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September 12th, 2025 File: W2020L8-0003 and W2020X0005

Ms. Kassandra DeFrancis
A/Regulatory Manager
Wek'èezhi Land and Water Board
#1-4905 48th St., Yellowknife, NT X1A 3S3

Dear Ms. DeFrancis,

Re: Kwetı̨ı̨aà (Rayrock) Remediation Project (W2020L8-0003)
Aquatic Effects Monitoring Program (AEMP) Design Plan – Version 1.2

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) Contaminants and Remediation Division (CARD) received from the Wek'èezhìi Land and Water Board (WLWB) a Type A Water Licence (W2020L8-0003) and a Type A Land Use Permit (W2020X0005) on November 18, 2021.

In accordance with Part F, Conditions 2 of W2020L8-0003, CARD submitted an Aquatic Effects Monitoring Program (AEMP) Design Plan (DP) Version 1.0 for review and comment on February 16, 2022. The WLWB rendered a Reasons for Decision on July 5, 2022, that did not approve Version 1.0 and required submission of a Version 1.1. An AEMP DP Version 1.1 was submitted to WLWB for review and comment on March 1, 2024. The WLWB rendered a decision on May 22, 2024, that approved the AEMP with the exception of the Response Framework in Section 12 of the Plan. On July 2, 2024, CIRNAC-CARD submitted the AEMP DP – Version 1.1 Reasons for Decision Response Framework Revisions # 1 to #4, which outlined intended changes to Section 12 of the AEMP DP. On June 28, 2024, CIRNAC-CARD notified the Board about AEMP High Action Level exceedances for water quality. On July 17, 2024, the Board received a new notification from CIRNAC-CARD of additional AEMP High Action Level exceedances. On July 19, 2024, CIRNAC-CARD submitted an AEMP Response Plan for the water quality exceedances referenced above to the Board. Another update to the item for review was made to include the AEMP Response Plan, and reviewers were asked to provide comments and recommendations on the Response Plan as part of this review. On November 4, 2024, the WLWB submitted an Information Request regarding the Response Plan and Response Framework to help inform the Board's decision regarding the Response Framework. CIRNAC-CARD responded to the Information Request on January 30, 2025.

On February 26, 2025, WLWB rendered a decision on an amendment to the Rayrock Water Licence. The following decisions were to be implemented in the AEMP DP:

- To update Annex A to include SNP stations 1663-14 and 1663-15 to require monitoring of TSS and turbidity at 100 and 250 metres from the MLWTP discharge point to verify TSS concentrations remain protective in the Receiving Environment in Sherman Lake;
- To require CIRNAC-CARD to integrate the new SNP stations 1663-14 and 1663–15 into the AEMP; and
- To require CIRNAC-CARD to submit an updated map showing the locations of SNP stations 1663- 14 and 1663- 15 and develop a separate Response Framework for TSS and turbidity, which is applicable only to these two monitoring stations, for Board approval. This updated map and new Response Framework are to be submitted within 45 days of issuance of the amended Licence.

On May 5, 2025, the WLWB rendered a decision that approved the AEMP Response Framework with two required revisions. On May 16, 2025, CIRNAC CARD provided the AEMP Response Framework and map required by the February 26, 2025, decision. Following Public review and comment, CIRNAC-CARD provided responses to reviewers on June 13, 2025.

On July 9, 2025, the Board approved the AEMP Response Framework for TSS and Turbidity, subject to two revisions outlined in the Reasons for Decision. Following CIRNAC's resubmission of the AEMP Design Plan Version 1.2 on August 6, 2025, addressing these revisions, the Board conducted a conformity check and, on August 13, 2025, identified outstanding items requiring further revision and/or clarification.

Enclosed with this cover letter, you will find the Rayrock AEMP Design Plan Version 1.2. A concordance table summarizing decisions from Reasons for Decisions dated May 22, 2024, February 26, 2025, May 5, 2025, and July 9, 2025 is attached as Appendix A to this letter. This resubmission also addresses the outstanding items requiring further revision and/or clarification identified by the Board during the conformity check issued on August 13, 2025.

If you have any questions regarding the Rayrock AEMP Design Plan Version 1.2, please do not hesitate to contact me.

Yours Truly,

Ron Breadmore
Project Manager, CIRNAC-CARD

Cc:
Andrew Richardson, Project Officer, CIRNAC-CARD
Ben Dosu, Project Specialist, CIRNAC-CARD

Att:
Concordance Table for Rayrock AEMP Design Plan Version 1.2
Encl:
Rayrock AEMP Design Plan Version 1.2

Concordance Table

Rayrock AEMP Design Plan Version 1.1 – Reasons for Decision Response Framework Revisions #1 to #4

Requirement	Location in Rayrock AEMP Design Plan V 1.2	Response
Response Framework Revisions:		
1. CIRNAC-CARD is to define how much of an increase from baseline freshet levels would trigger a response for Low, Medium, and High Action Levels.	Section 12.2.2 Table 12-2	The water level data collected from June to September 2022 for Sherman Lake, Lake A, New Control Lake, Gamma Lake, and Beta Lake provided a quality dataset for water level evaluations for each waterbody. Data collection was repeated in 2023, however, issues with wildlife damage/tampering caused incomplete data collection at most of the sites. The 2023 Sherman Lake station data provided water levels through June and July, that captured the freshet peak and the maximum water level recorded. Overall, the monthly and summer averages for each lake for 2022 and 2023 are very closely aligned and the Standard Error calculations for each location are low. A quantitative Action Level trigger for changes in water level on Sherman Lake has been set using the elevation difference between the maximum spring freshet water level and the average summer water level measured during the pre-remediation baseline in 2023. At the Sherman Lake hydrologic monitoring station, the maximum water level was measured in June at 180.475 masl and the average water level in 2023 was 180.345. This elevation difference of 0.130 m (130mm) between the annual peak and the summer average will be used as a numeric value for evaluating the Low Action Level for Sherman Lake hydrology. The elevation level difference of 0.130m (130mm) will be used in the Response Framework to increase the frequency of water level data downloads to weekly. If water levels remain above this 0.130m (130mm) difference threshold for a duration of more than three weeks, then it will be considered a Moderate Action Level value for water level. If it remains above the 0.130m threshold for more than six weeks, then it will be considered a High Action Level value for water level. In addition to the quantitative water level criteria, the qualitative evaluation of Sherman Lake shoreline habitat environmental change or stress from elevated water levels will remain as part of the Response Framework triggers for the aquatic environment Action Levels. It is also worth noting that the discharge is only expected to have any possible influence on Sherman Lake and Lake A. Due to site access and operational limitations during the spring break up and thaw period, annual commissioning and start-up of the Mill Lake Water Treatment Facility and the Confined Disposal Facility are not anticipated to occur until after the annual freshet. Therefore, freshet levels measured on Sherman Lake and Lake A will not be influenced by discharge of treated water from the Rayrock site. This will be calibrated by evaluating the water level in June 2024 as well as by observing changes in the other lakes at the start of the 2024 freshet and open water season. The inclusion of water level data collection for Gamma Lake and Beta Lake would still be evaluated to understand interannual variation in water levels at site and regionally, and to evaluate if other activity during the remediation changes water drainage patterns that influence those lakes.
2. CIRNAC-CARD is to clarify how the assessment of Action Levels relates to the proposed data download frequency from pressure transducers during the period of discharge.	Section 12.2.2 Table 12-2	As included in the response to Response Framework Revision #1, the elevation level difference of 0.130m (130mm) on Sherman Lake during discharge will be used in the Response Framework to increase the frequency of water level data downloads to weekly.

Requirement	Location in Rayrock AEMP Design Plan V 1.2	Response
		If this increase in the summer water level on Sherman Lake is detected when treated water discharge is occurring then an initial investigation of precipitation rates and potential blockages (e.g., beaver dam or log jam) of drainage pathways will be undertaken along with the evaluation of water levels on Beta and Gamma lakes and New Control Lake to determine if a similar trend is occurring. The frequency of water level data retrieval would switch to weekly until the water level falls to a measure below the 0.130m (130 mm) difference in elevation. If water levels remain above this 0.130m (130mm) difference threshold for a duration of more than three weeks, then it will be considered a Moderate Action Level value for water level. If it remains above the 0.130m threshold for more than six weeks, then it will be considered a High Action Level value for water level.
3. CIRNAC-CARD is to clarify the approach used to set Significance Thresholds (i.e., 95th percentile) and adjust the Low, Medium and High Water and Sediment Action Levels accordingly to reflect the Significance Thresholds.	Section 12.2 (no longer Significance Thresholds – V1.1 section removed) Table 12-1 (no longer Site-Specific Significance Thresholds – V1.1 table removed) Section 12.2.3 Section 12.2.5 Table 12-3 Table 12-4 Table 12-6 Table B-2 Table B-3 Table B-5 Table B-6	The original intent for including a reference to the Sherman Lake Site Specific Significance Thresholds (SSSTs) that were developed by CanNorth (CanNorth 2023) was to provide information on what SSSTs could look like in comparison to the established EQCs for discharge to Sherman Lake under the Water Licence. SSSTs were added for context about EQC setting but were never intended to inform any part of the AEMP Design Plan Response Framework Action Levels. Therefore, all reference to the CanNorth SSSTs for Sherman Lake has been removed from Section 12 and Appendix D to eliminate any further confusion or discussion related to the development of these thresholds for the purposes of the Rayrock AEMP Design Plan. Action Level triggers under the AEMP Design Plan have been set using measures of acceptable change in baseline water chemistry for each waterbody. Water quality, sediment quality, benthic invertebrate tissue concentrations, and large-bodied fish tissue concentrations will be screened against the baseline values (e.g., 95th percentile) developed for each AEMP sampling location using the data collected during the AEMP baseline sampling program (2021-2023). CIRNAC-CARD has proposed the use of the 95th percentile of the AEMP baseline data and an Action Level system based on gradual increases of 10% (Low), 20% (Medium) and 40% (High) from baseline levels. These thresholds have been determined based on the input and recommendations provided by the Tłįchǫ Government and GNWT-ECC. GNWT Comment # 7 on AEMP DP V 1.1 (Submitted April 2, 2024) recommended the use of 10% above the 95th percentile value for each lake location as an action level. GNWT indicated that, "Typically, a value of 20% is used to represent a significant departure from baseline conditions as this is considered the threshold for analytical error for metals in water (Austin 2020) and a practical limit for assessing change from baseline condition for water quality (ENV 2021). The BC Guidance for Derivation of Water Quality Objectives (ENV 2021) identifies levels of protection, including: • Full protection maintains existing water quality with no degradation, substantial alteration, or impairment by human activities. Numerical WQOs should be within 20% of established baseline or background conditions. This would apply where the goal is to fully protect the existing water quality and values or if a parameter of concern has naturally elevated levels such that the WQG cannot be met. In each instance, a change of 20% in current conditions is considered acceptable recognizing the precision for measurement of low-level concentrations in replicate samples is not usually better than 20% in ideal laboratory conditions and natural variability is often greater than 20%. For example, if current conditions for a parameter is a 30-day average of 10 mg/L, a WQO of 12 mg/L would be established to protect the identified water uses and values.

Requirement	Location in Rayrock AEMP Design Plan V 1.2	Response
		TG Comment #5 on AEMP DP V1.1 (submitted April 2, 2024) indicted that if the low action level was to be set at X% above the maximum baseline concentration (or X% above the 95% UCL value), then moderate action level could be set at 2X% above baseline maximum (or 95% UCL), and the high action level set at 4X% above the maximum (or 95% UCL) baseline concentration. With the recommendations and guidance provided on ranges of reasonable change from the established baseline condition, we have selected 10% above the 95th percentile value for the low action level where a change is measurable but still below an acceptable range, a 20% change for the moderate action level where conditions may indicate an increase beyond expected natural variability, and a 40% change for the high action level where the concentrations go beyond the intended water quality objectives (protection of baseline conditions). References: Austin, Joyce (editor). 2020. British Columbia Environmental Laboratory Manual. Analysis, Reporting and Knowledge Services, Knowledge Management Branch, B.C. Ministry of Environment and Climate Change Strategy, Victoria, B.C. ENV (British Columbia Ministry of Environment and Climate Change Strategy). 2021. Guidance for Derivation of Water Quality Objectives in British Columbia, WQO-04. Prov. B.C., Victoria B.C.
4. CIRNAC-CARD is to update the critical effects sizes for the benthic invertebrate program to reflect additional baseline data.	Section 12.2.4 Table 12-5 Table B-4	The Low Action Level for benthic invertebrates is defined as significantly lower invertebrate density and richness in the receiving waterbodies (Sherman Lake waterbody, Beta Lake, Gamma Lake, Kwetsǫ̀tìa) compared to the pre-remediation baseline conditions of a magnitude greater than 1 SD for benthic invertebrates (Table 12-5). A CES of 2 SD is used in EEM Technical Guidance (Environment Canada 2012). However, the variability of the pre-remediation baseline data in a few of the lakes is high enough that a decrease of 1 SD may approach or exceed densities of zero. This Action Level also requires reasonable evidence that changes to these endpoints is linked to activity at the Kwetıı̨ʔaà (Rayrock) Remediation Project, as indicated by water quality and sediment quality. The Low Action Level is focused primarily on change related to potential toxicity, as it is most directly relevant to preventing reductions in benthic communities.

Crown-Indigenous Relations and Northern Affairs Canada
Relations Couronne-Autochtones et Affaires du Nord Canada

Aquatic Effects Monitoring Program Design Plan Version 1.2

PROJECT ID: (Kwetı̨ı̨ɂaà) Rayrock Remediation Project

Water Sampling at 1663-8 Sherman Lake L, June 15th, 2025

SUBMITTAL ID: CIRNAC - CARD - AEMPDP - Version 1.2

DATE OF SUBMISSION: September 2025

SUBMITTED BY: Ron Breadmore – Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) – Contaminants and Remediation Division (CARD)

SUBMITTED TO: Wek'èezhìi Land and Water Board

July 2025

Plain Language Summary of the Aquatic Effects Monitoring Program Design Plan

Introduction

The Kwetı̨ı̨ɂaà (Rayrock) mine site is a former underground uranium mine located approximately 145 km northwest of Yellowknife, NT. The former mine is situated on Tłı̨chǫ traditional territory and is surrounded entirely by Tłı̨chǫ Lands per the Tłı̨chǫ Comprehensive Land Claim Agreement (CLCA). The main mine has been designated a Federal (Crown) defined exclusion zone (Figure 2) as the site remains a waste nuclear substance storage facility. The Government of Canada through Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) - Contaminants and Remediation Division (CARD) is the land manager and is responsible for the cleanup of the site.

The Kwetı̨ı̨ɂaà (Rayrock) Remediation Project involves the cleanup of the former Rayrock mine and other uranium exploration sites in the surrounding area of the Tłı̨chǫ Region. The Rayrock sites were impacted by historic mining activities that occurred between the 1950s and 1970s. Since 1984, information has been collected regarding the risks to humans and the environment which was used to complete a Human Health and Ecological Risk Assessment (HHERA). The HHERA used Tłı̨chǫ Traditional Knowledge studies and scientific studies about the soil, water, plants, and animals to understand how the site affects humans and wildlife. These studies answered questions such as:

- How much do the Tłı̨chǫ people use the site each year?
- How do wildlife, including species most affected by contaminants, use the site?
- What are the contaminants in the soil, water, and sediment?

The HHERA looked at the likelihood of the Kwetı̨ı̨ɂaà (Rayrock) mine site causing harm to people and wildlife and determined that animals may be harmed by the uranium in the water and sediment of Mill Lake. The water in Mill Lake is up to 3.9 m deep, and soft sediments cover the lake bottom. High amounts of uranium have been found in this sediment and water. CIRNAC-CARD proposes to clean up the water by draining the lake, treating the water in an onsite water treatment facility, and discharging treated water into Sherman Lake. Once the lake is drained, CIRNAC-CARD proposes to clean up the sediment by collecting the sediment, draining the extra water, and burying the sediment in an area near where the lake. By burying the sediment, the risk of chemicals spreading into the water, sediments and fish is reduced/eliminated. There is concern that work to complete the cleanup at Rayrock may cause uranium or other chemicals to be spread to areas that are clean now. The Government of Canada has designed all parts of the cleanup to make sure no chemicals are allowed to spread to clean areas.

Due to the discharge of treated water into Sherman Lake, a Type A Water Licence was applied for and was issued on November 18, 2021 by the Wek'èezhìi Land and Water Board (WLWB). The Water Licence (W2020L8-0003) requires an Aquatic Effects Monitoring Program (AEMP) Design Plan be prepared to monitor the aquatic environment. This AEMP Design Plan follows the Water Licence requirements and the Government of the Northwest Territories (GNWT) and Mackenzie Valley Land and Water Board's (MVLWB) guidance on how to develop AEMPs. However, CIRNAC-CARD would like to draw attention to the fact that the MVLWB and GNWT's guidance is for new projects rather than cleanup projects, like the Kwetı̨ı̨ɂaà (Rayrock) Remediation Project. This AEMP Design Plan has been scaled based on the scope of the Project.

Summary of Proposed Aquatic Effects Monitoring Program by Component

The AEMP will measure important characteristics of Sherman Lake and nearby lakes before the start of the cleanup, while the cleanup is happening, and after the cleanup is finished to make sure these characteristics do not change. Three other lakes in the area named New Control Lake, Alternate Reference Lake, and Dlah Lake are far enough away from Rayrock, so that they will not be affected by the work. These lakes will also be measured for these characteristics to make sure that changes that are happening all over the Tłı̨chǫ Region are not mistaken for changes from the work at Rayrock.

AEMPs are usually part of large work project, like active mines and hydroelectric facilities, where small changes to the environment can build up over time and cause problems. This build up is not possible during the Kwetı̨ı̨ɂaà (Rayrock) Remediation Project because most of the work will be completed in the first year and all of the work will be completed in three years. Baseline information was collected for the AEMP in 2021, 2022, and 2023 and the AEMP will be conducted during cleanup from 2024 to 2027 and for 5 years following clean up from 2028 to 2032.

The main activities that may cause changes to the nearby lakes are the pumping of treated water from Mill Lake into the clean water of Sherman Lake and water runoff from the work being done on the TCAs. Over a four-year period, approximately 360,000 m^3 of treated Mill Lake water will be discharged into Sherman Lake, which has an approximate volume of 5,355,000 m^3. The addition of Mill Lake treated water into Sherman Lake accounts for a 6.7% increase to Sherman Lake over four years, or an average of approximately 1.7% per year. To check whether the lakes are being affected, the following characteristics will be measured: aquatic environment (hydrology), water quality, sediment quality, benthic community, and fish community. A description of monitoring for each component is outlined in the following sections.

<u>Effluent Toxicity</u>

The objective of monitoring the effluent (treated water) is to make sure the treated Mill Lake water being discharged into Sherman Lake meets the water quality guidelines in the Water License and does not cause unexpected changed in the water and sediment quality of Sherman Lake. Discharge monitoring will be conducted during cleanup at two locations. One sampling location will be directly from the discharge water pipe and will be sampled daily and analyzed onsite. The other sampling location will be within Sherman Lake and will be sampled and analyzed weekly.

<u>Aquatic Environment (Hydrology)</u>

The objective of the aquatic environment or hydrology (lake water level) monitoring to make sure the addition of the treated water from Mill Lake into Sherman Lake does not cause flooding or other unexpected changes. Monitoring will take place at Sherman, Beta, Gamma Lakes, Lake A and New Control Lake. Lake water levels will be monitored year-round using remote monitoring stations and shorelines will be surveyed early summer and late fall. Information collected will be compared to baseline conditions from 2021, 2022 and 2023.

<u>Water Quality</u>

The objective of the water quality monitoring is to measure the quality of water in all the lakes to look for changes in the amounts of contaminants that may signify chemicals could potentially be spreading to clean areas. Lakes will be sampled monthly during open water season including Sherman Lake, Alpha Lake, Beta Lake, Gamma Lake, Lake A, Lake B, Kwetsǫ̀tia Lake, New Control Lake, Alternate Reference Lake, and Dlah Lake. Samples will be analyzed for ions, nutrients, solids, metals and radionuclides and compared to baseline conditions from 2021, 2022 and 2023.

Sediment Quality

The objective of the sediment monitoring is to sample the sediments/soil at the bottom of the lakes to look for changes in the amounts of contaminants that may signify chemicals could potentially be spreading to clean sediments. Sediments will be sampled monthly during open water season, will be analyzed for ions, nutrients, solids, metals and radionuclides and compared to baseline conditions from 2021, 2022 and 2023.

Benthic Assessment

The objective of monitoring the benthic community, or community of bugs living in the lake water, is to make sure they are not affected by adding treated water from Mill Lake into Sherman Lake, as the bugs are an important source of food for small fish. Sediment samples will be collected annually from Sherman Lake, Alpha Lake, Beta Lake, Gamma Lake, Lake A, Lake B, Kwetsǫ̀tia Lake, New Control Lake, Alternate Reference Lake, and Dlah Lake. The bugs within the sediments will be named and their tissue analyzed for metals and radionuclides and will be compared to baseline conditions from 2021 and 2023.

Fish Assessment

The objective of fish monitoring is to make sure the fish in Sherman Lake remain healthy and unaffected by the addition of treated water from Mill Lake, specifically that. Large-bodied fish samples will be collected from Sherman Lake and Alternate Reference Lake. Northern Pike will be targeted in both lakes for tissue analysis. Fishing efforts will take place every three years. Fish tissue, including muscle and liver will be analyzed for metals and radionuclides and compared to baseline conditions from 2021 and 2023.

Traditional Knowledge

Participation of the Tłı̨chǫ Elders will be an important component of the AEMP. Traditional Knowledge has been and will continue to be incorporated into the approach. CIRNAC-CARD will continue to fund aquatic environment surveys conducted by Tłı̨chǫ Elders. Feedback and knowledge provided by Elders may result in additional sampling and/or analyses being added to the AEMP.

AEMP Response Framework

The AEMP Response Framework provides a systematic approach for responding to the findings of the AEMP. Indications of possible unacceptable changes trigger Action Levels, with increasing responses required if unacceptable changes become more likely. As this is a cleanup project, unacceptable changes are not anticipated to occur and overall conditions at the Rayrock site are expected to improve.

Various Action Levels have been set to identify changes before they become unacceptable. Low and High Action Levels are identified as part of the AEMP Design Plan. Potential responses are listed for each Action Level, with growing responses required if unacceptable changes become more likely. The specific responses to be taken if an Action Level is exceeded will depend on the type and seriousness of the effect(s) determined from the AEMP.

For discharge from the water treatment facility, if the effluent quality does not meet the Effluent Quality Criteria (EQC) provided in the Water Licence, discharge to Sherman Lake will be stopped, the WLWB and the Inspector will be notified immediately, and a spill report will be filed. For the other components of the AEMP, if a Low Action Level is exceeded, it will be reported in the Aquatic Effects Monitoring Program Annual Report. If a High Action Level exceedance occurs that is linked to the remediation, notification to the WLWB will be provided within 24 hours of confirming the exceedance (effluent quality and water quality) or within the AEMP Annual Report (aquatic environment, sediment, benthic invertebrates or fish). An exceedance of a High Action Level that is Linked to the Kwetıı̨ɂaà (Rayrock) Remediation Project also requires development of an AEMP Response Plan to be provided within 30 days of the notification (water level, water quality, sediment quality) or 60 days following the submission of the AEMP Annual Report (i.e., end of June; aquatic environment, benthic invertebrates or fish). To be linked to the project, water, sediment or dust from a project area has to enter the water near the sampling location AND the water, sediment or dust has to be high in the contaminant that exceeds the High Action Level.

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APPENDICES

FIGURES (Appendix A)

TABLES (Appendix B)

Revision History

Version No.	Author	Document Date	Sections Revised
1	CIRNAC/CARD	February 2022	Water Licence Submission
1.1	CIRNAC/CARD and AECOM Canada Ltd.	February 2023	Revised version to address WLWB Decision Letter (July 2022)
1.1	CIRNAC/CARD and AECOM Canada Ltd.	December 2023	Revised version to address WLWB Conformity Check of the AEMP Design V1.1 (November 2023)
1.1	CIRNAC/CARD and AECOM Canada Ltd.	February 2024	Revised version to address WLWB Conformity Check of the AEMP Design V1.1 (January 2024)
1.2	CIRNAC/CARD and AECOM Canada Ltd.	September 2025	Revised version to address IR Responses and WLWB Decision Letters for the AEMP Design V1.1 (September 2025)

WLWB: Wek'èezhii Land and Water Board

CIRNAC/CARD: Crown-Indigenous Relations and Northern Affairs Canada – Contaminants and Remediation Directorate

1 INTRODUCTION

The Kwetıı̨ʔaà (Rayrock) mine site is a former underground uranium mine located approximately 145 km northwest of Yellowknife, NT (Figures 1 and 2). The former mine is situated on Tłı̨chǫ traditional territory and is surrounded entirely by Tłı̨chǫ Lands per the Tłı̨chǫ Comprehensive Land Claims Agreement (CLCA). The main mine has been designated a Federal (Crown) defined exclusion zone (Figure 2) as the site remains a waste nuclear substance storage facility.

The Kwetıı̨ʔaà (Rayrock) mine site is managed by Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) - Contaminants and Remediation Division (CARD). Public Services and Procurement Canada (PSPC) provides contracting services, contract management, and technical support services to CIRNAC-CARD. Additional information on CIRNAC-CARD, PSPC and the project team is provided in Section 3.

The approved Type A Water Licence (W2020L8-0003) was issued by the Wek'èezhìi Land and Water Board on November 18, 2021 and requires an Aquatic Effects Monitoring Program (AEMP). A concordance table of the Water Licence requirements and location within this AEMP is provided in Appendix C. Four documents are required to be submitted as part of the AEMP as described in the *Guidelines for Aquatic Effects Monitoring Program* (the AEMP Guidelines; MVLWB/GNWT 2019), including a Design Plan, Annual Report, Re-evaluation Report, and Response Plan. This document is the AEMP Design Plan; other reports are discussed in Section 13. The AEMP Guidelines (MVLWB/GNWT 2019) are applicable to both developmental and closure/remediation projects, however, they do not specify different monitoring requirements for the two types of projects. The Water Licence for Kwetıı̨ʔaà (Rayrock) was issued for remediation activities, and therefore, this AEMP Design Plan outlines monitoring tailored to the remediation activities.

Current activities at the Kwetıı̨ʔaà (Rayrock) mine site are in support of the Kwetıı̨ʔaà (Rayrock) Remediation Project (the Project). The next stages of remediation include the construction of a water treatment facility which will discharge treated Mill Lake water into Sherman Lake, the building of a Confined Disposal Facility (CDF), and the repair of tailings containment areas as follows:

- **Mill Lake Remediation:** Mill Lake will be drained and the water will be treated in an onsite water treatment facility. The treated water will be discharged into Sherman Lake. Once the lake is drained, the sediments will be collected, excess water drained and treated through the water treatment facility, and the sediment will be buried in the CDF. The remediation of Mill Lake required the Type A Water Licence and AEMP due to the removal and treatment of water from Mill Lake and the consolidation of the contaminated sediments in a CDF near the former lake basin. The transfer of the treated water from Mill Lake to Sherman Lake has the potential to impact the aquatic environment of Sherman Lake, so the AEMP is designed to monitor the Sherman Lake environment to verify that the transfer of the water does not significantly change the general aquatic environment of Sherman Lake.

- **Tailings Containment Area Repairs:** Civil works will be conducted to repair erosion within the tailings containment areas (TCAs). The repairs of the TCAs do not require a Type A Water Licence, and therefore do not require monitoring through the AEMP as the activity is not sufficiently significant. The TCA repairs can be completed under the existing Land Use Permit (W2020X005).

Since the remediation of Mill Lake and the TCA repairs will happen concurrently, information is provided in this AEMP Design Plan to describe both activities.

1.1 Scope and Objective

This AEMP Design Plan is focused on the discharge of treated wastewater from Mill Lake into Sherman Lake and is valid from 2024 to the end of a five-year post remediation monitoring period. The objective of this design plan is to outline the study design for monitoring aquatic components during and after remediation activities, and to meet the requirements of the Water Licence. This includes all other remediation related contamination sources that could affect aquatic ecosystems downstream of the remediation. For example, Beta Lake is sampled in case run-off from cap repairs or dust from the project change the concentrations.

2 BACKGROUND

2.1 Kwetįįʔaà (Rayrock) Mine Site

The Kwetįįʔaà (Rayrock) mine is a former uranium mine, located approximately 145 kilometres (km) northwest of Yellowknife, Northwest Territories (NT) and approximately 30 km east of the Snare Hydroelectric Facility (Figure 1). The coordinates of the Rayrock mine site are 63º 27’ 00’’ N latitude and 116° 32’ 45’’ W longitude with an approximate elevation of 230 m above mean sea level (as measured near the former mill building).

Milling operations at Rayrock commenced in June 1957 and the mine closed in July 1959 (Silke 2009). During operation, the mine produced 207,754 kg of uranium concentrate powder and discharged 70,903 tonnes of tailings into two areas, now known as the North and South Tailings Containment Areas (TCAs; CIRNAC 2019). The Rayrock mine consisted of the main mine site, the Sun Rose (Northland) Advanced Exploration site, the Horn Plateau (REX) Exploration site, three Rayrock-affiliated drilling sites (GS, MK and TED), the power line infrastructure between Rayrock and the Snare Hydroelectric Facility and a Rayrock-affiliated storage area at the Barge Landing on Marian Lake (Figure 1). Winter roads are also required to access the site.

The main mine site is comprised of a former mill and camp area, north TCA, south TCA, waste disposal area (dump), former northern borrow area, former airstrip (also used as a borrow area), mine openings (vents) on the Marian Ridge and various access trails (Figure 2). Only remnant concrete and waste debris remain at the former mill and camp area.

2.2 Kwetįįʔaà (Rayrock) Remediation Project

Historical investigations at Rayrock have identified impacts in various media across the site including impacted soil, sediment, and water. Spilled tailings, non-hazardous debris, hazardous debris, and physical hazards are also present on site. Environmental issues on site are associated with radioactive materials and gamma surveys have been utilized to delineate impacts and monitor containment infrastructure.

Initial remediation was conducted in 1996 to address areas of highest risk, including the tailings containment areas. A remedial action plan (RAP) was developed in 2020 (AECOM 2020e) which provides details on remaining remediation activities planned under the Project. A summary of the RAP in provided in Table 2-1 below.

Table 2-1 Kwetįį̀ɂaà (Rayrock) Remedial Strategies

Location	Driver	Remedial Strategy
Rayrock Main Mine Site	Mill Lake – Impacted Surface Water[1]	Pump and treat water and discharge into Sherman Lake.
	Mill Lake – Impacted Sediments	Construct a clay-lined and capped Confined Disposal Facility (CDF) within the Mill Lake footprint and place impacted sediments within the CDF. Lower the bedrock outlet into Mill Creek to create a free-flowing surface water pathway.
	Spilled Tailings/Waste Rock	Relocate to the CDF.
	Concrete Foundations	Relocate to the CDF.
	Impacted Soil	Relocate to the CDF.
	Mine Vents	Vent raises will be closed with an acceptable engineered cover (e.g., poly-urethane foam, concrete, stainless steel).
	Hazardous Debris	Consolidate and dispose off-site.
	Non-Hazardous Debris	Consolidate and dispose off-site.
	Borrow Area	Regrade and reclaim.
	Impacted Soil (Mill Creek)	No remediation.
	Mine Adit	No remediation.
Sun Rose	Mine Shaft Opening	Implement a solution for shaft closure in compliance with the applicable regulations and guidelines.
	Waste Rock and Blast Rock/Workings	Construct a containment cap over the material.
	Impacted Soil	No remediation.
	Lake/Pond Sediments	No remediation.
Satellite Sites	Impacted Soil	Relocate to the CDF.
	Hazardous Debris	Consolidate at Rayrock main mine and dispose off-site.
	Non-hazardous Debris	Consolidate at Rayrock main mine and dispose off-site.
	Exploration Workings/Trenches	Construct a capped containment cell over the material.

Source: Remedial Action Plan (AECOM 2020e)
[1] Remedial strategy requiring a Type A Water Licence.

2.2.1 Mill Lake Remediation

The proposed remedial strategy for Mill Lake will be completed in several stages. A process water treatment plant consisting of containerized components will be hauled to site via ice road. The surface water from Mill Lake will be pumped out and treated to reduce uranium and copper concentrations to a level meeting the Effluent Quality Criteria (EQC) provided in the Water Licence. Following treatment, the water will be discharged into Sherman Lake. The planned location for this discharge is in the bay on Sherman Lake where AEMP sampling locations Sherman Lake K and Sherman Lake L are located (Figure 6).

A CDF will be constructed near the former Mill Lake basin. Construction of the CDF, which will function in a similar way as a landfill containment cell, will include:

- Removal of waste rock overburden from CDF footprint.
- Bedrock blasting to achieve rough grade.
- Crushing of bedrock to meet project requirements for fill material.
- Grading of the CDF to achieve drainage towards Mill Lake.
- Construction of a sump at one end of the CDF to collect water from within the cell.
- Installation of liners at the cell base (geotextile, impermeable geomembrane and drainage tri-axial geocomposite).
- Install geotextile dewatering tubes and associated pumping system, manifolds and piping.
- Hydraulically pump sediment into geotextile tubes along with polymer sourced to facilitate sediment separation from water.
- Allow geotextile tubes to dewater on their own for one season prior to cell closure. Water to be captured and treated prior to closure.
- Disposal of waste concrete, waste rock, spilled tailings and contaminated soil in cell.
- Grade cell for positive drainage and cap with geomembrane covered with coarse rock and gas venting.

