMI (see Sections 5 through 9 for detailed on each AMI) and are outlined in Section 3.5 and 3.6. At project initiation and in the first few years of remediation, it is not thought that the triggers for the action levels can be lowered but it is expected these can be lowered once a remediation component is complete and found to be working appropriately. This could mean use of trends or other statistically significant shifts in water quality. | 3.4 |
| Water quality trends are a valuable indicator of changes in water quality and should be incorporated more directly in the AMIs, including the development of trend-based Action Levels. Trends can be used to predict and forecast future water quality conditions and timing, making them more proactive in many cases than threshold-based Action Levels. Action Levels can be tied to both the magnitude and rate of water quality trends. Trend-based triggers have been used for adaptive management at Faro in the past and should be included in the proposed OAMP. It may be beneficial to include both trend-based and threshold-based triggers for a single Action Level – i.e., exceedance of either type of trigger would be considered as exceedance of the Action Level. | • Written Operational AMP Feedback | There are four types of triggers included in the Project AMP: water quality concentration based, toxicity based, performance based and changes to the normal range (i.e., non-degradation). At this time, trends are not proposed as triggers because of a variety of issues in the data: breaks in data collection over time, lack of data sufficient to capture a reasonable number of seasonal cycles for a given AMI (e.g., five seasons and fifty samples) implementation of urgent works causing a step change in the data and moving stations over time. A qualitative trend analysis and seasonal trend analysis will be done annually for each indicator for each AMI (where data permits). | 3.5 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| Measuring water quality changes in receiving waters is important, but where possible it should not be the first line of defense in adaptive management. For example, NFRC-1 is intended to address the potential impact of loading from the North East Rock Dump. The Action Levels are based on conditions in NFRC receiving water. Table 5-1 identifies groundwater monitoring as part of the monitoring program, but neither the Action Levels nor the evaluation of monitoring results proposed for the AMI address groundwater conditions. At this location, changes in conditions in groundwater should be incorporated directly into Action Levels, or a separate AMI should be established to address groundwater conditions. | • Written Operational AMP Feedback | Groundwater quality-based triggers have been incorporated where sufficient understanding of the system allows for meaningful triggers. This is where groundwater modelling can be linked to surface water modelling to predict potential impacts of groundwater seepage to aquatic life in the receiving environment. If future groundwater modelling efforts progress to this point in other areas (e.g., NFRC-1) an AMI could be added through the AMP updating process. Until that time, groundwater wells have been added as supporting stations to monitor any major shifts or changing trends in groundwater quality. | 6.3 |
| Overall, the rationales for the proposed low-effect benchmarks lack detail. No supporting information is provided. For example, if toxicity datasets were considered and revised, there should be transparency about what toxicity results were considered, removed or selected. If the rationale relies on site-specific toxicity testing, results should be provided. Without additional information it is not possible to evaluate whether the proposed benchmarks will be effective for achieving the proposed protection goals. | • Written Operational AMP Feedback | References for toxicity studies are included in the AMP. These studies are publicly available for review are part of the YESAB adequacy submissions for Round 2 and 3. | Appendix C |
| Liard First Nation recommended an annual AMP meeting with First Nations as a mechanism to seek input about and discuss the AMP. Such meetings would provide an opportunity to discuss monitoring results, Action Level exceedances, and response plans, as well as the status and function of the overall AMP. Such meetings should include involvement from a broad range of project experts who collect and interpret monitoring data, assess AMP conditions, and develop response plans. | • Written Operational AMP Feedback | While an annual meeting is not planned at this time, CIRNAC has clarified that meetings could be held in communities upon request. | 10. 2 |
| CIRNAC should consider whether the monitoring regime should be revised to collect a dataset that is consistent with Yukon Government's draft guidance on the development of water quality objectives (i.e., monthly frequency plus at least one annual intense sampling event with 5 samples collected in 30 days, during period(s) of highest variability). | • Written Operational AMP Feedback | CIRNAC is investigating the feasibility of changing the monitoring regime for the Pelly River including review of logistical and health and safety constraints. | n/a |
| Could RC-1 be relocated to a location closer to the source so that it is not influenced by dilution from inflows on the west side of the diversion between the fuse plug and RC-SW010? | • Written Operational AMP Feedback | CIRNAC will add RC-SW002 to the AMI RC-1. | Table 6-1 |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| To remain consistent with federal contaminated sites terminology, COCP and COC are listed at contaminants of potential concern and contaminates of concern. | • Written Operational AMP Feedback | CIRNAC will continue to be consistent with the Project Proposal which uses constituent of potential concern. | Glossary |
| Appendix C does not include the details of which species will be considered for the toxicity testing. Additional which species will be considered when would be beneficial. Will all levels, fish, Invertebrates and plants be considered when toxicity testing is triggered. | • Written Operational AMP Feedback | CIRNAC will edit the section in AMP to be sure the species tested are listed. | Appendix C |
| TRC proposed AMI's that fall under the category of things that would be in the Yukon AMP guidance such as treated effluent and seepage capture as well as water level in the Faro Pit. TRC took the time to make sure these ideas were within the guidance and water quality in the receiving environment has a lot of contributing factors. TRC is not sure if CIRNAC and Golder have clearly explained in the presentation slides why having AMI operational controls would not make sense. | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | CIRNAC has highlighted what other documents include adaptive management components and what operational monitoring is intended to be in place to address concerns such as treated effluent and the Faro Pit level. | 2.1<br>Appendix A |
| How will things that are captured in AMI or Operations be tied together? | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | CIRNAC has highlighted a mechanism in Section 2.1 that speaks to the integration of plans. | 2.1 |
| AMI elements are not pulled out of the individual packages to highlight the need for action. An annual AMI meeting would be a good opportunity to review how things are going. | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | While an annual meeting is not planned at this time, CIRNAC has clarified that meetings could be held in communities upon request. | 10, Table 10-1 |
| Annual meetings on adaptive management have been conducted for Faro in the past, moving forward these meetings need to be structured discussions involving TRC members as well as the relevant discipline experts. Discussion should include the changes in AMIs and what has led to them, or what may be coming up. | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | CIRNAC has indicated that annual meetings are not planned at this time; however, all reports will be shared with stakeholders. | 10, Table 10-1 |
| Protection goals should be numeric. The TRC believes that protection goals are an overarching umbrella, yet some trigger values can bee exceeded without exceeding protection goals. Protection goals can be measured and TRC thinks that should be addressed in the Operational AMP. | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | Protection goals are statements that are over-arching and are meant to be at a high-level requiring multiple line of evidence to determine their exceedance. However numeric significance thresholds were included in the Project AMP. | 3.2, 5 through 8 |
| Strongly suggest looking at seasonal differences in the trend analysis, similar to what is done with the Pelly River AMIs. | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | Seasonal differences will be looked at annually in a statistical trend analysis for each AMI for each indicator where sufficient data exists. This will be used as supporting information to understand changes at an AMI. Seasonality has not been incorporated into triggers that use water quality benchmarks, as was done for PR-1. | |

**Table B-1 Engagement Key Comments and Responses**

| Engagement Key Comment | Source | Approach to Addressing Comment | Section |
|---|---|---|---|
| When looking at seasonal trends look at winter maximums to help identify upswings. | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | One component of the annual trend analysis will be to make a conservative estimate of potential water quality trigger exceedances. This will require additional within-season analysis to ensure the most significant seasonal trend with the greatest predicted magnitude of change is used for forward forecasting (e.g., winter maximums). | |
| There should be an AMI for effluent. TRC suggested tying action levels and triggers to metrics of volume discharged and effluent quality. If either the volume discharged or the quality of discharge declines, then that should be a trigger for actions around the treatment plants. | • Spoken Operational AMP Feedback, May 2021 TRC Meeting | Treated effluent requires management on a shorter time and response scale than the AMP. Therefore, CIRNAC has a separate mechanism for managing treated effluent on a day-to-day basis. In addition, the treated effluent will be bound to a Water Licence effluent quality standards. However, treated effluent quality is still included in RC-2. | 2.1, Appendix A and 6.2 |

# APPENDIX C - DEVELOPMENT OF ACTION LEVEL TRIGGERS

# Faro Mine Remediation Project

## Appendix C

## Development of Indicators, Benchmarks, and Triggers

**Crown-Indigenous Relations and Northern Affairs Canada**

**Version: July 2021**

# Table of Contents

# C. Project Adaptive Management Plan – Development of Indicators, Benchmarks, and Triggers

## C.1 Introduction

This attachment provides background support on the development of concentration-based screening values for use in the Project Adaptive Management Plan (AMP) for water-related Adaptive Management Initiatives (AMI).

## C.2 Derivations

The methods used to develop action levels for exposure scenarios followed a three-step process:

1. Identify AMP **indicator constituents** for each AMI—Indicators are the water quality parameters for which quantitative screening is conducted, including specification of the form of the substance (total or dissolved).
2. Derive **effect-level benchmarks** for each indicator constituent—Benchmarks represent concentration-based screening values that correspond to levels of predicted response (no-effect, low-effect, and moderate-effect) and that incorporate the concentration-response information from both site-specific toxicity testing and literature reviews.
3. Set significance thresholds and tiered **triggers** based on effect-level benchmarks or performance-based targets—Triggers represent the relationship between the site-specific benchmarks, significance thresholds, and the protection goals for the affected water bodies; these triggers define which action level applies to observed water quality conditions, recognizing that triggers and corresponding action levels can vary by waterbody and project phase.

### C.2.1 Identification of Indicators

Indicators are constituents used to evaluate water quality at a particular station for a particular AMI. The intent of the selection process was to identify a set of water quality indicators that adequately characterizes the environmental condition under evaluation, provides early detection of changes in the environmental conditions, represents the project specific issue(s)/project performance being assessed, and is easily measurable (YG 2020). For the Project AMP for the Project Proposal, selection process included the following steps:

- Step 1: Review of screening for constituents of potential concern (COPCs) in Project Proposal (Volume II, Section 7.3.4, Table 7.3.6).
- Step 2: Review of screening for indicator constituents completed as part of the Faro Mine Complex Operational Adaptive Management Plan (CIRNAC 2021).
- Step 3: Inclusion of key acid rock drainage indicators for all areas, regardless of the magnitude of concentrations of these parameters (sulphate, iron, manganese, and zinc).
- Step 4: Inclusion of indicators identified for upstream AMIs, regardless of the magnitude of concentrations (i.e., indicators identified upstream were automatically adopted for downstream AMIs despite dilution from the receiving environment).

The COPCs are the substances released by the Faro Mine Site to surface waters at concentrations that may hinder achievement of a water quality guideline (WQG) or site-specific water quality objective (SSWQO; YG 2019). COPCs were first identified for modelled conditions (i.e., conditions at Project initiation, active remediation, and long-term operations and maintenance) as part of the Project Proposal (Step 1). This screening process used a comparison of site loading sources and water quality from existing conditions with generic water quality guidelines. The COPCs identified through this process are based on comparisons of the observed water quality or predicted model results with appropriate WQGs and SSWQOs. Through this process a final list of COPCs were identified for each model node and Project phase (Volume II, Section 7.3.4, Table 7.3.6). Subsequent screening for AMP indicator constituents was then completed as part of the Operational AMP (CIRNAC 2021; Step 2). This additional screening serves as a more recent assessment of existing water quality conditions and is applicable specifically to AMP operational targets and triggers. Indicators identified through the Operational AMP screening were cross-referenced with COPCs identified as part of the Project Proposal (Volume II, Section 7.3.4) to develop a combined list of final AMP indicators for the Project AMP.

Two additional steps were completed to conservatively select the appropriate indicators. Key acid rock drainage indicators were automatically included, regardless of screening results (Step 3). This was done to be conservative, such that constituents that may indicate onset or progression of ARD are monitored as part of all AMIs, despite existing or predicted conditions. Finally, indicators identified for an upstream area have been applied to all downstream AMIs (Step 4). For example, indicators identified for North Fork Rose Creek were applied to Rose Creek, and further to Anvil Creek and the Pelly River, however those identified for Rose Creek are not applied upstream to North Fork Rose Creek. This approach provides confidence that downstream habitats are automatically evaluated for substances that could be early indicators of future changes, even if those conditions have not yet been observed in monitoring data/modelled predictions.

The indicators chosen for the Project AMP are provided in Table C.1. Indicators applicable for each AMI are provided in Table C.2. Note that in the case of the Pelly River AMI, indicators from the Operational AMP (CIRNAC 2021) from the Vangorda Mine Plateau Area were added in the event of cumulative effects in the Pelly River. These are not expected but the indicators were carried forward to be conservative.

**Table C.1 Overview of AMP Indicator Constituents Identified for Each Step**

| STEP | Description | Indicators Identified | Indicators Selected for Project AMP[(a)] |
|---|---|---|---|
| 1 | Project Proposal Screening | sulphate, cobalt, total iron, dissolved iron, manganese, silver, zinc | sulphate, total ammonia, nitrate, total aluminium, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, total selenium, total uranium, and dissolved zinc |
| 2 | Operational AMP Screening | sulphate, total ammonia, nitrate, total aluminium, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, total selenium, total uranium, and dissolved zinc[(a)] | |
| 3 | Acid Rock Drainage Indicators | sulphate, iron, manganese, and zinc | |
| 4 | Indicators identified from upstream AMI | Refer to Table C.2 | |

Notes:

(a) In practice, final indicators vary according to each AMI. Final indicators listed here reflect a complete list for all AMIs. Whether an indicator use dissolved or total fraction may also vary depending on purpose of the AMI (e.g., whether triggers are based on non-degradation or water quality benchmarks.

**Table C.2 Indicators Identified for Each Adaptive Management Initiative**

| AMI | Applicable AMP Exposure Station/Model Node [e] | COPCs from Project Proposal | Indicators from Operational AMP | Project AMP Indicators |
|---|---|---|---|---|
| NFRC-1 | NF-SW003/none | None | None | sulphate[a], total iron[a], dissolved iron[a], dissolved manganese[a], and dissolved zinc[a] |
| NFRC-2 | NF-SW008/X2 | total iron | dissolved cadmium, total cobalt | sulphate[a], dissolved cadmium, total cobalt, total iron, dissolved iron[a], dissolved manganese[a], and dissolved zinc[a] |
| NFRC-4 | NF-SW010/X2 | total iron | dissolved cadmium, total cobalt | sulphate[a], dissolved cadmium, total cobalt, total iron, dissolved iron[a], dissolved manganese[a], and dissolved zinc[a] |
| RC-1 | RC-SW002, RC-SW010/X3A | zinc | dissolved cadmium, total cobalt | sulphate[a], dissolved cadmium, total cobalt, total iron(a, dissolved iron[a], dissolved manganese[a], and dissolved zinc |
| RC-2 | NW-SW003/X14 | sulphate, cobalt, total iron, dissolved iron, manganese, silver[d], zinc | total ammonia, dissolved cadmium, total cobalt | sulphate, total ammonia, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, and dissolved zinc |
| RC-3 | Selected groundwater monitoring wells | N/A | N/A | sulphate, dissolved cadmium, dissolved cobalt, dissolved iron, dissolved manganese, and dissolved zinc |
| RC-4 | RC-SW014/X14 | sulphate, cobalt, total iron, dissolved iron, manganese, silver, zinc | total ammonia, dissolved cadmium, total cobalt | sulphate, total ammonia, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, and dissolved zinc |
| AC-1 | RC-SW030/R5, A1 | total iron, dissolved iron, manganese, zinc | total cobalt | sulphate[a], total ammonia[b], dissolved cadmium[b], total cobalt[b], total iron[a], dissolved iron[a], dissolved manganese[a], and dissolved zinc[a] |
| PR-1 | PR-SW004/P4 | none | sulphate, total ammonia, nitrate, total aluminium, dissolved cadmium, total cobalt, total iron, dissolved iron, dissolved manganese, total selenium, total uranium, and dissolved zinc | sulphate[a], total ammonia[b], nitrate[c], dissolved aluminium[c], dissolved cadmium[b], dissolved cobalt[b], dissolved iron[a], dissolved manganese[a], dissolved selenium[c], dissolved uranium[c], and dissolved zinc[a][f] |

(a) Included as key acid rock drainage indicator regardless of the magnitude of concentrations.

(b) Included due to upstream AMI, regardless of the magnitude of concentrations (i.e., indicators identified upstream were automatically adopted for downstream AMIs despite dilution from the receiving environment).

(c)Identified for the Vangorda Mine Plateau Area as part of the Operational AMP (CIRNAC 2021). These indicators are monitored as part of the Project AMP only on the Pelly River.

(d)Silver was identified as a COPC at model node X14 for predicted conditions at project initiation. Silver was not carried forward to the Project AMP indicator list as it was not identified in the Operational AMP screening, or through predicted conditions at active remediation and long-term operations and maintenance.

(e)The sampling locations have been updated since the time of submission of the Project Proposal both the new station name and the name used in the Project Proposal are presented herein.

Note that indicators for the Pelly River use the dissolved fraction, this was done to help reduce data variability associated with total suspended solids.

### C.2.2 Benchmarks

Low effect benchmarks and moderate effect benchmarks for the Project AMP were developed from a combination of sources, reflecting the state of scientific knowledge available for each substance. The key sources of technical information were:

- Draft Site Specific Water Quality Objectives (SSWQOs) from the Project Proposal — literature-based derivations that are protective of all forms of aquatic life and customized to site-specific water quality composition and toxicity modifying factors.
- Water quality guidelines from federal sources (e.g., Canadian water quality guidelines for the protection of aquatic life [CWQG-PAL], Federal Environmental Quality Guidelines [FEQG]) and provincial sources (e.g., BC Ministry of Environment water quality guidelines).
- Site-specific validation studies based on laboratory toxicity tests of site-representative water conducted for select constituents (total iron, manganese, sulphate, zinc) to evaluate acute and chronic toxicity over a range of simulated site water exposures.
- Literature-based derivations of effect benchmarks from the Aquatic Health Risk Assessment in the Project Proposal, corresponding to low to moderate risk to specific receptor groups (fish, invertebrates, and plants) (see Attachment 7I-2 of Appendix 7I Aquatic Health Risk Assessment of the 2019 Project Proposal [CIRNAC 2019]).
- Species sensitivity distributions for acute and chronic toxicity, indicating the proportion of species exhibiting adverse responses at concentrations at increments above the SSWQOs.

SSWQOs, low effect benchmarks, and moderate effect benchmarks are defined for each AMP indicator. Definitions of these terms are provided in Table C.3. The low effect benchmarks and moderate effect benchmarks for each area of the Faro Mine Site are provided in Table C.4, with summaries of the technical derivations, including the historical development of SSWQOs, provided below for each substance.

**Table C.3 Definitions of Site-specific Water Quality Objectives, Low Effect Benchmarks, Moderate Effect Benchmarks, and Significance Thresholds**

| Faro Terminology | Effect Level | Toxicity Endpoint | Narrative Description | Source |
|---|---|---|---|---|
| Site-specific water quality objective (SSWQOs) | No effect level | $HC_5$ (5% hazard concentration) from species sensitivity distribution (SSD) derived using a dataset primarily of $EC_{10}$ or threshold representing a no effect level for multiple species[a] | SSWQOs represent concentrations below which no negative effects on aquatic life are expected during indefinite exposures. As they are derived using the same protocol as for federal water quality guidelines (WQG), they have a similar level of protection (i.e., protect all forms of aquatic life including sensitive species and life stages in long-term exposures). CCME (2007) preferentially uses no-effect and low-effect data in their guideline derivation, with a hierarchy that selects thresholds for no negative effects, defined as "*an effect level on 10% or less of the exposed individuals of a species (i.e., $EC_{10}$) unless a more appropriate no-effects threshold is defined*" such as an $EC_x$ representing a no-effect threshold (CCME 2007). SSWQOs are customized to be protective of the aquatic life that can be found at a specific site, which means SSWQOs are less conservative than generic WQGs. SSWQOs are derived using toxicity estimates compiled from the toxicological literature.<br>SSWQOs may be validated with site-specific toxicity testing, and if warranted, revised from that based only on toxicological literature. Validated SSWQOs are available for sulphate, total iron, manganese, and zinc. | SSWQO from the Project Proposal as described in Volume II, Appendix 7H; Information Request R3-14<br><br>Site specific toxicity testing may validate or revise the SSWQO |
| Low effect Benchmark | Low effect level | $EC_{15\text{-}25}$ or threshold demonstrated to be at or near the low effect level; target $EC_{20}$ for use in benchmarks | The low effect benchmarks represent concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. When available, the low effect benchmark is selected as representative of a 20% effect ($EC_{20}$) level generated with site specific toxicity testing of one or more species. If the results from more than one species are considered appropriate, that is, more than one species have similar $EC_{20}$s and thus similar sensitivity to low-level effects, then the geometric mean of the $EC_{20}$s is selected as the low effect benchmark. Otherwise, an appropriate benchmark that is representative of the site and relevant species is selected from a toxicity dataset of $EC_{20}$s (or threshold representing a low effect level) found in the toxicological literature. This use of the $EC_{20}$ is consistent with the CCME (2007) definition for low effect level (i.e., $EC_{15\text{-}25}$). | Selected either from the results of site-specific toxicity testing or from a review of $EC_{20}$ values (or equivalent thresholds) found in toxicological literature (e.g., as used in the SSWQO or WQG derivation) |
| Moderate effect benchmark | Moderate effect level | $EC_{50}$ or threshold demonstrated to be at or near the moderate effect level where multiple species are affected | Moderate effect benchmarks are selected to reflect a potential for chronic, sublethal effects of approximately 50% effect size on individuals of sensitive species and life stages of invertebrates and fish, and potential effects on multiple species within a receptor group in long-term exposures. Concentrations greater than the moderate effect benchmark are interpreted to represent a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes.<br>The criteria for the selection of a moderate effect benchmark were:<br>• 50% adverse response in growth or reproduction of fish or invertebrate species; does not need to be the lowest $EC_{50}$ for the most sensitive species, unless that species is integral to the functioning of that ecosystem (e.g., Slimy Sculpin, Arctic Grayling, Chinook Salmon, Ephemeroptera/Plecoptera/Trichoptera)<br>• May be >50% adverse response in growth of sensitive algae species, or more than half of algal species affected such that there is high potential of indirectly affecting fish or invertebrates through lack of food/habitat<br>• A point on the SSD curve where multiple species are affected such that there is high potential for community-level effects; this point depends on the species ranking and is specific to each COPC<br>• As a check, the benchmark should not allow >25% lethality to fish or invertebrate species<br>Results from supplemental toxicity testing take precedence over literature-based toxicity data, unless the species tested was not a sensitive species in the lower tail of the species sensitivity distribution. | Selected either from the results of site-specific toxicity testing or from a review of $EC_{50}$ values (or equivalent thresholds) found in toxicological literature (e.g., as used in the SSWQO or WQG derivation) |
| Significance threshold | Depends on waterbody and Project phase | n/a | A significance threshold is defined as a threshold above which environmental changes are significantly adverse and can be interpreted as an indication of when there is a threat to maintaining the protection goal. The protection goal informs the significance threshold, which directs what the low, moderate, and high action level triggers will be. As protection goals are specific to the waterbody and project phase, so will the associated significance thresholds. For example, the significance threshold may be set at a less protective benchmark (e.g., moderate effect benchmark) for a particular waterbody, and then transition to a more protective benchmark (e.g., low effect benchmark) as remediation activities progress. | n/a |

Note: (a) SSDs were not used to develop SSWQOs for dissolved iron or sulphate.