Following completion of the CDF, a drainage swale will be constructed to provide surface drainage from the base of the former Mill Lake basin into Mill Creek. Construction of this swale will require the blasting of bedrock to lower the current inlet into Mill Creek. Blasting may also be required for creation of the channel in the former Mill Lake basin. The construction of this swale will help to keep the CDF dry and above standing water. Rock from the channel blasting may be installed on the CDF. After completion of the CDF and drainage channels, reclamation activities will be required for the former Mill Lake basin. The basin will be an exposed bedrock and clay surface that is intended to appear the same as the land surrounding the former lake. The proposed remediation design will control the ponding and accumulation of surface water in the Mill Lake basin by promoting overland flow with designed flow control and drainage to the Mill Creek inlet and down-gradient to Sherman Lake.

Potential Effects

Potential aquatic effects from the Mill Lake remediation may result from the treated water discharge phase, however, they will be mitigated by the conditions of the Water Licence:

- Work on the construction of the CDF will be within the confines if the Mill Lake basin and will be contained throughout the process.

- All water from the Mill Lake basin, including water drained from the sediment, will be treated through the Mill Lake Process Water Treatment Plant (PWTP) and will meet EQCs prior to discharge. If treated water does not meet the EQCs, it will not be discharged. Should accidental release of treated water not meeting EQCs occur, it will be reported and managed as a spill.

- Water treatment process wastes will contain concentrated uranium and will be managed on-site by depositing them in the CDF. Additional details on the water treatment system are provided in the Process Water Treatment Plant Operation and Maintenance Plan (Sanexen 2025).

The approximate volume of water in Mill Lake is estimated to be 86,500 cubic m^3 when full to the current Mill Creek outlet level (AECOM 2019). The water treatment system will also need to treat accumulated precipitation and geotextile tube filtrate during the operational period, which is estimated to be an additional

170,142 m^3 and 72,295 m^3, respectively. Therefore, the total volume of water anticipated to be treated is approximately 360,000 m^3. The volume of Sherman Lake is estimated at 5,355,000 m^3. The addition of treated Mill Lake water is approximately 6.7% of the volume of Sherman Lake over four years (or 1.7% per year).

Remediation Timeline

Remediation of Mill Lake started in the summer of 2024 and will be completed in 2026 or 2027. Approximately 50% of treated Mill Lake water was discharged in 2024 with the remaining 50% discharged between 2025 and 2026 or 2027. The AEMP is anticipated for up to five years after completion of the remediation. The treated water discharge to Sherman Lake is not expected to change the water quality or aquatic habitat of Sherman Lake.

2.2.2 Tailings Containment Area Repairs

As part of the RAP (AECOM 2020e), civil works will be conducted to repair erosion within the TCAs. During the 1996 remediation, the northern and southern TCAs were capped with silty clay material from local borrow sources, in order to reduce surface water infiltration and reduce the potential for contaminant mobilization (AECOM 2020e). The tailings caps are inspected regularly as part of the Canadian Nuclear Safety Commission (CNSC) Licence requirements, and in June 2016 CNSC noted that the caps were overall in a good condition with a vegetative cover, however, there were areas of exposed tailings around the perimeter.

As described in the RAP (AECOM 2020e), these exposed areas will be repaired, as needed, using the on-site borrow source from the former airstrip, and then regraded to promote positive drainage. An expected additional 0.5 m of clay will be added to the eroded areas, with field-fitting undertaken as necessary. Consideration will further be given to armouring the shorelines to mitigate the potential for erosion. Remedial activities will also include the placement of small stockpiles of clay and rock in the vicinity of the TCAs to facilitate future cap repairs.

Considerations when detailing the TCA repair will consider those areas most susceptible to erosional forces, and how to best counter fluctuating water levels in Gamma Lake or conversely, drying and cracking within drainage swale structures. This will include a consideration of life cycle costs to assess to what extent the cover (by adding gravel layers) and the drainage ditches (adding rip-rap or equivalent) should be made more robust to minimize long-term maintenance requirements.

Potential Effects

The repairs of the TCAs have the potential to temporarily cause sedimentation issues and has the potential to affect the adjacent water bodies through dust and other airborne transport mechanisms. The principal waterbodies that could be affected are the Alpha Lake portion of Sherman Lake, Beta Lake and Gamma Lake. The proposed sediment and erosion control plan (SECP) provides measures and controls to ensure that the concentration of sediment in the waterbodies does not increase; however, earthworks also have a lower potential to change the water chemistry through mechanisms not controlled through the SECP, such as through dust deposition or dissolved metals that pass through the sediment control infrastructure. The AEMP will monitor for these potential impacts.

As noted above, the objective of the AEMP monitoring will be to show no statistically significant change in monitored components from current conditions, through the conditions during remediation, to the post-remediation aquatic environmental conditions.

Remediation Timeline

Civil work to repair the tailings caps started in the summer of 2025 and will be completed in 2026 or 2027. The AEMP is anticipated for up to five years after completion of the remediation. Repair of the tailings caps is not expected to change the water quality or aquatic habitat of Alpha, Beta and Gamma Lakes, so post-remediation stabilization should be quickly proven.

3 PROJECT TEAM AND ACCOUNTABILITY

The Kwetı̨ı̨ʔaà (Rayrock) Remediation Project Team consists of CIRNAC, as Project proponent and land managers, and PSPC, as providers of contracting services, contract management, and technical support services to CIRNAC. PSPC develops specifications for all Project work and conducted the selection of a remediation contractor, who will be responsible for execution of Project work. PSPC has contracted an environmental consulting firm who will help with the development of specifications, provide technical input to Project design, and oversee the execution of the remediation contractor on behalf of the Government of Canada. This environmental consulting firm will be referred to as the Departmental Representative in this AEMP Design Plan, as they will be representing Government of Canada interest during the remedial phase of the Project.

The Kwetı̨ı̨ʔaà (Rayrock) Remediation Project Team is working towards permanent closure and reclamation of all Kwetı̨ı̨ʔaà (Rayrock) Remediation Project sites. While CIRNAC-CARD will ultimately be responsible for compliance with the Type A Water Licence and Land Use Permit issued for the Project, sampling for the proposed AEMP will be conducted by the Departmental Representative, and/or the remediation contractor under the guidance of the Departmental Representative, both of whom are managed by PSPC. The Departmental Representative will be responsible for reviewing the collected data, monitoring trends and recommending mitigative actions if potential changes in the aquatic environment are emerging. The Departmental Representative will analyze the AEMP data on an on-going basis to provide timely analysis of trends and recommendations for mitigative responses to changes.

The remediation contractor is Sanexen Environmental Services Inc., and the environmental consultant (Departmental Representative) is AECOM Canada Ltd. An organizational chart is provided below (Figure 3-1).

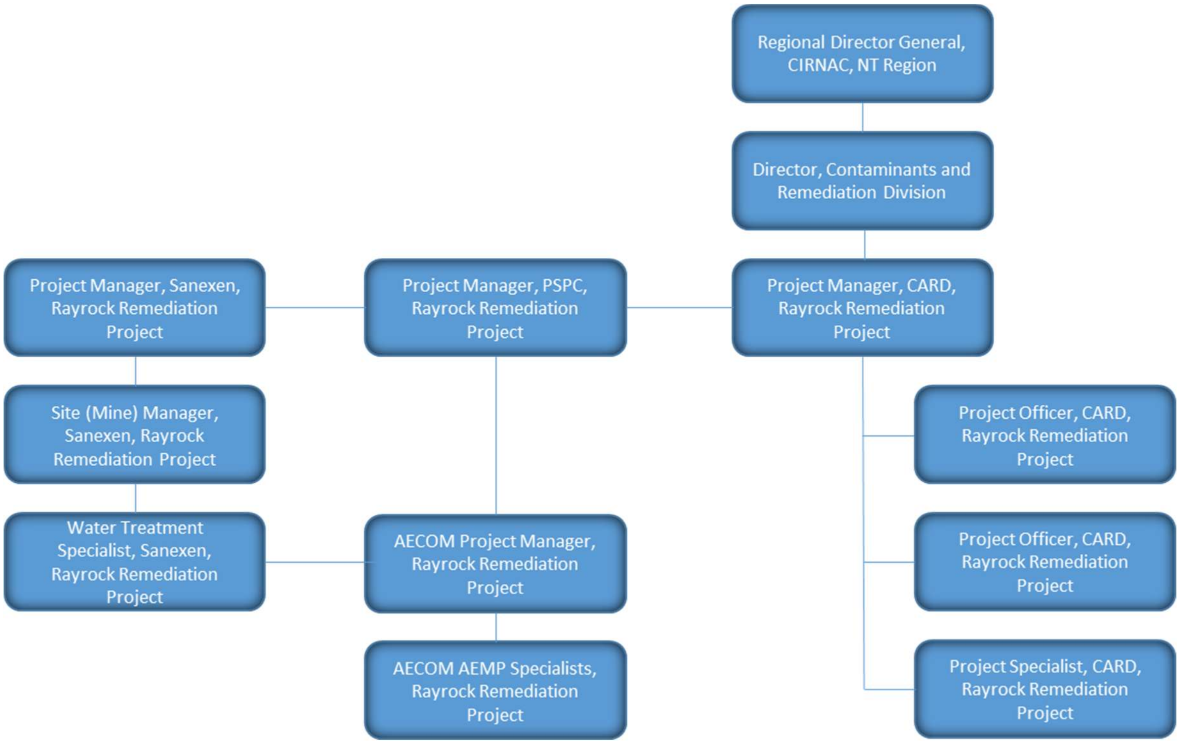


Figure 3-1 Organizational Chart

4 ENGAGEMENT

4.1 Kwetı̨ı̨ʔaà (Rayrock) Engagement Plan

An Engagement Plan for the Rayrock mine site was submitted as part of application for the current Rayrock Land Use Permit (LUP) W2020X005. Version 2.0 of the Engagement Plan was accepted October 7th, 2016, and Version 3.0 of the Engagement Plan was submitted in conjunction with AEMP Design Plan Version 1.0 in February 2022. Version 3.0 of the Engagement Plan included updates in accordance with the planned remediation activities.

Since 2016, all Kwetı̨ı̨ʔaà (Rayrock) Remediation Project activities have been regularly coordinated with the Tłı̨chǫ Government, and the Tłı̨chǫ Government has actively reviewed results and participated in the remediation planning. Update teleconferences are scheduled with the Tłı̨chǫ Government Department of Culture & Lands Protection (DCLP) and their representatives approximately every two weeks, and the schedule may be modified based on Project activity and with the agreement of DCLP. CIRNAC-CARD has been working with the Tłı̨chǫ Government, through the DCLP, on all regulatory submissions. Applications for the LUP and Water Licence for the Project, and all supporting documents and plans will be reviewed by the DCLP and obtain feedback on the information presented. A detailed list of Project engagement activities was provided as part of the RAP (AECOM 2020e).

4.2 AEMP Design Plan Engagement

Tłı̨chǫ Elders and community members have expressed concern over the health of Sherman Lake and Gamma Lake aquatic systems and other waterbodies at the Rayrock mine site. The Rayrock Human Health and Ecological Risk Assessment (HHERA; CanNorth 2018) indicated that there are no human health or environmental concerns with Sherman Lake, however, concerns remain regarding the health of the aquatic environment of Sherman Lake. The AEMP will be conducted to demonstrate that the remedial activities do not change the aquatic environment.

Several components of the AEMP Design Plan were incorporated based on engagement with the Tłı̨chǫ Government, including sampling slimy sculpin as part of the baseline fish assessment and the addition of Lake B-D as a sampling location. In addition, feedback from the Tłı̨chǫ Government's review of Version 1.0 of the AEMP Design Plan have been incorporated into this Version 1.1, where appropriate including but not limited to the addition of chronic toxicity testing to the Response Framework, and the analysis of effluent for all constituents of potential concern (COPCs).

Participation of the Tłı̨chǫ Elders will be an important component of the AEMP. Traditional Knowledge has been and will continue to be incorporated into the approach. CIRNAC-CARD will continue to fund aquatic environment surveys conducted by Tłı̨chǫ Elders. Feedback and knowledge provided by Elders may result in additional sampling and/or analyses being added to the AEMP.

4.2.1 Record of Engagement

A summary of key engagement activities specific to the AEMP Design Plan Version 1.2 is provided in Table 4-1. Specific to the development of AEMP Design Plan V1.1, CIRNAC-CARD has met with the Tłı̨chǫ Government and the Government of the Northwest Territories (GNWT) – Environment and Natural Resources (ENR) to review the proposed updates. Feedback has been gathered and incorporated.

TABLE 4-1 Summary of Key Engagement Activities for the Aquatic Effects Monitoring Program Version 1.2

Activity	Date	Purpose of Engagement	Outcome
AEMP Working Group Meeting	April 21, 2022	Meeting with Tłı̨chǫ Government to discuss the AEMP Design Plan.	• Discussion following submission of the AEMP Design Plan V1.0. • Feedback on V1.0 was provided.
Regulatory Review Meeting	February 2, 2023	Review engagement requirements requested by the WLWB, specific to Tłı̨chǫ Government.	• Reviewed and discussed the engagement requirements/topics specific to the Tłı̨chǫ Government. • A concordance table was provided to the Tłı̨chǫ Government following the meeting. The concordance table included the proposed responses to the Reason for Decision. Feedback was received by CIRNAC-CARD February 21 and 23, 2023.
Design Plan/Regulatory Review Check In	February 16, 2023	Regular meeting with Tłı̨chǫ Government and GNWT– ENR to discuss status of the Project.	• An overall review of the updated AEMP Design Plan V1.1 approach was provided. No initial feedback provided. Follow-up discussion required.
AEMP Working Group Check In	February 23, 2023	Review engagement requirements requested by the WLWB, specific to GNWT-ENR. Tłı̨chǫ Government was present and participated in the discussions.	• Reviewed and discussed the engagement requirements/topics specific to GNWT-ENR. • Specific feedback and recommendations on approach for the updated AEMP Design Plan V1.1 was provided.
Design Plan/Regulatory Review	July 25,2025	Review of Action Levels requested by the WLWB and edits requested as part of IR. And from Misc Letter in Nov 2024	• Reviewed and discussed Water Quality Action Levels and Significance Thresholds with GNWT-ENR. • Specific feedback and recommendations on approach for the updated AEMP Design Plan V1.2 was provided.

AEMP – Aquatic Effects Monitoring Program; CIRNAC-CARD: Crown Indigenous and Northern Affairs Canada – Contaminant and Remediation Division; GNWT: Government of the Northwest Territories; ENR: Environment and Natural Resources

5 REGULATORY ENVIRONMENT

The Kwetı̨ı̨ʔaà (Rayrock) mine site is located in the Northwest Territories, within the Mackenzie Valley area, and as such the Project is subject to federal and territorial legislation. Relevant legislation, guidelines and licences related to the AEMP Design Plan include:

- **Federal Legislation**
  - *Fisheries Act* (Government of Canada, 1985)
  - *Canadian Environmental Protection Act and the Toxic Substances Lists* (Government of Canada 1999)
  - *Mackenzie Valley Resource Management Act* (Government of Canada 1998)
  - *Nuclear Safety and Control Act* (Government of Canada 1997)
- **Territorial Legislation**
  - *Guidelines for Aquatic Effects Monitoring Programs* (MVLWB/GNWT 2019)
  - *Northwest Territories Devolution Act* (Government of Canada 2014)
  - *Mackenzie Valley Federal Areas Waters Regulations* (Government of Canada 2016)
- **Licences**
  - Water Licence W2020L8-0003, issued November 18, 2021
  - Canadian Nuclear Safety Commission (CNSC) Waste Nuclear Substance Licence (WNSL) WNSL-W5-3208.0/2027
  - Rayrock Land Use Permit (LUP) W2020X0005 issued November 18, 2021

- **Guidelines**
  - *Canadian Council of Ministers for the Environment - Canadian Environmental Quality Guidelines*
    - Water Quality Guidelines for the Protection of Aquatic Life (CCME 1999a)
    - Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 1999b)
  - *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials* (Health Canada 2014)

5.1 Mackenzie Valley Resource Management Act

The most relevant piece of legislation to the AEMP is the *Mackenzie Valley Resource Management Act* (Government of Canada 1998). Water use and the direct or indirect deposit of waste into water is regulated through the issuance of water licences by the Land and Water Boards of the Mackenzie Valley under the *Mackenzie Valley Resource Management Act* (Government of Canada 1998).

5.2 Water Licence

Part F of the Kwetı̨ı̨ʔaà (Rayrock) Remediation Project Type A Water Licence sets out the requirement of the AEMP. A concordance table of the Water Licence requirements and location within this AEMP is provided in Appendix C. The Water Licence also describes the Surveillance Network Program (SNP) that will be implemented and that has been included here as part of the AEMP. Water use monitoring is also described in the Water Licence; as the water discharge from Mill Lake following treatment is considered a liquid waste being tracked and reported in the AEMP.

5.3 Canadian Nuclear Safety Commission – Waste Nuclear Substance Licence

The CNSC WNSL for the Kwetı̨ı̨ʔaà (Rayrock) mine site regulates the possession, management, and storage (subject to the conditions of the licence) of the nuclear substances that are associated with the historic uranium mine and mill wastes. Requirements within the WNSL do not affect the AEMP, but the AEMP has been designed to respect the spirit of the WNSL.

5.4 Land Use Permit

The Rayrock LUP W2020X0005 specifies conditions for land use on the Rayrock (Kwetı̨ı̨ʔaà) Remediation Project sites. Although land use conditions do not directly impact the AEMP, the current permit Condition 26(1)(h) Wildlife and Fish Habitat summaries the principal intent of the Program:

> *51. The Permittee shall take all reasonable measures to prevent damage to wildlife and fish Habitat during this land-use operation.*

5.5 Fisheries Authorization

CIRNAC-CARD has concluded that remedial work can be completed without the need of a Fisheries Authorization from Fisheries and Oceans Canada (DFO), and DFO has accepted this assessment.

6 TRADITIONAL LAND USE

The Kwetı̨ı̨ʔaà (Rayrock) mine site is situated on Tłı̨chǫ traditional territory and while the mine is within a Federal (Crown) defined exclusion zone, it is surrounded entirely by Tłı̨chǫ Lands as part of the Tłı̨chǫ CLCA.

6.1 Historical Land Use

Historical traditional land use was described in the Conceptual Site Model (CIRNAC 2019) and provides information from "*The Trees All Changed to Wood*" (Dogrib 1996). A summary of historical land use from CIRNAC (2019) and referencing Dogrib (1996) is provided below:

Elders have described the resources at Rayrock as being accessible because they were located off the Įdaà Trail, which is the river system between Great Slave and Great Bear Lakes. There is consensus among the elders interviewed as part of Dogrib (1996) that the landscape around Rayrock used to be beautiful, and that the resources in the area were plentiful. The people would gather there several times a year. They arrived by canoe or dogsled and slept on the rock. Depending on the time of year the Dogrib would trap muskrat, beaver, lynx and fox, harvest fish, pick roots, berries and medicine plants, and hunt ducks, geese and moose. Around Rayrock, the landscape consisted of high hills which were used when hunters listened for moose.

In summary, prior to the mine development, the Rayrock area was a place where people would gather as they were sure they would find resources with which to support their families. Around Rayrock, they used the following resources: ptarmigan, duck, rabbit, muskrat, beaver, moose, lynx, spruce, birch, willow, blueberries, cranberries, roots, trout, and whitefish.

6.2 Current Land Use

The Kwetı̨ı̨ʔaà (Rayrock) mine is currently under controlled access as the site remains a waste nuclear substance storage facility. During remediation activities, access to the Rayrock main mine will be restricted due to safety concerns associated with ongoing remediation activities and heavy equipment.

6.3 Future Land Use

The Kwetı̨ı̨ʔaà (Rayrock) mine site is a waste nuclear substance storage facility and will remain a defined exclusion zone to be managed by the Government of Canada. Following the remediation of the Kwetı̨ı̨ʔaà (Rayrock) mine site, the Tłı̨chǫ people will be permitted unrestricted access to safely use the surface of the site for traditional land uses which may include but not be limited to hunting, trapping, gathering of medicinal plants, berry picking, teaching or spiritual uses.

A traditional knowledge study was conducted of the Kwetı̨ı̨ʔaà (Rayrock) mine site in 2015 (Tłı̨chǫ 2015), the elders were hesitant to provide input of future activities on the land at Kwetı̨ı̨ʔaà. It is understood that:

> "*within the traditional Tłı̨chǫ cultural framework, one should abstain from bragging or prediction of how many or what type of animal one will hunt, trap or fish. Within the traditional cultural framework, animals are understood as "gifts" provided to the harvesters from ndè and the Creator. One can/should thus not predict or brag about which animal one will be given"* (Tłı̨chǫ 2015).

One elder provided the following comment regarding future land use (Tłı̨chǫ 2015):

> *"We may go out there for [trapping] but we can't say for sure what we are going to do or what the outcome will be, nor can we say it should be like this or that. When that day comes it is possible we will do those things. Up to that point in time we can't say in advance what will happen in the future."*

7 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) has been prepared for the Kwetı̨ı̨ʔaà (Rayrock) site (CIRNAC 2019) and incorporated historical information and results of the Human Health and Ecological Risk Assessment (HHERA; CanNorth 2018). The intent of the CSM was to document the understanding of the Rayrock site and inform the remedial options. The CSM focused on the Kwetı̨ı̨ʔaà (Rayrock) mine site and all affiliated lands. Below is a site-specific CSM focused on Mill Lake and the receiving environment at Sherman Lake.

The Kwetı̨ı̨ʔaà (Rayrock) mine site is located along the southwestern shore of Mill Lake (Shìz ì tı), a water body perched along the side of the Marian River Fault (Figures 2 and 3). Mill Lake drains via Mill Creek (Shızì tì kwetıı̨ʔaà xı̨lı) and subsequently into Sherman Lake (Kwetıı̨ʔaà tì). Other proximate water bodies include Alpha, Beta, and Gamma Lakes and Lake A.

7.1 Remediation Environment – Mill Lake

Mill Lake is 3.1 ha, non-fish bearing and is surrounded on three sides by bedrock cliffs. Mill Lake collects water from drainage off the cliffs that surround the lake. Mill Lake does not appear to be fed by any up-gradient waterbody. Mill Lake drains into Sherman Lake (Kwetıı̨ı̨ʔaà tì) through Mill Creek (Shıżı̀ tì kwetıı̨ı̨ʔaà xı̨lı), an approximately 550 m long stream that drops steeply near Mill Lake and is gently graded in its lower reach near Sherman Lake.

Mill Lake is located adjacent to the mine adit and former ore storage and ore processing areas of the main mine site. Sampling in Mill Lake found up to 6,500 mg/kg of uranium in sediment samples (Arcadis 2016b) and up to 160 µg/L of uranium in water samples.

7.2 Receiving Environment – Sherman Lake Waterbody

Sherman Lake waterbody is the largest waterbody in the vicinity of the Kwetı̨ı̨ʔaà (Rayrock) mine site (CanNorth 2018) and has a volume of approximately 5,355,000 m^3. The Sherman Lake waterbody consists of three individual areas: Sherman Lake, Lake A, and Alpha Lake. Lake A is a down gradient basin of Sherman Lake and receives water from Sherman Lake through a 30 m wide channel. Alpha Lake is located at the western end of Sherman Lake. Sherman Lake and Alpha Lake were historically separated by a small man-made causeway but have over time become connected to form a larger waterbody. Sherman Lake, Lake A, and Alpha Lake are a continuous waterbody, with direct passage between them.

The aquatic environment at sampling location Sherman Lake K, the potential effluent discharge location into Sherman Lake, is characterized by shallow depths, clear water, and a high density of aquatic vegetation. The potential discharge location is in a shallow bay that is generally uniform in depth of approximately 0.5 m before dropping off to the southeast. Abundant emergent vegetation, primarily water lilies and horsetails, as well as emergent aquatic grasses, were found along the shoreline. Submerged vegetation and decayed vegetative material are apparent throughout the area. The dominant substrate in the area is clay overlain with loose organic material. The benthic invertebrate community at the potential discharge location has a high relative abundance and diversity compared to other lakes in the area. Cover consists primarily of boulders and partially submerged dead standing trees. In the deeper areas of the bay there is very little cover or aquatic vegetation to provide habitat for fish species. Fish species known to be supported in Sherman Lake include spottail shiners (*Notropis hudsonius*), ninespine sticklebacks (*Pungitius pungitius*), northern pike (*Esox Lucius*), yellow perch (*Perca flavescens*) and lake whitefish (*Coregonus clupeaformis*).

Sherman Lake is surrounded by mature stands of black spruce (*Picea mariana*) intermixed with white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), and Jack pine (*Pinus banksiana*). Shoreline habitat in the bay adjacent to site is dominated by large bedrock outcrops in the form of cliffs that are located directly to the south and east of the potential discharge location. The large bedrock cliff to the east spans over 300 m with only intermittent vegetation and large boulders. An active beaver lodge was also observed in the vicinity of the potential discharge location into Sherman Lake during 2021 and 2022.

7.3 Constituents of Potential Concern

The constituents of potential concern (COPCs) identified in the HHERA (CanNorth 2018) for the aquatic environment risk assessment were:

- **Water:** copper, fluoride, iron, lithium, and uranium
- **Sediment:** copper, nickel, uranium, and zinc, and uranium-238 and uranium-235 series radionuclides

The COPCs identified by CanNorth (2018) for the risk assessment for terrestrial ecological receptors and humans were arsenic, beryllium, boron, chromium, copper, lead, molybdenum, nickel, selenium, uranium, zinc, petroleum hydrocarbon (PHC) fractions 2 to 4 (F2-F4), and uranium-238 series radionuclides.

7.4 Potential Receptors

Potential receptors were summarized in the HHERA (CanNorth 2018). Potential receptors specific to the discharge into Sherman Lake include aquatic life (e.g., fish, benthic invertebrates) in Sherman Lake, and the terrestrial wildlife (e.g., beaver, muskrat, dabbling duck (mallard), diving duck (scaup)) and humans who drink the water of Sherman Lake and consume various fish species (CanNorth 2018).

7.5 Exposure Pathways

Exposure pathways provide a connection between the COPCs and the potential receptors. The main exposure pathways relevant to the AEMP include:

- Direct contact with COPCs in surface water and/or sediment by aquatic species (e.g., plankton, invertebrates, fish).
- Ingestion of COPCs through the consumption of surface water by mammals and birds.
- Ingestion of COPCs through the incidental consumption of sediments by mammals and birds.
- Ingestion of COPCs through the consumption of prey by mammals, birds, and some aquatic species (e.g., planktivores, piscivores).
- Ingestion of COPCs through the consumption of mammals, birds, and aquatic species by humans.

7.6 Impact Hypothesis

Water from Mill Lake will be treated to the EQCs outlined in the Water Licence and will be tested prior to discharge into Sherman Lake. Based on this, it is unlikely that the discharge of treated water from Mill Lake will have adverse impacts on Sherman Lake.

8 SUMMARY OF PREVIOUS MONITORING PROGRAMS

8.1 Historical Site Assessments and Monitoring Programs

Historical site assessments and monitoring programs have been conducted at the Kwetı̨ı̨ʔaà (Rayrock) mine site. A list of historical reports specific to environment monitoring, risk assessments, and site characterization at the main mine site is provided in Table 8-1.

Results from historical monitoring programs related to the AEMP Design Plan are provided in Appendix B (Tables B-1 to B-6) and summarized in Sections 8.2 to 8.5.

Table 8-1 Historical Site Assessment and Monitoring Program Reports

Report Name	Reference
Rayrock Northwest Territories History Uranium Tailing and Environment	Kalin, 1984
An Evaluation of Environmental Conditions Associated with the Abandoned Uranium Mines at Rayrock and Echo Bay	Hatfield Consultants Ltd. 1985
Monitoring of the Rayrock Abandoned Mine Site, Rayrock, NWT	Soniassy et al. 1986
Environmental Monitoring Program for Assessing Remediation Efforts at the Rayrock Uranium Mine	Golder 1996
Report on Review of the Short-term Monitoring Program, and Recommendations for Long-term Monitoring at the Rayrock Mine Site	Golder 1999
Short-term Environmental Monitoring Program: Rayrock Uranium Mine	Atomic Energy of Canada 2000
Report: Update on Risk Assessment of Former Rayrock Mine Site to Incorporate Fall 2000 Fish Radionuclide Data	Golder 2001a
Results of 2000 Rayrock Long-Term Monitoring Program	Golder 2001b
Rayrock Mine Long Term Monitoring Program Fall 2001 Site Inspection Integrity of Mine Openings	Knight Piésold Ltd. 2001a
Rayrock Mine Long Term Monitoring Program Fall 2001 Site Inspection Integrity of the Tailings Areas and Their Covers	Knight Piésold Ltd. 2001b
Revised Rayrock Long-Term Monitoring Program	Rescan 2002a
Results of Fall 2001 Rayrock Long-Term Monitoring Program	Rescan 2002b
Results of 2002 Rayrock Long-Term Monitoring Program	Rescan 2003
Results of Fall 2003 Rayrock Long-Term Monitoring Program	Rescan 2004
Results of Fall 2004 Rayrock Long-Term Monitoring Program	Rescan 2005
Results of Fall 2005 Rayrock Long-Term Monitoring Program	Rescan 2006a
Rayrock Transportation Route Enhanced Phase I Assessment	Rescan 2006b
Results of Fall 2006 Rayrock Long-Term Monitoring Program	Rescan 2006c
Results of Fall 2007 Rayrock Long-Term Monitoring Program	Rescan 2008
Results of Fall 2008 Rayrock Long-Term Monitoring Program	Rescan 2009
2009 Rayrock Long-Term Monitoring Program	Rescan 2010
Rayrock Supplemental Site Assessment and Monitoring Program	SENES Consultants Limited 2010
Rayrock Mine: Gap Analysis of Preliminary Quantitative Ecological Risk Assessment.	Rescan 2012a
Rayrock Mine, Rayrock Comprehensive Remediation Performance Assessment Report	Rescan 2012b
Gap Filling Program at Former Rayrock Mine Site	SENES Consultants Limited 2014
2014 Rayrock Compliance Monitoring Program Former Rayrock Mine, NT	Arcadis SENES Canada 2015
Human Health Preliminary Quantitative Risk Assessment	AMEC 2015
"Like a Sick Person Sleeping" TK Study for Aboriginal Affairs and Northern Development (AANDC) Risk Assessment of the Kwetı̨ı̨ʔaà Contaminated Mine Site	Tłı̨chǫ Government 2015

Report Name	Reference
Hydrologic Study of Beta and Gamma Lakes, Rayrock Mine, Northwest Territories	Arcadis 2016a
Rayrock Mine & Marian River Watershed Study - 2015	Fielding Environmental 2016
Phase III Environmental Site Assessment, Rayrock Mine, Northwest Territories	Arcadis 2016b
Delineation of Contamination of Mill Lake and the Associated Drainage Area Former Rayrock Mine, Northwest Territories	Arcadis 2017a
Phase I and II Environmental Site Assessments of Sherman Lake Camp and the Barge Landing and Aerial Reconnaissance of the Former Power Line	Arcadis 2017b
Hydrogeological Study, Rayrock Mine, Northwest Territories	Arcadis 2017c
Conceptual Site Model – Rayrock Uranium Mine, Sun Rose Site, Barge Landing and Associated Satellite Sites	CIRNAC 2017
Rayrock Freshet Observations and Data Collection Program	Arcadis 2017d
Data Collection Program Rayrock Remediation Project	Arcadis 2017e
Human Health and Ecological Risk Assessment for Rayrock Mine Site (Final Report)	CanNorth 2018
2017 Data Collection Program,	Arcadis 2018
Summary Report, Kwetı̨ı̨ʔaà Traditional Monitoring Program	Tłı̨chǫ Government 2018
2018 Field Program Summary	AECOM 2019
Rayrock Mine (Kwetı̨ı̨ʔaà) Remediation Project 2018/19: Multiday Elder-led Site Tour and Sampling Exercise at Rayrock Mine and Surrounding Area	Fielding Environmental 2019
Former Rayrock Mine, 2019 Field Program Summary Report	AECOM 2020a
Mill Lake Sediment Hydrogeology Report	AECOM 2020b
2019 Mill Lake Water and Sediment Depth Measurement Results	AECOM 2020c
2020 Mill Lake Sediment Hydrogeology Assessment	AECOM 2020d
Remedial Action Plan	AECOM 2020e
2020 Mill Lake Sediment Sampling	AECOM 2020f
Beta and Gamma Lake Remedial Options Review	AECOM 2021a
2020 Field Investigation Summary	AECOM 2021b
2021 Field Investigation Summary – Mill Lake Water and Sediment Thickness Measurements	AECOM 2021c
2021 Field Investigation Summary – Mill Lake Surface Water Sampling.	AECOM 2021d
July 2021 Sherman Lake Water Depth Measurements.	AECOM 2021e
2021 Rayrock Aquatic Effects Monitoring Program Report: Baseline AEMP Report	AECOM 2022a
2021 Field Investigation Summary	AECOM 2022b
Ecological Risk Assessment of Sediments in Beta and Gamma Lakes	AECOM 2022c
2022 Beta and Gamma Lake Investigation	AECOM 2022d
2022 Rayrock Aquatic Effects Monitoring Program Report: 2022 Baseline AEMP Report	AECOM 2023
2023 Rayrock Aquatic Effects Monitoring Program Report: 2023 Baseline AEMP Report	AECOM 2024

The AEMP Design Plan recognizes that historic data was collected before and after the 1996 remediation, and many previous studies were completed during different parts of the summer season, which would have a substantial effect on benthic studies. New baseline data was collected in 2021, 2022, and 2023 for the AEMP Design Plan in order to monitor and evaluate environmental quality before the remediation construction activity. All subsequent results will be primarily compared to this baseline data from 2021, 2022, and 2023; however, Sections 8.2 to 8.5 provide all historical data with the applicability of the data for future comparison to AEMP data provided for perspective.

The AEMP utilizes three different sites within Sherman Lake to look for spatial variability. The three stations in Sherman Lake are all being treated as independent locations and not replicates within Sherman Lake. Dlah Lake was added to the AEMP as a regional background lake prior to the September 2022 field program and for all future AEMP sampling events.

8.2 Aquatic Environment

Aquatic environment surveys and hydrological monitoring were conducted as part of the 2021, 2022, and 2023 baseline assessments (AECOM 2022a, AECOM 2023). Most of the hydrology data from 2021 were determined to be unrecoverable due to wildlife damage to the equipment; therefore, data collection for water levels only started in the 2022 monitoring season. Water level monitoring equipment was installed in 2022 at five hydrologic monitoring stations located at Beta Lake, Gamma Lake, Lake A, New Control Lake, and Sherman Lake. Within lake water levels were highly consistent over the 2022 and 2023 open water seasons, with a standard error of less than 0.001 m. The baseline water levels, and shoreline observations will be utilized during remediation phase to identify changes in lake levels as a result of water release of treated Mill Lake water. A summary of 2022 average hourly water levels is provided in Table 8-2.

Table 8-2 Average Hourly Water Levels at Hydrological Monitoring Stations (2022)

Location	Northing	Easting	Average Water Level +/- Standard Error (June to September)	Average Water Level (June)	Average Water Level (July)	Average Water Level (August)	Average Water Level (September)	Survey
Beta Lake	7035433	522413	181.70 +/- 0.000110	181.70	181.70	181.70	181.70	181.70
Gamma Lake	7034899	522252	185.68 +/- 0.000045	185.68	185.68	185.68	185.68	185.69
Lake A	7034996	523137	180.21 +/- 0.000202	180.21	180.21	180.21	180.21	180.21
New Control Lake	7038692	518776	204.11 +/- 0.000136	204.11	204.11	204.11	204.11	204.11
Sherman Lake	7035596	522837	180.19 +/- 0.000053	180.19	180.19	180.19	180.19	180.19

Source: 2022 AEMP Report (AECOM 2023)

Shoreline surveys were completed twice in 2021, 2022, and 2023, during freshet and late summer, at Sherman Lake, Beta Lake and Gamma Lake, and New Control Lake to collect an inventory of features for comparisons with future surveys (AECOM 2022a; AECOM 2023; AECOM 2024).

8.3 Water and Sediment Chemistry

Historical water and sediment quality results are provided in Appendix B (Tables B-2 and B-3). Water and sediments in Mill Lake, Beta Lake, Gamma Lake, Lake A, Lake B, Kwetsǫ̀tia Lake, and Sherman Lake were assessed by Rescan in 2011 (Rescan 2012a), Arcadis in 2014 (Arcadis SENES 2015), and Arcadis in 2017 (Arcadis 2018). Comparison of sediment samples to Thompson LEL guidelines has occurred in historical reports and references to Thompson LEL have been included in the discussion of historical data (Thompson et al., 2005)

Overall, the concentrations of metals in the Beta Lake and Gamma Lake water were higher than in the other AEMP waterbodies. Beta Lake and Gamma Lake exceeded CCME guidelines for aluminum, copper, iron, lead (Gamma Lake only), and selenium (Beta Lake only) during the majority or all the sampling events conducted between 2008 and 2017. Alpha Lake also exceeded CCME guidelines for copper and aluminum during the majority of sampling events but also exceeded for iron, lead and selenium between 2004 and 2006. At the Sherman Lake K and B sampling locations, Kwetsǫ̀tia Lake, and the downstream lakes (Lake A and Lake B) the concentrations of aluminum, copper (excluding Kwetsǫ̀tia Lake), iron exceeded CCME guidelines (CCME 1999a and 1999b) depending on the sampling event. Whereas the sampling location Sherman Lake L exceeded the CCME guideline (CCME 1999a and 1999b) for copper during every sampling event. The historical reference lake (New Control Lake) that represents regional background conditions did not have detectable concentrations of any metals that exceeded CCME guidelines (CCME 1999a and 1999b).

The pre-remediation baseline water quality screening conducted indicated that exceedances for several metals were detected in seven of the eleven study lakes sampled in 2021 (AECOM 2022a), in nine of the twelve study lakes sampled in 2022 (AECOM 2023), and in eleven of the twelve study lakes sampled in 2023 (AECOM 2024). Baseline sampling results were as follows:

- In 2021, screening indicated that most of the exceedances occurred in Gamma Lake (9), Beta Lake (11) Lake and Alpha Lake (5) and total metal exceedances were also detected for at least one metal in Sherman Lake B, Kwetsǫ̀tia Lake, New Control Lake and Lake A. No CCME guideline exceedances were detected in Alternate Reference Lake, Lake B, and two Sherman Lake sites (Sherman L and K) were all below CCME guidelines.

- In 2022, screening indicated that most of the exceedances occurred in Gamma Lake (14), Beta Lake (14) Lake, Kwetsǫ̀tia Lake (9) and Alpha Lake (6) and total metal exceedances were also detected for at least one metal in Lake A, Lake B, Sherman Lake B, Sherman L, Sherman Lake K. No CCME guideline exceedances were detected in the regional background lakes (Alternate Reference Lake, New Control Lake, and Dlah Lake).

- In 2023, screening indicated that most of the exceedances occurred in Beta Lake (6), Gamma Lake (4) Lake, Alpha Lake (3), Kwetsǫ̀tia (3), Lake A (3), and Sherman Lake B (3), and total metal exceedances were also detected for at least one metal in Sherman Lake L, Sherman Lake K, New Control Lake and Dlah Lake. No CCME guideline exceedances were detected in Alternate Reference Lake.

Baseline sediment quality was conducted in 2021, 2022, and 2023 (AECOM 2022a, 2023, and 2024). Sediment in 2021 was collected as a single composite sample according to the methodology in Version 1.0, whereas in 2022 and 2023 sediment was collected based on the updated methods identified in Section 10.3.4. The updated methodology aligns with the EEM guidance on replication. Elevated concentrations of COPCs have been observed during historical monitoring programs and will continue to be monitored as part of the Rayrock AEMP and post-remediation risk assessments. Historical concentrations up to 2023 for baseline water and sediment quality of the lakes are presented in Appendix B, Table B-2, and Table B-3.

Sediments in the study lakes consisted primarily of silty clay overlain by fine sediments with organics. The high organic content of the substrate would likely lead to dissolved oxygen depletion or anoxia in any areas not frozen to the bottom. Sediment concentrations in the Rayrock study lakes exceeded CCME guidelines (CCME 1999a and 1999b) and Thompson's lowest effect level (LEL; Thompson et al., 20005) for some combination of arsenic, chromium, copper, nickel, selenium, uranium, vanadium, and zinc. The highest concentrations of arsenic, chromium, copper, nickel, selenium, uranium, and vanadium were typically measured in Gamma Lake, Beta Lake, and Alpha Lake. However, many locations show no trend or no consistent change in concentrations between 2021 and 2023. The highest concentration of zinc was measured at Sherman Lake K. Radionuclide sampling was limited prior to the AEMP baseline sampling, but the general trends indicate that activities were highest in Alpha Lake and Gamma Lake. The activity of the radionuclides in the other study lakes were above their respective method detection limits and were generally consistent between study years. The exception was Lead-210 which was an order of magnitude higher in 2021 than in 2022.

8.4 Benthic Assessment

Historical benthic community and tissue data are provided in Appendix B (Tables B-4 and B-5). Historical benthic surveys have been conducted by Rescan in 2011 (Alpha Lake section, Gamma Lake and New Control Lake; Rescan 2012a) and Arcadis in 2014 (Mill Lake, Alpha Lake, and Sherman Lake; Arcadis SENES 2015), and 2017 (Lake A, Beta Lake, Gamma Lake, Kwetsǫ̀tia Lake, Mill Lake, and Sherman Lake; Arcadis 2018). Overall, benthic invertebrate densities (organisms/sample) were highest for Sherman Lake, followed by Kwetsǫ̀tia Lake and Lake A, and Beta Lake. The lowest densities occurred in Gamma Lake and Mill Lake. Species richness was highest in Sherman Lake and Lake A, followed by Kwetsòtia, Beta Lake, and Gamma Lake. Mill Lake had low species richness, densities and diversity, and these results are likely the result of historical sediment contamination. Arcadis (2018) noted that samples collected from Gamma Lake and Beta Lake show greater densities and diversity, suggesting that tailings may have been well covered/sealed and that there is less influence of metal contamination here.

Historical data for benthic invertebrate tissues metals and radionuclide concentrations is limited to 2011 (Rescan 2012a). Metal concentrations in tissue were generally higher in Gamma Lake relative to Alpha Lake and New Control Lake while radionuclide concentrations in tissue were typically greatest at Gamma Lake by one to two orders of magnitude and lowest at the reference location in New Control Lake.

Baseline AEMP benthic community data was collected in 2021 and 2022 (AECOM 2022a and 2023). In 2021, benthic community density was highest in Lake B, Kwetsǫ̀tia and at the Sherman Lake B and Sherman Lake K sites. Taxon richness was highest in Kwetsǫ̀tia, Sherman Lake B and Sherman Lake K.

Sherman Lake K also had the highest diversity index of all the sites and Kwetsǫ̀tia had the lowest diversity index. In 2022, results for benthic invertebrate density for all lakes sampled were significantly lower than what was recorded in 2021, including the regional background lakes. Benthic community density was highest in New Control Lake, Kwetsǫ̀tia, Lake B, and Gamma Lake. Taxon richness was also significantly lower across all lakes sampled in 2022. New Control Lake and Sherman Lake K had the highest diversity indices, whereas Alternate Reference Lake and Kwetsǫ̀tia had the lowest. The benthic community indices and statistical methods to be used for the AEMP are described in Section 9.9.1 and Section 10.4.6. Historical and AEMP benthic community results are presented in Appendix B, Table B-4.

In 2021 and 2022, the highest metals concentrations in benthic tissue generally occurred at Alpha Lake and Gamma Lake. The results from the regional background lakes were lower but generally within an order of magnitude of the results from the AEMP lakes. Some exceptions did occur such as the concentration of cadmium which was highest in the samples from Alternate Reference Lake, higher than the cadmium concentration from Gamma Lake and similar to the concentrations in Alpha Lake and Sherman Lake. For cobalt the highest concentrations occurred at one of the Sherman Lake sites and in Alpha Lake. The highest radionuclide concentrations also occurred in Alpha Lake and Gamma Lake which were generally an order of magnitude greater than Sherman Lake sites and the sites in the surrounding lakes. For both metals and radionuclides the baseline benthic tissue concentrations in Alpha Lake and Gamma Lake were higher than those used in the HHERA (CanNorth 2018), generally by an order of magnitude. The differences noted in these lakes can be assessed as part of future, post-remediation risk assessments.

No CCME guidelines were used to screen benthic tissue. However, for comparison purposes mercury and selenium concentrations in benthic tissues were compared to the Health Canada consumption guideline and United States Department of Environmental Protection Agency (US EPA; USEPA 2021) guidelines for fish tissue, respectively, and both were below their respective screening guidelines listed above. Tissue selenium results were also evaluated for comparison purposed to the British Columbia invertebrate tissue guideline of 4.0 mg/kg dry weight (BC MoE, 2014). The benthic tissue results were highest in Alpha Lake, Beta Lake, and Gamma Lake samples collected in 2022 and the concentrations in Alpha Lake and Beta Lake were greater than the BC MoE guideline. Overall, the significance of risk from tissue concentrations will be assessed through a post-remediation HHERA that considers the collected data

Elevated concentrations of COPCs have been observed during historical monitoring programs and will be assessed as part of future, post-remediation risk assessments. For the purposes of the AEMP Design Plan, the concentrations observed represent baseline levels for benthic tissue within the lakes. Statistical methods and the development of baseline values for the AEMP are described in Section 9.9.1. Historical and AEMP baseline benthic tissue results are summarized in Appendix B, Table B-5.

8.5 Fish Assessment

Protecting fish habitat and fish health are important goals of the Kwetı̨ı̨ɂaà (Rayrock) Remediation Project and substantial effort has been undertaken to study the local fish community. Interviews conducted with the Tłı̨chǫ Elders in 2015 by the Tłı̨chǫ Research and Training Institute (Tłı̨chǫ 2015) indicated that “One of the main cultural and economic land-use activities around Kwetı̨ı̨ɂaà (Rayrock) is fishing”. Fish have always been considered a secure and easily accessible food source with families and hunters using fishnets set in the lakes to supplement terrestrial hunting. Fish harvesting occurs in lake Kwetı̨ı̨ɂaàtì (Sherman Lake) and the numerous smaller lakes in the area. Within these lakes, harvests have consisted of primarily whitefish, but trout species, northern pike, and burbot were also harvested.

Three fish and fish habitat surveys of the lakes at Rayrock were completed in 2011, 2014, and 2017 (Rescan 2012a, Arcadis SENES 2015, Arcadis 2018). During the reported sampling programs fish were not captured or observed in Mill Lake, Beta Lake, Gamma Lake or Kwetsǫ̀tia and are considered not fish bearing. This historical information was used to justify the exclusion of these lakes from the fish assessment for the AEMP. Within Sherman Lake the most abundant species identified were northern pike while lake whitefish, and spottail shiner were also observed. In New Control Lake only northern pike has been captured; however, ninespine stickleback has been observed in the stomach contents of northern pike.

Fish tissue chemistry was investigated in 2017 only (Arcadis 2018), with limited analyses conducted due to low catch. Based on their findings the concentrations of lead-210 and radium-226 were not detected in any of the fish samples collected and copper, selenium and zinc concentrations in fish muscle tissue were elevated above background (relative to concentrations in Treasure Lake; 63° 30' 0" N, 116° 36' 5" W). A limited analysis of northern pike tissues indicated that metal concentrations in liver were generally greater than in muscle. Overall, detectable metals concentrations in northern pike muscle samples were generally greater than in lake whitefish muscle samples.

Baseline fish sampling was conducted in 2021 and 2022 (AECOM 2022a and 2023). The 2021 fish sampling was successful in capturing large-bodied fish using gill netting. The 2021 fish sampling was unsuccessful in capturing small-bodied fish using minnow traps and backpack electrofishing. There was low incidence of parasites or abnormalities during 2021 which is indicative of a healthy fish population. The total mercury concentrations in muscle tissue and liver samples from Alternate Reference Lake and Sherman Lake large-bodied fish were all below the consumption guidelines (Health Canada 2014). Selenium concentrations in fish muscle and liver tissue from Alternate Reference Lake and Sherman Lake were lower than the USEPA criteria for selenium in fish tissue (8.5 mg/kg dry weight). The average baseline fish tissue results for radionuclides for lake whitefish and walleye were below the method detection limits for their respective analyses. Statistical methods and the development baseline values for the AEMP are described in Section 9.9.1. Historical fish tissue data is provided in Appendix B (Table B-6).

The 2022 fish sampling was designed to focus on slimy sculpin and the effort was not successful in capturing sufficient numbers. Methods of capture used included baited G-minnow traps and backpack electrofisher. Non-target species were caught in Alternate Reference Lake and Sherman Lake. The visual inspection of each of the captured fish did not identify any abnormalities or parasites. The absence of abnormalities and parasites is an indicator of healthy populations.

8.6 Human Health and Ecological Risk Assessments

The HHERA (CanNorth 2018) was undertaken for the purpose of determining whether the concentrations of COPCs in various media (i.e., soil, sediment, surface water, fish, plants) may have an adverse effect on humans or animals that either use or may potentially use the Kwetįį̨ʔaà (Rayrock) mine site. The HHERA included the following steps, which are consistent with those provided by regulatory agencies such as Health Canada and the CCME:

- problem formulation and receptor characterization
- exposure assessment
- toxicity assessment
- risk characterization

Details on the assessment methods are provided in the HHERA (CanNorth 2018). Summaries of the aquatic, ecological and human health assessments are provided in the following sections.

8.6.1 Aquatic Assessment

The aquatic assessment involved the evaluation of various waterbodies at the Kwetį̨ʔaà (Rayrock) mine site. The results of the aquatic assessment demonstrate the following as outlined in CanNorth (2018):

- While elevated concentrations of selected COPCs in water and sediment are above benchmarks (CCME Guidelines; CCME 1999a and 1999b), negative impacts on the aquatic populations in Alpha and Sherman Lake, Beta Lake, Gamma Lake, Kwetsǫ̀tia, and Lake A were not indicated. Weight of evidence from benthic community assessments completed in these waterbodies indicates that the benthic communities are not significantly impaired. It is noted that Beta Lake, Gamma Lake, and Kwetsǫ̀tia do not contain fish.
- Mill Lake has high uranium concentrations in water and sediments. The benthic survey conducted in 2017 suggests that high uranium concentrations in the sediments may be affecting the benthic community.
- The assessment of radiological dose to aquatic receptors from radionuclides present in water and sediment at the Rayrock mine site indicated that calculated doses are well below the applicable reference dose benchmarks for aquatic receptors.
- Inputs from the Rayrock mine site are not impacting the Marian River.

8.6.2 Ecological Assessment

An assessment was carried out of ecological receptors present in the terrestrial environment. The receptors that were considered were avian species such as grouse and waterfowl, small mammalian species such as beaver (aquatic-based diet), muskrat (aquatic-based diet), red fox, and snowshoe hare, and larger mammals such as black bear, moose, wolf, and woodland caribou. The larger animals were evaluated on a site-wide basis, while smaller animals were assumed to be present as unique receptors at various locations. Species at risk were also considered for the assessment.

The results of the terrestrial ecological risk assessment for the Kwetį̨ʔaà (Rayrock) mine site demonstrated the following as outlined in CanNorth (2018):

- Exposure to radionuclides in the aquatic and terrestrial environment at the Kwetį̨ʔaà (Rayrock) mine site does not present a risk.
- Large terrestrial receptors and species at risk with large home ranges (i.e., short-eared owl and woodland caribou) are not at risk.
- Exposures at Alpha and Beta Lakes do not represent a risk for terrestrial receptors with an aquatic-based diet.
- Uranium concentrations in the sediments in Mill Lake are elevated and result in some exceedances of toxicity benchmarks for terrestrial receptors who consume large amounts of sediments such as beaver, muskrat, and diving ducks as well as the little brown bat.
- Uranium concentrations in the soils in Mill Creek drainage area exceed toxicity benchmarks for small terrestrial mammals; however, weight of evidence from hare and grouse collected from the site indicates that uranium is not transferring in the terrestrial environment.

- Waste rock and tailings samples at the mill workings have copper concentrations that result in toxicity benchmarks being exceeded for the hare and the rusty blackbird. These are localized "hot-spot' areas at the site; however, weight of evidence from hare and grouse collected from the site indicates that COPCs are not transferring into the terrestrial environment.

8.6.3 Human Health Assessment

A human health assessment was carried out for members of the public who would camp and hunt on the Kwetı̨ı̨ʔaà (Rayrock) mine site. Campers/hunters were assumed to be present on the site for three months of the year to hunt, trap, gather, and fish and to consume food obtained from the site for an additional three months in the community. Different life stages were evaluated ranging from a toddler to an adult. The results of the human health risk assessment for the Rayrock mine site demonstrate the following as outlined in CanNorth (2018):

- Radiological dose estimates were below the CNSC regulatory incremental dose limit of 1,000 µSv/y for members of the public.
- Exposure to non-radioactive COPCs is not predicted to result in adverse effects to individuals present at the site for 90 days per year who consume wild game and fish from the site for a total of six months.

8.6.4 Summary

Based on the results of the HHERA (CanNorth 2018), the water and sediment of Mill Lake represent a potential risk to human health and the environment. All terrestrial impacts, and residual impacts in all other lakes in the Rayrock area, are at concentrations that do not pose a risk to human health or the environment. Therefore, if the aquatic environments at Rayrock lakes are not changed by the remedial activities, the current aquatic environment in Sherman Lake, Beta Lake and Gamma Lake do not pose a risk, and will not pose a risk when remediation is complete.

8.6.5 Ecological Risk Assessment – Beta and Gamma Lakes

One concern posed by the Tłı̨chǫ Government regarding the HHERA (CanNorth 2018) was:

"we feel that the HHERA determination of 'no negative effect' on the benthic community in Gamma Lake and Beta Lake is questionable, as this determination solely relies on a benthic community comparison between the tailings impacted water bodies and New Control Lake, water bodies that differ significantly in character. Furthermore, this questionable comparison was coupled with the dismissal of the significant SEL guideline exceedances in the tailings impacted water bodies."

To address Tłı̨chǫ Government concerns, an Ecological Risk Assessment (ERA) of sediments in Beta and Gamma Lakes was conducted in 2022 (AECOM 2022c). The ERA built on the HHERA (CanNorth 2018) and incorporates additional lines of evidence generated as part of additional investigations in 2022. The objective was to arrive at a comprehensive assessment of potential risks to aquatic communities in the lakes. The ERA (AECOM 2022c) assessed sediment chemistry, benthic communities, bioavailability of metals within the sediments, and toxicity of the sediments. Radionuclides were not assessed in the ERA as the HHERA determined no potential risks from radionuclides in Beta or Gamma Lakes (CanNorth 2018).

The results of the ERA with respect to potential risk to aquatic communities in Beta and Gamma Lakes were in general agreement with the conclusions drawn in the HHERA (CanNorth 2018). Despite the observation that sediment chemistry in Beta and Gamma Lakes has been impacted by historic mining activities, the impact to benthic communities on a whole lake basis is considered to present a low risk to the identified assessment endpoint, including benthic invertebrate abundance, diversity, and ecological function. Based on the weight of evidence provided, the potential risks to aquatic communities in Beta and Gamma Lake is likely considered acceptable, with a low-to-moderate degree of uncertainty.

9 AEMP DESIGN

9.1 Objective of the AEMP Design Plan

The overall objective of the AEMP is to monitor potential impacts to aquatic environments during and following the remediation of Mill Lake. Remediation of Mill Lake will involve the removal and treatment of water from Mill Lake, consolidation of contaminated sediments into a CDF, and transfer of treated Mill Lake water into Sherman Lake. The transfer of treated water from Mill Lake to Sherman Lake may have the potential to impact the aquatic environment of Sherman Lake.

The objective of the AEMP is to monitor the Sherman Lake environment to verify that the transfer of treated water and other remediation components do not significantly change the aquatic environment of Sherman Lake.

This AEMP has been designed and will be implemented to meet the objectives outlined in Section 1.1.3 of the AEMP Guideline (MVLWB/GNWT 2019) which are to:

1. Determine the effects of a project on the aquatic receiving environment.
2. Test predictions from the regulatory process regarding the effects of a project on the receiving environment.
3. Provide data that can be used to assess cumulative effects and impact predictions.
4. Assess the effectiveness of mitigation measures and, if necessary, identify the need for additional mitigation measures to reduce or eliminate project-related effects.
5. Provide an early warning system to prevent or avoid adverse environmental impacts.

A discussion on how this AEMP Design Plan aims to meet the objectives outlined in the AEMP Guidelines (MVLWB/GNWT 2019) is provided below.

Objective 1: Determine the effects of a project on the aquatic receiving environment.

CIRNAC-CARD has determined a potential for impacts to the receiving Sherman Lake as a result of the transfer of treated water from Mill Lake. Over four years of remediation, approximately 360,000 m^3 of treated water from the Mill Lake basin will be transferred to Sherman Lake which has a volume of 5,355,000 m^3. Sherman Lake receiving environment was assessed as part of the HHERA (CanNorth 2018) and will not be re-assessed prior to the AEMP.

Objective 2: Test predictions from the regulatory process regarding the effects of a project on the receiving environment.

The AEMP will test the prediction that there will be no impact to the receiving environment of Sherman Lake.

Objective 3: Provide data that can be used to assess cumulative effects and impact predictions.

This AEMP Design Plan presents historical data collected and used to determine "baseline" current conditions as defined as conditions prior to the remediation of Mill Lake. It should be noted that "baseline" conditions are not deemed to be "clean" as the Rayrock project area has been impacted by uranium mining activities. A description of "baseline" conditions is provided in Section 8.

The AEMP will be implemented, and data collected during and following the remediation of Mill Lake will be used to determine potential impacts and if there are cumulative effects in the greater Rayrock project area. The remediation of Mill Lake is not anticipated to have cumulative effects as the remediation activities will take place over a short period of time (4 years) and the volume transfer into Sherman Lake is approximately 1.7% of the lake's current volume per year. A description of the AEMP methods is provided in Section 10.

Objective 4: Assess the effectiveness of mitigation measures and, if necessary, identify the need for additional mitigation measures to reduce or eliminate project-related effects.

The AEMP will be implemented before, during and following the remediation of Mill Lake and data collected will be used to assess the effectiveness of the water treatment system, the CDF and sampling of treated water prior to the transfer to Mill Lake. Should the data collected as part of the AEMP identify ineffectiveness or the need for additional mitigation measures, they will be implemented as appropriate. A response framework for the AEMP is provided in Section 12.

Objective 5: Provide an early warning system to prevent or avoid adverse environmental impacts.

The AEMP is designed to provide an early warning system. A response framework for the AEMP is provided in Section 12.

9.2 Overview of AEMP Design Plan

The majority of the AEMP effort derives from the remediation of Mill Lake specifically the discharge of treated water into Sherman Lake. Mill Lake will not be assessed within the AEMP as it will be under active remediation. The remaining AEMP is designed to ensure that civil works in the areas of the two TCAs does not change the aquatic environments of adjacent lakes.

Five primary components will be measured to determine if remedial activities are affecting the aquatic environment. These components are:

1) Aquatic Environment
2) Toxicity – Discharge Monitoring
3) Water and Sediment Chemistry
4) Benthic Assessment

5) Fish Assessment

9.3 Monitoring Endpoints

The Kwetįįʔaà (Rayrock) AEMP is designed to monitor components of the aquatic environment before remediation, during remediation and post-remediation. The AEMP annual results will be re-evaluated every three years and revisions will be made accordingly to the AEMP Design Plan. If no statistical differences are noted or Action Levels triggered for monitoring components, they may be altered in the sampling plan or removed. The AEMP requirements will continue to be evaluated throughout the remediation phases for the duration of the Water Licence.

The terms "assessment endpoint" and "measurement endpoint" are commonly applied in monitoring programs and provide concise statements of what environmental issues are being examined in a particular monitoring program. Assessment endpoints are valued aquatic ecosystem components that could be affected by changes in environmental conditions associated with the Rayrock site and they serve to focus monitoring activity on the key environmental values to be protected (Suter et al. 2000). As noted, this is a remediation project that has undergone environmental site assessment and risk assessments to characterize the current environmental quality and health conditions of the aquatic ecosystem. The EQCs for the remediation project were developed with the goal of preventing localized short-term changes in water quality in Sherman Lake due to the treatment and discharge of water from Mill Lake. Aquatic environmental conditions are expected to remain like the current pre-remediation condition both during and after remediation activity.

The assessment endpoints for were selected based on the following value statements intended to reflect the main purpose of the AEMP, which has been designed for a remediation project:

1) Maintain water and sediment quality in Sherman Lake at present levels reported by previous monitoring programs.

2) Preserve the ecological function of benthic communities in Sherman Lake and maintain healthy fish for consumption.

In designing AEMPs, assessment endpoints are used to select the appropriate measurement endpoints. The measurement endpoints are related to the valued environmental characteristics chosen as the assessment endpoint, but they also must represent measurable responses to the stressor(s) relevant to the study area (Suter 1990). Measurement endpoints may include measures of exposure (e.g., chemical concentrations in water, sediments, and fish tissues) and measures of effects (e.g., benthic invertebrate community structure, fish health) (CIRNAC and GNWT 2019). Measurement endpoints are assessed using appropriate field and laboratory studies.

A summary of the proposed AEMP assessment and measurement endpoints are provided in Table 9-1.

Table 9-1 Proposed Assessment and Measurement Endpoints

Assessment Endpoint	Measurement Endpoint	AEMP Component(s)
Maintain water elevations and the quality of shoreline aquatic habitats in the Sherman Lake waterbody at pre-remediation baseline conditions during the period of remediation when the Water Treatment Plant is in operation.	Water Level Shoreline Surveys	Aquatic Environment (Section 10.2)
Maintain baseline water and sediment quality in Sherman Lake waterbody (including Alpha Lake and Lake A), Beta Lake, and Gamma Lake at or close to baseline concentrations reported by previous monitoring programs.	Concentrations of metals, radionuclides, nutrients, ions, and supporting parameters in: • treated effluent • surface water • surficial sediments	Water Quality (Section 10.3) and Sediment Quality (Section 10.3)
	Acute toxicity testing of effluent	Toxicity - Effluent (Section 10.1)
Maintain a benthic invertebrate community in Sherman Lake, Beta Lake, and Gamma Lake at baseline conditions, as reported by previous monitoring programs.	Total benthic invertebrate density and diversity indices	Benthic Assessment – Invertebrate Community (Section 10.4)
	Benthic invertebrate richness	
Maintenance of baseline benthic tissue concentrations	Concentrations of metals and radionuclides in benthic invertebrate tissues	Benthic Assessment – Tissue Chemistry (Section 10.4)
Maintenance of baseline fish tissue concentrations	Concentrations of metals and radionuclides in fish tissues	Fish Assessment – Tissue Chemistry (Section 10.5)

9.4 AEMP Study Lakes

The Rayrock mine site and AEMP study area, occur in the Great Slave Upland High Boreal Ecoregion (Figure 1). The terrestrial landscapes are dominated by relatively flat bedrock outcrops with occasional hill structures. Forests occur on the upland regions but are thin and consist of Jack pine and black spruce stands, growing on rock fractures and lacustrine deposits. Soils are mostly Brunisols occurring in the rock fractures and lacustrine deposits previously said to support the regions treed environments, but the majority of the terrestrial landscape is bare rock and produces very little soil. The region has numerous lakes of large size that drain south or southwest towards Great Slave Lake. Peatlands form in the shallow depressions in rocky outcrops and on the outskirt bays of the many lakes in the region (GNWT 2008).

There are a number of impacted and regional background waterbodies included in the AEMP, with the impacted waterbodies having a somewhat convoluted connectivity and flow network (Figures 3 and 4). Mill Lake drains into Kwetsǫ̀tia and then into Sherman Lake. The flow path between Kwetsǫ̀tia and Sherman Lake is most active during periods of high water and is perennially connected to Sherman Lake.

While there is no visible connection, it is understood that Beta Lake drains into Sherman Lake through Alpha Lake, and eventually into Lake B. Gamma Lake follows a different drainage path and drains into Lake B through approximately 2 km of wetland. Gamma Lake, Beta Lake and Alpha Lake are impacted and receive overland runoff from the nearby TCAs.

Downstream of the Sherman Lake, Lake A drains into Lake B. Lake B then drains through more than 19 small ponds and lakes before entering the Marian River which eventually drains into Marian Lake. Lake B has been included as a downstream monitoring location in the baseline study. Description of each waterbody is provided below.

9.4.1 Impacted Waterbodies

Impacted waterbodies are lakes on or adjacent to the Rayrock site that have received inputs or impacts from the historical mining activity and may receive direct or indirect impacts from the remediation work, specifically the Sherman Lake waterbody (Figure 6) which includes Sherman Lake, Lake A, and Alpha Lake. Additional impacted waterbodies include Beta Lake, Gamma Lake and Kwetsǫ̀tia Lake and are described below.

Beta Lake and Gamma Lake are both historically impacted waterbodies situated near Sherman Lake. Beta Lake has an area of approximately 1,800 m^2 and a shallow depth, with the majority of the lake measuring less than 2 m. Gamma Lake has an area of approximately 18,000 m^2 and a relatively shallow depth. Gamma Lake is divided into two parts by dense floating aquatic vegetation. While there is no visible connection, it is understood that Beta Lake drains into Sherman Lake through Alpha Lake, and eventually into Lake B. Gamma Lake follows a different drainage path and drains into Lake B through approximately 2 km of wetland. Gamma Lake, Beta Lake and Alpha Lake are impacted and receive overland runoff from the nearby TCAs. The North and South TCAs (located near Beta Lake and Gamma Lake, respectively) are historic tailings areas which were capped under soil in 1996.

Kwetsǫ̀tia Lake has an area of approximately 3,600 m^2 and is densely populated with aquatic vegetation. It is located on the northern flow path between Mill Lake and Sherman Lake. This flow path is most active during periods of high water and is perennially connected to Sherman Lake. While no direct or indirect impacts on Kwetsǫ̀tia Lake from remedial works are anticipated, it receives drainage input from Mill Lake and therefore has been historically impacted.

Lake B is located south of Sherman Lake, Lake A, and Beta and Gamma Lakes. All waterbodies at Kwetıı̨ʔaà (Rayrock) drain to Lake B, which then drains approximately 7 km through more than 19 small ponds and lakes before discharging to the Marian River. Lake B receives all water and sediment flowing from the Rayrock site through both the Sherman Lake waterbody and the Gamma Lake drainage pathways (Figure 3). At the request of the Tłı̨chǫ Government this sampling location has been included in the AEMP Design Plan. Lake B is partially outside of the Rayrock Exclusion Zone (i.e. on Tłı̨chǫ Lands) and is considered a far-field sampling location that will continue to provide information on the health of the downstream aquatic environment (Figure 7). Compared to impacted lakes in the exposure area of Rayrock, metal concentrations in Lake B sediments are lower and are similar to background levels found in New Control Lake, Alternate Reference Lake, and Dlah Lake.

9.4.2 Regional Background Lakes

New Control Lake (254,000 m^2), Dlah Lake (133,000 m^2) and Alternate Reference Lake (1,282,000 m^2) act as regional background lakes with no direct flow between them, Sherman Lake, or other waterbodies within the Rayrock site. These lakes are monitored as regional background lakes for primary AEMP components throughout the remediation process.