**Table C.4 Proposed Water Quality Benchmarks for the Project AMP**

| INDICATOR | Unit | No Effect Benchmark (SSWQO) | Low Effect Benchmark | Moderate Effect Benchmark |
|---|---|---|---|---|
| | | No Effect Level | Low Effect Level | Moderate Effect Level |
| Sulphate | mg/L | Hardness dependent:<br>128 mg/L at hardness 0 to 30 mg/L as $CaCO_3$<br>218 mg/L at hardness 31 to 75 mg/L as $CaCO_3$<br>309 mg/L at hardness 76 to 180 mg/L as $CaCO_3$<br>429 mg/L at hardness 181 to 250 mg/L as $CaCO_3$<br>430 to 799 mg/L at hardness between 251 and 432 mg/L as $CaCO_3$ based on the equation ((2.0385 × [hardness]) - 80.615)<br>800 at hardness ≥432 mg/L as $CaCO_3$ | 1.5 × SSWQO<br>= 192 to 1200 | 1.75 × SSWQO<br>= 224 to 1400 |
| Total Ammonia | mg/L as N | pH and temperature dependent:<br>Look up Table<br>= 0.102 at pH 9.0 and temperature 20.0°C to 2.08 at pH 6.5 and temperature 0°C | pH and temperature dependent:<br>Look up Table<br>= 0.08 at pH 9.0 and temperature 30°C to 4.9 at pH 6.5 and temperature 0-7°C | pH and temperature dependent:<br>(0.041/(1/(POWER(10,((0.0901821+2729.92/(Temperature +273.15))-pH))+1)))*0.8224<br>= 0.173 at pH 6.0 and temperature 0°C to 192 at pH 10.0 and temperature 30°C |
| Cadmium, Dissolved | µg/L | Hardness dependent:<br>$\exp^{((0.736 \times \ln(\mathrm{hardness})) - 4.943)}$<br>= 0.0176 to 0.457 based on calibration range of 3.4 to 285 mg/L | 2.5 × SSWQO<br>= 0.0440 to 1.14 | 4 × SSWQO<br>= 0.0704 to 1.83 |
| Cobalt, Total | µg/L | Hardness dependent:<br>$\exp^{((0.414 \times \ln(\mathrm{hardness})) - 1.29)}$<br>= 1.41 to 3.27 based on the calibration range of 52 to 396 mg/L | 11 × SSWQO<br>= 15.5 to 36.0 | 35 × SSWQO<br>= 49.4 to 114 |
| Iron, Total | µg/L | pH and DOC dependent:<br>$\exp^{((0.671 \times \ln(\mathrm{DOC})) + (0.171 \times \mathrm{pH}) + 5.586)}$<br>= 337 to 4961 based on calibration range for DOC and pH of 0.3 to 9.9 mg/L and pH 6.1 to 8.1 | 2.7 × SSWQO<br>= 910 to 13 395 | 3.6 × SSWQO<br>= 1213 to 17 860 |
| Iron, Dissolved | µg/L | 350 | 1000 | Not derived[a] |
| Manganese, Dissolved | µg/L | pH and hardness dependent:<br>CCME Calculator<br>= 200 to 1500 based on the calibration range for hardness and pH of 25 to 670 mg/L and pH 5.8 to 8.4 | Hardness-dependent Level 1 Fish Benchmark[b]<br>$\exp^{(\ln(1096) - 0.411 \times (\ln(50)-\ln(\mathrm{hardness})))}$<br>= 823 to 3201 based on the calibration range for hardness of 25 to 670 mg/L | Hardness-dependent Level 2 Fish Benchmark[b]<br>$\exp^{(\ln(2052) - 0.411 \times (\ln(50)-\ln(\mathrm{hardness})))}$<br>= 1541 to 5993 based on the calibration range for hardness of 25 to 670 mg/L |
| Zinc, Dissolved | µg/L | Hardness, pH, and DOC dependent:<br>$\exp^{((0.947 \times \ln(\mathrm{hardness}])) - (0.815 \times \mathrm{pH}) + (0.398 \times \ln(\mathrm{DOC}) + 4.625)}$<br>= 1.7 to 516 based on the calibration range for hardness, pH, and DOC of 23.4 to 399 mg/L, pH 6.5 to 8.13, and 0.3 to 22.9 mg/L | 4 × SSWQO<br>= 6.8 to 2062 | 6 × SSWQO<br>= 10.2 to 3096 |

Notes: Where a range is provided, benchmarks are dependent on exposure and toxicity modifying factors and are calculated individually for each sample. Technical rationales for each benchmark are provided below. The benchmarks are provided for project initiation and active remediation and are used for long term operations and maintenance; however, its expected these could be updated for water licensing and as new information arises. [a] There is insufficient information to derive a moderate effect benchmark for dissolved iron. [b] Level 1, 2, and 3 receptor-specific benchmarks were derived in Attachment 7I-2 of Appendix 7I Aquatic Health Risk Assessment of the 2019 Project Proposal (CIRNAC 2019).

### *Sulphate*

The Project Proposal (Crown Indigenous Relations and Northern Affairs Canada [CIRNAC] 2019) was prepared before site-specific toxicity studies were available, and therefore the draft SSWQO was based on the British Columbia (BC) WQG of up to 429 mg/L (depending on water hardness) published by Meays and Nordin (2013). The Project Proposal acknowledged other studies and information from the water quality profile that suggested potential for a validated SSWQO that was greater than the draft SSWQO, but deferred the numerical derivation pending the completion of the studies.

Site-specific toxicity testing confirmed that the draft SSWQO as filed in the Project Proposal was overly conservative at higher hardness conditions applicable to the Faro Mine Site (Golder 2021a) and hence the SSWQO was updated in Information Request R3-14. The validated SSWQO of 800 mg/L for higher hardness is approximately the geometric mean of the two lowest chronic $IC_{10}$ from the battery of aquatic organisms tested in the site-specific toxicity testing with sulphate (i.e., 658 mg/L for growth of the green algae *Pseudokirchneriella subcapitata* and 918 mg/L for reproduction of the invertebrate *Ceriodaphnia dubia*). The SSWQO of 800 mg/L is considered protective because this value is similar to the No Observed Effect Concentration (NOEC) of 789 mg/L for the most sensitive species (*P. subcapitata*) (Table 4 in Golder 2021a), and the estimated magnitude of effect on growth at 800 mg/L was between 12 and 13% for this species. Tests with rainbow trout (*Oncorhynchus mykiss*) embryo-alevins yielded $EC_{10}$s between 1187 mg/L (normal alevin development) and 1273 mg/L (survival), indicating that the SSWQO would be protective of early life stages of fish.

The SSWQO is dependent on hardness. Site-specific toxicity testing with sulphate evaluated hardness conditions of 432 to 1560 mg/L for ionic mixtures that are sulphate-calcium dominant; therefore, the validated SSWQO of 800 mg/L is applicable to waters of ≥432 mg/L hardness and sulphate-calcium dominant ionic mixture. For waters with hardness less than 250 mg/L, the hardness-dependent BC WQG will apply. For waters with hardness between 250 and 432 mg/L, the SSWQO will be calculated assuming a linear increase in SSWQO between the BC WQG at 250 mg/L hardness (i.e., 429 mg/L sulphate) and the SSWQO at 432 mg/L hardness (i.e., 800 mg/L sulphate).

The low effect benchmark is derived from the site-specific toxicity studies with sulphate (Golder 2021a). The three lowest chronic $IC/EC_{20}$ from the battery of aquatic organisms tested in the site-specific toxicity testing with sulphate was 1211 mg/L for growth of *P. subcapitata*, 1154 mg/L for reproduction of *C. dubia*, and 1257 mg/L for normal alevin development of rainbow trout (Golder 2021a). The $IC/EC_{20}$s for these species are similar and within the range of water quality measurement error, and therefore, the $IC/EC_{20}$s from all three species are considered representative of a 20% effect level in sensitive species. The approximate geometric mean of these $IC/EC_{20}$s is 1200 mg/L. Therefore, at 1.5 times the SSWQO, there is the potential for low level effects on aquatic life. The difference between the SSWQO and the low effect benchmark is assumed to be consistent in waters with lower hardness. This assumption is supported by the species sensitivity information for sulphate in the BC WQG technical appendix (Meays and Nordin 2013). Meays and Nordin (2013) reported low-effect toxicity estimates (i.e., $IC/EC_{20\text{-}25}$) for multiple species tested in waters with hardness ranging from 6 to 250 mg/L as $CaCO_3$. The ratio of these low-effect toxicity estimates to the associated hardness-dependent WQG was generally typically greater than 1.5. Note that the BC WQG was derived by applying a safety factor of two to a low-level toxicity estimate for the most sensitive species (i.e., 21-day $LC_{20}$ embryo to alevin survival of rainbow trout). Therefore, 1.5 times the SSWQO was selected as a low effect benchmark for sulphate that is appropriate for all hardness levels.

The moderate effect benchmark for sulphate is derived from the site-specific toxicity studies with sulphate. Rainbow trout embryo-alevins had the lowest $EC_{50}$s (Golder 2021a). The $EC_{50}$s were 1387 mg/L for normal alevin development, 1439 mg/L for survival and 1803 mg/L for length. The highest test concentration had high effect on survival and normal alevin development (>60%) whereas the second highest concentration had no effect (<10%). The next lowest chronic $IC_{50}$ from the battery of aquatic organisms tested in the site-specific toxicity testing with sulphate was >1480 mg/L for *C. dubia*, where the highest test concentration had approximately 35% adverse effect on reproduction. A rounded estimate of 1400 mg/L in high hardness waters (≥432 mg/L as $CaCO_3$) or 1.75 times the SSWQO in softer waters was selected for further consideration as the moderate effect benchmark for sulphate. The proposed moderate effect benchmark was evaluated further with respect to magnitude of effects on aquatic plants, number of species affected, and potential for lethality to invertebrates and fish.

Low level effects on some species of aquatic plants may occur at the moderate effect benchmark, but moderate to high level effects are not expected. At 1400 mg/L, there was approximately 30% effect size on *P. subcapitata* growth in the site-specific toxicity testing. Elphick et al. (2011) reported a $IC_{25}$ of 1727 mg/L for the same species and endpoint in waters of 320 mg/L as $CaCO_3$. Meays and Nordin (2013) reported an $IC_{10}$ of 2314 mg/L for the duckweed *Lemna minor* frond increase in waters of 250 mg/L; toxicity estimates could not be derived for higher effect sizes. Thus the moderate effect benchmark of 1.75 times the SSWQO is not expected to cause significant reduction of aquatic plants.

Level 3 receptor-specific benchmarks were derived for the Aquatic Health Risk Assessment in the Project Proposal to indicate when there was a potential for adverse effects on a broader range of species that could trigger changes to receptor populations or the broader aquatic community. For sulphate, the level 3 benchmarks were selected to be equal to the $EC_{50}$ for the most sensitive species. The moderate effect benchmark of 1.75 times the SSWQO is lower than the level 3 benchmark for invertebrates (2.7 times the SSWQO) and fish (2.4 times the SSWQO), suggesting that the number of species that would be affected is low and population- or community-level changes are not expected.

Finally, the moderate effect benchmark is unlikely to cause significant mortality to invertebrate or juvenile fish. The NOEC for *C. dubia* and fathead minnow (*Pimephales promelas*) survival was higher than the highest test concentration of 1480 mg/L in the chronic toxicity tests conducted as part of the site-specific toxicity testing.

Based on the above, 1.75 times the SSWQO was selected as the moderate effect benchmark for sulphate. As with the low effect benchmark, this multiplier will be applied to all hardness levels.

### *Total Ammonia*

An SSWQO for total ammonia was not developed as it was not identified as COPC in the Project Proposal (CIRNAC 2019). For the AMP, the BC MOE (2009) chronic WQG was selected as the SSWQO for total ammonia. The SSWQO is pH and temperature dependent. BC MOE (2009) provides a look up table for the 30-day average (chronic) concentration of total ammonia as nitrogen for the protection of aquatic life. The lowest value is 0.102 mg/L as N at pH 9.0 and temperature of 20.0°C and the highest value is 2.08 mg/L as N at pH 6.5 and temperature of 0°C. At pH 8.0 and 5°C, the total ammonia SSWQO is 1.18 mg/L as N.

The low effect benchmark is based on the current US EPA criterion (2013), which was developed using $IC/EC_{20}$ values. US EPA (2013) conducted a literature search and compiled reliable chronic toxicity values for 21 species (ten invertebrates and 11 fish) published after 1985. Where test methods for the study were considered acceptable and the study results showed a reduction in survival, growth, or reproduction, the test data were used in calculating the chronic value. Data from studies that met the criteria were analyzed using a regression analysis to estimate the $IC/EC_{20}$. As the target effect level for this benchmark is $EC_{20}$, this recently derived water quality criterion by US EPA, which uses $IC/EC_{20}$ values, was considered appropriate to adopt as the low effect benchmark. The low effect benchmark for total ammonia is dependent on pH and temperature; US EPA (2013) provided look-up tables for sample-specific conditions. Values range from 0.08 mg/L as N at pH 9.0 and temperature 30°C to 4.9 mg/L as N at pH 6.5 and temperature 0-7°C. At pH 8.0 and 5°C, the total ammonia low effect benchmark is 1.8 mg/L as N.

The moderate effect benchmark is based on the CCME CWQG-PAL (CCME 2010). CCME derived a chronic guideline for un-ionized ammonia, with the understanding that un-ionized ammonia is known to be more toxic than the ammonium ion. The guideline for un-ionized ammonia is 0.019 mg/L, and can be converted to total ammonia using equations that consider pH and temperature. The un-ionized ammonia guideline is based on two lines of evidence. The first is the LOEC for most sensitive freshwater study, which was a five-year chronic study with rainbow trout. This study derived a LOEC for un-ionized ammonia of 0.04 mg/L based on the occurrence of pathological lesions in the gills and tissue degradation in the kidneys (Thurston et al. 1984 in CCME 2010). The second line of evidence was Environment Canada's (1999) aquatic community ecological risk model, which identified 0.041 mg/L as the concentration at which 5% of species in an aquatic community would exhibit a 20% reduction in growth or reproduction. Environment Canada used chronic $EC_{20}$s to populate their species sensitivity distribution. The 95% prediction limits for the $HC_5$ were 0.019 and 0.063 mg/L, and the lower limit was adopted as the CCME guideline. The moderate effect benchmark adopts the $HC_5$ or 0.041 mg/L for un-ionized ammonia, which can be converted to total ammonia using the equations provided in CCME (2010). The total ammonia benchmark can be applied over a range of pH 6.0 to 10.0 and temperature 0 to 30°C. At pH 8.0 and temperature of 5°C, the moderate effect benchmark for total ammonia is 2.7 mg/L as N.

### *Cadmium*

A draft SSWQO for dissolved cadmium was developed for Project Proposal (CIRNAC 2019), which adopted the long-term BC WQG for protection of aquatic life for dissolved cadmium (BC MOE 2015). Site-specific toxicity testing has not been conducted for cadmium, and therefore the draft SSWQO for cadmium was retained for the Project AMP. The SSWQO for cadmium is hardness-dependent, and therefore the SSWQO is expressed as an equation rather than a constant value. Values for the SSWQO can range from 0.0176 to 0.457 µg/L based on the calibration range for hardness of 3.4 to 285 mg/L as $CaCO_3$.

The low effect benchmark for cadmium is based on a review of toxicity data used in the developing the CWQG-PAL (specifically the species sensitivity distribution; CCME 2014) and the BC WQG. Both jurisdictions compiled large toxicity datasets; however, the same studies were not used by both parties and some studies were interpreted differently. These differences were taken into consideration when interpreting the toxicity data.

The low effect benchmark for cadmium was selected as 2.5 times the SSWQO; when applied to the long-term BC WQG of 0.127 µg/L at 50 mg/L hardness, this benchmark is 0.3175 µg/L. Based on the review of the species sensitivity distribution provided by CCME (2014), the low effect benchmark is above a low-effect threshold for one fish species (out of 14) and above no- and low-effect thresholds for three invertebrate species (out of 18 invertebrate taxa). The lowest toxicity estimate for a fish species in both the CCME and BC MOE datasets was a 62-day $IC_{10}$ of 0.15 µg/L or lowest observed effect concentration (LOEC) of 0.16 µg/L for growth (i.e., weight) of early life stage rainbow trout tested at a hardness of 29.4 mg/L as $CaCO_3$ (Mebane et al. 2008). When normalized to 50 mg/L hardness using CCME's normalization equation, the $IC_{10}$ was 0.233 µg/L. However, a review of the original study indicated that there was no clear dose-response in the 62-day test, and that the effect size for growth at the highest test concentration of 3.9 µg/L at approximately 13%. This suggests that the low effect benchmark would not cause low level effects to fish.

Based on a review of the CCME's species sensitivity distribution, the lowest normalized toxicity estimates ($IC_{10}$, maximum acceptable toxicant concentration [MATC], and $IC_{25}$) for three invertebrate species (*Daphnia magna*, *Ceriodaphnia reticulata*, and *Hyalella azteca*) ranged from 0.045 µg/L to 0.122 µg/L. Review of the original studies (where available) indicated that, at the low effect benchmark, there may be moderate effects on *D. magna* feeding rate and offspring production (approximately 50%), low effects on *H. azteca* survival and reproduction (approximately 20–30%), and low effects on *C. reticulata* reproduction (<25%). Although the selection of the 2.5 times the SSWQO as the low effect benchmark could result in low to moderate effects on three sensitive species of invertebrates, there would be no effects on any other invertebrates, including other sensitive crustaceans such as *C. dubia*, and no effects on fish or plants (all no- and low-effect thresholds for aquatic plants were much higher than the low effect benchmark). Therefore, 2.5 times the SSWQO may be indicative of possible low level responses to some sensitive invertebrates, but with protection of most of the invertebrate community. As the SSWQO varies with hardness, the low effect benchmark would range from 0.0440 to 1.14 µg/L depending on sample hardness.

The moderate effect benchmark for cadmium was also based on a review of species sensitivity information in CWQG-PAL and the BC WQG. At four times the SSWQO, there is a potential for moderate to high effects on some sensitive invertebrates, and no effects on fish or plants. The same three invertebrate species as noted above would be affected, but at higher magnitude of effects. Review of the original studies indicating that, at the low effect benchmark, there may be high effects on *D. magna* feeding rate and offspring production (>50%), moderate effects on *H. azteca* reproduction (approximately 50%), and low effects on *C. reticulata* reproduction (<25%). Therefore, four times the SSWQO may be indicative of moderate to high level responses to some sensitive invertebrates. As the SSWQO varies with hardness, the moderate effect benchmark would range from 0.0704 to 1.83 µg/L depending on sample hardness.