New Control Lake is a long, narrow lake measuring approximately 1.5 km long, and approximately 230 m at its widest area. The lake is surrounded by rocky outcrops, forming a pool between cliff faces on the northeast and southwest shores. The lake contains two riparian areas, one at each end of its length. Water enters New Control Lake via overland flow, dictated by the general topography and many outcrops in the surrounding area. New Control Lake has few topographic features along its shoreline,

Alternate Reference Lake is more similar to Sherman Lake, which has more diverse shoreline environments and lake basins. It measures approximately 2.3 km in length, by 1.2 km in width at its widest point. Alternate Reference Lake is an expensive waterbody with several discrete bays, multiple large islands forming deep channels between them, and varying shoreline and aquatic topography and environment. Alternate Reference Lake has clear water with sandy, organic substrates overlying clay in shallow water environments, and primarily packed clay in deeper areas of the lake.

Dlah Lake is a small circular lake that is surrounded by mature stands of paper birch, balsam poplar, black spruce, and jack pine. Rock outcrops surround the lake further from the shoreline. A shallow riparian area with abundant standing dead trees and woody debris was present in the south end of the lake. Dlah Lake has no direct point of inflow and therefore mainly receives water from overland flow. Dlah Lake flows approximately 1.2 km southwest though small channels before reaching the Marian River, with no direct connection to any of the other lakes within the Project Area. Dlah Lake was added to the AEMP as a regional background lake prior to the September 2022 field program. Dlah Lake's habitat more closely resembles some of the smaller study lakes than the other two regional background lakes and provides additional regional background data.

9.5 Sampling Schedule

The schedule of the AEMP Design Plan is presented in Table 9-2 and a summary of the sampling design is presented in Table 9-3. The schedule and design presented are intended to cover the AEMP period during which effluent will be discharged into Sherman Lake and active remediation will be occurring, as well as for the duration of the existing Water Licence. The AEMP Design Plan will be implemented during remediation activities which will extend from 2024 to 2027. The AEMP will be implemented for 5 years following completion of remediation activities and continue from 2028 until 2032. A schedule of sampling for the AEMP is outlined in Table 9-2.

Water quality monitoring at all AEMP sampling locations will be conducted as per the frequency required by the Water Licence SNP and outlined in Table 9-2. The other components of the AEMP (i.e., aquatic environment, sediment quality, benthic invertebrate community, and benthic tissue) will be monitored at a frequency of once a year (Table 9-2),

The large-bodied fish health and tissue chemistry surveys are conducted at a frequency of once every three years to balance the lethal effects of the program against the sampling requirements. This is consistent with the federal EEM program for metal and diamond mines (EC 2012). However, if the two sampling events during the remediation period demonstrate that tissue chemistry effects are not observed (i.e., Low Action Level has not been triggered), then the need for additional fish surveys would be discussed in the AEMP Re-evaluation Report and subsequent AEMP Design Plan submissions.

Table 9-2 Aquatic Effects Monitoring Program Sampling Schedule and Reporting

Component[a]	Sampling Periods								
	During Remediation[b]				Post-Remediation[c]				
	2024	2025	2026	2027	2028	2029	2030	2031	2032
Aquatic Environment	✓	✓	✓	✓	✓				
Toxicity – Effluent (SNP 1663-7)	✓	✓	✓	✓					
Water Quality – in Sherman Lake, Beta Lake, and Gamma Lake (SNP and AEMP)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sediment Quality	✓	✓	✓	✓	✓				
Benthic Assessment – Invertebrate Community	✓	✓	✓	✓	✓				
Benthic Assessment – Tissue Chemistry	✓	✓	✓	✓	✓				
Fish Assessment – Tissue Chemistry			✓			✓			✓
AEMP Annual Report[d]	✓	✓	✓	✓	✓	✓	✓	✓	✓
AEMP Aquatic Effects Re-evaluation Report[e]				✓			✓		✓
AEMP Design Plan - Revised[f]				✓			✓		✓

a) See Table 9-3 for sampling locations and frequency descriptions.
b) The proposed schedule during remediation is contingent on the timing and completion of the construction and operation of the Mill Lake PWTP.
c) The monitoring components for the post-remediation AEMP have not been determined as the sampling plan will be dependent on results of the AEMP re-evaluation reports and submission of revised AEMP Design Plans to be approved by the WLWB.
d) As per Water Licence - Part F, Item 5
e) As per Water Licence - Part F, Item 3
f) As per Water Licence - Part F, Item 4

AEMP = Aquatic Effects Monitoring Program; SNP = Surveillance Network Program; WLWB = Wek'èezhii Land and Water Board

Table 9-3 Summary of Kwetįį̀ʔaà (Rayrock) Aquatic Effects Monitoring Program Design Plan

AEMP Component	Waterbody	Location	SNP Station #	Coordinates (NAD 83)	Frequency and Timing	Sample Quantity, Type, Depth	Analysis
Effluent Quality and Toxicity	Effluent	Discharge from Mill Lake PWTP	1663-7	TBD	1) Weekly during discharge 2) Every two weeks during discharge 3) Monthly during discharge	End of pipe - One discrete sample of treated water prior to discharge	1) Daily: Field, uranium and copper 2) Weekly: Field, MI, Nut, Sol, Std, TM, TR Monthly: Acute toxicity
Aquatic Environment – Water Level (Figure 5)	Sherman Lake	Near the outlet of Mill Creek	n/a	7035683 N 523020 E	Hourly measurements downloaded monthly	Constant reading pressure transducers.	Water level measurement
	Beta Lake	Near North TCA	n/a	7035435 N 522431 E			
	Gamma Lake	Near South TCA	n/a	7034890 N 522265 E			
	Lake A	Near the former airstrip	n/a	7034651 N 522891 E			
	New Control Lake (NCL)	Background (Reference Lake)	n/a	7038516 N 519063 E			
Aquatic Environment – Shoreline Surveys (Figure 5)	Sherman Lake Beta Lake Gamma Lake Lake A New Control Lake	Nearshore sites: - 14 locations on Sherman Lake /Alpha Lake/Lake A - 1 location on each of Beta and Gamma lakes - 3 locations on New Control Lake (Reference Lake)	n/a	See Section 10.2.3 for specific locations	Twice per year - freshet and late summer	Qualitative shoreline and nearshore habitat description with photos	Annual comparison of lake features including inlets/outlets, non-perennial features, areas of aquatic and littoral vegetation, important fish spawning areas, sensitive and unique features within the waterbodies, aquatic vegetation, and overall shoreline environment.
Water Quality (Figures 6, 7)	Sherman Lake B	Between North TCA and Mill Lake Discharge	1663-1	7035566 N 522833 E	1) Monthly during open water and general construction activities 2) Every two weeks during immediately up-stream construction activities	One discrete sample at 0.5 m	Field, MI, Nut, Sol, Std, TM, TR
	Gamma Lake	At outlet of Gamma Lake	1663-2	7034745 N 522195 E			
	Beta Lake	Near North TCA	1663-3	7035430 N 522440 E			
	Alpha Lake	Near North TCA	1663-4	7035524 N 522561 E			
	Lake A	At outlet of the Lake	1663-6	7034281 N 523544 E			
	Water Discharge	Discharge from Mill Lake water treatment	1663-7	TBD	1) Weekly during discharge 2) Every two weeks during discharge 3) Monthly during discharge	End of pipe - One discrete sample of treated water prior to discharge	1) Daily: Field, uranium and copper 2) Weekly: Field, MI, Nut, Sol. Std, TM, TR 3) Monthly: Acute toxicity
	Sherman Lake L	Adjacent to Mill Lake discharge into Sherman Lake	1663-8	7035950 N 523320 E	1) Weekly during discharge 2) Every two weeks during discharge	One discrete sample at 0.5 m	1) Daily: Field, uranium and copper 2) Every two weeks: Field, MI, Nut, Sol. Std, TM, TR
	New Control Lake	Regional Background	1663-9	7038516 N 519063 E	Monthly during open water	One discrete sample at 0.5 m	Field, MI, Nut, Sol, Std, TM TR
	Sherman Lake K	In bay near discharge and drainage of Kwetsǫ̀tia to Sherman Lake	1663-10	7036101 N 523218 E			
	Kwetsǫ̀tia	Small lake on site along drainage between Mill Lake and Sherman Lake.	n/a	7036019 N 523045 E			
	Lake B	Far-field sample location at the outlet of Lake B.	n/a	7032399 N 523038 E			

AEMP Component	Waterbody	Location	SNP Station #	Coordinates (NAD 83)	Frequency and Timing	Sample Quantity, Type, Depth	Analysis
	Alternate Reference Lake	Regional background – A large lake east of Rayrock that drains to the Emile River and provides a size and profile similar to Sherman Lake.	n/a	7036794 N 526373 E			
	Dlah Lake	Regional background - small lake	n/a	7033716 N 522362 E			
	Sherman Lake	100 m from the Process Water Treatment Plant Effluent Discharge Location into Sherman Lake (1663-7)	1663-14	7036012 N 523484 E	1) Weekly during discharge	In-situ probe measurement of surface water	Field - Turbidity, TSS
	Sherman Lake	250 m from the Process Water Treatment Plant Effluent Discharge Location into Sherman Lake (1663-7)	1663-15	7036012 N 523634 E	1) Weekly during discharge	In-situ probe measurement of surface water	Field - Turbidity, TSS
Sediment Quality (Figures 6, 7)	Kwetsǫ̀tìa	Kwetsǫ̀tìa, midway between the southern shore and the drainage point in the north	n/a	7036019 N 523045 E	Once every year during open water (late summer)	Three discrete sediment samples (within 5 m of each other).	Field, MI, Nut, Sol, Std, TM, TR PV, EN
	Alternate Reference Lake	Regional background Lake east of Rayrock that drains to the Emile River and provides a size and profile similar to Sherman Lake.	n/a	7036794 N 526373 E			
	Sherman Lake B	Between North TCA and Mill Lake Discharge	1663-1	7035566 N 522833 E			
	Gamma Lake	At outlet of Gamma Lake	1663-2	7034745 N 522195 E			
	Beta Lake	Near North TCA	1663-3	7035430 N 522440 E			
	Alpha Lake	Near North TCA	1663-4	7035524 N 522561E			
	Lake A	At outlet of the Lake	1663-6	7035295 N 523290 E			
	Sherman Lake L	Near Mill Lake discharge into Sherman Lake	1663-8	7035950 N 523320 E			
	New Control Lake	Regional background	1663-9	7038516 N 519063 E			
	Kwetsǫ̀tìa	Kwetsǫ̀tìa, midway between the southern shore and the discharge point in the north	n/a	7036019 N 523045 E			
	Lake B	Lake B at the outlet of the Lake.	n/a	7032399 N 523039 E			
	Dlah Lake	Regional background - small lake	n/a	7033716 N 522362 E			
Benthic Assessment – Community	Sherman Lake B	Between North TCA and Mill Lake discharge	1663-1	7035566 N 522833 E	Annually during open water (late summer 2023 and 2026)	3 samples were collected at each location.	Benthic community: organisms will be identified down to the taxonomic level of family Benthic tissue: metals and radionuclides
	Gamma Lake	At outlet of Gamma Lake	1663-2	7034745 N 522195 E			

AEMP Component	Waterbody	Location	SNP Station #	Coordinates (NAD 83)	Frequency and Timing	Sample Quantity, Type, Depth	Analysis
and Tissue Chemistry (Figures 6, 7)	Beta Lake	Near North TCA	1663-3	7035430 N 522440 E		Kick and sweep for tissue analysis	
	Alpha Lake	Near North TCA	1663-4	7035524 N 522561E			
	Lake A	At outlet of the Lake	1663-6	7035295 N 523290 E			
	Sherman Lake L	Near Mill Lake discharge into Sherman Lake	1663-8	7035950 N 523320 E			
	New Control Lake	Background (See Figure 5-3 for location)	1663-9	7038516 N 519063 E			
	Kwetsǫ̀tìa	Kwetsǫ̀tìa midway between the southern shore and the discharge point in the north	n/a	7036019 N 523045 E			
	Lake B	Lake B at the outlet of the lake.	n/a	7032399 N 523039 E			
	Alternate Reference Lake	Regional background - lake east of Rayrock that drains to the Emile River and provides a size and profile similar to Sherman Lake.	n/a	7036794 N 526373 E			
	Dlah Lake	Regional background - small lake	n/a	7033716 N 522362 E			
Fish – large body tissue chemistry (Figures 6, 7)	Sherman Lake Alternate Reference Lake	Approximate net locations used for 2021 baseline sampling in Sherman Lake and Alternate Reference Lake	n/a	Various – Figure 6	Every three years (late summer 2026, 2029 and 2032)	Gillnetting to a maximum of 20 adult fish of one species (target Northern Pike)	Results to be recorded: - CPUE - Length, weight, age - Condition Factor, HSI, GSI - Abnormalities - Fish tissue chemistry for muscle, liver, and bone. Results to be used in Action Levels: - Tissue concentrations for muscle and liver and bone (Metals and Radionuclides)

CPUE: Catch per unit effort
EN: Extractable nutrients – available phosphate and total nitrogen
Field: Field parameters – pH, temperature, dissolved oxygen, conductivity, specific conductivity, total dissolved solids, oxidation-reduction potential, turbidity
GSI: Gonadosomatic Index
HSI: Hepatosomatic Index
MI: Major ions – alkalinity, calcium, chloride, fluoride, hardness, magnesium, potassium, sodium, sulphate.
n/a: not applicable
Nut: Nutrients – total ammonia, total nitrate + nitrite, total phosphorus, total organic carbon
PV: Physical variables – moisture, pH, total organic carbon, particle size
Sol.: Solids – total suspended solids, total dissolved solids
Std.: Standard parameters – pH, temperature, conductivity (measured in the laboratory)
TBD: to be determined
TCA: Tailings Containment Area
TM: total metals – unfiltered analyses of aluminum, arsenic, boron, barium, cadmium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, uranium, zinc
TR: total elemental analyses for lead-210, polonium-210, radium-226, thorium-230 and uranium-238

9.6 Data Storage

The LodeStar Database (or a similar replacement system) will be used to store all AEMP results. All pre-planned sampling for laboratory analysis will have LodeStar generated Chain-of Custody numbers as sample identifiers. Chain-of Custody forms for laboratory submission will be generated for each sample, and the Chain-of-Custody numbers must be strictly followed to ensure that all laboratory analysis remains "blind" and that all samples are correctly recorded for inclusion in the database. Since fish tissue and benthic samples cannot be pre-planned, as the success of the effort will not be known, the fish sampling will be provided a separate Chain-of-Custody number series from the other samples. The same format will be used, but numbers will be allotted sequentially as the catch is recorded and sampled. The sampling information and results will then be forwarded to the database manager, after sample collection, for completion of the LodeStar Chain-of-Custody forms.

9.7 Exclusions

The AEMP Design Plan has undergone several changes as a result of baseline data collection to establish pre-remediation conditions and through input provided on the AEMP Design Plan V.1.0. Specifically, there were assessment and measurement endpoints related to fish health that were intended to be included in the final AEMP Design Plan, however due to insufficient baseline data collection, they are unable to be monitored in a meaningful way to detect potential effects from changes in the aquatic environment during the remediation phase. Other assessment and measurement endpoints were recommended for consideration in the AEMP Design Plan V 1.1. Exclusions from the AEMP Design Plan and the rationale for exclusions are outlined below:

- Plankton
- Small-bodied fish assessment
- Chronic toxicity testing

9.7.1 Plankton

9.7.1.1 Rationale for Exclusion

Due to the variable nature of phytoplankton datasets, an extensive sampling effort would be required to collect adequate baseline information over a 2–3-year period to understand the seasonal cycles and inter-annual variation and be able to meaningfully evaluate changes and detect impacts. For the proposed effluent quality discharge over a short period of time in a large waterbody like Sherman Lake, it is our position that phytoplankton and zooplankton monitoring is not achievable or warranted and will not be included in the AEMP design for the Rayrock Remediation Project. The discussion and recommendation for plankton sampling was provided in the summer of 2022 when the baseline AEMP sampling was already underway and a minimum of 2 years of baseline data is required for these types of lake-wide monitoring programs. Additional rationale related to the challenges and limitation of plankton monitoring has been provided below. It is expected that focused efforts on the water quality, sediment quality and benthic invertebrate datasets will provide a more effective means of identifying changes and potential effects in the receiving environment.

Phytoplankton and macrophytes (such as zooplankton) provide a major energy source for metazoan food webs and form the base of riverine/lacustrine ecosystem productivity. Phytoplankton and macrophyte abundance and species composition are controlled by a wide range of abiotic and biotic factors, such as water column mixing, temperature, nutrient and light availability, predator grazing, and climate change and other anthropogenic stressors (Sommer et al., 2012, Winder & Sommer 2012, Dudgeon et al. 2006, Vörösmarty et al. 2010, Reid et al. 2019), variability of which can alter the structure and magnitude of phytoplankton assemblages. This results in seasonal dynamics and interannual variation in bloom timing and magnitude (Reynolds 1989, Sterner 1989).

The Metal Mining Environmental Effects Monitoring (EEM) Technical Guidance Document (Environment Canada 2012): "Consistent patterns of tolerance or intolerance to metal pollution are found in some species, and changes in community structure may serve as an early warning of metal pollution (AETE 1997). On a long-term basis, biomass does not appear to be a useful measure of the effects of metal contamination on primary producers since long-term shifts in species composition or reduction in grazing pressure can counteract any short-term depression in algal biomass (Yan 1979). Further, biomass disperses, and density and biomass tend to be similar between impact and reference areas (AETE 1997)."

9.7.1.2 Inclusion In the Response Framework

Discussions about Version 1.1 with GNWT-ENR occurred in the AEMP Working Group in February of 2023. The rationale for not proceeding with phytoplankton sampling was discussed and the inclusion of phytoplankton and zooplankton sampling in the AEMP under the Response Framework was provided. If the high action level for water quality is triggered, the response framework includes options to collect samples to analyze chronic (sublethal endpoints) and acute toxicity using phytoplankton and zooplankton species according to Environment and Climate Change Canada standard test methods. This was retained in the framework for the updated Response Framework Version 1.2 in Section 12.

9.7.2 Small-Bodied Fish Assessment

In 2021, baseline AEMP sampling efforts were undertaken to capture both large and small-bodied fish in order to monitor fish health in species that spend their entire life cycle directly adjacent to the Rayrock site Efforts to catch small-bodied fish were made in 2022 and were not successful (Section 8.5). As a result, a meaningful baseline dataset of whole-body tissue concentrations, including bone, is not available for which comparisons can be made. Additional small-bodied fish assessments are not included as part of the AEMP; however, additional discussions could be had as to how to monitor small-bodied fish outside the AEMP.

9.7.3 Chronic Toxicity Testing

Chronic toxicity testing has not been included as a component of the AEMP Design Plan, however, it has been included as a component of the Response Framework (Section 12, Table 12-4, Table 12-5).

Discussions with GNWT-ENR occurred in the AEMP Working Group in February of 2023. The rationale for not proceeding with phytoplankton sampling was discussed and the inclusion of phytoplankton and zooplankton sampling in the AEMP under the Response Framework was provided. If the High Action Level for water quality is triggered, samples will be collected to analyse sublethal and acute toxicity using phytoplankton and zooplankton species according to Environment and Climate Change Canada standard test methods. If the High Action Level for sediment quality is triggered, samples will be collected to analyze chronic (sublethal endpoints) and acute toxicity according to Environment and Climate Change Canada standard test methods. It should be noted that GNWT-ENR was engaged in this discussion and endorsed the approach.

9.8 Quality Assurance and Quality Control

A Quality Assurance/Quality Control (QA/QC) program will be implemented for all AEMP components. For all subjective surveys, data sheets will be reviewed at the end of each day by a biologist experienced in the subject component, to ensure data records are complete and were collected properly. Field notes will be transcribed onto electronic spreadsheets and checked for potential errors. Any identified errors will be corrected immediately, with the location re-visited should measurements or estimates need to be verified. These verifications will be completed by the senior biologist who is responsible for the program.

To assess the accuracy of the metal analyses for each media, the AEMP includes the use of blind duplicates and blanks to monitor the laboratory analysis. Blind duplicates will be submitted at a rate of 10% of total samples for each component. The duplicates will consist of a second sample of the media taken as a split of the original sample or as a separate sampling at the same time and location. Relative percent differences (RPD) will be calculated for each parameter that is over five times the method detection limit (MDL); with data being flagged if the calculated RPD is over ± 20%. Blanks will also be used for water analysis, with field blanks and travel blanks being submitted alternately for each sampling. All internal laboratory QA/QC will also be reported, and QA/QC laboratory flags will be noted in reports.

The QA/QC procedures for the AEMP will apply to the following program components:

- field programs – staff training, procedures and responsibilities, standard operating procedures, technical procedures, and written specific work instructions to field crews)
- sample collection – equipment calibration and cleaning, avoidance of cross-contamination, duplicate samples, field blanks, travel blanks, and equipment blanks)
- documentation – field logs, labelling, and LodeStar or equivalent chain-of-custody forms)
- sample handling and shipping
- sample analysis – equipment calibrations and cleaning, avoidance of cross-contamination, duplicate samples, field blanks, travel blanks, equipment blanks, detection limits, analytical spikes)
- assessment of data quality and decision rules for acceptance/rejection
- data entry, manipulations, and analyses
- report preparation

Detailed QA/QC procedures will be provided for each component in Section 10.

9.9 Statistical Evaluation

There are two methods that will be employed to determine statistical significance for the Kwetı̨ı̨ʔaà (Rayrock) AEMP: Critical Effect Size (CES) and Analysis of Variance (ANOVA).

The CES will be defined, and changes will be considered significant when the CES is exceeded (EC 2012). Although the Metal and Diamond Mining Effluent Regulation defines CES as a threshold above which an effect may be indicative of a higher risk to the environment, CES for this AEMP is intended as a magnitude of change that could be considered indicative of an issue. The proposed CES for this program might indicate an issue with operations though the change in risk to the environment may remain low.

Analysis of Variance (ANOVA) will also be conducted on each media for each metal and sampling location. Additional lakes in the Rayrock area will be monitored to confirm that civil works (i.e., any activity that involves the movement of soil, sediment and/or rock) on the site do not cause impacts to nearby lakes. Remedial action at Rayrock has been designed to not have an effect on the water quality and aquatic habitat of on-site lakes; the AEMP is designed to show the remedial design was successful and that impacts to the aquatic environment did not occur.

9.9.1 Critical Effect Size

Engagement on AEMP Design Plan Version 1.1 took place in February 2023, where draft Action Level tables using the average baseline values and proposed CES thresholds were shared with the Tłı̨chǫ Government and other working group members. The agreed approach for Version 1.1 was to use the 95th percentile of the baseline data as the threshold for an action level. For AEMP locations that do not have sufficient sample numbers to calculate a mean, SD, and 95th percentile, the maximum value will be used until re-evaluation of mean values can be undertaken. Action Level screening was updated in January 2025, following additional engagement with the WLWB, to incorporate significance thresholds for water quality and refine water quality parameters based on a COPC screening for the Rayrock Mine site (Section 12).

The primary method of analyzing the sediment, benthic community and benthic tissue data within the AEMP's Response Framework (Section 12) is to identify a statistically significant change by considering CES (EC 2012). Differences are considered significant when the CES is exceeded (±10%; EC 2012) and they are linked to remedial activity on site. Differences over time (or compared to baseline conditions) are considered significant when the CES is exceeded and they are linked to remedial activity on site. The CES for each monitored component in Version 1.1 is provided in Section 10 and a description of statistically significant changes are outlined below:

- **Water and Sediment Chemistry:** Updates to the water quality thresholds based on CCME guidelines and Site Specific Significance Thresholds occurred for Version 1.2 (See Section 12.3.3.3). A statistically significant change in sediment concentrations is defined as an increase of more than 10% from the average baseline value (Table B-2 and Table B-3, respectively).
- **Benthic Invertebrate Endpoints:** an exceedance of ±1 standard deviations from pre-remediation baseline conditions (2021 and 2022) will be considered a significant result (Table B-4).
- **Benthic and Fish Tissue:** the statistical significance level that would identify a potential effect or change in fish and benthic health is set as an increase in any metal or radionuclide concentration in the fish tissues or benthic invertebrate tissue of greater than 10% from the average or maximum (n=<3) pre-remediation benthic invertebrate (2021 and 2022) and the 95th percentile of the pre-remediation large-bodied fish (2021 and 2023) baseline conditions (Table B-5 and Table B-6, respectively). Comparable size and weight would be included in the evaluation of fish tissue concentrations.

For sediment and tissue concentrations a change of greater than 10% from average or maximum (n<3) baseline in an undesirable direction in any monitoring event will be flagged for attention on future sampling events, to evaluate trends and linkages to remediation activity on site, as outlined in the Response Framework (Section 12). Additional measurements (minimum of three) of greater than 10% from the mean baseline value in an undesirable direction will trigger further investigation into the cause of the change, including but not limited to step-out sampling, and increased sampling frequency (Section 12).

The primary method of analyzing the biological data for statistically significant change is considering CES. For the benthic invertebrate community endpoints, an exceedance of ±1 standard deviations from pre-remediation baseline conditions will be considered a significant result (EC 2012).

9.9.2 Analysis of Variance

To evaluate statistical differences over time, differences compared to baseline conditions and differences between reference and exposure areas, an ANOVA will also be used for water and sediment quality parameters, benthic invertebrate community endpoints, benthic invertebrate tissue analysis and fish measurements (i.e., length, weight, age, tissue analysis). Alpha (α) levels will be set at 0.05 for tests comparing water and sediment quality parameters and 0.10 for the remainder of the biological endpoints and measurements. Measured effects will then be evaluated and compared again using the CES to determine if the magnitude of difference is biologically significant.

Sample sizes will need to be sufficient per sampling station for statistical tests to be run. To compare sediment quality and benthic invertebrate community indices, three discrete replicates per station will be collected. For fish tissue, approximately 20 mature fish per lake is recommended.

9.10 Regional Background Lakes

Three background lakes have been included in the AEMP Design Plan to monitor trends overtime in these regional waterbodies (Figure 4 and Figure 7). The information will provide additional background values and ranges for water, sediment, benthic community and tissue, and fish tissue monitoring components:

- Aquatic Environment – New Control Lake.
- Water and Sediment Chemistry – New Control Lake, Alternate Reference Lake, Dlah Lake.
- Benthic Invertebrate Assessment – New Control Lake, Alternate Reference Lake, Dlah Lake.
- Fish Assessment – Alternate Reference Lake.

These background lakes will not be used for comparison purposes with impacted lakes but rather as an example of natural, regional conditions.

10 DESCRIPTION OF MONITORING COMPONENTS

10.1 Effluent – Toxicity

10.1.1 Objective and Scope

Treated water from Mill Lake is discharged to Sherman Lake in the area near SNP station 1663-8 Sherman Lake L. This SNP location represents the primary indicator of effects of Mill Lake treated water discharge on the water and sediment chemistry of the Sherman Lake waterbody. The objective of the discharge monitoring is to ensure that the treated water from Mill Lake into Sherman Lake meets the EQCs as outlined in the Water Licence and therefore does not impact the water and sediment chemistry in Sherman Lake.

Discharge monitoring will be conducted during remediation at SNP 1663-7 and 1663-8 – Sherman Lake L. SNP 1663-7 will be established as part of the discharge piping system of the Mill Lake PWTP, before the water enters Sherman Lake. There is no sediment component to this monitoring location. The daily water quality analyses will be confirmed with weekly submissions to an accredited laboratory for the full analytical parameter suite.

SNP 1663-8 is the primary location where effects from the discharge of treated water from Mill Lake would be observed if the discharge is creating a change in the water chemistry.

10.1.2 Sampling Locations

Discharge monitoring will be conducted during remediation at SNP 1663-7 and 1663-8 – Sherman Lake L as shown on Figure 6 and outlined in Table 10-4.

10.1.3 Sampling Methods

Timing

Timing of sampling at 1663-7 and 1663-8 will be as follows:

- **1663-7:** Sampling for in-house analysis will occur daily to confirm that the discharge is at or below EQCs for the principal COPCs (i.e., copper and uranium) in the water. Since this monitoring station will be part of the discharge system, it can only be active during periods of water treatment of Mill Lake water.

- **1663-8:** Water sampling will occur weekly at this location during periods of treated water discharge, to be analyzed in-house in conjunction with the 1663-7 sample for principal COPCs in the water. Sampling for the full laboratory suite will be completed monthly during open water in periods when treated water from Mill Lake is not being discharged. Although the Water Licence does not require laboratory submissions every two weeks during periods of discharge, sampling will take place every two weeks in the same frequency as other SNP stations.

Methods

Water samples will be collected as outlined in Section 10.3.3 – Sampling Methods Water and results will be compared to the EQC in the Water Licence and outlined in Table 10-1.

Table 10-1 Effluent Quality Criteria for SNP Station 1663-7 from Type A Water Licence W2020L8-0003

Parameter	Effluent Quality Criteria Maximum Grab Concentration
	µg/L
Ammonia (total)	499
Fluoride	120
Nitrate (NO_3)	13,000
Nitrite (NO_2)	197
Copper (total)	2.8
Iron (total)	300
Nickel (total)	25
Uranium (total)	15
Zinc (total)	23
	mg/L
Total Suspended Solids	25
Total Petroleum Hydrocarbons	5

Source: Type A Water Licence W20-20L8-0003

10.1.4 Laboratory Analyses

During discharge, the following parameters will be analyzed daily for water samples collected from SNP 1663-7 and SNP 1663-8 using on-site equipment:

- **In situ Ecological:** field multi-probe tests for temperature, conductivity, pH, redox potential, total dissolved solids (TDS), turbidity and dissolved oxygen; and
- **Metals (Analyzed on-site):** copper and uranium, cross-referenced through the program to the weekly/monthly results for precision; and

During discharge, water samples will be collected weekly from SNP 1663-7 and biweekly from SNP 1663-8 and analyzed for the following:

- **Major Ions** are alkalinity, calcium (Ca), chloride (Cl), fluoride (F-), hardness, magnesium (Mg), potassium (K), sodium (Na), and sulphate (SO_4);
- **Nutrients** are total ammonia (NH_3+NH_4+-N), total nitrate + nitrite (NO_3^- + NO_2^-), total phosphorous, and total organic carbon (TOC);
- **Solids** are total suspended solids (TSS) and TDS;
- **Standard** parameters are pH, temperature, and conductivity measured in the laboratory;

- **Total Metals** must include unfiltered analysis of aluminum, arsenic, boron, barium, cadmium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, uranium and zinc; and
- **Total Radionuclides** are total elemental analysis that must include, at a minimum, lead-210, polonium-210, radium-226, thorium-230, and uranium-238.

During discharge, water samples will be collected monthly from SNP 1663-7 to be analyzed for the following:

- **Acute toxicity analysis (multi-concentration; assessed off-site by accredited lab):** Rainbow Trout and Daphnia magna toxicity tests; as described in Reference Method *EPS 1/RM/13 – Biological Test Method: Acute Lethality of Effluents to Rainbow Trout* (Government of Canada 2000a) and *EPS 1/RM/14 – Biological Test Method: Acute Lethality of Effluents to Daphnia magna* (Government of Canada 2000b).

10.1.5 Data Analysis and QA/QC

Data QA/QC will be consistent with the general AEMP QA/QC approach outlined in Section 9.8.

10.1.6 Statistical Analyses

Statistical analyses for effluent toxicity to Rainbow Trout and Daphnia magna will be undertaken by an accredited lab in accordance with the referenced test methods identified in Section 10.1.4 above.

Sampling for all parameters specified in the Water Licence SNP for SNP 1663-7 and 1663-8 will take place and action levels for both SNP 1663-7 and SNP 1663-8 are included in the Response Framework. Results of all water quality parameters analyzed at SNP 1663-7 will be screened for compliance with the EQCs and the Mill Lake PWTP discharge performance criteria. Results of water quality parameters at SNP 1663-8 will be analyzed for comparison to CES as described in Section 9.9.1.

Results for all parameters, down to the reportable detection limit (RDL) specified by the lab, will be analyzed for comparison to established baseline and CES levels. If action levels are triggered, the parameter(s) will then move forward for additional evaluation and consideration through the response framework. The RDL is the lowest analyte concentration that can be reported with confidence for a specific method. (i.e., within specified limits of precision and accuracy during routine laboratory operations). The RDL is generally 5 to 10 times the MDL or equal to the lowest standard of the calibration curve. The MDL is the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. In other words, if a substance is detected at or above the DL, it can be reliably stated (with 99% confidence) that the analyte is present (there is a 1% chance that the analyte is not present (a false positive)).

The MDLs and concentrations for specific parameters that are reported below the RDLs (established by the lab) can be provided on a case-by-case basis as requested but will not be included in the evaluation of action levels as part of the Response Framework.

10.2 Aquatic Environment

10.2.1 Objectives and Scope

The objective of the aquatic environment surveys is to monitor for impacts to the hydrology and shorelines of lakes during remediation. Water level monitoring will detect changes in water elevation due to the addition of treated Mill Lake water. Shoreline surveys will be conducted to ensure there are no unexpected changes to the shoreline environment.

10.2.2 Sampling Locations

The aquatic environment surveys conducted under the AEMP will encompass the hydrological monitoring and shoreline surveys of:

- Sherman Lake
- Lake A
- Beta Lake
- Gamma Lake
- New Control Lake

The aquatic habitat of the Sherman Lake waterbody is variable through the large area of the waterbody. Beta and Gamma Lakes are small, with a relatively consistent habitat presented throughout the lakes.

Changes in the water levels of a waterbody are a normal part of the seasonal variation, but consistently elevated water levels can affect the aquatic habitat. Historically, the aquatic habitat of the Sherman Lake waterbody is variable through the large area of the waterbody. Beta and Gamma Lakes are small, with a relatively consistent habitat presented throughout the lakes.

In order to track the water levels in the target waterbodies, hydrological monitoring stations have been established on Sherman Lake, Lake A, Beta Lake and Gamma Lake. A hydrological monitoring station has also been established at New Control Lake (reference lake) to document the variability due to regional seasonal changes in water levels. Water levels will be plotted to show the change in elevation over time for each monitored waterbody.

Water Survey of Canada (WSC) monitoring stations with hydrometric data are located in the region, with the closest active WSC stations being 07TA001 LaMatre River Hydro Station (approximately 45 km southwest of Rayrock) and 07SA002 Snare River Hydro Station (approximately 80 km northwest of Rayrock). The WSC stations may be used to evaluate regional water level trends. These trends may also be used to compare to the local lake levels and variations measured in the water bodies at the Rayrock site.

10.2.3 Sampling Methods

Timing

Water level monitoring will be conducted throughout the year using established monitoring stations. The shoreline inventory will be completed in spring and late summer at approximately the same time of year for each survey.

Water Level Surveys

Water level monitoring station co-ordinates and water elevations were established at Sherman Lake, Beta Lake, Gamma Lake, Lake A, and New Control Lake (Table 10-2 and Table 10-3). Data from these locations was collected from June to September during 2022 and 2023. Each station will consist of two Instrumentation Northwest Aquistar PT2X Smart Sensor pressure transducers programmed to record water level every hour.

Leveling surveys were typically conducted annually during each data download using an engineer's level and stadia rod, which is accurate at measuring elevation differences (+/- 1 mm). Detailed location and benchmark information for PT2X water level monitoring stations are outlined in Table 10-2 and Table 10-3.

Table 10-2 Water Level Station Locations (2020)

Hydrology Station Location	Northing	Easting	2020 Water Elevation (m asl)	Benchmark Elevation (m asl)
Sherman Lake B	7035596 N	522837 E	180.14	180.52
Beta Lake	7035420 N	522419 E	181.75	183.06
Gamma Lake	7034899 N	522252 E	185.61	186.46
Lake A	7034929 N	523139 E	180.14	180.52
New Control Lake	7038516 N	519063 E	Not Surveyed	Not Surveyed

Source: 2021 AEMP Report (AECOM 2022a)
m asl: metres above sea level – Zone 11 V

Table 10-3 Average Hourly Water Levels (m asl) at Hydrologic Monitoring Stations (2022).

Location	Northing	Easting	Average Water Level +/- Standard Error (June to September)	Survey Benchmark
Beta Lake	7035433	522413	181.6998 +/- 0.000110	181.70300
Gamma Lake	7034899	522252	185.6828 +/- 0.000045	185.68900
Lake A	7034996	523137	180.2101 +/- 0.000202	180.21000
New Control Lake	7038692	518776	204.1130 +/- 0.000136	204.11300
Sherman Lake	7035596	522837	180.1930 +/- 0.000053	180.19300

Source: 2022 AEMP Report (AECOM 2023)
m asl: metres above sea level – Zone 11 V

Pressure Transducer Data Collection

Two pressure transducers are used at every station so that there is a second set of measurements to use as a backup in case one of the transducers fails. The transducer deployment described here assumes deployment of two PT2X units; if a different model of transducer is used, deployment will follow manufacturer's recommendations for installation. The PT2X pressure transducers are equipped with vented cables that allow the sensors to directly report the depth of the column of water immediately above the transducer, without the need for correction to compensate for changes in barometric pressure. There is an integrated data logger in each transducer, which is powered by two internal AA batteries. The transducers are placed in the lakes at sufficient depth such that they should remain immersed at all anticipated water levels and should not freeze during the winter. Given the lack of strong currents in the monitored lakes, the transducers can be placed on the lakebed without a permanent anchor. The vented cables are routed to a weather-proof enclosure on the lake shore, with the enclosure anchored to the surrounding ground. The ends of each of the two cables are secured inside the enclosure, and both are attached to a single external 12V battery for additional power supply. Additionally, the ends of the vent tubes are attached to a length of tubing containing indicating desiccant and a hydrophobic filter which prevent moisture in the air from entering the vent tube and potentially causing damage to the sensor.

Data from the PT2X pressure transducers is downloaded using a cable connected to a field laptop running the Aqua4Plus software. Data can be downloaded and immediately checked for quality by inspecting the data tables and graphing the period of record. Live readings from the pressure transducer can also be taken, along with readouts of date and time, available storage space and internal battery level. External 12 V and 2.2 Amp-hours batteries are used to allow continued use of the sensor so that the sensor does not need to be removed from the lake to change the internal AA batteries.

The PT2X pressure transducers also take measurements of water temperature. While these data are not directly relevant to hydrology measurement, the readings are useful for identifying periods of time when the transducers may have been frozen.

In order to translate the data from the PT2X pressure transducer to accurate water level elevations, leveling surveys will be conducted at each monitoring station. The leveling surveys allow water levels to be correlated to established benchmarks with a known elevation in metres above sea level (m asl). This information can then be used to compare water level elevations between lakes. Additionally, the surveyed water levels can be used as a check to depth measurements obtained from the pressure transducer. If the results differ, the pressure transducer may have moved, or the instrument readings may have drifted over time. In this manner, the leveling survey and data interpretation acts as a quality check of the gathered data.

A levelling survey requires one or more benchmarks to be established within the line-of-sight of the hydrology station. The benchmark would be established as a permanent station of known and precise co-ordinates and elevation. The benchmarks used at remote stations typically consist of anchors, such as short lengths of rebar or rock bolts, permanently attached to bedrock or large boulders that are not subject to seasonal displacement. Benchmarks will be installed, in bedrock outcrops and/or large boulders, near each hydrology station location. The coordinates and elevation of these benchmarks will be established by differential Global Positioning System survey so that distant stations could be referenced to each other.

Leveling surveys are typically conducted during each data download using an engineer's level and stadia rod, which is accurate at measuring elevation differences (+/- 1 mm). Typical hydrometric standards recommend that three independent benchmarks be used for control surveys of hydrometric stations because that makes it possible to determine whether any of the benchmarks have moved relative to each other before using them to calculate the water level elevation. During each survey, a full loop of all known benchmarks will be completed with multiple measurements of water level, closing the loop on the original benchmark to make sure that the instrument had not moved during the survey (within a tolerance of +/-2 mm). The instrument would then be then moved and a second loop, including water levels, would be completed using a different benchmark as a reference. This provides an independent check on the benchmark elevations and a number of water level elevations which can then be averaged. The surveyed lake water levels can vary due to wind and wave conditions, with an allowable range of +/-4 mm during each survey loop. Average water levels will be accepted if they are within +/-2 mm between the two survey loops.

Using the lake water level data from the PT2X pressure transducers, the fluctuation in the water level of the target lakes can be measured throughout the year. This will also permit tracking of water levels during Mill Lake water discharge to the Sherman Lake waterbody. Monitoring of the water levels will permit action levels to be established for Sherman Lake. It is currently anticipated that action will be required should water levels in the Sherman Lake waterbody rise above the freshet water levels. If action levels are exceeded, water levels will be downloaded weekly, during the period of high water.

Shoreline Surveys

Shoreline surveys of Sherman Lake waterbody (Sherman Lake and Lake A), Gamma Lake and New Control Lake will be completed by boat, and Beta Lake will be completed by foot. Survey locations are provided in Table 10-4.

Table 10-4 Shoreline Survey Locations

Shoreline Survey Location	Zone	Northing	Easting	Datum
NCLAS-01	11 V	7038864.98	518435.97	NAD 83
NCLAS-02	11 V	7038516.01	519063.01	NAD 83
NCLAS-03	11 V	7038188.65	519610.12	NAD 83
Beta Lake	11 V	7035430	522440	NAD 83
Gamma Lake	11 V	7034745	522195	NAD 83
SLAS-01	11 V	7035755	523295	NAD 83
SLAS-02	11 V	7036076	523240	NAD 83
SLAS-03	11 V	7036113	523594	NAD 83
SLAS-04	11 V	7036366	523927	NAD 83
SLAS-05	11 V	7036597	523974	NAD 83
SLAS-06	11 V	7036983	524595	NAD 83
SLAS-07	11 V	7036675	524571	NAD 83
SLAS-08	11 V	7036045	524001	NAD 83
SLAS-09	11 V	7034514	523470	NAD 83
SLAS-10	11 V	7035232	523138	NAD 83
SLAS-11	11 V	7035375	522897	NAD 83
SLAS-12	11 V	7035499	522690	NAD 83
SLAS-13	11 V	7035581	522896	NAD 83
SLAS-14	11 V	7036604	524377	NAD 83

Source: 2022 AEMP Report (AECOM 2023)

Shoreline surveys attempted to identify the following:

- Inlets and outlets,

- Non-perennial features,
- Areas of aquatic and littoral vegetation,
- Important fish spawning areas,
- Sensitive and unique features within the waterbodies as it pertains to the fish community,
- Aquatic vegetation, and
- The overall shoreline environment.

During the 2022 baseline survey, the presence of littoral vegetation was noted, and subsequent surveys will make note of any obvious changes. Photos will be taken for each survey location, with the angle of the photo replicated for each feature. Qualitative descriptions of the survey locations and any features of interest will be noted so that any potential changes in the aquatic environment can be documented during subsequent AEMP monitoring programs and compared to pre-remediation conditions. Shoreline survey results and site photos from 2021 and 2022 are included in the annual AEMP reports.

10.2.4 Laboratory Analyses

Laboratory analyses are not required.

10.2.5 Data Analysis and QA/QC

Data QA/QC will be consistent with the general AEMP QA/QC approach outlined in Section 9.8.

10.2.6 Statistical Analyses

No statistical analyses will be conducted on water level or shoreline survey data.

10.3 Water and Sediment Chemistry

10.3.1 Objectives and Scope

The objective of the water and sediment sampling component of the AEMP is to monitor for potential changes in surface water and sediment chemistry as a result of remedial activities and to show that there is no change to the water and sediment chemistry during or after the remediation program.

10.3.2 Sampling Locations

Water and sediment will be collected from the sampling locations outlined in Table 10-5 and shown on Figures 6 and 7.

Table 10-5 Water, Sediment and Benthic Invertebrate Sampling Locations

AEMP Sampling Locations	SNP #	Rationale	Zone	Northing	Easting	Datum
Sherman Lake B	1663-1	Represents a point part way between work being performed at the North TCA and the location of water discharge from the Mill Lake PWTP, allowing trend analysis of effects from either 1663-4 or 1663-8.	11 V	7035596	522837	NAD 83
Sherman Lake L	1663-8	To test the water quality of Sherman Lake near the location of the Mill Lake water discharge to Sherman Lake.	11 V	7035950	523320	NAD 83
Sherman Lake K	1663-10	To test the water quality of Sherman Lake near the location of the Mill Lake water discharge to Sherman Lake and at the principal benthic sampling area.	11 V	7036101	523217	NAD 83
Alpha Lake	1663-4	Tests for the effects of run off from North Tailings cap repair.	11 V	7035524	522561	NAD 83
Beta Lake	1663-3	Tests for the effects of run off from North Tailings cap repair.	11 V	7035430	522440	NAD 83
Gamma Lake	1663-2	Tests for the effects of run off from the South Tailings Containment Area (TCA) cap repair.	11 V	7034745	522195	NAD 83
Lake A	1663-6	To test water quality leaving the Sherman Lake waterbody	11 V	7034281	523544	NAD 83
Kwetsǫ̀tia Lake	n/a	To test water quality for trends at the Rayrock site.	11 V	7036019	523044	NAD 83
New Control Lake	1663-9	To test the background water quality for regional trends.	11 V	7038516	519063	NAD 83
Alternate Reference Lake	n/a	To test the background water quality for regional trends.	11 V	7036794	526373	NAD 83
Lake B	n/a	To test water quality downstream of Rayrock (far-field).	11 V	7032399	523038	NAD 83
Dlah Lake	n/a	To test the background water quality for regional trends.	11 V	7033716	522362	NAD 83

Source: Adapted from 2022 AEMP Report (AECOM 2023)

10.3.3 Sampling Methods – Water

Timing

Waterbodies will be sampled monthly during open water and using an accelerated sampling schedule during remediation. During remediation, sampling at SNP 1663-7 – Mill Lake Water Discharge will occur daily and sampling at SNP 1663-8 – Sherman Lake L will occur weekly.

Methods

Surface water chemistry will be measured by collecting water quality samples from approximately 0.1-0.2 m below the water surface and without disturbing the bottom sediment, at twelve monitoring stations including Sherman Lake (three sites), Alpha Lake, Beta Lake, Gamma Lake, Lake A, Lake B, Kwetsǫ̀tia Lake, New Control Lake, Alternate Reference Lake, and Dlah Lake.

In-situ surface water quality parameters will be collected by hand using a YSI 599 unit. Sample bottles that do not require preservation are triple-rinsed with ambient water prior to sample collection to avoid cross-contamination. Collected samples are filtered and preserved, as required, and placed into coolers to be kept cool (<5 ºC) until they are shipped to the analytical laboratory. Replicate samples will be obtained from random locations at a rate of 1 duplicate per event. Replicates may be obtained as a split sample of a single water sampling or by replicate retrievals.

Water samples will be shipped to an accredited laboratory for analyses. Field parameters will be measured including:

- pH
- temperature
- dissolved oxygen (% and mg/L)
- conductivity and specific conductivity (µS/cm)
- TDS (mg/L)
- Oxidation-Reduction Potential (ORP; mV)
- turbidity (NTU).

During remediation additional water samples will be collected at SNP 1663-7 – Mill Lake Water Discharge and at SNP 1663-8 – Sherman Lake L and analyzed onsite.

10.3.4 <u>Sampling Methods – Sediments</u>

Timing

Sediments will be sampled annually in late summer during open water.

Methods

Sediment sampling will be completed at the same location as the water sampling, after collection of the water sample and field measurements. At each location three discrete sediment samples (within 5 m of each other) will be collected using an Ekman sediment grab sampler at an approximate depth of 10 cm (minimum penetration depth into the sediment was between 6 cm and 8 cm) to ensure minimum disturbance of the upper layer during sampling. Sampling efforts should ensure minimum disturbance of the upper sediment layer during sampling. Each discrete sample will be placed in prepared and labelled containers, in quantities as defined by the laboratory for the analyses being performed. Collected samples are placed into coolers to be kept cool (<5 ºC) until they are shipped to the laboratory by aircraft. Replicate samples will be obtained from random locations at a rate of 1 duplicate per event, as a split sample of the original.

Analytical methods will be consistent with those historically used. Total metals in sediments will be analyzed with EPA Method 6020b (SW-846) – Inductively Coupled Plasma – Mass Spectrometry (EPA 2014).

Both water and sediment quality results will be compared to the mean concentrations and CES from the pre-remediation baseline conditions as described in Section 10.3.7.

10.3.5 Laboratory Analyses

The following laboratory parameter suites will be measured for water samples:

- **Major Ions** are alkalinity, calcium (Ca), chloride (Cl), hardness, magnesium (Mg), potassium (K), sodium (Na), fluoride (F) and sulphate (SO_4);
- **Nutrients** are total ammonia (NH_3+NH_4+-N), total nitrate + nitrite (NO_3^-+ NO_2^-), total phosphorous, dissolved organic carbon (DOC), and total organic carbon (TOC);
- **Solids** are total suspended solids (TSS) and TDS;
- **Standard** parameters are pH, temperature, and conductivity measured in the laboratory;
- **Total Metals** must include unfiltered analysis of aluminum, arsenic, boron, barium, cadmium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, uranium and zinc
- **Total Radionuclides** are total elemental analysis that must include, at a minimum, lead-210, polonium-210, radium-226, thorium-230, and uranium-238.

The following parameter suites will be measured in all sediment samples:

- **Physical Variables** are moisture, pH, TOC and particle size;
- **Extractable Nutrients** are available total phosphate and total nitrogen;
- **Total Metals** must include, at a minimum, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, uranium, vanadium and zinc; and
- **Radionuclides** are elemental analysis that must include, at a minimum, lead-210, polonium-210, radium-226, thorium-230, and uranium-238.

10.3.6 Data Analysis and QA/QC

Data QA/QC will be consistent with the general AEMP QA/QC approach outlined in Section 9.8.

10.3.7 Statistical Analyses

The primary method of analysing the water quality data for significant change is based on significance thresholds as described in Section 12.2. The primary method of analysing the sediment quality data for statistically significant change is considering Critical Effect Size (CES). Differences over the remediation period will be compared to baseline conditions and are considered significant when the CES is exceeded. A statistically significant change in sediment concentrations is defined as an increase of more than 40% from baseline. An exceedance of 40% from baseline will trigger the response framework (Section 12).

To evaluate statistical differences over time and differences compared to baseline conditions an Analysis of Variance (ANOVA) will also be used for sediment quality parameters. Alpha (α) levels will be set at

0.05 for tests comparing sediment quality parameters. Measured effects will then be evaluated and compared again using the CES to determine if the magnitude of difference is significant.

New Control Lake (SNP 1663-9), Alternate Reference Lake, and Dlah Lake will be monitored as regional background locations. These waterbodies are sufficiently distant from Rayrock that remedial activity will not affect their aquatic environments. If concentration increases are observed in Rayrock lakes and at the background locations, then the change is interpreted to be regional and not attributable to remedial activities. This regional increase will be considered during the assessment of results from Rayrock lakes, and Action Levels may be adjusted to compensate for the regional increase, where appropriate.

10.4 Benthic Assessment

10.4.1 Objectives and Scope

An indicator of habitat degradation due to contaminant impacts on an aquatic environment, is a change in the benthic community. The objective of the benthic community sampling is to determine if there are any changes or structural differences (total invertebrate density, number of taxa, shifts in the relative abundance of taxa, analyte concentrations in tissue) in invertebrate communities over the duration of remedial activities, and to show that remedial activities will not degrade the lake habitat in waterbodies within and adjacent to the Rayrock mine site.

To monitor the benthic community structure during all phases of remediation, benthic community data is collected pre-remediation (2021 and 2022), during remediation (2023 to 2026), and post-remediation (2027 to 2030) by sampling sufficient quantities of sediment for benthic community identification, and tissue analysis. Samples will be collected from Sherman Lake, Alpha Lake, Beta Lake, Gamma Lake, Lake A, Lake B, Kwetsǫ̀tia Lake, New Control Lake, Alternate Reference Lake, and Dlah Lake.

Benthic organisms will be identified down to the family level and each lake will be compared to baseline values during remediation phases. Collection of benthic organisms from background lakes will be used to monitor background conditions, assist in evaluating conditions in regional lakes and identify any trends over time.

10.4.2 Sampling Locations

Benthic invertebrate sampling locations will be consistent with the water and sediment sampling location outlined in Section 10.3.2, Table 10-4 and shown on Figures 6 and 7. The three stations in Sherman Lake are all being treated as independent locations and not replicates within Sherman Lake.

10.4.3 Sampling Methods

Timing

Benthic invertebrate samples will be collected in late summer (September) at the same locations and at similar depths each sampling year.

Methods

Benthic Community

Benthic invertebrate samples will be collected for taxonomic analysis, including density, taxonomic composition, and diversity and for tissue metal and radionuclide concentrations. Benthic invertebrate samples will be collected in late summer (September) at the same locations at similar depths each sampling year. Prior to sampling, in situ ecological parameters will be measured and recorded for each sampling location and a habitat description, with sediment type and depth will be recorded. Using an Ekman grab sampler, 3 samples will be collected at each location (within 5 m of each other).

The sampler will be lowered into the sediments using a metered line so the depth of water can be recorded. Samples are collected from all sample areas from similar water depths. Collected sediments are sieved using a 500 µm sieve bucket, and gently agitated. The retained material is transferred to a labelled plastic jar for taxonomic analysis, in accordance with laboratory instructions, and preserved in 10% formalin. Collected samples are kept cool until shipped for identification. Benthic taxonomic samples are packed tightly to avoid movement and potential to spill, placed inside a cooler or sturdy container and sealed for shipment. Samples will be shipped to qualified lab for analysis (AAE Tech Services Inc. in La Salle, MB used in 2021 and 2022).

Field standard operating procedures (SOPs) for the benthic invertebrate community survey will be developed to specify sampling equipment and protocols for the study to be followed to maintain high data quality throughout the program. The QA/QC plan for the field sampling will follow the EEM recommended guidance (Environment Canada 2012), including:

1. Personnel involved in the field sampling will have appropriate training and experience with field equipment and study objectives.
2. Safety measures will be identified, understood and adhered to.
3. Collection equipment selected is appropriate for the specific water body and target invertebrate group and will be checked frequently and maintained regularly.
4. A priori criteria will be set for acceptability of samples obtained and clear directions provided if acceptability guidelines fail (i.e., when to retake a sample; grab sample penetrations of 10-cm depth would be considered an acceptable sample, Gray et al. 1990).
5. Sampling methods will be consistent throughout the study.
6. A visual description of benthic grab samples will be recorded to describe sediment color, odour, texture and debris.
7. Contamination during chemical sampling will be checked through use of trip blanks and equipment rinsing solutions (rinsates).
8. Field sieving, if necessary, will be done as soon as possible after retrieval of samples.
9. Samples will be stored in appropriate containers with appropriate preservative to prevent breakage and spoilage.
10. Sample containers will be appropriately labelled.
11. Detailed field notes will be maintained in a bound waterproof notebook.
12. Chain-of-custody forms and appropriate shipping and storage procedures will be applied.

<u>Benthic Tissue</u>

Benthic invertebrate sampling for tissue analysis of metals and radionuclides will be collected from accessible near-shore littoral zones using a kick and sweep method with a D-net at all locations sampled to ensure sufficient volume. Benthos tissues collected for metal and radionuclide analysis using this method will be rinsed thoroughly with filtered site water, placed into Whirl-Pak bags and frozen prior to transport to the analytical laboratory. In cases where habitat was limited, the use of D-net sampling was supplemented with Eckman grabs and manual sorting.

Health Canada has a consumption guideline for mercury concentrations in fish tissue (Environment Canada, 2014). Although benthic invertebrates are not directly consumed by humans, they make up a large portion of the benthic food web and contribute to fish diets. Health Canada affirms that the standard maximum limit of consumable total mercury concentrations in fish tissue is 0.5 µg/g (0.5 mg/kg) wet weight. Benthic tissue will be compared to this concentration.

Chronic exposure to selenium can cause reproductive impairments in fish and aquatic invertebrates. The United States Environmental Protection Agency (US EPA) established a guideline for the chronic concentrations of selenium in fish for muscle tissue and whole-body levels. Results will be compared to the US EPA outlined 8.5 mg/kg dry weight for whole-body tissue of selenium as the criteria for the protection of aquatic life (USEPA 2016). The US EPA also outlines a criteria of 11.3 mg/kg dry weight for muscle tissue, however this criterion requires samples to be devoid of any bones and is less stringent. Tissue selenium results will also be compared to the British Columbia invertebrate tissue guideline of 4.0 mg/kg dry weight (BC MoE, 2014).

10.4.4 Laboratory Analyses

Benthic Community

A qualified lab will perform two rounds of benthic invertebrate sorting on benthic invertebrate community samples to catch individuals that were missed during the primary sample search. Although there are other laboratories available to perform the analysis, use of the same laboratory will reduce potential variability due to methodology.

The recommended level of taxonomic identification is family for freshwater systems (Environment Canada 2012), with all summary statistics and descriptive metrics (described below) calculated and reported at the family level. Entire samples will be sorted unless very high numbers of organisms are present or the amount of debris makes sorting the entire sample unreasonable. The taxonomic data will be used to calculate benthos density, taxa richness, and determine the benthos community composition.

Tissue Analysis

Benthic tissue samples will be analyzed for the following:

- **Metals** by Inductively Coupled Plasma Mass Spectrometry and mercury (at 0.001 mg/kg RDL) by Cold Vapor

- **Radionuclides** (lead-210, polonium-210, radium-226, thorium-230, and uranium-238)

10.4.5 Data Analysis and QA/QC

Benthic Community

The recommended protocol under Environment Canada's EEM guidelines is that all samples of a group should be sorted in their entirety if the error of subsampling exceeds 20% for that group of samples. This QA/QC protocol, and the QA/QC program described here, is derived from the Rescan (2012) procedure. The error of subsampling is calculated as:

*% Error in the estimate = [1-(estimated # in sample/actual # in sample)]*100*

For additional QA/QC, 10% of the benthos samples will be re-sorted by an independent analyst. If more than 10% error is found, all samples will be re-analyzed. This is consistent with EEM guidelines, which state that sorting efficiencies of 90% or greater are considered acceptable, while groups of samples containing greater error require resorting. Sorting efficiencies will be calculated as:

*% Sorting efficiency = [1- (# in QA/QC re-sort)/(# sorted originally + # in QA/QC re-sort)]*100*

Finally, 10% of the benthos samples will be identified by a second taxonomist. The percent similarity between the original and the QC taxonomist was calculated as:

$$\text{Percent Similarity} = 100 - 1/2 * \text{Sum} \mid p_i1 - p_i2 \mid$$

where p_i1 and p_i2 are the taxon i percent abundance for the original taxonomist and the QA taxonomist, respectively.

Tissue Analysis

To assess the accuracy of the benthic invertebrate tissue analysis, the preferred approach is to collect sufficient biomass from one sampling location, per sampling event, for a split sample to be submitted for analysis. The collected biomass would be homogenized and submitted to the laboratory as two distinct replicate samples.

10.4.6 Statistical Analyses

The taxonomic data received from the lab will be used to calculate the following effect endpoints for the benthic invertebrate communities:

- Total benthic invertebrate density;
- Taxa (i.e., family) richness;
- Evenness index (Simpson's) (equitability); and
- Diversity index (Simpson's).

Non-benthic organisms may be recorded by the laboratory, if present, but will not be included as part of the analyses. If it is documented that a given family of organisms can at some point become benthically attached (e.g., Simocephalus), then it is acceptable to include the organism within the benthic invertebrate community. However, species such as planktonic Daphnia will be removed from the data set prior to the calculation of benthic indices.

Benthic community organisms will be identified down to the taxonomic level of family, as identified in the Summary of AEMP Design Plan Table (Table 9-3). Invertebrate density will be calculated using the total number of individuals of all families taxonomic categories collected at a station expressed per unit area (e.g., numbers/m^2). Taxa richness will be measured as the total number of distinct taxa (families) collected at each sampling station. The Simpson's Evenness Index, evenness will be quantified for each station according to the Metal Mining EEM technical guidance (Environment Canada 2012). The Simpson's Diversity Index, diversity is related to the proportion of total organisms contributed by each taxon and considers both the abundance patterns and taxonomic richness of the community. The Simpson's Diversity Index will be calculated according to the EEM technical guidance (Environment Canada 2012) by determining, for each taxonomic group at a station, the proportion of individuals that it contributes to the total at that station.

- **Invertebrate density** will be calculated using the total number of individuals of all families collected at a station expressed per unit area (e.g., numbers/m^2). Values will be reported at each station, as well as the arithmetic mean ±SE, ±SD, median, minimum and maximum for the area (EC 2012).
- **Taxa richness** refers to the diversity of species and is measured as the total number of different taxa (families) collected at the station, and the arithmetic mean ±SE, ±SD, median, minimum and maximum for the area (EC 2012).
- For **Simpson's Evenness Index**, evenness (E) can be quantified for each station, and the mean E ±SE, ±SD, median, minimum and maximum for the area should be reported. Evenness is calculated as per the EEM technical guidance (EC 2012):

  $$\mathbf{E} = 1 / \sum_{i=1}^{s} (\mathbf{p}_i)^2 / \mathbf{S}$$

  Where E = evenness, p_i = the proportion of i^{th} taxon at the station, and S=the total number of taxa at the station.

- For **Simpson's Diversity Index**, diversity (D) considers both the abundance patterns and taxonomic richness of the community. It is calculated by determining, for each taxonomic group at a station, the proportion of individuals that it contributes to the total in the station. D for each station and mean (±SE, ±SD), median, minimum and maximum D for the area will be reported. Simpson's Diversity Index will be calculated as per the EEM technical guidance (EC 2012):

  $$\mathbf{D} = 1 - \sum_{i=1}^{s} (\mathbf{p}_i)^2$$

  Where D= Simpson's index of diversity, S=the total number of taxa at the station, and p_i = the proportion of i^{th} taxon at the station.

- **Taxa density** can be calculated as the number of individuals of each family expressed per unit area (e.g., numbers/m^2). Values should be reported for each taxon at each station and as the mean (±SE) of each taxon for the area.

- **Taxa proportion** are calculated as the percentage abundance for each taxon at each station and the mean (±SE) percentage abundance of each taxon for the area.
- **Taxa presence/absence** can be presented as a matrix indicating the presence and absence of each taxon at the sampling stations, consisting of stations (columns) and taxa (rows).

10.5 Fish Assessment

10.5.1 Objectives and Scope

Of all the lakes in the Rayrock Exclusion Zone, only Sherman Lake is considered fish bearing. As such, fish health will be monitored in Sherman Lake and Alternate Reference Lake. Fish health will be monitored through fish surveys targeting large-bodied fish, specifically Northern Pike (*Esox lucius*) for fish tissue analyses to determine if contaminants of concern related to the remedial activities are transferring into fish in Sherman Lake. The objective of the fish assessment is to demonstrate that there are no statistically significant changes in tissue concentrations for fish in Sherman Lake compared to the pre-remediation baseline conditions.

Alpha Lake, Sherman Lake and Lake A are one continuous waterbody (the Sherman Lake waterbody), and large-bodied fish are able to travel unimpeded through the waters represented by these areas. The standard fish health metrics used in EEM studies (e.g., growth, reproduction, condition) will not be undertaken as part of the fish assessments on Sherman Lake, as these health indices are intended to be used for sentinel fish populations that would spend the majority of their lifecycle using lake habitat immediately adjacent the potential exposure area (i.e., close to the area of the proposed water treatment discharge), such as Slimy Sculpin (*Cottus cognatus*). Additionally, during the baseline sampling program, insufficient numbers of large-bodied fish were caught in Sherman Lake and Alternate Reference Lake to conduct Von Bertalanffy growth function modeling for northern pike.

Small and large-bodied fishing efforts took place in Sherman Lake, Alternate Reference Lake, and New Control Lake in the fall of 2021, small-bodied fish efforts were repeated in 2022, and large-bodied fishing efforts were completed in Sherman Lake and Alternate Reference Lake in 2023. The tissue results for large-bodied fish from 2021 and 2023 were used as the baseline values for evaluation for the AEMP Design Plan.

Slimy Sculpin (*Cottus cognatus*) was identified as a suitable sentinel species, due to their preferred habitat within the benthic environment, low mobility within their home ranges, and high site fidelity. Slimy Sculpin may be more directly exposed to contaminated water and sediment than wide ranging large-bodied fish and can therefore be used as an advanced indicator of potential environmental change observed within Sherman Lake. No formal evidence of slimy sculpin occurring within the project lakes was available, therefore the 2022 baseline AEMP fish sampling efforts targeted the species to confirm their presence and obtain baseline fish health and tissue concentrations. However, despite the use of multiple gear-types for sampling and numerous sampling locations in Sherman Lake, Slimy Sculpin were not captured and therefore whole-body tissue analysis (including bone) of small-bodied fish is not part of this Design Plan.

Rationale on why small-bodied sentinel fish species were not included in the AEMP Design Plan is also provide in Section 9.7.

Large-bodied fish documented to date in the Sherman Lake waterbody and Alternate Reference Lake include the following:

- Northern Pike (*Esox lucius*)
- Lake Whitefish (*Coregonus clupeaformis)*
- Walleye (*Sander vitreus*)

10.5.2 Sampling Locations

Fishing will be conducted in Sherman Lake and Alternate Reference Lake as outlined in Table 10-6 and as shown on Figures 6 and 7.

Table 10-6 Fish Community Sampling Locations

Fish Community Sampling Location	Zone	Northing	Easting	Datum
Sherman Lake GN1	11 V	7035924 m N	523391 m E	NAD 83
Sherman Lake GN2	11 V	7035803 m N	523268 m E	NAD 83
Sherman Lake GN3	11 V	7035667 m N	523191 m E	NAD 83
Alternate Reference Lake GN1	11 V	7036669 m N	526424 m E	NAD 83
Alternate Reference Lake GN2	11 V	7037122 m N	526411 m E	NAD 83
Alternate Reference Lake GN3	11 V	7036895 m N	526917 m E	NAD 83

Source: 2021 AEMP Report (AECOM 2022a)

10.5.3 Sampling Methods

Timing

Fishing efforts will take place every 3 years for the target large-bodied species.

Methods

For population level surveys (versus community surveys) sampling gear can be more selective to target the specific species and size required for analyses. Gillnets have been used as the primary method of sampling for Northern Pike in 2021 and 2023 and will continue to be used in future AEMP's. Angling can be used as a supplemental method to capture sufficient numbers of fish. One-size gillnets can be used to target larger individuals and set for short time periods to minimize mortality, adjusting the setting times as necessary to achieve a sufficient number of samples; however, standardized sampling is a priority to compare between sampling periods.

Appropriate large-bodied fish will be captured and analyzed from Sherman Lake and Alternate Reference Lake. Northern Pike are the only large-bodied species that has consistently been captured during previous sampling programs in Sherman Lake; therefore, Northern Pike will be the primary target large-bodied species for the AEMP and the evaluation of change in tissue concentrations, including muscle, liver, and bone. If other large-bodied fish species such as Lake Whitefish, Walleye, or Sucker sp. are captured during the pre-remediation monitoring, they will also be used for evaluation of fish tissue concentrations, as they are important target species for both recreational and Indigenous users.

Gill netting locations for Sherman Lake and Alternate Reference Lake are provided in Table 10-5 and Figure 6. Fishing will be conducted to catch 20 total mature Northern Pike in each lake. At each sampling location, UTM coordinates, field conditions, habitat descriptions, gear used and information for catch-per-effort calculations are recorded. Gillnets are used for sampling Northern Pike. Gill net locations were chosen based on nearby habitat structure, with the intent to capture large-bodies fish. Gill nets are checked every two hours to avoid incidental mortalities of non-target fish and to reduce stress on fish.