### *Cobalt*

A draft SSWQO for total cobalt was developed for the Project Proposal (CIRNAC 2019). The draft SSWQO used a modified toxicity dataset from the recently derived Federal Environmental Quality Guideline (FEQG; Environment Canada 2017) to calculate an $HC_5$ from a species sensitivity distribution. Site-specific toxicity testing has not been conducted for cobalt and therefore the draft SSWQO for cobalt is retained for the Project AMP. The SSWQO for cobalt is hardness dependent, and therefore the SSWQO is expressed as an equation rather than a single value. Values for the SSWQO can range from 1.41 to 3.27 µg/L based on the calibration range for hardness of 52 to 396 mg/L as $CaCO_3$.

Species sensitivity information from the Project Proposal was used to select the low effect benchmark for cobalt. The level 2 receptor-specific benchmark for invertebrates was selected as the second lowest invertebrate toxicity estimate on the species sensitivity distribution (Appendix 7H, Figure 7H.9-1), which is the 7-day $IC_{20}$ of 11.1 µg/L for *C. dubia* reproduction (Stubblefield et al. 2020). The level 2 invertebrate benchmark is the lowest $IC_{20}$ for invertebrate and fish species in the species sensitivity distribution, indicating that this benchmark would provide a high level of protection for low level effects to other invertebrate and fish species. However, the published $IC_{20}$s for other sensitive invertebrates are similar and have overlapping 95% confidence intervals: Stubblefield et al. (2020) reported $IC_{20}$s of 17.6 (11.9-14.3) µg/L for *H. azteca* growth, 11.1 (1.9-65.3) µg/L for *C. dubia* reproduction and 23.1 (12.0-44.2) µg/L for the snail *Lymnea stagnalis* growth. The approximate geometric mean of these three $IC_{20}$s is 20 µg/L. A review of the supplemental information provided with Stubblefield et al. (2020) indicated that this concentration corresponds to approximately 17% effect on the endpoints. The $IC_{10}$s for other invertebrate species (e.g., *D. magna*, *Aeolosoma* species [annelid worm], *Chironomus tentans* [midge]) and fish (fathead minnow, rainbow trout) are higher (Stubblefield et al. 2020). Thus, at 11 times the SSWQO, there is the potential for up to 20% effects on multiple sensitive invertebrate species, but no effect to most invertebrate species or to any fish species. As the SSWQO varies with hardness, the low effect benchmark would range from 15.5 to 36.0 µg/L depending on sample hardness.

The moderate effect benchmark for cobalt of 35 times the SSWQO was based on a review of species sensitivity information from the Project Proposal. At 35 times the SSWQO, there is a potential for approximately 50% effect on multiple cladocerans (*D. magna* and *C. dubia* reproduction, *L. stagnalis* growth), based on a review of the supplemental information provided with Stubblefield et al. (2020). There would be less than 50% effect on growth of the most sensitive aquatic plant species (*L. minor* and *P. subcapitata*). The moderate effect benchmark occurred at approximately the $HC_{45}$ on the species sensitivity distribution provided in Appendix 7H of the Project Proposal. This indicates that several invertebrate and plant species, but no fish species, could be affected at the moderate effect benchmark. At 35 times the SSWQO, there is the potential for less than 30% mortality of *C. dubia* and *D. magna* in chronic exposures. As the SSWQO varies with hardness, the moderate effect benchmark would range from 49.4 to 114 µg/L depending on sample hardness.

### *Iron, Total*

In the aquatic environment, iron (Fe) exists in two primary forms: soluble ferrous ($Fe^{2+}$) iron and insoluble ferric ($Fe^{3+}$) iron, typically present as an amorphous orange solid ($Fe[OH]_3$). Oxidation-reduction reactions determine the chemical behaviour of iron in the aquatic environment. The oxidation of $Fe^{2+}$ to insoluble $Fe^{3+}$ oxyhydroxides is influenced by pH, redox potential, dissolved oxygen, the amount and type of dissolved organic matter, and other environmental factors, with acidic, non-humic water generally having the highest proportion of iron present in the dissolved form (Vuori 1995). Overall, the available information indicates that iron speciation varies in watercourses in the receiving environment (both spatially and temporally). Given this variability and that the mechanism of toxicity is different for ferric (total) iron and ferrous (dissolved) iron, SSWQOs and benchmarks were developed separately for both iron species. The physical effects of iron (flocculants and precipitation smothering or staining) are considered separately from these water quality-based derivations. The spatial extent and quality of iron precipitate is monitored annually and reported in the annual water quality report. Possible effects of this precipitate on aquatic life are assessed through the aquatic effects monitoring program.

A draft SSWQO for total iron was developed for the Project Proposal using a species sensitivity distribution of chronic toxicity data. However, ECCC published a draft FEQG for total iron since the submission of the Project Proposal, which considers the exposure and toxicity modifying factors (EMTF) of pH and dissolved organic carbon (DOC) (ECCC 2019). Consideration of these EMTFs better reflects the potential for chronic toxicity due to total iron in the receiving environment.

Site-specific chronic toxicity testing with total iron confirmed that the ECCC's draft FEQG for total iron provides an appropriate degree of environmental protection as a validated SSWQO (Golder 2021b). The SSWQO for total iron is dependent on pH and DOC and therefore the SSWQO is expressed as an equation rather than a single value. Values for the SSWQO can range from 337 to 4961 µg/L based on calibration range for DOC of 0.3 to 9.9 mg/L and pH 6.1 to 8.1.

The low effect benchmark for total iron is based on results from the site-specific toxicity testing (Golder 2021b). The lowest $IC_{20}$ obtained was for *C. dubia* reproduction, which was 2.7 times the SSWQO. The next higher $IC_{20}$ was for growth of *P. subcapitata* at four times the SSWQO, which could result in moderate level effects on *C. dubia* reproduction. Based on this information, the factor of 2.7 times the SSWQO was selected as the low effect benchmark for total iron. As the SSWQO varies with pH and DOC, the low effect benchmark would range from 910 to 13 395 µg/L depending on sample pH and DOC.

The moderate effect benchmark for total iron is based on a review of species sensitivity information in ECCC (2019) and the results of the site-specific toxicity testing (Golder 2021b). The toxicity data presented in ECCC (2019) were normalized to pH 7.5 and DOC of 0.5 mg/L so the toxicity estimates from the site-specific toxicity testing were also normalized to the same EMTF values to facilitate comparison between the two datasets. The unbounded $IC_{50}$ of >1953 µg/L for *C. dubia* reproduction from the site-specific toxicity testing was the lowest normalized $IC_{50}$ from the battery of aquatic organisms tested. The $IC_{50}$ is unbounded because the highest test concentration had less than 50% effect on reproduction. The extrapolated model estimate for the $IC_{50}$ was 2164 µg/L with 95% confidence limits of 1503 to 3005 µg/L. This extrapolated $IC_{50}$ is 3.6 times the SSWQO. There were no significant effects on survival or growth of fathead minnow in the 7-day test at the highest test concentration of 2524 µg/L, or on *C. dubia* survival at the highest test concentration of 1953 µg/L. Based on the extrapolated $IC_{50}$ for *C. dubia* reproduction, 3.6 times the SSWQO was selected for further consideration as the moderate effect benchmark for total iron. The proposed moderate effect benchmark was evaluated further with respect to magnitude of effects on aquatic plants, number of species affected, and potential for lethality to invertebrates and fish.

Low level effects on some species of aquatic plants may occur at the moderate effect benchmark, but moderate to high level effects are not expected. ECCC (2019) reported a 72-hour $IC_{10}$ for *P. subcapitata* growth of 1640 µg/L, based on a geometric mean of several studies; however, the original sources that supported this toxicity estimate could not be retrieved and therefore, the effect size at the moderate effect benchmark could not be determined. However, the normalized $IC_{20}$ for *P. subcapitata* (2404 µg/L) from the site-specific toxicity testing is four times the SSWQO, which suggests that 3.6 times the SSWQO would not result in more than low level effects to this algal species.

At 3.6 times the SSWQO, there is a potential for low level effects on some aquatic species and moderate to high level effects on the most sensitive species. There are four invertebrate and fish species on the ECCC species sensitivity distribution that have no-effect threshold below the moderate effect benchmark: *Daphnia pulex*¸ *C. dubia,* fathead minnow, and Coho salmon (*Oncorhynchus kisutch*). The most sensitive endpoint from the species sensitivity distribution by ECCC (2019) was a 21-day MATC of 946 µg/L for *D. pulex* reproduction (taken from Birge et al. 1985). At 3.6 times the SSWQO, there is the potential for a high effect (up to 80%) *D. pulex* reproduction and a low effect on *D. pulex* survival (<25%). ECCC (2019) used a 60-day $LC_{10}$ of 1290 µg/L for Coho salmon (Smith and Sykora 1976). At 3.6 times the SSWQO, there may be up to 25% effect on survival but no effect on growth for this species. ECCC (2019) reported $IC_{10}$s of 1090 µg/L for *C. dubia* reproduction and 1067 µg/L for fathead minnow growth. The original sources for these toxicity estimates could not be retrieved. However, site-specific toxicity testing with these species suggests that there may be moderate level effects (~50% effect size) on *C. dubia* reproduction but no effects on fathead minnow at the moderate effect benchmark. The moderate effect benchmark is also below the chronic toxicity estimates for the last two species on ECCC's species sensitivity distribution: the 21-day IC16 of 2477 µg/L for *D. magna* reproduction and the 90-d NOEC of 5100 µg/L for brook trout (*Salvelinus fontinalis*) survival and growth.

Finally, the moderate effect benchmark is unlikely to cause significant mortality to invertebrate or juvenile fish. At 3.6 times the SSWQO, there is a potential for up to 25% mortality of two sensitive invertebrate species (*D. pulex* and *C. dubia*) and one sensitive fish species (Coho salmon). Based on the site-specific toxicity testing, no effects on survival of fathead minnow are expected.

Based on the site-specific testing results and the review of ECCC's species sensitivity distribution, the moderate effect benchmark of 3.6 times the SSWQO for total iron may cause moderate to high effects on two sensitive invertebrate species and low level effects on survival on a sensitive fish species (i.e., Coho salmon), but no effects on other sensitive invertebrate and fish species, and no effects on plants. As the SSWQO varies with pH and DOC, the moderate effect benchmark would range from 1213 to 17 860 µg/L depending on sample pH and DOC concentration.

### *Iron, Dissolved*

A draft SSWQO for dissolved iron of 350 µg/L was developed for the Project Proposal and was based on the BC MOE (2008) WQG. Supplemental toxicity testing was not conducted for dissolved iron because maintaining a consistent proportion of dissolved iron over a chronic exposure is very difficult. As discussed by Phippen et al. (2008) "*ferrous iron is generally chemically unstable in water and exists in this state only between pH 4 and 5 in low oxygen conditions*." Therefore, it is challenging to evaluate dissolved iron without reducing pH and oxygen to levels that could confound interpretation of toxicity testing in laboratory exposures.

A low effect benchmark for dissolved iron was developed using information from the BC WQG derivation. Phippen et al. (2008) considered both the direct toxicity effects of dissolved ferrous iron ($Fe^{2+}$) and the indirect effects on habitat and species displacement by iron precipitates. They recommended a maximum WQG of 350 µg/L for dissolved iron, based on independent toxicity tests that resulted in a 96-hour $LC_{50}$ of 3500 µg/L for the amphipod *H. azteca* and a chronic $LC_{50}$ of 3600 µg/L for *P. subcapitata*, each multiplied by an uncertainty factor of 10. The low effect benchmark for dissolved iron of 1000 µg/L was calculated as the geometric mean of the chronic WQG of 350 µg/L and the lowest 96-hour $LC_{50}$ of 3500 µg/L and rounded down to 1000 µg/L. This use of a geometric mean of the no effect threshold (BC WQG) and the lowest reliable toxicity estimate is consistent with CCME's use of a MATC in their hierarchy of acceptable endpoints to use as representative no-effects or low-effects threshold (CCME 2007).

The methods used to derive the low effects benchmark for dissolved iron deviate from the methods described in Table C.3 because there are no $EC/IC_{20}$s available for dissolved iron. Phippen et al. (2008) did not provide the raw data or concentration-response curves from the *H. azteca* and *P. subcapitata* tests so that the concentrations corresponding to a lower effect size could be estimated. Although the lowest reliable toxicity estimate is based on acute lethality of *H. azteca*, the next reliable toxicity estimate is for chronic toxicity to *P. subcapitata* and yielded a similar result (i.e., 3500 vs 3600 µg/L). Phippen et al. (2008) deemed the 96-hour test with *P. subcapitata* to represent a chronic exposure, which is consistent with CCME's (2007) interpretation of algal toxicity tests with exposure durations of longer than 24 hours. Although the *P. subcapitata* effect type is indicated to be lethality (reported as $LC_{50}$), it is likely that the Environment Canada growth inhibition test method was employed (Environment Canada 1992; the BC MOE tests were conducted in 1997 and 1998), and thus the response is more likely to be growth inhibition than lethality. The toxicity test protocol was not described in Phippen et al. (2008). Due to the lack of available toxicity data, there is higher uncertainty in the derived low effect benchmark for dissolved iron than there are for other COPCs. However, selection of the geometric mean (1000 µg/L) as the low effect benchmark provides an estimate of a potential effect greater than the no effect threshold but less than a moderate adverse response size (i.e., similar to the MATC [Maximum Acceptable Toxicant Concentration] under the CCME endpoint preference ranking).

The low effect benchmark of 1000 µg/L is also lower than all other toxicity estimates generated for other species by BC MOE (Phippen et al. 2008). For example, after *H. azteca* and *P. subcapitata*, the next most sensitive species was *D. magna*. The 21-day chronic test with *D. magna* yielded NOEC and LOEC of 5300 and 10 700 µg/L, respectively. Toxicity estimates were less sensitive for chironomid (acute 96-hour test), rainbow trout (acute 96-hour and 7-day embryo tests), and the bioluminescent bacteria *Vibrio fischeri* (5-minute and 15-minute Microtox® test).

As described above, the acute 96-hour $LC_{50}$ of 3500 µg/L for *H. azteca* and the chronic $LC_{50}$ of 3600 µg/L for *P. subcapitata* from testing conducted by the BC MOE was used, in combination with safety factors, to derive the BC WQG for dissolved iron. Phippen et al. (2008) describes a limited number of other studies that propose a WQG for dissolved iron to support the derivation of the BC WQG. A NOEC of 400 µg/L from bioassays with clams was derived by Milam and Farris (1998). Warnick and Bell (1969) reported a 96-hour median tolerance limit of 320 µg/L for mayfly (*Ephemerella subvaria*), and a 9-day and 7-day $LC_{50}$ of 16 000 µg/L for stonefly (*Acroneuria*) and caddisfly (*Hydropsyche*), respectively. A maximum permissible concentration of 370 µg/L (i.e., 10-fold safety factor applied to $EC_{50}$) was reported for common duckweed (*Lemna minor*) (Wang 1986). Last, a water quality criterion for dissolved iron of 210 µg/L was proposed by Linton et al. (2007). This criterion was developed for total iron, but Phippen et al. (2008) suggests it is functionally equivalent to dissolved iron as the criterion was based on the response of biological communities.

There are insufficient data to calculate a reliable benchmark for dissolved iron indicative of moderate level risk to aquatic life. Additional studies are reported in Appendix I and II of Phippen et al. (2008) that characterize the acute and chronic toxicity of dissolved iron for fish and invertebrate species. There are 96-hour $LC_5$s to $LC_{95}$s ranging from 11 800 to 63 400 µg/L reported for the invertebrate *Cyclops veridis,* and 96-hour $LC_5$s to $LC_{95}$s ranging from 6500 to 119 600 µg/L are reported for Tilapia (*Mossambica*). The pH of these studies varied between 6.5 and 8.5. A single chronic value of 1900 mg/L at pH 6.7, described as "harmful", was reported for the fish species pike and tench. No EC/$IC_{50}$s for growth or reproduction of fish or invertebrate species are available. Therefore, it is difficult to derive and evaluate a moderate effect benchmark based on the methods and criteria outlined in Table C.3.

### *Manganese*

A draft SSWQO for dissolved manganese was developed for the Project Proposal (CIRNAC 2019) and was based on the recently derived CCME chronic WQG (CCME 2019). Site-specific chronic toxicity testing with dissolved manganese confirmed that CCME chronic WQG provides an appropriate degree of environmental protection as a validated SSWQO. The toxicity testing yielded results for the invertebrates *C. dubia* and *H. azteca*, and the fish *P. promelas* that were similar to those used by CCME in their WQG derivation. The results for the green algae *P. subcapitata* yielded less sensitive toxicity estimates. As with the CCME dataset, *H. azteca* was the most sensitive species to manganese toxicity. However, CCME noted high variability in published studies with *H. azteca*, with very low unexplained results in some studies. Overall, the toxicity testing validates the SSWQO, and therefore this SSWQO was selected for use in the AMP.

The SSWQO for dissolved manganese is dependent on pH and hardness, with the normalization procedure different for fish/invertebrates (hardness only) and plants (pH only). Therefore, the SSWQO cannot be expressed as an equation; instead, CCME (2018) provides a calculator that assigns the most appropriate species sensitivity distribution based on the sample-specific chemistry and provides the associated $HC_5$ to use as the chronic WQG. Values for the SSWQO can range from 200 to 1500 µg/L based on calibration range for pH 5.8 to 8.4 and hardness 25 to 670 mg/L.

The low effect and moderate effect benchmarks for manganese are based on the results of the site-specific toxicity testing (Golder 2021b) and a review of species sensitivity information in CCME (2019). Specifically, the results of the site-specific toxicity testing were considered in context of the receptor-specific benchmarks derived for the Aquatic Health Risk Assessment in the Project Proposal, which were based on the species sensitivity distribution in CCME (2019). Three levels of receptor-specific benchmarks were derived for the Project Proposal, corresponding to increasing magnitude of response on individuals of the sensitive indicator taxon (i.e., up to approximately 10%, 20%, and 50%) and increasing proportion of species along the species sensitivity distribution. Taken together, this information was used to set appropriate low effect and moderate effect benchmarks. As stated above, the no effect thresholds for *C. dubia*, *H. azteca*, and *P. promelas* from the site-specific toxicity testing were similar to those used by CCME in their water quality guideline derivation, but the *P. subcapitata* results were less sensitive. It is assumed that this relative consistency between the site-specific toxicity testing results and the CCME species sensitivity distribution can be applied when setting benchmarks for higher effect levels.

The low effect benchmark for manganese was selected to be the level 1 fish benchmark, based on a review of the site-specific toxicity testing $EC/IC_{20}$s and the CCME species sensitivity distribution. At a hardness of 50 mg/L, the level 1 fish benchmark is 1096 µg/L. The rationale for this benchmark is provided below:

- When normalized to a hardness of 50 mg/L (for invertebrates and fish) and pH 7.5 (for algae), the site-specific toxicity testing yielded $EC/IC_{20}$s of 273 or 481 µg/L for *H. azteca* growth or survival, 4994 µg/L for *P. subcapitata* growth, and 5340 µg/L for *C. dubia* reproduction. The $IC_{20}$s for *P. promelas* growth were greater than the highest test concentration, but the normalized $IC_{10}$ for *P. promelas* growth (geometric mean of results from two hardnesses) was 3560 µg/L. With the exception of *H. azteca*, all of these toxicity estimates were less sensitive than the level 1 fish benchmark derived in the Project Proposal.
- The level 1 fish benchmark is lower than the level 2 receptor-specific benchmarks (i.e., level 2 benchmarks for plants, fish, and invertebrates), but higher than the level 1 benchmarks for invertebrates (which was the lowest invertebrate toxicity value on the species sensitivity distribution) and for plants (which was the lowest plant toxicity value). This suggests a potential for low-level effects on invertebrates and plants, but not for fish.
- The level 1 fish benchmark is based on the no effect threshold 65-day $IC_{10}$ of 1096 µg/L (geometric mean of multiple toxicity estimates normalized to hardness of 50 mg/L) for growth of brook trout used by CCME (2019) in their long-term species sensitivity distribution. Other fish species were more tolerant to manganese toxicity, as indicated by the no effect thresholds for other fish species including rainbow trout, brown trout (*Salmo trutta*), and fathead minnow, which ranged from 1232 to 2223 µg/L (geometric mean values, normalized; CCME 2019). This confirms that using the level 1 fish benchmark as the low effect benchmark will be protective of all fish species.
- Toxicity estimates for most invertebrates (i.e., *Aeolosoma* species, *C. dubia*, *D. magna*, and *Chironomus tentans*) and plants (i.e., green algae *Scenedesmus quadricaula* and *L. minor*) were less sensitive than the level 1 fish benchmark, with normalized values ranging from 2563 to 12 892 µg/L for invertebrates and 1868 to 13 725 µg/L for plants (CCME 2019). Based on the site-specific toxicity testing, there would be no effect on *P. subcapitata* at the level 1 fish benchmark. Therefore, using the level 1 fish benchmark as the low effect benchmark will be protective of most invertebrates and plants.
- At the level 1 fish benchmark, there could be a moderate to high effect on a sensitive invertebrate species. Specifically, survival and growth of *H. azteca* may be affected based on the concentration-response curves observed in the site-specific toxicity testing (Golder 2021b).

In conclusion, although the selection of the level 1 fish benchmark as the low effect benchmark could result in high effects on one sensitive species of invertebrate (i.e., *H. azteca*), there would be no effects on any other invertebrates, including sensitive species such as *C. dubia*, and no effects on fish or plants. As the level 1 fish benchmark varies with hardness, the low effect benchmark would range from 823 to 3201 µg/L depending on sample hardness.

The moderate effect benchmark for manganese was selected to be the Level 2 fish benchmark, based on a review of the site-specific toxicity testing EC/$IC_{50}$s and evaluation of the CCME species sensitivity distribution. At a hardness of 50 mg/L, the level 2 fish benchmark is 2052 µg/L. The rationale for this benchmark is provided below:

- When normalized to a hardness of 50 mg/L (for invertebrates and fish) and pH 7.5 (for algae), the site-specific toxicity testing yielded EC/$IC_{50}$s of 361 and 1255 µg/L for *H. azteca* growth, 579 µg/L for *H. azteca* survival, >5942 µg/L for *C. dubia* reproduction, >8116 µg/L for *P. subcapitata* growth, and >5251 µg/L for *P. promelas* growth. With the exception of *H. azteca*, all of these toxicity estimates were less sensitive than the level 2 fish benchmark.
- The level 2 fish benchmark is based on the no effect threshold 62-day $IC_{10}$ of 2052 µg/L (normalized to 50 mg/L hardness) for growth of brown trout used by CCME (2019) in their long-term species sensitivity distribution. This toxicity estimate is more sensitive than the no effect thresholds for *P. promelas*, the zebrafish *Danio rerio*, all invertebrates except *H. azteca*, and *L. minor* as presented in CCME (2019), indicating that the moderate effect benchmark would be protective of multiple fish and invertebrate species and at least one plant species.
- At the level 2 fish benchmark, there would be approximately 25% effect on growth of brook trout and rainbow trout, based on the geometric means of normalized $IC_{25}$s calculated from information provided in Appendix A in CCME 2019. The 65-day $IC_{25}$ for brook trout growth is 2220 µg/L and the 65-day $IC_{25}$ for rainbow trout growth is 1960 µg/L. No significant mortality to either fish species is expected at the moderate effect benchmark; the no effect thresholds are less sensitive than the level 2 fish benchmark, with a NOEC for mortality of 3535 µg/L for brook trout and a 65-d $LC_{10}$ for rainbow trout of 3721 µg/L.
- At the level 2 fish benchmark, there could be a high effect on survival and growth of *H. azteca*, based on the concentration-response curves observed in the site-specific toxicity testing (Golder 2021b).
- The level 2 fish benchmark is higher than the normalized 12-day $IC_{50}$ of 1868 µg/L for chlorophyll content of the green algae *Scenedesmus quadricauda*. However, based on the site-specific toxicity testing, there would be <20% effect on the green algae *P. subcapitata* growth at the level 2 fish benchmark. The level 2 fish benchmark is also well below the no effect threshold for the third plant species on the species sensitivity distribution, the 7-day $IC_{10}$ of 13 725 µg/L for frond count for *L. minor*.

In conclusion, although the selection of the level 2 fish benchmark as the moderate effect benchmark could result in high effects on one species of invertebrate (i.e., *H. azteca*), there would be no effects on any other invertebrates, including sensitive species such as *C. dubia*, and low level effects on fish or plants. As the level 2 fish benchmark varies with hardness, the moderate effect benchmark would range from 1541 to 5993 µg/L depending on sample hardness.

### *Zinc*

A draft SSWQO for dissolved zinc was developed for the Project Proposal (CIRNAC 2019) and was based on the recently derived CCME chronic WQG (CCME 2018). Site-specific chronic toxicity testing with dissolved zinc confirmed that CCME chronic WQG provides an appropriate degree of environmental protection as a validated SSWQO. The SSWQO for dissolved zinc is dependent on pH, hardness, and DOC, therefore the SSWQO is expressed as an equation rather than a single value. Values for the SSWQO can range from 1.7 to 516 µg/L based on the calibration range for pH of 6.5 to 8.13, hardness of 23.4 to 399 mg/L as $CaCO_3$, and DOC of 0.3 to 22.9 mg/L.

The low effect benchmark for zinc is based on the results of the site-specific toxicity testing (Golder 2019) and a review of species sensitivity information in CCME (2018). Results from site-specific toxicity testing showed $IC_{20}$s ranged from 49.5 to 54.4 µg/L and NOECs ranged from 30.7 µg/L to an unbounded NOEC of >94.8 µg/L at a hardness of 50 mg/L, pH of 7.5, and DOC of 0.5 mg/L for invertebrate and fish species (i.e., *C. dubia* and fathead minnow). The site-specific NOECs and $IC_{20}$s are 4.4 to 13.6 times greater than the SSWQO (6.97 µg/L) at a hardness of 50 mg/L, pH of 7.5, and DOC of 0.5 mg/L. Based on this review, four times the SSWQO, approximately the minimum factor in which the NOECs and $EC_{20}$ values exceeded the SSWQO, was selected as a concentration indicative of low-level effects to multiple species. As the SSWQO varies with pH, hardness, and DOC, the low effect benchmark would range from 6.8 to 2062 µg/L depending on sample conditions.

The moderate effect benchmark for zinc is based on the results of the site-specific toxicity testing (Golder 2019) and a review of species sensitivity information in CCME (2018). Specifically, the results of the site-specific toxicity testing were considered in context of the receptor-specific benchmarks derived for the Aquatic Health Risk Assessment in the Project Proposal, which were based on the species sensitivity distribution in CCME (2018). An $IC_{50}$ of 53.7 µg/L for *C. dubia* reproduction at a hardness of 50 mg/L, pH of 7.5, and DOC of 0.5 mg/L was the lowest $IC_{50}$ from the fish and invertebrate species tested during the site-specific toxicity testing. This value is 7.7 times the SSWQO. However, 7.7 times the SSWQO was determined to not be sufficiently protective of key site-specific fish species (slimy sculpins), and six times the SSWQO was determined to be a more appropriate moderate effect benchmark. At a hardness of 50 mg/L, pH of 7.5, and DOC of 0.5 mg/L, 6.1 times the SSWQO is 42.7 µg/L. The rationale for selecting six times the SSWQO instead of 7.7 times the SSWQO as the moderate effect benchmark is provided below:

- Moderate level effects on some species of invertebrates may occur at 7.7 times the SSWQO. This value occurred at approximately the $HC_{35}$ on the species sensitivity distribution provided CCME (2018) and is above the level 3 benchmark for invertebrates. At $HC_{35}$, there is potential for low to moderate-level effects in many cladoceran species. There is a 55% effect size for *C. dubia* (most sensitive invertebrate species) reproduction at the Level 3 invertebrate benchmark. While no effect size could be calculated for *D. magna* (second most sensitive invertebrate species) at the level 3 invertebrate benchmark due to unreported dose-response data, an $EC_{50}$ of 22.7 µg/L was reported for this species, which suggests that there would be a high effect size at 7.7 times the SSWQO.
- At six times the SSWQO, there is still the potential for moderate level effects on some sensitive invertebrate species, but the magnitudes are lower. This value occurred at approximately the $HC_{30}$ on the species sensitivity distribution provided by CCME (2018) and is still above the level 3 invertebrate benchmark.
- Moderate level effects on some species of fish may occur at 7.7 times the SSWQO, which is above the level 2 fish benchmark. At the level 2 benchmark for fish, a 10 to 15% effect size was reported for flagfish (*Jordanella floridae*) growth, and a 40% effect size was reported for mottled sculpin (*Cottus bairdii*) 30-day survival. At 7.7 times the SSWQO the effect size for mottled sculpin 30-day survival is 50%. Both flagfish and mottled sculpin are the most sensitive fish species, and sculpin is a key species in Rose Creek. Therefore, due to the high effect size for mottled sculpin survival at 7.7 times the SSWQO, this value was determined to not

be appropriate for use as the moderate effects benchmark. A value of 41.8 µg/L, six times the SSWQO, was derived as an appropriate moderate effects benchmark. At 6.1 times the SSWQO or 42.7 µg/L, for mottled sculpin 30-day survival is 20%, and there is a potential for low level effects to flagfish but no effects to other fish species, whose chronic toxicity estimates are less sensitive (i.e., no effect thresholds for other fish species occurred higher on the species sensitivity distribution provided by CCME [2018]).

- At six times the SSWQO, there is a potential for high level effects on the most sensitive algal species, and no effects to less sensitive algal species. The most sensitive aquatic plant species on the species sensitivity distribution provided by CCME (2018) was *P. subcapitata*. Based on the results of site-specific testing, there is approximately a 90% or higher effect size on *P. subcapitata* growth (*P. subcapitata* $EC_{50}$ = 13.2 µg/L) at six times the SSWQO. However, this value is well below the toxicity estimate for the next most sensitive aquatic plant species (the Level 2 benchmark for plants of 32 times the SSWQO is based on a 48-hour $IC_{50}$ for growth of the green algae *Chlorella* species), indicating the moderate effect benchmark is unlikely to cause significant effects to most algal and plant species.

Based on the above, six times the SSWQO was selected as the moderate effect benchmark for zinc. At the moderate effect benchmark, there is the potential for moderate to high level effects to sensitive invertebrate and plant species, and low-level effects to sensitive fish species. However, most fish and plant species would not be affected. As the SSWQO varies with hardness, pH, and DOC, the moderate effect benchmark would range from 10.2 to 3096 µg/L depending on sample hardness, pH, and DOC concentration.

### C.2.3 Triggers

Triggers are numeric values and/or conditions that, if reached, result in the attainment of an action level linked to initiation of a specific action or management response (YG 2020). Triggers represent the value and/or condition being exceeded, whereas action levels indicate the requirement for management response (also see Section 3 of the main document).

Protection goals are specific to each waterbody and project phase (Table C.5). Protection goals were developed based on consideration of several factors: including current ecological condition, goal achievability, stakeholder and rights holder engagement, future predicted conditions, and regulatory considerations (see Section 3.2. of the main document for further details). These goals are narrative statements that describe an ecological condition to be maintained for a specific location and timeframe. To determine whether conditions described by a protection goal are being maintained, multiple lines of ecological evidence are required. One of these lines of evidence involves comparing current water quality conditions to water quality benchmarks (see Section B.2.2). Significance thresholds represent water quality benchmarks above which a protection goal is at risk of failure. As such, exceedance of a significance threshold suggests that water quality conditions are insufficient to maintain a protection goal, but do not necessarily indicate a protection goal is failed. Additional information, such as toxicity testing and analysis completed through the Aquatic Effects Monitoring Program, are also required to make a final determination of protection goal failure. Significance thresholds were selected for each AMI based on the location of the exposure station, as well as the protection goal established for that waterbody and project phase.

Following selection of the significance threshold, action levels were established for each AMI in three tiered categories: low, moderate, and high. Triggers were then developed for each action level. Triggers can be categorized as one of four types; 1. Triggers based on water quality benchmarks, 2. Triggers that include toxicity testing, 3. Triggers based on performance targets, and 4. Triggers based on non-degradation. Triggers may also include additional conditions, such as the frequency of exceedance and/or source of constituent loading. The required frequency of exceedance typically decreases as the potential risk to aquatic life increases. This approach balances the need for confirmation of an issue with its associated risk to the environment. Triggers also require verification that the issue identified is “due to the Project” or “due to an AMI specific source” rather than an artifact of a separate source, a laboratory quantitation issue, or other factor unrelated to the Project. This is completed by conducting quality assurance checks and reviewing trigger exceedances at an associated reference or baseline station. This approach allows for each AMI to trigger only due to station specific sources and not falsely trigger due to a change in reference condition or influence from an upstream AMI.

Protection goals, significance thresholds, and triggers for each waterbody and project phase are summarized in Table C.5. Further details are provided below.

**Table C.5 Relationship between Protection Goals, Significance Thresholds, and Triggers for Each Waterbody and Project Phase**

| Waterbody | Project Phase | Protection Goal | Significance Threshold | Triggers |
|---|---|---|---|---|
| **North Fork Rose Creek & Rose Creek** | Active Remediation | Water quality in Rose Creek supports survival and reproduction of fish and benthic invertebrate communities | Moderate Effect Benchmarks – concentrations at which a high potential for adverse effects on multiple sensitive species, potentially resulting in population- or community-level changes. | **LOW**: >SSWQO at the exposure station due to the Site, confirmed for 4 monthly samples collected within a year,<br>**MODERATE**: >75% of low effect benchmark[(a)] at the exposure station due to the Site, confirmed for 3 monthly samples collected within a year,<br>**HIGH**: >Low effect benchmark[(a)] at the exposure station due to the Site, confirmed for 2 monthly samples collected within a year. |
| | Post Remediation | Water quality in Rose Creek supports the maintenance of self-sustaining populations of fish and self-sustaining and functional communities of invertebrates and aquatic plants. The communities will continue to perform necessary ecological services including provision of diversity and abundance of food for fish. | Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures. | **LOW**: >75% SSWQO at the exposure station due to the Site, confirmed for 4 monthly samples collected within a year,<br>**MODERATE**: >SSWQO at the exposure station due to the Site, confirmed for 3 monthly samples collected within a year,<br>**HIGH**: >75% of Low effect benchmark the exposure station due to the Site, confirmed for 2 monthly samples collected within a year. |
| **Anvil Creek** | Active Remediation | Water quality in Anvil Creek supports the maintenance of self-sustaining populations of fish, and self-sustaining and functional communities of invertebrates and aquatic plants that will continue to perform necessary ecological services including provision of food for fish. | Low Effect Benchmarks - concentrations at which low level negative effects could occur on at least one representative species in long-term exposures | **LOW**: >60% of SSWQO at the exposure station due to the Site, confirmed for 3 samples collected within a year,<br>**MODERATE**: >75% of SSWQO at the exposure station due to the Site, confirmed for 3 samples collected within a year,<br>**HIGH**: >SSWQO at the exposure station due to the Site, confirmed for 2 samples collected within a year. |
| | Post Remediation | Same narrative goals as Interim, but with greater frequency of meeting more stringent water quality benchmarks such as SSWQOs. | Low Effect Benchmarks - no change from active remediation | No change from active remediation |
| **Pelly River** | Active Remediation | No measurable change in Pelly River water quality concentrations due to the Project. | Water quality concentrations in the Pelly River at designated downstream station exceed upstream background conditions and it is due to the Project. | **Conceptual only:**<br>**LOW**: Seasonal rolling mean/median > 85% Upper confidence limit of the mean/median(a) of upstream station, or more than X samples per season > 85th percentile of upstream reference.<br>**MODERATE**: Seasonal rolling mean/median > 90% upper confidence limit of the mean/median(a) of upstream station, or more than X samples per season > 90th percentile of upstream station.<br>**HIGH**: Seasonal rolling mean/median > 95% rolling upper confidence limit of the mean/median(a) of upstream station, or more than X samples per season > 95th percentile of upstream station, and due to the Project |
| | Post Remediation | No change from active remediation | No change from active remediation | No change from active remediation |

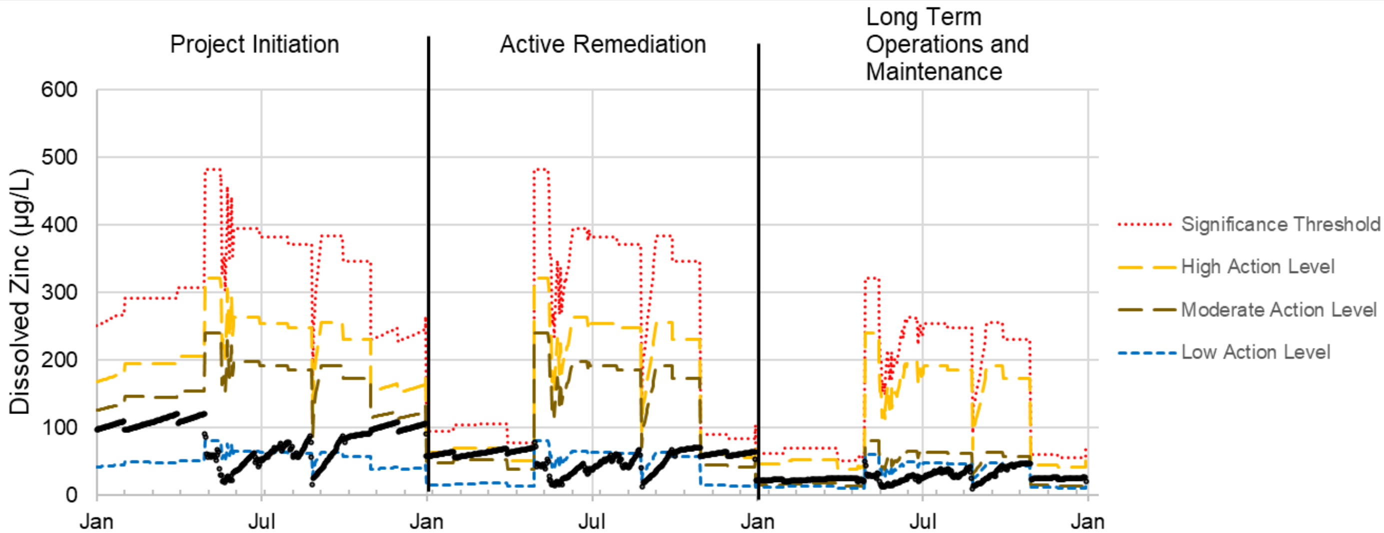
### C.2.3.1 Triggers Based on Water Quality Benchmarks

The Project AMP consists of six AMIs that use triggers based on water quality benchmarks; NFRC-1, NFRC-3, NFRC-4, RC-1, RC-4, and AC-1. This includes one on Anvil Creek (AC-1), two on Rose Creek (RC-1, RC-4), and three on NFRC (NFRC-1, NFRC-3, NFRC-4). During active remediation, the significance threshold for Rose Creek and North Fork Rose Creek will be set as the moderate effect benchmark (above which concentrations indicate a high potential for adverse effects on multiple sensitive species). The significance threshold for both watercourses is anticipated to be lowered post-remediation with the exact timing of the change dependent on the progression of remediation activities in each area. Once the significance threshold is lowered for a particular AMI, the associated triggers and action levels for that AMI will also be lowered. The rationale for this is that once an area is remediated and determined to be functioning as designed, the potential for adverse effects to species should lessen and the magnitude of change requiring management response should also decrease (i.e., less change is acceptable once a remediation work is complete).

During active remediation, AMIs located in Rose Creek and NFRC will use the moderate effect benchmarks as a significance threshold. Triggers will be set to provide early-warning as water quality conditions approach this benchmark, using the SSWQO as a low, followed by 75% of the low effect benchmark as a moderate, and the low effect benchmark as a high trigger (Figure C.1). During post remediation, AMIs located in Rose Creek and NFRC will be lowered to use the low effect benchmark as the significance threshold. Post remediation triggers would also be lowered to reflect this change, using 75% of the SSWQO as a low, followed by the SSWQO as a moderate, and 75% of the low effect benchmark as a high trigger (Figure C.2; Appendix E).

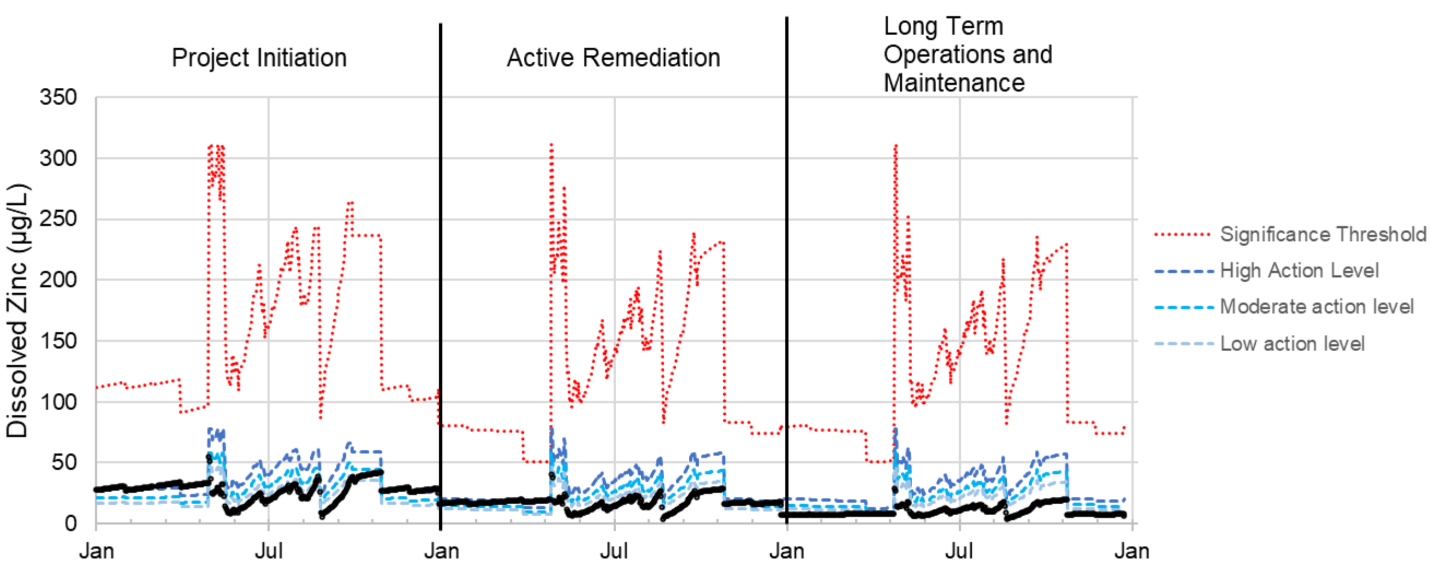
For the AMI located in Anvil Creek (AC-1), a significance threshold will be used to reflect the more stringent protection goal established for this waterbody. During active remediation, and through to long-term operations and maintenance, low effect benchmarks will be used as a significance threshold for Anvil Creek. Triggers will be set to provide early-warning as water quality conditions approach these benchmarks, using a percentage of the SSWQO as a low and moderate (e.g., 60 or 75%), and the SSWQO as a high trigger. Percentages of a water quality benchmark are not intended to indicate a specific effect level in the aquatic environment but instead provide a buffer from potential effects and allow time to investigate sources or implement a management response (Figure C.2; Appendix E).