Collected fish are either released immediately or placed in a temporary holding bucket that is regularly refreshed with well-oxygenated water. Both target and non-target species are measured for fork length to the nearest 1 mm and weighed to the nearest 0.1 g. Target species of large-bodied fish are euthanized for tissue samples, ageing structures (otoliths), and for measurement of growth and reproductive indices. Fish are euthanized with a sharp blow to the back of the head and spinal severance to avoid any unnecessary stress to the animal. Sample processing to obtain lengths and weights is completed as quickly as possible and is conducted using wet gloves to minimize damage to the mucosal layer and stress to the fish. All sampling and handling of fish is done in accordance with the approved DFO Licence to Fish for Scientific Purposes and Animal Use Protocol which will be obtained for each fish assessment program. Prior to release or sample preparation, an external assessment is conducted for abnormalities and species identification.

During the fish survey, a visual examination of fish will be conducted in order to identify the presence of any internal or external abnormalities, such as of body form, body surface, fins, eyes, lesions, tumours, neoplasms, scars or other abnormalities such as eroded, frayed or hemorrhagic fins, internal lesions, abnormal growths, parasites, and any other unusual observations. An area on the data sheet will be included for other significant observations. Photographs will be used to document any obvious abnormalities

Large-bodied fish are processed in the field, including a health examination, and a sex determination to ensure the sampling program collected an equal ratio of males and females. The health survey will include a visual examination, and photographs of each fish in order to identify for the presence of any internal or external abnormalities or unusual observations and abnormalities. Euthanized fish are kept in a cooler with ice packs until they are processed.

Total weight, length, gonad weight and liver weights are assessed for each lethally sampled large-bodied fish. Total weight and length were assessed in non-target species and for individuals over the 20 target fish limit, before being immediately released. Weights are collected in the field using a scale measuring to the nearest 0.1 g. A minimum of 50 g of dorsal muscle, liver, and bone tissue are to be collected from the target large-bodied fish species up to a maximum of 20 individuals per lake. The tissue samples are then placed in sample bags to be frozen for metals and radionuclides analyses.

Aging structures from large-bodied fish (e.g., Lake Whitefish otoliths and Northern Pike cleithra) are removed in the field from each lethally sampled large-bodied fish. Aging structures are removed, cleaned, and kept dry in scale envelopes. All large-bodied fish aging structures will be shipped to a qualified lab for analysis (AAE Tech Services Ltd. was used in 2021). Ages of large-bodied fish, based on aging structures, will be analyzed independently by two technologists, a primary ager and a QA/QC ager, to determine the age of individuals.

10.5.4 <u>Laboratory Analyses</u>

Fish tissue samples will be analyzed for the following parameters:

- **Metals** include, at a minimum, arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), uranium (U), vanadium (V) and zinc (Zn); and
- **Radionuclides** are elemental analysis that must include, at a minimum, lead-210 and radium-226.

Fish tissue analysis results will be compared to the following:

- Health Canada consumption guideline for mercury concentrations in fish tissue (0.5 mg/kg wet weight; Environment Canada, 2014); and

- US EPA outlined 8.5 mg/kg dry weight of selenium as the criteria for the protection of aquatic life (USEPA 2021).

10.5.5 Data Analysis and QA/QC

Field standard operating procedures (SOPs) for the fish assessment will be developed to specify sampling gear and protocols for the study to be followed to maintain high data quality throughout the program. The QA/QC plan for the field sampling will be developed as part of the detailed sampling plan, and will include procedures recommended in EEM guidance (Environment Canada 2012), including:

- Preparation of data recording sheets beforehand using waterproof paper

- Field conditions, habitat, gear used and information for catch-per-effort calculations will be recorded.

- The same balance and measuring devices will be used for all measurements, and having the same person taking the measurements, to reduce measurement error.

- Fish collection methods and equipment should be appropriate for the specific water body and fish species.

- The sampling gear and collection methods will be consistent between the sampling areas, and throughout the study, because most sampling methods select for certain age- or size-classes, and thus inconsistent sampling gear between sampling sites or sampling periods could result in detecting false differences (e.g., in age or size).

- Early initiation of communication with local government agencies to obtain required licences and permits (e.g., fishing licence, dates of fish collection, location of collection, endangered species, etc.).

- Personnel involved in field sampling will have appropriate education and/or training and be familiar with the written standard operating procedures and objectives for the survey.

- Field health and safety measures will be identified, understood and adhered to.

- Habitat descriptions will be recorded, including possible modifying factors (water depth and current, dissolved oxygen concentration, temperature, substrate classification, evidence of pollution [discolouration, odour, residues], salinity, conductivity, etc.).
- Date and time of collection are recorded.
- Location of sampling areas and fish collection areas documented (geographic coordinates) with photographs the collection location.
- The number of fish species and incidental species caught per collection stations will be recorded.
- Estimate of catch per unit effort will be calculated.
- Samples from fish (e.g., ovaries, age structures, stomach content) will be placed in appropriate containers.
- Suitable preservatives/fixatives (e.g., ovaries--frozen or formalin) will be used.
- All samples will have appropriate labelling.
- All measurements will be taken using appropriate equipment of acceptable accuracy and precision (this should be documented);
- Instruments will be calibrated and maintained in good working order (records and methods should be available).
- Detailed field notes will be maintained in datasheets and/or a bound notebook.
- Chain-of-custody forms and appropriate shipping and storage procedures will be used.

10.5.6 Statistical Analyses

The effect endpoint for the AEMP fish assessment will focus on fish tissue chemistry and results will be used to evaluate changes in tissue concentrations, as a percentage, compared to the baseline concentrations for that lake.

Additional measurements on the large-bodies fish will be taken and recorded (e.g. length, weight, age, liver weight, gonad weight, internal and external abnormalities); however, these will not be used to evaluate measurement endpoints for large-bodied fish within the Response Framework. The additional supporting measurements can be used to provide information on the size, age, and condition of the fish population.

Additional information that will be calculated to assess the relative abundance of fish collected from Sherman Lake and Alternate Reference Lake includes catch per unit effort (CPUE). This metric can also be applied to electrofishing, seining, and hoop net sets, using area fished or net size and/or duration of sampling time.

Catch per unit effort (CPUE) will be calculated as follows:

Equation 1

$$CPUE = number\ of\ fish\ caught\ per\ gill\ net\ \ x\ [1/set\ time\ (hours)]$$

11 SPECIAL EFFECTS STUDIES

The AEMP Design Plan will be implemented during remediation activities which will extend from 2024 to 2027. The AEMP will continue to be implemented for 5 years following completion of remediation activities and continue from 2028 until 2032 (Table 9-2). A special effects study was not required as part of the Water Licence. Due to the short duration of the AEMP and the terms of the water Licence, special effects studies are not required. Any exceedance of an Action Level measured as part of the AEMP will follow the Response Framework. No additional studies will be conducted.

12 RESPONSE FRAMEWORK

12.1 Overview

This section describes the Response Framework for the AEMP that has been developed in recognition that the Kwetıı̨ʔaà (Rayrock) Remediation Project is a short-term remediation project and therefore may be different to those developed for new development projects. The Response Framework links monitoring results to actions with the objective of maintaining the valued aquatic ecosystem conditions or assessment endpoints described in Section 9.3 within the current or existing baseline range. The Response Framework provides an approach to responding to the results of the AEMP and was developed with guidance from the *Guidelines for Adaptive Management – A Response Framework for Aquatic Effects Monitoring* (WLWB 2010; MVLWB/GNWT 2019) and Racher et al. (2011).

The AEMP is designed to detect potential changes in Sherman Lake after discharge commences from the Mill Lake PWTP, as well as any changes to other receiving water bodies (i.e., Gamma and Beta Lakes) during remediation. Changes are not deemed "effects" until a link to the Rayrock Remediation Project has been established. Should an effect be detected, a corresponding "action" will occur. The type of action taken depends on the magnitude or severity of an effect relative to an assessment endpoint. This is termed the "Action Level."

The goal of the Response Framework is to systematically respond to monitoring results to prevent significant adverse effects from occurring. This is accomplished by requiring proponents to take actions at defined Action Levels, which are triggered well before significant adverse effects could occur. A level of change that, if exceeded, would result in a significant adverse effect is termed a "significance threshold."

The Rayrock Remediation Project is a federal contaminated site that is undergoing remediation. The EQCs developed and approved in the Water Licence were established to meet the Canadian Water Quality Guidelines (CWQGs) for the protection of aquatic life (CCME 1999a) and existing pre-remediation baseline conditions in Sherman Lake so as not to change the water quality. As a result, there was no requirement to establish an effluent mixing zone. If treated effluent exceeds the EQCs set out in the Water Licence in any one grab sample, it will not be discharged to the receiving environment, therefore conditions in Sherman Lake are not anticipated to change during the AEMP.

However, if upset conditions were to occur during remediation or other changes to water quality parameters identified due to remediation activities, the AEMP has been designed to address two impact hypotheses: 1) changes to Sherman Lake are from effluent discharges or 2) changes to the receiving water bodies is due to physical remediation activities.

The measurement of an effect is determined by comparing AEMP results from Sherman Lake sampling sites (Sherman Lake B, Sherman Lake L, Sherman Lake K, Alpha Bay (Alpha Lake) and Lake A) as well as other Rayrock water bodies (i.e., Lake B, Kwetsǫ̀tìa, Gamma Lake and Beta Lake) to Action Levels provided in this document. For example, a water quality result that falls within the normal range of the baseline data set or is well below an applicable CWQG would not lead to an action. Whereas a water quality result that falls outside the range of normal variability of the baseline data and or exceeds an applicable CWQG while also being linked to the Rayrock Remediation Project would be of low ecological consequence. This would be classified as a Low Action Level and constitutes a "flag" for follow up and possible additional investigation and or proactive management actions.

Should the initial Low Action Level management interventions or investigation results not be sufficient to mitigate the potential threat to the Sherman Lake aquatic environment, and conditions worsen to a level that is of high concern relative to the Significance Threshold, then the magnitude of the effect will be classified as a High Action Level. Water quality results that exceed the High Action Level while also being linked to the Rayrock Remediation Project are considered effects that have increased considerably above the normal variability of the baseline data and/or applicable CWQG. High Action Levels require timely management interventions to stop or reverse the effect. Any effect that exceeds the High Action Level and poses a potential threat to the aquatic receiving environment of Sherman Lake must be investigated by measures including: additional investigation into dissolved metals concentrations (if the action level is triggered by metals) and/or ortho phosphate (if the action level is triggered by total phosphorus), the collection of samples for acute toxicity testing, and the development of a Response Plan.

The Response Framework involves definition of conditions for the Low and High Action Levels for all aquatic environment components of the AEMP (water level survey, water quality, sediment quality, benthic invertebrate community, benthic tissue, and fish tissue) as per the MVLWB el al. (2019) guidance on AEMP response frameworks. Action Levels were established for key water quality indicators of possible significant adverse effects and were not developed for every water quality parameter being measured in the AEMP. Therefore, the Response Framework consists of Action Levels and Significance Thresholds for key water quality indicators and spells out the types of action that may be taken. Similarly, the Action Levels for the other AEMP components spell out the types of responses required. Specific actions to be taken depend on the type and severity of the effect detected. Specifics on the Significance Thresholds, Action Levels, and types of actions that may be taken are outlined below.

12.2 Significance Thresholds

It is important to recognize the context in which the Response Framework for the Rayrock Remediation Project has been developed. Changes to the exposure endpoints of water and sediment quality in the Rayrock study lakes have already occurred due to historical mining activities and other anthropogenic activities in the area. Unlike other large-scale and long-term civil projects in the Northwest Territories, the duration of the water discharge will be short (during the open water season only) and there is little opportunity for a chronic build-up of Constituents of Potential Concern (COPC).

The Significance Thresholds and Action Levels were therefore designed around identifying if unacceptable changes in the water quality COPC's selected for this project are occurring. These thresholds will protect Sherman Lake from unacceptable changes that can impact the aquatic receiving environment and would precede possible downstream changes. The rationale for each endpoint and related effect to describe the Significance Threshold are discussed below.

12.3 Action Levels

The proposed Action Levels for the aquatic environment survey, water quality, sediment quality, benthic invertebrate community, benthic tissue, and fish tissue are presented in Tables 12-2 to 12-7. The spatial extent of the Action Level evaluation includes all receiving water bodies adjacent to the Rayrock Remediation Project, which includes the Sherman Lake waterbody (Sherman Lake, Alpha Lake, Lake A), Gamma Lake, Beta Lake, and Kwetsǫ̀tìa. Responses to occur if an Action Level is triggered are also presented in Tables 12-1 to 12-6, and follow recommendations provided on Version 1.0 and guidance in MVLWB and GNWT (2019).

12.3.1 Effluent Quality

The effluent quality Action Level is based on the EQCs established in the Water Licence W2020L8-0003 (Table 10-1). The EQCs apply to effluent coming directly out of the PWTP (SNP 1663-7), prior to discharge to the receiving environment of Sherman Lake. The Water Licence established these EQCs based on both the baseline water quality conditions in Sherman Lake and the CWQGs for the protection of aquatic life (CCME 1999a). The CWQGs are set to protect all forms of aquatic life and all aspects of aquatic life cycles, including the most sensitive life stage of the most sensitive species (i.e., alga species) over the long term from anthropogenic stressors such as chemical inputs or changes to physical components. They provide a science-based benchmark for a nationally consistent level of protection for aquatic life in Canada. The CCME guidelines which are used to define several of the Low Action Levels in the receiving environment, identify waterborne concentrations intended to protect all forms of aquatic life during indefinite exposure periods. The High Action Level for water parameters evaluated in Sherman Lake were based on Site Specific Significance Thresholds (SSSTs), as defined in Section 12.3.3.3.

The effluent quality treatment goals, established in the Water Licence, for Mill Lake effluent include:

- Ammonia - 499 µg/L, Total Ammonia Nitrogen
- Fluoride - 120 µg/L
- Nitrate - 13,000 µg/L
- Nitrite - 197 µg-NO2/L
- Copper - 2.8 µg/L
- Iron - 300 µg/L
- Nickel - 25 µg/L
- Uranium - 15 µg/L
- Zinc - 23 mg/L
- Total Petroleum Hydrocarbons - 5 mg/L
- Total Suspended Solids - 15 mg/L

Compliance

Compliance with the Water Licence requires that effluent discharge stop if the effluent quality exceeds the EQCs in any one grab sample or if the effluent is determined to be acutely toxic to fish (i.e., Rainbow Trout) and zooplankton (i.e., *Daphnia magna*). Effluent quality and toxicity are tested prior to commencing or resuming discharge. Daily tests of effluent for ecological parameters (i.e., temperature, conductivity, pH, redox potential, TDS, turbidity, dissolved oxygen), and daily on-site analysis of copper and uranium is required. Effluent quality samples will be shipped weekly to a certified laboratory for all sampling parameters outlined for SNP 1663-7, including major ions, nutrients, solids, standard laboratory parameters, total metals, and total radionuclides, and monthly for acute toxicity testing (Table 9-3).

These effluent quality compliance levels have been established through the Water Licence and discharge must stop if the PWTP does not meet either the EQCs or toxicity requirements (Table 12-3). The WLWB and the Inspector will be notified immediately, a spill report will be submitted, and corrective actions taken and reported on.

Total Suspended Solids and Turbidity Monitoring

Two additional monitoring sites have been assigned to monitor the effluent receiving environment in Sherman Lake. These locations (1663-14 and 1663-15) will be located approximately 100 m and 250 m, respectively from the discharge location and will be monitored more frequently for TSS and turbidity at a depth of 0.1-0.2 m (Table 12-1). The monitoring frequency will begin as weekly and will change to daily if the monitoring results at either location exceed the Low Action Level Threshold.

Table 12-1. Low and High Action Level Thresholds for In-situ Readings of Total Suspended Solids and Turbidity at SNP Stations 1663-14 and 1663-15, Located 100 m and 250 m, respectively, from the Process Water Treatment Plant Effluent Discharge Location into Sherman Lake (1663-7).

Parameter	Units	Mill Lake PWTP	Action Level Threshold		
		EQC	Low	High	SSST
Turbidity*	NTU	-	4.7	7.0	9.3
Total Suspended Solids**	mg/L	15	8	21	28

* Turbidity is an optical property that is measured in nephelometric turbidity units (NTUs). Field turbidity is determined by in-situ probe measurements of light scattered by suspended particles and does not have direct toxicological properties. Therefore, the SSST used for evaluating turbidity is based on the relationship between TSS and Turbidity outlined in the CCME guidance for Total Particulate Matter (CCME, 2002). The SSST for turbidity was calculated based on the SSST for suspended sediment using the correlation of 3 to 1. Based on the SSST of 28 mg/L for TSS developed for Sherman Lake (CanNorth, 2023), the corresponding SSST for turbidity at Sherman Lake is 9.3 NTU. The Low Action Threshold for Turbidity is set at 50% of the SSST value and the High Action Threshold for Turbidity is set as 75% of the SSST.

** TSS guidelines for water quality are typically based on a change from background. The CCME (2002) specifies a maximum increase of 25 mg/L from background for a short-term exposure (e.g., 24-hr period) and a maximum average increase of 5 mg/L from background for longer term exposures (e.g., 24-hr to 30-d). Sherman Lake has a measured TSS concentration of 3 mg/L. The Low Action Level for TSS is based on a change of 5 mg/L above baseline and the High Action Level is based on 3/4 of the SSST value developed for Sherman Lake (CanNorth, 2023).

12.3.2 Aquatic Environment

The target lakes included in the aquatic environment survey are the Sherman Lake waterbody, Beta Lake, Gamma Lake, and New Control Lake. The Action Levels for aquatic environment combine both water level (hydrology) and shoreline observation results that may change due to the Rayrock Remediation Project.

A physical change in water level and shoreline aquatic habitat is not expected due to the discharge of Mill Lake water into the Sherman Lake waterbody. Approximately 360,000 m^3 of treated Mill Lake water will be discharged into Sherman Lake over the course of four open water seasons. In total, the water treatment plant is expected to operate for less than 12 months over the four years of operation, with the majority of the Mill Lake water to be treated and discharged in the first year (46,500 m^3) in 2024, and the remaining during the following two seasons in 2025 and 2026 (19,920 m^3 and 19,920 m^3, respectively) plus an estimated 242,000 m^3 of precipitation and geotextile tube filtrate from 2025 to 2027 (Sanexen 2025).

The Sherman Lake waterbody is 178.5 ha in area and is quite deep in places, with depths of up to 9 m measured in the Lake. Assuming an average water depth of 3 m, then the volume of Sherman Lake is approximately 5,355,000 m^3. Taking all of the discharge inputs into consideration, this project would lead to a 6.7% increase to Sherman Lake over four years, or approximately 1.7% per year. The first year of discharge would add approximately 1.0% of the total volume of Sherman Lake, approximately 2.3% and 1.7 % of the total volume would be added in the second and third seasons respectively, and approximately 1.2 % of the total volume in the fourth treatment season, Without consideration of lake water retention or discharge rates, these annual volumes would contribute approximately 0.04 m in year one and year four and up to 0.08 m to the water level in year two and three (if the water in Sherman Lake waterbody remained static).

The probability of an Action Level being triggered is extremely low due to the volume of water to be discharged from Mill Lake relative to the size of the Sherman Lake waterbody, the daily discharge limits, and the short duration of time that discharge will occur in the open water season. Also, due to site access and operational limitations during the spring break up and thaw period, annual commissioning and start-up of the Mill Lake PWTP and Confined Disposal Facility construction are not anticipated to occur until after the annual freshet. Therefore, freshet levels measured on Sherman Lake and Lake A will not be influenced by discharge of treated water from the Rayrock site.

The Action Level triggers for changes in water level on Sherman Lake have been set using the elevation difference between the maximum spring freshet water level and the average summer water level measured during the pre-remediation baseline in 2023. At the Sherman Lake hydrologic monitoring station, the maximum water level was measured in June at 180.475 masl and the average water level from June to September 2023 was 180.345. This elevation difference of 0.130 m (130mm) between the annual peak and the summer average will be used to trigger Action Levels for Sherman Lake hydrology.

Water level data will be downloaded each June, immediately prior to commencement of effluent discharge, and then on a monthly schedule during open water. The annual water level data collected before and during discharge periods on Sherman Lake and on the other lakes will be used to actively update our understanding of the expected hydrograph and seasonal ranges for the Sherman Lake waterbody.

Low Action Level

The Low Action Level is based on maintaining water elevations and shoreline aquatic habitats in the Sherman Lake waterbody at pre-remediation baseline conditions during the period of remediation when the Water Treatment Plant is in operation. The Low Action Level is triggered if during active effluent discharge water levels rise by 130 mm (based on the water level measured at the start of discharge), indications of environmental change or stress are observed at 25% of the observation locations, and the changes are due to the Rayrock Remediation Project (Table 12-4). The Low Action Level is intended to be sensitive to changes in water level in the Sherman Lake waterbody that are outside of the normal or expected hydrograph. Seasonal and annual fluctuations in water level are anticipated, and regions in the north have been experiencing extreme variability in water levels in recent years (ECCC and GNWT 2021). If this water level is reached, and an increasing or irregular trend in the summer water level on Sherman Lake is detected when treated water discharge is occurring, then an initial investigation of precipitation rates and potential blockages (e.g., beaver dam or log jam) of drainage pathways will be undertaken. This investigation will be accompanied by an evaluation of water levels on Beta and Gamma lakes and New Control Lake to determine if a similar trend is occurring. The frequency of water level data retrieval would switch to weekly until the water level falls to a measure below the 130 mm difference in elevation. Results of shoreline surveys would be used to determine whether the change in water level has affected the stability and structure of habitat features. A review of remediation activity, including the discharge volumes from the PWTP and physical works adjacent to shoreline locations and site drainage features would be undertaken to determine if an Action Level related to activity at the remediation site has been confirmed.

High Action Level

The High Action Level is based on water levels in Sherman Lake rising by 130 mm during active effluent discharge without any blockage of drainage pathways and persisting for more than six weeks. This duration of elevated water level combined with evidence of environmental changes in shoreline aquatic habitat (e.g., altered shoreline features or stress to vegetation) observed at 75% of the observation locations would trigger the High Action Level (Table 12-4). Evaluation and comparison to water levels in Beta, Gamma, and New Control lakes would be undertaken along with a review of remediation activity. If the High Action Level is triggered, notification will be provided within 24 hours of confirmation of the Action Level exceedance, and a response plan will be prepared and submitted within 30 days, as required under the Water Licence.

12.3.3 Water Quality

Low and High Action Levels for water quality are intended to screen COPC's from all water bodies adjacent to the Rayrock Remediation Project with concentrations that are increasing due to the Rayrock Remediation Project. This includes the Sherman Lake waterbody (Sherman Lake, Alpha Lake, Lake A), Gamma Lake, Beta Lake, and Kwetsǫ̀tìa. The results from the other AEMP study lakes not adjacent to the Remediation Project (Lake B, Dlah Lake, New Control Lake, and Alternate Reference Lake) will be evaluated against the Action Levels for water quality in the monthly and annual reports but will not be reported to the inspector for exceeding the Action Levels.

The screening of water quality COPC's was established using the pre-remediation baseline conditions in these receiving waterbodies (Section 8.3 and Appendix B). The Low Action Levels are based on screening baseline data against CCME guidelines (or 95th Percentile of the baseline concentration for a given study lake that was above CCME Guidelines) and the High Action Levels are based on 75% of the SSSTs developed for CanNorth, 2023 and described in Section 12.3.3.3 (Table B-2; Appendix B).

Water quality Action Levels are independent of Action Levels for water level, benthic invertebrates and fish. Biological monitoring of benthic and fish communities will determine if effects are occurring on aquatic organisms from changes in the environment from remediation activity and have their own Action Levels. Water quality parameter concentrations for COPC's in the Rayrock Study Lakes should remain below values that are protective of freshwater aquatic life to allow suitable types and quantity of food for fish eat to survive and fish to survive, grow, and reproduce. Relevant AEMP WQOs and SSSTs will be used to assess the degree of potential impact to the water quality in the receiving water downstream of the treated effluent discharge ranging from negligible to approaching the Significance Threshold. An exceedance of a relevant Action Level does not automatically mean that adverse effects will occur, unless it is linked to the remediations activities occurring on site. Exceedance of a Significance Threshold indicates that impacts to the aquatic receiving environment are likely occurring.

12.3.3.1 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

A selection process was performed to identify COPCs at the Rayrock Mine site. The following sections describe the process followed for the selection of chemicals of concern. The 97 constituents that were provided by the analytical laboratory during the AEMP water quality baseline program of the study lakes and the Mill Lake (PWTP effluent monitoring include:

General Chemistry Parameters:

- Alkalinity
- Bicarbonate
- Carbonate
- Total ammonia
- Calcium
- Chloride
- Conductivity
- Hydroxide
- Magnesium
- Total phosphate
- pH
- Fluoride
- Hardness
- Magnesium
- Nitrate
- Nitrite
- Nitrate plus Nitrite
- Ortho Phosphate
- Total Phosphate
- Potassium
- Sodium
- Elemental Sulfur
- Sulfate
- Total dissolved solids (TDS)
- Total Suspended Solids (TSS)
- Dissolved Organic Carbon (DOC) and
- Total Organic Carbon (TOC)

Total Metals and Metalloids:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nickel
- Phosphorus
- Potassium
- Selenium
- Silicon
- Silver
- Sodium
- Strontium
- Thallium
- Tin

- Titanium
- Uranium
- Vanadium
- Zinc

Dissolved Metals, Metalloids, and Radionuclides:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Calcium
- Chloride Ion
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nickel
- Phosphorus
- Potassium
- Selenium
- Silicon
- Silver
- Strontium
- Thallium
- Tin
- Titanium
- Uranium
- Vanadium
- Zinc
- Uranium-238
- Lead-210
- Radium-226
- Polonium-210
- Thorium-230

12.3.3.2 Water Quality COPC Selection Process

At a minimum, the COPC selection process encompasses the parameters listed in the Water Licence including Dissolved Nitrate, Dissolved Nitrite, Total Ammonia, pH Range, TSS, Dissolved Fluoride, Copper, Iron, Nickel, Uranium, Zinc. A conservative screening for other potential parameters was performed using the maximum effluent concentrations from 2024 and the maximum concentrations from the Sherman Lake study sites from the AEMP baseline sampling program conducted from 2021 to 2023. To address the potential influence of the PWTP an effluent screening was conducted on both the effluent data collected during 2024 and the pre remediation sediment concentrations in Mill Lake. Using the maximum measured concentrations in Mill Lake sediment the list of COPCs were informed by the maximum possible concentrations that may occur during the treatment of Mill Lake water. Additional screening of potential sediment influence on water quality at the Rayrock Mine Site was completed by comparing the highest sediment concentrations in the waterbody being treated (Mill Lake) and in the receiving waterbody (Sherman Lake). Parameters were screened in if the maximum concentrations from the Sherman Lake sites exceeds the available CCME sediment quality guidelines (PEL values) and if the maximum concentrations in the Mill Lake sediment exceeded the baseline concentrations from Sherman Lake study sites by 10X.

The details of the screening are summarized in Figure 12-1. The screening steps include:

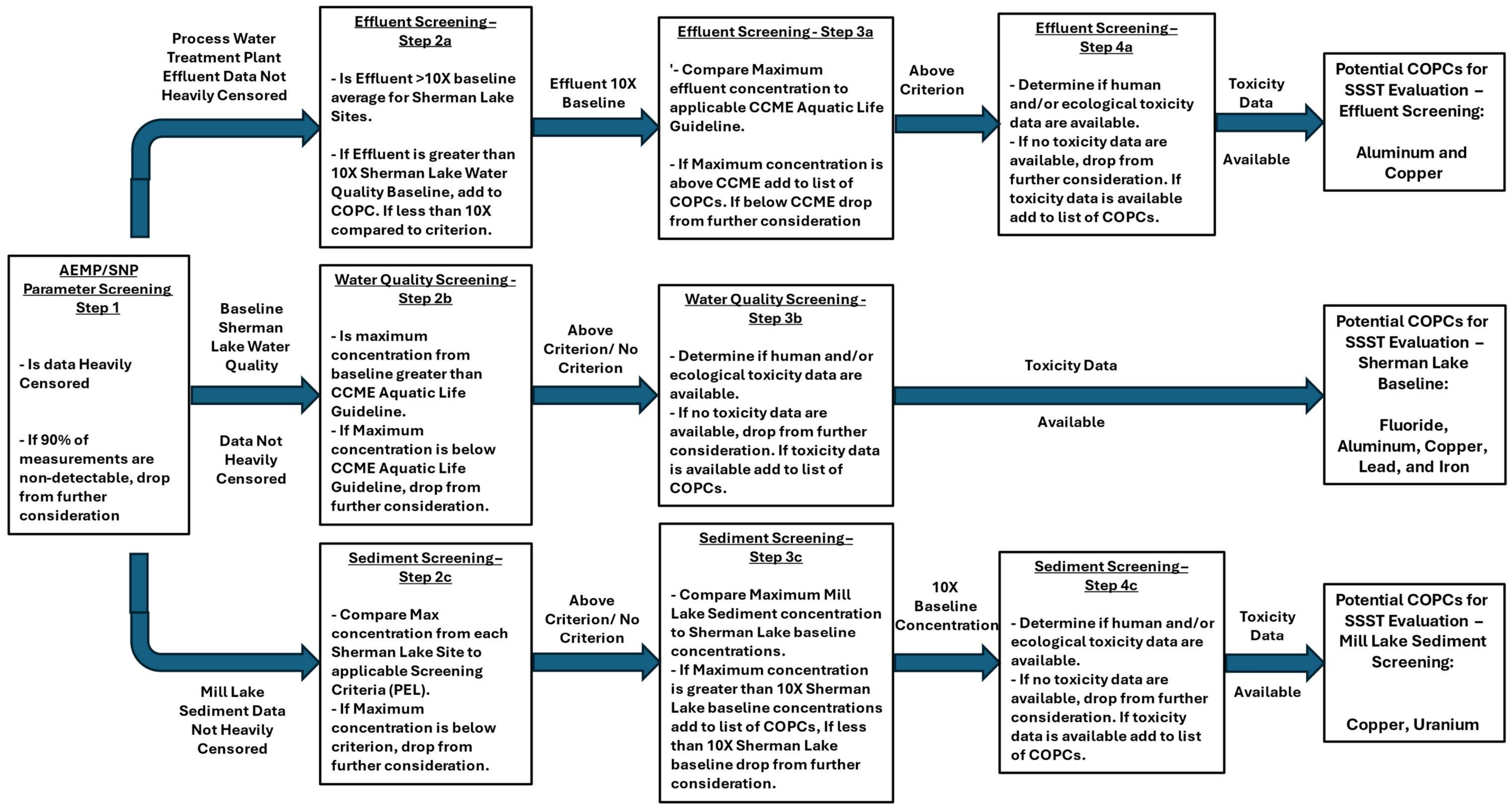
1. For each screening (effluent, surface water, or sediment), if 90% or more of the measurements for a constituent were non-detectable (i.e., below the method detection limit [MDL]), then the data were considered to be essentially not measured, and the constituent was dropped from further assessment.

2. The maximum measured concentrations were compared to the appropriate screening criteria (as discussed below). Constituents with concentrations lower than the screening criteria were dropped from further assessment, while those with concentrations exceeding the screening criteria, or with no criteria available, were carried forward to Step 3.

3. Constituents remaining as potential COPC after steps 1 and 2 were then checked to see if corresponding human health and/or ecological toxicity data are available. Constituents with available toxicity data were selected as COPC, while those without toxicity data were not further assessed. Dismissing parameters with no available toxicity data adds some uncertainty to the assessment, however, the lack of toxicity data generally denotes constituents that are not considered to be toxic.

4. Of the remaining parameters select constituents were removed for other reasons specific to the parameter and/or knowledge of the site conditions.

Figure 12-1. Contaminants of Potential Concern Screening for Water Quality Action Levels.



The Final List of COPCs For SSSTs for Design Plan Includes: Dissolved Nitrate, Dissolved Nitrite, Total Ammonia, TSS, Dissolved Fluoride, Copper, Iron, Nickel, Uranium, Zinc, Radium-226, Uranium-238, Lead-210, Polonium-210, Thorium-230.

Exclusion Notes:

- Aluminum is not generally a COC at Rayrock but results from the effluent and 2 Sherman Lake sites are higher than the CCME guideline. Aluminum was not considered in the HHERA after considering aluminum speciation. " At pH values between 5.5 and 9, there is very little aluminum that is in true solution and available for uptake by biological species. The pH in the water at Rayrock Mine typically measures between 7.5 and 7.9 pH units, thus it is not expected that aluminum is in solution to exert a toxic effect, and it is dropped from further assessment."

- Lead is not generally a COC at Rayrock but results from 1 Sherman Lake B baseline sample were higher than the CCME guideline. Lead was not considered in the HHERA for the aquatic environment.

- pH Range will be monitored in the receiving environment and pH results outside of the CCME guidelines will be reported in the monthly and annual reports.

12.3.3.3 Development of Action Levels and Site Specific Significance Thresholds

A significance threshold is defined as a limit of environmental change which, if reached, would theoretically result in significant adverse impacts. As part of the AEMP for the Rayrock Remediation, SSSTs were developed for surface water in Sherman Lake so that adaptive management actions can be taken to ensure that significant adverse impacts will not occur in Sherman Lake while remedial activities are completed. In order to develop SSSTs the potential for adverse impacts in the aquatic environment were considered for total concentrations of ammonia, fluoride, nitrate, nitrite, copper, iron, nickel, uranium, zinc and radionuclides in accordance with AEMP guidance (MVLWB and GNWT 2019).

For the Rayrock Remediation Project SSSTs for the non-radionuclides were primarily derived from species sensitivity distributions (SSDs) and the radiological SSSTs were based on a back-calculation of acceptable doses associated with a factor of 10 times the radiation dose benchmark. The detailed rationale for development of each SSST was provided in CanNorth, 2023 and additional rationale for the use of a factor of 10 to set upper thresholds is provided in CanNorth, 2025. The final COPC's for water quality evaluation include the following nutrients, metals, and radionuclides (Table 12-2).

Table 12-2. Water Quality COPC's and CCME Guidelines and SSST's used for Action Level Evaluations.

Parameter	CCME Guideline	SSST*	SSST Rationale
Dissolved Nitrate,	13 mg/L	82 mg/L	Protection of 50% of the aquatic community from the species sensitivity distribution (SSD) curve
Dissolved Nitrite,	0.197 mg/L	1.4 mg/L	Protection of 50% of the aquatic community from the SSD curve
Ammonia, Total Ammonia Nitrogen	0.499 mg/L	4 mg/L	Protection of 50% of the aquatic community from the SSD curve, adjusted to pH 7 and temperature 20º C
TSS,	15 mg/L	28 mg/L	Change from baseline
Dissolved Fluoride,	0.120 mg/L or 95th Percentile of the Baseline Concentration (Each Study Lake)	19 mg/L	Protection of 50% of the aquatic community from the SSD curve
Total Copper,	0.0028 mg/L or 95th Percentile of the Baseline Concentration (Each Study Lake)	0.018 mg/L	Protection of 50% of the aquatic community from the SSD curve
Total Iron,	0.3 mg/L	19 mg/L	Protection of 50% of the aquatic community from the SSD curve
Total Nickel,	0.025 mg/L	0.063 mg/L	Protection of 50% of the aquatic community from the SSD curve
Total Uranium,	0.015 mg/L	0.744 mg/L	Protection of 50% of the aquatic community from the SSD curve
Total Zinc,	0.023 mg/L	0.135 mg/L	Protection of 50% of the aquatic community from the SSD curve, adjusted for 50 mg/L hardness
Total Radium-226	95th Percentile of the Baseline Concentration (Each Study Lake)	39.6 Bq/L	Based on back-calculated dose
Total Uranium-238		0.33 Bq/L	Based on back-calculated dose
Total Lead-210		11.6 Bq/L	Based on back-calculated dose
Total Polonium-210		0.66 Bq/L	Based on back-calculated dose
Total Thorium-230		0.66 Bq/L	Based on back-calculated dose

Notes:

- CCME Guidelines - CWQGs for the protection of aquatic life (CCME 1999a)
- SSST's (CanNorth, 2023).

Low Action Level

For water quality the Low Action Level indicates that impacts have the potential to occur and is considered to be sensitive to changes in water quality. The baseline concentrations of parameters in Sherman Lake are low and the EQCs for discharge to Sherman Lake have been established to meet the CWQGs level of aquatic protection, but where baseline conditions are greater than the CCME guideline the Low Action Level shall be equal to the 95th percentile of the baseline values. Copper and fluoride are the only parameters with an EQC that may trigger a Low Action Level in the AEMP. The mean copper concentration of 2.1 µg/L for Sherman Lake K is only 25% lower than the current CWQG of 2.8 µg/L in the Water Licence. The mean fluoride concentration of 170 µg/L for Sherman Lake K is higher than the current CWQG of 120 µg/L in the Water Licence. All other mean values for parameters in Sherman Lake with associated EQCs are between 200-2,400% lower than the EQC values.

The Low Action Level is triggered if the concentration from an AEMP location in a receiving waterbody during one sampling event is greater than the CCME guideline or the 95th percentile of the baseline values (copper, fluoride, and radionuclides only), is part of an increasing trend observed for that parameter, and the increase is linked to the Rayrock Remediation Project (Table 12-5). The Low Action Level indicates that impacts have the potential to occur and is intended to be sensitive to changes in water quality.

High Action Level

The High Action Level is triggered if the concentration from an AEMP station in a receiving waterbody during one sampling event is 3/4 of the SSST values and the increase is linked to the Rayrock Remediation Project. However, where baseline conditions are greater than the SSST values (e.g. Beta Lake and Gamma Lake) the High Action Level shall be equal to the 95th percentile of the baseline + 100% of the 95th Percentile. Beta Lake and Gamma Lake are not associated with the effluent receiving environment but are associated with capped tailings at the Rayrock Site.

Triggering of High Action Levels are not expected as action will be taken to prevent water from being discharged that does not meet the EQCs and to bring water quality concentrations down if they are found to be increasing during treatment or in the receiving environment (e.g. previous Low Action Level flag). A single exceedance of an EQC or a result above the established pre-remediation baseline concentration is not expected to result in effects to the biological components; however, these would be unexpected occurrences requiring action (Table 12-5).

A concentration above the High Action Level could occur due to one high outlying value (e.g., one high concentration and three results below) or could be a result of a persistent increase in concentration over the course of a month (e.g., four values that are above or close to Action Levels). A short-term spike in water quality levels at concentrations compliant with the discharge EQCs are not expected to cause acute effects and the short-term duration of the effluent discharge is unlikely to cause sublethal (chronic) effects to aquatic life in Sherman Lake. However, if concentrations in water continue to increase up to or exceeding the High Action Levels, additional investigations, mitigation, and an immediate response will occur (Table 12-5).

12.3.4 Sediment Quality

Low and High Action Levels for sediment quality are intended to screen COPC's with concentrations that are increasing due to the Kwetıı̨ʔaà (Rayrock) Remediation Project. Results from the AEMP locations in the Sherman Lake waterbody (Sherman Lake, Alpha Lake, and Lake A), Gamma Lake, Beta Lake, and Kwetsǫ̀tìa will be evaluated against the Action Levels for sediment quality. Sediment quality parameter concentrations in the Rayrock Study Lakes should remain below values that are protective of freshwater aquatic life to allow suitable types and quantity of food for fish eat to survive and fish to survive, grow, and reproduce. Sediment quality Action Levels were developed using the existing baseline conditions, with the understanding that some of these waterbodies have impacts from historical mining. These Action Levels are independent of Action Levels for water level, water quality, benthic invertebrates and fish.

The High Action Level for sediment quality is based on a magnitude of change from baseline conditions, with the intent of preventing parameters from increasing in the receiving environment. A Low or High Action Level is triggered if the concentration from an AEMP location in a receiving waterbody during one sampling event are 10% or 40% greater, respectively than the 95th percentile of the pre-remediation baseline concentration and the increase is linked to the Rayrock Remediation Project (Table 12-6).

For sediment quality, the focus will be on the AEMP locations in waterbodies immediately adjacent to the Rayrock Remediation Project that may receive surface runoff or drainage from the remediation site. Sediment quality results from each of the receiving waterbodies (i.e., Sherman Lake, Alpha Lake, Lake A, Gamma Lake, Beta Lake, and Kwetsǫ̀tìa) will be compared to the 95th percentile of the pre-remediation baseline values from each respective lake (Table B-3; Appendix B). An exceedance of a relevant sediment Action Level does not automatically mean that adverse biological effects will occur, unless it is linked to the remediations activities occurring on site. Separate biological monitoring of benthic and fish communities will determine if effects are occurring on aquatic organisms from changes in the environment from remediation activity and have their own Action Levels. A Sediment and Erosion Control Plan (SECP) has been approved for civil works close to the site waterbodies. The SECP includes more frequent monitoring of remedial activity for the potential movement of solids and the development of erosion issues that could lead to sedimentation events. It outlines methods that will be employed before, during, and after remediation to prevent erosion and mitigate movement of sediment through local runoff to receiving waterbodies.

It is possible that concentrations in sediment may approach or exceed the 95th percentile plus 10% from the pre-remediation baseline period simply due to seasonal fluctuations or other factors (e.g., single high result due to a wind event, sample contamination, natural variability). Treated effluent concentrations, remediation activity, temporal trends (i.e., changes over time), and spatial trends (e.g., proximity to immediate discharge point or civil work) will be considered when determining if an Action Level trigger is due to activity from the Kwetıı̨ʔaà (Rayrock) site, and what actions are necessary to be taken. If no source from the Rayrock Remediation Project is identified (i.e., the result is not linked to the remediation activity), there is no increasing trend (visual evaluation or statistical test), and/or the spatial pattern is unexpected (e.g., an increase occurred at a farther downstream station but not immediately downstream of the effluent discharge or adjacent to the site), the result may be due to analytical error, inhomogeneous distribution of contaminants in the sediment, contamination of the sample, or other unidentified source. Individual anomalous or erroneous results would not immediately trigger a Low Action Level but would be further investigated as appropriate depending on the nature of the exceedance (e.g., parameter, magnitude, duration of the trend, and confirmation of link to remediation activity) prior to an Action Level response being confirmed.

12.3.4.1 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

The AEMP will monitor and evaluate each of the 32 constituents in sediment that were provided by the analytical laboratory. These include:

- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Chromium
- Chromium (Hexavalent)
- Cobalt
- Copper
- Lead
- Mercury
- Molybdenum
- Nickel
- Phosphorus
- Selenium
- Silver
- Thallium
- Tin
- Uranium
- Vanadium
- Zinc
- Percentage moisture
- Percentage nitrogen
- pH
- Percentage Elemental Sulfur
- Percentage Total Organic Carbon (TOC);
- Uranium-238
- Lead-210
- Radium-226
- Polonium-210
- Thorium-230

12.3.5 Benthic Invertebrates

Biological monitoring of benthic invertebrates is used to detect effects on the benthic community. Action Levels have been set for two benthic invertebrate indicators: invertebrate density (i.e., how many) and richness (i.e., how many different types of invertebrates). Invertebrate density and richness were chosen as they are expected to respond predictably to increased toxicity or nutrient enriched conditions, according to identifiable response patterns (Environment Canada 2012). A decrease in density and richness greater than the CES indicates reductions in both the number and type of invertebrates, which provides the most reliable and interpretable evidence of community change in a negative direction. Community indices (e.g., dominance, Simpson's diversity index, Simpson's evenness index) provide additional useful information for inclusion in the overall community assessment but were not included in the Action Levels. Indirect responses in the benthic community assemblages are of interest for evaluating long-term trends and for investigating potential linkages to environmental causes (e.g., habitat, substrate, sediment quality, and water quality); however, they are less useful for establishing Action Levels, particularly when the alterations are not easily categorized as harmful to ecological function.

As outlined in Section 10.4, benthic invertebrates are to be collected directly from the sediment at each AEMP location. The spatial extent of the Action Level evaluation is focused on the sample locations immediately adjacent to the Rayrock Remediation Project but applies to all sampling sites in the receiving waterbodies in order to understand and evaluate potential changes in the aquatic environment. As part of the benthic invertebrate assessment, the water and sediment quality monitoring will be used to indicate the potential cause of any unacceptable effects and inform potential management responses. Sediment quality and habitat data are also important to support the biological evaluation and to establish if there is a linkage to the Rayrock Remediation Project (primarily effluent discharge) or if the observed effects to the community are due to other factors (e.g., habitat differences, historical sediment contamination, changes in climate).

Low Action Level

The Low Action Level for benthic invertebrates is defined as significantly lower invertebrate density and richness in the receiving waterbodies (Sherman Lake waterbody, Beta Lake, Gamma Lake, Kwetsǫ̀tìa) compared to the pre-remediation baseline conditions of a magnitude greater than 1 SD for benthic invertebrates (Table 12-7). A CES of 2 SD is used in EEM Technical Guidance (Environment Canada 2012). However, the variability of the pre-remediation baseline data in a few of the lakes is high enough that a decrease of 1 SD may approach or exceed densities of zero. This Action Level also requires reasonable evidence that changes to these endpoints is linked to activity at the Rayrock Remediation Project, as indicated by water quality and sediment quality. The Low Action Level is focused primarily on change related to potential toxicity, as it is most directly relevant to preventing reductions in benthic communities.

High Action Level

The conditions required for the High Action Level to be triggered for benthic invertebrates are defined in Table 12-7. This Action Level provides a more definite warning of potential alteration of the invertebrate community in the receiving waterbodies. The High Action Level requires a link to the Rayrock Remediation Project and either:

a) A magnitude of change that represents more than a 50% reduction in mean densities of three key invertebrate taxa compared to baseline conditions (i.e., chironomids, bivalves, oligochaetes) over two successive sampling events; or

b) A magnitude of change that represents more than an 80% reduction in mean densities of four key prey taxa compared to baseline conditions (i.e., chironomids, bivalves, oligochaetes, and mayflies) during a single sampling event.

Under the High Action Level an 80% reduction in mean densities, requires a reduction in mean mayfly densities as well as a reduction in mean chironomids, bivalves, and oligochaete densities. Collectively, these four taxonomic groups represent a large proportion of the dietary food items available fish species Sherman Lake. Mean densities of these taxa can be variable, but a reduction of this magnitude in multiple invertebrates would signal a definite change that should be addressed consistent with a High Action Level. The inclusion of the trigger of 50% reduction over two successive sampling events that confirms a pattern may represent a more substantial outcome than a single event which is more likely to be due to chance or a confounding factor.

12.3.6 Fish and Benthic Tissue

Conditions required for Action Levels related to changes in the concentration of metals in fish and benthic tissues are outlined in Table 12-8. For fish and benthic tissue, the effects indicators were identified as an increase in tissue concentrations compared to the pre-remediation baseline levels. Muscle, liver, and bone tissue will be analyzed on large-bodied fish (i.e., Northern Pike) and a composite sample of whole benthic organisms to monitor the potential movement of contaminants into the food chain. The typical effect indicators for sentinel fish species used in EEM programs (i.e., length, weight, condition, relative liver size, and relative gonad size) will be recorded for the large-body fish collected but are not included in the Action Level evaluation for the Response Framework. Change in tissue concentrations is not indicative of an impairment to fish or benthic health but will inform on going assessment and risk evaluation of the Rayrock Remediation Project.

12.3.6.1 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

The AEMP will monitor and evaluate each of the 35 constituents in benthic tissue and fish tissue that were provided by the analytical laboratory. These include:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Bismuth
- Boron
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nickel
- Phosphorus
- Potassium
- Selenium
- Silver
- Sodium
- Strontium
- Thallium
- Tin
- Titanium
- Uranium
- Vanadium
- Zinc
- Radium-226
- Uranium-238
- Lead-210
- Polonium-210
- Thorium-230

Low Action Level

The Low Action Level for fish and benthic tissue is triggered if an increase in any metal or radionuclide concentration is measured in the tissue that is greater than 10% above the average or maximum (n=1) pre-remediation benthic invertebrate (2021 and 2022) and the 95th percentile of the pre-remediation large-bodied fish (2021 and 2023) (Table 12-8). Reasonable evidence that the change is linked to inputs from the Kwetıı̨ʔaà (Rayrock) Remediation Project is also required, as indicated by water and sediment quality data.

High Action Level

The High Action Level for fish and benthic tissue is triggered if an increase in any metal or radionuclide concentration is measured in the tissue that is greater than 40% above the 95th percentile of the pre-remediation baseline concentration for that waterbody (Table 12-8). Reasonable evidence that the change is linked to inputs from the Rayrock Remediation Project is also required, as indicated by water and sediment quality data.

12.4 Action Level Responses and Notifications

The AEMP Action Levels and Response Framework are outlined in Tables 12-1 to 12-9.

12.4.1 Responses to Action Levels

Low and High Action Levels for water quality, sediment, benthic invertebrates, fish and benthic tissue, and water levels will apply to the Sherman Lake study sites and the other Rayrock study lakes (i.e., Lake B, Beta Lake, Gamma Lake, and Kwetsǫ̀tìa). Screening and reporting will also be conducted for the other Rayrock study lakes (i.e., Lake B, Dlah Lake, New Control Lake, and Alternate Reference Lake) but the results will not be reported to the inspector.

Part F Conditions 6 and 7 of the Type A Water Licence (W2020L8-0003) include responses to low and high Action Levels. Responses that will occur following an exceedance of an AEMP Action Level are provided in Table 12-3 to 12-9 and include guidance provided in MVLWB and GNWT (2019). The AEMP responses apply to the aquatic environment (water level), water quality, sediment quality, benthic invertebrates, and fish and benthic tissue quality. If an Action Level is exceeded the initial steps are to follow AEMP best practices and to confirm and verify the data used to determine the Action Level exceedance.

If a Low Action Level trigger is confirmed, additional steps include evaluating temporal trends and examining linkages between the remediation activity and the change in the aquatic component being monitored. If the concentration continues to increase, an evaluation to predict when a High Action Level would be exceeded (if the trend continues) may be undertaken. Follow-up desktop and field studies may be recommended to address data gaps, linkages, or areas of uncertainty, and the need to increase the extent or frequency of monitoring.

If a High Action Level is triggered and is linked to the Rayrock Remediation Project, then the responses for the Low Action Level apply. However, other possible immediate responses will be to collect additional water samples to look at dissolved metals or other factors affecting bioavailability, toxicity samples for acute and chronic testing, and to develop an AEMP Response Plan, and implement mitigation, if applicable.

If a High Action Level is triggered, the responses for the Low Action Level applies, and efforts will focus on understanding the trend, mitigating, or reversing where possible, and preventing further adverse environmental changes from occurring. Typically, special studies are required to evaluate the long-term trends, potential ecological implications, and the recovery of the aquatic ecosystem. The High Action Levels may be reviewed and adjusted, if warranted and scientifically defensible, based on new data collected as part of the response. Proposed changes would be submitted to the WLWB for review and approval.

12.4.2 Notification and Response Plan Timeline

As outlined in the Water Licence (Part H, Condition 9), an AEMP Response Plan is not required for a Low Action Level exceedance for water quality, sediment quality, benthic invertebrates, or fish. If responses, mitigations, or follow-up studies are initiated the year following the Low Action Level exceedance, then these results will be reported in the following annual AEMP report.

For all High Action Level triggers, the WLWB and Inspector will be notified within 24 hours of the confirmation of the data triggering the Action Level and is confirmed to be linked to the Rayrock Remediation Project. Notification and submission of an AEMP Response Plan to the Board for approval will be completed within 30 days of the confirmation of the data triggering the high Action Level.

Table 12-3 Effluent Discharge Action Levels and Responses Licence Requirement for the Kwetıı̨ɂaà (Rayrock) Aquatic Effects Monitoring Program

Location	SNP 1663-7	
Action Level Type	**Effluent Discharge Quality**	**Action Level Response**
Compliance	If one of the following are met: 1. Effluent quality exceeds the Effluent Quality Criteria (EQCs) established in the Water Licence in any one grab sample (daily tests for in situ ecological, copper and zinc done onsite and weekly submissions to lab). 2. Effluent quality is determined to be acutely toxic (tested prior to initial discharge and monthly during discharge).	Action to be undertaken in accordance with Part E, Condition 21 of the Water Licence: - Cease discharge - Notify Inspector and WLWB immediately - Report the spill immediately - Submit report of incident with summary of corrective actions

a) All water quality results must be confirmed, meaning that the final analytical result or field measurement has been checked and validated (i.e., no probe calibration or transcription errors).

b) Acute toxicity analysis (multi-concentration) – Rainbow Trout and Daphnia magna; as described in Reference Method EPS 1/RM/13 – Biological Test Method: Reference method for Determining Acute Lethality of Effluents to Rainbow Trout and EPS 1/RM/14 – Biological Test Method: Reference for Determining Acute Lethality of Effluents to Daphnia magna.(as specified in Annex A, Part A of the Water Licence)

EQC = effluent quality criteria; WLWB = Wek'èezhìi Land and Water Board

Table 12-4 Aquatic Environment Action Levels for Surface Water Elevation Changes and Responses for the Kwetıı̨ɂaà (Rayrock) Aquatic Effects Monitoring Program Response Framework

Location	**Water Level Increase in Sherman Lake and Lake A**	
Action Level Type	**Aquatic Environment**	**Possible Responses to Action Levels**
Low	If the following are met: 1. Water levels rise in Sherman Lake by 130 mm from the water level measured at the start of effluent discharge. **AND** 2. Signs of stressed vegetation or other clear indications of environmental change are present along the shoreline at any 25% of the shoreline observation locations **AND** 3. Linked to the Kwetıı̨ɂaà (Rayrock) Remediation Project activity (i.e., during effluent discharge,)	Increase water level logger download frequency to weekly. Compare water levels to New Control Lake and other study lakes – if similar trends are observed, then no further action. Review precipitation records and check the drainage pathways for potential blockage – if blocked, develop a plan for clearing the pathway. Compare shoreline location with previously documented conditions from 2021,2022, and 2023. Evaluate links to Rayrock Remediation Project activity upstream or adjacent to the shoreline location (e.g., comparing to regional background lakes, inspecting site for potential blockages, reviewing recent remediation activities, comparing to baseline shoreline conditions). Identify potential mitigation measures.
High	1. Water levels rise by 130 mm from the water level measured at the start of effluent discharge and continues for >6 weeks. **AND** 2. Signs of stressed vegetation or other clear indications of environmental change are present along the shoreline at any 75% of the shoreline observation locations **AND** 3. Linked to the Kwetıı̨ɂaà (Rayrock) Remediation Project activity (i.e., during effluent discharge, tailings cap repair)	Increase download frequency of water levels to weekly. Compare trends to New Control Lake and other study lakes – if changes observed are similar, then no further action is required. Review precipitation records and check the drainage pathways for potential blockage – if blocked, develop a plan for clearing the pathway. Compare shoreline locations* with previously documented conditions, including pre-remediation baseline records from 2021,2022, and 2023. Evaluate links to Rayrock Remediation Project activity upstream or adjacent to the shoreline location (e.g., comparing to regional background lakes, inspecting site for potential blockages, reviewing recent remediation activities, comparing to baseline shoreline conditions). Identify potential mitigation measures. The WLWB and Inspectors will be notified within 24 hours of confirmation of the Action Level. An AEMP Response Plan will be prepared by a qualified hydrologist within 30 days of the Action Level being identified, with detailed actions to correct the issue.

* Temporal trends to be evaluated visually.
AEMP = Aquatic effects monitoring program; WLWB = Wek'èezhii Land and Water Board

Table 12-5 Water Quality Action Levels and Responses for the Kwetıı̨ʔaà (Rayrock) Aquatic Effects Monitoring Program

Locations	**All AEMP stations located in receiving water bodies adjacent to the Rayrock Remediation Project (Sherman Lake, Alpha Lake, Lake A, Gamma Lake, Beta Lake, Kwetsǫ̀tìa)**	
Action Level Type	**Water Quality**	**Possible Responses to Action Levels**
Low	All of the following are met: 1. A concentration greater than the Low Action Threshold (CCME Guideline or site-specific maximum baseline concentration). **AND** 2. Supported by an increasing temporal trend **AND** 3. Linked to the Kwetıı̨ʔaà (Rayrock) Remediation Project	Follow AEMP best practices: - confirm Low Action Level* was triggered (e.g., confirm reliability of chemistry data) - review processes, procedures, and data to further evaluate cause/linkage to Site (e.g., water treatment plant effluent), as appropriate - Visually evaluate temporal trends in water quality parameters at monitoring stations - examine potential linkage between increased concentration and results for other aquatic monitoring parameters. Report in Annual AEMP Report. Increase monitoring frequency at the station to weekly, increase sample numbers, include monitoring at depth, and expand the monitoring area around that location for water quality to confirm findings. Apply Mitigation Measures • Identify potential mitigation options (e.g., investigate changes in source water [mine water] chemistry and treatment practices). • Implement mitigation/further controls, as appropriate (e.g., install extra sediment control measures in construction areas). • Initiate follow-up desktop/field studies if required – examine linkages between concentration, toxicity, and biological responses. • Predict water quality trends and predict time to reach a potential next action level, where appropriate. Review appropriateness of the Low Action Level and refine if warranted and scientifically defensible.
High	Both of the following are met: 1. A concentration greater than the High Action Threshold. **AND** 2. Linked to the Kwetıı̨ʔaà (Rayrock) Remediation Project	Confirm High Action Level. (e.g., confirm reliability of chemistry data) and confirm Link to the Rayrock Remediation Project. Conduct desktop or field special study to examine ecological significance, causation, and/or linkage Rayrock Remediation Project as described for the Low Action Level. This may include additional toxicity tests and/or benthic invertebrate surveys described below. Notify Inspector and WLWB within 24 hours. Follow AEMP best practices as outlined for Low Action Level. Increase Monitoring: • Collect additional water samples for evaluation of dissolved metals if Action Level triggered by metals. • Collect additional water samples for evaluation of orthophosphate if Action Level triggered by total phosphorus. • Increase or continue to increase monitoring frequency or spatial extent of monitoring for water quality, toxicity, benthic invertebrates • Collect water sample for chronic and acute toxicity analysis (including more sensitive phytoplankton and zooplankton species) following ECCC standard test methods. Develop Response Plan. If the High Action Level is confirmed, implement appropriate mitigations on a priority basis to slow or stop trend as recommended in the approved Response Plan. The focus would be on eliminating the source and preventing adverse impacts to biological receptors in Sherman Lake. Conduct special study to examine effectiveness of mitigation, long-term monitoring of mitigation effectiveness ecological significance and reversibility, causation, and/or linkage to Site. Refine Low and High Action Levels if warranted and scientifically defensible.

* All water quality results must be confirmed, meaning that the final analytical result or field measurement has been checked and validated (i.e., no probe calibration or transcription errors).
AEMP = Aquatic effects monitoring program; ECCC = Environment and Climate Change Canada

Table 12-6 Sediment Quality Action Levels and Responses for the Kwetıı̨ʔaà (Rayrock) Aquatic Effects Monitoring Program

Locations	All AEMP stations located in receiving water bodies adjacent to the Rayrock Remediation Project (Sherman Lake, Alpha Lake, Lake A, Gamma Lake, Beta Lake, Kwetsǫ̀tìa)	
Action Level Type	**Sediment Quality**	**Possible Responses to Action Levels**
Low	All of the following are met: 1. An increase in concentration greater than 10% above the 95th percentile of the pre-remediation baseline monitoring period. **AND** 2. Supported by an increasing temporal trend **AND** 3. Linked to the Kwetıı̨ʔaà (Rayrock) Remediation Project	Follow AEMP best practices: - confirm Low Action Level was triggered (e.g., confirm reliability of chemistry data) - review processes, procedures, and data to further evaluate cause/linkage to Site (e.g., sediment and erosion control plan implementation and results), as appropriate - evaluate temporal trends in sediment quality parameters at monitoring stations - examine the potential linkage between the increased concentration and results for other aquatic monitoring parameters. Report in Annual AEMP Report. Increase monitoring frequency at the station and expand the monitoring area around that location for sediment quality to confirm findings. Identify potential mitigation options (e.g., investigate changes in water chemistry and erosion and sediment control practices). Implement mitigation/further controls, as appropriate (e.g., install extra sediment control measures in construction areas). Initiate follow-up desktop/field studies if required – examine linkages between concentration, toxicity reference values, and biological responses. Predict sediment quality trends and predict time to reach a potential next action level, where appropriate. Review appropriateness of the Low Action Level and refine if warranted and scientifically defensible.
High	Both of the following are met: 1. An increase in concentration greater than 40% above the 95th percentile of the pre-remediation baseline monitoring period. **AND** 2. Linked to the Kwetıı̨ʔaà (Rayrock) Remediation Project	Follow AEMP best practices as outlined for Low Action Level. Confirm High Action Level. (e.g., confirm reliability of chemistry data). Notify Inspector and WLWB within 24 hours. Collect samples for chronic and acute toxicity analysis following ECCC standard test methods. Develop Response Plan. If the High Action Level is confirmed, implement appropriate mitigations on a priority basis to reverse trend, review SECP and site runoff conditions, as well as increasing or continuing to increase monitoring frequency or spatial extent of monitoring for water quality, sediment quality, toxicity, benthic invertebrates. Conduct desktop or special field study to examine ecological significance, causation, and/or linkage to Rayrock Remediation Project as described for the Low Action Level. This may include additional toxicity tests and/or benthic invertebrate surveys. Conduct special study to examine effectiveness of mitigation, long-term monitoring of mitigation effectiveness, ecological significance and reversibility, causation, and/or linkage to Site.

a) All sediment quality results must be confirmed, meaning that the final analytical result or field measurement has been checked and validated (i.e., no transcription errors).
b) Temporal trends to be evaluated visually.

AEMP = Aquatic effects monitoring program; ECCC = Environment and Climate Change Canada

Table 12-7 Benthic Invertebrate Density and Richness Action Levels and Responses for Kwetıı̨ɂaà (Rayrock) Aquatic Effects Monitoring Program

Locations	**All AEMP stations located in receiving water bodies adjacent to the Rayrock Remediation Project (Sherman Lake, Alpha Lake, Lake A, Gamma Lake, Beta Lake, Kwetsǫ̀ɂìa)**	
Action Level Type	**Benthic Invertebrates[a]**	**Possible Responses to Action Levels**
Low	Both of the following are met: 1. Density and richness[b] in the receiving water bodies are significantly lower compared to baseline conditions, with an effect size equal to or above the CES (i.e., 1 SD) **AND** 2. Linked to the Kwetıı̨ɂaà (Rayrock) Remediation Project	Follow AEMP best practices: - confirm Low Action Level was triggered (e.g., confirm reliability of sample and lab data) - review processes, procedures, and data to further evaluate cause/linkage to Site (e.g., WTP effluent, Sediment and Erosion Control Plan implementation and results), as appropriate - evaluate temporal trends in water and sediment quality parameters at monitoring stations - examine the potential linkage between increased concentration and results for other aquatic monitoring parameters. Report in Annual AEMP Report. Increase monitoring frequency and expand the monitoring area to confirm findings. Identify potential mitigation options (e.g., investigate changes in water chemistry and erosion and sediment control practices). Initiate follow-up desktop/field studies if required – examine linkages between concentration, toxicity, and biological responses. Review appropriateness of the Low Action Level and refine if warranted and scientifically defensible.
High	1. . Significantly lower mean densities (50% or more difference) of chironomids, bivalves, and oligochaetes compared to baseline conditions over two successive sampling programs that confirm a pattern[c] **AND** 2. Density and richness(b) in the receiving water bodies are significantly lower compared to baseline conditions, with an effect size equal to or above the CES (i.e., 1 SD) **OR** All of the following are met: 1. Density and richness[b] in the receiving water bodies are significantly lower compared to baseline conditions, with an effect size equal to or above the CES (i.e., 1 SD) **AND** 2. Significantly lower mean densities (80% or more difference) of chironomids, bivalves, oligochaetes, and mayflies, compared to baseline conditions **AND** 3. Linked to the Kwetıı̨ɂaà (Rayrock) Remediation Project	Follow AEMP best practices as outlined for Low Action Level. Confirm High Action Level. (e.g., confirm reliability of chemistry data). Conduct desktop or field special study to examine ecological significance, causation, and/or linkage Rayrock Remediation Project as described for the Low Action Level. This may include additional toxicity tests and/or benthic invertebrate surveys. Increase or continue to increase monitoring frequency or spatial extent of monitoring for water quality, sediment quality, toxicity, benthic invertebrates. Notify Inspector and WLWB within 24 hours. Collect samples for chronic and acute toxicity analysis following ECCC standard test methods. Develop Response Plan. If High Action Level confirmed, implement appropriate mitigations on a priority basis to reverse trend, with focus on eliminating source and preventing adverse impacts to biological receptors in Sherman Lake. Conduct special study to examine effectiveness of mitigation, long-term monitoring of mitigation effectiveness, ecological significance and reversibility, causation, and/or linkage to Site.

a) For this biological component of the AEMP Design Plan it is more appropriate to be consistent with monitoring under the EEM Framework and evaluate data against critical effects sizes as opposed to normal ranges.
b) Density and richness have been identified by EC (2012) as being primarily responsible for response patterns in benthic invertebrate communities.
c) Represents a more consequential outcome than a single event which is more likely to be due to chance or a confounding factor.
AEMP = Aquatic effects monitoring program; ECCC = Environment and Climate Change Canada; CES = critical effect size; SD = standard deviations

Table 12-8 Benthic and Fish Tissue Action Levels and Responses for the Kwetıı̨ɂaà (Rayrock) Aquatic Effects Monitoring Program

Location	All receiving water bodies adjacent to the Rayrock Remediation Project (Sherman Lake, Alpha Lake, Lake A, Gamma Lake, Beta Lake, Kwetsǫ̀tìa)	
Action Level Type	**Tissue Burden**	**Action Level Response**
Low	1. An increase in any metal or radionuclide concentration in the benthic or fish tissue of greater than 10% above the 95th percentile of the pre-remediation baseline monitoring period for that water body. **AND** 2. Linked to the Kwetıı̨ɂaà (Rayrock) Remediation Project	Follow AEMP best practices: - confirm Low Action Level was triggered (e.g., confirm reliability of sample and lab data) - review processes, procedures, and data to further evaluate cause/linkage to Site (e.g., WTP effluent, Sediment and Erosion Control Plan implementation and results), as appropriate - evaluate temporal trends in water and sediment quality parameters at monitoring locations Report in Annual AEMP Report. Initiate follow-up desktop/field studies if required – examine linkages between concentration, toxicity, and biological responses. Increase monitoring frequency and expand the monitoring area to confirm findings. Increase sample numbers and tissue volumes for analysis. If the average concentrations remain 25% greater than baseline in the second sampling, an investigation into the cause of the change will be completed by a biologist. Additional action may be required based on the recommendations of the biologist. Refine Low and High Action Levels if warranted and scientifically defensible.
High	1. An increase in any metal or radionuclide concentration in the benthic or fish tissue of greater than 40% above the 95th percentile of the pre-remediation baseline monitoring period for that water body. **AND** 2. Linked to the Kwetıı̨ɂaà (Rayrock) Remediation Project	Follow AEMP best practices as outlined for Low Action Level Confirm High Action Level. (e.g., confirm reliability of chemistry data). If High Action Level confirmed, implement mitigation(s) to stop or slow trend as recommended in the approved Response Plan Notify Inspector and WLWB within 24 hours. Develop Response Plan Conduct special study to examine ecological or human health significance, causation, and/or linkage to Site.

a) All tissue quality results must be confirmed, meaning that the final analytical result or field measurement has been checked and validated (i.e., no transcription errors).
b) Temporal trends to be evaluated visually.