Although post remediation triggers have been proposed within this document, these triggers should be considered draft and are expected to be reviewed and revised through Project AMP updates and regulatory approvals.




Note: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.

**Figure C.1. Timeseries Plot for AMI RC-4 (Station RC-SW014; Rose Creek); showing Triggers for Dissolved Zinc for each project phase relative to water quality predictions (black line).**




Note: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.

**Figure C.2. Timeseries Plot (2008-2020) for AMI AC-1 (Station RC-SW030; Anvil Creek), showing Triggers for Dissolved Zinc for each project phase relative to water quality predictions (black line).**

### C.2.3.1 Triggers Based on Performance Targets

The Project AMP consists of two AMIs that use performance-based targets in the development of triggers; RC-2 and RC-3. These triggers evaluate the potential for a particular source, or combination of sources, to impact a receiving waterbody. To evaluate this potential risk, concentration limits were estimated using the downstream water quality prediction model (Project Proposal, Appendix 7F). As described in the Project Proposal, this is a conservative mass balance mixing model, where flows and constituent loadings are progressively added at each downstream node. Concentration limits are estimated by progressively added additional loading to a particular source or model node until a specified endpoint is reached at a downstream location. To evaluate the potential for trigger exceedances at a downstream location, a low precipitation year (i.e., “dry year”) will be used as a hydrological input to the model. This is considered a conservative approach, as low flow conditions result in a reduced assimilative capacity and typically lower concentration limits. Determination of whether a trigger is found to be exceeded at a downstream node will use both concentration-based triggers, as well as the frequency of exceedance as specified in the trigger (i.e., number of months the concentration-based trigger is expected to exceed). Although outputs from the model offer daily predictions, specifying the frequency of exceedance will allow the predictions to more closely reflect results excepted from onsite sampling efforts. Concentration limits will be estimated for each trigger level (i.e., low, moderate, and high) as well as the significance threshold. The significance threshold for performance-base triggers will be the estimated load required from the source of interest to result in exceedance of the significance threshold specified for a downstream receiving environment location. To estimate groundwater concentration limits, surface water concentration limits will then be back-calculated to estimate concentration thresholds for each monitoring well used as an input to the groundwater model. The groundwater model will also be used to determine the frequency and number of wells required for trigger exceedance for each action level (i.e., low, moderate, and high).

Concentration limits generated using this procedure will have the same limitations and model assumptions as described in the Project Proposal (Appendix 7F). Due to these assumptions, concentration limits require annual update to maintain applicability to existing conditions. Concentration limit applicable to each project phase are not included in the Project AMP, as the limits currently used as part of the Operational AMP will no longer be applicable at Project initiation. Concentration limits therefore must be reviewed and updated at project initiation and annually thereafter throughout active remediation.

Because this approach requires a current understanding of loading from multiple sources, these limits will require annual updates to ensure correct representation of the system. Factors that will affect the current concentration limits include:

- Actual CVP-TP effluent quality vs. assumed effluent quality in the model.
- Changes in IWTS effluent quality.
- Actual percentage capture of groundwater by short-term DV-SIS.
- Actual load reporting to RC-SW014 after stabilization of loading to NFRC.

Factors which will affect future concentration limits include:

- Changes in groundwater capture systems.
- Changes in contact water conveyance.

- Changes in water treatment.
- Redirection of surface water or non-contact water flow.

#### C.2.3.2 Triggers Based on Toxicity Testing

Toxicity testing conducted in the receiving environment has been used as part of several triggers (i.e., RC-2 and RC-4). This additional testing provides further assurance that benchmarks are providing the intended level of protection. If onsite toxicity testing indicates a greater effect-level compared to the corresponding benchmark, this result could override the concentration-based triggers (subject to quality assurance and reliability checks), and the AMI would escalate to higher action level response. This mechanism would only work in one direction, meaning a lower effect-level result would not be used to de-escalate to a lower action level response. This approach also provides a test result that considers the combined influence of multiple constituents opposed to the potential effects of a single COPC.

Acute and chronic toxicity testing will be conducted on samples collected from stations NW-SW003 (for RC-2) and RC-SW014 (for RC-4), with acute tests conducted monthly (potential to decrease frequency after 12 months with no acute toxicity) and chronic tests conducted quarterly.

Acute toxicity testing is conducted using the following test protocols:

- Environment Canada (2000a): Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout (EPS 1/RM/13)
- Environment Canada (2000b): Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to *Daphnia magna* (EPS 1/RM/14)

Chronic toxicity testing is conducted using the following test protocols:

- Environment Canada (2011): Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows (EPS 1/RM/22)
- Environment Canada (2007a): Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia* (EPS 1/RM/21)
- Environment Canada (2007b): Biological Test Method: Test for Measuring the Inhibition of Growth Using the Freshwater Macrophyte, *Lemna minor* (EPS 1/RM/37)
- Environment Canada (2007c): Biological Test Method: Growth Inhibition Test Using a Freshwater Alga (EPS 1/RM25)

RC-2 uses performance-based triggers that utilize concentration limits generated through model predictions (see Section B.2.3.1). Exceedance of these triggers indicates that surface water flow from the outlet of NWID is likely to result in trigger exceedances in Rose Creek (station RC-SW014). Monthly acute toxicity testing and comparison to acute water quality guidelines have been incorporated to ensure that discharge from NWID is not acutely toxic to aquatic life. In some cases, concentration limits may be above the expected threshold for acute effects. This is particularly true for constituents that currently have low concentrations in Rose Creek and would therefore require substantial loading from NWID to exceed the triggers. Both the toxicity test result and acute guideline screening are applicable to the high Action Level trigger. Acute toxicity is defined as more than 50% mortality in

100% sample in an acute lethality test (e.g., 96-hr rainbow trout test or 48-hr Daphnia magna test). Observation of this result triggers verification of test results followed by a High Action Level investigation or response (Table C.6).

RC-4 uses triggers based on water quality benchmarks and incorporates quarterly chronic toxicity testing to ensure that benchmarks are providing the intended level of protection. During active remediation, quarterly toxicity testing will be used to assess whether pronounced, or substantial and pervasive, chronic toxicity has occurred in laboratory samples. If results show pronounced chronic toxicity, defined as more than 25% adverse response to two or more test species in a single sampling event, or a high magnitude (>50%) to fish or invertebrates, then this will trigger verification of test results followed by a Moderate Action Level investigation or response. If results show substantial and pervasive chronic toxicity, defined as more than 50% adverse response to two or more test species, including either a fish or invertebrate endpoint, and in consecutive sampling events, this will trigger verification of test results followed by a High Action Level investigation or response. During post remediation, the triggers will be lowered to correspond with a more stringent protection goal. During this phase, pronounced chronic toxicity in laboratory samples would be used to trigger a High Action Level investigation or response.

**Table C.6 Overview of Triggers that Incorporate Toxicity Testing**

| AMI | Project Phase | Triggers |
|---|---|---|
| **RC-2** | Active Remediation | **LOW**: >low concentration limits at station NW-SW003, confirmed for 4 monthly samples collected within a year,<br>**MODERATE**: >moderate concentration limits at station NW-SW003, confirmed for 3 monthly samples collected within a year,<br>**HIGH**: >high concentration limits at station NW-SW003, confirmed for 2 monthly samples collected within a year, OR *>acute water quality guidelines*, OR, *acute toxicity in laboratory samples*[(a)] |
| | Post Remediation | RC-2 will be discontinued during the post-remediation period. |
| **RC-4** | Active Remediation | **LOW**: >SSWQO[(a)] at station RC-SW014, confirmed for 4 monthly samples collected within a year<br>**MODERATE**: >75% of low effects benchmark(a) at station RC-SW014, confirmed for 3 monthly samples collected within a year, OR, *pronounced chronic toxicity in laboratory samples*[(b)],<br>OR, *25% or greater mortality to standard test species*<br>**HIGH**: >Low effect benchmark(a) at station RC-SW014, confirmed for 2 monthly samples collected within a year, or *substantial and pervasive chronic toxicity(c) in laboratory samples, OR, 50% or greater mortality to standard test species* |
| | Post Remediation | **LOW**: >75% SSWQO[(a)] at the exposure station due to the Site, confirmed for 4 monthly samples collected within a year,<br>**MODERATE**: >SSWQO[(a)] at the exposure station due to the Site, confirmed for 3 monthly samples collected within a year,<br>**HIGH**: >75% of low effects benchmark(a) at station RC-SW014, confirmed for 2 monthly samples collected within a year, OR, *pronounced chronic toxicity in laboratory samples(b) OR, 25% or greater mortality to standard test species* |

Notes:

*Blue text* indicates toxicity-based components of the triggers.

(a) Acute toxicity is defined as more than 50% mortality in 100% sample in an acute lethality test (e.g., 96-hr rainbow trout test or 48-hr Daphnia magna test)

(b) Pronounced chronic toxicity is defined as more than 25% adverse response to two or more test species in a single sampling event, or a high magnitude (>50%) response to fish or invertebrates in a single sampling event.

(c) Substantial and pervasive chronic toxicity is defined as more than 50% adverse response to two or more test species, including either a fish or invertebrate endpoint, and in consecutive sampling events.

### C.2.3.3 Triggers Based on Non-Degradation

The Project AMP includes one AMI with a non-degradation protection goal (Pelly River - PR1); this AMI requires unique triggers. The protection goal established for the Pelly River is defined as “No measurable change in Pelly River water quality concentrations due to the Project” and the significance threshold is “Water quality concentrations in Pelly River at designated downstream station exceed upstream background conditions and it is due to the Project". Triggers were developed to indicate when concentrations diverge from conditions upstream of the Project's influence on the Pelly River. In this case, station PR-SW004 is located downstream from the Pelly River and Anvil Creek confluence and is used as the exposure station where the triggers apply. PR-SW003 is located directly upstream of the potential influence from the Faro Mine Site, but downstream of potential influence from the Vangorda Plateau Mine area (and/or other upstream influences). Station PR-SW003 is therefore used as the upstream 'baseline' station which defines the 'baseline' water quality required to determine whether the significance threshold established for the Pelly River is being met. As outlined in Section 3.8 of the main document, 'baseline conditions' refer to the those located upstream from "AMI specific sources" but downstream from another potential source or AMI. This station is not referred to as a 'reference station' given it is downstream of possible influence of the Vangorda Plateau Mine Area or the Town of Faro. To factor in the potential cumulative effects from Vangorda Plateau Mine Area, the indicators identified for the Vangorda Plateau Mine Area as part of the Operational AMP have been retained. Station PR-SW001 was previously used as an upstream reference location in the Operational AMP. However, it is distant from the exposure station (~50 kilometers) and because there are multiple anthropogenic influences between Station PR-SW001 and Station PR-SW004, it was not selected as the upstream station for this AMI.

Different types of triggers with varying sensitivity were explored for the Pelly River. This included use of alternate statistics like a prediction interval, seasonal trend analyses or model predictions. These were not adopted at this time given reviewer feedback on the lack of familiarity with the prediction interval, insufficient number of samples to perform seasonal trend analyses and the fact that model updates to predictions for the Pelly River would be expected during the water licence phase but are not available now. These options for triggers remain open for future versions of the AMP when more data/updated predictions are available.

For the Project AMP for YESAB, the triggers that are proposed are conceptual and were developed with the following considerations:

1) Use examples from the AMP guidance (YG 2021) for non-degradation goals. This includes the use of a 'two part 'trigger: a) a comparison of a mean to an upper confidence limit of the mean or b) comparison of a individual sample concentration to a 95th percentile of a 'reference' data, where either one could trigger an action level. The Pelly River dataset (to date) does not include sufficient samples to meet the requirements outlined in the draft Yukon guidance for developing water quality objectives (YG 2019) for non-degradation targets. This means the confidence around the upper limits of the mean and 95th percentile of the upstream 'baseline' is currently low. This is one of the main reasons why final triggers for the Project AMP are not proposed. Additional sampling is planned to increase this sample size prior to licensing so final triggers can be proposed in the next version of the AMP.

2) The guidance does not provide specifics around triggers for data that is not normally distributed, which is the case for many of the indicators for the Pelly River. Given this non-normal data, the Project AMP includes triggers that may require a non-parametric statistic such as a median.

3) The guidance also does not explicitly advise how to deal with waterbodies that might experience climate change over a longer time frame, such as the Pelly River might given the duration of the Project. It does offer opportunity to use past 20 samples in a trigger. Therefore, to account for the consideration of climate change effects on the river, the Project AMP proposes triggers with a rolling mean or median and rolling upper confidence limit of the mean, based on last 20 samples.

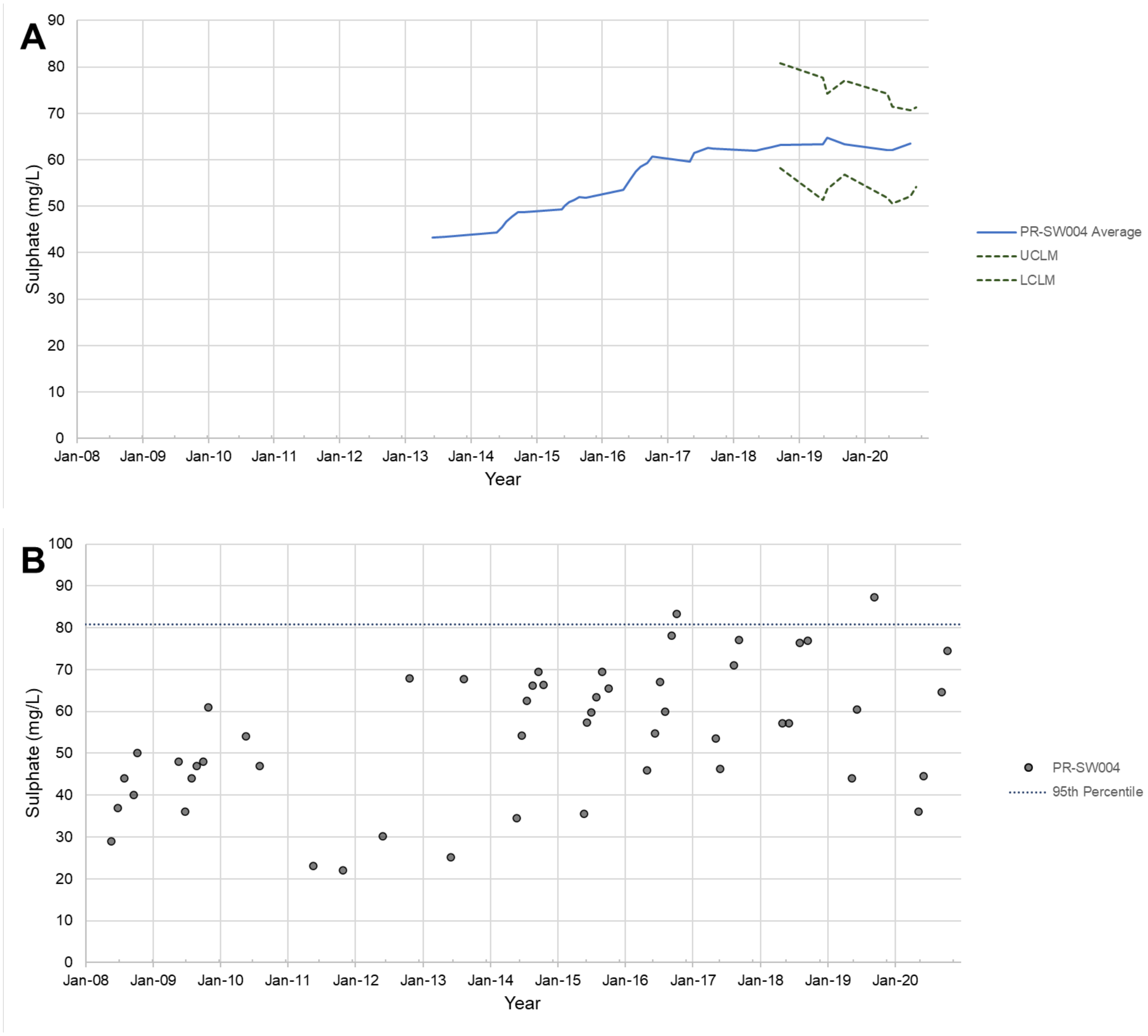
4) The Pelly River exhibits seasonal variability that requires consideration. The Project heard feedback from reviewers on the importance of consideration of seasonality in triggers and has accordingly built this into the trigger.

The following conceptual triggers are proposed:

- *Low action level*: seasonal rolling mean (or median) greater than the 85% upper confidence limit of the mean/median or an individual sample concentration exceeding the 85th percentile of upstream baseline station.
- *Moderate action level*: a seasonal rolling mean (or median) greater than the 90% upper confidence limit of the mean (or median) or individual sample concentrations exceeding the 90th percentile of upstream baseline station.
- *High action level*: seasonal rolling mean (or median) greater than the 95% upper confidence limit of the mean (or median) or individual sample concentrations exceeding the 95th percentile of upstream baseline station and due to the Project.

The high action level requires that the exceedance be confirmed “due to the Project”. It is anticipated that a management response plan under the high action level would require additional investigation(s) including evaluation of whether deviation from baseline can be attributed to mass loading from the Faro Mine Site. Confirmation that a high trigger exceedance was “due to the Project” is considered a failure of both the protection goal and significance threshold.

The upper confidence limit of the mean (or median) and percentile values will be calculated using constituent concentrations from the most appropriate sampling period (e.g., last 20 samples) at the baseline station located upstream of the confluence of Anvil Creek with the Pelly River (i.e., station PR-SW003). The decision whether to use upper confidence limit of the mean or median will be based on an evaluation of the distribution of the data and selection of appropriate statistics. Triggers will also be calculated for each season, when appropriate, to reduce the variability in concentrations due to seasonality. The upper confidence limit of the mean and percentile statistics are proposed to be recalculated following each sampling event, resulting in a rolling statistic which considers the most up to date water quality of the baseline station. An example plot showing comparison of triggers using existing data is provided in Figure C.3.




Note: Concentrations and triggers are based on measured concentrations at PR-SW003 and PR-SW004 from available data from 2018 to 2020 and 2008 and 2020, respectively, and are shown here to illustrate the concept of how the high action level for AMI PR-1 would apply to constituent concentration in the Pelly River, downstream of the Project. Data shown are for open water. UCLM = upper confidence limit of the mean; LCLM = lower confidence limit of the mean.

**Figure C.3 Timeseries Plots (2008-2020) for AMI PR-1, showing the High Action Level for Sulphate. (A) Mean concentrations of the past 20 samples ('rolling average') at PR-SW004 compared to the 95% upper confidence limit of the mean calculated using reference data from PR-SW003 from 2018 to 2020 and (B) concentrations at PR-SW004 compared to the 95th percentile concentration calculated using data from PR-SW003 from 2018-2020.**

## C.3 References

Birge WJ, Black JA, Westerman AG, Short TM, Taylor SB, Bruser DM, Wallingford ED. 1985. Recommendations on numerical values for regulating iron and chloride concentrations for the purpose of protecting warmwater species of aquatic life in the Commonwealth of Kentucky. University of Kentucky, Lexington, KY. 73 pp.

BC MOE (British Columbia Ministry of the Environment). 2008. Ambient Aquatic Life Guidelines for Iron)—Overview Report. Water Stewardship Division, Ministry of Environment, Province of British Columbia. March 2008.

BC MOE. 2009. Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia)—Overview Report Update. Water Sustainability Division, Ministry of Environment, Province of British Columbia. September 2009.

BC MOE. 2015. Ambient Aquatic Life Guidelines for Cadmium—Technical Report. Water Protection and Sustainability Branch, Ministry of Environment, Province of British Columbia. February 2015.

Crown Indigenous Relations and Northern Affairs Canada. 2019. Faro Mine Remediation Project. Project Proposal submitted May 2019 to the Yukon Environmental and Socio-Economic Assessment Board.

CCME (Canadian Council for Ministers of the Environment). 2007. A protocol for the derivation of water quality guidelines for the protection of aquatic life 2007. In: Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment. Winnipeg MB. ceqg-rcqe.ccme.ca/download/en/220/.

CCME. 2010. Canadian water quality guidelines for the protection of aquatic life: ammonia. In: Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg MB.

CCME. 2014. Canadian Water Quality Guidelines: Cadmium. Scientific Criteria Document. Canadian Council of Ministers of the Environment, Winnipeg MB.

CCME. 2018. Canadian water quality guidelines for the protection of aquatic life: zinc. In: Canadian environmental quality guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg MB.

CCME. 2019. Canadian water quality guidelines for the protection of aquatic life: manganese. In: Canadian environmental quality guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg MB.

ECCC (Environment and Climate Change Canada). 2019. Federal Environmental Quality Guidelines – Iron. Environment and Climate Change Canada. Draft. May 2019.

Elphick JR, Davies M, Gilron G, Canaria EC, Lo B, Bailey HC. 2011. An aquatic toxicological evaluation of sulfate: the case for considering hardness as a modifying factor in setting water quality guidelines. Environmental Toxicology and Chemistry 30(1):247-253.

Environment Canada. 1999. Canadian Environmental Protection Act Priority Substances List II – Supporting document for Ammonia in the Aquatic Environment. DRAFT –August 31, 1999.

Environment Canada. 2000a. Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout. EPS 1/RM/13. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, ON.

Environment Canada. 2000b. Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Daphnia magna. EPS 1/RM/14. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, ON.

Environment Canada. 2007a. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran Ceriodaphnia dubia. EPS 1/RM/21. Environmental Science and Technology Centre, Science and Technology Branch, Environment Canada, Ottawa, Ontario. Second Edition – February 2007.

Environment Canada. 2007b. Biological Test Method: Test for Measuring the Inhibition of Growth Using the Freshwater Macrophyte, Lemna minor. EPS 1/RM/37. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario. Second Edition – January 2007.

Environment Canada. 2007c. Biological Test Method: Growth Inhibition Test Using a Freshwater Alga. EPS 1/RM25. Environmental Science and Technology Centre, Science and Technology Branch, Environment Canada, Ottawa, Ontario. Second Edition – March 2007.

Environment Canada. 2011. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows. EPS 1/RM/22. Method Development and Applications Unit, Science and Technology Branch, Environment Canada, Ottawa, Ontario. Second Edition – February 2011.Environment Canada. 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring. National EEM Office, Ottawa, ON, Canada.

Environment Canada. 2017. Federal Environmental Quality Guidelines – Cobalt. Environment Canada. May 2017.

Golder 2019. Faro Mine Complex and Faro Mine Remediation Project – 2019 Chronic Toxicity Testing Program for Zinc. Technical Memorandum Prepared for Crown-Indigenous Relations and Northern Affairs Canada. October 2019.

Golder. 2021a. Faro Mine Complex and Faro Mine Remediation Project – 2020 Update to the 2019 Site-Specific Toxicity Testing Program for Sulphate. Technical Memorandum Prepared for Crown-Indigenous Relations and Northern Affairs Canada. March 2021.

Golder. 2021b. Faro Mine Complex and Faro Mine Remediation Project – 2020 Acute and Chronic Toxicity Testing Program with Total Iron and Dissolved Manganese. Technical Memorandum Prepared for Crown-Indigenous Relations and Northern Affairs Canada. March 2021.

Government of Yukon (YG). 2019. Draft Yukon Guide for Developing Water Quality Objectives and Effluent Quality Standards for Quartz Mining Projects. Whitehorse, Yukon. December 2019.

Government of Yukon (YG). 2021. Guidelines for developing adaptive management plans in Yukon: Water-related components of quartz mining projects. January 2021.

Linton TK, Pacheco MAW, McIntyre DO, Clement WH, Goodrich-Mahoney J. 2007. Development of bioassessment-based benchmarks for iron. Environmental Toxicology and Chemistry 26(6): 1291-1298.

Meays C, Nordin R. 2013. Ambient Water Quality Guidelines for Sulphate—Technical Appendix. Ministry of Environment, Province of British Columbia. Water Protection & Sustainability Branch. Environmental Sustainability and Strategic Policy Division. BC Ministry of Environment. April 2013.

Mebane CA, Hennessy DP, Dillon FS. 2008. Developing acute-to-chronic toxicity ratios for lead, cadmium, and zinc using rainbow trout, a mayfly, and a midge. Water, Air, and Soil Pollution 188(1): 41-66.

Milam CD, Farris JL. 1998. Risk identification associated with iron dominated mine discharges and their effect on freshwater bivalves. Environmental Toxicology and Chemistry 17: 1611-1619.

Phippen B, Horvath C, Nordin R, Nagpal N. 2008. Ambient water quality guidelines for iron. Prepared for Science and Information Branch, Water Stewardship Division, British Columbia Ministry of Environment. 28 February 2008.

Stubblefield WA, Van Genderen E, Cardwell AS, Heijerick DG, Janssen CR, De Schamphelaere KA. 2020. Acute and chronic toxicity of cobalt to freshwater organisms: using a species sensitivity distribution approach to establish international water quality standards. Environmental Toxicology and Chemistry 39(4): 799-811.

Thurston RV, Chakoumakos C, Russo RC. 1981. Effect of fluctuating exposures on the acute toxicity of ammonia to rainbow trout (*Salmo gairdneri*) and cutthroat trout (*S. clarki*). Water Research 15: 911-917.

Vuori K. 1995. Direct and indirect effects of iron on river ecosystems. Annales Zoologici Fennici 32: 317–329.

US EPA (United States Environmental Protection Agency). 2013. Aquatic Life Ambient Water Quality Criteria For Ammonia-Freshwater 2013. EPA 822 R 13 001. April 2013.

Wang W. 1986. Toxicity tests of aquatic pollutants using common duckweed. Environmental Pollution Series B 11: 1-14.

Warnick SL, Bell HL. 1969. The acute toxicity of some heavy metals to different species of aquatic insects. WPCF 41: 280-284.

# APPENDIX D – ADAPTIVE MANAGEMENT PLAN MONITORING STATIONS

**Table D-1: Details of Adaptive Management Plan Monitoring Stations**

| Group | AMI | Station (NEW ID) | Station (OLD ID) | Type | Sampling Frequency | Sampling Months | Discharge Collected | Synoptic Group | Hydrology/Data Considerations |
|---|---|---|---|---|---|---|---|---|---|
| Pelly River | PR-1 | PR-SW001 | P1 | Surface Water | 6 times per year | April, May, June, September, early October, and February | NO (Estimated values available) | 1 | Flows in the Pelly River at station PR-SW001 are estimated by subtracting daily discharge at station VC-SW005 from daily discharge at station 09BC004. (WSC Station Pelly River below Vangorda Creek (WSC ID 09BC004). |
| Pelly River | PR-1 | PR-SW002 | P2 | Surface Water | 6 times per year | April, May, June, September, early October, and February | NO (Estimated values available) | 1 | - |
| Pelly River | PR-1 | PR-SW003 | P3 | Surface Water | 6 times per year | April, May, June, September, early October, and February | NO (Estimated values available) | 1 | - |
| Pelly River | PR-1 | PR-SW004 | P4 | Surface Water | 6 times per year | April, May, June, September, early October, and February | NO (Estimated values available) | 1 | Daily discharges in the Pelly River at station PR-SW004, located downstream of Anvil Creek, are estimated by multiplying discharges at 09BC004 (operated by Water Survey of Canada) by a factor of 1.025 to account for runoff generated in the 544 km2 draining to the Pelly River between Vangorda and Anvil Creek, and adding daily discharge from station AC-SW001 near the mouth of Anvil Creek. |
| Anvil Creek | AC-1 | RC-SW040 | R6A | Surface Water | 6 times per year | April, May, June, September, early October, and February | YES (6 measurements per year); continuous | 2 | Station previously ID R6. timeseries mix of RC-SW035 (R6) and R6A |
| Anvil Creek | AC-1 | RC-SW030 | R5 | Surface Water | 6 times per year | April, May, June, September, early October, and February | YES (6 measurements per year + Continuous (Estimated)) | 2 | Discharge at RC-SW030 (R5) is estimated as RC-SW025 (R4) + RC-SW040 (R6A). Estimated continuous daily data typically has good agreement with manual measurements. |
| North Fork Rose Creek | NFRC-1 | NF-SW001 | R7 | Surface Water | monthly | April to March | YES; (Continuous; Monthly) | 3 | - |
| North Fork Rose Creek | NFRC-1/NFRC-3 | NF-SW003 | R8C | Surface Water | monthly | April to March | No | 3 | Consider R8B for historical WQ data. Manual gauging of discharge is not possible at this location. |
| North Fork Rose Creek | NFRC-1 | FA-MW021 | CH15-107-MW032 | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-1 | FA-MW022 | CH15-107-MW033 | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-1 | FA-MW023 | CH15-107-MW034 | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-1 | FA-MW002B | BH13B | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-1 | FA-MW003A | BH14A | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-1 | FA-MW003B | BH14B | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-3/NFRC-4 | NF-SW008 | N/A | Surface Water | - | - | - | 3 | - |
| North Fork Rose Creek | NFRC-4 | NF-SW010 | X2 | Surface Water | weekly | April to March | YES; (Continuous; Monthly) | 3 | Data quality and frequency under review. |
| North Fork Rose Creek | NFRC-4 | FA-MW128B | SRK08-SP8B | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW105 | CH15-107-MW019 | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW108 | CH15-107-MW025 | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW109 | CH15-107-MW026 | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW128A | SRK08-SP8A | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW1001A | CH14-107-MW007A | Groundwater | biannually | June, September | N/A | N/A | - |

**Table D-1: Details of Adaptive Management Plan Monitoring Stations**

| Group | AMI | Station (NEW ID) | Station (OLD ID) | Type | Sampling Frequency | Sampling Months | Discharge Collected | Synoptic Group | Hydrology/Data Considerations |
|---|---|---|---|---|---|---|---|---|---|
| North Fork Rose Creek | NFRC-4 | FA-MW1001B | CH14-107-MW007B | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW103 | CH14-107-MW009 | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW118B | S2B | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW127B | SRK08-SP7B | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW127A | SRK08-SP7A | Groundwater | biannually | June, September | N/A | N/A | - |
| North Fork Rose Creek | NFRC-4 | FA-MW104 | CH14-107-MW010 | Groundwater | biannually | June, September | N/A | N/A | - |
| Rose Creek | RC-1 | RC-SW001 | X3A | Surface Water | monthly | April to March | YES; (Continuous; Monthly) | 4 | Discharge measurements are not always possible under ice covered conditions due to recurring safety concerns. Also, the development of several layers of ice with flow between the layers results in unsuitable conditions for dilution gauging (salt slug) methods. |
| Rose Creek | RC-1 | RC-SW002 | X3B | Surface Water | monthly | April to March | YES; (Monthly) | 4 | - |
| Rose Creek | RC-1 | RC-SW010 | X10 | Surface Water | monthly | April to March | YES (Monthly) | 4 | Discharge measurements have been omitted in some months due to field constraints. (i.e. turbulence impacting ADCP measurements, unsafe wading conditions; unsafe ice conditions, etc.) |
| Rose Creek | RC-2 | NW-SW003 | CVS1 | Surface Water | monthly | April to March | YES (Monthly) | 4 | The stage - discharge relationship is highly variable due to intermittent beaver activity and fluctuating backwater effects from Rose Creek. |
| Rose Creek | RC-2 | NW-SW002 | CVS3 | Surface Water | monthly | April to March | YES (Monthly) | 4 | |
| Rose Creek | RC-2 | DV-SW002 | CVS2 | Surface Water | monthly | April to March | YES (Monthly) | 4 | Estimated as $Q_{CVS2} = Q_{CVS8} - Q_{CVS3}$ |
| Rose Creek | RC-2 | - | CVS8 | Surface Water | monthly | April to March | YES (Monthly) | 4 | |
| Rose Creek | RC-2 | FA-WT003 | EPO (IWTS EPO) | Surface Water | weekly and monthly during discharge | during discharge (~April to November) | NO | 4 | Discharge measured by the treatment plant. |
| Rose Creek | RC-3 | DV-MW008C | MW-17-08D | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW008B | MW-17-08M | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW008A | MW-17-08S | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW023B | MW-18-40D | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW023A | MW-18-40S | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW032A | X18A | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW032B | X18B | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW003A | MW-17-03S | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW003B | MW-17-03M | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW003C | MW-17-03D | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW011B | MW-17-11D | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW011A | MW-17-11S | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW012C | MW17-12D | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |

**Table D-1: Details of Adaptive Management Plan Monitoring Stations**

| Group | AMI | Station (NEW ID) | Station (OLD ID) | Type | Sampling Frequency | Sampling Months | Discharge Collected | Synoptic Group | Hydrology/Data Considerations |
|---|---|---|---|---|---|---|---|---|---|
| Rose Creek | RC-3 | DV-MW012B | MW-17-12M | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW012A | MW-17-12S | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-3 | DV-MW018 | MW-18-35 | Groundwater | quarterly | January, February, June, September | N/A | N/A | - |
| Rose Creek | RC-4 | RC-SW014 | X14 | Surface Water | Monthly (station will continue to be sampled weekly during discharge by Parsons) | April to March | YES; (Continuous; Monthly) | 4 | - |
| Rose Creek | RC-4 | NW-SW001 | NWID | Surface Water | monthly | April to March | YES; (Monthly) | 4 | Not currently enough data (paired measurements for stage and discharge) to support development of a standard rating curve due to changing physical conditions. The development and use of rating curves or weir equations to estimate discharge from water level measurements assumes that local geometry is static. Periodic and recurring damage to the weirs installed at NWID mean that a continuous record is not available for 2019 to 2020). Success in the future will require that the physical geometric conditions at the site are static.<br><br>Historic Notes: In August 2018, a sharp crested metal plate weir with a rectangular opening was installed, replacing a sharp crested v-notch weir that had been in place prior to August 2018. Elevation of the weir crest was back calculated to be 98.22 m, using paired discharge measurements on 25 September 2018 and 17 October 2018, to calculate the flow depth relative to the surveyed water level. However, in June 2019, the channel bank was eroded, and the weir was outflanked, leading to failure of the weir. The installation of the present weir means that paired measurements collected prior to August 2018 are not comparable to those after August 2018. As well, paired measurements collected before June 2019 and after June 2019 are also likely not comparable, due to the bank erosion and failure. The right bank was repaired by the August 2019 station visit and was observed to be eroded again in May 2020. |

Note: Synoptic group refers to a group of stations that are sampled on the same date such that samples can be directly compared.

**Table D-2: Suite of Water Quality Parameters Monitored at Faro Mine Site**

| Category | Parameter |
|---|---|
| **Surface Water** | |
| Field measurements | water depth, ice depth, snow depth, pH, temperature, dissolved oxygen, specific conductivity, oxidation reduction potential, and turbidity |
| Physical and conventional parameters | total suspended solids, total dissolved solids (calculated), pH, conductivity, alkalinity (as calcium carbonate), hardness. |
| Major ions | calcium, chloride, fluoride, magnesium, potassium, sodium, sulphate |
| Nutrients | total phosphorus, total and dissolved organic carbon, total ammonia (as nitrogen [N]), nitrate (as N), nitrite (as N) |
| Metals[(a)] | Total and dissolved metals: aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, cesium, chromium, cobalt, copper, iron, ferrous iron (dissolved only), calculated ferric iron (dissolved only), lead, lithium, manganese, mercury (total only), molybdenum, nickel, rubidium, selenium, silicon, silver, strontium, sulfur, tellurium, thallium, thorium, tin, titanium, tungsten, uranium, vanadium, zinc, zirconium. |
| **Groundwater** | |
| Field measurements | depth to water, depth to bottom, stick-up height, pH, temperature, dissolved oxygen, specific conductivity, ORP and turbidity |
| Physical and conventional parameters | total suspended solids, pH, conductivity, alkalinity (as calcium carbonate), hardness, acidity |
| Major ions and nutrients | calcium, chloride, fluoride, magnesium, nitrate, nitrite, potassium, phosphorus, sodium, sulphate |
| Metals[(a)] | dissolved metals: aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, cesium, chromium, cobalt, copper, iron, ferrous iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silicon, silver, strontium, sulphur, tellurium, thallium, thorium, tin, titanium, tungsten, uranium, vanadium, zinc, zirconium |

Note:
(a) Includes metalloids (e.g., arsenic) and non-metals (e.g., selenium).

**Table D-3: Expected Laboratory Detection Limits for the Water Quality Parameters**

| Parameter | Units | Quoted Detection Limit (ALS 2021) |
|---|---|---|
| **Physical and Conventional Parameters** | | |
| Alkalinity | mg/L | 1 |
| Conductivity | µS/cm | 2.0 |
| Computed Conductivity | µS/cm | 0.20 |
| Hardness | mg/L | 0.5 |
| pH | pH units | 0.1 |
| Total Dissolved Solids (calculated) | mg/L | 1 |
| Total Suspended Solids | mg/L | 1 |
| **Major Ions** | | |
| Calcium (Ca) | mg/L | 0.05 |
| Chloride (Cl) | mg/L | 0.5 |
| Fluoride (F) | mg/L | 0.02 |
| Magnesium (Mg) | mg/L | 0.005 |
| Potassium (K) | mg/L | 0.05 |
| Sodium (Na) | mg/L | 0.05 |
| Sulphate ($SO_4^{2-}$) | mg/L | 0.3 |
| **Nutrients** | | |
| Ammonia, N | mg/L | 0.005 |
| Nitrate, N | mg/L | 0.005 |
| Nitrite, N | mg/L | 0.001 |
| Total Phosphorus, P | mg/L | 0.002 |
| Dissolved Organic Carbon | mg/L | 0.5 |
| Total Organic Carbon | mg/L | 0.5 |
| **Total Metals** | | |
| Aluminum (Al) | mg/L | 0.003 |
| **Total Metals (cont'd)** | | |
| Antimony (Sb) | mg/L | 0.0001 |
| Arsenic (As) | mg/L | 0.0001 |
| Barium (Ba) | mg/L | 0.0001 |
| Beryllium (Be) | mg/L | 0.00002 |
| Bismuth (Bi) | mg/L | 0.00005 |
| Boron (B) | mg/L | 0.01 |
| Cadmium (Cd) | mg/L | 0.000005 |
| Cesium (Cs) | mg/L | 0.00001 |
| Chromium (Cr) | mg/L | 0.0005 |
| Cobalt (Co) | mg/L | 0.0001 |
| Copper (Cu) | mg/L | 0.0005 |
| Iron (Fe) | mg/L | 0.01 |

**Table D-3: Expected Laboratory Detection Limits for the Water Quality Parameters**

| Parameter | Units | Quoted Detection Limit (ALS 2021) |
|---|---|---|
| Lead (Pb) | mg/L | 0.00005 |
| Lithium (Li) | mg/L | 0.001 |
| Manganese (Mn) | mg/L | 0.0001 |
| Mercury (Hg) | mg/L | 0.000005 |
| Molybdenum (Mo) | mg/L | 0.00005 |
| Nickel (Ni) | mg/L | 0.0005 |
| Rubidium (Rb) | mg/L | 0.0002 |
| Selenium (Se) | mg/L | 0.00005 |
| Silicon (Si) | mg/L | 0.1 |
| Silver (Ag) | mg/L | 0.00001 |
| Strontium (Sr) | mg/L | 0.0002 |
| Sulfur (S) | mg/L | 0.5 |
| Tellurium (Te) | mg/L | 0.0002 |
| Thallium (Tl) | mg/L | 0.00001 |
| Thorium (Th) | mg/L | 0.0001 |
| Tin (Sn) | mg/L | 0.0001 |
| Titanium (Ti) | mg/L | 0.0003 |
| Tungsten (W) | mg/L | 0.0001 |
| Uranium (U) | mg/L | 0.00001 |
| Vanadium (V) | mg/L | 0.0005 |
| Zinc (Zn) | mg/L | 0.003 |
| Zirconium (Zr) | mg/L | 0.0002 |
| **Dissolved Metals** | | |
| Aluminum (Al) | mg/L | 0.001 |
| Antimony (Sb) | mg/L | 0.0001 |
| Arsenic (As) | mg/L | 0.0001 |
| Barium (Ba) | mg/L | 0.0001 |
| **Dissolved Metals (cont'd)** | | |
| Beryllium (Be) | mg/L | 0.000020 |
| Bismuth (Bi) | mg/L | 0.00005 |
| Boron (B) | mg/L | 0.01 |
| Cadmium (Cd) | mg/L | 0.000005 |
| Cesium (Cs) | mg/L | 0.00001 |
| Chromium (Cr) | mg/L | 0.00050 |
| Cobalt (Co) | mg/L | 0.0001 |
| Copper (Cu) | mg/L | 0.0002 |
| Iron (Fe) | mg/L | 0.01 |
| Ferric Iron (Fe[III]) | mg/L | 0.03 |