AEMP = Aquatic effects monitoring program; WLWB = Wek'èezhii Land and Water Board

Table 12-9 In-situ Water Quality Action Levels and Responses for the Kwetıı̨ʔaà (Rayrock) Aquatic Effects Monitoring Program at Monitoring locations 1663-14 and 1663-15, located 100 m and 250 m from the Process Water Effluent Discharge Location (1663-7) into Sherman Lake.

Locations	Weekly In-situ readings of Total Suspended Solids and Turbidity at SNP Stations 1663-14 and 1663-15	
Action Level Type	**Water Quality**	**Possible Responses to Action Levels**
Low	All of the following are met: 1. The concentration of a weekly sample from 1663-14 and 1663-15 was greater than the Low Action Threshold for in-situ TSS or turbidity readings occurs during the Process Water Treatment Plant discharge period[a]. AND 2. Supported by an increasing temporal trend (assessed visually) AND 3. Linked to the Kwetıı̨ʔaà (Rayrock) Remediation Project	Follow AEMP best practices: - confirm Low Action Level was triggered (e.g., confirm reliability of chemistry data) - review processes, procedures, and data to further evaluate cause/linkage to Site (e.g., water treatment plant effluent), as appropriate - visually evaluate temporal trends in water quality parameters at monitoring stations - examine potential linkage between increased concentration and results for other in-situ monitoring parameters. Report in Monthly SNP and Annual SNP AEMP Reports. Also include a summary of the nature and extent of any Low Action Level exceedances, a description of actions taken in response to the exceedance, and an evaluation of any adaptive management response actions implemented; Increase monitoring frequency at the station to daily and include verticle profile monitoring at 1 m intervals or as required to collect a minimum of four measurements below the surface. Identify the potential source(s) of TSS or turbidity increase(s) and potential mitigation options (e.g., investigate changes in treatment practices). Predict water quality trends and predict time to reach a potential next action level, where appropriate. Review appropriateness of the Low Action Level and refine if warranted and scientifically defensible.
High	Both of the following are met: 1. The concentration of a weekly (or daily) sample from 1663-14 and 1663-15 was greater than the High Action Threshold for in-situ TSS or turbidity readings occurs during the Process Water Treatment Plant discharge period. AND 2. Linked to the Kwetıı̨ʔaà (Rayrock) Remediation Project.	Confirm High Action Level. (e.g., confirm reliability of data). Confirm Link to the Rayrock Remediation Project (evidence Process Water Treatment Plant effluent has exceeded the High Action Level). Communicate with Process Water Treatment Plant operators to investigate the cause of this High Action Level. Notify Inspector and WLWB within 24 hours. Follow AEMP best practices as outlined for Low Action Level. Continue increased (daily) monitoring and to confirm findings expand spatial extent of monitoring for water quality to include existing Sherman Lake AEMP locations (e.g. Sherman Lake L and Sherman Lake K,) and additional locations at 100 m intervals from 1663-15 to identify the extent of the elevated TSS. Develop Response Plan. If High Action Level confirmed, immediately communicate with Process Water Treatment Plant operators to investigate the cause. Appropriate mitigations should be implemented on a priority basis to slow or stop the identified trend. The focus should be on identifying and eliminating the source and preventing adverse impacts to biological receptors in Sherman Lake. Continue increased (daily) monitoring at all locations listed in the High Action Level response until TSS and/or turbidity concentrations are below the Low Action Level for a minimum of 3 days and are part of a decreasing trend. Detail and evaluate any adaptive management response actions implemented and refine Low and High Action Levels if warranted and scientifically defensible.

Notes: All water quality results must be confirmed, meaning that field measurements have been checked and validated (i.e., no probe calibration or transcription errors); Monitoring Station UTMs include: 1663-14 (UTM: 7036013 N, 523484 E); 1663-15 (UTM: 7036013 N, 523634 E)

13 AEMP REPORTING

13.1 AEMP Reporting Requirements

Part F of the Water Licence outlines the reporting requirements for the AEMP. The requirements and a proposed schedule are outlined in Table 13-1.

Table 13-1 Water Licence AEMP Conditions and Proposed AEMP Schedule

Water Licence AEMP Conditions	Timeline
1. *The Licencee shall design and implement an Aquatic Effects Monitoring Program (AEMP) in accordance with the MVLWB/GNWT Guidelines for Aquatic Effects Monitoring Programs.*	Ongoing activities as outlined below
2. *Within 90 of the effective date of this Licence, the Licencee shall submit to the Board, for approval, an **AEMP Design Plan**. The Plan shall be in accordance with the MVLWB/GNWT Guidelines for Aquatic Effects Monitoring Programs.*	January 2023
3. *Three years following implementation of the **AEMP Design Plan**, and every three years thereafter, or as directed by the Board, the Licencee shall submit to the Board, for approval, an **AEMP Re-Evaluation Report**. The Report shall be in accordance with the MVLWB/GNWT Guidelines for Aquatic Effects Monitoring Programs and shall evaluate the overall effectiveness of the AEMP to date.*	2026
4. *Every three years following implementation of the **AEMP Design Plan**, or as directed by the Board, the Licencee shall submit to the Board, for approval, a revised **AEMP Design Plan**. The revised Plan shall be in accordance with the MVLWB/GNWT Guidelines for Aquatic Effects Monitoring Programs.*	2026
5. *Beginning May 31st, 2023 and no later than May 31st of each year thereafter, the Licencee shall submit to the Board, for approval, an **AEMP Annual Report**. The Report shall be in accordance with the MVLWB/GNWT Guidelines for Aquatic Effects Monitoring Programs and the requirements of Schedule 5, Condition 1.*	Annually by May 31 2023 to 2031
6. *If any low Action Level established in the approved **AEMP Design Plan** is exceeded, the Licencee shall, at a minimum, implement the response actions described in the approved **AEMP Design Plan**, and report the exceedance in the **AEMP Annual Report.***	Annually, as needed.

Water Licence AEMP Conditions	Timeline
7. If any moderate or high Action Level established in the approved ***AEMP Design Plan*** *is exceeded, the Licencee shall:* *a) Within the timeframe identified in the approved* ***AEMP Design Plan****, notify the Board and an Inspector; and* b) *Within the timeframe identified in the approved* ***AEMP Design Plan,*** *or as otherwise directed by the Board, submit an* ***AEMP Response Plan*** *to the Board for approval. The Response Plan shall be in accordance with the MVLWB/GNWT Guidelines for Aquatic Effects Monitoring Programs.*	a) Notification within 24 hr of confirmation of moderate or high Action Level exceedance. b) Notification and submission of an AEMP Response Plan within 30 days of confirmation of moderate or high Action Level.

A Re-Evaluation Report and Revised AEMP Design Plan are requirements of Part F of the Water Licence and are required 3 years following the implementation of the AEMP Design Plan. In addition, Part H, Condition 5 of the Water Licence requires a Post-Closure Monitoring and Maintenance Plan to be submitted post-remediation and is required to cover the monitoring associated with the AEMP. Since the AEMP Design Plan will be implemented beginning in 2024 and remediation will be completed in 2027, the Re-Evaluation Plan and Post-Closure Monitoring and Maintenance Plan will be due concurrently in 2027**.**

13.2 AEMP Annual Report

An annual report will be prepared to summarize the AEMP activities conducted during the reporting year and will be submitted by May 31 of the following year as per Part F of the Water Licence. The AEMP annual report will meet the requirements of Part F, Schedule 5 of the Water Licence outlined below:

1. The ***AEMP Annual Report*** *referred to in Part F, condition 5 of this Licence shall include, but not be limited to, the following:*

- *a) A plain language summary and interpretation of the major results obtained in the preceding calendar year;*
- *b) A summary of activities conducted under the AEMP;*
- *c) A summary of any spills, activities, or other considerations within the report time frame that could influence the results of the AEMP;*
- *d) Tabular summaries of all data and information generated under the AEMP, in Excel format;*
- *e) An interpretation of the results, including an evaluation of any identified environmental effects that occurred as a result of the Project;*

f) *A comparison of predicted mixing and dilution of Effluent in Sherman Lake in comparison to monitoring data;*

g) *An analysis that integrates the results of individual monitoring components collected in a calendar year and describes the ecological significance of the results;*

h) *A comparison of monitoring results to Action Levels as defined in the approved AEMP Design Plan;*

i) *For any low Action Level exceedances, a summary of the nature and extent of the exceedance, as well as a description of actions taken in response to the exceedance;*

j) *An evaluation of any adaptive management response actions implemented;*

k) *Recommendations, with rationale, for changes to any aspect of the AEMP Design Plan; and*

l) *Any other information specified in the approved AEMP Design Plan*

REFERENCES

AECOM Canada Ltd., (AECOM). 2024. *2023 Rayrock Aquatic Effects Monitoring Program Report, 2023 Baseline AEMP Report.* Report prepared for Public Services and Procurement Canada. May 2024.

AECOM Canada Ltd., (AECOM). 2023. *2022 Rayrock Aquatic Effects Monitoring Program Report, 2022 Baseline AEMP Report.* Report prepared for Public Services and Procurement Canada. May 2023.

AECOM Canada Ltd. (AECOM). 2022a. *2021 Rayrock Aquatic Effects Monitoring Program Report: Baseline AEMP Report.* Report prepared for Public Services and Procurement Canada. Calgary, AB. March 2022.

AECOM Canada Ltd. (AECOM). 2022b. *2021 Field Investigation Summary, Kwetıı̨ʔaà (Raryock) Remediation Project.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. July 2022.

AECOM Canada Ltd., (AECOM). 2022c. *Ecological Risk Assessment of Sediments in Beta and Gamma Lakes, Kwetıı̨ʔaà (Raryock) Remediation Project.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. December 2022.

AECOM Canada Ltd., (AECOM). 2022d. *2022 Beta and Gamma Lake Investigation, Kwetıı̨ʔaà (Raryock) Remediation Project.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. December 2022.

AECOM Canada Ltd. (AECOM). 2021a. *Beta and Gamma Lake Remedial Options Review, Rayrock Remediation Project.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. May 2021.

AECOM Canada Ltd. (AECOM). 2021b. *2020 Field Investigation Summary, Kwetıı̨ʔaà (Raryock) Remediation Project.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. August 2021.

AECOM Canada Ltd. (AECOM). 2021c. *Kwetıı̨ʔaà (Raryock) Remediation Project, 2021 Field Investigation Summary – Mill Lake Water and Sediment Thickness Measurements.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. October 2021.

AECOM Canada Ltd. (AECOM). 2021d. *Kwetıı̨ʔaà (Raryock) Remediation Project, 2021 Field Investigation Summary – Mill Lake Surface Water Sampling*. Report Prepared for Public Services and Procurement Canada. Calgary, AB. October 2021.

AECOM Canada Ltd. (AECOM). 2021e. Kwetıı̨ʔaà (Raryock) Remediation Project, July 2021 Sherman Lake Water Depth Measurements. Report Prepared for Public Services and Procurement Canada. Calgary, AB. October 2021.

AECOM Canada Ltd. (AECOM). 2020a. *Former Rayrock Mine, 2019 Field Program Summary Report*. Report prepared for Public Services and Procurement Canada. Calgary, AB. March 2020.

AECOM Canada Ltd. (AECOM). 2020b. *Mill Lake Sediment Hydrogeology Report.* Report prepared for Public Services and Procurement Canada. Calgary, AB. March 2020.

AECOM Canada Ltd., (AECOM). 2020c. *2019 Mill Lake Water and Sediment Depth Measurement Results, Rayrock Remedial Action Planning.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. March 2020.

AECOM Canada Ltd., (AECOM). 2020d. *2020 Mill Lake Sediment Hydrogeology Assessment*. Report Prepared for Public Services and Procurement Canada. Calgary, AB. May 2020.

AECOM Canada Ltd., (AECOM). 2020e. *Remedial Action Plan - Kwetı̨ı̨ʔaà (Raryock) Remediation Project.* Report prepared for Public Services and Procurement Canada. Calgary, AB. August 2020.

AECOM Canada Ltd., (AECOM). 2020f. *2020 Mill Lake Sediment Sampling.* Report Prepared for Public Services and Procurement Canada. Calgary, AB. September 2020.

AECOM. 2019. *2018 Field Program Summary, Mine Remediation Project*. Report prepared for CIRNAC. Calgary, Alberta. March 2019.

AMEC Environment & Infrastructure (AMEC). 2015. *Human Health Preliminary Quantitative Risk Assessment*. March 2015.

Arcadis Canada Inc. (Arcadis). 2018. *Human Health and Ecological Risk Assessment for Rayrock Mine Site.* Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. January 2018.

Arcadis Canada Inc. (Arcadis). 2017a. *Delineation of Contamination of Mill Lake and the Associated Drainage Area, Former Rayrock Mine, Northwest Territories.* Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. January 2017.

Arcadis Canada Inc. (Arcadis). 2017b. *Phase I and II Environmental Site Assessments of Sherman Lake Camp and the Barge Landing and Aerial Reconnaissance of the Former Power Line.* Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. March 2017.

Arcadis Canada Inc. (Arcadis). 2017c. *Hydrogeological Study, Rayrock Mine, Northwest Territories.* Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. March 2017.

Arcadis Canada Inc. (Arcadis). 2017d. *Rayrock Freshet Observations and Data Collection Program.* Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. October 2017.

Arcadis Canada Inc. (Arcadis). 2017e. *Data Collection Program Rayrock Remediation Project.* Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. December 2017.

Arcadis Canada Inc. (Arcadis). 2016a. *Hydrological Study of Beta and Gamma Lakes, Rayrock Mine, Northwest Territories.* Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. January 2016.

Arcadis Canada Inc. (Arcadis). 2016b. *Phase III Environmental Site Assessment, Rayrock Mine, Northwest Territories*. Report prepared for Public Works and Government Services Canada. Richmond Hill, ON. February 2016.

Arcadis SENES Canada (Arcadis SENES). 2015. *2014 Rayrock Compliance Monitoring Program, Former Rayrock Mine, NT.* Report prepared for Public Works and Government Services Canada. March 2015.

Atomic Energy Canada. 2000. *Short-term Environmental Monitoring Program: Rayrock Uranium Mine.* Low-Level Radioactive Waste Management Office, Atomic Energy of Canada. February 2000.

Aquatic Effects Technology Evaluation Program (AETE). 1996. *1995 Field evaluation of aquatic effects monitoring methods - Pilot Study.* Volume 1. AETE Project 4.1.1. Canada Centre for Mineral and Energy Technology. Ottawa, ON. September 2006. https://mend-nedem.org/wp-content/uploads/4.1.1_V1.pdf

British Columbia Ministry of Environment (BC MoE). 2014. Ambient Water Quality Guidelines for Selenium Technical Report Update. Prepared by: J.M. Beatty and G.A. Russo

Canadian Council of Ministers of the Environment (CCME). 1999a. *Canadian Environmental Quality Guidelines – Canadian Water Quality Guidelines for the Protection of Aquatic Life.* Canadian Council of Ministers of the Environment. Winnipeg, MB. 1999. https://ccme.ca/en/current-activities/canadian-environmental-quality-guidelines

Canadian Council of Ministers of the Environment (CCME). 1999b. *Canadian Environmental Quality Guidelines – Canadian Sediment. Quality Guidelines for the Protection of Aquatic Life.* Canadian Council of Ministers of the Environment. Winnipeg, MB. 1999. https://ccme.ca/en/current-activities/canadian-environmental-quality-guidelines

Canada North Environmental Services (CanNorth). 2025. Technical Memo: *Response to Land and Waterboard Comment on Radionuclides.* Report prepared for Public Services and Procurement Canada. Markham, ON. June 2025.

Canada North Environmental Services (CanNorth). 2023. *Development of Site Specific Significance Thresholds for Sherman Lake, Rayrock Remediation Project.* Report prepared for Public Services and Procurement Canada. Markham, ON. March 2023.

Canada North Environmental Services (CanNorth). 2018. *Human Health and Ecological Risk Assessment for Rayrock Mine Site.* Report prepared for Public Services and Procurement Canada. Markham, ON. March 2018.

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC). 2019. *Conceptual Site Model – Rayrock Uranium Mine, Sun Rose Site, Barge Landing and Associated Satellite Sites.* Yellowknife, NT. September 2019.

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC). 2017. *Conceptual Site Model – Rayrock Uranium Mine, Sun Rose Site, Barge Landing and Associated Satellite Sites.* Yellowknife, NT. June 2017.

Dogrib Renewable Resources Committee (Dogrib). 1996. *The Trees All Changed to Wood.* Dogrib Treaty 11 Council. 1996.

Dudgeon, D., A.H. Arthington, M.O. Gessner, Z. Kawabata, D.J. Knowler, C. Lêvêque, R.J. Naiman, A. Prieur-Richard, D. Soto, M.L.J. Stiassny and C.A. Sullivan. 2006. *Freshwater biodiversity: importance, threats, status and conservation challenges.* Biological Reviews Cambridge Philosophical Society 81: 163−182. May 2006.

Environment Canada. 2012. *Metal Mining Technical Guidance for Environmental Effects Monitoring.* May 2012. https://www.canada.ca/en/environment-climate-change/services/managing-pollution/environmental-effects-monitoring/metal-mining-technical-guidance/metal-mining-technical-guidance-environmental-effects-monitoring.html

Environment and Climate Change Canada (ECCC) and Government of the Northwest Territories (GNWT). 2021. *Hyrological Evaluation for Great Slave Lake 2020*. December 2020. https://www.enr.gov.nt.ca/sites/enr/files/resources/hydrological_analysis_for_great_slave_lake_2020_final_report_2021-01-28.pdf

Environmental Protection Agency (EPA). *Method 6020B (SW-846): Inductively Coupled Plasma-Mass Spectrometry.* Revision 2. Washington, DC. July 2014. https://www.epa.gov/esam/epa-method-6020b-sw-846-inductively-coupled-plasma-mass-spectrometry#:~:text=EPA%20Method%206020B%20%28SW-846%29%3A%20Inductively%20Coupled%20Plasma%20-,6020B%20%28SW-846%29%3A%20Inductively%20Coupled%20Plasma-Mass%20Spectrometry%2C%22%20Revision%202.

Fielding Environmental. 2019. *Rayrock Mine (Kwetį̨ìʔaà) Remediation Project 2018/19: Multiday Elder-led Site Tour and Sampling Exercise at Rayrock Mine and Surrounding Area.* Report prepared for the Tłı̨chǫ Government. March 2019.

Fielding Environmental. 2016. *Rayrock Mine & Marian River Watershed Study – 2015*. Report prepared for the Indigenous and Northern Affairs Directorate. Smithers, BC. January 2016.

Golder Associates Ltd. (Golder). 2001a. *Rayrock Mine Long Term Monitoring Program Fall 2001 Site Inspection Integrity of Mine Openings.* March 2001.

Golder Associates Ltd. (Golder). 2001b. *Results of 2000 Rayrock Long-Term Monitoring Program.* March 2001.

Golder Associates Ltd. (Golder). 1999. *Report on Review of the Short-term Monitoring Program, and Recommendations for Long-term Monitoring at the Rayrock Mine Site.* April 1999.

Golder Associates Ltd. (Golder). 1996. *Environmental Monitoring Program for Assessing Remediation Efforts at the Rayrock Uranium Mine*. October 1996.

Government of Canada. 2016. *Mackenzie Valley Federal Areas Waters Regulations, SOR/93-303.* Ottawa, ON. Current as of February 2023. https://laws-lois.justice.gc.ca/PDF/SOR-93-303.pdf

Government of Canada. 2014. *Northwest Territories Devolution Act, S.C. 2014, c.2*. Ottawa, ON. March 2014. https://laws-lois.justice.gc.ca/PDF/2014_2.pdf

Government of Canada. 2000a. *EPS 1/RM/13 – Biological Test Method: Acute Lethality of Effluents to Rainbow Trout*. Environmental Protection Series, Method Development and Applications Section, Environmental Technology Centre, Environment Canada. Ottawa, ON. December 2000.

Government of Canada. 2000b. *EPS 1/RM/14 – Biological Test Method: Acute Lethality of Effluents to Daphnia magna.* Environmental Protection Series, Method Development and Applications Section, Environmental Technology Centre, Environment Canada. Ottawa, ON. December 2000.

Government of Canada. 1999. *Canadian Environmental Protection Act – Schedule 1: Toxic Substances Lists.* Ottawa, ON. Updated May 2021. https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/substances-list/toxic/schedule-1.html

Government of Canada. 1998. *Mackenzie Valley Resource Management Act, S.C., 1998, c. 25.* Ottawa, ON. Current as of February 2023. https://laws-lois.justice.gc.ca/PDF/M-0.2.pdf

Government of Canada. 1997. *Nuclear Safety and Control Act, S.C. 1997, c.9.* Ottawa, ON. Current as of February 2023. https://laws-lois.justice.gc.ca/PDF/N-28.3.pdf

Government of Canada. 1985. *Fisheries Act, R.S.C., 1985, c. F-14.* Minister of Justice. Ottawa, ON. Current as of February 2023. https://www.laws-lois.justice.gc.ca/PDF/F-14.pdf

Government of Northwest Territories (GNWT). 2008. Ecological Regions of the Northwest Territories. Retrieved December 16, 2022: https://www.enr.gov.nt.ca/sites/enr/files/wkss_taiga_shield-2008.pdf

Hatfield Consultants Limited (Hatfield). 1985. *An Evaluation of Environmental Conditions Associated with the Abandoned Uranium Mines at Rayrock and Echo Bay.* Report prepared for Science Institute of the Northwest Territories. July 1985.

Health Canada. 2014. *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM).* Prepared by the Canadian NORM Working Group of the Federal Provincial Territorial Radiation Protection Committee. Ottawa, ON. April 2014

Kalin, M. 1984. *Raryock Northwest Territories, History, Uranium Tailings, and Environment.* Institute for Environmental Studies, University of Toronto. Report prepared for Environmental Protection Service, Environment Canada, and Indian and Northern Affairs Canada. Toronto, ON. June 1984.

Knight Piésold Ltd. 2001a. *Rayrock Mine Long Term Monitoring Program Fall 2001 Site Inspection Integrity of Mine Openings.* October 2001.

Knight Piésold Ltd. 2001b. *Rayrock Mine Long Term Monitoring Program Fall 2001 Site Inspection Integrity of the Tailings Areas and Their Covers.* October 2001.

Mackenzie Valley Land and Water Board and Government of the Northwest Territories (MVLB/GNWT). 2019. Guidelines for Aquatic Effects Monitoring Programs. March 2019. https://www.enr.gov.nt.ca/sites/enr/files/resources/aemp_guidelines.pdf

Racher KI, Hutchinson N, Hart D, Fraser B, Clark B, Fequet R, Ewaschuk P, Cliffe-Phillips M. 2011. *Linking environmental assessment to environmental regulation through adaptive management*. Integrated environmental assessment and management. 7(2):301-2.

Reid, A.J., A.K. Carlson, I.F. Creed, E.J. Eliason, P.A. Gell, P.T.J. Johnson, K.A. Kidd, T.J. MacCormack, J.D. Olden, S.J. Ormerod, J.P. Smol, W.W. Taylor, K. Tockner, J.C. Vermaire, D. Dudgeon, S.J. Cooke. 2019. *Emerging threats and persistent conservation challenges for freshwater biodiversity.* Biological Reviews Cambridge Philosophical Society 94: 849−873. June 2019.

Rescan Environmental Services Ltd. (Rescan). 2012a. *Rayrock Mine: Gap Analysis of Preliminary Quantitative Ecological Risk Assessment.* Prepared for Aboriginal Affairs and Northern Development Canada by Rescan Environmental Services Ltd. Yellowknife, NT. March 2012.

Rescan Environmental Services Ltd. (Rescan). 2012b. *Rayrock Mine, Rayrock Comprehensive Remediation Performance Assessment Report.* Prepared for Aboriginal Affairs and Northern Development Canada by Rescan Environmental Services Ltd. Yellowknife, NT. March 2012.

Rescan Environmental Services Ltd. (Rescan). 2010. *2009 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. January 2010.

Rescan Environmental Services Ltd. (Rescan). 2008. *Results of Fall 2007 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. March 2008.

Rescan Environmental Services Ltd. (Rescan). 2006a. *Results of Fall 2005 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. February 2006.

Rescan Environmental Services Ltd. (Rescan). 2006b. *Rayrock Transportation Route Enhanced Phase I Assessment.* Report prepared for Public Works Canada. Yellowknife, NT. February 2006.

Rescan Environmental Services Ltd. (Rescan). 2006c. *Results of Fall 2006 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. November 2006.

Rescan Environmental Services Ltd. (Rescan). 2005. *Results of Fall 2004 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. January 2005.

Rescan Environmental Services Ltd. (Rescan). 2004. *Results of Fall 2003 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. February 2004.

Rescan Environmental Services Ltd. (Rescan). 2003. *Results of 2002 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. February 2003.

Rescan Environmental Services Ltd. (Rescan). 2002a. *Revised Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. March 2002.

Rescan Environmental Services Ltd. (Rescan). 2002b. *Results of Fall 2001 Rayrock Long-Term Monitoring Program.* Report prepared for Public Works Canada. Yellowknife, NT. April 2002.

Reynolds, C.S. 1989. *Physical determinants of phytoplankton succession.* Chapter In: Plankton ecology: succession in plankton communities. U. Sommer (ed). Brock/ Springer Series in Contemporary Bioscience. Springer, Berlin, p 9−56.

Sanexen Environmental Services Inc. (Sanexen). 2025. Process Water Treatment Plant Operation and Maintenance Plan - Kwetıı̨ʔaà (Rayrock) Remediation Project, Rayrock Mine, NT. Revised Final. May 9, 2025.

SENES Consultants Limited. 2014. *2013 Gap Filling Program at Former Rayrock Mine Site.* Report prepared for Contaminants and Remediation Directorate, Indian and Norther Affairs Canada. March 2014.

SENES Consultants Limited. 2010. *Rayrock Supplemental Site Assessment and Monitoring Program.* Report prepared for Contaminants and Remediation Directorate, Indian and Norther Affairs Canada. March 2010.

Silke, Ryan. 2009. *The Operational History of Mine in the Northwest Territories, Canada*. Northwest Territories Geoscience Office. Yellowknife, NT. 2009. https://buyandsell.gc.ca/cds/public/2014/05/27/edcb878b7f96e1d30e5359a53406c671/ABES.PROD.PW_NCS.B107.E10183.ATTA040.PDF

Sommer, U., R. Adrian, L. De Senerpont Domis, J.J. Elser, U. Gaedke, B. Ibelings, E. Jeppesen, M. Lürling, J.C. Molinero, W.M. Mooij, E. van Donk, and M. Winder. 2012. *Beyond the plankton ecology group (PEG) model: mechanisms driving plankton succession.* Annual Review of Ecology, Evolution and Systematics 43: 429−448. December 2012.

Soniassy, R., E. Ladoucer, and A. Macdonald. *Monitoring of the Rayrock Abandoned Mite Site, Rayrock, NWT.* Environment and Conservation Division, Renewable Resources and Environmental Directorate, Northern Affairs Program, Indian and Norther Affairs Canada. Yellowknife, NT. October 1986.

Sterner, R.W. 1989. *The role of grazers in phytoplankton succession.* Chapter In: Plankton ecology. U. Sommer (ed). Brock/ Springer Series in Contemporary Bioscience. Springer, Berlin, p 107−170

Suter GW, Efroymson RA, Sample BE, Jones DS. 2000. Ecological Risk Assessment for Contaminated Sites. Lewis Publishers, New York, NY, USA.

Thompson, P.A., J. Kurias And S. Mihok. 2005. *Derivation and Use of Sediment Quality Guidelines for Ecological Risk Assessment of Metals and Radionuclides Released to the Environment from Uranium Mining and Milling Activities in Canada*. Environmental Monitoring and Assessment (2005) 110: 71–85; November 2005.

Tłı̨chǫ Government (Tłı̨chǫ). 2018. *Summary Report, Kwetıı̨ʔaà Traditional Monitoring Program.* Tłı̨chǫ Research and Training Institute. December 2018.

Tłı̨chǫ Government (Tłı̨chǫ). 2015. *"Like a Sick Person Sleeping" TK Study* for Aboriginal Affairs and Northern Development (AANDC) Risk Assessment of the Kwetı̨ı̨ɂaà Contaminated Mine Site. Tłı̨chǫ Research and Training Institute. 2015.

United States – Environmental Protection Agency (USEPA). 2021. *Technical Support for Fish Tissue Monitoring for Implementation of EPA's 2016 Selenium Criterion.* Office of Water. October 2021. https://www.epa.gov/system/files/documents/2021-10/selenium-fishtissue-tsd-draft-2021.pdf

Vörösmarty, C.J., P.B. McIntyre, M.O. Gessner, D. Dudgeon, A. Prusevish, P. Green, S. Glidden, S.E. Bunn, C.A. Sullivan, C.R. Liermann, and P.M. Davies. 2010. *Global threats to human water security and river biodiversity.* Nature 467: 555−561. September 2010.

Winder, M. and U. Sommer. 2012 *Phytoplankton response to a changing climate.* Hydrobiologia 698: 5−16. May 2012.

WLWB (Wek'èezhìi Land and Water Board). 2010. *Guidelines for Adaptive Management – a Response Framework for Aquatic Effects Monitoring.* Draft. Yellowknife, NT, Canada. October 2010.

Yan, N.D. 1979. *Phytoplankton community of an acidified, heavy metal contaminated lake near Sudbury, Ontario: 1973-1977.* Water, Air, and Soil Pollution. 11:43-45.

14 ACRONYMS, GLOSSARY, AND UNITS OF MEASURE

ACRONYMS

AEMP	Aquatic Effects Monitoring Program
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
CARD	Contaminants and Remediation Division
CCME	Canadian Council of Ministers for the Environment
CDF	Confined Disposal Facility
CES	Critical Effect Size
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CLCA	Comprehensive Land Claims Agreements
CNSC	Canadian Nuclear Safety Commission
COPC	Constituent of Potential Concern
CPUE	Catch per Unit Effort
CSM	Conceptual Site Model
DCLP	Department of Culture & Lands Protection, Tłı̨chǫ Government
DELT	Deformities, Erosion, Lesions and Tumours
DFO	Fisheries and Oceans Canada, formerly Department of Fisheries and Oceans
EEM	Environmental Effects Monitoring
EPA	Environmental Protection Agency, United States
EQC	Environmental Quality Criteria
ERA	Ecological Risk Assessment
GNWT	Government of the Northwest Territories
GS	Rayrock-affiliated drilling site
GSI	Gonadosomatic Index
HHERA	Human Health and Environmental Risk Assessment
HIS	Hepatosomatic Index
ISQG	Interim Sediment Quality Guideline
LEL	Lowest Effect Level
LUP	Land Use Permit
MDL	Method Detection Limit
MK	Rayrock-affiliated drilling site
MVLWB	Mackenzie Valley Land and Water Board
NT/NWT	Northwest Territories
QA/QC	Quality Assurance/Quality Control
PHC	Petroleum Hydrocarbon
PSPC	Public Services and Procurement Canada
PWTP	Process Water Treatment Plant
RAP	Remedial Action Plan
REX	Horn Plateau Exploration Site
RPD	Relative Percent Difference
SECP	Sediment and Erosion Control Plan
SNP	Surveillance Network Program
TCA	Tailings Containment Area
TDS	Total Dissolved Solids

TED	Rayrock-affiliated drilling site
TOC	Total Organic Carbon
TSS	Total Suspended Solids
US	United States
WLWB	Wek'èezhìi Land and Water Board
WNSL	Waste Nuclear Substance Licence
WSC	Water Survey of Canada

UNITS OF MEASURE

m asl	metre above sea level
cm	centimetre
ha	hectares
km	kilometre
m	metre
m^2	squared metre
m^3	cubic metre
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm	millimetre
mV	milliVolts
NTU	Nephelometric Turbidity Units
V	Volts
%	percent
µg/g	microgram per gram
µg/L	microgram per litre
µS/cm	microsiemen per centimeter

GLOSSARY

Action Level	A pre-determined qualitative or quantitative trigger which, if exceeded, requires the proponent to take appropriate actions.
assessment endpoint	General statement about what is being protected (e.g., suitability of water quality to support a health aquatic ecosystem) through the existing conditions of the site, and into the future during remediation and into post-closure.
background	An area not influenced by chemicals released from the site under evaluation.
baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated
critical effect size (CES)	A statistical analysis that reflects the breaking point between non-adverse and adverse changes in toxicological effect parameters.
method detection limit (MDL)	The lowest signal, or lowest corresponding quantity to be determined from a signal, that can be observed with a sufficient degree of confidence or statistical significance.
effect	Change which is a result or consequence of an action or cause.
effluent	Treated or untreated liquid waste being discharged into surface water.
monitoring component	A characteristic or parameter being monitored.
measurement endpoint	valued aquatic ecosystem components that could be affected by changes in environmental conditions associated with activities and they serve to focus monitoring activity on the key environmental values to be protected.
plankton	Small, often microscopic, plants (phytoplankton) and animals (zooplankton) that live in the open water column of non-flowing waterbodies such as lakes. They are an important food source for many larger animals.
Response Framework	A systematic approach to responding to the results of a monitoring program through adaptive management actions.
Response Plan	Document describing the actions that will be taken by a proponent in response to an Action Level exceedance.
sediment	Mineral deposits found on the bottom of a lakebed.

sedimentation	The process of deposition of suspended matter carried by water, wastewater, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material.
significance threshold	A limit of environmental change which, if reached, would likely results in significant adverse impacts.
sentinel species	Species that can be used as an indicator of environmental conditions.
Simpson's diversity index	A method to measure the diversity of a species in a community.
Simpson's evenness index	A measure of the relative abundance of a species within an area.
tailings	By-product of mining activities leftover following the separation of the valuable fraction.
toxicity	The degree to which a chemical/substance can damage an organism.