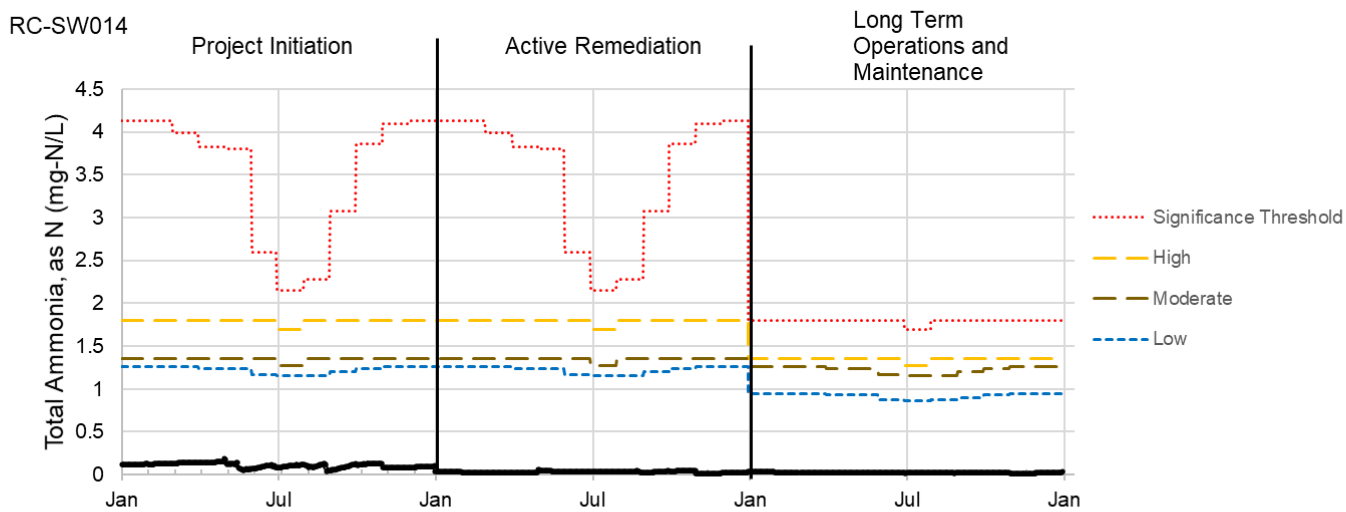
**Table D-3: Expected Laboratory Detection Limits for the Water Quality Parameters**

| Parameter | Units | Quoted Detection Limit (ALS 2021) |
|---|---|---|
| Ferrous Iron (Fe[II]) | mg/L | 0.02 |
| Lead (Pb) | mg/L | 0.00005 |
| Lithium (Li) | mg/L | 0.001 |
| Manganese (Mn) | mg/L | 0.0001 |
| Molybdenum (Mo) | mg/L | 0.00005 |
| Nickel (Ni) | mg/L | 0.0005 |
| Rubidium (Rb) | mg/L | 0.0002 |
| Selenium (Se) | mg/L | 0.00005 |
| Silicon (Si) | mg/L | 0.05 |
| Silver (Ag) | mg/L | 0.00001 |
| Strontium (Sr) | mg/L | 0.0002 |
| Sulfur (S) | mg/L | 0.5 |
| Tellurium (Te) | mg/L | 0.0002 |
| Thallium (Tl) | mg/L | 0.00001 |
| Thorium (Th) | mg/L | 0.0001 |
| Tin (Sn) | mg/L | 0.0001 |
| Titanium (Ti) | mg/L | 0.0003 |
| Tungsten (W) | mg/L | 0.0001 |
| Uranium (U) | mg/L | 0.00001 |
| Vanadium (V) | mg/L | 0.0005 |
| Zinc (Zn) | mg/L | 0.001 |
| Zirconium (Zr) | mg/L | 0.00030 |

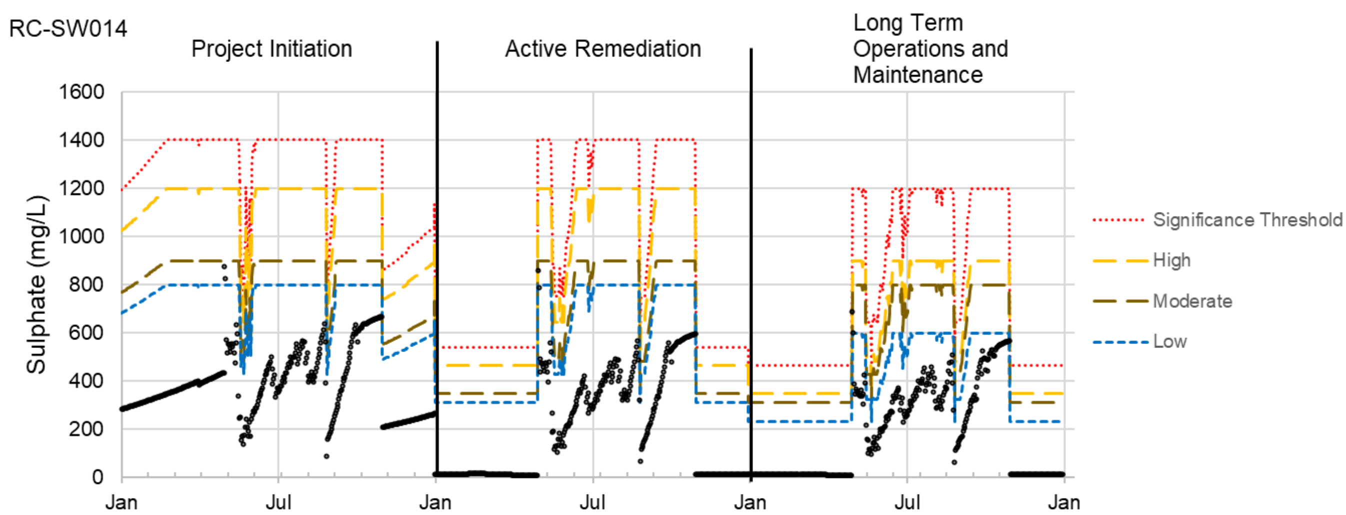
# APPENDIX E – PROJECT PROPOSAL WATER QUALITY PREDICTIONS AGAINST THE AMP ACTION LEVELS

**Appendix E – Plot Series 1: Predictions for Rose Creek Station SW014 versus the draft triggers and significance thresholds throughout the project phases for each indictor for AMI RC-4**

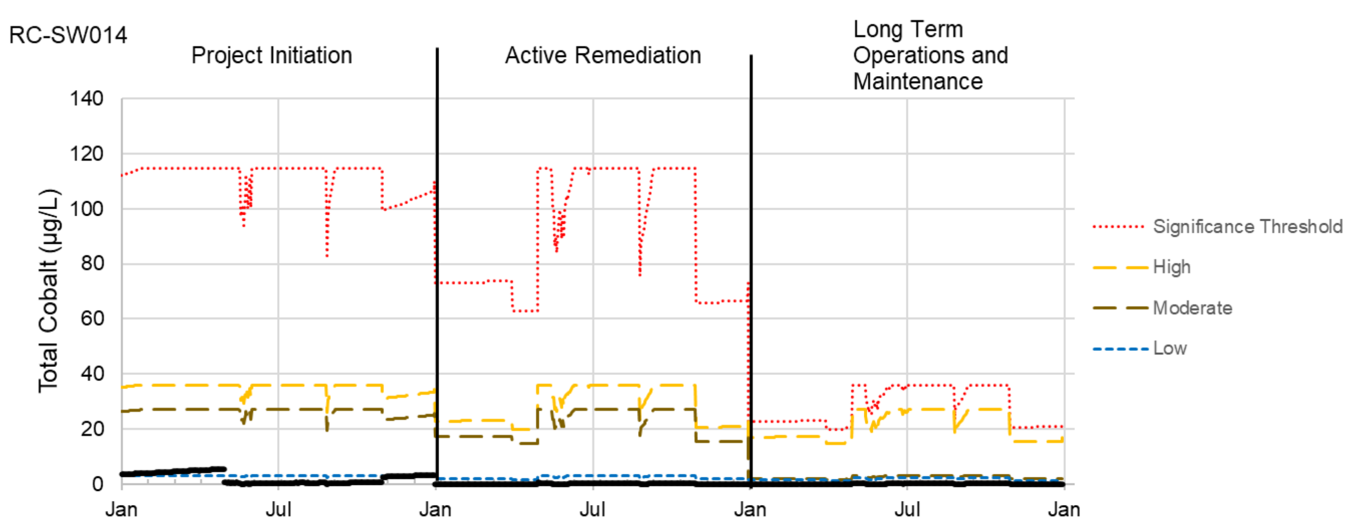
*Disclaimer: Plots are not provided for all AMP exposure stations. Surface water quality predictions are only available for model nodes and are shown here to illustrate how draft triggers and significance thresholds change due to water quality conditions and project phase. Examples are provided for stations RC-SW014 (Rose Creek) and RC-SW030 (Anvil Creek).*



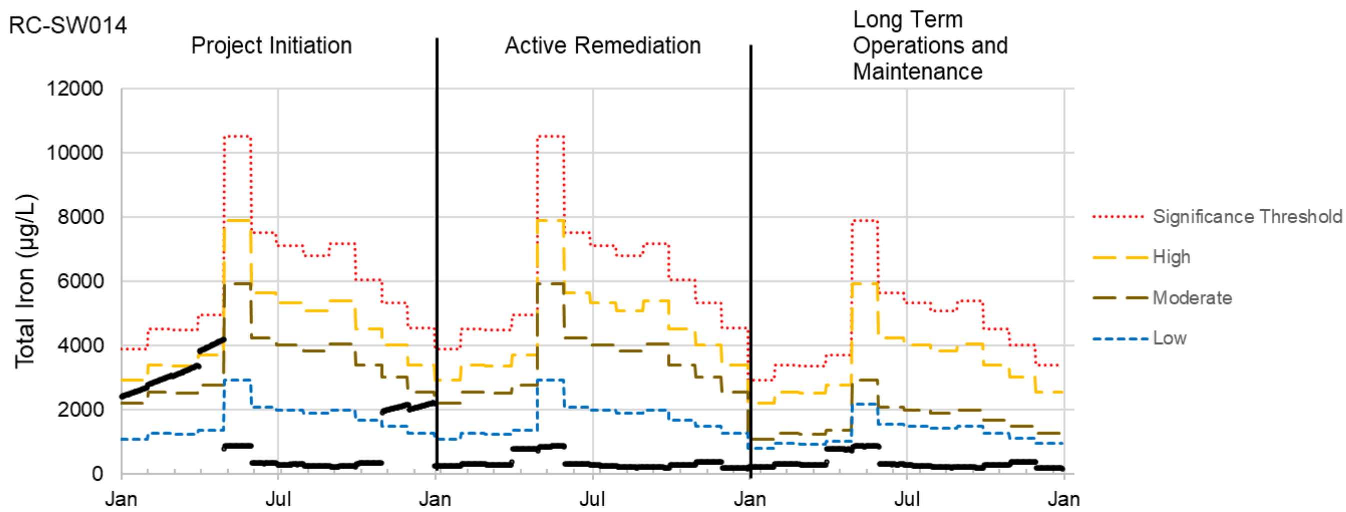

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



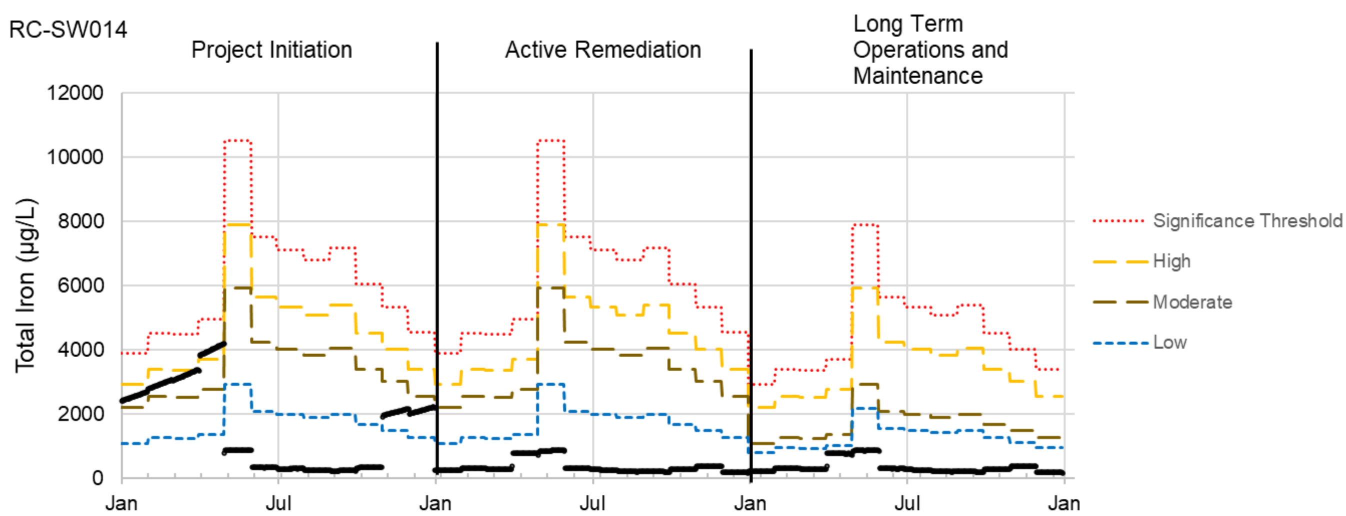

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



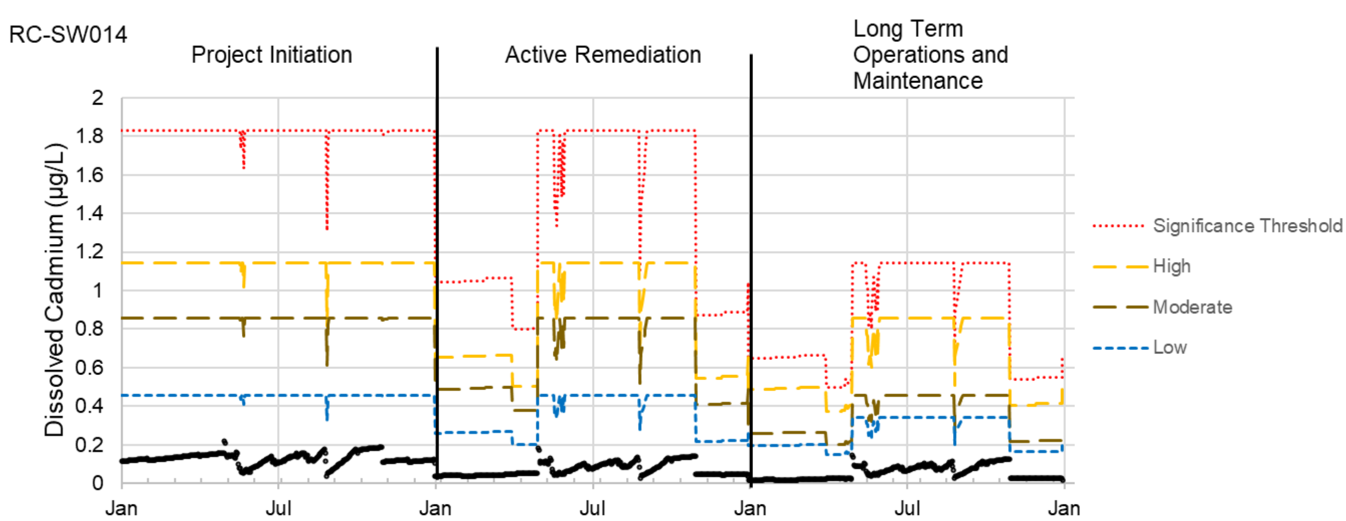

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



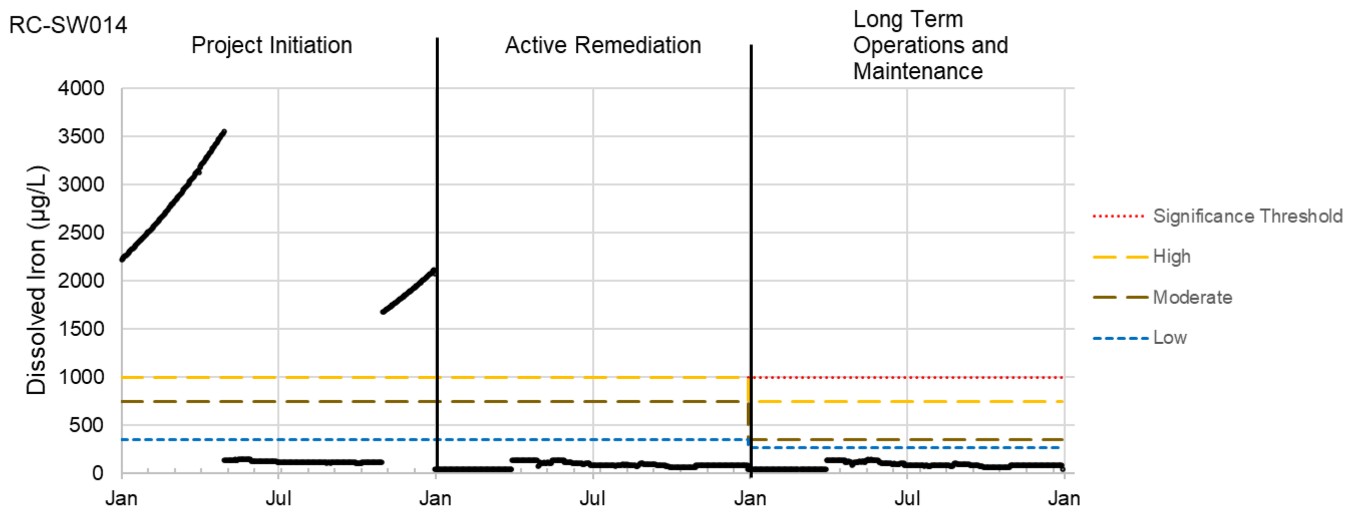

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



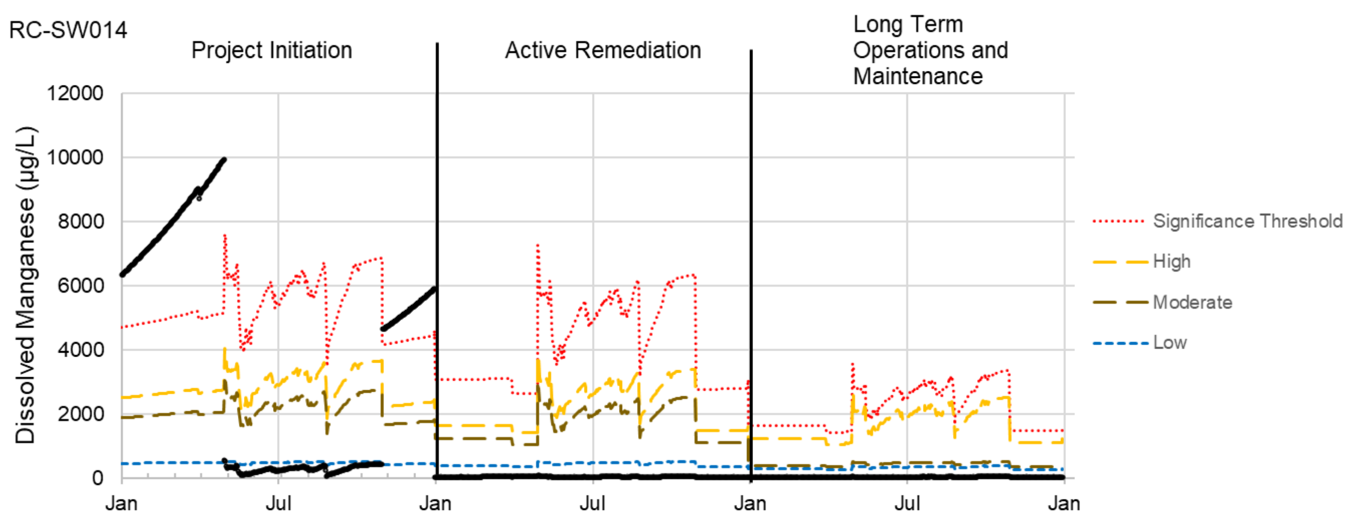

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



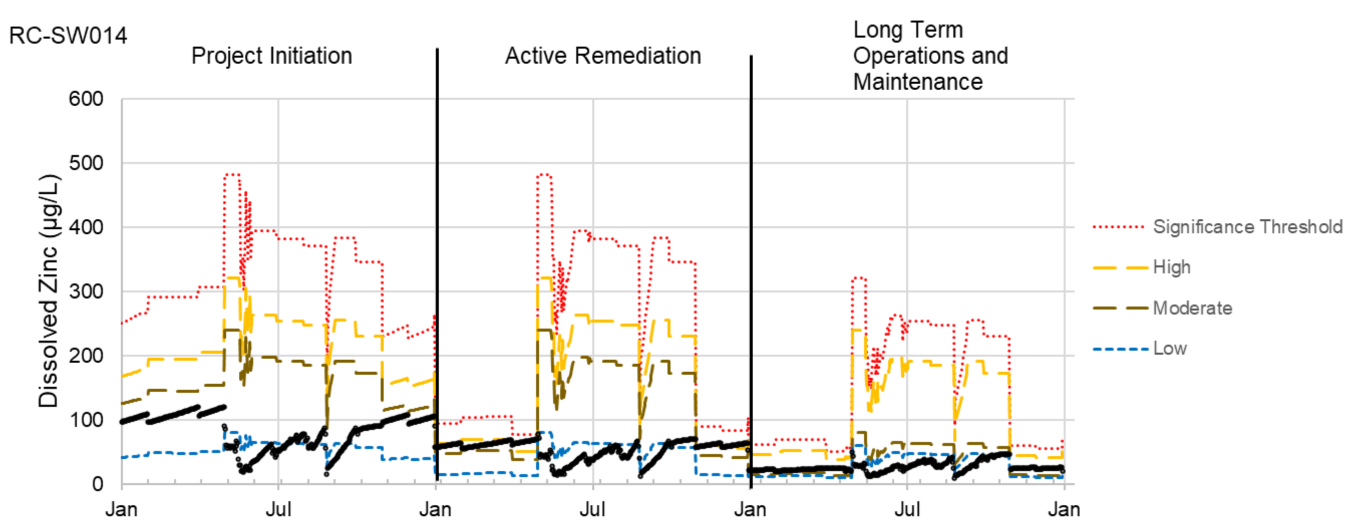

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*




*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*

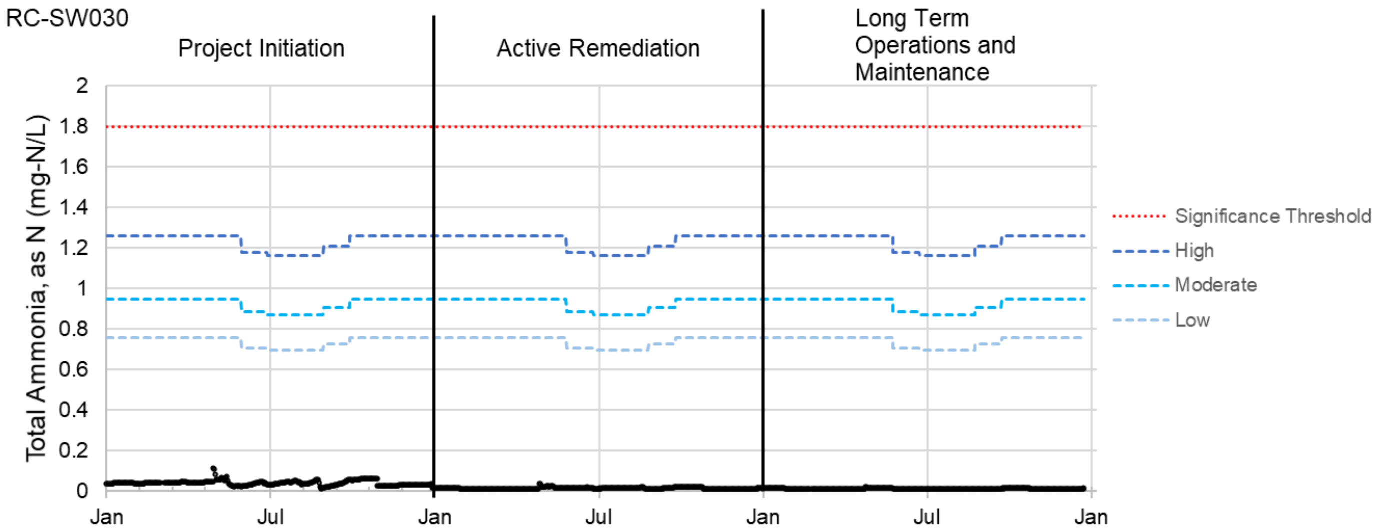



*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*

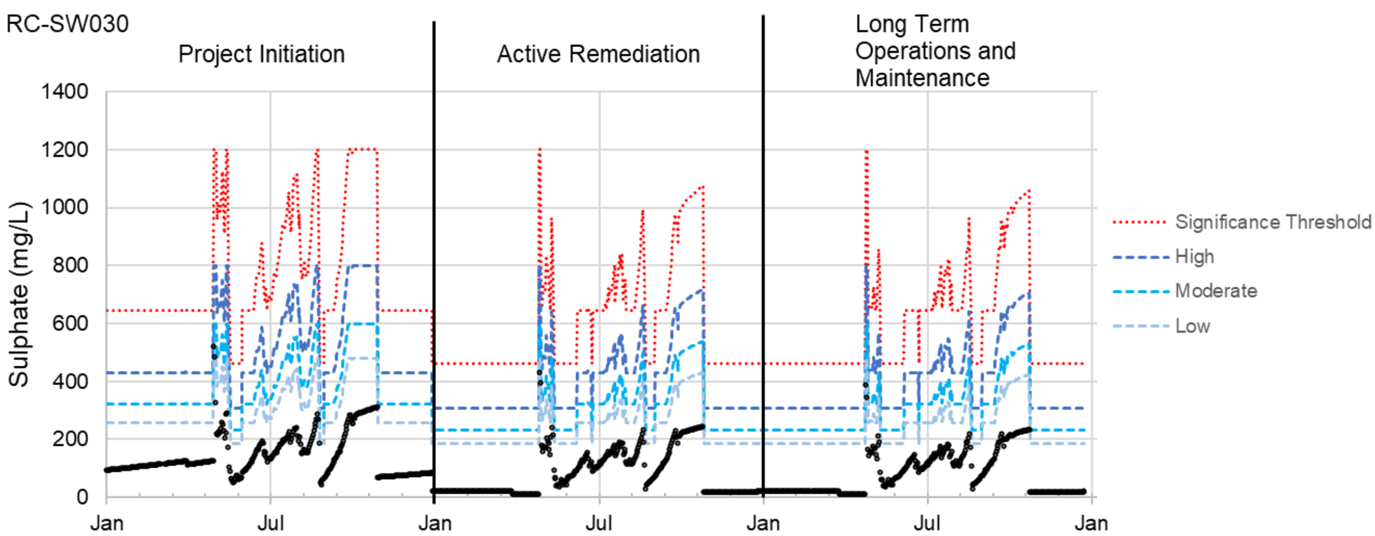



*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*

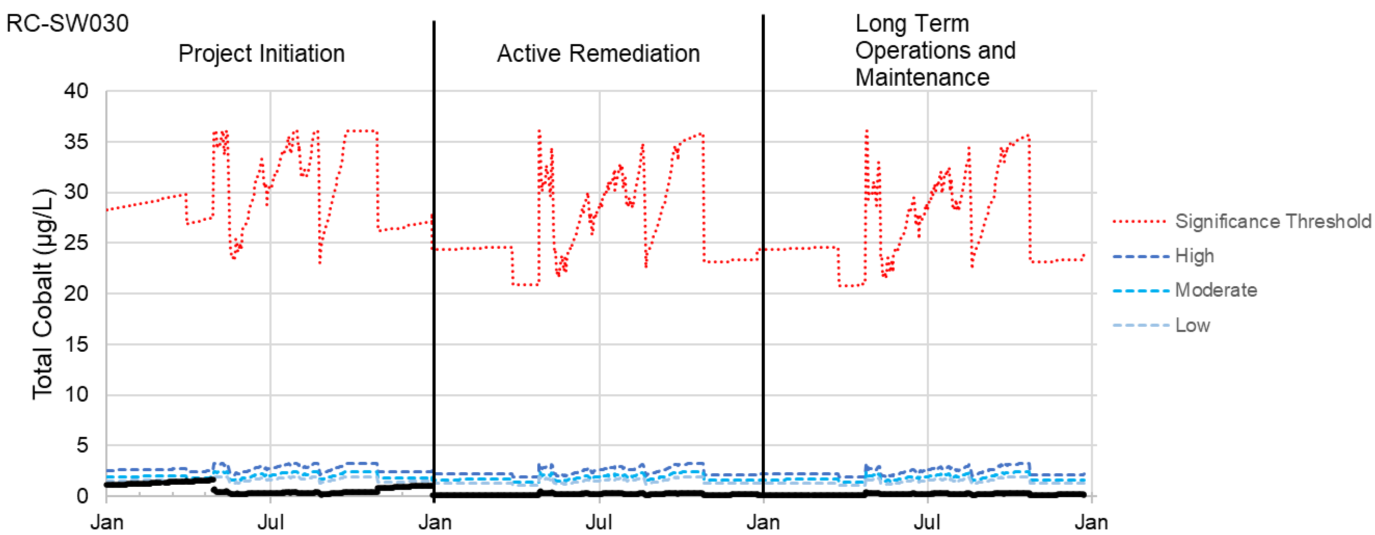
***Appendix E – Plot Series 2: Predictions for Anvil Creek Station SW030 versus the draft action levels and significance thresholds throughout the project phases for each indictor for AMI AC-1***



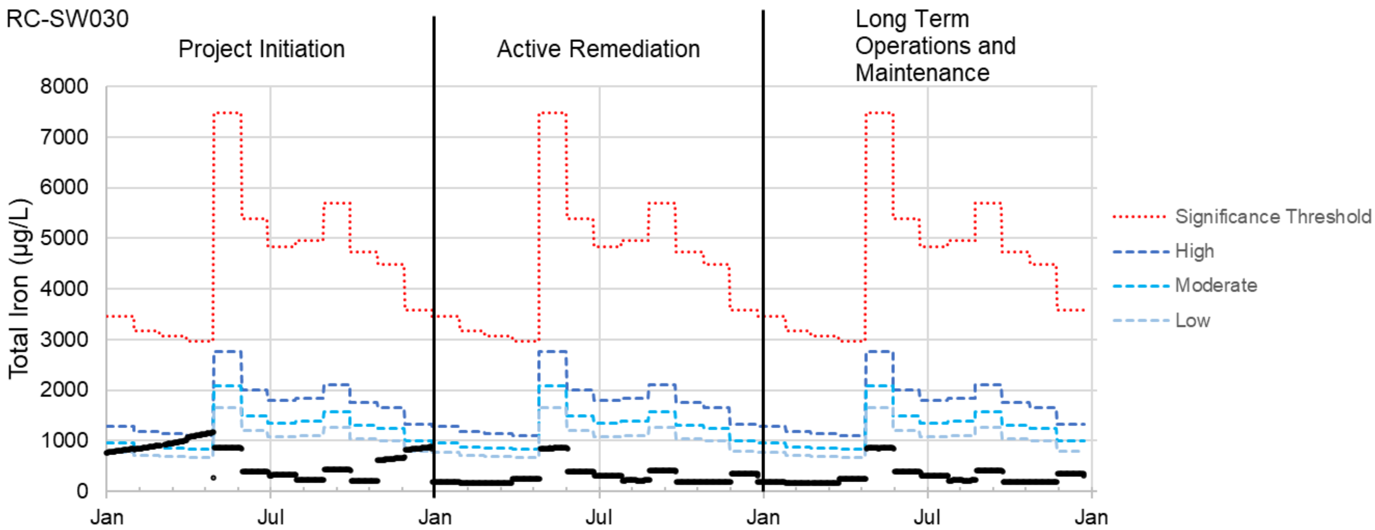

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



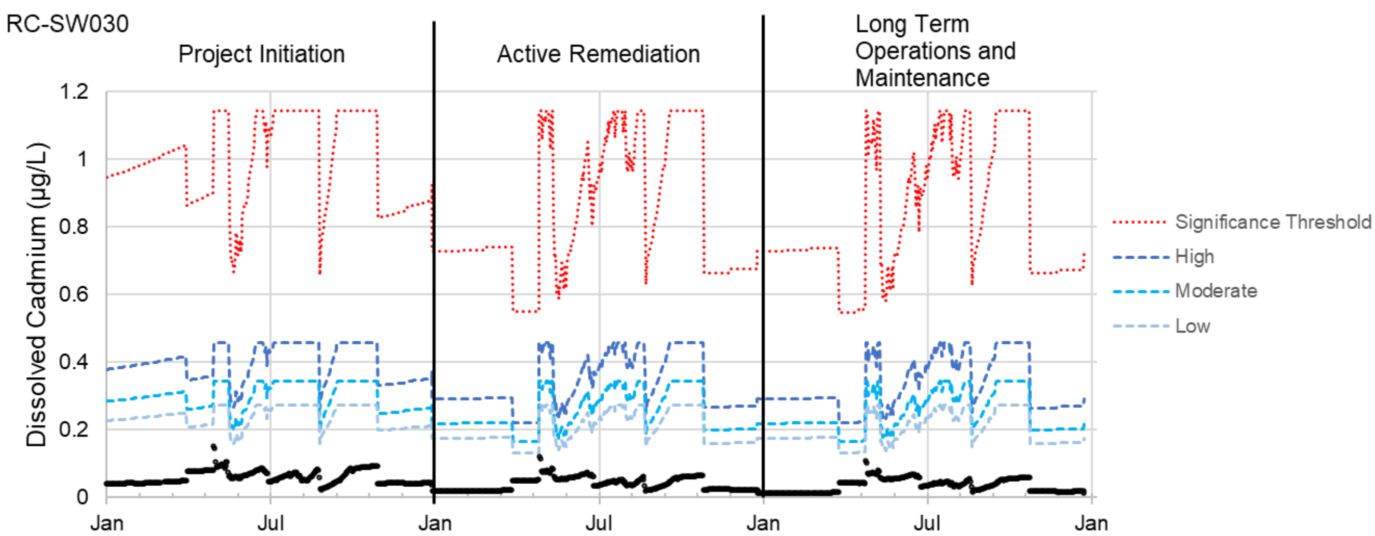

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



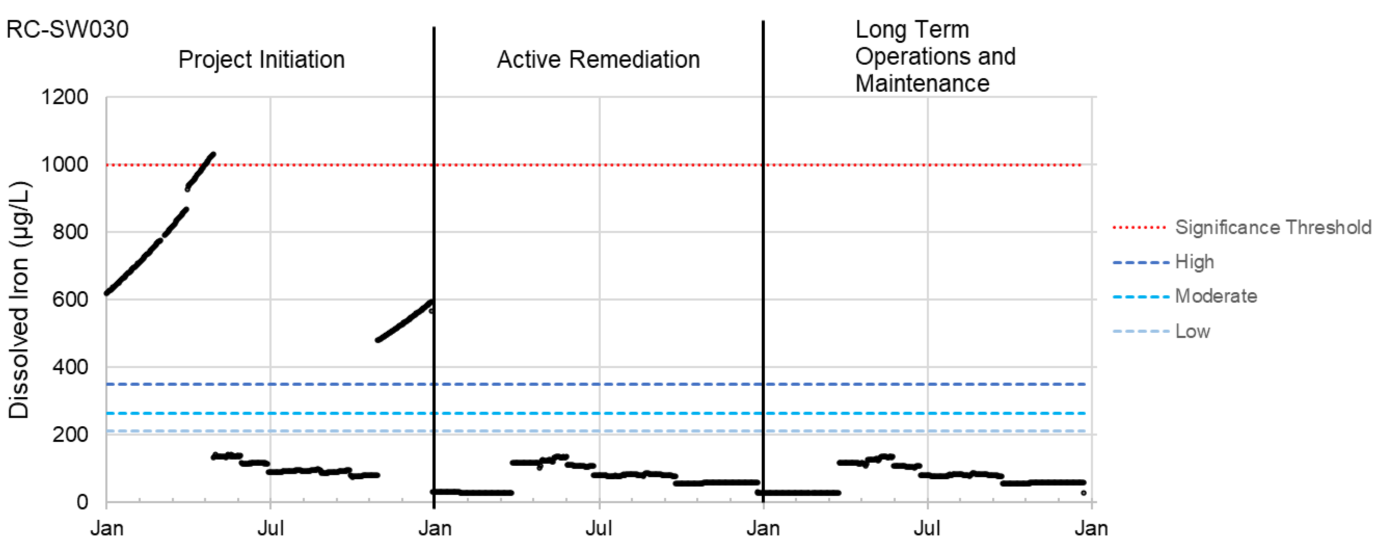

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



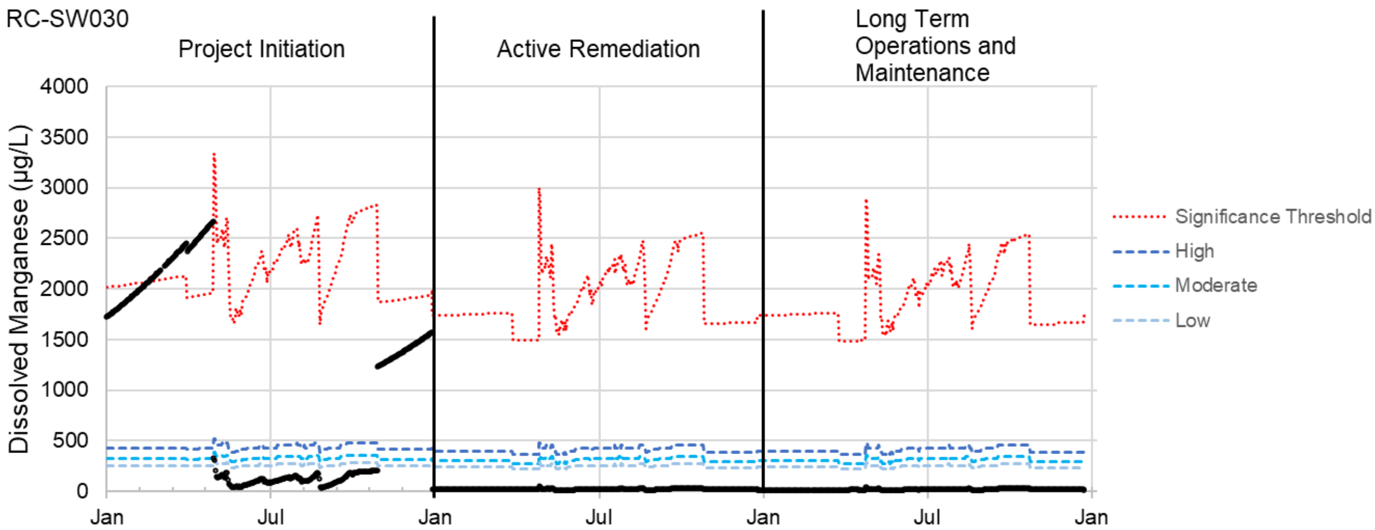

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*



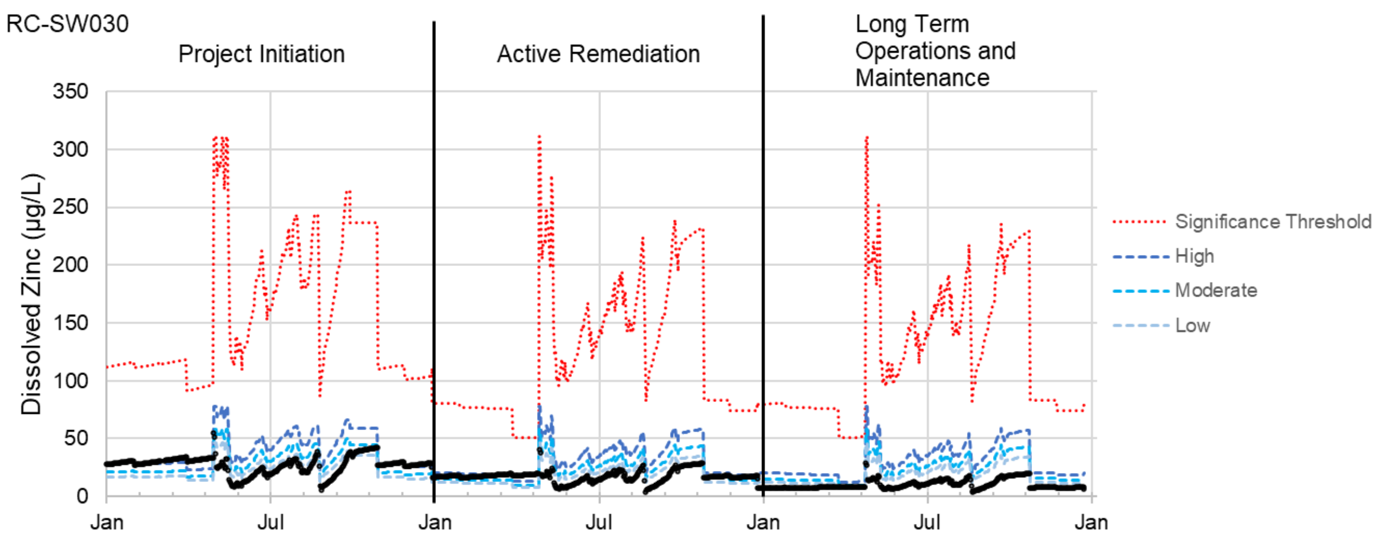

*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*




*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*




*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*




*Notes: The daily predictions of the dry year scenario from Section 7F.2.7 of the Project Proposal are plotted as black circles that overlap and appear as a black line. Significance threshold and triggers are considered draft and will be revised through the regulatory process.*